RESEARCH ARTICLE OPEN ACCESS

AN ADAPTIVE CONTROL METHOD OF A VSC USED AS A STATCOM FOR POWER FACTOR COMPENSATION

Vipin Rajput[1], Vaibhav Jha[2]
[1]M.Tech(Power system), EE Engineering,
Vipinrajput8@gmail.com

[2]Asst.Professor, EE Engineering department,
Jha.vaibhav78@gmail.com

--************************----------------------------------

Abstract:

The headway in Power Gadgets Circuits has prompted the improvement of Converter circuits which finds application in controlling the power sharing and to accomplish the power soundness issues. In this proposal work an immediate dynamic and receptive power control procedure added with a sliding mode approach is explored (2). An accomplishment of vector control is proposed where extra PI regulators is given to remunerate undesired negative grouping parts from an unequal burden. The regulator is planned in view of a twofold simultaneous reference outline. The creators were proposed an evenness based strategy where force of VSC is a level result and a Lyapunov capability is utilized to infer the regulator. A streamlining based multivariable PI regulator is proposed for space vector adjustment. This paper is proposed a versatile control of a VSC utilized as a STATCOM for power factor remuneration as it were. In this postulation coordination control calculation is proposed for all converters to smooth power move among source and burden joins 2 when the framework is changed starting with one working condition then onto the next under different burden and asset conditions which is checked by Matlab/Simulink (4).
Keywords — Harmonic Resonance Damping ; Power Quality; Passive power filters; Inverters.

--************************----------------------------------

I. INTRODUCTION

The movement in Power Electronics Circuits has provoked the improvement of Converter circuits which finds application in controlling the power sharing and to achieve the power reliability issues. In this hypothesis work a quick unique and responsive power control technique added with a sliding mode approach is investigated (2). An achievement of vector control is proposed where additional PI controllers is given to compensate undesired negative game plan parts from an unbalanced burden.The controller is arranged considering a twofold organized reference frame. The makers were proposed an equity based strategy where power of VSC is a level outcome what's more, a Lyapunov capacity is used to decide the controller. A smoothing out based multivariable PI controller is proposed for space vector change. This paper is proposed a flexible control of a VSC used as a STATCOM for power factor compensation in a manner of speaking.(3,4)

II. METHODOLOGY

To assessment the introduction of the space vector beat width change of static composed compensator, Reproduction model has made in SIMULINK block set of MATLAB 2013 (a). The helpful block set of room vector beat width change of static synchronous compensator system in SIMULINK environment. The practicality of room vector beat width guideline of static concurrent compensator difference and two extraordinary such 48 heartbeat inverter and DSTATCOM investigated for various working conditions using the Simulink model. Liberated from the strategy utilized in showing of STATCOM and its controlling equipment, it is critical to see the nonlinear thought of power structures and that the objective of adding some controlling contraption like PI controller and DC converter and Inverter control with STATCOM system is to extend power capacity limits by further develop system dangerous using SIM-POWER SYSTEMS(2).

1) Standard of 48 Pulse VSC based STATCOM

Two 24-beat GTO converters, stage moved by 7.5 from each other, are used to give the full 48-beat converter action. The 48-beat converter contains four vague 12-beat GTO converters interlinked by four 12-beat transformers with stage shift windings. Fig. 4.5 depicts the schematic outline of a 48-beat Voltage Source GTO converter.(5)

