Research on Measurement and Control System of Common Parameters of Agricultural Equipment Based on Wireless Transmission

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ABSTRACT

To resolve the limited transmission and complicated layout, the common parameter measurement and control system of agricultural equipment use virtual instrument technology and embedded technology. The research results show that the wireless transmission data of the system is accurate and reliable. The linearity errors of acquisition divestiture (AD) and frequency counting (FI) channel measurements are only 0.38% and 0.006%, respectively, and the resolution is 0.01V and 1 Hz. This performance evaluation fully meets equipment detection in agricultural use. The system is integrated with various wireless transmission platforms, intelligent agricultural equipment, and computer wireless reception and processing. These parameters can significantly improve the automation level and quality of agricultural equipment.

KEYWORDS

Data Collection, Equipment Information, Retrieval Device, Wireless Transmission

1. INTRODUCTION

The best embodiment of the joint development of measurement and control technology and computer technology is the virtual instrument technology. An important symbol of the development of instruments has begun to be applied to the automatic control and performance testing of agricultural equipment(Wan et al., 2020). There are also certain differences in the development of detection systems as different detection tasks that use different agricultural equipment are different. The number of pulses, frequency signals, voltage virtual signals, and character display signals represents the input system received from each sensor from the different signals (Rao et al., 2020). The analysis

DOI: 10.4018/IJAEIS.20210401.oa6

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is done to choose different signals that meet the performance of their respective systems to receive different sensor signals from different agricultural equipment. To avoid the need to research and develop multiple detection systems to detect multiple agricultural equipment's, and make full use of the system is discussed in Jiang et al., 2020. Traditional agricultural equipment testing instruments have shortcomings such as limited transmission, difficulty in real-time monitoring, and cumbersome wiring. Agricultural machinery for field operations of agricultural equipment, moving and detecting while moving, will generate high-frequency vibration and huge noise. In this case, the detection effect is not good, and it cannot be compared with indoor work and professional detection. Most of the ordinary detection equipment cannot finish the work. It is necessary to develop equipment specially used for performance testing of agricultural equipment to improve the reliability of testing equipment. Therefore, the best way to solve these practical engineering problems is to develop a portable wireless transmission measurement and control system.

This design solves the problems of single instrument function, poor work reliability, and inability to process data.

- Virtual instrument technology
- Embedded technology

should be used to design multiple wireless transmission methods. To achieve intelligent transmission equipment, common data collection, computer wireless reception, and processing, agricultural equipment is designed in this paper. The article is thus organized in the following order. A literature review of various techniques and procedures is detailed in Section 2. Section 3 discusses the different methods and hardware designs to analyze the system. Section 4 discusses the experimental results of the present structure. Finally, the manuscript is concluded in Section 4.

2. LITERATURE REVIEW

A compensation topology parameter of optimization design based on an anti-bias performance optimization scheme is proposed in Sani M. I. et al., 2016. In this scheme, two freely adjustable variables K1 and K2 are used to optimize the compensation network parameters of the wireless power transmission system. The system can automatically adjust the transmitting current of the primary coil and keep the output power relatively stable. A 120W experimental prototypes were built when the lateral offset percentage of the coil is less than 35%. The maximum fluctuation rate of the system output power is kept within 10%, and the efficiency of the whole machine is kept above 81% (Wang et al., 2019). Gao, Q. et al. designed an automatic roll position adjustment system that can predict roll parameters. The system adopts automatic control technology, sensor technology, and industrial communication technology, and takes a high-performance PLC controller as the control core. PLC (S7-1500) controls the three-phase asynchronous motor to drive the gear connected with reducer and coupling. The drive roll connects with the upper and lower horizontal shafts to move. PCA-BP algorithm is used to train the roll parameter prediction model to predict the roll parameters of the given square pipe model(Wang et al., 2019). The system can predict the corresponding roll parameters according to the specifications of the new type of square tube and adjust automatically. The system not only improves the adjustment speed and precision but also avoids the waste of manpower, thus greatly improving the production efficiency of enterprises(De Wagter et al., 2018). Yan, H. et al proposed a nonlinear adaptive inverse step control method. PMSM1 with 5th and 7th harmonics and PMSM2 without 5th and 7th harmonics are derived to reduce the torque pulse generated by 5th and 7th harmonics. The simulation comparison with the PI controller shows that the adaptive inverse step control scheme can provide conditions for decoupling control of two serial motors, inhibit parameter change and load disturbance, and have better responsiveness, robustness, and tracking performance.

