Enhancement of Voltage Stability & reactive Power Control of Distribution System Using Facts Devices

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ABSTRACT
The modern power distribution network is constantly being faced with an ever-growing load demand. Distribution networks experience distinct change from a low to high load level every day. Electric load growth and higher regional power transfers in a largely interconnected network becoming more complex and less secure power system operation. Power generation and transmission facilities are unable to meet these new demands. Voltage control is a difficult task because voltages are strongly influenced by random load fluctuations. Voltage profile can be improved and power losses can be considerably reduced by installing Custom Power Devices or Controllers at suitable location. FACTS are devices which allow the flexible and dynamic control of power systems. Enhancement of system stability using FACTS controllers has been investigated. These controllers which are also named Distribution Flexible AC Transmission System (D-FACTS) are a new generation of power electronics-based equipment aimed at enhancing the reliability and quality of power flows in low-voltage distribution networks. This work includes first the optimal location of FACTS devices, second voltage stability analysis and third control of reactive power of system. The model can be simulated in MATLAB. The performance of the whole system such as voltage stability, transient stability, frequency and power swings will be analyzed and compared without FACTS and with FACTS device.

For stability analysis after creating the faults (disturbances) in the system the FACT device (SVC, STATCOM, SSSC, and UPFC) and power system stabilizers (PSS) can be used to improve transient stability and power oscillation damping of the system.

Keywords – AC, FACTS, D-FACTS, SVS, STATCOM, SSSC, UPFC.

I. INTRODUCTION
Power quality is set of electrical boundaries that allow the piece of equipment to function in its intended manner without significant loss of performance or life expectancy. The electrical device like electric motor, a transformer, a generator, a computer, a printer, communication equipment, or a house hold appliance. All of these devices and others react adversely to power quality issues, depending on the severity of problems. Reactive power cannot be transmitted across large power angle even with substantial voltage magnitude gradient. Reactive power should be generated close to the point of Consumption. We can make several reasons to minimize reactive power transfers.
1) It is inefficient during high real power transfer and require substantial voltage magnitude gradient
2) It causes high real and reactive power losses
3) It can lead to damaging temporary overvoltage’s following load rejections
4) It requires larger equipment size for transformer and cables

Due to this here D STATCOM as shunt device is used. DSTATCOM is a voltage-source inverter (VSI) based shunt device generally used in distribution system to improve power quality. The main advantage of DSTATCOM is that, it has a very sophisticated power electronics based control which can efficiently regulate the current injection into the distribution bus. The second advantage is that, it has multifarious applications, e.g. i. cancelling the effect of poor load power factor, ii. Suppressing the effect of harmonic content in load
currents, iii. Regulating the voltage of distribution bus against sag/swell etc., compensating the reactive power requirement of the load and so on.

II. D STATCOM

A DSTATCOM is a controlled reactive source, which includes a Voltage Source Converter (VSC) and a DC link capacitor connected in shunt, capable of generating and/or absorbing reactive power. The operating principles of a DSTATCOM are based on the exact equivalence of the conventional rotating synchronous compensator. The DSTATCOM protects the utility transmission or distribution system from voltage sags and/or flicker caused by rapidly varying reactive current demand. In utility applications, a DSTATCOM provides leading or lagging reactive power to achieve system stability during transient conditions.

The DSTATCOM can also be applied to industrial facilities to compensate for voltage sag and flicker caused by non-linear dynamic loads, enabling such problem loads to co-exist on the same feeder as more sensitive loads. The DSTATCOM instantaneously exchanges reactive power with the distribution system without the use of bulky capacitors or reactors.

In most applications, a DSTATCOM can use its significant short-term transient overload capabilities to reduce the size of the compensation system needed to handle transient events. The short-term overload capability is up to 325% for periods of 1 to 3 seconds, which allows applications such as wind farms and utility voltage stabilization to optimize the system’s cost and performance. The DSTATCOM controls traditional mechanically switched capacitors to provide optimal compensation on a both a transient and steady state basis.

