SeaSPY2

Operation Manual

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1 Introduction

SeaSPY2 is a high-sensitivity total field magnetometer packaged in a rugged marine housing that is designed to be towed behind a marine vessel. A standard SeaSPY2 system consists of the following components:

- A towfish unit that contains an Overhauser magnetometer sensor and driving electronics
- A high-strength marine tow cable, containing a single twisted wire pair
- A deck leader cable that is waterproof, but designed to be used out of water
- An isolation transceiver for powering and communicating with the towfish, and time synchronization
- An RS232 interface cable that connects to a standard PC RS232 port
- A universal input (100 to 240VAC 50/60Hz) power supply that allows the system to be powered from line power anywhere in the world
- BOB software for Windows 10 or later.
  See BOB User Manual for minimum recommended requirements for optimal BOB operation.

Measurement of the magnetic field is done completely inside the towed fish. The tow cable supplies power to the towfish, and provides a bidirectional digital communication link. All control of the fish is through RS232, using a PC or any RS232–capable computer.

The towfish requires DC power, with a range of +15 to +50VDC. For medium or long tow cables (longer than 300m), it is recommended to keep the supply voltage above +20VDC, and it is always recommended to keep the supply voltage as high as possible to reduce the voltage drop in the tow cable. In most cases, power will be supplied to the SeaSPY2 from the Isolation Transceiver, which produces a clean, constant +48VDC to power the towfish. The input range for the Isolation Transceiver is +9 to +28VDC.

The AC power supply (included with all complete SeaSPY2 tow systems) will produce a clean, constant +24VDC from a 100 to 240VAC at 50/60Hz source. The maximum power consumed by the fish is about 3W when acquiring data, and is typically around 1W when in standby. The Isolation Transceiver consumes an additional 1.5W.

1.1 Understanding the System Components

Marine Magnetics supplies a separate document called our *SeaSPY2 Technical Application Guide* that describes in depth how a SeaSPY2 magnetometer works, and how it can be used for different applications. Marine Magnetics provides this document to anyone free of charge, so please contact us if you do not already have a copy.

1.1.1 Overhauser Total Field Sensor

This is the main sensor of the system. It operates on the proton spin resonance principle, but it is drastically different from a conventional proton magnetometer sensor. The proton-rich liquid within the sensor has been specifically engineered to allow a principle known as the Overhauser effect to occur within it. This effect allows a SeaSPY2 magnetometer to measure with one to two orders of magnitude more sensitivity but with a tiny fraction of the power of a standard proton sensor, while keeping the excellent absolute accuracy and operational characteristics that have made conventional proton sensors so popular.

All SeaSPY2s are supplied with an omnidirectional sensor that is completely isotropic with respect to magnetic field direction. The only restriction that must be observed is that **the fish must not be oriented vertically with the nose facing up**. This is a restriction with respect to the direction of gravity, not magnetic field.

The Overhauser sensor measures *magnetic flux density*, the unit for which is the Tesla (T). Magnetic flux density on the surface of the Earth typically varies between about 18μT to 70μT, depending on location. The flux density at any fixed location on the Earth's surface also varies with time due to diurnal effects, which include influence from the Sun, and movement of the Earth's molten interior.

One often speaks of a magnetometer as measuring magnetic field instead of flux density, since the two values are directly related given an environment of constant magnetic permeability (such as air or water). Some materials will distort the surrounding magnetic flux density by 'amplifying' or adding to the ambient magnetic field. Such objects are known as *paramagnetic*. Some materials (such as iron, nickel, cobalt and alloys containing these materials) exhibit this effect very strongly, and are known as *ferromagnetic*. Objects made from these materials are very easily detectable by a magnetometer. Most building materials, especially those used to build modern boats and ships, contain iron alloys and are therefore magnetic. Some stainless steels (austenitic alloys such as 316) are only weakly ferromagnetic, but will become more strongly magnetic if their microstructure is disturbed by annealing, welding, machining or severe stressing.

When an object of high magnetic permeability distorts the flux density around it, it creates a magnetic gradient that is proportional to the magnitude of its permeability. If the magnetic gradient through the volume of the magnetometer sensor is

too great, the sensor will not operate correctly. For this reason, massive magnetic objects must be kept away from the sensor. **Do not expect the sensor to produce good results on the deck of a ship, or inside a building,** any more than you would expect a high-powered telescope to see distant stars in the middle of the day.

For more information on magnetic fields and how SeaSPY2 magnetometers work, please refer to the *SeaSPY2 Technical Application Guide*. This document can be obtained from Marine Magnetics.

1.1.2 Leak Detector

Each SeaSPY2 magnetometer is equipped with a leak sensor that sounds a warning when water is present inside the towfish housing. Every reading, in text mode, displays an 'Lx' parameter, where x is a number between 0 and 9. A value of 9 indicates that water is present. Even a small drop of water will activate the leak sensor.

In the event of a leak warning, the SeaSPY2 should be retrieved immediately, as it is very likely that a leak has developed in the electronics housing. Water inside the electronics pod may damage the electronics module and Overhauser sensors.

1.1.3 Pressure Sensor

The standard SeaSPY2 pressure sensor is a Wheatstone bridge on a silicon diaphragm. The maximum pressure that this sensor can stand before potentially suffering damage is 2500psi (1725m of water). Exceeding this depth can cause a change in the calibration tuning of the sensor, and its accuracy may suffer as a result. The pressure sensor will not suffer serious mechanical damage (i.e. will not rupture and cause a leak) until twice that pressure (about 3450m of water).

Note that the standard SeaSPY2 housing as a whole is rated to a depth of 1000m, which should never be exceeded or damage to the housing may result.

SeaSPY2s can interface seamlessly to a variety of other pressure sensors, suited for shallow or deep water surveying. In general, a larger pressure sensor range will result in lower precision in the pressure reading. The table below lists the different pressure sensor types, their required housing ratings, and the corresponding maximum precision.

Pressure Range (psi)	Depth Range (m)	Precision	Housing
500	345	0.1 m	1000m standard
1500	1000	0.3 m	1000m standard
5000	3450	1 m	3000m deep-tow
10000	6895	2 m	6000m deep-tow

table 1-1: Pressure sensor options

The pressure sensor is an analog device that may drift with temperature and with time. For proper operation, the pressure sensor zero-level should be reset before every survey. In moderate climates, this can be done on the deck of your ship; however, for optimal results the towfish should be submerged to allow the temperature of the pressure sensor to reach the ambient water temperature. The **p** command will zero the pressure sensor.

The **P** command will display the current pressure sensor calibration settings, and will offer the option to set the full-scale pressure calibration. The full-scale calibration is factory-set, and does not need to be altered by the operator unless below-nominal full-scale accuracy is suspected.

The pressure sensor may be calibrated by entering the factory full-scale calibration value; by entering a nominal value that is valid for a generic sensor of a given pressure range; or by submerging the towfish to a known depth and entering that depth.

1.1.4 Altimeter echo sounder (Optional)

A 200 kHz narrow-beam echo sounder is located on the bottom of the nose bulkhead altimeter block. This device senses the distance from the face of the transducer to the sea floor by emitting 10 sound pulses per second, and providing these altitude readings to the SeaSPY2 electronics.

The SeaSPY2 altimeter has a range of 0.5m to 60m, and a resolution of 0.01m. To see the current altitude of the platform, use the d command. Altitude is displayed in meters as 'A005.00m'. In addition, an altitude reading is included in every magnetic field reading to allow real-time monitoring. Note that the altitude data field does not appear if the altimeter is not installed in the towfish.

The altimeter does not work when out of the water, and will display a value of 599.99m representing an out-of-range condition. This indicates that the altimeter cannot 'find' a surface underneath the platform, but otherwise working properly. If the altimeter were to stop working, the altitude reading would disappear from the data stream completely.

1.1.5 Electronics Module

The SeaSPY2 electronics module is the core of the SeaSPY2 system, located within the towfish. It controls all of the sensors in the towfish, monitors their performance, and reports their data to the host acquisition device digitally over the tow connection. Interface to the electronics module is through a single two-wire connection. DC Power and telemetry are multiplexed into the same two connections.

The electronics module requires approximately 700mW of power in standby (waiting for commands), and approximately 2.7W at full power while sampling the magnetic field.

All SeaSPY2 electronics modules are completely interchangeable. The only difference between them is a 16-bit serial number that is stored in non-volatile RAM within the unit.

1.1.6 Towfish

The SeaSPY2 towfish is a pressurized vessel that carries all of the system sensors and the SeaSPY2 electronics module. It consists of 2 filament-wound fiberglass cylinders coated with polyurethane for abrasion and shock resistance. The nose contains a brass tow connector that is designed to bear the entire load of the tow system, in addition to providing an electrical connection. Note that the shell of the connector is isolated from the system common ground, and is connected electrically to the surrounding water.

A standard SeaSPY2 towfish is rated to a water depth of 1000m (3280ft). For maintenance recommendations and a list of replacement O-ring sizes in the housing seals, refer to section 10 (page 31).

1.1.7 Isolation Transceiver

The SeaSPY2 Isolation Transceiver contains three important components:

- power-conditioning electronics that supplies clean constant electrical power to the SeaSPY2
- microprocessor to bridge the communication between the magnetometer FSK protocol and the PC's RS232 interface
- Integrated GNSS receiver that ensures precise time synchronization of the connected magnetometer (beginning in 2023)

Power and RS232 are both fully isolated from the supply ground, providing extremely high immunity to noisy power supplies at all frequencies. The wide input range of +9VDC to +28VDC allows for operation with both 12VDC and 24VDC lead acid batteries. Internal regulators produce a constant +48VDC to power the SeaSPY2. The power and communication to the SeaSPY2 are multiplexed together for use with a two-conductor tow cable. The isolation transceiver is sealed in a rugged housing that is splash proof, but not waterproof.

The Isolation Transceiver is able to communicate with a SeaSPY2 platform across up to 10,000m (32,808ft) of the standard SeaSPY2 twisted-pair tow cable.

The transceiver also supports USB interface for use with computers that do not have a standard serial port. For more information on how to connect the transceiver, refer to Sections 2 and 3.

A new generation Isolation Transceiver is available as of 2023, which includes an additional connector for the external GPS input. An external GPS adapter cable allows the transceiver to receive time synchronization data from an external RS232 GPS, whenever the integrated GPS is unable to receive satellite signal (e.g. when the transceiver is placed inside a vessel's cabin).

1.1.8 Gradiometer Transceiver (discontinued)

The Gradiometer Transceiver has been discontinued in 2023, and replaced with the GPS-enabled 4-port universal transceiver.

1.1.9 USB Cable

The USB cable connects the Isolation Transceiver to your PC. It is a gray cable with one USB connector that plugs into the PC, and one female 8-pin circular connector that connects to the Isolation Transceiver.
This cable is useful for laptops or computers that do not have a standard serial port. The Isolation Transceiver contains a built-in RS232-USB adapter, which acts as a virtual COM port on the computer. The USB driver for this adapter is supplied with BOB software. Please note that this virtual COM port is available only when the transceiver is powered.

1.1.10 RS232 Cable (Optional)

The RS232 cable is an optional replacement for the USB cable. It is a gray cable with one female 9-pin DSUB connector that plugs into the serial port of your PC, and one female 8-pin circular connector that connects to the Isolation Transceiver. An RS232-USB adapter (commercially available) can be used for computers lacking a serial port. Unlike the USB cable, using an external RS232-USB adapter makes the virtual COM port available even when the transceiver is not powered.

1.1.11 AC Power Supply

The standard SeaSPY2 AC power supply can accept any AC power from 100 to 240VAC, at 50/60Hz, and is therefore capable of operating worldwide. It produces a constant 24VDC to power the Isolation Transceiver and SeaSPY2 system.

Note that the AC power supply uses a 3-prong North American style plug. **It is extremely important that the third (middle) prong from this plug is connected to a proper ground**. If not, you may experience communication problems, or even a degradation of magnetometer performance.

The Isolation Transceiver contains protection against polarity reversal. Therefore, connecting the black clip to the positive terminal, and the red clip to the negative terminal will cause no damage. **However, no protection exists against over-voltage. Use caution not to connect the battery clips to any voltage higher than 28V**.

1.1.12 Battery Clip Cable (Optional)

If AC power is unavailable, or if battery power is more convenient, the battery clip cable may be connected in place of the AC power supply. This cable has two large alligator clips for easy connection to a standard 12VDC or 24VDC vehicle battery.

Note that the voltage of a typical 12VDC lead-acid battery will vary from approximately 14VDC when fully charged to approximately 9VDC when nearly discharged. A 24VDC lead-acid battery will provide a range of 18 to 28VDC going to the SeaSPY2 system over the full charge cycle of the battery set.

Connecting two 12V batteries in series can also provide a 24V power supply.

When using a gradiometer with altimeters, a 24V power supply is required to meet the added power demand.

The SeaSPY2 system has protection against polarity reversal. Therefore, connecting the black clip to the positive terminal, and the red clip to the negative terminal will cause no damage. However, no protection exists against over-voltage. Use caution not to connect more than 28V to the SeaSPY2 system.

1.1.13 Tow Cable

The standard SeaSPY2 tow cable (yellow in colour) is a shielded twisted pair (two conductors plus shield) with a high strength, lightweight braided Vectran strength member. The tow cable can withstand loads of up to 1000lb without any damage, and loads of up to 6000lb without breaking. It is sheathed in a tough polyurethane jacket and is fully water blocked. This means that if the jacket is cut or damaged, water migration through the tow cable will be greatly slowed, but not completely stopped depending on the external pressure. A damaged cable jacket should be repaired as soon as possible.

