Research of the diagnostic parameters of the electronic control system HORSCH sowing complexes

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Abstract

A training stand has been developed, which completely simulates the operation of the electronic control system of the drill. It is expedient to use the training stand for training of experts on operation of sowing machines, its use allows to model various malfunctions of electronic system, to investigate more thoroughly possible ways of diagnostics and repair.

The proposed method of diagnostics of the electronic control system is to determine the basic parameters of the electronic components. To do this, with the help of an oscilloscope taken oscillograms of the main sensors of the drill in different modes of operation. The reference values of the oscillograms of the information signals of serviceable components can be compared with the parameters of the sensor signals of each individual sowing section. This method makes it impossible to incorrectly replace a working sensor, or receive incorrect signals from the sensors in case of damage to the sensor itself or its power supply circuit or information wires.

During the testing of this method, its high efficiency was found when testing optical seeding sensors. It is advisable to check the components of the electronic control system for precision seeders. This allows you to ensure high quality sowing due to the correct operation of the sowing control system.

Keywords

Sowing complex, electronic control system of the seeder, training stand, diagnostics

1. Introduction

Sowing complexes are characterized by high standards of technological efficiency, productivity and quality of manufacture [1]. The use of sowing complexes provides a significant reduction in sowing time. The main trends in the improvement of such machines include, first of all, preparation and leveling of the soil, formation of the seedbed and its compaction, rolling of crops, application of fertilizers within one technological operation. The next areas of improvement are the uniformity and accuracy of sowing seeds, as well as increasing the speed of the unit [2 5].

Simultaneous provision of a large number of agro-technological requirements leads to the need to use complex technological and structural systems in the development of agricultural machinery. In addition, a large number of integrated interconnected systems require knowledge of the principles of their operation, configuration and maintenance [4, 5].

2. The purpose of the study

The purpose of the study is to develop equipment and methods for establishing the basic diagnostic parameters of sowing machines equipped with electronic control systems. The initial conditions for

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creating such equipment are compactness and convenience of the main electronic elements, low metal and material consumption, and its use would not require significant time and resources, the use of additional equipment and machinery (tractor for aggregation, etc.) [6].

2.1. Materials and methods

Kompas-3D V14 program was used for design and visualization of the designed equipment. Non-standard elements are made by means of 3D printing. To do this, the models were pre-processed using a slicer Cura Ultimaker v.3.4.1 and the processing resulted in a g-code for the 3D printer Printo H3.

The power supply circuits of electrical and electronic systems were checked with a digital automatic multimeter UNI-T UT61D, and the diagnostics of the sensors were performed using a portable PC and a digital oscilloscope Hantek 1008B.

2.1.1. Results of the researches and discussion

HORSCH sowing complexes of the Pronto DC series are high-performance machines with large dimensions and weight (Figure 1), the working width of sowing of complexes of this series varies within 3… 12 m, and the number of openers can reach 60 [1]. To ensure uniformity and a given seeding rate under conditions of high speed units in modern sowing technology widely used electronic control systems. The use of electronic systems allows you to automatically control the quality of sowing, to adapt the work of the seeder to changes in movement parameters, or to signal to the operator about certain faults or non-compliance with agronomic requirements [7, 8].

