IQRA NATIONAL UNIVERSITY

Department of Electrical Engineering

Term Project

Power Electronics

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1st group member: Muhammad Farhan Ali

Id:13032

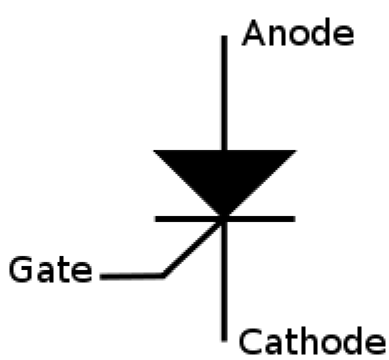
2nd group member: Farhan Shah

Id:13180

Battery Charger Circuit Using SCR

Introduction to SCR:

SCR is abbreviation for Silicon Controlled Rectifier. SCR has three pins anode, cathode and gate as shown in the around four semi conductor layers. SCR can conduct the current in a single direction or we can say SCR's are unidirectional. The SCR can be triggered only at the gate through the current. SCR will combine the features of rectifier and below figure. It is made up of there PN junction diodes also; it is solid state equivalent of gas filled triode and has transistor. They are mainly used in switching applications. They can also be triggered with the break over voltage (if the forward voltage is more than the break down voltage of the component). They are mainly used in the high voltage and high power for controlling purpose. They are also used in the light dimming, voltage regulators, motor control etc.

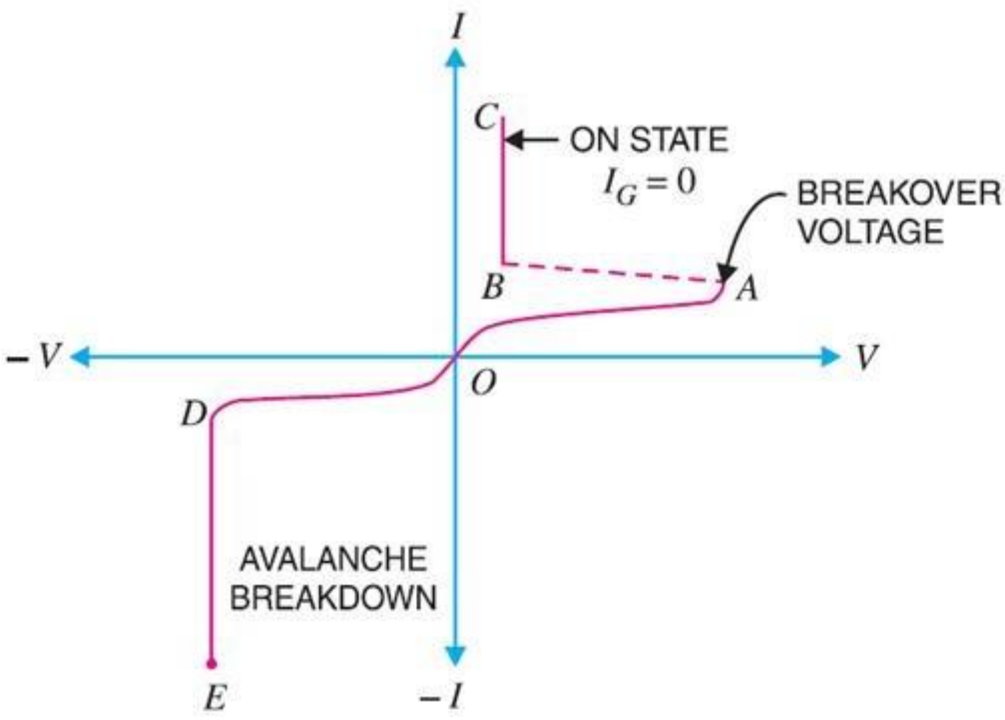


SCR Operating Modes:

- To turn on the SCR the small amount of voltage or voltage equal to break over voltage is required to the gate which will trigger the SCR and when the SCR is turned on, it will have very low resistance and allow the power to conduct and also increase the anode current. Even if we remove the gate voltage also it will be in conduction. The only way to make the SCR to turn off is to make the voltage to zero or make the current less than the handling current between the anode and cathode.
- There are two ways to turn on the SCR is the first way is to turn on by opening the gate and

compensate the power supply to the break over voltage. And second way is to supplying the voltage to operate the SCR with less than break over voltage and applying the small amount of about 1.5V applied to the gate which will trigger the SCR.

- When the SCR is turned off it will have high resistance and restrict the current to the leakage current. To turn off the SCR from on state also have only one ways normally people think that if we stop the gate current the SCR will become turn off, but it will not this state is called "loss of control", the only way is turnoff the SCR is reducing the supply voltage to zero.



Advantages of **silicon controlled rectifier** (SCR)

- The silicon controlled rectifier (SCR) can handle large voltage , current and power.
- It can be protected with the help of fuse.
- It is easy to turn ON.
- The Triggering circuit for silicon controlled rectifier (SCR) is simple.
- It is simple to control.
- It cost is low.
- It is able to control AC power.

