

LAB 3 source code

April 18, 2021

```
[152]: import numpy as np
import matplotlib.pyplot as plt
import csv
import math

#function for reading the csv data
def csv_reader(name):
    with open(name) as f:
        data = np.asarray(list(csv.reader(f, delimiter=',')))
    Xval = np.asarray(data[1:,0]).astype('float')
    Yval = np.asarray(data[1:,1]).astype('float')

    return Xval, Yval

#plotting function
def plotter(xdata, ydata, xlabel=' ', ylabel=' ', ptitle=' ', noshow=1,
    →legend=' '):
    fig1 = plt.plot(xdata, ydata, label=legend)
    plt.xlabel(xlabel)
    plt.ylabel(ylabel)
    plt.title(ptitle)
    if legend == ' ': # ignores legend if no input
        pass
    else:
        plt.legend()

    plt.savefig(ptitle, dpi=100)
    if noshow == 0: # doesn't call show(), usefull for when you need multiple
    →plots in the same figures
        plt.show()

# how lineplotting works
# plot([x1, x2], [y1, y2], color='k', linestyle='-', linewidth=2)
```

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# function for extracting the -3db freq
def breakpoint(xdata, ydata, crop=0, BWP=1, DCP=0):
    if crop == 1:
        Datapoint = np.where(0 <= ydata)
        xpoints = xdata[Datapoint]
        ypoints = ydata[Datapoint]
    else:
        xpoints = xdata
        ypoints = ydata

    maxV = np.amax(ypoints, axis=0)
    dbVal = 20*math.log10(maxV) #Ref point is set to 1V
    BWpoint = (10**((dbVal-3)/20))
    Xbw = np.asarray(np.where(BWpoint <= ypoints))

    intpoint = Xbw[0,-1]
    print("the -3db point is at: ", BWpoint, "V")
    print("maximum voltage is: ", maxV, "V")
    print("DC gain is:", dbVal, "db")
    print("Bandwidth is: {:.2e} Hz".format(xpoints[intpoint]));
    print("GBW is: {:.2e}".format(maxV*xpoints[intpoint]))

    if BWP == 1:
        bandwidth = xpoints[intpoint]
        return BWpoint, intpoint, bandwidth
    else:
        return BWpoint, intpoint

```

[166]: *# Task 1 Bandwidth*

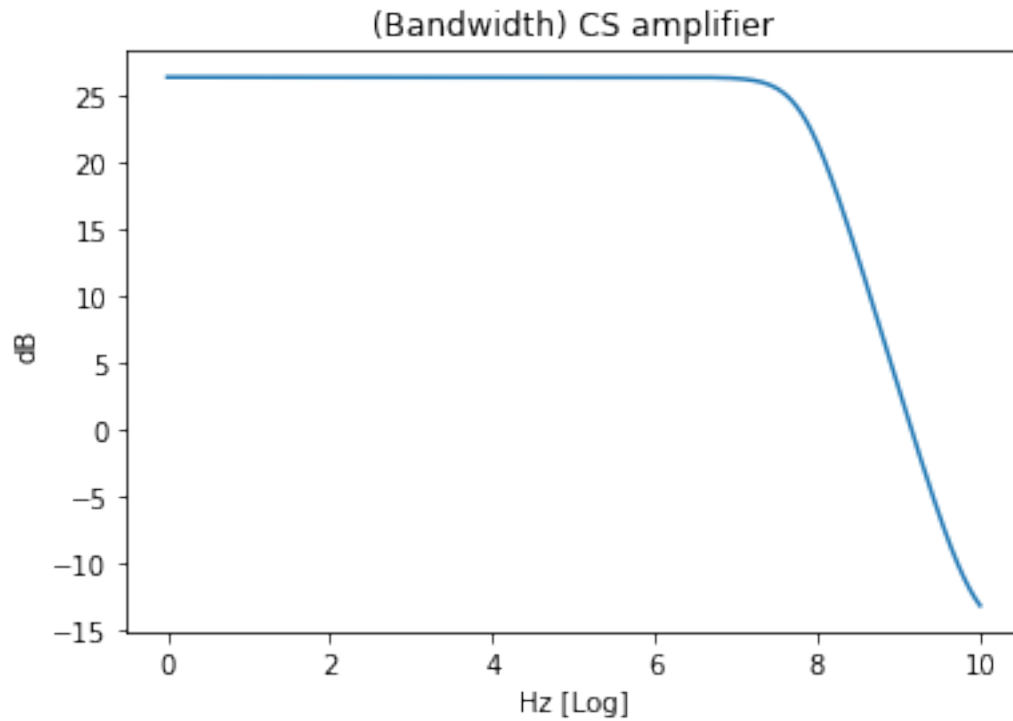
```

