

SINGLE PHASE INVERTER/CHARGER CONVERTER

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Abstract: - This study presents a development of a Single-Phase Inverter/Charger Converter. The controller is developed using Peripheral Interface Controller (PIC). This system utilises Power Mosfet as a main power switching devices. The Single Phase Inverter/Charger Converter convert DC-AC and charge or discharge the battery simultaneously. The inverter/charger has two types of input DC voltage to supply the inverter which are photovoltaic modules and battery . These two types of DC supplies are used at certain time depend on the value of the voltage of the photovoltaic modules and battery. The modes of operation for the inverter/charger converter are controlled by corresponding PWM applied to the gate of Power Mosfet. The simulation of the inverter/charger converter using PSIM are presented to verify the circuit operation. The laboratory model of the converter is developed and tested. The experimental result is presented.

Keywords:-Peripheral Interface Controller (PIC), Pulse Width Modulation (PWM), inverter. Power Mosfet (MOS).

1.0 INTRODUCTION

The bi-directional inverter/charger are increasingly used in battery-backup stand-alone inverter systems and alternative energy systems such as wind power and photovoltaic applications [1].

The simplified block diagram of such a system connected to the Single-Phase Inverter/Charger Converter is shown in Figure 1. The input voltage supply of the inverter/charger converter have two types of DC voltage which are the photovoltaic application and battery [2]. When the input voltage supply is received from PV modules, the battery will charge until the battery fully charged. The battery will supply the input voltage to the inverter if battery is fully charged [3].

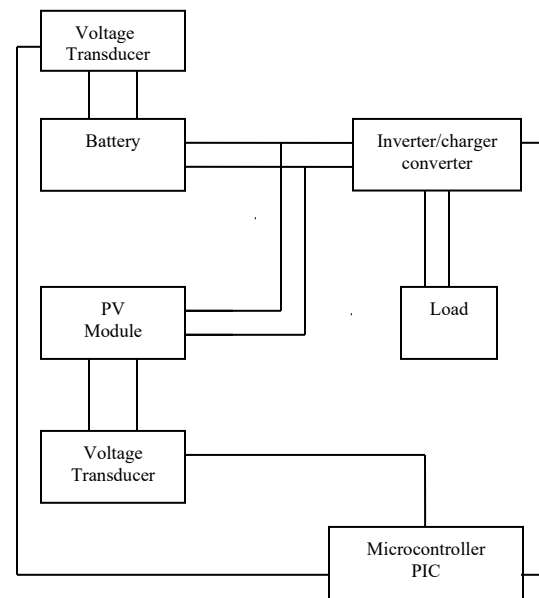


Figure 1: The simplified block diagram of such a system connected to the single phase inverter/charger converter.

The modes operations will continue by exchange the condition of charging or discharging for the battery charger [4].

2.0 SCOPE OF WORK

2.1 Switching Strategy

This project used Power Mosfet as the main switching devices. Power Mosfet has simpler driving circuits than others power transistors and could lead to high-switching applications [5]. For this project, a set of two Power Mosfet is arranged in anti-parallel capable of bi-directional operation. The full-bridge inverter, LC filter, capacitor, diode and resistive load, R is also used in this project. The practical circuit of DC-AC Single Phase Inverter/Charger Converter is shown in Figure 2.

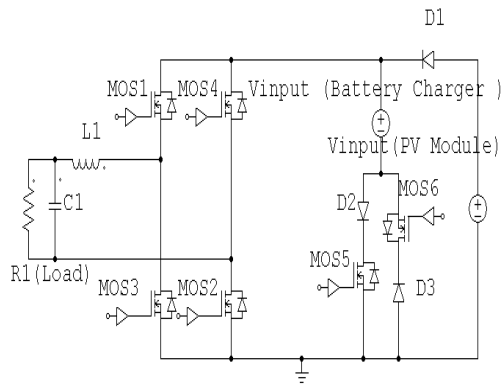


Figure 2: Practical circuit of DC-AC Single Phase Inverter/Charger Converter

The Single Phase Inverter/Charger Converter has two input DC voltages. The modes of input DC voltages are control by corresponding SPWM injecting into gate of Power Mosfet.

