Homework III

1. Filtered Gaussian Noise method

In filtered gaussian noise nethod, we first compute ζ for each f_mT by

$$\zeta = 2 - \cos\left(\frac{\pi f_m T}{2}\right) - \sqrt{(2 - \cos\left(\frac{\pi f_m T}{2}\right))^2 - 1}.$$

Setting $\Omega_P = 1$, we can compute the variance of the gaussian source by

$$\sigma^2 = \frac{1+\zeta}{1-\zeta} \cdot \frac{\Omega_P}{2}$$

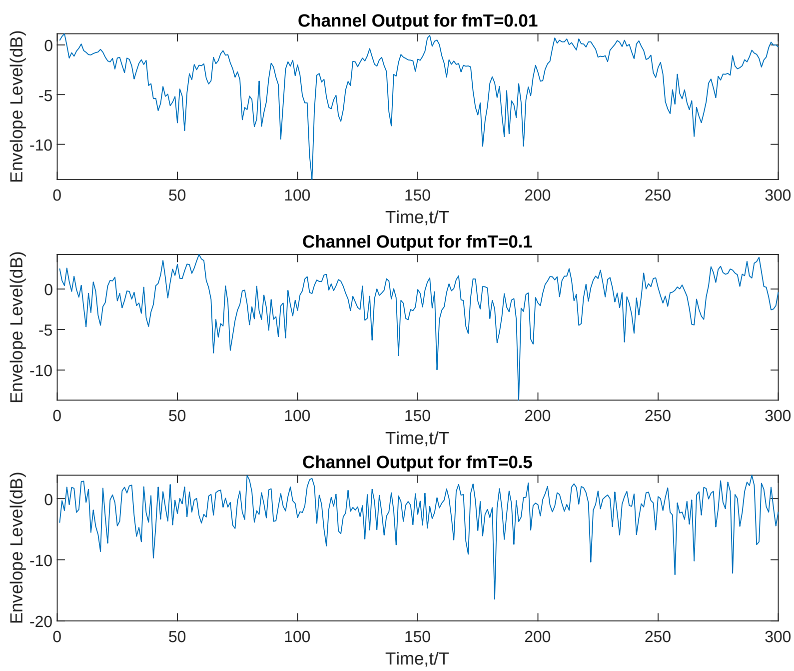
Finally, we generated the fading through

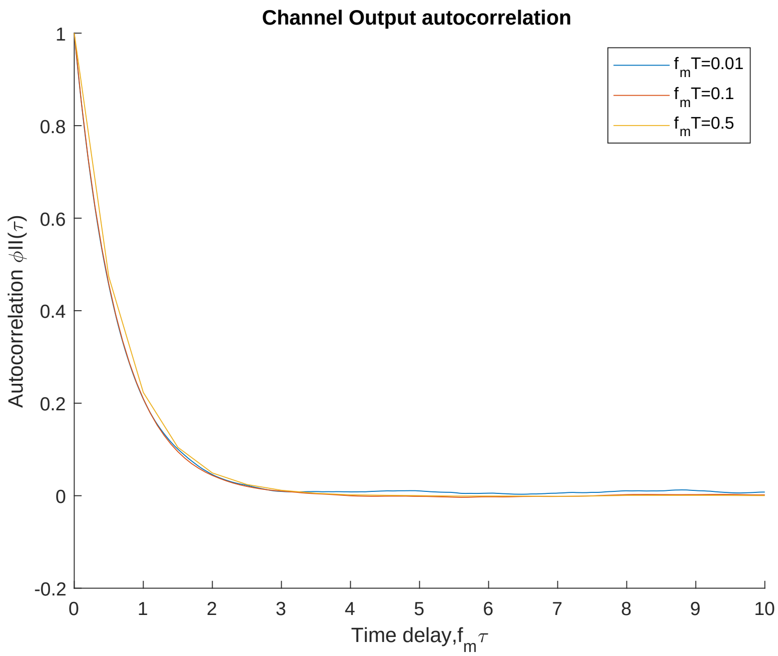
$$(g_{I,k+1}, g_{Q,k+1}) = \zeta \cdot (g_{I,k}, g_{Q,k}) + (1-\zeta) \cdot (w_{I,k}, w_{Q,k})$$

where $w_{I,k}, w_{Q,k} \sim \mathcal{N}(0, \sigma^2)$. The channel output envelope and auto correlation function is then obtained as

$$\begin{aligned} g_k &= g_{I,k} + j g_{Q,k} \\ \|g_k\| &= \sqrt{g_{I,k}^2 + g_{Q,k}^2} \\ \phi_{gg}(n) &= \sum_k g_{k+n} g_k^* \end{aligned}$$

