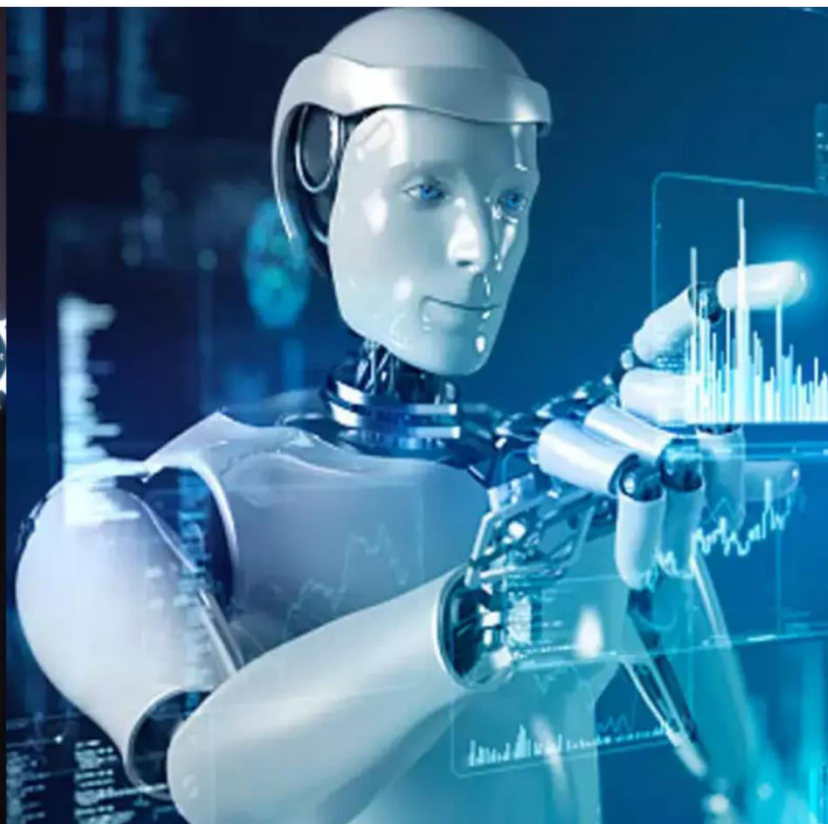




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# Analysis of Cascaded Multilevel Inverter based Device for Power Quality Improvement

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**ABSTRACT:** In this paper a cascaded based multilevel inverter has been designed and simulated for the installation in the power system connected with statcom. The idea of multilevel inverter connected with statcom has combined advantage of multilevel inverters with the dynamic performance of statcom. The cascaded multilevel inverter consists of a series connection of multiple H bridge inverter modules and each module has its own isolated DC source like capacitor or batteries and their outputs are combined to synthesize a staircase like AC voltage waveforms. The Statcom based controller plays a vital role in the power system where the renewable energy sources has a lot of intervention in the system. The major reason is the reactive power injection and this needs to be compensated by the use of facts devices. The research is going on this field to improve the performance of the power quality improvement.

**KEYWORDS:** FACTS Flexible AC transmission system, Statcom static compensator, CMLI Cascaded multilevel inverter.

## I. INTRODUCTION

Modern power systems are complex networks comprising hundreds of generating stations and thousands of load centres, interconnected through extensive transmission and distribution lines. While power generation is generally reliable, the quality of power delivered to end-users is often inconsistent.

Ideally, a power distribution system should provide an uninterrupted flow of energy with a smooth sinusoidal voltage waveform at the specified magnitude and frequency. However, various factors compromise this quality, especially in distribution networks where numerous nonlinear loads are present. These nonlinear loads significantly degrade power quality (PQ).

In addition to nonlinear loads, events such as capacitor switching, motor starting, and unusual faults also contribute to PQ disturbances. A power quality problem is typically defined as any deviation in voltage, current, or frequency that leads to equipment malfunction or failure.

