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Fault to Earth and Electric Shock Protection System Minimising Stray Currents Caused by 3 kV D.C. Traction System.

The suitable electric shock protection level in 3kVDC railways net circuits is obtained by enable a quick switch-off of short-circuiting current by a high-speed breaker (HSB) of a feeder in a traction substation. Breaking of the current comes when its value is higher then setting of overcurrent release in HSB. Breaking time, for actually used breakers type BWS, normally is no more than 30 miliseconds.
Presented below Electric Shock Protection and Earth Fault Protection System equipped with Voltage-Limiting Devices type TZD provides breaking earth-fault currents (quick transformation earth-fault to pole-to-pole fault with high current), reliable electric shock protection level and significantly reduces stray currents.

PKP Energetyka company has been leading for over a dozen years study and research works connected with earth fault breaking capacity assurance in the 3 kV d.c. feeding traction system under several conditions, such as: reliable electric shock protection and stray currents minimisation. Requirements concerned breaking capacity of short-circuit currents, electric shock protection and stray current limiting usually are contradictional to each other or even exclude each other.
The presented below system, called *a group bonding system* meets all the requirements; guarantees breaking capacity of earth current in a feeding systems of d.c. traction, assures the suitable electric shock protection level and minimisation of stray currents.

There is presented in the Figure 1 the diagram of the placement of equipment and resistances to earth having influence on the system operation. Under normal state of the system a track return system is isolated from resistance to earth of supports of catenary R_s, resistance to earth of the protected object and from resistance to earth of a feeder station R_u. Such a situation

creates a state, in which the return system resistance to earth is not shunted by other resistances, which means that depends only on construction and technical condition of a track.. All of these, as a result, minimise stray currents. In a case of fault to earth, according to the point of this fault, a Voltage-Limiting Device TZD-1NR or EZZ starts to conduct the current**.** As a result, earth fault is changed into a pole(+)-to-pole(-) fault. This anables a quick switch-off of short-circuiting current by a high-speed breaker of a feeder in a traction substation.
After a short-circuit is clearing, the resistance of a short-circuiting thyristor device returns to a high level. The process is natural when traction vehicle goes along the rails near the point where the conducted VLD is mounted. If minus pool on substation is isolated from earth, the change of rail voltage is possible regarding of energy consumption place. Reverse polarization causes switching off the VLD.

In the enclosed figures there are presented example situations showing a path of flowing current under breakdown situation (Fig.2 and 3) or during tests (Fig. 4).
For purposes of testing system elements and measurements of the resistances, having influence of the operation of the protection system, a special measuring equipment has been worked-out.
Portable pulse resistance meter IMR has been made for the R_L, (equivalent to earth resistance of a group bonding system), R_s, R_{uz} and R_{ob} resistance measurement. The meter is suitable for measurements, made during normal operation of the protection system, without turn off voltage in the catenary. The track return system is used as a reference , when it's resistance R_{sz} is known (range: 0,1÷0,2). It is possible to use the meter for measurements of other type of to earth resistance around electrified railways and tramway tracks.

The stationary type of the meter is device TCK – a tester of continuity of return cables used in traction substations and track sectioning cabins for monitoring to earth resistance and to control continuity of return cables.

For testing the Voltage-Limiting Devices a special equipment has been worked out. This tester is adapted for making measurements of basic parameters of TZDs during their normal operation without turn off the power supply of catenary.

At Polish State Railways network all of 450 traction substations and most of the track sectioning cabins are equipped with to earth fault protection system type EZZ, TUZZ or UZZ.

Continuity of return cables test devices TCK are installed in dozens of feeder stations, which nowadays it is an obligatory standard in newly constructed and modernised objects.

Voltage-Limiting Devices type TZD in a group bonding system are installed on several hundred kilometres of electrified railways (about 5000 pcs) and hundreds of them are used for protection of other objects such as: bridges, viaducts, signalling switchboard and distribution containers and others.

