Synapse

Quick Start Guide

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1 Introduction

The Synapse system consists of 1 to 30 Synapse marine magnetometers that can be used individually or as an array when mounted on a gradiometer frame. The array network utilizes a robust CAN bus integrated into the array wiring harness, enabling communication with the entire array through a single data port.

Each Synapse towfish is equipped with a scalar total field magnetometer sensor and a leak detector. Additional auxiliary sensors can also be installed, including an altimeter, a depth sensor and a tilt/attitude sensor (IMU). The integrated altimeter is a 200 kHz single-beam echo sounder. When two Synapse units with altimeters are used at the same time, one of the altimeters must be disabled (by selecting the active altimeter in software) or pointed upwards to prevent mutual interference. (Pointing the altimeter upwards turns it into an effective depth sensor).

At the initial launch, Synapse supported only FSK telemetry and required an isolation transceiver to operate. The isolation transceiver electronics provides a regulated and isolated power supply to the towfish array and handles time synchronization as well as all communication between the towfish and the top-side data logger.

The new generation Synapse gen.2 introduces support for direct RS-232 telemetry, making the transceiver optional.

The underwater isolation transceiver model supplied with magnetometer arrays is enclosed in pressure housing similar to those of the towfish and has two connections: the brass end cap is the input from the frame/towing system, and the black plastic end cap is the output towards the array.

1.1 Synapse gen.2

At the heart of Synapse gen.2 is a more powerful and versatile electronics module (SYN), that introduces a number of improvements to the Synapse communication protocol, adds support for RS-232 in addition to FSK interface, features an expanded set of supported commands, automatic master/client arbitration for arrays, and standardized command format and addressing. When used with FSK transceiver it requires a new gen.3 isolation transceiver with firmware 3.0 or newer.

All legacy SeaSPY2 style single-byte terminal commands have been obsoleted in Synapse gen.2 and transceiver firmware, and replaced with new commands. All toggle-style commands have also been eliminated and replaced with clear on/off states expressed as 1 or 0.

The FSK transmit and receive frequencies are now set to different channel bands, to ensure error-free full-duplex operation even with many magnetometers connected to the same FSK cable. This means that new SYN devices are no longer compatible with older gen.2 transceivers or previous generation Synapse 1.0 nodes. The new generation gen.3 transceiver will have a legacy support mode to communicate with older devices that used previous FSK transmit and receive channels.

1.2 Synapse array network

Synapse was developed to enable arrays of flexible sizes to be perfectly synchronized using a CAN bus network integrated into the array wiring harness. One of the array nodes (i.e. towfish) acts as the master node and communicates with the host computer or the transceiver. Other 'client' nodes send data to the master via the CAN bus, to be combined into a single data string that then gets forwarded to the host. The master node is also in charge of accurately synchronizing all connected array nodes to ensure that data is collected in perfect synchronicity. Each unit's serial number serves as its array network address. All interface and configuration commands can be addressed either to the master unit, or to any specific individual unit using its serial number.

1.3 FSK and RS-232 connection modes.

Each Synapse gen.2 towfish has an 8-pin interface connector with allowance for both RS-232 and FSK communication. Both modes can be used simultaneously or separately.

When connected via FSK and transceiver, all Synapse array nodes share the same FSK communication lines, and receive the same commands sent to the array by the transceiver and host. Only the master node sends data and responds to the transceiver over FSK, unless the command was addressed to a specific node within the array.

When connected via RS-232 without a transceiver, communication is between the computer and a single Synapse unit: the unit connected to the serial port. Multiple serial ports on the host computer can be used to interface to multiple Synapse nodes. Each node will always output its own local data over its serial port when sampling, whereas the master node will output the combined data string from the entire array (provided that CAN bus is in place).

1.4 Automatic master/client arbitration

In an array of Synapse nodes, the master node will output the combined array data string from all nodes and will keep the network in sync automatically.

Early Synapse models required the user to manually configure a single master node when combining several units into an array. If no master was selected, the array appeared unresponsive. And if multiple master nodes were present there was crosstalk leading to loss of data.

Synapse gen.2 introduced in June 2025 features automatic master/client arbitration that seamlessly selects a single master node in any array immediately following the system power-up, or any time a configuration changes during the operation of the array. This eliminates the earlier scenarios with either multiple masters leading to crosstalk, or lack of master leading to silence. If the master node is unplugged from the array or stops communicating, another node will automatically take over as the new master, thus ensuring continuous communication.

Individual nodes can be programmed to power-up as master or client, allowing for predictable operation, especially when a direct RS-232 connection is used through a single serial port connected to a specific node. The master node will output the full Synapse data string from all nodes and will keep the network in sync automatically.

The Synapse gen.2 network will function even if all nodes are configured as master, or all are configured as client, since the nodes will always arbitrate the selection of a single master automatically.

If the Synapse CAN bus network is not connected (or damaged), then all nodes continue to operate as independent masters. If the Synapse network is connected, a single master node gets selected by the SYN CAN bus protocols, enabling normal array operation even in the case of a single serial port connection.

When the master node receives commands over the direct serial connection, it will forward some of those commands to the rest of the array as needed, via the CAN bus connection.

2 Connection diagrams

2.1 FSK / transceiver telemetry for soft tow cable

The top-side telemetry for towing with a long soft tow cable or coaxial cable is handled by the isolation transceiver. The transceiver provides a stable supply to the towfish and converts the RS-232 data interface to FSK for communication over the long cable. Second generation transceivers introduced in 2023 include an integrated GNSS for synchronizing the towfish to UTC time. An optional external GNSS input connector is also provided.

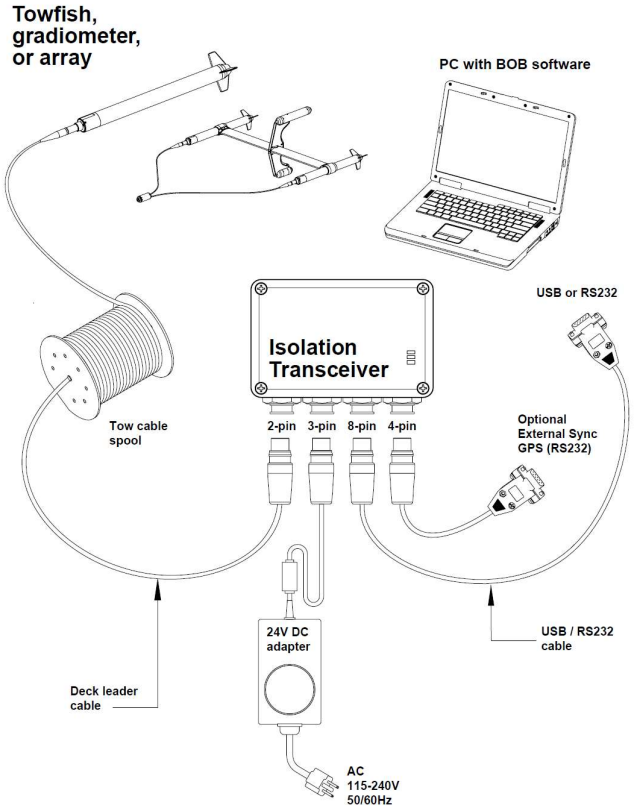


Figure 2-1 - Connection diagram for towing a single Synapse or a Synapse gradiometer using a desktop isolation transceiver

Synapse arrays of arbitrary size can be wired using a simple wiring scheme shown in Figure 2-2, where a high-power underwater isolation transceiver connects the entire array to a single RS-232 host port on the array frame or the ROTV. The transceiver converts RS-232 to FSK and provides both power and communication to the whole array via the same pair of conductors. An additional 3-conductor CAN bus wiring connecting all Synapse nodes is integrated into the array wiring harness, enabling the Synapse network operation.

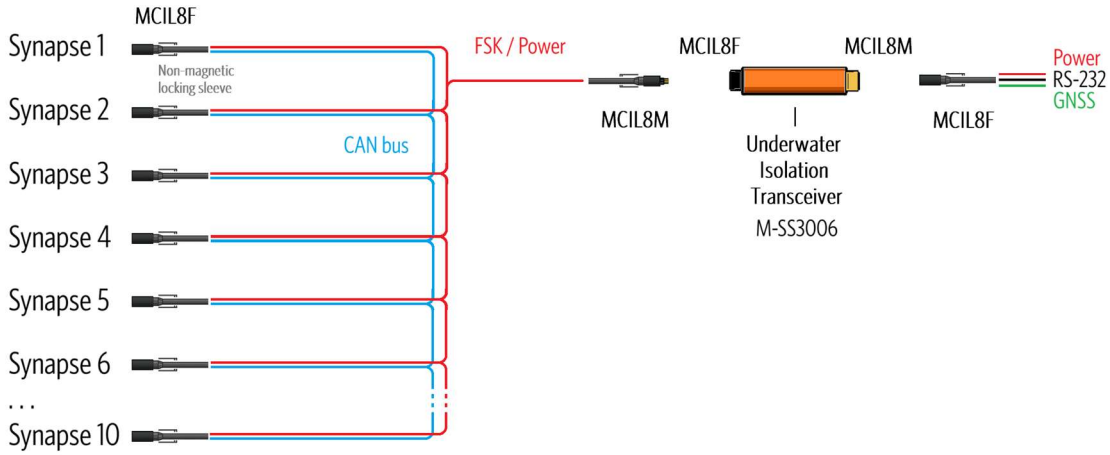


Figure 2-2 - Connection diagram for a 10-node array using an underwater isolation transceiver mounted on the array frame

The high-power underwater isolation transceiver is supplied with a lab test cable that provides connections for a DC power input (24V DC recommended) and RS-232 interface to the host PC. An additional RS-232 input is provided for connecting an optional external GNSS, which enables the transceiver to synchronize itself and the Synapse array to GNSS time.

Note: the high-power underwater isolation transceiver is designed to dissipate excess heat into the water through its brass end cap. When testing in a lab environment, ensure that the transceiver is immersed in water to prevent overheating. Do not immerse the transceiver in water unless connectors at both ends of the transceiver have cables plugged into them or are otherwise sealed from water.

