Signals Systems and Transforms
EEET-332
Lab 5

Prelab: There is no prelab/quiz this week.

Section 1: Skill Building (BODE Plots)

This handout provides instructions on making a BODE plot in MATLAB. A Bode plot is a graphical representation of the frequency response of a system. The example below plots the transfer function Av.

$$\boldsymbol{Av} = \frac{\boldsymbol{K(s+z)}}{\boldsymbol{(s+p1)(s+p2)}}$$

Create a new script, name it section1.m, and enter the MATLAB code below.

Lab 5

Section 1 Transfer Function in Symbolic Form

```
% Enter symbolic transfer function
syms s k z p1 p2
Av = k*(s+z)/((s+p1)*(s+p2))
k=25; z=7; p1=0.01; p2=200;
Av=subs(Av)
```

Section 2: Bode plot of a Continuous-time model

In MATLAB, a polynomial is represented by a row vector of its coefficients, for example, the polynomial $s^3 + 4s + 10$ is specified as [1 0 4 10].

1) The transfer function from Section 1 can be converted to row vectors using the numden() and sympoly() functions. Create a new script and name it section2.m, add the code below to your script.

Section 2 Transfer function converted to Continuous Time Model.

```
% Convert symbolic equation to numerator and denominator row vectors
[symNum,symDen] = numden(Av)
num = sym2poly(symNum)
den = sym2poly(symDen)
```

2) The tf() command is used to create Creating Continuous-Time Models that are used by bode(), impulse(), step() and many other Control System Toolbox functions. Add the code below to your script.

```
% Create a continuous-time model of the transfer function
AvTF =tf(num,den)
```

3) The bode() command creates a Bode plot of a Creating Continuous-Time Models. Add the code below to your script.

```
bode(AvTF)
```

Section 3: Setting Bode Options

We can add a grid, change the x scale, and change the y scale and much more using the bodeoptions.

1) To add a grid call bodeoptions. This function puts all the options in a variable of your choosing (the example uses opts). Then, as shown below, opts. Grid is set to 'on' and opts is passed to bode as the last argument.

Section 3 Setting Bode options

```
opts = bodeoptions
%Turning on a grid
opts.Grid = 'on';
bode(AvTF,opts)
```

Lots of options are available.

```
opts =

                  FreqUnits: 'rad/s'
                  FreqScale: 'log'
                   MagUnits: 'dB'
                   MagScale: 'linear'
                 MagVisible: 'on'
             MagLowerLimMode: 'auto'
                  PhaseUnits: 'deg'
                PhaseVisible: 'on'
              PhaseWrapping: 'off'
              PhaseMatching: 'off'
          PhaseMatchingFreq: 0
    ConfidenceRegionNumberSD: 1
                MagLowerLim: -Inf
       PhaseMatchingValue: 0
     PhaseWrappingBranch: -180
                IOGrouping: 'none'
              InputLabels: [1×1 struct]
             OutputLabels: [1×1 struct]
             InputVisible: {'on'}
            OutputVisible: {'on'}
                    Title: [1×1 struct]
                   XLabel: [1×1 struct]
                   YLabel: [1×1 struct]
                TickLabel: [1×1 struct]
                     Grid: 'off'
                GridColor: [0.1500 0.1500 0.1500]
                     XLim: {[1 10]}
                     YLim: {[1 10]}
                  XLimMode: {'auto'}
                  YLimMode: {'auto'}
```

2) Changing the x and y limits can help when hand sketching the SLA (straight line approximation) on the bode plot to check it. Change your code to remake the bode plot with new x y limits. Besides, change the frequency units to Hz.

```
% Setting x and y limits
opts = bodeoptions;
opts.Grid = 'on';
opts.xlim = [10^-4 10^3];
opts.ylim ={[-60 60],[-90 0]};
opts.FreqUnits = 'Hz';
bode(AvTF,opts)
```

