Long-Distance Data Communication Based on Wireless Communication Technology

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Abstract—**Aimed at control automation and unmanned manage systems which are located in open country, field and orchard have difficult in putting wire, a wireless data communication system was designed. Wireless radio frequency technology was used as transmission interface in this system, STC89C52 micro control unit(MCU) was used as major controller and logic processer, wireless radio frequency chip CC1101 was used as data transfer, system was wired with computer by Universal Asynchronous Receiver/Transmitter. When master's data was received by MCU, it would control CC1101 to send data, CC1101 would finish handling frame, modulating signal and sending data automatically. Signal demodulation was finished by receiver when it detected signal, data was sent to computer by MCU, and then wireless data transit was achieved. Through tests, the system's communication distance could achieve 131m with the low power module CC1101 and 633m with the high power module CC1101 in opened environment. In the occluded environment, the distance would be decreased to 366m with the high power module CC1101. The system's communication distance also could achieve 289m at the orchard environment with the middle power module CC1101. At the frame lost rate of two points which apart 100m was 17.8%.**

Keywords-Wireless communication; CC1101; Data transfer

I. INTRODUCTION

Not only automatic measurements and control but also unmanned managements are important ways for the development of modern agriculture. In order to achieve the automatic and unmanned control, data real-timed transmission has to be set as an important part. The information and data, which were obtained by sensors, are emitted into host computer through the transmission system [1]. The control information is emitted back after the analysis of system. Then the corresponding conditions can be changed and the objective of adjusting production also can be achieved [2].

The transmission medium of transmission system is composed of wired and wireless. The position of wired transmission is fixed and couldn't be changed with terrain flexibly. If the positions of sensor are limited, every node will need a transmission system. It is really inconvenient to construct a senor network [3]. These cables are difficult to be laid and easy to be broken. Besides that, the maintenance of it is inconvenience and the fault is also very difficult to be found out [4].

Most of the agricultural data transmission systems are based on the wireless communication technology which can be applied in home and abroad. The using technology of wireless communication is composed of Bluetooth, radio frequency, infrared, Wi-Fi and so on. The radio frequency technology is widely used with its advantages of low power loss, long communication distance and good communication performance [5]. The number and position of sensor nodes are arbitrary by the technology of wireless communication. The influence of sensors' drifting also can be ignored. But this kind of technology also needs to be improved in the face of system power loss, communication stability and the connection interface with computer. This design's wireless communication platform is set by the ultra-low power consumption radio frequency chip CC1101. Connect it with host computer through the chip of PL2303 [6]. The data transmission system which can be used in orchard is realized. Thus not only the automatic measurement and control but also the unmanned management of orchard all can be achieved.

II. THE DESIGN OF FUNCTIONAL CIRCUIT

As shown in Fig. 1, the hardware of this design is composed by power module, MCU module, A/D module and serial port module [7]. The Power module provides 5V and 3.3V DC voltage for the whole system. The MCU module is the logic control part of the whole system. The A/D module transformed the signals which are collected and exported by sensors. The serial port module provides the connection inference for program writing and it is also the wired interface for the communication between host computer and system.

The radio module is the wireless interface. It can be used to achieve the functions of signal modulation, data emitting, signal demodulation and data receiving [8].
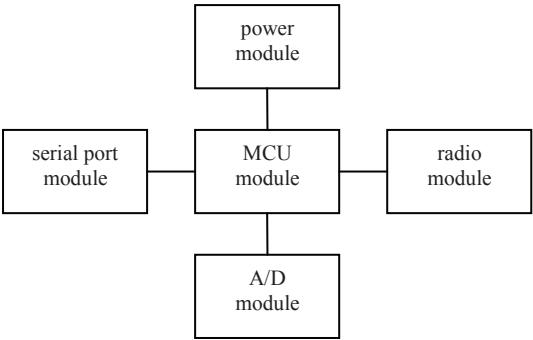

