1: $Z_S=50-j100\Omega$, $P_{S\cdot max}=1W$, $L=\frac{3}{8}\lambda$, $Z_0=50\Omega$.

(1): 若欲单向传输, 则应有反射系数 $\Gamma_0=0$.

此时有: $Z_L=Z_0=50\Omega$

此时有功率反射系数: $P_R=\left\|\frac{Z_L-Z_S^*}{Z_L+Z_S}\right\|^2=\frac{P_{S\cdot max}-P_L}{P_{S\cdot max}}$

立刻得到: $P_L=P_{S\cdot max}\left[1-\left\|\frac{Z_L-Z_S^*}{Z_L+Z_S}\right\|^2\right]=0.5W$

(2): 若欲最大功率传输匹配, 则应有.

$\cancel{Z_L=Z_S^*=50+j100\Omega}$

$$Z_{in}=Z_S^*=Z_0\frac{Z_L+jZ_0\tan\frac{3\pi}{4}}{Z_0+jZ_L\tan\frac{3\pi}{4}}=Z_0\frac{Z_L-jZ_0}{Z_0-jZ_L}$$

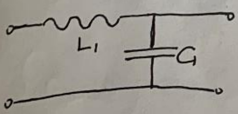
由此解得: $Z_L=50-j100\Omega$.

此时负载获得额定功率: $P_L=P_{S\cdot max}=1W$

2. 最大功率传输匹配

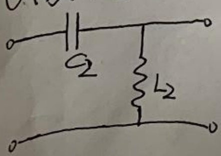
設計 $R_S=50\Omega$, $R_L=1k\Omega$ 的L型低通和高通网络, 在 $f_0=100MHz$ 频点上实现最大功率传输匹配

①: 低通网络



$$\begin{cases} L_1=\frac{R_S}{2\pi f_0}\sqrt{\frac{R_L}{R_S}-1}=0.35\mu H \\ C_1=\frac{1}{2\pi f_0 R_L}\sqrt{\frac{R_L}{R_S}-1}=6.94pF \end{cases}$$

②: 高通网络.



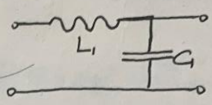
$$\begin{cases} C_2=\frac{1}{2\pi f_0 R_S}\Big/\sqrt{\frac{R_L}{R_S}-1}=7.30pF \\ L_2=\frac{R_L}{2\pi f_0}\Big/\sqrt{\frac{R_L}{R_S}-1}=0.37\mu H. \end{cases}$$

考查传带函数: 见 Cadence 与 Matlab.

3: 宽带匹配网络实现

$R_S=10\Omega$, $R_L=1k\Omega$, $f_0=10MHz$

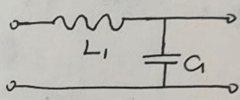
(1): 一节L型低通:



$$\begin{cases} L_1=1.584\mu H \\ C_1=158.4pF. \end{cases}$$

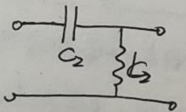
(2): 低通-高通级联:

①: 第一节低通: $10\Omega\Rightarrow100\Omega$



$$\begin{cases} L_1=0.48\mu H \\ C_1=47.5pF. \end{cases}$$

②: 第二节高通: $100\Omega\Rightarrow1k\Omega$



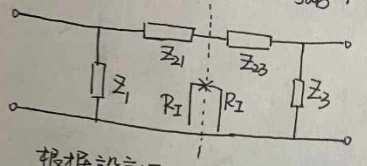
$$\begin{cases} L_2=5.31\mu H \\ C_2=53.1pF. \end{cases}$$

绘图知低通⟺高通级联系统具有更大

4：π型低通匹配网络： $R_S = 10\Omega$

$R_L = 1k\Omega$.

$f_0 = 10\,MHz$, $BW_{3dB} = 100\,kHz$.



