2019/2020 SEMESTER ONE 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
Diploma in Engineering Systems (DES) 1st Year FT
Diploma in Energy Systems and Management (DESM) 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 one of the following materials has the lowest conductivity?

(a) Intrinsic germanium
(b) Extrinsic germanium
(c) Extrinsic silicon
(d) N-type silicon

A2. A P-type semiconductor is formed by

(a) joining silicon and germanium together.
(b) joining silicon and carbon together.
(c) adding a trivalent material such as boron.
(d) adding a pentavalent material such as bismuth.

A3. Which one of the following devices in a DC power supply produces a constant dc output voltage?

(a) Transformer
(b) Voltage regulator
(c) Filter
(d) Rectifier

A4. Line regulation is determined by

(a) changes in the load resistance and the output voltage.
(b) changes in the output voltage and the input voltage.
(c) changes in the load current.
(d) changes in the load resistance.

A5. Which one of the following devices is used as a transducer in the design of a heating system?

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

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

(a) 0.7 V
(b) 3.125 V
(c) 5 V
(d) 10 V

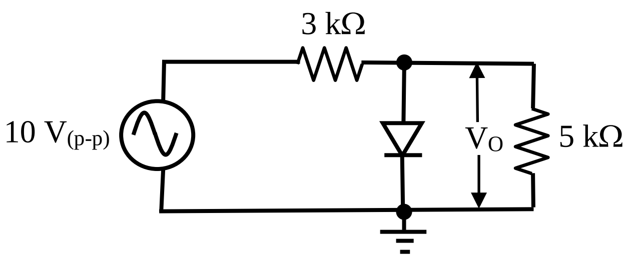

Figure A6

A7. For the Zener regulator circuit shown in Figure A7 if V_Z = 3 V at I_Z = 12 mA, the supply voltage V_S is equal to

(a) 0.6 V
(b) 2.4 V
(c) 3 V
(d) 5.4 V

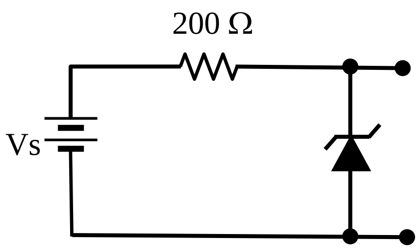

Figure A7

A8. When a bipolar junction transistor reaches saturation, any further increase in the base current will

(a) cause the collector current to decrease.
(b) cause the collector current to increase.
(c) cause the transistor to turn off.
(d) not affect the collector current.

A9. For the transistor shown in Figure A9 if I_C= 200 mA and α_{DC} = 0.995, I_E is equal to

(a) 2 mA
(b) 199 mA
(c) 201 mA
(d) 401 mA

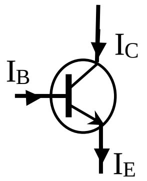

Figure A9

A10. One of the characteristics of a practical operational amplifier is

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

SECTION B

SHORT QUESTIONS (80 marks)

B1. For the circuit shown in Figure B1,

(a) name Device A and Device B; (2 marks)
(b) explain how the circuit works; (6 marks)
(c) name one application of the circuit. (2 marks)

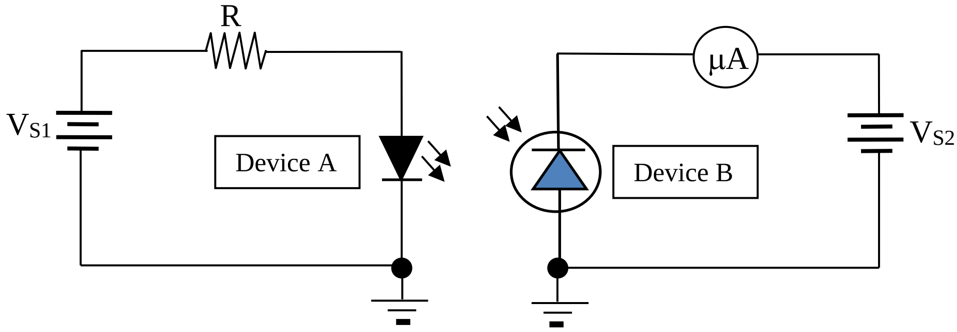

Figure B1

B2. The moisture sensor circuit shown in Figure B2 is used to detect rain drops. The circuit has the following parameters:
Resistance of the moisture sensor when it is wet, $R_{M(wet)} = 0\ \Omega$
Resistance of the moisture sensor when it is dry, $R_{M(dry)} = \infty\ \Omega$
The forward voltage, $V_{LED} = 2$ V and $V_{CE(sat)} = 0.2$V