Figure1. Hardware design of system

III. THE SOFTWARE DESIGN OF SYSTEM

As shown in Fig. 2, the internal structure of CC1101 is clearly. The modularization idea is used in the design of system software. The program is written with C language. The host computer program is composed by radio module power-on reset, interface initialization, serial port initialization, radio module initialization, data emitting and data receiving. The radio module power-on reset interface initialization and serial port initialization are preferred when the program coming into the main program. After initialization, the program begins to wait for the data which is emitted by host computer. When receiving the data, which is coming from serial port, orders and data are emitted to CC1101 through SPI. At the same time, the control interface of power amplification can be started. CC1101 is going to complete some functions by the relevant setting automatically after receiving the launch commands [9]. As shown in Fig. 3, these functions are composed by increasing preamble frames, CRC calibration, the modulation and demodulation of signal, and so on.
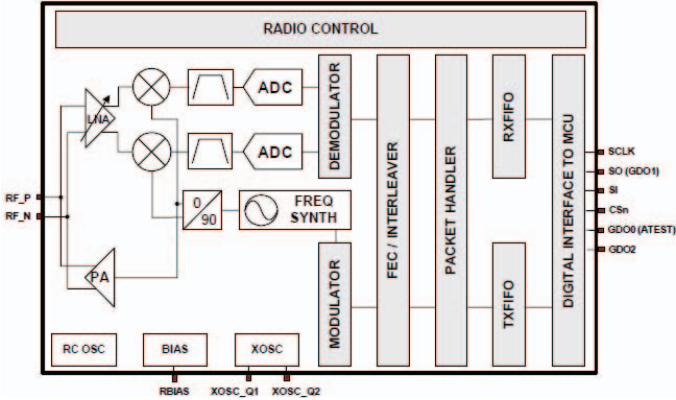

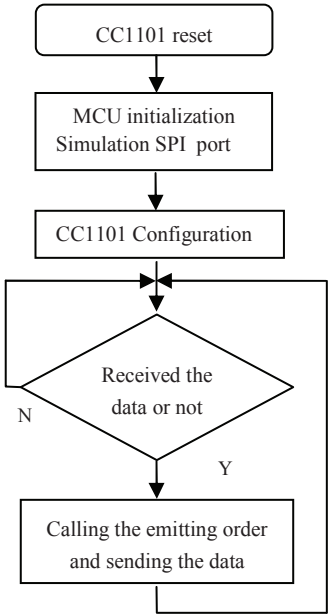
Figure 2．The internal structure of CC1101

Figure 3. Program process of host computer

The CC1101 reset, port initialization and writing configuration of slave computer's program are uniformed with the host computer [10]. As shown in Fig. 4. The slave computer is always at the state of waiting to receive after the configuration of CC1101. When receiving the preamble frames which were emitted by host computer, receiving data packets, demodulating data and CRC calibration will be completed by CC1101 [11]. The data is transformed to MCU by SPI after CRC calibration and it will display in host computer through the serial port after received by MCU.
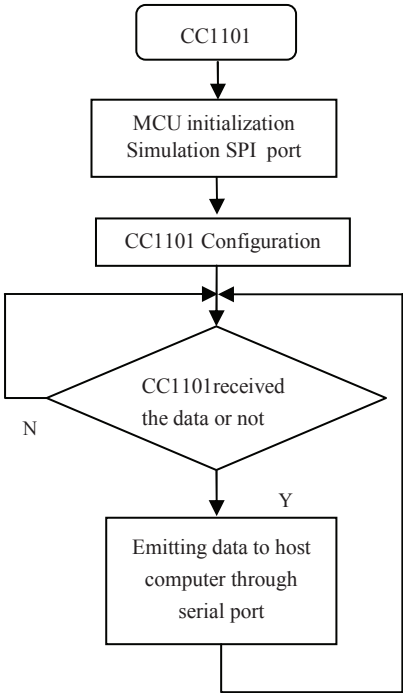

Figure 4. Program process of sliver computer

IV. PERFORMANCE TEST

A. *Communication distance test of CC1101 low power module in opened environment.*

The test condition is composed by CC1101 low power module, universal plate welding system, signal emission power +10dBm. And the location of this test is the Huashan playground in South China Agricultural University. Then putting the furthest and most stability distance of CC1101 low power radio module as the objective. One hold the system and stand at the start point of track on playground. Signals can be emitted in every second. The other person hold the receiving system with eight led displays walked from the start point to the end point with normal speed. Then the data and receiving interval could be gotten during this period. The test result could be displayed in TABLE I.

TABLE I. COMMUNICATION DISTANT OF LOW POWER MODULE IN OPEN ENVIRONMENT

	1	2	3	4	5
Distance	133m	136m	130m	127m	132m

As shown in TABLE I, the normal data and receiving interval could be gotten in the limited distance of 103m. Repeat five times, the average distance 131.6m could be obtained. Through rounding, the furthest and most stability distance is 131m of CC1101 low power radio module.

B. *Communication distance test of CC1101 high power module in opened environment.*

The test condition is composed by CC1101 high power module, PCB welding system, signal emission power +33dBm. A PCB welding system of the radio communication was set at the door way of 601 Room in engineering college. Signal could be emitted in every second. The other person who was holding the receiving system climbed to the top of library. The straight-line distance between the two points was 940m. Started the systems and observed the data and receiving interval weather right or not. Then moved the position of these systems and decreased the distance between them. The test result could be displayed in TABLE II.