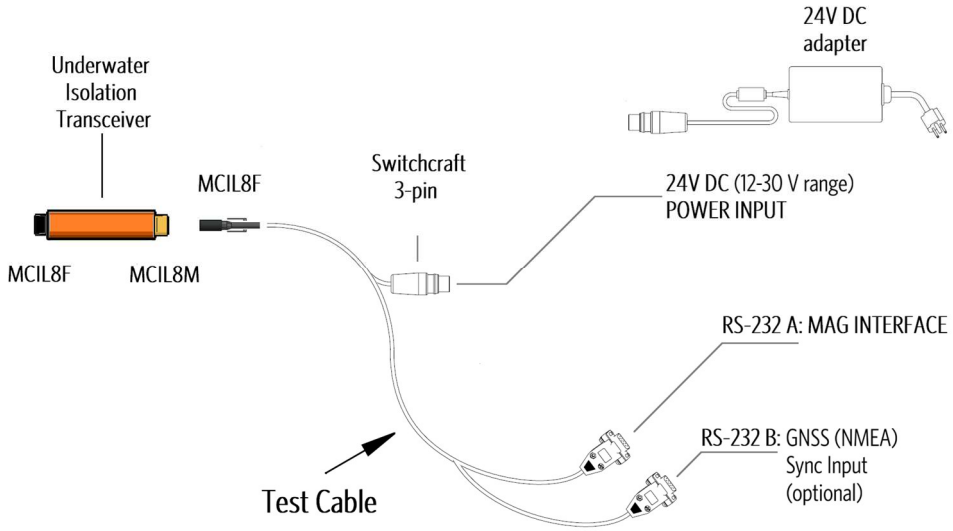


Figure 2-3 - Connection Diagram for lab testing using an underwater isolation transceiver.

Synapse gen.2 adds the option of using RS-232 telemetry without the isolation transceiver, connecting each Synapse towfish to a dedicated RS-232 port on the frame's multiplexer as shown in Figure 2-4. An additional wiring harness joins the CAN bus conductors of all tow cables together to enable the Synapse network operation.

Note that only a single RS-232 port is needed to interface to the entire Synapse array when the CAN bus network is connected. However having all Synapse nodes connected to available RS-232 ports may provide additional redundancy.

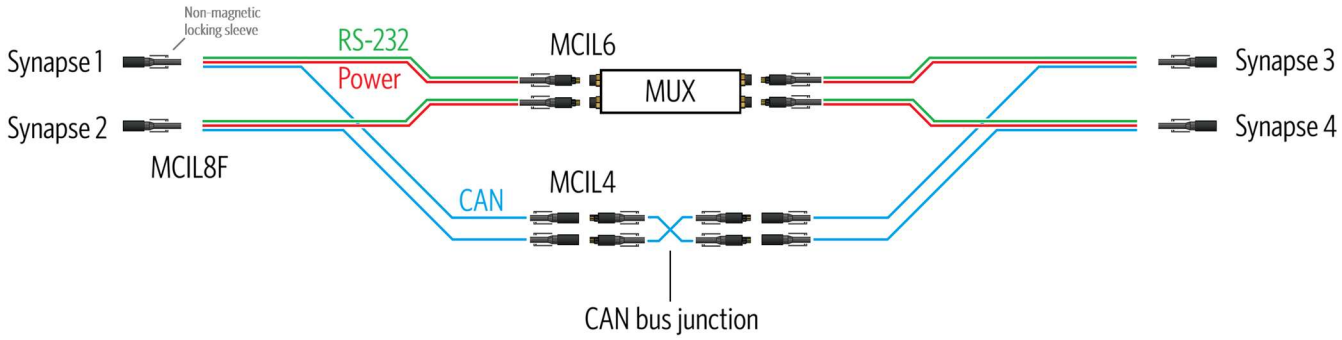


Figure 2-4 - Connection diagram for a 4-node array using RS-232 connections between each magnetometer and the multiplexer on the frame

2.2 Side Scan Sonar interface

The Side Scan Sonar (SSS) interface for Synapse operated through FSK consists of a short 5 or 10m tow cable and a submersible SSS interface module that contains an isolation transceiver. The SSS interface module is coupled mechanically to the SSS tow point and connected to the magnetometer interface port on the SSS unit. The SSS interface module is supplied with a lab test cable that provides connections for a DC power input (24V DC recommended) and RS-232 interface to the host PC.

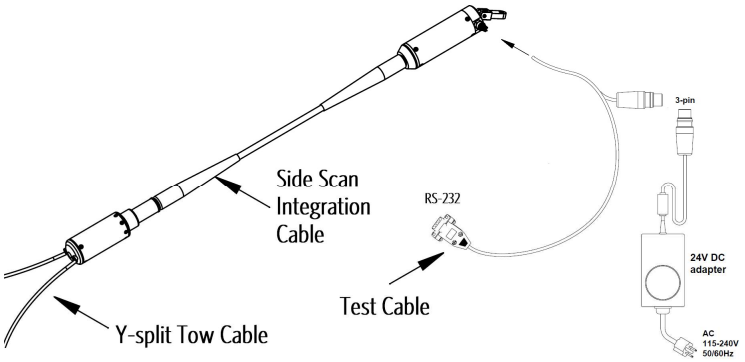


Figure 2-5 - Side Scan Sonar interface connection diagram for a single Synapse or a Synapse gradiometer

2.3 Synapse gen.2 electrical specifications

Synapse gen.2 supports dual telemetry: FSK (pins 6 and 7), and RS-232 (pins 1,8,7). CAN bus is only necessary when connecting multiple Synapse units together.

Table 2-1 - Synapse gen.2 towfish electrical connector wiring (front MCBH8M connector)

Pin	Function	Notes
1	RS-232 – MAG > PC	RS-232 Tx/Rx lines must be shielded
2	CAN H	CAN H/L lines should be a twisted pair
3	CAN L	
4	CAN GND	Must be isolated from power GND and RS-232 GND
5	N/C	
6	V+ / FSK +	20-55V range. 24V recommended.
7	GND (Power, FSK, RS-232)	Must be isolated from CAN bus GND
8	RS-232 – PC > MAG	RS-232 Tx/Rx lines must be shielded

Table 2-2 - Synapse gen.2 towfish electrical specifications

Parameter	Min	Typ.	Max
Input voltage	20 V	24 V	55 V
Input power	3.5 W	4.5 W	7.0 W*

*Note: When equipped with the optional altimeter

2.4 RS-232 Interface

Synapse gen.2 magnetometer as well as the isolation transceiver use the following RS-232 settings:

RS-232 Baud Rate: 115200 baud Data bits: 8, Stop bits: 1, Parity: None

Transceiver RS-232 baud rate can be configured through the transceiver settings menu, by sending the command **$menu,0,** in the RS-232 terminal. Note that older isolation transceivers (prior to 2025) do not support the $menu command and use Ctrl+B instead for RS232 baud rate settings. These transceivers are only compatible with Synapse gen.1 and earlier products (SeaSPY and SeaQuest).

Synapse magnetometer RS-232 settings can be configured through the towfish menu, by sending the command **$menu,<SN>,** where SN is the unit serial number (e.g. 16042). When only a single towfish is connected, of when communicating with the master node, the command can be abbreviated to: **$menu,,** (note that replacing SN with 0 redirects the command to the transceiver i.e. node zero)

Baud rates below 9600 are not recommended for use with Synapse magnetometers and can lead to communication delays and errors. When faced with a system bandwidth limitation consider changing the Synapse data format from Full to Compact or Base64 compressed, which allows more efficient use of the available bandwidth. These settings are accessible via the BOB Synapse configurator screen, or by sending the command **$data,<SN>,<D>** where <D> indicates the data format (0: standard, 1: compact, 2: Base64 compressed)

e.g. **$data,,1** will set the master node data output to Compact, while **$data,,** will query the current data format setting.

Please refer to Synapse Command Protocol for further details.

2.5 Isolation transceiver electrical specifications

An isolation transceiver is required when operating a Synapse magnetometer or Synapse array system via a 2-conductor tow cable. The transceiver provides a clean regulated power supply to the towfish or array and converts the RS-232 data interface to FSK, enabling telemetry over long tow cables. The isolation transceiver also features a battery-powered clock for synchronizing the towfish or array, and an integrated GPS to ensure precise synchronization to UTC time.

A standard desktop isolation transceiver is used when powering up to three Synapse magnetometers. Systems containing more than 3 magnetometers require the use of a high-output isolation transceiver.

The recommended input voltage for the isolation transceiver is 24V.

Table 2-3 – Desktop isolation transceiver electrical specifications

Parameter	Units	Min	Typ.	Max
Input Voltage (transceiver)	VDC	9 V	24 V	30 V
Output Voltage (transceiver)	VDC	45 V	45 V	45 V
Output Power (Max)	W	-	-	25 W
Output Power – single Synapse	W	3.5 W	5 W	7 W
Output Power – 2-mag gradiometer	W	7 W	10 W	14 W
RS-232 Baud Rate	baud	9600*	115200	115200

Table 2-4 - Electrical connector wiring for desktop isolation transceiver (2-pin towfish connector)

Pin	Function	Notes
1	V+ / FSK +	45 VDC + FSK telemetry
2	GND	

If the transceiver output current exceeds 3.4 A, 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 circuit in the tow cable or at the tow connector will not cause damage to either the interface electronics or the towing system.

Table 2-5 - High-output power underwater transceiver electrical specifications

Parameter	Units	Min	Typ.	Max
Input Voltage (transceiver)	VDC	11 V	24 V	30 V
Output Voltage (transceiver)	VDC	50 V	50 V	50 V
Output Power (Max)	W	-	-	160 W
Output Power – gradiometer (2 mags + 2 ALT)	W	10 W	10.5 W	11 W
Output Power – array (10 mags + 2 ALT)	W	60 W	65 W	70 W
RS-232 Baud Rate	baud	9600*	115200	115200

Table 2-6 - Electrical connector wiring for high-power underwater isolation transceiver (Input brass MCBH8M connector)

Pin	Function	Notes
1	V+	11-30 VDC, 125W
2	RS-232 – PC > MAG	Telemetry interface
3	RS-232 – MAG > PC	Telemetry interface
4	GND	Power and RS-232 GND
5	N/C	
6	N/C	
7	GNSS RS-232 Rx	Optional NMEA GNSS input for time synchronization. Should be shielded.
8	GNSS RS-232 GND	

NOTE: The brass end cap of the underwater isolation transceiver serves as a heatsink for dissipating the heat from the internal power supply. When used in a lab setting, it is important to provide a means of active cooling to the bulkhead by immersing it in water.

Table 2-7 - Electrical connector wiring for high-power underwater isolation transceiver (Output MCBH8F connector)

Pin	Function	Notes
1	N/C	
2	N/C	
3	N/C	
4	N/C	
5	FSK + / V+	50 VDC + FSK telemetry
6	FSK + / V+	50 VDC + FSK telemetry
7	GND	
8	GND	

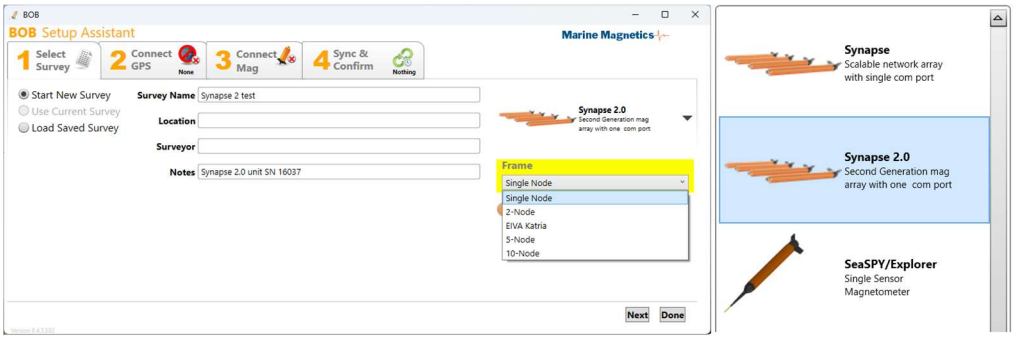
3 Operating the Synapse gen.2 system using BOB Software

Marine Magnetics BOB is the magnetometer interface software that provides data logging, survey planning and data correction features for all Marine Magnetics products. Additional processing and data visualization features can also be activated using the BOB Analytic Module (BAM) license. Free BOB software is available from the following URL: https://bob.marinemagnetics.com/

Described below are BOB Setup Assistant steps for configuring a new Synapse system survey.

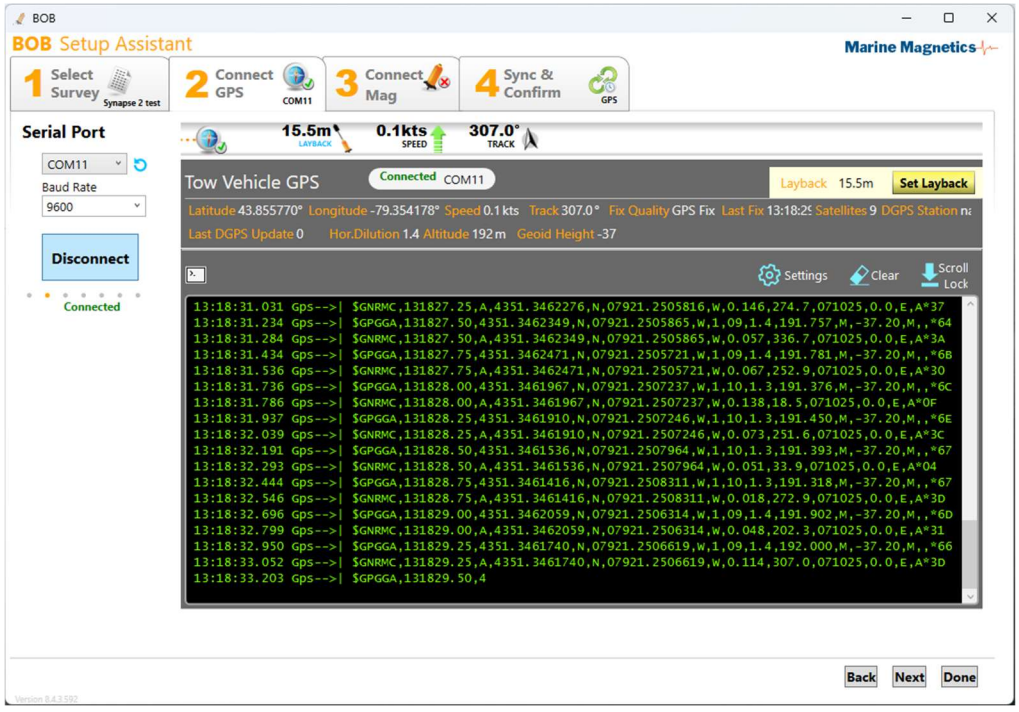
3.1.1 Create a new BOB survey and select the appropriate magnetometer type

Due to the inherent flexibility of Synapse arrays, BOB requires the array 'frame' to be configured before proceeding with data collection. The array configuration may include 1 or more nodes and can use various frames and arrangements. Once the magnetometer type is selected and the array size is configured, the number of nodes cannot be changed without creating a new survey.



3.1.2 Connect to the survey GPS via COM port.

BOB supports RS-232 or virtual COM port GPS input, and uses only GGA, RMC and ZDA NMEA data strings. A 5Hz or higher update rate is recommended. Default Layback is set to 15.5m, and can be modified later via the BOB GeoPlot window, as well as during post-processing.



3.1.3 Connect to the Magnetometer via COM port.

BOB supports RS-232 or virtual COM port connections, and communicates with the isolation transceiver, or directly with Synapse gen.2 via the RS-232 port. Use 115,200 baud rate for Synapse systems. Refer to Section 3.7 for details on RS-232 baud rate configuration.

Synapse magnetometers are designed to start sampling at 10 Hz upon power-up, and may require up to 1 minute for all sensors to begin data output.

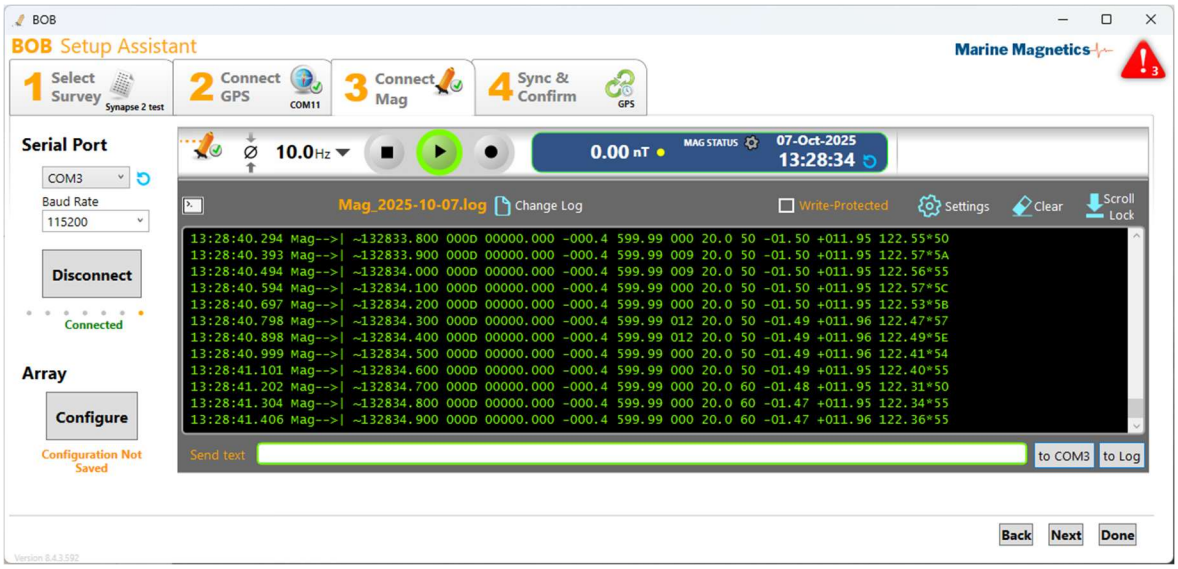


Figure 3-1 - Typical data output of a single Synapse magnetometer during start-up

Note the 'Send text' box below the terminal window introduced in BOB 8.5. It allows sending whole commands as a string.
Using the keyboard up arrow will recall recently used commands.
Prefixing the string with // will turn it into a comment in the log file.

BOB keeps two sets of diagnostic logs for backup purposes:

- **mag log**, containing magnetometer data plus system time stamps on the left, and captures all commands sent to the magnetometer COM port, as seen in the terminal window.
- **raw mag log**, containing only the data received from the magnetometer COM port and nothing else

3.1.4 Configure Synapse towfish or array

Before any data can be stored, the array configuration must be checked and saved. BOB Synapse Configurator provides an intuitive interface for:

- assigning individual Synapse units to specific slots on the frame (for arrays)
- selecting the master unit (for arrays)
- configuring the internal sensors in each Synapse unit
- selecting the data format (Normal, Compact or Base64 compressed)
- selecting an active altimeter (when more than one altimeter unit is connected)

The Synapse configurator can be accessed from Step 3 of the Setup Assistant, as well as from the mag status panel beside the data sampling controls.

