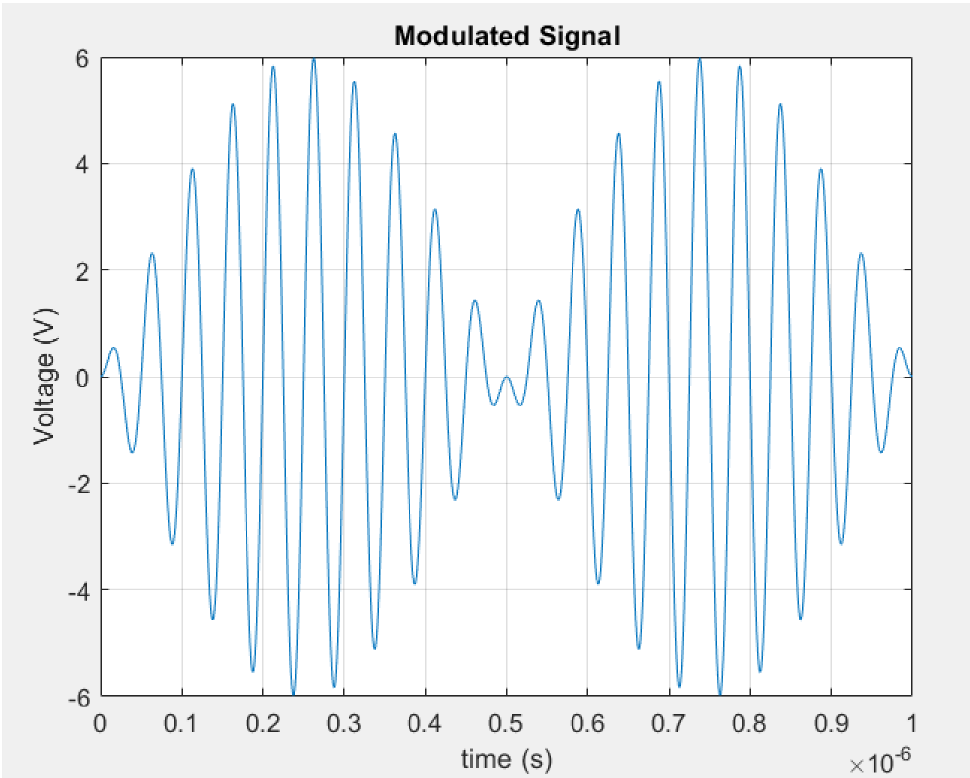
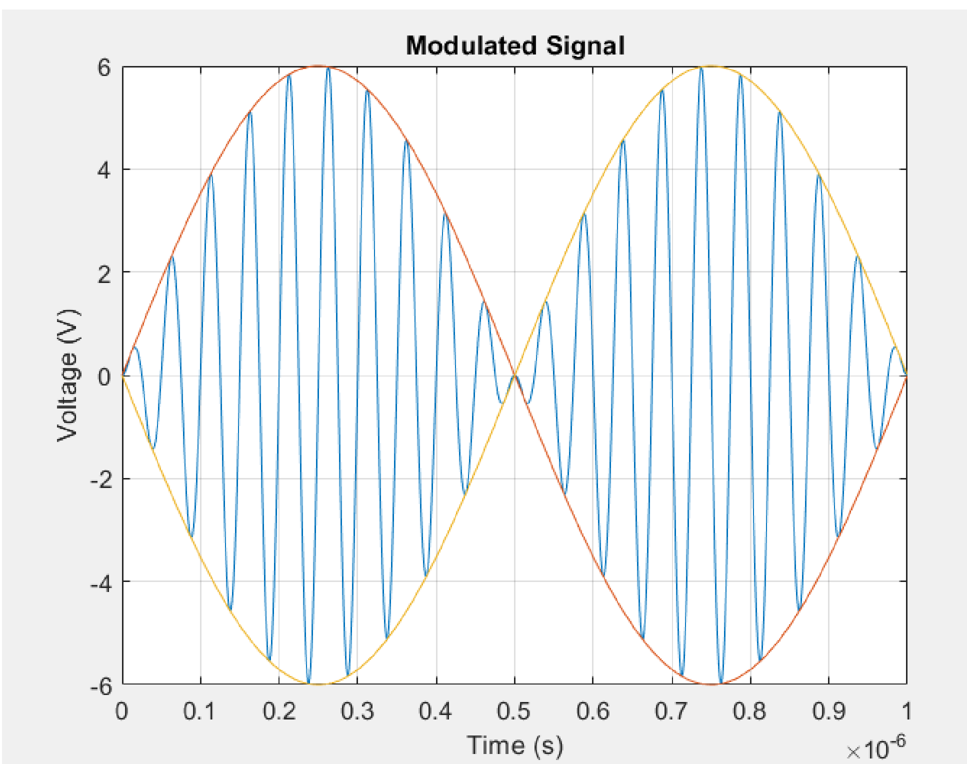
```matlab
% HW11
% Abdullah MEMİŞOĞLU
% 171024001

close all
clear classes
clear all

A1 = 2;
A2 = 3;
f1 = 10^6;
f2 = 20*10^6;
w1 = 2*pi*f1;
w2 = 2*pi*f2;
N = 2000;
t = [0:N-1] / N * 1 / f1;

Sig1 = A1*sin(w1*t);
Sig2 = A2*sin(w2*t);
Sig3 = cos( (w2-w1) * t );
Sig4 = cos( (w1+w2) * t );
Sig = Sig1.*Sig2;
Sig5 = 1/2 * A1 * A2 * ( Sig3 - Sig4 );
figure(101)
h1 = plot(t , Sig)
hold off;
hold on;
h2 = plot(t , A2*Sig1 );
hold off;
hold on;
h3 = plot(t , -A2*Sig1 );
hold off;
grid on;

xlabel('Time (s)');
ylabel('Voltage (V)');
title('Modulated Signal')

figure(102)
h4 = plot(t , Sig5 );
hold off;
grid on;

xlabel('time (s)');
ylabel('Voltage (V)');
title('Modulated Signal')
```