The two conductors in the tow cable carry the towfish DC power, and also the towfish telemetry, multiplexed with the power supply. The red conductor carries the positive voltage and telemetry, and the black conductor carries the negative voltage and common ground. The outer braid is only used to shield the inner two wires from external noise, not to carry electric current. It is connected to the cable's negative conductor at the source (topside) end of the cable only.

Tow cable length must be adjusted appropriately before entering it into the survey data collection software (such as BOB or Hypack). The magnetometer sensor is located at the back of the SeaSPY2 towfish, increasing the effective length of the tow cable. Use of a Y-split cable (for horizontal gradiometers) further increases the effective cable length. Refer to table 1-1.1 to determine the tow cable length adjustment:

Magnetometer model	Tow cable length adjustment
Explorer	+ 0.6 m
SeaSPY2	+ 1.0 m
SeaSPY2 + Altimeter	+ 1.1 m
SeaSPY2 Horizontal gradiometer	+ 3.5 m

table 1-1.1: Adjustment required to determine the effective tow cable length for different magnetometer models

1.1.14 Floatation Cable (Optional)

The SeaSPY2 floatation cable is mechanically and electrically similar to the standard SeaSPY2 tow cable, but has the addition of a syntactic foam layer underneath its outer polyurethane jacket. It is distinguishable by its larger thickness and orange colour. The floatation cable provides enough buoyancy to keep the magnetometer at a depth of about 2 to 3m, regardless of how much cable is deployed.

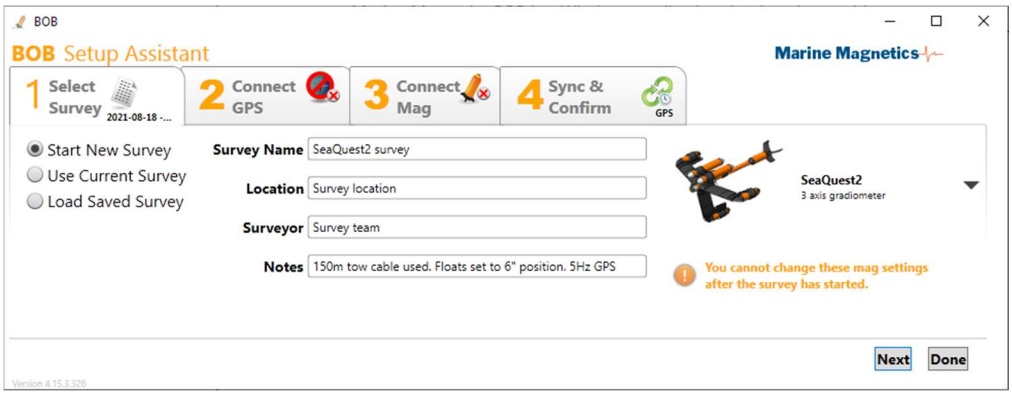
Floatation cable is very useful for shallow water environments, or when deploying with a great deal of other gear (such as seismic guns and streamers) when it is important keep the cable at a controlled depth, visible to the operators at all times.

1.1.15 Deck Cable

The deck cable is designed to connect the main tow cable spool, which is usually left on the deck of the deployment vessel near the stern, to the Isolation Transceiver, which is normally kept in a controlled interior environment. The deck cable's jacket is very tough polyurethane that is designed to withstand extreme abrasion and crushing, but is not designed to withstand towing force.

1.1.16 BOB Software

Marine Magnetics BOB is a Windows application that interfaces with your magnetometer, to allow full control over the towfish, data collection, survey planning and data visualization. For detailed information on using this program refer to the *BOB Operation Manual*. Visit: https://bob.marinemagnetics.com/



2 Communication via the Isolation Transceiver

NOTE: Please refer to the Isolation Transceiver Operating manual for latest details and transceiver features.

By default, all communication with the SeaSPY2 is via the Isolation Transceiver, which inserts an intelligent layer between data logging software and the towfish. The transceiver assumes complete control over the tow cable communication link, and time synchronization with the GPS, as well as supplies optimal power to the towfish for a wide variety of cable lengths and specifications.

2.1 Transceiver Serial interface

The connection between the data logging computer and the Transceiver is via RS232 interface, using:

- 115200 baud
- 8 data bits
- No parity
- 1 stop bit

Communication is full-duplex. Any commands that are sent to the SeaSPY2 while it is transmitting will not disrupt the transmission.

When using the supplied USB cable, the transceiver's integrated RS232-USB converter is used, which emulates a virtual COM port with the same settings.

When you send a command to transceiver, you may get a response even if there is no SeaSPY2 connected. For example, you can query and set the transceiver's internal time and date without the SeaSPY2 connected. As soon as you connect the SeaSPY2, the transceiver will recognize the SeaSPY2, and set its time as necessary.

Refer to Section 6 (page **Error! Bookmark not defined.**) for details on the command interface.

2.2 Transceiver Internal Real-Time Clock

The Isolation Transceiver contains a real-time clock that it used to synchronize the clock inside the SeaSPY2 during the survey. The transceiver real-time clock continues running when power is disconnected. The clock is powered by an internal lithium battery that automatically recharges when power is applied to the transceiver. The clock will keep time accurate to 0.65 seconds per day in ambient temperatures of –40 to +85˚C, or accurate to 0.15 seconds per day in ambient temperatures of 0 to +40˚C.

Note that after an extended storage period between surveys (several weeks), the internal real-time clock battery may discharge and the clock will reset to zero. For this reason, it is recommended to "charge" the transceiver for at least 6 hours prior to the survey following an extended period of storage. This will ensure that the real-time clock battery will be sufficiently charged to ignore any power cycles that may occur during the survey.

2.3 Transceiver Output Voltage

Standard isolation transceiver units are built to output +48VDC to the SeaSPY2 tow cable, using input voltages of +9 to +28VDC. Power and RS232 are both fully isolated from the supply ground, providing extremely high immunity to noisy power supplies at all frequencies.

Note that all isolation transceiver units use a 1.0A resettable input fuse. If your input voltage is too low, the transceiver will have to draw more current to supply the same power to the SeaSPY2 tow system. For this reason a 24V input source is recommended for most situations.

The resettable fuse has a variable trip delay based on the amount of over-current. For example, if the transceiver is drawing 1200mA, you may find that the SeaSPY2 system will work well for a short while, and then trip the fuse for no apparent reason. If your transceiver seems to 'go dead,' it is possible that you have simply tripped the fuse due to input voltage being too low. Simply power down the system, wait a few seconds, and then turn it on again.

You can monitor the transceiver input and output voltages and currents at any time using the **d** command. Refer to Section 6 (page **Error! Bookmark not defined.**) for details on the command interface.

2.4 Transceiver Status LEDs

The Isolation Transceiver has three status LEDs, indicating power, communication with towfish, and GPS lock.
(the GPS LED was introduced in 2023).

The LED modes indicate the following states:

Power LED	Orange	Towfish not connected/detected.
	Green	Towfish is detected and powered.
	Red	Fault condition. Or Transceiver disabled power to towfish.
Communications LED	Blue (flashing)	Data is being transmitted.
GPS Lock LED*	Blue (flashing)	Searching for GPS signal. No satellite lock.
	Blue (solid)	GPS satellite signal lock is obtained, and the transceiver is able to synchronize itself and the connected towfish to the GPS time.

Table 2-1 - LED indicators on the Isolation Transceiver

2.5 Text and Binary Modes

Two modes of communication are possible with a SeaSPY2 magnetometer. Text mode is the simplest method of communicating with a single magnetometer on a single tow cable. In this mode, only a simple ASCII terminal is required, which can be a PC running a terminal program such as Windows HyperTerminal, or BOB software provided with your magnetometer system. In text mode, the fish responds to single byte commands sent from the terminal.

Binary mode is a less intuitive, yet more efficient mode of communicating that is intended to be used by automated data collection systems. Commands and data are sent and received in a special protocol that requires decoding software on the host (user) end. This protocol allows more than one magnetometer to be connected to the same tow cable, creating an along-the-track gradiometer configuration. A user can switch to binary mode from text mode by sending the **@** command. After this, commands must be sent according to the special binary protocol.

If SeaSPY2 is inadvertently placed into binary communication mode, it will not respond as expected to standard text mode commands, and may seem as if it is malfunctioning. If your fish does not seem to be responding to commands, send the **#** command at least twice to return to text mode. Turning SeaSPY2 off and on again will reset its communication mode to text.

3 Connecting the Equipment

The SeaSPY2 magnetometer system is designed for quick and easy deployment and can be setup without the use of any tools.

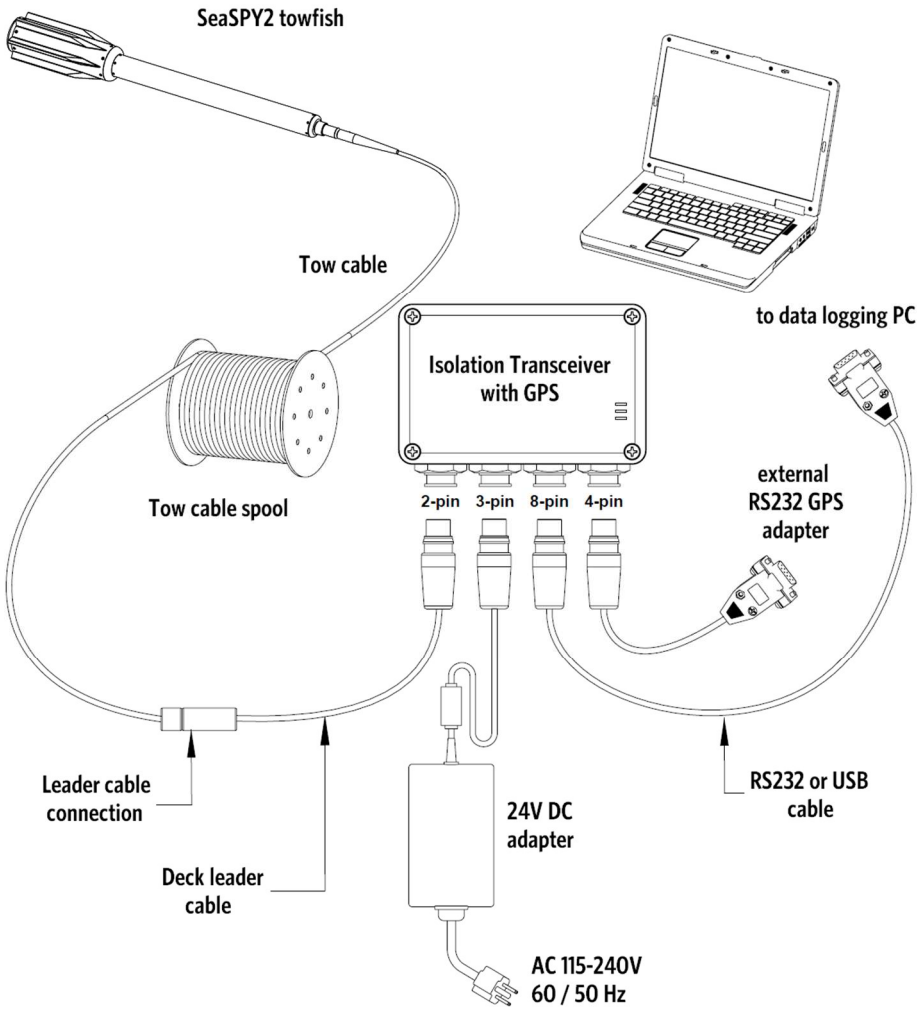


Figure 1 - SeaSPY2 connection diagram with a GPS-enable Isolation Transceiver

NOTE: GNSS integrated in the isolation transceiver is used for time synchronization only, and cannot be used for navigation or as a source of magnetometer positions during the survey. A dedicated survey GPS with appropriate antenna placement is required for positioning, and is not part of the magnetometer interface system.

Please refer to the Isolation Transceiver Operating Manual for further details.

NOTE: The external GPS connection is optional, for situations where the transceiver and its internal GPS are not exposed to satellite signal.

NOTE: If you are using a side scan sonar with your magnetometer, refer to Section **Error! Reference source not found.** (page **Error! Bookmark not defined.**) for further instructions.

- Connect the Isolation Transceiver to a PC or other type of host computer using either the USB or the RS232 cable provided with the system. If your PC does not have an available serial port, you can use either a USB-to-Serial converter.
- If you are powering your unit from an AC power source, plug the circular 3-pin female connector end of the AC adapter into the transceiver and then plug the power cable into 100-240VAC, 50/60 Hz. The unit can also be powered from a DC source using the optional Battery Clip Cable by connecting the two large alligator clips to the battery terminals and the circular 3-pin female connector to the transceiver. Refer to Section 1.4.8 (page **Error! Bookmark not defined.**) for further details on the Isolation Transceiver.
- The deck leader is a long black cable (typically 20 to 30 feet) that connects the transceiver to the main tow cable. Plug the circular 2-pin male connector end into the transceiver and then plug the coax connector on the other end into the main tow cable of the system. Note that the deck leader is not designed for underwater use and is not designed to withstand any towing force. Its connectors are sealed but not submersible.
- The tow cable must be firmly secured to the towing vessel. On larger vessels, this is sometimes done by winding the tow cable on a secured winch, and connecting the deck leader to the slip ring connection on the winch. The deck leader then provides a connection between the winch and the transceiver, which is typically in an enclosed area close to the data acquisition equipment.
- When using a tow cable spool without a slip ring, always disconnect the deck leader cable from the tow cable spool before adjusting the tow cable length.

