Product Manual

Bioshutter

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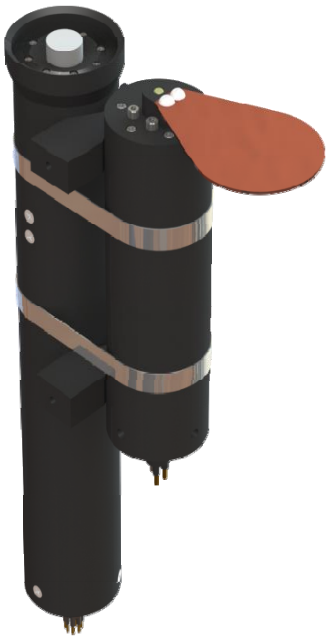

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A. OVERVIEW

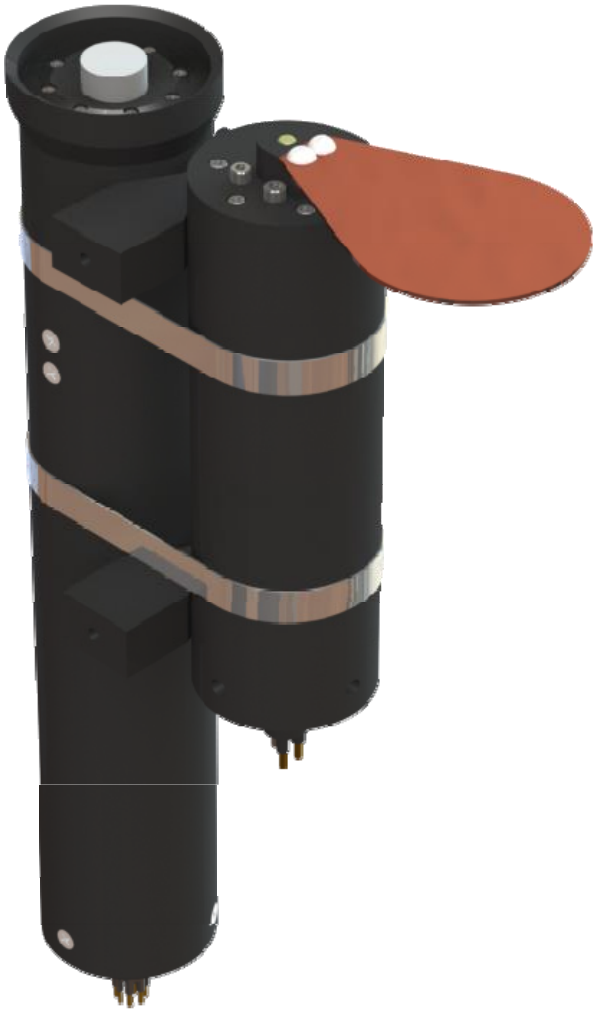


Figure A-1: The Bioshutter

The Bioshutter is an autonomous underwater shutter attachment primarily intended for use with Sea-Bird Scientific OCR-500 series and HyperOCR instruments. The primary purpose of the shutter is to reduce marine biofouling on the sensor optics in moored applications.

See Figure A-1, The Bioshutter

Purpose

Marine biofouling – the growth of marine organisms on submerged surfaces - is a common occurrence. It is found on marine structures such as wharves, boat hulls, and moorings. Unfortunately, ocean sensor optical detectors are also prone to biofouling, and various methods, particularly toxic coatings, have been used in an attempt to prevent it. However, less environmentally dangerous methods would be preferred.

Background

Copper (and copper-based alloys, such as copper-nickel) has long been known to provide good resistance against biofouling. This characteristic has been used to advantage in a number of commercial products, and it has even been used as a cladding on ship hulls.

Scientists working at the University of California Santa Barbara Ocean Physics Lab under the auspices of the National Ocean Partnership Programs' (NOPP) Ocean-Systems for Chemical, Optical, and Physical Experiments (O-SCOPE) project developed an underwater shutter device for use with instruments such as Sea-Bird Scientific Lu-50 and OCR-504 instruments. By constructing the shutter from copper, marine growth on the sensor optics is restricted. The Sea-Bird Scientific Bioshutter device builds upon the success of this instrument.

Features

- Restricts marine growth on sensor optics in moored applications
- Robust mechanical design
- Completely autonomous – only external power required
- Simple operation – opens when power applied, closes when power removed
- Fast operation – 6 seconds to open, 6 seconds to close (typical)
- Low power consumption
- Wide operating voltage range (8 – 20 VDC)
- User-selectable 180 degree (default) or 90 degree shutter movement
- Available with clockwise (default) or counter-clockwise shutter motion
- Currently available for use with Sea-Bird Scientific OCR-500, OCR-200, and HyperOCR series instruments

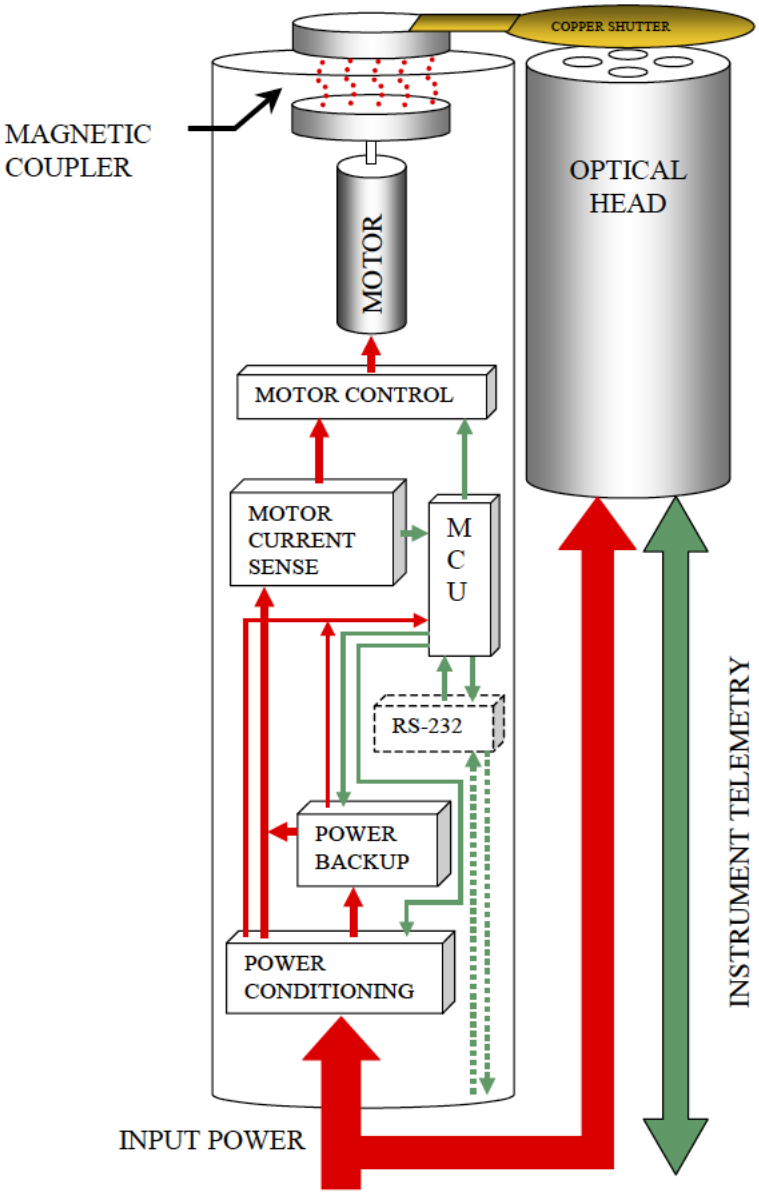


Figure A-2: The Bioshutter System Diagram

Bioshutter System

The Bioshutter system is designed to impede biofouling on the optical detectors of marine sensors. By prohibiting biological growth on the sensor optics, the deployment duration may be extended.

