



Hardware Implementation of 5 Level Inverter Using Microcontroller

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ABSTRACT: An inverter is utilized to transform a direct current (DC) source into an alternating current (AC) source using electronic component like switch. While converting DC to AC, it is conceivable to acquire the preferred output voltage and frequency by two types of inverters, one is two level and another one is multi-level inverter (MLI). Cascaded H-Bridge type of Multi-level inverter is more efficient compare to the other topologies of Multi-level inverter. Minimum total harmonic distortion, reduced EMI are the advantages of MLI, and it can be operated on different voltage levels. Here MOSFETs are used as switches. In this Paper, Simulation and hardware implementation of single phase 5-level cascaded Multi-level inverter with separate DC sources are presented.

KEYWORDS: EMI, Micro-controller ,multilevel inverter, Simulink, THD.

I. INTRODUCTION

Inverter is a device, which transforms a DC source into an AC source. In the real world, all loads (appliances/machines) do not use direct current (DC) power supply as their sources. Induction heating, HVDC transmission, Uninterruptible power supply, electric motor speed control require alternating current (AC) source. If the only available supply is DC, then the conversion of DC to AC is needed, when the loads or any applications require AC power source. In these situations there is a need of inverters. So the inverters show a very significant character in the real world.

In recent years many industrial applications need higher power devices .The moderate voltage and higher power like megawatt power level are requisite by certain moderate voltage motorized drives and utility uses, hence a multi-level power inverter association progresses as an unusual in high power and medium voltage circumstances[1-6].

The conventional inverters yield an output voltage with levels $\pm V_{dc}$, which are termed as the two level inverter. But this output is not a sinusoidal wave. To obtain nearly sinusoidal wave, multi-level inverters are used. Conventional inverters cannot be called as multilevel inverters. If the output of inverter consists of more than 2 levels then only that type of inverter can be called as multilevel inverter. Three level inverter is the initiation of multilevel concept. However, the fundamental perception of a multilevel inverter is to attain higher power with the use of sequence of H-Bridges with numerous low voltage Direct current sources to accomplish the power transformation by generating a set of steps or stepped voltage waveform. Input Direct current sources to the multilevel inverter may be either Batteries or Capacitors or any renewable energy voltage sources.

The advantageous features of a multilevel inverter are listed below,

- Staircase output voltage waveform: Output voltages with very low distortion are generated by multilevel inverters and also with reduced dv/dt stresses. Therefore the problems occurred due to electromagnetic compatibility (EMC) will be reduced.
- Input current: Input current drawn by Multi level inverter is with little distortion.
- Switching Frequency: Multilevel inverters can be functioned at poorer switching frequency which outcomes in lesser switching loss and greater efficiency [7-9].

II. 5 LEVEL INVERTER STRUCTURE

The quantity of distinct levels in the output voltage of cascaded multilevel inverter is well-defined by $m = 2N + 1$. When the number of DC sources is 2 (i.e. $N=2$), then the number of levels would be, $m=2N+1=2(2)+1=5$. Hence when the

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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quantity of DC sources is two, a five level output is obtained. The 5 level inverter consists of two H-bridges shown in Fig.1, which are fed by Separate DC sources. There are four switches namely and S1, S2, S3, S4 in the first H-Bridge and there are four more switches namely S5, S6, S7, S8 in the second H-bridge. The load is associated between the terminals A and B. [5]

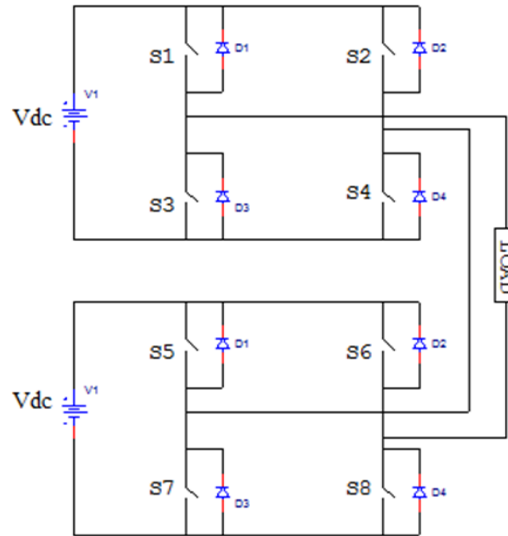


Fig.1. Five level H-bridge inverter circuit.

