

# Life-Watch

## Wearable Medical Device



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William Toledo – EE  
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and Computer Science**

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# Motivation

- Hospital miscommunication and errors 2,000 lives and \$1.7 billion, Up to 80% of serious medical errors due to miscommunication while transferring patients (Source: Joint Commission)
- Patients being confused for other patients
- Patients being sent to wrong areas of the hospital
- Worst case scenario, patients having wrongful surgeries



# Solution

- The use of modern integrated circuits to provide a cost-effective way to reduce cases of human error
  - Identify patients wirelessly
  - Track patient within hospital
  - Monitor heart rate
  - Provide emergency response system
  - Battery powered, wrist-worn device

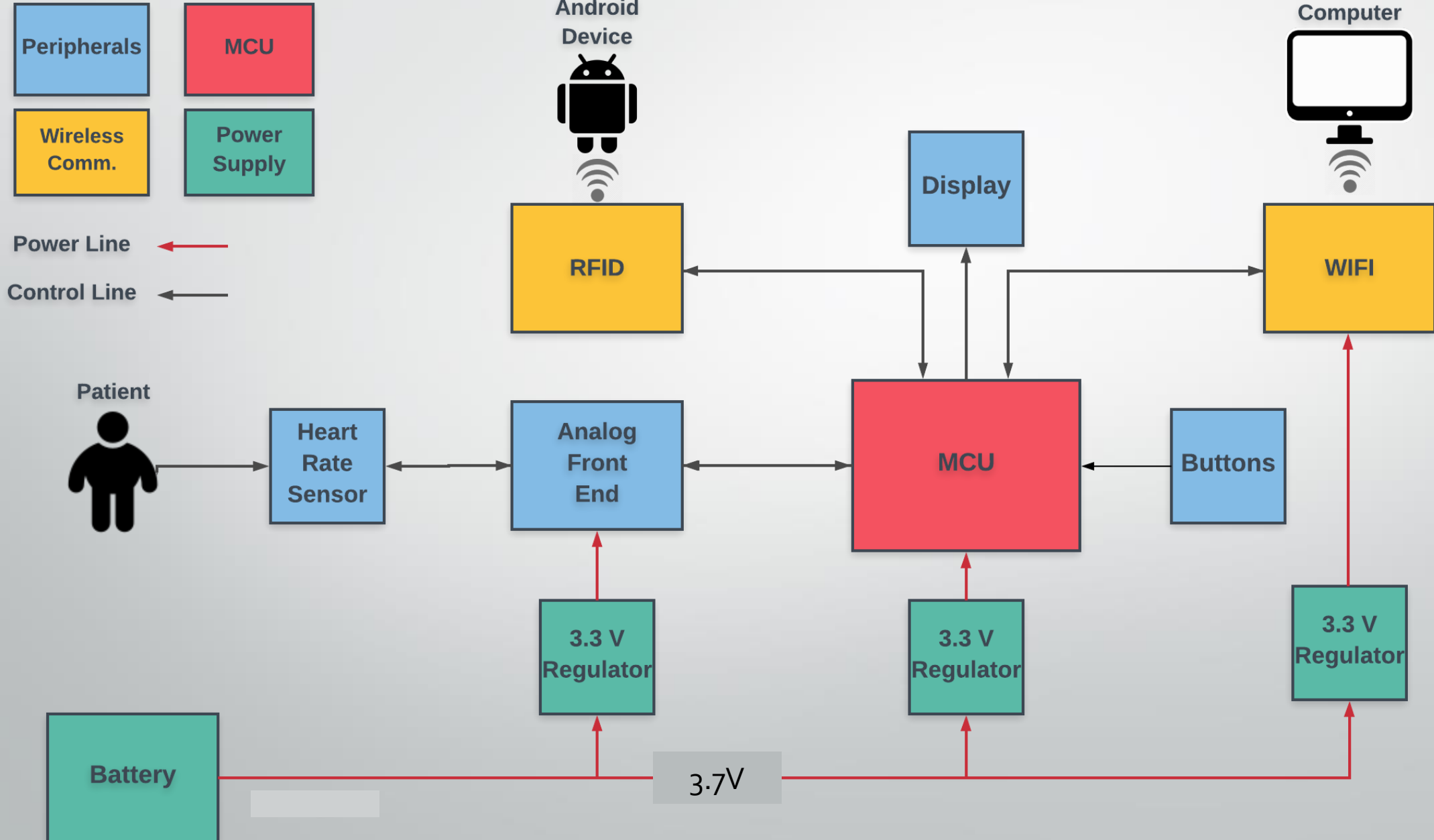


# Engineering Specifications

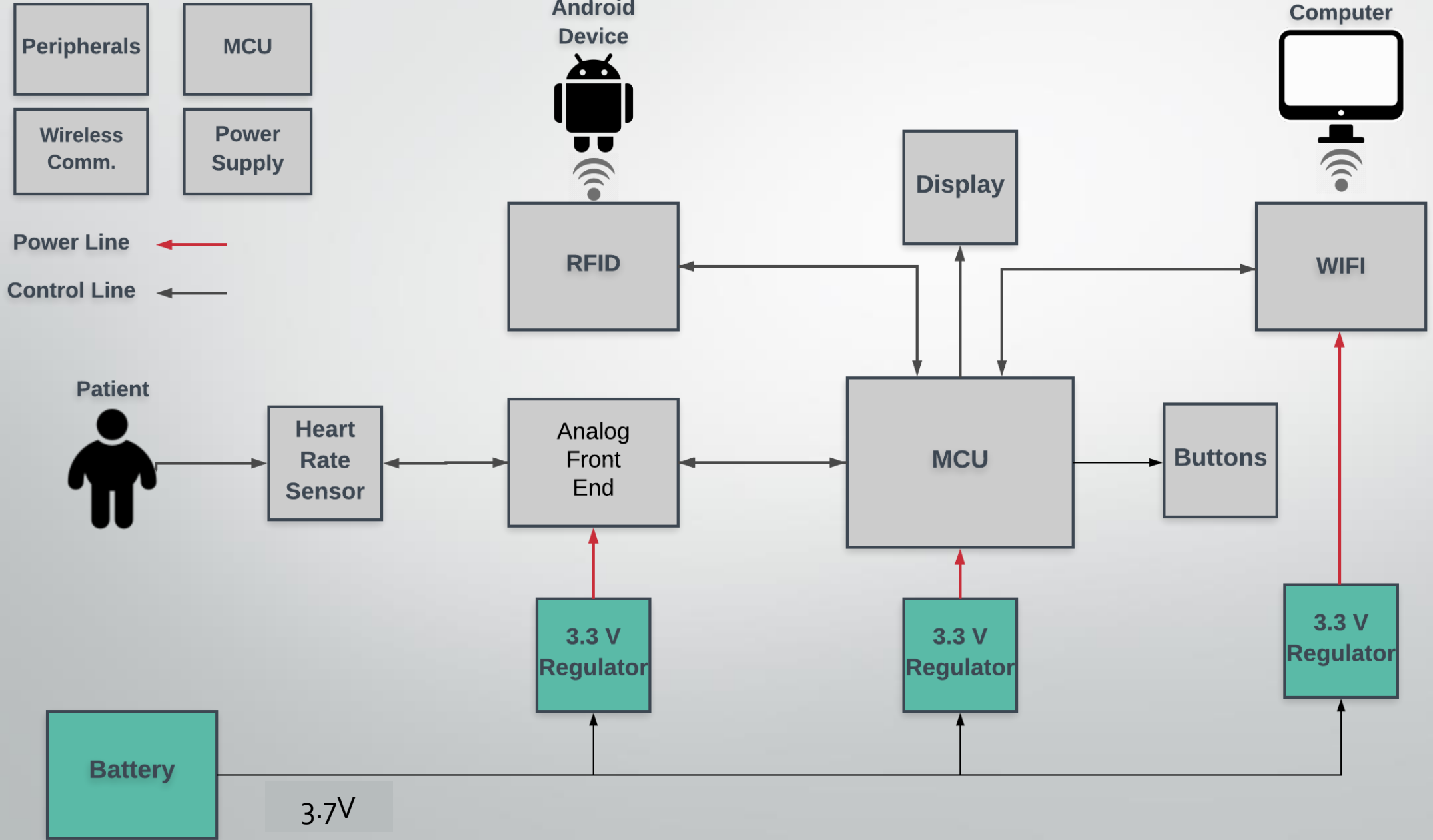
- 100x100 mm<sup>2</sup> PCB Area
- Weigh less than 300 grams
- 5 hour Battery Life
- Within 5m Location Accuracy of the patient
- Cost less than \$250



# Block Diagram



# Power Supply



# Voltage Regulators

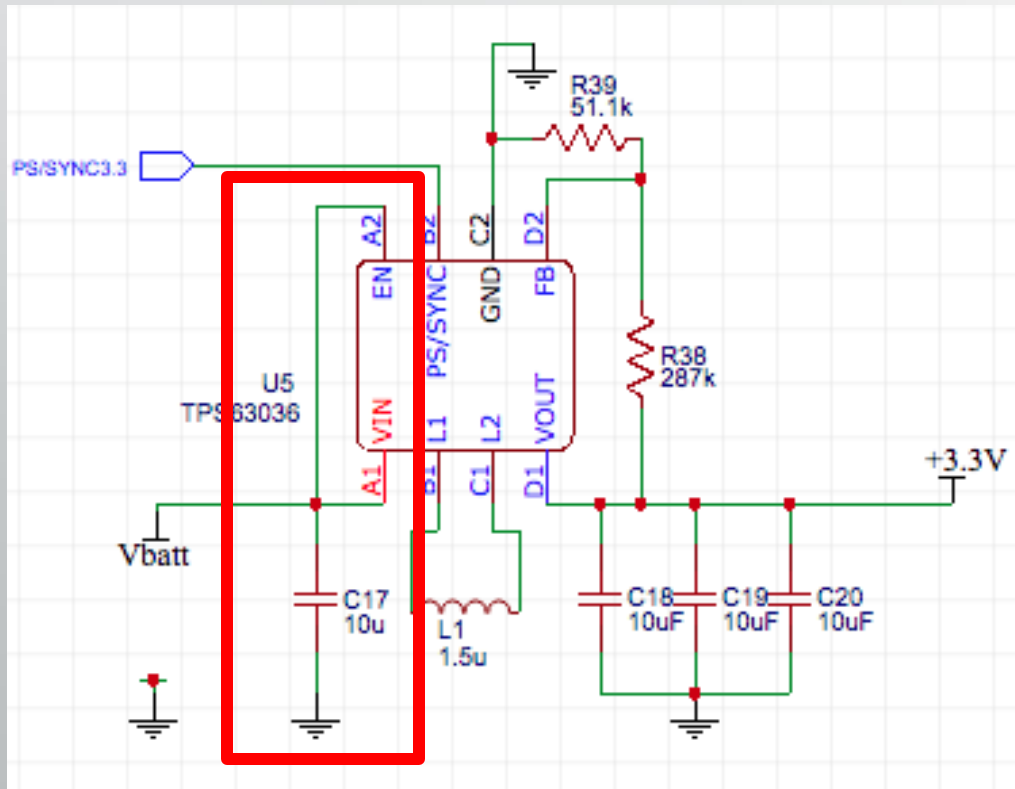


Spec	TPS63036	TI Reg 104-3.3
Input voltage	1.8V - 5.5V	4.2V-3.4V
Output voltage	1.2V - 5.5V	3.3V
Size	1.854 mm × 1.076 mm	2.9mm x 2.9mm
Cost	\$1.71	\$6.52

