

OVERVOLTAGE PROTECTION DEVICES

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Abstract – This article states about overvoltage protection methods, especially lightning overvoltages. Different types of lightning protection devices are presented and described, according to their construction and application methods. The pressure was put on protection in accordance with European standards.

I. INTRODUCTION

Nowadays business, industry and all public institutions depend on electronic data engineering. Electronic data processing, measuring and control systems, instrumentation and control as well are all part of a modern industrial plant. All data recording devices at the production plants are connected to terminals and computers at offices by information networks distributed between buildings - together making the computer integrated manufacturing. Often, the basis of computer integrated manufacturing are open networks, where different types of computers and different operating systems communicate. This business process is rapidly expanding and is now approaching the computer integrated enterprise or computer integrated business. Differently speaking all ranges of administration are completely integrating into a electronic data processing system. It can be clearly seen that the future lies in the computer-integrated factory or in computer-integrated business and administration. This networked system, with its growing flow of information, is severely hindered by damage to the essential transmission systems in the telephone and data networks, as well as at terminals or by interference. Strong dependence on electronic data processing can quickly lead to catastrophe if the system will fail. An American investigation in 1987 highlighted the seriousness of the situation. According to it, banks will be able to manage without electronic data processing for only 2 days, enterprises that are sales-oriented will be able to manage for 3.3 days, manufacturers for 4.9 days and insurance companies for about 5.6 days. Enterprises without functioning EDP, according to an investigation by IBM Germany, will collapse after about 4.8 days. It has to be taken into account that in the past 15 years the growth of computer appliances in business, industry and everyday life has increased rapidly, so former mentioned times have probably decreased. Computer safety experts have pointed out that ninety percent of enterprises would close if their computer fails for two weeks. Disturbance of the data flow and destruction of

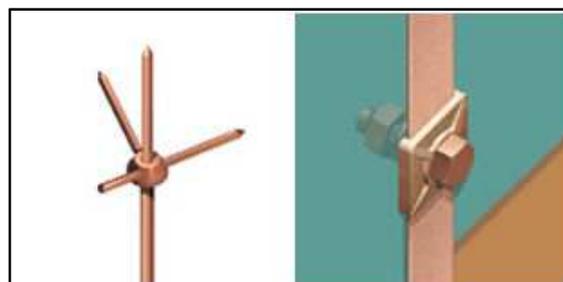


Fig.1. Air terminator and equipotential bonding

electronic equipment is the most frequent reason for the failure of such electronic systems. Mostly it is made by transient electromagnetic interferences. This risk can be controlled by electromagnetic compatibility measures, what specifies conditions under which any kinds of electric equipment disturbs or not each other. Also where electromagnetic phenomena, like lightning discharges, will not disturb their function. In 1989 the European Community has declared electromagnetic compatibility as a protection goal by issuing the “Council Directive of 3 May 1989 to Harmonise Laws of the Member Nations concerning Electromagnetic Compatibility”. According to it all apparatus, facilities and systems that include electric or electronic components must demonstrate sufficient withstand levels against electromagnetic disturbances, to guarantee stable and proper operation of all equipment. The directive of the Council especially mentions the industrial equipment, telecommunication networks and equipment facilities. Violation of the electromagnetic compatibility general instructions, is deemed with a summary offence. A great extent the protective measures that must be undertaken in the framework of electromagnetic compatibility. Among the threats from the electromagnetic environment, lightning discharge is the most dangerous and therefore it determines the protective measures. Modern lightning protection does not only mean protection of buildings, but especially the protection of devices stored in it, meaning that a lightning protection system also must be achieved, even if it is not necessary for the building itself, but for the equipment it contains.

