STUDY ON MONITORING SYSTEM OF WHEAT SOWING

Weiqiang Fu, Zhijun Meng, Guangwei Wu, Jianjun Dong, Hebo Mei, and Chunjiang Zhao

National Engineering Research Center for Information Technology in Agriculture,
Beijing, 100097, P. R. China;

ABSTRACT

In order to real-time monitoring the sowing status of the multi-channel seeder, a distributed monitoring system is developed. The monitoring module of sowing and the monitoring terminal is designed with microcontroller unit. Based on ISO 11783 protocols, a proprietary communication protocol are formulated to achieve the communication between the monitoring module and the monitoring terminal. The photoelectric sensor used to monitor the sowing tubes outputs analog voltage. When the tubes are jammed or empty, the LCD shows the numbers of the fault tubes accurately. Results show that the system with high sensitivity can improve the quality of wheat sowing effectively.

Keywords: Monitor of sowing, ISO11783, Photoelectric sensor, Analog sensor

INTRODUCTION

Precision sowing is a state-of-art crop planting method, which contributes to reasonable plant distribution in farm, so plant can benefit from bigger nutrition room, better ventilation and sunlight, following mechanized operation, and so on. However, it is because of totally closed sowing process that a missing seed would occur to a large extent when some problems take place, e.g., malfunction of mechanical driving, empty of the seed container and blockage of the seed tube , etc., then loss becomes inevitable. Some statistics indicate that in china average the missing rate is 1%, which means a land as large as Japan’s total agricultural cultivation area.

Food production loss would reduce dramatically if sowing monitor system could be widely applied. Therefore, it is obviously important to monitor seeding quantity in food production and food security.

Photoelectricity sensor and capacitance sensor are main options to monitor wheat drill seed tube. Photoelectricity sensor has many advantages, such as simple circuit, strong anti-electromagnetic capability, easy to install, low price, etc., however, its anti-dust capability is not good. Capacitance sensor, compared with photoelectricity sensor, has a good performance in a condition filled with dust, but while wheat seeds passing by, a capacitance sensor's capacitance variation is in class of pF, and results in a complicated signal modulator circuits and low anti electromagnetic capability.

This paper introduces the CAN-bus-based wheat sowing monitor system. In this system, a new monitoring sensor is designed, and photo electricity sensor outputting analog voltage signal directly is applied to improve anti-dust capability.

DESIGN OF SYSTEM

The system consists of seed tube monitoring sensor, monitor module, monitor terminal, and so on. Monitor module is used to measure rotation rate of seed shaft and drill travel speed. seed tube monitoring sensor is a photoelectricity sensor, and monitor module 1~n determine if drill is on regular sowing procedure by monitoring voltage signal change output by photoelectricity sensor, and send every tube's status to terminal display equipment through CAN bus. Terminal displays sowing status is normal while the drill is operating normally. Once sowing malfunction occurs on certain a row or several rows, terminals display fault type and fault row numbers, simultaneously buzzer alarm to notify driver to fix problems and reduce chance of large-scale missing.

Design of seed tube monitor sensor

Seed tube monitoring sensor is made of four LEDs（D1, D2, D3, D4 ）and four phototransistors（Q1, Q2, Q3, Q4 ）. Infrared light sent by LEDs is modulated into light pulse by seed stream, and photosystems output electric current varying with infrared light intensity. Total output current of every sowing

