Project goal: assuming known probabilistic models for the receiver synchronisation (timing and phase) offsets in a digital communications system, are the optimum decision region boundaries at the detector equivalent to those corresponding to the perfect transmitter-receiver synchronisation case?

Assume equiprobable source symbols.

The decision region boundaries are given by the points of intersection between "adjacent" conditional probability density functions.

e.g. For 4-PAM with perfect transmitter-receiver synchronisation and overall system channel gain of unity, the decision statistic at the detector is given by

$$X = \omega_0 + n,$$

where $\omega_0 \in \{-3, -1, +1, +3\}$ is the transmitted source symbol and n is AWGN of variance σ^2. The conditional probability density function of X is given by

$$f_X(y) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(y-\omega_0)^2}{2\sigma^2}\right)$$

and the decision region boundaries are given by $\{-2, 0, +2\}$ (see also Fig. 1).

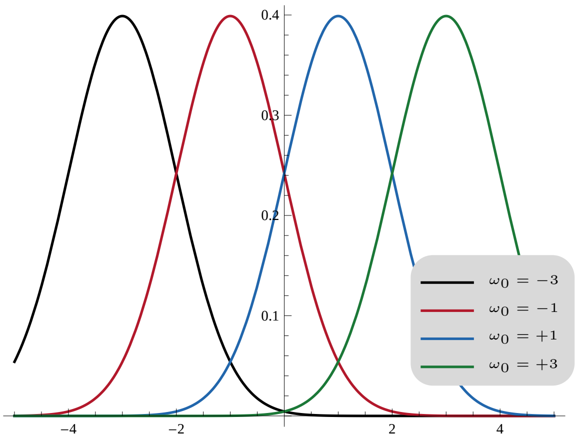

Figure 1: 4-PAM conditional distributions.

Timing offsets at the receiver will introduce intersymbol interference and the decision statistic probability density functions will now typically be unobtainable. The project will use two approaches to approximating the distributions:

- Approximate the conditional (on fixed synchronisation offsets) distributions via a Gram-Charlier series and average over "discretised" receiver synchronisation probability density functions.
- Randomly generate decision statistics and approximate the resulting distributions via kernel density estimation.

Assume root rasied cosine transmit and receive filters with roll-off factor of 0.5 and investigate BPSK, 4-PAM, QPSK, 8-PSK and rectangular 16-QAM signalling formats. Once the optimum thresholds have been identified, characterise the system performance (with respect to signal to noise ratio) via the resulting symbol error rates.

Extend the project to Nakagami-m fading channels with both maximal ratio combining and equal gain combining diversity.