2018/2019 SEMESTER ONE EXAMINATION

Diploma in Aerospace Electronics (DASE) 1st Year FT
Diploma in Energy Systems and Management (DESM) 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. Electrons in a P-type semiconductor are

(a) majority carriers that are thermally produced.
(b) minority carriers that are thermally produced.
(c) majority carriers that are produced by doping.
(d) minority carriers that are produced by doping.

A2. An N-type semiconductor is formed when

(a) a trivalent material is added to intrinsic silicon.
(b) a pentavalent material is added to intrinsic silicon.
(c) thermal energy is applied to intrinsic silicon.
(d) a dc voltage source is applied to intrinsic silicon.

A3. The correct order of connection of a DC power supply is

(a) transformer, rectifier, voltage regulator and filter.
(b) transformer, voltage regulator, rectifier and filter.
(c) transformer, filter, voltage regulator and rectifier.
(d) transformer, rectifier, filter and voltage regulator.

A4. Which one of the following devices is a transducer?

(a) Thermistor
(b) Germanium diode
(c) Silicon diode
(d) Transistor

A5. When a 50 Hz sinusoidal voltage is applied to the input of a full-wave rectifier, the output frequency is equal to

(a) 25 Hz
(b) 50 Hz
(c) 100 Hz
(d) 150 Hz

A6. For the silicon diode circuit shown in Figure A6, current I is equal to

(a) 0.359 mA
(b) 0.717 mA
(c) 0.833 mA
(d) 2.867 mA

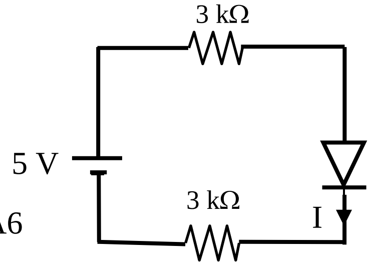

Figure A6

A7. Figure A7 shows an NPN transistor. Given that I_B = 150 μA and β_{DC} = 180, calculate current I_E

(a) 26.85 mA
(b) 27 mA
(c) 27.15 mA
(d) 270 mA

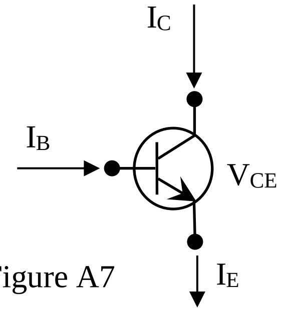

Figure A7

A8. For the transistor circuit shown in Figure A8, the emitter current I_E is equal to

(a) 0.13 mA
(b) 0.27 mA
(c) 0.6 mA
(d) 0.8 mA

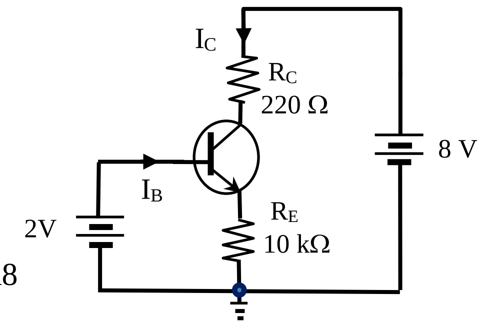

Figure A8

A9. The device symbol shown in Figure A9 represents

(a) a Zener diode.
(b) a photo diode.
(c) a light dependent resistor.
(d) a relay.

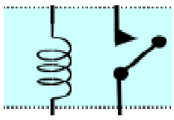
Figure A9

A10. Which one of the following devices is reverse biased for its typical applications?

