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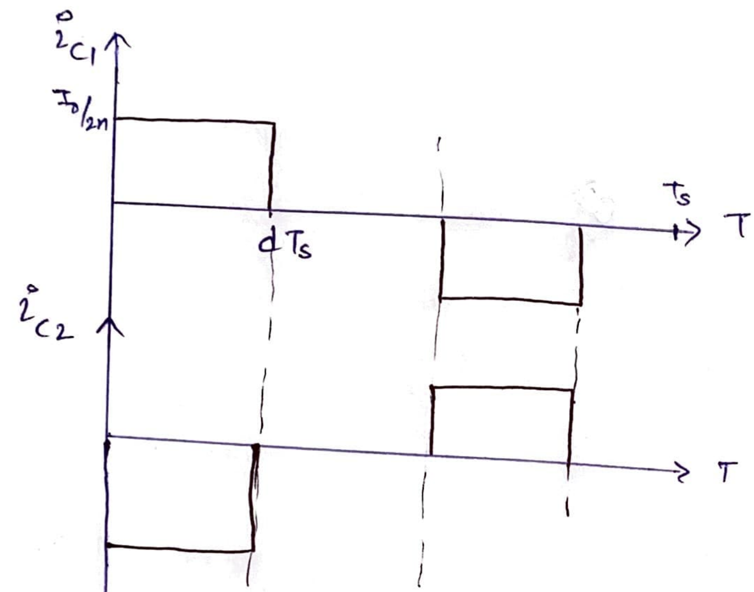
ROLL NO - M200203EE

SUBJECT - SMRC ASSIGNMENT - 2

BRANCH - POWER ELECTRONICS

Ques 1. a) To find :- I_{c1} , I_{c2}



$$I_o/2n = \frac{10}{2 \times 9} = 0.556$$

$$V_o = \frac{DV_{in}}{n}$$

$$12 = \frac{D \times 300}{9}$$

$$D = 0.36$$

$$\therefore \; i_{c1} = \frac{\frac{I_o}{2n} \times dT_s}{T_s/2} = \frac{I_o}{\cancel{2}n} \times d\cancel{T_s} \times \frac{\cancel{2}}{\cancel{T_s}} = \frac{I_o d}{n}$$

$$i_{c1} = \frac{10 \times 0.36}{9}$$

$$\boxed{i_{c1} = -i_{c2} = 0.4\,A}$$

b) leakage inductance = 3%

Duty ratio = ?

$$L_e = 0.03 \times 2.7m = 81\mu H$$

$$\text{Voltage loss} = \frac{3}{2}\frac{L_e i_o f_s}{n^2} = \frac{3}{2} \times \frac{81\mu \times 10 \times 50k}{81} = 0.75\,V$$

$\therefore \quad V_o = \dfrac{d V_{in}}{n} - V_{ron}$

$$12 = \frac{d \times 300}{9} - 0.75$$

$$\boxed{D = 0.3825}$$

Ques 3. EE '65/32/13

Core Area = 266 mm^2

Window area = 537 mm^2

Mean turn length = 150 mm

Mag. path length = 146.3 mm

$\mu_r = 2200$

$A_L = 4833\ nH/T^2$

Soln:-

$$K_i = \left(1 + \frac{0.2}{2}\right) = 1.1$$

$$A_p = \frac{1}{2} L I^2 \left(\frac{2 K_i}{K_s J B_{max}}\right)$$

$$L = \frac{A_p K_s J B_{max}}{I^2 \times K_i}$$

$$J = 4 \times 10^6\ A/m^2$$

$$L = \frac{1.428 \times 10^{-7} \times 0.36 \times 4 \times 10^{-6} \times 10^6}{130}$$

$$\boxed{L = 41.54\ \mu H}$$

$$N = \frac{K_s J A_w}{I} = \frac{0.36 \times 4 \times 537 \times 10^{-6} \times 10^6}{30}$$

$$N = 25.776 \approx 26$$

$$L = \frac{\mu_0 \mu_r N^2 A}{l_e + 2g\mu_r}$$

$$\mu_r = 2200$$

$$l_e = 146.3\ mm = 0.1463\ m$$

$$\mu_0 = 4\pi \times 10^{-7}$$

$$41.54 \times 10^{-6} = \frac{4\pi \times 10^{-7} \times 2200 \times 26^2 \times 266 \times 10^{-6}}{0.1463 + 2g \times 2200}$$

$\boxed{g = 2.68\ mm}$ → Required Air gap.

Ques 6. I/P = 250 – 400 V

O/P : 12 V

I_o = 5A – 20A

O/P Ripple < 2% p-p

ΔI_L < 4A p-p

Im peon < 20% of I_o

f_s = 50 kHz

$\boxed{d_{max} = 0.45}$

$$V_o = \frac{d\,V_{in}}{n}$$

$$n = \frac{d_{max}\,V_{in\,min}}{V_o} = \frac{0.45 \times 250}{12}$$

$n = 9.375$

$\boxed{n \approx 9}$

$$\therefore d_{min} = \frac{n\,V_o}{V_{in(max)}} = \frac{9 \times 12}{400}$$

$\boxed{d_{min} = 0.27}$

∴ d vary from 0.27 to 0.45

$$\Delta I_L = \frac{V_o(0.5 - d)T_s}{L}$$

Using d_{min} ⇒ $L = \dfrac{V_o(0.5 - d)T_s}{\Delta I_L}$

$$= \frac{12(0.5 - 0.27)}{4 \times 50 \times 10^3}$$

$\boxed{L = 13.8\,\mu H}$

Now, ESR × 4 = 0.24

ESR = 0.24/4

$\boxed{ESR = 0.06\,\Omega}$

Assuming 50μs Electrolytic Capacitor.

