

SeeStar II Camera Module
Technical Manual, v0.3

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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 camera module contains the camera, Arduino Pro-Mini and the Controller Shield.



Figure 1: Picture of the SeeStar II Imaging System

System Level Description

The camera module is responsible for capturing the still images and/or videos as well controlling the power and triggering of the external LED light module. A GoPro Hero 3 or 3+ is used as the imager; an Arduino Pro-Mini plugs into a custom control board which interfaces the camera as well as the battery and LED modules. The camera module is connected to both the LED and battery modules via 8-pin inter-module cables. The camera housing is rated to 1500 meters under water. Figure two displays a block diagram of the camera module while figure three shows a sealed camera module.

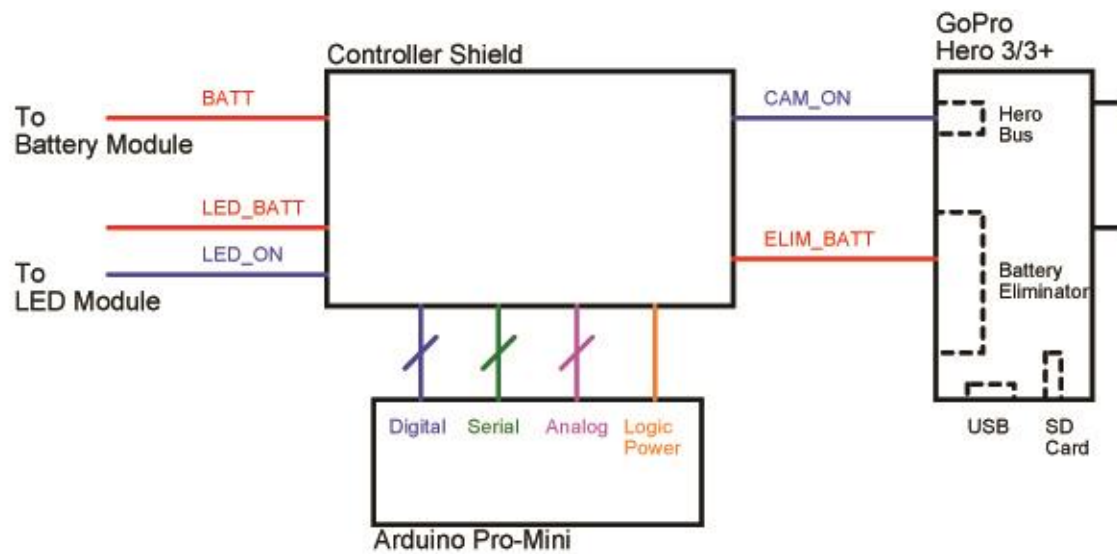


Figure 2: Camera Module Block Diagram



Figure 3: A sealed camera module ready for deployment

Functional Descriptions

GoPro Hero 3/3+

The imager used in SeeStar II is the GoPro Hero 3 or 3+ Black. Remote operation of the Hero is accomplished via the user-defined software scripts contained in the root directory of the SD card in the Hero (see the programming documentation for details and examples). The capabilities of the Hero remain the same when installed in SeeStar; meaning that all of the resolutions and angle settings can be selected by the user. Refer to the camera-specific GoPro User's Manual for details and descriptions of the various settings.

The standard battery is replaced with an off-the-shelf battery eliminator. The battery eliminator accepts 9-15Vdc and generates the necessary Hero battery voltage.

The Hero is turned on by pulling pin #12 on the Hero bus low for 1000msec; this is equivalent to turning on the Hero by pressing the ON button. Once on, the Hero will perform the instructions contained in the user written script file.

Optical properties

The GoPro Hero 3/3+ has various settings for the field of view, as shown in the user manual. Due to the flat port of the camera housing, the field of view will be modified in water. Appendix 3 shows the field of view in water for the different settings. The image quality will be slightly degraded in water, due to chromatic aberration and distortion, especially at the wide angle setting. Testing has shown that the medium field of view yields good results. The medium field of view corresponds well with the beam angle of the light module, resulting in even illumination. Testing in a controlled environment such as a tank or a pool is recommended prior to deployment in the field.

Arduino Pro-Mini

Due to the relatively simple control needed, the Pro-Mini was chosen. This small, low power CPU contains digital inputs/outputs, analog inputs, a SPI bus, and one serial port. An onboard FTDI connector allows programming of the Pro-Mini. Either the 3.3V 8-MHz or 5V 16-MHz version can be used.

Controller Shield

The Controller Shield is the only custom made part used on SeeStar II. This board interfaces the Arduino Pro-Mini as well as all of the external peripherals such as the GoPro camera and LED module. See the Controller Shield Hardware Interface Document for detailed information.

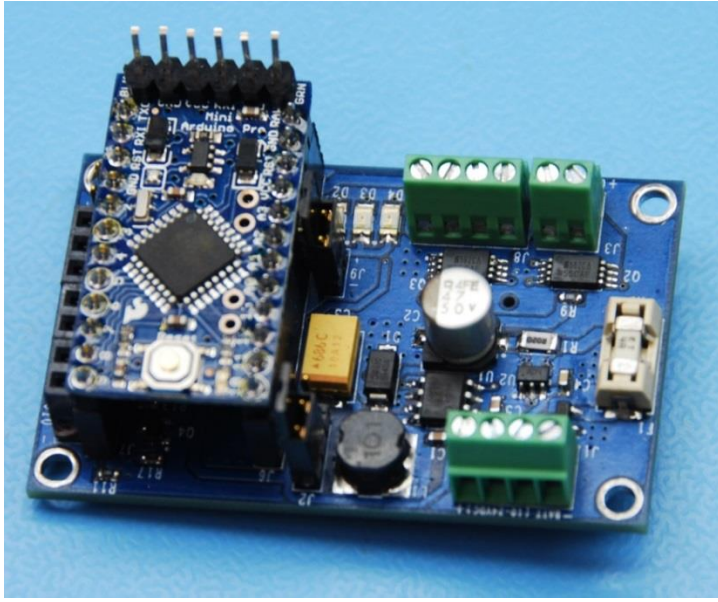


Figure 4: The Arduino Pro-Mini plugged into the custom controller shield

Assembly Instructions

Attention was paid during the design of the SeeStar II Imaging System in order to minimize the need for specialized tools and parts. A few simple tools are all that is required to assemble the SeeStar camera module.

