Space Vector Pulse Width Modulation (SVPWM) for Harmonic Reduction for Three Phase Inverter System

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Introduction

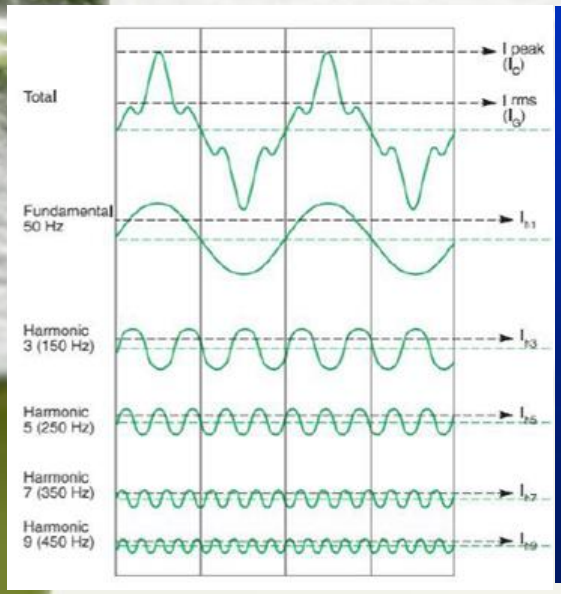
- Majority renewable energy sources produce DC.
- Conversion is required for integration into the microgrid.
- INVERTERS produce AC power output from DC power input using different circuit designs and components.
- Classifications identified by the source or input; Voltage Source Inverters (VSI) and Current Source Inverters (CSI).
- VSI is used in this work.

Problem Statement

- Devices causing harmonics are present in industrial, commercial and residential installations.
- Harmonics are as a result of non-linear loads. A load is non-linear when the current it draws does not have the same waveform as the supply voltage.
- Harmonic is a quantity having a frequency that is integral multiple of the fundamental frequency.

- Total Harmonic Distortion (THD) is the sum of the harmonics amplitudes expressed as a percentage of the fundamental frequency.

  Harmonics must be reduced to avoid causing problems to equipment and the distribution system.



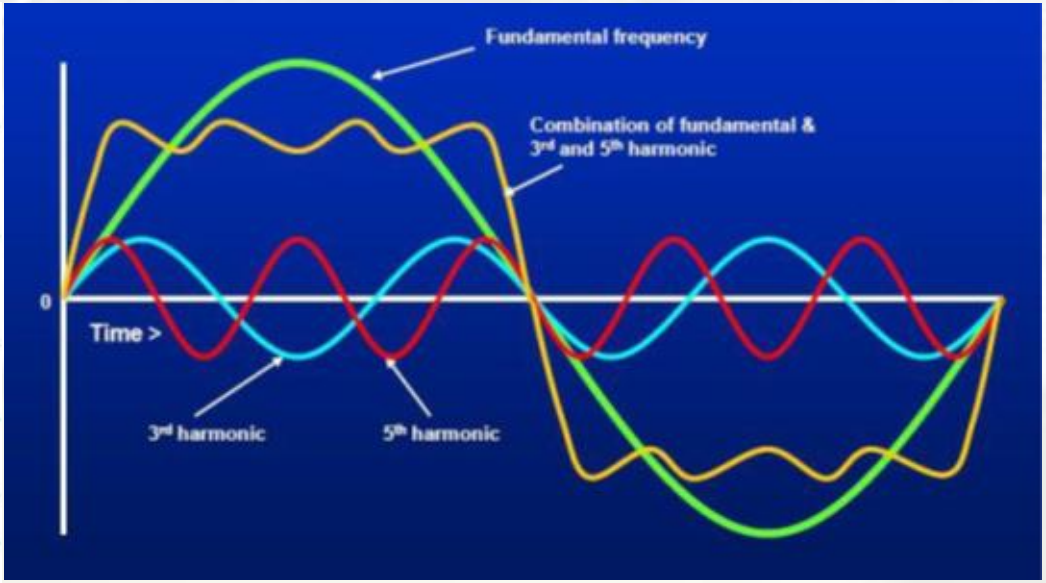


Figure 1: Illustrations of harmonics

Objectives

- To develop SVPWM technique for a three phase inverter system.
- To investigate the THD improvement using the proposed SVPWM control topology.
- To experimentally validate the results of the proposed technique.

