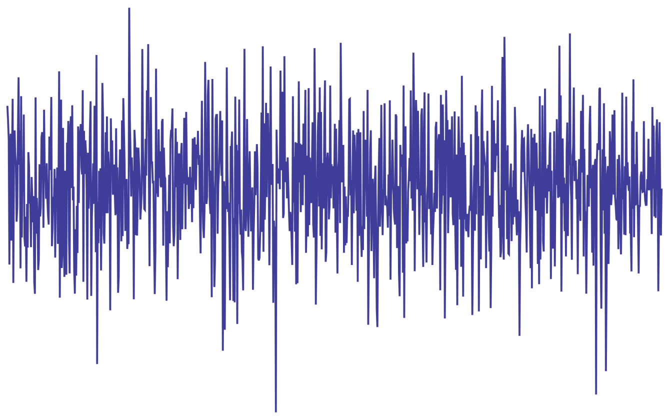
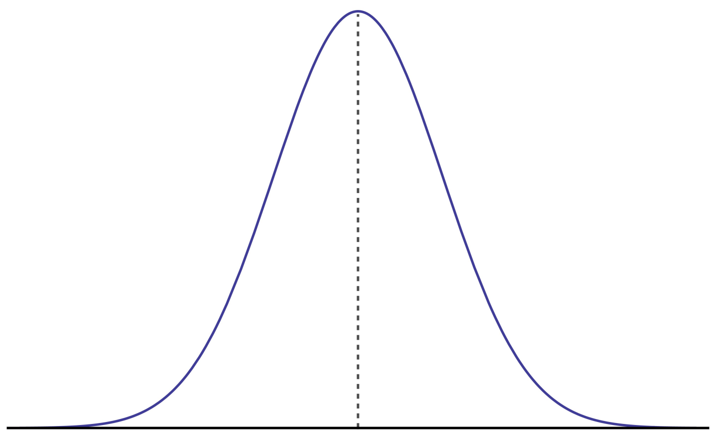
“Effects of Tikhonov-distributed Timing Error on Equal Gain Combining And Maximal-Ratio Combining with Sub-Optimal Design”

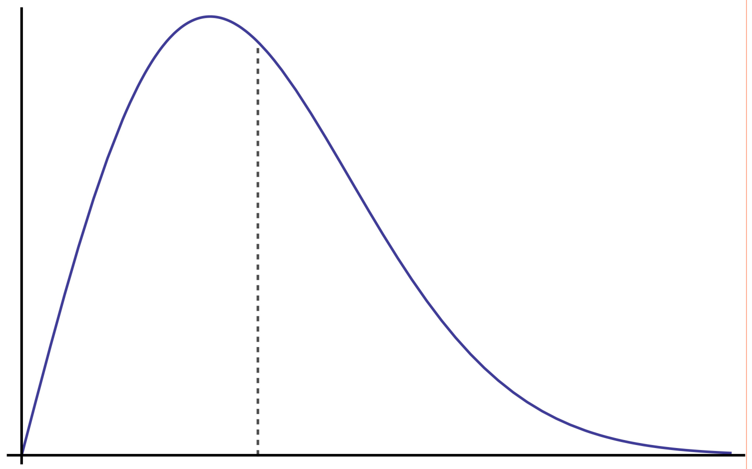
Communications Theory has long been concerned with the study of interference from other sources and from signal reflections, represented in communications models as **Noise** and **Fading**, respectively. Equally likely, but hardly studied, are the effects of **Timing Errors** which lead to the transmitter and receiver becoming unsynchronised.



