International Journal of Research Publication and Reviews, Vol 4, no 10, pp 1691-1696 October 2023

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Study of the Operation and Output Waveforms of a Programmable Unijunction Transistor (PUT) Relaxation Oscillator

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DOI: https://doi.org/10.55248/gengpi.4.1023.102655

A B S T R A C T

Electronic oscillators, or programmable unijunction transistors (PUT) relaxation oscillators, produce non- sinusoidal repeated output signals like triangle or square waves. Timer, pulse, and audio frequency generators are just a few of the numerous uses for PUT relaxation oscillators. A programmable variable transistor of model 2N6027 has been used in this experiment. Many other components have been used, such as variable resistors, resistors, capacitors, Potentiometer and oscilloscopes. By changing the resistance value through the variable register, I have seen the different types of programmable variable transistors on the wave-shaped oscilloscope. In this experiment, the output was monitored on an oscilloscope by varying the resistance value twice, and the effect of the resistance on the programmable variable transistor was observed.

Keywords: PUT (2N6027), Capacitor, Variable Resistor, Resistor, Voltmeter, Potentiometer, Oscilloscope

1. Introduction

The PUT, also known as a programmable unijunction transistor, is a member of the thyristor family. Similar to thyristors, it is made of four layers and contains three terminals with the names anode (A), cathode (K), and gate (G). Despite this, some writers refer to it as a programmed UJT because of its similarities to the unijunction transistor's properties and parameters. It is referred to as programmable because two external resistors allow for programming characteristics like the inherent standoff ratio (), peak voltage (Vp), and others. In a UJT, parameters like Vp are fixed and cannot be changed. Timing circuits, pulse circuits, relaxation oscillators, and thyristor firing are the principal uses of programmable UJTs. Currently, ON Semiconductor® is the only producer of PUT—the majority of 2N6027.

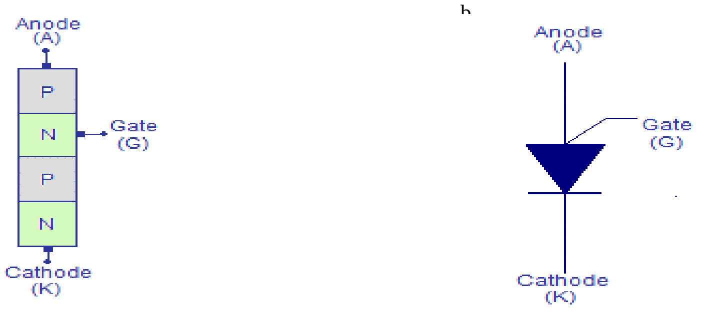

Fig. 1 - (a) Put internal block diagram; (b) PUT circuit symbol.

One can observe that the PUT is constructed of four layers from the above diagram. The anode (A) is the top P-layer. The gate (G) is the N-layer located next to the anode. Close to the gate, the P-layer is left unattended. The cathode (K) layer is the lowest N layer. For external connection, ohmic connections are established on the anode, cathode, and gate layers.[1]

1.1 Working principle

The function of the Gate is the Programmable part of the Programmable junction transistor. By choosing a voltage for the Gate, you establish the Threshold point when the current starts to flow and the Programmable junction transistor starts conducting. The Basic construction of PUT can be shown below. Notice that the Gate is connected to the n-region adjacent to the Anode. The Gate is always biased positively concerning the Cathode. A simple biasing example using a Programmable Unijunction Transistor can be given below. A Few points that need to be considered while employing a Programmable Unijunction Transistor in a correctly biased way are as follows:

- The Gate should be between these two extremes, with the Anode being more advantageous than the Cathode.
- Current surges through and flows from the Anode to the Cathode if the anode voltage rises above a threshold point.
- If the anode voltage falls below the Threshold, the transistor shuts off the flow.
- The Threshold's height is determined by the voltage we apply at the Gate.
- The two resistors, R1 and R2, in the preceding example are used to modify the Gate voltage. Each resistor typically has a value of 20k. Because a small amount of current is needed to bias the transistor, R3, which can have a fantastic deal of 100k or more, protects the Programmable Unijunction transistor from full positive voltage.
- At the Anode, we add the input signal as a positive voltage. It pours out of the Cathode and can regulate some output devices when it rises above the Threshold.
- The Voltage at the Gate is determined by, or the Threshold is given by,
    - Vgate = [R1/(R1+R2)] x Vcc.
- Since R1 and R2 can be changed and selected to determine the Threshold Voltage, it is known as a Programmable Unijunction Transistor.[2]

2. Literature Review

2.1 Programmable Unijunction Transistor (PUT)

The programmable unijunction transistor (PUT) is a three-lead electronic semiconductor device with properties comparable to those of a unijunction transistor, except that it allows for externally controlled behavior. The base area of a unijunction transistor is split in half by the emitter. The voltage division created by the two base components determines the operating points of UJTs. Two physical resistors attached to the PUT's gate terminal can be used to program that voltage divider. As a result, the designer can control the PUT's operating end. [3]

2.2 Variable resistors

The resistors described in this section are con-structed so the user can vary the resistance between two device terminals. These resistors are known as potentiometers and vary in size and construction. Large panel-mounted devices are generally designed for applications where relatively frequent adjustment may be required. In contrast, small printed circuit board-mounted devices, sometimes known as trimmer potentiometers, are used in applications where only a few adjustments will be made during the life of the equipment. Both types of potentiometers can be single-turn, in which the wiper sweeps across the whole resistance element for one turn of the control spindle, or multi-turn, in which many complete spindle rotations are required to move the wiper across the resistance element. Multi-turn potentiometers are capable of more accurate settings but are more expensive than single-turn devices.[4]

2.3 Oscilloscope

Oscillographs, also known as cathode ray oscilloscopes (CROs), are frequently used in laboratories to measure amplitude and time over a wide range of frequencies. Creating a visual representation of waveform is the central goal of developing an oscilloscope. After being applied to the CRO, the signal is amplified by the vertical amplifier, bent by the cathode ray tube's vertical deflection plate, and ultimately projected onto the screen. A portion of the vertical amplifier's amplified signal is used as the sweep trigger's triggering input, which activates the sweep generator and starts the sawtooth waveform. The horizontal amplifier then amplifies this wave and causes it to incident on the flat deflection plates. Additionally, external signals can be supplied to the vertical and horizontal amplifier's vertical and horizontal inputs and are occasionally utilized as external triggers. Voltage is plotted along the x-axis and time is plotted along the y-axis in a two-dimensional graph [5].

2.4 Potentiometer

Potentiometers are often used in measurement and control systems, notably the servo control system. This severely impacts the servo motor's accuracy and dependability in the servo control system. The selection of the best potentiometer depends on the automatic detection and analysis of the potentiometer's indicators. Automated testing and data processing typically make use of virtual instruments, which are based on digital test and measurement equipment. Instrument technology development is moving toward combining instrument capabilities, such as data collection, control, data analysis, output of results, and user interface generation, through software. This architecture fully utilizes virtual instrumentation to facilitate signal acquisition, data analysis and processing, and hardware monitoring.[6]

2.5 Voltmeter

A voltmeter is the name of a device that measures voltage. For instance, to determine how much power is left in a battery, use a voltmeter. The simplest basic voltmeter was created by Hans Oersted in 1819, which made it possible to make voltmeters.[7]

2.6 Resistor

A resistor is an element or component that controls how much power is supplied to electrical or electronic components while reducing the electrical current. Additionally, it protects these items from damage brought on by an overabundance of electricity. [8]

2.7 Capacitor

An electronic component called a capacitor builds up electric charges on two distant surfaces that are kept isolated to store electrical power in an electric field. It contains a passive electrical component and two terminals. A capacitor's effect is referred to as capacitance. Any two neighboring electrical lines in a circuit have some capacitance, but a capacitor is a part that increases capacitance. Initially, the capacitor and condenser were used interchangeably [9].