x_ac1, y_ac1 = csv_reader('T1_BW_PL.csv')
BWpoint = np.amax(y_ac1, axis=0)
BWy = np.asarray(np.where((BWpoint - 3) <= y_ac1))
BWHz = x_ac1[BWy[0,-1]]
print("{:.4e} Hz".format(BWHz))
print("DC gain is:", BWpoint, "dB")
plotter(np.log10(x_ac1), y_ac1, xlabel="Hz [Log]", ylabel='dB',
        title='(Bandwidth) CS amplifier')

```

6.7608e+07 Hz

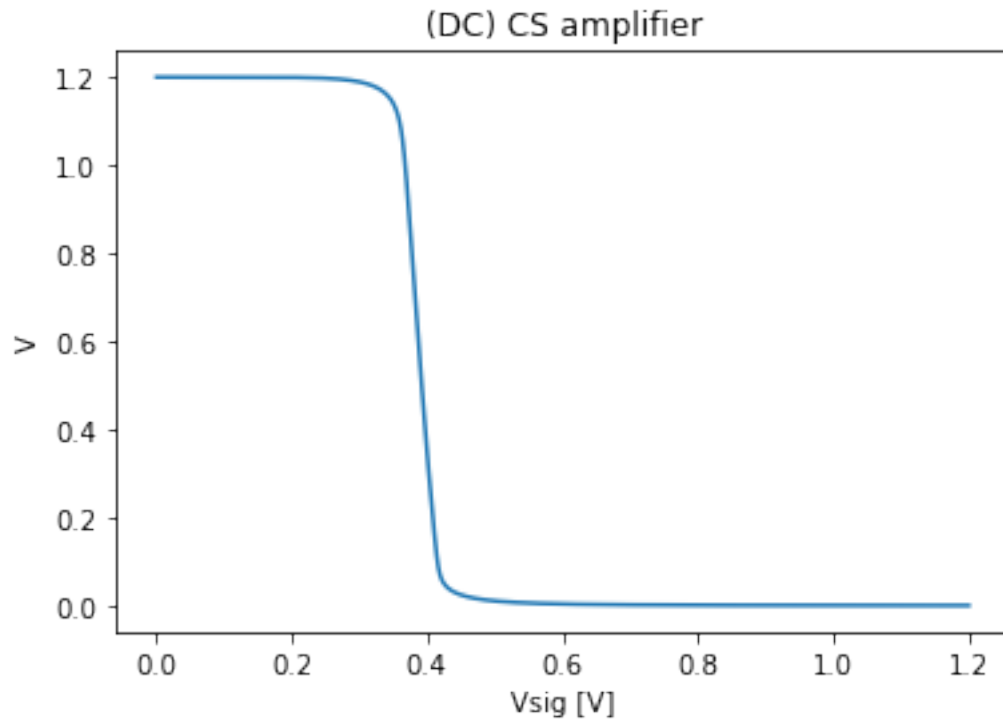
DC gain is: 26.30225944979901 dB



```
[154]: # Task 1 operating point
x_ac1, y_ac1 = csv_reader('T1_CS_operating_point.csv')

plotter(x_ac1, y_ac1, xlabel="Vsig [V]", ylabel='V', ptitle='(DC) CS_
→amplifier', noshow=0)

DCpoint = np.asarray(np.where(0.6 <= y_ac1))
print("Calculated Vsig bias: {:.4f} V".format(x_ac1[DCpoint[0,-1]]))
```



Calculated Vsig bias: 0.3864 V

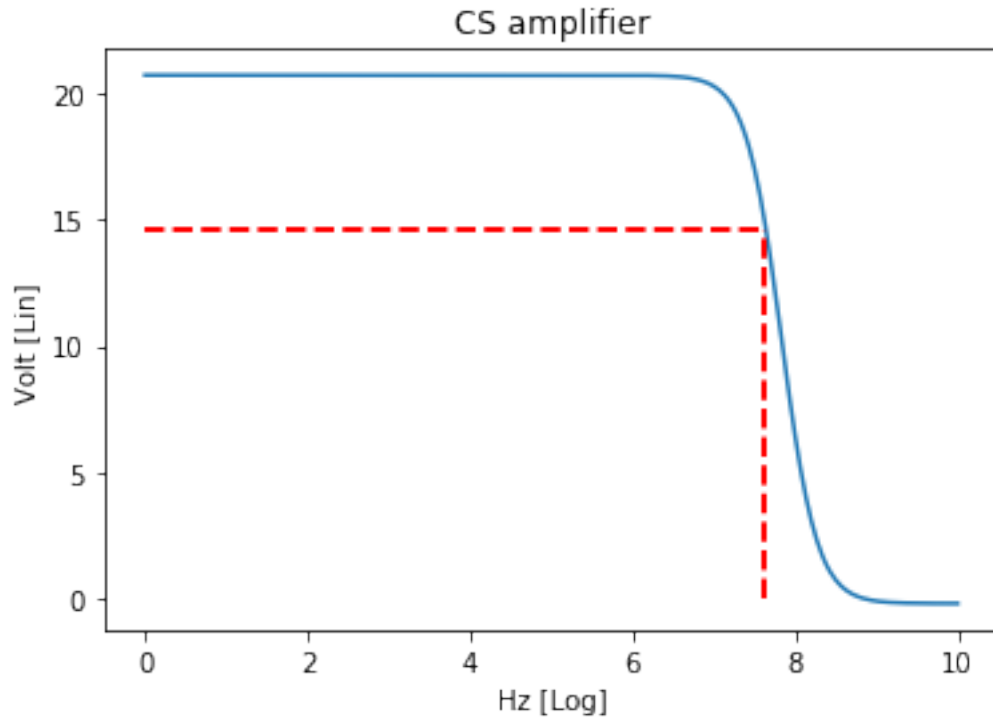
```
[155]: # Task 1
x_ac1, y_ac1 = csv_reader('T1_CS_AC_SW.csv')

