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# Arrester Resistive Current Measuring System Based on Heterogeneous Network

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**Abstract.** Metal Oxide Arrester (MOA) suffers from aging and poor insulation due to long-term impulse voltage and environmental impact, and the value and variation tendency of resistive current can reflect the health conditions of MOA. The common wired MOA detection need to use long cables, which is complicated to operate, and that wireless measurement methods are facing the problems of poor data synchronization and instability. Therefore a novel synchronous measurement system of arrester current resistive based on heterogeneous network is proposed, which simplifies the calculation process and improves synchronization, accuracy and stability and of the measuring system. This system combines LoRa wireless network, high speed wireless personal area network and the process layer communication, and realizes the detection of arrester working condition. Field test data shows that the system has the characteristics of high accuracy, strong anti-interference ability and good synchronization, which plays an important role in ensuring the stable operation of the power grid.

## 1. Introduction

The metal Oxide arrester (MOA) is widely used in power system, and its condition under the continuous voltage plays a vital role in safe operation of power grid system. After a long term operation, the arrester will appear the problems of internal damp, surface contamination, resistors aging and insulation deterioration, resulting in the lightning protection performance of the arrester become worse [1]. As the resistive current can reflect the operation of the arrester, the resistive current detection is listed as a standard experimental project.

At present, the common method of MOA resistive current measurement requires to layout long cables, which has increased the workload and insecurity of field testers. And the wireless method can simplify the complexity of field wiring and easy to operate[2-4], however the anti-interference ability of ordinary wireless communication is poor[5]. In view of the above problems, combined with the existing process layer communication network[6] that confirming to I0 interface specification in the substation, and based on LoRa wireless network[7], high speed wireless personal area network and heterogeneous network[8-9], this paper has done some research, and then a novel synchronous measurement has been designed, through the wireless communication in two frequency bands, which not only could solve the field complex wiring problems and simplify the calculation process, but also could greatly improve the synchronization performance and the measurement accuracy of the system.



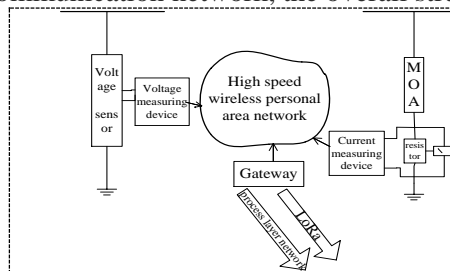
## 2. Measurement method of arrester resistive current based on heterogeneous network

The heterogeneous network[10-11] is a new network composed of different manufacturers of computers, network equipment and systems, in order to meet the diversity of terminal services, different types of networks are integrated[12]. In this system, the heterogeneous network mainly refers to high speed wireless personal area network and LoRa wireless network. And the full name of LoRa is “Long Range”, and it mainly aims at internet of things, and is applied to battery powered wireless equipment. LoRa signals are also powerful for building penetration and large scale internet of things deployment, and the high speed wireless personal area network is used at the end of the whole network chain to realize the communication among different terminals.

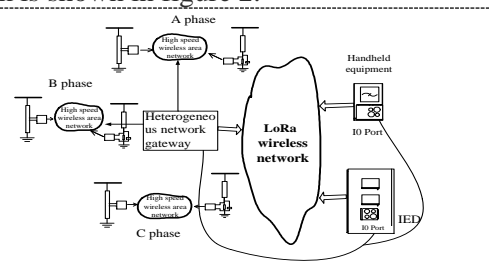
Based on the advantages of the heterogeneous network, the arrester resistive current detection system has been designed. The smallest cell of the system is shown in figure 1, which uses the voltage and current measuring device respectively to collect the secondary voltage signal and the leakage current signal of the arrester on the same phase[13], then voltage and current signals are handled by using the Hanning window with FFT, which decreases the time of calculation, and the simplified window function is shown as formula (1). And then the handled data is transmitted to the gateway.

$$\omega(n)=1/2-1/2\cos(2\pi n/N), n=0, 1, \dots, N-1 \quad (1)$$

The gateway is used to receive voltage and current signals of A, B and C three phase arresters, and analyze and calculate the measured signals, and obtain the resistive current value of three phase arresters. The system can be used as both on line monitoring equipment and charged detection equipment in the substation. When used as charged detection equipment, it is necessary to configure with handheld device in LoRa wireless network. And when the system is used as on line monitoring device, data is interacted with IED through the LoRa wireless network or the process layer communication network, the overall structure of the system is shown in figure 2.



