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Application of fiber optical sensors for counting axes of a mobile stock systems of automation and telemechanics on railway transport

Saitov Aziz Azimovich

Dept., assistant, Tashkent state transport university Department of automation, telemechanics, Tashkent, Republic of Uzbekistan

ABSTRACT: In this research work have been investigated and is represented by advanced optical sensors based on the use of modern electronic meters electromagnetic relays used on the railways, hauls and stations in the Republic of Uzbekistan. The electronic axle counting system (EACS) electromagnetic relay device increases the transmission of false messages under the influence of magnetic induction. This leads to a decrease in the level of reliability. Research has shown that the recommended axle counting sensors have a high sensitivity when passing wheels on the sensors on tracks and stations, which can improve reliability and reduce operating costs for trains, main roads and station roads.

KEY WORDS: optical fiber, emitter, receiver, sensor, motion, station, trunk, operating line, reliability, converter, analog, digital, centralization.

I. INTRODUCTION

The development of the economy is inextricably linked with the development of rail transport, as it occupies a leading position in the world in land freight transportation.

In the context of an increase in the value of freight turnover and travel speeds, as well as the widespread automation of rail transport management, the question of determining the presence of rolling stock on the tracks arises. This leads to the need to account for the passage of locomotives and wagons on a particular section during train, shunting and sorting work.

The entire accounting of the position of the rolling stock was initially assigned to the station attendant, but with an increase in traffic intensity, it became necessary to automate the receipt of data. Automatic data entry will allow you to keep track of the numbers of train receiving tracks, draw up daily schedules, and will also allow you to use the information received when developing logistics software. It will make it possible to implement electronic document exchange, keep records of clients, manage projects and orders, keep records and control of employees, etc. If there is reliable data from the control and accounting of rolling stock, it is possible to develop fundamentally new logistics systems and complexes.

When using the existing logistics programs developed for rolling stock on railway transport, there is an urgent need to duplicate data from control and accounting tools by manually entering them by the operator, this is necessary to ensure traffic safety and to avoid emergency situations.

Axle counting is one of the main ways to record the fact of the passage of rolling stock. For its implementation, various systems are used to record the fact of the passage of rolling stock.

The main type of accounting systems are electrical (electronic) systems of various configurations. The basic requirements for such systems are: reading accuracy, reliability of operation subject to minimization of maintenance, service life, complexity of installation and adjustment, the amount of energy expended, protection from external factors, cost, and the possibility of remote control.

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II. ANALYSIS OF PUBLICATIONS

In the course of the analysis of various literature, it was found that the use of track circuits to account for the occupancy of the track, directly establishing the vacancy or occupation of the track section, is widespread. In contrast, the axle counting system works indirectly.

If in the initial period the section was free, and then the number of entered and exited wheelsets coincided, then it is marked as free of rolling stock. If this condition is not met, the site is considered occupied.

A generalized block diagram of modern axle counting systems using the example of control of the simplest section is shown in Fig.1[4]. Such systems include:

- a track sensor that registers the wheel travel. To determine the direction of movement, the sensors are installed in pairs;
- an analog-to-digital converter converts the analog signal of the path sensor into digital information.
- an electronic solver calculates the results and provides information about the vacancy or occupation of the site. Modern systems use safe microprocessors for this. In some systems, the elements that perform the tasks of the electronic solver are partially placed in the travel box along with the ADC.

