SINGAPORE POLYTECHNIC ET1006

2019/2020 SEMESTER TWO EXAMINATION

Diploma in Aerospace Electronics (DASE) 1st Year FT
Diploma in Computer Engineering (DCPE) 1st Year FT
Diploma in Electrical & Electronic Engineering (DEEE) 1st Year FT
Common Engineering Programme (DCEP) 1st Year FT
Diploma in Engineering with Business (DEB) 2nd Year FT

PRINCIPLES OF ELECTRICAL & ELECTRONIC ENGINEERING II

Time Allowed: 2 Hours

Instructions to Candidates

1. The examination rules set out on the last page of the answer booklet are to be complied with.

2. This paper consists of **TWO** sections:
   Section A - 10 Multiple Choice Questions, 2 marks each.
   Section B - 8 Short Questions, 10 marks each.

3. **ALL** questions are **COMPULSORY**.

4. All questions are to be answered in the answer booklet.

5. Start each question in Section B on a new page.

6. Fill in the Question Numbers, in the order that they were answered, in the boxes found on the front cover of the answer booklet under the column "Questions Answered".

7. This paper contains 10 pages, inclusive of formulae sheets.

SECTION A

MULTIPLE CHOICE QUESTIONS (20 marks)

1. Please **tick** your answers in the **MCQ box** on the inside of the front cover of the answer booklet.

2. No marks will be deducted for incorrect answers.

A1. Which statement best describes an N-type semiconductor?

(a) The minority carriers are holes.
(b) The minority carriers are electrons.
(c) It is formed by adding trivalent impurity.
(d) The majority carriers are holes.

A2. In an intrinsic semiconductor,

(a) the majority carriers are electrons.
(b) there are no free electrons.
(c) there are as many electrons as there are holes.
(d) the majority carriers are holes.

A3. Which one of the following statements is true for a light emitting diode?

(a) Its forward conducting voltage drop is equal to 0.2 V.
(b) Its forward conducting voltage drop is equal to 0.7 V.
(c) Its forward conducting voltage drop is higher than that of a PN junction diode.
(d) Its forward conducting voltage drop is lower than that of a PN junction diode.

A4. Which one of the following devices can be used as a transducer in the design of an automatic sun tracker?

(a) Moisture sensor
(b) Light dependent resistor
(c) Thermistor
(d) Light emitting diode

A5. The resistance of a thermistor

(a) increases with an increase in temperature.
(b) decreases with an increase in temperature.
(c) increases with increase in light intensity.
(d) decreases with increase in light intensity.

A6. The circuit shown in Figure A6 uses a silicon diode. During the positive half cycle of the supply voltage, the peak current, I is equal to

(a) 0.663 mA
(b) 1.325 mA
(c) 1.5 mA
(d) 3 mA

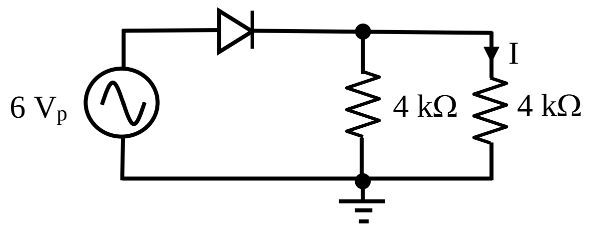

Figure A6

A7. For the Zener diode regulator circuit shown in Figure A7 if V_Z = 2.7 V at I_Z = 15mA, the supply supply current, I is equal to

(a) 6 mA
(b) 9 mA
(c) 21 mA
(d) 24 mA

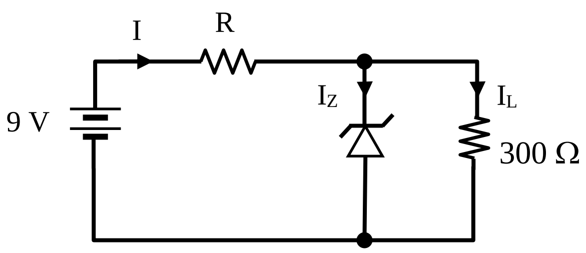

Figure A7

A8. If the LED shown in Figure A8 has a forward voltage drop of 2 V, the current flowing in the LED, I is equal to