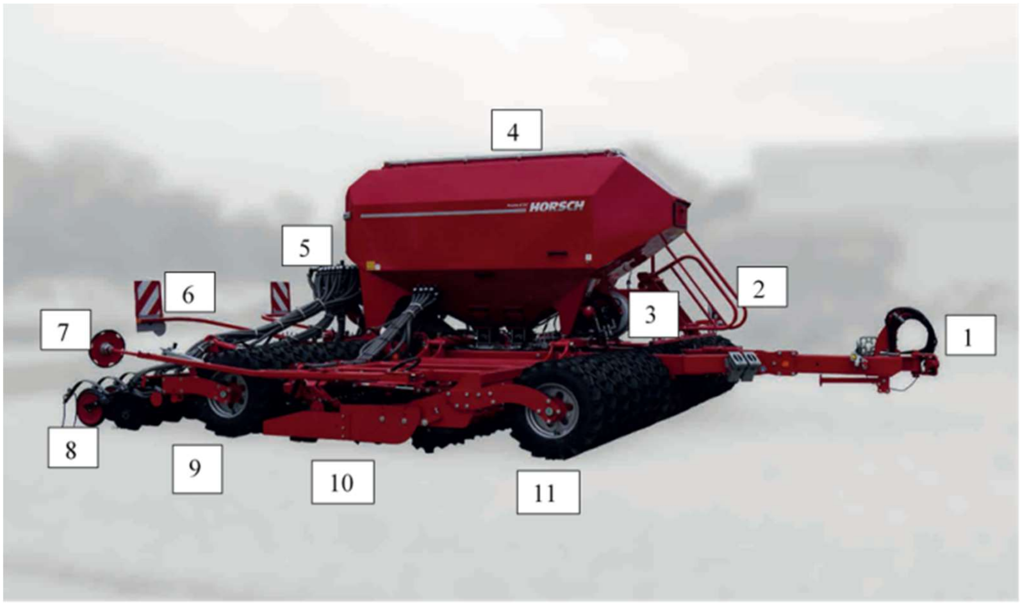


Figure 1: HORSCH sowing complex of the Pronto DC series:
1 - draw-bar; 2 - footboard; 3 - air blower; 4 - two-section bunker; 5 - seed distributor; 6 - lighting system; 7 - track marker; 8 - sowing openers TurboDisc; 9 - tire compactors; 10 - two-row disk system; 11 - primary soil compactors

Debugging the correct operation of the seeder is to prepare its mechanical part, hydraulic and pneumatic systems, electronic control system and a large number of software settings. It is more expedient to study the program menu, set the set seeding rate, calibrate sensors and actuators with the use of training equipment that fully reproduces the work of the electronic control system. For this purpose, a training stand (Figure 2) was designed and manufactured to study the structure, configuration and diagnostics of the electronic control system of the sowing machine [9].

The training stand was developed in the university laboratory, it is equipped with an electronic control system of the drill, which is used on sowing machines of the manufacturer. As sowing machines are dimensional and metal-intensive, it is more convenient to study the parameters of the electronic system on the developed training equipment.

The power supply of the electric and electronic seeder system comes from the mains of the tractor with a voltage of 12, and the data is exchanged using the ISOBUS protocol using only one cable with a nine-pin connector [1].

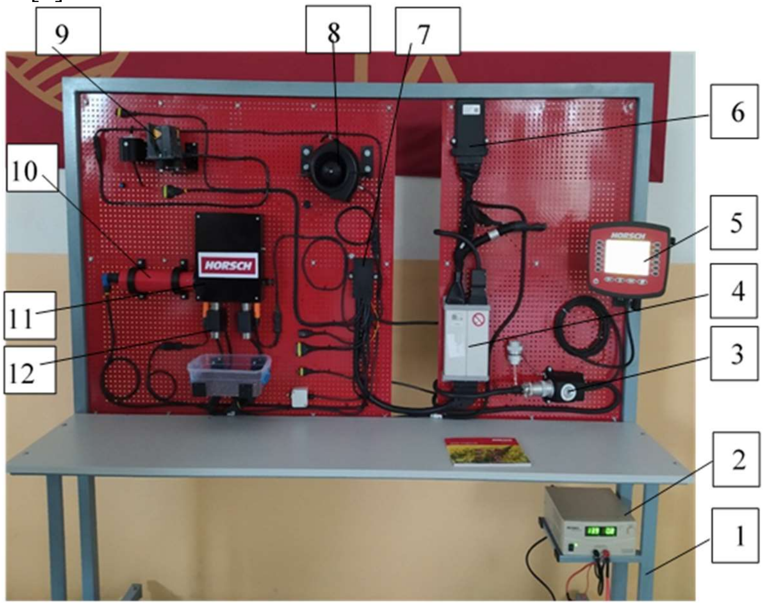
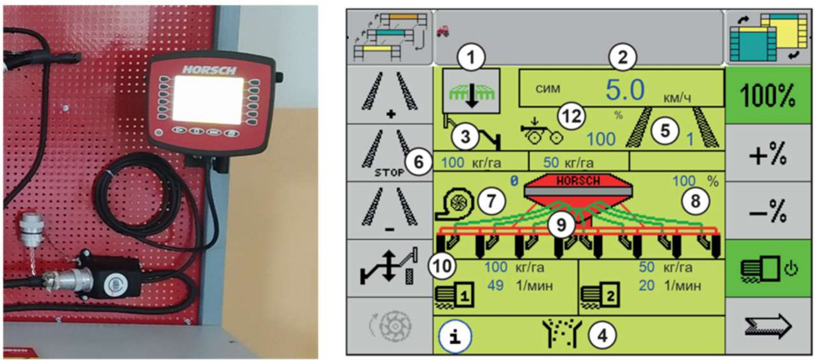


