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Rectangular Waveform Generator with Varying Duty Cycle and Frequency Using a Given Source

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Abstract: ***This paper presents a novel method to obtain rectangular waveforms of 16 different frequencies of varying duty cycle and frequency using a given source. Therefore, in order to obtain the above waveforms, the Rectangular Waveform Generator(RWG) with varying duty cycle and frequency has been designed The thought provoking design uses a 555 timer based an astable multivibrator to generate frequency, a synchronous counter, a rotary switch and a de-multiplexer to divide the generated frequency into 16 different divisions.***
Keywords: 555 timer, synchronous counter, rotary switch and de-multiplexer

I. INTRODUCTION

Obtaining rectangular waveforms of 16 different frequencies with varying duty cycle is of paramount importance in science and technology. Producing different frequencies with varying duty cycle using a given source with very high degree of precision at negligible cost has always been a challenge. This uses 555-Timer as an astable multi-vibrator to produce digital waveform or signal of a defined frequency. The **Rectangular Waveform Generator (RWG)** is capable of producing rectangular waveforms of 16 different frequencies with varying duty cycle**.** In other words, the device can produce sixteen different frequencies with very high degree of precision. And if the source frequency is changed then it will produce a different set of sixteen frequencies, for another frequency yet another set of frequencies and so on and so forth. It is here worth mentioning that the RGW is independent of type of rectangular waveform producing source. Although a 555-Timer based astable multi-vibrator has been chosen here as yet one has the freedom to choose any digital source that produces rectangular waveforms.

The device is extremely rugged and it is reliable too. Commercially available signal generators are highly complex and costly. But device with simple solutions are generally not available in the market and paper similar to this was also not found. As a result no previous papers could be linked to it. This simple yet thought provoking device just uses an astable multi-vibrator, a synchronous counter, a rotary switch and a de-multiplexer to achieve the desired objectives.

A. Required Details of Components used in the Circuit Design

The 555 Timer: It is low cost, highly stable, versatile integrated circuit. It is a precision timing device. When it is used an astable multivibrator which can generate precise rectangular oscillations. Its duty cycle and other parameters are given below: Duty Cycle (D) =Ton/T_{on}+T_{off} = R_A+R_B/R_A+2R_B; T_{on}=0.693(R_A+R_B) C; T_{off}=0.693R_BC; Frequency (f) =1.44/ (R_A+R_B) C