Copper has long been known to exhibit a high natural resistance to biofouling. This property has been exploited in a number of ways, including as a cladding on underwater pipes and ship hulls. The oceanographic community can further take advantage of copper's unique properties by using it to protect optical sensors from fouling.

The antifouling mechanism of copper when used as a protective cladding is not fully understood. However, the mechanism by which marine growth is prohibited on objects in very close proximity to copper is generally believed to be due to the leaching of copper ions into the water. While trace amounts of copper are essential for life, larger quantities are toxic, especially to bacteria, algae, and fungae[Φ]. By maintaining a close proximity between the two devices, the copper contained in this small volume of water separating the shutter and the optical sensor reaches toxic levels.

While other products employ the same antifouling principles in order to protect optical sensors against biofouling, the Bioshutter extends the devices capabilities. The Bioshutter is a completely self-contained instrument, easing the requirements on the data acquisition system. All that is required by the device is a power input.

See Figure A-2, The Bioshutter System Diagram

The default interface to the Bioshutter is a simple two-pin male bulkhead connector. Typically, power is shared with the sensor that the Bioshutter is protecting using a Y-spliced cable. When power is applied to the instrument, the shutter opens. When the open position is detected, the instrument enters a low power shutdown state. During this time, an internal backup supply is charging. When power is removed from the device, the internal supply provides sufficient power to close the shutter. This mode of operation is well suited to moored applications, as it allows the Bioshutter to operate independent of the acquisition schedule. The mooring controller does not have to be concerned with controlling the Bioshutter, as long as adequate time is allowed to charge the internal supply. Under most circumstances, 30 seconds from the time power is first applied is adequate.

[Φ] Petrucci, Ralph H. General Chemistry Principles and Applications: page 893. New York, Macmillan Publishing Company, 1989

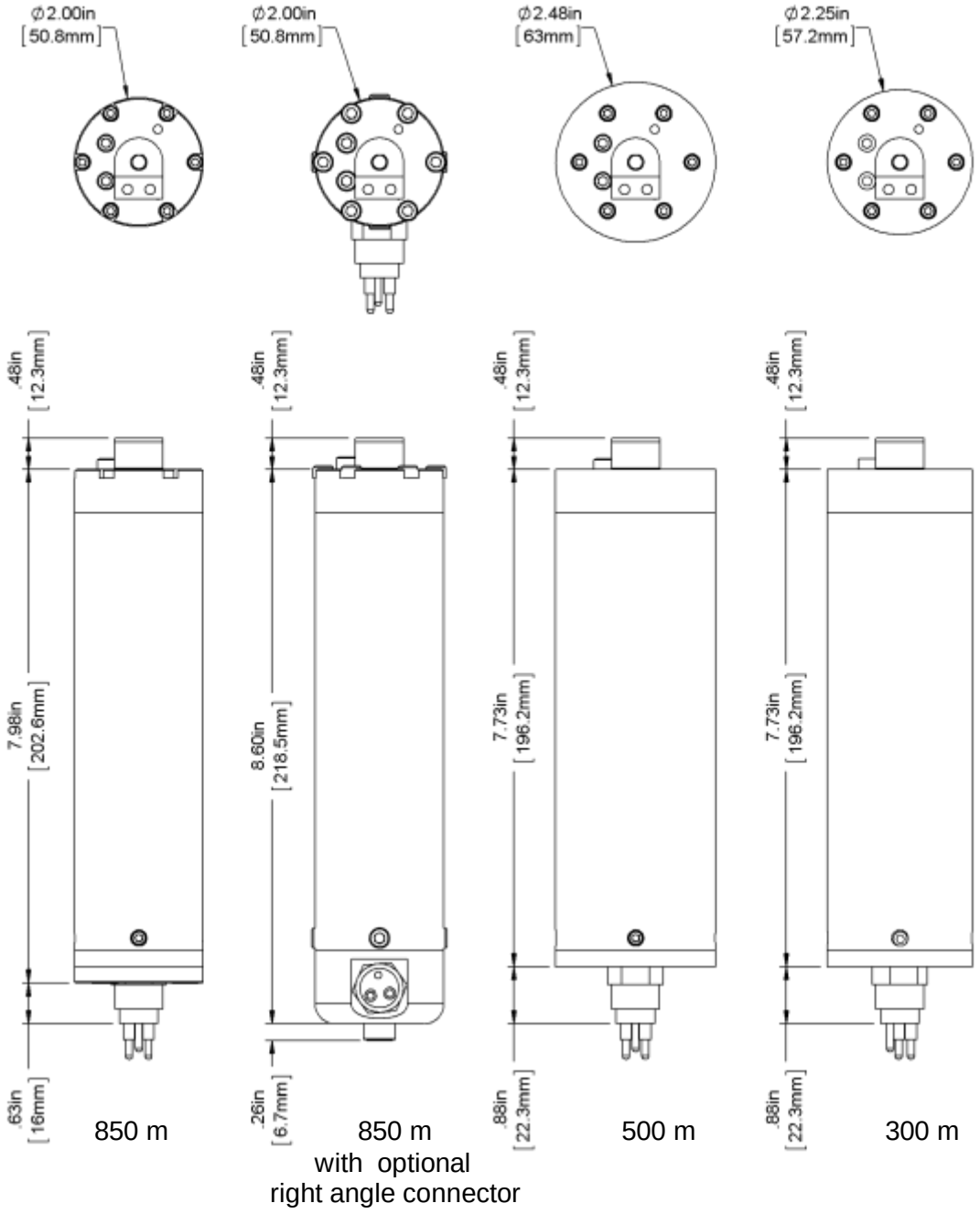


Figure A-3 Bioshutter
Models (Copper Shutter Not Shown)

Major Components

The major components of the Bioshutter are the instrument body, copper shutter, magnetic coupler, mounting hardware, gearmotor, and the power port.

See Figure A-3, Bioshutter Models

Please note that the gearmotor and magnetic coupler are contained within the instrument body and cannot be seen in the figure. A diagram of the mounting plate can be seen in the Mounting section

Instrument Body

The instrument body is a standard Sea-Bird Scientific pressure case design, available in three operating depth ratings shown in **Error! Reference source not found.**. The 850 m rated model is constructed of anodized aluminum; the 500 m and 300 m rated models are constructed of acetal plastic. On the bottom of the pressure housing is an end cap with a 2-pin male bulkhead connector that is used to provide power to the Bioshutter. The 850 m model only has an optional right angle connector.

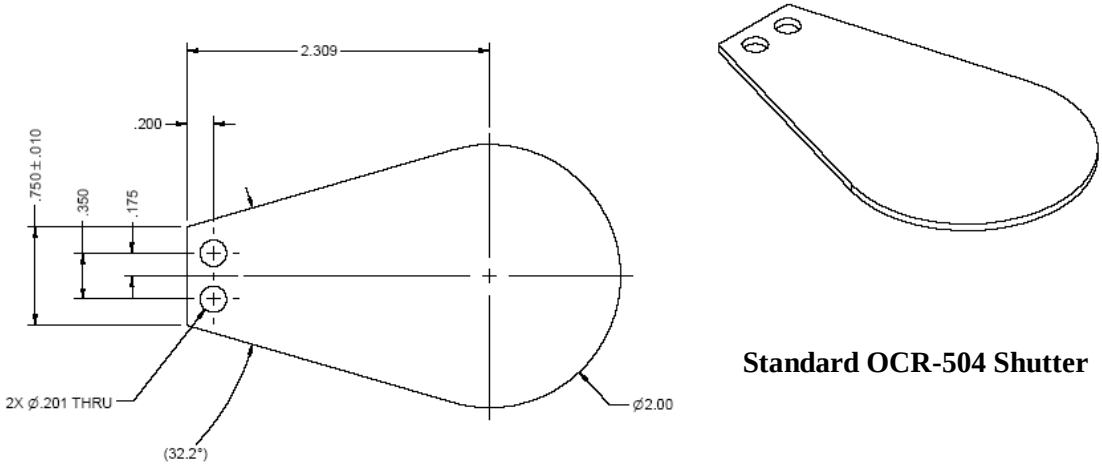
On the top of the pressure case is an end cap through which the shutter shaft passes, in order to rotate the shutter. This end cap supports the top half of the magnetic coupler. A dynamic seal prevents foreign matter from entering the space beneath the outer half of the magnetic coupler. Note that if this seal allows water to pass, the instrument will not flood.