II. AIR TERMINATIONS

To protect the volume from direct lightning strikes and to avoid uncontrolled strikes air termination are used [Fig.1], which are fixed points for likely

lightning strikes. Air termination is comprised by air-termination rods and air-termination wires. The location of air terminations is usually defined by the ‘rolling sphere’ method. It bases on use of an imaginary sphere of radius S over the surface of a protected object. The sphere rolls up and over and is supported by lightning masts, shield wires, substation fences, and other grounded metallic objects that can provide lightning shielding. A piece of equipment is said to be protected from a direct stroke if it remains below the curved surface of the sphere [Fig.2]. This means that a certain radius of rolling sphere will be assigned to every protection level. Finally, air terminations form a system of protection for structures on the roof, such as ventilators and air-conditioning systems.

Partially isolated lightning protection systems are usually installed on flat roofs. This protection can be achieved by individual or a combination of several air termination rods for smaller roof structures. For larger roof structures protection by means of air termination rods is not often possible as the rods would be too high and thus there is danger of their leaning. An isolated air termination is a second solution as an alternative. The calculated safety distance must be smaller than distance between air terminations and structures on the roof. Air-termination networks must form a protective volume that is including all structures on the roof.

III. BUILDING AND ROOM SHIELDS

Extended metal components, like for example: metal roofs and facades, steel reinforcements in concrete, expanded metals in walls, lattices, metal supporting constructions and piping, which form an effective electromagnetic shield by their meshed interconnection are especially important for shielding magnetic fields. They are also important for creation of lightning protection zones.

In principle, a steel reinforcement and the metal window and door frames can form an electromagnetic cage. In practice, however, it is not possible to weld or clamp every nodal point for large structures. For bridging expansion joints or bonding the reinforcement of prefabricated concrete parts, fixed earthing terminals are provided. To such earthing terminals or projecting bonding conductors the “earth bus” or “earth ring bus” (ring equipotential bonding bars) are connected. Metal facades are also used for shielding purposes. The facade steel sheets, being interconnected, are to be bonded to the metal construction and to the reinforcement.

Some of the above mentioned shielding measures can also be applied to the establishment of room shields (lightning protection). In particular this concerns the use of steel reinforcements (in floors, walls and ceilings), expanded metal (in walls and ceilings) and lattices.

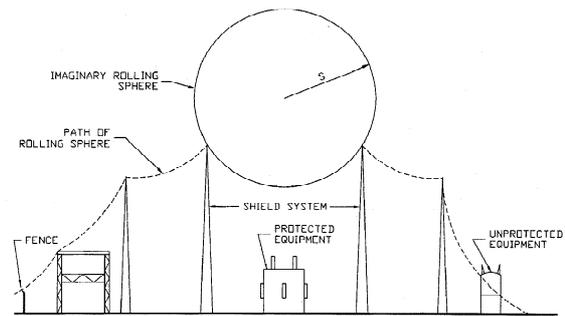


Fig.2. “Rolling sphere” method

Smaller shields for lightning protection zones and higher, or shields of local lightning protection zones are usually formed by the enclosures (sheet steel cabinets, sheet steel covered racks, sheet steel enclosures) of telecommunication systems and devices.

IV. SHIELDS FOR CABLES IN BUILDINGS

Cables shall be run near the equipotential bonding lines. These are parts of the steel construction, reinforced walls, cable supporting structures, cable trays or other electrically conductive parts which are connected to the equipotential bonding system at least at both ends. In principle, shielded cables should be used. This applies for electronic or data cables as well as for higher voltage levels. Pair-twisted signal cables are to be preferred. For related lines of one signaling circuit a twisted pair each is to be used, so that the incoupled transverse voltage on cable runs must be neglected. The limitation of the incoupled series voltage determines the protection measures.

To lessen surges by overcoupling, power and signaling cables must be consequently separated, if possible by using cable supporting structures which are included in the equipotential bonding. Different separations are needed depending on the cable parallel running length.

Also in existing systems it may become necessary to shield the cable routes (subsequently). For this purpose a retrofit set consisting of shielded sleeveings provided with a closing system in the longitudinal direction.

