Sol

(1) $y(t) = m_1(t)\cos(2\pi f_1(t)t) + m_2(t)\cos(2\pi f_2(t)t)$

(a) $y(t)\cos 2\pi f_1(t)t = m_1(t)\cos^2(2\pi f_1(t)t) + m_2(t)\cos(2\pi f_2(t)t)\cos(2\pi f_1(t)t)$

$$= \frac{m_1(t)}{2}\left[1 + \cos 4\pi f_1(t)t\right] + \frac{m_2(t)}{2}\left[\cos(2\pi f_1 t + f_2 t) + \cos 2\pi f_1 - f_2(t)t\right]$$

Now passing through Low pass filter $f_1 - f_2 > 2kHz$

$$y(t) = \frac{m_1(t)}{2}$$

If $f_1 = f_2$

$$y(t) = \frac{m_1(t) + m_2(t)}{2}$$

(2)

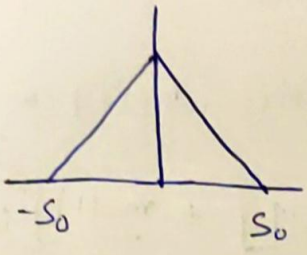
(b) $P(\underset{\text{in 10 seconds}}{\text{no collision}}) = \frac{\text{Outcomes without collision}}{\text{No of outcomes}}$

$$= \frac{^{20}C_2 \times 2! \times 10}{20 \times 20 \times 10} = 95\%$$

(c) As an eavesdropper, If we hear a particular band, then a signal is heard with probability $\frac{19}{200}$ and nothing otherwise

(d) If seed is wrong there is no signal in the band. So demodulated signal gives sequence of zeros

(c)
(d)

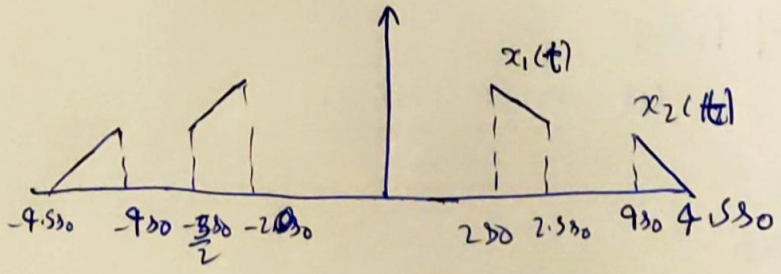


Bandwidth $= S_0$

Blocked spectrum : $[2s_0, 2.5s_0]$

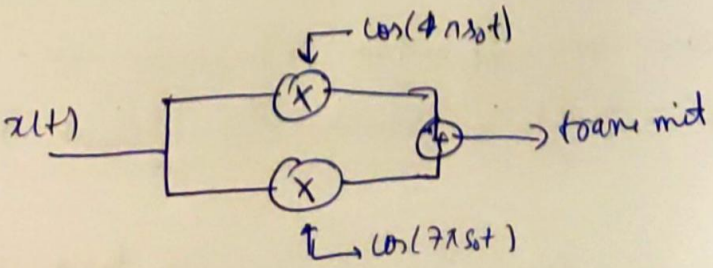
$[4\ s_0$ to $4.5s_0]$

(e) What can be done is split the half of spectrum from $2s_0$ to $2.5s_0$ and other half at $4s_0$ to $4.5s_0$.