Tools and Parts Needed for Assembly

1. All parts for camera module (See appendix 11)
2. Flathead screwdriver, small
3. Phillips screwdriver, medium
4. Set of small Allen wrenches
5. Wire stripper (covering 20AWG to 24AWG)
6. Wire cutters
7. Needle nose pliers
8. Soldering iron & solder
9. O-ring grease (Type 55 MolyKote, Parker O-lube, or similar)
10. Four plastic standoffs (Male-female type, 1/2" long, 4/40 thread)
11. Four stainless steel allen screws (1/4" long, 4/40 thread)

Hero Bus Cable Assembly

The Hero bus cable connects the Controller Shield to the GoPro Hero camera. Only two pins are used: pin 12 (mode button) and pin 30 (ground). For the fabrication of the cable assembly, a specialized high pitch 30-pin connector is needed to plug into the Hero Bus on the camera. This is a low level signal and 24 AWG wire can be used. Extra care should be taken when soldering the wires onto the pins of the Ridax connector due to the tight pitch of the pins. The receiving connector on the Controller Shield is a 2-pin 0.025" square post socket. The other end of the cable needs only be attached to two straight pins like the one shown in Figure 6.

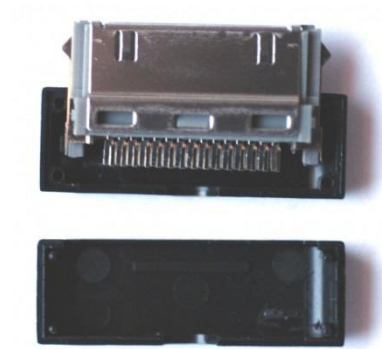


Figure 5: 30-Pin Ridax Connector. As assembled (left) and disassembled (right)



Figure 6: Mating Connector for GoPro Mode Signal on the Controller Shield

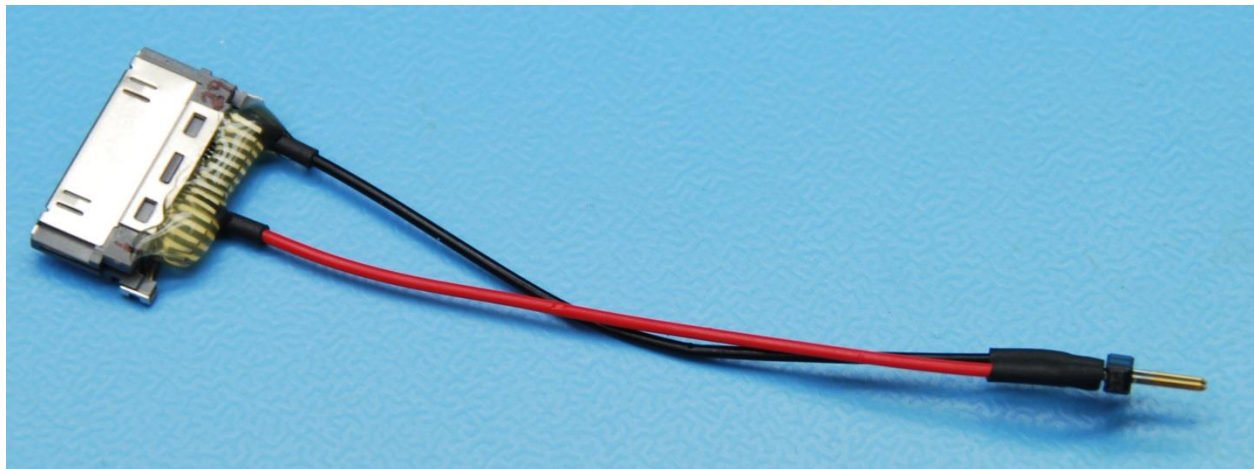


Figure 7: Assembled Hero bus connector assembly

Battery Eliminator Modification

Depending on the exact type of battery eliminator used, (the output connector can be a barrel connector, USB, or unterminated) you may need to modify it. The output side needs to be unterminated in order to attach it to the wire-to-board style connector on the Controller Shield. Simply cut off the output connector and strip the two wires to expose about 3" of conductor (Fig. 8).

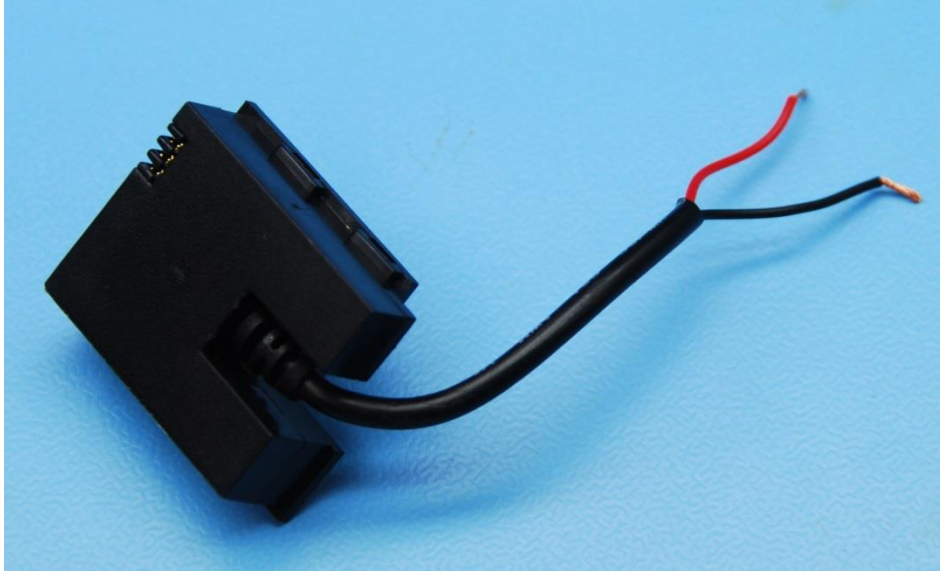


Figure 8: Battery Eliminator

Camera Installation

Prior to installing the GoPro into the underwater housing, verify that it is configured with the desired mode and operating parameters. Next, install the battery eliminator; it snaps into place just as a standard battery would. The output wires from the eliminator should extend backwards (approximately 3-4" in length). Finally, plug in the Hero bus assembly. Figure 9 shows a GoPro Hero ready to be installed into the camera housing.

The rectangular underwater housing from GroupBinc was designed to accommodate the GoPro Hero 3/3+ cameras. The lens mount slides into the front endcap and holds the camera in place.

