SPEED CONTROL OF INDUCTION MOTOR BY THYRISTOR USING CYCLO-CONVERTER

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ABSTRACT

This paper presents the Speed control of Induction motor by using Step-down Cyclo-converter. The speed of the Induction motor can be controlled by changing the frequency of the Cyclo-converter. Frequency at the output is proportional to the speed of the Induction motor. As the AC supply frequency can not be changed, thyristor/SCR controlled Cyclo-converter is used to control the speed in three steps. Pair of Frequency selector switches are provided to select the desired speed range (F, F/2 and F/3). These switches are interfaced with the microcontroller to generate PWM signal. The type of commutation used is Natural commutation to avoid the complexity in the design. The novelty in Cyclo-converter design is exhibited by the use of step down Cyclo-converter to reduce the switching rate of AC signal. At different frequencies and loads the speed of the Induction motor varies.

Keywords: Induction motor, Step down Cyclo-converter, Commutation, PWM signal.

I. INTRODUCTION

Cyclo-converters are used in high power and very high power applications driving Induction and Synchronous motors. They are usually phase-controlled and they traditionally use Thyristors/SCR's due to their ease of phase commutation. The Power conversion systems such as those used for large propulsion motor drives will often utilize Cyclo-converter technology in order to take advantage of the power handling capability of the modern Thyristors. Because of Cyclo-converters produces a non-integer harmonics of an input power frequency, both the input current and the output voltage requires detailed study in order to ensure trouble-free operation of both the supplying power system and the connected motor load. The Cyclo-converter is a device which converts input AC power at a one frequency to output AC power at a different frequency with a one stage conversion. The frequency conversion is achieved by using a phase control method [1]. Phase controlled Cyclo-converters have the ability to operate in all the 4 quadrants in the V-I plane. Thus, Cyclo-converters are capable of providing a variable frequency power supply to an AC machines. Due to its 4-quadrant operations, the Cyclo-converter can be handling the loads of any power factor. The Cyclo-converter allows the power to flow freely in either direction. Over most of its range, the Cyclo-converter produces a reasonable sine wave output that leads to a good output performance, particularly at a lower frequency.

Traditionally, satisfactory performance has been understood to be available when the output frequency is up to approximately 40 percent of the input frequency (example: 24 hertz output from the 60 hertz supply). Above this output frequency, the waveforms become more distorted due to the interactions between the mains and output frequencies [2]. The Cyclo-converter performance deteriorates progressively as output frequency increases. The switching of the AC waveform creates noise, or harmonics, in the system that depends mostly on the frequency of an input waveform. These harmonics can be damage sensitive electronics equipments. If the relative difference between the input and output wave forms is small, then the converters can produces sub harmonics. Sub harmonic noise occurs at a frequency below the output frequency, and cannot be filtered by load inductance [8]. This limits the output frequency relative to the input. These limitations make Cyclo-converters often inferior to the DC link converter systems for the most applications [3], [4].In the proposed system, the PWM control scheme is used to keep THD level low in spite of complicated hardware design [12].

II. PROPOSED SCHEMATIC BLOCK DIAGRAM

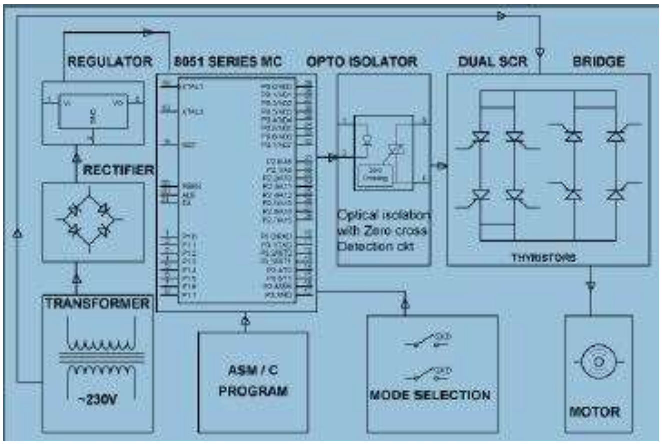

Fig1: Schematic Block Diagram

DESCRIPTION

A Single Phase 230V Power supply is given to the transformer for step-down the voltage from 230V AC to 12V AC. Output of a rectifier is then fed to the Voltage regulator 7805 to get 5V DC at the output [6]. The microcontroller At89s52 [9], [10] has been programmed in ASM/C language to give output to the Optical Isolator with Zero crossing detection circuitry. Whenever the zero crossing occurs microcontroller gives an output signal/pulse [4] to trigger the SCRs. A microcontroller programmer code is developed to control the firing pulses of a gate driving Thyristor/SCR circuitry. These firing pulses are controlled by TRIACs in the Opto Isolator. The Output of the Cyclo-converter is then applied to the Induction motor to control the speed at different frequencies [2].

