ELECTRICAL ENGINEERING TECHNOLOGY PROGRAM
EET 433 – CONTROL SYSTEMS ANALYSIS AND DESIGN
LABORATORY EXPERIENCES

PROGRAM CC TUTORIAL

The following are few of the most used functions in Program CC that will get you started with this powerful simulation tool.

Program CC is based on entering a series of commands in the active line of the command window that opens by default. In order to use each one of these functions at their full potential, you need to read the help online, tutorials and demos. This is just an abbreviated version of few of these commands.

We can always find additional help on any function by typing **help name_of_function** from the command line

Don't forget to save your work periodically!!

1.- ENTERING A TRANSFER FUNCTION

ALL transfer functions in CC require a name. For example, g, or g1 or g2, etc…

1.1 Transfer functions can be entered as algebraic expressions.

To enter the following transfer function:

$$g(s) = \frac{10(s+1)}{s(s^2 + 2s + 100)}$$

You need to type:

CC>g=10*(s+1)/(s*(s^2+2*s+100))

After typing

CC>g

The screen will display:

$$g(s) = \frac{10(s+1)}{s(s^2 + 2s + 100)}$$

1.2 Entering a transfer function using the menu

To enter the previous transfer function, type:

CC>enter

The following window will appear in the screen:

From this window you can enter each one of the polynomials in the numerator and denominator.

Hint: The constant (gain) needs to be entered as a polynomial order zero

Hint: A simple polynomial (not a transfer function) can be entered by choosing a denominator equal to 1.

1.3 Alternative and faster way of entering a transfer function:

The transfer function g(s) can be re-entered with its coefficients:

(1) the number of polynomials in the numerator
(2) the polynomials, each starting with its order
(3) the number of polynomials in the denominator
(4) the polynomials, each starting with its order

To enter the same transfer function, type:

 CC>g=enter(2,0,10,1,1,1, 2,1,1,0,2,1,2,100)

And again, after typing
CC>g

The display will show:

$$g(s) = \frac{10(s+1)}{s(s^2 + 2s + 100)}$$

Note that in this case, both the numerator and the denominator have two polynomials each.

1.4 Other methods for entering transfer functions

There are few more ways of entering transfer functions that are less commonly used. Consult the online help to learn these methods.

2. DISPLAYING TRANSFER FUNCTIONS

2.1 Regular Display

The regular display (as entered) is achieved with the following command:

CC>display(g)

The screen will show:

$$g(s) = \frac{10(s+1)}{s(s^2 +2s +100)}$$

2.2 Shorthand Display

Enter the following command:

CC>shorthand(g)

The screen will then show:

$$g(s) = \frac{10(1)}{(0)[0.1, 10]}$$

Note that it is also possible to enter the transfer function in shorthand mode (see #1)

2.3 Single Display

In Single Display, the transfer function has a single polynomial in the numerator and a single polynomial in the denominator.

Enter the following command:

CC>single(g)

and the screen will read:

$$g(s) = \frac{10s+10}{s^3 +2s^2 +100s}$$

2.4 Unitary Display

In Unitary Display, the coefficient of each higher order is set to one.

Enter

CC>unitary(g)

And the screen will read

$$g(s) = \frac{10(s+1)}{s(s^2 + 2s + 100)}$$

2.5 Pole-zero form

In this form, the transfer function is displayed as poles and zeros

Enter the following:

CC>pzf(g)

And the transfer function will be displayed as poles and zeros

$$g(s) = \frac{10(s+1)}{s[(s+1)^2 + 9.95^2]}$$

Zero: s = -1

Poles s = - 1 ± j 9.95

2.6 Time Constant Form:

To display the transfer function as the time-constant-form, type:

CC>tcf(g)

And the result will be:

$$g(s) = \frac{0.1(s+1)}{s(0.01s^2 + 0.02s + 1)}$$

2.7 Poles of the Transfer function

If we are only interested in finding the poles of the transfer function, we can do this by typing

CC>poles(g1)

3.- PARTIAL FRACTION EXPANSION

Program CC also has a command to find the Partial Fraction Expansion for a given transfer function

Enter the following command:

CC>pfe(g)

The display will show the P.F.E as:

```
         0.1         0.1s-9.8
 g(s) = -----   -   ---------------------
          s          [(s+1)^2+9.95^2]
```

4. INVERSE LAPLACE TRANSFORM

The Inverse Laplace Transform of a given transfer function can be easily found by entering the command:

CC>ilt(g)

It will result in the following function in the time domain

g(t) = 0.1 + sin(9.95t-0.1002)*exp(-t) for t >= 0

Note that stating t>=0 is equivalent to multiplying g(t) by u(t) - step function-

Hint.- The software does not assume any input. If we want to calculate the response to a step function, for example, we need to multiply the transfer function g(t) by the Laplace Transform of the step function and perform *ilt* on the new, resulting transfer function.

