INTERVAL REGULATION WITH TEMPORARY CHANNEL DIVISION

Bestemyanov, Petr F., *Moscow State University of Railway Engineering(MIIT), Moscow, Russia.*
Zakharov, Denis P., *Moscow State University of Railway Engineering (MIIT), Moscow, Russia.*

ABSTRACT

Known automatic cab signaling (continuous automatic cab signaling (CACS), integrated continuous cab signaling (ICCS)) involves integration of a separate signaling channel in the rail line, which is a disadvantage in terms of material and energy costs. Except for the coverage of the numerical code automatic locking cab signaling maintains its inherent weaknesses, in particular the problem of electromagnetic compatibility of transmission / reception path of track circuits in parallel operation of automatic blocking and automatic cab signaling. The objective of this article is to consider options for organization of polling / transmission based on requirements for the response time of the system for interval regulation with time division. With account for requirements for reducing energy consumption in the traffic control it is proposed to use a signal of the rail line control as a signal for automatic cab signaling using temporal division of channel for polling of track circuits and information transmission to the locomotive. Useful signal parameters are determined depending on the polling time of the area (response time of the system). It is shown that during temporary control of the rail line it is necessary to strive to have a selection of chains with approximately equal length, and to comply with a number of conditions.

Keywords: *railway, control system, interval traffic control, automatic locking, automatic cab signaling, time division.*

Background. *Known automatic cab signaling (continuous automatic cab signaling (CACS), integrated continuous cab signaling (ICCS)) involves the construction of a separate signaling channel in the rail line, which is a disadvantage in terms of material and energy costs. Except for the coverage of the numerical code automatic locking cab signaling maintains its inherent weaknesses, in particular the problem of electromagnetic compatibility of transmission / reception path of track circuits in parallel operation of automatic blocking (hereinafter-AB) and automatic cab signaling (hereinafter-ACS).*

Besides, long-term experience of operation of such systems, followed by improvement of circuit solutions, either experimental and theoretical research aimed at reducing the number of failures in the code cab signaling, did not permit to eliminate the existing shortcomings. On the railway network there is still a lot of operation disorders of ACS [1].

Many failures are associated with interference from reverse traction current of the rolling stock. Often they are neutralized by increasing amplitude of the useful signal at the input end of the track circuit. In general, the situation inevitably leads to search for adequate solutions.

One of them is organization of a time division of the channel for polling of a rail line. At the same time requirements for the parameters of the signal for rail line control and cab signaling should be changed. In the first place it refers to requirements for the signal-carrier frequency.

The work [2] contains the results of a study that shows the ability to transmit information to the locomotive using signals whose frequency lies in the tonal range.

The work [3] justifies the choice of the minimum current of ACS for the track circuit system of the microprocessor automatic blocking – central automatic blocking (CAB). Also, there are calculations of ACS mode using the time division of the polling / transmission channel.

Objective. *The objective of this article is to consider options for organization of polling / transmission based on requirements for the response time of the system for interval regulation with time division.*

Methods. *The authors use electric engineering analysis, comparative method, evaluation method.*

Results.

1. Polling channel of the track circuit

The main idea of the method of time division is a cyclic polling of track circuits using a single transmitter and receiver for multiple track circuits that are switched by the commutation switch [4] (Pic. 1).

When engineering systems of interval regulation it is necessary to take into account the response time of the system, since this parameter has a significant impact on the capacity of the site.

For temporary control of the track circuit the most important parameter is time for polling of the controlled area T_{pol}, during which all track circuits of the haul will be polled. This is also a maximum possible time interval when there is a change in train situation solutions, provided that the actual change in state of the track circuit (block section) had passed immediately after removing the control and transition to the next stage. This interval characterizes the response time of the system.

Under the time of polling a track circuit $\tau_{TC}=\tau_{COM}+\tau_{TRP}+\tau_{TS}$ we understand:

τ_{COM} is the time required for triggering of switching commutation devices of the transmitter and the receiver;

τ_{TRP} is the time for transmission, reception and processing of the signal;

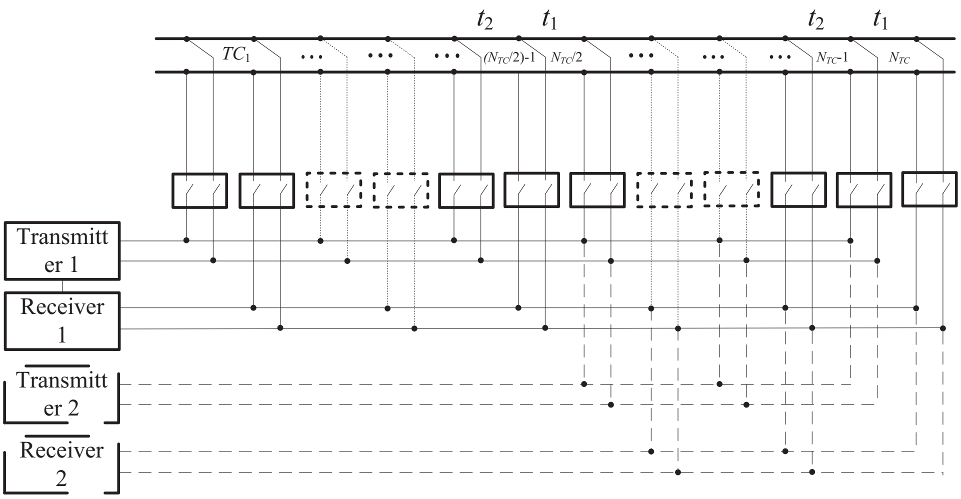
τ_{TS} is the time to make decision on the train situation.