Among the various power quality issues, voltage sags and swells are particularly problematic in industrial processes—with voltage sags often being more severe and frequent. Over the past few decades, the power industry has recognized that these PQ issues can be mitigated through conventional methods. However, advanced power electronic (PE) solutions, especially those employing fast-switching, force-commutated devices, have proven to be more effective.

Power quality compensators are generally categorized into two types:

1. Shunt-connected devices – These primarily address current-related issues such as harmonics, reactive power, and unbalanced loads.
2. Series-connected devices – These are more effective for voltage-related problems, such as voltage sags, swells, and distortions originating from the power system side.

By integrating these power electronic compensators, modern power systems can significantly enhance voltage stability, reliability, and overall power quality for end users.

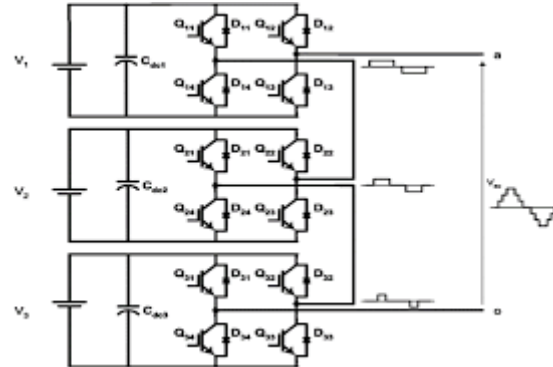


Fig. 1 Cascaded H- Bridge multilevel inverter

## II. CASCADED 7 BRIDGE MULTILEVEL INVERTER

A cascaded 7-level multilevel inverter (also known as a Cascaded H-Bridge Multilevel Inverter) is a power electronic device used in high-voltage and high-power applications to synthesize a desired AC voltage from several DC voltage sources. It is widely used in STATCOMs, HVDC systems, industrial motor drives, and renewable energy systems. In a 7 level cascaded bridge multilevel inverter three H-bridge inverter cells are connected in series per phase. Each H-bridge generates three output voltage levels:  $+V_{dc}$ , 0, and  $-V_{dc}$ . By combining these voltages in different ways, the inverter produces seven distinct output voltage levels. For a single phase 7 level inverter, the output voltage levels are  $+3 V_{dc}$ ,  $+2V_{dc}$ ,  $V_{dc}$ , 0,  $-V_{dc}$ ,  $-2V_{dc}$ ,  $-3V_{dc}$ . All these outputs can be achieved by turning On/Off appropriate switching device.

Each H bridge consists of 4 switches for a single phase 7 level inverter 3 number of H bridges per phase is required and 12 switches per phase. For a three phase system 9 H bridges total required.

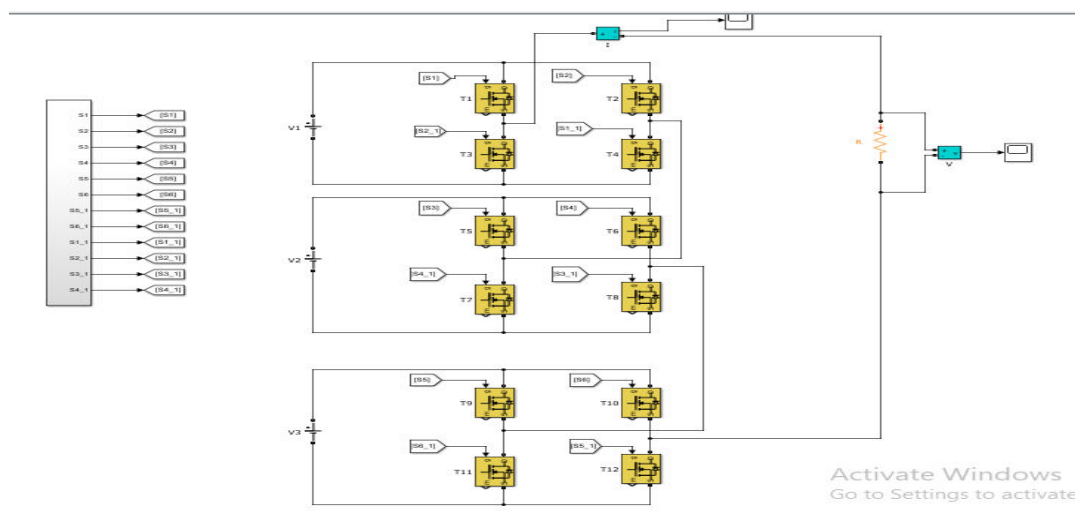


Fig. 2 Cascaded 7 level multilevel inverter

The main advantages of 7 level multilevel inverter is for obtaining high quality waveform with less total harmonic distortion. It is having modular design, low switching losses and does not require bulky transformers.