3. Methodology

Through this experiment, the effect of the resistor on the programmable transistor is shown experimentally. Some types of equipment are used to complete the test, like Capacitors, Resistors, Variable registers, Voltmeter, Potentiometer, Oscilloscope, breadboard, power supply and (PUT (2N6027).

3.1 Working procedure:

- PUT (2N6027) was set on the bread board remarking the Anode, Gate and Cathode pin.
- Resistors 2k and 30k were connected series with gate pin.
- Variable resistor R_r was connected with 30k resistor, Anode and 0.01 µF Capacitor.
- Variable resistor R_R was connected with 30k resistor, 2k resistor and ground.
- Resistor (2k) was connected with Cathode pin.

3.2 Experimental Setup

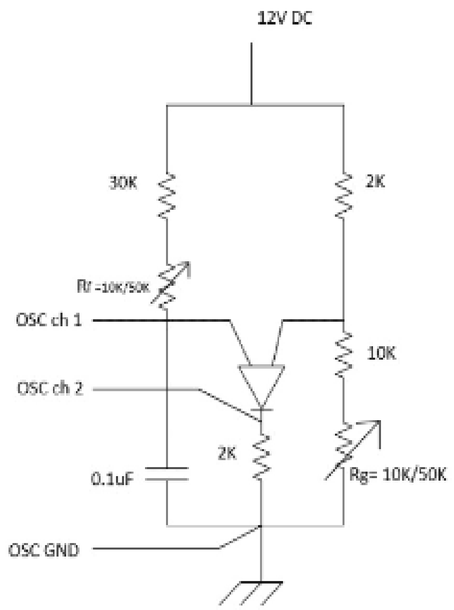

Fig. 2 – Circuit Diagram (PUT)

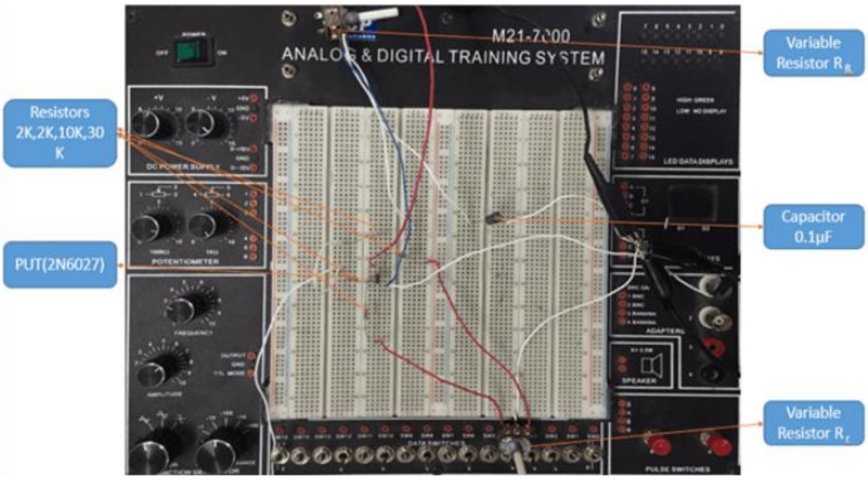

Fig. 3 – Assembled Circuit on bread board.

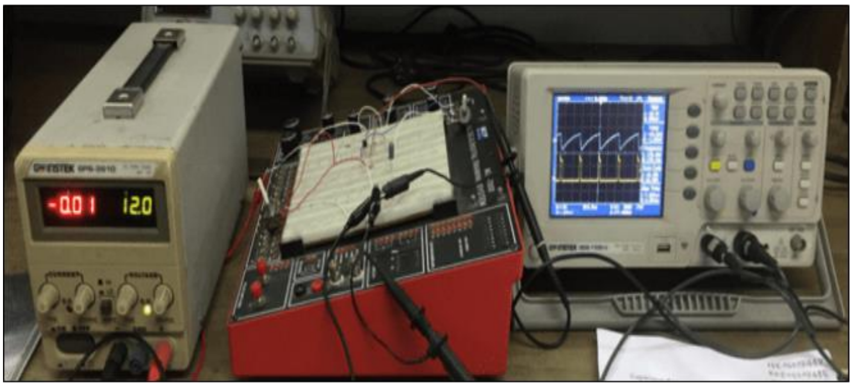

Fig. 4 – Trainer broad, DC power supply, Oscilloscope.

