SINGAPORE POLYTECHNIC ET1006

2016/2017 SEMESTER TWO 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

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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.

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A1. Which one of the following materials has the lowest conductivity?

(a) intrinsic silicon
(b) n-type germanium
(c) p-type silicon
(d) n-type silicon

A2. A p-type semiconductor is formed by:

(a) joining silicon and germanium together
(b) adding a pentavalent material such as phosphorous
(c) adding a trivalent material such as aluminium
(d) joining silicon and carbon together

A3. The Zener regulator circuit shown in Figure A3 supplies a voltage of 7 V to the load $R_L$. The supply current I is

(a) 1.2 mA
(b) 20 mA
(c) 30 mA
(d) 50 mA

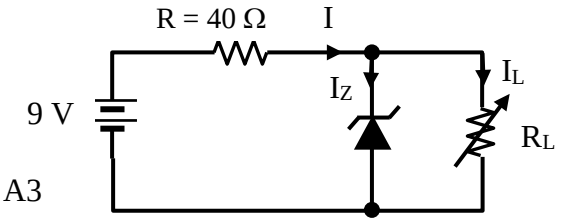


Figure A3

A4. For the circuit shown in Figure A4, the current I in the silicon diode is

(a) 3.53 mA
(b) 4.5 mA
(c) 16 mA
(d) 18 mA

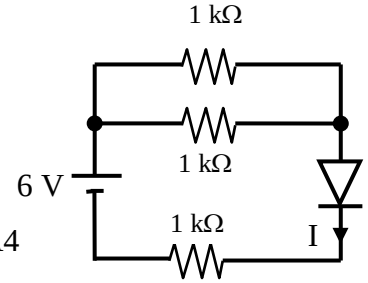


Figure A4

A5. When a photodiode in a light detecting circuit is not exposed to light, its
(a) reverse biased current will increase.
(b) reverse biased current will decrease.
(c) forward biased current will increase.
(d) forward biased current will decrease.

A6. For the transistor circuit shown in Figure A6, the emitter current, $I_E$ is

(a) 23 mA
(b) 33 mA
(c) 40 mA
(d) 60 mA

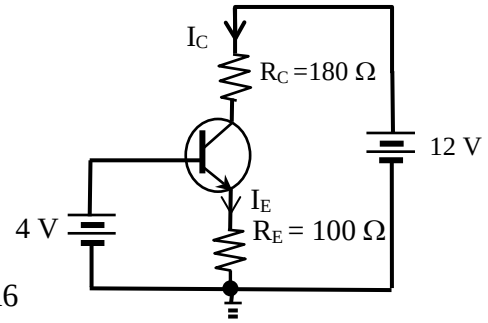



Figure A6

A7. For the transistor circuit shown in Figure A6, if $\alpha_{dc} = 0.99$, $V_{CE}$ is

(a) 0.2 V
(b) 0.7 V
(c) 2.82 V
(d) 12 V

A8. A RL series circuit has a true power of 3 kW and an apparent power of 5 kVA, the current is lagging the supply voltage by

(a) 30.96°
(b) 36.87°
(c) 41.41°
(d) 53.13°

A9. The branch currents of a pure RLC parallel circuit are $I_R$ = 2 A, $I_L$ = 5 A and $I_C$ = 3 A. The total current is

(a) 1 A
(b) 9 A
(c) (2 – j2) A
(d) (2 + j2) A

A10. For the operational amplifier circuit shown in Figure A10, the output voltage $V_o$ is

(a) -8 $V_{(p-p)}$
(b) 8 $V_{(p-p)}$
(c) 9 $V_{(p-p)}$
(d) -9 $V_{(p-p)}$

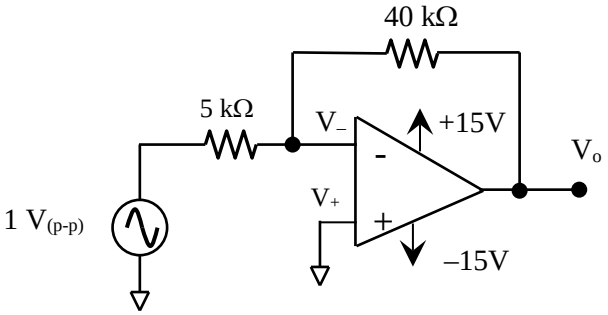



Figure A10

## SECTION B

## SHORT QUESTIONS (80 marks)

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

(a) Sketch the output voltage waveform across resistor $R_3$ in Figure B1, indicating the maximum and minimum values.

