PROBLEM:

- Let fc be the frequency of carrier, f_i be that of the image signal, and f_{IF} be that of IF carrier. Calculate f_i.
- Let $f_c = 16\text{MHz}$, the symbol rate be 1MHz, $f_{IF} = 10\text{MHz}$, the sampling rate of ADC be 16MHz, and that of the DMA filter be 64MHz.
- Redesign the system in S9P3 to upcovert and downconvert the transmit signal, and recover the transmit symbols.
- Design an image rejection filter, and add the filter to the above system.
- Add a sinusoidal image interference and conduct the simulation again.

I. Transmitter

$$\text{b[n]}\ (symbol\ rate = 1M\ Hz)$$

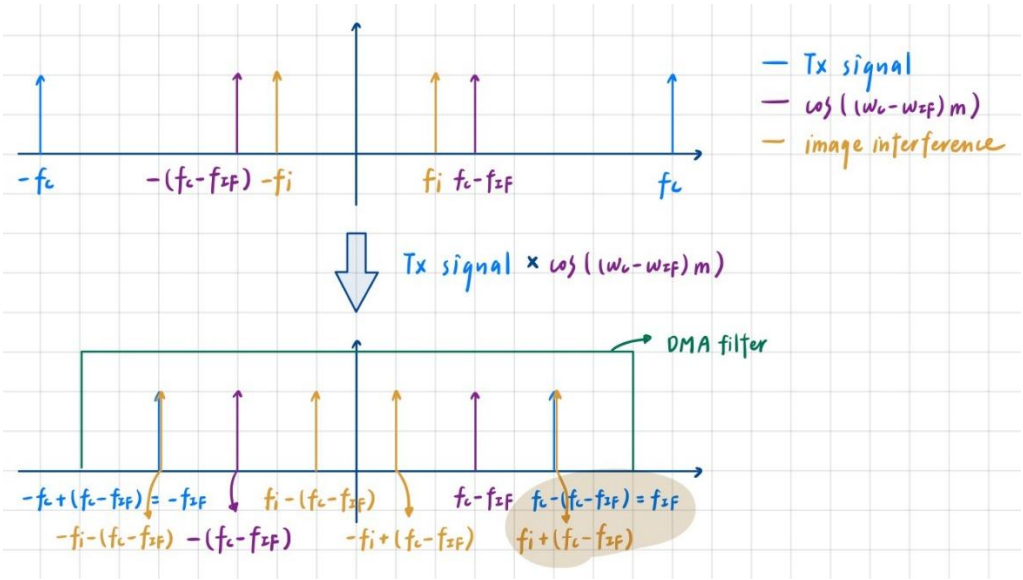
$$\xrightarrow{upsampling\ M_1=16} pulse\ shaping\ (SRRC)\ (sampling\ rate = 16M\ Hz)$$

$$\xrightarrow{upsampling\ M_2=4} DMA\ filter\ (LPF)\ (sampling\ rate = 64M\ Hz)$$

$$\xrightarrow{upcovert} \times e^{j\omega_c m} \rightarrow \text{Re}\{\cdot\}$$

II. Interference

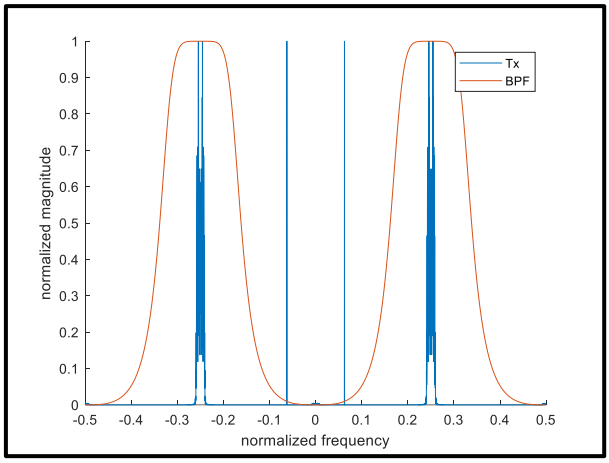
```
fi = 2*fif - fc;
I = cos(2*pi*(fi/fs)*(1:length(Tx))) * max(abs(Tx));
scaler = max(abs(fftshift(fft(Tx)))) / max(abs(fftshift(fft(I))));
Tx = Tx + I*scaler;
```