4. Result and Discussion

By changing the variable resistance value, the change in the waveshape of the programmable junction transistor can be seen through the oscilloscope.

4.1 For variable resistor value $R_p = 6.4\ k\Omega$

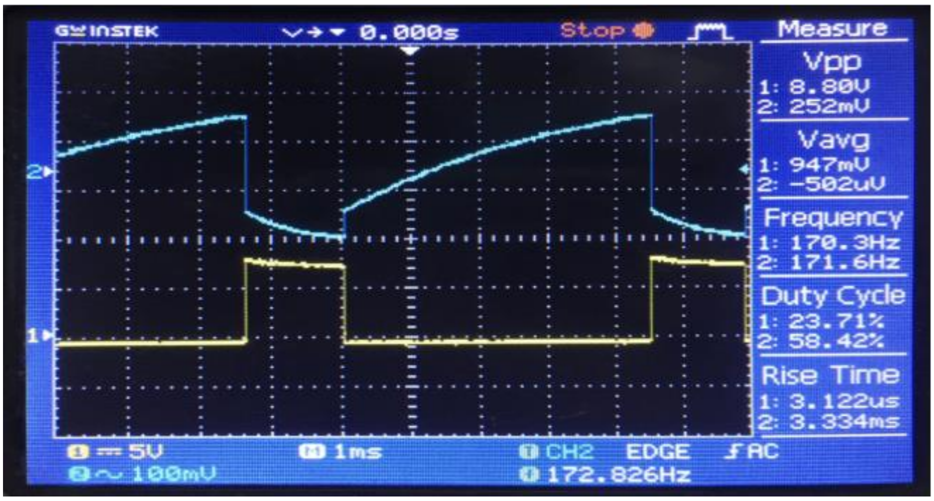

Fig. 5 – PUT Output Result taken from oscilloscope.

Table 1 - PUT Output Result taken from oscilloscope.

SL NO.	Vpp	Vavg	Frequency	Duty Cycle	Rise Time
1	8.80V	947mV	170.3Hz	23.71%	3.122us
2	252mV	-502uV	171.6Hz	58.42%	3.334ms

4.2 For variable resistor value $R_p = 10.03\ k\Omega$

Fig. 6 – PUT Output Result taken from oscilloscope.

Table 2 - PUT Output Result taken from oscilloscope.

SL NO.	Vpp	Vavg	Frequency	Duty Cycle	Rise Time
1	10.4V	-23.6mV	178.3Hz	10.15%	7.200us
2	256mV	-1.03mV	178.1Hz	62.50%	3.384ms

The programmable unijunction transistor, also known as a PUT, is a close relative of the thyristor. Like thyristors, it consists of four layers and has three terminals: anode (A), cathode (K), and gate (G). Two variable resistor was used. One variable resistor value is fixed, while another variable is varied. OSC Ch1 was connected to an anode pin. OSC Ch1 was connected to the cathode pin. Finally, finish the work and get the oscillator from Oscilloscope.

5. Conclusion

This study has presented a detailed analysis of the operation and output waveforms of a programmable unijunction transistor (PUT) relaxation oscillator. The study has shown that the values of the external components, such as the capacitor and variable resistor, determine the oscillator's frequency. The study has also shown that the output waveform of the oscillator can be varied by changing the values of these components. After the experiment, the characteristics and working principle of PUT are clear to me.

6. Acknowledgements

I thank my honourable teacher, Prof. Abu Muhammad Wahidullah**,** Professor, Faculty of Electrical and Electronics Engineering Department, Stamford University Bangladesh, for his supervision, continuous caring and guidance discussion. I am very grateful to him for his constant support, unforgettable help and kind encouragement throughout the process of my project work. There is also great support from the various lab assistants from the Institute and other technical staff for this paper's publication work.

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