HARDWARE DESIGN FOR EMBEDDED-Z (EZ) SOURCE INVERTER FOR THE SPEED CONTROL OF INDUCTION MOTOR

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Abstract—This paper represents the topology and hardware design of Embedded-Z (EZ) source feed induction motor. Conventionally there are two converters used for ASD systems i.e. Voltage Source Inverter (VSI) and Current Source Inverter (CSI), but they have a limited output voltage range. Conventional VSI and CSI support only either buck or boost DC-AC power conversion and need a relatively complex modulator. The problems in traditional source converters can be overcome by Z source inverter. In this LC impedance are employed for fast power conversion. Due to requirement of additional LC filter the cost of operation also increases. Therefore, instead of using an external LC filter in Z-source inverters, this paper gives an alternative family of Z-source inverters i.e. EZ-source inverter. In which input DC source has embedding between LC impedance, which perform the current and voltage filtering operation in current type and voltage type EZ source inverter. This paper illustrate the hardware design of EZ source inverter fed induction motor which overcome problems of conventional VSI and CSI inverters. And it gives the smooth speed control of induction motor.

Keywords—EZ-source inverters-source inverters, Z-Source inverter Pulse Width Modulation, Adjustable Speed Drive System, PIC Controller.

I. INTRODUCTION

Due to the recent advancements in the fields of power conversion and energy storage, it is essential to design an new topology of inverter which can operate efficiently with variable voltage sources. In particular, the converter may need to provide voltage enhancing capability in renewable energy (e.g. fuel cell and solar energy) applications due to unbalanced output voltage from the electrical sources, which are unnecessarily affected by their output current and the ambient condition. So an alternative solution for this is Z-source inverter, which has a unique passive elements structure which provide voltage buck-boost capability but Z-source source inverter has some deficiencies which overcome by advanced family of Z-source inverter i.e. Embedded Z-source inverter. An EZ-source inverter provides inherent features for ASD system. As we know, we have two conventional converters i.e. VSI and CSI where they have operate only in either voltage buck operation or boost operation at a time.

II. EXISTING SYSTEM

Inverters are used to dc to ac power conversion where the input is dc supply either voltage or current is converted in to variable output ac voltage. The output of inverter can be controlled by controlling input dc supply or by varying gain of the inverter. Nowadays there are two types of conventional inverter are using in industries for adjustable speed drives system. They are:

1) Voltage source Inverter
2) Current source Inverter.

In conventional voltage source inverter (VSI), the DC input voltage source connected across a large capacitor. The voltage produced by this dc link is fed to main network. The input dc supply may be a battery or fuel cell or diode rectifier, or capacitors. The inverter circuit consists of six switches; each is consist of antiparallel combination of power transistors and diode which gives bidirectional flow of current and blocking capability reverse voltage. In conventional current-source inverter (CSI), the large DC inductor are connected to form a DC current source and connected in series with input dc supply such as a battery or fuel-cell or diode rectifier or converter etc. Like VSI network CSI also consist of six switches each consist of antiparallel combination of power transistors and diode which gives bidirectional flow of current and blocking capability reverse voltage. The control voltage pulse width modulation (PWM) technique used for on/off time of the switching devices in voltage source inverter and current source inverter.

A. Disadvantages of existing system

The VSI based system has the following disadvantages and limitations-

- They are only either a buck or a boost converter.
- In VSI main network of inverter circuits cannot be interchangeable. In other words the VSI main network cannot use as CSI main circuit or vice versa.
- The output voltage range is limited below and DC bus voltage cannot exceed.
- In this upper and lower semiconductor switching devices of each leg of phase cannot switched on simultaneously.
- There is problem of electromagnetic interference (EMI), which reduces reliability

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Z-Source inverter consists of a X-Shaped Z-source impedance structure which consists of L1, L2, C1, and C2. Due to this X-shaped LC components we get both buck-boost operations in single stage power conversion. In this network the input DC Source is placed at left in series with diode. So, due to this, in the source current chopping is occurred which is caused by diode D commutation, so to avoid this problem and to smoothen out the source current an extra LC filter is required which increase the overall cost of the system and by addition of additional LC filter network become more complex. So there is an alternative to overcome the above drawbacks, proposed new technique is embedded Z (EZ) source inverter shown in fig.2.

III. EMBEDDED Z-SOURCE INVERTER

In the proposed Embedded EZ-Source Inverter input DC sources embedded in between the X shaped LC impedance network. Its L1 and L2 inductive elements used in voltage type EZ-source inverters for filtering the currents and its C1 and C2 capacitive elements are used for voltage filtering in current EZ-Source inverter, so in EZ-source inverter smoothens the source current without adding an additional LC filter but the Z-Source and EZ-Source has same gain. By dividing the input DC source between LC impedance it does not require any additional filter. So in EZ-source inverter requires two sources which are cost effective. So the input DC voltage is divided as \( V_{dc}/2 \), due to this no extra stresses occurs at time of loading condition. In this paper, induction motor is taken as a load. The proposed topology of Embedded Z source inverter provides voltage ride through capability and increase the output voltage range also.

