Sentinel2

Base Station Magnetometer

Operating Manual

Revision 1.3

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1. Introduction

A base station magnetometer measures background noise caused by fluctuations in the earth's magnetic field. Removing that noise from the mobile magnetometer's readings reveals the signal caused only by the features of the surveyed area, and makes survey data easier to interpret.

Sentinel2 is an advanced new generation marine base station magnetometer with features such as Wi-Fi wireless interface for ease of operation, integrated GPS for perfect time synchronization prior to each deployment, and an integrated tripod for easy deployments on land or underwater, with a maximum depth rating of 1000m.

At the heart of Sentinel2 is an Overhauser-effect magnetometer sensor, which is omni-directional and offers high sensitivity and high absolute accuracy, while requiring no maintenance. The Overhauser sensor inside the Sentinel2 is guaranteed to provide a drift-free reference correction for all the unexpected and unpredictable daily variations in Earth's ambient field.

High-visibility three-color RGB LEDs on the base of Sentinel2 use a combination of colors and pulse duration to communicate the system status to the operator. For example, they signal each reading and indicate excessive magnetic gradients caused by the presence of nearby magnetic sources.

Sentinel2 presents its own Wi-Fi access point that any device with a browser can connect to and access the web-based user interface to monitor readings, configure settings and download collected data.

Buoy and ballast line attachment points are provided for underwater mooring deployments.

The combination of these features makes Sentinel2 a robust, reliable, and easy-to-operate reference magnetometer for both land and underwater surveys.

Included with the Sentinel2 are an on/off wet-mate dongle (mag key), a charger cable with optional USB download connector, and a universal charger adapter. An optional cable that allows operation while connected to external battery power is also available.

Refer to Section 5 for a quick summary of Sentinel2 deployment steps for land-based and underwater settings.

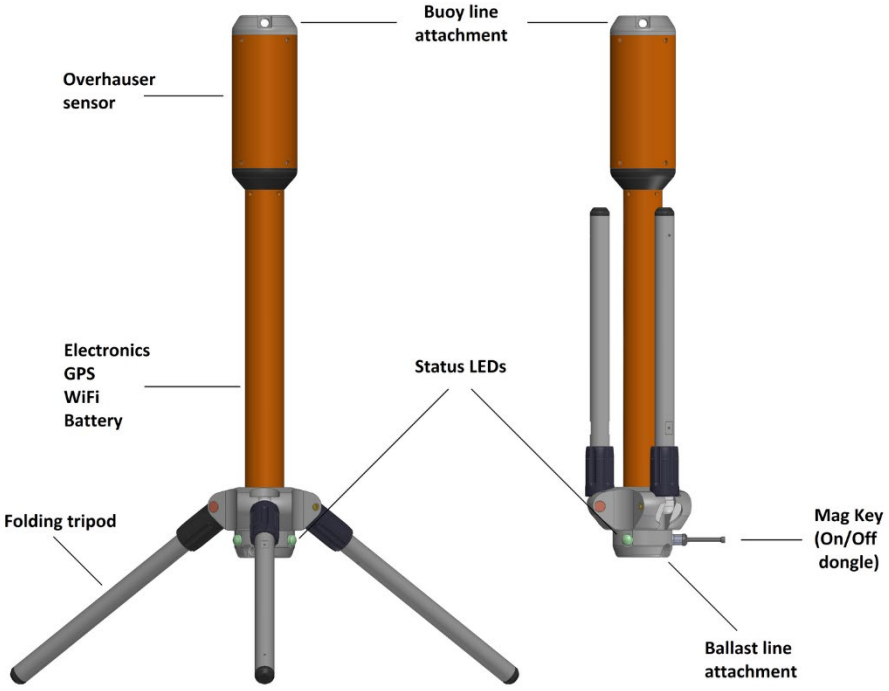


Figure 1-1 – Sentinel2 exterior features showing views with the integrated tripod in unfolded and folded positions

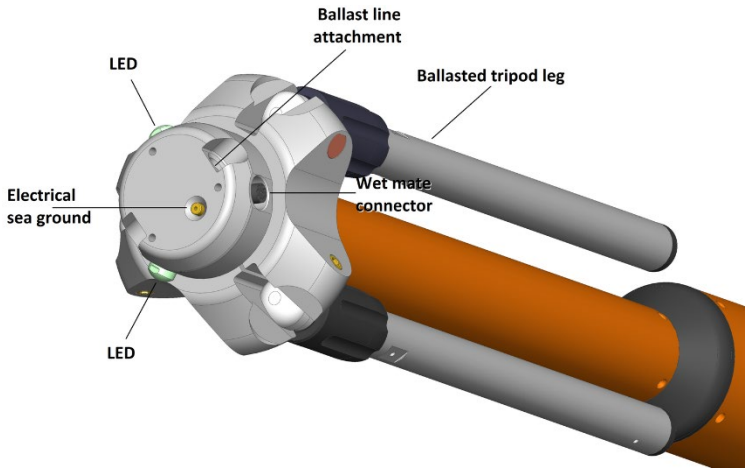


Figure 1-2 – Sentinel2 bottom bulkhead features a wet mate connector, a sea ground lug and bright RGB LEDs.

1.1. Interface cables

The waterproof wet-mate connector at the base of the Sentinel2 can be used for plugging in all available cables.

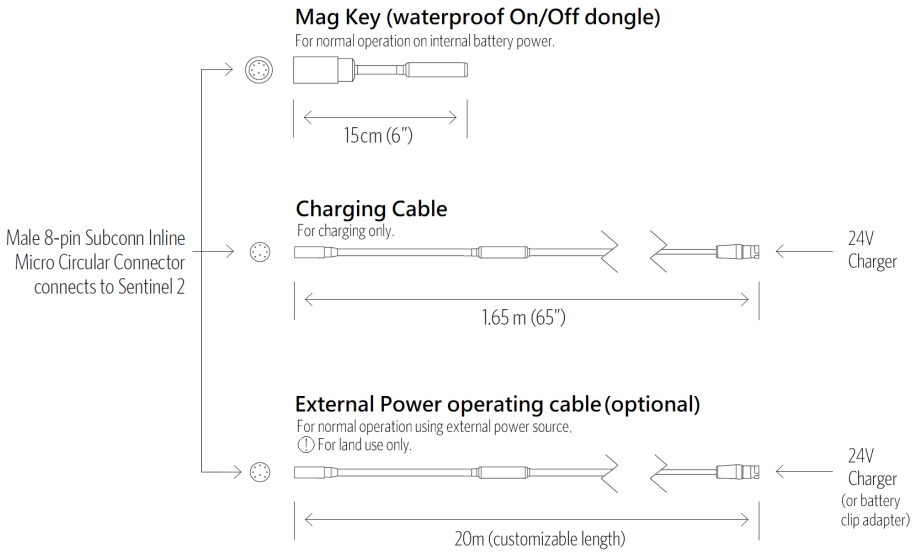
The Mag Key is a waterproof submersible dongle that serves the function of an On/Off switch, and is used for normal operation on land and underwater, using internal battery. Web User Interface is available during normal operation (while on land).

The charging cable can only be used for charging the battery, and is not waterproof. While the magnetometer is inactive during battery charging, Web User Interface remains available for wireless downloading of stored data.

An optional external power cable is required for simultaneous operation and battery charging, or for operation using external power. This cable is typically 20m long and water-resistant (not submersible).

If your application requires prolonged operation on external power while deployed underwater, please contact Marine Magnetics with your specific cable parameters and a custom cable may be made.

IMPORTANT: Mag Key must be removed/disconnected after the internal battery reaches the low charge level and the device shuts down automatically, and when the device is being stored.



1.2. Emergency pressure relief valve

Sentinel2 is equipped with an emergency pressure relief valve, to provide a safe relief mechanism in the event of unexpected internal pressure build-up. Such pressure may be caused by the following highly unlikely (but nevertheless possible) circumstances:

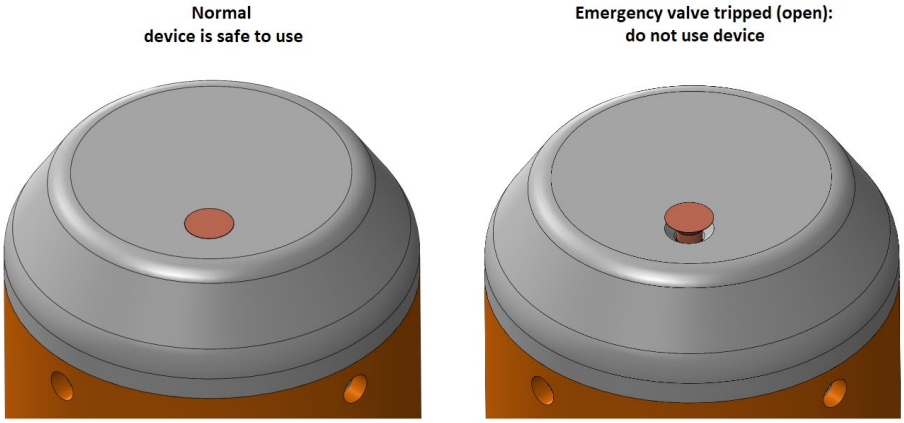
- A leak that occurs at depth, under very high pressure, following which the device is raised back to surface level.
  Such a leak may be caused by a damaged o-ring seal somewhere in the device.
- Damage to, or failure of the internal battery.

