Fiber-optical wind direction sensing system

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***Abstract*— We experimentally demonstrated a real-time wind direction monitoring method using the fiber optic collimator to obtain the wind direction value and display it on the computer.**

Keywords—Fiber optical sensing, Wind direction, Fiber Colli mator

I. INTRODUCTION

The flow of air produces wind. In meteorological research, the wind is usually measured as a two-dimensional vector, which is mainly determined by two parameters, wind speed, and wind direction[1]. Wind direction monitoring is an important part of engineering applications. On transmission lines, the wind direction partially determines the probability of galloping and icing on transmission lines. With the development and utilization of renewable energy, wind direction monitoring is also an important monitoring method to ensure the normal operation of wind power generation. [2].

The measurement of wind direction is mainly based on the measurement of the wind vane. The wind tail of the wind vane generates a rotational moment under the action of the wind force so that the axis of the wind tail of the indicator rod continuously adjusts its orientation to keep in line with the wind direction. Other methods of measuring wind direction include ultrasonic wind detectors, jet flow wind sensors, spherical wind direction indicators, and the like[3-7]. However, the above-mentioned methods basically rely on electronic components to realize monitoring. The application of the transmission power system will be affected by strong electromagnetic interference, and the accuracy and stability are difficult to guarantee. The way active power supply reduces its versatility. Therefore, a passive wind direction monitoring method capable of resisting strong electromagnetic interference is needed in the power system, and this is precisely where the advantages of optical fiber sensing lie[6].

In this work, we propose a fiber-optical collimator-type wind direction sensor, which uses the difference in the optical power received by the photoelectric detector when the wind vane rotates to determine the wind area, and the peak incoming voltage of the received optical power converted to high and low levels in the voltage comparator. According to the corresponding conditions, the single-chip microcomputer can calculate the real-time wind direction. This solution improves the reliability of the wind direction monitoring system and reduces maintenance costs. At the same time, due to the use of the optical source in the 1310 nm band fiber optic transceiver, the use of wavelength division multiplexing technology can further improve the monitoring utilization of the fiber core, which provides an important reference for realizing real-time wind direction monitoring.

II. SCHEME

First, the wind direction partition disk is placed on the fixed. The central position of the base is fixed, the central ring passes through the connecting shaft, and the connecting shaft passes through the fixed pillars at both ends to make the direction partition disk in the center. The middle position is suspended and can rotate freely, and the two ends of the direction partition disk are fixed with clip springs so that the partition plate can follow the connecting shaft rotate at the same angular velocity. A collimator fixing base is placed at the corresponding positions at both ends of the three-layer ring structure of the direction partition disk. The height of the base depends on the height of the ring of the partition plate. Usually, the meteorological status monitoring of transmission lines only needs to confirm the direction of the wind force, so the partition disk of eight wind zones is designed naturally as shown in Figure 1.

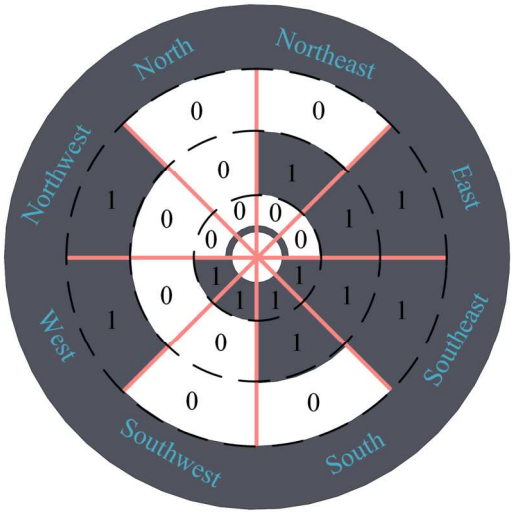

Figure1 Eight wind direction partition disk

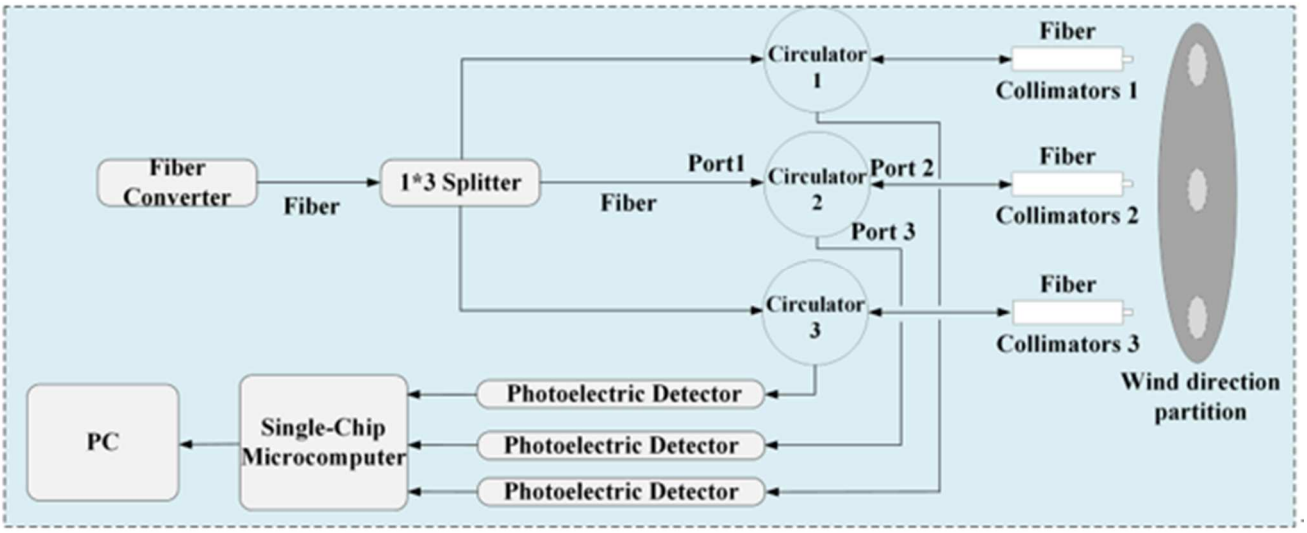

Figure2 Schematic diagram of wind direction collimator

The measurement principle is shown in Figure 2. In this paper, an optical fiber optic transceiver with a wavelength of 1310nm and an optical power of -9dbm is used to collect. The transceiver is used as the optical source, when the light emitted by the light source passes through the optical coupler, the light beam is transmitted to the Port 1 of the three circulators, and port 2 of each circulator respectively connected to three fiber collimators. When the wind vane is rotating in an environment with a constant direction of the wind, it will drive the wind zone to rotate at the same speed, and finally, stay at a certain position. At this time, if the light emitted by the fiber collimator is reflected back by the wind direction wheel, it will pass through the loops in the respective loops and enter the PD from port 3 to convert the optical signal into an electrical signal, and send it to the single-chip microcomputer module for voltage judge and count.

TABLE I. CONDITIONS FOR JUDGING THE WIND AREA

Wind area	First layer	Second layer	Third layer
North	0	0	0
Northeast	0	1	0
East	0	1	1
Southeast	1	1	1
South	1	1	0
Southwest	1	0	0
West	1	0	1
Northwest	0	0	1

Since the wind direction partition disk is a three-layer ring structure, the partition disk and the wind vane rotate in the same direction and at the same speed. Each layer of the three-layer ring structure is half hollow and half solid. When the light from the collimator hits the partition plate, it will be reflected back. At this time, the light is in the coupling state. The photodetector at the end can receive the light of -23dBm, and the threshold is set to -25dBm. The optical power higher than the threshold is converted into a high-level pulse signal by the voltage comparator through the PD and counted as 1. In the hollow part, the optical path is disconnected, the photodetector cannot receive light, and the voltage comparator sends a low level, which is recorded as 0. Since each of the eight wind zones is divided by a three-layer ring, each wind zone can be represented by a three-digit Gray code, and the specific correspondence is shown in Table Ⅰ.