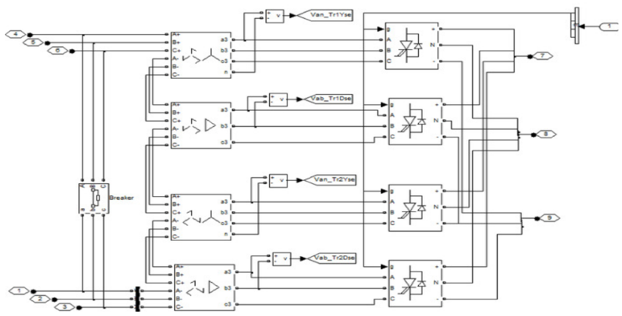

Fig 1. 48 Pulse VSC based STATCOM

Transformer affiliations, stage moving using crosswise transformers and ending beat reasonings, for period of STATCOM yield voltage are shown in the said Fig 1 to triumph ultimately the last 48 heartbeat movement. The 48-beat converter can be used in high power applications without the necessity for any air conditioner channels due to its tip top presentation and extremely low symphonious substance on the air conditioner side. The outcome voltage have sounds n = 48r ± 1, where, r = 0, 1, 2,...; i.e., 47th, 49th, 95th, 97th, ..., with all around ordinary degrees of 1/47th, 1/49th, 1/95th, 1/97th,..., independently, in regards to the fundamental; on the DC side, the lower streaming dc current symphonious substance is the 48th. The stage shift plan on each 12-beat converter is suggested in. The resultant outcome voltage made by 48-beat GTO STATCOM controller is given underneath.(3):

The resultant result voltage created by first 12-pulse converter is,

$$Vab12\ (t)\ 1 = 2\ [Vab1 \sin(\omega t+30) + Vab11 \sin(11\omega t+195) + Vab12 \sin(13\omega t+255) + Vab23 \sin(23\omega t+60) +...] \quad ....(4)$$

The resultant result voltage created by second 12-pulse converter is,

$$Vab12\ (t)\ 2 = 2\ [Vab1 \sin(\omega t+30) + Vab11 \sin(11\omega t+15) +Vab12 \sin(13\omega t+75) + Vab23 \sin(23\omega t+60)+ ...] \quad ....(5)$$

The resultant result voltage created by third 12-pulse converter is,

$$Vab12\ (t)\ 3 = 2\ [Vab1 \sin(\omega t+30) + Vab11 \sin(11\omega t+285) + Vab13 \sin(13\omega t+345) + Vab23 \sin(23\omega t+240) +...] \quad ....(6)$$

The resultant result voltage created by fourth 12-pulse converter is,

$$Vab12\ (t)\ 4 = 2\ [Vab1 \sin(\omega t+30) + Vab11 \sin(11\omega t+105) + Vab13 \sin(13\omega t+165) + Vab23 \sin(23\omega t+240) +......] \quad .....(7)$$

Yield AC voltages of these four 12-pulse, given by conditions (1 to 4) shows up across optional windings of the transformers and are added by associating the windings in series. The articulation for the 48-pulse AC yield voltage is given by:

$$Vab48\ (t) = 8\ [Vab1 \sin(\omega t+30) + Vab47 \sin(47\omega t+150) + Vab49 \sin(49\omega t+210) + Vab95 \sin(95\omega t+330) +......] \quad ....(8)$$

The 48-beat VSC makes less symphonious twisting and reduce power quality issues than various converters, for instance, (6, 12 and 24-beat. This results in least utilitarian over-troubling and system symphonious shakiness issues.

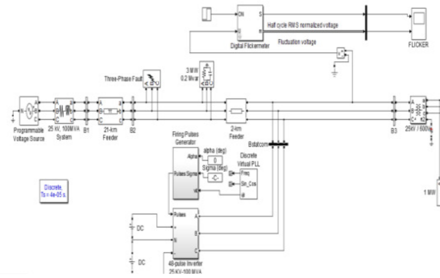

Fig 2. Circuit diagram of 48-beat based STATCOM

In 48 pulse inverter STATCOM, ideal switches and bungle stage moving transformers are used to manufacture a GTO-type 100 MVA, 25 kV voltage source inverter. This kind of converter is used in high-power (up to 150 MVA) Adaptable AC Transmission Frameworks (Realities) which are used to control power stream on transmission grids. It will in general be used, for example, to create a model of shunt or series static compensator (STATCOM or SSSC) or, using two such converters, a blend of shunt and series devices known as Bound together Power Stream Controller(UPFC).(7)The inverter portrayed in this model is a symphonious killed, 48-beat GTO converter depicted in reference. It involves four 3-stage, 3-level inverters what's more, four phase moving transformers.(6)

