

SeeStar II
Operations Manual, v0.2

Monterey Bay Aquarium Research Institute

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DRAFT

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System Overview

SeeStar II is an open-source imaging system developed at the Monterey Bay Aquarium Research Institute (MBARI). All of the parts with the exception of one circuit board are commercial off-the-shelf items. The cost of the entire system is \$2,500 and is rated to a depth of 1500 meters. It is an autonomous system which can take over 3,000 pictures or 3 hours of HD video on a single charge.



Figure 1: Picture of the SeeStar II Imaging System

System Documentation

A number of individual documents have been prepared to assist the user with the fabrication and operation of the SeeStar II Imaging System. All of the prepared documents, as well as schematics, datasheets, and mechanical drawings are available online at the SeeStar repository. Figure 2 displays the documents in a hierarchal tree format. A listing and short description of each document follows.

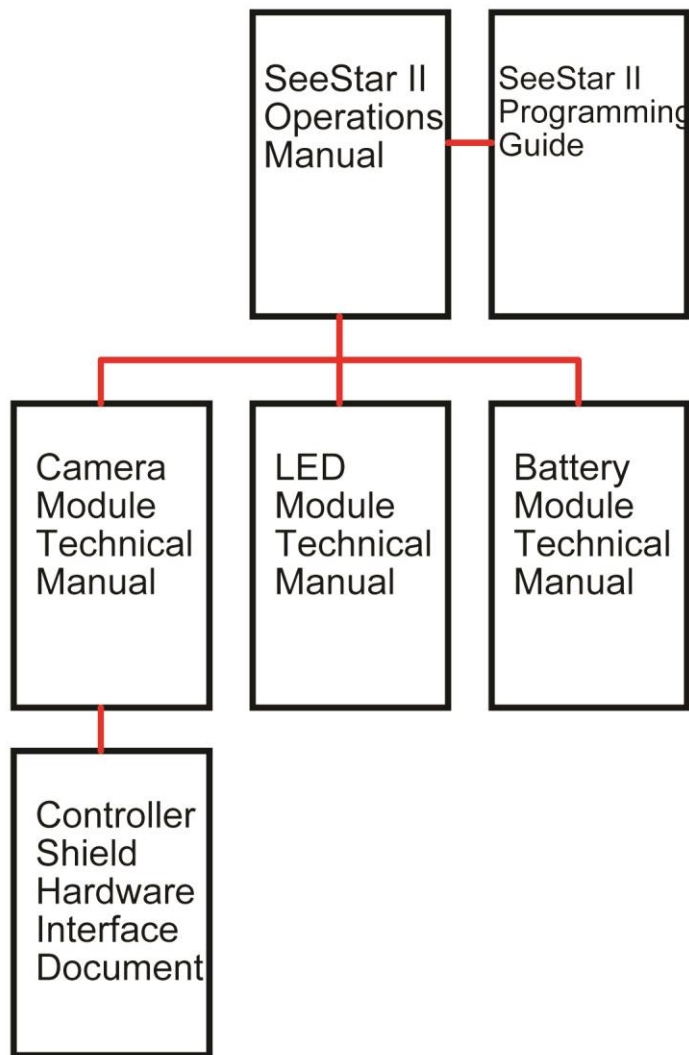


Figure 2: Hierarchy of the SeeStar II Documentation

SeeStar II Operations Manual

The operations manual is a top level document which covers the basic operation and deployment of the system. This manual allows the casual user to take a pre-assembled SeeStar II and deploy it without necessarily understanding every technical aspect of the system. The more specific and detailed information has been left out and is covered in other documentation.

SeeStar II Programming Guide

The programming guide contains every aspect of programming SeeStar II. It covers loading the Arduino sketches, setting up the GoPro camera, writing the custom script files, and communicating to SeeStar II from an external serial cable. Example sketches and scripts can also be found online on our repository and codebender.

Camera Module Technical Manual

The camera technical manual covers every aspect of the camera module. It includes descriptions of every sub module and detailed assembly instructions. This document gives the user all of the information necessary to assemble a camera module.