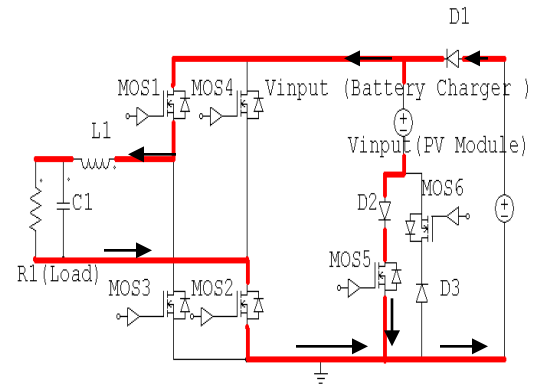
The output of the DC-AC Inverter/Charger is being synthesized using the well-known SPWM technique. Conceptually, there exist two switching state for DC-AC Inverter/Charger; state 1 and state 2. State 1 is during the positive cycle and state 2 is during the negative cycle of the reference signal.

Figure 3(a) and (b) shows the direction of current flow during battery charger is charging. For state 1, MOS1, MOS2 and MOS5 are ON while MOS3, MOS4 and MOS6 are OFF.

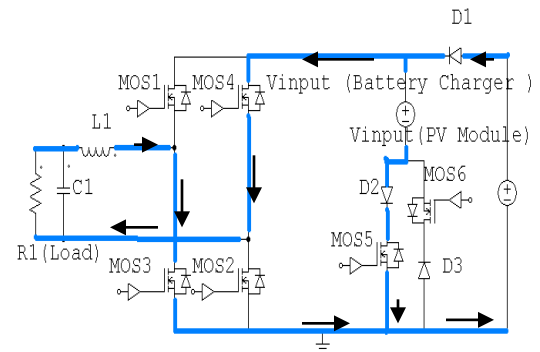
For state 2, MOS3, MOS4 and MOS5 are ON while MOS1, MOS2 and MOS6 are OFF.

Figure 4(a) and (b) shows the direction of current flow during battery charger is discharging. For state 1, MOS1, MOS2 and MOS6 are ON while MOS3, MOS4, and MOS5 are OFF. For state 2,

MOS3, MOS4 and MOS6 is ON while MOS1, MOS2, MOS5 are OFF.

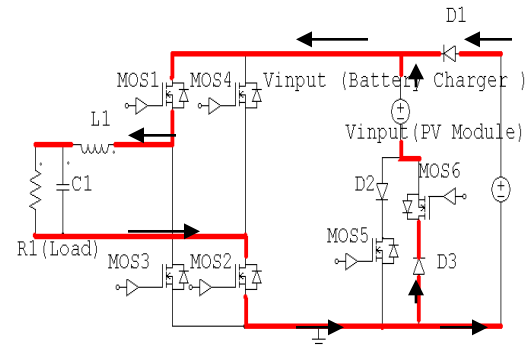


(a) Current flows during State 1



(b) Current flows during State 2

Figure 3: The switching strategies for DC-AC Single Phase Inverter/Charger Converter during battery charger is charging



(a) Current flows during State 1

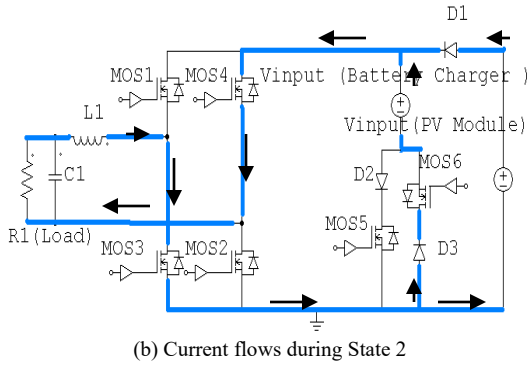


Figure 4: The switching strategies for DC-AC Single Phase Inverter/Charger Converter during battery charger is discharging

2.2 Objectives of The Project

The objectives of the proposed Single-Phase Inverter/Charger Converter scheme are to:

- To design and construct a Single Phase Converter that could perform as inverter and charger.
- To evaluate and analyse the performance of the Converter and controller.

2.3 Scope of Work

The work plan in this project covered the main areas of development:

- Build and simulate the circuit designed using PSIM software.
- Developed and executing a program to run the switching by using PIC MPLAB IDE from Microchip Technology Inc.
- Transferring/burn program to target chip PIC 16F84A and PIC 16F873.
- Assemble the Inverter/Charger circuit.
- Make observation on the result.
- Analyze the result and make comparison between simulation and experimental.

3.0 METHODOLOGY

The implementation of Single-Phase Inverter/Charger Converter is development and tested by using PSIM simulation, PIC software, and hardware prototype. The research methodology flow chart is shown in Figure 5.

