Inverter based AC Drives for Low Rating Induction Motor

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Abstract - DC-AC converters are widely used to efficiently produce a regulated voltage from the source. Utilization of renewable energy sources has attached a significant interest for many commercial and industrial application. Conventionally, to supply to different loads and obtain energy from different sources, power inverter is implemented. As a result, cost, size and weight of inverter increase and further, efficiency and reliability also reduced. Hence inverter-based ac drives are introduced.
In this project work, 45W inverter topology designed for speed control of low rating induction motor. Providing an input voltage of 12V by using lead acid battery as a source, the inverter of is simulated at a switching frequency of 25KHz and its implemented to obtain the output voltage of 220V. The MOSFET switching state was conducted for equal duration and according to the operation, duty ratios are considered. The MOSFET switches are triggered by PWM pulses obtained by programming atmega328 microcontroller. Voltage and current waveform of each circuit element is studied and data obtained is used for selection of components to improve the hardware.

***Key Words*: Inverter, Transformer, Induction motor, Voltage regulation, PWM controller, battery, MOSFET driver.**

1. INTRODUCTION

Single-phase induction motors are most commonly used in Industrial and household appliances control because of their cost as well as useful application. Variable speed drives are used in many industrial processes for various applications. Using microcontroller Atmega328, this project investigates the speed control of single-phase induction motor.

PWM technique is employed to supply the motor with variable frequency. The purpose of amplification of voltage between the microcontroller circuit and the inverter is done by MOSFET driver. Also, it supplies the gate voltage required for the conduction of the power MOSFET (IRF540) in the inverter, the microcontroller senses the feedback signal from the speed and in turn provides the variation in pulse width signal that sets the frequency, which provides the different switching frequency for the desired speed [1].

1.1 Multilevel inverter

Multilevel inverters used most of the Application because of their high EMF operation combability, reduction in electromagnetic interference, low switching loss and high efficiency. The multilevel inverter was first developed by Nabea El Al in 1981. The multilevel inverters are popularly used power electronics application and with the reduction of hormonic disturbance and electromagnetic interference [3].

1.2 Control technique

The inverter output voltage is controlled by inverter input voltage control (Changing DC voltage level) or by voltage control within the inverter. PWM approach is based on switching control in the inverter to control the voltage and optimize the harmonics. PWM techniques are Selected harmonics elimination (SHE)PWM, SPWM, Minimum ripple current PWM, Random PWM, Sinusoidal PWM with instantaneous current control [4].

2. BLOCK DIAGRAM OF AC DRIVE

The proposed block diagram of the AC drive is as shown in Fig 1.

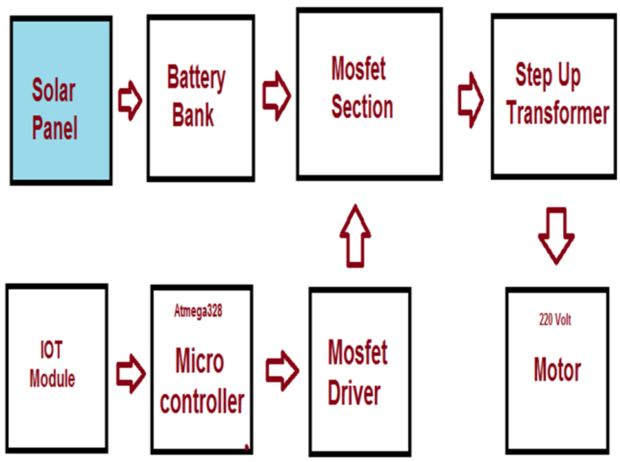

Fig 1 Schematic Representation of the AC drive

By providing suitable input voltage, IRF540 MOSFET turns on and current flows from drain to source terminal. The input pulses for the IRF540 MOSFETs are generated using Arduino atmega328. These input pulses of IRF540 MOSFET complemented each other. The IRF540 MOSFET trigger with input voltage of around 10V to 12V for properly switching ON, but since Arduinos work with 5V its output cannot be directly configured with a MOSFET. Arduino runs with 5V supply, and all of its outputs are designed to produce 5V as the logic high supply signal. Although this 5V may have the ability to switch ON a MOSFET, it results in an inefficient switching of the devices and heating up issues. For effective MOSFET switching, and to transform the 5V output from Arduino into a 12V by using MOSFET driver circuit and resistor are used to limit the gate terminal current of the MOSFET. The resistor values between 10 and 100 ohms could be used at MOSFET gates for safeguarding their gates from unexpected voltage spikes. The output generated from inverter is provided as input to the transformer. The input voltage of 12V at the primary side is converted into to a high voltage of 220V at secondary side, which is given as input to the induction motor.

Input or Battery bank: The input DC voltage source is associated to a solar PV array to gets regulated and constant DC output voltage.

Inverter Section: The proposed inverter includes power switches; diodes and it provides higher voltages at load as compare to input voltages.

Load: The inverter provides the output voltage of 220V and 45W induction motor load. In this project, the inverter is designed to offer output voltage of 220V.

Transformer: A Step-up transformer 12-0-12V, 220V, 3A is used to convert primary side i.e. 12V to high voltage at secondary side i.e. 220V.

Optocoupler: Optocoupler are used to provide isolation between the circuits interconnecting by means of light sensitive optical interference. In this project, it is connected between inverter switches and microcontroller to provide isolation.

Microcontroller: The switching pulses are generated by using Atmega328 controller for 25KHz as operating frequency and it requires regulated 5V power supply.

MOSFET driver: The MOSFET trigger with input voltage of around 10V to 12V for properly switching on by using driver circuit.

The proposed AC drives specifications are mentioned as follows.

Input voltage	: 12V
Output voltage	: 220V
Power Rating	: 45W
Efficiency (η)	: >80%
Voltage regulation	: < ±5%
Power factor	: 0.9
Frequency	: 50Hz
Speed	:900rpm

3. SIMULATION AND HARDWARE IMLEMENTATION

The circuit of multilevel inverter simulated in MATLAB as appeared in Fig 2. The simulated circuit includes 8 MOSFET switches, Load, Four Comparator, Four Not gate. The Voltmeter scope connected across load to measure output voltage of the inverter. Current

scope connected across the MOSFETs. The input voltage 12V is boosted to output voltage of 230V. MOSFETs are used in this simulation and also in hardware due to a lower cost.

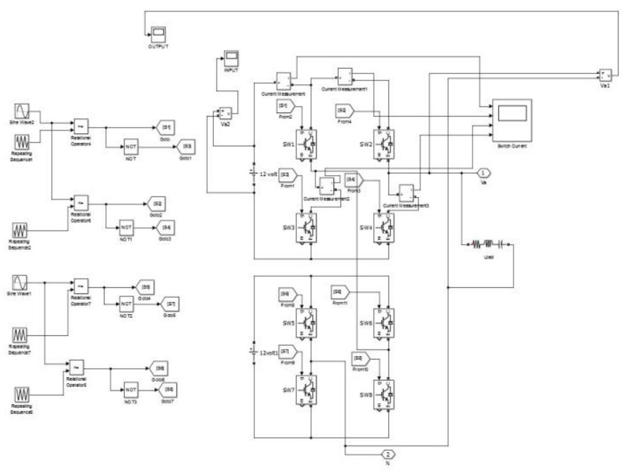

Fig 2 Simulated circuit

The hardware module as shown in Fig 3.

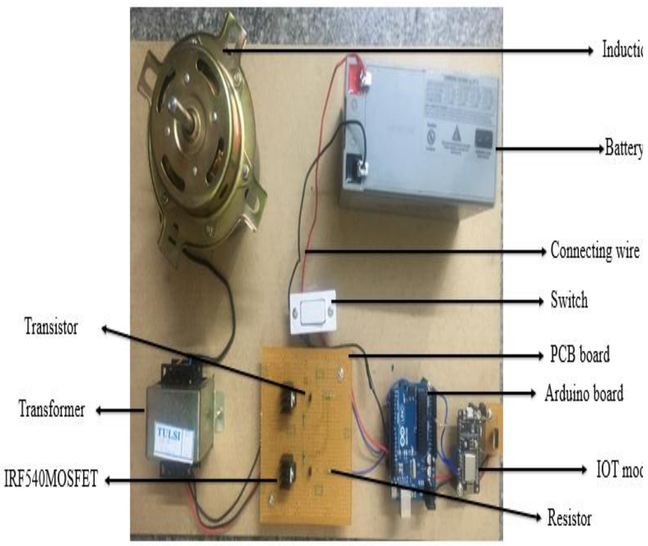

Fig 3 Hardware Module

The hardware setup for testing is as shown in Fig 4.

