

National Exams May 2002

98-BS-4 Electric Circuits and Power

3 hours duration

Notes:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit, with the answer paper, a clear statement of any assumptions made.
2. Candidates may use one of two calculators: a Casio FX-991 or a Sharp EL-540.
3. This is a closed book exam
- 4 a. Candidates must answer Q1 and Q2, and three of Q3 - Q7 in Part 1 Basics of the exam.
b. Candidates must answer two out of the four questions of Part 2 Power.
c. Candidates must answer two out of the four questions of Part 3 Electronics.
5. Marks for each question are as indicated in square brackets associated with each part of each question

98-BS-4 Electric Circuits and Power

- # For all of the numerical answers which you calculate, it is required that you clearly specify the units for all answers.

PART 1 BASICS

The National Syllabus for this course shows the main topics and their weight in percent for the Basics section.

1.	Electrical quantities	3%
2.	Circuit principles and network theorems	10%
3.	Signal waveforms and transient response	7%
4.	Steady state AC circuits	16%
5.	Magnetic fields and circuits	10%

- Total value of 46%, appearing as 32 Marks in the following Questions.

- ☛ Please answer Q1, Q2 and 3 of Q3, Q4, Q5, Q6, Q7 (for a Total of 32 marks).

Q1. A resistive load has been supplied by a 120 volt source for two hours. A kWh meter measuring the energy to this load shows an energy consumption of one kWh.

- A. What is the power supplied to the load.
- B. How much electrical charge has passed through the load.

[Total of 4 marks]

Q2. A simple digital readout device has a numerical readout of 100 micro-amps when a voltage of 0.01 volts is placed across it. We want to construct an ammeter which uses the same digital readout, but which is capable of reading 10 amps. Design this ammeter.

[Total of 4 marks]

Q3.

- Using Nodal Equations, find the values of the voltages v_1 and v_2 . [6 marks]
- Then find the current flowing from left to right in the 10 ohm resistor [2 marks].

[Total of 8 marks]

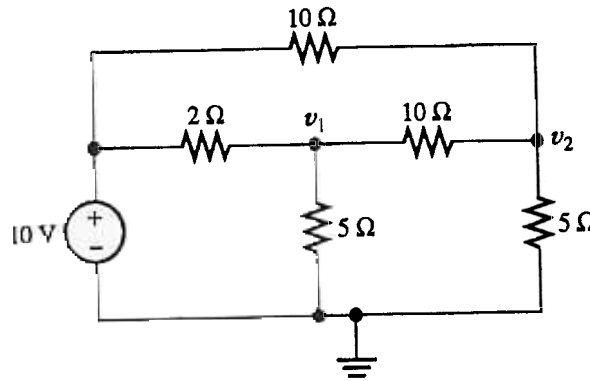


Figure for Question 3.

- The periodic current waveform $i(t)$ shown is flowing in the series R-L branch indicated. Calculate and plot the variation of v_{AB} with time from 0 to 12 msec. [Total of 8 marks].

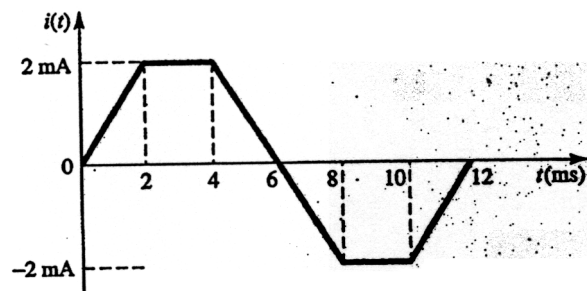
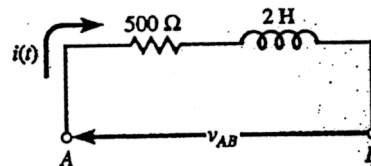


Figure for Question 4



A resistor and an inductor are connected in series as a load. The current in the series path is:

$$i(t) = 2.82 \cos(7000 t) \text{ amps}$$

Three RMS voltage measurements were taken in this circuit with a voltmeter:

i It was found that:

$$V_R = 0.5 V_L$$

ii The source voltage is:

$$V_S = 100 \text{ volts}$$

- a. Find the magnitude of the load impedance [3 marks]
- b. Find the phase angle of the load impedance. [3 marks]
- c. Find the power taken from the source in watts. [2 marks]

[Total of 8 marks]