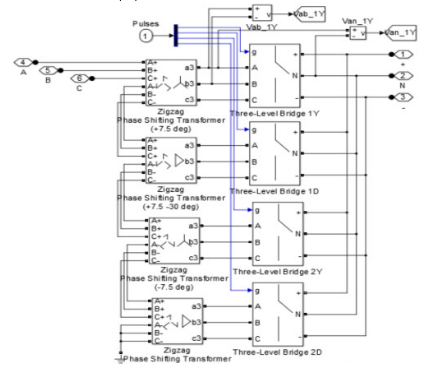

Fig 3. 48 pulse converter circuit

1) **Space Vector Pulse Width Modulation based STATCOM**

The voltage source converter can make fitting entrance signal dependent upon the control procedure. The chief place of the control plot is to stay aware of predictable voltage degree where a sensitive weight is related, under structure disrupting impacts. In this control plot it assesses the RMS voltage at the pile point and negative necessities of responsive power assessments. Here the sinusoidal PWM strategy is used for the trading of VSC offers ease and incredible response.(8.9)

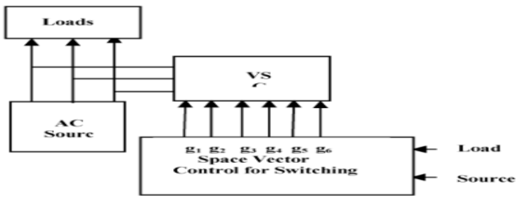

Fig 4. Control Circuit of Voltage Source Converter

Three phase input to the voltage source Converter is given as

Va = Vm sin(ωt) ....(9)

Vb= Vm sin (ωt - 2π/3) ....(10)

Vc=Vm sin (ωt + 2 π/3) ....(11)

Exactly when the driver circuit is planned with sinusoidal PWM strategy or with a SVPWM exchanging method a regulation record factor is added with the every time of info voltage. Thusly the tweaking signal is given as

Vma = Am sin (ωt + δ) ....(12)

Vmb=Am sin(ωt- 2 π/3 + δ) ....(13)

Vmc=Am sin(ω.t+2π/3 + δ)...........................(14)

To deliver the trading signals for the VSC valves, the reasonable sign vector control is taken a gander at against a three-sided signal as shown in fig. 4 The ampleness change rundown of sign and the repeat guideline record of the three-sided signal are the central limits of the sinusoidal PWM plot. Complete compensation isn't achieved in that frame of mind of nonlinear weight anyway this framework is easy to do and is good and can give fragmentary open power compensation without consonant disguise (19).

A) Circuit Description of D-STATCOM

A Conveyance Static Simultaneous Compensator (D-STATCOM) is utilized to manage voltage on a 25-kV circulation organization. Two feeders (21 km and 2 km) communicate capacity to loads associated at transports B2 and B3. A shunt capacitor is utilized for power factor revision at transport B2. The 600-V burden associated with transport B3 through a 25kV/600V transformer addresses a plant retaining consistently evolving flows, like a curve heater, consequently creating voltage glimmer. The variable burden current size is tweaked at a recurrence of 5 Hz so that its clear power changes roughly between 1 MVA and 5.2 MVA, while keeping a 0.9 slacking power factor. This heap variety will permit you to notice the capacity of the D-STATCOM to relieve voltage glint. The D-STATCOM controls transport B3 voltage by retaining or producing responsive power. This responsive power move is finished through the spillage reactance of the coupling transformer by producing an optional voltage in stage with the essential voltage (network side). This voltage is given by a voltage-obtained PWM inverter. At the point when the auxiliary voltage is lower than the transport voltage, the D-STATCOM behaves like an inductance engrossing receptive power. At the point when the optional voltage is higher than the transport voltage, the D-STATCOM behaves like a capacitor producing receptive power. The D-STATCOM comprises of the accompanying parts: a 25kV/1.25kV coupling transformer which guarantees coupling between the PWM inverter and the organization. a voltage-obtained PWM inverter. In this model, the PWM inverter is supplanted on the air conditioner side with three identical voltage sources found the middle value of more than one pattern of the exchanging recurrence (1.68 kHz).(33) Sounds produced by the inverter are subsequently not apparent with this typical model. On the DC side, the inverter is displayed by an ongoing source charging the DC capacitor. The DC current Idc is registered with the goal that the prompt power at the air conditioner contributions of the inverter stays equivalent the immediate power at the DC yield (Va*Ia + Vb*Ib + Vc*Ic = Vdc*Idc).LC damped channels associated at the inverter yield. Protections associated in series with capacitors give a quality component of 40 at 60 Hz. a 10000-microfarad capacitor going about as a DC voltage hotspot for the inverter a voltage controller that controls.(10,12)

