# Cycloconverters using Thyristors

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*Abstract*— The project 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. As the AC supply frequency cannot be changed, so this project uses a thyristor controlled cycloconverter which enables the control of speed in steps for an induction motor. The microcontroller used in this project is Atmega 328P, a mobile phone-bluetooth control switch is provided to select the desired speed range (F, F/2 and F/3) of operation of the induction motor. These switches are interfaced to the microcontroller. The status of the switches enables the microcontroller to deliver the pulses to trigger the SCRs in a dual bridge. Thus, the speed of the induction motor can be achieved in three steps i.e. (F, F/2 and F/3). This very concept can be further enhanced and implemented to control the speed of a three phase induction motor. It can also be coupled with _ring angle control for any desired speed.
***Key words:*** Cycloconverters, Thyristors

## I. Introduction

Cycloconverters are used in high power applications driving induction and synchronous motors. They are usually phase-controlled and they traditionally use thyristors due to their ease of phase commutation. Power conversion systems such as those used for large propulsion motor drives will often utilize cycloconverter technology in order to take advantage of the power handling capability of modern thyristors. Because cycloconverters produce non-integer harmonics of the input power frequency, both input current and output voltage require detailed study in order to insure trouble-free operation of both the supplying power system and the connected motor load. The cycloconverter is a device which converts input AC power at one frequency to output AC power at a different frequency with a one stage conversion. The frequency conversion is achieved using a phase control method. Phase controlled cycloconverters have the ability to operate in all 4 quadrants in the V-I plane. Thus, cycloconverters are capable of providing a variable frequency power supply to AC machines. Due to its 4-quadrant operation, the cycloconverter can handle loads of any power factor.

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The development of the semiconductor devices has made it possible to control the frequency of the cycloconverter according to the requirement and deliver a large amount of controlled power with the help of semiconductor switching devices like Thyristors, MOSFETs in order to get alternating output of variable frequency. The quality of the output waveform improves if more switching devices are used. Split-phase induction motors are widely used in many applications due to their energy efficient characteristics. Improvements in its performance mean a great saving in electrical energy consumption.

Thus, a cycloconverter has the facility for continuous and independent control over both its output frequency and voltage. Cycloconverter eliminates the use of flywheel because the presence of flywheel in machine increases torsional vibration and fatigue in the component of power transmission system.

## II. Schematic diagram

In the block diagram shown in figure, a single phase 230V power supply is given the transformer for step down the voltage from 230V AC to 12V AC. The 12V AC is then fed to the bridge rectifier. The rectifier converts 12 AC to 12V DC. The output of the rectifier is fed to the Voltage regulator 7805. It gives an output of 5V DC. The 5V DC is given to Vcc of the micro controller ATMEGA 328P.The micro controller has been programmed i.e. ASM/C program to give output to optical isolation with zero cross detection circuit. It compares two signals in order to get zero crossing. Whenever the zero crossing occurs, it gives an output. A microcontroller program is developed to control the _ring pulses of gate driving circuit, these _ring pulses are controlled by DIACs. The output of the cycloconverter is fed to the induction motor to control the speed at different frequencies.