3.1 Main Tow Connector

The main tow connector provides the electrical connections to the towfish, and also bears the load of the towfish as it is towed through the water. It is a rugged, heavy-duty connector that is able to withstand a great deal of physical punishment.

The male connector has a locking slot that fits into a groove in the female side. When assembling the connector, line up the slot with the groove, and insert. The male connector should slide in all the way up to the locking ridge. Use the brass locking nut to fasten the connector in place. Do not be afraid of over-tightening this nut. It is too strong to be damaged by hands alone.

When the connector is assembled, no part of the thread on the towfish should still be visible. If it is, the nut has not been tightened fully, or the slot was not inserted properly in the groove. Also, if you can still rotate the bend restrictor after the connector has been assembled, the slot was not inserted properly in the groove.

The most important feature of the tow connector is that all parts are fixed in place when it is fastened – no part moves against any other part. If you have used shackle connections on other marine instruments in the past, you will notice a great benefit to the ruggedness and longevity of the SeaSPY2 connection system. Keeping the connector in operational order requires very little effort. See section 10.1 for maintenance tips.

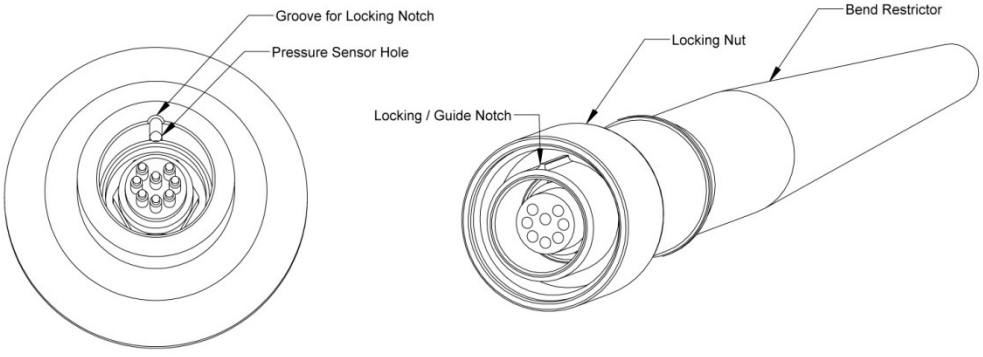


Figure 3-2 - SeaSPY2 main tow connector

3.2 SeaSPY2 electrical specifications and tow connector pin-out

SeaSPY2 supports dual telemetry:

- standard FSK telemetry (pins 5,6 and 7,8) for use with the isolation transceiver and a 2-conductor tow cable,
- optional RS-232 telemetry (pins 2,3,4) for direct interface without a transceiver, over short cables (<50m).

NOTE: standard SeaSPY2 tow cable is a 2-conductor cable for use with the FSK isolation transceiver. RS-232 pins are not connected in a standard tow cable.

Table 3-1 – SeaSPY2 towfish electrical connector wiring (front MCBH8M connector)

Pin	Function	Notes
1	n/c	
2	GND (RS-232)	
3	RS-232 – PC > MAG	RS-232 Tx/Rx pair must be shielded from FSK
4	RS-232 – MAG > PC	RS-232 Tx/Rx pair must be shielded from FSK
5	**V+ / FSK +**	12-55V range.
6	**V+ / FSK +**	12-55V range.
7	**GND (Power)**	GND and V+ must be in a twisted pair
8	**GND (Power)**	GND and V+ must be in a twisted pair

Table 3-2 – SeaSPY2 towfish electrical specifications

Parameter	Min	Typ.	Max
Input voltage	12 V	50 V	55 V
Input power	1W standby, 3W normal, 5W with altimeter		

3.3 Longitudinal Gradiometer

A Longitudinal Gradiometer system consists of two SeaSPY2 units connected in line via an inter-fish cable. The two towfish can be towed from a standard main tow cable but require the Isolation Transceiver to be switched to Gradiometer Mode in order to communicate properly. Figure 3-4 shows how to assemble a Longitudinal Gradiometer system. The front towfish in the assembly has a tow connector on both ends**. If you are using gradiometer towfish alone, always make sure that the tail plug with seal is in place, or else the towfish can be damaged.**

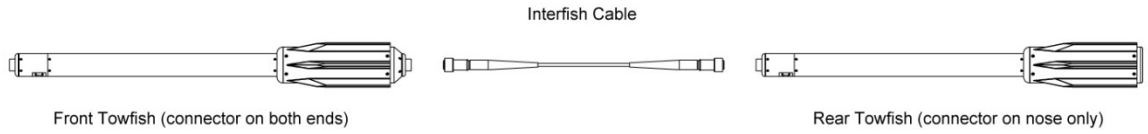


Figure 3-3 - Longitudinal gradiometer assembly

3.4 Horizontal Transverse Gradiometer

The SeaSPY2 Horizontal Gradiometer expansion kit converts two standard SeaSPY2 magnetometer towfish into a simultaneous horizontal gradiometer. The kit consists of a rigid frame structure, and a Y-split tow cable that carries the SeaSPY2 power and telemetry signals simultaneously to both towfish from a single tow cable. A Gradiometer Transceiver is required for communicating with the two towfish. The Gradiometer Transceiver software supports simultaneous communication of two SeaSPY2 magnetometer towfish over the same single twisted-pair tow cable; it combines data streams from both towfish into one data stream sent to the data logging computer, and handles time synchronization of both towfish.

The gradiometer frame features a streamlined design to minimize drag, and is constructed from hard-anodized aluminum, making it relatively lightweight, yet very strong, rigid and resistant to damage from collisions with obstacles while being towed. The frame's high rigidity is very important for producing precise, high-quality gradiometer data.

The aluminum frame is anodized to prevent corrosion, and is additionally equipped with sacrificial anodes made of zinc for harsh salt water environments. These anodes are designed to corrode first, thus preventing corrosion of the aluminum frame. As the anodes corrode over time, they may require replacement.

Note that the fasteners used to attach the anodes must be completely non-magnetic in order to ensure proper operation of the gradiometer. Only brass or titanium fasteners can be used.

IMPORTANT: Do not attempt to replace any frame fasteners with replacement ones, if you cannot obtain 100% non-magnetic fasteners. Only titanium or Naval Brass are sufficiently non-magnetic so as to exclude any possibility of magnetic interference. Using stainless steel fasteners anywhere on the frame will cause magnetic interference and compromise the sensitivity and performance characteristics of the gradiometer.

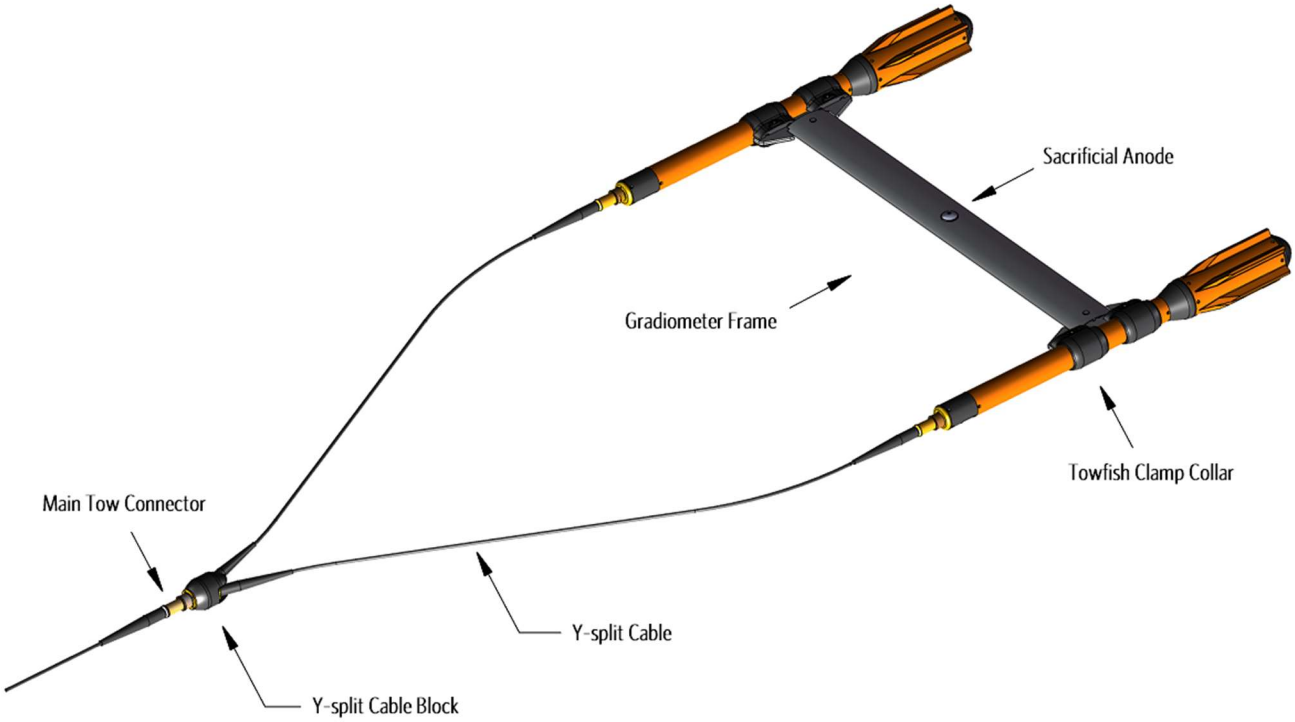


Figure 3-4 - The horizontal gradiometer in fully assembled state

3.4.1 Horizontal Gradiometer Assembly Instructions

The horizontal gradiometer frame is shipped as a fully assembled streamlined transverse "wing" with two clamp collars on each side and non-magnetic brass or titanium fasteners. The clamping bolts located in the center of each collar contain rubber O-ring washers to prevent loosening through vibration.

Step 1: Position the SeaSPY2s

For proper frame alignment, lay the two SeaSPY2's on the ground 150 cm apart with the tow connector notch facing up as shown in Figure 3-5. If the SeaSPY2's are equipped with altimeters, the altimeters should be pointing downward when the connector notch points upward. This alignment ensures that the internal ballast in each SeaSPY2 is facing downward.

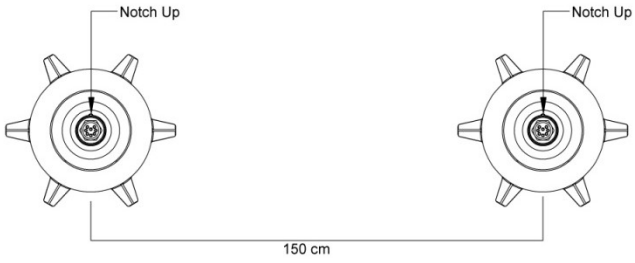


Figure 3-5 - Correct towfish orientation prior to attaching the frame

Step 2: Loosen the clamping bolts in the collars just enough to allow the collar to slide over the SeaSPY

In order to install the assembled frame onto the SeaSPY2, simply loosen the clamping fasteners (one on each collar) enough to allow the collar to slide onto the SeaSPY2. Take care not to lose the nut on the opposite side of the bolt as you loosen it! It is not necessary to remove the collar from the wing. The rubber O-ring washers are required to prevent the collar fasteners from getting loosened should any unnecessarily harsh vibration occur during the survey.

Step 3: Align the Collars

For proper frame geometry, the collars must be aligned the same way on both sides of the frame. The front collar should be aligned with the edge of the orange tube, or the edge of the altimeter block if equipped with altimeter. If not aligned with the edge, then the distance between the edge of the tube and collars must be the same on both sides. See Figure 3-6.
NOTE: If the SeaSPY2's are equipped with altimeters, ensure that the collars do not cover the altimeter blocks!

Step 4: Fasten the Collars

Fasten the 4 collar bolts (one in the center of each collar) enough to prevent towfish from sliding through or rotating inside the collar. The clamping bolt is located in the center of the collar. The other two bolts fasten the collar to the frame, and should not be removed or loosened.

NOTE: When used in cold water, the SeaSPY2 tube may experience thermal compression at a different rate than the frame collar. Thus, in cold water applications, the collar fasteners should be tightened more, to prevent them from slipping.

Step 5: Check the Frame's Integrity

The frame may now be stood up on the tails of the two towfish. Observe the structure from the side. If it appears 'warped,' slightly loosen the collars and adjust their positioning.

Step 6: Install the Y-split Cable

The Y-split cable should be installed prior to deployment. Stretch the cable out so that there is no torsion in each of the segments, and the two cables are not twisted, with the cable connector notches oriented the same way as the grooves on the SeaSPY2 connectors.

Attach the two sides of the Y-split cable to the SeaSPY2 towfish by installing the male brass connector into the bulkhead connector on the SeaSPY2.

The male connector on your SeaSPY2 tow cable connects to the female connector of the Y-split cable. Please refer to section 4 for further information on pre-deployment preparation and normal operation of your gradiometer system.

Note: the Y-split cable adds 2.5m to the effective length of the tow cable. This should be factored into the tow cable length (layback) calculation, along with the length of the towfish itself. Refer to Tow Cable section of this document, or the BOB software user manual, for instructions on determining the correct effective cable length (layback).

