Smart door lock with STM32 Blue Pill

Duong Anh Khoa

November 24, 2023

Contents

Chapter 2

Power supply

2.1 Power requirement:

2.2 Power source:

2.3 Power supply method, definition and topology:

2.4 Component selection and sizing:

2.4.1 Requirements specification:

As a bare minimum, we require these parameters to be defined, then we can choose a buck converter IC!

1. **Input voltage range:**
$$12V \leq V_{in} \leq 16.8V$$
2. **Nominal output voltage:**
$$V_{Out,nom} = 3.3V$$
3. **Maximum output (load) current:**
$$I_{Out,max} = 500mA$$

As a rule of thumb, when choosing buck converter ic, after fill out all of the above requirement in the search field, make sure to choose the **switching frequency** above $500kHz$, as this will explain bellow.

2.4.2 Maximum switching current:

Switch (typically in IC), diode (can be in IC), and inductor need to sustain currents larger than the load current!

1. **Calculate duty cycle (efficiency around 80% to 90%):**
$$D \approx \frac{V_{Out}}{V_{In,max} \cdot H} = 0.25$$

2. **Calculate inductor ripple current (using 'average' L value from datasheet):**

$$\Delta I_L = \frac{(V_{In,max} - V_{Out}) \cdot D}{f_{sw} \cdot L_{ava}} = 325mA$$

3. **Check if IC can deliver required max output current:**

$$I_{IC,max} = I_{LIM,min} - \frac{\Delta I_L}{2} = 1.84A$$

4. **Calculate peak switch/diode/inductor current:**

$$I_{SW,max} = I_{Out,max} + \frac{\Delta I_L}{2} = 660mA$$

2.4.3 Inductor selection:

$$L_{min} = \frac{V_{Out} \cdot (V_{In,max} - V_{Out})}{\Delta I_L \cdot f_{sw} \cdot V_{In,max}}$$

But how do we choose inductor ripple current if L isn't known yet?

We estimate ripple current is 20% to 40% of maximum output current!

$$L_{min} = \frac{3.3V \cdot (16.8V - 3.3V)}{0.3 \cdot 0.5A \cdot 800kHz \cdot 16.8V} = 22uH$$

Remark: From the formula above we can see that:

1. The higher the switching frequency f_{sw} the lower the L_{min} value.
2. The higher the output voltage V_{Out} the lower the inductance.
3. The higher the approximation of the ripple current, ie 0.3 in our formula, the lower the inductance.
4. The higher the maximum output current, ie $0.5A$ in our plot, the lower the inductance.

2.4.4 Diode selection:

Diode is often included in IC. However, if it isn't, it is needed to choose suitably **Schottky** diode, with current rating at off frequency $(1 - D)$ of at least:

$$I_F = I_{Out} \cdot (1 - D) = 375mA$$

Also, check power dissipation of diode!

$$P_D = I_F \cdot V_F$$

2.4.5 Input/Output capacitor selection:

Input capacitor: typically given in datasheet! Use low-ESR caps, suitable dielectric/voltage rating.

Output capacitor: minimum and/or equations typically given in datasheet! Low-ESR + larger value to reduce output voltage ripple. Check dielectric/voltage rating.

2.4.6 Feedback network:

Feedback voltage divider sets output voltage! V(feedback) V_{FB} typically fixed internally by (precision) voltage reference (typ. 0.8V). *(Given in datasheet)*

$$V_{Out} = V_{FB} \cdot \left(1 + \frac{R_{FB_1}}{R_{FB_2}}\right)$$

Datasheet will provide information on suitable order of magnitude of R(feedback), typically 10-100 kOhms. Check tolerance (typ. 1%)!

$$V_{Out} = 0.8V \cdot \left(1 + \frac{75k\Omega}{24k\Omega} = 3.3V\right)$$

Remark: We will look at how the tolerance of the resistor affect the output current range:

$$V_{Out} = V_{FB} \cdot \left(1 + \frac{(1+d) \cdot R_{FB_1}}{(1-d) \cdot R_{FB_2}}\right)$$

With d is the resistor tolerance, if:

- $d = 1\%$
$$\Rightarrow 3.25V \leq V_{Out} \leq 3.35V$$
- $d = 5\%$
$$\Rightarrow 3.05V \leq V_{Out} \leq 3.55V$$
- $d = 10\%$
$$\Rightarrow 2.85V \leq V_{Out} \leq 3.85V$$

So the lower the resistor tolerance the better the output voltage range is, note that we want the output voltage range as tightly to our nominal voltage output, ie 3.3V.

2.5 Buck converter PCB design rule: