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Analysis of Influence of Disturbing Signals Caused by Rail Magnetization to a Cab Signaling System

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Introduction

The Automatic cab signaling system ALS (rus. АЛС – Автоматическая Локомотивная Сигнализация) is a road and cab equipment designed to transmit information about permissible train speed to a cab driver.

ALS equipment makes train control easier, controls actions of a cab driver, limits train speed and, if needed, stops the train. It also logs actions of a cab driver, train speed and other parameters.

The signaling system used in Lithuania is the uninterrupted automatic cab signaling system ALSN (rus. АЛСН – Автоматическая Локомотивная Сигнализация Непрерывного действия).

The ALSN equipment transforms traffic-light signals into a code – a combination of modulated pulses with 25 or 50 Hz alternating signal as a carrier. Pulses of current are transmitted to rails in front of a train and induce proportional electromotive force in pick-up coils of a cab. After signal processing and decoding, a respective signal is turned on in a cab dashboard. Code information is also used to control cab brakes in case train speed exceeds allowed by traffic-light signal.

During code generation, transmission and reception, disturbances occur. In case of wrong detection of codes, equipment of cab limits the train speed or even stops the train.

Unreasonable decreasing of speed, extra braking may constitute accidents, increase fuel consumption and disturb schedules. All these factors are being reflected in financial expenses [1].

According to information of SC “Lithuanian Railways”, up to 70% ALS disturbances occur due to uneven magnetization of rails.

Methods

Disturbing signals in a signaling system may occur due to magnetization of rails. Magnetization is possible due to various reasons: during manufacturing of rails, during welding, while exploiting, due to external magnetic fields or defects [2–5].

For evaluation of magnetization influence the measured data was used. There are different methods for measuring magnetic fields [6]. The measurement system was designed for experimental measurements [7]. The measurement system can measure magnetic flux density in three directions.

Model

The computer model of ALSN signals acquisition and processing in a cab was created. The aim of a computer simulation was to determine the influence of rail magnetization to the decoding of traffic-light signals while a train moves in different speeds. Measurements of rail magnetization were performed in railway and that data was used as a disturbing signal. The data was selected from a segment of rails where magnetization was relatively high.

The computer model includes generation of informative traffic-light signals, simulation of train movement, reception of useful and disturbing signals in a pick-up coil, filtration of signals in first stages of detection circuitry and decoding of information signals.

The model can be relatively divided into different stages. These are: generation of useful and disturbing signals, simulation of train movement, signal reception and signal processing.

The disturbing signal is shown in Fig. 1. It is magnetization of rail in respect of distance.

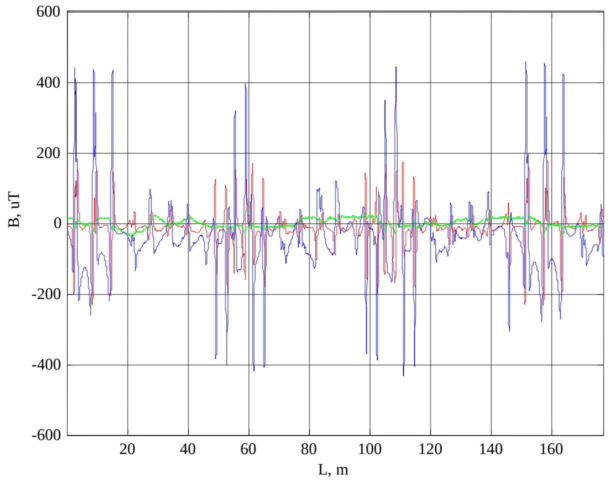

Fig. 1. Magnetization of rails (distance of 180 m)

While the train is moving, the received signal becomes the signal in time domain. Magnetization in respect of time as the train moves at speed of 10 m/s is shown in Fig. 2.

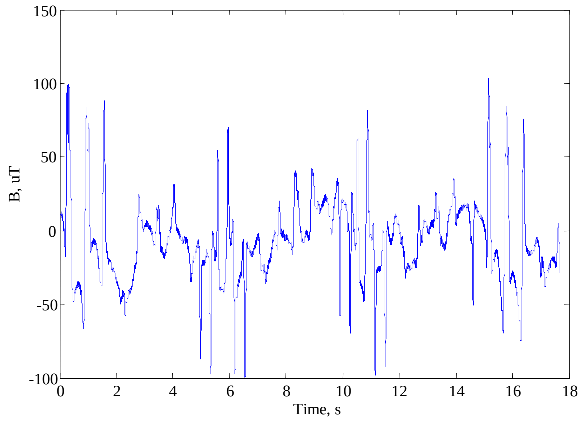

Fig. 2. Disturbing signal, when the train moves at speed of 10 m/s

The green traffic-light signal will be used as information signal as it has highest complexity. Parameters of the green signal are listed in table 1 [8].