(6 marks)

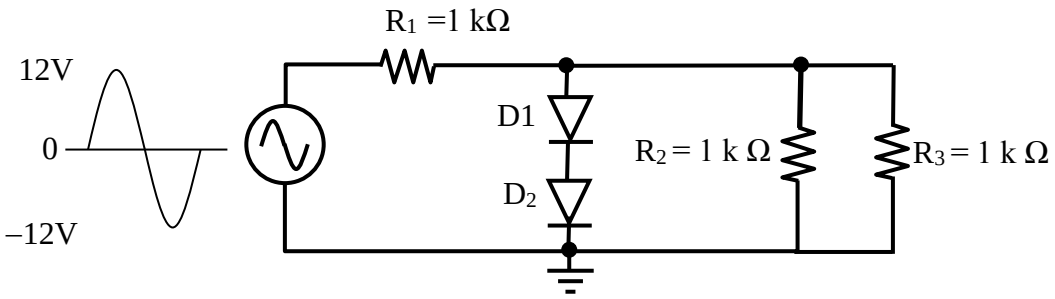



Figure B1

(b) Find the peak current flowing in the diodes during the positive cycle.

(4 marks)

**B2.** For the circuit shown in Figure B2,

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

(b) if Vcc = 12 V, coil resistance of relay = 1.2 kΩ, $V_{CE(sat)} = 0.2$ V and $\beta_{DC} = 200$ find the minimum base current, $I_B$ to saturate the transistor. (4 marks)

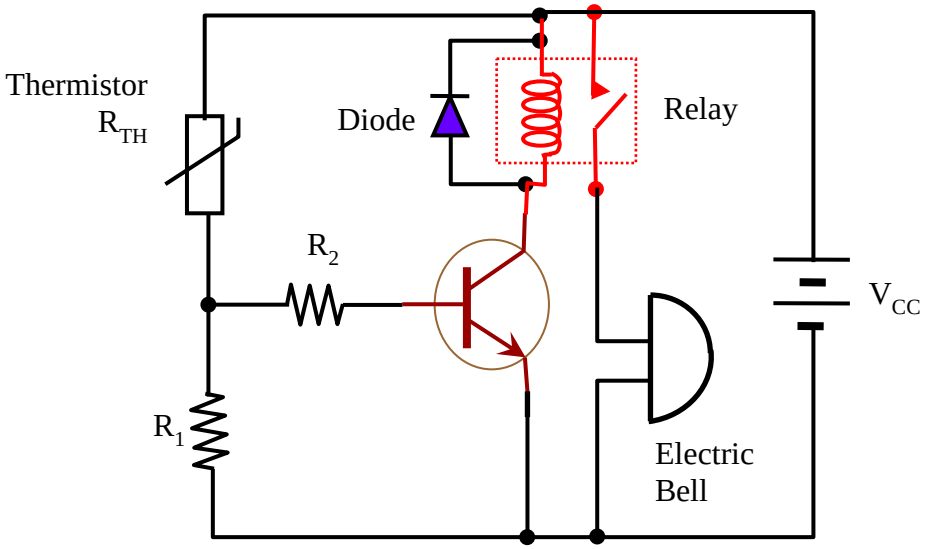



Figure B2

B3. For the circuit shown in Figure B3, if $V_{in1}$ = 0.5 V and $V_{in2}$ = 1 V,

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

(b) calculate the output voltage, $V_{out2}$. (4 marks)

(c) draw a circuit to be connected to $V_{out2}$ such that its output is $-V_{out2}$. (3 marks)