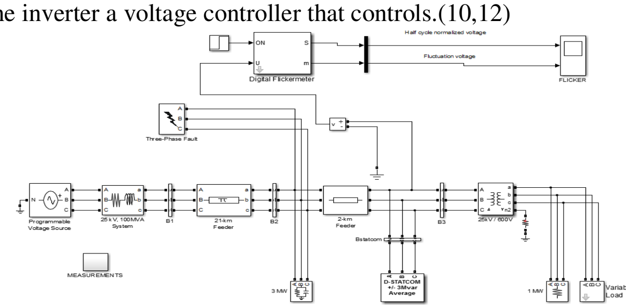

Fig 5. Control Circuit of D-STATCOM

B) Circuit Description of Space Vector Pulse Width Modulation STATCOM

A space vector pulse width balance STATCOM (SVPWM STATCOM) is utilized to control voltage on a 25-kV dispersion network. Two feeders (21 km and 2 km) send capacity to loads associated at transports B2 and B3. A shunt capacitor is utilized for power factor revision at transport B2. The 600-V burden associated with transport B3 through a 25kV/600V transformer addresses a plant retaining constantly evolving flows, like a bend heater, subsequently creating voltage flash. The variable burden current greatness is balanced at a recurrence of 5 Hz so that its obvious power differs roughly between 1 MVA and 4 MVA, while keeping a 0.9 slacking power factor. This heap variety will permit you to notice the capacity of the SVPWM STATCOM to relieve voltage gleam.(30) The SVPWM-STATCOM controls transport B3 voltage by retaining or creating responsive power. This receptive power move is finished through the spillage reactance of the coupling transformer by producing an optional voltage in stage with the essential voltage (network side). This voltage is given by a voltage-obtained SVPWM inverter. At the point when the auxiliary voltage is lower than the transport voltage, the SVPWM-STATCOM behaves like an inductance engrossing receptive power. (11)At the point when the optional voltage is higher than the transport voltage, the SVPWM-STATCOM behaves like a capacitor creating receptive power.(13)

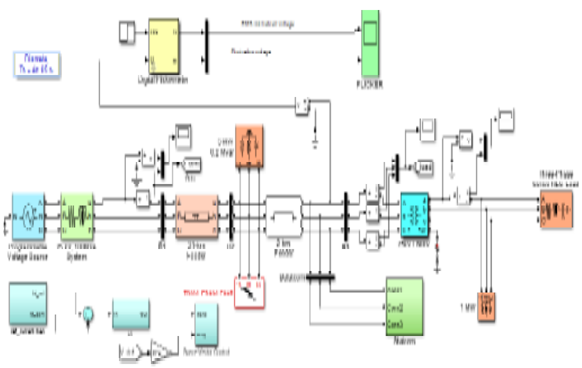

Fig 6. Simulation model of a STATCOM .

III.RESULT AND DISCUSSION

1) Result obtained without fault while using 48-Pulse VSC based STATCOM

We concentrated on the presentation of 48-beat STATCOM with a power framework associated without issue condition in MATLAB the result waveform of the proposed strategy are

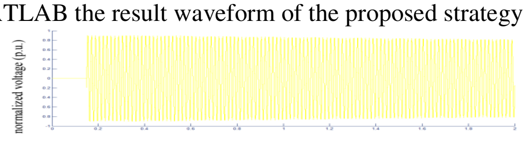

Fig 7. Result obtained without fault while using 48-Pulse VSC based STATCOM

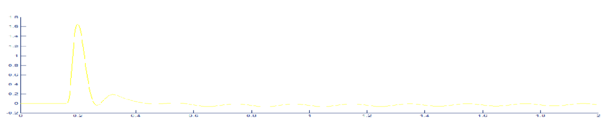

Fig. 8. Fluctuation voltage without fault (48-Pulse based STATCOM)

