PRELIMINARY

ACOUSONDE™ USER MANUAL

Model B003A and B003B

Firmware version 3.0.2, PalmOS client software version 3.0.2
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PRELIMINARY

CONTENTS

PREFACE

This is a preliminary draft of the Acousonde user manual that includes features new to AcOS 3. This is an early release; it is missing many sections, and has not yet been proof edited.

DOS AND DON'TS

DO set your Palm's time correctly before commanding the Acousonde.

DO bring a spare backup Palm to the field, as well as Palm chargers and/or spare batteries.

DO, before each deployment, swab the positive battery contact (at the deep end of the battery housing) and the contact surfaces on the battery with isopropyl alcohol, and allow to dry.

DO, before each deployment, inspect the o-rings and o-ring seats (both on the battery cap and the battery enclosure) for cuts, abrasions, contamination, and adequate lubrication.

DO use fresh, recently manufactured batteries.

DO tighten the battery cap securely, with **gentle** mechanical assistance. **Hand-tight is not adequate.**

DO save the log file and configuration report after deployments for future reference.

DO check the latest "Tips & Tricks" at http://acousonde.com/tips_n_tricks.html.

DON'T allow any lithium battery to become shorted, by salt water or anything else.

DON'T force a MicroUSB plug into the Acousonde's MicroUSB jack. Do not use a rigid tool to insert the MicroUSB plug, as such a tool may allow excessive force. Damage to the MicroUSB jack is beyond repair and will render the Acousonde permanently unusable.

DON'T allow magnets near the Acousonde except to reset it using its magnetic switch, to avoid altering compass calibration or unintentional reset.

DON'T drop the Acousonde or its battery cap, especially when they are separated. An impact may permanently deform the watertight sealing surfaces of the battery housing and/or cap.

DON'T force the battery cap if it will not "bottom" when being screwed in by hand. Remove the cap, check threads and o-rings, and try again. Tighten hard only *after* tightening by hand.

DON'T grasp an Acousonde 3A far from the battery cap when tightening the cap. The resulting twist could permanently damage the embedded electronics.

DON'T use a metal object, such as a knife or metal tweezers, to remove o-rings.

DON'T use abrasive material to clean the anodized o-ring facing wall in the battery housing or the anodized o-ring seats in the battery cap.

DON'T use petroleum-based lubricants (e.g. Vaseline) on the o-rings, it will degrade them.

DON'T allow alcohol to remain in contact with the polyurethane body of the Acousonde; if any alcohol contacts the urethane during cleaning, wipe it away quickly.

DON'T secure the Acousonde 3A around the depth sensor (silver disk) or hydrophones.

DON'T subject the Acousonde to depths exceeding its depth rating.

DON'T store your Palm for long periods with batteries installed (if it uses field-replaceable batteries). They will deplete unnecessarily, and may leak, damaging the Palm.

DON'T store lithium batteries in heat or humidity.

DON'T disconnect USB while erasing (red LED cycling brightness after "erase" command).

DON'T sample auxiliary sensors so fast that auxiliary storage fills prematurely.

DON'T offload data from multiple volumes of a given Acousonde simultaneously.

FIELD CHECKLIST

Tools

- ☐ Cable, USB A male to Micro-USB B, data capable (i.e. not only for charging)
- ☐ Cutters, diagonal, miniature (i.e. dikes, snips, side cutters) to cut cable ties in close quarters
- ☐ Magnet, kitchen or similar *(to avoid compass damage, keep away from Acousondes unless to reset them!)*
- ☐ Palms, with charger or spare batteries, at least two for redundancy
- ☐ Pliers, needlenose, for tightening cable ties in close quarters
- ☐ Screwdriver, jumbo flat blade (for securing Acousonde 3B dome-type battery caps)
- ☐ Wrench, open-end, 15/16" or 24 mm, short-handled (for securing Acousonde 3A flange-type battery caps)
- ☐ Wrench, adjustable, small (for securing eyebolts in flange-type battery caps)
- ☐ Wrench, hex, deep, with T or screwdriver handle (for securing 3A floats)

Materials

- ☐ Alcohol, isopropyl, 99% or electronics grade
- ☐ Bags, plastic, for Palms, zip-loc or similar
- ☐ Batteries, Saft LS17500 lithium A-cell
- ☐ Cable "zip" ties, select size for securing VHF transmitter in float
- ☐ Glue, cyanoacrylate ("super glue"), Loctite 230992 or similar
- ☐ Grease, silicone, Dow Corning 111 or similar (NOT petroleum-based!)
- ☐ Marker, waterproof, Sharpie or similar
- ☐ Q-tips
- ☐ Tape, electrical, Scotch Super 33+ or Super 88, or similar
- ☐ Tape, reflective (for float)
- ☐ Tape, rubber self-fusing, Scotch 23 or similar (gripping battery cap, attachment foundation, other uses)
- ☐ Tissues, wipe/low-lint

Deployments screwing 3A float or eyebolt to battery cap

- ☐ Anti-seize compound, Permatex/Bostik Never-Seez (Mariner's Choice or Nickel), or Loctite Marine Grade, or other similar
- ☐ Eyebolts, 10-24 threads, with nut, 1.25" min. threaded shaft, for line attachments
- ☐ Screws, hexhead, 10-24 threads, and washers, for securing 3A float or other gear

Spare parts (optional)

- ☐ Battery caps, spare (in case of loss or damage)
- ☐ Cable "zip" ties, 0.1" width, short ∼4", UV resistant (for Acousonde 3B suction cups)
- ☐ Floats (spares typically only for 3A)
- ☐ O-rings, round cross-section, Buna-N 70 durometer size 019 or equivalent
- ☐ Suction cups (specific to 3A or 3B, choose as needed)

Suggested general deployment and retrieval gear

- ☐ Antenna, VHF, with cable, compatible with receiver/transmitter frequencies
- ☐ Chart or map of study area
- ☐ Compass, handheld
- ☐ Deployment grip
- ☐ Deployment line and/or mooring gear (for fixed or boat-based deployments)
- ☐ Deployment pole
- ☐ GPS, handheld
- ☐ Headphones, silencing (e.g. aircraft cockpit), compatible with VHF receiver
- ☐ Receiver, VHF, compatible with transmitter frequencies, with batteries (built-in?) and charger
- ☐ Transmitter(s), VHF, compatible with tag (3A or 3B) and with frequencies documented

1 OVERVIEW

The Acousonde™ is a miniature, self-contained, autonomous acoustic/ultrasonic recorder designed for underwater applications. The recorder incorporates one or, optionally, two hydrophones as well as depth, attitude, orientation, and other sensors, digital recording electronics, data storage, and a field-replaceable battery in a single sealed unit. Once the Acousonde is retrieved, data are offloaded via USB.

