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HARMONICS MITIGATION IN INVERTER BY IMPLEMENTING SHEPWM TECHNIQUE

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Abstract: The use of power electronic converters has increased significantly in recent years due to their high efficiency, flexibility, and reliability. However, the switching action of these converters causes harmonic distortion in the output waveform, leading to undesirable effects such as electromagnetic interference, reduced power quality, and increased losses. To mitigate these issues, various modulation techniques have been developed, such as Pulse Width Modulation (PWM) and Selective Harmonic Elimination Pulse Width Modulation (SHEPWM). This paper presents a comparative study of the harmonic distortion in between PWM and SHEPWM techniques, analyzing their advantages and disadvantages, and providing insights into their performance under different operating conditions. The results indicate that SHEPWM offers superior harmonic distortion reduction at the cost of increased complexity, while PWM is simpler to implement but may require additional filtering to achieve acceptable distortion levels.

Keywords: Opto Coupler Driver, IGBT, SHEPWM, Resistive Load.

I. INTRODUCTION

An inverter is one of the most important pieces of equipment in a solar energy system. It's a device that converts direct current (DC to alternating current. The resulting AC frequency obtained depends on the particular device employed. Inverters do the opposite of rectifiers which were originally large electromechanical devices converting AC to DC. A typical inverter requires a stable DC power source capable of supplying enough current for the intended power demands of the system. The input and output voltage depends on the design and purpose of the inverter. There are 3 major types of inverters - square wave, modified sine wave (actually a modified square wave), and sine wave. A square wave inverter is the cheapest one used to run simple things like tools with universal motors. Square wave inverters are seldom seen anymore. On the other hand, sine wave inverters can be used to run any type of load but they are very expensive. Here, the role of modified sine wave inverter (also referred as modified square wave inverters) comes into picture since these are effective than the square wave inverters and very much cheaper than the sine wave. A modified sine wave inverter will work fine with most equipment. The performance of the modified square wave inverter can be improved further for improving the power quality particularly to reduce the harmonics.

II. BLOCK DIAGRAM

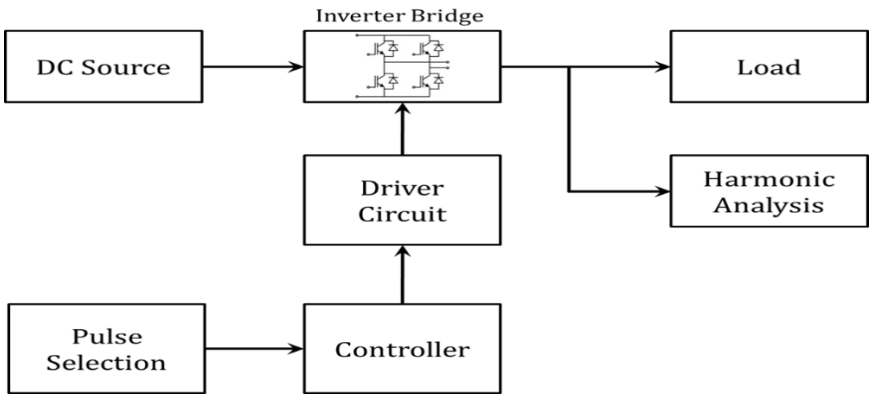

Fig. 1. Block Diagram

This requires the carrier modulation techniques to be incorporated in inverter. Recently the multilevel inverters have been

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introduced for mitigation of harmonics. However, the multilevel inverter requires additional switches in inverter bridge and complex controlling circuit. This project work aims to analyse the harmonics profile of PWM inverter and investigate the effect of carrier frequency on harmonic contents.

III. HARDWARE REQUIRED

A. Controller

Fig. 2. Arduino Uno

- Features of The Controller:

1. Analog to digital converter input voltage sensing
2. Serial communication interface for debugging
3. Digital input/ output ports for relays & Level sensor interface
4. 5 Volt interface with I/O devices

- Key Features OF Arduino Uno

1. Microcontroller: AT Mega 328
2. Operating Voltage: 5V
3. Supply voltage: 7 – 20V
4. 14 digital I/O pins
5. 6 Analog input pins
6. 6 configurable PWM outputs

B. H- Bridge Inverter

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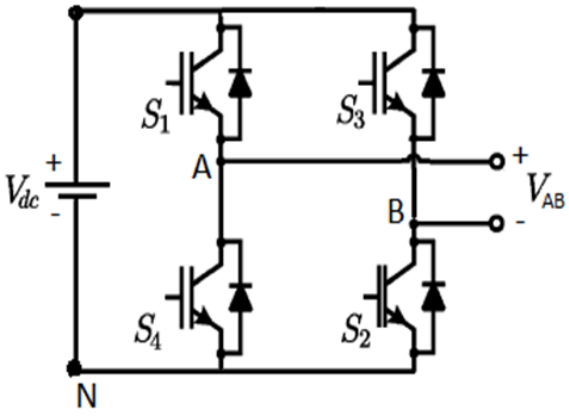