$$C = \frac{50\mu s}{R}$$

$$C = \frac{50 \times 10^{-6}}{0.06}$$

$$\boxed{C = 833.33\,\mu F}$$

$$\boxed{C \approx 1000\,\mu F}$$

Now, $\Delta I_L = \dfrac{V_o\,(0.5 - d_{max})}{f_s \cdot L}$

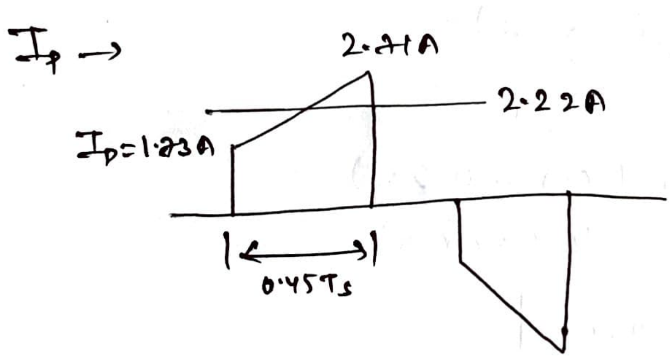
$$\Delta I_L = \frac{12 \times (0.5 - 0.45)}{50 \times 10^{3} \times 13.8 \times 10^{-6}}$$

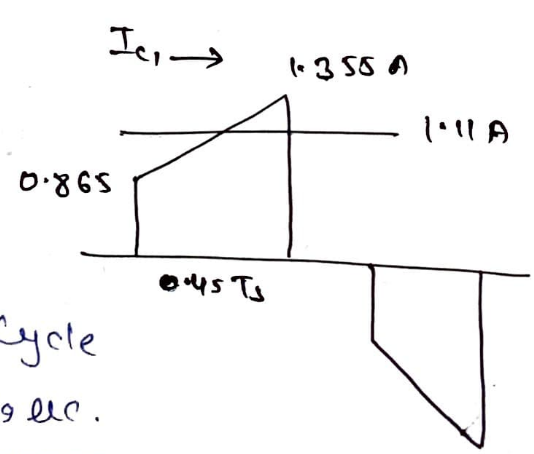
$$\boxed{\Delta I_L = 0.869\ A}$$

$\therefore$ Secondary Current varies between 19.56 A to 20.43 A.

Reflected secondary Current varies from 2.1739A to 2.2705 A with average Current of 2.22 A.

$\therefore$ Primary Current varies between $(2.17 - 0.44)A$ to $(2.27 + 0.44)A$





I_{c1} is half of this.

$\therefore$ Charge Contained in the half Cycle

$$= \frac{1.11 \times 0.45}{50 \times 10^{3}} = 9.99\,\mu C.$$

Permitted p-p ripple in volt. splitting Capacitor and DC Blocking Capacitor $= 5\%$.

$\therefore \frac{250}{2} \times 0.05 \times C = 9.99 \mu C$

$\boxed{C_1 = C_2 = 888 nF}$

Splitting Cap $= C_1 = C_2 \approx 1 \mu F$

Charge Contained in one half cycle of $I_p = \frac{0.45 \times 2.22}{50 \times 10^3}$

$C_b = 1.776 \mu F$

$\boxed{C_b \approx 2.2 \mu F} \rightarrow$ Blocking Cap.

- Switch peak Current $= 2.71$ A ≈ 3 A
- Switch avg Current $= 2.22$ A
- Switch rms Current $= 2.2 \sqrt{0.45} = 1.475$ A
- primary rms Current $= 2.2 \sqrt{0.9} = 2.087$ A

- $(I_{secondary})_{rms} = 13.784$ A

$\therefore$ The o/p diode peak Current $= 22$ A $(22 A > 20 A)$

- o/p diode avg Current $= 20 \times 0.45 + 2 \times 0.05 \times 10$
$= 10$ A

- o/p diode rms Current $= 13.8$ A
- o/p inductor rms Current $= 20$ A
- o/p Capacitor rms Current $= 2/\sqrt{3}$ A
- L_m of primary $= \frac{d V_{in} T_s}{a} = \frac{n V_o T_s}{a}$

$$V_o = \frac{d V_{in}}{n}$$

$$L_p = \frac{9 \times 12}{0.88 \times 50 \times 10^3}$$

$$\boxed{(L_m)_p = 2.45 \text{ mH}}$$

Area product calculation in Half Bridge Converter

Primary rms Current $= \frac{I_o}{n} \sqrt{2 d_{max}}$

Secondary rms Current $= \frac{I_o}{2} \sqrt{2 d_{max} + 1}$

$$K_s A_w = n_p \times \frac{I_o}{n} \frac{\sqrt{2 d_{max}}}{J} + \frac{I_o \sqrt{2 d_{max} + 1}}{2J} \times 2 n_s$$

$$\frac{n_p}{n_s} = n = 9$$

$$K_s A_w = 2.33 \frac{n_s I_o}{J}$$

$$A_c = \frac{n_s V_o T_s}{2 B_m}$$

$$A_p = A_c A_w = \frac{2.33 V_o I_o T_s}{2 B_m J K_s}$$

$$A_p = 2.6628 \times 10^{-8} \text{ m}^4$$

$$\boxed{A_p = 26628 \text{ mm}^4}$$

Hence, E 42/21/15 has $A_c A_w = 45575 \text{ mm}^4$

$$\therefore n_s = \frac{1}{\frac{2 f_s B_m A_c}{V_o}}$$

$$\boxed{n_s = 3.29 \approx 4}$$

$n_s = n n_s = 9 \times 4 = 36$ turns

RMS value of $I_L \approx 20A$

Copper area of a turn $= 10/3 = 3.33\ mm^2$

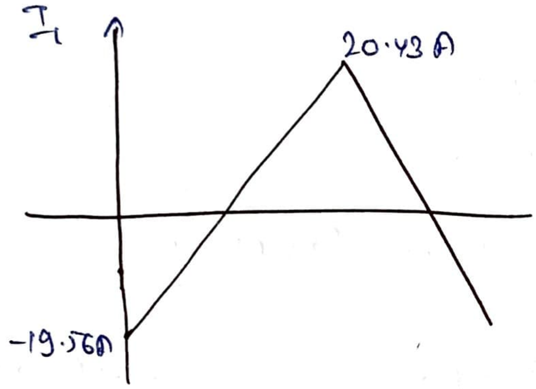
SWG = 13

Cu Area = $4.289\ mm^2$

Cu dia = 2.337 mm

Overall dia = 2.441 mm

$$N = \frac{L I_{max}}{A_c B_{max}} = \frac{13.8 \times 10^{-6} \times 20.43}{A_c \times B_{max}}$$



L chosen = $13.8\ \mu H$

Design $B_{max} = 0.2\ Wb/m^2$

$J = 3\ A/mm^2$

$$K_i = \frac{20.43}{20} = 1.0215$$

$K_s = 0.35$

$$A_p = \frac{1}{2} L I^2 \frac{2 K_i}{K_s J B_{max}}$$

$$= \frac{\frac{1}{2} \times 13.8 \times 10^{-6} \times (20)^2 \times 2 \times 1.0215}{0.35 \times \frac{3}{10^{-6}} \times 0.2}$$

$$\boxed{A_p = 26850.85\ mm^4}$$

We will use the core
EE 42/21/15

$A_w = 256\ mm^2$
$A_c = 178\ mm^2$
$A_p = 45568\ mm^2$

Mean turn length $= 4\left[29.5 + \frac{29.5 - 12.5}{2}\right]$

$= 76\ mm$

$\boxed{N \approx 8}$

N = 8 is taken

Window Height $= 2 \times 14.8$
$= 29.6\ mm$

1mm thick Bobbin + 2mm Creepage.

Winding Height $= 29.6 - 3 \times 2 = 23.6\ mm$
Wire diameter $= 2.441\ mm$

$\left(\frac{23.6}{2.441}\right) = 9.668 \approx 9$ turns in 1 layer.

So here one turn extra i.e, $(9-8) = 1$ turn.

$h = 0.866d$
$h = 0.866 \times 2.337$
$\boxed{h = 2.023\ m}$

$\frac{Nd}{h} = \frac{8 \times 2.337}{23.6} = 0.79$

A = Skin depth at 50KHz $= 0.141\ mm$
$F_R = \frac{2\sqrt{F_L}}{A} = \frac{2.023\ \sqrt{0.79}}{0.141}$

$\boxed{f_R = 12.25}$

X - Co-ordinate at Do-well's Curve $f_R = 12.25$

$R_{ac} = R_R \cdot R_{dc}$

$R_{dc} = \frac{76\,mm \times 23.6}{1000} \times 0.004 \frac{\Omega}{M} \times 1.2$

$4\Omega/mm$ for SWG 13 wire & 1.25 f for temp.

$\boxed{R_{dc} = 8.609\,m\Omega \text{ at } 70^\circ c}$

$R_{ac} = 12.25 \times 8.609$

$\boxed{R_{ac} = 109.76\,m\Omega}$

Cu loss $= (20)^2 \times 8.609 \times 10^{-3} + \left(\frac{0.43}{\sqrt{3}}\right)^2 \times 0.10976$

$\boxed{\text{Cu loss} = 3.45 \text{ Watt}}$

Ques 7. $V_P = 250 - 400\,V$

O/p = 12 V

I = 2.5 A

o/p Ripple < 2% peak to peak

f = 100 KHz

MOSFET Voltage Rating = 900 V

$B_m = 0.25\,wb/m^2$

$J = 3A/mm^2$ ..

$K_S = 0.35$ for T/F coil

Coil T = 1mm

Creeping D = 2mm

Soln: From the 2nd design eqn.

