Research Article

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Experimental investigation of synchronized UJT trigger circuitusing UJT 2N2646

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Abstract

As the name implies unijunction transistor (UJT) is a one junction, two layered three lead electronic semiconductor device and acts exclusively as an electrically controlled switch. UJT is a very popular current controllable negative resistance semiconductor device and exhibits switching characteristics. UJT is commonly used for generating triggering signals for silicon controlled rectifiers, thyristors as well as triacs for AC power control applications. UJTs are also used in gate pulse, timing circuits and pulse generating circuits referred to as relaxation oscillator. The state of the art presented in the paper is the experimental investigation of synchronized UJT trigger circuit using UJT 2N2646. Experimental circuit was designed and the entire system produced excellent results in the form of voltage waveforms at different points which were observed on the cathode ray oscilloscope (CRO).

Keywords

Unijunction transistor, Current controllable, Negative resistance, Semiconductor device, Electrically controlled switch, Experimental investigation, Triggering signals.

1.Introduction

1.1Construction of UJT

The constructional features of UJT are diagrammatically represented as shown in *Figure 1*. As it can be seen from the figure, UJT comprises a lightly doped N-type silicon bar with two Ohmic contacts called base terminals B1 and B2 made two its two extreme ends and a P-type emitter placed closer to base B2 to form a PN junction.

The electrical equivalent circuit comprises a potential divider arrangement of two resistors R_{BB1} and R_{BB2} and a PN junction diode. Resistor R_{BB1} represents the resistance of the base bar betweenB_1terminal and the PN junction and resistor R_{BB2} represents the resistance of the base bar between B_2terminal and the PN junction. R_{BB1} has been shown as a variable resistance as its value depends on the emitter current flowing through the PN junction when it is forward biased.ForI_E =0, the total resistance of the base bar is termed as R_{BB} (R_{BB} = R_{BB1}+ R_{BB2}). R_{BB} lies in the range of 4 KΩ to 10 KΩ. Another parameter defined for a UJT is the intrinsic stand-off ratio denoted by η [1−3]. It is given by (1).

$$\eta = R_{BB1} / (R_{BB1} + R_{BB2}) \quad (1)$$

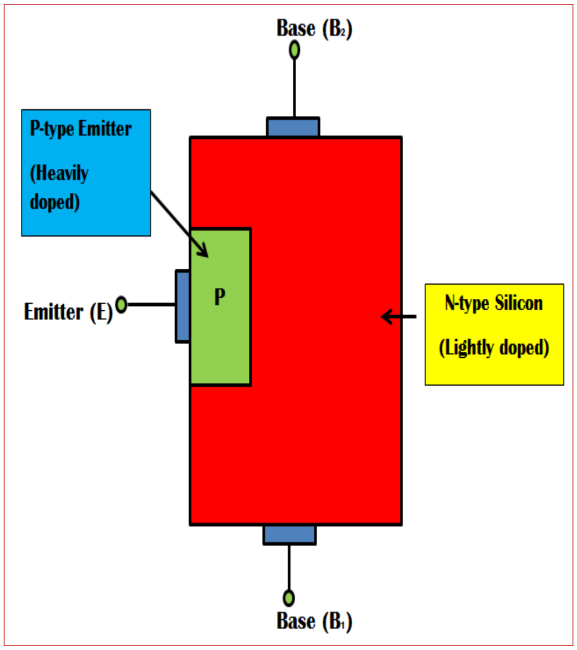

Figure 1 Construction of UJT

The circuit symbol of UJT is illustrated in *Figure 2*. Electrical equivalent of UJT is shown in *Figure 3*.