5.- ALGEBRAIC MANIPULATIONS

Transfer functions can also be manipulated algebraically.

Consider two transfer functions g1(s) and g2(s)

To add them, type

CC>g=g1+g2

After typing **display(g),** the screen will show the new function g(s) that is the addition of g1(s) and g2(s)

Similarly, the transfer functions can be substracted with:

CC>g=g1-g2

multiplied:

CC>g=g1*g2

or divided:

CC>g=g1/g2

6.- BODE PLOTS

Program CC has the capability to graph different types of plots (Bode, Nyquist, Nichols, etc.). We will only consider here those used commonly in this and previous courses. For information about the rest of the plots, please consult the online help.

<u>6.1 General Bode Plot</u>

Consider the following transfer function for which we want to plot its BODE graph:
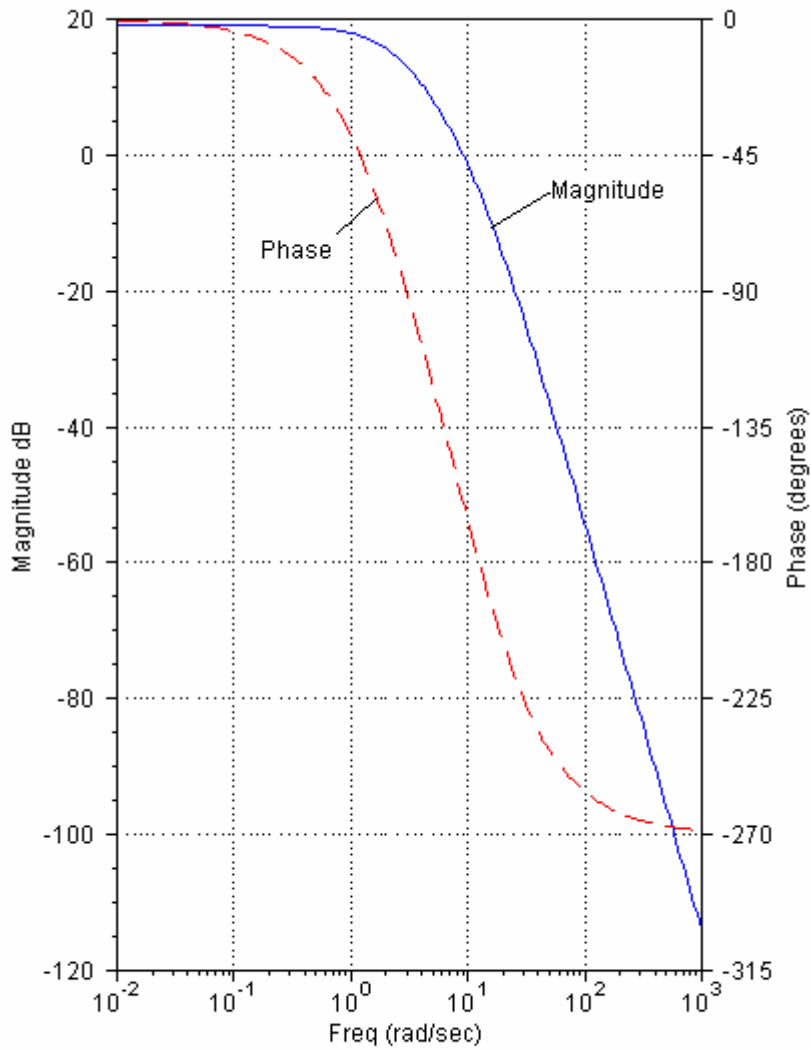
$$g(s) = \frac{2000}{(s+2)(s+7)(s+16)}$$

Enter the transfer function as

CC>g=2000/((s+2)*(s+7)*(s+16))

To plot the frequency responses of the transfer function above, use the BODE command:

CC>bode(g)

The resulting Bode plot will open in a new window as:

On the resulting graph we can move the cursor over the graphs and a window will open with information on the cursor position.