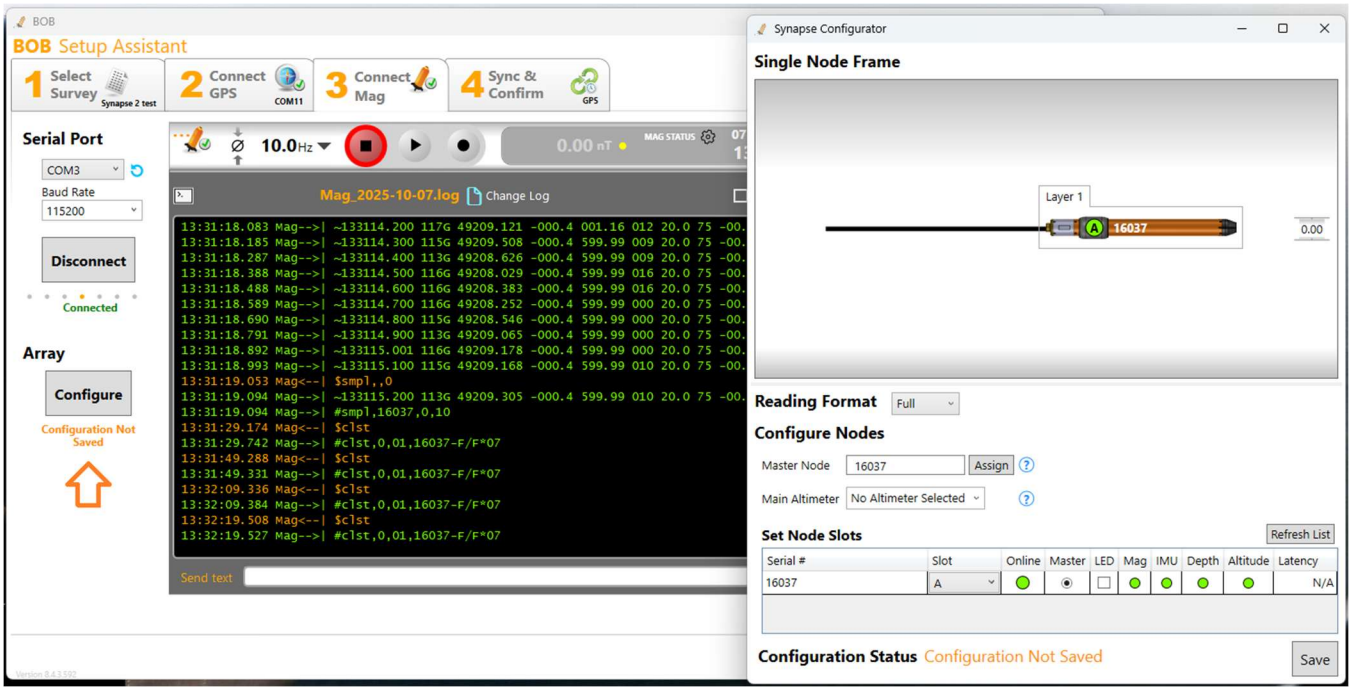


Figure 3-2 - Synapse configurator can be used to assign each Synapse node to its slot on the array frame, and configure internal sensors

All Synapse array systems require that a single Master node be assigned. Any node in the array can be assigned to act as a master node, but only one Master node can be present in the system for communication to work.

In early Synapse models the master node had to be assigned manually.

Synapse gen.2 makes this process automatic and seamless by introducing smart master/client arbitration. As nodes get added to or removed from the array, the master node gets assigned automatically as needed.

The master node will combine all the readings from the entire array into a single time-stamped data string and communicate with the isolation transceiver or the host computer via RS-232.

The current master node is identified in the configuration window and can be changed if needed.

Please refer to Section 6 for details on Synapse Data Format.

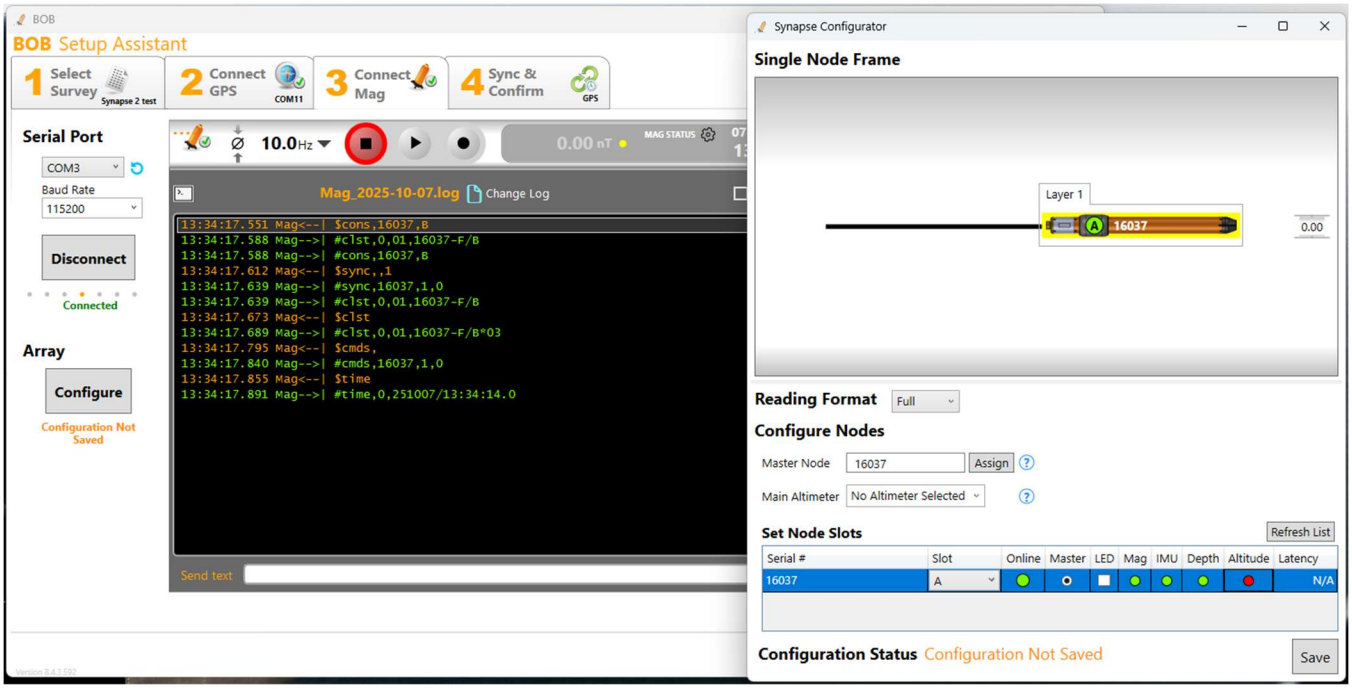


Figure 3-3 - Synapse configurator and provides click-on controls for internal sensors such as Magnetometer, IMU, Depth and Altimeter.

The configuration commands being sent to the Synapse by the configurator can be monitored in the terminal window, and will be captured in the diagnostic logs.

Please refer to Synapse Command Protocol for further details.

3.1.5 Finalizing the equipment configuration in BOB

The final step 4 in BOB Setup Assistant presents a summary of the survey parameters and COM port connections and offers options for time synchronization reference device for the magnetometer towfish.

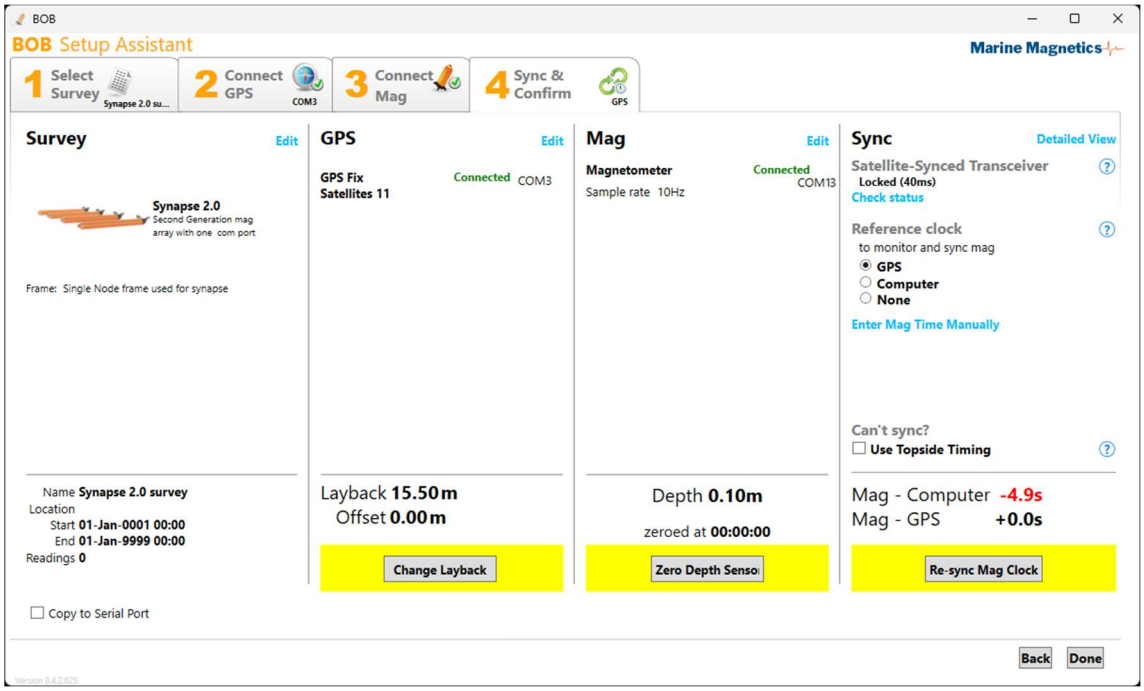
For best results the magnetometer should be synced to GPS (UTC) time. This requires a GPS connection.

If your isolation transceiver contains an integrated GPS (or is connected to an external GPS), it will automatically sync the magnetometer clock to satellite (UTC) time and maintain the sync as long the transceiver is able to obtain satellite lock.
The high-power underwater isolation transceiver as well as the side scan interface transceiver feature dedicated NMEA GPS inputs for the purpose of maintaining precise synchronization with satellite time.

Please note that a separate dedicated survey GPS is needed for tracking position of the vessel and towfish or array, while the transceiver GPS is only used for time synchronization.

In the absence of a GPS connection (e.g. during lab testing), the Mag clock can be set to either PC time or entered manually. For best results ensure that your PC's date and time are set accurately or configured to automatically sync to Internet time, and that your time zone is configured correctly to help determine the UTC time.

The Topside Timing option is reserved for situations where there are no means of setting the magnetometer date and time. It will time stamp incoming data using the Windows system time. This method of time stamping is less accurate and may result in variable latencies throughout the data capture.



3.2 Magnetometer data display in BOB

BOB user interface is divided into two windows: Main BOB window containing the data capture (sampling) controls, sensor profile graphs and a table of data readings below; and the GeoPlot window displaying the location of the survey equipment in a map view.