III. VOLTAGE REGULATOR

The 3-terminal positive regulators are available in TO-220/D-PAK package and with several fixed output voltages like 5,6,8,910,12,15 and 18v, making them useful in a very Wide range of applications [3], [4]. Each type employs the internal current limiting, thermal shut-down and safe-operating area protection, making it essentially indestructible. If the adequate heat sink is provided, the regulator can deliver over 1A output Current. Although they designed primarily as fixed voltage regulators, can used with external components to obtain adjustable voltages and Currents [6].

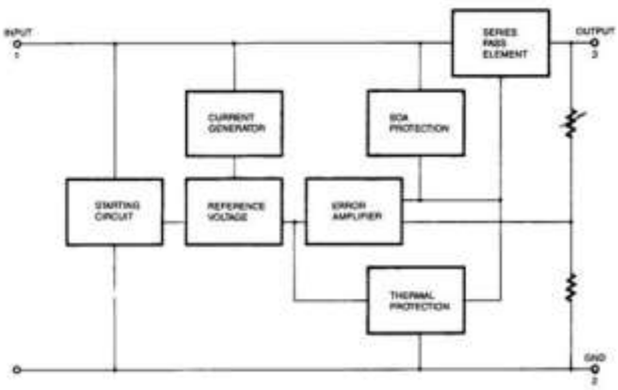

Fig2: Block diagram of Voltage Regulator

IV. ZERO CROSSING DETECTOR

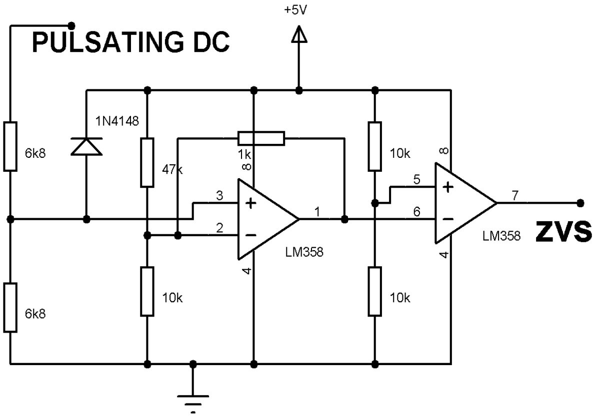

Fig3 (a): Zero Voltage Crossing Detector Circuit

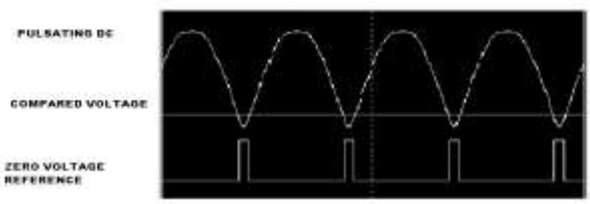

Fig3 (b) : Zero Voltage Crossing Detector Output

A Zero voltage crossing detector means the supply voltage waveforms that passes through the zero voltage for every 10msec of a 20msec input cycle generates the square waveform at the output. For 50Hz ac signal, the total cycle time period is 20msec (T=1/F=1/50=20miliseconds) in which, for every half cycle (i.e. 10ms) the zero signal is required. This is achieved by using pulsating dc obtained from the bridge rectifier before being filtered [4], [6].

V. Thyristors Switching by Zero Voltage Reference

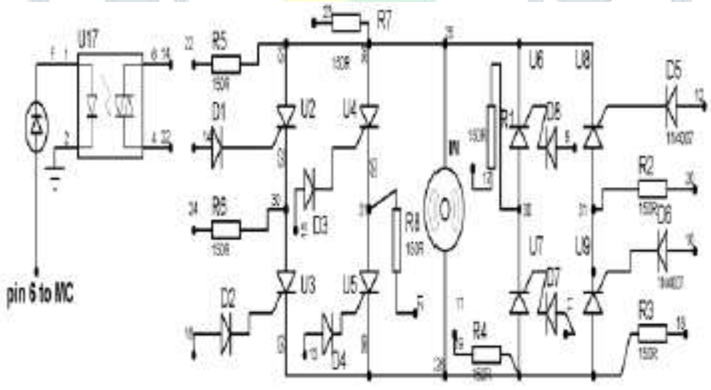

Fig4: Thyristors Switching by Zero Voltage Reference

Opto-isolators are used for driving the 8 Thyristor/SCR’s [11]. The four SCR’s are used in full bridge in anti-parallel connection with the set of four SCR’s as shown in Fig4. Triggering pulse is generated by the microcontroller which fed as the input to the Opto – isolators to drive the respective Thyristor/SCR’s [7]. SCR conducts for 20ms for the 1st bridge and next 20ms for the 2nd bridge to get the output, with the total time period of one AC cycle of 40ms which is 25 Hertz. Thus F/2 is delivered to load when switch 1 is closed. Similarly for the F/3, the conduction takes place for a 30ms in the 1st bridge and next 30ms for the next bridge, such that the total time period of one cycle will be 60ms when switch 2 is operated. Fundamental frequency of 50Hertz is available by triggering 1st bridge for 1st 10ms and the next bridge for 2nd 10ms where both the switches are kept in “OFF” conditions. Reverse current flowing in the gates of a Thyristor/SCR’s are isolated by the Opto–isolator output [5].

