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AC to AC STEP DOWN CYCLOCONVERTER

Viren Patel[1], Dipak Makawana[2], Vishal Rangpara[3], Jaydipsinh Zala[4]

[1.2.3] *B.E. in Electrical Engineering, DSTC, Junagadh, Gujarat, India*
[4] *Assistant Professor, Department of Electrical Engineering, DSTC, Junagadh, Gujarat, India*

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Abstract - *To control the speed of a single phase induction motor in three steps using SCR based single phase cycloconverter technique. A.C. motors have great advantages of being relatively inexpensive and very reliable. The induction motors in particular are very robust. Therefore they are used in many domestic appliances such as washing machines, vacuum cleaners, water pumps, and in industries as well. Induction motor is known as constant speed machine. The difficulty of varying its speed by a cost effective device is one of its main disadvantage. As AC supply frequency cannot be changed, so this uses a thyristor controlled cycloconverter which enables control of speed in steps for an induction motor. The microcontroller used in this is arduino. A pair of slide switches are provided to select desired speed range F, F/2 and F/3 of operation of induction motor. These switches are interfaced to the microcontroller. The status of switches enables the microcontroller to deliver pulses that trigger a set of SCRs in dual bridge. Thus, the speed control of induction motor can be achieved in three steps i.e. (F, F/2 and F/3).*

Key Words: **SCRs, Tap Changing Transformer, Opto Coupler, AC Fan.**

1. INTRODUCTION

A Cycloconverter refers to a frequency changer that can to change AC power from one frequency to AC power at another frequency. It converts the frequency without help of any intermediate DC link. The output voltage and frequency of a cycloconverter can be varied continuously and independently using a control circuit. Therefore, unlike other converters, it is a single stage frequency converter.

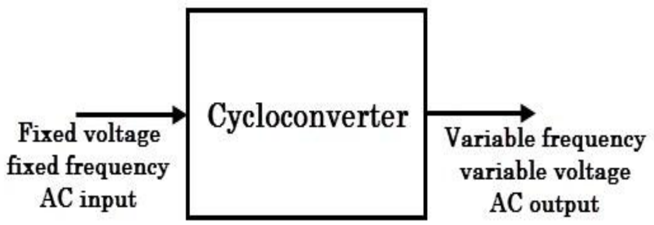

Fig 1: Cycloconverter

Single phase cycloconverter has two full wave converters connected back to back. If one converter is operating the other one is disabled, no current passes through it.

In step down cycloconverter forced commutation and results in an output with a frequency lower than that of the input Fo (Output Frequency) < Fs (Supply Frequency). The step down cycloconverter is physically commutated and the output frequency is limited to a value that is a fraction.

1.1 Block Diagram of AC to AC Step down Cycloconverter

Fig 2 shows the block diagram of step down cycloconverter in this the arduino microcontroller to be used.

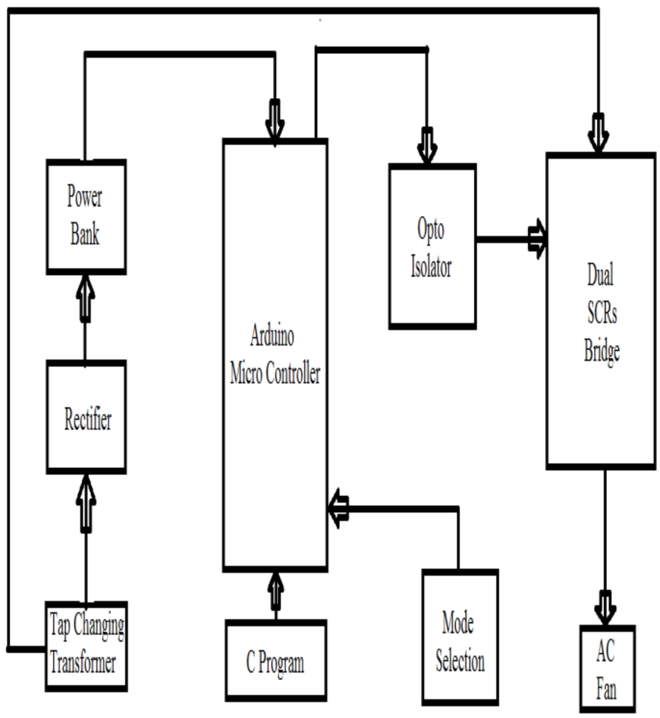

Fig 2: Block Diagram

Components Used:

