Designing a Media of Active Learning for Teaching the Passive High Pass Filter (PHPF) by developing its Bode Plot by using Excel

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Designing a Media of Active Learning for Teaching the Passive High Pass Filter (PHPF) by developing its Bode Plot by using Excel

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Abstract

In this paper, the writer developed an active learning media that is used in a class that has implemented an active learning strategy in the class, and especially for the developing nation student to help them in addressing their hindrances in mastering the technology due to the lack of budget and facility to run the conventional way of teaching and learning, especially in this era of Covid 19 Pandemic that has forced us to do virtual learning to inhibit the widespread of the deadly virus; this media will be helpful. This media will help the teacher to develop his/her teaching planning and strategy and help the student in understanding the attributes or the properties of the Passive High Pass Filter (PHPF) easily by observing the Excel table of the PHPF variables value and the Bode Plot of the PHPF instead of calculating each of the variable values of the PHPF manually; the student can not observe and see the big picture of the PHPF characteristics promptly and will not enable them to understand it immediately. This media was developed by using two well-known application programs Excel and Intelligent Schematic Input System-ISIS Proteus. The Excel shows the Bode Plot of the PHPF by using the table variables values of the PHPF (the frequency of the input, the Gain of the PHPF in Decibel-dB, and the Phase Angle between the output voltage (Vo) of the circuits and the input voltage (Vin) put into the PHPF input port) and the ISIS Proteus will be used to prove the values shown on the excel table and the Bode Plot shown by excel; ISIS Proteus is a specially purposed simulator to simulate Electrical, Electronics, Computer, Microprocessor, Microcontroller, and control devices working principle and their properties. The developed media of teaching has successfully shown the attributes of PHPF.

Keywords: Active Learning; High Pass Filter; Bode Plot; Excel; Proteus ISIS; Media of Teaching

INTRODUCTION

The filter is one of the fundamental elements of signal processing and is widely used in many electronic devices. Based on the components used in the designing of the filter, the filter can be classified into two types, Active Filter (the use of active components such as OP-Amp, and Transistor beside the filter main components it's self such as Resistor, Capacitor, and Inductor), and Passive Filter (the used of resistor, Capacitor, and Inductor in its design). As mentioned before in the Active Filter, the Operational Amplifier (the Op-Amp) is used to amplify the output signal of a filter to be processed further. Based on the type of the required signal frequency to be passed to the output of the filter, the filter can be divided into two types of filters as follows, the High Pass Filter, and the Low Pass Filter. A combination of the two filters mentioned above (HPF and LPF) result in the third and the fourth types of filter can be built; the Band Pass Filter-BPF, and Band Stop Filter-BSF. To make the output of the filter close enough to the output of an ideal filter, a high-order type of filter can be used. The higher the order of the filter (by cascading the first order of the filter to form the higher order of the filter) the better the output of the filter, but as the consequence, the math equation of the filter will be more complex and of course it will be more expensive. In this paper, we will discuss only the first type of filter, the Passive High Pass Filter (PHPF); First Order High Pass Filter. Some engineers and scientists call the filter a transfer function and are widely mentioned in Control System Engineering. Understanding the characteristics of a filter is a prerequisite for an Engineer to design complex electronic devices. Due to the importance of understanding how the filter works and as an effort to help the student in answering the worksheet on signal filter provided by some organization[1], the author develops an active learning media in teaching this subject. This application will enable the teacher to run the class conveniently and the student can understand the subject easily and can use it to design their own first order PHPF conveniently.

RELATED WORK

Many scholars and researchers have developed a lot of kinds of media of active learning and teaching by using computer programming or not in the form of simulation. Some of the published papers in this field are as follows, in this paper [2] the author reported the design of a decoder to display the result of the digital voltage level on a seven-segment display in the form of characters "H" and "L". The author proposed the use of his design is implemented in active learning classes especially in the electronic digital laboratory. In paper [3] the authors develop an active learning simulator using both MCU8051 IDE and (Small Devices C Compiler-SDCC). In this paper, the author reported that the simulator will display the level voltage of a pin of an 8051 port on a virtual seven-segment display and propose to use it as a media of teaching especially in the classes that have adopted active learning strategies. In this paper [4] the authors reported the development of a simulator program that simulates the process of multiple interrupts runs on an 8051 microcontroller by using MCU8051 IDE and ASEM 51 [4]. In this paper [5] the author developed a media of active learning and teaching in the microcontroller field and programming it in C language (SDCC) by using struct and pointer in retrieving a character stored in IRAM of the microcontroller to be displayed on a virtual LED. In this paper [6] the author developed a teaching media for ALFHIE class, that simulates the interfacing of MCS-51 to a 4 X 4 Keypad and displays the character input from the Keypad onto two different displays (LED and LCD), the program run on ASM-51. In this paper [7] the author develops a simulation for ALFHIE class. This simulation program was developed by using Small Devices C Compiler SDCC) to simulate how to read the Busy Flag of the LCD and proposed it rather than using a delay time that is hard to calculate it and each and every LCD has its own delay time.

