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Control Method & Modeling of Transformerless H-Bridge Cascaded STATCOM Using Star Configuration of an Advanced Grid Connected

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ABSTRACT

In electric power system, the harmfulness to system because of lack of reactive power can not be neglected. STATCOM is an vital member of versatile AC transmission, comparing with ancient reactive power compensation device, it not only decrease the volume and price of the device, but additionally has quicker response speed and a lot of swish control property. On the basis of thorough analysis on reactive power compensation device breathing, this paper study on two, three & five-level STATCOM. The device uses NPC method to divide the electrical converter circuit into positive, negative and zero three level, so that every element subject to the utmost voltage reduced to 1/2 the normal electrical converter circuit. The performance of the proposed power STATCOMs system is studied victimisation MATLAB/Simulink.

Key words: STATCOM (Static Synchronous Compensator), power-quality (PQ), custom power devices (CPD), dynamic voltage restorer (DVR), unified power-quality conditioner (UPQC), adjustable speeds drives (ASDs)

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1. INTRODUCTION

Distribution systems are facing severe PQ issues, such as poor voltage regulation, high reactive power and harmonics current burden, load unbalancing, excessive neutral current, etc. The remedial solutions to the PQ problems are investigated and mentioned in the literature and therefore the cluster of devices is understood CPDs. The distribution STATCOM is proposed for compensating PQ issues in the current, and the DVR is employed for mitigating the PQ issues within the voltage whereas the UPQC is planned for resolution current and voltage PQ issues. There are several techniques rumored for the elimination of harmonics from the supply current as well because the compensation of the neutral current and cargo leveling. Some neutral current compensation techniques have been patented. Three-phase four wire distribution systems have been accustomed supply single-phase low-tension hundreds. The typical loads could also be s, office automation machines, lighting ballasts, ASD in small air conditioners, fans, refrigerators, and other domestic and industrial appliances, etc., and generally behave as nonlinear hundreds. These loads could produce issues of high input current harmonics and excessive neutral current. The neutral current consists of mainly triplenharmonics currents.

The zero-sequence neutral current obtains a path through the neutral conductor. Mostly, the unbalanced single-phase loads additionally result in serious zero-sequence elementary current. The total neutral current is that the sum of the zero sequence harmonic elements and also the zero-sequence elementary part of the unbalanced load current, and this may overload the neutral conductor of the three-phase four-wire distribution system. Most of the surveys are cited regarding the causes of excessive neutral current within the distribution system. There are completely different techniques for the mitigation of neutral current in the three-phase four-wire distribution systems.

2. MATERIALS AND METHODS

Principle of STATCOM

A STATCOM is a controlled reactive source, which includes in VSC and DC link condenser connected in shunt, capable of generating and/or absorbing reactive power. The operating principles of a STATCOM ar primarily based on the precise equivalence of the standard rotating synchronous compensator. The AC terminals of the VSC are connected to the PCC through Associate in Nursing inductance, which might be a filter inductance or the outpouring inductance of the coupling electrical device, as shown fig.1

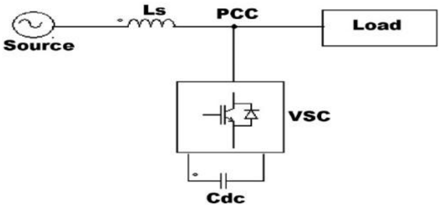

Fig. 1 Line diagram of STATCOM

The DC side of the convertor is connected to a DC electrical device, which carries the input ripple current of the convertor and is the main reactive energy storage component. This capacitor may be charged by battery supply, or could be pre-charged by the convertor itself. If the output voltage of the VSC is equal to the AC terminal voltage, no reactive power is delivered to the system. If the output voltage is greater than the AC terminal voltage, the STATCOM is in the capacitive mode of operation and the other way around. The quantity of reactive power flow is proportional to the distinction within the 2 voltages. It is to be noted that voltage regulation at PCC and power factor correction can not be achieved at the same time. For a STATCOM used for voltage regulation at the PCC, the compensation ought to be such that the provision currents should lead the provision voltages; whereas, for power factor correction, offer the availability the provision} current should be in part with the supply voltages. The control ways studied in this paper area unit applied with a read to learning the performance of a STATCOM for power issue correction and harmonic mitigation.

