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Power Quality Improvement in Transmission line by Using Hybrid Power Flow Controller

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Abstract— The Electronic based FACTS controllers are static equipment. Its principle purpose is to control AC transmission. The parameters of FACTS are enhancement of controllability, ability of power transfer, control of line impedance, load angle and the magnitude of bus voltage. A unified power controller is to be a static device and this system device should have quick reactive transmission. This paper focuses on the issues like voltage sag and swell of power quality. HPFC is used to moderate the voltage variation and improve power quality and also used tocouple the phase controllable bridges to produce current which is injected into a transmission line by using series of transformers. The UPFC is a combination of a static synchronous compensator (STATCOM) and a static synchronous series compensator (SSSC)which is coupled with common DC link. The HPFC eliminates the common dc link between the shunt and series converters and alsoit performs in transmission line to exchange real power between converters at the 3rd harmonic frequency. The HPFC employs. Several 1-phase converters like D-FACTS concepts as the seriescompensator .These concepts reduce the rating of the components and offer a high reliability. Since the HPFC can immediately control the active and reactive power flow and the voltage magnitude, it implies a great potential for power oscillation damping. The case study contains a HPFC located in an exceedingly single-machine infinite bus power grid with 2 parallel transmission lines that simulated in MATLAB/Simulink.

Keywords— Power Quality, voltage Sag and voltage Swell, Unified Power Flow Controller, Hybrid Power Flow Controller.

1. INTRODUCTION

Now a day's demand for power grows radically. Expansion in transmission and generation is constrained with the rigid environmental constraints and limited availability of resources .How ever their courses the power systems to be operated close to be stability limits. The power electronics based FACTS which defined by IEEE, through this is a supplementary static equipment it is very helpful in control of one or more ac-transmission system parameters to improve controllability , enhance power-transfer capability[1].The past years, major concern of the power Companies was to produce/provide quality electrical power . The concept of FACTS design is to enhance the Controllability and to improve the operation of existence Power system capacities by means of reliable and high-speed power electronic devices. The devices are used its place of mechanical controllers which are used to moderate the voltage fluctuations. The FACTS devices are very helpful to understand the power quality Problems. To moderate the mentioned power quality problems, the operation of FACTS devices such as unified power flow controller (UPFC) and synchronous static compensator. A Hybrid power flow controller, introduce a novel FACTS device, is used to moderate voltage and current waveform variation and improve power quality in short duration (few seconds)[10]. The HPFC has similar capability of UPFC to balance the line parameters, i.e. Line impedance, load angle and bus voltage magnitude and improve power quality[11].

II. HPFC OPERATING PRINCIPLE

In comparison of UPFC, the main advantage is to eliminate the large DC-link and provide using Third -harmonic current to exchange of active power. The HPFC fundamental principle and operation are explained below.

A. DC link eliminated and Exchange of real power

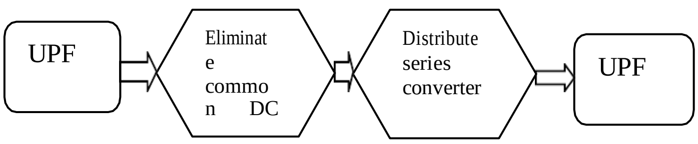
To analyze the active power, it is combination of voltage quantity and current quantity and italso analyze active power by using equivalent circuit of HPFC structure. For active power P=VI Cos ϕ

$$P=\sum V_i\ I_i \cos \phi_i$$

Wherever V_i is the voltage magnitude of ith harmonic and I_i are current magnitude of i^{th} harmonic, respectively, and ϕ_i is the phase angle between the voltage and current.

In case of HPFC which is used to employ as affiliation n between the DC terminal of shunt device and also the AC terminal of series converters, rather than direct affiliation using DC-link for exchange of real power between converters. .

Fig.1. power Flow diagram from UPFC to HPFC



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Generally HPFC of a shunt converter be able to absorb real power at one frequency and generate other frequency. The power flow diagram of HPFC structure shown in fig. (1) The HPFC is located in transmission line between two bus systems as shown in fig2.