The multilevel output voltage can be obtained by closing the appropriate switches mentioned in the switching sequence table1. Example: by opening all the switches, we get zero output voltage across the load. To get V_{dc} across the load, close the switches S1, S4,S7,S8.

	SWITCHES							
Output Voltage	S1	S2	S3	S4	S5	S6	S7	S8
0	0	0	0	0	0	0	0	0
V_{dc}	1	0	0	1	0	0	1	1
$2V_{dc}$	1	0	0	1	1	0	0	1
$-V_{dc}$	0	1	1	0	0	0	1	1
$-2V_{dc}$	0	1	1	0	0	1	1	0

Table 1: Switching States of a 5 Level Inverter

III. SIMULATION ANALYSIS

The Simulink model for 5 level H-bridge inverter is developed using MATLAB is as shown in Fig.2. The subsystem pulse generator consists of 8 pulse generators in order to generate the gate pulses for each MOSFET's. The delays and pulse widths in each pulse generator are calculated according to the switching pulses.

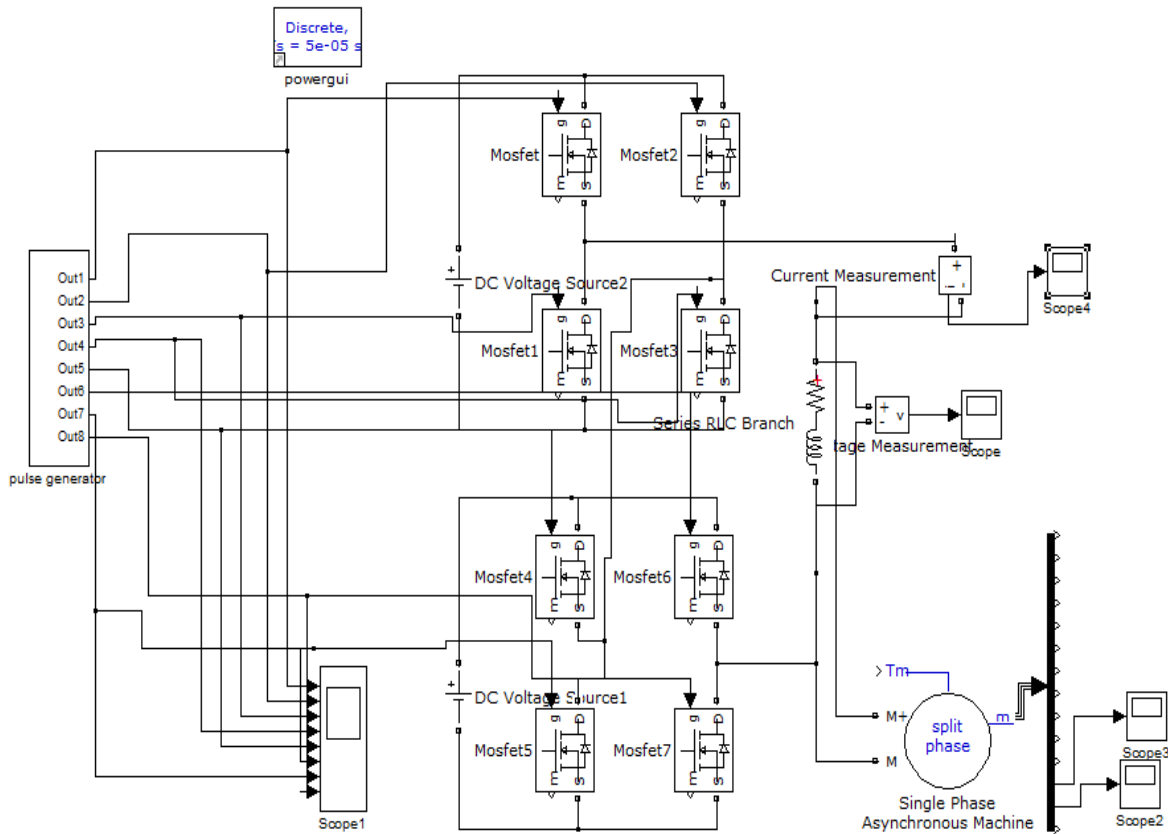


Fig. 2. Simulink model of 5 level inverter

INVERTER SPECIFICATIONS:

Input voltage=24V for each h bridge

Output voltage= 48 V (for 5 level)

Motor: Type: Split phase induction motor

1) Rated Voltage 110V

2) Rated Power (P) 0.25HP

3) Main winding stator resistance 2.02Ω

4) Main winding rotor resistance 4.12Ω

IV. HARDWARE IMPLEMENTATION

In the hardware prototype shown in Fig.3, a supply voltage of 230V is stepped down to 12V using a ‘step-down’ transformer, which is then transformed to Direct Current using a diode bridge rectifier. The rectified voltage is then fed to the voltage regulator IC, which regulates the voltage to 5V and it is fed to microcontroller as supply. The required components for hardware setup are as shown in table2.

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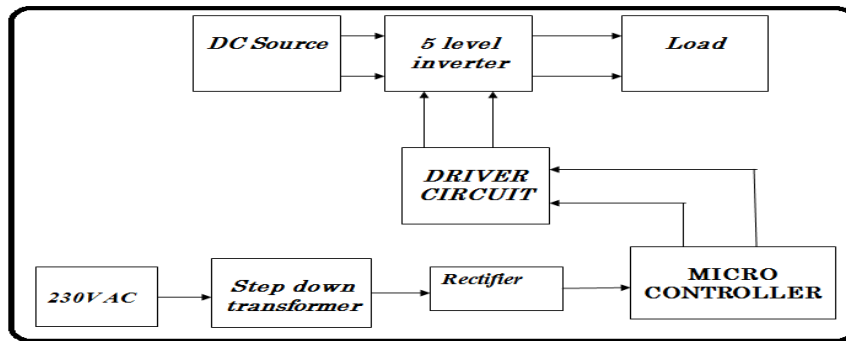


Fig.3. Block diagram of experimental setup of 5 level inverter

Table 2: Components used for Hardware Setup:

Sl.No	Name of the Component	Specification
1	MOSFET	IRF250N
2	Step down transformer	0-12V, 5mA
3	Diode	IN4007
4	Capacitors	1000 μ F
5	Opto coupler	MCT2E
6	Transistors	2N2222,CK100
7	Buffer	HCF4050BE
8	Resistors	100 Ω , 1k Ω
9	Micro controller	AT89C51

Driver Circuit:

The fundamental motivation behind driver circuit (fig.4) is to improve the switching voltage for the MOSFET or any switching device. And also it gives the isolation between the power circuit and the microcontroller circuit. In this project MCT2E opto-coupler is used, which isolates the power circuit with the microcontroller circuit. Signal from microcontroller is given to the driver circuit.

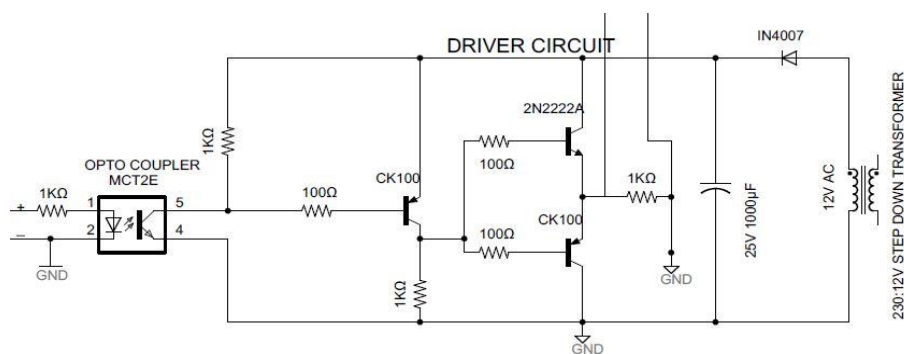


Fig.4. Driver Circuit

Microcontroller (AT89C51):

Microcontroller (AT89C51) is a standout amongst the most generally utilized microcontrollers particularly as a part of car, modern machines and customer applications. In this Paper, it is utilized to create the gate pulses for the MOSFETS.

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HARDWARE SPECIFICATIONS:

The complete hardware specification of the proposed 5 level inverter is as follows, 5V Pulses are produced from the micro controller and the driver output is of 12V.