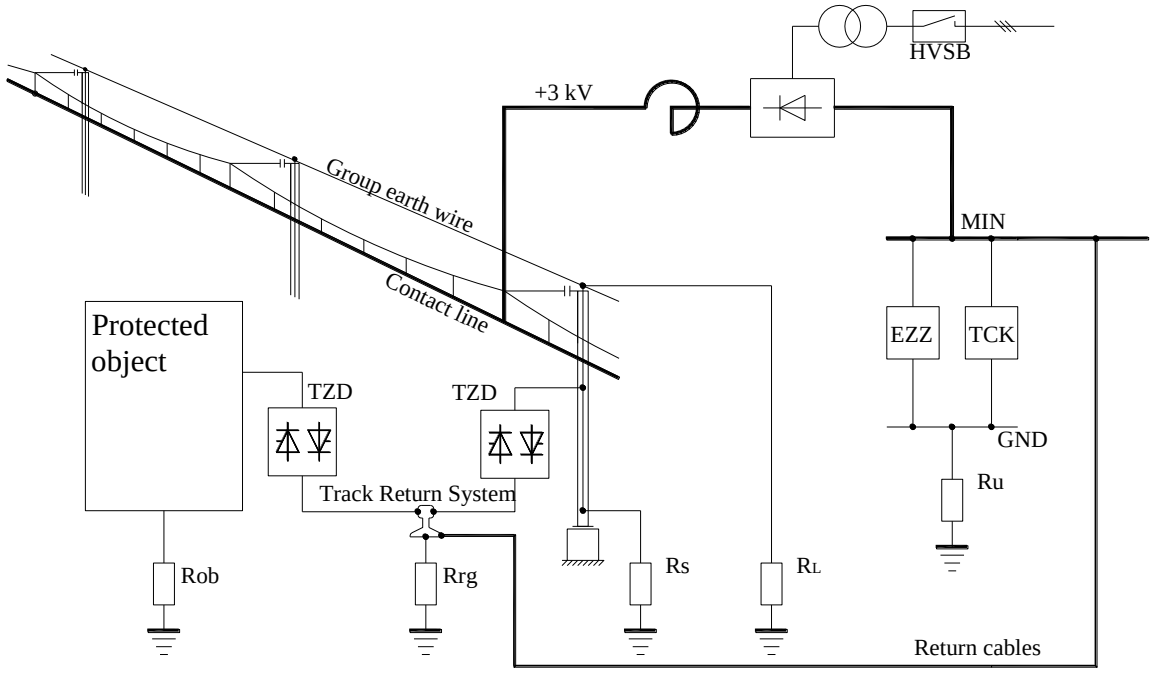

Fig. 1. Elements of the group bonding protection system

- EZZ *(= **E**lektroniczne **Z**abezpieczenie **Z**warciowe)* – Electronic Earth Fault Protection in a feeder station
- TCK *(= **T**ester **C**iągłości **K**abli)* – Continuity of return cables test device
- TZD-1NR *(= **T**yrystorowy **Z**wiernik **D**oziemiający)*- Bidirectional Voltage-Limiting Device assign to conduct short-circuiting current
- R_u *(= **R**ezystancja **u**ziomu podstacji)* – To earth resistance of feeder station
- R_{sz} *(= **R**ezystancja przejścia **s**zyny – **z**iemia)* – To earth resistance of the track return system
- R_{ob} *(= **R**ezystancja uziemienia **ob**iektu)* – To earth resistance of the protected object