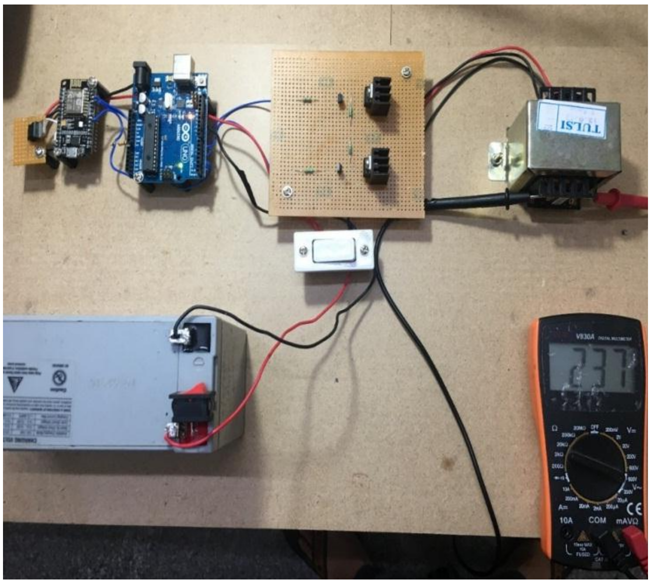

Fig 4 Hardware setup

The proposed hardware module includes battery, modular switch, Arduino board, IOT module, MOSFET (IRF540), transistor (BC547), step up transformer, Induction motor load, resistor and connecting wires are shown in Fig 4.

The battery which supplies the voltage of 12V to the inverter circuit. It changes the DC input voltage into AC output voltage. The AC output voltage of the inverter circuit is step up to 220V by using Step-up transformer. The IOT module and Arduino board used to control and generate the switching pulses. The driver circuit is utilized to supplies the sufficient voltage to drive the MOSFET. To limit the current flow of the gate terminal by using resistors.

4. RESULTS AND WAVEFORMS

Results of simulation

The supply voltage provided to the circuit from constant DC source is 12V as appeared in Fig 5.

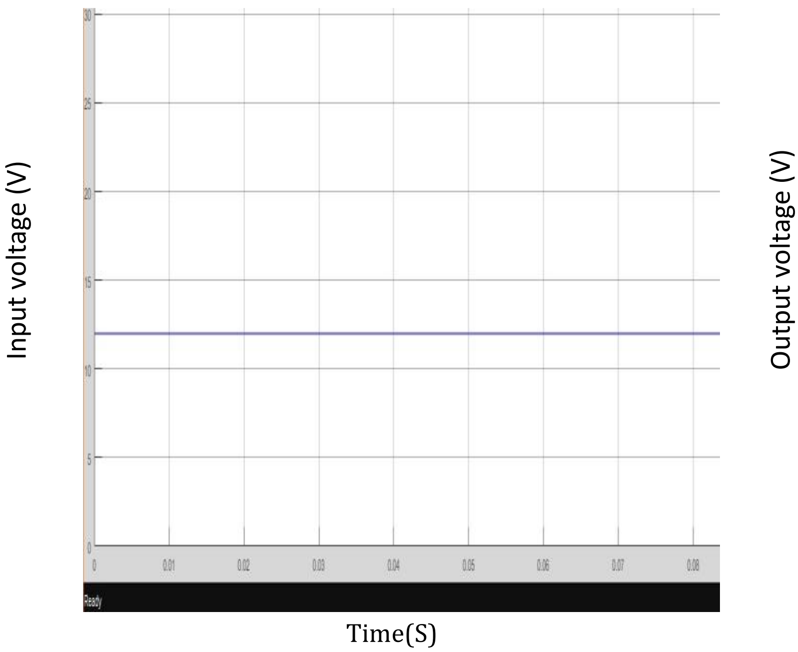

Fig 5 Input waveform

The switching current of the inverter switch S1, S2, S3 and S4 as appeared in Fig 6

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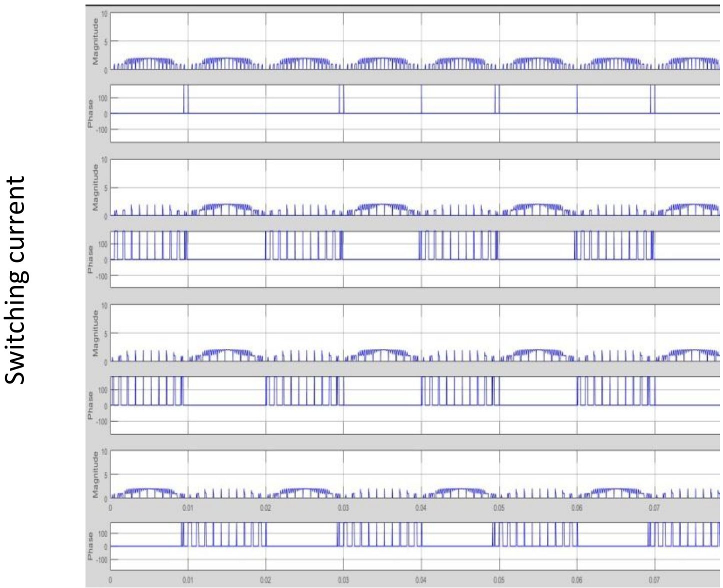

Fig 6 Switching current

The simulation of inverter of output voltage as shown in Fig 7. The observed output voltage is 220V.