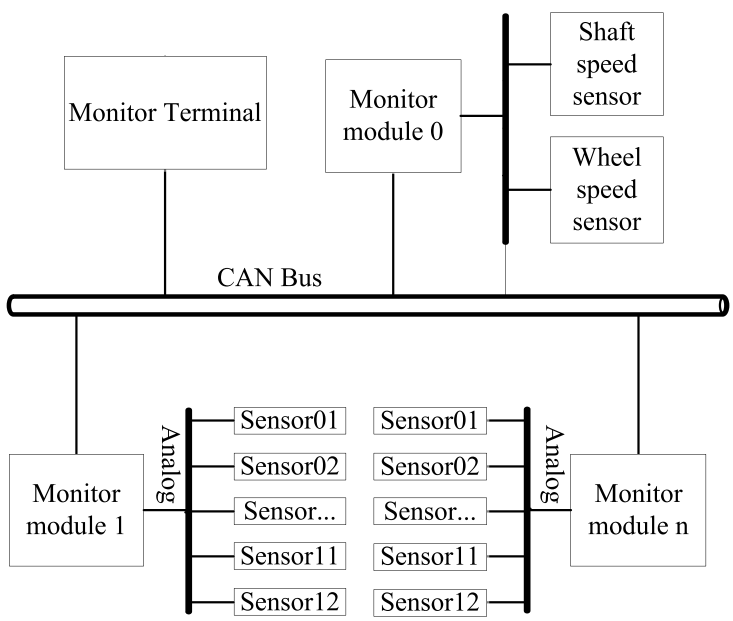


Fig. 1 Block diagram of the monitoring system of sowing

monitor sensor is sum of currents of four phototransistors, and is converted into voltage signal (U_{out}) through current-voltage conversion resistance. Change of senor output voltage (U_{out}) is used to determine tube status.

When sensor output voltage is greater that certain a value and keep content, seed tube is determined as Null, otherwise, when sensor output voltage is less that certain a value and keep content, seed tube is determined as Block. When output voltage is Specific frequency signal, Normal is determined.

When there is no seed stream in tube, U_{out} is not less that specific voltage U_{outL} and voltage variation ΔU_{out} is not greater than specific value ΔU; when there is a n seed stream, U_{out} is between specific voltage interval （U_{outL}, U_{outH}） and ΔU_{out} is greater than specific value ΔU; when the tube is blocked, U_{out} is not greater than U_{outL}.

In order to improve anti-dust capability, the dust-proof equipment is designed. It consists of main shell and sealed cover. There are 8 even distributed little holes on main shell's monitoring section to fix 4 pairs of photoelectric sensors and make the monitoring range cover the cross section. The cylindrical sections of LEDs and phototransistors inward through little holes of the sealed cover and their transparent glass parts face internal, so would be touched by seed stream while there are seed stream passing by, and dust on them are, by the way, cleaned

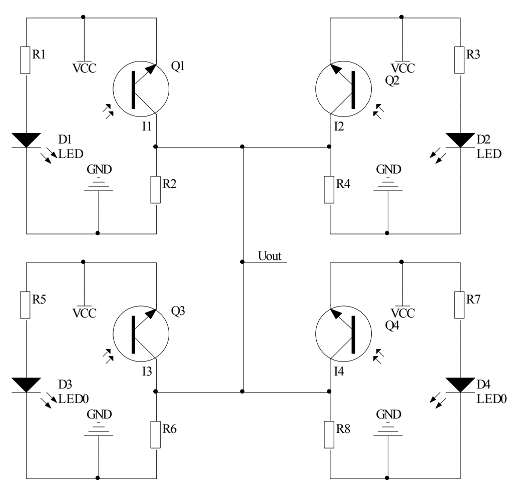


Fig. 2 Schematic diagram of monitoring circuit of photoelectric sensors

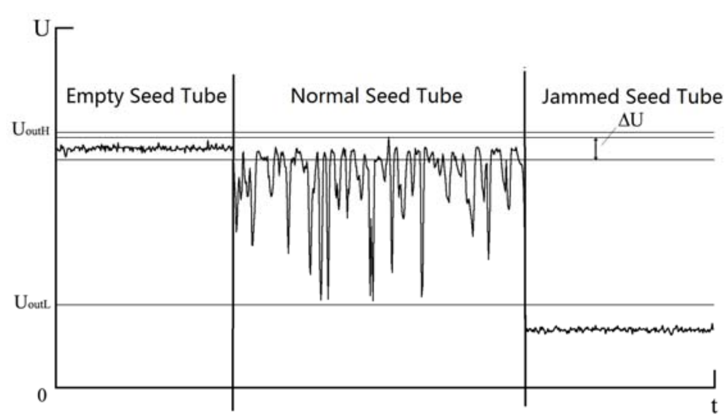


Fig. 3 Output curves of the sensor in different states

by seed stream, and anti-dust capability is enhanced. Main shell and sealed cover are connected by six screws and sealed space forms. It helps keep dust out while sowing. There are seed tube connections on both the upper end and lower end of the sealed shell.

