

SeeStar II Battery Module
Technical Manual, v0.2

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Table of Contents

Overview	5
System Level Description	5
NiMH Cells.....	6
Polyfuse.....	6
Charging the Battery Module.....	7
Discharge Profile	8
Assembly Instructions	9
Tools and Parts Needed for Assembly	9
Assembly	9
References	13
Appendices.....	14

Figure 1: Picture of the SeeStar II imaging system	5
Figure 2: SeeStar II battery module block diagram.....	6
Figure 3: A single HHR450A cell	6
Figure 4: Charge curve of the battery module at a 0.33C rate	7
Figure 5: Discharge curve of the 12-cell NiMH battery.....	8
Figure 6: The 12-cell NiMH battery pack from Battery Specialties (PN# 11021184).....	9
Figure 7: Endcap with connector	10
Figure 8: The battery wired to the output connector.....	11
Figure 9: Battery inserted into the housing	12
Figure 10: The complete battery module (with dummy plug).....	13

Table 1: Polyfuse electrical characteristics	6
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Appendix 1: Electrical Specifications	14
Appendix 2: Mechanical Specifications.....	14
Appendix 3: Battery Module External Connector Pinout	14
Appendix 4: Calculation of C rate	15
Appendix 5: Wiring Diagram of the SeeStar Battery Module	16
Appendix 6: Exploded View of the SeeStar Battery Module	17
Appendix 7: SeeStar Battery Module Bill of Material	18

Overview

SeeStar II is an autonomous and modular imaging system (Fig. 1). It is programmed prior to deployment and can be left unattended for months at a time. It is an open source project and is distributed under a Creative Commons Attribution-ShareAlike 4.0 License. SeeStar II consists of three individual modules: the camera, battery, and LED. The battery module contains the 12-cell battery and polyfuse.



Figure 1: Picture of the SeeStar II imaging system

System Level Description

The battery module is the energy source for the SeeStar Imaging System. The SeeStar II battery module contains 12 rechargeable NiMH cells in series for a nominal bus voltage of 14.4Vdc and a capacity of 4500mAh. The battery resides in a housing which is rated to a depth of 1500 meters under water. The battery module attaches to the camera module with an 8-pin inter-module cable and can be recharged without opening the housing. Figure 2 displays a block diagram of the battery module.



Figure 2: SeeStar II battery module block diagram

NiMH Cells

The battery from Battery Specialties contains 12 Panasonic HHR450A rechargeable Nickel Metal Hydride (NiMH) cells in series. The HHR450A is an L-Fat A size cell with a diameter of 0.76" and height of 2.6". The battery has a capacity of 4500mAh and a nominal bus voltage of 14.4Vdc. See Ref. 1 for more details.



Figure 3: A single HHR450A cell

Polyfuse

The battery module contains an inline resettable fuse in the event of a catastrophic failure. The part used is a TE Connectivity SRP350F PolySwitch PTC (Positive Temperature Coefficient) Device.

	I_{HOLD}	I_{TRIP}	V_{MAX}	I_{MAX}	$P_{D MAX}$	Max Time-to-Trip		R_{MIN}	R_{MAX}	R_{1MAX}
Part #	(amps)	(amps)	(Vdc)	(amps)	(watts)	(amps)	(seconds)	(ohms)	(ohms)	(ohms)
SRP120F	1.20	2.70	15	100	1.2	6.00	5.0	0.085	0.160	0.220
SRP175F	1.75	3.80	15	100	1.5	8.75	5.0	0.050	0.090	0.120
SRP200F	2.00	4.40	30	100	1.9	10.00	4.0	0.030	0.060	0.100
SRP350F	3.50	6.30	30	100	2.5	20.00	3.0	0.017	0.031	0.050
SRP420F	4.20	7.60	30	100	2.9	20.00	6.0	0.012	0.024	0.040

Table 1: Polyfuse electrical characteristics

Charging the Battery Module

There are numerous methods for recharging NiMH batteries (See Ref. 2, pp. 17), and they depend upon a number of variables, the most important being the charge level of the battery prior to re-charging. In general, the charge rate should never exceed 1C. See appendix 5 for details on how to calculate the C rate.

