DEVELOP AND APPLICATION OF NETWORK REAL TIME THEORETICAL LINE LOSS CALCULATION AND ANALYSIS SYSTEM

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ABSTRACT

The network real time theoretical line loss calculation and analysis system (RTLLCAS) is designed to theoretically compute and analyze the line losses of the medium-voltage and over power networks at different voltage classes in real time. It collecting real-time information, e.g. active (reactive) power, voltage and current, from existing power grid dispatching system, load management system and the relative systems automatically, and conversion to the data and graphic model, topology analysis, load flow study and statistical analysis. The system mainly has such functions: (1) Real-time computation of the theoretical loss and line loss rate of power grid; (2) Computation and storage of the daily theoretical loss and line loss rate of power grid within a period of time; (3) Enquiry and analysis of the real-time (or off-line) theoretical losses and compositions of the components of power grid at different voltage classes within any one period of time; (4) Automatic summarization of various analysis results; (5) Calculation of the economic benefits of various loss reduction measures. Practical application of the system proves that this system can help the operators acquire exact real-time information and providing a guide for economic operation of power grid.

INTRODUCTION

To enhance the accuracy of the theoretical computation of line loss, and to reduce the workload of the personnel who are responsible for line loss management, Shaanxi Electric Power Company in China developed a network real time theoretical line loss calculation and analysis system. This system can collect real-time information automatically from existing automation systems such as active (reactive) power, voltage and current, and automatically conduct real-time theoretical computation and analysis of various component losses for power networks 6-10kV and over at different voltage classes through automatic conversion of data and graphic model, topology analysis, load flow study and statistical analysis. The development of this system change the previous manual data acquisition, computation and summarization into automatic acquisition and real-time computation. Besides, compositional analysis of network loss is changed from single computation at a certain time to continuous real-time computation that varies with load, network structure and operation mode.

1. OPERATING ENVIRONMENT AND MAIN FUNCTIONS

In order to fully application of the existing hardware and software resources available in the data management system of power supply enterprise to reduce investment cost, the Oracle 8i for background database, TCP/IP LAN for network environment, and Windows 98/2000/XP for front-end clients was selected for such operating environment of this system. The system was completely established based on existing operating environment of the enterprise's data management system. No additional cost was needed to invest in software and hardware except some investment on the development of this system.
The relation between this system and existing automation systems is as shown as follows.

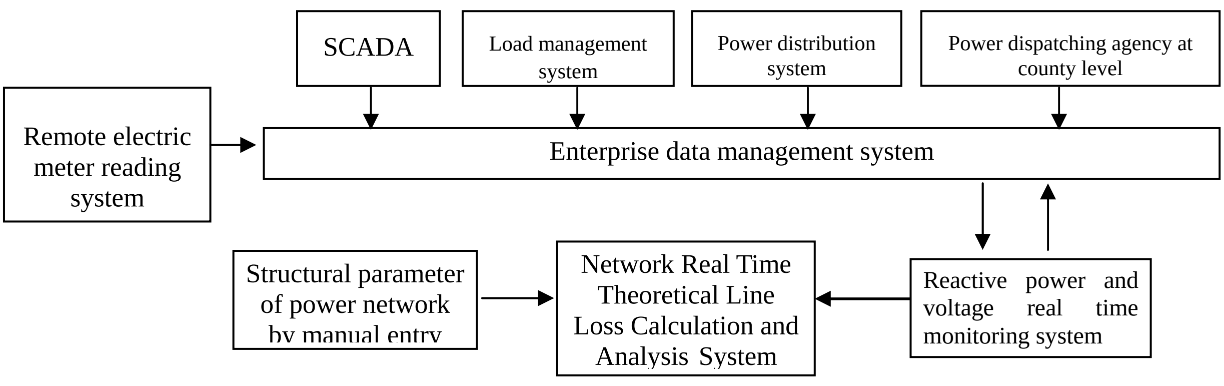

Fig. 1 The relation between the RTLLCAS and existing automation systems

The network real time theoretical line loss calculation and analysis system consists of 7 modules, i.e. graphing module, calculation item and system setting module, interface (with other real time systems) module, topology analysis module, online line loss statistical calculation & analysis module, offline line loss calculation & analysis module and print & chart module, as shown in following block diagram.