Fig. 3. H- Bridge Inverter

Table: Inverter specifications

Type	Three phase four leg
Voltage	220V
Power	500W
Frequency	50HZ

On the basis of the parameters as given in table 4.1, the current is calculated from the equation of power as

$$P = V_L I_L \cos\varphi$$

$$I_L = \frac{P}{V_L \cos\varphi}$$

$$I_L = \frac{500}{220 \times 1}$$

$$I_L = 2.27A$$

Considering the voltage rating of inverter as 220V and current as 3A the IGBT devices are selected on following points

❖ The voltage rating of the selected IGBT shall be greater than three times the maximum working voltage

Voltage rating shall be greater than 660V

❖ The current rating of the selected IGBT shall be greater than two times the maximum working

Current rating shall be greater than 6A

❖ The operating frequency (response time) of the selected IGBT shall be competent with the required frequency of inverter

Response time less than 10 mS (frequency 50Hz)

Considering above stipulations, IGBT 25N120 is selected for prototype development (refer datasheets of 25N120). The key specification of IGBT 25N120 are

Voltage = 1200V
Current = 25A
TON = 50nS
TOFF = 190nS
TR = 60nS
TF = 100nS
Total response time = 400ns = 0.4μS

C. Opto-coupler Drivers:

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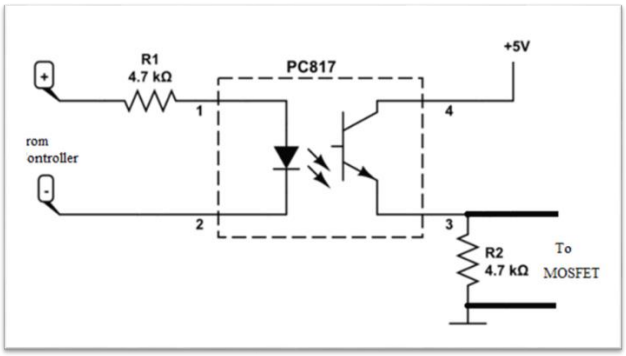

Fig. 4. Opto-coupler Drivers

IGBT is power electronic switching device operating at high voltage. The microcontroller gives control signal in form of PWM. The desired isolation and coupling between low voltage microcontroller and high voltage MOSFET is provided through PC817 based opto coupler driver circuit as mentioned in figure. Opto coupler driver circuit working on Photosynthesis effect.

D. DC Power Supply for Driver Circuit

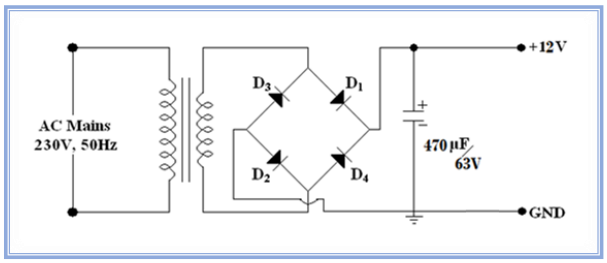

Fig. 5. DC Power Supply for Driver Circuit

The required output voltage from DC supply is 12V and output current is 1A.
But output of filter should be 2 to 3 V greater than 12V i.e., Vdc at filter = 14V

$$V_{dc} = \frac{2V_m}{\pi}$$

$$V_m = \frac{V_{dc}\pi}{2} = \frac{14 \times 3.14}{2} = 21.98V$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{21.98}{1.414} = 15.54V$$

Thus, selected step-down transformer is 230V/15V and 1A.
Selection of Diode:
The step-downed AC voltage is given to bridge rectifier which transforms into DC. During positive half cycle of AC signal, only two diodes (D1, D2) are in conducting state, while in negative half cycle, the remaining two diodes (D3, D4) are to be conducted. So in both half cycles, current flows through load in only one direction but magnitude changes continuously. Thus, output of rectifier becomes pulsating DC. For rectification, diodes with following rating are required.
Peak Inverse voltage of diode PIV > 2Vm. i.e. PIV > 2 X 22 = 44V.
Diode current > load current > 1A
So, 1N4007 diode has been selected.
Selection of Capacitor:
The frequency of rectifier output is 100Hz.
Therefore, ΔT = 1 / F, the time period = 1 / 100Hz = 0.01S = 10mS.
Assume voltage change in capacitor of 10% when minimum input voltage of 207V.

