Signal based Effective Communication Systems

Stanio Kolev, Veska Georgieva, Lyubomir Laskov, Kalin Dimitrov
Technical University of Sofia
8 Kl. Ohridski Blvd, Sofia 1000
Bulgaria
{skolev@tu-sofia.bg, vesg@tu-sofia.bg, laskov@mail.com, kld@tu-sofia.bg}

ABSTRACT: *The signals and systems constitute effective communication and it is the base for an effective communication system. In this paper, we intend to generate signal with a good range of frequency and modulation can be used. We also address the low and high order modulation. We are able to analyse the possible types of modulation in the MATLAB environment. We also plan to include this kind of developments in educational systems.*

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1. Introduction

The modulation is a very important part of telecommunications. Practically every transmitter and receiver has a modulator and demodulator. That is why it is extremely important and should be taught in the course "Signals and Systems", which is fundamental for Telecommunications, Computer Systems and Technology, Electronic Engineering and Technology and others. Interesting is the fact that the principle of modulation is borrows from the music. The definition of modulation is that it is a process in which a lowfrequency signal is used to control any parameter of another RF signal. One of the main objectives of modulation is by high-frequency signal to carry information long distances. Digital modulation, called manipulations is characterized by the fact, that the signal level changes with a jump as the control signal is digital and takes a value of 0 or 1. There are various types of manipulations of the carrier wave. The change of the symbol of the digital information stream leads to a change of state of one or two parameters of the carrier wave [1-3]. Symbol is 1bit or group of bits that are transported from the 1 position of the carrier wave. The binary signal from the base band is converted into radio signals in the frequency band of the communication channel, that is, by the analog signal to transmit digital information on a specific physical environment of communication. There are three main types of modulations in both analogue and digital form: ASK, FSK and PSK [6, 7]. Each stroke of the manipulation of the carrier signal in the three types of modulation are called symbol, and transmitted to 1bit information and parameters such as amplitude *A,* frequency *f,* and phase φ can accept only values that correspond to '0' or '1'. There modulations with 48, 16, 32, 64, 128 and more conditions corresponding to 2^n (for example, $2^5 = 32$), where n is the number of bits which are transmitted [4, 8].

The main criteria for evaluation of modulation are:

- Efficient using of bandwidth of the communication channel. It is characterized by a coefficient of utilization of channels *(Bit /*

s / Hz). Normalized speed.

- Minimum required *S / N* ratio for unerringly reception.

- Resistance to selectively collapse of parts of the frequency range (fading).

We propose to use the program code in MATLAB environment for deep investigations of this process. So, during the exercises, the students will have the possibility to analyze the different types of modulations. They will be able to change the parameters of the generated signals and analyze their influence on the modulated signal. The obtained results can be presented as graphics in the time and the frequency domain.

2. Problem Formulation

The process of analog modulation can be described as follows. Let the high-frequency signal has the form [5]:

$$S_0(t) = A_0 \cos(\omega_0 t) \quad (1)$$

Modulating signal is mono harmonic:

$$S_m(t) = Am\, cos(\Omega t) \quad (2)$$

Amplitude modulated signal is:

$$S_{am}(t) = A_0(1 + m.\, cos(\Omega t)\, cos(\omega_0 t) \quad (3)$$

where $m = A_m / A_o$ is the ratio of the modulation.

This coefficient takes values between 0 and 1, and in practice often used values between 0.3 and 0.5. By *m*>1 is obtained pre-modulation process. The coefficient of modulation can be determined practically by measured by maximum and minimum values of the amplitude of the carrier signal, using the following formula:

$$m = \frac{A_{max} - A_{min}}{A_{max} + A_{min}} \quad (4)$$

When the initial phases are not taken into account, which does not diminish the validity of the expression, we can obtain for amplitude modulated signal[9]:

$$S_{am}(t) = A_0 \cos(\omega_0 t) + \frac{mA_0}{2}\cos(\omega_0 - \Omega)t + \frac{mA_0}{2}\cos(\omega_0 + \Omega)t \quad (5)$$

This expression shows the composition of the spectrum.

