Matlab Tutorial

In this tutorial we will show some of the most important functions in Matlab and how they work. Each function will be described with a note in a contest of an example. It is strongly advised that the reader tries this examples on his/her own time for better understanding and repeatability.

1. Modeling in the Frequency Domain
   In order to create a transfer function in Matlab, one has to specify the coefficients of the numerator and the denominator polynomials and use Matlab function tf in order to display it:

   num=150*[1 2 7]    Create and display the numerator
   den=[1 5 4 0]      Create and display the denominator
   F=tf(num,den)      Create and display Transfer Function
   bode(F)            Create and display Bode plot of function F

   In order to operate in state-space, we need to first be able to represent a matrix:
   For example, matrix A is a 3x3 matrix with a space or comma separating the elements of each row. The next row is separated by a semicolon or carriage return. The entire matrix is enclosed in square brackets:

   A=[0 1 0; 0 0 1; 1 2 3]  Displays 3x3 matrix A

   Or
   A=[0 1 0
     0 0 1
     1 2 3];

   A row vector can be represented with elements separated by spaces or commas and enclosed in square brackets. A column vector can be represented with elements separated by semicolons or carriage returns or as the transpose (’) of a row vector:

   C=[2 3 4]          Displays row vector
   B=[7;8;9]         Displays column vector
   Or
   B=[7 8 9]’        Transpose of row vector is column vector
The state space consists of specifying 4 matrix: A, B, C and D followed by a specific matlab function, ss(A, B, C, D):

\[
\begin{align*}
A &= \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 2 & 3 \end{bmatrix} \quad \text{Creates and displays matrix A} \\
B &= [7 \ 8 \ 9]' \quad \text{Creates and displays matrix B} \\
C &= [2 \ 3 \ 4] \quad \text{Creates and displays matrix C} \\
D &= 0 \quad \text{Creates and displays matrix D} \\
F &= \text{ss}(A, B, C, D) \quad \text{Creates and displays LTI object}
\end{align*}
\]

Transfer function that is represented by numerator and denominator polynomials can be converter to state-space form:

\[
\begin{align*}
\text{num} &= 24 \quad \text{Creates and displays numerator} \\
\text{den} &= [1 \ 9 \ 26 \ 24] \quad \text{Creates and displays denominator} \\
[A, B, C, D] &= \text{tf2ss}(\text{num}, \text{den}) \quad \text{Converts TF to SS} \\
[\text{num}, \text{den}] &= \text{ss2tf}(A, B, C, D, 1) \quad \text{Converts back to TF form from SS}
\end{align*}
\]

The above examples will get you started using Matlab’s basic function for linear systems and controls. Matlab contains an enormous amount functions and it is impossible to describe them all in this tutorial. The best way to learn about new functions is to use Help menu of the program, since it considered being one of the most comprehensive ones. Also, there are many websites, such as Carnegie Melon, where you can find many useful examples: [http://www.engin.umich.edu/group/ctm/](http://www.engin.umich.edu/group/ctm/)

Here is the list of some commonly used functions:

- **Abs(x)**: Obtain absolute value of x
- **Acker(A,B,poles)**: Finds gains for pole placement
- **Plot(x,tout)**: Plots x versus tout
- **Roots(F)**: Finds roots of polynomial F
- **Lsim**: Simulates LTI model response