

Active Filters Design Teaching Using FilterPro™ Software

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Abstract – The paper discusses the using of the software application FilterPro™ of Texas Instruments in teaching active filters in Electronic Circuit Design course. The use of FilterPro™ as a tool of e-learning gives the students the opportunity to verify the simulation results with the results obtained from the physical lab experiments with Analog System Lab Kit PRO. The module that has been developed will be included in the DIPSEIL project-based learning system used at Paisii Hilendarski University of Plovdiv.

Keywords – e-learning, FilterPro™, Lab Kit PRO, DIPSEIL

I. INTRODUCTION

E-learning, the use of information and communication technologies and electronic methods of education facilitates the access of Bulgarian students to the European higher education institutions. It is a process of delivering interactive information and an opportunity to acquire knowledge at a time, in a place and in a way that are convenient for the students. It is mostly oriented towards autonomous construction of knowledge by the students.

Interactive methods of teaching have been well-known in education and are now widely used as an up-to-date model for the establishment of educational dialogue.

The Strategy for Efficient Application of Information and Communication Technologies in Education and Science in the Republic of Bulgaria 2014-2020 (DRAFT) states that “the greater openness and access to knowledge and skills due to the use of technology will give the opportunity to the higher education institutions in Bulgaria to adapt their teaching methods and educational materials to the needs of the students who will be working in the global labour market” [1].

Teaching in the technical higher education institutions places special emphasis on practical classes. The curricula of the various courses are so structured that there is a close connection between the fundamental theoretical knowledge and practical skills and the curricula meet the requirements of the qualification characteristics of the students taught in the respective educational and qualification programmes. The teaching of every discipline combines classes and self-study. Classes include lectures, interactive computer training and laboratory exercises. Self-study regulates the autonomous study activities of the students that include

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designing and developing individual and group projects and exam preparation.

The use of interactive teaching strategies when teaching lecture courses provokes students to think critically and be creative, to hold small group and whole class discussions, and to clearly explain the concepts that have been studied. Interactive teaching makes the material taught more achievable and easily understandable so that the students who graduate develop the competencies included in the curricula so that they are more recognizable on the labour market [2].

Blended learning that includes interactive lectures has been developed and is used in the Electronic Circuit Design course at the Technical College in Smolyan. The course is attended by students who have been given Microsoft PowerPoint slides for each of the basic traditional (passive) lectures as well as reference literature. This frees the students from the necessity to take extensive notes during the lecture course. When doing laboratory exercises Analog System Lab Kit PRO is used for physical exploration of filters and the software application FilterPro™ is used for simulation experiments.

The topic of active filters and their design and application in electronic circuits and devices is a fundamental one. The quality of teaching in this course which is attended by students majoring in different professional fields is crucial for the acquiring knowledge and skills in other majors.

II. BRIEF THEORY AND MOTIVATION - FILTERPRO™

One of the fundamental aspects of teaching students in this subject is the opportunity to experiment with different variants when designing filters and rapidly obtaining the final results. On the other hand, this allows a new approach and marks the advantages of using the simulation products such as electronic methods of education. The accent of this paper is the use of the software application FilterPro™ in filter design which is intended to develop new methods of teaching and motivate the students to acquire knowledge.

What follows is a brief theory and motivation of the effective use of the software application FilterPro™ in designing analog filters during laboratory exercises within the Electronic Circuit Design course.

Electronic filters are circuits passing signals of certain frequency bands with or without amplification or creating frequency dependence of the phase difference between the output and input voltage. They are implemented for frequencies up to 100 kHz. Electronic filters that provide certain frequency dependence of the output amplitude are called amplitude filters while those that are used to create

certain frequency dependence of the phase difference between the output and the input voltage are called all-pass filters. The presence of phase difference also means that there is a delay of output voltage in relation to input voltage. When this feature of the filters is used, they are called delay lines.

The Texas Instruments FilterPro™ program makes it easy to design low-pass, high-pass, bandpass, bandreject, and all-pass active filters.

An ideal low-pass filter would completely eliminate signals above the cutoff frequency, and perfectly pass signals below the cutoff (in the passband). In real filters, various tradeoffs are made attempting to approximate the ideal. Some filter responses are optimized for gain flatness in the passband; some trade off gain variation (ripple) in the passband for steeper roll-off; still others trade off both flatness and rate of roll-off in favor of pulse-response fidelity. FilterPro™ supports several commonly-used filter responses: Butterworth, Chebyshev, Bessel, Gaussian, and Linear-Phase.