Originally designed as an intelligent tag for temporary attachment to protected marine species, the Acousonde has expanded into other fields requiring general autonomous acoustic recording, such as moorings, gliders, remotely-operated vehicles, and seafloor monitors. Applications include:

- Acoustic/behavioral recording tags for marine wildlife
- Miniature, highly portable underwater acoustic recorders
- Low-power autonomous sound monitors
- Acoustic and attitude/orientation recorders for underwater vehicles
- Temporary attitude/orientation monitors for towed cables

The Acousonde replaces the Bioacoustic Probe, which was discontinued in 2007.

The Acousonde is available in two configurations: the cylindrical Acousonde 3A (Figure 1), primarily for oceanographic applications, and the hydrodynamic Acousonde 3B (Figure 2) for animal tagging.

The Acousonde is designed to be mechanically robust and to require minimal effort to prepare for deployment. Except for the battery housing, no wires or other parts penetrate the polyurethane encapsulant. Power consumption is extremely low, due to direct-memory-access sampling hardware, frequency-scaled core voltage, and other low-power design optimizations.

Programming takes place by means of infrared signaling with a handheld commanding unit presently based on the Palm™ platform. The commanding unit allows the programming of highly flexible sampling strategies tailored to the needs of each individual deployment. Sampling rates, date, time, and other metadata are kept within each data file to ensure they remain with the data.

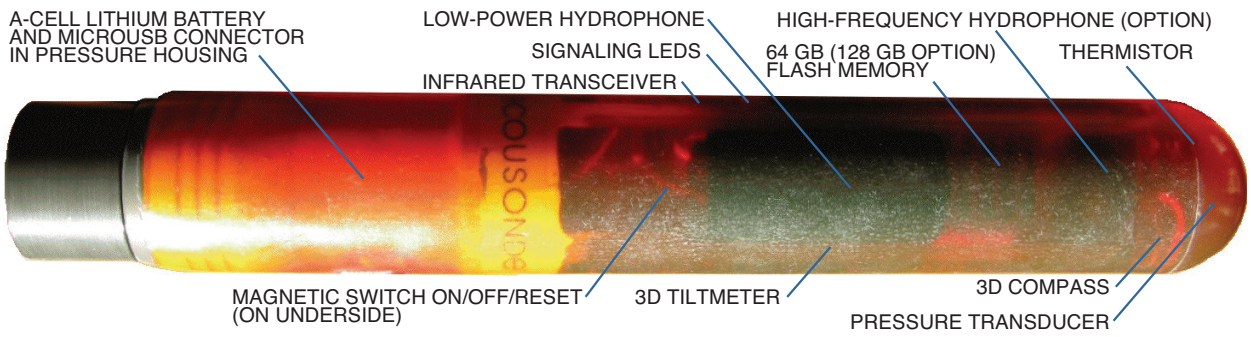

Figure 1. Acousonde 3A.

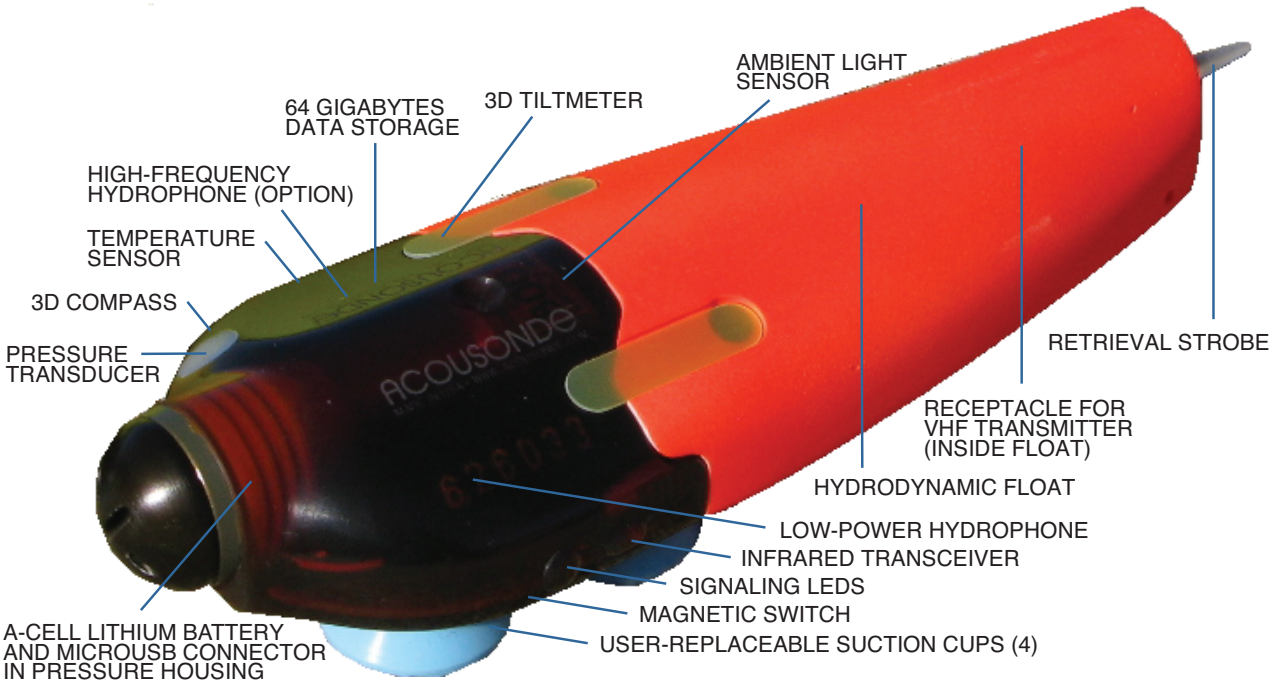

Figure 2. Acousonde 3B.

2 QUICK-START GUIDE

2.1 MOUNT THE ACOUSONDE™ FILESYSTEM ON A PERSONAL COMPUTER

1. Remove the battery cap from the Acousonde. If it is difficult to grip the battery cap by hand, use either a 15/16” (24-mm) short-handled wrench (flange caps) or a jumbo flat screwdriver in the cap’s slot (dome caps). Remove the battery if present.

2. Insert the MicroUSB end of the supplied MicroUSB/B-to-USB/A cable into the socket located in the battery housing. **The MicroUSB plug must be aligned with its USB logo and ‘B’ mark facing the wall of the battery housing**. Wiggle the connector cable until the connector seats, then push the connector in gently, using a fingernail against the back end of the MicroUSB plug. It may be necessary to apply enough force that your fingernail bends, but not much more. ***Caution: Do not force the MicroUSB plug into the Acousonde’s socket. Do not use a rigid tool to apply pressure on the plug; you could use more force than necessary. IF YOU DAMAGE THE SOCKET THE ACOUSONDE WILL BE UNUSABLE AND PERMANENTLY BEYOND REPAIR.***

3. Plug the other end of the MicroUSB cable into an ordinary personal-computer USB socket. The yellow System LED (Figure 3) should light briefly.

