

Research on the Adjacent Charged Object Monitoring Device Based On MEMS Electric Field Sensing Technology

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Abstract. In order to strengthen the safety protection of the construction of the adjacent charged object and ensure the safety of the construction. Based on the MEMS electric field sensor technology, the MEMS electric field monitoring and alarm device is developed for the two different electric field conditions of DC and AC. The device has wireless transmission, GPS/ Beidou Positioning and other functions. It can realize real-time local alarm, remote server monitoring based on GPRS signal transmission, mobile APP online monitoring and so on. Both DC and AC power frequency electric fields are measured in a large range of range of 0~1000kV/m, the resolution is 20V/m, and the total uncertainty is within 2%. In the Changji -Guquan and other transmission line projects, the functions are well tested and the results are accurate.

1. Introduction

Due to the restriction of the transmission line corridor, the parallel hypothesis and shared corridor are becoming more and more common in the new power line and the existing line. The induced electric field produced by the parallel line is more and more serious to the construction of the new line, even in the operation of the construction safety regulations, there are some direct or indirect accidents caused by electric damage. It is of great significance to develop the device with accurate measurement of electric field and convenient to carry, which is of great importance to the safety construction of the adjacent live line.

There are two kinds of electric field sensors, which are mostly induced by induction probe and field mill. But the traditional electric field sensor is large and difficult to carry. It is very difficult to measure electric field in a narrow space or easily disturbed area. The MEMS electric field sensor has the advantages of small volume, low cost and low power consumption. It can play a unique role in the electric field measurement of the adjacent live line.

2. Functional Requirement

The MEMS electric measurement monitoring alarm device based on the adjacent electrified line, mechanical equipment or components can use artificial carry or at risk conditions, but does not interfere with the normal construction, when reaching the farm safety threshold setting device, an alarm signal, electric field to remind the construction workers here have been overrun value.

3. Design of Device Scheme

According to the difference between AC line and DC line, based on MEMS electric field sensor



technology, research and design are applied to two kinds of electric field measurement and alarm devices which are suitable for DC and AC applications.

The alarm device comprises a MEMS electric field sensor probe, excitation and signal processing module, analog demodulation module (for AC), AD (for DC), Beidou positioning module, CPU, 232, 232 DTU, 433 DTU distributor, GPRS DTU, a power supply module, lithium batteries, lights, switches, high brightness and light alarm loud buzzer.

The MEMS electric field sensor probe is placed outside, and other key modules or units are placed in a metal box. CPU reads the original value of the electric field output from the MEMS DC electric field sensor and the time information of the Beidou positioning module and the latitude and longitude information through the serial port. Because the MEMS DC electric field sensor output electric field is the original value, unit mV, be converted into electric field value, unit is kV/m, this part of the work to be done, however, in CPU, the transformation coefficient of MEMS DC electric field sensor by different, so it is necessary to turn the different coefficients in the PC written by CPU USART. The parameters to be written mainly include the zero point value, the sensitivity value, the magnification coefficient and the electric field threshold.

The other work of CPU is alarm recognition. When the converted electric field value is greater than the threshold value, CPU should judge and output the alarm information. At last, the output information of CPU includes sensor number, AC and DC electric field identification information, electric field value, alarm status, Beidou time service and latitude and longitude location information.

RS232 CPU data output by 232 divider into three roads, respectively through the 232DTU output, 433DTU output and GPRS DTU output, 232DTU output for debugging use, 433 DTU output is used for testing the site monitoring and local data storage, GPRS DTU output is used to send the data to the server by sending a remote network.

When the switch is opened, the indicator lights up and the system starts to work.

Installation environment and use method:

- 1) In order to avoid the impact on the measurement of lightning DC electric field measurement, the best choice for fine measurement;
- 2) Installed in the construction equipment, to remind the related equipment has entered the strong electric field area;
- 3) It is carried by the operator to determine the most critical point of the electric field in the construction of the adjacent live line, and to protect the safety of the staff.

4. System integration development

In order to facilitate the measurement of the construction site, the distance between the MEMS electric field and the control box is 1.5m for the effective system assembly of the equipment component module, such as Figure 1.



Figure1. MEMS Electric Field Measurement Device

In order to facilitate the local test and the storage of electric field data, the host computer software for monitoring and alarm of the adjacent live line is written in Labview. The software can also display

the change curve of electric field in real time. The host computer software is simple and easy to operate, Only the serial port is configured, the baud rate is 9600, the start button is clicked.

5. System Test

The performance of the device is mainly determined by the MEMS electric field sensor probe. Therefore, the DC electric field and the power frequency electric field are mainly tested on the probe, including the resolution and the total uncertainty.

