# Method for protecting neutral inserts of the contact line from interphase short-circuit currents

S.A. Norjigitov[1][a], I.A. Karimov[1][b], I.U. Abduazimova[1][c]
[1]Tashkent state transport university, Tashkent, Uzbekistan

Abstract: The method relates to electrified railways and, more specifically, to the protection of neutral inserts of an AC contact line. The technical result consists in automatically disconnecting the operating voltage prior to the occurrence of an inter-phase short circuit on the device to be protected.
Keywords: contact line, neutral insert, microcontroller, feeder zone, electric rolling stock

## 1. Introduction

In the protection method, special modules are used that react to the appearance of a load current when approaching neutral inserts of the contact line. Then, the signal is transmitted via a wireless communication line to another module, which will give the command to disconnect the power supply switch of the contact line. The current sensor is set in such a way that the switch switch is switched off before the start of a possible short circuit. This method effectively prevents the occurrence of interphase short-circuits on neutral inserts.

## 2. Methodology

On AC traction lines, in order to symmetrize loads to the power system, the feeder zones of the contact line (CL) and the rail chains are fed alternately from different phases (A, B and C) (Fig-1). To ensure reliable insulation between the different phases of the CL (1), neutral inserts (NI) are mounted. NI consist of two insulating interfaces (2 and 6) between which is a section of the contact line with a neutral potential (3). When following the electric rolling stock (ERS) on NI, the screw of the current collector (4) alternately closes the insulating interfaces (2) and (6). If the ERS follows the NI in the current consumption mode, an electric arc (5) is formed on the insulating interfacial short circuit (2), resulting in an interphase short circuit between the CL sections. In cases where adjacent substations supply both sides of the NI, the existing relay protection system is not able to react proactively, since the instantaneous values of current, voltage and resistance vectors during the short circuit will be outside the area of operation of the shield.

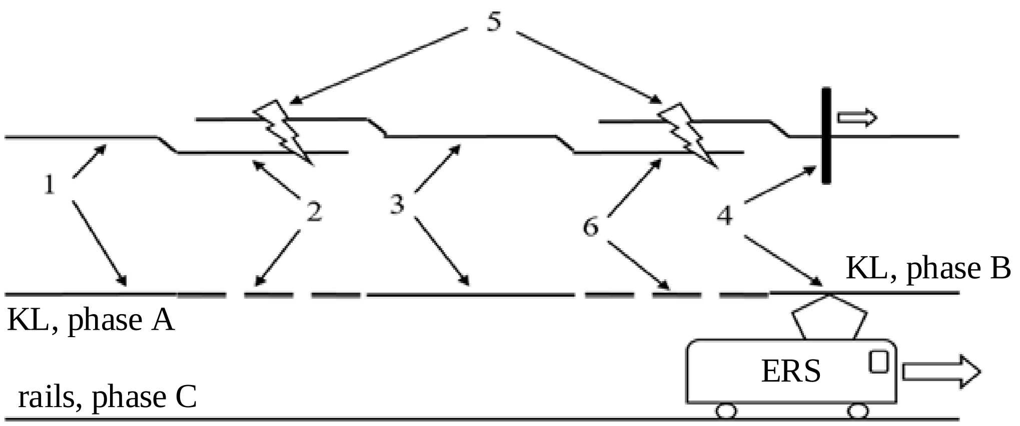


**Fig.1. The feeder zones of the contact line**

In order to prevent carbon repetition of neutral inserts, according to the requirements of railway technical regulations (RTR), when approaching NI, ERS drivers are obliged to relieve the traction load by disabling the main switch (MS) on ERS and follow NI with its inertia. To indicate to the driver of the ERS the border beyond which he must follow with the shutdown of the entire load, a railway sign «turn off the current» is installed at a distance of 50 meters before the start of NI. In the absence of a traction load during the transition through NI, a weak electric arc is formed on the insulating interfaces (2) and (6), which is extinguished immediately after the passage of the current collector (4). The safe running of ERS on NI is ensured only by the vigilance of the locomotive crew, and known methods of automated protection react after the appearance of an electric arc with a significant power of the short circuit. Therefore, the loss of vigilance of the locomotive crews in

[a] https://orcid.org/0009-0005-0999-7032
[b] https://orcid.org/0000-0002-5221-0443
[c] https://orcid.org/0009-0002-6036-9857

the approach to NI results in the overtaking of the NI and the resulting negative consequences.

