

Parallel Battery Management Evaluation Board

“Power to the People”

Team 1

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AHEAD OF WHAT'S POSSIBLE™

Project Impact: Parallel Battery Management

- Parallel battery management systems are necessary for all devices with two or more batteries powering one device or multiple components of a device
- Allows simultaneous, proportional charging for multiple devices or components



Airpod Pro



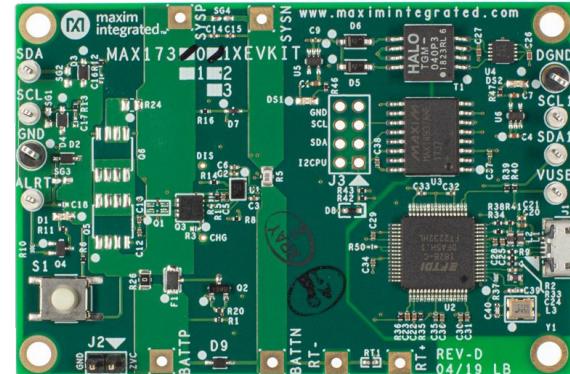
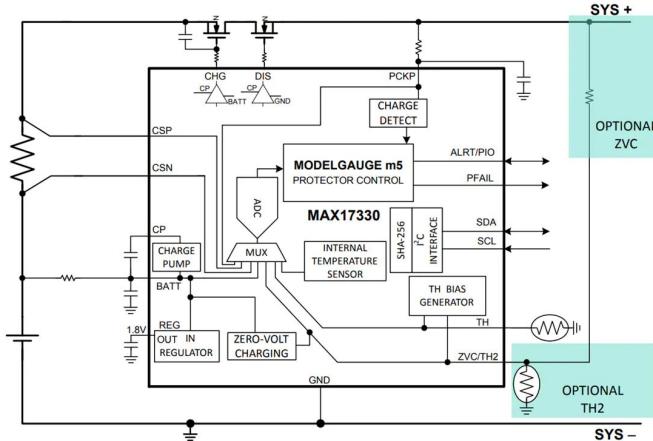
Ring Camera



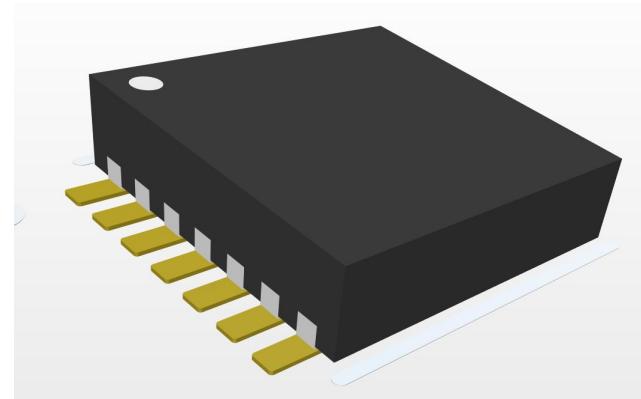
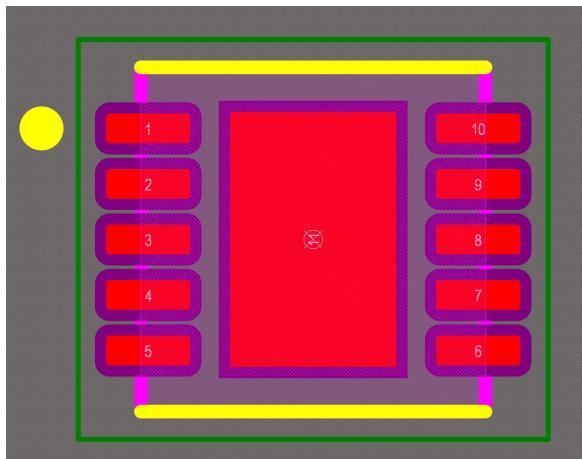
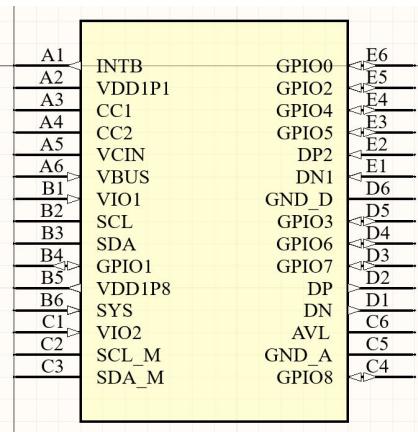
Meta Quest 2

Project Description

We are designing an incorporated system with a Type-C PPS input and software to showcase the parallel battery management functionality of the MAX17330 (charger, fuel gauge, and protector for lithium ion batteries) for customer technology demonstrations and trade shows.

