

Integrated Grounding, Equipotential Bonding and Lightning Protection in Smart Grids and Smart Buildings – A Multi-Faced Approach

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ABSTRACT

With the implementation of smart meters many new electric energy applications in supply areas and in buildings (single or multiple dwelling, office buildings, industry) will be initiated. The usage of smart meters in smart buildings and smart grids requires enhanced communication lines and the usage of modern electrical installations and sensitive measurement, data acquisition and control systems in the area of the customer installations and the grid under consideration of the demands of high reliability. To guarantee the reliable functioning of the required electronic equipment low induction grounding, equipotential bonding and lightning protection systems are a pre-condition starting from the transformer stations via the mains connection to the location of the electrical / electronic equipment in the buildings.

The increasing number of sensitive electronic equipment and the necessary bidirectional information and data flow requires not only the provision of new intelligent measurement equipment (e.g. smart meters and communication lines), but also new concepts regarding the implementation of grounding, bonding, lightning protection and shielding with regard to inductive and resistive influences and disturbances in the fundamental and transient frequency range.

To provide the base for a safe and reliable use concerning the low and high frequency effects in new buildings on the one hand and for the revitalization of existing buildings on the other hand are presented in the paper two approaches are presented:

1. *The first approach includes the implementation of grounding, bonding, lightning protection and shielding from the beginning of the planning and construction phase of the electrical installation.*
2. *The second approach demonstrates the integration of a closed-meshed fish trap structure of grounding, bonding, lightning protection and shielding.*

In this context the introduced coordination and installation measures representing the state-of-the-art and scientific results for new buildings are relatively easy and cost-effective if considered in the planning phase, for the renewal and revitalization of existing buildings, these

measures may be very complex and additional restrictions in functionality have to be accepted.

INTRODUCTION

To provide the safe and reliable operations of electric / electronic equipment in modern low-voltage grids intended to be suitable for a bidirectional energy and information flow and further to fulfil requirements of ensuring protection measures against electric shock, special attention has to be focused on the integration of earthing, equipotential bonding, shielding and lightning protection - starting from the transformer stations via the interconnection point to the location where the equipment used for the electrical and information technology is located. Beginning in the planning phase and continued in the implementation and examination state these themes usually are considered mostly separately, leading in practice to a multitude of problems caused on the one hand by stray-currents, undesired interfering electromagnetic fields and inductive influences by low-frequency and transient currents and on the other hand by effects due to switching operations in the grid or as a result of atmospheric discharges.

In the following proposal a functional, comprehensive approach for the planning, installation and refurbishment of grounding, equipotential bonding, shielding and lightning protection systems is presented, taking the operational frequency as well as transient frequency processes to assure the basic requirements of different electrical grid-bound supply systems such as electricity, gas, water and telecommunications and the shielding of energy- and information- and communication technology (ICT) - lines into account.

METHODOLOGY - NEW BUILDINGS

In order to ensure safe functionality of both, the protection against electric shock as well as protection measures against resistive, inductive and capacitive influences of electrical / electronic equipment in electrical installations grounding, equipotential bonding and shielding measures and lightning protection systems have to be suitable coordinated already at the planning stage [1] ... [8]. As in single buildings, building complexes (smart buildings) and spacious electrical systems (smart grids), the function of the

infrastructure for information technology management systems is of great importance and a functional disruption can cause serious consequences, disturbances have to be avoided as best possible.

In the planning stage and depending on the risk of damages and disturbances, the type and the arrangement as well as the integration of the earthing system, the equipotential bonding system, the shielding method and the lightning system has to be obeyed, because of the overlapping of the necessary requirements

- Personal safety and safety of property,
- Protection measures for objects, areas, space and electrical / electronic equipment,
- External and internal lightning protection (EMC),
- Safety measures (grounding, equipotential bonding system),
- Utilization of existing or planned on-site metallic components and structures such as metal facades, concrete reinforcing steel, metal cases, ...

From the well-timed cooperation of all involved professionals significant benefits for the entire structural system can be realized as the design, the construction and refurbishment of an integrated installation, technical and functional issues can be considered easier and better, and the effectiveness of the earthing, equipotential bonding and lightning protection system can be improved significantly optimizing economic burdens.