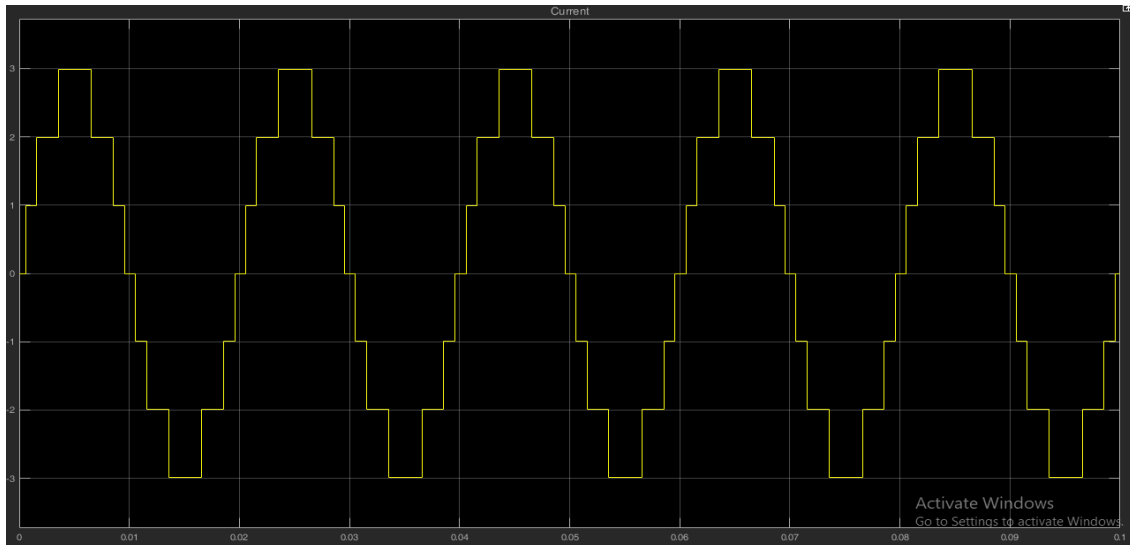


Fig. 3 Single switch pulses

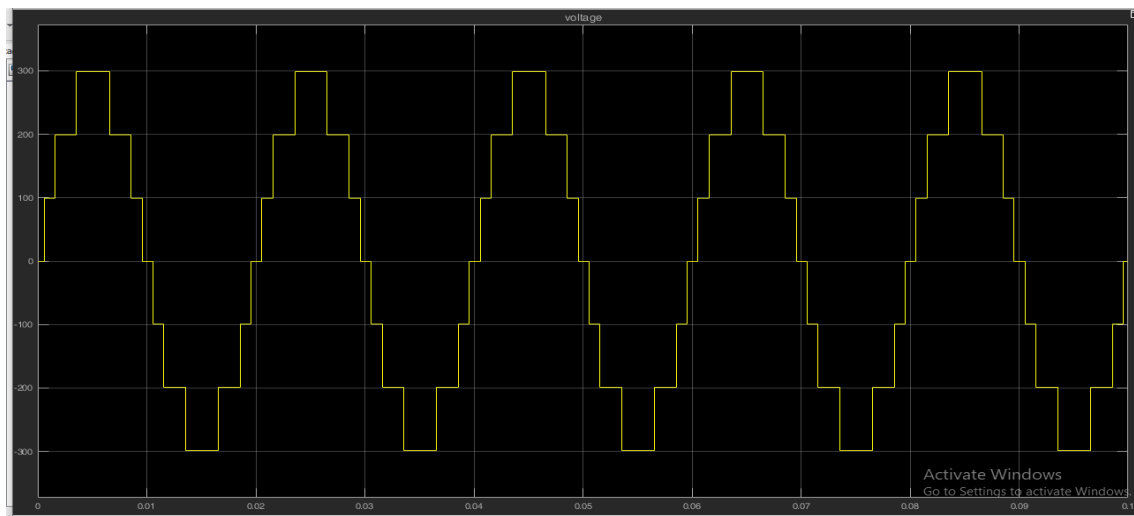


Fig. 4 Overall switch pulses after simulation

A machine connected to an infinite bus represents a typical power system stability problem where a synchronous generator (SG) is connected to a very large grid (infinite bus) via a transmission line. In such a setup, the infinite bus has constant voltage and frequency. The generator's performance, especially its stability, depends on its ability to maintain synchronism with the grid during disturbances.

A Static VAR Compensator (SVC) is a FACTS (Flexible AC Transmission System) device used to provide fast-acting reactive power compensation. It helps in voltage regulation, improving transient and dynamic stability, and enhancing power transfer capability.