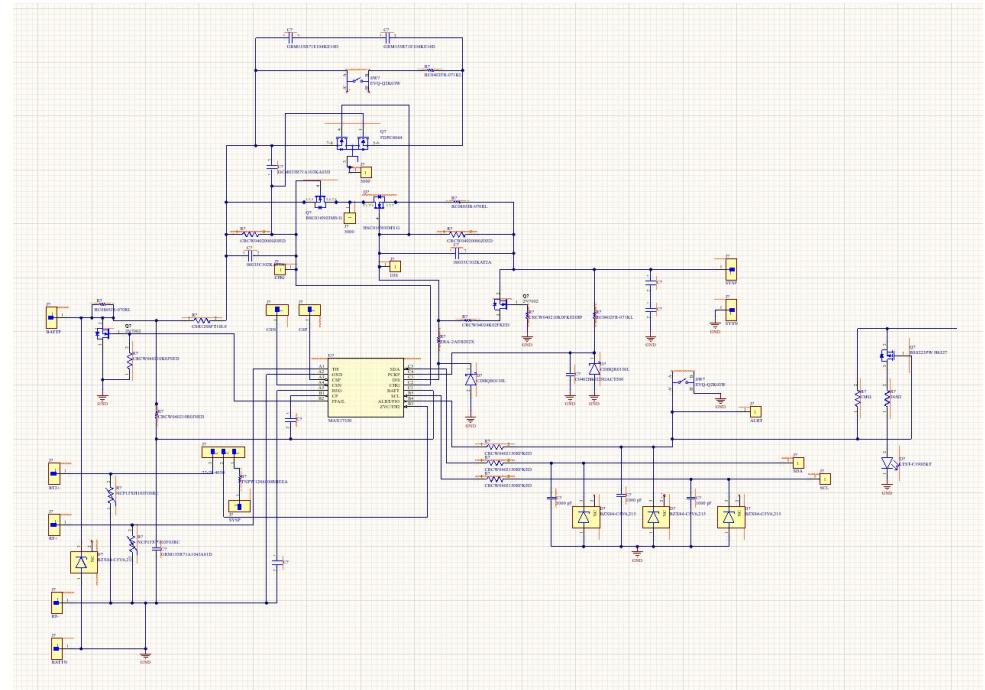


Progress: Completed Altium Schematic Symbols & Footprints



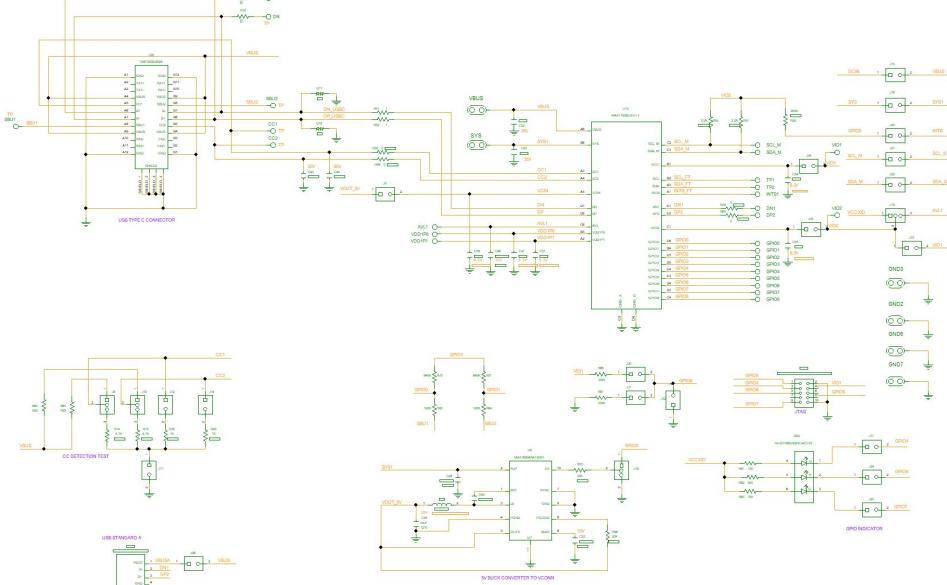
Progress: Partially Completed Schematic in Altium

- Proved to be very tedious
- Lots of components needed to be made from scratch
- Would not be feasible within our timeline

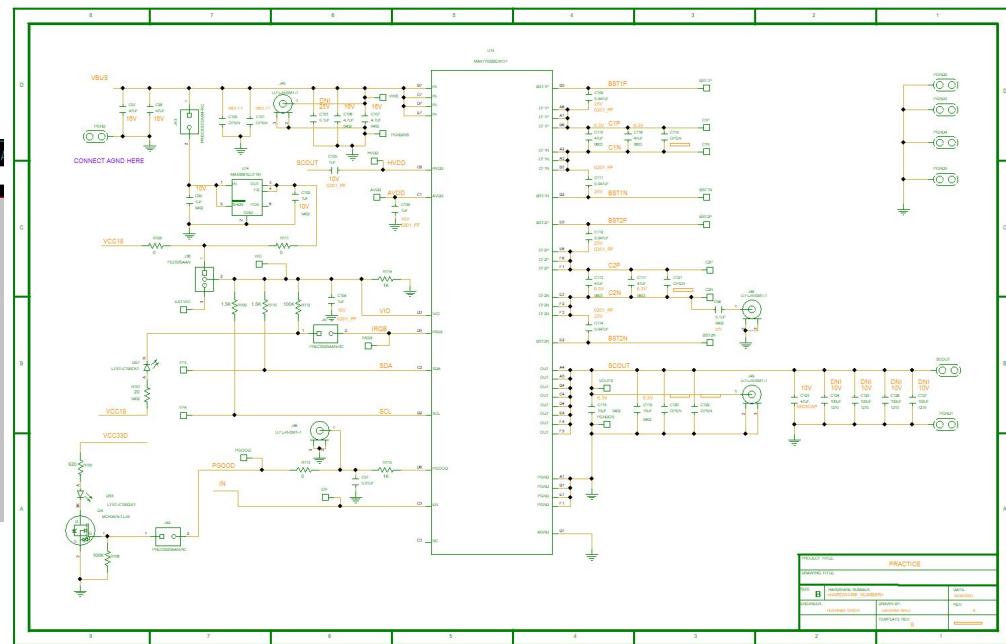
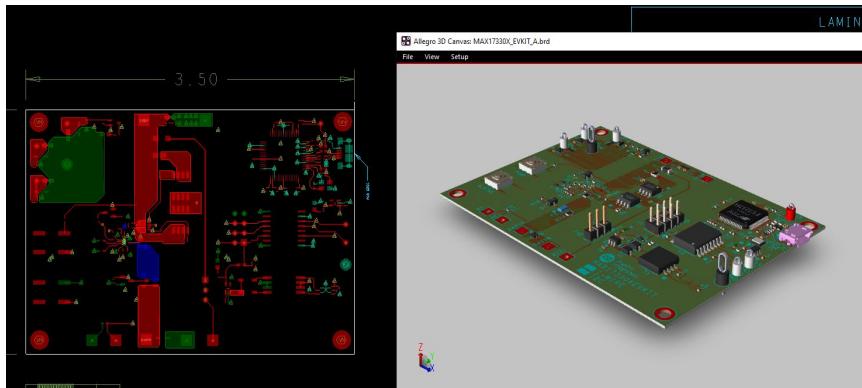


Progress: Completed Schematic in Allegro

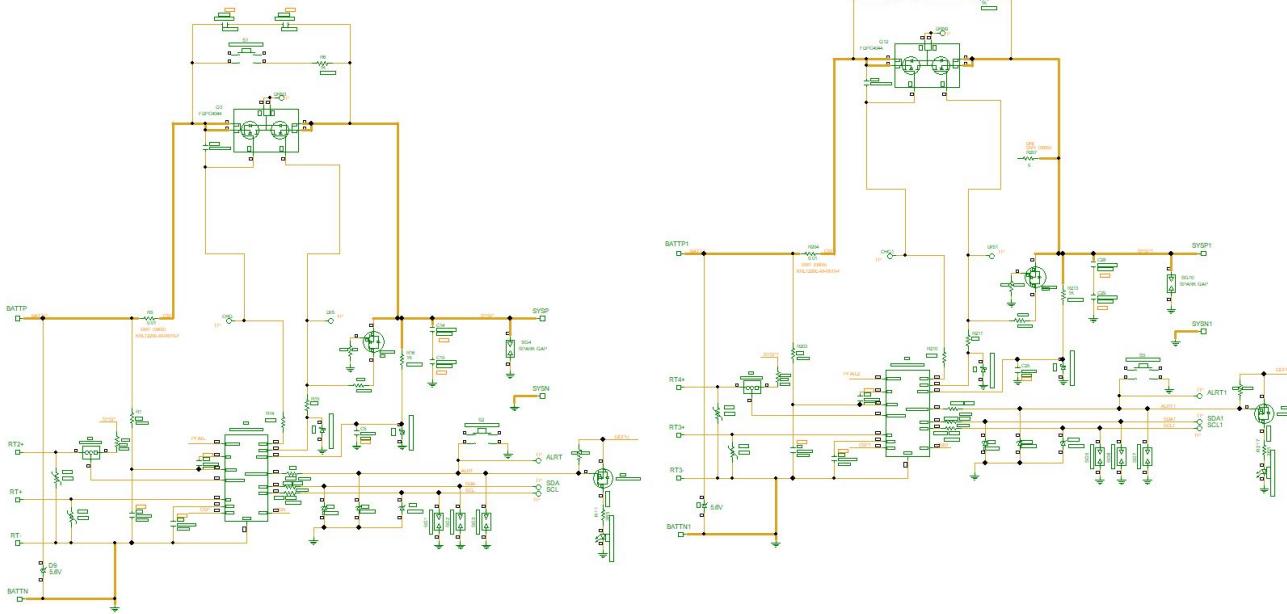
- Switched from Altium to Allegro
- ADI shared component libraries with us
- We fear this may not work with our timeline



