Q.3 (a) Which one of the following truth tables is incorrect in accordance with the standard format given in the EG1108 lecture? Reconstruct the incorrect truth table in the standard format.

A	B	C	**Z**
0	0	0	**0**
0	0	1	**1**
0	1	0	**1**
0	1	1	**1**
1	0	0	**0**
1	0	1	**1**
1	1	0	**0**
1	1	1	**1**

(i)

A	B	**Z**
0	0	**0**
0	1	**1**
1	0	**1**
1	1	**1**

(ii)

A	B	C	**Z**
0	0	0	**0**
0	0	1	**1**
0	1	0	**1**
0	1	1	**1**
1	0	1	**0**
1	1	0	**1**
1	0	0	**0**
1	1	1	**1**

(iii)

(5 marks)

Write your answer to Q.3(a) in the space below.

Solution: (iii) is incorrect. The correct form is

A	B	C	**Z**
0	0	0	**0**
0	0	1	**1**
0	1	0	**1**
0	1	1	**1**
1	0	0	**0**
1	0	1	**0**
1	1	0	**1**
1	1	1	**1**

(b) Which one of the following Karnaugh maps is incorrect? Reconstruct the incorrect Karnaugh map in the standard format.

	$A \cdot B$	$A \cdot \overline{B}$	$\overline{A} \cdot \overline{B}$	$\overline{A} \cdot B$
$C \cdot \overline{D}$	0	0	0	0
$\overline{C} \cdot \overline{D}$	0	0	1	0
$C \cdot D$	0	0	0	0
$\overline{C} \cdot D$	0	0	0	0

(i)

	$A \cdot \overline{B}$	$\overline{A} \cdot \overline{B}$	$\overline{A} \cdot B$	$A \cdot B$
$C \cdot D$	0	0	0	0
$C \cdot \overline{D}$	0	0	1	0
$\overline{C} \cdot \overline{D}$	0	0	0	0
$\overline{C} \cdot D$	0	0	0	0

(ii)

	$\overline{A} \cdot \overline{B}$	$\overline{A} \cdot B$	$A \cdot B$	$A \cdot \overline{B}$
$C \cdot \overline{D}$	0	0	0	0
$\overline{C} \cdot \overline{D}$	0	0	1	0
$\overline{C} \cdot D$	0	0	0	0
$C \cdot D$	0	0	0	0

(iii)

(5 marks)

Write your answer to Q.3(b) in the space below.

Solution: (i) is incorrect. The correct form is

	$A \cdot B$	$A \cdot \overline{B}$	$\overline{A} \cdot \overline{B}$	$\overline{A} \cdot B$
$\overline{C} \cdot \overline{D}$	0	0	1	0
$C \cdot \overline{D}$	0	0	0	0
$C \cdot D$	0	0	0	0
$\overline{C} \cdot D$	0	0	0	0

(c) Simplify the following logical expression using only the 18 basic rules of Boolean algebra:

$$F = A \cdot B \cdot C \cdot \overline{D} + A \cdot \overline{B} \cdot \overline{C} + \overline{A} \cdot \overline{C} + \overline{A} \cdot B \cdot \overline{D} + B \cdot \overline{C}$$

(5 marks)

Write your answer to Q.3(c) in the space below.

Solution:

$$\begin{aligned} F &= A \cdot B \cdot C \cdot \overline{D} + A \cdot \overline{B} \cdot \overline{C} + \overline{A} \cdot \overline{C} + \overline{A} \cdot B \cdot \overline{D} + B \cdot \overline{C} \\ &= (A \cdot C + \overline{A}) \cdot B \cdot \overline{D} + (A \cdot \overline{B} + \overline{A} + B) \cdot \overline{C} \\ &= (C + \overline{A}) \cdot B \cdot \overline{D} + (\overline{B} + \overline{A} + B) \cdot \overline{C} \\ &= \overline{A} \cdot B \cdot \overline{D} + C \cdot B \cdot \overline{D} + \overline{C} \\ &= \overline{A} \cdot B \cdot \overline{D} + B \cdot \overline{D} + \overline{C} \\ &= (\overline{A} + 1) \cdot B \cdot \overline{D} + \overline{C} \\ &= B \cdot \overline{D} + \overline{C} \end{aligned}$$

(d) Simplify the following logical expression in the SOP form using the Karnaugh map simplification technique:

$$F = A \cdot B \cdot C + A \cdot \overline{B} \cdot \overline{C} + \overline{A} \cdot \overline{C} + \overline{A} \cdot B \cdot \overline{D} + B \cdot \overline{C}$$

(5 marks)

Write your answer to Q.3(d) in the space below.

Solution:

	$A \cdot B$	$A \cdot \overline{B}$	$\overline{A} \cdot \overline{B}$	$\overline{A} \cdot B$
$C \cdot D$	$1 \cdot 1$	0	0	0
$C \cdot \overline{D}$	$1 \cdot 1 \cdot 1$	0	0	$1 \cdot 1$
$\overline{C} \cdot \overline{D}$	$1 \cdot 1 \cdot 1$	1	1	$1 \cdot 1$
$\overline{C} \cdot D$	$1 \cdot 1$	1	1	1

$$F = \overline{C} + A \cdot B + B \cdot \overline{D}$$

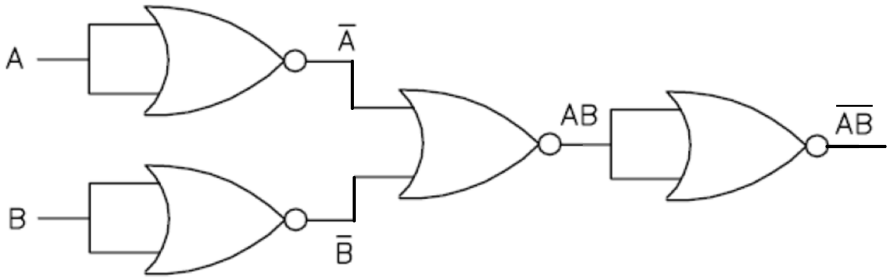
(e) Realize a two-input NAND gate using only NOR gates.

