Battery Management System

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What is a BMS

A Battery Management System (BMS) is a crucial component in managing the safety, health, and performance of batteries. It monitors key parameters like cell voltage, temperature, and charge levels to ensure the battery operates within safe limits. By preventing conditions such as overcharging, overheating, and voltage imbalances, the BMS helps protect the battery from damage and ensures optimal performance and longevity.

3 major components to BMS

1 | Temperature Sensing

Reads voltage changes across the thermistor to track temperature variations in each battery cell, ensuring they stay within safe operational limits to prevent thermal issues and extend battery life.

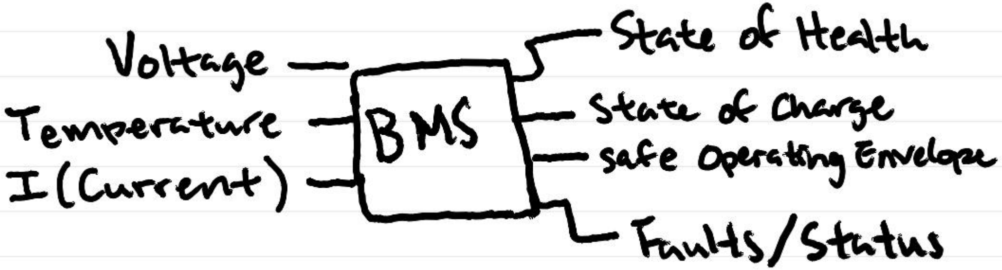
2 | Voltage Sensing

Detects and compare voltage levels across battery cells by taking the difference of V+ and V- . Continuously ensures that no cell within the battery pack exceeds its upper voltage limit or falls below its lower voltage limit, which is important for safety and battery health.

3 | Cell Balancing

Using MOSFETs transistor switches we can control voltage levels, when the BMS detects a particular cell has a higher voltage comparatively, it can activate its switch to allow some charge to drain, thus lowering voltage of that cell to match/equalize

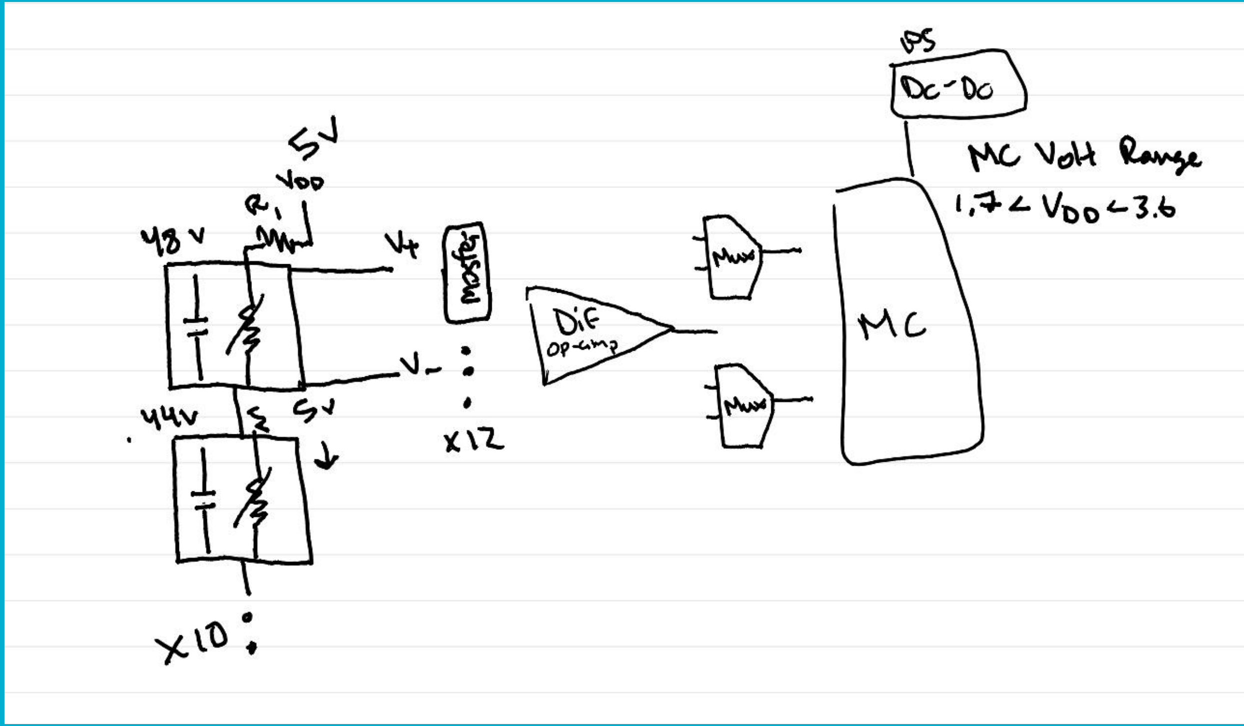
General Overview of BMS



SOE: allows me to know how much
current charge/discharge
at any given time
w/ MOSFET transistor

Faults/Status signals from my Transceiver CANbus
allows MCU and other components to communicate
(CAN High, CAN Low)

BMS



5V
VDD
R1
48 V
V+
Mosfet
Dif
op-amp
Mux
Mux
MC
DC-DC
MC Volt Range
1.7 < VDD < 3.6
V-
44V
5V
x12
x10

