Capacitive Transfer System Cable for Efficient Power Delivery

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ABSTRACT

The transition to a sustainable energy system drives the need to develop more efficient and cost-effective cable systems. The proposed Capacitive Transfer System (CTS) cable allows reduction in the line reactance, lowering voltage drop and increasing the transmission capability while reducing power losses. A higher current rating in comparison with a conventional cable system can be achieved with the same conductor cross section while reducing cost, size and weight of the cable. The paper explains the concept of CTS and its benefit applied in a case study for a given 33kV grid situation to demonstrate the advantages of CTS over conventional cable.

KEYWORDS

Power cable, efficiency, voltage drop, reactive power, transmission. distribution

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INTRODUCTION

With more and more concern for sustainable development, renewable energy, especially the proportion of wind and solar energy, continues to grow in remote areas where power networks have not been yet developed. However, currently available cable systems have lower power ratings than overhead lines, inherent reactive power management complexities and associated voltage drop. In addition, when at the lower limit of power generation, owing to low load current and high shunt capacitive current in the cable, there is voltage rise at the receiving end (so-called Ferranti effect) limiting the power delivery to the main electric networks. Moreover, when the length of cable increases, these two phenomena are more pronounced. In this case, there are several traditional methods to avoid high voltage drop or voltage rise in long cable circuits [1]: to increase the transmission voltage level to decrease load current thereby reducing voltage drop; to increase the number of paralleled cables to divide load current to decrease voltage drop and reduce losses; to switch off cables to avoid voltage rise when load current is low; to apply reactive power compensation to reduce the line impedance thereby reducing voltage drop.

Series capacitors have been successfully used for many years in order to enhance the stability and load ability of medium and high voltage (MV, HV) transmission networks [2]. The principle is to compensate the inductive voltage drop in the line by an inserted capacitive voltage or in other words to reduce the effective reactance of the transmission line. The generated reactive power provided by the capacitor is proportional to the square of the current with a self-regulating impact. However, series compensation is usually used in high voltage transmission line or remote distribution line because of high costs of the series compensation devices in investment and maintenance. Consequently, Capacitive Transfer System (CTS) cable is proposed to balance the inductive reactance by inherent capacitive dielectric layer design without any extra requirement of series compensation devices [3].

This novel cable concept allows reduction of the voltage drop and power losses in T&D systems and higher energy transmission efficiency, by delivering more power over the same mass of metal conductor, thus achieving more energy conservation and environmental protection through lower use and processing of natural resources [4].

In this paper, the CTS concept is introduced and a prototype design is presented. Then, the performance of the CTS cable and a traditional cable is compared in a case study analysis of an application in a 33kV power network

CAPACITIVE TRANSFER SYSTEM CABLE

CTS cable is designed to transfer AC power with low reactance without any extra series reactive power compensation device requirement. The concept of CTS cable is designed to counteract the inductive reactance and increase the conductive area in wires by the design where the input wire is connected to the power source and the output wire to the load with a dielectric layer in-between. This is shown in Fig. 1Fig. 1. The system is scalable to various voltages from 11kV to 150kV.

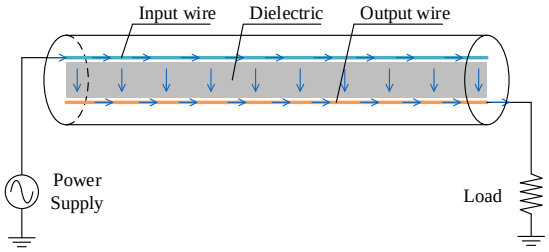

Fig. 1: A simplified CTS cable concept design