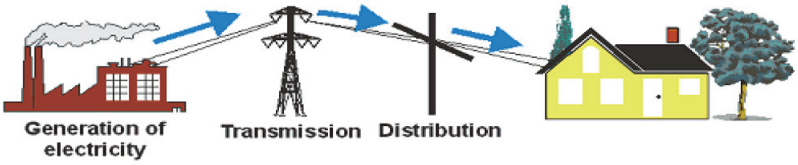
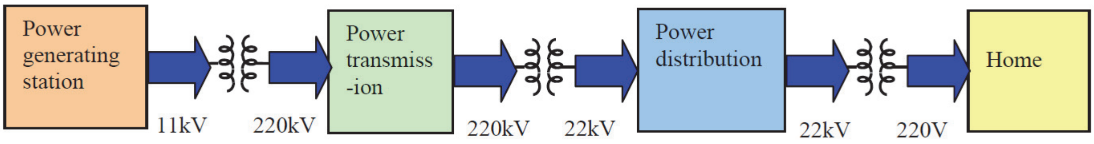
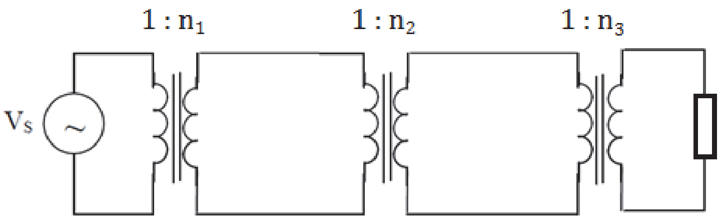
Q.3 (a) Shown in the figure below is a typical electric power distribution network. Assume that all the transformers and transmission lines are ideal, i.e., they do not consume energy. When you connect a device with a resistance $R_L = 100\ \Omega$ to the power outlet at home, what is the equivalent resistance seen by the power generating station? What is the power consumed by your device?





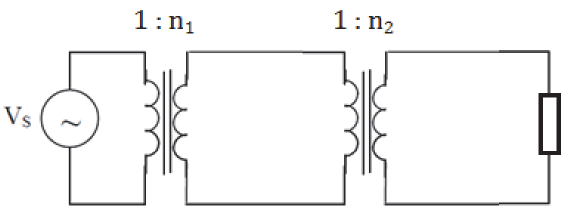
(15 Marks)

Solution: Find the transformer turn ratios

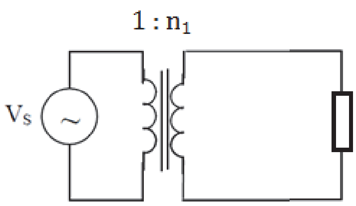


$R_L = 100\,\Omega$

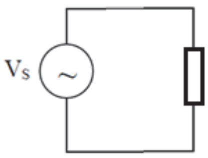
$$n_1 = \frac{220000}{11000} = 20 \qquad n_2 = \frac{22000}{220000} = 0.1 \qquad n_3 = \frac{220}{22000} = 0.01$$



$$R_{\text{equiv},3} = \frac{R_L}{n_3^2}$$



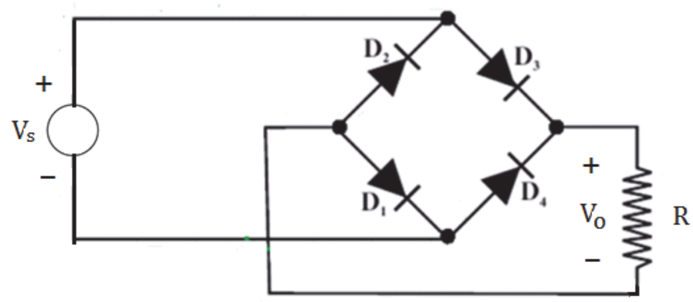
$$R_{\text{equiv},2} = \frac{R_{\text{equiv},3}}{n_2^2} = \frac{R_L}{n_3^2 \cdot n_2^2}$$

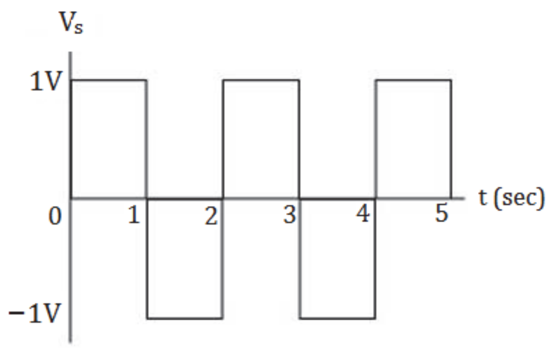


$$R_{\text{equiv}} = \frac{R_{\text{equiv},2}}{n_1^2} = \frac{R_L}{n_3^2 \cdot n_2^2 \cdot n_1^2} = \frac{100}{0.01^2 \cdot 0.1^2 \cdot 20^2} = 250000\,\Omega = 250\,\text{k}\Omega$$

$$P_{\text{load}} = \frac{|V|^2}{R_L} = \frac{220^2}{100} = 484\ \text{W}$$

(b) A full wave bridge rectifier shown below is connected to a square voltage source.

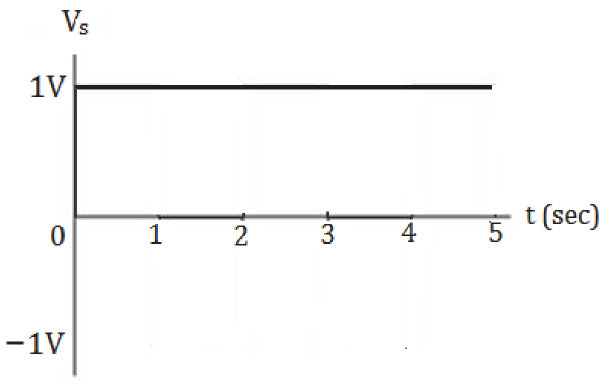




Draw the output voltage across the load resistor. What is the capacitance of the required capacitor to obtain a pure DC output?

(10 Marks)

Solution:



Obviously, there is no need to add a capacitor in this case.

Q.4 (a) Prove the following De Morgan's Law:

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

(7 Marks)

Solution: Proof by the following truth table:

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

(b) Simply the following logical expression using the rules of Boolean algebra and the De Morgan's Laws:

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

(7 Marks)

Solution:

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

(c) Use Karnaugh map to simplify the following logical expression:

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

(7 Marks)

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

	$\mathbf{A \cdot B}$	$\mathbf{A \cdot \overline{B}}$	$\mathbf{\overline{A} \cdot \overline{B}}$	$\mathbf{\overline{A} \cdot B}$
$\mathbf{C}$	0	0	1	1
$\mathbf{\overline{C}}$	1	1	1·1	1·1

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

(d) Draw a logic circuit implementation for the simplified logical expression obtained in Part (c) using a single two-input NAND gate (i.e., the NAND gate only has two input channels).

(4 Marks)

Solution: $F = \overline{A} + \overline{C} = \overline{A \cdot C}$