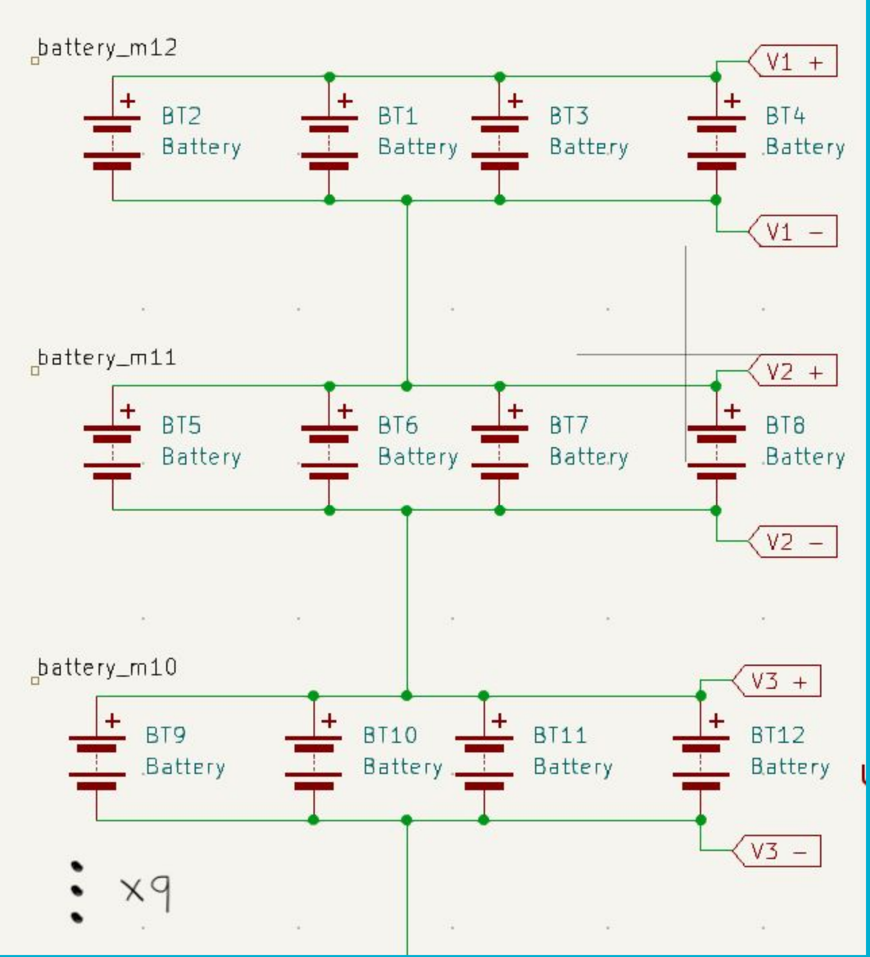
Battery Module

...as the first component :)

Li-ion building block Li4P2

Battery: Li4P25RT

- 12 series, 4 parallel battery module (12s4p)
- Vmax: 4.2, Vmin: 2.5 voltage per individual battery
- Vmax: 50.4, Vmin: 30V entire battery module
- Rechargable

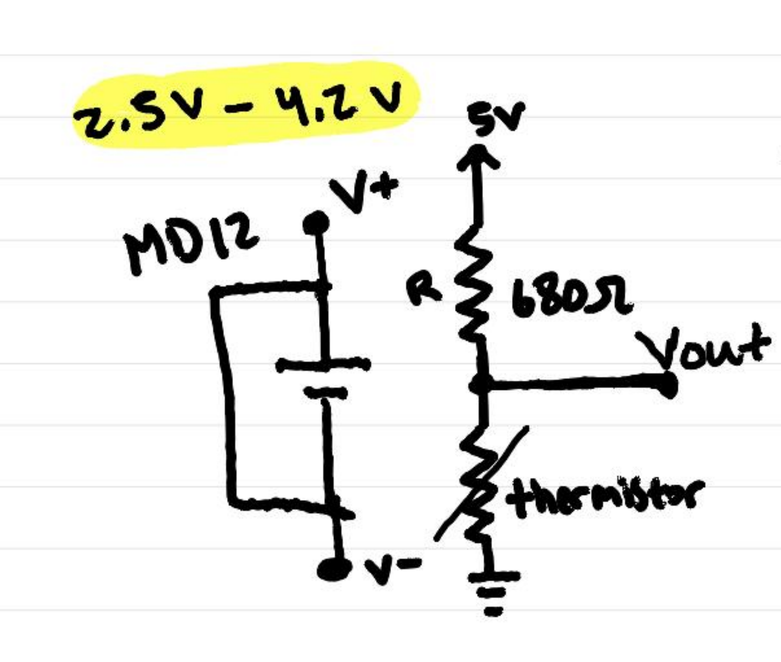


Temperature Sensing

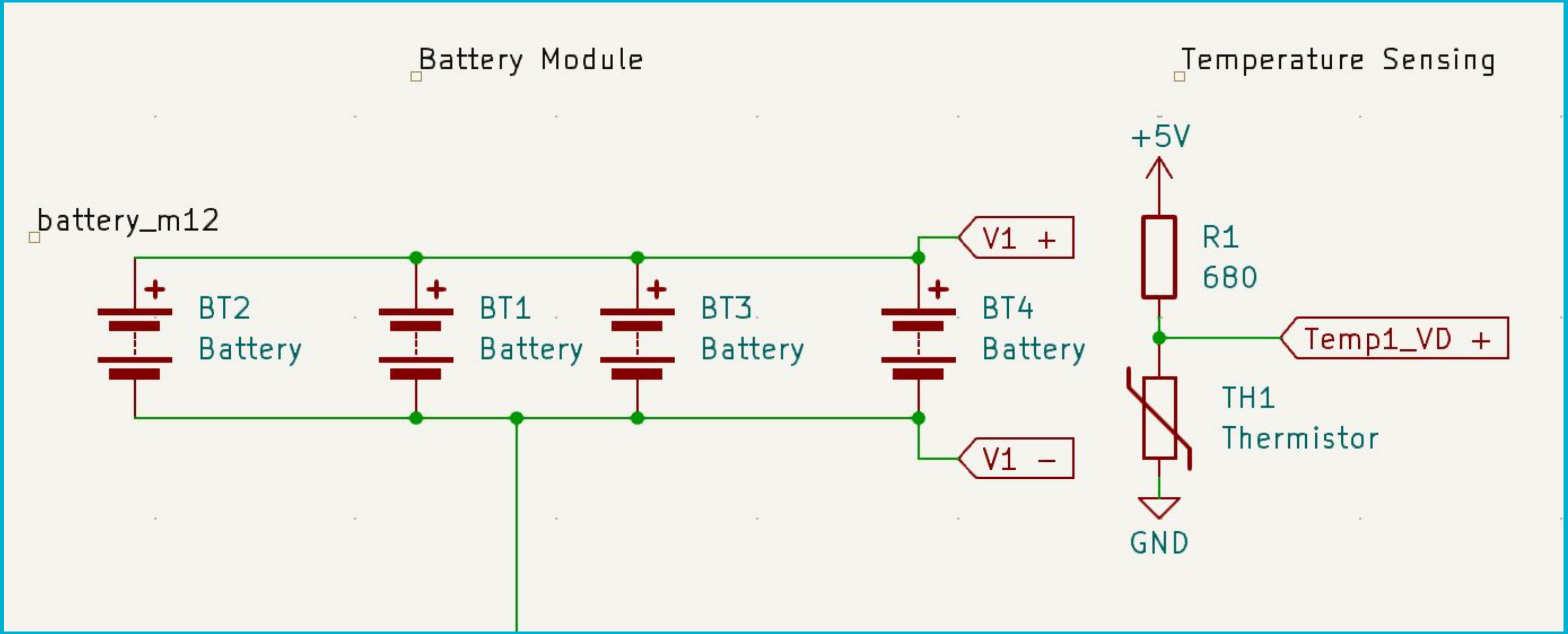
Temperature sensing voltage divider is next to each battery cell in the casing to gauge a temperature

