Research of Facts Devices for Stability

C. Sharan, S. Subasangkari, V.N. Ganesh, J. Ajay Daniel

Abstract--- Nowadays the consumption and need for the power is more hence there is great demand on power consumption by the people which may often cause instability in power system. This instability in Voltage or current in the power system can be controlled using various kinds of facts device. Hence, this paper explains the role of the facts devices in maintenance of stability and their optimal placements in power system. Thus this paper gives a comprehensive and comparative study of different types of facts device and their role in Voltage or transients stability analysis methods.

Keywords--- FACTS, Stability Analysis, Optimal Placements.

I. INTRODUCTION

The ability of the equipment to consume the energy being supplied to it is known as power quality. If the voltage stays within the prescribed range then it is said to be a good power quality or if it exceeds the prescribed range of voltage then it is said to be of poor quality.

There are many different ways for the power quality improvement[16].

The power system becomes unstable due to increase in power demand hence it becomes more difficult to operate and causes damage to the power system due to increase loss in power[1].

Nowadays a new technique known as facts device is used for the power quality improvement in power system. Optimization is a technique which is used to optimally locate the FACTS device in the power system[13].

Flexible alternating current transmission system (FACTS) is static equipment used for the AC transmission of electrical energy.

It is used for the enhancement of controllability and increases poor transfer capability[37]. It is generally a power electronic device.

There are many different types of FACTS devices are[15]:

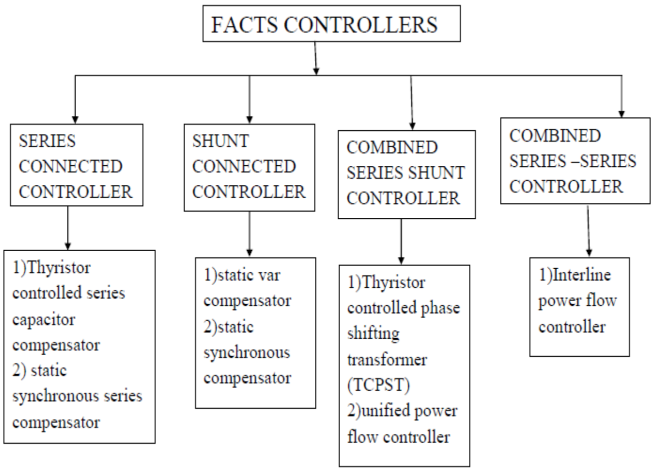

Figure 1: Classification of FACTS devices

Out of these facts devices we choose,

- STATCOM
- IPFC
- TCSC

For the review purpose as they are more important than the others.

The optimal placement of facts devices explains us about, where these facts devices has to be placed and their correct location in the power system[2,9]. Such as STATCOM is usually placed in the midpoint of the transmission lines and TCSC is placed at the 500KV transmission lines and IFPC acts as a voltage source converter[3,10].

Power system all over the world has to be operated very close to stability limits owing to the ever increasing power demand[5].

If the system returns back to its normal form then it is said to be a stable system otherwise the system is said to be unstable[25,40]. This maintenance of stability in the power system can be achieved by some useful techniques using FACTS devices.

II. STATIC SYNCHRONOUS COMPENSATOR (STATCOM)

A static synchronous compensator (STATCOM) is a directing device utilized on alternating current transmission systems[7]. It depends on power devices such as voltage-source converter and can act as either a source or sink of reactive AC capacity to an electric network. If it is associated with the power source it can also provide active AC power.

Revised Version Manuscript Received on August 19, 2019.

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It is an individual from the FACTS group of device[31]. It is intrinsically secluded and electable.

These compensators are likewise usable to lessen voltage changes. The STATCOM is used to support the electrical network that has poor power factor and poor voltage regulation[8,12]. A STATCOM is a voltage source converter (VSC) - based device, with the voltage source behind a reactor.

The voltage source is made from a DC capacitor and along these lines a STATCOM has less reactive power ability[18]. In any case, its active power ability can be enhanced if an appropriate energy storing device is associated over the DC capacitor. The reactive power at the terminals of the STATCOM relies upon the amplitude of the voltage source[28].

