21/08/23

August 21, 2023 8:12 AM

Start: 8:00am

I am getting pretty close to the end. This is my last week.

There are not too many things to do.

- Start cell balancing circuit
- Meet with grant and nick to review progress
- Edit report

I am hoping that Nick and Grant will read through my report and give some feedback on things that may be unclear.

Especially Grant as he as not been as involved along the way so his perspective will be more similar to that of a new student coming onto the project. Where Nick I have talked to throughout the whole process so he has a lot more background information

I read through the report again and made some edits. I am hoping that Nick and Grant will read it soon so that they can let me know what is unclear and I can edit it. Also I would like Grant to have read it before we meet so that we can focus more of what is unclear or giving more details on certain aspects, as opposed to me just trying to summarize the past 3 months verbally off the top of my head. I think the meeting will be much more effective when

Cell Balancing

I finished wiring the prototype of the cell balancing circuit on a solderless bread board.

Currently it appears that the OP-AMP circuit is working, however these is some offset which is not good.
When I measure the voltage of the cell with a multimeter, I get a value of 3.484V
When I use the multimeter to measure the output of the OP-AMP, I get 3.29V

However for the rest of prototyping, a small offset should not matter.

	Voltage
Cell	3.484
B4	3.3
B3	3.296
B2	0.3
B1	3.293
Cell (After)	3.484

Clearly there is a wiring issue with B2, however the rest are fairly consistent in their offset.
I will fix B2 wiring and get a getter number.

Found the issue, now reading 3.293V.

The ADC on the PIC is not measuring these properly however.

This is what I get when I connect the 3.484V cell in place of B4.

Name	Type	Address	Value	Binary
<Enter new watch>				
decReadings; file:C:\Us	float[4]	0x560		
decReadings[0]	float	0x560	2.227	01000000 00001110 10000111 00101011
decReadings[1]	float	0x564	0.089	00111101 10110110 01000101 10100010
decReadings[2]	float	0x568	0.08800001	00111101 10110100 00111001 01011001
decReadings[3]	float	0x56C	4.0950003	01000000 10000011 00001010 00111110
readings; file:C:\Users\	unsigned short[4]	0x547		
readings[0]	unsigned short	0x547	0x08B3	00001000 10110011
readings[1]	unsigned short	0x549	0x0059	00000000 01011001
readings[2]	unsigned short	0x54B	0x0058	00000000 01011000
readings[3]	unsigned short	0x54D	0x0FFF	00001111 11111111

The value for B4 is reading 4.095V (Max reading when you look at raw reading) and the following reading is reading 2.227V

I know that this is a measurement error cause when I made the table above I connected the multimeter to the pin of the PIC.

Im gping to use the DC power supply to generate a lower voltage (<VDD) of 2.00V to see what reading I get.

Output | Watches | Variables | Call Stack

Name	Type	Address	Value	Binary
<Enter new watch>				
decReadings; file:C:\Us	float[4]	0x560		
decReadings[0]	float	0x560	0.81200004	00111111 01001111 11011111 00111100
decReadings[1]	float	0x564	0.098000005	00111101 11001000 10110100 00111010
decReadings[2]	float	0x568	0.098000005	00111101 11001000 10110100 00111010
decReadings[3]	float	0x56C	2.499	01000000 00011111 11101111 10011110
readings; file:C:\Users\	unsigned short[4]	0x547		
readings[0]	unsigned short	0x547	0x032C	00000011 00101100
readings[1]	unsigned short	0x549	0x0062	00000000 01100010
readings[2]	unsigned short	0x54B	0x0062	00000000 01100010
readings[3]	unsigned short	0x54D	0x09C3	00001001 11000011

I am noticing that the B4 reading is extremely consistent, while the B1 reading is changing by almost 0.1V.
I am curious if attaching the voltage to B3 will cause the noise to move to B4

Output | Watches | Variables | Call Stack

Name	Type	Address	Value	Binary
<Enter new watch>				
decReadings; file:C:\Us	float[4]	0x560		
decReadings[0]	float	0x560	0.097	00111101 11000110 10100111 11110000
decReadings[1]	float	0x564	0.096	00111101 11000100 10011011 10100110
decReadings[2]	float	0x568	2.5040002	01000000 00100000 01000001 10001010
decReadings[3]	float	0x56C	0.097	00111101 11000110 10100111 11110000
readings; file:C:\Users\	unsigned short[4]	0x547		
readings[0]	unsigned short	0x547	0x0061	00000000 01100001
readings[1]	unsigned short	0x549	0x0060	00000000 01100000
readings[2]	unsigned short	0x54B	0x09C8	00001001 11001000
readings[3]	unsigned short	0x54D	0x0061	00000000 01100001

This time there is no error on the following pin. I wonder if this is related to the other pins having no cell connected. I am going to connect

Output | Watches | Variables | Call Stack

Name	Type	Address	Value	Binary
<Enter new watch>				
decReadings; file:C:\Us	float[4]	0x560		
decReadings[0]	float	0x560	2.4986103	01000000 00011111 11101001 00111011
decReadings[1]	float	0x564	0.09702369	00111101 11000110 10110100 01011011
decReadings[2]	float	0x568	0.09602344	00111101 11000100 10100111 11110000
decReadings[3]	float	0x56C	0.09502321	00111101 11000010 10011011 10000111
readings; file:C:\Users\	unsigned short[4]	0x547		
readings[0]	unsigned short	0x547	0x09C2	00001001 11000010
readings[1]	unsigned short	0x549	0x0061	00000000 01100001
readings[2]	unsigned short	0x54B	0x0060	00000000 01100000
readings[3]	unsigned short	0x54D	0x005F	00000000 01011111

This is 2.00V connected to B1

B1 = 2.00V	Reading
B1	2.4986
B2	0.097
B3	0.096
B4	0.095

B2 = 2.00V	Reading
B1	0.092
B2	2.4946
B3	0.093

B4	0.092

B3 = 2.00V	Reading
B1	0.099
B2	0.097
B3	2.505
B4	0.098

B4 = 2.00V	Reading
B1	0.806
B2	0.100
B3	0.100
B4	2.499

The multimeter agrees that there is excess error in the B1 reading when B4 = 2.00V
I will have to check the wiring of that circuit. It appears to be wired correctly…

Leave 3:30

22/08/23

August 22, 2023 8:05 AM

Start 8:00

Yesterday I was looking at the cell balancing circuit. I only focused on the measurement side for testing so far

All of the measurements are off, and I found that on the 4th cell the measurement of the other cells is affected.

