RAJSHAHI UNIVERSITY OF ENGINEERING & TECHNOLOGY
DEPARTMENT OF ELECTRONICS & TELECOMMUNICATION ENGINEERING,
RAJSHAHI-6204, BANGLAGLADESH.

PROJECT REPORT
On
Electronic Project Design and Development
(Sessional)
ETE-2200

Project Name: Experimental and Practical Analysis of Single Phase Full Wave Controlled Rectifier, Single Phase to Single Phase Step Down Cycloconverter and Single Phase AC-AC Voltage Controller Using Arduino Uno.

SUBMITTED TO:
Shuvra Prokash Biswas
Assistant Professor
Dept. of ETE, RUET

SUBMITTED BY:
Name: Shahriar Amin
Roll:1804052
Year:2nd year (EVEN)
Submission Date: 20-03-2022

Table of Contants

Chapter-01

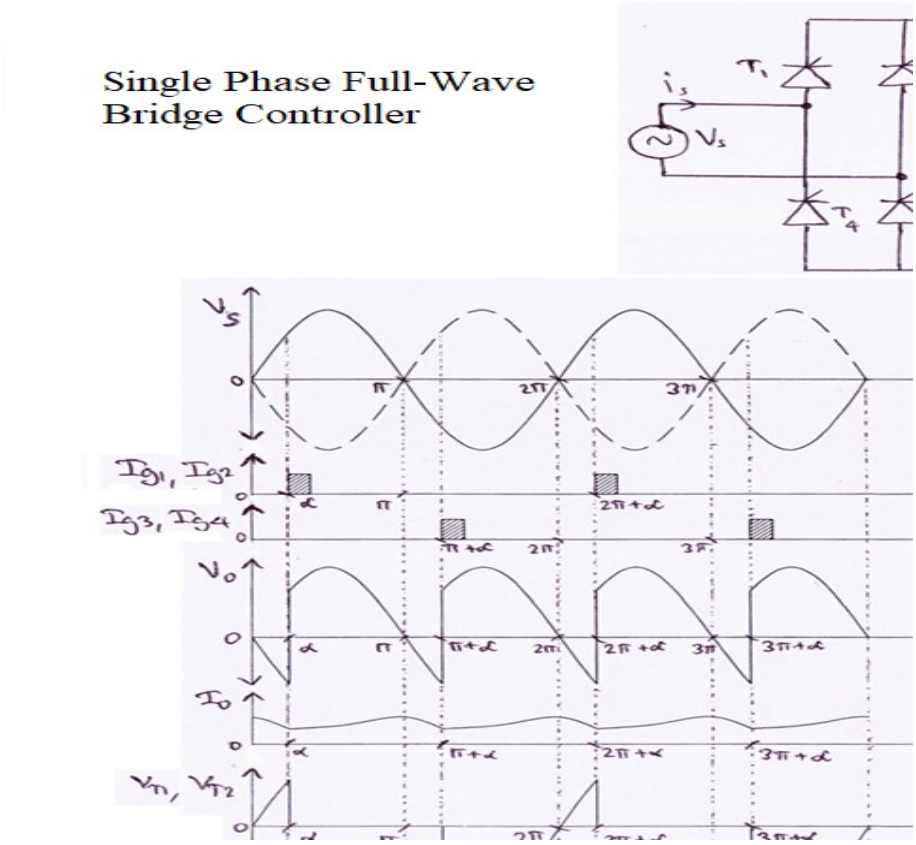
Introduction,Theory & Objective

Introduction:

Single phase control rectifier is consists of two scr and two diode (halfly controlled) which is controlled by zero crossing detector using arduino uno. The two scr are controlled by using arduino code and zero crossing detector.The optocoupler is used to connect the circuit with arduino uno. In cycloconverter(mid point) , four SCR are used and arduino code applied these scr by optocoupler which are controlled by zero crossing detector. In AC-AC voltage controller, two scr are used to control AC voltage. The same arduino code is applied in aruino uno to control AC voltage.

Theory:

Single Phase Full Wave Controlled Rectifier: Single phase fully-controlled bridge rectifiers are known more commonly as AC-to-DC converters. Fully-controlled bridge converters are widely used in the speed control of DC machines and is easily obtained by replacing all four diodes of a bridge rectifier with thyristors as shown. The single phase fully controlled rectifier allows conversion of single phase AC into DC. Normally this is used in various applications such as battery charging, speed control of DC motors and front end of UPS (Uninterruptible Power Supply) and SMPS (Switched Mode Power Supply). All four devices used are thyristors. The turn-on instants of these devices are dependent on the firing signals that are given. Turn-off happens when the current through the device reaches zero and it is reverse biased at least for duration equal to the turn-off time of the device specified in the data sheet.



Single Phase to Single phase Full Wave (Mid point) Step Down Cycloconverter: A cycloconverter (CCV) or a cycloinverter converts a constant amplitude, constant frequency AC waveform to another AC waveform of a lower frequency by synthesizing the output waveform from segments of the AC supply without an intermediate DC link . The main forms of electrical energy commonly available are constant DC (Direct Current) and constant AC (Alternating Current). Often though, we need to swap between AC and DC, change the frequency, or swap from constant to variable power. For these conversion purposes, several converters like inverters, rectifiers, DC choppers and cycloconverters are employed. Step-down cycloconverter is a device which steps down the fixed frequency power supply input into some lower frequency. It is a frequency changer. If f_s & f_o are the supply and output frequency, then $f_o < f_s$ for this cycloconverter