1. Tap Changing Transformer
2. Rectifier
3. Arduino Microcontroller
4. Opto Isolator
5. SCRs
6. AC Fan
7. Bulb
8. Slider Switch
9. Power Bank

1.2 Working of AC to AC Step down Cycloconverter

It consists of two full-wave, fully controlled bridge thyristors, where each bridge has 4 thyristors, and each bridge is connected in opposite direction (back to back) such that both positive and negative voltages can be obtained as shown in figure below. Both these bridges are excited by single phase, 50 Hz AC supply.

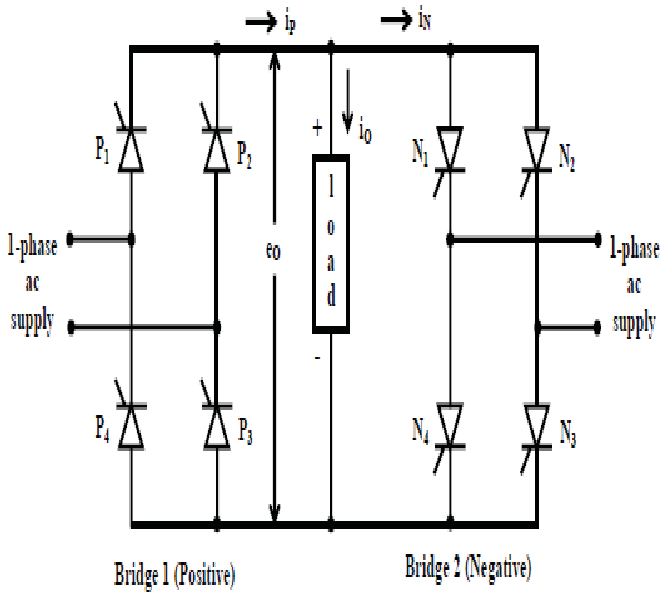

Fig 3: Equivalent Circuit

During positive half cycle of the input voltage, positive converter (bridge-1) is turned ON and it supplies the load current. During negative half cycle of the input, negative bridge is turned ON and it supplies load current. Both converters should not conduct together that cause short circuit at the input.

To avoid this, triggering to thyristors of bridge-2 is inhibited during positive half cycle of load current, while triggering is applied to the thyristors of bridge 1 at their gates. During negative half cycle of load current, triggering to positive bridge is inhibited while applying triggering to negative bridge.

By controlling the switching period of thyristors, time periods of both positive and negative half cycles are changed and hence the frequency. This frequency of fundamental output voltage can be easily reduced in steps, i.e., 1/2, 1/3, 1/4 and so on.

The figure 4 shows output waveforms of a cyclo-converter that produces one-fourth of the input frequency. Here, for the first two cycles, the positive converter operates and supplies current to the load.

It rectifies the input voltage and produce unidirectional output voltage as we can observe four positive half cycles in the figure. And during next two cycles, the negative converter operates and supplies load current.