根据设计有：

$$Q_1 = \sqrt{\frac{R_S}{R_I} - 1}, \quad Q_2 = \sqrt{\frac{R_L}{R_I} - 1}.$$

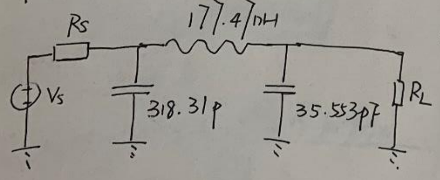
故有：

$$\begin{cases} Q_1 = \dfrac{2\pi f_0 C_1}{\frac{1}{R_S}} = 2\pi f_0 R_S C_1 \\ Q_1 = \dfrac{2\pi f_0 L_{21}}{R_I} \\ Q_2 = \dfrac{2\pi f_0 C_3}{\frac{1}{R_L}} = 2\pi f_0 R_L C_3 \\ Q_2 = \dfrac{2\pi f_0 L_{23}}{R_I} \end{cases}$$

故有：

$$\begin{cases} C_1 = \sqrt{\frac{R_S}{R_I} - 1} \Big/ 2\pi f_0 R_S \\ L_{21} = R_I \sqrt{\frac{R_S}{R_I} - 1} \Big/ 2\pi f_0 \\ C_3 = \sqrt{\frac{R_L}{R_I} - 1} \Big/ 2\pi f_0 R_L \\ L_{23} = R_I \sqrt{\frac{R_L}{R_I} - 1} \Big/ 2\pi f_0 \end{cases}$$

一个合理的设计是.



4.2：修改通带频率 $f_c = 50\,MHz$,

此时 $R_L \neq R_S$，不能用其解析解数值进行运算：

与例1不同之处在于此时 ω 应换为 $\left(\frac{\omega}{2\pi f_c}\right) = \frac{\omega}{\omega_c}$

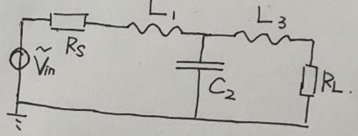
$$\|T_p(j\omega)\|^2 = 1 - \|H(j\omega)\|^2 = 1 - \frac{0.64}{1 + \left(\frac{\omega}{2\pi f_c}\right)^6} = \frac{0.36 + \left(\frac{\omega}{2\pi f_c}\right)^6}{1 + \left(\frac{\omega}{2\pi f_c}\right)^6}$$

$$T_p(s)T_p(-s) = \cancel{0.36} \cdot \frac{0.36 - \left(\frac{s}{2\pi f_c}\right)^6}{1 - \left(\frac{s}{2\pi f_c}\right)^6}$$

其解可以理解为：

$$Z_{in}(s) = 127.74\left(\frac{s}{2\pi f_c}\right) + \cfrac{1}{0.01804\left(\frac{s}{2\pi f_c}\right) + \cfrac{1}{43.40\cdot\left(\frac{s}{2\pi f_c}\right) + 80}}$$

于是有：

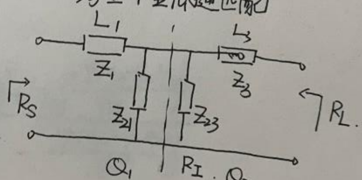


$$\begin{cases} L_1 = 406.61\,nH \\ C_2 = 57.423\,pF \\ L_3 = 138.15\,nH \end{cases}$$

显然并不是最大功率传输匹配.

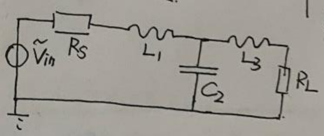
100MHz衰减满足：$\alpha_S = 18.1302\,dB$.

考查T型低通匹配



$$\begin{cases} L_1 = 196.22\,nH \\ C_2 = 66.041\,nF \\ L_3 = 324.61\,nH \end{cases}$$

$\Rightarrow$



仿真图像基本符合最大功率传输匹配.