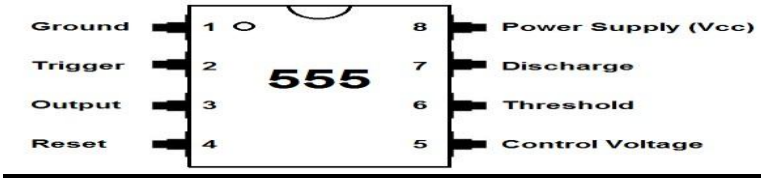
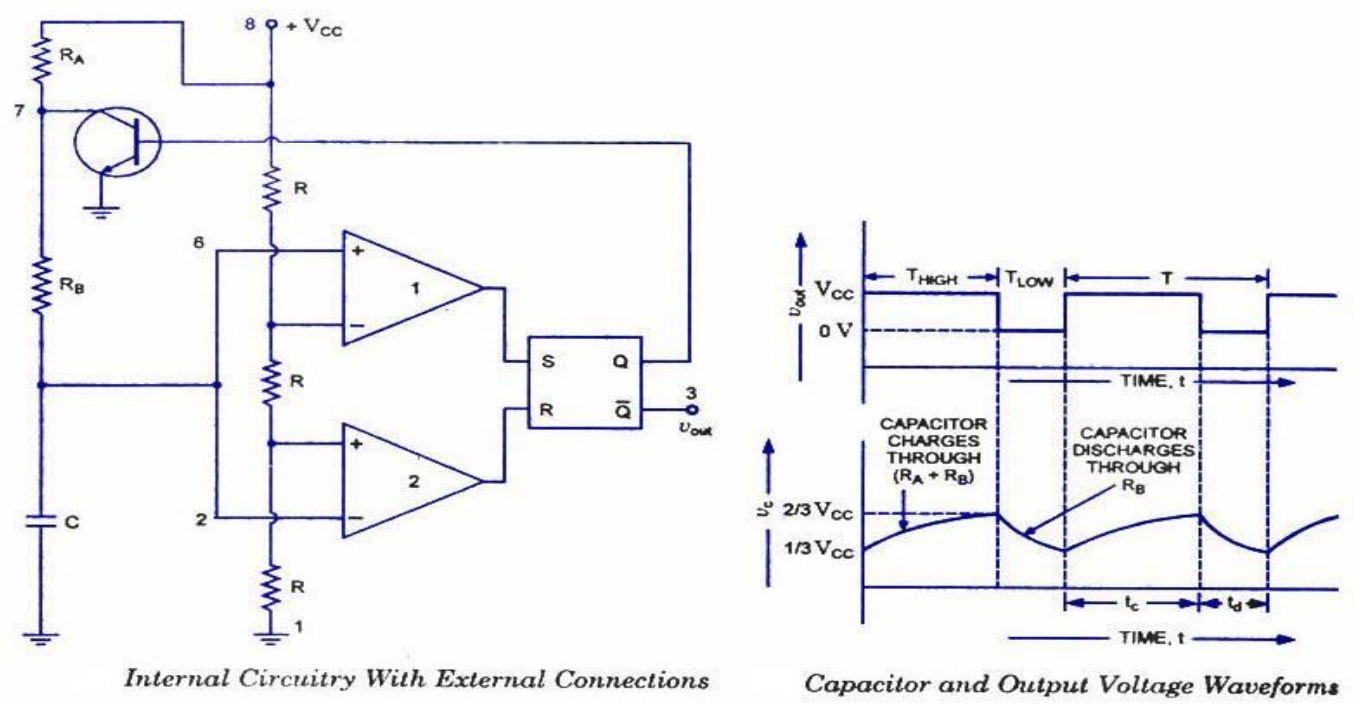


Fig.1 The IC 555 timer Pin out Diagram

The IC 555 timer as an Astable Multivibrator: It acts as a free running oscillator or square wave generator. It does not need external triggering. It produces square wave. The capacitor C charges through R_A, R_B and VCC. It discharges through R_B and transistor. And output is taken from Pin3 of the timer



Internal Circuitry With External Connections *Capacitor and Output Voltage Waveforms*

Fig.2 The IC 555 timer as an Astable Multivibrator and its output waveform

B. IC74LS163

It is an IC 4-bit Synchronous up Counter. Here "LS" stands for Low–power-Schottky. Its states change with rising edge clock pulse. It has 16 states i.e. $(0000)_2$ to $(1111)_2$.The PIN Out Diagram, PIN description and functional table for the IC are given below:

