Improve Power Quality in Power Grid using STATCOM with Hysteresis Control Technique

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Abstract – *Reactive power compensation is an important and serious aspect in modern power system. As we know today there is maximum load in the industry is inductive so there Power Quality Can Be Considered As A Set Of Various Parameters Like Voltage/Current Magnitude Variation, Voltage Sag, Voltage/ Current Unbalance, Harmonic Voltage/Current Distortion, High Frequency Voltage Noise Etc STATCOM is one of the FACTS device that can mitigate this all problem. STATCOM work on both supplying or consume the reactive power. When the system needs reactive power, it acts as a source and supplies reactive power but when there is excess of reactive power in the system, it acts as a sink and consume reactive power. This paper explains that how HBCC system and STSTCOM can mitigate the power system problem.*

***Key Words*:** HBCC, DC capacitor, Fuzzy logic, Reactive power PI controller, PQ theory.

1. I NTRODUCTION

The increasing the use of nonlinear and time varying loads has led to disturb the current and voltage waveform and increase in the reactive power in the system .harmonics disturbance is the source of several problems such as increased power losses, excessive heating in rotating machinery ,voltage swag , voltage swell, current magnitude variation ,high frequency voltage noise. The HBCC technique will improve the reactive power compensation problem. So, many FACTS controller device to control the flow of reactive power. And among all the FACTS device the STATCOM provides A fast response to the system. STATCOM is the most widely use VAR compensator.

This system includes the VSI and hysteresis band current controller and DC link capacitor. The VSI consist of three pair of the IGBT. Each pair consists two devices is on then the bottom device is off and vice versa. HBCC provides the switching signals to the IGBT by making the actual current follow the reference signal within the limited hysteresis band.

In this system load change in the resulting the reactive power also change and voltage also change .and the change in the voltage will sense by the voltage sensor which is compare with the reference voltage and generate the error signal which will passed through the PI controller and produce direct axis current and the quadrature axis current as same as the DC link capacitor voltage is compared with the value of the voltage that we desire it to be constant and generate an error signal which is fed to the PI controller and it will be generate the direct axis current. the reference direct and quadrature axis currents when passed through parks transformation dq to abc transform and produce the reference abc phase current through the STATCOM branch with the reference current which produce signal foe each leg of IGBT.

1.1 HBCC

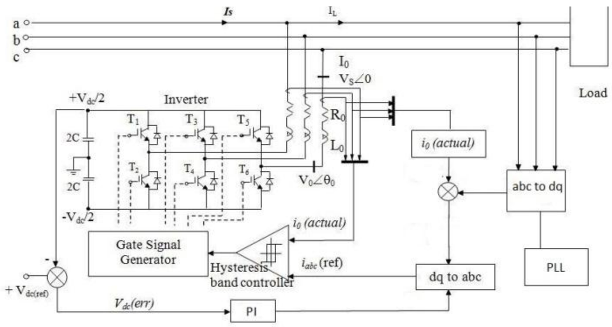


Fig 1: Basic diagram of HBCC

1. Design of DC capacitor

Charging in the capacitor is referred to the reactive power in the system. The capacitor charged when the current in the system is higher than in the STATCOM and discharged when the current is lower. The fault current is the difference between the after and before fault current.to mitigate the voltage sag the desire value of DC capacitor will needed. The harmonics effect must be considered when the designing the DC capacitor because it will affect the voltage. The following equation will be used for the designing the DC capacitor.

$$\tfrac{1}{2} C_{DC} [V_{CMAX}^2 - V_{DC}^2] = \tfrac{1}{2} V_{SM} . \Delta I_L .T$$

Above equation is used for mitigate harmonics in single phase system. For three phase system following equation will be used.

$$C_{DC} = 3 \times \frac{V_s . \Delta I_L . T}{V_{C_{max}}^2 - V_{DC}^2}$$

Where,

VS = peak phase voltage

IL = step drop of load current

T = period of one cycle

VCMAX = pre set upper limit of the energy storage

VDC = voltage across C

The Value of the ΔIL can be found by measuring the load current before and the during the voltage sag

The value of VDC is given by,

$$V_{DC} = \frac{3\sqrt{3}.V_s.\cos\alpha}{\pi}$$

where,

α = delay angle

if α = 0, the equation become,

$$V_{DC} = \frac{3\sqrt{3}.V_s}{\pi}$$

The value of VCmax is the upper limit of VDC.