When a synchronous generator is connected to an infinite bus, the system may suffer from:

- **Transient instability** due to sudden disturbances (e.g., short circuits, load changes).
- **Voltage instability** due to insufficient reactive power support.
- **Poor damping of oscillations** in rotor angle (swinging).

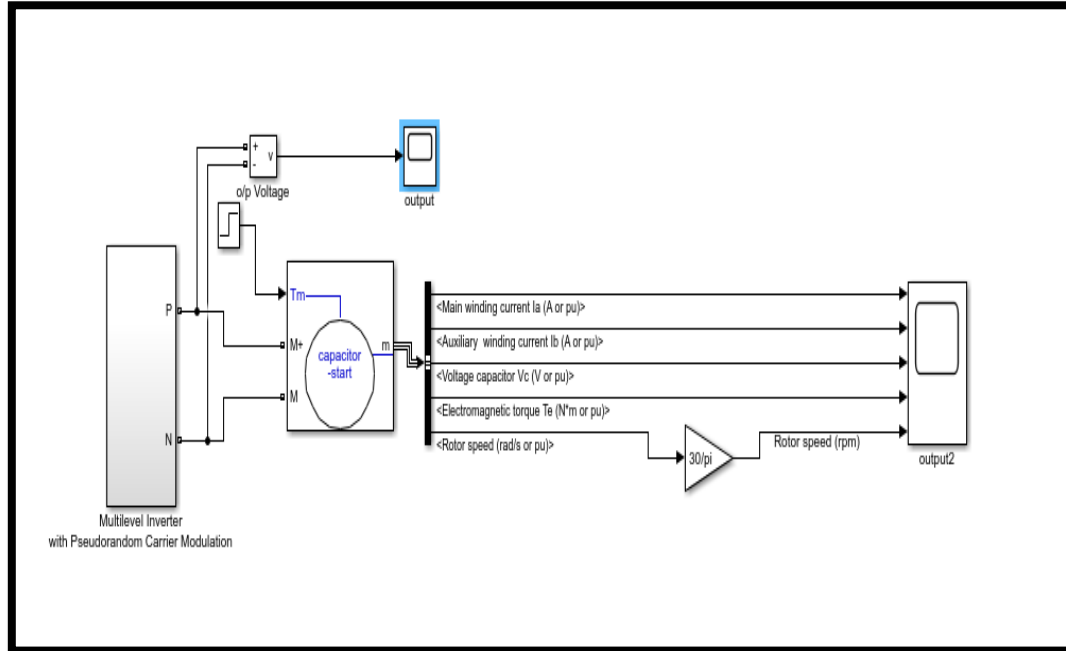


Fig. 5 Multilevel inverter feeding machine

This model represents a simulation model of a 7 level multilevel inverter connected to the induction motor, the pseudorandom carrier modulation is a form of pulse width modulation that spreads harmonic energy over a wider frequency band reducing THD.

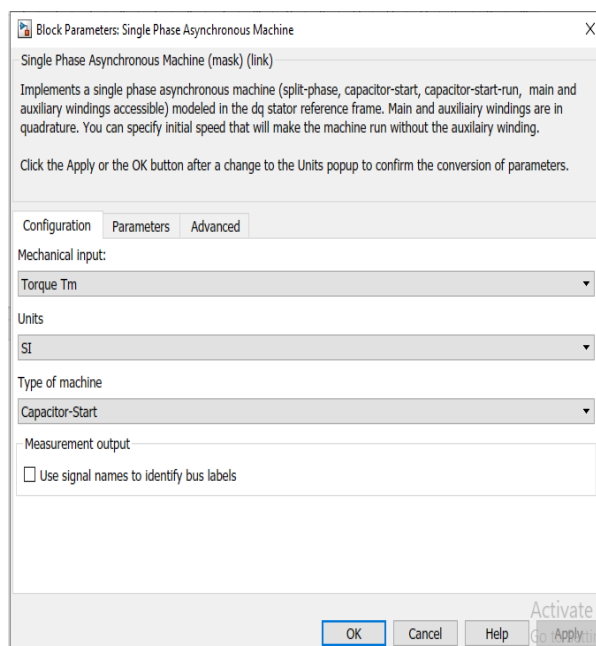


Fig. 6 Parameters of Induction machine

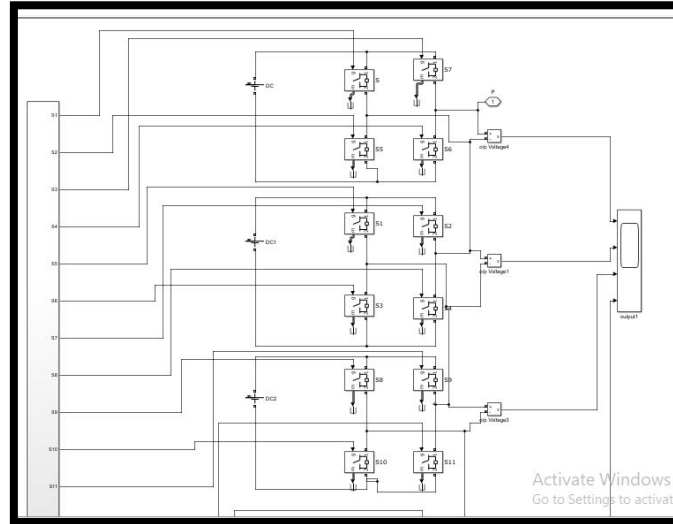


Fig. 7 Multilevel inverter used in simulation model

### III. RESULT AND DISCUSSION

This waveform shows the simulation result of a capacitor start single phase induction motor fed by a cascaded multilevel inverter using pseudorandom carrier modulation. Each subplot represents motor parameters.

