DUBLIN CITY UNIVERSITY

Autumn 1997

COURSE:	APPLIED PHYSICS
:	PHYSICS with a LANGUAGE
YEAR:	2
EXAMINATION:	Physics B: Electronics
EXAMINERS:	Prof. C. Lewis. Prof. D. Williams Dr B. Lawless
DURATION:	3 hours
INSTRUCTIONS:	AP students: Answer FIVE questions PL students: Answer FOUR questions

Question 1. (a) Calculate the resistance between the two adjacent corners, A and B, of the circuit shown in Figure 1. The resistors are all 1 kΩ and lie along the edges of the cube.

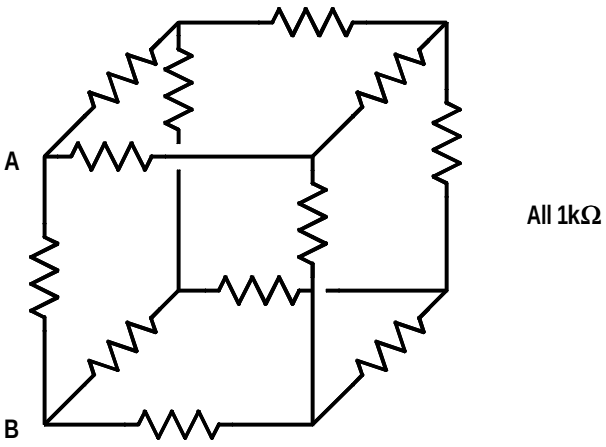

Figure 1: Question 1 (a)

(b) Calculate the complex impedance in the form $Z = R + jX$ for a frequency of 1 kHz for each of the circuits shown in Figure 2 and also plot the complex impedance on the complex impedance diagram.

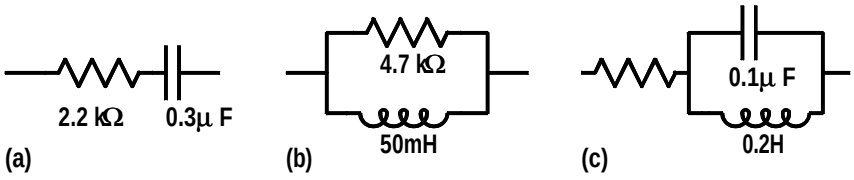

Figure 2: Question 1 (b)

Question 2. Give an expression for the $\frac{V_{out}}{V_{in}}$ for each of the filters shown in Figure 3.
Sketch the Bode plot for each of these filter circuits.
Use this Bode plot to estimate the frequency components of the output waveform when a square waveform of frequency 2 kHz is applied at the input.

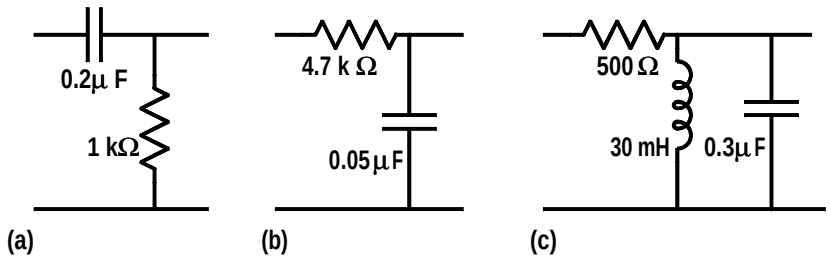

Figure 3: Question 2

Question 3. Calculate the DC voltages and currents in the transistor amplifier circuit shown in Figure 4.
Calculate the small signal gain for the amplifier for sinusoidal signals at 5 kHz.
A signal of 1.5 mV_{pp} at 5 kHz is applied to the input to the amplifier. Give scaled sketches of the waveforms which you would observe at:

(a) the input.
(b) the base
(c) the collector
(d) the output

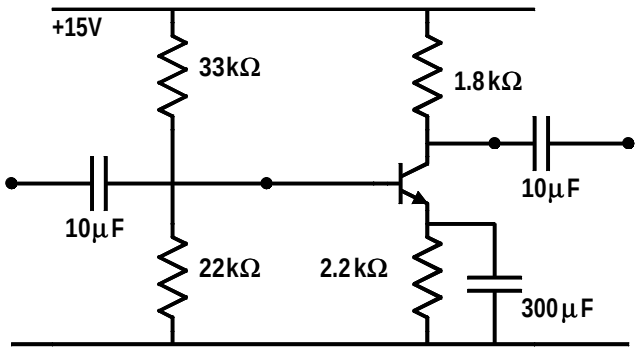

Figure 4: Question 3

Question 4. Give sketches of the construction of a transistor such as the npn BC109, a junction FET and a MOSFET.
Discuss the differences in the construction of these three types of devices. Sketch cross sections of the devices. Sketch the $I_C - I_B$ and $I_D - V_{GS}$ characteristics of the devices as appropriate.