$$f_i + (f_c - f_{IF}) = f_{IF} \Rightarrow f_i = 2f_{IF} - f_c$$

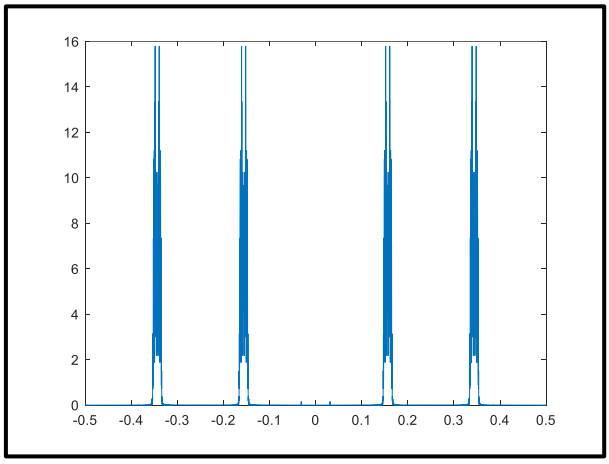
III. Receiver

A. Rx signal → BPF (remove interference)



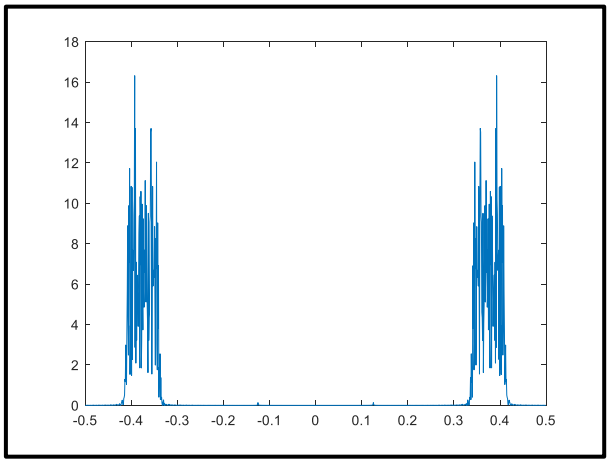
B. $\times \cos((\omega_c - \omega_{IF})m)$

```
fs = 1e6*M1*M2; % symbol rate * M1 * M2
Rx = Tx.*cos(2*pi*((fc-fif)/fs)*(1:length(Tx))) *2; % amplitude *2
```



C. DMA filter (LPF) → *downsampling* ($M_2 = 4$)

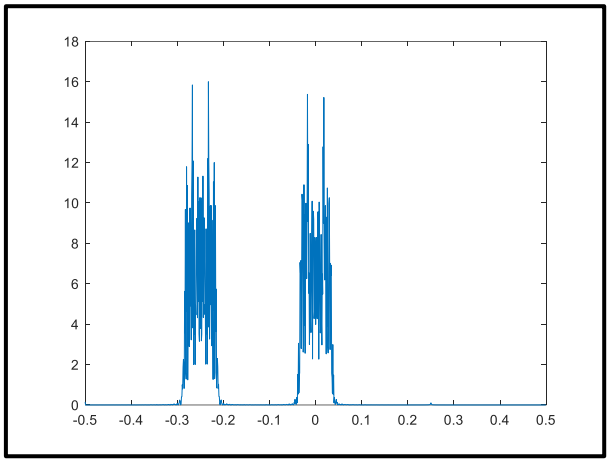
```
Rx = filter(LPFRxhw, Rx);
delay = 1 + 6 + 2; % LPF(Tx) + BPF + LPF(Rx)
bd2 = Rx(1+delay:M2:end) * M2; % amplitude *M2
```



D. $\times e^{-j\omega_{IF}k}$

1. 前面做完 $downsampling\ (M_2 = 4)$ 後，$sampling\ frequency = symbol\ rate \times M_1$。
2. 第一階段降頻是把訊號降到 f_{IF}，再來要從 f_{IF} 降到 baseband。
3. 額外考慮 DMA filter(Tx)、BPF、DMA filter(Rx)，三個 IIR filter 的 phase delay。

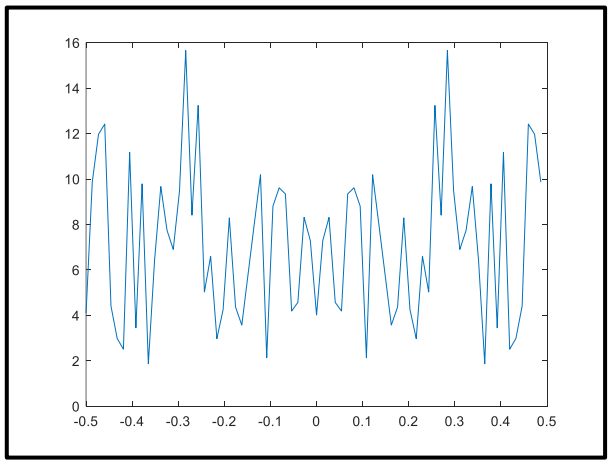
```
fs = 1e6*M1; % symbol rate * M1
bd2 = bd2.*exp(-1i*2*pi*(fif/fs)*(1:length(bd2)));
bd2 = bd2*exp(-1i*2*pi*(fif/fs)*(delay/M2)); % phase delay
```

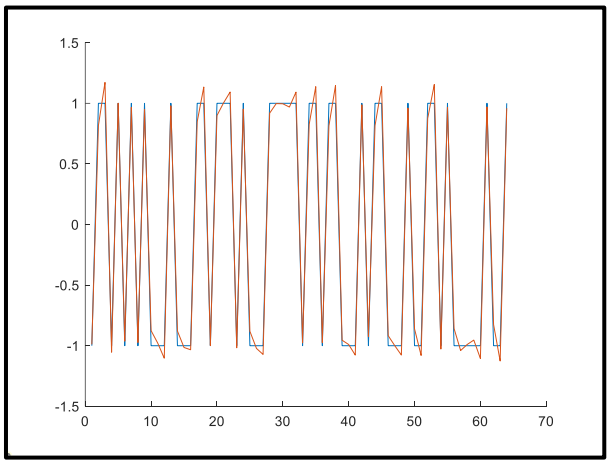


E. SRRC $\rightarrow downsampling\ (M_1 = 16)$

1. 因為畫圖只取 real part，但為了振幅大小正確，將 real part 振幅大小放大成和完整的 real+imag part 相同，所以有乘一個倍數。
2. 底下兩張圖為最終還原訊號的頻域(左)，與時域(右)訊號。

```
bd2 = conv(SRRC, bd2);
delay = L-1; % SRRC(Tx) + SRRC(Rx) = ((L-1)/2)*2
bd1 = bd2(1+delay:M1:end) * M1; % amplitude *M1
bd1 = real(bd1) .* (abs(bd1)./abs(real(bd1))); % amplitude *abs(bd1)./abs(real(bd1))
```





IV. Overall System