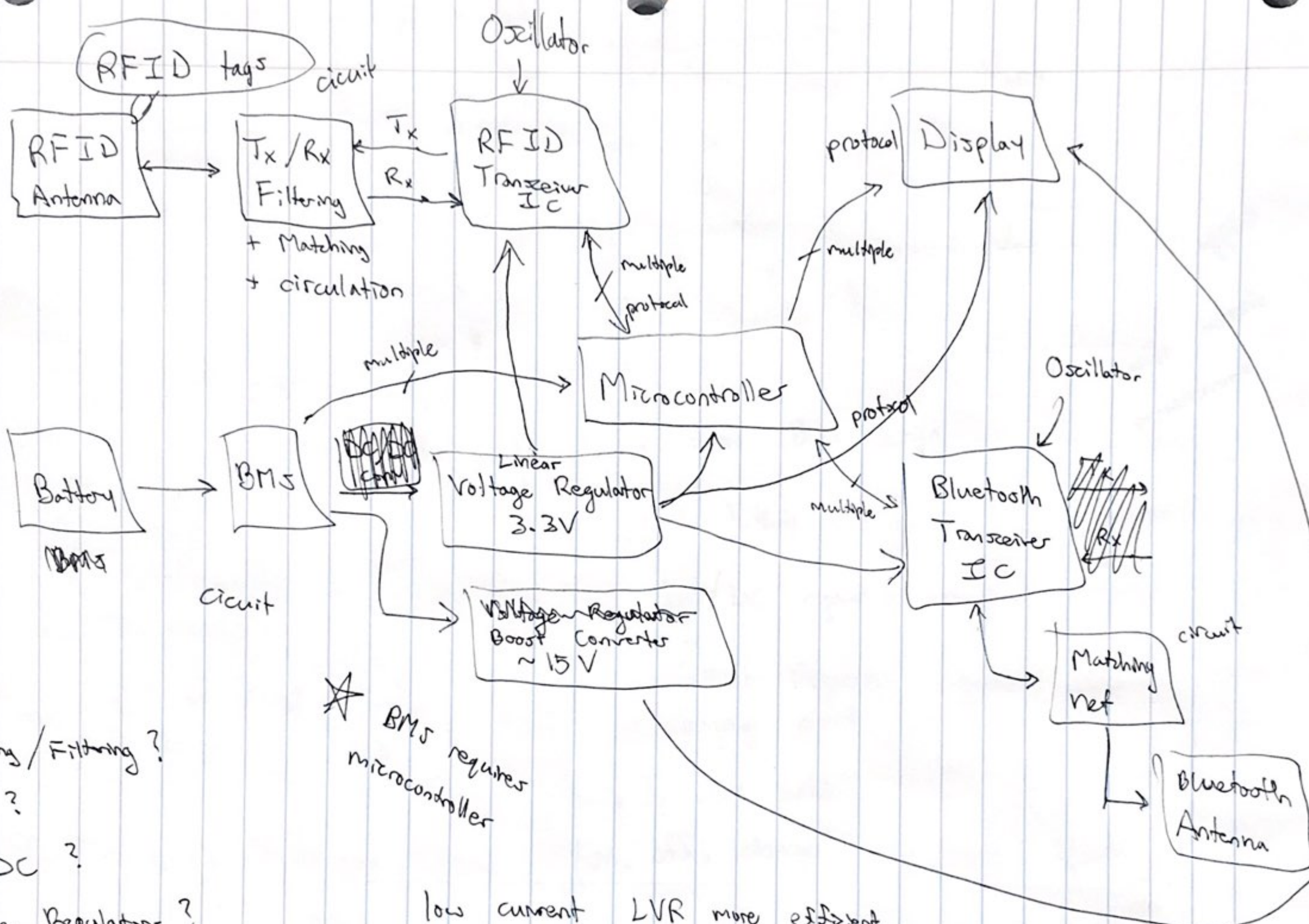


☆ BMS requires microcontroller

Matching / Filtering ?

BMS ?

