University of KwaZulu-Natal

Electrical, Electronic & Computer Engineering

Examinations: November 2013

DURATION: 2 HOURS **TOTAL MARKS: 60**

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Instructions:

1. Your answers to Sections A, B and C must be submitted in **separate examination books**
2. Answer **ALL** questions.
3. Programmable calculators may be used provided their **memories** have been **cleared**
4. Answers may be written in a **dark** pencil

Data: $\mu_0 = 4\pi \times 10^{-7}\ H/m$ $\varepsilon_0 = \frac{10^{-9}}{36\pi}\ F/m$ $c = 3 \times 10^8\ m/s$

Section A: Electronic Design

Question 1:

Design a digital electronic system that functions as a down counting Stopwatch with a 7-segment display for the minute, the 10s of seconds and the second time. The system should have buttons to 1. Set a time value eg 3.45 (mins) and 2. Start.

a) Provide a functional block diagram for your design solution to the above functional specification. **[5]**

b) Use a 555 timer in Astable mode to provide the system clock for the Stopwatch. The duty cycle can be any value but the frequency should be 1Hz. Draw a schematic of the timer, give a detailed explanation of its operation in this mode and show your calculations. **[10]**

c) Give a definition of fan-out for a logic family. **[2]**

d) Table 1 shows the output loading specifications for HC-series CMOS chip with a 5V+-10% supply. Use the data in Table 1 to show a calculation to determine the (theoretical) fan-out in the LOW output state of the HC-series output driving HC-series inputs (the maximum input current required is 5 microAmp) at TTL levels. **[3]**

Parameter	CMOS Load		TTL Load	
	Name	Value	Name	Value
Maximum LOW-state output current (mA)	IOLmaxC	0.02	IOLmaxC	4.0
Maximum LOW-state output voltage (V)	VOLmaxC	0.1	VOLmaxC	0.33
Maximum HIGH-state output voltage current (mA)	IOHmaxC	-0.02	IOHmaxC	-4.0
Minimum HIGH-state output voltage (V)	VOHmaxC	4.4	VOHmaxC	3.84

Table 1

Section B: Instrumentation

Question 2: Instrumentation & measurement basics [5]

This question consists of several multiple choice questions worth 1 mark each. Simply write down the capital letter of the statement you believe matches best.

2.1) The meaning of the term accuracy is

A. Closeness of an instrument reading to the true value of the variable being measured.
B. A measure of the reproducibility of the measurement.
C. The ratio of the response of the instrument to a change of the measured variable.
D. The smallest change in the measured value to which the instrument will respond.

2.2) A d'Arsonval meter movement can be used to measure either current, voltage or resistance but the moving coil responds to

A. The voltage across its winding.
B. The amount of current passing through its winding.
C. The resistance of the winding.
D. Either A or B but not C.

2.3) Which of the following types of error is the fault of the person using the instrument such as incorrect reading, incorrect recording or incorrect use?

A. Absolute error.
B. Gross error.
C. Systemic error.
D. Random error.

2.4) A thermocouple is an example of

A. A self-generating transducer.
B. A modulating transducer.
C. A modifying transducer.
D. None of the above.

2.5) The function of the sample and hold circuit in analog-to-digital conversion is

A. To reduce the time of conversion to digital format.

B. To improve the accuracy of the conversion to digital format.
C. To hold the analog signal constant while the conversion to digital format takes place.
D. To improve the resolution of the conversion to digital format.

Question 3: Permanent-magnet moving-coil (PMMC) meter **[5]**

The circuit of a multiple range DC voltmeter is shown in Figure 1. Calculate the values of shunt resistors R_{S1}, R_{S2}, and R_{S3}, so the range values are 5V, 50V and 500V respectively.

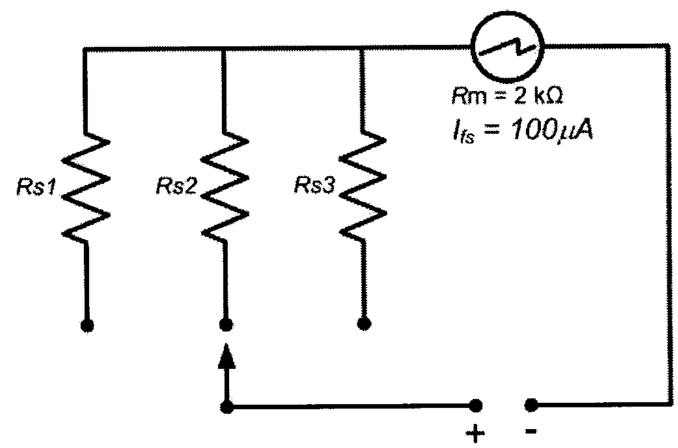


Figure 1

Question 4: Use of measurement equipment **[5]**

The ISO-Tech ISR622 oscilloscope used in the Second Year Laboratory has input impedance comprising a resistance of 1 MΩ in parallel with capacitance of 25 pF.
A BNC - croc clip coaxial cable which has a capacitance of 100 pF is available to connect an input signal to the oscilloscope.
(a) Draw the equivalent circuit of the coaxial cable probe connected to the oscilloscope. [3]