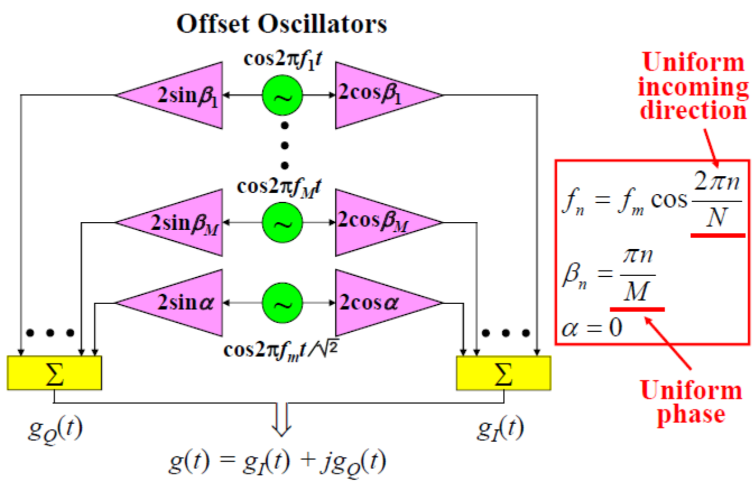
We plot the envelope and autocorrelation for different f_mT.





2. Sum of Sinusoids method

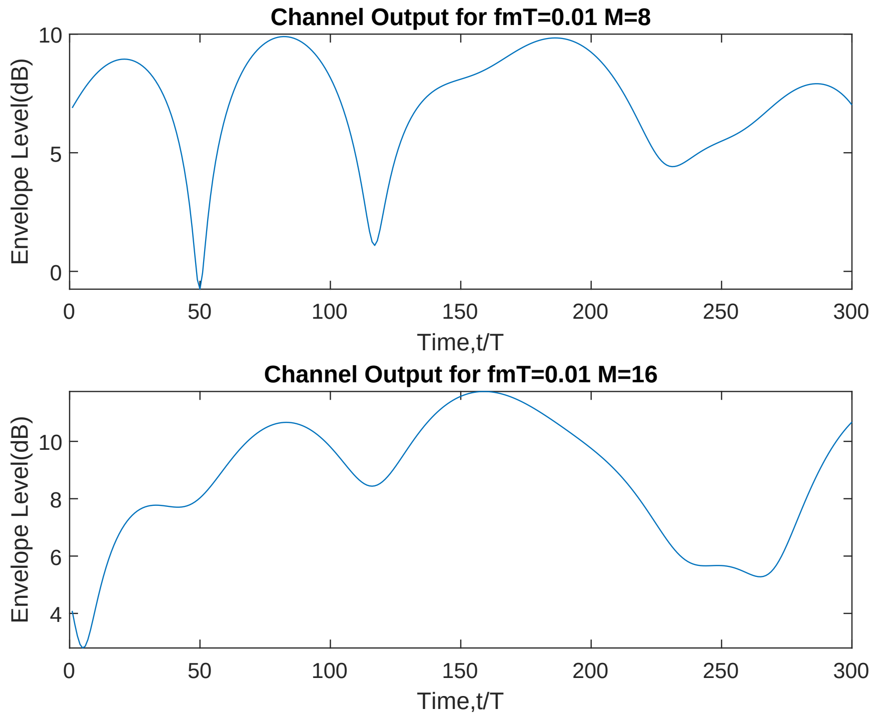
In sum of sinusoids nethod, we use the following architecture to generate different sinusoidal signal