The (mandatory) minimum level in most European countries as well as in Austria [1] ... [5] is preferably the establishment of a concrete footing-type grounding electrode system in the foundation area (eg. base plate, granular sub-grade course, blinding concrete) wherein in buildings with specific EMC requirements of information technology equipment for EMC reasons (especially for the reduction of magnetic interference fields, inductive and resistive influences by transient currents) the construction of an additional equipotential bonding system for each floor is essential [8] ... [12].

As can be shown easily, considering only low-frequency effects, a close-meshed structure of the concrete footing-type grounding electrode system or earthing system is not necessary to achieve a low resistance of the ground grid (a mesh distance of 10 m or less affects the reduction of the resistance of the grounding grid only a little). To reduce step and touch voltages and to achieve an appropriate shielding effect (about 20 dB in the lightning-relevant frequency range) however, a further reduction of the grid dimensions (10 m x 20 m maximum - as required in [8]) to a minimum distance about 5 m grid or less, and the bonding of concrete reinforcement in the floor (distance of the connection approximately ≤ 2 m) and the concrete reinforcement in the walls in the combined earthing, equipotential bonding, shielding and lightning protection

system may be necessary additionally.

Many synergies can be utilized if the earthing, equipotential bonding, shielding and lightning protection system is planned and implemented in compliance with the requirements of the generic ICT cabling system and the definition of the EMC and lightning protection zones and in compliance with the dimensioning of the cross-sectional area of the cables, lengths, location and distances. If the worst-case scenario is the basis of dimensioning (dimensions based on normal operation, short circuit, equipotential bonding, PEN and lightning protection conductor currents) the coordinated entire system can fulfil several functions and multiple implementations of components for reasons of grounding, of equipotential bonding and of lightning protection and shielding can be avoided. The result is an efficient overall system, that - and only that - can meet the modern requirements of a single building or a building complex. To provide a successful protection against overvoltages the requirements of low impedant connections of surge arresters can be realised because the needed short distances (transient voltage drop 1 kV/m) between the surge arrester and the grounding/equipotential bonding system can be achieved - see Fig. 1.

In Fig. 1, on the left side, the combined high and low voltage grounding system of the distribution network is depicted [7] leading in combination with earth grounding conductors in all trenches and the integrated grounding systems of each building (as required by law in Austria, [2]) to a low impedant global grounding system. This global grounding system ensures the basis of all further safety and protection measures.

In the centre of Fig. 1 a new building as mentioned above is depicted [2], [5] and [11]. The advantage of this construction is that in all parts of the building structure sensible ICT-components can be installed. The coordination and planning efforts can so be minimised.

METHODOLOGY - OLD BUILDINGS (REFURBISHMENT)

The refurbishment of old buildings to meet the modern ICT-demands is a complex challenge, because most of the before mentioned measures concerning the low inductive meshed grounding, equipotential bonding and lightning protection system cannot be realized. The proposal is, to invert the grounding and equipotential bonding system as shown before for the new buildings and to realize a fish trap like structure of conductors with an appropriate profile to achieve a preferably low impedant equipotential system (see Fig. 1, right side). As the grounding and equipotential bonding system changes to a predominate equipotential system the refurbished grounding system has now to meet only the demands of a proper lightning protection system

and can be realized usually with vertical grounding rods. A well dimensioned and designed connection to the PEN conductor has been proved in the Austrian practice too [2], [3], [10], [13]. As the fish trap like equipotential structure provides a low impedance protection and safety measures can easily be realized (RDC, RCCB, equipotential and function equipotential bonding, overvoltage suppression). In classically refurbished buildings often to long connection

wires with to small cross-section between the overvoltage suppressor and the low impedant grounding point appear so that the assumed protection level cannot be achieved. The only disadvantage of this proposal is that the low impedance equipotential system is provided only in dedicated areas in near vicinity of the fish trap like construction.

