Design of power cable grounding wire anti-theft monitoring system

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Abstract. In order to prevent the serious consequences of the power grid failure caused by the power cable grounding wire theft, this paper presents a GPRS based power cable grounding wire anti-theft monitoring device system, which includes a camera module, a sensor module, a micro processing system module, and a data monitoring center module, a mobile terminal module. Our design utilize two kinds of methods for detecting and reporting comprehensive image, it can effectively solve the problem of power and cable grounding wire box theft problem, timely follow-up grounded cable theft events, prevent the occurrence of electric field of high voltage transmission line fault, improve the reliability of the safe operation of power grid.

Keywords. power cable; Anti - theft monitoring; Ground wire.

1. Introduction
With the rapid development of the national economy, the continuous improvement of the level of urban modernization, the construction of urban power grid has made rapid development. Domestically, 110KV and above single-core cable metal sheath usually uses cross-connect double-ended grounding operation mode or one end grounding with the other one grounding with protector. Commonly, the cable metal sheath has no more than 50V frequency induction voltage to the ground. Just because of its low voltage, high-value copper wire, power cable grounding wire has become the target of theft. In recent years, there has been so many high-voltage grounding system due to grounding cable was cut off caused by failure Events, and triggered serious consequences [1, 2].

When the high-voltage single-core cable grounding system fails, the voltage on the cable metal sheath will be changed from the normal operation of the frequency induced voltage to the suspension voltage. The suspension voltage will rise over the cable jacket pressure allowable value. In this case it will lead to the formation of single-ended grounding for jacket breakdown, and the suspension voltage will disappear. So that it cannot effectively ground, and there will be a long-term discharge at the ground, which may lead to fire accidents, serious impact on high pressure safe and stable operation of power grid. The traditional methods for the power cable grounding detection of anti-theft have limitations. Therefore, it has great practical significance to develop automated detection which can find high-voltage cable ground wire stolen in real time, and timely deal with ground system failure [3, 4].

This paper presents a GPRS-based power cable grounding monitoring system. The system realizes the integration of electronic signal and image monitoring by automatically detecting the ground stolen, sending the alarm information and the live image to the control center and the staff through the microprocessor system and the wireless communication technology.
2. General design
The application of the system is a suburban remote areas of multiple building facilities, tower cable and other real-time monitoring. Besides, the scene picture will be transmitted to the console, such as whether the ground of the tower is stolen. The system monitors the device in real time. The exception will be automatically reported to the control center, and a picture will be shoot, compressed, saved and transmitted. The general design is shown in Fig 1.

The whole system achieves the function of capture-to-interruption, images collecting by the camera module, picture data dealing by the microprocessor system module, picture saving and finally transmitting and so on. The specific functions of each part are as follows:

1). Real-time monitoring of monitored targets. The system can monitor the target in real time and save the target monitoring picture according to the preset cycle, or send it to the data monitoring center module if required. When triggering an external interrupt, the system immediately captures the monitoring target and sends the data to the data monitoring center module and triggering the alarm or other forms of security.

2). Saving the target image. The system saves the monitoring pictured according to set the cycle. The monitoring pictures are numbered by time and saved to the local SD card, which can effectively prevent the loss of data, and provide the evidence of the exact time when the cable ground wire was stolen.

3). Detecting in time when the monitored target is lost. The system will immediately acquire the monitoring image and send it to the server, meanwhile it gives out the alarm or takes other security measures to reduce the loss.

4). Sending the monitoring pictures to the data monitoring center module. The system can send the pictures by MMS or GPRS to the data monitoring center module. Managers in data monitoring center can get the situation of the monitored target in real time, and forward the information to the maintenance personnel mobile terminal.

![Fig. 1 General design](image-url)
3. Main function module

3.1. Microprocessor module
As the system works more in suburbs and field, the system is required to be low power consumption to avoid frequent replacement of power. Besides, the system has to compress a large number of pictures’ image data, so the processor must have a strong ability to deal with digital computing and consume lower power.

The system selects STM32F429IGT6 which has 1M Byte internal Flash, 256K Byte internal SRAM, and high-speed SDRAM module interface. Meanwhile, its power consumption is very low, as F429 series of chips’ stop mode’s typical current is only 100uA. 256K RAM is not enough for high resolution picture data, so when the system verifies the low-resolution pictures, it uses onboard 8M bytes of high-capacity SDRAM on the STM32F429.

3.2. Cable electronic detection module
The voltage detection used for the detection of theft of the cable, can also be used to detect the voltage of the battery. In the case that it can’t be charged as in cloudy time, the relevant energy-saving measures will be taken. Voltage detection circuit block diagram is shown in Fig 2.

Switch monitoring circuit can take whether the ground is stolen as a switch. When the local line is intact, the switch is in the closed state, without triggering the microprocessor interrupt. When the ground line is stolen, the state of the closed switch is broken, the switch is turned on, triggering the interruption. The specific principle is that the IO port under the normal state is "1"; when something wrong occurs, the IO port’s voltage will be pulled low, in "0" state, and trigger interruption.

3.3. Camera module
Analog camera can collect analog signals of the monitored object. The advantage is that it can be connected by only a AV cable, and the output is the analog signal. Before entering the microcontroller, it needs to go through analog-to-digital conversion circuit. In the debugging phase, Hikvision as DS-2CE56F5P-IT3 950 line high-definition camera was selected, as it can take a clear and delicate image, support ICR infrared filter switch, day and night monitoring, have the IP66-class waterproof design and other characteristics and meet the basic needs of the system.

The signal collected by analog camera is the analog signal, which can not be handled by the microcontroller, so that the analog-to-digital conversion circuit between the camera and STM32 is needed. The core chip of the analog-to-digital conversion circuit is TVP5150AM1. The TVP5150AM1 is a simple, ultra-low power consumption, and very small digital video decoder that includes two 9-bit ADC converters, a sync detector, a Chroma processor, and a brightness processor. The decoder power consumption is only 115mW, which is in line with the system low power requirements. VP5150AM1 supports the output of YUV (4: 2: 2), YCbCr and other data formats. In addition to digital video output, it can also generate synchronization signals, lock signals, field signals and so on.

![Fig. 2 Voltage Detection Circuit](image-url)
3.4. Communication module
Get the picture data and compressed, the need to send data. The system uses SIM900A communication module. SIM900A module supports GSM / GPRS, low power consumption, and power supply range is 3.2V ~ 4.8V. You can use the microcontroller directly to the power supply and achieve low-power information transmission. The system data transmission module is mainly composed of SIM900A main chip and peripheral circuit, and peripheral circuit including SIM card, RS232 interface circuit, SMA antenna, power input and power switch, etc. All the control and data of SIM900A are transmitted through the serial port, and STM32 and SIM900A only need to connect the serial port. You can directly use the serial cable to connect STM32 to SIM900A. STM32 serial port 2 and SIM900A SXRD, TXD connected to the data sent and received.

3.5. Power supply
The power supply module is used to power the individual modules of the system, and the source is the solar panel.

The schematic diagram of the solar panel module is shown in Figure 3, where the core includes a solar panel, a controller and a battery. The solar panel is mainly used for solar energy collection. In the sun sunshine sufficient circumstances, the solar panel emits clean power at full capacity, and is responsible for charging the battery. The solar panel itself is not power. The battery is used to collect electricity, using a single 12V32AH lead acid maintenance-free battery, for the system power supply.

![Fig. 3 Solar Panel Module](image)

4. Design of monitoring software

4.1. The overall framework
In view of the system in the future use, maintenance and upgrade on the convenience, in the program architecture, the B / S mode Web-based Web application architecture can be used. The operating system in server is a stable and efficient Microsoft Windows 2007 system, the development tools are Eclipse luna, Myeclipse blue, Webstorm, etc., and the development of language framework are Java and JavaScript. The terminal device uses SMS, MMS and GPRS to communicate with each other in three ways. Users can access the system through the Chrome browser, and the administrator can update the data and send and receive data to manage the entire system [5-7].