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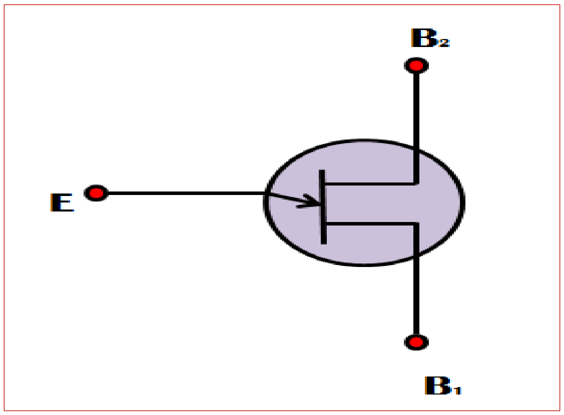

Figure 2 Circuit symbol of UJT

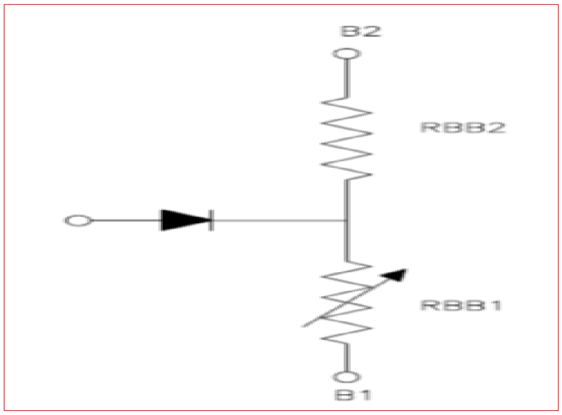

Figure 3 Electrical equivalent of UJT

1.2Principle of operation of UJT

The operational principle of a UJT can be best understand with the help of its electrical characteristics or to be more precise its input V-I characteristics. *Figure 4* shows the electrical circuit for determining the input characteristics.

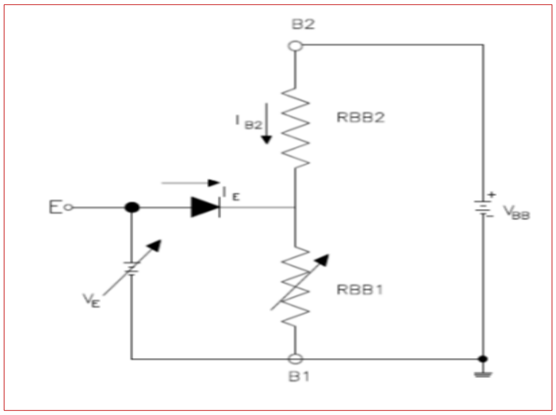

Figure 4 Electrical circuit for determining the input characteristics of UJT

During operation, B_2 terminal is made more positive with respect to B_1 terminal. Also, it is essential to forward bias the PN junction diode by a voltage equal to its cut-in voltage V_Y which is in the range of 0.35-0.7 V for any significant emitter current I_E to flow through the PN junction. In the absence of the required forward bias, voltage across $R_{BB1}$is given by η V_{BB}. Therefore, if the PN junction were to be forward biased, the externally applied voltage to the emitter terminal must be at least equal to the sum of η V_{BB} and the cut-in voltage of the diode junction. It is expressed by (2). The emitter voltage V_E at which the diode starts conducting is termed as V_P [1−7].

$$V_P = \eta\, V_{BB} + V_Y \qquad (2)$$

Figure 5 shows V_E-I_E characteristics.

