# ee597-assignment1

Modeling bit error with M-PSK and fitting the simple path loss model to collected data.

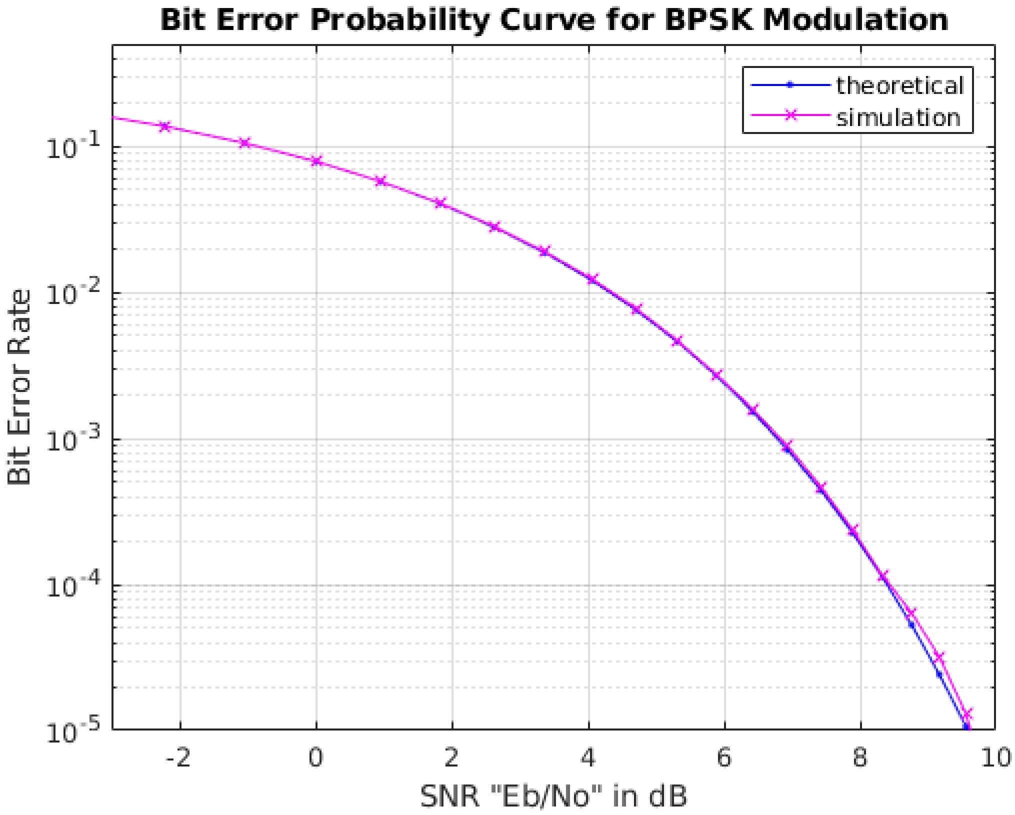
## Sources

- bit error for various schemes in matlab: https://www.mathworks.com/help/comm/ug/bit-error-rate-ber.html#fp12932
- bit error calculation theory: https://www.unilim.fr/pages_perso/vahid/notes/ber_awgn.pdf