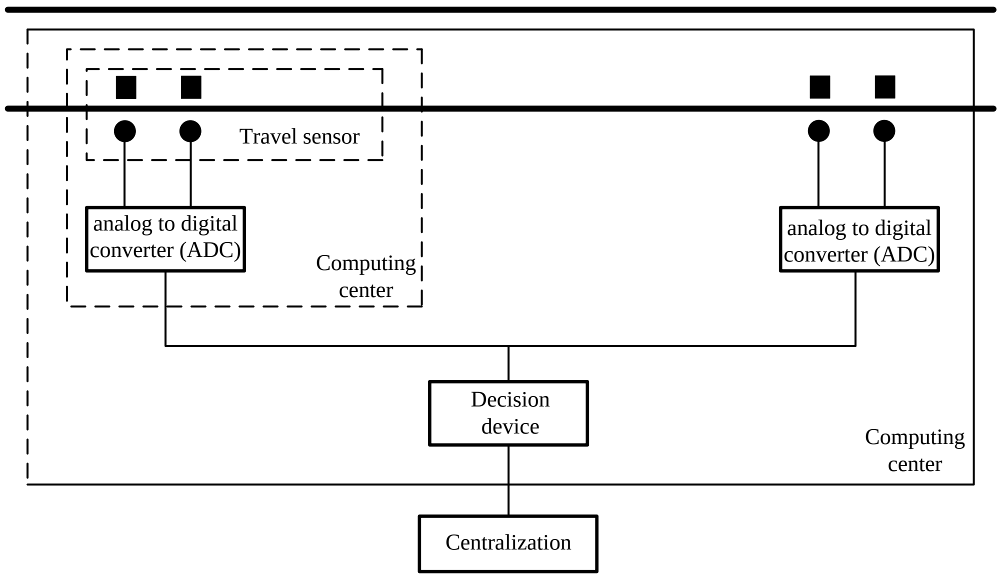

Fig. 1. Elements of the axle counting system

The axle counting system consists in the simplest case of two counting points located on opposite sides of the site, the occupancy of which must be monitored. However, in modern systems, a large number of inputs from located near track sensors are connected to the solver, which makes it possible to monitor the occupancy of several sections (Fig. 2). The number of counting points connected to one solver is different and is determined by its model, but usually up to several dozen [4].

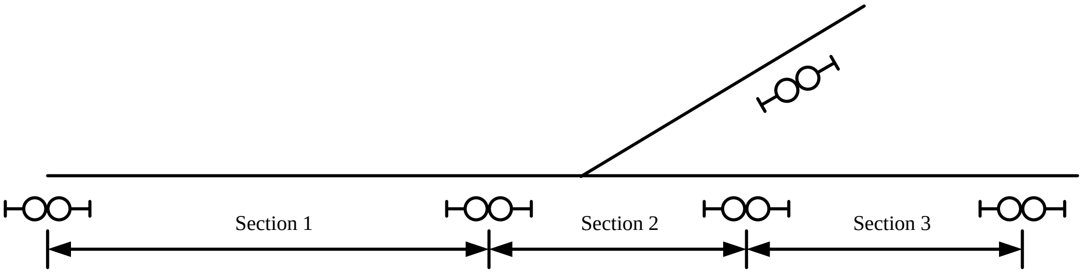

Fig. 2. Several sections connected to one counting system

Registration of wheelsets movement in modern rolling stock positioning systems is carried out by various sensors according to the principle of operation. They must register each axle separately, as well as determine the direction of movement of locomotives and wagons.

In addition to determining the direction of movement, with the help of sensors for registering the movement of wheelsets, it is possible to obtain information about the passage of a certain point of the way by the rolling stock.

Sensors registering the movement of wheelsets in modern positioning systems continuously monitor their condition for timely registration of the fact of passing the axle, which in turn avoids the occurrence of emergency situations on access roads.

To determine the direction of movement of a wheelset, it is necessary to use two sensors, separated by a short distance. The distance between the sensors should also ensure reliable registration of the activation of the first and second sensors separately, as well as their deactivation after passing the wheel pair. Such placement of sensors, in systems for counting the axles of rolling stock, allows you to reduce the impact of vibration and increase the reliability of the entire accounting system.

Existing wheelset axle counting systems in modern positioning systems are highly reliable, erroneous registration occurs in less than one percent of cases. Such errors occur if one of the wheelsets was not found, or the wheelsets were counted twice, or there was a false triggering of the axle counter, as well as in the case of an erroneous determination of the direction of movement of the rolling stock.

On the basis of existing safety requirements, in cases where an erroneous registration of the axle of a wheelset occurs, the track section is considered occupied.

Currently, a huge number of systems allow us to ensure that a train passes through a given section, among them: Az S 350 U, ZP43, Thales and many others.

Such systems are built on different principles and use different technologies. The most common sensors in such systems are inductive and optical sensors. Sensors of mechanical or magnetic types are used much less often.

These approaches have a number of significant drawbacks. The disadvantages of positioning systems based on induction sensors include the fact that the sensors have low anti-vandal protection and when a foreign moving metal object is introduced or when an external magnetic field is introduced into the sensor's field of action, a false triggering of the positioning system will occur. The disadvantages of positioning systems using photo and video captures should be considered the need for significant costs for equipment for collecting and processing information, as well as the cost of software and service. It is necessary to monitor the maintenance of the cleanliness of the optical system and provide illumination of the test object at night. The disadvantage of positioning systems based on magnetic contact sensors is that such sensors also have low anti-vandal protection and when a foreign moving metal object is introduced (when an external magnetic field is introduced into the sensor's field of action), they are susceptible to false triggering of the positioning system. In addition, it is necessary to ensure the tightness of the sensor if a relay insert is used instead of a reed switch. The disadvantages of a positioning system based on the mechanical principle of registering the axles of wheelsets is that mechanical contact devices may stop working when the sensor is dirty or when condensate or moisture freezes inside it, which will lead to deterioration of contact or jamming of the mechanical component of the mechanical contact. devices.

