

The Role of Simulation Tools in Blended Education Environment.

Jyoti Bhola*, Mona Bhatnagar** and Namrata Dewan Soni***

* (Department of Mathematics, Hansraj College, University of Delhi, Delhi-07.)

** (Department of Electronics, Hansraj College, University of Delhi, Delhi-07.)

*** (Department of Physics, Hansraj College, University of Delhi, Delhi-07)

ABSTRACT

Practical experiments are a vital part of science curriculum. Theoretical knowledge is important but practical acquaintance helps in acquiring deeper insight into the details of the subject and boosts the overall learning mechanism by acting as a catalyst in the process of conceptual understanding. For Gen Z learners, there is a need of complete overhauling in terms of pedagogy. With the advent of technology, the use of simulation tools has proved to be an important methodological approach for a better understanding of the practical papers taught to science students at undergraduate level. In this paper we demonstrate the use of a mathematical program to complement the concepts acquired in laboratory work through an example. We have used an open source software scilab along with Wolfram Mathematica cloud that enables the students to learn the concept without any financial burden.

Keywords – Laboratory work, undergraduate science, function generator, Mathematica, scilab

Date of Submission: 10-03-2021

Date of Acceptance: 25-03-2021

I. INTRODUCTION

Technology is an indispensable element in the teaching-learning environment today [1]. Teachers in the present time are adept at using ICT tools power point presentations, smart boards, videos, etc. are used in classroom [2, 3]. These tools make the learning of theory subject effective and interesting for students. Online platforms like Google Meet, Zoom, M S Teams, etc. have proven to be instrumental in imparting knowledge remotely [4, 5]. Along with the theory work, science students need to carry out the practical work in laboratory and the latter is a vital part of science undergraduate curriculum [6, 7]. There exist various virtual labs like Amrita lab, iitb lab, etc. that help in learning laboratory work remotely [8, 9]. These cybernetic tools have a couple of limitations. To name a few, availability of all circuits is an issue, manipulation of the circuit parameters as per the requirement is not always possible, etc. Fortunately, Computer Algebra Systems (CAS) have come to our rescue and have proven to be a real boon in the blended learning environment. Their use has not only added another dimension to teaching methods [10, 11] but has also helped the students to virtually visualise the concept they are learning in the theory classes [2]. In this article, an attempt has been made to show that these systems are almost equally effective, when compared to laboratory work carried out in physical mode. The Computer Algebra Systems considered in present study are Wolfram Mathematica and open

source programming application - scilab. The authors present the designing of a basic function generator with the help of a mathematical program written in scilab and Mathematica. The specifications of all the constituents needed to design the function generator are computed by means of a simple program composed in open software application scilab. The program written in Mathematica displays the wave output of the intended function generator circuit. The purpose of this effort is to familiarize the science undergraduate students with the potential of Computer Algebra Systems in designing techniques. This will facilitate them to visualize the output of a practical circuit before realizing it practically. The circuit is then made actually, using the parameters obtained from the software. The obtained output of function generator so designed is in close agreement with the program output. So, the authors establish through an example, the significant role of Computer Algebra Systems in providing practical knowledge to students in today's challenging times.

II. THEORY AND PROCEDURE

The circuit diagram of basic function generator realized in the present work is shown in Figure 1 [12].

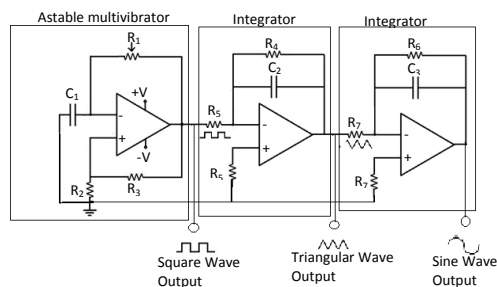


Figure 1. presents the circuit diagram of basic function generator.

It comprises of three-cascaded operational amplifiers used as an astable multivibrator and integrators to produce different (square, triangular and sine) output. The square wave output of free running multivibrator circuit is fed to the input of the integrator circuit to produce triangular output. This output so obtained is integrated again using second integrator circuit to generate sine wave output. In this way, all the three basic functions can be produced with the simple circuit shown in Figure 1. The frequency and amplitude of the output wave functions can be varied with the help of potentiometer R_1 and bias voltage ($\pm V$) respectively. The output frequency of the square function wave is given by [13, 14]

$$f = \frac{1}{2R_1C_1 \ln\left(\frac{1+\beta}{1-\beta}\right)} \quad (1)$$

where $\beta = \frac{R_2}{R_2 + R_3}$; and R_1, R_2, R_3 are the resistance involved in the multivibrator circuit. The output voltage of the first, second and third section of the function generator circuit respectively are given by [13, 14]

$$V_{square} = \begin{cases} +\beta V & 0 \leq t \leq T/2 \\ -\beta V & T/2 \leq t \leq T \end{cases} \quad (2)$$

where $T = 1/f$;

$$V_{triangular} = -\frac{1}{R_5C_2} \int_0^T V_{square} dt \quad (3)$$

$$V_{sine} = -\frac{1}{R_7C_3} \int_0^T V_{triangular} dt \quad (4)$$

For the integrator sections 2 and 3 of the function generator circuit to work properly in low frequency region as well, compensatory resistances R_4 and R_6 are introduced in the respective sections such that

$$T \geq R_4C_2 \text{ and } T \geq R_6C_3 \quad (5)$$

Thus the circuit can be designed for the desired frequency using equations 2, 3 and 4 in equations 5 and 6.

Although, the circuit appears to be simple, but the requirement of several components makes it complex to be designed.