VI. WORKING MODEL

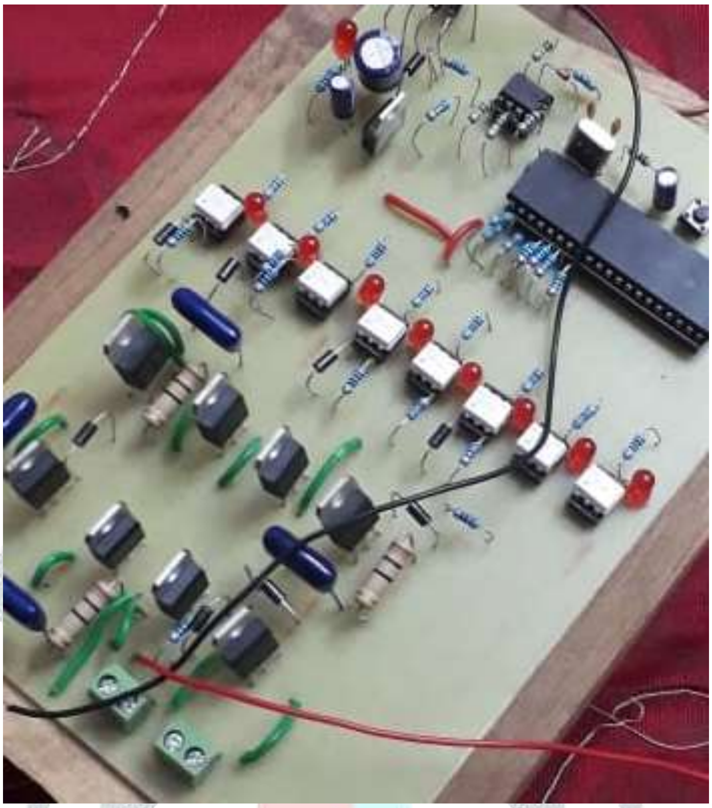

Fig5: Proto Model

VII. RESULTS

The speed of an induction motor is controlled in three steps i.e. (F, F/2 and F/3). For F/2 frequency, the one complete cycle of input is used to trigger the positive bridge of the SCR and another next complete cycle is used to trigger the negative bridge of the SCR. For F/3 frequency, the three half of input cycles are used to trigger the positive bridge of a SCR and another next three half of cycles are used to trigger the negative bridge of a SCR.

Final Output Waveforms

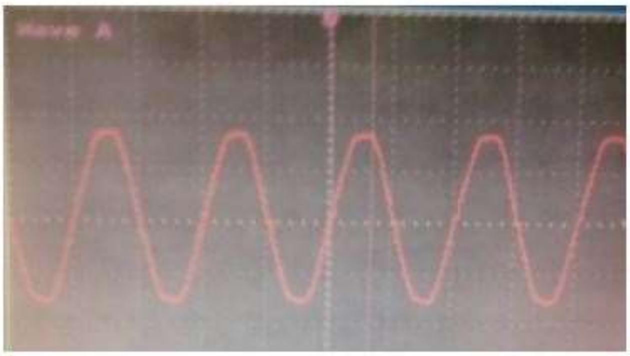

Fig6(a) Output At Load For Normal Frequency F=50Hz

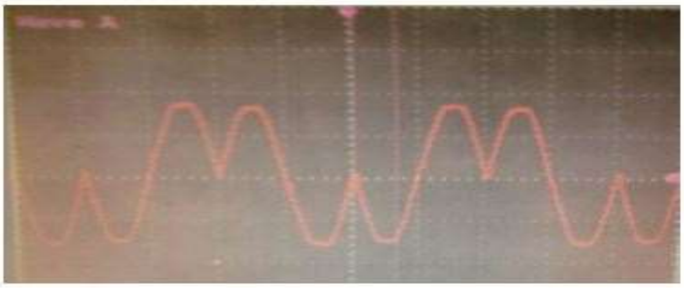

Fig6 (b) Output At Load For Frequency F=25Hz [F/2]

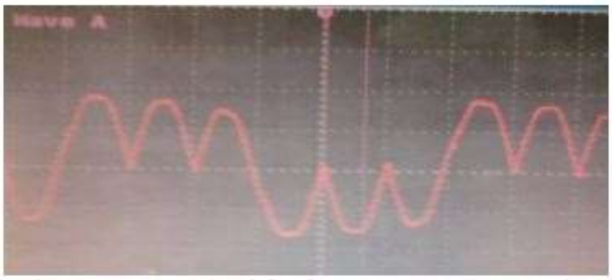

Fig6(c) Output At Load For Frequency F=16.66 Hz [F/3]

VI. CONCLUSION

The Cyclo-converter or a variable frequency generator designed to generate 3 frequency signals [F, F/2, F/3] where the frequencies measured is very close to the actual values. It is observed, the switching rate of AC signal is reduced because of Step down Cyclo-converter. In future, the Single-Phase Step down Cyclo-converter circuit can be extended to 3-Phase step down Cyclo-converter with the advanced microcontroller.

VII. REFERENCES

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