(a) 10 mA
(b) 20 mA
(c) 30 mA
(d) 40 mA

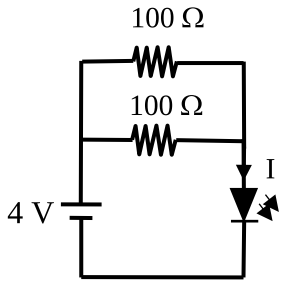

Figure A8

A9. To operate an NPN transistor in the active mode the base of the transistor must be

(a) positive with respect to the emitter.
(b) negative with respect to the emitter.
(c) positive with respect to the collector.
(d) connected to ground.

A10. Which one of the following is not a characteristics of an ideal operational amplifier?

(a) It has an infinite bandwidth.
(b) It has an infinite voltage gain.
(c) It has a very high input impedance.
(d) It has zero output impedance.

SECTION B

SHORT QUESTIONS (80 marks)

B1. The circuit shown in Figure B1 uses silicon diodes.

(a) Calculate the peak secondary voltage of the transformer. (2 marks)

(b) Calculate the peak current flowing through the load resistor, R_L. (4 marks)

(c) Determine the PIV for each diode. (2 marks)

(d) Given that the dc output voltage is 29.35 V and the peak to peak ripple voltage is 0.7 V, what is the ripple factor? (2 marks)

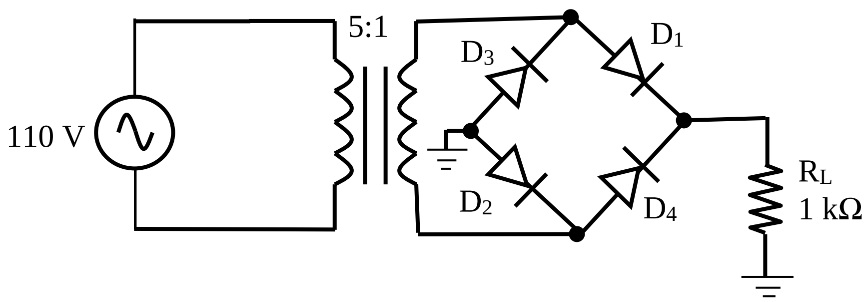

Figure B1

B2. The transistor circuit shown in Figure B2 is operating in the saturation mode. If the current gain, β_{DC} is 220 and $V_{CE(sat)} = 0.2$ V, calculate

(a) the saturation current, $I_{C(sat)}$; (2 marks)

(b) the voltage, V_{BB}; (4 marks)

(c) the current gain α_{DC}; (2 marks)

(d) the voltage V_{CB}. (2 marks)

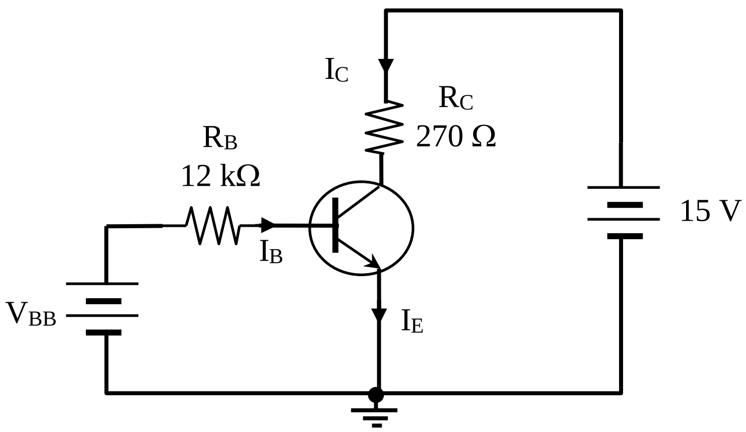

Figure B2

B3. For the circuit shown in Figure B3, if V_{in1} = 0.2 V and V_{in2} = 0.4 V

(a) calculate the output voltage V_{out1}. (3 marks)

(b) calculate the output voltage V_{out2}. (3 marks)

(c) calculate the output voltage V_{out3}. (4 marks)