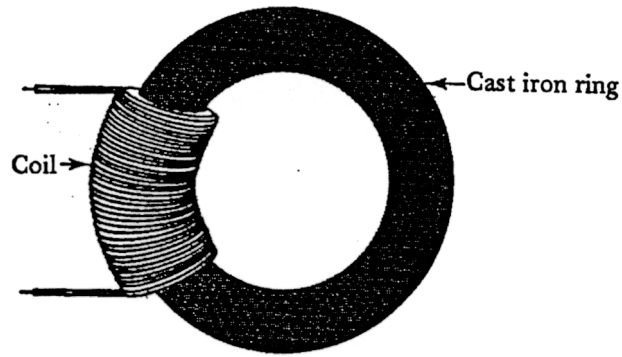
A 240 volt, 60 Hz source is connected to two parallel loads

1. Load 1 - A 12 kW load with an 80% power factor lagging.
2. Load 2 - A 15 kVA load with a power factor angle of 30° leading.

- A. Determine the reactive power of the source in kVA. [2 marks].
- B. Determine the apparent power of the source [2 marks].
- C. Determine the source current which would be measured by an ammeter [2 marks].
- D. Determine the power factor of the source [2 marks].

[Total of 8 marks]

Q7. A cast iron ring has a 2500 turn coil that carries 0.12 amps. The cross sectional area of the ring is 4 cm^2 , and the length of the magnetic path is 20 cm. The core has a relative permeability of 500. $\mu_0 = 4 \pi \times 10^{-7} \text{ H/m}$



- a. Calculate the reluctance of the core. [3 marks]
 - b. Find the magnetic field intensity H in the core [3 marks]
 - c. Find the flux density in the core [2 marks]
- [Total of 8 marks]

PART 2 POWER

The National Syllabus for this course shows the main topics and their weight in percent for the Power section.

6.	Transformers	10%
7.	DC machines	10%
8.	AC machines	10%

- Total value of 30%, appearing as 20 Marks in the following Questions.

☛ Please answer 2 of 4 questions from this Power area (for a Total of 20 marks)

- Q8. Three single phase transformers each rated 250 kVA, 7200/600 volts have been purchased by an industrial plant. The available voltage on the three-phase transmission line coming to the plant is 12,470 volts (line-to-line). Rated three-phase load is taken by the industrial plant is at 600 volts.

- A. Find the current in the primary windings of the three-phase transformer [3 mark].
- B. Find the current in the secondary windings of the transformer [3 mark].
- C. Calculate the kVA rating of the three-phase transformer [2 marks].
- D. If the load on the transformer is at 0.85 power factor lagging, what is the maximum allowable kW value for this load. [2 marks].

[Total of 10 marks]

Q9. A 240 volt dc motor drives a conveyor at 2000 rpm. The armature resistance is 0.15 ohms, and the field resistance is 120 ohms. The motor draws a rated current of 42 amps from the 240 volt source.

- (a) What is the torque developed by the motor [5 marks]
- (b) Now we want to stop this motor as quickly as possible by making it a generator and, in this way, remove its rotational energy. What value of resistor should be connected to the armature terminals if the initial stopping current should not exceed six times rated armature current [5 marks]

[Total of 10 marks]

At a 60 Hz hydroelectric power plant, the three-phase 600 RPM alternator (a-c generator) is rated at 360,000 kW at 20,000 volts line-to-line and 0.85 power factor lagging. The synchronous reactance of the Y-connected generator is 0.5 ohm per phase. For rated conditions:

- (i) Calculate the number of poles [2 marks].
- (ii) Calculate the stator current [2 marks]
- (iii) Determine the generated EMF [3 marks]
- (iv) Determine the power angle [3 marks]

[Total of 10 marks]

Q11. For a 3-phase, 600 volt, 60-Hz, 20-hp induction motor operated at a slip of 3%

Determine:

- (a) The speed of the rotor with respect to the stator (rpm) [2 marks]
- (b) The speed of the stator field with respect to the rotor field [3 marks]
- (c) The operating speed of the motor [2 marks]
- (d) The frequency of the currents in the rotor [3 marks]

[Total of 10 marks]

PART 3 ELECTRONICS

The National Syllabus for this course shows the main topics and their weight in percent for the Electronics section.

9.	Semiconductor diodes and rectifiers	8%
10.	Simple transistor amplifiers and switches	8%
11.	Introduction to digital logic and devices	8%

- Total value of 24%, appearing as 16 Marks in the following Questions.

