A survey on the Impact of FACTS controllers on Power System performance

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Abstract *-In this paper examination of different period FACTS contraptions have done and examination being done to know the impact of different FACTS devices and there use for different conditions in power systems. A clear survey on the compensation strategies are similarly done to fathom course of action, shunt topologies and united topology, to comprehend the differing approach of FACTS controller in power structure. At the end progressed DFACTS devices and there study is done.*

Keywords — *Distrusted Power Floe Controller (DPFC), Genetic Algorithm.*

I. Introduction

In present situation, control request is expanded yet its era and use is limited by power frameworks imperatives. Subsequently, some transmission lines are intensely stacked and the power framework steadiness gets to be distinctly encouraging components. Adaptable AC transmission frameworks (FACTS) controllers have turned out to be one of the promising controller and compensator to the power frameworks [14]. Realities gadgets and their excursion from I-era to cutting edge D-FACTS controller are taken quickly in this writing. As FACTS gadgets are compensators so arrangement and shunt compensators idea is likewise overhauled. In this work, effect of force framework strength by the utilization of FACTS controllers was examined and checked on. As FACTS devices are compensators so series and shunt compensators concept is also revised. In this chapter, impact of power system stability by the use of FACTS controllers was discussed and technology of FACTS controller is taken in brief.

II. Compensation Method

Compensation methods for the power system, parameters is divided in two types mainly as

A. Shunt compensation

Shunt compensation are used to enhance/improve power-transfer capability and for reactive voltage drop compensation in the line (transmission/distribution)[16].

Shunt Compensation is employed mainly at the mid-point named mid-point compensation or at the end of transmission system to improve the voltage profile and providing power quality incrementation of the line power.

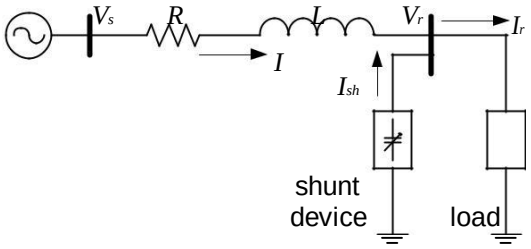


Fig.1 Shunt compensator located in power systems

B. Series Compensation

Series compensation of the power-lines are done to increase the maximum power transmission capability of the lines.

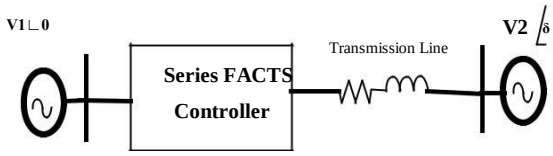
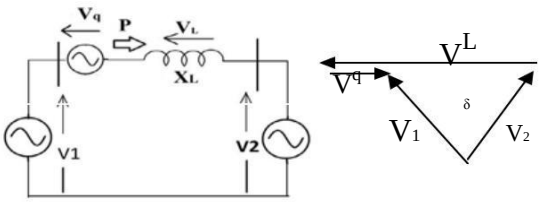


Fig.2 Series Controller Location In Power Systems.

By arrangement remuneration net line voltage drop would turn out to be less vulnerable to line stacking state of force framework, since pay decrease the line reactance of Power transmission line by presenting the arrangement compensators which kill the counter reactance impact in existing framework [16] . Combination of series and shunt compensation led to combined compensation techniques also called topologies.

Fig.3 Synchronous Voltage Source in Series With The Line



III. FACTS Devices an over view

In the late 1980s, the Electric Power Research Institute (EPRI) planned the vision of the Flexible AC Transmission Systems (FACTS) in which