Table 1. Time parameters of the green traffic-light signal

Signal code	**Duration of code signal, s**		
	1 pulse	**1 interval**	**2 pulse**
Green	0,35±0,0035	0,12±0,0012	0,22±0,0028
	2 interval	**3 pulse**	**Long interval**
	0,12±0,0012	0,22±0,0024	0,57±0,0048

The green traffic-light signal in time domain is shown in Fig. 3. Carrier frequency is 25 Hz.

Voltage proportional to a change of magnetic field is induced in a cab pick-up coil (magnetic field induces electromotive force). Therefore a signal acquired in a pick-up coil is equal to the differential of the magnetization distribution. The total acquired signal in the coil is shown in Fig. 4.

A diagram of signal acquisition model is shown in Fig. 5.

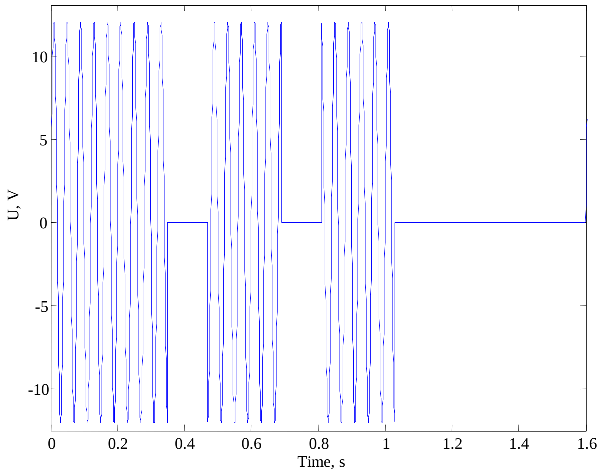

Fig. 3. "Green" signal in time domain

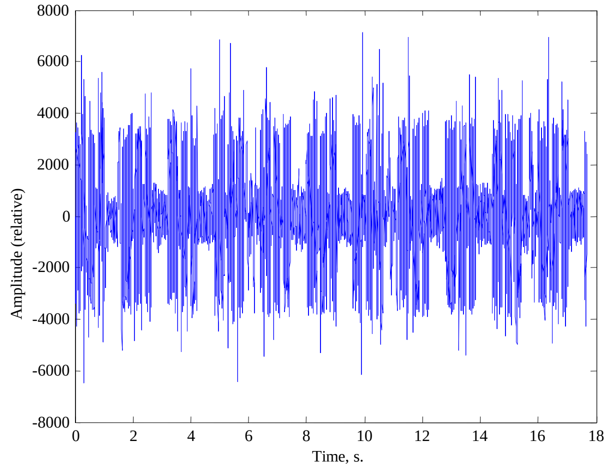

Fig. 4. The total acquired signal in a pick-up coil (information signal + noise)

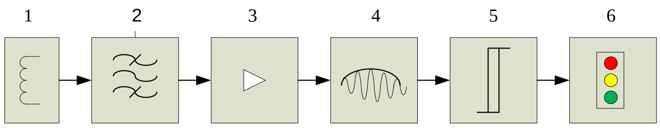

Fig. 5. A diagram of signal acquisition: 1 – pick-up coil; 2 – filter; 3 – amplifier; 4 – envelope detector; 5 – comparator; 6 – decoder

The pick-up coil acquires useful information signal together with a disturbing signal. Spectral views of information and disturbing signals are displayed in Fig. 6.

Acquired signal is passed through a resonant LC circuit. The center frequency of the contour is matched to the carrier frequency of the information signal, quality of the resonant circuit – 4.

A comparator forms rectangular pulses according to a given threshold level (in our case it is 0.5). The comparator uses hysteresis in order to avoid oscillations when the signal crosses the threshold level. The resulting packets are decoded by a decoder according to the lengths of pulses and intervals. Correctly and incorrectly decoded packets are shown in Fig. 7. A decision about the present traffic-light signal in decoder is taken if two of three recent packets match. The decoding system signalizes code failure after 6 consecutive incorrect packets.