4. After about 30 s, the red Alert LED (Figure 3) should begin a series of flashes (Figure 4). Shortly after flashing completes, at least two USB volumes should mount on your personal computer. One of these volumes holds the configuration report and, if present, the log and auxiliary-sensor data. The other volume(s) hold only acoustic data. *Note: Occasionally volumes may fail to mount. If this happens, disconnect and reconnect the Acousonde. If the mounting failure persists, try connecting the Acousonde directly to the computer avoiding any USB hubs; or, try a computer with a different operating system.*

5. Copy any important unsaved files. *Note: The Acousonde filesystems are read-only.* ***Caution: Do not copy files from more than one volume at a time.***

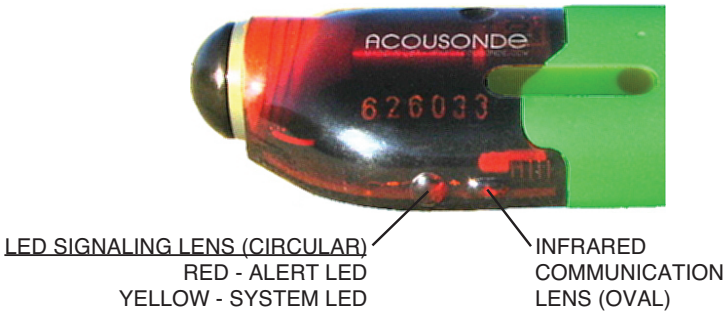

Figure 3. Location of signaling and infrared communication lenses. An Acousonde 3B is shown; the lenses are similar on an Acousonde 3A.

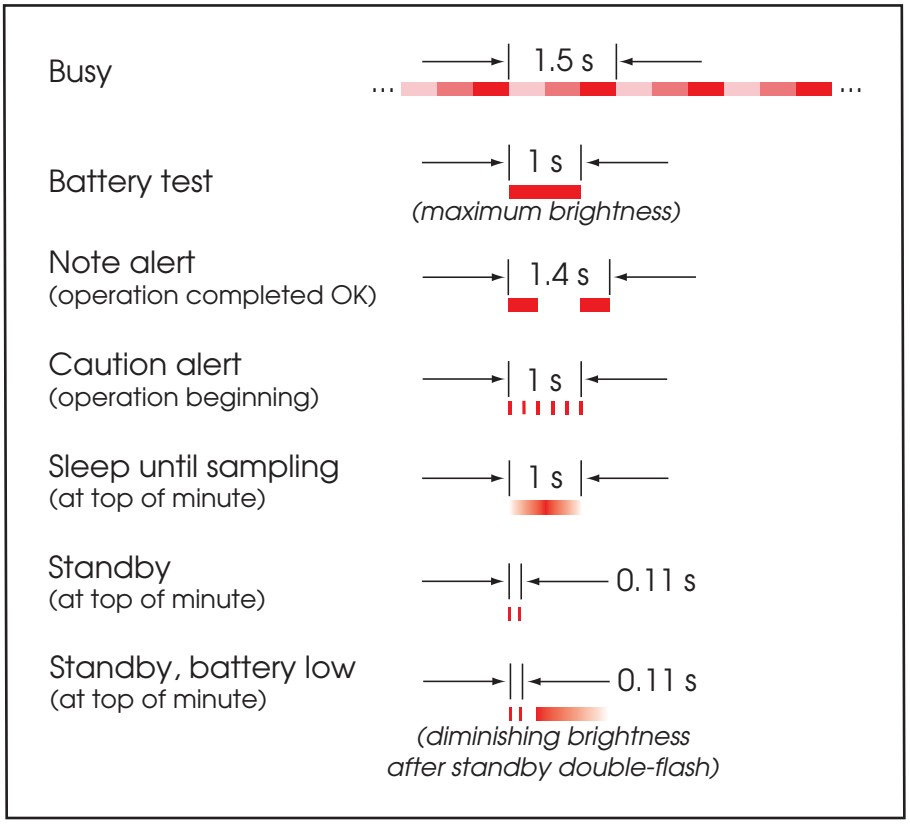

Figure 4. Normal red (Alert) LED behavior.

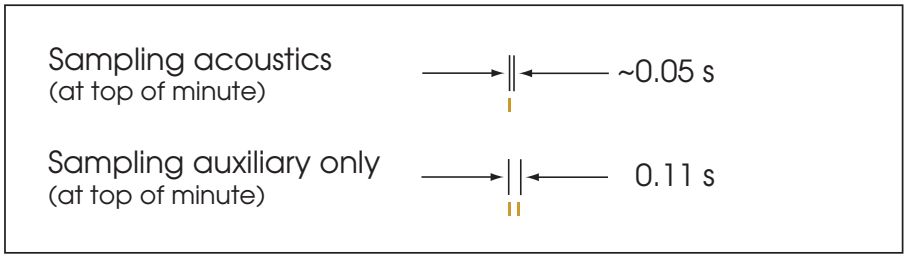

Figure 5. Normal yellow (System) LED behavior.

2.2 PREPARE THE PALM AND MAKE SURE THE ACOUSONDE™ FILESYSTEM IS ERASED

1. Ensure your PalmOS-compatible device (henceforth "Palm") has fresh or recharged batteries, and has been set to the correct date and time using the Palm's built-in **Prefs** application. Whatever date and time you set will automatically export to the Acousonde when you use the Palm to interact with it.

2. If the Palm has not been loaded with the **Acousonde** client application since the last time it lost power (because its batteries were either removed or fully depleted), you may need to reload the application onto the Palm. You can do this via infrared directly from the Acousonde; no cables or other software are necessary. Create a text memo using the Palm's built-in **Memo Pad** application. The memo should contain a single word – "Send" – with the S capitalized and the other letters lower-case, and without any quotes or leading spaces. Then select the **Beam Memo** item from the Palm's drop-down menu (accessed in newer Palms by pressing the stylus to the upper-left corner of the screen, or, in all Palms, the menu soft key in the lower left corner of the screen). Ensure that the Palm and Acousonde infrared ports are facing each other and that the optical path between them is not obstructed. Once the memo has been beamed to the Acousonde, it will respond by beaming the **Acousonde** application to the Palm. Maintain the optical path between the Palm and the Acousonde until the transfer completes.

3. Start the **Acousonde** application on the Palm. Note that the Palm assigns every application a category such as "System", "Utilities", "Unfiled", etc; if the **Acousonde** app is not immediately visible, it could be that the Palm is only showing apps belonging to a category other than what was assigned to **Acousonde**. Once the **Acousonde** app has been started, use the drop-down menu to select the **STORAGE** page.