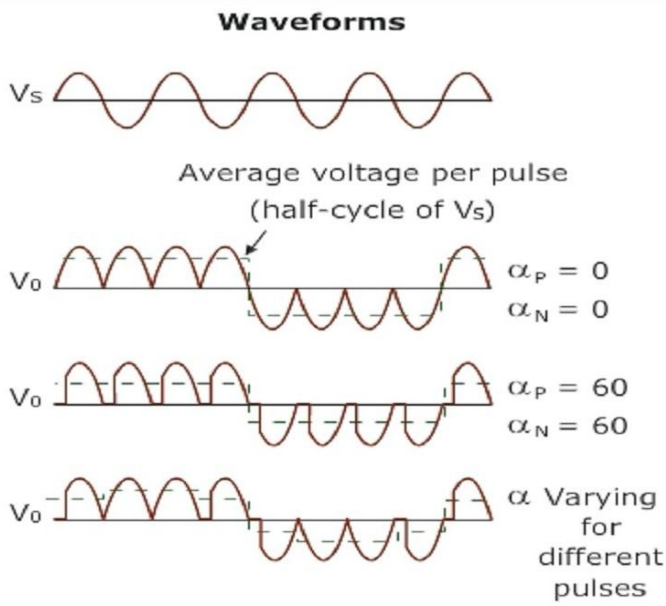

Fig 4: Waveform

Here one converter is disabled if another one operates, so there is no circulating current between two converters. Since the discontinuous mode of control scheme is complicated, most cyclo converters are operates on circulating current mode where continuous current is allowed to flow between the converters with a reactor.

This circulating current type cyclo-converter can be operated on with both purely resistive (R) and inductive (R-L) loads.

2. MATLAB DESIGN AND RESULTS

Circuit:

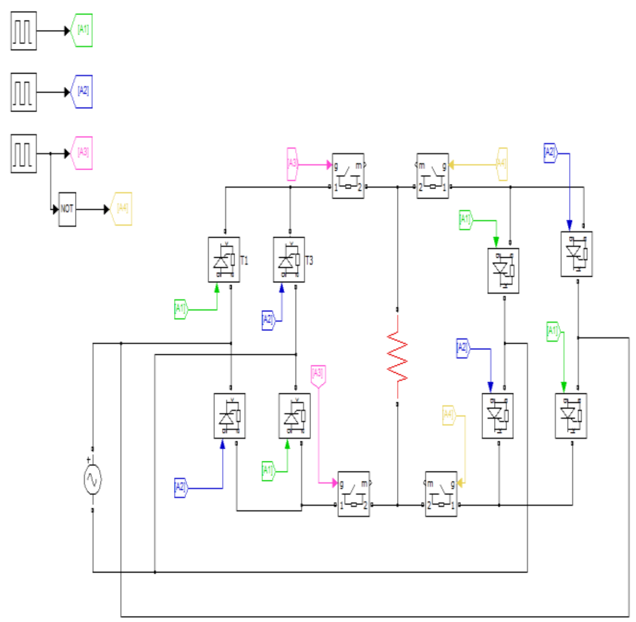

Fig 5: MATLAB Circuit

Waveforms:

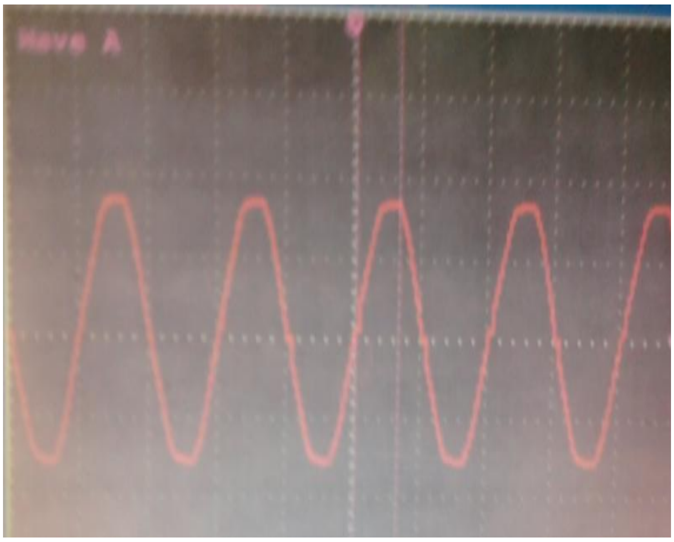

Fig 6: Output at load for normal frequency (f)

