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A CYCLO CONVERTER BASED INDUCTION MOTOR SPEED CONTROL

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ABSTRACT:
The speed of the motor can be varied in two ways, one is by changing the number of poles and the second method is by changing the frequency. The speed control through the first method is uneconomical and the number of poles can't be varied under running conditions and the size of the machine also becomes bulky. These problems can be overcome by the second method. In this method, the frequency can be varied under running conditions also and there is no change in the size of the motor. In this method, the frequency changing device is Cyclo-converter. A Cyclo-converter is a power electronic device used to convert constant voltage constant Frequency AC power to adjustable voltage adjustable frequency AC power without a DC link. In among all the methods this method is simple, reliable and economical. The various speed of induction motor is obtained by varying the supply frequency by using Cycloconverter. In the modern era, Power Electronic and motion control has emerged as a very important technology in the industrial automation. In the industrial process, most of the drives are constant torque type and need to drive such loads at different speeds, because of which generation of supply with variable frequency become essential. Single phasecycloconverters are used for AC-AC power conversion particular for speed control of AC drives. To avoid the voltage spikes that appear during the dead time, safe commutation strategy is employed. In this project we convert the single phase uncontrolled to single phase controlled output using cycloconverter and this is fed to a scott transformer to obtain three phase controlled output and these are going to be analyzed by MATLAB Simulink.

1. INTRODUCTION

Speed control of Induction motor plays Important role in industries, there are various ways to control speed of motor but considering its efficiency, we proposed is designed to control the speed of a single phase induction motor in three steps by using cyclo convertor technique by thyristors. A.C. motors have the great advantages of being relatively inexpensive and very reliable. Induction motors in particular are very robust and therefore used in many domestic appliances such as washing machines, vacuum cleaners, water pumps, and used in industries as well. The induction motor is known as a constant-speed machine, the difficulty of varying its speed by a cost-effective device is one of its main disadvantages [1]. Cycloconvereter have several importants features, cycloconveter frequency can be varied by conduction period for each MOSFET.

However, control of induction motor is challenging task, many authors have suggested different techniques for speed control of induction of induction motor. These includes sliding mode control [2], fuzzy logic control [3] and model predictive control [4] and cycloconverter [6-8] etc. In [2] control methodology could be viewed as an advancement of the standard field oriented control. It consists of two control loops, i.e. the rotor flux and the speed control loops, designed using the active disturbance rejection control method, with the aim to cope with both exogenous and endogenous disturbances, which are estimated by means of two linear extended state observers and then compensated. Moreover, with the aim of achieving total robustness, a sliding mode based component is designed, in order to take into account disturbance estimation errors and uncertainties in the knowledge of the control gains. The design of Fuzzy controller is carried out by fuzzy set theory in MATLAB/Simulink 2013a, using Takagi-Sugeno (T-S) fuzzy model. The simulation results for both controllers are then compared and the results revealed that T-S Fuzzy Controller perform better in terms of control delay to load variations, as compared to Conventional PI controller. The overall pre and post disturbance analysis presented the robustness of the proposed controller to all load disturbances. The T-S fuzzy controller thus can be used as an alternative to PI controller, where dynamic superior performance of nonlinear systems is required [3]. In some cases, such as restarting after power interruption or starting a motor rotated by external load, the motor may be rotating before being powered by the inverter. For speed-sensorless operation, as both the initial rotational direction and speed is unknown, it would be difficult to achieve smooth and fast resumption of normal operation if the starting scheme is not deliberately designed. In this paper, a method based on adaptive full order observer (AFO) is proposed to address this problem. For AFO without a properly designed feedback gain matrix, the estimated speed cannot converge to the actual speed if initial estimated speed is significantly lower than the actual speed. Through analyzing the transfer function of stator current error, the convergence condition of speed estimation is deduced. A feedback gain matrix and the condition for shifting to normal operation are subsequently proposed to improve restarting performance [4].

Which the inhabitants make use of energy resources in actions that propitiate a sustainable progress, while preserving the welfare of future generations. Electricity has been key in the development of any society and because of its involvement in the progress and modernization of Mexico, is considered a fundamental issue in state policy [1]. The availability and use of the electric power promotes the economic growth and the well-being of the population. Therefore it is important to assure the generation and transmission of electric power, as well as its distribution in both urban and rural centers. The distribution of electricity is usually carried out by means of a three-phase system, at least in industrial and densely populated areas. In rural areas

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of developing countries, mainly due to the high cost associated with the building of a distribution system, the supply of electric power has seen a way to encourage the social welfare rather than to bring economic benefits. For example, Mexico has a national coverage of 96.85% of the population with access to electricity, but still has backward villages in rural areas, since in these ones the coverage is of the 87.2% and only 85% of rural households are electrified [2]. This represents approximately 4 million of inhabitants without electric energy, whose distribution is shown in Fig. 1.

In addition, to diminish this backwardness of rural areas, the villages are electrified using single-phase distribution systems and in some cases by a two-phase system. However, these electrification schemes were not designed considering the expected needs of users, affecting the future potential of economic, social and cultural development of the rural community. For example, a farm whose source of electric power is a single-phase system will not be able to use three-phase electric machinery to improve its production process.

2. OVERVIEW OF CYCLO-CONVERTER

The single-phase to single-phase Cyclo-converter with mid-tap transformer type converter is shown in Fig.1, this type of arrangement midpoint tap transformer is use to obtain variable voltage and variable frequency. Waveforms shown are obtained by varying the number of cycle covered by positive and the negative converters and firing angle.

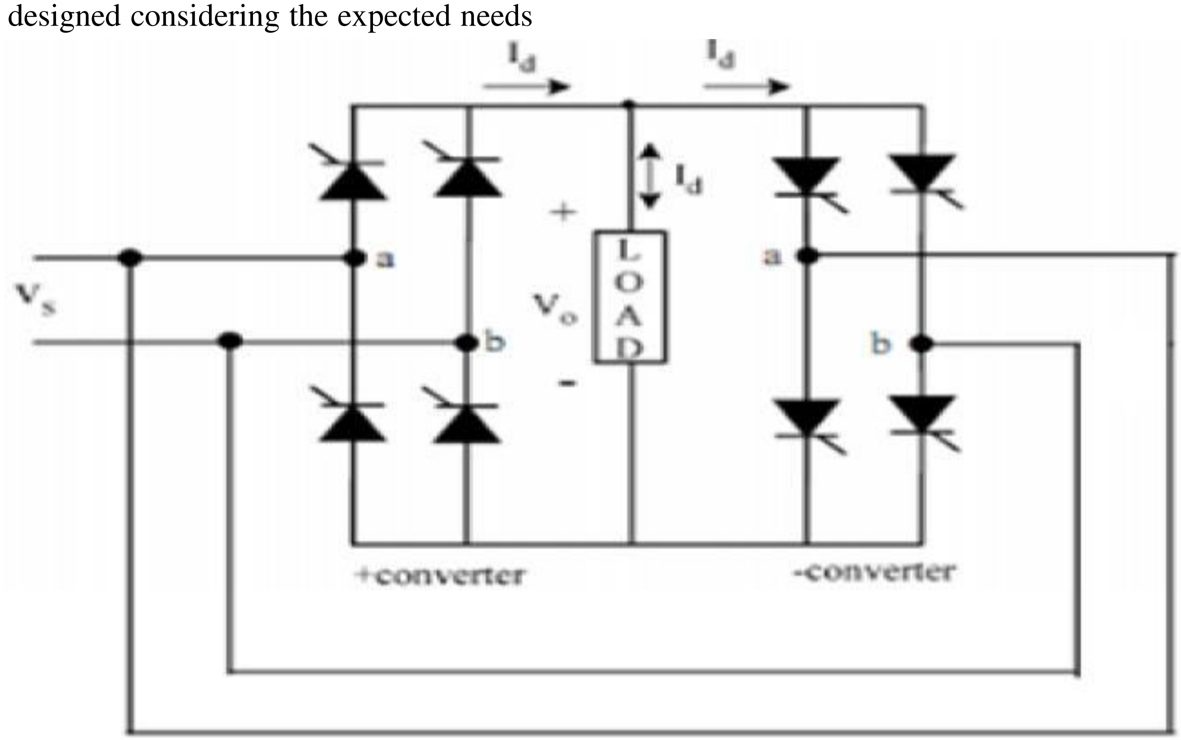

Fig. 1: single-phase to single-phase Cyclo-converter with mid-tap transformer

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The frequency can be varied by varying the conduction period for each MOSFET. The gate pulse for SCR can be provided by either by using firing circuit. Here for positive half cycle of input or supply. T1, T2‟ are forward biased, T1 is given pulse. For negative half cycle of input or supply T1‟, T2 are forward biased. T1‟ is given pulse. For another positive half cycle T2‟ is given pulse. For another negative half cycle T2 is given pulse. By using Cycloconverter we can vary voltage and frequency. As AC motor characteristics require the applied voltage to be proportionally adjusted whenever the frequency is changed in order to deliver the rated torque this method is also called volts/hertz. For optimum performance, some further voltage adjustment may be necessary especially at low speeds, but constant volts per hertz are the general rule. This ratio can be changed in order to change the torque delivered by the motor.

3. ELECTRONIC PHASE CONVERTERS

The development in power electronics devices makes possible to propose several switching schemes, rectifiers, inverters or a combination of these to use them in the design and manufacturing of electronic phase converters. In this section we include some works related to this technology. A simple electronic phase converter of single-phase to three-phase based on the principle of direct cycloconversion is presented in [4]. The conversion is accomplished by six solid-state switches, as shown in Fig. 2. Only six gating signals are required that can be produced by a simple logic circuit. The expressions of output voltages and input current permit determine the advantages and disadvantages of this converter. It provides balanced three-phase output voltages and generates a low-distortion in the input current. Nevertheless, the output voltages contain large third harmonic components and the utilization of an appropriate filter is indispensable. Furthermore, the voltage utilization is low and to solve this problem is necessary to employ a matching step-up transformer. An experimental 1 kVA phase converter was implemented to verify the theoretical results.

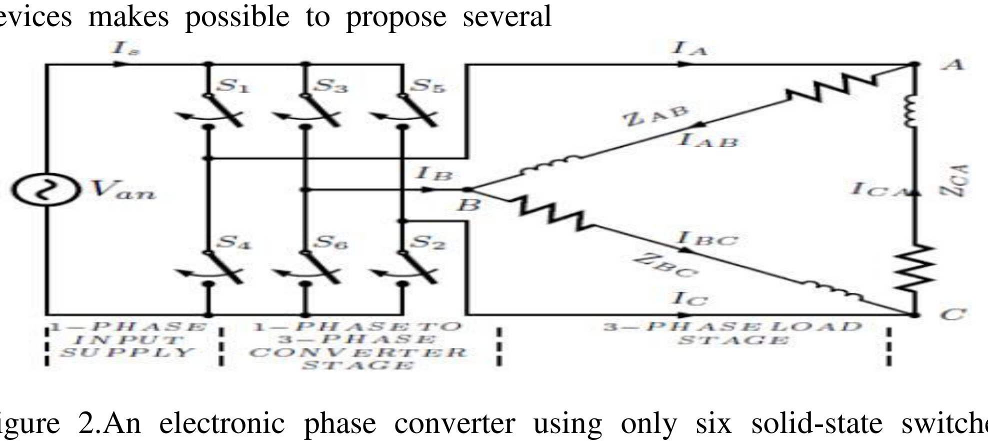

Figure 2.An electronic phase converter using only six solid-state switches in the process conversion (copyright © 1989 IEEE [4], reprinted with permission).

To supply an induction motor drive, a single-phase to three-phase converter is presented in [5]. Four bidirectional semiconductor switches are employed in the process of conversion to obtain two output voltages; the third one is taken from the single-phase source. Each bi-directional switch is built with two anti-series MOSFETs or IGBTs and to maximize the gain between the output and the input a control strategy in required to generate the gate signals. A Fourier series analysis considering the switching functions demonstrate that the input power factor directly corresponds to the load power factor. The advantages of this converter are: it does not employ any reactive component in the process of conversion, it can be controlled to generate a variable frequency and output voltage for an adjustable speed operation of the driver, the circuits of bi-directional switches do not require the use of snubbers, and the converter is compact and small in size and weight. The main advantages of the proposed converter are: at 60 Hz the voltage gain between the input and the output is 63% for the fundamental component (this imply the use of a motor with a lower voltage or an autotransformer to step-up the voltage), and the input current, the output voltages and currents show a large harmonic distortion (a harmonic filter is required). This last is verified with the graphs obtained experimentally and by simulation.

