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Hardware Implementation of 3-level Inverter using Microcontroller for Single Phase Induction Motor

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ABSTRACT

The conventional two level inverter has many limitations for high voltage & high power applications. The term multilevel began with the three-level inverter. Subsequently, several multilevel inverter topologies have been developed. However, the elementary concept of a multilevel inverter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform. Output voltage of 3 level inverter consists of 3 levels, which results smoother output. And hence the THD will be reduced. In this paper Simulink of 3 level inverter and the hardware implementation of micro controller based control of multilevel inverter for single phase Induction motor are presented.

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1. INTRODUCTION

Multilevel inverters have drawn tremendous interest in power industries. There is a requirement of medium voltage and megawatt power level for Some medium voltage motor drives and utility applications. It is troublesome to connect only one power semiconductor switch directly for a medium voltage grid. As a result of this, development of multilevel power inverter has been done as an alternative in high power and medium voltage situations.

The multilevel inverter concept had introduced since 1975. The term multilevel began with the three-level inverter. Subsequently, several multilevel inverter topologies have been developed. However, the elementary concept of a multilevel inverter to achieve higher power is to use a series of power semiconductor switches with several lower voltage dc sources to perform the power conversion by synthesizing a staircase voltage waveform.The dc voltage sources can replaced by Capacitors, batteries, and renewable energy voltage sources .

The conventional inverters produce an output voltage with levels ± Vdc. They are known as the two level inverter. This output is not a sinusoidal wave. To obtain near sinusoidal wave multilevel inverters are used.

MLIs are mainly classified into three types i.e. (a) Cascaded H-Bridge type which can be series or parallel connected and more advantageous to use than other topologies. (b) Diode clamped type which provides different voltage levels by connecting series bank capacitors and the number of levels that are being limited to three levels because of the voltage balancing issues. The main disadvantage of using this topology is the use of more number of diodes. (c) Flying capacitor type which is designed by series connection of capacitor clamped switching cells and disadvantageous to use because of the more number of use of capacitors.

The topology cascaded H-bridge multilevel inverter is advantageous with respect to other topologies as voltage level can be easily increased in steps by increasing the number of dc sources. Multilevel inverter

helps in synthesizing desired staircase output voltage waveform from several dc sources used as input for the multilevel inverter. Increase in the number of dc source leads closer to the pure sinusoidal voltage waveform. These multilevel inverters found their applications in induction motor drives, static VAR compensation, UPS system, laminators, mills, conveyors and compressors etc. To obtain the sinusoidal voltage waveform from multiple dc sources the semiconductors switches are switched on and off in appropriate way so that the total harmonic distortion (THD) % will be reduced.

2. FEATURES OF MULTILEVEL INVERTER

- Due to the utilization of multiple levels it has the ability to reduce the voltage stress on each power device on the dc bus.
- It can be operated at low switching frequency.
- It gives the staircase output waveform, which is almost near to sinusoidal wave, which results in a less THD.
- Reduced dv/dt stresses.

3. 3 LEVEL INVERTER STRUCTURE

The smallest number of voltage levels for a multilevel inverter using cascaded inverter with separate dc sources is three. To achieve a three-level output waveform, a single full-bridge inverter is employed.The inverter circuit consists of four main switches and four freewheeling diodes, which can also be called as H-Bridge.

By closing the appropriate switches, each H-bridge inverter can produce three different voltages: +Vdc, 0 and –Vdc. When switches S1 and S4 are closed, the output voltage is +Vdc. When switches S2 and S3 are closed, the output voltage is –Vdc and when either the switches S1 and S2 or the switches S3 and S4 are closed, the output voltage is 0.

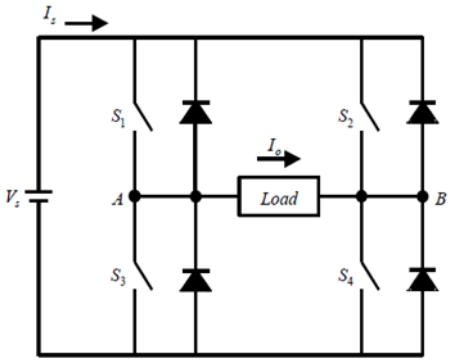

Figure 1. Three level or H-bridge inverter circuit

The number of output phase voltage levels in a cascaded inverter is defined by m = 2s +1.When the number of DC source is 1 (ie S=1), then the number of levels would be

m=2S+1=2 (1)+1=3

Hence when the number of dc sources is one, a three level output is obtained.