Disadvantages of **silicon controlled rectifier** (SCR)

- The silicon controlled rectifier (SCR) is unidirectional devices, so it can control power only in DC power during positive half cycle of AC supply. Thus only DC power is controlled with the help of SCR.
- In AC circuit, it needs to be turned on each cycle.
- It cannot be used at higher frequencies.
- The gate current cannot be negative.

Parameters of SCR:

1. **Break Over Voltage:** minimum forward voltage which will make the SCR to turn on for conduction. Normally SCR break over voltage is around 50V to 500V.

Peak Reverse Voltage: maximum reverse voltage which help the SCR not to conduct in the reverse direction. Reverse direction implies cathode is at positive and anode is negative. This is very important in power electronic application because in the negative half of AC supply is also given to the SCR, in this SCR should not go to the reverse bias, if the peak reverse voltage is high then SCR will go to the avalanche break down always a external circuit is needed to limit the Peak reverse voltage. The maximum peak reverse voltage for SCR is around 2.5KV.

1. **Holding Current:** maximum anode current required to turn off the SCR from on state when gate being open. Suppose if holding current of SCR is 5ma, to turnoff the SCR we need make current less than 5ma.
2. **Forward Current Rating:** maximum forward current that allowed by the SCR without any damage to it. Commercial SCR have forward current rating around 30ma to 300ma. If the forward current will exceed the maximum forward current then automatically SCR will be damage due to overheating.

There are also other factors like Critical Rate of Raise of Voltage which is defined as the rate at which the voltage will raise in forward direction without triggering the SCR, Snubber Circuit which avoid the triggering of SCR due to parasitic capacitance in RC circuits.

Applications of SCR:

SCR as Switch: SCR can be used as switch, because SCR has two states ON and OFF state. We know that to turn on the SCR we need to increase the supply voltage equal to break over voltage or by giving the small voltage to the gate for triggering, by this we can turn on the SCR; we can turn off the SCR by decreasing the current to less than holding current, or we have another method called force communication in this we discharge a capacitor in parallel with SCR to make it turn off; by this we can use SCR as typical SWITCH. There is lot of advantages using SCR as switch like

- Switching speed of SCR is very high like switching operation per second.
- It allows huge current up to 100 ma through the load just by triggering the gate with very low voltage to turn it on.
- Small in size and has low noise which give high efficiency and reliable.

SCR can be used in half wave rectifier, full wave rectifier, inverter circuits, power control circuits, static contactor, over light detector, speed control circuit, crowbar circuit, automobile ignition circuits, etc.

NOTE

- SCR is a current trigger device.
- SCR is made up of silicon and some time SCR is called as thyristor.
- Gate is the control element of SCR.
- Angle of conduction can be changed by changing the gate voltage.

Introduction to Battery Charger Using SCR:

The battery is charged with small amount of AC voltage or DC voltage. So if you want to charge your battery with AC source then should follow these steps, we need first limit the large AC voltage, need to filter the AC voltage to remove the noise, regulate and get the constant voltage and then give the resulting voltage to the battery for charging. Once charging is completed the circuit should automatically turned off.

Block Diagram of Battery Charger Using SCR:

In this work, the illustrative block diagram of the battery charger using SCRs is shown in figure 1. Clearly, the diagram encloses fundamentally an AC voltage source, single-phase transformer, bridge rectifier, voltage regulator, SCR and chargeable battery. In the following sections, the operation of the suggested charger using SCR will be described

