Characteristics Comparisons of Hybrid STATCOM with Different Compensating Devices

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Abstract- *This method proposed Hybrid Static Synchronous Compensator (hybrid-STATCOM) in athree-phase power transmission system that has a wide compensation rang. Because of these prominent characteristics, the system costs can be greatly reduced. In this thesis, the circuit configuration of hybrid-STATCOM is introduced first. Its V–I characteristic is then analyzed, discussed, and compared with traditional STATCOM. The system parameter design is then proposed on the basis of consideration of the reactive power Compensation range and avoidance of the potential resonance problem. After that, a control strategy for hybrid-STATCOM is proposed to allow operation under different voltage and current conditions, such as unbalanced current, voltage dip, and voltage fault. Finally, simulation and experimental results are provided to verify the wide compensation range and the good dynamic performance of the proposed hybrid-STATCOM.*

Keywords- Hybrid-STATCOM, low dc-link voltage, STATCOM, wide compensation range

I. INTRODUCTION

In electric power transmission and distribution, volt-ampere reactive (var) is a unit by which reactive power is expressed in an AC electric power system. Reactive power exists in an AC

Circuit when the current and voltage are not in phase. The correct symbol is var and not Var,Var, or VAR, but all three terms are widely used, and VAR is widely used throughout the power industry. A sinusoidal alternating voltage applied to a purely resistive load results in an alternating current that is fully in phase with the voltage. However, in many applications it is common for there to be a reactive component to the system, that is, the system possesses capacitance, inductance, or both. These electrical properties cause the current to change phase with respect to the voltage: capacitance tending the current to lead the voltage in phase, and inductance to lag it. For sinusoidal currents and voltages at the same frequency, reactive power in vars is the product of the RMS voltage and current, or the apparent power, multiplied by the sine of ϕ (phase angle between the voltage and the current). The reactivepower Q (measured in units of volt-amperes reactive or var) is given by:

$$Q = V\,r\,m\,s\,I\,r\,m\,s\,\sin(\phi)$$

Where ϕ is the phase angle between the current and voltage. Q refers to the maximum valueof the instantaneous power absorbed by the reactive component of the load. is expressed in watts. The imaginary part is properly expressed in volt-amperes reactive. In a linear circuit, the reactive power is defined as the ac component of the instantaneous power, with a frequency equal to 50- or 60-Hz system. The reactive power generated by the ac power source is stored in a capacitor or a reactor during a quarter of a cycle, and in the next quarter cycle is sent back to the power source. In other words, the reactive power oscillates between the ac source and the capacitor or reactor, and also between them, at a frequency equals to two times the rated value (50 or 60 Hz). For this reason, it can be compensated using Var generators, avoiding itscirculation between the load (inductive or capacitive) and the source, and therefore improving voltage stability of the power system. Reactive power compensation can be implemented with Var generators connected in parallel or in series.

1.1 Physical significance of reactive power

In power transmission, since loads such as motors are inductive, reactive power is present in the system. Since reactive power does not do any real work, the extra current supplied to provide the reactive power means greater line losses and higher thermal limits for equipment which translates to higher cost to operators which is why industrial users are charged extra if they have a low power factor, the ratio between real power and apparent power in the circuit. Managing the reactive power flow in addition to real power flow becomes a very important task for operators to ensure voltage stability throughout the system. In general terms, decreasing a supply of reactive power to the system causes voltage to fall while increasing it causes voltage to rise. A voltage collapse occurs when the system serves a transient load that has a higher reactive power demand than the system can suppl Reactive power is required for electrical components that make use of an alternating magnetic field, primarily motors and transformers. In addition, many switching power supplies in computers and TVs draw current only during a part of the cycle, thus creating a net reactive load. Similar remarks apply for mercury-vapor lamps. There are no common household or industrial devices that present a capacitive load Reactive power is required to maintain voltage on motors and transformers, and hence, on the power system. A modern utility grid issue with reactive power is that many solar generators and wind turbines may generate no reactive power. Conventional central station power plants can generate reactive power, but fuel is not required to generate it. In fact, reactive power can be generated with passive capacitors, common on distribution systems. Advanced DC-AC inverters on solar plants can be set to generate or absorb reactive power as needed for voltage control. In some cases, old generators are used only to provide reactive power; these units, which no longer burn any fuel, are called synchronous condensers. Other sources of reactive power at the bulk Level include the static Var compensator, static synchronous compensator and the dynamic Var compensator: the first being essentially a thyristor-controlled bank of capacitors, the last a more complex high-power electronic device

II. SYSTEM DESIGN

Hybrid STATCOM transfers the power between the grid and medium voltage bus bar. Hybrid-STATCOM that consists of a thyristor-controlled LC (TCLC) part and an active inverter part, The TCLC part provides a wide reactive power compensation range and a large voltage drop between the system voltage and the inverter voltage so that the active inverter part can continue to operate at a low dc-link voltage level. The small rating of the active inverter part is used to improve the performances of the TCLC part by absorbing the harmonic currents generated by the TCLC part, avoiding mistuning of the firing angles, and the contributions of this paper are summarized as follows:

1) A hybrid-Statcom is proposed, with the distinctive characteristics of a much wider compensation range than traditional-STATCOM and other series-type PPF-STATCOMs and a much lower dc-link voltage than traditional STATCOM and another parallel-connected hybrid-STATCOMs.
2) Its V–I characteristic is analyzed to provide a clear view of the advantages of hybridSTATCOM in comparison with traditional STATCOM
3) Its parameter design method is proposed based on consideration of the reactive power compensation range, prevention of the potential resonance problem, and avoidance of mistuning of firing angle.

4) A new control strategy for hybrid-STATCOM is proposed to coordinate the TCLC part and the active inverter part for reactive power compensation under different voltage and current conditions, such as unbalanced current, voltage fault, and voltage dip. In this paper, the system configuration the V–I characteristic of Hybrid-STATCOM is proposed in comparison with traditional STATCOM. Finally, the simulation and experimental results will provide to prove the wide compensation range and low dc-link voltage characteristics and the dynamic performance of the proposed hybrid-STATCOM.The proposed TCLC part is a newly proposed SVC structure which designed based on the basis of the consideration of the reactive power compensation range (for LPF and CPF) and the prevention of the potential resonance problem (for Lc). The active inverter part (DC-link voltage VDC) is designed to avoid mistuning of the firing angle of TCLC part.

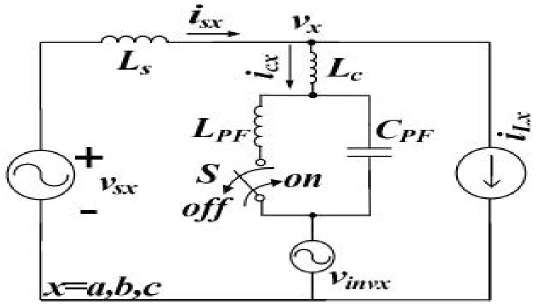

Fig.No 1. Simplified single-phase equivalent circuit

2.1 Design of CPF and LPF

The purpose of the TCLC part is to provide the same amount of compensating reactive powerQcx, TCLC (αx) as the reactive power required by the loads QLx but with the opposite direction. Therefore, CPF and LPF are designed on the basis of the maximum capacitive and inductive reactive power. The compensating reactive power Qcx range in term of TCLC impedance XTCLC (αx) can be expressed as,

$$Q_{Cx,TCLC}(\alpha_x) = \frac{V_X^2}{X_{TCLC}(\alpha_x)} \quad (1)$$

Where Vx is the RMS value of the load voltage and XTCLC (αx) is the impedance of the TCLC part. In (1), When the XTCLC (αx) = XCap and XTCLC (αx) =XInd (min) (αx =90o), the TCLC part Provides the maximum capacitive and inductive Compensating reactive power Qcx and Qcx, respectively.

$$Q_{cx(MaxCap)} = \frac{V_x^2}{X_{Cap(min)}(\alpha_x=180^0)} = -\frac{V_x^2}{X_{C_{PF}}-X_{L_C}} \quad (2)$$

$$Q_{cx(MaxInd)} = \frac{V_x^2}{X_{Ind(min)}(\alpha_x=90^0)} = -\frac{V_x^2}{\frac{X_{C_{PF}}X_{L_{PF}}}{X_{C_{PF}}-X_{L_{PF}}}+X_{L_C}} \quad (3)$$

Where the minimum inductive impendence XInd (min) and the capacitive impendence XCap (min) are obtained. Therefore, based on (2) and (3) the parallel capacitor CPF and inductor LPF can be designed as,

$$C_{PF} = \frac{Q_{Lx(\,MaxInd\,)}}{\omega^2 Q_{Lx(\,MaxInd\,)} L_c + \omega V_x^2} \quad (4)$$

$$L_{PF} = \frac{V_x^2 + \omega L_c Q_{Lx(\,MaxCap\,)}}{-\omega Q_{Lx(\,MaxCap\,)} + \omega^3 L_c C_{PF} Q_{Lx(\,MaxCap\,)} + \omega^2 V_x^2 C_{PF}} \quad (5)$$

Where ω is the fundamental angular frequency and Vx is the RMS load voltage.