plotter(np.log10(x_ac1), -y_ac1, xlabel="Hz [Log]", ylabel='Volt [Lin]',
        title='CS amplifier')

BWpt, intpoint, cbandwidth = breakpoint(x_ac1, -y_ac1, crop=0)

plt.plot([0, np.log10(x_ac1[intpoint])], [BWpt, BWpt], color='r',
        linestyle='--', linewidth=2)
plt.plot([np.log10(x_ac1[intpoint]), np.log10(x_ac1[intpoint])], [0, BWpt],
        color='r', linestyle='--', linewidth=2)
plt.show()
```

the -3db point is at: 14.654910952190274 V
maximum voltage is: 20.70061193307196 V
DC gain is: 26.319663677474914 db
Bandwidth is: 4.30e+07 Hz
GBW is: 8.90e+08

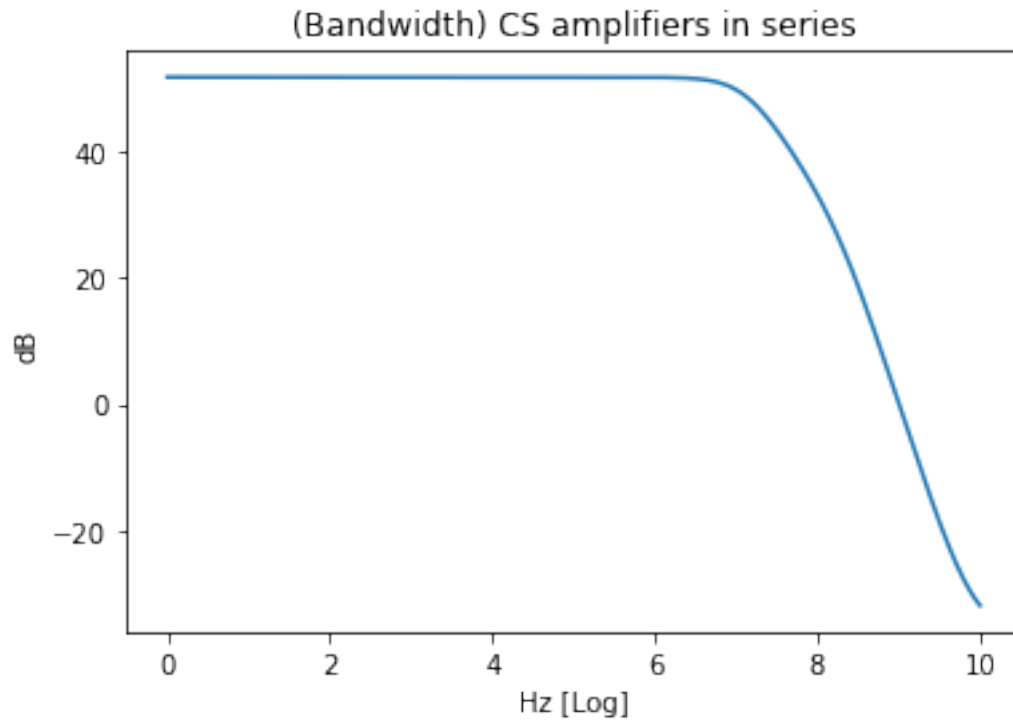


[167]: *# Task 2 Bandwidth*

```
x_ac1, y_ac1 = csv_reader('T2_BW_PL.csv')
BWpoint = np.amax(y_ac1, axis=0)
BWy = np.asarray(np.where((BWpoint - 3) <= y_ac1))
BWHz = x_ac1[BWy[0,-1]]
print("{:.4e} Hz".format(BWHz))
print("DC gain is:", BWpoint, "dB")
plotter(np.log10(x_ac1), y_ac1, xlabel="Hz [Log]", ylabel='dB',
        ptitle='(Bandwidth) CS amplifiers in series')
```

1.2882e+07 Hz

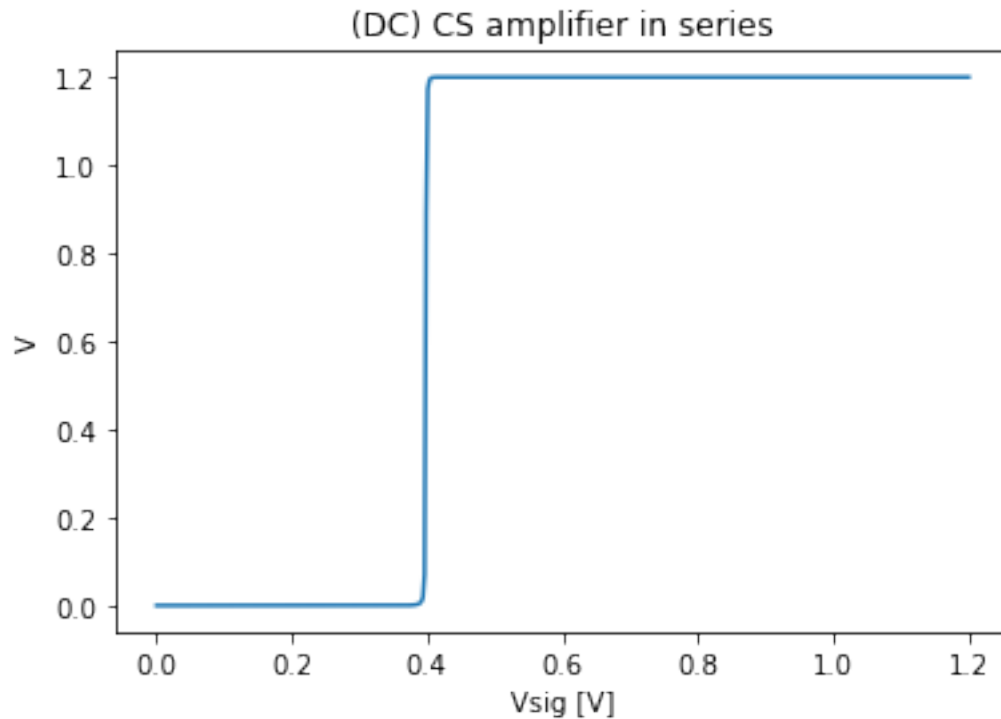
DC gain is: 51.77278902711033 dB



```
[157]: # Task 2 operating point
x_ac1, y_ac1 = csv_reader('T2_CS_operating_point.csv')

plotter(x_ac1, y_ac1, xlabel="Vsig [V]", ylabel='V', ptitle='(DC) CS amplifier_
→in series', noshow=0)

DCpoint = np.asarray(np.where(0.6 <= y_ac1))
print("Calculated Vsig bias: {:.4f} V".format(x_ac1[DCpoint[0,0]]))
```



Calculated Vsig bias: 0.3984 V

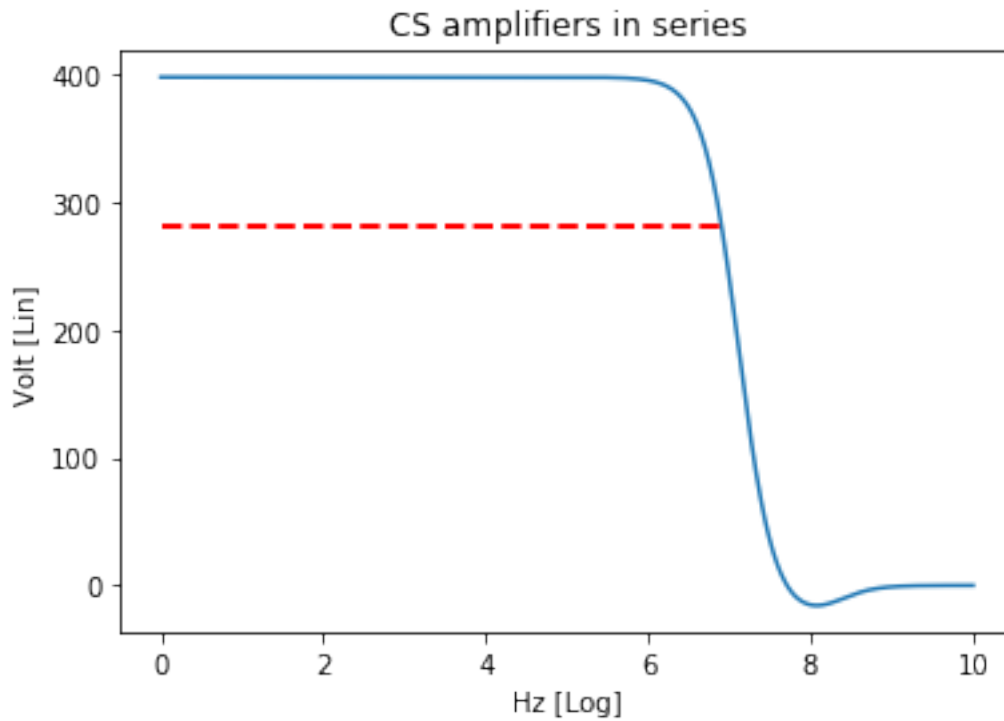
```
[158]: #Task 2