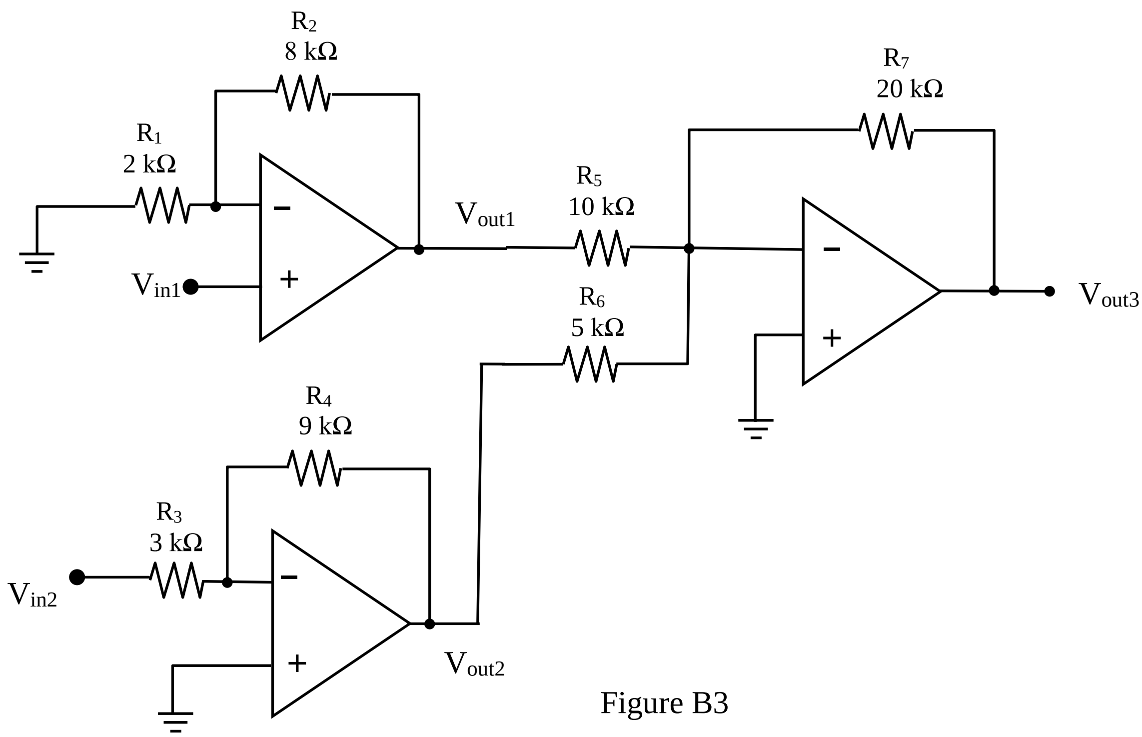

Figure B3

B4. For the circuit shown in Figure B4,

(a) calculate V_{UTP} and V_{LTP}. (4 marks)

(b) determine the value of V_{out} when V_{in} is larger than V_{UTP}. (1 mark)

(c) determine the value of V_{out} when V_{in} is smaller than V_{LTP}. (1 mark)

(d) draw the output waveform of V_{out}. (4 marks)

Assume that the saturation voltages of the operational amplifier are $+V_{sat}$ = 12 V and $-V_{sat}$ = –12 V

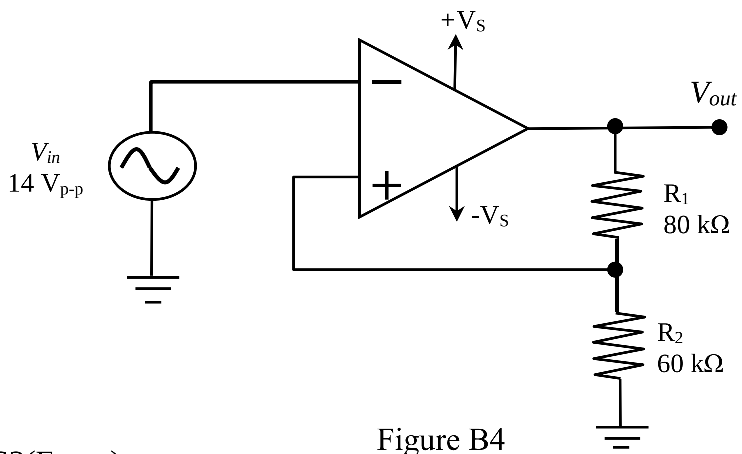

Figure B4

B5. The phasor diagram for 3 sinusoidal voltage sources (A, B & C) is shown in Figure B5.