Voltage divider takes the voltage drop across the 5V ideal power supply to allow room for a lesser voltage Vout. Thermistor resistance changes according to temperature

Vout = Rt/ R + Rt (Vs)



Temperature Sensing



Cell Balancing w/ MOSFET Transistor

- 2N7002NXAK (NMOS)
- Operates based on the gate-source voltage Vgs. It turns on when Vgs exceeds a threshold range allowing current to flow between the drain and source allowing power distribution through its switch (connects or disconnects battery cells to balance charge or prevent excessive discharge)

FET Type	N-Channel
Technology	MOSFET (Metal Oxide)
Drain to Source Voltage (Vdss)	60 V
Current - Continuous Drain (Id) @ 25°C	190mA (Ta), 300mA (Tc)
Drive Voltage (Max Rds On, Min Rds On)	5V, 10V
Rds On (Max) @ Id, Vgs	4.5Ohm @ 100mA, 10V
Vgs(th) (Max) @ Id	2.1V @ 250µA
Gate Charge (Qg) (Max) @ Vgs	0.43 nC @ 4.5 V
Vgs (Max)	±20V
Input Capacitance (Ciss) (Max) @ Vds	20 pF @ 10 V

Passive Cell Balancing ->

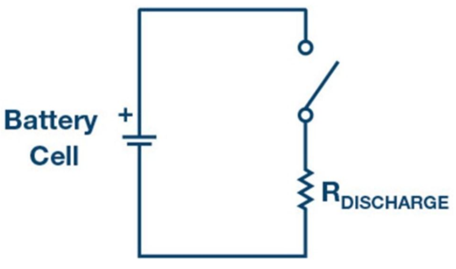
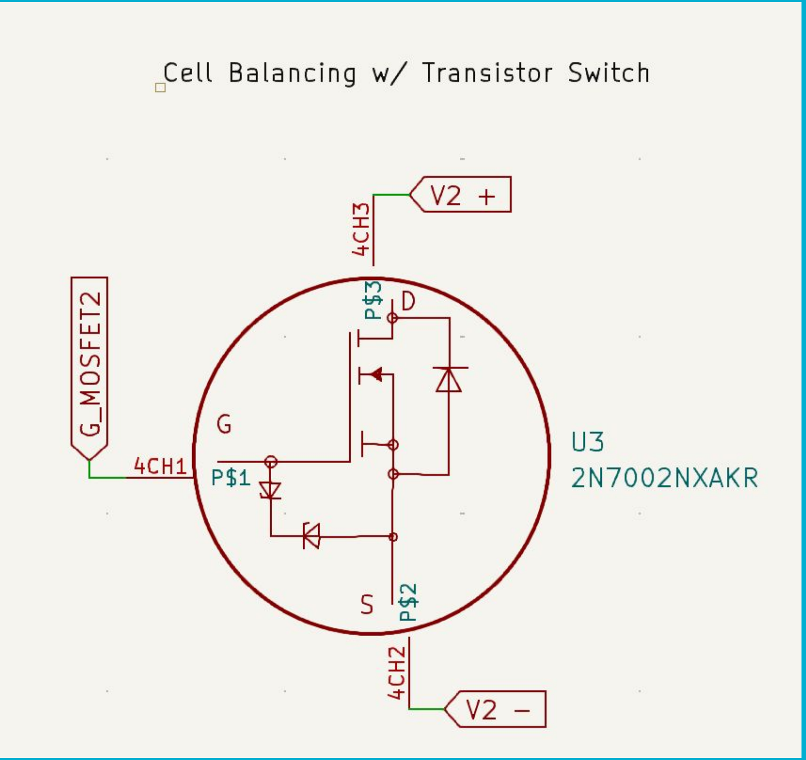
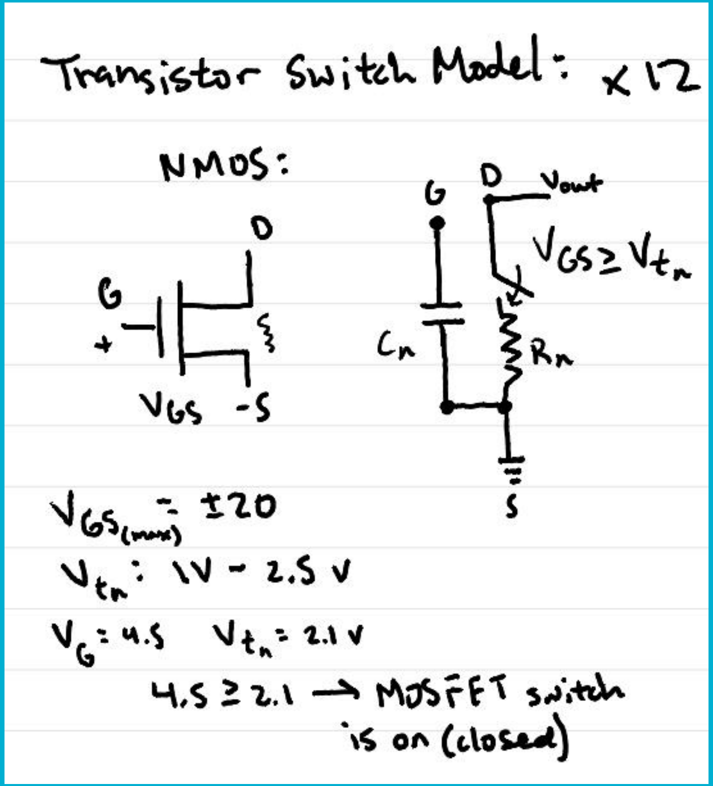


Figure 1. Passive cell balancer with bleed resistor.

