

Argos

total field gradiometer

for divers and ROV integrations

Operating Manual

Revision 1.4

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System Overview

Argos is a new type of magnetometer that is capable of measuring the total magnetic gradient using just a single omni-directional total-field sensor, and converting the output to an intuitive audible signal. It allows the diver to focus on diving, without having to interpret numerical measurement values, and effectively zero-in on the epicenter of a magnetic anomaly of a buried source. The audible signal consists of repeating pings, whose tone changes and rate increases as the diver approaches the magnetic source, making the interface even more intuitive.

In addition to the audio interface, a 7-LED array is included in the handle, which is tuned to be more sensitive than the audio interface, and provides an early indication to the operator that a magnetic source may be nearby.
The status LED on the back bulkhead indicates each measurement pulse, as well as the state of charge during charging.

Argos is turned on by plugging in the audio cable, and turned off by unplugging the cable. A separate charger cable is provided for battery charging only. It does not turn Argos on. A serial interface cable is also provided for attachment to a computer COM port, which allows firmware updates using the Argos app, as well as manual tuning adjustments.

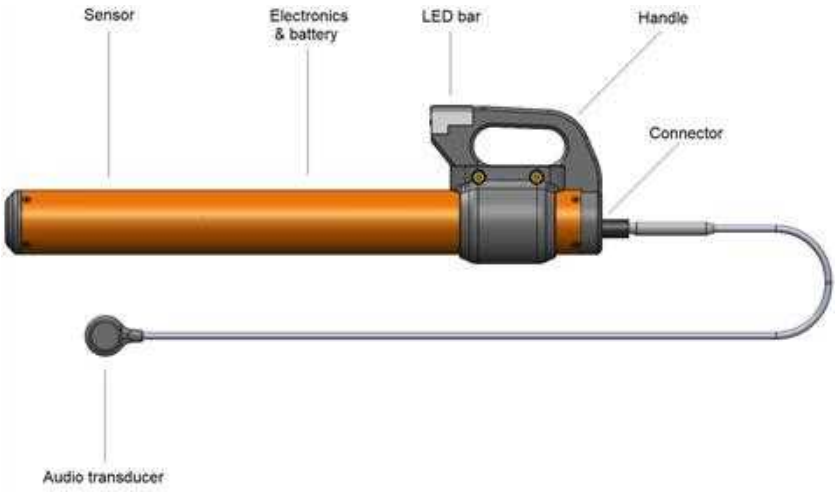


Figure 1 - Argos configured for normal operation

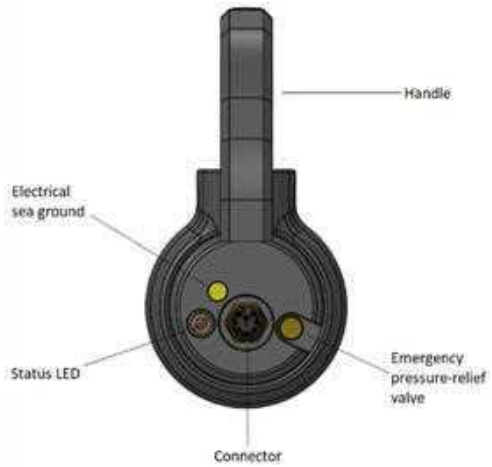


Figure 2 - Argos status LED, sea ground and main connector locations

Audible signal interface and LED bar

Argos' array of LEDs and audio output work together to indicate the presence of nearby magnetic targets. The audio signal is not synthetically generated. It is the true nuclear magnetic resonant signal generated by the sensor used to by the Argos computer to measure the magnetic field. The signal is initiated with an electronic ping that causes the sensor material to resonate at a frequency proportional to the magnetic field. The rate of decay of the resulting resonance serves as the measure of local gradient.

When there is no magnetic gradient present, which will happen when there are no magnetic targets nearby, the signal will decay after the ping at a relatively slow rate, and the blue LED bar will be off. As Argos approaches a magnetic target, the magnetic gradient will increase, causing the signal to decay at a faster rate. Argos can detect this before the human ear can, and will indicate it by gradually increasing the LED bar. By the time the LED bar is fully illuminated, the human ear can begin to detect a change in the signal decay rate. As the approaches the target, the magnetic gradient will increase further. The ping rate will increase in response to increasing gradient, from once per second up to 5 times per second, allowing the diver hear the increasing magnetic gradient in both the tone and the rate of audible signal. The rate of flashing of the large status LED will also increase.

The combination of these different feedback methods together enable the diver to zero-in on the epicenter of the source of magnetic anomaly. The rate of decay of the audible ping signal under various magnetic gradient conditions is illustrated in Figure 3. Note that profiles are approximate renditions of a single ping / reading, and are meant for illustrative purposes only.

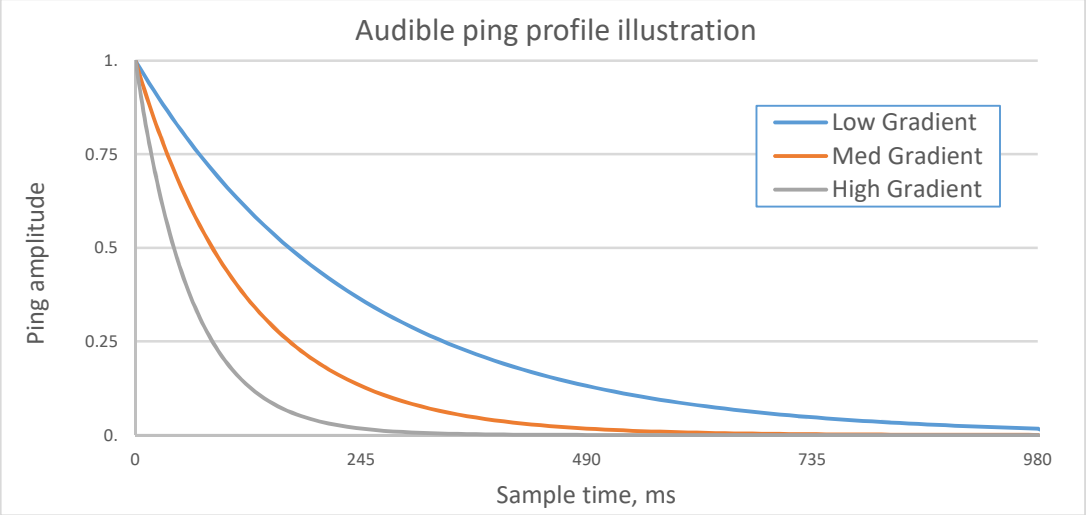


Figure 3 - Illustration of the audible ping profile under various gradient conditions

