

An e-tool to assist Basic Electronics learning

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Abstract

This paper describes the work that the authors have been developing to assist under-graduate electrical engineering students in their study of basic electronics. This work is primarily aimed at ordinary students but the authors intend to extend it for special students -- those that work or live far away -- who have limitations in attending normal lectures. The work consists firstly in a text to be explored on the Internet and will include solved and unsolved problems, circuit simulations, animated gifs to illustrate theorems or circuit transformations and, eventually, short video streams where the authors explain what they think is more difficult to be done otherwise. Simultaneously, a paper text is being prepared to be also given to the students. As it is intended to complement the electronic version, special features have to be considered.

In this phase the work has concentrated in the first set of items listed above (text, problems and simulations) and a group of students is testing its effectiveness. Moreover, the work started focusing only in some chapters but will be extended to cover all the classical topics covered normally by basic electronics textbooks.

1. Introduction

Both the authors have a long experience in teaching Electronics to under-graduate Electrical and Computers Engineering students. In their courses, the emphasis is put on the characteristics and behaviour of the electronic components and devices and on the analysis and design of electronic circuits, as normally covered in classical textbooks, of which [1] is a good example. Three main analysis techniques are usually stressed: "pencil and paper" analysis, computer simulation and laboratory testing. The ability to perform these procedures is essential to allow mastering the electronic design techniques: if the second corresponds to a major improvement that was made possible by the generalised use of PC's, the third is what brings confidence both to circuit analysis and to simulation, but "pencil and paper" is what gives the student insight and the flexibility needed for synthesis.

Learning the laboratory techniques requires the presence of the students in the school – but this can be done in concentrated periods. All the rest can be learned in very different ways but a good teacher can be an important facilitator and, therefore, it is important to ensure an easy communication between the student and the teacher. Traditionally, this is done through lectures, tutorial classes and personal contact in the teacher's office. Nowadays,

however, many students tend to refuse conventional lectures. Students' ways of life changed as changed their cultural paradigms, much faster than most of the professors' ways of teaching. Still today many persist in exhaustive expositions of the subjects, as if they were talking books. This practice is mostly useless, once the difficulty levels of the contents require the personal effort of the student to understand and master it and only afterwards are they able to ask sensible questions and then indeed the role of the teacher becomes really important.

Therefore, a more fruitful procedure would be reducing the lectures to the minimum necessary to give a first orientation for the students to start studying and gain time for subsequent contacts.

Other times, the students simply cannot attend the lectures because they have a professional occupation, or live far away, which strongly restrains their time for attending classes. In the 1990s, the incorporation of multimedia techniques on personal computers has opened new ways of improving and aiding the teaching process, [2]. These innovative tools were first used in distance learning, for a minority of the students, but the increasingly available and powerful information and communication technologies (ICT) have allowed not only enhancing distance education but also changing and hopefully improving the conventional one, where they can be used synchronous or asynchronously, [3]. Big universities have also used the method to overcome the difficulties created by the huge number of students, [4]. All this has led to all sorts of experiments, namely calling for the complete substitution of traditional lectures by computer-aided learning, [5].

As it was said above, nowadays students very frequently have rather establishing their own learning pace and path. Self-study, to be efficient, requires flexible asynchronous learning tools. Although the books are easy to use asynchronously, they are mostly written to be used sequentially. With the new computer based systems, however, the use of hypertext provides powerful means to let a text be used in a very personal way: the reader can follow the suggested links or disregard them upon his level of knowledge and degree of learning progression.

This type of "interactive text" can be supplied either in a CD ROM or via Internet. The latter, outside a campus environment, can be hampered by limited communication bandwidth. However, it is easy to change and up-date, susceptible to integrate new sets of problems or answers to generalised questions and difficulties; it allows the teacher to offer his point of view about the contents to be studied as

well as about specific methods of analysis. And the experience of teaching can considerably help anticipating the students' needs thereby facilitating the achievement of a really effective document.

