

## ELEC 433 LAB #2: Digital Modulation

For all the exercises below:

- Normalize constellations to an average power of 1W. MATLAB's `modnorm` and the minimum distance parameter in Simulink's modulation blocks will be useful.
  - Use Gray encoding to map bits to constellation symbols for all modulation schemes.
  - Make comparisons of BER vs.  $E_b/N_0$ .
1. Use MATLAB's `bertool` to reproduce the plot shown in the slides comparing the theoretical BER performance of various PSK and QAM modulation schemes.
  2. Build a BER testing model in Simulink using blocks from the Communications and Signal Processing blocksets. You don't need to use any Xilinx blocks at this point. Simulate the BER performance of 4-QAM, 16-QAM, 64-QAM, 8-PSK and 16-PSK for a subset of the  $E_b/N_0$  values you used in `bertool` ([0:18] by default). MATLAB's `Bertool`'s Monte Carlo mode are useful for scripting the repeated execution of Simulink models. Plot the results against the theoretical curves (use `bertool`'s export function to save plotted values to the workspace). Hint: MATLAB has an built-in BPSK BER testing model and the corresponding documentation (`doc bertool`).
  3. Build a System Generator model which implements the same five modulation schemes. The system should have a single input for binary data bits, running at a fixed sample rate. Each scheme's output symbol rate depends on the constellation size. Use outputs of no more than 12 bits for all five output signals. Verify your modulators visually using Simulink's Discrete-Time Scatter Plot (in the Communications Blockset → Comm Sinks). Hint: serial to parallel block is used for part 3 and part 4.
  4. Build a System Generator model which implements the same five modulation schemes. This system should have an input for a control signal which selects which modulation scheme to use. The output should be a pair of `Fix_12_11` signals (for I and Q) with a sample rate which does **not** depend on the selected modulation scheme. In other words, the symbol rate output from your model should be constant, regardless of which modulation scheme is selected. Verify your design visually using Simulink's Discrete-Time Scatter Plot. Hint: the input sample rate of each scheme is different.