HPFCs to be an essential segment of any AC-DC conversion system due to their well-regulated DC output reduced size and higher efficiency. There are variants of HPFCs, which are widely inherited for their characteristics such as sinusoidal input currents, negligible THD of input currents, good supply pf, controlled dc output voltage fewer ripples in the dc output voltage, low switching stresses and, low electro-magnetic interference (EMI) emissions. The converters are connected through a common dc link to exchange active power; this active power exchange and related losses affect the dc voltage across the capacitor. The HPFC can also be used to regulate its terminal voltages. More affordable. The HPFC converters exchange active power through the dc link, with the flow through the link and losses in the controller Components affecting the dc voltage level.

At the same time as the power supply generates the active power, and shunt converter has the facility to absorb power in fundamental frequency of current. If 3rd harmonic component is attentive in star-delta transformer. Output terminal of the shunt converter injects the third harmonic current into the neutral of delta-star transformer (Fig.3). Accordingly, the harmonic current flows through the transmission line. This harmonic current controls the DC voltage of series capacitors (Fig.2). Illustrate how to exchange of active power between the shunt and series converters are very conveniently by using HPFC. As exposed, above and beyond the input components, namely the shunt and series converters.

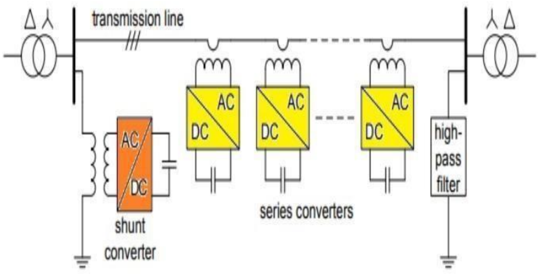


Fig.2. HPFC Structure

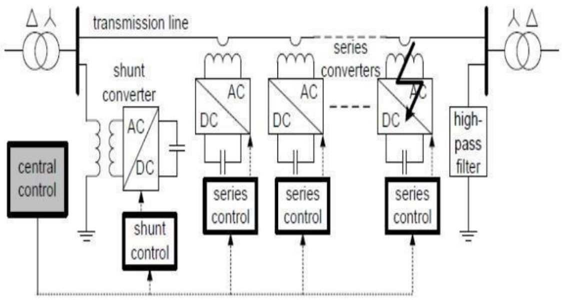


Fig.3. HPFC control structure

HPFC also requires a high-pass filter is shunt connected at the other side of the transmission line, and two star–delta transformers at both side of the line. If 3rd harmonic component is selected to interchange of active power in the HPFC and high-pass filter is mandatory to create a locked loop for the harmonic current. The 3rd harmonic current is surrounded by the delta-winding of transformer. This type of connection is nothing but connecting the cable between the delta winding of a transformer and ground. It is also connected to load side with provide star and ground/Δ-transformer to eliminating third-harmonic components.

B. Mathematical modelling of HPFC

In order to research the impact of shunt-series converters on power systems effectively, appropriate models of those devices are analyzed shown in fig (4) shows, the shunt converter current I_{shunt}, may be written as:

For shunt current $I_{shunt} = I_t + I_q$

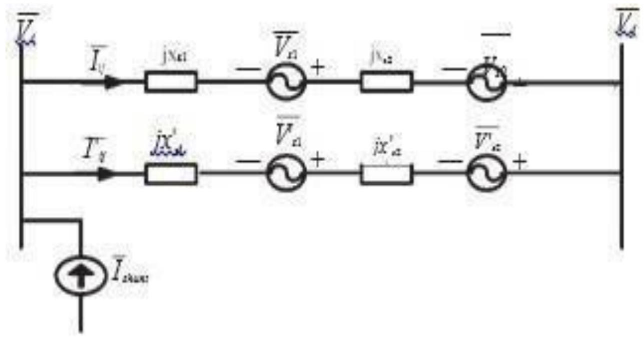
Where it's in phase with V_i and I_q is quadrature to V_q.
The voltage sources V_{s1} ,$V_{s2,}V'_{s1,}V'_{s2}$ has replaced by rather than of series converters. The X_{s1}, X_{s2}, X's1, X1s2 are reactance of parallel transmissions lines. The magnitude and phase angle of series converters are controllable, during this paper we assume that they need same values.