Progress: Completed Schematic in Allegro

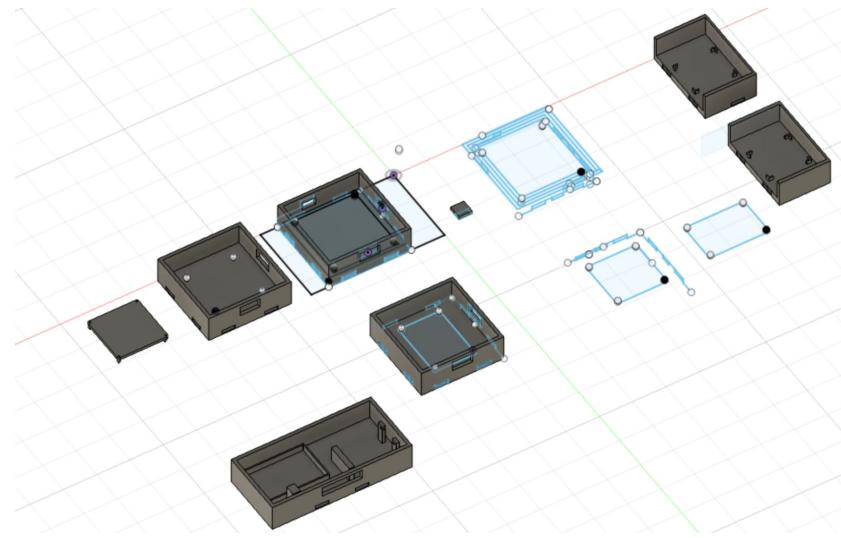


Progress: Completed Schematic in Allegro



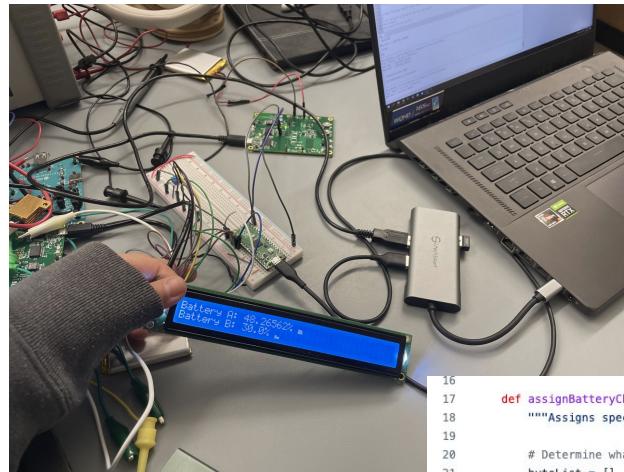
Progress: 3D Printed Enclosure for Demo Boards

- We are struggling to meet the timeline with our PCB Design
 - Time difference and physical distance makes it difficult to meet with ADI for help
 - Software and package differences make cooperation with ADI harder
 - Up to 3 week manufacture time
- Plan B: 3D Printed enclosure for working demo boards
 - Same functionality



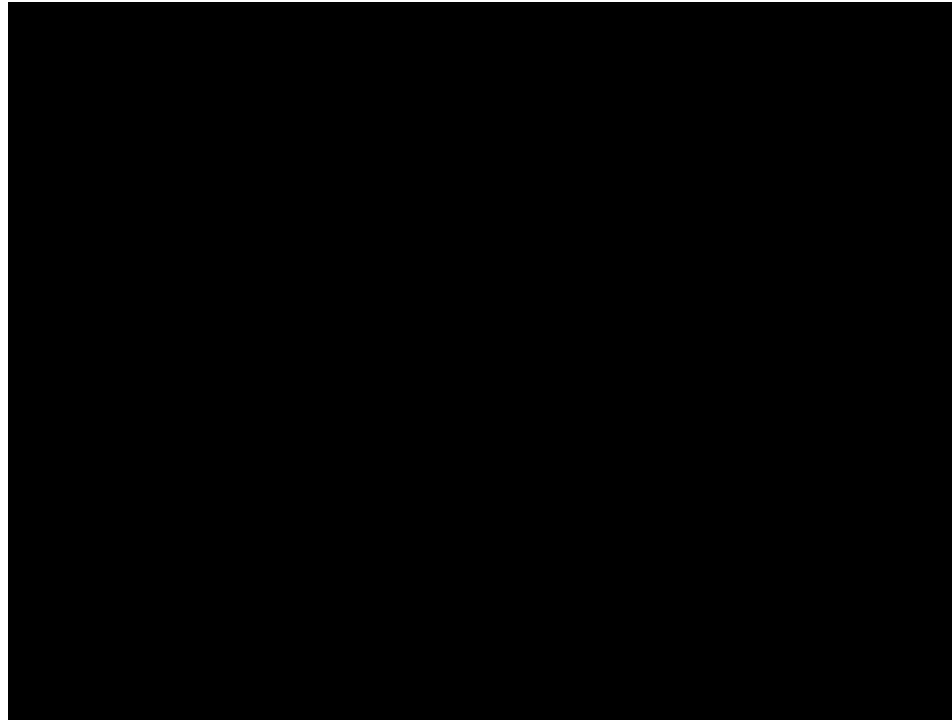
Progress: Pico and LCD Communication

- Programmed Pico to read effective battery levels from MAX17330 via I2C
- Pico communicates with LCD to display live readings
- Incorporation of basic battery graphics