2.2 Design of LC

For exciting resonance problems, a sufficient level of harmonic source voltages or currents must be present at or near the resonant frequency. Therefore, Lc can be designed. The thyristor for each phase of the TCLC part can be considered as a pair of bidirectional switches that generate low-order harmonic currents when the switches change states. The simplified single-phase equivalent circuit model of hybrid-STATCOM is shown in Fig.1

Referring to Fig.1, when switch S is turned off, the TCLC part can be considered as the Lc in series with CPF, which is called LC-mode. Incontrast, when switch S is turned on, the TCLC can be considered as the Lc inseries with the combination of CPF in parallel with LPF, which is called LCL mode. And expressed as

$$X_{LC,n}(n) = \left|\frac{1-(n\omega)^2 L_C C_{PF}}{n\omega C_{PF}}\right|$$

$$X_{LC,n}(n) = \left|\frac{n\omega(L_c+L_{PF})-(n\omega)^3 L_{PF} L_C C_{PF}}{1-(n\omega)^2 L_{PF} C_{PF}}\right| \quad (6)$$

Based on the above discussion, the design criteria of Lc can be expressed as,

$$L_c = \frac{1}{(\omega n_1)^2 C_{PF}} \text{ and } L_c = \frac{1}{(\omega n_2)^2 C_{PF} - 1/L_{PF}} \quad (7)$$

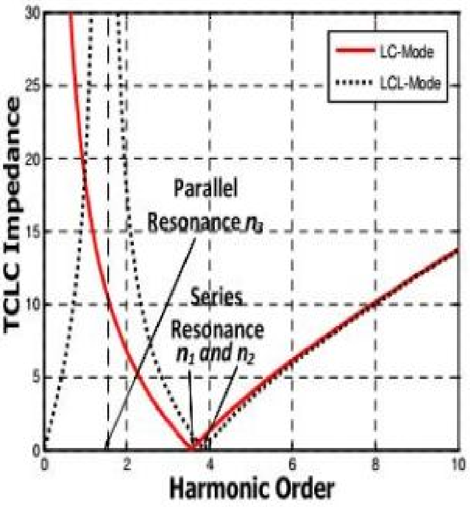

Fig..2. TCLC impedance under different harmonic

2.3 Design of VDC

Different with the traditional V_{DC} design method of the STATCOM to compensate maximum load reactive power, the V_{DC} of Hybrid STATCOM is design to solve the firing angle mistuning problem of TCLC (i.e., affect the reactive power compensation) so that the source reactive power can be fully compensated.

The inverter voltage Vinvx can also be expressed as,

$$V_{invx} = V_x\left(1+\frac{V_x I_{Lqx}}{V_x^2 / X_{TCLC}(\alpha_x)}\right) = V_x\left(1+\frac{Q_{Lx}}{Q_{cx,TCLC}(\alpha_x)}\right) \quad (8)$$

Where QLx is the load reactive power, Qcx, TCLC (α x) is the TCLC part compensating reactive power, and Vx is the RMS value of the load voltage. Combing (8) with

$$V_{DC} = \sqrt{6}\left|V_{invx}\right|,$$

the required DC – link voltage V_{DC} for hybrid STATCOM can =be expressed as

$$V_{DC} = \sqrt{6}V_x \left| 1 + \frac{Q_{Lx}}{Q_{cx,TCLC}(\alpha_x)} \right|$$

(9)

Ideally, Qcx, TCLC (αx) is controlled to be equal to –QLx so that the required V_{DC} can be zero. However, in the practical case, the Qcx, TCLC (αx) may not be exactly equal to –QLx due to the firing angle mistuning problem. The worst case of mistuning QLx/Qcx, TCLC (αx) ratio can be premeasured to estimate the required minimum V_{DC} value. Finally, a slightly greater V_{DC} value can be chosen.Based on (4), (5), (7), and (9), the system parameters CPF, LPF, Lc, and V_{DC} of hybrid-STATCOM can be designed accordingly. In the following section, the control strategy of hybrid-STATCOM is proposed and discussed.

III. CONTROL STRATEGY OF HYBRID STATCOM

A control strategy for hybrid-STATCOM is proposed by coordinating the control of the TCLC part and the active inverter part so that the two parts can complement each other's disadvantages and the overall performance of hybrid-STATCOM can be improved. The control strategy of hybrid-STATCOM is separated into two parts for discussion: A. TCLC part control and B. Active inverter part control.

3.1. TCLC part control

Different with the traditional SVC control based on the traditional definition of reactive power, to improve its response time, the TCLC part control is based on the instantaneous p-q theory . The TCLC part is mainly used to compensate the reactive Current with the controllable TCLC part impedance XTCLC. The trigger signals tocontrol the TCLC part can then be generated by comparing the firing angle αx with θx, which is the phase angle of the load voltage vx. θx can be obtained by using a phase lock loop (PLL). Note that the firing angle of each phase can differ if the unbalanced loads are connected.The reactive power of each phase can be compensated and the active power can be basically balanced, so that DC link voltage can be maintained at a low level even under unbalanced load compensation.