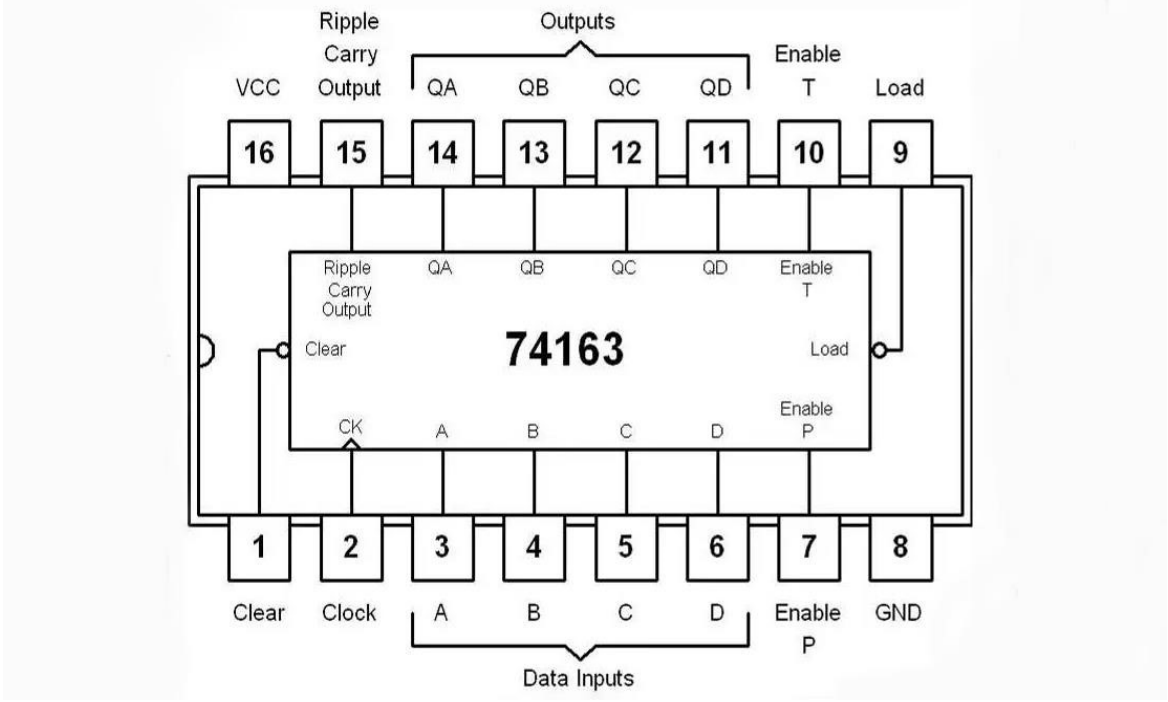


Fig.3-IC74 LS 163: Pin Out Diagram

TABLE-I
PIN Description: IC74LS163

PIN Number	Symbol	Description:
1.	CLR’	Master Reset: When this pin goes low, all outputs goes low on the next clock pulse.
2.	CLK	Clock Input: Drives the counter with rising edge triggering
3.	A(P0)	Parallel Data Input 0(LSB)
4.	B(P1)	Parallel Data Input 1
5.	C(P2)	Parallel Data Input 2
6.	D(P3)	Parallel Data Input 3(MSB)
7.	ENP	Enable Parallel: This must be high to count.
8.	G	Ground Connection
9.	PE/LD’	Parallel Enable(Active Low)
10.	ENT	Enable Trickle: It is needed to enable counting
11.	QD	Counter Output(MSB)
12.	QC	Counter Output
13	QB	Counter Output
14	QA	Counter Output(LSB)
15.	TC/RCO	Terminal Count/Ripple Carry Output: This goes high when count reaches maximum count i.e.15.
16.	VCC	Supply Voltage

TABLE-II
Functional Table: IC74 LS163

CLEAR	**LD**	**ENP**	**ENT**	**CLK**	**Operation**
L	X	X	X	Rising clock edge	All outputs are zero
H	L	X	X	Rising clock edge	Synchronous Load A,B,C,D will be loaded, pre-set values if any
H	H	L	X	Rising clock edge	Count does not change
H	H	X	L	Rising clock edge	Count does not change(RCO=L)
H	H	H	H	Rising clock edge	Up count

C. State Diagram of IC74LS163

The state diagram tells how the 16 states are reached. It goes on increasing count from 0000 to 1111 with rising edge of the clock pulse. And then comes back to 0000 and again the cycle is repeated. It executes the following sequence: 0000→0001→0010…..→1111. This is shown in the following state diagram.