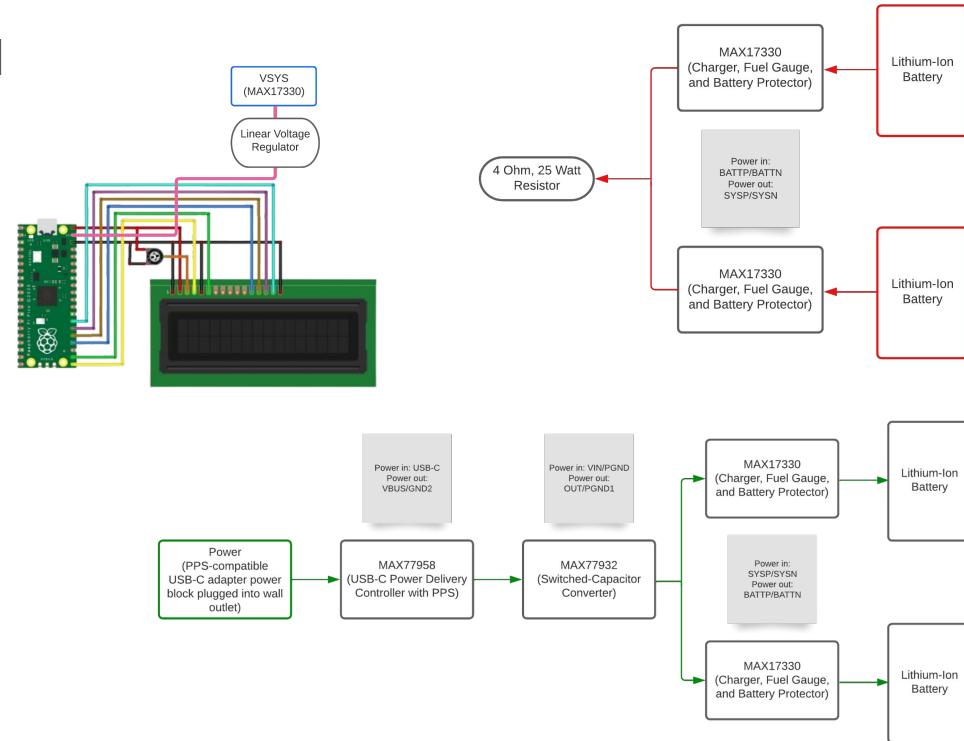
```
16     def assignBatteryChar(self, battPercentage, charAddr):
17         """Assigns special character to a given character address"""
18
19
20         # Determine what the character should look like
21         byteList = []
22
23         for pixLevel in range(8):
24             if battPercentage/(0.125*(pixLevel+1)) >= 1:
25                 byteList = [0x1f] + byteList
26             else:
27                 # Determined shift by knowing how many pixels need light
28                 # One pixel is 2.5% (.025) and one line is 12.5% (.125)
29                 shiftBy = int((battPercentage % .125)//.025)
30
31                 # shiftBy is the number of pixels to turn on
32                 # then bitwise & to only get last 5 bits
33                 byteList = [(0b1111100000 >> shiftBy) & 0x1f] + byteList
34
35                 for _ in range(7-pixLevel):
36                     byteList = [0x00] + byteList
37
38             # set as a custom character
39             self.lcd.custom_char(charAddr&8,bytearray(byteList))
```

