Chapter 76
Research on Wide-Area Mal-Operation Prevention in Power Network Based on the GPRS

Hong Yang

Abstract In this paper, the importance of the ant-misoperation locking of electrical equipments and the requirements of the modern power network on the application of wide-area anti-misoperation locking are analyzed, and then a wide-area mal-operation prevention system in power network based on the GPRS is proposed, and finally the general design idea of the system is introduced. Also, the designs of the software and hardware (important components of the system) of field controller as well as anti-jamming performance are discussed in detail, and simultaneously the designing method of the mal-operation prevention monitoring center (another important component) is introduced. The wide-area mal-operation is judged by using GPRS wireless Internet to interact field switch state and management monitoring center in real-time. Therefore, it features simple logic judgment, easy-to-implement, and low cost, etc.

Keywords Power network · Wide-area operation · Anti-misoperation locking · GPRS

76.1 Introduction

The security and stable operation of power system are the goals of power enterprises, and correct operation of electrical equipments in power network is the premise of ensuring the security and stability of power system. Although various measures are taken, mal-operation accidents still occur in power system. Currently, power enterprises, by combining the operational experience at home and abroad, propose a

H. Yang (✉)
Chongqing Water Resources and Electric Engineering College, Chongqing 402160, China
e-mail: aoleow@yeah.net

Y. Yang and M. Ma (eds.), *Proceedings of the 2nd International Conference on Green Communications and Networks 2012 (GCN 2012): Volume 2*,
Lecture Notes in Electrical Engineering 224, DOI: 10.1007/978-3-642-35567-7_76,

requirement on the anti-misoperation locking of electrical equipments and provide the principles of operation, management, design, and use of mal-operation prevention for electrical equipments.

According to the requirement and principle of the anti-misoperation locking, a large quantity of researches have been made by people on the anti-misoperation locking in converting stations and power stations, and hence a comprehensive mal-operation system combining the microcomputer five-protection system and the electric locking is formed [1–3]. The application of such a mal-operation prevention system can makes field operations necessarily ensured in security, but its limitations are also very outstanding. In recent years, this has been researched by domestic and foreign scholars from different levels [4]. In this paper, based on existing researches, a wide-area anti-misoperation locking system in power network based on the GPRS is proposed. In the system, the states of all switches in wide-area power network are collected with several field controllers, and then are transferred to the mal-operation prevention monitoring center through the GPRS wireless communication technology. Then, according to the changes of all switch states, the mal-operation prevention monitoring center generates unlocking and locking commands and then transfers to the spot controller, and then the spot controller carries out the unlocking or locking according to the received command. As a result, the wide-area anti-misoperation locking is reliably realized in interconnection between converting stations, and power network, etc.

76.2 Overall Designing Plan of the Wide-Area Anti-Misoperation Locking System

The wide-area anti-misoperation locking system in power network mainly comprises of the anti-misoperation monitoring center and several field controllers, as shown in Fig. 76.1. The anti-misoperation monitoring center comprises of PC or industrial control computers, and is a centralized control center). Monitoring software is responsible for the management and monitoring of the whole power system. GPRS wireless communication network is the communication media of the whole system; the high-speed wireless TCP/IP protocol, and the APN communication model with high security and real-time are applied in this system so that the real-time and security of the system's communication are ensured; at the same time, GSM short message way will be enabled for data transmission if there is a fault in wireless network communication. The anti-misoperation host and locksets are connected by GPRS wireless communication network and field controller distribution anti-misoperation control network for realizing the information interaction between anti-misoperation host and field control equipment; the one-time location state of equipment and the locking and unlocking states of locksets can be transferred to the anti-misoperation monitoring host in real-time. Based on this, equipment state in the system diagram is updated by anti-misoperation main control software, and also locking or unlocking control command is sent through