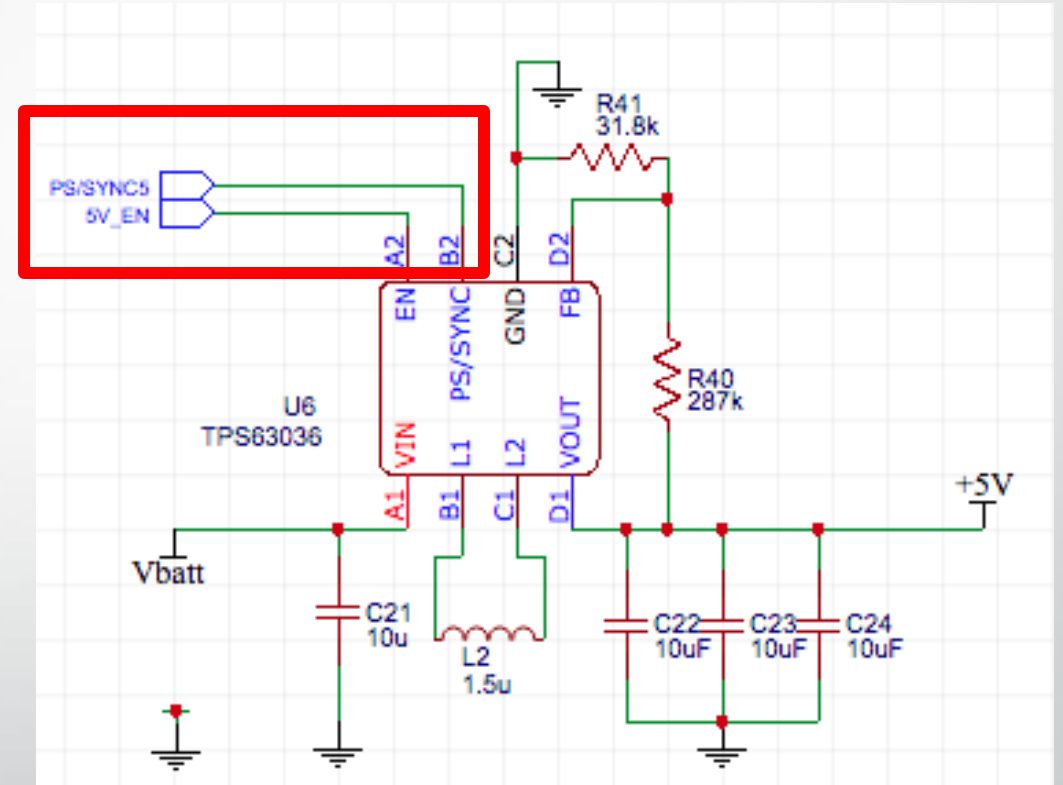


# Voltage Regulators TPS63036 Schematic

3.7V to 3.3V



3.7V to 5V

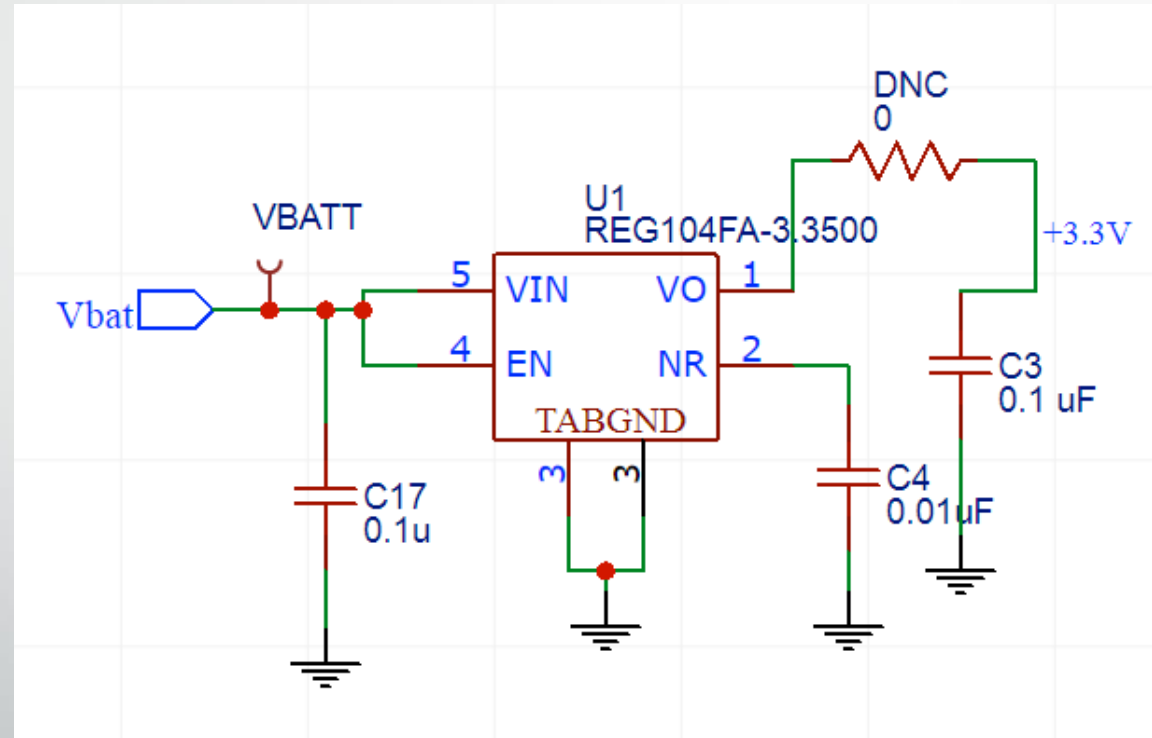


$$R1 = R2 \times \left( \frac{V_{OUT}}{V_{FB}} - 1 \right)$$



# Voltage Regulators TI Reg104-3.3 Schematic

3.7V to 3.3V



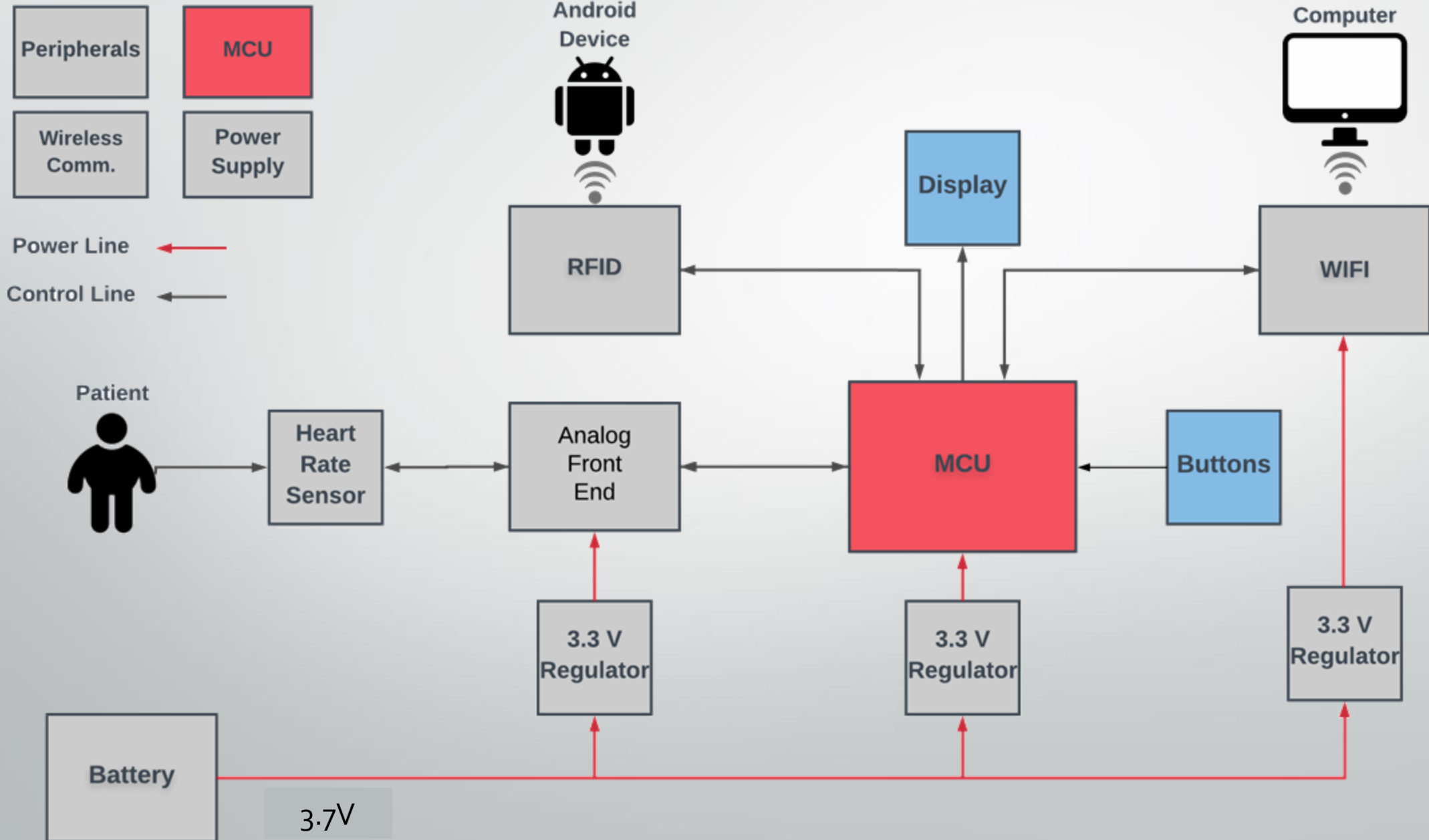
# Battery

Spec	EBL 18650 3.7V Li-ion	Adafruit 3.7V Li-Ion 2.5Ah
Capacity	3000 mAh	2500mAh
Size	3 x 1.6 x 1.8 inches	2" x 2.55" x 0.30" (51mm x 65mm x 8mm)
Cost	\$3.25	\$15.00





# MCU



# Communication Protocols

- *I2C*
  - ✓ *2 Wires, Simple*
  - X *Limited Addresses*
  - X *Slower, Pull-Up Resistors*
- *SPI*
  - ✓ *Unlimited Devices, Fast*
  - X *Enable pin per device; more I/O pins required*

Main Components	Serial Communication
NFC	I2C
WIFI	I2C or SPI
Analog Front End	SPI
Display	4 Pin Communication

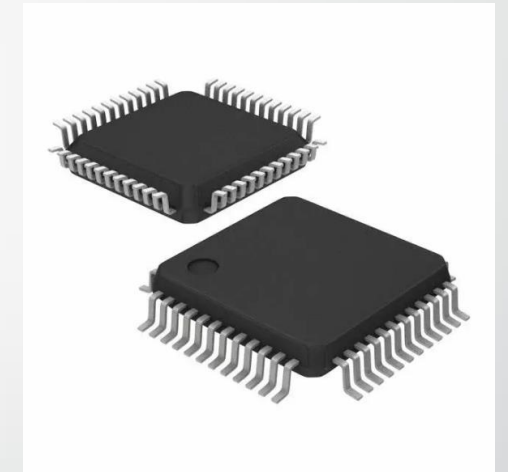
# Microcontroller

## MSP430FR4133

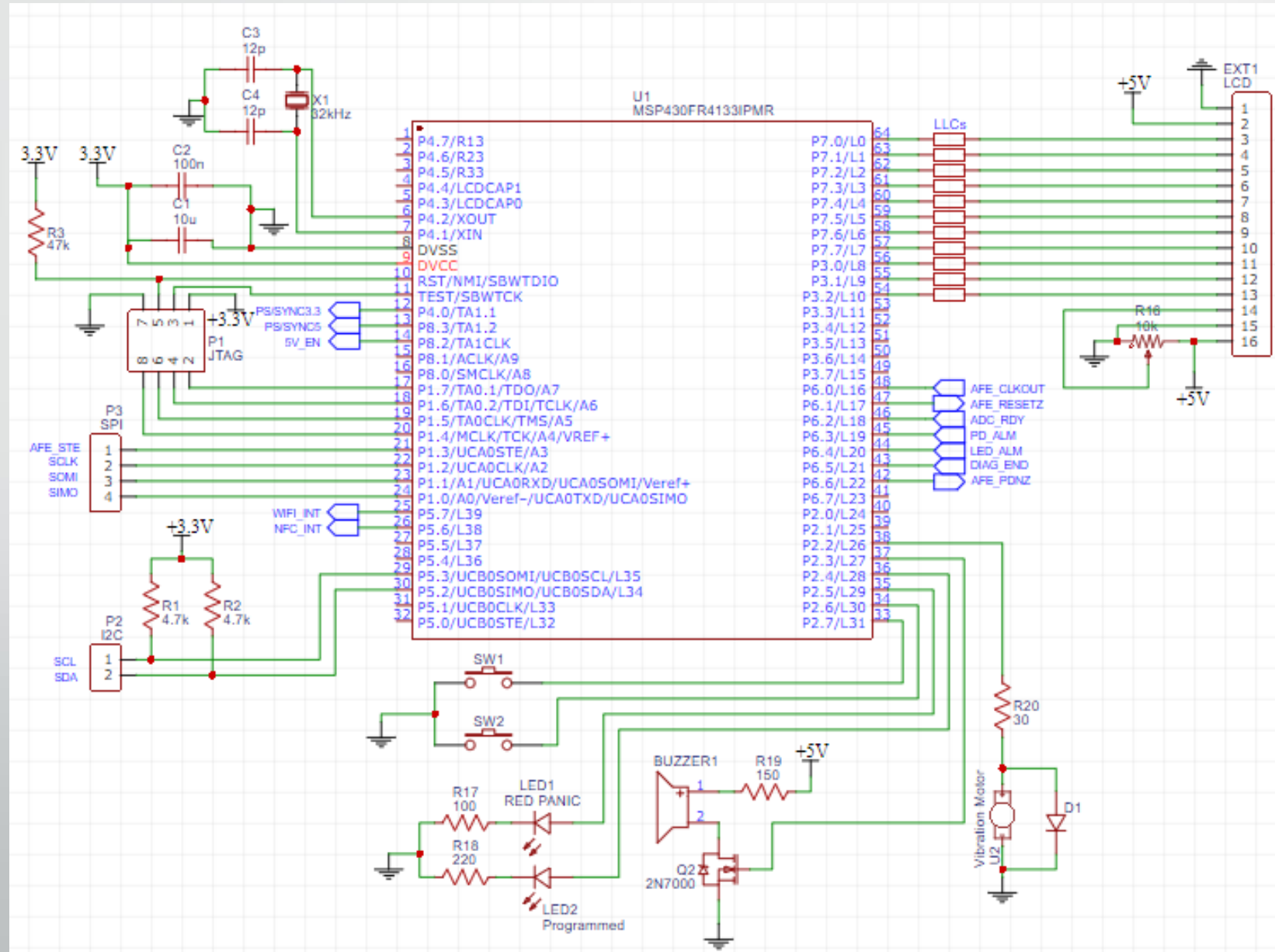
### *Main Requirements*

- *Low Power*
- *GPIO*
- *Serial Communications*
- *Helpful IDE, CCS*
- *Community*

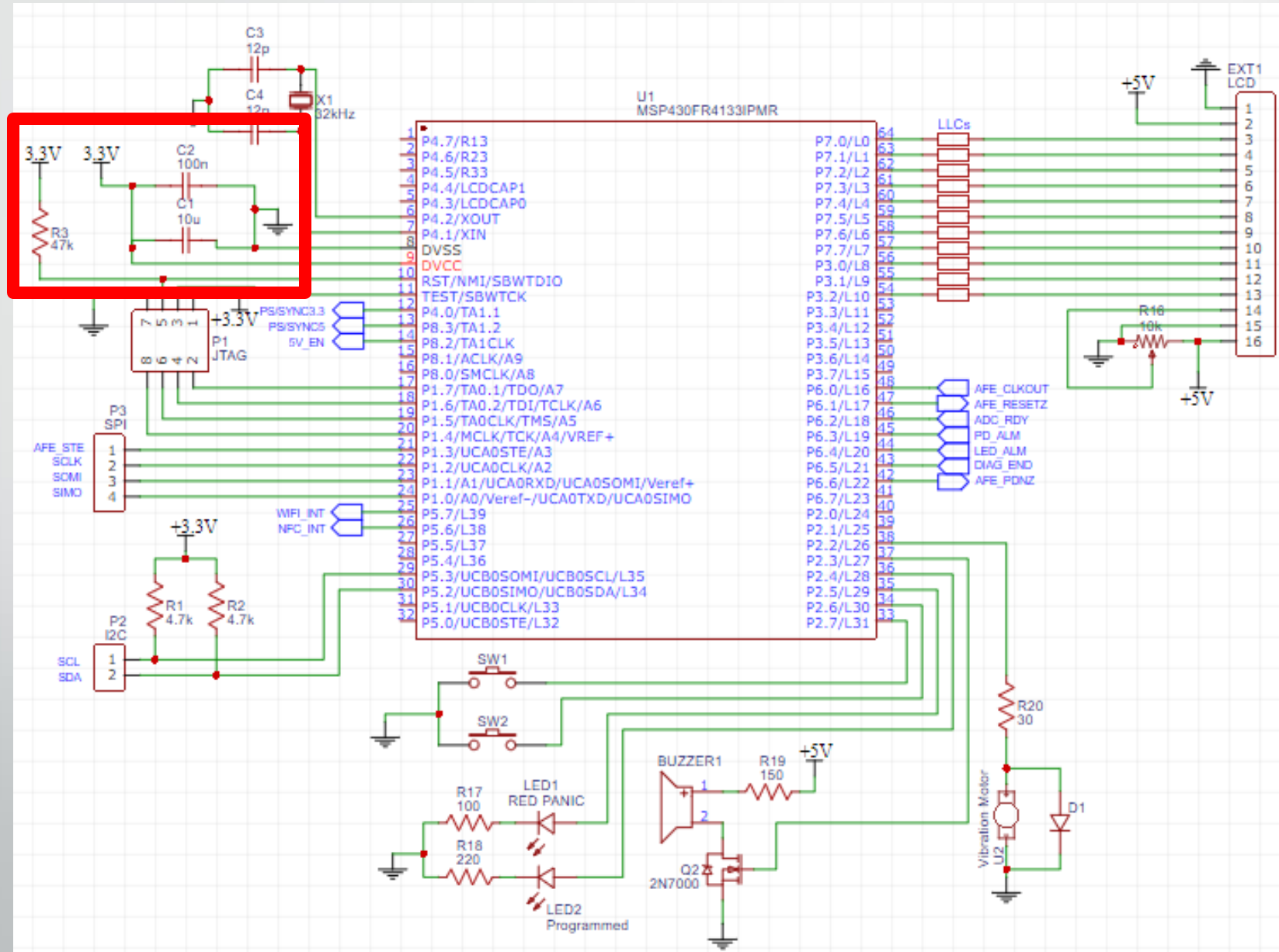
Spec	MSP430FR4133	ATmega328PB
Current	0.5mA	1.4mA
Idle Mode	0.77u	2.1uA
Low Power	80uA	2.1uA
Size	12.2x12.2mm <sup>2</sup>	9x9mm <sup>2</sup>
GPIO	60	27
Cost	\$1.21	\$1.61
Comm. Ports	1xI2C, 1xSPI	2xI2C, 2xSPI
Memory	16KB	32KB