Progress: LCD Updating Battery Levels

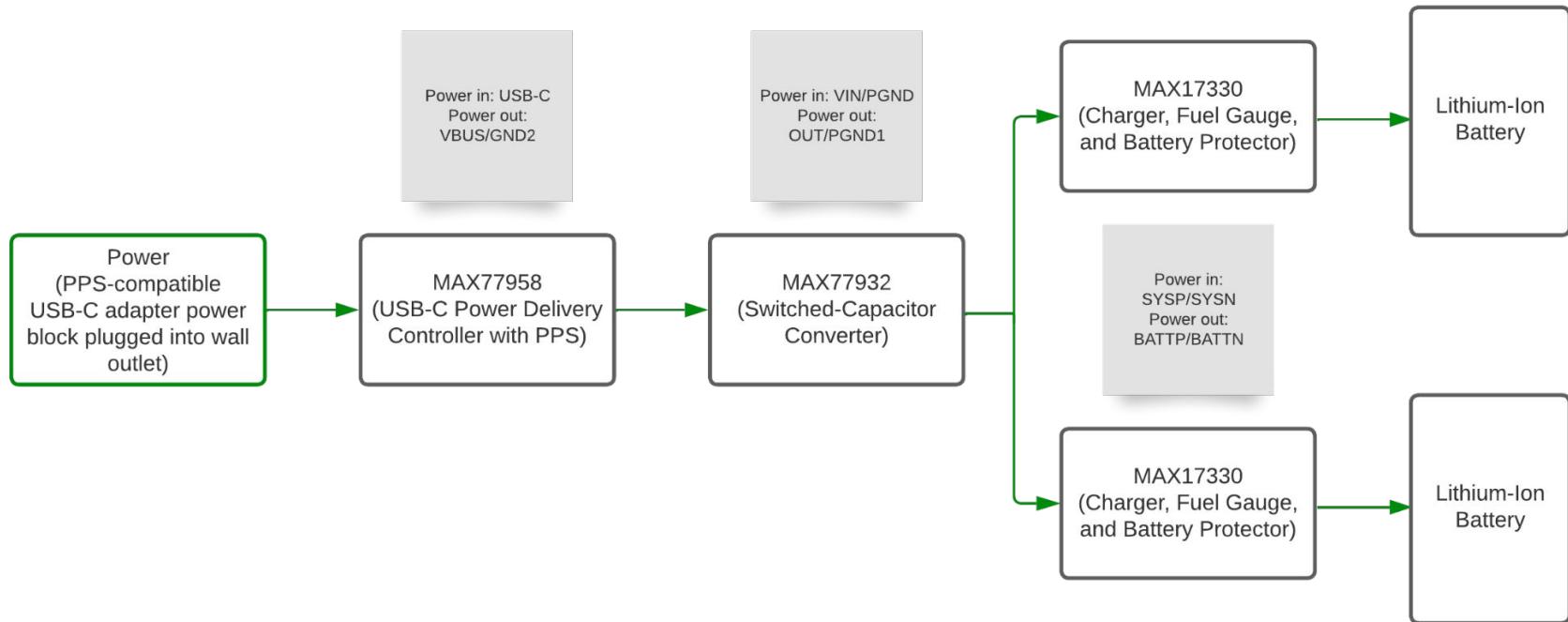


Progress: Full Physical Prototype Completed

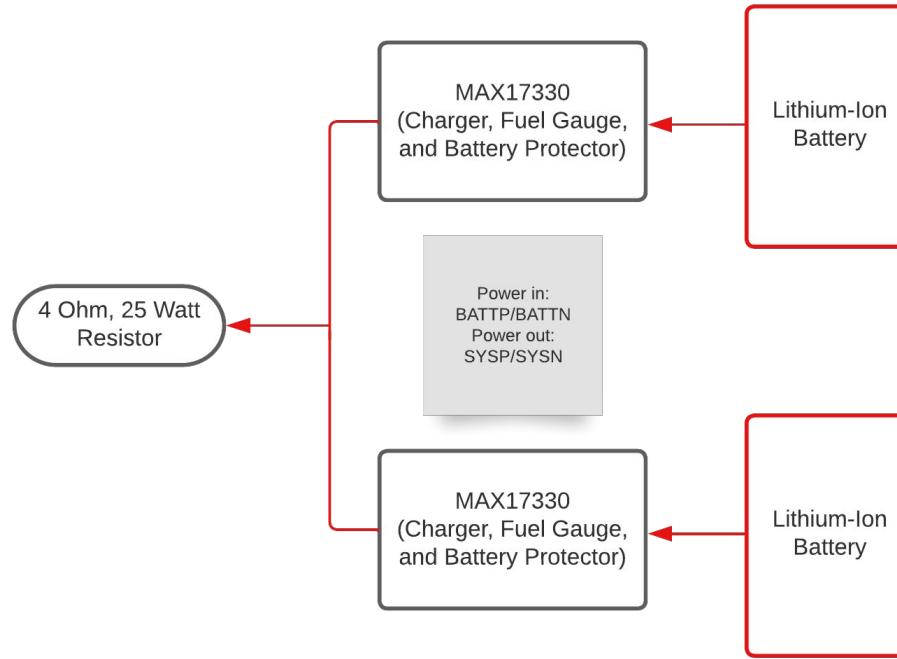
- Orientation for charging and discharging
- Connections between the evaluation (EV) boards
 - MAX77958
 - MAX17330
 - MAX77932
- Connections between EV boards, Pico, and LCD



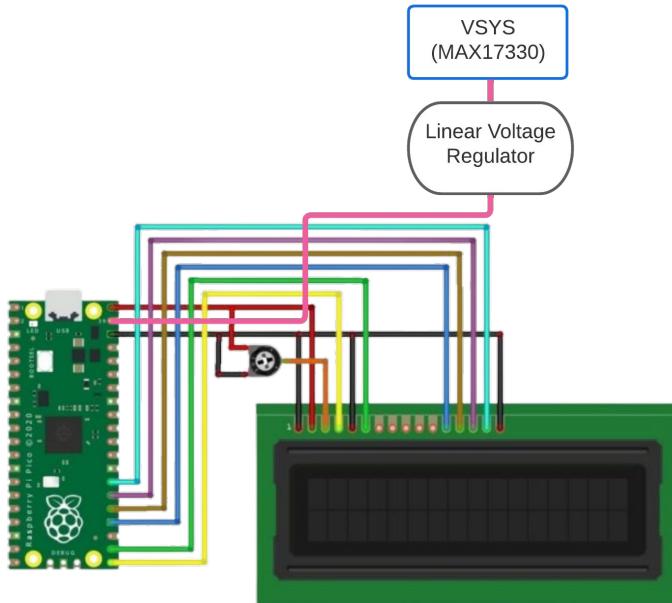
Progress: Charging Power Setup & Power Flow



Progress: Discharging Power Setup & Power Flow

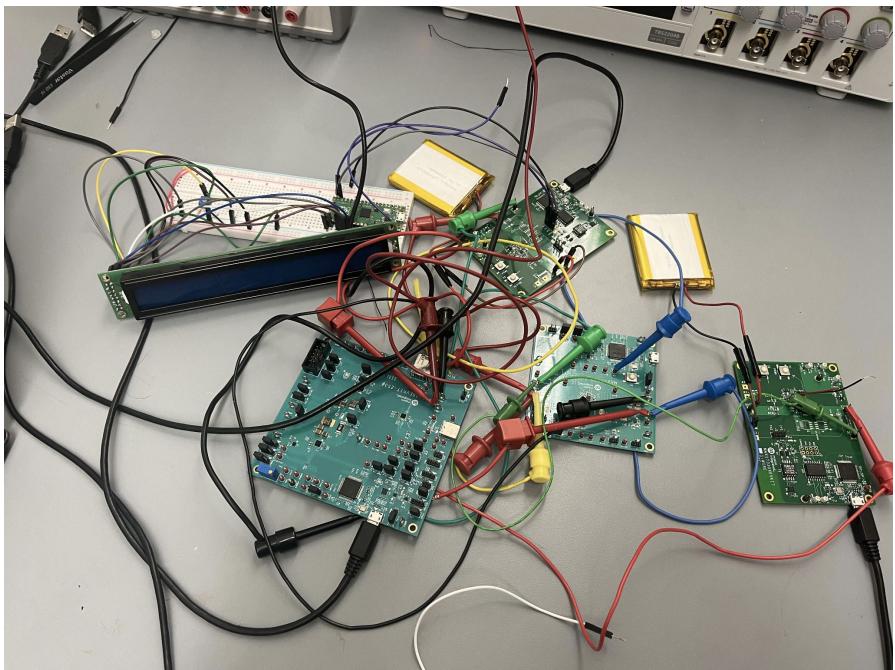


Progress: Raspberry Pi Pico Pin Connections with LCD



Raspberry Pi Pico Pin	LCD Pin	Potentiometer Pin
GPIO 16	RS	-
GPIO 17	E	-
GPIO 18-21	D4-D7	-
VBUS (5V)	VCC, LED+	VIN
GND	R/W, VSS, LED-	GND
-	VEE	VOUT

Physical Prototype



Progress: Pico Reading of Chip Registers

- Used I2C to read RepSOC register to find battery charge level (as %)
- Used datasheets to find important and relevant register addresses

RepSOC Register (006h) ←

Register Type: Percentage

Nonvolatile Backup: None

RepSOC is a filtered version of the _AvSOC register that prevents large jumps in the reported value caused by changes in the application such as abrupt changes in load current. RepSOC corresponds to _RepCap and [FullCapRep](#). RepSOC

```
1  class readRegs:
2      def __init__(self, i2c):
3          """Initialize object"""
4          self.i2c = i2c
5
6      def readfrom_mem(self,addr,memaddr,nbytes,addrsize=8):
7          """Reads defined register and returns list with 8bit-ints of size nbytes"""
8          bstring = self.i2c.readfrom_mem(addr,memaddr,nbytes,addrsize=addrsize)
9          return [bstring[i] for i in range(nbytes)]
10
11     def readRepSOC(self,addr=0x36,memaddr=0x06,addrsize=8):
12         data = self.readfrom_mem(addr=addr,memaddr=memaddr,nbytes=2,addrsize=addrsize)
13         return ((data[1] << 8) + data[0])/256
```