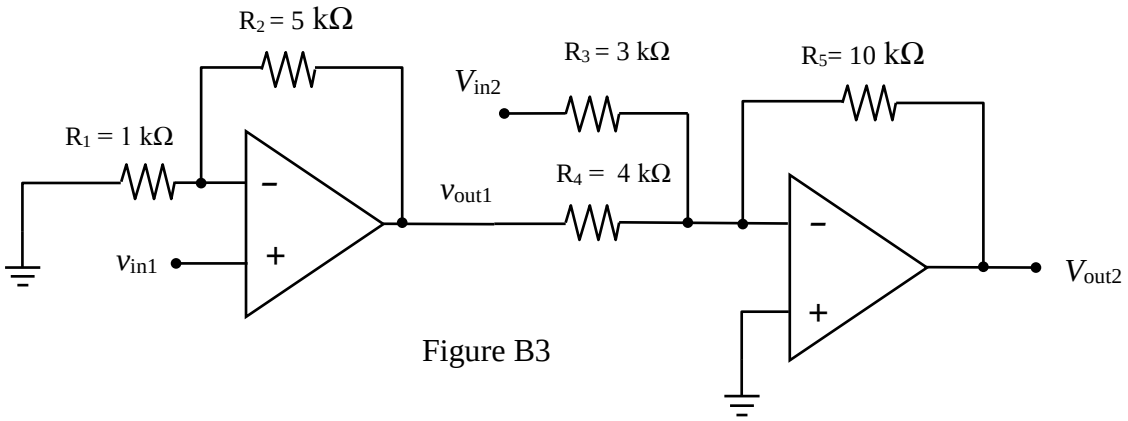



Figure B3

B4. For the circuit shown in Figure B4,

(a) identify the circuit. (2 marks)

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

(c) calculate the output voltage, $V_{out}$. (2 marks)

(d) if $V_{in}$ is reduced to 1 V, will the LED be in the On state or the Off state? Support your answer with reasons. (3 marks)

Assume $+V_{sat}$= 12 V and $-V_{sat}$= -12 V

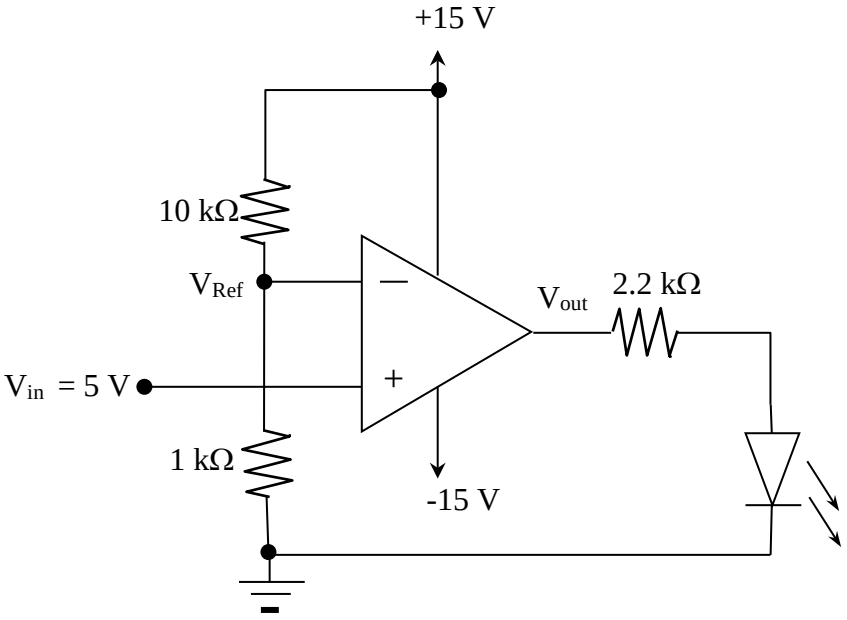



Figure B4

B5. For the circuit shown in Figure B5, the expressions for the two voltage sources are $v_{S1}(t) = 15\sin(\omega t)$ V and $v_{S2}(t) = 28\sin(\omega t + 45^o)$ V respectively.