$1.3[V_{in\,max} + n(V_o + V_r)] \le 0.8\,V_R$

$\because V_r = 1V$

$1.3[400 + n(12+1)] \le 0.8 \times 900$

$1.3[400 + n(13)] \doteq 720$

$n = 11.83$

$\boxed{n \simeq 12 \text{ turns}}$

for d_{max},

$$d_{max}\left(1 + \frac{V_{in\,min}}{n(V_o + V_r)}\right) \le 0.8$$

$$d_{max} = \frac{0.8}{1 + \frac{V_{in\,min}}{n(V_o + V_r)}} = \frac{0.8}{1 + \frac{250}{12(12+1)}}$$

$$\boxed{d_{max} = 0.31}$$

$$\because \quad d_{max} = \frac{\sqrt{2 L_p P_{o\,max} f_s}}{V_{in\,min}}$$

$$P_{o\,max} = V_o \times I_{o\,max} = 12 \times 5 = 60 \text{ Watt}$$

$$P_{o\,min} = V_o \times I_{o\,min} = 12 \times 2 = 24 \text{ Watt}$$

$$\therefore \quad 0.31 = \frac{\sqrt{2 \times L_p \times 60 \times 100k}}{250}$$

$$\boxed{L_p = 500.5\,\mu H}$$

Now, $$I_p = \frac{V_{in\,min}\, d_{max}}{L_p f_s}$$

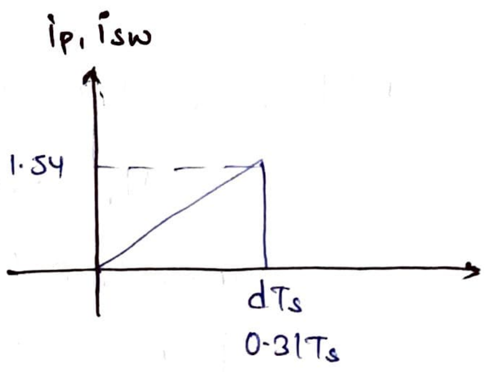
$$= \frac{250 \times 0.31}{500.5\mu \times 100k}$$

$$\boxed{I_p = 1.54A}$$

$$\boxed{I_p \approx 1.5 A}$$

$$\therefore (i_p)_{rms} = (i_{sw})_{rms} = \sqrt{\frac{1}{T_s}\int_0^{dT_s}\left(\frac{1.5}{dT_s}t\right)^2 dt}$$

$$= \sqrt{\frac{1}{\cancel{T_s}} \times \frac{(1.5)^2}{(0.31)^2 \times 3} \times (0.31)^3 \cancel{T_s^3}}$$

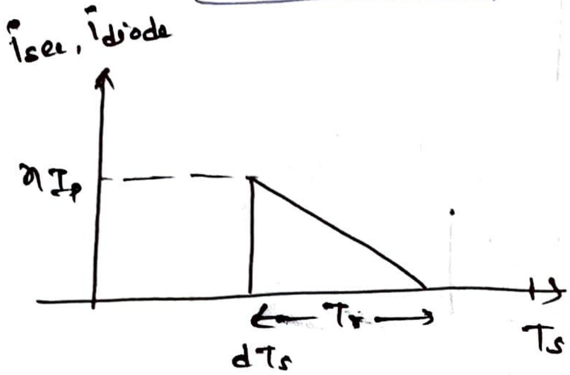


$$\boxed{(i_p)_{rms} = 0.482 \text{ Amp}}$$

Now, we need to calculate T_r for secondary diode rms current.

$$T_r = \frac{d_{max} V_{in\,min} T_s}{n(V_o + V_r)} = \frac{0.31 \times 250 \times T_s}{12 \times 13} = 0.496 T_s$$

$$\boxed{T_r = 0.496\, T_s}$$



$$(i_{diode})_{rms} = \sqrt{\frac{1}{T_s} \cdot \int_0^{0.496T_s} \left(\frac{nI_p}{T_r} t\right)^2 dt}$$

$$\frac{nI_p}{T_r} = \frac{12 \times 1.5}{0.496\, T_s} = \frac{36.29}{T_s}$$

$$\therefore (i_{diode})_{rms} = \sqrt{\frac{1}{T_s} \int_0^{0.496T_s} \left(\frac{36.29}{T_s} t\right)^2 dt}$$

$$= \sqrt{\frac{1}{\cancel{T_s^3}} \times \frac{(36.29)^2}{3} \times (0.496)^3 \cancel{T_s^3}}$$

$$= 7.31\ A.$$

$$\boxed{(i_{diode})_{rms} = 7.31\ A}$$

- Diode peak current rating $\geq nI_p$
  $\geq 12 \times 1.50$
  $\geq 18A.$

- Diode Avg current rating $\geq 5A$

- Diode rms current $\geq 7.31A.$

$\left\{ \begin{array}{l} P_{omax} = 16.2 \\ I_{max} = 5A \end{array} \right.$

- MosFET peak Current $\geq I_P \geq 1.5\,A$.
- MosFET avg Current $\geq 0.24\,A$

$$\left\{ \begin{aligned} P_{omax} &= V_{inmin} \times I_{mos} \\ 60 &= 250 \times I_o \\ I_{mos} &= 0.24\,A \end{aligned} \right.$$

