Homework 7 submission

ECET 512 — Wireless Systems

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1 Submitted files

For this assignment, besides this report, the following archives were created:

1.1 SRC Folder

+ *"main.py"*: This **script** demonstrates the fading statistics of a Rayleigh fading envelope, as well as a Bit Error Rate Simulation using the generated fading envelope. A user is simulated walking through a basestation to visualise performance of the system.

1.2 DOC Folder

+ *"f20stats.png"* A Rayleigh fading envelope with its fading statistics overlayed at fm=20.
+ *"f200stats.png"* A Rayleigh fading envelope with its fading statistics overlayed at fm=200.
+ *"user.gif"* Animation of a single user moving across one base cell.
+ *"BERvsSNR.png"* A plot of bit error rate vs SNR for multiple transmission tests.
+ *"BER.png"* Plot of how the BER changes as a mobile user moves through a cell.
+ *"SNR.png"* Plot of how the SNR changes as a user moves through a cell.

2 Fading Statistics

Below are demonstrations of the Rayleigh channel's fading statistics and their summary statistics.

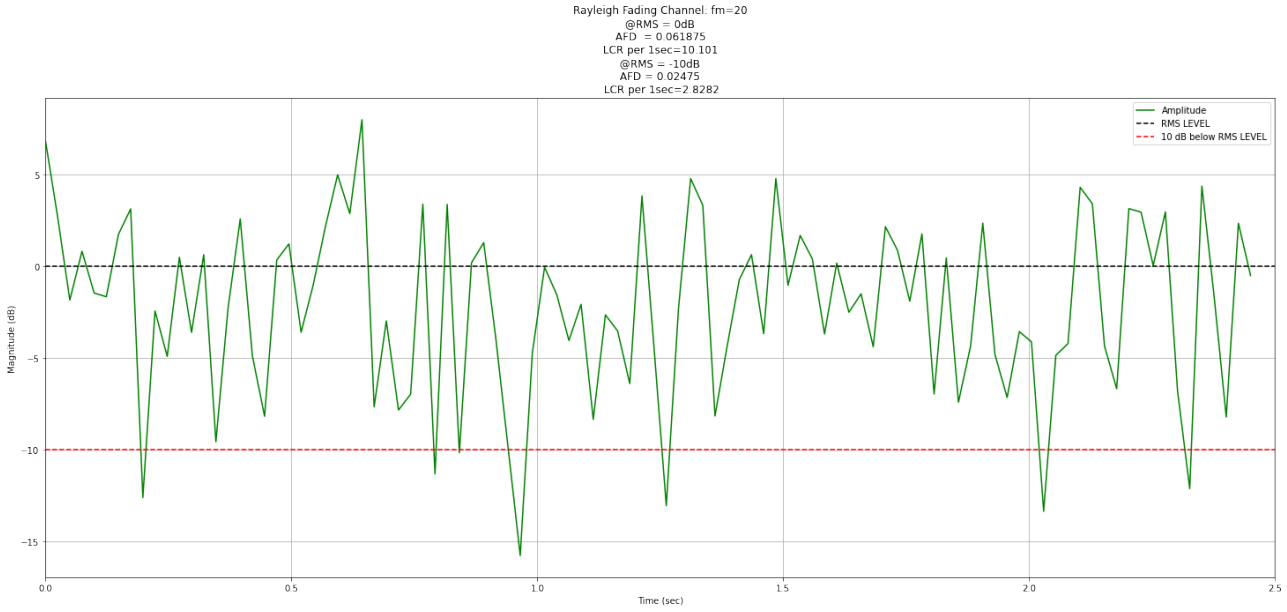

Figure 1: Characteristics of a Rayleigh fading channel at fm=20. Level Crossing Rate and Average Fade Duration at different thresholds are displayed on the graph.

