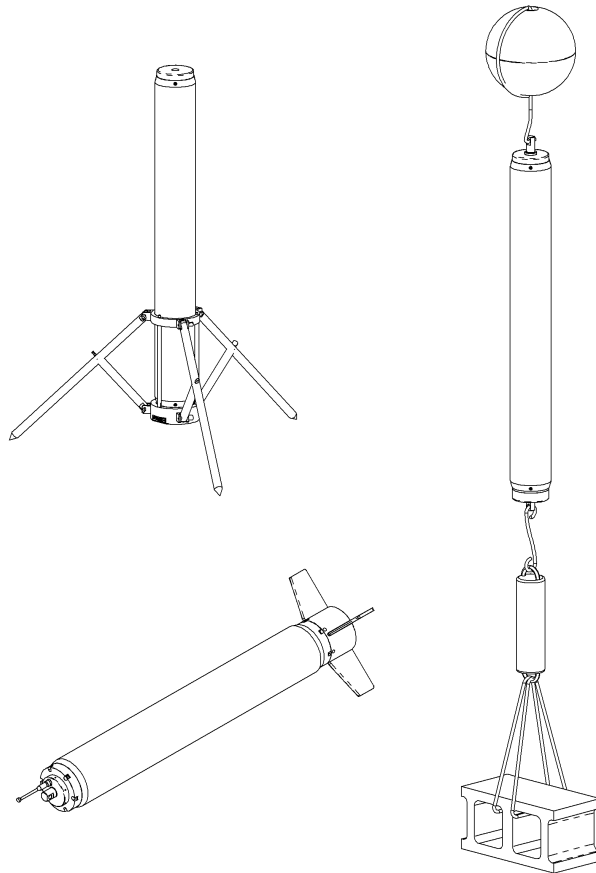




## SENTINEL

### Marine Base Station Magnetometer Operation Manual



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## **1 Introduction**

Sentinel is a high performance base station magnetometer system that is designed to be used in the harshest underwater and above-water environments. A standard Sentinel system consists of the following components.

- The main magnetometer unit, consisting of an omnidirectional Overhauser magnetometer sensor, driving electronics with the ability to store one million readings, and a high capacity battery pack. The unit is packaged in a pressurized fibreglass cylinder, coated with tough polyurethane armour.
- An aluminum bulkhead at the base of the unit that is equipped with a micro-circular Subconn connector, and a status LED window. The base is also equipped with an eyelet attachment that allows it to be tethered to an acoustic release system for underwater use.
- A 'dummy plug', that connects to the Subconn connector on the base of the Sentinel and acts as a switch when deploying the unit underwater or without the tripod assembly.
- A white plastic eyelet that screws into the top of the magnetometer. This part allows for the attachment of a syntactic buoy for underwater deployment, or may be used to suspend the unit from above when used on land.
- A battery charger.
- An interface cable that connects to a standard PC RS232 port, and also allows connection of the battery charger at the same time.
- BaseLINK software for Windows 95/98/NT

A land-deployment Sentinel system is also equipped with a collapsible aluminum tripod base, to allow the system to be used on land.

The magnetometer sensor is located at the top end of the magnetometer tube, while the battery pack provides ballast at the bottom end of the tube (the end with the circular Subconn connector). Configuration, control and data access is all via RS232 through this connector.

Note that the Sentinel is always 'off' unless mounted in the tripod assembly or unless the supplied dummy plug is installed. When deploying the unit without the tripod, it is very important to remember to install the dummy plug. Otherwise, the unit will not acquire data. This safeguard exists in order to protect the integrity of the brass contacts of the bulkhead connector on the Sentinel housing, which would slowly corrode if exposed to seawater and the unit was powered on. With the unit powered down, the connector will not corrode or be damaged by seawater.

### **1.1 6000m full-ocean-depth version**

The most important difference between the 6000m-rated housing and the standard housing is strength of construction. The 6000m-rated cylinder is constructed from the same filament-wound fiberglass, but is substantially heavier. The end caps are machined to fit the cylinder with extremely high precision.

The caps are made from titanium primarily for corrosion resistance. It is important to note that titanium has a highly positive corrosion potential in seawater, and it will cause other metals placed in contact with it to corrode faster, especially if the other metal's surface area is small. This includes all steels, stainless steels, aluminum and

brass. We recommend electrically isolating any tether that is attached to the front of the unit.

## 1.2 Understanding the Overhauser Total-Field Magnetometer Sensor

The main sensor of the system is based on the Overhauser effect principle, a principle that allows Sentinel to measure at much higher sensitivity and with a tiny fraction of the power of a standard proton sensor.

All Sentinel magnetometers are supplied with an omnidirectional sensor that is completely isotropic with respect to magnetic field direction. The only restriction is **the magnetometer should not be operated while upside down, i.e. with the connector facing straight up.**

The Overhauser sensor measures magnetic flux density, the unit for which is the Tesla (T). Magnetic flux density on the surface of the Earth typically varies between about  $18\mu\text{T}$  to  $70\mu\text{T}$ , depending on location. The flux density at any fixed location on the Earth's surface also varies with time due to diurnal effects, which depend primarily on influence from the solar activity.

One often speaks of a magnetometer as measuring magnetic field, instead of flux density, since the two values are directly related given an environment of constant magnetic permeability (such as air or water). In this light, it is easier to think of all magnetic objects as creating a dipolar magnetic field, either *permanent* or *induced*.