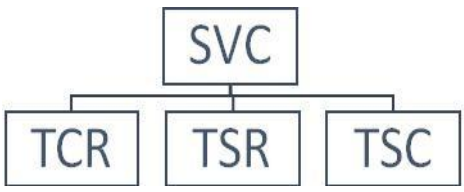
different power-hardware based controllers manage control stream and transmission voltage and alleviate dynamic unsettling influences [16]. In present force to be reckoned with stream controllers are to a great extent changing from mechanical to electrical cases in past reactors are associated with electrical cables by mechanical switches and now a days they are changed to control electronic based exchanging gadgets. Thyristor, GTO, IGBT, MCT are power hardware gadgets which constitute the FACTS controller for power stream administration. Contingent upon the improvement stages FACTS are separated into era of gadgets which incorporate arrangement and shunt example of game plans. Presently a days because of modernization one plan is not completely fit for pay so Distributed Flexible AC Systems DFACTS are rising up out of there previous outlines.

A. ***First Generation of FACTS Devices.***

Original FACTS gadgets prompted to establishment stone in this idea as they have mechanical control which is altered to electrical and afterward facilitate similarity towards advanced control, original gadgets prompted to establishment of mechatronics idea in one way or other, inalienably they kept their maxim of pay of electrical cables by their trademark conduct by infusion and ingestion of Reactive power. They changes the impedance of the framework by their in place time to the framework for stream of force.

1. *Static VAR Compensators (SVC)*

SVC are shunt associated FACTS gadgets for the power stream control in the framework, they comprise of settled or exchanged capacitor bank or reactors or mix of both relying upon the necessity of framework [14]. These compensators draws driving or slacking Reactive power from the lines, hence they direct voltage, enhance framework dynamic and relentless state soundness. These are likewise named as Static VAR Switches as they representatives exchanging idea of control of VAR.



2. *Thyristor Controlled Series Capacitor (TCSC).*

Because of the advancements in cutting edge control gadgets, for example, GTO, IGBT, IGCT, MTO and Power Transistors with enhanced appraisals of Thyristor's likewise, these prompted to productive operation of exchanging control innovation because of change of exchanging innovation, capacitance in arrangement bank of TCSC [14] can be controlled easily and in stepwise these prompted to taking after methods of operation of TCSC as specified roar.

a) By passed Thyristor Mode.
b) Blocked Thyristor Mode.
c) Partially conducting Thyristor Mode; Capacitive Vernier.
d) Partially conducting Thyristor Mode; Inductive Vernier.

Due to above three modes of operation of operation utilizing efficient switching technology of modern semiconductor technology we get two variants of TCSC as

- Thyristor Controlled Series Capacitors (TCSC).

These provide smooth and continuous control over capacitive and inductive reactance.

- Thyristor Switched Series Capacitor (TSSC).

These provide discrete control over the capacitive reactance, TSSC are more commonly employed.

3. *Thyristor controlled phase shifters*

TCPS have the ability to produce a phase shift between phasor's of terminal voltage which are independent of throughput current[14]. If we neglect the losses of the system and device action then TCPS do not consume or produce active and reactive power. TCPS are mainly employed as Thyristor controlled phase shifting transformer which we also knows as 'Phase Angle Regulation Transformer' (TCPAR) producing phase shift in the voltage phasor's of the system for control of the active power flow in the system[14]

B. ***Second Generation FACTS Devices***

Next generation FACTS devices are termed as II generation due to advancement in powersemiconductor devices which are used in FACTS devices mainly such as Power Transistors, IGBT, IGCT, MCT, use of these advanced power electronics devices increase power rating of the equipment's and also improve their performance.

1. *Static Synchronous Compensators (SSC or STATCOM)*

STATCOM is shunt compensator connected in shunt to the line thus introducing current vector control of the system. STATCOM are of two types.

- Voltage sourced STATCOM.
- Current sourced STATCOM.

In the former capacitors are used as energy storing components of the system thus it act as a voltage source due to storage of potential charge where as in latter inductors/reactors are used for energy storage components, which are mainly current modulation system thus termed as current sourced. Though former is used mainly due to economical and design

feasibility effects. STATCOM are able to generate and absorb reactive power of the system[14]. STATCOM improve system performance as it provide, dynamic voltage control, power oscillation damping, transient stability; it also act as active filter to absorb system harmonics.