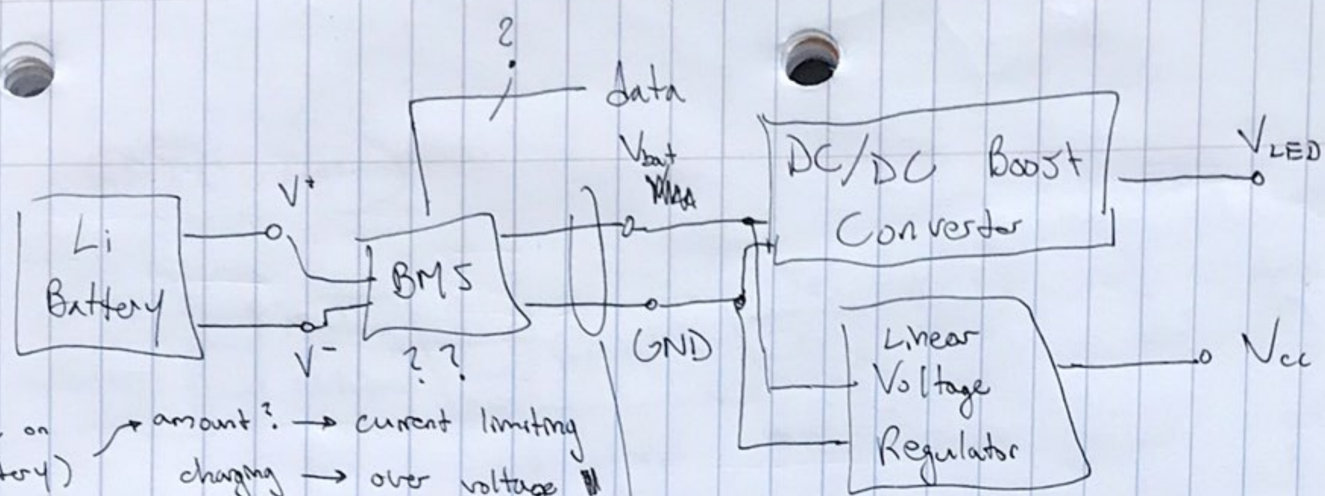
DC/DC ?

Voltage Regulators ?

Microcontroller programming ?

Charging ?

low current LVR more efficient than buck converter



(based on battery) → amount? → current limiting

charging → over voltage

usage → under voltage

SOC approx

SOC approx with current measurements

GND common

$V^+ - V^- = $ Li output (subject to change)

$$V_{bat} = \begin{cases} V^+ - V^-, & \text{if allowed} \\ 0, & \text{if blocked} \end{cases}$$