# Microcontroller Schematic

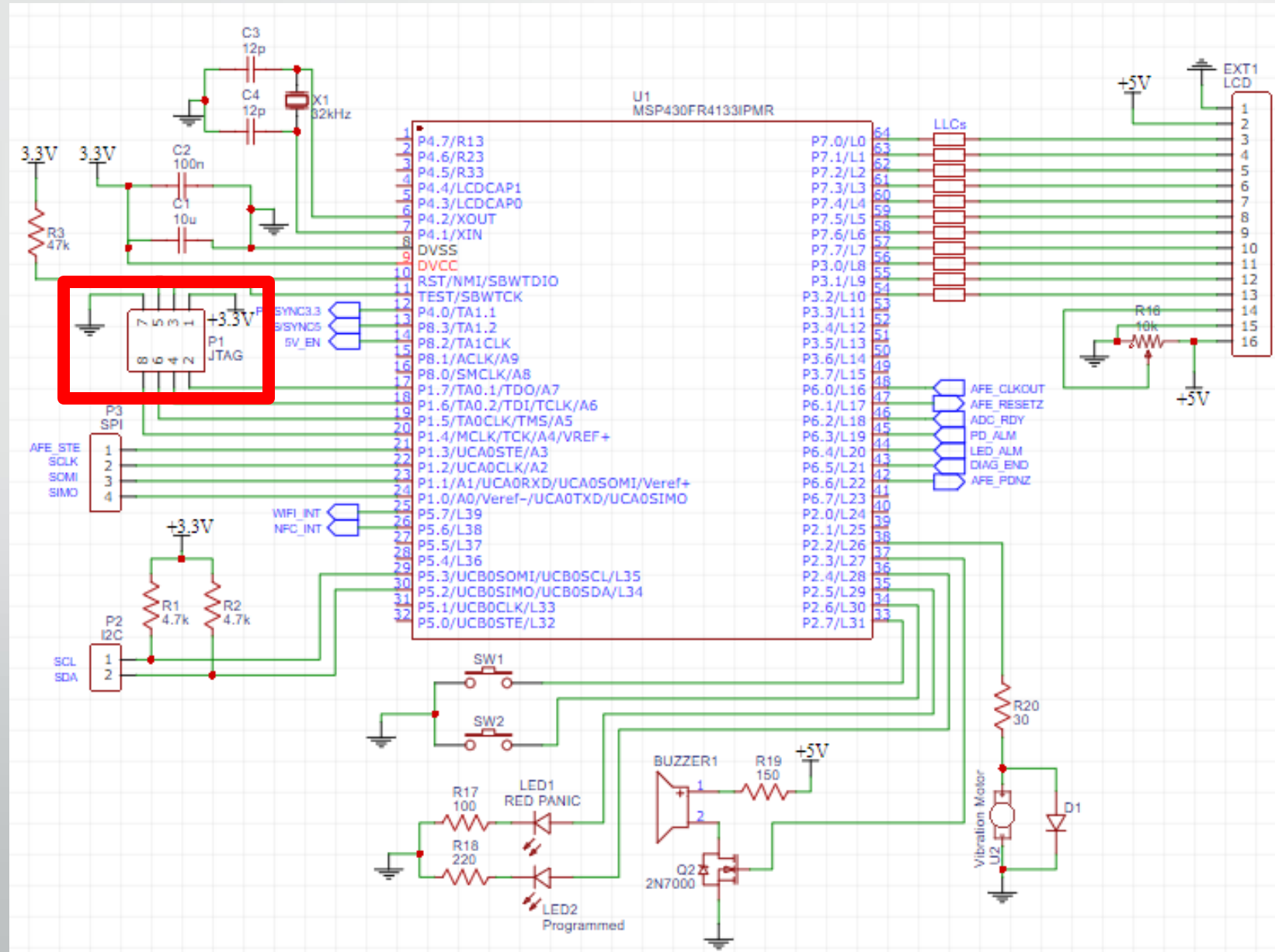


# Microcontroller Schematic

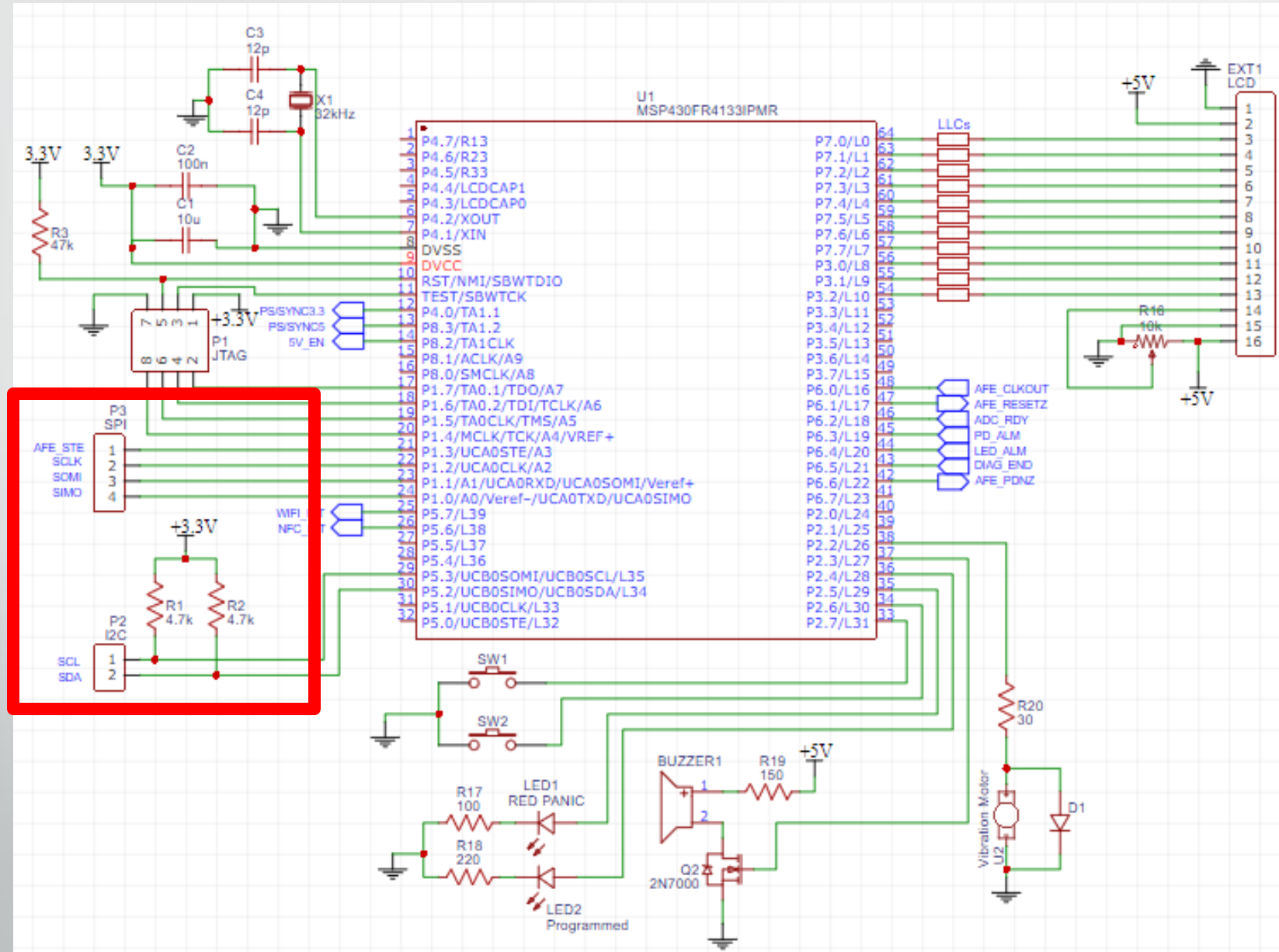




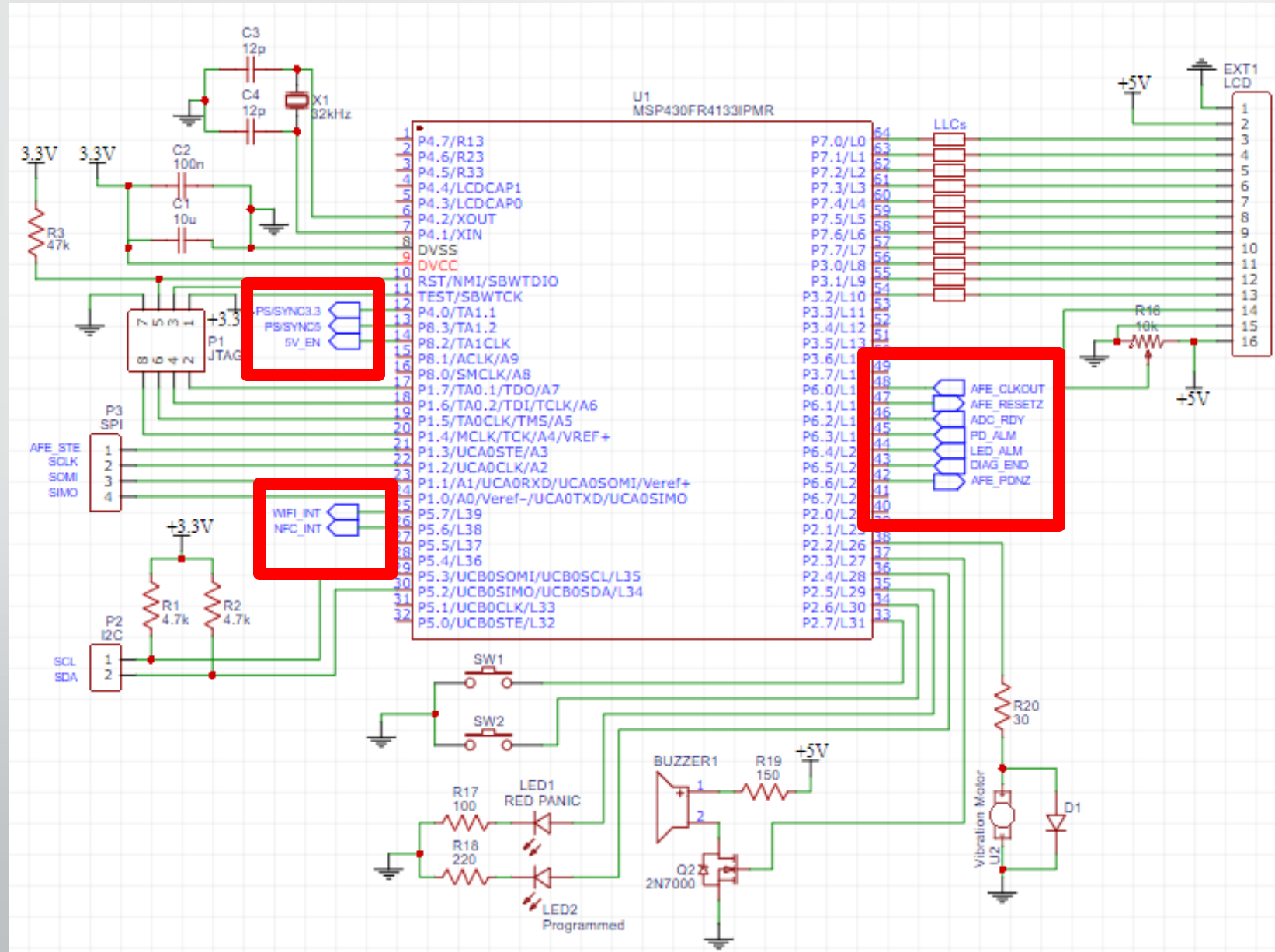
# Microcontroller Schematic



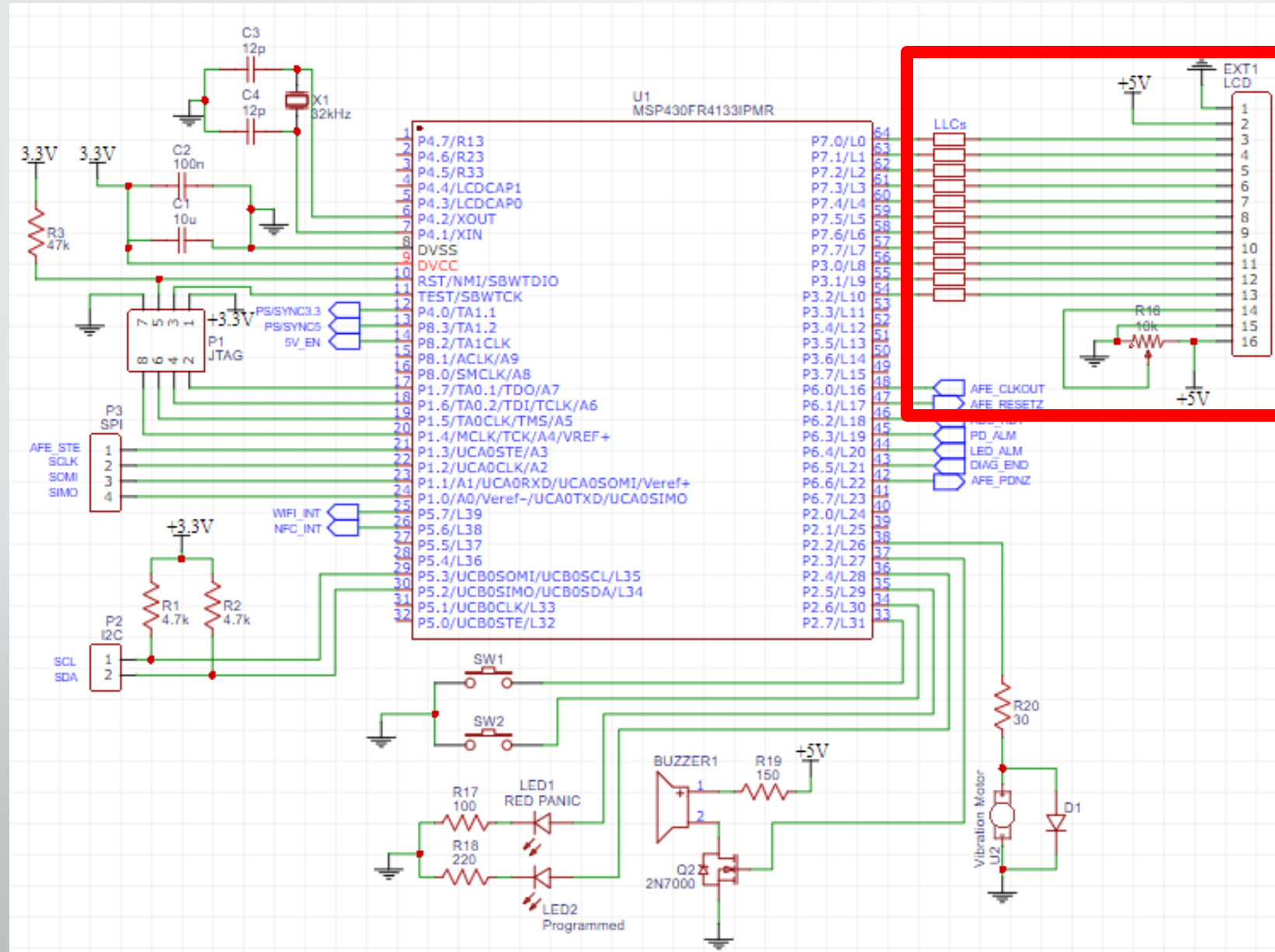
# Microcontroller Schematic



# Microcontroller Schematic



# Microcontroller Schematic



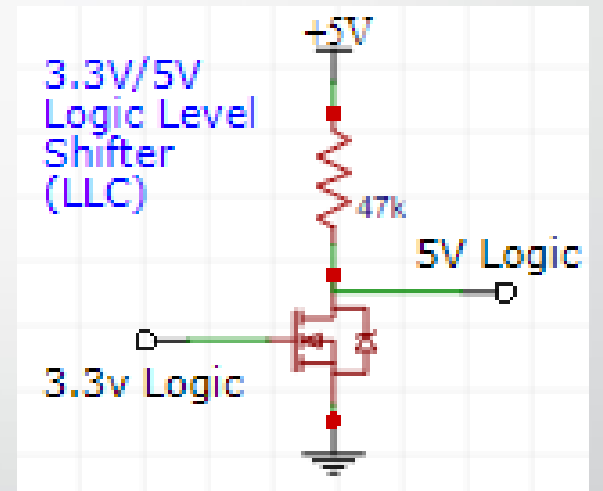
## Main Requirements

- *Small Size*
- *Use Few GPIO*
- *Adjustable Backlight*

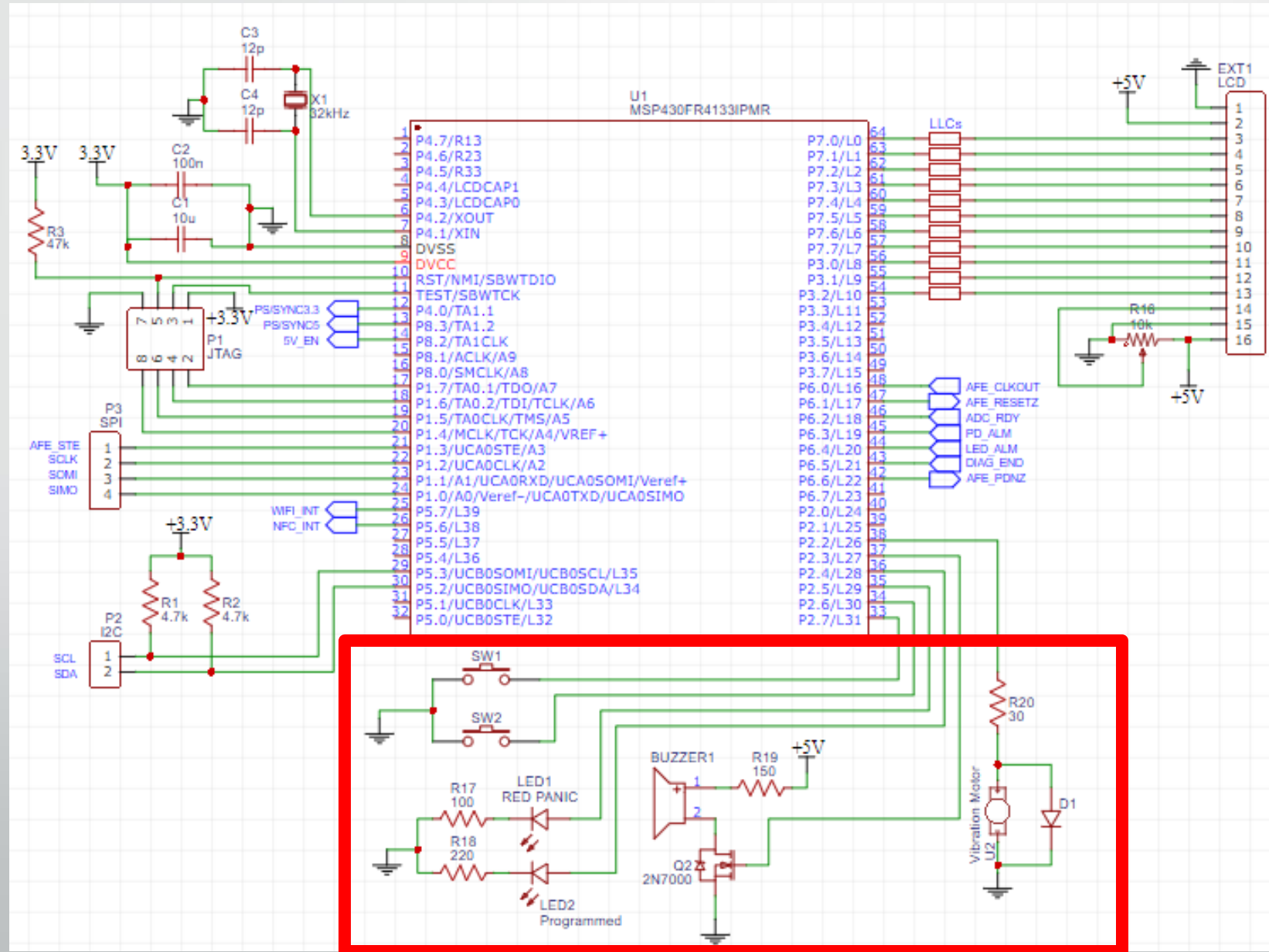


# LCD Display

Spec	NHD-C0216AZ-FSW-GBW	NHD-0216HZ-FSW-FBW-33V3C
Characters	16x2	16x2
Resolution	5x10 pixels	5 x 8 dots
Display	49.4x12.3mm <sup>2</sup>	54.00mm L x 14.40mm W
Total Size	54.6x25.3mm <sup>2</sup>	65.50mm x 36.70mm x 15.00mm
GPIO	4 or 8	4 or 8
Cost	\$10.11	\$11.60
Logic	5V	3.3V