Displaying data in a coherent format is key for final users to understand what is happening in the field. The most common way to display agricultural data has been in the format of maps, as mapping is useful to define spatial trends and homogeneous zones. However, displaying agronomical information in beautiful maps should not be the goal of map generation. Maps need to be useful for making decisions, they need to be a help to answer a question, providing an interpretation of spatial information (Basnet B. and Bang J.2018).The goal of building maps is obtaining a few management zones with the parameters of interest so that a treatment can be efficiently applied. To get plausible management zones, kriging is one of the most used interpolation techniques to delimit areas of manageable sizes (Adamchuk, V.I. et al., .2004.)Taking into account the considerable amount of data that Smart Farming generates, there are many software applications to cope with interpolation, in general, or kriging in particular (Oliver, M.; Webster, R..2014). Also, when building a map, a coordinate system needs to be supplied along with the map. One ideal alternative for agricultural maps is brought by the Local Tangent Plane (LTP) coordinate system, which features Euclidean geometry, allows user-set origins, and employs the intuitive coordinate frame east-north. Regarding the coding and display of data in the maps, grids allow the systematic quantization of the LTP coordinate system to manage crop production information more efficiently, facilitating the exchange of information among successive seasons and the comparison of multiple parameters on the same field (Spencer, D.B., 2005.). A practical example of grid-based maps using LTP coordinates is shown in Figure 3. Taking into account the key role of positioning systems, a map-based approach is the method in which a Global Positioning System (GPS)or any other Global Navigation Satellite System (GNSS)—receiver and a data logger (e.g., an onboard computer) are used to record the position of a particular measurement (georeferenced data), so several maps can be generated and processed along with other layers of spatially variable information (Adamchuk, V.I.;et.al .2014). In general, GNSS receivers are the universal position devices used to build maps; however, in some cases, for example in greenhouses or dense fields of tall trees, GNSS is not the best option to use due to the difficulty of getting signals with reliable accuracy; so, in some cases, alternative solutions such as machine vision must be implemented (Cossell, S.; 2016)

3. RESEARCH METHODOLOGY

3.1 General Design Parameters of The System

The wireless data transmission technologies selected in this article mainly include Wireless Fidelity (Wi-Fi), General Packet Radio Service (GPRS), Global System for Mobile Communications (GSM), ZigBee, and Bluetooth, etc. According to the comparative analysis of their respective usage, these several technologies have their advantages and disadvantages. The specific technical comparison analysis is shown in the following table.It can be seen from the above table that GPRS is mainly used for large data volume and long-distance transmission. Its application occasions the upper and lower computers are far away, transmission cannot be realized by ZigBee mode. The parameter detection in the cell phone signal coverage area can use GPRS. If the detection range is relatively large, such as testing throughout China or calculating the workload of searching a larger area, then GPRS can be used at this time (Tripathi and De, 2018). However, GPRS also has conditions for use. Its host computer must have a fixed port to connect to the Internet and be positioned at that point. The location cannot be changed at will; this method will charge a corresponding fee based on the consumed traffic, so the use cost is higher than the ZigBee method.

The characteristic of GSM receiving and sending is that it can be applied in a relatively long distance. Although GSM has the same transmission distance as GPRS, the transmission speed is only 1110 of GPRS(Zheng et al., 2019). The advantage is that there is no need for a fixed port number and Internet Protocol (IP) address. The working place of the host computer can be moved at any time, and there is no need to connect to the Internet, and data can be sent directly to the mobile phone. GSM does not need to be tested anytime and anywhere. Unlike ZigBee and GPRS, which are subject to different venues, such as agricultural products service venues, the amount of information retrieved is

Table 1. Comparison of the characteristics of wireless transmission modes

Parameter	Wireless Transmission Method			
	GPRS/GSM	Wi-Fi	Bluetooth	ZigBee
Application field	WAN, voice, and data	Web, mail, and video	Replace peripheral cables	Monitoring and control
System resource	>16MB	>1MB	>250Kb	4~60Kb
Battery life	1~7	0.5~5	1~7	100~1000
Network node	1	32	8	65535
Data transfer rate (kb/s)	64~128	11000	720	20~250
Transmission range (m)	1000	1~100	1~10	1~100
Advantage	Large coverage and high data quality	Fast and flexible	Low cost and easy to use	High reliability, low power consumption, low cost
Disadvantage	Large delay and high power consumption	High power consumption and short distance	Close distance, high power consumption	Closer

small, and what is the situation at work. But it will cost according to the number of SMS messages sent and received as compared to various methods(Wang et al., 2019).