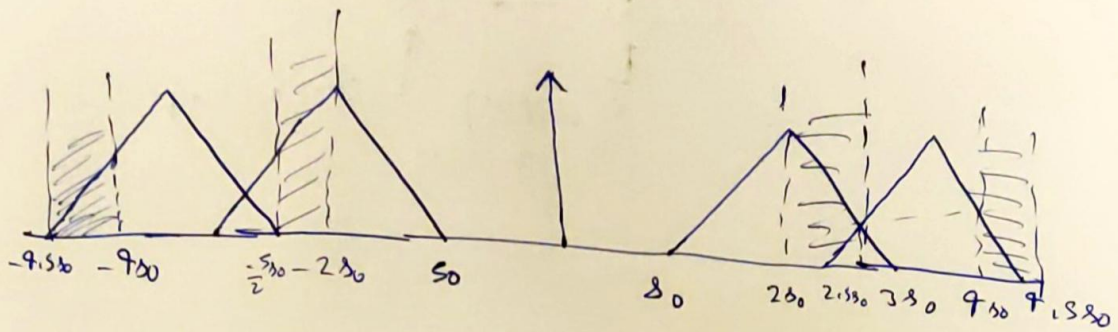


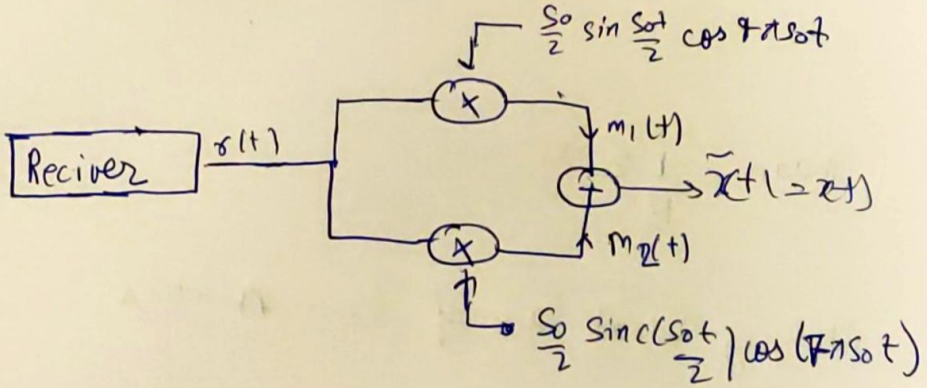
$$x_1(t) = x(t)\cos(2\pi(2s_0)t) = x(t)\cos(4\pi s_0 t)$$
$$x_2(t) = x(t)\cos(2\pi(3.5s_0)t) = x(t)\cos(7\pi s_0 t)$$

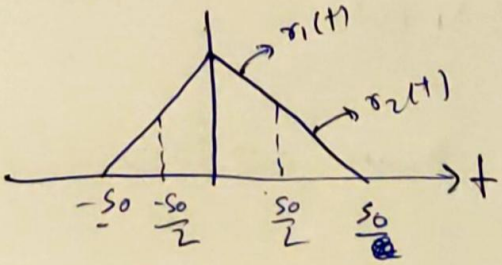
We can transmit $x_1(t) + x_2(t)$



transmit Signal

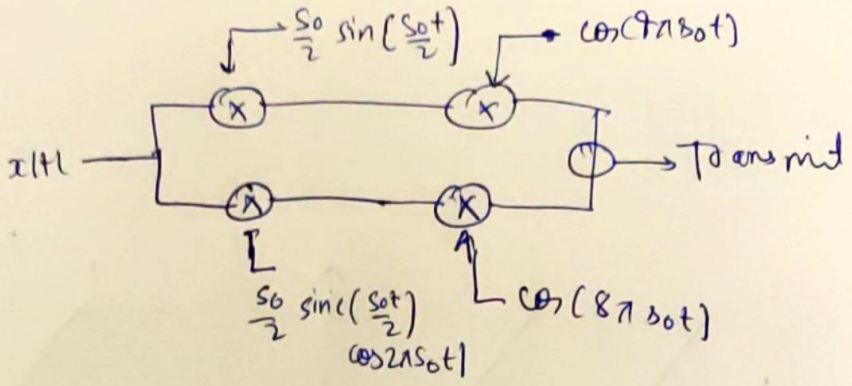






x(t) is the required signal

(b) Now since Dr evil is eavesdropping blocked signals we ensure all information lies in $[2\omega_0, 2.5\omega_0]$ and $[4\omega_0, 4.5\omega_0]$ ~~so we have to be attty~~ We ~~have~~ use low pass & high pass filter to transmit in available regions.



Q3.

