homework 4
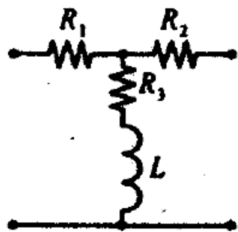
For the following T-network inserted into a transmission line with characteristic impedance of Z0 = 50Ω, the three resistances are R1=R2=8.56Ω, and R3=141.8Ω. Find the S-parameters of this configuration and plot the insertion loss as a function of inductance L for the frequency of f=2GHz and L changing from 0 to 100nH.

当电路插入到无限长的传输线中后，其电路 1所示：
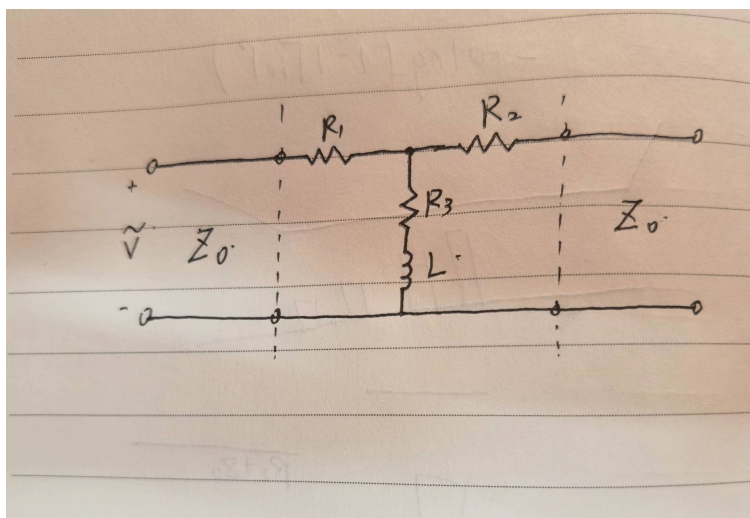

Figure 1: 电路图

通过从电压源正极看入，可以得到输入电阻：

$$Z_{in} = Z_0 + R_1 + \cfrac{1}{\frac{1}{R_2+Z_0} + \frac{1}{R_3+j\omega L}}$$

由此可得反射系数 $|\Gamma_{in}|$，也即 S11 参数：

$$S_{11} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

matlab 计算得到的结果如图 2所示：

```
ans =

(69095816858483726725*L - 820747436032i)/(172039524931314070475*L - 24620965556032i)
```

Figure 2: S11 计算值

对于 S21，可以将其视为插入损耗，其值可以通过 S11 计算得到：

$$S_{21} = -10lg(1 - |S_{11}|^2)$$

根据以上计算，借助 matlab 代码，可以得到 S11 和 S21 随 L 的变化曲线：

```matlab
%已知参数
syms L;
x=0:100;
l=x*10^(-9);
z0=50;
r1=8.56;
r2=8.56;
r3=141.8;
f=2e9;

%输入阻抗
zin=z0+r1+1./(1./(1i.*2.*pi.*f.*l+r3)+1./(r2+z0));
zin1=z0+r1+1./(1./(1i.*2.*pi.*f.*L+r3)+1./(r2+z0));

%S11参数
S11_1=(zin1-z0)./(zin1+z0);
simplify(abs(S11_1))
gin=(zin-z0)./(zin+z0);
S11=20*log10(abs(gin));
figure(1);
plot(x,S11);
title("S11参数变化曲线");
xlabel("L/nH");
ylabel("S11(dB)");

%S21参数
S21=-10.*log10(1-abs(gin).^2);
figure(2);
plot(x,S21);
title("S21参数变化曲线");
xlabel("L/nH");
ylabel("S21(dB)");
```
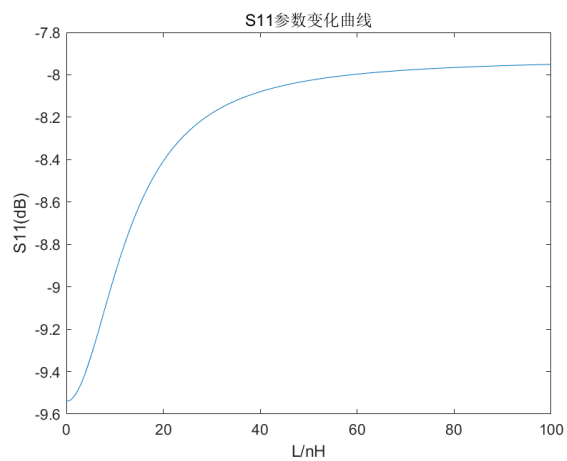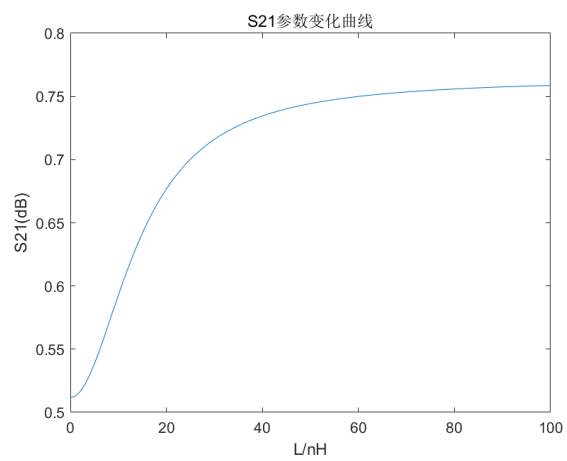
Figure 3: S11 变化曲线

Figure 4: S21 变化曲线

从电路图中可以看出，该电路有极高的对称性，所以满足：

$$S_{11} = S_{22}. S_{21} = S_{12}$$

因此，S22 和 S12 不用重复计算。