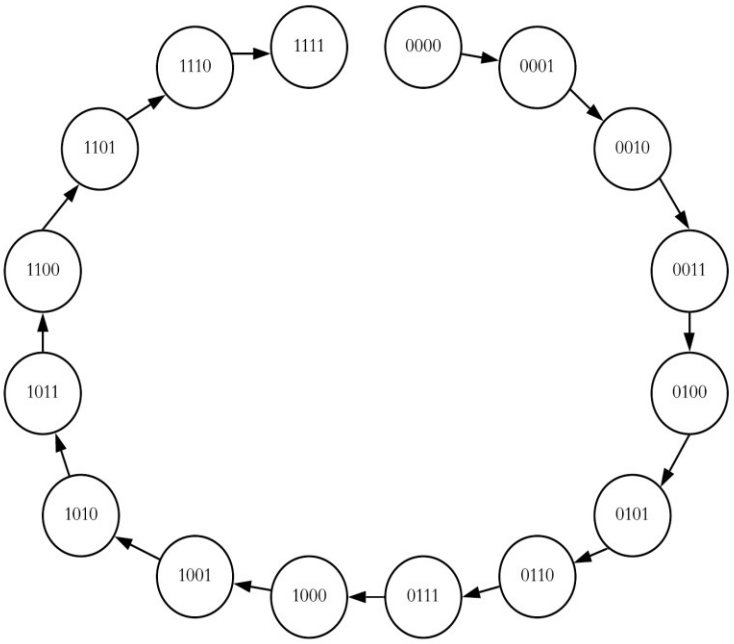


Fig.4 State Diagram of IC74 LS163

D. IC74 LS154

It is 24- PIN TTL series IC that acts as a 4x16 line decoder or de-multiplexer. It converts a 4-bit binary input into one of the 16 mutually exclusive active low outputs. The PIN Out Diagram, PIN description and functional table for the IC are given below:

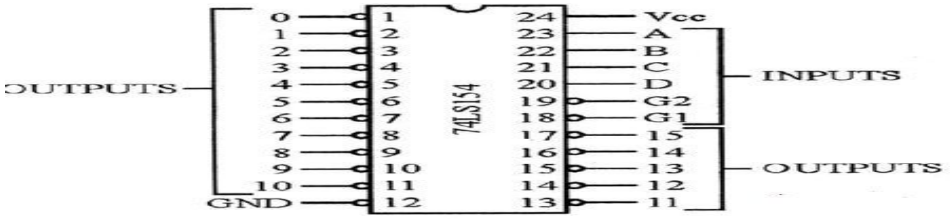


Fig.-5 IC74 LS154 Pin Out Diagram

TABLE-III
IC74 LS154: PIN Description

PIN Number	Symbol	Description:
23, 22, 21, 20	A, B, C, D (or A0-A3)	Inputs: They receive 4-bit binary inputs.
1 to 11 and 13 to 17	Y0 to Y15	Outputs: They are active low. Here one of the 16 pins goes low based on input.
18,19	G1,`G2(or E1, E2)	Enable/Strobe: These two pins must be low for IC to function
24	VCC	It provides positive power supply(05V)
12	Ground	This is ground or 0v reference point

TABLE-IV
Functional Table: IC74 LS154

INPUTS						OUTPUTS															
G1	G2	D	C	B	A	Y15	Y14	Y13	Y12	Y11	Y10	Y9	Y8	Y7	Y6	Y5	Y4	Y3	Y2	Y1	Y0
0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1
0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1
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0	0	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	0	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0	1	X	X	X	X	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	0	X	X	X	X	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	X	X	X	X	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

E. 16-Pin Rotary Switch

It is an electromechanical device which can select one of 16 pins and direct the output to the right path. Although it seems to be less important but in fact it is the principal steering element of the circuit. It is connected to 74LS 154 which is 4x14 demultiplexer and connected 16 output lines of the de-multiplexer

Fig.-6 Rotary Switch (16 Pin)

F. Rectangular Waveform Generator (RWG) with varying duty cycle and Frequency: Functioning:

Here IC74LS163 is used as a synchronous binary counter and IC74LS154 is for de-multiplexing and selecting different frequency. Thus, we get different preset (as selected through the selection switch) counts to divide the basic frequency by 16 different digits to get 16 different frequencies with stable oscillator.

The output of the frequency source is given to the Data in pin of IC74LS163.Outputs of this IC i.e.Q_A, Q_B, Q_C, Q_D are given to control pins of IC74LS154.Thus, a particular output line of IC74LS154 is selected as per the state of the output pins of IC74LS163.The only pin which has count passed equal to the Data in will be low and the rest of the pins be high for IC74154. If the selected pin goes low then this signal is passed to the clear pin of IC 74LS163 which resets it and operation restarts. Thus, data in frequency is divided by the select value of the switch. By selecting different numbers at switch we get different frequencies.

