

Power Quality Control using STATCOM in Electrical Systems

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Abstract - *With the consistently expanding requirement for vitality, many power transmission systems are arriving at their cutoff points. Building new transmission lines might lighten this issue, yet the related expense is very high, and the degree of advancement in numerous locales frequently makes this unthinkable. One potential arrangement is to streamline existing systems. The requirement for high power contraction in industry has expanded as of late. The Flexible AC Transmission Systems (FACTS) innovation is another exploration territory in power building. The DSTATCOM is innovation of the FACTS and it depends on a voltage-source inverter. Burden pay, voltage adjusting and voltage guideline are a portion of the serious issues being looked by electric power utilities over the globe. If not tended to, these issues can cause power misfortunes in lines, mal-activity of basic burdens, harm to client gear, and possibly power system precariousness. The exploration speaks to concentrate of the profound investigation of the DSTATCOM and survey of the literature.*

keywords- *DSTATCOMP, DC Capacitor, Unbalanced Grid, Voltage Balancing, Cascaded H-Bridge, STATCOM, AC power, FACTS, Fuzzy logic, Fuzzy controller, Inverter.*

I. INTRODUCTION

A few gadgets can be utilized so as to improve arrange transient dependability. One such gadget is the Static Synchronous Compensator or STATCOM as it will be alluded to from here on. Notwithstanding improving system transient dependability, STATCOMs can likewise be utilized for voltage support and to improve power quality in numerous mechanical procedures. Utilities force severe power quality necessities on ventures, and the expenses related with the punishments for not satisfying these prerequisites are very high. Thusly, STATCOMs are frequently a beneficial venture for huge modern clients.

The dissemination system is moderately seen as an interface between the mass and the custom powers, whose control objective is to find some kind of harmony between the two for keeping up ceaseless sound activity of the system. A decent dissemination control system is thusly expected to improve the general system productivity through misfortune decrease and power quality control. By and by, conveyance system gear, for example, the tap evolving transformers, simultaneous machines, capacitor banks, static volt-ampere-receptive compensators (SVCs), and numerous other adaptable air conditioning

transmission systems (FACTS) controllers at gadget level, including DSTATCOM are being applied for such control. Nonetheless, there are various difficulties confronting the territory right now as far as the brilliant framework de-unifying usefulness which include: voltage and receptive power remuneration (presently known as Volt-VAR streamlining); conveyance system mechanization (DSA); power factor amendment (PF); stage current adjusting; incorporate capable low misfortune transformers (to improve effectiveness), disseminated resources (regularly, between 1kW - 50MW), and scattered energy storerooms (typically sited at purchaser loads), which call for radical change in the sort of controllers structured in these hardware for general system power quality improvement.

Power quality issues, causes, impacts and investigation have become a significant part of exploration work as of late. As the power is created in power stations which are commonly far away from load focuses, the immense measure of power produced from a producing station is moved to the purchaser through transmission lines. The transmission of power from the creating point to the point of utilization is joined with varieties of climate, varieties in loads, varieties in requests and so on which bargains the quality of power. Mechanical and business shoppers of electrical power are getting progressively touchy to power quality issues. Unwavering quality and quality are two significant boundaries in the field of power designing. Issues of deregulation, principles and client mindfulness (financial aspects and lawful) have delivered a lot of center and inspiration in these territories.

II. BRIEF ABOUT MODEL

The voltage list is a significant issue that the power system organize is confronting now-a-days. This is a serious issue and influences the working of the gear. Along these lines, this issue ought to be alleviated so as to keep up the productivity of the power arrange. The utilization of custom power gadgets takes care of this issue.

A. Distribution Static Compensator (DSTATCOM)

DSTATCOM is a shunt associated gadget intended to manage the voltage either by producing or engrossing the receptive power. The schematic chart of a D-STATCOM is

as appeared in Figure 1.1 which contains DC capacitor, Voltage Source Inverter (VSI), coupling transformer and reactor.

It is a power electronic converter based gadget used to shield the distribution transport from voltage unbalances.