- Please answer 2 of 4 questions from this Electronics area (for a Total of 16 marks).

Q12. We have a voltage input of $v_i = 20 \sin 1000 t$.

Ideal diodes, a resistor, and a d-c voltage source are available to you.

- A. Design a clipping and rectifying circuit that will provide an output voltage which is never negative and which is clipped at a maximum value of 12 volts [6 marks].
- B. Sketch the output voltage [2 marks]

[Total of 8 marks]

- Q13. Assume that the operational amplifier of this circuit is ideal.
- A. Determine the gain of the operational amplifier [4 marks]
 - B. Determine the value of voltage measured by the voltmeter [4 marks].
- [Total of 8 marks]

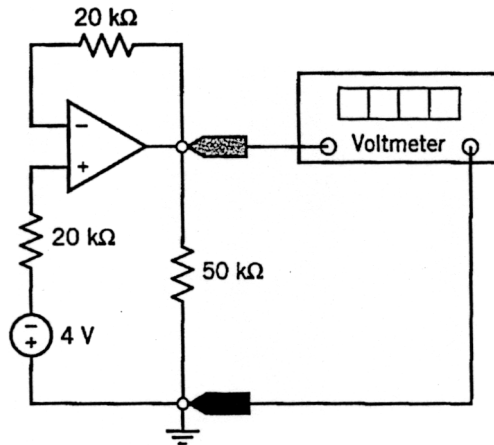
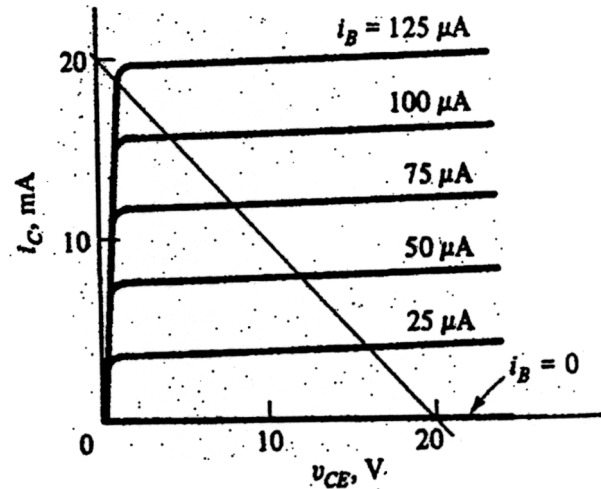
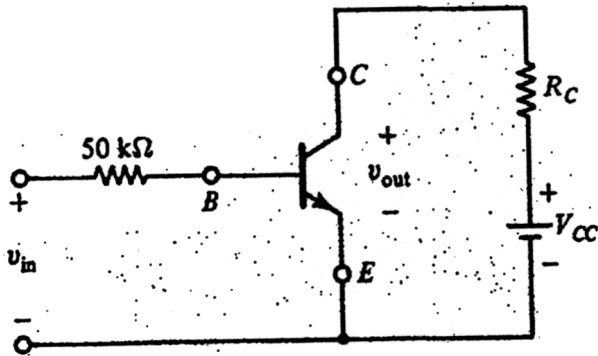


Diagram for

Question 13

A transistor amplifier-switch has a load line as shown on the transistor characteristics. Assume that v_{BE} is 0.5 volts when the transistor is ON.



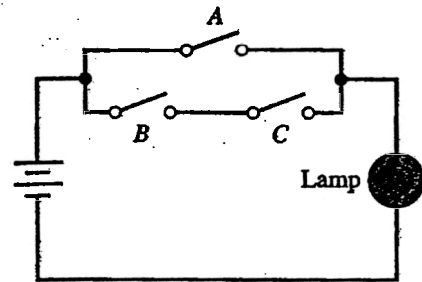
- What are V_{CC} and R_C for the circuit [4 marks].
- Determine the DC bias voltage in order for the operating point to be at a base current of 50 microamps [2 marks]
- What is gain of the circuit at this operating point (Assume that it does not saturate) [2 marks]

[Total of 8 marks]

Q15. A logic circuit for turning on a lamp L is shown. A switch closed is designated logic 1, and the lamp illuminated is also designated logic 1.

- Fill in the truth table. [5 marks]
- Write the logic equation for lamp L [3 marks].

[Total of 8 marks]



Inputs			Output
A	B	C	Lamp
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Figure for
Question 15

END OF EXAM