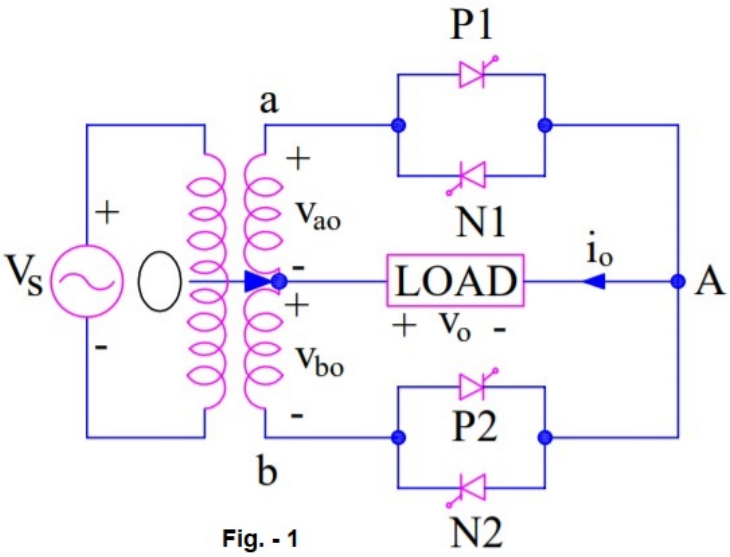


Fig:01: Single phase mid point step down cycloconverter

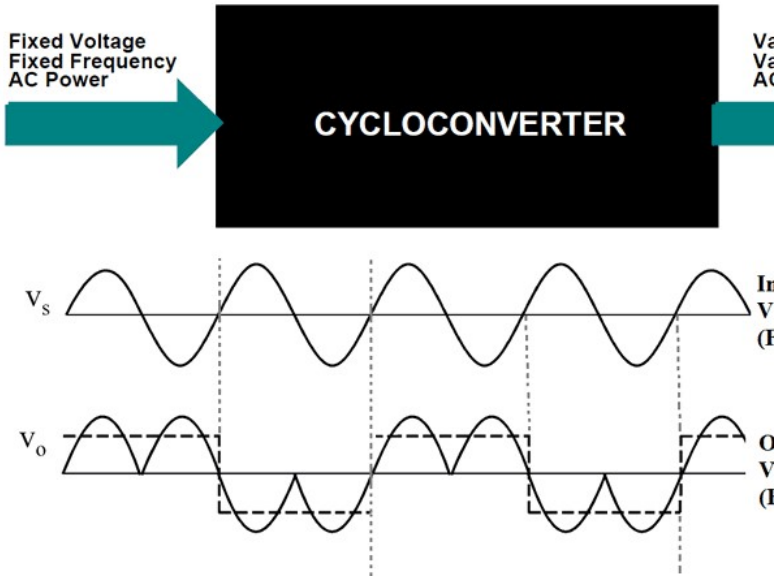
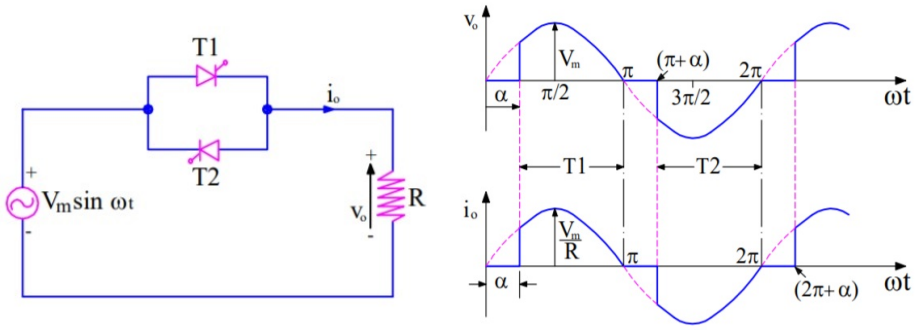


Fig:02: Single phase mid point step down cycloconverter waveform

Single Phase AC-AC voltage Controller:

A single phase full wave AC voltage controller comprises of two thyristor connected in anti-parallel. The circuit diagram is shown in figure below.



The load is assumed resistive for the sake of simplicity. The input source is V_mSinωt.

For the positive half cycle of input source, thyristor T1 is forward biased and hence it is able to conduct provided gate signal is applied. This means that T1 will remain OFF until gate signal is applied. Now suppose, at some angle α (called the firing angle), thyristor T1 is gated. As soon as T1 is fired / gated, it starts conducting and hence, load gets directly connected to the source. This makes load voltage V_o = V_mSinα and load current I_o = (V_mSinα / R) at the instant T1 is fired. From wt = α to π, the load voltage and current follows the input voltage waveform V_mSinωt and (V_mSinωt / R) respectively.

Objective:

1. To learn about the single phase full wave controlled rectifier,cycloconverter and AC-AC voltage controller.
2. To know about the application of single phase full wave controlled rectifier,cycloconverter and AC-AC voltage controller.
3. To analyze the output waveform of single phase full wave controlled rectifier,cycloconverter and AC-AC voltage controller.
4. To know about the practical uses of single phase full wave controlled rectifier,cycloconverter and AC-AC voltage controller.

Chapter-02

Component Description

Introduction:

In this section, the required components are described. Here a brief description is given about each component of the circuit diagram. The components which are used in this project such as arduino uno, thyristor, optocoupler, comparator,diode ,resistor,220v to 12v transformer,10k potentiometer,breadboard,jumper wires.

Hardware Required:

- Arduino board
- 2 x Thyristor (SCR). I used TYN1225
- 2 x optocoupler. I used PC817
- LM393 (or LM339) comparator
- 6 x IN4007 diode
- 10k ohm resistor
- 10k ohm potentiometer
- 4 x 1k ohm resistor
- Resistive load. I used 270 ohm resistor
- 2 x 220 ohm resistor
- 220V to 12V step down transformer
- Breadboard
- Jumper wires

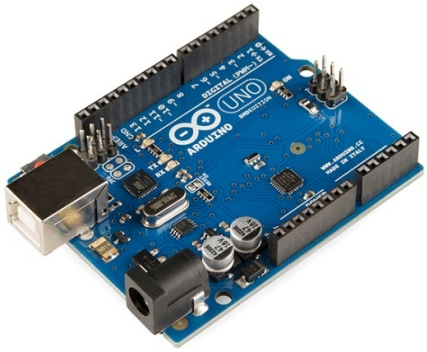
Required Software:

- Arduino-1.8.16(Arduino Coding)
- Express PCB (PCB layout)

Hardware Description

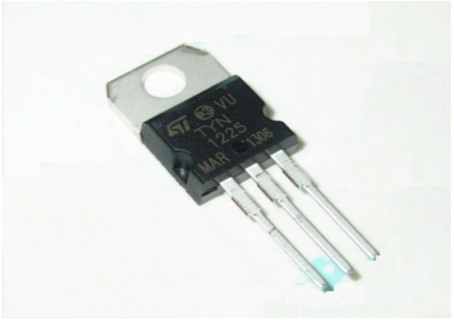
Arduino Uno:

The Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analog input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital I/O pins (six capable of PWM output), 6 analog I/O pins, and is programmable with the Arduino IDE (Integrated Development Environment), via a type B USB cable. It can be powered by the USB cable or by an external 9-volt battery, though it accepts voltages between 7 and 20 volts. It is similar to the Arduino Nano and Leonardo. The hardware reference design is distributed under a Creative Commons Attribution Share-Alike 2.5 license and is available on the Arduino website. Layout and production files for some versions of the hardware are also available.