x_ac2, y_ac2 = csv_reader('T2_CS_AC_SW.csv')

plotter(np.log10(x_ac2), y_ac2, xlabel="Hz [Log]", ylabel='Volt [Lin]',
        ↳ptitle='CS amplifiers in series')
# Bandwidth is 13.081 MHz
BWpt, intpoint, cbandwidth = breakpoint(x_ac2, y_ac2, crop=0)

plt.plot([0, np.log10(x_ac2[intpoint])], [BWpt, BWpt], color='r',
        ↳linestyle='--', linewidth=2)
#plt.plot([np.log10(x_ac2[intpoint]), np.log10(x_ac2[intpoint])], [0, BWpt],
        ↳color='r', linestyle='--', linewidth=2)
plt.show()
```

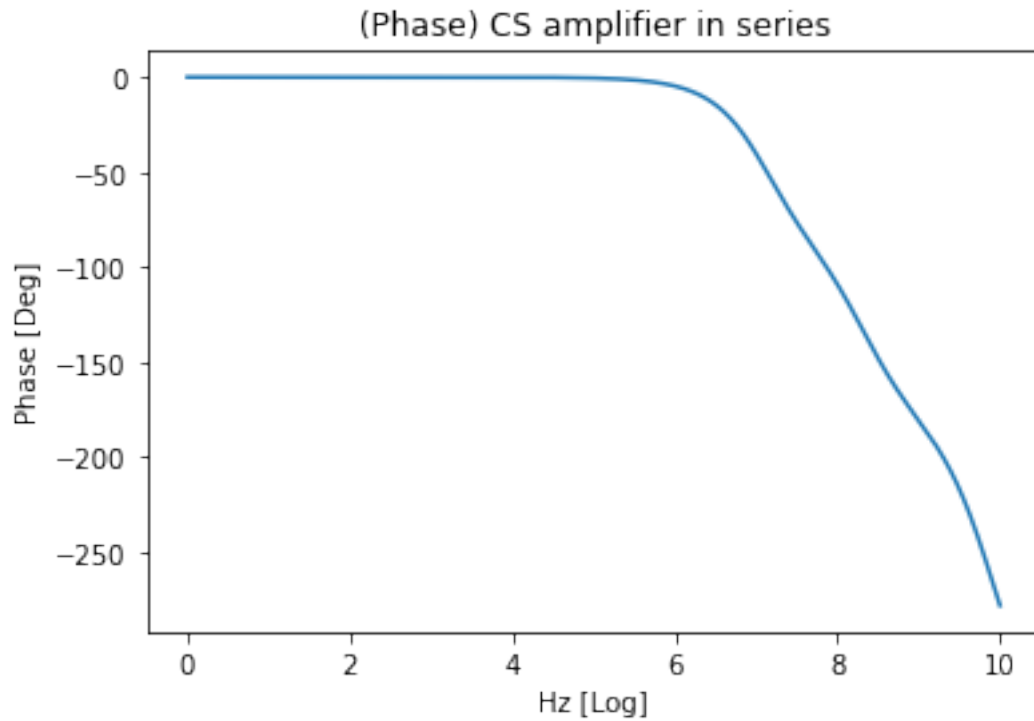
the -3db point is at: 281.853710682784 V
maximum voltage is: 398.1289484306718 V
DC gain is: 52.00047513603874 db
Bandwidth is: 7.94e+06 Hz
GBW is: 3.16e+09



```
[159]: # task 2 Phase plot
x_ac2, y_ac2 = csv_reader('T2_PH_AC_SW.csv')

plotter(np.log10(x_ac2), y_ac2, xlabel="Hz [Log]", ylabel='Phase [Deg]',
        ↳ptitle='(Phase) CS amplifier in series')

