DESIGN AND IMPLEMENTATION OF THREE PHASE INVERTER FED TO DRIVE THREE PHASE MOTOR

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Abstract

This paper describes the design and implementation of three-phase inverter. Generally inverters are used in high power applications as industrial based induction motor etc. Here the Three-phase Inverter is formed by three legs, each leg consists of two switches. So there are total of six switches. This Three-phase Inverter circuit consists of MOSFETs/IGBT's as switching devices for which the gate pulses are given using Microcontroller. The microcontroller used here is ARDUINO/NI-MYRio through which pulses are generated and given to the switches. The operation of Three-phase Inverter can be performed in two different conduction mode, which are 180^{0}and 120^{0}mode. In this thesis the operation is performed through 180^0 conduction mode. Arduino is interfaced with Mat Lab, where the pulses are generated in the mat lab and given through Arduino. In case of NI-myRIO, pulses are generated through LabVIEW software.In this paper the hardware implementation of this three phase inverter which is fed to a three phase induction motor is successfully carried out.

Keywords: *Voltage Source Inverter (VSI), Arduino, myRIO, LABVIEW, MATLAB.*

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1. INTRODUCTION

By using power electronic devices Inviter converters DC power into AC power at desired output voltage and frequency. In industrial applications most of the inverters are used for adjustable-speed AC drives, High Voltage DC transmission lines etc. The input DC power to the inverter can be taken from Power supply networks, fuel cells, rectifiers etc.

There are commonly two different types of inverter, one is voltage source inverters (VSI) and the other is current source inverter (CSI). The inverter with a DC source of small negligible impedance, i.e. there is a stiff DC voltage source at the input terminals of the inverter, then it is known as Voltage Fed Inverter (VFI) or Voltage Source Inverter. If the DC source at the input terminal is high, i.e. it has a stiff DC current source, this inverter is known as Current Fed Inverter (CFI) or Current Source Inverter. In this the hard ware implementation of three phase voltage source inverters will be discussed.

There are different types of inverters available and each inverters are designed in such a way that it performs or suits a particular applications. Inverters can be classified in to two main types.
1. SINGLE PHASE INVERTER
2. THREE PHASE INVERTER

2. THREE PHASE INVERTER

In this three phase inverter is formed by six Step Bridge by using six switches, and each phase of this inverter consists of two switches. Here for one complete cycle of 360^0, each step is of 60^0 interval for a six step inverter. The figure of three phase inverter using six switches is shown below

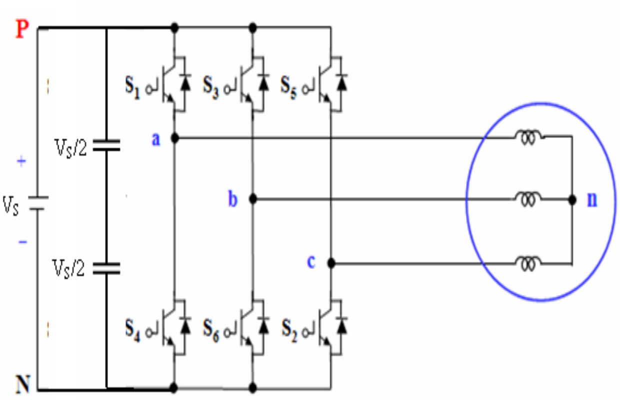

Fig 1 Three phase inverter using six switches

In the above fig. there are capacitors which are connected at the input terminals, these capacitors suppresses the harmonics which are fed back to the source and also keeps the DC input constant.Two different patterns can be used for gating switches.
(a). 180^0 Conduction Mode
(b). 120^0 Conduction Mode

In 180^0 Conduction Mode each switch conducts for 180^0 and three switches will in ON condition at any instant of time.