Compute the impedance a 2 MHz signal sees when applied to the oscilloscope using the above arrangement. [2]

Question 5: Format conversion **[5]**

Figure 2 below shows a 4-bit digital-to-analog converter (DAC) based on an operational amplifier. In the circuit if the input bit is 1, the corresponding switch is up; if the bit is 0 the switch is down. Let the binary input be represented by $b_3b_2b_1b_0$, where b_3 controls S_3, b_2 controls S_2, etc.

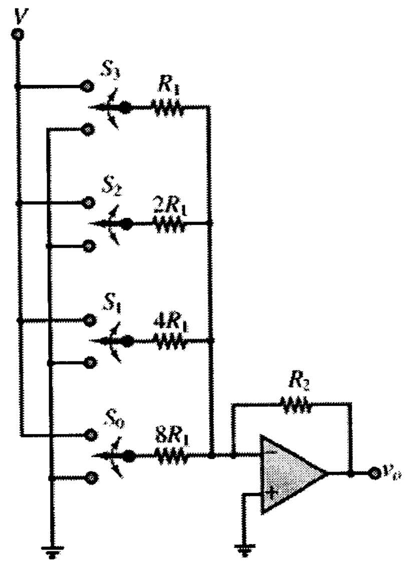


Figure 2

a) Using values of 10kΩ for each of R_1 and R_2, and a value of 6 volts for V, solve for the analog output for input $b_3b_2b_1b_0$ = *1110*. Assume all components of the circuit, the voltage source V and the ground connection are ideal. [3]

b) The above circuit produces an analog output with ±3 % full-scale error. Comment on the match of resolution and accuracy for this DAC. Support your answer with reason. [2]

Section C: Actuator Design

Question 6

Consider the DC electromagnetic actuator shown in Figure 3 which is constructed using **Hot-rolled Silicon Steel laminations** (see B_H curves on the last page of the exam paper). All dimensions shown are in millimeters. For this actuator 0.5 mm diameter Copper wire is used for the winding, the bobbin has a thickness of 5 mm, the number of turns is 80 and the current in the coil is 4 A. At a particular position of the plunger, the width of the air gap x_{AG} is 0.125 mm.

(a) Calculate the reluctance of the entire magnetic circuit when the air gap width is 0.125 mm. Neglect fringing in the air gaps but **do not neglect the reluctance of the iron**. Work to an accuracy of less or equal to three percent. (Hint: You may start your solution by assuming that 40% of the input magnetomotive force to the actuator drops in the top air gap). [8]

(b) Re-calculate the reluctance of the entire magnetic circuit for the condition when the width of the air gap has been increased to 0.135 mm. Neglect fringing in the air gaps but **do not neglect the reluctance of the iron**. Work to an accuracy of less or equal to three percent. (Hint: You may start your solution by assuming that 42% of the input magnetomotive force to the actuator drops in the top air gap). [8]

(c) Estimate the force exerted by the actuator for the condition when the width of the air gap x_{AG} is 0.125 mm. [4]

