HW#2 Simulations

WIRELESS COMMUNICATIONS

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Part a:

After defining the constants, channel gains are simulated:

SIMULATING CHANNEL GAIN:

As we know channel gain is a random variable with **complex normal** distribution. For simulating it, first delays should be simulated.

Based on the question, delays have uniform distribution form *1 μs* to *10 μs*. Using this information, 100,000 samples of these delays are created.

With delays in hand, $2\sigma^2$ is calculated using the given formula. Then g is simulated with "***normrnd***".

Since we have 100,000 samples and 10 clusters, g is a matrix with 10*100,000 as its dimensions.

OVERALL GAIN:

For finding the overall gain, gains of all 10 clusters are summed up.

COMPUTING POWER GAIN ($|h|^2$):

For this part using the above part, the absolute value of h is calculated. (h is the overall gain that's calculated in the last part.)

COMPUTING AVERAGE POWER GAIN ($E\{|h|^2\}$):

For an estimation of $E\{|h|^2\}$, all the 100,000 samples are summed up and then averaged.

As expected the result is very close to $2\sigma^2$.

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The simulated power gain is 0.000369, while the actual its value is 0.000372.
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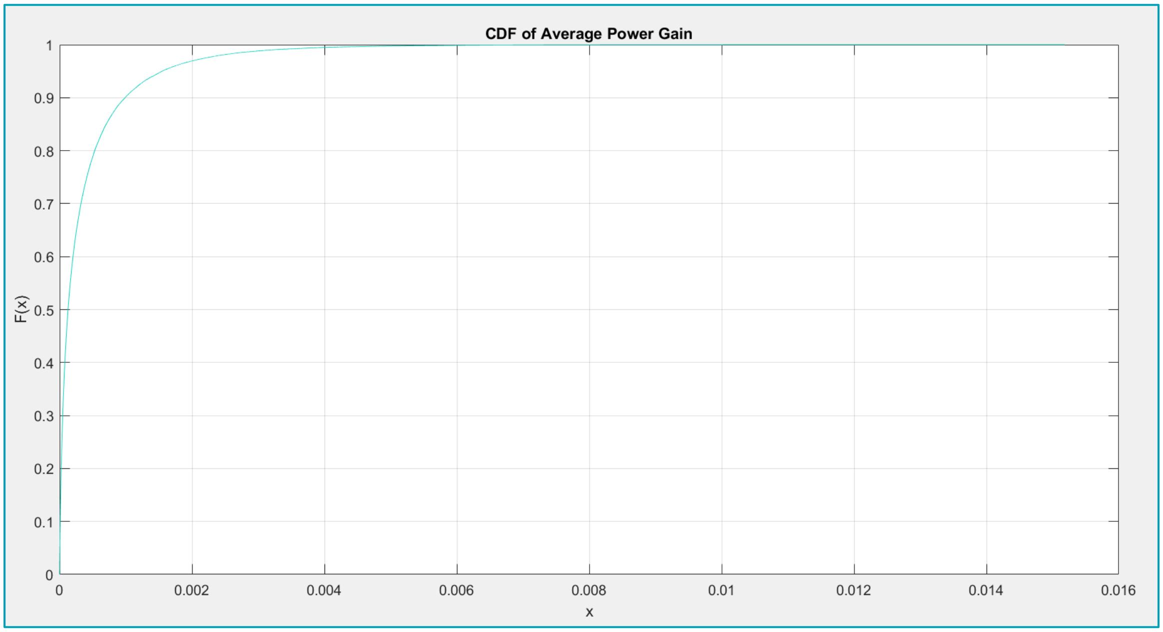
CDF OF POWER GAIN ($|h|^2$):

As we know h is a random variable with complex normal distribution. So $|h|^2$ will have exponential distribution.

Below the CDF of $|h|^2$ can be found which proves the above statement about its distribution.