The 850 m version of the instrument weighs approximately 907 grams in air , the 500 m version about 871 grams in air, and the 300 m version about 719 grams in air, all without the shutter and mounting hardware attached.

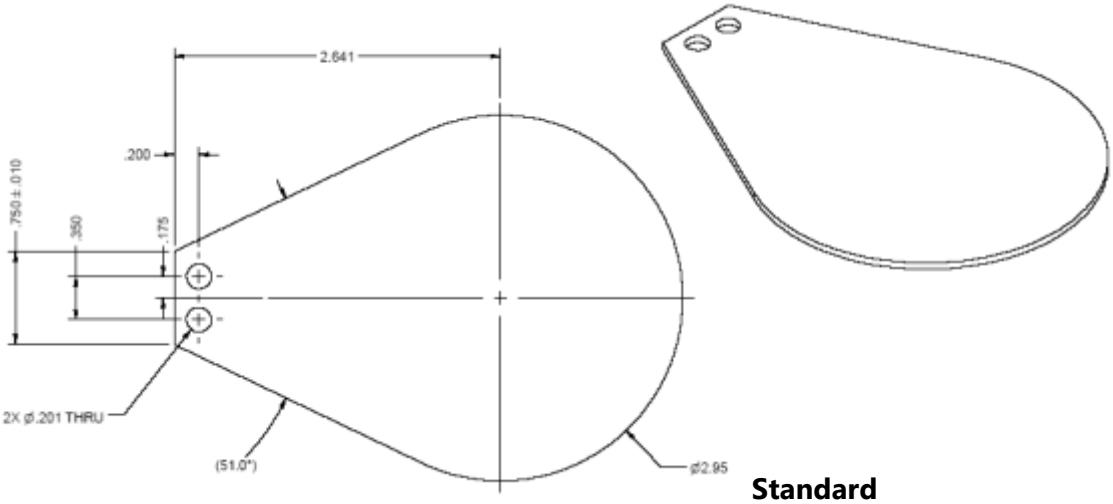
Gearmotor

The actuator used to perform the shutter motion in the device is actually a small motor/gearhead combination, also referred to as a gearmotor. Use of a small precision gearmotor allows low-power, high-torque (for motor size) operation. The gearmotor opens the shutter at a typical speed of 5 to 10 RPM. While closing, shutter speed is typically 4 to 5 RPM.

The gearmotor is coupled to the shutter with a custom magnetic coupler.



Standard OCR-504 Shutter



Standard HyperOCR Shutter

Figure A-4: Example Copper Shutters

Copper Shutter

The copper shutter is a circular or teardrop-shaped paddle, constructed from 0.0625-inch (0.159 centimeter) thick copper sheet. Copper-nickel alloys are under investigation to determine their anti-fouling effectiveness and corrosion resistance.

The shutter is attached to an Acetron paddle adapter mounted on the motor shaft using two 10-32 UNF by 3/8" Nylon slotted-head screws. A minimal amount of metal is used in the Bioshutter design in order to maintain galvanic isolation with the shutter. Any less-noble metal, such as stainless steel, could form a galvanic cell with the copper shutter. The stainless steel would slowly electroplate on to the copper if they were allowed to remain in direct contact, due to its higher cell potential. Over time, the effectiveness of the shutter as a biofoulant would be reduced.

See Figure A-4, Example Copper Shutters

As the Bioshutter can be used with a variety of optical sensors and mounting arrangements, the exact dimensions of the copper shutter will change with the application. For example, the standard OCR-504 copper shutter used with the 300 m version of the Bioshutter is in the shape of a teardrop, with its length being about 2.409 inches (6.12 centimeters) and having a radius of 1 inch (2.54 centimeters). Its weight in air is about 31 grams (1.1 ounces). The much larger OCR-504 UV shutter is circular with a diameter of 2.95 inches (7.49 centimeters). A mounting tab increases the overall length to 4.116 inches (10.45 centimeters). The weight of the OCR-504 UV copper shutter in air is about 100 grams (3.5 ounces).

Before deploying the Bioshutter, check the condition of the shutter. When signs of corrosion and/or deep pitting are apparent, the shutter will need to be replaced in order to maintain maximum anti-fouling efficiency.

DO NOT PUSH, PULL, OR ATTEMPT TO MANUALLY TURN THE SHUTTER! Doing so may damage the gearmotor and drivetrain. While the device is designed to withstand such abuse (refer to Bioshutter Protection Mechanisms), it is best to treat the instrument with care in order to maximize its lifespan.

NOTES:
1. MATERIAL IS 3/4" BLACK HDPE SHEET

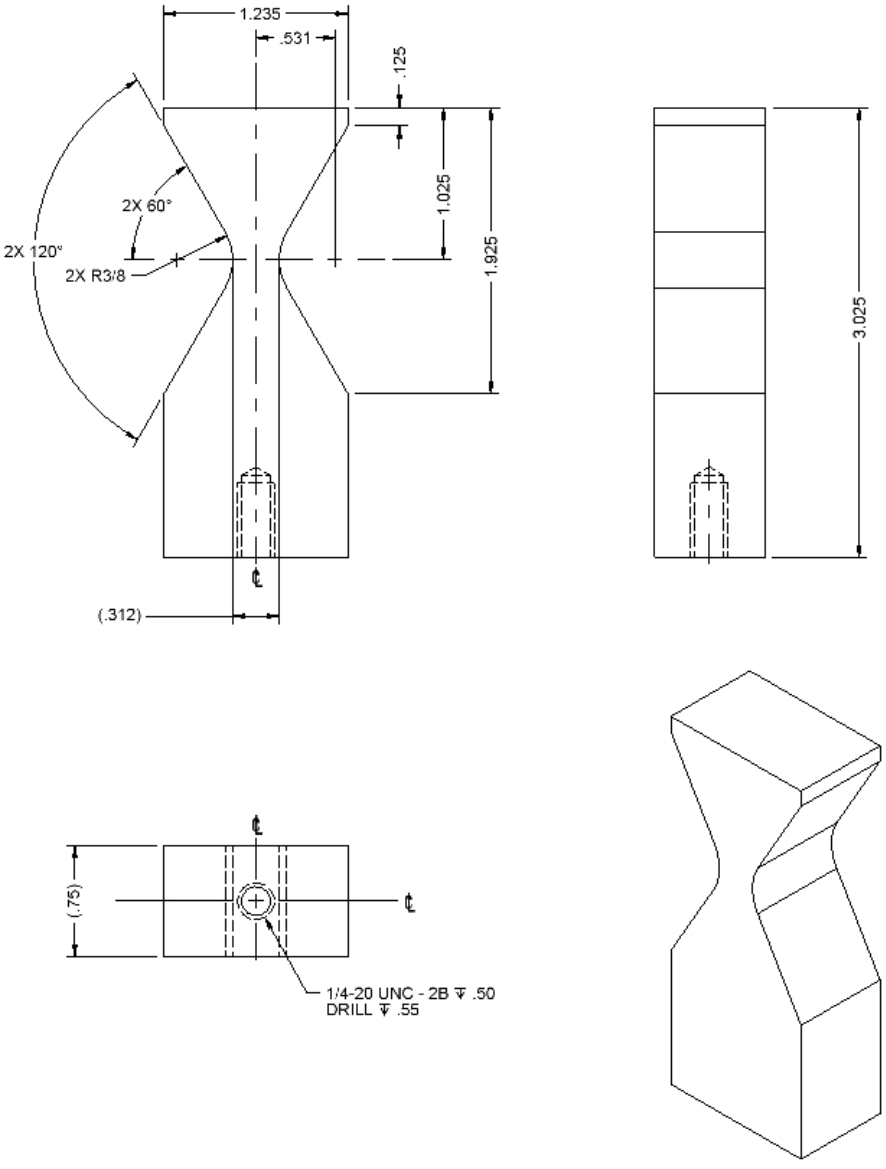


Figure A-5: Mounting Hardware (V-block)

Mounting Hardware

Currently, Sea-Bird Scientific offers a simple but effective V-block mounting configuration for the Bioshutter. Two V-blocks are attached to both the Bioshutter and the optical sensor using band clamps. The V-blocks also provide a surface for mounting the module in the field using ¼-20 screws. The V-block is normally constructed from 0.75 inch thick black HDPE.

