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Powerformer- A Discontinuous Innovation

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Abstract - *This paper provides an overview of a technology that offers a direct connection to the power network without a step up transformer. Implementation of powerformer will bring a change in the present scenario of generation. It is also shown that powerformer can act as differential protection scheme for high voltage cable wound generator. Many other applications like stability control, controlling high voltage bus, are mentioned.*

Key Words: Powerformer, self-adaptive compensation, technology-push.

1.INTRODUCTION

Recently, use of step up transformers are implemented for increasing output voltage of synchronous generator voltage as it is being limited to maximum of 30kv due to insulation problems. A high voltage generator with graded insulated cables called powerformer resolves such limitations. Powerformer, by configuring armature winding of stator can generate voltage at the levels of transmission lines. Hence use of step up transformer can be removed or stopped by implementation of such generators. Windings of this new generator are of graded insulated cables. These cables are of circular diameter instead of rectangular bars. [1],[3]. Difference between conventional generator and powerformer in the plant is shown in fig 1. and fig. 2. Due to such construction drawbacks because of insulation, are overcome and high voltage generation at generator terminal is possible. [1]

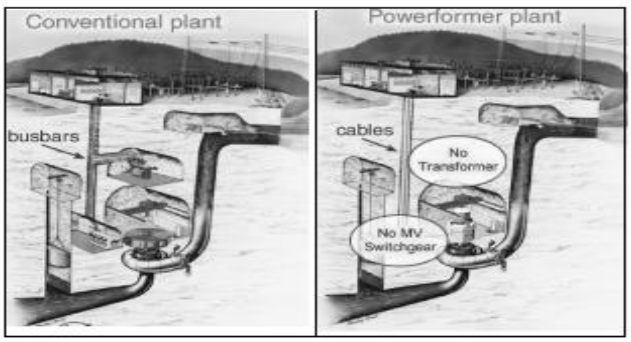

Fig -1: Conventional generator and powerformer in the plant [1]

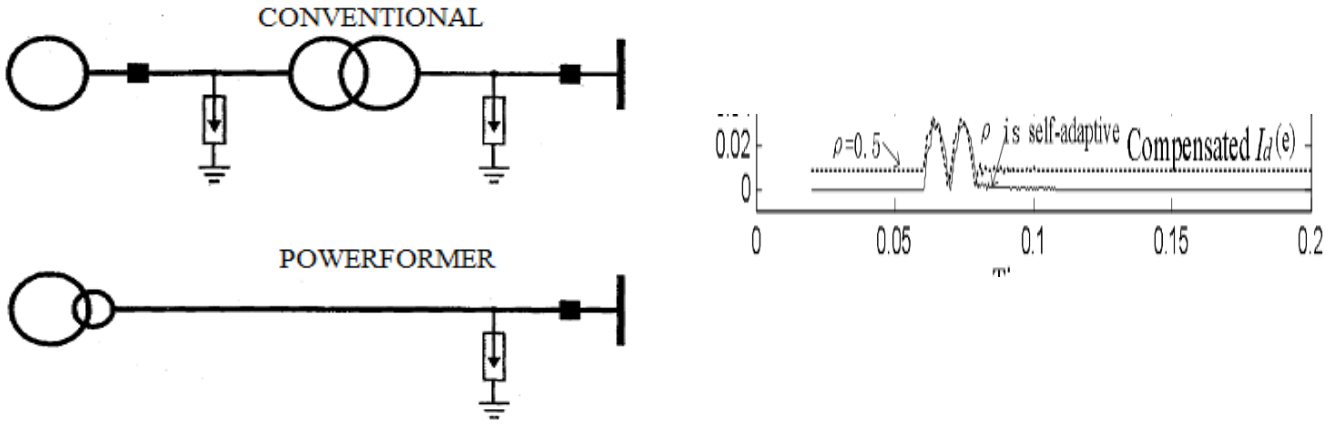

Fig. -2: Single line diagram of conventional generator and powerformer [3]

The powerformer has the ability to maintain an overload in its stator windings for a longer period than conventional generator, that is it can provide reactive power when needed for more time than obtained by conventional generator [4],