GeoPlot window features a multi-layered map view of the collected data and real-time magnetometer position. With a BAM license activated, the data can be visualized as interpolated maps such as Total Field, Analytic Signal and Partial Gradient maps. A background image or navigational chart may also be added (must be in GeoTiff format). Please refer to BOB User Manual for more information.

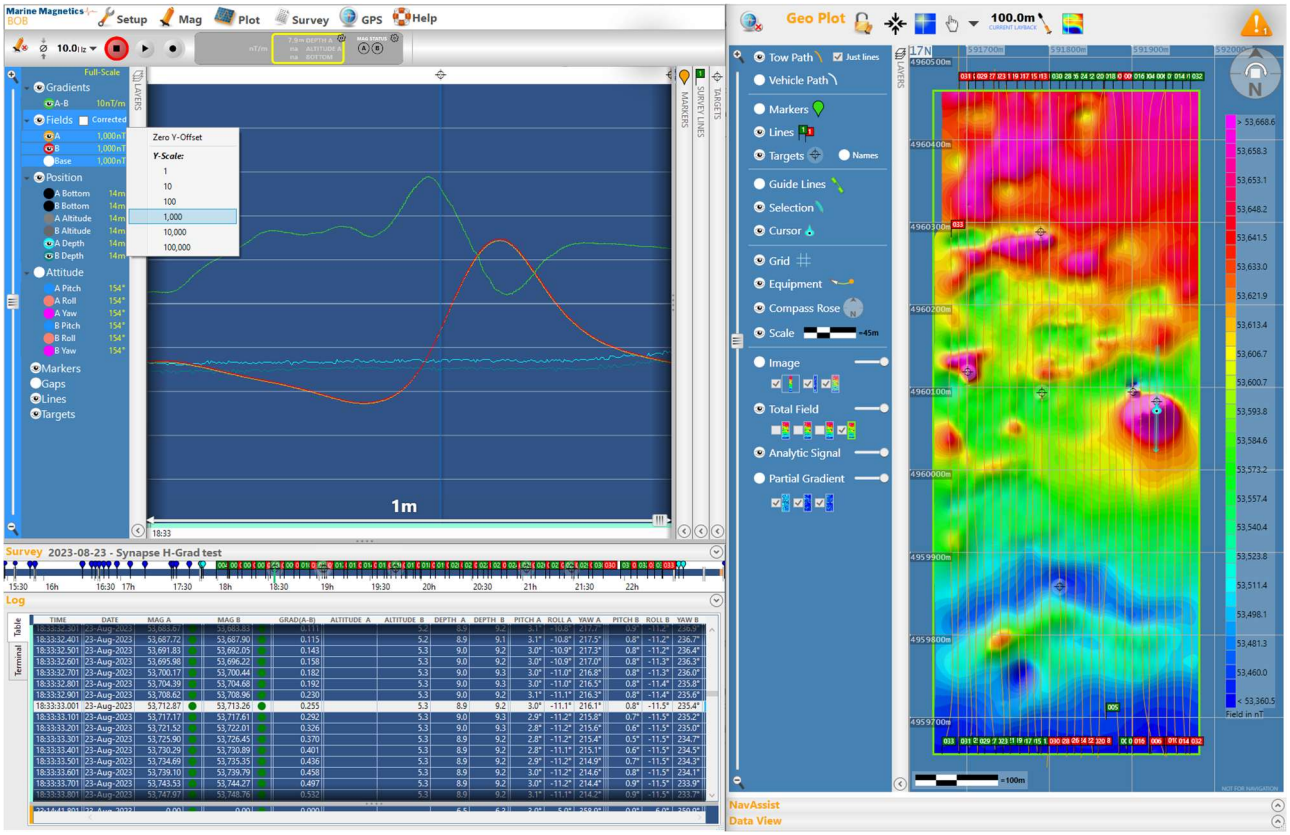


Figure 3-4 - Typical BOB user interface when reviewing existing Synapse Horizontal Gradiometer data and interpolated maps generated in BAM.

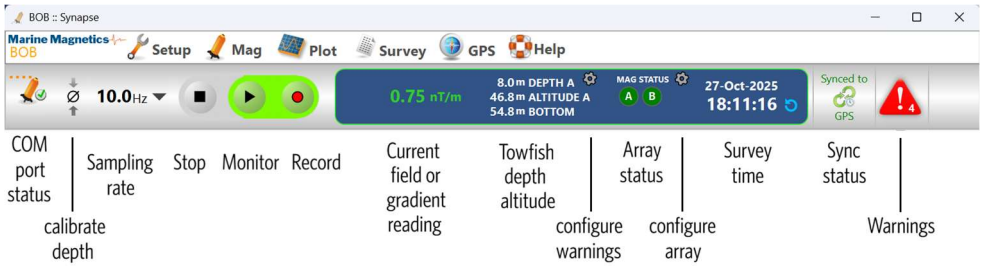


Figure 3-5 - New layout of the survey control panel in BOB 8.5

3.3 Profile Plot: Real-time and Review panes

The Profile Plot window in BOB contains a vertical divider that can be used to split the view into Review pane (left) and Real-Time Readings pane (right). The Horizontal scale (time span) can be set separately for each pane using the horizontal slider at the bottom of each pane. The timeline bar below the profile plot will highlight the time interval currently displayed in the Review Pane.

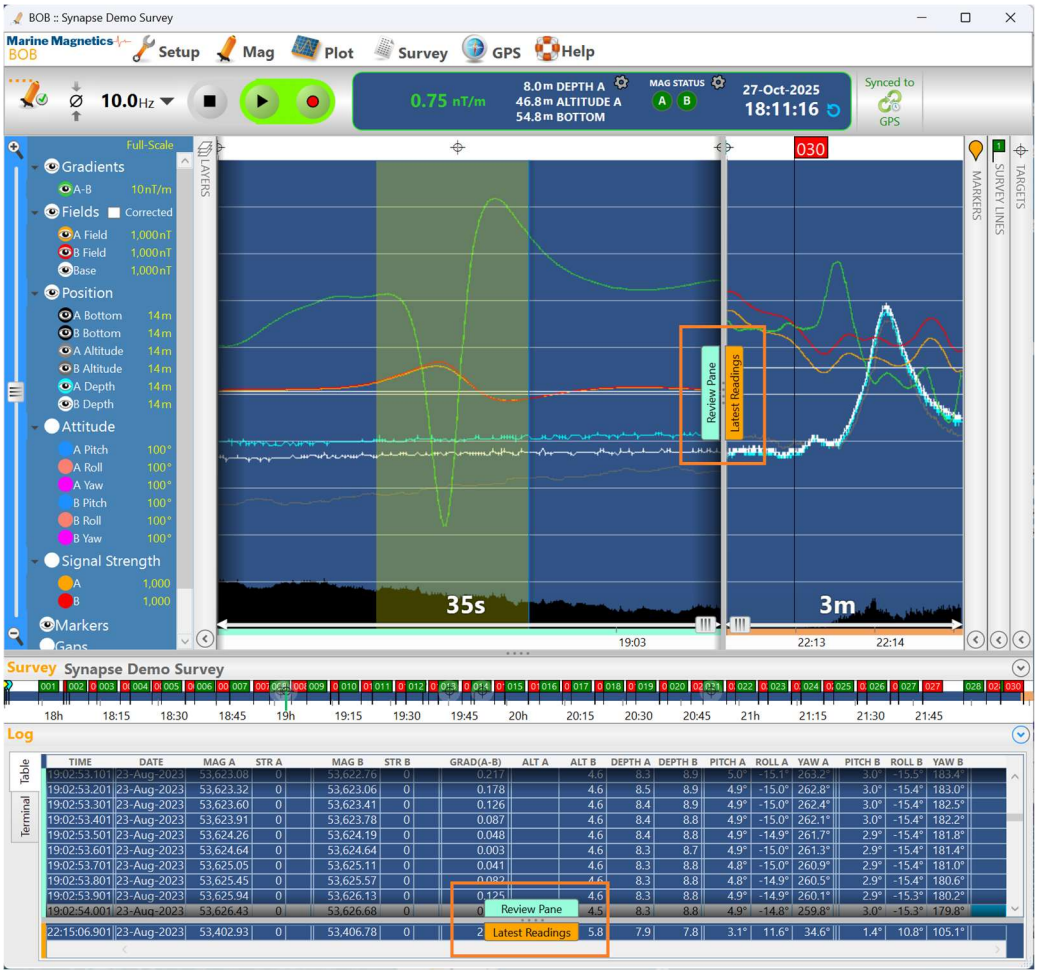


Figure 3-6 - BOB Profile Plot can be divided into Review (left) and Real-time (right) data panes, with different time spans for each. The Log table below the plot can be similarly divided with a horizontal bar.

Synapse magnetometer data is grouped into Fields, Positions and Attitude signals.
The vertical scale for each of the signal groups can be selected individually or as a group by selecting the group heading in the Layers panel and right-clicking on it. You can also multi-select individual components by holding down the *Ctrl* or *Shift* keys.
The vertical slider to the left of the Layers panel can also be used to adjust the vertical scale of the selected signal or group.

Data profile traces of the Fields group can be dragged up and down with a mouse (while holding down the Shift key) as well as scaled via the layers panel, for convenience and comparison. Data traces in Position and Attitude groups can only be scaled, but not dragged, as they have predefined reference “0” positions. When viewing the depth signal, the top of the profile window represents the water surface, and sea bottom is estimated as the sum of depth and altitude. Pitch and Roll traces are centered to display both positive and negative deviations.

Please refer to the BOB User Manual for further details on all features and functions.

3.4 Calibrating the depth sensor zero level

It is recommended to calibrate the zero-depth level of the pressure sensor at the start of each survey. Submerge the magnetometer towfish for a few minutes to allow it to adjust to the water temperature, then bring it out of the water to set the ambient pressure as zero depth level.

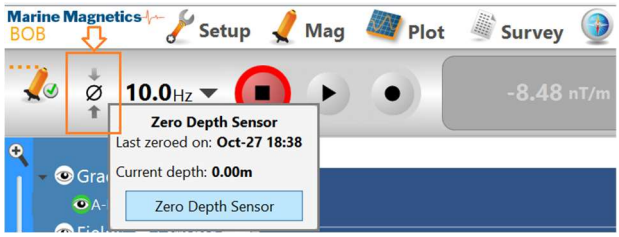


Figure 3-7 – Use the dedicated button for calibrating the depth sensor zero level prior to each survey

3.5 Towfish Attitude Indicator

Real-time orientation of the Synapse magnetometer or gradiometer array can be monitored using the Attitude Indicator display, which can be accessed through the Mag menu. The indicator presents the horizon from the point of view of the towfish looking forward in the direction of travel.