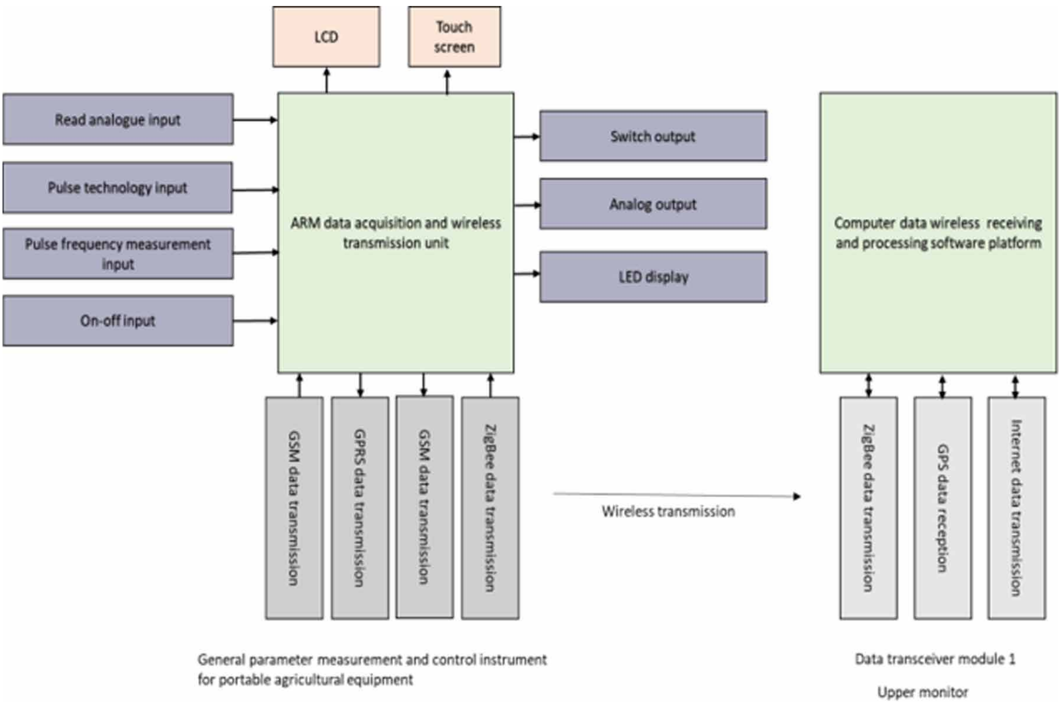
The ZigBee method is mainly used for short-distance measurement and control. It can meet the range of 100m. The distance between the machine, the equipment, and the amount of information retrieved is large, has a short distance, and requires real-time. It is used when reporting location and time information. It can detect equipment on-site and receive and send a larger range. For example, this method can be used to realize the wireless transmission of data to detect the upper computer located at the head of the field to receive the parameters of agricultural equipment working in the field (Zhang and Chen, 2018).

The transmission method should first consider using ZigBee during the actual use of the measurement and control system. If the task cannot be completed at this time, then GPRS can be considered. If the problem is still not resolved, only GSM short message service (SMS) can be used. Due to the complex retrieval of information by the equipment and the relatively large area of work, sending data cannot be completed by one method alone (Smith et al., 2019). Therefore, to complete the task, the above three methods can only be used together, and the three methods are combined to improve the stability of the wireless transmission. Solve the problem that can't be done using a certain method alone (Merk et al., 2015). Figure 1 shows the design of the wireless transmission system design and the common parameter measurement and control instrument for portable agricultural equipment. The commonality and usability of agricultural equipment measurement and control invented a portable measurement and control instrument, which has multiple measurement and control channels.

The special machine that can detect various related data, such as equipment speed, acceleration and displacement, engine speed, oil temperature, vibration frequency, environmental temperature and humidity, noise, wind force when the equipment is used, the size, location, current condition of the equipment, the tensile and compressive stress and bending torque of the equipment, the linear displacement, angular displacement, flow, fuel consumption, and other counting signals; and can be used Control virtual digital switch quantity.