- MosFET RMS Current $\geq (i_{sw})_{rms}$ or $(i_p)_{rms}$

$$\boxed{(I_{mosfet})_{rms} \geq 0.482\,A.}$$

Transformer Design

- Primary wire rms Current $= (i_{sw})_{rms}$

$$\boxed{(i_{primary})_{rms} = 0.482\,A}$$

- Primary Wire size =

$\therefore B_m = 0.25\ wb/m^2$

$J = 3\,A/mm^2$

$J = I/A \Rightarrow 3 = \dfrac{0.482}{A}$

$$\boxed{A = 0.16\ mm^2}$$

- Secondary Wire RMS Current $= (i_{diode})_{rms} = 7.31\,A$
- Secondary Wire size $= 2.436\ mm^2$

$J = 3\,A/mm^2 = I/A$

$3 = \dfrac{7.31}{A} \Rightarrow 2.436\ mm^2$

- Transformer :

$$\boxed{\begin{aligned} L_p &= 500.5\,\mu H \\ n &= 12 \end{aligned}}$$

Ques 8. flyback Converter CCM

$V_{in} = 250 - 400V$

O/P = 12V, 2A - 5A

f_s = 100 kHz

Mosfet Rating = 900 V

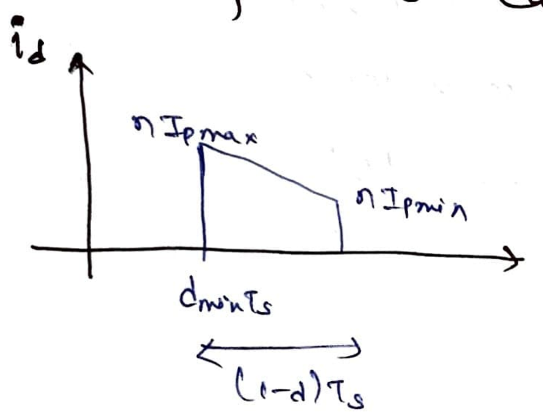
Soln:- Using $n = 12$ (already Calculated)

$$(L_p)_{min} = \left(\frac{12 \times 13 \times 400}{12 \times 13 + 400}\right)^2 \times \frac{1}{2 \times 100 \times 10^3 \times 24}$$

$$\left\{ \begin{aligned} P_{omin} &= V_o \times I_{omin} \\ &= 12 \times 2 \\ &= 24\,W. \end{aligned} \right.$$

$$= 2.33\ mH$$

Secondary RMS Calculation



Using $d = d_{min}$

$V_{in} = V_{in\,max}$

$$i_d = \left(\frac{n I_{pmax}}{1-d}\right) \cdot t + n I_{pmin}$$

for I_{pmax} and I_{pmin}

$$\frac{I_{pmax} + I_{pmin}}{2} = \frac{I_o}{n(1-d)}$$

$$I_{pmax} + I_{pmin} = \frac{2 P_{omax}}{n V_o (1 - d_{min})}$$

$$d_{min} = \frac{n(V_o + V_r)}{n(V_o + V_r) + V_{in\,max}}$$

$$= \frac{12(12+1)}{12 \times 13 + 400}$$

$$\boxed{d_{min} = 0.28}$$

$$\text{-lly} \quad d_{max} = \frac{n(V_o + V_r)}{n(V_o + V_r) + V_{in\,min}}$$

$$= \frac{12 \times 13}{12 \times 13 + 250}$$

$$\boxed{d_{max} = 0.384}$$

$$\therefore \quad I_{pmax} + I_{pmin} = \frac{2 \times 60}{12 \times 12 (1 - 0.28)}$$

$$\left\{ \begin{aligned} P_{omax} &= V_o I_{omax} \\ &= 12 \times 5 \\ &= 60 \end{aligned} \right.$$

$$I_{pmax} + I_{pmin} = 1.157 \quad \text{--- (1)}$$

$$I_{pmax} - I_{pmin} = \frac{n(V_o + V_r)(1 - d_{min})}{L_p f_s}$$

$$= \frac{12(13)(1 - 0.28)}{2.33\,m \times 100K}$$

$$I_{pmax} - I_{pmin} = 0.482 \quad \text{--- (2)}$$

from (1) and (2)

$$\boxed{I_{pmax} = 0.8195\ A}$$

$$\boxed{I_{pmin} = 0.3375\ A}$$

$$I_{secondary} \approx \left(\frac{n I_{pmax} + n I_{pmin}}{2} \right) \sqrt{1 - d_{min}}$$

$$\approx \left(\frac{12 \times 0.8195 + 12 \times 0.3375}{2} \right) \sqrt{1 - 0.28}$$

$$\boxed{(I_{sec})_{rms} \approx 5.89\ A}$$

$$I_{avg} = I_o = \frac{P_o}{V_o} = \frac{60}{12} = 5A$$

$$\boxed{I_{avg} = 5\ A}$$

$(I_d)_{peak} = n\, I_{p\,max} = 12 \times 0.8195$
$= 9.834\,A$

$(I_d)_{avg} = \left(\dfrac{n\, I_{p\,max} + n\, I_{p\,min}}{2}\right)(1 - d_{min})$

$= \left(\dfrac{12 \times 0.8195 + 12 \times 0.3375}{2}\right)(1 - 0.28)$

$= 4.992$

$\boxed{I_{d\,avg} \simeq 5\,A}$

Now, primary conducts most under $V_{i\,min}$ Cond^n,
$\therefore$ Using $d = d_{max} = 0.384$

$I_{p\,max} + I_{p\,min} = \dfrac{2 I_{o\,max}}{n(1 - d_{max})}$

$= \dfrac{2 \times 5}{12(1 - 0.384)} = 1.3528$ — (I)