$$\Delta V = 184 \times 0.1 \times \sqrt{2} = 26V$$

The current drawn at full load Idc =1A
Therefore, the value of capacitor is calculated from equation (4.5) is given by,

$$C = \frac{I \times \Delta T}{\Delta V}$$

$$C = \frac{1 \times 0.01}{26}$$

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$C = 0.000384F = 384\mu F$

Selected Capacitance $C = 470\mu F$

D. Load

Fig. 6. Lamp as A Resistive Load

E. Pot, Switches and LEDs

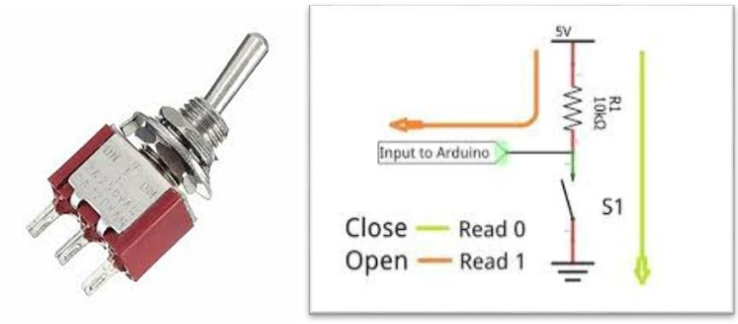

Fig. 7. Toggle switch & interfacing with Arduino

A Toggle Switch is an electromechanical switch which uses a lever or baton as an actuator. Toggle switches are available in many sizes and configurations and offer a wide range of uses. They are popular for their ease of operation and generally offer positions to open or close a circuit.

A potentiometer is a simple mechanical device that provides a varying amount of resistance when its shaft is turned. The variable terminal of the pot gives out the variable analog output voltage.

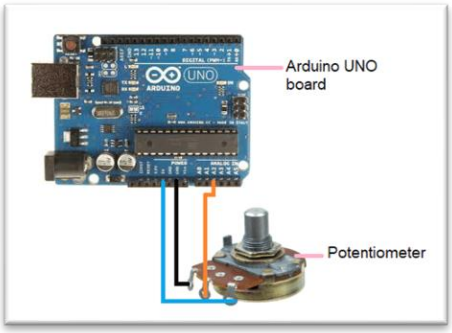

Fig. 8. Schematic of Arduino – Pot Interface

IV.WORKING

The H bridge inverter is the core component of the system. By using four IGBT circuit We are developed the H bridge inverter. The operation is performed of H bridge inverter by using driver circuit. In a driver circuit, the opto coupler device is used. The opto coupler is an electronic component that transfer the signal between two isolated circuit by using

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photosynthesis effect. The opto coupler is provided triggering pulses to the inverter bridge. It is excited with DC source. These triggering pulses are generated by a controller. The controller takes input from a pulse election switch which is

Unit Of Harmonics	TOTAL HARMONIC DISTORTION	
Technique of Harmonics Reduction	PWM	SHEPWM
THD reduction in System	44.1	29.0

used as an input to the controller for selecting either square wave triggering pulses or SHEPWM triggering pulses. Arduino used as a controller for producing the gate pulses. The power quality analysis is performed for harmonics. Comparison of harmonics between square wave inverter and SHEPWM inverter would indicate mitigation of harmonics. Selective Harmonic Elimination (SHE) Pulse Width Modulation (PWM) is a technique used in power electronics to eliminate specific harmonics in the output waveform of a power converter. The basic idea behind SHE PWM is to determine the switching angles of the power converter in such a way that certain harmonics in the output waveform are cancelled out or eliminated. This is achieved by solving a set of non-linear equations that relate the switching angles of the power converter to the desired harmonic elimination. Identify the harmonics to be eliminated: The first step is to identify the specific harmonics that need to be eliminated from the output waveform. This is typically done based on the requirements of the particular application. Overall, SHE PWM is a powerful technique for achieving high-quality output waveforms from power converters. By eliminating specific harmonics, it can reduce distortion in the output waveform and improve the performance of the power converter in a variety of applications.

TABLE I
MAIN COMPONENT

Components Required	Specification	Quantity
Arduino Uno	ATmega328p	1
IGBT	200V, 500W	1
Opto coupler	PC817	1
Driver circuit		1
Lamp	100W	1
Pot		1
LED		2
Rectifier		1
Toggle switch		1
Switch		2
Transformer	12v	4

V. RESULT

As per discussion we are conclude that the total harmonics distortion are reduced in the SHEPWM technique is more than the PWM technique.

CONCLUSION

The SHEPWM technique of switching the power electronic devices in the inverter reduces the harmonics as compared to the conventional square wave inverter. The lower order harmonics are mitigated. Such inverter significantly improves the performance of the system which involves induction motors. This inverter is built at lower cost as compared to sine wave inverter

FUTURE SCOPE

The ill effects of harmonics are well known. The surface current effect of harmonics causes heating of electrical equipment's. Here, the concept of SHEPWM inverter can be extended further for development of induction motor drives. The requirements of sine wave inverter can be eliminated with SHEPWM inverters.

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