The upper computer data analysis and processing system and two types of data transceiver modules can form a wireless transmission system. Different sending modes will cause different processing

Figure 1. Block diagram of the measurement and control system



methods of module 1, and then corresponding to the relative module, send and receive data to module 2; module 2 is responsible for sending and receiving the data sent by module 1, and then pass it to the host computer (Ravi M. et al., 2007). The development of virtual instrument technology gave birth to a platform for computer data receiving and processing upper computer data analysis and processing software, which can display the analysis and storage results in a time when receiving data.

3.2 System Hardware Design

Using Samsung's processor is the core of this system, which can manage memory units. It is mainly used in handheld devices, high-cost performance, low consumption, and small functions. S3C 2410A has the following functions in the portable measurement and control instrument (Spencer, 2005):

- Eight-channel 10-bit ADC: Six channels are used for analog channels and two channels are used for the touch screen input interface.
- Twenty-four channels of external interrupt sources, five 16-bit timers: the counter of external pulse signals consists of four interrupt sources and a timer.
- One hundred and seventeen universal input/output ports: 16 ports can be selected arbitrarily, which can realize input and output of eight-way switch status.
- One internal LCD controller: different LCDs can display information on different channels.

To develop more functions, the following hardware devices are combined:

- Two programmable counter timers 8253 can receive six pulse signals at the same time.
- GPS can locate and display time.
- One-half GPRSSGSM module can directly send and receive data wirelessly.

- Two ZigBee modules can realize data processing in a short distance.

3.3 System Software Design

The software design of the portable measurement and control instrument and the host computer is the main part of the software design. The software design of the measurement and control instrument can be divided into six subroutines, namely human-computer interaction interface, pulse counting, measuring frequency, GPS positioning, digital IIO, AD acquisition (Mallampati et al., 2018). The human-computer interaction interface is composed of three interfaces, which are the main interface, the interface for setting system parameters, and the interface for testing system data (Teimouri, N. et al.,.2018) When setting the system parameters, you first need to determine the number of collection points, channels and frequencies, then calculate the number of pulses and determine the pulse frequency, and finally choose a reasonable switch channel and wireless transmission mode. Figure 2 shows the entire process of software design for the measurement and control instrument.

The virtual instrument technology will be used when the computer wirelessly transmits data and when the computer processes the software platform, the two corresponding programs compiled by it both use Lab Windows CVI as the development medium. When the host computer performs wireless transmission, the way of receiving data can be one or more of GSM, ZigBee, GPRS, and the design process can be seen from the figure below. The three wireless detection subsystems of ZigBee, GPRS, and GSM are the main components of the upper computer software (Pimentel D., et al., 2004)

4. EXPERIMENTAL RESULTS AND ANALYSIS

Under the conditions of 47% relative humidity and 20 degrees Celsius of the ambient temperature, the Chinese Academy of Metrology, when the zero point and full-scale correction are both zero, measure AD acquisition 1 channel and frequency count 1 channel, and the results are shown in Table 2. (AD in the table corresponds to AD acquisition, Fl corresponds to frequency counting:

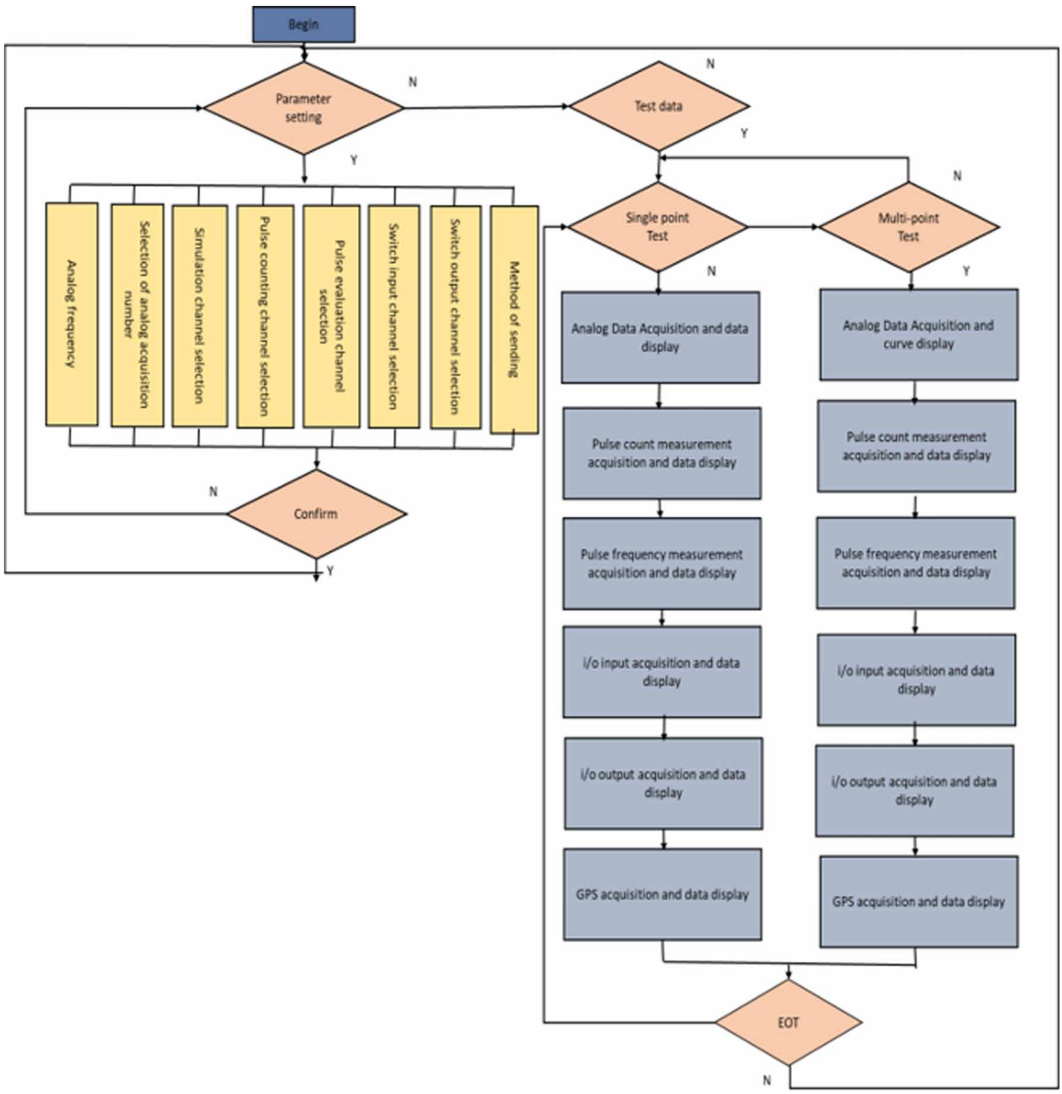
4.1 ZigBee Mode Subsystem

The data transmission method is selected to be sent by frame. Each frame of data sent is composed of the length and type of the data, the channel to obtain the data, the frame header, and the frame end, etc., to ensure that the host computer can easily analyze the data or analyze the data. The byte format sent using ASCII code can effectively increase the data transmission rate (Zsoldos F., et al.. 1987). The size of the ZigBee memory buffer will affect the size of each frame of data. The larger

Table 2. Data collected by 10m distance system for AD 1 and FI 1 channels

Standard value	AD-1	0.000	0.500	1.000	1.500	2.000	3.000	4.000
	FI-1	5	10	100	200	500	1000	5000
Measuring and controlling instrument	AD-1	0000	0478	0967	1466	1964	3002	3978
	FI-1	00005	00009	00099	00198	00499	00998	04999
Standard value	AD-1	5.000	6.000	7.000	8.000	9.000	9.500	
	FI-1	8000	10000	20000	30000	35000		
Measuring and controlling instrument	AD-1	5004	5972	6989	8015	9012	9481	
	FI-1	07999	09999	19999	29999	34998		

Figure 2. Flow chart of software design for measuring and controlling instrument



the memory buffer, the greater the upper limit of the data per frame, but it takes longer to accept. Figure 4 shows the plot of the 10m ZigBee mode subsystem for AD 1 and FI 1 channels. Shown in the table are the data collected by AD and Fl channels. Adding the flag bit data can make the lower computer filter the subroutine, thereby effectively separating the collected frame flag and data, reducing internal conflicts after data transmission