4. If the Acousonde filesystems mounted on your personal computer contain files, erase them using the **Erase** soft key on the **Acousonde** application's **STORAGE** page. This will send an erase command via infrared to the Acousonde. Again, for the infrared command to be received, the optical path between the Palm and Acousonde infrared ports must be clear. Erasure may take up to 30 minutes to complete depending on the Acousonde's hardware and software configuration. Erase time does not depend on how much or how little data may have been stored on the Acousonde. During the erase process, the Acousonde will signal busy by cycling the brightness of its red Alert LED (see Figure 4).

5. ***Caution: Do not remove USB power from the Acousonde while it is flashing its red Alert LED during the erase process! Doing so may corrupt its filesystem and render it unusable until the erase process can be repeated and run to completion.***

6. When the red Alert LED turns off, indicating erase completion, remove the MicroUSB cable from the Acousonde by tugging gently.

2.3 PREPARE THE ACOUSONDE™ FOR DEPLOYMENT

1. Inspect the Acousonde's battery cap. Ensure the o-rings and o-ring seats in the Acousonde's battery cap are clean, undamaged, and lubricated with silicone (NOT petroleum-based) grease.
2. Inspect the Acousonde's battery housing. Check for obvious deformation or other damage that could result in leaks. Ensure the o-ring facing wall in the Acousonde's battery compartment is smooth and clean.
3. Ensure that the battery springs (both in the battery cap and deep in the battery housing) are clean. If in doubt, wipe the springs using a cotton swab wetted with isopropyl alcohol. Allow to dry thoroughly.
4. Prepare a Saft LS17500 A-size lithium battery cell by cleaning its contact surfaces using a cotton swap wetted with isopropyl alcohol. Allow to dry thoroughly.
5. Insert the LS17500 lithium cell into the battery compartment, button end first, and screw in the battery cap. Do not force the battery cap! If it does not screw in smoothly, an o-ring may be out of place or contaminated; remove the cap and check the o-rings. Once the battery cap is screwed in all the way, *tighten it very hard*. To ensure the cap is very secure, use gentle mechanical assistance: for Acousonde 3A "flange" caps, use a short-handled 15/16" or 24mm short-handled wrench, or for Acousonde-3B "dome" caps, use a jumbo flat screwdriver. If the cap has not been snugged down with mechanical assistance, it may shift under pressure/temperature cycling or vibration and lose electrical contact, which would reset sampling. *Note: No damage will occur if the battery is inserted backwards. In that event a bright orange LED will light continuously to signify the error.* ***Caution: For Acousonde 3A cylindrical units, grasp the unit as close to the battery cap as possible while tightening the cap to minimize twist of the electronic components. Excessive mechanical twist can result in permanent damage. See Figures 6 and 7.***
6. Ensure that the Acousonde boots up properly by watching the behavior of its red Alert LED (Figure 3), which should begin its flash sequences about 30 s after power is applied.

2.4 PROGRAM THE ACOUSONDE™ AND START SAMPLING

Programming the Acousonde takes place via the **Acousonde** PalmOS application.

1. Start the **Acousonde** application on the Palm; when the application is started, it will present the default **CONTROL** page. Or, if the application is already running, select the **CONTROL** page using the Palm's drop-down menu.
2. Select the acoustic channel from which you wish to acquire data, either **LoPower** or **HiFreq** (Figure 8). Other options include **LP[HF]**, which alternates between the Low Power channel for a selected number of minutes and the High Frequency channel for a selected number of minutes; **LP/HF**, which is not supported as of this writing; and **HF+HV**, which is only for use with certain customized Acousonde units.

Figure 6. Incorrect technique for tightening battery cap on Acousonde 3A. Grasping the Model 3A far from the battery cap while tightening the cap applies a mechanical twist to the embedded electronics. Excessive twist may result in permanent damage.

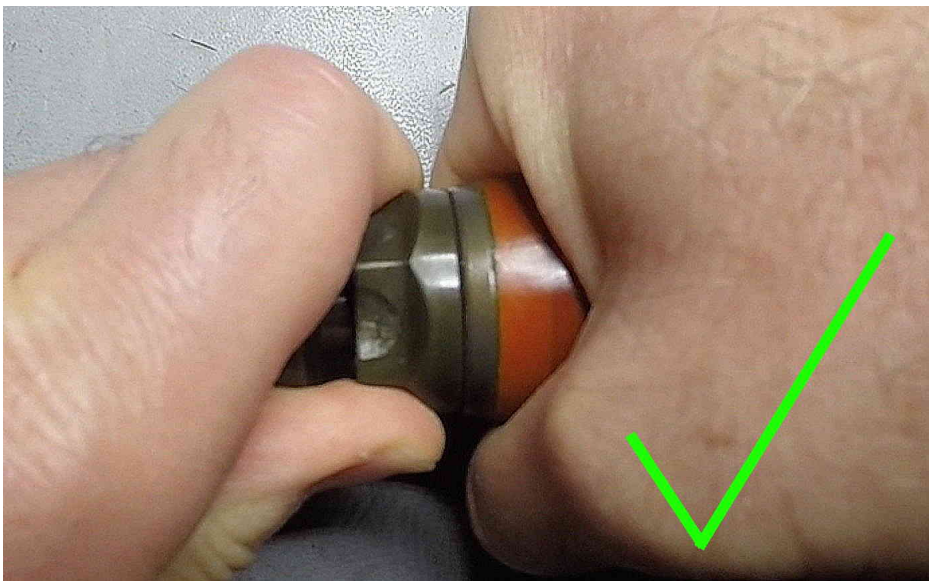

Figure 7. Correct battery-cap tightening technique for Acousonde 3A. Grasping the Model 3A near the battery cap minimizes twist to the embedded electronics.

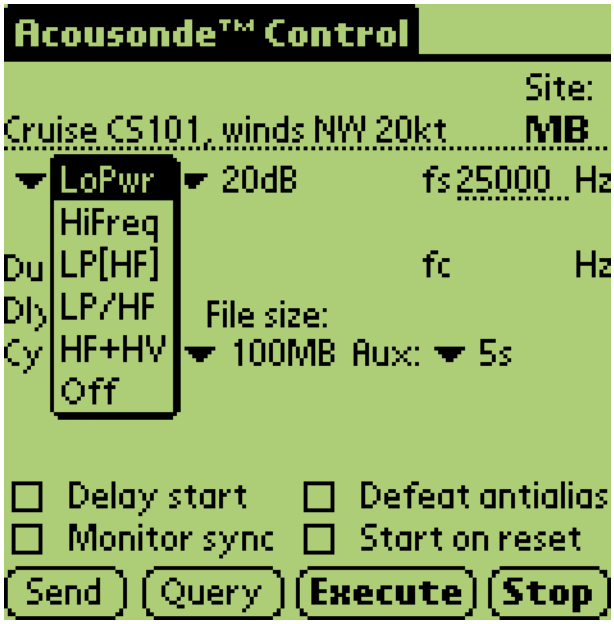

Figure 8. Acoustic sampling programs available via the PalmOS interface. The user has requested an acoustic sampling rate of 25000 Hz with a gain of 20 dB, and has filled in the **Site** and **Deployment Title** fields. The auxiliary sampling rate is set for a 5-second period, but other choices are available as shown in Figure 9.