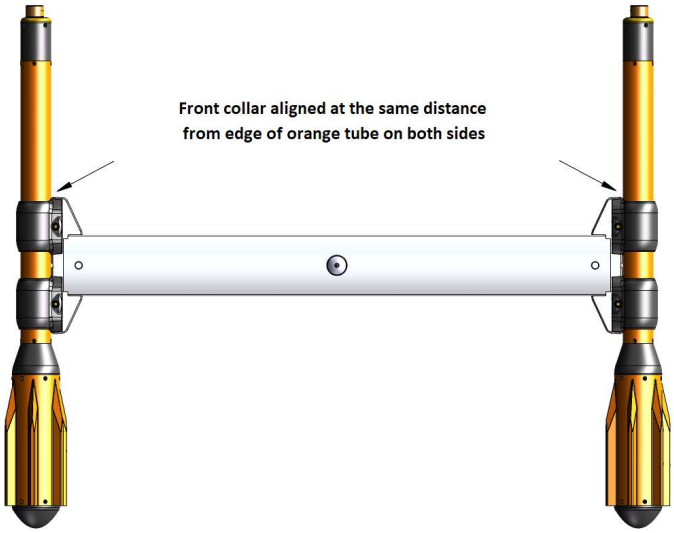


Figure 3-6 - Correct collar positions for optimal frame alignment

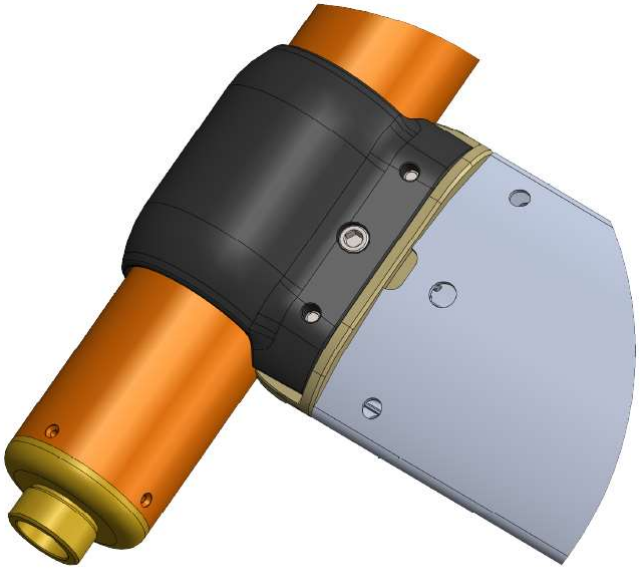


Figure 3-7 - Each collar has a single bolt in the center that tightens it over the towfish.
The other two bolts affix the collar to the frame, and should not be removed or loosened.

3.4.2 Spare fasteners for the frame clamping bolts:

Each frame collar has a single titanium bolt used to clamp and tighten the collar over the towfish.

You should never need replacement fasteners unless you loosen the clamping bolts so excessively as to let the nut fall off completely, without supporting the nut in any way.

The bolt itself is kept in place with a rubber o-ring which prevents it from falling out, as well as provides secure anti-loosening protection during survey.

Should you need to replace the nut for the clamping bolt, use the following specifications when sourcing a replacement:

Size: 3/8”-16 UNC heavy hex nut

Material: Grade 2 Titanium

QTY: 2

You may substitute Naval Brass for titanium, if necessary. No other material aside from titanium or brass shall be used anywhere near the gradiometer to prevent magnetic interference.

4 Getting Started

When the transceiver is first powered up, the *Power* LED will glow orange and it will transmit a brief identification message to the PC. If a SeaSPY2 is detected, then the LED will turn green and the SeaSPY2's own identification header will also be displayed. You will notice the *Comm* LED will flicker blue as data is transmitted between the SeaSPY2 and the transceiver. Upon detection of the towfish, the transceiver will automatically set the towfish time.

A good way to start is by checking battery voltage at the magnetometer with the **d** command. The **d** command provides important information about the status of both the transceiver and the towfish. The first line of data comes from the transceiver and represents the voltage, current and power being supplied to the towfish. The second line of data comes from the SeaSPY2 and reports the status of three important sensors as well as the voltage at the towfish end of the tow cable. The first column shows the amount of signal currently being produced by the Overhauser sensor. This is a raw number between 0 and 255, and should nominally be less than 10 when the magnetometer is idle. The second column is battery voltage. The voltage should be at least +15VDC. If it is lower, communication may be erratic, and the magnetometer may not operate properly. The voltage drop between the transceiver and the fish will depend on the length of your tow cable. The third and fourth columns display the temperature of the electronics, and the depth of the fish in meters.

4.1 Setting pressure sensor zero-depth level

Prior to each survey, it is a good idea to zero the depth sensor. In moderate climates this can be done on the deck of the vessel when the SeaSPY2 has already cooled or warmed to the ambient air temperature, since the output of the depth sensor will vary slightly with temperature.

If the water temperature is significantly different from the air temperature, the SeaSPY2 may need to be immersed in water for 5-10 minutes to allow it to adjust to the water temperature, before the pressure sensor zero-depth level can be set (after raising the SeaSPY2 back to or above the surface). This will ensure the most accurate depth readings during survey.

Set the zero depth level using the **p** (lower-case p) command. You will be prompted for confirmation before the sensor is zeroed.
The scale of the depth sensor can be set using the **P** (capital P) command. **You should not change this unless you suspect the accuracy of the depth measurement**.

4.2 Getting Started with a New Gradiometer System

All new gradiometer systems are configured for use in gradiometer (GRAD) mode. The above procedure is the same for these systems. All commands issued will be applied to both SeaSPY2s when in GRAD mode. Note that in order to survey with a single magnetometer you must issue the **c** command and select MAG mode. The c command toggles between single magnetometer (MAG) mode and gradiometer (GRAD) mode.

NOTE: Gradiometer mode relies on knowing the serial numbers of both towfish connected to the transceiver for correct operation. If you replace one of the units with a spare, you must exit GRAD mode (c command) and re-enter it again, and then enter the new unit's serial number when prompted. If you see a response 'NOT Responding' from one of the magnetometers in a gradiometer configuration, it is likely because of the incorrectly entered serial number.

NOTE: The gradiometer system relies on knowing which towfish is the Front/Port side, and which is Rear/Starboard side, based on the serial numbers entered into GRAD mode by the operator. If in doubt, you can verify that you have the gradiometer sides configured correctly by bringing an iron object close to one of the towfish while monitoring the magnetic field readings during sampling.

4.3 Upgrading to a Gradiometer System

If you have purchased a gradiometer expansion kit separately from your SeaSPY2s then some additional configuration will be required. Follow the steps in section 11.4 for configuring and testing your gradiometer system.

5 SeaSPY2 Commands

Interaction with the SeaSPY2 system can be done with single-character commands typed in the terminal window. A complete summary of these commands is available in the following two tables. The commands are separated into normal commands, and commands that require entry into a special 'diagnostic mode'. This mode prevents accidental activation of features that may disrupt optimal performance of the system.

5.1 Normal Commands

Command	Description
?	Get command menu Example: *?* *XCVR COMMANDS* *SPC:Get Time/Date T:Set Time/Date ^T:Resync towfish* *D:Check Output Power ^O:Power on/off ^B:Set bps rates* *G:Position Data ON g:Position Data OFF !:Xcvr/towfish versions* *COMMANDS* *SAMPLING- 1:4Hz 2:2Hz 3:1Hz 4:0.2Hz 0:Stop* *F:Single Reading I:Initialize Tuning L:Set Tuning* *y:autotuning off x:autotuning on <,>:adjust tuning* *u:show sensor tuning* *SPC:Get Time/Date T:Set Time/Date p:Zero Depth P:Calibrate Depth* *n:Noise Test m:IMU raw D:Batt/Depth/Alt/Hdg b:Enable/Disable Devices*
Space	Get Time and Date. Requests current magnetometer time, which is displayed with a resolution of 0.1 seconds in a 24-hour cycle. The oscillator used to keep time on the magnetometer has a frequency stability of 1 ppm over its entire temperature range, so a SeaSPY2 may gain or lose a maximum of 86.4ms in a day in the worst possible environment. SeaSPY2's time is automatically set to the Real Time Clock of the transceiver each time it is connected. If a GPS connection to Transceiver is used, the Real Time Clock closely reflects the GPS clock. **Example:** *2021-12-16(350) 17:55:49.277*
d or D	Scan sensors. This command provides useful diagnostic information on the state of the platform at any given time. The first value is the battery voltage, followed by the output current and power supplied by the isolation transceiver to the towfish.) If a GPS signal is detected, satellite lock and time synchronization difference between magnetometer and GPS are also shown. The second line of the response shows the sensor noise level (lower is better), followed by voltage measured at the magnetometer, internal electronics module temperature, depth sensor reading and leak detector status (L0 = no leak) **Example 1: no GPS lock on internal GPS** *D* *Output 45.4V, 105mA, 04.7W int:NoPos* *S:007 B:+46.9V T:+027.0C D:+000.4m L0* **Example 2: successful GPS lock on internal GPS** *D* *Output 45.4V, 105mA, 04.8W int:Lock(10ms)* *S:007 B:+46.9V T:+027.0C D:+000.4m L0*

T	Input time manually. The magnetometer will respond with a prompt to enter eleven digits that represent a date and a time. There is no carriage return necessary. As soon as the eleventh digit is received, time will start from the entered value. The first three digits are Julian day, followed by two digits for year, and six digits for time in HHMMSS format. Note that this command can be executed while the system is cycling (taking readings). **Example:** *T* *Enter Time (yymmddhhmmss)* *221214173528* *Time set - 2021-12-14(348) 17:35:28.000* *Setting Towfish Time...* *Towfish time was set*
f or F	Take a single reading. The SeaSPY2 will immediately respond with an acknowledgement, and start the reading procedure, which will take 3 seconds If the tuning value is 0 when the reading is started, tuning initialization will automatically be performed. On conclusion, the SeaSPY2 will transmit the data obtained from the reading.
4	Start sampling at 0.2 Hz
3	Start sampling at 1 Hz
2	Start sampling at 2 Hz
1	Start sampling at 4 Hz
0 (zero)	Stop sampling. This command will terminate all cycling. The SeaSPY2 will complete a reading if one is in progress at the time of the command, and return to idle mode (awaiting further commands).
p	Set the depth sensor zero pressure. Use this command prior to survey while the towfish is out of the water. This will calibrate the zero level for the depth transducer. The response will report the actual zero level in mV.
P	Set depth sensor scale. This command will calibrate the slope parameter used to calculate the depth of the fish. Select options 1-3 to use a factory default value, or for higher accuracy press 4 to calibrate manually. The fish should be submerged under 1 to 9 meters of water when this command is executed. The unit will prompt for the depth of the fish. Press **ctrl-X** to abort. The response will report the new slope in mV/m.
y	Auto-tuning off. By default, an optimal tuning value is calculated at the end or every reading with 100 or more zero crossings. Fast changes in magnetic field may cause the unit to mistune. This command may be used to disable auto-tuning.
x	Auto-tuning on. Use this command to re-enable auto-tuning. Auto-tuning should be enabled for most situations, except when testing the magnetometer in a strongly-magnetic environment, such as inside a building or on the deck of a ship.
l or L	Enter tuning value manually. When this command is sent, the unit will prompt for the entry of a new two-digit tuning value in µT. The magnetometer will calculate the actual tuning step number that may be incremented or decremented by the following commands.
. or >	Increment tuning. This adjusts the magnetometer tuning in the smallest possible step. The number of that step is reported as a response to the command, and also the corresponding magnetic field value in µT. If auto-tuning is not selected, the default tuning value is zero, which will cause a tuning initialization when the first reading is attempted. If auto-tuning is disabled, the default power up tuning value will be whatever the setting was when the unit was powered off.
, or <	Decrement tuning.
R or r	Toggle RF Power. R: Enable r: Disable This command may be used to turn the RF polarization circuit on or off manually. If you are measuring the unit's power consumption, you will see the current draw increase in response to this command. The RF is turned on automatically when the magnetometer is taking readings.
!	Get platform serial number, firmware version and platform sensor separations. **Example:** *!* *Xcvr s/n: 6601* *Xcvr Firmware 2.00* *SQ s/n: 14101* *SQ Firmware: 1.70* *Sensor Separation H:1500mm V:750mm L:810mm*

G or g	Display GPS time and position data. G: Enable g: Disable Use this to verify the GPS connection to the Transceiver. GPS NMEA data is used to synchronize the towfish date and time to the GPS, to ensure best match between the magnetometer readings and the GPS positions. GPS positions from the Transceiver are not used by the data logging software. A separate GPS connection to the computer is required. When GPS is connected, the following data will be displayed: *@21.354/14:32:13.200 la+43.4557094 lo-079.2541113 sp000.04 tr195.20 dp01.2 sa10* When GPS is not connected, no data will be displayed, and the Transceiver will rely on its Real Time Clock to synchronize the towfish.
@	Switch to Binary Mode. It is not recommended to send this command manually. It is used by the automatic protocol control in the Gradiometer Transceiver. There is no acknowledgement for this command.
#	Switch to Text Mode from Binary Mode. If the fish is not responding to normal commands, it may have been switched to binary mode. Press # at least twice to switch back to text mode. The switch will be acknowledged in ASCII.

Table 5-1 - Normal operating commands

5.2 Gradiometer Mode Commands

The following commands are useful when operating a gradiometer.