III. RESULT AND DISCUSSION

In our experiments, photoelectric detectors determine the state of the light output from the collimator as it passes through the wind direction partition disc condition. It has been verified by experiments that the light power reflected back by the light passing through the partition disk is -25dBm. While the collimator is divided into the optical power is -60dBm when the area is blocked, which is caused by back Rayleigh scattering, Raman scattering, and environmental noise. Figure 3 shows this state

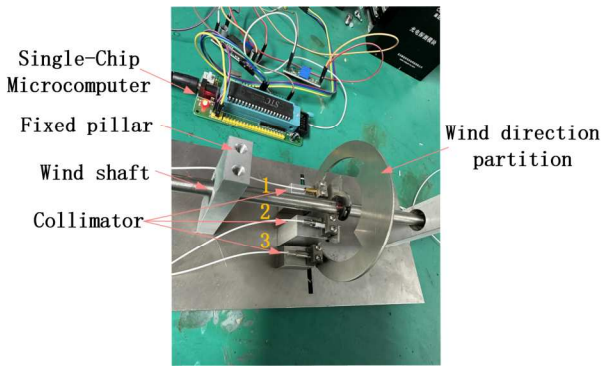

Figure3 Light coupling in collimator 1 and passing in 2 and 3

Since the light emitted by the collimator is different enough at different positions of the direction partition disk to distinguish the state of the wind direction, so set the threshold of the optical power to -25dBm, and the PD transmits electrical signals according to the received optical power into the voltage comparator, the voltage comparator transmits the corresponding high and low-level signals to the microcontroller. The microcontroller is set with a discrimination program, comparing the three levels with the

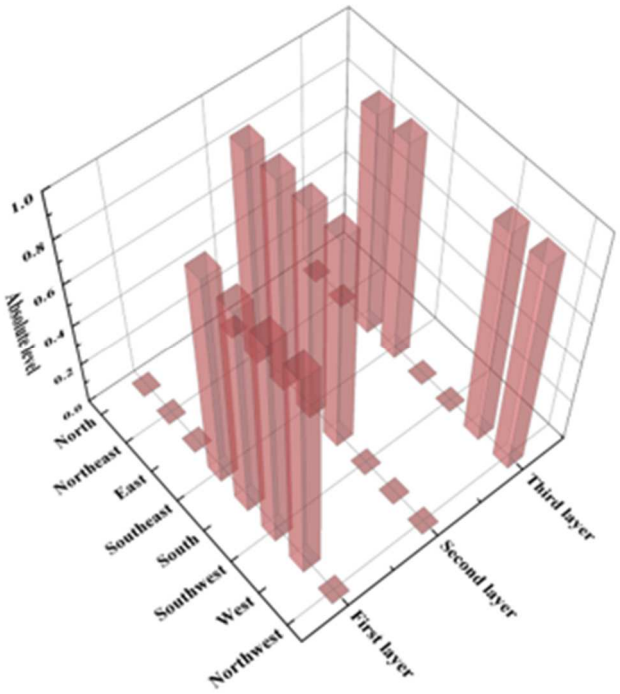

Figure4 Schematic diagram of wind direction collimator

wind zone judgment conditions, and the correct wind zone can be obtained.

IV. Conclusion

In conclusion, we propose and investigate a wind direction measurement scheme. It has previously been demonstrated that a fiber-optic collimator-based wind direction sensor can be used as the basis for wind direction measurement. The results show that the proposed fiber optic sensor has good performance and can accurately distinguish eight wind directions. We believe that this scheme will have a broader application prospect in transmission power systems.

Acknowledgment

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