The digital modulation is most used in the modern communications systems, so they will be discussed a little more detailed than the analog. Digital modulation (or manipulation) is a method for converting a digital BBS signal into a high-frequency analog modulated signal, which is suitable for transmission in the communication channels through stepped change (SK, Shift Keying) of the amplitude, frequency and / or phase of the carrier signal (ASK, FSK, PSK). In most cases this modulation works by the most efficient using of the spectrum (The maximum transmitted bits at 1 Hz). An important parameter is the BR (Band Rate): *BR = Rb/BWSK*, where *BWSK* is the bandwidth of the modulated digital signal. In general, however, these signals require less bandwidth and therefore additional treatments for narrowing the spectrum are needed (for example filtration). The latter, however, leads to undesirable effects parasitic AM modulation and ISI.

The modulated signal (PBS, Pass-Band Signal) is obtained by non-linear mixing of a signal in a main band with a carrier signal (at high frequencies it is most common analog harmonic signal:

$$C(t) = Cm\cos(2\pi fct + \varphi c) \quad (6)$$

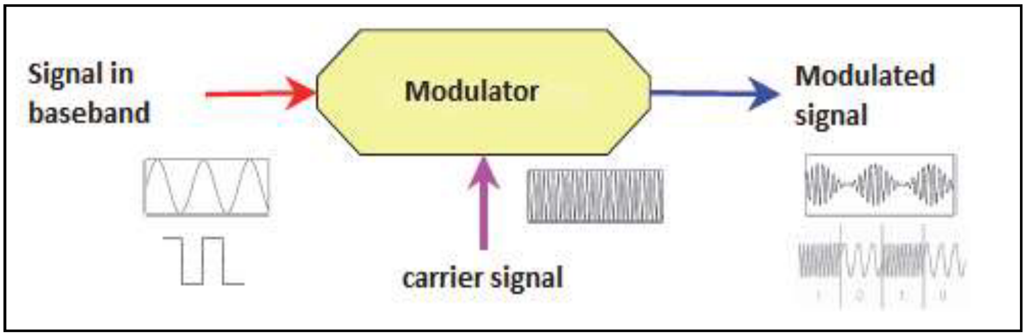

Figure 1. Basic block diagram of modulation

The modulation is divided into analog and digital (manipulation) depending on the type of BBS signal. The information from the BBS can be obtained by each of the three main parameters of the carrier signal amplitude *Cm, fc* frequency or phase φc.

The simplest type of PSK modulation is BPSK, in which the bits "0" and "1" are transmitted with two phase states of the carrier signal in 180 and 0 degrees, respectively.

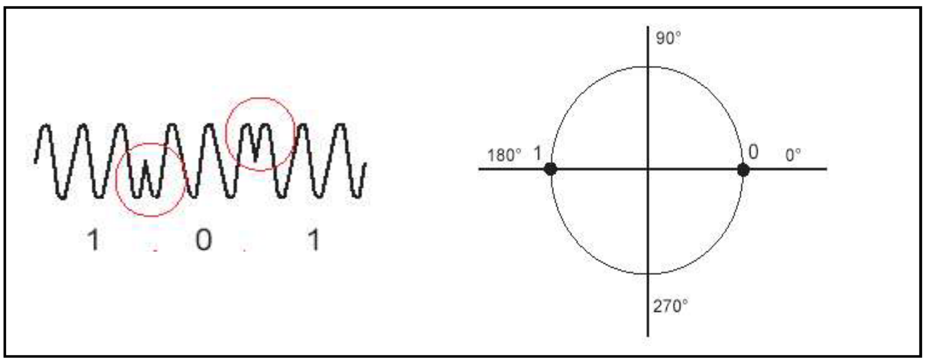

Figure 2. BPSK modulation

Doubling of the transmission rate of the manipulated signal (and the necessary bandwidth) is obtained by QPSK (Quadrature PSK) modulation, where the bits are transmitted in pairs (00, 01, 10, 11) with a 4 phase states of the carrier 90 degrees, which is shown in figure 3. In order to avoid unwanted jumps 180 degrees (eg. in the transmission of a group of bits 0010), where there are parasitic AMmodulations using OQPSK modulation with displacement of the odd and even bits of 45 degrees.