Magnetic Gradients

In areas free of magnetic objects the Earth's magnetic field is generally relatively constant and changes little over short distances. Magnetic gradients exist where the total magnetic field changes rapidly over short distances and commonly found nearest to sources of magnetic anomalies. Magnetic anomalies are typically created by objects containing concentrations of magnetic metals or naturally-occurring minerals. Most commonly these are objects and structures containing iron and steel, but can also be accumulations of a variety of magnetic materials such dark-colored igneous rocks, objects containing magnetite, nickel or cobalt, or permanent magnets. Common beach sand often contains particles rich in magnetite and can be weakly magnetic. Rocky outcrops, boulders, concrete containing gravel or iron rebar, and large accumulations of black sand may create magnetic anomalies.

As a general rule – large objects or structures have magnetic influences that extend over significant distances, and can be detected from many meters away. Their magnetic gradient will increase gradually as one approaches them.
Small compact objects, even highly magnetic ones, create magnetic anomalies concentrated in relatively small volume, and require the magnetometer to be closer in order to detect their influence. Gradients created by compact objects usually increase very rapidly over short distances.

The range of detection for a given object or structure is primarily dependent on the size of the object and its magnetic content.

Operating Notes

Status LED during normal operation and charging

Normal operation requires the audio cable to be plugged in. The status LED flashes with each ping during operation and indicates the state of charge with its color.

Color	Meaning	Notes
Orange	Initial setup on power-up, or connection to PC	Scanning for ambient noise
Red	Too much magnetic noise, or no electrical ground to water	Immerse Argos in water to provide electrical grounding, Or move away from sources of magnetic anomalies, and touch the grounding pin or restart Argos by unplugging/reconnecting the cable. See Troubleshooting section for details.
Green	Ambient noise acceptable	Tuning initialization to determine good starting value for field and gradient
White flashing	Normal operation Battery above 25%	Flashes indicate readings/samples, and coincide with audible pings As gradient increases, rate of samples and pings increases
Yellow flashing	Normal operation Battery below 25%	Between 1.5 hours and 3.5 hours of operating time is remaining
Red flashing	Normal operation Battery below 10%	Less than 1.5 hours of operating time is remaining

Table 1 - Status LED colors during normal operation

Color	Description
Orange	Initial setup on power-up
Green	Battery below 75%
Cyan	Battery 75-95%
White	Battery above 95%

Table 2 - Status LED colors during battery charging

Battery charging requires battery cable to be plugged in. Normal operation is disabled during charging.

While the battery is charging, the status LED will flash once every two seconds. Between flashes, the LED will remain dimly lit to let you know charging is in progress.
The duration of the flash indicates the charge level of the battery. A short flash means the battery is still nearly empty. As the battery charges, the flash duration will get longer until it becomes nearly continuous to indicate full charge.

Argos has a long battery life, approximately 15 hours. It is not necessary to charge it to 100% every time. Once the LED changes color to cyan, you should have at least 11 hours of runtime. For best battery service life, store Argos with the battery at approximately 50% charge level, when long storage period is expected.

Initial self-tuning on power-up

The device is designed to operate under water. It will not work correctly out of the water because the water provides an electrical ground that is important for normal operation. If you power it up (by plugging in the audio cable) while on your vessel right before you dive (which is the typical expected power-up situation), the LED will turn solid red to indicate that there is no seawater connection, and it will wait until a grounding connection is established.
As soon as the device is immersed in water, the status LED will flash green once, and then start flashing white to indicate that it's operating normally.

When there is no target present, it will be pinging at 1Hz, and the rate of pinging will increase to 5 Hz as the magnetic gradient increases (in proximity of a ferrous target).

Occasionally Argos may start working too early, before it is immersed in water, or may tune to the wrong magnetic field value (e.g. while onboard a vessel or in proximity of a large ferrous object). Incorrect tuning may be indicated by the immediate switch to the high ping rate following power-up. This may seem like it is detecting a magnetic target. This condition can be remedied by powering it down and powering it up again (by disconnecting and then reconnecting the audio cable), or by manually setting the tuning to the ambient magnetic field value (refer to following section for details).
For best results when deploying from a large vessel or in proximity of large ferrous objects, you can repower it in water after swimming away from the source of magnetic influence (e.g. the vessel) to ensure that the initial tuning will successfully find the correct ambient magnetic field value. Repowering can be done while holding Argos above water, or even while immersed; the connector is wet-mate-able. If repowering while immersed, it may be necessary to place your thumb over the Argos connector after unplugging the audio cable until you see all the LEDs go off, before re-connecting the audio cable.

Please refer to the Auto-Tuning section for more details.

LED bar

The LED bar may occasionally max-out following rapid or abrupt motion of the device in the water even when there is no magnetic object present. This happens more with rapid rotations or swivels of the device around an axis, and may take a couple of seconds to subside. This is normal, and a result of the complex physics governing the operation of this device. For best results, attempt to use smooth motion while operating the device, and avoid waving it back and forth over the sea floor, shaking it, or any rapid movements. You can keep it horizontal, or keep it at any angle, even straight down, so long as your movements are smooth and gradual.

Proximity to magnetic sources

This device is designed to detect targets as far away as possible, and the larger the target's ferrous mass, the greater its magnetic influence extends, and the further away it can be detected.

The device will also work fine very close to a target, even touching it. Don't be afraid to get close, or even touch the ground, or bury it right into sand if you are trying to pinpoint the exact location of a target. When you are that close, the earpiece provides the most valuable feedback. Much detail can be heard in the quality of the ping sound, especially at close distance to a ferrous object, once you have accustomed your ear to the sound.

Caring for the device

Use only the charger provided with the device for charging the internal battery.

After each use, especially in salt water, we recommend rinsing the device with fresh water, same as with any diving gear.