Question 5. A differentiator circuit is to have a response which is described by the expression:

$$V_{out} = -1.5\frac{dV_{in}}{dt}$$

Draw a suitable circuit diagram and calculate the component values.
Calculate the output voltage waveform which results when a sinusoidal signal of 25 mV_{pp} and frequency 3 kHz is applied to the input.
Give a scaled sketch of the input and output waveforms.

Question 6. A circuit for a 555 timer based rectangular wave oscillator is shown in Figure 5.
Explain the principle of operation of the 555 timer.
Calculate the waveforms which would be observed across the capacitor (V_C) and also at the output (pin 3).
Give scaled sketches of the waveforms.

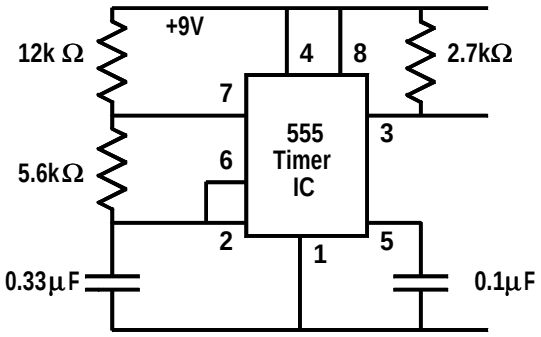

Figure 5: Question 6

Question 7. (a) Explain the principles of each of the following coding systems:

i. Binary
ii. Two's complement negative numbers
iii. BCD (Binary Coded decimal)
iv. Weighted and unweighted codes
v. Gray code
vi. Hamming code

(b) Explain the operation of a RS flip-flop.
What is meant by "Indeterminate state"?
Show how JK flip-flops avoid the ocurrance of indeterminate states.
What is meant by "Toggling action"?

Question 8. (a) The four windings of a stepper motor are connected to bits 1 to 4 of Port A of an 8255 interface chip which is located at Base address 640 in a computer.
Write a C program which will output the fillowing signal patterns shown in Figure 6 to the windings of the stepper motor so as to cause it to step with a step time of 70 ms.

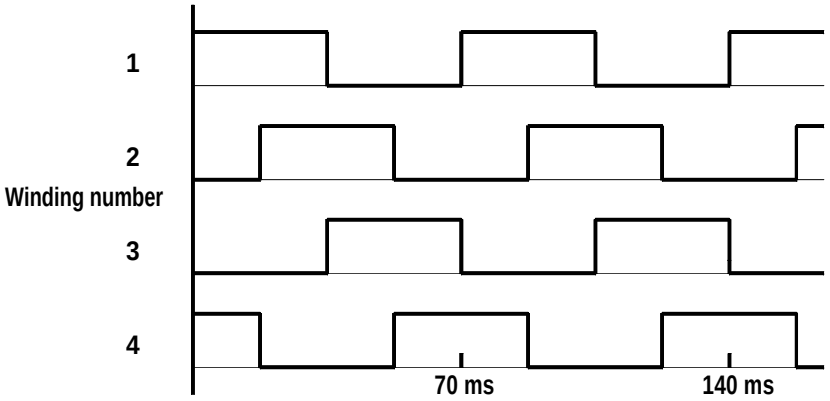

Figure 6: Question 8 (a)

(b) Write a PSPICE input file to model the response of the band stop or notch filter shown in Figure 7. The response of the filter for an input signal of 1.0 V amplitude and for frequencies between 10 Hz and 20 kHz should be plotted. Sketch the response which you would expext to see plotted by PSPICE.

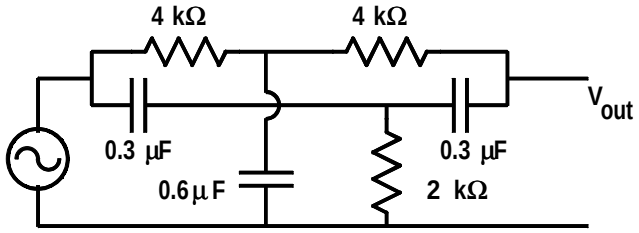

Figure 7: Question 8 (b)