6.6 A forward PWM converter is supplied by a European single-phase rectified utility line voltage, $V_O = 12$ V, and $n_1 = n_3 = 8$. Find the minimum, nominal, and maximum duty cycle.

$V_O = 12V \quad n_1 = n_3 = 8$

$V_{Imin} = (220 - 0.1 \times 220) \times \sqrt{2} = 280V$

$V_{Inom} = \sqrt{2} \times 220 = 311V$

$V_{Imax} = \sqrt{2} \times (220V + 0.1 \times 220V) = \sqrt{2} \times (220 + 22)$

$= 342V$

$M_{VDCnom} = \frac{V_O}{V_{Imax}} = \frac{12}{342} = \frac{1}{28.5}$

$M_{VDCmin} = \frac{V_O}{V_{Imax}} = \frac{12}{280} = \frac{1}{23.3}$

min: $D_{min} = n_1 M_{VDCmin} = 8 \times 0.03509 / 0.9 = 0.3119$

nominal: $D = 8 \times 0.03858 / 0.9 = 0.3428$

max: $D = 8 \times 0.04286 / 0.9 = 0.381$

6.11 A forward PWM converter has $V_O = 12$ V, $I_O = 4$–40 A, $n_1 = n_3 = 8$, $L = 20$ µH, $V_{Imax} = 342$ V, $D_{min} = 0.3119$, and $f_s = 75$ kHz. Find the magnetizing inductance such that its peak current is less than 12% of the maximum peak current of the primary of the ideal transformer.

$f_s = 75 KHz$

$V_{Imax} = 342V$

$I_{mx} = I_D M_{max} / n_1 = 42.753 / 8 = 5.344\,A$

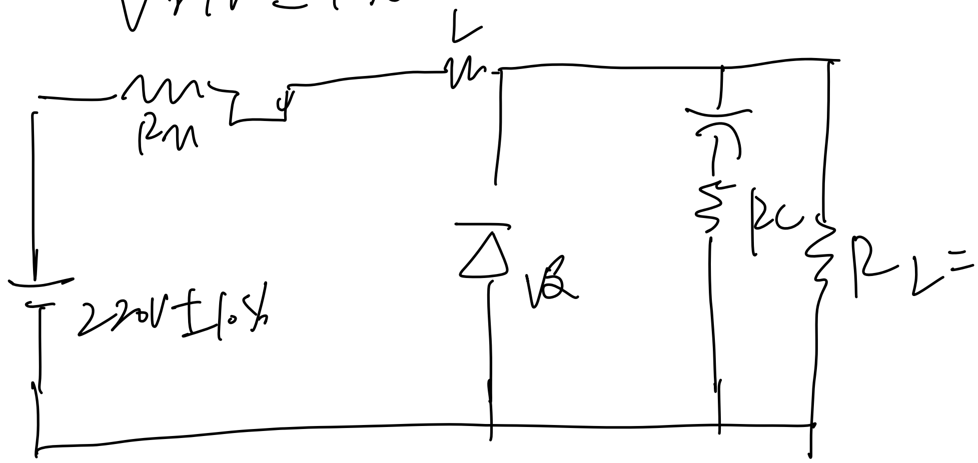
$\Delta i_{Lm} = 0.12 I_{1mx} = 0.12 \times 5.344 = 0.641\,A$

$L_{m(min)} = D_{min} V_{Imax} / f_s \Delta i_{Lm(max)} = 2.219\,mH$

we pick $L_m = 2.3\,mH$

6.14 Design a PWM forward converter that will meet the following specifications: the CCM, V_I is the European single-phase rectified line voltage with $V_{rms} = 220$ V$\pm$10%, $V_O = 14$ V, $I_{Omin} = 2$ A, $I_{Omax} = 20$ A, and $V_r/V_O \leq 1\%$. Assume $r_{DS} = 1\ \Omega$, $V_F = 0.56$ V, $R_F = 25$ mΩ, $r_{L(dc)} = 20$ mΩ, $r_{T1} = 100$ mΩ, $r_{T2} = 25$ mΩ, $C_o = 100$ pF, $L_m = 5$ mH, and $f_s = 100$ kHz. Find component values, component stresses, and converter efficiency.

$V_r / V_O \leq 1\%$



$I_{mx} = 20\,A$

$I_{min} = 2\,A$

ratio $D = \frac{V_O}{V_m} = \frac{14}{242} = 0.0579$

$D_2 = \frac{V_O}{V_{max}} = \frac{14}{198} = 0.0707$

$$\Delta I_L = \frac{V_s t_D}{L} \times DT =$$

(i) $0.2 < d < 0.7$

2) Energy delivered $= 27\ \mu H$.

3) efficiency $= 87.8\%$

7.6 A half-bridge converter has $V_{Imin} = 280$ V, $V_{Imax} = 342$ V, $V_O = 12$ V, $I_O = 1$–20 A, $L = 25$ μH, $n = 9$, $\Delta i_{Lmax} = 1.513$, and $f_s = 50$ kHz. Determine the minimum magnetizing inductance at which its peak-to-peak current is less than 10% of the maximum peak current of the ideal transformer primary.

$$\bar{I}_1 = I_{omax}/n = 20/9 = 2.2222\ A$$

$$\Delta i = \frac{\Delta i_{Lm}}{n} = 1.513/(2\times 9) = 0.084\ A$$

$$I_{max} = 0.084 + 2.2222 = 2.3066\ A$$

$$\Delta i_{Lmax} = 0.1 \times I_{max} = 0.1 \times 2.306 = 0.2306\ A$$

$$L_m(min) = \frac{D_{min} V_{Imax}}{2 f_s \Delta i_{Lmax}} = \frac{0.3434 \times 342}{2\times 50\times 10^3 \times 0.2306} = 5.08\ mH$$

