Improvement of the power grid system of the East Siberian Railway

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Abstract. The foreign experience analysis and the mathematical modeling system use have shown that the use of virtual coupling train driving technology will increase line section by an average of 10 to 40%, depending on the energy network and traffic schedule saturation.

1. Introduction
ERTMS is based on the monitoring of the transportation process using a various technical means combination, which ensures a safe reduction in the passing traffic interval, which means an increase in the railway lines sections capacity, and energy loss amount minimization in the contact network [1-2].

Electronic monitoring devices that determine the release of the train by the pressure drop in the brake line in the last railroad car are widely used in North America and South Africa. The disadvantage of these systems is that they do not allow you to detect a train break quickly enough. On Kazakhstan railways, full-component control modules are duplicated by wheel-set counters [3-4].

The foreign experience analysis and the mathematical modeling system use have shown that the use of virtual coupling train driving technology will increase the capacity of a railway line section by an average of 10 to 40%, depending on the energy network and traffic schedule saturation [5-6].

2. Automated intelligent driving system
In order to ensure regular and safe driving of increased mass trains up to 18 thousand tons and length up to 780 axles with locomotives distributed along their length, one locomotive team of VNIIZHT has created an intelligent automated driving system for such trains (AIDS-RT) (figure 1) [7].
The AIDS-RT auto-driving system provides automatic limitation of longitudinal dynamic forces in excess of the permissible ones in the connected train, which eliminates the possibility of squeezing railroad cars and breaking auto-couplings in all control modes. The system is used on all electric locomotives trains.

The further development work of AIDS-RT-M is scheduled. Currently, the system allows you to drive only two trains in a virtual coupling. By the end of the year, the task is to finalize the equipment for automatic management of a five-train package. However, with the large trains in the number introduction, the distance between locomotives increases and serious difficulties arise in the radio channel operation [1, 8].

3. Improvement of the 27.5 kV system

The main operating mode metrics of the network system of the Achinsk–Mariinsk according to the results are presented in table 1, and the Achinsk – krasnyarsk-Vostochny section – in table 2.
Connected train’s batch schedule is 54 minutes, and the interval between two trains in virtual coupling mode is 4 minutes, then with a virtual coupling is 50 minutes (figure 3).

![Figure 3](image1.png)

**Figure 3.** Train schedule with a 50-minute interval on the Achinsk – Mariinsk.

![Figure 4](image2.png)

**Figure 4.** Train schedule with a 24-minute interval on the Achinsk – Mariinsk.

The calculation results of the traction power network system operating modes on the Achinsk – Mariinsk, shown in table 1, it is clear that all the traction network characteristics accept the permissible norms (figure 4).

Accordingly, the interval for a train schedule consisting of trains with a virtual coupling will be 42 and 38 minutes (figure 5-6).
Table 1. Main operating modes’ characteristics.

| Parameters                           | Connection   | “Virtual coupling” |
|--------------------------------------|--------------|--------------------|
| Inter-train interval, min            | 54           | 50 + 4             |
| Calculation time, min                | 660          | 665                |
| Air temperature, °C                  | 20           | 20                 |
| Power consumption, active, kW·h      | 366868       | 364457             |
| Traction network losses, kW·h        | 12521 (3.4 %)| 8741 (2.4 %)       |
| Load limiting factor                 | 1.43         | 1.31               |
| Transformer oil temperature, °C      | 68           | 65                 |
| Voltage, kV                          | 21.02        | 22.71              |
| Temperature limit, °C                | 21           | 23                 |

Figure 5. Train schedule on the Achinsk – Krasnoyarsk-Vostochny.
Figure 6. Train schedule on the Achinsk – Krasnoyarsk-Vostochny with a 38-minute interval.

For a batch schedule with a virtual coupling, we reduce the interval to the minimum value (figure 7). The calculation results of the power network system operating modes of the Achinsk – Krasnoyarsk-Vostochny, shown in table 2, it is clear that all the traction network characteristics accept the permissible norms [7].

Figure 7. Train schedule on the Achinsk – Krasnoyarsk-Vostochny with a 25-minute interval.
Table 2. Main characteristics of the Achinsk – Krasnoyarsk-Vostochny section.

| Parameters                        | Type                  | Connection     | Virtual regime           |
|----------------------------------|-----------------------|----------------|--------------------------|
| Inter-train interval, min        | 42                    | 38 + 4         | 25 + 4                   |
| Calculation time, min            | 555                   | 560            | 445                      |
| Air temperature, °C              | 20                    | 20             | 20                       |
| Power consumption, active, kW·h  | 514724                | 500992         | 496048                   |
| Power consumption, reactive, kW·h| 271795                | 255973         | 265146                   |
| Traction network losses, kW·h    | 12406 (2.5 %)         | 12817 (2.6 %)  |                          |
| Load limiting factor             | 1.45                  | 1.45           |                          |
| Transformer oil temperature, °C  | 21.46                 | 21.28          | 21.86                    |
| Voltage, kV                       | minimum               | (2nd line of Buchag – K-sk-Vostochniy section, train No. 2 on km 4113.1 in 169 min) | (1st line of Buchag – K-sk-Vostochniy section, train No. 17 on km 4114.74 in 175 min) |
| Voltage, kV                       | average 3-min         | (2nd line of Buchag – K-sk-Vostochniy section, train No. 2 on km 4115.46) | (1st line of Buchag – K-sk-Vostochniy section, train No. 17 on km 4115.51) |
| Temperature limit, °C            | in the contact network | 26             | 35                       |
| Temperature limit, °C            | in the suction line   | (F4 EChE Achinsk) | (F4 EChE Achinsk) |

4. Conclusion

For a batch schedule consisting we reduce the minimum value. According to the calculation results of the power network system operating modes it is clear that all the traction network characteristics accept the permissible norms.

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