a) $\text{Mean} = \frac{1}{N}\sum x_i$

Applying Weak law of large numbers

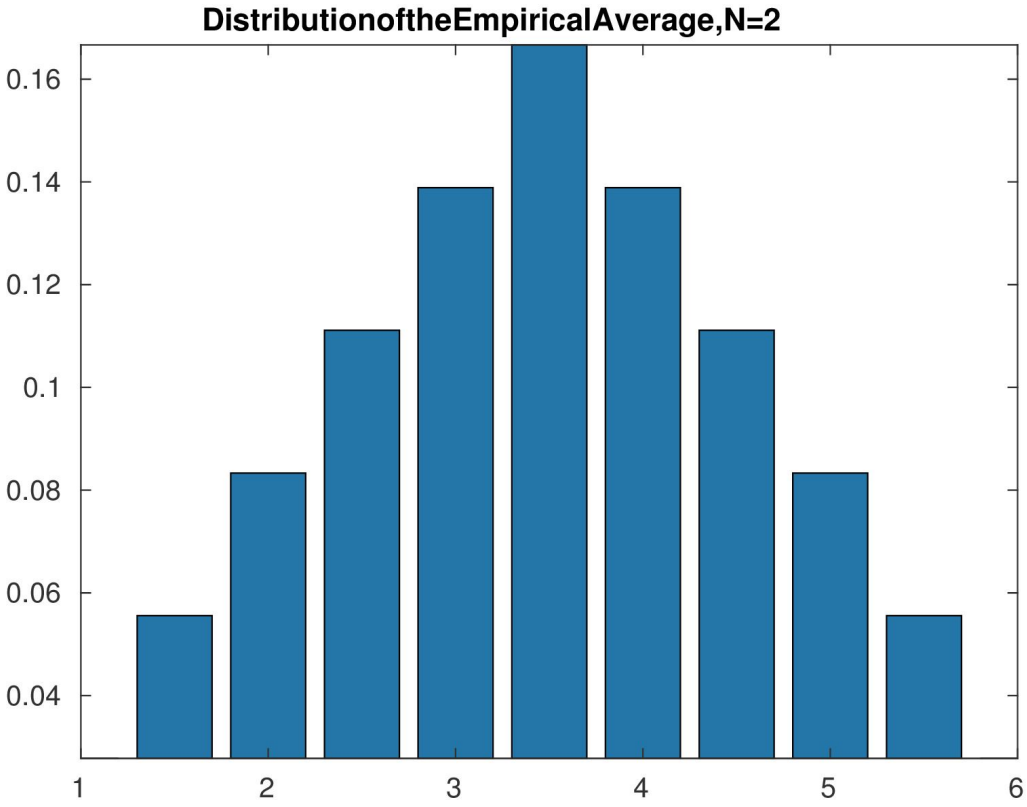
$$\text{Mean} = \sum X_i\, p(X_i) = \frac{1+2+3+4+5+6}{6} = 3.5$$