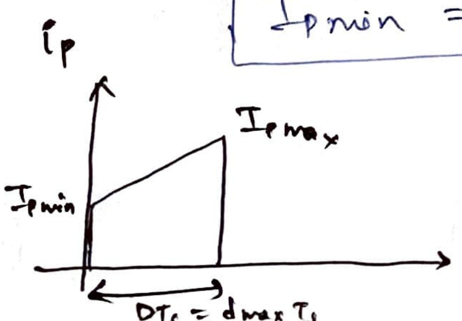
$I_{p\,max} - I_{p\,min} = \dfrac{n(V_o + V_r)(1 - d_{max})}{L_p f_s}$

$= \dfrac{12 \times 13\,(1 - 0.384)}{2.33m \times 100k}$

$= 0.412$ — (II)

from (I) and (II)

$\boxed{\begin{aligned} I_{p\,max} &= 0.8824 \\ I_{p\,min} &= 0.4704 \end{aligned}}$



$(i_{primary})_{rms} = \left(\dfrac{I_{p\,max} + I_{p\,min}}{2}\right)\sqrt{d_{max}}$

$$(i_{primary})_{rms} = \left(\frac{0.8824 + 0.4704}{2}\right)\sqrt{0.384}$$

$$\boxed{(i_{primary})_{rms} = 0.692\,A}$$

$$\boxed{i_{peak} = I_{pmax} = 0.8824\,A}$$

$$i_{avg} = \left(\frac{I_{pmax} + I_{pmin}}{2}\right) \times d$$

= ~~[illegible]~~

$$= \left(\frac{0.8824 + 0.4704}{2}\right) \times 0.384$$

$$\boxed{i_{avg} = 0.259\,A}$$

MOSFET : Peak = 0.8824A , Avg = 0.259A , RMS = 0.692A

Diode : Peak = 9.834A , Avg = 5A , RMS = 5.89A

To find Area product

$$I_{pmax} = 0.8824\,A$$

$$L_p I_{pmax} = A_c n_p B_m$$

$$2.33 \times 0.8824 = A_c n_p B_m$$

Using $B_m = 0.25\ Wb/m^2$

$$A_c = \frac{2.33m \times 0.8824}{n_p \times 0.25 \times 10^{-6}} = \frac{8223}{n_p} \approx \frac{8223.9}{n_p}$$

$$A_w = n_p \times A_p + n_s \times A_s$$

$$= \frac{n_p}{K_s}\left[A_p + \frac{n_s}{n_p} A_s\right]$$

$$A_w = \frac{n_p}{K_s}\left[0.141 + \frac{2}{12}\right] mm^2 \qquad \{K_s = 0.35$$

$$A_c A_w = \frac{8223}{\cancel{n_p}} \times \frac{\cancel{n_p}}{K_s}\left[0.141 + \frac{2}{12}\right] mm^2$$

