Lightning and Surge Protection for Railway Systems
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H. Pusch

The progressing automation of operational processes has already captured entire railway systems. Operational processes and expansions of ranges are increasingly centralised in Europe. This combination leads to high requirements on the availability and reliability of the systems used. System failures, e.g. of an electronic signal box, or – as shown in Fig. 1 – parts of it, affect railways not only locally, but also nationally. As the operation of railways must also be ensured during thunderstorms, both the operator and railway supplier’s industry are requested to face the subject of transient overvoltages due to switching operations and lightning discharges.

1. Application examples for different parts of railway systems

Comprehensive protection of buildings and electrical or electronic systems against the effects of electromagnetic lightning impulses (LEMP) can be achieved by means of a LEMP protection system (LPMS). It consists of an individual combination of

- earthing and equipotential bonding measures
- lightning protection measures for magnetic and spatial shielding
- conductor routing and shielding measures as well as
- measures for energy-coordinated protection by means of SPDs

The following application examples will show the use of surge protective devices in parts of railway systems. Detailed information about further LEMP protection measures can be taken from the Lightning Protection Guide published by DEHN + SÖHNE and is available on www.dehn.de.

It has to be noted, that protection concepts for railway systems should always be agreed among the operator of the railway system, the designer, system supplier as well as the constructor (main contractor) and responsible expert. Only then, different interpretations of guidelines, directives, standards and recommendations can be coordinated and brought together in a consensus. The question of necessity and extent of lightning and surge protection measures has to be answered by performing a risk analysis according to IEC/EN 62305-2 by means of a software, e.g. DEHNsupport. The decision cannot be made only upon economic aspects. Personal protection always has higher priority than protection of installations or material assets and must therefore be taken into consideration.

1.1 Stand-by and standard power supply systems 50 Hz/16.7 Hz

For standard 50 Hz power supply systems like in electronic signal boxes, lightning equipotential bonding is performed with combined lightning current and surge arresters (refer to Fig. 2). SPDs Class I according to IEC/EN 61643-1. As often a direct zone boundary between lightning protection zone LPZ 0, and LPZ 2 has to be realised in compact signal boxes installed according to the lightning protection zones concept, a combined lightning current and surge arrester as mentioned before, should be used. It is capable of discharging lightning currents up to 100 kA (10/350 μs) several times without destroying the equipment. This is achieved through the RADAX-Flow spark gap technology by DEHN + SÖHNE. In addition to high discharge capacity, this technology, if applied in combined lightning current and surge arresters type DEHNventil® modular, makes it possible to protect terminal devices directly without requiring additional surge protective devices. Even in case of high short-circuit currents up to 50 kA, mains follow currents are considerably reduced. A selectivity to upstream overcurrent protective devices up to 20 A G1/G2 is achieved. This allows for maximum system availability which ensures the functioning of the electrical power supply system for the operator of the railway system. Expenses can be saved due to reduced maintenance work caused by false tripping of overcurrent protective devices and due to the easy exchanging of modules without tools or wiring work during testing procedures and maintenance. In different applications of railway systems, the railway power supply system is more and more used as a supply system for other systems as well, like for signalling systems or even as a stand-by power supply system. The overhead line voltage up to 25 kV is transformed to low voltages of 2 x 231 V by means of transformers. The short-circuit currents vary between 3 and 20 kA, according to location.
As there are different loads and thus different performances the lightning current arresters used are exposed to, especially in railway systems with operating frequencies of 16.7 Hz, the applicability of the protective devices should be documented by a test report of an independent test laboratory. The additional parameters should be added to the technical data sheet of the manufacturer. DEHNventil® modular is a universal combined lightning current and surge arrester, which fulfils the requirements for both 50 Hz and 16.7 Hz railway systems.

1.2 Point controllers for local public railway systems

Fig. 3 shows parts of an electronic point controller used for local public railway systems. It safely controls point controlling devices for different traction technologies in signal installations and point areas. Such point controllers can be adapted flexibly to the requirements of the railway operator and correspond to safety class SIL 3 according to IEC/EN 61508-2. Apart from the safety level with signal controller, point controller and monitoring system, also the evaluation unit of the track switching equipment and, where necessary, an isolating transformer unit for power supply, are installed into an outdoor cabinet. According to the lightning protection zones concept as per IEC/EN 62305-4, the cabinet is the zone boundary from LPZ 0b to LPZ 1. The surge protective devices shown in Fig. 3 are SPDs of Category D1 according to IEC/EN 61643-21. These are capable of conducting lightning currents up to 5 kA (10/350 μs) safely and without damage. Furthermore, the SPDs selected for this application provide energy-coordinated surge protection for the parts of the installation through combined lightning current and surge arresters type Blitzductor® BCT BD 24 to BD 48. Lightning currents as well as currents inductively coupled into the periphery (point operating unit, signal transmitter, key switch) are safely controlled.

The latest development of these protective devices is LifeCheck with RFID technology, which offers a further benefit: It allows for contactless, very quick (in a second) and economical testing of surge protective devices. Existing and older installations, which were based on Blitzductor BCT, can be easily converted to the LifeCheck modules BCT MLC by exchanging the modules without signal interruption or new wiring. For new installations the new, space-optimised Blitzductor® XT should be used.