3.2 Active inverter part control

In the proposed control strategy, the instantaneous active and reactive current id-iq method implemented. The calculated icx* contains reactive power, unbalanced power, and current harmonic components. By controlling the compensating current icx to track its reference icx*, the active inverter part can compensate for the load harmonic currents and improve the reactive power compensation ability and dynamic performance of the TCLC part under different voltage conditions.The calculated icx* contains reactive power, unbalanced power, and current harmonic components. By controlling the compensating current icx to track its reference icx*, the active inverter part can compensate for the load harmonic currents and improve the reactive power compensation ability and dynamic performance of the TCLC part under different voltage conditions. The icx* can be computed as

$$\begin{bmatrix} i^*_{ca}\\ i^*_{cb}\\ i^*_{cc}\end{bmatrix} = \sqrt{\frac{2}{3}}\cdot \begin{bmatrix}1 & 0\\ -1/2 & \sqrt{3/2}\\ -1/2 & -\sqrt{3/2}\end{bmatrix}\cdot\begin{bmatrix}\cos\theta_a & -\sin\theta_a\\ -\sin\theta_a & \cos\theta_a\end{bmatrix}\cdot\begin{bmatrix}i_d\\ i_q\end{bmatrix}$$

Where id and iqare the instantaneous active and reactive current, which include DC components ī dand ī q and AC components and ĩd. ĩdis obtained by passing id through a high-pass filter. id and iqare obtained by,

$$\begin{bmatrix}i_d\\ i_q\end{bmatrix} = \begin{bmatrix}\cos\theta_a & -\sin\theta_a\\ -\sin\theta_a & \cos\theta_a\end{bmatrix}\begin{bmatrix}i_\alpha\\ i_\beta\end{bmatrix}$$

3.3 Response Time Of Hybrid-Statcom

The TCLC part has two back-to-back connected thyristor in each phase that are triggered alternately in every half cycle, so that the control period of the TCLC part is one cycle (0.05s). The proposed hybrid-STATCOM structure connects the TCLC part in series with an instantaneous operated active inverter part, which can significantly improve its overall response time. With the proposed controller, the active inverter part can limit the compensating current icx to its reference value icx* via pulse width modulation (PWM) control, and the PWM control frequency is set to be 12.5 kHz During the transient state, the response time of hybrid-STATCOM can be separately discussed in the following two cases.

a) If the load reactive power is dynamically changing within the inductive range the response time of hybrid-STATCOM can be as fast as traditional STATCOM.
b) In contrast, when the load reactive power suddenly changes from capacitive to inductive or vice versa, the hybrid-STATCOM may take approximately one cycle to settle down.The proposed hybrid STATCOM can be considered as a

fast-response reactive power compensator in which the dynamic performances of hybrid-STATCOM will prove by the simulation results.

3.4 Harmonic Sources & Effects

A good assumption for most utilities in the United States is that the sine-wave volt- age generated in central power stations is very good. In most areas, the voltage found on transmission systems typically has much less than 1.0 percent distortion. However, the distortion increases closer to the load. At some loads, the current waveform barely resembles a sine wave. This has given rise to the widespread use of the term harmonics to describe distortion of the waveform. Harmonics problems counter many of the conventional rules of power system. Design and operation that consider only the fundamental frequency. Therefore, the engineer is faced with unfamiliar phenomena that require unfamiliar tools to analyses and unfamiliar equipment to solve. Harmonic distortion is not a new phenomenon on power systems. Concern over distortion has ebbed and flowed a number of times during the history of ac electric power systems. Scanning the technical literature of the 1930s and 1940s, one will notice many articles on the subject. At that time the primary sources were the transformers and the primary problem was inductive interference with open-wire telephone systems. The forerunners of modern arc lighting were being introduced and were causing quite a stir because of their harmonic content not unlike the stir caused by electronic power converters in more recent times. We can define harmonic as the frequency which is integer multiple of the fundamental frequency (i.e. 50 or 60 Hz). For example second harmonic is two time of fundamental (i.e. 100 or 120 Hz), similarly for third harmonic it is thrice of the fundamental component (i.e. 150 or 180 Hz) and so on. Harmonic currents cause problems both on the supply system and within the installations. The effects and the solutions are very different and need to be addressed separately; the measures that are appropriate to controlling the effects of harmonics within the in-stallation may not necessarily reduce the distortion caused on the supply and vice versa. There are several common problem areas caused by harmonics: -Problems caused by harmonic currents:

- overloading of neutrals
- overheating of transformers
- nuisance tripping of circuit breakers
- over-stressing of power factor correction capacitors
- Skin effect
- Voltage distortion in induction motors
- zero-crossing noise
- Problems caused when harmonic currents reach the supply. There are a number of Methods to modify adverse system responses to harmonics
- Add a shunt filter. Not only does this shunt a troublesome harmonic current off the system, but it completely changes the system response, most often, but not always, for the better.
- Add a reactor to detune the system. Harmful resonances generally occur between the system inductance and shunt power factor correction capacitors. The reactor must be added between the capacitor and the supply system source. One method is to simply put a reactor in series with the capacitor to move the system resonance without actually tuning the capacitor to create a filter. Another is to add reactance in the line.
- Change the capacitor size. This is often one of the least expensive options for both utilities and industrial customers.
- Move a capacitor to a point on the system with a different short-circuit impedance or higher losses. This is also an option for utilities when a new bank causes telephone interference moving the bank to another branch of the feeder may very well resolve the problem. This is frequently not an option for industrial users because the capacitor cannot be moved far enough to make a difference.

