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PS1/2-11 – DC/DC Converters. Question 1.17: DC-DC converters are gaining significance and new types are being proposed. How do DC-DC converters compare with other types of AC-DC converters in terms of power losses? How do they compare to AC-DC converters in terms of harmonic emissions?

The DC-DC converter is the enabling technology for the future DC networks. It will interface low voltage direct current (LVDC), medium voltage direct current (MVDC) and high voltage direct current (HVDC) systems. The main role of the DC-DC converter is to adapt the voltage between two DC systems. This is similar to the role of transformer in AC networks. However, the DC-DC converter can also provide power flow controllability and fault current blocking (or limiting). The DC-DC converters can be classified according to three criteria: power flow directionality, galvanic isolation and modularity.

The power flow directionality is the one of the major functional differences between a DC-DC converter in DC systems and a transformer in AC systems. The transformer is inherently bidirectional but the DC-DC converter can be designed to be either unidirectional or bidirectional.

The choice between isolated and non-isolated DC-DC converters for DC systems is likely to be similar to the choice between transformers and autotransformers in AC systems. The galvanic isolation between two systems allows the independent isolation coordination design and grounding choice between lower and higher voltage circuits. The choice of isolated DC-DC converter may be also driven by the power electronic design constraints. The DC-DC converter with high stepping ratio is likely to be isolated.

The DC-DC converters can be designed as monolithic or modular. In LVDC applications monolithic designs would be preferred while in HVDC applications modular designs seem the only viable solution.

Power losses of DC-DC converters depend on converter topology and technology. A bidirectional, isolated and modular DC-DC converter for HVDC application is composed of 3 components: modular multilevel inverter (DC-AC), transformer and modular multilevel rectifier (AC-DC). The power loss of the DC-DC converter is a sum of those 3 components, resulting in the total efficiency at approx. 98% for an insulated gate bipolar transistor (IGBT) based converter. A non-isolated DC-DC converter requires one modular multilevel bridge only and the expected efficiency is >98%. On the other hand, some low voltage, high power (~100 kW) bidirectional, isolated and monolithic DC-DC converter prototypes have been reported at >99%. To reach such a high efficiency, while keeping the small converter size, modern power semiconductors such as silicon carbide (SiC) must be used.

Harmonics emissions of DC-DC converters are expected low. In HVDC, the harmonic emissions would be equal or lower to voltage source modular multilevel converter (VSC-MMC) at DC terminals. Lower harmonics are possible because DC-DC converter can operate at the fundamental frequency higher than 50/60 Hz (for example 150 Hz). The harmonics of low and medium voltage DC-DC converters are expected to be even lower. Such a converter would most likely operate at medium frequency (>>1 kHz) so any harmonic is easily filtered.