

1. For the 16-QAM constellation shown below calculate E_b in terms of A . Assume that the transmitted symbol is corrupted by adding $N = N_c + jN_s$ where N_c and N_s are independent zero-mean Gaussian random variables with variance $\frac{N_0}{2}$. If all the constellation points are equally likely to be transmitted, calculate the following in terms of E_b and N_0 .

- [5 points] The exact error probability of the optimal decision rule.
- [5 points] The union bound on the exact error probability.
- [5 points] The intelligent union bound on the exact error probability.
- [5 points] The nearest neighbor approximation of the exact error probability.