In its normal closed state, the pressure relief valve acts as a seal against leaks. Always check the status of this valve before each deployment.

IMPORTANT:

Once tripped, the pressure relief valve becomes open and will remain in the open position until reset by the user.
Do not operate the device if the valve is in the tripped/open position. Disconnect all cables from the device and contact Marine Magnetics technical support immediately.

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.



1.3. Specifications

Height on tripod	1.29 m	(50.7 in)
Length (without tripod)	1.05 m	(41.5 in)
Weight on land	17.7 kg	(39 lbs)
Weight in water	5.9 kg	(13 lbs)
Depth rating	1000 m	(3,280 ft)
Battery life	30 hrs at 1 Hz (1 sample/sec) 40 hrs at 0.2 Hz (1 sample / 5 sec). 45 hrs at 0.1 Hz (1 sample / 10 sec)	
Charging time	8-12 hours	
Sensor type	Overhauser effect total field	
Sensitivity	0.01 nT (standard); 0.02 nT (optional)	
Absolute accuracy	0.1 nT	
Sampling rate range	0.1 Hz – 4.0 Hz (1 Hz recommended)	
Measurement Range	18,000 – 120,000 nT	
Gradient tolerance:	10,000 nT/m	

2. Deployment considerations for optimal effectiveness

For optimal effectiveness, the base station magnetometer must be:

- located relatively close to the survey area
- deployed away from sources of magnetic interference
- kept stationary throughout the survey
- synchronized with the mobile survey magnetometer

Refer to Section 5 for a quick summary of Sentinel2 deployment steps for land-based and underwater settings.

2.1. Base Station distance from survey area

For maximum effectiveness, a base station magnetometer needs to be deployed in a setting similar to that of the survey site, such that both the base station and the survey magnetometer experience the same or very similar daily variation of the ambient magnetic field.

It is recommended to select a location with similar regional geology and within < 100 km of the survey site.

If the survey site is at shallow depth and reasonably close to shore, then the base station can be located on shore to simplify deployment process. See Sections 2.1 and 2.3 for deployment recommendations.

For surveys taking place at remote offshore locations, or at significant depths, the base station should be deployed underwater, ideally to a depth similar to that of the survey site.

Note that underwater deployment in sea water exposes the base station to the magnetic effects of moving salt water, which may result in regular rhythmic 'noise' associated with surface waves and currents to be present in the captured data. Such 'noise' can be easily filtered out during post processing.

2.2. Deployment away from magnetic gradients

To collect readings representative of ambient background magnetic variation, a base station magnetometer must be located away from local sources of magnetic interference, and magnetic gradients. This will ensure that any variation in background field recorded by the base station will be due to temporal atmospheric and solar effects, and unaffected by local gradients.

Strong magnetic gradients exist where the magnetic field changes rapidly over short distances. This can happen near objects containing magnetic metals or minerals, or near electric currents. Most commonly this includes objects and structures containing iron and steel but can also be accumulations of a variety of magnetic materials such, , magnetite, nickel, cobalt (commonly found in dark-colored igneous rocks), or concrete containing gravel or iron rebar. Rocky outcrops, boulders and large accumulations of gravel or dark-colored sand may also create magnetic anomalies in their vicinity.

The extent of magnetic interference created by a given object or structure is usually determined by its overall size and iron content. As a general rule – large objects or structures have magnetic influences that extend over significant distances and create measurable magnetic gradients tens or hundreds of meters away (e.g., buildings, vehicles or vessels). 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. Magnetic gradients created by compact objects usually decrease very rapidly over short distances, while those created by larger objects decrease more slowly with distance. Magnetic gradients created by pipelines or electric currents decrease much slower over distance and can be detected from further away compared to magnetic gradients created by isolated objects.

Sentinel2 contains no magnetic materials to guarantee operation free of measurement errors. When deployed, it is imperative that only completely non-magnetic materials be used within several meters of the magnetometer, including the mooring hardware, shackles, ballast, and buoys. Non-magnetic materials include brass, aluminum, titanium, plastic, or rope made of polymer or fiber. Although stainless steel is commonly considered to be non-magnetic, it is too magnetic when it comes to highly sensitive magnetometers. Stainless steel hardware must be kept at least 5m away from the Sentinel2 to prevent interference.

No stainless-steel rigging, shackles, swivels or fasteners shall be used anywhere within 5m of the Sentinel, as they will be picked up by the sensitive instrument and recorded as unwanted 'noise' in the data.
Absolutely no iron or regular steel must be used anywhere within 10 meters of the instrument, including stainless steel braided cables.

All rigging materials within 5m of the instrument must be made only of rope, plastic, titanium, brass, or aluminum fittings.

Other examples of magnetic interference include electrical power lines, vehicles and vehicle traffic, computers, smartphones, direct electrical currents, and permanent magnets of any kind. Avoid any form of direct current (e.g., DC chargers or charging cables) near the Sentinel2 during its operation, because direct current can produce significant magnetic fields.
Never bring powerful magnets anywhere near a magnetometer as it may cause permanent issues and impair its operation.

While it is difficult to provide specific guidelines for a safe distance from any given source of interference, the general recommendation is to set up the base station magnetometer at least 100m away from any buildings or vehicles, 200m away from any major roadways or marine traffic, and 1000m away from any high-voltage power lines, transformer stations, railroads, commercial shipping lanes or industrial facilities. Avoid concrete surfaces and structures which may contain iron rebar and other magnetic materials.

Refer to Table 2-1 for a summary of minimum recommended separation distance between the Sentinel and an iron object of a given mass to help prevent unwanted magnetic interference.

When deploying on lake bed or sea floor where overhead vessel traffic is expected, the Sentinel2 should be deployed to a depth of at least 20m to prevent registering small motor boats, or 50-100m when larger vessels may be present.

Table 2-1 - Minimum required separation between the Sentinel2 and iron objects to prevent unwanted magnetic interference. (Based on reducing magnetic effect to <0.1 nT)

Ferrous weight	Minimum required separation to prevent magnetic interference
1 kg	8 m
10 kg	16 m
100 kg	35 m
1,000 kg	76 m
10,000 kg	164 m

2.3. Stationary deployment

The purpose of a base station magnetometer is to capture only the temporal (diurnal) variation of the ambient magnetic field. Whenever a magnetometer begins moving relative to ground or seafloor, it stops being a base station and becomes a survey magnetometer, recording spatial variation in the magnetic field in addition to the temporal variation. For this reason, any movement should be avoided when choosing a deployment method. The best approach is to set up the base station on a firm level surface such as lawn, meadow, beach, lake bed or seafloor, using the integrated tripod. The slope of the surface must not exceed 15 degrees from horizontal (27% slope). When strong currents are expected, additional ballast must be tied to the anchor point to guarantee stability and prevent the instrument from swaying and getting toppled. All such ballast must be completely non-magnetic: e.g., lead or brass/bronze, affixed with rope made from polymer or fiber. Avoid using bricks and all forms of pottery because those are often magnetic. Do not use any steel or stainless-steel fasteners or hardware to prevent magnetic interference. Refer to Table 2-1 for safe distances from ferrous objects/hardware.

When deploying underwater, ensure that the buoy line attached to the top of the Sentinel2 will not lift the device off the bottom, or make it bounce or sway as a result of surface wave action and currents. It is recommended to provide a mechanism for isolating the surface wave energy from the Sentinel. Consider attaching the surface buoy to a (non-magnetic) anchor weight, and then connecting it to the Sentinel, to help isolate the device from all surface buoy vibrations and movements (see case “B” in Figure 2-1).

When deploying in mid water column, the recommended mooring style should have a subsurface float above the Sentinel2 (non-magnetic); the surface buoy line should be connected to an anchor block on the seafloor, rather than Sentinel2 itself. This will prevent unwanted swaying and rotation and guarantee data free of unwanted noise (see case “D” in Figure 2-1).

NOTE: When deploying on land on multi-day projects, it is important to use the same location each day, to avoid shifts in base station average between survey days caused by local magnetic gradients in the ground. For best results, mark the deployment location with a non-magnetic marker, and re-use the same location each day.