See Figure A-5, Mounting Hardware

As the Bioshutter can be used with a variety of optical sensors, the exact placement of the V-blocks will change with the application. Custom mounts can be provided on request.

Magnetic Coupler

The Bioshutter utilizes a customized magnetic coupler to link the gearmotor with the shutter. Use of the coupler eliminates the use of a dynamic rotary seal on the motor shaft, which are prone to leaking. Sealing is achieved through a stationary titanium can with a reliable flange seal. The gearmotor shaft is magnetically coupled to the copper shutter assembly through the can.

The "wet" side of the magnetic coupler is attached to the shutter via a titanium shaft. A dynamic seal is used here to prevent foreign matter from entering the space between the outer half of the magnetic coupler and the titanium can. While it is preferable to keep water out of this space, it is not essential. As an added measure of corrosion prevention, this space is filled with a thick silicon-based grease.

Power Port

The power port is a 2-pin male bulkhead connector located on the bottom end cap.

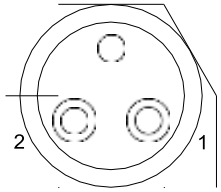


Figure A-6: Power Port

The pin assignment for this connector is contained in the following table.

Table 1

Pin	Signal	Description	Notes
1	V+	Power Supply input	8-20VDC input
2	V-	Ground	Power Return

This connector is a MCBH2M, manufactured by Subconn®. The dummy connector and locking sleeve should always be replaced on this port when the instrument is not in use. The dummy connector prevents dirt and debris from sticking to the connector pins, as well as protecting the pins against damage.

B. SAFETY & HAZARDS

Please ensure that all users of the Bioshutter have read and understand this section.

Power

Y Use extreme care when connecting power supply cables to the instrument. A shorted power supply or battery can output many amperes of current, potentially harming the user or equipment.

Instruments

Y Do not leave instruments in direct sunlight on deck when not in use.
Extreme heat (35°C or greater) can potentially damage them.

Y When deploying the Bioshutter or other instruments, always be aware of power and telemetry cable locations. Boat drift can entangle the cable and cause damage or instrument loss.

Y Do not push, pull or exert any force on the copper shutter, as this may damage the gearmotor or magnetic coupler.

Y Do not handle the bioshutter while it is powered as it has an unguarded rotating shutter that could injure the user.

Cable

Y The operators should always remain aware of the cable. Any cable or line released from a ship can be dangerous. Keep a safe distance from the cable coil on deck when the instruments are being used.

Y Ensure the power/telemetry cable is not pinched or bent to a radius less than
18 cm, to prevent damage to the conductors within the kevlar strength member.

Y Take care to prevent the power/telemetry cable from being drawn into the vessel's propellers or thrusters when maneuvering. The cable weighs only 700g/100m in water but will sink and is very strong and difficult to cut.

Connections

Y Handle electrical terminations carefully, as they are not designed to withstand strain. Disconnect the cables from the components by pulling on the connector heads and not the cables. Do not twist the connector while pulling, as this will damage the connector pins.

Y Do not use petroleum-based lubricants on connectors. Connectors should be free of dirt and lightly lubricated before mating. We recommend using DC-111 silicone grease (made by Dow-Corning) on the male pins prior to connection.

Troubleshooting

Y While checking voltages with a voltmeter, extreme care should be used so as not to short the probe leads. A shorted power supply or battery can output many amperes of current, potentially harming the user, starting fires, or damaging equipment.

Recovery

Y Remember never to grab the electrical portion of the cable during recovery. This can cause damage to the bulkhead connector and the underwater splice.

Y Lens caps should always be replaced on the optical sensors as soon as the instrument comes back on board. This will help protect the heads from direct damage.

Y Dummy connectors should always be replaced as soon as the instrument comes back on board. This will help protect the bulkhead pins from dirt and damage.

Y Be sure to rinse the instrument with fresh water prior to storage. Corrosion resulting from failure to do so is not covered under warranty.

C. START UP

This section provides a brief overview of setting up and deploying the Bioshutter. Greater detail is provided in the *Operations* section. Please read the entire *Startup* and *Operations* sections to ensure that you have a good understanding of what is required before attempting to deploy the instrument.

We recommend that you assemble and simulate the deployment of your system before investing time and resources in costly deployments. It's a good idea to check for grounding, corrosion, and telemetry problems if possible before heading out on an experiment in a remote region. A cost effective body of water is the best method to accomplish this. Every variable is important; even the water will have an effect on the capacitance of telemetry cables and could possibly cause problems if the system is "pushing the limits".

Assembly Procedure

If you have any questions about the information presented in this or any other section, please feel free to contact Sea-Bird Scientific for further information or clarification. It is important to understand the information and adhere to the guidelines presented in order to ensure successful use of this equipment.

Preparation

In preparation for assembly, the Bioshutter components should be checked against the packing list to ensure that all required items are included. The dummy connector and locking sleeve should be stored so that they can be replaced when the instrument is retrieved at the end of the deployment. The instrument packing should be retained and reused to prevent instrument damage during transport.

Lubrication for the male pins on all connectors should be used prior to connection. We recommend DC-111 silicone grease (made by Dow-Corning). ***DO NOT*** use petroleum-based lubricants.

Mount the Bioshutter Assembly

If the Bioshutter has been purchased with Sea-Bird Scientific optical sensors, it will generally be preassembled with the mounting hardware. However, if you need to mount the Bioshutter in the V-blocks yourself, the general steps are:

1. Mount the optical sensor and Bioshutter in the V-blocks.
2. Fasten the hardware on the deployment structure. Ensure that no point on the structure will interfere with the motion of the shutter.

Remember to clean the copper shutter immediately before deployment!
Refer to the *Pre-deployment Maintenance* section for details.

Connect the Components and Cables

Connectors should be inspected to ensure they are free of dirt and then lightly lubricated before making connections.

Note: this procedure assumes that a Y-Spliced interconnect cable was supplied with the Bioshutter, for use with a Sea-Bird Scientific OCR-500 series optical sensor. Please adapt the instructions to your specific application.

1. After mounting the Bioshutter and the optical sensor, ensure that all cables are disconnected from the shutter and the optical sensor.
2. Remove and store dummy connectors and locking sleeves as necessary.
3. Ensure that the Y-Splice cable is not connected to any power source.
4. Connect the 2-pin female connector on the Y-Spliced cable to the Bioshutter.
5. Connect the female connector to the optical sensor.
6. Connect the 6-pin male on the Y-Splice cable to the data logger/power source.

Begin Deployment

The Bioshutter is now ready for deployment. Please note that the actual physical deployment procedure will depend on the application.