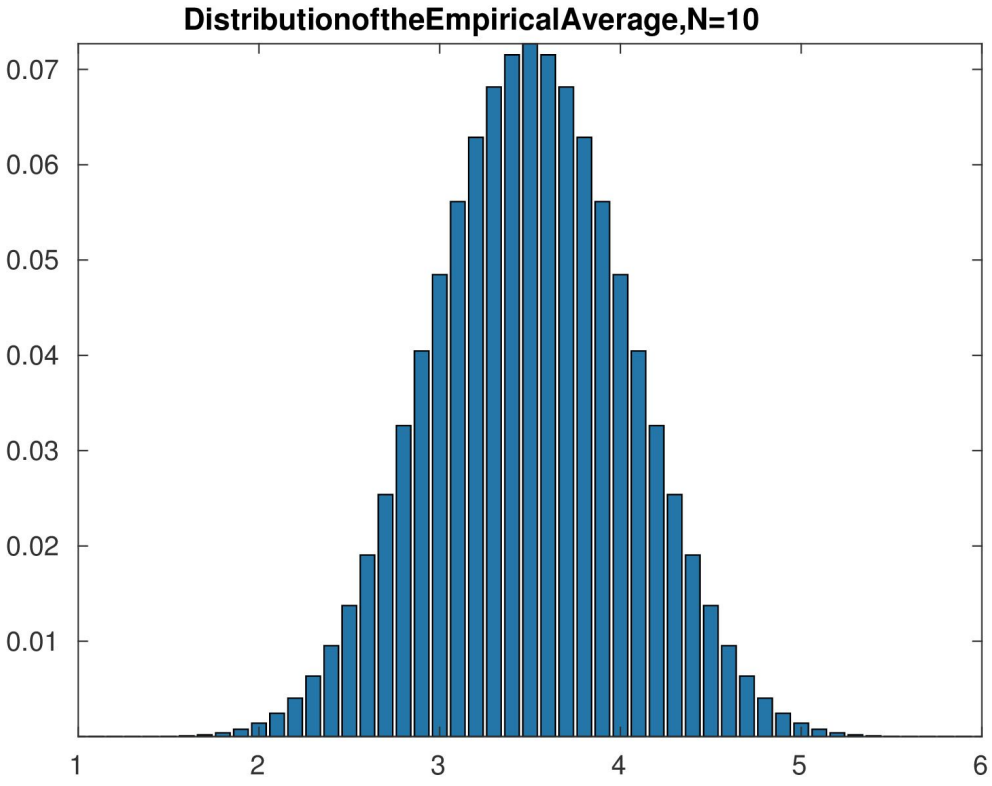
as $n \to \infty$ Mean $\to 3.5$

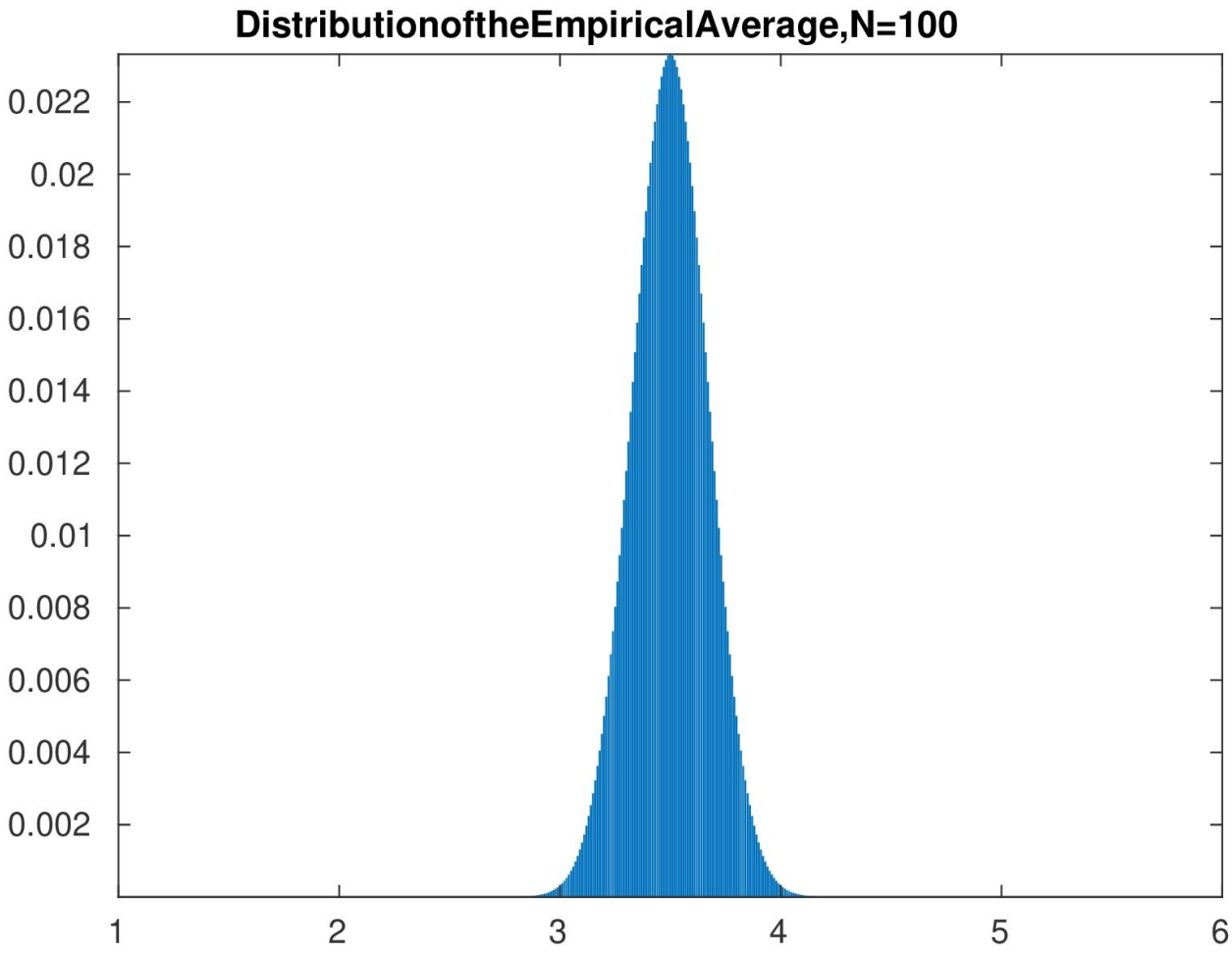
(b)

(4) There is not much difference between filtered and original sound file. If we directly downsample then there is decrease in quality compared to downsampling after filtering