I should also be able to test if the MOSFETs are working properly by connecting the multimeter from the high of the cell I want to turn on to the high of the capacitor to see if there is continuity, then do the same with the negative.

So long as there is always continuity with the one cell selected, this should be good.

Once the measurement is working, and the control is working, I should be ready to test the complete system.

One issue I still need to address is switching the PWM for the high cell without losing the low cell. Since I can attach the PWM to multiple cells, I need to clear the PWM on the original pin before setting it to another, however I cant just clear all the pins cause some may be attached to the low cell.

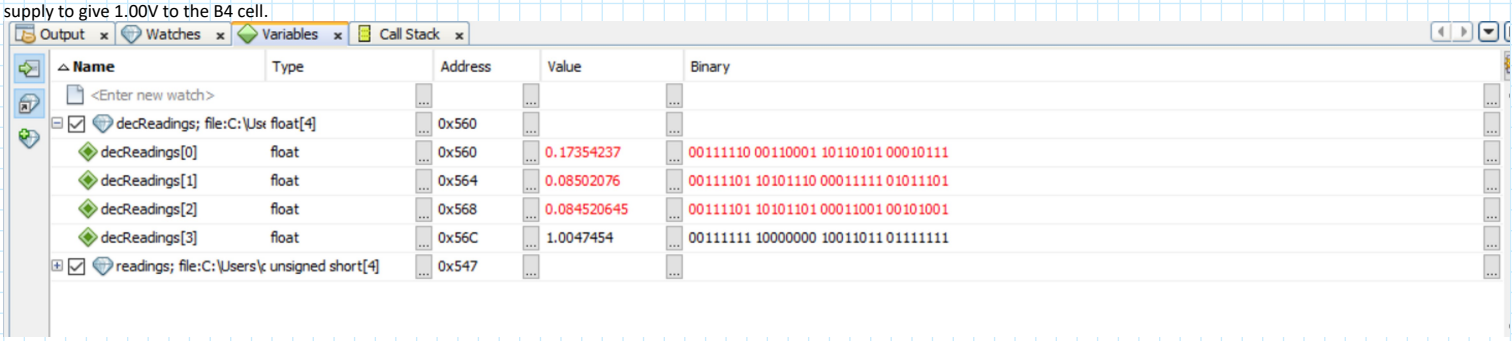
Since I am running at only ~300Hz, I could just reset both signals. The downtime would be negligible considering it would like only be a few instruction cycles in the middle.
4MHz clock @ 4 cycles / instruction
1MHz instruction is 1us period
303Hz is 1/303=0.0033 = 3300us

I don't think it will matter significantly if the on period is actually 3290us as opposed to 3300us

The other option would be to track the pervious high and low pin to make sure that they don't get cleared.
I don't really see an issue with just reseting them all. The downtime will be nothing with this slow of a frequency

I can just clear the 4 pins, and then set the 2 that I want. I could add a condition to do this only when either the low or high pin changes. This would be easier than only reseting an individual pin while also reducing the downtime issue.

I talked with Nick about the measurement system and we decided that the FVR cant actually get to 4.096V which is messing with my readings. I changed the FVR to the 2.048V reference and used the DC supply to give 1.00V to the B4 cell.



It can be seen that this is not measuring accurately. There is still the error will cell 4 spilling into cell 1

I will connect to the other cells and document the output

B1=1.00	Voltage
B1	1.0037
B2	0.0810
B3	0.0800
B4	0.0800

B2=1.00	Voltage
B1	0.0810
B2	1.0007
B3	0.0810
B4	0.0810

B3=1.00	Voltage

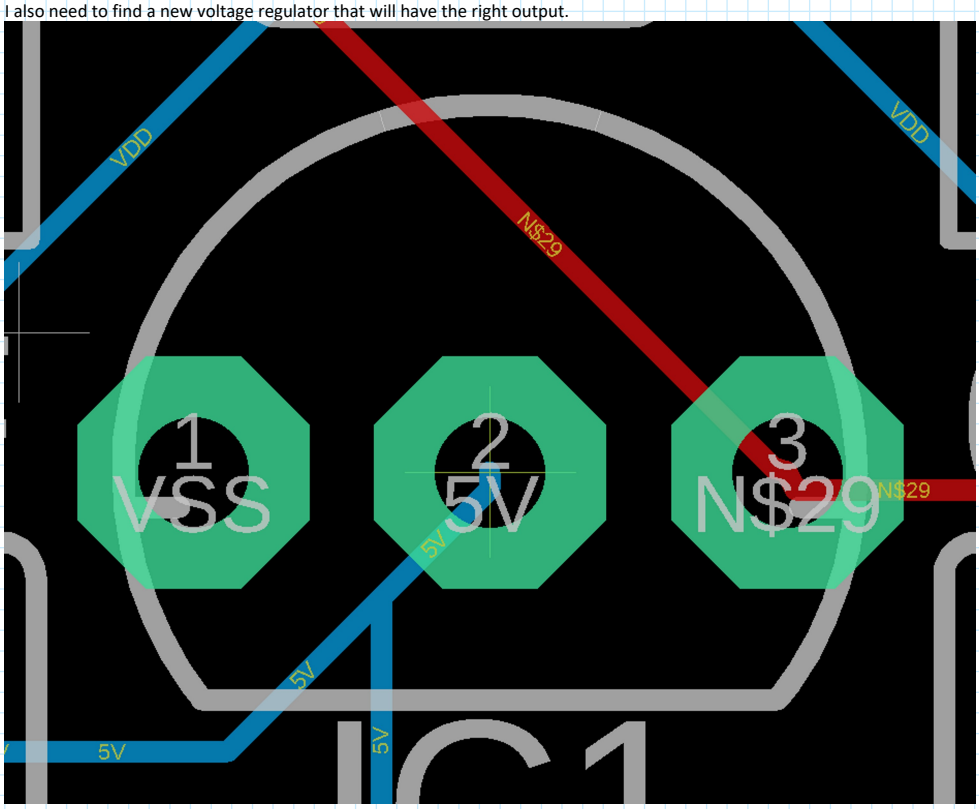
B1	0.0855
B2	0.0850
B3	1.0097
B4	0.0850

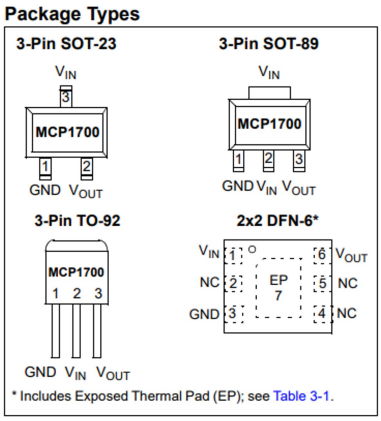
B4=1.00	Voltage
B1	0.154
B2	0.0860
B3	0.0855
B4	1.0042

Meeting with Grant and Nick

- Order parts to make at least 2 more dev board
- Order USB-UART converters
- Make a lab with instuctions and pictures on how to use the PWM.