TABLE II. COMMUNICATION DISTANCE OF CC1101 HIGH POWER MODULE IN OPEN ENVIRONMENT

	1	2	3	4	5
Distance	630m	635m	628m	639m	636m

As shown in TABLE II, the normal data and receiving interval could be gotten in the limited distance of 630m. Repeat five times, the average distance 633.6m could be obtained. Through rounding, the furthest and most stability distance is 633m of CC1101 high power radio module.

C. *Communication distance test of CC1101 high power module in occluded environment.*

The test condition is composed by CC1101 high power module, PCB welding system, signal emission power +33dBm. A PCB welding system of the radio communication was set at the door way of 601 Room in engineering college. Signal could be emitted in every second. The other person who was holding the receiving system walked to the third teaching building with normal speed. There are lots of trees between the two positions. Observed the data and receiving interval during the period. When the data or receiving interval was abnormal, stopped and tested several times. If it was even abnormal or couldn't be received anymore, the conclusion of failed receiving could be obtained. And then the distance could be recorded. The test result could be displayed in TABLE III.

TABLE III. COMMUNICATION DISTANCE OF CC1101 HIGH POWER MODULE IN OCCLUDED ENVIRONMENT

	1	2	3	4	5
Distance	368m	365m	369m	371m	361m

Compared to the trees occluded station, the opened environment could bring the butter signal receiving at the same communication distance. As shown in TABLE III, the normal data and receiving interval could be gotten in the limited distance of 366.8m. Repeat five times, the average distance 366m could be gotten.

D. *Communication distance test of CC1101 middle power module in orchard.*

The test condition is composed by CC1101 middle power module, PCB welding system, signal emission power +20dBm. And the location of this test is the subtropical orchard in South China Agricultural University. There are so many leaves in the practical environment of the orchard. The height of trees is mostly between 2m and 3m. Comparing to nothing leaf under trunks, there are lots of leaves between crown and the position which is 1m away from ground. The spacing between trees is 3m to 4m. The overall layout of orchard is seemed as tidy as a grid, and it also very tidy. There are many clearances between trees without occlusion. Then putting the furthest and most stability distance of CC1101 middle power radio module as the objective in the practical environment of orchard. The test result could be displayed in TABLE IV

TABLE IV. COMMUNICATION DISTANT IN ORCHARD

	1	2	3	4	5
Distance	286m	293m	291m	280m	297m

As shown in TABLE IV, the electromagnetic wave attention was very hard. The stable communication distance was reduced by it. The average communication distance is 289.4m.We can get 289m through rounding. So the stable communication distance is 289m in orchard environment of the system.

E. Test of dropping packet rate

The test condition is composed by CC1101 middle power module, PCB welding system, signal emission power +20dB.The communication distance were 100m, 150m and 200m. The host computer emit data to the host through serial port with the rate of 1bit every 2s. The capacity of data is 100bit. After receiving data, slave computer cent it to the host computer through serial port. And the location of this test is the subtropical orchard in South China Agriculture University. Then put the communication state of CC1101 middle power module in the appointed communication distance with the practical environment of orchard as the objective. The test result could be displayed in TABLE V.

TABLE V. TEST OF FRAME LOST RATE

dropping packet rate（%）				
100m	18	20	17	16	18
150m	25	26	25	28	23
200m	31	31	27	29	30

As shown in TABLE V, the test of dropping packet rate was taken in three kinds of distance with the practical environment of orchard. The average dropping packet rates are 17.8%, 25.4% and 29.6% with the distance of 100m, 150m and 200m. So the conclusion could be gotten that the dropping packet rate is increased and stability is decreased with the increase of distance.

V.   CONCLUSION AND DISCUSSION

This paper is researched to the specific applications of wireless communication technology in agricultural production. The transceiver principle, controlling principle and the whole design of system are mainly introduced in it. The core of this system is wireless transceiver chip CC1101. Host computer receive data to host through serial port, or treat and emit data through CC1101 as soon as the data has been collected by A/D. Slave computer receive the data and emit to another host computer through serial port. So the wireless transmission of data can be achieved. It can relive the burden of routing and the dependence to environment also can be reduced.

Through the testing, the communication distance of CC1101 module can reach to 289m in the terrible occlusion environment. This distance can meet the design requirement of system. The communication performance of this system is superior. It can be used in the wireless communication of agricultural production and industrial field. As wireless air interface, it solves so many problems such as the inconvenience of field routing, high cost of maintenance and so on.

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