# UNIVERSITY OF DUBLIN

## TRINITY COLLEGE

Faculty of Engineering, Mathematics & Science
School of Computer Science & Statistics

**B.A.(Mod.) Computer Science** **Trinity Term 2008**
Junior Freshman Examination

## Electrotechnology and Telecommunications (1BA5)

**Thursday 5th June 2008** GOLDHALL **14:00-17:00**

**Mr. Paul Laird**

---

**Instructions to Candidates:**

- Answer 4 out of the 6 questions, two from each section
- All questions are marked out of 25
- Illustrate your answers where appropriate

**Materials permitted for this examination:**

- Calculator
- Mathematical tables

## SECTION A

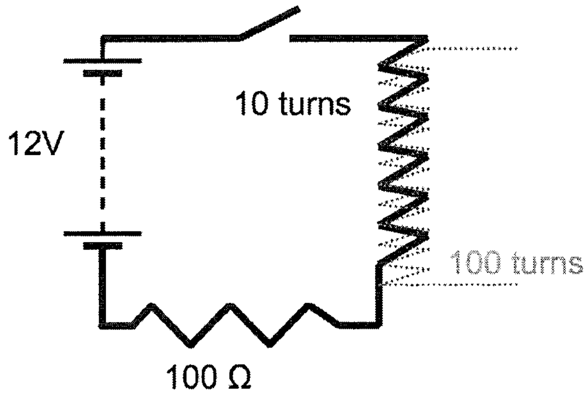
1.

a) Calculate the electric field strength and direction on the Z-axis resultant from three line charges of 2 nC/m, 1 nC/m and -1.5 nC/m located at (x=y=1), (x=-1, y=2) and (x=0, y=2) respectively.
[10 marks]

b) In the scenario described in part (a), a charge of 1nC moves unimpeded and undeflected along the Z-axis at $2ms^{-1}$. Calculate the static magnetic field at the Z-axis [15 marks]

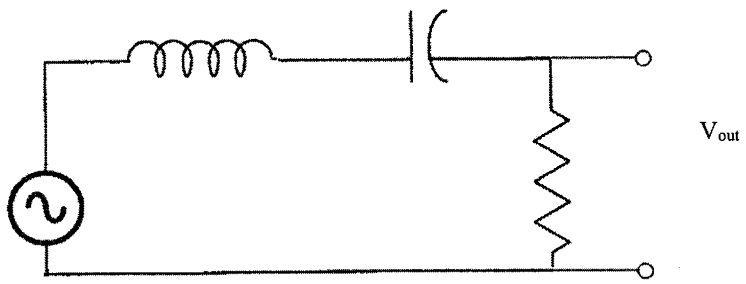
2.

a) In the figure shown, there are 10 loops on the primary coil, and 100 on the secondary coil. The area of the each loop on both coils is $12cm^2$ The power source is a 12V battery. When the switch is closed, the initial rate of change of current through the primary coil is 12A/s.




What is the initial voltage across the terminals of the output coil?
If the switch is opened and the magnetic field collapses in 0.00001s, what voltage appears at the terminals of the output coil during this time?
Suggest a use for the circuit. [15 marks]

b) In the following circuit, given an ideal supply of 10Vpk, a 1mH inductor, a 1μF capacitor and a 100Ω resistor, what supply frequency will result in the greatest output voltage?
What output voltage will be seen at:
I. Double that frequency?
II. Half that frequency?

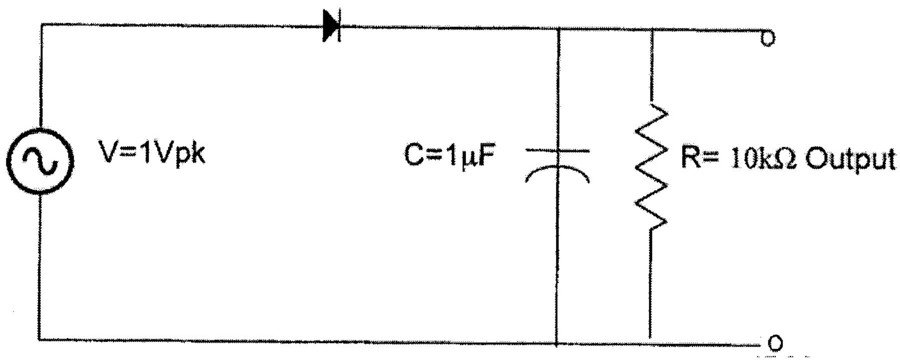



[10 marks]