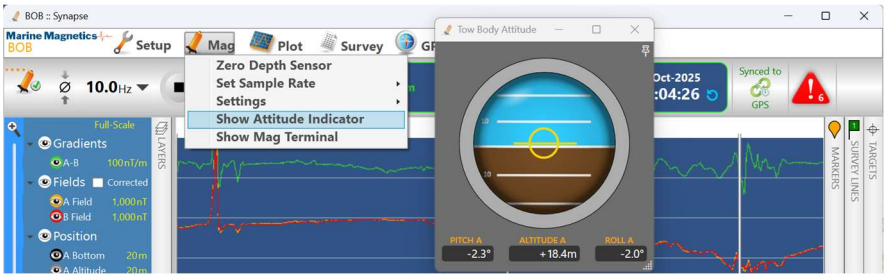


Figure 3-8 - The Attitude Indicator displays Pitch, Roll and Altitude readings from the active node whenever the Synapse magnetometer is actively sampling.

3.6 Saving and exporting survey data

All data captured by BOB gets stored in the BOB survey database whenever sampling is enabled, in addition to being captured in the diagnostic logs. The database is stored internally and cannot be accessed directly, but a copy of it can be backed up to a file for archiving or exported in CSV format for processing in 3rd party software.

To create a backup copy of the BOB survey database, use **Survey** > **Backup to File**. This will create a file with the extension .MMS, that will contain all data captured during the survey, including all markers, targets, notes, layback settings, background charts and BAM maps. This file can be imported into a BOB installation on another computer for sharing or post processing.

To export survey data for post-processing in 3rd party software, use the menu selection **Survey** > **Export Survey Log**. This option offers a flexible interface for selecting specific data channels and corrections to be applied and exported. The resulting file will be ASCII text formatted as CSV (Comma Separated Values), or a space-separated value file.

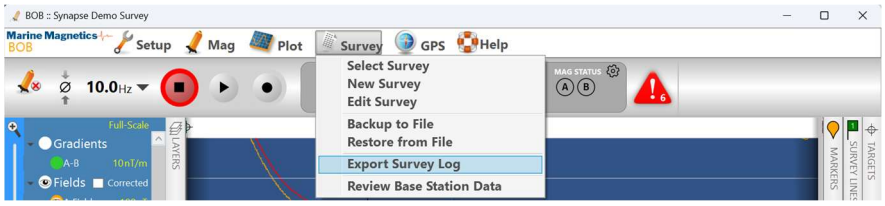


Figure 3-9 - Survey data can be backed up as a BOB-compatible backup (MMS) or exported as universal CSV format

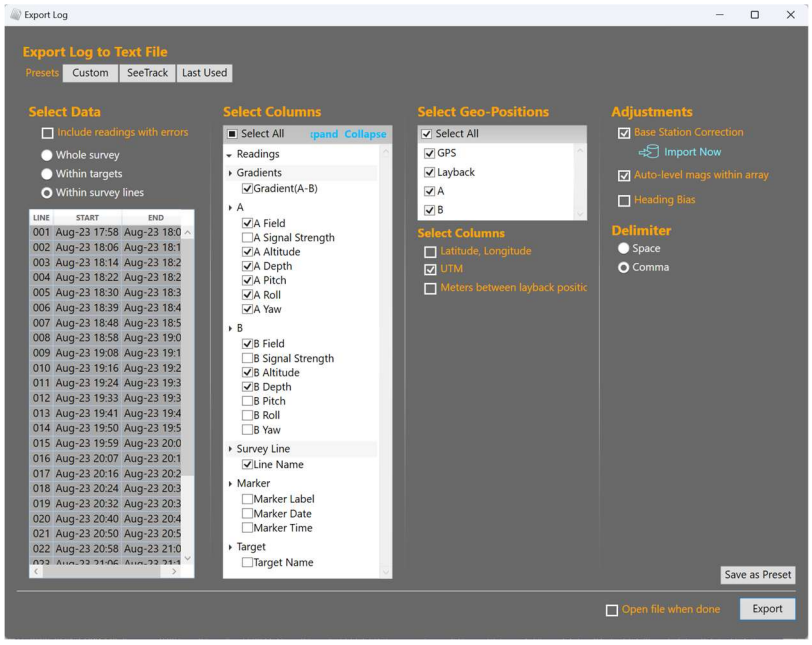


Figure 3-10 - Data export interface offers a flexible selection of available data channels, positions and corrections

3.6.1 Survey Export Log format – Description of all data columns and units

(*) represents n/a

Column	Value	Description
Reading_Date	23-Aug-2023	Date of the sample reading, magnetometer clock
Reading_Time	17:59:00.001	Time of the sample reading, magnetometer clock
Gradient(A-B)	-1.702	Measured gradient, nT/m (difference between raw fields at A and B slots divided by the separation between slots (frame width).
A_Field	53664.055	Magnetic field at frame slot A (nT)
B_Field	53666.608	Magnetic field at frame slot B (nT)
A_Altitude	*	Magnetometer Altitude at frame slot A (m) (if enabled)
B_Altitude	4.5	Magnetometer Altitude at frame slot B (m) (if enabled)
A_Depth	8.5	Magnetometer Depth at frame slot A (m)
B_Depth	8.6	Magnetometer Depth at frame slot B (m)
A_Pitch	2.75	IMU Pitch angle at frame slot A (deg). Positive is Nose-down. Includes IMU gyro correction.
A_Roll	-5.08	IMU Roll angle at frame slot A (deg). Positive is to Starboard. Includes IMU gyro correction.
A_Yaw	245.79	IMU Yaw angle at frame slot A (deg). Includes correction based on IMU's MEMS compass.
B_Pitch	1.85	IMU Pitch angle at frame slot B (deg). Positive is Nose-down. Includes IMU gyro correction.
B_Roll	-5.54	IMU Roll angle at frame slot B (deg). Positive is to Starboard. Includes IMU gyro correction.
B_Yaw	240.23	IMU Yaw angle at frame slot B (deg). Includes correction based on IMU's MEMS compass.
Reading_ID	74539	Unique Reading ID since start of database
System_Date	23-Aug-2023	Date of the sample reading, Windows PC clock
System_Time	17:59:01.441	Time of the sample reading, Windows PC clock
Line_Name	L004	User-marked survey line (if marked)
Marker	*	Name of the note marker corresponding to current time (if marked by user)
Marker_Date	*	Date corresponding to the marker
Marker_Time	*	Time corresponding to the marker
Error		Error code identifying the magnetometer sensor operating state (A,..,F). Blank if no errors.
Target_Name	*	Name of the anomaly target corresponding to current time (if marked by user)
GPS_Latitude	44.79073146	Latitude of the GPS receiver (Boat) location. WGS84
GPS_Longitude	-79.83807075	Longitude of the GPS receiver (Boat) location. WGS84
GPS_Easting	591910.60	UTM Easting of the GPS location (m), WGS84
GPS_Northing	4960360.37	UTM Northing of the GPS location (m), WGS84
GPS_Zone	17N	UTM Zone
Layback_Latitude Layback_Longitude Layback_Easting Layback_Northing	(see above)	Coordinates of the end of tow cable (layback point, or single towfish location). WGS84. See Note below on specific component positions.
A_Latitude A_Longitude A_Easting A_Northing	(see above)	Coordinates of the array node A on the selected frame. WGS84. See Note below on specific component positions.
Heading_Bias	-0.000	Heading bias applied based on GPS heading (as configured in the heading correction dialog)
Fish_Heading	182.4	Towfish heading (based on GPS heading, corrected for layback)
Base_Station_Correction	-5.906	Base station correction (nT) (Base Station Field less the average value for the base data imported)
Base_Station_Field	53671.211	Base Station Field (nT) interpolated for this point in time using available base station readings
A_Field_Leveling	1.304	Sensor-specific levelling correction, computed individually for each marked survey line
B_Field_Leveling	-1.304	Sensor-specific levelling correction, computed individually for each marked survey line
A_Field_(Corrected)	53671.265	Corrected magnetic field at frame slot A, with all selected corrections applied (Base station, Heading bias, Automatic Sensor Leveling)
B_Field_(Corrected)	53671.211	Corrected magnetic field at frame slot B (nT).
Corrected_Gradient(A-B)	0.037	Magnetic gradient derived from corrected magnetic fields at slots A and B (nT/m). (Difference between corrected fields divided by the separation between slots (frame width)).

Notes: Latitude and Longitude of the Towfish and Mag nodes (slots) are computed by BOB based on the position of the GPS (Boat) and the specified layback distance, and accounting for the curve of the tow cable and the vessel path. While GPS (Boat) latitude and longitude remain fixed in the database, you can re-compute mag coordinates at any time by entering a new layback distance in BOB.
"Layback" represents the end of the single tow cable. For gradiometers, this represents the position of the head of the Y-split cable. Use the slot-specific coordinates (e.g. A_Latitude) for positions corresponding to specific magnetometer sensors within a frame.

3.7 Layback distance estimation for optimal magnetometer positions

BOB software computes the position of the magnetometer sensor(s) during the survey by applying a layback offset behind the point with known coordinates (e.g. GNSS antenna). The layback is a curvilinear horizontal offset measured along the modified curve of the vessel's path. For best positional accuracy the layback needs to include all longitudinal and transverse offsets between the GNSS antenna and the tow cable length mark. The layback does not include the vertical offset due to towfish depth.

Array frame dimensions can be configured into a frame preset, which defines the X,Y and Z offsets of every magnetometer frame slot relative to the end of the tow cable. Please contact MMC with your frame dimensions and we will provide you with a frame preset for BOB.