Figure 2: Training stand based on electric components of the seeder of the Pronto DC series (HORSCH): 1 - mounting frame; 2 - power supply (0… 24 V); 3 - ISOBUS mounting kit with extended cable; 4 - computer E-Manager Midi 3.0; 5 - terminal compatible with ISOBUS; 6 - seeding control module; 7- DrillManager ISOBUS mounting kit with extended cable; 8 - air blower; 9 - speed radar; 10 - the electric drive of the of the dispenser coil; 11 - dispenser body, 12 - seeding control system

E-Manager Midi 3.0 is fully controlled by all seeder systems, while data display and configuration change is performed via a digital terminal 5 with a software interface. It receives information from the sensors, processes it and transmits it to the tractor controller, which, if necessary, issues control commands to the electric drives or hydraulic system of the tractor, while all key indicators are displayed on the screen of the terminal (Figure 3) [1].



a b

Figure 3: The terminal is compatible with ISOBUS 2015 (a); the first page of the program menu of the terminal (b)

After turning on the terminal, the first page of the program menu is loaded. Placement and indication on the display depends on possibilities of adjustments and additional equipment of the device. The second page shows the settings of the electronic control system. The third page is mainly used to set the seeding rate, adjust the sensitivity of the seed supply control system and to troubleshoot clogging or damage to the sensors. The context menu is presented in the form of the following information blocks in accordance with the designation in Figure 3 b.

Seeder maintenance engineers very often troubleshoot the electronic components of the control system. Most often, an elementary replacement of a particular element. However, there are often situations when the serviceable element is replaced or the seeding machine receives incorrect data from the system sensors. For a more thorough study of the effectiveness of the electronic control system of the drill in difficult operating conditions, a system of additional load in electrical circuits and lines that transmit information signals was proposed. This allows you to assess the quality of seed sowing on the basis of potentially erroneous data of the control system (Figure 4).