Progress: Verified Parallel Charging (via EV Kit GUI)

MAX17330 ModelGauge m5 EZ Fuel Gauge, Charger, and Protector

File Device Help **ModelGauge m5** **Charger + Protection** **Graphs** **Registers** **Commands** **Configuration** **Authentication** **History** **I2C Traffic Log**

State of Charge

Reported State of Charge
RepSOC Register 48.0%
Remaining Capacity
RepCAP Register 1199.500mAh
Time to Full
TTF Register 0.823hr
Time to Empty
TTE Register 102.398hr

Cell Information

IC Information

Cell Full Capacity
FullCapReg Register 2500.000mAh
Cell Health
Age Register 115.9%
Cell Lifetime Cycles
Cycles Register 0.010cycles
Cell Age
Timerf Register 0.000hr
Cell Resistance
RCell Register 389.404mOhms

IC Part Number MAX17330
IC Firmware Revision DevName Register 0xd0E0
IC Serial Number ROM ID EE00013098ABF326

Measurements

Pack Current Current Register 631.875mA
Pack Average Current AvgCurrent Register 635.469mA

Fuel Gauge Temperature Temp Register 25.0°C
FET Temperature Disabled

Charge Status

Charging Voltage ChargingVoltage Register 4.200V
Charging Current ChargingCurrent Register 1280mA

Parallel Management

- CC (C)
- CV (C)
- CP (C)
- CT (FET)
- CD (Dropout Prevention)

Stop Charging **Block Discharge**

Alerts

- Charging Protection
- Over Voltage Under Voltage
- Over Temperature Under Temperature
- Over Current Under Current
- Over SOC Under SOC

Protection Status

- CHG FET DIS FET
- OVP UVP
- TooColdC TooHotC TooHotD DieHot
- OCCP OC ODCP OO
- QovfW Full
- Shdn ChgWDT

At Rate

AtRate	6C:04 0x00
AtQResidual	6C:0C 0x00
AITTE	6C:10 0x32
AIA/SOC	6C:1B 0x30
AIA/Cap	6C:1F 0x09

Data Logging: On **Communication: I2C** **Mode: Active** **Sense: 10.0 mΩ** **Device Serial Number: EE00013098ABF326** **Software Ver: 1.0.3.0 Firmware Rev: 4080**

MAX17330 ModelGauge m5 EZ Fuel Gauge, Charger, and Protector

File Device Help **ModelGauge m5** **Charger + Protection** **Graphs** **Registers** **Commands** **Configuration** **Authentication** **History** **I2C Traffic Log**

State of Charge

Reported State of Charge
RepSOC Register 94.1%
Remaining Capacity
RepCAP Register 2352.000mAh
Time to Full
TTF Register 0.678hr
Time to Empty
TTE Register 102.398hr

Cell Information

IC Information

Cell Full Capacity
FullCapReg Register 2500.000mAh
Cell Health
Age Register 115.9%
Cell Lifetime Cycles
Cycles Register 0.010cycles
Cell Age
Timerf Register 0.000hr
Cell Resistance
RCell Register 160.156mOhms

IC Part Number MAX17330
IC Firmware Revision DevName Register 0xd0E0
IC Serial Number ROM ID A400013098ABF26

Measurements

Pack Current Current Register 475.781mA
Pack Average Current AvgCurrent Register 463.125mA

Fuel Gauge Temperature Temp Register 25.2°C
FET Temperature Disabled

Charge Status

Charging Voltage ChargingVoltage Register 4.200V
Charging Current ChargingCurrent Register 1040mA

Parallel Management

- CC (Constant Current)
- CV (Constant Voltage)
- CP (Constant Power)
- CT (FET Temperature Limit)
- CD (Dropout Saturation Prevention)

Stop Charging **Block Discharge**

Alerts

- Charging Protection
- Over Voltage Under Voltage
- Over Temperature Under Temperature
- Over Current Under Current
- Over SOC Under SOC

Protection Status

- CHG FET DIS FET
- OVP UVP
- TooColdC TooHotC TooHotD DieHot
- OCCP OC ODCP OO
- QovfW Full
- Shdn ChgWDT

At Rate

AtRate	6C:04 0x0000 0.000mA
AtQResidual	6C:0C 0x0000 0.000mA
AITTE	6C:10 0xFFFF 102.398hr
AIA/SOC	6C:1B 0x21D 94.1%
AIA/Cap	6C:1F 0x1242 2353.000mA

Data Logging: On **Communication: I2C** **Mode: Active** **Sense: 10.0 mΩ** **Device Serial Number: A400013098ABF26** **Software Ver: 1.0.3.0 Firmware Rev: 4080**

READING

Progress: Verified Parallel Discharging

MAX17330 ModelGauge m5 EZ Fuel Gauge, Charger, and Protector

File Device Help **Charger + Protection** **Graphs** **Registers** **Commands** **Configuration** **Authentication** **History** **I2C Traffic Log**

State of Charge

Reported State of Charge
RepSOC Register 42.5%
Remaining Capacity
RepCAP Register 1061.500mAh
Time to Full
TTF Register 2.388h
Time to Empty
TTE Register 102.399h

Cell Information

IC Information

Cell Full Capacity
FullCapReg Register 2500.000mAh
Cell Health
Age Register 115.9%
Cell Lifetime Cycles
Cycles Register 0.01cycles
Cell Age
Timewrt Register 0.000hr
Cell Resistance
RCell Register 370.695mOhms

Measurements

Voltages
VCell Register 4.072V
PCKP Register 4.084V

Pack Current
Current Register 830.313mA

Pack Average Current
AvgCurrent Register 808.438mA

Fuel Gauge Temperature
Temp Register 25.1°C

Die Temp
DieTemp Register 25.09°C

Alerts

- Charging
- Over Voltage
- Over Temperature
- Over Current
- Over SOC
- Under Voltage
- Under Temperature
- Under Current
- Under SOC
- SOC Change

Protection Status

- CHG FET
- OVP
- TooColdC
- OCCP
- Qovfw
- Shdn
- DIS FET
- UVP
- TooHotC
- OC
- Full
- ChgWDT
- PermFail
- UVD
- TooHotD
- ODCP
- OD
- SC
- Leak Detect

At Rate

AtRate	6C:04	0x00
AtQResidual	6C:00	0x00
ATTE	6C:02	0x00
AtAvSOC	6C:03	0x00
AtAvCap	6C:01	0x00

Charge Status

Stop Charging **Block Discharge**

MAX17330 ModelGauge m5 EZ Fuel Gauge, Charger, and Protector

File Device Help **Charger + Protection** **Graphs** **Registers** **Commands** **Configuration** **Authentication** **History** **I2C Traffic Log**