Formula for Output Frequency = 1/Selected Pin No. of the Rotary Switch x Time Period of the Clock
=1/NxT
Where N= Selected Pin No. of the Rotary Switch (N=1, 2, 3…..16)
T= Time Period of the Clock (555 Timer)

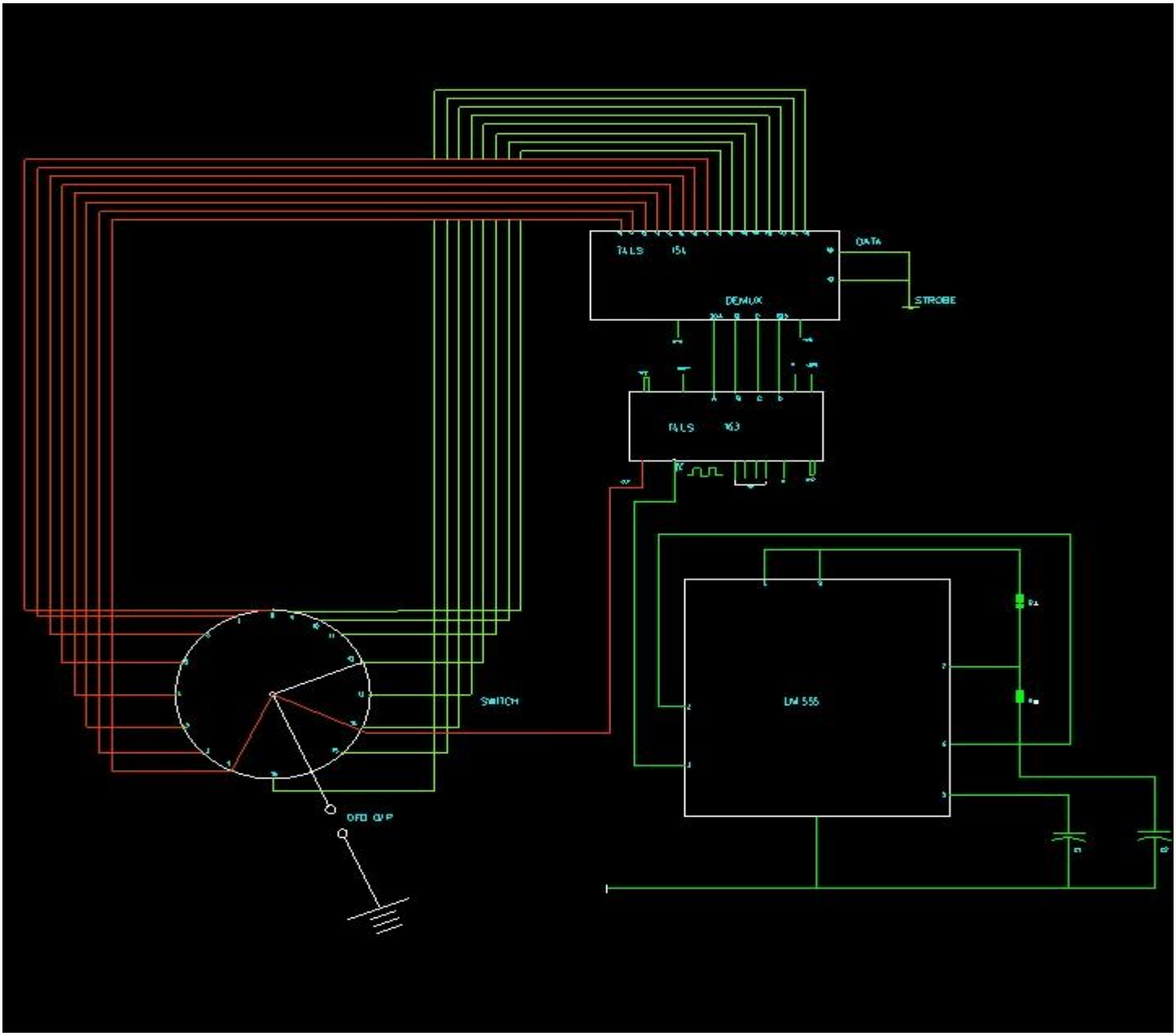

Fig.-7 Rectangular Waveform Generator (RWG) with Varying Duty Cycle and Frequency