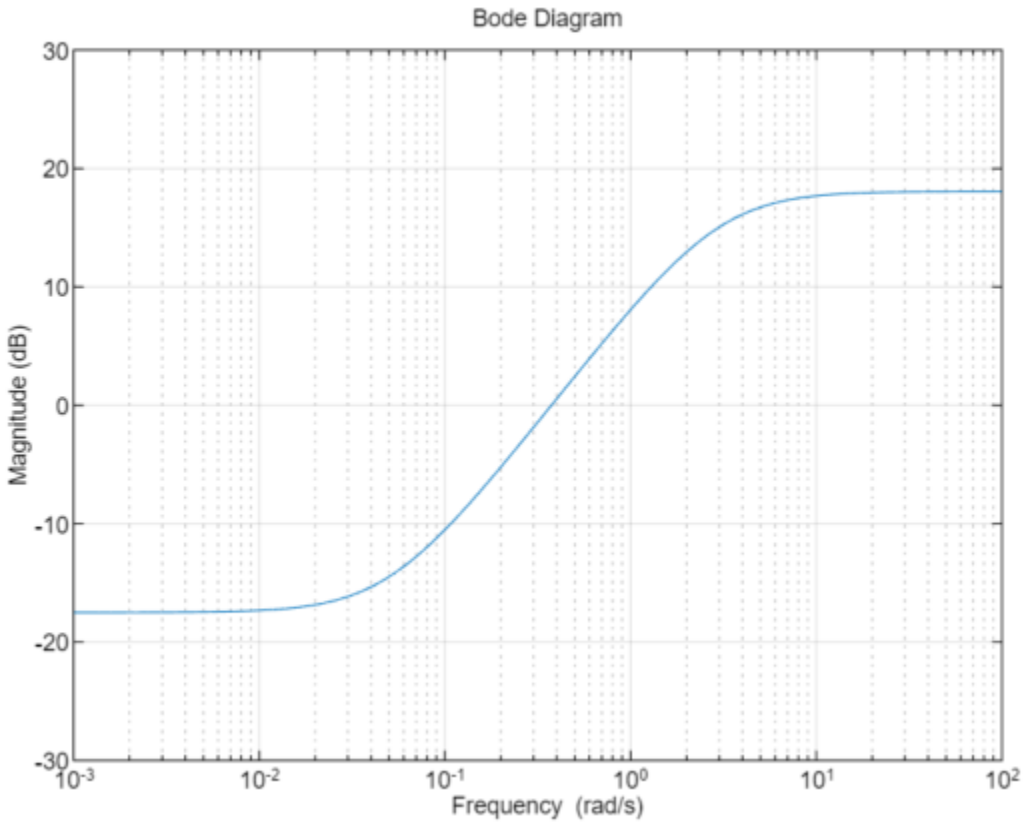
A single set of limits is used for xlim that apply to both the magnitude and phase plots. Two sets of limits are used with ylim. The first set applies to the magnitude and the second to the phase.

3) For a larger magnitude plot, the code below turns off the phase plot. Change your code to display only the magnitude plot. Notice that only a single set of ylim values are provided.

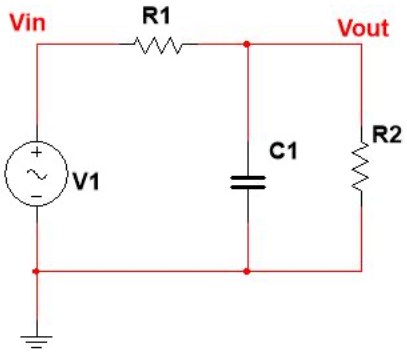
```
% Only magnitude plot
opts = bodeoptions;
opts.Grid = 'on';
opts.PhaseVisible = 'off';
opts.xlim = [10^-4 10^3];
opts.ylim ={[-60 60]};
opts.FreqUnits = 'Hz';
bode(AvTF,opts)
```

4) Plot a magnitude only Bode for Av2 (answer given below) **and get a sign-off**. It's a good idea to use bode without opts on the first run to help you find the x and y limits you want. Sometimes the default values are fine, if not you can expand the y limits to make the SLA easier to draw.

$$\boldsymbol{Av2 = \frac{8(s + 0.05)}{(s + 3)}}$$



Section 4: Circuit



The code below makes a bode plot for $\frac{V_{out}}{V_{in}}$. Create a new file and name it section4.m, add the code below.

Section 4 Transfer function.

```
46  syms s C1 R1 R2
47  % Symbolic Function
48  Zc=1/(s*C1)
49  Zp=simplifyFraction(R2*Zc/(R2+Zc))
50  Zin=simplifyFraction(R1 + Zp)
51  Av3=simplifyFraction(Zp/Zin)
52  % Plug in values
53  C1=2; R1=5; R2=3;
54  Av3=subs(Av3)
55  % Convert to polynomials
56  [symNum,symDen] = numden(Av3)
57  num = sym2poly(symNum)
58  den = sym2poly(symDen)
59  % Create a continuous-time model of the transfer function
60  Av3TF =tf(num,den)
61  bode(Av3TF)
62
```

The code below creates the transfer function in continuous-time mode directly. It is similar to the symbolic method used above but does not need to be converted to continuous-time. The variable s is defined as a continuous time variable**.**

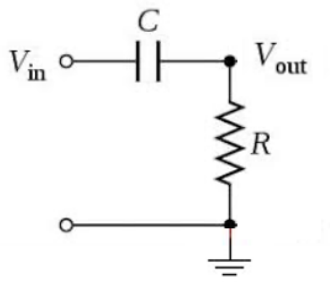
Enter Transfer Function as Continuous Time Model

```
s=tf('s');
C1=2; R1=5; R2=3;
ZC1=1/(s*C1)
Zp=minreal(R2*ZC1/(R2+ZC1))
Zin=minreal(R1+Zp)
Av4=minreal(Zp/Zin)
bode(Av4)
```

Show the bode plot with a grid, set the x-axis (frequency) units to Hz, and get a sign-off.

Section 5. RC Circuit

Make a magnitude-only Bode plot for $\frac{V_{out}}{V_{in}}$ of the circuit below, add a grid, and set the x-axis (frequency) units to Hz. **Submit a screenshot of the MATLAB code and the magnitude Bode plot.**



C = 0.0047 F and R = 10 Ohms

Report:

Create your cover page.
Submit your cover page, the requested screenshots from section 5, and this sign-off sheet.

Sign-offs

Name _____

Section 3: Bode plot with grid

	/ /
Signature	Date

Section 4: Frequency response in Hz

	/ /
Signature	Date