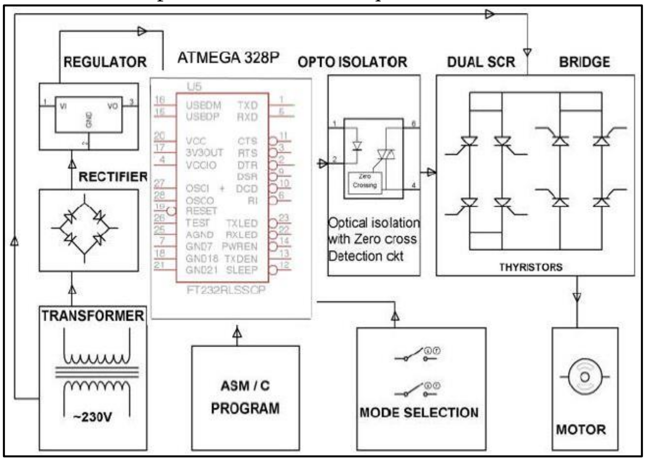

Fig. 1: Block Diagram of Cycloconverters using Thyristors

Cycloconverter consists of two single phase full bridge Circuits Bridge 1 and bridge 2, load is connected in between these two bridge circuits. Each bridge consists of four thyristors. From these, upper group thyristors are positive and lower group are negative group thyristors. These thyristors gate pulses are controlled by zero crossing detector and microcontroller. The _ring angle control consists of eight MOC 3063 op to isolators. MOC 3063 contains an LED and a light sensitive DIAC. When the LED is switched on, then the DIACs in MOC3063 gets the input and they turn on. The op to isolators (MOC 3063) isolates the high frequency modulated driver control circuit with low frequency cyclo converter circuit. At time t=0+, the thyristors on the 1st bridge switches on for pre-defined time period t1, during this time period t1, other bridge is kept in off position. To control the speed of the induction motor, frequency of the output voltage is controlled by turn ON and turn- O_ time periods of the thyristors. When the Bluetooth controlled switch 1 is closed, SCR gets conducting for 20ms for 1st bridge and next 20ms for 2nd bridge so the total time period of AC cycle is 40ms. So it gives the frequency 25Hz i.e. F/2. When the Bluetooth controlled switch 2 closed, the time period of conduction for the 1st bridge takes place for 30ms and then other bridge for 30ms so the total time period of AC cycle is 60ms 16.66 Hz i.e. F/3. This supply is given to the motor by using F/2 and F/3 supply in order to control the speed of the AC motor.

## *A. Voltage Regulator*

The LM78XX/LM78XXA series of three-terminal positive regulators are available in the TO-220/D-PAK package and with several fixed output voltages, making them useful in a Wide range of applications. Each type employs internal current limiting, thermal shutdown and safe operating area protection as in figure, making it essentially indestructible. If adequate heat sinking is provided, they can deliver over 1A output Current. Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and currents.

## *B. Zero Crossing Detector*

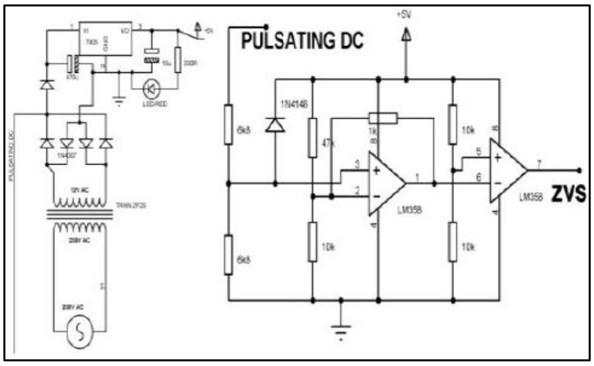

Fig. 2: Circuit Diagram (ZCD)

In the circuit diagram of zero crossing detector, we are using 50Hz ac signal, the total cycle time period is 20msec (T=1/F=1/50=20msec) in which, for every half cycle (i.e. 10ms) we have to get zero signals. This is achieved by using pulsating dc after the bridge rectifier before being filtered. For that purpose we are using a blocking diode D3 between pulsating dc and the filter capacitor so that we can get pulsating DC for use. The pulsating DC is given to potential divider of 6.8k and 6.8K to deliver an output about 5V pulsating from 12V pulsating which is connected to non-inverting input of comparator pin 3. Here Op-amp is used as comparator. The 5V DC is given to a potential divider of 47k and 10K which gives an output of about 1.06V and that is connected to inverting input pin no 2.One resistance of 1K is used from output pin 1 to input pin 2for feedback. As we know the principle of a comparator is that when non-inverting terminal is greater than the inverting terminal then the output is logic high (supply voltage) .Thus the pulsating dc at pin no 3 is compared with the fixed dc of 1.06V at pin no 2. The o/p of this comparator is fed to the inverting terminal of another comparator. The non-inverting terminal of this comparator pin no 5 is given a fixed reference voltage i.e., 2.5V taken from a voltage divider formed from resistors of 10k and 10k. Thus we get ZVR (Zero Voltage Reference) detection whose output wave form is shown in figure. This ZVR is then used as input pulses to microcontroller.

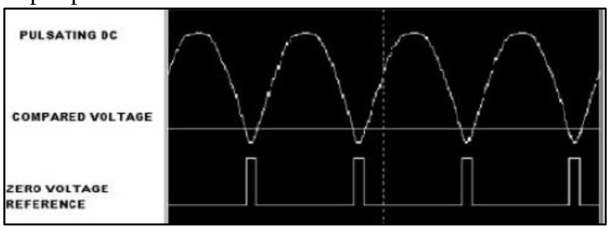

Fig.3 Output waveform of ZCD

## *C. Atmega 328P*

The high-performance Microchip picoPower 8-bit AVR RISC-based microcontroller combines 32KB ISP ash memory with read-while-write capabilities, 1024B EEPROM, 2KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, a 6-channel 10-bit A/D converter (8-channels in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. By executing powerful instructions in a single clock cycle, the device achieves through puts approaching 1 MIPS per MHz, balancing power consumption and processing speed.