Modulated Signal
Voltage (V)
time (s)
×10^-6



Modulated Signal
Voltage (V)
Time (s)
×10^-6

Q2

HW. 11

Abdullah MENTİŞOĞLU
171024001

Q2. A large number of radio stations transmit their programs at various carrier frequencies. A radio receiver is tuned to receive an AM wave transmitted at a carrier frequencies of $f_{RF} = 980\,kHz$. The LO inside the receiver is set at $f_{LO} = 1435\,kHz$.

find: (a) The frequencies coming out of the receiver's mixer.

(b) Which frequency is IF.

(c) The frequency of a radio station which would represent an image frequency to the radio station. (d) The frequency graph of the frequencies involved.

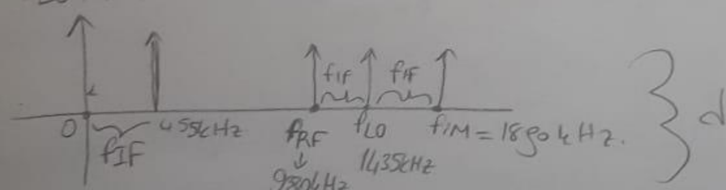
* Mixer outputs two frequencies

$$\left.\begin{aligned} f_{RF} + f_{LO} &= 980k + 1435k = 2415\,kHz \\ |f_{RF} - f_{LO}| &= 455\,kHz \end{aligned}\right\} a$$

$f_{IF} \rightarrow$ intermediate frequency $\rightarrow 455\,kHz \rightarrow$ b

f_{IF} when mixer with the signal with f_{LO}:

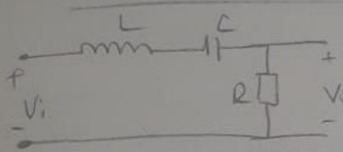
$$\left.\begin{aligned} f_{LO} - f_{IF} &= 1435k - 455k = 980\,kHz \\ f_{LO} + f_{IF} &= 1435k + 455k = 1890\,kHz \end{aligned}\right\} c$$



Q3

Q3. Prepare a short report on the Q factor of LC resonators, on how it relates to bandwith and signalattentuation