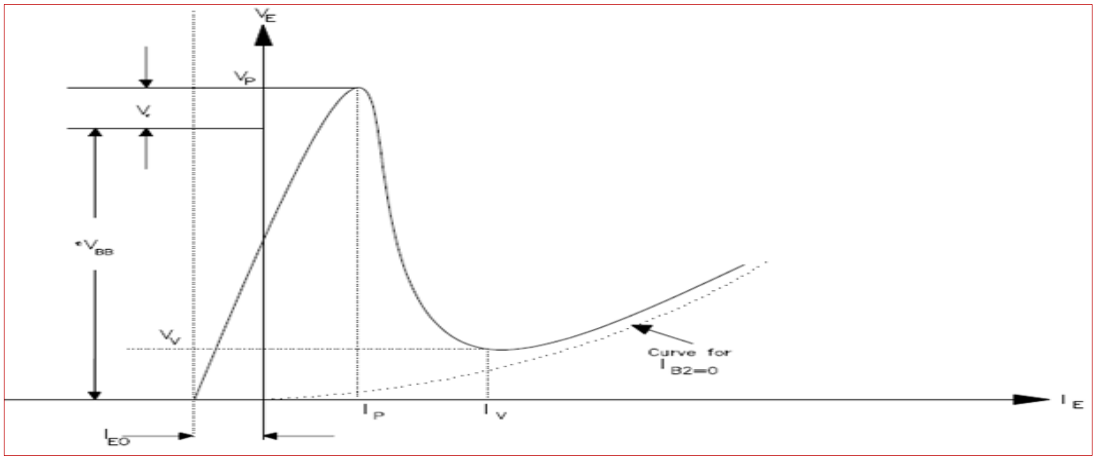

Figure 5 VE-IE characteristics of UJT

2.System design

2.1Hardware design

The circuit schematic for the system is illustrated in *Figure 6*.

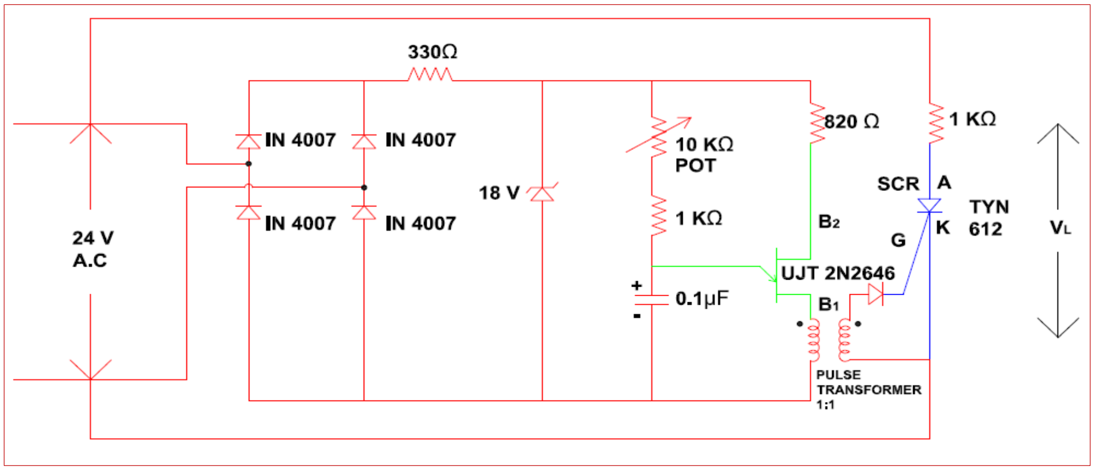

Figure 6 Circuit schematic for the system

2.2System specifications

The system specifications are illustrated in *Table 1*.

Table 1 System specifications

S. No	Specifications
1.	Domain: Power Electronics
2.	Power supply: DC regulated power supply voltage & 24 volts AC supply.
3.	Step down transformer: 24 volts, 2A.
4.	UJT device : UJT 2N2646
5.	SCR device : SCR TYN 612
6.	Resistors : 330Ω, 820Ω, 1 KΩ (2)
7.	Capacitor : 0.1µF
8.	10 KΩ Potentiometer
9.	1:1 Pulse transformer
10.	Diode IN4007 (4)
11.	18V Zener diode 1N5931B
12.	Multimeter
13.	Cathode ray oscilloscope
14.	Breadboard
15.	Single stranded wires, connecting probes, patch cord, crocodile clips.
16.	Applications of UJT: Generating trigger signals, gate pulse, timing circuits, electrically controlled switch.

2.3 UJT 2N2646 overview

The silicon planar UJT 2N2646 possesses electrical features such as lower saturation voltage, peak point current and valley current as well as much higher base-one peak pulse voltage. Apart from these features, UJT 2N2646 devices are much faster switches.