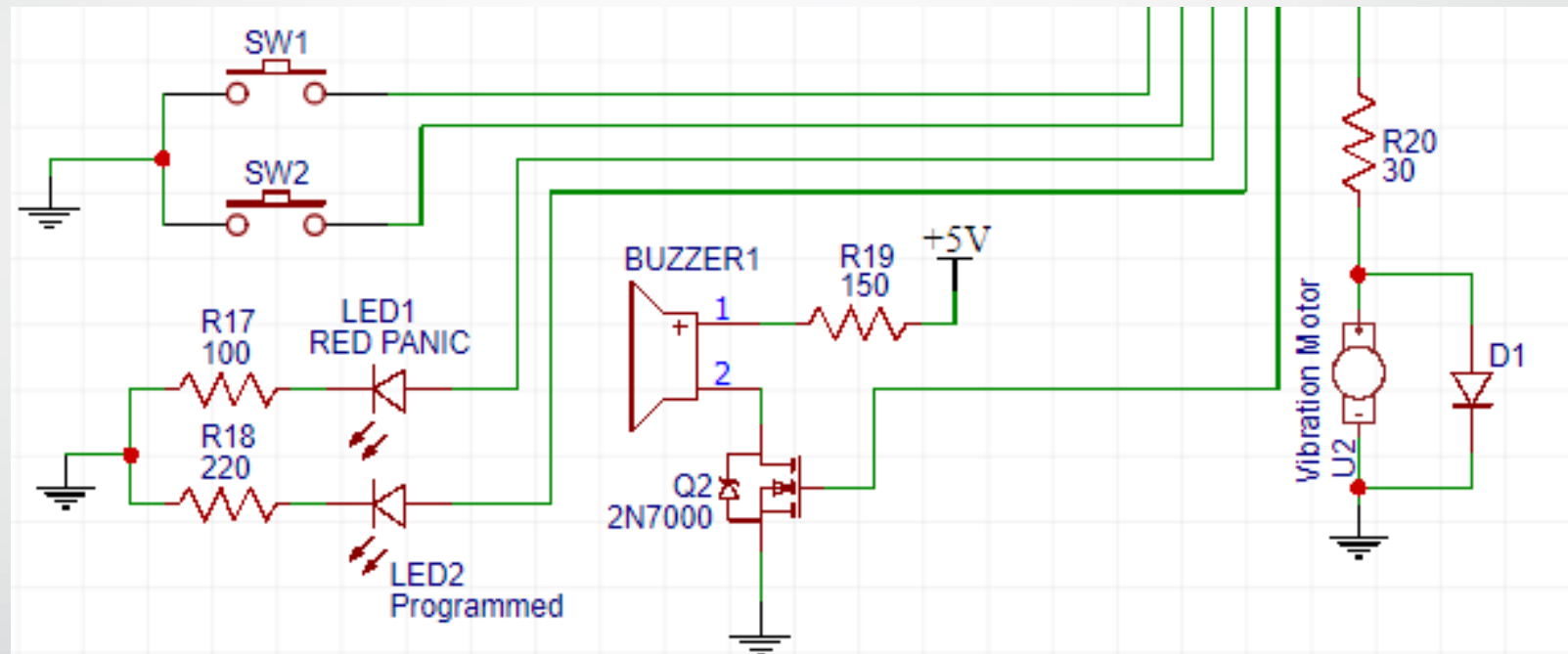


# Microcontroller Schematic



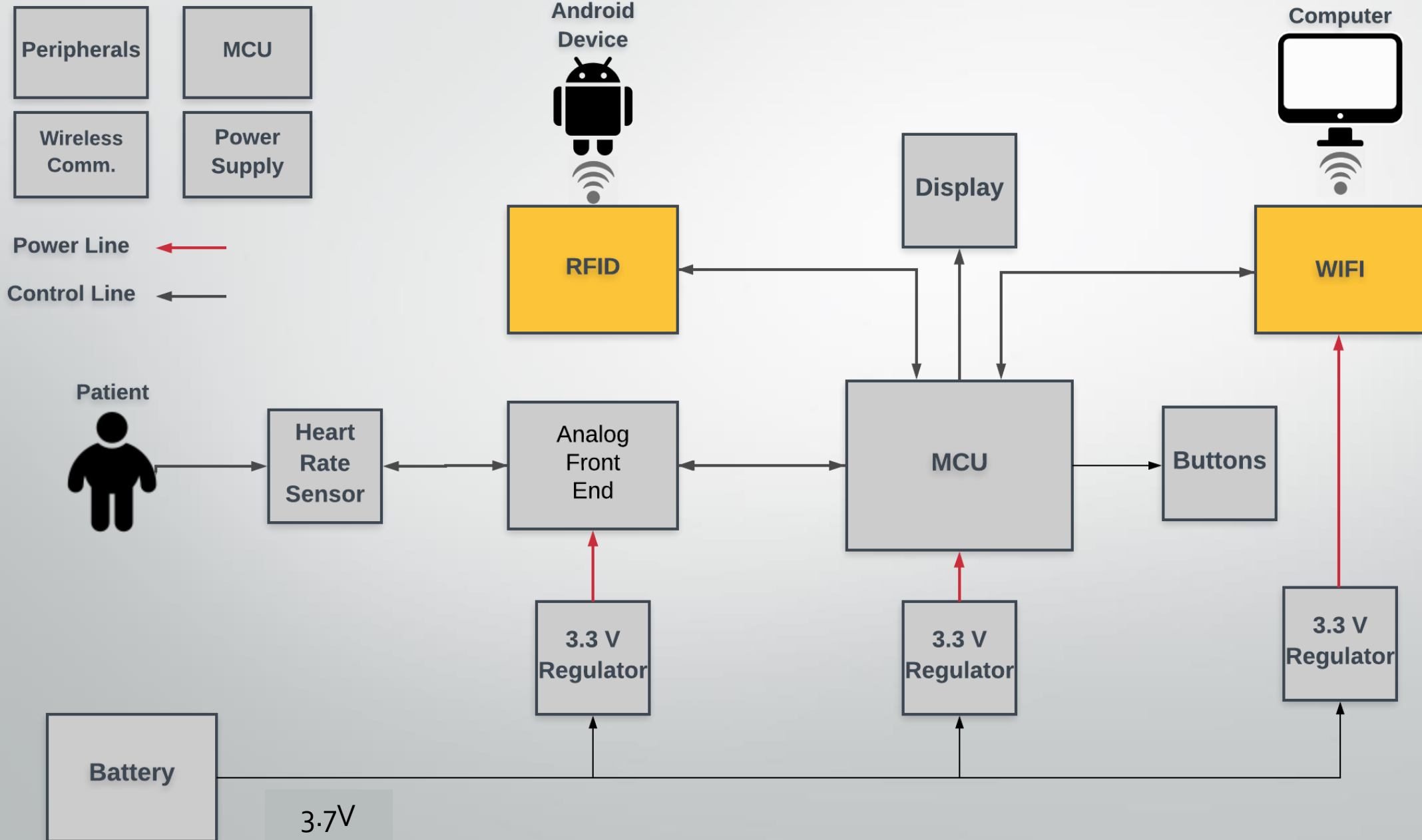
# Emergency Response

- *Two Buttons, Long Press*
- *Turn on alarm*





# Wireless Communication





# WIFI

- Indoor Localization
- Communicate Data to Computer

# Data Communication

- Data sent over LAN to computer
- Computer will be responsible for:
  - Data Storage
  - Data processing (Localization)

# WIFI Chip

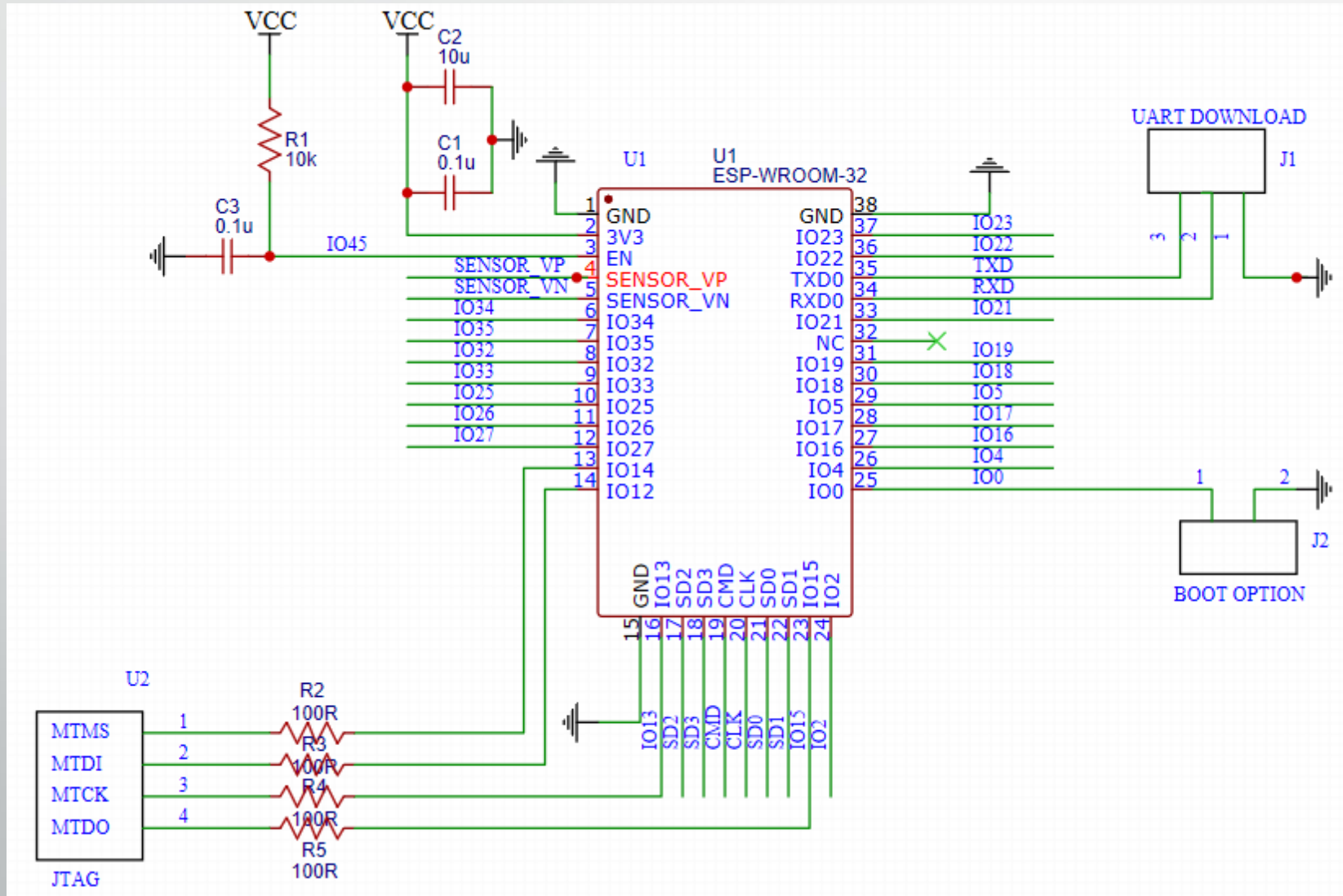
## ESP32

- Two main requirements:
  - Integrated antenna
  - Good development support
- ESP32 was chosen

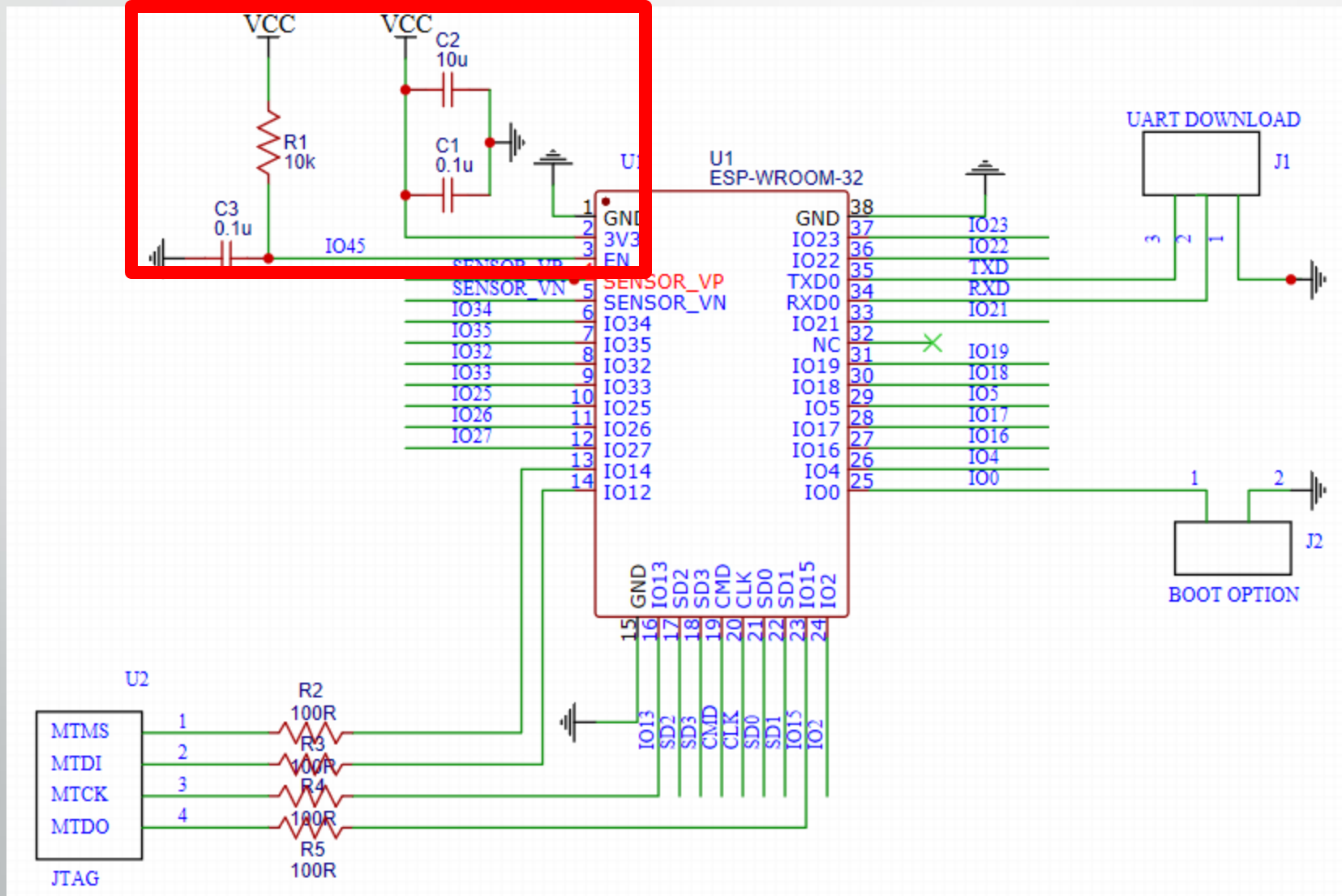
Spec	ESP32	CC3220
Current (mA) (LP Mode)	0.8 to 31 mA 240, 100 (Tx, Rx)	0.710 (DTIM 1) 286, 74 (Tx, Rx)
Size ( $mm^2$ )	25.50 x 18	20.5 x 25.50
Cost	\$3.80 (mod.) \$10.00 (dev)	\$ 11.69 (mod.) \$ 59.99 (dev)
Technology	BLE & BT 4.2	N/A