Based on the analysis of the disadvantages of positioning systems using these types of sensors, the article proposes to use a strain gauge sensor as a sensor and place the sensors between the rail and the sleeper, and place all electronic components and the power supply in a housing similar in size to the sleeper. This design will provide a higher level of anti-vandal protection, and since the electronic part of the axle counter is planned to be powered from a battery and use wireless data transmission (between the axle counter and the data collection and processing system), such a design will be easy to operate and maintain.

III. ESSENTIALSOF PERFORMANCE

Improvement of methods and technologies for automated control and detection of rolling stock in railway transport based on fiber-optic sensors.

Based on the studies, an improved device for the detection and automatic control of rolling stock in railway transport has been developed. The device is created on the basis of elements developed by foreign manufacturers. The connection diagram of the proposed device is shown in Fig. 3.

Optical sensors are electronic devices that are affected by changes in the received light output. Optical sensors are used to detect the presence (absence) of objects of a given width, which leads to a change in the parameters of the luminous flux due to the presence (absence) of the sensors used. To improve the efficiency of optical sensors and improve the selection width of light radiation and the characteristics of their modulation. These techniques help prevent light rays and interference from other optical sensors.

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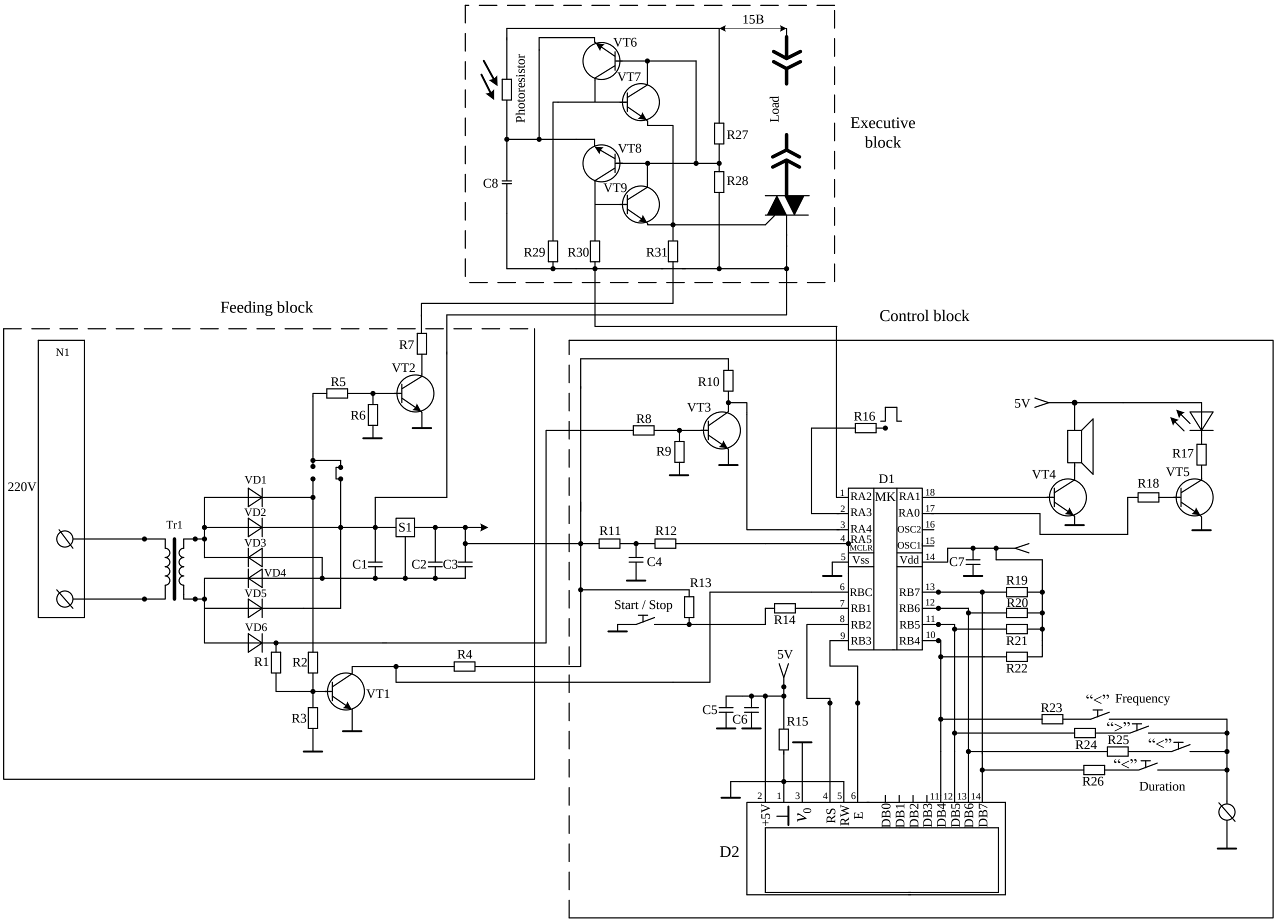