The preferred method of charging is actually a combination of different rates; this method requires monitoring cells temperatures and a smart charger that can change charge rates on the fly. With typical use, the batteries can safely be charged using a medium charge rate (0.33C) with an occasional trickle charge (0.1C) to top off batteries that have been stored.

The battery module can either be charged assembled or disassembled. As the fully charged battery voltage can go as high as 16.8Vdc, the DC charging source should be set to 18.0Vdc.

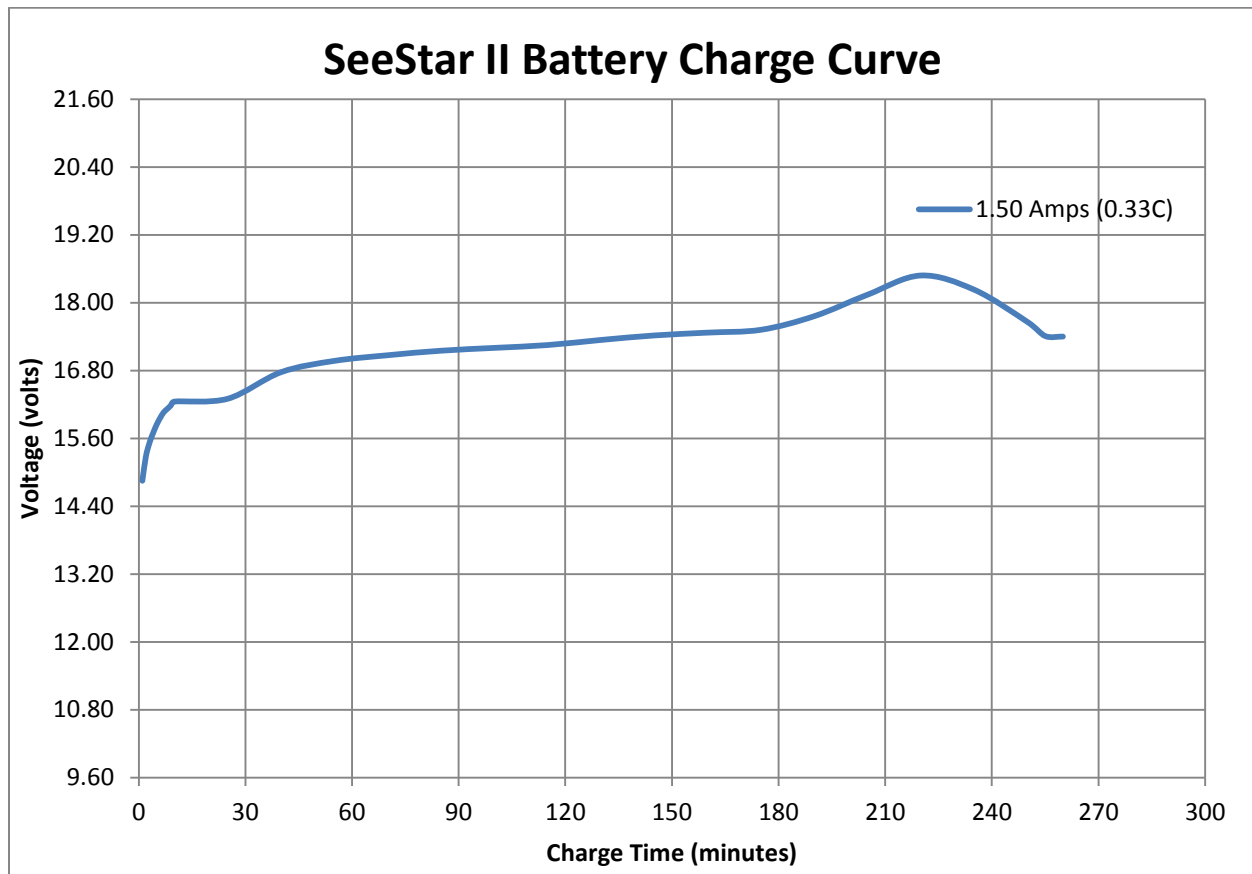


Figure 4: Charge curve of the battery module at a 0.33C rate

Discharge Profile

Figure 5 displays the discharge profile of the battery pack under a 0.2C condition. The curve is nearly identical in shape to that of a single cell. The battery should typically not be discharged below 12.0Vdc (1.0Vdc per cell) as this will shorten the overall lifespan of the battery. The Controller Shield in the camera module monitors battery voltage and the Arduino sketch (code) can be written such that operation of the camera and lights is not possible when the battery reaches a specified voltage level.