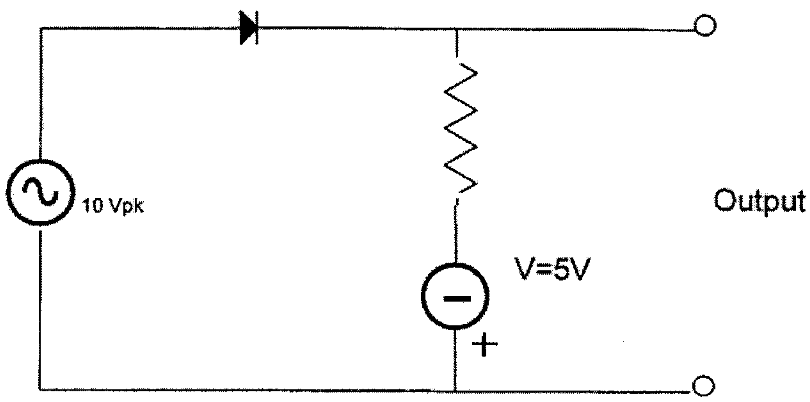
3.

a) Sketch the output from an oscilloscope for the following circuits, assuming ideal diodes (Forward voltage drop = 0V):

I. Circuit one

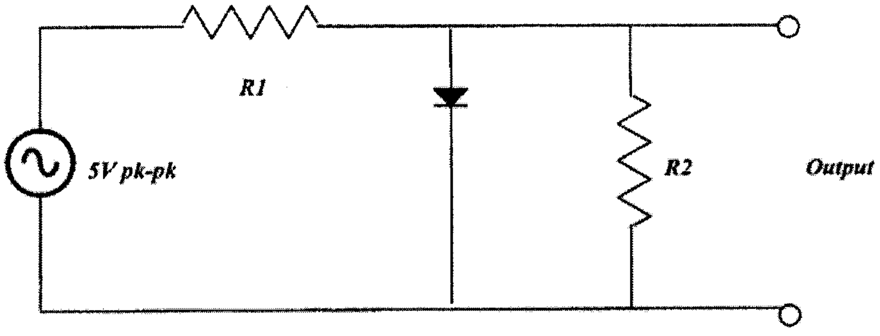



II. Circuit two




[2*5 marks]

b) Sketch the output from an oscilloscope for the following circuit where R1=50Ω, R2=200Ω, assuming real silicon diodes, and explain the output with reference to a characteristic V/I curve for a silicon diode:




[15 marks]

## SECTION B

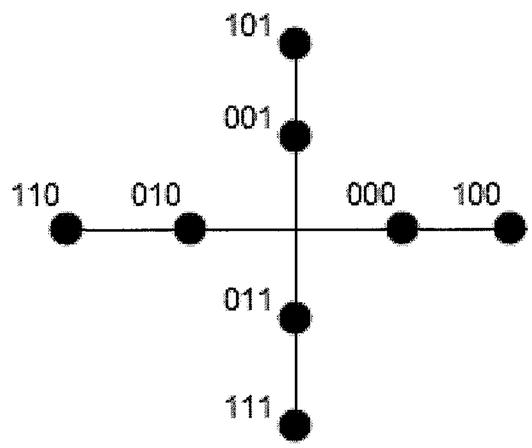
4.

a) Define Phase Shift Keying.
Sketch the resulting signal when 1011 is modulated with the following characteristics:
- F=2kHz
- Baud rate = 1000 bauds/sec
- $P_0$ = 0,
- $P_1$ = 180

b) Define Frequency Shift Keying.
Sketch the resulting signal when 1101 is modulated with the following characteristics:
- $F_0$ =1500Hz
- $F_1$ =2500Hz
- Baud rate = 500 bauds/sec

c) Define Amplitude Shift Keying.
Sketch the resulting signal when 1010 is modulated with the following characteristics:
- F=1kHz
- Baud rate = 1000 bauds/sec
- $V_0$ = $1V_{pk\text{-}pk}$
- $V_1$ = $3V_{pk\text{-}pk}$

d) Define Quadrature Amplitude Modulation.
How would you interpret the following constellation diagram?