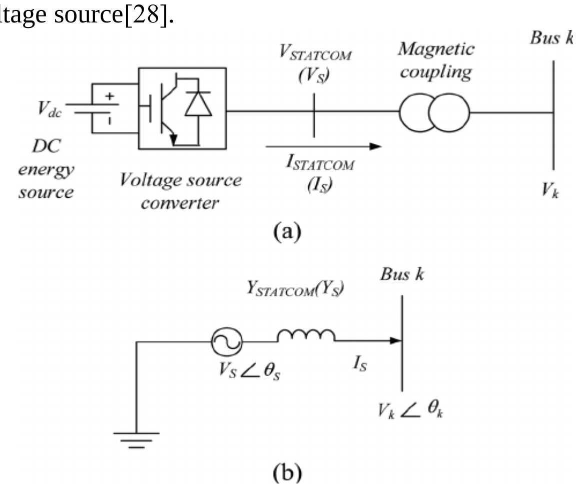

Figure 2: Equivalent circuit of the STATCOM

The optimal placement of the STATCOM in the buses is found here dependent on the voltage sensitivity[14]. As of now, sensitivity investigation is ending up to an ever increasing extent essential in practical power system activities[21].

The power administrator utilizes these to study and monitors the power system and identifies the defects in the power system[19]. Voltage imbalance is basically connected with reactive power instability in a nearby organize or a predefined transport in a system which isknown as the frail transport[26,39]. In this manner voltage sensitivity factor is utilized by selecting the ideal areas of VAR support.

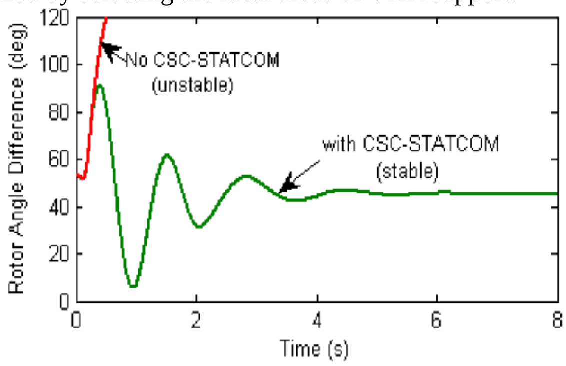

Figure 3: Stability analysis waveform with or without STATCOM

The system is bought back to control by injecting the current in parallel to the line that changes the reactive power which in turn influences the rotor angle. Thus the best optimal placement of the STATCOM can be obtained[41].

The STATCOM plays out indistinguishable capacity from the SVC. This is because of the way that the most extreme capacitive power produced by a SVC is corresponding to the square of the system voltage (consistent susceptance) while the greatest capacitive power created by a STATCOM diminishes straightly with voltage (steady current)[43,44]. This capacity to give progressively capacitive responsive power amid blame is one imperative preferred standpoint of the STATCOM over the SVC[50,51].The STATCOM can be worked in two unique modes: In voltage guideline mode (the voltage is managed inside breaking points as clarified beneath)[23] .In var control mode (the STATCOM receptive power yield is kept consistent).

III. INTERLINE POWER FLOW CONTROLLER (IPFC)

Interline Power Flow Controller. The goal of acquainting this controller is with location the issue of repaying various transmission lines associated at a substation[17].

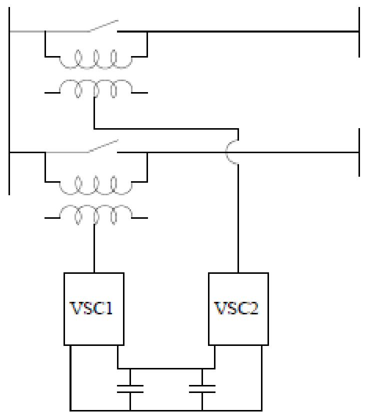

Figure 4: Equivalent circuit of IPSC

The dynamic power stream in a line is controlled or directed by the series reactive compensation (as a TCSC or SSSC)[22]; the control of reactive power isn't possible except if dynamic (genuine) voltage in stage with the line current isn't infused[29].

The use of a TCSC (or SSSC with impedance copying) results in the decrease of net arrangement reactance of the line. In any case, X/R proportion is decreased fundamentally and accordingly expands the responsive power stream (infused at the less than desirable end) and losses in the line[24]. All the dc capacitors of individual converters are connected in paralleled such that they provide controllable series compensation to each and individual line by transferring the real power series connected VSCs with the lines[58].

