Introduction of Voltage Stability and Power Flow Analysis Incorporated with STATCOM in Newton Raphson Method in IEEE14 Bus System

Ankita Shukla[1], Dr. Sameena Elyas Mubeen[2]
[1]*M tech Researcher, REC Bhopal*
[2]*HOD of Electrical & Electronics Department, REC Bhopal*

Abstract - This paper presents a review of voltage stability & STATCOM in Newton Raphson for power flow analysis. The main purpose of this paper is to present a review of voltage stability and STATCOM is incorporated in power flow analysis. Reactive power flow compensation is improves by the use of STATCOM and voltage profile of the system improves and reduce losses. In this paper a review of voltage stability enhancement by the use of STATCOM. To study the effect of STATCOM in load flow study is performed on IEEE 14 buses with and without STATCOM and the results are then compared to show the effect of STATCOM on the system.NR method is used for the load flow analysis of the system.

Keywords: Facts, Power flow analysis, voltage stability, STATCOM, Newton Raphson.

I. INTRODUCTION

For the power system analysis and design power flow analysis is used and for planning, optimization, operation and control power flow study is most important at all stages of power system. They are important for planning, economic scheduling, operation and exchange of power between utilities [4]. Over the time human race has become very much dependent upon electrical energy, to fulfil their daily needs. There are few problems that we face. They are individual power outages and power disruption. To maintain the urban lifestyle there is enormous demand of power so transmission systems are being pushed to operate closer to their stability limit and also reaching close to their thermal limits. The constraints faced in maintain the demand and supply of power equal or matched are:

1. To full fill the need of power within the thermal limit.
2. Sometimes when the power demand is greater than the supply then there is stability.

Problem and this causes blackouts incurring vast losses. The characteristic of the power delivered is affected by the above two reasons. Now the requirement arises to check the above constraints and they can be done by enhancing the power system control. These limitations can be controlled by FACTS devices. Flexible ac transmission system is full form of FACTS. To determine the match between the demand and provisions of power, organize over the control flow with improvement in scheme stability is important which can be achieved by the FACTS devices. . FACTS devices have now became the require of the hour. It is now becoming our need to use FACTS devices to enhance the efficiency of the power system [2].

To decrease the power transmission loss reactive power reimbursement is used. Immediate power compensation is also used to maintain power transmission capability and to maintain the supply voltage [2].

To maximize the steady state transmittable power and to control the voltage profile shunt compensation is used. STATCOM (Static Compensator) is a shunt compensator and comes under FACTS device category that is being applied to long transmission lines maintain the supply voltage [5]. Reactive power compensation improves the voltage profile of the system, increase the power transfer in the lines and reduce losses. Synchronous compensator is one such device that is used for reactive power compensation. It provides reactive power compensation thereby improving the voltage profile of the system [2].STATCOM is most important used for voltage stability.

II. POWER FLOW ANALYSIS

Power flow analysis with the vast spread in population is in peak demand in electrical power now-a –days. The main aim is to supply in a huge amount of power to the consumer safely. Except these the task is to reduce the cost of the

transmission system. There are many constraints like smooth, easy and economical operations are followed for the electrical utilities companies. The addition of other equipments like generator sometimes makes the more faults in the power system. As we know about the power system the power system after discussion that huge interconnections of generators and transformers are combined together at various points of the system. If any faults determined it should be minimized as it would lead to large economical losses.

Sometimes the function is to draw maximum efficiency with safty.load flow study applied to the power system to study about the network and its behavior when it is supplied to upgrade for nay system [9]. When power flow equation solved it expressed the steady state voltages at all the buses of the between and real & reactive power can be calculated by these equations. But the problem is that they are non-linear in nature and cannot be solved by normal mathematics calculations. By taking an appropriate of a value these non linear equations are normally solved and correcting it in solutions has permissible values. There are many more various methods like gauss method, gauss seidal, NR and fast decoupled to solve the equation [10].

III. FACTS

Flexible AC transmission system (FACTS) gives solution to the problems and limitations which are introduced in power system with the introduction of power electronics based control for reactive power [12].