Proposed System

In this paper, the author proposed the development of an active learning media of the First Order Passive High Pass Filter. The media is in the form of a simulator and was developed by using two famous application programs Excel and ISIS Proteus. It can be used by the teacher or lecturer to teach students of the Filter characteristic or attributes and the student can use it by themselves and change the values of the filter variables (frequency of the input signal, the Capacitor, and Resistor variables). As mentioned above the Excel will display the Bode plot of the filter based on the value of the filter variables input namely Signal frequency, Resistor, and Capacitor values to the excel table. The teacher can ask the student to observe the Bode Plot of the filter and compare the Bode Plot's result to the theory taught by the teacher or the lecturer. The teaching participants can also compare the result shown on the Bode Plot to the result obtained by the ISIS Proteus. The output of the Excel (table and Bode Plot) and the ISIS Proteus (Simulation of a particular output gain and Phase Angle between the output voltage and the input voltage of a specific value of the Filter Frequency)[8][9][10][11]. After running the simulation student can ponder in their heart and mind the three results obtained from the theory given by the lecturer or the teacher, from the Bode Plot shown by the Excel, and from the result obtained by the ISIS Proteus as well; they should be in accord.

Simulation

In this simulation, the author simulated a PHPF frequency response with Resistor values and Capacitor values 20 KΩ, 1.5nF respectively; the student can change these two variables in their future simulation and analysis as their wish. The cutoff frequencies, Gain in dB, and the Phase angle, 5305 Hz, -3dB (0.707), 45 degrees respectively[12]. Figure 1 below shows the diagram of the PHPF

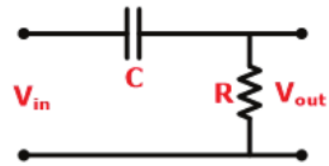

Fig. 1: The Diagram of PHPF[13]

It can be seen from the diagram that the output voltage is measured across the resistor. We can apply the voltage divider equation to find the output voltage[14]. The equation for the gain of a PHPF is as follows[12][15],

$$G = \frac{R}{(R^2 + \left(\frac{1}{\omega C}\right)^2)^{1/2}}$$

The cutoff frequency for the PHPF is

$$Fc = 1/(2\pi RC) \; [12][15]$$

And the gain of the PHPF at the cutoff frequency is 0.707 (1/((2)^1/2) or -3 dB[15][12]

The phase shift equation for PHPFF [12] is

$$Phase\ Shift\ (\theta) = arctan(1/\omega CR)$$

By using the mentioned above equations Gain in dB (20 log Vo/Vin) [15], Fc, and Phase Shift (θ) and putting the values of the PHPF components (R and C) and the variable frequency of the input signal into the Excel as shown in figure 1 below, we can observe the result of the simulation; the result of the simulation has been captured and shown in Fig. 2, Fig. 3, and Fig. 4. Fig. 2 shows the table of PHPF variables values, the input signal frequency, the gain in dB, and the Phase Angle in degree. Fig. 3 shows the Bode Plot of the filter as the result of the simulation. Fig. 4 (Fig. 4.1-Fig. 4.4) shows the result of the ISIS Proteus Simulation.

f (Hz)	dB	PhaseAngle in Degree	H(V0/Vin)
10	-54,49399297	89,89200013	0,001885
15	-50,97218708	89,83800043	0,002827
20	-48,47343935	89,78400102	0,00377
25	-46,53527381	89,730002	0,004712
30	-44,95169132	89,67600345	0,005655
35	-43,61280567	89,62200548	0,006597
40	-42,4530246	89,56800819	0,00754
45	-41,43003972	89,51401166	0,008482
50	-40,5149632	89,46001599	0,009424
60	-38,931508	89,35202763	0,011309
70	-37,59277278	89,24404387	0,013194
80	-36,43316525	89,13606548	0,015078
90	-35,41037706	89,02809323	0,016962
100	-34,49552034	88,92012788	0,018846
110	-33,66799055	88,8121702	0,02073
120	-32,91257407	88,70422096	0,022614
130	-32,2177175	88,59628092	0,024497
140	-31,5744402	88,48835084	0,02638
150	-30,97562289	88,38043149	0,028263
160	-30,41552636	88,27252363	0,030146
170	-29,8894563	88,16462804	0,032028
180	-29,39352412	88,05674546	0,03391
190	-28,92447244	87,94887666	0,035791
200	-28,47954554	87,84102241	0,037672
300	-24,96541795	86,76344696	0,056458
500	-20,55298396	84,61590408	0,093832
1000	-14,64560681	79,32525059	0,185234
2000	-9,05050375	69,34400262	0,352756
3000	-6,156552019	60,51241904	0,492235
4000	-4,407593076	52,98435543	0,602033
4100	-4,272080978	52,3020101	0,611499
4200	-4,142224867	51,6319975	0,62071
4300	-4,017729581	50,97416461	0,629671
4400	-3,898318963	50,32835107	0,638387
4500	-3,783734317	49,69439011	0,646864
4600	-3,673733023	49,0721094	0,655109
4700	-3,568087303	48,4613319	0,663125
4800	-3,466583088	47,86187658	0,67092
4900	-3,369019014	47,27355915	0,678499
4950	-3,321654848	46,98351882	0,682209
5000	-3,275205496	46,69619269	0,685867
5100	-3,184963894	46,1295883	0,69303
5200	-3,09812575	45,57355561	0,699993
5300	**-3,01453209**	**45,02790334**	**0,706762**
5300	-3,010434846	45,00088977	0,707096
5400	-2,934032786	44,49243973	0,713343
5500	-2,856485973	43,96697302	0,71974
5600	-2,781757505	43,45131179	0,725959
5700	-2,709720464	42,94526534	0,732005
5800	-2,640254699	42,44864405	0,737883
5900	-2,573246406	41,96125958	0,743597
6000	-2,508587734	41,48292521	0,749153
7000	-1,971104267	37,15778527	0,796975
8000	-1,582907316	33,55017259	0,833402
9000	-1,29517924	30,51776584	0,861472
9500	-1,178853195	29,18066797	0,873087
10000	-1,077008969	27,94668725	0,883384
100000	-0,012205951	3,036788653	0,998596
1000000	-0,000122229	0,303960699	0,999986
10000000	-1,22231E-06	0,030396352	1
100000000	-1,22231E-08	0,003039636	1
1000000000	-1,2223E-10	0,000303964	1
10000000000	-1,22277E-12	3,03964E-05	1
1E+11	-1,15719E-14	3,03964E-06	1
1E+12	0	3,03964E-07	1
1E+13	0	3,03964E-08	1
1E+14	0	3,03964E-09	1
1E+15	0	3,03964E-10	1
1E+16	0	3,03964E-11	1
1E+17	0	3,03964E-12	1
1E+18	0	3,03964E-13	1
1E+19	0	3,03964E-14	1
1E+20	0	3,03964E-15	1
1E+21	0	3,03964E-16	1
1E+22	0	3,03964E-17	1
1E+23	0	3,03964E-18	1
1E+25	0	3,03964E-20	1
1E+25	0	3,03964E-20	1

Fig. 2: The Table of PHPF Variables

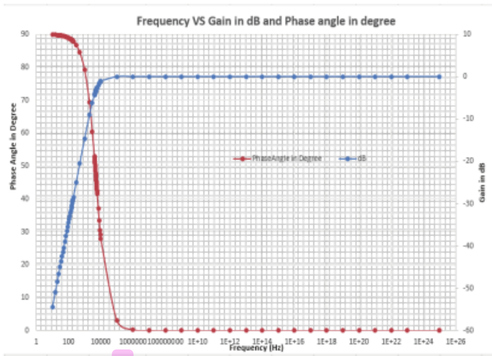

Fig. 3: The Bode Plot of PHPF[11]

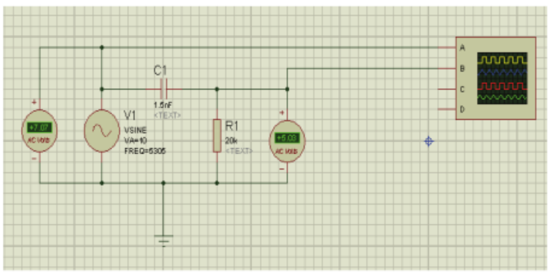

Fig. 4.1: The result of the ISIS Proteus Simulation; the PHPF circuits.

From Fig. 4.1 it can be seen clearly that for an input of a sinusoidal signal with an amplitude of 10 V (AC), a 7.07 V (AC) voltage will be read by the AC voltmeter; V_{AC} = $V_P/(2\text{^}0.5)$ and the output voltage at the Cutoff Frequency will be read as a 5.03 V; 0.707 x Vin=0.707 X 7.07 V.

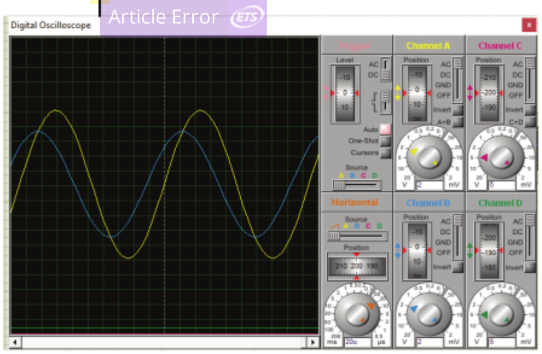

Fig. 4.2: The result of the ISIS Proteus Simulation; The Phase Angle at the Cutoff Frequency

Fig. 4.2 shows the Phase Angle of 45^0; the input signal lagging the output signal (the output signal leading the input signal) by 45^0 at the cutoff frequency; at 5305 Hz (5.305 KHz)[16][17].

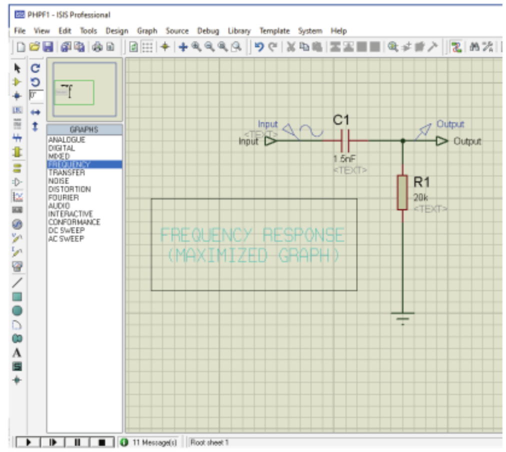

Fig. 4.3: The Citcuit simulation of PHPF to obtain the Bode Plot of Fig. 4[18]

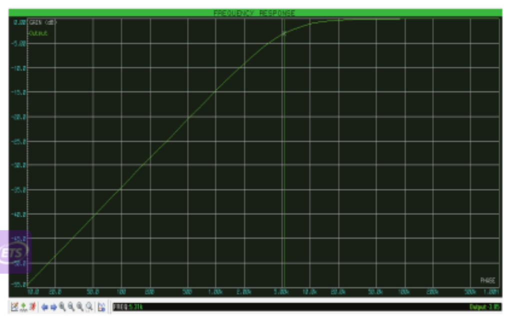

Fig. 4.4: The result of the ISIS Proteus Simulation; Bode Plot obtained from the ISIS Proteus simulation[18]

From Fig. 4.4 we can see that the cutoff frequency of the PHPF is 5.3 KHz; the gain is -3 dB.

The Flow Chart of the program

The flow chart below shows the taken steps to input the variables of the PHPF into the Excel table and run it and compare the obtained result to the obtained result by ISIS Proteus; the Gain (in dB), Phase Angle in degree, and the cutoff frequency in Hz [19] [20][21].