Be sure to rinse away any stray mud or other particles after the dive. Common sand may contain a large percentage of magnetic particles, and it is best to prevent those from accumulating in any crevices in the device.

Protect the device from direct and prolonged UV exposure, and avoid leaving it in direct sun in hot locations where it can overheat.

Always place the device in the shade when it is charging.

Never allow the device to come into contact with very strong magnets, such as neodymium magnets. Such magnets are orders of magnitude stronger than anything found in natural ferrous structures.

Always check the state of the pressure relief valve prior to and after each use, as it may indicate an internal issue.

Emergency pressure relief valve

The purpose of this valve is to provide a safe relief in the event of unexpected internal pressure. Such pressure may be caused by the following highly-unlikely but nevertheless possible circumstances:

- A leak that occurs at depth (where ambient pressure is very high), following which the device is raised back to surface level. Such a leak may be caused by a damaged o-ring seal somewhere in the device.
- Damage to, or failure of the internal battery

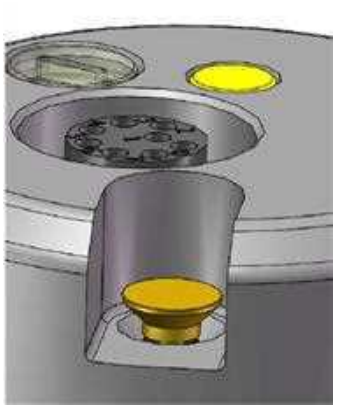
In its normal closed state, the pressure relief valve acts as a seal against leaks.

IMPORTANT: **Once tripped, the pressure relief valve becomes open and will remain in the open position until reset by the user. Submerging the device with the pressure relief valve in the open state will cause leakage and possible damage to the internal components of the device.**

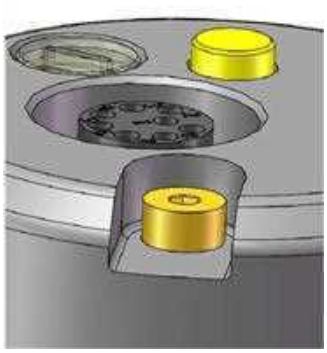
As illustrated in Figure 4, when in the open state the top of the valve will pop to a higher position than normal, and will become loose to touch. Be sure to inspect the device prior to and after each use, and check the status of the pressure relief valve.



Normal (closed) state of emergency pressure relief valve



Tripped (open) state of emergency pressure relief valve



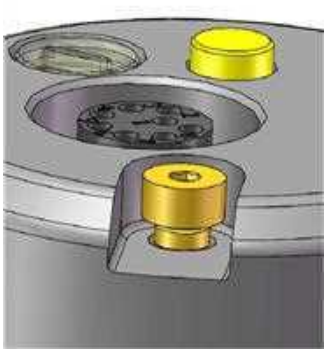


Figure 4 - States of the emergency pressure relief valve on various Argos models.

If the pressure relief valve is found in the open position following a period of storage, it may indicate an issue with the internal battery.

Do not operate or charge the device in this case, and contact Marine Magnetics support for guidance and troubleshooting.

Interface cables

The waterproof connector at the back of the handle can be used for all cable options: charger, audio interface and data interface. Connecting any of the interface cables turns Argos power ON by shorting pin 7 of the connector to GND (pin 8).

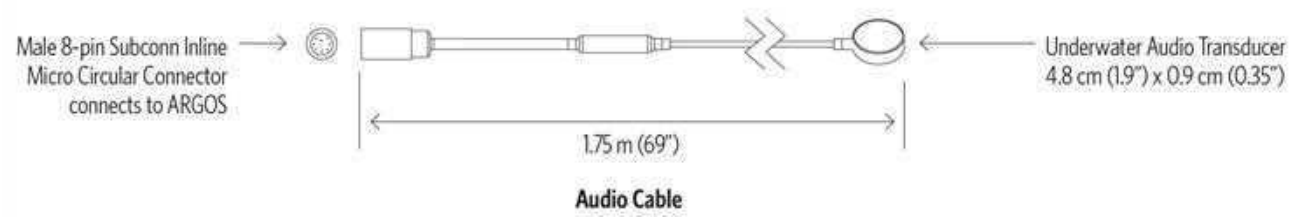


Figure 5 - Diver audio cable contains a piezo-electric audio transducer

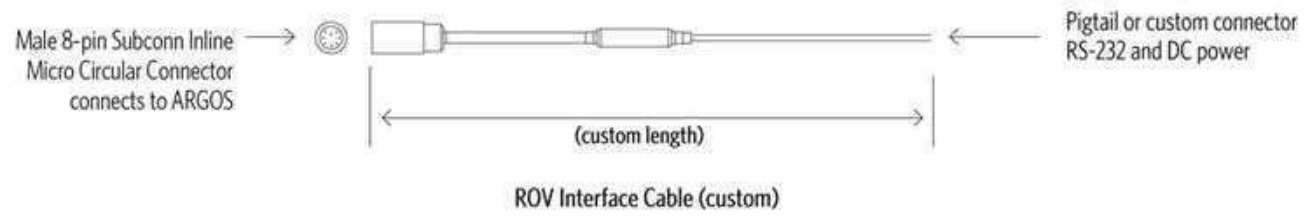


Figure 6 - ROV interface RS-232 cable can be customized to suit each integration application

The computer data interface cable provides an RS-232 DB-9 style connector for connecting to a serial port ora USB-Serial converter.

RS-232 settings: 38400 baud, 8-N-1

Argos Monitor app can be used to monitor and control Argos, and change some of the operating parameters. However, under normal operating conditions there should be no need for the user to interface with Argos using a computer. The status LED provides ample information to the user about the state of Argos.

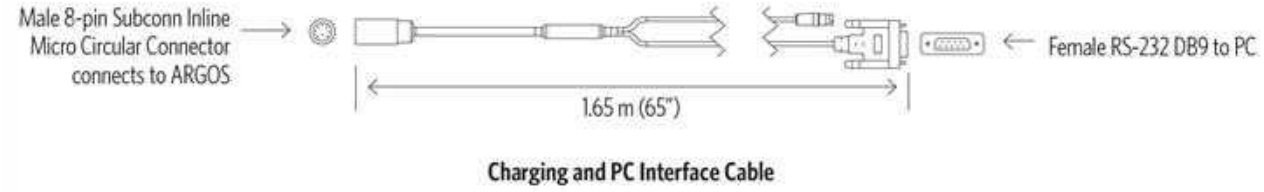


Figure 7 - Charger and RS-232 PC interface cable

Argos contains a built-in charge controlled that ensures safe management of the integrated Lithium-Polymer battery. Charging is accomplished using a 24V DC power adapter in combination with the charging cable.

Electrical connector pinout

Connector: MCBH8 style micro-circular; Female on Argos, Male on cable.

PIN	Function	Notes
1	Audio +	To external piezo speaker
2	Audio -	
3	RS-232 Tx	To DB9 pin 2
4	RS-232 Rx	To DB9 pin 3
5	V+	External power or battery charger. 24VDC nominal (20-30VDC accepted range)
6	RS-232 GND	To DB9 pin 5
7	ON/OFF	On/Off shunt, shorted in cable
8	GND	

Table 3 - Argos electrical connector pin-out

Notes:

1. RS-232 pair is twisted and shielded; shield connected to RS-232 GND.
2. V+/GND pair is twisted
3. Cable shield: connected to RS-232 GND only at the external DB9 end, but disconnected on the Argos side.
4. RS-232 settings: 38400 baud, 8-N-1

Argos data format

Argos uses ASCII readable text output, consisting of a single message for every measurement sample taken. The data sample is identified by #samp, and is followed by several parameters. The sampling rate is 1 Hz by default, and increases automatically up to 5 Hz as the magnetic gradient increases.

```
#samp,00:14:39.162,075%,+18.5,0783,052526.984,0975,0877.5,477
_____ ____________ _____ _____ ____ ___________ ____ ______ ____
SMPL     TIME      BATT% TEMPC SIG  MAG FIELD  DUR   TAU   GRAD
```

ID	Parameter	Notes
1	`#samp`	Identifier of the data sample response
2	`00:14:39.162`	Time of reading (reset to 0 whenever Argos is restarted). Can be set to current time using the $time command. See command reference for details.
3	`075%`	Battery charge remaining, %
4	`+18.5`	Internal temperature, deg.C
5	`0783`	Signal strength (0000-0999)
6	`052526.984`	Magnetic field, nT
7	`0975`	Sample duration, ms (0 – 999 ms). Sample duration shortens as gradient increases.
8	`0877.5`	Tau (decay constant). Optional parameter, roughly inverse of gradient.
9	`477`	Gradient strength (0-1000 scale)

Table 4 - Argos data format

Argos Monitor

Argos Monitor is a Windows-based app available on the Marine Magnetics web site. It uses the serial port interface connection to interact with Argos, and enables the user to monitor the data readings in real time, check battery charge status, switch between auto-tuning and manual tuning when needed, and to update the Argos firmware.

Key features:

- Toolbar with tabs for Setup, Monitor and Battery information.
- Battery level and flashing sampling indicator (top right)
- COM port selection
- Auto/Manual tuning setting
- Time sync panel
- Reboot button
- Real-time gradient plot with time scale and vertical scale selection options
- Vertical gradient bar with a recent maximum indicator
- Command terminal (for reference only; read-only by default, but can be used to send manual commands to Argos)

