Ollscoil na hÉireann, Gaillimh GX_____
National University of Ireland, Galway

Semester II Examinations, 2003/2004

Exam Code(s)	3BN121 3BP121
Exam(s)	Third Year Electronic Engineering Third Year Electronic and Computer Engineering
Module Code(s)	EE308
Module(s)	Signals and Communications
Paper No.	2
Repeat Paper	_____ Special Paper .....
External Examiner(s)	Professor S. McLaughlin
Internal Examiner(s)	Professor D.J. Wilcox Dr. J. Breslin

Instructions: Answer 3 questions.
All questions carry equal marks.

Duration	2hrs
No. of Answer books	1
Requirements:	
Handout	
MCQ	
Statistical Tables	
Graph Paper	
Log Graph Paper	
Other Material	Yes Standard Mathematics Tables
No. of Pages	6
Department(s)	Electronic Engineering

1.

(a) What is meant by the term "modulation", and why do we use it? **[2 marks]**

(b) State the general equation for a bandpass signal, and define a bandpass signal for normal AM. **[2 marks]**

(c) Fig. 1 shows a modulating or message signal m(t). Assuming a suitably high carrier frequency (f_c), sketch an example of a normal AM modulated signal for each of the following three states of modulation index m. **[6 marks]**

- $m < 1$
- $m = 1$
- $m > 1$

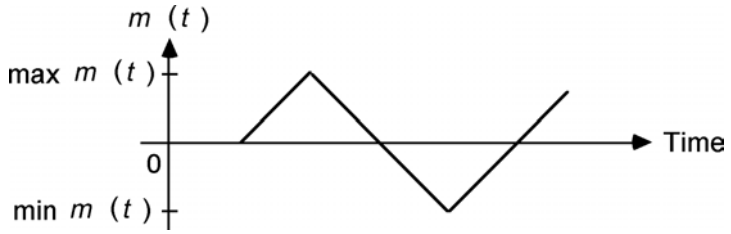

Fig. 1

(d) If m(t) as shown in Fig. 1 has a maximum value of 9 and a minimum value of –6, what is the range of values for A (the amplitude of the carrier signal) that will *not* cause overmodulation? **[2 marks]**

(e) Explain why an audio signal with a total bandwidth of 5.5 kHz requires a total bandwidth of 11 kHz to be transmitted via an AM carrier. You may include a sketch of the frequency spectrum of an AM signal in your answer. **[2 marks]**

(f) A normal amplitude modulator with a diode is shown in Fig. 2. If the input-output characteristic of a diode can be approximated with a power series, $v_o(t) = av_i(t) + bv_i^2(t)$, show that the output of this system is a normal AM signal. **[6 marks]**

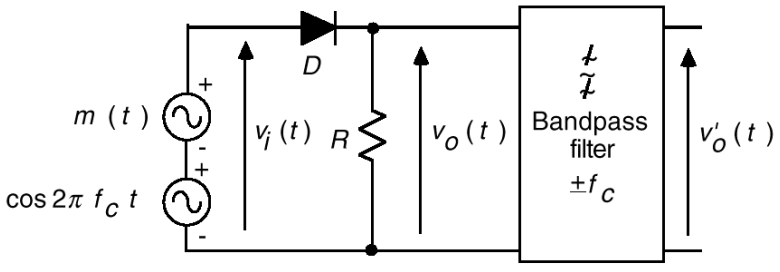

Fig. 2

[cont'd]

2.

(a) Fig. 3 shows a block diagram for SSB modulation using the filter method. If the spectrum of the modulating signal m(t) is as shown in Fig. 3, and the upper side band is being transmitted on a carrier frequency of f_c, sketch the magnitude spectra for $S_{DSB}(f)$, $|H(f)|$ and $S_c(f)$. **[3 marks]**

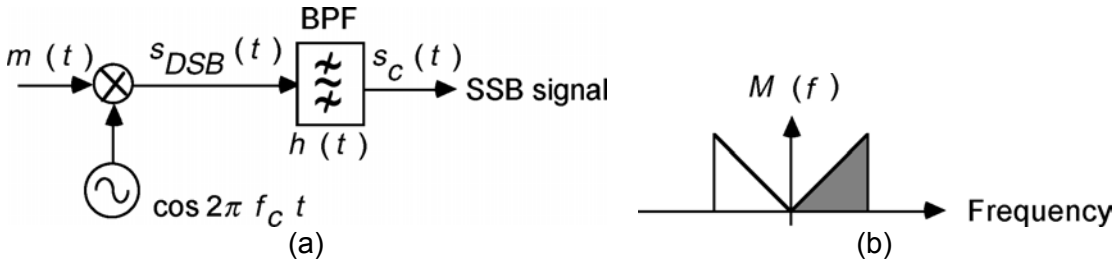

Fig. 3

(b) What is the main difference between the bandpass modulated signals for normal AM (DSB-LC) and DSB (DSB-SC)? **[1 mark]**

(c) If a modulating signal has a bandwidth of f_m, draw a table showing the relative bandwidth requirements for the following types of amplitude modulated signals. **[3 marks]**

- Normal AM (DSB-LC)
- DSB (DSB-SC)
- SSB
- VSB

(d)

(i) Define QAM. **[2 marks]**

(ii) Give a sample application for QAM. **[1 mark]**

(iii) Draw a block diagram showing the transmitter for a QAM system. **[4 marks]**

(iv) The receiver for a QAM system is shown in Fig. 4. Ideally, demodulating the message signals requires coherent demodulation (detection of the phase of the incoming modulated signal). What is the effect on the message signals if coherent demodulation is not used (i.e. if there is a phase error of ϕ_0 in the locally generated carrier)? Can you get the original message signals back? Support your answer. **[6 marks]**

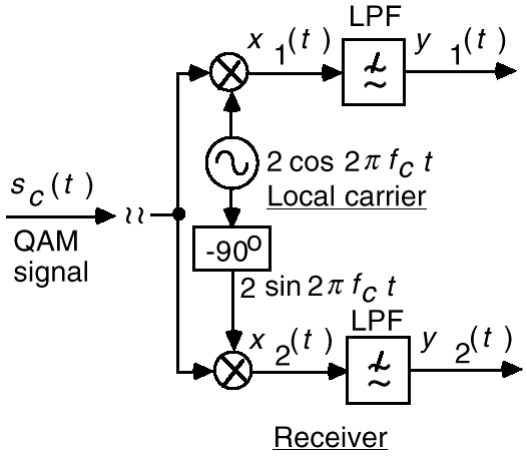

Fig. 4

[cont'd]

3.