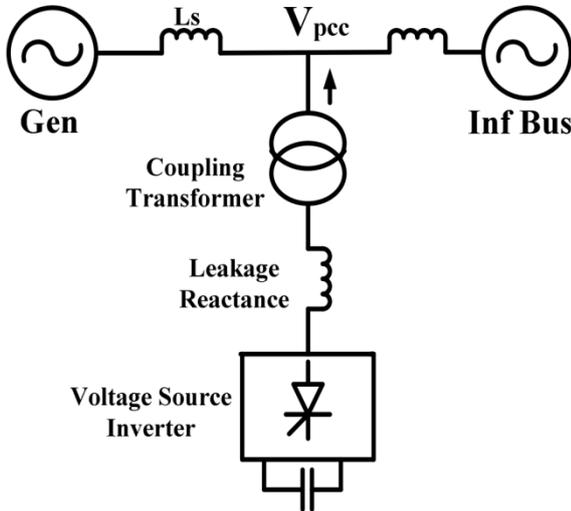


Figure 2.1 Schematic diagram of a D- STATCOM.

As on account of Dynamic Voltage Regulator (DVR), the VSI produces voltage by taking the contribution from the charged capacitor. It utilizes Pulse Width Modulation (PWM) exchanging method for this reason. This voltage is conveyed to the system through the reactance of the coupling transformer. The voltage distinction over the reactor is utilized to deliver the dynamic and responsive power trade between the STATCOM and the transmission organizes.

D-STATCOM is a shunt associated gadget intended to direct the voltage either by creating or retaining the responsive power. The schematic graph of a D-STATCOM is as appeared in Fig. 1.1. It contains

- DC Capacitor
- Voltage Source Inverter (VSI)
- Coupling Transformer
- Reactor

As on account of DVR, the VSI creates voltage by taking the contribution from the charged capacitor. It utilizes PWM exchanging strategy for this reason. This voltage is conveyed to the system through the reactance of the coupling transformer. The voltage contrast over the reactor is utilized to deliver the dynamic and responsive power trade between the STATCOM and the transmission organizes. This trade is done considerably more quickly than a coordinated condenser and improves the presentation of the system.

Control Strategy: The primary point of the control methodology actualized to control a D-STATCOM utilized for voltage moderation is to control the measure of responsive power traded between the STATCOM and the gracefully transport. At the point when the PCC voltage is not exactly the reference (evaluated) esteem then the D-ATACOM produces responsive power and when PCC voltage is more than the reference (appraised) esteem then the D-ATACOM assimilates receptive power.

B. Space Vector Modulation (SVM)

The space vector balance procedures contrast from the bearer situated in that manner, there are no different modulators utilized for every one of the three stages. Rather than them, the reference voltages are given by space voltage vector and the yield voltages of the inverter are considered as space vectors.

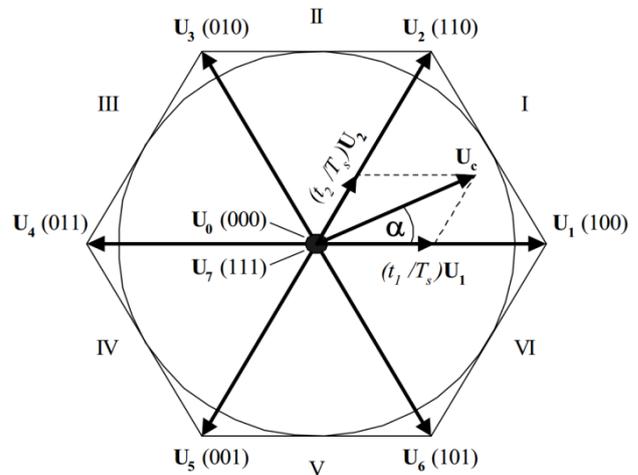


Figure 2.2 Space Vector Modulations Principle.

There are eight possible output voltage vectors, six active vectors $U_1 - U_6$, and two zero vectors U_0, U_7 (Fig. 2.2). The reference voltage vector is realized by the sequential switching of active and zero vectors. In the Fig. 2.2 there are shown reference voltage vector U_c and eight voltage vectors, which corresponds to the possible states of inverter. In the each sector the reference voltage vector U_c is obtained by switching on, for a proper time, two adjacent vectors. The reference vector U_c can be implemented by the switching vectors of U_1, U_2 and zero vectors U_0, U_7 .

III. RELATED WORK

N. Henini, F. Benzerafa and A. Tlemçani,[1] Exertion for development of power quality in distribution systems has been slowly expanded. Customarily, fixed, mechanical exchanged reactor/capacitor banks and Static Var Compensator have been utilized for improving the power quality issue in distribution systems. As of late, utilizations of inverter based power quality conditioner have been

developing for receptive power pay in distribution systems, since their reaction is quicker than that of the regular compensators. Distribution STATCOM (D-STATCOM) is an inverter based power quality conditioner gadget used to improve the power quality issues in distribution systems. This examination work portrays the displaying and the control of a distribution static coordinated compensator (DSTATCOM), with the point of improving the quality of electric system; we were likewise required to create and actualize a technique for control by a fluffy rationale controller. Exchanging beats for the five-level inverter are created by Space Vector Modulation (SVM). Reenactment results are given to show the presentation of our controller. Approval of models and control calculations is brought out through reproductions in SimPowerSystems of MATLAB/Simulink.