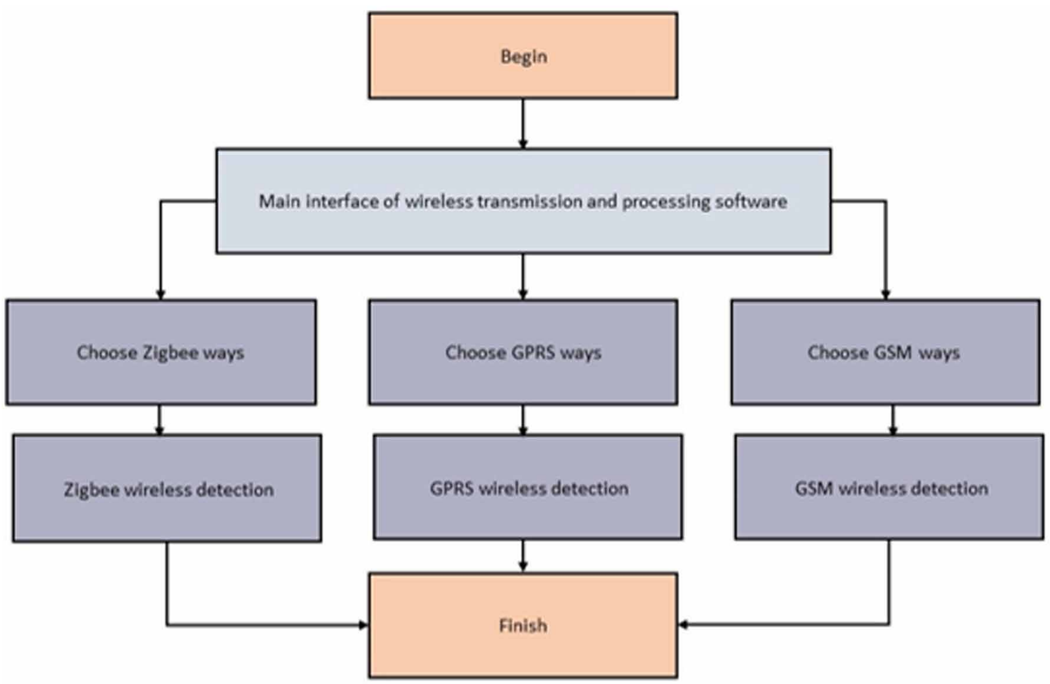
4.2 GPRS Mode Subsystem

The GPRS subsystem is similar to the above-mentioned subsystem software. The concept of the communication protocol is similar. The only and biggest difference is that the upper and lower computers in the GPRS subsystem communicate with the GSM network as the core, and there are more nodes in the network than ZigBee. So the communication speed is slower. To cope with the poor signal of the mobile phone, when the GPRS system uses network transmission, there is a module in the

Table 3. Data collected by the 10m ZigBee mode subsystem for AD 1 and FI 1 channels

ZigBee	AD-1	0.000	0.470	0.970	1.469	1.969	3.007	3.976
	FI-1	00005	00009	00099	00198	00499	00998	04999
	AD-1	5.005	5.984	6.993	8.021	9.030	9.500	
	FI-1	07999	09999	19999	29999	34998		

Figure 3. Flow chart of upper computer software development



lower computer to enhance the signal interruption data buffer function; when the signal temporarily disappears or there is no signal, the GPRS subsystem will not stop working. It will continue to collect data and store it in the memory of the portable measurement and control instrument until the signal appears, and then return to the normal mode of wireless transmission. (Lakhiar, I. A. et al., 2018).

The lower computer can encode the transmitted data twice, mainly relying on the PDU transmission mode (Aqeel R. et al., 2009). This mode can select the transmission data according to its own needs, which enhances the directivity of the data and improves the efficiency of the data transmission (Werheit, P. et al.,2011). There are certain defects in the work of the GPRS subsystem. Figure 5 indicates the plot of the 10m GPRS mode subsystem for AD 1 and FI 1 channels. Errors and other situations require data decoding and secondary encoding, resulting in large communication delays. Therefore, to improve the communication efficiency of the system, the lower computer needs to filter some subroutines when collecting data. The collected data is shown in the table below.