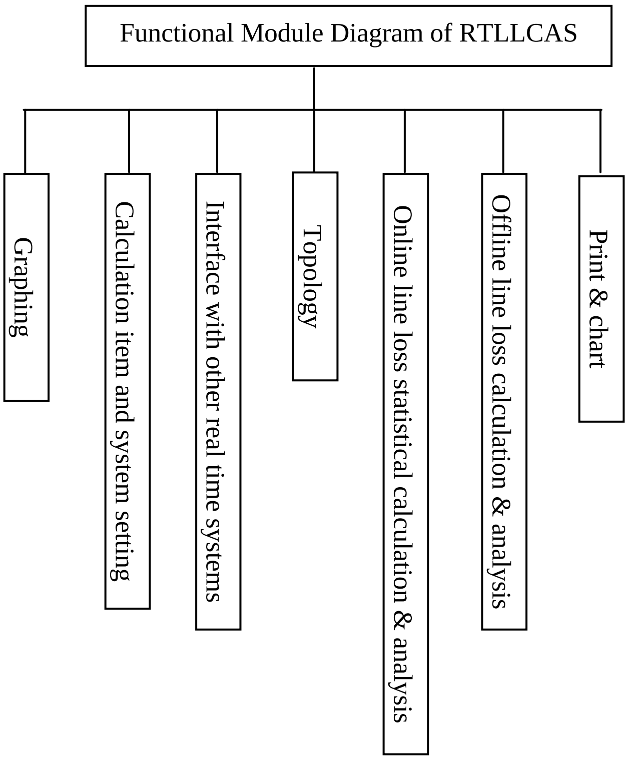

Fig.2 the modules of the RTLLCAS

1.1 Graphing

Graphing module is designed to carry out the synchronous conversion of mathematical model into graphs. The close combination of mathematical computation with graphs allows the structure of power network to be visually displayed. (1) Plotting function: Graphing platform and graphic element library are provided. Operators can draw line connection and operation mode according to actual status. All graphs are vector diagrams, and can be freely operated, e.g. copy, delete, rotate and zoom in/out. The attributes of visual graphic elements are editable. (2) Parameter entry function: Equipment parameters entered can be of rated value, named value or per unit value. The tap position of main transformers in 24 hours can be entered. Drawing method and color of the equipment such as line, switch and transformer can be freely set. The structured data of power network can be entered in graphic or tabular form. (3) Parameter statistics function: Automatic statistics of the length and cross section of various types of conductors and the quantity and capacity of transformers can be carried out. (4) Topology analysis and graphic model transformation can be carried out automatically.

An example for the use of graphing model is given below:

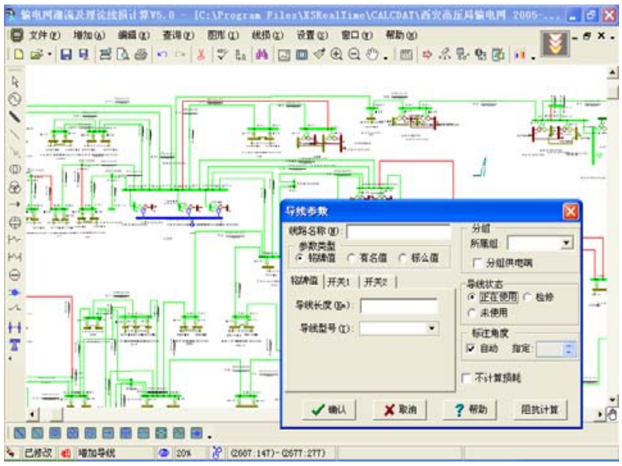

Fig.3 An example for the use of graphing model

1.2 Calculation Item and System Setting

Calculation item and system setting module can be used to set calculation method, maximum iterations and allowable error. The effect of temperature on calculation results can be taken into account. When temperature is taken into account, either a calculation temperature is specified, or a temperature curve is entered to figure out the calculation temperature. An example for calculation item setting is given below:

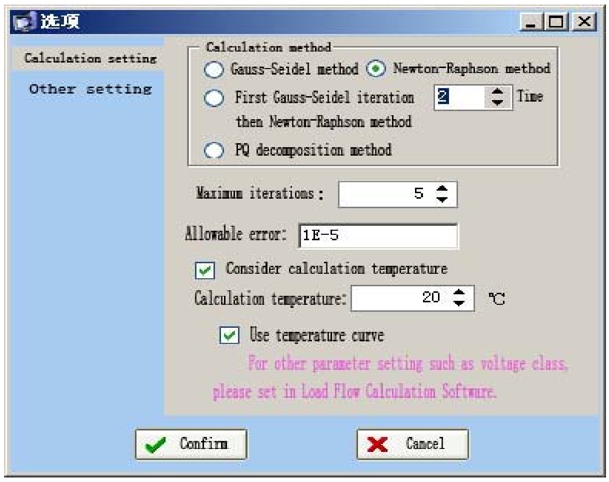

Fig.4 An example for calculation item setting

1.3 Topology Analysis Module

Topology analysis module is designed to allow the users to carry out the calculation of power network in groups or in blocks in accordance with network structure and operation mode, so that the structural diagram of power grid can be generated, and the load flow diagram and load operation state can be inquired at any time. Besides, the results can output by printer or graph plotter. In such way, after real-time network structure and the flow diagram are generated by the real-time line loss calculation system, further calculation and analysis of the load flow diagram can be conducted using offline program. An example for the calculation result of power network is given below:

Fig.5 An example for the calculation result of power network

1.4 Online Line Loss Statistical Calculation and Analysis Module

Online line loss statistical calculation & analysis module, the core of this system, is designed to compute the real time power flow and the line loss within any period of time and can generate the power flow diagram and the line loss distribution diagram at a certain time, and provide the theoretical line loss data within any one time interval by statistics. The theoretical line losses are accurately calculated in real time follow the change of load, network structure and operation mode. Compared with traditional theoretical calculation of line loss, this system is much better in timely and accuracy. In addition, this module offers the option of calculation mode, and can automatically compute and store hourly load flows and daily line loss rates, and automatically compute the real-time theoretical losses and line loss rate of various network components, and can conduct the statistical analysis of calculation results. Hereunder is an example of the calculation result by this module:

Fig.6 An example of the calculation result by Online Module

1.5 Offline Line Loss Calculation & Analysis Module

Offline line loss calculation and analysis module is designed to call historical data from database, and provide statistical load data from multiple angles to reflect the variation state of network losses through offline calculation and enquiry of the theoretical losses of whole network, blocks, main transformers and lines at different voltage classes within any one period of time. This module can figure out the ratios of transformer copper loss and iron loss and of conductor loss to total loss as well as the ratios of the losses at different voltage classes to total loss. Through the calculation and analysis of this module, comparative analysis between theoretical and statistical network losses can be made. Hereunder is an example of the calculation of 10kV and below power network:

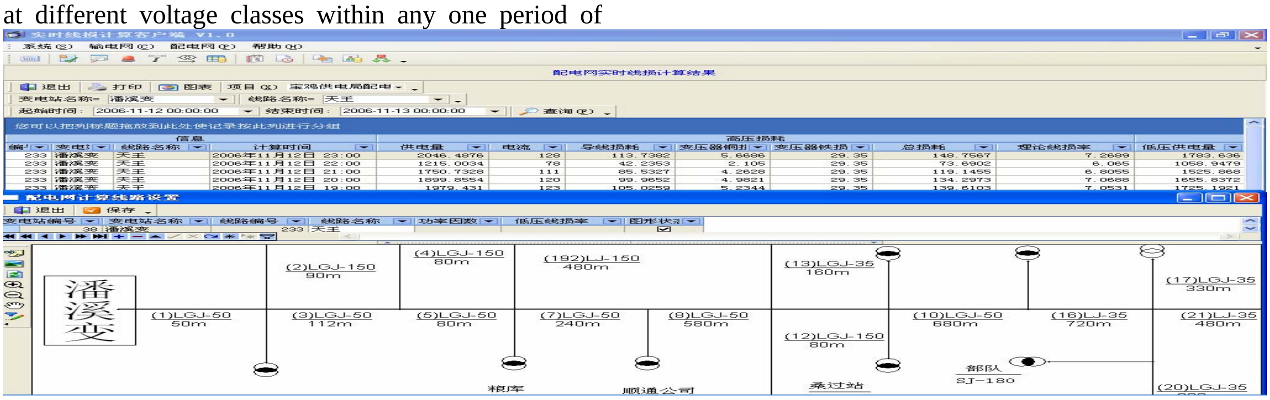

Fig.7 An example of the calculation of 10kV and below power network by Offline Modulo

1.6 Print & Chart Module

According to the requirement of line loss management, print & chart module can provide as many as 35 kinds of statistical statements based on calculation results such as statistics of line losses at different voltage classes, statistics of line losses in different areas, statistics of line losses in different blocks, statistics of the losses of different lines, statistics of substation transformer losses, statistics of 24-hour substation losses and etc. The module has been incorporated into B/S module. Data can be generated automatically, and can be viewed on Web. An example of generated statement is presented below:

Fig.8 An example of Print & Chat Module

2. MAIN TECHNICAL DIFFICULTIES AND SOLUTIONS

To reduce the clients' difficulty in maintenance and enhance software practicality, we adopted three-layer structure in the design of this system. In addition, an easily maintained real-time data to graphic element correspondence table was prepared to ease maintenance difficulty due to the alteration of network operation mode and network structure.

To ensure the normal operation of overall system, the databases and interface programs of related SCADA system and reactive power and voltage real-time monitoring system were optimized, and an alarm and diagnosis function was added. Thus, the trouble point can be promptly pinpointed and solved in the event of system faults.

This system will receive and process a large quantity of real-time data from other systems. To deal with data interrupt, error and jamming, we took following measures to assure the smooth operation of the system: (1) For real-time data interrupt where it is necessary to complement data, and to avoid the occurrence of data jamming in calculation, the system adopts multithread calculation, which allows the data at multiple time points to be computed at the same time; (2) For the occurrence of measuring points insufficiency and measured data error in calculation process which will cause the calculation result error, the system can judge the calculation results and filtered off those which exceeding normal values, conducting compulsive convergence to avoid computer death and computer resource waste.

For power grids of 35kV and over whose line loss theoretical calculation is complex in operation, automatic graphic topology analysis and converted mathematical model can be applied. For power grid of 6-10kV whose line loss theoretical calculation involves too much work, the recursive computation of topology analysis can be applied.

3. APPLICATION OF THE SYSTEM

Application of this system achieved very good effect. Taking Xi'an Power Supply Bureau in China as an example, for previous yearly theoretical calculation, around 500 persons were needed to deal with meter reading job at the representative days of each year and associated calculation work needs to be done by 20 persons for 3 months. However, since the application of this system, theoretical calculation could be carried out automatically at real time. Not only is working efficiency enhanced, but a large number of manpower and financial resources are saved. Through real-time theoretical line loss calculation and analysis, not only were statistical line loss rates made available, but also many problems of power grid were found. For example, power supply capacity was insufficient; some main transformers and lines were overloaded, inter-substation load distribution was unreasonable; and reactive power compensation was inadequate. Specific technical measures were also proposed for loss reduction.

4. PROSPECT

At present, there haven't found an economical and practical way to collect the enormous and wild spread low voltage network information online. Therefore, real-time calculation cannot be conducted for this voltage class. Further research needs to be made to allow the system to cover whole power network, and finally provide real-time line loss statistics through the acquisition of real-time operating data, enhancing the operation and management level of the whole power network.