$V_{LED} = 15.5V \pm$ tolerance

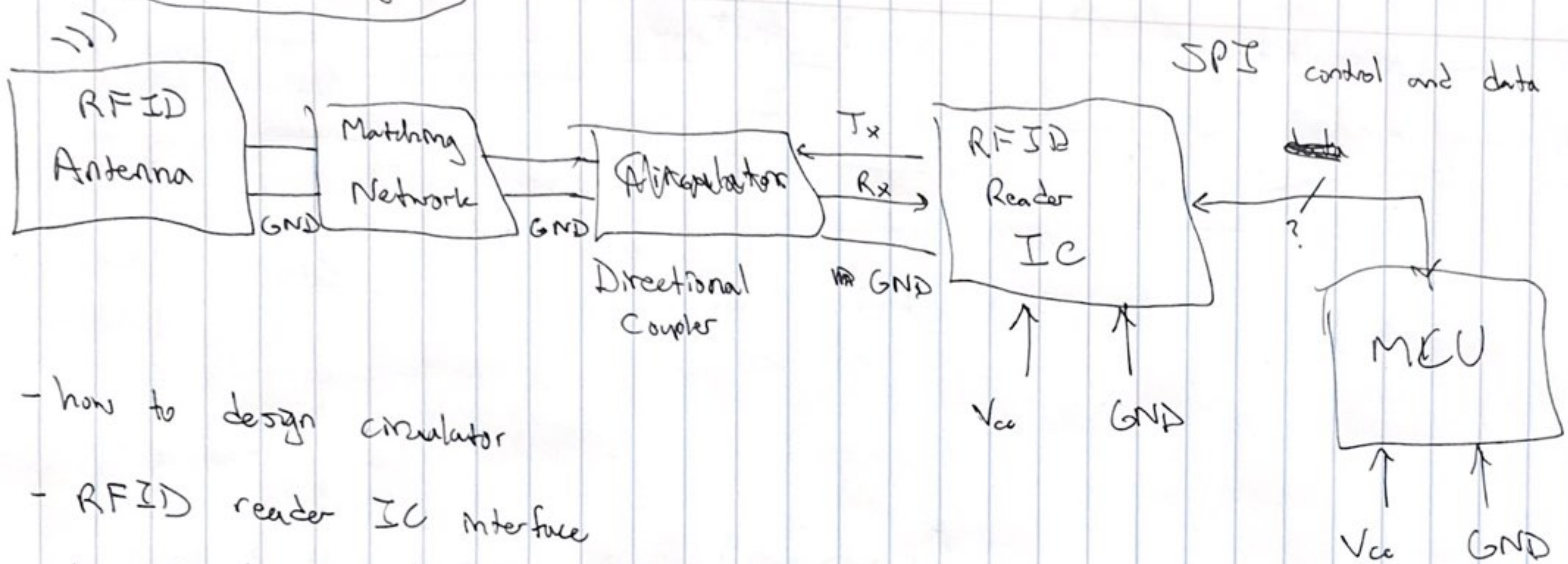
$V_{cc} = 3.3V \pm$ tolerance

- need BMS design
- Li battery choice
- DC/DC regulation circuitry
- Voltage Regulator regulation circuitry
- charging port

→ 3 way switch (on, off, charge)