(a) Moisture sensor
(b) Light emitting diode
(c) PN junction diode
(d) Photo diode

SECTION B

SHORT QUESTIONS (80 marks)

B1. For the circuit shown in Figure B1,

(a) name the circuit and explain how it works; (6 marks)

(b) if Vcc = 10 V, Rc = 270 Ω, V_{LED} = 2 V, $V_{CE(sat)}$ = 0.2 V and β_{DC} = 230, find the minimum base current $I_{B(min)}$ to saturate the transistor. (4 marks)

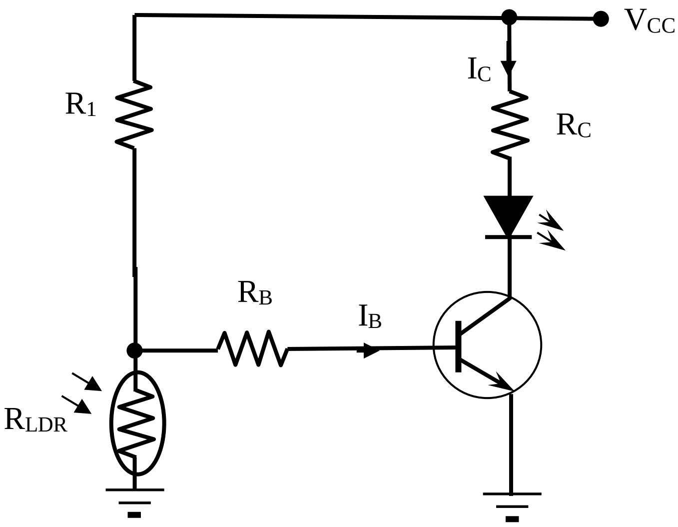

Figure B1

B2. The circuit shown in Figure B2 uses silicon diodes.

(a) Calculate the peak current I and I_L during the positive half cycle of the supply voltage. (5 marks)

(b) Sketch the voltage waveform v_{out} across the 2 kΩ resistor. Indicate the minimum and maximum values. (5 marks)

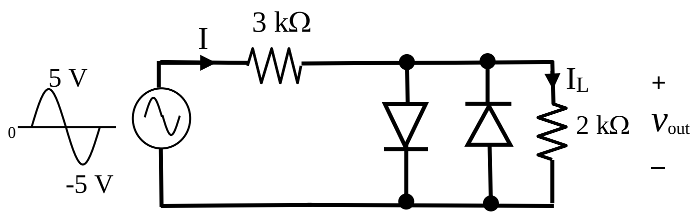

Figure B2

B3. For the circuit shown in Figure B3,

(a) calculate the peak output voltage $V_{out(p)}$; (4 marks)

(b) sketch the output waveform v_{out} and indicate the voltage levels; (3 marks)

(c) draw a circuit to be connected to v_{out} such that its output is $-2v_{out}$. (3 marks)

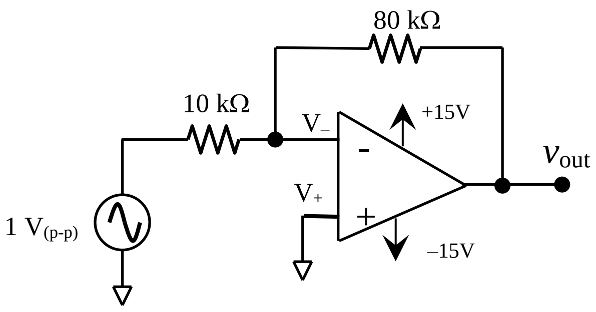

Figure B3

B4. For the circuit shown in Figure B4,

(a) identify the circuit; (2 marks)

(b) calculate the reference voltage V_{Ref}; (4 marks)

(c) determine the output voltage V_{out}; (2 marks)

(d) calculate the resistance of R_L which allows the LED to light up with a forward current 15 mA. (2 marks)

Assume $+V_{sat}$ = 13 V and $-V_{sat}$ = -13 V and the LED forward voltage, V_{LED}= 2 V.