3. THEORY/CALCULATION

Multilevel Converter

An electrical converter is AN electrical device that converts electricity DC to AC , the born-again AC are often at any needed voltage and frequency with the utilization of acceptable transformers, switching, and control circuits. Static inverters wasdo not have moving parts and square measure employed in a good vary of applications, from small switch power provides in computers, to large electrical utility high-voltage direct current applications that transport bulk power. Inverters are ordinarily used to provide AC power from DC sources like star panels or batteries

A single-phase structure of an m-level cascaded electrical converter is illustrated in Figure thirty one. 1. Each separate dc supply is connected to a single-phase full-bridge, or H-bridge, inverter. Each electrical converter level will generate 3 totally different voltage outputs, +Vdc, 0, and –Vdc by connecting the dc source to the ac output by totally different combos of the 4 switches, S4, S3, S2, and S1. To obtain +Vdc, switches S4 & S1 are turned on, whereas –Vdc can be obtained by turning on switches S2 and S3. By turning on S3 & S4 or S2& S1, the output voltage is 0. The ac outputs of each of the various full-bridge electrical converter levels area unit connected asynchronous specified the synthesized voltage wave form is that the total of the electrical converter outputs. The number of output section voltage levels m during a cascade electrical converter is outlined by m = 2s+1, where s is the variety of separate dc sources. An example section voltage wave form for associate degree 11-level cascaded H-bridge electrical converter with five SDCSs and five full bridges is shown in Figure thirty one.2. The phase voltage van = va5 + va42 + va3 + va2 + va1.

if stepped wave such as the one portrayed in Figure 31.2 with s steps, the Fourier Transform waveform shown below

$$V(\omega t)=\frac{4V_{dc}}{\pi}\sum_{n}\left[\cos(n\theta_1)+\cos(n\theta_2)+\ldots+\cos(n\theta_s)\right]\frac{\sin(n\omega t)}{n},\quad \text{where } n=1,3,5,7,\ldots$$

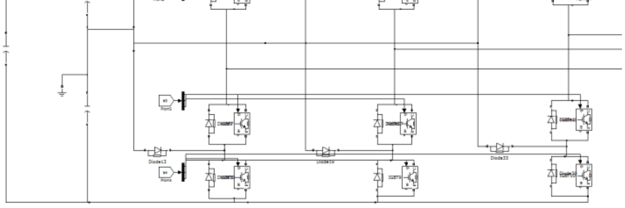

Fig. 2 Three level STATCOM

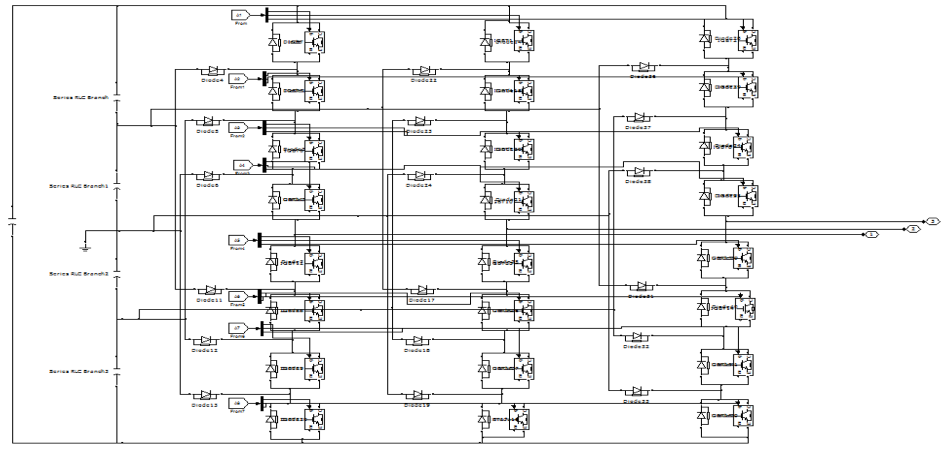

Fig. 3 Five level STATCOM

The Fourier coefficients magnitudes are when normalized with respect to V_{dc} are as follows

