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WIRELESS TECHNOLOGY AND ITS APPLICATION IN PNEUMATIC SYSTEM

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ABSTRACT

It is well known that wireless technology has been widely used in communication. In recent years it has been ubiquitous in nearly every aspect of industry, medicine, environment and meteorology. The wireless technology will revolutionize these fields. This paper presents a wireless pneumatic system which consists of a controlled wireless pneumatic proportional valve based on SMC VEF-312 and a wireless transducer of flowmeter for monitoring the flowrate. The results about the application of wireless technology in pneumatic system were discussed.

KEY WORDS

wireless technology, pneumatic system

INTRODUCTION

As all known wireless technology has quickly development in past decades. Wireless communications is capable of reaching every location on the face of the earth. In resent years wireless technology has been ubiquitous in every aspect of industry, such as medical equipment, environment and meteorology, manufacturing and process control system. Although traditional hard-wired technologies continue to rein these fields, applications of wireless technologies will revolutionize these fields. For instance, nowadays manufacture factory usually has many sensors and actuators, which require cable and wire installation throughout a plant floor in order to connect between the sensors and the control house for both power supply and communications. Cables are easy to damage and need to be removed and re-run. Therefore, the cost related to maintenance is usually prohibitive. The advent of wireless technology provides the solution to these problems. Using wireless technology, it can greatly reduce sensor installation cost, amount of cable, labor hours, faster installation and setup time and etc.

In this paper a controlled wireless pneumatic system is presented. The system consists of a controlled wireless pneumatic proportional valve based on SMC VEF-312 and a wireless transducer of flowmeter MFDN-15 for monitoring the flowrate.

1、Hardware system configuration

The hardware system configuration is shown in Figure 1. It consists of server PC, base station, flowmeter, electro-magnetic valve, client station 1 and 2.Server PC uses Windows XP as operating system.

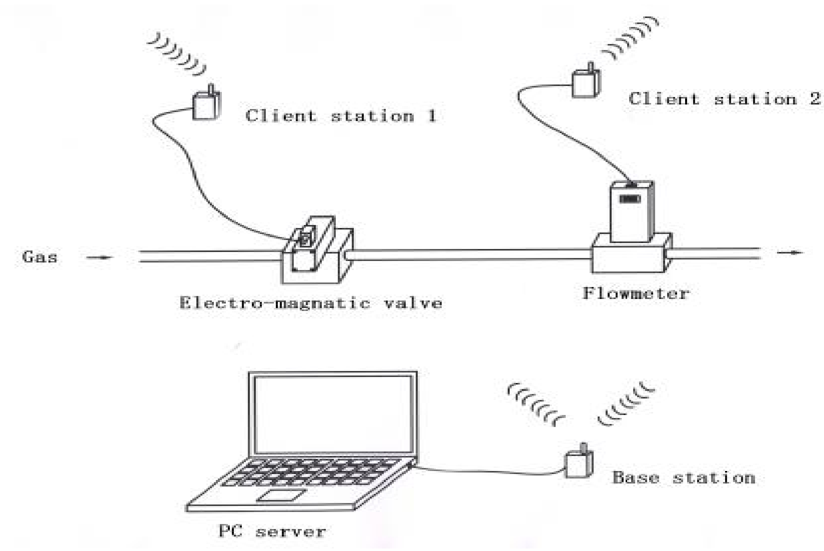

Figure 1: The hardware system configuration

1.1 Mass flowrate measurement

A mass flowmeter was built using the thermistor sensor, once the setpoint is reached the heat balance state that when the supplied energy is equal to the heat dissipation, the temperature of sensor is to keep constant. The supplied energy, which is a function of the fluid speed or flowrate, is detected using a special electronic circuit. The flowmeter is a MFDN-15 gas mass flowmeter designed by SMC–Tsinghua University Pneumatic Technology Center. It contains an amplification circuit, an analogy-to-digital converter and a microprocessor. The power supply voltage is in 12V. The range of measurement is 0-100L/min; the voltage output is 1-5 volts. The flowmeter was calibrated using a commercial flowmeter with high accuracy. The calibration shows that the flowmeter response is linear and repeatable shown in Fig.2.