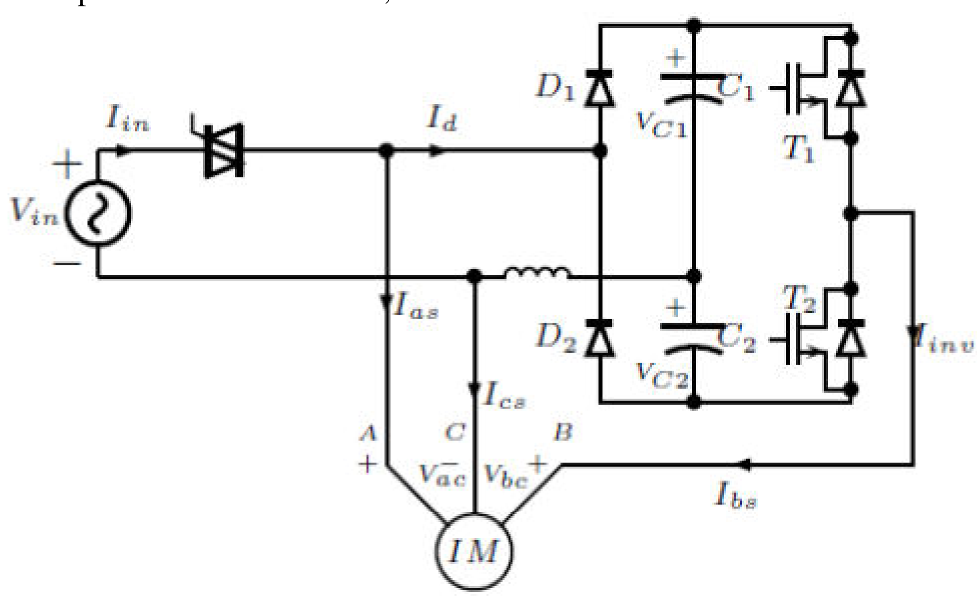

Figure 3.A single-phase to three-phase converter to supply an induction motor (reproduced from [6]).

A relatively simple single-phase to three-phase converter is proposed in [6] to supply three-phase induction motors in the 10-100 hp range with a power factor about 94%. This converter, shown in Fig. 3, is built with an input line inductor, a rectifier bridge of two diodes, a pair of capacitors, a triac as a bidirectional switch, and two power semiconductor switches to obtain an inverter. Because only three switches are employed in the conversion process, the efficiency of the converter is about 97%. One phase between bi-directional switch and the inverter input and the last one is connected directly from the input line. With the strategy considered (two digital PI controllers) to control the bi-directional switch and inverter it is possible to provide the capability of soft start, a limited inrush current, and balanced voltages and currents in the motor under start-up and steady state operating conditions. According to experimental results reported by the authors, the steady state output currents have a total harmonic distortion less than 5%, and the input line current and voltage have a distortion of approximately 30%.

A phase reduced topology converter to drive a three-phase motor from a single-phase supply is proposed in [7]. This converter is based on the topology of the converter presented in [8] and it uses two power semiconductor switches to generate a phase, i.e. six power switches are needed; also there are two capacitors and one inductor between the single-phase source and the input converter. The converter was simulated and its predicted performance was compared with an ideal three-phase inverter with the same switching strategy. Considering the torque-speed characteristics, the average torque of the two schemes is almost the same but in steady state with the reduced topology there is a torque ripple, though this ripple has little effect on the speed of the motor. The simulations show that the current of the converter is √3 times greater than the line current of the ideal inverter. The supply current and voltage waveforms of the reduced topology are sinusoidal and the power factor is near unity; and in the ideal three-phase converter the current laggs the voltage. No control techniques were implemented to compensate the effect that, switching dead time, on-state voltage and dc-link voltage ripple have on the total harmonic distortion of the output voltage waveforms. Consequently, filtered voltage waveforms still present a higher harmonic content. The starting torque and the time to reach full speed were measured and were the same in both schemes. However, there is a noticeable difference in the torque curve when the motor reaches a speed of approximately 200 rpm. In general, the achieved performance by reduced topology phase converter and the ideal three-phase inverter were similar. This suggest that the reduced topology is a good option for rural applications, but according to authors, is necessary further research and analysis on this converter.

CONCLUSION

The cyclo-converter circuit have designed for speed control of induction motor for adjustable frequency. Single phase Cyclo-converter used to change the speed of induction motor with the help of microcontroller, different desired frequency is obtained to equalize the desired speed. This different frequency of cyclo-converter is obtaind in the manner of adjustable speed to F, F/2 & F/3. Furthermore, it provides means for limiting the slip and consequently the motor current, also high voltage circuit from affecting the system receving the signal can be prevent with the help of opto-coupler. This means a reduction in the Cyclo-converter rating and better efficiency.

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