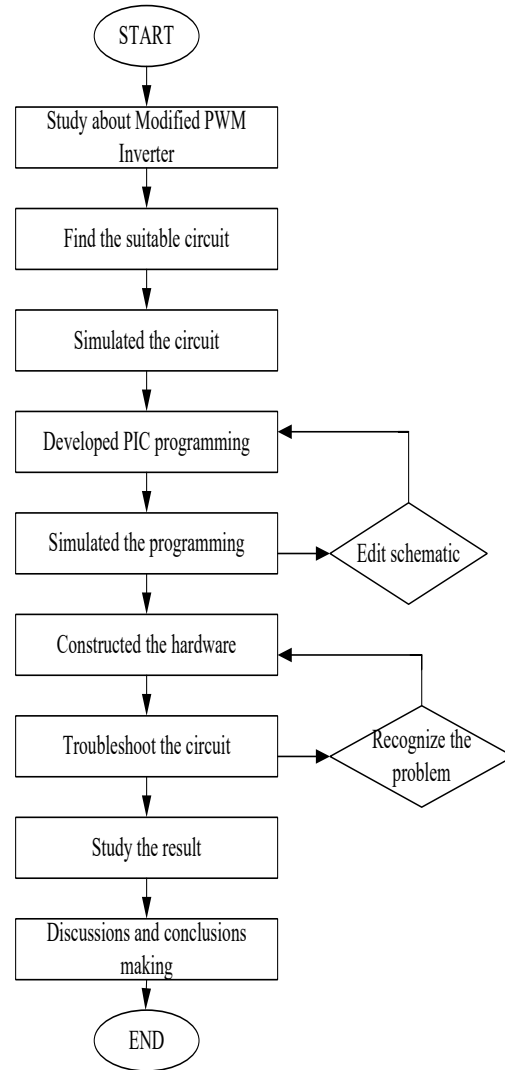


Figure 5: Research methodology flow chart

The simulation of the circuit for Single Phase Inverter/Charger Converter are simulated using PSIM software model. The load consists of resistor at $10\ \Omega$. The DC input voltage is 12V. The complete circuit is shown in Figure 6. The block diagram for the proposed modified sinusoidal PWM control is shows in Figure 7. The sinusoidal signal is compare with pulse signal. Figure 8 shows the proposed modified sinusoidal signal waveforms. Figure 9 shows the PWM control switching generation, where the proposed modified sinusoidal is compared with triangular signal.

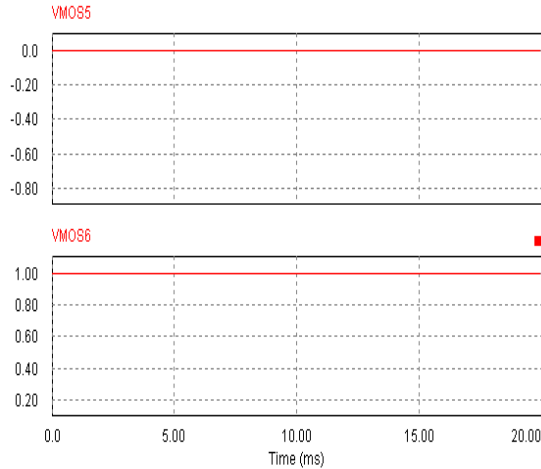


Figure 12: Simulation control switching during battery charger is discharging

Exactly, there is an undesired harmonic in the output spectrum. The output waveform without filter of the DC-AC inverter as shows in Figure 13 and the frequency spectrum of the waveforms is shows in Figure 14. The output voltage after used a filter is shows in Figure 15 and the frequency spectrum of the waveforms is shows in the Figure 16.

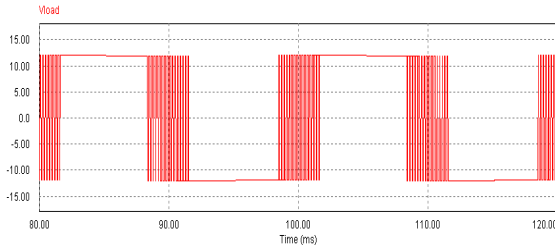


Figure 13: Simulation result of output voltage without filter

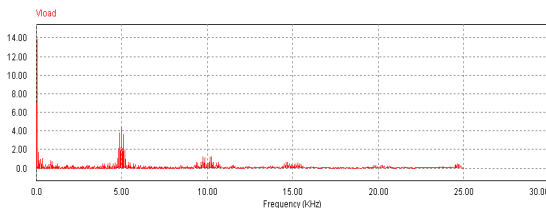


Figure 14: Simulation result of frequency spectrum of the output Voltage without filter