Analysis of the performance of the new generator was examined when employed in ALSTOM power hydro and proved to be a technology-push of a discontinuous innovation [1]. Generator performance is highly dependent on mini-electrical field strength. In conventional hydro generators stator coils consist of 'ROEBEL-BARS' composed of rectangular copper wires. Due to rectangular construction electrical field peaks are generated at the corners of the bar, as a result insulation has to be done accordingly which decreases overall performance. Hence this technical problem is overcome by using cables with a circular diameter. Thus, benefit of powerformer technology is generation of power at grid voltages without transformer unit. Because of constructional features expenses and protective schemes required are reduced. According to the study from [1] innovation of powerformer increases product performance by a factor of 5-10 times, and reduction in cost by almost greater than 30%.

2. DIFFERENTIAL PROTECTION BY POWERFORMER

Powerformer uses graded insulated cables, this cable can be considered as a capacitor with charges on electrodes. As per [2],[4] winding capacitance is divided into two portions in lump parameters pCw associated with voltage at neutral end of phase winding rest part i.e (1-pCw) associated with voltage at line terminal of the winding. In [2], the conclusion was derived from the simulation of an electromagnetic transient model for normal operation state, external fault and internal fault state for powerformer. The model comprises of multiparallel path powerformer which is connected to an infinite bus through transmission line (TL) and neutral of powerformer is grounded through high impedance as shown in fig. 3.

Fig. 3 Representation of the simulated powerformer [2]

The model can be used for different types of internal fault ananlysis of different parts of stator winding. Complete description of model is available in [5].

Simulation result on external phase to ground fault at 60% of transmission line is shown below fig. 4

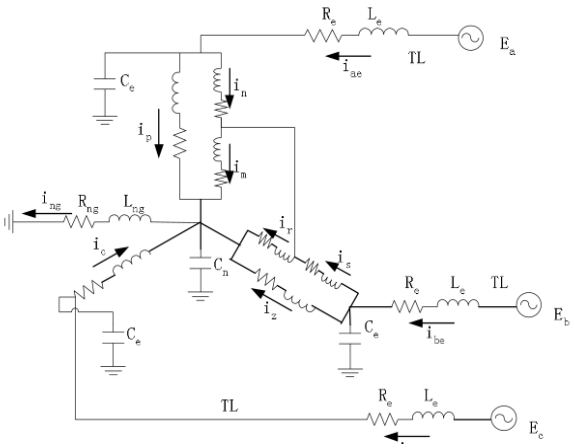

Fig -4: comparison of current compensation by self adaptive and fixed compensation method[2]

It is observe that threshold of differential potential should be raised to prevent mal operation of protection scheme which affects sensitivity of the relay, which is case with fixed compensated protection scheme represented by dotted line in the fig. 4. Whereas, using powerformer capacitive current is thoroughly eliminated without disturbing the set values of protection scheme shown by solid line in fig. 4. thus proving to be a self adaptive method for differential protection scheme [2].

Sensitivity of differential protection of powerformer is improved by using novel generator model where effect of winding capacitance, lump parameter equivalence capacitance of stator winding is considered. The self-adaptive compensated differential protection uses the terminal phase voltages, neutral voltage, total phase-earth capacitance and initial capacitive current to obtain accurate capacitance partition co-efficient ρ, where ρ remains constant under all circumstances [2].

3. ADVANTAGES

Since no main transformer and no MV switch-gears are required there is savings in material cost also reduction in maintenance cost. Improved generator efficiency. More reliable because of absence of main transformer and low voltage make/break switch. Thus merits of improved efficiency of new high voltage generator will be higher, higher is the output voltage and higher is its capacity. Moreover, limitation on stator current is one of the aspects that contribute to the collapse of the system. Since the powerformer has the overload capacity that is it can maintain an overload in its stator winding for longer time than the conventional generator, it helps in improving voltage stability. This has been proved in [3] Nordic Test System.

4. CONCLUSIONS

Thus a brief introduction to the powerformer along with the advantages is discussed and is concluded that implementation of powerformer in power station will increase the capacity and efficiency of power delivered by the power plant. Also the existing alternators can be easily replaced reducing the cost of power production. Moreover poweformer acts as a self adaptive compensated differential protection scheme for synchronous generators that provides advanced protection functions.

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