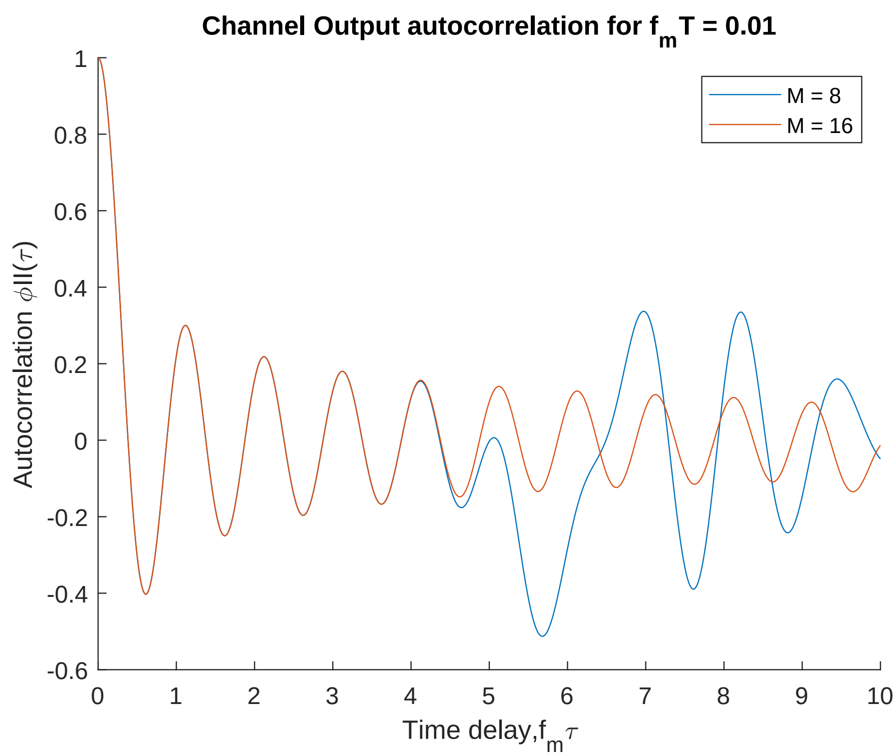


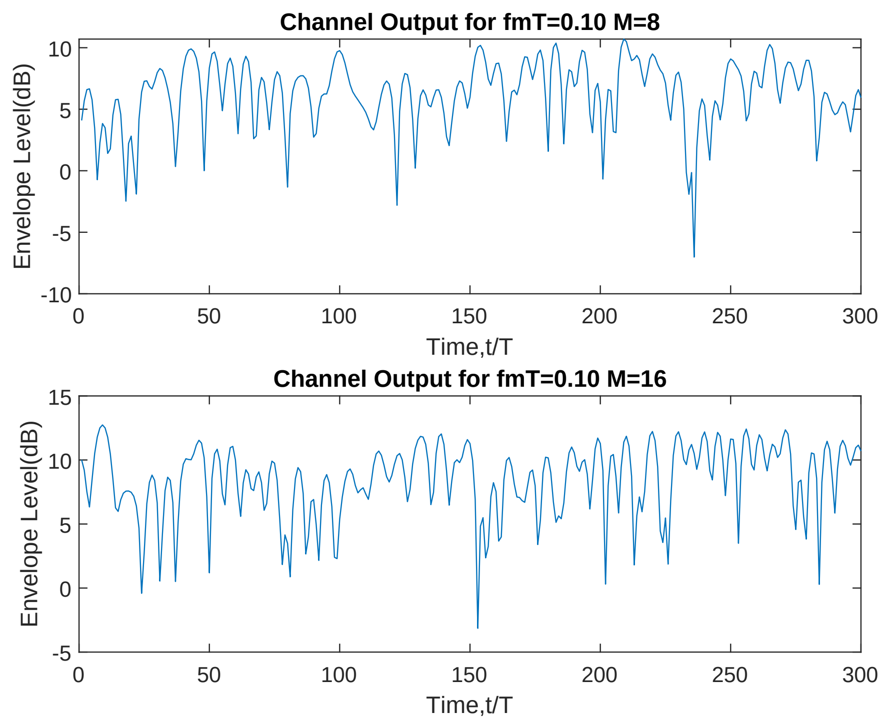
where

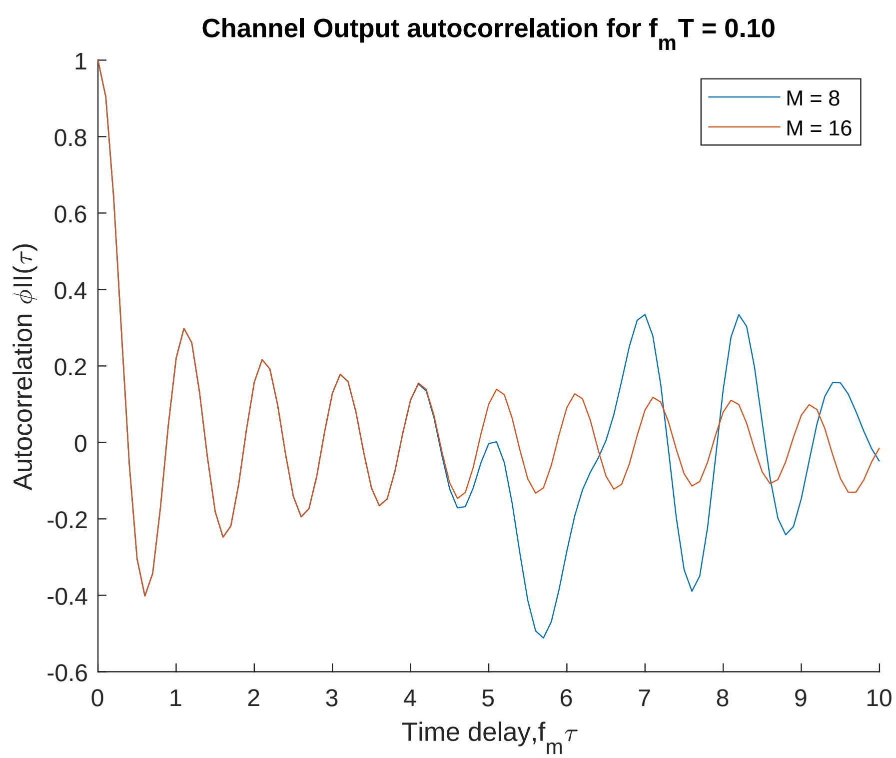
$$g(t) = \sqrt{2} \cdot \left\{ \sum_{n=1}^{M} 2\left(\cos\beta_n + jsin\beta_n\right)\cos 2\pi f_n t + \sqrt{2}\left(\cos\alpha + jsin\alpha\right)\cos 2\pi f_m t \right\}.$$