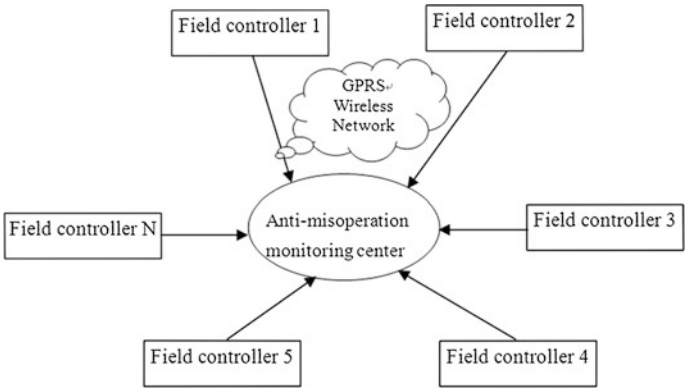

Fig. 76.1 The structure of the wide-area anti-misoperation locking system

network for completing the anti-misoperation function of the whole transfer switching process. Therefore, the whole control network is not only an independent system but also an open system, which can be connected to converting station, microcomputer five-protection system, and other third parties for realizing information sharing [5].

76.3 Design of Field Controller

76.3.1 Hardware Design

Field controller mainly comprises of central processor LPC2368, power management module, power-down memory module, GPRS wireless communication module, audible and visual alarm, switch quantity acquisition module, switch quantity output module, as shown in Fig. 76.2. GPRS wireless communication module is responsible for keeping communication with anti-misoperation monitoring center, sending switch state information back to monitoring center, and receiving the unlocking or locking command from monitoring center. The working process of the field controller is briefly described as follows.

After controller is started up, it can login the anti-misoperation monitoring center through the GPRS wireless network. After the successful login, switch quantity input signals begin to be collected by relevant modules. If switch quantity signal changes in location, switch state change information is sent to the anti-misoperation monitoring center through wireless network. When field controller receives the unlocking or locking command processed by the anti-misoperation monitoring center, relevant exit relays are driven for unlocking or locking operation. To increase the working stability of system, field controller regularly sends collected switch input state to the monitoring center and will automatically enable GSM to communicate with the monitoring center [6, 7] for ensuring smooth

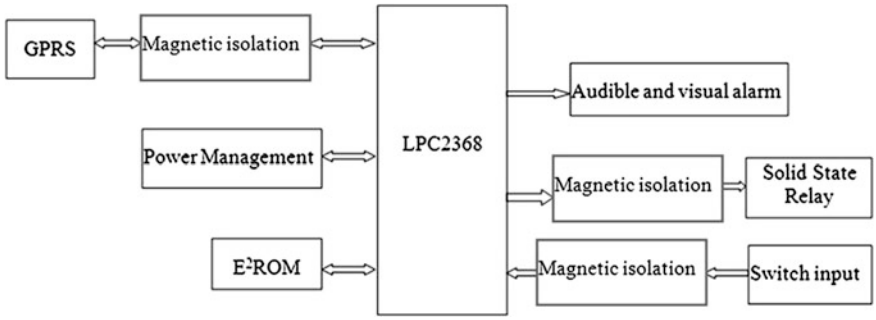

Fig. 76.2 Structure of field controller

communication once a fault occurs in wireless network transmission, and simultaneously switch states and unlocking/locking commands are transferred with encryption and coding methods.

76.3.2 Software Design

The main program of field controller is the main framework of the whole terminal monitoring software. A circle structure and functional modular scheme are applied in the coding of main program; a flag is set for each sub-function; through continuously judging flags in circulation, a functional module necessary to be accessed for executing tasks can be suggested. The flow chart of main program of field units is shown in Fig. 76.3.

In the main program of field controller, the initialization of system software and hardware is implemented first, and then the circulation of the main program is started. In the main circulation, functional modules necessary to be executed are as follows: confirming the sending and receiving of GPRS module information, switch input changing, and unlocking/locking states, etc. In the circulation of main program, all functional modules can be executed only if conditions are fulfilled, and otherwise next functional module will be immediately judged.

76.3.3 Anti-Jamming Design

In this system, a series of anti-jamming measures are applied, so as to ensure its secured and reliable operation.

