Auto-Recloser Circuit Breaker in Power System Based on Internet of Things for Smart Grid

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Abstract- The Internet of Things (IoT) technology has become an important issue in improving the competitiveness of the industry, making our daily lives more comfortable. Electricity is not only a pillar of the country’s economy but also a key factor in the development of human life. Therefore, the integration of things in the field of power to solve the problem of power interruption is one of the solutions to reliability problems. For better performance and reliable supply to customers. The study focused on the re-closer device and developing the smart grid. Auto Re-Closing is a key element in the concept of self-healing grids. According to statistics, many faults of the transmission and distribution network are transient faults. In the Smart grid, an important aspect of intelligent power distribution systems is integrated with intelligent control and protection equipment. Therefore, there is an urgent need to find a new smart self-reclosing model to improve the protection of power distribution systems to solve and overcome the challenges of the smart grid and distributed power generation integration.

This paper proposes a auto-reclosing protection with a controller designed for Smart Grid Integration. The model control circuit is synchronized with the circuit breaker so that after a fault occurs, the switch automatically turns off without any human interference. The article analyzes the impact of the integration of IoT technologies and decentralized power generation on the reliability of power systems. According to the research results, the Internet of things can significantly improve system reliability through fast and reliable data management. This paper introduced the application of IoT in the online monitoring system of the power transmission line.

Keywords – Internet of things, Smart Grid, Microgrid, Distributed energy resources, Auto-reclosing protection

I. INTRODUCTION

Everyone is willing to deploy a “smart grid” to provide energy services and information technology that significantly improves the protection, reliability, operational efficiency, power quality, safety and customer satisfaction of distribution systems. Auto-reclosing is used to restore the original state of the network without any human interaction [1]. Recently, electricity supply has been the main issue discussed in the media and conferences both on the national or international level. As a result, the rapid development of the world, an electricity supply issue is important to the whole country. However, due to a transient fault, blackouts have become one of the main problems that often occur. This situation creates a major problem because most of the damaged equipment is caused by an unexpected current overload [2, 3]. Because of this damage, consumers have suffered substantial losses, particularly in the factory and industrial sectors, which then affects productivity. Therefore, Iraq's major electricity suppliers must guarantee high-reliability power supply to their customers. Thus, each overhead line is fitted with an auto-reclosing circuit breaker to ensure uninterrupted power supplies. In addition, the device is also suitable for transmission lines [4,5].

This project mainly focuses on the use of low voltage power supplies with domestic users, such as residential communities as Smart Grids. In addition, the project is also capable of over-current protection. The larger the current, the hotter the conductor, because more heat is being generated. Therefore, there must be an overcurrent protection device on all devices. This also reduces the risk of damage to the equipment. In addition, the protection system is, therefore, more reliable for the user. With the development of Science and technology in the new era, the circuit breaker has become one of the most reliable protective equipment [6-8]. Circuit breakers are mechanical switches used in most overhead power lines to protect the line from faults that may cause damage to the power line. It should be able to safely turn off the devices with the specified capability and safely turn them on. The circuit breaker will automatically interrupt the abnormal current until it reaches the breaking capacity and is capable of continuously carrying any current-up to the rated current. The abnormal condition is referred to as the overload and short circuit. It works by measuring the current balance between the two current transformers. As long as the current difference between the line and the neutral conductor are detected, the device opens the contact point [9,10].

The rest of this paper is arranged as follows. Section II explains the recommendations for embedded monitoring systems based on the internet. The proposed algorithm is explained in section III. The experimental results are presented in Section IV. The concluding observations are contained in Section V.
II. TRANSMISSION LINE ONLINE MONITORING SYSTEM BASED ON INTERNET OF THINGS

Transmission line monitoring system is one of the most important applications of the Internet of things in the smart grid, especially for disaster prevention and mitigation of transmission lines. In recent years, natural disasters have posed many challenges to high-voltage transmission facilities, including security, stability and reliability. Moreover, the current transmission line monitoring operation is mainly achieved by manual operation, these operations face low efficiency, low accuracy, long operating cycle problems.

At present, some transmission line monitoring system has been put into operation. These systems typically use a wireless public network or other wireless communication networks for data transmission to each sensor, but there are high operating and maintenance costs, network coverage is not complete, the data transmission rate is low, complex network maintenance, will restrict the transmission line monitoring system development, hinder the transmission efficiency.

In order to achieve real-time online monitoring of transmission lines, the wireless sensors deployment. Transmission line monitoring system consists of two parts. Apart is installed together with the power transmission line to monitor the state of the conductor; another part is installed on the transmission tower to monitor the state of the environment and the tower. Communication between IoT devices on power transmission lines and transmission towers is typically based on short-range wireless communication technology.