Here in this controlling technique, each switch conducts for a period of 180^0. Three switches remains ON at any instant of time. When the switch MOSFET/IGBT S1 is switched ON, positive terminal of input DC voltage is connected. When switch MOSFET/IGBT S4 is turned ON, negative terminal of input DC voltage connected. In each cycle there are six modes of operation and each mode is for a duration of 60^0. The numbering of MOSFET/IGBT are given depending up on the gating pulse sequence. To obtain balanced three phase voltage the gating signals are shifted by 60^0 with one another.The load may be of Star connection or Delta connection, the switches in the inverter which are on the same leg (S1 and S4, S3 and S6, S5 and S2) should not be switched on at same time. If not this would result in short circuit of DC link voltage supply. In the same way switches of the same leg should not be switched off at the same time i.e. to avoid undefined AC output line voltages.

In 120^0 Conduction Mode each switch conducts for 120^0 and two switches will be in ON condition at any instant of time.

The circuit diagram of this is similar to that of three phase bridge inverter using six switches. For the 120^o degree mode (VSI) each switch conducts for $120^o$of cycle. Similar to that of 180^oconduction mode, 120^oconduction mode also need six steps, each switch with a duration of 60^0, for an output AC voltage of full complete cycle. In first 120^o S1 switch conductswith switch S6 for $60^o$and then conducts with S2 for remaining 60^o. S3 will conducts for 120^o (from 120^o to 240^o) 60^o (from 120^o to 180^o) with S2 and then conducts another 60^o (from 180^o to 240^o) with S4. S5 will conducts 120^o (from 240^o to 360^o) with S4 for 60^o (from 240^o to 300^o) and for remaining $60^o$is (from 300^0 to 360^o) with T6. The sequence of the conduction can be shown as: - S6S1, S1S2, S2S3, S3S4, S4S5, S5S6, and S6S1.

Fig 2 Pulses given to three phase inverter for 180^0 conduction

Table.1 Switching States of Three-phase Full-Bridge Inverter for 180^0Conduction

State No.	Switching states						V_{ab}	V_{bc}	V_{ca}
	S1	S2	S3	S4	S5	S6			
1	On	On	Off	Off	Off	On	V_S	0	$-V_S$
2	On	On	On	Off	Off	Off	0	V_S	$-V_S$
3	Off	On	On	On	Off	Off	$-V_S$	V_S	0
4	Off	Off	On	On	On	Off	$-V_S$	0	V_S
5	Off	Off	Off	On	On	On	0	$-V_S$	V_S
6	On	Off	Off	Off	On	On	V_S	$-V_S$	0
7	On	Off	On	Off	On	Off	0	0	0
8	Off	On	Off	On	Off	On	0	0	0

2.1 SPWM Technique

In Pulse Width Modulation (PWM) technique by modulating pulse duration and by modulating the Duty cycle we can generate a constant amplitude pulse. In this PWM technique it requires both reference and the carrier signals.With low frequency is taken as the reference and triangular wave with high frequency is taken as carrier signal. This output signal is used for controlling the switches. The comparison is shown in the fig. Below

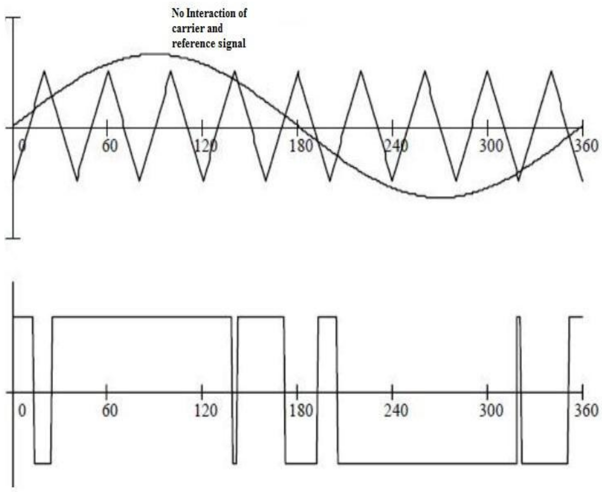

Fig.3 SPWM pulse

2.2 Filter

Due to the switching action of the switches and non-linear characteristics of the semiconductors devices, the output of inverter consists of harmonics. Thus to eliminate harmonics filtersare used. The inverter side filters and the line side filters are basic types of filters.