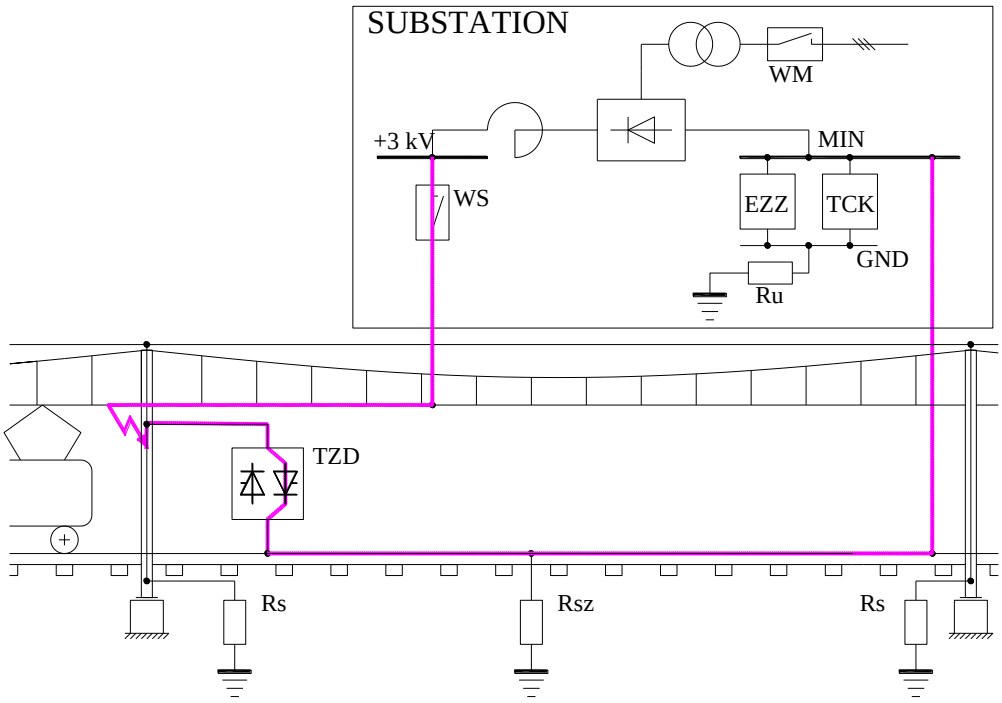

Fig. 2. Earth fault of a catenary

In Fig. 2 there is shown a current circuit after a breakdown of insulation to earth in catenary. Similar fault current circuit is formed after a falling of contact line on a protect object. Voltage-Limiting Devices of types TZD-1NR, and EZZ are adapted to conduct fault current as long as a high-speed breaker or a main switch of the substation turns off a fault current.