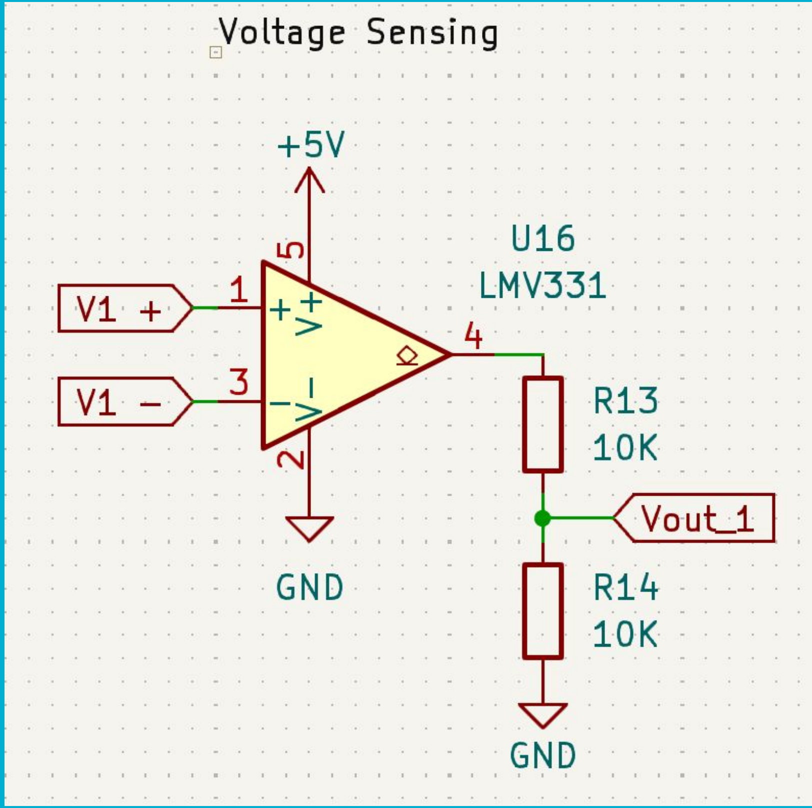
Cell Balancing w/ MOSFET Transistor



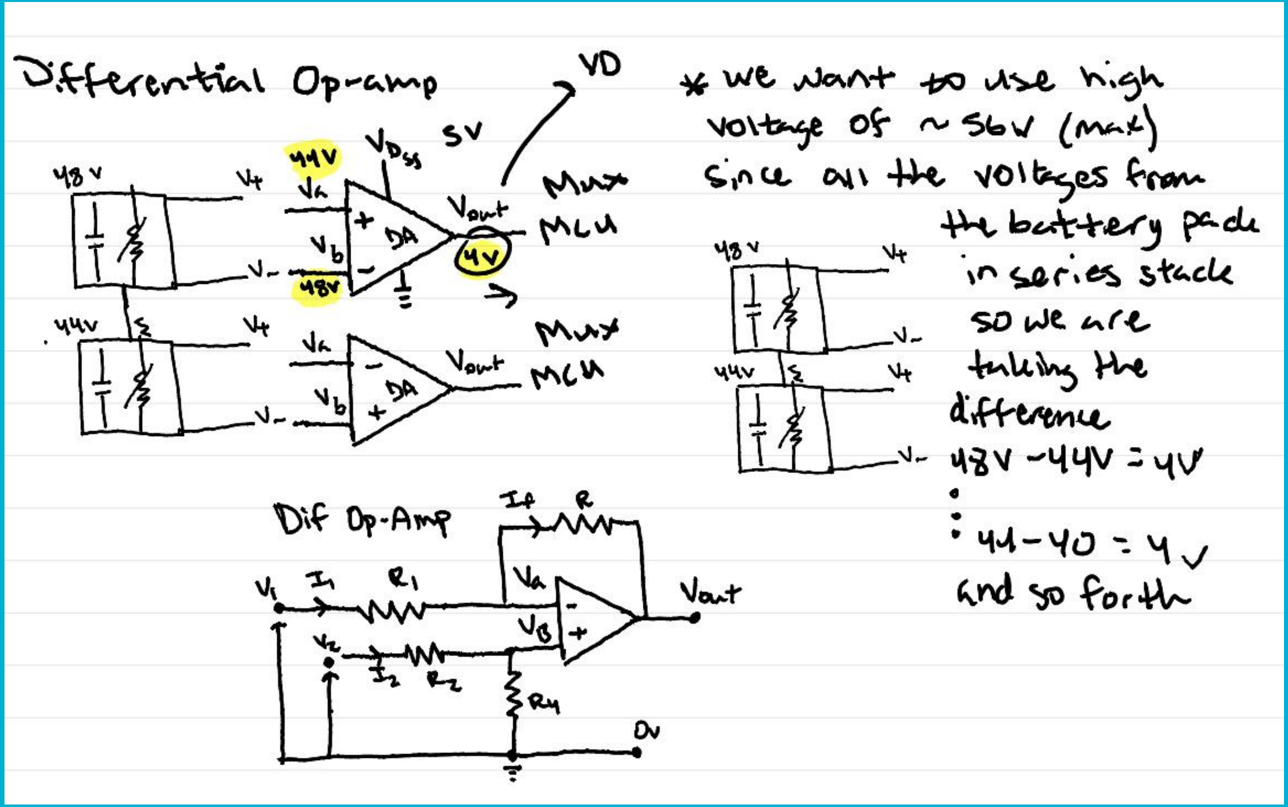


Voltage Sensing

Differential Op-Amp outputs the voltage difference between two voltage inputs used for voltage reading. Using a voltage divider we can scale down the max supply voltages (5V) to output a voltage with room for the MCU voltage range of 1.7 - 3.6 V, we don't want a high voltage for MCU since we don't want to over supply it