Power Module

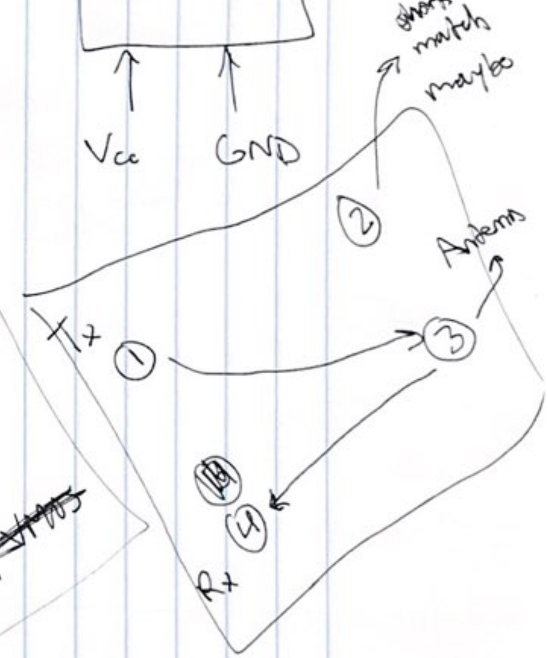
RFID Tags

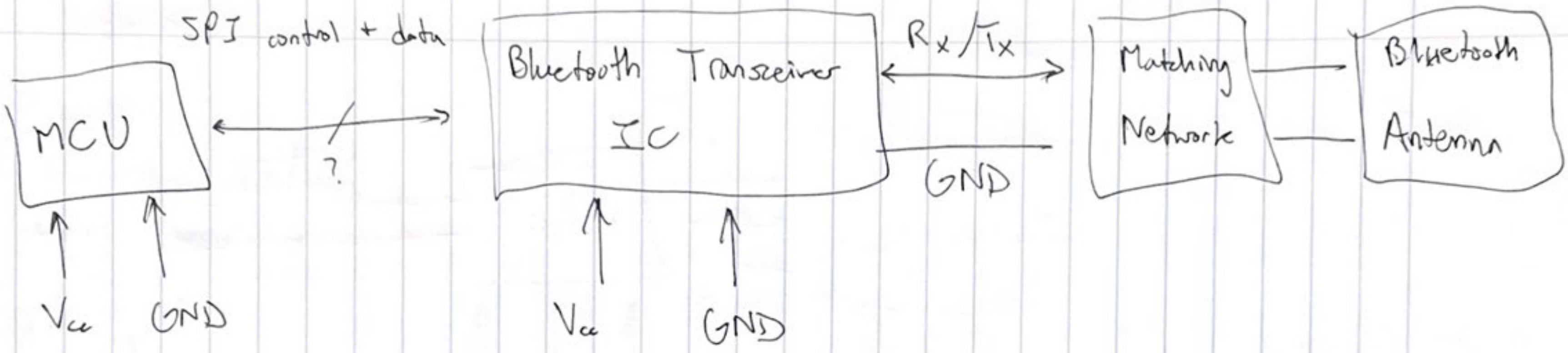


- how to design circulator
- RFID reader IC interface
- do RF lines need to have extra considerations
  (coupled line approach)
- oscillation for reader IC
- matching design
- directional coupler choice

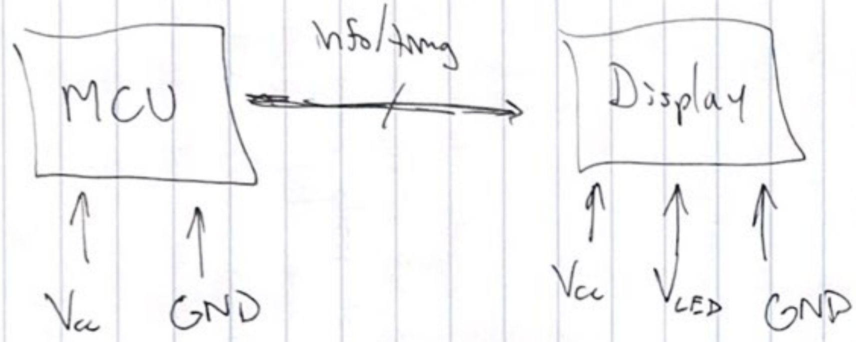
direct coupler
C as close to O as possible
D as close to O as possible