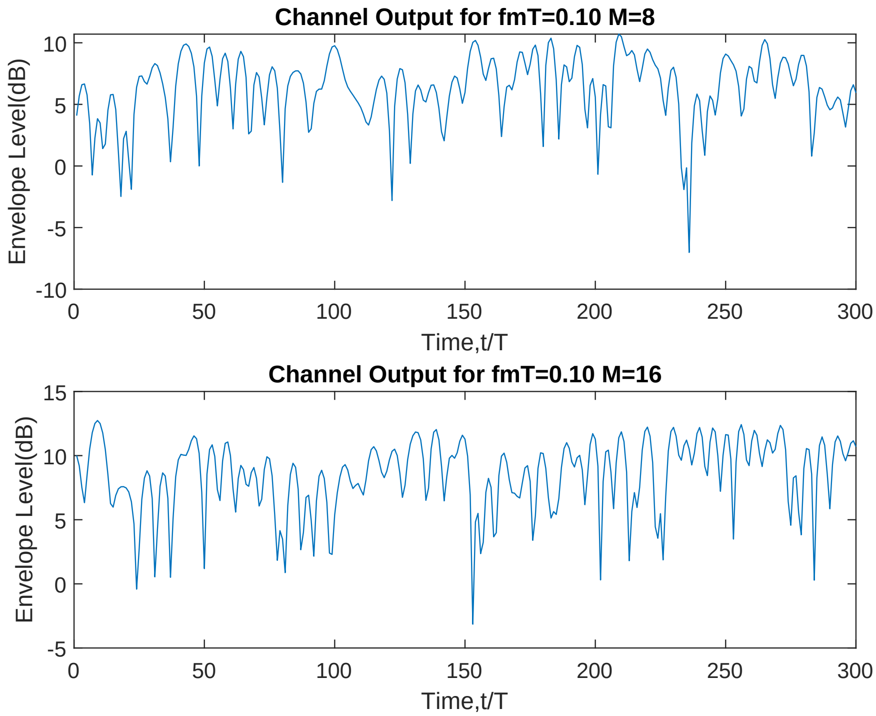
We plot the envelope and autocorrelation for different $f_m T$ and M. Notice that when plotting envelope, we neglect the initial part. The reason is that $f_m t$ is small at the beginning, resulting in undesired waveform.

