VE311 Homework 9

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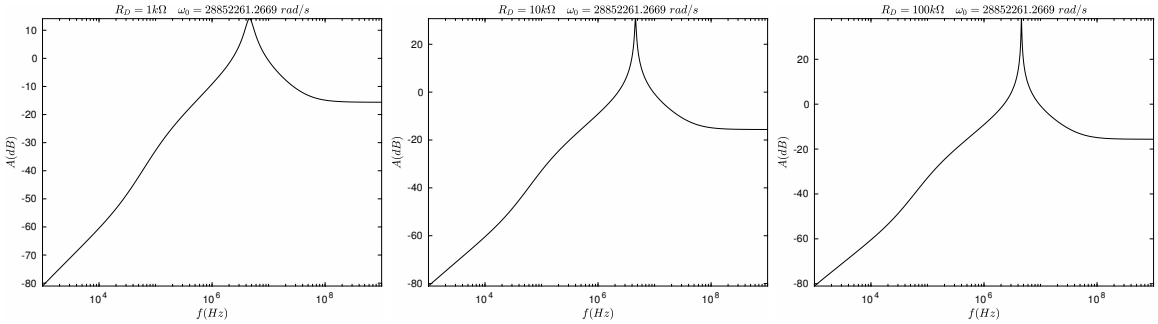
Problem 1.



(a) $R_D = 1k\Omega$ (b) $R_D = 10k\Omega$ (c) $R_D = 100k\Omega$

(d) $R_D = 500k\Omega$ (e) $R_D = 1M\Omega$

Figure 1: Output response different values of R_D.

In Figure 1, We can find that $\omega_0 = 28.852\,\text{Mrad/s}$ in different values of R_D. There is also a figure of all resistances (Figure 2), in which we can find that the larger R_D is, the larger the output response.

The spice code is

[p1.cir.head]

```
p1.cir
.TITLE Problem 1

Vi  1   0   AC  10V
C1  1   2   0.01U
CGD 2   4   20P
CGS 2   3   50P
```

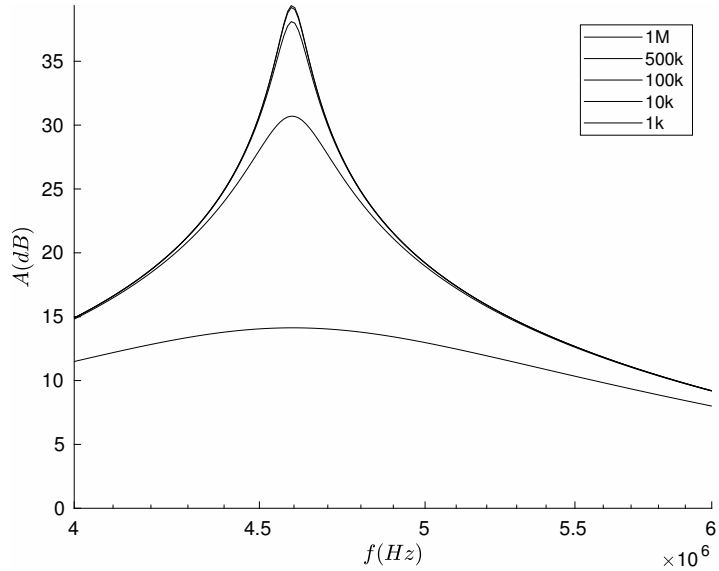


Figure 2: Output response different values of R_D in one graph.

```
RG  0   2   100K
RS  0   3   500
CS  0   3   0.01U
L   4   5   10U
CL  4   5   100P
C2  4   6   0.01U
R3  0   6   100K
VDD 5   0   DC  15V
M1  4   2   3   3   NFET
.MODEL NFET NMOS (LAMBDA=0.02 VTO=-2 KP=5M)
```

[p1.cir.tail]

```
.AC DEC 1000 1K 1G
.MEASURE AC w0 MAX_AT VM(6)
.PRINT AC VM(6)
.PROBE
.END
```

The shell code is

```
#/bin/bash

RD=(1K 10K 100K 500K 1MEG)

for ((i=0;i<${#RD[@]};++i)); do
    cat ./p1.cir.head > temp.cir
    echo "RD  4   5   ${RD[$i]}" >> temp.cir
    cat ./p1.cir.tail >> temp.cir
    ngspice -b temp.cir > p1_${i}.result
```

```
done

rm -f ./temp.cir
```