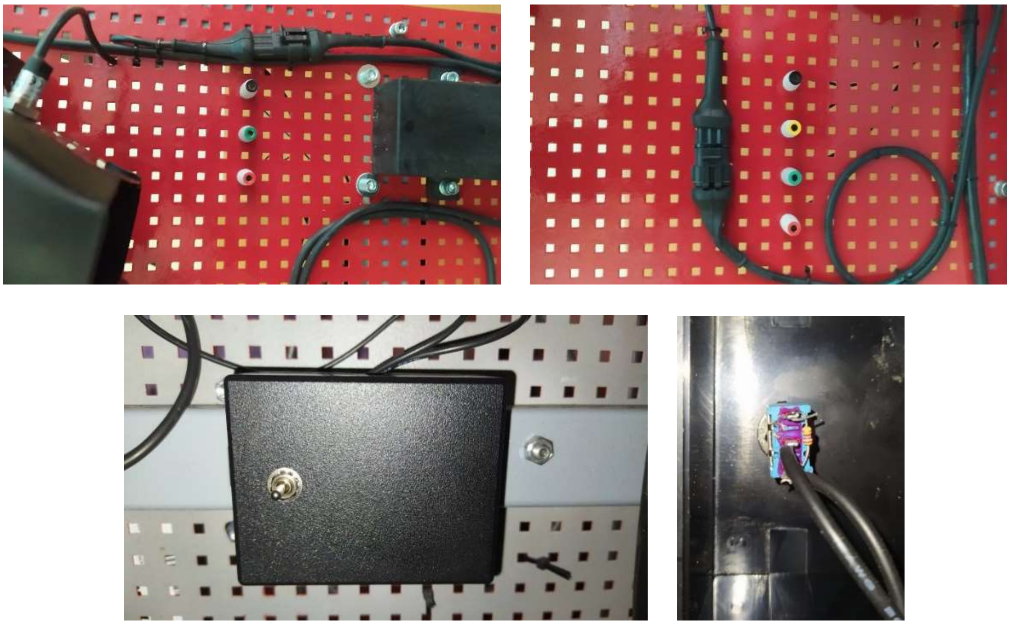


Figure 4: Additional load system of the electronic seed drill control system

The drill works in difficult operating conditions at high humidity, presence of a large amount of dust, pesticides, fertilizers. Severe operating conditions affect the electrical and electronic components of the drills, which disrupts the integrity of electrical circuits, data buses, and reduces the quality of contact in connectors. Therefore, it is very interesting to study the quality of the drill under these conditions. To do this, it was proposed to mount additional resistors of different electrical resistance in the power supply circuits of the drill sensors, which allows you to simulate poor contact in the connections, the presence of moisture or corrosion in the connectors, line breaks. To do this, junction boxes are installed in the power supply circuits, in which the wires are mounted through 4…20 kOhm resistors. The value of resistance was changed by a switch. Special connectors have been installed on each of the wires of the electronic system to connect a multimeter or oscilloscope.

Before sowing, adjust the seeding rate and calibration of the dispenser (Figure 5). Typically, this operation is performed in triplicate to avoid error [10 - 13].

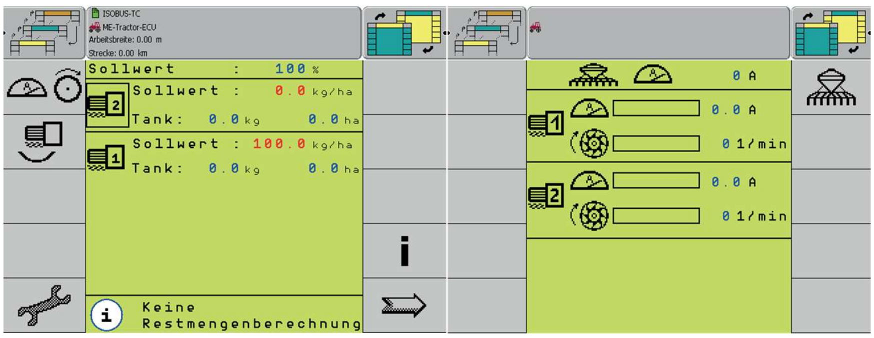
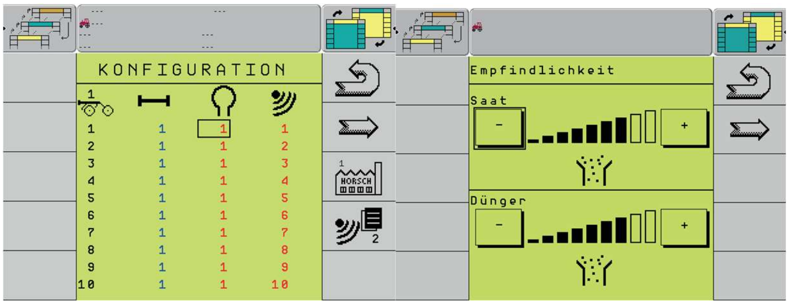


Figure 5: Fragment of setting the seeding rate and calibration of the dispenser

At the next stage of preparation, the air blower is calibrated, which involves software settings and setting the coded number of pulses of the sensor relative to the actual speed of the blower fan.

After determining the contours of the row spacing, it is necessary to determine the number of installed sensors that monitor the supply of seed. As a rule, they are determined automatically, and changes are made only when the number of openers and sensors do not match, or when the sensor fails (Figure 6).



a

b

Figure 6: Adjustment and calibration of seeding control sensors and filling the bunker: software settings (a); optical seeding control sensors with diagnostic ports (b)

Digital multimeters can be used to determine the serviceability of power supply circuits, electrical and electronic seeder systems, while oscilloscopes must be used for high-quality diagnostics of seeding control sensors, radar speed sensors, fan speed sensors and metering devices. By the nature of the waveform of the information signal, you can get reliable data on the serviceability and correct operation of these sensors. Since the technological process of sowing is fully controlled by a complex electronic control system, it is possible to identify the following types of faults [14, 15]:

- damage to power circuits;
- complete damage or malfunction of the sensor;
- incorrect operation of the sensor (presence of pulses and transmission of incorrect signals);
- inconsistency of software settings (conversion of physical pulses into program codes).

Many sowing machines use many sensors. Their number and serviceability is determined by the computer in automatic mode and signals only its failure. However, their incorrect operation must be checked by service engineers with the help of specialized equipment. Particular attention should be paid to optical seeding sensors on precision seed drills. In practice, it is very common to replace serviceable sensors in the event that the power and data cables are not working properly. Under such conditions, the increasing electrical resistance in the electronic circuit also decreases the amplitude and distortion of the information signal. As a result, the system does not identify the sensor and falsely signals its malfunction.