2. *Static Synchronous Series Compensator (SSSC)*

SSSC is arrangement associated gadget utilizing a coupling transformer in arrangement by which it can control voltage of the line and changes line impedance, because of the power hardware controller's it has a capacity to deliver stage move in connection to the line current[13]. SSSC can trade both genuine and responsive power in transmission framework. On the off chance that the infused voltage is in stage with line current then Real Power will be controlled, then again if infusion of voltage is in quadrature to line current then Reactive Power will be managed.

SSSC because of its trademark behavioural worthwhile in supplanting TCSC as it is fit for managing line reactance and furthermore line resistance as per power swing. These offer better control capacity by utilizing appropriate input of the framework parameters to the terminating circuit to work by framework variable change.

3. *Unified Power Flow Controller (UPFC)*

UPFC is consolidated power stream controlling gadget having both arrangement and shunt part, because of this conduct UPFC ready to control line impedance, line voltage, and power edge each of the three parameters of force framework which are fundamental to course the stream of force in the framework networks[15].

Because of extensive variety of controllability these gadget are having dynamic conduct over the transmission framework parameters. UPFC is equipped for controlling directional stream of force in the framework. It improve the power exchange ability of transmission line to be inside warm stacking breaking points of the transmission framework.

C. *Distributed Flexible AC Transmission Systems (DFACTS) Devices*

In cutting edge control framework interconnections of the framework is normal marvel, where as in present time conveyed era is likewise a piece of framework in recent decades which increment the intricacy of the control of force and direction.

Distributed FACTS (DFACTS) are now a day getting popular due to deregulated structure and interconnection of power system. Due to better controlling ability and wider operating range of there characteristic DFACTS[9] are future as they accomplish the different present and past technology in a new encapsulated format which is efficient for the requirement of the power system at the place where it is required.

1. *Distributed Static Series Compensator (DSSC)*

DSSC is new generation DFACTS device derived from the parent SSSC (or S^3C) controller. DSSC is distributed device rather than to be put halfway situated at one place in framework [8]. Because of this dispersed segments along the transmission line it is having better control ability as far as framework reaction change rather remedying at halfway remuneration control. In DSSC single turn transformer is utilized as arrangement component to disperse the static gadget which in set at ideal area along the line.

2. *Distributed Power Flow Controller (DPFC)*

DPFC is derived from UPFC carrying all its inherent characteristics only difference is that despite of fixed capacitor in UPFC, DPFC provides distributed capacitor and central control capability[3]. Due to this characteristic behaviour it has ability to control the transmission line voltage, impedance and angle. DPFC is advantageous over UPFC as it required series convertor of small power rating which may be also of single phase, insulation level due to voltage is less than three phase convertor in single phase converter which increase reliability and reduce cost.

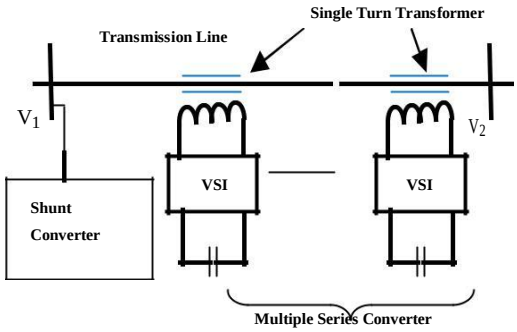


Fig. 4 Distributed Power Flow Controllers

DPFC is also from the family of combined power flow controller of FACTS having wide range of control capability, it have shunt controller and series controller, whereas series controller is distributed along the line and shunt controller is located at the end of transmission line, it act as active high pass filter to eliminate harmonics.