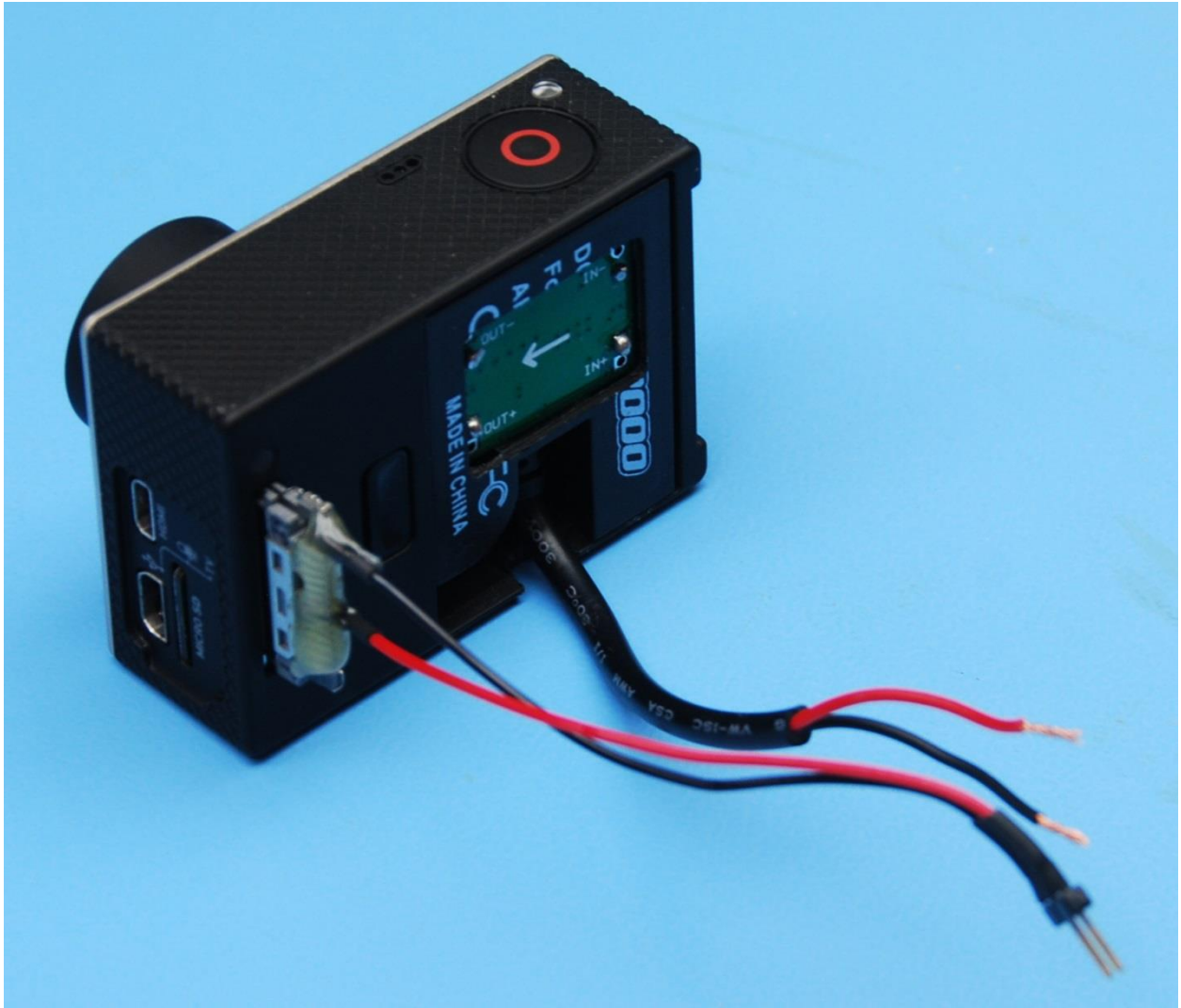


Figure 9: GoPro Hero camera ready for installation

Subconn Connector Installation

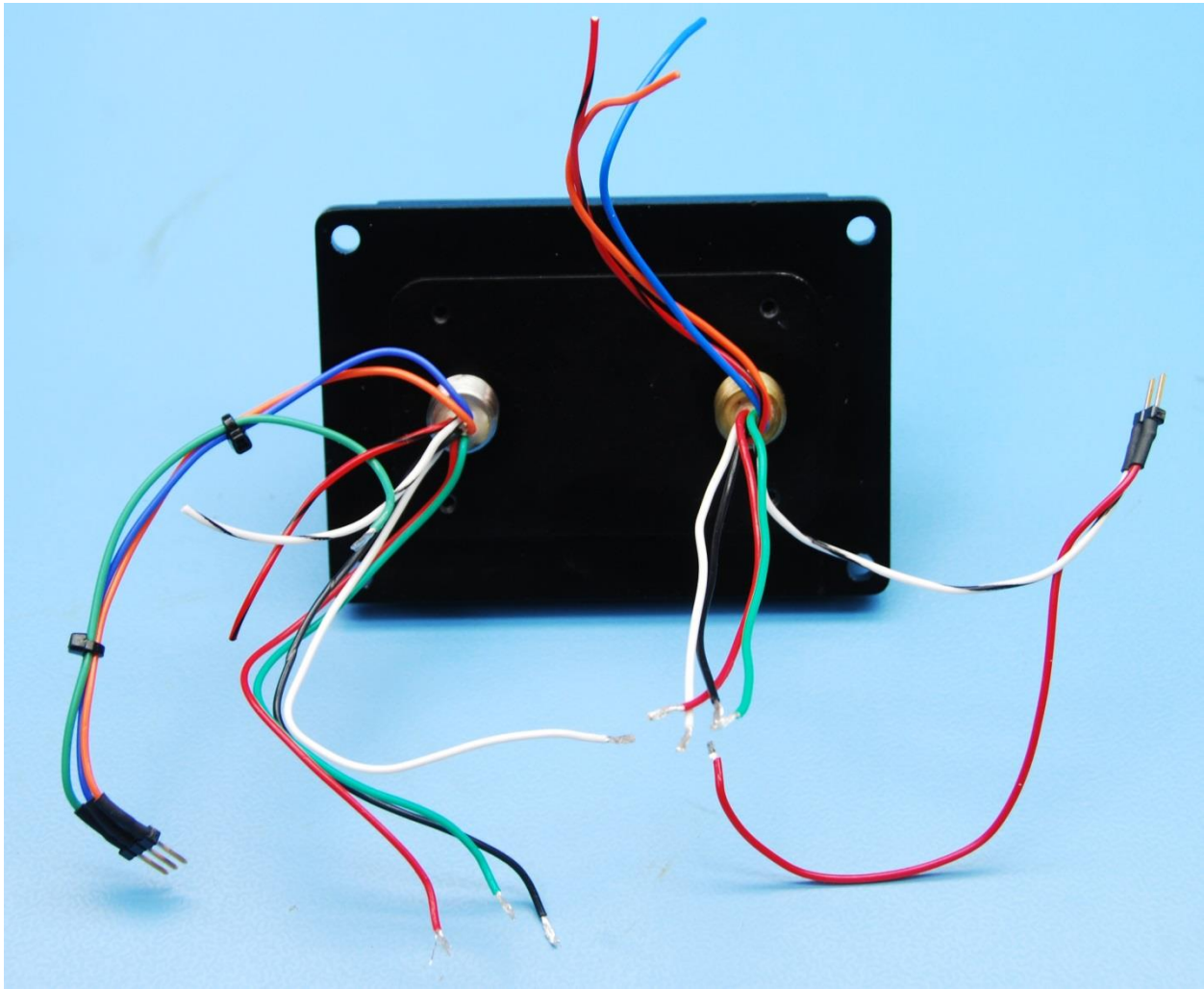


Figure 10: Subconn connectors installed on endcap

1. Apply O-ring grease on the O-ring (2-014) for the 8-pin Subconn connectors. 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.
2. Insert the connectors into the threaded holes on the rear endcap and thread them in. Tighten with a wrench. [J1 is the male connector, J2 is the female]
3. The default lengths of the wires attached to the connectors are 12". Cut them down to approximately 6".
4. Using wire strippers, strip back the black, white, red, green, orange, and blue wires on J1 approximately $\frac{1}{4}$ ". The wires are 20AWG so use the 20AWG multi-stranded setting on the wire strippers.
5. Using wire strippers, strip back the black, white, red, green, and white/black wires J2 approximately $\frac{1}{4}$ ". The wires are 20AWG so use the 20AWG multi-stranded setting on the wire strippers.
6. On J2, solder the blue and orange wires to a 3-pin male header. Solder a separate green or red wire to the third pin.
7. On J1, solder the white/black wire to a 2-pin male header. Solder a separate green or red wire to the second pin.

The SeeStar II system has a common pinout in all of the housings, but not all signals are used in all of the housings. Appendices 3 and 4 list the exact pinouts of both external connectors on the camera module while Table 1 below lists the Subconn color/size standards for the MCBH 8-pin connectors.

Subconn MCBH8F/M Pin Definitions		
Pin #	Color	Gauge
1	Black	20 AWG
2	White	20 AWG
3	Red	20 AWG
4	Green	20 AWG
5	Orange	20 AWG
6	Blue	20 AWG
7	White/Black	20 AWG
8	Red/Black	20 AWG

Table 1: Subconn MCBH8 F/M Pin Definitions

Controller Shield Installation

The Controller Shield is mounted to the rear endcap using ½" tall plastic standoffs which accept 4-40 size screws. The height of the standoffs is crucial due to the inserts of the two external Subconn connectors behind the shield (Appendix 8). The orientation of the Controller Shield must be such that the Arduino Pro-Mini sits behind the battery eliminator. Installing in the opposite position will cause interference with the Hero Bus connector.

The wiring of the Controller Shield requires no special crimping tools. Wire-to-Board style connectors from Phoenix allow the stripped wires from the external connectors to be attached and secured using a flat head screwdriver. Appendix 5 is a wiring diagram of the camera module. The final wiring of the circuit boards in the camera module is shown in Figure 11.