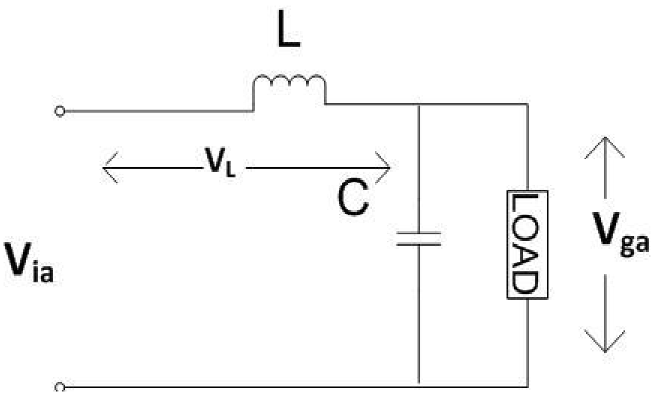

Fig 4. L-C filter topology

To prevent the penetration of Harmonic current in to the series injection transformer, the inverter side filters are used because it is closer to the harmonic source and low voltage side. Which can cause phase-shift and voltage drop in the fundamental component of inverter output. In case of line side filter which is closer to the high voltage the higher rating transformer is required.The problem in the phase-shift and voltage drop does not disturb the system. In both filters, filtering capacitors causes increase in inverter ratings.

3. SIMULATION CIRCUIT THREE PHASE SPWM INVERTER AND RESULTS

This three phase inverter module is designed in MATLAB, the MATLAB circuit is shown below in fig.5