$$= \frac{8223}{0.35}\left[0.141 + \frac{2}{12}\right]$$

$$A_c A_w = 7228.4 \ mm^2$$

E/32/66/4

$$A_c = 97 \ mm^2$$

$$A_w = 14784 \ mm^2$$

$$A_p = 14340 \ mm^4$$

With given A_c

$$n_p = \frac{8223}{97} = 84.77$$

$$n_s = \frac{84.77}{12} = 7.06$$

$$\therefore \boxed{n_p = 96} \qquad \boxed{n_s = 8}$$

$$\because n = \frac{n_p}{n_s}$$

$$12 = \frac{n_p}{8}$$

$$\boxed{n_p = 96}$$

Primary : 96 turns of SWG 26

Secondary : 8 turns of SWG 16

Ques 9. Boost Converter

$V_i = 10.8$ to $13.6V$

$V_o = 24V$

$L = 25\mu H$

$C = 680\mu F$

$\tau = 40\mu s$

$f = 50kHz$

$I_o = 1-4A$

Sensing gain = 0.125 V/A

Soln :- Boost Converter

for Duty Cycle,

$$V_o = \frac{V_{in}}{1-D}$$

$$24 = \frac{10.8}{1-D} \qquad \text{llly} \qquad 24 = \frac{13.6}{1-D}$$

$$1-D = 0.45 \qquad\qquad 1-D = 0.566$$

$$\boxed{D = 0.55} \qquad\qquad \boxed{D = 0.433}$$

$$\therefore \boxed{D_{max} = 0.55}$$

Now, $P_{OP} = P_{IP}$

$$V_{in} I_{in} = V_o \cdot I_o$$

$$\cancel{V_{in}} I_{in} = \frac{\cancel{V_{in}}}{1-D} I_o$$

$$I_{in} = \frac{I_o}{1-D}$$

$$I_{in} = \frac{1}{1-0.55} = 2.22A \quad \{ \text{ for } I_o = 1A$$

$$I_{in} = \frac{4}{1-0.55} = 8.88A \quad \{ \text{ for } I_o = 4A.$$

Sensing gain = 0.125 V/A

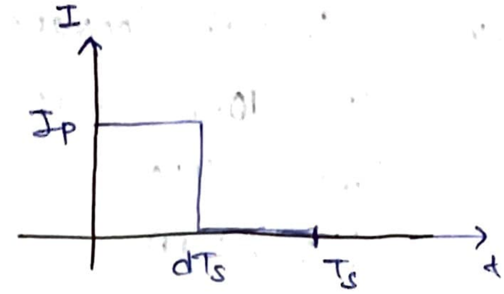
for $I = 1A$, $V = 0.125V$

$I = 8.88A \Rightarrow V = 8.88 \times 0.125 = 1.11A.$

let $n = 1$

$I = 8.88A$, $V = 1.11V$, $V_{fino} = 0.6$

$D_{max} = 0.55$ $f_s = 50 kHz$



$$nL_m \geq \frac{100\, D_{max} (V + V_{five})}{n f_s I}$$

$$= \frac{100 \times 0.55 (1.11 + 0.6)}{1 \times 50 \times 10^3 \times 8.88}$$

$nL_m = 211.82\ \mu H \cdot T$

	n	$(I_s)_{max}$	B_m (wb/m^2)
T_{10}	276	0.023	0.011
T_{12}	129	0.036	0.0087
T_{16}	142	0.046	0.0066
T_{20}	187	0.035	0.00457
T_{27}	114	0.037	
T_{32}	87	0.075	
T_{45}	89	0.074	

$$B_m = \frac{D_{max} (V + V_{five})}{n f_s A_c} = \frac{0.55 (1.11 + 0.6)}{50 \times 10^{-3}\, n A_c}$$

$$= \frac{1.851 \times 10^{-3}}{n A_c}$$

let $J = 2.5\ A/mm^2$

$J = I/A$

$$A = I/J = \frac{0.074}{2.5} = 0.03\ mm^2$$

So we choose T45 / 89T / SWG 32

$$V_b = \frac{D_{max}}{1 - D_{max}} (V + V_{Fino}) - V_{F(al)}$$

$$V_b = \frac{0.55}{1-0.55}(1.11+0.6) - 0.59$$

$= 1.5\,V$

Power rating of gener $= \frac{L_m I_m^2 f_s}{2}$ $\left\{ \begin{array}{l} I_m = 10\% \text{ of } I \\ = 0.1 \times 8.88 \end{array} \right.$

$$= \frac{2.37 \times 10^{-6} \times (0.1 \times 8.88)^2 \times 50k}{2}$$

$= 468.2\,mW$

for this power rating we need $n = 88$, $I = 1.67\,A$, $V = 0.835\,V$

Now, $R_s = \frac{nV}{I} = \frac{88 \times 0.835}{1.67}$

$= 44\,\Omega.$

$\boxed{R_s = 44\,\Omega}$

RMS of current through R_s $= 0.0188\sqrt{0.2}$
$= 8.45 \times 10^{-3}$

$\therefore$ Power in R_s $= (8.45 \times 10^{-3})^2 \times 44$
$= 3.14\,mW$

So $47\,\Omega \,/\, 1/4\,W$ resistance. $\rightarrow$ Design.

Ques 10. $I = 1.11A$ $V = 0.139\,V$

$0.125\,V \rightarrow 1A$

$1.11\,A \rightarrow 1.11 \times 0.125 = 0.139\,V$

$n L_m \geq \frac{3.2V}{I f_s} = \frac{3.2 \times 0.139}{50 \times 10^3 \times 1.11}$ | 1% of 1.11 $= 0.011A.$

$I_m = \frac{dV}{2 n L_m f_s} = \frac{0.36 \times 0.139}{2 \times 8.01 \times 10^{-6} \times 50 \times 10^3} = 0.0624$

$I_m = 0.0624 > 1\%$ of 1.11 ie, 0.011

So, $0.011 = \dfrac{0.36 \times 1}{2 \times 50 \times 10^{+3} \, n L_m}$

$n L_m = \dfrac{0.36 \times}{0.011 \times 2 \times 50K}$

$n L_m = 327.27 \, \mu H \cdot T$

n	I_s	B_m
T_{10}	427	1.39×10^{-4}
T_{12}	217	1.5×10^{-4}
T_{16}	220	'
T_{20}	209	/
T_{22}	176	
T_{32}	134	/
T_{45}	138	/

