R221/308

**DUBLIN INSTITUTE OF TECHNOLOGY**
**KEVIN STREET, DUBLIN 8**

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**Honours Diploma in Electrical/Electronic Engineering**
**YEAR 3**

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**AUTUMN EXAMINATIONS 2000**

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COMMUNICATIONS ENGINEERING (MAJOR)

M**R**. P. Tobin
M**R**. C. Bruce
DATE:
Attempt **FIVE** questions

Bessel function tables
Linear cm graph paper
Laplace tables
565 Data sheet

1.(a)For a phase lock loop (PLL), explain the terms: Capture range and Lock range. Explain how the capture range may be reduced below that of the lock range. Determine the free-running frequency, lock (or hold in) range using the 565 data sheet supplied. The PLL is connected to a 6-volt dual power supply and the loop filter is formed from the internal 3.6 kΩ resistance and a 330 pF capacitor. The circuit elements, which control the VCO are: 10 kΩ resistance and a 220 pF capacitance.

[8 marks]

(b) Obtain a transfer function for an uncompensated PLL, which relates the output voltage and the input signal phase.

[8 marks]

(c) Give one communications application for a PLL and briefly explain the circuit operation.

$k_o$ = -0.75 kHz / Volt, $k_\theta$ = 0.318 Volts / radian, $k_a$ = 1 Volt /Volt.

[4 marks]

2.(a) Sketch the layout of a *multi-frame*, *frame* and *time slot* as applied to a 30-channel *TDM PCM* system (Include time duration values in your answer for these quantities). Show how synchronising and signalling information is accommodated.

[7 marks]

(b)Explain briefly why *companding* is required in the codec section of a *TDM PCM* system. Include a reference to the signal to quantisation noise ratio. Sketch the segmented, *A*-law companding characteristic and relate the 8-bit allocation to the quantised signal.

[7 marks]

(c)State the factors, which determine the channel capacity of a telecommunications channel. The channel capacity of a telephone channel is 29.92 kb/s and has an available bandwidth of 3 kHz. Calculate the maximum signal to noise ratio. Calculate how many signalling levels are required for this channel if the received signal is decoded error free.

[6 marks]

3.(a)Draw a block diagram of an AM superhetrodyne receiver and explain the function of each block. Hence explain image channel interference and adjacent channel interference, indicating, in the receiver, where each interference signal is reduced to acceptable levels.

[10 marks]

(b)Explain one technique for implementing *SSBSC*. Include a block diagram and relevant equations in your answer.

[6 marks]

(c)Draw a simple block diagram illustrating the twelve-channel *FDM* application of *SSBSC* in the public switched telephone network (*PSTN*).

[4 marks]

4.(a) An FM receiver is tuned to receive an FM broadcasting station whose frequency is 96.9 MHz. The superheterodyne receiver has the local oscillator operating on the high side of the 96.9-MHz input and uses 10.7-MHz IF amplifiers. Determine the LO frequency and hence calculate the image frequency. Determine the bandwidth of the FM signal assuming the modulation index is 5 and the maximum modulating

frequency is 15 kHz. Hence determine the characteristics required for the RF and IF filters.

[8 marks]

(b) A 2 MHz carrier with a peak amplitude of 4 volts is frequency modulated by a modulating signal $m(t) = 2\sin(2\pi 500t)$ volts and the peak frequency deviation is 1 kHz. If the amplitude and frequency of the modulating signal are increased to 8 volts and 2 kHz respectively, write an expression for the new modulated carrier signal.

[8 marks]

(c) Discuss briefly the difference between frequency modulation and phase modulation. Illustrate by means of a block diagram, how a stable phase modulated signal is produced. Hence show how a phase modulator may be modified to produce an *fm* signal.

[4 marks]

5.(a) Explain with the aid of a block diagram, a system for producing a quadrature phase shift keying (*QPSK*) signal. Draw the phase constellation for this system, which uses a Gray code.