(a) Express the 3 ac voltage phasors in polar form. (3 marks)
(b) Write down the sinusoidal equations for the 3 voltage sources. (3 marks)
(c) Express the sum of phasor B and phasor C in rectangular form. (2 marks)
(d) State the phase relationship between phasor A and phasor B. (2 marks)

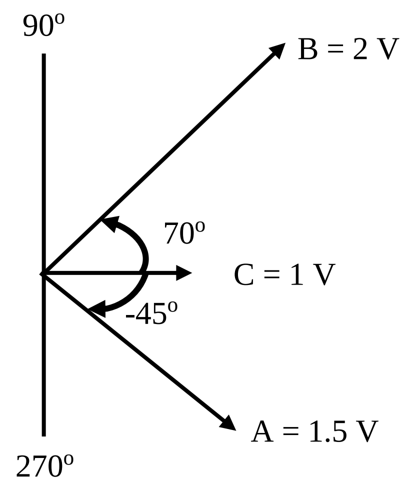

Figure B5

B6. For the circuit shown in Figure B6, calculate

(a) the total impedance, Z_T in polar form; (2 marks)
(b) the circuit current, I in polar form; (2 marks)
(c) the total true power; (2 marks)
(d) the voltages V_R and V_C in polar form. (4 marks)

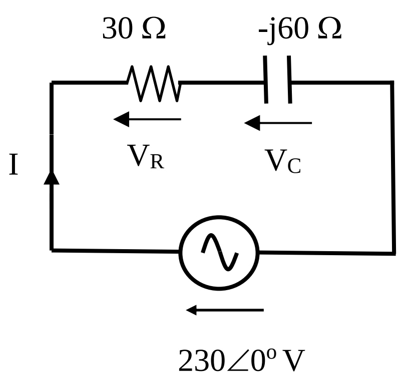

Figure B6

B7. For the circuit shown in Figure B7, if the current I is $3\angle{-60^{o}}$ A calculate

(a) the total impedance, Z_T; (2 marks)
(b) the resistance R; (2 marks)
(c) the inductance L; (2 marks)
(d) the total reactive and apparent power. (4 marks)

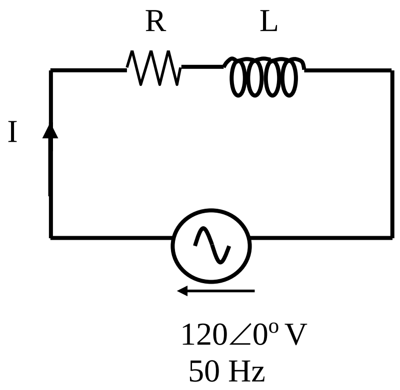

Figure B7

B8. For the circuit shown in Figure B8, calculate

(a) the currents I_R, I_L and I_T in polar form; (5 marks)
(b) the total impedance in polar form; (2 marks)
(c) the current, I_T if a 100 μF capacitor is now connected across the supply. (3 marks)

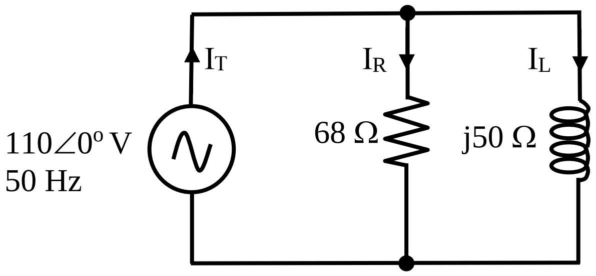

Figure B8

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Formulae List

Number of electrons in a shell (band) = $2N^2$

6.25×10^{18} electrons ➔1C of negative charge

Ohm's Law for ac:

$$\bar{V} = \bar{I}\bar{Z} \qquad \bar{I} = \frac{\bar{V}}{\bar{Z}} = \bar{V}\bar{Y} \qquad \bar{Z} = \frac{\bar{V}}{\bar{I}}$$