Remove the capacitor and simply accept the higher losses, lower voltage, and power factor penalty. If technically feasible, this is occasionally the best economic choice. Somewhat faster time constants are associated with the dynamics of generator rotor windings. These time constants are in the range of 0.1 second, which is smaller than those of the rotation. The power system dynamic models which include electromagnetic dynamics of rotor windings and mechanical dynamics of rotation are known as the two-axis and the one-axis (flux-decay) models. The difference between the two is in the number of details they describe. The first represents dynamics of the damper and the excitation windings while the second one captures only dynamics of the excitation winding. The dynamics of the damper windings are usually faster than the one of the excitation winding which is due to the relative difference in their sizes.

3.5 Basic Structure Of Hybrid Statcom

The following fig.3 shows the basic structure of hybrid Statcom connected in three phase systems in grid with three phase series RLC branch. The Three-Phase V-I Measurement block is used to measure instantaneous three-phase voltages and currents in a circuit. When connected in series with three-phase elements, it returns the three phase-to-ground or phase-to-phase peak voltages and currents.it consist of load and source active and reactive power. The hybrid-Statcom is proposed, with the distinctive characteristics of a much wider compensation range than traditional-STATCOM and a much lower dc-link voltage and another parallel-connected hybrid-STATCOMs. Its parameter design method is proposed based on consideration of the reactive power compensation range, prevention of the potential resonance problem, and avoidance of mistuning of firing angle.

Hybrid STATCOM is gaining momentum and is to an increasing degree catching the interest of utilities looking for options that can offer additional benefits to those already available. In particular for very large Mvar operation ranges, the STATCOM power must be supplemented by thyristor switched branches (TSC/TSR) to attain the desired Mvar output, i.e. Hybrid

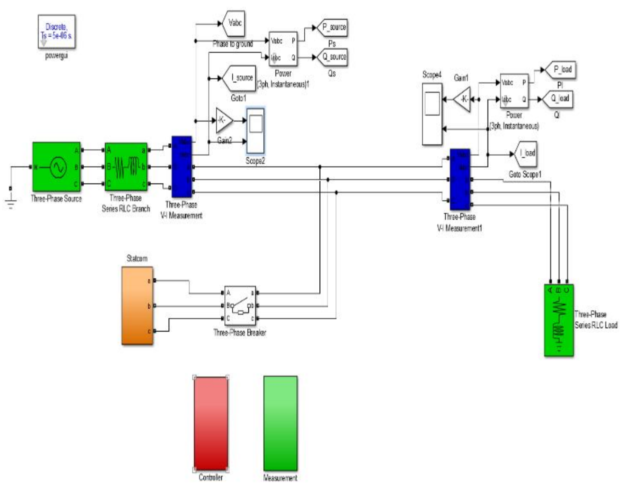

Fig.3. Basic structure of hybrid Statcom connected in three phase systems in grid

STATCOM comes into the picture. TSR provides extension of the inductive range, whereas TSC provides extension of the capacitive range of the device. By means of fast switched thyristor valves in joint operation with the VSC, TSR and TSC enable rapid, repeated and transient free switching of reactive elements (reactors and capacitors).

- Hybrid STATCOM offers easy extension of dynamic range, lower total losses, and superior contingency handling.
- Adding a TSR branch gives superior overvoltage performance.
- With a TSC branch, fast blocking can be applied to prevent overvoltage after fault clearing.

Furthermore, STATCOM in itself provides a symmetrical operating range. For asymmetrical operation and in order to optimize performance, Hybrid STATCOM may be the best solution. As a matter of fact, most applications worldwide are asymmetrical. Using a STATCOM to cover the whole swing range would lead to an overdesign on either the capacitive or inductive Mvar output sides.Multilevel VSC based STATCOM has low harmonic generation. As neither TSC nor TSR add any harmonics to the picture, Hybrid STATCOM has low harmonic generation, too. As a benefit, no low order harmonic filters are required in the installation.STATCOM as well as Hybrid STATCOM for power transmission applications normally make use of a power transformer between the grid and the medium voltage bus bar. On this bus the VSC is connected in series with a coupling reactor. In addition, in the Hybrid case, TSR and TSC are added in parallel.