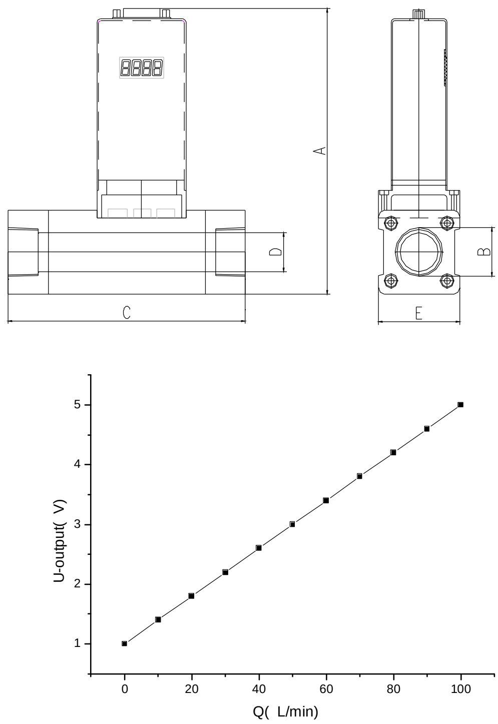

Figure 2 MFDN-15 gas mass flowmeter and its characteristic of output

1.2 Electro-magnetic proportional valve
Electro-magnetic proportional valve is VEF-312 made by SMC Corporation It can adjust the gas flow of pneumatic air source system. The external power supply DC voltage is 24 volts. The range of control voltage is 0-5 volts. The opening of the valve is in variation with the operation voltage. The characteristics of proportional valve at the pressure of entrance 0.2 MPa is shown in Fig. 3.

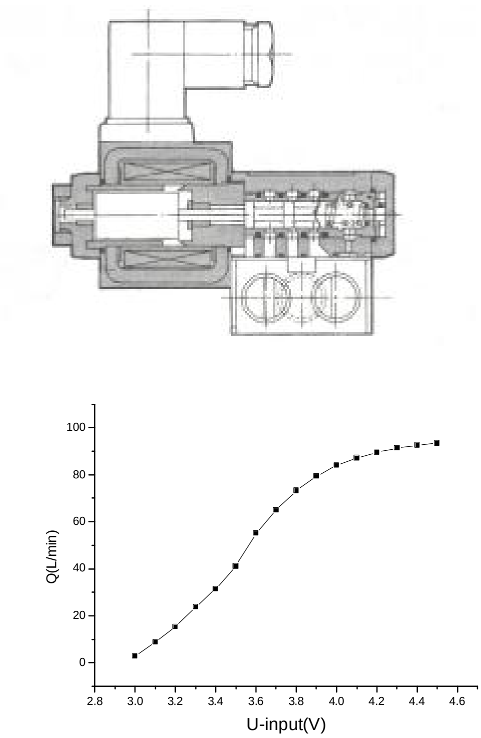

Figure 3 Flowrate output vs input voltage of VEF-312 valve

1.3 Transmitter and Receiver board

1.3.1 The base station module
Figure 4 is a block diagram of the base station module. The main component of the base station is a CC1000 wireless module, which has an RF transmitter, receiver and a base band modem. A microcontroller 43 is used to serve as central control unit, which sends the control and handshaking information to CC1000. RS-232 serial interface is used to communicate with the server PC.

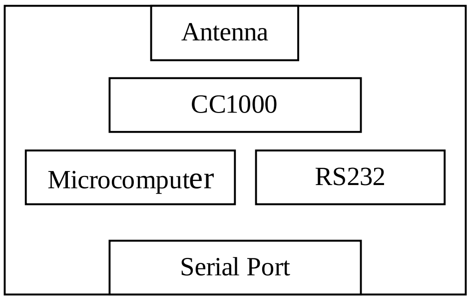

Figure 4 Base station

1.3.2 Client station 1
Figure 5 illustrates the block diagram of the client station, which consists of microprocessor (as an MCU), analog to digital converter module, CC1000 module, and a power supply unit. MCU is responsible for the following tasks 1) control ADC for sampling 2) configure CC1000 by setting MAC (Measurement And Control) address and initializing the communication routines. 3) Encode the ADC output data using forward error correction (FEC) code and send the frames to CC1000 4) Process the acknowledgement information and the data request from CC1000. MAX187 from MAXIM is used for data sampling and analog to digital conversion.