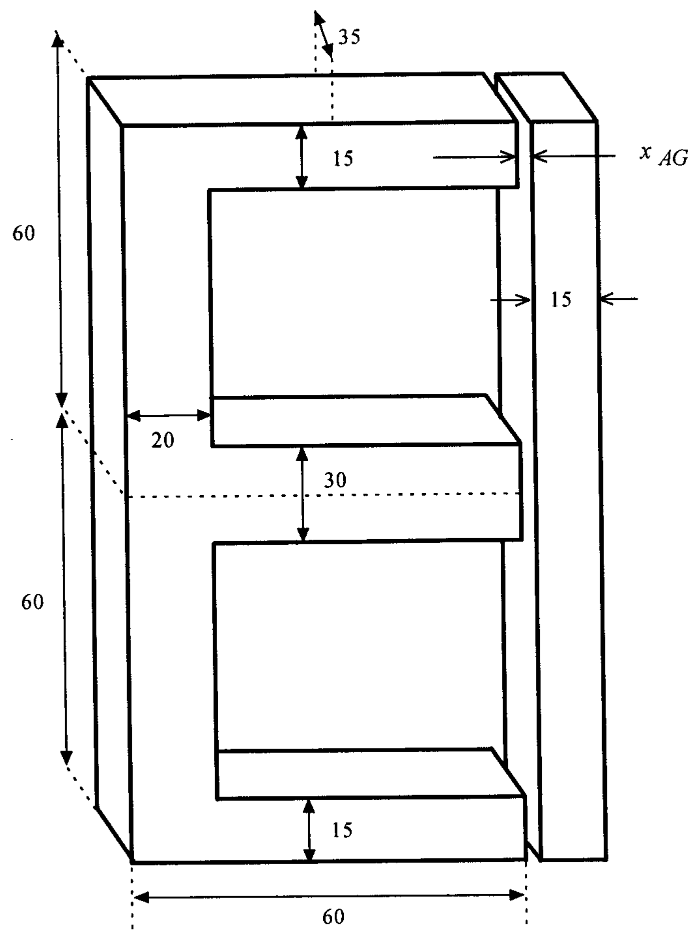
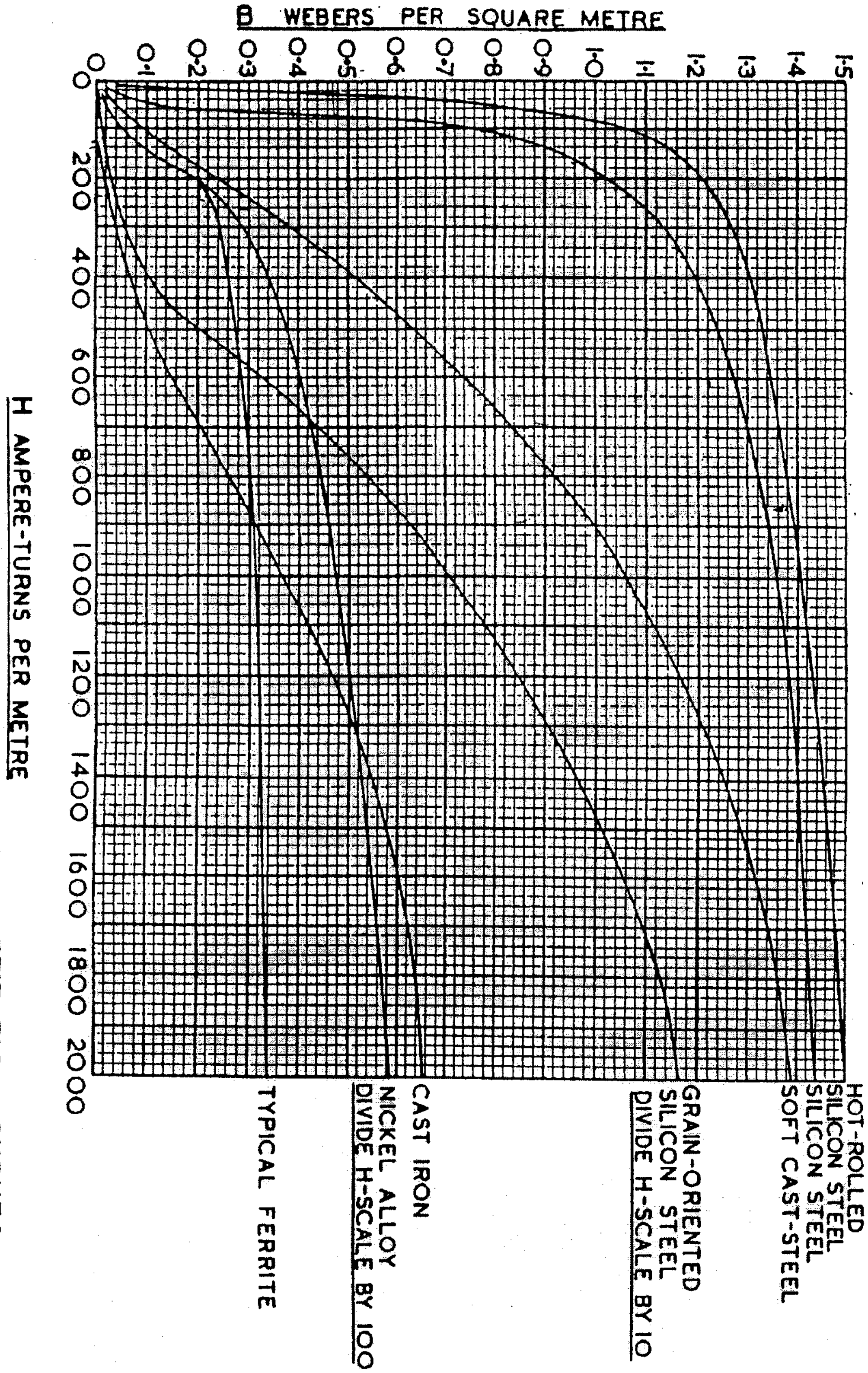


Figure 3



MAGNETIZATION CURVES