

Buck Converter Calculation

1st Approach (More Practical Approach)

$$\Delta i_{L_{on}} = \frac{V_s - \bar{V}_o}{L} D \cdot T$$

$$= \frac{V_s - \bar{V}_o}{L} \frac{D}{f_s}$$

$$2 = \frac{27 - 10}{L} \cdot \frac{D}{f_s}$$

$$2 = \frac{27 - 10}{L} \cdot \frac{0.3703}{f_s}$$

$$L = \frac{(27 - 10) \cdot 0.3703}{2 \cdot f_s}$$

$$L \approx 63 \mu H$$

$$V_{S_{in}} = 15V_{ee} - 25V_{el}$$

$$V_{S_{avg\ in}} = 20V_{el}$$

$$V_{S_{out}} = \frac{352}{T_1} \cdot 20 = 27.00g$$

$$\bar{V}_o \text{ assume } 10V$$

$$\Delta i_{L_{on}} \% 20 \quad i_{L_{on}} = 10A$$

$$\Delta i_{L_{on}} = 2$$

$$D_2 \frac{V_o}{V_s} = 0.3703$$

2nd Approach

$$L_c = \frac{(1 - D_{max}) R_{max}}{2f} = 0.30717$$

$$V_o = D V_{in}$$

$$R_{max} = \frac{V_o}{I_{min}} = \frac{10}{9} = 1.111$$

$$10 = D_{max} 27\sqrt{2}$$

$$f = 50 \text{ kHz}$$

$$D_{max} = 0.6928$$

$$L_c = 3.413 \text{ } \mu\text{H}$$

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$$V_{S_{in}} = 15V_{ee} - 25V_{pe}$$

$$\bar{V}_o \text{ assume } 10V$$

$$V_{S_{out,in}} = 20V_{ee}$$

$$\Delta i_{on} \% 20 \rightarrow i_{on} = 10A$$

$$V_{S_{out}} = \frac{3\sqrt{2}}{\pi} \cdot 20 = 27.00g$$

$$\Delta i_{on} = 1 \rightarrow \text{try to make it } \% 10$$

$$V_{S_{out,rms}} = 25.40 \text{ (simulink)}$$

This calculation is held by assuming average values so that I take $D = 0.5$

$$f_s = 50 \text{ kHz}$$

$$D = \frac{\bar{V}_o}{V_S} = 0.37037 \quad D = \frac{10}{25.40} = 0.3937$$

$$\text{Inductor: } \frac{(1-D)}{2f} \frac{V_o}{\Delta i_o} = \frac{(1-0.37037)(10)}{2 \times 50 \times 10^3 \times 1} = 60.629 \mu\text{H}$$

$$L_{crit} = 63 \mu\text{H}$$

$$\text{Let } L \approx 65 \mu\text{H}$$

Capacitor :

$$C = \frac{(1-D)}{8Lf^2} \cdot \frac{1}{V_0} = \frac{(1-0.37037)}{8 \times 65 \times 10^{-6} \times (50 \times 10^3)^2} \cdot \frac{1}{20}$$

$$= 24.21 \text{ nF}$$

$$= 25 \text{ nF}$$

To Summarize

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Key equations summarized:

- $I_{Switch\text{-max}} > \overline{I}_{o\text{max}} \cdot D_{\text{max}}$
- $V_{switch\text{-max}} = V_{in\text{max}}$
- $I_{L\text{max}} = \bar{V}_0 \left[\frac{1}{R_{\min}} + \frac{(1-D_{\min})}{2Lf} \right]$
- $L_C = \frac{(1-D_{\max})R_{\max}}{2f}$
- $I_{Crms} = \sqrt{\left(I_o \sqrt{D} \sqrt{\left(1 + \left[\frac{\Delta i_L}{2 \cdot I_o} \right] \right)^2} \right) - (D \cdot I_o)^2}$
- $\overline{I}_F > \overline{I}_{o\text{max}} \cdot (1 - D_{\min})$
- $C = \frac{(1-D_{\min})}{8Lf^2 (\Delta \bar{V}_o / \bar{V}_o)}$
- $V_{cmax} = \bar{V}_o + \Delta \bar{V}_o / 2$
- $i_{Crms} = \frac{(1-D_{\min}) \bar{V}_o}{2\sqrt{3}L}$
- $V_{RRM} = V_{in\text{max}}$

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From the calculations above, current = 1 A avg.

We may change V_{out} to charge battery

Now let assume $V_{out} = 14 \text{ V}$

$$D = \frac{\overline{V_o}}{V_s} = \frac{14}{25.40} = 0.5511$$

$$\text{Inductor: } \frac{(1-D)}{2f} \frac{V_o}{\Delta i_o} = 62.83 \mu\text{H}$$

$$L_{crit} = 63 \mu\text{H}$$

$$L_{crit} \approx 65 \mu\text{H}$$

Capacitor:

$$C = \frac{(1-D)}{8 L f^2} \cdot \frac{1}{\gamma_0 V_0} = 17,26 \text{ nF}$$

Not Working.

Theoretical calculations are useless.