(a) Find the total voltage $V_T$ in polar form. (4 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 $V_T$ and I. (2 marks)

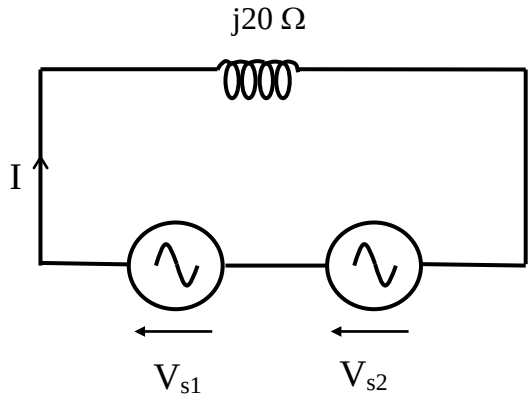



Figure B5

B6. For the circuit shown in Figure B6, calculate

(a) the currents, $I_R$, $I_L$, $I_T$. (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.

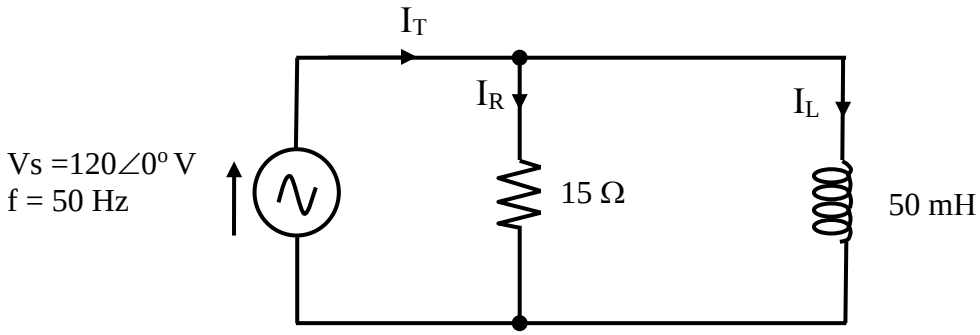



Figure B6

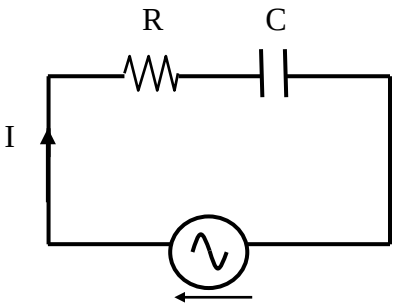
**B7.** For the circuit shown in Figure B7, the power dissipated in the circuit is 100 W and the current, I is $2\angle\phi^o$ A. Calculate

(a) the resistance, R. (2 marks)

(b) the power factor. (2 marks)

(c) the angle $\phi^o$. (2 marks)

(d) the capacitance, C. (4 marks)




$V_s = 200\angle 0^o$ V
f = 50 Hz

Figure B7

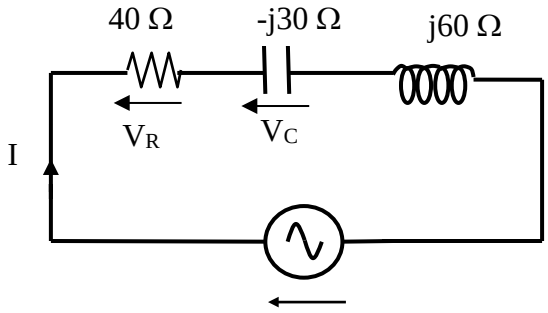
B8**.** For the circuit shown in Figure B8, calculate

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

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

(c) the true power. (2 marks)

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




$240\angle 0^o$ V

Figure B8

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# Formulae List

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

$6.25 \times 10^{18}$ 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, $X_L = 2\pi fL$ in ohms

**AC Voltages and Currents:**

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

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

**AC Impedance/Admittance:**

*Series circuit,*

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

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

*Parallel circuit,*

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

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

**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 $Z_Z = \frac{\Delta V_Z}{\Delta I_Z}$

**Half-Wave Rectifier:**

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

**Centre-Tapped Full-Wave Rectifier:**

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

**Full-Wave Bridge Rectifier:**

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

**Ripple Factor:**

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

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

**Transistors:**

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

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

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

**Operational Amplifiers**

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

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

Output voltage of summing amplifier:

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

Threshold Voltages for comparator with positive feedback:

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

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