3. Enter your application's minimum acceptable sampling rate, in hertz, in the **fs** field (the **fc** field is read-only and used by the Acousonde to report the low-pass anti-alias cutoff frequency it will use). The Acousonde will choose the next highest supported sampling rate. Supported sample rates are determined approximately with the formula 464 kHz / 1, 2, 3...; thus, 464 kHz, 232 kHz, 154 kHz, 116 kHz, 92 kHz, etc.
4. Select 0 or 20 dB gain (selecting other gain options will round off to either 0 or 20 dB).
5. Select an **Aux** (auxiliary) sampling program, if one is desired, from the choices shown in Figure 9. Table 1 describes the available auxiliary sampling choices.
6. Enter one or two arbitrary letters/numbers for the **Site**. Whatever is entered here will appear as the first two characters of the filenames for all data files acquired with this recording program. The choice of these characters is entirely up to you.
7. Consider entering text in the **Deployment Title** field in the upper left of the **CONTROL** page. This text is kept in the metadata header of all sampled acoustic and auxiliary data files, although depending on what tools you use to handle the data it may not be visible in postprocessing. If you do enter text in this field, it is most helpful to enter descriptions of the circumstances under which the data are acquired, such as test identifier, cruise number, weather conditions, etc. It is least helpful to enter redundant information, such as the sample rate or the date and time, as these are already kept elsewhere in the metadata.

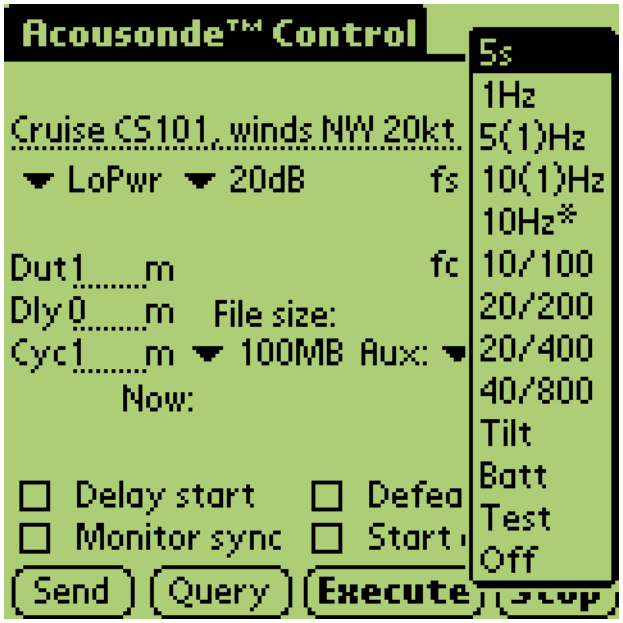

Figure 9. Auxiliary sampling programs available via the PalmOS interface.

Table 1. Auxiliary sampling choices.

Select	Description
5s	Sample all aux channels once every 5 seconds
1Hz	Sample all aux channels once per second
5(1)Hz	Sample 3D compass & accelerometer at 5 Hz, pressure at 1 Hz
10(1)Hz	Sample 3D compass & accelerometer at 10 Hz, pressure at 1 Hz
10Hz*	Sample all aux channels at 10 Hz (* = recommended for TrackPlot compatibility)
10/100	Sample 3D accelerometer at 100 Hz, 3D compass & pressure at 10 Hz
20/200	Sample 3D accelerometer at 200 Hz, 3D compass at 20 Hz, pressure at 10 Hz
20/400	Sample 3D accelerometer at 400 Hz, 3D compass at 20 Hz, pressure at 10 Hz
40/800	Sample 3D accelerometer at 800 Hz, 3D compass at 40 Hz, pressure at 10 Hz
Tilt	Sample 3D accelerometer once per second; no other aux channels sampled
Batt	Sample temperature and battery voltage once every 5 seconds; no other aux channels sampled
Test	Do not use
Off	No auxiliary sampling will take place

Note 1: Battery voltage is never sampled except under the **Batt** auxiliary program.

Note 2: Acousonde 3A units sample temperature at the same rate as pressure.

Note 3: Acousonde 3B units have a light-level sensor, while Acousonde 3A units do not.

Note 4: Acousonde 3B units do not sample light level or temperature faster than 5 Hz.

8. Select program options, if any. The program options are:
   - **Delay start** allows sampling to start at a specified time. When the program is executed, the Acousonde will sleep until the programmed wakeup time.
   - **Monitor sync** logs timestamps for infrared pulses received during sampling. It is for specific custom applications.
   - **Defeat antialias** bypasses the onboard acoustic anti-alias filtering hardware.
   - **Start on reset** has two effects. First, if a sampling program with this option enabled is sent to the Acousonde using the **Send** soft key, the Acousonde will load the program by default every time it is powered up or reset. Second, if the Acousonde resets after the program is sent *without having lost power for more than a few seconds*, it will execute (or resume executing) the program thus saved. The **Start on reset** option is automatically deselected if power is lost or if the sampling program is explicitly stopped by the user, but the saved program will continue to reside in non-volatile memory and will still be loaded by default at every power-up and reset.
9. Use the **Send** soft key to beam the sampling program to the Acousonde. The Acousonde will confirm by beaming back the closest sampling program it can support. As with all infrared interactions, ensure that the optical path between the Palm and the Acousonde is unobstructed during this exchange.
10. Inspect the sampling program with which the Acousonde responded, especially the date and time shown on the **CONTROL** page as "Now". If the sampling program accepted by the Acousonde is not what you want, adjust the sampling parameters. If the date or time is wrong, adjust the Palm's time-of-day clock using the Palm's **Prefs** application. Once you have made the necessary adjustments, you will need to **Send** the sampling program from the **CONTROL** page again to transmit the modifications to the Acousonde.
11. Once you are satisfied with the sampling program, use the **Execute** soft key to tell the Acousonde to activate the sampling program. The red Alert LED will flash a "Caution Alert" or "Sleep Alert" (Figure 4) to indicate that the program has been activated. In the case of immediate sampling, acqusition will start $\sim$15 seconds after the Caution Alert.
12. After sampling should have started, confirm that the yellow System LED flashes at the top of the minute as expected (Figure 5). If acoustic sampling is underway, the System LED will produce a single yellow flash; if no acoustic sampling is occurring but auxiliary sampling is underway, the System LED will produce a double yellow flash.
13. To terminate sampling, use the **Stop** soft key on the Palm application's **CONTROL** page to send a stop request via infrared to the Acousonde. *Note: When sampling, the Acousonde is unable to devote as much processor time to handling infrared transactions. Your Palm may report errors when attempting to beam your request to stop sampling. You may need to retry the stop attempt, in some cases several times, before the stop command is received. At very fast acoustic sample rates, persistent attempts to transmit the stop command (or any other infrared command) may terminate acoustic sampling by starving the Acousonde of processor time. In this case auxiliary sampling, if enabled, may continue and will still need to be stopped separately with the stop command.*