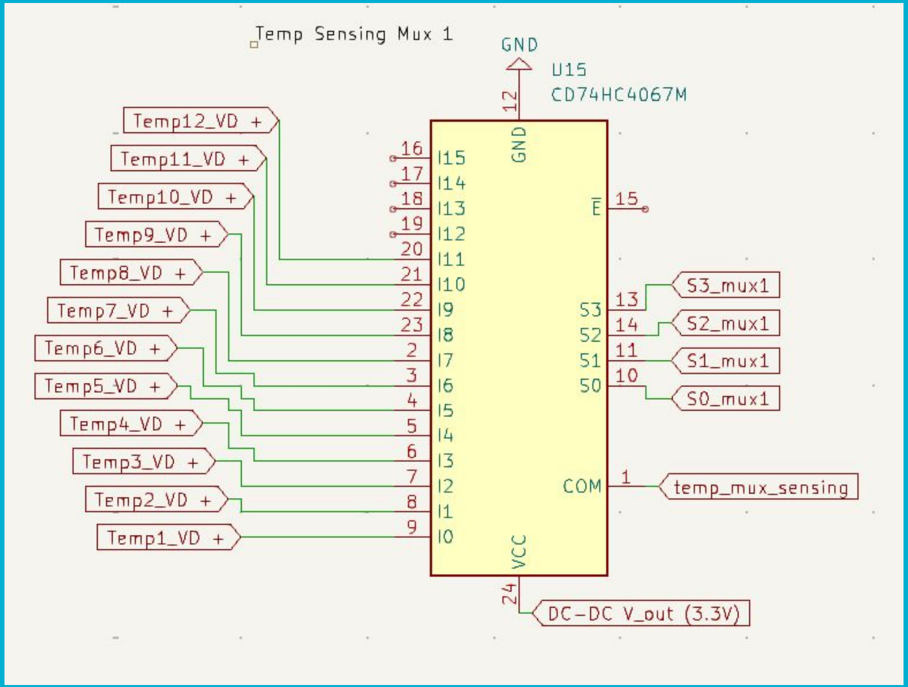
Voltage Sensing

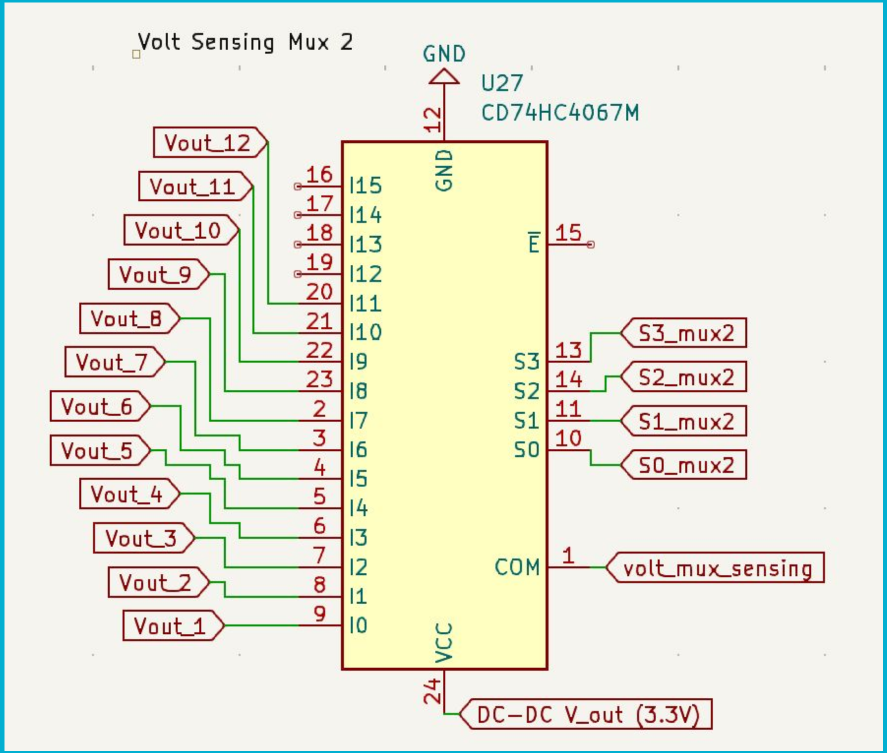


Multiplexers

- Used to condense the number out outputs that came from all my temperature sensing reading (12 outputs from each of the components)
- Used to condense all the outputs from my voltage sensing Op-amps
- 16:1 ratio muxer w/ 2^4 -> 4 selector bits which are 1, 0 binary values that essentially the MCU determine to output the proper reading from the inputs
- Supplied with a 3.3 V

Condensing the Number of Analog Inputs





Microcontroller

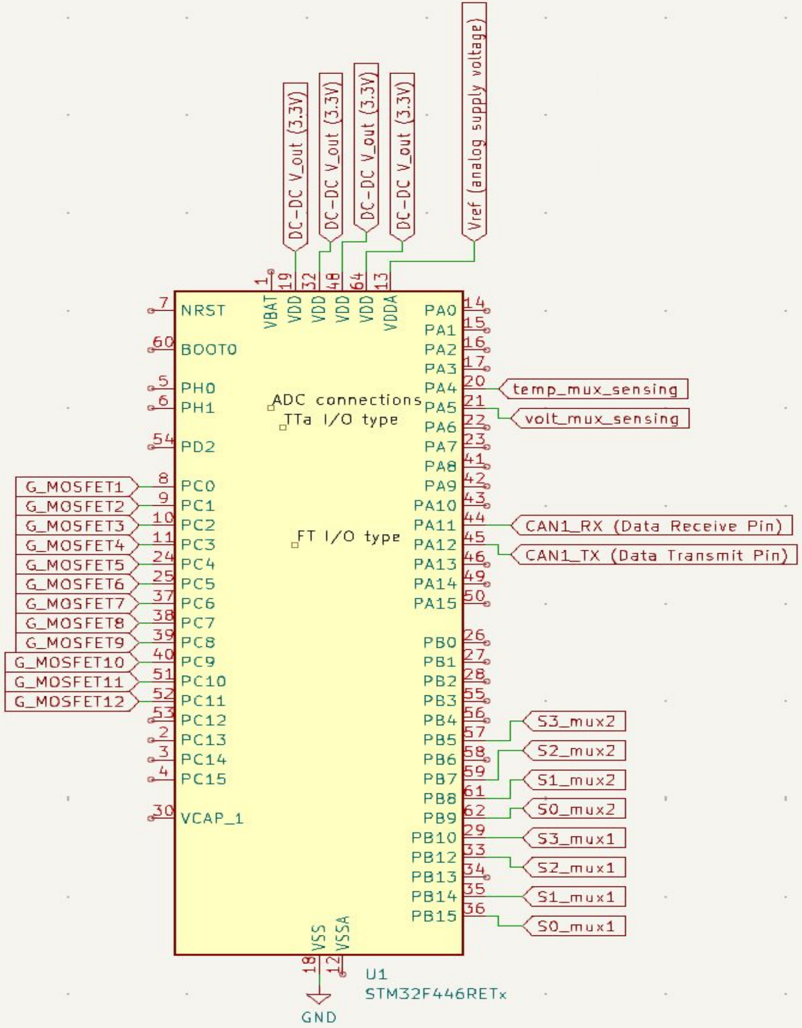
- STM32F446RE
- Supplied though 3.3V from DC-DC converter
- Used TTa ADA 3.3V tolerant pins mux outputs
- Used FT 5V tolerant pins for CANbus signal inputs
- Reads temp sensing, volt sensing, and cell balancing MOSFET Gate channel reading as GPIO pins Input/Output

