

# USE OF COMPUTERS FOR TEACHING FUNDAMENTALS OF DIGITAL SIGNAL PROCESSING

Gordana Jovanovic-Dolecek, Department of Electronics, INAOE  
 Ap.postal 51 y 216, Puebla, Pue. Z.P. 72000, MEXICO  
 Email: gordana@inaoep.mx

## ABSTRACT

*This paper presents the educational software package intended for teaching fundamentals of digital signal processing. The package was implemented in MATLAB.*

## INTRODUCTION

The development and usage of software tools in education allows a better understanding of the subject matter and increases teaching efficiency, (W.Ebel and N.Younan, 1995). In that way passive learners become active participants in a teaching process. The study of G. S. Ng, (G.S.Ng, 1997), shows that “whenever computer graphics can be used as a teaching aid, it is worthwhile to make an effort to introduce it in lectures as well as tutorials”.

In pursuance of this goal we developed the educational software package to support the theory provided in a basic graduate course on digital signal processing, (DSP).

The package was implemented in MATLAB, but for its application no previous knowledge of MATLAB or any other programming is necessary. We choose MATLAB because MATLAB is the tool of choice for most educational and research purposes, especially in the field of DSP, (G.Orsak, and M. Etter, 1995). It provides powerful computation and advanced visualization tools and it is available on a number of hardware platforms. Its Signal Processing Toolbox provides a large number of files for the implementation of digital signal processing operations. We used the MATLAB tool *makeshow*, which allows you to create your own interactive slideshows without building your own graphic interface.

In the next chapter we briefly describe the package and give some examples of demonstrations.

## DESCRIPTION OF THE PACKAGE

There are two windows in each slide. We used the upper windows for some explications, like in Fig.1.a, or for some graphics, like in Fig.1.b. In the case that the graphic needs more space we used a special window, like in Fig.1.c.

The bottom window was used for the explanations of the upper graphics, like in Fig.1.b, or for the instructions to the user, like in Fig.1.a.

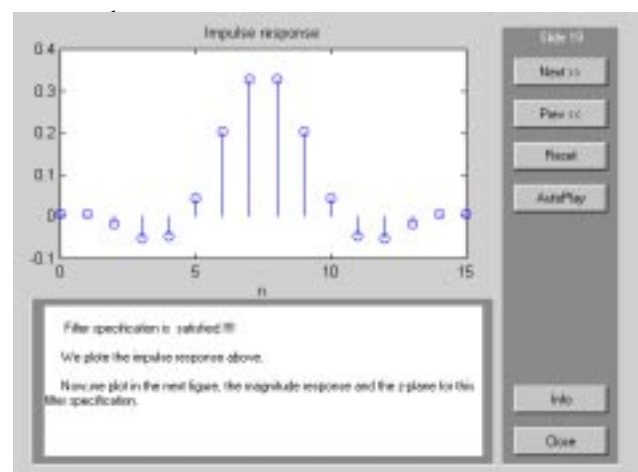
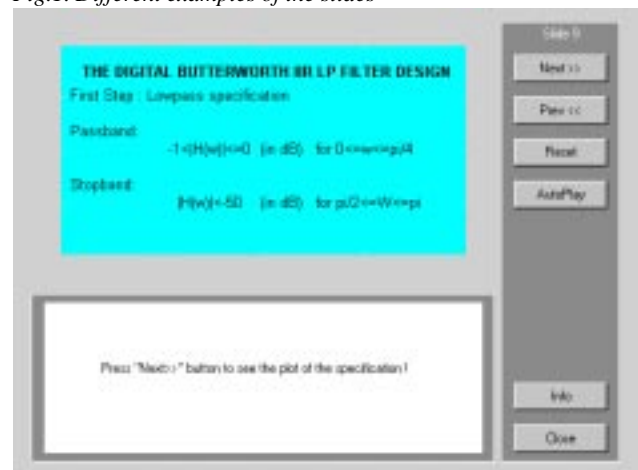
The order number of the slide and the command buttons are on the right side of each slide.