2 Design of PI controller

The discrete PI controller that takes in the reference voltage and the actual voltage and gives the maximum value of the reference current depending on the error in the reference and the actual values. The question for the PI controller is

The voltage error $V(n)$ is given as:

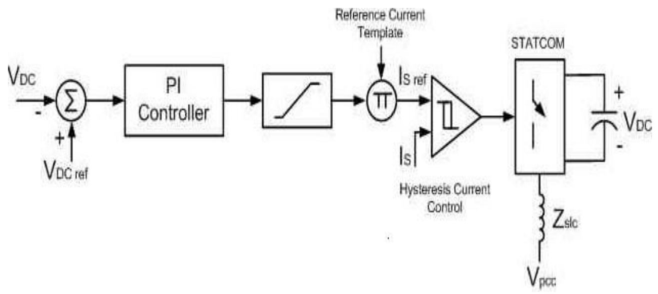
$$V(n)=V^*(n)-V(n)$$

The output of the PI controller at the nth instant is given as below

$$I(n)=I(n-1)+K_p[V(n)-V(n-1)]+K_iV(n)$$

When the DC link voltage is sensed and compared with the reference capacitor voltage to discrete the reference current the source current will also have sixth harmonics distortion for three phase system and second harmonics distortion for the single-phase system

A low pass filter is generally used to filter these ripples which introduce a finite delay and affect the transient response. To avoid this a low pass filter will be used.



3 Axes Transformstion

The instantaneous active and reactive power theory or simply the pq theory is based on a set of instantaneous value of active and recative powers defined in the domain.our aim to transform three phase stationary frame (as-bs-cs) variable into two phase stationary refernce frame varible and then transform these to synchronously rotating refernce frame and vice versa

the supply voltae and load currewnt are transfromed into alfa and beta quantities.The instataneous active and reactive power , p and q are calculated from the transfromed voltages and currentas given in below equestion.

$$\begin{bmatrix} u_d \\ u_q \\ u_0 \end{bmatrix} = \frac{2}{3}\begin{bmatrix} \cos(\omega t) & \cos\left(\omega t-\frac{2\pi}{3}\right) & \cos\left(\omega t+\frac{2\pi}{3}\right) \\ -\sin(\omega t) & -\sin\left(\omega t-\frac{2\pi}{3}\right) & -\sin\left(\omega t+\frac{2\pi}{3}\right) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix}\begin{bmatrix} u_a \\ u_b \\ u_c \end{bmatrix}$$

$$u_d = \frac{2}{3}\left[u_a\cos(\omega t) + u_b\cos\left(\omega t-\frac{2\pi}{3}\right) + u_c\cos\left(\omega t+\frac{2\pi}{3}\right)\right]$$

$$u_q = -\frac{2}{3}\left[u_a\sin(\omega t) + u_b\sin\left(\omega t-\frac{2\pi}{3}\right) + u_c\sin\left(\omega t+\frac{2\pi}{3}\right)\right]$$

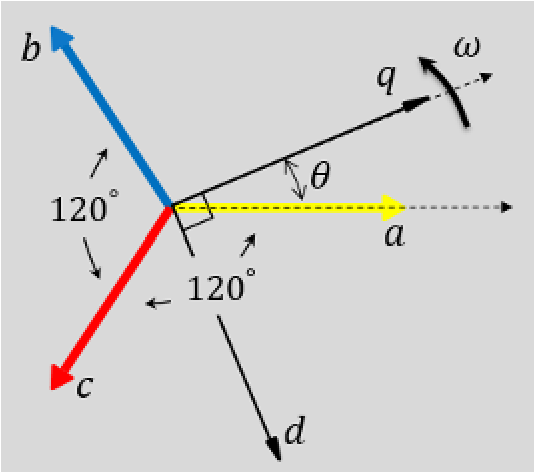
$$u_0 = \frac{1}{3}[u_a + u_b + u_c]$$

the above equestion is the transformation of dq to abc formation,

a, b, and c are the components of the three-phase system in the abc reference frame

d and q are the components of the two-axis system in the rotating reference frame.

0 is the zero component of the two-axis system in the stationary reference frames



2.1 Fuzzy Logic

Fuzzy logic is a new control approach with great potential for real time application. Load voltage and load current taken as input to fuzzy system. For a close loop control, error input can be selected as current, voltage or impedance, according to control type to get the linearity triangular membership function is taken with 50% overlap. the output of fuzzy logic controller taken as the control signal and the pulse generator provides synchronous firing pulses to thyristors. The fuzzy logic is a rule-based controller where a set of rules represents a control decision. Mechanism to correct the effect of certain causes coming from power system in fuzzy logic the five linguistic variables expresses by fuzzy defined on their respective universe of discourse.