Q-factor of a series LC



$$G(s) = \frac{V_o}{V_i} = \frac{R}{R + Ls + \frac{1}{Cs}} = \frac{RCs}{LCs^2 + RCs + 1} = \frac{Rs/L}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

$$w_o^2 = \frac{1}{LC} \qquad \boxed{w_o = \sqrt{\frac{1}{LC}}}$$

↳ rezonans frekansı

$$G(s) = \frac{2\delta w_o s}{s^2 + 2\delta w_o w + w_o^2}$$

$$2\delta w_o = \frac{R}{L} \Rightarrow 2\delta \frac{1}{\sqrt{LC}} = \frac{R}{L} \qquad \boxed{\delta = \frac{R}{2}\sqrt{\frac{L}{C}}}$$

$$G(jw) = \frac{2\delta w_o jw}{(w_o^2 - w^2) + 2\delta w_o jw} \qquad G(jw)\big|_{w=w_o} = 1$$

$$\boxed{|G(jw)|^2 = \frac{1}{2}}$$

$$\frac{(2\delta w_o w)^2}{(w_o^2 - w^2)^2 + (2\delta w_o w)^2} = \frac{1}{2}$$

$$(2\delta w_o w)^2 = (w_o^2 - w^2)^2$$

$$|2\delta w_o w| = |w_o^2 - w^2|$$

$w_L = -\delta w_o + w_o\sqrt{1+\delta^2}$ ← $2\delta w_o w = w_o^2 - w^2$ eq. 1 → Low freq

$w_H = \delta w_o + w_o\sqrt{1+\delta^2}$ ← $-2\delta w_o w = w_o^2 - w^2$ eq. 2 → high freq.

or first high then low

Bandwidth $= w_H - w_L = 2\delta w_o = \frac{2R}{2}\sqrt{\frac{C}{L}} \cdot \frac{1}{\sqrt{LC}} = \frac{R}{L}$

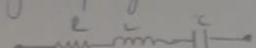
$$\boxed{BW = \frac{R}{L}} \qquad Q = \frac{w_o}{BW} = \frac{1/\sqrt{LC}}{R/L} = \boxed{\frac{1}{R}\sqrt{\frac{L}{C}} = Q}$$

2

Q4

Q4. A tuned RF amplifier has an LC tank with $Q=20$ and it is tuned at RF frequency to Estimate the attenuation of the image signal, if the image frequency is 10% higher than RF signal.

Series RLC →



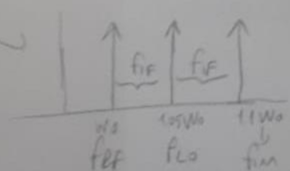
$$G(s) = \frac{R_s/L}{s^2 + \frac{R}{L}s + \frac{1}{LC}} \rightarrow w_0 = \frac{1}{\sqrt{LC}},\ BW = \frac{R}{L},\ Q = \frac{w_0}{BW}$$

$$G(s) = \underbrace{\frac{w_0}{Q}}_{BW=\frac{R}{L}} \cdot s \Big/ s^2 + \underbrace{\frac{w_0}{Q}}_{BW} s - w_0^2 = \frac{\frac{w_0}{Q}s}{s^2 + \frac{w_0}{Q}s + w_0^2}$$

$$G(jw) = \frac{\frac{jw \cdot w_0}{Q}}{(w_0^2 - w^2) + jw\frac{w_0}{Q}} \rightarrow |G(jw)|^2 = \frac{\frac{w^2 w_0^2}{Q^2}}{(w_0^2 - w^2)^2 + \left(w\frac{w_0}{Q}\right)^2} = \left(\frac{1}{A}\right)^2$$

$w = kw_0$ ise

$$|G(jkw_0)|^2 = \frac{(k/Q)^2}{(1-k^2)^2 + \left|\frac{k}{Q}\right|^2} = \left|\frac{1}{A}\right|^2$$



$k = 1.1$ ve $Q = 20$ için

$$\left(\frac{1}{A}\right)^2 = \frac{(1.1/20)^2}{(1-1.1^2)^2 + \left(\frac{1.1}{20}\right)^2} = 0.06\ldots \rightarrow \frac{1}{A} = 0.253 \rightarrow \boxed{A = 3.946}$$

$$\boxed{20\log_{10} A = 11.925\,dB}$$