Design of On-Line Monitoring System for Insulator of Transmission Line

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Abstract

Transmission line insulator is one of the key components to ensure the safe and stable operation of power supply system, and most pollution flashover accidents are caused by pollution accumulation on insulator surface. In this paper, the on-line monitoring technology for insulator contamination of optical fiber sensor was used. Due to the sensitivity of optical fiber sensor and the real-time nature of monitoring system, the limitation of traditional manual contamination sampling detection which is time-consuming and laborious and can not be obtained remotely and in real time is broken through. The measurement results are correlated with the pollution level of insulators of transmission lines, which provides a new scheme for preventing pollution of insulators of transmission lines and ensuring stable operation of power grid.

Keywords

Transmission Line Insulator; Pollution Flashover Accidents; Sensor; Monitoring System; Pollution Level Of Insulators.

1. Introduction

In recent years, with the rapid development of the power industry, the scale of transmission line erection is also growing. Insulator is an important part of transmission line and the only electrical insulator. The performance and configuration of insulator directly affect the safe operation of transmission line [1]. The working property of insulator determines its working environment. Long-term outdoor operation of insulator results in a large amount of dirty substances on the surface. When encountering rain, fog and snow weather conditions, the conductivity of the pollutants attached to the insulator surface will increase, resulting in the decline of its insulation performance. Long term flashover may cause accidental power failure [2]. To reduce the occurrence of pollution flashover accidents, the electric power department regularly checks and maintains. Although the above-mentioned methods can reduce the occurrence of pollution flashover accidents, it will cost a lot of manpower, and the state and individuals will suffer great economic losses due to power failure and maintenance. Online monitoring technology can effectively overcome the above problems [3].

In this paper, the on-line monitoring technology of optical fiber sensor insulator contamination was used. The sensitivity of the sensor and the real-time performance of the monitoring system break through the limitations of traditional manual sampling measurement [4]. The main control chip of the optical sensor pollution monitoring system is STM32F107 series, and the power supply is provided by the solar panel. The proper selection of hardware ensures that the system can work properly. The backstage management system adopts the configuration software of American Wonderware company, which meets the management requirements of on-line monitoring of insulator surface contamination [5].

2. Design of Pollution Monitoring System for Optical Sensor

2.1 Framework of Monitoring System

The optical sensor pollution monitoring system consists of power supply, optical sensor, monitoring box and communication base station, including power supply module, optical sensor, isolation

protection module, photoelectric conversion module, data acquisition module, main control module, communication module and background monitoring center, as shown in Fig. 1.