3. b) Matlab Plots and file



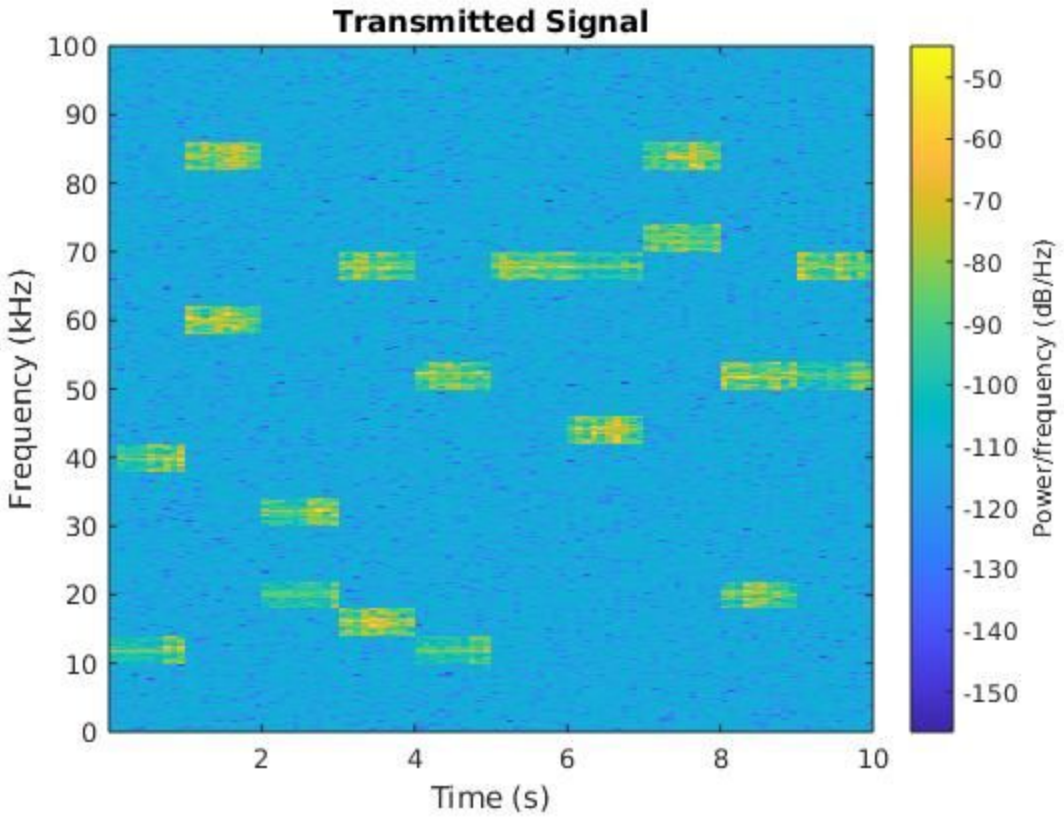




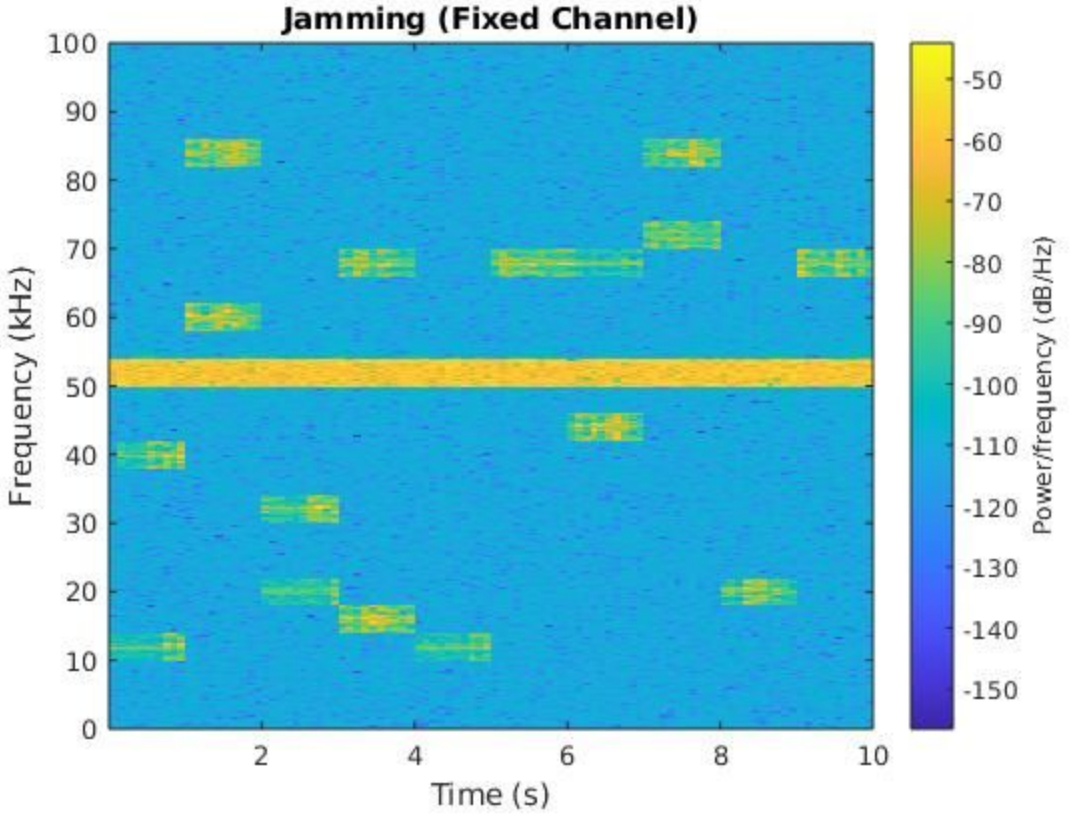
4. Matlab Codes attached with audio files