I am going to place an order for enough parts to construct 2 more dev boards
I also need to find a new voltage regulator that will have the right output.





This should be the right footprint

Leave 3:30

23/08/23

August 23, 2023 8:58 AM

Start 8:15

I finished my document for the lab exercise setting up PWM that Grant had requested.

Spudnik-1 2023S -...

I believe now I just have the cell balancing to work on.

```
        }
        NOP();
        //Write to FETs
        //LATCbits.LATC2 = 1;
        //LATBbits.LATB4 = 1;
        //LATBbits.LATB5 = 1;
        //LATBbits.LATB6 = 1;

    }
```

I turned on each on the gate pins one at a time and used a multimeter to check continuity between the High and Low side of the capacitor and the High and low side of each cell.

B1 Gate	B4 H	B4 L	B3 H	B3 L	B2 H	B2 L	B1 H	B1 L
Cap H	0	0	0	0	0	0	1	0
Cap L	0	0	0	0	0	0	0	1

B2 Gate	B4 H	B4 L	B3 H	B3 L	B2 H	B2 L	B1 H	B1 L
Cap H	0	0	0	0	1	0	0	0
Cap L	0	0	0	0	0	1	0	0

B3 Gate	B4 H	B4 L	B3 H	B3 L	B2 H	B2 L	B1 H	B1 L
Cap H	0	0	1	0	0	0	0	0
Cap L	0	0	0	1	0	0	0	0

B4 Gate	B4 H	B4 L	B3 H	B3 L	B2 H	B2 L	B1 H	B1 L
Cap H	1	0	0	0	0	0	0	0
Cap L	0	1	0	0	0	0	0	0

It appears that this is working properly.

Next I will manually set the cell volatges, rather than using the ADC and ensure that the PWM signals are being attached to the correct output pins.

For the PWM I want 303Hz
1/303=0.0033
3300us period

4e6/303=13,201.3201

1.00000000/4.0000e6=2.5E-7
0.25us period

13201*0.25=3300.25

I need to count to 13201 to get the desired period.
Actually, do I need that or double that…. Let me check my old notes.

> On the PIC it is going to generate the push-pull PWM frequencies, which means that each one should be double the frequency found in the model I believe

It should be double the Freq, so half the period

13201/2=6600.5

The channel_map reads B1 to B4, meaning that index 0 = B1, index 3 = B4

```
uint8_t prev_index_max = 0;
uint8_t prev_index_min = 0;

Vcell[0] = 60;
Vcell[1] = 40;
Vcell[2] = 50;
Vcell[3] = 50;
```

So if I set the 'readings' as such, the lowest cell will be overcharged and the highest cell will be under charged.

So I want PWM1S1P1 to attach to pin RB6, and PWM1S1P2 to attach to pin RB5.

	B1 Max	B2 Max	B3 Max	B4 Max
B1 Min		C1	C2	C3
B2 Min	C4		C5	C6
B3 Min	C7	C8		C9
B4 Min	C10	C11	C12	

These are the possible combinations.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
B1 Gate	2	2	2	1	0	0	1	0	0	1	0	0
B2 Gate	1	0	0	2	2	2	0	1	0	0	1	0
B3 Gate	0	1	0	0	1	0	2	2	2	0	0	1
B4 Gate	0	0	1	0	0	1	0	0	1	2	2	2

0 = No PWM
1 = PWM 1 (PWM1S1P1)
2 = PWM 2 (PWM1S1P2)

```
150         Vcell[0] = 50;
151         Vcell[1] = 50;
152         Vcell[2] = 60;
153         Vcell[3] = 40;
154
155         for(int i = 0; i < 4; i++){
156             //uint16_t reading = ADCread(i);
157             //Vcell[i] = reading;
158             uint16_t reading = Vcell[i];
159
160             if(reading >= max){
161                 max = reading;
162                 prev_index_max = index_max;
163                 index_max = i;
164             }
165
166             if(reading <= min){
167                 min = reading;
168                 prev_index_min = index_min;
169                 index_min = i;
170             }
171         }
172
173         if(index_max != prev_index_max || index_min != prev_index_min){
174             RC2PPS = 0x29;
175             RB4PPS = 0x29;
176             RB5PPS = 0x29;
177             RB6PPS = 0x29;
```

```
178             switch(index_max){
179                 case 0:
180                     RB6PPS = 0x0A;  //Configure to PWM1S1P1_OUT
181                     break;
182                 case 1:
183                     RB5PPS = 0x0A;  //Configure to PWM1S1P1_OUT
184                     break;
185                 case 2:
186                     RB4PPS = 0x0A;  //Configure to PWM1S1P1_OUT
187                     break;
188                 case 3:
189                     RC2PPS = 0x0A;  //Configure to PWM1S1P1_OUT
190                     break;
191             }
192             switch(index_min){
193                 case 0:
194                     RB6PPS = 0x0B;  //Configure to PWM1S1P2_OUT
195                     break;
196                 case 1:
197                     RB5PPS = 0x0B;  //Configure to PWM1S1P2_OUT
198                     break;
199                 case 2:
200                     RB4PPS = 0x0B;  //Configure to PWM1S1P2_OUT
201                     break;
202                 case 3:
203                     RC2PPS = 0x0B;  //Configure to PWM1S1P2_OUT
204                     break;
205             }
206         }
```

I tested all 12 combinations of min and max cells with this script and it performed properly

I think it would be cool to set this up so that the data is logged somehow. So when I go to perform the real test I can watch the trend of the cell voltage in like an excel graph.

I could probably use an arduino just to read the same ADC values as the PIC and send them over the Serial monitor to the PIC.

I could do the same on the PIC, however I am concerned about just getting bad readings from using jumpers in the breadboard for the RX and TX pins. I can connect it and do a test to see if this will be a real issue.

I also still have the issue where the Cell4 appears to affect the Cell 1.

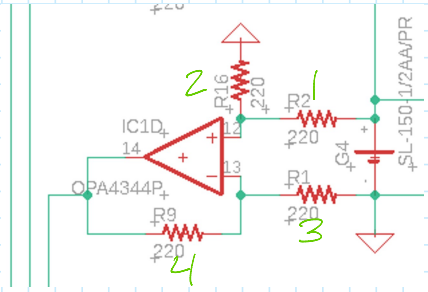
I looked at the wiring and it appears to be correct.

Im going to measure the resistances in the circuit to see what I find

	Cell High to OPAMP output
B1	400k
B2	600k
B3	600k
B4	600K

The resistance on cell 1 is lower than the others.

resitor	resistance
1	100.2k
2	100.2k
3	100.2k
4	99.6k



I wonder if this has to do with that fact that the negative side is connecting to ground through the resistor. Technically I shouldn't need this OPAMP in the current configuration, but when the new resistors come I will need it to drop the gain

Resistance between B1 and other outputs

B2	
B3	
B4	

Leave 3:45

24/08/23

August 24, 2023 8:39 AM

Start 8:30

Cell Balancing circuit

I still need to figure out what is wrong with this cell balancing circuit. The only read issue seems to be that the voltage on B4 shows up in the reading of B1

I did a test where I put a voltage across various cells and measured the others with a multimeter.
It is clear that cell B1 is not isolated from the others, but the others appear to be.

When I power B3, I can see that B2 and B4 are uneffected, but B1 voltage increases.

When I power B4, I can see B2 and B3 are uneffected, but B1 voltage increases.

B4	B3	B2	B1
1.00V	7.0mV	6.8mV	130mV
0.00V	16.2mV	9.2mV	8.3mV

B4	B3	B2	B1
7.0mV	1.00V	6.8mV	8.3mV
18.2mV	0.00V	16mV	10.4mV

B4	B3	B2	B1
8.3mV	7.2mV	1.00V	7mV
8.7mV	18.6mV	0.00V	22mV

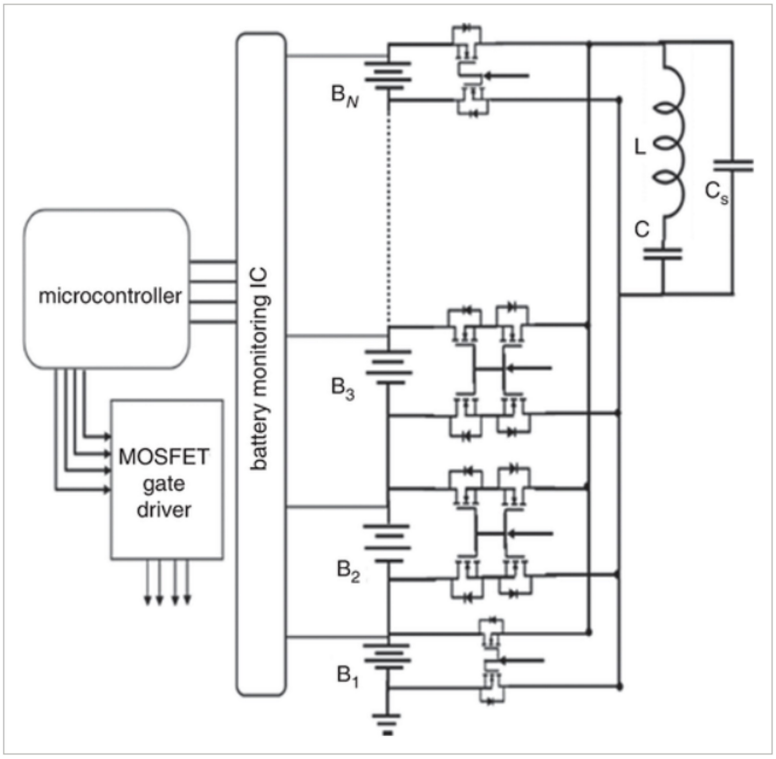
B4	B3	B2	B1
8.8mV	8.8mV	8.1mV	1.00V
8.8mV	8.7mV	9.2mV	0.00V

I found it.

The noise is coming though the switching system somehow. When I disconnect the source of the transistor running off the high cell, the noise goes away.

I am going to remove the wires for the high side switches and redo it from the paper drawing to see if that fixes it.

I redid the circuit with the based off the diagram in the paper, but I am wondering if there is a mistake in the paper



Notice that all the high side of the cells connects to the drain of the transistors, except the top. Even the bottom where there is only two, the high voltage going into the drain…

I am going to try switching the direction of the top two MOSFETs to see what happens.

It appears that I have fixed the voltage problem, I will redo the 4 tables from above to confirm. Then I need to make sure the switching circuit still works

B4	B3	B2	B1
1.00V	5.0mV	5.1mV	6.2mV
0.00V	16.8mV	8.2mV	6.5mV

B4	B3	B2	B1
5.0mV	1.00V	8.3mV	6.4mV
17.6mV	0.00V	16.4mV	9.7mV

B4	B3	B2	B1
5.9mV	4.8mV	1.00V	4.5mV
6.0mV	18mV	0.00V	22.4mV

B4	B3	B2	B1
6.1mV	6.2mV	8.1mV	1.00V
6.2mV	6.0mV	6.2mV	0.00V

The measurement issue seems to be resolved, now I just need to check the MOSFETs to make sure they connect what they are supposed to.

The switching side is also working.

I think I have resolved the problem. That means that this would be overall ready to test.

