Design of meteorological intelligent sensor based on POE Technology

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Abstract: An application scheme of Poe based Ethernet technology in meteorological intelligent sensor system is designed. The working principle and implementation method of Ethernet power supply system (POE) based on IEEE802.3af Ethernet power supply industry standard are experimentally analyzed. The power supply part of the meteorological intelligent sensor makes full use of Poe technology to provide current on the network cable transmitting data, which greatly reduces the complexity of the power supply system and improves the reliability of the system power supply design. Through the test of the actual system, the function and performance of the meteorological intelligent transmission system have achieved the expected results.

1. Introduction
At present, POE(Power Over Ethernet) power supply technology has been widely used [1]. Yin [2] studied the application of POE technology in security network monitoring. Riley [3] and Ding [4] studied the application of POE in the Internet of things. Lin et al. [5] studied the safety performance of POE in lightning surge protection. Wang [6], Zeng [7] and Xu [8] studied the application of POE technology in LED lighting system. Li [9] and Xing [10] studied the application of POE technology in weak current engineering and intelligent substation. Xue et al. [11] Application of POE technology in clean environment system. Yan et al. [12] studied the application of POE technology in 5G and wireless communication. In recent years, the increase of global extreme climate has posed a great threat to industrial and agricultural production and the safety of people's lives and property, which puts forward higher requirements for meteorological forecasting. The most important thing is to improve the intelligent level of relevant technologies and equipment of meteorological forecast, and the meteorological intelligent sensor is the basis to improve the ability of meteorological forecast, disaster prevention and reduction, and improve the accuracy, accuracy and density of observation data. The "China Meteorological Observatory ground integrated observation business platform" being implemented by the meteorological department puts forward higher requirements for meteorological intelligent sensors. Figure 1 is the schematic diagram of the ground comprehensive observation business platform of China's National Meteorological Observatory. It can be seen from the figure that the intelligent sensor equipment, as the infrastructure of the meteorological observatory, is composed of intelligent sensors that collect meteorological elements such as rainfall, temperature, humidity and air pressure. The intelligent observation equipment is located in the observation field, The collected data information is transmitted to the database service system through the network switch. The
database service system performs statistical processing, fusion and other processing on the collected meteorological data, and the processed data is uploaded to the "Tian Qing" database. Due to the dispersion and uncertainty of the installation location of the meteorological intelligent sensor, the intelligent temperature sensor may be installed in the louver box or underground soil, and the wind speed sensor must be installed on the wind pole to collect data. Therefore, the power supply of the intelligent sensor has become a thorny problem in the system design. If the mains rectifier power supply is adopted, the cost is high and the stability cannot be guaranteed. The wiring of each intelligent sensor is also complex. POE technology is used to solve the power supply problem of intelligent sensor, which can be popularized and applied in meteorological intelligent sensor.

![Figure 1. Flow chart of ground comprehensive observation business platform of China's national meteorological stations](image)

2. Overall structure design

2.1. IEEE802.3af standard

The International Institute of Electronic Engineers (IEEE) approved the 802.3af standard for providing power over standard Ethernet cables on June 23, 2003. The standard defines a method that allows 48VDC power supply to be transmitted while transmitting data through Ethernet. At present, the Ethernet cable used is class 6 or super class 5. It uses one pair to send data, one pair to receive data, and the other two pairs are standby pairs. In IEEE802.3af standard, two ways can be used to supply power to PD (Power Device) equipment, One is to use two spare pairs; The other is to use the data line to transmit DC power, that is, the center tap of two groups of isolation transformers at both ends of the cable is used to provide nominal 48VDC. It must be pointed out that PSE (Power Supply Equipment) equipment can choose one of the power supply methods to supply power to PD equipment, and PD equipment must be compatible with two modes of power supply. This power supply method can safely and reliably introduce the Ethernet Power Supply (POE) technology into the existing network infrastructure and is compatible with the original network equipment. At present, it can provide about 12.95w power at the maximum. Therefore, some small network equipment such as IP phone, network camera Wireless access points and data terminals can be connected to supply power through Ethernet without using AC power socket, which greatly simplifies wiring, reduces the construction cost of network infrastructure, and will further expand the application of Ethernet technology.
2.2. PSE equipment
In POE system, PSE mainly completes the power management function of the whole POE system. Power management is to carry out equipment detection, power classification, power supply monitoring and module test on PE equipment, and obtain various technical indexes of PE equipment. The system constructed with these technical indexes can realize Ethernet power supply while protecting the reliability of network data transmission, and prevent various possible hazards of PSE equipment and power receiving equipment due to power supply to equipment not suitable for network power supply.

According to the network topology and implementation mode of PSE providing power to PD, PSE equipment is divided into END-POINT PSE and MID-POINT PSE. Terminal PSE uses Ethernet devices supporting POE function, such as switches and routers, to provide power, as shown in Figure 2; Mid span PSE is a way to add a mid span hub that provides power to Ethernet switches and PD devices, as shown in Figure 3. The system adopts the terminal Poe system, directly adopts the Ethernet switch supporting POE technology.