#These values were copied from cadence, as we couldnt find a way to link them
↳after exporting the data
#Phase angle at 0db: 782MHz -174deg, approx
```

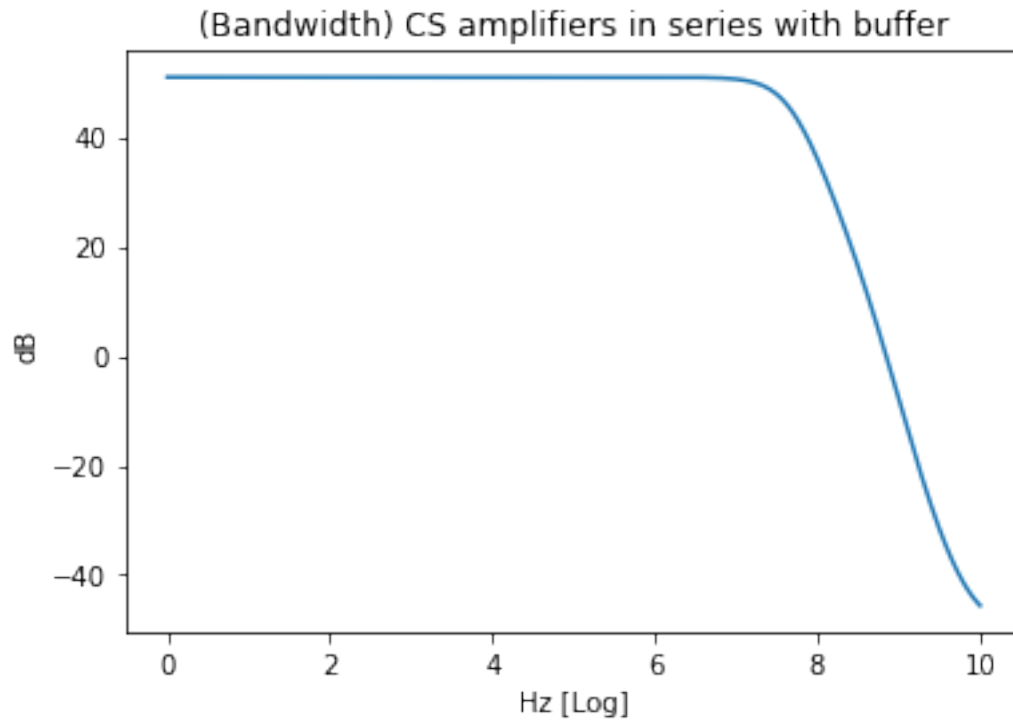



```
[160]: # Task 3 Bandwidth

x_ac1, y_ac1 = csv_reader('T3_BW_PL.csv')
BWpoint = np.amax(y_ac1, axis=0)
BWy = np.asarray(np.where((BWpoint - 3) <= y_ac1))
BWHz = x_ac1[BWy[0,-1]]
print("{:.4e} Hz".format(BWHz))

plotter(np.log10(x_ac1), y_ac1, xlabel="Hz [Log]", ylabel='dB',
        ↳ptitle='(Bandwidth) CS amplifiers in series with buffer')
```

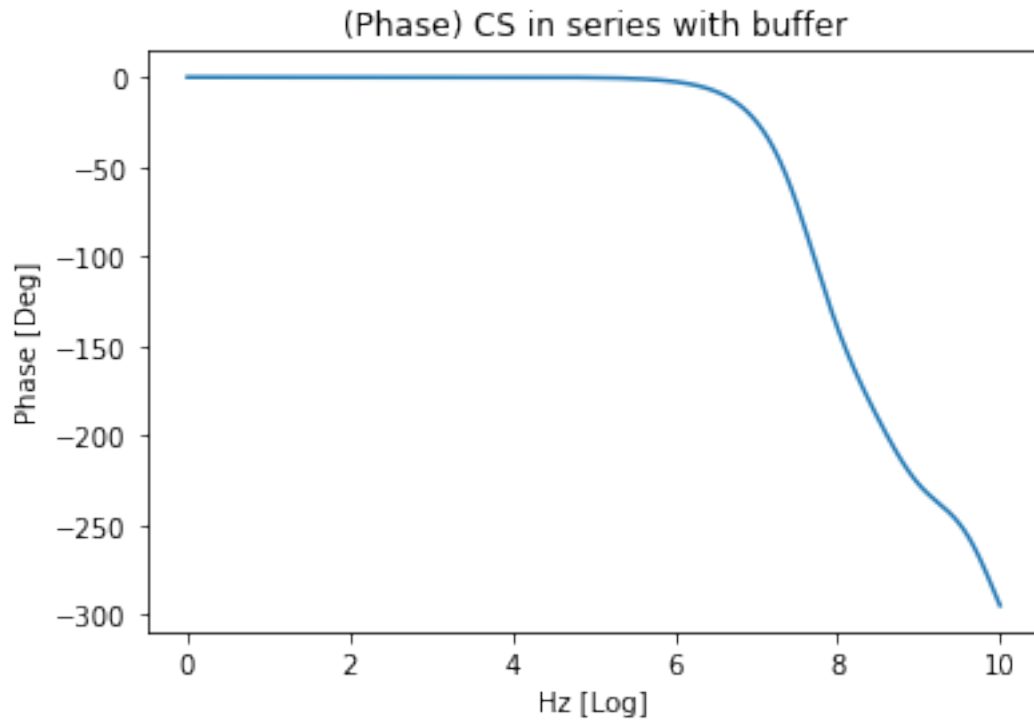
3.0200e+07 Hz



```
[161]: # task 3 Phase plot
x_ac2, y_ac2 = csv_reader('T3_PH_AC_SW.csv')