1) Result obtained without fault while using D – STATCOM

We concentrated on the presentation of Conveyed STATCOM with a power framework associated without issue condition in MATLAB the result waveform of the proposed strategy

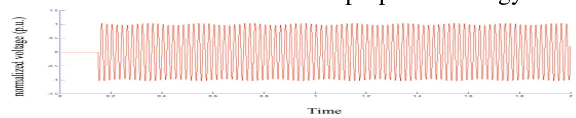

Fig 9. Result obtained without fault while using D – STATCOM

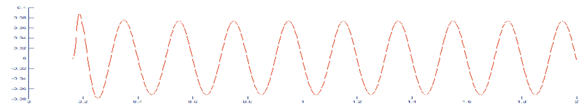

Fig 10 Fluctuation voltage without fault (D-STATCOM)

1) Result obtained without fault while using SVPWM- STATCOM

We concentrated on the exhibition of Room vector beat width regulation STATCOM with a power framework associated without shortcoming condition in MATLAB the result waveform of the proposed technique are as follow

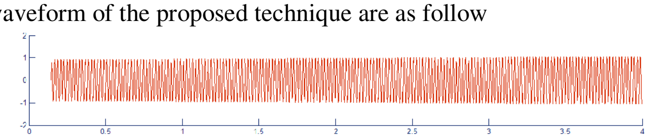

Fig. 11. Half cycle normalized voltage without fault (SVPWM STATCOM)

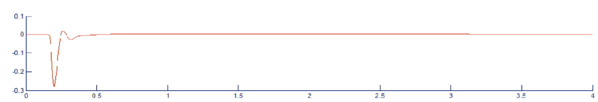

Fig. 12.Fluctuation voltage without fault (SVPWM STATCOM)

2) Comparison of 48-pulse STATCOM, D-STATCOM and SVPWM-STATCOM under normal condition.

STATCOM	Voltage Fluctuation	Settling Time	Flicker wave
48- Pulse VSC based STATCOM	1.2 p.u.	2.7 sec	High Deviation
D-STATCOM	0.01 p.u.	2.5 sec	Smooth
SVPWM STATCOM	-0.2 p.u.	0.5 sec	Very Smooth

Table 4.1 Comparison of 48-pulse STATCOM, D-STATCOM and SVPWM-STATCOM under normal condition.

The proposed work shows the abatement in transient period and moreover the significance of fluctuating voltage. Usage of variable DC voltage gives the benefit of ejection of transformer and moreover invigorates better the system. Removal of transformer makes the system less monstrous. From the entertainment focus on it shows that the Space Vector PWM STATCOM appreciates advantage over other during issue condition. Additionally, enjoys benefit more than 48-beat STATCOM under average movement with load condition. Moreover, the D-STATCOM appreciates high ground over others in average movement with load condition in adequacy figuratively speaking. This hypothesis has depicted an organized reference control, method to oversee and change the voltage at a weak vehicle in six vehicle system using a SVPWM STATCOM contraption. This control method was developed expressly for a PWM controlled voltage source inverter related with the weak vehicle association through AC channel.(15) Entertainment results have shown that the controller achieves changed voltages at the slight vehicle while keeping a fast transient response. It has similarly been shown that the correspondence between a SVPWM STATCOM contraption and a slight vehicle network is fragile to non-ideal stock circumstances and weight assortment. Thusly, tuning of the controller to achieve a fast and stable response under fluctuating system conditions requires mindful arrangement and assessment for each specific foundation. It has in like manner been shown that the correspondence between a SVPWM STATCOM contraption and a stock system makes the rural buyers sound and well off.