### *D. Opto Isolator*

In electronics, an opto-isolator, also called an optocoupler, photocoupler, or optical isolator, is a component that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal. An opto-isolator contains a source (emitter) of light, almost always a near infrared light-emitting diode (LED), that converts electrical input signal into light, a closed optical channel (also called diele ctrical channel, which detects incoming light and either generates electric energy directly, or modulates electric current owing from an external power supply.The sensor can be a photoresist or, 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. An optocoupled solid-state relay contains a photodiode opto-isolator which drives a power switch, usually a complementary pair of MOSFETs. A slotted optical switch contains a source of light and a sensor, but its optical channel is open, allowing modulation of light by external objects obstructing the path of light or reflecting light into the sensor.

### *E. Bluetooth Module HC-O5*

HC 05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave con_guration, making it a great solution for wireless communication. This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It uses CSR Bluecore 04External single chip Bluetooth system with CMOS technology and with AFH (Adaptive Frequency Hopping Feature). The Bluetooth module HC-05 is a MASTER/SLAVE module. By default, the factory setting is SLAVE. The role of the module (Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices. The user can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to embedded project, etc.

## III. WORKING

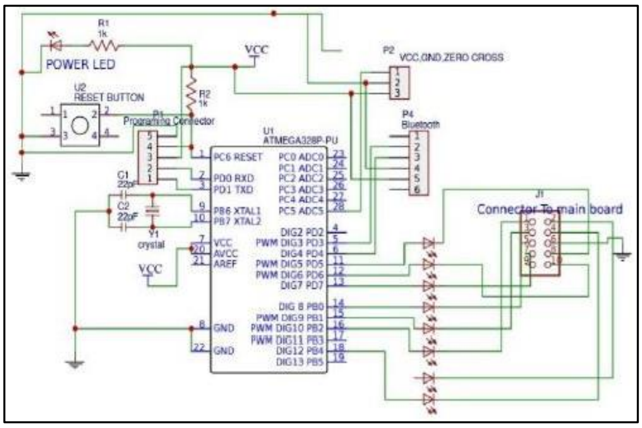

Fig. 4: Control Circuit

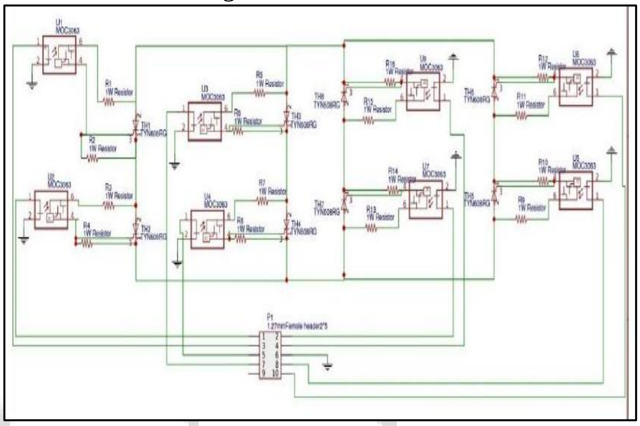
Fig. 5: Cycloconverter Circuit

Fig 4 and 5 shows the control and cycloconverter circuits of hardware components. The project uses zero voltage reference as described above at pin no.28 i.e., port 3.3, interrupt 1. Eight Opto isolators i.e., MOC3063 are used for driving 8 SCRs U1 to U8. 4 SCRs used in full bridge are in anti-parallel with another set of 4 SCRs as shown in the diagram. Triggering pulses so generated by the MC as per the program written provides input condition to the Opto isolator that drive the respective SCR. SCR gets conducting for 20ms from 1st bridge and next 20ms from the 2nd bridge to get the output, total time period of one AC cycle of 40ms which is 25 Hz. Thus F/2 is delivered to the load while bluetooth controlled switch-1 is closed. Similarly for F/3 the conduction takes place for 30ms in the 1st bridge and next 30ms from the next bridge, such that a total time period of 1 cycle comes to 60ms which in turn in F/3 while bluetooth controlled switch-2 is operated. Fundamental frequency of 50Hz is available by triggering on pair from the 1st bridge for 1st 10ms and for the next 10ms from the next bridge while both the bluetooth controlled switches are kept in OFF condition. Reverse current owing in the gates of the SCRs are Opto isolator output.

