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Single-Phase Transformer less Inverter Using Power Correction by Frequency Control Method

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ABSTRACT: This paper discusses the design and construction scheme of an inverter system which converts the DC voltage collected from a transformerless rectifier into AC voltage. The output is sine wave. The system consists of transformer less dc voltage to the full bridge inverter circuitry with a passive filter. The power supply supplies the DC voltage needed to activate the optocouplers, which are connected to the switches of the full bridge circuitry. The optocouplers work as an isolation for the full bridge circuit. High frequency Pulse Width Modulated (PWM) pulses are generated by pwm generator ic SG3525 and provided to the switches of full bridge connection. The full bridge inverter outputs a square wave which is later conditioned convert to sine by an L-C filter.

KEYWORDS: PWM pulse generation, soft start, frequency control circuit, driver circuit, IGBT based inverter, induction motors, switching element, variable speed drive

I. INTRODUCTION

Single-phase induction motors are widely used in home appliances and industrial control. The multispeed operation and multipurpose operation are provided by controlling the speed of these motors. This research paper is variable speed drive of induction motor using frequency control method. The proposed variable speed drive includes power conversion section (AC to DC and DC to AC), used the switching element of IGBT. The four IRG 4PC30U IGBT'S are used as H-bridge inverter to provide the alternating current to the motor. In this drive, opto isolators and Darlington pair's transistors are used as driver circuit to drive the H-bridge inverter. There are four power supplies in this drive. The 12 V power supply is used for frequency control circuit and driver circuit. The 350 V power supply is used for H-bridge inverter. For power correction circuit using IRG 4PC30U IGBT with extra triggering and isolation circuit and separate regulated power supply was used in which drive, pulse width modulation IC is used to control the frequency. The frequency range of the constructed variable drive circuit is 16 Hz to 56 Hz at constant voltage for changing the speed of induction motor. In this research paper, drive schemes of single-phase induction motor with reduced transformer inverter and power correction facility , principle operations of components used in constructed variable speed drive, and design calculation to construct this drive are included.

II. RELATED WORK

M. R. Kandgaonkar et.al[1] proposed a inverter design using Maximum Power Point Tracking (MPPT) technique which employed two-stage topology for DC-AC conversion. For first phase MPPT method was employed while for second stage a control circuit for single phase inverter using Pulse Width Modulation (PWM) IC was used.. R.Senthilkumar[2]presented single phase inverter design in which design AC line voltage was rectified using diode