V. EQUIPOTENTIAL BONDING

Lightning protection equipotential bonding of a protected volume includes all incoming metal installations. In the case of extended telecommunication systems, a duly shaped lightning protection equipotential bonding bar installed at ground level inside the building also functions as an earth bus and is usually installed as an earth ring bus inside the building. The earth ring bus, a ring equipotential bonding bar, is a copper bar having a minimum cross section of 50mm^2 for surface mounting at a distance of some centimeters

from the wall. At distances about 5m it should be bonded to the foundation earth electrode. This bonding can also be realized over the reinforcement. An equipotential bonding bar can be sufficient for small local systems. If the discharge system consists of plain metal components which constitute an effective electromagnetic shield, the equipotential bonding bars can be directly bonded with the shield. Equipotential bonding is, therefore, often carried out using a bonding plate with multiple radial or even coaxial connections of the conduits or line shields.

Equipotential bonding is not only for the protection of electronic systems, but it must also fulfill special functions. A low-impedance equipotential bonding system, which is an entity formed of interconnected equipotential bonding lines including the metal parts of the electric systems (such as enclosures, racks, cable trays etc.) and the building (e.g. reinforcement in floors, walls [Fig.1.] and ceilings, supporting structures between floors) is possible using a meshed, plane-covering or space-covering formation. Such a meshed overall building equipotential bonding system is the best way to reduce overvoltages in telecommunication systems and is the basis for the coordinated use of arresters (surge protection devices, filters, etc.).

Different types of functional equipotential bonding systems are needed for telecommunication facilities and systems. Metal supports, cabinets, enclosures, cable racks etc. in rooms with telecommunication facilities and systems must be included in the meshed functional equipotential bonding. Another possibility for achieving functional equipotential bonding is to create an equipotential bonding network by means of the metal supporting structures between floors. It is useful to install a local ring equipotential bonding bar which then is connected to the earth ring bus several times.

Above all, equipotential bonding should include:

- metal enclosures and racks of the telecommunication systems
- conductors of electrical systems which do not carry operational voltages and/or currents.

In the latter case, these include: protective conductors of the power system, earth electrode conductors of the telecommunication system, outer shields of the telecommunication cables and if necessary, the chassis terminals of the electronic devices and systems.

TABLE 1
Comparison of arresters classes according to standards

| DIN VDE 0675 Part 6/A1 | IEC 37A/447/CDV |
|--|----------------------|
| Arresters class B, for lightning protection equipotential bonding purposes according to DIN VDE 0185 Part 1 | Arrester 'Class I' |
| Arresters class C, for surge protection purposes in the permanent installation, especially for use in surge withstand category III | Arrester 'Class II' |
| Arresters class D, for surge protection purposes in the mobile/permanent installation, especially for use in surge withstand category II | Arrester 'Class III' |

VI. ARRESTERS

According to their range of application, surge protective devices (SPDs) for power engineering and for information technology can be subdivided into two kinds: lightning current arresters and surge arresters. SPDs are internationally standardized in IEC 61643-1:1998-02 "Surge protective devices connected to low-voltage power distribution systems" part 1: "Performance requirements and testing methods". In this standard the SPDs are distinguished according to test classes. It is difficult for the user to understand this classification because it is primarily meant for the producers of the SPDs. A rather user-convenient SPD standardization is included in the German DIN VDE 0675 Part 6/6A1 and 6A2. As requirements and tests of the German standard are more severe than the international standards, the German standard is taken as a basis for arrester classification (Table 1).

We distinguish many kinds of arresters, generally basing on their application:

- Lightning current arresters must be able to discharge lightning currents or considerable parts of them non-destructively. They are dimensioned and tested in accordance with IEC 61643-1/E DIN VDE D675 Part 6 and Part 6/A1.
- Surge arresters only serve limiting overvoltages at relatively low-energy surge currents.

VII. SUMMARY

Application of devices mentioned in this article can significantly increase the reliability of protected networks and safety of people and equipment inside protected structures .

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