A permanent dipole is created by objects such as permanent magnets. The magnitude of the magnetic field created by such dipoles is independent of which direction they are facing, or of the ambient magnetic field surrounding the object. The Earth behaves as a permanent magnet, as does the Sun. The magnetic fields of the Earth and the Sun are constantly changing and interacting, causing variations in the magnetic flux density at the Earth's surface, which is what your magnetometer measures.

An induced dipole is created by an object that is magnetically permeable, and that is placed in the ambient magnetic field of a permanent dipole. An induced dipole will always be in the same direction as the ambient field, and will either add to it or subtract from it. Materials such as iron and nickel are extremely paramagnetic, meaning that they are permeable and their induced field will add to the ambient field. While all materials exhibit some degree of para- or dia-magnetism, iron, nickel and cobalt are orders of magnitude more paramagnetic than any other pure elements, and are therefore known as ferromagnetic. Alloys of these elements can be ferromagnetic as well.

An object that creates a permanent or induced magnetic field will distort the surrounding magnetic flux density. These distortions will be in the form of a magnetic gradient, i.e. the distortion will decrease in intensity the farther one goes from the object.

Ideal conditions for a base station magnetometer are zero magnetic gradient, especially if the purpose of the deployment is to monitor variations in the Earth's field. A zero gradient usually means there are no magnetic objects nearby. If a permanent or induced dipole comes very close to the sensor, the magnitude of the gradient may exceed the specification of the magnetometer, and it may stop providing noise-free data. Since most man-made building and structural materials contain iron or nickel, it is best to deploy Sentinel as far from man-made structures and interference as possible. Stainless steel is often misconstrued as being non-

magnetic, although most grades are very magnetic, especially if they have been welded.

Do not expect the sensor to produce good results on the deck of a ship, or inside a building.

A standard proton magnetometer sensor uses a strong DC magnetic field to polarize itself before each reading can be taken. An Overhauser sensor, in contrast, uses an AC magnetic field of radio-frequency to polarize. The benefit of this is that a tiny fraction of the polarization power is required, and the AC field may be left active while the sensor is producing a valid output signal. This allows an Overhauser proton magnetometer to measure more frequently than a standard proton magnetometer, and produce results at least two orders of magnitude more precise.

## **2 Communication**

All communication with the magnetometer is RS232 using 9600 baud, 8 data bits, no parity, and one stop bit. No hardware or software handshaking is used. You can communicate with the magnetometer using any RS232 terminal.

The most common hardware used to communicate with the magnetometer is a PC. BaseLINK software that runs under Windows is included with every Sentinel system.

The RS232 link is used to program the magnetometer, and to download data when your mission is complete. Sentinel is designed to operate unattended, but it can be monitored at any time through its RS232 link. Whenever Sentinel takes a reading, or performs a self-test, it will report the results automatically over the serial port.

### **3 Connecting and Using the Equipment**

The main Sentinel housing is a complete self-contained magnetometer, and does not require any other components to operate. The extra hardware that has been included with your system makes it easy to deploy the magnetometer quickly in almost any environment on Earth, both above and below the surface of the sea.

#### **3.1 Step 1: Connecting the Magnetometer**

Locate the gray and black interface cable terminated with a Subconn micro-circular connector at the magnetometer end and a 9-pin D-sub connector at the PC end. This cable also has one circular three-pin connector, which is used for charging the Sentinel. Plug the D-sub connector to your PC's serial communication port and the Subconn connector to the magnetometer tube. You are now ready to program the magnetometer. Connection of the charging unit is not necessary unless the magnetometer batteries have been depleted.

**Important: Do not boot-up a PC while it is connected to the magnetometer.**

Windows often tests the COM ports for the presence of mice and other peripherals while it is booting, which the magnetometer may interpret as erroneous commands.

#### **3.2 Step 2: Programming the Magnetometer**

To install BaseLINK, insert the first installation disk into the PC's floppy drive, and run `a:\setup`. Then, just follow the instructions. When setup is complete, run BaseLINK by double-clicking its icon.

When you first run BaseLINK, chances are that the magnetometer will be asleep. Sentinel always goes to sleep if it has not received commands in the last 60 seconds, and it is not acquiring data faster than once every 10 seconds. To wake the unit up, just press any key.

You should now see a wake-up message appear. Sentinel is now ready to be programmed. For a list of commands, press the `?` key. You can also get a look at Sentinel's current status by pressing the ``` (reverse single quote) key. Another useful command is `D`, which shows you the battery voltage. A voltage of 12.7V indicates the battery is fully charged, while a voltage of 10V or lower means the battery is low.

