Thapar Institute of Engineering & Technology, Patiala

Department of Electronics and Communication Engineering

UEC639 – Digital Communication

B. E. (Third Year): Semester-V (ENC)

Solution Tutorial-2

Q1	If a continuous signal with highest frequency component 15 kHz is sampled and transmitted using PCM system at a transmission rate of 144 Kbps (Data Rate = R_b = 144 kbps) then determine the values of sampling rate fs, the quantizing level L, and the binary digits.
Sol	$$f_s \geq 2\, f_m = 2 * 15\ kHz = 30\ kHz$$ $$n\, f_s \leq R_b = 144 * 10^3$$ $$n \leq \frac{R_b}{f_s} \leq \frac{144 * 10^3}{30 * 10^3} \leq 4.8$$ Hence, number of bits = n = 4 Finally, the sampling rate for this combination will be $$f_s = \frac{R_b}{n} = 144 * \frac{10^3}{4} = 36\ kbps$$
Q4	In a binary PCM system, the output signal to quantization noise ration is required to be held to a minimum value of 40 dB. Determine the value of quantization level and mean square value of quantization error.
Sol.	In a binary PCM system, $L = 2^n$, where n is the number of binary digits. $$\left(\frac{S}{N_q}\right)_{0\,\text{dB}} = 1.76 + 20 \log 2^n = 1.76 + 6.02n \quad \text{dB}$$ Now $\left(\frac{S}{N_q}\right)_{0\,\text{dB}} = 40\ \text{dB} \rightarrow \left(\frac{S}{N_q}\right)_o = 10\,000$ $$(\text{SNR})_o = \left(\frac{S}{N_q}\right)_o = \frac{3}{2}L^2$$ $$L = \sqrt{\frac{2}{3}\left(\frac{S}{N_q}\right)_o} = \sqrt{\frac{2}{3}(10\,000)} = [81.6] = 82$$ and the number of binary digits n is $$n = [\log_2 82] = [6.36] = 7$$ Then the number of levels required is $L = 2^7 = 128$, and the corresponding output signal-to-quantizing-noise ratio is $$\left(\frac{S}{N_q}\right)_{0\,\text{dB}} = 1.76 + 6.02 \times 7 = 43.9\ \text{dB}$$