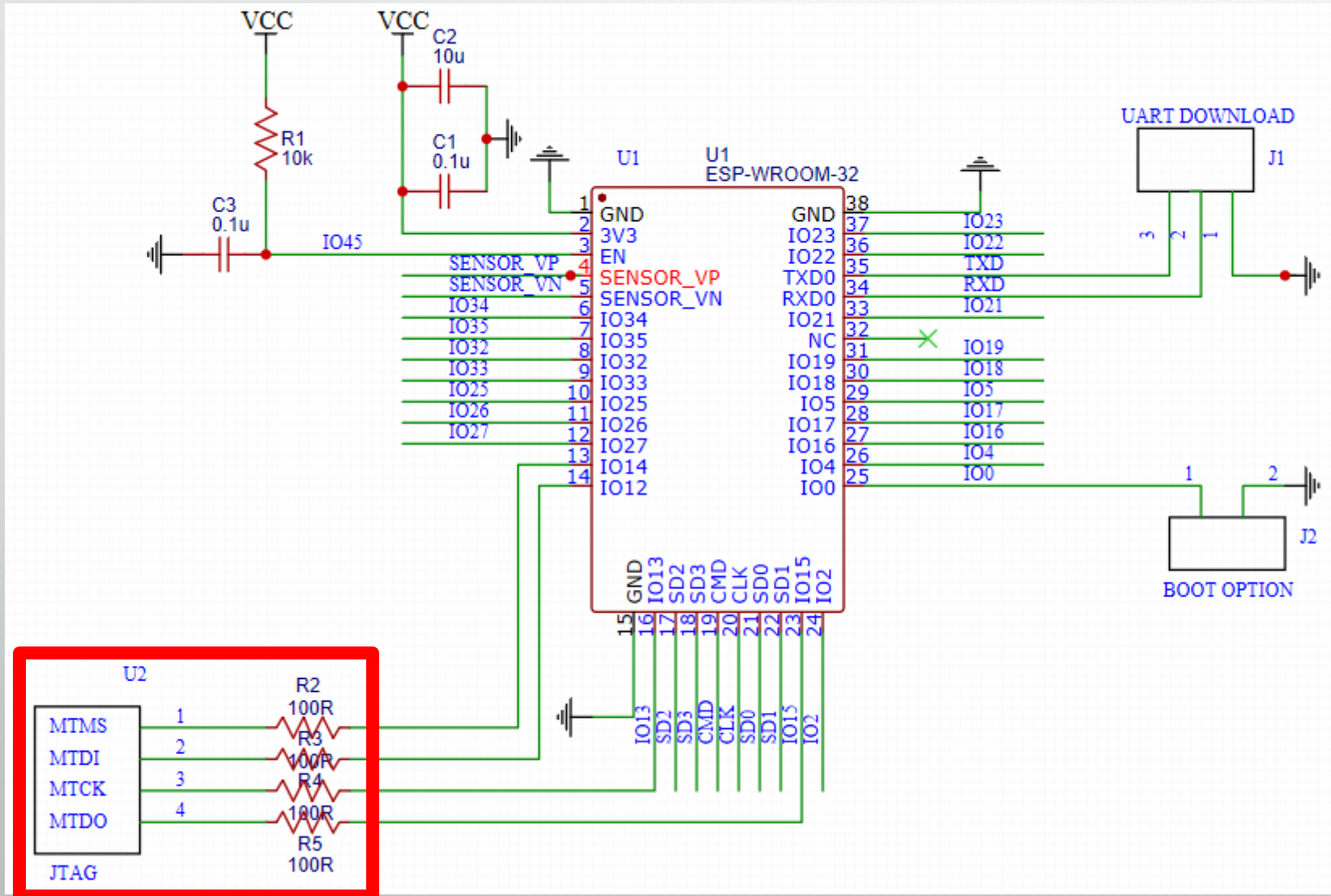
# WIFI Schematic



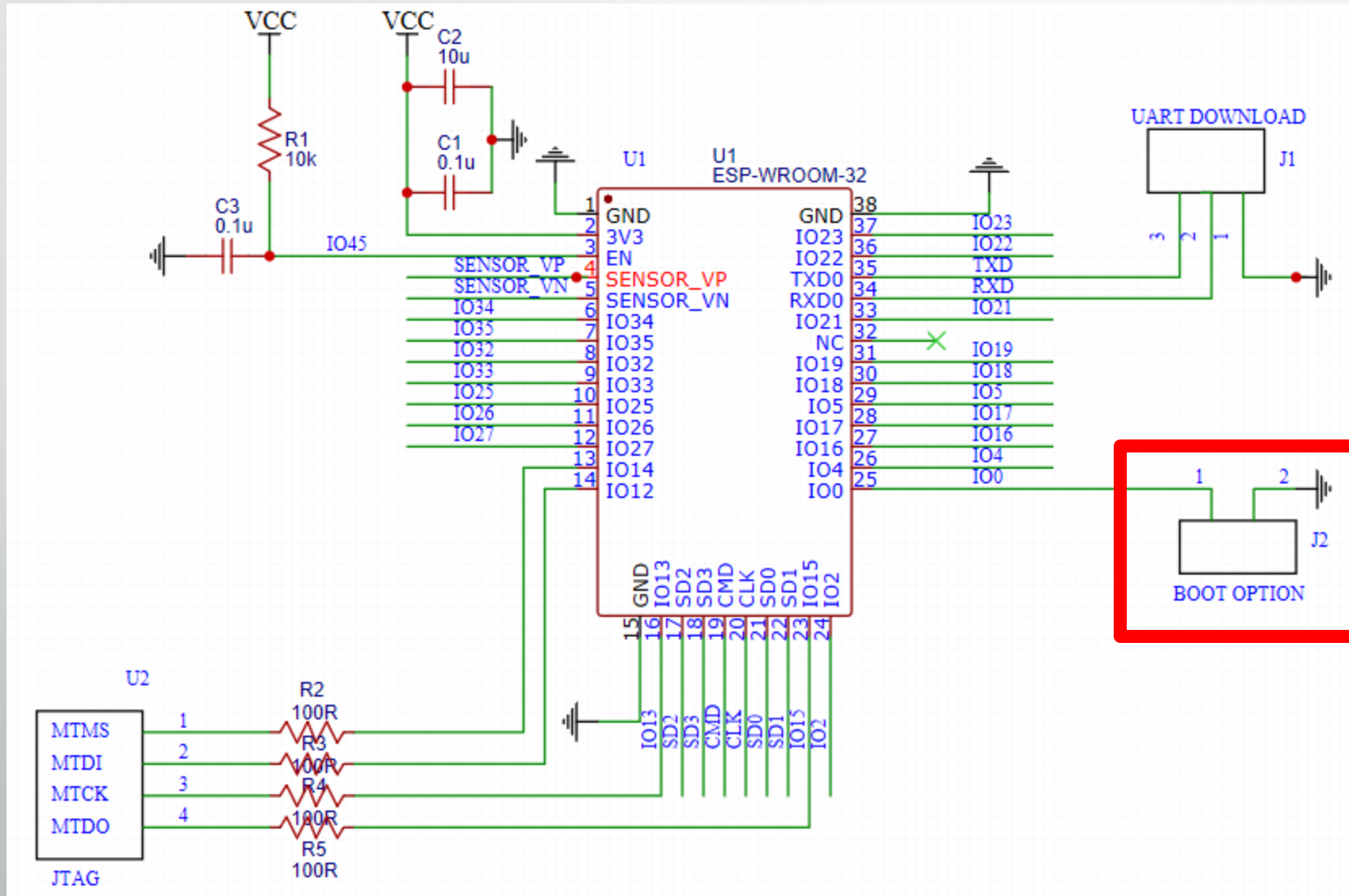
# WIFI Schematic



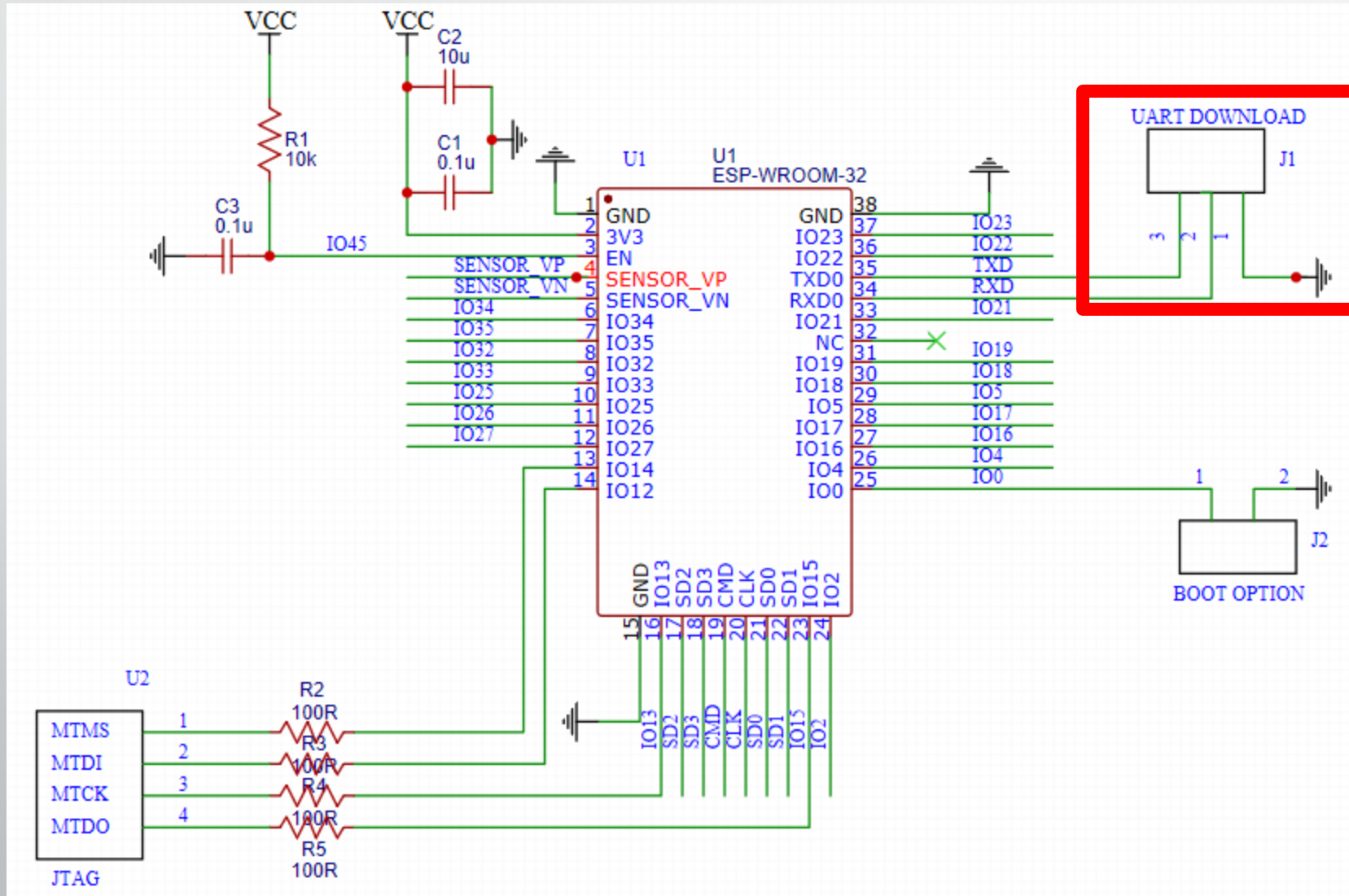
# WIFI Schematic



# WIFI Schematic



# WIFI Schematic





# NFC Chip

- Quick wireless Patient Identification
- NFC will identify which patient it is, then access their medical information over WIFI on the android device
- Not secure enough according to HIPPA (Health Insurance Portability and Accountability Act)



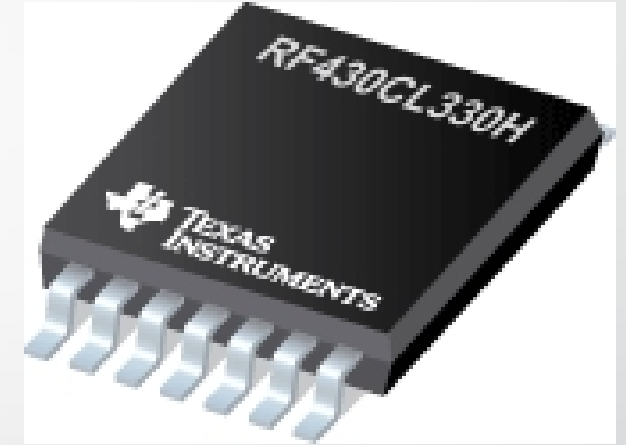
# NFC

## RF430CL330H

Includes:

- Direct Connect to MSP430
- Close range for pickup
- Read and write
- 3KB of SRAM
- Very Compact

Spec	Chosen Device
Current	2 mA
Size	5 mm x 4.4 mm
Cost	\$1.16
Serial Com	I2C or SPI
Frequency	13.56 MHz

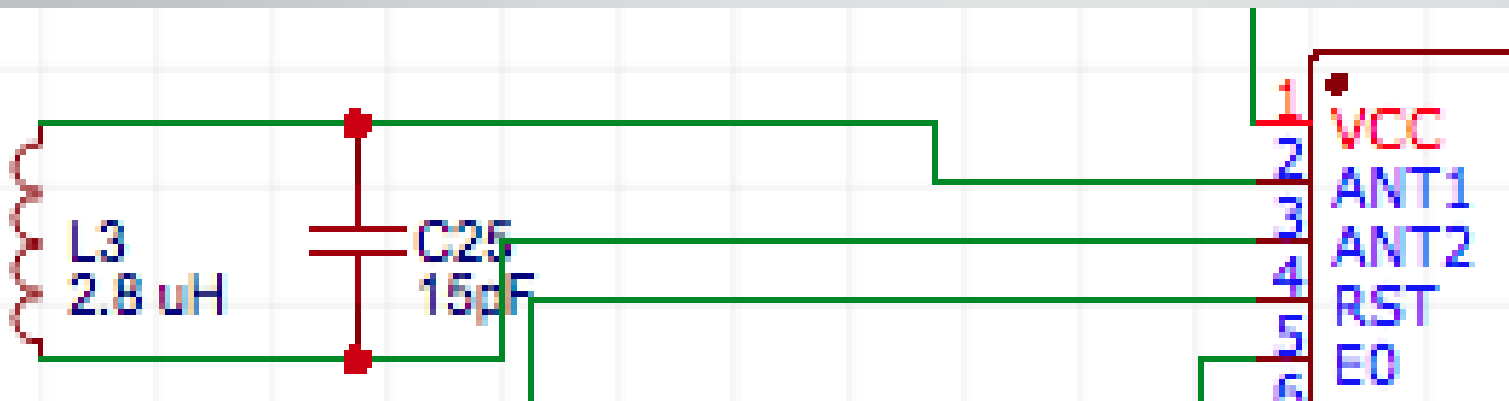
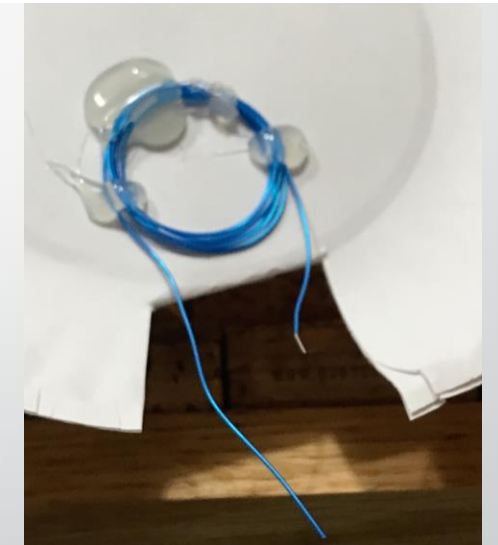


# Antenna design

- The closer to 13.56MHz, the better the pick up range for android device
- Created our own antenna for testing by using formula

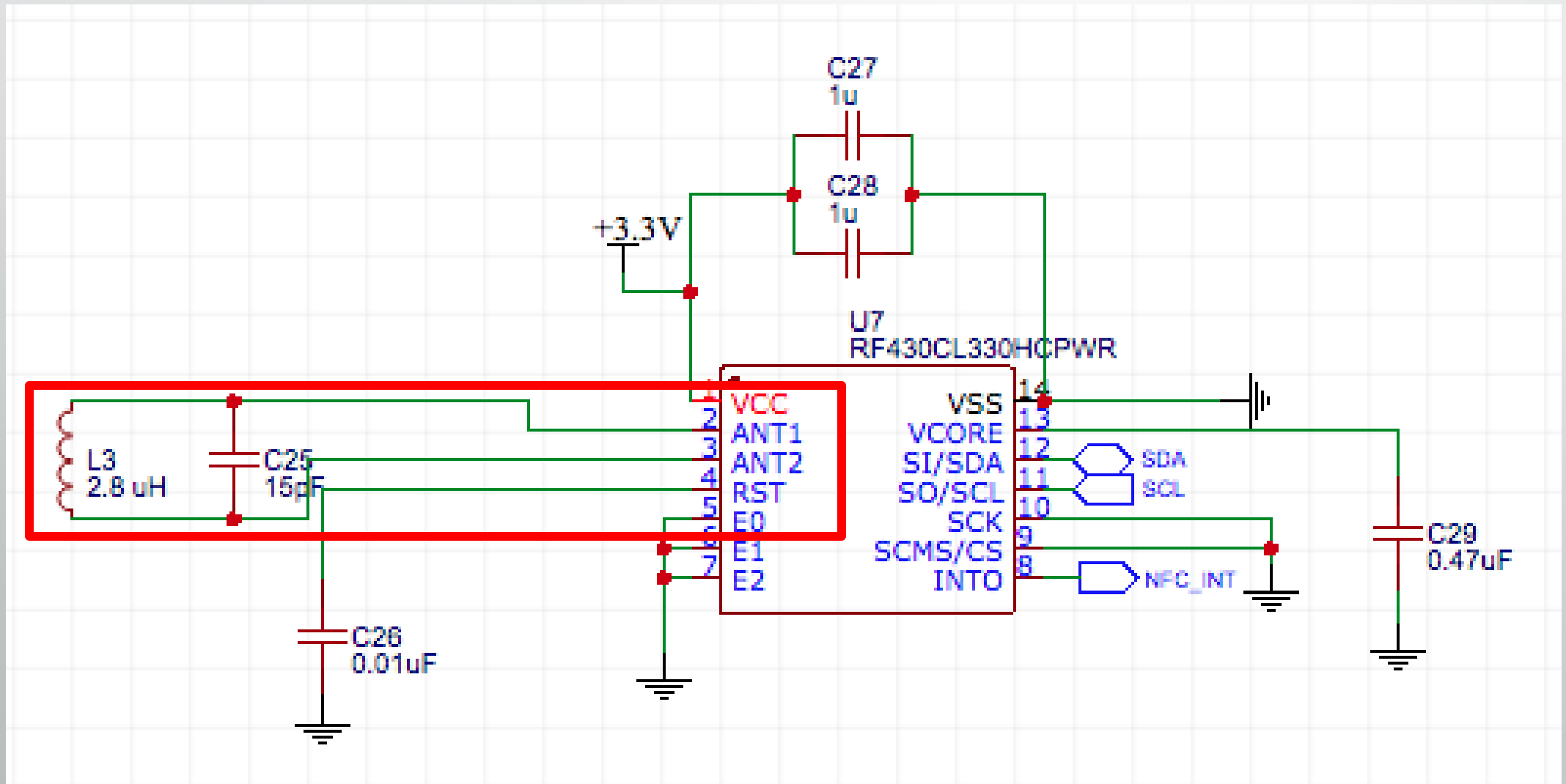
$$L_{loop} \approx N^2 \mu_o \mu_r \left( \frac{D}{2} \right) \cdot \left( \ln \left( \frac{8 \cdot D}{d} \right) - 2 \right)$$