Design of monitor module

The system monitors up to 48 seed tubes monitoring sensor. Excessive conductor jointing to monitor terminal would cause complex wiring, low maintainability and low reliability. In order to reduce wiring complication and enhance designing flexible, the system use four seed tube monitoring modules. Each of the monitoring modules is in charge of 12 photoelectric sensors. Can bus is adopted to complete communication between monitoring modules and monitoring terminals

Monitoring module uses AT90CAN128 microprocessor. It has 8 ADCs and supports CAN controller. Because of the restriction of only 8 ADCs of the AT90CAN128, TI's CD4067B is used to select monitor sensors. Based on Hall sensor, rotation rate of seed shaft and drill travel speed are measured by using the method of measuring cycle.

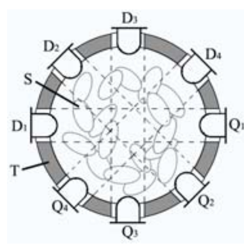
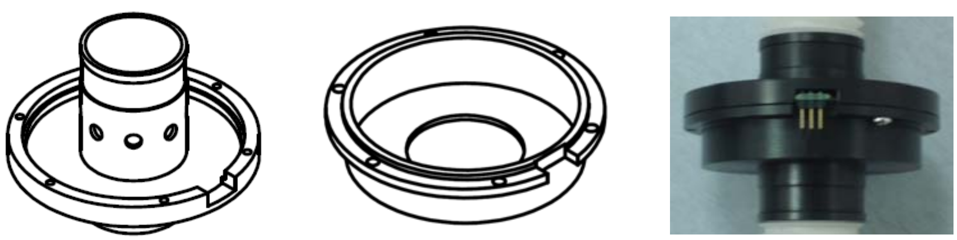


Fig. 4 Schematic of distribution of LEDs and phototransistors



（a） Main shell （b） Sealing cover （c） Prototype

Fig. 5 Dust-proof device of sensor

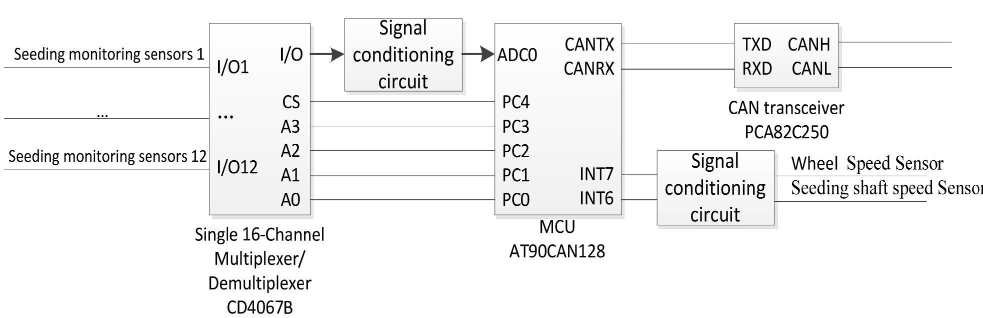


Fig. 6 Block diagram of monitor module

Design of monitor terminal

Atmel's AT90CAN128 microprocessor is used to design monitoring terminal, a Philips' PCA82C250 chip is connected to its CAN ports to expend CAN bus communication. LCD is used to display.

