

BASICS OF MATLAB

MATLAB is working with vectors and matrices, using different operators and functions.

The vectors are indexed starting with 1 not 0.

A line-vector is introduced using SPACE or COMMA as separators:

```
>> a = [1 2 3 4 5]    [ENTER]
```

1. *Write this command in Command Window. What is the displayed result?*

For a column-vector, SEMI-COLON is used as separator:

```
>> b = [1; 2; 3; 4; 5] [ENTER]
```

2. *Launch this command. Compare the two vectors, a and b.*

In the same way, a matrix is written. The rows are separated by SEMI-COLON:

```
>> m = [1 2 3 4 5; 2 3 4 5 6; 3 4 5 6 7]    [ENTER]
```

3. *Write the matrix above in the Command Window. How many rows and columns has this matrix?*

If we don't want to display the result of a command, a semi-colon is written at the end. For example:

```
>> p=3*a;           [ENTER]
```

4. *Launch the command from above. What content is displayed after it?*

Remark: The vector p was calculated by the program, but it was not displayed. If you want to display a variable, you have to write its name and then press ENTER key. Pay-attention: MATLAB is case-sensitive!

```
>> p    [ENTER]
```

You can request many variables to be displayed writing all the elements separated by comma after the prompter and pressing ENTER key (comments begin with %):

5. *Try to display a, the first value of b, one element from m and the vector a transposed.*

```
>> a, b(1), m(2,3), a'      % a' is the transposed of a      [ENTER]
```

6. *How many elements are displayed by running this command?*

Remark: Many commands can be written on the same line of the program, separated by commas or semi-colons.

MATLAB uses arithmetical and logical operators: +, -, *, /, NOT, AND, OR.

7. *Let us multiply two vectors, a and b:*

```
>> c=a*b;      [ENTER]
```

Let's show c:

```
>> c      [ENTER]
```

8. *Try to display C (capital letter). What message do you get?*

The length of a vector is read with the MATLAB function **length(vector)**. Usually, the arguments of a MATLAB function are written after its name, in round parenthesis.

Another MATLAB function used to get the number of rows and columns of a matrix is **size**.

9. *Run the following commands:*

```
>> L = length(a)      [ENTER]
```

```
>> s = size(m)      [ENTER]
```

MATLAB uses different statements: if, for, while.

Example:

```
for i=1:5
    k(i) = a(i)^2; % raise all the elements to the power of 2
end
```

10. *Run the command above in Matlab window and display k.*

The commands can be nested.

Example:

```
for i=1:s(1)
    for j=1:s(2)
        if m(i,j) == 2
            m(i,j)=0;
        end
    end
end
end
```

11. Run the commands from the previous example. Display matrix m.

MATLAB allows new functions to be defined by users. A new function is saved as a file with the extension .m, having the same name as the function itself. Do not use the same names as an existing MATLAB function. In order to call a new function, the folder containing it must be specified:

```
>> cd <'path to the user's folder'>
```

The function is written accordingly to the following template:

```
function [output arguments] = name (input arguments separated by comma)

% comments

commands
```

12. Create a new function and save it on d:\, in your work directory.

Launch in MATLAB the help command with your function's name:

```
>> help <name>
```

Do you get your comments?

Apply the function created by you on a set of numerical arguments.

Check if the result is correct.

IN CONCLUSION: MATLAB can be used to test and to implement different coding and decoding algorithms used by telecommunication systems.

DISCRETE INFORMATIONAL SOURCE ANALYSIS

1. Create a 2-3 pages text file (<name>.txt) with at least 1000 characters.
2. „Read” and display the file in MATLAB command window, using the functions: fopen, fread, setstr.
3. Use length function to find out the total number of characters.
4. What type of values does MATLAB read? (binary, hexadecimal, decimal)

What code is used by Matlab to convert characters in numerical format?

5. What are the minimum and maximum values for your own file? Use the following functions: min, max. How many bits are used to encode characters? How many characters can be encoded by this code?
6. Create a vector (nc) in order to store the number of appearances of each numerical value (from 1 to 128 or 256). Use ones function to initialize the vector.
7. Use sum function to calculate the total number of cases nt analyzed by yourselves. Create the probability vector prob.
8. Represent the histogram of nc vector using bar function. Use clf function to clear the image.
9. What can you notice analyzing the histogram? What is the value that the maximum sample corresponds to? Choose a threshold value (v) to compare the samples with. Which are the first 20 to 25 significant samples of this histogram? Complete Table 1.

Table 1: The most significant characters of the informational source

Crt. No.	Character	ASCII Code	No. of appearances	Probability

10. Calculate the probability of a non-significant character (different from the ones in Table 1) and complete the probability vector with this value. Check the sum of this vector. This step completes the modelling process of the discrete informational source.

11. Calculate the entropy of the informational source:

$$h = - \sum \text{prob}(i) * \log_2(\text{prob}(i)),$$

12. Design the lossless compression code using the obtained source model. Complete Table 2.

Table 2. Code Table

Crt. No.	Character	Probability	Code Word	Length (bits)

Calculate the average length of code words, the redundancy, the efficiency and the compression rate of the designed code.