Protection for the 230/400 V power supply in the type shown is not part of it, as this – a combined lightning current and surge arrester as shown in Fig. 2 – is installed into a separate upstream switchgear cabinet with an isolating transformer.

For further rating of the m.v. surge arresters, it has to be taken into account, that the maximum non-permanent voltage \( U_{\text{max}} \) arising in the railway system defines a maximum voltage value, which may come up only for a limited period of time and not longer than five minutes. The continuous voltage \( U_{c} \) of the surge arrester has to be defined correspondingly \( U_{c} \geq U_{\text{max}} \). SPDs for d.c. railway power supply systems are also based on the aforementioned selection criteria. With m.v. surge arresters type DEHN-track, d.c. railway power supply systems can be protected effectively against the effects of lightning strokes.

1.3 Railway power supply systems – Applications for surge arresters for medium-voltage installations

Electrified a.c. current railway lines form a tightly linked network resulting in a wide equivalent collecting area for direct and indirect lightning strokes. In order to minimise the effect of such sources of damage to the railway power supply network and the systems connected to it, surge arresters for medium-voltage installations are used. To select the right m.v. surge arrester for the application, the energy absorption capacity, maximum continuous voltage arising within the railway network and the environmental conditions on site have to be taken into consideration. Fig. 4 shows an m.v. surge arrester type DEHNmid DMI 39 10 3 SN, line discharge class 3, used at a supply transformer in a 25 kV/50 Hz railway power supply system. This is applied every 10 to 20 km, also in high speed lines, for example, to ensure constant voltage. The rating of line discharge class 3 ensures sufficient energy absorption capacity. The surge arresters can thus resist the loads on site without damage for a longer period of time.

With respect to railway earthing systems, EN 50122-1 has to be observed. It defines the requirements for protective measures for electrical safety in the locally fixed installations, which are connected to a.c. and d.c. railway systems. But EN 50122-1 also includes the requirement on all installations threatened through power supply installations of electrical railways. It comprises the requirements for protection of both persons and installations.

Protection against accidental contact has to be ensured by railway earthing. Railway earthing implies connection between conductive parts and railway earth. The tracks represent the earth. They are used as a return circuit and are intentionally connected to the earth (in a.c. circuits!). The railway earth includes all conductive parts connected to it.
Distinction is drawn between
• direct railway earthing
• direct connection between conductive parts and railway earth
• open railway earthing
• indirect connection of conductive parts with the railway earth by means of voltage limiting devices or short circuiters (e.g. one-sided insulated track circuits, d.c. circuits with insulated tracks)

The protective devices used have to ensure protection of persons and material assets both at a disruption of the overhead line and in case of a lightning strike.

For this purpose, voltage limiting devices (SDS) are used. These provide safe equipotential bonding both in case of lightning current loads and loads caused by short circuit currents through their permanent short-circuit connection due to heavy-current-resistant welding of the SDS electrodes. When the SDS is short-circuited and its electrodes are therefore welded, this SDS has to be replaced by the maintenance staff of the railway operator. Examinations of the DB AG [German National Railways] in Germany have shown that, opposite to operating failures, lightning strokes were the more frequent reason for the welding of the electrodes. Based on this result, DEHN + SÖHNE have developed a lightning-current-resistant SDS, which avoids the permanent welding of the electrodes when discharging lightning currents. The aim was to achieve a considerably improved system availability and saving of costs due to less maintenance work. With the lightning-current-resistant SDS, safe equipotential bonding is established only temporarily, for the duration of the lightning effects. The electrodes are not permanently welded any more. If, however, a short-circuit current load comes up, safety for persons and material assets is still provided, like with a non-lightning-current-resistant SDS, by safe welding of the electrodes. Fig. 5 shows two types of lightning-current-resistant SDS. While type SDS 1 can be integrated into common rail adapters, type SDS 2 NH 00 is designed to allow for easy adaptation to NH fuse holders or NH switch disconnectors, size 00. The special benefit of this type is easy installation and riskless exchanging of fuse links even in case of being affected by interference voltages. By means of the measuring and evaluation unit DISO SN 1533, a unique monitoring and remote signalling device is provided as an accessory for potential-free fuse links even in case of being affected by interference voltages. By means of the measuring and evaluation unit DISO SN 1533, a unique monitoring and remote signalling device is provided as an accessory for potential-free fuse links even in case of being affected by interference voltages. By means of the measuring and evaluation unit DISO SN 1533, a unique monitoring and remote signalling device is provided as an accessory for potential-free fuse links even in case of being affected by interference voltages. By means of the measuring and evaluation unit DISO SN 1533, a unique monitoring and remote signalling device is provided as an accessory for potential-free fuse links even in case of being affected by interference voltages.

2. Conclusion
Damage to installations of railway systems due to the effects of lightning strokes, whether directly or indirectly, can be avoided. With a risk analysis according to IEC/EN 62305-2 and the resulting protection measures, effective solutions are available. Both railway operators and the supplier’s industry are requested to analyse the risk of their installations. Protection for complex electronic systems requires a LEMP protection system according to IEC/EN 62305-4. With a consequent realisation of the protection measures according to the lightning protection zones concept, future railway news may say: “Trouble-free rail traffic despite of heavy thunderstorms”.

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Author
Dipl.-Ing. (FH) Helmut Pusch, DEHN + SÖHNE GmbH + Co. KG, Marketing Services