An electric field test automatic calibration system is used to test the MEMS electric field sensor probe. First, the resolution of the DC electric field is measured. The test method is as follows:

- 1) Adjust the input of the electric field, apply the load (the lower limit of the range is the minimum resolution) as the base point, and read the output value of the sensor chip.
- 2) Increase the load to read the output value of the sensor chip.
- 3) The load is reduced to the lower limit of the range, and the output value of the sensor chip is read.

The test results of the DC electric field resolution of the MEMS electric field sensor probe, and the resolution of the probe is reached to 20V/m.

The total uncertainty of the MEMS electric field sensor is used to measure the total uncertainty of the DC electric field measurement. The method is as follows:

- 1) 6 calibration points (including the upper and lower limits of the measurement range) are taken evenly in the range of 0~1000kV/m. (0V/m, 200kV/m, 400kV/m, 600kV/m, 800kV/m, 1000kV/m);
- 2) From the lower limit of measurement range (0V/m), according to the provisions of the calibration points (0V/m, 200kV/m, 400kV/m, 600kV/m, 800kV/m, 1000kV/m) stationary load to be stable after 5S, output read sensor values of components, until the upper limit of measurement range (1000K V/m) (known as travel);
- 3) Will limit load to fluctuation of about 2 per thousand, and then back to the upper limit, then read the output value as the initial value of the reverse stroke, according to the original order back to school on time (called anti trip);
- 4) 3 times each of the positive and counter itinerary.

The total uncertainty of the MEMS electric field sensor probe is 1.63% according to the calculation method of 4.2 provisions in GB/T 18459-2001 of China national standard.

The MEMS electric field sensor is used to measure the resolution of the 50Hz power frequency electric field, and the test method is the same as that of the DC electric field resolution. The resolution of the power frequency electric field of the probe of the MEMS electric field sensor also reaches 20V/m.

The total uncertainty of power frequency electric field measured by MEMS electric field sensor probe is also tested. The method of measurement is also the same as the total uncertainty of DC electric field. The total uncertainty is 1.53%.

6. Engineering Application

The engineering application of DC electric field and AC electric field safety monitoring and alarming device is achieved in the 3 section of Changji 1000kV UHVDC project, Anhui 3 bid section, as shown in Figure 2.



Figure 2 .MEMS electric field safety monitoring and alarm device engineering application

Adjacent DC lines carrying equipment shaped tower from the ground to the cross arm at a total of 5 planes in the "T" by people, the measured 10 points were observed in high altitude operation, electric field changes facing; adjacent AC lines along the AC line just below the projection center position, both ends of the outward every 5m distance field strength measurements from the ground at 1.5m, to observe the distribution of the electric field.

Table 1. Inductive electrical values of adjacent $\pm 800\text{kV}$ UHV DC lines

Location	Value 1	Value 2	Value 3	Value 4	Value 5	Average Value
1	-1.71	-1.8	-1.87	-1.9	-1.84	-1.824
2	0.78	0.61	2.04	1.54	2.21	1.436
3	16.64	15.74	15.86	16.19	19.84	16.854
4	10.72	10.13	11.51	10.43	10.18	10.594
5-1	14.47	13.55	11.84	11.52	12.73	12.822
5-2	7.16	10.32	8.68	8.12	8.54	8.564
5-3	26.59	24.27	24.62	23.97	23.83	24.656
5-4	8.25	8.71	6.83	4.51	4.86	6.632
5-5	13.2	14.48	15.18	15.24	15.69	14.758

5-6 52.68 50.99 51.66 53.38 57.59 53.26

Table 2. 1000kV UHV AC line induced electrical values

Testpoint(m)	0	15	20	25	30	35	40	45
Measured value(kV/m)	2.24	3.77	3.98	3.15	2.36	1.92	1.16	0.44
Test point(m)	0	-15	-20	-25	-30	-35	-40	-45
Measured value(kV/m)	2.24	3.83	3.96	3.62	3.21	2.88	2.63	2.259

Table 1 shows that the measured results are basically the same as the distance calculated from the calculated distance of live lines, and the trend of the magnitude of induction is the same. Table 2 is also consistent with reality, that is, the farther away from the live line, the less the trend of induced electricity.

7. Summary

Electric field sensor based on MEMS measurement technology, developed for the adjacent DC lines and communication lines and 2 sets of safety monitoring and alarm device configuration, data transmission module, Beidou positioning module, overrun alarm module, data acquisition and transmission, with local wireless remote monitoring, local and remote alarm functions, is of great significance to live nearby the line engineering construction safety monitoring.

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