STM32F446RE

Pin Number: LQFP64

Pin: I/O → Input/Output pin

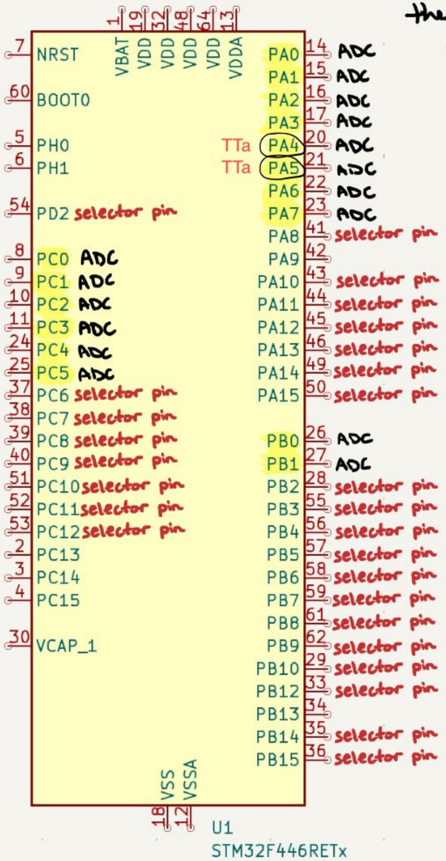
GPIO: General-purpose input/output



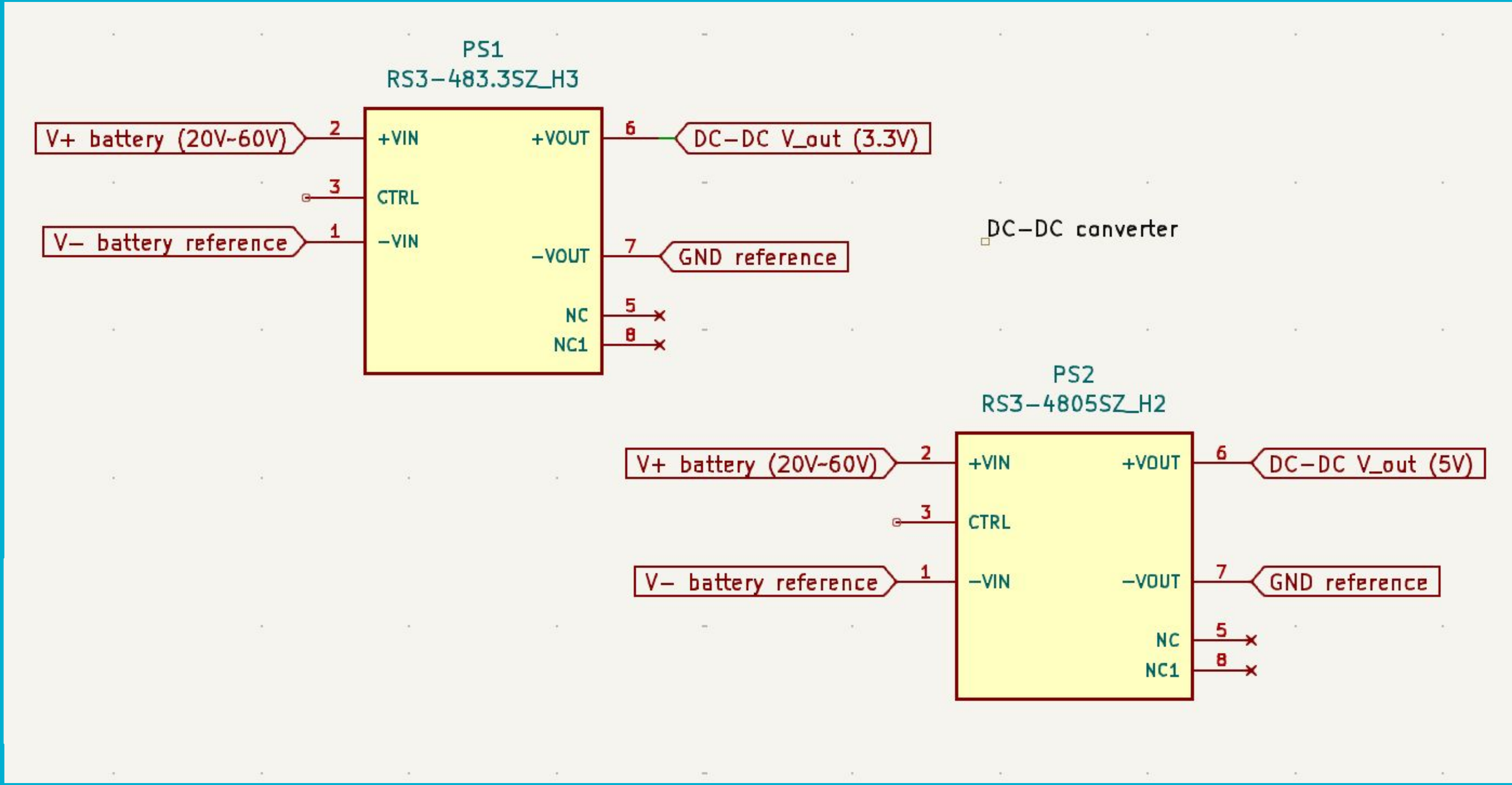
selector pins can be used for GPIO → I/O