The user can change the slides automatically using the option *AutoPlay*. In this case the user may use the button *Stop* and later *Continue*. In the other case, the user can choose the option to change slides manually with the mouse, clicking *Next*, to go forward or *Prev*, to go back. The button *Reset* is for reset the demonstration.

The button *Close* is used to go out of the demonstration. That possibility enables the user to spend as many times as he needs for each slide and also to go back to see again any previous slide.

The content of the package is given in the Principal menu, (Fig.2). Each main demonstration is composed of the set of demonstrations shown in submenus.

Fig.1. Different examples of the slides



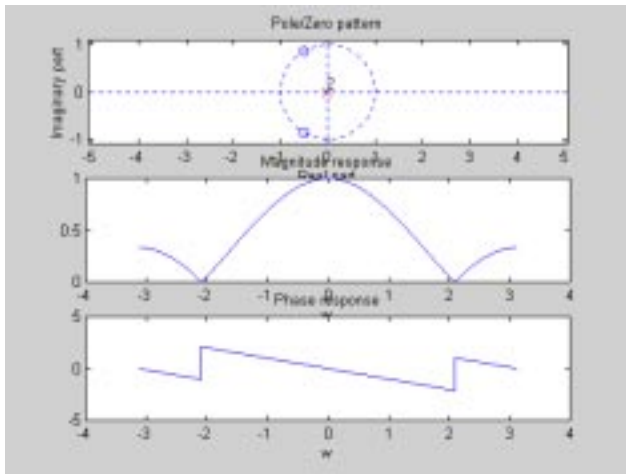
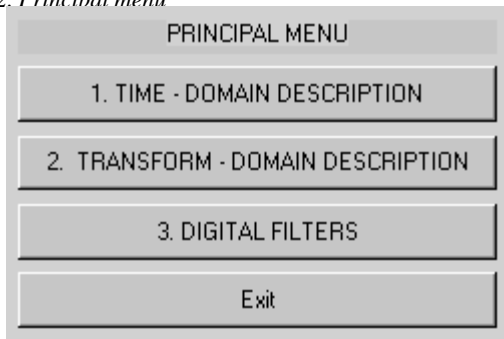


Fig.2. Principal menu

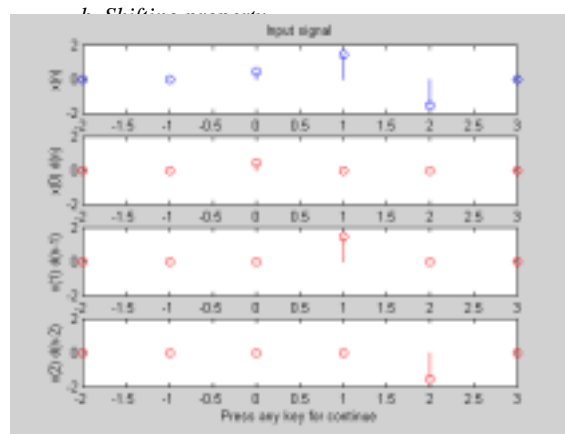
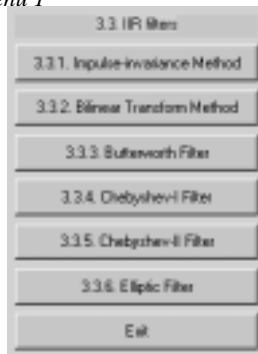


In the following we will describe briefly the demonstrations in the principal menu and the submenus.

The demonstrations TIME-DOMAIN-DESCRIPTION have 4 demonstrations shown in the Submenu 1. in Fig3.a. The demonstrations include the characteristics of the unit-sample, unit step and sinusoidal sequences. Finally, one of the most important operations, such as a linear convolution, is explained. As an example in the Fig.3.b is shown one slide from the Demonstration 1.1, which presents the Shifting property.