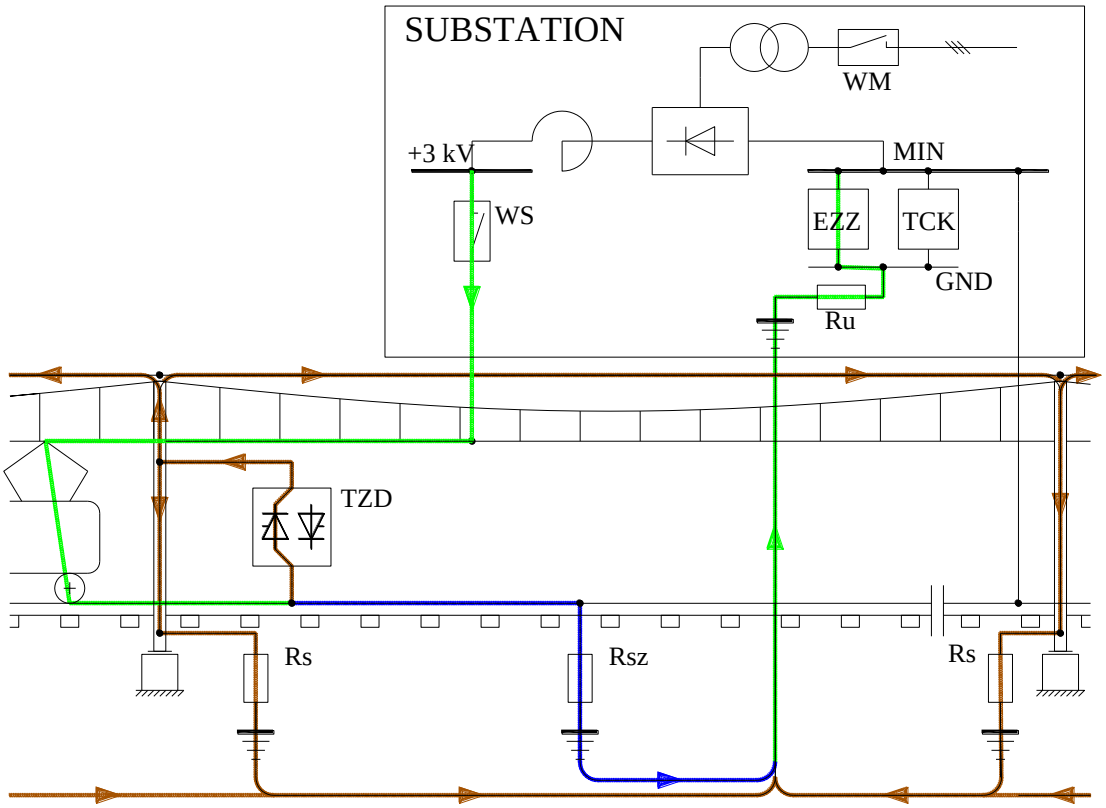

Fig. 3. Discontinuity in track return system

In the Fig. 3 there is a current circuit after discontinuity in a track return system shown. A part of a return current flows directly from track to ground via resistance R_{sz} while the second part - via a thyristor of the Voltage-Limiting Device of type TZD-1NR and to earth resistance of a group bonding system. The return current comes back to negative end MIN of a rectifier in a traction substation via resistance R_u and a thyristorized Voltage-Limiting Device of type EZZ. A switch off of a traction substation is being triggered in a case of exceeding by this current the defined level for the overcurrent relay setting value.

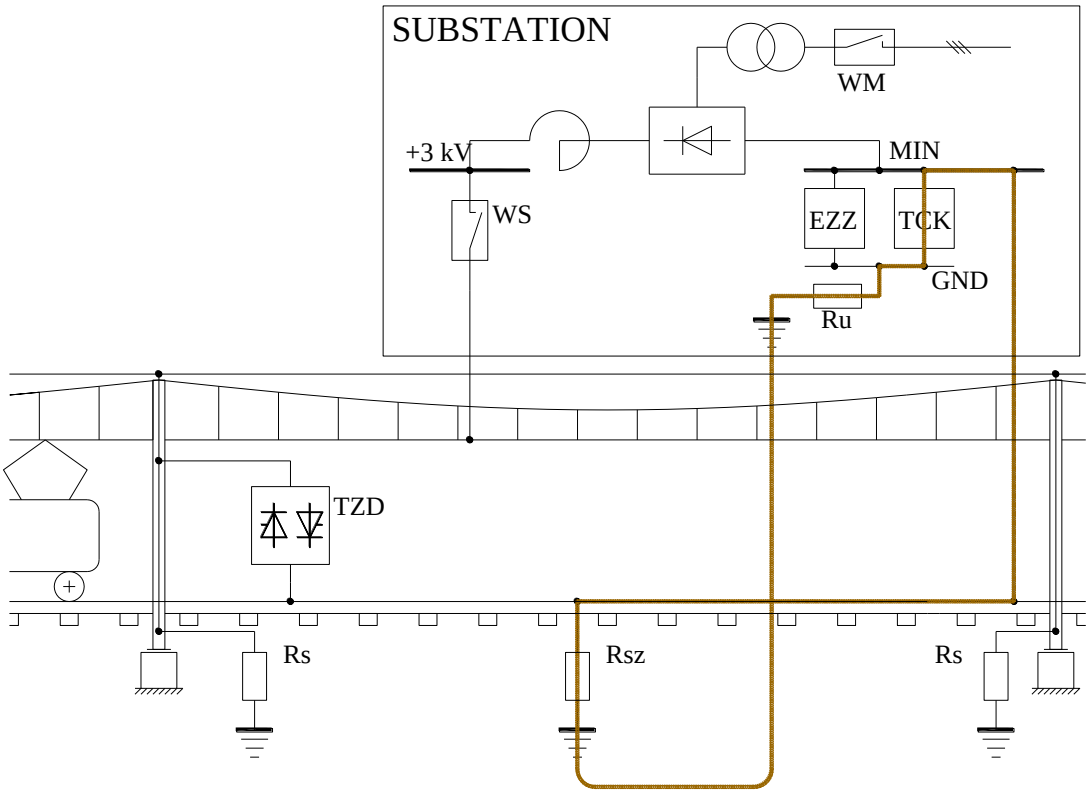

Fig. 4. Control of continuity of return cables and to earth resistance.

In the Fig. 4 there is shown a current circuit during testing continuity of return cables by the device TCK. The current flows by to earth resistance of a feeder station (R_u), resulted resistance to earth of the track return system (R_{sz}) and return cables. Distress signal informs that the resistance increases the accepted value and then the a switch off of a traction substation is being triggered.