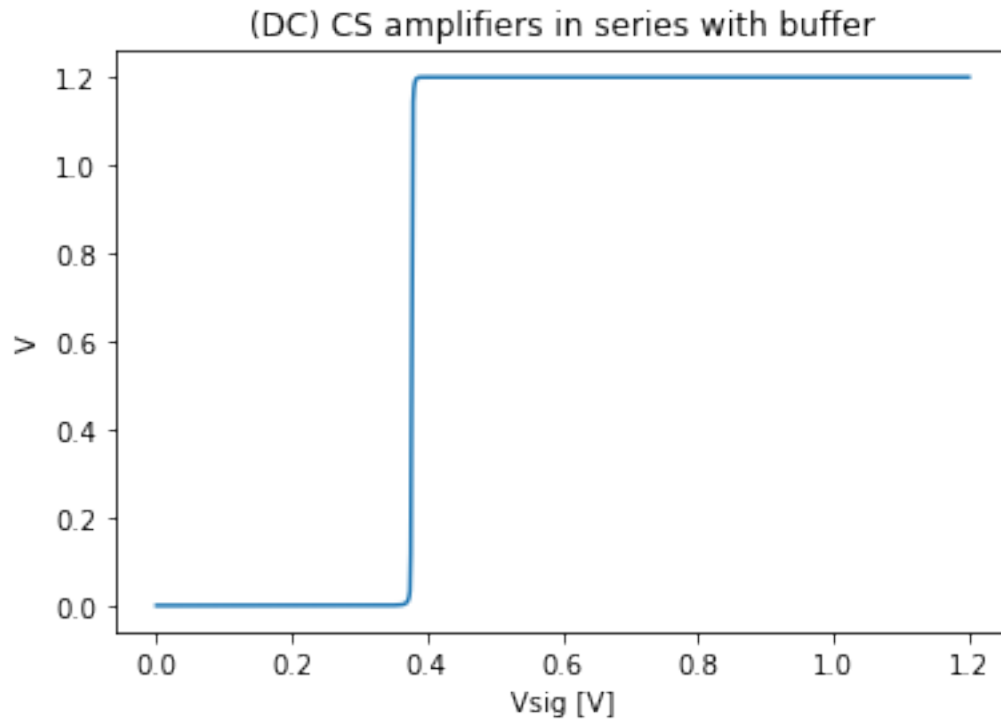
plotter(np.log10(x_ac2), y_ac2, xlabel="Hz [Log]", ylabel='Phase [Deg]',
        ↳ptitle='(Phase) CS in series with buffer')

#These values were copied from cadence, as we couldnt find a way to link them
↳after exporting the data
#Phase angle at 0db: 120MHz -149deg, approx
```



```
[162]: # Task 3 operating point
x_ac1, y_ac1 = csv_reader('T3_DC_SW.csv')

plotter(x_ac1, y_ac1, xlabel="Vsig [V]", ylabel='V', ptitle='(DC) CS amplifiers_
↳in series with buffer', noshow=0)
# Bandwith is 30.7719 MHz
DCpoint = np.asarray(np.where(0.6 <= y_ac1))
print("Calculated Vsig bias: {:.4f} V".format(x_ac1[DCpoint[0,0]]))
```



Calculated Vsig bias: 0.3780 V

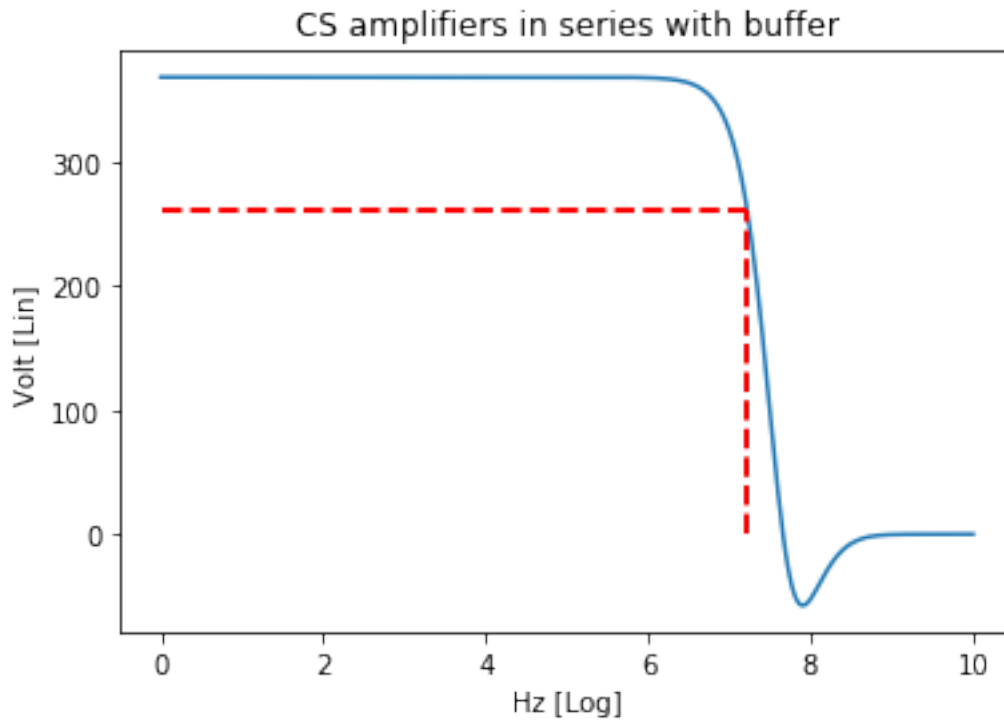
```
[163]: #Task 3 AC sweep
x_ac2, y_ac2 = csv_reader('T3_CS_SF_AC_SW.csv')