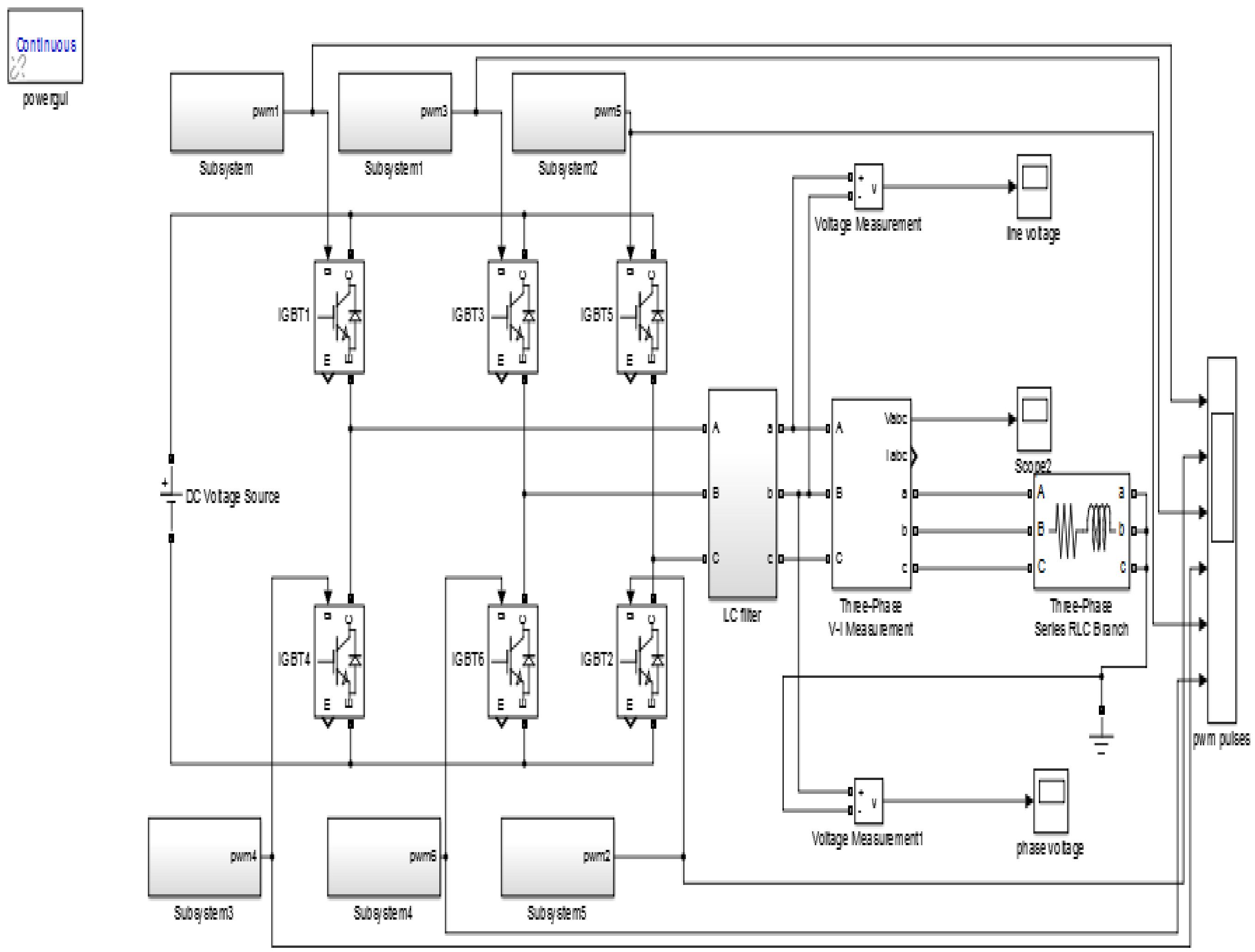

Fig.5 Three phase SPWM inverter

This circuit consist of LC-filter, the load is of RL-load. In this circuit the switches are triggered using the SPWM technique. The switches here are IGBT's/MOSFET, there is a voltage measurement block which is used to measure phase voltage and line voltage and there is a scope which is used to observe the output voltage waveforms.

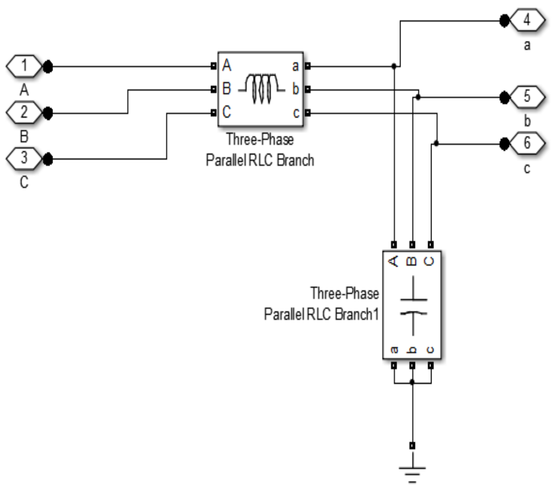

Fig 6 LC-filter

The simulation results of output wave forms of three phase inverter with and without LC-filter are shown in fig below

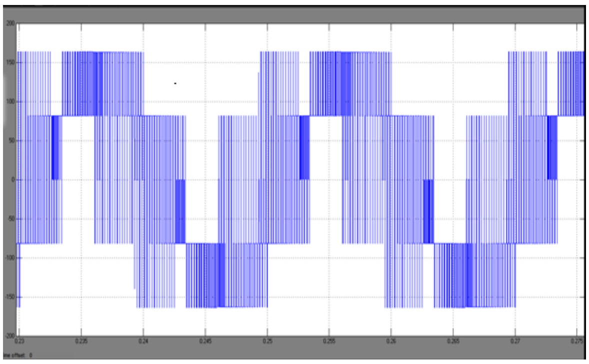

Fig 7 Phase voltage of Three-phase Inverter(without filter)