IV. PERFORMANCE ANALYSIS

4.1 **Simulation models of traditional and hybrid Statcom**

The Matlab simulation of traditional and hybrid Statcom consist of voltage source of 400v then source resistance of 0.04 Ω and impedance of 0.02mH
We will consider the two types of load:

I. 50kw 25kvar
II. 75kw 25kvar

4.2 Simulation model of traditional Statcom

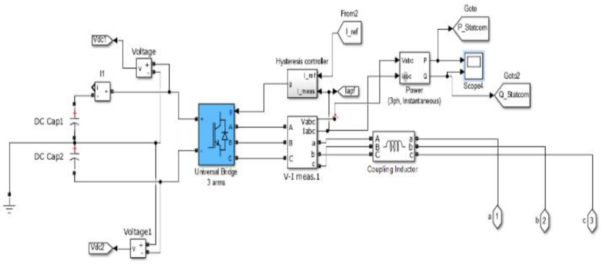

Fig.4. Matlab simulation of traditional Statcom connected in three phase systems.

4.3. Simulation model of hybrid Statcom

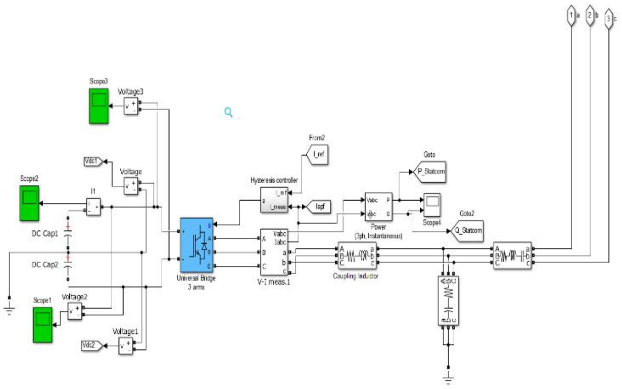

Fig.5. MATLAB simulation of traditional Statcom with three phase systems

4.4. Simulation models of controller

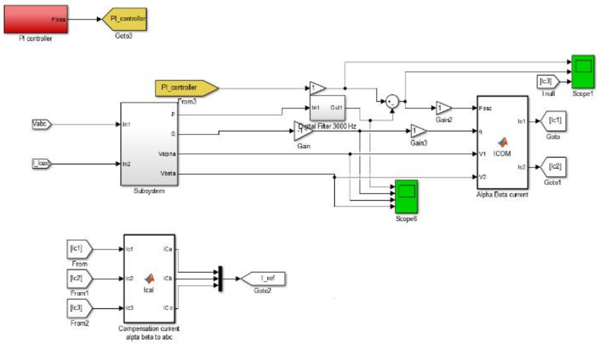

Fig.6.MATLAB simulation of controller

4.5. Experiment Results and Discussion

The objective of the experiment results is to verify that the proposed hybrid-STATCOM has the characteristics of a wide compensation range and low dc-link voltage under different voltage and current conditions.Following are the standard grid parameters with considering line voltage, line Resistance, line inductance, and frequency which are shown by table 1

Table.1.Grid Parameter

Sr. No.	Parameter	Value
1	Line voltage	400V
2	Line Resistance	0.04 Ω
3	Line Inductance	0.02mH
4	Frequency	50Hz

Table 2 shows the output values of total harmonics distortion (THD) according to changewith load.

Table .2.Output Values of THD According To Load.

Sr. No.	Load	Statcom	THD
1	50KW 25KVAR	Traditional Statcom	4.96
		Hybrid Statcom	3.49
2	75KW 25KVAR	Traditional Statcom	3.62
		Hybrid Statcom	2.74

IV. GRAPHICAL REPRESENTATION

These are the graphs of FFT analysis of load and source power.

4.1Graphical Representation Power Measure At Load Side

The below fig shows the graphical results of power measure at load side. After we compensating the reactive power into the system we measured the load power. We apply the load of 50kw, 25kvar find the active and reactive power.

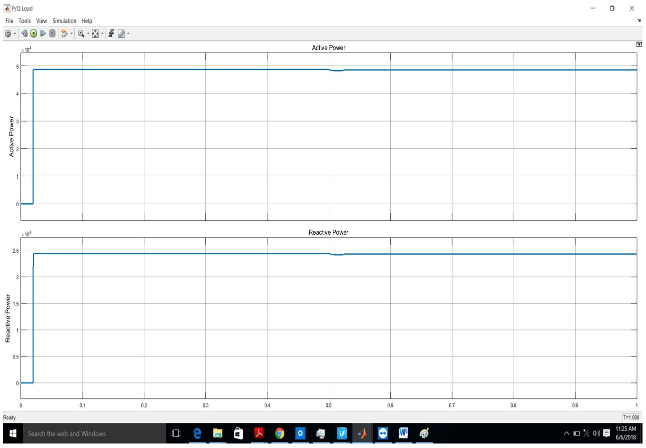

Fig.7. Graphical representation of Power measure at load side

4.2 Graphical Representation of Power Measure at Source Side

The below fig shows the graphical result of power measure at source side. We observed that before the time of 0.5second in which Statcom connected in grid the active power which peak to load is increases and reactive power which fed by load is decreases.