The transmission line online monitoring system based on the Internet of things can transmit the information farther through the multi-hop relay communication network, thus ensuring the effective information transmission facilities of long span and long distance. According to the different application scenarios of transmission lines, the system network topology can be based on the cluster chain type. Each sensor can communicate directly with a nearby backbone node, and the communication link between the sensor and the backbone node is generally unidirectional; each backbone node can communicate with up to 256 sensors. The communication link between the backbone nodes based bidirectional link. Some parts of the backbone node can access the public network or power optical network. As shown in Figure 1.

![Figure 1 Data transmission network](image)

The specific monitoring contents are as follows:

1. **Transmission tower leaning**
   The leaning sensor will transmit the status of the transmission tower to the nearby nodes nearby, the data from multiple tilt sensors are combined to form a transmission tower tilt information, real-time monitoring and early warning.

2. **Conductor galloping**
   According to the calculation and analysis of the monitoring point acceleration, the number of vertical and horizontal half-waves of the galloped conductor can be analyzed and the motion track can be calculated. Thus whether the conductor is in galloping danger can be determined, and the discharge between phase conductors and tower collapse can be avoided.

3. **wind deviation**
Wind deflection can be calculated by deploying a three-dimensional acceleration sensor on the conductor. Wind deviation data from the wind speed sensor, an acceleration sensor may be provided for the winding conductor deviation verification field test data. The operator can take reasonable measures to resist wind bias.

(4) micro-Meteorology
Temperature, humidity, wind speed, sunshine and rainfall can be recorded by wireless sensors along the conductor or tower. Based on the results of micro-meteorological sensors and tension sensors. The data analysis system at the monitoring centre analyzes the information collected by the sensors and makes early warning decisions.

![Figure 2 Sensor deployment for transmission lines and transmission towers](image-url)

(5) conductor temperature
The operating temperature of the conductor can be collected along the conductor by a wireless temperature sensor. Transmission lines and Tower sensor deployment scheme is shown in Figure 2. Equipment including temperature, humidity, wind and other meteorological sensors, vibration sensors, ultrasonic sensors, Tower sensors, infrared sensors, leakage current sensors, cameras and backbone nodes, to build transmission lines and tower monitoring system. Wireless sensor image and its deployment as shown in Figures 3.

![Figure 3 Wireless sensors](image-url)

Backbone nodes deployed within the transmission tower to collect data near the wireless sensor, the combined information is transmitted to the Monitoring Center via a mobile communication network or a private network of electricity, to achieve long-distance, flexible, convenient, high-speed transmission of information. Reliable, high-quality interconnection between the transmission facilities and the monitoring centre. Transmission line on-line monitoring system through the information management system to achieve real-time monitoring, information display, statistical analysis. The status of the power transmission facility can be visually displayed. Operators can make decisions and give orders based on the results of the analysis of the information management system, in order to identify or eliminate risks as early as possible, to ensure reliable operation of the transmission facilities[11-13].

III. PROPOSED SOLUTION
Recloser is a circuit breaker as well as overhead power line protection system designed to reconnect to the fault. It detects the fault and turns on the pre-programmed time before it turns off automatically. The cycle can be repeated 4 times. And usually locked in the fifth trip, as shown in Figure 4. Reclosing can be used anywhere on the system where the recloser rating is sufficient for the logical location of the system requirements[14-16] :

* In the substation as the main feeder protection device.
* On the line at a distance from the substation, the long feeder segment, thereby preventing the feeder in the vicinity of the end of permanent failure of the entire feeder down.
* On the tap of the main feeder to protect the main feeder from interruptions and power outages caused by tap failure.[7]

![Figure 4 Power recloser with disconnect links schematic diagram.](image)

This paper illustrates a new protection scheme for smart microgrids systems and their simulation performance using digital relays in Matlab / Simulink. The proposed AR control circuit is responsible for tripping and closing the circuit breaker in different fault situations to isolate or restore energy services[17-19].

3.1 Auto-Recloser Protection Scheme
The Hall Effect current sensor adopts the following principle of electromagnetic isolation, which are small size, lightweight, low price, fast response, high precision, good stability, non-invasive entry, the whole diameter of 35mm-55mm and installation in DIN rail. The Hall effect AC current sensor is widely used for measuring current in several fields [11].