This is achievable as all the series converters are located closest to the substation. The UPFC is more similar to that of the IPFC in magnitude and phase angle of the given voltage in the primary system that can be controlled by transferring the real power with the secondary system[35,36].

The essential distinction with an UPFC is that the emotionally supportive network in the last case is the shunt converter rather than an arrangement converter[32].

The arrangement converter related with the primary system (of one IPFC) is named as the monitor converter while the arrangement converter related with the secondary network is named as the slave converter[20].

The monitor converter controls both the dynamic and reactive voltage within a considerable range while the slave converter controls the DC voltage (over the capacitor) and the reactive voltage extent[30].Correlation of results with different areas guarantees that arrangement of IPFC at the proposed area is a sound area for the arrangement of IPFC regarding decrease of blockage. A decrease in Genuine and receptive power misfortune has likewise been watched[34]. Thus, the general system execution has been concentrated under various stacking conditions and the outcomes are observed to be good.

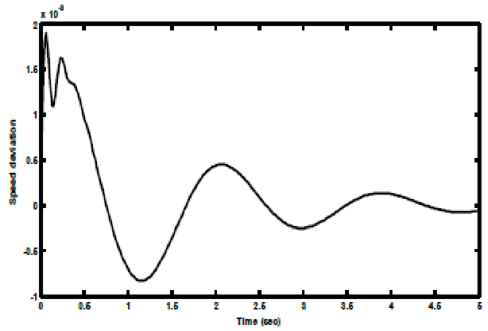

Figure 5: Angle deviation waveform without IPFC

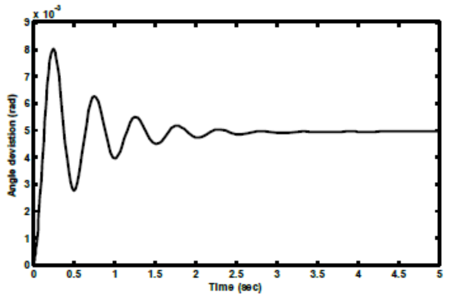

Figure 6: Angle deviation waveform with IPSC

IV. THYRISTOR CONTROLLED SERIES COMPENSATION (TCSC)

The reactance of transmission line is compensated to control the power flow by using the TCSC which is one of the series compensator[6]. It is located either at the center of transmission lines or at the line terminals but in most of the cases it is located at the center of the transmission line[11]. This is because the fault current in the center of the transmission line are low.

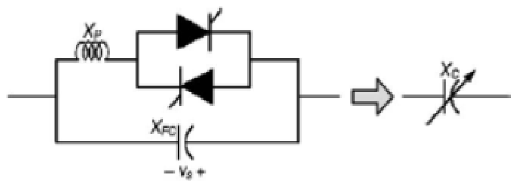

Figure 7: Equivalent circuit of TCSC

The TCSC present in transmission lines is useful for maintenance of power system.

Voltage collision:

While comparing STATCOM and IPFC the voltage collision in transmission lines is more when we use TCSC.

With TCSC:

$$V=E\cos(\delta) \pm \sqrt{E^2\cos^2 - 4Q_L x} / 2$$

Without TCSC:

$$V=E\cos(\delta)\pm\sqrt{E^2\cos^2(\delta)-4Q_L(x-x_1\csc(a))}/2$$

δ- Rotor angle of generator

Q_L- load reactive power

The SMDL system is unstable with positive and real Eigen values of TCSC. Since the stability level is less using TCSC **LQR** controller is added to the system. LQR controller when added to the system it provides more stability to the overall system[55,56].

The smooth variable series capacitive reactance is provided by the thyristor controlled reactor when shunted by the series capacitor bank that consists of capacitive reactance compensator[57].The series impedance is changed it increase the loadability of the power system and reduces the transmission losses when the thyristor controlled series capacitors are installed in the transmission lines[45,46].

This model limits the normal estimation of intensity misfortune cost and the venture cost of TCSC thinking about the likelihood of various situations, which are created by utilizing the traditional copula hypothesis, where the transient relationship among wind and burden is considered[53,54].