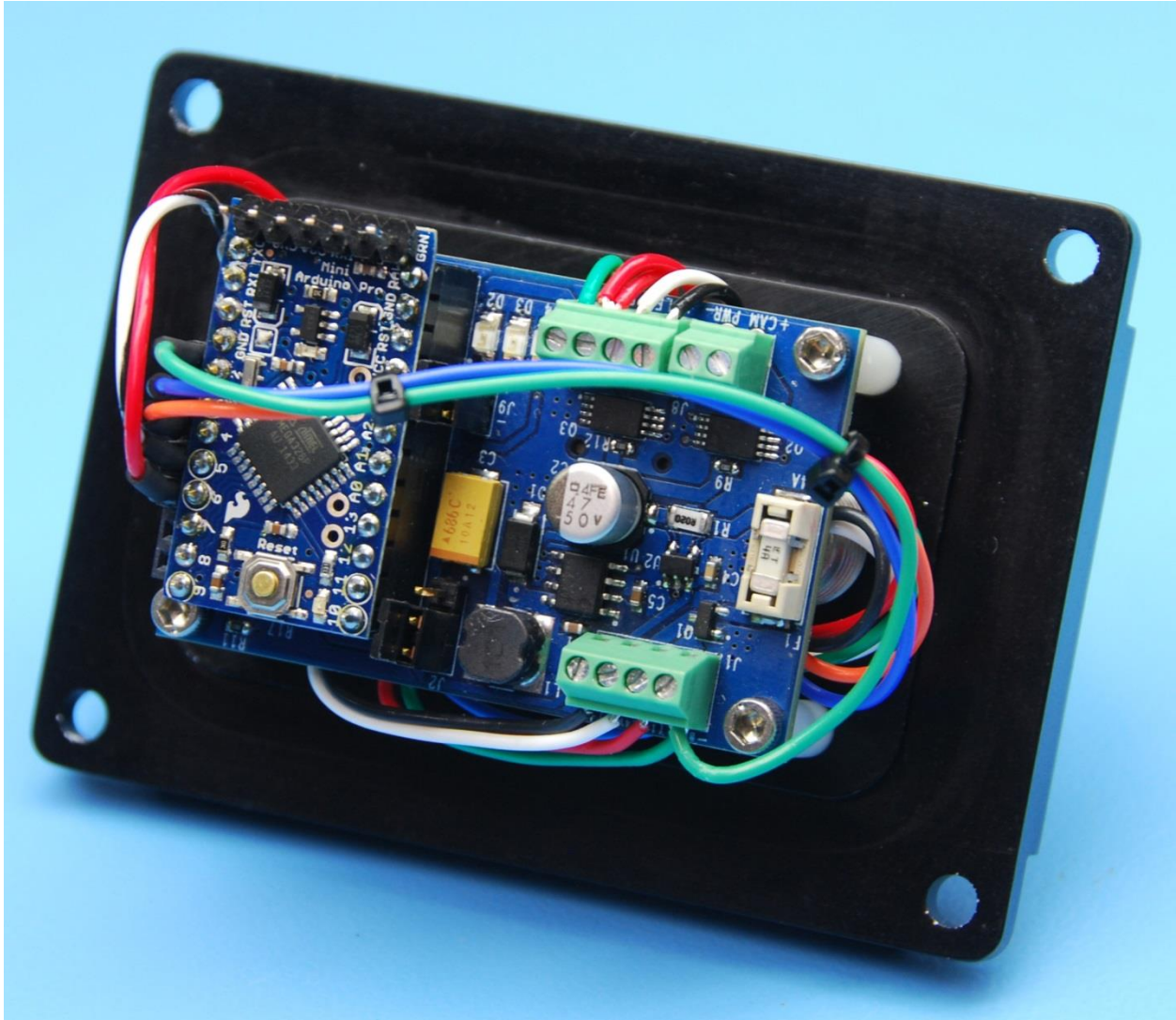


Figure 11: Boards installed and wires dressed on endcap

Sealing the Underwater Housing

It is a good idea to check to make sure the lenses on the GoPro camera and on the front endcap are wiped clean prior to sealing the housings. Verify all of the wired connections are secure and that the wires do not extend out to the endcap-to-housing interface. The 30-pin Hero bus connector can sometimes wiggle loose; make sure it is properly seated into the camera. Also make sure the SD card is installed (and has the proper script file on it).

The GroupBinc housing has been pressure tested to a depth of 1500 meters. To ensure a proper seal, care must be taken when closing the housing. Verify the O-Rings have a light coating of O-ring grease on them. The surfaces should also be wiped clean to ensure there is no debris to cause a bad O-Ring seal. Even a human hair across the O-Ring can cause a slow water leak at pressure. The addition of a small desiccant pack is not required but is recommended to remove any ambient moisture in the housing. The Allen screws holding the housing together should be tight but over tightened.