IV. PROPOSED SYSTEM

The block diagram of single phase E-Z-source inverter using pic controller for speed control of induction motor is shown in fig.3. It contains following main section EZ-source inverter, pic controller, driver section, triggering circuit, speed control circuit.

A prototype has been built to verify the hardware results. It should be noted that the inductors and capacitors were oversized in the prototype for possible regenerative operation during inverter trips. The requirement of z source network is similar to the traditional drives. The inductor used to minimize the line harmonics current and voltage distortion. The required dc capacitance is relatively small for a tolerable voltage ripple mainly resulted from rectification. The dc capacitance should be sized for
possible regenerative operation. Fig 3. Shows block diagram for z source inverter, the prototype system rectifier bridge produces the dc output. The parameter used for hardware selected on their output performance. PIC microcontroller is used for prototype system because PWM technique is inbuilt and switching period depends on input frequency of the system. In simulation model the simple boost control is used to generate the gate pulse for inverter.

V. HARDWARE DESIGN DESCRIPTION

A. Control Strategy

a. DC regulated power supply
The regulated power supply is needed for driver circuit and controller. In this regulated power supply is obtained from bridge rectifier and regulator which are feed to step down transformer. The 5V is for controller and 12V for controller circuit. This circuits generates a PWM pulses which are utilized for on and off operation of switching devices.

b. Step Down Transformer
The step down transformer is used to step down the input 230V to 12V for operation of control circuit. Then the 12V supply is feed to bridge rectifier and it converts in 12V DC which is required for the operation for control circuit. The maximum current rating of this transformer is 1A. For control circuit DC is needed so conversion takes place by rectifier and rectifier component also rated at 1A.

c. Diode Bridge Rectifier
The ac input from the main supply is stepped down using a 230V/5V step down transformer. The stepped down AC voltage is converted into DC voltage using a diode bridge rectifier. The diode bridge rectifier consists of four diodes arranged in two legs. The diodes are connected to the stepped down AC voltage. For positive half cycle of the ac voltage, forward biased the diodes D1 and D4. For negative half cycles diodes D2 and D3 are forward biased. Thus dc voltage is produced to provide input supply to the Converter.

When the positive half cycle is applied to the diode bridge rectifier, forward biased the diodes D1 and D4. The diodes start conducting and the load current flows through the positive of the supply, diodeD4, the load, the diode D1 and the negative of the supply. The reverse biased diode D2 and D3 do not conduct.

During the negative half cycle, reverse biased the diodes D1 and D4 are and they stop conducting. The diodes D2 & D3 are forward biased and they start conducting. The load current flows in the same direction for both the half cycles. Thus the ac supply given to diode bridge rectifier is converted into pulsating dc.

d. Filtering Unit
The output Dc voltage obtained from bridge rectifier will not be pure DC, so in order to get a pure DC without containing harmonics and ripple content a filtering circuit is provided. It provides DC voltage of 0 Hz; we have to use a low pass filter. So that a capacitive filter circuit is used where a capacitor is connected at the rectifier output & a dc is obtained across it. The filtered waveform is essentially a dc voltage with negligible ripples & it is ultimately fed to the load. A R1 is connected as a load resistor so the ground is maintained. In this network for bypassing ripples the passive elements C1,R1 is used and for low pass filter C2,R2 is used, i.e. this filter passes only low frequency signals and high frequency signals get blocked.

e. Voltage Regulator
The voltage regulators are an important device in any electric power supply circuits. The primary function of a voltage regulator is to provide a constant DC voltage to the electric device. In this hardware most components are electronic semiconductor devices, so any sudden rise in input voltage to such devices causes to damage it. Any variation in DC voltage cans disoperation the switching devices used in inverter circuit. In this hardware design we use regulator IC7805 which provides 12 V constant DC voltages. This regulator IC has chosen because it has inherent features as-

Features
- It is 3-Terminal Regulators
- Output Current up to 1.5 A & regulated O/P Voltage is 5V
- Voltage rating 35V
- For 5v power supply we need LM7805
- IC rating- Input voltage -7v to 35 volt, I0 -1A, output voltage range=Vmax=5.2v, Vmin=4.8v

B. Peripheral interfacing controller
Peripheral Interface Controllers (PIC) is an advanced microcontrollers developed by microchip technologies. In modern electronics applications these microcontrollers are widely used. This PIC controller is an integration of all type of memory modules and interfacing ports. This PIC controller is much more advanced controller than 8051 microcontroller. The PIC controller also combination of central processing unit(CPU) and different memory modules and I/O and O.P ports. In this hardware PIC16F877A IC is used for PWM pulse generation purpose because it has inbuilt PWM generation port.

a. PWM generation in PIC microcontroller
PIC16F877A IC of microcontroller has chosen to obtain the gate pulses for the switching operation of MOSFETS to drive the three phase Induction Motor. This IC PIC Microcontroller has inherent features as-
• Operating speed is 20 MHz, 200 ns instruction cycle time.
• Maximum operating voltage 4V to 5V.
• Maximum temperature withstand range -40°C to +85°C.
• Interrupt sources-15
• Flash memory-14.3 Kbytes, data EPROM-256 bytes.
• It has inbuilt-PWM technique.