LED Module Technical Manual

The LED technical manual covers every aspect of the LED module. It includes descriptions of every sub module and detailed assembly instructions. This document gives the user all of the information necessary to assemble an LED module.

Battery Module Technical Manual

The battery technical manual covers every aspect of the battery module. It includes descriptions of every sub module and detailed assembly instructions. This document gives the user all of the information necessary to assemble a battery module.

Controller Shield Hardware Interface Document

This document covers the Controller Shield circuit board contained in the camera module. This is the only custom piece of hardware in the SeeStar II system and this document provides detailed circuit descriptions as well as initial board bring up procedures.

Setting up the Camera Module

To program the SeeStar II Imaging System for taking videos or still images, three separate, but simple, tasks need to be performed. These are: configure the GoPro camera in the desired operating mode, install the script file onto the SD card, and set the operating parameters in the Arduino sketch (code). Prior to describing the three steps, the timing of the camera will be discussed. An understanding of the timing diagram will greatly assist with future programming.

Camera Timing

Figure 3 shows a simplified timing diagram of the SeeStar II Imaging System. Below are quick descriptions of the events displayed.

CAM_POWER: Battery voltage is applied to the GoPro (but it is not turned on yet).

LED_POWER: Battery voltage is applied to the LED module (but it is not turned on yet).

CAM_ON: The GoPro is turned on.

LED_ON: The LED is turned on.

Scripts: The script file is activated.

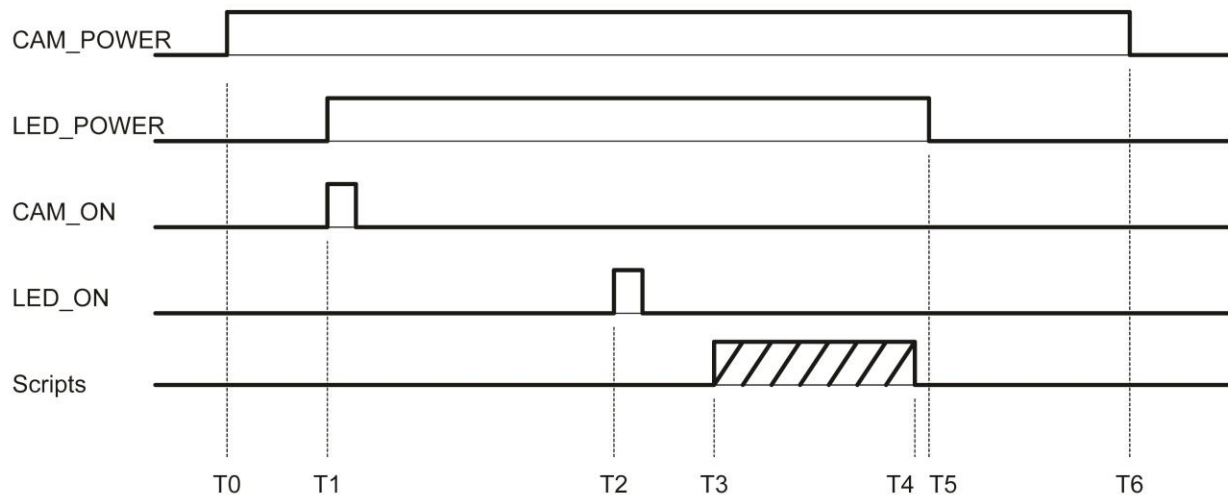


Figure 3: Timing Diagram of the SeeStar II Imaging & Lights

T0: Battery voltage is applied to the GoPro camera.

T0-T1 Delay: An approximate 5 second delay.

T1: Battery voltage is applied to the LED module and the GoPro is turned on.

T1-T2 Delay: An approximate 10 second delay in order for the GoPro to boot up.

T2: The LED is now turned on.

T3: Once the GoPro has booted up, the script file is automatically initiated.

T3-T4: The script file runs. The length is determined by the specific script function.