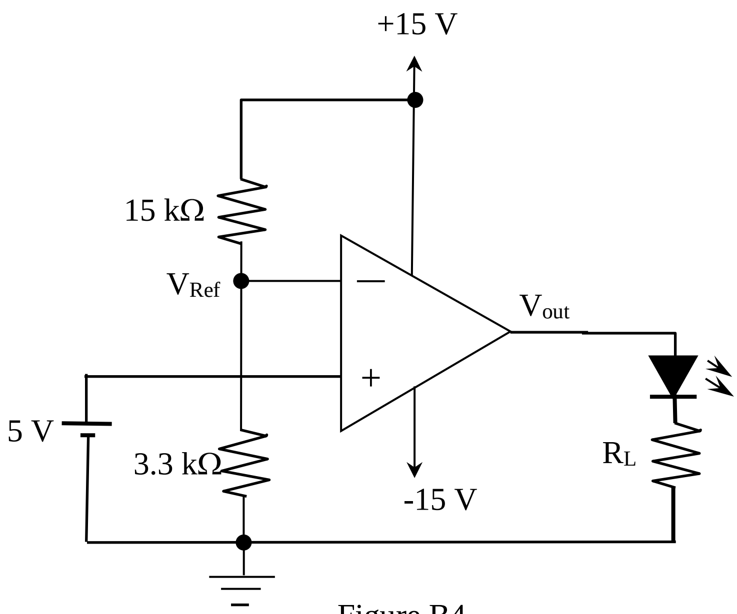

Figure B4

B5. The three voltage sources in Figure B5 are $v_{S1}(t) = 8\sin(\omega t - 12^o)$ V, $v_{S2}(t) = 12\sin(\omega t)$ V and $v_{S3}(t) = 15\sin(\omega t + 30^o)$ V respectively.

(a) Find the total voltage V_T in polar form. (6 marks)

(b) Find the circuit current I in polar form. (2 marks)

(c) Write down the time-domain sinusoidal equation for the circuit current. (2 marks)

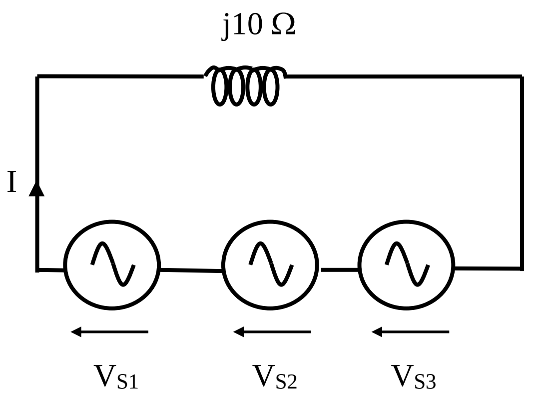

Figure B5

B6. For the circuit shown in Figure B6, if the total power of the circuit is 200 W and the power factor is 0.8 leading, calculate

(a) the current I in polar form; (3 marks)

(b) the total impedance in polar form; (2 marks)

(c) the resistance R; (3 marks)

(d) the capacitance C. (2 marks)

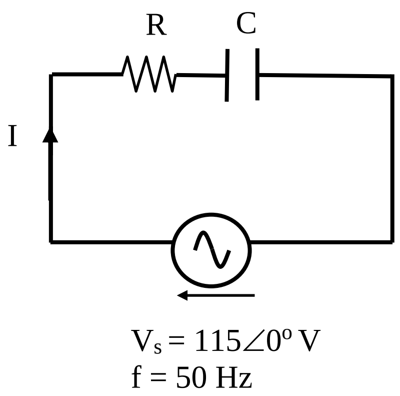

Figure B6

B7. For the circuit shown in Figure B7, calculate

(a) the currents, I_R, I_L and I_T; (7 marks)

(b) the total admittance. (3 marks)

Express all your answers in polar form.

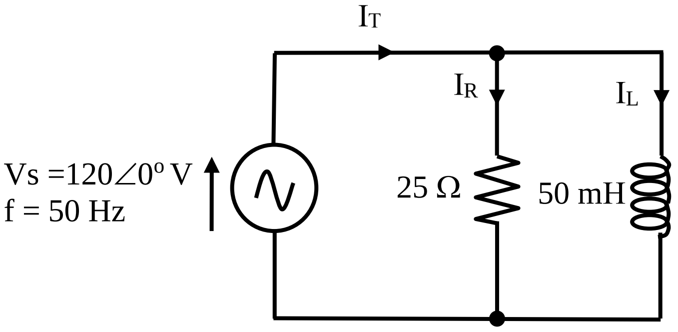

Figure B7

B8. For the circuit shown in Figure B8, calculate

(a) the total impedance Z in polar form; (2 marks)