76.3.3.1 Anti-Jamming Hardware Technology

First, according to the overall design requirement of a complete machine, circuit units are divided and also the circuit of designed printed board is confirmed, and

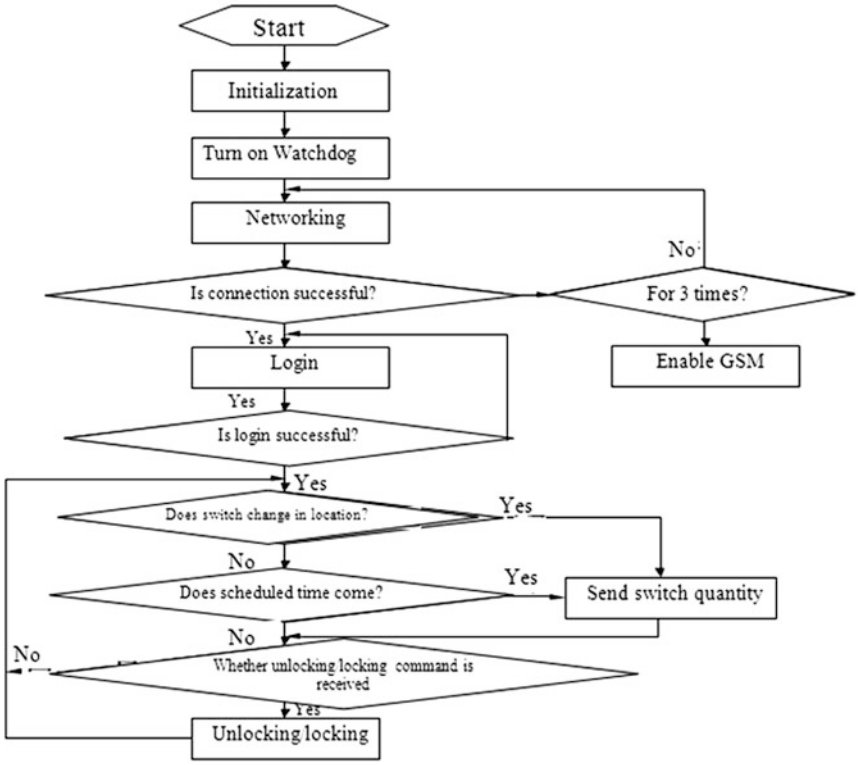

Fig. 76.3 The flow of the main program of field controller

then circuit components are selected (Surface Mount components should be selected as much as possible).

Second, special requirements of components, necessarily-shielded, regularly-adjusted or changed components, necessarily-shielded wires, working frequency and working voltage, and environmental conditions in working of circuit are confirmed.

Third, a high frequency capacitor of 0.01–0.1 μF is joined to the pin of each IC power supply of circuit board in parallel, so as to reduce the affect of IC on power. It is worth noting that high frequency capacitor should be closer to the location of power pin as much as possible, and also the wires should be thick and short as much as possible and otherwise filtering effect can be affected.

Fourth, magnetic isolation chip is added in the process of signal transfer, so as to cut off the electromagnetic contact of signals.

Fifth, in the wiring of crystal oscillator, it is necessary to make crystal oscillator closer to the pin of SCM as much as possible, and also isolate clock zone with ground wire. Therefore, the shell of crystal oscillator is grounding and fixed.

Sixth, digital zone and simulation zone are isolated with ground wire. It is necessary to confirm the sending and receiving of digital ground and block messages, switch input displacement, and unlocking/locking states, etc.

Seventh, anti-jamming components such as magnetic beads, magnetic rings, power supply filter, and shield are applied in the key positions such as the I/O out let, power line, and circuit board wires of ARM processor. This method can make the anti-jamming performance of circuit significantly improved.

Eighth, to guarantee the reliability of communication, communication module encapsulated with stainless steel is applied in the design of the system, and also the receiving ability of wireless signals can be improved with external GPRS antennae.

76.3.3.2 Anti-Jamming Software Technology

First, monitoring and tracking timer is set, and the running state of program is monitored with timing interrupt.

Second, abnormal interrupt is set. If ARM is out of control and makes program fly disorderly and enter nonprogram zone continuously, it automatically enters the abnormal interrupt processing program and recovers the running of program in the abnormal interrupt processing program.

Third, port is refreshed based on a period, so as to prevent port entering an unknown state because it has not been refreshed for a long time [8, 9].