Flexible AC transmission system (FACTS) controller are power electronic based controller with the application of FACTS knowledge, bus power extent and power flow along the broadcast line can be more flexible controlled[1].With the enhancing problems in the system, suitable solutions must be used by considering different factors such that the problem can be defeated completely. One of the approaches is FACTS controllers [5]. There is different classification for these devices according to the problems rising in the system:

1. Series Controllers are used for power flow control specifically.

2. Shunt Controllers are used for voltage profiles.

3. Series-Shunt Controller is actually the combination of two. Therefore, can be used for both the cases.

FACTS Controllers in programme system have subsequent benefit such as-

1. The reliability of transmission system is increased.

2. Utilization of existing power system is superior.

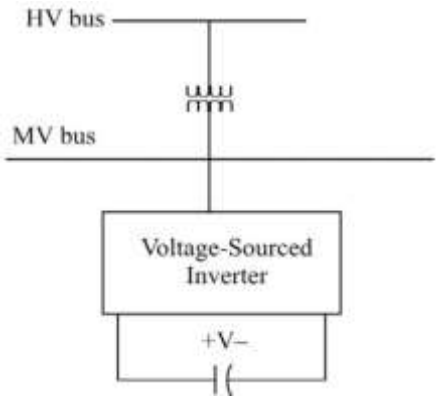
3. Assist to increase the transient stability of the system [6].

To create the match between supplies of power and the demand control over the power flow and enhancement in system stability is important which can be achieved by the FACTS devices. FACTS devices are used to enhance the efficiency of the power system.

Different FACTS Controller 1. Static Var Compensator 2. Thyristor Controlled Series Compensator3. Static Synchronous series compensator 4. Static Synchronous Compensator 5. Unified Power Flow Controller 6.Convertible Static Compensator 7. Interline Power Flow Controller 8 Generalized Unified Power Flow Controller.

IV. STATCOM

STATCOM is also known as the "static synchronous organizer". It is push linked static variable controller whose capacitive or inductive output current can be unnatural autonomous of the ac organization voltage" [5]. The STATCOM is a facts controller based on VSC (voltage sourced converter). A VSC generate a synchronous voltage of primary frequency, controllable importance and phase approach. If a VSC is shunt linked to a organization via a coupling transformer, the resulting STATCOM can inject or absorb reactive power to or from the bus to which it is connected and thus regulate the bus voltage magnitude [1].



STATCOM is used to provide reactive power to the AC arrangement, alongside that, it will offer the DC power necessary for both inverters. The thoughtless power can be

compensated either by improving the receiving voltage or by reducing the line reactance [7].

V. VOLTAGE STABILITY

Voltage stability is concerned with the ability of a power system to maintain acceptable voltage level at all nodes in the system under normal and contingent conditions. A power system is said to have a situation of voltage instability when a disturbance causes a progressive and uncontrollable decrease in voltage level. The voltage instability is usually caused by a disturbance or change in operating circumstances, which generate increased demand for reactive power [8]. This improve in electric power demand makes the power system work close to their limit conditions such as high line current, low voltage stage and comparatively high power angle differences which point out the system is operating under heavy loading conditions. Such a situation may cause system losing stability, islanding or voltage collapse [1]. The main problem facing many utilities in maintaining adequate voltage level is economic. They are squeezing the maximum possible capacity for their bulk transmission network to avoid the cost of building new lines and generation services. When a mass broadcast system is operated close to the voltage volatility edge, it becomes hard to manage the reactive power margin for that system [3]. As a result the system stability becomes one of the major concerns and an appropriate way must be found to monitor the system and avoid system collapse. Many algorithms have been planned in the literature for voltage stability analysis. Most of the utilities have a tendency to depend regularly on conventional load flows for such analysis [5]. Some of the proposed methods are concerned with voltage instability analysis under small perturbations in system load parameters. The analysis of voltage stability, for planning and operation of a power system, involves the examination of two main aspects;

Many algorithms have been planned in the literature for voltage stability analysis. Most of the utilities have a tendency to depend regularly on conventional load flows for such analysis. Some of the proposed methods are concerned with voltage instability analysis under small perturbations in system load parameters. The analysis of voltage stability, for planning and operation of a power system, involves the examination of two main aspects;

i) How close the system is to voltage instability.

Proximity and ii) the key contributing factors such as the weak buses, area involved in collapse and generators and lines participating in the collapse when voltage instability occurs [9]. Proximity can provide information regarding voltage security while the mechanism gives useful information for operating plans and system modifications that can be implemented to avoid the voltage collapse. Various techniques are available for voltage stability studies such as P-V curves, Q-V curves, modal analysis, minimum singular value, sensitivity analysis, reactive power

Optimization, artificial neural networks, euro-fuzzy networks, reduced Jacobian determinant, Energy function methods, Thevenin and load impedance indicator and loading margin by multiple power-flow solutions [2]. The Flexible AC Transmission System (FACTS) controllers [5-6] are increasingly used to provide voltage and power flow controls. Addition of FACTS devices is found to be highly effective in preventing voltage instability [5]. Owing to high cost, the number of FACTS devices to be used should be minimized.