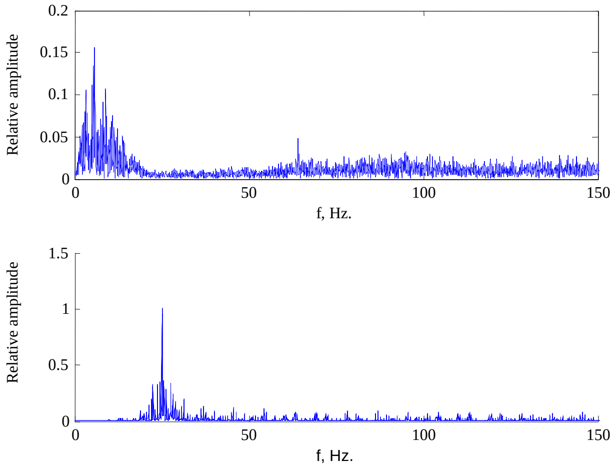

Fig. 6. Spectra of disturbing (top) and information (bottom) signals when speed of train is 10 m/s

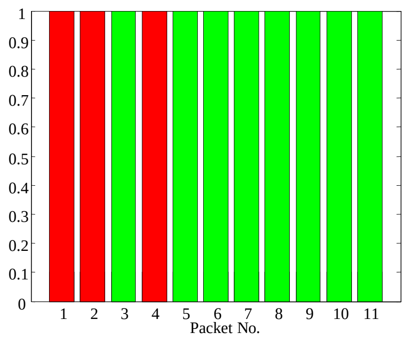

Fig. 7. Correctly (green) and incorrectly (red) decoded packets

3 of 11 packets are decoded incorrectly when speed of cab is 10 m/s. Thus 72.7% of packets are decoded correctly. Results, when speed of cab is 20 and 30 m/s, are shown in Figures 8 and 9.

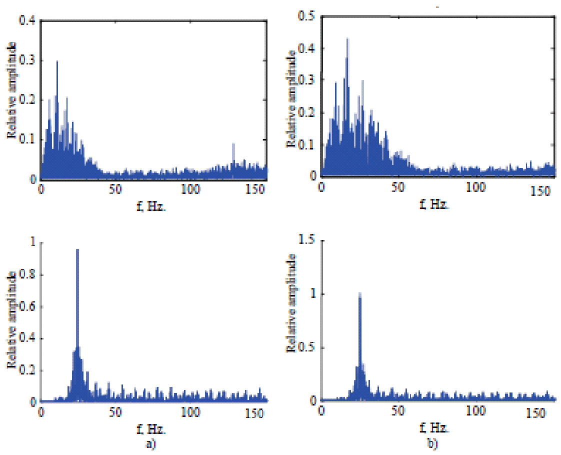

Fig. 8. Spectra of disturbing (top) and information (bottom) signals, when speed of a cab is 20 m/s (a) and 30 m/s (b)

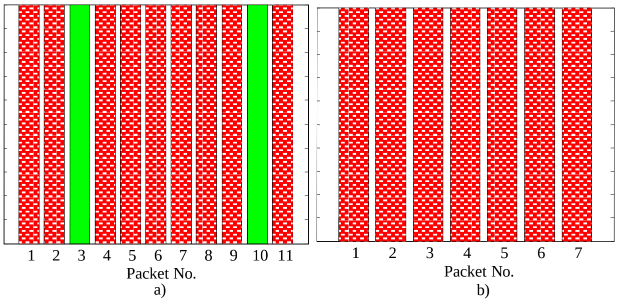

Fig. 9. Correctly and incorrectly decoded packets, when speed of a cab is 20 m/s (a) and 30 m/s (b)

According to the above examples, the ratio of correctly and incorrectly decoded packets decreases while speed of a cab increases. Further we will determine the relations between speed of train and correct signal decoding.

Fig. 10 displays relation between correctly decoded packets and cab speed, when the carrier frequency is 25 Hz.

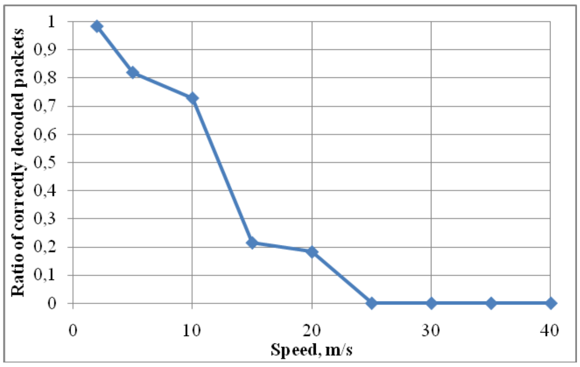

Fig. 10. Relation between correctly decoded signals and a cab speed, when the carrier frequency is 25 Hz

Fig. 11 shows the results, when the frequency is 50 Hz.