D. OPERATION

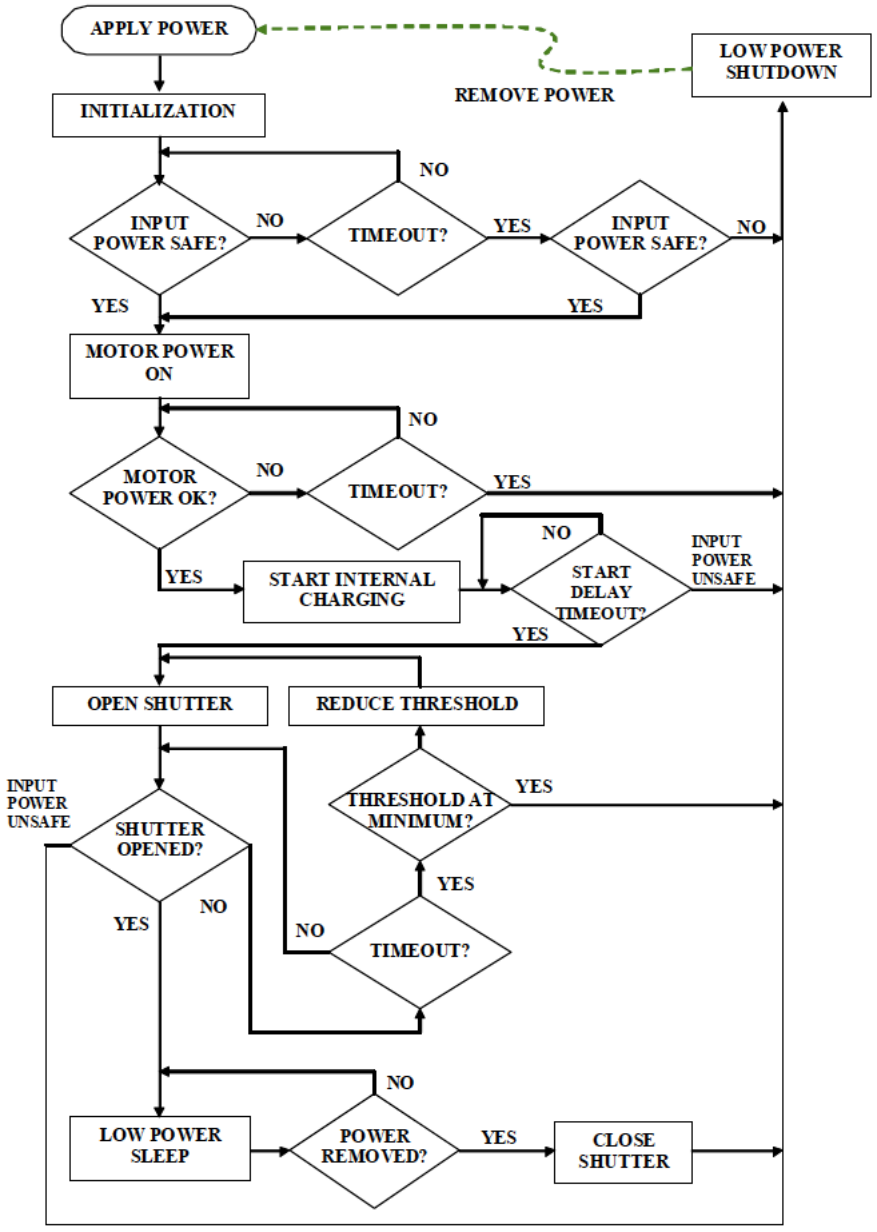


Figure D-1: Bioshutter Operational Flowchart

Introduction The operation of the Bioshutter follows a very simple power-cycle loop.

See Figure D-1, Bioshutter Operational Flowchart

While not currently implemented, the Bioshutter hardware supports RS-232 communications. This feature is provided to allow for future configurations. For example, it would be possible to implement an "always-on" version of the device, where the Bioshutter would respond to RS-232 serial port commands to open and close. Please contact Sea-Bird Scientific with any special design needs.

Deployment Operations

The Bioshutter deployment process consists of two basic steps: mounting the device to the optical sensor and deploying the system.

Once deployed, the copper shutter simply remains in the closed position, directly over the optical sensor in order to prohibit biofouling of the sensor optics. When power is applied to the device, the Bioshutter waits for the voltage to rise to a useable level, starts the internal backup supply charging process and then opens the shutter. After the shutter is in the open position, the device enters a low- power sleep state while continuing the charging process. As long as a minimum of 30 seconds is allowed before removing power, enough energy will be retained to allow the shutter to close. While in the low power state, the internal backup supply will continue to charge. Typical operating currents start at around 250 to 300 mA but quickly decrease to 13 mA or less as the internal supply charges. Note that there may be a very fast initial surge current exceeding 500 mA when the motor circuitry is first enabled – refer to the Power Supply Currents section. For this reason, it is suggested that the power source for the Bioshutter be rated at a minimum of 750 mA. Please note that if the power supply voltage at the Bioshutter connector sags below the minimum operating voltage while the internal backup supply is charging, or while the shutter is opening, the shutter will stop moving and the instrument will enter its low-power shutdown state. This approach helps prevent abnormal operation, particularly when operating from batteries that are approaching their end-of-life.

When power is removed from the Bioshutter, it is immediately detected by the internal microcontroller, which wakes up from its low-power sleep and closes the shutter. The microcontroller reenters the low-power sleep and forces a rapid discharge of the internal supply to ensure proper startup operation when power is reapplied.

How the Bioshutter Detects Position

A very simple method of position detection (open and closed) is used by the Bioshutter. Hard stops are used to prevent further shutter motion. One stop defines the closed position (shutter over the instrument it is protecting) while a second stop at either 90 or 180 degrees defines the open position. The stops are actually 10-32 screws, so it is very easy for the user to decide whether a 90- degree or 180-degree open position is best. Such flexibility is advantageous when the device is mounted in tight spaces, such as inside a mooring cage. In addition, the customer may specify a counter-clockwise opening motion for the shutter when ordering, hence there is an additional stopper hole location on the end cap.

The device constantly monitors the gearmotor current – when the shutter mount contacts the stopper, gearmotor current quickly ramps up. When the preset threshold is reached, the motor is turned off. The figure below illustrates the position stoppers.

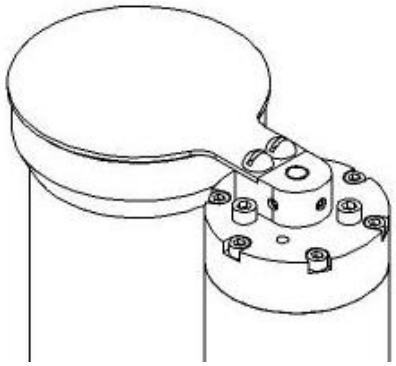


Figure D-2: Bioshutter Open/Close Stoppers

As is to be expected, it is important that the shutter path be clear. Any objects that interfere with shutter motion may cause the device to falsely detect the open or closed position.

Bioshutter Protection Mechanisms

Although not shown in the operational flowchart, the Bioshutter contains some protection mechanisms, specifically input power protection and gearmotor torque protection. These mechanisms serve to protect the device from the realities of field use.

Limited Input Overvoltage Protection

The Bioshutter power system design provides some protection against input over- voltage conditions through the use of an internal zener diode which limits momentary over-voltages to 24 V. This component cannot protect the instrument for more than a few milliseconds. The use of fuses has been avoided in order to eliminate the possibility of nuisance trips during deployments, which would make the device unusable.
Do not apply voltages greater than 20 V to the input. The input **is not** reverse voltage protected.

Gearmotor Output Torque Protection

As previously mentioned, a custom magnetic coupler is used to link the gearmotor to the shutter. Although the primary reason for using the magnetic coupler is to eliminate the rotary shaft seal, careful matching of the magnetic coupler with the gearmotor allows the coupler to act as a torque-limiting device. The breakaway torque of the magnetic coupler is less than the intermittent output torque rating for the motor, providing an inherent level of protection.

Setting Up for a Deployment

Ensure that you are familiar with the entire manual before attempting to use the system. Failure to do so may result in frustration at best and severe damage to equipment at worst.

