**ENGR 4323/5323: Digital and Analog Communication**

**HW 5B\_Ch5**

**1)** The output SNR of a 10-bit PCM (*n* = 10) was found to be 30 dB. The desired SNR is 42 dB. It was decided to increase the SNR to the desired value by increasing the number of quantization levels *L*. Find the fractional increase in the transmission bandwidth required for this increase in *L*.

**2)** A message signal *m*(*t*) is normalized to peak voltage of ±1 V. The average message power equals 120 mW. To transmit this signal by binary PCM without compression, uniform quantization is adopted. To achieve a required SNR of at least 36 dB, determine the minimum number of bits required to code the uniform quantizer. Determine the actual SNR obtained with this newly designed uniform quantizer.

**3)** Repeat problem 7 if a *μ*-law compandor is applied with *μ* = 100 to achieve a non-uniform quantizer.

**4)** The American Standard Code for Information Interchange (ASCII) has 128 binary-coded characters. If a certain computer generates data at 600,000 characters per second, determine the following:

1. The number of bits (binary digits) required per character.
2. The number of bits per second required to transmit the computer output, and the minimum bandwidth required to transmit this signal.
3. For single error-detection capability, an additional bit (parity bit) is added to the code of each character. Modify your answers in parts **(a)** and **(b)** in view of this information.
4. Show how many DSI carriers would be required to transmit the signal of part c in the North American digital hierarchy.

**5)**  Consider a simple DPCM encoder in which *N* = 1 is used for *m*(*t*) = *Am* cos(*ωmt* + *θm*). The sampling interval is *Ts* such that *m*[*k*] = *m*(*kTs*) with *θm* = 0.5ω*mTs*. The first-order estimator is formed by

With prediction error

*d*[*k*] = *Am* cos(*ωm kTs* + *θm*) - *Am* cos(*kωm (k-1)Ts* + *θm*)

1. Determine the peak value of *d*[*k*].
2. Evaluate the amount of SNR improvement in dB that can be achieved by this DPCM over a standard PCM.

**6)** A DM system has input message signal

*m*(*t*) = 50e-200*t* cos(1000π*t*).*u*(*t*)

1. Determine the minimum step size E necessary to avoid DM slope overload.
2. Calculate the minimum average quantization noise power based on part (**a**).

**Bonus Question:** In a nonideal sampler, the following pulse

*q*a(*t*) = Δ(2*t*/*Ts*)

is used as the time-averaging filter impulse response. The sampling rate *fs* is selected to be higher than the Nyquist frequency. Design a reconstructed system diagram to recover the original analog signal. Determine all the necessary filter responses. **(see section nonideal practical A/D sampling analysis)**