ENCRYPTION TECHNIQUES. RSA ALGORITHM

OBJECTIVE:

IMPLEMENT AND TEST THE RSA ENCODING AND DECODING ALGORITHMS

PROCEDURE:

1. Create a text file (.txt) containing the first names of the team members (use space as word separator).
2. Open the file in MATLAB (*use fopen*). Display the file identifier (fid).
3. Read the file in MATLAB (*use fread*). Display the vector *f*, containing the decimal ASCII character codes.
4. Display the content of the file in MATLAB (*use setstr*)
5. Choose a pair of distinct prime numbers (*p*, *q*) that will be used for RSA code design.
the numbers will be chosen so that the code can process individually each byte, character-by- character .
6. Deduce the encryption and decryption keys: (*e,n*),(*d,n*).
**** If $d = e$, change the pair of numbers (*p,q*).
7. Implement the RSA encoding algorithm (the spaces between words are not encrypted).
8. Encode vector *f* using your encryption key. Display the coded vector (*c*). Display the encrypted characters, corresponding to the coded vector (*c*).
9. Implement the RSA decoding algorithm.
10. Decrypt *c* using your decryption key (denote the decrypted vector as *v*). Display the decrypted text.

CONCLUSIONS:

What difficulties did you meet by implementing the RSA encryption and decryption algorithms?

Make some comments and recommendations.

LABORATORY

INTRODUCTION TO COMMUNICATION

MEASURING TELECOMMUNICATION CABLES

Objective:

Measure the characteristic impedance (Z_c) and the attenuation (a) of the cable for different cable types:

UTP, FTP, thin coaxial, thick coaxial.

Procedure:

Long enough cables (> 10 meters) must be used.

For each test cable, follow the steps:

1. Connect the conductor wire and the ground of the cable to the signal generator. Select 1 MHz rectangular signal to be generated.
2. Connect the same wires to the 2-channel oscilloscope.
3. The other end of the cable is unloaded in order to get total reflection of the transmitted wave.
4. Display the transmitted wave combined with the reflected wave at the input of the cable. Remark the delay between them. Explain the reflection phenomenon. How does the reflected wave change when the cable is short-circuited. Draw on your papers the displayed waveforms on the oscilloscope.
5. Measure the delay between the two waves (adjust the time base of the oscilloscope).
6. Measure the voltage levels of the transmitted wave and of the received signal.
7. Estimate the cable length.
8. Calculate the primary parameters (R, L, G, C), the characteristic impedance (Z_c) and the cable attenuation (a) per meter.
9. Compare the result with the nominal parameters of the cable (written on the cable).
10. Why do these different values occur? Which values are correct, the measured or the nominal ones?

LABORATORY

Introduction to Communications

Digital Modulation Techniques

Objective:

Analyze some well-known digital modulation techniques (state diagram, BER, SNR)

Procedure:

1. Start MATLAB.
2. Use specific Matlab functions in order to generate different modulated signals and their corresponding transmitted state diagram. Run the following scripts with a different number of states ($M = 4; 8; 16; 32$):

- Create PSK Constellation Scatter Plot

Example:

```
M = 16;  
x = [0:M-1];  
scatterplot(pskmod(x,M));
```

- Create QAM Constellation Scatter Plot

Example:

```
M = 16;  
x = [0:M-1];  
y = qammod(x,M);  
scale = modnorm(y,'peakpow',1);  
y = scale*y; % Scale the constellation.  
scatterplot(y); % Plot the scaled constellation.
```

Draw one state diagram of each type and map the states with bit sequences.

2. Display the same state diagrams at the receiver considering a communication channel affected by additive white Gaussian noise (AWGN) and different values of the received SNR (15; 12; 9; 6; 3 dB).

Example:

```
% Create a random digital message  
M = 16; % Alphabet size  
x = randint(5000,1,M); % Message signal  
% Use QAM modulation.  
y = qammod(x,M);  
% Transmit signal through an AWGN channel.  
ynoisy = awgn(y,15,'measured');
```


% Create scatter plot from noisy data.
scatterplot(ynoisy);

Repeat the simulation for received PSK modulated signals.
Complete the following table:

TABLE 1. Is it possible to decide what type of modulation is received and to distinguish the number of states?

SNR (dB)	32QAM	16QAM	8QAM	4QAM	32PSK	16PSK	8PSK	QPSK
15								
12								
9								
6								
3								

3. Start BER tool:

>> bertool

For digital modulation techniques (PSK, FSK, QAM), with a different number of states (2, 4, 8, 16, 32), plot BER, considering coherent and non-coherent demodulators, eventually with Hamming or Reed-Solomon pre-coding blocks. Two channel types are considered:

- (1) AWGN channel
- (2) Rayleigh fading channel

If it is necessary, change the SNR range from 0:18 dB to 0: 30dB or 0:60dB.

- Write in a table the values of SNR corresponding different values of BER: 10^{-2} , 10^{-4} , 10^{-6} , 10^{-8} .
- Compare modulation techniques with the same number of states. Analyze the quality of service (QoS).

TABLE 2. SNR dB values

Log BER	32QAM	16QAM	8QAM	4QAM	32PSK	16PSK	8PSK	QPSK
-2								
-4								
-6								
-8								

CONCLUSIONS:

- Which modulation is more performant for transmission by AWGN channel? What about fading channel?
- What is the goal of error-correcting coding techniques?