Methodology

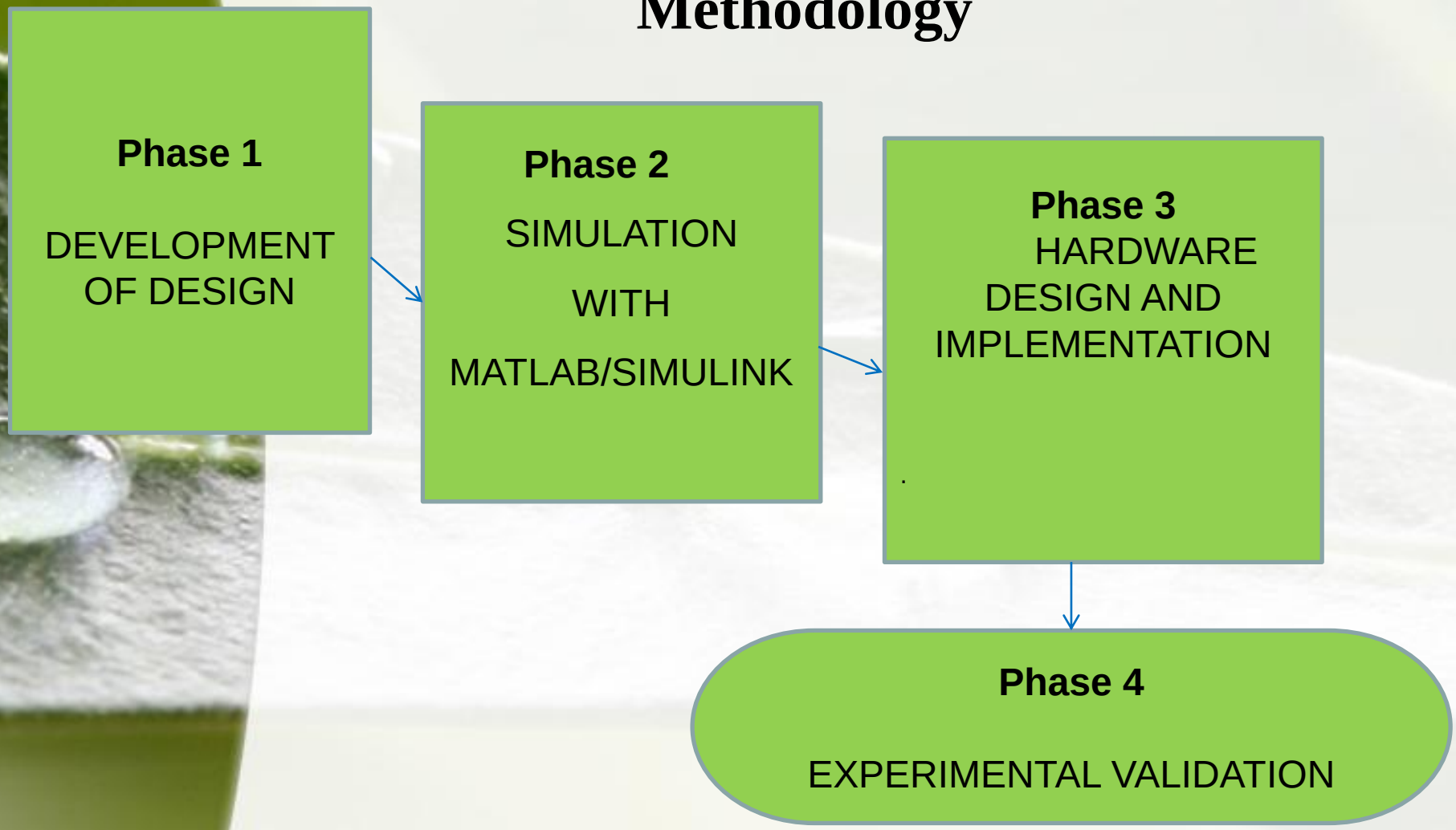


Figure 2: Development process

Proposed SVPWM Technique

The proposed modulation technique is SVPWM. SVPWM utilize the DC voltage and works with vector control to give better efficiency and lesser switching losses at high frequencies. The SVPWM technique uses the space vectors of the inverter together with the space vector references to modulate the width of the semiconductor switches gating pulses. Generated with MATLAB/Simulink, the modulated pulses resulting from the SVPWM are sent to the switching devices (MOSFETs).