(5 marks)

Write your answer to Q.3(e) in the space below.

Solution: Exclusive NOR gate can be expressed as

$$X = \overline{A \cdot B} = \overline{\overline{A} + \overline{B}}$$



Q.4 (a) Consider an ideal transformer circuit shown in Figure Q4 (a) below. The transformer turns ratio is 2:1. The input to the circuit is the voltage source, $v_s(t)$, as given in the circuit.

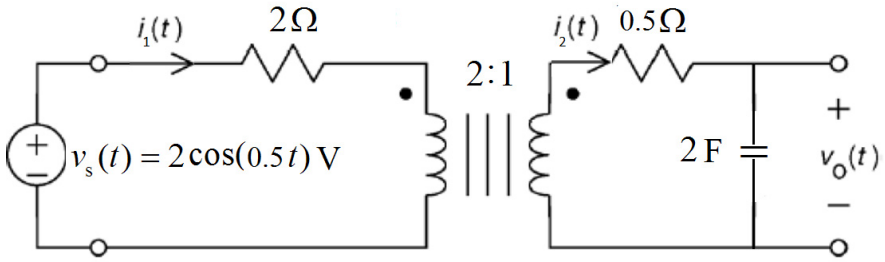


Figure Q4 (a)

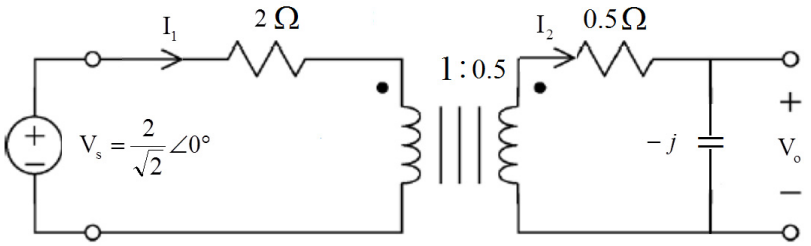
i) Determine the output voltage, $v_o(t)$, across the capacitor.

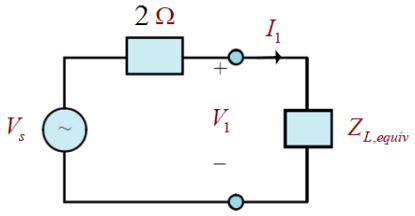
(5 marks)

ii) Determine the average power consumed by the capacitor and the transformer.

(5 marks)

Solution: i)





$$Z_{L,equiv} = \frac{0.5 - j}{0.5^2} = 2 - j4 \qquad I_1 = \frac{V_s}{4 - j4} = \frac{2}{\sqrt{2}} \cdot \frac{1}{4\sqrt{2}\angle -45°} = \frac{1}{4}\angle 45°$$

$$I_2 = \frac{I_2}{0.5} = \frac{1}{2}\angle 45° \quad \Rightarrow \quad V_o = -j \cdot I_2 = \frac{1}{2}\angle -45° \quad \Rightarrow v_o(t) = \frac{\sqrt{2}}{2}\cos(0.5t - 45°)$$

ii) Both the capacitor and the transformer do not consume any power.

Q.4 (b) A DC power supply consists of a transformer feeding a full-wave bridge rectifier with a capacitor filter. It supplies a DC current of 1 A at 5 V DC to a computer. The AC input source to the transformer is 230 V (rms) at 50 Hz. The filter capacitor has a capacitance of 0.05 F.

(i) Draw the circuit diagram of the supply arrangement.

(5 marks)

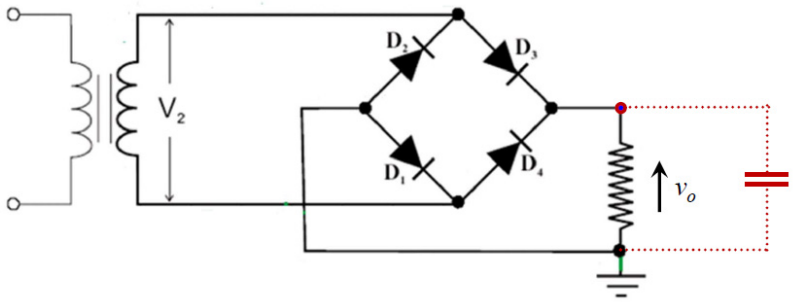
(ii) Determine a suitable winding ratio for the transformer.

(5 marks)

(iii) Determine the magnitude of the peak-to-peak ripple in the output voltage.

(5 marks)

Solution: i)



ii) The required turn ratio of the transformer:

$$\frac{1}{n}=\frac{230\sqrt{2}}{5}=65 \qquad \Rightarrow \qquad 1:n=65:1=1:0.0154$$

iii) The magnitude of the peak-to-peak ripple in the output voltage:

$$V_{p-p}=\frac{I_L T}{2R_L C}=\frac{I_L}{2fC}=\frac{1}{2\times 50\times 0.05}=0.2\ \text{V}$$