ABSTRACT

This thesis is concerned with a digital computer study on several aspects of HVDC-AC system interactions involving study of harmonics, critical fault distance, short circuit levels, transient stability and optimal response under varying operating and control conditions. The following aspects have received attention:

(a) Development of a unified approach to harmonic analysis

A unified or most general approach is developed to analyse both characteristic and uncharacteristic harmonics on both DC and AC sides of HVDC converter. This approach makes use of unit pulse functions to simulate simultaneously AC side current as well as DC side voltage wave from for any sort of unbalanced operation. A digital computer program is developed which is versatile enough to compute simultaneously DC and AC side harmonics for symmetrical as well as unsymmetrical converter operation. The effects of various converter control modes such as constant current, constant power, constant power factor are also incorporated in this study of harmonics. The results for characteristic harmonics are shown to be a special case of the unified approach and these are compared with those obtained using well-known formulae for verification. It is observed from this study that the relative harmonics differ for different converter control modes and different commutating reactance.

(b) CFD of parallel HVDC-AC transmission system

The effects of various AC line faults on the critical Fault Distance (CFD) in parallel AC-DC system, with varying parameters such as inverter power factor, commutating reactance, steady-state margin angle etc., are studied. A method of mitigating inverter failure with the help of series booster is suggested.

(c) Short-circuit levels of parallel HVDC-AC system

Developing a simple equivalent circuit of HVDC link in terms of complex impedances, short-circuit level ratio (SCLR) of parallel HVDC-AC system is computed for various parameters such as DC to AC power ratio, converter p.f., magnitude and phase-angle difference between the sending-end and receiving-end buses, commutating reactance, and DC line resistance. This study reveals the influence of the above mentioned various parameters on the short circuit levels of parallel HVDC-AC system.

(d) Improving the transient stability in a joint AC-DC system

Here, attention is devoted to study a method of improving the transient stability in a joint AC-DC system by the help of controlled inverter failure and switched capacitor. It is shown that by this method the transient power limit can be extended upto the peak of the post-fault power-angle curve. Using Lyapunov's method and phase-plane technique a relationship between the fault duration and inverter failure duration has been established to obtain a required transient power limit.

(e) Transient and optimal response of parallel HVDC-AC system fed by a two-axis synchronous machine

The transient response of a parallel HVDC-AC system connecting two-axis synchronous machine to an infinite bus is investigated. With a linearised state-space model of the system, improvement in the system transient response is first obtained with normal types of feed-back signals to machine regulators and DC reference regulators. The controlled transient response is then optimised by applying linear optimal control theory which minimizes a suitable quadratic performance index. It is shown that by the application of linear optimal control it is possible to obtain improvement in the transient response of a parallel DC-AC system.

The results of this study are expected to be of significance in designing and ascertaining the overall performance of a mixed AC-DC system.