		MIN	NOM	MAX	UNIT		
$f_c$	Carrier frequency		13.56		MHz		
$V_{ANT\_peak}$	Antenna input voltage			3.6	V		
Z	Impedance of LC circuit	6.5		15.5	kΩ		
$L_{RES}$	Coil inductance <sup>(1)</sup>		2.66		μH		
$C_{RES}$	Total resonance capacitance <sup>(1)</sup> $C_{RES} = C_{IN} + C_{Tune}$		51.8		pF		
$C_{Tune}$	External resonance capacitance		$C_{RES} - C_{IN}^{(2)}$		pF		
QT	Tank quality factor		30				
$C_{IN}$	Input capacitance	ANT1 to ANT2, 2 V RMS		31.5	35	38.5	pF

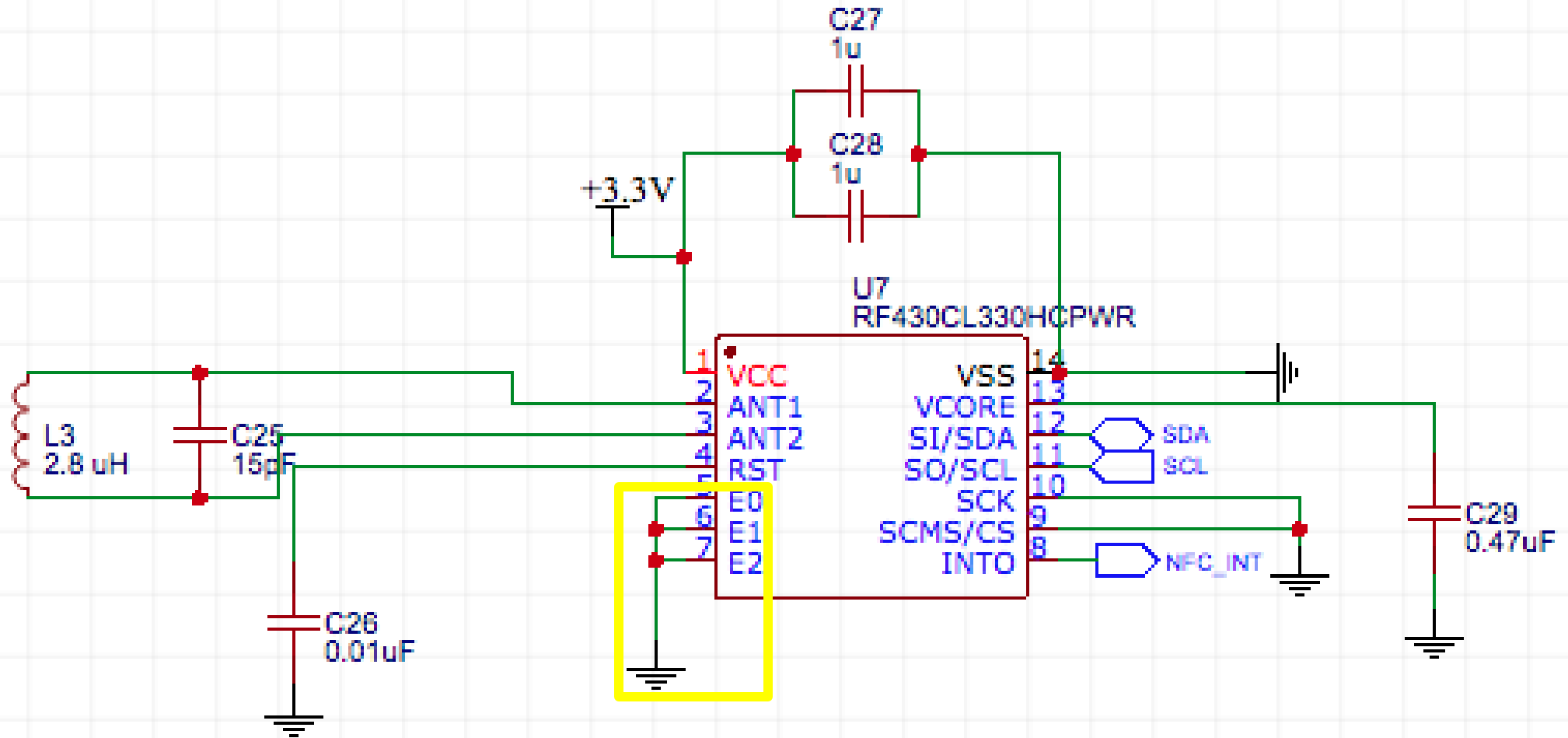


$$f_{RES} = 1 / [2\pi(L_{RES}C_{RES})^{1/2}] = 1 / [2\pi(L_{RES}(C_{IN} + C_{Tune}))^{1/2}] \approx f_c$$

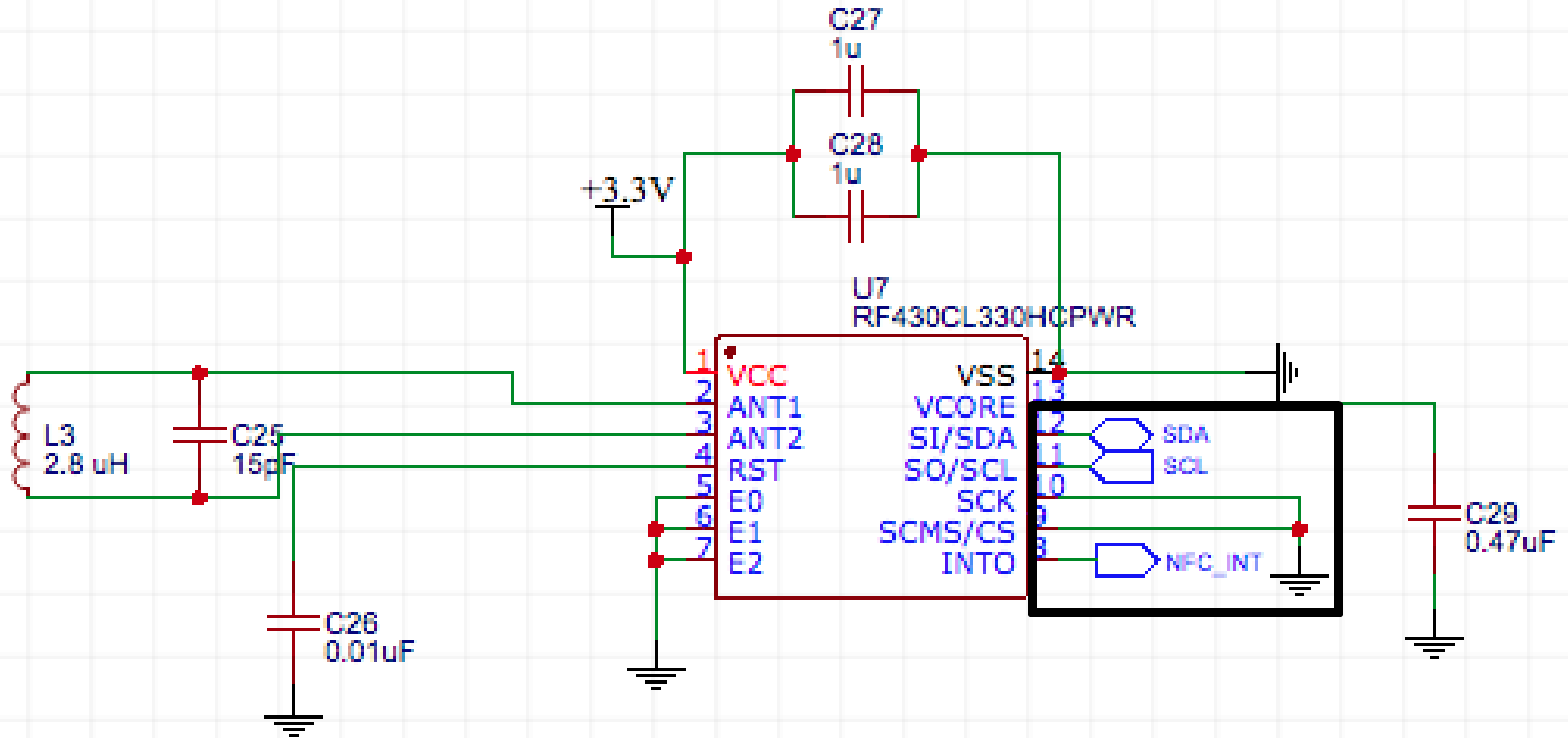
# NFC Schematic



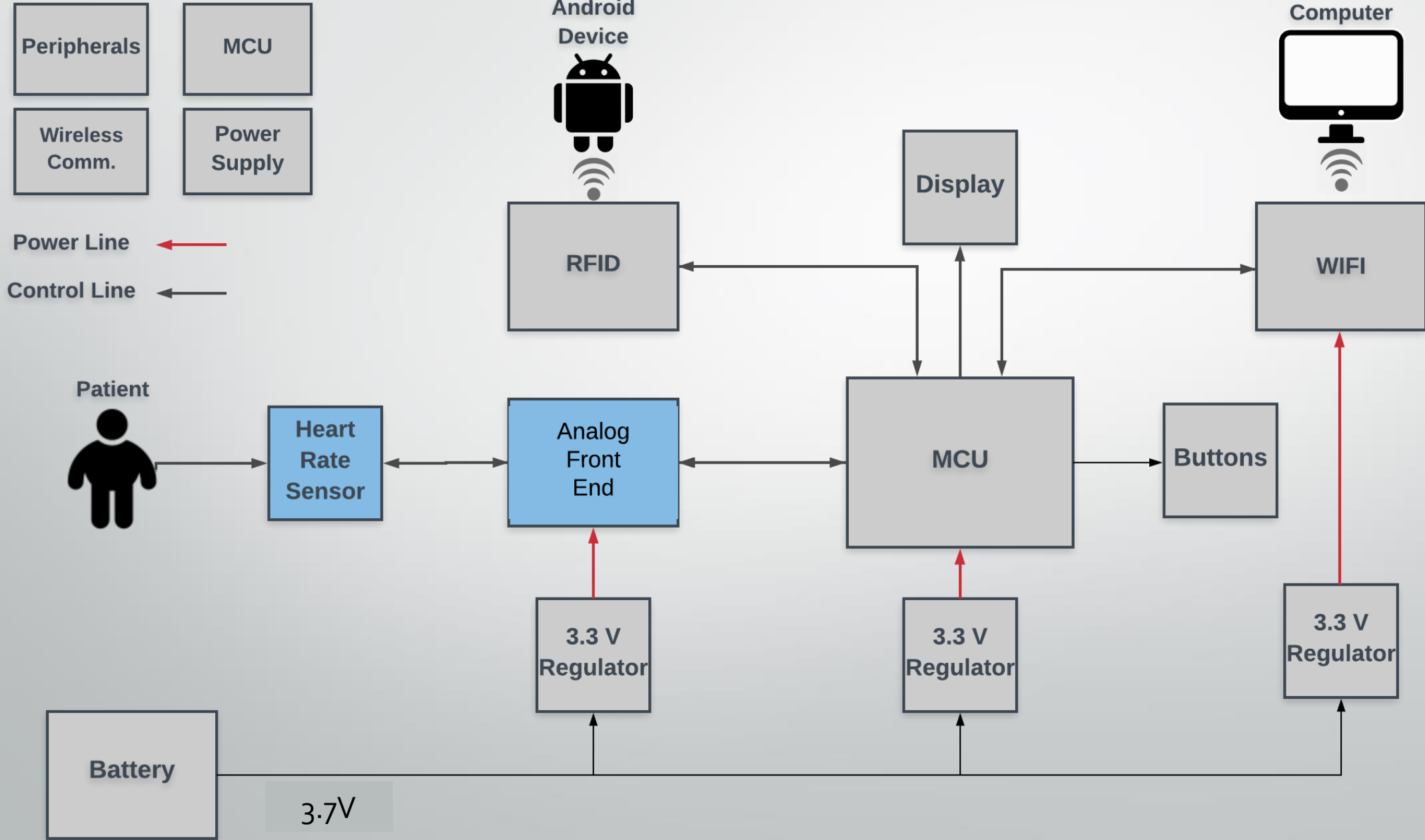
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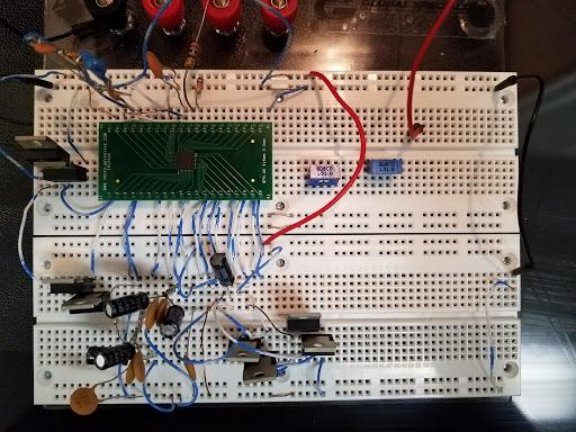


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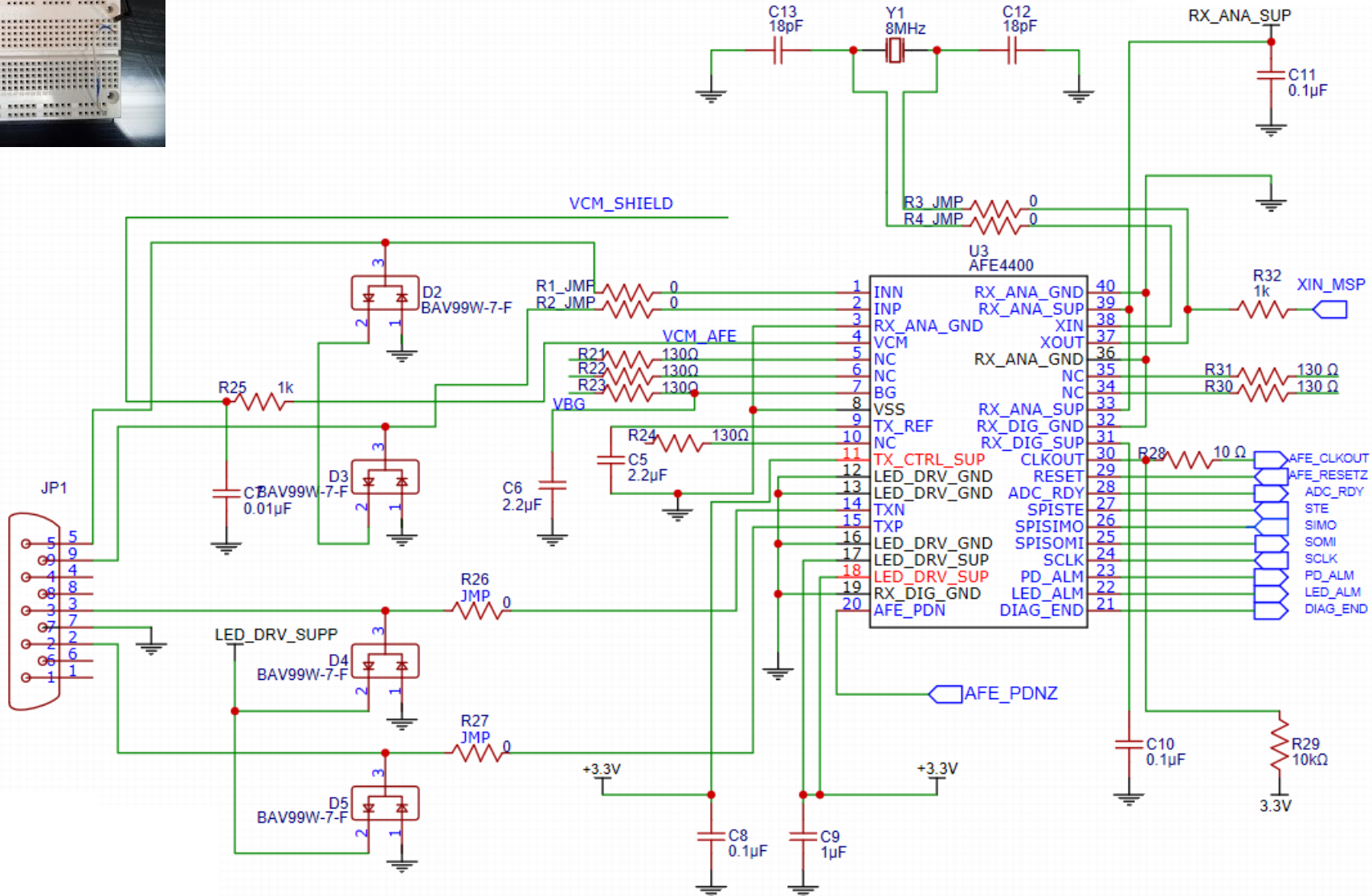