To determine the serviceability of the main electrical and electronic systems of the seeder, oscillograms were taken from the seeding control sensors, the radar speed sensor and the fan speed sensor. Since the bunker filling sensors are similar to the fan speed sensor, the signal from these sensors was examined by a similar method using two channels of a digital oscilloscope.

Seed control sensors are equipped with 4-pin connectors and are connected in parallel to the network. It can be assumed that these sensors use a digital data signal. After measuring, we investigated that the 1st and 4th contacts of the connector are used to power the sensor (12 V). Contact 2 generates the signal shown in Figure 7.

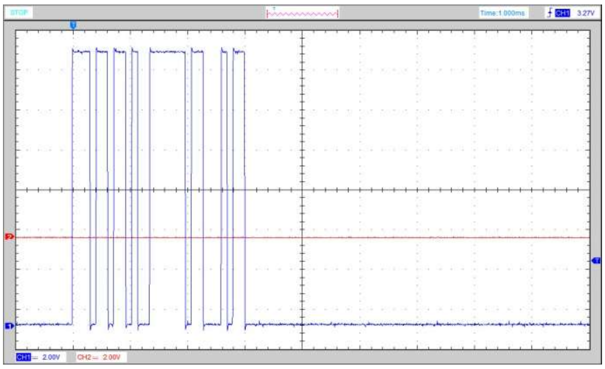
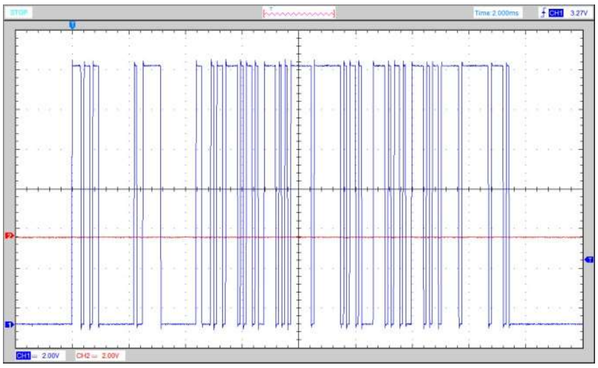


Figure 7: The shape of the information signal at terminal 2 of the connector of the optical seeding control sensors

The shape of the oscillogram of the information signal (Figure 6) did not change depending on whether or not the seed flies through any of the sensors.

Measuring the oscillogram (Figure 8) on the 3rd contact of the connector under different operating conditions: no seed flow (Figure 8 a), the seed comes only through the first sensor (Figure 8 b), the seed comes through two sensors simultaneously (Figure 8 c), the following waveforms are obtained.



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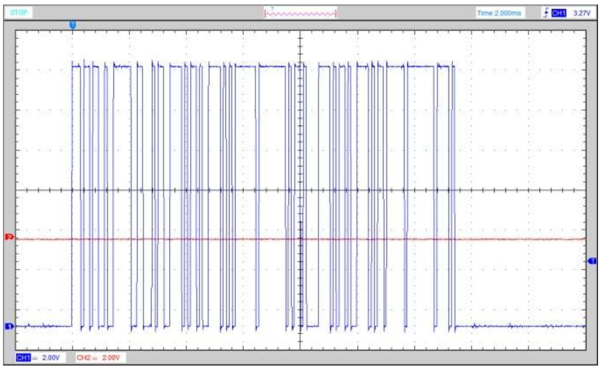

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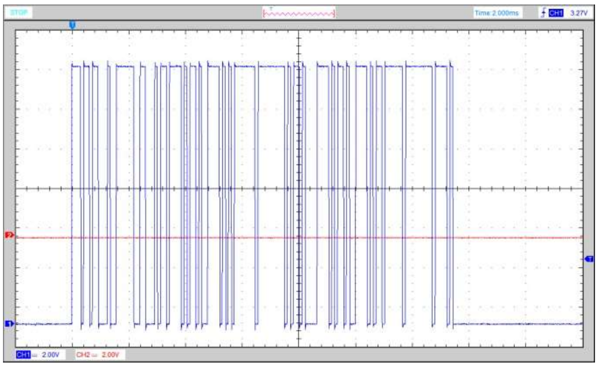