## Results and Comments

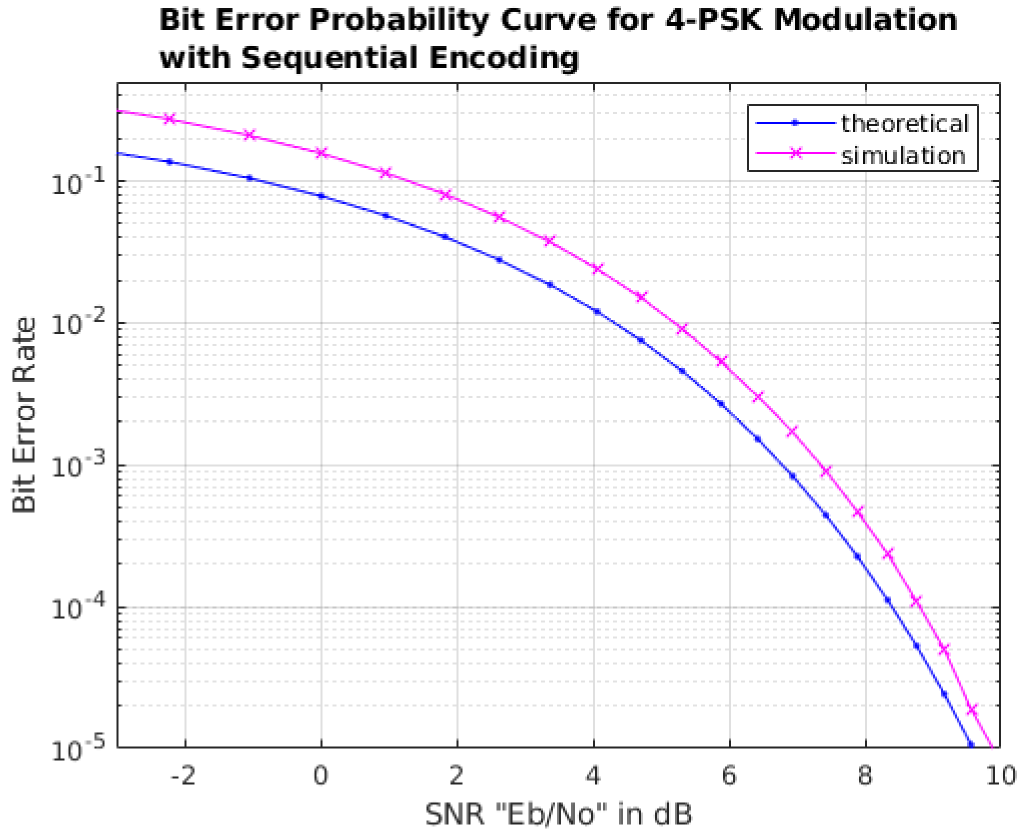
### Problems 1 and 2 - Simulated Modulation Schemes (BPSK and 4-PSK)

**Figure 1** - Probability of Error for BPSK Modulation



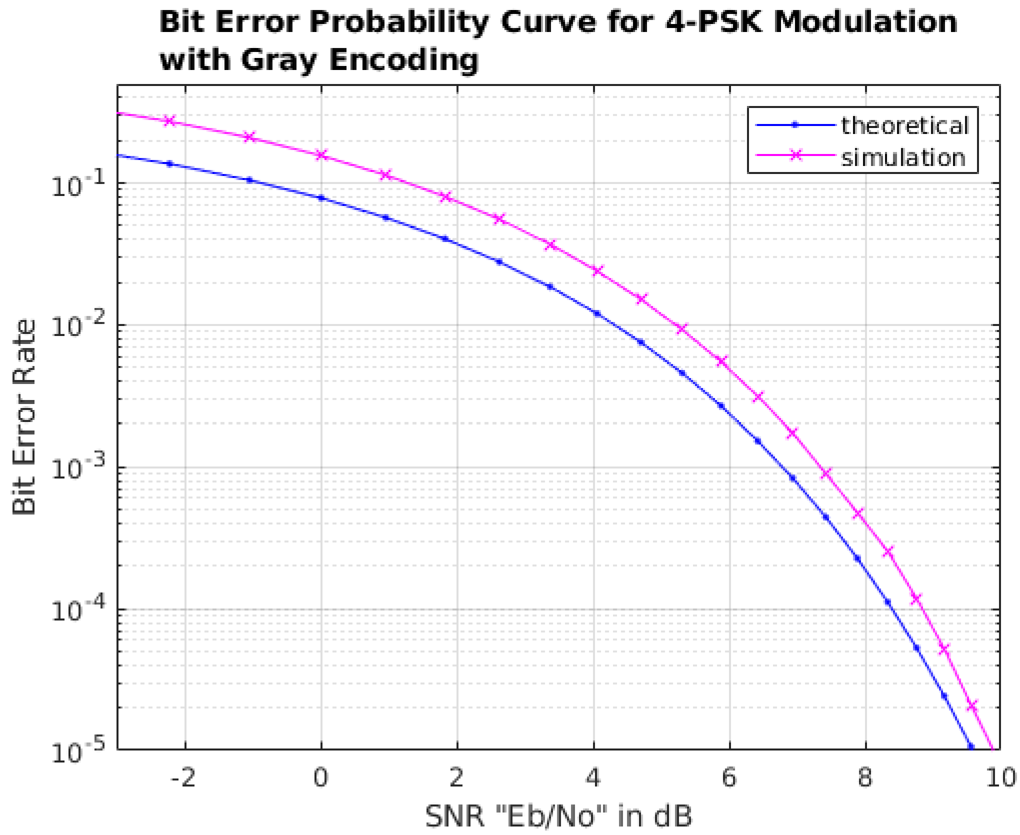

By plotting simulation of BPSK, we can see that the sumulated error curve (with respect to SNR) stays very close to the theortical expression curve. This is because the theoretical expression Pb = Q(sqrt(2*SNR)), where SNR = Eb/N0, is an accurate approximation for the BPSK bit error rate (BER).