2.3. Design and implementation of PD equipment
In POE system, PD equipment is power receiving equipment. The design of power receiving equipment requires an interface chip conforming to Poe protocol to provide PSE equipment with PD equipment detection characteristic signal, hierarchical characteristic signal and program-controlled surge current signal. In this system, compatible standard high-power PD controller TPS2376-H introduced by TI company is adopted, as shown in Figure 4, as specified in IEEE802.3af standard, PSE equipment only needs 1,2 line pairs, 3,6 line pairs or 4,5,7,8 line pairs to supply power, but it cannot supply power at the same time. PD equipment needs to deal with these two pairs of line pairs. Therefore, two rectifier bridges are selected to prevent reverse polarity of DC voltage between line pairs. Diode D1 is designed to eliminate over voltage caused by lightning strike on the network line. The resistance between IIIM pin and VSS pin is used to the limit value of surge current. The setting formula is: \( ILIM = \frac{40000}{R_{ILIM}} \). It is recommended to select 287 kΩ when connecting with general PSE equipment. The setting of surge current limit value can prevent the output voltage from being lower than the lowest UVLO value by the subsequent step-down capacitor. When adjusting the surge current value, the capacitance of the step-down capacitor can be larger, which is beneficial to the design of the later step-down circuit. Pin ILIM is not allowed to be suspended or short circuited with VSS.
DET pin is the detection resistance of PSE equipment to detect PD equipment, and the resistance value is 24.9 \( (1 + 1) \) K12. When PSE equipment detects, measure two V_1 point or the slope between them to calculate the resistance value and judge the existence of the common mode terminal of the port. For Ethernet power supply, detection is critical because it can ensure that 48V DC voltage is only applied to the effective PD and will never damage the equipment that does not need to receive 802.3af power supply. PD detection must be completed within 500ms, otherwise if the PSE waiting time is too long, the Ethernet equipment plugged in the original PD location that does not need power supply will be damaged. After successfully completing the detection, PSE provides 15.5 \( \sim \) 20.5v voltage to the port and puts PD in hierarchical mode. In particular, if the PD terminal does not need to be powered due to special reasons, the PD equipment must try to reduce its impedance below 12kfz or above 45kq, so as to ensure that it will not be detected by PSE equipment. Due to the limited power supply resources of PSE equipment, it is impossible to provide electric energy of any size to PE equipment. Therefore, after PSE successfully detects PE equipment, it is necessary to carry out hierarchical operation. The class pin is externally connected with the hierarchical resistance of PD equipment. As shown in Table 1, PD equipment is divided into five levels, and each level corresponds to a power range of PD equipment, ranging from 0 to 12.95w, The resistance value of this resistor can be selected according to the power value required by the later stage equipment. In the grading stage, PSE will apply 15 \( \sim \) 20V voltage to PD, and determine the specific level of PD by measuring the current. At this stage, the power supply part of the PD will be maintained in the passive state by the undervoltage locking (UVIO) circuit in order to isolate the switch stage until the characteristic and classification stage is completed.

Table 1. Energy level of power receiving equipment

| Gradation | PD power (W) | Graded resistance (Ω) | Grade current (mA) | Remarks |
|-----------|--------------|-----------------------|-------------------|---------|
| 0         | 0.45 ～ 12.96| 4422±1%                | 0～4.5            | default |
| 1         | 0.45 ～ 3.85 | 952±1%                 | 9.0 ～ 12.0       | optional|
| 2         | 3.85 ～ 6.48 | 548±1%                 | 17.0 ～ 20.0      | optional|
| 3         | 6.48 ～ 12.96| 356±1%                 | 26.0 ～ 30.0      | optional|
| 4         | retain       | 254±1%                 | 36.0 ～ 44.0      | retain  |

If the detection and grading operations are successfully completed, the PSE equipment will continuously supply power to the PD equipment according to the grading power. While continuously supplying power, the PSE equipment will also prepare to supply power to the next PD equipment, and will continuously detect the current PD equipment to ensure that the PD equipment is still connected. 802.3af standard specifies that PSE uses DC disconnect and AC disconnect to judge whether it remains connected with a PD. If the current PD equipment is detected to be disconnected, Poe power supply will be stopped immediately.
In this system, the post PD equipment adopts the arm core. The start-up of the arm requires an instantaneous large current. If the instantaneous current is not enough, the arm cannot be started and the POE power supply will not succeed. At this time, the resistance of Ilim pin can be adjusted to increase the surge current, or the capacitance of DC/DC pre stage capacitor can be reduced. Similarly, the instantaneous current can be increased to make the arm start normally. After actual test, POE system works normally.

3. Conclusion
This paper presents a meteorological intelligent sensor system based on POE Ethernet technology. The working principle and implementation method of Ethernet power supply system based on IEEE802.3af Ethernet power supply industry standard are experimentally analyzed. After POE power supply is adopted, the power supply part of the meteorological intelligent sensor system is very simple, and the node part does not need to be close to the power supply part, so the distribution of terminal nodes is flexible and diverse. The communication protocol adopts Ethernet protocol, which greatly reduces the difficulty and complexity of hardware and software design, and enhances the reliability and scalability of the system. Through the actual system test, all the initial assumptions are realized.

Acknowledgments
This work is financially supported by the Research project of Shanxi Province (20188243003).

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