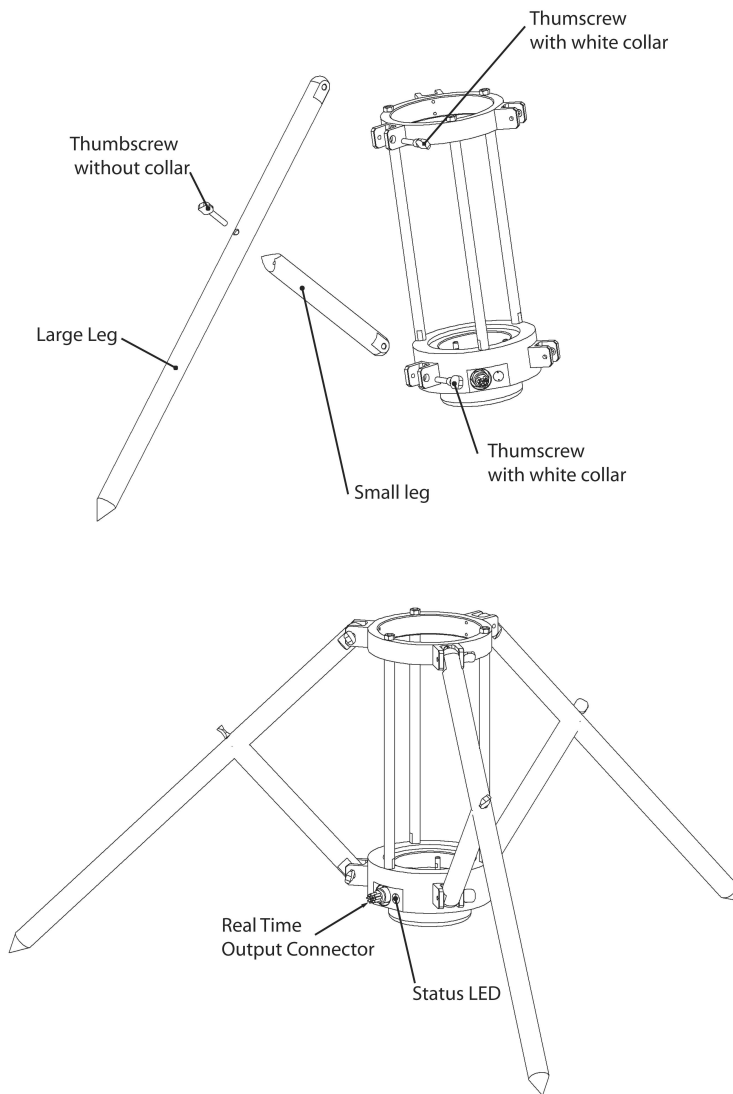
Press the space bar to see the current system time setting. Sentinel is programmed to UTC time at Marine Magnetics prior to shipment. If you need to change this, set the time using the `T` (capital) command. Sentinel will send a prompt to enter date (Julian day, and year) and time (hour, minute, second). When you enter the last digit, the clock will start immediately. The best reference to use for time is a GPS receiver that has held a position lock for at least 10 minutes. BaseLINK will show you the current Julian day at the bottom of its window.

Now program your desired sample rate. Most users will use a sample rate of 1 reading per second. This retains Sentinel's maximum sensitivity, and will allow continuous operation for approximately 80 hours (just over three days). Users that do not need such frequent data and need more operation time should survey at 1 reading every 10 seconds, which will allow continuous operation for approximately 540 hours (about three weeks). Run time can be extended to more than three months by cycling at one reading per minute.

**Important:** Sentinel will wait indefinitely for input, and will **not** go to sleep, or begin acquiring data, if you are setting time (T command) or setting tuning (L command). To abort either of these prompts, use ctrl-X (ctrl key, then X at the same time).

When you are done, just unplug the RS232 cable. Sentinel will not begin acquiring data until it is placed in its tripod base, or the dummy plug is inserted.

### 3.3 Step 3: Deploying Sentinel on Land



The aluminum tripod base makes deployment on land very easy. Assemble the base by attaching the six leg segments as shown in the diagram. Then, just insert the magnetometer tube into the base, and rotate the tube until it snaps into place.

Installing the magnetometer into the base will automatically start the unit, and removing the magnetometer will automatically stop it.

As soon as you install the tube in the tripod, Sentinel will begin its self-test. You will see the Status LED on the base flash on and off for approximately 5 seconds, followed by a solid green-only light for about 1 second. If at any time the LED displays solid red for about 2 seconds, that means that the self-test detected an error. This is probably because the unit was placed in a noisy, or high-gradient area. Try moving it away from power lines, cars, buildings, or any other possible sources of ferromagnetic or electromagnetic interference.

You can communicate with the magnetometer without removing it from the base. Just plug the communications interface cable (the one with two cables attached) into the Subconn micro-circular connector on the base, and follow the instructions in section 3.2 above.

While the magnetometer is taking readings, it will automatically store the readings in its internal memory, and also report them over the RS232 link in real time. You can monitor this process by plugging in your PC, and running BaseLINK.

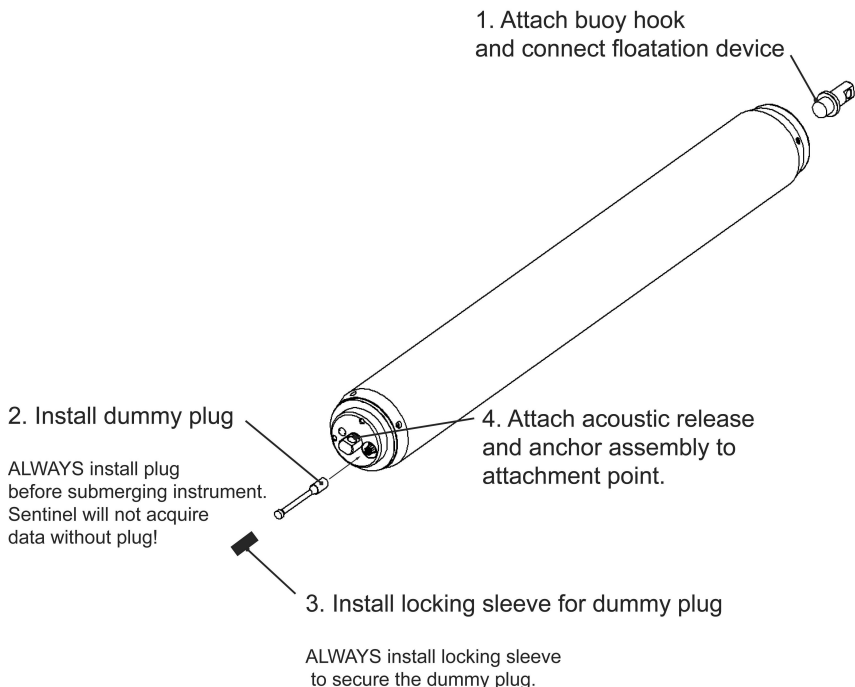


**Note:** When the battery voltage falls below 9.2V, Sentinel will stop acquiring data, and go to sleep to protect the battery pack from over-discharge. You will be able to wake the unit up, and communicate with it as usual, but it will not take another magnetometer reading until the battery voltage rises above a threshold level.

### 3.4 Step 3: Deploying Sentinel (std) Under Water

Most deployments under water will require hookup to an acoustic release system and anchor that are available through Marine Magnetics other suppliers. This setup will require the magnetometer to be buoyant for retrieval at the surface when its mission is complete.

1. The magnetometer tube is not buoyant. It weighs about 2kg in fresh water. To make it buoyant, you will need a buoy that can produce enough lift to counteract the weight of Sentinel and your acoustic release. You can tether your buoy to the top of Sentinel's tube **using the detachable white eyelet** that is included with the system.
2. To activate the magnetometer, insert the supplied dummy plug. **It is very important to remember to install the dummy plug. Otherwise, the unit will not acquire data.** Once the plug is installed, Sentinel will immediately turn on and perform a self-test, which will not succeed on the deck of your vessel. Sentinel will shut itself down for two minutes and try again, and will keep trying every two minutes until it is far enough from your vessel to start taking good readings.
3. Now install the supplied **threaded locking sleeve** that secures the dummy plug. **It is very important that this sleeve be installed over the plug prior to deploying the instrument.** It is also important to remember to remove this sleeve (by rotating it counter-clockwise) before attempting removal of the dummy plug.
4. Finally, connect your acoustic release and anchor to the eyelet on the bottom of the tube, and throw the entire assembly overboard. Be sure that the water depth in your area will not exceed the depth rating of the magnetometer tube.



**Note:** When the battery voltage falls below 9.2V, Sentinel will stop acquiring data, and go to sleep to protect the battery pack. You will be able to wake the unit up, and

communicate with it as usual, but it will not take another magnetometer reading until the battery voltage rises above a threshold level.

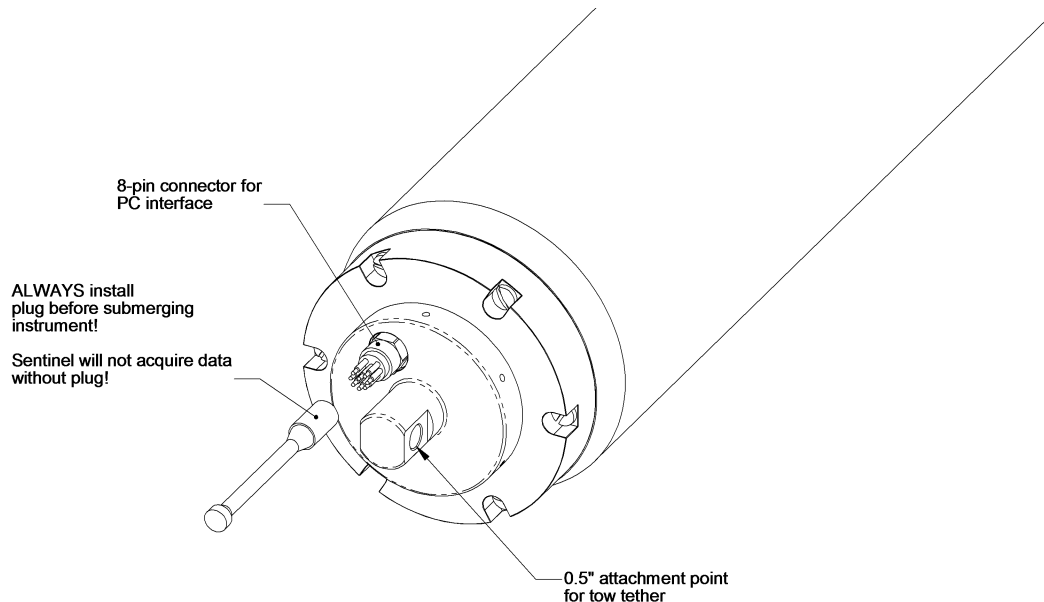
### **3.5 Step 3 (optional): Deploying the Tripod Base Underwater**

Sentinel's aluminum tripod base is a fully sealed unit and can be deployed underwater if desired. The depth rating of the tripod base is 100 m.

Note that the supplied dummy plug and locking sleeve must be installed over the Subconn circular connector on the tripod base for underwater operation. For more information on the tripod base please refer to Section 3.3.

### **3.6 Step 3: Deploying 6000m-Sentinel Under Water**

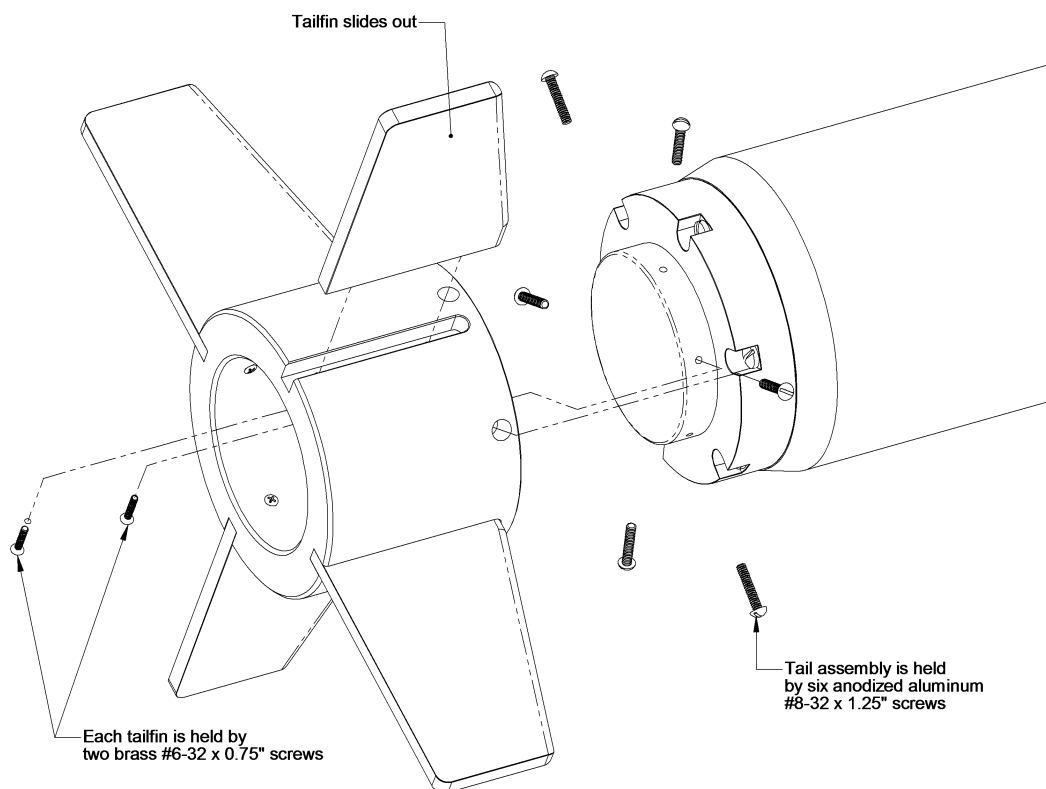
The 6000m-rated Sentinel unit may be used as a stationary reference, as in section 3.4 above, or is also designed to be used in a tow system. By using battery power and storing data on-board, the need for costly electrical cable is eliminated, and operation is greatly simplified.



The 6000m Sentinel unit is always 'off' unless the supplied dummy plug or RS232 cable are installed. When deploying the unit, it is very important to remember to install the dummy plug. Otherwise, the unit will not acquire data.

To deploy your system, simply program the time and desired sampling rate you're your PC as in the sections above. Sentinel will immediately begin trying to acquire data. As soon as you unplug the connector from the front of the Sentinel unit, it will power down. When you are ready to deploy, just insert the dummy plug, and the unit will automatically reactivate. Every reading it acquires will automatically be stored in its memory.

If towing the 6000m-rated Sentinel system, the tail assembly must be installed (the normal shipping configuration).



### 3.7 Step 4: Retrieving the Data

Every reading Sentinel takes is stored sequentially in non-volatile memory, along with the reading's date, time and a quality indicator. To find out how many readings are used, use the ctrl-D command.

To begin data transfer, send ctrl-G. BaseLINK will automatically recognize that a data transfer has begun, and begin saving the data to your hard drive using the file name and directory specified. To abort a data transfer, press the stop transfer button, or use ctrl-X if you are not using BaseLINK.

A data transfer will require approximately one hour for every 100,000 records, for a maximum of about 10 hours for full memory.

Records stay in Sentinel's memory until they are intentionally erased. To erase the memory, use ctrl-E. You will be prompted for confirmation. The erase memory procedure may take several minutes, and cannot be interrupted.

### **3.8 Step 5: Charging the Battery**

To charge the Sentinel, connect the communications cable to the magnetometer as described in Section 3 (it is not required to connect the PC). Now connect the included battery charger to the interface cable using the 3-pin circular connectors. Connect the battery charger to a power supply with 120-240 VAC (50/60 Hz).

The battery charger that was supplied with your Sentinel system may be connected to the magnetometer at any time, and for any duration. Charging will take place automatically. When the charge is 80% complete, the yellow light on the charger will change to green. An 80% charge will require approximately 5 hours from a completely discharged battery, and a full charge will require approximately 10-12 hours.

The battery charger is a 'smart charger' unit that may be left connected to Sentinel indefinitely without damaging the battery. All magnetometer functions, including data acquisition will operate correctly with or without the charger connected.

**Important: Do not connect any power source other than the supplied battery charger to your Sentinel unit, or damage to the battery pack may occur.**

Sentinel contains a reverse voltage protection diode, so that the battery pack cannot be discharged by shorting the power pins on its connector.

Sentinel also contains an over-discharge protection feature, which protects the battery from damage. It will completely shut itself down when the battery voltage falls below 9.1V. This does not affect the data in memory. Sentinel data is stored in nonvolatile flash memory, and is safe even if the electronics are completely disconnected from power.

## 4 OEM Sentinel

Sentinel's electronics module and Overhauser sensor can be provided without the standard pressurized marine housing and tripod base. This is convenient for applications such as mounting onto an ROV or AUV, when the unit can be housed and pressurized by the end user.

The electronics module itself is completely water and air tight, and it keeps the electronics inside safe from static discharge. Note that this housing is not designed to withstand high water pressure, and should not be submerged to a depth of more than two or three meters.

The Overhauser sensor is individually sealed and shock mounted. Again, this housing is not designed to withstand high water pressure. Also, take note that salt water can corrode the beige conductive paint that coats the housing within the shock mounts. Lengthy exposure to salt water should be avoided.

The Overhauser sensor is supplied with two 2m cables, both terminated with male SMA connectors. One cable is a coaxial RG-58 type, identifiable by a shiny finish on the cable jacket. This cable is responsible for sending RF polarization power to the sensor. The other cable, identifiable by a matte finish on the cable jacket, is a shielded twisted pair that is specially designed to eliminate microphonic effects in the audio range. This cable is responsible for sending the magnetometer signal back to the electronics module.

If the Overhauser sensor and electronics module are packaged separately, the length of cable between the two may be extended to as much as 30m, provided proper cabling is used for the connection. Contact Marine Magnetics for assistance in this area.

Interface to the electronics module is through an 8-pin circular connector on the other end of the electronics module. The pinout of this connector is shown in the table below. Pin 1 is marked with a dot. Pin 8 is the center pin.

Number	Name	Description
1	GLED	Green LED pulse output
2	SW1	External power switch. Grounded=ON, Floating=OFF. See note.
3	RLED	Red LED pulse output
4	SW2	External power switch. Grounded=ON, Floating=OFF. See note.
5	RSIN	True-level RS232 input at 9600bps.
6	RSOUT	True-level RS232 output at 9600bps.
7	PWR+	Positive power supply. Range is 9V to 15VDC. When below 9V, Sentinel will interpret a low battery condition, and shut itself down.
8	PWR-	Negative power supply and ground.

**SW1 and SW2 inputs:** Sentinel's operation is heavily dependent on the state of an external switch. This characteristic was specifically designed so that Sentinel could be activated or deactivated with a single simple action. When the signals SW1 and SW2 are grounded, Sentinel will see the external switch as ON. When the signals are floating, Sentinel will see the external switch as OFF. **It is very important that the signals are not shorted together when floating.** If using a hard switch, it should be DPST, with one end connected to PWR-, and with SW1 and SW2 connected to separate contacts on the other pole. If controlling the unit electronically, SW1 and SW2 should be connected to separate open-drain outputs. Both SW1 and SW2 must have the same logical state at all times. Otherwise, unpredictable operation will result.

**Note: When connecting and disconnecting power, the switch state must be OFF.**

**GLLED and RLED outputs:** The LED signals are 5V CMOS-level current-limited outputs that are designed to drive the red and green LEDs on the Sentinel stand as described elsewhere in this manual. These outputs can be used to monitor Sentinel's activity if the unit is being controlled electronically. Every time a reading is taken, a pulse will appear on the GLLED signal if the reading was successful. A pulse will appear on both the GLLED and RLED signals if the reading was taken under less than ideal conditions, such as in the presence of a high gradient. A pulse will appear on only the RLED signal if a reading was attempted, but failed.

The SW and LED signals can be a convenient way of controlling and monitoring the unit if you do not have an RS232 link available.

## 5 Commands

This section describes all commands that can be sent to Sentinel over the RS232 link.

Sentinel will go to sleep if it does not receive any input for 60 seconds, and if it is not acquiring data faster than one reading every 10 seconds. Once asleep, any byte will wake the unit up, but that byte will not be interpreted as a command.

If the switch is in the off position, Sentinel will enter command mode when it is woken up. If the switch is in the on position, Sentinel will take a reading and shut itself down immediately. This is the way to trigger samples externally. You can abort the reading by sending another byte before the reading completes (about 3 sec).

Some commands will not work when Sentinel is cycling (acquiring data).

Command	Keystroke	Description
Input Time Manually	T	The magnetometer will respond with a prompt to enter eleven digits that represent a date and a time. There is no carriage return necessary. As soon as the last digit is received, time will start from the entered value. The first three digits are Julian day, followed by two digits for year, and six digits for time in HHMMSS format. Note that this command can be executed while the magnetometer is cycling (taking readings). <b>While the unit is waiting for input, it cannot go to sleep. To abort this command, press ctrl-X.</b>
Get Time	SPC or t	Requests current magnetometer date and time, which is displayed with a resolution of 0.1 seconds in a 24-hour cycle. Magnetometer time is used for determination of cycle timing, i.e. units with the same time value cycling at the same interval will take readings at exactly the same time, regardless of when cycling was initiated. In addition, a unit cycling at a slower interval will be synchronized with one at a faster interval for appropriate readings. For example, a unit cycling at 5000ms will be synced with a unit cycling at 1000ms every five seconds.
Take a single reading	f or F	The magnetometer will immediately respond with an acknowledgement, and start the reading procedure, which will take 3 seconds. If the tuning value is 0 when the reading is started, tuning initialization will automatically be performed. On conclusion, the magnetometer will transmit the data obtained from the reading.
Initialize tuning	I	This command will cause Sentinel to search for the value of the ambient field. Sentinel will do this automatically when it is commanded to take a reading if its tuning value is set to 0 (init).
Self-test now	P	Will initiate a five second self-test procedure, identical to when Sentinel is switched on while configured to auto-cycle. The results of the self-test will be output over the serial port, and the LEDs will flash accordingly if the unit is installed in the tripod.
Enable/Disable Self-test on startup	p	When Sentinel is configured to auto-cycle, and it is switched on or installed in its base, it will automatically perform a self-test before continuing to acquire data. This toggle command will disable the automatic self test feature. You can check the status of the auto-self-test feature in the status list ( ` command).

Command	Keystroke	Description
1 reading per minute Cycle Rate	7	Puts the magnetometer in a mode that measures magnetic field readings at a rate of one per minute, if the switch is ON. The magnetometer will continue in this mode until ordered to enter a different mode. After every reading, the magnetic field data will be transmitted automatically. To save power, the magnetometer will go to sleep when in this mode if no command is received for 60 seconds. It will automatically wake up when it is time to take a reading, then shut itself down again immediately when the reading is complete.
0.1 Hz Cycle Rate	6	Same as above, but will take one reading every 10 seconds.
0.2 Hz Cycle Rate	5	The magnetometer will take one reading every 5 seconds, if the switch is ON. It will not go to sleep when in this mode, unless the switch is OFF.
0.3 Hz Cycle Rate	4	Same as above, but will take 1 reading every 3 seconds.
1 Hz Cycle Rate	3	Same as above, but will take 1 reading every second.
2 Hz Cycle Rate	2	Same as above, but will take 1 reading every half second.
Stop Cycling	0	This command will terminate all cycling. The magnetometer will complete a reading if one is in progress at the time of the command, and return to idle mode (awaiting further commands).
Input tuning manually	I or L	When this command is sent, the unit will prompt for the entry of a new two digit tuning value in $\mu\text{T}$ . The magnetometer will calculate the actual tuning step number that the user can increment or decrement using the next two commands. To set the unit in a state where it will auto-initialize itself when it takes its next reading, enter 00. <b>While the unit is waiting for input, it cannot go to sleep. To abort this command, press ctrl-X.</b>
Increment tuning	. or >	This adjusts the magnetometer tuning in the smallest possible step. The number of that step is reported as a response to the command, and also the corresponding magnetic field value in $\mu\text{T}$ . If auto tuning is not selected, the default tuning value is zero, which will cause a tuning initialization when the first reading is attempted. If auto tuning is disabled, the default power up tuning value will be whatever the setting was when the unit was powered off.
Decrement tuning	, or <	Same as above, but opposite.
Sensor Information	d or D	Retrieves extra sensor information. The first number is signal strength (for advanced diagnostics only), the battery voltage, and the switch state. A voltage of 12.7V indicates a fully charged battery, and a voltage of 10V or less indicates a low battery.
Memory Status	ctrl-D	Displays how many records are stored in memory, and the percentage used. The maximum number of readings is 1048576 ( $2^{20}$ )
Erase Memory	ctrl-E	Erases all records stored in memory. You will receive a prompt to confirm. <b>While the unit is waiting for input, it cannot go to sleep. To abort this command, press n</b>
Transfer Memory	ctrl-G	Transfers all records in memory. The approximate transfer time is one hour for every 100,000 records. BaseLINK will automatically detect when a transfer begins, will log the records to a file, and will calculate time remaining. <b>To abort data transfer, press ctrl-X</b>
Menu	?	Get a brief description of the most important commands.
Status	`	(reverse quote) Get a description of magnetometer status, including serial number, sample rate, and memory free.



<b>Command</b>	<b>Keystroke</b>	<b>Description</b>
Retransmit last reading	g	The last reading that was taken will be retransmitted in the real-time format described later in the manual.
Auto tuning off	y	By default, an optimal tuning value is calculated at the end of every reading with 100 or more signal periods. Very large and fast changes in magnetic field may cause the unit to mistune. This command may be used to disable auto tuning.
Auto tuning on	x	Use this command to re-enable auto-tuning.
Toggle long deflect	k or K	Long deflect is a technique used in Overhauser magnetometers to boost signal strength in low fields. SeaSPY will automatically switch to long deflect in fields below about 42 $\mu$ T. Although long deflect provides better signal strength, it also shortens measurement time, and it may be beneficial under certain circumstances to disable it. It is recommended to keep this function enabled.
Toggle RF	r or R	This command may be used to turn the RF polarization circuit on or off manually
Connect/Disconnect Sensor	e or E	This command connects the sensor to the magnetometer's amplifier chain. When off (normal standby), the amplifiers are isolated from the sensor. Use the D command to check the signal level from the sensor when it is connected.
Get unit serial number	!	The unit will report its serial number.
Get firmware checksum	%	Get firmware checksum. The firmware checksum can be used to identify your firmware version when calling Marine Magnetics for technical support. The response will be an 8 digit hex number.

## 6 Data Format

Sentinel will transmit data in real time as it is collected, and also after the mission is complete in the form of a data transfer. The data format for these two different modes is described herein.