The proposed work shows the decrease in transient period. Utilization of variable DC voltage gives the advantage of evacuation of transformer and furthermore gives strength to the framework. From the reenactment concentrate on it shows that the Space Vector PWM STATCOM enjoys upper hand over other during shortcoming condition. Also, enjoys upper hand north of 48-beat STATCOM under ordinary activity with load condition. What's more, the D-STATCOM enjoys upper hand over others in typical activity with load condition in abundancy as it were. This proposition has depicted a coordinated reference control, procedure to manage and adjust the voltage at a feeble transport in six transport framework utilizing a SVPWM STATCOM gadget(16). This control methodology was grown explicitly for a PWM controlled voltage source inverter associated with the powerless transport network through AC channel. Recreation results have exhibited that the regulator accomplishes adjusted voltages at the powerless transport while keeping a quick transient reaction. It has likewise been shown that the communication between a SVPWM STATCOM gadget and a powerless transport network is delicate to non-ideal stockpile conditions and burden variety. In this way, tuning of the regulator to accomplish a quick and stable reaction. It has likewise been shown that the communication between a SVPWM STATCOM gadget and a stock framework makes the provincial shoppers sound and rich.(32)

REFERENCES

[1] Abderrahmen Abdellaoui and Abderrazak Yangui, Amara Saidi and Hsan Hadj Abdallah," STATCOM-Based 48-Pulses Three Level GTO Dedicated to V AR Compensation and Power Quality Improvement", 978-1-4673-9529-2015 IEEE

[2] M.Jayashree, J.Chitra,"Buck-Boost Converter based SHE-PWM technique Multilevel Inverter Control for STATCOM System", 978-1-4799-6805-2015 IEEE

[3] Georgios Konstantinou, Josep Pou, Gabriel J. Capella,Kejian Song, Salvador Ceballos, Vassilios G. Agelidis,"Interleaved Operation of Three-Level Neutral Point Clamped Converter Legs and Reduction of Circulating Currents under SHE-PWM", 0278-0046-2015 IEEE.

[4] S.K.Acharya, J.K.Moharana, "Effect of DC-link Voltage on Design of Linear Controller for a STATCOM on Reactive power Compensation", 01.IJEE.1.1.1 Feb 2014

[5] Bhim Singh, Kadagala Venkata Srinivas, "Fuzzy Logic Control with Constant DC LinkVoltage of 48-Pulse VSC Based STATCOM", 956-1-4466-5315-2014 IEEE.

[6] Mohamed S. A. Dahidah, "New Current Control Algorithm Incorporating Multilevel SHE-PWM Approach for STATCOM Operation under Unbalanced Condition", 978-1-4799-5115-2014 IEEE.

[7] Sreejith.S, Upama Bose, K. Muni Divya Sree Vachana, Vallathur Jyothi, "Application of D-STATCOM as Load Compensator for Power Factor Correction", 978-1-4799-4190-2014 IEEE

[8] Law Kah Haw, Mohamed S. A. Dahidah, Haider A.F. Almurib,"SHE-PWM Cascaded Multilevel Inverter with Adjustable DC Voltage Levels Control for STATCOM Applications", 0885-8993-2013 IEEE.

[9] Gishin Jacob George, Rakesh Nirmalkar" Modeling Of STATCOM under Different Loading Conditions "2012 IEEE.

[10] Kah Haw Law, Mohamed S.A Dahidah, Georgios S. Konstantinou, Vassilios G. Agelidis, "SHE-PWM Cascaded Multilevel Converter with Adjustable DC Sources Control for STATCOM Applications", 978-1-4577-2088-2012 IEEE

[11] Amin Nazarloo, Seyed Hossein Hosseini, Ebrahim Babaei, "Flexible D- STATCOM Performance as a Flexible Distributed Generation in Mitigating Faults", 978-1-61284-421-2011 IEEE

[12] N. Flourentzou, V. G. Agelidis, "Harmonic Performance of Multiple Sets of Solutions of SHE-PWM for a 2-Level VSC Topology with Fluctuating DC-Link Voltage", 124 (13-13) AUPEC'07

