Comparative Analysis and Simulation of Different Astable Multivibrator Circuits Design Using PSPICE

Rajender Kumar, Krishan Kumar and Sandeep Dahiya

Abstract: This paper aims at presenting the comparative analysis of astable multivibrator circuit design using different IC's such as Timer 555, uA741 operational amplifier and LM111 comparator IC's. This paper also presents the various applications of astable multivibrator which are frequently used in communication system such as is digital data transmission and pulse position modulation.

Computer simulation of astable multivibrator can greatly aid in the analysis, design and comparison of their performances. An astable multivibrator can constructed for given specification one of which is, it must have a duty cycle of 50 percent and frequency of oscillation must be 1 KHz. The workability of the proposed circuits is confirmed through PSpice simulations and then the various circuits and their experimental work is compared.

Keywords: Astable Multivibrator, 555 timers, uA741 operational amplifier, LM 111 IC, PSPICE.

1. INTRODUCTION

A multivibrator is an electronic circuit used to implement a variety of simple two state systems such as oscillators, timers and flip-flops. An astable multivibrator finds its applications in all types of communication system shown in fig. 1 such as FSK generator, pulse position modulation and RFID system.

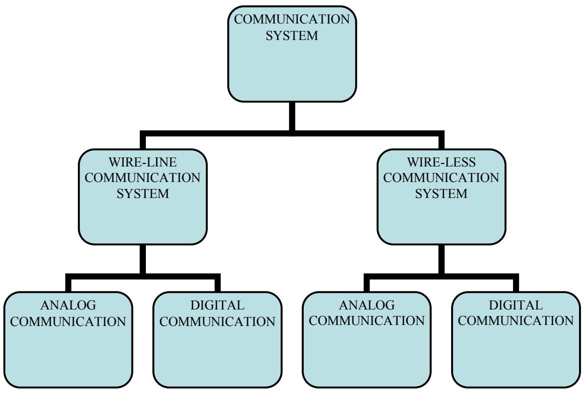

Fig1 Types of Communication System

An astable multivibrator which is often called getable operating modes or free running multivibrator is one which toggles between one stable state to another without the influence of any external control signal [1]. Two primary methods for generating basic waveform for these applications are (1) Timing method and (2) Unity loop gain method. The timing method employs RC timing circuits and components that charges starts at certain critical levels. It is used to generate rectangular waveform which can be produced by adding two resistors and a capacitor commonly known as timing circuit to the basic internal diagram of 555 timers IC. The time duration in which output is either high or low is determined by these two resistors (Ra & Rb) and capacitor(C).

2. DESIGN CONCEPT

Astable Multivibrator can be designed by using op-amps, bipolar transistors or timer IC. In this paper we are using the internal diagram of 555 Timer IC shown by figure 2 which, was first introduced by Signetics, for designing because this timer IC is versatile in nature and easy to use compared to other known IC or components. Some main features of 555 timer IC is shown in table 1. The internal diagram of 555 timer IC and its pin diagram is shown in figure 2 (a, b) [2]. It consists of two comparators (simply op-amps), RS flip-flop, two transistors and a resistive network (Three equal resistors to act as voltage divider).

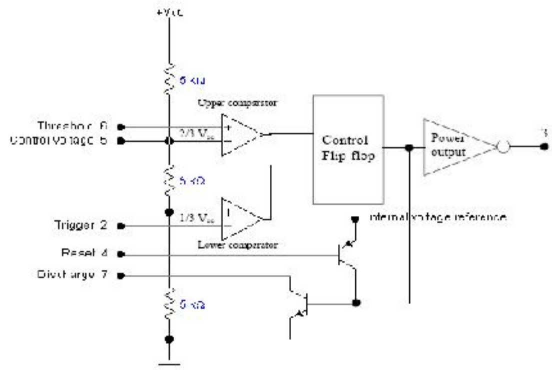

Fig.2 (a) Internal Diagram of 555 timers IC

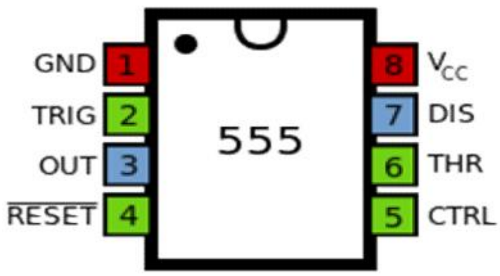

Fig.2 (b) Pin Diagram of 555 timers IC

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3. THEORY AND DESIGN IMPLEMENTAION

The basic circuits for astable multivibrator are shown in figure 3 (a, b) [3]. The timing circuit consists of two resistors (Ra, Rb) and a capacitor (C).