$$H(n) = \frac{4}{\pi n}\left[\cos(n\theta_1) + \cos(n\theta_2) + \ldots + \cos(n\theta_s)\right], \quad \text{where } n = 1, 3, 5, 7, \ldots$$

The conducting angles, θ1, θ2, ...,θs, can be chosen specified the voltage total harmonic distortion could be a minimum. Generally, these angles are chosen therefore that predominant lower frequency harmonics, 13th,11th, 7th, and 5th, harmonics are distorted. Most of the cases harmonic elimination techniques can be given within the next section. Multilevel cascaded inverters have been planned for such applications as static volt-ampere generation, an interface with renewable energy sources, and for battery-based usages. Three-phase cascaded inverters can be connected in wye, as shown in Figure, or in delta. Peng has demonstrated relative structure cascaded static volt-ampere generator connected in parallel with the electrical system that may generate reactive current from AN electrical system.

4. RESULTS AND DISCUSSION

Controling Strategies

Satisfactory performance, ultra response, reliable and simple implementation square measures the most objectives of any compensation strategy. The control methods of a STATCOM square method find in the mostly enforced in the Measurements of signal conditioning and system variables, Extraction compensating signals and also Implement of firing angles in switches.

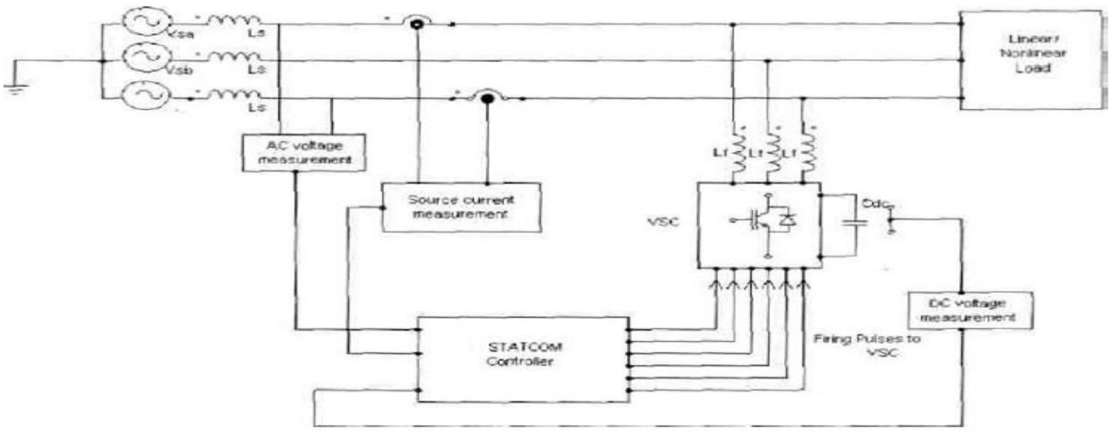

Fig. 4 Schematic diagram of STATCOM

The generating of efficient PWM firing is the mostly stair case part of STATCOM and it's an better impact on its compensation objectives, transient as well as steady state performance and STATCOM shares many thoghts with that of a STATCOM at the transmissions, a few control techniques are directly enforced to a STATCOM, incorporating PWM switching, rather than FFS methods. A PWM based distribution static compensator offers instant response and capability for harmonic reducing. This method is an try to compare the schemes of a STATCOM for power loss correction and harmonic elimination based mostly on:

1. Phase shift
2. Indirect method for decouple control current
3. Regulation of DC link voltage and AC bus

- **Phase shift**

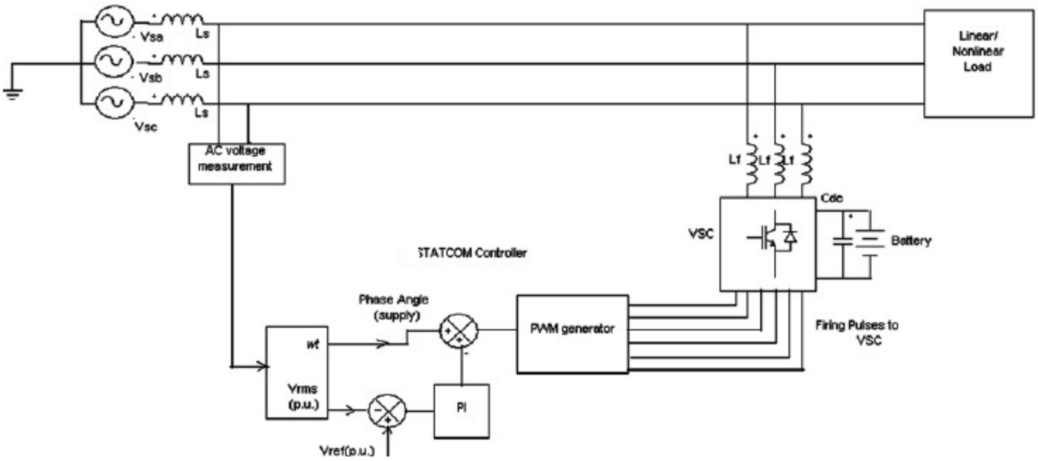

Fig. 5 Control diagram of STATCOM

The schematic diagram of section shift management is shown in figure. During this methodology, the compensation is achieved by the activity of the rms voltage at the load purpose, whereas no reactive power measurements area unit needed. Curving PWM technique is employed with constant change frequency. The error signal obtained by scrutiny the measured system rms voltage and also the reference voltage is fed to a PI controller, that generates the angle for deciding the required section shift between the output voltage of the VSC and also the AC terminal voltage. This angle is summed with the point in time of the balanced provide voltages, assumed to be equally spaced at a hundred and twenty degrees, to supply {the desired|thespecified|the needed} synchronizing signal required to control the PWM generator. During this theme, the DC voltage is maintained constant, using a separate battery supply.