From application point of view the 2N2646 is intended for general purpose industrial applications where circuit economy is of prime importance and is ideal for use in firing circuits for silicon controlled rectifiers and other applications where guaranteed minimum pulse amplitude is required [7].

2.4System setup and its working

The experimental set up was done in Power electronics laboratory. The circuit was rigged as per the circuit diagram. The transformer secondary voltage was checked using digital multimeter (ac mode) or CRO. The required power supply was provided to the circuit. The AC input was rectified to DC through diodes IN4007. The 330Ω resistor minimizes the DC voltage to a suitable value for the zener diode as well as the UJT 2N2646 employed in the circuit. The zener diode is used for the purpose of clipping the rectified voltage to a standard level which remains constant except near the DC voltage. The charging of RC circuit comprised of 1KΩ resistor and a 0.1 µF capacitor is done with zener voltage. The 0.1 µF capacitor charges at a rate determined by the RC time constant. When the capacitor reaches the peak point the UJT 2N2646 starts conducting and the 0.1 µF capacitor discharges through the primary of the 1:1 pulse transformer. Since the current through the primary is in the form of a pulse, the secondary windings have pulse voltages at the output. The pulse at the secondary feeds the SCR TYN612. As the zener voltage reaches zero value at the end of each half cycle, the synchronization of the trigger circuit with the supply voltage across the SCRs is achieved and small variations in supply voltage and frequency has no effect on circuit operation [4,5]. The required voltage waveforms at different points were observed on the CRO which is explained in section 3 of the paper.

3.Experimental results and discussion

The AC voltage waveform was displayed on CRO by connecting the probes across the step down transformer as Shown in *Figure 7*.

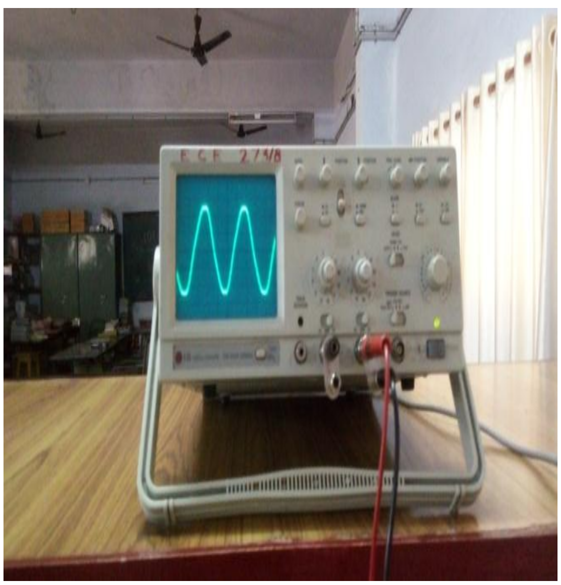

Figure 7 AC voltage waveform

The circuit configuration for getting full wave rectified output was obtained by connecting the probes across the diode IN4007 as depicted in *Figure 8*.

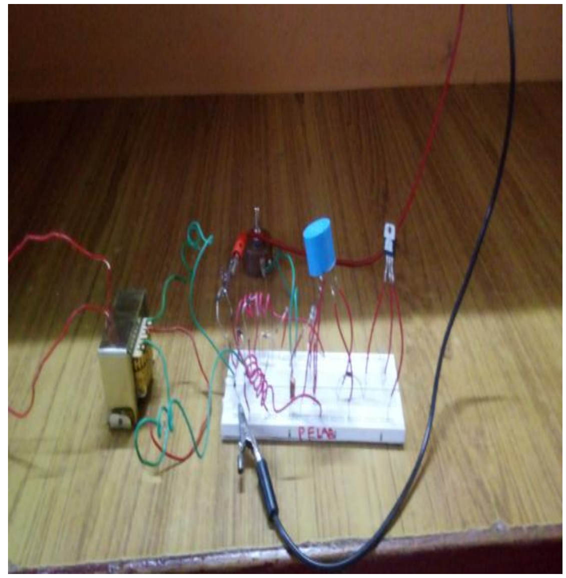

Figure 8 Electrical circuit for full wave rectified waveform

The photographic view of the full wave rectified output displayed on the CRO is shown in *Figure 9*.