The MATLAB code is

```
figure(1);clf;
figure(2);clf;
RD={'1k','10k','100k','500k','1M'};
for i=0:4
    fid=fopen(['p1_',num2str(i),'.result']);
    x=[];y=[];
    while 1
        line=fgetl(fid);
        if ~ischar(line), break, end
        if isempty(line), continue, end
        if isempty(str2num(line(1))), continue, end
        data=sscanf(line,'%d %f %f');
        x=[x;data(2)];
        y=[y;20*log10(data(3)/10)];
    end
    figure(1);
    hold on;
    plot(x,y);
    hold off;
    figure(2);
    plot(x,y);
    set(gca,'XScale','log');
    axis([x(1) x(end) min(y) max(y)]);
    xlabel('$$f(Hz)$$','Interpreter','Latex');
    ylabel('$$A(dB)$$','Interpreter','Latex');
    [M,I]=max(y);
    title(['$$R_D=',char(RD(i+1)),'\Omega\quad\omega_0=',num2str(x(I)*2*pi),'\
    ↪  rad/s$$'],'Interpreter','Latex');
    saveas(gcf,['p1_',num2str(i),'.eps'])
    fclose(fid);
end
figure(1);
set(gca,'XScale','log');
legend('1M','500k','100k','10k','1k');
axis([4*1e6 6*1e6 0 max(y)]);
xlabel('$$f(Hz)$$','Interpreter','Latex');
ylabel('$$A(dB)$$','Interpreter','Latex');
saveas(gcf,['p1.eps'])
%set(gca,'YScale','log')
```

Problem 2.

$$
\begin{aligned}
L(s) &= \left(1+\frac{R_4}{R_3}\right)\cdot\frac{Z_p}{Z_p+Z_s} \\
&= \left(1+\frac{R_4}{R_3}\right)\cdot\frac{1/C_1 s \parallel R_1}{1/C_1 s \parallel R_1 + 1/C_2 s + R_2} \\
&= \left(1+\frac{R_4}{R_3}\right)\cdot\frac{R_1C_2 s}{R_1R_2C_1C_2s^2+(R_1C_1+R_1C_2+R_2C_2)s+1} \\
L(j\omega) &= \left(1+\frac{R_4}{R_3}\right)\cdot\frac{R_1C_2 j\omega}{-R_1R_2C_1C_2\omega^2+(R_1C_1+R_1C_2+R_2C_2)j\omega+1}
\end{aligned}
$$

$$
\begin{cases}
\omega = 2000\pi\,\text{rad/s} \\
R_1 = R_2, R_4 = 10\,\text{k}\Omega \\
C_1 = 0.1\,\mu\text{F}, C_2 = 0.22\,\mu\text{F} \\
-R_1R_2C_1C_2\omega^2+1=0 \\
\left(1+\dfrac{R_4}{R_3}\right)\cdot\dfrac{R_1C_2}{R_1C_1+R_1C_2+R_2C_2}=1
\end{cases}
\Longrightarrow
\begin{cases}
R_1 = 1.073\,\text{k}\Omega \\
R_2 = 1.073\,\text{k}\Omega \\
R_3 = 6.875\,\text{k}\Omega
\end{cases}
$$

Problem 3.

The spice code is

```
p3.cir
.TITLE Problem 3

Vi   1    0    SIN(0 10V 1000HZ)
C1   0    1    0.1U
R1   0    1    1073
R2   1    2    1073
C2   2    3    0.22U
R4   3    4    10K
R3   4    0    6875
X1   4    1    3    OPAMP1

.SUBCKT OPAMP1   1    2    6
RIN      1    2    10MEG
EGAIN    3    0    1    2    100K
RP1      3    4    1K
CP1      4    0    1.5915UF
EBUFFER  5    0    4    0    1
ROUT     5    6    10
.ENDS

.TRAN    10NS     2MS
.PRINT TRAN V(3)
.PROBE
.END
```

The simulation result in PSPICE is shown in Figure 3

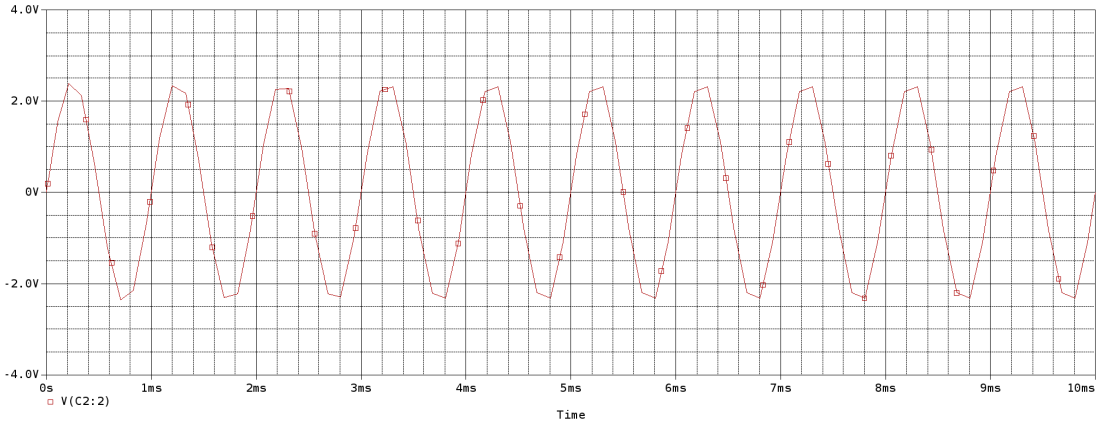


Figure 3: Simulation result.