[10 marks]

(b) The inputted carrier for a *QPSK* system is $V(t) = 2\sqrt{2}\cos 10^4 t$ Volts. Write an expression for the output *QPSK* signal $V_{QPSK}$ with $a_1(t)$ and $b_1(t)$ as the binary modulation of the carrier and a phase-shifted version respectively. The serial input data is 300 b/s.

[6 marks]

(c) Show the calculation for the required absolute minimum *QPSK* output bandwidth.

[4 marks]

6.(a) Draw the diagram of an *AM* diode detector circuit, which includes *AGC*. Explain briefly the circuit operation.

[6 marks]

(b) Diagonal-clipping distortion is avoided in a diode detector when suitable values are chosen for the time constant *CR*. Show, from first principles, how a suitable expression for the time constant *CR* is:

$$CR \le \frac{\sqrt{1/m^2 - 1}}{2\pi f_m}$$

The modulation index is *m* and the maximum modulation frequency is $f_m$.

[9 marks]

(c) Calculate suitable component values for the diode detector circuit as discussed in part (b) if the envelope voltage is expressed as:

$$V_c = E_c[1 + 0.5\cos 2\pi 10^3 t]$$

[5 marks]

7.(a)A carrier signal defined as $v_c(t) = E_c\cos(2\pi f_c t)$ is amplitude modulated by a sinusoidal signal $v_m(t) = E_m\cos 2\pi f_m t$, derive an expression for the resultant *AM* signal and identify each frequency component and its amplitude. Sketch the *AM* signal in the time and frequency domains. Specify the maximum and minimum envelope values. How can the *AM* modulation index be determined from these extreme values?

[12 marks]

(b)For the *AM* signal described in part (a) derive equations for:
(i) The carrier power,
(ii) The sideband power, and
(iii)The total power, and
(iv)An *AM* transmitter has an output power of 18 kW when modulated to a depth of 100%. What is the carrier output power?

[8 marks]

8. (a) A telephone line channel is equalised to allow bandpass data transmission over a frequency range of 600 Hz to 3000 Hz with raised cosine-roll-off filtering. The available channel bandwidth is 2400 Hz with a mid-channel frequency of 1800 Hz. Design a 2400-bit/sec *QPSK* transmission system with $f_c$ = 1800 Hz. Show that the spectrum of this signal will fit into the channel when $r$ = 1. Find the absolute and 6-dB bandwidths.

[8 marks]

(b)Compare and contrast, the magnitude of allowable peak noise for the 16-*PSK* and 16-*QAM* constellations shown in figure 1 and figure 2. The maximum peak signal amplitude *A*, is the same for both systems.

[12 marks]

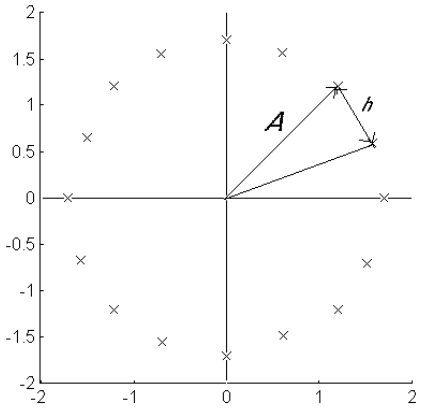


**Figure 1**

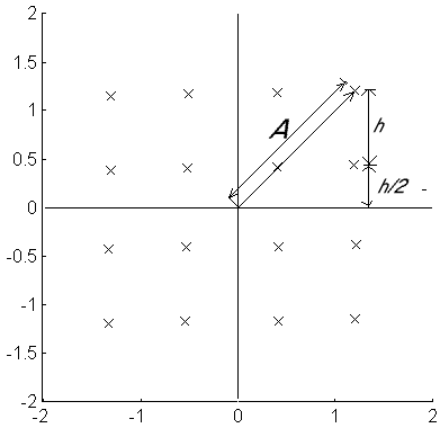


**Figure 2**