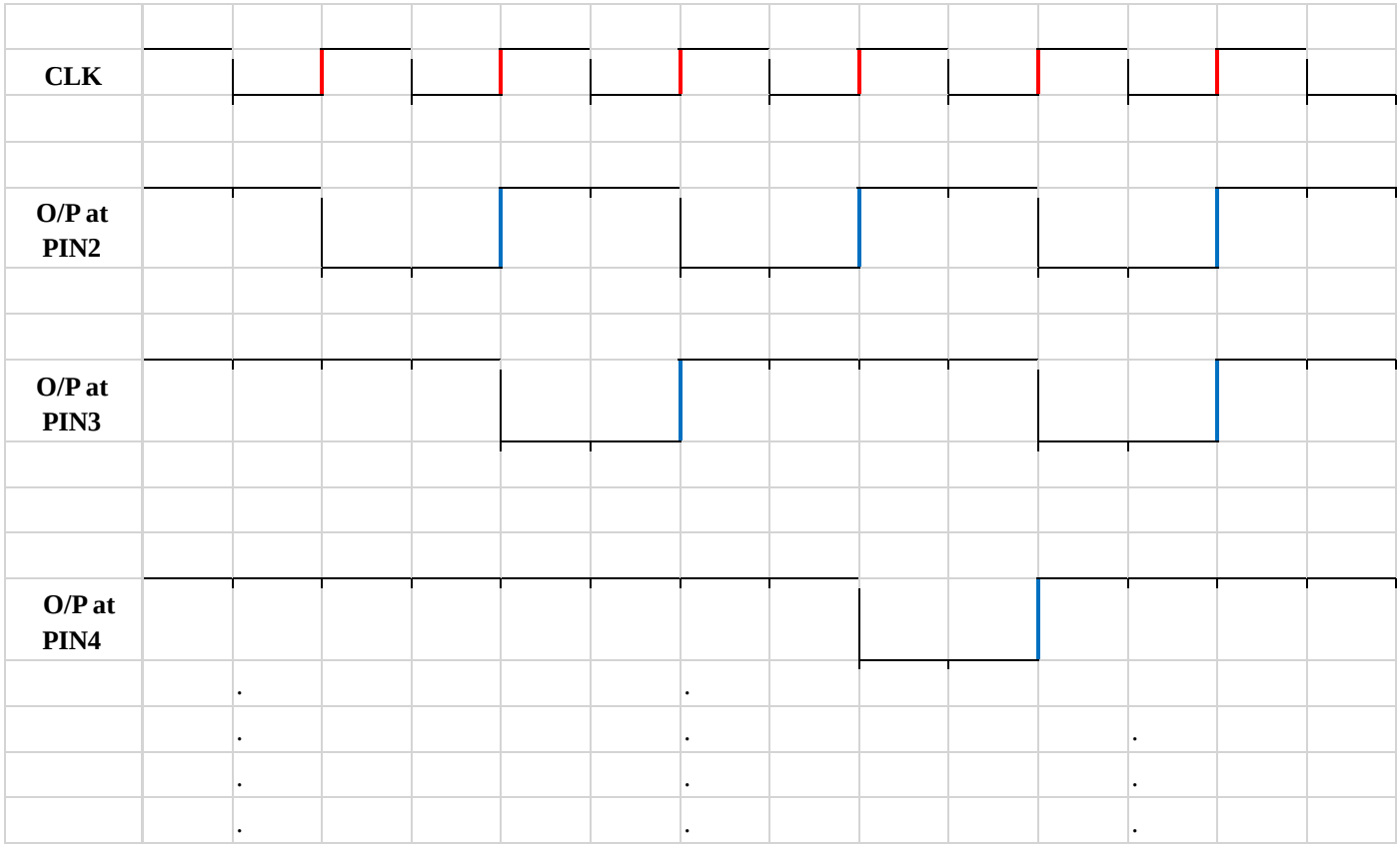

Fig.8: Output Waveforms

II. CONCLUSIONS

Rectangular Waveform Generator with varying Duty Cycle and Frequency using a given source is a novel and thought provoking design. Being extremely low cost and rugged in construction, it may be suitably used for scientific research institutions and industry alike. If any component is damaged, it can be easily repaired. It needs negligible maintenance. If R_A, R_B & C are made variable then a multiple set of 16 frequencies can be obtained. Thus, the device provides an opportunity to obtain a large set of frequencies and varied duty cycles.