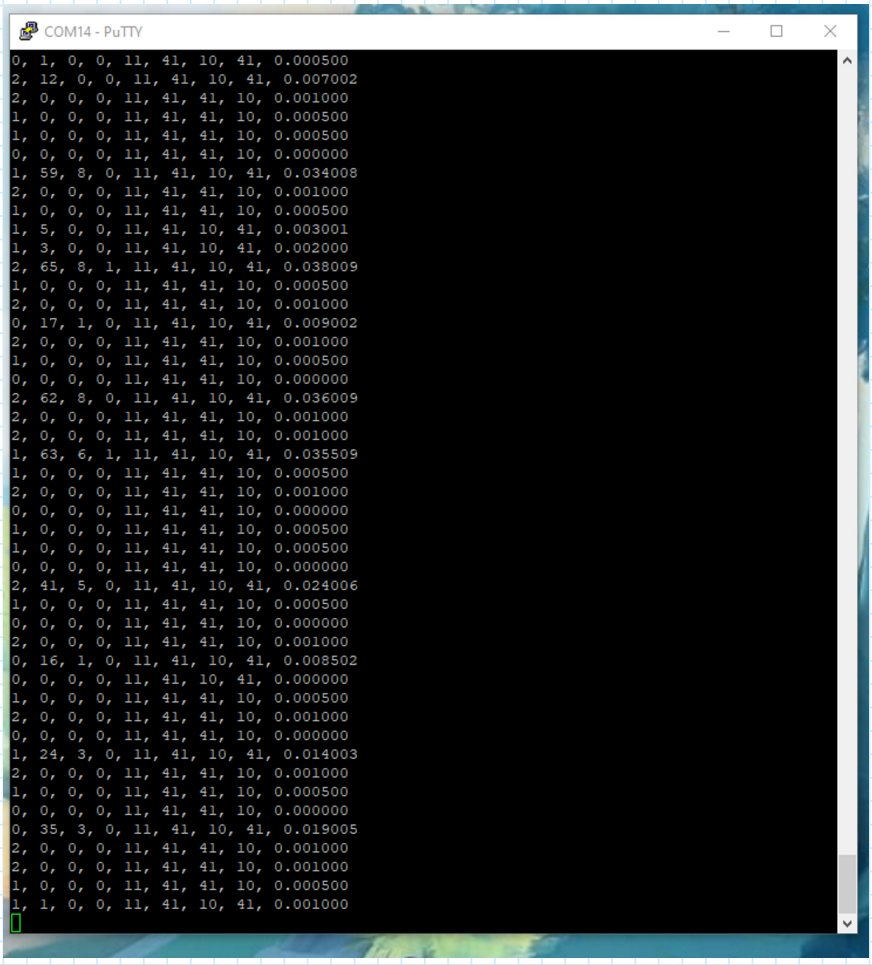
It would be really nice to setup the UART on the PIC in order to send back data on what the switches are doing. I am not sure if I can read that on the Arduino. Unless maybe I used a capacitor and read the pins with an analog pin. That way when there is some voltage I know the PWM is active. Not sure how reliable that would be though.

I also need those 50K resistors to come in so that I can actually measure the cell voltages. Right now the cells would exceed 3.3V so I can't actually run a test. Unless I tried to power the PIC off 5V input, then it should work...

I added UART to the PIC

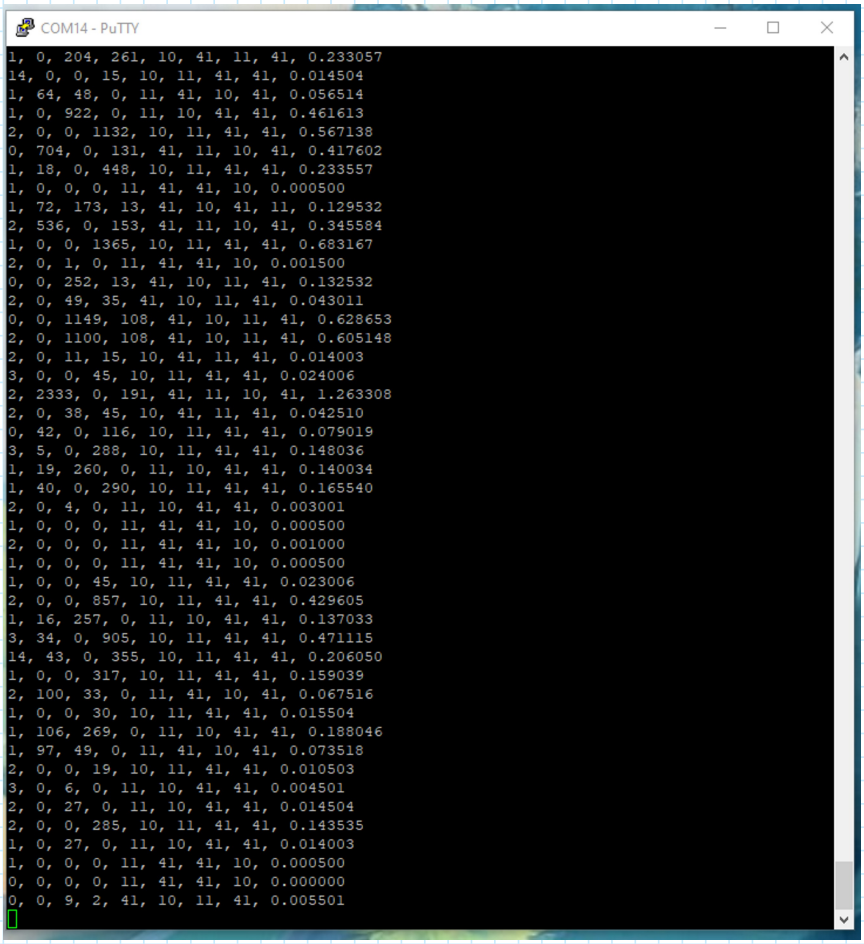
```
218  void sendData(){
219      char msg[64];
220      //Message format: 'Vcell[3], Vcell[2], Vcell[1], Vcell[0], B1Gate, B2Gate, B3Gate, B4Gate, Total voltage'
221      sprintf(msg, "%d, %d, %d, %d, %d, %d, %d, %d, %f\n\r",
222              Vcell[3], Vcell[2], Vcell[1], Vcell[0],
223              RB6PPS, RB5PPS, RB4PPS, RC2PPS,
224              Vt);
225
         for(int i = 0; i<64; i++){
227          TX(msg[i]);
228          if(msg[i] == 0x0D){
229              break;
230          }
231      }
232      NOP();
233  }
```

This will send back the ADC reading for each cell, the PPS of the PWM signals so you can see which is attached to what, and then the total cell voltage as a float.