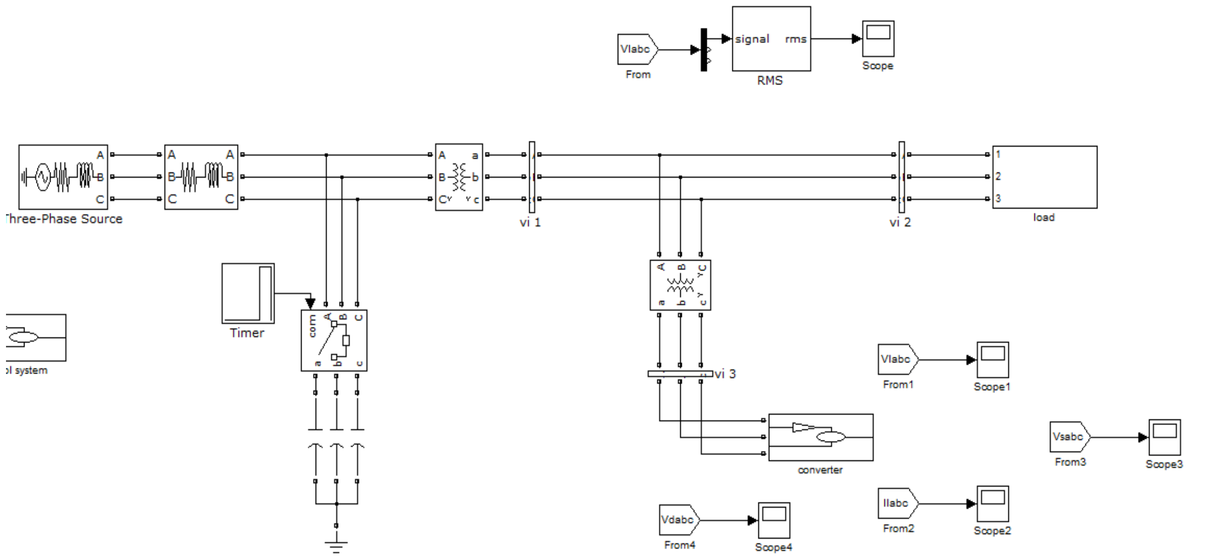

Fig. 6 Simulation model of three level STATCOM

Figure a and figure b indicate the simulation outputs of obtained victimization part shift management for reactive power compensation and harmonic mitigation for a balanced variable linear load and for a non linear load severally. it's determined that the supply current and also the supply voltage square measure in part, correcting the ability issue of the system just in case of a linearly variable load; whereas, complete compensation isn't achieved just in case of nonlinear load (24.34%). The frequency spectrum of the supply current for a nonlinear load, before and when compensation, is shown in Figure a and Figure b. although this strategy is simple to implement, is strong and may offer partial reactive power compensation while not harmonic suppression, it's the subsequent major disadvantages:

- The controller doesn't use a self supporting DC bus and so needs a really giant DC supply to pre charge the electrical device.
- Balanced supply offer as rms voltage is assumed and therefore the offer point area unit calculated over the elemental solely.
- Nopartial compensation and harmonic suppressions are achieved in nonlinear loads

