*Ollscoil na hÉireann, Gaillimh* GX 914
*National University of Ireland, Galway*

**Semester II Examinations, 2002/2003**

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|---|---|
| Exam Code(s) | 4BS2, 4EL3, 1EM1 |
| Exam(s) | 4th Science |
| Module Code(s) | 4BS2-AX407, 4EL4 AX402-4, 1EM1-EP413 |
| Module(s) | EP413: Communications |
| Paper No. | |
| Repeat Paper | Special Paper |
| External Examiner(s) | Professor E. Kennedy |
| Internal Examiner(s) | Professor S. G. Jennings |
| | Dr. J. Martin |

**Instructions:** Answer THREE questions.

| | |
|---|---|
| Duration | 2 hrs |
| No. of Answer Books | 1 |
| **Requirements**: | |
| Handout | |
| MCQ | |
| Statistical Tables | |
| Graph Paper | |
| Log Graph Paper | |
| Other Material | |
| No. of Pages | 3 |
| Department(s) | Experimental Physics |

# EP413: Communications

Constants: Boltzmann's constant, $k = 1.38 \cdot 10^{-23}$ J K$^{-1}$ = -228.6 dB J K$^{-1}$.
Standard (noise) temperature, T0 = 290 K.

Q.1 State *Nyquist's Law*, *Hartley's Law* and *Shannon's Theorem* in communications, briefly defining all symbols used.

***[3 marks]***

Answer the following questions for a communications channel with a bandwidth of 1.5 MHz.

(a) What is the maximum baud rate useable in the channel?

(b) Assuming the channel is noiseless, what are the maximum errorless data rates attainable with (i) binary and (ii) 8-level signals? If the data rate is required to be 5 Mbps, find the minimum number of signal levels, M, required in a M-ary (M-level) signal.

(c) If the channel signal power is 2.5 mW and the noise power is 15 μW, calculate the noise density No, the SNR (Signal to Noise Ratio in dB), and the channel information capacity C.

(d) With the same SNR find the new information capacity if the channel bandwidth is doubled to 3 MHz. Say why doubling the bandwidth does not quite double the channel capacity.

(e) What SNR value is required to support a data rate of 20 Mbps with the original channel bandwidth of 1.5 MHz?

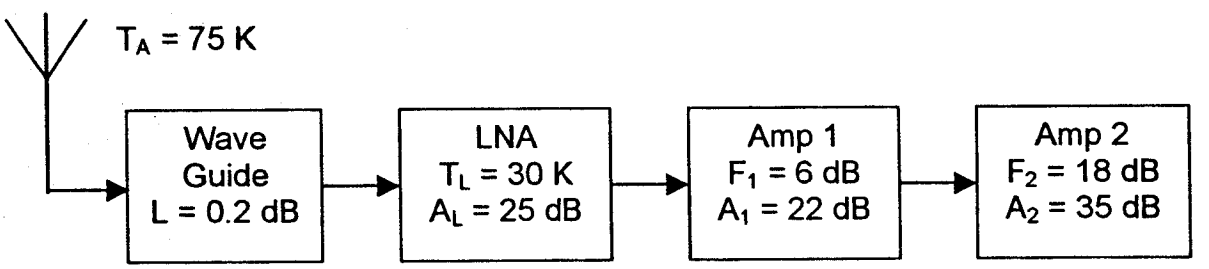
(f) Calculate the maximum channel capacity as the bandwidth is increased to ∞, using the same signal and noise power parameters given in part (c).

***[7 marks]***

Q.2 Define the concepts of *(Equivalent) Noise Temperature* and *Noise Figure* of an electronic amplifier stage. State also how the *Insertion Loss* of a passive network is defined.

***[3 marks]***

The block diagram of a microwave antenna (noise temperature = 75 K) and receiver is shown in the figure below, together with relevant parameters, such as Insertion Loss L, Noise Temperatures T, Power Gains A, and/or Noise Figures F. (LNA ≡ Low Noise Amplifier).




Calculate the equivalent noise temperatures of the waveguide, of the amplifier Amp 1, and of the output stage Amp 2. Hence find the total system noise temperature, and the output SNR (Signal to Noise Ratio in dB) if the input SNR is 28 dB.

***[7 marks]***

Q.3 Give a very brief description of the technological development of the *Public Switched Telephone Network* (PSTN), to show how the present day characteristics of a standard voice grade line (M.1020) have been largely determined by past technologies. As a result, state the major problems for data communications on the PSTN, and briefly list some of the techniques whereby modern day modems attempt to overcome these limitations.

***[5 marks]***

Describe the general mode of operation of *Cellular (Mobile) Phone Systems*. Illustrate your answer with specific descriptions of relevant aspects of *GSM* digital cell telephony.

***[5 marks]***

Q.4 Give a very brief account of the main frequency regions of the electromagnetic spectrum in modern wireless communications. List relevant parameters such as propagation mode, range, main areas of application, etc, for each frequency range. Explain briefly why satellite communication frequencies are chosen to be in the range that they are.

***[4 marks]***

The following table lists the parameters for a 4 GHz communications satellite downlink, where Tx denotes the satellite transmitter, and Rx the Earth station 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 Earth station during a bad rain storm. You may estimate the free space path loss by: Lp = 183.6 + 20·log(f/GHz), dB

| Tx power | Tx antenna gain | Atmospheric loss | Loss in heavy rain |
|---|---|---|---|
| 900 W | 30 dB | -1 dB | -12 dB |
| Rx antenna gain | Rx noise temperature | Receiver bandwidth | Data rate |
| 42.5 dB | 355 K | 50 MHz | 120 Mbps |

***[6 marks]***

Q.5 Answer any TWO of the following. ***[5 marks for each section]***

(a) Give an account, with explanatory block diagrams, of the technology used in commercial *Stereo FM Broadcasting*.

(b) Discuss the general topic of *Speech Coding*, with particular emphasis on *Vocoders*.

(c) Distinguish briefly between *Source, Line and Error Coding*. Describe and discuss some of the more popular *Line Coding* techniques used in wired communications.