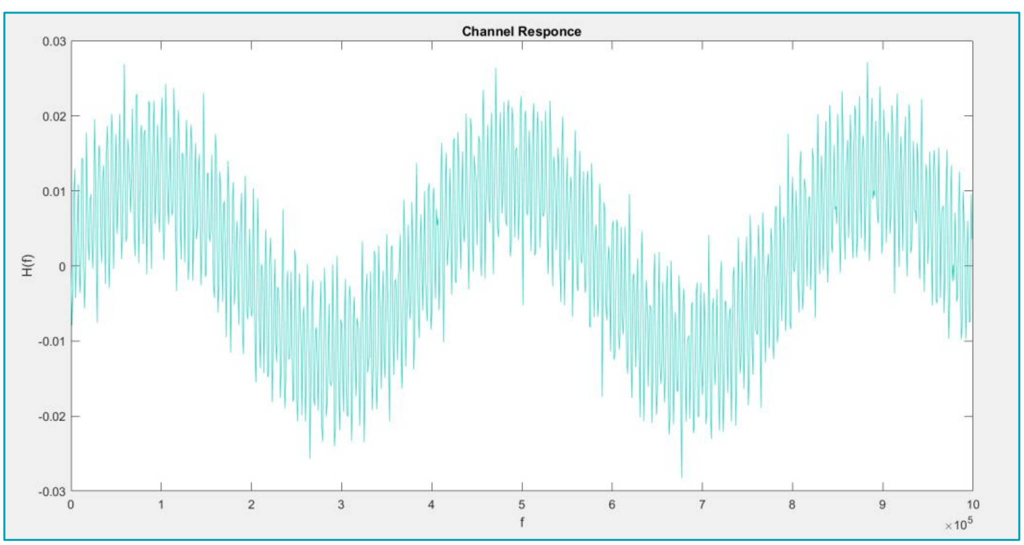


Part b:

In this part frequencies are created. After that H which is the frequency response is calculated as below:

$$h(\tau) = \sum_{i=\text{١}}^{\text{١٠}} g_i \delta(\tau - \tau_i) \overset{F_\tau}{\rightarrow} H(f) = \sum_{i=\text{١}}^{\text{١٠}} g_i \exp(-j2\pi f \tau_i)$$

The result is plotted as below:



As can be seen in the above plot, the result has a lot of noise which is a result of all the random delays.

Part c:

SIMULATING DOPPLER FREQUENCY:

For this first θ are simulated. As stated in question, they have uniform distribution from 0 to 2π.

Then f_d is simulated with the below formula:

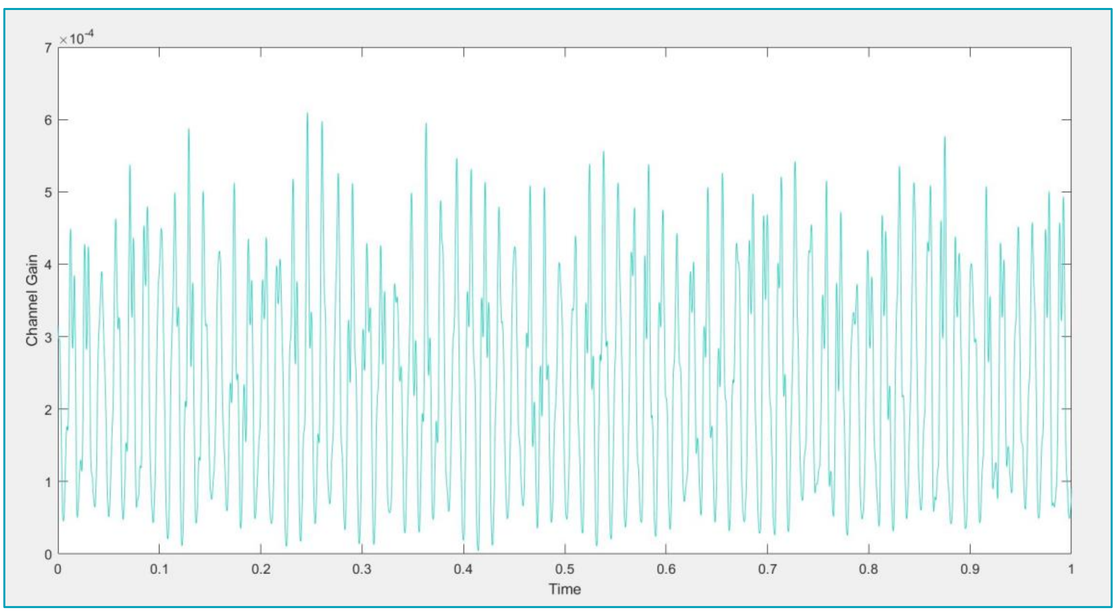
$$f_d = \frac{v}{\lambda} cos\theta \,.\, \lambda = \frac{c}{f_c} \rightarrow f_d = f \frac{v}{c} cos\theta$$

CALCULATING OVERALL CHANNEL GAIN FOR ONE REALIZATION:

Channel gain while considering Doppler's effect is calculated as below:

$$gain\ with\ doppler = \sum_{i=o} g_i \exp(j2\pi f_d t)$$

The result is plotted below:



COMPUTING POWER GAIN ($|h|^2$), AVERAGE POWER GAIN ($E\{|h|^2\}$):

These parameters are calculated like what I did in part a. If that procedure is followed the average power would be as below:

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The simulated power gain with doppler gain is 0.000290
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One point which should be mentioned about the above number is that it can change in different runs. If the value of "g" s are constant, the reason it changes is that θ is a random variable so differs in different runs. As a result f_d changes. The other change that can be faced is when g is not considered constant. In this way the change between the 2 values of $E\{|h|^2\}$ can be pretty huge, in a way that one can be below $2\sigma^2$ while other can be more than that.

Because of the difference between the calculated average power gain in this part and part a, its CDF is slightly different. In general if the average power of part c be larger than that of part a, its CDF is under part a's, otherwise is above part a's.

The discussed point can be seen in the below plot: