Parameter Setteing

```
clear; clc;
T = 2000;
fs = 1000;              % Sampling Frequency
t = 1/fs: 1/fs: 2;

f_D = [1, 10, 100];     % Max Doppler frequency
N = 34;
sigma = sqrt(1 / 2);
```

Jake Fading Model

Received signal : $r(t) = \mathrm{Re}\left\{u(t)\cdot e^{\mathrm{j}2\pi f_c t}\cdot\left[\sum_{n=0}^{N}\alpha_n(t)e^{-j\phi_n(t)}\right]\right\} = \mathrm{Re}\left\{T(t)e^{\mathrm{j}2\pi f_c t}\right\}$

Phase of each path : $\phi_n(t) = -2\pi f_D t\cdot\cos(\alpha_n) - \beta_n$

- Assume Arrival Angle = Uniformly Distributed : $\alpha_n = \frac{2\pi n}{N}$

Fading Channel:

$$T(t) = \frac{E_0}{\sqrt{N}}\left\{\sqrt{2}\sum_{n=1}^{N_0}\left[e^{j(2\pi f_D t\cdot\cos(\alpha_n)+\phi_n)} + e^{-j(2\pi f_D t\cdot\cos(\alpha_n)+\phi_{-n})}\right] + e^{j(2\pi f_D t+\phi_N)} + e^{-j(2\pi f_D t+\phi_{-N})}\right\}$$

- $N_0 = \frac{1}{2}\left(\frac{N}{2}-1\right)$
- Uniform Distribution of Initial Phase : $\beta_n = \frac{\pi n}{N_0}$
- Doppler term: $e^{j\phi_n} = e^{-j\phi_{-n}} \Rightarrow \frac{\sqrt{2}}{2}e^{j\beta_n} = \frac{\sqrt{2}}{2}[\cos(\beta_n) + \mathrm{j}\sin(\beta_n)]$
- Max Doppler term: $e^{j\phi_N} = e^{-j\phi_{-N}} \Rightarrow \frac{\sqrt{2}}{2}e^{j\alpha} = \frac{\sqrt{2}}{2}[\cos(\alpha) + \mathrm{j}\sin(\alpha)]$

In-phase Component : $h_c(t) = 2\sum_{n=1}^{N_0}\cos\beta_n\cos(2\pi(f_D\cos\alpha_n)\cdot t) + \sqrt{2}\cos(\alpha)\cos(2\pi f_D t)$

Quadratic Component: $h_s(t) = 2\sum_{n=1}^{N_0}\sin\beta_n\cos(2\pi(f_D\cos\alpha_n)\cdot t) + \sqrt{2}\sin(\alpha)\cos(2\pi f_D t)$

```
N_0 = 1 / 2 * (N / 2 - 1);
h_c = zeros(3, T);
h_s = zeros(3, T);

for e = 1 : 3
for n = 1 : N_0
    beta_n = pi * n / N_0;
    alpha_n = 2 * pi * n / N;
    % alpha = pi / 4
```

```
    h_c(e, :) = h_c(e, :) + 2 * cos(beta_n) * cos(2 * pi * f_D(e) * cos(alpha_n) * t) + ...
                cos(2*pi*f_D(e) * t);
    h_s(e, :) = h_s(e, :) + 2 * sin(beta_n) * cos(2 * pi * f_D(e) * cos(alpha_n) * t) + ...
                cos(2*pi*f_D(e) * t);
end
end

h_c = h_c * sigma / sqrt(N);
h_s = h_s * sigma / sqrt(N);
```