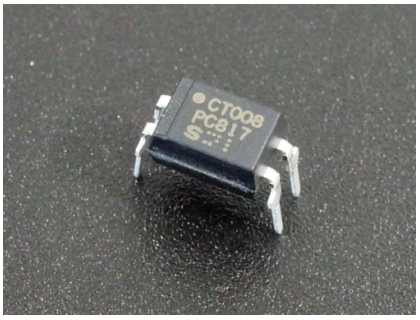
Thyristor(SCR-TYN1225):

A silicon controlled rectifier or semiconductor controlled rectifier is a four-layer solid-state current-controlling device. The name "silicon controlled rectifier" is General Electric's trade name for a type of thyristor.SCRs are mainly used in electronic devices that require control of high voltage and power. This makes them applicable in medium and high AC power operations such as motor control function.An SCR conducts when a gate pulse is applied to it, just like a diode. It has four layers of semiconductors that form two structures namely; NPNP or PNPN. In addition, it has three junctions labeled as J1, J2 and J3 and three terminalsanode,cathodeandagate. I used TYN1225 scr in this project.



Optocoupler(PC-817):

An optocoupler (also called optoisolator) is a semiconductor device that allows an electrical signal to be transmitted between two isolated circuits. Two parts are used in an optocoupler: an LED that emits infrared light and a photosensitive device that detects light from the LED. Both parts are contained within a black box with pins for connectivity. The input circuit takes the incoming signal, whether the signal is AC or DC, and uses the signal to turn on the LED.



Comparator(LM-393):

The LM393 is a dual differential comparator; this means that it accepts 2 inputs for comparison. It compares these voltage inputs and determines which is the larger value. Based on this, electronic decisions can be made based on which input is greater and which is smaller. Thus, a comparator is very useful in circuits where we measure levels and want our circuit to act a certain way based on whether the level of an input is greater or smaller than a certain threshold.This component is used for creating zero crossing detector.

Potentiometer (10K):

A potentiometer is a three-terminal resistor with a sliding or rotating contact that forms an adjustable voltage divider. If only two terminals are used, one end and the wiper, it acts as a variable resistor or rheostat. The measuring instrument called a potentiometer is essentially a voltage divider used for measuring electric potential (voltage); the component is an implementation of the same principle, hence its name.

Jumper wires:

A jump wire (also known as jumper, jumper wire, DuPont wire) is an electrical wire, or group of them in a cable, with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Transformer(220v to 12v):

A transformer is a passive component that transfers electrical energy from one electrical circuit to another circuit, or multiple circuits. A varying current in any coil of the transformer produces a varying magnetic flux in the transformer's core, which induces a varying electromotive force across any other coils wound around the same core. Electrical energy can be transferred between separate coils without a metallic (conductive) connection between the two circuits.

Resistor:

A resistor is an electrical component that limits or regulates the flow of electrical current in an electronic circuit. Resistors can also be used to provide a specific voltage for an active device such as a transistor.

Diode:

Diode, an electrical component that allows the flow of current in only one direction. In circuit diagrams, a diode is represented by a triangle with a line across one vertex.

Breadboard:

A breadboard is used to make up temporary circuits for testing or to try out an idea. No soldering is required so it is easy to change connections and replace components. Parts are not damaged and can be re-used afterwards.

PCB board:

A printed circuit board, or PC board, or PCB, is a non-conductive material with conductive lines printed or etched. Electronic components are mounted on the board and the traces connect the components together to form a working circuit or assembly.

Chapter 03

Circuit Diagram & Connection

Single Phase Full Wave Controlled Rectifier:

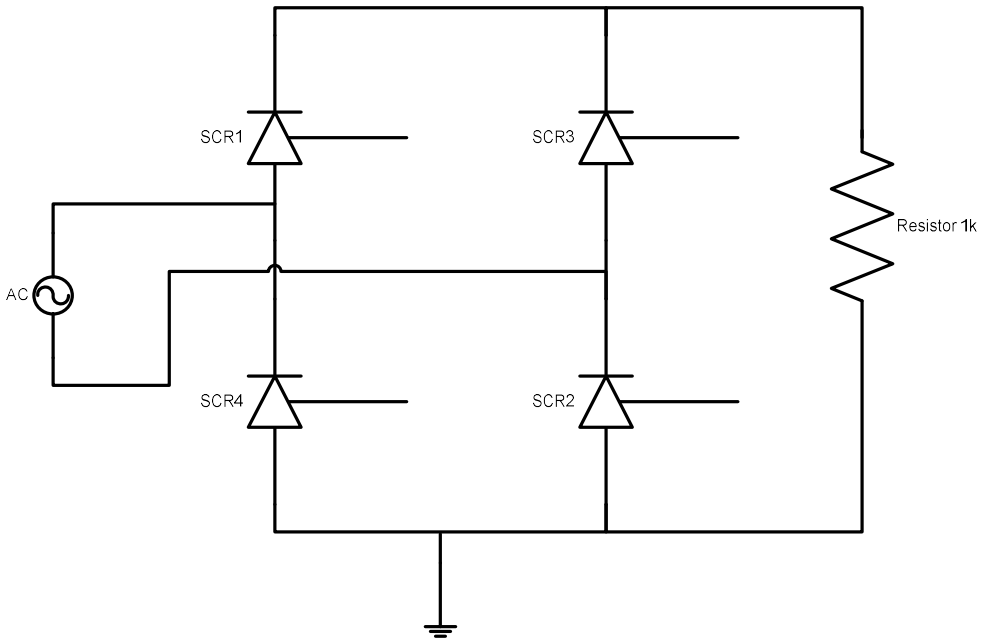


Fig-03: Single phase full wave controlled rectifier circuit diagram

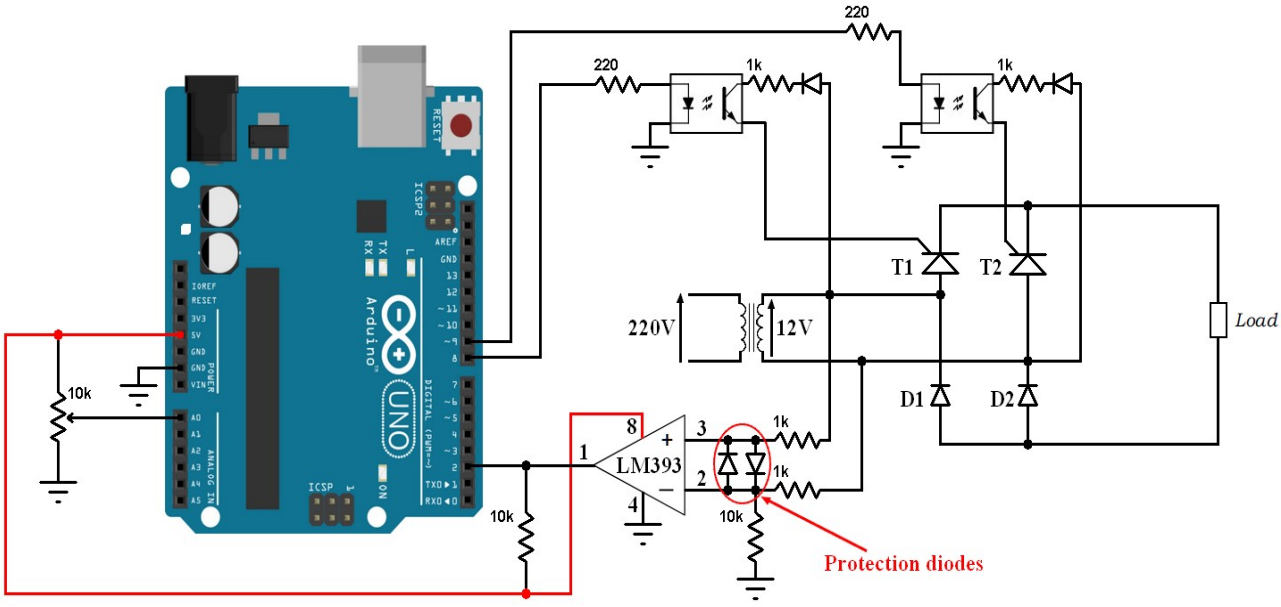


Fig-04: Single phase full wave controlled rectifier connection diagram

Breadboard Connection:

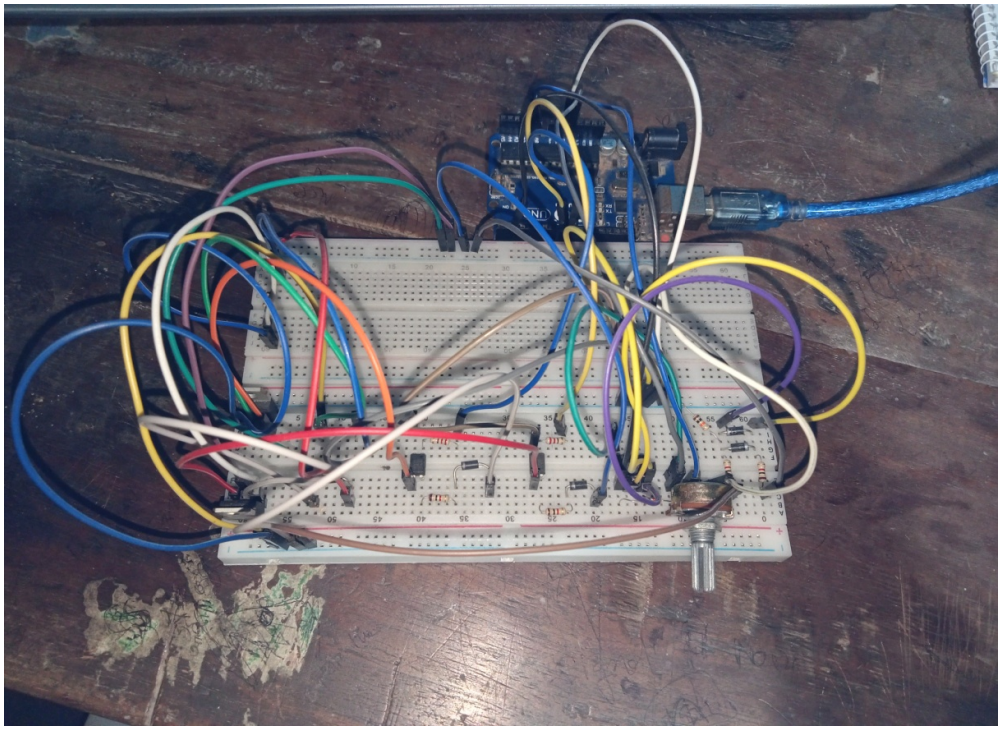


Fig-05: Breadboard Connection

Output Waveform:

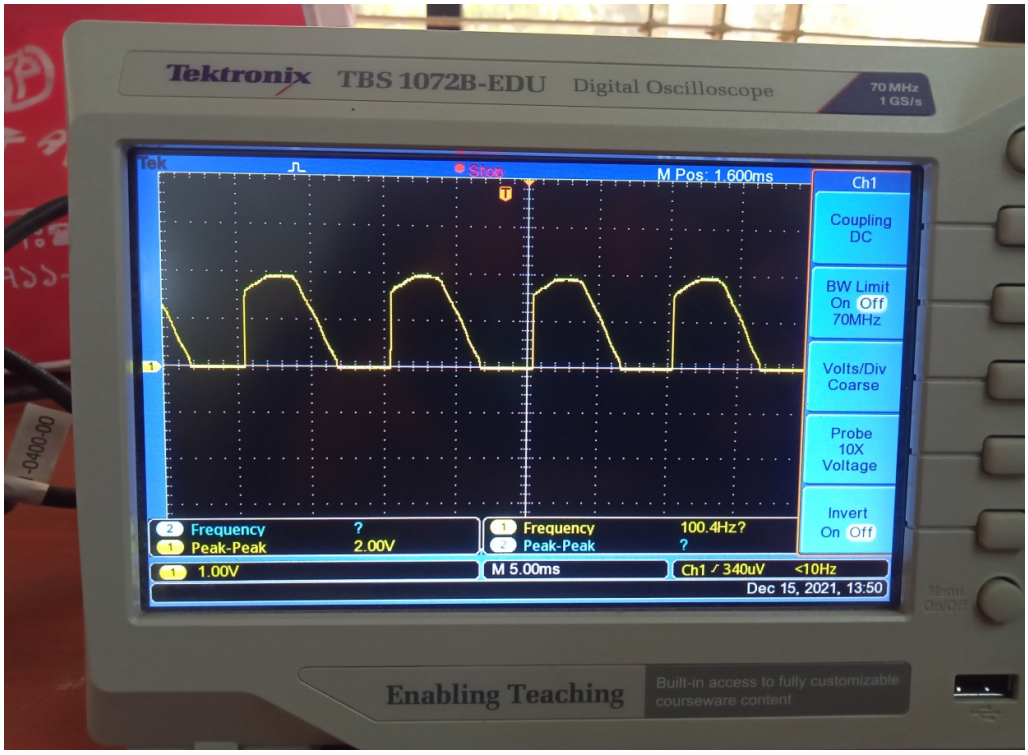


Fig-06: Output Waveform-01

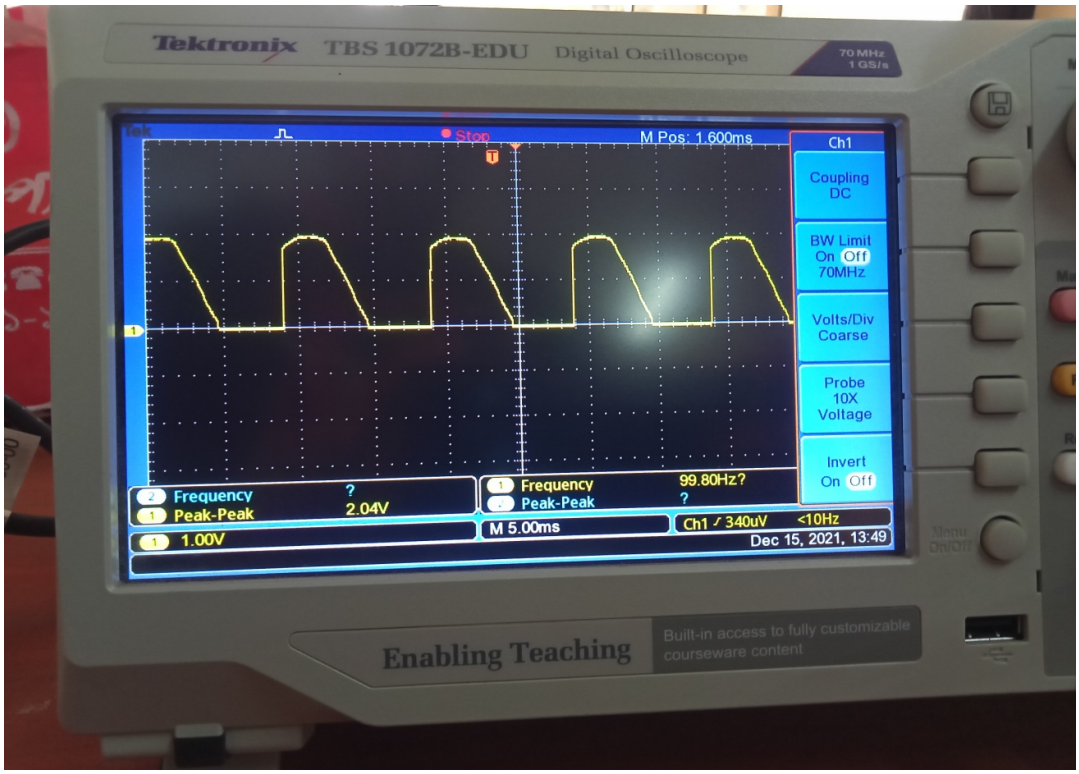


Fig-07: Output Waveform-02

Arduino Code:

```
// Controlled bridge rectifier with Arduino

#define scr1_gate   8
#define scr2_gate   9
#define pot         A0

byte ZC = 0;
uint16_t alpha;
void setup(void) {
  pinMode(scr1_gate, OUTPUT);
  digitalWrite(scr1_gate, LOW);
  pinMode(scr2_gate, OUTPUT);
  digitalWrite(scr2_gate, LOW);
  attachInterrupt(0, ZC_detect, CHANGE);       // Enable external interrupt (INT0)
}

void ZC_detect() {
  if(digitalRead(2))
    ZC = 1;
  else
    ZC = 2;
}
void loop() {
  if(ZC == 1){
```

```
   delayMicroseconds(alpha);
   digitalWrite(scr1_gate, HIGH);
   delay(2);
   digitalWrite(scr1_gate, LOW);
   alpha = analogRead(pot) * 7;
   ZC = 0;
  }
  if(ZC == 2){
   delayMicroseconds(alpha);
   digitalWrite(scr2_gate, HIGH);
   delay(2);
   digitalWrite(scr2_gate, LOW);
   alpha = analogRead(pot) * 7;
   ZC = 0;
  }
}
```

Connection Description:

All grounded terminals are connected together.

The rectifier bridge consists of two thyristors T1, T2 and two diodes D1 , D2 (half controlled bridge rectifier). The transformer is used to step down the 220V into 12V.

In the circuit there are two optocouplers, each one is used to fire one thyristor (give current to the gate of the thyristor), thyristor T1 is fired with Arduino pin 8 and thyristor T2 is fired with arduino pin 9.