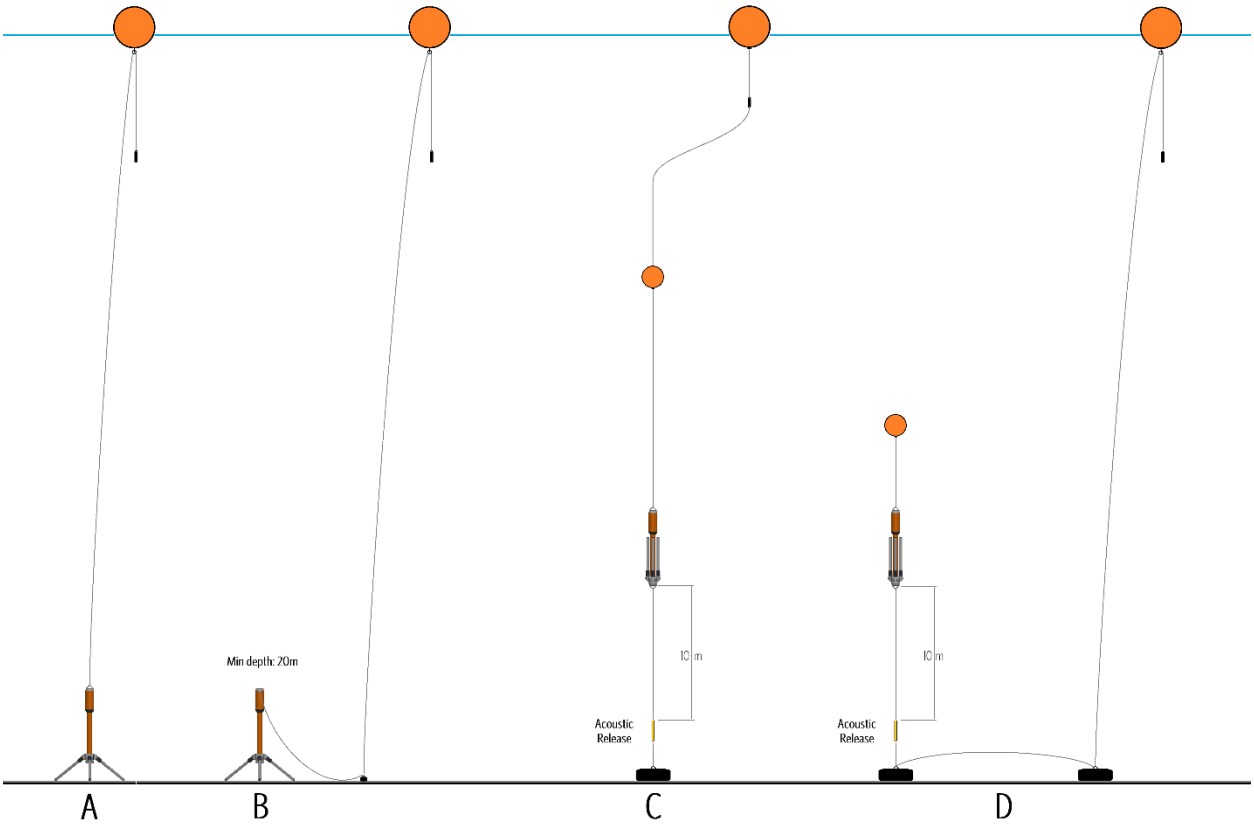


Figure 2-1 - Mooring configurations for underwater deployment. "B" is recommended for most situations. "C" and "D" are for deep water deployment. A slack compensating mechanism is strongly recommended at the surface buoy to isolate the Sentinel from surface wave energy.

- **A**: Shallow lakes without current on fine weather days (without waves).
  Surface buoy connected directly to the top of Sentinel; with slack compensation at the buoy.

- **B**: Recommended configuration for most situations.
  Surface buoy connected to a small non-magnetic ballast on bottom, with a loose connection to the top of the Sentinel. The ballast helps isolate the Sentinel from the vibration in the buoy line caused by surface waves and wind. The connecting line must be at least 3m long. Ballast weight must be at least 4 kg (or heavier for wavy conditions) and must be non-magnetic (made of lead, brass or bronze). Use of bricks and cinder blocks not recommended, unless positioned > 10m away from the Sentinel.

- **C**: Mid-water deployment with a subsurface float and a bottom ballast anchor for deep water locations.
  The subsurface float must offer at least 13 kg of lift capacity to help keep the Sentinel vertical and upright, and have appropriate depth rating. Slack compensation must be provided between the subsurface float and the surface buoy to help absorb wave energy. Acoustic release may be fitted between the Sentinel and bottom ballast, and must be at least 10m away from the Sentinel to avoid magnetic interference.

- **D**: Mid-water deployment with a subsurface float and two bottom ballast anchors for deep water high-energy locations.
  The subsurface float must offer at least 13 kg of lift capacity to help keep the Sentinel vertical and upright, and have appropriate depth rating. Additional isolation from surface wave energy is ensured by the second ballast on the bottom, with a loose connection to Sentinel's ballast. Slack compensation must be provided below the surface buoy. Acoustic release may be fitted between the Sentinel and bottom ballast, and must be at least 10m away from the Sentinel to avoid magnetic interference. Anchor blocks must be non-magnetic, or be sufficiently separated from the Sentinel to prevent magnetic interference. (Refer to Table 2-1).

2.4. Time Synchronization

Base station and mobile magnetometers should each be synchronized to within 1 second of GPS UTC time before surveying.

The main purpose of the integrated GPS in the Sentinel2 is to ensure the accurate time synchronization of the magnetometer clock.

Once the initial GPS sync is obtained, the Sentinel's internal clock and magnetometer clock will remain accurate for the duration of the battery life. However if the Sentinel2 is powered off for several hours after last obtaining a GPS time sync, or started up at a location without GPS signal, the user should ensure the internal time (i.e. Sentinel Clock) is set as accurately as possible using either a smartphone, or a computer that is synchronized to Internet time. Refer to section 4.4 for details on setting the Sentinel clock and Magnetometer clock via the Web UI Settings screen.

Table 2-2 lists the time reference device options for synchronizing the magnetometer clock, along with their availability and relative accuracy.

Table 2-2 - Time synchronization device options

Time reference device	Availability	Accuracy
GPS clock	Available whenever GPS signal fix can be obtained (clear open sky view). Automatically used to set the Sentinel clock and Magnetometer clock on power-up.	Most accurate
Sentinel clock – Internal battery-powered clock	Always available. Used automatically on start-up if the initial GPS sync fails.	Not very accurate after several days after the last GPS time sync
Smartphone clock	Available whenever a smartphone accesses the Sentinel2 Web UI via Wi-Fi	Considered accurate whenever a cellular connection is available
Laptop / Tablet / Computer clock	Available whenever a computer or tablet accesses the Sentinel2 Web UI via Wi-Fi	Least accurate, due to absence of cellular connection. Ensure your laptop or tablet clock is set as accurately as possible. For best results: ensure your computer is configured to auto-sync its date and time to Internet time.

TIP: Try to get a good GPS time sync each time you use the Sentinel2 by selecting an intial location in an open area with a clear view of the sky to guarantee a good initial GPS signal fix.

If GPS signal is unavailable at your selected deployment location, it is recommended to first power-up the device in an open area to guarantee good GPS sync, and then transport it to the desired location for deployment. During the transport the magnetometer can be set to idle mode (mag key connected, but magnetometer sampling turned off) until it is ready to deploy.

For further details on time synchronization in the Sentinel2, please refer to: Appendix A: Time synchronization details.

3. Operating the Sentinel2

3.1. Sentinel2 Operating Modes

Sentinel2 has five operating modes outlined in Table 3-1:

Table 3-1 - Status LED colors during startup and normal operation

Mode	Description	LED status	Wi-Fi	Magneto meter
OFF	Sentinel2 is off, except for the internal clock.	Off	OFF	OFF
Starting-up	A sequence of powering up various internal systems and GPS signal search	Series of different color flashes : **Blue flashes** during initial system power-up **Cyan flashes** during GPS signal search (1). **Orange flash** marks completion of start-up	OFF	OFF
ON	All systems ON, magnetometer resumes sampling at a rate selected prior to shut down; or idle. Web UI available.	**Green flashes:** magnetometer sampling, good sync (i.e. GPS or smartphone sync) **Yellow flashes:** magnetometer sampling, internal clock sync only. Try syncing to a smartphone via Settings if GPS is unavailable. **Purple flashes:** magnetometer sampling, poor reading quality due to nearby magnetic interference. Try repositioning the Sentinel2. **Red flashes:** magnetometer ON but idle (not sampling) **Red constant**: problem detected. Try restarting the Sentinel2.	ON	ON
Shutting down	A sequence of safely shutting down various internal systems	**Blue flashes** during system shut-down sequence. Do not re-connect the mag key dongle during this state.	OFF	OFF
Charging only	Battery charging (2). Wi-Fi enabled, magnetometer disabled	**White Duty-Cycle pulsing** (3) Pulse duration indicates % battery charge.	ON	OFF

Notes:

1) During the start-up sequence, the Sentinel2 attempts to get a GPS signal lock for up to 35 seconds, during which the LED flashes cyan. If unable to secure a GPS sync, Sentinel2 uses its internal clock to sync the magnetometer, and flashes yellow to indicate magnetometer sampling without synchronization. Connecting a Wi-Fi client device synchronizes the magnetometer clock to the client device, and the LEDs flash green to indicate reliable synchronization. When operating the Sentinel2 without GPS access, ensure that your client device has its clock set as accurately as possible. A mobile phone with cellular connection is considered reliable. A laptop computer that has not been recently synchronized to the internet time reference is less reliable.
2) Standard accessories supplied with Sentinel2 include a mag key (for normal operation) and charging cable (for charging only). An optional external power cable must be used to enable the Sentinel2 magnetometer to operate while on external power or while charging. See Section 1.1 for details.
3) The state of the battery is indicated by the “duty cycle” of the light – i.e. the ratio between the time it’s on vs. the time it’s off. For example a pulse that is on 50% of the time, and off 50% of the time indicates that the battery level is 50%. A short white pulse with a long pause between pulses indicates a low battery. A long white pulse with a short pause indicates a high battery level.

3.2. Sentinel 2 status LED sequence and modes

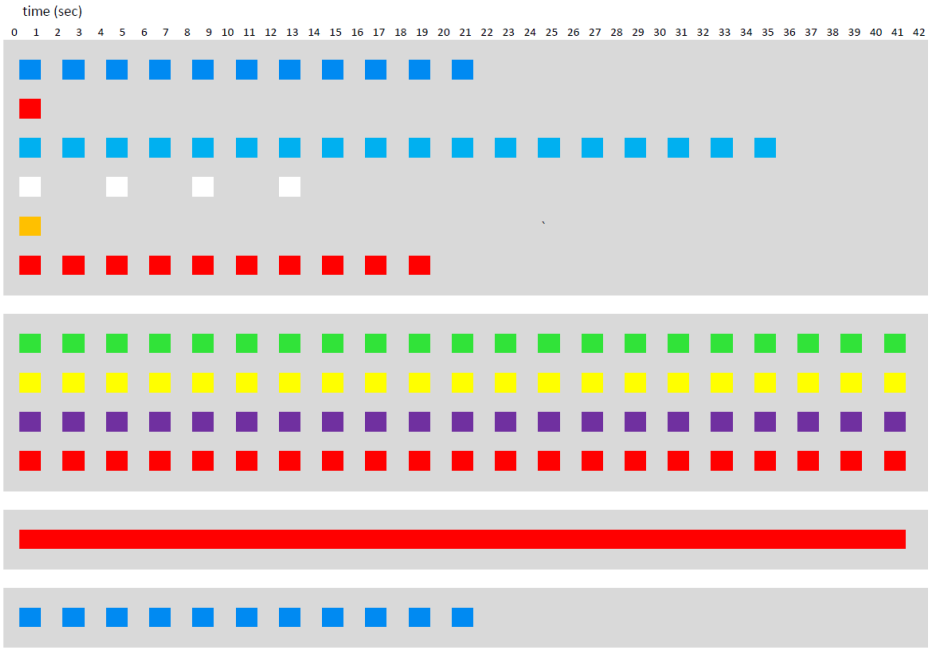
Sentinel2 LED Sequence

SW Release: 12/6/2022

Sentinel2 uses a combination of LED colors and pulsing/flashing modes to indicate its state.
Battery level is only indicated during charging-only mode.
During normal opration (mag key connected) the LED never indicates the battery state. Use WiFi user interface instead.
Sentinel2 will sync its clock to the connected client device (smartphone or computer) each time WiFi user interface is accessed.
WiFi becomes available after WiFi start, and stops when H/W Shutdown begins.

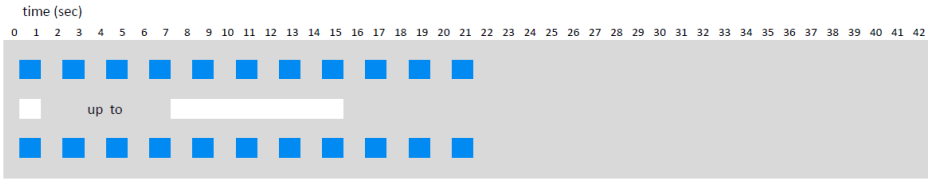
NORMAL OPERATION (Mag Key connected)

	Stage	LED pattern	Duration
1	**H/W Startup** **Liam start**	**Blue flashes**	20 s @ 1 Hz
		Red flash	1 flash
2	**GPS Fix search**	**Cyan pulsing**	1-35 s @ 1 Hz
	(syncs Sentinel internal time to GPS and/or Internal Real-Time Clock)		
3	**BOB Server start**	White throb	15 sec @ 0.3 Hz
4	**WiFi start**	**Orange flash**	1 flash
5	**Mag power up; Idle**	**Red throbbing**	1-20 s @ 2 Hz
	(enables auto-tuning, syncs mag time and resumes sampling automatically)		
		Green Pulses	(mag good, sync good)
6	**Sampling** (any of the following:)	**Yellow Pulses**	(mag good, sync poor)
		Purple Pulses	(mag bad / interference)
		Idle (sampling disabled)	red throbbing
	Mag Error, or **Mag unresponsive**	**Red solid**	
	(enable diagnostic logs in Settings, try restarting)		
7	**H/W Shutdown**	**Blue flashes**	20 s @ 1 Hz
	(after mag key gets disconnected)		



CHARGING ONLY (Charging cable connected)

	Stage	LED pattern	Duration
1	**H/W Startup**	**Blue flashes**	20 s @ 1 Hz
2	**Charging**	**White duty cycle pulsing**	0.1s up to 1s pulses @ 1 Hz
3	**H/W Shutdown**	**Blue flashes**	20 s @ 1 Hz
	(after external power is disconnected)		



IMPORTANT:
Never interrupt the H/W Startup or H/W Shutdown stages by disconnecting or re-connecting the cable/mag key during blue flashing modes.
Always wait for the startup/shutdown to complete before reconnecting the cable/mag key.

Time Sync status: Good sync: GPS or Web Client (aka smart phone or PC)

Poor sync: Internal backup clock. No GPS during startup
Try re-syncing to GPS via Settings in Web UI.

3.3. Turning ON / OFF

Sentinel2 is turned on by connecting the mag key (on/off dongle) to the mating connector on the base of the device. Take care to observe correct connector alignment and prevent any dirt or debris from getting into the connector. **Do not insert the connector blindly to avoid pin misalignment and potential damage.** Use the plastic locking sleeve on the mag key to secure it to the Sentinel2 and prevent it from coming loose.

The power-up process takes approximately 1-1.5 minutes, depending on GPS signal availability. Avoid disconnecting the mag key during the power-up sequence as it may lead to unexpected modes.

To turn off the Sentinel2, simply unplug the mag key during its normal operating state. The shutdown process takes approximately 30 seconds to 1 minute, during which the LEDs will continue flashing blue. The shutdown is complete when the LEDs stop flashing completely. Wait at least 30 seconds after seeing the last flash before powering up the device, to prevent unexpected modes.

3.4. Charging

To charge the Sentinel2, simply connect the charging cable instead of the mag key, and connect it to the included universal charger. Use only the charger provided with the device for charging the internal battery. Always place the device in the shade (or indoors) when it is charging, to prevent overheating.

Always wait for the safe shutdown sequence to be completed after disconnecting the mag key, before plugging in the charging cable. Wait at least 30 seconds after seeing the last flash of the shutdown sequence, before connecting the charger cable.

Note that simultaneous charging and normal magnetometer operation is only possible with the optional external power cable. See Section 1.1 for details.

3.5. Storage and Caring for the device

Prior to long-term storage, ensure the battery charge level is 50-75%, but not higher, in order to maximize battery longevity.

Store the device dry and clear of salt, debris, and contaminants. After each underwater use, especially in salt water, we recommend rinsing the device with fresh water, same as with any diving equipment. Be sure to rinse away any stray mud or debris. If salt water has entered the connector on the base of the Sentinel, be sure to rinse it out with fresh water, blow it out with compressed air and allow to dry fully.

Do not allow sand, mud, or dirt to accumulate in the crevices of the device, as it will cause friction and unwanted wear, as well as potentially trap magnetic particles or materials very close to the sensor and lead to unwanted noise in data.

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

Never allow the device to fall over or drop onto hard surfaces as it may damage the internal components.

Never allow the device to come close to strong magnets. Such magnets are orders of magnitude stronger than anything found in natural ferrous structures and may cause permanent damage to the magnetometer or magnetize its components.

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

3.6. Transporting the device

Sentinel2 features a robust exterior shell able to withstand external pressure up to 100 bar / 1000m, and some mechanical shocks. However, as with any sensitive precision instrument, care must be taken to prevent drops, falls and mechanical shocks that may lead to damage of internal components or compromise pressure seals.

Always transport the Sentinel2 inside its shipping case.
Never stand up the Sentinel2 without its tripod being securely un-folded.
Never allow the Sentinel2 to drop from a standing position onto a hard surface.

4. Web User Interface

Sentinel2 provides full access to its settings and features via a web interface, by creating a Wi-Fi access point and allowing client devices to connect to it.

4.1. Connecting to the Sentinel2 Wi-Fi

After Sentinel2 has been powered up and has completed its startup sequence, you can connect to its Wi-Fi network using the password provided with your Sentinel2.

Sentinel2 UNIT SERIAL NUMBER: XXXX (write your S/N here: _____)

WiFi SSID: sentinel_xxxx
WiFi PSW: marinexxxx

If you are unable to see the Sentinel2 network, try coming closer or changing your position by walking around the Sentinel2.

The WiFi antenna is on the same side of the unit as the Mag Key connector.

Once connected, open the browser and navigate to: http://192.168.42.1

For ease of use, consider creating a bookmark or shortcut to this page in your browser or on the home screen.

NOTE: Some browsers may try to automatically switch from http:// to http**s**://, which will prevent the Web UI from opening. In this case you can manually edit the URL to ensure it begins with http://, or change the browser setting that automatically changes the URL.

If you temporarily lose your connection to the Sentinel2, and later return to it, the page may appear unresponsive. Simply refresh the web page to restore the link.

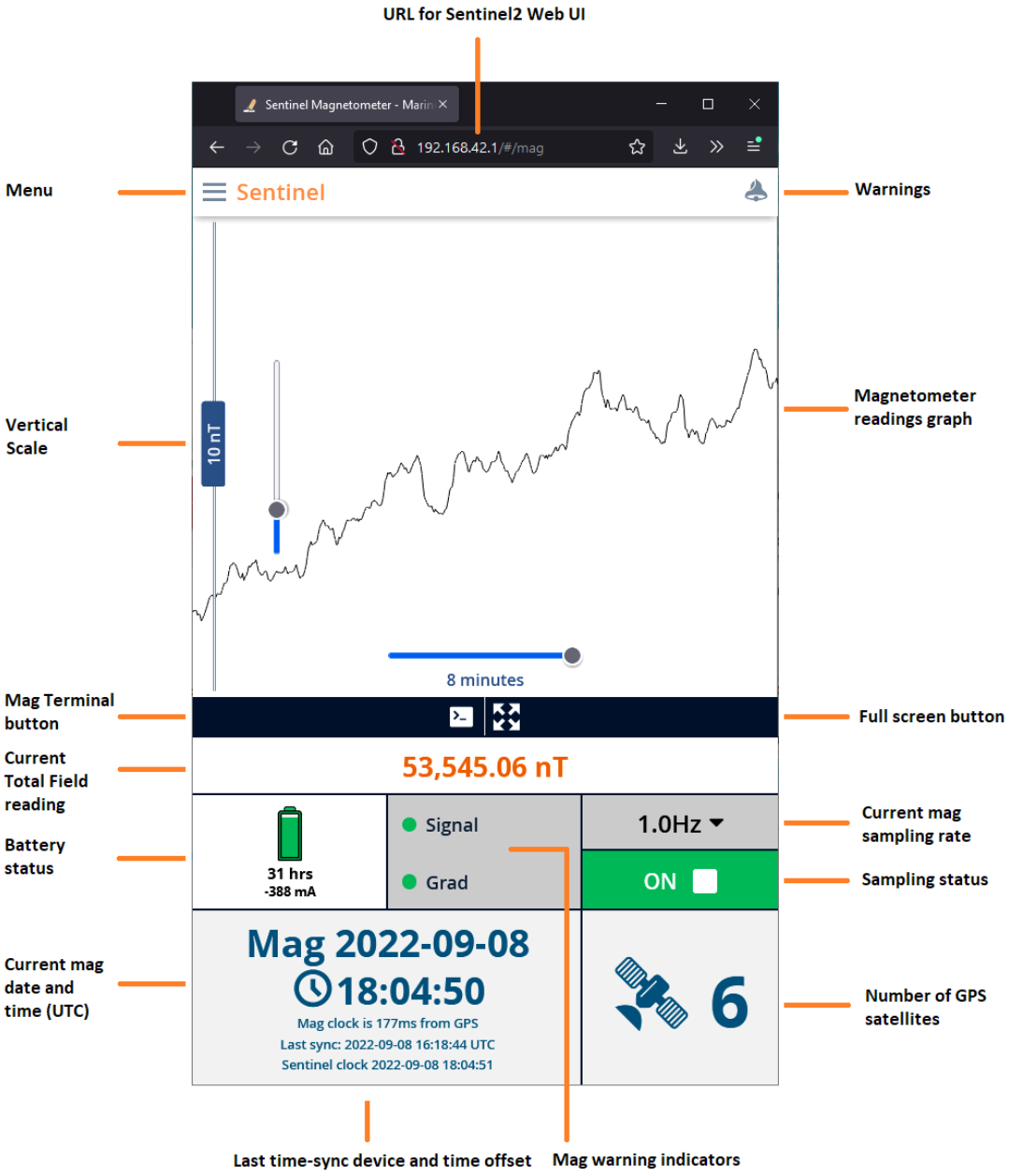
4.2. Main screen

The main screen of the Sentinel2 Web UI provides a general summary while focusing on the magnetometer data and status.
The main view features a profile graph of recent magnetometer readings, with vertical and horizontal scale adjustments.

Below the mag profile is a tool bar with a mag data terminal view button and full screen button. (See Section 4.6 for mag terminal details)

Current battery life is shown beside the magnetometer warning indicators, mag sampling rate and sampling status.

Current magnetometer clock date and time (UTC time zone) are shown at the bottom, along with the last reference device used to sync the magnetometer clock (e.g. GPS), as well the number of GPS satellites currently visible.



4.2.1. Time synchronization status

When it comes to time synchronization, the most important thing is to have the mag synchronized to the GPS with a difference that's less than 0.5 seconds (500 ms). Sentinel2 will display the current date and time of the mag clock, and below it the relative offset to the last sync device. The 'Sentinel' clock reflects the 'system time' of the built-in computer, and is distinct from the mag clock.

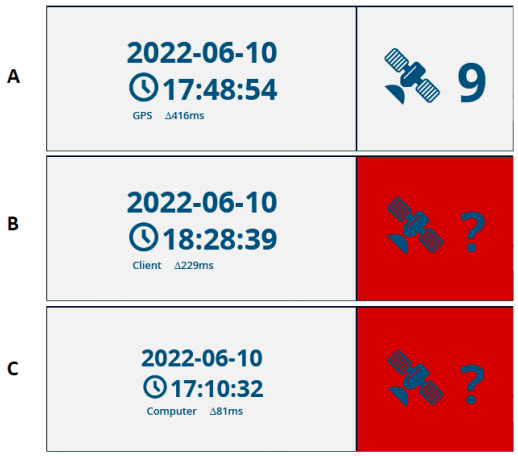
The following three options are possible, in order of reliability (as time reference source):

A. "GPS" is the most reliable time reference device. Time offset should be < 750ms

B. "Client" – meaning WEB client: either a smartphone with a cellular connection (better),
or a laptop computer without cellular (less reliable)

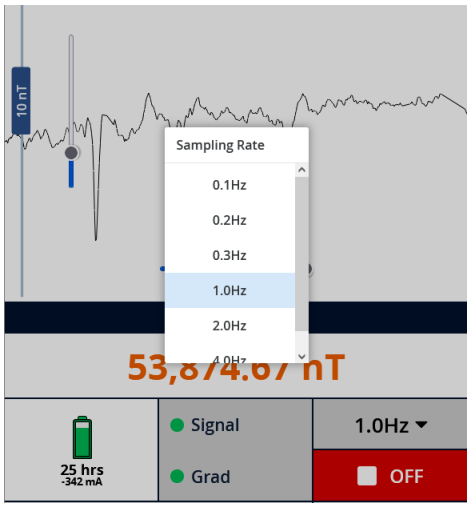
C. "Sentinel"– meaning the internal battery-powered clock in the Sentinel (least reliable unless recently synchronized).

If you see that the mag time offset is specified relative to "Sentinel" time instead of the "GPS" time, while the GPS satellites are visible, try manually syncing the Sentinel2 to GPS through the Settings screen. See Sections 4.4 and 2.4 for details.



4.2.2. Selecting a mag sampling rate

Magnetometer sampling rate can be selected from the drop-down menu above the sampling status button.
The available choices range from 0.1 Hz (one reading every 10 seconds) to 4 Hz (4 readings per second).
Generally, a 1 Hz sampling rate is considered high resolution for a base station magnetometer.
In most cases, a slower sampling rate such as 0.2-0.3 Hz will provide good data resolution while improving battery life.
Consider that typical magnetic observatory data contains only 1 sample per minute (0.016 Hz).



4.3. GPS screen

The GPS screen of the Sentinel2 Web UI features a real-time GPS data stream terminal window, with a summary below.
Here you can check if the GPS NMEA data strings contain valid data (A) or empty data fields (B).

The Sentinel2 GPS tracks two NMEA data strings: GPGGA and GPRMC, both of which begin with the current UTC time, and contain the key minimum GPS data.

Detecting a valid fix:

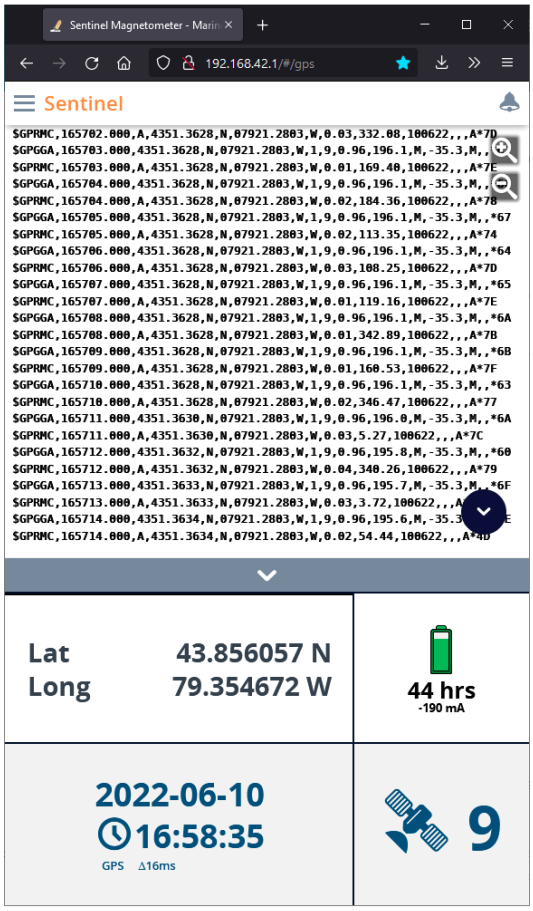
If the fix is invalid the satellite image is red.

In the terminal, the $GPRMC sentence indicates fix quality right after the time value:
"A" indicates a valid GPS signal lock and is followed by valid Lat/Lon coordinates. (e.g., case A)

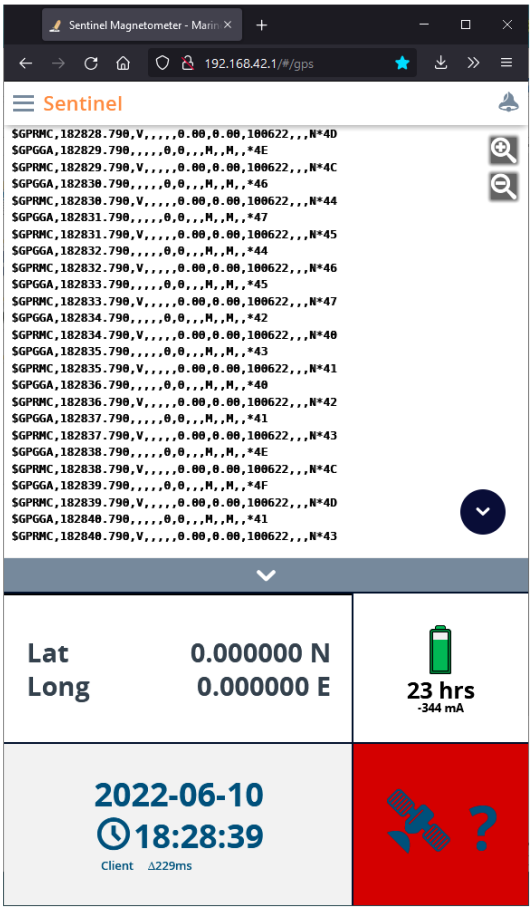
"V" indicates an invalid GPS signal lock, without any visible satellites or valid coordinates. (e.g., case B)
Note that in the case of invalid GPS lock, the latest time reference device is usually something other than "GPS".

[See the NMEA manual for details on the other values in these sentences.]

A



B

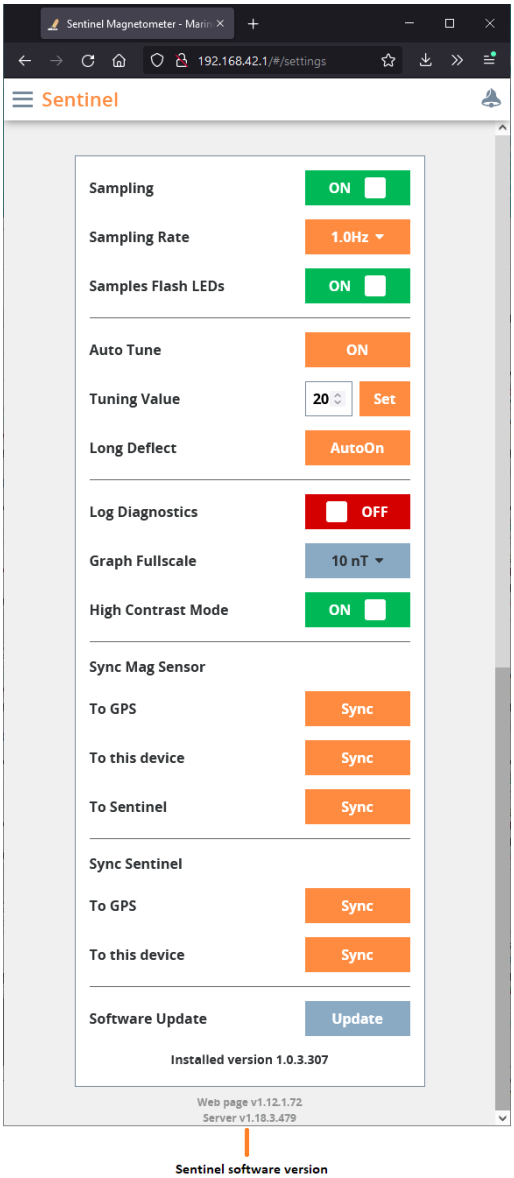


4.4. Settings screen

The Settings screen of the Sentinel2 Web UI provides all the necessary configuration options for the key system components, including: Magnetometer sampling controls and LED settings, Magnetometer tuning parameters, Log and Profile graph settings, and time synchronization settings.
Auto-Tuning is a feature that enables the magnetometer to automatically self-adjust to the local magnetic field strength and obtain the highest signal strength possible for that location. As such, auto-tuning should always be enabled, unless you have a compelling reason not to (e.g. testing or experimenting indoors or in the vicinity of strong magnetic gradients).

Log Diagnostics option enables detailed diagnostic logs to be saved, which may be useful for troubleshooting.

Software Update button allows a previously downloaded update file to be uploaded to the Sentinel. (See Section 4.7 for details).



The variety of time synchronization options may seem redundant, but it covers all the possibilities. The most important goal for synchronization is to sync the mag sensor to GPS, and ideally also the Sentinel2 (i.e. Sentinel's internal computer) to GPS.
"This device" represents the device used to connect to the Web UI. Refer to Section 2.4 for details on time synchronization.

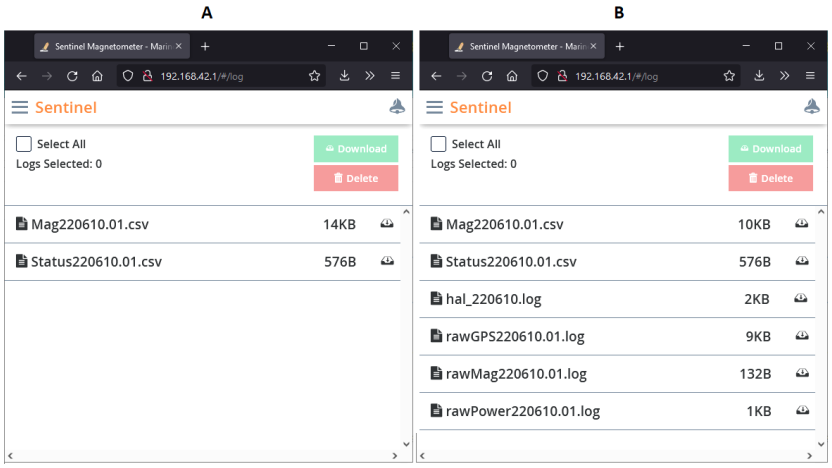
4.5. Logs screen

The Logs screen of the Sentinel2 Web UI provides a list of available data log files stored in the internal memory, and options for downloading those. Log file names begin with the log type identifier (e.g. Mag, Status or GPS), followed by date and additional daily count number. The latter gets incremented each the Sentinel2 is restarted on the same calendar day. New log files are automatically created for each new calendar day when the Sentinel2 is operating continuously overnight.