Deepmala and A. Kumar,[2] This examination work presents the displaying of D-STATCOM for spiral distribution system. The gadget is utilized to repay the hub voltage to 1 p.u and its impact is concentrated on consistent power (CP) and conventional ZIP model. With the gadget position at every hub genuine power, receptive power, size of responsive pay and percent pace of under voltage alleviated hubs are determined. The best area of the gadget is settled based on power misfortune decrease and percent pace of under voltage alleviated hubs (RUVMN) independently. The impact of summer load minor departure from the D-STATCOM situation is additionally introduced in this exploration work.

A. Jain, A. R. Gupta and A. Kumar,[3] This examination work presents a successful technique for the recognizable proof of up-and-comer transport for DSTATCOM arrangement for the minimization of power misfortunes and improvement of voltage profile in spiral distribution system with load displaying. The D-STATCOM is displayed for assurance of its size by accepting the voltage greatness as 1 p.u. at the applicant transport. The legitimacy of the technique is tried on the standard IEEE 33-transport spiral distribution system by performing load stream examination subsequent to remunerating the up-and-comer transport utilizing MATLAB programming. The outcomes acquired are contrasted without and the D-STATCOM for all load models. The voltage profile and the misfortunes decrease is gotten for IEEE 33 transport test system with the ideal situation of D-STATCOM dependent on the affectability list.

V. M. Hrishikesan, K. Venkatraman, M. P. Selvan and S. Moorthi,[4] Wind energy transformation systems contribute a noteworthy part of all out electric power age from sustainable power source based systems. Since quite a few years, Squirrel Cage Induction Generator (SCIG) has been considered as the foundation of wind power industry.

The idea of dynamic responsive power remuneration of acceptance generator based breeze ranches is increasing principal significance as a result of the development of feeble frameworks because of the expanded infiltration of such wind ranches. The reason for the current work is to investigate the utilizations of Distribution STATic Compensator (D-STATCOM) in SCIG based breeze ranches for the remuneration of responsive power during both ordinary and unusual lattice conditions.

Y. Deng, Y. Wang, K. H. Teo and R. G. Harley,[5] This examination work presents a summed up space vector balance (SVM) strategy for any particular staggered converter (MMC). The proposed SVM technique delivers the most extreme level number (i.e., $2n+1$, where n is the quantity of submodules in the upper or lower arm of each period) of the yield stage voltages and a higher identical exchanging recurrence than other tweak strategies, which subsequently prompts diminished music in the yield voltages and flows. Contrasted and before tweak strategies for MMCs, the proposed SVM technique gives two additional degrees of opportunity, i.e., the excess exchanging arrangements and the movable obligation cycles, in this way offering huge adaptability for enhancing the circling current concealment and capacitor voltage adjusting. This SVM strategy is a valuable device for additional investigations of MMCs, as it very well may be advantageously reached out for any control targets. The showed outcomes approve the examination.

T. Durán and J. Pereda,[6] DC to AC transformation innovation has prevailing with regards to getting high power quality (voltages and flows) utilizing staggered inverters. These inverters can create a few degrees of voltage that lessen the symphonious twisting of the produced sine waves in the AC side. Nonetheless, the yield voltages consistently are discrete, so a non-insignificant symphonious mutilation remains. This mutilation can be diminished by expanding the quantity of voltage levels created by the staggered inverter, however this implies decrease the unwavering quality and increment the quantity of semiconductors. This exploration work proposes a novel constant space vector regulation (C-SVM) that produces nonstop AC voltages without utilizing channels and diminishes the all out consonant contortion (THD) of the voltage under 1%. This proposed regulation requires two variable power sources (for example buck converters) however can be actualized in improved three-stage fell staggered converters. Also, this constant balance permits the execution of a novel fell staggered inverter with a diminished geography. Reproduced results show the proposed space vector balance and the yield voltage and flows got in inductive loads and in an acceptance engine.