**Figure 1.** Single phase arrester resistive current detection system.



**Figure 2.** The overall structure of detection system of three phase arresters.

The heterogeneous network gateway can communicate well with the field handheld device and the IED through LoRa network, mainly relying on the characteristics of high reliability, strong penetration, long distance and low power consumption. As the flexibility and reconfiguration of heterogeneous network, the system can be extended to the on line monitoring and charged detection of all arresters or other equipment in the station. The LoRa network brings together information of all kinds of arresters at different voltage levels, and carries out the comprehensive analysis to get the health status of each arrester, and finally realize the automation and intelligentization of power grid[14].

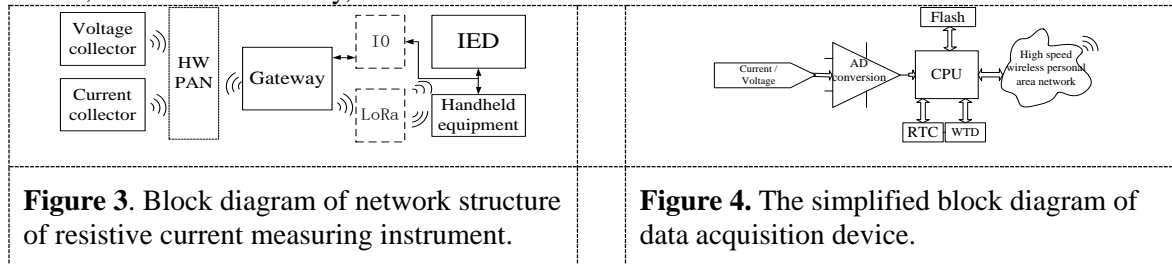
## 3. System design and implementation

The heterogeneous network transmission architecture of this system mainly adopts the idea of layered structure design, the network structure layer is divided into three parts: high speed wireless personal area network layer, LoRa wireless network layer and the process layer network, and the data in different network layers can be exchanged through the data information processing and conversion unit of the heterogeneous network gateway, and the network block diagram of resistive current measurement system for MOA based on heterogeneous network is shown in figure 3. As a data transmission layer of current and voltage of three phase arresters for A, B and C, the high speed wireless personal area network is used to transmit the data of arrester collected by acquisition terminal to heterogeneous network gateway, and after calculated and analyzed by the gateway, the data is

transmitted to handheld device and IED through LoRa wireless network and the process layer network.

### 3.1. Implementation principle of the system

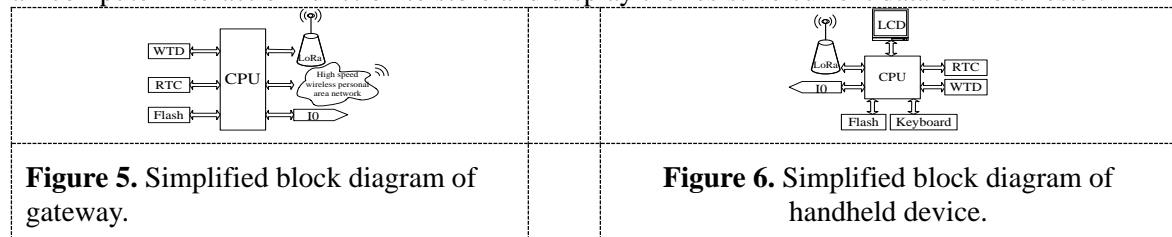
The data acquisition unit includes A, B, C three phase voltage acquisition devices and A, B, C three phase current acquisition devices, as shown in figure 4, a simplified block diagram of a single phase current or voltage data acquisition device is presented, which mainly includes current and voltage sensors, analog to digital conversion unit, central processing unit, high speed wireless personal area network, non-volatile memory, etc.



The current sensor is used to measure the leakage current of arrester; and the voltage sensor is used to measure the voltage of the secondary side of the voltage transformer; the central processor unit is integrated with the DSP kernel to calculate and analyze the data; the analog to digital conversion unit uses a 16 bit high precision analog to digital conversion chip; the high speed wireless personal area network adopts 2.4G wireless module for communication, which has the advantages of high communication rate and strong anti-interference ability; the nonvolatile memory is used to store dynamic configuration instructions and measurement data.

