

TPS5420 3.3V Supply Design

Design Parameters

$$\begin{aligned}
 V_{in_min} &:= 10 \text{ V} & V_{in_ripple} &:= 300 \text{ mV} \\
 V_{in_max} &:= 35 \text{ V} & V_{out_ripple} &:= 50 \text{ mV} \\
 V_{out_nom} &:= 3.3 \text{ V} & I_{out_max} &:= 2 \text{ A} \\
 K_{ind} &:= 0.2 & F_{sw} &:= 500 \text{ kHz} \quad \text{Fsw fixed by TPS5420}
 \end{aligned}$$

Input Capacitors

$$\begin{aligned}
 C_{bulk} &:= 10 \cdot 10^{-6} \text{ F} & ESR_{max} &:= 0.002086 \text{ } \Omega & ESL_{max} &:= 1200 \cdot 10^{-9} \text{ H} \\
 V_{in_ripple_calc} &:= I_{out_max} \cdot \frac{0.25}{C_{bulk} \cdot F_{sw}} + (I_{out_max} \cdot ESR_{max}) = 0.104 \text{ V}
 \end{aligned}$$

$$I_{cin} := \frac{I_{out_max}}{2} = 1 \text{ A}$$

Choose input capacitors rated for at least 50V with a ripple current capacity for each at 3A at 500kHz

Output Filter Components

Inductor Selection

$$\begin{aligned}
 L_{min} &:= V_{out_nom} \cdot \frac{(V_{in_max} - V_{out_nom})}{(V_{in_max}) \cdot K_{ind} \cdot I_{out_max} \cdot F_{sw} \cdot 0.8} = (1.868 \cdot 10^{-5}) \text{ H} \\
 L_{nom} &:= 22 \cdot 10^{-6} \text{ H}
 \end{aligned}$$

$$I_{L_rms} := \left(I_{out_max} \cdot I_{out_max} + \frac{1}{12} \left(\frac{(V_{out_nom} \cdot (V_{in_max} - V_{out_nom}))^2}{(V_{in_max} \cdot L_{nom} \cdot F_{sw} \cdot 0.8)} \right)^{0.5} \right)^{0.5} = 2.002 \text{ A}$$

$$I_{L_peak} := \left(I_{out_max} + \frac{V_{out_nom} \cdot (V_{in_max} - V_{out_nom})}{1.6 \cdot V_{in_max} \cdot L_{nom} \cdot F_{sw}} \right) = 2.17 \text{ A}$$

Choose an inductor with at least 2.5A rms and 3A saturation current

Output Capacitor Selection

$F_{co} := 10 \text{ kHz}$ Target Crossover frequency

$$C_{out} := \frac{1}{(3357 \cdot L_{nom} \cdot F_{co} \cdot V_{out_nom})} = (4.103 \cdot 10^{-4}) \frac{s^6 \cdot A^3}{kg^2 \cdot m^4}$$

~100uF

$N_c := 5$ Select 5x 22uF capacitors to approximate 100uF

$$C_{out_esr_max} := \frac{1}{(2 \cdot \pi \cdot C_{out} \cdot F_{co})} = 0.039 \frac{kg^2 \cdot m^4}{s^5 \cdot A^3}$$

~88mOhms

$$V_{pp_max} := C_{out_esr_max} \cdot V_{out_nom} \cdot \frac{(V_{in_max} - V_{out_nom})}{N_c \cdot V_{in_max} \cdot L_{nom} \cdot F_{sw} \cdot 0.8} = 0.003 \frac{kg^2 \cdot m^4}{s^5 \cdot A^2}$$

6mV pk-pk ripple

Ensure output cap is rated for $V_{out} + 1/2$ ripple voltage + derating, ~
 $5.006 \cdot 1.3 = 6.5V$, round up to 25V

Estimate ripple current max at 150mA

Output Voltage Set

$R1 := 10 \text{ k}\Omega$ $R1_{min} := R1 \cdot .999$ $R1_{max} := R1 \cdot 1.001$

$$R2 := \frac{R1 \cdot 1.221}{(V_{out_nom} - 1.221 \text{ V})} = (5.873 \cdot 10^3) \frac{1}{A} \quad 5.76KOhms \text{ +/-0.1\%}$$

$R2_{min} := R2 \cdot .999$ $R2_{max} := R2 \cdot 1.001$

$$V_{out_min} := R1_{min} \cdot \frac{1.221}{R2_{max}} + 1.221 \text{ V} = 3.296 \text{ V}$$

$$V_{out_max} := R1_{max} \cdot \frac{1.221}{R2_{min}} + 1.221 \text{ V} = 3.304 \text{ V}$$

Boot Cap

Datasheet gives 0.01uF for the boot capacitor. NP0/COG preferred

Catch Diode

$$D_{reverse_voltage_min} := V_{in_max} + 0.5 \text{ V} = 35.5 \text{ V}$$

$$D_{iout_max} := I_{out_max} + 0.5 \cdot I_{L_rms} = 3.001 \text{ A}$$

Diodes, Inc B340A has a reverse voltage of 40V, forward current of 3A and forward voltage drop of 0.5V