4.5.1. Standard vs. Diagnostic data logs

Standard logs saved by the Sentinel2 during its operation include **Mag.csv** and **Status.csv** logs, both formatted as plain text CSV. (case A in figure below). Mag Log is the only file necessary for base station correction. The additional Status log contains details about time synchronization.

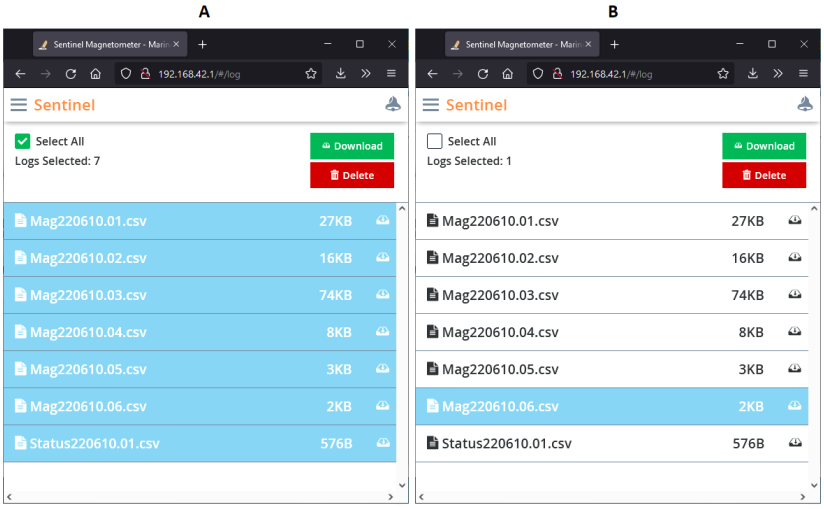
If "Log Diagnostics" option is enabled in Settings, additional detailed logs will be created that can be useful for troubleshooting (B). Among those is **hal.log** containing detailed power-up and shutdown sequence records, GPS log and battery charge/discharge logs.



4.5.2. Downloading data log files

Downloading logs is as easy as clicking on the download icon beside each file or selecting several and clicking the **Download** button above. Choosing "**Select All**" + "**Download**" will create a single ZIP/TAR file with all the files.

Note that on Windows computers you may need to install **7-Zip** in order to open .TAR packages.
7-Zip is a freeware multi-platform program available from: https://www.7-zip.org/download.html



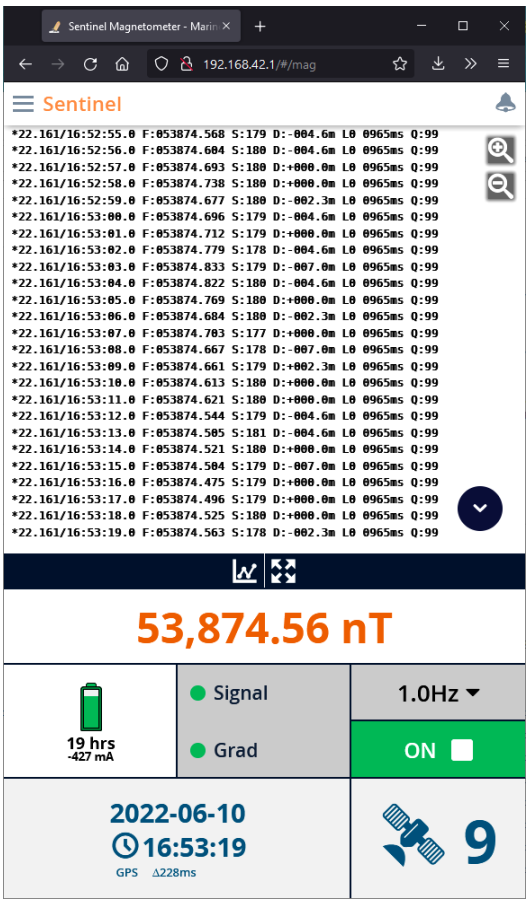
4.6. Mag Terminal view

Mag terminal view is available from the main mag screen of the Web UI and allows users to monitor the raw data readings coming from the magnetometer. The readings follow the SeaSPY magnetometer data format, and contain date and time, the value of the measured total magnetic field, signal strength, depth and leak sensor status (not applicable in case of the Sentinel2), measurement duration and signal quality. In addition to the time and magnetic field values, the most important parameter is the signal strength (e.g. S:180), which should remain in the 140-200 range under normal operating conditions.

Higher signal strength indicates better data accuracy, and anything above 160 is considered excellent. Low values (under 120) may indicate the presence of magnetic interference nearby and is usually accompanied by gradient condition and low signal warning indicators below the terminal window. The LED will also flash purple instead of green whenever a gradient condition is detected. Having the signal strength for each reading in the mag data log file provides a convenient means of excluding poor-quality readings during import into post-processing software (e.g. BOB).

When deploying the Sentinel2 on land, use the signal strength as an indication of how magnetically quiet your chosen location is. If you consistently get poor signal strength values (also indicated by purple LED flashes), while Auto-Tuning is enabled in Settings, your location may not be suitable for magnetometer deployment, and you should choose a different location. Avoid concrete surfaces which may contain iron rebar and other magnetic materials. Refer to Section 2.1 for details on avoiding magnetic interference.

Note: Clicking on the terminal window allows the user to manually type in commands to be sent to the magnetometer for troubleshooting purposes. Avoid doing so unless specifically instructed by the Marine Magnetics technical support.



4.7. Software Update procedure

Consider registering your Sentinel2 to receive email notifications about important updates:

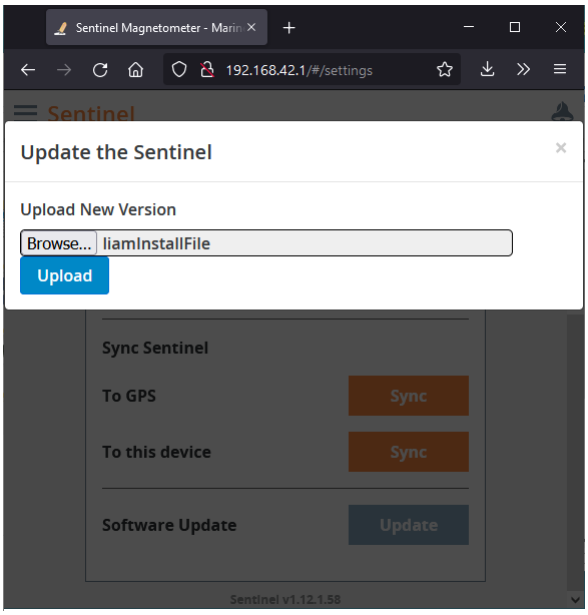
https://marinemagnetics.com/get-sentinel-software/

Sentinel2 Software Updates are released regularly and can be downloaded from the following URL:

https://marinemagnetics.com/install/sentinel/default.htm

To update software in the Sentinel2, follow these steps:

1. On your computer connected to the Internet, download the latest **liamInstallFile** from the above URL
2. Connect to the Sentinel2 Web UI
3. Open the Settings screen, and select the **Software Update** option near the bottom
4. Navigate to the downloaded update file
5. Follow the on-screen instructions to update the file
6. Restart the Sentinel2 when instructed
7. Verify the version of the Sentinel Software near the bottom of the Settings page



5. Deployment steps

5.1. Land-based deployment

Select a location in an open area with a clear view of the sky to guarantee a good initial GPS signal fix and time synchronization. If deploying in a wooded area with poor view of the sky, it is recommended to first power-up the device in an open area to guarantee good GPS sync, and then transport it to the desired location for deployment. During the transport the magnetometer can be set to idle mode (sampling off) until ready to deploy. (Refer to section 2.4 for details).

The selected location should be free from sources of magnetic interference. Refer to Section 2.1 for details.