Please note that gradiometer response contains identifiers FT: and RT: which indicate readings from the Front / Port and Rear / Starboard towfish. It is essential that correct serial numbers are configured in gradiometer mode; otherwise the transceiver may not be able to communicate with the towfish.

Command	Description
c or C	GRAD mode. With this command you can switch between gradiometer (GRAD) mode and magnetometer (MAG) mode. This is also the command you use to set the serial numbers of the towfish in the array. **Entering Grad Mode:** C Current mode: MAG - Single Towfish Switch to GRAD mode (Y/N)? **Y** Grad Mode Enabled Front/Port Towfish: 14998 Rear/Starboard Towfish: 14996 Change Towfish s/ns? **N** Now in GRAD mode FT:0:Stop Sampling RT:0:Stop Sampling FT:%:Firmware 79 RT:%:Firmware 79 FT:d:S:008 B:54.6V T:+20.5C D:-0000.1m RT:d:S:006 B:54.9V T:+15.3C D:+0000.0m Syncing time... 2023-11-01(305) 14:58:11.005 **Exiting Grad Mode:** **C** Current mode: GRAD - 2 Towfish Front Towfish: 14329 Rear Towfish: 14330 Switch to MAG mode (Y/N)? Y Activate F)ront or R)ear Towfish: F Please Wait Now in MAG (single towfish) mode
ctrl-T	Synchronizes the gradiometer towfish clocks.

Table 5-2 - Gradiometer Mode commands

5.3 Isolation Transceiver Commands

NOTE: Please refer to the Isolation Transceiver Operating manual for latest details and transceiver features.

The Isolation Transceiver (IT) inserts an intelligent layer between the host PC and the SeaSPY2 platform, allowing it to optimize the telemetry system parameters for a wide variety of tow cable specifications and lengths.

All normal SeaSPY2 commands are perfectly valid when using an IT. In addition, several commands are available to access IT functions. These commands are valid whether there is a SeaSPY2 connected to the tow system or not.

When the transceiver is powered up, it will attempt to verify if a SeaSPY2 is connected or not. This may take 3 to 4 seconds. If it detects a SeaSPY2, it will immediately set the SeaSPY2 time to the transceiver time.

A rechargeable lithium battery is used within the transceiver as the power source for the internal clock. The transceiver will keep time for approximately three months if left 'on the shelf'. If power is connected at any time, the on-board battery will automatically recharge. This battery never requires replacement under normal usage.

Command	Description
SPC	Gets time and date of the transceiver Real Time Clock. If a SeaSPY2 is connected it will also check the SeaSPY2 time and synchronize it to the transceiver time if there is a discrepancy.
T	Sets transceiver Real Time Clock time and date. As soon as the time is set, the transceiver will attempt to set the time of the SeaSPY2, provided one is connected. The transceiver will remember the time after it is powered off.
d or D	Check Output Power. In addition to querying the SeaSPY2, as described in Table 6-1 - Normal operating commands Table 6-1, this command also displays the voltage being supplied by the transceiver, and the current and power consumption of the SeaSPY2.
?	Display command menu
!	Get platform serial number, firmware version and platform sensor separations.
Ctrl+T	Resynchronizes SeaSPY2 time with transceiver time.
Ctrl+O	Power On/Off. Toggles power to the SeaSPY2. Disables power to the towfish, but maintains power to the Transceiver.
Ctrl+B	Change transceiver baud rates. Controls the baud rate between the SeaSPY2 and the transceiver, and between the PC and the transceiver, as well as the GPS port. Towfish (FISH) baud rate should be set to 9600bps for SeaSPY magnetometers. ^B Change comm settings **PC-115200bps** GPS-9600bps **FISH-9600bps** **1- xcvr<->PC** 2- xcvr<->GPS **3- xcvr<->towfish** 4- xcvr<->towfish comm channel
Ctrl+X	Abort/Cancel current command
G or g	Display GPS time and position data. G: Enable g: Disable Use this to verify the GPS connection to the Transceiver. GPS NMEA data is used to synchronize the towfish date and time to the GPS, to ensure best match between the magnetometer readings and the GPS positions. GPS positions from the Transceiver are not used by the data logging software. A separate GPS connection to the computer is required. When GPS is connected, the following data will be displayed: **@21.354/14:32:13.200 la+43.4557094 lo-079.2541113 sp000.04 tr195.20 dp01.2 sa10** When GPS is not connected, no data will be displayed, and the Transceiver will rely on its Real Time Clock to synchronize the towfish.
*	Enters transceiver diagnostic mode. A security code is required.

Table 5-3 - Isolation Transceiver commands

6 SeaSPY2 Data Format

Data that is presented by the magnetometer during cycling can appear in one of three formats. An operator can choose between formats using the **b** command in diagnostic mode.

6.1 Standard Format

The Standard data format is the most commonly used, and is usually the default setting when a SeaSPY2 magnetometer is first shipped. The data string appears as follows:

*YY.JJJ/HH:MM:SS.S F:FFFFFF.FFF S:SSS D:+DDD.Dm A:AAA.A L:L TTTms_Q:QQ !!!! CR LF

The first character of each line is always * (ASCII code 42). This leading character is supplied for automated data collection systems that require periodic synchronization with the data stream.

Each letter shown in italics stands for a digit of a particular record in the reading.

Number	Description
Y	Year (time of reading).
J	Julian day (time of reading).
H	Hour (time of reading).
M	Minute (time of reading).
S	Second (time of reading).
F	Magnetic field (nT).
S	Signal strength of reading. This is a raw number generated by the magnetometer that gives (in part) a good indication of the quality of the final total field measurement. Anything over 80 is considered an acceptable signal, and anything over 130 is considered excellent.
D	Towfish Depth. The value shown is in meters. The depth sensor can be calibrated using the **P** and **p** commands.
A	Towfish Altitude. The value shown is in meters. If no altimeter is installed, this field will not be present. If an altimeter is installed, but it cannot obtain a 'lock' on the seafloor (for example if it is too far away) this value will be 000.0m.
L	Leak sensor output, 0-9. 0 indicates no leak, and 9 indicates that a leak is present.
T	Measurement time. Ideally, this should be the magnetometer's cycling time minus 35ms, with a maximum of 965ms. If you see a G message, indicating that measurement was prematurely terminated due to a high gradient condition, this value will tell you how severe the gradient is.
Q	Signal quality. This is a two-digit number between 00 to 99. The left digit is a good indication of signal strength, and the right digit indicates how much information was available for measurement.
!	Warning Messages.
CR	Carriage Return (ASCII code 13).
LF	Line Feed (ASCII code 10).

table 6-1: Standard data format description

The data string also contains various letter designators throughout the string (non-italicized letters) to help identify data types (table 6-2).

Letter	Meaning
F:	Total magnetic field reading following
S:	Signal strength following
D:	Depth reading following (+/-)

A:	Altitude reading following
L:	Leak indicator value following

table 6-2: Letter designators in the data string

6.1.1 Warning Messages

There are four different warning messages that can be displayed in the raw data log by the magnetometer. The warning messages may be summarized as follows (table 6-3). See section 6.1 for the location of warning messages in the raw data log ('*!*' in example string).

Letter	**Meaning**
W	Weak signal. This message is displayed if the signal strength for the reading is below a threshold value
G	Gradient condition. In high magnetic gradients, the signal produced by the sensor decays more quickly. This message occurs if the measurement time was prematurely terminated due to a quickly decaying signal. The strength of the gradient can be estimated by observing the measurement time. Note that sensitivity will decrease as the measurement time decreases.
P	Poor reading. This message is displayed if the signal is sampled for too short a time period, for whatever the reason. Expect this message under conditions of extremely high magnetic gradient.
M	Instrument Mistuned. The magnetometer may decide to display this message under extremely poor signal conditions, which is characteristic of poor tuning settings. When this message occurs, the instrument will attempt to retune by executing an initialize tuning procedure, if the auto-tuning feature is enabled.

table 6-3: Warning messages

6.2 Compact Format

The compact format contains most of the information of the standard format, but with no annotation. It contains 24h time information, but no date, no signal quality value, and does not support the optional altimeter. The compact data format is necessary if interfacing to an Edgetech DF-1000 digital side scan sonar.

The compact data string appears as follows:

```
*HH:MM:SS.S FFFFFF.FFF SSS TTTT +DDDD.Dm !!!!! CR LF
```

Each letter shown in italics stands for a digit of a particular record in the reading.

Letter	**Description**
H	Hour (time of reading).
M	Minute (time of reading).
S	Second (time of reading).
F	Magnetic field (nT).
S	Signal strength of reading. This is a raw number generated by the magnetometer that gives (in part) a good indication of the quality of the final total field measurement. Anything over 80 is considered an acceptable signal, and anything over 130 is considered excellent.
T	Measurement time. Ideally, this should be the magnetometer's cycling time minus 35ms, with a maximum of 965ms. If you see a G message, indicating that measurement was prematurely terminated due to a high gradient condition, this value will tell you how severe the gradient is.
D	Towfish Depth. The value shown is in meters. The depth sensor can be calibrated using the P and p commands.
W	Warning messages.
CR	Carriage Return (ASCII code 13).
LF	Line Feed (ASCII code 10).

table 6-4: Compact data format description

The warning messages above are identical to those in the standard data format description, summarized in table 6-3. The one additional message is the leak message, the first of the group. If a leak is present, an 'L' message will be visible in this section.

6.3 SIS-1000 Compatible Format

The SIS-1000 compatible format contains only magnetic field, signal strength, and pressure depth. The optional altimeter is not supported in this mode. It is necessary to switch to this format when interfacing to a Benthos SIS-1000 or SIS-3000 system. Note that this mode is not required if interfacing to a Benthos SIS-1500 digital side scan sonar system.

The SIS-1000 compatible data string appears as follows:

```
$ FFFFFF.FFF SSSS DDDD CR LF
```

Note that the first character of the SIS-1000 compatible data string is a '$', not a '*' as is the case with the other two data formats.

Letter	Meaning
F	Magnetic field (nT). If the field value is less than 100,000nT (which is usually the case) there will be a space after the $ sign. If the field value is 100,000nT or greater, the space will be replaced with a '1'.
S	Signal strength of reading. This is a raw number generated by the magnetometer that gives (in part) a good indication of the quality of the final total field measurement. Anything over 800 is considered an acceptable signal, and anything over 1300 is considered excellent. It is identical to the signal strength value in the other data formats, multiplied by 10.
D	Towfish Depth. The value shown is in units of 0.1 meter. If the towfish depth exceeds 999.9m, an extra digit will be displayed. Important: if a leak is detected, this value will consistently read 9999.
CR	Carriage Return (ASCII code 13).
LF	Line Feed (ASCII code 10).

table 6-5: SIS1000 compatible data format description

6.4 Gradiometer Data Format

When conducting a gradiometer survey (see section 4.1), the following data format will be displayed in the main terminal when the magnetometers start cycling:

```
*YY.JJJ/HH:MM:SS.S F[FFFFFF.FFF SSS TTTT DDDD.D !!!] R[FFFFFF.FFF SSS TTTT DDDD.D !!!] –GRADIENT
```

Refer to table 6.1 for the meaning of the letters in italics. An example of a typical string is as follows:

```
*02.233/09:33:45.0 F[056397.170 244 0197 0316.6 ___] R[056397.224 129 0197 0316.8 ___] -000000.054
```

Note that the string has two bracketed areas, beginning with 'F' and 'R' designators. This means that the information following in the bracketed area refers to the Front and Rear towfish respectively. In case of the horizontal transverse gradiometer, 'F' corresponds to Port side, and 'R' corresponds to Starboard side towfish.

The last column is the difference in the measured field value between the two towfish (F-R). To obtain the true magnetic gradient, divide the value by the distance between the two towfish.

Note that the underscores in the warning message fields for each towfish represent that no warning messages are occurring (see table 6-3 for warning messages).

7 Interfacing to a Side Scan Sonar

A SeaSPY2 can be towed simultaneously with a multitude of different side scan sonar units. A variety of factors, including connection details, deployment method, and operating parameters will vary depending on the type of side scan you are working with. The SeaSPY2 must be configured differently depending on the side scan system being used. The following table shows the relevant electrical specifications for interfacing with a side scan sonar unit. Ensure that your side scan unit can output the required data rate, voltage level and power listed below. It is also essential that the side scan sonar unit provides bidirectional communication with the SeaSPY2 system.

Parameter	Min	Typ.	Max	Units
Input Voltage	9	24	27	VDC
Input Power	6	12	14	W
Output Voltage	48	48	48	VDC
Output Current - fused	-	-	1.0	A
Output Power	6	12	14	W
RS232 Baud Rate	38400	115200	115200	bps

Table 8-1 - Side Scan Integration electrical specifications

7.1 Analog Systems

In general, interface to an analog side scan sonar system requires the use of a tow cable that is capable of carrying the sonar signal and SeaSPY2 telemetry on separate conductors. Electrically, this is identical to running both systems stand-alone, but packaging their tow cables under a single jacket for most of the deployment length.

Since this type of interface depends on the type of tow cable used more than the actual type of side scan unit deployed, these types of integrations will almost always be custom-made for a specific configuration or application. Operation of the SeaSPY2 towfish is exactly as it would be in a stand-alone configuration.

7.2 Digital Systems

Interface to a digital side scan sonar system involves sending the digital data output from the SeaSPY2 to a data input port on the side scan unit. The side scan unit's telemetry is then used to relay the magnetometer data to the surface, where it is then decoded from the side scan data stream. Also, the SeaSPY2 towfish draws power directly from the side scan unit.