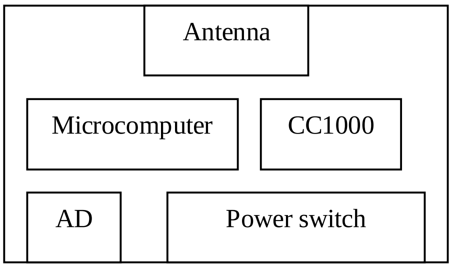

Figure 5 Client station 1

1.3.3 Client station 2
The block diagram of client station 2 is shown in Figure 6. The only difference between client station 2 and client station 1 is that the analog interface is changed to digital to analog converter (DAC). MAX5302 from MAXIM is used for this purpose.

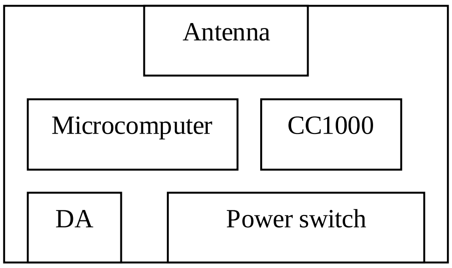

Figure.6 Client station 2

Frequency range	433.1-434.6 MHz
Number of Channels	11
Modulation scheme	FSK
Duplex mode	half duplex
Maximum transmit power	+10dBm
Receiver sensitivity	-105dBm
ADC resolution	12bits
Coverage	100m (Line of Sight)
Physical layer data rate	9.6kbps
Temperature range	-25-70C
Power supply voltage	12V

Table 1 System specifications

1.4 System specifications

The wireless system described in this paper transmits over unlicensed ISM band. The antenna can be placed externally or internally. The detailed specifications are listed in Table 1.

2 System software

Figure 7 shows the user interface of software and control program of base station module.

It was written using C ++ Builder 6.0. The following features are offered by the program: the initialization of CC1000 module，the program for monitoring serial port，the processing receiving data, display the dynamic results and sending control voltage value. Figure 8 shows a flow chart of initializing control program. The program of client station was written using the C51 programming language for a microprocessor.

It contains a control program for sampling data of A/D and D/A converters, setting and control for serial port of AT89C51 which is connected with CC1000 module. Sending data of frame channel coding and analyzing command words received.