4.3 GSM Mode Subsystem

The functions and communication protocols of the GSM subsystem are similar to those of the other two methods, but it cannot collect data continuously. The GSM subsystem uses two different modes

Figure 4. Plot of 10m ZigBee mode subsystem for AD 1 and FI 1 channels

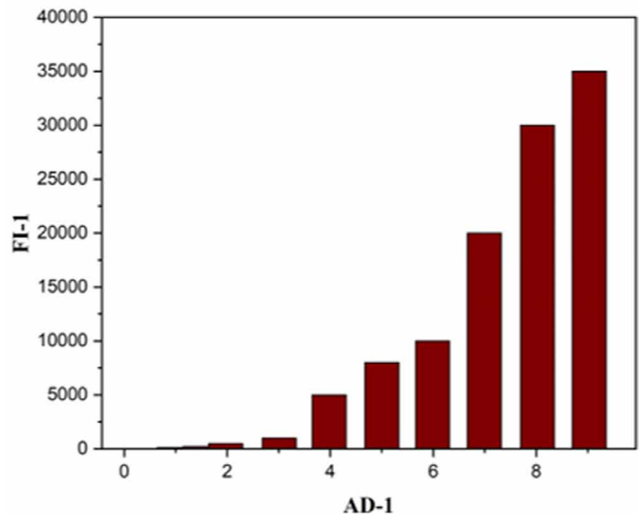
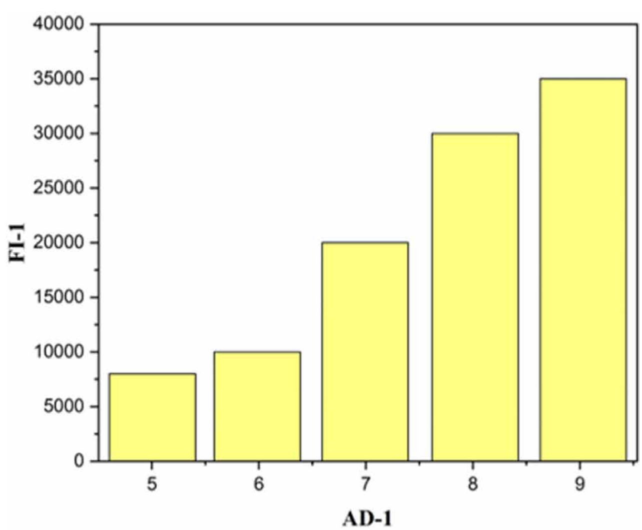


Table 4. Data collected by the 10m GPRS mode subsystem for AD 1 and FI 1 channels

GPRS	AD-1	0.000	0.470	0.970	1.469	1.969	3.007	3.976
	FI-1	00005	00009	00099	00198	00499	00998	04999
	AD-1	5.005	5.984	6.993	8.021	9.030	9.500	
	FI-1	07999	09999	19999	29999	34998		

Figure 5. Plot of the 10m GPRS mode subsystem for AD 1 and FI 1 channels



when sending and receiving data (Basnet B. et al.2018). It is worth noting that the lower computer is in the text mode when sending data. The upper computer needs to initialize all the receiving data modules before complete communication is established (Buer C. S., et al. 1996). Table 5 shows the data collected by the subsystem ten meters away (Kumar D., et al.2019). It can be concluded from the above five tables that the data collected by the three types of subsystems are similar. It can be said that the wireless transmission data is reliable. Figure 6 shows the plot of the 10m GPRS mode subsystem for AD1 and FI 1 channels (Shidujaman, M. et al. 2014).

All errors come from the calculation errors of the upper computer and the lower computer in the measurement and control instrument that can be ignored (Ruiz-Garcia L., et al 2009; Zhang W., et al., 2004). It can also be seen from Table 5 that the AD and Fl channels are measured accurately. Taking 1 channel as an example, the linear error is only 0.38% and 0.006%, respectively, and the resolution is 0.01V and 1 H.

The performance evaluation is fully achieved with a qualified level of equipment testing when used in agriculture. The following table shows the data collected by the AD1 channel in different distance ranges. To simulate the working environment of agricultural equipment at work and achieve as realistic results as possible. The three modes of subsystems must be arranged in different locations, so the ZigBee and GSM subsystem host computer tests are selected outdoors, and the GPRS subsystem is tested indoors (Zobel R. W. et al.,1999). For computer testing, the distance between the lower computer and the upper computer for several sets of data is different. The lower computer is mainly responsible for collecting and sending data (Sani M. I., et al. 2016).