State of Charge

Reported State of Charge
RepSOC Register 27.7%
Remaining Capacity
RepCAP Register 567.500mAh
Time to Full
TTF Register N/A
Time to Empty
TTE Register 0.000h

Cell Information

IC Information

Cell Full Capacity
FullCapReg Register 2500.000mAh
Cell Health
Age Register 115.8%
Cell Lifetime Cycles
Cycles Register 0.01cycles
Cell Age
Timewrt Register 0.000hr
Cell Resistance
RCell Register 991.455mOhms

Measurements

Voltages
VCell Register 3.218V
PCKP Register 3.205V

Pack Current
Current Register -776.406mA

Pack Average Current
AvgCurrent Register -510.625mA

Fuel Gauge Temperature
Temp Register 24.3°C

Die Temp
DieTemp Register 24.29°C

Alerts

- Charging
- Over Voltage
- Over Temperature
- Over Current
- Over SOC
- Under Voltage
- Under Temperature
- Under Current
- Under SOC
- SOC Change

Protection Status

- CHG FET
- OVP
- TooColdC
- OCCP
- Qovfw
- Shdn
- DIS FET
- UVP
- TooHotC
- OC
- Full
- ChgWDT
- PermFail
- UVD
- TooHotD
- ODCP
- OD
- SC
- Leak Detect

At Rate

AtRate	6C:04	0x0000	0.000mA
AtQResidual	6C:00	0x0000	0.000mAh
ATTE	6C:02	0xFFFF	102.398h
AtAvSOC	6C:03	0x1ED5	30.8%
AtAvCap	6C:01	0x0606	771.000mAh

Charge Status

Stop Charging **Block Discharge**

Data Logging: On **Communication I2C** **Mode: Active** **Sense: 10.0 mΩ** **Device Serial Number: E00013098ABF326** **Software Ver: 1.0.3.0 Firmware Rev:4080** **READING**

Digital Reports in Coursespace

Audacity **Arduino IDE**

Adobe Acrobat **Autodesk Fusion 360**

New Text Document **ARD 3D.D...**

Progress: Verified One Charging, One Discharging

MAX17330 ModelGauge m5 EZ Fuel Gauge, Charger, and Protector

File Device Help

ModelGauge m5 Charger + Protection Graphs Registers Commands Configuration Authentication History I2C Traffic Log

State of Charge

Reported State of Charge
RepSOC Register 48.6%

Remaining Capacity
RepCAP Register 1214.500mAh

Time to Full
TTF Register 0.873h

Time to Empty
TTE Register 102.398h

Cell Information

Cell Full Capacity
FullCapReg Register 2500.000mAh

Cell Health
Age Register 115.9%

Cell Lifetime Cycles
Cycles Register 0.01cycles

Cell Age
Timerf Register 0.000hr

Cell Resistance
RCell Register 359.414mOhms

IC Information

IC Part Number
MAX17330

IC Firmware Revision
DevName Register 0x0B0

IC Serial Number
ROM ID EE00013098ABF326

Measurements

Voltages VCell Register 4.115V
PCKP Register 4.124V

Pack Current Current Register 682.500mA

Pack Average Current AvgCurrent Register 677.344mA

Fuel Gauge Temperature Temp Register 25.1°C
FET Temperature Disabled

Die Temp DieTemp Register 25.27°C

Charging Voltage ChargingVoltage Register 4.200V

Charging Current ChargingCurrent Register 1040mA

Parallel Management

Stop Charging
Block Discharge

Alerts

- Charging
- Over Voltage
- Over Temperature
- Over Current
- Over SOC
- Under Voltage
- Under Temperature
- Under Current
- Under SOC
- Protection
- UVF
- UVP
- TooColdC
- TooHotC
- TooHotD
- DieHot
- OCCP
- OC
- ODCP
- OO
- Qonfw
- Full
- Shdn
- ChgWDT
- SOC Change

Alert Triggered

Clear Alerts

Data Logging: On Communication: I2C Mode: Active Sense: 10.0 mΩ Device Serial Number: EE00013098ABF326 Software Ver: 1.0.3.0 Firmware Rev: 40B0 REA

MAX17330 ModelGauge m5 EZ Fuel Gauge, Charger, and Protector

File Device Help

ModelGauge m5 Charger + Protection Graphs Registers Commands Configuration Authentication History I2C Traffic Log

State of Charge

Reported State of Charge
RepSOC Register 54.5%

Remaining Capacity
RepCAP Register 2352.500mAh

Time to Full
TTF Register N/A

Time to Empty
TTE Register 2.167h

Cell Information

Cell Full Capacity
FullCapReg Register 2490.000mAh

Cell Health
Age Register 115.9%

Cell Lifetime Cycles
Cycles Register 0.01cycles

Cell Age
Timerf Register 0.000hr

Cell Resistance
RCell Register 498.047mOhms

Measurements

Voltages VCell Register 3.258V
PCKP Register 3.238V

Pack Current Current Register -766.19mA

Pack Average Current AvgCurrent Register -654.375mA

Fuel Gauge Temperature Temp Register 24.9°C
FET Temperature Disabled

Die Temp DieTemp Register 24.92°C

Charging Voltage ChargingVoltage Register 4.200V

Charging Current ChargingCurrent Register 1280mA

Parallel Management

Stop Charging
Block Discharge

Alerts

- Charging
- Over Voltage
- Over Temperature
- Over Current
- Over SOC
- Under Voltage
- Under Temperature
- Under Current
- Under SOC
- Protection
- UVF
- UVP
- TooColdC
- TooHotC
- TooHotD
- DieHot
- OCCP
- OC
- ODCP
- OO
- Qonfw
- Full
- Shdn
- ChgWDT
- SOC Change

No Alerts Triggered

Data Logging: On Communication: I2C Mode: Active Sense: 10.0 mΩ Device Serial Number: A400013098ABF326 Software Ver: 1.0.3.0 Firmware Rev: 40B0 READING

MAX17330 ModelGauge m5 EZ Fuel Gauge, Charger, and Protector

File Device Help

ModelGauge m5 Charger + Protection Graphs Registers Commands Configuration Authentication History I2C Traffic Log