2.5 INSPECTING DATA RECORDED BY THE ACOUSONDE™

1. To inspect acquired data, mount the Acousonde's filesystems on a personal computer as described in the beginning of this quick-start guide.
2. At least two volumes should be available to you. One volume is the "auxiliary" volume, denoted with a volume name suffixed with "_X". The auxiliary volume holds the log file (in plain text format) and all of the auxiliary data that has been gathered (temperature, pressure, orientation, etc.). Other volume(s) are "acoustic" volumes that contain only acoustic data files.
3. All data files, whether auxiliary or acoustic, share a common file naming convention:

   `AABCCCCC.MT`

   where

   `AA` = 2-letter site field entered when recording was programmed
   `B` = 1-letter sensor code
   `CCCCC` = 5-digit index for files recorded from a given sensor

   The sensor code letter may be one of the following:

   `I,J,K` = Accelerometer X, Y, Z axes respectively
   `X,Y,Z` = Compass X, Y, Z axes
   `S` = Acoustics from low-power hydrophone
   `H` = Acoustics from high-frequency hydrophone
   `P` = Pressure (i.e., depth)
   `T` = Temperature

   For example, the filename MBP00012.MT would indicate the thirteenth pressure file recorded since the last time storage was erased (the first file would be index 0). The "MB" that begins the file name is arbitrary, being whatever the user entered when the recording was programmed. Perhaps in this example it might stand for "Monterey Bay", or it might be a code identifying the animal to which the tag was attached.
4. The creation date reported by the operating system for all data files is correct for the time zone in which the files were recorded.
5. All data files, whether auxiliary or acoustic, are in "MT" format. A MATLAB "M"-file that reads MT files may be downloaded from the Acousonde web site. For programmers, a "C" language header file that describes MT format is available on request.

Caution: Do not attempt to transfer files from the Acousonde to a personal computer from more than one Acousonde volume at a time! While the volumes appear to be simultaneously accessible, in reality only one storage card can be powered up within the Acousonde hardware at a time. Transferring files from multiple volumes may cause the Acousonde to cycle power rapidly to its different storage cards. This will be severely inefficient and may lead to premature storage failure.

3 POWER, MECHANICAL & HANDLING

3.1 BATTERY, BATTERY HOUSING, AND BATTERY CAP

As an underwater instrument powered by a field-replaceable battery, the Acousonde provides a pressure-tolerant *battery housing* that is secured by a separate *battery cap*.

The battery housing is made of either aluminum or titanium and is integrated into the body of the Acousonde. The battery cap is a removable, anodized, machined-aluminum cover that screws onto the battery housing. The battery cap connects the electrical negative between the battery's negative terminal and the chassis.

Two different families of battery cap are in use depending on Acousonde model. Cylindrical Acousonde 3A recorders typically use a *cylindrical cap* or a *flange cap*, usually with "flats" allowing tightening by a 15/16-inch or 24-mm short-handled wrench. Animal-tag Acousonde 3B recorders typically use a convex *dome cap* that improves hydrodynamics.

As far as Acousonde operation is concerned, all battery-cap types are interchangeable. The different shapes were designed only for different application environments.

3.1.1 Battery specification and installation

The only battery specified to work in the Acousonde is the Saft LS 17500, a 3.6-V A-size primary lithium cell. No other battery manufacturers, types or sizes have been tested to work correctly.

Insert the battery with its positive "button" end in first, and the negative, smooth end exposed to contact the battery cap when the latter is screwed on.

If the battery is inserted backwards by mistake, a bright orange LED will light to indicate the problem. No damage to the Acousonde will result even if the battery is allowed to remain backwards indefinitely. The orange reverse-battery light will not appear under any other circumstances.

Caution: As with all battery-operated equipment, it is best to remove the battery when the battery will not be necessary for an extended period. A powered-up Acousonde will gradually drain its battery, and battery leakage, should it occur, could damage the Acousonde.

3.1.2 Battery contacts

The *positive battery terminal* consists of a bent flat spring located at the deep end of the battery housing. The *negative battery terminal* is a coil spring located inside the battery cap.

Periodically it may help to clean the battery terminals. Dirty or oxidized contacts increase resistance in the power supply, increasing the probability of premature power failure. Moisten a cotton applicator with a small amount of isopropyl alcohol and wipe the contacts as well as the mating surfaces of the battery to be used. Allow to dry thoroughly.

Caution: The higher the purity of the isopropyl alcohol used the better, as low-purity alcohol will leave water behind after evaporation of the alcohol content. Always be sure the battery housing is completely dry before securing the battery cap.

3.1.3 O-rings

Two identical o-rings, fitted to the battery cap, keep water out of the battery housing when immersed.

Before securing the battery cap, always examine the o-rings closely for wear, contaminants, or damage. Be certain the o-ring seats are smooth and clean, both on the battery cap and the mating surface of the battery housing. The o-rings should be greased lightly, with just enough grease to ensure smooth movement when the cap is screwed back on, and proper sealing deformation when under pressure. More grease than this is not necessary and will attract contaminants. Adding a slight amount of the same grease to the threads of the enclosure cap will smooth mating of the cap to the enclosure.

Contaminated o-rings and seats may be cleaned by removing the o-rings, wiping the o-rings and seats with isopropyl alcohol, and re-greasing. O-rings have a limited life span, especially when stored compressed with the battery cap screwed on. Replace o-rings found to be worn or damaged.

Caution: If alcohol comes in contact with the polyurethane body of the Acousonde, wipe it off immediately. Alcohol will damage the polyurethane.

Caution: When removing or replacing o-rings, be careful not to cut or abrade them while slipping them over the sharp threads of the enclosure cap.

WARNING: NEVER use Vaseline, WD-40, or any other petroleum-based lubricant on o-rings. Petroleum products can damage o-rings and result in failure, potentially leading to a short-circuited battery. Use only a high grade silicone valve lubricant/sealant such as Dow Corning 111.