(b) the circuit current I in polar form; (2 marks)

(c) the power factor; (2 marks)

(d) the total reactive power and the total apparent power. (4 marks)

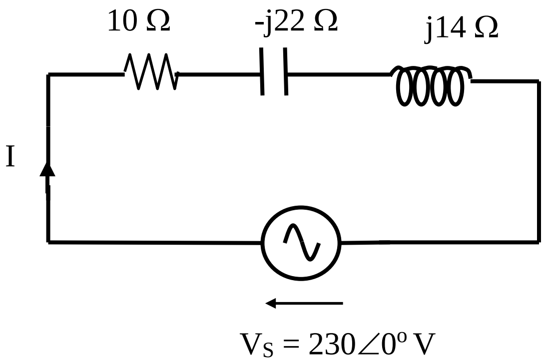

Figure B8

- End of Paper -

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Formulae List

The maximum number of electrons in a shell (band) = $2N^2$

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

Ohm's Law for ac:

$$\overline{V} = \overline{I}\,\overline{Z} \qquad \overline{I} = \frac{\overline{V}}{\overline{Z}} = \overline{V}\,\overline{Y} \qquad \overline{Z} = \frac{\overline{V}}{\overline{I}}$$

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:

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

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

AC Impedance/Admittance:

Series circuit,

$$\overline{Z}_R = R \qquad \overline{Z}_C = -jX_C = -j\frac{1}{\omega C} = \frac{1}{\omega C}\angle -90^o \qquad \overline{Z}_L = jX_L = j\omega L = \omega L \angle 90^o \qquad \omega = 2\pi f$$

$$\overline{Z} = \overline{Z}_1 + \overline{Z}_2 + \overline{Z}_3 + \ldots\ldots\ldots \qquad \phi = \angle\overline{Z} = \angle\overline{I} = \tan^{-1}\frac{X_{tot}}{R_{tot}}$$

Parallel circuit,

$$\overline{Y}_R = G \qquad \overline{Y}_C = jB_C = j\omega C = \omega C \angle 90^o \qquad \overline{Y}_L = -jB_L = -j\frac{1}{\omega L} = \frac{1}{\omega L}\angle -90^o \qquad \omega = 2\pi f$$

$$\overline{Y} = \overline{Y}_1 + \overline{Y}_2 + \overline{Y}_3 + \ldots\ldots\ldots \qquad \phi = \angle\overline{Y} = \angle\overline{V}_S = \tan^{-1}\frac{B_{tot}}{G_{tot}}$$

AC Power:

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

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

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

Half-Wave Rectifier:

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

Centre-Tapped Full-Wave Rectifier:

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

Full-Wave Bridge Rectifier:

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

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:

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

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

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

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:

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

Threshold Voltages for comparator with positive feedback:

Upper Trigger Point (UTP) = $\dfrac{R_2}{R_1 + R_2}(+V_{O[max]})$

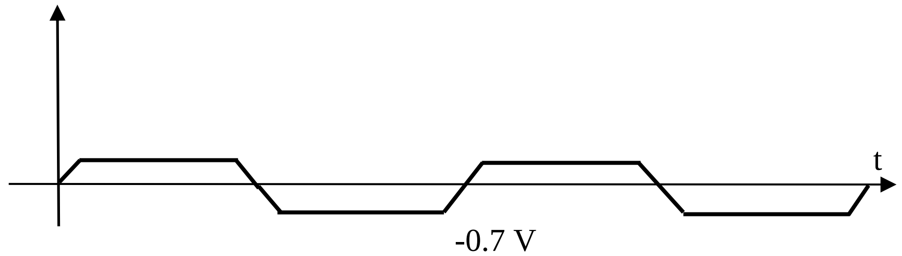
Lower Trigger Point (LTP) = $\dfrac{R_2}{R_1 + R_2}(-V_{O[max]})$