Cross-province* means that the GPRS mode subsystem can be used for data reception at this time; cross-province** means that only the GSM mode subsystem can be used for data reception at

Table 5. Data collected by the 10m GSM mode subsystem for AD 1 and FI 1 channels

GPRS	AD-1	0.000	0.470	0.970	1.469	1.969	3.007	3.976
	FI-1	00005	00009	00099	00198	00499	00998	04999
	AD-1	5.005	5.984	6.993	8.021	9.030	9.500	
	FI-1	07999	09999	19999	29999	34998		

Figure 6. Plot of the 10m GPRS mode subsystem for AD 1 and FI 1 channels

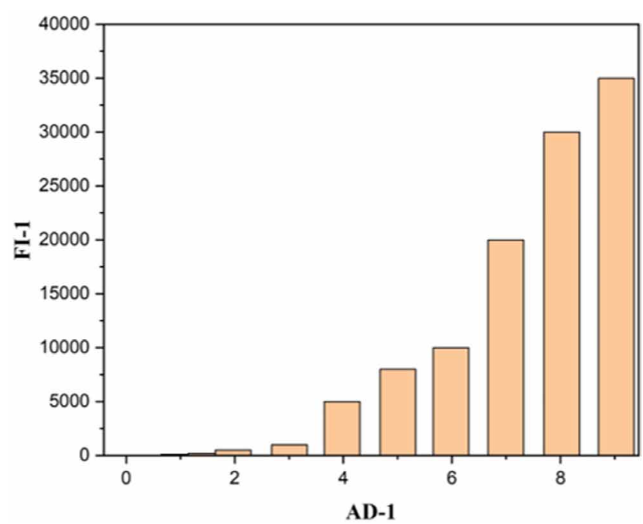


Table 6. Acquisition results of AD 1 Channel parameters at a different distance range

Transmission distance	Measurement and control instrument AD11mV	ZigBee AD1/V	GPRS AD1/V	GSM AD1/V
50m	5.004	5.005	5.005	5.005
100m	4.995	4.996	4.996	4.996
5km	4.987		4.988	4.988
Interprovincial*	4.995		4.996	4.996
Interprovincial**	5.004			5.005

Note: The standard voltage when testing data in the table is all five volts, and each data is collected ten times and the average value is taken to reduce the influence of errors and accidental data;

this time. The above methods cannot be used; the test delay is determined by a specific method (Yue, et al., 2012). Make the upper computer and the lower computer process the data in the same position, which is the delayed test (Zheng, X., et al., 2019).

From the analysis of the data results in the above five tables, we can get:

- Both GSM and GPRS subsystems can complete accurate data transmission within short and long distances. The GSM method will not be restricted by the local network conditions during the experiment. Unlike these two methods, the ZigBee subsystem can only be accurate data transmission within one hundred meters (Bhalaik S, et al. 2020).
- The measurement accuracy of this equipment is accurate. Whether indoors or outdoors, the average error of the measurement data is lower than the allowable error value of the laboratory. The measurement is accurate, so this equipment has a high degree of reliability and can be used for agricultural equipment promotion (Sharma A., et al., 2019).

5. CONCLUSION

This article aims to use wireless transmission methods to complete the measurement and evaluation of agricultural equipment. To reasonably use ZigBee, GPRS, and GSM three modes of subsystems for data transmission, accurately achieve the data collection and analysis of agricultural equipment, and improve the performance of agricultural equipment. Own quality and automation level.

This equipment can accurately retrieve equipment information status, measure equipment parameters, achieve wireless data transmission, and realize the perfect handover between equipment and data, which greatly improves the utilization rate of the detection device and reduces the number of inspection sites. The equipment is mainly used in a piece of farmland, so the probability of interference is minimal, and the transmission is transparent and efficient. This equipment not only solves the various difficulties encountered in the detection of agricultural equipment by traditional means but also strengthens the monitoring and management of agricultural equipment. It also makes agricultural equipment resistant to interference, easy wiring, convenient maintenance, unobstructed transmission, and diverse functions. Tracking the positioning coordinates and usage status of agricultural equipment at any time has significantly improved. Its level of intelligence rationally used contemporary high-tech technologies and made a major contribution to the advancement of agricultural equipment. To welcome the arrival of the 5G era, realize the Internet of everything laying a good foundation is a big step for China to develop together with agriculture in the future and lead the world.

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