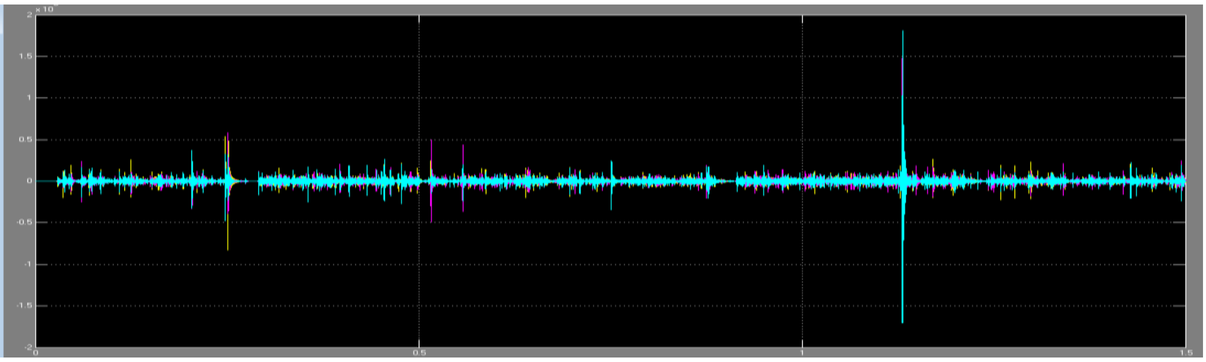

Fig. 7 Five level STATCOM source current

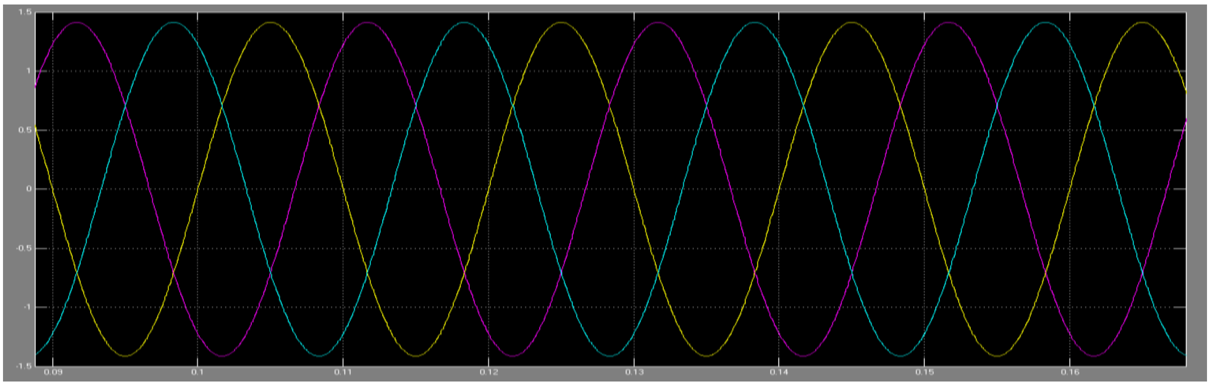

Fig. 8 Five level STATCOM load current

Indirect method for decouple control current

This theme relies on the governing equations of modern static power unit compensator. It needs the mensuration of fast values of 3 section line voltages and current. Figure shows the diagram illustration of the management theme. The management theme relies on the transformation of the 3 section system to a synchronously rotating frame, exploitation Park's transformation.

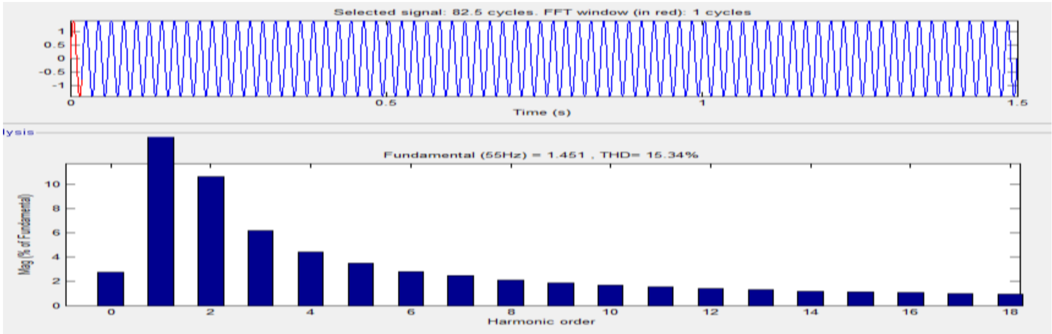

Fig. 9 THD of three level STATCOM

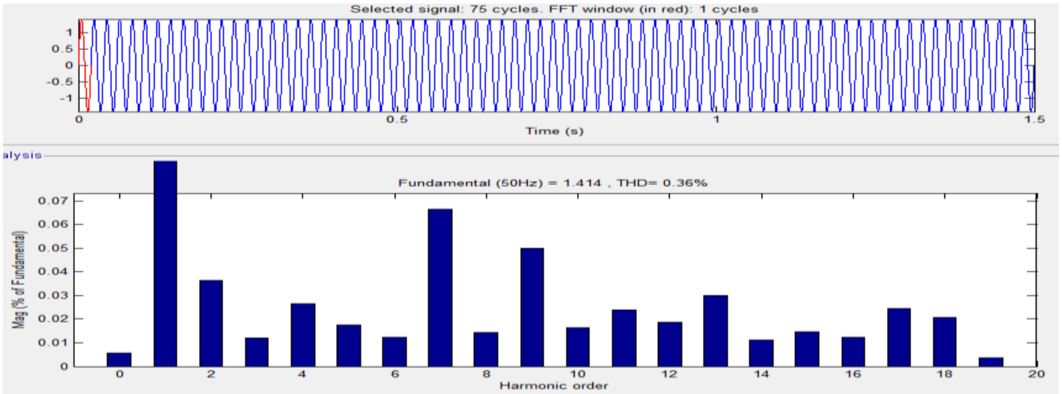

Fig. 10 THD of five level STATCOM

5. CONCLUSIONS

The standards, problems and mitigation technical methods of the excessive neutral current are investigated within the 3 phase 4 wire distribution system. The simulated results and modelling of the T Connected electronic device has been incontestable for compensating the neutral current method. The T-connected electrical device has mitigated the supply neutral current. The entire potential unit amperes rating of the electrical device in T-connected is below a star/Delta electrical device is to be provide NCM.

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