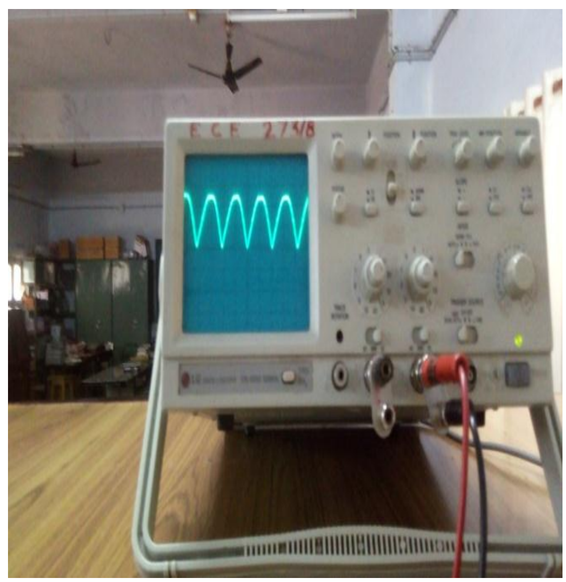

Figure 9 Full wave rectified waveform

The zener voltage V_Z waveform was obtained on the CRO by connecting the probes across the zener diode as depicted by the experimental circuit view in *Figure 10*. The zener voltage waveform is shown in *Figure 11*. The capacitor voltage V_C waveform was generated and displayed on the CRO by connecting the probes across the 0.1µF capacitor. The required circuit and capacitor waveform are illustrated in *Figure 12* and *13* respectively.

