ELC 4350 – Principles of Communication

Chapter 6 Supplemental Homework

S6.5-1. Pulse code modulation (PCM) and differential pulse code modulation (DPCM) can be used to encode the message

$$m(t) = 4\cos(2000\pi t)$$

For all parts of this problem, if the sampled PCM analog value exceeds m_p or is below $-m_p$, place it in the extreme bin closest to the value. Respond similarly for DPCM if the difference is greater than d_p or less than $-d_p$.

(a) What is the Nyquist rate?

(b) Find the sampling rate, if sampling is performed at 8 times the Nyquist rate.

(c) What are the first four analog sample values.

(d) If PCM is used with 2-bit quantization, $m_p = 4$, and the bin ranges being inclusive upward, find the bitstream representing the first four samples, starting with the sample at $t = T_s$ for $m[1]$.

(e) If DPCM is used with 2-bit quantization, $d_p = 2$, and the bin ranges being inclusive upward, find the bitstream representing the first four samples. Use the 2-bit PCM quantization of the actual value with $m_p = 4$ for the first two bits, followed by the DPCM representations to find the second, third, and fourth samples. Use the predictor $\hat{m}(t) = m(t-1)$.

(f) Repeat part (e) using the predictor $\hat{m}[k] = 2m[k-1] - m[k-2]$. Assume $m[k] = 0$ for $k \leq 0$.

(g) For part (d), perform decoding of the bitstream as at the receiver. Provide the four quantized signal values $m_q[1], m_q[2], m_q[3], m_q[4]$ in decimal representation that would be obtained by using PCM at the receiver. Find the values of the quantization error at each sample: $q[1], q[2], q[3], q[4]$.

(h) For part (e), perform decoding of the bitstream at the receiver. Provide the four quantized signal values $m_q[1], m_q[2], m_q[3], m_q[4]$ in decimal representation that would be obtained by using DPCM and the predictor $\widehat{m_q}[k] = m_q[k-1]$. Find the values of the quantization error at each sample: $q[1], q[2], q[3], q[4]$.

(i) For part (f), perform decoding of the bitstream at the receiver. Provide the four signal values $m_q[1], m_q[2], m_q[3], m_q[4]$ in decimal representation that would be obtained by using DPCM and the predictor $\widehat{m_q}[k] = 2m_q[k-1] - m_q[k-2]$. Find the values of the quantization error at each sample: $q[1], q[2], q[3], q[4]$.

(j) Comparing the results of PCM with the results from the two DPCM predictors, attempt to qualify the differences you observe between the accuracies of the methods at the receiver. Find the values of the quantization error at each sample: $q[1], q[2], q[3], q[4]$.