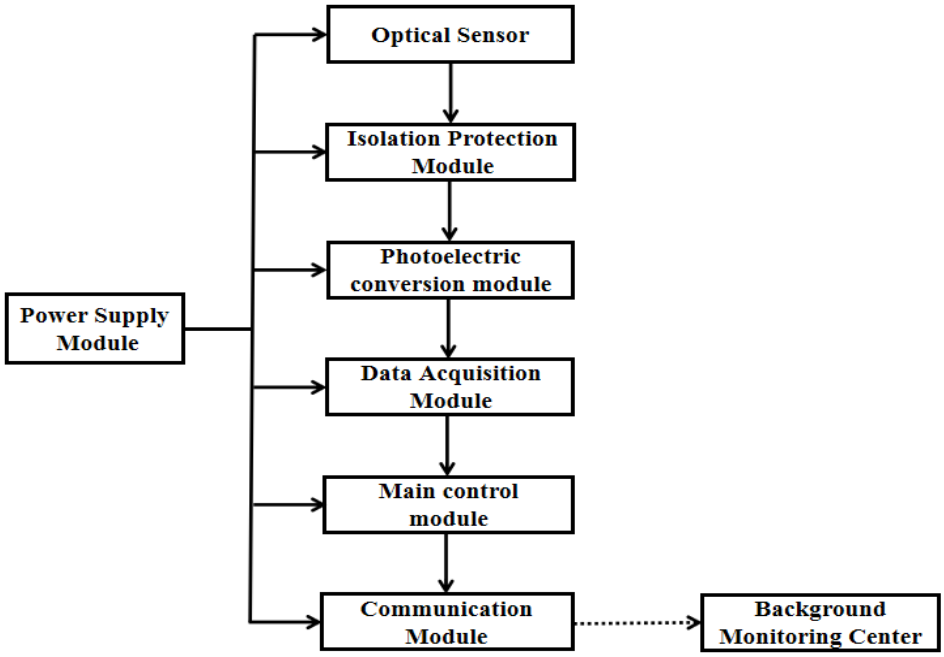

Fig. 1 The framework of optical sensor contamination monitoring system

Power supply module: including solar panel, solar controller and battery, which provides stable operating voltage to other modules to ensure reliable real-time monitoring of insulator surface contamination.

Optical sensor: the pollution degree (salt density and ash density) of insulator surface is monitored by optical sensor technology, and the pollution degree of transmission line insulator surface is measured and transmitted to the isolation protection module.

Isolation protection module: the signal transmitted from optical sensor is transmitted to data acquisition module after isolation and protection processing.

Data acquisition module: the isolated and protected signal is transferred to the main control module through A/D conversion.

Main control module: the received digital signal is processed and transmitted to the communication module for data output.

Communication module: transmitting and exchanging data through wireless communication module. The wireless transmitter sends data to the server through the monitoring center, and the operator uses the service terminal for editing and processing to monitor the contamination of insulators.

Background monitoring center: including host, input and display equipment, with functions of insulator contamination database, calculation model, communication program and database of ability to absorb contamination.

2.2 Hardware Composition of Monitoring System

Data monitoring terminal and background monitoring center constitute the online monitoring system of optical sensor pollution, which has the functions of real-time monitoring, wide coverage, intelligence and remote monitoring. The main controller combines with the peripheral circuit to realize data monitoring and adds anti-theft alarm function to the peripheral circuit, which can make the system more optimized. Solar cell is used as the power supply, and related hardware is used to measure the voltage of the power supply, so as to grasp the power consumption of the system in real time. Fig. 2 shows the hardware design of the monitoring system.

