Research of multi-channel data acquisition system based on Wi-Fi Technology

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ABSTRACT: As the main content of the modern information technology system, the data acquisition technology has been widely used in various fields of production and life. Traditional wired data acquisition system has good reliability, but it has the disadvantages of high cost, difficult maintenance, poor adaptability and so on. In this paper, based on the real needs of data acquisition, the wireless data acquisition system based on Wi-Fi is explored and studied. A wireless multi-channel dynamic data acquisition system is designed in this paper. This system takes the stm32f103c8t6 as the node master, carries on the transmission to the node data by the Wi-Fi module, takes the router as the transmission medium, the LabVIEW software design host computer virtual instrument. The feasibility of the proposed scheme is verified by experiments.
KEYWORD: Data acquisition; Wi-Fi wireless technology; LabVIEW; Router

1 INTRODUCTION

With the development of social demand and the diversification of the data collection environment, the traditional cable wiring method cannot completely meet the transmission requirements. Wireless sensor networks as a new technology development direction, has the advantages of traditional wired way cannot be compared. To measure the vibration and torque of the high speed rotating structure, if the wire transmission mode is adopted, it will bring many difficulties to the measurement, compared with the current commonly used wireless communication technology, considering the transmission rate, transmission distance, transmission reliability and other factors, this paper constructs a wireless data acquisition system based on Wi-Fi.

Same as Bluetooth and Zigbee, Wi-Fi technology is a short-range wireless communication technology. Wi-Fi works in the ISM band of 2.4GHz. With the introduction of 802.11a and 802.11b/g standards, the transmission rate up to 54Mbit/s, coverage up to 100m or so.

2 SYSTEM ARCHITECTURE

This dynamic strain acquisition system is composed of a wireless router, a wireless sensor network node and a host computer terminal. The system structure is shown in Fig. The design of Wireless sensor node is the key point of the system. Wireless router used to complete the network formation and data forwarding. The router is set up in advance, and then a local area network is set up automatically after power on, node and host computer PC are connected to this local area network. The upper computer realizes the wireless communication that based on TCP protocol by searching and connecting the IP address and port of the lower computer node which wants to access. The host computer sends commands to control the data transmission, and realize Real-time display and storage of data by virtual instrument based on LabVIEW. The block diagram of the system is shown in figure 1.

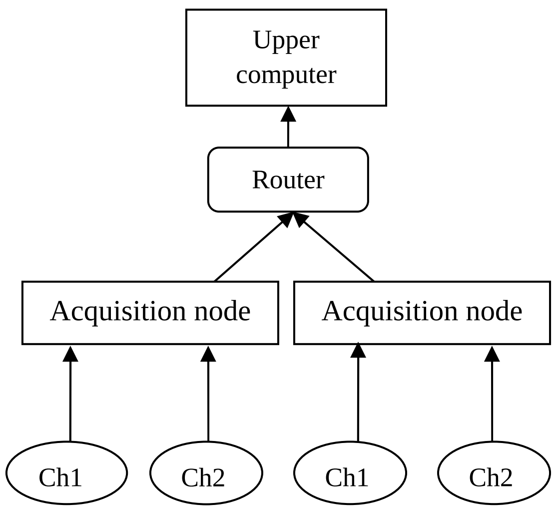

Figure 1. System architecture diagram.

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This figure is just a simplified system architecture, the number of acquisition channels depends on the selected A/D module. The sensor network composed of nodes should be able to realize the on-line monitoring of some structures in a certain area.

3 HARDWARE DESIGN

This paper focuses on the design and implementation of wireless sensor network node. The node is mainly composed of constant voltage bridge, signal conditioning unit, analog to digital conversion unit, power supply module, main control unit and Wi-Fi module. Node block diagram is shown in figure 2.