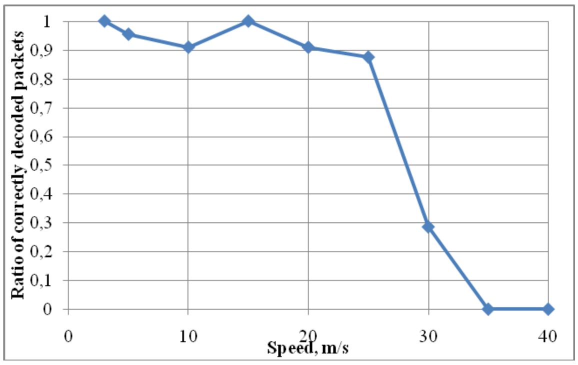

Fig. 11. Relation between correctly decoded signals and a cab speed, when the carrier frequency is 50 Hz

It can be seen that as the carrier frequency is 25 Hz, the ratio of correclty decoded signals starts decreasing almost linearly from the lowest speed and at speed of 25 m/s no packets are decoded correctly. When the carrier frequency is 50 Hz, the ratio of correctly decoded signals starts decreasing only from speed of 25 m/s and decreases rapildy. At speed of 35 m/s no packets are decoded correctly.

Conclusions

Acquisition and processing of information and disturbing signals in a cab have been made using computer simulation method. Influence of disturbing signal has been determined to the correct decoding of information signals, relations between locomotive speed, carrier frequency and decoding have been found.

The higher the cab speed, the higher influence the disturbing signal makes. Also, the disturbing signals make less influence if the carrier frequency is increased.

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A cab signaling system is used to transfer traffic-light signals to a cab. The signaling signals are magnetic field signals measured by a pick-up coil of a cab. A reception of informative signals is often disturbed by permanent magnetization of rails that occur due to different factors. In this article influence of such disturbing signals is described and their influence to signal reception system is analyzed. Different effects of disturbances to the detection of signaling signals are analyzed in subject to signaling signal frequency, cab speed and other factors. Ill. 11, bibl. 8, tabl. 1 (in English; abstracts in English, Russian and Lithuanian).

В. Аугутис, Д. Гайлюс, Р. Мисевичюс, В. Пронько. Исследование мешающего влияния намагничивания рельсов на локомотивную сигнализацию // Электроника и электротехника. – Каунас: Технология, 2010. – № 5(101). – С. 103–106.

Автоматическая локомотивная сигнализация используется для передачи сигналов светофоров в локомотив. Сигнализационные сигналы это магнитные сигналы, принимаемые приемными катушками локомотива. Прием информационных сигналов может искажатся из за постоянного намагничивания рельсов, которое имеет разные причины возникновения. В этой статье описывается такие мешающие сигналы, анализируется их влияние на прием сигнальных сигналов. Также анализируется влияние помех на прием сигнальных сигналов при разных сигнализационных частотах, скоростях локомотива и других факторах. Ил. 11, библ. 8, табл. 1 (на английском языке; рефераты на английском, русском и литовском яз.).

V. Augutis, D. Gailius, R. Misevičius, V. Pronko. Geležinkelio bėgių įmagnetinimo trukdžių lokomotyvo signalizacijai tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2010. – Nr. 5(101). – P. 103–106.

Geležinkelio signalizacijos sistema naudojama šviesoforo signalams perduoti į lokomotyvą. Signalizacijos signalai yra magnetinio lauko signalai, priimami lokomotyvo priėmimo ritėmis. Informacinių signalų priėmimą dažnai sutrikdo nuolatinis bėgių įmagnetinimas dėl įvairių veiksnių. Šiame straipsnyje aprašomi tokie trukdymo signalai, analizuojama jų įtaka signalizacijos signalų priėmimui. Analizuojama trukdžių įtaka signalizacijos signalų aptikimui priklausomai nuo jų dažnio, lokomotyvo greičio ir kitų veiksnių. Il. 11, bibl. 8, lent. 1 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).