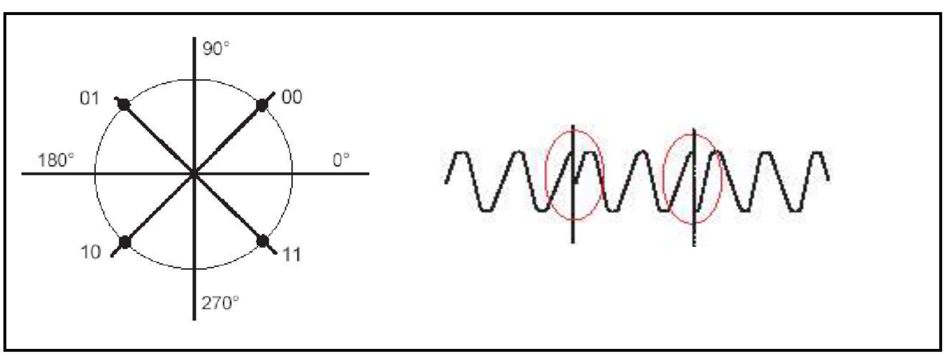

Figure 3. QPSK (Quadrature PSK) modulation

3. Experimental Part

To obtain an analog amplitude modulated signal, the *'ammod'* function (*x, Fc, Fs*) can be used. Initially, students can set the following basic parameters: modulation signal *x*, sampling frequency *Fs* and carrier frequency *Fc*. The amplitude and frequency of the modulation signal can be changed. Alternatively, a multichannel signal matrix can be used, where each column of the matrix represents one channel. The vector *y* represents the modulated signal. In Figure 4 are shown the input signal *x(t)* and the modulated signal *y*(*t*) in time domain, when the index of modulation is $m = 0.5$ and frequencies of input and carrier signals are $f_i = 10$ kHz and $f_0 = 500$ kHz respectively.

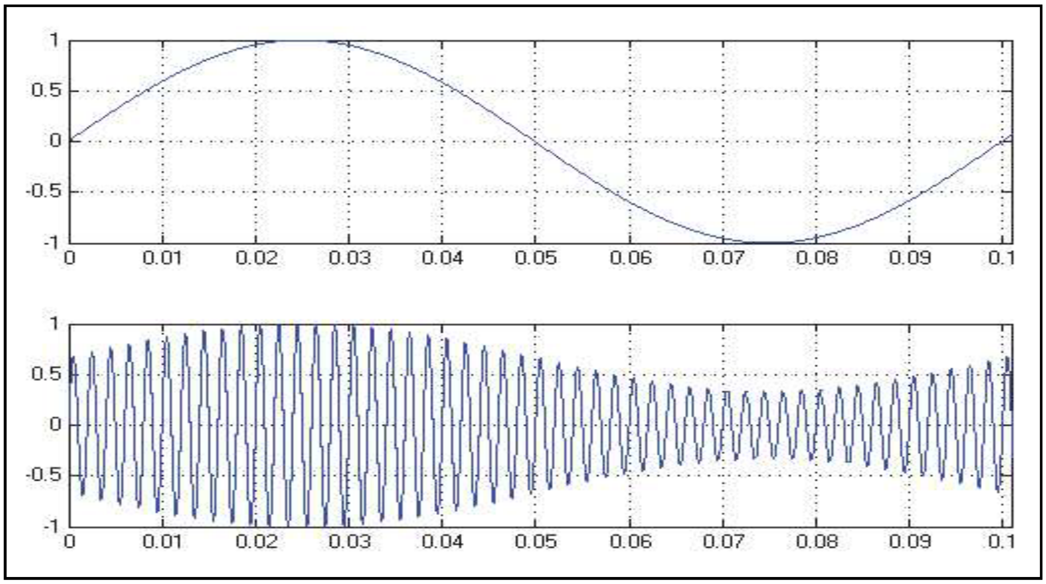

Figure 4. An example of analog amplitude modulation

In Figure 5 is shown an example of amplitude modulated signal, which is obtained by the use of a high frequency modulating signal ($f_i = 25$ kHz).