Interfacing a SeaSPY2 to a digital side scan sonar system is inherently more complex than to an analog system, but it has the benefit of not requiring extra conductors in the tow cable. Furthermore, fewer components are needed topside, since only a single telemetry decoder is required. This allows the SeaSPY2 to simply 'plug in' to an existing working setup.

Clearly, the two instruments work very closely together in such a configuration. Specific design features have been added to SeaSPY2 magnetometers, and to several side scan products to allow seamless, trouble-free operation together. Table 8-1 shows the requirements for interfacing a side scan sonar unit with the SeaSPY2 system. In all cases, a magnetometer interface kit is required from the side scan sonar manufacturer.

ALWAYS ENSURE THAT THE SIDE SCAN UNIT IS OFF BEFORE CONNECTING OR DISCONNECTING THE INTEGRATION!!!

7.3 Communication

The SeaSPY2 will only work with side scan systems that provide bidirectional communication with the SeaSPY2. With these systems, the SeaSPY2 is controlled the same as in stand-alone mode. Only the baud rate has to be programmed correctly before deployment.

7.4 Baud Rate

The SeaSPY2 baud rate can be configured using the **ctrl-B** command. Ensure that the SeaSPY2 baud rate matches that of the side scan unit being used. Note that if the baud rate is not set correctly prior to connecting the towfish to the side scan unit, no communication will be possible.

7.5 Electrical Power

The SeaSPY2 Side Scan Integration electronics will accept input voltages ranging from +9 to +27VDC and generate +48VDC output to power the magnetometer. If the output current to the magnetometer exceeds 1.0A, an internal fuse will trip and stay tripped until the output load returns to a reasonable level. It will then automatically reset itself. A short in the tow cable or at the brass tow connector will not cause damage to either the interface electronics or the side scan system itself.

The SeaSPY2 Side Scan Integration can also be powered through the test cable provided. The test cable includes an AC power supply with an output voltage of +48VDC. **Note: The SeaSPY Side Scan Integration test cable cannot be used to power the SeaSPY2 Side Scan Integration.**

7.6 Mechanical Tow Point and Electrical connector Pin-out (Side scan interface only)

The Side Scan Integration consists of a stainless steel interface housing that functions as a tow point, and contains power conditioning and interface electronics. The interface housing is permanently connected to a 10m tow cable that is terminated with a standard SeaSPY2 brass tow connector on the other end.

The interface tow point connects to an extension bar that is fastened to the side scan towfish at its center of gravity or at the rear of the platform for heavier units. The side scan tow cable connects to the top of the bar, and the SeaSPY2 interface clips directly to the bar with a clevis pin, through a universal link that allows full rotation in two dimensions. There are two different types of universal links available (a tab or a slot), depending on which side scan system is being used.

The Side Scan Integration uses an 8-pin Subconn micro-circular connector (p/n MCBH8M) which mates with a female inline connector (p/n MCIL8F)..

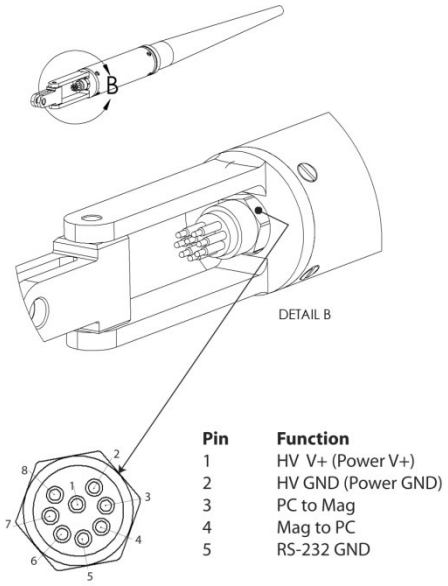


Figure 8-1 – Side scan towing interface details

IMPORTANT: The side scan interface uses a different electrical pin-out from the SeaSPY magnetometer. Refer to section 3.2 for details on the SeaSPY tow connector pin-out and electrical specifications.

8 Estimating Towing Depth

Controlling the depth of the SeaSPY2 towfish during a survey is essential to obtaining good results. The following factors will influence the depth of the towfish while towing.

1. Survey speed (slower=deeper)
2. Deployed tow cable length (longer=deeper)
3. Weight of tow cable (heavier=deeper)
4. Weight of towfish (heavier=deeper)

The above may seem obvious, but it is important to note that these are the only factors that will affect single towfish depth. Manipulation of these four variables is the only way to regulate the depth of the towfish.

The following charts show the SeaSPY2 towing depth relative to the amount of cable deployed and the towing speed. A horizontal gradiometer frame may tow at shallower depth due to the angle of the frame.

Horizontal gradiometer frame may require a single cable weight when used with short tow cables (<70m), in order to adjust the orientation of the frame to be closer to horizontal. For best results, this cable weight can be installed approximately 10-15m ahead of the magnetometer.

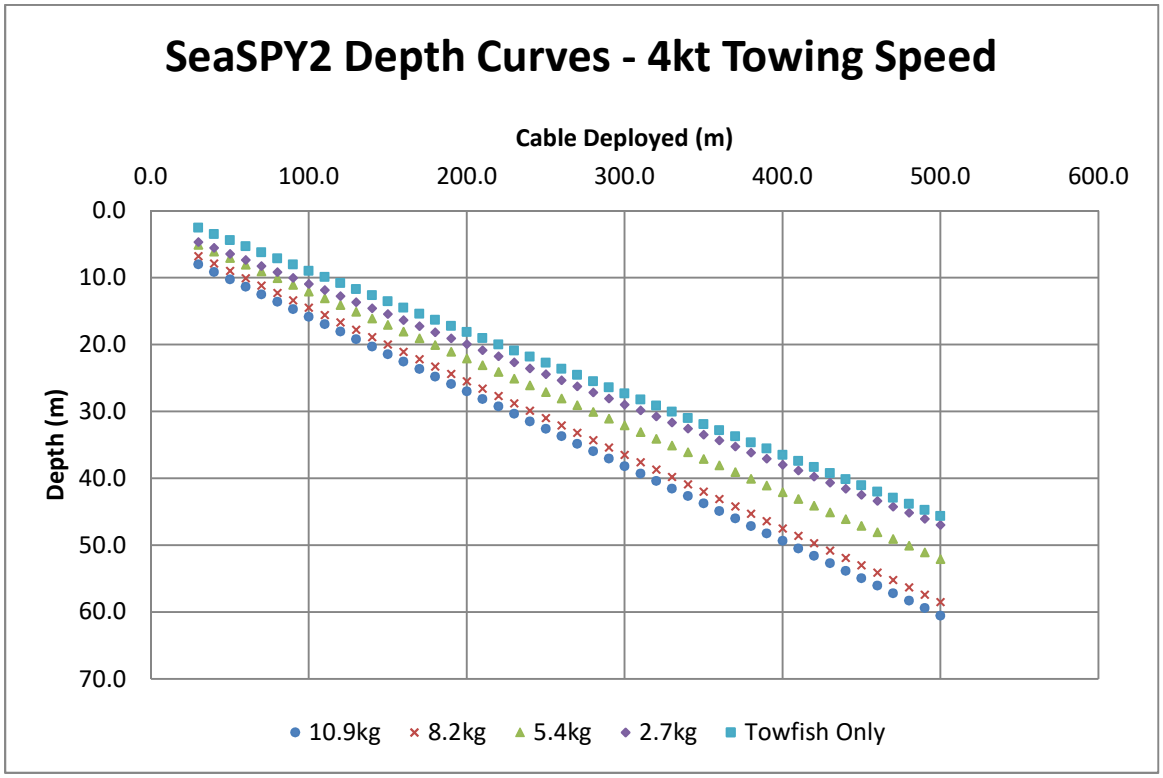


figure 8-1: Towing depth of the SeaSPY2 with various weight configurations at a typical towing speed of 4 knots. Each cable weight weighs 2721g

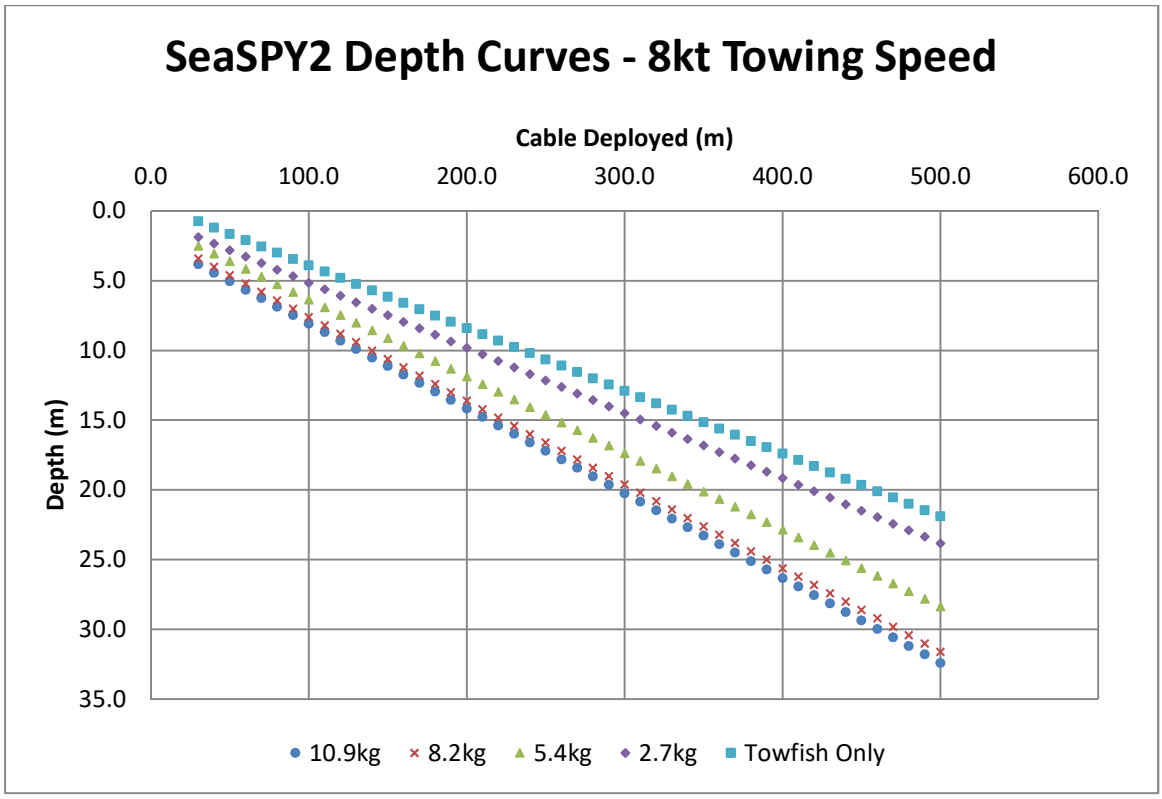


figure 8-2: Towing depth of the SeaSPY2 with various weight configurations at a typical towing speed of 8 knots. Each cable weight weighs 2721g

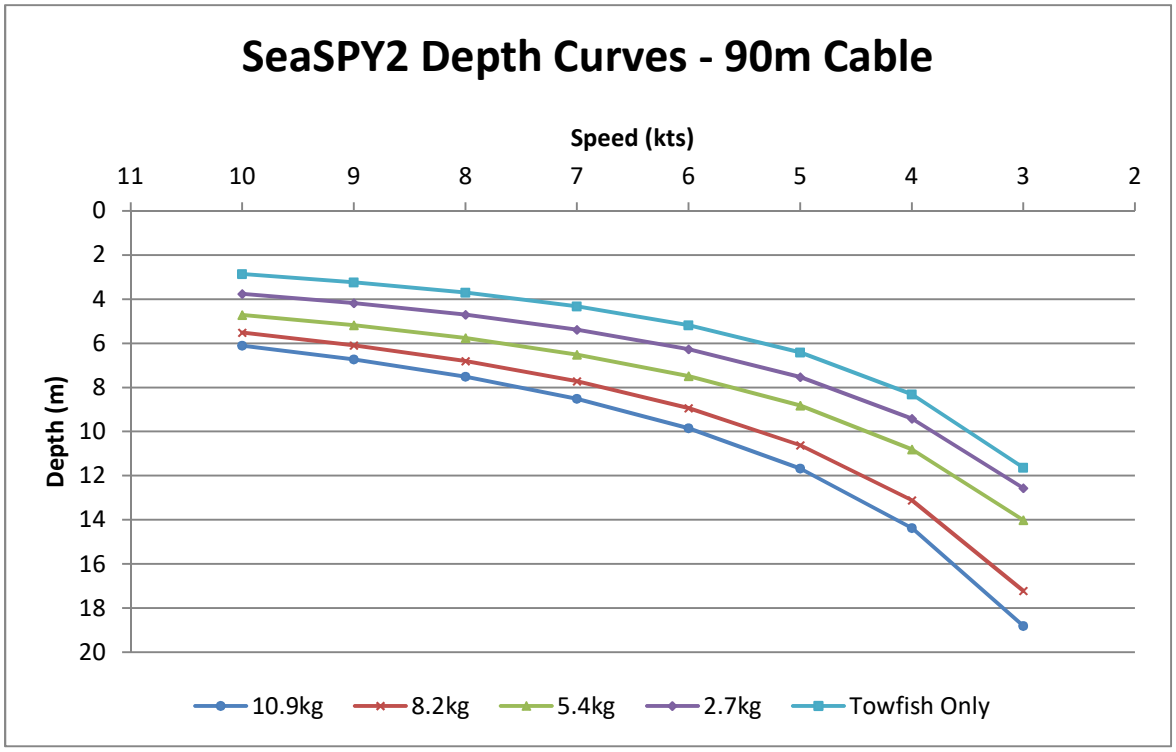


figure 8-3: Towing depth of the SeaSPY2 at various towing speeds between 3 and 10 knots with 90 m of cable deployed and various cable weights

9 Inside the Towfish

9.1 Standard Towfish

SeaSPY2 has a modular construction that allows for quick and easy connection and disconnection of all components and parts. For normal use, the only connection you will have to think about is the main brass tow connector. Sometimes it becomes necessary to access the internal components of the towfish - for example if you suspect something has become damaged. This section describes how to access the internal components and what these components do.