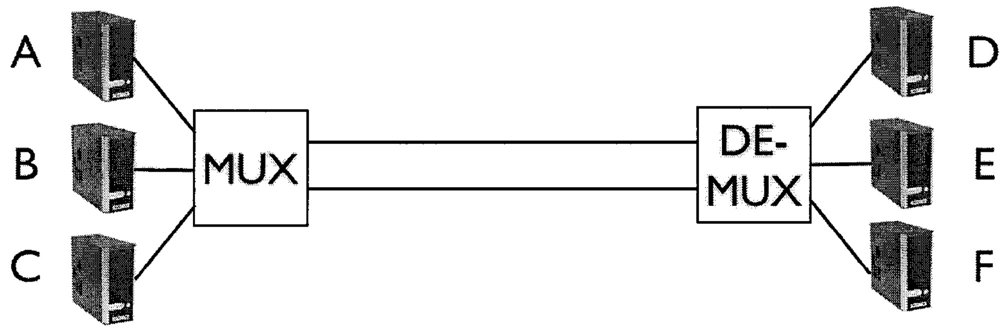



e) Sketch the resulting signal when 101110001 is modulated at 1000Hz and 1000 bauds/sec using the modulation scheme shown in the constellation diagram in part (d).
What is the bit rate (bps) in the question (d)? [5*5 marks]

5.

a) Distinguish between:
   I. Frequency Division Multiplexing
   II. Synchronous Time Division Multiplexing
   III. Asynchronous Time Division Multiplexing [5 marks]

b) Three computers: A, B and C, are connected to three other computers: D, E and F respectively, via a time-division multiplexed link with a 4 bit time slot.




A wishes to send the following data (right to left order):
1001 1101
B wishes to send the following data (right to left order):
1100 1011 1001
C wishes to send the following data (right to left order):
0100 1000 1010

   I. If Synchronous Time Division Multiplexing is used, draw a diagram and fill in in the data sent over the line following a '0' framing bit from the previous frame (A transmits first.).

   II. If Asynchronous Time Division Multiplexing is used, where data destined for D contains '10' as addressing bits, while data destined for E contains '01' as addressing bits and data destined for F contains '11' as addressing bits, draw a diagram and fill in the data sent over the line following the addressing bits from the previous frame (A transmits first.). [12 marks]

c) What set-up would you use if:
   I. The three multiplexed signals generally carried equal amounts of data?
   II. One signal generally carried greater amounts of data, but to a varying extent?
   III. One signal generally carried three times as much data as the other two.
   IV. There was no consistent pattern.

In each case, state why. [4*2 marks]

6. Gigabit ethernet is used to transmit up to $10^9$ data bits per second over 4 pairs of cable (category 5 twisted pair cables). These have a bandwidth of 100MHz. If, for error correction purposes, the data is sent over the connection using 12 bits to represent each data byte (8 bits),

   a) What bit rate is needed on each pair of cables?

   b) What is the maximum signal/noise ratio that can be tolerated by Gigabit ethernet while operating at maximum transmission data rate.

   c) How many signal levels are required to facilitate transmission at maximum data rate.

   d) Would it be possible to encode a digital transmission over this cable at the same data rate using biphase (e.g. Manchester or differential Manchester) encoding? Why?

   e) Gigabit ethernet uses a linear feedback shift register based scrambler to ensure that long strings of the same value are extremely unlikely to cause a DC bias. Show how a DC bias can be avoided in simple bipolar encodings by encoding the following string using a bipolar encoding of your choice

      110100001011110000000000101111111111000001

[5*5 marks]

Shannon Formula:
Maximum data rate = Bandwidth*$\log_2$(1+Signal/Noise)

Nyquist Formula
Ideal channel data rate = 2*Bandwidth*$\log_2$(levels)

Permittivity of free space, $\varepsilon = 8.854 \times 10^{-12}\ \mathrm{Fm}^{-1}$

Faraday's Law:
$$E = -n \times \frac{d\phi_m}{dt}$$
$\phi_m$ is magnetic flux
E is electromotive force