1. For R load:

Input Voltage - 24V for each H-Bridge

Output voltage - 48 V

Load - 330k Ω wire wound resistor

2. For Motor load

Input Voltage - 24V for each H-Bridge

Output voltage - 30 V

Load- Single phase induction motor-Sewing machine of 220V, 1/12 HP, 70M Ω , 180Mh.

V. SIMULATION AND EXPERIMENTAL RESULTS

With inverter specifications, simulation has been carried out and the output voltage obtained from the Simulink model (fig.2) for R load and RL load was observed from Fig.5 and Fig7, and FFT analysis has been carried out and is as shown in Fig.6.and Fig.8.

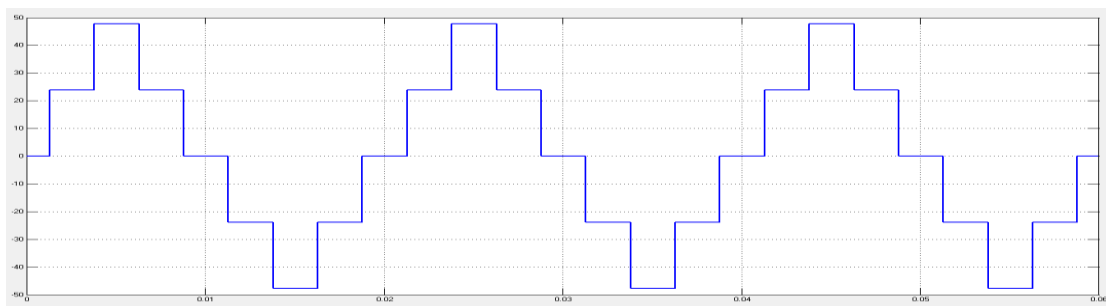


Fig.5.Output voltage of 5 level inverter for R load

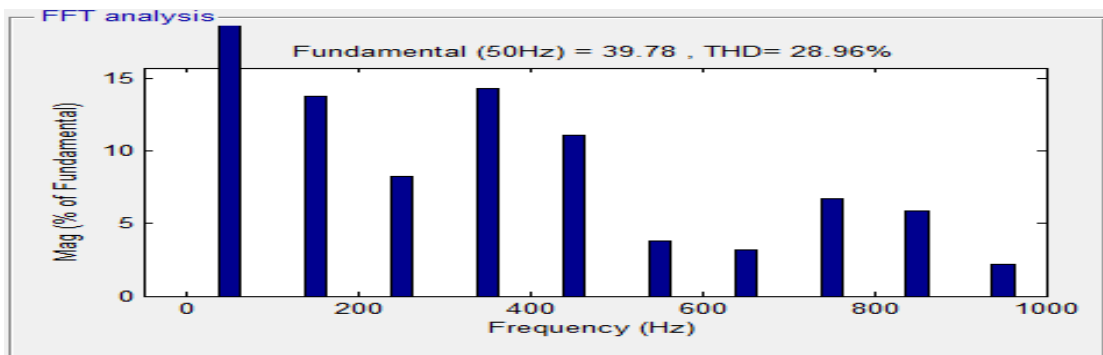


Fig.6.TH D calculation from FFT analysis

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

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Vol. 5, Issue 1, January 2016

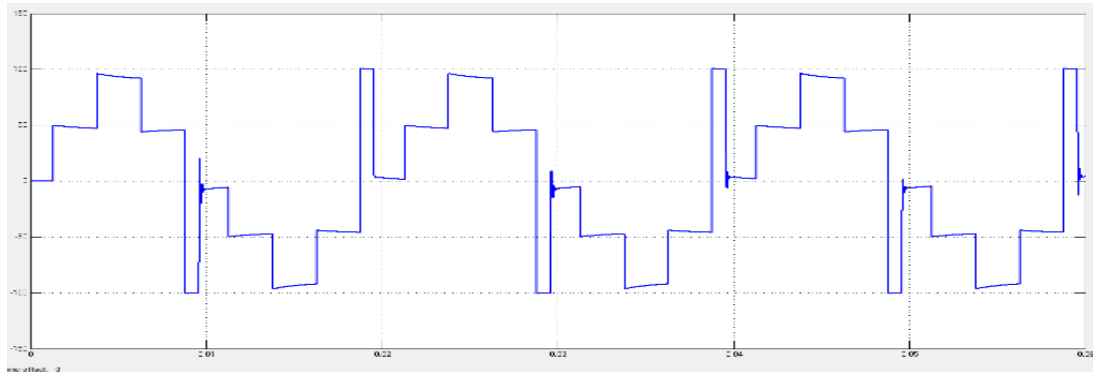


Fig.7. Output voltage of 5 level inverter for RL load

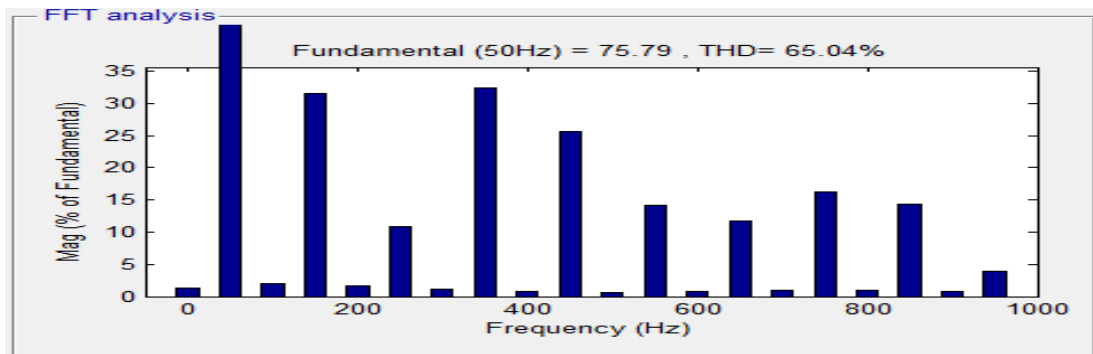


Fig.8. THD calculation from FFT analysis

The experimental set up for 5 level inverter is as shown in the Fig.9, The driver output of 12 V given to the each MOSFET is as shown in the Fig.10. The stepped output voltage waveform across the R and RL load are as shown in Fig.11 and Fig.12.