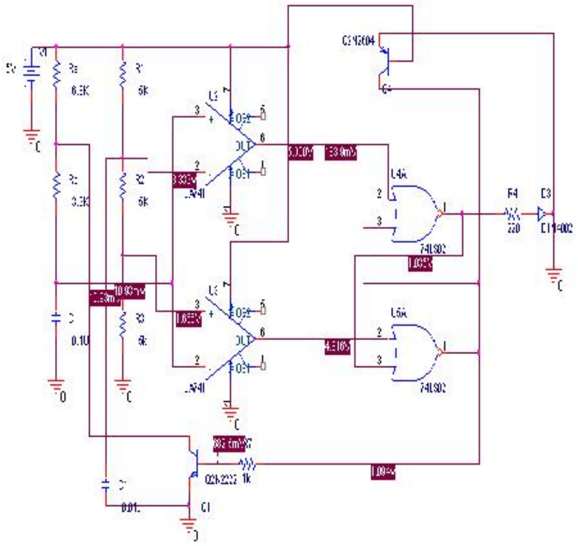

Fig3 (a) Astable Multivibrator Circuit Diagram

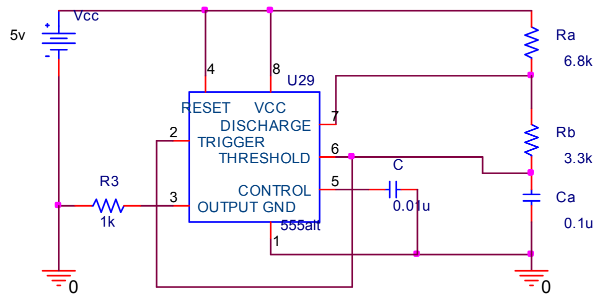

Fig 3 (b) Astable Multivibrator Circuit Diagram with NE555 timer IC

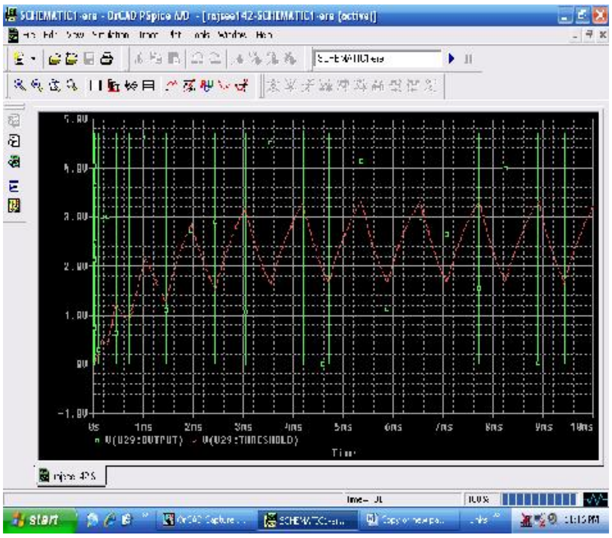

Fig 3 (c) Pspice Simulated waveform of Atsable Multivibrator

Period and frequency of oscillation:

Let us consider T_{high} and T_{low} represents time during which output assume high state and low state respectively. The expression for T_{high} and T_{low} for astable multivibrator is given as

T_{high}= 0.693*(Ra+Rb)*C --- (1) and T_{low}=0.693*Rb*C --- (2)

The total time duration of oscillation is given by

T= T_{high} +T_{low} => T=0.693*(Ra+2Rb)*C --(3)

The frequency being reciprocal of total time of oscillation is given by

F=1.45/ (Ra+2Rb)*C --- (4)

Finally the standard definition of duty cycle (D) which is often used for most pulse generator circuit is

D=high interval*100/total time => Ra*100/Ra+2Rb --- (5)

Now we will design astable multivibrator which can generate a pulse of 1 KHz frequency with 50% duty cycle. To do so consider the value of capacitor(C) equal to 0.1uF and time duration for which output to be low and high is 0.25ms and 0.70ms respectively. Using the equations (2), value of Rb calculated is 3.3 KΩ & using equation (1), value of Ra comes out to be 6.8 KΩ. We will use another capacitor (C1) between voltage control and ground to by-pass noise or ripple from the supply.

Further, second circuit can be used to design and simulate the same multivibrator using LM 111 IC shown in fig 4.

