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DISTRIBUTED STATIC SERIES COMPENSATOR (DSSC) APPLICATION TO POWER SYSTEM- A REVIEW

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Abstract- This paper is showcasing review of distributed static series compensator (DSSC) & explains the effect of insertion of DSSC in transmission line power flow control. FACTS (Flexible AC Transmission System) technology the aspect of Power Electronics offers High speed & reliability of switching & thus the value of electric energy is enhance. Along with merits there are certain problems offered by FACTS technology which leads to complexity in operation & overall cost investment becomes large. The solution to this is DFACTS technology i.e Distributed FACTS devices can be used in distributed position and DSSC belongs to DFACTS family.

Keywords- FACTS, SSSC, DSSC, power control.

I. INTRODUCTION

TODAY'S, Electric Power sector require reliable & technically controlled approach to control flow of power in a transmission line. Generated power should be adequately taken to distribution point. Irrespective of various hurdles existing transmission assets should be utilized.

FACTS devices have ability of controlling transmission line power flow. Power system flexibility can be improved using FACTS devices by controlling system parameters such as voltage, impedance & Power. They can therefore improve system stability , increase transfer capability & provides reliability to transmission system. FACTS controllers can be series, shunt or phase angle compensating devices or a combination of above three types such as UPFC i.e. Unified power flow controller. Two FACTS devices provide series compensation: (1) Thyristor controlled series capacitor(TCSC) & (2)static synchronous series compensator.

Several TCSCs have been installed to improve small disturbance & transient stability of power system. However it injects low order harmonic component & transient response of circuit is rather slow because of controlling thyristor firing pulse & due to presence of inductor & capacitor in parallel it is susceptible to parallel resonance.

The Static Synchronous Series Compensator(SSSC) is a voltage sourced converter based series compensator. The SSSC provides series compensation to the transmission line by injecting compensating voltage in series with the line irrespective of the line current. The objective of series connected FACTS controller is to control the power flow & to increase thermal capacity which enhances utilization of existing power lines. However there

exists certain obstacles in employment of SSSC & FACTS controller such as it requires high rating power electronics component resulting in high investment also requires maintenance & repairs also it is not satisfying reliability constraints.

To overcome these above discussed hurdles a new concept of DSSC (Distributed Static Series Compensator) a member of DFACTS (Distributed FACTS) devices have been introduced. The DSSC has a spread nature which can convert the lumped & high rating SSSC into a distributed lots of power modules of low rating providing same amount of compensation

II. COMPARISION OF SSSC WITH DSSC

The SSSC is connected at one point in series with the transmission line. SSSC is an arrangement of coupling transformer, magnetic interface ,DC Capacitors & Voltage source converter. The coupling transformer is placed in series with the transmission line to inject the quadrature voltage in series with the line. Multi-pulse voltage configuration is provided by magnetic interface to eliminate low order harmonics. DC capacitor is connected to VSC.

The DSSC is advanced type of SSSC .The DSSC system is made up of large number of modules ,each module contains a small rated single phase inverter (10~20 kw), a communication link and a single turn transformer(STT) which can be mechanically clamped on to or suspended from the transmission line conductor. STT has transmission conductor as secondary winding & injects the desired voltage into the cable itself . The inverter is self powered by induction from the line & injects a voltage that is orthogonal to the current. The module can be suspended from the conductor . The STT remains in bypass mode until the inverter is activated & the DC control power supply transformer gets excited with

the STT secondary winding current. The DSSC schematic is shown in fig 2.

Large number of DSSCs devices are connected are clamped to conductors of a transmission line to control the line reactance[1]This feature provides variation in line reactance which results in control of power flow. There is no requirement of phase-ground insulation for DSSC hence has a flexibility of clamping it to any transmission line irrespective of its voltage level.

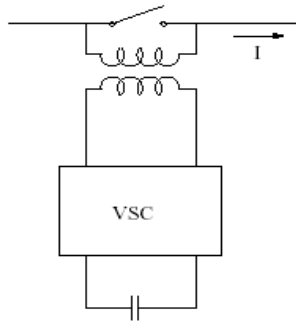


Fig. 1: Schematic of SSSC

There exists significant benefits because of distributed nature of DSSC. As an example a SSSC is located at one point in a transmission line which indicates injection of compensated voltage at single point i.e lumped network also it means high power electronic devices are connected at one point. With the use of number of DSSC modules compensation is provided at the actual point of requirement. Through Facts devices it is possible to match the investment with actual existing demand. For example if a system planners want to install FACTS system with SSSC or TCSC they would have to plan on for 30 -35 years operating life & have to design the system to operate as per the increasing power demand. This would not provide proper utilization of available power which would result in low return on capital employed (ROCE). However the implementation of DSSC could be expanded with actual increase in load which will maximize capital utilization. A cost comparison of lumped devices with distributed solutions in a 138kV/750 A Line (U.S. Dollars) has been shown in Table .1[1]

	Lumped	Distributed
Equipment Cost	\$ 4.17M	\$1.91M
Cost of Capital Over 30 Yr		
Energy Costs over 30 Y	\$2.69M	\$1.46 M
Total Cost of Ownership	\$6.86M	\$3.37 M

