TPS5420 5V Supply Design

Design Parameters

$Vin\_min := 10\ V$ $\quad Vin\_ripple := 300\ mV$

$Vin\_max := 35\ V$ $\quad Vout\_ripple := 50\ mV$

$Vout\_nom := 5\ V$ $\quad Iout\_max := 2\ A$

$K\_ind := 0.2$ $\quad Fsw := 500\ kHz$ Fsw fixed by TPS5420

Input Capacitors

$C\_bulk := 10 \cdot 10^{-6}\ F$ $\quad ESRmax := 0.002086\ \Omega$ $\quad ESL\_max := 1200 \cdot 10^{-9}\ H$

$$Vin\_ripple\_calc := Iout\_max \cdot \frac{0.25}{C\_bulk \cdot Fsw} + (Iout\_max \cdot ESRmax) = 0.104\ V$$

$$I\_cin := \frac{Iout\_max}{2} = 1\ A$$

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

Output Filter Components

Inductor Selection

$$L\_min := Vout\_nom \cdot \frac{(Vin\_max - Vout\_nom)}{(Vin\_max) \cdot K\_ind \cdot Iout\_max \cdot Fsw \cdot 0.8} = (2.679 \cdot 10^{-5})\ H$$

$L\_nom := 33 \cdot 10^{-6}\ H$

$$I\_L\_rms := \left(Iout\_max \cdot Iout\_max + \frac{1}{12} \left(\frac{(Vout\_nom \cdot (Vin\_max - Vout\_nom))}{(Vin\_max \cdot L\_nom \cdot Fsw \cdot 0.8)} \right)^2 \right)^{0.5} = 2.002\ A$$

$$I\_L\_peak := \left(Iout\_max + \frac{Vout\_nom \cdot (Vin\_max - Vout\_nom)}{1.6 \cdot Vin\_max \cdot L\_nom \cdot Fsw} \right) = 2.162\ A$$

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

Output Capacitor Selection

$Fco := 10\ kHz$ Target Crossover frequency

$$Cout := \frac{1}{(3357 \cdot L\_nom \cdot Fco \cdot Vout\_nom)} = (1.805 \cdot 10^{-4})\ \frac{s^6 \cdot A^3}{kg^2 \cdot m^4}$$

~100uF

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

$$Cout\_esr\_max := \frac{1}{(2 \cdot \pi \cdot Cout \cdot Fco)} = 0.088\ \frac{kg^2 \cdot m^4}{s^5 \cdot A^3}$$

~88mOhms

$$Vpp\_max := Cout\_esr\_max \cdot Vout\_nom \cdot \frac{(Vin\_max - Vout\_nom)}{Nc \cdot Vin\_max \cdot L\_nom \cdot Fsw \cdot 0.8} = 0.006\ \frac{kg^2 \cdot m^4}{s^5 \cdot A^2}$$

6mV pk-pk ripple

Ensure output cap is rated for Vout + 1/2 ripple voltage + derating, ~ 5.006*1.3=6.5V, round up to 25V

Estimate ripple current max at 150mA

Output Voltage Set

$R1 := 10\ k\Omega$ $R1\_min := R1 \cdot .999$ $R1\_max := R1 \cdot 1.001$

$$R2 := \frac{R1 \cdot 1.221}{(Vout\_nom - 1.221\ V)} = (3.231 \cdot 10^3)\ \frac{1}{A}$$ 3.24KOhms +/-0.1%

$R2\_min := R2 \cdot .999$ $R2\_max := R2 \cdot 1.001$

$$Vout\_min := R1\_min \cdot \frac{1.221}{R2\_max} + 1.221\ V = 4.992\ V$$

$$Vout\_max := R1\_max \cdot \frac{1.221}{R2\_min} + 1.221\ V = 5.008\ V$$

Boot Cap

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

Duty Cycle (Max)

$\eta := 0.9$ $D\_min := \frac{Vout\_nom}{Vin\_max \cdot \eta} = 0.159$ $D\_max := \frac{Vout\_nom}{Vin\_min \cdot \eta} = 0.556$

Catch Diode

$D\_reverse\_voltage\_min := Vin\_max + 0.5\ V = 35.5\ V$

$D\_iout\_max := Iout\_max + 0.5 \cdot I\_L\_rms = 3.001\ A$

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

$If := Iout\_max \cdot (1 - D\_min) = 1.683\ A$ $If\_2 := Iout\_max \cdot (1 - D\_max) = 0.889\ A$