Fig.3. Time-domain description

a. Submenu 1



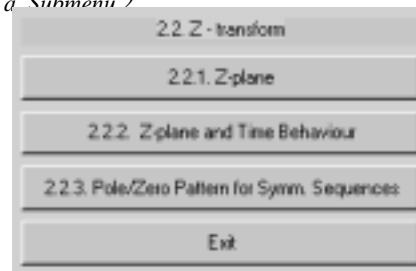
The demonstrations TRANSFORM-DOMAIN DESCRIPTION include Fourier and Z- transformation, as is shown in Fig.4 a. The Fourier transform includes demonstrations about Magnitude and Phase response, relation between Fourier and Discrete Fourier transform, as well as, the relation between Linear and Circular convolution, (Submenu 2.1 in Fig.4.b).

The Z-transform includes the demonstrations about the positions of singularities in the Z-plane, their relations with the time behavior and the singularity positions for symmetrical sequences, (Submenu 2.2 in Fig. 4.c)

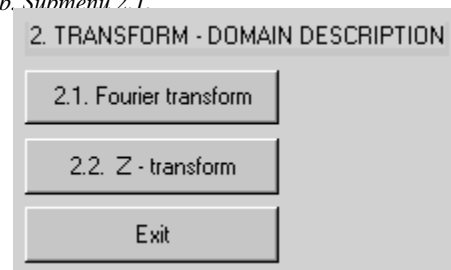
As an illustration, in Fig.5, are presented two slides from the demonstration 2.1.1, where are shown the examples of the phase jumps and the conclusion about it.

Fig.4. Transform domain description

a. Submenu 2



b. Submenu 2.1



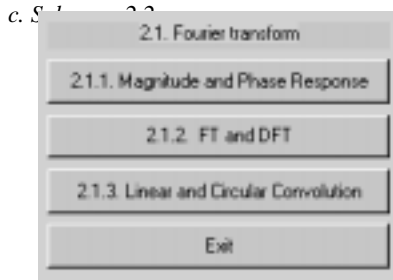
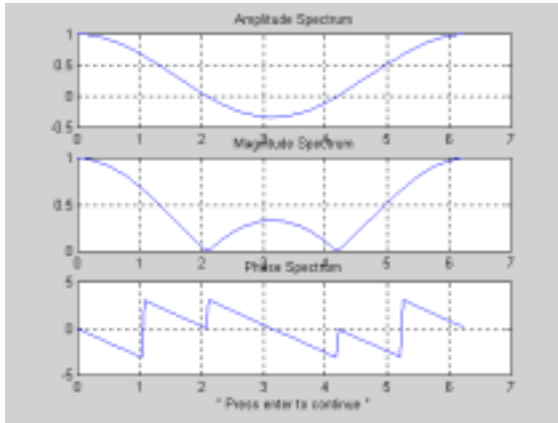
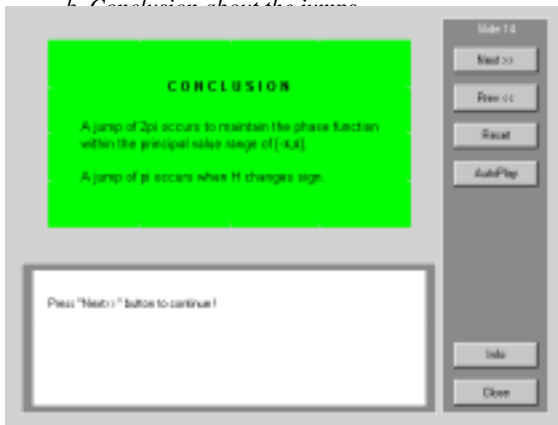


Fig.5. Illustration of the demonstration 2.1.