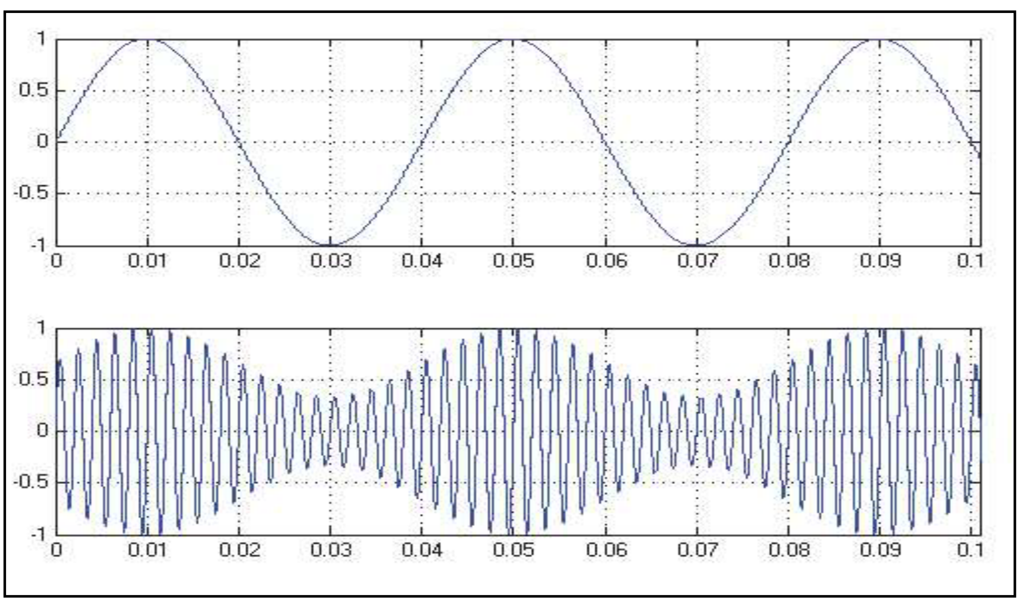

Figure 5. An example for analog amplitude modulation with higher frequency modulation signal ($f_i = 25$ kHz)

In the following examples modulation and demodulation process are presented. In the channel for the connection Gaussian white noise *(AWGN)* is added. This example is for phase modulation, but it illustrates the basic principle of analog modulation and demodulation. Figure 6 shows the original and recovered signal. Similar to the amplitude modulation discussed above, we use for the modulation the function *'pmmod'* and for 'demodulation' the function *'pmdemod'*, respectively. The Gaussian white noise is introduced by the function *y = awgn (y, 10, 'measured')*.

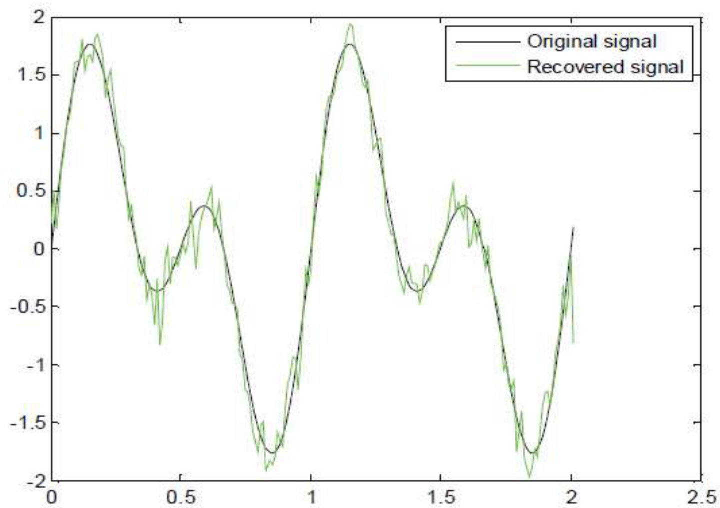

Figure 6. Analog Phase Modulation

Another example of digital modulation is QAM. In the following simulations, the functions *'modem.qammod'* for the modulation and *'modem.qamdemod'* for demodulation were used at 16QAM in our case. In this example, a random digital signal is generated, modulated signal azazand noise is added. The students are able to modify the modulation scale *M*. The obtained results from the simulation are presented in Figure 7 and Figure 8, respectively.