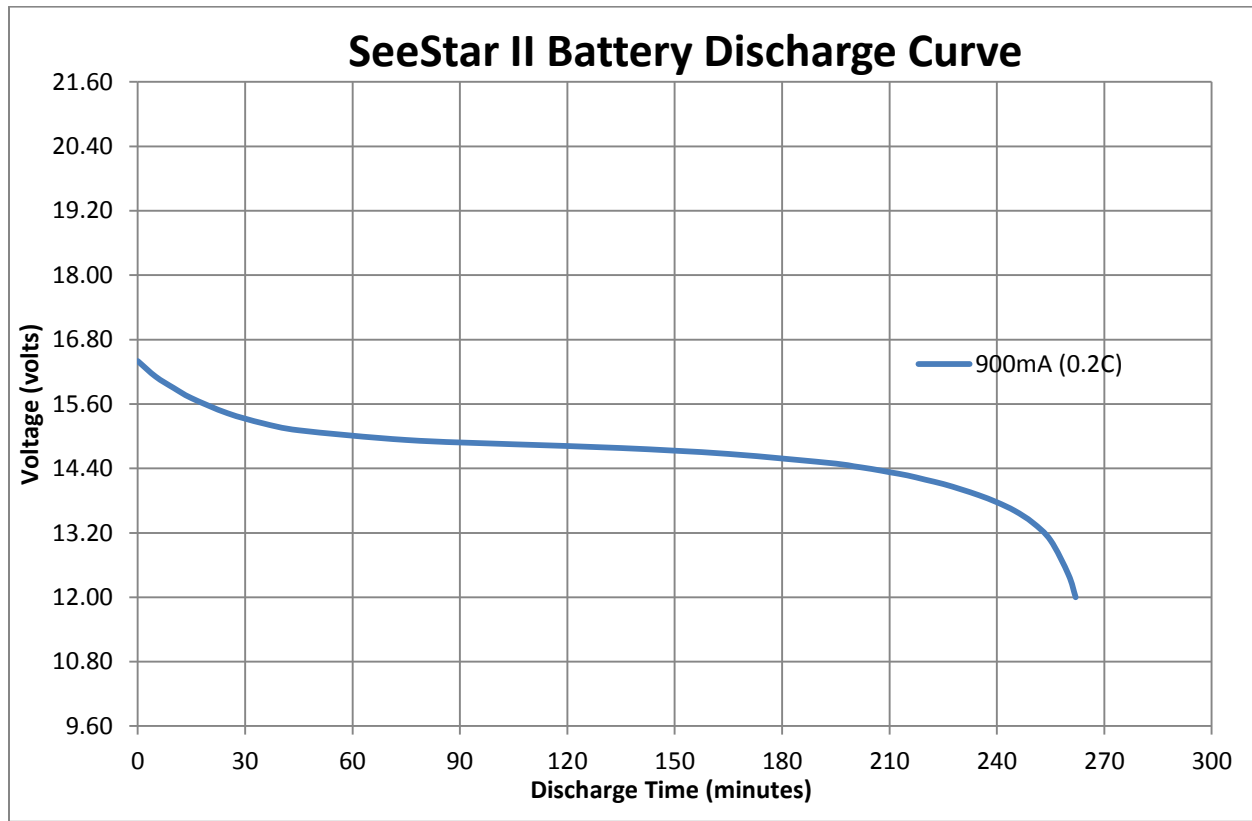


Figure 5: Discharge curve of the 12-cell NiMH battery

Assembly Instructions

The assembly of the battery module is very simple and should take no longer than 30 minutes. Care should be taken when dealing with the exposed battery leads. The battery contains 4.5 amp-hours of energy and an accidental shorting of the positive and negative leads can lead to damage and, potentially, injury. There is an internal polyfuse in the battery assembly, but even it may be damaged with a direct short.

