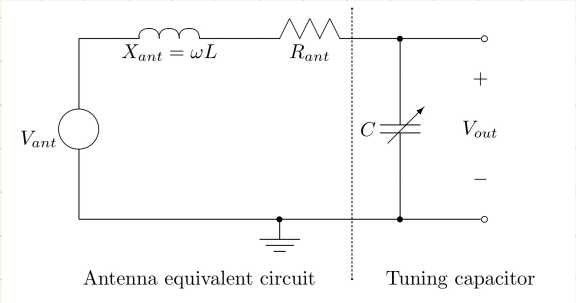
3.1



Antenna equivalent circuit　　Tuning capacitor

(a)

$$Z_L = jwL \quad . \quad Z_C = \frac{1}{jwC} \quad . \quad Z_R = R$$

$$H(jw) = \frac{V_{out}}{V_{ant}} = \frac{\frac{1}{jwC}}{jwL + R + \frac{1}{jwC}}$$

$$= \frac{1}{-LCw^2 + jwCR + 1}$$

$$\Rightarrow H(s) = \frac{1}{LCs^2 + CRs + 1}$$

(b)

	Peak freq. (kHz)	3dB BW (kHz)	Quality Factor
C = 100 pF	513.65	3.312	155.09
C = 30 pF	937.77	14.685	63.86

Table 3.1: Values from Plot

```
R = 20;
L = 960e-6;
C = 100e-12;
freq = logspace(5, 7, 10000);

% 绘制第一条曲线
H1 = 20*log10(abs(1./(-L*C.*(2*pi.*freq).^2+R*C*1i*2*pi.*freq+1)));
p = semilogx(freq, H1);
p.LineStyle = '--';
grid on;
hold on;

% 修改线条颜色为红色
p.Color = 'r';

R = 90;
C = 30e-12;

% 绘制第二条曲线
H2 = 20*log10(abs(1./(-L*C.*(2*pi.*freq).^2+R*C*1i*2*pi.*freq+1)));
semilogx(freq, H2);

% 修改线条颜色为蓝色
h = gca;
h.Children(1).Color = 'b';

[m1, index1] = max(H1);
pf1 = freq(index1);
l1 = line([pf1, pf1], [-60, m1], 'linestyle', '--');
l1.Color = '#77AC30';
```

①

```
l1.Color = '#77AC30';
text(pf1, -50, strcat('pf=', num2str(pf1, 6)));

[m2, index2] = max(H2);
pf2 = freq(index2);
l2 = line([pf2, pf2], [-60, m2], 'linestyle', '--');
l2.Color = '#77AC30';
text(pf2, -50, strcat('pf=', num2str(pf2, 6)));

db1 = m1 - 3;
l3 = line([1e5, 1e7], [db1, db1], 'linestyle', '--');
l3.Color = '#77AC30';

H11 = H1(1:index1-1);
[~, index11] = min(abs(H11 - db1));
H12 = H1(index1+1:length(H1));
[~, index12] = min(abs(H12 - db1));
bw1 = freq(index11) + freq(index12+index1);
text(freq(index1), m1, strcat('BW=', num2str(bw1, 5)));

db2 = m2 - 3;
l4 = line([1e5, 1e7], [db2, db2], 'linestyle', '--');
l4.Color = '#77AC30';

H21 = H2(1:index2-1);
[~, index21] = min(abs(H21 - db2));
H22 = H2(index2+1:length(H2));
[~, index22] = min(abs(H22 - db2));
bw2 = freq(index21) + freq(index22+index2);
text(freq(index2), m2, strcat('BW=', num2str(bw2, 5)));
```

②

	Peak freq. (kHz)	3dB BW (kHz)	Quality Factor
C = 100 pF	513.67	3.316	154.92
C = 30 pF	937.83	14.924	62.85

Table 3.1: Values from Equations

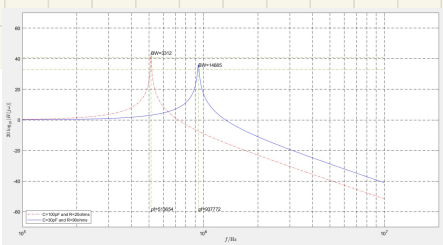
```
l4 = line([1e5, 1e7], [db2, db2], 'linestyle', '--');
l4.Color = '#77AC30';

H21 = H2(1:index2-1);
[~, index21] = min(abs(H21 - db2));
H22 = H2(index2+1:length(H2));
[~, index22] = min(abs(H22 - db2));
bw2 = freq(index21) + freq(index22+index2);
text(freq(index2), m2, strcat('BW=', num2str(bw2, 5)));

qf1 = pf1 / bw1;
qf2 = pf2 / bw2
hold off;

ax = gca;

% 修改坐标系的范围和比例
axis([1e5 2e7 -70 70]);

ax.GridLineStyle = '--';
ax.GridColor = 'k';
ax.GridAlpha = 1;
ax.MinorGridLineStyle = '--';
ax.MinorGridColor = 'k';
ax.MinorGridAlpha = 1;

legend('C=100pF and R=20ohms', 'C=30pF and R=90ohms', 'Location', 'southwest');
xlabel('$$f/\mathrm{Hz}$$', 'Interpreter', 'latex');
ylabel('$$20\log_{10}|H(j\omega)|$$', 'Interpreter', 'latex');
```