Binary: 1, 0

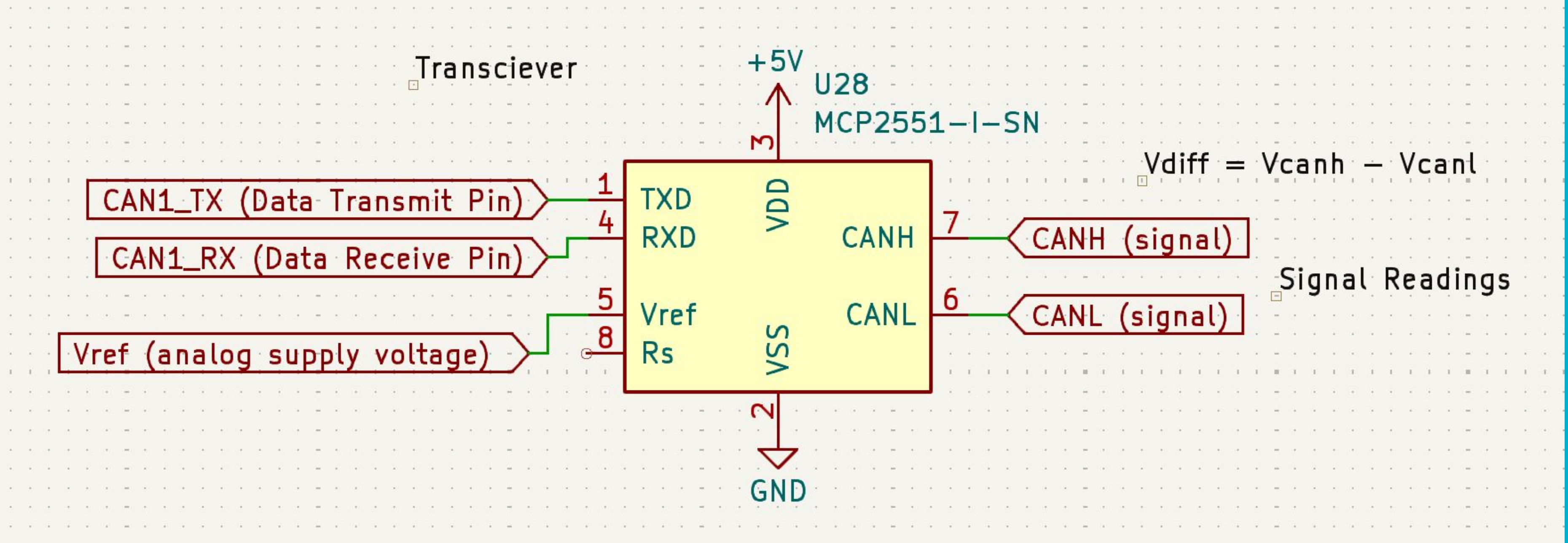
ADC pins reserved for thermistor → mux outputs