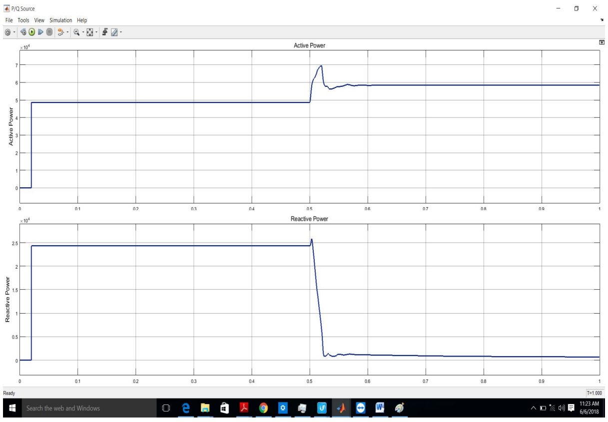

Fig.8.Graphical representation of Power measure at source side

4.3 Graphical Representation OfPower Injected By Hybrid Statcom

The below Fig.9. shows the graphical representation of Power injected by hybrid Statcom. The Statcom injected reactive power in system. When it connected to grid it inject 22kw in grid.

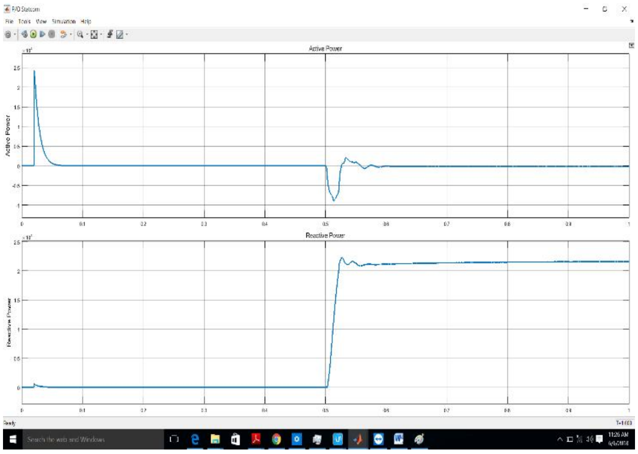

Fig.9.Graphical representation of Power injected by hybrid Statcom

But at this time the larger problem of harmonics is created in grid system.so our main objectives are to inject reactive power and remove harmonics from the system.Therefore we consider the two cases,

4.3.1 Case 1: THD 50KW25KVAR

In first case when we apply the load of 50kw 25kvarat this time the traditional Statcom is used the Total harmonic distortion (THD) of 4.96 and hybrid Statcom used the Total harmonic distortion (THD) of 3.49 from this both results we find that hybrid Statcom reduced the total harmonic distortion Which is shown by the below fig. Graphical representation of traditional Statcom and fig. Graphical representation of hybrid Statcom.

THD Traditional Statcom: 4.96

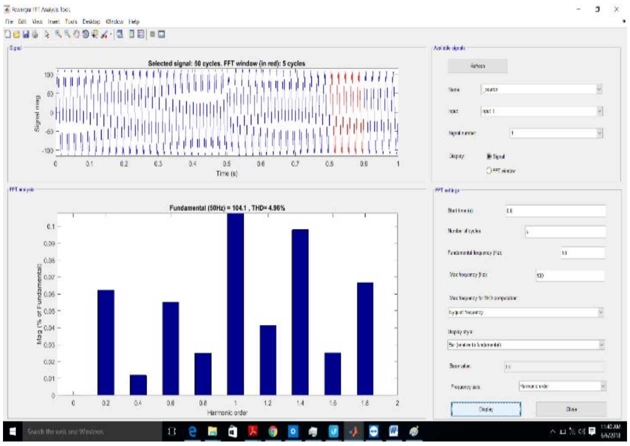

Fig.10.Graphical representation of traditional Statcom with THD 4.96 and Dynamic compensation waveforms of by applying traditional Statcom under different loadings cases

THD Hybrid Statcom: 3.49

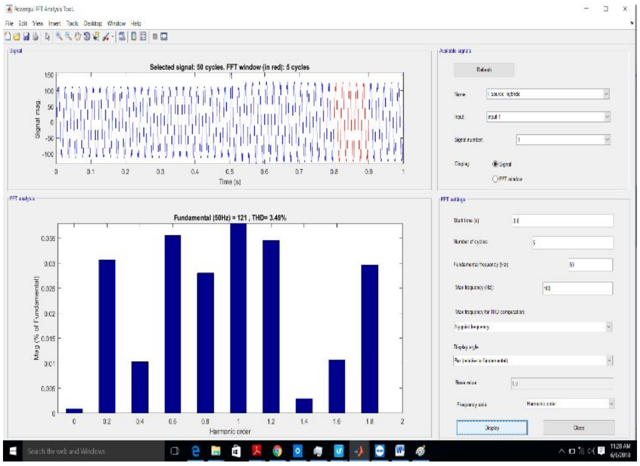

Fig.11. Graphical representation of hybrid Statcom with THD 3.49 and Dynamic compensation waveforms of by applying hybrid Statcom under loadings cases

4.3.2 Case 2: THD 75KW25KVAR

In second case when we increases the load of 75kw 25kvar at this time the traditional Statcom is used the Total harmonic distortion (THD) of 3.62 and hybrid Statcom used the Total harmonic distortion (THD) of 2.76 from this both results we find that hybrid Statcom reduced the Total harmonic distortion. Which is shown by the below fig. Graphical representation of traditional Statcom and fig. Graphical representation of hybrid Statcom.