2. The work

As it was pointed out above, the work started by focusing in only some chapters. The experience reported here concerns the multistage amplifiers. This is supposed to be introduced after having studied the basic configurations of bipolar and field effect transistors, when the students begin learning to handle the electronic circuits, choosing and applying the basic configurations in order to find the most adequate solutions for a successful amplifier design.

However, even within this limited scope, frequency response aspects as well as feedback amplifiers fundamental notions were included, since many circuit solutions can only be properly understood taking into account these two aspects. In the proposed text a lot of references to basic electronics and circuit theory have been included.

The authors have also incorporated some innovative circuit analysis techniques that they claim are useful to get fast and insightful results. The methods reported in [6] are just an example.

Both the Internet and paper texts were originally written in Portuguese, but they are now being translated into English.

3. The web document

The document consists in a main text with links to complementary ones. These are of two types: one type contains detailed theorem proofs or explains methods of analysis or concepts; the other contains problems' solutions and analysis of special cases. The complementary documents can also have links to other pages, what can raise troubles in navigating them and the reader may get lost. To minimize this possibility all the documents have returning links to the former one allowing for an organised way back to the departure point. Also, different backgrounds are used to give the reader an immediate indication if he is in the main text or in one of the complementary ones (figure 1).

2.2. Funcionamento para pequenos sinais	Transistor como fonte controlada	Resolução do Exercício 1
Aplicando uma tensão diferencial v_D	Como sabemos, um transistor funciona como uma fonte controlada. O modelo de pequenos sinais, de justamente essa função da seguinte maneira: entre a base e o emissor, a corrente de coletor é igual a βv_{be} . Todavia, a corrente de	Se considerarmos os transistores, as suas resistências R_{BE} e R_{CE} sendo o quociente $R_{CE} = \beta R_{BE}$. Esta é a série das junções de emissor e coletor. Assim, a corrente de
Um ponto de vista alternativo para o funcionamento para pequenos sinais		
A resistência de entrada $R_{in} = 2 r_{\pi}$		

Fig. 1. The three different backgrounds

Some explanation documents, being large enough, open in a full window, whereas the shorter ones open in small windows. Some words or expressions deserving a short explanation show a text box when the mouse is placed over them (figure 2). In some cases, the reader can directly access a deeper exposition of the matter.

Fig. 2. Text boxes with short explanations

The main text includes several exercises to be solved by the students. They can access just the solution or the whole development so that they can confirm their own results (figure 3).

Fig. 3. Example of an exercise to be solved

The way back from the page can always be easily reached by means of a floating arrow on the lower right (figure 4).

Fig. 4. Coming back to the starting screen

The starting screen was designed to provide an easy way to access any part of the document. Here, the reader can find instructions to explore the web text as well as to go the two different tables of contents (figure 5).

Fig. 5. The starting screen

The main one is designed as a pop down menu, allowing the student to reach directly any indexed point of the main text (figure 6).

ÍNDICE	
1. Introdução	
2. O par diferencial bipolar	
3. Circuitos de polarização dos pares diferenciais	
4. Melhoria da largura de banda	4.1. Largura de banda da montagem de EC * Exercício 5
5. Maximização do ganho do par diferencial	4.2. Par "cascode" EC-BC
6. Andares de resistência de entrada e ganho elevados	4.3. Par "cascode" complementar EC-BC
7. Andares de saída	4.4. Par "cascode" complementar CC-BC * Exercício 6
8. Obtenção de resistência de entrada elevada	4.5. Par diferencial "cascode"
9. O par diferencial com JFETs	
10. Pares diferenciais com MOSFETs	

Fig. 6. The main index

As referred above, there are many complementary documents helping the student to understand the topics analysed in the main text. These documents can be accessed through the links in the main text, but it would be fastidious to find the appropriate link whenever the reader would need it. So, the starting screen provides the access to a second table of contents concerning the annexes, from where the reader can reach the most relevant complementary documents (figure 7).