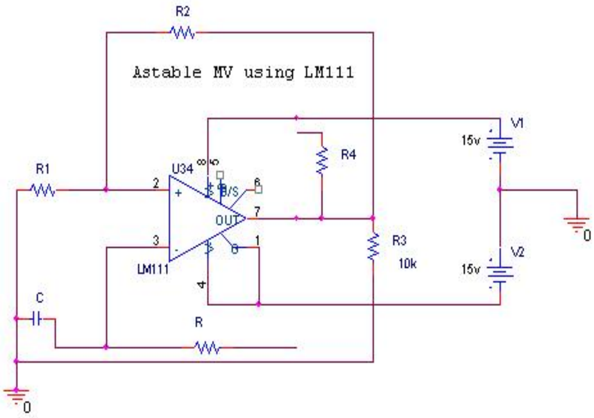

Fig 4 (a) Astable Multivibrator using LM111 IC

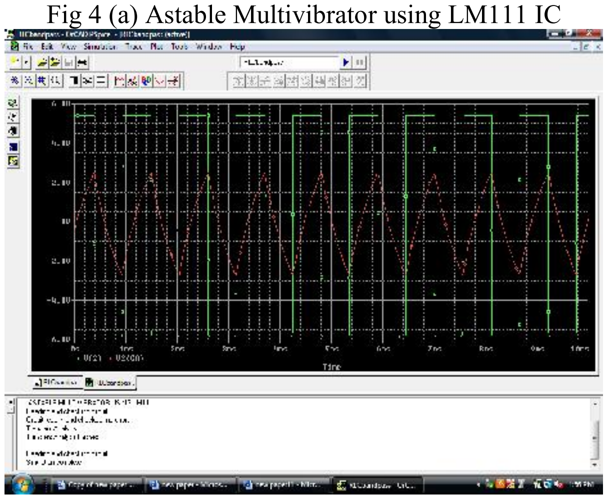

Fig 4 (b) Simulation of Circuits using LM111 IC

Finally, the approach is applied for the design of astable multivibrator using uA741 IC whose circuit diagram is shown in fig 5 (a) and the simulated output is as shown in fig 5 (b).

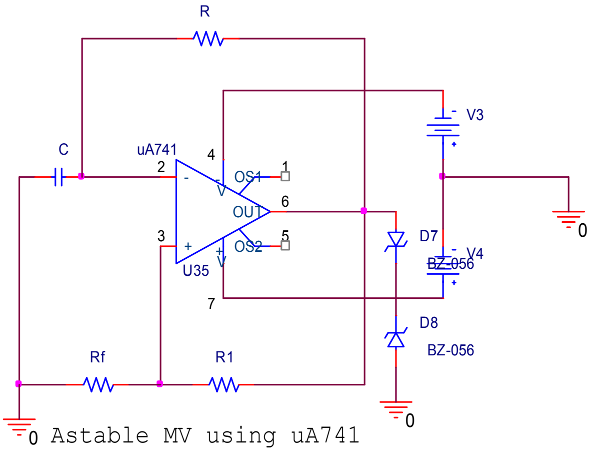

Fig 5 (a) Astable Multivibrator using uA 741

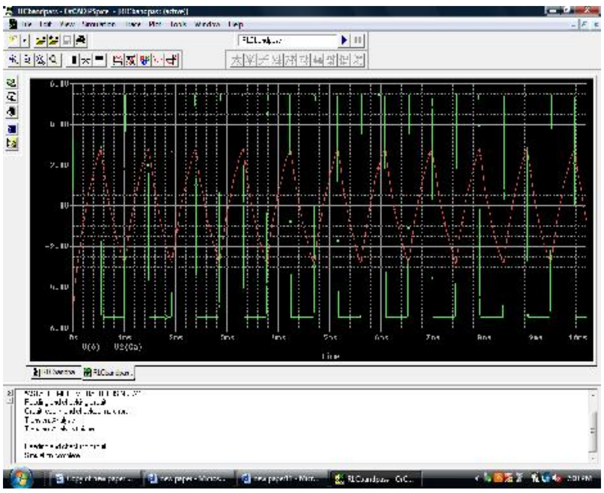

Fig 5 (b) Simulation of Circuits using uA741 IC

The main features of various IC used in designing of astable multivibrator is shown by table 1.