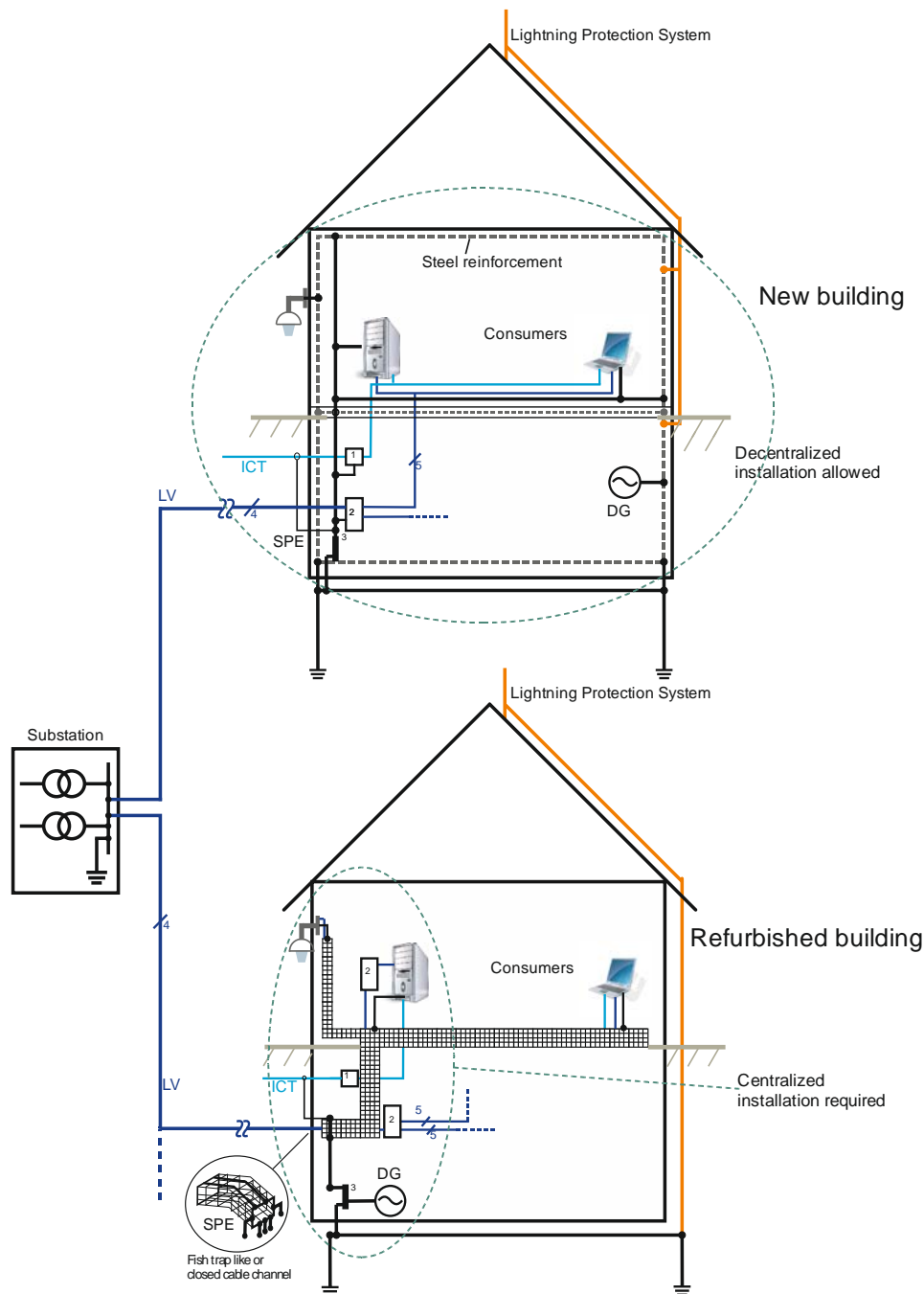


Figure 1: Concept of an integrated grounding, equipotential bonding and lightning protection system in Smart Grids considering new and refurbished Smart buildings; 1 ... ICT-switchgear, 2 ... LV-switchgear, 3 ... Main equipotential bonding, DG ... Decentralized generation, SPE ... Single point entry

CONCLUSIONS

The presented holistic approach by realising the grounding, equipotential bonding and the lightning protection system as well as EMC- and lightning protection-zones as a jointly coordinated system, taking into account operational frequency and transient frequency processes in modern and future-proof electrical equipment provides flexible operation and meets the requirements for protection against electric shock, minimizes resistive, inductive and capacitive interference, reduces the occurrence of electromagnetic fields and enables the implementation of high-quality measures for the electric/electronic equipment safety, as well as a efficient lightning and surge protection. In addition the reduction of the data transfer rates by inductive, capacitive and ohmic interference can be minimized. The necessary functionality of a grounding and equipotential bonding system in the design concept of an architectural structure, including the lightning protection and other protection concepts (eg. internal lightning protection, EMC, shielding concepts, ICT-concepts) can be integrated easily considering the proposed, if early enough considered.

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