(a) What is the voltage across R_2 when the moisture sensor is dry? (2 marks)

(b) When the moisture sensor is wet, voltage across R_2 is 3.2 V determine

(i) the base current, I_B; (3 marks)

(ii) the saturated collector current, $I_{C(sat)}$. (3 marks)

(c) Name an application of the circuit. (2 marks)

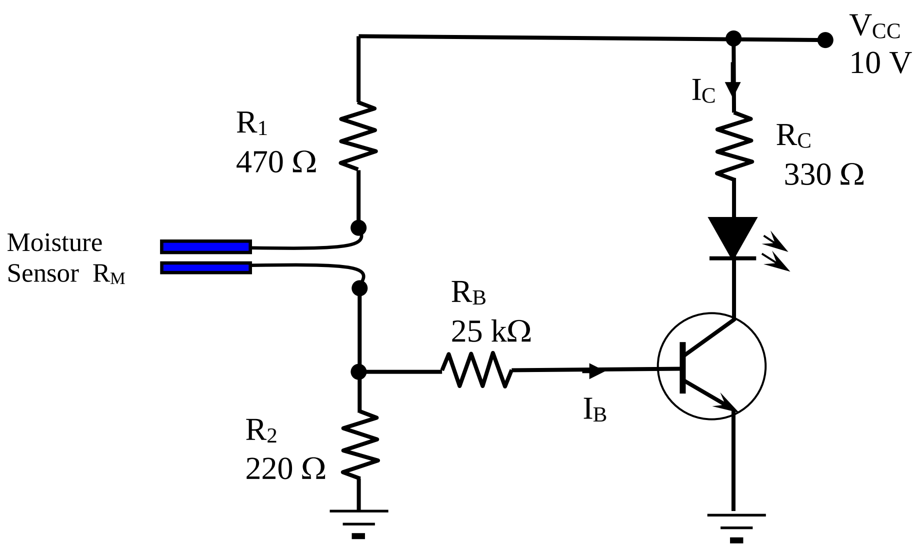

Figure B2

B3. The amplifier circuit shown in Figure B3 has a gain of -5.

(a) Calculate the feedback resistor, R_f. (2 marks)

(b) Calculate the peak output voltage, $V_{out(p)}$. (2 marks)

(c) Sketch the input and output waveforms on a common x-axis and indicate the peak values. (4 marks)

(d) State the changes to the output waveform if the input voltage is increased to 8 $V_{(p-p)}$. (2 marks)

Assume $+V_{sat}$ = 13 V and - V_{sat} = -13 V

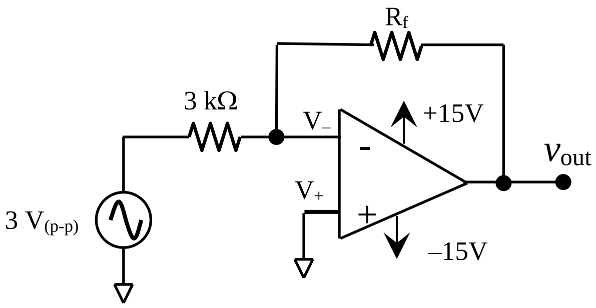

Figure B3

B4. For the circuit shown in Figure B4,

(a) calculate the reference voltage, $V_{Ref.}$; (3 marks)

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

(c) state whether LED1 and LED2 are in the On state or the Off state; (2 marks)

(d) calculate the current flowing in the 1 kΩ resistor. (3 marks)

Assume $+V_{sat}$= 13 V and $-V_{sat}$= -13 V and the 2 LEDs are identical. The forward voltage, V_{LED} = 1.6 V.

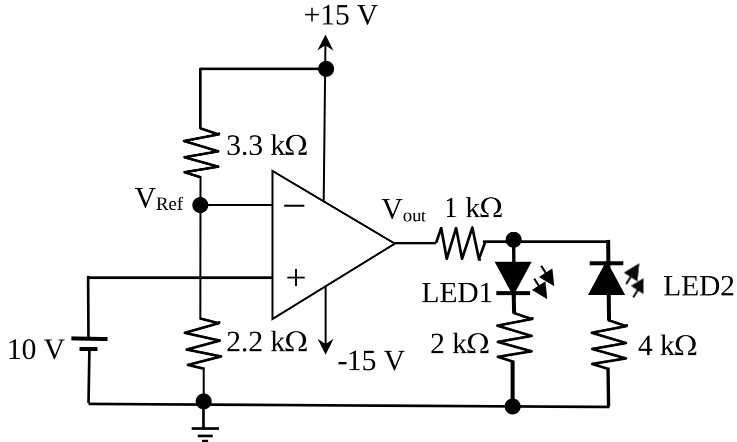

Figure B4

B5. For the circuit shown in Figure B5, the expressions for the two voltage sources are $v_{S1}(t) = 12\sin(\omega t)$ V and $v_{S2}(t) = 18\sin(\omega t + 60^o)$ V respectively.

(a) Find the total voltage, V_T in polar form. (3 marks)

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

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

(d) Draw the phasor diagram for V_{S1}, V_{S2} and V_T. (3 marks)

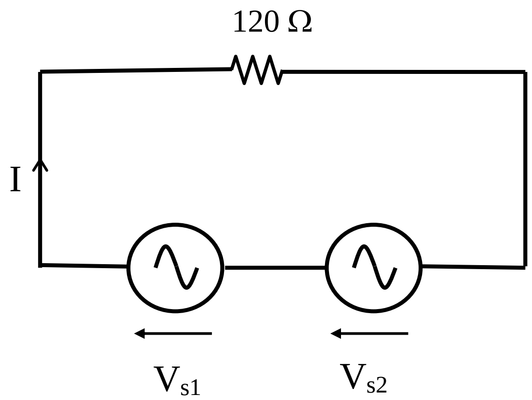

Figure B5

B6. For the circuit shown in Figure B6, calculate

(a) the currents, I_R, I_C and I_T; (6 marks)

(b) the total impedance, Z_T; (2 marks)

(c) the total admittance, Y_T. (2 marks)

Express all your answers in polar form.

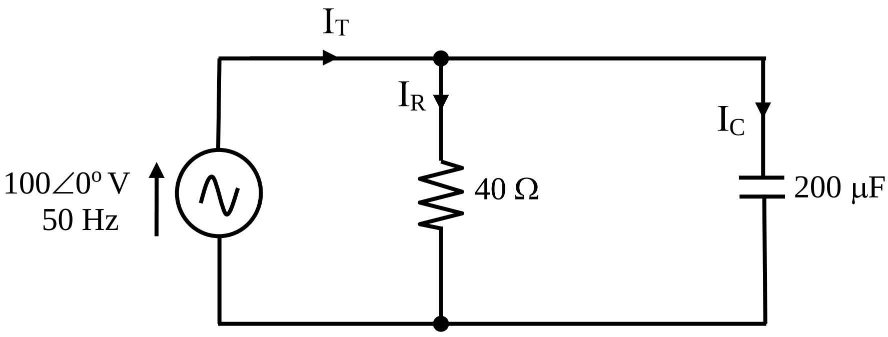

Figure B6

B7. For the circuit shown in Figure B7, if the reactive power of the circuit is 200 VAR and the current I is $5\angle{-30^o}$ A, calculate

(a) the power factor; (2 marks)

(b) the supply voltage, V_S; (3 marks)

(c) the resistance, R; (3 marks)

(d) the inductance, L. (2 marks)

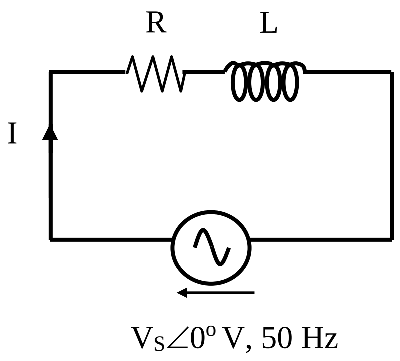

Figure B7

B8. For the circuit shown in Figure B8, calculate

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

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

(c) the true power; (2 marks)

(d) the voltages V_L and V_C in polar form. (4 marks)

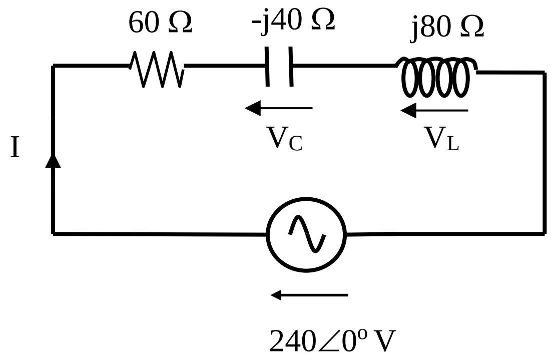

Figure B8

- End of Paper -

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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, $X_C = \dfrac{1}{2\pi fC}$ in ohms

Inductors:

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

AC Voltages and Currents:

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

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

$\omega = 2\pi f$

AC Impedance/Admittance:

Series circuit

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

Parallel circuit

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

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 $\quad Z_Z = \dfrac{\Delta V_Z}{\Delta I_Z}$

Half-Wave Rectifier:

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

Centre-Tapped Full-Wave Rectifier:

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

Full-Wave Bridge Rectifier:

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

Ripple Factor:

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

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:

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

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

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

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:

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

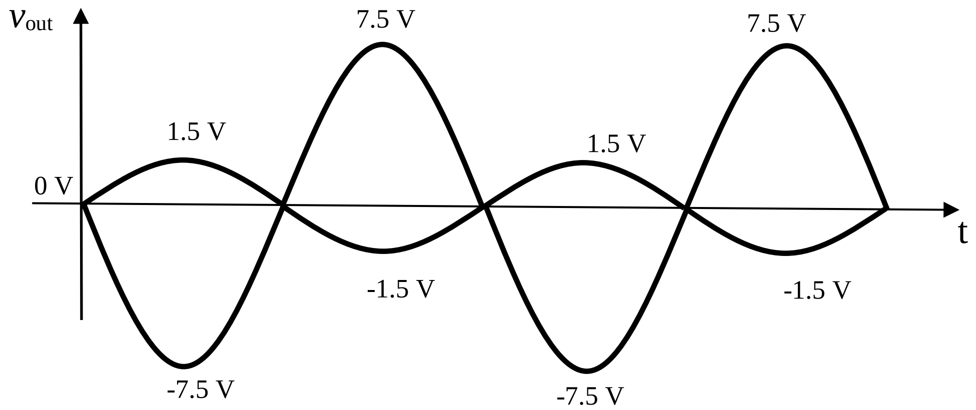
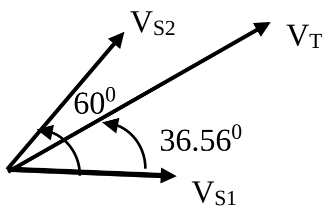
Threshold Voltages for comparator with positive feedback:

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

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

	SECTION A (MCQs)
A1	**a**
A2	**c**
A3	**b**
A4	**b**
A5	**c**
A6	**a**
A7	**d**
A8	**d**
A9	**c**
A10	**a**

B1	
(a)	Device A = Light emitting diode or LED Device B = Photodiode
(b)	The LED is forward biased so it will emit light. The photodiode is reversed biased so a current will flow when it detects light. When there is no object blocking the light from the LED, the photodiode detects light therefore its resistance reduces causing a current to flow in the photodiode circuit. Hence the microammeter will display a reading. When there is an object blocking the light from the LED the photodiode will no longer detect light therefore its resistance increases so no current or negligble current is indicated in the ammeter.
(c)	Any one of these answers or other answer which in your opinion is acceptable Counting of items in a production line Counting of human/vehicle entering a venue Controlling the opening and closing of the lift door
B2	
(a)	Voltage across R_2 = 0 V when moisture sensor is dry.
(b) (i)	I_B = 0.1 mA
(ii)	$I_{C(sat)}$ = 23.64 mA
(c)	Any one of these answers or other answer which in your opinion is acceptable Automatic plant watering system. Alert system when baby or elderly wets the bed. Automatic clothes hanging system. Automatic closing of windows.
B3	
(a)	R_f = 15 kΩ
(b)	$V_{out(p)}$ = -7.5 V

(c)	
(d)	Since it is above V_{sat} the waveform will be clipped.
B4	
(a)	$V_{ref} = 6$ V
(b)	$V_{out} = +V_{sat} = 13$ V ($V_{ref} < 10$ V)
(c)	LED1 will be "ON" since it is forward biased. LED2 will be "OFF" since it is reverse biased.
(d)	$I_{LED} = 3.8$ mA
B5	
(a)	$\overline{V}_T = 18.5\angle 36.56^o$ V
(b)	$I = 0.154\angle 36.56°\ A$
(c)	$i(t) = 0.218\sin(\omega t + 36.56^o)$ A
(d)	 (1 mark for each correct phasor V_{S1}, V_{S2} and V_T)
B6	
(a)	$I_R = 2.5\angle 0°$ A $I_C = 6.28\angle 90°$ A $I_T = 6.76\angle 68.29°\ A$
(b)	$Z_T = 14.79\angle -68.29°\ \Omega$
(c)	$Y_T = 67.61\angle 68.29°\ mS$
B7	
(a)	Power factor = 0.866 lagging
(b)	$V_s = 80$ V
(c)	R = 13.86 Ω

(d)	L= 25.46 mH
B8	
(a)	$Z_T = 72.11\angle 33.69°\ \Omega$
(b)	$I = \frac{V_s}{Z_T} = \frac{240\angle 0°}{72.11\angle 33.69^o} = 3.33\angle -33.69°$ A
(c)	True power, P = 664.98 W
(d)	$V_L = 266.4\angle 56.31^o$ V $V_C = 133.2\angle -123.69^o$ V