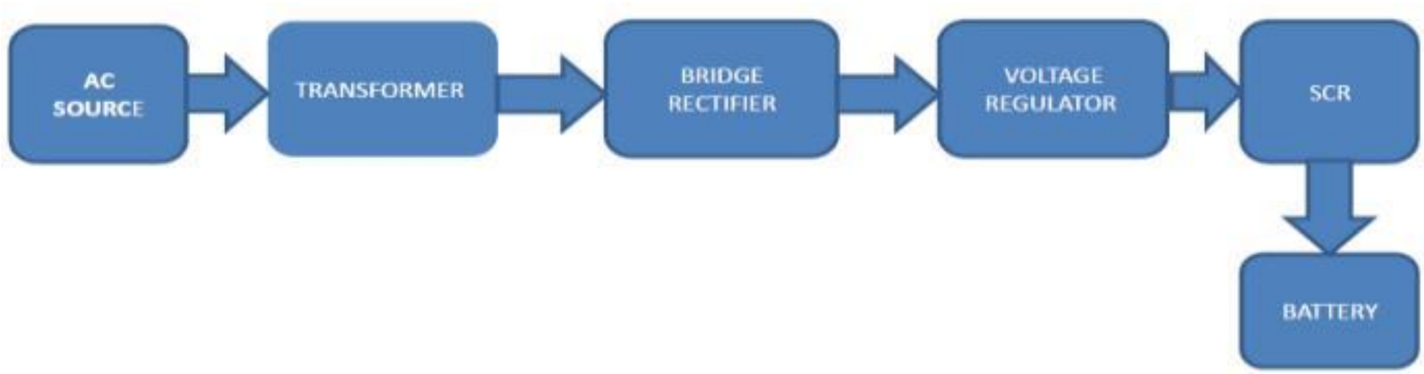
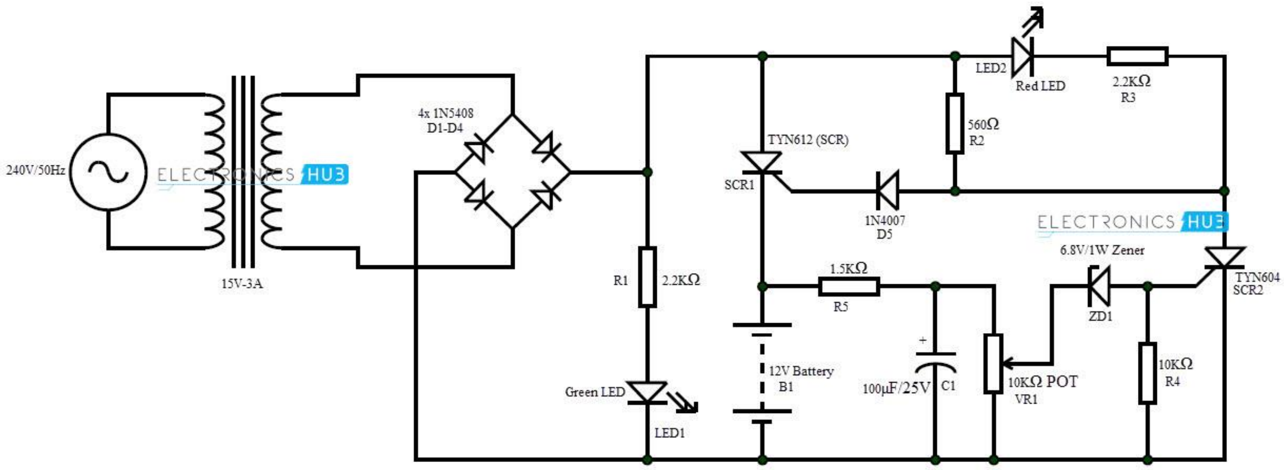


Figure 1: Block diagram of the battery charger using SCRs

- **Battery charger circuit with two SCRs:**

The electronic circuit of the automatic battery charger circuit using SCRs is partially designed, simulated and implemented. The circuit can be used to charge batteries with different level of voltages, for instant, 6V, 9V or 12V in choosing appropriate components. As well as, it can be used to power-driven low power loads such as, cell phone, camera, etc.

Circuit Diagram:



Circuit Diagram Explanation:

- The AC main voltage is given to the step down transformer the voltage should be down to 20V approx. the step down voltage is given to the SCR for rectification and SCR rectifies AC main voltage. This rectified voltage is used to charge battery.
- When the battery connecter to the charging circuit, the battery will not be dead completely and it will get discharged this will give the forward bias voltage to the transistor through the diode D2 and resistor R7 which will get turned on. When the transistor is turned on the SCR will get off.

  When the battery voltage is dropped the forward bias will be decreased and transistor gets turned off. When the transistor is turned off automatically the diode D1 and resistor R3 will get the current to the gate of the SCR, this will triggers the SCR and gets conduct. SCR will rectifies the AC input voltage and give to the battery through Resistor R6.
- This will charge the battery when the voltage drop in the battery decreases the forward bias current also gets increased to the transistor when the battery is completely charged the Transistor Q1 will be again turned on and turned off the SCR.

Simulation of the charger:

The simulated circuit as shown in figure 2, contains in addition to the main and auxiliary SCR’s, two LED's, and many other electronics and power components such, single-phase transformer, single-phase full-wave diode rectifier, voltage regulator, rechargeable battery, diodes , capacitors, and resistors. Each of the pointed out components has its role in the operation of the circuit as it will be illustrated. The main SCR (D1) uses in the charging process and the second auxiliary SCR (D2) uses to indicate the ending of the charging process and the fully charging of the battery. The LED in the two cases uses to indicate the operation period of the two SCR's respectively.