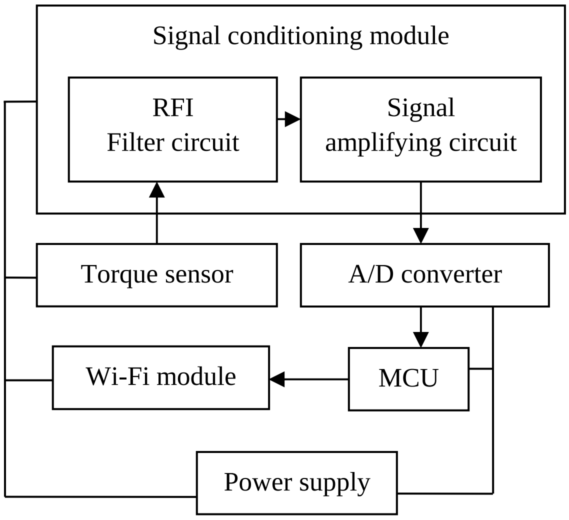

Figure 2. Hardware structure diagram of node.

The measuring bridge is formed by sticking the strain gauge on the elastic axis, when the elastic axis is changed by the torque, the resistance value of the bridge can be changed, and the weak voltage change of the output end of the bridge can be caused. The output voltage of the bridge is filtered by the RFI filter circuit, and then the signal is amplified by the differential amplifier. The amplified signal is input to the A/D module for analog to digital conversion. The output of the A/D module is controlled by MCU, which is transmitted by the Wi-Fi module on the node. Focus on the constant voltage bridge, signal conditioning unit to do a detailed introduction.

3.1 *Constant voltage bridge circuit*

The accuracy of the measurement results is largely determined by the stability of the voltage of the bridge. This node realizes the acquisition of multiple strain, it is required to drive a number of strain bridge simultaneously, and in order to enhance the integrity of the circuit, and reduce the error caused by a number of bridge voltage, it is required to provide a constant voltage source with powerful driving ability for the node, and the constant voltage source should with high precision output voltage. Due to the limited space, the specific schematic diagram is not given in the text, only do a simple introduction on the chip in the schematic diagram and circuit implementation.

The ADR127 used in this paper is a LDO precision reference voltage source, the input voltage is only 3.3V, the accuracy can reach 0.12%, the temperature drift is 3ppm. It can meet the requirement of the experiment, but the output current is only 5mA. Due to the voltage required to drive the sensor can not be too low. The ultra low power precision operational amplifier OPA2333 is used to form a voltage amplifier to amplify the 1.25V voltage to 4.96V. However, it is not enough to just increase the supply voltage of the bridge. In order to make the sensor work normally, it is necessary to improve the driving ability of the bridge. At the end of the last ,the voltage follower and the transistor were used to increase the driving ability of constant pressure source.

3.2 *Signal conditioning unit*

According to the measured data, the output voltage of the bridge is a millivolt level, the faint signal is not easy to be collected, can not be processed by the general operational amplifier. Thus, instrumentation amplifier with high input impedance and high common mode rejection ratio was choiced. In order to prevent the RFI interference caused by the data transmission module, the RFI filter circuit is added to the front end of the instrument amplifier, so that the white noise in the output signal of the bridge can be filtered out to a certain extent. Signal conditioning unit circuit as shown in figure 3.

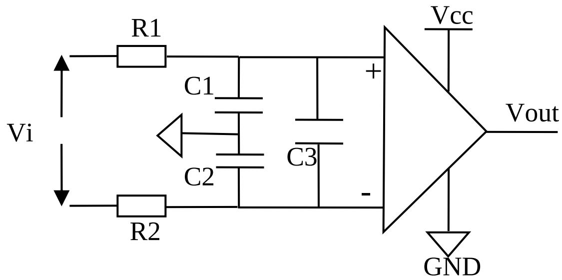

Figure 3. The schematic of signal conditioning unit.

The RFI filter circuit is composed of resistors R1, R2, capacitors C1, C2 and C3. Among them, R1 and C1, R2 and C2 formed a common mode filter circuit. R1+R2 and C1, C2, C3 formed a differential mode filter circuit. In the design, it should be R1=R2, C1=C2, to keep both ends of the output balance. In addition, if the input RC network time constant does not match, then the spurious differential signal is generated. In order to suppress spurious differential signal, the value of C3 should be ten times more than C1 and C2.

The cutoff frequency of the common mode filter is:

$$F_{CM} = \frac{1}{2\pi R1C1} = \frac{1}{2\pi R2C2} \quad (1)$$

The cutoff frequency of the differential mode filter is:

$$F_{DIFF} = \frac{1}{2\pi(C3 + \frac{C1C2}{C1+C2})(R1+R2)} \quad (2)$$

Select Instrument amplifier INA333, it is a low power, high precision instrumentation amplifier.
Its gain is controlled by external resistance Rg, and the relationship between the two is:

$$G = 1 + \frac{10K}{R_G} \quad (3)$$

The relationship between the output voltage and the input voltage is:

$$V_{OUT} = G \times (V_{IN+} - V_{IN-}) + V_{REF} \quad (4)$$

Rg need to use high precision, low temperature drift precision resistance, if the Rg is not inaccurate or temperature drift is too large, the measurement results will be a serious error.

4 SOFTWARE DESIGN

The software part mainly includes the program design of the node, the configuration of the Wi-Fi module, and the program design of the terminal host computer. Only realize the coordination of those three part can correctly complete the sensor signal acquisition, transmission, display and storage.

4.1 *The program flow of the node*

A battery is used to supply the node, in order to ensure the working time, the node needs to have a low power consumption function. When no information is needed, the node is in standby mode, only to maintain the power supply to the main control unit and Wi-Fi module, and to ensure that the module can receive the commands from the host computer. The program flow of node is shown in figure 4.

After have received the command from the host computer terminal, the node in the standby state was awakened and the node enters turned into the normal operation mode. The collected voltage signal is filtered and amplified before enter into the A/D unit, and the output data of A/D converter is converted to string by the main control unit. And coding the data according to the specified data frame protocol, and making further packing, then sent to the host computer through the Wi-Fi module on the node.

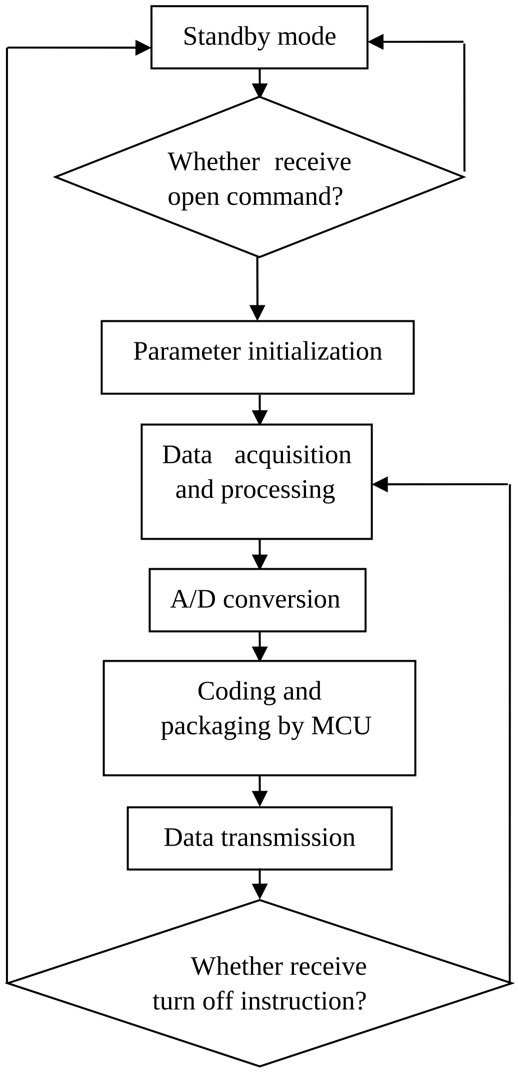

Figure 4. The overall process flow diagram of node.

4.2 *Configuration of Wi-Fi module*

The parameter configuration of Wi-Fi module is an important step to realize wireless communication. The node connected to a computer vias a serial port. Running SSCOM3.2 software on the computer, and then send AT + i command to node to configure channel and SSID, encryption, node's IP address and port number, host IP address and port number, trigger, baud rate, data bits, and stop bit all of these parameters. Finally through send AT + i!Snmd instruction to make the module into the transparent transmission mode to complete the module configuration.

4.3 *Realization of upper computer*

In order to display the real-time data in the computer terminal equipment, this design uses the LabVIEW Company’s NI software to design Interactive interface. Any PC with a wireless internet access function can be used as the host computer. Running the program based on LabVIEW language on the host computer, if the network connection is successful, the node can communicate with the host computer to realize the on-line monitoring of the node.