2.2 Need of fuzzy logic

As compare to PI controller and other controller the main in this controller the fine tuning of the controller so as to achieve the optimal of the main task, the main disadvantage of this PI controller is that it will face the process of non linear and when the system having oscillation. Consider this all problem the fuzzy logic was implemented. Fuzzy logic can work in the linear as well as in nonlinear design parameter. logic required some numerical parameter in order to operate such as what is considered significant rate of change of error but there is problem is that value of these is number is usually not critical unless responsive performance is necessary in such case would determine them.

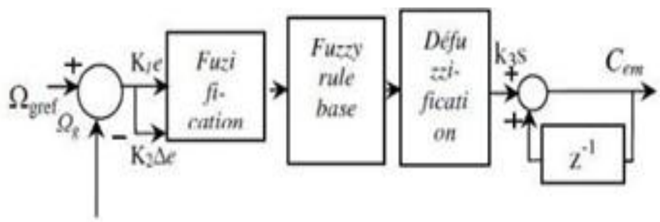


FIG 2: Basic fuzzy logic diagram

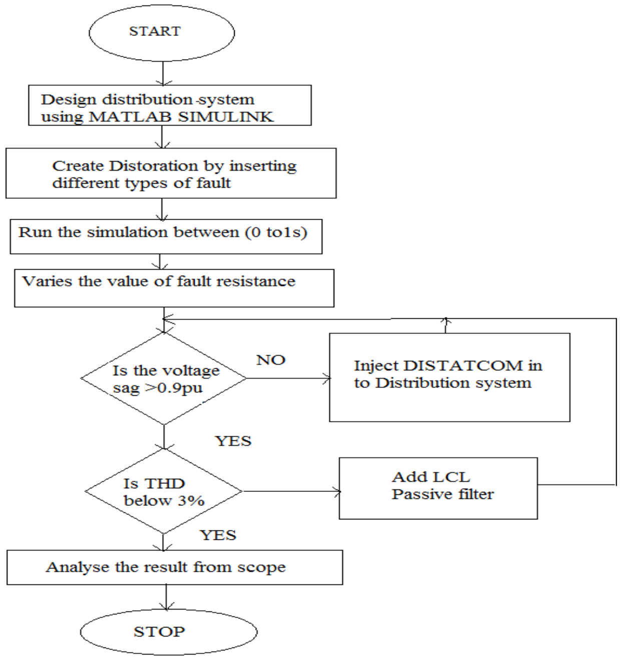


Fig 3: Flowchart of Fuzzy logic with STATCOM

3.1 Operation of HBCC

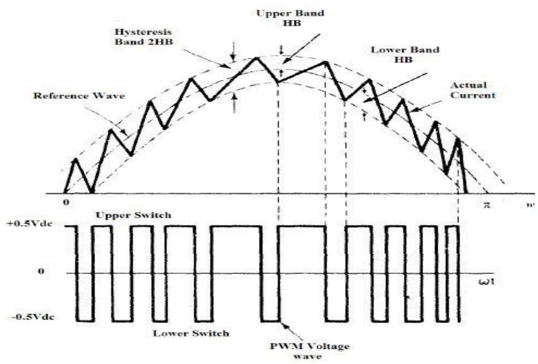


Fig 4: Basic principle of hysteresis controller

A hysteresis current controller is implemented with a closed

System is shown in figure. An error signal e(t) is used to control the IGBT switches in the inverter. The error signals

e(t) is the difference between the desired current iref(T) and the current will be injected by the inverter I actual (t). Now when this error will reach an upper limit the IGBT are forced to switched to current down and on the other side when the error reaches a lower limit the current is forced to increase.