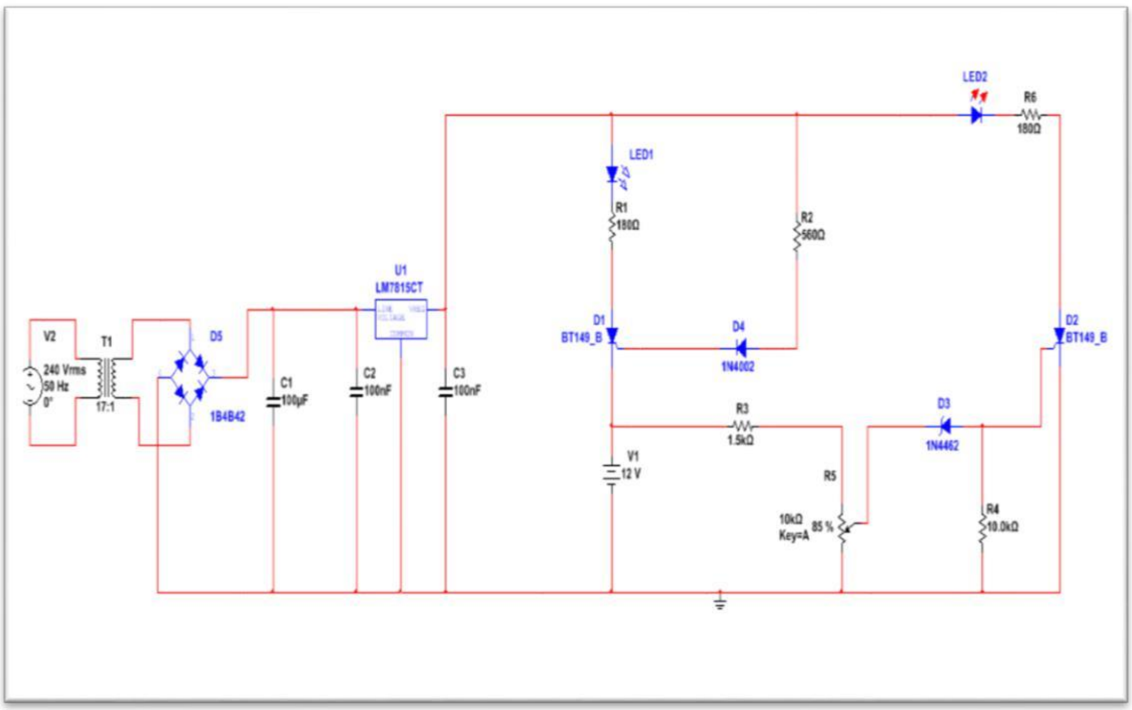


Figure 2: Diagram of the simulated circuit

NO	Component's Name	Component's Type	Value or code
1	Voltage source	AC voltage source	240V(rams), 50HZ
2	Transformer	Step down transformer	240/14 V
3	Battery charger	Lead acid battery charger	12V
4	Diode 1, D_1	Silicon controlled rectifier	BT149-B
5	Diode 2, D_2	Silicon controlled rectifier	BT149-B
6	Diode3, D_3	Zener diode	1N4462
7	Diode4, D_4	Single Standard Switching Diode	1N4002
8	Bridge rectifier, D_5	Full wave rectifier	1B4B42
9	Voltage regulator	IC	LM7815CT
10	Capacitor ,C_1	Aluminum electrolytic capacitor	100 uF
11	Capacitor, C_2	Ceramic	100 nF
12	Capacitor , C_3	Ceramic	100 nF
13	Resistor 1, R_1	Ceramic	1.2 kΩ
14	Resistor 2, R_2	Ceramic	560Ω
15	Resistor 3, R_3	Ceramic	1.5 KΩ
16	Resistor 4, R_4	Ceramic	10 kΩ
17	Resistor 5, R_5	Potentiometer	10 kΩ
18	Resistor 6, R_6	Ceramic	2.2KΩ
19	LED_1	Green LED	-
20	LED_2	Red LED	-

Table 1: Elements used in Battery charger circuit with two SCRs:

Operation of the charger

The circuit operation starts in supplying 240 V from AC voltage source to the circuit passing through a single-phase transformer 240/14 V and a single-phase full-wave diode rectifier to rectify the AC-to-DC voltage that is needed for battery charging. By the way, the capacitors C1-C3 use for DC voltage smoothing and the voltage regulator uses for controlling the output DC voltage at a value of 15 V as show in figure 3 that is appropriate for charging process. Initially, the main SCR1, (D1) starts conducting at the instant of receiving the required gating signal through R2 and D4. In the conducting period, green LED1 which is connected in series turns ON, to ensure the starting period of battery charging. During this period the output of the voltage regulator, 15V DC will apply across the serial combination of (D1, resistor R1 =180Ω, and the battery to be charged). The charging current will flow through the battery and the charging process will start till the fully charging of the battery approximately equal to 12 V. At this instant, the charging current will be less than the holding current, IH which is the minimum needed current to keep the SCR in its On-state and the conduction will be ended and the SCR1state will be changed to Off-state.When the main SCR1 stops conducting and the battery is fully charged, the auxiliary SCR2 conducting period is started at the instant of the battery 12 V applied across the combination of R3and R5 and a current will flow through this combination and a part of the voltage across the variable resistor of 10 kΩ, reaches to a value of 7.5 V that is necessary for letting the Zener diode (D3) to be in On-state and a triggering gating current by applied to SCR2 (D2) changing its state from Off to On-state, and the red LED2 which is connected in series with SCR2 (D2) will be in the On-state indicating the ending of the charging period.