ANSWERS

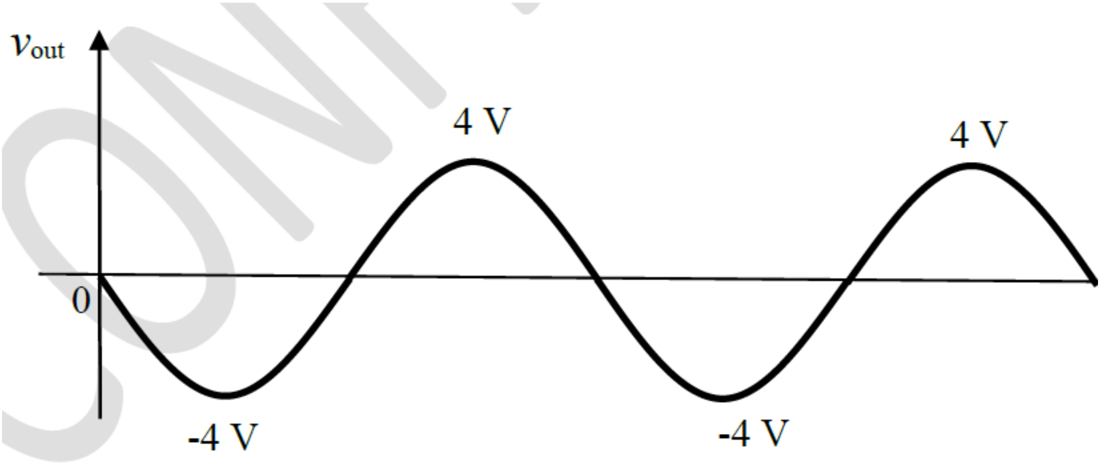
A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
B	B	D	A	C	B	C	A	D	D

B1(a) Automatic lighting circuit (b) 125.6 μA

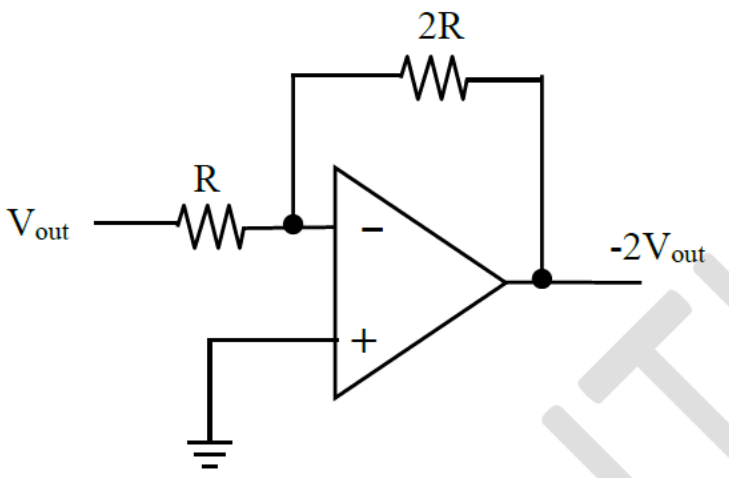
B2 (a) 1.433 mA, 0.35 mA
B2(b)



B3(a) -4V
B3(b)



B3(c)



B4(a) Comparator (b) 2.705 V (c) +Vsat = +13 V (d) 733.33 Ω

B5 (a) $23.568\angle 10.09^{o}$ V (b) $2.3568\angle -79.91° A$ (c) $3.333\sin(\omega t - 79.91^{o})$ A

B6 (a) $2.174\angle 36.87^{o}$ A (b) $52.898\angle -36.87°\ \Omega$ (c) 42.318 Ω (d) 100.29 μF

B7(a) $4.8\angle 0°\ A, 7.639\angle -90°\ A,\ 9.022\angle -57.86°\ A$
$(b) 0.0752\angle -57.86°\ S$

B8(a) $12.806\angle$-$38.66^{o}\ \Omega$ (b) $17.96\angle 38.66°\ A$ (c) 0.7809 leading

(d)reactive power Q = 2.58 kVar , apparent power S = 4.13 kVA