Tools and Parts Needed for Assembly

1. All parts for battery module (See appendix 4)
2. Flathead screwdriver, small
3. Wire cutters
4. Wire stripper (Covering 18AWG to 22AWG)
5. O-ring grease (Type 55 Molykote, Parker O-lube, or similar)
6. Foam sheet, anti-static Polyethylene (or similar)

Assembly

1. The NiMH battery from Battery Specialties arrives with 18" leads. These need to be cut back in length due to the tight spacing in the housing. Cut each wire separately back to approximately 6". **Do not cut them at the same time as this will short out the battery!**

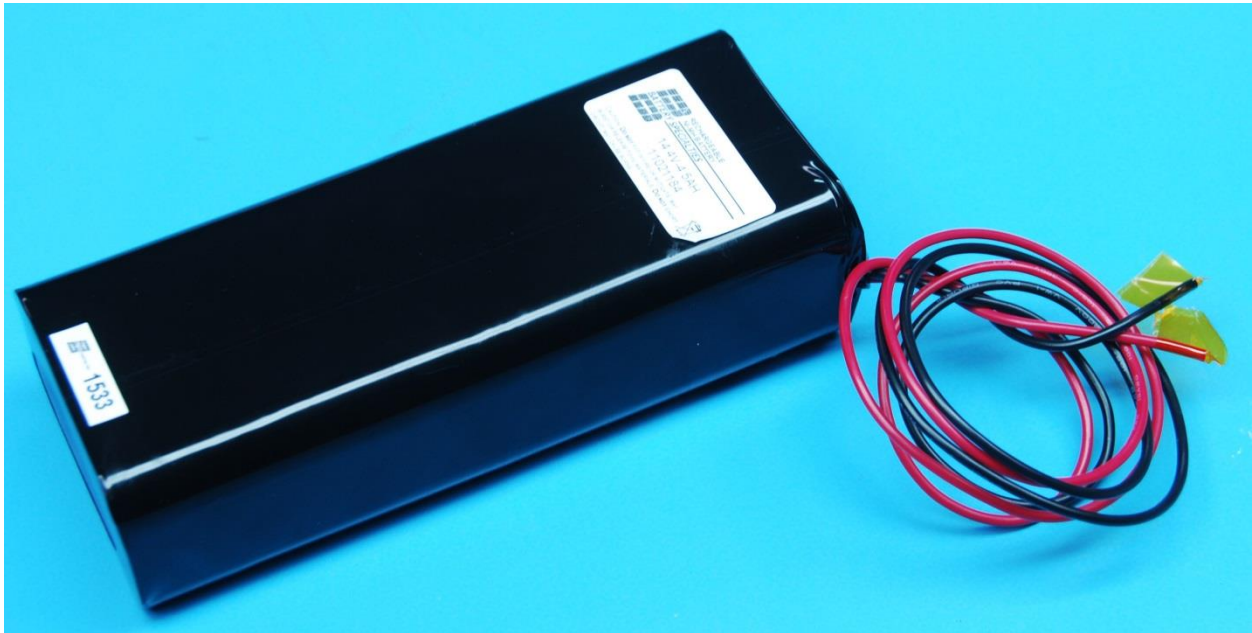


Figure 6: The 12-cell NiMH battery pack from Battery Specialties (PN# 11021184)

2. The battery leads can now be screwed into the terminal strip. To prevent possible shorting of the battery, do this one lead at a time. Strip back the red lead $\frac{1}{4}$ " and screw into the terminal strip. Repeat for the black lead.

3. Apply O-ring grease on the O-ring for the 8-pin Subconn connector. Only a very thin layer is required; wipe any excess with your fingers. Make sure there is no lint or hair on the O-ring.
4. Insert the connector into the threaded hole on the rear endcap and thread into it.
5. The default lengths of the wires attached to the connector are 12". Cut them down to approximately 6".
6. Using wire strippers, strip back the black, white, red, and green wires approximately $\frac{1}{4}$ ". The wires are 20AWG so use the 20AWG multi-stranded setting on the wire strippers. Note: some connectors arrive with all white wires which are labeled 1-8. If this is the case, strip back 1-4.



