Problem 9(a)

In a Flyback converter operating in steady state, $V_m = 48V$, duty-ratio $D = 0.385$, $N_1/N_2 = 6$, the magnetizing inductance $L_m = 150\mu H$, and the switching-frequency $f_s = 200 kHz$. Neglect the leakage inductances and assume this converter to be lossless. Assume the output voltage to be ripple-free.

(a) This converter is operating at the output power $P_o$, at which the flux in the core is at the border of incomplete-demagnetization and the complete-demagnetization modes (similar to the border of continuous and the discontinuous current-conduction modes in non-isolated dc-dc converters).

1. Calculate the output voltage $V_o$.
2. Calculate and draw the waveforms of the input current, and the current supplied to the output stage consisting of the parallel combination of the output capacitor and the load-resistance.
3. Calculate the output power $P_o$.

(b) If this converter is operating at double the power calculated in part (a), calculate the following:

1. The output voltage $V_o$.
2. Calculate and draw the waveforms of the input current, and the current supplied to the output stage consisting of the parallel combination of the output capacitor and the load-resistance.

\[ V_o = \frac{N_2}{N_1} \frac{D}{1-D} V_{in} = 5V \]

\[ I_{in}(\theta) = 0, \quad \dot{I}_{in} = \frac{48 \times 0.385 \times 5 \mu H}{150 \mu} = 0.616 A \]

\[ I_{in(0.385)} = \frac{1}{2} \dot{I}_{in(0.385)} = 0.1186 A \]

\[ P_o = 48 \times 0.1186 = 5.69 W \]
(b) $P_o = 2 \times 5.69 = 11.38 \text{W}$

$V_o = 5 \text{V}$

$I_{in, (avg)} = \frac{11.38}{48} = 0.237 \text{A}$

$I_{in} = \frac{48 \times 0.385 \times 5 \mu}{150 \mu} = 0.616 \text{A}$

$I_{out} = 6 \times I_{in} = 3.696 \text{A}$

$I_{out, (avg)} = 6 \times I_{in, (avg)} = 1.8456 \text{A}$
**Problem 9 (b)** Suppose an industrial plant is served from a three-phase 208 V (RMS line-line) transformer. The real power demand of the plant is 80 kW at a power factor of 0.5 (lag).

(i) Find the apparent power and RMS line current magnitude.

\[ P_{3\phi} = 80 \text{ kW} \]
\[ = \sqrt{3} V_{LL} I_L \cos \theta \]
\[ = S_{3\phi} \cos \theta \]
\[ \Rightarrow S_{3\phi} = \frac{80 \text{ kW}}{0.5} = 160 \text{kVA} \]
\[ I_L = \frac{80}{\sqrt{3}(208)(0.5)} = 444 \text{ A} \]

(ii) Suppose the power factor is corrected to 0.9 (lag) with capacitor banks. Find the new apparent power and RMS line current magnitude.

\[ S_{3\phi} = \frac{80 \text{ kW}}{0.9} = 88.9 \text{kVA} \]
\[ I_L = \frac{80}{\sqrt{3}(208)(0.9)} = 247 \text{ A} \]

(iii) Suppose the line losses before power factor correction were 4 kW. What are the line losses after power factor correction?

\[ \frac{P_{loss, before}}{P_{loss, after}} = \frac{I_{L, before}^2}{I_{L, after}^2} \]
\[ \Rightarrow P_{loss, after} = 4 \text{ kW} \times \frac{247^2}{444^2} = 1.24 \text{kW} \]