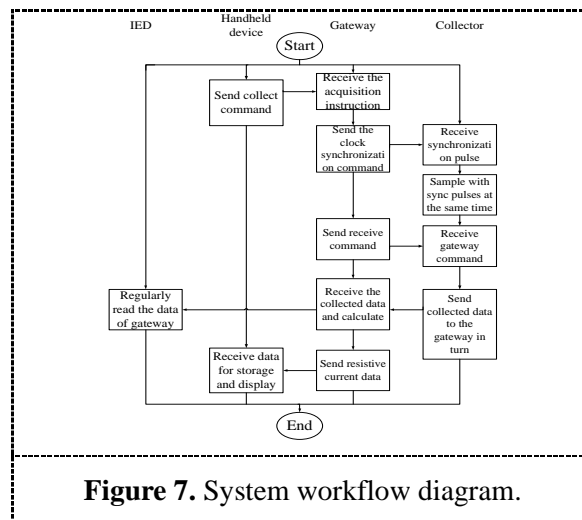
The heterogeneous network gateway mainly includes high speed wireless person area network, central processing unit, LoRa wireless network, process layer communication and nonvolatile memory, as shown in figure 5. LoRa wireless network has the characteristics of long distance wireless transmission, low power consumption, long battery life, multi node and low cost, which provides great convenience for field measurement of arrester; the process layer communication can be achieved by Ethernet or 485 field bus for data communication with IED.

Handheld equipment mainly includes LoRa wireless network, process layer, central processing unit, liquid crystal display and nonvolatile memory as shown in figure 6. The central processing unit adopts 800M industrial level microprocessor AM3359, and the large size LCD provides a good man-computer interaction function to store and display the resistive current data of the arrester.



### 3.2. System function implementation

The system work flow chart is shown in figure 7. The arrester current measurement system mainly includes four parts: arrester voltage and current collector, heterogeneous network gateway, handheld device and IED. The collector is used to measure the resistive current of the arrester and collect the voltage signal of the voltage transformer synchronously, and then send the data to heterogeneous network gateway; and the gateway is used to receive the data collected from the collector, then the data is analyzed and calculated, and the calculated results are passed to handheld and IED through LoRa wireless network and process layer network to complete a data collection, communication and display.



#### 4. System Verification

First of all, the accuracy test of the system was carried out by using the DK-34B1 three phase current source in the laboratory, when the angular phase difference  $\Phi$  between the fundamental voltage and the fundamental full current was set to  $85^\circ$ , the measurement results of different full current values were shown in table 1, and the unit of all data is mA in this table. Then the system was verified at 220kV 50HZ test field in Shenyang tiger stone station. The packet loss rate with different communication distance was tested.

**Table 1.** The variation of resistive current of arrester at different full current.

Set the full current rms	Theoretical resistive peak current	Measured value 1	Measured value 2	Measured value 3	Measured value 4
0.1	0.012	0.012	0.012	0.012	0.012
1.0	0.123	0.123	0.124	0.122	0.123
4.0	0.492	0.494	0.495	0.496	0.495
6.7	0.826	0.828	0.829	0.826	0.827
10	1.232	1.243	1.242	1.239	1.241

The MOA related data was transmitted with 1000 packets once, the result was shown in table 2.

**Table2.** The quality of network communication varies with distance.

Number of group	Distance (Km)	Receive packets	Packet loss rate
1	0.2	1000	0.0%
2	0.5	999	0.1%
3	1.2	995	0.5%
4	2.5	987	1.3%

The three phase arresters of the 220kV 17L group was measured by this system at the same time, the measurement result was shown in table 3.

**Table 3.** The actual measurement situation of the field.

Test items	A phase	B phase	C phase
Voltage RMS (V)	236.19	236.19	236.19
Three harmonic (%)	0.72	0.7	0.71
Five harmonic (%)	0.12	0.13	0.12
Seven harmonic (%)	0.04	0.03	0.04
Full current(mA)	0.586	0.596	0.59.
Resistance current fundamental peak (mA)	0.119	0.073	0.088
Phase angle difference ( $^\circ$ )	81.7	85	83.9

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