The wireless communication function of the host computer program is mainly realized by TCP function and VI in LabVIEW. Run LabVIEW 8.6, built a new VI, add a "open TCP connection" function into the program block diagram, and define the IP address, remote port and other terminal . The IP address and port number are consistent with the parameters of the slave computer. The program is to realize the data communication with the lower computer through this channel.

After the host computer program has received the data from the node, the program would split the received data in accordance with the specified data transmission protocol. Next, the string data was converted into digital array by numerical conversion. And according to the seted baud rate on virtual interface to display data in the form of waveform, at the same time, through the operation interface to completed the storage of data.

5 TEST RESULTS AND ANALYSIS

First of all, the standard strain gauge is used for static calibration of the two channels of the node. In theory, the output of the sensor changes with the change of the strain, which is shown as the linear increase of the output voltage corresponding to the linear increase of the strain. On the contrary, it is the opposite. The calibration results show that the data acquisition system has a good linear output. And the measurement precision is within 3 micro strain range, and the measuring range is 3000 micro strain. For the case without obstacles, the effective transmission radius is 70m, and the data transmission rate is stable.

The node is designed to fit the structure of the rotating body. Experiments are carried out to test the torque and thrust of the blades of the windmill model in the process of rapid rotation. Through the operation on the host computer virtual instrument that we can control the work of the node. Due to the high node acquisition frequency, the amount of data is very large. While ensuring the validity of the data, the data can be optimized through the interface to reduce the amount of data. The test results are shown in figure 5.

The output waveform shows the physical changes of the object detected by the sensor. By switching, the output waveform of each path can be displayed online. And data can be storaged, so as to provide the possibility of data analysis. Through data analysis, prove the wireless transmission scheme meets the requirements of the transmission rate, stability, effective distance, dynamic performance and good capability of wireless communication.

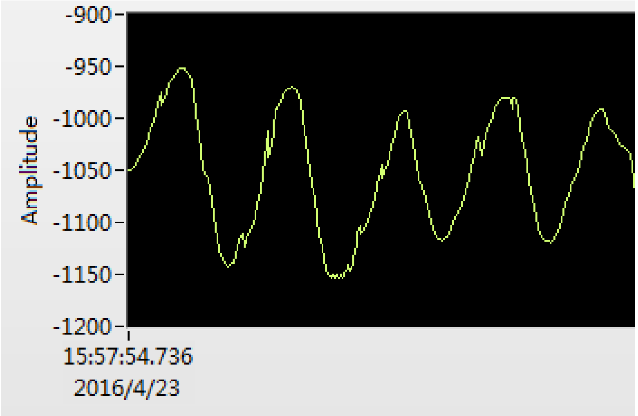

Figure 5. Output waveform of acquisition result.

6 SUMMARY

The data acquisition system can correctly and ensure the quality of the collected signal is the key to the system, stable and reliable transmission is also the problem that has to be solved to obtain expected data. In the process of data acquisition, it is easy to be disturbed by noise, but if the front end of the system is well designed, the system can get better denoising effect.

Wireless transmission not only reduces the cost of line layout and maintenance, but also effectively improves the flexibility, scalability and maintenance of the system. The experimental results show that the wireless data acquisition system based on Wi-Fi has fast data transfer rate, good stability and considerable transmission distance, which provides an effective reference for the future wireless sensor networks.

REFERENCES

He Xuewen & Sun Han & Cao Qingmei. 2014. Design on wireless temperature and humidity monitoring system of metal mine[J]. Metal Mine.

Li Cui & Hailin & Miao Yong. 2005. Overview of wireless sensor net-works [J]. Journal of Computer Research and Development.

Pottie G J & Kaiser W J. 2010. Wireless intergrated network sensors[J]. Communications of the ACM.

Ma Tianbing. 2011. Sensors State Monitoring Based on LabVIEW and Wireless Nodes[J]. Procedia Engineering.

Zahariadis Th & Pramataris K. 2012. Multimedia home networks: standards and interfaces[J]. Computer Standards & Interfaces.