Test the Bioshutter

Hold (or mount) the Bioshutter such that the copper shutter will be able to rotate freely. Next, apply power to the Bioshutter. After a brief delay, the shutter will begin to rotate clockwise (unless counter-clockwise operation was specified at time of order). When the shutter reaches the stopper defining the fully open position, the shutter will stop and the instrument will enter a low power state. During this time the internal back up supply will continue to charge, indicated by a steadily decreasing current consumption. Wait about 30 seconds (longer if you wish) then remove power. The shutter will close, although more slowly than it opened. This is simply because the motor is operating at a lower voltage than during the opening sequence. However, as power has been removed from the Bioshutter, the longer time has no effect on the overall energy required by the device.

Use caution with the following test; if the instrument doesn't detect the stop condition, the motor may continue to turn, causing the magnetic coupler to realign and the shutter to snap back quickly.

Wait a few seconds, and then reapply power. Try holding your finger in front of the shutter to try to stop it. As you can see, a large force is not required, depending on where you contact the shutter. Keep in mind that the torque is the relevant physical quantity here. Torque is the product of force and the distance from the center of rotation, hence the farther you are from the motor shaft, the easier it is to stop it. Wait another 30 seconds, and then remove power – the shutter will close.

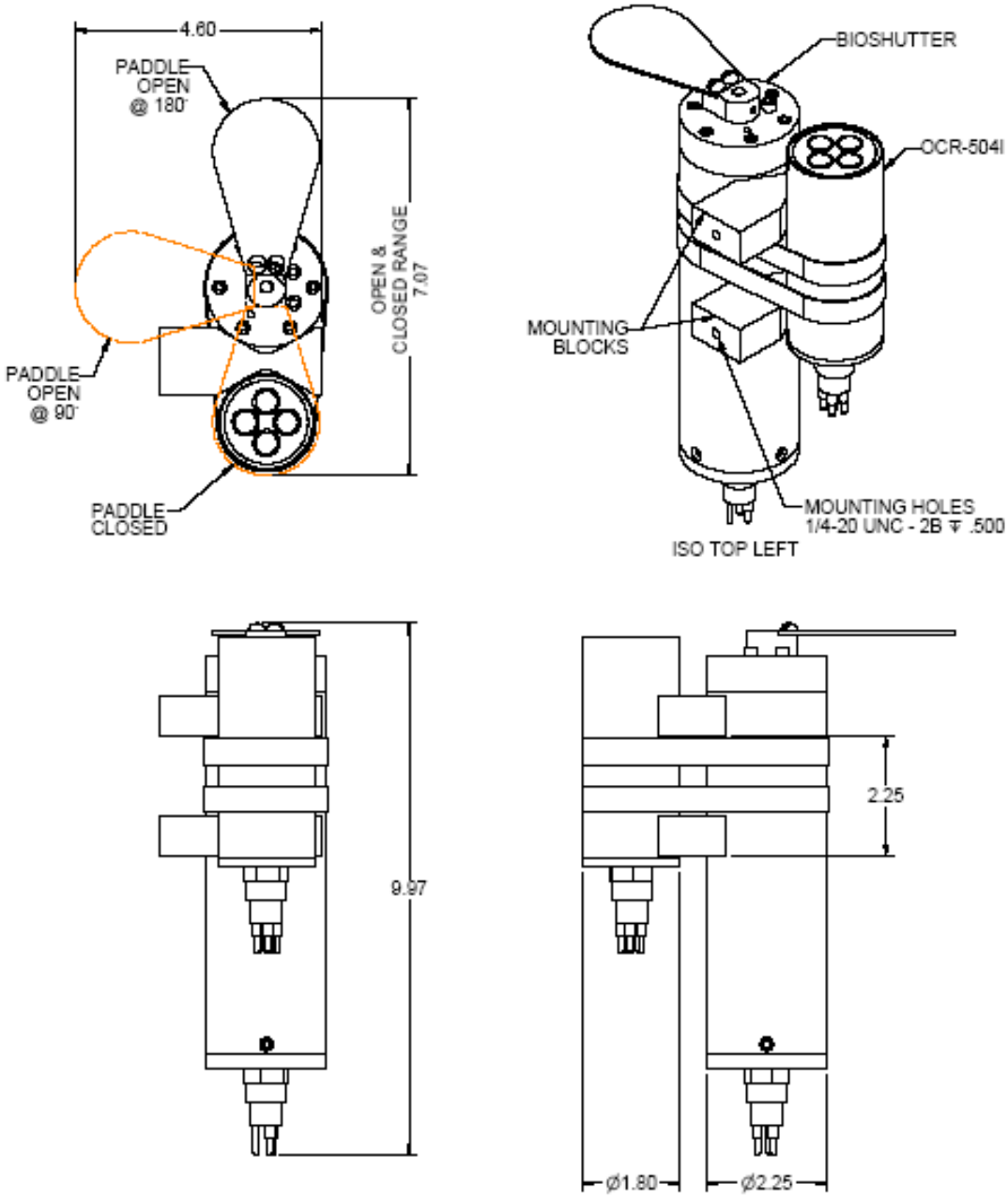


Figure D-3: Bioshutter Mounted with OCR-504

Mounting the Bioshutter

There are three steps involved in mounting the Bioshutter assembly prior to deployment:

1. Mount the optical sensor and Bioshutter in the V-blocks.
2. Fasten the hardware on the deployment structure. Ensure that no point on the structure will interfere with the motion of the shutter.

These steps are outlined in greater detail in the following sections.

See *Figure D-3: Bioshutter Mounted with OCR-504*

Mounting the Instruments

The copper shutter should be in the fully closed position before attaching it to the V-blocks. The shutter will be in the closed position following a successful test; please refer to the section entitled Test the Bioshutter. Also note that **all surfaces of the copper shutter should be cleaned immediately before deployment**. Refer to the *Pre-Deployment Maintenance* section for details.

To mount the optical sensor and Bioshutter on to the two V-Blocks, set the blocks on a flat surface on the face with the ¼-20 screws. The idea is to keep the V-blocks as far apart as possible, therefore the space between the blocks will be dependent on the optical sensor used. For example, an OCR-504 sensor is significantly shorter than the Bioshutter so that the blocks will be much closer together than on a Bioshutter mounted with a HyperOCR. The top V-block should be mounted high up on the Bioshutter, usually just below or on the seam joining the top endcap to the main housing. This can be seen in the figure at left. The lower V-block should be as far down the optical sensor as possible. The top of the optical sensor should be very close to the copper shutter, but must not contact it.

When you have determined the proper spacing for the blocks, it is best to measure the distance between them and then mount the V-blocks on a thin plate using the ¼-20 screw holes. This will make adjusting the sensor positions much easier as you tighten the band clamps. Also, the instrument housings should be covered with clear heat shrink tubing or wrapped in a thin layer of black splicing tape before mounting – this allows the band clamps and V-blocks to get a very good grip on the instruments without extreme tightening. While holding the instruments in position, wrap the band clamps around the instruments and tighten until the

clamps start to grip. The shutter should be directly above the optical sensor, but not touching. Adjust the position of the Bioshutter in the clamp so that the shutter is about 0.5 to 1 millimeter (0.02 - 0.04 inches) above the highest point on the top of the optical sensor (for example, the cosine collectors on a Sea-Bird Scientific irradiance head). The design allows some deflection of the shutter, which can be tested for by pushing down gently on the copper shutter. The shutter should not touch the optical head when deflected – adjust the height of the sensor in the V-block accordingly. Refer to Figure D-4: Shutter/Sensor gap. Tighten the band clamps.