A method is known for protecting NI by disconnecting the supply switches in case the current and voltage vectors are at a certain angle from each other (Patent RU2241295C2 from 10.07.2000). For the implementation of this method, the voltage on the tyres and currents on the right and left of the sectioning station buses and the phase angle between this voltage and each of the above-mentioned currents are measured at each sectioning station. In this case, the conclusion about the occurrence of a short-circuit on the neutral insert and the need to disconnect the feeders of the sectioning station, directed towards the neutral insert separating the area in question from the adjacent interstage zone, shall be made, supplied by an upstream voltage if the current exceeds the specified value (or the pull resistance will be below the specified value)and its phase angle is not less than 70 degrees less than the voltage on the buses of the sectioning station and not more than 180 degrees less than the electric degree, or the disconnection of feeders of the sectioning station directed towards the neutral insert, separating the area in question and the adjacent interdirectional zone fed by a lagging voltage if the current exceeds the specified value (or the drag resistance of the traction line will be below the specified value)And its phase angle exceeds the voltage on the sectioning station tires by no more than 20 electric degrees or lags no more than 15 electric degrees.

The known method has the following drawbacks:

1) The protective voltage cut-off occurs after the interphase short-circuit occurs on the neutral insert. Therefore, until the moment of activation of the protective voltage cut, the electric arc that has appeared on the insulating conjugation for some time will have time to adversely affect the elements of the contact line;

2) when changing the power supply circuit of the contact line (power supply of the contact line section is provided from another section of buses or from another substation), this method will not give the required effect. In fact, regularly during maintenance, as well as in emergency situations, the power circuit of the contact line is changed. In such cases, in order to ensure the sensitivity of the protection to short-circuit currents and to relieve the load currents, the operating parameters of the protection devices should be redefined and set for each version of the power supply scheme [1, p.485].

3) the presence in the line of reactive power compensation devices prevents the adequate functioning of the protection method (in the mode of reactive power overcompensation, the protection will be falsified) [2, p.191].

The proposed NI protection system provides for the automatic deactivation of the CL feeder switches in the event that the ERS approaches the NI without disabling the load. The simplified operating principle of this method is indicated in Fig.2. For the implementation of the method, electrical shunts (3, 4) with CT-1 and CT-2 current transformers are mounted on two sides of the insulating interfaces (1, 2). Electric shunts (3, 4) should be installed as the ERS moves, after the sign «disconnect current» (5, 6) and until the insulation coupling (1, 2). Each current transformer is connected to its SPTM-1 and SPTM-2 signal processing and transmission module, which via the GSM wireless line can transmit signals to the corresponding signal receiving modules (SRM-1, SRM-2) connected to the circuit breaker CB-1 and CB-2. When the SRM-1 and SRM-2 signal is received, CB-1 and CB-2 switches can be switched off.

The method of protection works on the following principle:

Moving towards NI, the electric locomotive passes the sign «cut off the current», and then under the electric shunt (3). If at this time the load on the ERS is not switched off, according to the Kirchhoff laws, there are currents ($I_1$) and ($I_2$) flowing between the points a and b, the sum of which is the load current ($I_L$). From the effect of current ($I_2$) on the secondary winding CT-1 will be generated an analog signal, which is transmitted to SPTM-1. In SPTM-1 is converted, compared with established limits. If the level and duration of the signal exceed the established limits, the signal is transmitted via the wireless line to the SRM-1 module. After that, the SRM-1 gives the switch CB-1 a signal to disconnect and thus the left power arm NI. As a result, the possibility of formation of an inter-phase short-circuits is prevented.

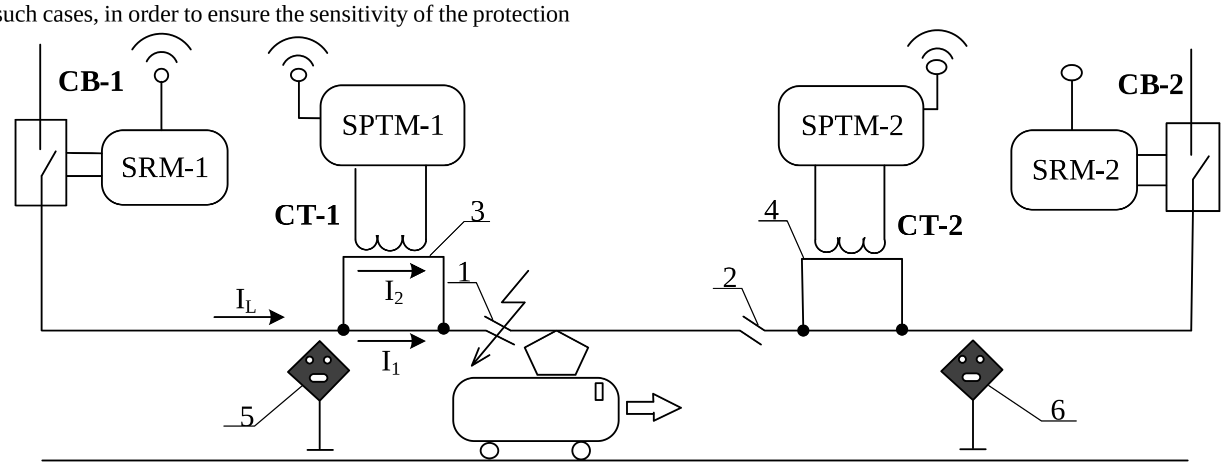


**Fig. 2. The simplified operating principle of this method is indicated**

In the opposite direction of the ERS, the process occurs in a similar way, but with the participation of SPTM-2 and SRM -2.

In order to reduce the deactivation, the communication between the modules is organized so that SPTM-1 can only transmit signals to SRM-1 and SPTM-2 to SRM-2. In this way, the power will be deactivated on the CL site from which ERS enters NI.

The main functional elements in the implementation of the proposed method are the modules SPTM-1 and SPTM -

2, which consist of three main components: a microcontroller (MC), a GSM communication module and a power supply unit (PSU) (Fig.3). The signal from the CT first goes to the MC, where in the block of the ADC (analog-digital converter), the analog signal is converted into a digital signal and transmitted to the microprocessor MC. The microprocessor compares the received signal with the established limits. If the level and duration of the signal exceed the established limits, the signal is transmitted to the GSM communication module. In the GSM module, the signal is converted according to the TCP/IP communication protocol and further via the M2M technology via wireless transmission to the receiving modules of SRM-1 or SRM-2. The SRM-1 and SRM-2 modules look simpler than SPTM modules. A stand-alone power supply is not required.