Table. 1

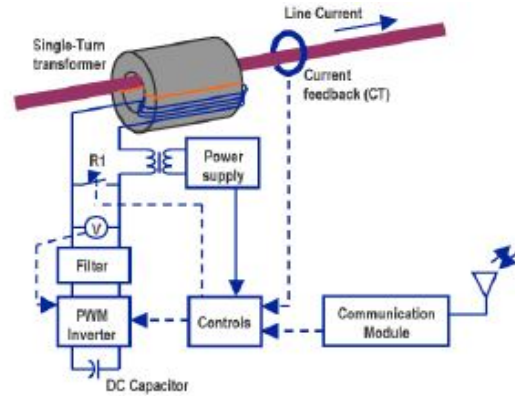


Fig. 2 : Schematic of DSSC [1]

Table. 2 Comparison of DSSC with SSSC

Parameters	SSSC	DSSC
Size & Weight	Large	Small
Cost	High	Low
Controllability	Less	More
Power Utilization	Less	More
Position	Connected at single place	Connected at different places
Flexibility	Less	More
Reliability	Less	More

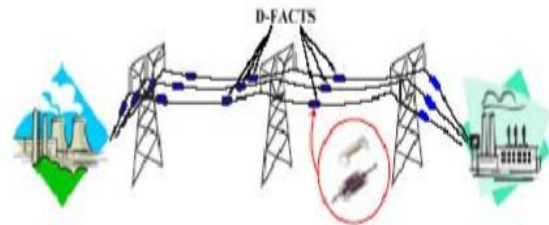


Fig. 3 : Distributed Compensation System[4]

III. PRESENT SCENARIO OF DSSC IN POWER SYSTEM

Various simulation have been performed using different softwares connecting DSSC to transmission lines of different ratings .This indicates the use of DSSC might have better results for a low voltage distribution network. It also helps to improve system voltage margin. Transmission line impedance is adjusted employing DSSC which increases available transmission network capacity. With the deployment of DSSC in transmission line system reliability increases. Enhancement of power system transient stability is possible with the use of DSSC. Laboratory testing of DSSC has been performed at 480V & was observed that injected voltage is orthogonal to the line current[1]. In case of fault DSSC shorts the

transformer primary winding & protects itself. DSSC module do not contribute to system fault current.

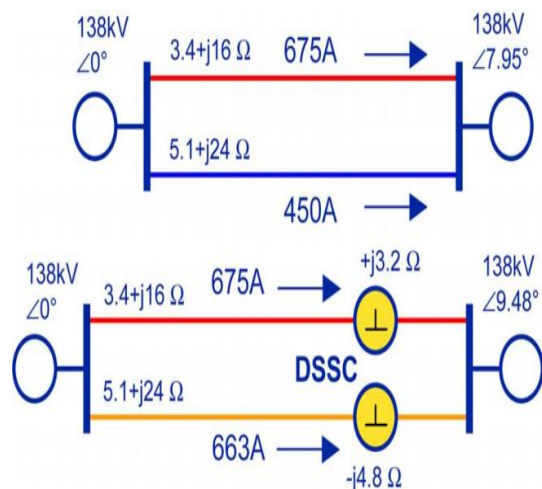


Fig. 4 : DSSC control of power flow over parallel lines connecting voltage buses: uncompensated (top) and with DSSC compensation (bottom). [1]

Fig 4 explains the importance of DSSC in transmission line. This example shows two lines of unequal length transfers power from bus 1 to bus 2. In first case where DSSC unit is not connected in the line the current carrying capacity in second line is less as compared to a line connected with a DSSC. It is observed from above simulation that in case of DSSC connected to the line the current carrying capacity of second line is increased by reducing the reactance in the line where as the current carrying capacity of first line in second case is kept constant by keeping it in its thermal limit simply by increasing the the reactance of transmission line. As the current capacity is increased in second line it indicates that power transfer capacity is also increased.

DSSC is certified for enhancement of power system operation . For verification of capability of DSSC for increasing the capability of whole system a two machine power system is investigated. The simulation results shows when DSSC is not in circuit the rotor angle between two machines increases rapidly and two machines falls out of step after clearing of fault. However when DSSC is connected in the system the system gets stabilized even without a specific controller. In case of severe fault occurrence the system becomes unstable even in the presence of DSSC. Therefore a POD controller is added to the main control loop of DSSC in order to improve transient stability margin of the system. The DSSC offers more reliability constraints to the power system.

The reliability model has been proposed for DSSC & this model is analyzed & reduced to an equivalent three state Markov model. This model is then associated with transmission line model which is equipped with number of DSSC modules. This

reliability model has been studied the best suitable location for DSSC can be found out based on this reliability study. Several indices have been calculated for bulk power transmission where DSSCs can be easily placed.

IV. CONCLUSION

This paper present comparison of SSSC with DSSC which gives a idea that distributed nature of DSSC is more beneficial. Several existing results have been discussed for DSSC which leads to the conclusion that application of DSSC system provides more improved sustaining environment for maximum utilization of existing power. Also system stability standards is improved & a more reliable system can be possible. This concept of DSSC with actual implementation to system will bring new era of power . Flexibility of power system will be extended. At present laboratory testing of DSSC & simulations have been carried out & corresponding results have been compared which indicates that its actualimplementation in power system should not be delayed India's power sector should take innitiative to get benefits of DSSC device by implementing DSSC in actual power system.

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