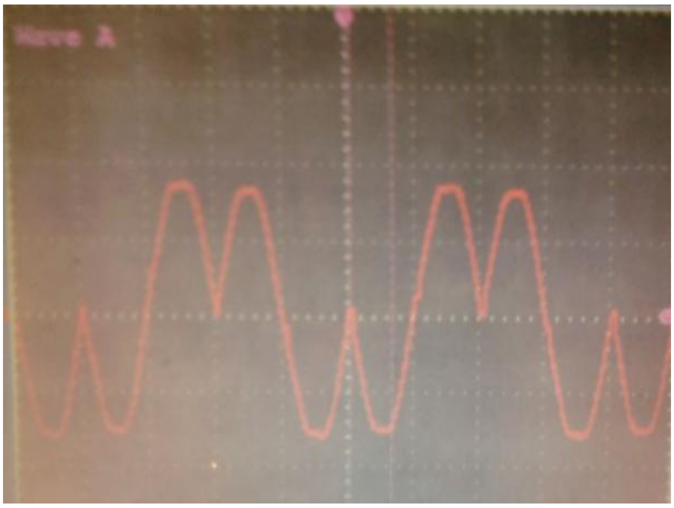

Fig 7: Output at load for frequency f=25Hz (f/2)

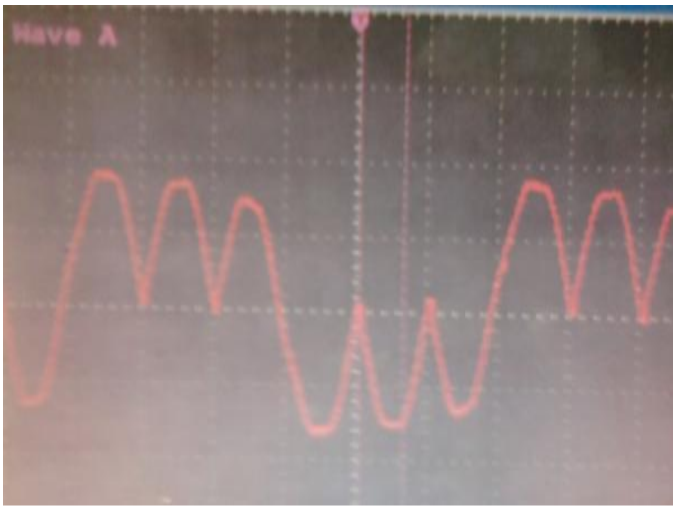

Fig 8: Output at load for frequency f=16.6Hz (f/3)

3. ARDUINO MICRO CONTROLLER

The arduino microcontroller is used in the AC to AC stepdown cycloconverter.