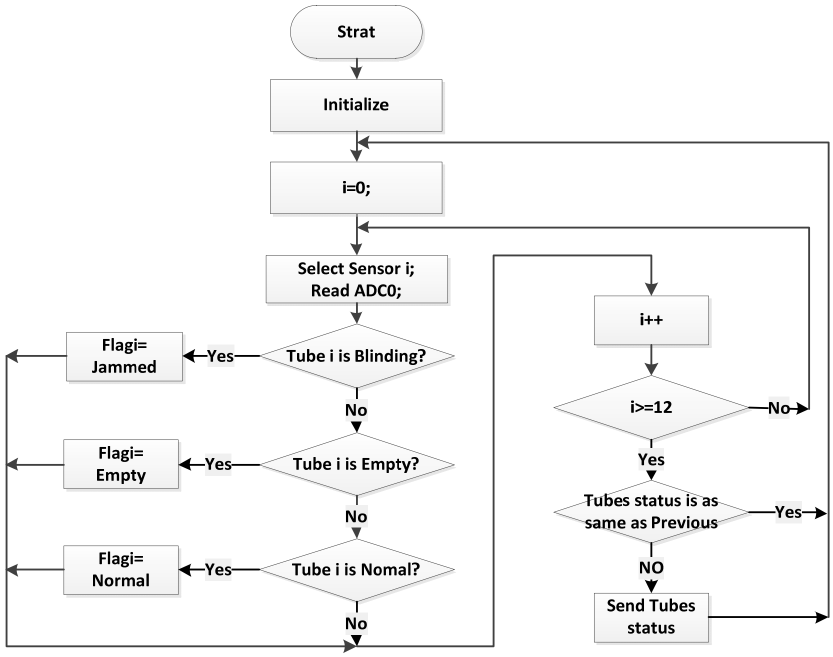


Fig.7 Flow chart of monitor module

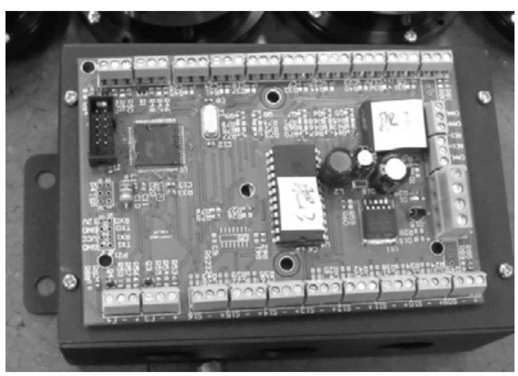


Fig. 8 Monitor module prototype

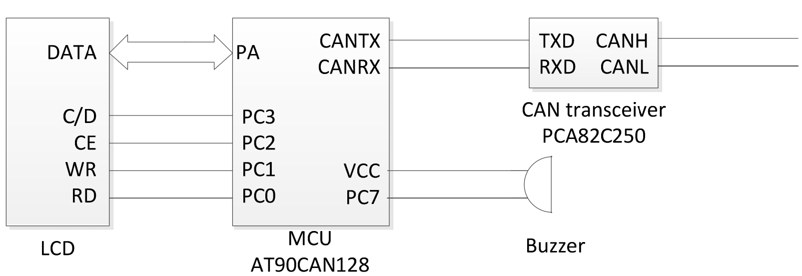


Fig. 9 Block diagram of monitor terminal

COMMUNICATION PROTOCOL

The system's communication protocol is made based on ISO 11783, the main messages of the system are sowing monitoring fault, seed shaft rotation rate and drill travel speed, etc.

