Matlab as a support for education of 'Signals and systems'

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Abstract

This paper involves examples of education and practice of subject 'Signals and systems' which is a part of accredited specialization 'Communication and Informational Systems' taught at University of Defence. There is a methodic leading the students to use Matlab via experience study. Afterwards, graphical examples of operations with harmonic functions prove how useful Matlab for practical demonstration of explained theory is. Another example is the comparison of Fourier transform calculations in Matlab with the manual calculation. Finally, the possibilities of Matlab usage in this subject are concluding this article.

1. Matlab in education

For modernization of education, we involved Matlab as a multimedia support. The effort is to show to student possibilities of Matlab usage in communication systems, but also in other branches [1], they should be able to make the best of Matlab anytime.

In class work, for student is easier to understand physical base of correlations between quantities through graphs form Matlab. They see influences of changes in any parameters on resulting graphical behaviour. Correlations between quantities are interpreted with graph and mathematical relation from books serves as a support. Difficulty numerical methods were counted manually, now, with Matlab support, they are solved very quickly, but students know process of this method as well.

Students are familiarized with Matlab environment, its structure, and than they solve tasks which leads to knowledge of basic work in this environment [2]. Higher attention is devoted to Matlab web support and Help. Student familiarize 2D and 3D graphic via Help and demos. New knowledge are implemented to creating graphs of selected functions and correlations from lecture. From programming function and watching its behaviour, students understand and remember it's basic, are able to work on with this function and understand relations between quantities and function mutually. We recommended students for solving problems and tasks out of our education Matlab Help, first of all, and than web support and discussion groups highlighted on Matlab (http://www.mathworks.com/matlabcentral/).

2. Graphical examples of Matlab usage

2.1. Harmonic signal

Following graphical example of operations with harmonic functions prove how useful Matlab for practical demonstration of explained theory is. Students have to know harmonic signal and next operation in details, if they don't, they can not continue in next study, which utilizes this knowledge. One of lectures about harmonic signal is influences of changes in amplitude and phase on signal. In Fig. 1. we can see graphical result of change in amplitude and phase of harmonic signal and for comparison there is origin signal too. Students choice value of changes themselves and compare results with origin and other results. By changing phases students see correlation between function sine and cosine also.

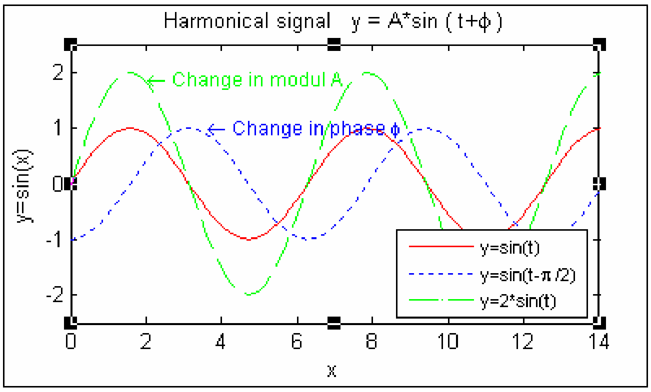

Fig. 1. Education of harmonic functions

2.2. Amplitude modulation

Through Matlab, students create their own modulated signal. By changing parameters in modulatory and carrying signal they can observe changes in resulting modulated signal. Students learn continuously amplitude, frequency and phase modulation. In Fig. 2. we can see creation of amplitude modulated signal. There is modulatory, carrying and amplitude modulated signal programmed accordance with their mathematical definitions [3]:

modulatory signal $m(t)$:

$$m(t) = U_m cos(2\pi f_m t) \qquad (1.1)$$

carrying signal $u_c(t)$:

$$u_c(t) = U_c cos(2\pi f_c t) \qquad (1.2)$$

amplitude modulated signal $u_{AM}(t)$:

$$u_{AM}(t) = [U_c + U_m cos(2\pi f_m t)] cos(2\pi f_c t) \qquad (1.3)$$

where
f_x is frequence of appropriate signal
U_x is amplitude of appropriate signal