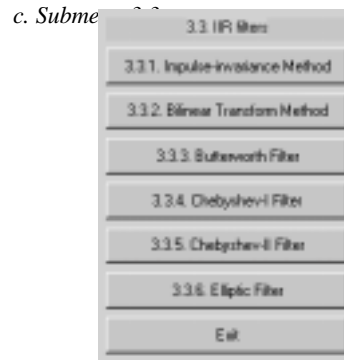
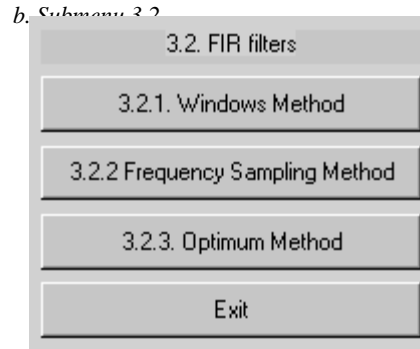
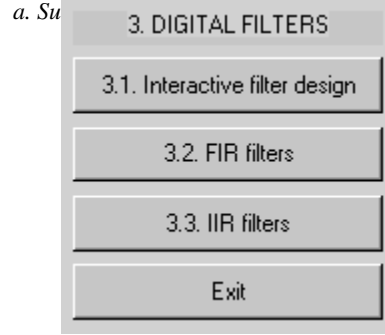


b. Conclusion about the jump



The demonstrations 3. DIGITAL FILTERS include 3 groups of demonstrations: Interactive filter design, FIR filters and IIR filters as is shown in the Submenu 3 in Fig.6.a. FIR filters include 3 demonstrations of the FIR filter design such as Window method, Frequency sampling method and the Optimum method, (Submenu 3.2 in Fig. 6.b). The characteristics and the design of IIR filters are given in the demonstrations in the Submenu 3.3 in Fig.6.c.

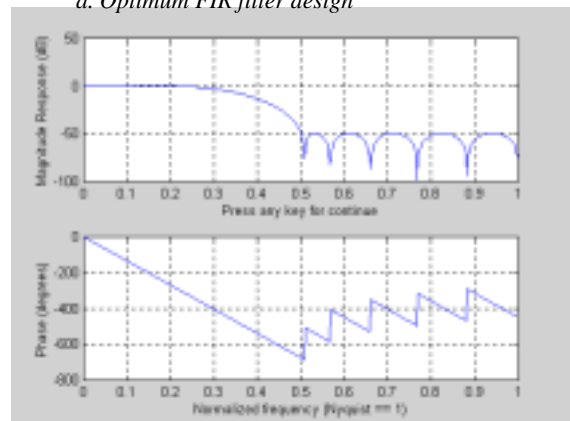
Fig.6. Menu and submenus of Digital filters

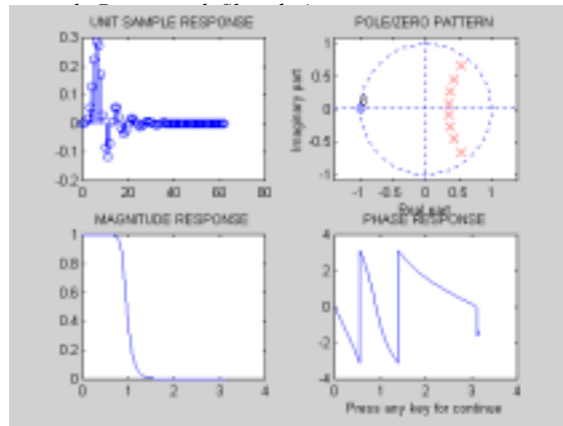


As one illustration in Fig.7.a. is shown an optimum FIR filter design and in Fig. 7. b a Butterworth digital filter design.

Fig.7. Examples of Filter design

a. Optimum FIR filter design





## CONCLUSION

We created an educational software package with idea of supporting a graduate course on fundamentals of digital signal processing. The demonstrations include basis for understanding digital signal processing, such as time-domain presentation, transform domain presentation and digital filters. The package was implemented in MATLAB and uses graphical tool *makeshow*, available in MATLAB. This tool allows us to create our own interactive slideshows without building our own graphic interface. In that way, the demonstrations are composed of slides that contain the plots of the corresponding signals and a short explanation. Each demonstration can run automatically, or clicking with the mouse on the corresponding button on the slide. Each slide can be recalled many times. In this way the user can compare the actual result with any previous one.

Our experience in INAOE has shown that such an education tool allows a better understanding of this important subject and increases teaching efficiency.

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