It appears to be working good.
The PPS registers will read:
10 - High cell PWM
11 - Low cell PWM
41 - No PWM

I do notice a problem however. The over circuit is with the PWM disabled. When I enable the PWM, I get this:

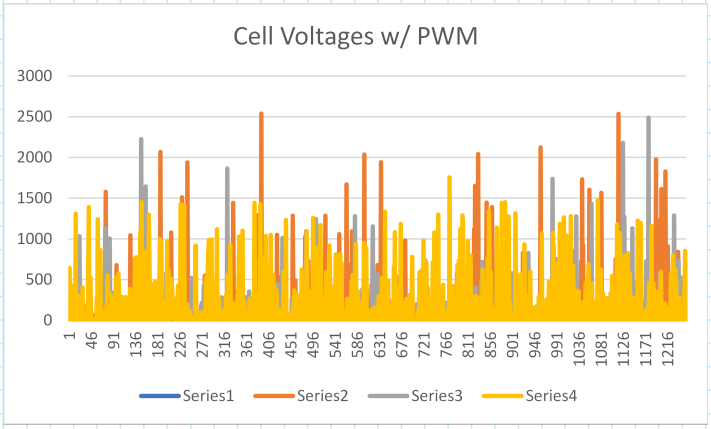


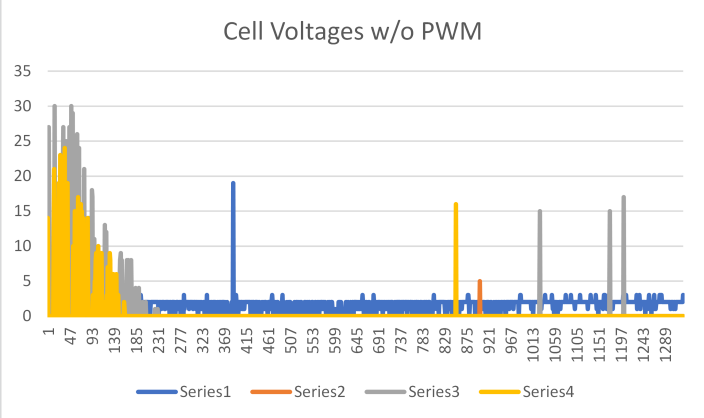
There is a lot more noise in the ADC readings. This might be because the cells are actually not connected, so the interference from the PWM is substancial compared to the actual signal. I may need to perform a test when I get the correct resistors to see if there is a noise difference when cells are connected.

For now, I am going to log some data for both and analyze the data in excel.

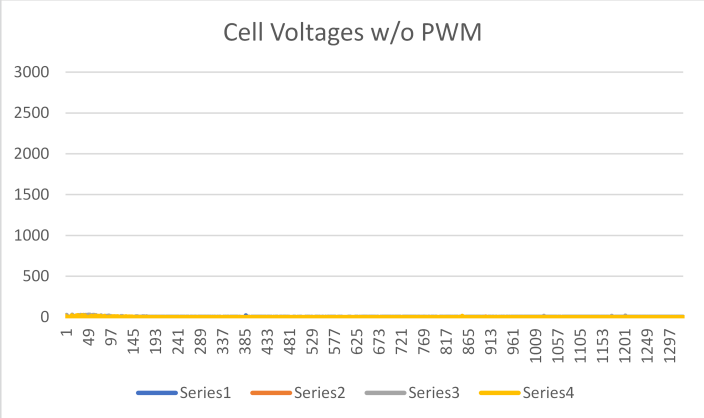
I will do a test where I let the program run for 5 minutes on each, I may also drop the delay I have from 1s to 100ms to get more samples.

I logged 5 minutes of data for the device with PWM enabled and without, these were the results.





Notice the y axis scale… If I convert the w/o to the same scale, I get this.



Clearly the PWM in causing a lot of interference.

I also logged the PWM signals, So I can see of it is making sense.

B4 B3 B2 B1 B1σ B2σ B3σ B4σ Vtotal

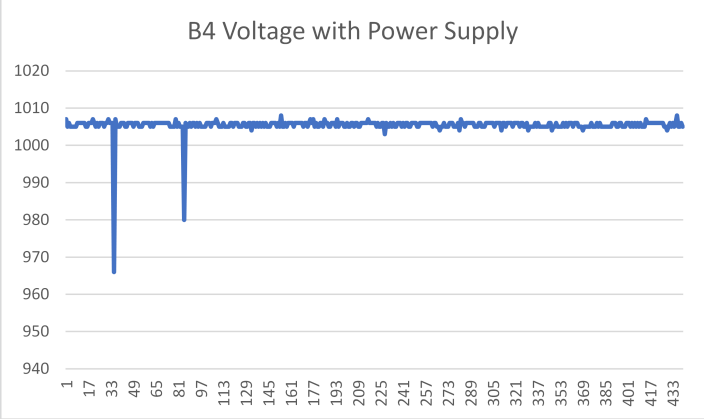
=~=~=~=~=~=~=~=~=~=~=~= PuTTY log 2023.08.24 11:40:45 =~=~=~=~=~=~=~=~=~=~=~=

2	min 0	min 0	max 499	B1	10	B2	11	41	41	0.250561
2	0	0	3		10		11	41	41	0.002501
1	57	0	641		10		11	41	41	0.349585
2	36	109	0		11		10	41	41	0.073518
1	0	160	0		11		10	41	41	0.08052
1	108	0	302		10		11	41	41	0.20555
2	0	240	55		41		10	11	41	0.148536
1	0	172	0		11		10	41	41	0.086521
2	47	0	427		10		11	41	41	0.238058
2	0	71	62		41		10	11	41	0.067516
2	0	61	43		41		10	11	41	0.053013
1	0	61	0		11		10	41	41	0.031008
2	0	0	247		10		11	41	41	0.12453
2	0	22	0		11		10	41	41	0.012003
2	0	0	1308		10		11	41	41	0.65516
1	0	0	2		10		11	41	41	0.0015
1	119	226	0		11		10	41	41	0.173042
3	0	234	0		11		10	41	41	0.118529
3	0	125	0		11		10	41	41	0.064016
2	38	24	0		11		41	10	41	0.032008
1	0	342	301		41		10	11	41	0.322079
2	0	48	51		10		41	11	41	0.050512
1	0	1032	0		11		10	41	41	0.516626
2	0	0	0		11		41	41	10	0.001
0	76	0	42		41		11	10	41	0.059014
1	0	0	261		10		11	41	41	0.131032
1	42	165	0		11		10	41	41	0.104025

I am going to change the order of the cell voltages to B1-B4 cause this is confusing me. Next time it will make more sense.

I mentioned before that there is a lot of noise in the cells when the PWM is enabled.
I redid a test with the power supply connected to B4 at 0.5V

The noise was almost entirely removed. Any noise seen was within the range that was seen without the PWM enabled.



ADCwoPW...

ADCwPW...

