UNIVERSITY ELECTRICAL ENGINEERING • EXERCISE SHEET

11.5 PCM and baseband transmission

Name: _____ Class: _____ Date: _____ **Total: 24 marks**

KEY WORDS quantisation • raised-cosine

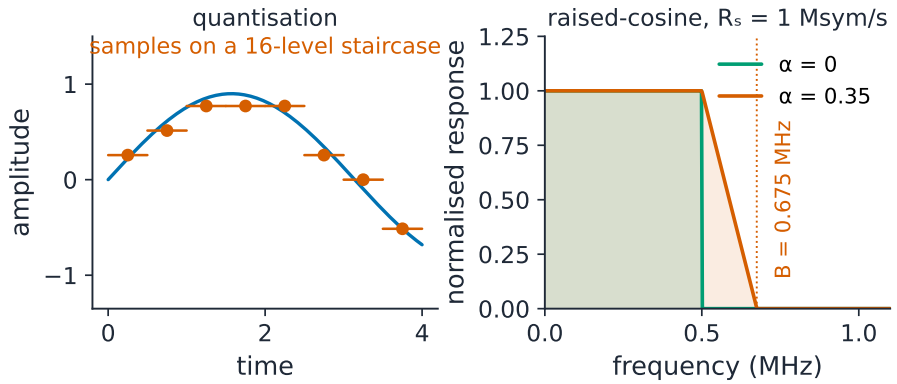
Objective

Quantise a signal and compute SQNR, apply line coding with its spectral costs, and design against inter-symbol interference with raised-cosine shaping.

1 Key knowledge and worked examples

■ Quantisation arithmetic

n bits → 2^n levels, $SQNR \approx 6.02n + 1.76$ dB. Error at most half a step; each added bit buys 6 dB.



Sampling freezes time, quantisation freezes amplitude, shaping fences the spectrum.

■ Worked example: the telephone number

4 kHz voice, 8 kHz sampling, 8 bits: 64 kbps at SQNR $6.02 \times 8 + 1.76 = 49.9dB$ – the PCM trunk standard.

■ Raised cosine

$B = (1+\alpha)R_s/2$: roll-off α buys timing tolerance with bandwidth. $R_s = 1$ Msym/s, $\alpha = 0.35 \rightarrow 0.675$ MHz. Line codes: NRZ carries DC and no clock; Manchester doubles bandwidth to carry a strong clock.

2 Practice

2.1 Compute the SQNR of a 12-bit uniform quantiser. [3]

2.2 A 20 kHz audio signal is sampled at 40 kHz with 16 bits per sample. Compute the bit rate. [3]

2.3 A link runs $R_s = 2$ Msym/s with raised-cosine roll-off $\alpha = 0.5$. Compute the required bandwidth. [3]

3 Exam-style questions

3.1 Design a PCM channel for music: top frequency 20 kHz, target SQNR at least 60 dB.

Choose the sampling rate (with the rule it obeys). Choose the bit depth for the SQNR target and verify. Compute the resulting bit rate and the bytes stored per minute. State what companding changes in a speech system and why music masters skip it. [8]

3.2 A binary baseband link runs 1 Mbps over a channel that must not exceed 0.75 MHz.

Compute the minimum-bandwidth choice ($\alpha = 0$) and its ISI risk. Choose α so the signal fits the 0.75 MHz channel at 1 Msym/s and verify. Compare NRZ and Manchester line coding for the same data rate: give each one's bandwidth and its DC/clock behaviour, and state which fits this channel. [7]