The s'More Driver

A more or less Complete Guide to Calculate Every Value for Your Specific LED Application

Schoki - BudgetLightForum

February 15, 2018

1 Control circuit

1.1 Calculate R7

R_8 is given (4.7k on my case) and forms a voltage divider with R_7. The maximum smoothed PWM voltage is equal to the LDO voltage, that your MCU is connected with (at a light load). In my case, the LDO has 2.8V, so 100% PWM signal V_{MCU} is 2.8V as well.
The next thing you need to know is the maximum voltage drop over the sense resistor V_{SENSE}.
With this in mind, you now can calculate R7:

$$R_7 = R_8\left(\frac{V_{MCU}}{V_{SENSE}} - 1\right)$$

1.2 Calculate R10, R11

Next thing is R_{10} and R_{11}. Those two resistors limit the voltage the boost circuit can output.

Here:
$R_{10} = R_2$
$R_{11} = R_1$

Meaning:

V_{O1} = Minimum Output Voltage
V_{O2} = Maximum Output Voltage
V_{C1} = Minimum Control Voltage (0V with my circuit)
V_{C2} = Maximum Control Voltage (2.8V with my circuit)
V_{FB} = IC Feedback Voltage (1V with the MP3431)

R_3 has to be given (20k in my driver)

$$R_1 = R_3 \frac{(V_{O2} - V_{FB})(V_{C2} - V_{FB}) - (V_{C1} - V_{FB})(V_{O1} - V_{FB})}{V_{FB}(V_{C2} - V_{C1})}$$

$$R_2 = \frac{R_1 R_3 (V_{C1} - V_{FB})}{V_{FB}(R_1 + R_3) - R_3 V_{O2}}$$

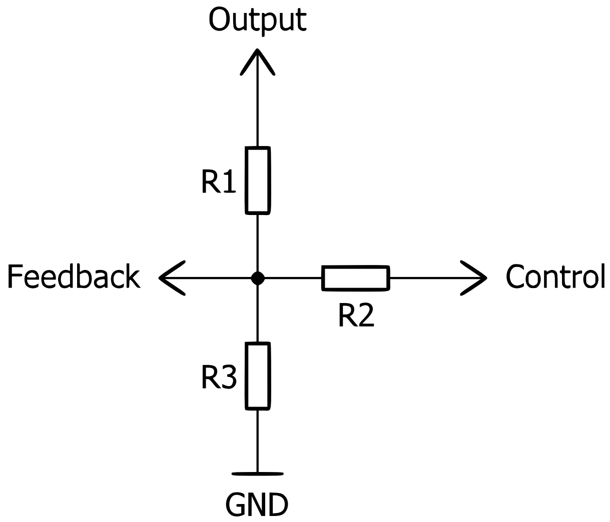

Figure 1.1: The circuit

2 Boost Circuit

2.1 Inductor

The minimum switch current $I_{LIM(MIN)}$ of the MP3431 is 19A, and with this equation, you get the inductance you need for your application. I used ΔI_L = 10% $* 19A$ = 1.9A

$$L = \frac{V_{IN}\left(V_{OUT} - V_{IN}\right)}{f_S \ V_{OUT} \ \Delta I_L}$$

f_S = 600000Hz

Of course ΔI_L depends on the maximum switch current you want, but 10% of the maximum switching current should be good.

To roughly calculate you ripple current (so you can use the formula above):

$$\Delta I_L = (0.1 \ to \ 0.4) * I_{OUT(max)} * \frac{V_{OUT}}{V_{IN}}$$

To see if your desired current is possible:

$$I_{MAXOUT} = \left(I_{LIM(MIN)} - \frac{\Delta I_L}{2}\right) * (1 - D)$$

with

$$D = 1 - \frac{V_{IN(min)} \ \eta}{V_{OUT}}$$

η is efficiency, I used 0.85 at the maximum switching current.

For more info, see: http://www.ti.com/lit/an/slva372c/slva372c.pdf

2.2 Input Capacitor

Not much to say here:

$$\Delta V_{IN} = \frac{V_{IN}}{8\, f_S^2\, L\, C} \left(1 - \frac{V_{IN}}{V_{OUT}}\right)$$

Use ceramic capacitors with X5R or X7R dielectrics, high current capability and low ESR. The same applies for the output capacitor.
Just keep in mind:

$$V_{EMPTYBATTERY} - \frac{\Delta V_{IN}}{2} - V_{LDO-DROPOUT} < V_{LDO-OUT}$$

2.3 Output Capacitor

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S\, R_L\, C} \left(1 - \frac{V_{IN}}{V_{OUT}}\right)$$

You just have 2 pads here (17mm), so get good 1206 ceramics. Look out for DC bias (higher voltage caps tend to be better at the same capacity), low ESR, high current capability. Just get the best you can find.