$$Vs1 = Vs2, = Vs1 =, Vs2 = rVie^{i\lambda}$$

Where r and λ are relative magnitude and phase angle relation to V_i respectively

$$I_{s1} = V_{s1}/jx_{s1} = -jb_{s1}\, rV_i e^{i\lambda}$$
$$I_{s2} = V_{s2}/jx_{s2} = -jb_{s2}\, rV_i e^{i\lambda}$$
$$I^1_{s1} = V'_{s1}/jx_{s1} = -jb'_{s1}\, rV_i e^{i\lambda}$$
$$I^1_{s2} = V'_{s2}/jx_{s2} = -jb'_{s2}\, rV_i e^{i\lambda}$$

Where $b_{s1}=1/x_{s1}$, $b_{s2}= 1/x_{s2}$, $b^1_{s1}=1/x^1_{s1}$ and $b^1_{s2}=1/x^1_{s2}$
The active power supplied by the shunt current source will be calculated as follows:



$$P_{shunt} = Re\, [V_i\, (-I^*_{shunt})] = -V_i\, I_i$$

Fig.4.HPFC converters of case study

Neglect the HPFC losses

$$Pshunt = Pseries = Ps1 + Ps2 + p^1s1 + P^1s2$$

The apparent power supplied by the series converter V_{s1} maybe calculated as follows:

$$S_{s1}=V_{s1} I^*_{ij}= rV_i e^{ij} [(V_i +V_{s1}+V_{s2}-V_j)/j (x_{s1}+x_{s2})]^*$$

$$P_{s1} = (b_{s1} + b_{s2}) [rV_iV_j \sin (\Theta_i- \Theta_j+\lambda) - rV^2_i \sin (\lambda)]$$

$$Q_{s1} = (b_{s1} + b_{s2}) [r V^2_i \cos (\lambda) +2r^2V^2_i - rV_i V_j \cos (\Theta_i-\Theta_j+\lambda)]$$

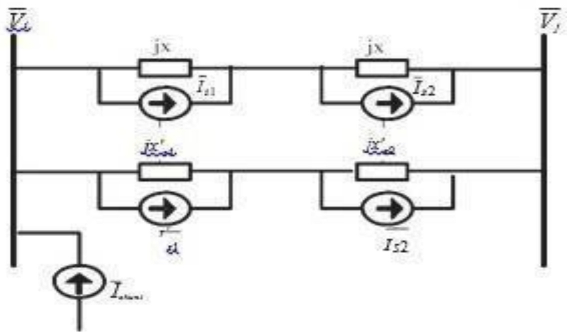


Fig.5. representation of a series voltage sources by current sources.

$$P_{s2} = (b_{s1} + b_{s2}) [rV_iV_j \sin (\Theta_i- \Theta_j+\lambda) - rV^2_i \sin (\lambda)]$$

$$Q_{s2} = (b_{s1} + b_{s2}) [r V^2_i \cos (\lambda) +2r^2V^2_i - rV_i V_j \cos (\Theta_i-\Theta_j+\lambda)]$$

$$P'_{s1} = (b'_{s1} + b'_{s2}) [rV_iV_j \sin (\Theta_i- \Theta_j+\lambda) - rV^2_i \sin (\lambda)]$$

$$Q'_{s1} = (b'_{s1} + b'_{s2}) [r V^2_i \cos (\lambda) +2r^2V^2_i - rV_i V_j \cos (\Theta_i-\Theta_j+\lambda)]$$

$$P'_{s2} = (b'_{s1} + b'_{s2}) [rV_iV_j \sin (\Theta_i- \Theta_j+\lambda) - rV^2_i \sin (\lambda)]$$

$$Q'_{s2} = (b'_{s1} + b'_{s2}) [r V^2_i \cos (\lambda) +2r^2V^2_i - rV_i V_j \cos (\Theta_i-\Theta_j+\lambda)]$$

C. Advantages of HPFC

The HPFC has more advantages then UPFC when compared and therefore the advantages are,

1) High Reliability

The combination of series and shunt converters are very reliable, as there's no feedback connection, and it's also very reliable converters redundancy raises the HPFC reliability for the amount of converters operation. Just in case of failure in anyone of the series converters, the others can still effort.

2) Highly management Capability

The structure of HPFC has extremely manageable capability compare to UPFC it'll management all parameters of a transmission network, like line impedance, impedance angle, and voltage magnitude

3) lowest price

The cost of HPFC device is low compare to UPFC, if the 1-phase series devices ratings are less than one 3-phase converter. Moreover, the series converters haven't any high voltage isolation in conductor connecting single-turn transformers which are at home with drop the series converters.

III. HPFC CONSTRUCTION

The HPFC is design is three control methods: series control, shunt control and central controller.

A. Series Control

The basic function of series controller is employed to maintain the capacitor dc voltage. by using the third-harmonic frequency components and to provide series voltage at the fundamental Frequency that's approved by the central control. If HPFC Controller inputs area unit series capacitance voltages , line current, and series voltage reference within the dq-frame.

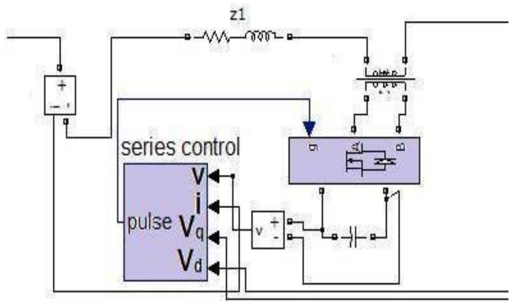


Fig.6. functional diagram for series converters

The diagram of the series converters in MATLAB/SIMULINK setting is incontestable to analyzing the results of a system as Shown in (Fig.6).Any series controller incorporates a low-pass and a 3rd-pass filter to make fundamental and 3rd –order harmonic currents separately. In this diagram to design a two single-phase phase locked loop area unit accustomed take Frequency, phase angle information from the system. Thediagram of series controller is as shown in (fig.6).

B. Shunt Control

The design of shunt converters includes connected to 3-phase back to back converter, this converter absorb theactive power from grid at fundamental frequency and control the dc voltage from capacitor between in the converter and one single-phase converter. Different task of the shunt device is to inject constant 3rd harmonic current inject into the lines through the neutral cable of delta/star transformer.

C. Central control

If design of central control is generate the reference signal from the shunt and series converters of a HPFC structure .It is absorbed on the HPFC responsibilities at the power-system side, such as power-flow controller, low-frequency power oscillations and balancing of an unsymmetrical components. According to the system condition the central control provides equivalent voltage reference signals for the series converters and reactive current signal for the shunt converter. All the reference signals generated by the central control are at the fundamental frequency.

IV PROPOSED SYSTEM

Generally UPFC device has some difficulties to exchange of real and reactive power, and also completely mitigation of voltage sag and voltage swells, in case any device (series (or) shunt) will be failure UPFC is not operated because of feedback connection. By placing HPFC exchange of real and reactive power is easily transfer in transmission system. The completely simulation diagram of HPFC is shown in (fig.7). If system consists of a 3-phase source is connected to non-linear RLC load through parallel transmission lines (both lines are equal lengths).The simulation system parameters are given TABLE-I

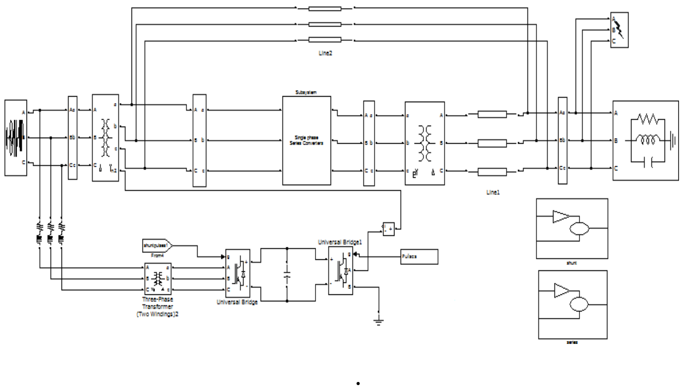


Fig.7. Simulation model of the HPFC (single machine with infinite bus)

TABLE-1
Simulation System Parameters

Parameters	values
Three phase source	
Rated voltage	230 kV
Rated power/Frequency	100MW/60HZ
X/R	3
Short circuit capacity	11000MW
Transmission line	
Resistance	0.0120 p.u per km
Inductance/ Capacitancereactance	0.120 p.u per km /0.0120 p.u per km
Length of transmissionline	100 km
Shunt Converter 3-phase	
actual power	60 MVAR
DC link capacitor	600 µF
Coupling transformer (shunt)	
actual power	100 MVA
Rated voltage	230/15 kV
Series Converters	
Rated voltage	6 kV
actual power	6 MVAR
Three-phase fault	
Type	RYB-G
Ground resistance	0.01ohm

VI. CONCLUSION

In this study, to improvement of power quality in power system, there are some efficient methods are accustomed moderate the voltage sag and voltage swell. By using FACTS controllers to cut back the power quality disturbances, just in case UPFC replaced by novel FACTS controllers is named Hybrid Power Flow Controller (HPFC) is offered. The HPFC control structure is expounded to unified power flow controller (UPFC) and has a similar manage ability to balance the line parameters, like bus voltage magnitude, line impedance and load angle. on the other hand, the HPFC offer several advantages, in compare with UPFC, such at the identical time as high control capability, high reliability, and low cost.

The entire cost of a HPFC is moreover much lower than that of UPFC, for the reason that no high-voltage isolation is important at the series-converter component and also the rating of the apparatus of is low. The HPFC is model and three control loops, i.e., central controller, series control, and shunt control are design. If the system is analyzed to atleast one machine, is connected to infinite-bus system, with and without HPFC and also it's proved that the shunt and series converters. The HPFC can exchange of real power at the 3rd -harmonic frequency and series converters are capable to inject convenient active and reactive power at the basic frequency. To simulate the energetic performance of a three-phase fault is measured near to the load. Shows with the aim of the HPFC provides a Satisfactory performance in power quality improvement and controlling of power.

References

[1] Ramesh. M., Laxmi,A.J. "Stability of Power Transmission Capability of HVDC system using facts controllers" Computer Communication and Informatics (ICCCI), 2012 International Conference on Year: 2012.

[2] Ross R.P.; de Souza, L.F.W." Power quality investigation in a distribution utility"in the south of Brazil Brasil, Luciano; Harmonics and Quality of Power, 2000. Proceedings. Ninth International Conference on year 2000.

[3] Nita R I. Patne, Krishna L. Thakre "Factor Affecting Characteristics Of Voltage Sag Due to Fault in the Power System" Serbian Journal Of Electrical engineering. vol. 5, no.1, May2008, pp. 171-182.

[4] Enslin J. R., "Unified approach to power quality mitigation," in Proc. IEEE Int. Symp. Industrial Electronics (ISIE '98), vol. 1, 1998, pp. 8– 20

[5] Hingorani JNG, Gyugyi L. Understanding FACTS: concepts and Technology of flexible AC transmission systems. New York: IEEE Press; 2000.

[6] Yuan, S. W. H. de Haan, and B. Ferreira, "A new facts component: Hybrid power flow controller (HPFC)," in *Power Electronics and Applications, 2007 European Conference on*, 2007, pp. 1–4

[7] Pohjanheimo P. and. Lakervi E, "Steady state modelling of custom power components in power distribution networks," in Proc.

IEEE Power Engineering Society Winter Meeting, vol. 4, Jan, pp. 2949–2954, 2000.

[8] Go swami, A.K.; Gupta, C.P.; Singh, G.K. Effect of apparatus sensitivity on placement of facts devices for voltage sag mitigation India Conference (INDICON), 2011 Annual IEEEYear: 2011

[9] Olimpo A. L. and Acha E., "Modeling and analysis of custom power systems by PSCAD/EMTDC," IEEE Trans. Power Delivery, vol. 17, no.1, pp. 266–272, Jan. 2002

[10] Zhihui Yuan, Sjoerd W.H de Haan, Braham Frreira and Dalibor Cevoric "A FACTS Device: Hybrid Power Flow Controller (HPFC)" IEEE Transaction on Power Electronics, vol.25, no.10, October 2010.

[11] Zhihui Yuan, Sjoerd W.H de Haan and Braham Frreira "HPFC control during shunt converter failure" IEEE Transaction on Power Electronics 2009.