N. Jarutus and Y. Kumsuwan,[7] In this exploration work, a stage move space vector adjustment method is proposed to control the double load of the nine-switch inverter. The proposed calculation depends on a transporter based space vector beat width balance (SVPWM) under the steady recurrence (CF) and the variable recurrence (VF) activity modes. The balance signals are worked by without hybrid to stay away from the bending of yield voltages. The exchanging states can forestall the short through in the inverter leg. For the CF-mode, the adjustment files are indistinguishable and not exactly, or equivalent to $2/\sqrt{3}$. In this manner, the aggregate of stage move edges is 0° . For the CF and VF modes, the dislodging stage move edge can change from 0° to 360° , when the total of tweak records is not exactly, or equivalent to $2/\sqrt{3}$. The proposed stage move SVPWM strategy is checked by recreation results, indicating great consistent state execution.

J. J. Jung, J. H. Lee, S. K. Sul, G. T. Child and Y. H. Chung, [8] In this work, a thorough control conspire for a delta-associated fell h-connect (CHB) converter based static coordinated compensator(STATCOM) is introduced, particularly concentrating on improving powerful execution by novel feedforward control strategy. The strategy can prominently improve the elements of circling current guideline of delta associated CHB STATCOM particularly under matrix deficiency condition just as load unbalance without over the top DC cell capacitor voltage variance. The full scaled reproduction results and the down scaled trial results check that steady activity is ensured for both imitated lattice and load unbalance conditions.

P. Sochor and H. Akagi,[9] This work gives a hypothetical conversation and examination in energy adjusting between a measured staggered course inverter dependent on single-star connect cells (SSBC) and that on single-delta connect cells (SDBC). Consideration is paid to applications including topsy-turvy dynamic power age in utility-scale lattice tied photovoltaic systems. Both subjective and quantitative assessment measurements to evaluate the energy-adjusting ability are acquainted and applied with both SSBC and SDBC inverters. Concerning the SSBC inverter, six zero-succession voltage waveforms with various consonant substance empowering upgraded energy-adjusting capacity are examined and thought about in regards to their viability. This work additionally stresses on the SDBC as an option in contrast to the SSBC and features its boss working qualities under unbalanced dynamic power age.

D. Lu, H. Hu, Y. Xing, X. He, K. Sun and J. Yao [10] To contemplate the grouped voltage adjusting instrument for fell H-connect STATCOM, the dynamic power from the network is decayed of by utilizing positive and negative groupings in dq outline. In light of the definite

investigation, bit of grouped dynamic power produced by negative-succession voltages and flows, alluded as negative-arrangement bunched dynamic power (NCAP), can redistribute the dynamic power among three bunches, which suggests it tends to be used to adjust the three bunched voltages. At that point, the connection among NCAP and control factors obligation cycle is fabricated. The relationship uncovers that three bunched voltages are fit for meeting to stable voltages with no grouped adjusting control, demonstrating the fell H-connect STATCOM having the grouped voltage self-adjusting highlight. At last an adjusting control strategy is accounted for to direct NCAP. The viability of the revealed control technique is confirmed by the analyses.

J. I. Y. Ota, Y. Shibano and H. Akagi,[11] This work gives a trial conversation on zero-voltage-ride-through (ZVRT) ability of a stage moved pulsewidth-adjustment distribution static simultaneous compensator (D-STATCOM) utilizing the secluded staggered course converter dependent on single-star connect cells (SSBC). The group adjusting control delivering a noteworthy impact on the ZVRT ability is demonstrated and broke down with center around either a low-pass channel (LPF) or a moving-normal channel (MAF) to constrict the 100-Hz (twofold the line recurrence) segment inalienable in every dc capacitor voltage. The group adjusting control utilizing the MAF is preferable in transient execution over that utilizing the LPF. A three-stage downscaled SSBC-based D-STATCOM evaluated at 150 V and 10 kVA is planned, developed, and tried to confirm the ZVRT capacity under the severest single-, two-, and three-stage voltage droops with a voltage profundity of 100%. Test waveforms show that the STATCOM keeps working steadily as though no voltage droop happened.

H. C. Chen, P. H. Wu, C. T. Lee, C. W. Wang, C. H. Yang and P. T. Cheng, [12] This work presents a dc capacitor voltage adjusting control strategy for the star-associated fell H-connect pulsewidth regulation converter in the static simultaneous compensator applications. With the zero-grouping voltage infusion as a reason for dc capacitors voltage adjusting, this work explores the nitty gritty power stream of the converter in general and inside individual modules under uneven lattice voltages and afterward proposes a technique to control the receptive power yield and the dc capacitors voltage by correctly dealing with the power stream. This methodology improves the low-voltage ride-through capacity, which is basic as the infiltration of distributed energy resources develops quickly. The revealed control strategy is checked by a downsized model in the research facility.