T5: The battery voltage is removed from the LED module (thus turning off the LED).

T5-T6 Delay: An approximate 6 second delay to ensure the SD card has finished closing files.

T6: The battery voltage is removed from the camera module (thus turning off the GoPro).

Camera Configuration

The GoPro Hero needs to be placed in the desired mode of operation prior to installation into the camera module. This can be either a video or imaging mode, with multiple resolutions and viewing angles available. Refer to the programming guide or the GoPro user's manual for specific information on those modes. The medium field of view is recommended because it is less sensitive to chromatic aberration and distortion than the wide field of view, due to the flat port. Also the medium field of view will be more evenly lit. The default mode, video or stills, should also be set; this causes the camera to enter that mode upon boot up (and should match the script functionality).

Script Writing

The script is a simple batch file that is initiated every time the GoPro is powered up. Simple script functions such as button presses allow software control of the GoPro. More detail is provided in the programming guide, but a sample script would look like the following:

```
#####  
## Hero3+: wait 5, PhotoMode, wait 5, Take one image, wait 5 seconds and power down #  
#####  
//  
//sleep 5  
//t app appmode photo  
//sleep 5  
//t app button shutter PR  
//sleep 5  
//poweroff yes  
//reboot yes
```

The script files need to be saved in Unix format, meaning they only have a line feed (\n). (no carriage return \r). The filename of the script must be autoexec.ash and it must reside in the root folder of the SD card (Figure 4).

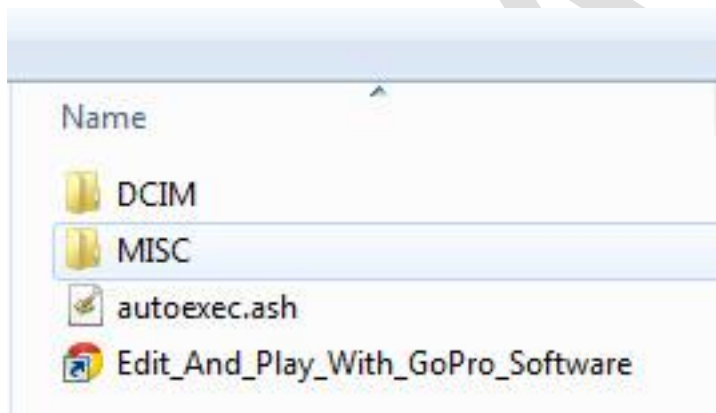


Figure 4: Location of the script file on the SD card.

Arduino Programming

There are a number of methods of programming the Arduino Pro-Mini; the development team at MBARI has been utilizing codebender (www.codebender.cc). Once an account has been made, the sketch can be compiled and downloaded to the Arduino directly using a USB-serial cable. See the Programmer's Guide for more detailed information.

Pre-Deployment

Checklists

Prior to sealing up the housings, it is wise to check off items from a pre-made list. The following is a list of items the MBARI team uses before sealing up the housings.

Camera Housing

1. GoPro camera is in the desired mode (and default mode).
2. SD card is properly formatted, installed, and contains a valid script file.
3. The Arduino has been programmed with the desired deployment settings.
4. The real time clock on the Controller Shield has the current time set.
5. The Controller Shield has a watch battery installed.
6. The Controller Shield has jumper J9 removed to disable board level LEDs (saves power).
7. All of the internal connectors and wire-to-board connections are physically secured.

LED Housing

1. The wire connections to the internal terminal strip are physically secured.
2. The DC-DC Converter is sufficiently wrapped in non-conducting material.

Battery Housing

1. The wire connections to the internal terminal strip are physically secured.

Sealing the Housings

All of the GroupBinc housings have been pressure tested to a depth of 1500 meters. To ensure a proper seal, care must be taken when closing the housings. Verify the o-rings have a light coating of o-ring grease on them. The mating 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 depth. The addition of a small desiccant pack in the housings is not required but is recommended to absorb any ambient moisture in the housing.