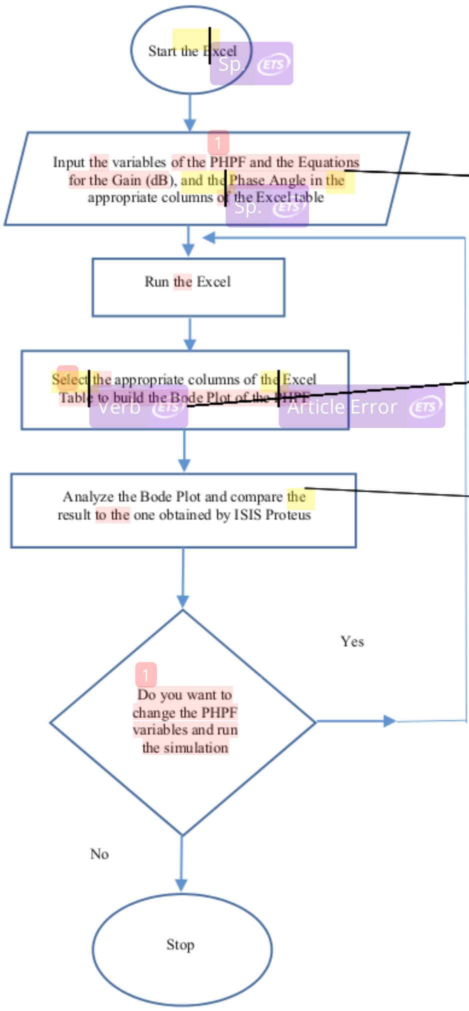

Fig. 5: The flow chart of the Bode Plot simulation development

CONCLUSION

From the result of the simulation of the excel, and the comparison of the excel Bode Plot simulation to the result of the ISIS Proteus Simulation some things can be observed and some conclusions can be made.

1. Excel can be used to simulate the attributes or characteristics of the Passive High Pass Filter-PHPF
2. The result of the excel (Gain in dB, The Phase Angle) in accordance with the standard theory of Passive High Pass Filter
3. The Result of the ISIS Proteus Simulation of the Gain in dB, the Phase Angle are in accordance with both the result of the Excel and the standard theory of Passive High Pass Filter
4. The Excel can show the trend of the gain (in dB) and the Phase angle (in Degree) or in Radian
5. The teaching participants (Teacher/Lecturer and the Students) can use the simulator to study and pondering the attributes of the Filter by his/herself.

Closing

This paper hopefully can contribute to Science especially in the field of filter designing and control. This simulation can be used to teach the student in advance of this topic (Passive High Pass Filter) conveniently by the lecturer/teacher in their classes, or by the Instructor in a vocational training center before doing the real laboratory work or experimentation; to cut the budget to buy the devices for underdeveloped countries. It can also be used widely in the classes that have adopted Active Learning Strategy, especially in countries that have implemented the teaching strategy of Active Learning For Higher Education (ALFHE), and the Low and middle-income countries, especially those who do not have the capability or budget to buy or to provide the devices to be used by their students. Hopefully, this paper will enable the teaching participants (the teacher/Lecturer or instructor) to run the teaching and learning process comfortably, conveniently, and happily in the Covid-19 Pandemic era.

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P/V You have used the passive voice in this sentence. Depending upon what you wish to emphasize in the sentence, you may want to revise it using the active voice.

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P/V You have used the passive voice in this sentence. Depending upon what you wish to emphasize in the sentence, you may want to revise it using the active voice.

Prep. You may be using the wrong preposition.

Article Error You may need to use an article before this word. Consider using the article **the**.

Missing "," You may need to place a comma after this word.

Proofread This part of the sentence contains a grammatical error or misspelled word that makes your meaning unclear.

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Article Error You may need to remove this article.

PAGE 3

PAGE 4

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Article Error You may need to remove this article.

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PAGE 5

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

Pronoun This pronoun may be incorrect.

Dup. You have typed two **articles** in a row. You may need to delete one of them.

Missing "," You may need to place a comma after this word.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

Verb This verb may be incorrect. Proofread the sentence to make sure you have used the correct form of the verb.

Article Error You may need to remove this article.

Dup. You have typed two **articles** in a row. You may need to delete one of them.

Article Error You may need to remove this article.

Article Error You may need to remove this article.

Article Error You may need to use an article before this word. Consider using the article **the**.

Wrong Article You may have used the wrong article or pronoun. Proofread the sentence to make sure that the article or pronoun agrees with the word it describes.

Missing "," You may need to place a comma after this word.

Sp. This word is misspelled. Use a dictionary or spellchecker when you proofread your work.

Frag. This sentence may be a fragment or may have incorrect punctuation. Proofread the sentence to be sure that it has correct punctuation and that it has an independent clause with a complete subject and predicate.

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Article Error You may need to use an article before this word.

S/V This subject and verb may not agree. Proofread the sentence to make sure the subject agrees with the verb.

Article Error You may need to use an article before this word.

Article Error You may need to remove this article.

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