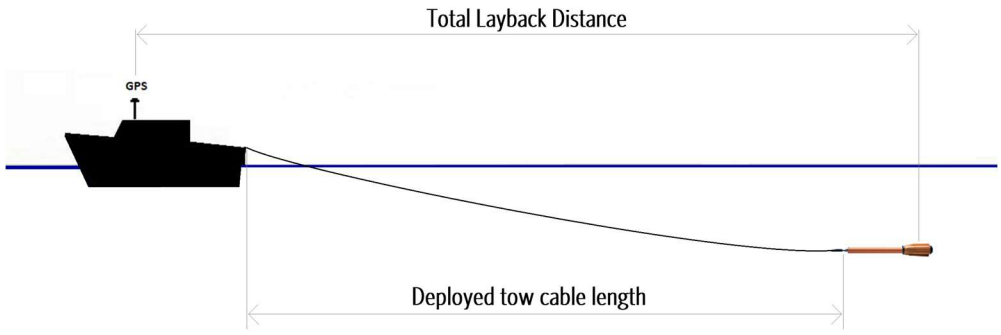


Figure 3-11 - Layback distance estimation for the simple case of a towed magnetometer without a frame on a soft tow cable

4 External ballast module

Synapse towfish are neutrally buoyant for sidescan sonar and AUV integrations, as well as array frame installations. The optional external ballast module can be used when a single Synapse towfish is towed from a long soft tow cable, to help sink the towfish deeper, as well as help keep the altimeter transducer pointing down when used with a stiff tow cable.

The recommended installation position for the external ballast module is illustrated below. Ensure that the ballast pod is lined up with the downward facing tail fin and the direction of the altimeter transducer and is positioned no closer than 12in / 30cm from the tail end of the towfish.

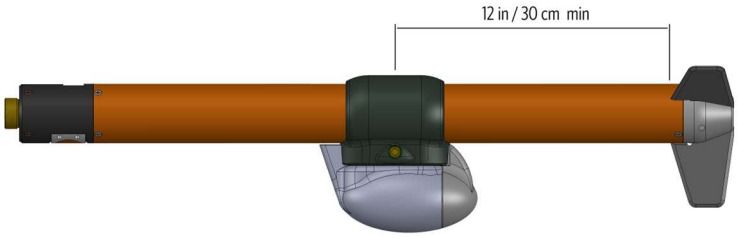


Figure 4-1 - Optional external ballast module

5 Configuring the gen.3 isolation transceiver and Synapse 2 towfish

Gen.3 isolation transceiver supports Synapse gen.2 magnetometers, as well as legacy products such as Synapse gen.1 and SeaSPY2.

The isolation transceiver (IT) contains a battery-powered clock, which keeps the magnetometer synchronized to current date and time. This clock is set by the integrated GPS, or by top-side PC (e.g. BOB software) and should remain accurate for several days following its setting. The integrated on-board battery will automatically recharge whenever power is connected to the transceiver. This battery never requires replacement under normal usage.

Command	Description
$time	**Get Time and Date**. Requests current transceiver time. If a towfish is connected it will also check the towfish time and synchronize it to the transceiver time if there is a discrepancy. e.g. response: #time,0,250922/15:22:39.2
$time,,**250922**152239	**Set transceiver date and time.** (Formerly T command) As soon as the time is set, the IT will attempt to set the time of the towfish, provided one is connected. The IT will remember the time after it is powered off for as long as the internal battery retains charged. Note that if the integrated GPS has a satellite lock, the satellite time will always override any user-configured time.
$stat,0	**Scan sensors in the transceiver**. (Formerly D command) Get output voltage (45.9V), current (123mA), power (05.6W) from the transceiver. e.g. response: #stat,0,45.9,123,05.6 In addition to querying the towfish this command also displays the voltage being supplied by the IT, and the current and power consumption of the magnetometer, as well as the depth sensor reading.
$stat,<sn>	**Scan sensors in the Synapse towfish** SN <sn>. (Formerly D command)
$fver,0	**Get firmware version** from the transceiver e.g. response: #fver,<sn>,3.5.0,C4A8DDFB,02.0.0 Firmware Version (3.5.0) and checksum (C4A8DDFB) and protocol revision (2.0.0)
$fver,16043	**Get firmware version** from the Synapse towfish SN 16043
$clst	**Get list of all connected Synapse towfish**, and their internal sensor configurations
$sync,,1	**Resync Synapse network**
$smpl,,10	**Begin sampling** at 10 Hz (this command propagates to all connected towfish)
$smpl,,0	**Stop sampling** (this command propagates to all connected towfish)
$data	**Get data format setting** from current master towfish e.g. response: #data,16043,0 - (0: normal, 1: compact, 2: base64 compressed)
$data,,1	**Set data format** to Compact (1) in the current master towfish (,,)
$dzro	**Get zero-depth calibration** from current master towfish e.g. response: #dzro,<sn>,0,672,0004.2 0:depth not zeroed. Current zero setting is 672mV. Current depth reading 4.2m
$dzro,,1	**Set zero depth to current pressure**. (this command propagates to all connected towfish) e.g. response: #dzro,<sn>,1,672,0000.1 1:depth was zeroed. Zero level Is 672mV. Current depth reading 0.1m
$cons,<sn>,F	**Enable all available sensors in unit <sn>** e.g F = 1111, where IMU = bit 3, altimeter = bit 2, depth = bit 1, mag = bit 0.

Table 5-1 - Isolation Transceiver gen.2 and Synapse 2 commands

5.1 Configuring the gen.2 Side Scan integration transceiver

Gen.2 isolation transceiver is integrated into the side scan integration cable, and it supports Synapse gen.1 magnetometers, but is not compatible with Synapse gen.2. The information below is included here for reference only.

The isolation transceiver (IT) integrated into the side scan integration contains a battery-powered clock, which keeps the magnetometer synchronized to current date and time. This clock is set by the top-side PC (e.g. BOB software) and should remain accurate for several days following its setting. The integrated on-board battery will automatically recharge whenever power is connected to the transceiver. This battery never requires replacement under normal usage.

Command	Description
SPC or t	Get Time: Requests current transceiver time. If a towfish is connected it will also check the towfish time and synchronize it to the transceiver time if there is a discrepancy.
T	Set transceiver time and date. As soon as the time is set, the IT will attempt to set the time of the towfish, provided one is connected. The IT will remember the time after it is powered off for as long as the internal battery retains charged.
d or D	Scan sensors. In addition to querying the towfish this command also displays the voltage being supplied by the IT, and the current and power consumption of the magnetometer, as well as the depth sensor reading.
?	Display command menu
!	Get towfish serial number.
Ctrl+O	Power On/Off. Toggles power to the towfish.
Ctrl+B	Change transceiver RS-232 baud rate for the top-side telemetry link (PC-Transceiver)
Ctrl+T	Resync towfish to the transceiver clock
Ctrl+X	Abort/Cancel current command
*	Enter transceiver diagnostic mode. A security code is required.

Table 5-2 - Isolation Transceiver gen.1 commands

Use <Ctrl+B> to configure the transceiver's communication settings:

```
^B
Change comm settings
PC-115200bps GPS-9600bps FISH-31200bps
1- xcvr<->PC
2- xcvr<->GPS
3- xcvr<->towfish
4- xcvr<->towfish comm channel
```

Selection option 1 to change the Transceiver-PC baud rate:

```
1
>1-Set xcvr<->PC baud rate
1:2400 2:4800 3:9600 4:38400 5:115200
```

Use <Ctrl+X> to if you need to cancel the command

```
^X
>
Aborted
-Baud rate not changed
```

6 Synapse Data Format

6.1 Standard Format – Single magnetometer

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

```
~HHMMSS.sss SSSL FFFFF.FFF DDDD.D AAA.AA ASG AV.V AW +PP.PP +RRR.RR YYY.YY*CS CR LF
___________ _____________ ______ ________________ ___________________ __
   TIME         MAG DATA   DEPTH   ALTIMETER DATA          IMU DATA      CHKSM
```

Example:

```
~162046.101 104G 52846.465 0000.1 599.99 030 18.0 99 -02.37 +010.07 357.07*2E
```

The first character of each data line is always ~ (ASCII code 126). This leading character is supplied for automated data collection systems that require periodic synchronization with the data stream.

The first character of each Synapse protocol command sent to the Master node is $.

The first character of each response from the Master node is #.

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

Column	**Description**
HHMMSS.sss	UTC Time of the magnetometer reading. Nominally, it occurs at the even fraction of a second as determined by 1/sample-rate. However, a string can be delayed by slight differences in sync between sensor nodes, and transmission times from sensor nodes. e.g. *162406**.101***
SSS	Signal Strength of the current sensor reading e.g. *104*
L	Sensor Lock Status. (G during normal sampling) A,B,C or D: Starting up, E: heat stabilizing, F: Scanning for signal, G: Locked.
FFFFF.FFF	Magnetic field in nT, with a precision of 1pT. e.g *53577.252*
DDDD.D	Depth sensor reading in meters, with a precision of 0.1m. e.g *0012.3* or *-000.2*
AAA.AA	Echo sounder altimeter reading, in meters (if installed), with a precision of 0.01m. Maximum theoretical range: 0-599.99m, where 599.99 indicates no return.
ASG	Altimeter return signal strength. 000 indicates no return.
AV.V	Altimeter output drive pulse amplitude (Volts). Range: 1-18V during normal operation. 25.5V indicates that altimeter is disabled.
AW	Altimeter output drive pulse width (µs x 10). e.g. *33* = 330 µs
+PP.PP	IMU Pitch angle (deg). e.g. *-02.37*
+RRR.RR	IMU Roll angle (deg). e.g. *+010.07*
YYY.YY	IMU Yaw reading (deg. Azimuth). e.g *357.07*
**CS CR LF*	Checksum followed by Carriage Return and Line Feed (ASCII 13 and 10)

table 6-1: Standard data format description

Please refer to the Synapse Array Interface Protocol for details on all commands and data format.

6.2 Gradiometer Data Format

A 2-unit horizontal gradiometer equipped with altimeter, depth sensor and IMU will have the following data format:

(note that only one set of altitude readings is reported, corresponding to the active altimeter (See Section **Error! Reference source not found.**))

```
~HHMMSS.sss SSSL FFFFF.FFF DDDD.D AAA.AA ASG AV.G AW +PP.PP +RRR.RR YYY.YY SSSL FFFFF.FFF DDDD.D +PP.PP +RRR.RR YYY.YY*CS CR LF
```

Example:

```
~162046.101 103G 52846.465 0000.1 599.99 030 18.0 99 -02.37 +010.07 001.07 091G 53017.299 0000.1 +00.88 +006.89 011.34*2E
```

The gradiometer data format follows the standard data format but includes individual unit's magnetometer and depth readings.