WARNING: NEVER use any metal object to pry out o-rings. Knife blades, tweezers, paper clips, and the like may damage the o-rings or, worse, their aluminum seats. Damage to the o-ring seats greatly increases the likelihood of failure, potentially leading to a battery short-circuit while underwater.

3.1.4 Securing the battery cap

Screw in the battery cap carefully to be certain, as you do so, that the o-rings seat properly. It is possible for poorly seated o-rings to bind out of their seats as the cap is screwed in.

After the battery cap “bottoms” with hand tightening, snug it down securely with the appropriate tool, either a 15/16” or 24mm short-handled wrench (for cylindrical or flange caps) or a jumbo flat-blade screwdriver (for dome caps). This ensures a robust electrical connection through the threads. If the enclosure cap is not secured with gentle mechanical assistance,

tiny movements of the threads under pressure/temperature cycling may interrupt power to the electronics and reset sampling.

WARNING: If you cannot "bottom" the battery cap while turning it by hand, STOP and do NOT attempt to finish screwing in the cap with or without mechanical assistance. If the enclosure cap does not "bottom" by hand, it indicates that foreign material is contaminating the threads, that the o-rings have been pinched, or that the enclosure or cap have been damaged. Any of these may cause a leak, permanent damage, and a potential short-circuit of the battery. Remove the cap and inspect the threads and o-rings for damage or contamination.

WARNING: For Acousonde 3A cylindrical units, grasp the unit as close to the battery cap as possible when tightening the cap to minimize twist of the electronic components. Excessive mechanical twist in the body of the Acousonde can result in permanent damage and potential short circuits within the electronics. See Figures 6 and 7.

Caution: When tightening battery caps with a wrench or screwdriver, avoid excessive force as doing so could damage the cap. "Snugging" them down, that is, simply better than hand-tight, is adequate. When using a wrench for a flange-type battery cap, choose a short-handled wrench or hold the wrench close to the end to minimize leverage.

3.1.5 Caring for the battery compartment and cap

After retrieving a Acousonde from the field, rinse it with fresh water before unsealing the battery cap. This will discourage intrusion of salt water or other contaminants into the battery compartment when you open it.

Caution: NEVER drop the instrument or the battery cap at any time, but especially when the two are separated. When separated, both cap and enclosure are more easily damaged by impacts. If the battery compartment or cap become deformed, they will not seal properly, and the instrument can no longer be used underwater.

3.2 ACOUSONDE 3A BATTERY-HOUSING BULKHEAD AND ORIENTATION DIMPLE

Mechanically, the battery-housing bulkhead is the strongest part of the Acousonde. Although encapsulated in urethane like the rest of the battery housing, the bulkhead consists of a heavy, solid section of metal with a larger diameter than the body/shaft of the housing. The urethane layer over the bulkhead is thinner, causing the bulkhead metal to appear brighter through the urethane.

On the Acousonde 3A, the rim of the battery-housing bulkhead features an orientation "dimple" to indicate the "up" direction of the Acousonde's built-in tiltmeter (Figure 10). This is provided because the 3A's cylindrical shape provides no other distinct orientation cues.

The battery-housing bulkhead is an ideal location to wrap a securing strap, as compression there is very unlikely to damage internal components.

Figure 10. Acousonde 3A battery-housing bulkhead with "up" orientation dimple. Besides being the location of the orientiation dimple, the battery-housing bulkhead is the strongest part of the Acousonde 3A and an ideal location for a securing strap.

3.3 MAGNETIC RESET AND DEEP POWER-DOWN SWITCH

The Acousonde is equipped with a magnetically-operated switch (see Figures 1 and 2 for the different locations on the 3A and 3B models).

Operating this switch by holding a sufficiently strong magnet close by will reset the processor, equivalent to a "restart" or "reboot" operation on a personal computer. When the switch "sees" the magnet, the Acousonde will flash the system LED and begin the restart process. Once the system LED flashes, the magnet may be removed.

One may also use the magnetic switch to place the Acousonde in *deep power-down*, a low-power mode in which battery drain is about one-quarter of that in ordinary standby mode. For example, if the Acousonde may not be used for some time, but it is inconvenient to remove the battery, deep power-down may be used to improve battery longevity.

Deep power-down maintains the Acousonde's time-of-day clock but nothing else. It is effectively turned off and unavailable for infrared interaction.

To enter deep power-down, first reset the Acousonde as described above, but do NOT remove the magnet. Instead, leave the magnet in place over the magnetic switch throughout the restart process. After the Acousonde finishes restart, it will detect the presence of the magnet. The

Alert LED will flash very rapidly followed by a bright-fading-to-dim pulse, and the Acousonde will then enter deep power-down.

When ready to use the Acousonde, restart it by swiping a magnet past the magnetic switch, and wait for it to reboot normally. If the Acousonde has been programmed to start sampling on reset, it will do so after restarting, provided power has at no time since power-down been interrupted for more than a few seconds. Sample-on-reset will engage once the unit completes reboot.

At present, there is no way to ask the Acousonde to begin sampling when the magnet is removed. For a magnet to reset the Acousonde, it must be away from the Acousonde's magnetic switch for at least several seconds, then brought back to cause a reset.

3.4 USB

When connected to a personal computer via a USB cable, the Acousonde is designed to boot as a flash drive (for custom applications, the Acousonde may instead boot as a USB host and write data to a USB flash drive.) The Acousonde's Micro-USB AB socket is located at the deep end of the battery housing, adjacent to the positive battery terminal. When the battery cap and battery are removed, a standard Micro-USB 2.0 plug may be inserted for connection with a computer host.

The Acousonde 3 series relies on a circa-2006 low-power microprocessor that is only capable of "full speed" USB. Mechanically and electrically, the Acousonde is compatible with all USB 2.0 systems; however the data transfer rate is limited to a theoretical maximum of 12 Mbps or about 6 GB/hour. In practice the Acousonde has demonstrated transfer rates up to 3.3 GB/hour.

Erasing the Acousonde's onboard storage is only allowed when the Acousonde has been booted on USB. This is due to the power draw required.

Note: Do not use a Micro-USB cable intended only for recharging mobile devices. These cables omit data-signaling wires. The Acousonde will boot, but it will not be possible to transfer data from it.

3.4.1 Plug alignment and insertion

The USB socket's position within a deep recess may lead to initial frustration seating and securing a USB cable. With proper alignment, patience, and a little practice, the process will go smoothly. Note that Micro-USB is not mechanically symmetric, so **be sure to align the plug with its USB logo and 'B' mark facing the wall of the battery housing**.