Table 1. Switching states of a 3 level inverter

Output voltage	S1	S2	S3	S4
0	0	0	0	0
Vs	1	0	0	1
-Vs	0	1	1	0

4. SIMULATION RESULTS

For simulation of a 3-level MLI, single dc source is used as shown in Figure 1. In this paper single 12V dc source is selected. Ie input voltage is 12V for the inverter and the output voltage levels are 0,12V, -12V. There are 3 ouput levels hence the name 3 level inverter.

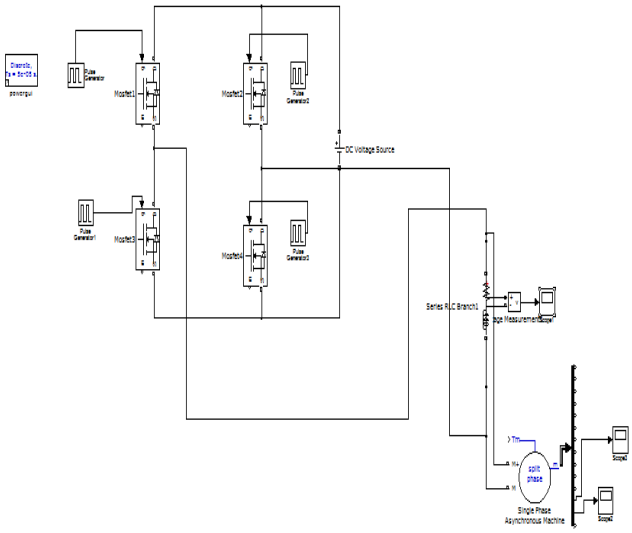

Figure 2. Simulink of 3 level inverter

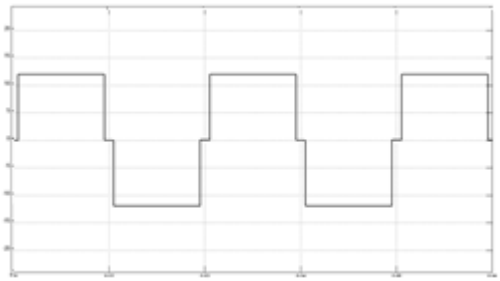

Figure 3. Output voltage of 3 level inverter

5. HARDWARE IMPLEMENTATION

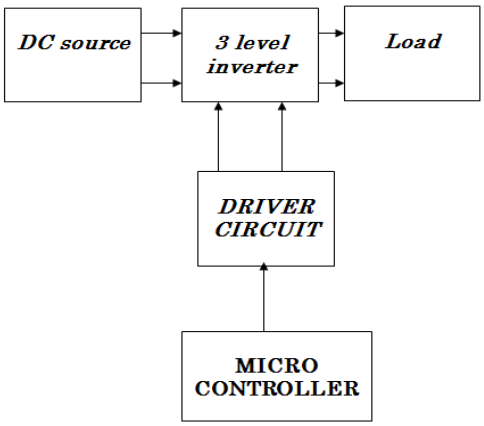

Figure 4. Block diagram of experimental setup of 3 level inverter

Battery is used as a dc source, which is given as input to the H-bridge. MOSFETS are used as switches. Microcontroller is used to generate pulses of 5V (inverted & non inverted pulses shown in Figure 7) and then these pulses are given to the driver circuit.

1. Driver Circuit

The main purpose of driver circuit is to enhance the swithching voltage for the mosfet or any switching device.And also we have to isolate the power circuit from the microcontroller circuit.Because the power circuit current must not enter into the microcontroller circuit. MCT2E is the optocoupler which isolates the power circuit with the microcontroller circuit.After it gets the signal from thre microcontroller & it will get enhanced using the 2N2222 transistor to higher level of voltage. After this the voltage get regulated by the use of darlington pair. The darlington is made of 2N2222 (NPN) and CK100 (PNP) transistor.