[13] Ashwin Kumar Sahoo, K.Murugesan, T. Thygarajan, "Modeling and Simulation of 48-pulse VSC Based STATCOM Using Simulink's Power System Blockset", India International Conference on Power Electronics 2006

[14] Wanmin Fei, Xinbo Ruan,and Bin Wu ,"A Generalized Formulation of Quarter- Wave Symmetry SHE-PWM Problems for Multilevel Inverters", 0885-8993-2009 IEEE

[15] Wanmin Fei, Xiaoli Du,Bin Wu."Half-Wave Symmetry SHE-PWM Method for Multilevel Voltage Inverters", 978-1-4244-4783-2010 IEEE

[16] Kah Haw Law, Mohamed S. A. Dahidah, “DC-DC Boost Converter Based MSHE-PWM Cascaded Multilevel Inverter Control for STATCOM Systems”, 978-1-4799-2705-2014 IEEE
[17] Hendri Masdi, Norman Mariun; Senan Ma1imud, Azah Mohamcd, Sallehhudin Yusuf, “Design of a Prototype D-Statcom for Voltage Sag Mitigation”, 0-7803-8724-2004 IEEE.
[18] Jie Tang, Yanbin Xie, Xiaofang Wang, “Active Disturbance Rejection Control of DSTATCOM under Unbalanced Voltage Conditions”, 978-1-61284-722-2011 IEEE
[19] Yueqiu Wang, Jie Tang, Xionger Qiu, “Analysis and Control of D-STATCOM under unbalanced voltage condition”, 978-1-61284-722-2011 IEEE
[20] Zhengping Xi, Subhashish Bhattacharya, “STATCOM Operation under Single Line-Ground System Faults with Magnetic Saturation in Series Connected Transformers based 48-pulse Voltage-Source Converter”, 589-1-62464-752-2011 IEEE
[21] Yu Liu, “Dead-Band Controller For Balancing Individual Dc Capacitor Voltages In Cascade Multilevel Inverter Based STATCOM “2009 IEEE.
[22] Ali Fazli1 , Mehrdad Fazli1 , Abbas Seif “Condition Monitoring For Detecting Vfc And STATCOM Faults In Wind Turbine Equipped With Dfig” 2012 IEEE.
[23] Yao Sun” A Novel Balancing Method For Dc Voltage Of Cascaded Multilevel Statcom” 2012 IEEE
[24] E.Najafi,” Design And Application Of A Novel Current Mode Controller On A Multilevel STATCOM” 2011 IEEE.
[25] Chong Han, Bin Chen, Karan Tewari, “An Eto Thyristor And Modular H-Bridge Pwm Converter-Based 4.5mva Statcom: 480v/500a Transformer less Grid- Connected Experimentation” 2006 IEEE.
[26] Yun Xu, Yunping Zou, Wei Chen, Chengzhi Wang, Xiong Liu, Feng Li A Novel Statcom Based On Hybrid Cascade Multilevel Inverter” 2008 IEEE.
[27] Yanjun Shi” Non Ideal Effect Of Current Transformer And Its Influence On Controller Design Of Cascade Multilevel STATCOM “2012 IEEE.
[28] H. Mohammadi Pirouz “New Transformer less Medium-Voltage STATCOM Based On Half-Bridge Cascaded Converters” 2010 IEEE.
[29] Abbas Soltani Nia, Mohammad Javad Sadeghi,” An Optimum Control Strategy Of The STATCOM For Electrified Railway Systems Using Pso” 2010 IEEE.
[30] Zhengping Xi,” Magnetic Saturation In Transformers Used For A 48-Pulse Voltage-Source Converter Based Statcom Under Line To Line System Faults” 2007 Ieee.
[31] P. C. Pradhan, P. K. Ray, R. K. Sahu3, J. K. Moharana, “Modeling, Analysis and Simulation for Voltage Regulation of a Weak Bus System Using STATCOM”,IJETAE Volume 3, Issue 12, December 2013\
[32] Dayananda. B. R, Velappagari Sekhar, Dr. Ramesh Babu, “Implementation of Linear Controller of a STATCOM Design in DC Link Voltage”, IJETAE Volume 4, Issue 9, September 2014)

