HYBRID AC/DC DISTRIBUTION GRIDS ARCHITECTURES: ANALYSIS OF POWER QUALITY AND PROTECTION ASPECTS

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Abstract

During the last years, distribution power systems working with Direct Current (DC) are gaining visibility and becoming more competitive. The growth in the number of theoretical and experimental studies using low-voltage DC grids can be justified as the result of three facts: the improvements in power electronics, the increase in the use of DC-based loads and a growing presence of DC energy generation through Renewable Energy Sources. However, there are still some challenges limiting the deployment of DC in distribution systems. Among the aspects that need further studies and are also crucial for the normalization of DC in low-voltage environments, it is possible to highlight the normalization of distribution voltage levels, protection, and power quality.

Regarding the choice of voltage levels, the efforts made through different studies that exist in the literature show that a good trade-off between protection and efficiency for LVDC distribution can be obtained using a voltage level within the 350-400V range. In terms of protection schemes, the challenge relies in two different aspects. Firstly, the limited short-circuit currents of power electronic converters generally does not leave a temporal marge to selectively coordinate standard protection devices with the available short-circuit power. Secondly, the absence of Residual Current Devices in DC makes the use of TT grounding impossible, creating the need of new solutions in the protection against electric shock. Finally, a third vital aspect to consider for every power system concerns the domain of power quality. In DC, the concept of power quality is still to be defined. Considering that steady-state voltage/high-frequency disturbances can be destructive to some equipment connected to the distribution grid, measurement methods along with evaluation parameters and limitations must be defined, in order to ensure a fully compatible DC distribution system.

In this thesis the study of DC faults, protection strategies, protection devices, high/low frequency disturbances and resonance phenomena will be done with the objective to conceive a methodology of design for DC distribution grids, considering the protection of people and equipment and searching for an appropriate level of power quality, allowing the compatibility between sources and loads. Simulation models and an experimental prototype represent the two main tools, which will be used to guide this research.