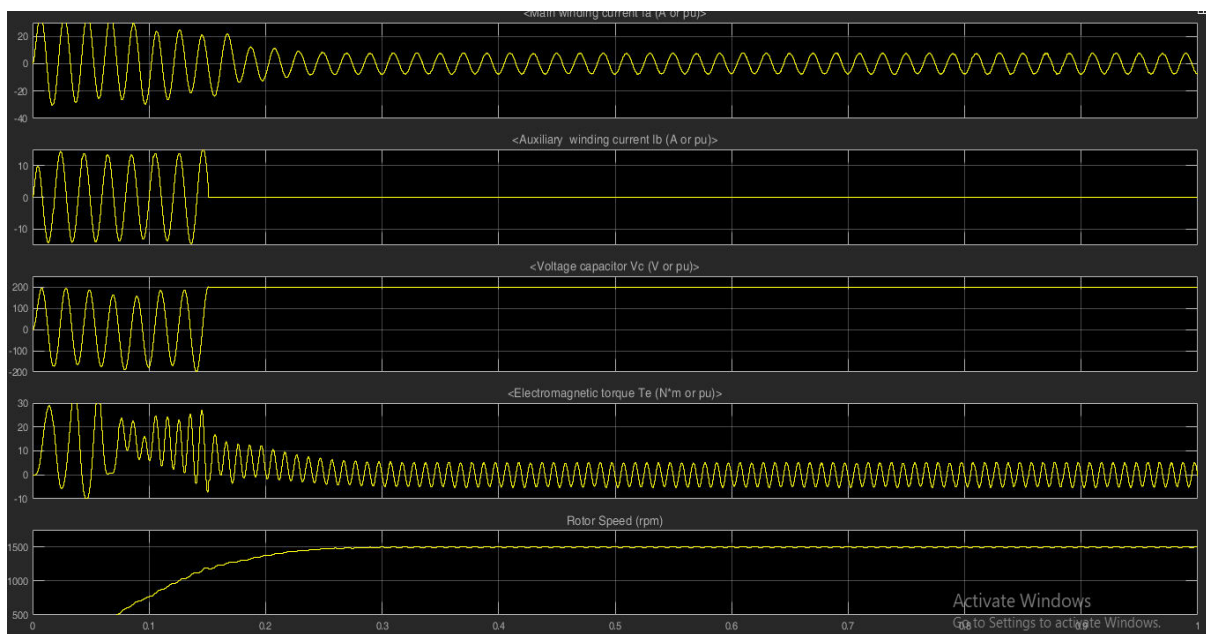


Fig. 8 Output Waveform of Induction machine after feeding with MLI

The main winding current has high oscillations as the motor starts, settles into a steady sinusoidal waveform after 0.25 seconds and shows the normal operation of the main winding, this indicates inverter is smoothly driving the motor. The current during the initial start drops after 0.15 seconds, the start capacitor disconnected after motor picks up the speed. The oscillatory voltage at the time of start is becomes steady after the capacitor gets disconnected. The torque initially fluctuates and stabilize after start up.