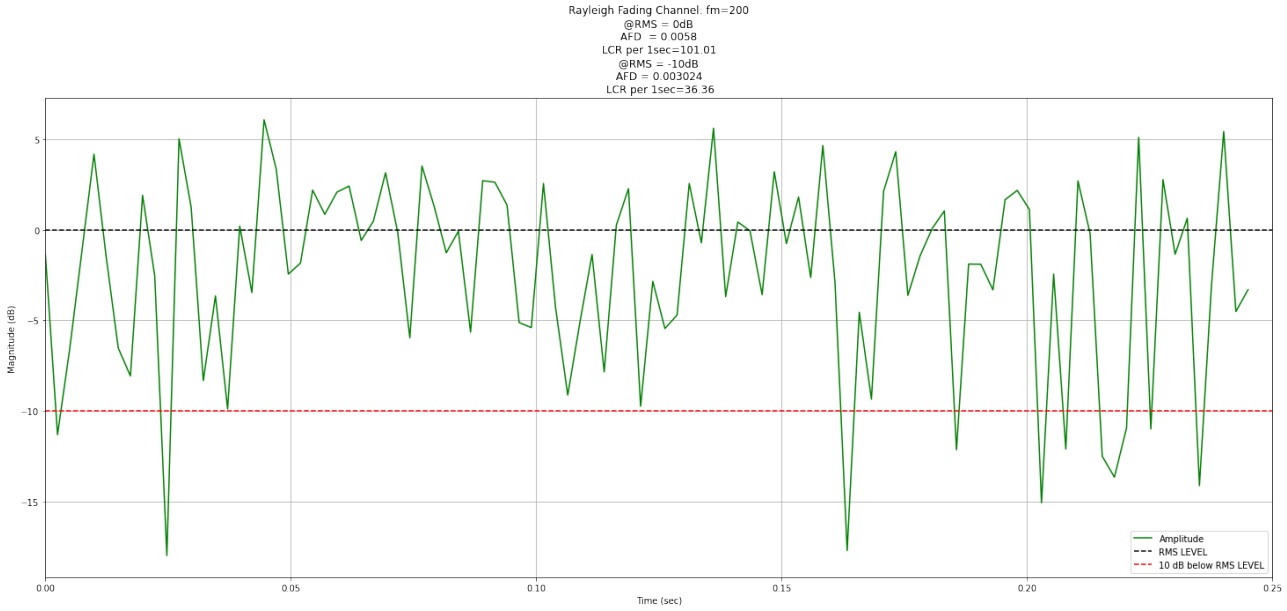

Figure 2: Characteristics of a Rayleigh fading channel at fm=200. Level Crossing Rate and Average Fade Duration at different thresholds are displayed on the graph.

3 Bit Error Rate

Below are the results of a 4-QAM transmission scheme that is colored by noise in the Rayleigh fading channel. Previous simulations are extended to show the change in SNR and BER as a mobile user moves through a single cell.

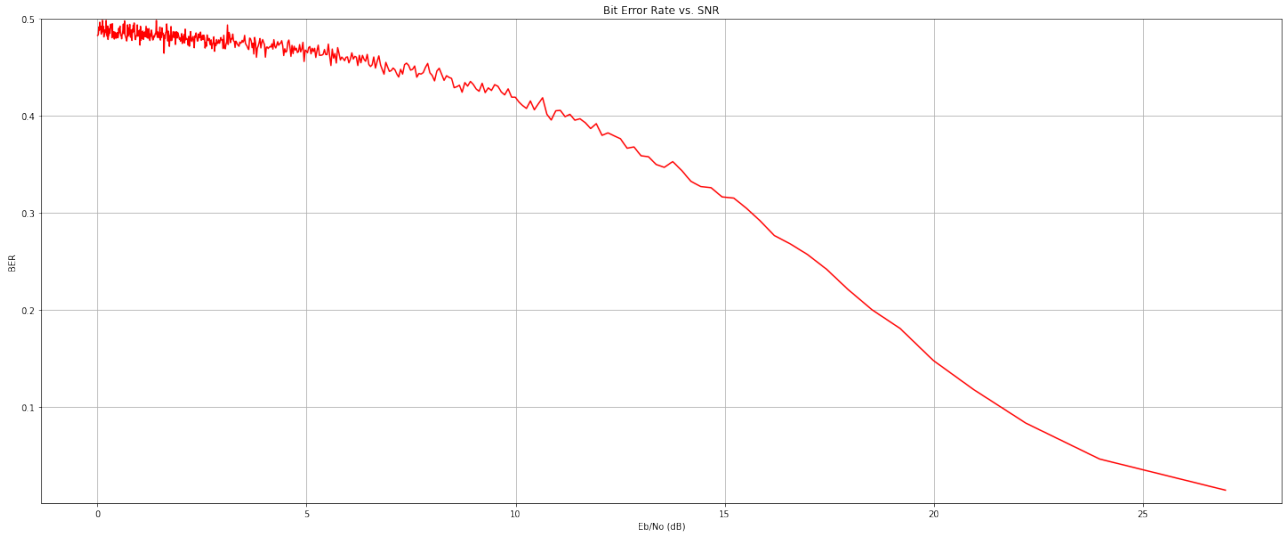

Figure 3: Bit Error Rate vs SNR in decibels for multiple realizations of the transmission scheme. You can see that the BER caps at 0.5 as we are in a single bit scheme, and as the signal to noise ratio improves, the BER decreases.

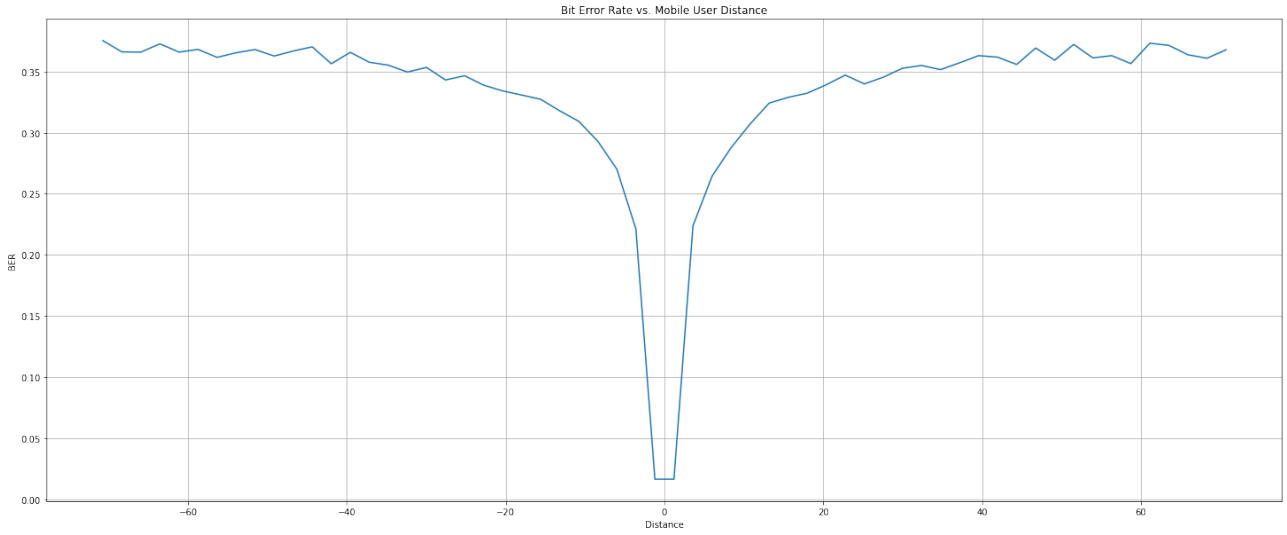

Figure 4: Bit error rate as a user moves through a mobile station. As the signal is improved, the user recieves less error.

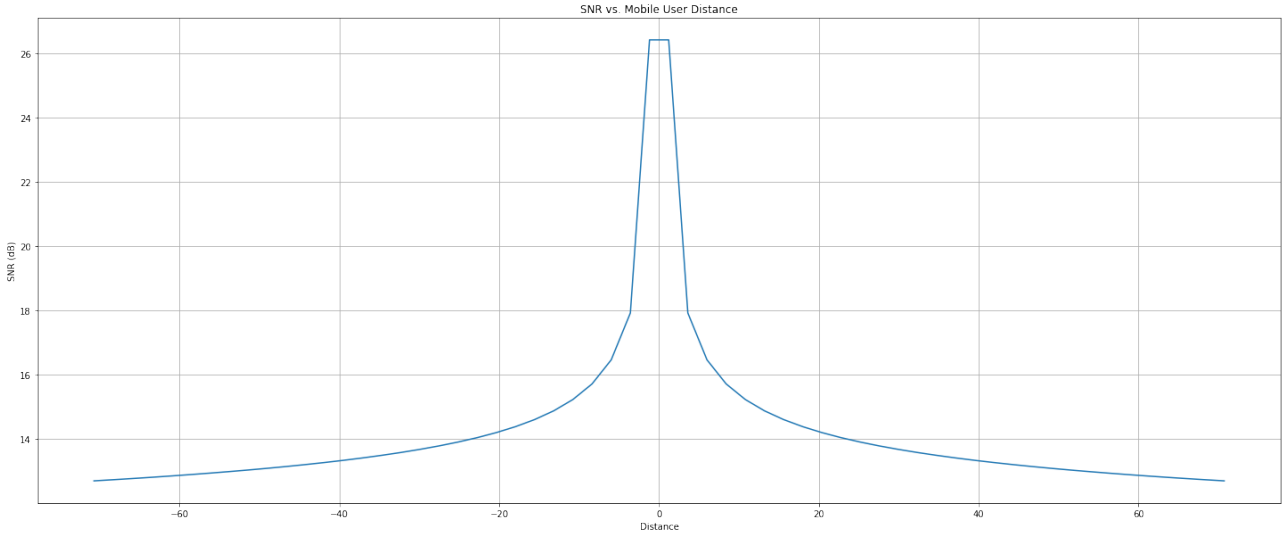

Figure 5: Signal to noise ratio as user moves through a single channel. As power recieved from the basestation improves, the SNR improves as well.

4 Python code

```
# generate bit string
bits = np.zeros(10000, dtype=int)

for i in range(10000):
  bits[i] = random.randint(0, 1)

# create encoded bit sequence
bitsencoded = []

for i in range(int(len(bits)/2)):

  b1 = bits[2*i]
  b2 = bits[2*i+1]

  if b1 and b2:
    bitsencoded.append(-1+1j)
  elif (not b1) and b2:
    bitsencoded.append(1+1j)
  elif b1 and (not b2):
    bitsencoded.append(-1-1j)
  elif (not b1) and (not b2):
    bitsencoded.append(1-1j)

ZdB = np.arange(3,20)
Z = 10**(ZdB/10)

1/Z

z= np.linspace(0, 1, 500)
print(z)

def ispositive(x): return 1 if x >= 0 else 0

BERs = []

for i in z:
  # generate channel h(t) samples
  r, T = rayleighfade(10000, 20)
  theta = np.exp(-1j*np.random.uniform(0, 2*np.pi, 10000))
  h = r*theta
  n = np.random.normal(0, 1, 10000)*i

  # recover signal
  cnoise = n/h
  eq_bits = bitsencoded + cnoise[:5000]

  # decode recieved signal
```