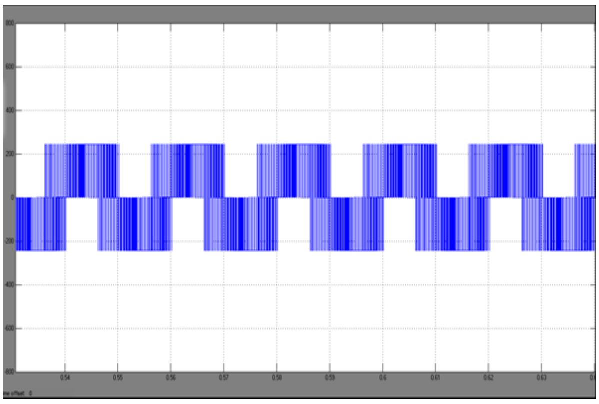

Fig 8 Line voltage of Three-phase Inverter (without filter)

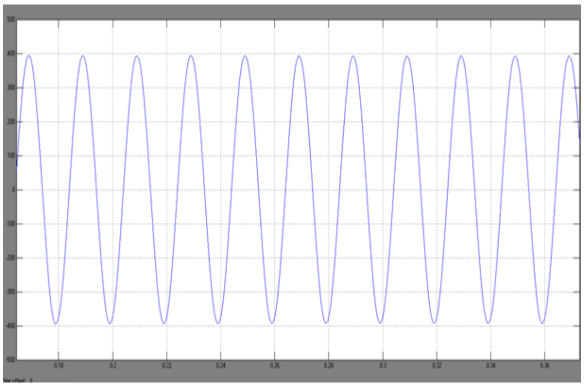

Fig 9 Line voltage of Three-phase Inverter (with filter)

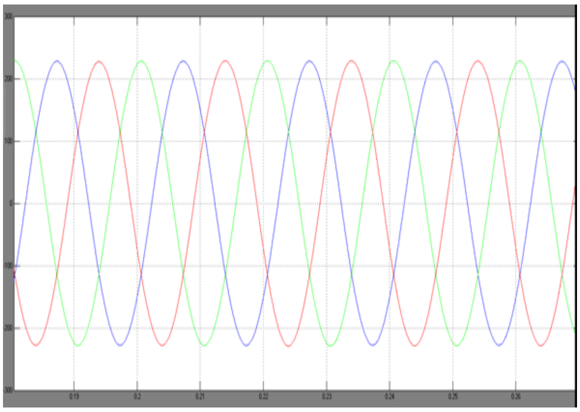

Fig 10 Output voltage of Three-phase SPWM Inverter (with LC-filter)

4. HARDWARE IMPLEMENTATION

The hardware implementation of three phase inverter model is shown below in fig.11

Fig 11 Hardware setup of three phase inverter fed to three phase induction motor

The above circuit diagram can be explained by different modules
1. Arduino/ myRio (Microcontroller)
2. Dead band Circuit
3. Isolation Circuit
4. Inverter

By using MYRio as a microcontroller PWM pulse is generated which is given to the inverter, but before giving the pulse to the inverter there are two other modules in between, they are Dead band circuit and the other one is Isolation circuit.

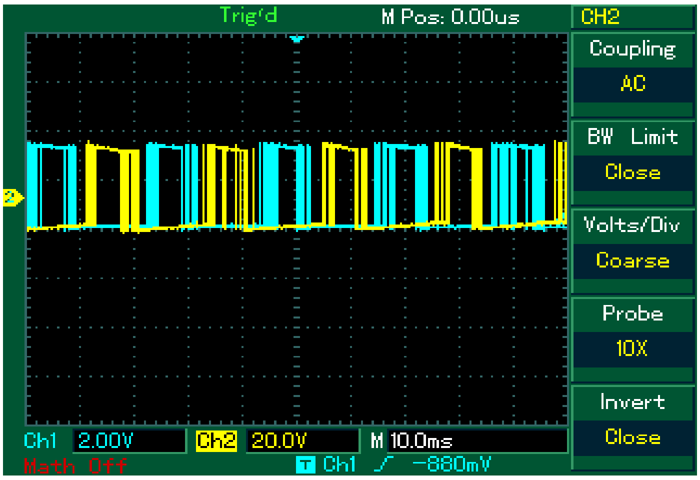

Fig 12 PWM pulse generated by microcontroller

The above shown pwm pulses are given to the three phase inverter. The output waveform is shown below

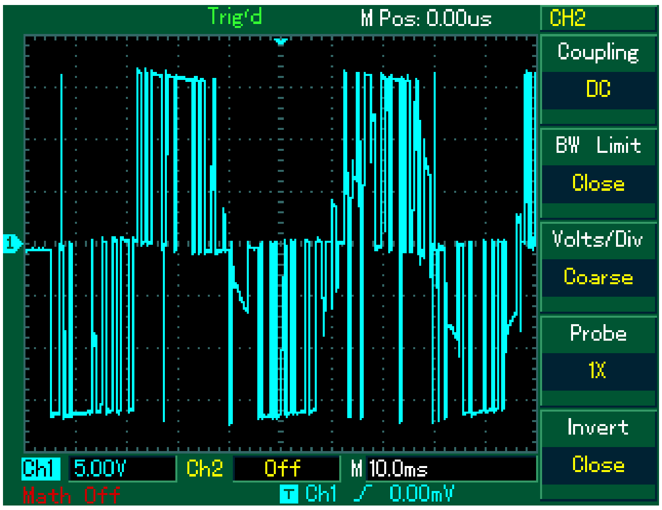

Fig .13 Line voltage of three phase SPWM pulse inverter with RL-load

5. CONCLUSION

In this paper hardware circuit of a "single phase DC supplied three phase inverter fed, to a three phase induction motor" is designed. Here the practical output wave forms are obtained when a single pulse and SPWM pulse with a phase shift of 120^0 is given to switches. It is an open loop circuit. In this project two different types of microcontrollers are used one is Arduino and other one is NI-MYRio. This hardware design described in this thesis is a cost effective one. This design can also be used for high power application which is successfully implemented.

REFFERENCES

[1] C.Y.Wang, Zhinhong Ye & G.Sinha – Output filter design for a gried connecter Three Phase Inverter, Conference pp.779-784 PESE 2003.
[2] Ned Mohan, Tore M Undeland, Willam p Robbins, Power electronics: Converters , Applications and Design 1989.
[3] Milan Pradanovic & Timotyy Green – Control and Filtering Design of Three phase Inverter for high power quality grid connection – IEEE Transaction on Power Electronics, Vol.18 pp.1-8, Jan-2003.
[4] Milan Pradanovic& Timothy Green, ―Control and filter design of three phase inverter for high power quality grid connection, ―IEEE transactions on Power Electronics,Vol.18. pp.1- 8, January 2003.
[5] Sun J.-Small-Signal Modeling of Variable frequency Pulse Width Modulation. IEEE Trans.Aerosp. 38(3), 1104-1108 (2002)
[6] Miss Sangitha, R Nandurkar, Mrs. Mini Rajeev "Design and Simulation of Three Phase Inverter For Grid connecter Photovoltaic System" NCNTE-2012, Feb 21-24 PP.80-83
[7] Samul Araujo & Fernando Luiz – LCL filter design for grid Connected NPC inverters in offshore wind turbines, 7th International Conference on Power Electronics, pp. 1133-1138 oct-2007.
[8] Dr J Praveen, A Vinay Kumar, "Power Quality Improvement with Dynamic Voltage Restorer using Direct Power Control Strategies" published in International Journal of Electrical, Electronics and Computing Technology pp 20-25 Volume -1, Issue-2, January-April 2011. ISSN 2229-3027
[9] Vinay Kumar Awaar, Praveen Jugge, Tarakalyani S "PQ Improvement by Moderation of Multi-Level Inverter Controlling Techniques and Intensifying the Performance of DVR" VOLUME: 13, 2015 ,JUNE. Advances In Electrical And Electronic Engineering

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