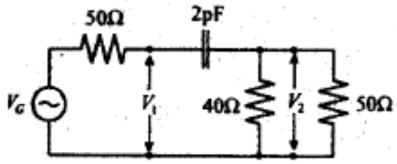
homework 5

For the simple integrator circuit shown,



determine the following quantities:
- **Transfer function $H(\omega) = V_2/V_G$**
- **Attenuation versus frequency behavior $\alpha(\omega)$**
- **Phase versus frequency behavior $\varphi(\omega)$**
- **Group delay t_g**

Plot these factors for the frequency range from DC to 1 GHz.

For the simple integrator circuit shown,

Determine the following quantities:

1 Transfer function *H(ω)=V2/VG*

2 Attenuation versus frequency behavior α(ω)

3 Phase versus frequency behavior φ(ω)

4 Group delay tg

Plot these factors for the frequency range from DC to 1GHz.

假设电阻从左到右依次为 R1,R2,R3。则可以得到如下的矩阵模式：

$$\begin{bmatrix} A & B \\ C & D \end{bmatrix} = \begin{bmatrix} 1 & R_1 \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & \frac{1}{j\omega C} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 \\ \frac{1}{R_2} & 1 \end{bmatrix}, \begin{bmatrix} 1 & 0 \\ \frac{1}{R_3} & 1 \end{bmatrix} = \begin{bmatrix} 1+(\frac{1}{j\omega C}+R_1)(\frac{1}{R_2}+\frac{1}{R_3}) & \frac{1}{j\omega C}+R_1 \\ \frac{1}{R_2}+\frac{1}{R_3} & 1 \end{bmatrix}$$

所以，可以得到传输函数：

$$H(\omega) = \frac{1}{A} = \frac{1}{1+(\frac{1}{j\omega C}+R_1)(\frac{1}{R_2}+\frac{1}{R_3})}$$

其图像为：

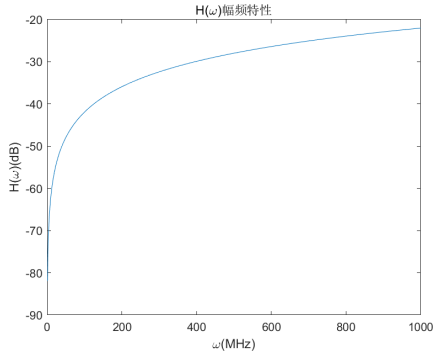


Figure 1: transfer function

Attenuation factor：

$$\alpha(\omega) = -ln(|H(\omega)|) = -20log(|H(\omega)|)$$

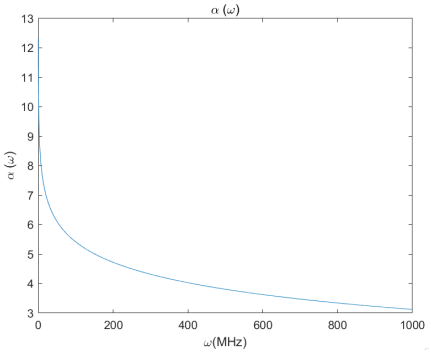


Figure 2: Attenuation factor

Corresponding phase:

$$\phi(\omega) = \arctan(\frac{Im(H(\omega))}{Re(H(\omega))})$$

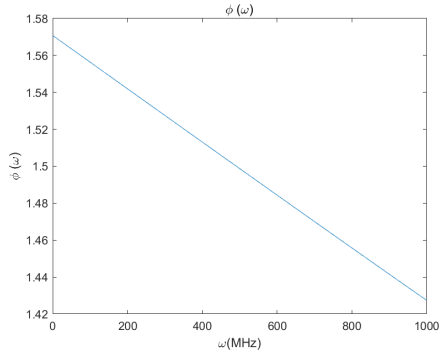


Figure 3: Corresponding phase

Group delay:

$$t_g = \frac{d\phi(\omega)}{d\omega}$$

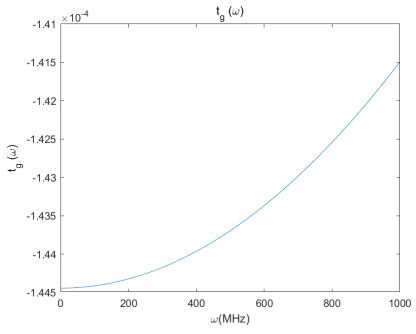


Figure 4: Group delay

matlab 代码附下：

```
%已知参数
omega=0:0.1:1000;
omega_g=omega.*10^6;
r1=50;
r2=40;
r3=50;
c=2e-12;

%transfer function
H=1./(1+(1./(1i.*omega_g.*c)+r1).*(1/r2+1/r3));
Hr=10*log10(real(H));
figure(1);
plot(omega,Hr);
title("H(\omega)幅频特性");
xlabel("\omega(MHz)");
ylabel("H(\omega)(dB)");

%Attenuation factor
a=-log(abs(H));
figure(2);
plot(omega,a);
title("\alpha (\omega)");
xlabel("\omega(MHz)");
ylabel("\alpha (\omega)");

%Corresponding phase
phi=atan(imag(H)./real(H));
figure(3);
plot(omega,phi);
title("\phi (\omega)");
xlabel("\omega(MHz)");
ylabel("\phi (\omega)");

%Group delay
aphi=diff(phi);
aw=diff(omega);
tg=aphi./aw;
figure(4);
plot(omega(1:end-1),tg);
title("t_g (\omega)");
xlabel("\omega(MHz)");
ylabel("t_g (\omega)");
```