Chapter 2 Activity

Activity 1

The information in an analog waveform, with maximum frequency f_m=3kHz, is to be transmitted over an M-ary PAM system, where the number of pulse levels is M=16. The quantization error is specified not to exceed (+/-)1% of the peak-to-peak analog signal.

(a) What is the minimum number of bits/samples, or PCM word size that should be used in digitizing the analog waveform?

(b) What is the minimum required sampling rate, and what is the resulting bit transmission rate?

(c) What is the PAM pulse or symbol transmit rate?

(d) If the transmission bandwidth equals 12 kHz, determine the bandwidth efficiency for this system.

Activity 1

1. According to bits per PCM word equation, we have

$$l \geq \log_2 \frac{1}{2p} = \log_2 \frac{1}{0.02} = \log_2 50 = 5.6$$

So it requires 6 bits.

2. The sampling rate is determined by Nyquist sampling rate, i.e. $f_s=2f_m=6000$ samples/second. Since each sample has 6 bits, so the bit transmission rate is:

$$R = l * f_s = 6 * 6000 = 36000 bits / \sec$$

3. Since $M=16=2^k$, k=4, the symbol transmission rate:

$$R_s = \frac{R}{k} = \frac{36000}{4} = 9000 symbols / \sec$$

4. Bandwidth efficiency is described by data throughput per Hz, i.e. R/W

$$\frac{R}{W} = \frac{36000}{12000} = 4 bits / \sec / Hz$$