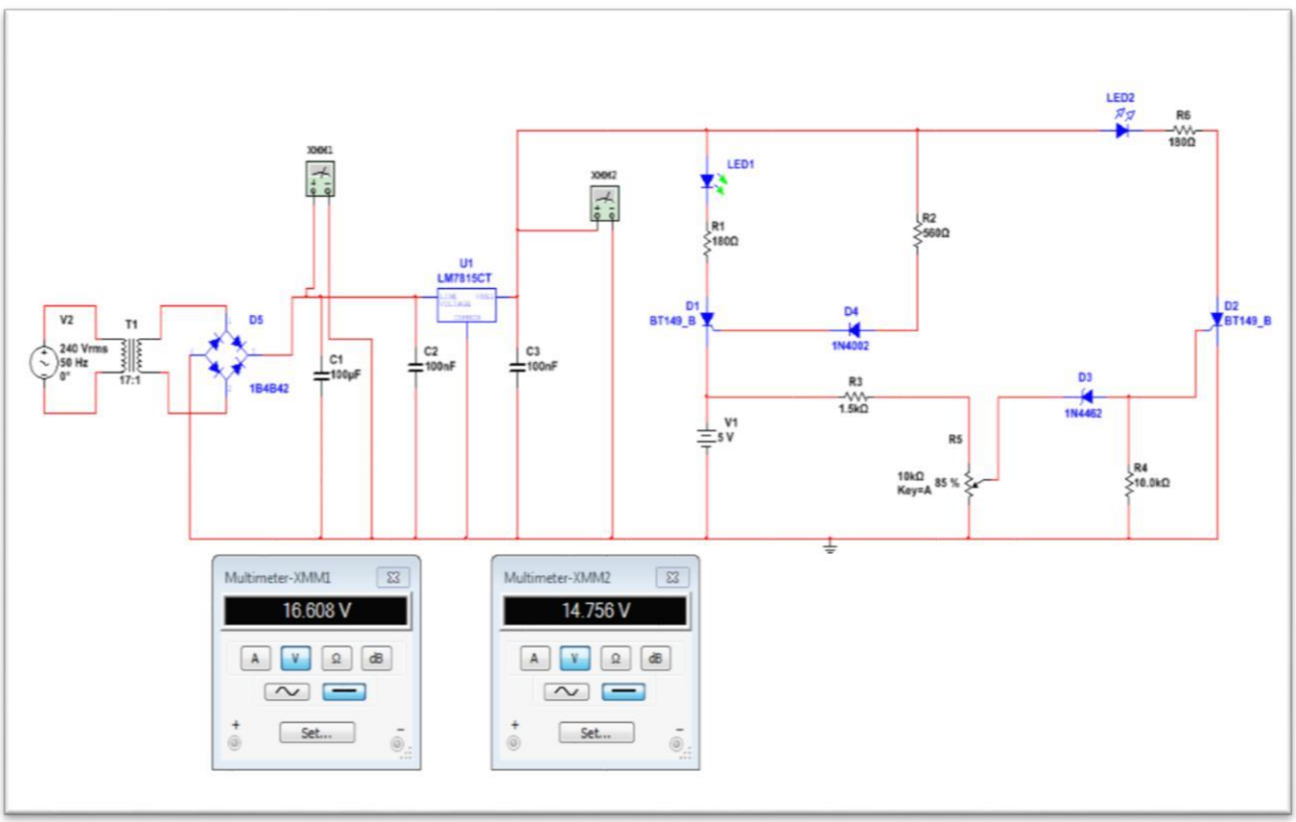


Figure 3: Input and output voltage of the voltage regulator

Output of the charger

Simulation tests were performed using MULTISIM. From the reading of the meters in figure 4, it is clear that during charging process, with a battery voltage of value 5 V, the current flow through the Thyristor SCR1 has a value of 38.926 mA and through the second Thyristor SCR2 is 6.523 uA (very small), which mean that the SCR1 is in On-state and the SCR2 is in Off-state. While at the fully charging process, and at a value of battery voltage equal to 12 V, it is clear from figure 5 that the current value through the Thyristor SCR1 is 1.248 mA (smaller than that in the charging process) and through the second Thyristor SCR2 is 66.955 mA (much larger than that in the charging process). Which means that the SCR1 is in off- state while the SCR2 is in On- state.

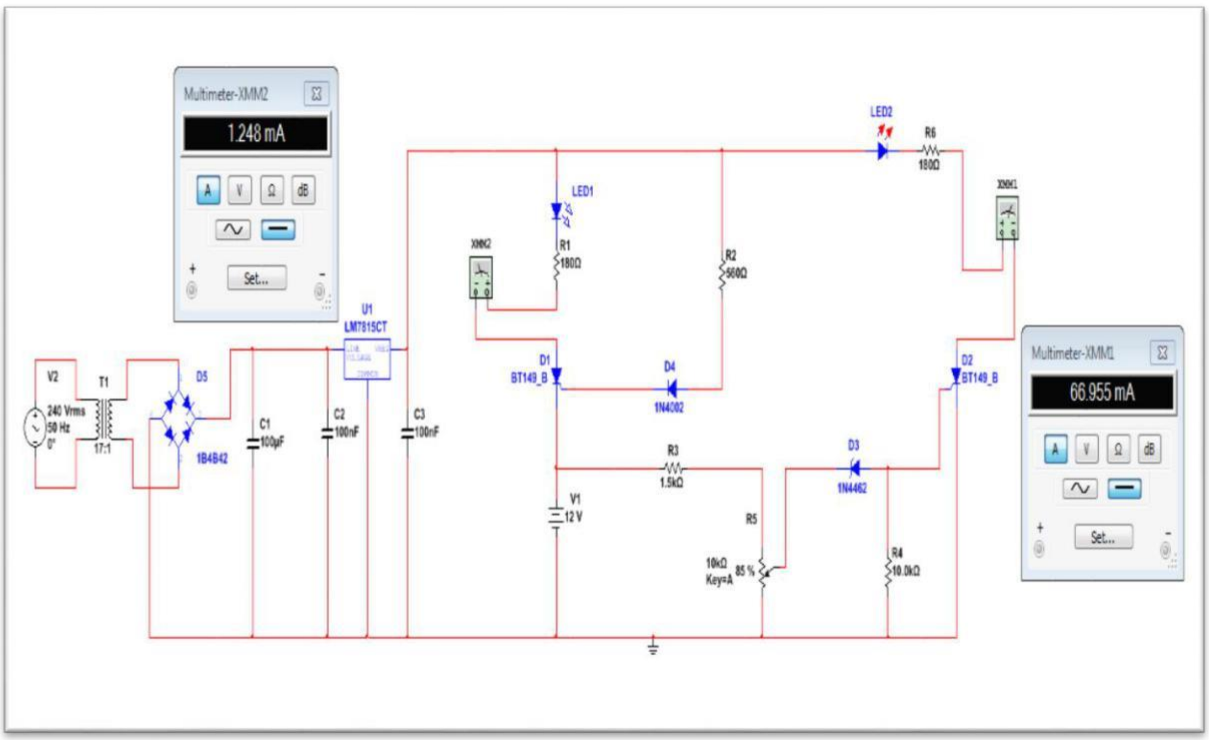


Figure 4: The current values at charging process

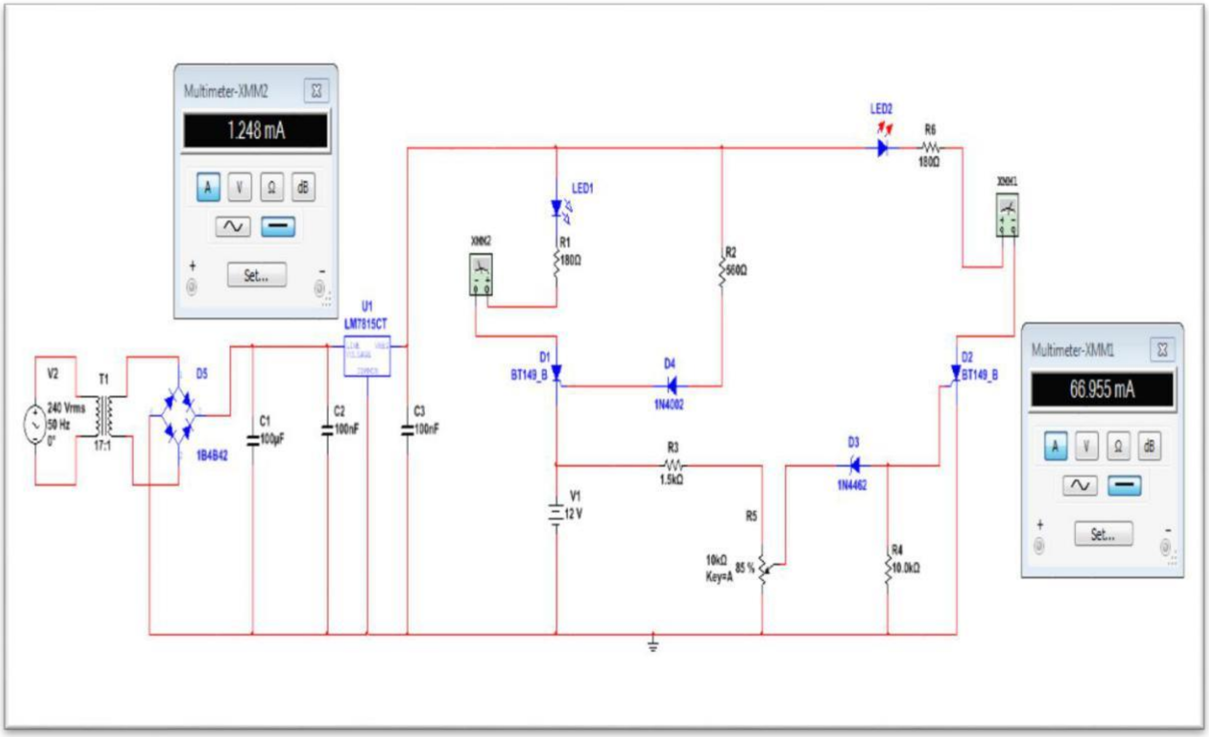


Figure 5: The current values at fully charging process

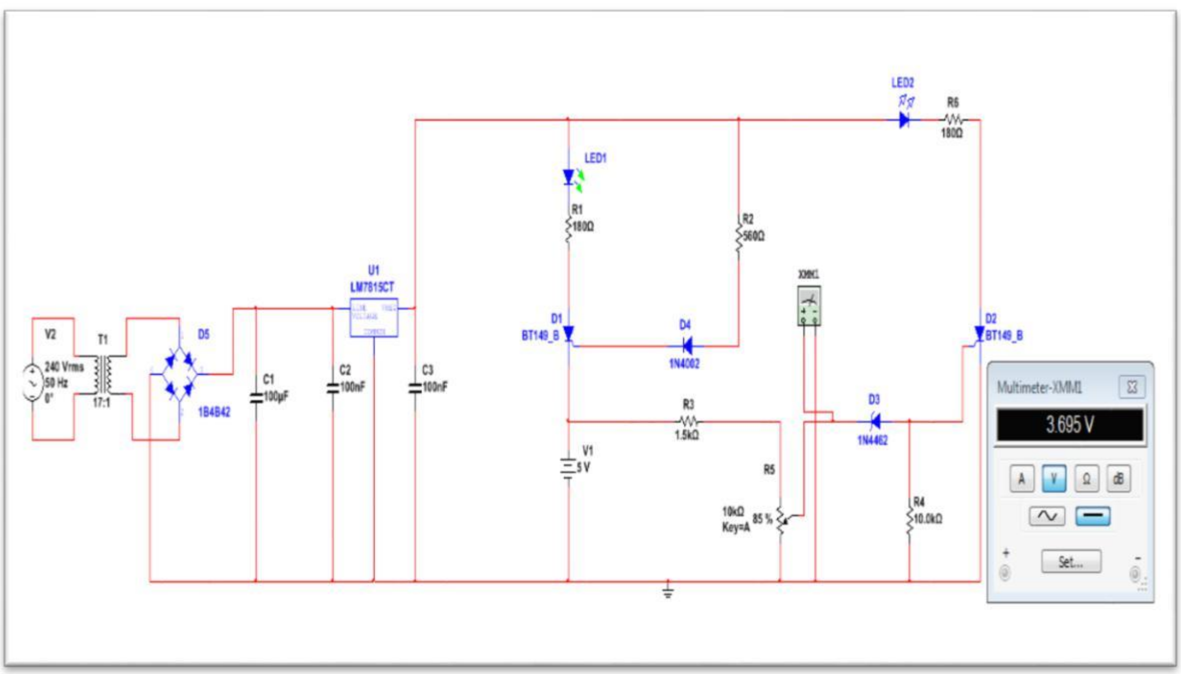


Figure 6: The potentiometer voltage at charging process

From figure 6,the potentiometer voltage at charging process is 3.695 V which is not enough for turning on the Zener diode and the SCR2 is not triggering so it stays in Off- state and red LED is Off. While at the fully charging period, the voltage at the potentiometer is reached to 8.064 V which is enough for letting the Zener diode to be in On-state and letting current flows to the SCR2 and turn it On and at the same time, turning the red LED on as shown in figure 7.

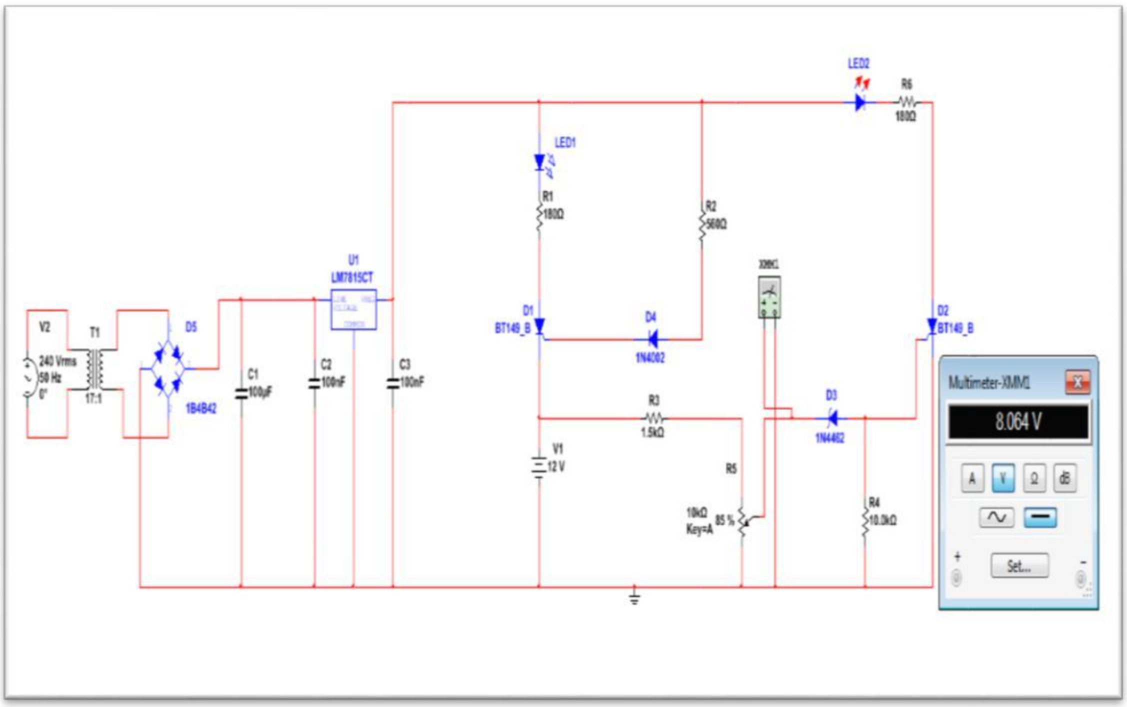


Figure 7: The potentiometer voltage at fully charge process

EXPERIMENTAL SETUP

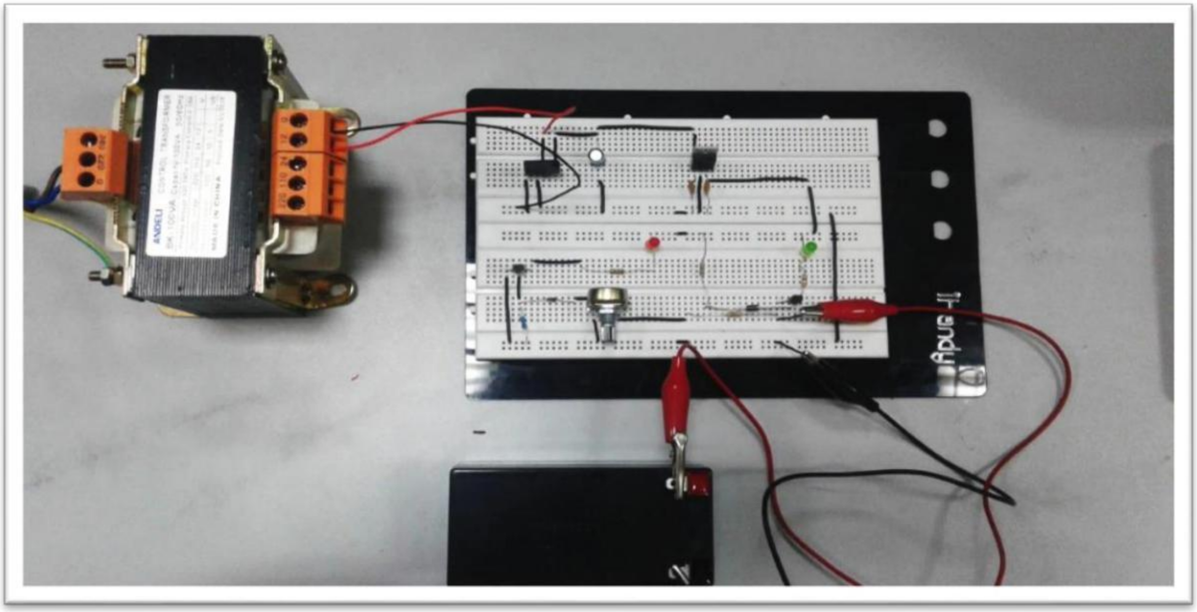


Figure 8: Experimental set up of the project

CONCLUSSION

The paper presented an automatic battery charger using two SCRs, main for charging course and auxiliary for discharge course. Depending on the charging process requirement some electronic elements of the charger have been designed. The designed circuit has been simulated using MULTISIM, constructed in the laboratory and then tested for verification. The simulated and experimental results were compared and they found to be in match and satisfy the main goal of the suggested charger.

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