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Comparative analysis of techniques for control of switching overvoltages during transmission lines energization☆

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ABSTRACT

The energization of long transmission lines can cause high overvoltage stresses not only along the transmission line, but also in the rest of the network. The traditional method of limiting switching overvoltages to acceptable levels is the use of circuit breakers equipped with pre-insertion resistors. The present paper describes a study comparing this traditional method with two other alternatives for the limitation of switching overvoltages during line energization in an actual 500 kV transmission system: the use of metal oxide surge arresters at both line closing of circuit breaker poles. Digital simulations were made with PSCAD/EMTDC software and the degree of shunt compensation is considered as an independent parameter.

1. Introduction

Energization of a long transmission line can cause undesirable overvoltages in transmission networks. As a consequence, special overvoltage protection measures are required for the adequate planning of the insulation coordination.

The traditional method involves the installation of pre-insertion resistors in the line circuit breakers. Although it is an effective method, its implementation and maintenance costs are very high [1–3].

One alternative for the substitution of such circuit breaker resistors is the installation of metal oxide surge arresters (MOSA) at the two line terminals. The effective protection characteristics, the high reliability and the high discharge energy capabilities of these arresters are often adequate for the limitation of overvoltages. Further reduction of switching overvoltage can be achieved by the use of an additional arrester in the middle of the line or by the application of special arresters with lower protection level and higher energy discharge capability [1,2,4].

Another method which can be used to reduce transient switching overvoltages is synchronous switching of circuit breaker poles. This method reduces transient overvoltages through time controlled switching operations, with the closing commands of circuit breakers delayed, so they will occur at the optimum instant in relation to the voltage of the phase. Field experiences using synchronized control in banks of capacitors and shunt reactors have proved quite successful [5–7].

The objective of the present paper is the analysis of the effectiveness of the three methods for the overvoltages control during transmission line energization for a given 500 kV system. The comparison between these methods should enable the adoption of the most adequate method. Two levels of shunt compensation (75% and 91% of the total reactive power) are considered.

2. System modeling

The study was performed using a real 500 kV power system with the configuration shown in Fig. 1. The digital simulations were made using PSCAD/EMTDC software [8].

The line parameters were calculated for the fundamental frequency (60 Hz) using the PSCAD/EMTDC routine LINE CONSTANT and are presented in Table 1. The line was considered to be ideally transposed and the frequency dependence of the longitudinal parameters was modeled using the PHASE MODEL.

The line energization procedure involved each of the line segments being sequentially energized from one extremity (B1 or B5) to the other, assuming that the previous bus bar voltage has already stabilized at an adequate level of voltage, prior to the energization of the following segment. The pre-switching voltage at the sending end was established to be 1.00 p.u. and 0.95 p.u. for 75% and 91% shunt compensation, respectively.

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