need
resistors
capacitors
Xtals
~~DMOS~~

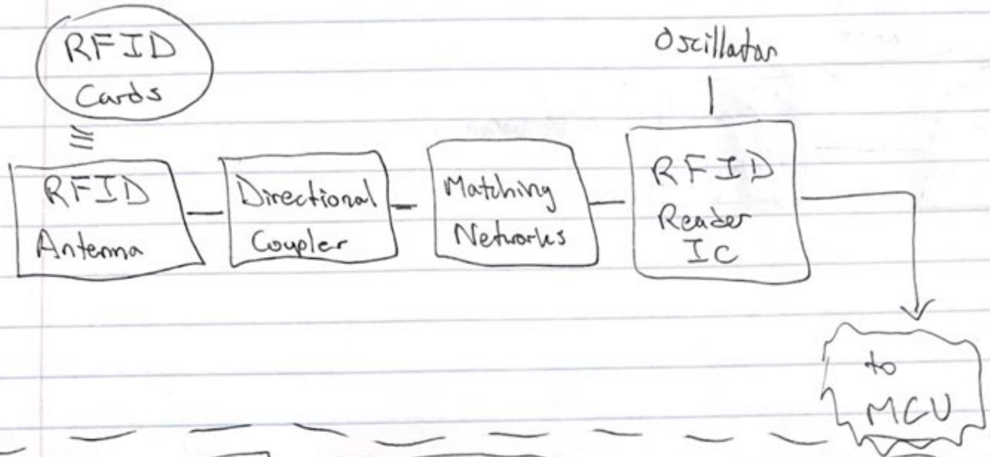


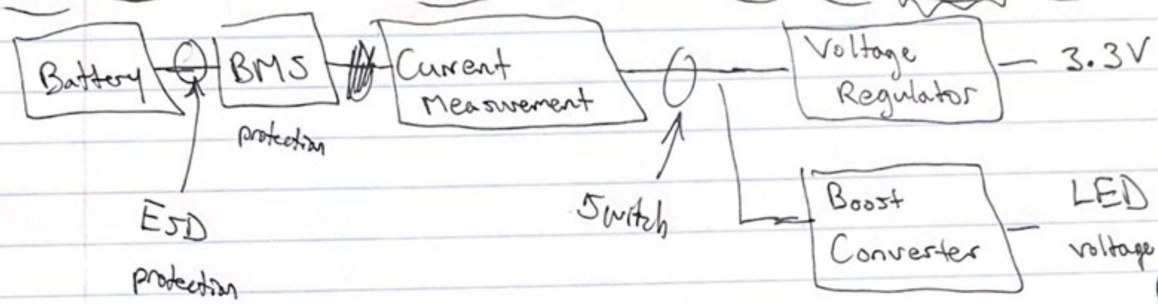


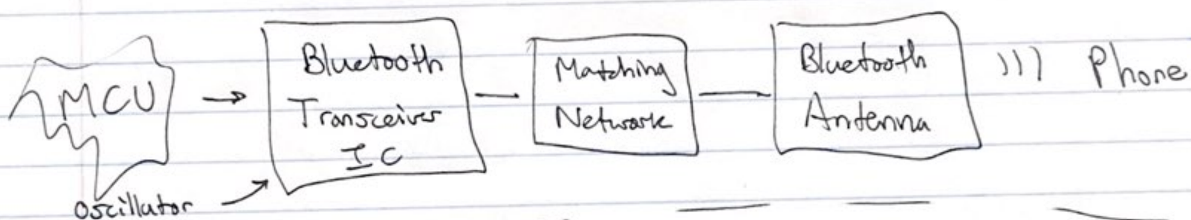
- transceiver IC interface
- matching network design (?)
- Oscillation circuit for transceiver