Proposed Design

Design has software and hardware parts. SVPWM control technique is implemented in MATLAB/Simulink and forwarded to DSP microcontroller. Gate driver accepts SVPWM signals and applies to three phase inverter and subsequent load. The inverter is a 2-level inverter designed using Proteus software.

There are six controlled switches. S1,S3 and S5 are upper switches and conduct during positive half cycle. The negative half cycle uses the lower switches S2,S4 and S6 to conduct.

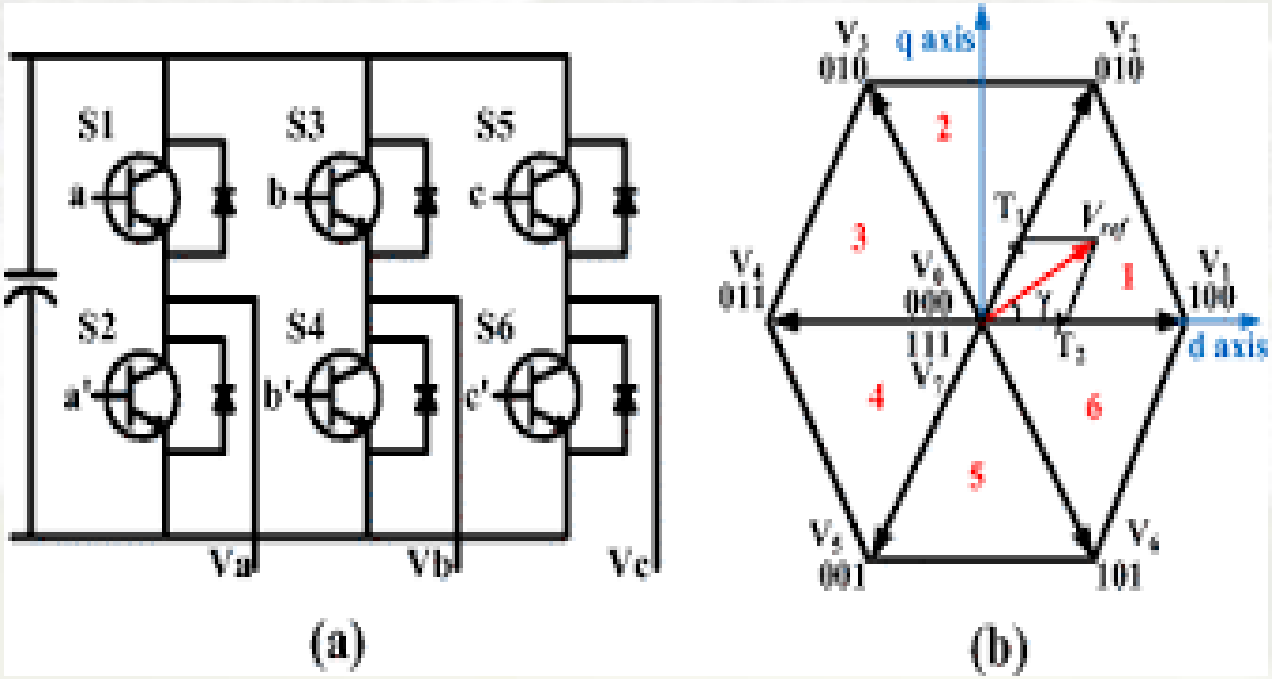


Figure 3: Eight inverter voltage sector (V0-V7)

