

Step-Up (Boost) Converter Calculation

Input Data

*Power Stage Topologies Topology Reference Handbook
Guide (Markus Zehendner, Matthias Ulmann)*

Minimum Input Voltage:

$$V_{in.min} := 3.7 \text{ V}$$

*Concept KIT: PWM Boost Converter Average
Model (Bee Technologies)*

Maximum Input Voltage:

$$V_{in.max} := 4.2 \text{ V}$$

More information and tests:

<https://cxemka.com/74-raschet-i-test-preobrazovatelja-naprijazhenija-na-stm32-dcdc-boost-step-up.html>

Input Voltage (average):

$$V_{in} := \frac{V_{in.min} + V_{in.max}}{2} = 3.95 \text{ V}$$

Forward Voltage Drop:

$$V_f := 0.79 \text{ V}$$

Output Voltage:

$$V_{out} := 5 \text{ V}$$

Output Voltage Ripple:

$$V_{out.ripple} := 0.01 \text{ V}$$

Minimum Output Current:

$$I_{O.min} := 0.01 \text{ A}$$

Maximum Output Current:

$$I_{O.max} := 0.3 \text{ A}$$

Output Current:

$$I_{out} := 0.3 \text{ A}$$

Output Ripple Current:

$$I_{ripple} := 0.001 \text{ A}$$

Switching frequency of the power supply's FET:

$$f_{switch} := 40000 \text{ Hz}$$

Switching period:

$$T := \frac{1}{f_{switch}} = 2.5 \cdot 10^{-5} \text{ s}$$

Timings

FET on, increasing current:

$$t_1 := \frac{1}{f_{switch}} \cdot \frac{V_{out} + V_f - V_{in}}{V_{out} + V_f} = 7.9447 \cdot 10^{-6} \text{ s}$$

FET off, decreasing current:

$$t_2 := \frac{1}{f_{switch}} - t_1 = 1.7055 \cdot 10^{-5} \text{ s}$$

Duty cycle:

$$D := \frac{t_1}{t_1 + t_2} = 0.3178$$

Minimum Duty cycle:

$$D_{min} := 1 - \frac{V_{in,max}}{V_{out}} = 0.16$$

Maximum Duty cycle:

$$D_{max} := 1 - \frac{V_{in,min}}{V_{out}} = 0.26$$

Average Input Current:

$$I_{in} := I_{out} \cdot \frac{V_{out} + V_f}{V_{in}} = 0.4397 \text{ A}$$

Inductor

Inductor value (Continuiuos Current Mode):

$$L_{CCM} := \frac{D_{min} \cdot \left(1 - D_{min}\right)^2 \cdot V_{out}}{2 \cdot f_{switch} \cdot I_{O.min}} = 0.0007 \text{ H}$$

Inductor ripple current:

$$\Delta I_L := \frac{V_{in.min} \cdot D_{max}}{L_{CCM} \cdot f_{switch}} = 0.0341 \text{ A}$$

Min. Inductor Current:

$$I_{min} := I_{in} - \frac{I_{ripple}}{2} = 0.4392 \text{ A}$$

Max. Inductor Current:

$$I_{max} := I_{in} + \frac{I_{ripple}}{2} = 0.4402 \text{ A}$$

Average Inductor Current:

$$I_{Llav} := \frac{I_{min} + I_{max}}{2} \cdot (t_1 + t_2) \cdot f_{switch} = 0.4397 \text{ A}$$

Min. Inductor Voltage:

$$V_{Llmin} := V_{in} - V_{out} - V_f = -1.84 \text{ V}$$

Max. Inductor Voltage:

$$V_{Llmax} := V_{in} = 3.95 \text{ V}$$

FET

Average FET Current:

$$I_{Q1avg} := \frac{I_{min} + I_{max}}{2} \cdot t_1 \cdot f_{switch} = 0.1397 \text{ A}$$

Min. FET Voltage:

$$V_{Q1min} := 0 \text{ V}$$

Max. FET Voltage:

$$V_{Q1max} := V_{out} + V_f = 5.79 \text{ V}$$

FET Voltage during t3:

$$V_{Q1t3} := V_{in} = 3.95 \text{ V}$$

Diode

Average Diode Current:

$$I_{D1avg} := \frac{I_{min} + I_{max}}{2} \cdot t_2 \cdot f_{switch} = 0.3 \text{ A}$$

Min. Diode Voltage:

$$V_{D1min} := -V_{out} = -5 \text{ V}$$

Max. Diode Voltage:

$$V_{D1max} := V_f = 0.79 \text{ V}$$

Diode Voltage During t3:

$$V_{D1t3} := V_{in} - V_{out} = -1.05 \text{ V}$$

Input Capacitor

Min. Input Capacitor Current:

$$I_{Cimin} := -I_{max} + I_{min} = -0.001 \text{ A}$$

Max. Input Capacitor Current:

$$I_{Cimax} := -I_{min} + I_{in} = 0.0005 \text{ A}$$

Average Input Capacitor Current:

$$I_{Ciavg} := 0 \text{ A}$$

Input Capacitor Voltage:

$$V_{Ci} := V_{in} = 3.95 \text{ V}$$

Output Capacitor

Minimum Capacitor value:

$$C := \frac{D_{max} \cdot I_{O.max}}{V_{out.ripple} \cdot f_{switch}} = 0.0002 \text{ F}$$

Capacitor current:

$$I_{C.Rated} := \frac{\Delta I_L}{2} = 0.017 \text{ A}$$

Capacitor ESR:

$$C_{ESR} := \frac{V_{out.ripple}}{I_{C.Rated}} = 0.5868 \text{ } \Omega$$

Output Capacitor Current during t1:

$$I_{C0t1} := -I_{out} = -0.3 \text{ A}$$

Min. Output Capacitor Current during t2 and t3:

$$I_{C0mint23} := I_{min} - I_{out} = 0.1392 \text{ A}$$

Max. Output Capacitor Current during t2 and t3:

$$I_{C0maxt23} := I_{max} - I_{out} = 0.1402 \text{ A}$$

Average Output Capacitor Current:

$$I_{C0avg} := 0 \text{ A}$$

Output Capacitor Voltage:

$$V_{C0} := V_{out} = 5 \text{ V}$$