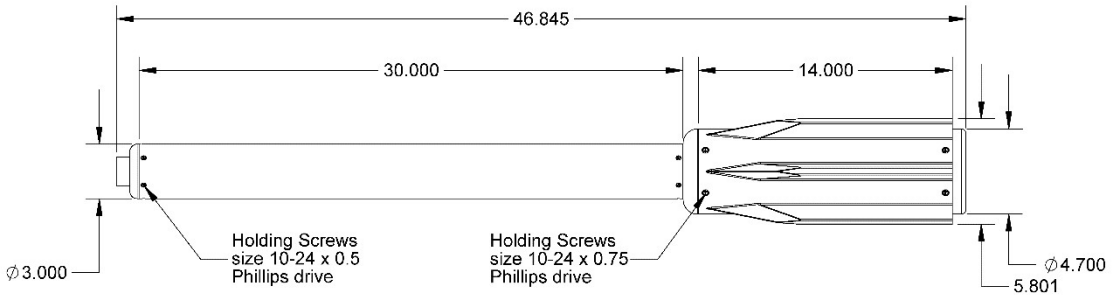


figure 9-1: Standard 1000m SeaSPY2 towfish dimensions

To open the towfish, remove the four brass holding screws near the nose of the towfish, as indicated in figure 9-1. The electronics module is mounted to the nose bulkhead and will slide out with the nose bulkhead. Care must be taken when removing the nose bulkhead, as the sensor cables are connected to the electronics module with just enough slack to slide the electronics out of the tube. The ballast weights are mounted to an aluminum rack that is attached to the centre bulkhead. The Overhauser sensor is located in the aft section of the towfish inside the rear tube and is also secured to the centre bulkhead. Once the sensor cables have been disconnected, then the electronics module can be completely removed. To access the sensor, remove the front holding screws on the sensor pod and slide off the sensor tube.

Figure 9-2 clearly shows all elements in the internal structure. The electronics module and Overhauser sensor are individually replaceable. Note the position of the leak sensor. If your towfish has warned of a leak, you will need to make sure that this sensor is completely dry before redeploying your towfish.

The altimeter-equipped towfish is slightly different. The main difference between an altimeter-equipped towfish and a standard towfish is a nose extension that is necessary to accommodate the transducer. In addition, some extra electronics are included to run the altimeter.

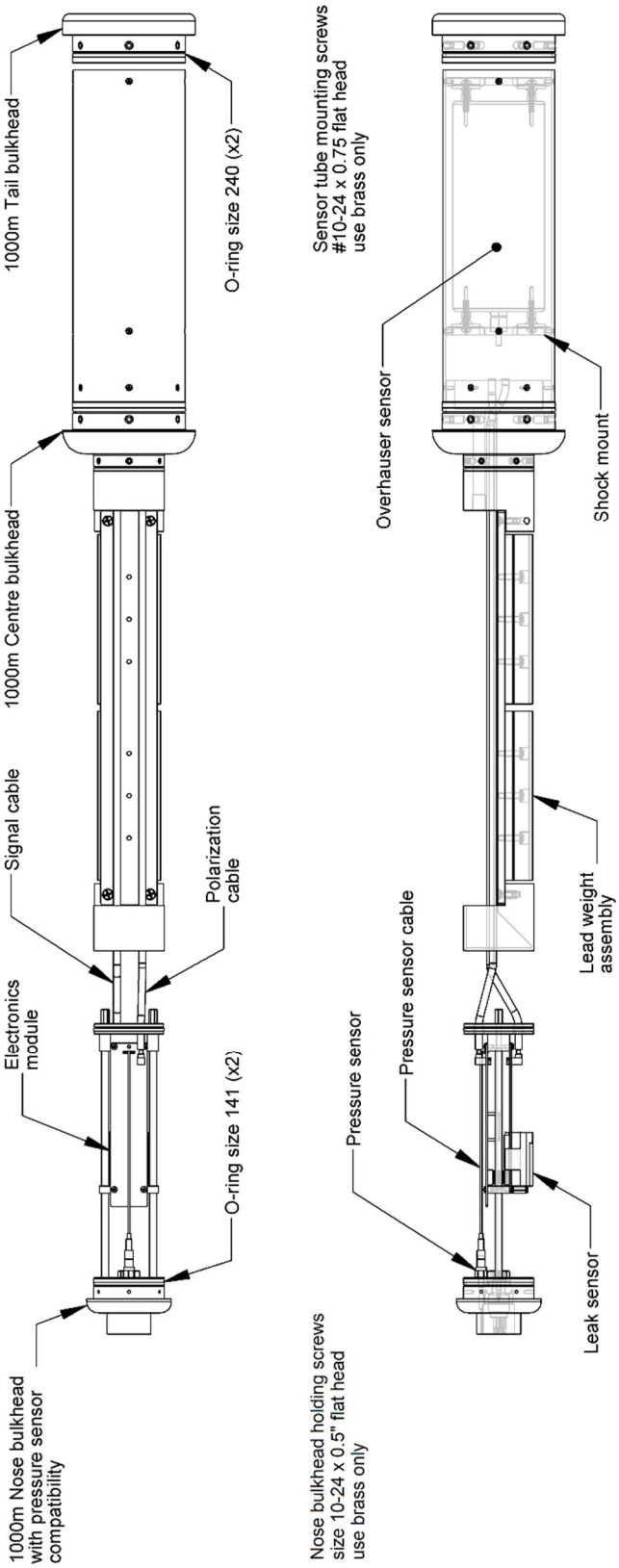


Figure 10-2 - SeaSPY2 internal structure

10 Maintenance

A SeaSPY2 system is designed to withstand years of use in harsh marine environmental conditions. If some simple procedures are observed when deploying and storing the instrumentation, your SeaSPY2 system will continue to deliver high quality performance with no need for service at the Marine Magnetics facility.

10.1 Deployment and Storage Tips

- Do not allow the towfish to fall onto hard surface when handling or transporting it, or to strike the lake/sea floor during survey. Sudden impact shock may damage the highly-sensitive Overhauser sensor!
- Always apply a coat of Molykote or similar high-vacuum grease to the SubConn connectors to ensure a waterproof seal.
- When connecting the main tow connector, ensure that the alignment slot is properly inserted into the groove, and that the male connector is fully inserted. Tighten the holding nut firmly.
- Always allow the towfish to come to the ambient water temperature before beginning the survey. Allow the magnetometer to be immersed in water for 5-10 min prior to calibrating the zero-depth level of the depth sensor. The temperature difference between deep water and deck of the vessel can be significant!
- Use a towing speed and cable length combination that keeps the towfish submerged at least 1m below the surface, and as far below waves and swell as possible if the water is rough. Other than this, there is no restriction on tow speed.
- Do not, under any circumstances, exceed the maximum rated operating depth of the towfish. In some cases, permanent damage may occur to certain components (such as the pressure sensor) if the towfish's rated depth is exceeded by even a small amount.
- Rinse the towfish with fresh water after removal from salt water. Surface corrosion of the brass fittings and screws will only significantly take place after exposure to atmospheric oxygen in the presence of salt water. Rinsing with fresh water will keep the brass fittings clean and shiny.
- Blow out the pressure sensor hole with compressed air after removal of the towfish from salt or fresh water. Stagnant water in the pressure sensor hole can cause pitting corrosion of the pressure sensor after long-term use.
- Wait for the tow connector to dry before installing the protective dust cap, to prevent moisture being trapped inside.
- Do not store the towfish in direct sunlight, and keep it away from very hot environments. The operating and storage temperature range for a towfish is
  -40˚C to +60˚C, but an unsheltered towfish in a sunlit area can easily exceed +60˚C. Keeping the towfish stored in moderate temperatures will prolong the lifetime of the seals and the internal electronics.
- During transit to and from the work site, store the towfish in its transit case, or if stored on deck, the towfish should be laid flat on the decking. Never stand up the tow fish vertically unless you are absolutely sure it cannot fall or be knocked over.
- The zinc sacrificial anodes on the horizontal gradiometer frame are designed to prevent the corrosion of the anodized aluminum by corroding first. In corrosive salt water environments these zinc anodes will need to be replaced from time to time.

10.2 O-ring sizes

All O-rings used in the SeaSPY2 towfish are made from 70-durometer nitrile-rubber. All sizes are ASTM. O-rings will not need replacement unless the towfish itself is disassembled and the O-ring receives mechanical damage.

When replacing O-rings, ensure that the new O-rings are well greased and free from dust and dirt particles. Also ensure that a coating of grease exists on the mating surface, and that it is free from scratches or gouges.

Recommended grease: Molykote Medium, or equivalent high-vacuum grease.

Size	Quantity	Location
022	2	SeaSPY2 tow connector housing
129	2	SeaSPY2 altimeter transducer shell
141	2 + 1	SeaSPY2 nose and centre bulkhead + optional altimeter block
240	2	SeaSPY2 centre and tail bulkhead

table 10-1: SeaSPY2 O-ring sizes

11 Troubleshooting

The transceiver provides detailed diagnostic information about the status of the system. It is important to ensure that the transceiver is working properly before trying to diagnose and fix other issues. **Disconnect all cables from the transceiver before proceeding.**

11.1 Transceiver Test Procedure

1) Power the transceiver

Connect the *AC Power Supply* or *Battery Clip* cable to the power source and then to the transceiver.

2) Check the status of the *Power* LED

If the ***Power* LED is orange** then the transceiver has powered up properly. Proceed to step 3.

If the ***Power* LED is off** then the transceiver is not receiving power. Verify the connection from the power supply to the transceiver and from the power supply to the AC power lines. If you are using a battery, check the battery voltage. The transceiver requires an input voltage in the range of +9 to +28VDC. Use a voltmeter to verify the voltage across pins 1 and 2 on the 3-pin connector that plugs into the transceiver.

If the ***Power* LED is red** then the transceiver is experiencing an output overload that is causing the internal poly-fuse to trip. This usually indicates a short on the output path of the transceiver. If this occurs with nothing connected to the output (2-pin connector) of the transceiver then verify that nothing is shorting the pins on the 2-pin connector, and then contact Marine Magnetics directly for assistance.

If the ***Power* LED is green** then the towfish is connected. Remove the deck leader cable from the transceiver and start the checklist again. If the deck leader cable is not connected then the transceiver is not working properly. Contact Marine Magnetics directly for assistance.

3) Check the status of the *Comm* LED

The *Comm* LED should be off if no towfish is connected. If the *Comm* LED flashes blue without a towfish connected, the transceiver may be malfunctioning. Contact Marine Magnetics directly for assistance.

4) Connect the transceiver to your PC using the RS232 or USB cable

Identify which COM port the transceiver is connected to. If you are using the USB cable then a virtual COM port will be created if BOB is installed. You can check the COM port using Windows Device Manager.

5) Configure BOB software communication settings

Open BOB and select the *Connect Mag* tab from the BOB Setup Assistant. Click the COM radio button and then select the COM port from the dropdown menu. The default baud rate for SeaSPY2 is 9600 bps. Press *Connect* to apply settings and reveal the *Terminal window*. If the settings are correct, BOB will automatically recognize the transceiver and will display its serial number in the terminal window. For more information about using BOB refer to the BOB Software Operation Manual.

6) Issue the Scan Sensors command (d or D)

The response from this command should be a single line of data in the terminal window indicating the output levels from the transceiver (e.g. Output 47.4V, 001mA, 00.0W). Verify that the power consumption is zero and that the output voltage is around 48V.

7) Connect the SeaSPY2 to the transceiver

Ensure that the magnetometer, tow cable and deck leader are all connected when the deck leader cable is connected to the transceiver. If everything is connected properly then the *Power* LED should turn solid green and the *Comm* LED will flash blue temporarily while the SeaSPY2 transmits its start-up header string. If the *Power* LED turns red then there is a possible short in one of the cables, which can be caused by a damaged cable or connector. Refer to table 11-1 for troubleshooting details.

11.2 SeaSPY2 Test Procedure

If the SeaSPY2 is communicating properly, then the following procedure will verify that the magnetometer is operating correctly and is ready for a survey.

1) Check the clock

Issue the **t** or **SPC** command twice to check the clock. Verify that the time has advanced from one line to the next.

2) Scan the sensors

Issue the **d** or **D** command to check the state of the towfish. If you are using an Isolation or Gradiometer Transceiver then it will respond to the command with the first line of data before the SeaSPY2 responds with the second line. With a Side Scan Integration only the response from the SeaSPY2 (line 2) will appear. The following is a sample response to the **d** command. Note that the altitude field will only be present if the magnetometer possesses an altimeter.