III. PREPARING THE STUDENTS FOR LABORATORY WORK USING ELECTRONIC TEACHING METHODS

The second conceptual aspect is the preliminary preparation of the students through the completion of individual assignments to make a better motivated transition to the actual physical experimentation with laboratory models within various topics.

After acquiring theoretical knowledge, the students are prepared for work in laboratory environments. In order to achieve this, they first simulate the operation of the four filter types (Low pass, High Pass, Band Pass, Band Stop) and expand their knowledge of their frequency response (phase and amplitude). The students are familiar with the concept of simulation and can simulate certain circuits. The obtained simulation results are verified when developing physical experiments with the filters that are being examined.

The preliminary preparation of the students is realized through designing of active filters while working on assignments given to them by the laboratory exercises instructor.

The effectiveness of this teaching method depends to a great extent on how well the assignments have been planned. Research in this area shows that when defining a task the following factors have to be considered:

- to assign tasks which the students regard as worthwhile;
- to allow for various methods for finding the solution of a problem;
- to take into account the students' experience when determining the complexity of the assignments;
- to bear in mind what knowledge the students will acquire with the completion of the assignment;
- to bear in mind how the students will utilize that knowledge.

The software application gives the students certain variety and results when designing filters depending on their specific goals. These specific parameters provide flexibility in the completion of the assignment, giving them the following opportunities [3]:

1. Filter type choice according to the individual assignment (Fig. 1).

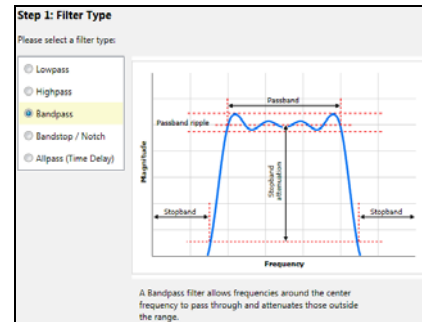


Fig. 1. Filter type choosing.

2. Specifying the parameters of the chosen filter type (Fig. 2). Each student, depending on the individual assignment, determines the specific settings of the filters that are being designed.

Fig. 2. Filter specifications.

3. Generating frequency response (Fig. 3). A graphics analysis of the transfer characteristics and comparison between the approximation methods for each specification is conducted at this stage of the design.

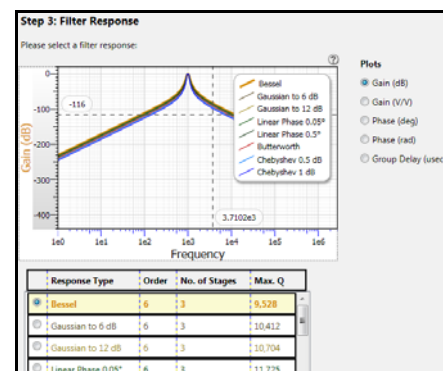


Fig. 3. Filter Response.

4. Choice of circuit topology (Fig. 4). The possible topologies are Multiple – Feedback (Single ended), Sallen – Key, Multiple – Feedback (Fully differential). The students have to compare the efficiency of the three topology types that can be generated by the application.

5. Circuit implementation of the designed filter. After generating the circuit implementation of the designed filter, the students can conduct parameter analysis through changing the tolerances of the resistors and capacitors (Fig. 5) in order to understand better the influence of element parameters on the transfer characteristic of the filters.

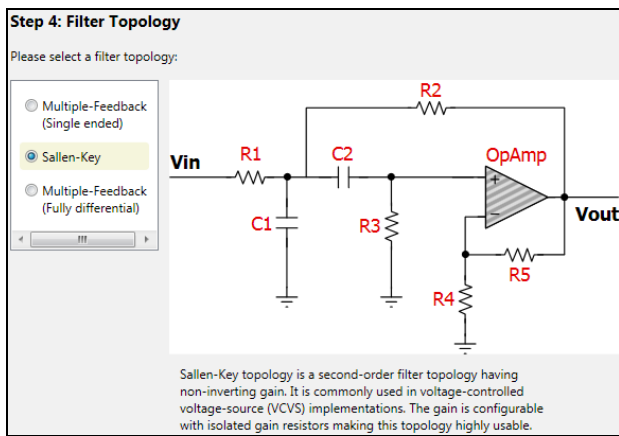


Fig. 4. Circuit topology choosing.