Figure 7: Endcap with connector

7. Apply O-ring grease on the O-ring for the connectorized endcap. Only a very thin layer is required; wipe any excess with your fingers. Make sure there is no lint or hair on the O-ring.
8. The connector leads can now be screwed into the terminal strips. Screw the black and white wires (or #1 and #2) into the terminal strip opposite the red wire from the battery.
9. Screw the red and green wires (or #3 and #4) into the terminal strip opposite the black wire from the battery.



Figure 8: The battery wired to the output connector

10. Cut a 5" by 10" sheet from the foam packing material.
11. Wrap the battery with the cut sheet from step #9.



Figure 9: Battery inserted into the housing

12. Slide the wrapped battery into the housing. It should be a snug fit.
13. Apply O-ring grease on the O-ring for the blank endcap. Only a very thin layer is required; wipe any excess with your fingers. Make sure there is no lint or hair on the O-ring.
14. Screw the blank endcap on the non-connectorized side of the battery housing.
15. Carefully screw the connectorized endcap on the other end. You may need to pre-twist the endcap so the wires coil nicely ontop of the battery.



Figure 10: The complete battery module (with dummy plug)

References

- (1) Panasonic HHR-450A NiMH Cell Datasheet
http://na.industrial.panasonic.com/sites/default/pidsa/files/panasonic_nimh_hhr450a.pdf
- (2) Panasonic Nickel Metal Hydride Handbook
http://www.mouser.com/pdfdocs/PanasonicBatteries_NI-MH_Handbook.pdf
- (3) Handbook of Batteries, Third Edition, McGraw-Hill Handbooks ISBN 0-07-135978-8

Appendices

Output Voltage	9-15 Vdc
Current Limit	3.5 Amps

Appendix 1: Electrical Specifications

Length	4 1/2 in
Diameter	3 in
Operating Temperature (Min)	0°C
Operating Temperature (Max)	70°C
Operating Depth	1500m
Dry Weight	3.53 lbs
Wet Weight	1.69 lbs

Appendix 2: Mechanical Specifications

Battery Module J1 (To Camera Module)			
Pin #	Signal Name	Description	Destination
1	BATT_POS	Power Output to Camera Module	TB1-1a
2	BATT_POS	Power Output to Camera Module	TB1-2a
3	BATT_NEG	Power Return to Camera Module	TB1-3a
4	BATT_NEG	Power Return to Camera Module	TB1-4a
5	COMM_A	Serial TXD Out from Camera Module	N/C
6	COMM_B	Serial RXD In to Camera Module	N/C
7	TRIG_OUT	Trigger Output from Camera Module	N/C
8	TRIG_IN	Trigger Input to Camera Module	N/C

Appendix 3: Battery Module External Connector Pinout

The “C” Rate is a common method for expressing the charge and discharge rates of batteries and is defined by:

$$I = M \times C_n$$

where:

I = Electrical current in amps

M = Multiple or fraction of C

C = Numerical value of rated capacity of the battery in ampere-hours (Ah)

n = time, in hours, for which rated capacity is declared

In the case of the SeeStar battery, C=4.5 Ah.

Charging the battery at 0.5C (or C₂) would require:

$$I = 0.5 \text{ (1/hour)} \times 4.5 \text{ (amp-hour)}$$

$$I = 2.25 \text{ amps}$$

and take 2 hours

To calculate the current needed for a 0.33C (or C₃) discharge:

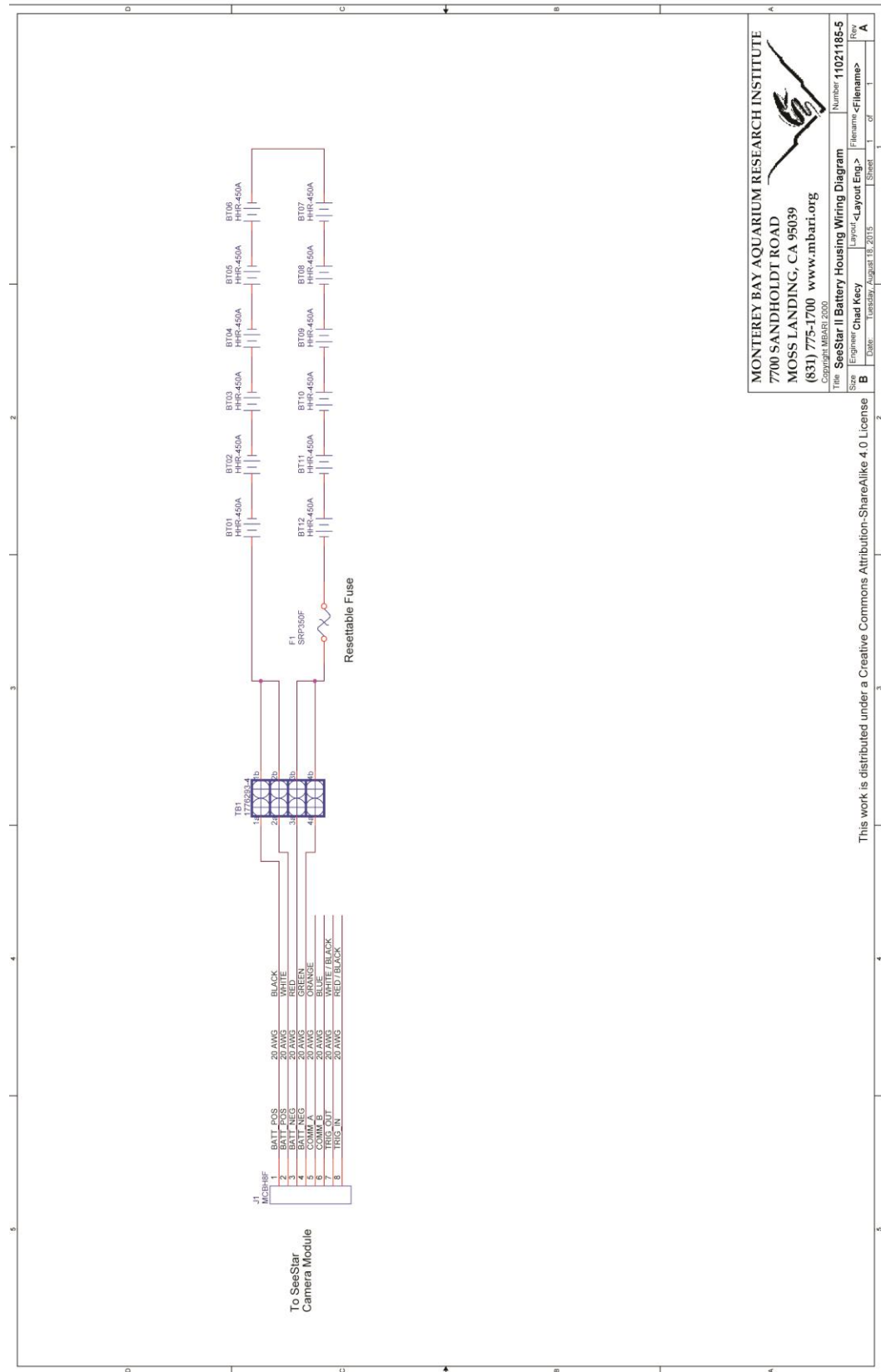
$$I = 0.33 \text{ (1/hour)} \times 4.5 \text{ (amp-hour)}$$