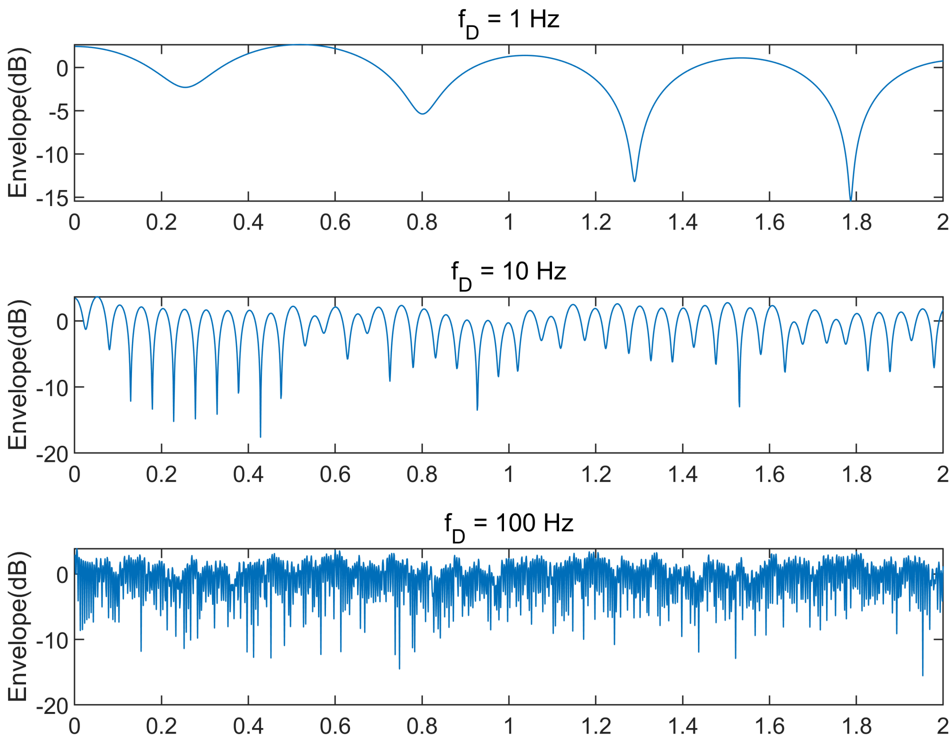
Plot

```
h_env = sqrt(h_c.^2 + h_s.^2);
h_norm = h_env ./ mean(h_env, 2);
h_norm_dB = 10 * log10(h_norm) ;

subplot(3, 1, 1)
plot(t, h_norm_dB(1, :))
ylabel('Envelope(dB)')
title('f_D = 1 Hz')

subplot(3, 1, 2)
plot(t, h_norm_dB(2, :))
ylabel('Envelope(dB)')
title('f_D = 10 Hz')

subplot(3, 1, 3)
plot(t, h_norm_dB(3, :))
ylabel('Envelope(dB)')
title('f_D = 100 Hz')
```

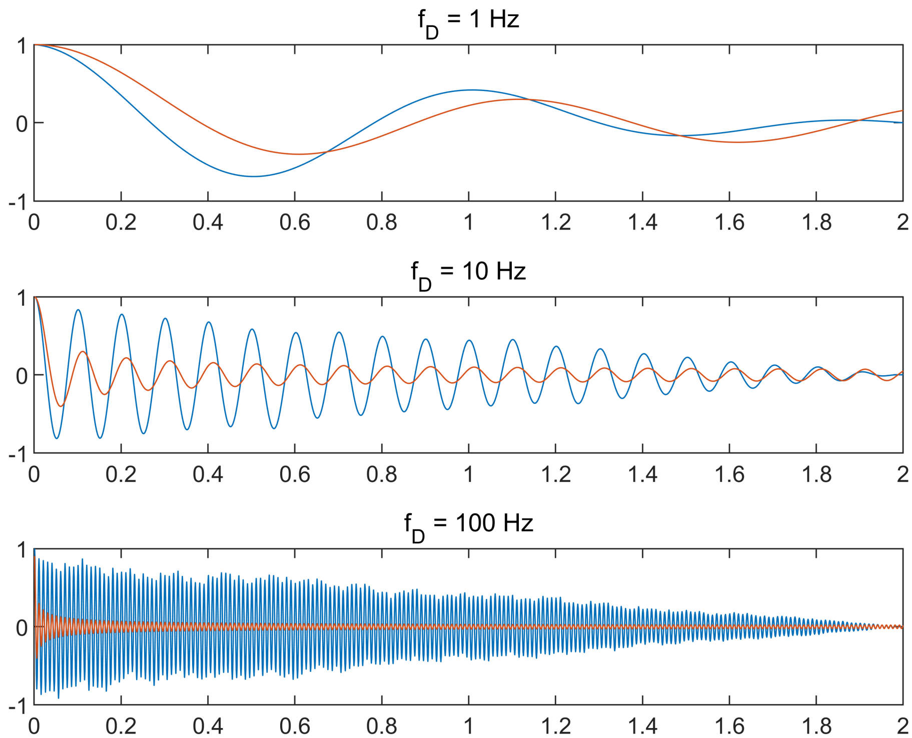


Auto-Correlation

```
auto_corr_1 = xcorr(h_c(1, :), 'coeff');
auto_corr_2 = xcorr(h_c(2, :), 'coeff');
auto_corr_3 = xcorr(h_c(3, :), 'coeff');

r_1 = [auto_corr_1(2000:3999); besselj(0, 2*pi*f_D(1) * t)];
r_2 = [auto_corr_2(2000:3999); besselj(0, 2*pi*f_D(2) * t)];
r_3 = [auto_corr_3(2000:3999); besselj(0, 2*pi*f_D(3) * t)];

figure
subplot(3, 1, 1)
plot(t, r_1)
title('f_D = 1 Hz')
subplot(3, 1, 2)
plot(t, r_2)
title('f_D = 10 Hz')
subplot(3, 1, 3)
plot(t, r_3)
title('f_D = 100 Hz')
```


f_D = 1 Hz
f_D = 10 Hz
f_D = 100 Hz
1
0
-1
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2