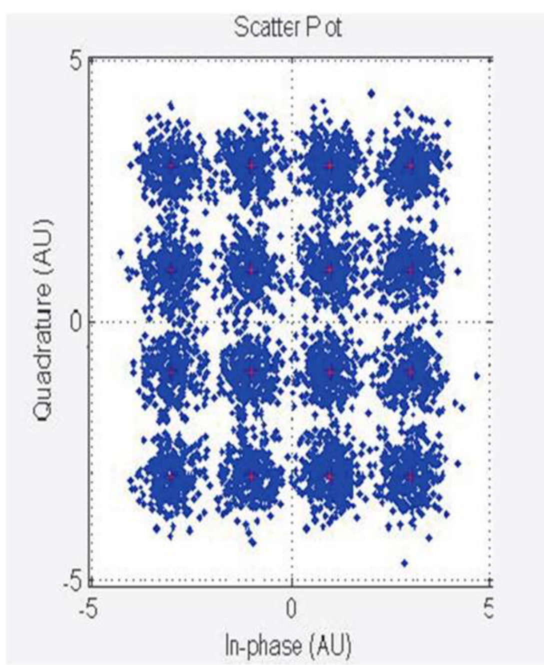

Figure 7. Digital Amplitude Modulation (16QAM) with *S/N*=15

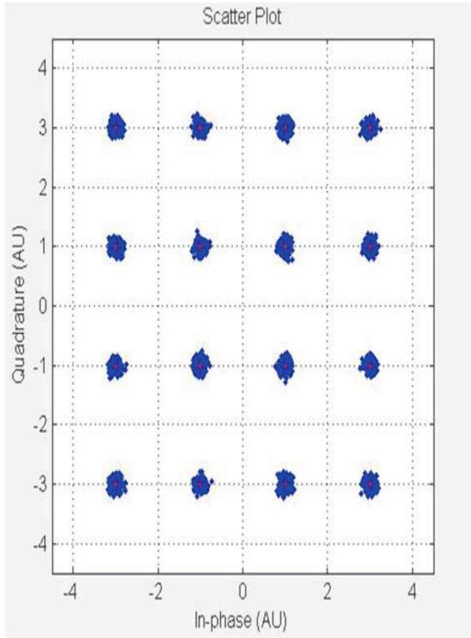

Figure 8. Digital Amplitude Modulation (16QAM) with *S/N*=30

In Figure 9 the 16PSK digital phase modulation diagram is presented. In this case the following functions are used: *'modem.pskmod* for modulation' and *'modem.pskdemod'* for demodulation.

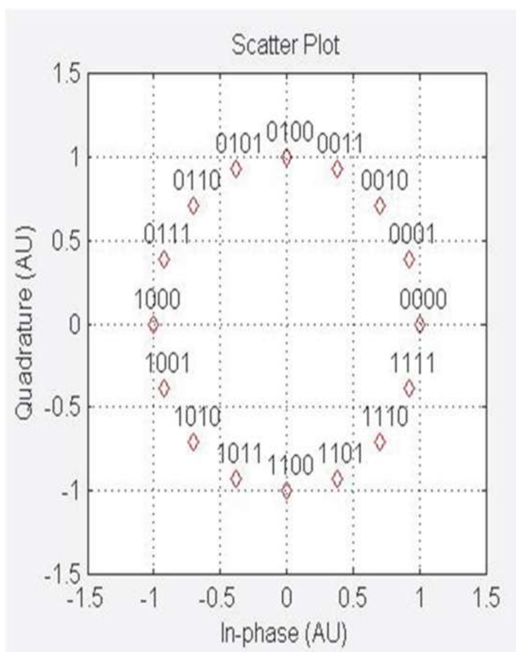

Figure 9. An example for Digital Phase Modulation (16-PSK)

4. Conclusion

In this paper an approach for in-depth studying on the process of the main types of modulations of low and higher order has been discussed. For computer simulation an implemented program code in MATLAB environment has been developed. So, the students will have ability to create software models for different type of analog and digital modulation. They will be able to change different parameters and analyze their influence on the modulated signals in time and frequency domain.

The proposed approach can be developed for making exercises, which will be used for web based distance education.

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