$B_m = \dfrac{dv}{2 n f_s A}$

$J = 2.5 \; A/mm^2 = I/A$

$A = I/J = \dfrac{4.22}{2.5} = 2 \, mm^2$

So, choose T_{45} toroid core

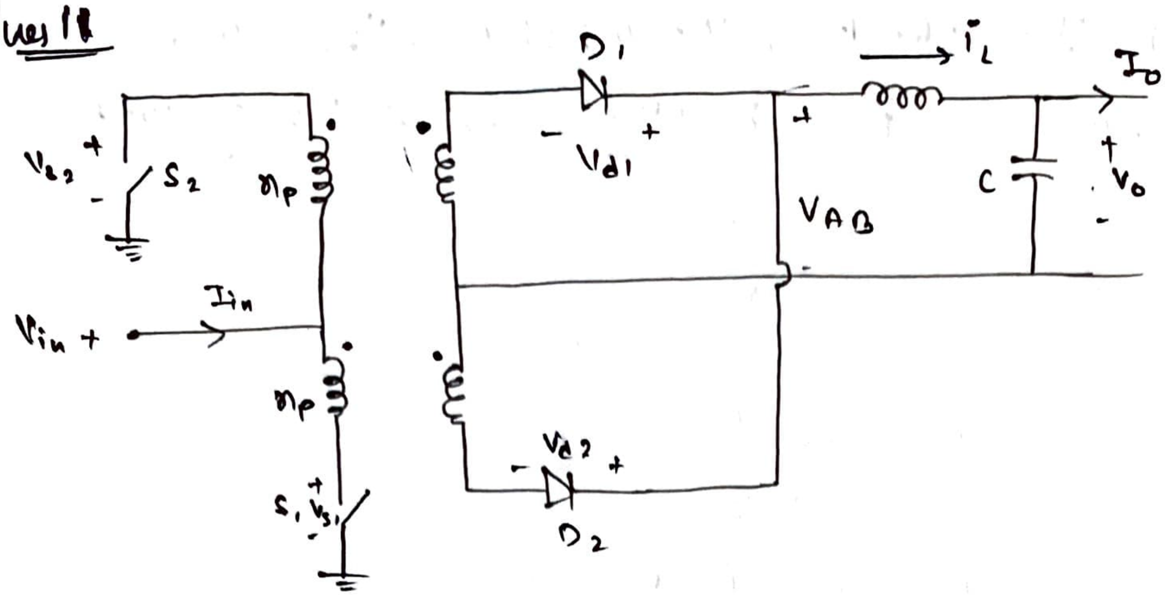
SWG 15

138 turns of SWG 15

($2.627 \, mm^2$, 1.92 mm dia)

$R_s = \dfrac{0.139 \times 138}{1.11} = 17.21 \, \Omega / 1 \, w.$

Ques 18



$V_{in} = 180 - 240V$

$V_o = 12V$

$n = 6$

$L_m = 0.5mH$ $f_s = 40$ KHz

$L = 68\mu F$, $C = 40\mu s$ family at the o/p

$I = 4-10A$

Sensing gain = 0.5 V/A

Now, $V_o = \frac{2 V_{in} d}{n}$

$d_1 = \frac{n V_o}{2 \cdot V_{in}} = \frac{6 \times 12}{2 \times 240}$ { Using $V_{in\,max} = 240$

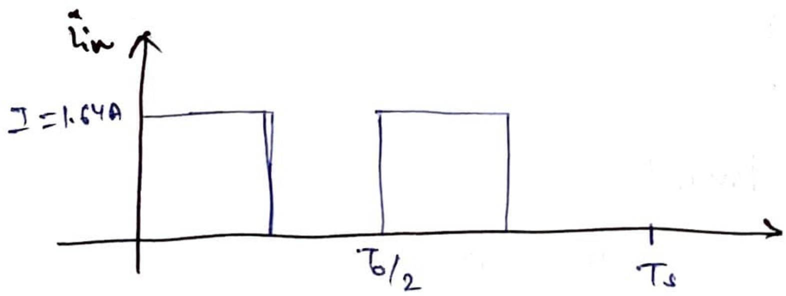
$\boxed{d_1 = 0.15}$

$d_2 = \frac{6 \times 12}{2 \times 180}$ { Using $V_{in\,min} = 180V$

~~= 0.066~~

$\boxed{d_2 = 0.2}$

$\therefore \boxed{d_{max} = 0.2}$



Considering. $I = 1.67\,A$, $V = 0.835\,V$, $V_{Fw} = 0.6$

$D_{max} = 0.2$, $f_s = 80\,kHz$, $I_m < 1\%$ of $1.67\,A$

for $1A \rightarrow 0.8\,V$

$1.67A \rightarrow 0.835\,V$

$$n L_m \geq \frac{100\, d_{max} (V + V_{Fw})}{n f_s I}$$

$$\geq \frac{100 \times 0.2 (0.835 + 0.6)}{1 \times 80 \times 10^3 \times 1.67}$$

$$= 0.214\, mHT$$

	n	$(I_s)_{mm}$	$B_m\ (wb/m^2)$
T10	280	2.66×10^{-3}	2.066×10^{-3}
T12	182	4.1×10^{-3}	1.642×10^{-3}
T10	145	5.15×10^{-3}	1.237×10^{-3}
T20	190	3.93×10^{-3}	3.38×10^{-4}
T27	116	6.43×10^{-3}	
T32	88	8.48×10^{-3}	
T45	90	8.29×10^{-3}	

$$B_m = \frac{D_{max}(V + V_{Fw})}{n f_s \cdot A} = \frac{0.2\,(0.835 + 0.6)}{n A_c \times 80 \times 10^3 \times 10^{-6}}$$

$$= \frac{3.58}{n A_c}$$

$J = 2.5\, A/mm^2$

T32, $n = 88$, $I_s = 8.48 \times 10^{-3}$

$J = I/A$

$A = I/J = \frac{8.48\times10^{-3}}{2.5}$

$= 0.0039\ mm^2$

SWG 45

T42 / 887 / SWG 45

$V_z = \frac{d_{max}}{1-d_{max}}(V + V_{fw})$

$= \frac{0.2}{1-0.2}(0.835 + 0.6)$

$= 0.458$

Power rating of zener $= \frac{L_{m}\, I_m^2\, f_s}{2}$

$= \frac{2.44\times10^{-6}\times(0.01\times1.67)^2\times 80k}{2}$

$= 27.2\ \mu W$