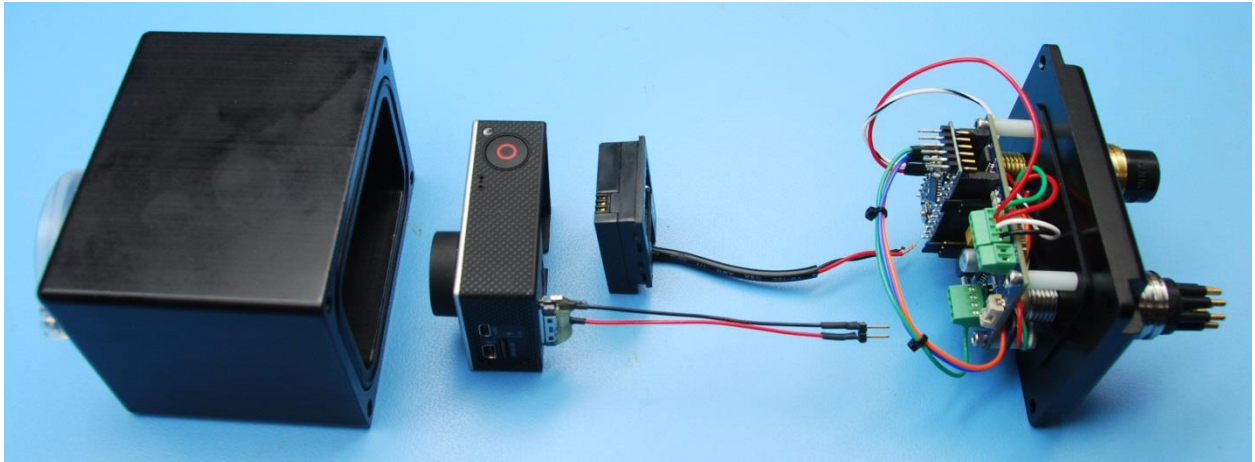


Figure 12: Exploded view of SeeStar camera module

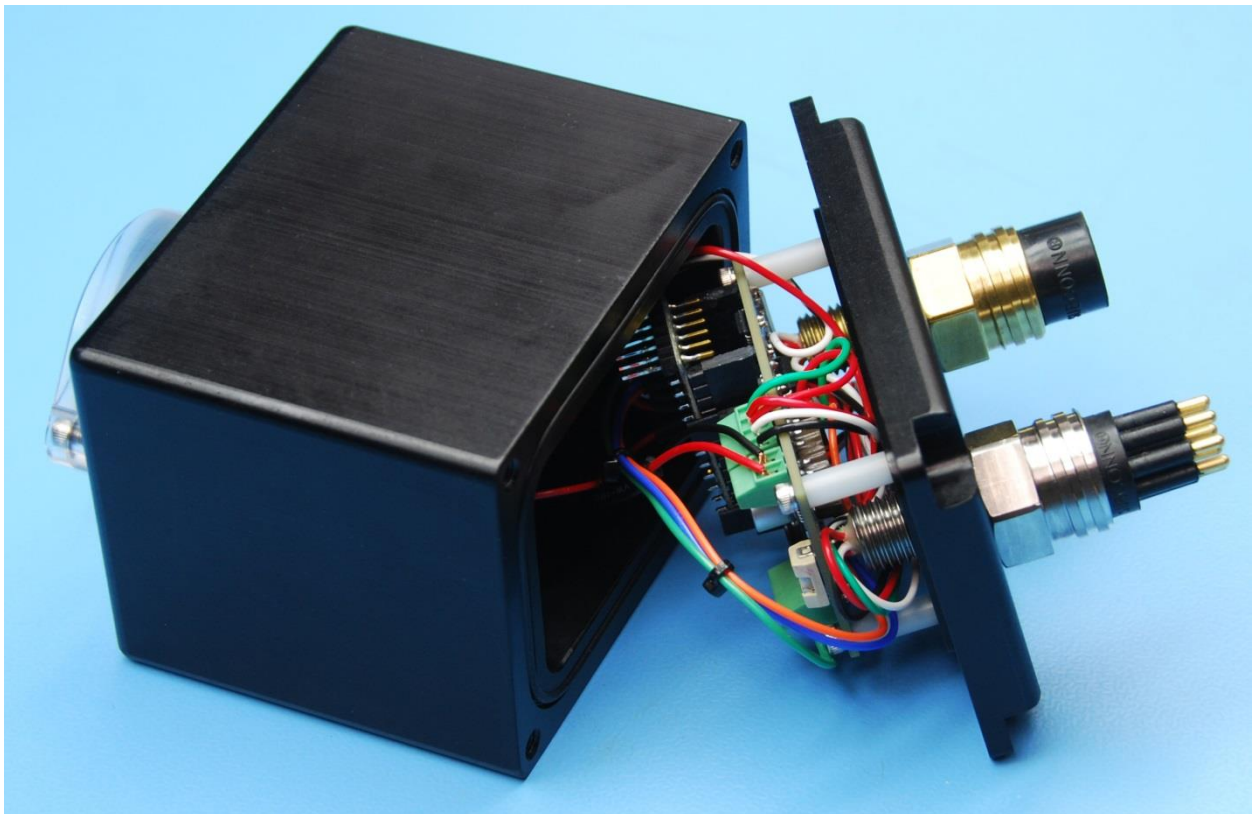


Figure 13: Final assembly of camera module

Appendices

Input Voltage	9-15 Vdc
Current Draw (Nom)	40 ma
Current Draw (Camera On)	300 ma
Current Draw (Camera & LED On)	1.6 A

Appendix 1: Electrical Specifications

Length	5 in
Width	3 1/2 in
Height	2 1/2 in
Operating Temperature (Min)	0° C
Operating Temperature (Max)	70° C
Operating Depth	1500m
Dry Weight	1.9 lbs
Wet Weight	0.9 lbs

Appendix 2: Mechanical Specifications

GoPro setting	Vertical FOV in air (deg)	Horizontal FOV in air (deg)	Vertical FOV in water (deg)	Horizontal FOV in water (deg)
4 x 3 W	94.4	122.6	67.0	82.5
4 x 3 M	72.2	94.4	52.6	67.0
4 x 3 N	49.1	64.6	36.4	47.4
17 x 9 W	69.5	125.3	50.8	83.8
16 x 9 W	69.5	118.2	50.8	80.4
16 x 9 M	55	94.4	40.6	67.0
16 x 9 N	37.2	64.4	27.8	47.2