Table 1: Features of various ICs

SN0	Main feature	uA741	Timer 555 IC	LM111 IC
1	Year of introduction	Dave Fullagar-1968	Hans Camenzind 1971	John Ragazzini 1967
2.	Operating power Supply	Plus/minus 15 down to 5	Plus/minus 18 down to 5	Plus/minus 15 down to 5
3.	Power dissipation	500 mV	200 mV for cmos,600 mV for BJT	135 mV
4	Oscillation Prone Capability	High prone to spurious oscillation	Medium prone to spurious oscillation	Less prone to spurious oscillation
5.	Compatibility with RTL, DTL & Cmos Ckt	Less	Medium	High
6.	Temperature stability	Less	Good	Excellent
7.	Applications	Summing amplifier Differentiator/integrator Active filters Function generator	Timing Delay Tone Burst generator Missing pulse generator	Detector for magnetic transducer Digital Transmission isolator

4. APPLICATIONS of ASTABLE MULTIVIBRATOR

The various applications of astable multivibrator are described as below:

4.1 Square Wave Oscillator

An astable multivibrator can be used to form a square wave output by connecting diode across Rb. The capacitor C charges through Ra and D towards 2/3 Vcc and then discharges through Rb and Q, until amplitude equals 1/3 Vcc. The cycle then repeats. To develop a square wave output, Ra must be a combination of a fixed resistor and a potentiometer. Therefore the potentiometer can be adjusted for the exact square wave [8].

4.2 Free-Running Ramp Generator

The astable multivibrator can be used as a free-running ramp generator replacing Ra and Rb by a current mirror. The current mirror starts charging capacitor towards Vcc. Practically the time period of the ramp waveform is equal to the charging time given by T = Vcc*C/3Ic

Where Ic = (Vcc-Vbe)/R constant current in amperes

The free-running frequency of the ramp generator is

f0 = 3Ic/Vcc*C

4.3 FSK Generator

In digital communication binary information is sent by shifting a carrier frequency between two reference frequencies (f1 and f2) (f1 for 0 and f2 for 1 and vice versa).this is known as frequency shift keying. A 555 timer in a stable mode can be used to generate FSK signal. The standard frequency for digital data input is 150 hz. When input is high Q1 is off and 555 timer functions in the astable mode. The frequency of the output waveform is Q1.

4.4 Pulse Position Modulator

The pulse position modulator can be made by applying a modulating signal to pin 5 of a 555 timer. The output pulse position changes with the modulating signal since the threshold voltage and hence the time decay is changed. It may be observed from the output that the frequency is changing, leading to pulse position modulation.

5. SIMULATION RESULTS

The results of PSPICE simulation software for astable multivibrator using different circuits are shown in figures and its applications are shown in fig. 3 (c), 4 (b), 5 (b) and 6 (b) [4,6,7]. It can be seen that simulation results looks good and resemble with theoretical results calculated using different equations. The comparison of simulated and theoretical results is shown in table 2.

Table: 2 Comparison of simulated and theoretical results of different ICs

SNo.	Types of Circuit used in astable multivibrator	Theoritical value of Frequency of Oscillation in KHz	Simulated value of Frequency of Oscillation in KHz
1	uA741 IC	1 KHz	1099Hz
2.	LM 111 IC	1KHz	1040 Hz
3.	NE 555	1KHz	1045 Hz

6. CONCLUSION

Simulation and analysis of astable multivibrator using different circuits and its applications in communication system is presented in the paper. The results provided by simulation of these three circuits resembles with the theoretical results. The circuit with uA 741 shows that transitions take place at slow rate as compared to other circuits NE 555 timer and LM 111 IC because of its low slew rate. These simulations may be uniformly applied for testing the circuit performance and reliability under different changing conditions like temperature, pressure etc before actual circuit or product is ordered and thereby decided to be implemented in the real world.

REFERENCES

[1] Sanjay K. Tupe, Sayyad S. B., and Behre S. H. 2009. Comparative Study of Different Spice Software's Using Astable Multivibrator in Different Spice Software. International Journal of Recent Trends in Engineering, Vol 2, No. 6, November 2009. Available at http://ijrte.academypublisher.com/vol02/no06/ijrte02062629.pdf. Retrieved at November, 22-2012.

[2] Rashid M. H. Microelectronics Circuit Analysis and Design, PWS Publishing Co, 1999.

[3] Gayakwad, R.A, Op-amps and Linear integrated circuits, Prentice-Hall India, 2000.

[4] PSPICE Schematics Evaluation Version 9.1, Cadence Design System, www.cadence.com

[5] L. V. Hmurcik, M. Hettinger, K. S. Gottschalck, and F. C. Fitchen, "SPICE applications to an undergraduate electronic program," *IEEE Trans. Educ.*, vol. 33, pp. 183–189, 1990.

[6] L.K Maheshwari MM S Anand, Laboratory Experiments and PSPICE Simulation in analog Electronics,PHI.2007

[7] M. H. Rashid, "SPICE For Circuits and Electronics Using PSpice," Prentice-Hall Inc., 2ndedition 1994, 364 pages, ISBN 0-13-124652-6.

[8] Admin. 2008. Square wave generator using uA 741. Available from Circuits Today. URL:http://www.circuitstoday.com/square-wave-generator-using-ua-741**.** Retrieved at February, 15-2013.

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