The University Of Sheffield.

Data Provided: Bessel functions

DEPARTMENT OF ELECTRONIC AND ELECTRICAL ENGINEERING

Spring Semester 2009-2010 (2 hours)

Communication Systems 2

Answer **THREE** questions. **No marks will be awarded for solutions to a fourth question.** Solutions will be considered in the order that they are presented in the answer book. Trial answers will be ignored if they are clearly crossed out. **The numbers given after each section of a question indicate the relative weighting of that section.**

1. a. Briefly describe the advantages and disadvantages of amplitude modulation AM and frequency modulation FM. **(6)**

b. Explain why the expression $V_{AM} = V_c\left(1+m\sin\omega_m t\right)\sin\omega_c t$ **(2)**

describes an amplitude modulated signal.

Sketch the waveforms and the frequency components for V_{AM}. **(4)**

c. An AM-DSB transmitter develops an unmodulated average power output of 2kW across a 50 Ω resistive load. When a sinusoidal test tone with a peak amplitude of 8 V is applied to the input of the modulator, it is found that the amplitude of the spectral line for each sideband is 40 % of the amplitude of the carrier line. Determine **(8)**

(i) the peak amplitude of the lower sideband

(ii) the ratio of total sideband to carrier power

(iii) the total average power output if the peak amplitude of the modulation sinusoid is reduced to 6 V

2. a. Explain why modulation is used in communication systems **(4)**

b. Using a block diagram explain how stereo audio signals with independent left and right channels are transmitted in FM broadcast systems without losing compatibility with mono systems. Include a sketch of the spectrum of the composite broadcast signal. **(8)**

2. **c.** An FM transmitter is modulated with a single sine wave. The output for no modulation is 10 kW into a 50 Ω resistive load. The peak frequency deviation of the transmitter is carefully increased from zero until the first sideband amplitude in the output is zero. Under these conditions determine

(i) the average power at the carrier frequency

(ii) the average power in all the remaining sidebands

(iii) the average power in the second order sidebands **(8)**

NOTE: A plot and table of Bessel functions is given at the end of the paper.

3. **a.** Explain what is meant by quantisation noise and quantisation errors in pulse code modulation (PCM) systems. **(6)**

b. Describe with the aid of a circuit diagram how a PCM signal is obtained using an A/D convertor. **(6)**

c. A continuous data signal is to be linearly quantised and transmitted using PCM. If each data sample at the receiver must be known to within ± 1 % of the peak-to-peak full-scale value, how many bits must be transmitted to represent each data sample?

Calculate the resulting signal-to-quantisation noise ratio and estimate the minimum channel bandwidth if a 20 kHz channel is encoded. **(8)**

4. **a.** State the Hartley-Shannon Law and define the various quantities contained within it. **(4)**

b. The sound transducer in a games console sends out 2^{10} equiprobable pulse amplitudes at a sampling rate of 44 kHz. Estimate:

i) the minimum bandwidth required;

ii) the signal to noise ratio of the recovered signal;

iii) the channel capacity. **(6)**

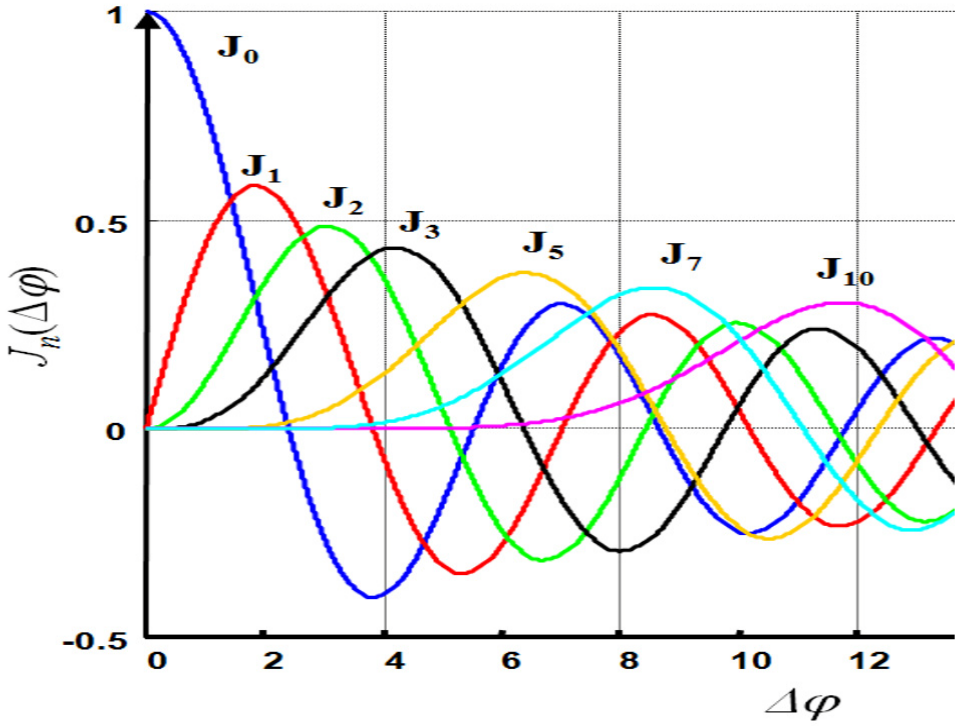
Note : $\log_2(x) = \log_{10}(x)/\log_{10}(2)$

c. Explain what is meant by the term "multiplexing". Describe either an FDM or TDM system, illustrating your answer with diagrams where appropriate. **(5)**

d. A coaxial cable passes frequencies in the range 0 to 45 MHz. Determine the maximum number of music channels, each 20 kHz wide, that can be transmitted down the cable via a frequency division multiplexed system using single sideband suppressed carrier techniques. Assume that guard bands of 4 kHz exist between adjacent channels. **(3)**

e. Comment on what you would expect if in part (d) a time division multiplexed PCM system was used . **(2)**

BESSEL FUNCTIONS



Sample of Bessel Function Zero Crossings						
$J_0(\beta)$	$J_1(\beta)$	$J_2(\beta)$	$J_3(\beta)$	$J_4(\beta)$	$J_5(\beta)$	$J_6(\beta)$
$\beta = 2.40$	$\beta = 3.83$	$\beta = 5.14$	$\beta = 6.38$	$\beta = 7.59$	$\beta = 8.77$	$\beta = 9.94$
$\beta = 5.49$	$\beta = 7.05$	$\beta = 8.42$	$\beta = 8.42$	$\beta = 11.1$	$\beta = 12.3$	$\beta = 13.6$
$\beta = 8.65$	$\beta = 10.2$	$\beta = 11.6$	$\beta = 11.6$	$\beta = 14.4$	$\beta = 15.7$	$\beta = 17.0$
$\beta = 11.8$						

RJL