C. T. Lee, H. C. Chen, C. W. Wang, P. H. Wu, C. H. Yang and P. T. Cheng, [13] This work presents a dc capacitor

voltage adjusting control strategy for the star-associated full H-bridge PWM converter in the static coordinated compensator (STATCOM) applications. The announced control uses the zero-succession voltage infusion to achieve the dc capacitor voltage adjusting, and the this activity of zero-grouping voltage doesn't influence the first responsive power control. The announced control technique likewise works for the low-voltage ride-through activity. The control calculation is confirmed with a 220-V 1kVA STATCOM dependent on star-associated full PWM converter, and the test outcomes check that all the dc capacitor voltages are as yet managed at the told esteem even as the framework voltage droop happens.

Y. Posse, Z. Lidan, Y. Pack, F. Ruifeng and L. Dongdong, [14] Based on dynamic power voltage vector expansion, another basic and clear calculation is introduced in this article to explain the existed marvel of the irregularity issue of the DC capacitor voltage of full static simultaneous compensator. The system has clear physical significance and basic calculation and it's anything but difficult to actualize. Both reproduction and exploratory outcomes demonstrate its rightness.

Lin Wang, Ping Wang, Zixin Li and Yaohua Li, [15] Recently measured staggered converters are profoundly alluring for medium, high-voltage power change and electrical machine drive. Capacitor voltage arranging is significant for capacitor voltage-adjusting control

I. PROBLEM STATEMENT

A few distinct topologies can be accomplished by interfacing the VSCs in various manners. For instance, two of the most straightforward and progressively natural topologies are, where each phase of the STATCOM is associated phase-to-ground, and the delta-coupled converters, where each phase of the STATCOM is associated phase-to-phase. Variations of these topologies just as different topologies likewise exist. In any case, every one of them experiences the ill effects of a similar issue which is DC capacitor voltage unbalance. The capacitor banks were utilized for responsive power remuneration and voltage guideline, yet they have extraordinary issues, for example, stress and abrupt changes in capacitances. Additionally their reaction to transient blunders is moderate, so they were supplanted by Static Var Compensators which will decrease the hour of reaction and improve the voltage security. Be that as it may, the SVC transient steadiness is low, so DSTATCOM is assume to be utilized rather than these gadgets since it has quick reaction in remuneration and voltage profile amendment. For different reasons, loads might be lopsided also. Frequently, this is brought about by the nearness of single phase loads. Single phase loads are in some cases

favoured at the distribution level due to took care of by less conductors than three-phase loads.

IV. CONCLUSION

Adaptable AC Transmission Systems (FACTS) gadgets, for example, Static Synchronous Compensator (STATCOM) can be utilized to explain the power quality issues identified with transmission lines while DSTATCOM can improve the power quality and dynamic execution in a distribution arrange. The Static Synchronous Compensator (STATCOM) is a shunt-associated receptive power remuneration gadget that is equipped for producing and additionally retaining responsive power at a given transport area and in which the yield can be changed. It is utilized to infuse the AC voltage to remunerate the reduction in the gracefully voltage. The switches of the VSI are worked dependent on the beat width regulation (PWM) strategy to create the voltage of required greatness and frequency. The structure of FLCs for a DSTATCOM to improve power quality and dynamic execution of a distribution power system, FLC must be intended for the DC voltage controller, the AC voltage controller, and the current controller.

In this study a broad survey of literature has been accounted for on DC Capacitor Voltage Balancing Control for Delta-Connected Cascaded H-Bridge STATCOM Considering Unbalanced Grid and Load Conditions. The power system today is confounded systems with several producing stations and load focuses being interconnected through power transmission lines. An electric power system can be partitioned into four phases: i) age, ii) transmission iii) distribution and iv) use (load). The power system is a profoundly nonlinear system that works in a continually evolving condition; loads, generator yields, geography, and key working boundaries change persistently. Presently a-days it is getting hard to completely use the current transmission system resources because of different reasons, for example, natural enactment, capital venture, privileges of ways issues, development cost of new lines, deregulation arrangements, and so on. The major rule of a STATCOM introduced in a power system is the age air conditioning voltage source. The STATCOM can likewise build transmission limit, damping low frequency swaying, and improving transient security. The voltage of the source is in phase with the air conditioner system voltage at the purpose of association, and the extent of the voltage is controllable.

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