III. ACKNOWLEDGEMENT

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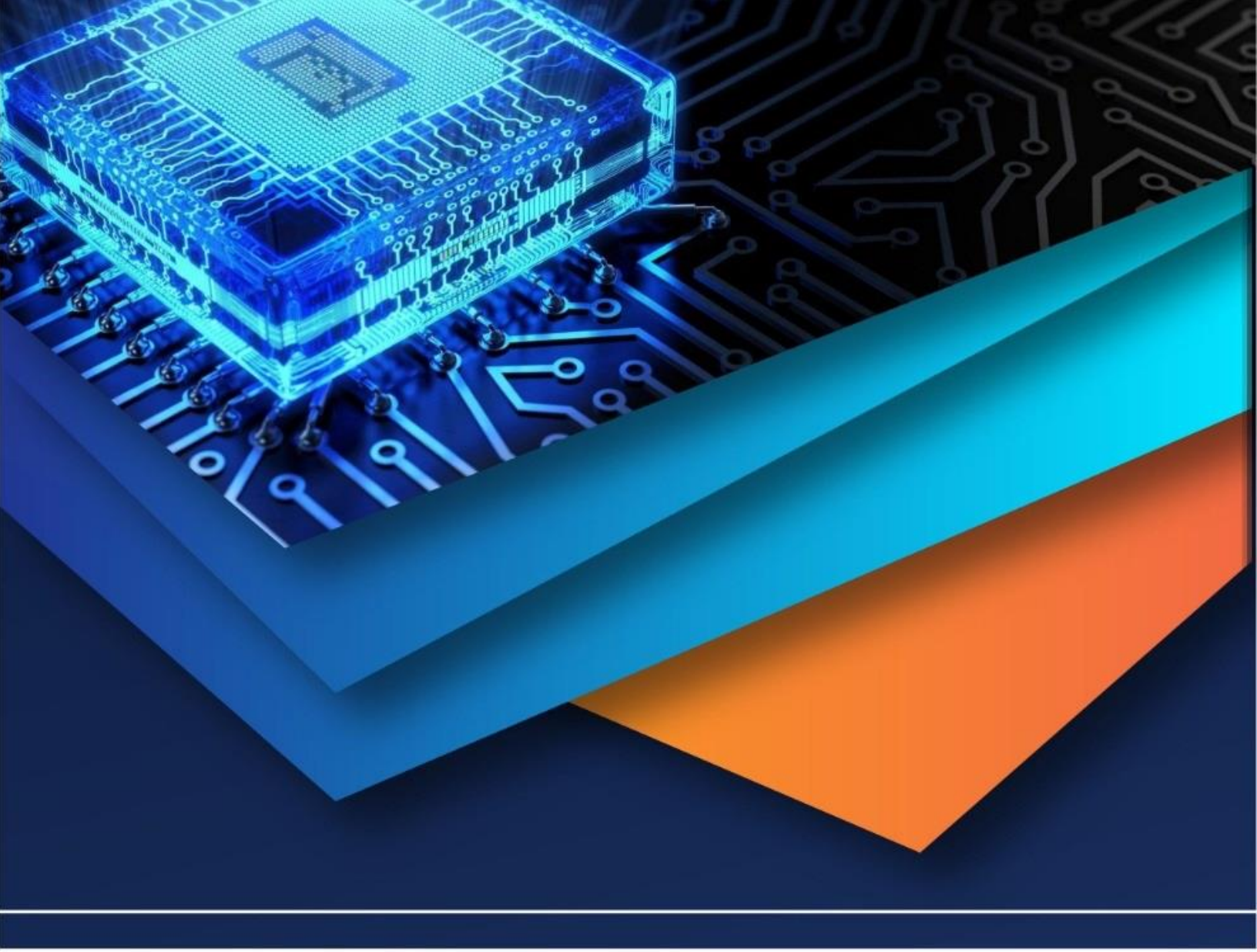
[6] https://share.google/stWrB556dha216q3A



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