Output 48.3V, 078mA, 03.8W
S:005 B:+47.7V T:+021.7C D:-000.3m A:000.00m L0

The output voltage should be close to 48V and the current will depend on the state of the system. For an altimeter-equipped magnetometer, the current draw should be around 75mA in idle and without an altimeter it should be close to 10mA.

3) Activate the RF polarization circuit

Issue the **r** command to activate the polarization circuit and then send the **d** command again. You should notice the current draw increase by about 40mA with the RF circuit activated. Deactivate the polarization circuit with the **r** command.

4) Zero the depth sensor

If the depth sensor is reading greater than +0.005m while out of the water then you should zero the pressure sensor using the **p** command.

5) Prepare for an environment test

In order to perform the environment test, the magnetometer needs to be far from any magnetic material. If you are testing on land then ensure that the magnetometer is far from any buildings or other ferrous material. If you are on a vessel then deploy the magnetometer from the stern at a distance of at least 3 times the length of the vessel.

6) Perform an environment test

Issue the **o** (oh) command to perform an environment test. If it passes, you should see a message similar to the following.

Initiating Self-diagnostic
Amp test: 193 – Passed
Initiating Self-diagnostic
Noise Test: 000 0367 – Passed
Noise Test: 001 0351 – Passed
Noise Test: 002 0348 – Passed
Noise Test: 004 0409 – Passed
Noise Test: 008 0485 – Passed
Noise Test: 016 0460 – Passed
Noise Test: 032 0978 – Passed
Noise Test: 064 0634 – Passed
Noise Test: 128 0732 – Passed
Checking gradient – Passed

If it fails one of the noise tests, try the test again, as there may be some ambient noise interfering with the sensor. If it continuously fails the test, move the SeaSPY2 to a different location and try the test again, as there is too much interference in its current location.
When the SeaSPY2 passes an environmental test it is in a location where it should be able to take good readings of the magnetic field.

7) Start Sampling

Start cycling at 1Hz by issuing the **3** command and take 5 to 10 sample readings. Each reading should be similar to the following.

**06.327/15:16:47.0 F:055294.465 S:192 D:+000.1m L0 0965ms Q:99*

Systems equipped with an Altimeter will display a message similar to the following.

**00.001/00:00:22.0 F:055056.525 S:178 D:+010.9m A:000.00m L0 0965ms Q:99*

Notes:

- The value of the F: field may differ significantly when tested at your location.
- The value for S: should be between 130 and 200 for good quality readings.
- The value for the ms reading should be 965 when F: is greater than 42000 and it should be 465 when F: is less than 42000.
- The value of Q: should always be 99 if the SeaSPY2 is taking proper readings.

If the SeaSPY2 passes all of these tests then it is functioning properly and is ready for operation.

11.3 Side Scan Integration Test Procedure

The following procedure can be used to test a SeaSPY2 with a Side Scan Integration unit. Before connecting the magnetometer to the side scan unit, you can use the test cable to verify that everything is operating correctly.

1) Connect the test cable to the Side Scan Integration

Attach the 3-pin connector to the AC power adapter or battery clip cable and the female DB9 connector to the serial port on your computer. The female 8pin Subconn connector attaches to the Side Scan Integration unit.

2) Configure BOB software communication settings

Open BOB and select the *Connect Mag* tab from the BOB Setup Assistant. Click the COM radio button and then select the COM port from the dropdown menu. The default baud rate for SeaSPY2 is 9600 bps. Press *Connect* to apply settings and reveal the *Terminal window*. If the settings are correct, BOB will automatically recognize the transceiver and will display its serial number in the terminal window. For more information about using BOB refer to the BOB Software Operation Manual.

3) Connect the Side Scan Integration to the SeaSPY2

Attach the tow connector end of the Side Scan Integration cable to the magnetometer. The blue LED on the Side Scan Integration should flash momentarily as the SeaSPY2 sends its start-up header string to the PC. You should see this data appear in the command window of BOB. The LED will flash anytime data is received from the magnetometer.

4) Follow the SeaSPY2 test procedure outlined in section 11.2

5) Connect to the side scan unit (powered off)

ALWAYS ENSURE THAT THE SIDE SCAN UNIT IS OFF BEFORE CONNECTING THE INTEGRATION! Disconnect the Side Scan Integration test cable and connect the integration directly to the side scan unit using the 8-pin Subconn connector.

6) Follow the side scan manufacturer's instructions for operating with a magnetometer.

Table 7-1 shows the standard configuration for operation with the most common side scan units.

7) Repeat the SeaSPY2 test procedure outlined in Section 11.2 to ensure that the system is still working properly.

ALWAYS ENSURE THAT THE SIDE SCAN UNIT IS OFF BEFORE CONNECTING OR DISCONNECTING THE INTEGRATION!!!

11.4 Gradiometer Test Procedure

1) Follow steps 1 through 6 of the test procedure in section 11.1

2) Set the transceiver to MAG mode

Issue the **c** command to check the mode of the transceiver. If the transceiver is in GRAD mode then press **y** to switch to MAG mode and then **f** to select the front towfish. If the transceiver was already in MAG mode then press **n** to abort.

3) Connect the rear/starboard side towfish

Complete step 7 of section 11.1 using the rear towfish. For a longitudinal gradiometer, the front towfish is the one two tow connectors, on at each end of the towfish; whereas the rear towfish only has a since tow connector at front end. For a horizontal gradiometer, the front and rear towfish are physically the same, but Front corresponds to Port, and Rear corresponds to Starboard from the software point of view. (Thus, the serial numbers must be entered correctly with the above in mind, when entering GRAD mode).

4) Check the serial number of the rear towfish

Issue the **!** command to query the serial number of the rear towfish.

5) Start SeaSPY2 Test Procedure

Perform steps 1 through 4 of the SeaSPY2 Test Procedure from section 11.2 on the rear towfish.

6) Repeat with the front towfish

Disconnect the rear towfish and connect instead the front towfish. Repeat steps 3 to 5.

7) Connect both SeaSPY2s

For longitudinal gradiometers, use the Interfish Cable to connect the rear towfish to the back of the front towfish.

8) Set the transceiver to GRAD Mode

Issue the **c** command to enter into GRAD mode. The serial numbers for both towfish will displayed. Ensure that they are correct or press **y** when prompted to change the serial numbers if necessary.

9) Perform SeaSPY2 Test Procedure

Perform the SeaSPY2 Test Procedure from section 11.2 on the entire gradiometer system. You should expect the output power from the transceiver to be double what it was with a single magnetometer. Note that the environment test cannot be performed in GRAD mode.

11.5 Troubleshooting Specific Issues

The following table (table 11-1) addresses specific issues that may occur. For more details or other issues please contact Marine Magnetics directly.

Symptom	Possible causes	Solution
Transceiver *Power* LED is off	• Insufficient power is being supplied to the transceiver	• Verify the connection from the power supply to the transceiver and from the power supply to the AC power lines • Check the battery voltage • The transceiver requires an input voltage in the range of +9 to +28VDC. Use a voltmeter to verify the voltage across pins 1 and 2 on the 3-pin connector that plugs into the transceiver
Transceiver *Power* LED is red *OR* ***Output Overload!*** *OR* **Towfish is drawing more current than the maximum specification**	• There is a short in the cable or in the SeaSPY2 • Water is present in the circuit • Gradiometer towfish is being used alone without a plug in the rear tow connector • Slip-ring is wired incorrectly	• Starting from the towfish end of the system, remove one component or cable at a time until the LED turns orange • If the LED remains red with the deck leader disconnected from the transceiver then try cycling the power to the transceiver • If the cable is determined to be the issue, then examine it for cuts or leaks and inspect connectors for damage or shorts • If the SeaSPY2 is determined to be the issue, then inspect the connector. • Using an ohmmeter, verify that none of the cables or connectors are shorted • If the system is powered by a single 12V car battery, and includes altimeters or a gradiometer, an additional battery may be needed (connected in series) for an effective 24V supply to meet the added power demand.
Transceiver *Power* LED is orange *OR* **Towfish is drawing less current than the minimum specification**	• No towfish is connected	• Connect the towfish • Make sure enough voltage is being supplied
No response from the towfish	• Error in the equipment setup	• Make sure all cables are connected and the Power LED on the transceiver is green • Make sure baud rate and communication protocol of the terminal software are set correctly • Make sure the towfish serial number is entered correctly in GRAD mode • If all else fails, try exiting and re-entering GRAD mode

Communication issues	• Insufficient voltage • Damaged cable • Poor wiring or grounding through slip-ring • Gradiometer incorrectly configured	• Check the voltage going to the towfish • Inspect all cables for damage • Inspect the slip-ring connections • For gradiometers, make sure that the towfish serial numbers are entered correctly and that the transceiver is set to GRAD mode
Poor magnetic field readings	• External noise on the sensor • Power supply amplifiers are adding noise to the system	• Move the towfish to a different location and run the environment test again • Avoid interferences such as radio waves, train tracks, on-board generator • Use batteries instead of AC power to rule-out power supply noise. Note that gradiometers or altimeter models may require 24V instead of 12V.
Towfish leak	• SeaSPY2 housing damaged from impact • SeaSPY2 sensor bottle damaged from impact • Damaged O-ring • Maximum depth rating exceeded for SeaSPY2 • Gradiometer towfish used alone without a plug in the rear tow connector	• Shutdown towfish • Retrieve towfish immediately • Unscrew nose bulkhead • Check for water or sensor chemical • If water is present then examine housing and O-rings for damage • Check plug for gradiometer towfish

table 11-11-1: Troubleshooting specific issues

11.6 Electrical Specifications

The following table shows the expected measurements under working conditions. If you are experiencing abnormal results then consult table 11-1 for troubleshooting tips.

Location	Parameter	Min	Typ.	Max	Units
Transceiver	Input Voltage	9	24	28	V
@ 24V	Input Current (no towfish)	60	66	184	mA
	Output Voltage	47.5	48	48.5	V
	Output Current	-	-	500	mA
Side Scan Integration	Input Voltage	24	-	225	V
	Output Voltage	19	20	21	V
	Output Current	-	-	500	mA
SeaSPY2	Input Voltage[1]	15	48	50	V
Cycling	Input Power	-	3.6	7.2	W
Standby @ 48V	Input Current[2] (no altimeter)	10	15	20	mA
Standby @ 48V	Input Current[2] (with altimeter)	75	80	85	mA
Cycling @ 48V	Input Current[2] (no altimeter)	65	75	85	mA
Cycling @ 48V	Input Current[2] (with altimeter)	120	135	150	mA
Tow cable	Resistance (along conductors)	-	15	-	mΩ/m
	Resistance (between conductors)	10	∞	-	MΩ

Notes:

1) The voltage will drop over extremely long cables and may cause the current consumption values to increase. This is normal. For optimum results, we suggest performing these tests over as short a cable as possible.

2) When the system is in standby, the current consumption will be quite constant. When a command is sent to the towfish, a short jump in the current consumption can be observed, which is due to the towfish communication circuitry powering up momentarily.

table 11-2: Electrical specifications

12 How to Reach Us

If you encounter a problem using your SeaSPY2 system, you should contact the distributor that you received the product from. You can also contact Marine Magnetics directly at the address mentioned below. If you have access to the Internet, our World Wide Web page offers support in the form of documents and file utilities, as well as information on product updates.

Marine Magnetics

135 SPY Court
Markham, ON L3R 5H6
Tel: 1 905 479-9727 fax: 1 905 479-9484
Email: support@marinemagnetics.com
URL: www.marinemagnetics.com

13 Warranty

All of the equipment manufactured by Marine Magnetics, with the exception of consumable items, is warranted against defects in materials and workmanship for a period of twenty-four months from the date of shipment. This warranty is not transferable.

During the warranty period, if any defects become evident under normal use, the buyer must notify Marine Magnetics of the defect and describe the symptoms in writing. Within thirty days of receiving said notification, Marine Magnetics will take action to remedy the defect or problem by choosing one or more of the following courses of action:

1. Replace the defective item(s)
2. Request the buyer to return the defective item(s) to Marine Magnetics for repair.

During the warranty period, replacement or repairs to items as described in 1 and 2 will be made free of charge. However, Marine Magnetics' liability in such cases will not extend to transportation charges for any item to or from the buyer, or to any lost time or to other costs that the buyer may incur.

If the buyer requests a technician on-site to complete the repair(s), the buyer will pay for all of the lodging, food and local transportation costs while the technician is affecting the repair(s).

During the warranty period, the *SeaSPY2* should not be opened or repaired in the field, unless instructed to do so by Marine Magnetics technical support staff. **Opening the *SeaSPY2* without Marine Magnetics technical support approval will render the warranty null and void.**

13.1 Indemnity

The Customer agrees to indemnify and save Marine Magnetics harmless from and against all loss, damage and expense whatsoever resulting from any personal injury or damages to property directly or indirectly caused by the Equipment or any part thereof during the term applicable to such Equipment, including the operation and handling of the Equipment.

13.2 Disclaimer

Marine Magnetics makes no representation or warranties and there are no conditions with respect to the merchantability, the suitability or durability of the Equipment or any part thereof for the purposes or uses of the Customer, unless the Customer notifies Marine Magnetics in writing of any defects in the Equipment or part thereof on delivery of such Equipment. All such Equipment or part thereof shall be deemed conclusively to have been delivered to the Customer in good and efficient working order and repair, and the Customer shall be deemed conclusively to have accepted delivery thereof on the date of delivery.