**Figure 2** - Probability of Error for 4-PSK Modulation with Sequential Encoding




However, as we can see after plotting 4-PSK over the same SNR range, the 4-PSK simulated BER for sequential encoding follows the same order as the theoretical expression given for BPSK, but with a higher y-intercept. This is because the BPSK theoretical expression is an adequate approximation for 4-PSK, but not as accurate as it is for BPSK.

**Figure 3** - Probability of Error for 4-PSK Modulation with Gray Encoding



We can make a slight improvement on the behavior of 4-PSK by changing our encoding scheme to gray-coding. This minimizes our chance of 2-bit errors, and as we can see on the resulting plot, the simulated BER converges to the theoretical BER at higher SNRs.

### Problem 3 - Determining Model Parameters of the Simple Path Loss Model

**Figure 4** - Data Scatter Plot

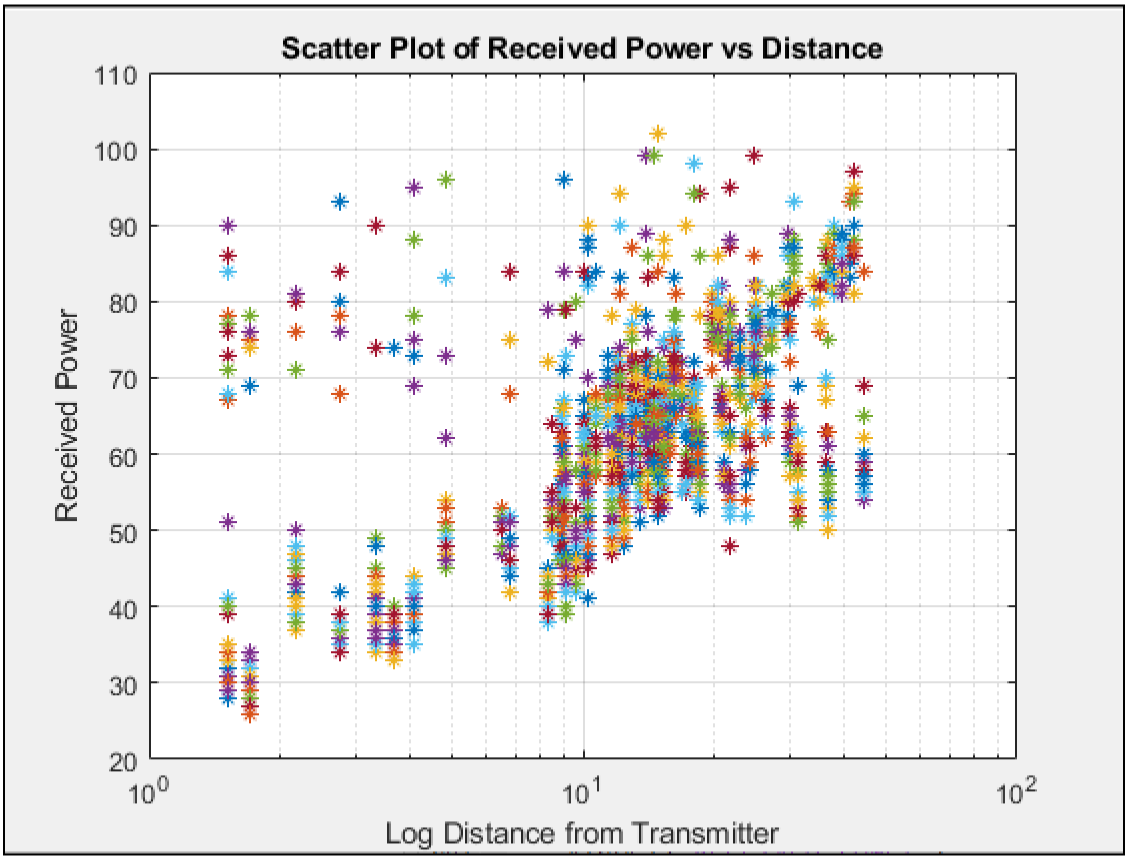
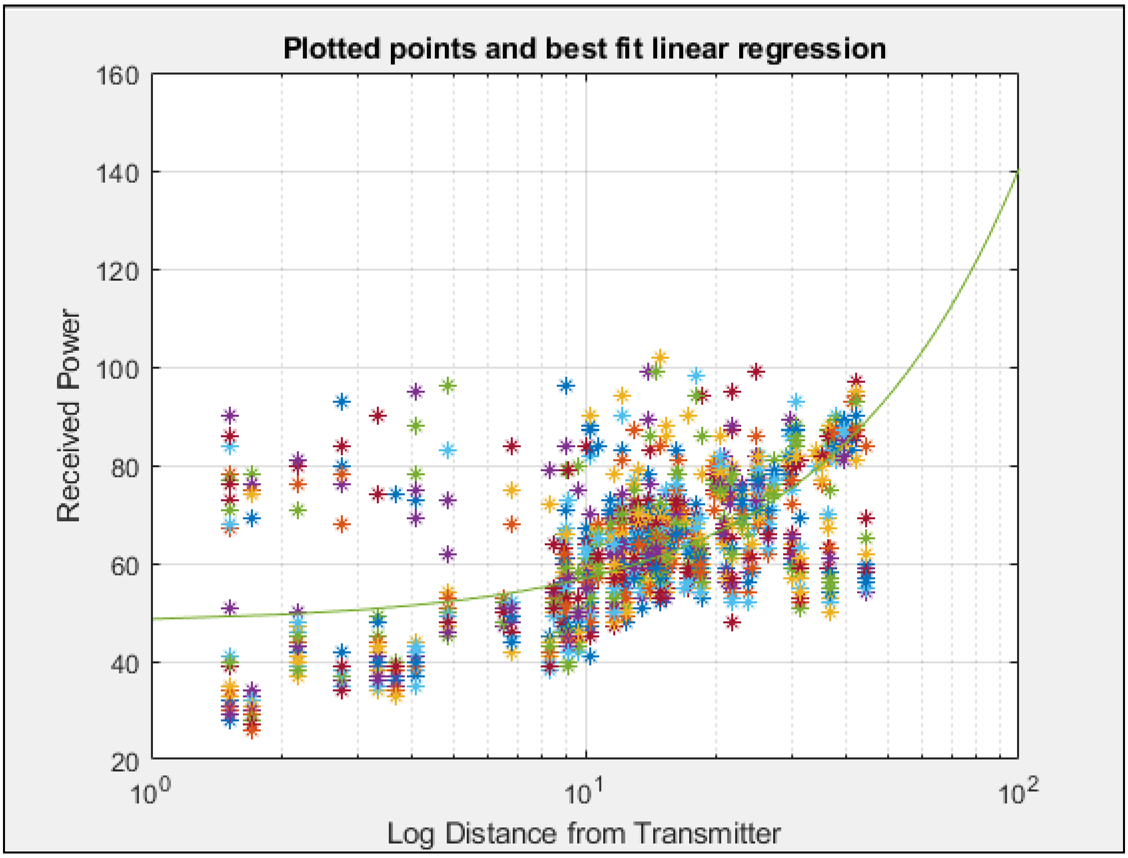


**Figure 5** - Regression Line to Find Model Parameters




**B) Parameters**

Paremeters contained in the coeffs variable.

K = 47.6988 (y-intercept) N "eta" = 0.9264 (slope)

Keep in mind all experimental values were negative, and so these are similarly negative in real life, in line with a decreasing Received Power with increasing distance.

**C) Standard Deviation**

There are 96 values for standard deviation, in line with the 96 different 12 experiments * 8 receivers. Values can be found in the variable sd. First few terms pulled with [bfg(:,1) sd']: 8.9200 4.5238 9.0504 10.6344 23.6733 4.4869 36.4862 9.8520 17.8566 3.0887 30.5840 NaN 41.7016 NaN 12.3894 2.9205 15.3300 3.7573 2.7483 18.6356 17.2697 8.4716

**D) Missing Samples**

By leaving out samples corresponding to lost packets (-500 dBm in data), we are biasing out results. Because packets received below a power threshold are a valid occurrence in the real world, yet we are tossing these as outliers in our experimental analysis, we are actually tightening the standard deviation and analyzing only the successful packets. With as many outliers as we saw in the experimental data, our standard deviation would be much larger.