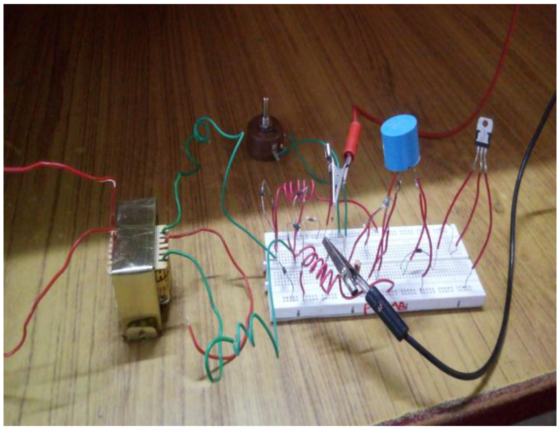

Figure 10 Electrical circuits for zener voltage waveform

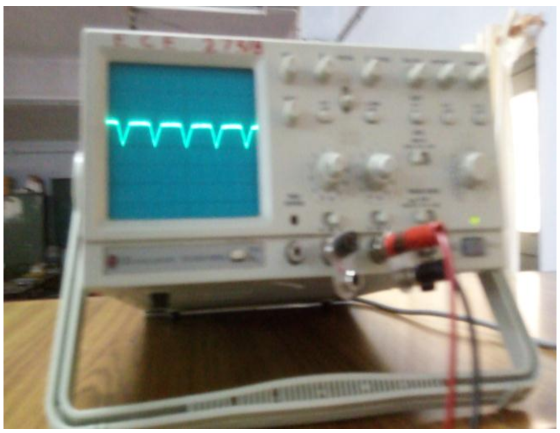

Figure 11 Zener voltage waveform

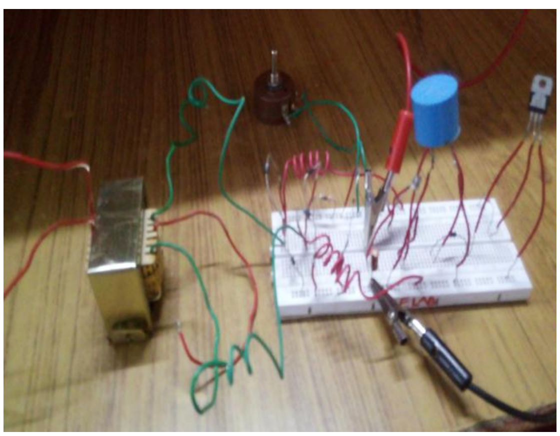

Figure 12 Circuit for capacitor voltage waveform

The circuit for firing pulses is obtained by connecting the probes across the 1:1 pulse transformer as shown in *Figure 14.*

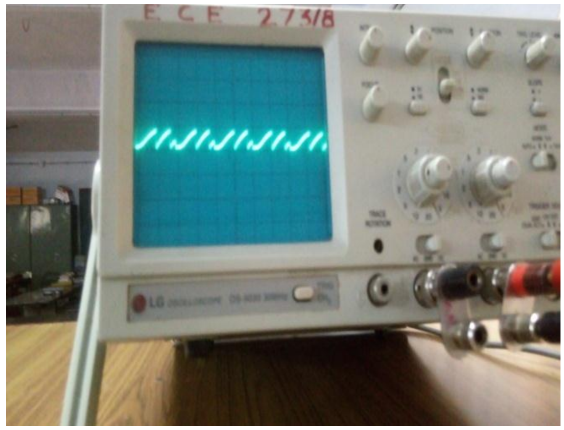

Figure 13 Capacitor voltage waveform

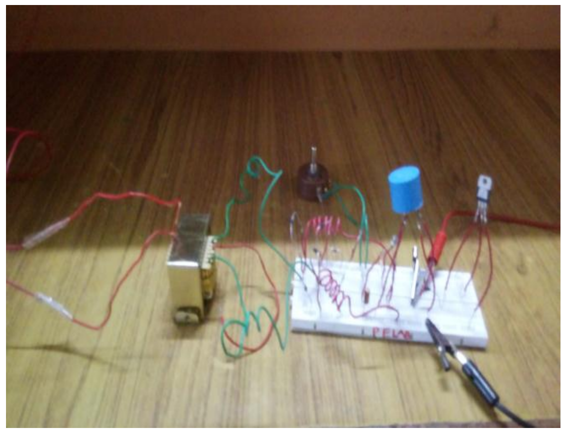

Figure 14 Circuit for firing pulses

The firing pulses generated and displayed on the CRO are illustrated by the photographic view in *Figure 15*.

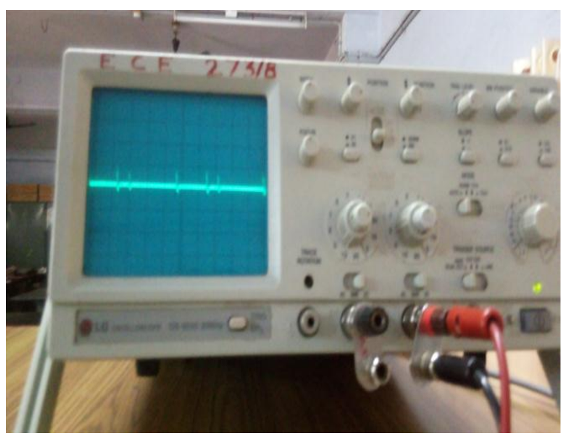

Figure 15 Firing pulses

The output voltage waveforms V_O also referred to as the load voltage waveforms were displayed on the CRO by connecting the probes across the 1KΩ load resistor. The circuit configuration for the load voltage waveform is illustrated in *Figure 16*.