Double-clicking on the graph will open a window that will allow to further refine the graph and add labels, titles, etc.

For additional, detailed information about Bode plots, type

CC>help bode

6.2 Robustness

To check the robustness margin, use the MARGIN command by typing:

CC>margin(g)

The display will read:
    At w= 9.18 r/s, Phase margin= 19.79 deg, Delay margin= 0.0376 sec
    At w= 9.76 r/s, Mp= 3.16 (10.00 dB)
    At w= 12.6 r/s, Gain margin= 1.86 (5.40 dB)

To check the robustness margin at specific frequency type:

CC>point(g,1)

The display will read:
    At s = 0 + 1j
    g(s) = 6.195 - 4.887j
    Magnitude = 7.890 (17.94 dB)
    Phase = -38.27 deg

7.- OTHER GRAPHS

The function **time** plots the time response to a step function

For example, to find the time response to a step function of
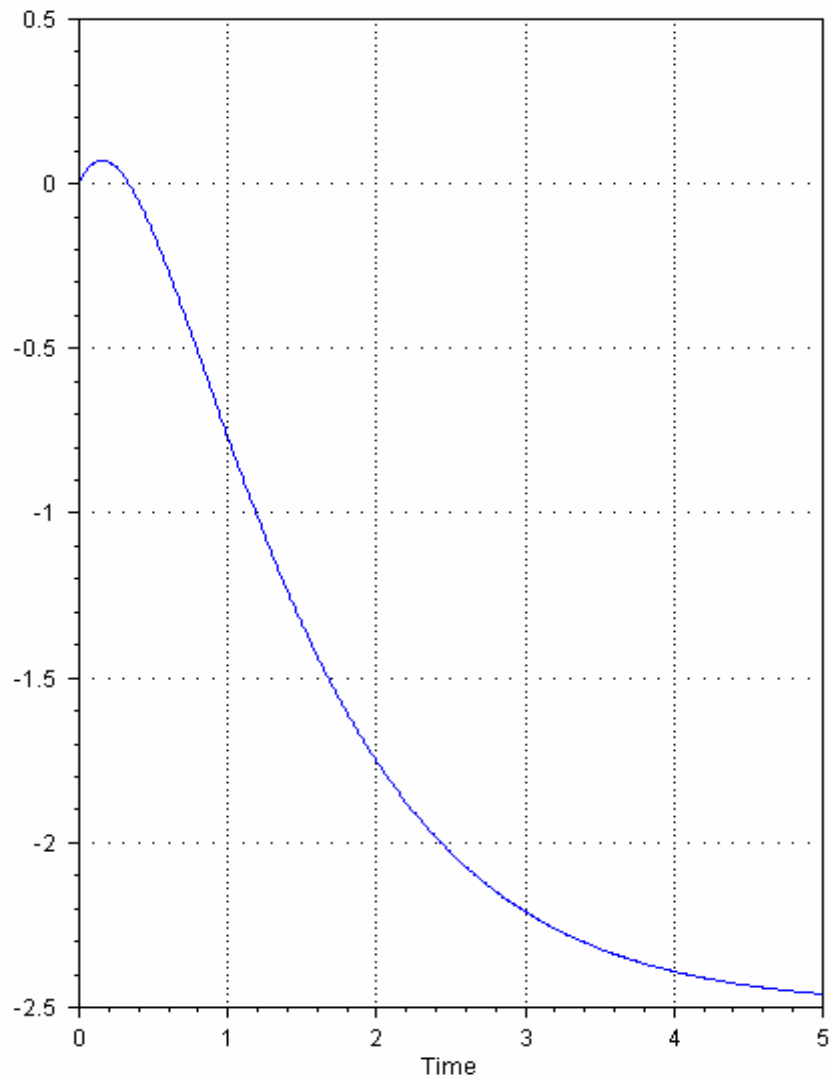
$$g(s) = \frac{s-5}{s^2 +3s +2}$$

we will have to enter the function first

CC>g=(s-5)/(s^2+3*s+2)

Followed by

CC>time(g)