For a fixed time of polling of one track circuit τ_{TC}=const the polling time of the section is:

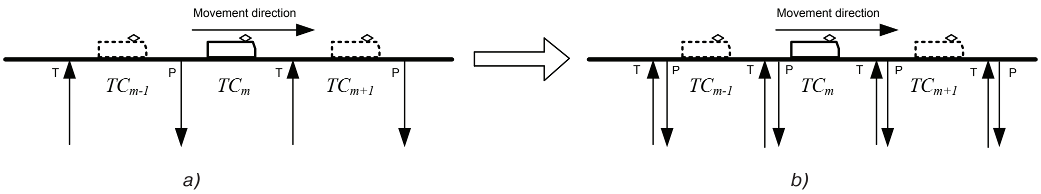
$$T_{pol}=\frac{N_{TC}}{\tau_{TC}}, \qquad (1)$$

where N_{TC} is a number of track circuits at the section.

To determine the change of the operating mode of each track circuit, the time when the train moves with a maximum speed at the shortest cir-



Pic. 1. Organization of polling track circuits of the section.



Pic. 2. Options for transmitting a signal to the locomotive with track circuits at time division of the polling / transmission channel.

cuit of the haul must be greater than the polling time of the whole section:

$$T_{pol} < \frac{l_{TC\min}}{V_{\max}}, \qquad (2)$$

where V_{max} is a maximum speed of the train motion at the section, l_{TCmin} is a minimal length of the track circuit at the controlled section.

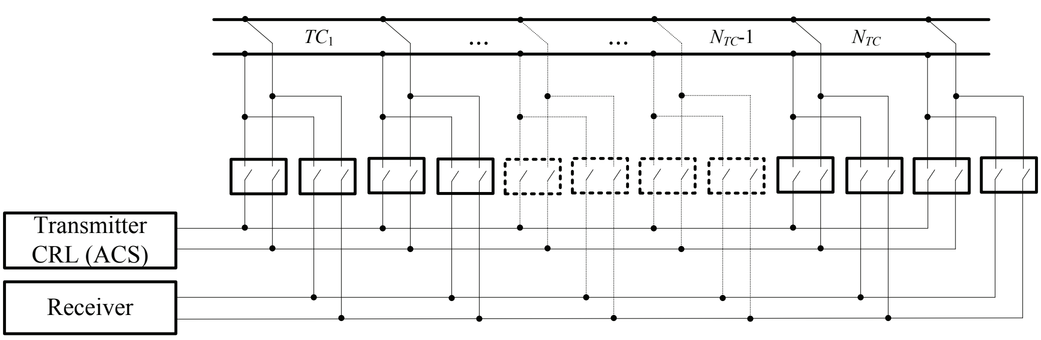
This requirement imposes limitation on the number of track circuits, which can be controlled by one transmitter and one receiver:

$$N_{TC} < \frac{l_{TC\min}}{V_{\max}\cdot\tau_{TC}}. \qquad (3)$$

In other words, if within the controlled section there is a track circuit, the length of which is much smaller than that of all the others, this entails a reduction in the polling time and, as a consequence, the number of track circuits that can be polled by one pair of transmitter / receiver.

To a greater extent the polling time is affected by the time for transmission, reception and processing of the signal τ_{TRP} [5]. If there is a number of track circuits which do not satisfy the condition (3) at the section, it is necessary to use another pair of transmitter-receiver. For this purpose a first pair of transmitter-receiver will carry out polling track circuits from $N_{TC}/2$ (for an odd number – $(N_{TC}\pm1)/2$) to N_{TC}. The second transmitter-receiver pair controls remaining track circuits from the first to $N_{TC}/2$ $(N_{TC}\pm1)/2$).

For track circuits without isolating joints it is required to exclude interference of signals of track circuits polled simultaneously. One of the easiest options is a synchronous polling of circuits, the most distant from each other. For this purpose it is necessary at the polling time t_1 (Pic.



Pic. 3. Organization of polling of track circuits using a signal CRL=ACS.

1) of the track circuit N_{TC} to poll a track circuit $N_{TC}/2(N_{TC}\pm1)/2)$, at the polling time t_2 – a track circuit $N_{TC}-1$ and $(N_{TC}/2)-1$ $((N_{TC}\pm1)/2)-1)$, and so forth. With an odd number of track circuits the pair of transmitter-receiver will control one track circuit more than the other. Therefore, we need to delay the start of the next cycle by the second pair (τ_{TC}) that does not reduce the total polling time of the section. The number of commutation switches in the polling of the section will be $N_{TC}+1$.