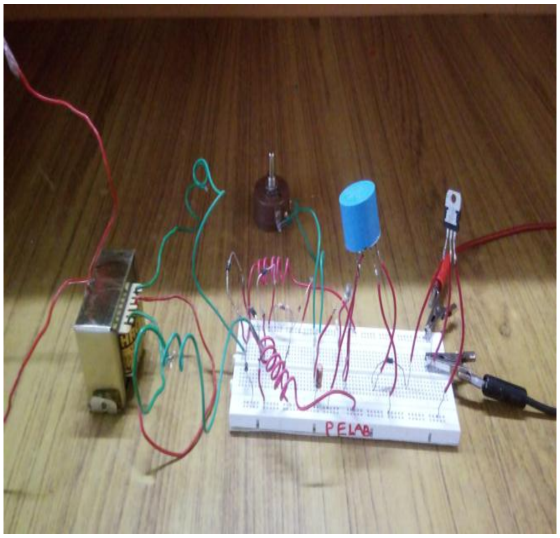

Figure 16 Electrical circuit configuration for load voltage waveform

The load voltage waveform illustrated in *Figure 17* is when the SCR fires at 45^0 and similarly the load voltage waveform shown in *Figure 18* is when the SCR fires around 120^0.

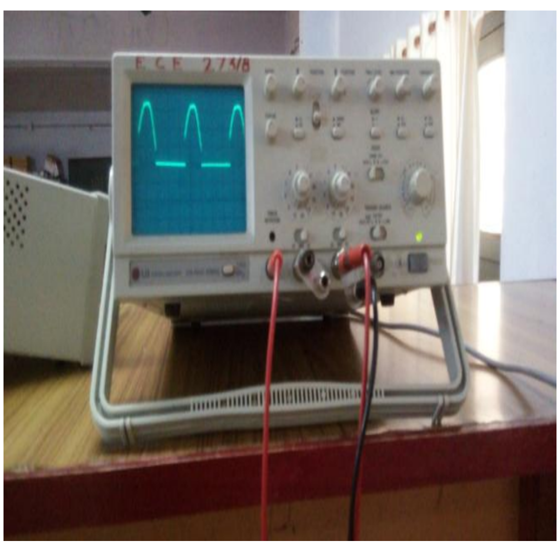

Figure 17 Load voltage waveform at firing angle of about 45^0

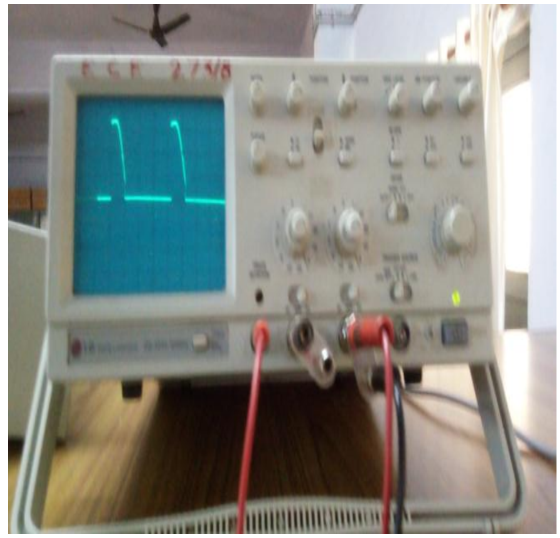

Figure 18 Load voltage waveform at firing angle of about 120^0

4.Conclusion

The synchronized UJT trigger circuit was experimentally investigated and the required output pulses were generated. Care was taken in properly connecting all the required components according to the required schematic in order to ensure the error free output. Various voltages were observed on the CRO in the form of output voltage V_O which is nothing but a full wave rectified output. Apart from this, waveforms such as zener voltage V_Z, capacitor voltage V_C, load voltage V_L and firing pulses were displayed on the CRO by making proper connections at various points on the circuit. The waveforms obtained were very clear and precise. To sum up, the system is very stable, cost effective, and easy to design and use. In this experiment, the research was carried out using UJT device 2N2646. In future, this experiment can be tested with other UJT device such as UJT 2N2647 and the experimental circuit can be reconfigured with other design values and possible changes in result can be observed.

Acknowledgment

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Conflicts of interest

The authors have no conflicts of interest to declare.

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