# Heart Rate



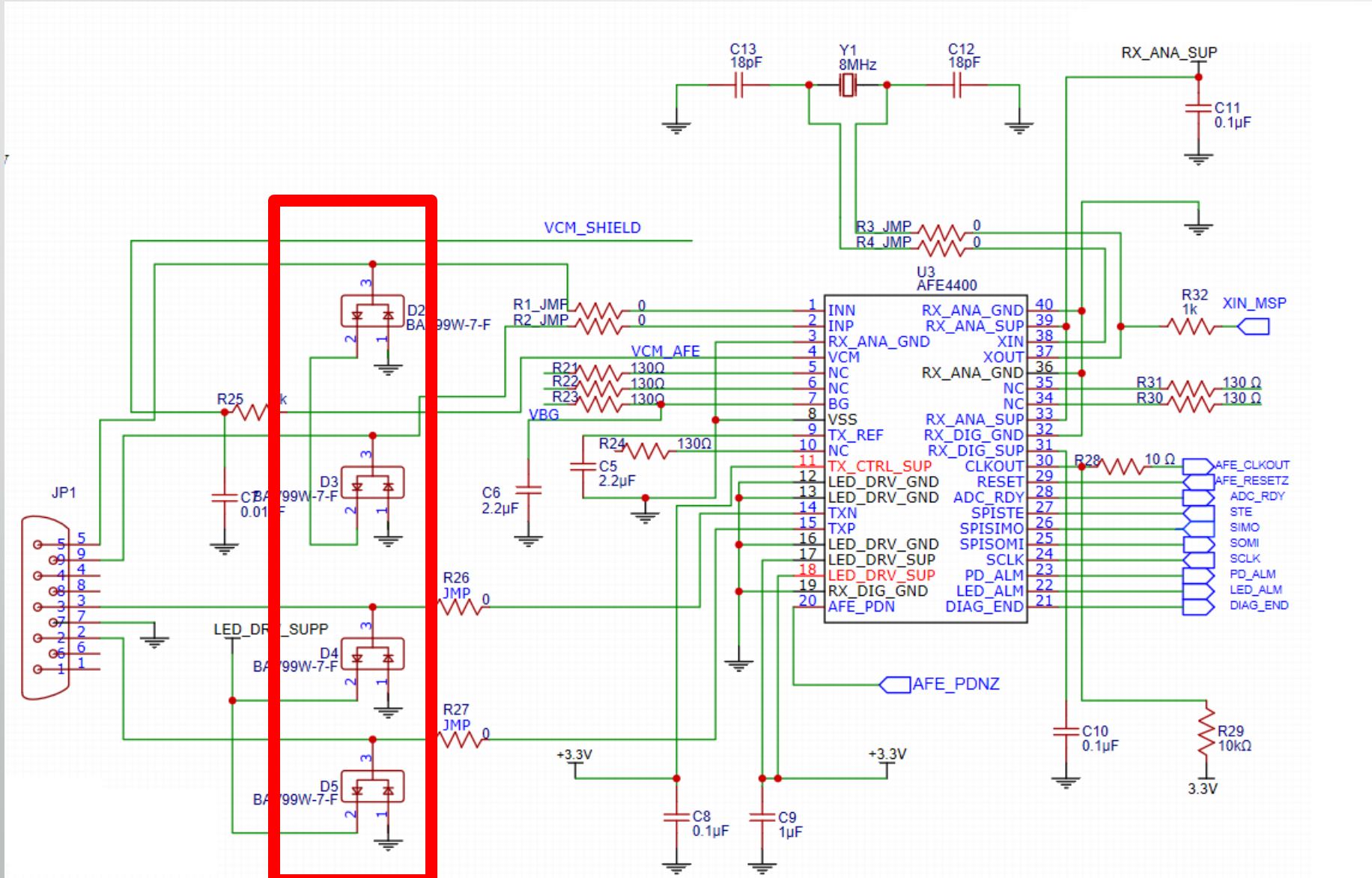


# AFE Schematic

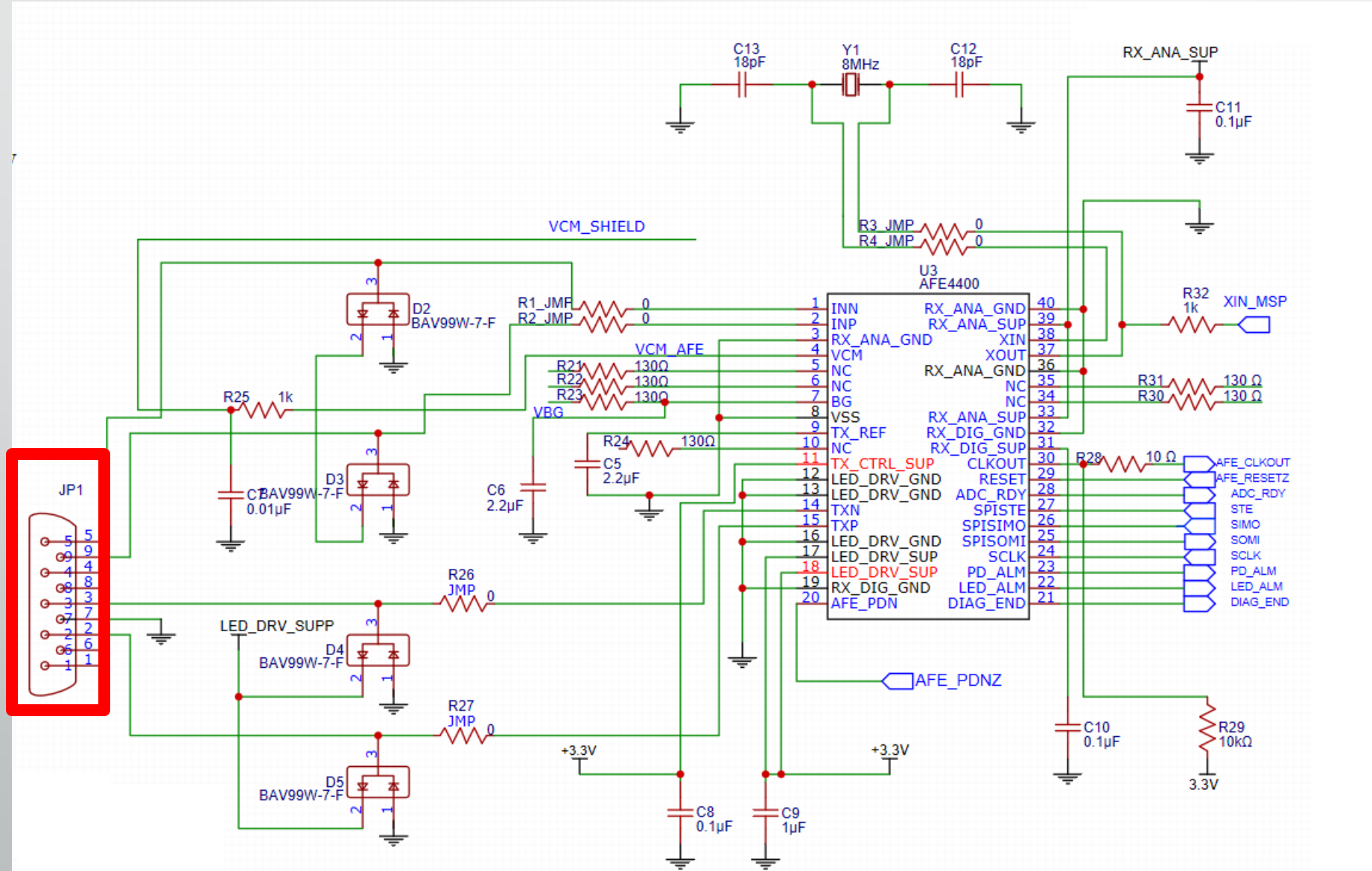




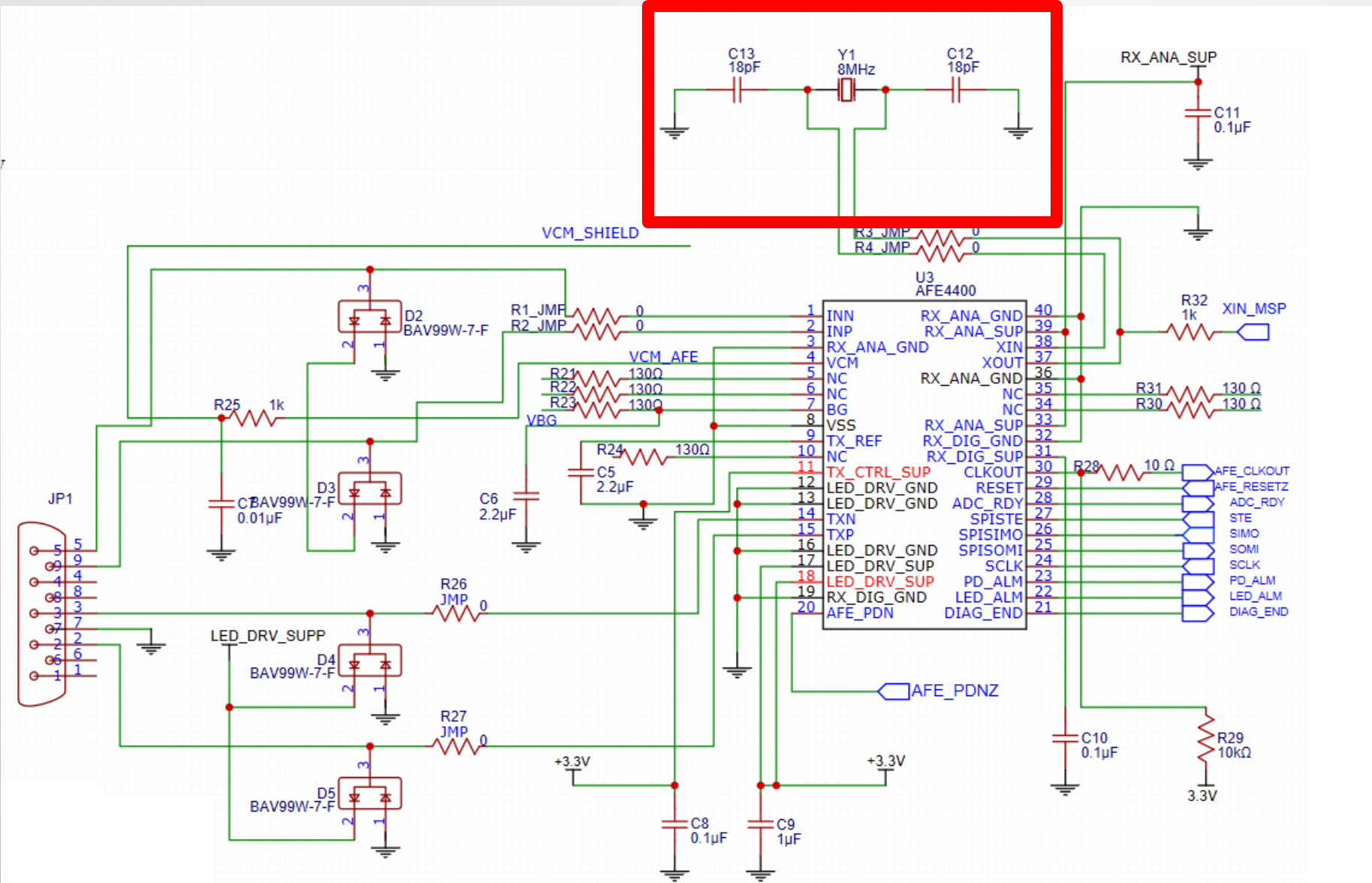
# AFE Schematic



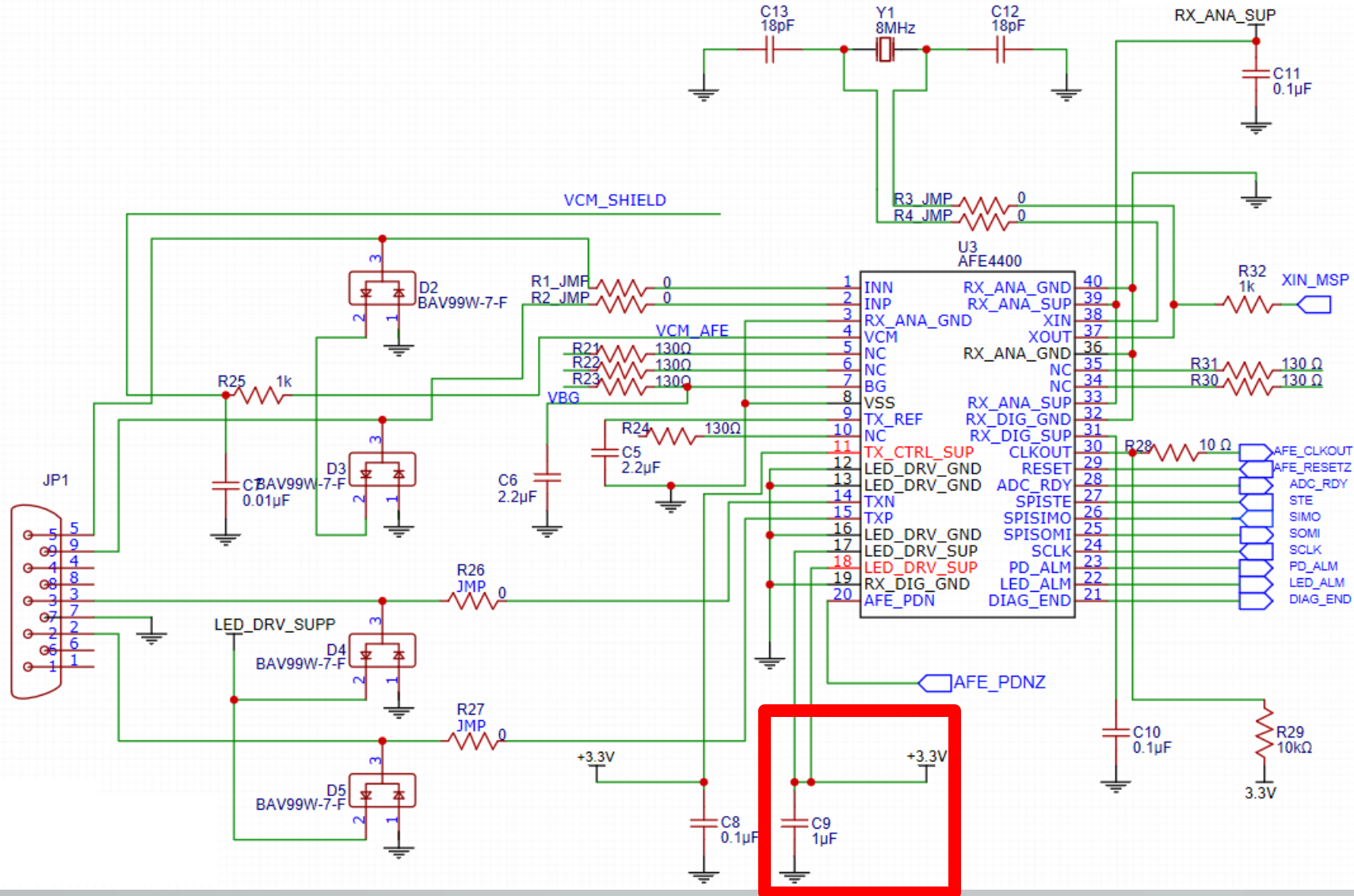
# AFE Schematic



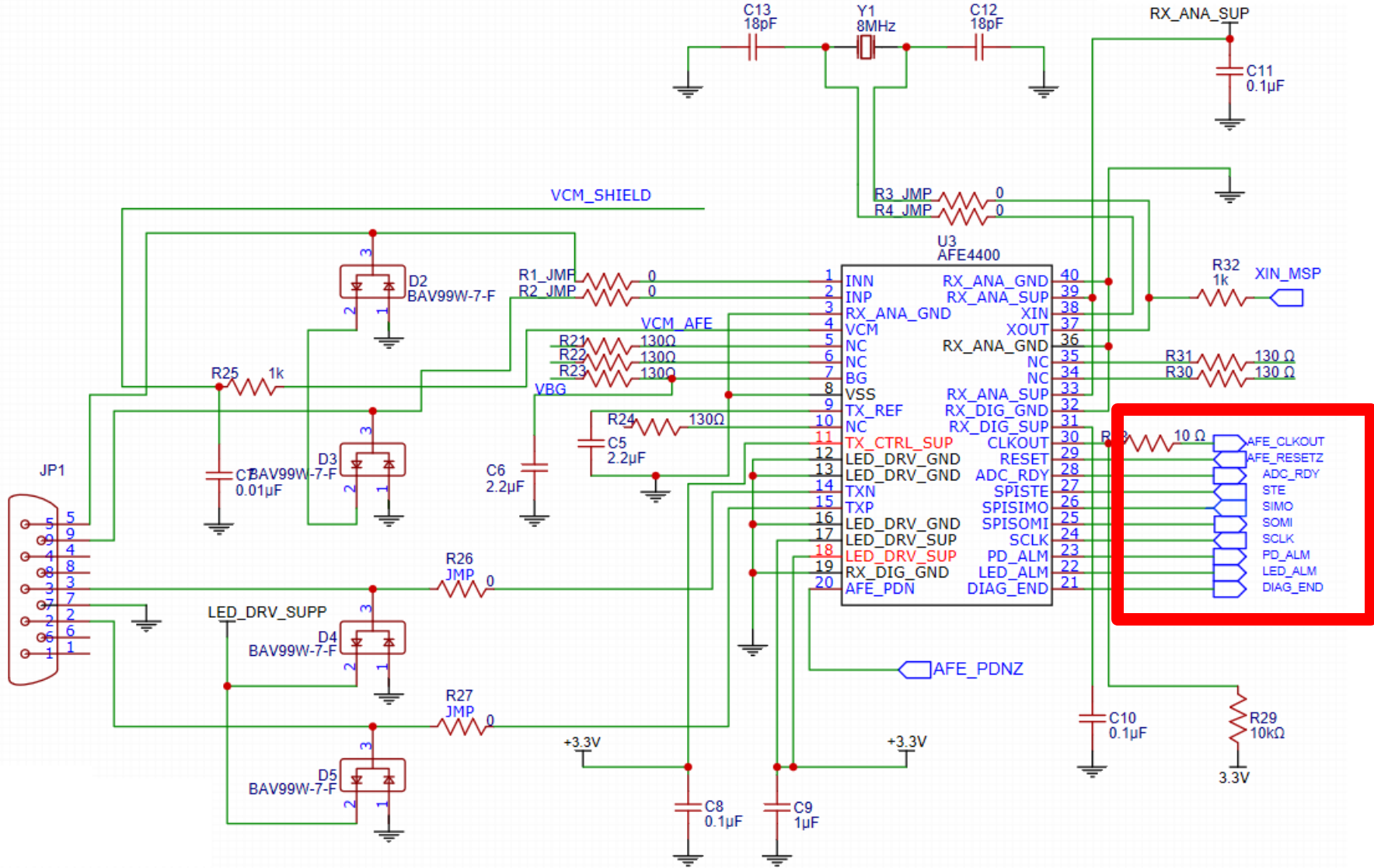
# AFE Schematic



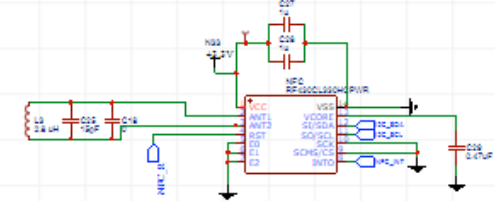
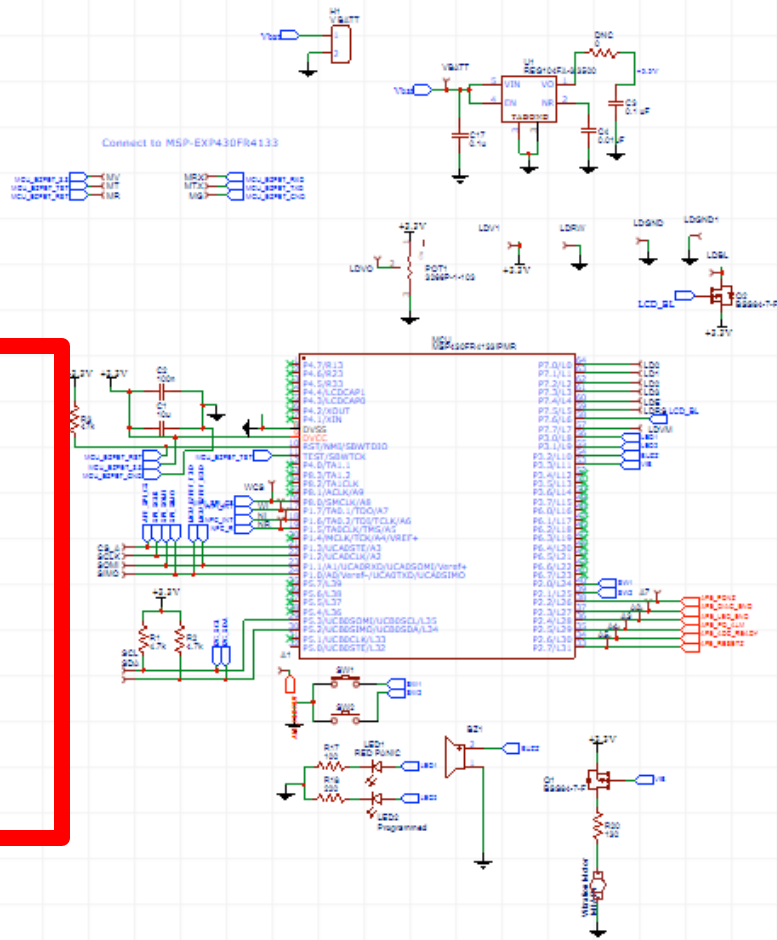
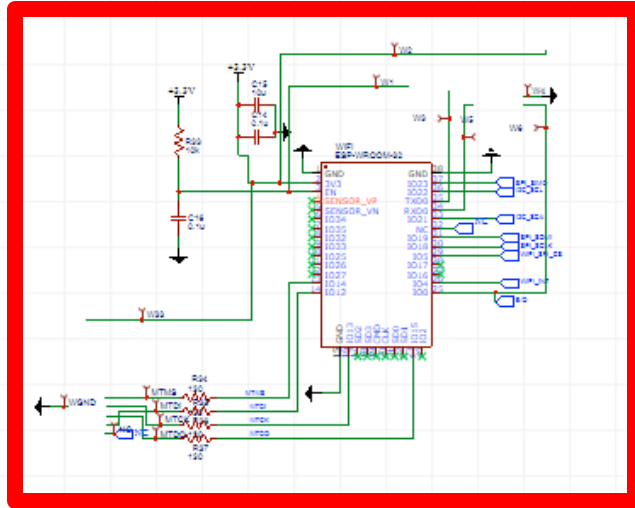
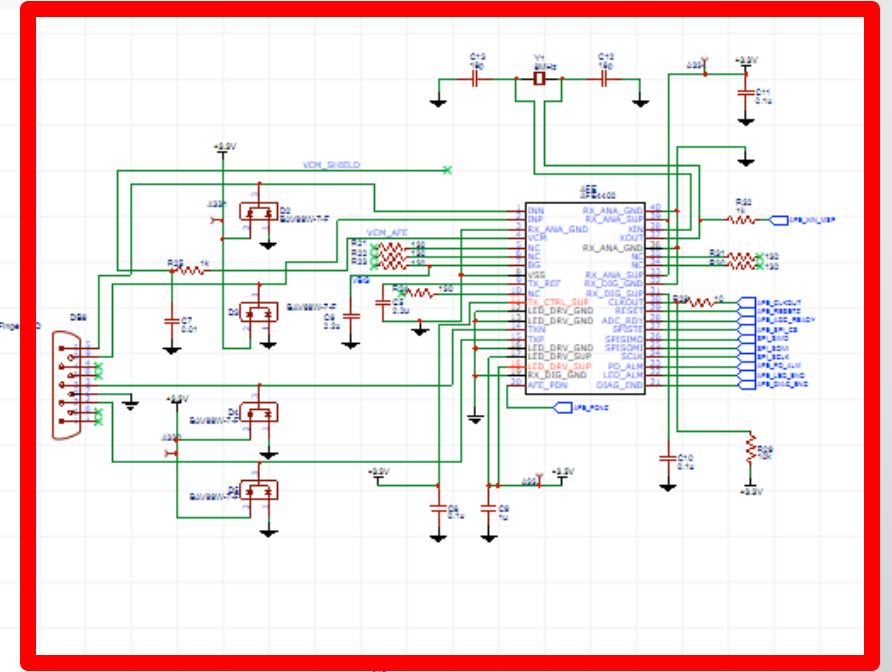
# AFE Schematic



# AFE Schematic

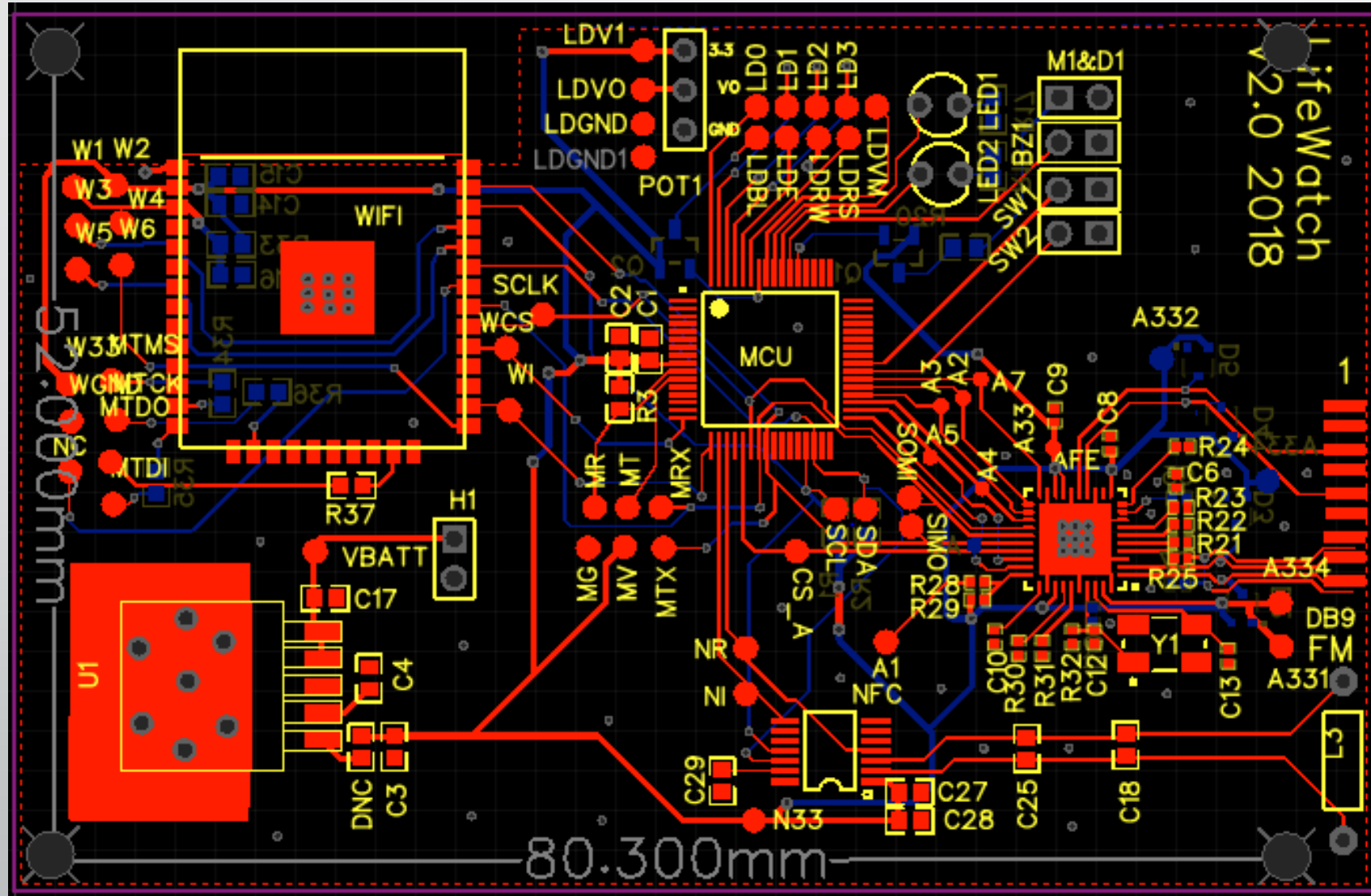


# Overall Schematic





# Overall PCB



# Cost Table

Part	Cost
MSP-EXP430FR413	\$ 14.490
AFE4400 Breakout Board	\$ 12.990
PA0033 (NFC Breakout Board)	\$ 3.6900
AFE4400SPO2EVM	\$ 149.00
BOOSTXL-SENSHUB	\$ 49.990
IRFP250NP Power MOSFET	\$ 3.1400
AFE4400 Breakout Board	\$ 12.990
Shipping	\$ 30.000
<b>Total</b>	<b>\$ 276.00</b>
Saved by TI LAB	\$ 215.12
<b>Total</b>	<b>\$ 61.17</b>

Part	Cost	Part	Cost
1N4448	\$ 0.0167	Micro USB-B 5P-Female-SMT_C40940	\$ 0.1099
Crystal	\$ 0.0959	MSP430FR4133IPMR	\$ 2.8200