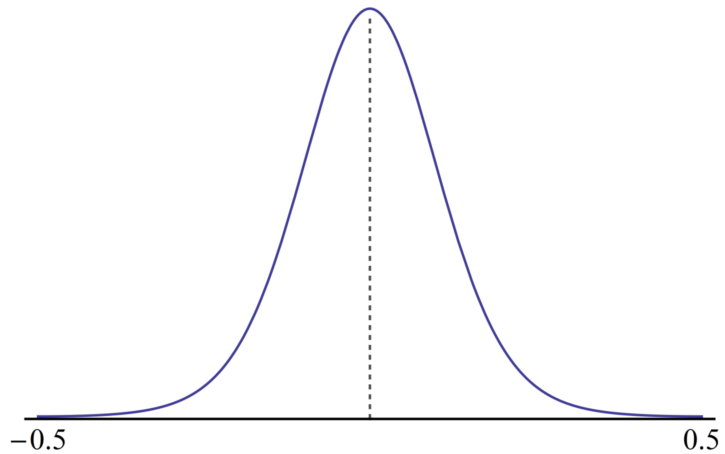
Noise



Fading



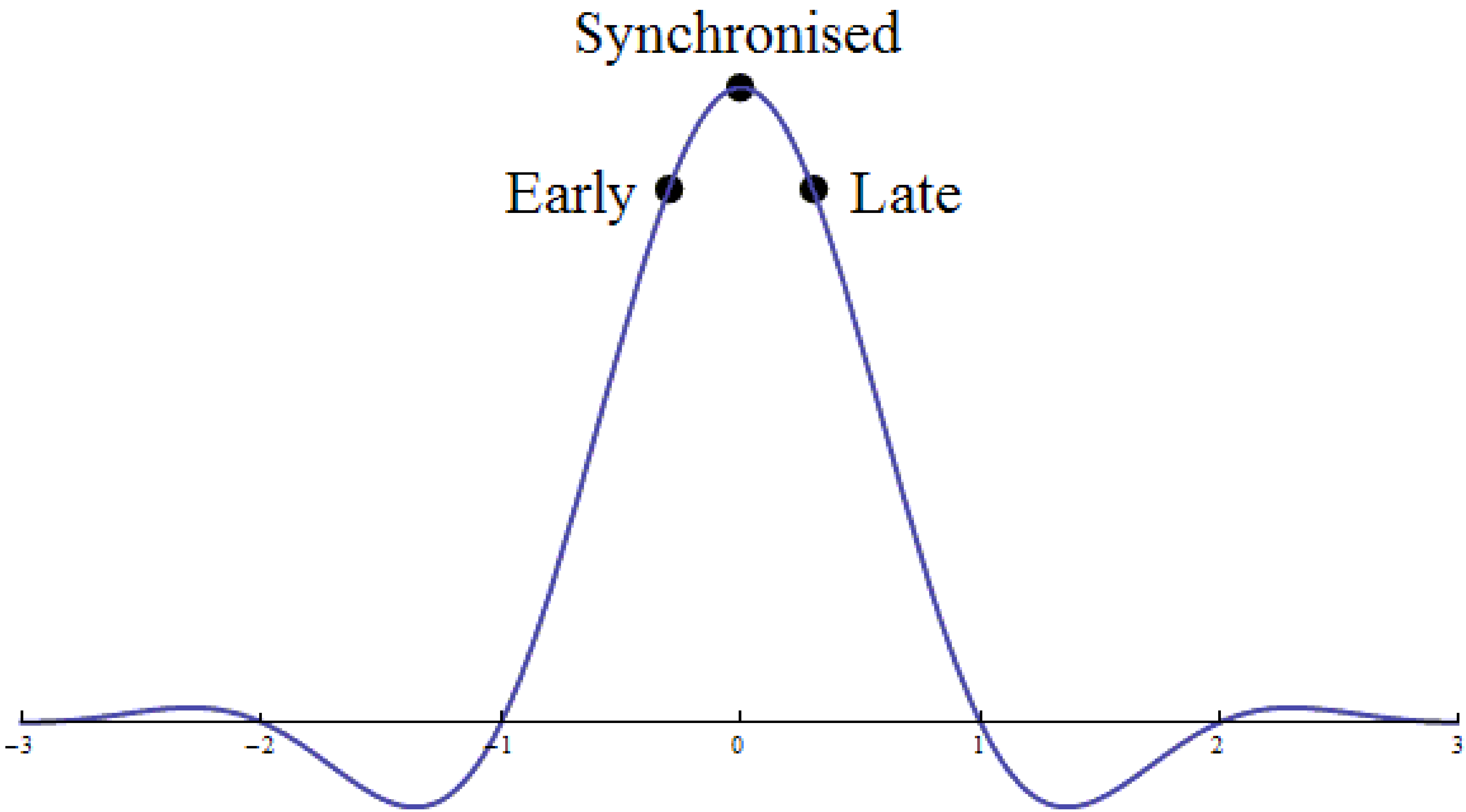
Timing Error



This project used the Wolfram Mathematica numerical computation environment to numerically **Simulate** and mathematically **Analyse** a communications system model, evaluate the effects of timing error on error rates, and **Improve Receiver Performance** in the presence of timing errors.

Effects of Timing Offset on Amplitude-Modulated Receivers

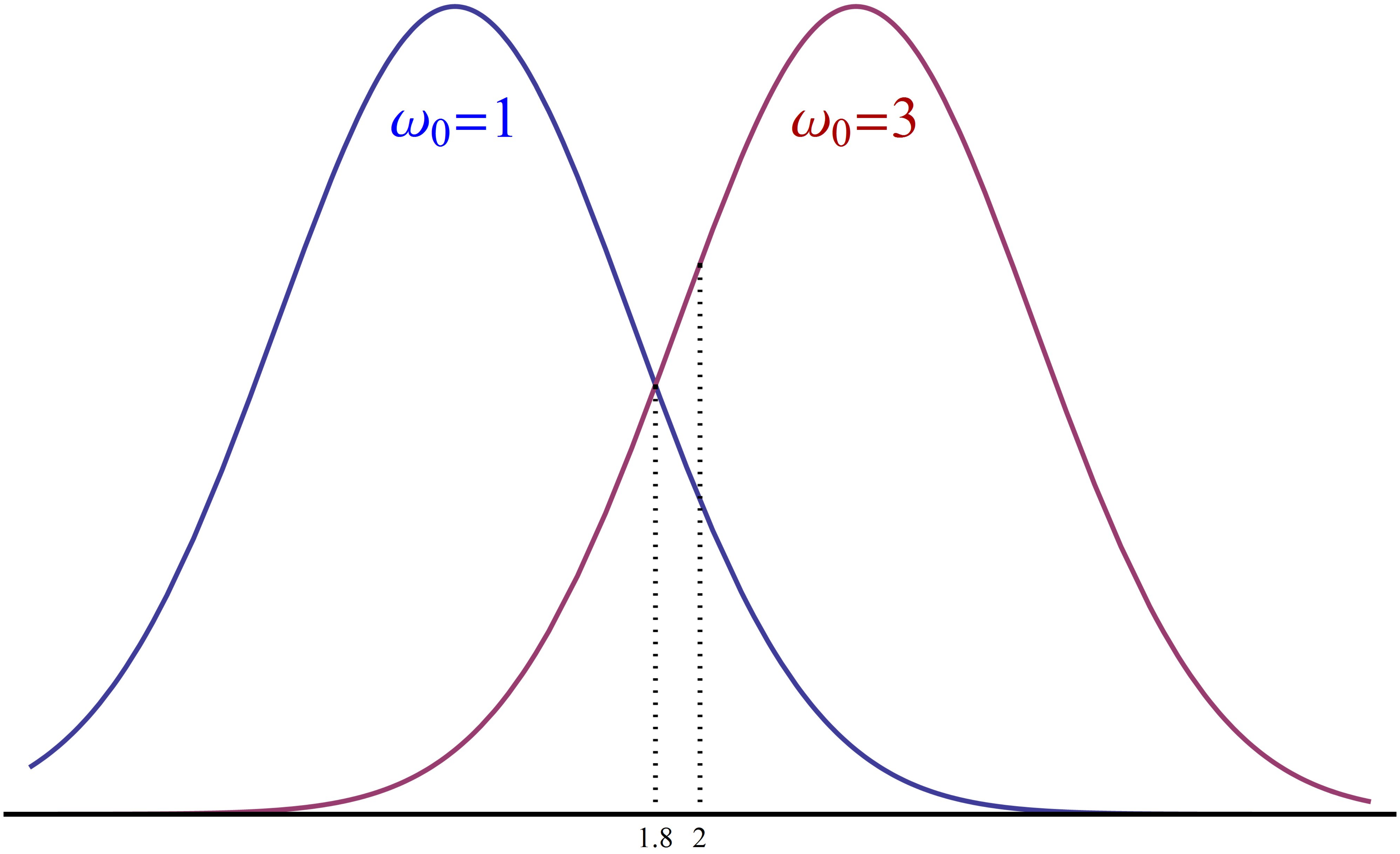
Random Timing Errors lead to the receiver sampling the signal slightly later or earlier than the transmitter sends it. Since most communications systems use a root-raised cosine response, this gives the received signal a **Reduced Amplitude** compared to the transmitted signal.



This leads to **Higher Error Rates** when trying to decode the signal using traditional techniques.

Improved Receiver Design - Simulation

If the decoder had knowledge of the severity (*variance*) of the timing errors, it could counter-act them by **Reducing Decision Boundaries** accordingly. This approach was examined in a numerical simulation, and assuming an urban environment with fading a 4-symbol Pulse Amplitude modulated symbol using Maximum Ratio Combining was saw error rate reductions of **7-38%**.



Improved Receiver Design - Analysis

An analytical approach was used to verify the simulation. The received signal was approximated using a **Gram-Charlier PDF** and an improved decision boundary was found for a number of channel gains. The error rates were then calculated for a number of channel gains and timing offsets and averaged. This approach demonstrated **Greatly Increased Error Rates** using traditional receivers, which are be significantly reduced with redefined decision boundaries.

The technique described here can be implemented with **Minimum Implementation Cost**. The optimum decision region boundaries can be determined through simulation, and stored on-chip in a register array. Using the MRC block's channel gain information, the corresponding decision region boundary is selected and fed to the detector block.