2. Features of Microcontroller (AT89C51):

- Compatible with MCS-51™ Products
- 4K Bytes of In-System Reprogrammable Flash Memory
- Endurance: 1,000 Write/Erase Cycles
- Fully Static Operation: 0 Hz to 24 MHz
- 32 Programmable I/O Lines
- Two 16-bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial Channel
- Low-power Idle and Power-down Modes

3. Pin Description of AT89C51

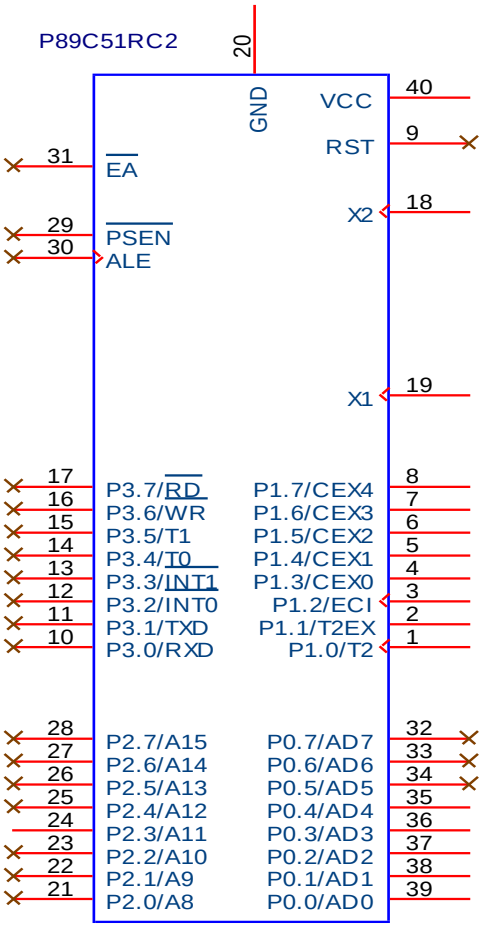

Table 2. Components Table for Hardware Setup

S.No	Name of the Component	Specification
1	MOSFET	IRF250N
2	Stepdown transformer	12V, 5mA
3	Diode	IN4007
4	Capacitors	1000µF
5	Optocoupler	MCT2E
6	Transistors	2N2222,CK100
7	Resistors	100Ω, 1kΩ
8	RMC connector	

4. Hardware Specifications
The complete hardware specification of the proposed system is as follows,
Multilevel Inverter Input and Output :
1. For R load (1kΩ):
Storage Battery of 12V, 1.3Ah as input DC source
Output voltage of 12 V
Output frequency 50Hz
2. Motor load: single phase induction motor-Sewing machine of 220V, 1/12 HP, 70MΩ, 180mH
Rectified ouput of 80V as input to the H-bridge
Output voltage of 78 V
Output frequency 50Hz

In case of a R load battery of 12V is used as input but for motor load AC supply is taken from the autotransformer and is given to the bridge rectifier, which converts ac to DC. The resulted DC is given as input to the H-Bridge.