AFE4400	\$ 2.5000	PCB	\$ 20.0000
Battery 2200mAh	\$ 3.0000	RF430CL330HCPWR	\$ 1.2900
BAV99W-7-F	\$ 0.0696	SMD Capacitors	\$ 2.3940
Buzzer	\$ 0.1793	SMD Inductor	\$ 9.0000
DW01A	\$ 0.0227	SMD Resistor	\$ 9.3545
ESP-WROOM-32	\$ 3.8000	Thermistor NTC	\$ 0.1037
Finger Probe	\$ 20.0000	TP4056	\$ 0.2452
FS8205A	\$ 0.2334	TPS63036	\$ 3.3400
NHD-C0216AZ-FSW-GBW	\$ 10.1100	Vibration Motor	\$ 1.2000
LEDs	\$ 0.0924	Case 3D Print	\$ 0.00
		<b>Total</b>	<b>\$ 89.98</b>



# Division of Labor

	NFC	Heart Rate	Localization	MCU	Power
John Alcala		P		S	P
Carter Lankes	P				P
William Toledo	S	S	S	P	S
Josue Ortiz	S		P	S	

P - Primary  
S - Secondary

# Difficulties and Obstacles

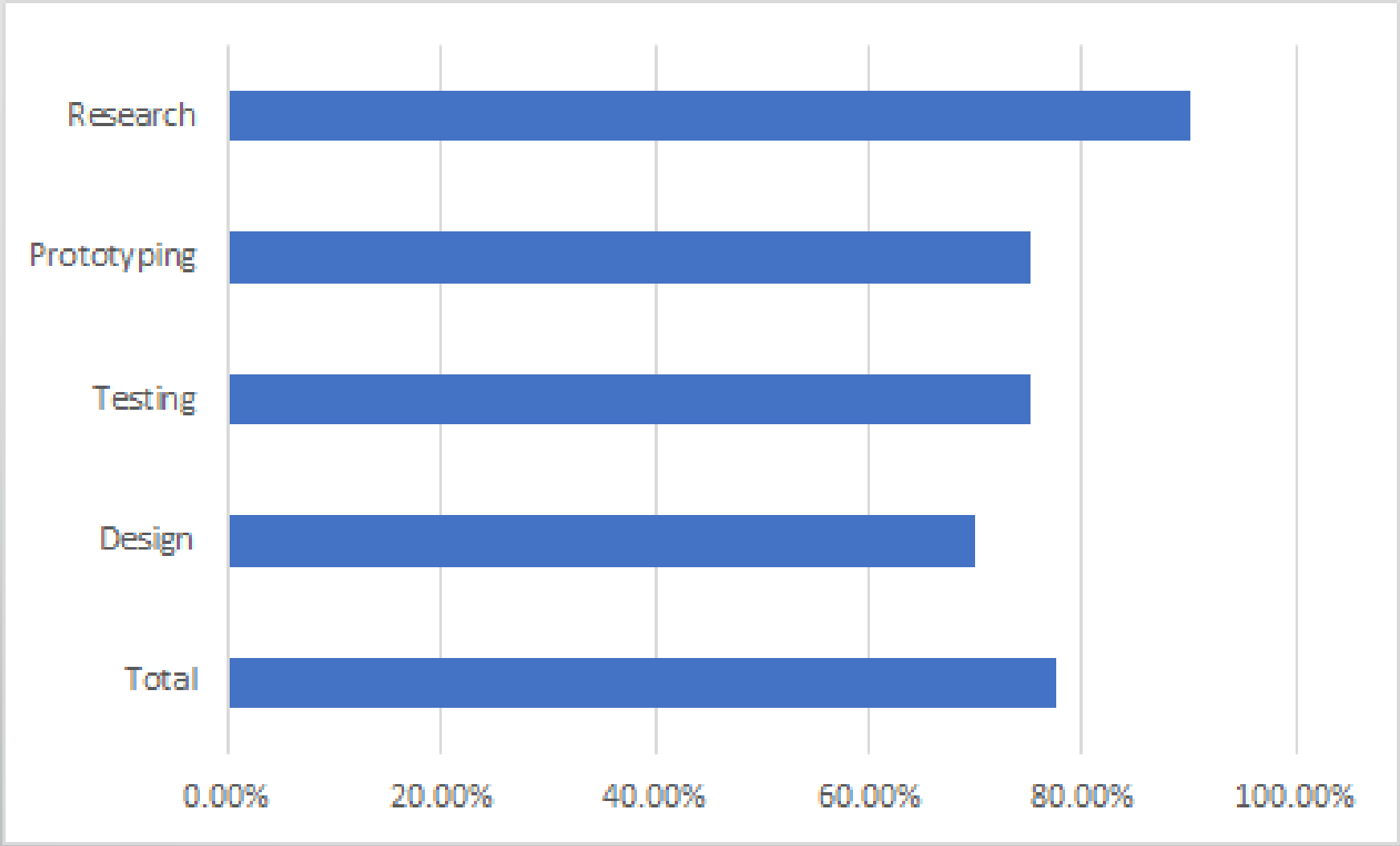
1. Connection to UCF WIFI networks
2. Inexperience with Server Applications
3. Android App
4. Very Small, SMD components

# Extended Goals

1. Advanced GUI Phone App to Read and Write NFC
2. Encryption of Patient-ID, for NFC
3. OLED display for patient Info
4. Water Proof/Sterile
5. Reduce Size to  $<50 \times 50 \text{ mm}^2$



# Progress





**Questions?**