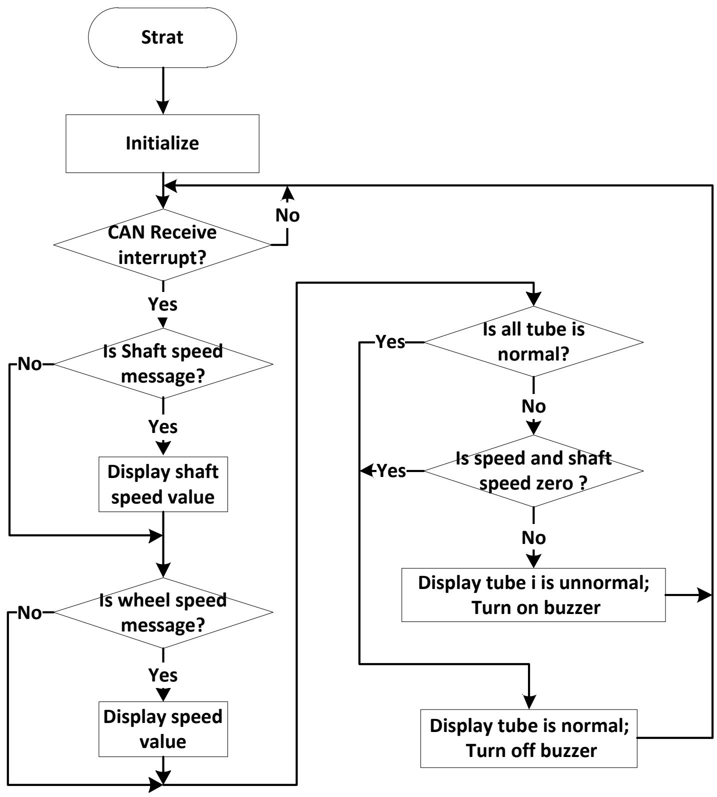


Fig. 10 Flow chart of monitor terminal

Fig. 11 Monitor terminal prototype

Sowing monitoring fault

Only when seed tube faults occur messages are submitted. The message ID is 0x18ff0421, and the message content is as table 1.

Seed shaft rotation rate

The message ID is 0x18fe6c21, and the message content is as table 2.

Drill travel speed

The message ID is 0x0cfe4821, and the message content is as table 3.

TESTING AND DATA ANALYSIS

The system is tested on 6-line test beach of monitoring sowing, as diagram 12. Seed tubes are plunged up one by one and alarm response times of the sowing machine monitoring system are lodged while sowing machine are operating normally. CAN bus send data when seed tube is blocked and stop sending data while buzzer alarming. The time between data sending and stop is the alarm response time. The CAN-bus time resolution of sending data is 0.1ms. The seed tube's row serial number (1~6) are recorded and displayed on the terminals. Three group tests are launched, and their data is as table 4.

Table 1. Protocol of the failure of the sowing monitoring

Protocol content			
byte, bit.	length	parameter	meaning
1	8 bits	module type	1-monitor sowing; other-reserve
2	8 bits	module ID	0-module 1; 1- module 2; 2- module 3; 3-module 4
3.1-3.5	5 bits	number of sensors	0-16: number of sensors
3.6	1 bits	reserve	0- reserve
3.7-3.8	2 bits	module status	00-disable 01-enable; 10-error; 11- don't care
4-8	4 bytes	sensor status	00-empty, 01-jammed; 10-normal; 11- don't care

Table 2. Protocol of the seed shaft rotation rate

Protocol content			
byte, bit.	length	parameter	meaning
1-4	4 bits	reserve	0 - reserve
5-6	2 bits	rotation rate	unit: 0.125r/min
7-8	2 bits	reserve	0 - reserve

Table 3. Protocol of the drill travel speed

Protocol content			
byte, bit.	length	parameter	meaning
1-2	2 bits	drill travel speed	unit：0.001m/s
3-8	6 bits	reverse	0- reverse

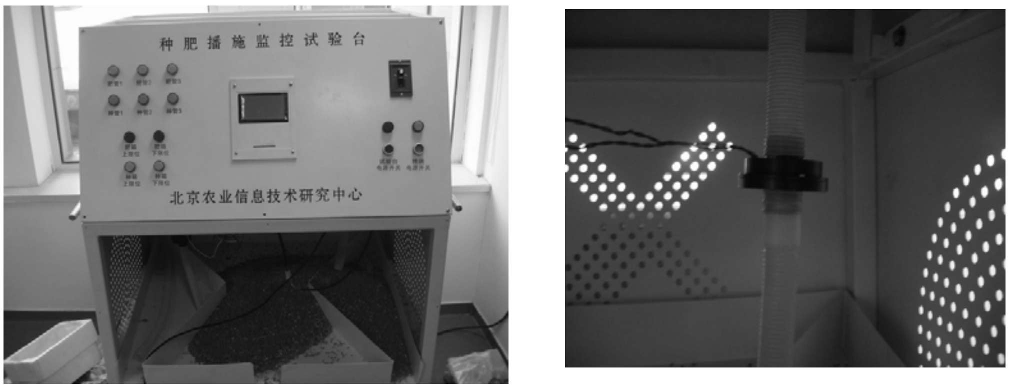


Fig.12 Test beach of monitoring sowing

Table 4. Three comparison of alarm response rate

Alarm response time			
row number	1st time	2nd time	3rd time
	- millisecond -		
1	29.3	25.7	34.1
2	33.6	28.5	30.9
3	27.7	34.3	26.5
4	38.4	40.7	35.0
5	44.1	33.7	37.5
6	29.4	22.1	20.8