③

Eq (2.2.4) : $f_{res} = \frac{1}{2\pi} \frac{1}{\sqrt{LC}}$

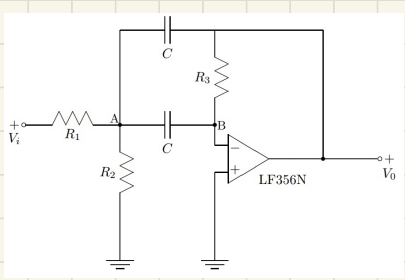
Eq (2.2.6) : $BW_{3dB} = \frac{1}{2\pi} \frac{R}{L}$

Eq (2.2.7) : $Q = 2\pi f_{res} \frac{L}{R}$



plot

3.2



$$\begin{cases} \frac{V_A}{R_2} + \frac{V_A - V_0}{\frac{1}{jwC}} + \frac{V_A}{\frac{1}{jwC}} = \frac{V_i - V_A}{R_1} \\ \frac{V_A}{\frac{1}{jwC}} = \frac{-V_0}{R_3} \end{cases}$$

$$\Rightarrow \frac{-V_0}{R_2 R_3} \left(\frac{1}{jwC}\right)^2 + \frac{-V_0}{R_3} \left(\frac{1}{jwC} - V_0\right) + \frac{-V_0}{R_3} \frac{1}{jwC}$$

$$= \frac{1}{R_1} V_i \frac{1}{jwC} + \frac{V_0}{R_1 R_3} \left(\frac{1}{jwC}\right)^2$$

$$\Rightarrow \frac{V_0}{V_i} = \frac{\frac{-sC}{R_1}}{s^2C^2 + \frac{1}{R_1 R_3} + \frac{1}{R_2 R_3} + \frac{2sC}{R_3}}$$

$$\Rightarrow \begin{cases} a_1 = \frac{R_2 R_3 C}{R_1 + R_2} = 1.61 \times 10^{-6} \\ a_2 = \frac{C^2 R_1 R_2 R_3}{R_1 + R_2} = 2.41 \times 10^{-12} \\ a_3 = \frac{2 R_1 R_3 C}{R_1 + R_2} = 3.21 \times 10^{-7} \end{cases}$$

(b) $$H(s) = \frac{R_1+R_2}{R_1R_2R_3C^2} \cdot \frac{-R_2R_3C^2}{2(R_1+R_2)} \cdot \frac{\frac{2}{R_3C}s}{s^2+\frac{2}{R_3C}s+\frac{R_1+R_2}{R_1R_2R_3C^2}}$$

$$= \frac{-R_3}{2R_1} \cdot \frac{\frac{2s}{R_3C}}{s^2+\frac{2s}{R_3C}+\frac{R_1+R_2}{R_1R_2R_3C^2}}$$

Since $H(s) = H_0 \cdot \frac{\beta \cdot s}{s^2+\beta s+w_0^2}$

$$|H_0| = \frac{R_3}{2R_1} = 5$$

$$BW_{3dB} \approx \beta = \frac{2}{R_3C} \cdot \frac{1}{2\pi} = 2.12\times10^4 \text{ Hz}$$

$$w_0^2 = \frac{R_1+R_2}{R_1R_2R_3C^2} \Rightarrow f_0 = \frac{2\pi}{w_0} = 1.025\times10^5 \text{ Hz}$$

(c)

According to the equation: $f_0 = 1.025\times10^5$ Hz, $BW_{3dB} = 2.12\times10^4$ Hz, $|H_0| = 5$

According to the plot: $f_0 = 1.02\times10^5$ Hz, $BW_{3dB} = 2.11\times10^4$ Hz, $|H_0| = 5$

```
R1=1e3;
R3=1e4;
R2=120;
C=1.5e-9;
sys=tf([R2*R3*C/(R1+R2) 0],[R1*R2*R3*C^2/(R1+R2) 2*R1*R2*C/(R1+R2) 1]);
fb=bandwidth(sys);
[mag,phase,wout]=bode(sys);
[gpeak,fpeak]=getPeakGain(sys);
```