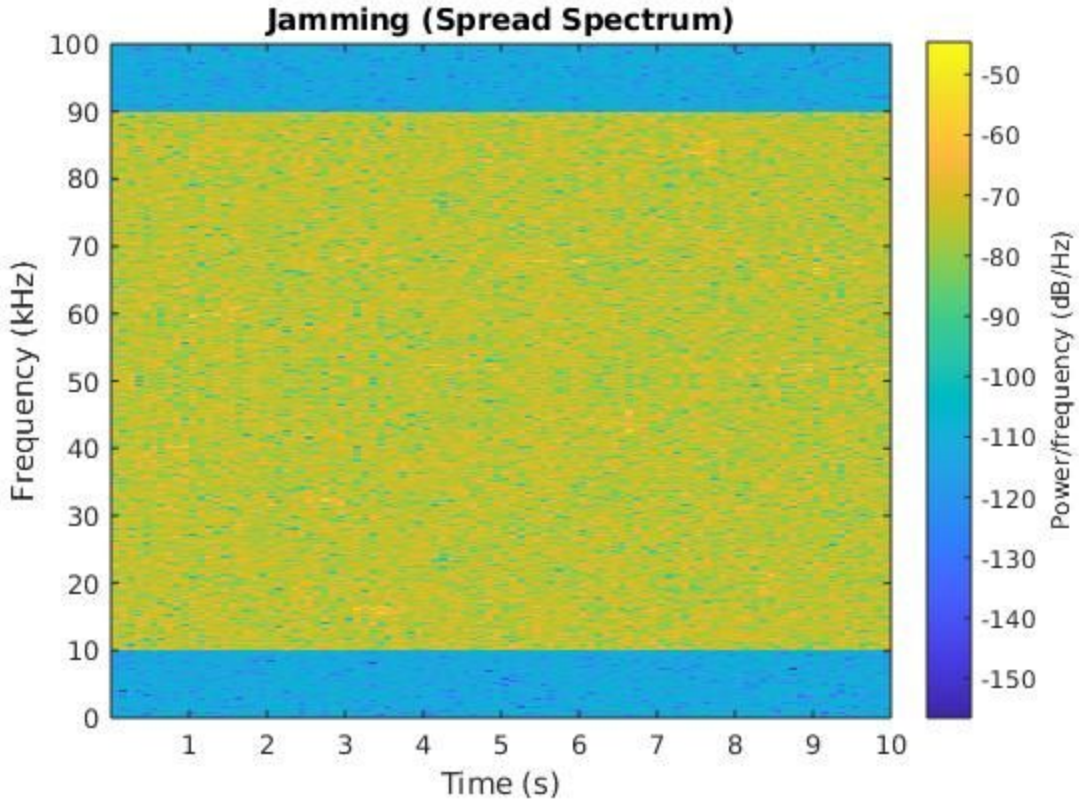
1.Matlab Codes attached

Spectograms



There is chance of collision/overlapping between bands of 1 and 2. This does not occur with probability 19/20 which is calculated above.


Jamming (Fixed Channel)
Frequency (kHz)
Time (s)
Power/frequency (dB/Hz)
100
90
80
70
60
50
40
30
20
10
0
2
4
6
8
10
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150


Jamming (Spread Spectrum)
Frequency (kHz)
Time (s)
Power/frequency (dB/Hz)
100
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150