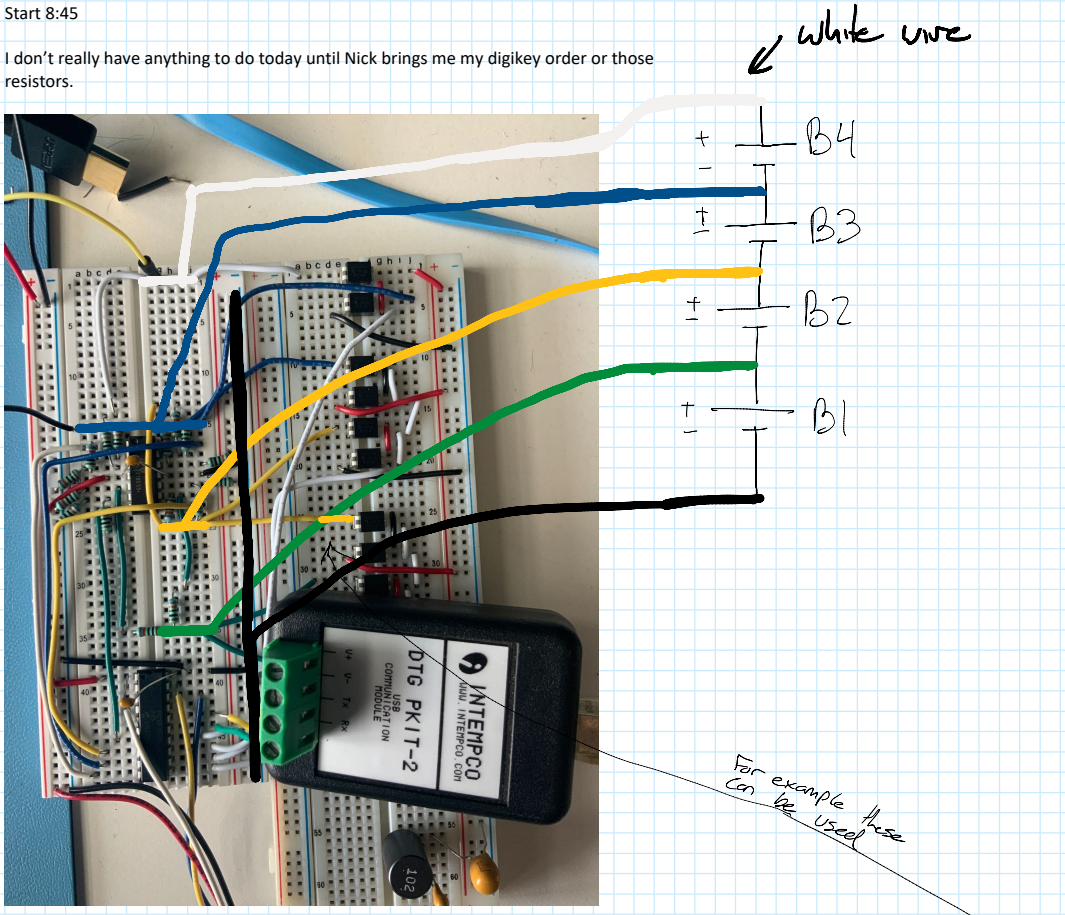
ADCwPWM

25/08/23

August 25, 2023 8:44 AM

Start 8:45

I don't really have anything to do today until Nick brings me my digikey order or those resistors.



This is how the cells are connected to the balancing breadboard

B4+ → row 1, column Fghij

B4-
B3+ → row 15, column abcdefghij

B3-
B2+ → row 25, column Fghij

B2-
B1+ → row 35, column Fghij

B1- → GND/VSS

Any wires connected to these pins can also be used as long as no resistors

Tera Term Test

I want to make sure that Tera Term isnt going to hit a limit with the data logging. Im going to log a session while I do other stuff and make sure it will last a few hours.

Op Amp resistors

Nick brought me some resistors that I can use for the OP AMPS to drop down the gain.

I found 8 that were all 44.3kOhm

Using this, I will get a gain of 44.3/100=0.443

Differential Amplifier Equation

$$V_{OUT} = \frac{R_3}{R_1}(V_2 - V_1)$$

Differential Amplifier

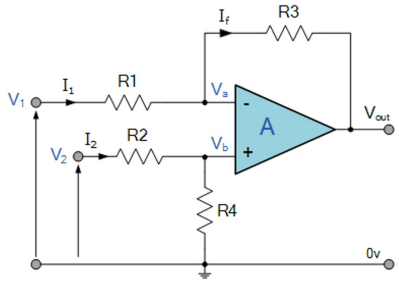
OP AMP test

2.00V	Measured	Expected
B1	0.883	0.886
B2	-0.42	0.886
B3	0.44	0.886
B4	0.883	2.00*0.443=0.886

Cell B1 and B4 are close enough, but there is something going on with the others...

I think I blew up one side of the OP AMP

Differential Amplifier



Note R1=R2 and R3=R4

So I need to swap the resistors tying Vin- to Vout, and the resistors tying Vin+ to GND

If I use the 2.048 reference, I can measure up to
2.048/0.443=4.623

This should be higher than a cell ever reaches.

I am going to modify the code now such that the total voltage is scaled accordingly

Once I swap the resistors, and have some confidence the logging will hold all the data, I think I am ready to run the test. I let the Tera Term run for an hour. If all the data is there, I am happy with moving forward. An hour of data should give a good indication of how it performs even if it doesn't finish.

I don't have any time to stay late today so I want to get the final test running.
I am also going to reduce the rate that the PIC checks the voltages and changes PWM. I have it at 100ms Right now. This is really not necessary in my opinion, as the cells arent going to change very fast. Maybe 1000ms would be better. There isn't really a hard in doing it more often but I also don't see a benefit.

I could also just log every nth data point as well. But I like the idea of seeing every time the PIC measures and sets the PWM.

Cell Balancing Test

Initial cell voltages (measured by multimeter)

	Voltage
B1	
B2	3.484V
B3	4.07V
B4	3.86V

When I connected B2, there was smoke. I am not sure what I burnt, I think it came from the MOSFET

I disconnected all the cells. I am going to try and check that each cell us still reading, and that the Switching circuits are working.

All the cells are reading properly except B2 is unclear.
It is fluxuating a lot, even though it is around the right value

The two locations I plugged the cell into has a resistance of 250kohm, so it couldn't have shorted through the battery.

There is 150kOhm from B2+ to GND
Same with B2- to GND

I checked every connection to B2-, there is nothing with >100kOhm. Which if somehow all the power sources connected in series, 10/100000=0.0001A which would not burn anything.

B2+ also has at least 100kOhm to any other connection.
I am going to reconnect it and see what happens. If it smokes again. I will also connect B2 through the meter to measure the current when I connect it

I connected everything. No smoke, everything is reading right except for B2. I think I am going to try replacing the OP AMP, but I am going to disconnect everything first

The high cell + MOSFET was burnt. I replaced it.