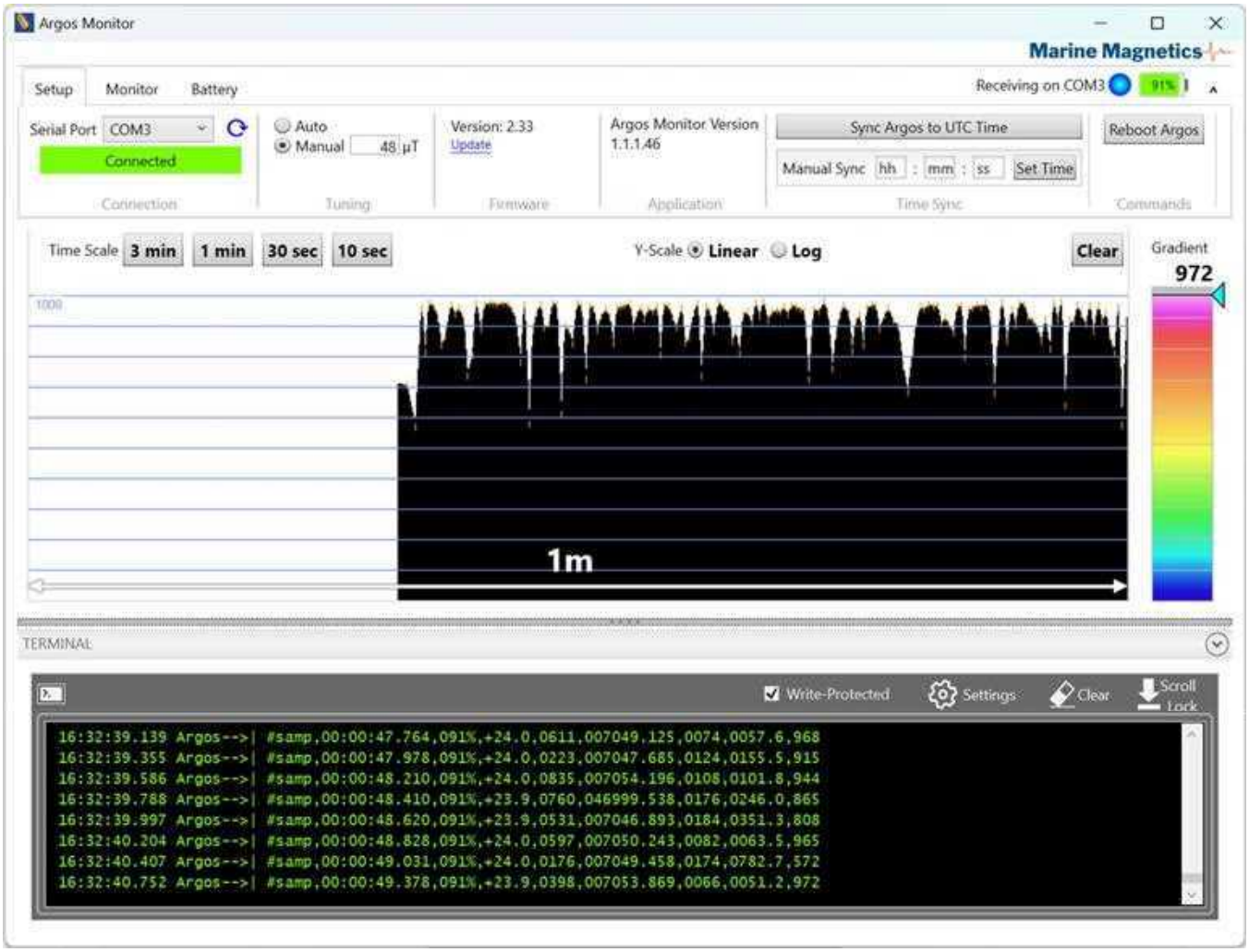


Figure 8 - Argos Monitor main interface: Setup tab

Auto Tuning vs. Manual Tuning

Auto-tuning is a feature that allows Argos to automatically and continuously optimize its operation to the average background magnetic field strength of its environment. Under normal circumstances auto-tuning should be enabled, and the user should have no need for connecting Argos to a computer.

Upon power-up, Argos will quickly tune itself to the current magnetic field, and will begin taking regular measurements at 1 Hz. When tuning is set correctly, the measured gradient should be relatively low unless Argos is in close proximity of a magnetic object.

Whenever the tuning is set incorrectly, Argos may shift from regular to rapid sampling rate immediately after powering up.

Auto-tuning may not be effective at setting the optimal tuning value if the ambient field changes dramatically, such as when working near industrial infrastructure or around large magnetic sources, or anywhere with strong and variable electromagnetic energy (power lines), or if Argos is powered up while in close proximity of strong magnetic interference.

In such cases, move away from sources of interference, and restart Argos. If that fails, setting the tuning value manually may help the sensor operate in high-gradient environments.

Setting the manual tuning using Argos Monitor

Illustrated below are steps required to connect to Argos and switch to Manual Tuning.

1. Select the COM port to which Argos is connected. You can determine the correct port number using the Windows Device Manager, under Ports.
2. Switch from Auto to Manual tuning
3. Enter the estimated field value, in micro-Tesla. (e.g. enter 43 for 43,350 nT)
4. You should see the $ptun command being issued to Argos, and a #ptun in acknowledgement of manual tuning.

If you are unsure of the typical magnetic field value for your survey area, you may determine it using one of several online magnetic field calculators. NOAA Magnetic Field Calculator is one such source, which generates several characteristic parameters for the Earth's magnetic field at a given location. Look for the value of Total Field, specified in nano-Tesla (nT), and convert it to micro-Tesla (µT).

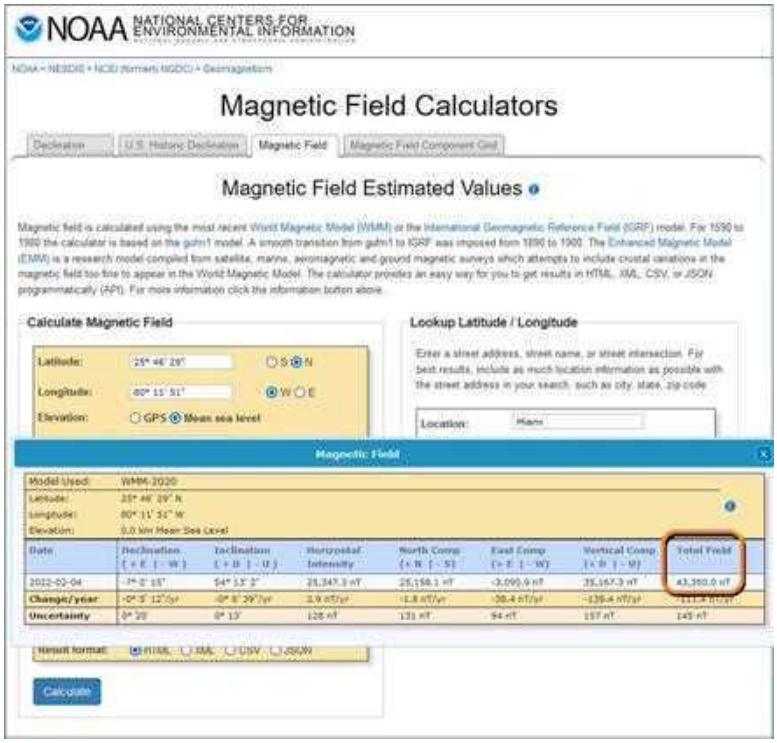


Figure 9 - Estimated Magnetic Field for a given geographic location, obtained using the NOAA Magnetic Field Calculator for a location in Southern Florida, USA.

The Monitor tab in Argos Monitor provides a detailed summary of the measurements reported in each #samp message.