1. Unfold the integrated tripod and secure the locking nuts. Take care not to drop the device to prevent damage.
2. Set the device vertically on a level surface (if possible).
   The slope of the surface must not exceed 27% (angle < 15°) to ensure good stability. If strong winds are expected, use additional ballast to prevent the device from swaying or getting toppled. Ballast must be 100% non-magnetic.
   (See Section 2.1 for details).
3. With the device on its tripod, connect the mag key to turn on the device.
4. Wait for the normal start-up sequence to be completed. The device will resume normal magnetometer operation at the previous sampling rate.
5. Connect to the Wi-Fi Web UI (Web User Interface).
6. Check the time sync status and time reference device using the Web UI. (See section 4.2.1 for details)
7. Ensure that Auto-Tuning is enabled in Settings unless you have a specific reason to disable it. (See section 4.4 for details)
8. Set the desired sampling rate and enable sampling.
   1 Hz sampling rate is recommended for most situations. Use a lower rate (0.2-0.3 Hz) to extend battery life.
9. Ensure you are seeing green LED flashes that indicate good quality magnetic readings and good time synchronization.
10. If you are seeing purple LED flashes, this indicates poor signal strength or magnetic gradient condition warnings.
    Reposition the device away from magnetic objects and structures. (See Section 2.1 for details).
    Avoid standing too close to the device while holding a smartphone, tablet or a computer as it may trigger gradient warnings and cause low signal strength and noisy readings.
11. If you are seeing yellow LED flashes, this indicates poor initial time synchronization.
    Try repositioning the Sentinel2 to get a better GPS signal fix, or set the magnetometer clock manually to a smartphone via the Settings screen. (See section 4.4 for details).
12. If you are seeing red LED flashes, this indicates that the magnetometer sampling is turned off, and the Sentinel is in idle mode.
    Turn sampling ON before deploying!

If the internal battery has become depleted by the time you return to collect the Sentinel, the LEDs and Wi-Fi will be OFF.
Simply connect the charger, wait for the startup sequence to complete (indicated by the white duty-cycle LED flashes) and use the Web UI to download the stored data log while the Sentinel is charging.

5.2. Underwater deployment

Never immerse the device without first plugging in the mag key and securing it with the locking sleeve.

Never immerse the charging cable or the included universal charger underwater.
Underwater operation is only possible with the mag key.

Refer to Section 2.3 for recommendations on preventing unwanted movement and vibration for underwater deployments.

Prior to deployment underwater, prepare to power up the device on a flat surface with a clear view of the sky to guarantee a good initial GPS signal lock and time synchronization. Initial GPS sync can be obtained while still onshore, or on the deck of a vessel. Following a GPS time sync, the magnetometer can then be set to idle mode (sampling off) until ready to deploy.

1. Unfold the integrated tripod and secure the locking nuts. Take care not to drop the device to prevent damage.
2. With the device on its tripod, connect the mag key to turn on the device.
3. Set the device vertically on a level surface (if possible).
4. Wait for the normal start-up sequence to be completed. The device will resume normal magnetometer operation at the previous sampling rate.
5. Connect to the Wi-Fi Web UI (Web User Interface).
6. Check the time sync status and time reference device using the Web UI. (See section 4.2.1 for details)
7. Ensure that Auto-Tuning is enabled in Settings unless you have a specific reason to disable it. (See section 4.4 for details)
8. Set the desired sampling rate and enable sampling.
   1 Hz sampling rate is recommended for most situations. Use a lower rate (0.2-0.3 Hz) to extend battery life.
9. Ensure you are seeing green LED flashes that indicate good quality magnetic readings and good time synchronization.
10. If you are seeing purple LED flashes, this indicates poor signal strength or magnetic gradient condition warnings .
    This may be due to being on deck of a vessel. This is normal. As long as Auto-tuning is enabled in Settings, the magnetometer will self-tune to optimal settings once lowered to the bottom and away from the vessel.
11. If you are seeing yellow LED flashes, this indicates poor initial time synchronization.
    Try repositioning the Sentinel2 to get a better GPS signal fix, or set the magnetometer clock manually to a smartphone via the Settings screen. (See section 4.4 for details).
12. If you are seeing red LED flashes, this indicates that the magnetometer sampling is turned off, and the Sentinel is in idle mode.
    Turn sampling ON before deploying!
13. Ensure the buoy line and anchor line (if used) are securely attached to the device.
14. **Ensure the surface buoy line is sufficiently long for the desired depth of deployment!**
15. Lower the device to the lake bottom or seafloor slowly and carefully, to prevent it striking the bottom at high speed, or falling over after making contact with bottom.
    If using additional ballast between the Sentinel and the surface buoy (as shown in diagram B on Figure 2-1) , ensure it does not fall onto the Sentinel during deployment!
16. Mark the GPS position of the surface buoy after deployment.

If the internal battery has become depleted by the time you return to collect the Sentinel, the LEDs and Wi-Fi will be OFF.
Simply connect the charger, wait for the startup sequence to complete (indicated by the white duty-cycle LED flashes) and use the Web UI to download the stored data log while the Sentinel is charging.

6. Troubleshooting

If you experience unexpected behavior while operating the Sentinel2, please try restarting the Sentinel2 and checking the Settings screen to ensure Auto-Tuning is enabled and date and time are synchronized.

Please note that using the Sentinel2 indoors or in close proximity to buildings, large metal structures or electrical power lines will cause magnetic interference and prevent the magnetometer from getting good signal strength. This will be indicated by purple LED flashes during sampling, and by low signal strength values in the Mag Terminal screen. (See Section 4.6 for details).

Poor-quality magnetometer readings (purple LED flashes)	Try repositioning the Sentinel2 to a location away from sources of magnetic interference. See Section 2.2 for details.
Poor WiFi connectivity	Try changing your position relative to Sentinel2.
Poor or no GPS signal	Try re-orienting the Sentinel, or repositioning it to an area with a clear and unobstructed view of the sky. Note that the GPS signal is only needed once, during the startup, to guarantee the initial time sync to GPS time. After the time sync has been established (green LED flashes) the Sentinel2 can be set up at different location, without GPS access.
Red constant LED status after power-up	Problem with the magnetometer sensor or interface. Try restarting the Sentinel2.

If the problem persists, please contact the Marine Magnetics technical support:

support@marinemagnetics.com

Our task will be made easier if you are able to provide a detailed summary of the situation that led to the problem, and were able to supply a set of recent log files for our analysis (especially diagnostic log files which contain additional detail on the system operation)

IMPORTANT: If you are able to reproduce the error(s) or unwanted behavior, please try to do so after enabling the Diagnostic Logs in Settings (see Section 4.5.1 for details) in order to capture the specifics of the system state, and then include those log files in your support request.

7. Appendix A: Time synchronization details

Base station and mobile magnetometers should each be synchronized to GPS UTC time to within 1 second before surveying.

The Sentinel2 has access to four clocks to ensure accurate synchronization:

1. Magnetometer sensor clock – this very precise clock timestamps each reading. Must be set each time on start-up.
2. Internal battery-powered clock – keeps time while the unit is off. Used as reference during start-up when GPS fix is unavailable.
3. GPS clock – updated with each GPS fix, accurate within milliseconds. Used as reference during start-up if available.
4. Connected device's clock – available whenever a smart device accesses the Sentinel Web UI. Not used as reference unless user manually syncs to it via Settings.

When the magnetometer is powered up, its clock must be set by one of the other clocks.

At startup, the Sentinel2 waits up to 30 seconds for the GPS to get a fix and then synchronizes its internal clock with the GPS first, then it synchronizes the magnetometer clock with the internal clock.

The status of GPS signal during startup is indicated by the LED color. Please refer to the LED color chart in Section 3.1 for details.

In the absence of GPS signal (e.g. if underwater, underground, or indoors) the Sentinel2 uses its internal clock. The internal clock keeps time even while the unit is off. Like computers it can drift but if recently synchronized, it can be quite accurate. This enables the user to start the Sentinel2 where satellites are available (to obtain an accurate initial GPS time sync), turn it off, and then deploy it in another location and the internal clock automatically and accurately synchronizes the magnetometer.

If for some reason the magnetometer clock is not set correctly, the time stamps paired with magnetometer's readings in the mag log file will be wrong. However, each reading is also timestamped by the Sentinel's internal clock (aka "system time"). This is less accurate, but usually good enough for gathering useful base station data.

The user is responsible for verifying that the Sentinel2 mag date and time are set as accurately as possible at each deployment.

Clock drift

All clocks drift gradually from their set time, some more than others.

The magnetometer sensor's high-precision clock is reliable to 1ppm, drifting less than 1s every 12 days.

The internal battery-powered clock is reliable to 100ppm or 8s per day and should be synchronized as soon as possible before setting the magnetometer clock – ideally less than a few hours to keep the drift less than 1s.

The GPS time is set with each fix and is not considered to drift as long as it is updated regularly. Otherwise, it drifts by 8s per day from the last valid fix received.

Mobile phones with cellular connections are considered a good time reference because they are frequently synchronized with the cellular network.

Computer and tablet clocks typically drift up to 8s per day and are considered unreliable unless recently synchronized over the internet.

Auto-synchronization

After the initial startup, the Sentinel may auto-synchronize the magnetometer clock, if it detects a large difference in time.

The magnetometer clock will be auto-synced to GPS time whenever GPS fix is established, and GPS time differs by more than 750ms from magnetometer time. If a GPS fix has not been received recently (> 14 hours), and the user connects a device to the Sentinel2, it only auto-synchronizes if the magnetometer clock is off by more than 5 seconds.