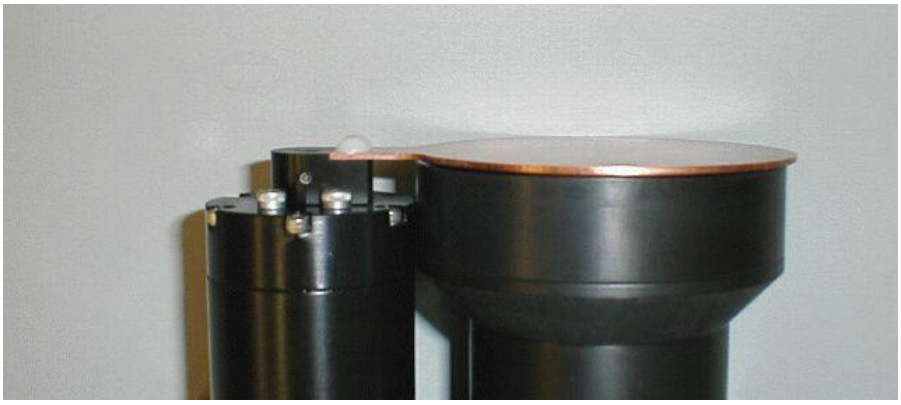


Figure D-4: Shutter/Sensor gap

Fastening the V-Blocks to the Deployment Structure

The mounting plate may now be mounted on the deployment structure. Use the two ¼-20 holes located on the back of the mounting blocks as the attachment points.

IMPORTANT NOTE:
The copper shutter rotates 180˚ (optionally 90) during the operating sequence. It is imperative that no point on the deployment structure will interfere with the motion of the shutter.

Connect the Components and Cables

After mounting the assembly to the deployment structure, the components and cables must be connected. Typically, a Y-spliced cable is used to connect to the Bioshutter and optical sensor, providing power to both devices and telemetry from the optical sensor. The other end of the Y-splice cable is used to connect to the data acquisition device. Connectors should be inspected to ensure they are free of dirt and then lightly lubricated before making connections.

Note: this procedure assumes that a Y-Spliced interconnect cable was supplied with the Bioshutter, for use with a Sea-Bird Scientific optical sensor. Please adapt the instructions to your specific application.

1. Ensure that all cables are disconnected from the Bioshutter and the optical sensor.
2. Remove and store dummy connectors and locking sleeves as necessary.
3. Ensure that the Y-Splice cable is not connected to any power source.
4. Connect the 2-pin female connector on the Y-Spliced cable to the Bioshutter.
5. Connect the 8-pin female connector to the optical sensor.
6. Connect the male connector on the Y-Splice cable to the data logger/power source.

Begin Deployment

The Bioshutter is now ready for deployment. Please note that the actual physical deployment procedure will depend on the application. Typically, the Bioshutter will be used in a moored application, and no special precautions need to be taken. Ensure that the device is not bumped or dropped during deployment, and that no objects will interfere with rotation of the shutter.

Remember to double-check the y-splice cable connections!

Power Supply Considerations

The Bioshutter device will operate from a power supply voltage in the range of 8 to 20 Volts DC. This range allows efficient use of most battery chemistries. In most cases, it also allows the device to operate from the same supply as the optical sensor it is protecting.

As the Bioshutter is typically used in battery-powered moored applications, the power requirements of the device must be considered in order to determine the battery capacity required.

The daily battery requirements, in Ampere-hours (Ah), for the Bioshutter can be estimated from the following:

$$DBCR \approx (N / 3600) \times \left(\int_0^{t_{SS}} 0.2427 e^{-0.0971t} dt + \frac{I_{MTR}}{R} \times t_{OPEN} + I_{SS} \times t_{ON} \right)$$

where

DBCR = the Daily Battery Capacity Required (in Ah)
N = the number of events per day
I_{MTR} = motor current (in Amps) – assume 100 mA
t_{OPEN} = the time to open the shutter (in seconds) – assume 10 seconds I_{SS} = the current (in Amps) required in steady state – assume 13 mA
t_{SS} = the amount of time (in seconds) per event that the instrument has power applied

The integral part of the equation is derived from the exponentially decreasing charge current of the internal backup supply.

As an example, let's assume an application where the Bioshutter is turned on for 60 seconds every hour for 24 hours, a typical long term mooring application. Substituting the values into the equation yields a DBCR value of only 0.025 Ah **per day**, a very low-power system. In comparison, a servomotor-based system in a similar application could require as much as 0.08 Ah per day, assuming that 200 mA is required by the servo for the full t_{ON}. The power savings become more apparent, however, as the open time (t_{ON}) of the device increases. A servomotor that remains powered during t_{ON} will continue to draw full current (~200 mA), while the Bioshutter draws only 13 mA. The real advantage of the Bioshutter, however, is that the shutter closes when power is removed.

While this equation provides a good estimate of energy required by the Bioshutter, it is no substitute for actual testing of the device in your application. Always allow a healthy factor of safety.

Power Supply Currents

The following figure illustrates a typical current profile for the Bioshutter. In this example, you can see the brief high-current surge when the motor is first enabled, highlighting the requirement for a power source capable of supplying up to 750 mA. This spike can vary from one use of the device to the next.

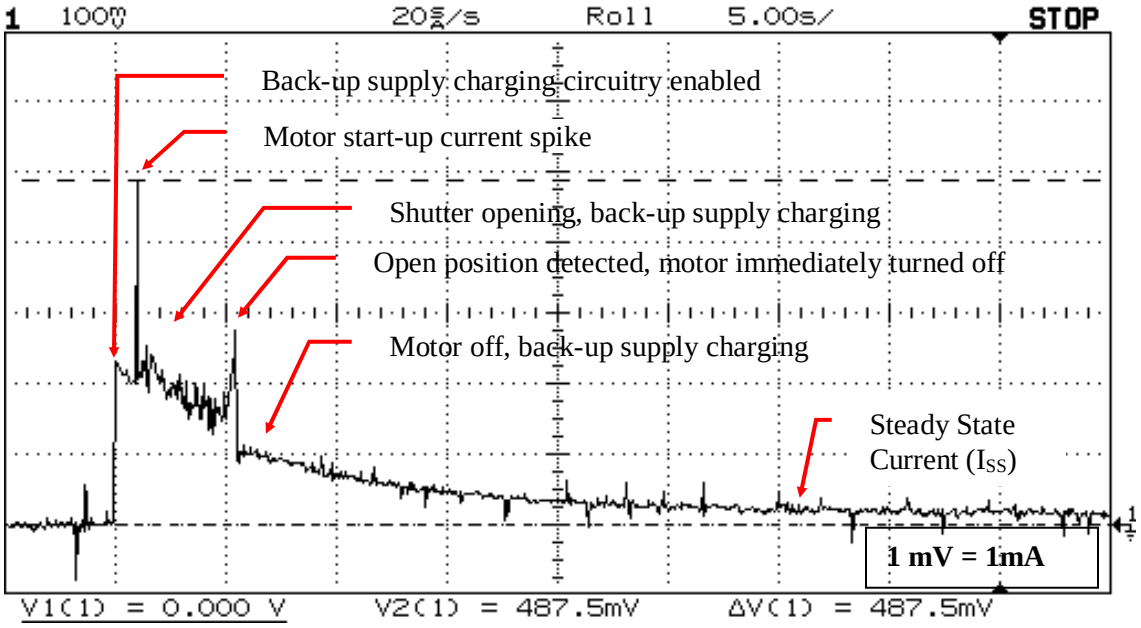


Figure D-5: Typical Current Profile

E. RECOVERY

The recovery procedure for the Bioshutter will depend on the application.. Normally, recovery is simply the reverse of the deployment.

A generic recovery procedure is as follows:

1. Ensure that power to the Bioshutter and optical device is off.
2. Remove the power/telemetry cable from the devices, and replace the associated dummy connectors and locking sleeves.
3. Carefully remove the mounting hardware from the deployment structure.
4. If possible, leave the optical sensor and Bioshutter mounted to the V-blocks for the next deployment.
5. Carefully clean the devices with fresh water.
6. Inspect both devices for any damage that may have occurred during the deployment period.
7. Inspect the copper shutter for corrosion and/or pitting. If necessary, contact Sea-Bird Scientific to obtain a replacement shutter.
8. Store the instruments, preferably in their original shipping case(s) to protect them from damage.