## IV. SIMULATION

Simulink model of split phase induction motor and single phase to single phase cycloconverter is shown in Fig 6. The objective of this project is to analyse the speed of induction motor performance. The stator of a split phase induction motor has two windings, the main winding and auxiliary winding. Since, the d-q axis model of an induction motor is only valid for sinusoidal input voltage. Fig 7 and Fig 8 shows output phase voltages and currents for 25Hz and 12.5Hz output frequency of the single-phase Cycloconverter. The triggering pulses to SCR pairs are shown in figure 9

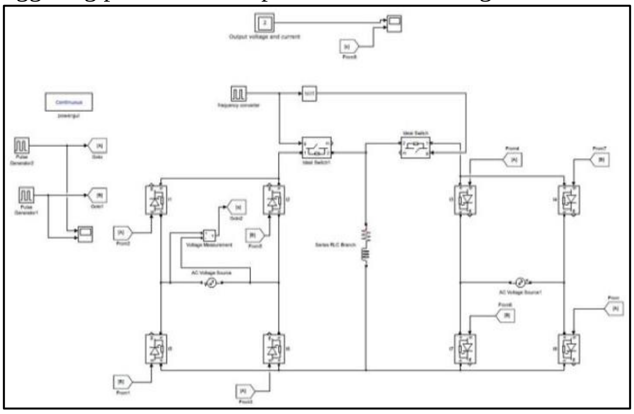

Fig. 6: Simulation Circuit

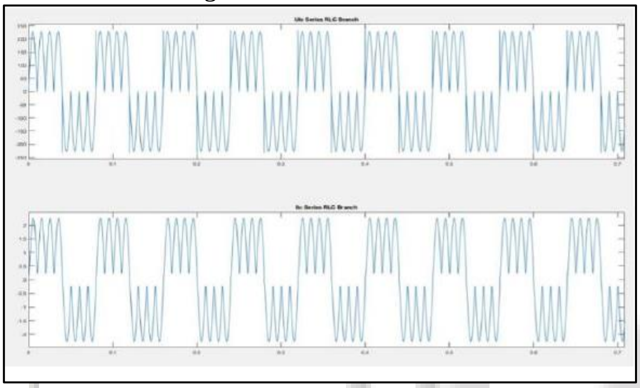

Fig. 7: Simulation Result (Frequency=12.5Hz)

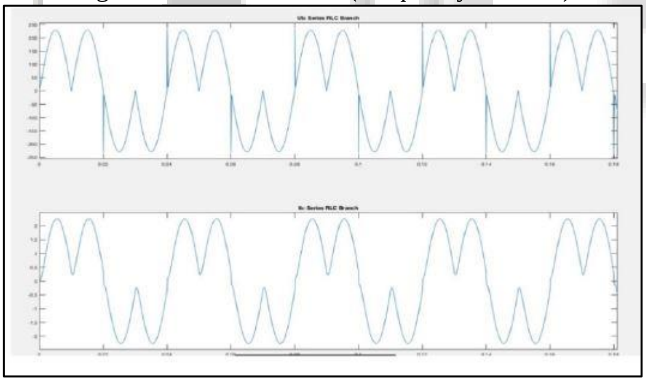

Fig. 8: Simulation Result (Frequency=25Hz)

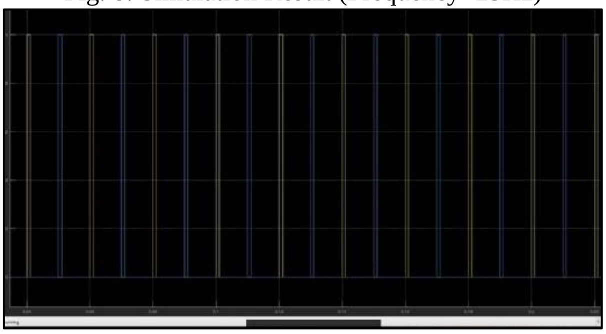

Fig. 9: Triggering Pulses to SCR

## V. CONCLUSION

In manufacturing and process industries, the variable frequency is required for driving various electrical machineries. The cycloconverter plays a significant role in driving those electrical machineries. The project mainly focuses on the design and construction of the bluetooth controlled single phase cycloconverter using thyristors. The cyclo-converter circuit is designed for speed control of induction motor for adjustable frequency. Single phase Cyclo-converter is 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.

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