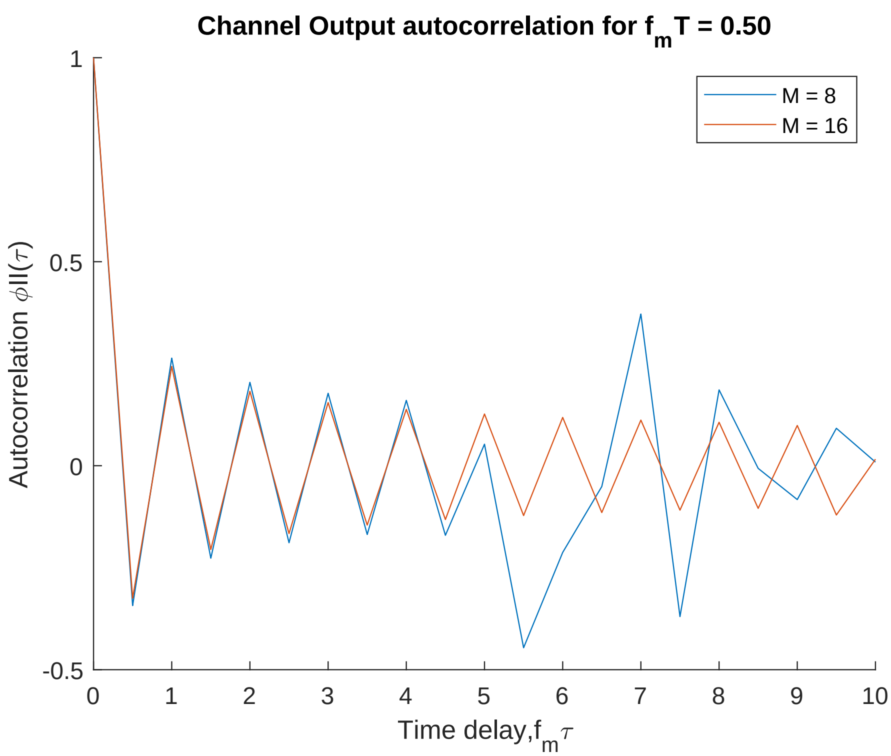

Channel Output for fmT=0.01 M=8
Envelope Level(dB)
Time,t/T
Channel Output for fmT=0.01 M=16
Envelope Level(dB)
Time,t/T


Channel Output autocorrelation for $f_m T = 0.01$
Autocorrelation ϕII(τ)
Time delay,$f_m \tau$
M = 8
M = 16


Channel Output for fmT=0.10 M=8
Envelope Level(dB)
Time,t/T
Channel Output for fmT=0.10 M=16
Envelope Level(dB)
Time,t/T


Channel Output autocorrelation for $f_m T = 0.10$
M = 8
M = 16
Autocorrelation $\phi II(\tau)$
Time delay,$f_m \tau$





3. Comparison

- **Filtered Gaussian Noise method**
  In filtered gaussian noise method, we may notice that the fluctuation of the envelope increases as $f_m T$ getting bigger. On the other hand, the auto correlation is not affected by $f_m T$ a lot.
  - Advantage: Different paths are uncorrelated.
  - Disadvantage: This method is based on first-order filter. Therefore, the power spectrum density of the generated siganl is much different from the ideal case (U shape). To have a more accurate result, we can use a higher order filter, which increases the complexity.
- **Sum of Sinusoids method**
  In sum of sinusoids method, we may notice that the fluctuation of the envelope increases as $f_m T$ getting bigger. Moreover, autocorrelation behaves more like the ideal autocorrelation as M increases. That is, for larger M, the undesired behavior occurs later.
  - Advanatges: generate isotropic scattering fading environment with low complexity by using less oscillator.
  - Disadvantage: There's no randomness in the generating process. Therefore, in order to use it for modeling the real case, some modification is needed. For example, different simulation should start from different point to confront different fading.