76.4 Design of Anti-Misoperation Monitoring Center

Anti-misoperation monitoring center refers to a computer and monitoring software installed in power administrative department. It comprises of backend database and front-end service program. The converting station numbers, field controller numbers and switch states corresponding to each converting station are stored with database. The front-end service program is responsible for initializing system parameters, reading current machine IP, and setting port number, serial communication baud rate, duty personnel's basic information, inspection personnel's numbers, and simultaneously provide message and network data group sending functions. Inspection command is regularly sent to all field controllers: if a reply is not received from the field monitoring end to the inspection command in the stipulated time, equipment maintenance personnel are noticed to check and maintain equipment on site. The main program flow of the monitoring center is shown in Fig. 76.4.

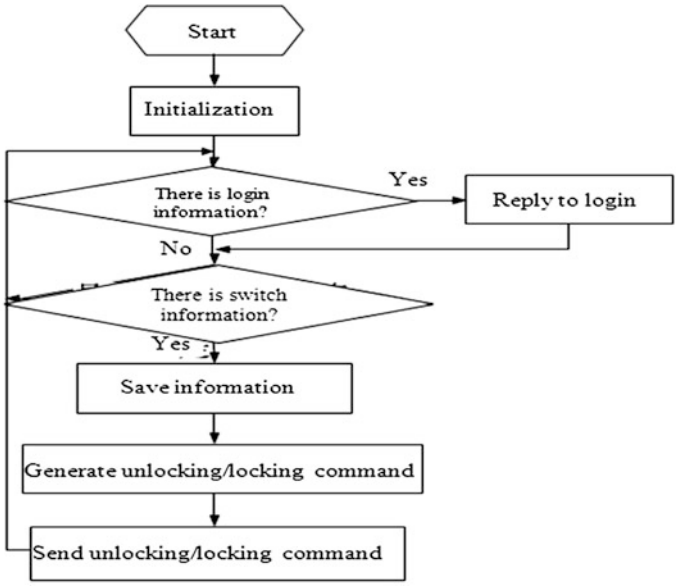

Fig. 76.4 The main program flow of the monitoring center

76.5 Conclusion

According to the demands of power system on the wide-area anti-disoperation locking and in combination of the GPRS communication technology, a wide-area anti-disoperation locking system in power system is researched and proposed. This scheme, through the interaction between GPRS and management center, can reliably realize the wide-area anti-misoperation locking in the interconnections between converting stations, power system, etc. Also, the wide-area anti-misoperation locking system, researched in this paper, features low cost, small volume, convenient operation, easy-to-operation, unnecessary networking, and maintenance, low communication fee, etc.

References

1. Ma ZW, Yang JH, Zhou HM (2001) Discussion on the shortcomings of five-protection equipment in electrical operation. Central China Electr Power 14(2):70
2. Huang JS (2001) Discussion on the anti-misoperation locking equipments in comprehensive and automatic power substations of 220 kV. Zhejiang Electr Power 3:62–64
3. Liu N, Duan B, Xiao HG et al (2006) Online locking method and implementation model of power operation. Autom Electr Power Syst 30(23):58–63
4. Luo JW, Duan B, Xiao HG (2008) Research on on-line interlocking mechanism of substation automation based on wide area security defense. Autom Electr Power Syst 2(32):58–62

5. Luo X, Duan B, Xiao HG et al (2006) Analysis and design of mal-operation prevention in converting stations based on control model IEC 61850. Autom Electr Power Syst 30(22):1–5
6. Chen PP, Guo ZH, Pan HH et al (2008) Design and realization of core component for power monitoring software system. J Comput Appl 28(6):366–368
7. Zhou LG et al (2005) ARM embodied system fundamental textbook, vol 17. Beihang University Press, Beijing, pp 26–38
8. Zhou X (2005) Electronic equipment prevent interference principle and technology, vol 27. Defense Industry Press, Beijing, pp 76–78
9. He H, Zhang BF, Zhang DJ et al (2007) Electromagnetic compatibility and electromagnetic interference, vol 21. Defense Industry Press, Beijing, pp 30–37