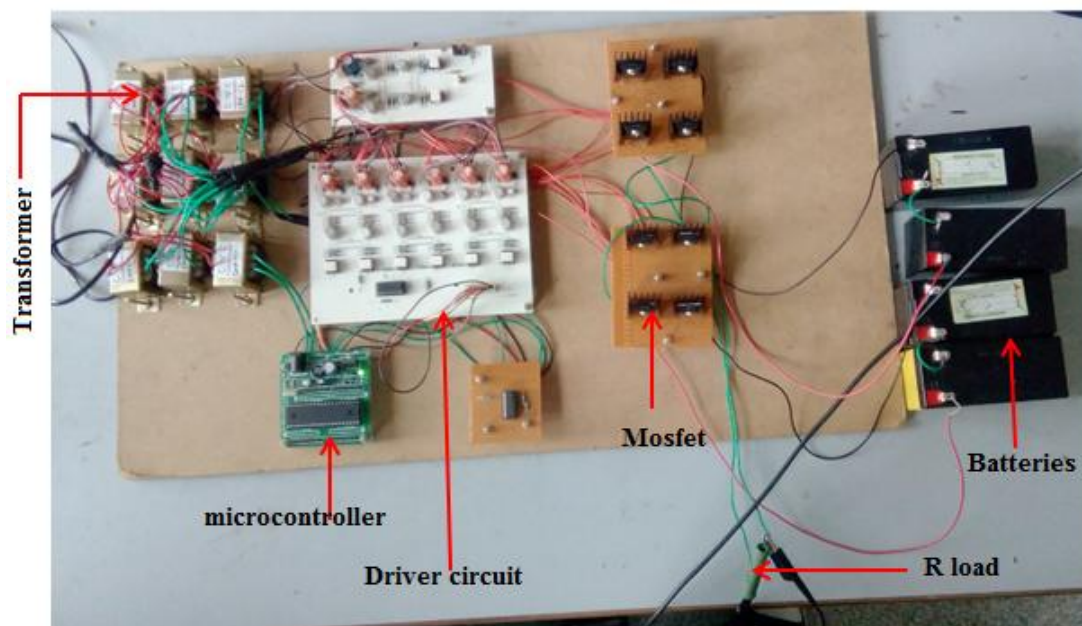


Fig.9. Hardware prototype for 5 level inverter with Induction Motor

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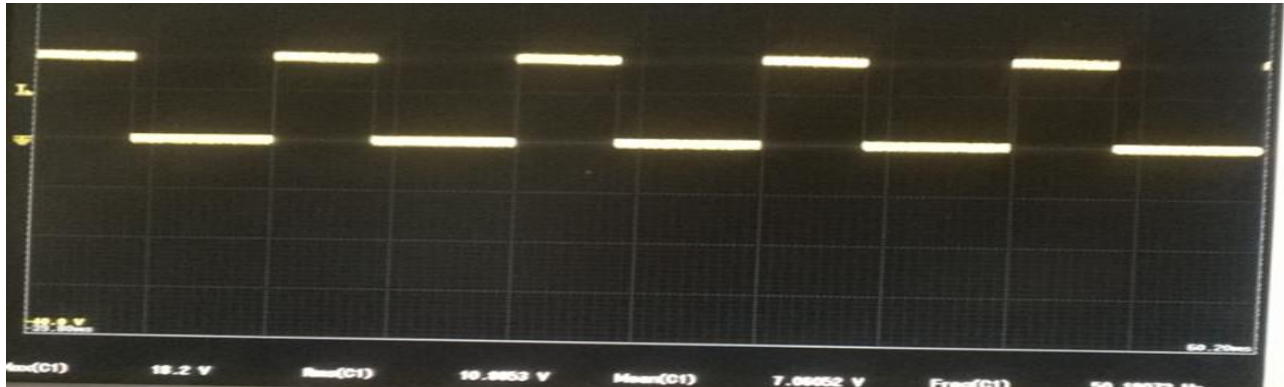


Fig.10.Driver circuit Output



Fig.11.Output voltage across R load

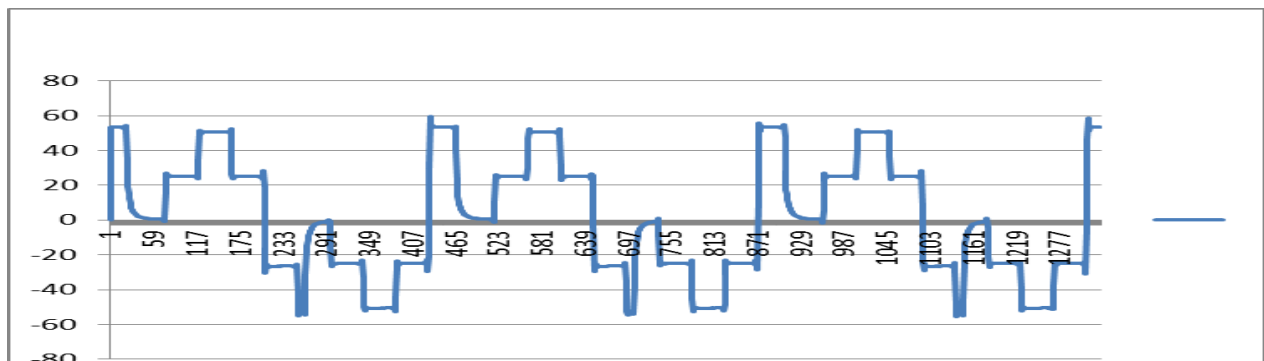


Fig.12. output voltage across RL(motor) load

VI. CONCLUSION

In this paper, simulation of 5 level inverter with single phase induction motor has been proposed and the hardware prototype of 5 level inverter with induction motor using microcontroller AT89C51 is implemented. Future work will be towards the implementation of 7, 9 and 11 level inverters. As the levels of output increases, nearly sinusoidal waveform will be obtained, this results in reduced THD. So the benefits of multilevel inverter include, lower transient power loss due to low-frequency switching, less THD, reduced ac filters, and possibility to replace MOSFETs with IGBTs, and thereby providing compact power conversion. It can be concluded that, in order to maintain the good quality of power, it is necessary to replace the conventional drives with 2 level inverters by multilevel inverters.



ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 1, January 2016

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