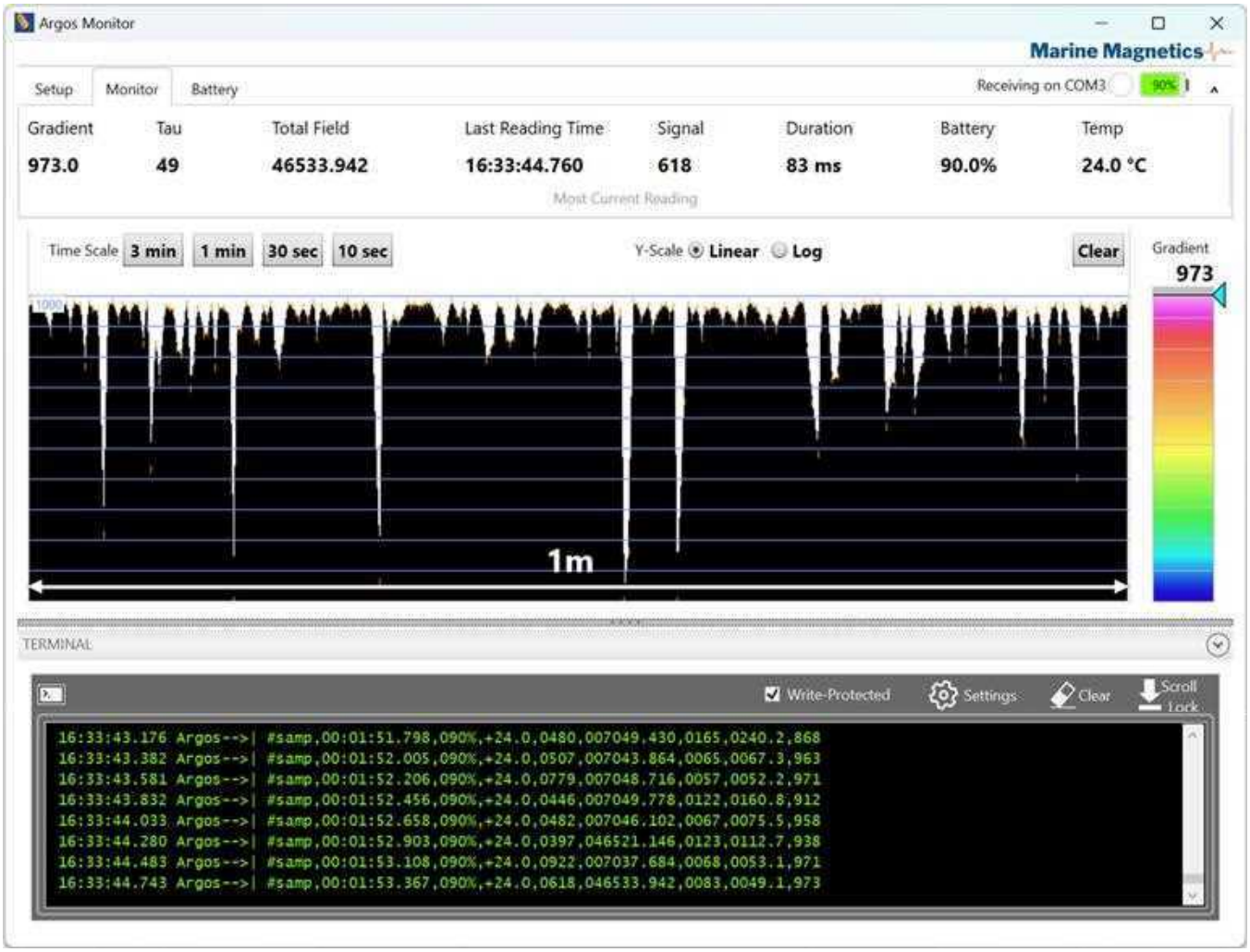


Figure 10 - Monitor tab in Argos Monitor decodes the #samp data messages

Noisy data can be identified by rapidly changing magnetic field and gradient measurements. This may be an indication of incorrectly set tuning, or that Argos is in close proximity of a strongly magnetic object or energy source.

Linear vs Log scales

The vertical scale of the profile plot can be set to Linear or Logarithmic.

Linear scale is the default setting, and is suitable for most gradient values between 100 and 1000 nT/m.

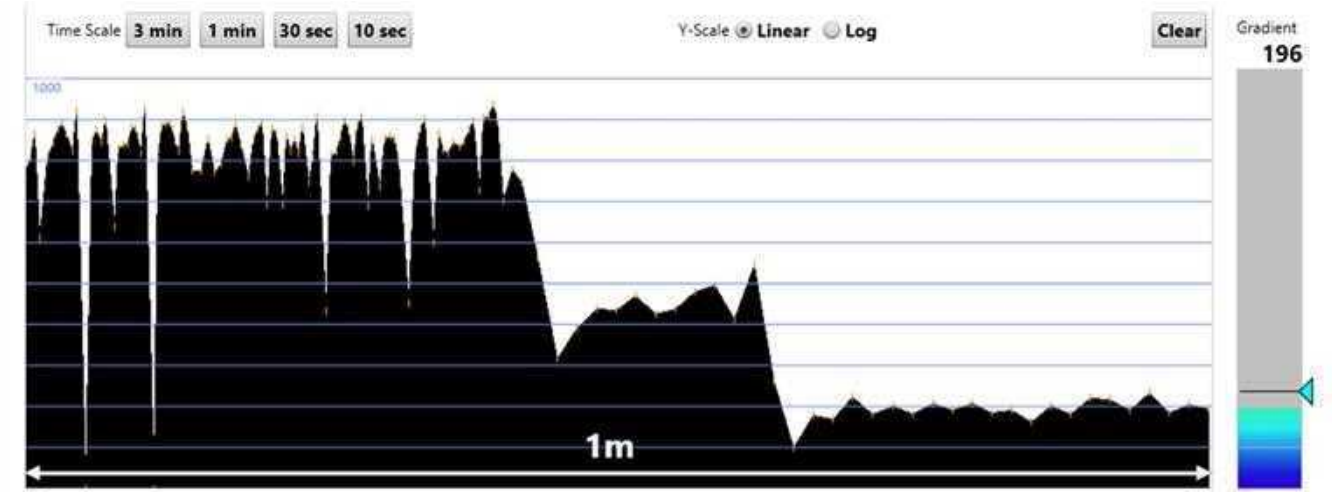


Figure 11 - Linear vertical scale

Log scale can be beneficial for low gradient signals (0-200), as it visually magnifies the low readings and compresses the high ones.