6. EXPERIMENTAL RESULTS

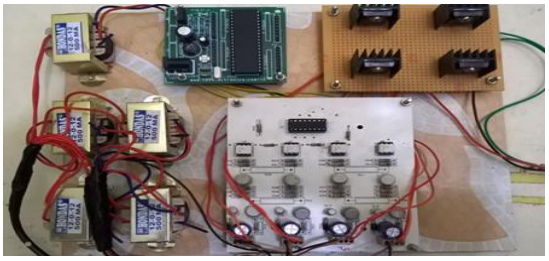

Figure 5. 3 level inverter Hardware circuit board

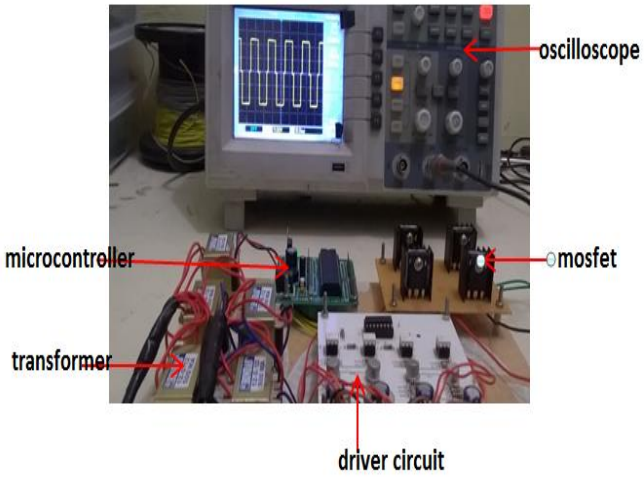

Figure 6. Hardware set up of 3 level inverter with R load

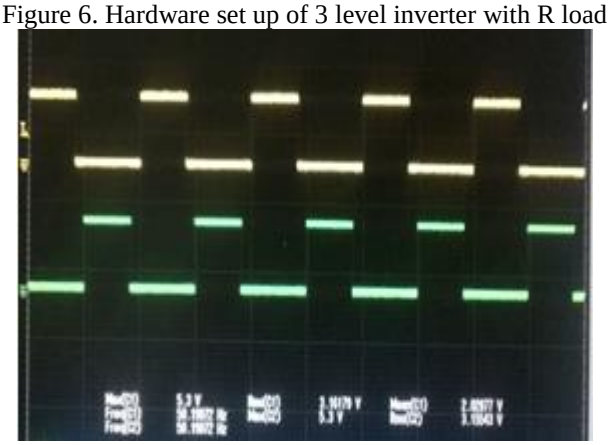

Figure 7. Microcontroller output

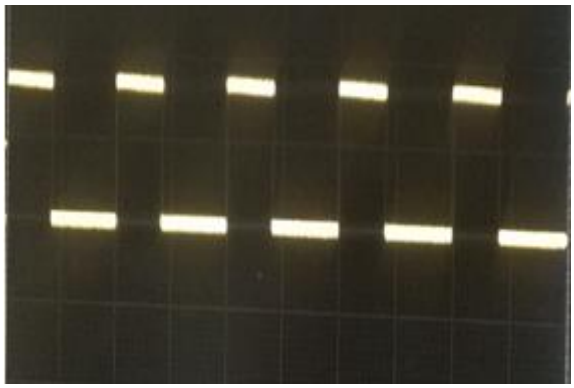

Figure 8. output of driver circuit

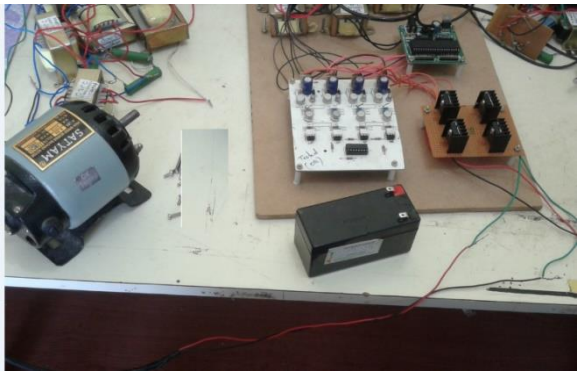

Figure 9. Hardware setup of 3 level inverter with single phase induction motor as load

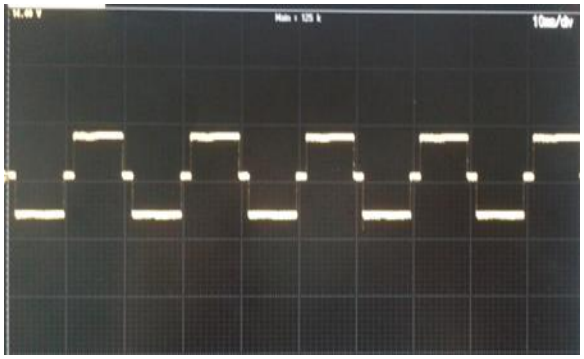

Figure 10. Output voltage across load

7. CONCLUSION

In this paper simulation of 3 level inverter with single phase induction motor has been proposed and the prototype of 3 level inverter with induction motor using microcontroller AT89C51 is implemented. Future work will be towards the implementation of 5, 7, 9 and 11 level inverters.As the levels of output increases, nearly sinusoidal waveform will be obtained, this resuls 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.

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