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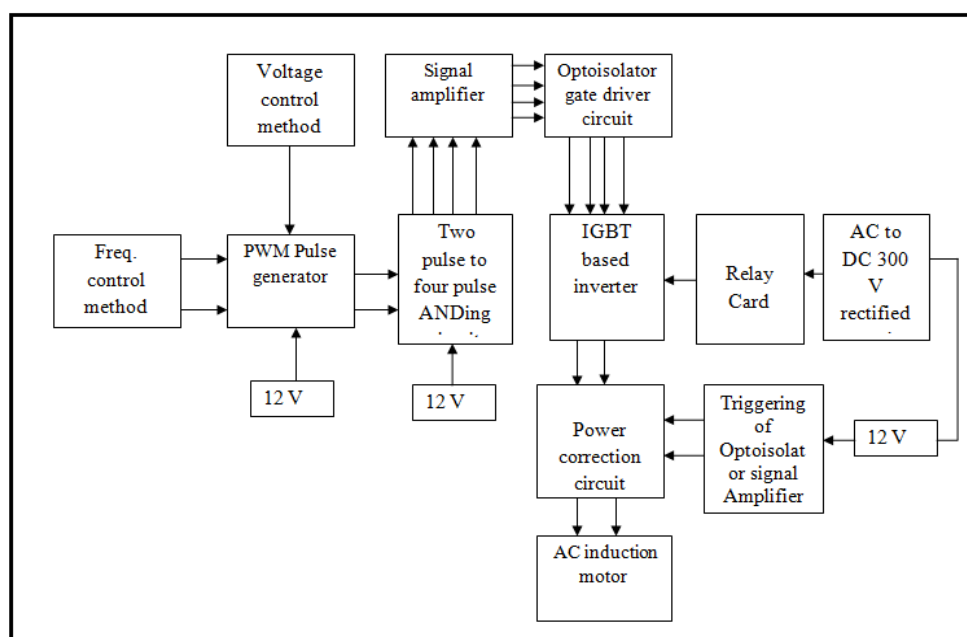
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bridge rectifier whereas unipolar PWM technique was employed for switching of IGBTs. The digital signal Peripheral Interface Control was used to generate pulses which trigger gate of IGBTs. The simulations were performed on MATLAB using Simulink and final output waveform is compared using simulation results. Rafid Haider et.al[3] proposed an efficient pure sine wave inverter scheme which converts DC voltage obtained from photovoltaic (PV) array into AC voltage with minimum losses. SMPS and full bridge inverter circuit was utilized with LC passive filter. Ahmed[4] proposed a single phase pure sine wave inverter technique that has low switching loss high efficiency, small size and simple control. In this method Sinusoidal PWM is generated using microcontroller simulation is carried out on PSIM software and efficiency of 97% is achieved. T.H. Lobaru [5] mentioned a low powered inverter that can be used with single solar module. It was indented for developing countries rural areas with low power applications. The system consisted of switch mode power supply, with DC-AC H-bridge inverter and finally LC filter to obtain desired results. High frequency PWM pulses were generated with microcontroller which output of inverter was 220V PWM sine wave which was later filtered by an LC filter. Meraj Hasan[6] proposed a pure sine wave inverters which has carried out work on producing cost-effective and efficient pure sine wave inverter and proposed a design that is highly useful for low power based applications also utilizing renewable solar energy by incorporating Multi vibrator IC (NE 555). Mohamed A.Ghali[7] developed the control circuit for a single phase inverter which produces a pure sine wave with an output voltage that has the same magnitude and frequency as a grid voltage. The simulation results to perform at PSIM. Suling Xi et.al[8] the design of 100W active power correction factor circuit. It gives main calculating parameter of circuit structure, In a wide range of input voltage, improving the power factor and reducing the pollution of electronic grid. Rafid Haider et.al[9] the design and construction scheme of an inverter system which converts the DC voltage collected from a photovoltaic (PV) array into AC voltage. The system consists of a Switch Mode Power Supply (SMPS) and full bridge inverter circuit with a passive filter. The full bridge inverter outputs a PWM sine which is later conditioned to pure sine by an L-C filter. Finally, the output voltage and current was measured and displayed on an LCD display.

III. PROPOSED SYSTEM

Proposed system consists different blocks which are mentioned in below figure. Each blocks having its individual functions.





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1] PWM pulse generator:

It produces PWM pulses and these pulses are provided to the IGBT switches such that the IGBT gates can be triggered ON and OFF. This is responsible for generating oscillating signals that controls the ON and OFF action of the IGBT switches. The control circuit as a whole was made with a 3525A PWM IC and combination of some passive components. The oscillation from its output pins is controlled by a timing resistor and capacitor connected to pins 5 and 6 terminal of the IC.

2] Design of two pulse to four pulse converter

For designing of gate driver circuitry two pulses from PWM can be converted into four pulses by ANDing circuit it also be known as two pulse to four pulse converter. In the block diagram we have ANDing gate pulse circuit having positive & negative. The input to this circuit is from PWM, This circuit is used for the converting of single pulse to four pulses which is used to drive the IGBT.

3] Design of Gate Driver Circuitry

Opto-isolator can transfer the light signal, the sensor can be a photoresistor, a photodiode, a phototransistor, a silicon-controlled rectifier (SCR) or a triac. Because LEDs can sense light in addition to emitting it, construction of symmetrical, bidirectional opto-isolators is possible. The output of opto-coupler is not sufficient to drive the IGBT so signal amplifier is used to increase the current. The Darlington transistor is a compound structure consisting of two bipolar transistors (either integrated or separated devices) connected in such a way that the current amplified by the first transistor is amplified further by the second one. This configuration gives a much higher common/emitter current gain than each transistor taken separately and, in the case of integrated devices, can take less space than two individual transistors because they can use a shared collector.

4] Design of power supply to inverter circuit

A 230V A.C. main are provided to the rectifier circuit for the field. In series with the field winding resistance a 12V relay coil is connected. The NO contact of this relay is used to provide supply to the armature circuit. In this way field failure protection is ensured. It consists of unregulated power supply, a relay circuitry and IGBT for handling high power.