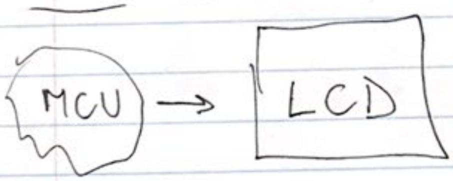


- protocols





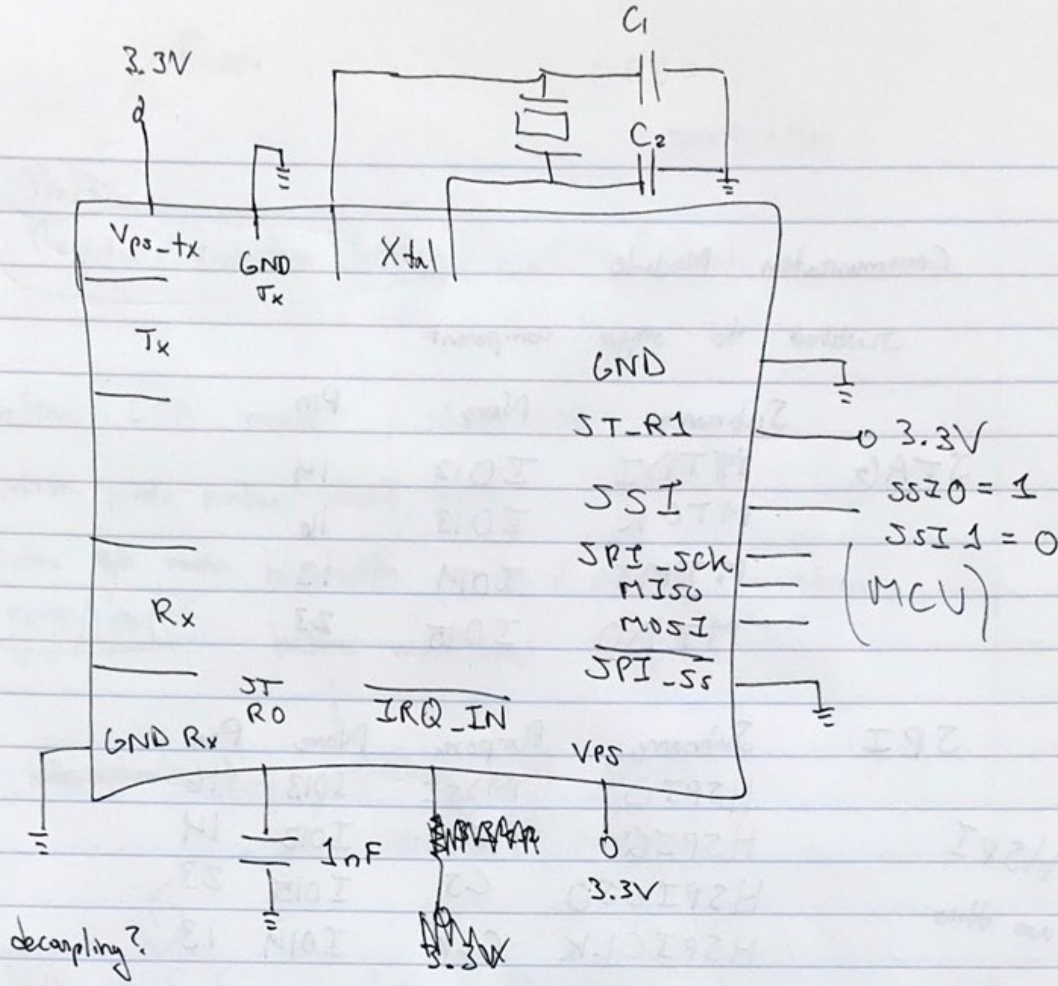




checking out tablet

device specific current draw

RF circuitry



(needs falling edge at startup)

to MCU

★ ~~communication~~ communication protocols specification block

tolerance analysis
(digital transfer / control through SPI reliable and robust with enough reading. and debugging)
(RF circuitry can be inconsistent due to high frequency effects leading to difficult application
↳ more for bluetooth since high 2.4 GHz signal

AC/DC charging circuit
Overall power consumption] separate PCB

design boost converter + power system components

finalize components and issues

Communication Module

switched to single component

	Subname	Name	Pin
JTAG	MTDI	IO12	14
	MTCK	IO13	16
	MTMS	IO14	13
	MTDO	IO15	23

SPI	Subname	Purpose	Name	Pin
HSPI can't use this	HSPID	MOSI	IO13	16
	HSPIQ	MISO	IO12	14
	HSPICS0	CS	IO15	23
	HSPICLK	CLK	IO14	13
VSPI	VSPID	MOSI	IO23	37
	VSPIQ	MISO	IO19	31
	VSPICS0	CS	IO5	29
	VSPICLK	CLK	IO18	30

Reset

GPIO

specification

Startup

Register / Interface Config / GPIO / Clock

Define LCD mode / Start LCD

(refresh, pixels, porches, clock, pins)

Define ~~BLE~~ ~~mode~~ bluetooth mode / pairing operation

~~main loop~~ before main loop

~~Interrupt based~~ polling based RFID

since SPI interface

User input to game type + # players

before checking for RFID

Each loop is data update for display

(single frame, not ton of changes) better for memory space

poll for RFID, poll for battery,

interrupt for some battery problems?

$P_{in(max)} = \frac{0.48}{0.7} \approx 0.7W$ 210 mA

$P_{out} = 9.6(0.05) \approx 0.48W$ $I_{in(max)}$

$V_{in(min)} = 3.3V$ $V_{in(max)} = 3.7V$

$V_{out} = 9.6V$ $I_{out(max)} = 50mA$ $(40 * 1.25)$ safety)

$$D = 1 - \frac{V_{in(min)} * \eta}{V_{out}} = 1 - \frac{3.3 * 0.7}{9.6}$$

continuous conduction mode

$D = 0.76$ CCM for us since LED backlight always on

★ Assume low efficiency $\eta = 0.7$

Switching consideration

$V_{in(max)} = 3.7V$

$$I_{peak} = I_{out(max)} + I_{ripple} = \frac{P_{in(max)}}{V_{pv}} + \Delta \frac{P_{in(max)}}{V_{pv}}$$

Δ depends on inductor

Inductor → large = slow start (recommended ferrite core)

small = higher current ripple

(low DC resistance coil)

