COLÁISTE NA hOLLSCOILE
GAILLIMH

NATIONAL UNIVERSITY OF IRELAND
GALWAY

SEMESTER II (SUMMER) EXAMINATIONS 2001

B.Sc. (Honours) Applied Physics and Electronics
B.Sc. (Honours) Physics and Computing

EP413: Communications – Paper I

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Time Allowed: TWO hours	Answer THREE questions

Q.1 Describe the general processes of *Amplitude Modulation* (AM) and *Envelope Detection*, defining the AM *Modulation Index, m,* in your account. Define also the terms *DSB-AM*, *DSB-SC-AM* and *SSB-AM*, and sketch typical frequency spectra in each case. [3 marks]

Prove that the transmitter power efficiency, ε, in DSB-AM, using envelope detection, is given by $\varepsilon = \dfrac{m^2}{1+m^2}$. Hence find the best-case value for ε when using DSB-AM. How do the efficiencies of DSB-SC-AM and SSB compare with this figure? In what respect(s) would SSB be regarded as a superior modulation scheme to DSB-SC? [2 marks]

Give a block diagram, and briefly outline the operation, of a standard commercial AM radio receiver. [5 marks]

Q.2 Define, or very briefly explain, the following terms as used in digital communications: *PCM, DPCM, TDM, baseband, line coding, ASK, PSK* and *QAM.* [4 marks]

Describe and compare the following different line coding methods for baseband digital signals: *direct* (i.e., non-coded) *NRZ, Manchester Coding, AMI*, and *HDB3*. Name at least one important application which uses any *one* of these line coding methods. [6 marks]

Q.3 Define the terms: *spectral efficiency r, AWGN, BER* and *EbNo*, as used in digital communications. How is the parameter EbNo usually evaluated in practise? Explain its practical significance. [4 marks]

Show that there is an upper limit to the spectral efficiency, r_{max}, which can be attained for a specified EbNo value in any communications channel. Derive the appropriate equation whose numerical solution determines r_{max}, and make a rough sketch of r_{max} vs EbNo. [4 marks]

Prove also that there is a lower limit on the value of EbNo, below which digital communications are not possible. Find the numerical value of this limit. [2 marks]

p.t.o.

Q.4 Give a very brief account of the different frequency regions of the radio spectrum and their use in modern wireless communications. Mention relevant parameters such as propagation mode, range, application areas, etc, for each frequency range. In particular, explain why satellite communication frequencies are chosen to be in the range that they are. [4 marks]

The following table lists the parameters for a 6 GHz communications satellite uplink, where Tx denotes the earth station transmitter, and Rx the satellite receiver. Define and calculate the spectral efficiency, r. Draw up a link budget to calculate the carrier and noise powers, the carrier to noise ratio, and bit energy to noise density ratio EbNo, at the satellite receiver during a bad rain storm. Assume that the free space path loss can be estimated by:

[6 marks]

$$Lp = 183.6 + 10\log(f/GHz), \text{ dB}$$

Tx power	Tx antenna gain	Atmospheric loss	Loss in heavy rain
1200 W	40 dB	-1 dB	-10 dB
Rx antenna gain	Rx noise temperature	Receiver bandwidth	Bit rate
30 dB	680 K	40 MHz	100 Mbps

Boltzmann's constant, $k = 1.38\times10^{-23}$ J K^{-1} = -228.6 dB J K^{-1}.

Q.5 Write full accounts on any *TWO* of the following.

(a) Nyquist's Theorem, Hartley's Law, and Shannon's theorem. [5 marks]

(b) Speech coding techniques. [5 marks]

(c) Cellular digital telephony. [5 marks]

(d) Modems and the PSTN (Public Switched Telephone Network). [5 marks]