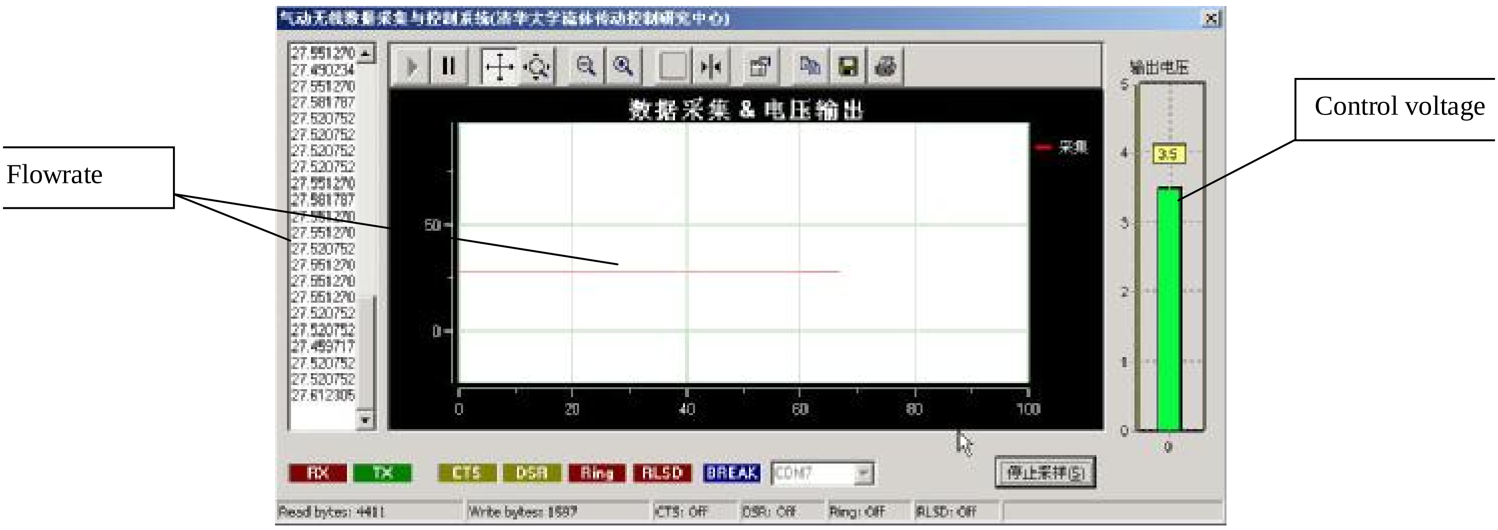

Figure 7. The user interface of software

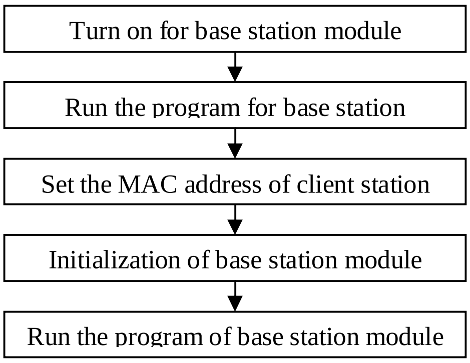

Figure 8. The flow chart of initializing control program for base station module

3 Wireless transceiver design and error protection mechanism

Fading and interference are two major factors affecting the performance and reliability of wireless communication. Our system adopts classical protection mechanism used in modern wireless access system, such as cellular and Wi-Fi, to make the communication more reliable. These mechanisms include channel coding, CRC check and ARQ.

3.1 Channel coding

Channel coding has been widely used in wireless communication systems to combat channel fading and interference. The theory is that by adding redundant information to the original source bits, the receiver can recover the source bits even if soft of the received bits are wrong. This method can lower the bit error rate for the whole system.

After careful calculation and selection of the codes, we finally chose (8, 5) code. This particular code increases the Hamming distance to facilitate the error correction at the receiver side.

3.2 CRC check

CRC check is a method to check the integrity of the received packets. The transmitter adds a small segment of the checksum based on the source packets. This CRC segment along with the original source bits are transmitted to the receiver. The receiver uses the same equation to calculate the checksum. By comparing the local checksum with the received checksum, the receiver can know whether the received packet is correct or not.

CRC stands for cyclical redundancy check, which offers outstanding error detection performance. By combining the channel coding and CRC check, the error packets can be detected and recovered effectively, which reduces the error rate at the server. The flowchart of this process can be seen in figure 8.

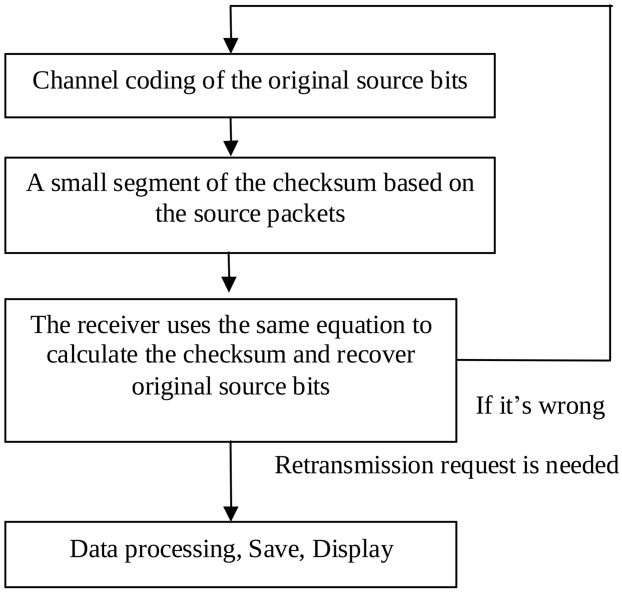

Figure 9. Flow chart of CRC check

3.3 ARQ (Automatic Retransmission request)

When the interference is severe, the error rate will go up significantly and the channel coding can not correct all the error bits. CRC check will fail in this case, which indicates the packet is not received correctly. A retransmission request for the current packet is generated and the received error packet is discarded. This retransmission mechanism can prevent the error packets from propagating to the server, which guarantees the reliability of the wireless communication.

4 Conclusions

We have successfully completed the design and development of a wireless measurement and control pneumatic system. It is easy to monitor and control a manufacturing process.

Right now this system is provided for showing experiment of laboratory. CC1000 module has 11 channels for client station. Therefore the system can be developed into a wireless network in duplex mode to realize multipoint measurements and control function.

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