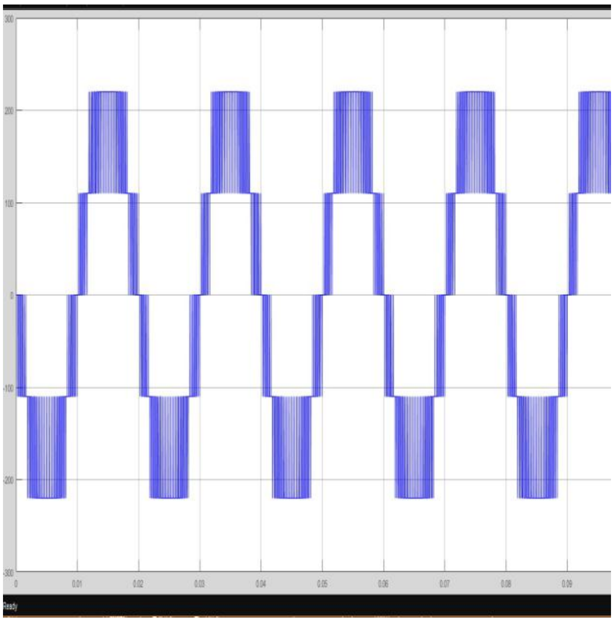

Fig 7 Output voltage

Results of Hardware

The hardware implementation of proposed work involves power supply circuit and PWM controller circuit. The design specification for supply voltage of 12V and output voltage of 220V is successfully implemented. The hardware module and output voltage estimated across the load as appeared in Fig 8.

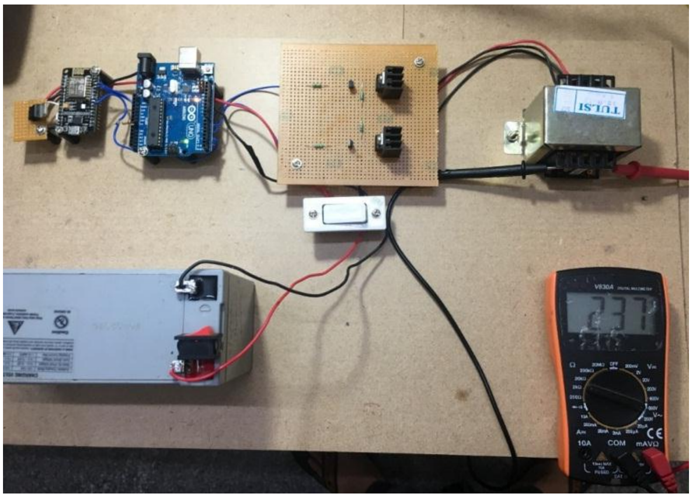

Fig 8 Output voltage of 237V

Calculation of voltage regulation:

$$\%\text{Voltage regulation} = \frac{Vo(vinmax) - Vo(vinmin)}{Vo(nominal)} * 100$$

$$Voltage\ regulation = \frac{229 - 237}{237} * 100$$

Voltage regulation = 3.37%

The simulated and hardware results as shown in Table 1.

Table 1: simulated and hardware result

Parameter	**Output Results**	
	Simulation Result	**Hardware Result**
Input voltage	12V	12V
Output Voltage (Vnl)	220V	229V
Output voltage (Vfl)	220V	237V

5. CONCLUSIONS

In this project work, 45W inverter topology designed for speed control of low rating induction motor. Providing an input voltage of 12V by using lead acid battery as a source, the inverter of is simulated at a switching frequency of 25KHz and its implemented to obtain the output voltage of 220V. The MOSFET switching state was conducted for equal duration and according to the operation, duty ratios are considered. The MOSFET swathes are triggered by PWM pulses obtained by programming atmega328 microcontroller. Voltage and current waveform of each circuit element is studied and data obtained is used for selection of components to improve the hardware. 45W inverter is designed for low rating induction motor, simulated in MATLAB and implemented to analyze the performance of the inverter. The inverter for low rating induction motor is designed and successfully implemented for input voltage of 12V to get the output voltage of 220V and output regulation is less than 5%

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