The test data shows the maximum alarm response time is 44.1ms, which means when seed tube in row 6 is fault the maximum time interval monitored in row1 is 44.1ms

The same test method is launched in Laishui city, Hebei province. The drill is 2BMQ-48, designed by the Modern Agricultural Equipment Co., Ltd. The sowing monitoring system is equipped on the precision drill, and seed tubes are labeled as 1~48 (Fig. 13).

Three group tests are completed. In each group of test 48 seed tubes are plugged up one by one, the row serial number and alarm response time are displayed and logged in terminals for each time. In the three group tests, the maximums alarm response time is less than 0.5s. It means the maximum time interval monitored in row1 is less than 0.5s when seed tube in row 48 is blocked.

Fig. 13 Installation of the monitoring system

CONCLUSION

The wheat sowing intelligent monitoring system is able to monitor 48 seed tubes, give alarm while various faults occur, and display fault types and row serial number where fault occurs on terminals.

The system adopts photoelectric sensor as seed tube monitoring sensor, and improves photoelectric sensor's anti-dust capability efficiently by outputting analog voltage signal.

The sowing monitoring communication protocols based on ISO 11783 are designed to improve system's reliability and maintainability.

The tests on lab and field indicate that the system has many merits, such as low rate of false alarm, short response time (<0.5s), and is able to meet the requirement of practical application.

Acknowledgement: Thanks are due to National High Technology Research and Development Program 863 (2012AA101901) for financial support, and BAAFS-Youth Foundation(QNJJ201020) .

REFERENCES

[1] Wenchang Lu. 2004. Design of rotation speed sensor for automotive wheel based on CAN bus. Journal of Transducer Technology. 23(2): p.34-37.

[2] Chen Shaobin, Lv Xinmin, Zhang Lijun. 2007. Study and Exploitation on Monitoring System of Precision Drill . Journal of Agricultural Mechanization Research. (5):p.112-114.

[3] Zhang Xiaohui, Zhao Baitong. 2008. Automatic reseeding monitoring system of seed drill. Transactions of the CSAE. 24(7):p119-123.

[4] Zhou Liming, Zhang Xiaochao. 2009. Monitor System of Precision Seeder Based on Capacitive Sensor, Journal of Agricultural Mechanization Research, (11):p.37-39.

[5] Ma Xu, Wang Jianping. 2001. Detection of a Precision Seedmeter Performance Using Image Processing Technology. Transactions of the CSAM. 32(4):p.34-37.

[6] Pasto P. Garcia, Nobutaka Ito, Koji Kito etc. 1998. Computer based Optimal Control of Seeding Rate Based on Travel Speed and Seed Signals (Part2).

Journal of the Society of Agricultural Machinery Japan. 60(3):p79-86.
[7] Panning J W, Kocher M F. 2000. Laboratory and filed testing of seed spacing uniformity for sugarbeet planters. Applied Engineering in A2 griculture. 16 (1) :p.7-13
[8] Shi Zhixing, Gao Huanwen. 2003. Numerical Measuring Method and Application of Anti-dust Capability of Photoelectric Sensors. Transactions of the CSAM. 34(3):p.86-88.
[9] Shi Zhiixng. 2002. Study on the Detection System & Key Techniques for Seeding Quality of Precision Planter. Beijing.
[10] Feng Quan, Li Zhenxiao, Wu Jianmin etc. 2006. Development of Dustproof Annunciator System for No-ti llage Planter. Transactions of the CSAM. 37(9):p.68-70,78.