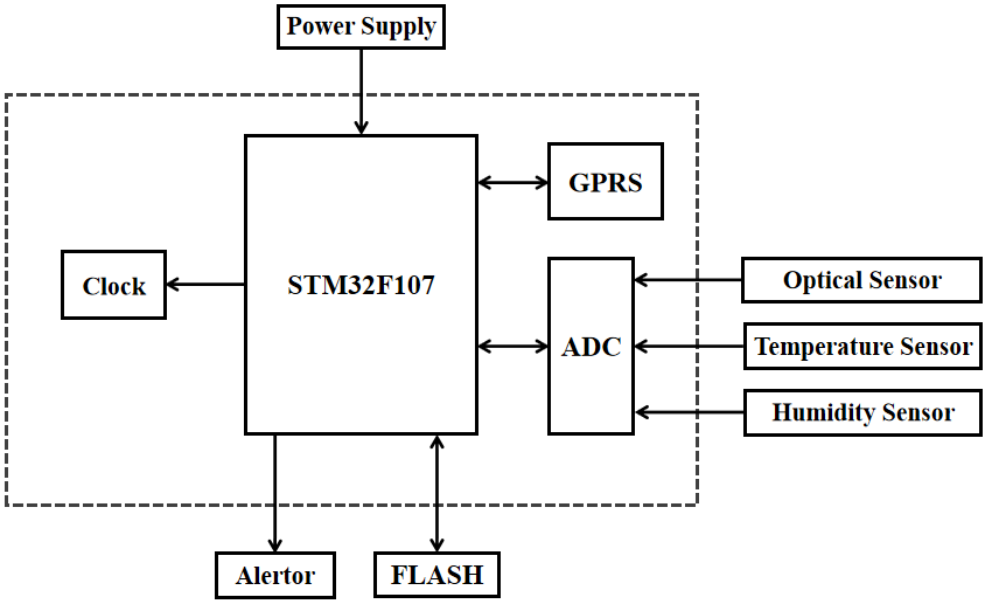

Fig. 2 The hardware design of the monitoring system

2.2.1 Design of Power Supply System

With the development of solar power supply technology and cost reduction, it is common to use solar energy to power detection systems. In this paper, the monitoring terminal is powered by a solar panel battery. The working principle of the power supply module is shown in Fig. 3. The system makes a judgment on the adequacy of solar energy. Indicators light up when there is enough solar energy, and photovoltaic panels generate electricity to power the load. The system also detects the working state of the battery. When the battery is under voltage, the battery is charged, and when the battery is fully charged, the charging circuit is disconnected. When there is insufficient solar energy, the photovoltaic panel stops working and analyses whether the battery can power the load. The load runs when the battery is full and stops when the battery is undervoltage. The state of the battery and photovoltaic panel needs to be checked at this time, because the battery can be put into operation at any time when there is no fault.

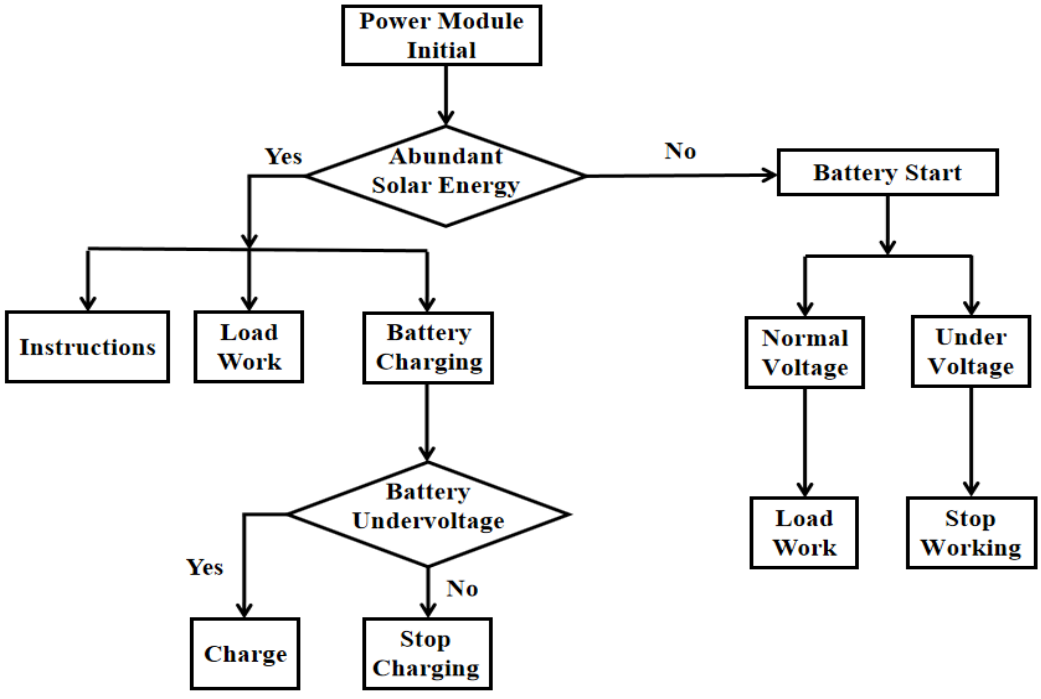

Fig. 3 The workflow of power module

2.2.2 STM32F107 System

For monitoring terminals, the main control panel is the heart, and its good performance has a significant impact on the operation of the entire system. STM32F107 chip has a large number of resources, which can meet the requirements of the system without peripheral interface. It can realize simulation function through serial line internal interface.

2.2.3 Data Acquisition Nnit

The signal is collected by external monitoring terminal sensors such as optical fiber, temperature and humidity sensors, and then converted to analog signal amplified by signal conditioning circuit to be processed by main control chip. The luminous flux data collected by the optical fiber sensor needs to be converted into electrical signals which are received and stored by the core board. The optical fiber sensor has a ring design, and salt will adhere to the surface when exposed to air. The beam produced by the laser acts as a parallel beam through the connector and the self-focusing rod and injects into the optical sensor at a certain angle. The attenuated light is received by the photoelectric converter and converted into electrical signal, which is displayed by the optical power meter. The optical signal acquisition is shown in Fig. 4.

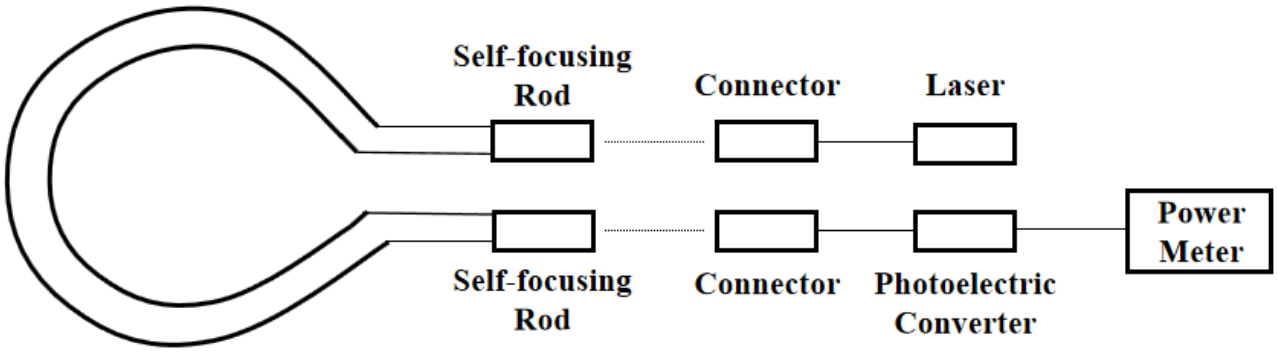

Fig. 4 Principle of light signal acquisition

The temperature sensor type is LM35CZ and the temperature range is -40~110℃. Due to the harsh working conditions of the monitoring system, it is necessary to ensure accurate feedback high and low temperatures for normal operation. Two diodes are connected to the LM35 to achieve the rated temperature range. In addition, the output voltage of LM35CZ is -0.4~1.1V, which needs to be filtered, amplified and converted into A/D acquisition terminal. The humidity sensor model is IH-3605A, and the output voltage of 0.8V~4V is higher than the internal reference voltage of 2.5V of STM32F107, so the output signal needs to be partially processed. AD7705, a 16 bit Σ-Δ converter, is a low cost digital to analog converter. The collected temperature, humidity, light flux and other signals are converted into digital signals and transmitted to the main controller.

2.2.4 Communication Module

Huawei EM310 is used as GPRS wireless communication module of line monitoring terminal. Em310 is efficient in data processing, with multiple connections and ACK response functions. MAX232 chip is used in serial communication circuit of monitoring system, which can generate 232 level and communicate with upper computer.

3. Workflow of Monitoring System

On-line monitoring of transmission line insulator contamination is carried out by photochemical method. High purity quartz optical waveguide is used as the main body of the sensor, and the pollution attached to it causes light scattering into the optical waveguide. The density of salt and ash is calculated by measuring the intensities of incident, transmitted and scattered light. Referring to the historical dirty database, the data model between grey density, salt density, light energy parameters, humidity and time is established.

The output end of the optical fiber sensor is connected to the input of the isolation protection module, then to the photoelectric conversion module, and the optical signal is converted to electrical signal and then to the main control module. The optical sensor pollution monitoring system collects and stores data of grey density, salt density, air temperature and relative humidity near insulator of transmission line according to sampling period. The 12-bit accuracy data of AD sampling is stored in the main control CPU, and the timer samples and stores the optical sensor data according to the time set by the system. The quartz rod is placed in the same environment as the insulator to simulate the contamination of the insulator, and the corresponding algorithm is selected according to the contamination ability of different materials. Through wireless communication technology, online monitoring can be realized without power failure to detect the operation status of insulators. After repeated calculation, the background monitoring center can get more accurate gray density and salt density.

4. Conclusion

In this paper, the proposed optical sensor contamination monitoring system is based on the light flux collected under different contamination conditions to establish on-line monitoring of insulator contamination. Through analysis of environment around insulator, measurement of site pollution degree and operation experience of power grid, pollution detection can be carried out without power failure, which greatly reduces labor costs and economic losses. The operation mode is changed from remedy after accident to prevention in advance, and the insulator pollution flashover is pre-judged in advance, which ensures the stable operation of power grid equipment.

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