At that point the linearization strategies are embraced to change the model to a blend whole number straight program. Thyristor Controlled Series Capacitors (TCSC) addresses explicit dynamical issues in transmission systems[48,49]. Right off the bat it increments damping when vast electrical system are interconnected. Also it can defeat the issue of Sub-Synchronous Resonance (SSR), a wonder that includes cooperation between expansive warm producing units and arrangement remunerated transmission system[59,60].

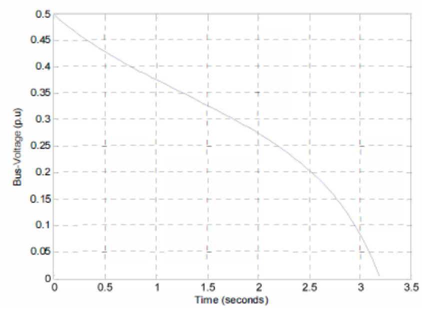

Figure 8: Voltage waveform without TCSC

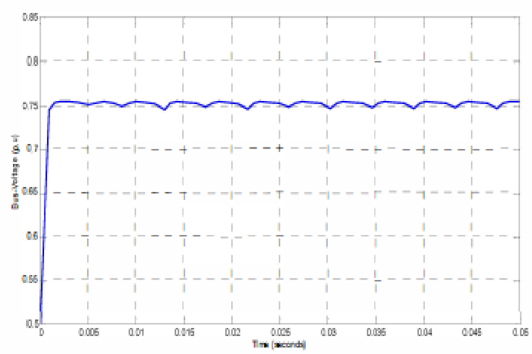

Figure 8: Voltage waveform with TCSC

Retrieval Number: B11090882S819/2019©BEIESP
DOI:10.35940/ijrte.B1109.0882S819

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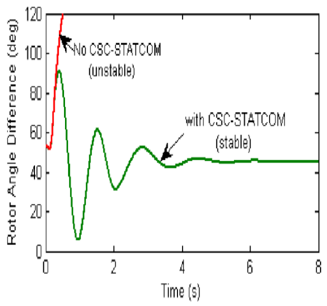
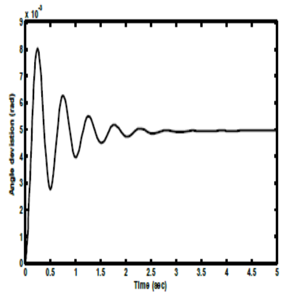
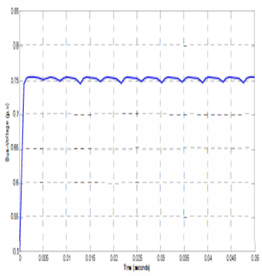
V. COMPARISON BETWEEN THE STATCOM, IPFC, TCSC

Table 1: Comparisons between STATCOM, IPSC and TCSC

TOPICS	STATCOM	IPFC	TCSC
expansion	Static synchronous Compensator.	Interline power flow controller.	Thyristor controlled series compensation.
Definition	STATCOM is usually connected in shunt and it is one of the FACTS devices used in power electronics and to improve the instability on power grids.	IPFC manages the flow of power in multi-line transmission system and it is one of the voltage source convertors.	TCSC is utilized in power frameworks to progressively control the reactance of a transmission line so as to give adequate burden remuneration.
Optimal placements	It is placed at the midpoint of the of the transmission lines.	It is placed on the transmission lines that have the highest range of danger.	It is placed at the transmission lines of 500 kv.
Technical characteristics	1. Voltage control VAR compensation. 2. Transient and dynamic Stability. 3. Voltage stability Damping oscillations	1. Current control. 2. Transient and dynamic Stability. 3. Voltage stability damping oscillations.	1. Voltage control Reactive power control. 2. Transient and dynamic Stability. 3. Voltage stability damping oscillations.
Stability analysis curve			

VI. CONCLUSION

Thus this paper gives us a complete review on the three facts devices such as STATCOM, TCSC, and IPFC in a comparative manner. This paper also gives us their role in stability analysis. Thus STATCOM is used for the control of faults in the transmission system while TCSC is used for the control of voltage and IPFC is used to control the current and power instability. We find that IPFC is comparatively better than STATCOM and TCSC because it has better controllability on the power system fault.But cost wise STATCOM is the cheaper than IPSC.

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