5：推导用y参量表述的双端共轭匹配相关公式：

由 $y = \begin{bmatrix} y_{11} , & y_{12} \\ y_{21} , & y_{22} \end{bmatrix}$，立刻得到：

$$z = y^{-1} = \frac{1}{y_{11}y_{22} - y_{12}y_{21}} \begin{bmatrix} y_{22} , & -y_{12} \\ -y_{21} , & y_{11} \end{bmatrix}$$

于是立刻有：

$$Z_{m01} = \sqrt{Z_{1,2S} \cdot Z_{1,2O}} = \sqrt{\left\| \frac{y_{22}}{y_{11}} \right\| \cdot \frac{1}{\| y_{11}y_{22} - y_{12}y_{21} \|}}$$

$$Z_{m02} = \sqrt{Z_{2,1S} \cdot Z_{2,1O}} = \sqrt{\left\| \frac{y_{11}}{y_{22}} \right\| \cdot \frac{1}{\| y_{11}y_{22} - y_{12}y_{21} \|}}.$$

由 y, z 参量可获得 ABCD 参量：

$$ABCD = \begin{bmatrix} -\frac{y_{22}}{y_{21}} , & -\frac{1}{y_{21}} \\ -\frac{y_{11}y_{22} - y_{12}y_{21}}{y_{21}} , & -\frac{y_{11}}{y_{21}} \end{bmatrix}$$

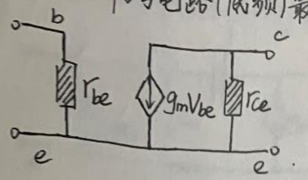
于是有：

$$k = \frac{Re(A^*D + B^*C)}{\| AD - BC \|} = \frac{Re\left(\frac{y_{22}}{y_{21}} \left(\frac{y_{11}}{y_{21}} \right)^* + \left(\frac{1}{y_{21}} \right)^* \frac{y_{11}y_{22} - y_{12}y_{21}}{y_{21}} \right)}{\left\| \frac{y_{11}y_{22}}{y_{21}^2} - \frac{y_{11}y_{22} - y_{12}y_{21}}{y_{21}^2} \right\|}$$

$$= \frac{Re\left(\frac{1}{y_{21}^2} \left(y_{11}^* y_{22} + y_{11}y_{22} - y_{12}y_{21} \right) \right)}{\left\| \frac{y_{12}}{y_{21}} \right\|}.$$

$$MAG = \left\| \frac{y_{21}}{y_{12}} \right\| \left[\frac{Re\left(\frac{1}{y_{21}^2} \left(y_{11}^* y_{22} + y_{11}y_{22} - y_{12}y_{21} \right) \right)}{\left\| \frac{y_{12}}{y_{21}} \right\|} - \sqrt{\frac{Re^2\left(\frac{1}{y_{21}^2} \left(y_{11}^* y_{22} + y_{11}y_{22} - y_{12}y_{21} \right) \right)}{\left\| \frac{y_{12}}{y_{21}} \right\|^2} - 1} \right].$$

6: BJT小信号电路(低频)最大功率增益：



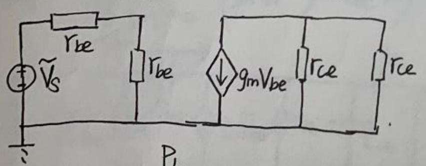
首先立刻得到其y参量：

$$y=\begin{bmatrix}\frac{1}{r_{be}} , & 0\\ g_m , & \frac{1}{r_{ce}}\end{bmatrix}$$

由T5结论立即得到

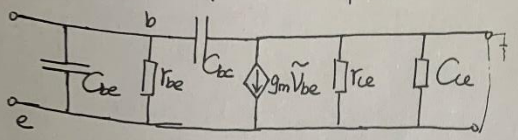
$$\begin{cases} Z_{01}=\sqrt{\dfrac{r_{be}}{r_{ce}}\cdot\dfrac{1}{\frac{1}{r_{be}\cdot r_{ce}}-g_m\cdot 0}}=r_{be} \\ Z_{02}=\sqrt{\dfrac{r_{ce}}{r_{be}}\cdot\dfrac{1}{\frac{1}{r_{be}r_{ce}}-g_m\cdot 0}}=r_{ce}. \end{cases}$$