plotter(np.log10(x_ac2), y_ac2, xlabel="Hz [Log]", ylabel='Volt [Lin]',
        title='CS amplifiers in series with buffer')

BWpt, intpoint, cbandwidth = breakpoint(x_ac2, y_ac2, crop=0)

plt.plot([0, np.log10(x_ac2[intpoint])], [BWpt, BWpt], color='r',
        linestyle='--', linewidth=2)
plt.plot([np.log10(x_ac2[intpoint]), np.log10(x_ac2[intpoint])], [0, BWpt],
        color='r', linestyle='--', linewidth=2)
plt.show()
```

the -3db point is at: 260.8422051892759 V
maximum voltage is: 368.4494080520445 V
DC gain is: 51.32755726250462 db
Bandwidth is: 1.58e+07 Hz
GBW is: 5.84e+09



```
[164]: # Task 3 Phase plot

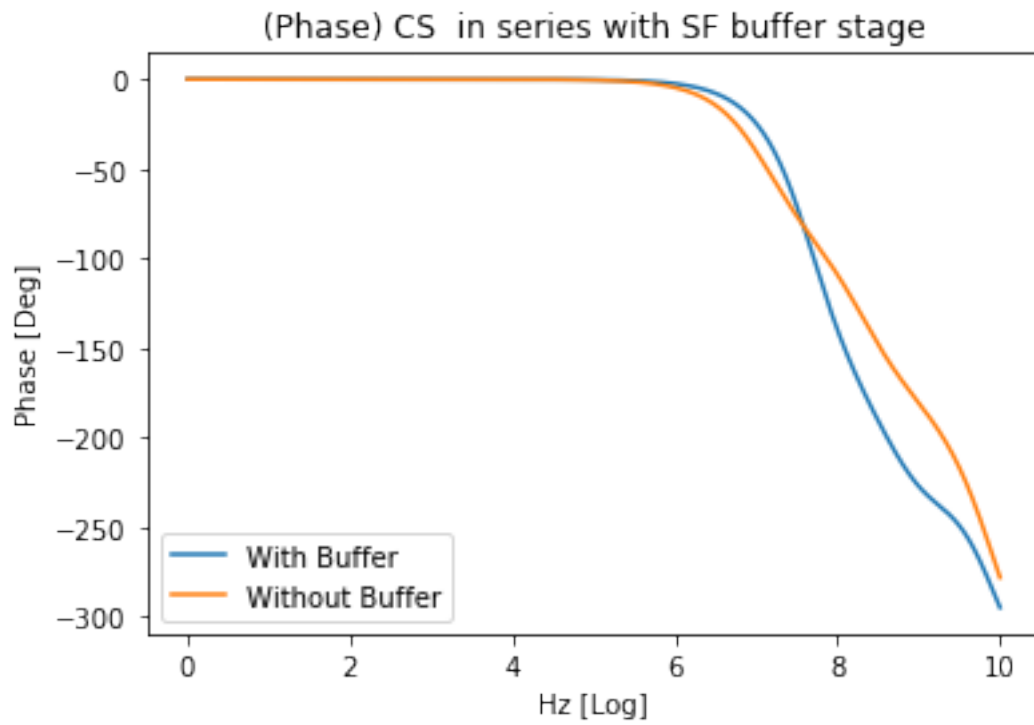
x_ac2, y_ac2 = csv_reader('T3_PH_AC_SW.csv')

plotter(np.log10(x_ac2), y_ac2, xlabel="Hz [Log]", ylabel='Phase [Deg]',
        ↳ptitle='(Phase) CS in series with SF buffer stage', legend='With Buffer')

x_ac2, y_ac2 = csv_reader('T2_PH_AC_SW.csv')

plotter(np.log10(x_ac2), y_ac2, xlabel="Hz [Log]", ylabel='Phase [Deg]',
        ↳ptitle='(Phase) CS in series with SF buffer stage', legend='Without Buffer')

plt.show()
```



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