Capacitors:

Capacitive reactance, $X_C = \dfrac{1}{2\pi f C}$ in ohms

Inductors:

Inductive reactance, $X_L = 2\pi f L$ in ohms

AC Voltages and Currents:

$I_{rms} = I_p /\sqrt{2} = 0.7071\ I_p$ $\qquad I_{p\text{-}p} = 2I_p$ $\qquad I_{av} = 2I_p/\pi = 0.637I_p$

$V_{rms} = V_p /\sqrt{2} = 0.7071\ V_p$ $\qquad V_{p\text{-}p} = 2V_p$ $\qquad V_{av} = 2V_p/\pi = 0.637V_p$

$\omega = 2\pi f$

AC Impedance/Admittance:

Series circuit

$Z_R = R \qquad Z_C = -jX_C = X_C\angle{-90^0} \qquad Z_L = jX_L = X_L\angle 90^0 \qquad \phi\angle Z_T$

Parallel circuit

$Y_R = G \qquad Y_C = jB_C = B_C\angle 90^0 \qquad B_L = -jB_L = B_L\angle{-90^0} \qquad \phi\angle Y_T$

AC Power:

$$S = V\ I = I^2 Z \qquad P = V\ I\cos\phi = I^2 R \qquad Q = V\ I\sin\phi = I^2 X \qquad \cos\phi = \frac{P}{S}$$

Diodes:

Forward voltage drop is 0.7 V for silicon diode and 0.3 V for germanium diode

Zener impedance $\qquad Z_Z = \dfrac{\Delta V_Z}{\Delta I_Z}$

Half-Wave Rectifier:

$V_{out(p)} = V_{\sec(p)} - 0.7V$ $\quad V_{AVG} = \dfrac{V_{out(p)}}{\pi}$ $\quad PIV = V_{\sec(p)}$

Centre-Tapped Full-Wave Rectifier:

$V_{out(p)} = \dfrac{V_{\sec(p)}}{2} - 0.7V$ $\quad V_{AVG} = \dfrac{2V_{out(p)}}{\pi}$ $\quad PIV = 2V_{out(p)} + 0.7V$

Full-Wave Bridge Rectifier:

$V_{out(p)} = V_{\sec(p)} - 1.4\ V$ $\quad V_{AVG} = \dfrac{2V_{out(p)}}{\pi}$ $\quad PIV = V_{out(p)} + 0.7\ V$

Ripple Factor:

$r = \dfrac{V_{r(rms)}}{V_{DC}}$ where $V_{r(rms)} = \dfrac{V_{r(p-p)}}{2\sqrt{3}}$

Line Regulation = $\left(\dfrac{\Delta V_{OUT}}{\Delta V_{IN}}\right)100\%$ **Load Regulation =** $\left(\dfrac{V_{NL} - V_{FL}}{V_{FL}}\right)100\%$

Transistors:

$I_E = I_C + I_B$ $\quad \beta_{DC} = \dfrac{I_C}{I_B}$ $\quad \alpha_{DC} = \dfrac{I_C}{I_E}$ $\quad \beta_{DC} = \dfrac{\alpha_{DC}}{1-\alpha_{DC}}$

$V_{BE} = 0.7V$ $\quad V_{CC} = V_{CE} + I_C R_C$

$V_{BB} = V_{BE} + I_B R_B$ $\quad V_{CE} = V_{CB} + V_{BE}$

Operational Amplifiers

Voltage Gain of Inverting Amplifier: $-\dfrac{R_f}{R_i}$

Voltage Gain of Non-inverting Amplifier: $1 + \dfrac{R_f}{R_i}$

Output voltage of summing amplifier:

$V_O = -\left(\dfrac{R_f}{R_1}V_1 + \dfrac{R_f}{R_2}V_2 + \dfrac{R_f}{R_3}V_3 + \ldots\ldots\ldots + \dfrac{R_f}{R_n}V_n\right)$ for “n” inputs

Threshold Voltages for comparator with positive feedback:

Upper Trigger Point (UTP) = $\dfrac{R_2}{R_1 + R_2}(+V_{sat})$

Lower Trigger Point (LTP) = $\dfrac{R_2}{R_1 + R_2}(-V_{sat})$