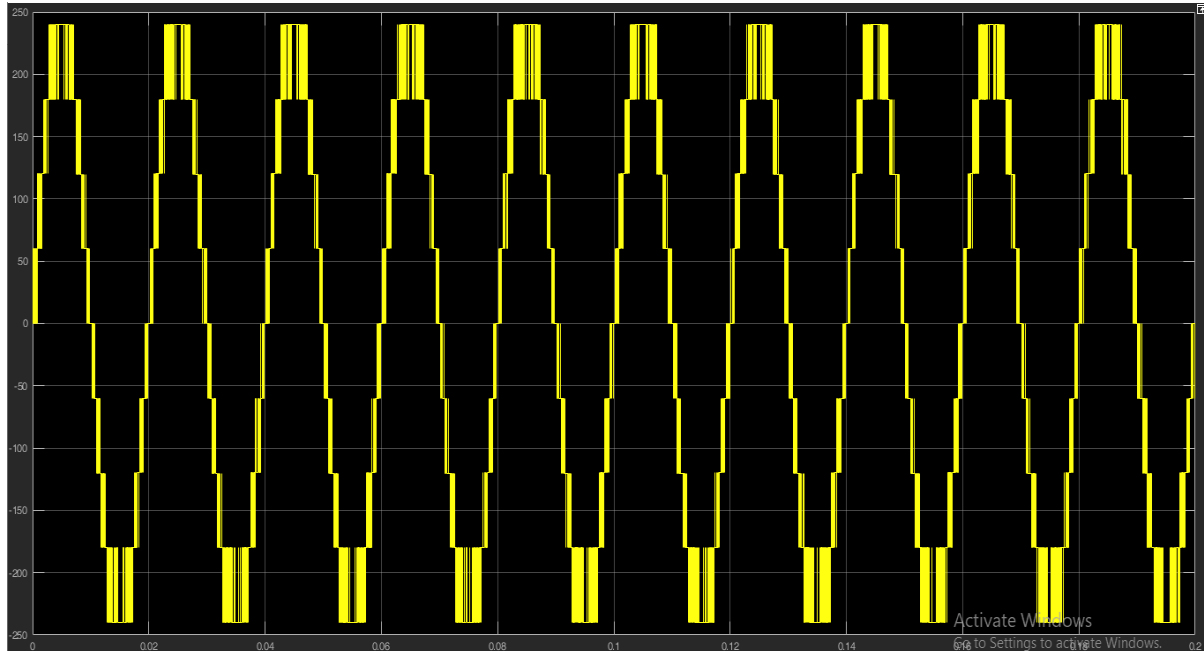


Fig. 9 Waveform of 7 level MLI

#### IV. CONCLUSION

In this work, a 7-level cascaded multilevel inverter (MLI) has been designed and analyzed for its application in power system environments. A simplified electrical model was implemented in MATLAB/Simulink to test the inverter's performance. The simulation results demonstrate that the system reaches a steady state shortly after startup. The smooth waveform profiles and reduced oscillations indicate effective inverter operation, contributing to a lower Total Harmonic Distortion (THD) and improved overall system stability.

For future work, the multilevel inverter will be integrated with a Static Synchronous Compensator (STATCOM) and connected to a long transmission line to enhance system voltage stability. With the increasing penetration of renewable energy sources, which introduce significant non-linearities and disturbances into the grid, the use of a cascaded multilevel inverter-based STATCOM emerges as a promising solution for harmonic mitigation and dynamic stability improvement.

#### REFERENCES

1. R. Neduraman and P. Senthil Kumar "A control scheme of cascaded multilevel inverter based D – Statcom for improving the voltage control and total harmonics reduction" IJSR, Volume 4 Issue 3 2015.
2. Sunita Kumari and Sudhir Y Kumar, "Design and simulation of cascaded H bridge multilevel inverter with statcom for industrial applications," IJAR, article doi 10.21474/IJAR01/4384 june 2017.
3. Rakesh Kumar B. Shah, "Modelling of statcom utilizing cascaded 13 level H bridge", International Journal of Scientific research, Vol 4 issue 12 december 2015.
4. Wanki Min, Joonki Min and Jaeho Choi, "Control of STATCOM using Cascade Multilevel Inverter for High Power Application", IEEE International Conference on Power Electronics and Drive Systems, Hong Kong, July 1999
5. Slaven Kincic, Student Member, IEEE, Ambrish Chandra, Senior Member, IEEE, and Slobodan Babic, "Multilevel Inverter and its limitations when applied as STATCOM", IEEE, April 10, 2001.
6. Jingsheng Liao, Keith Corzine and Mehdi Ferdowsi Member IEEE, "A New Control Method for Single DC Source Cascaded H-Bridge Multilevel Converters Using Phase-Shift Modulation", IEEE 2008.

7. Geza Joos, Xiaogang Huang and Boon-Teck Ooi, "Direct-Coupled Multilevel Cascaded Series Var Compensators", IEEE Transactions On Industry Applications, Vol. 34, No. 5, September 1998.
8. G.W.Chang and T.C.Shee, "A comparative study of active power filter reference compensation approaches", Proc. IEEE Power Eng. Soc. Summer Meeting, Vol.2, July 2002, pp. 1017-1021.
9. J.Rodriguez, Jih-sheng Lai, and F Zheng peng, "Multilevel Inverters;A Survey of Topologies, Controls, and Applications," IEEE Trans.Ind.Electron., vol.49, n04., pp.724-738. Aug.2002.
10. Roozbeh Naderi, and Abdolreza rahmati, "Phase-shifted carrier PWM technique for general cascaded inverters," IEEE Trans. Power.Electron., vol.23, no.3, pp. I 257-I 269. May.2008.
11. Bhim Singh, Kamal AlHaddad & Ambrish Chandra, 1999, A Review of Active Filter for Power Quality Improvements, IEEE Trans on Industrial Electronics, 46(S), pp.960970
12. B. P. McGrath and D. G. Holmes, "Multicarrier PWM strategies for multilevel inverters," IEEE Trans. Ind. Electron., vol. 49, no. 4, pp. 858- 867, August 2002.





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