Fig. 3. Connection diagram of fiber-optic sensor devices for recording the composition of traffic

This figure shows the electrical diagram of the fiber optic sensor device for counting the axles of the rolling stock. The device diagram consists of 3 main blocks: the source block, the executive block and the main control blocks. The source block is connected to an alternating voltage of 220 V, and the transformer reduces the voltage to 5 V. Using a diode bridge circuit, the 5V AC voltage is converted to DC. To obtain an uninterruptible power supply, a 5V voltage in the circuit uses transistors VT1 and VT2 and capacitors C1, C2 and C3.

The main control unit also consists of 2 programmable microprocessors D1 and D2 (microcontrollers), D1 provides a sequence of logic commands in the device, and D2 allows you to configure these commands. This unit also installs additional accessories, such as an audible error warning speaker.

The block of actuators is controlled by transistors VT6, VT7, VT8 and VT9, operating in 4 switching modes, and these elements are connected to light-emitting and receiving diodes in the field (pole). The parameters of the light emitting and receiving diodes are given at the bottom of the text.
An optical position sensor is an electronic device that responds to changes in the received luminous flux. Optical position sensors are used to determine the presence (absence) of an object in a given space, since the presence (absence) of an object leads to a change in the parameters of the light flux received by the sensor. To increase the efficiency of the optical position sensors and improve their characteristics, modulation and spatial selection of light radiation are performed. These measures allow to eliminate the influence of extraneous light flares and interference from other optical sensors.

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The principle of operation of optical position sensors.

Optical position sensors consist of 2 functionally complete units - a source of optical radiation and a receiver of this radiation. The source of optical radiation (transmitter) and the receiver can be in the same housing or in different housings (Fig. 4).

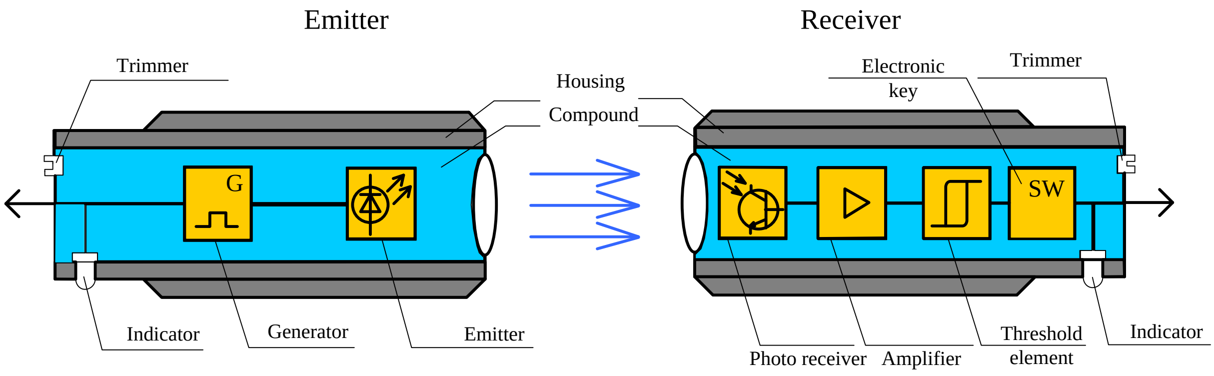

Fig.4. Optical sensor

Transmitter

The generator generates a sequence of electrical pulses to the emitter of the optical position sensor

Emitter is a light-emitting diode that creates radiation in the optical range.

The indicator shows the presence of supply voltage at the transmitter of the optical position sensor.

The optical system forms the radiation pattern and, if necessary, its polarization.

The compound provides the required degree of protection against the ingress of solid particles and water. The housing provides mounting of the switch, protects against mechanical influences. Made of brass or polyamide, complete with hardware.

Radiation receiver

The optical system forms the directional diagram of the radiation receiver and, if necessary, performs polarization selection.

The photodetector perceives optical radiation and converts it into an electrical signal.

The amplifier amplifies the input signal to the required value.

The threshold element provides the required slope of the output signal and the amount of hysteresis.

The electronic key switches the output current of the sensor, determines the load connection scheme, and has overload and short circuit protection.

The color LED indicator shows the status of the sensor, allows you to determine the functional reserve for the selected object, provides performance control, efficiency of adjustment.

The sensitivity regulator allows you to adjust the sensor according to the actual contrast of the object against the background of surrounding objects.

The functional reserve is defined as the ratio of the luminous flux received by the receiver to the minimum luminous flux that causes the switch to trip. The functional reserve allows you to compensate for signal attenuation due to contamination of the optics and the presence of aerosol components in the surrounding space.

The color LED indicator works as follows:

- when there is no signal at the input of the receiver, the indicator does not light

- when a signal appears with a level at which the switch is triggered, the indicator glows green
- with a further increase in the signal level, the green color smoothly changes through yellow - orange to red

The contrast of an object is determined by its intrinsic reflectance and the amount of light reflected from the surrounding background.

How the fiber optic sensor works

The switches with fiber optic cable are able to detect objects in the most difficult to reach places (Fig. 5). Fiber optic sensors can operate on both reflected beam (type D) and direct beam (type T).

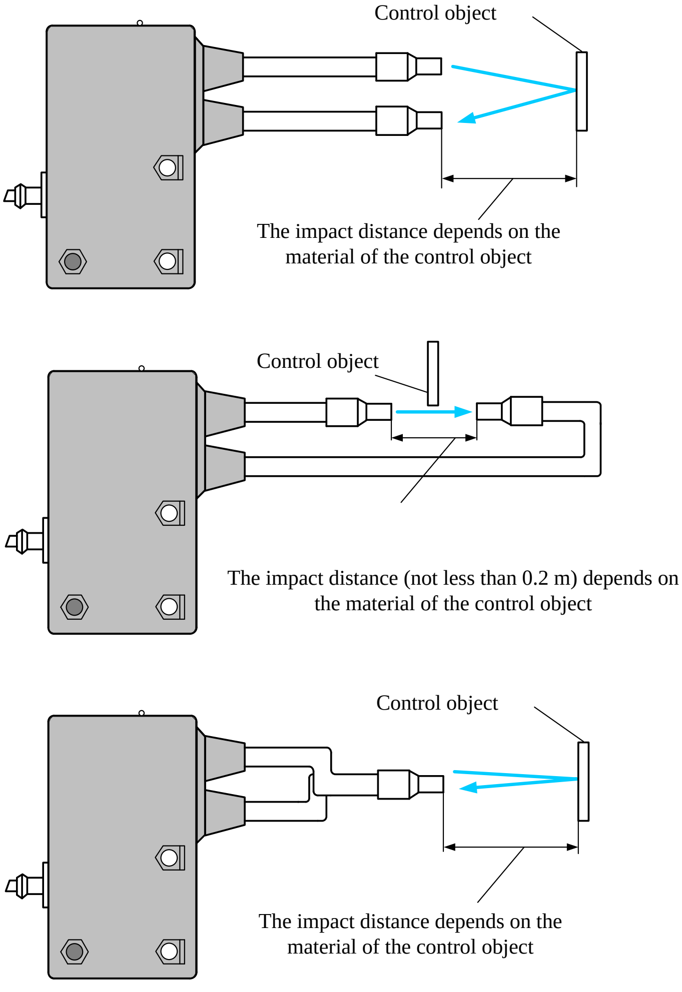

Fig. 5. Fiber optic sensors

IV. CONCLUSION

Today, electromagnetic induction sensors are used to count axles when organizing the movement of trains, as a result of which induction sensors are magnetized by magnetic induction after the movement of high-speed trains. Because of this, the electronic axle counting system gives a false message. The axle counting device, developed on the basis of the proposed optical sensors, is not influenced by high-speed trains, and in any conditions it is possible to calculate the axles of the rolling stock.

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