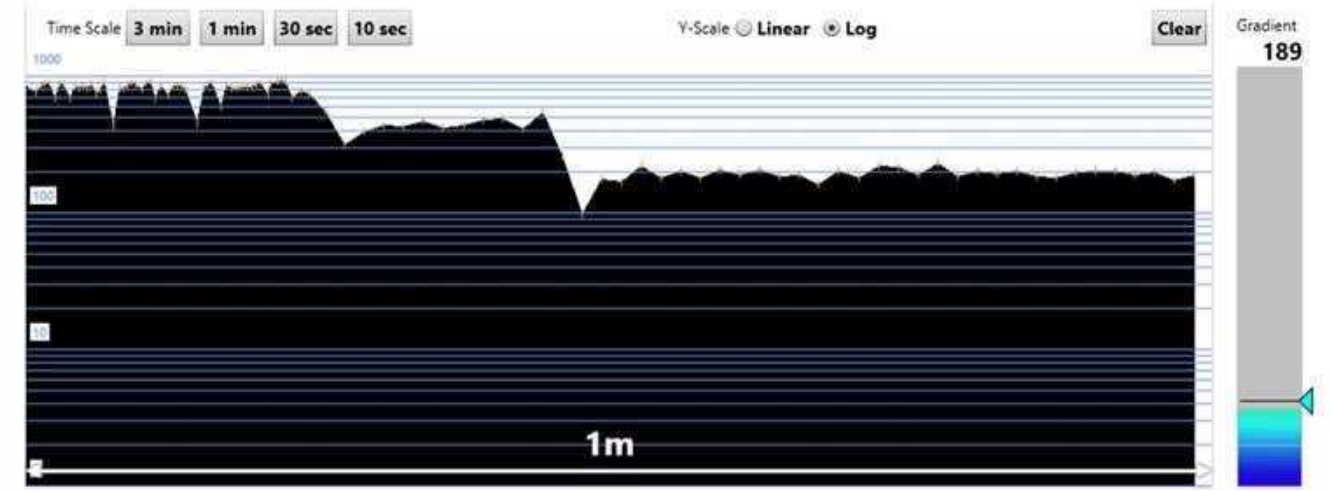


Figure 12 - Logarithmic vertical scale, suitable for low gradients

Data terminal

The data terminal shows the real-time raw data messages, and also provides a means for sending manual commands to Argos. Click on the terminal window to bring focus to it, disable the Write-Protected option box, and simply type in the command.
e.g. Command **$smpl,0** will stop sampling, and will be acknowledged with **#smpl,0**

The outgoing characters and commands are not shown by default, but can be enabled in the terminal Settings menu.

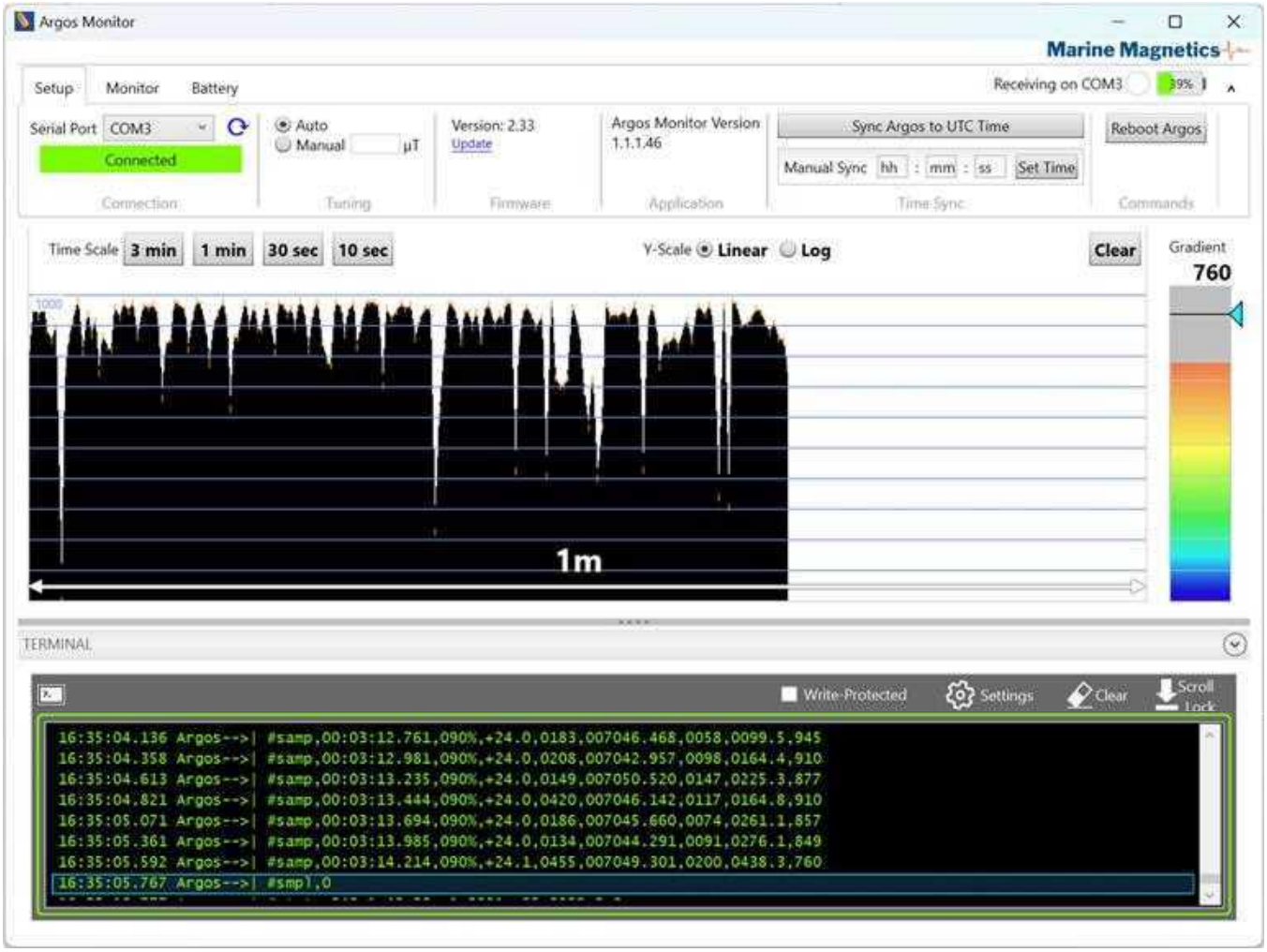


Figure 13 - Data terminal window shows raw data output and allows commands to be sent to Argos