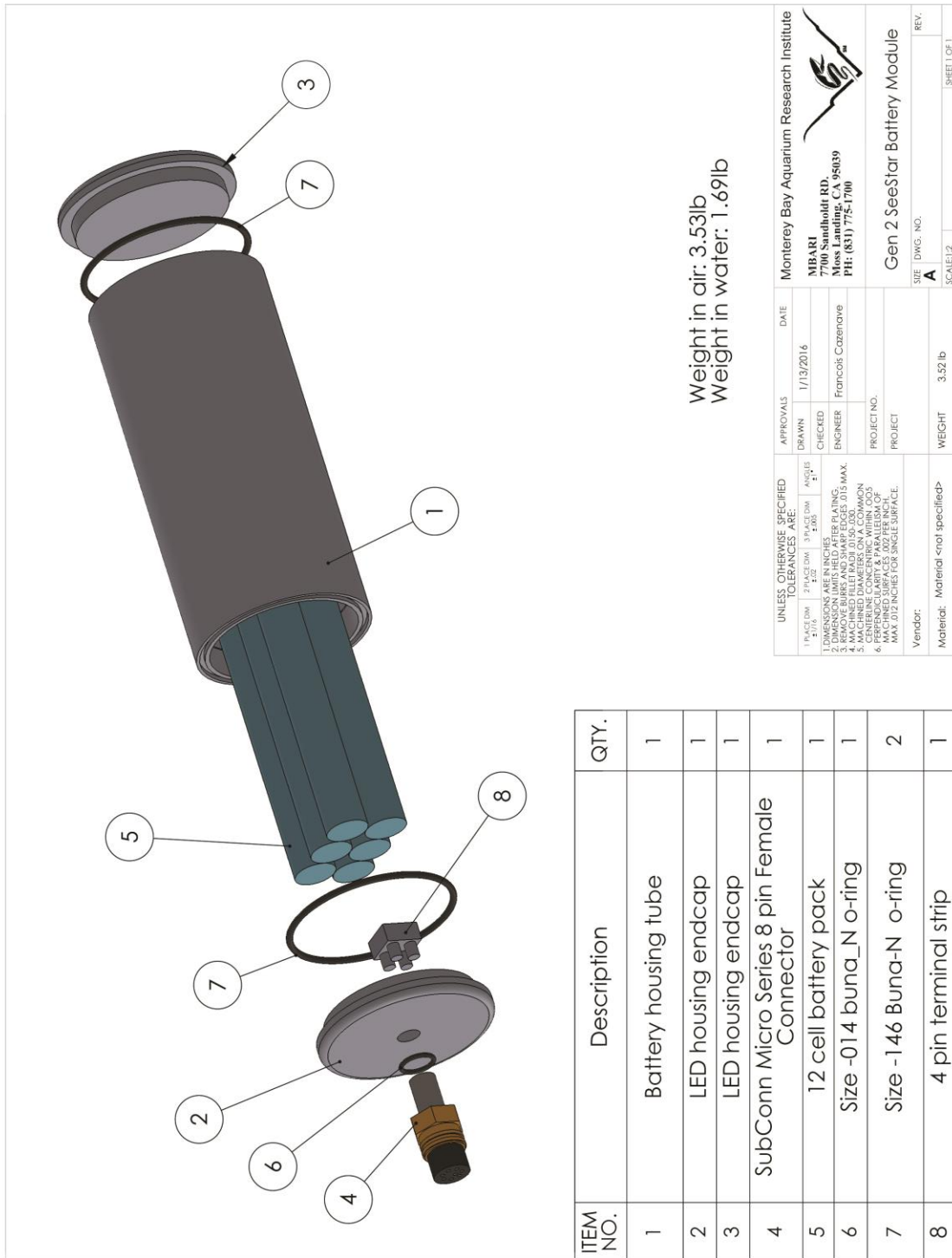
$$I = 1.50 \text{ amps}$$

and take 3 hours

Appendix 4: Calculation of C rate

Appendix 5: Wiring Diagram of the SeeStar Battery Module





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SeeStar Battery Housing Bill of Materials						
Item #	Quan	Part	Manufacturer	Manufacturer PN#	Description	Distributor
1	1	Housing Body	Groupbinc	TBD	Standard cylindrical housing, aluminum	Groupbinc
2	1	Front Endcap	Groupbinc	Sub-assy of battery housing	Endcap with connector hole, aluminum	Groupbinc
3	1	Rear Endcap	Groupbinc	Sub-assy of battery housing	Solid Endcap, Aluminum	Groupbinc
4	1	8-pin Female Connector	Subconn	MCBH8F	8-pin female bulkhead connctor, micro series	Ocean Innovations
5	1	12-Cell Battery	Battery Specialties	11021184	12-cell NiMH battery	Battery Specialties
6	1	Size -.014 buna-N o-ring	many	9452K58	Buna-N, A70 multipurpose o-Ring, OD=0.629"	McMaster-Carr
7	2	Size -.146 buna-N o-ring	many	9452K153	Buna-N, A70 multipurpose o-Ring, OD=2.818"	McMaster-Carr
8	1	4-Pin Terminal Strip	TE Connectivity	1776293-4	4-pin (2-position) terminal strip	Digikey

Appendix 7: SeeStar Battery Module Bill of Material