### 6.1 Real Time Data

Real time data contains more diagnostic information than stored data. The format is as follows.

```
*YY.JJJ/HH:MM:SS.S_F:FFFFFF.FFF_S:SSS_TTTms_Q:QQ_WWWW CR LF
```

The first character of each line is always \* (ASCII code 42). This leading character is supplied for automated data collection systems that require periodic synchronization with the data stream. Each letter shown in *italics* stands for a digit of a particular record in the reading.

Letter	Description
Y	Year (time of reading).
J	Julian day (time of reading).
H	Hour (time of reading).
M	Minute (time of reading).
S	Second (time of reading).
F	Magnetic field (nT).
S	Signal Strength of reading. This is a raw number generated by the magnetometer that gives (in part) a good indication of the quality of the final total field measurement. Anything over 70 is considered an acceptable signal, and anything over 130 is considered excellent.
T	Measurement time. Ideally, this should be the magnetometer's cycling time minus 32ms, with a maximum of 968ms. If you see a G message, indicating that measurement was prematurely terminated due to a high gradient condition, this value will tell you how severe the gradient is.
Q	Signal quality. This is a two-digit number between 00 to 99. The left digit is a good indication of signal strength, and the right digit indicates how much information was available for measurement.
W	Warning Messages.
CR	Carriage Return (ASCII code 13).
LF	Line Feed (ASCII code 10).

Real time data output format description

There are five different warning messages that can be displayed in real time data, four of which are not mutually exclusive. The warning messages may be summarized as follows.

Letter	Meaning
W	Weak signal. This message is displayed if the signal strength for the reading is below a low threshold value
G	Gradient condition. In high magnetic gradients, the precession signal produced by the sensor decays more quickly. This message occurs if the measurement time was prematurely terminated due to a quickly decaying signal. The strength of the gradient can be estimated by observing the measurement time. Take note that sensitivity will decrease as the measurement time decreases.
P	Poor reading. This message is displayed if too few zero crossings are taken, for whatever reason. Expect this message under conditions of extremely high magnetic gradient.
M	Instrument Mistuned. The magnetometer may decide to display this message under extremely poor signal conditions, which is characteristic of poor tuning setting. When this message occurs, the instrument will attempt to retune by executing an initialise tuning procedure, if the auto tuning feature is enabled.
NS	No signal. This message is never displayed in conjunction with any other messages. It occurs when the magnetometer determines that signal conditions are so poor that there is very likely no sensor connected to the instrument. Since running the unit with no sensor attached for an extended period of time abuses the polarization circuitry, the magnetometer will cease cycling if this message occurs.

Real time data warning messages

## 6.2 Stored Data

To maximize memory usage, all of the diagnostic information that is stored with each record is limited to two warning messages, which are triggered only if the reading was not of optimal quality. The stored data format is as follows:

`YY.JJJ/HH:MM:SS.S_FFFFFFFF_FF_WW CR LF`

Note that magnetic field is only stored to a resolution of 0.01nT.

Letter	Meaning
S	Weak signal. This message is displayed if the signal strength for the reading is below a low threshold value.
G	Gradient condition. In high magnetic gradients, the precession signal produced by the sensor decays more quickly. This message occurs if the measurement time was prematurely terminated due to a quickly decaying signal. This message indicates that the measurement time was less than optimal.

Stored data warning messages

## 7 Specifications

Note: These specifications are preliminary, and may not be exact. For exact specifications please contact Marine Magnetics.

Magnetometer cylinder weight (std)	14kg
Magnetometer cylinder size (std)	113cm x 13cm dia
Magnetometer cylinder weight (6000m)	46kg
Magnetometer cylinder size (6000m)	130cm x 16.5cm dia
Docking base weight	5kg
Maximum incline angle for deployment in docking base	40 degrees
Magnetometer cylinder depth rating, with brass seal installed (std)	1000m – 100bar
Operating temperature	-25C to +50C
Storage temperature	-60C to +60C
Communication	Full duplex, 3-wire RS232. 9600bps, 8 data bits, no parity, 1 stop bit.
Data transfer speed	approximately 30 records per second, or 100,000 records per hour
Battery pack	Gel cell 12V, 7Ah
Battery charge time	5 hours 80% charge. 10 hours full charge.
Maximum power consumption, while battery charging	25W
Power consumption – asleep	96 $\mu$ W
Power consumption – command mode	180mW
Average Power consumption – sampling 1Hz, 2Hz	960mW, 80 hours run time on full battery
Average Power consumption – sampling 0.3Hz	700mW, 110 hours run time
Average Power consumption – sampling 0.2Hz	490mW, 155 hours run time
Average Power consumption – sampling 0.1Hz	150mW, 540 hours run time
Average Power consumption – sampling once per minute	25mW, more than 2500 hours run time – may vary depending on self-discharge rate of battery.

## **8 How to Reach Us**

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

### **Marine Magnetics**

16-52 West Beaver Creek Road  
Richmond Hill, ON L4B 1L9  
Tel: 1 905 709-3135 fax: 709-0805  
Email: [support@marinemagnetics.com](mailto:support@marinemagnetics.com)  
URL: [www.marinemagnetics.com](http://www.marinemagnetics.com)

## **9 Warranty**

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

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

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

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

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

### **9.1 Indemnity**

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

### **9.2 Disclaimer**

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