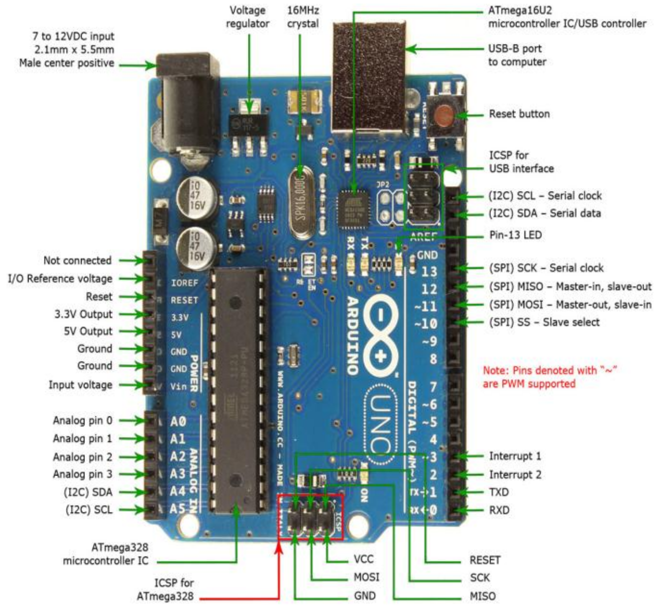

Fig 9: Arduino Micro Controller

As the microcontroller used in this is arduino. A pair of slide switches are provided to select desired speed range F, F/2 and F/3 etc. of operation of induction motor. These switches are interfaced to the microcontroller. The status of switches enables the microcontroller to deliver pulses that trigger a set of SCRs in dual bridge. Thus, the speed control of induction motor can be achieved in three steps i.e. F, F/2 and F/3.