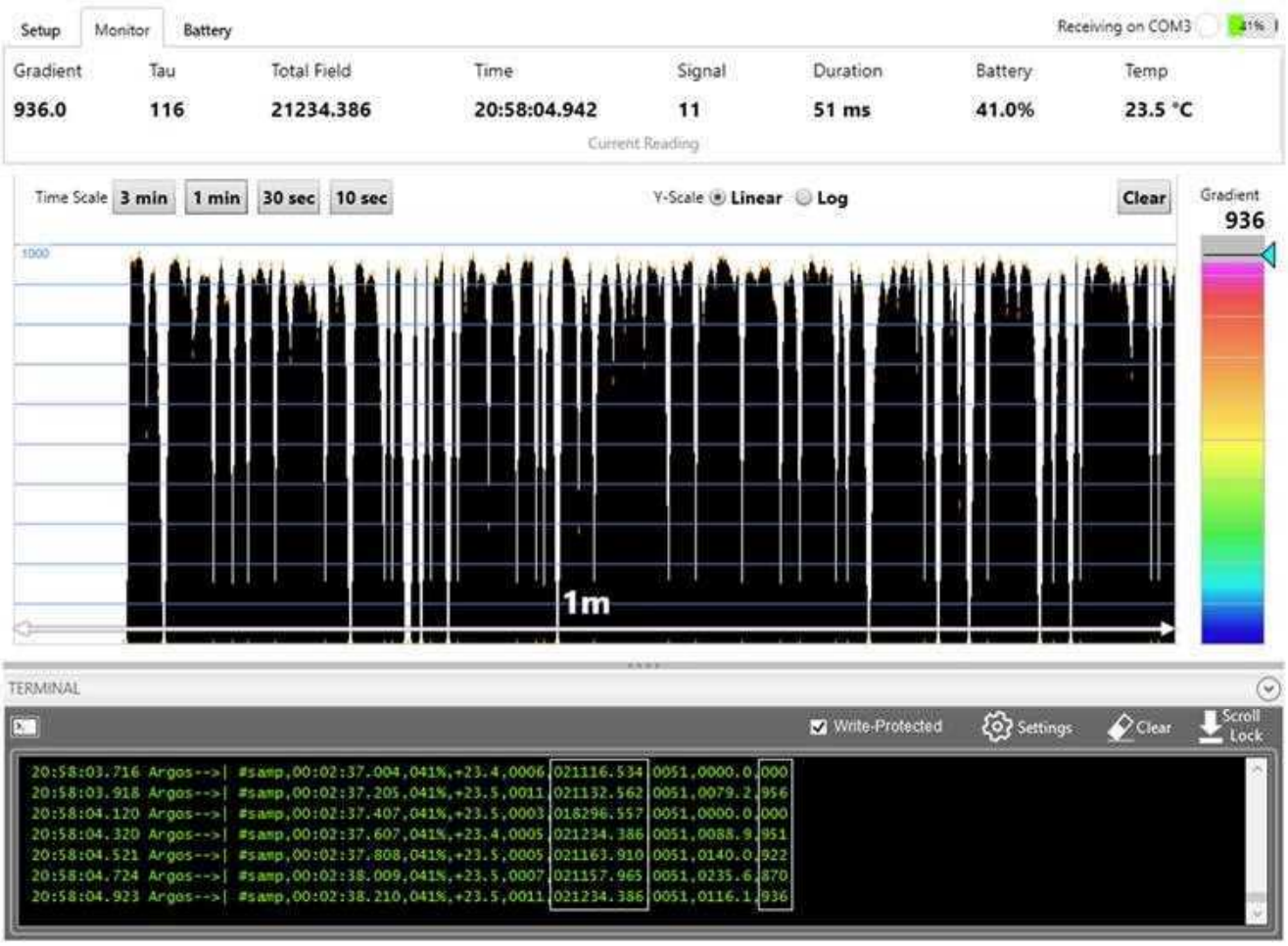
Argos Command Interface

Argos uses a proprietary command protocol developed by Marine Magnetics. Please refer to the Argos Command Interface document for a complete reference on commands, command parameters, responses and acknowledgements.

Troubleshooting

Argos is a total field gradiometer designed to measure high magnetic gradients in real-time.

However, when brought into immediate proximity of extremely-magnetic objects, or into varying magnetic noise environments (e.g. such as indoor locations with strong electrical mains noise), it may display erratically-varying gradient and field readings in the profile plot. If this occurs, move the Argos away from the source of interference, or try modifying the Tuning setting to a more suitable value for that location.



"Noise detected" warnings:

Argos outputs Noise Detected warnings and shows a solid red LED when it's unable to auto-tune at power up.
This indicates excessive electromagnetic noise, but may also be caused by lack of sea ground connection (e.g. when Argos is not immersed in water), and simply touching the grounding pin on the back of Argos near the cable connector will often fix the issue.

In this situation, the serial port data may look like this:

Noise detected: 437959 Noise detected: 542534 Noise detected: 387715 Noise detected: 185945 Noise detected: 364874 Noise detected: 311543 Noise detected: 287702 Noise detected: 348702 Noise detected: 135021 Noise detected: 3305458 Noise detected: 3061499 Noise detected: 4221170 Noise detected: 3489304 Noise detected: 3125150 Noise detected: 17881	**LED:** Red solid **Issue:** Excessive noise due to strong interference from a nearby source, or due to lack of sea ground (when testing in a lab, and not immersed in water)

Initializing 127:0 063:0 031:0 015:0 007:0 003:0 #samp,00:05:03.956,088%,+18.7,9999,000000.000,0051,0000.0,000 #samp,00:05:04.729,088%,+18.7,5314,047108.570,0499,0465.3,723 #samp,00:05:04.965,088%,+18.6,1743,047159.671,0119,0087.6,947 #samp,00:05:05.177,088%,+18.6,0958,047197.141,0145,0097.5,942 #samp,00:05:05.429,088%,+18.7,0757,047038.198,0121,0168.2,900 #samp,00:05:05.787,088%,+18.6,1043,047294.396,0072,0051.6,969 #samp,00:05:06.086,088%,+18.7,0566,047215.014,0086,0082.0,951 #samp,00:05:06.303,088%,+18.7,0712,047191.922,0112,0067.5,959 #samp,00:05:06.505,088%,+18.7,0747,047197.286,0119,0109.2,935 #samp,00:05:06.714,088%,+18.7,0526,047158.793,0128,0119.6,929 #samp,00:05:07.021,088%,+18.7,0750,047255.873,0113,0099.7,940 #samp,00:05:07.276,088%,+18.7,0621,046446.438,0122,0129.7,923 #samp,00:05:07.477,088%,+18.7,0949,047225.173,0083,0060.1,964	Moving Argos away from sources of electromagnetic noise, or providing electrical ground to the grounding pin on the back of Argos near the connector, results in successful tuning and transition to normal operation. **LED:** White flashes to indicate normal operation.