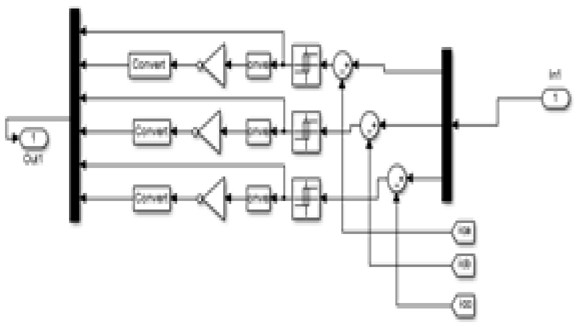


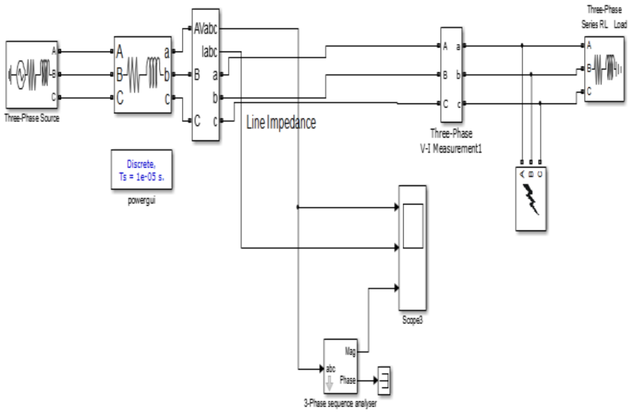
Fig 5: pulse generation in HBCC

With the hysteresis control limit are set on either side of a signa representing the desired output waveform. The inverter switches are operated as the generated signals within limits. The control circuit generates the sine reference signal wave of desired magnitude and frequency and it is compared with the actual signal.as the signal exceeds a prescribed hysteresis band the upper switch in the half bridge is turned OFF and the lower switch is turned ON. As the signal crosses the lower limit the lower switch is turned OFF and the upper switch is turned ON. The actual wave is thus forced to track the sine reference wave within the hysteresis limits.

4.1 Simulation and Result

Here simulation results are presented for three cases, in case one when power system without STSTCOM and HBCC technique and on counter part with the STATCOM and HBCC technique and on third one in which we get the Reactive power and active power with the use of Fuzzy logic.

Case 1 (Without STATCOM and)



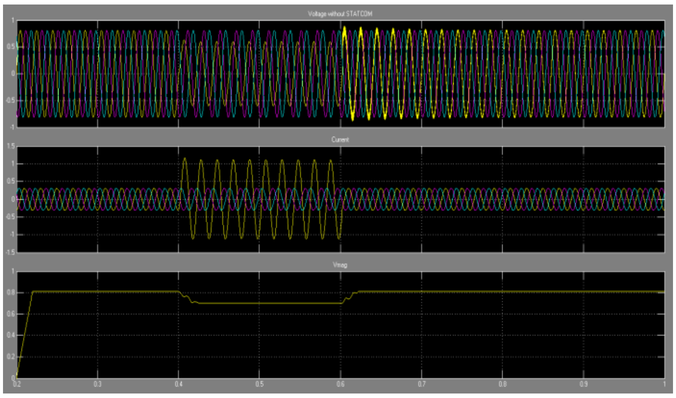


fig 6: 1-phase to ground fault current and voltage waveform without STATCOM

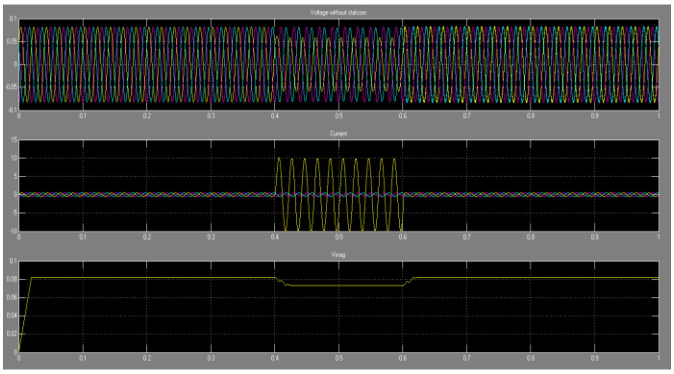
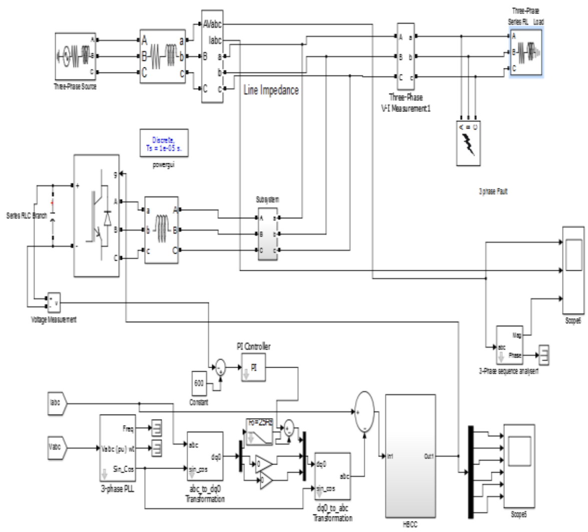


Fig 7: single-phase to ground fault current and voltage waveform without STATCOM using unbalanced load

Case 2 (with STATCOM and HBCC)