We pick $L_m = 5.1\ mH$

7.8 Design a half-bridge converter operating in CCM to meet the following specifications: V_I is the single-phase rectified European line voltage with V_{rms} is 220 V ± 10%, $V_O = 5$ V, $I_{Omin} = 2$ A, $I_{Omax} = 20$ A, and $V_r/V_O \le 1\%$. Assume $r_{DS} = 1\ \Omega$, $r_{T1} = 150\ \text{m}\Omega$, $r_{T2} = r_{T3} = 40\ \text{m}\Omega$, $r_L = 9\ \text{m}\Omega$, $r_C = 35\ \text{m}\Omega$, $r_{Cb} = 350\ \text{m}\Omega$, $R_F = 10\ \text{m}\Omega$, $V_F = 0.3$ V, and $C_o = 80$ pF. Assume initially the converter efficiency $\eta = 85\%$.

$$P_{Omax} = V_O \cdot I_{Omax} = 20 \times 5 = 100\ W$$

$$P_{Omin} = V_O I_{Omin} = 2 \times 5 = 10\ W$$

$$R_{Lmin} = \frac{V_O}{I_{Omax}} = \frac{5V}{20A} = 0.25\ \Omega$$

$$R_{Lmax} = \frac{V_O}{I_{Omin}} = \frac{5V}{2A} = 2.5\ \Omega$$

$$M_{VDCmax} = \frac{V_O}{V_{Imin}} = \frac{5}{198} = 0.0253$$

$$M_{VDCmin} = \frac{V_O}{V_{Imax}} = \frac{5}{242} = 0.0207$$

$$M_{VDCnom} = \frac{V_O}{V_{Inom}} = \frac{5}{220} = 0.0227 \qquad D_{max} = 0.4$$

$$n = \frac{\eta D_{max}}{M_{VDCmax}} = \frac{85\% \times 0.4}{0.0253} = 13.44$$

$$D_{min} = \frac{n M_{VDCmin}}{\eta} = 0.3273$$

$D_{max} = 0.4$

$D_{nom} = 0.3589$

$$\Delta i_{Lmin} = \frac{R_{Lmax}\left(\frac{1}{2} - D_{min}\right)}{2f_s} = \frac{5V\left(\frac{1}{2} - 0.3273\right)}{2\times10^{5}\times10^{-6}}$$

$$= 0.43175\,A$$

$$L_{min} = \frac{R_{Lmax}\left(\frac{1}{2} - D_{min}\right)}{2f_s} = 2.16\,\mu H$$

$$V_r = \frac{V_o}{100} = 50\,mV$$

$$r_{Cmax} = \frac{V_r}{\Delta i_L} = \frac{50\,mV}{0.43175} = 115.8\,m\Omega$$

$$C_{min} = \max\left\{\frac{D_{max}}{2f_s r_C}, \frac{\frac{1}{2} - D_{min}}{2f_s r_C}\right\}$$

$$= 17.27\,\mu H$$

RICR C 27μF / 100mΩ / 16V

$$V_{max} = \frac{V_{2max}}{n} = \frac{242}{13} = 18.62\ V$$

$$I_{max} = I_{oav} + \frac{\Delta i_{Lm}}{2} = 20 \times (0.43115/2)$$

$$= 20.216\ A$$

$$I_{1max} = \frac{I_{max}}{n} = \frac{20.216A}{13} = 1.555A$$

$$\Delta i_{Lmax} = 0.1 \times 1.555A = 0.1555A$$

$$L_{s1(min)} = \frac{D_{min} V_{2max}}{2 f_s \Delta i_{Lm}} = \frac{0.3273 \times 242}{2 \times 10^5 \times 0.1555}$$

$$= 2546.8\ \mu H$$

$$V_{Smax} = V_{2max} = 242\ V$$

$$I_{Smax} = \frac{I_{max}}{n} + \frac{\Delta i_{Lm}}{2} = \frac{20.216}{13} + \frac{0.1555}{2}$$

$= 1.633A$

8. A full-bridge PWM converter has $V_{Imin} = 127$ V, $V_{Imax} = 187$ V, $n = 2$, $V_O = 48$ V, $P_O = 1–2.5$ kW, and $f_s = 35$ kHz. Find the current stresses of the transistors and the diodes.

Soln

$I_{om} = 2500\ kW / 48V = 52A$

$\Delta i_{Lmax} = \frac{V_O(1 - D_{min})}{f_s L} = 31.542A$

$\Delta i_{Lm(max)} = 0.1 \times I_{max} = 3.318A$

$n = \frac{\eta_{max}}{M_{Vmax}} = \frac{n \times \eta_{max}}{0.378} = 2$

$M_{Vmax} = \frac{V_O}{V_{Imin}} = \frac{48}{127} = 0.378$

$I_{S\,max} = \frac{I_{om}}{n} + \frac{\Delta i_{Lmax}}{2n} + \frac{\Delta i_{Lm}}{2n}$

$= \frac{52}{2} + \frac{31.548}{2 \times 2} + \frac{3.38}{2}$

$= 35.6A$

$$I_{Dmax} = I_{omax} + \frac{\Delta i_{Lmax}}{2}$$

$$= 52 + \frac{31.6}{2} = 67.8\,A$$