3.1 Connection Circuit:

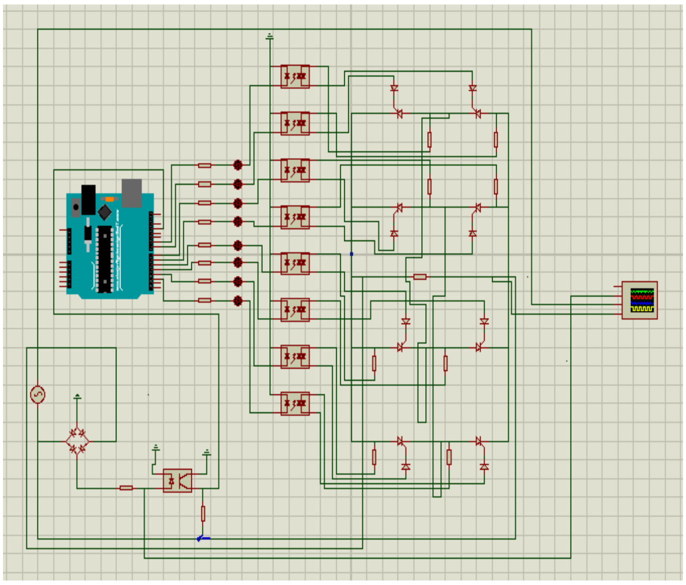

Fig 10: Connection Circuit of Arduino Microcontroller

3.2 Programing of Arduino Microcontroller for AC to AC Stepdown Cycloconverter

```
int moc1 = 2;
int moc2 = 3;
int moc3 = 4;
int moc4 = 5;
int moc5 = 6;
int moc6 = 7;
int moc7 = 8;
int moc8 = 9;
int button1 = 10;
int button2 = 11;
int zero = 13;
int var1;
int var2;


void setup()
{
Serial.begin(9600);
pinMode(moc1,OUTPUT);
pinMode(moc2,OUTPUT);
pinMode(moc3,OUTPUT);
pinMode(moc4,OUTPUT);
pinMode(moc5,OUTPUT);
pinMode(moc6,OUTPUT);
pinMode(moc7,OUTPUT);
pinMode(moc8,OUTPUT);

pinMode(button1,INPUT);
pinMode(button2,INPUT);
pinMode(zero,INPUT);
digitalWrite(zero,HIGH);
}

void loop()
{
var1 = digitalRead(button1);
var2 = digitalRead(button2);

if (digitalRead(zero)==LOW)
{
if ( var1 == HIGH && var2 == HIGH)
{
digitalWrite(moc1,HIGH);
digitalWrite(moc2,HIGH);
digitalWrite(moc3,HIGH);
digitalWrite(moc4,HIGH);
digitalWrite(moc5,LOW);
digitalWrite(moc6,LOW);
digitalWrite(moc7,LOW);
digitalWrite(moc8,LOW);
delay(0.5);
digitalWrite(moc1,LOW);
digitalWrite(moc2,LOW);
digitalWrite(moc3,LOW);
digitalWrite(moc4,LOW);
delay(19.5);
digitalWrite(moc5,HIGH);
digitalWrite(moc6,HIGH);
digitalWrite(moc7,HIGH);
digitalWrite(moc8,HIGH);
delay(0.5);
digitalWrite(moc5,LOW);
digitalWrite(moc6,LOW);
digitalWrite(moc7,LOW);
digitalWrite(moc8,LOW);
delay(19.5);
}
else if ( var1 == HIGH && var2 == LOW)
{
digitalWrite(moc1,HIGH);
digitalWrite(moc2,HIGH);
digitalWrite(moc3,HIGH);
digitalWrite(moc4,HIGH);
digitalWrite(moc5,LOW);
digitalWrite(moc6,LOW);
digitalWrite(moc7,LOW);
digitalWrite(moc8,LOW);
delay(0.5);
digitalWrite(moc1,LOW);
digitalWrite(moc2,LOW);
digitalWrite(moc3,LOW);
digitalWrite(moc4,LOW);
delay(29.5);
digitalWrite(moc5,HIGH);
digitalWrite(moc6,HIGH);
digitalWrite(moc7,HIGH);
digitalWrite(moc8,HIGH);
delay(0.5);
digitalWrite(moc5,LOW);
digitalWrite(moc6,LOW);
digitalWrite(moc7,LOW);
digitalWrite(moc8,LOW);
delay(29.5);
}

else if( var1 == LOW && var2 == HIGH)
{
digitalWrite(moc1,HIGH);
digitalWrite(moc2,HIGH);
digitalWrite(moc3,HIGH);
digitalWrite(moc4,HIGH);
digitalWrite(moc5,LOW);
digitalWrite(moc6,LOW);
digitalWrite(moc7,LOW);
digitalWrite(moc8,LOW);
delay(0.5);
digitalWrite(moc1,LOW);
digitalWrite(moc2,LOW);
digitalWrite(moc3,LOW);
digitalWrite(moc4,LOW);
delay(29.5);
```

```
digitalWrite(moc5,HIGH);
digitalWrite(moc6,HIGH);
digitalWrite(moc7,HIGH);
digitalWrite(moc8,HIGH);
delay(0.5);
digitalWrite(moc5,LOW);
digitalWrite(moc6,LOW);
digitalWrite(moc7,LOW);
digitalWrite(moc8,LOW);
delay(29.5);
}

else
{
digitalWrite(moc1,LOW);
digitalWrite(moc2,LOW);
digitalWrite(moc3,LOW);
digitalWrite(moc4,LOW);
digitalWrite(moc5,LOW);
digitalWrite(moc6,LOW);
digitalWrite(moc7,LOW);
digitalWrite(moc8,LOW);

}
}
}
```

3.3 Technical Specifications of Arduino Micro - Controller

Table of Technical Specifications:

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12 V
Input Voltage (limit)	6-20 V
Digital I/O Pins	14
Clock Speed	16MHz
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pins	20mA
DC Current for 3.3V Pin	50mA
SRAM	2KB
EPROM	1KB
Flash Memory	32KB
LED BUILTIN	13

4. CONCLUSIONS

From this work it is observed that speed of an induction motor can be efficiently controlled by using Cycloconverter. The role of Cycloconverter is in speed control of induction motor is to vary the supply frequency which in turn, changes the speed of motor. The speed control of induction motor can be achieved in three steps i.e. (F, F/2 and F/3).

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BIOGRAPHIES

Viren J. Patel
B.E. in Electrical Engineering at Dr. Subhash Technical campus - Junagadh, Gujarat, India

Dipak K. Makawana
B.E. in Electrical Engineering at Dr. Subhash Technical campus - Junagadh, Gujarat, India

Vishal M. Rangpara
B.E. in Electrical Engineering at Dr. Subhash Technical campus - Junagadh, Gujarat, India

Jaydipsinh B. Zala
Assistant Professor in Electrical Engineering Department at Dr. Subhash Technical Campus - Junagadh, Gujarat, India