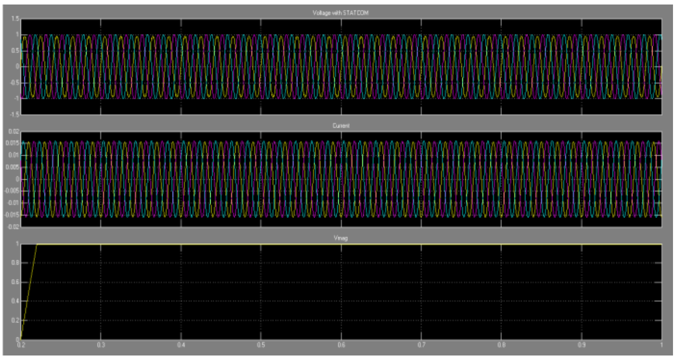


Fig 8: single-phase to ground fault current and voltage waveform with STATCOM

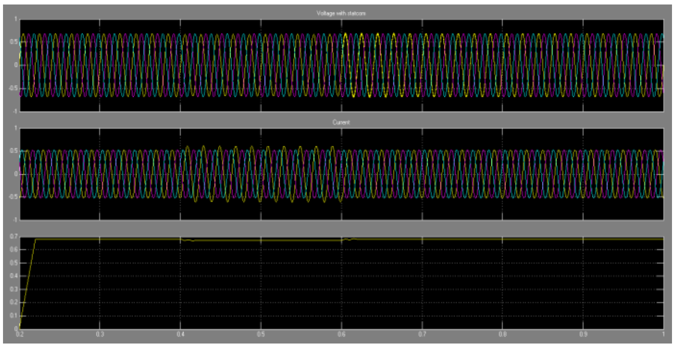
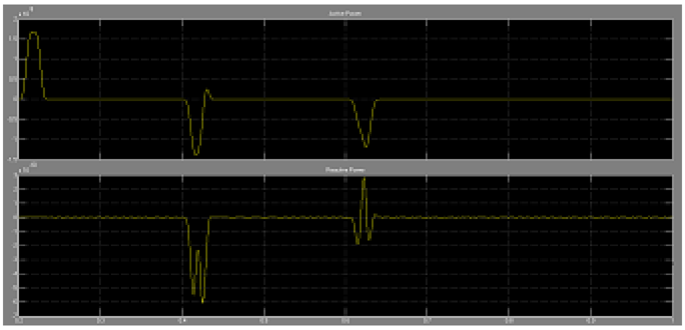
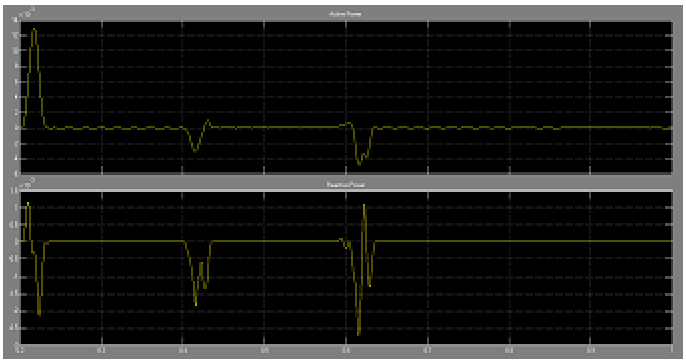


Fig 9: single-phase to ground fault current and voltage waveform with STATCOM using unbalanced load

Case 3: (without fuzzy logic and when fault is occurs)



This is the waveform of active and reactive power when the fuzzy logic is not applied to the HBCC and the fault occur.



This is the waveform of active and reactive power with fuzzy logic and HBCC.

Conclusion

A detail investigation of both PI and FLC has been studied for various cases. As compare the both technique we can say that FLC shows better damping response, transient behavior. A simulation shows that FLC give less steady state error. It is clear that FLC gives a robust control and better stability than traditional PI controller.

Table: value of system parameter

PARAMETERS	VALUES
DC-link Voltage V_{dc}	600V
Fundamental Frequency	50Hz
Filter Inductance	1mH
Load Resistance	5
Load Inductance	4mH
Kp, Ki	0.005,30

Reference

1) Rakesh Kantaria and S.K.Joshi "A review on power quality problems and solutions" Power electronics National Conference November 2008.

2) Bhim Singh, Ambrish Chandra and Kamal Al-Haddad "A Review of active filters for power quality improvement "IEEE Tras. Ind. Electronics, VOL, 46 NO 5, pp 960-971 October 1999

3) CL Wadhwa, Electrical Power Systems, New Age international Publishers, New Delhi2009.

4) P Kundur, Power System Stability and Control, McGraw Hill, New York, New York1993.

5) FACTS application, FACTS application task force, IEEE power engineering society, 1998.

BIOGRAPHIES

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