Camera 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. The Allen screws holding the housing together should only be hand tightened.

LED and Battery Housings

Verify the clear acrylic port on the LED housing is clean. The screw-on circular endcaps should only be hand tightened. A very small amount of grease can be applied to the threads for smoother operation. You should stop tightening after you see the o-ring slightly deform.

Mounting and Deployment

SeeStar II was designed to be a platform-independent imaging system. The small size of the housings allows them to be easily mounted to nearly any type of structure or experiment. The housings can be secured using simple items such as metallic hose clamps or tie wraps. The manufacturer of the housing can add blind threaded holes (1/4-20 thread, 1/4" depth) to the endcaps upon request.

Cable and Connector Management

The underwater cables and connectors used on SeeStar II are from the Subconn Micro series. The bulkhead connectors are male style with threads which accept a female locking sleeve found on the interconnection cables. Before deployment, o-ring grease should be applied to all of the female connector sockets prior to mating.

When mounting the individual modules on your frame or vehicle, be aware of the cables. Try to route the cables such that they can be secured to a frame with tie wraps. This prevents from placing unnecessary strain on the connectors.

Camera and LED Orientation

The light and camera modules were kept separate intentionally in order to maximize deployment flexibility. The GoPro Hero is generally a poor imager in low light conditions; therefore, the user should try to maximize the light distribution near the imaging plane. Our in-house testing has found that a light level of 2000 lumens provides sufficient illumination for proper imaging at a distance of about 1m to 1.50m. To reduce back-scatter effect, some separation of the camera and the light is needed. Consult the camera and light modules' technical manuals for more information on their optical properties

Bio-Fouling

SeeStar II does not have active anti-biofouling protection. If deployed at a shallow depth for extended periods of time, bio-fouling will most likely occur. Maintenance dives or recoveries to wipe the camera and LED ports may be necessary.

Post Deployment

Upon recovery, it is a good idea to rinse the SeeStar II system (and any other recovered gear) down with fresh water. Depending on the deployment turn-around time, the system can be serviced in the field. With a proper charging cable, the battery module can be recharged without opening the housing.

Recovering Images/Video

To recover the stored images or videos, the camera housing must be opened. The SD card needs to be removed in order to download the files. Swapping SD cards can shorten turn-around time if performing this onboard a ship.

Battery Charging

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.

To prevent overheating, the charge rate should never exceed 0.33C (or 1.5 amps). For more details, see the Battery Module Technical Manual.

System Cleaning and Care

As mentioned previously, it is good practice to rinse off the SeeStar II system with fresh water immediately after it is recovered. A buildup of salt can lead to surface pitting and corrosion.

The housings are anodized aluminum so care should be taken to prevent scratches. Any exposed bare aluminum will oxidize rapidly and could lead to pitting. When using metallic band clamps or any other material that could scratch the housings, place a protective layer such as plastic or cloth in between them.

If the inter-module cables are removed, dummy plugs should be placed on both the bulkhead and inline connectors. O-ring grease should be applied to the female sockets before every mating.

The desiccant packs should be replaced whenever the housings are opened. Desiccant can packs can be dried in an oven and reused.

Appendices

Physical	
Depth Rating	1500 m
Temperature Rating	2°C
Dry Weight (3 modules and 2 cables)	7.7 lbs
Wet Weight	3.7 lbs
Platform	Any

Appendix 1: System Level Physical Specifications

Optical	
Field of View (with gopro set to 4x3 medium)	67° vertical, 82.5° horizontal
Max Image Resolution	12MP
Max Video Resolution	4K
Camera Control	Automated
Rate of Images	Once /2 sec
Image Storage	2900
Video Storage	2 Hrs @ 2.7K

Appendix 2: System Level Optical Specifications.

Electrical	
Battery Capacity	4500 mAH
Bus Voltage	9-16Vdc

Appendix 3: System Level Electrical Specifications

Lighting	
Intensity	2000 Lm
Beam angle	Approx. 110°
Color	White

Appendix 4: System Level Lighting Specifications