ANEXOS	
Teoremas	
Métodos	Método das transformações de circuito Técnica do dipolo equivalente
Analises	Método das constantes de tempo Método de análise dum amplificador realimentado
Conceitos	

Fig. 7. The index of annexes

A feature that is being included is the ability to simulate the circuits presented in the main text or as proposed exercises. This really makes a definite difference for a common book and there seems to be very appellative for the students.

4. The paper text

Another decision that was made based on the authors' experience, concerns the development of printed text to be included as part of the whole project. In fact, the experience has shown that most of the students would start by printing the computer version and use it in parallel. This printout was really a very poor text, missing some "normal" explanations and obviously being unable to provide hyperlinks. Therefore the decision was made to provide an especially developed paper version the design of which deserved considerable attention. The result is a text that in some occasions is different from the what the students may be seeing on-screen, either by rephrasing the sentences or paragraphs to overcome the lack of simulations, animations or a hyperlink, other times these are mimicked by a pointer inserted on the left margin (figure 8). The main text and the

two types of annexes referred in section 2 are organised as 3 volumes of the same book, keeping different backgrounds to be easily associated to the screen version.

AMPLIFICADORES DIFERENCIAIS E MULTIANDAR	
1. Introdução	
Realimentação negativa	O uso de amplificadores operacionais (AmpOps) com <u>realimentação negativa</u> permite realizar montagens amplificadoras muito versáteis e, particularmente, com ganho muito estabilizado. Realmente, hoje em dia, os amplificadores que se usam são praticamente sempre com realimentação.
Um AmpOp tem realimentação negativa quando há uma ligação entre a saída e a entrada inversora	Por exemplo, a montagem inversora da fig. 1 tem um ganho v_o / v_i muito aproximadamente igual a $-R_2 / R_1$, requerendo-se, simplesmente, que o ganho do AmpOp seja muito grande, ainda que possa variar significativamente (i.e. $A \gg R_2 / R_1$), que a resistência de entrada seja
Mais? Vol. II -pág. 1.	

Fig. 8. Navigation in the paper text

5. Validation of the work

The authors have been using this work in their regular teaching of the electronics courses they are responsible for. Although still under development, both in extension and depth, whenever a new and sufficiently stable version is reached, it is offered to the students. Up to now, their response is quite encouraging.

However, in order to systematize and record the students' feedback, a test group with a dozen selected students was organized and duly briefed to provide a fast interaction and answers to a set of specific questions.

As a first task they were asked to assess the quality of the navigation procedure, general web text appearance, design and background colours, as well as to identify any mistakes and miss-spellings. In a second phase, they were asked to evaluate the number and opportunity of the complementary documents, interest of text boxes with short explanations, and number and quality of the proposed exercises.

As a consequence of the first set of responses, some adjustments were made in the design and set up of the web document.

The links to complementary documents have been considered valuable and their number, depth and clarity of contents were considered sufficient.

The text boxes with short explanations appearing when the mouse overlays a coloured word or group of words, were considered one of the most successful features.

It should be stressed that there was a valuable contribution for finding mistakes and miss-spellings, which was also an indication of carefulness and attention the students dedicated to the task.

Finally, the students' opinions have confirmed the need for an adequate paper text and the convenience of using a CD-ROM instead of the Internet, since most students do not have wide band connections at home.

6. Conclusions and future work

The work that has been presented is still in a preliminary phase but already seems to be well accepted by the students. Some interesting results can already be retained for future development.

At present, the text is almost totally translated into English. The connection to the simulator is being optimised and

preliminary trials with animated gifs have proven their usefulness. Finally, the incorporation of video streams is being prepared.

The students test group will finalise their work soon but a new group will be set up among the next year students.

The authors expect to have a fully developed version, of at least a couple of chapters, by the end of 2003.

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