(a) Define angle modulated signals for:

(i) Frequency modulation. **[1 mark]**

(ii) Phase modulation. **[1 mark]**

(b) Define <u>each</u> of the following terms as they relate to general angle modulated signals:

(i) Instantaneous frequency. **[1 mark]**

(ii) Instantaneous frequency deviation. **[1 mark]**

(iii) Peak frequency deviation. **[1 mark]**

(iv) Instantaneous phase deviation. **[½ mark]**

(v) Peak phase deviation. **[½ mark]**

(c) Show that it is possible to generate:

(i) An FM signal using a phase modulator. **[3 marks]**

(ii) A PM signal using a frequency modulator. **[3 marks]**

(d) Explain using diagrams where necessary how the frequency discrimination method can be used to demodulate the frequency modulated bandpass signal $s_c(t) = A\cos\theta(t)$ [where $\theta(t) = 2\pi f_c t + \phi(t)$]. **[8 marks]**

[cont'd]

4.

(a) Define the modulation index β and the peak frequency deviation Δf for FM with a sinusoidal modulating signal. **[2 marks]**

(b) An angle modulated signal using FM has an angular carrier frequency $\omega_c = 2000$ rad/s, and a peak frequency deviation of 500 Hz. If the modulating signal is given by the equation $f(t) = 30\cos(160\pi t)$, determine the bandwidth of the FM signal using Carson's rule. **[4 marks]**

(c) Explain briefly what is meant by narrowband FM and in what particular way it is similar to AM. You may refer to the respective vector representations in Fig. 5 illustrating modulation of a sinusoidal modulating signal. **[5 marks]**

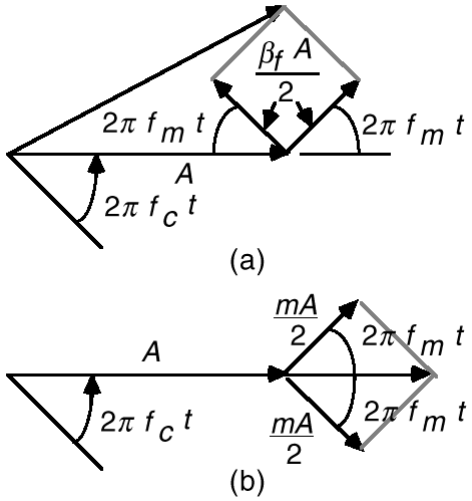

Fig. 5

(d) With the aid of a block diagram, describe the steps involved in the indirect method for generating a wideband FM signal. **[7 marks]**

(e) Fig. 6 illustrates the direct method of generating a wideband FM signal. What is the function of the empty block in the middle, and what is it called? **[2 marks]**

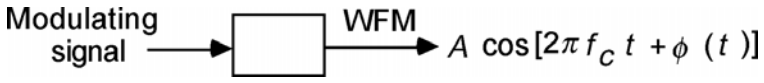

Fig. 6

[cont'd]

5.

(a)

(i) Define a band limited signal. **[2 marks]**

(ii) State the sampling theorem. **[2 marks]**

(iii) If f_m is the bandwidth of m(t), what is the problem with the modulated signal in Fig. 7, and what is this phenomenon called? **[3 marks]**

(iv) What is meant by interpolation? **[2 marks]**

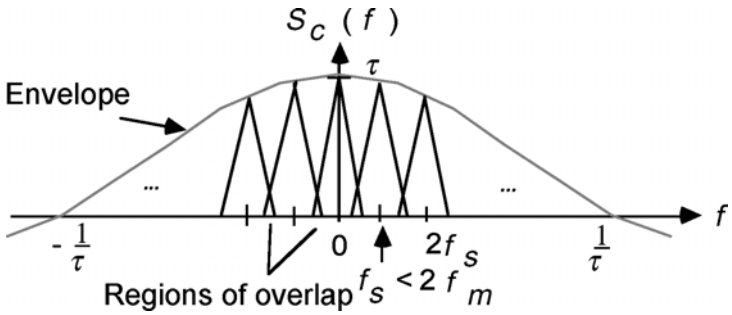

Fig. 7

(b) What is PAM? Name the empty blocks in the PAM system shown in Fig. 8. **[3 marks]**

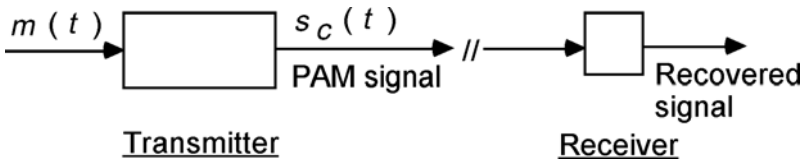

Fig. 8

(c) One of the basic problems in communication engineering is the design of a pulse communication system which allows signals from many users to be transmitted simultaneously over a single communication channel. Explain using diagrams what TDM is and how it can be used as a solution to this problem. **[8 marks]**