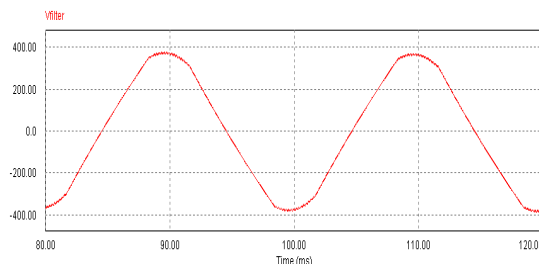


Figure 15: Simulation result of output voltage with filter

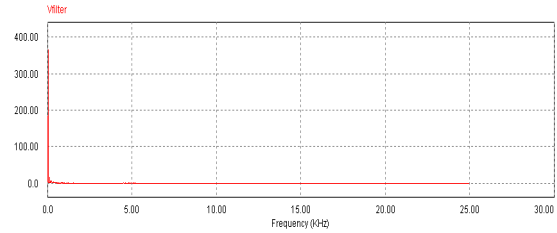


Figure 16: Simulation result of frequency spectrum of the output Voltage with filter

3.2 Software Development

There are two types of PIC were used in developing of the Single Phase Inverter/Charger Converter. The PIC16F84A is the controller that provide the switching control for inverter part. The charger part is control by PIC16F873 due to analog to digital conversion. The flowchart of the program that has been implemented for PIC16F84A is shown in Figure 17. The layout of the PIC16F84A is shown in Figure 18. Figure 19 shows the flowchart of the program that has been implemented for PIC16F873. Figure 20 shows the layout of the PIC16F873.