III. SIMULATION

A program is written in open source scilab along with Wolfram Mathematica to obtain the values of the components used to realize the basic function generator. The program code is shown in Figure 2. The output of the program gives the values of all the components $R_1, R_2, R_3, R_4, R_5, R_6, R_7, C_1, C_2$ and C_3 needed to design the circuit in the lab as well as different output function waveforms. The amplitude and frequency of the wave could be varied easily, by changing the value of V and R_1 respectively in the circuit mentioned in Figure 1.

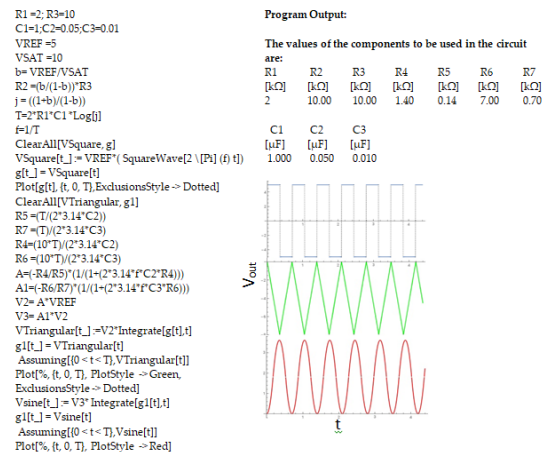


Figure 2. Simulation Code written in Mathematica and the program outputs

IV. EXPERIMENTAL

The circuit given in Figure 1 was realized for different frequencies using an operational amplifier IC LM 324 and the component values were obtained using the code given in Figure 2. For the implementation of the function generator circuit, the actual values of $R_1, R_2, R_3, R_4, R_5, R_6, R_7, C_1, C_2$ and C_3 used were chosen to be nearest to the standard values available. Instead of resistance R_1 , a potentiometer of 100 kΩ was used so that the frequency of the output waveform could be varied instantly. The output voltage $V_{out}(t)$ and the frequency of the output wave of the circuit were measured using Tektronix TDS 1002B 60MHz. Figure 3 shows the wave output of experimentally designed function generator.

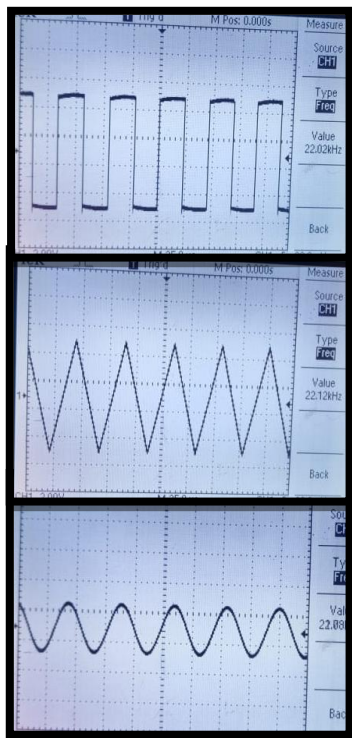


Figure 3: Waveform outputs of experimentally designed basic Function generator circuit.

The experimentally obtained results show closeness to the one obtained using mathematical program. The maximum deviation between the theoretical and experimentally obtained frequency is about 4% and is attributed to the tolerances (10%) of the components.

V. CONCLUSION

This paper demonstrates the use of a mathematical program to realize a basic function generator circuit. The software tools help the students to understand the concept of circuit designing in a better way, before realizing it practically in the laboratory. This program also gives an appropriate display of the output of the generator circuit. The basic function generator circuit is actually realized in the lab using the component values obtained through the program. The experimental results showed imminence with the theoretical achieved results.

REFERENCES

- [1] R. Raja, P. C. Nagasubramani, "Impact of modern technology in education" *Journal of Applied and Advanced Research*, 3, 2018, S33-S35.
- [2] S. Ghavifekr, T. Kunjappan, L. Ramasamy and A. Anthony, "Teaching and Learning with ICT Tools: Issues and Challenges from

- Teachers' Perceptions" *Malaysian Online Journal of Educational Technology*, 4(2), 2016, 38-57.
- [3] Ghavifekr, S. & Rosdy, W.A.W., "Teaching and learning with technology: Effectiveness of ICT integration in schools" *International Journal of Research in Education and Science*, 1(2), 2015, 175-191.
- [4] S. Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis" *J. Edu. Tech. Sys.*, 0(0), 2020, 1-18.
- [5] L. Mishra, T. Gupta and A. Shree, "Online Teaching-Learning in Higher Education during Lockdown period of COVID-19 pandemic", *International journal of education and Research*, 1, 2020, 100012.
- [6] Hofstein A., *The Role of Laboratory in Science Teaching and Learning. Science Education. New Directions in Mathematics and Science Education.* (Sense Publishers, Rotterdam 2017).
- [7] E. Hegarty-Hazel, *The student laboratory and the science curriculum: An overview.* (London: Routledge 1990) 3-26.
- [8] Virtual lab: <https://vlab.amrita.edu/>
- [9] Virtual lab: <http://vlabs.iitb.ac.in/vlab/>
- [10] D. Ibrahim, "Engineering simulation with MATLAB: improving teaching and learning effectiveness", *Proc. Comp. Sci.*, 3, 2011, 853-859.
- [11] B. Kramarski and C. Hirsch, "Using computer algebra systems in mathematical classrooms" *Journal of Computer Assisted Learning*, 19(1), 2003, 35-45
- [12] Krishnagiri Chinnathambi Selvam, Voltage-to-Frequency Converters using Operational Amplifiers, *IETE Journal of Education*, 56(1), 2015, 34-38, DOI: 10.1080/09747338.2015.1026850
- [13] Gayakwad, R.A, *Op-amps and Linear integrated circuits* (Prentice-Hall India, 2000)
- [14] R. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory* (Pearson 11th Edition 2015).