State of Charge

Reported State of Charge
RepSOC Register 94.6%

Remaining Capacity
RepCAP Register 102.398h

Time to Full
TTF Register 102.398h

Time to Empty
TTE Register 2354.500mAh

Cell Information

Cell Full Capacity
FullCapReg Register 0.000mAh

Cell Health
Age Register 115.9%

Cell Lifetime Cycles
Cycles Register 0.01cycles

Cell Age
Timerf Register 0.000hr

Cell Resistance
RCell Register 2354.500mOhms

Measurements

Voltages VCell Register 3.258V
PCKP Register 3.238V

Pack Current Current Register 1280mA

Pack Average Current AvgCurrent Register 1280mA

Fuel Gauge Temperature Temp Register 24.9°C
FET Temperature Disabled

Die Temp DieTemp Register 24.92°C

Charging Voltage ChargingVoltage Register 4.200V

Charging Current ChargingCurrent Register 1280mA

Parallel Management

Stop Charging
Block Discharge

Alerts

- Charging
- Over Voltage
- Over Temperature
- Over Current
- Over SOC
- Under Voltage
- Under Temperature
- Under Current
- Under SOC
- Protection
- UVF
- UVP
- TooColdC
- TooHotC
- TooHotD
- DieHot
- OCCP
- OC
- ODCP
- OO
- Qonfw
- Full
- Shdn
- ChgWDT
- SOC Change

No Alerts Triggered

Data Logging: On Communication: I2C Mode: Active Sense: 10.0 mΩ Device Serial Number: A400013098ABF326 Software Ver: 1.0.3.0 Firmware Rev: 40B0 READING

MAX17330 ModelGauge m5 EZ Fuel Gauge, Charger, and Protector

File Device Help

ModelGauge m5 Charger + Protection Graphs Registers Commands Configuration Authentication History I2C Traffic Log

State of Charge

Reported State of Charge
RepSOC Register 94.6%

Remaining Capacity
RepCAP Register 102.398h

Time to Full
TTF Register 102.398h

Time to Empty
TTE Register 2354.500mAh

Cell Information

Cell Full Capacity
FullCapReg Register 0.000mAh

Cell Health
Age Register 115.9%

Cell Lifetime Cycles
Cycles Register 0.01cycles

Cell Age
Timerf Register 0.000hr

Cell Resistance
RCell Register 2354.500mOhms

Measurements

Voltages VCell Register 3.258V
PCKP Register 3.238V

Pack Current Current Register 1280mA

Pack Average Current AvgCurrent Register 1280mA

Fuel Gauge Temperature Temp Register 24.9°C
FET Temperature Disabled

Die Temp DieTemp Register 24.92°C

Charging Voltage ChargingVoltage Register 4.200V

Charging Current ChargingCurrent Register 1280mA

Parallel Management

Stop Charging
Block Discharge

Alerts

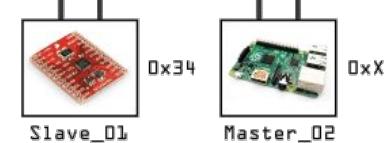
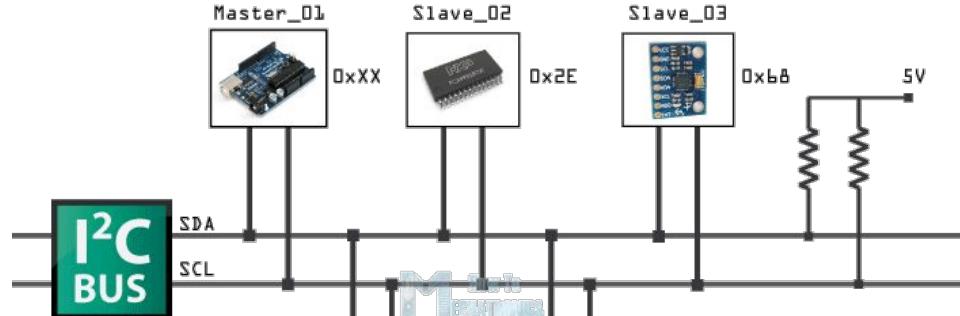
- Charging
- Over Voltage
- Over Temperature
- Over Current
- Over SOC
- Under Voltage
- Under Temperature
- Under Current
- Under SOC
- Protection
- UVF
- UVP
- TooColdC
- TooHotC
- TooHotD
- DieHot
- OCCP
- OC
- ODCP
- OO
- Qonfw
- Full
- Shdn
- ChgWDT
- SOC Change

No Alerts Triggered

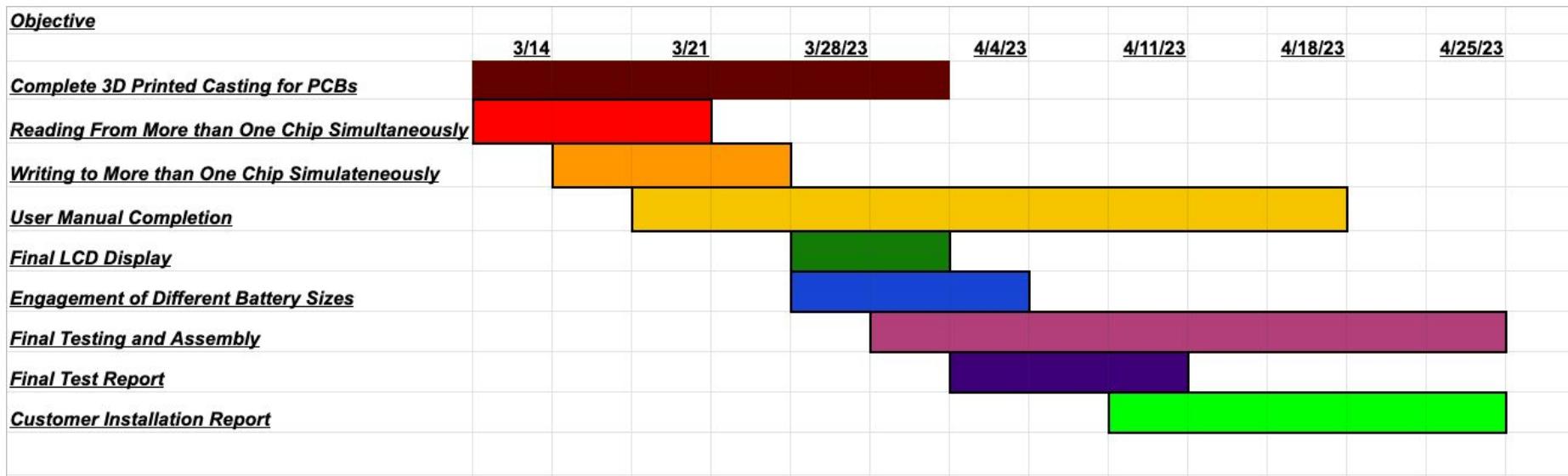
Data Logging: On Communication: I2C Mode: Active Sense: 10.0 mΩ Device Serial Number: A400013098ABF326 Software Ver: 1.0.3.0 Firmware Rev: 40B0 READING

To be Completed

1. Reading from multiple chips
 - a. I2C communication
2. Writing to multiple chips
 - a. I2C communication
3. Developing 3D printed enclosure
 - a. Demo-boards
 - b. Pico
 - c. Batteries
 - d. LCD
4. Final LCD Display
 - a. Display more values such as charging current and voltages



Updated Gantt Chart





Thank you!