![Figure 5 Power recloser with disconnect links schematic diagram.](image)

The ATmega328 is an 8-bit Complementary Metal–Oxide–Semiconductor (CMOS) microcontroller based on the AVR-improved RISC architecture. By allowing only powerful commands in the clock cycle, the Atmega328 also gains product access to 1 MIPS per 1MHz. Arduino one is a microcontroller board based on ATmega328. There are 14 digital I/O pins (6 of which can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, using the analog voltage comparator, the inputs can be tested with 2 analog A0, A1 inputs, and digital outputs [20-21]. Below is the code for the proposed program.
Note that the arduino inputs can detect analog voltages from 0 to 5V to the ground, the sampling rate is approximately 67 microseconds between each analog reading, the discrimination resolution is approximately 5 milli-Volts.

IV. SIMULATION AND RESULTS
The current sensor detects over current in case of overloading. After the sensor detects the current flow of a larger load, the programmed pre-set, the microcontroller will activate the relay to cut off the power from the main electricity provider to the load. For simulation, MATLAB software was used. In this software, the simulation is performed by ensuring that the transmission line has a load. The circuit breaker is used to open loads during the fault moment and is re-closed when the fault has been cleared. The Simulink model is shown in Figure 3. In this model, when the signal is given to the switch, there will be a fault within the system, and the immediate circuit breaker operation will begin and disconnects from the system and the faulty components. Different voltage imbalances have been observed, such as (Line to Line), LG (Line to Ground), 3L(Three Lines). These failures are performed by shutting down the faulty switch in the Simulink model. These faults are both temporary and permanent. The x-axis displays the time, and the y-axis shows the three system voltages, currents, and fault currents between the two contacts of the circuit breaker. As it can be seen in Figure 5, the fault occurs in a line within 0.5 seconds and is cleared within 0.7 seconds. This is a temporary failure, which is cleared by an automatic reset.

4.1 Case One-
In the case of a temporary fault, the system's faulty zone must be isolated automatically to protect the network from adverse consequences. Due to the high current level caused by a permanent fault, overcurrent protection with the auto-recloser system will resume, so the trip signal will take the time delay setting, and then the circuit breaker opens its contacts to eliminate the error. Figure 5 shows the proposed performance of the auto-recloser system in the case of a constant single phase to ground, which is also common in the grid.

4.2 Case Two-
The case of a temporary double fault is that the object causing the fault requires extra time. The AR will close the successful connection, and restore the system in safe mode, and there is no extra outage time that will additionally affect the reliability and quality of the distribution system. Figure 6 shows the performance of the system in the case
of a two-phase fault of the system. In addition, the performance of the proposed system appears in the case of a temporary fault.

![Figure 7 Temporary Double phase to ground fault](image)

V. CONCLUSION

The Internet of things is considered the third revolution in digital technology after computers and the internet. At present, the power grid is transforming to the smart grid, and the requirements of automation and intelligence will lead to the deep integration of the Internet of things and the smart grid. Through the technology of IoT, the operating parameters of the power transmission line and the tower can be achieved. Therefore, Disaster Monitoring and early warning can be carried out, which will effectively resist or reduce the damage of major natural disasters to the power grid.

Utility companies are implementing advanced smart grids, computerized distribution networks to increase efficiency and minimize disruption to consumers during temporary faults. By using the modern control distribution automation for remote reconnection, utility companies are able to implement intelligent protection floor to isolate short sections of the feeder that are defective and divert energy to ensure that, as many consumers remain connected to the network in case of failure.

The main functions of the power system are continuity and reliability, it is the correct operation of the system; all its components work normally. The recent technological advances have improved the reliability of the network. The purpose of the AR function is to restore the continuity of the feeding system as soon as possible. The auto-close function works after each breakdown and automatically closes the line that has been disabled due to the trigger signal sent from the protection system when a fault occurs usually, this function turns off the line for several cycles after the Circuit Breaker (CB) is turned on. When the system detects a temporary or unsuccessful error, it must then notify the automatic auto-reclose cycle in order to be ready. Only the damaged line is isolated. Then the other lines continue to supply energy to the energy system. To provide energy for consumers the start time can be adjusted. One of the most important reasons for using a bus scheme is reliability.

In this paper, a new auto-recloser device is proposed with directional overcurrent protection, which adds new features to the protection system. As a preparation for the integration of Distributed Generation (DG), new challenges are placed on traditional protection systems. The system was simulated, the performance of the auto-reclosing was verified, and the auto-recloser device will successfully eliminate the transient and semi-permanent faults on the distribution line. There are two kinds of faults that are common to the distribution system which are simulated.

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VII. REFERENCES