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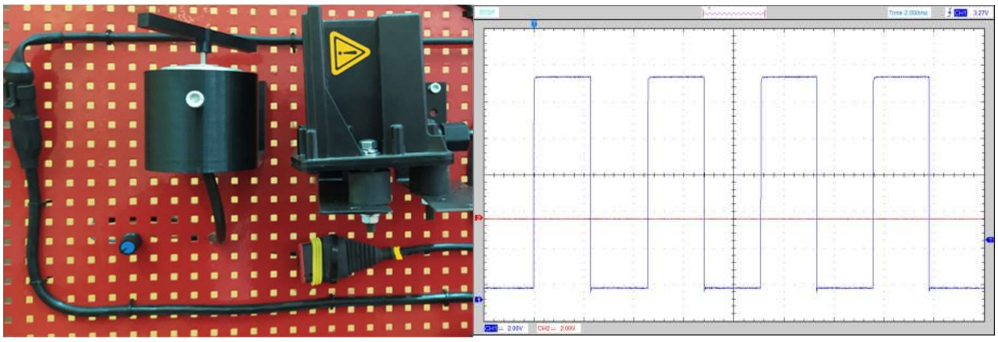
Figure 8: The form of the information signal on the contact 3 of the optical sensors connector of sowing control under the conditions: the seed enters through two sensors (a); the seed enters through the first sensor (b); the seed comes through the second sensor (c)

Analyzing the obtained waveforms, we can assume that the sensors use the UART data protocol. In this case, the contact 2 of the sowing control sensor connector is the receiver (RX), and the contact 3 is the transmitter (TX) of the digital signal [14, 15]. Using such a data transfer protocol allows you to place a large number of sensors on one data line and you can detect from which sensor the information signal is coming. Thanks to this implementation, it is possible to diagnose the efficiency of each individual seeding sensor.

Figure 9 shows a fragment of the study of the radar speed sensor of the unit. The speed change was performed using a motion simulator, its speed was changed by a PWM regulator with a power of 1.5…16 V. This allows us to obtain the characteristics of the pulses, and accordingly the radar, in the whole range of changes in the speed of the sowing machine.



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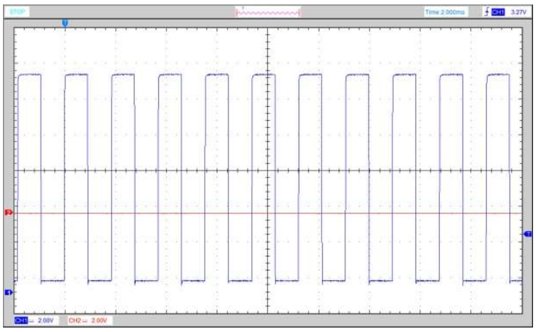

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Figure 9: Investigation of the radar speed sensor: test fragment (a); the form of the information signal at a speed of 3 km/h (b); information signal form at a speed of 10 km/h (c)

As can be seen from the oscillograms (Figure 9 b), the signal has a rectangular shape, with a filling factor of 50%. As the speed increases, the frequency of the signal increases, and it increases in direct proportion. Thus, by measuring the signal frequency, the main control unit has the ability to obtain the value of the current speed of the seeder. If in real conditions the speed of the seeder according to the readings of the radar sensor does not coincide with the real one, then in the system it is possible to correct the speed to the set conditions.

3. Conclusions

A training stand has been developed, which completely simulates the operation of the electronic control system of the drill. It is expedient to use the training stand for training of experts on operation of sowing machines, its use allows to model various malfunctions of electronic system, to investigate more thoroughly possible ways of diagnostics and repair. The convenience of using training stands is their compactness, ease of location of the main elements of the electronic control system, and its use does not require a significant amount of time and resources, the use of additional equipment.

In the course of research the principles of work and technology of data transmission of the main elements of the electronic control system of the drill are established. According to the nature and patterns of change of oscillograms of information signals, the main diagnostic parameters of seed drill sensors are set.

The proposed method of diagnostics of the electronic control system is to determine the basic parameters of the electronic components. To do this, with the help of an oscilloscope taken oscillograms of the main sensors of the drill in different modes of operation. The reference values of the oscillograms of the information signals of serviceable components can be compared with the parameters of the sensor signals of each individual sowing section. This method makes it impossible to incorrectly replace a working sensor, or receive incorrect signals from the sensors in case of damage to the sensor itself or its power supply circuit or information wires.

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4. Acknowledgements

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