The system network topology is shown in Figure 4 below:
Monitoring software, in the form of WEB as a presentation layer, use the classic Spring-MVC + spring + MyBatis framework as its server, and Angular as its Interface framework developed by WEB.

4.2. Design of interface
This project uses B / S way, the user can login to the main system through the Chrome browser, and the system interface consists of three parts, separated by three labels. As shown in Figure 5. It can be divided into the following four interfaces.

(1).Monitoring interface
The main interface element contains four elements: map, information field, toolbars and terminal list. Users can click on the interface button in the toolbar to monitor, send the command and save the document.

(2).Query interface
The query interface lists all the data and pictures sent by the local terminal device. The user can view it and the interface also provides a text box for the user to retrieve and find the history records of the corresponding terminal device.

(3).Exception handling interface
The exception handling interface records and reports all exception events detected by all end devices and local centers. Administrators can immediately learn of unusual events and arrange for staff to handle exceptions.

(4).Management interface
The interface directly points to the database and the storage point, and the administrator can log on this page on the user's account permissions to modify and increase or decrease the users.

**Fig. 4 System Network Topology**

| Presentation Layer                      | WEB framework (Spring-MVC+Spring) | Web interface (AngularJS+jQuery) |
|-----------------------------------------|-----------------------------------|----------------------------------|
| Business Layer                          | Map logo                          | Monitoring data                  |
|                                         | Terminal configuration            | Exception handling              |
| Transaction Service Layer               | Network map API                   | Data retrieval                   |
|                                         | Network comm.                     | Exception management             |
|                                         |                                   | Search engine                    |
| Basic Service Layer                     | Data read                         | GPRS comm.                       |
|                                         |                                   | MMS&SMS comm.                   |
|                                         |                                   | Analysis & save                  |
| Data Access Layer                       | MyBatis                           | OnCache MySQL                    |
|                                         |                                   | Caching service                  |
| Data Storage Layer                      | MySQL                             | Cache/Local file system          |

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5. Conclusion

For the problem of theft of metal grounding system in remote areas, this paper presents a GPRS-based anti-theft monitoring system for power cable grounding wire, which automatically detects the ground stolen situation, and automatically integrates the electronic signal and image monitoring. By using two methods of cable detection and image reporting, real-time detection of cable ground line stolen events, and promptly notify the management personnel disposal, can effectively prevent the cable ground wire theft caused by grid failure.

References

[1] Wang Weijun, Yang Yuan. The harms and countermeasures of high voltage cable metal sheath of stolen grounding line [J]. Guizhou Electric Power Technology, 2016, 19(11):53-57.
[2] Sun Hongmei, Luo Longfu, Lu Jiazheng, etc. Research on Solution of On-line Monitoring of 110/220kV XLPE Cable Insulation [J]. High Voltage Engineering, 2004, 30(1):28-30.
[3] Ma Jian. Development of visualization supervisory system for HV distribution network equipment based on MMS[J]. Ningxia Power Company,2013(6):34-37.
[4] Tian Ersheng, Wang Xingning, Shi Zhihong, etc. Development of new cable ground wire breaking monitoring protection equipment [J]. Power System Protection and Control, 2014(1):134-138.
[5] Lv Zecheng, Deng Yurong, Zhang Wei, etc. Communication Technology Between the Integrated Processing Unit and Substation Platform of On-line Monitoring System [J]. Southern Power System Technology, 2013, (06): 136-140.
[6] Zhang Wei, Wu Rongrong, Qin Wei. Icing Load Monitoring of OPGW Based on Strain Analysis[J].Southern Power System Technology, 2016,(11):52-58.
[7] Yang Junquan, Wang Yong, Zhang Xinlin. Technology and Application Research of Power Communication Resources Management System in CSG [J]. Southern Power System Technology, 2009, (S1):