Buck Converter Duty Cycle, Inductor and Output Capacitor

Duty cycle, inductance for a chosen ripple, peak current, output capacitance for a ripple voltage and the continuous-conduction limit of a buck converter.

Method: Steady-state buck converter relations (volt-second and charge balance)

Input parameters

Unit system: SI

Parameter	Value	Unit
Input voltage	12.000	V
Output voltage	3.3000	V
Output current	3.0000	A
Switching frequency	500.00	kHz
Inductor ripple ratio ΔI/I_out	30.000	%
Allowed output ripple (peak to peak)	20.000	mV
Estimated efficiency	90.000	%

Calculated results

Parameter	Value	Unit
Duty cycle	30.556	%
Inductance	5.9074	µH
Inductor ripple current (peak to peak)	0.90000	A
Peak inductor and switch current	3.4500	A
Minimum output capacitance (ignoring ESR)	11.250	µF
Load below which conduction becomes discontinuous	0.45000	A
Average input current	0.91667	A

Notes for this case

• Continuous conduction: L = (V_in − V_out)D/(f ΔI), C ≥ ΔI/(8fΔV). Capacitor ESR adds ESR·ΔI to the ripple and often dominates with electrolytics; check L at the maximum input voltage, where ripple is largest.

Formula and method

$$D = \frac{V_{out}}{\eta V_{in}}, \quad L = \frac{(V_{in} - V_{out})D}{f_s \, \Delta I_L}, \quad C_{out} = \frac{\Delta I_L}{8 f_s \Delta V_{out}}, \quad I_{pk} = I_{out} + \frac{\Delta I_L}{2}$$

Variables

V_{in}	Input voltage	V
V_{out}	Output voltage	V
I_{out}	Output current	A
f_s	Switching frequency	1/s
r	Inductor ripple ratio ΔI/I_out	-
ΔV_{out}	Allowed output ripple (peak to peak)	V
η	Estimated efficiency	-
D	Duty cycle	-
L	Inductance	H
ΔI_L	Inductor ripple current (peak to peak)	A

I_{pk}	Peak inductor and switch current	A
C_{out}	Minimum output capacitance (ignoring ESR)	F
I_{CCM}	Load below which conduction becomes discontinuous	A
I_{in}	Average input current	A

Method and standards

Buck converter steady-state analysis.

Assumptions and limits

- Continuous conduction, steady state, ideal components except the efficiency.

References

Steady-state buck converter relations (volt-second and charge balance)

Report details

Report reference	FCC-DYWC-KP63 (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/electrical/electronics/buck-converter-design

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.