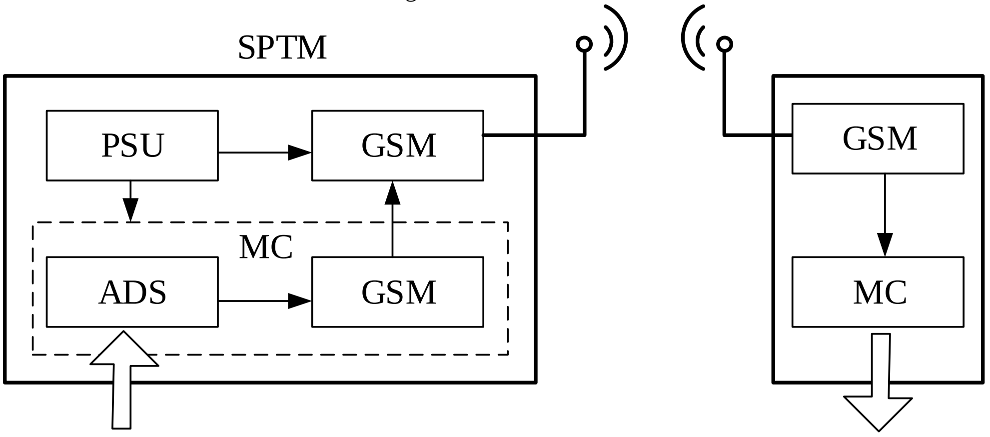


**Fig.3. GSM communication module and a power supply unit**

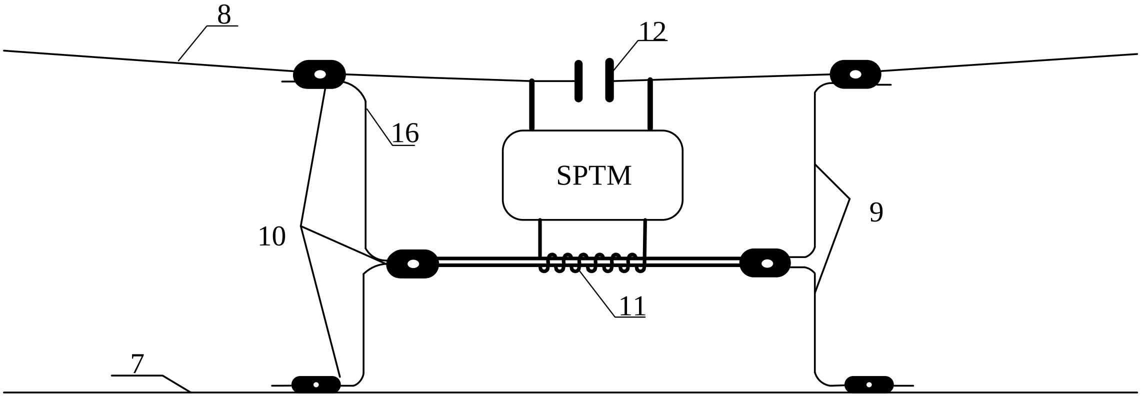


**Fig. 4. An approximate method of mounting SPTM on the contact suspension**

Account should be taken of the fact that the SPTM is suspended on the bearing cable of the contact suspension and will be under the potential of 25 kV from the ground. In this regard, all parts of the SPTM, except the antenna, should be protected by the screen from electromagnetic interference of the medium. Also, PSU should operate autonomously, that is, you need to use rechargeable batteries. To extend the life of the PSU batteries, you can mount a fragment of the solar panel on the SPTM. Figure 4 shows an approximate method of mounting SPTM on the contact suspension. Electrical connectors (9) are fixed to the bearing cable (8) and to the contact wire (7) by means of connecting clamps (10) which act as shunt. A winding (11) is wound onto the shunt, which acts as a current transformer. In order to increase the sensitivity of current measurement, an insulator (12) is cut onto the bearing cable (8).

## 3. Conclusion

The selection of types of components (electric shunts, current transformers, microcontrollers, GSM modules, etc.) will be carried out taking into account local conditions and the results of preliminary calculations. The SPTM and SRM modules can be integrated with existing ACS or SCADA systems.

## References

[1] Markvardt K.G. Electricity supply of electrified railways. -M.: Transport. 1982. 528 p.

[2] Electricity supply of railways: textbook. E.V. Ter-Oganov, A.A. Pyshkin. UrSUP. Yekaterinburg-2014. - 432p.

[3] Bondarev N.A. Chekulayev V.E. Contact Line: textbook. - M.: Route, 2006. - 590p.

[4] Microcontrollers for automation systems: training manual. Moscow. Info-Engineering, 2022. - 168s.

[5] Zhilenkov N. New technologies of wireless data transmission // STA. 2003.

[6] Samarin A.V., Rygalin D.B., Shklyaev A.A. Modern technologies of monitoring of air power grids of power lines // Natural and technical sciences. 2012. 1, 2.

[7] Amirov S.F., Karimov I.A., Abduazimova I.U. Application of the method of direct mathematical modeling to diamond-shaped contact lines // E3S Web of

Conferences 401, 02060 (2023) *CONMECHYDRO – 2023* https://doi.org/10.1051/e3sconf/202340102060

[8] Yakubov M., Karimov I., Abdullaev D. Structure and distribution of function between the stages of the information and measurement system for diagnostics of traction substations and contact network installations // (2023) E3S Web of Conferences, 383.

[9] *Ildar* Bayanov*, *Timur* Badretdinov, *Sardor* Muminov, *Islom* Karimov, *Saidaziz* Saydivaliev, and *Elyor* Saliyev The electric field of the sliding contact during the interaction of the pantograph and the contact wire E3S Web of Conferences 264, 04029 (2021) *CONMECHYDRO – 2021* https://doi.org/10.1051/e3sconf/202126404029.

## Information about the author


| | |
|---|---|
| **Norjigitov Sayfiddin** | senior lecturer, Department of Electricity Supply, Tashkent State Transport University. Email: sayfiddinnorjigitov@gmail.com https://orcid.org/0009-0005-0999-7032 |
| **Karimov Islom** | senior lecturer, PhD, Department of Electricity, Tashkent State Transport University. Email: nauka.islom@gamil.com https:/orcid.org/0000-0002-5221-0443 |
| **Abduazimova Iroda** | assistant at the Department of Applied Mechanics, Tashkent State Transport University. Email: abduazimova1993@gmail.com https://orcid.org/0000-0003-2727-2180 |