NOTE: The master node is always the first node whose readings are reported, followed by other nodes in the order of increasing serial numbers.

#clst – this command returns the list of all connected nodes, their serial numbers and installed sensors (as a 1-byte code), always beginning with the master node

Please refer to the Synapse Array Interface Protocol for details on all commands and data format.

6.3 Synapse data examples

Synapse data string has a fixed length set by the number of activated sensors in each towfish. The data string will show dashes in place of readings for sensors that aren't working properly. If a particular sensor is not installed, its data columns won't be present in the data string at all. #clst response indicates which sensors are installed
e.g. #clst,01,16001-**F**/F - the first F indicates which sensors are installed (F = 1111, i.e. all 4 sensors are installed)

NOTE: If a sensor gets deactivated using the $cons command (e.g. via Synapse Configurator in BOB), its readings will be replaced with dashes until a $sync command is issued. After that the entire data column corresponding to that sensor will disappear from the data string.
e.g. #clst,01,16001-F/**F** - the 2nd F indicates which sensors are currently enabled (F = 1111, i.e. all 4 sensors are enabled)

Single Synapse unit: SN 16001

Normal operation. All sensors enabled. All sensors are ok.
Mag transitions from warm-up (E) to scanning (F) to normal sampling (G) as part of normal start-up sequence

```
#clst,01,16001-F/F
~203828.601 000E 00000.000 0000.1 599.99 030 18.0 75 -01.25 +005.34 002.37*4F
~203828.701 000E 00000.000 0000.1 599.99 030 18.0 75 -01.25 +005.34 002.37*4F
~203828.801 041F 14064.086 0000.1 599.99 030 18.0 75 -01.25 +005.34 002.37*45
~203828.901 054F 31151.584 0000.1 599.99 030 18.0 75 -01.25 +005.34 002.37*46
~203829.001 066F 33406.056 0000.1 599.99 030 18.0 75 -01.25 +005.34 002.36*4D
~203829.101 089G 47356.675 0000.1 599.99 030 18.0 75 -01.25 +005.34 002.36*4C
~203829.201 090G 48755.684 0000.1 599.99 030 18.0 75 -01.25 +005.33 002.37*4A
~203829.301 091G 48812.688 0000.1 599.99 030 18.0 75 -01.25 +005.34 002.36*4C
~203829.401 094G 48812.205 0000.1 599.99 030 18.0 75 -01.26 +005.34 002.36*4E
_____________ _____________ _______ ____________________ ____________________ __
   TIME          MAG DATA    DEPTH    ALTIMETER DATA           IMU DATA        CHKSM
```

Mag, depth and IMU are OK, altimeter is not working (dashes)

```
~155948.101 100G 33893.000 -000.3 ---.-- --- --.- -- +00.75 -004.58 359.61*46
~155948.201 200G 44290.652 -000.3 ---.-- --- --.- -- +00.75 -004.58 359.61*4E
~155948.301 300F 51138.018 -000.3 ---.-- --- --.- -- +00.75 -004.57 359.61*4D
```

Mag and Altimeter are not working, but depth and IMU are OK

```
~155948.101 ---- -----.--- -001.3 ---.-- --- --.- -- +00.75 -004.58 359.61*46
~155948.201 ---- -----.--- -001.3 ---.-- --- --.- -- +00.75 -004.58 359.61*4E
~155948.301 ---- -----.--- -001.3 ---.-- --- --.- -- +00.75 -004.57 359.61*4D
```

Only depth sensor is working (likely cause: sensor power got disabled by the $pwrt command)

```
~155948.101 ---- -----.--- -001.3 ---.-- --- --.- -- ---.-- ----.-- ---.--*46
~155948.201 ---- -----.--- -001.3 ---.-- --- --.- -- ---.-- ----.-- ---.--*4E
~155948.301 ---- -----.--- -001.3 ---.-- --- --.- -- ---.-- ----.-- ---.--*4D
```

Two Synapse units: SN 16001 and 16002, with 16001 configured as Master

Unit #1: Only depth sensor is working
Unit #2: Everything except for the altimeter is working

```
#cmds,10001,1
Syncing Network...
#clst,02,16001-F/F,16002-F/F
Syncing Rb Mag...
~153648.815 ---- -----.--- -000.3 ---.-- --- --.- -- ---.-- ----.-- ---.-- 800F 28390.383 -000.3 ---.-- --- --.- -- +00.60 +001.42 358.63*63
~153648.915 ---- -----.--- -000.3 ---.-- --- --.- -- ---.-- ----.-- ---.-- 900G 43692.051 -000.2 ---.-- --- --.- -- +00.59 +001.42 358.63*6F
~153649.015 ---- -----.--- -000.4 ---.-- --- --.- -- ---.-- ----.-- ---.-- 000F 52363.888 -000.3 ---.-- --- --.- -- +00.59 +001.42 358.63*6E
~153649.115 ---- -----.--- -000.3 ---.-- --- --.- -- ---.-- ----.-- ---.-- 100F 40664.911 -000.3 ---.-- --- --.- -- +00.59 +001.42 358.63*69
~153649.215 ---- -----.--- -000.4 ---.-- --- --.- -- ---.-- ----.-- ---.-- 200F 26748.515 -000.3 ---.-- --- --.- -- +00.59 +001.41 358.63*6A
~153649.315 ---- -----.--- -000.4 ---.-- --- --.- -- ---.-- ----.-- ---.-- 300G 39774.320 -000.3 ---.-- --- --.- -- +00.60 +001.41 358.63*60
_____________ _____________ _____ _____________ _____________ _____________ _____ _____ _____________ _____________ __
   TIME          MAG1      DEP 1   ALTIMETER 1          IMU1          MAG2      DEP 2   ALTIMETER 2          IMU2          CHKSM
```

Unit 1: Mag, depth and IMU are working, altimeter not working.
Unit 2: Depth and IMU are working, mag and altimeter are not.

```
~154329.015 999F 44832.320 -000.4 ---.-- --- --.- -- +00.44 +000.26 003.20 ---- -----.--- -000.3 ---.-- --- --.- -- +00.00 +000.00 360.00*62
~154329.115 099F 50500.261 -000.3 ---.-- --- --.- -- +00.44 +000.26 003.20 ---- -----.--- -000.3 ---.-- --- --.- -- +00.00 +000.00 360.00*60
~154329.215 200F 36900.111 -000.3 ---.-- --- --.- -- +00.43 +000.27 003.20 ---- -----.--- -000.3 ---.-- --- --.- -- +00.00 +000.00 360.00*6F
~154329.315 300F 26495.567 -000.3 ---.-- --- --.- -- +00.43 +000.25 003.20 ---- -----.--- -000.3 ---.-- --- --.- -- +00.00 +000.00 360.00*68
~154329.415 400G 44076.427 -000.4 ---.-- --- --.- -- +00.43 +000.27 003.20 ---- -----.--- -000.3 ---.-- --- --.- -- +00.00 +000.00 360.00*64
_____________ _____________ _____ _____________ _____________ _____________ _____ _____ _____________ _____________ __
   TIME          MAG1      DEP 1   ALTIMETER 1          IMU1          MAG2      DEP 2   ALTIMETER 2          IMU2          CHKSM
```

7 Troubleshooting

For normal operation, the Synapse system relies on the master node to communicate with the isolation transceiver at the correct baud rate of 31200; and on the isolation transceiver to communicate with the top-side data logging system at a correct baud rate of 115200. See Section 3.7 for details on configuring the transceiver baud rates.

The isolation transceiver should still communicate with the top-side data logger via RS-232 even without the towfish or tow cable connected to it. If you cannot communicate with the isolation transceiver (including the one integrated into the side scan integration cable), check the baud rate and the power supply.

Check LED indicator on the front bulkhead of the Synapse unit.

Blue background indicates that unit is still powering up (wait 1 min) or is out of lock (in dead zone). Ensure the towfish is horizontal or move away from any iron/magnetic objects or electrical appliances.
Green background indicates normal operation. Green + White Flash indicates normal sampling. Green + Red flash identifies the master node.
Red background indicates fault.
No LED lights: indicates loss of power to the towfish. Either an issue with the tow cable, or no power output from the transceiver.

The Synapse system requires one of the array nodes (units) to be assigned to act as master node.
In Synapse 1.0 when no master node is assigned, it will appear as though the towfish is not connected. In this case assign a master node manually using commands **$cmdx,1** followed by **$cmds,<sn>,1** (where <sn> is the serial number of the unit, e.g. 16023).
In Synapse gen.2 one of the connected towfish will always automatically be assigned to be master. Look for the Green LED with Red flash on the front of the master unit.

In Synapse 1.0 when multiple master nodes are connected, the data seen in the RS-232 terminal will contain unreadable text and non-ASCII characters. Simply assign one of the nodes to act as master node using commands **$cmdx,1** followed by **$cmds,<sn>,1** (see Section **Error! Reference source not found.**).

Synapse gen.2 prevents multiple-masters scenario automatically. When the data seen in the RS-232 terminal contains unreadable text it usually indicates that either the towfish baud rate setting in the transceiver is incorrect, or that CAN bus terminations are not configured properly in one or more towfish. At least one and no more than 2 connected units should have their CAN bus termination enabled. Use the command **$cant,<sn>,1** to enable CAN bus termination in unit <sn>, or **$cant,<sn>,0** to disable it.

If the data shows dashes in place of one of the sensors readings, that sensor may be malfunctioning or has been disabled. Use the BOB Synapse configurator to enable the sensors as needed, or toggle sensor power off/on. Alternatively use the **$cons** command to enable the sensors, or the **$pwrt,<sn>,0** command to toggle the internal sensor power to 0; followed by **$pwrt,<sn>,1** to re-enable it.

For additional support, please do not hesitate to contact Marine Magnetics and we will be happy to assist you!

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