The PIC controller provides the controlling action for the different driver circuits which are designed separate for each switching device. The separate driver circuit feed the gate signal to their respective MOSFET switch. To vary the frequency of the PWM signal that controls the frequency of the voltage applied at the gate drives so for this PIC microcontroller IC has programmed, and hence the switching frequency of inverter circuit has controlled, as result the it gives variable output of adjustable speed drive system.

b. Driver circuit
The primary function of driver circuit is to amplify PWM pulses coming from PIC microcontroller and pass to individual gate terminals of respective switching devices. For the operation of driver circuit 12 V supply is required and which is provided from 230V/12V step down transformer. The driver circuit consists of optocoupler, buffer and transistors. The PIC16F877A controller output pins 1 and 2 of is passed to the buffer where buffer provide expected PWM signals to switching devices through optocoupler and transistors.

c. Optocoupler
In project the optocoupler is used as protection device in the driver circuit. When there is problem of overvoltage occur in driver circuit it will damage to complete circuit, so to avoid this optocoupler are used to isolate the voltage between the main circuit and microcontroller circuit. The pulse is provided to the MOSFET switch using a microcontroller circuit; this circuit produces a waveform of 5V DC. This pulse is supplied to MOSFET switch which is supplied by 12V AC as the source and destination voltage is different they have to be isolated, which is done using optocoupler.

d. Buffer IC
The buffer provide the excepted magnitude of PWM signal. In this hardware buffer IC CD4050BC is used. The output from the buffer IC is passed to the two optocoupler where buffer IC acts as a NOT gate. This buffer IC is CMOS integrated electronic circuit where it is constructed with P and N channel. This IC operates on logic level configuration which provides only VDD. When these devices are used for logic level conversions then input signal high level (VIH) can exceed the VDD supply voltage. This IC has inherent features which make a system supply voltage reliable and that features are:

• Wide range of supply voltage: 3.0V to 15V
• Direct drive loads operates at 5.0V over full operating temperature range
• Sink current capability and high source
• When input voltages greater than VDD Special input protection is available.
• Supply Voltage (VDD) -0.5V to +18V
• Input Voltage (VIN) -0.5V to +18V Voltage at Any Output Pin (VOUT) -0.5V to VDD + 0.5V
• Storage Temperature Range (TS) -65°C to + 150°C Dual-In-Line 700 mW Small Outline 500 mW Lead Temperature (TL5)

e. Transistor
In this hardware transistor is used to amplify the signal pulse coming from the microcontroller circuit. In this there two transistors are used in Darlington pair of connection in driver circuit. The transistors IC 2N2222 and CK100 are selected for signal amplification purpose. Transistor is a solid state semiconductor electronic device which has three terminals for output circuit connection. Here the voltage applied by at one pair of transistors changes the current flowing through other pair of transistors. So this pairs controlling the large output power and hence the transistor provides for amplification of a signal. The transistors circuit is an additional in driver circuit but it is necessary to get desired amplitude of PWM signals from PIC controller. The features of transistors ICs are

Features of 2N2222:-
• High current (max. 800 mA)
• PD-500 mW/1.8 W
• FT-300 MHz

Features of CK100
• Maximum collector power dissipation (Pc), W: 0.8
• Maximum collector-base voltage [Vcb], V: 60
• Maximum collector-emitter voltage [Vce], V: 50
• Maximum emitter-base voltage [Veb], V:
• Maximum collector current [Ic max], A: 1
• Maximum temperature (Tj), °C: 175.

C. Induction motor
Induction motors have many advantages compared to DC motors and synchronous motors in many aspects, such as size, efficiency, cost, life span and maintainability. Low cost and ease of manufacturing have made the induction motors a good choice for electric and hybrid vehicles. In our project prototype
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motor is used. It is 3phae induction of 0.25 HP rating.

CONCLUSION

This paper has presented a new ASD system based on the EZ-source inverter. The operating principle and analysis have been given. This paper presents, the theoretical analysis and prototype design of EZ-source inverter is studied. Due to presence of unique LC impedance in network EZ-source inverter it overcomes all theoretical and practical barriers and limitation conventional VSI and CSI inverter. The EZ-source inverter for adjustable speed drive (ASD) in industrial application system is implementing then it provides

1. Desired output ac voltage.
2. Extend output voltage range during voltage sags without using any additional energy storage system and due to this minimizes the motor ratings to deliver a required power
3. Reduce the harmonics and improve the power factor.

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