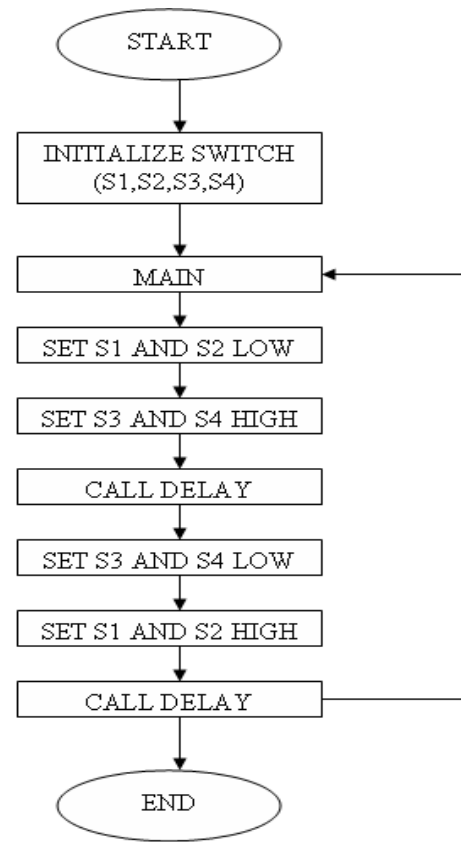


Figure 17: The flowchart of the program that has been implemented for PIC16F84A

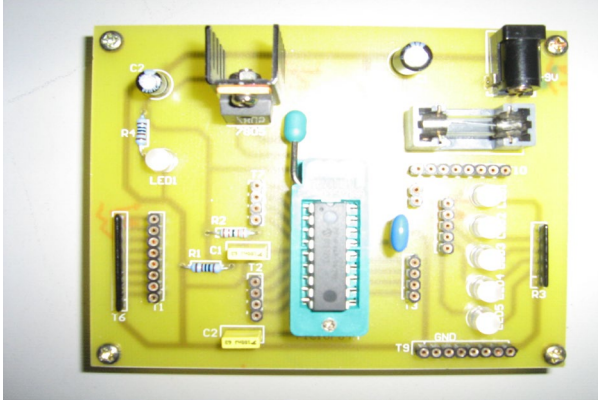


Figure 18: The layout of the PIC16F84A

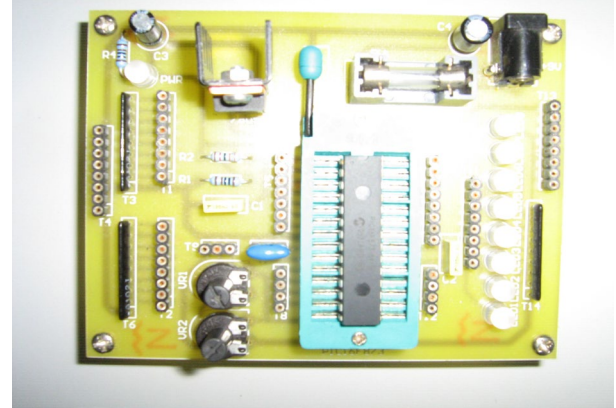


Figure 20: The layout of the PIC16F873

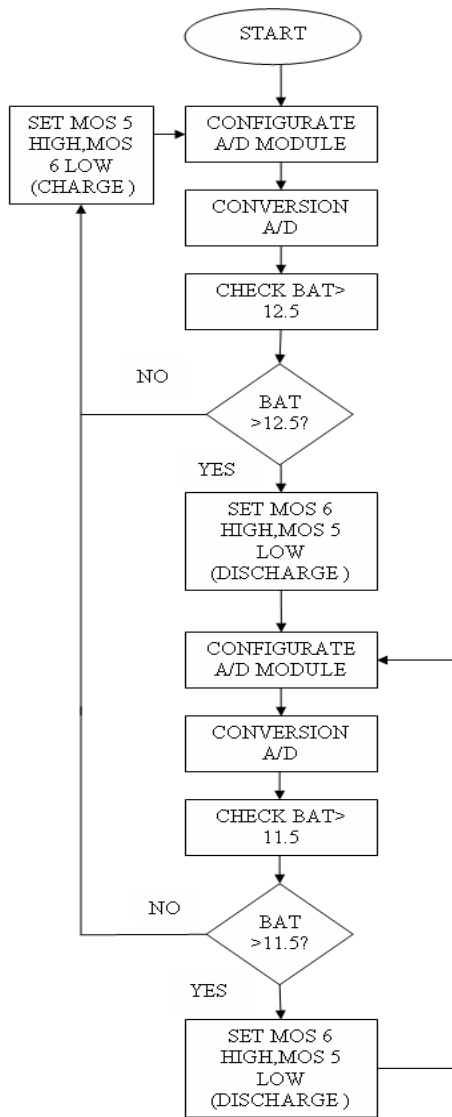


Figure 19: The flowchart of the program that has been implemented for PIC16F873

3.3 Development of Single Phase Inverter /Charger Converter Prototype

The development of The Single Phase Inverter/Charger Converter is divided into two part. For inverter part, four IRF540N Power Mosfet with two IR2110 driver circuits. Two IRF540N Power Mosfet with two IR2110 driver circuit used for charger part. Figure 21 shows the circuit diagram of The Single Phase Inverter/charger Converter. Figure 22 shows the actual prototype.

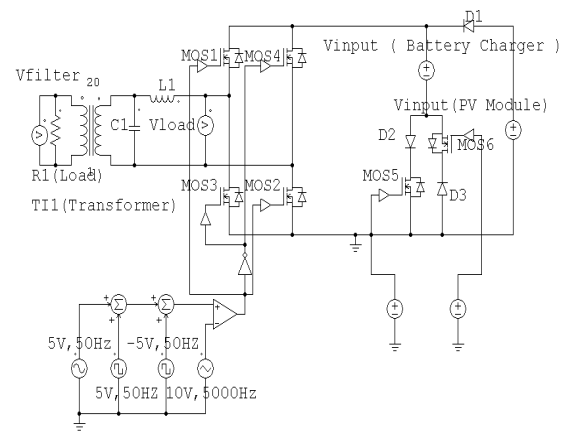


Figure 21: The circuit diagram of The Single Phase Inverter/charger Converter

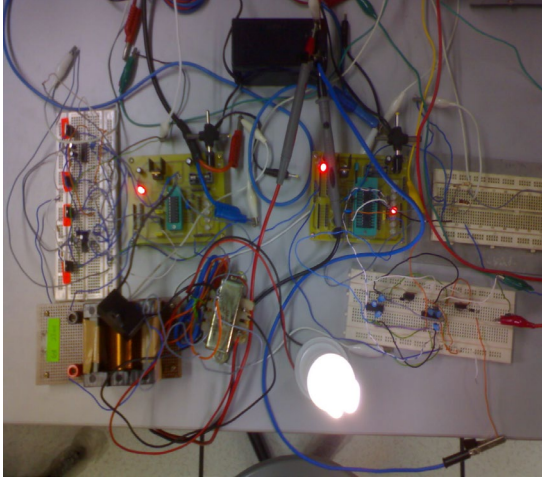


Figure 22: The actual Single Phase Inverter/charger Converter prototype

4.0 EXPERIMENTAL RESULTS

The purposes of this experiment is to determine and ascertain the performance of the system and to ascertain validity of the results within those results obtained in simulation. A resistance of 10 ohm was used as a load in this experiment. Figure 23 show the switching of the inverter by PSIM software. Figure 24 shows the switching of the inverter positive cycle and negative cycle respectively by experimental. The switching of the charger part is shown in Figure 25 which have been done by simulation. The experimental results of switching control of the charger part during battery charger is charging is shown in Figure 26. Figure 27 shows the switching of the charger part during the battery charger is discharging. Figure 28 shows the experimental result of the switching control of the charger part during the battery charger is discharging. The simulation of the output voltage without filter is shown in Figure 29. The experimental result of the output waveform of the inverter without filter is shown in Figure 30. The output voltage value is 12V with current value of 0.7A. Figure 31 shows the simulation result of frequency spectrum of the output Voltage without filter. Figure 32 shows the experimental result of frequency spectrum of the output Voltage without filter.