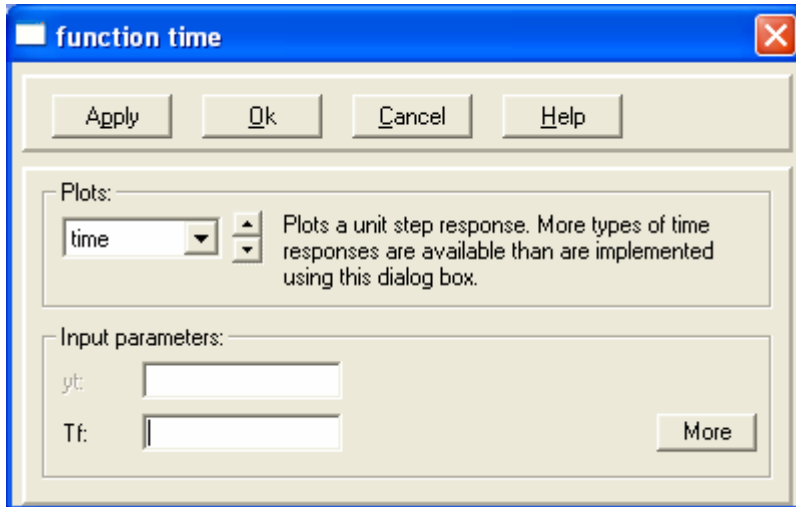Afterwards, a new window will open with the time response:

Once again, double clicking on the graph will allow to change values for the axes, add labels, etc.

Alternatively, by just typing

CC>time
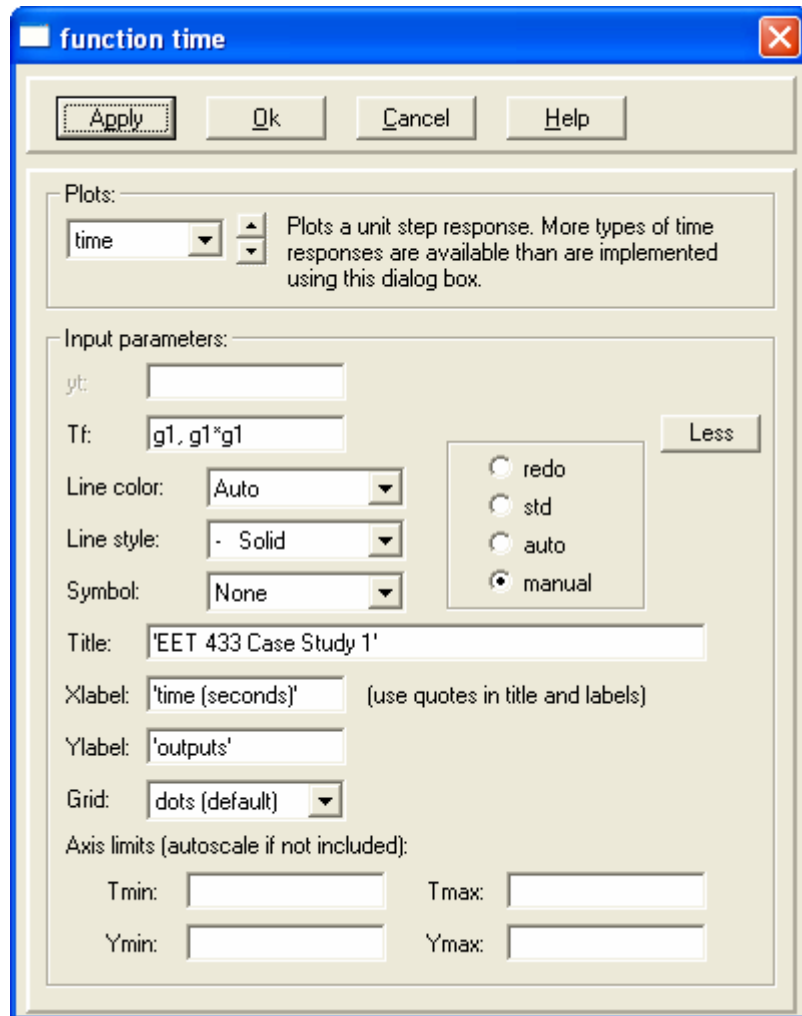
The following dialog window will appear:

That will give us more flexibility in choosing parameters. The dialog box can be expanded by clicking on the **More** button. This will allow to place labels, colors of the graph, etc:

You can also plot the time response of different functions, separating them by commas in the box **Tf**. You can also enter mathematical operations in this box.
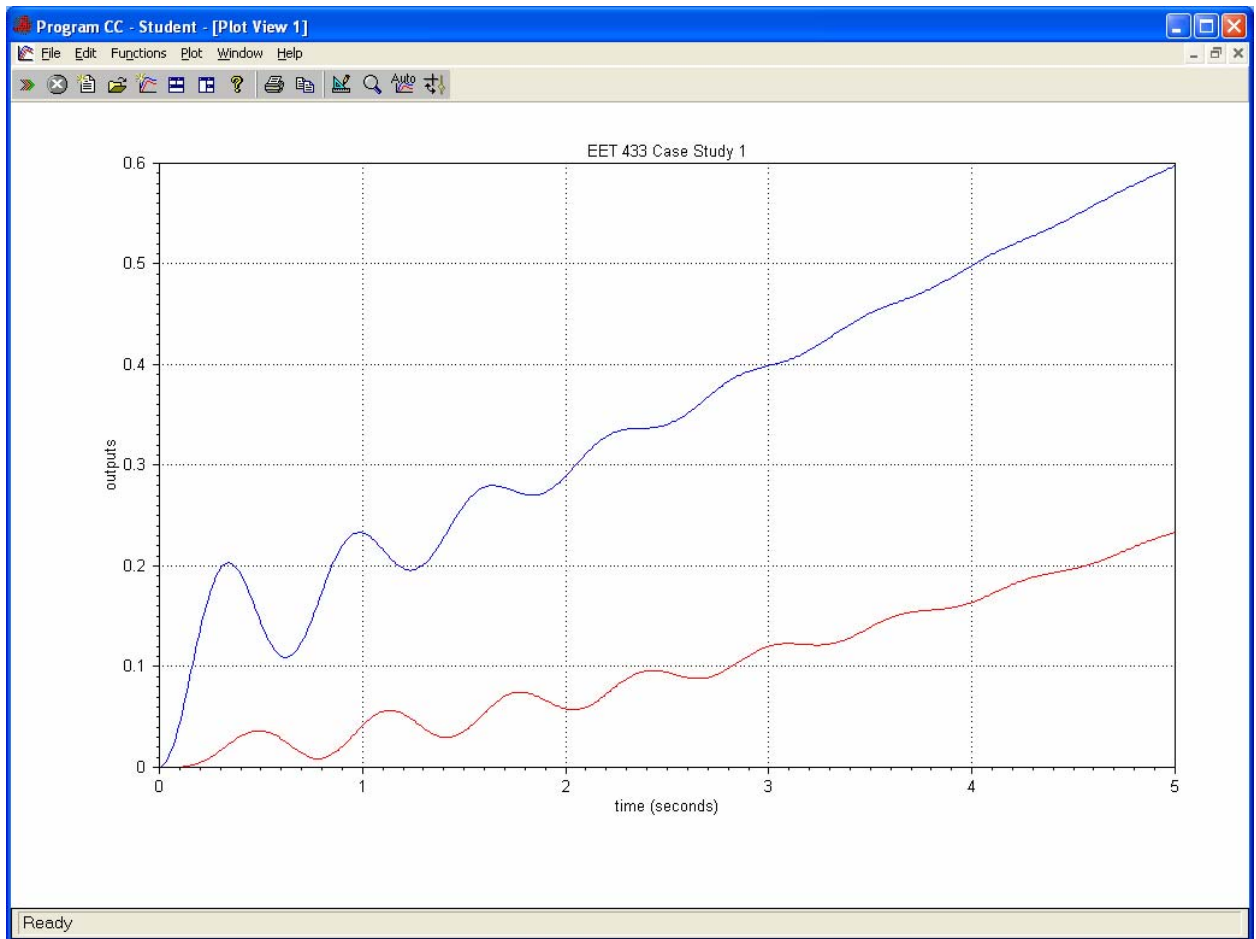
Example: We want to plot the step response of two functions: g1(s) and $[g1(s)]^2$. We will proceed as

CC>time   and the following window will appear:

We enter the transfer functions we want to plot, titles, labels, etc.

The output will display both functions:

Important! Remember that *time* plots the step response, so it automatically multiplies the transfer function by 1/s. Keep this in mind when trying to find different outputs.

The function *sim* produces a vector that contains the response of the system for different input functions. In order to plot the output, use the function *plot.*

8.- ADDITIONAL FUNCTIONS

This tutorial has explored some of the functions that will be commonly used in this course. The full list of commands and functions can be found at:

http://www.programcc.com/pdf/PCC_command_list.PDF