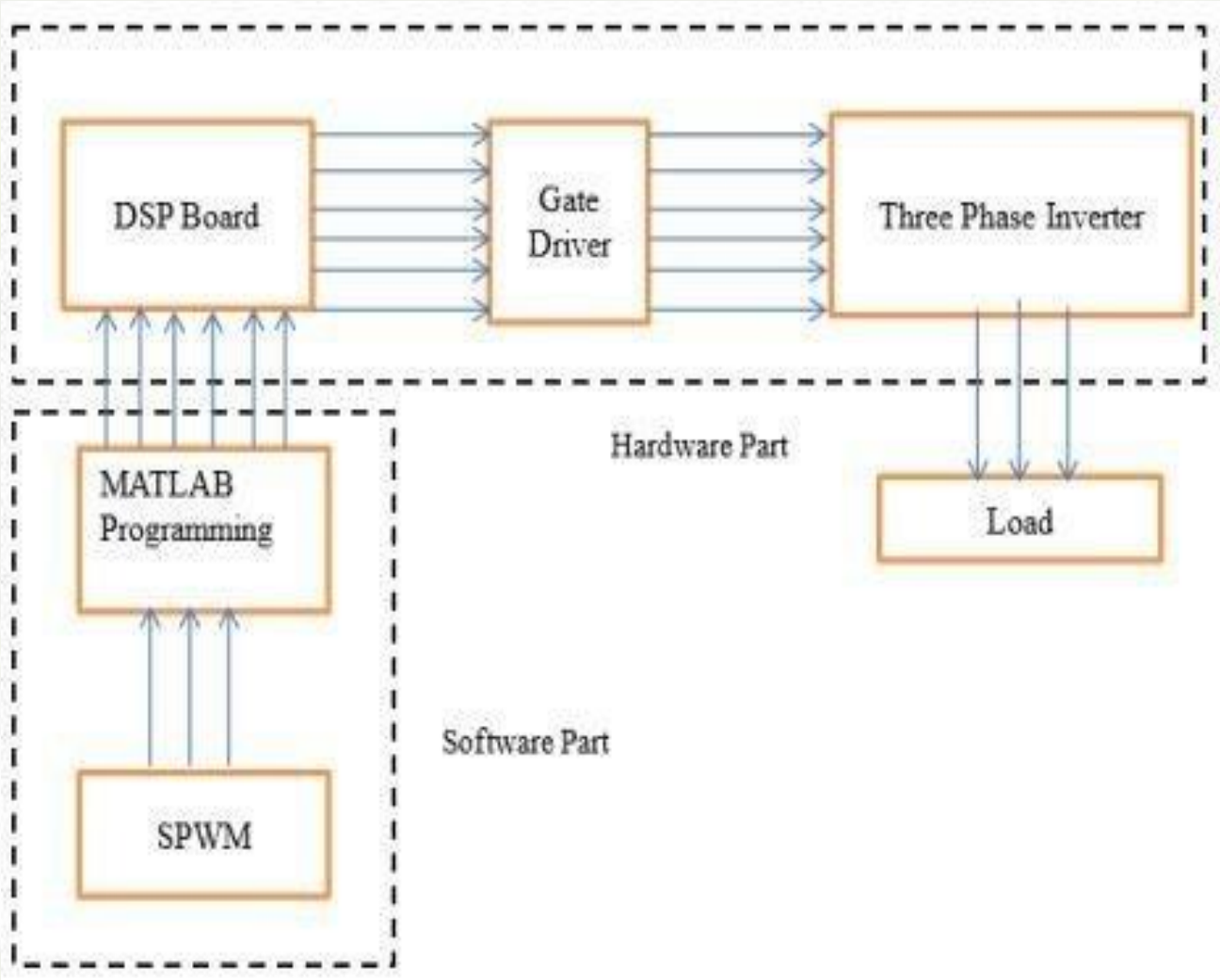


Figure 4: SVPWM Three Phase Inverter Design

MATLAB Simulink Simulation

- SVPWM control topology and inverter circuit are implemented in MATLAB Simulink.
- Simulation parameters:

  DC Voltage: 400V

  Fundamental frequency: 50 Hz

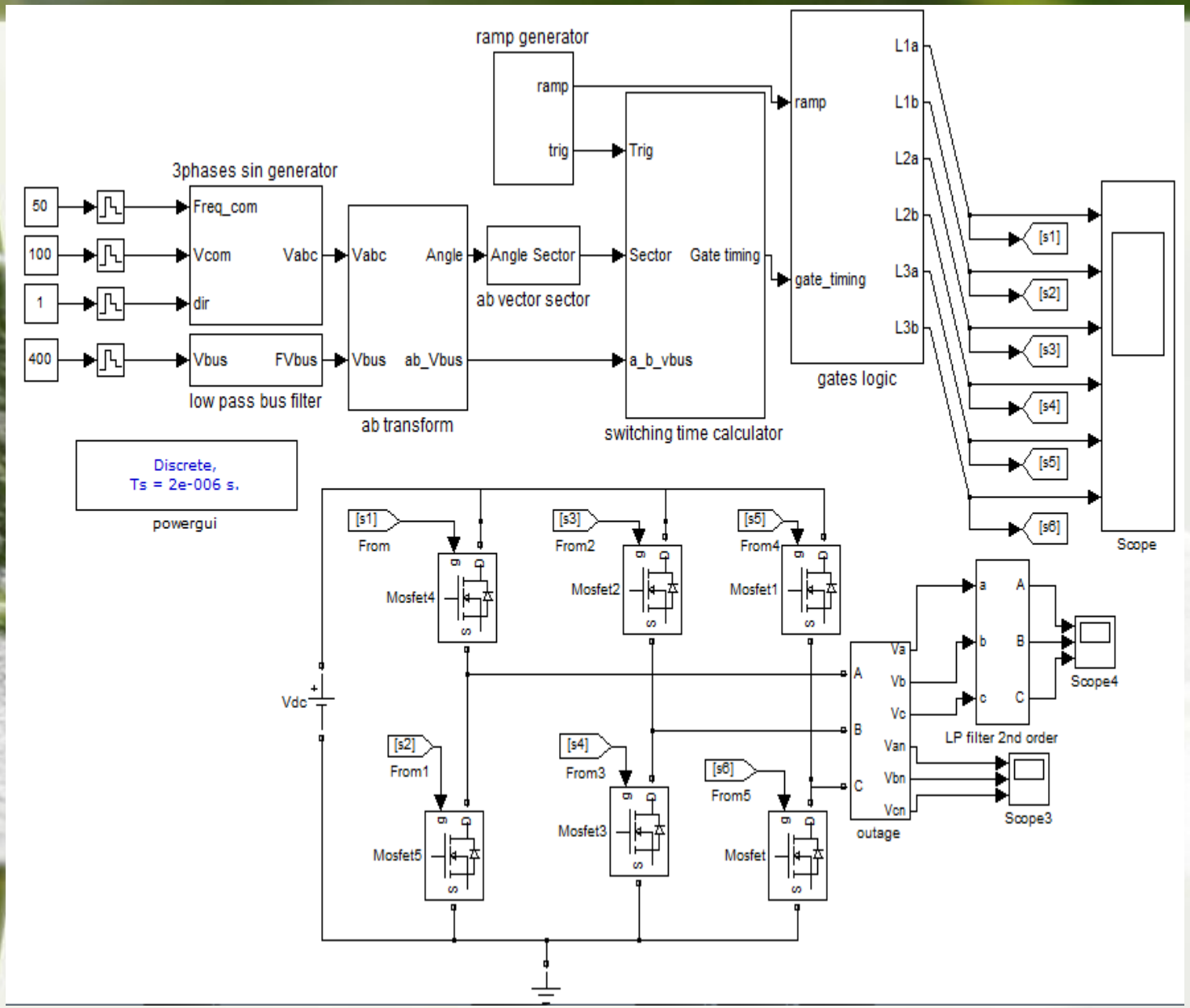


Figure 5: Three phase inverter with SVPWM controller circuit in MATLAB/Simulink

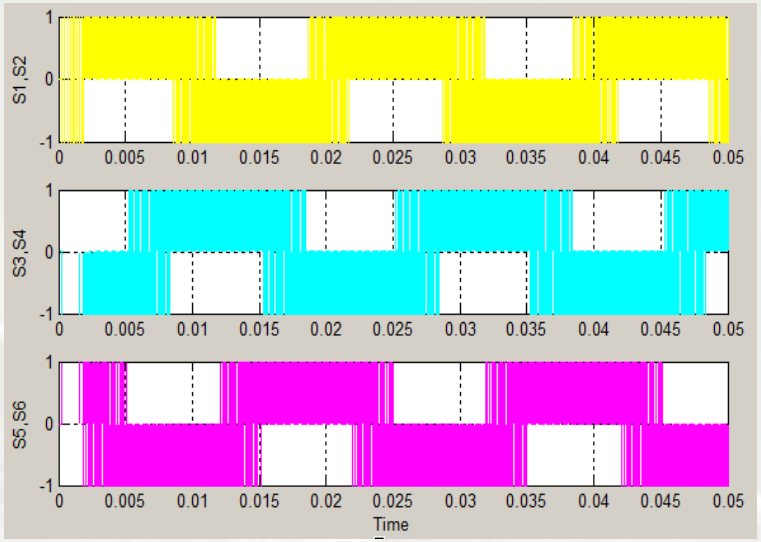


Figure 6: Gate pulse of switch signal in MATLAB

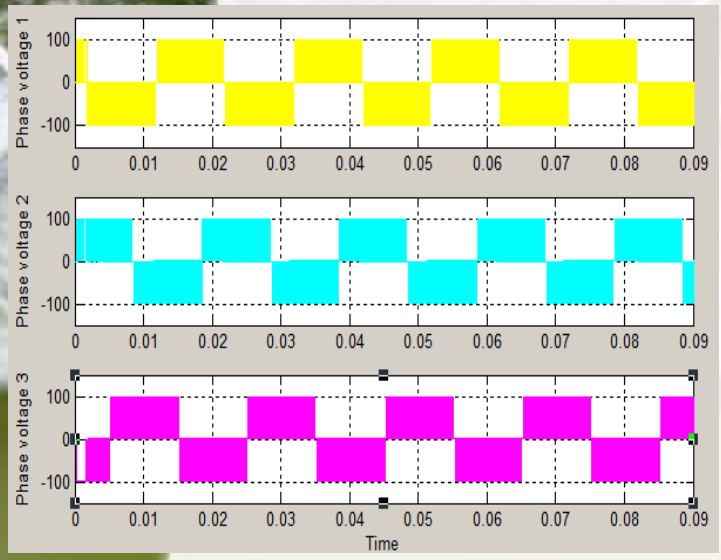


Figure 7: Output voltage without filter

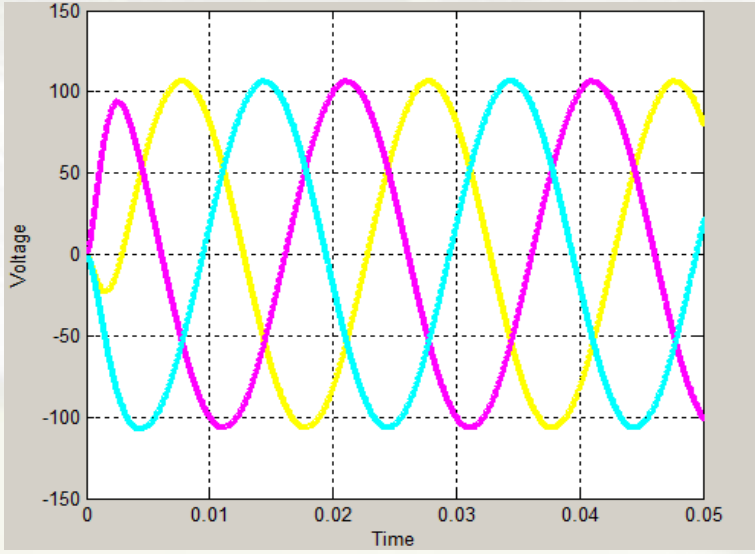


Figure 8: Three phase output voltage with filter

Experimental Validation

- Inverter hardware is developed on printed circuit board (PCB).
- SVPWM control topology from MATLAB Simulink is used to control switches via DSP microcontroller and gate driver.
- Oscilloscope is used to monitor and obtain results.