Cell B1 and B4 are close enough, but there is something going on with the others…

I think I blew up one side of the OP AMP

I swapped it for a new one, and these are the results

2.00V	Measured	Expected
B1	0.896	0.886
B2	0.41	0.886
B3	0.886	0.886
B4	0.897	0.886

Swapping it fixed B3, which I might have accidentally shorted with a resistor tail… whoops.

I checked all the components and it looked like it was wired properly.
In checking it, it started working… Im going to run through each cell again.
This time I am going to read the PIC readings for the cell
0.886/2.048=0.4326
0.4326*4095=1771.497

2.00V	Measured	Expected
B1	1774	1771
B2	1740	1771
B3	1755	1771
B4	1773	1771

Cells B2 and B3 are still not perfect… But it is hard to tell if that is just a difference in the OP AMP resistors, or more resistance in the circuit.

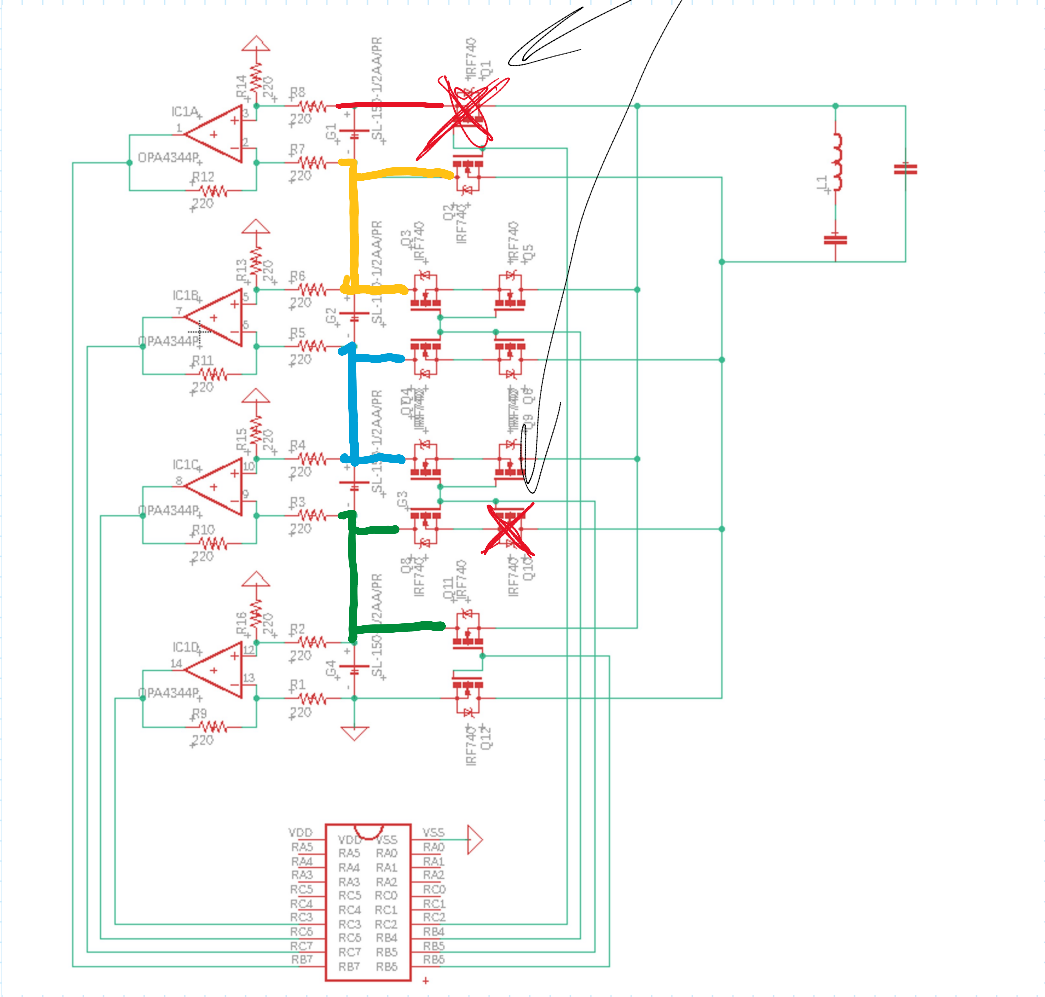
It is ~30 off, which is 2.048*30/4095=0.015
15mV, which on the cell would be 15/0.443=33.86
33.8mV off on the cells… This should be close enough for me to test.

Although with this error, the high cell can probably end up being 60mV lower than the low cell at the end. This should matter aside from the fact that the caps are polarized. But 60mV in the wrong polarity should not damage anything.

B2 4th MOSFET was blown, I replaced it.

The B2 cell is now reading consistently. It seems that just the MOSFET was damaged.

I am going to turn off the PIC and recheck all the resistances



When I connect a cell to B4, there is a 0.75V difference between the gate and source of the FET. But the Source-Drain is still 10Mohm.

This is not open

I am going to connect each cell one at a time and see if any og the MOSFETs open.

I connected B3 and found that the 2nd and 3rd MOSFET has only only a few hundred ohms between Source-Drain across it…. This is strange.

It this from the fly back diode? What if I swap the leads
It's the same both ways…

Do I see the same phenomenon with cell 2
It does. I am really unsure if this is a circuit error or the way the circuit is supposed to work….

I am going to try connecting it one more time.
This time I will connect the B2 cell with a multimeter attached to see if there us a current spike through that cell when it is attached.

Right now I have B4 and B3 connected, and the PIC is reading and sending back data.
I connected B2 through the meter to measure current. And there was no current measured, but also no voltage detected. I am wondering if the fuse in the meter is blown.

I can connect the power supply to the two meter probes and turn on 5V, as long as I set the current limit down to like 0.5A it should tell me if that's broken.

The meter is blown. Not sure if I did that.
I am going to use the power supply instead of the cell, they should act the same except I can limit the current from the supply to like 0.25A to not blow anything.

There is a problem. The power supply is maxing the current with 0V.

I am going to try disconnecting B4 since it seemed like that's where the current was going.

It still maxed the current with B4 disconnected.

With B3 disconnected it can get 3.5V (set point) with 38mA going somewhere

When I connect B4 and B3, and put the power supply in B1, I again get a short.
When I connect B4 and B2, and put the power supply in B1, I again get a short.

It appears that B2 and B3 are shorted
B1 and B2 are not quite shorted cause there is some voltage but the current exceeds 100mA
B1 and B3 are the same.

I have no idea what is wrong with this.
I think the next person is going to have to figure this one out, cause it is getting to the end of the day
Good Luck