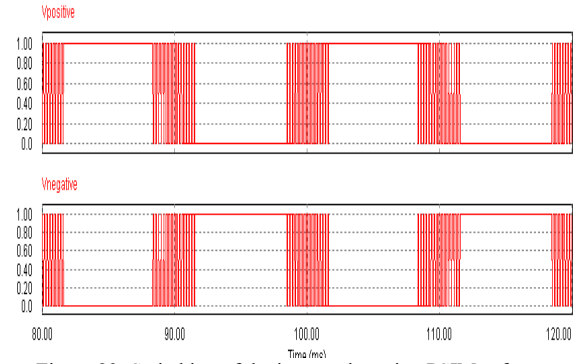


Figure 23: Switching of the inverter by using PSIM software

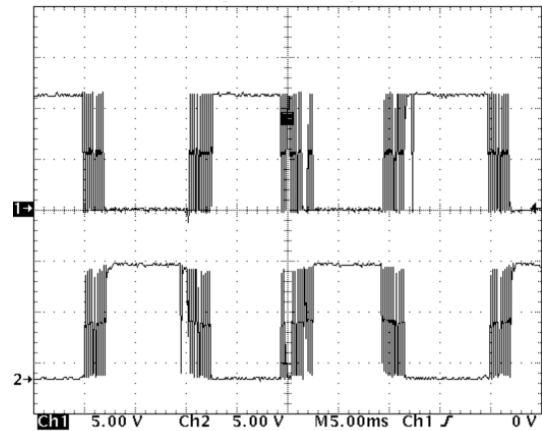


Figure 24: Experimental result of switching control of the inverter

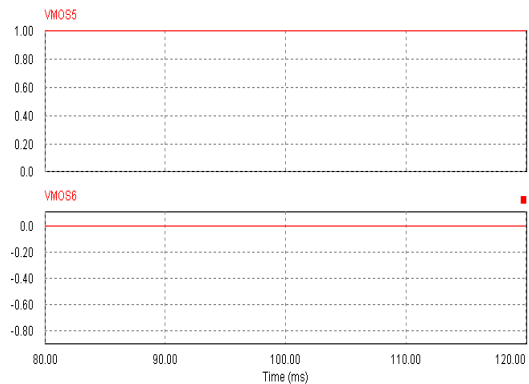


Figure 25: Switching of the charger part during battery charger is charging

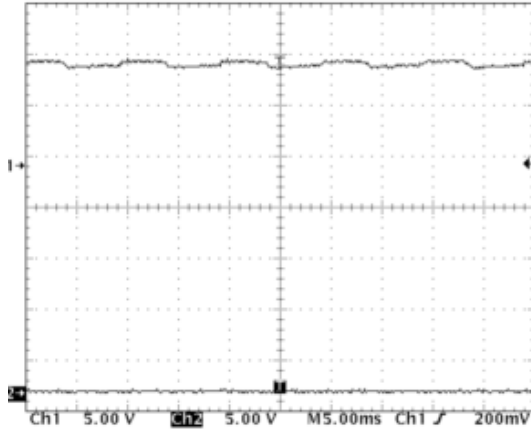


Figure 26: Experimental result of switching control of the charger part during battery charger is charging
Channel 1: Switching control charging
Channel 2: Switching control discharging