In this example I used the LM393 (dual comparator IC) for the zero crossing detection, an optocoupler can be used for the same purpose but I think the comparator is better. The two diodes which are connected between the non-inverting input (+) and the inverting input (-) of the comparator are used to limit the voltage across those pins (the LM393 can work directly with 12V, so they are optional). The output of the LM393 (or LM339) is an open collector, so I added the 10k ohm resistor there (between +5V and arduino pin 2). Also the comparator chip is supplied with +5V which comes from the Arduino board.

In this example I used a resistive load with resistance of 270 ohm

The 10k ohm potentiometer is used to control firing angle.

PCB Design:

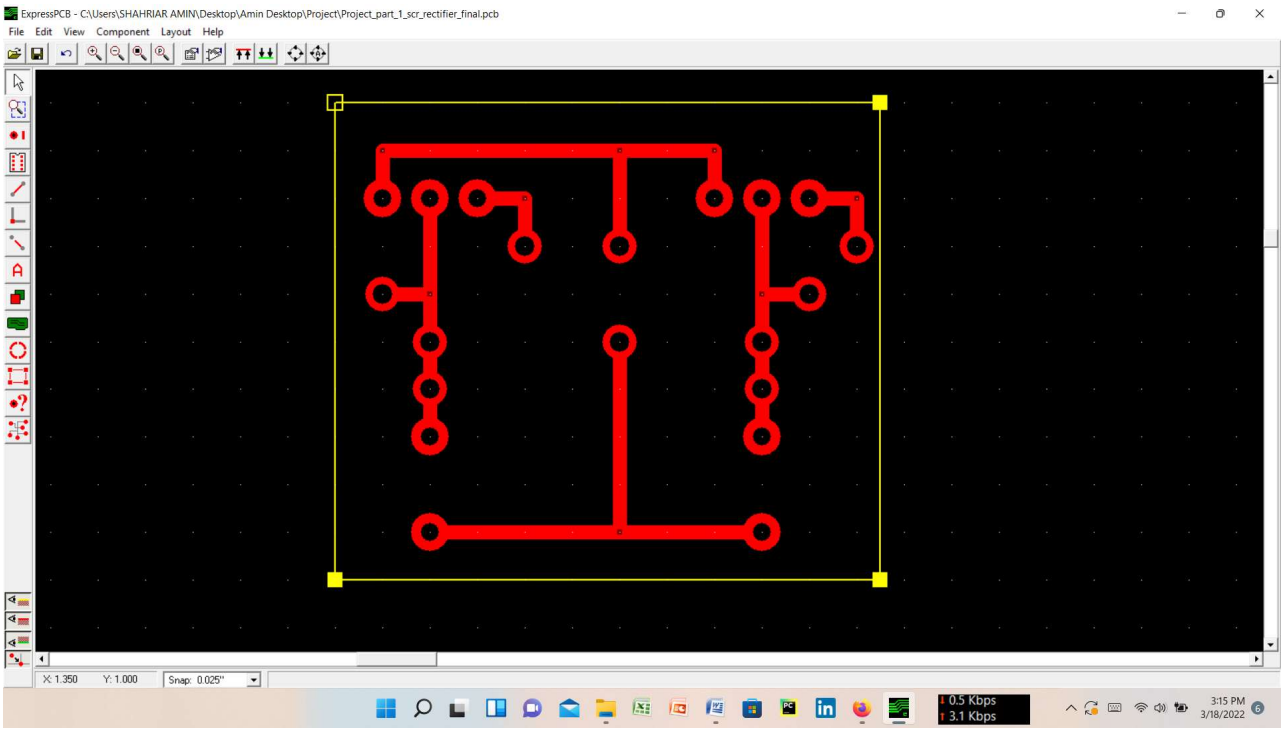


Fig-08: PCB board of part-1(main circuit)

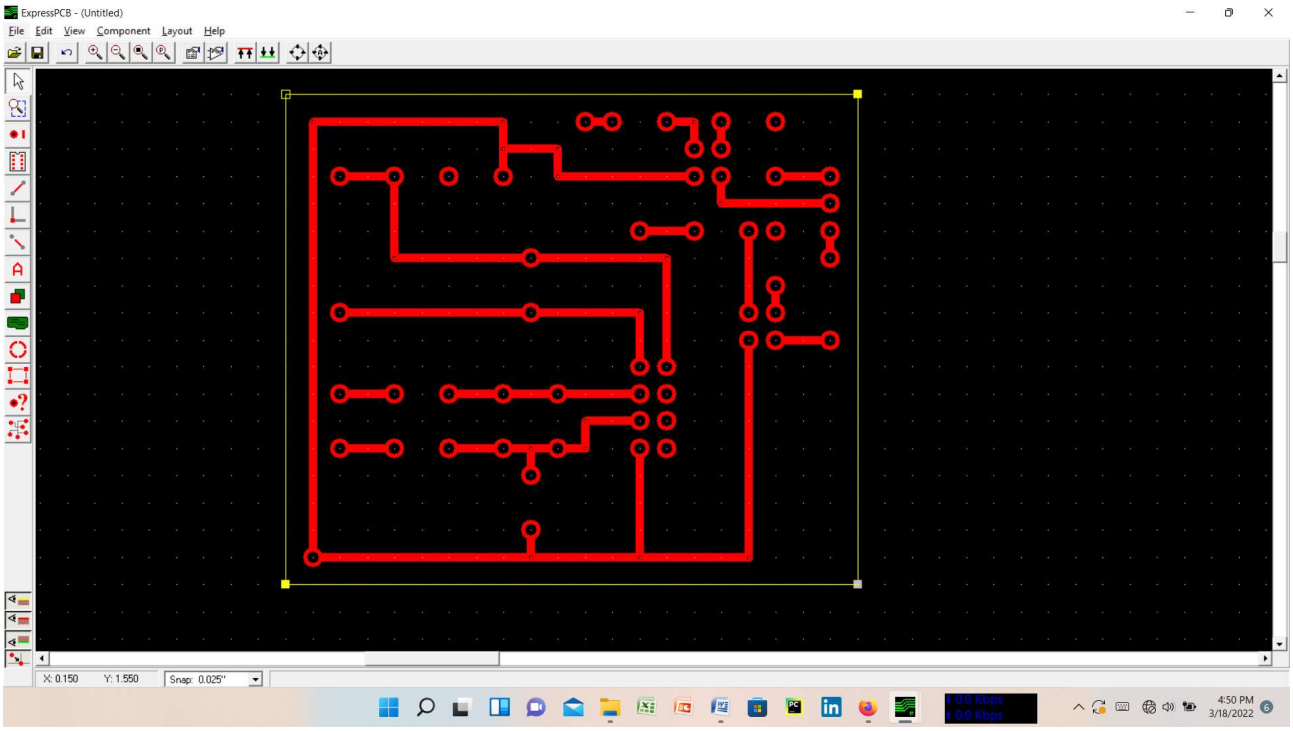


Fig-09: PCB board of part-2(Controlling part)

Single Phase to Single Phase Step Down Cycloconverter:

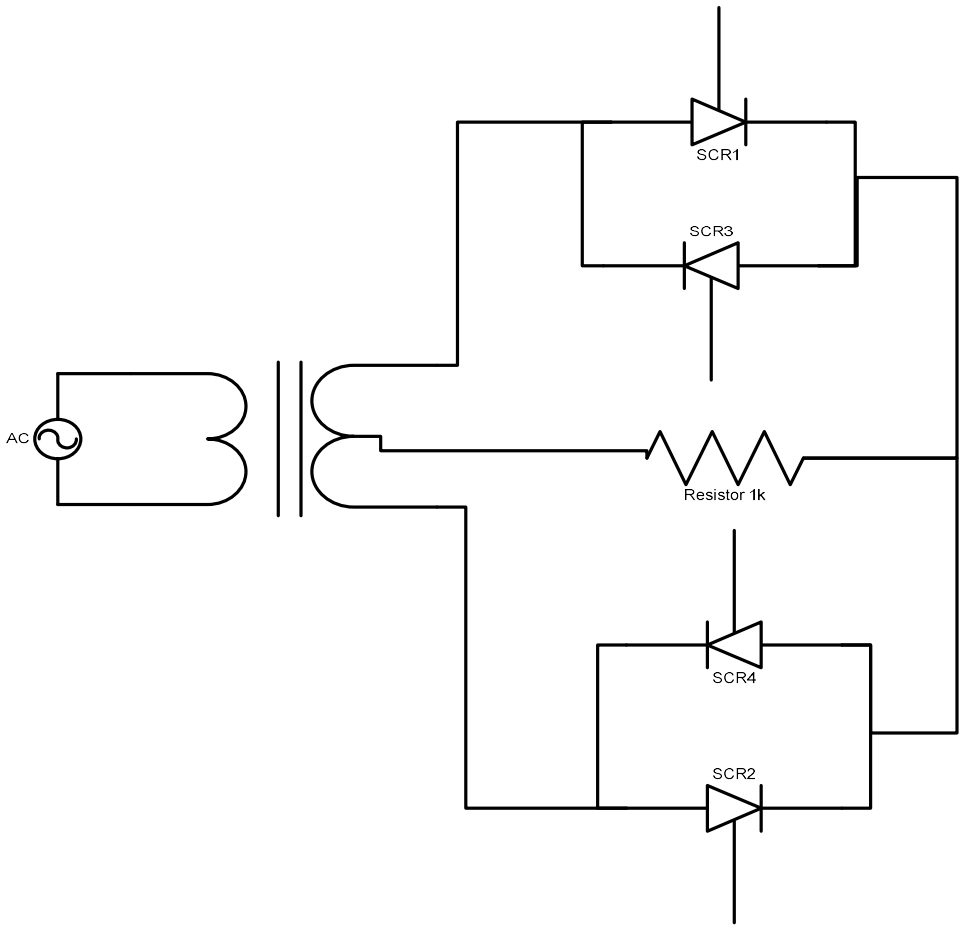


Fig-10: Single Phase to Single Phase Step Down Cycloconverter Circuit Diagram.

Arduino Code:

```
// Controlled single phase to single phase(mid point)step down cycloconverter with Arduino
 #define scr1_gate   8
#define scr2_gate   9
#define scr3_gate   10
#define scr4_gate   11
#define pot        A0
byte ZC = 0;
uint16_t alpha;
```

```
void setup(void) {
  pinMode(scr1_gate, OUTPUT);
  digitalWrite(scr1_gate, LOW);
  pinMode(scr2_gate, OUTPUT);
  digitalWrite(scr2_gate, LOW);
  attachInterrupt(0, ZC_detect, CHANGE);
   pinMode(scr3_gate, OUTPUT);
  digitalWrite(scr3_gate, LOW);
  pinMode(scr4_gate, OUTPUT);
  digitalWrite(scr4_gate, LOW);
  attachInterrupt(0, ZC_detect, CHANGE);  // Enable external interrupt (INT0)
}
void ZC_detect() {
  if(digitalRead(2))
    ZC = 1;
  else
    ZC = 2;
}
void loop() {
  if(ZC == 1){
    delayMicroseconds(alpha);
    digitalWrite(scr1_gate, HIGH);
    delay(2);
    digitalWrite(scr1_gate, LOW);
    alpha = analogRead(pot) * 7;
    ZC = 0;
    delayMicroseconds(alpha);
    digitalWrite(scr3_gate, HIGH);
    delay(2);
    digitalWrite(scr3_gate, LOW);
```

```
    alpha = analogRead(pot) * 7;
    ZC = 0;
   }
   if(ZC == 2){
    delayMicroseconds(alpha);
    digitalWrite(scr2_gate, HIGH);
    delay(2);
    digitalWrite(scr2_gate, LOW);
    alpha = analogRead(pot) * 7;
    ZC = 0;
    delayMicroseconds(alpha);
    digitalWrite(scr4_gate, HIGH);
    delay(2);
    digitalWrite(scr4_gate, LOW);
    alpha = analogRead(pot) * 7;
    ZC = 0;
   }
}
```

Single Phase AC-AC voltage Controller:

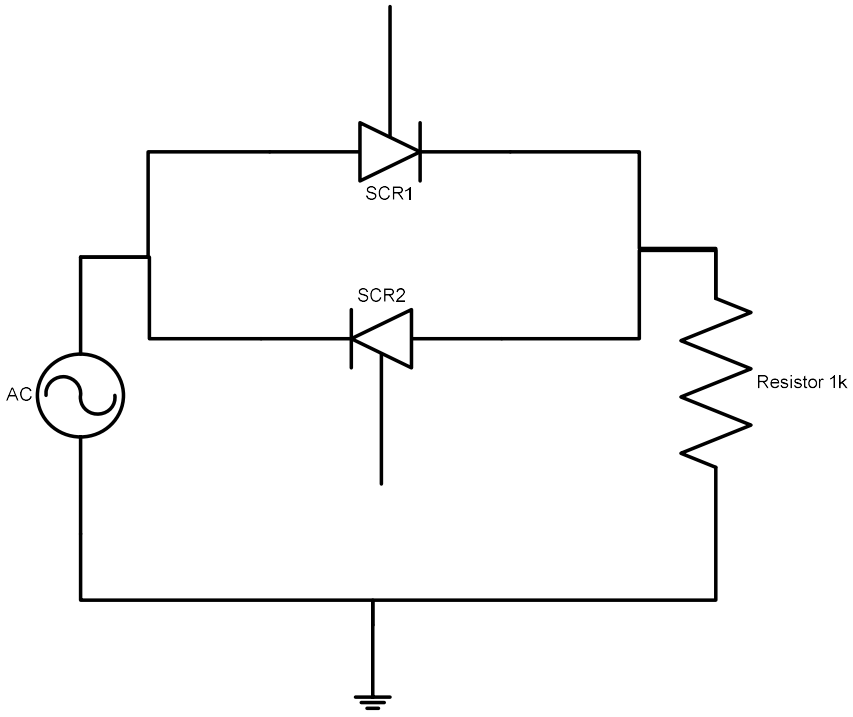


Fig-11:Single Phase AC-AC voltage Controller Circuit Diagram

Arduino Code:

```
// Controlled single phase AC-AC voltage contoller with Arduino
#define scr1_gate   8
#define scr2_gate   9
#define pot        A0
byte ZC = 0;
uint16_t alpha;
void setup(void) {
  pinMode(scr1_gate, OUTPUT);
  digitalWrite(scr1_gate, LOW);
  pinMode(scr2_gate, OUTPUT);
  digitalWrite(scr2_gate, LOW);
  attachInterrupt(0, ZC_detect, CHANGE);       // Enable external interrupt (INT0)
}
```

```
void ZC_detect() {
  if(digitalRead(2))
    ZC = 1;
  else
    ZC = 2;
}
void loop() {
  if(ZC == 1){
    delayMicroseconds(alpha);
    digitalWrite(scr1_gate, HIGH);
    delay(2);
    digitalWrite(scr1_gate, LOW);
    alpha = analogRead(pot) * 7;
    ZC = 0;
  }
  if(ZC == 2){
    delayMicroseconds(alpha);
    digitalWrite(scr2_gate, HIGH);
    delay(2);
    digitalWrite(scr2_gate, LOW);
    alpha = analogRead(pot) * 7;
    ZC = 0;
  }
}
```

Chapter-04

Application,Advantage ,Discussion & Conclusion

Application:

Application Of single phase rectifier:The single phase fully controlled rectifier allows conversion of single phase AC into DC. Normally this is used in various applications such as battery charging, speed control of DC motors and front end of UPS (Uninterruptible Power Supply) and SMPS (Switched Mode Power Supply). SCRs are mainly used in devices where the control of high power, possibly coupled with high voltage, is demanded. Their operation makes them suitable for use in medium- to high-voltage AC power control applications, such as lamp dimming, power regulators and motor control

Applications of Cycloconverter:

The applications of cycloconverters include:

- Cement mill drives
- Rolling mills
- Ship propulsion drivers
- Water pumps
- Washing machines
- Mine winders
- Industries

Application of AC-AC voltage controller:

Lighting / Illumination control in ac power circuits.

- Induction heating.
- Industrial heating & Domestic heating.
- Transformers tap changing (on load transformer tap changing).

Advantage:

Single Phase Controlled Rectifier Advantage:

To limit voltage drops caused by load variations.
• To increase the power that can be delivered by the conversion substations.
• To compensate the DC line voltage variations caused by voltage variations on the medium voltage power network.
• To keep voltage constant even in case of load variations.
• To control the fault current on faults far from the electrical substation and consequently to increase line protection settings.
• To limit short-circuit current on faults near the electric substation to reduce stress on extra-rapid switches and decrease respective maintenance.
• To improve the load distribution among all electrical substations of the traction line.
• To improve energy management flexibility to the power networ

Advantages of cyclo-converter :

- Efficiency is very high compared to other converters
- Four quadrant operation is possible because cyclo-converter is capable of power transfer in both the directions
- AC power at one frequency is directly converted to a lower frequency in a single conversion
- If one of the SCR fails, the cyclo-converter operates with a distorted output
- In this converter, power transfer is possible from supply load and vice versa at any power factor
- Dynamic response is good
- Smooth low-speed operation

Advantage of AC-AC voltage controller: Thyristor based ac voltage controllers have high efficiency, flexibility in control and require less maintenance. The disadvantage of ac voltage controllers is the introduction of harmonics in the supply current and load voltage waveforms particularly at low output voltage levels.

Discussion & Conclusion:

Single phase control rectifier, cycloconverter and AC-AC voltage controller were practically and graphically analyzed in this project. The waveform of these circuits were viewed in oscillator . The wave form was similar to the theory and it was controlled by moving potentiometer. In this project, I had learned about the basic power electronics scr based rectifier, cycloconverter and AC-AC voltage controller. This experience which will help me for further research and job field. During the project, I applied arduino code in circuit and connected the circuit in breadboard with various types of component in many times which will help me to developed my arduino coding skill and hardware knowledge.

Reference:

https://www.wikipedia.com

https://www.electronics-tutorial.net/ac-dc-power-converters/single-phase-full-wave-controlled-rectifier/

https://www.electrical4u.com/cycloconverter/

https://simple-circuit.com/arduino-controlled-bridge-rectifier/