IV. Issues related to FACTS installation

For the adequacy of the controllers, the choice of area and input signs of FACTS-based stabilizers ought to be resolved. Then again, the strength of the controller to the variety of force framework working conditions is similarly imperative component to be attempted. Additionally, the coordination among various power frameworks stabilizers is an issue to

keep away from the symptoms. Furthermore, execution examination is an imperative consider that helps choice of a particular FACTS gadget. Receptive power pay require required by framework by FACTS to be explored. Certainties have wide impact on the framework remuneration so powerful and appropriate choice to be done [15].

A. *Reactive power compensation by FACTS for power transmission line led to:*

- Enhancement of transmission capacity, providing permissible line loading and influencing to work within the boundary conditions.
- To keep voltage profile along the transmission line within acceptable limits. These led to optimization of line-insulation cost-factor.
- Controlled compensators (Reactive power compensators) are used to improve system stability depending on their characteristic they enhance the system response (Steady state, Dynamic, Transient).
- These are used for power oscillation damping control of the system which enhance the system stability.

B. *Controller Design issues for FACTS devices.*

In modern deregulated power systems, DFACTS devices providing following assistance for enhancement of power system stability.

- Balanced power flow control over wide range of operating condition including contingencies of power system, this led to utilization of power system efficiently.
- Balancing flow of power in parallel networks operating at different voltages.
- Diminishing inter area power oscillations.
- Suppuration of Sub Synchronous Resonance (SSR).
- Avoid the construction of new transmission facilities by enhancement of power transfer capabilities of existing corridors of power systems.
- Controllers for DFACTS device are designed on the basis of intelligent adaptive digital controllers based technique, with response capable for wide area.

Controller should not be designed for high level of damping, as it is not supportive way of designing for wide area system control.

V. FACTS Devices and its impacts

In this table FACTS devices and its impact on power system with different issues related to stability and performance are taken in to considerations. Problems and its eradication are also discussed which led to quick assessments at the time of sudden disturbances and finding solution immediately.
Type of FACTS controller for different purposes are also listed which helps in selection of device during designing of compensating devices.

ISSUE	PROBLEM	CORRECTIVE ACTION	FACTS CONTROLLER
VOLTAGE LIMIT.	Low Voltage At Heavy Load	Supply Reactive Power Reduce Line Reactance	SVC, STATCOM, TCSC, DSTATCOM
	High Voltage At Low Load	Absorb Reactive Power	SVC, STATCOM, DSTATCOM
	High Voltage Following An Outage	Absorb Reactive Power, Prevent Overload's	SVC, STATCOM, DSTATCOM
	Low Voltage Following Outage	Supply Reactive Power, Prevent Over Loads	SVC, STATCOM, DPFC
THERMAL LIMITS	Transmission Line Loading	Increase Transmission Capacity	TCSC, SSSC, UPFC, IPFC, DPFC
SHORT CIRCUIT POWER	High Short Circuit Current	Limitation Of Short Ciruit Current	TCSC, UPFC, IPFC, DSSC, DPFC
LOAD FLOW	Power Distribution On Parallel Lines And Load Flow Reversal	Adjust Line Reactance	TCSC, SSSC, DSSC, UPFC, IPFC, DPFC
		Adjust Phase Angle	TCSC, SSSC, DSSC, PAR,DPFC
STABILITY	Limited Transmission Power	Decrease Line Reactance	TCSC, SSSC, DSSC,DPFC

Table .1 FACTS controller adaptation table

VI. CONCLUSIONS

In the above research work it is being reasoned that the present day DFACTS gadgets are better over past era Controller. Realities gadget gives extensive variety of control of force framework parameters to the stream of force in transmission and circulation frameworks of current frameworks and also this paper research provide a detailed over view of the FACTS devices and technology. DPFC which is new to The family of FACTS controller having combined topology adaptation and mutated from UPFC-DPFC is proved to be superior over other FACTS controller, reliable due to its distributed nature and which is economical also. DPFC is need of modern Power line compensation technique in near future. In FACTS controller execution of various remuneration topologies prompted to improvement of various controllers, current pattern is of joined controller as they determine better properties and attributes from their parent controllers. An examination on the FACTS establishment and effect is finished.

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