故而双端特征阻抗匹配时小信号电路有：



$$G_p=\frac{P_L}{\frac{1}{4}\frac{\tilde{V}_s^2}{r_{be}}}=\frac{1}{4}g_m^2r_{be}r_{ce}.$$

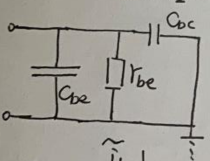
7: BJT小信号电路(高频)最大功率增益.

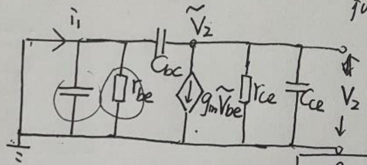


仍然考查其y参量, 此时y参量非常复杂.

$$\begin{bmatrix}\tilde{i}_1\\ \tilde{i}_2\end{bmatrix}=\begin{bmatrix}y_{11}, & y_{12}\\ y_{21}, & y_{22}\end{bmatrix}\begin{bmatrix}\tilde{V}_1\\ \tilde{V}_2\end{bmatrix}$$ 考虑其变换域电路.

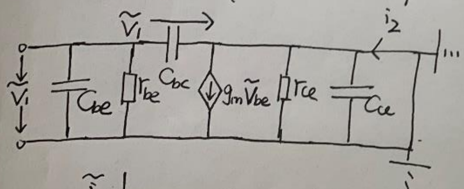
$$y_{11}=\left.\frac{\tilde{i}_1}{\tilde{V}_1}\right|_{\tilde{V}_2=0}==g_{be}+j\omega(C_{be}+C_{bc}).$$



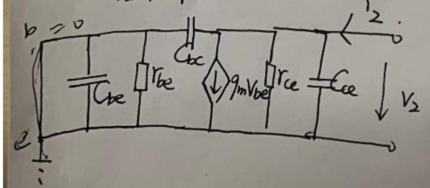


$$y_{12}=\left.\frac{\tilde{i}_1}{\tilde{V}_2}\right|_{\tilde{V}_1=0}==-j\omega C_{bc}$$

$$y_{21}=\left.\frac{\tilde{i}_2}{\tilde{V}_1}\right|_{\tilde{V}_2=0}==\left(g_m\tilde{V}_1-j\omega C_{bc}\tilde{V}_1\right)\Big/\tilde{V}_1=g_m-j\omega C_{bc}.$$



$$y_{22}=\left.\frac{\tilde{i}_2}{\tilde{V}_2}\right|_{\tilde{V}_1=0}==g_{ce}+j\omega(C_{ce}+C_{bc}).$$



于是.

$$y=\begin{bmatrix}g_{be}+j\omega(C_{be}+C_{bc}), & -j\omega C_{bc}\\ g_m-j\omega C_{bc}, & g_{ce}+j\omega(C_{ce}+C_{bc})\end{bmatrix}$$

双端共轭匹配阻抗:

$$Z_{01}=\sqrt{\left\|\frac{g_{ce}+j\omega(C_{bc}+C_{ce})}{g_{be}+j\omega(C_{be}+C_{bc})}\right\|\frac{1}{\|(g_{be}+j\omega(C_{be}+C_{bc}))(g_{ce}+j\omega(C_{bc}+C_{ce}))+j\omega C_{bc}(g_m-j\omega C_{bc})\|}}.$$

$$Z_{02}=\sqrt{\left\|\frac{g_{be}+j\omega(C_{be}+C_{bc})}{g_{ce}+j\omega(C_{ce}+C_{bc})}\right\|\frac{1}{\|(g_{be}+j\omega(C_{be}+C_{bc}))(g_{ce}+j\omega(C_{bc}+C_{ce}))+j\omega C_{bc}(g_m-j\omega C_{bc})\|}}.$$