F. MAINTENANCE

Pre-deployment Maintenance

When exposed to air, the copper shutter quickly tarnishes to a dull brown/red color. The color is a result of the copper reacting with oxygen to form a thin layer of copper oxide (Cu_2O). The tarnish is easily removed by cleaning with a cleansing pad (i.e. ScotchBrite®) or steel wool. Please refer to the figure below. **Note that it is best to leave the shutter attached to the Bioshutter – you should not remove it from the shaft or remove the plastic screws holding the shutter to the Acetron adapter**. These screws have a threadlocking compound applied (Loctite 425) that is rated for use with plastic. **DO NOT USE THREADLOCKING COMPOUNDS FOR USE WITH METAL SCREWS ON PLASTIC!**

Tarnished shutter Clean shutter

Figure F-1: Cleaning the Copper Shutter

Cleaning the shutter immediately before deployment removes the copper oxide layer, exposing copper for the maximum protection against biofouling.

Preventative Maintenance

The Bioshutter requires virtually no maintenance. Protecting it from impacts, rinsing it with fresh water after each use, and properly storing it with the dummy connector in place will prolong the life of the instrument. External power sources should always be removed during storage. Remember to clean the copper shutter to remove any tarnishing before deployment.

If the instrument is not working properly the troubleshooting techniques in this section can be applied. If these are not successful, please contact Sea-Bird Scientific for assistance.

Troubleshooting For Hardware Problems

If the instrument is failing to operate properly, there could be a hardware problem. The connections can be verified and voltage checks can be conducted on the cables and components. A multimeter with DC voltage measurement, resistance measurement, and continuity check capabilities is required.

WARNING! While checking voltages, extreme care should be used so as not to short the probe leads. A shorted power supply or battery can output many amperes of current, potentially harming the user, starting fires, or damaging equipment. If battery cases are used with the instrument, be extremely careful not to generate any sparks. Batteries normally release Hydrogen gas during the charging process and may create an explosive environment.

Check Connections

Ensure that the power cable is properly connected to the Bioshutter and to the power supply or battery.

Check the Bioshutter Supply Voltage

The Bioshutter requires an input voltage in the range of 10 – 20 VDC in order to operate. Input voltages higher than the maximum operating voltage will cause the input protection circuitry to activate. Input voltages sufficiently lower than the minimum rated input voltage will cause the device to shut down when the controller detects the condition.

Procedure:

1. Set the meter to measure a DC voltage
2. If using a battery as the power source, measure the voltage directly at the battery terminals. A fully charged 12V battery usually measures from 13 – 15 V. If the voltage is low (under 11 V) the battery needs to be recharged or replaced (although the voltage may still be within operating range of the Bioshutter). If using a power supply, check to ensure that the voltage is in the acceptable range.
3. Connect the power/telemetry cable to the power source.
4. **Being extremely careful not to short the probe leads**, measure the voltage between the pins on the supply cable. It should read approximately the same as the measurement taken in step 2. If the voltages are not the same, recheck the power supply cable connections. If they are still not the same, there is likely a break in the cable that requires repair (a wire break can be confirmed with a *continuity check*).
5. If the voltage is ok, connect the power supply cable to the Bioshutter. Again measure the voltage at the power supply terminals. The voltage should remain approximately the same as before, although there may be a small

voltage drop when using a battery (battery voltage drops under load). If there is a significant voltage drop, disconnect the power immediately and check for shorts in the cable.

Check Cable Continuity

Often, system problems can be traced to cable breaks or shorts. Usually, these cable failures are a result of improper handling or storage. Cable continuity can be checked as outlined below. All cables should be disconnected from the instrument while performing these tests.

Note: Standard Sea-Bird Scientific cables are one-to-one, that is, pin 1 on the connector on one end of a cable is connected to pin 1 on the other. For these types of cables, the following procedure may be used:

Procedure:

1. Set the meter to measure continuity. The resistance measurement setting can also be used.
2. Check for continuity by measuring from pin 1 on one end of the cable to pin 1 on the other. The meter should confirm that the connection is continuous by either giving an audible signal or measuring a low resistance. If there is not continuity, there is a break in the cable, requiring repair.
3. Repeat Step 2 for all pins in the cable.
4. Check for shorts from pin 1 to all other pins in the cable by keeping one probe lead on pin 1 and touching the other probe lead to each of the other pins in turn. All pins should be isolated from one another. The meter should read this as open or a very high resistance. If any of the pins are not isolated, there is a short that requires repair.

If your system uses the standard Y-splice cable, the pin connections for the two 8-pin connectors will be one-to-one. The 2-pin connector will be connected to pins 1 and 2 of the other connectors.

G. WARRANTY

Warranty Period

All Sea-Bird Scientific equipment is covered under a one-year parts and labor warranty from date of purchase.

Restrictions

Warranty does not apply to products that are deemed by Sea-Bird Scientific to be damaged by misuse, abuse, accident, or modifications by the customer. The warranty is considered void if any optical or mechanical housing is opened. In addition, the warranty is void if the warranty seal is removed, broken or otherwise damaged.

Provisions

During the one year from date of purchase warranty period, Sea-Bird Scientific will replace or repair, as deemed necessary, components that are defective, except as noted above, without charge to the customer. This warranty does not include shipping charges to and from Sea-Bird Scientific.

Returns

To return products to Sea-Bird Scientific, whether under warranty or not, contact the Sea-Bird Scientific Customer Support Department and request a Returned Material Authorization (RMA) number and provide shipping details. All claims under warranty must be made promptly after occurrence of circumstances giving rise thereto and must be received by Sea-Bird Scientific within the applicable warranty period. Such claims should state clearly the product serial number, date of purchase (and proof thereof) and a full description of the circumstances giving rise to the claim. All replacement parts and/or products covered under the warranty period become the property of Sea-Bird Scientific.

Liability

IF SEA-BIRD SCIENTIFIC EQUIPMENT SHOULD BE DEFECTIVE OR FAIL TO BE IN GOOD WORKING ORDER THE CUSTOMER'S SOLE REMEDY SHALL BE REPAIR OR REPLACEMENT AS STATED ABOVE. IN NO EVENT WILL SEA-BIRD SCIENTIFIC BE LIABLE FOR ANY DAMAGES, INCLUDING LOSS OF PROFITS, LOSS OF SAVINGS OR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING FROM THE USE OR INABILITY TO USE THE EQUIPMENT OR COMPONENTS THEREOF.

H. DECLARATION OF CONFORMITY

DECLARATION OF CONFORMITY

Company contact details:
Satlantic LP
Richmond Terminal, Pier 9, 3481 North Marginal Road, Halifax, Nova Scotia, B3K 5X8, Canada
Tel: +1 902-492-4780 Fax: +1 902-492-4781 Email: info@satlantic.com

Satlantic LP declares that their:
1) PAR Sensor - Photosynthetically Active Radiation Sensor
2) OCR-500 - Ocean Color Radiometer
3) HyperOCR - Hyperspectral Ocean Color Radiometer
4) SAT-THS - Tilt Heading Sensor.
5) Bioshutter
6) Profiler II
7) ISUS - In Situ Ultraviolet Spectrophotometer
8) STOR-X
9) Alkaline Battery Pack

are classified within the following EU Directive:
Electromagnetic Compatibility Directive 2004/108/EC

and further conform with the following EU Harmonized Standard:
EN 61326-1:2006

Dated: 12 October 2012
Position of signatory: President
Name of Signatory: Marlon Lewis
Signed below:
on behalf of Satlantic LP

I. MANUAL REVISIONS

Date	Author	Rev.	Comments
July 2001	SKF	A	
December 2003	SKF	B	
2004-02-04	SKF	C	
2004-12-14	SKF	D	
2006-02-17	SKF	E	
2007-05-23	KMB	F	Warranty statement
2011-06-02	SKF	G	Extended supply voltage range. Flow chart update. Added body options.
2012-01-25	SKF	H	Changed company name from Satlantic Inc to Satlantic
2012-11-27	SKF	I	Removed references to input reverse protection diode – no longer present in hardware. Added Declaration of Conformity.
2017-05-18	TVY	J	Changed company branding from Satlantic to Sea-Bird Scientific