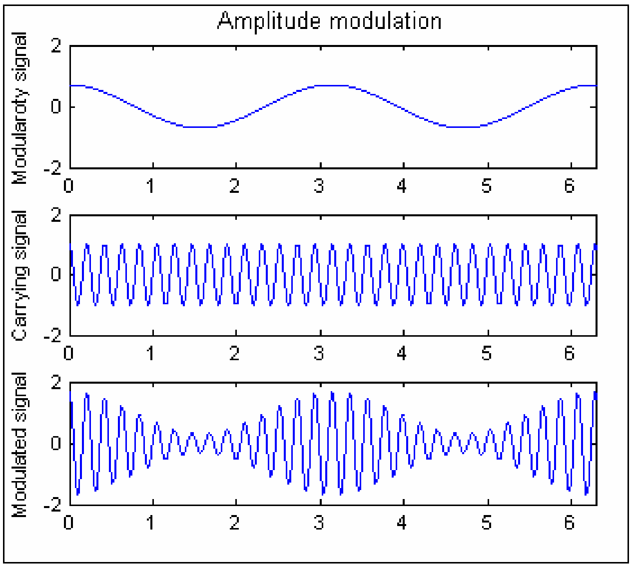

Fig. 2. Creation of amplitude modulated signal

2.3. Discrete Fourier transform

Next example is the comparison of Fourier transform calculations in Matlab with the manual calculation. In practical lectures, students count manually coefficients of Fourier series through discrete Fourier transform (DFT) according to relation [4]:

$$c_k = \sum_{n=0}^{N-1} s(n)(e^{-j2\pi/N})^{kn} \qquad (2.1)$$

where
$s(n)$ is input value of signal sample n
N is number of input values
$k = 0,1,\ldots, N-1$

Manual count is time-consuming even for small number of input values, but student will understand principle of DFT. More effective method is manual count for few coefficients and rest of coefficients is counted with Matlab. Students find out Fourier transform theme in Matlab Help and destine needed commands leading to correct solve. Command Y = fft(X) returns the discrete Fourier transform of vector X, computed with a fast Fourier transform algorithm. Complicated manual count (2.1) is changed in two simple commands – vector X definition and count itself.

In very short time, students understand principle of DFT, they are able to count coefficients of Fourier series in Matlab, they learn how to effectively search commands and they can find other information about Fourier transform and samples in Help.

2.4. Optical communication systems

In lecture about optical fibers, students gain basic information about signal transmission via optical fiber. There are graphs with multiparametric correlations made in Matlab for better understanding of complicated relations between quantities. In Fig. 3. we can see influence of dispersion on band width with dependence on wavelength and laser spectral line width[5].

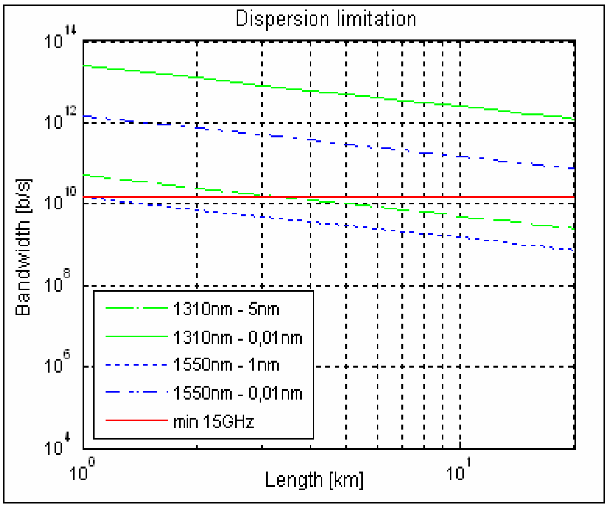

Fig. 3. Influence of dispersion on band width

Responsivity of photodetector is changing with changes in wavelength and it depends on material from which is fiber made too. From Fig. 4. is obvious that we can not use silicon fibers for application, which is designed for 1310nm or 1550nm wavelength. For these two wavelengths we can use germanium or InGaAs fibers only. Responsivity is increasing with wavelength until critical value where damage of photodetector occurs for each of different fibers.

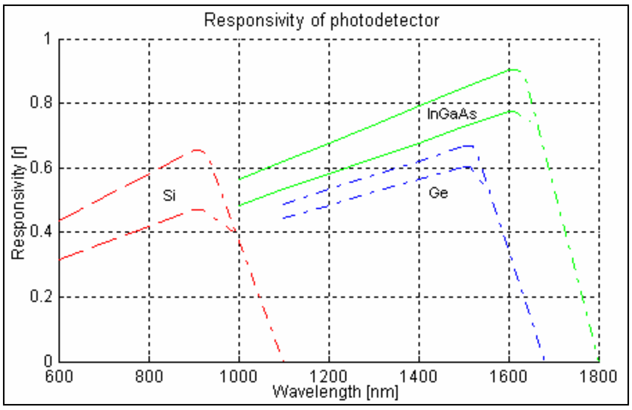

Fig. 4. Responsivity of photodetector

3. Conclusion

Matlab usage as a support in education was proved as competent. Education is more pleasant for students because they see, what is behind mathematical relations and they learn how to use Matlab to solve problems not only from signal theory, but others branches too. We plan spreading of multimedia to other subject. We are creating subject called Optical communication systems, which will be teached in blended-learning form in our learning management system Barborka. This system is established in other university and is fully use by students and teachers.

4. References

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[4] K. Pelikán, *Signály a systémy* [Scriptum], Univerzita obrany, Brno, 2005.

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