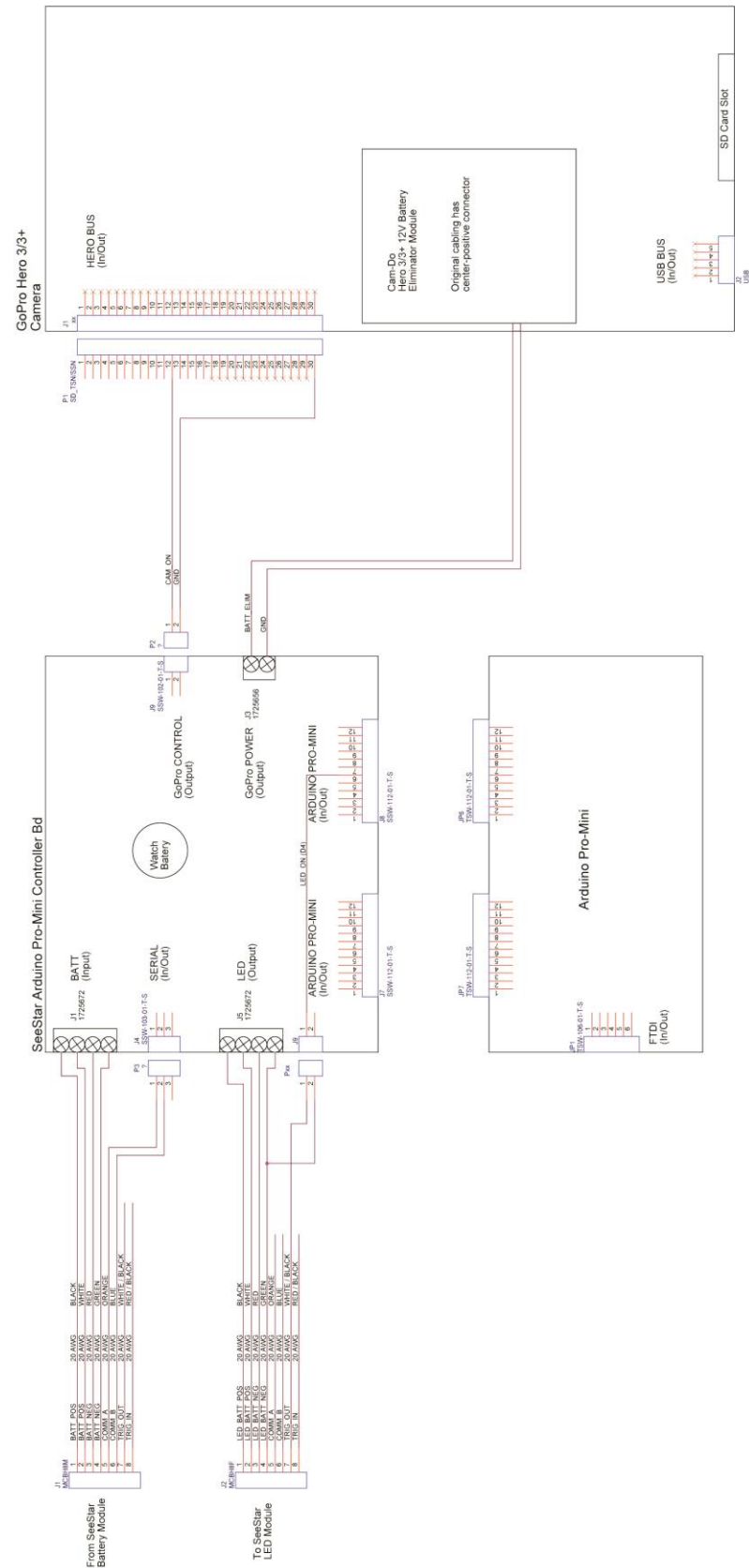
Appendix 3: Camera field on view in water and in air for different GoPro setting

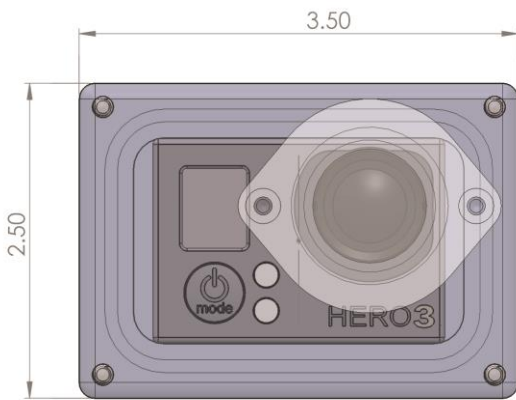
Camera Module J1 (MCBH8M) - From Battery Module			
Pin #	Signal Name	Description	Destination
1	BATT_POS	Power Input from Battery Module	Controller Shield J1-1
2	BATT_POS	Power Input from Battery Module	Controller Shield J1-2
3	BATT_NEG	Power Return from Battery Module	Controller Shield J1-3
4	BATT_NEG	Power Return from Battery Module	Controller Shield J1-4
5	COMM_A	Serial TXD Out from Camera Module	Controller Shield J4-1
6	COMM_B	Serial RXD In to Camera Module	Controller Shield J4-2
7	TRIG_OUT	Trigger Output from Camera Module	N/C
8	TRIG_IN	Trigger Input to Camera Module	N/C

Appendix 4: Camera Module J1 Pinout

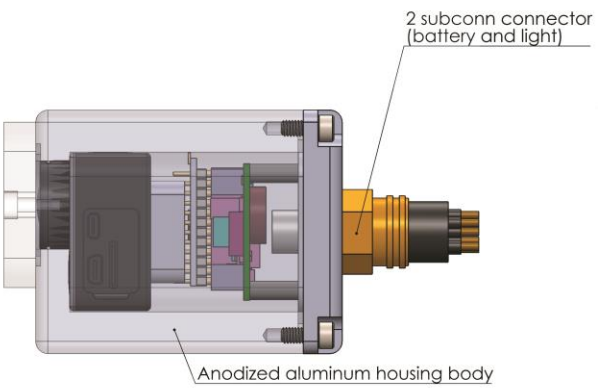
Camera Module J2 (MCBH8F) - To LED Module			
Pin #	Signal Name	Description	Destination
1	LED_BATT_POS	Switched Power Output to LED Module	Controller Shield J5-1
2	LED_BATT_POS	Switched Power Output to LED Module	Controller Shield J5-2
3	LED_BATT_NEG	Switched Power Return to LED Module	Controller Shield J5-3
4	LED_BATT_NEG	Switched Power Return to LED Module	Controller Shield J5-4
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	LED_ON Signal to LED Module	Controller Shield J9-1
8	TRIG_IN	Trigger Input to Camera Module	N/C