The AC terminals of the VSC are connected to the Point of Common Coupling (PCC) through an inductance, which could be a filter inductance or the leakage inductance of the coupling transformer, as shown in figure 1. The DC side of the converter is connected to a DC capacitor, which carries the input ripple current of the converter and is the main reactive energy storage element. This capacitor could be charged by a battery source, or could be recharged by the converter itself. If the output voltage of the VSC is equal to the AC terminal voltage, no reactive power is delivered to the system. If the output voltage is greater than the AC terminal voltage, the DSTATCOM is in the capacitive mode of operation and vice versa. The quantity of reactive power flow is proportional to the difference in the two voltages. It to be noted that voltage regulation at PCC and power factor correction cannot be achieved simultaneously. For a DSTATCOM used for voltage regulation at the PCC, the compensation should be such that the supply currents should lead the supply voltages; whereas, for power factor Correction, the supply current should be in phase with the supply voltages.

III. Basic Configuration of D STATCOM

The D-STATCOM is a three-phase and shunt connected power electronics based device. It is connected near the load at the distribution systems. The major components of a D-STATCOM are shown in figure 2. It consists of a dc capacitor, three-phase inverter (IGBT, thyristor) module, ac filter, coupling transformer and a control strategy. The basic electronic block of the D-STATCOM is the voltage sourced inverter that converts an input dc voltage into a three-phase output voltage at fundamental frequency.

![Figure 1. Basic structure of D STATCOM](image1)

![Figure 2. Simplified diagram of a D-STATCOM connected to a distribution network](image2)
Fig 2 shows a simplified diagram of a STATCOM connected to a typical distribution network represented by an equivalent network.

The D-STATCOM consists mainly of a PWM inverter connected to the network through a transformer. The dc link voltage is provided by the capacitor which is charged with the power taken from the network. The control system ensures the regulation of the bus voltage and the dc link voltage. The principle operation of the DSTATCOM depends upon reactive current generation, so \( I \) varies as

\[
I = \frac{V_0 - V_b}{X}
\]

Where \( V_0, V, X \) are the output voltage of the IGBT-based inverter, the system voltage, the total circuit reactance (transformer leakage reactance plus system short circuit reactance) respectively.

When the secondary voltage (VD) is lower than the bus voltage (VB), the D-STATCOM acts like an inductance absorbing reactive power from the bus. When the secondary voltage (VD) is higher than the bus voltage (VB), the DSTATCOM acts like a capacitor generating reactive power to the bus.

OPERATING MODES OF D STATCOM

- No load mode \((V_i = V_d)\)
- Inductive Mode \((V_i < V_d)\)
- Capacitive Mode \((V_i > V_d)\)

IV. Model Description & Simulation Result

Modelling the D-STATCOM includes the power network and its controller in simulink environment require electrical block from power system block set. Test System
Fig 6 shows the test system implemented in MATLAB SIMULINK. The test system comprises an 11kV, 50Hz transmission system, a 50 MW load suddenly occur at the load end thereby the most important parameter of the system i.e. Voltage is varied or it may crosses its permissible limits so to maintain the voltage stability of the system I am using D-STATCOM. Using D-STATCOM we can also control the reactive power flow in the distribution lines. Circuit Breaker is used to control the period of operation of the D-STATCOM.

The first simulation contains no STATCOM and 50 MW load suddenly applied at the load end. A new set of simulations was carried out but now with the D-STATCOM connected to the system as shown in fig 8 where the very effective voltage regulation provided by the D-STATCOM can be clearly appreciated.

V. CONCLUSION

The model of a D-STATCOM was analyzed and developed for use in simulink environment with power system block sets. Here a control system is designed in MATLAB simulink. A D-STATCOM can control reactive power and also regulate bus voltage. It can improve power system performance. Here waveform shows the performance of DSTATCOM in a distribution system. By varying an inductive load at some amount we can observe that D-STATCOM can regulate load side voltage approximately constant which shows the voltage stability of the D-STATCOM.

VI. REFERENCES

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