Traditional Statcom: THD 3.62

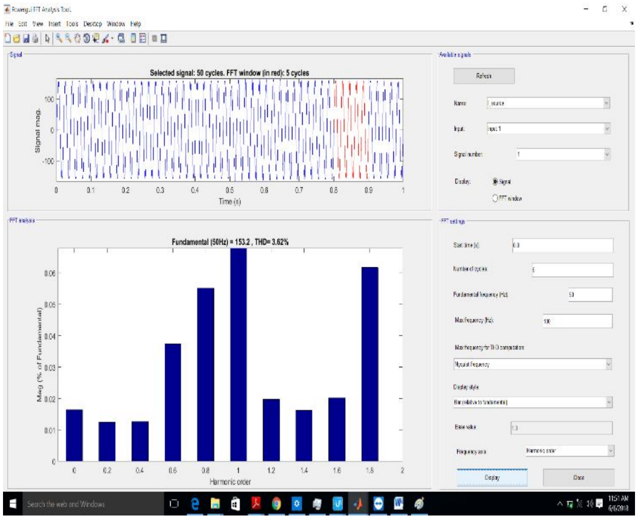

Fig.12. Graphical representation of traditional Statcom with THD 3.62 and Dynamic compensation waveforms of by applying traditional Statcom under loadings cases

Hybrid Statcom: THD 2.74

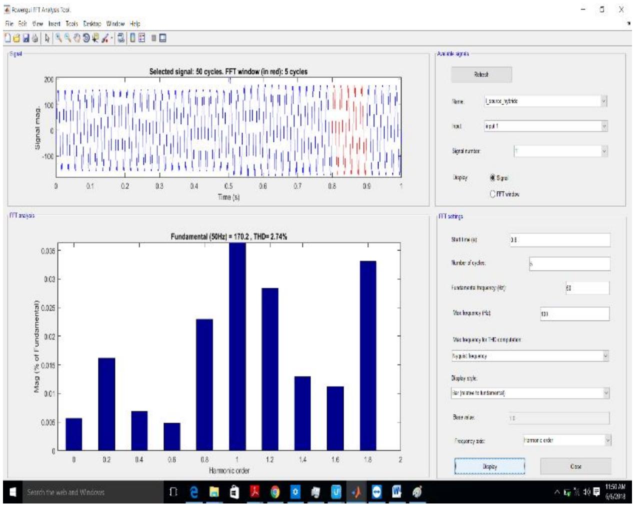

Fig.13.Graphical representation of hybrid Statcom with THD 2.74 and Dynamic compensation waveforms of by applying hybrid Statcom under loadings cases

According to the simulation results, with similar compensation performance, the capacity of the active inverter part of the proposed hybrid STATCOM is only about 16% of that of traditional STATCOM under wide range compensation. The proposed hybrid STATCOM can avoid the use of multilevel structures in Medium voltage level transmission system in comparison to traditional STATCOM, the system reliability can be highly increased and the system control complexity and operational costs can be greatly reduced.The traditional STATCOM can compensate for both inductive and capacitive reactive currents with a high DC-link operating voltage due to a small coupling inductor. Due to its high DC link voltage, the traditional STATCOM obtains the poor Source current caused by switching noise) compared with hybrid STATCOM. The hybrid STATCOM obtains the best performances of the two STATCOMs under inductive loadings. The hybrid STATCOM has a wide compensation range with low DC-link voltage characteristic and good dynamic performance

V. CONCLUSION

In this paper a hybrid-STATCOM in three-phase power system is introduced and discussed as a cost-effective reactive power compensator for medium voltage level application. The system configuration and *V–I* characteristic of the hybrid-STATCOM were analyzed, discussed, and compared with traditional STATCOM. In addition, its parameter design method was proposed on the basis of consideration of the reactive power compensation range and prevention of a potential resonance problem. According to the simulation results, with similar compensation performance, the capacity of the active inverter part of the proposed hybrid STATCOM is only about 16% of that of traditional STATCOM under wide range compensation. The proposed hybrid STATCOM can avoid the use of multilevel structures in Medium voltage level transmission system in comparison to traditional STATCOM, the system reliability can be highly increased and the system control complexity and operational costs can be greatly reduced. Hence, the wide compensation range and low dc-link voltage characteristics with good dynamic performance of the hybrid-STATCOM were proved by both simulation and experimental results.

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