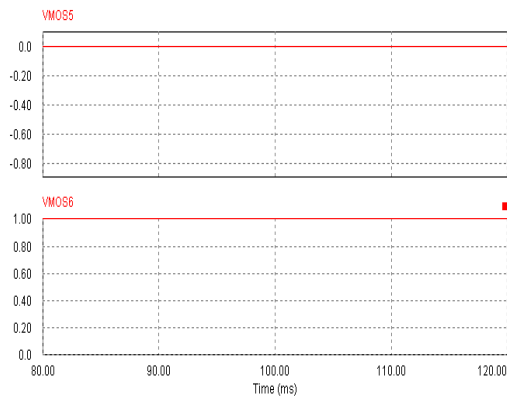


Figure 27: Switching of the charger part during battery charger is discharging

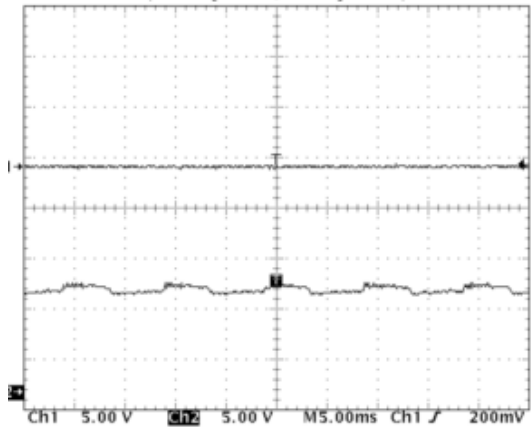


Figure 28: Experimental result of switching control of the charger part during battery charger is discharging
Channel 1: Switching control charging
Channel 2: Switching control discharging

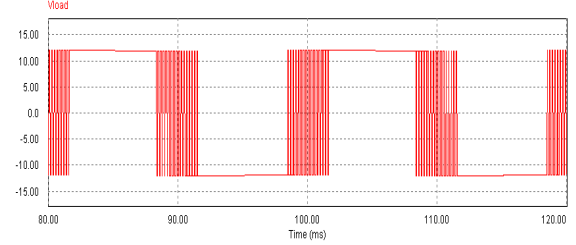


Figure 29: Simulation result of output voltage without filter

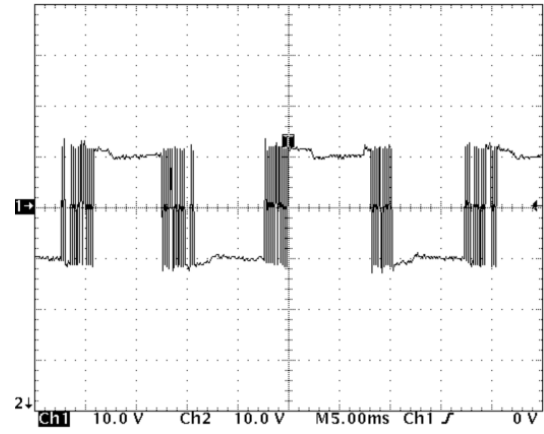


Figure 30: Experimental result of the output waveform of the inverter without filter

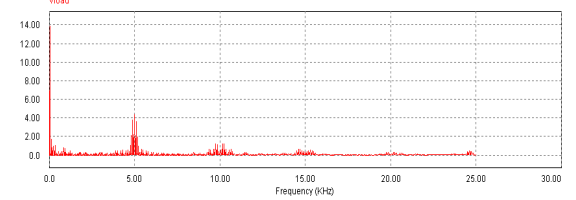


Figure 31: Simulation result of frequency spectrum of the output Voltage without filter

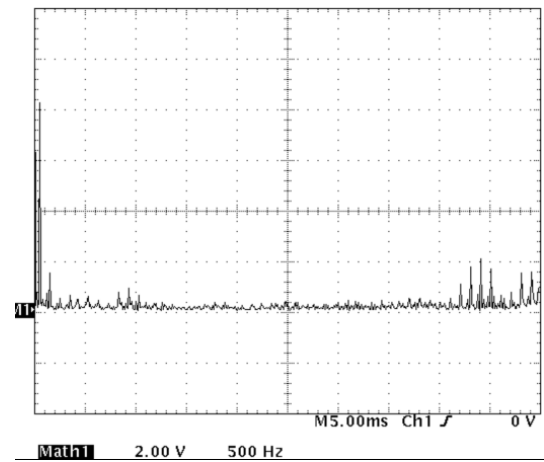


Figure 32: Experimental result of frequency spectrum of the output Voltage without filter

The output voltage is boost up to 240V using step up transformer. Figure 33 shows the output voltage with filter by simulation. The output voltage waveform of the inverter with filter by experimental shows in Figure 34. The simulation result of frequency spectrum of the output Voltage with filter is shown in Figure 35. The experimental result of frequency spectrum of the output Voltage with filter is shown in Figure 36. The experimental result is not exactly simulation result due to filter design. From the simulation result, the value of capacitance is $4.7\mu\text{F}$ and the value of inductance is 0.005mH . However, the value of capacitance and inductance used in experimental is not exactly as simulation because difficult to find the same value. So, the nearest value of capacitance and inductance are selected. From the simulation result, the value of capacitance is $1.25\mu\text{F}$ and the value of inductance is 23mH . Here the current are not the interest in the experiment since the load is resistive.

