

## CHAPTER 9

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# **CONCLUDING REMARKS and FUTURE SCOPE**

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The hybrid multilevel inverter is presented in this work. The project work presents the design, simulation, analysis and implementation of hybrid multilevel inverter. Many projects are implemented with this theory and circuit but in this research work, DSP 28335 with MATLAB/SIMULINK, CCS 3.3 and emulator C2000 series is used to obtain control signals along with DC regulated power supply. The DSP based control unit reduces the system hardware and makes it more flexible in comparison with conventional digital control.

Hybrid multilevel inverter has many merits such as: ability to synthesize waveforms with better harmonic spectrum, an output voltage level that is higher than those of the power semiconductor switching devices', reduced THD, dv/dt stress and common mode voltage and different approaches to achieve the goal of multilevel output.

## 9.1 GOALS REACHED

- The work presents the use of different modulation techniques simulation, analysis and implementation of the control of hybrid multilevel inverter.
- Regulated power supply for DC 40V/80V is developed with 5A current rating. Load regulation is 7.09%.
- Simulations are done for single phase cascaded multilevel inverters(five level, seven level and nine level) and THD is compared.
- Simulations are also done for different hybrid multilevel inverters like asymmetric hybrid multilevel inverter, symmetrical hybrid multilevel inverter and half bridge module based hybrid multilevel inverter with single phase and three phase configurations. Simulations are done with and without modulation. As obvious THD is high for simulated circuits without modulation. For simulated circuits with modulation THD is varying from 0.6% to 1.8% for different topologies with different modulation techniques for single phase and three phase as done in MATLAB R2009a.
- Similarly, simulations are done for selected hybrid multilevel inverter with different modulation techniques for single phase and three phase and comparison is done on basis of THD. For single phase THD varies from 1.15% to 1.52% and for three phase THD varies from 0.84% to 1.41% as done in MATLAB R2009a.
- In hardware for single phase hybrid multilevel inverter 5 levels are obtained using 12V/24V batteries.

- The circuit is further developed for three phase hybrid multilevel inverter. In the project multicarrier modulation techniques including PD, POD, APOD and THIPDPWM is used for implementation purpose with constant modulation index which can be changed to achieve different results.
- THD obtained as low as 1.2% from hardware and 0.19% from simulations in MATLAB R2013a as shown in chapter 8. Trying recent tools it may be possible to modify the system to reduce THD.
- This system can work for 1.5KW power output.

## 9.2 INNOVATIONS

- The power module and digital controller interface is developed as separate units with provisions for change of configuration or up gradation in power module as well as hardware interface to make it suitable for load up to 1.5 KW.
- The control signals are developed using combination of MATLAB/SIMULINK, code composer studio and emulator which eliminates writing a code for the software. The technique can be used by the user who is not proficient in programming.

## 9.3 FUTURE PLANS FOR EXTENSION

- Software can be generated for closed loop system.
- Circuit of HMLI with capacitors as voltage source can be used as other HMLI topology. For portable HMLI regulated power supply can be replaced with batteries and rechargeable voltage source, which may be taken as future project.
- The power module can be modified to realize other hybrid multilevel inverters such as symmetrical or asymmetrical hybrid multilevel inverter or half bridge multilevel inverter for single phase or three phase and modulation techniques developed in this project can be used with minor modifications.
- It is possible to realize different power electronics system applications such as drives, EV.
- As already stated it is possible to modify the power and control circuit so that HMLI can be used for load more than 3 KW otherwise same power and control circuit can be used.
- With some small modification other topologies can be developed for HMLI.
- It is possible to implement this system with digital signal controller and make the system more cost effective.

- Other modulation techniques can be applied to this system to reduce THD.

#### **9.4 INDUSTRY, INVOLVEMENT AND INTERACTION**

- The wiring for the power module, signal conditioning circuits and assembly work was done with the help of technical assistant at the Control System Engg., GIDC, Makarpura, Vadodara manufacturers of drives.
- The software development tools for DSP were supplied by Edutech Systems, Dandia Bazar, Vadodara. The software engineers of the company helped in software development and interfacing EPB29335 with power circuit module.