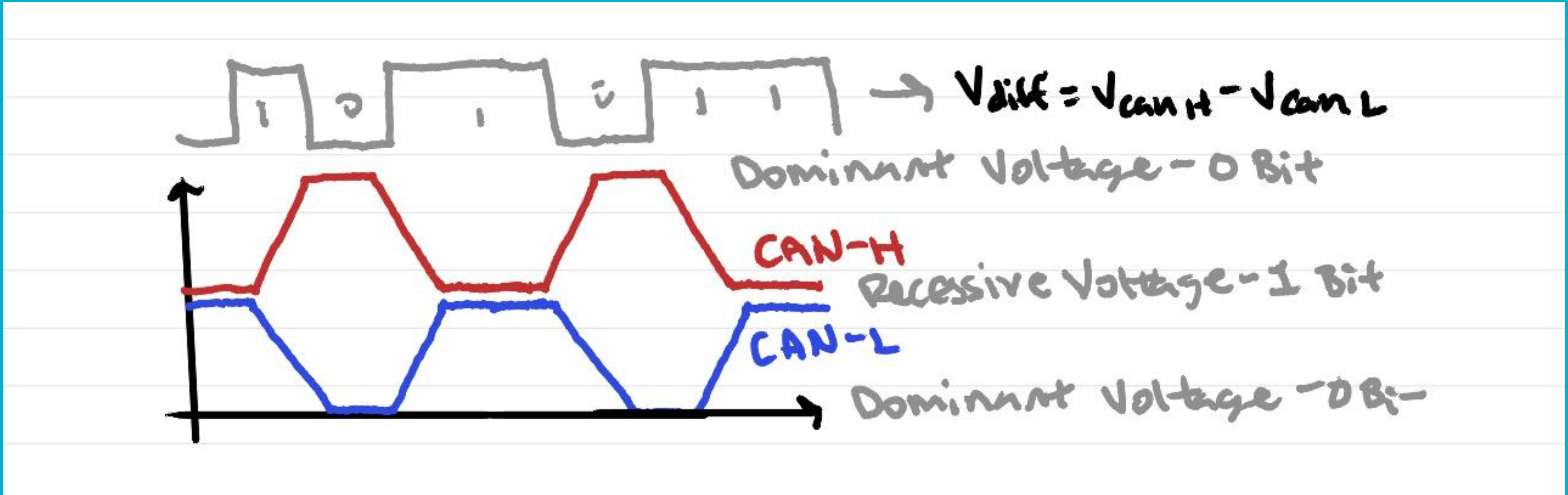
DC-DC Converters



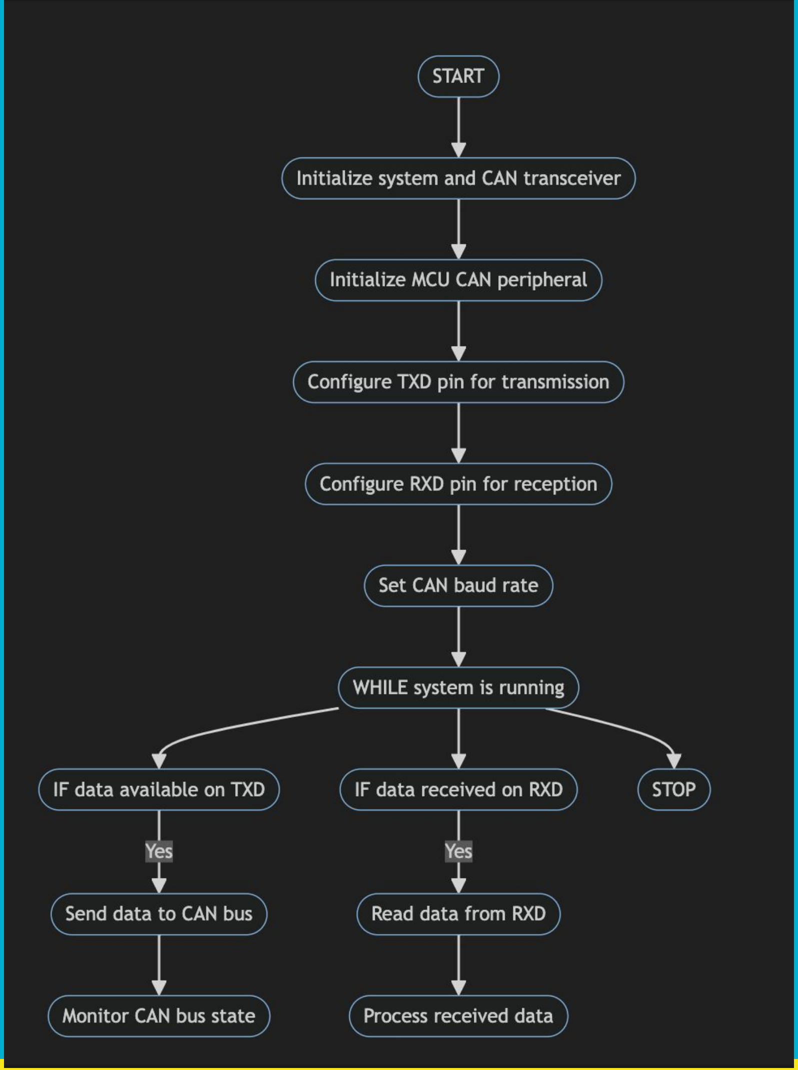
Transceiver



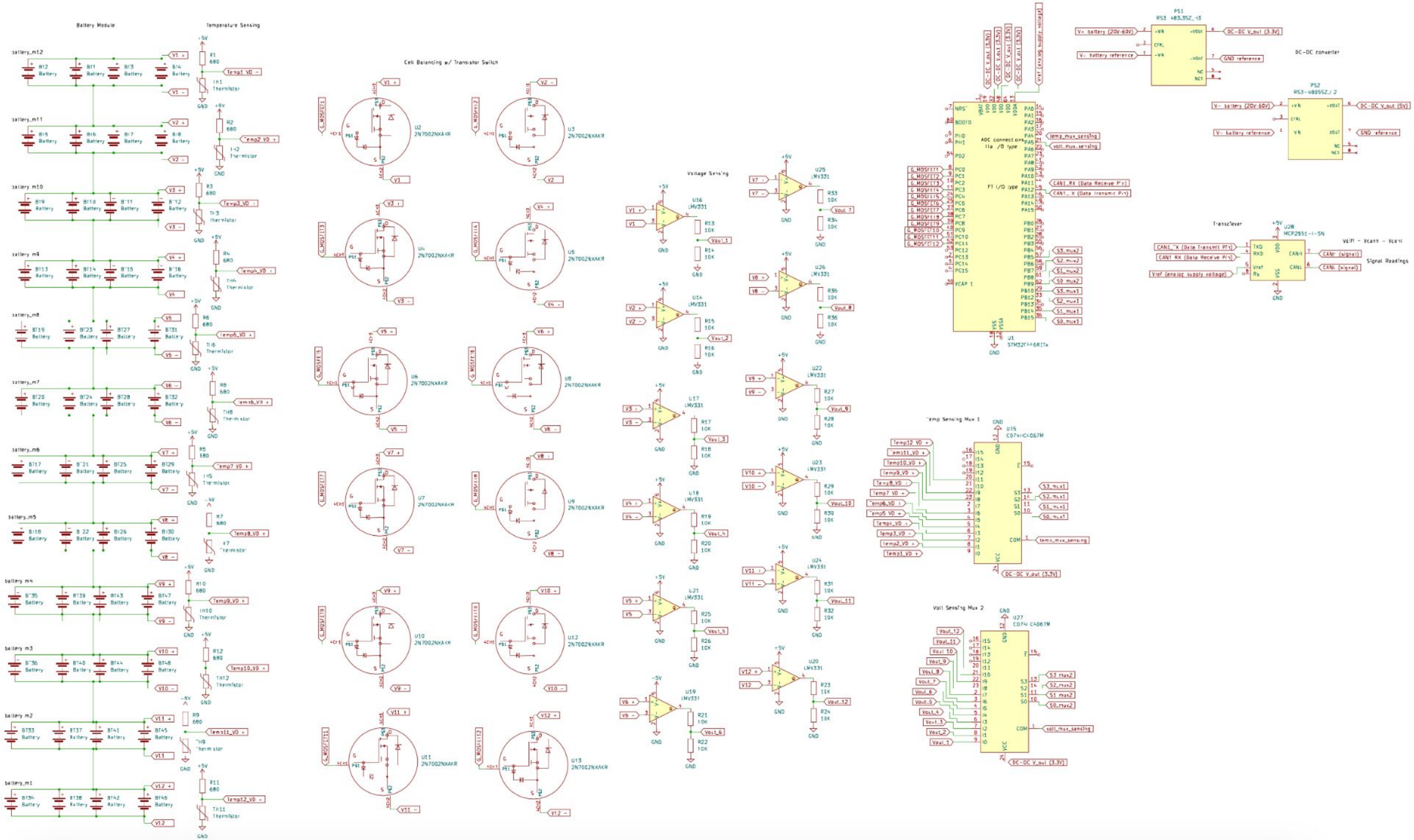
CANbus Transceiver



Flowchart



START
Initialize system and CAN transceiver
Initialize MCU CAN peripheral
Configure TXD pin for transmission
Configure RXD pin for reception
Set CAN baud rate
WHILE system is running
IF data available on TXD
IF data received on RXD
STOP
Yes
Yes
Send data to CAN bus
Read data from RXD
Monitor CAN bus state
Process received data


Battery Module
Temperature Sensing
Cell Balancing w/ Transistor Switch
Voltage Sensing
DC-DC converter
Transceiver
Signal Readings
Temp Sensing Mux 1
Volt Sensing Mux 2
U1
STM32F446RETx
ADC connections
FT I/O type
PS1
PS2
U28
MCP2551-I-SN
U15
CD74HC4067M
U27
2N7002NXAKR
LMV331
Battery
Thermistor
temp_mux_sensing
volt_mux_sensing
CAN1_RX (Data Receive Pin)
DC-DC V_out (3.3V)
DC-DC V_out (5V)
V+ battery (20V-60V)
V- battery reference
GND reference
+5V
GND