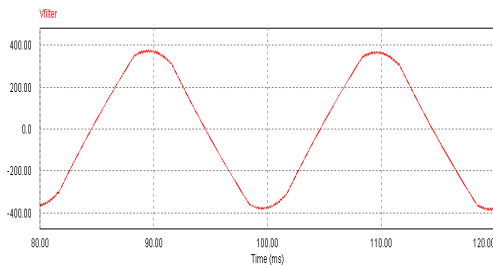


Figure 33: Simulation result of output voltage with filter

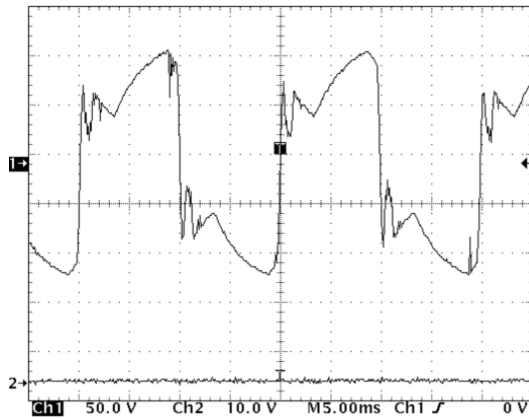


Figure 34: Experimental result of the output waveform of the inverter with filter

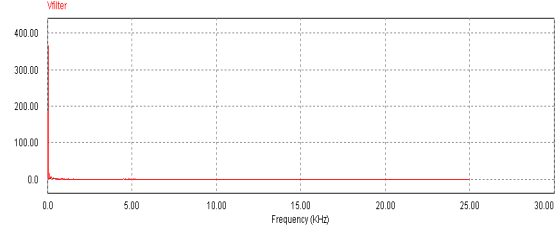


Figure 35: Simulation result of frequency spectrum of the output Voltage with filter

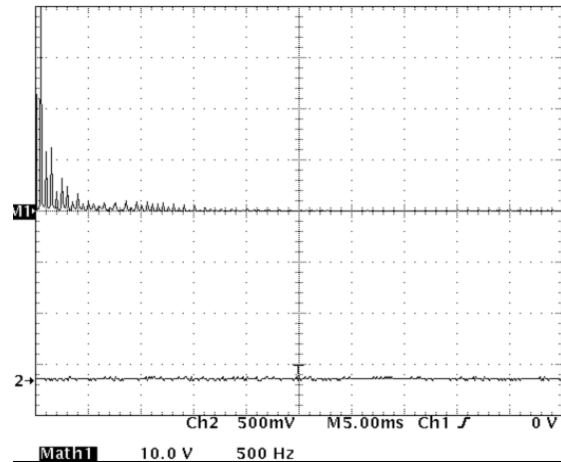


Figure 36: Experimental result of frequency spectrum of the output Voltage with filter

5.0 DISCUSSIONS

The Single Phase Inverter/Charger Converter is simulated with switching strategy being implemented to achieve direct frequency conversion. The simulation has been used to confirm the converter operation in detail under a variety of operating condition, including different switching frequency, different sources input. In particular, this simulation has been to confirm the specific current flow through each Power Mosfet switch under various operating conditions. After the simulation have been confirmed, the next step is hardware construction. During developing the programming to match with the hardware requirements, the problem occurred in the prototype circuit. However, the problem was rectified by reprogramming the PIC and modified the circuit.

The observations during implementation of this project is the PIC characteristics and Power Mosfet characteristics. The characteristics for each types PIC have been studied to select the suitable PIC. The characteristics of the Power Mosfet which includes on-state resistance, the maximum current and the maximum peak voltages are considered during design stage.

6.0 CONCLUSION

The results obtained from the PSIM simulation is free from any distortion and give the smooth output waveforms. The result obtained from PSIM simulations are compared with experimental results. The results from experimental is different due to internal and external distortion. The PIC16F84A provide a compact controller that control inverter part and PIC16F873 control the charger part. The filter design should be enhanced further to get smooth output voltage for future development.

PWM switching technique has become very popular and widely used in industrial applications. The Single-Phase Inverter/Charger Converter converts 12VDC to a 240VAC, 50 Hz sinusoidal waveform and charge or discharge the battery simultaneously. Future work could be done to further improve efficiency, total harmonic distortion, and the filter. With these additional improvements, the standard could be raised for future DC/AC power supplies.

7.0 ACNOWLEDGEMENT

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8.0 REFERENCES

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