Buck converter operated in CCM

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1) Input data

$D:=0.3338$ $\quad L_1:=10\ \mu H$ $\quad T_{sw}:=4\ \mu s$ $\quad V_{in}:=15\ V$ $\quad R_{load}:=0.5\ \Omega$

2) Calculations

$V_{out}:=D\cdot V_{in}=5.007\ V$ $\quad I_{out}:=\frac{V_{out}}{R_{load}}=10.014\ A$ $\quad F_{sw}:=\frac{1}{T_{sw}}=250\ kHz$ $\quad M:=\frac{V_{out}}{V_{in}}=0.334$

Beyond this load value, the converter operates in DCM: $R_{crit}:=2\cdot L_1\cdot F_{sw}\cdot\left(\frac{V_{in}}{V_{in}-V_{out}}\right)=7.505\ \Omega$

$$\Delta I_L:=\frac{V_{in}-V_{out}}{L_1}\cdot D\cdot T_{sw}=1.334\ A$$

$I_p:=I_{out}+\frac{\Delta I_L}{2}=10.681\ A$ $\quad I_V:=I_{out}-\frac{\Delta I_L}{2}=9.347\ A$ $\quad \tau_L:=\frac{L_1}{R_{load}\cdot T_{sw}}=5$

2.1) Inductor rms current

$$I_{L1}:=\frac{\sqrt{I_V^2+I_V\cdot I_p+I_p^2}}{\sqrt{3}}=10.021\ A \qquad \frac{\sqrt{12\cdot I_{out}^2+\Delta I_L^2}}{2\cdot\sqrt{3}}=10.021\ A$$

$$I_{out}\cdot\sqrt{1+\frac{(1-D)^2\cdot R_{load}^2}{12\cdot F_{sw}^2\cdot L_1^2}}=10.021\ A \qquad \frac{V_{out}}{R_{load}}\cdot\sqrt{1+\frac{1}{12}\cdot\left(\frac{1-D}{\tau_L}\right)^2}=10.021\ A$$

2.2) Switch rms current

$$I_{SW}:=\sqrt{\frac{D\cdot\left(I_V^2+I_V\cdot I_p+I_p^2\right)}{3}}=5.79\ A \qquad \frac{\sqrt{D\cdot\left(12\cdot I_{out}^2+\Delta I_L^2\right)}}{2\cdot\sqrt{3}}=5.79\ A$$

$$I_{out}\cdot\sqrt{D+\frac{D\cdot(1-D)^2\cdot R_{load}^2}{12\cdot F_{sw}^2\cdot L_1^2}}=5.79\ A \qquad \frac{V_{out}}{R_{load}}\cdot\sqrt{D\cdot\left(1+\frac{1}{12}\cdot\left(\frac{1-D}{\tau_L}\right)^2\right)}=5.79\ A$$

2.3) Diode rms current

$$I_{DIODE}:=\sqrt{\frac{(1-D)\cdot\left(I_V^2+I_V\cdot I_p+I_p^2\right)}{3}}=8.18\ A \qquad \frac{\sqrt{\left(12\cdot I_{out}^2+\Delta I_L^2\right)\cdot(1-D)}}{2\cdot\sqrt{3}}=8.18\ A$$

$$I_{out} \cdot \sqrt{1 - D + \frac{(1-D)^3 \cdot R_{load}^2}{12 \cdot F_{sw}^2 \cdot L_1^2}} = 8.18\ A$$

$$\frac{V_{out}}{R_{load}} \cdot \sqrt{(1-D) \cdot \left(1 + \frac{1}{12} \cdot \left(\frac{1-D}{\tau_L}\right)^2\right)} = 8.18\ A$$

2.4) Output Capacitor rms current

$$I_{Cout} := \sqrt{\frac{12 \cdot I_{out}^2 + \Delta I_L^2}{12} - I_{out}^2}$$

$$\frac{\Delta I_L}{2 \cdot \sqrt{3}} = 0.385\ A$$

$$I_{out} \cdot \sqrt{\frac{(1-D)^2 \cdot R_{load}^2}{12 \cdot F_{sw}^2 \cdot L_1^2}} = 0.385\ A$$

$$\frac{V_{out}}{R_{load}} \cdot \left(\frac{1-D}{\sqrt{12 \cdot \tau_L}}\right) = 0.385\ A$$

2.5) Input Capacitor rms current

$$I_{Cin} := \sqrt{I_{SW}^2 - (M \cdot I_{out})^2} = 4.728\ A$$