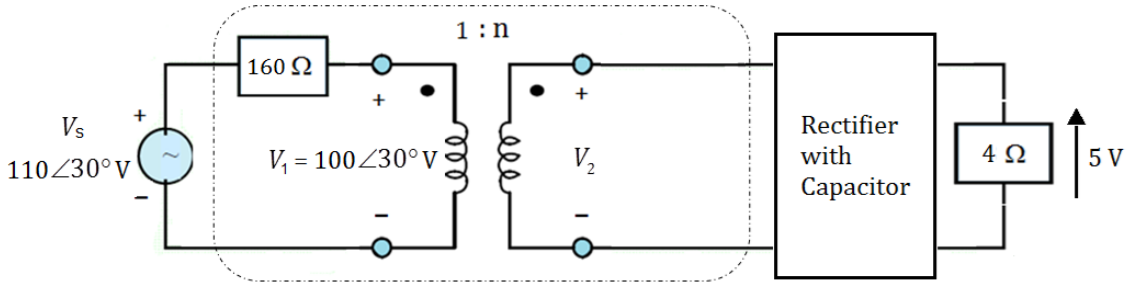
Q.3 As depicted in the circuit below, a practical transformer (dash-boxed) is utilized to step down an AC source Vs to a rectifier circuit with a sufficiently large capacitor before it is connected to a computer, which has a load resistance of 4 Ω and takes a DC voltage supply of 5 V.



Practical Transformer

(a) Determine V_2 in the phasor form.

(5 Marks)

Solution: The average output voltage of the rectifier is 5 V implies that the peak value of the secondary winding voltage = 5 V. Since V_1 and V_2 has to be in phase, thus,

$$V_2 = \frac{5}{\sqrt{2}}\angle 30°$$

(b) Determine the required turn ratio *n*.

(5 Marks)

Solution:

$$\frac{1}{n} = \frac{V_1}{V_2} = \frac{100\angle 30°}{\frac{5}{\sqrt{2}}\angle 30°} = 20\sqrt{2} \quad \Rightarrow \quad n = \frac{1}{20\sqrt{2}} = \frac{\sqrt{2}}{40} = 0.035$$

(c) Determine the power consumed by the computer.

(5 Marks)

Solution: It is a DC voltage at the output of the rectifier circuit. Thus

$$P_{4\Omega} = \frac{\left(V_{4\Omega}\right)^2}{4} = \frac{5^2}{4} = 6.25 \text{ W}$$

(d) Determine the power consumed by the practical transformer.

(5 Marks)

Solution: Power consumed by the resistance inside the practical transformer is

$$P_{160\Omega} = \frac{\left|V_{160\Omega}\right|^2}{160} = \frac{\left|110\angle 30° - 100\angle 30°\right|^2}{160} = \frac{10^2}{160} = \frac{5}{8} = 0.625 \text{ W}$$

(e) Determine the power supplied by the source.

(5 Marks)

Solution: Power consumed by the source is given by

$$P_{\text{source}} = P_{160\Omega} + P_{4\Omega} = 6.875 \text{ W}$$

Q.4 A tank of fluid employed in a chemical process is being monitored with three sensors. The sensors measure temperature (**T**), pressure (**P**), and fluid level (**L**). If all the sensor measurements are in the normal range, the sensor outputs are low. If the measurements are outside the normal range, the sensor outputs are high. Design a logic circuit that will produce a high signal for an alarm (A) under the following conditions:

- Pressure (**P**) and temperature (**T**) are too high;
- Fluid level (**L**) is too high and either pressure (**P**) or temperature (**T**) or both are too high.

(a) Construct a truth table with inputs **L**, **P** and **T**, and output **A**.

(8 Marks)

Solution: The truth table

	L	P	T	A
0	0	0	0	0
1	0	0	1	0
2	0	1	0	0
3	0	1	1	1
4	1	0	0	0
5	1	0	1	1
6	1	1	0	1
7	1	1	1	1

(b) Obtain the logical expression for **A** in the SOP form.

(5 Marks)

Solution: The truth table

$$A = \overline{L} \cdot P \cdot T + L \cdot \overline{P} \cdot T + L \cdot P \cdot \overline{T} + L \cdot P \cdot T$$

(c) Simplify the logical expression obtained in Part (b) using the K map technique.

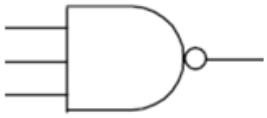
(5 Marks)

Solution: The K map

	$L\,P$	$L\,\overline{P}$	$\overline{L}\,\overline{P}$	$\overline{L}\,P$
T	1	1	0	1
$\overline{T}$	1	0	0	0

$$A = P \cdot T + L \cdot P + L \cdot T$$

(d) Draw a logic circuit realization for the logical expression obtained in Part (c) using no more than 4 three-input NAND gates, i.e., the following logic gate



(7 Marks)

Solution: Logic circuit realization

$$A = \overline{\overline{P \cdot T + L \cdot P + L \cdot T}} = \overline{\left(\overline{P \cdot T}\right) \cdot \left(\overline{L \cdot P}\right) \cdot \left(\overline{L \cdot T}\right)} = \overline{\left(\overline{P \cdot P \cdot T}\right) \cdot \left(\overline{L \cdot L \cdot P}\right) \cdot \left(\overline{L \cdot T \cdot T}\right)}$$