6. FilterPro™ design report. The final stage of the design is printing the FilterPro™ Design Report - Schematic, Frequency and Phase Responses, Bill of Materials and obtaining the data from the conducted experiments.

After designing the filter using FilterPro™ the students will:

- be able to compare the approximations through the Bessel, Butterworth, Gaussian, Chebyshev, and Linear Phase methods;
- be able to determine the basic parameters of the filters on the basis of their amplitude frequency response and phase frequency response;
- be able to understand that the smoothness of the pass band and the steepness of the filter depend on the order of the transfer function.

The Analog System Lab Kit PRO (ASLK PRO) is designed for easy integration into the classroom for undergraduate or postgraduate curriculum and provides students with the platform bed they need to test almost any analog system using general-purpose ICs such as OP-Amps and analog multipliers [5]. It allows experiments that bring out several important issues, such as measurement of gain-bandwidth product, slew-rate, as well as saturation limits of the operational amplifiers. Also integrators and differentiators can be studied, which are essential for

implementing filters. The results obtained from the experiment that has been developed verify the simulation research which has been conducted by the students using FilterPro™ during their self-study. This confirms the efficiency achieved when using the suggested method of teaching active filters using the FilterPro™ application.

IV. CONCLUSION

Implementing new information technologies in education leads to the emergence of new methods of teaching based on electronic methods of processing and presentation of information.

The interactive programs are the basis of the intensive development of electronic means of teaching in the system of higher education with the goal of a more efficient and personalized instruction.

The implementation of FilterPro™ software program of Texas Instruments for designing analog filters when teaching active filters within the Electronic Circuit Design course in the Technical College in Smolyan led to the improvement of the examination results of the students with 25%.

This lead to the development of a module of teaching active filters which will be included in the DIPSEIL project-based training system of Paisii Hilendarski University of Plovdiv [4]. The system uses the project-based method in the distance education within the higher education in the field of engineering.

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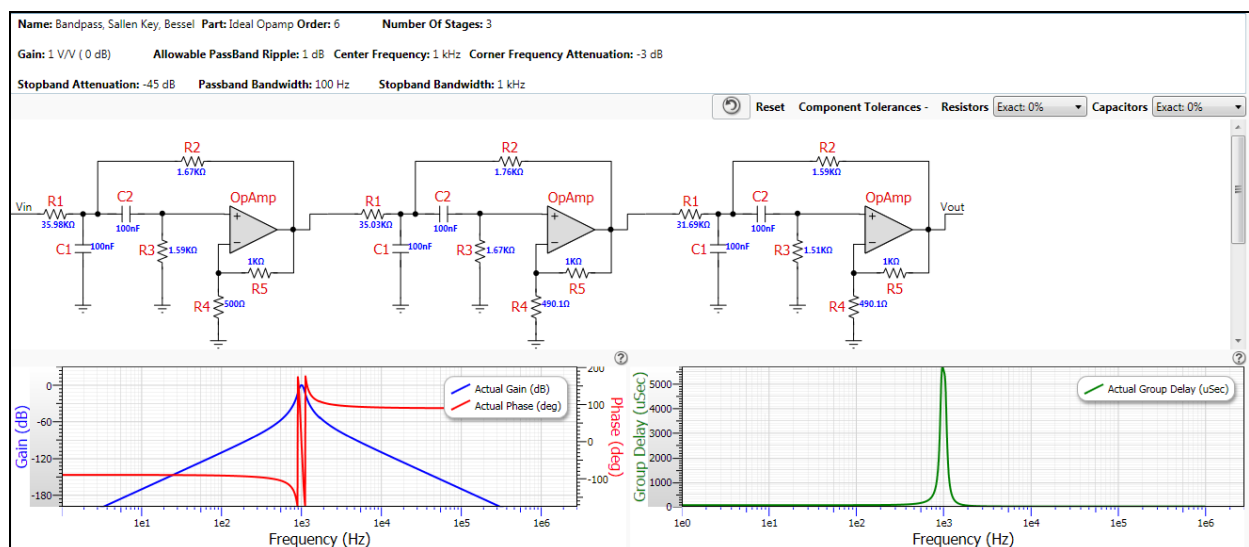


Fig. 5. Circuit implementation of the designed filter and frequency response.