Appendix 5: Camera Module J2 Pinout

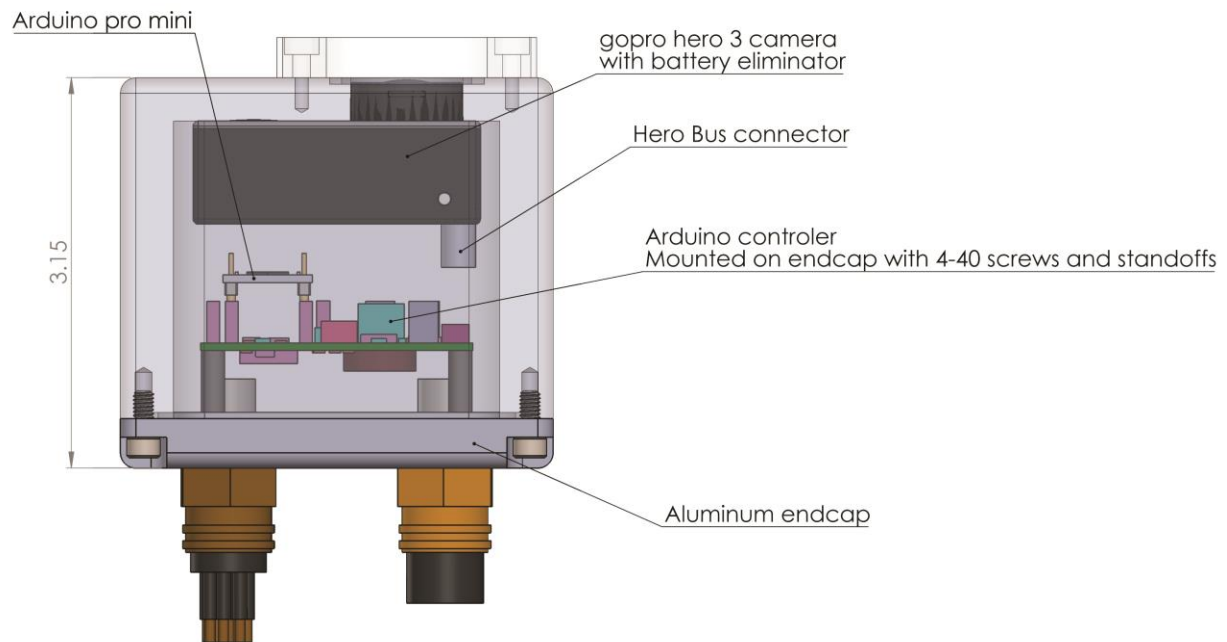




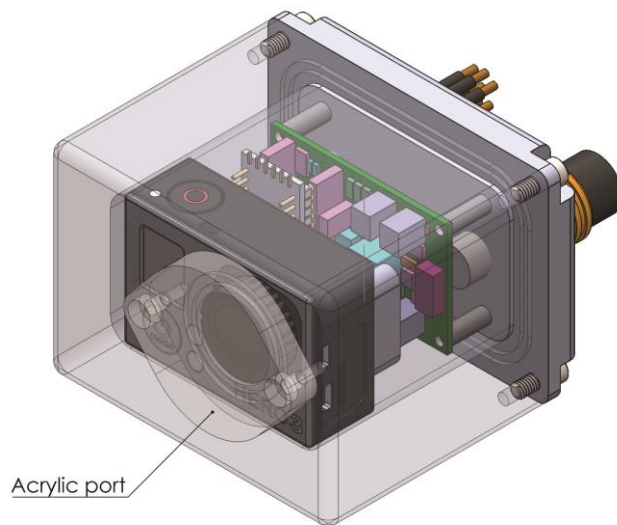
Appendix 7: Front View of Camera Module



Appendix 8: Side View of Camera Module



Appendix 9: Bottom View of Camera Module



Appendix 10: Isometric View of Camera Module

SeeStar Camera Housing Bill of Materials					
Item #	Quan	Part	Manufacturer	Manufacturer PN#	Description
1	1	Housing Body	Groupbinc	TBD	Rectangular camera housing, aluminum, black anodized
2	1	GoPro Hero 3 Camera	GoPro	Hero 3 or Hero 3+	Hero 3 or Hero 3+ Black or Silver version
3	1	Camera Housing Endcap	Groupbinc	Sub-assy of camera housing	Flat rear endcap of camera housing, aluminum, black anodized
4	1	SeeStar Camera PCB	custom	Distributor PN TBD	Camera control board
5	1	Hero Bus Connector	Ridax	SD_BUS	30-Pin Bus Connector
6	1	8-pin Female Connector	Subconn	MCBH8F	8-pin female bulkhead connector, micro series
7	1	8-pin Male Connector	Subconn	MCBH8M	8-pin male bulkhead connector, micro series
8	1	Camera Housing Port	Groupbinc	Sub-assy of camera housing	Clear acrylic port for camera lens
9	1	Arduino Pro-Mini	Arduino	Arduino Pro-Mini	Arduino Pro-Mini CPU board
10	4	Nylon Spacer	many	94639A714	3/16" OD, 1/2" Length, for #4 screw
11	4	Socket Head Cap Screw	many	92185A192	Stainless steel socket head cap screw, 8-32 thread, 3/8" length
12	4	Socket Head Cap Screw	many	92185A112	Stainless steel socket head cap screw, 4-40 thread, 3/4" length
13	2	Socket Head Cap Screw	many	92185A147	Stainless steel socket head cap screw, 6-32 thread, 3/8" length
14	1	Size -039 buna-N o-ring	many	9452K127	Buna-N, A70 multipurpose o-Ring, OD=2.879"
15	2	Size -014 buna-N o-ring	many	9452K58	Buna-N, A70 multipurpose o-Ring, OD=0.629"
16	1	Size -023 buna-N o-ring	many	9452K77	Buna-N, A70 multipurpose o-Ring, OD=1.191"
17	1	Battery Eliminator	Cam-Do	Battery Eliminator, 12V	Battery Eliminator, 9-17Vdc input
					www.cam-do.com