5] H Bridge Inverter

An H-Bridge or full-bridge converter is a switching configuration composed of four switches in an arrangement that resembles an H. By controlling different switches in the bridge, a positive, negative, or zero -potential voltage can be placed across a load. The inverter, also known as DC to AC converter converts dc power to ac power at desired output voltage and frequency.

6] Design of Power Factor Correction Circuitry

Power factor correction IC L6561 is used for power factor correction. Boost topology is used by IC L6561 for power factor correction. The IC L6561 operates on borderline current control technique. The triggering pulse generated by PWM is given to the IC as a reference signal. According to the reference signal the IC L6561 generates a triggering pulse for IGBT.

[7] Designing of L-C filter

For converting square output of inverter into sine wave inverter used L-C filter gives smooth sine output

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IV.PERFORMANCE ANALYSIS

SG-3525 is used for PWM pulse generation. These four pulses are given to optocoupler MCT2E. This optocoupler is used for isolation of voltage between the control circuit and power circuit. Gate driver voltage is 3.2v across the output of signal amplifier. Signal amplifier TIP-122 is used for current boosting. Time period calculation of PWM pulses. The total time period is calculated by ON time plus OFF time. Finally frequency is calculated on the basis of total time period.

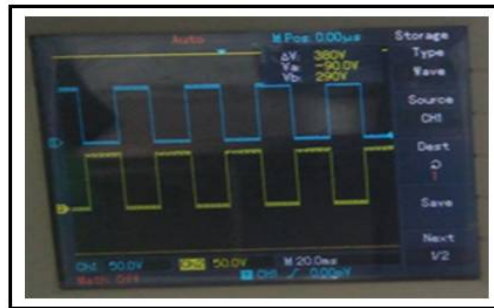


Figure: Gate driver waveform

$$T_{ON} = 2 \times 5 \times 10^{-3} \text{Sec}$$

$$T_{OFF} = 2 \times 5 \times 10^{-3} \text{sec}$$

$$T = T_{ON} + T_{OFF}$$

$$T = 20 \text{ msec}$$

$$F = 1/T$$

$$F = 50 \text{ Hz}$$



Figure: H bridge Inverter output

Calculation of L-C-L Filter

In design of Sine Waver Inverter, there are harmonics produced in output waveform caused by semiconductor switching. For harmonics reduction, Low Pass filter is implemented. for 50 hz output frequency inductor and capacitor are selected by formula,

$$F = 1 / 2\pi \sqrt{LC}$$

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L= 350mh and C= 10 μ hz

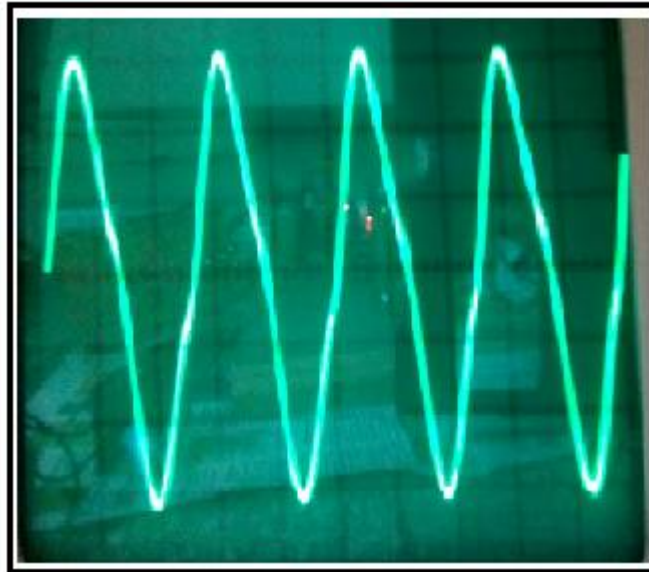


Figure: Sine wave output after L-C-L filter

IV. CONCLUSION AND FUTURE WORK

The system has significant excellences with sine wave output. A scheme that address on building up system single phase inverter with power factor correction for load schedule. The basic aim of proposed system is to generate the single-phase inverter with power factor correction along with lc filter which convert square wave to sine wave inverter. Here we can generate four pulse PWM output. The frequency of the PWM output can be varied from 16hz to 56hz .

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