VI. EXPERIMENTAL RESULTS

Case Study for an IEEE 14 Bus System Consider a standard IEEE 14 bus system for load flow study by Newton Raphson load flow method. The source impedance is Xvr= 0.1 p. u.

Bus no	Bus Code	VM	ANGLE DEGREE	LOAD MW	LOAD MVAR	GEN MW	GEN MVAR
1	1	1.060	0	0.00	0.00	0.00	0
2	2	1.045	0	21.00	0.00	40.00	0
3	3	1.010	0	94.00	12.70	0.00	0
4	3	1.000	0	47.00	19.00	0.00	0
5	3	1.000	0	76.00	39.00	0.00	0
6	2	1.070	0	11.00	75.00	0.00	0
7	3	1.000	0	0.00	0.00	0.00	0
8	2	1.090	0	0.00	0.00	0.00	0
9	3	1.000	0	29.50	16.60	0.00	0
10	3	1.000	0	90.00	5.80	0.00	0
11	3	1.000	0	35.00	1.80	0.00	0
12	3	1.000	0	61.00	1.60	0.00	0
13	3	1.000	0	13.50	5.80	0.00	0
14	3	1.000	0	14.90	5.00	0.00	0

Line Data:

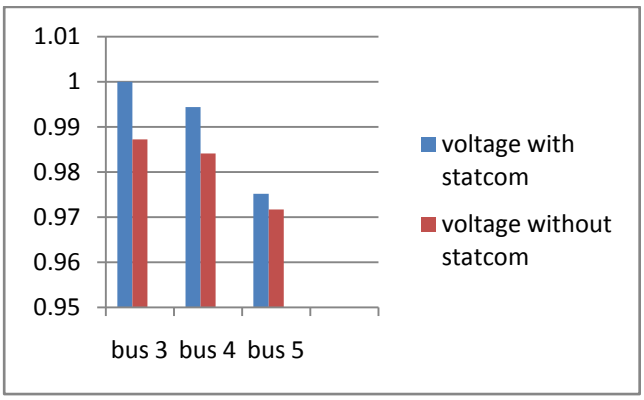
The table 1shows the transmission line data. Columns 1 and 2 outline the corresponding line bus numbers. Columns 3 through to 5 contain the line resistance, reactance, and one half of the total line charging suspectance in per unit on the MVA base of 100MVA.

Results for Load Flow:

Bus voltages and phase angle The Newton Raphson load flow IEEE 14 bus system implemented on MATLAB return following results For Iteration count = 6 .The bus voltages and phase angle obtained are shown in table- Line Data for IEEE 14 Bus.

BUS NL	BUS NR	R	X	B
1	2	0.0194	0.0592	0.0528
2	3	0.0800	0.2400	0.0438
2	4	0.0600	0.1800	0.0374
1	5	0.0600	0.1800	0.0492
2	5	0.0400	0.1200	0.0340
3	4	0.0100	0.0300	0.0346
4	5	0.0800	0.2400	0.0128
5	6	0.0200	0.0600	0.0000
4	7	0.0800	0.2400	0.0000
7	8	0.0600	0.1800	0.0000
4	9	0.0600	0.1800	0.0000
7	9	0.0400	0.1200	0.0000
9	10	0.0100	0.0300	0.0000
6	11	0.0800	0.2400	0.0000
6	12	0.0200	0.0600	0.0000
6	13	0.0800	0.2400	0.0000
9	14	0.0600	0.1800	0.0000
10	11	0.0600	0.1800	0.0000
12	13	0.0400	0.1200	0.0000
13	14	0.0100	0.0300	0.0000

From the results voltage profile has been improved with the inclusion of STATCOM in the network. Here voltage at bus 3 is increased 0.98 P.U. to 1.00 P.U. also the voltages of bus 4 is improved and is almost equal to 1 p.u. Voltage of bus 5 is also improved. The effect of STATCOM on the nodal voltage of bus 14 is minimum as it is far away from it.



VII. CONCLUSION

The best operating condition of power system network is decided by power flow study. To solve power flow equation Newton Raphson load flow method has been used as to research the effect of STATCOM. A modified power flow of the STATCOM is ventured. In various bus systems and at different locations STATCOM is placed and the modified power flow is being used to access the effect of STATCOM on the system. This can be done through MATLAB. Load flow study of all three bus (IEEE 14) is considered and it is shown that the voltage profile of the system is improved and it is shown using plots. It was also obvious that the voltage magnitude of that particular bus at which STATCOM is placed is maintained at 1 p. u. The hasty power making and inclusion of the slack bus producer is reduce. The buses located far away starting from the STATCOM are smallest amount affected while there was no effect of STATCOM on the real power.

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