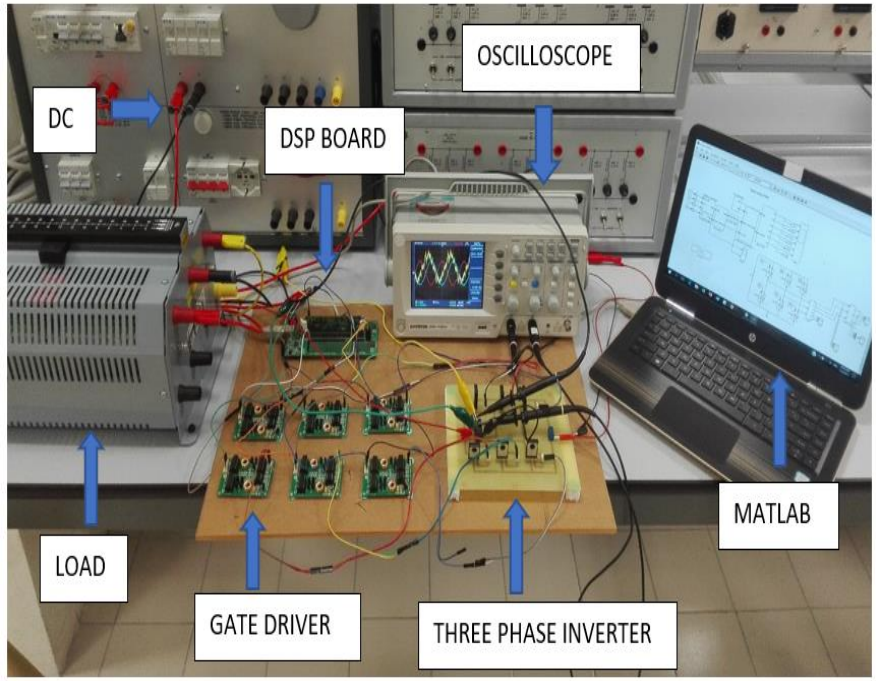


Figure 9: Hardware experimental setup

Experimental Results

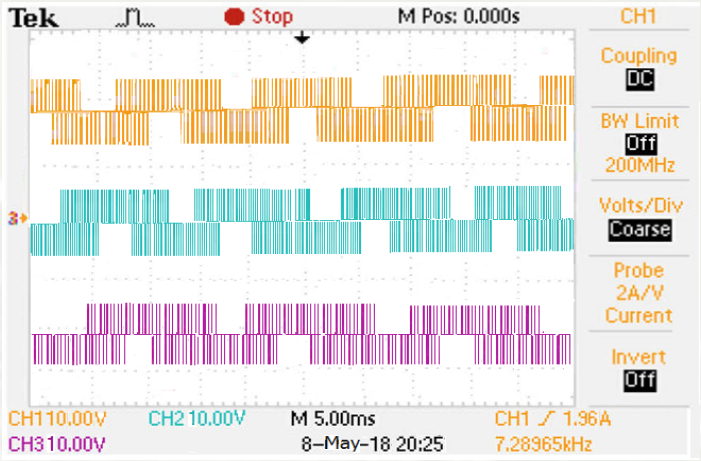


Figure 10: Gate pulse of SVPWM switch signal pulse

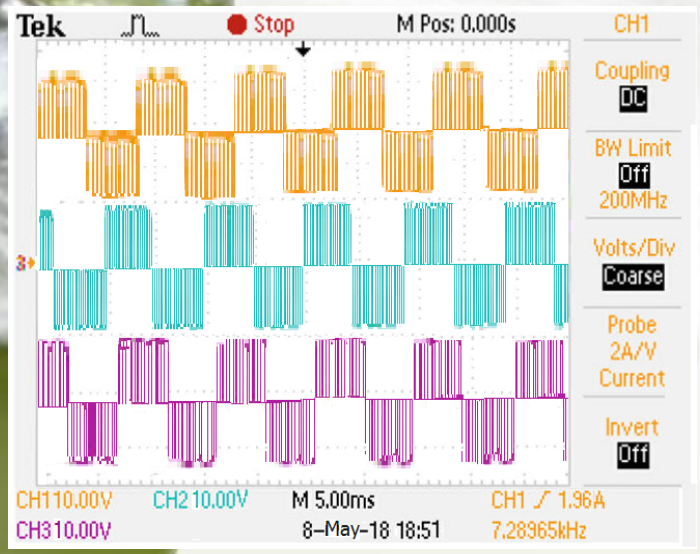


Figure 11: Output voltage without filter

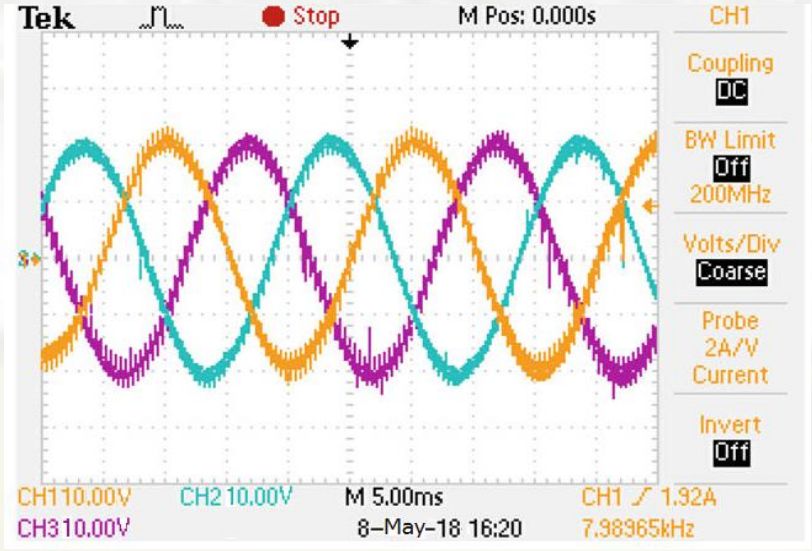


Figure 12: Output voltage with filter

THD Analysis

- FFT analysis in Simulink to is used to determine THD.
- Proposed SVPWM technique can reduce THD up to 0.26%, improve equipment performance and power quality.

THD Analysis: 0.26%

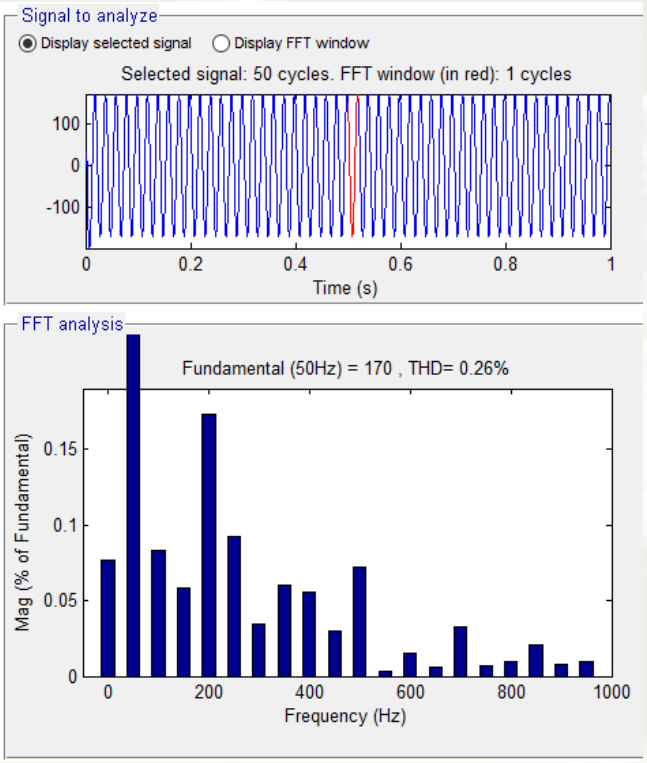


Figure 13: THD analysis results

Comparison with previous works

Table 1: THD comparison of previous works

Research	THD reduction performance
Bhattacharjee et al. (2016)	1.65%
Zahira et al. (2014)	0.88%
This work	0.26%

Conclusions

- The design and implementation of SVPWM for a three phase inverter system in MATLAB/Simulink software and hardware is achieved. SVPWM control technique successfully generated smooth and sinusoidal output voltage.
- Reduced harmonics were obtained during simulation using SVPWM when compared to other works.
- The proposed SVPWM control technique has been verified experimentally.

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Thank you very much