$V_{in} = 3.3 - 3.7$ $\quad I_{in} = 210 \text{ (max) } mA$ $\quad P_{in} = 0.7\,W$

$V_{out} = 9.6$ $\quad I_{out} = 50 \text{ (max) } mA$ $\quad P_{out} = 0.48\,W$

~~AN~~ reference with $\boxed{L = 10\,\mu H}$ $\quad V_D \simeq 0.4V \quad 500kHz = f$

CCM.

$$I_{pk} = \frac{V_{out} + V_D}{V_{in}} \cdot I_{out} + \frac{(V_{out} + V_D - V_{in}) \cdot V_{in}}{2 \cdot (V_{out} + V_D) \cdot f_{osc} \cdot L}$$

$$= \frac{9.6 + 0.4}{3.3}(0.05) + \frac{(9.6 + 0.4 - 3.3)(3.3)}{2(9.6+0.4)(500 \times 10^3)(10 \times 10^{-6})}$$

$$= \cancel{0.373\,A}$$

$\boxed{V_D = 0.4V}$

$R_{osc} = 250k\Omega \rightarrow 500\,kHz$

$R_{duty} = 230 - 250k\Omega \rightarrow 84 - 85\,\%$ max duty

$C_{sp} \sim 0.05\,\mu F$

R_{FB1} $\quad$ ~~RFB2 ≈ 40k~~

$\hookrightarrow 82k \quad R_{FB2} = 9.5k$

LDO →

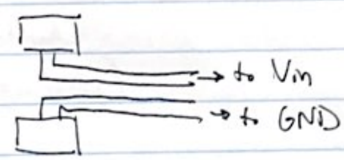
- no voltage source on other side so no reverse current low (1A peak maybe from ~~inductor~~/cap energy storage but this is unlikely and acceptable
- very low dropout
  (good for source range 3-3.7 and output 3.3
- shows following when below 3.3
- accepts up to 1.5A current
- LDO for low noise and EMI around computer parts + RF signals
  (charger Buck for larger drop + more efficiency + less need for low EMI)

$$R_2 = R_1\left(\frac{V_{out}}{1.216} - 1\right) = 17.138k$$

$C_{in} = 68\,\mu F$ ESR $< 100\,m\Omega$ ✓

$C_{out} = 33\,\mu F$ (Tantalum) ESR $\leq 1.6\,\Omega$

Kelvin connect Caps



Buck Controller

$$\cancel{L = \frac{V_{out} \times (V_{in(max)} - V_{out})}{V_{in(max)} \times f_s \times 0.2 \times I_{out(max)}}}$$

Charging current = 1.5A then

$I_{out(max)} = 2A$

$\cancel{R_{T2} = 1k\Omega \quad R_{T1} =}$

$R_2 = 47k$

$$\cancel{R_3(4.2) = 0.8(R_3) + 47}$$
$$\cancel{R_3 = 13.82\ k\Omega}$$

$R_{DS,on} \simeq 35\ m\Omega$

$$I_{ripple} = \frac{5-4.2}{5(500\times10^3)(3.36\times10^{-6})}(4.2) = \frac{0.8(4.2)}{8.4} = 0.4$$

$$L = \frac{4.2(5-4.2)}{5(500\times10^3)(0.2)(2)} = 3.36\ \mu H$$

$R_{ds} \approx 35\times10^{-3}$

$R_{SW} = 2\Omega$

$$I_L = 2 + \frac{1}{2(0.4)} = 3.25$$

$$R_{CS} = \frac{35 m\Omega}{200 \mu A}(3.25 A) = 569\ \Omega \qquad C_{ss} = 0.1\mu F$$

$$I_{pp} = \frac{4.2(5-4.2)}{5(500\times10^3)(3.36\times10^{-6})} = 0.4 \qquad I_{pk} = 2 + 0.2 = 2.2 ✓$$

$C_{in} =$ 100μF $C_{out} =$ 150μF tant

$R_3 = 8.2\,k\Omega$

$$R_2 = \frac{V_{ref} \times 8.2}{V_0 - V_{REF}} = 1.93\,k\Omega$$