To eliminate the interference, it is possible to use a block joint, then the time delay prior to the commencement of a new polling cycle by one pair of transmitter-receiver is not necessary.

To increase the maximum possible time to poll the site using a transmitter and receiver it is better not to poll one track circuit, but one block section.

The time of train movement at a maximum speed on the block section with the shortest length l_{BSmin} should be more than polling time of the controlled section:

$$T_{pol} < \frac{l_{BS\min}}{V_{\max}}. \quad (4)$$

The largest time is required to poll a block section with the greatest number of track circuits. In this case a limitation is imposed on a number of track circuits, located within the whole controlled section –

$$N_{TC} < \frac{l_{BS\min}}{V_{\max}\cdot\tau_{TC}}, \quad (5)$$

as well as on their number within each of block sections. If the number of circuits of one block section will be significantly different from their counterparts in the other, it will lead to reduction in the amount of track circuits that can be controlled by a single pair of transmitter-receiver. The best option is a case where the number of circuits within the block section N_{TCBS} tends to the average for the entire section:

$$N_{TCBS} < \frac{l_{BS\min}}{V_{\max}\cdot N_{BS}\cdot\tau_{TC}}, \quad (6)$$

where N_{BS} is a number of controlled block sections.

Such a method of control is characterized by an increased response time as compared to the previous, since the time of the train movement on the block section is longer than the movement time on one track circuit.

2. Additional channel of information transmission to the locomotive

Let's consider options for transmitting a signal to the locomotive on the background of a time division of a channel polling/transmission (CRL), that is, by using the CRL signal as information for ACS.

From the feed end of the rail line, the signal is transmitted to the locomotive devices of the train.

At the time division of the channel of the rail line polling using track circuits without isolating joints the reception of a signal is possible when it is located on TC_m (Pic. 2a), i. e., during motion of the train to the supply end of the track circuit and at the time of the polling TC_{m+1} or TC_m.

Being on the track circuit TC_{m-1}, locomotive loses the opportunity of a qualitative reception of the signal, a number of limitations arises, because at the time of polling TC_{m+1} and TC_m a train moves to the relay end.

Consequently, the cyclical polling of track circuits in the direction to the train movement a locomotive does not receive information about the train situation on TC_{m-1} and TC_{m+1}, and twice receives the information on TC_m.

Conclusions. For locomotive devices to have the ability to receive a signal being at any track circuit of the section, it is necessary to change the organization of polling as shown in Pic. 2b, by the method of connecting the transceiver devices (Pic. 3). Such an organization of polling of track circuits will enable to transmit information to the locomotive as it moves in both directions. The number of commutation switches is $2N_{TC}+2$.

When using track circuits with insulating joints within the rail line it is necessary to use an opportunity to connect a transmitter and a receiver at each of its ends. Then the number of required commutation switches will be $4N_{TC}$.

REFERENCES

1. Gorenbeyn, E.V., Lukoyanov, S.V., Vologzhanin, V. V. Failures of CACS codes and their account [*Sboi kodov ALSN i ih uchet*]. *Avtomatika, svyaz' i informatika*, 2012, Iss.7, pp.18–22.

2. Bestemyanov, P.F., Zakharov, D. P. On the study of signal transmission path from the track to the locomotive [*K issledovaniyu trakta peredachi signalov s puti na lokomotiv*]. *Elektronika i elektrooborudovanie transporta*, 2013, Iss.5, pp.5–11.

3. Bestemyanov, P.F., Zakharov, D. P. Methods of selecting parameters of automatic cab signaling in the system of interval traffic control with time division of channels [*Metodika vybora parametrov signalov avtomaticheskoy lokomotivnoy signalizatsii v sisteme interval'nogo regulirovaniya dvizheniya poezdov s vremennym razdeleniem kanalov*]. *Elektrotehnika*, 2014, Iss.8, pp.3–11.

4. Bestemyanov, P.F., Lisenkov, V. M. Automatic blocking. Patent RU 2341394 C2, B61L1/00. Posted on 27.09.2007 Bulletin № 27 / 2007 [*Ustroystvo avtomaticheskoy blokirovki. Patent RU 2341394 C2, B61L1/00. Opublikovano 27.09.2007 Byul. № 27/2007*].

5. Pavlov, E. V. Methods to improve the safety of operation of the centralized systems of automatic locking. Ph. D. (Tech.) thesis [*Metody povysheniya bezopasnosti funktsionirovaniya tsentralizovannyh sistem avtoblokirovki. Dis... kand. tehn. nauk*]. Moscow, 2005, 154 p.

Information about the authors:
Bestemyanov, Petr F. – D. Sc. (Eng.), professor, director of the Institute of transport vehicles and control systems of Moscow State University of Railway Engineering(MIIT), Moscow, Russia, bestpetr4@gmail.
Zakharov, Denis P. – Ph. D. student of the department of Automation, remote control and communication in railway transport of Moscow State University of Railway Engineering (MIIT), Moscow, Russia, dannyz@bk.ru.

Article received 15.10.2014, accepted 27.12.2014.

Acknowledgments. The research was held and article was written with the support of Russian Foundation for Basic Research, grant № 13–08–13138.