Once you are sure the plug is not reversed relative to the socket, insert the connector cable into the vicinity of the socket and wiggle it while applying slight pressure until the connector seats. Then push the connector in gently, using a fingernail against the back end of the MicroUSB plug.

To seat the plug, enough force may be necessary that your fingernail bends, but not much more. If more force seems required, then the plug is improperly seated. It may take practice to develop the "feel" of a properly-seated plug.

Caution: Never force the Micro-USB plug into the Acousonde's socket. Never insert metal tools into the battery housing to push or guide the Micro-USB plug. Use extreme caution when applying any rigid tool to apply pressure on the plug; you could unintentionally use more force than necessary. IF YOU DAMAGE THE SOCKET, THE ACOUSONDE WILL BE UNUSABLE AND PERMANENTLY BEYOND REPAIR.

3.5 APPLICATION PLACEMENT AND SECURING (ACOUSONDE 3A)

The Acousonde 3A may be secured and/or tied off at four locations: the 10/24 threaded hole in the end of the battery cap, the battery-cap neck, the battery-housing bulkhead, and the MicroSD card stack (Figure 11). Of these, the MicroSD card-stack area is the most fragile and the minimum mechanical stresses possible should be applied there. While the methods used to attach the Acousonde 3A will depend on the application, a few guidelines apply to all attachment techniques.

Do not secure around the hydrophone(s)!

As depicted in Figure 11, the low-power hydrophone is located near the center of the Acousonde 3A, while the optional high-frequency hydrophone is located near the nose. Attaching the instrument by cinching hose clamps or cable ties around the hydrophone(s) may reduce their sensitivity, change their frequency response, or damage them, or may introduce unwanted local noise.

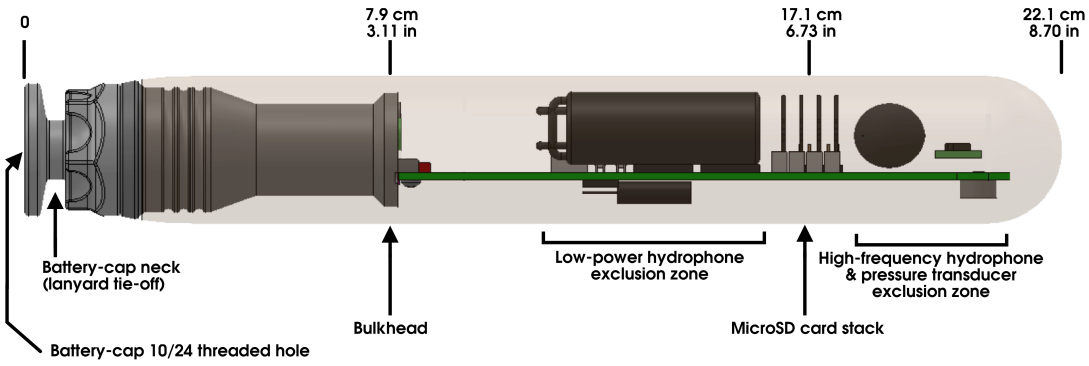

Figure 11. Location of securing/tie-off points on Acousonde 3A. The bulkhead region can tolerate much more mechanical stress than the MicroSD card stack region. Avoid securing anything in the exclusion zones. The "flange" type battery cap is shown.

Do not secure directly over the pressure transducer

The pressure transducer is visible through the polyurethane as a small silver disk near the nose. While it is unlikely that cinching the Acousonde 3A at the pressure transducer will damage deep-rated pressure transducers, it will introduce an unwanted offset on the pressure record. Shallow-rated pressure transducers are very fragile and may be destroyed, or at least saturated, if exposed directly to cinched straps or ties.

Avoid local sources of acoustic noise

An attachment system that creaks, bumps, strums or oscillates is guaranteed to introduce unwanted noise in the acoustic record. The noise may be strong enough to saturate the recording electronics, rendering the acoustic record unusable.

Consider flow-noise effects

When the Acousonde is moving through the water, flow noise is unavoidable; however, care in the attachment design can significantly reduce the impact of flow noise.

3.6 FLOAT, STROBE, AND SUCTION CUPS (ACOUSONDE 3B)

Text to come.

4 SIGNALING

4.1 LED SIGNALS

The Acousonde has three LED indicators – the *Alert LED*, the *System LED*, and the *Reverse-battery LED* – all clustered together under a raised circular bump on the side of the resin encapsulation (Figure 3). These three LEDs operate as follows:

Alert LED **Bright red.** Signals alerts and non-sampling status (see Figure 4). The alert LED double-flashes once a minute when the Acousonde is in standby awaiting instructions (see Figure 4).

System LED **Dim yellow.** Lights when the Acousonde first turns on, indicates the detection of infrared communication, and shows status once a minute when data sampling is active (see Figure 5).

Reverse-battery LED **Bright orange.** Only lights when the battery has been inserted backwards; it does not light during normal operation.

4.2 LED BATTERY DIAGNOSTICS

If the battery is inserted backwards by mistake, a bright orange LED will light to indicate the problem. No damage to the Acousonde will result, even if the battery is allowed to remain backwards indefinitely. The orange reverse-battery light will not appear under any other circumstances.

If a dead battery is inserted, the Acousonde may show no signs of operation at all; or, it may light the yellow system LED continuously; or, it may flash the yellow system LED briefly about once per second.

The Acousonde cannot assess the exact capacity remaining in the battery. It can only identify batteries that appear to be significantly depleted. If such a battery is detected on startup, the Acousonde will flash the LED in a unique “battery low” sequence – three pulses of fading-to-dark brightness – after initial boot-up is complete. Low-battery detection at any time will also change the once-per-minute standby flash from a simple double-flash to a double-flash followed by a pulse of bright-fading-to-dark brightness (see Figure 4).

5 SENSORS

The Acousonde's acoustic channels are sometimes called *primary* channels (to distinguish them from the *auxiliary* channels).

All Acousonde units come with a *low power* (LP) hydrophone channel. As the name suggests, this channel is optimized for low power consumption and thus longer recording life. Its anti-alias filter has a maximum cutoff frequency of 9.26 kHz.

Additional text to come.

6 COMMANDING

All commanding and interrogation of the Acousonde takes place through its infrared interface using a "Palm" handheld computer.* The Palm must be loaded with a custom commanding app called **Acousonde**. See the Quick Start chapter for instructions on transferring the **Acousonde.PRC** app file from the Acousonde to your Palm.

The most important thing to remember about your Palm is that you **must set its date and time correctly.** The **Acousonde** app obtains the date and time from the PalmOS and provides them automatically to the Acousonde during infrared communications. If your Palm has not been set to the correct date and time, all your data files will be timestamped incorrectly.

This preliminary release of the manual does not cover all the capabilities of the **Acousonde** app.

6.1 NOTE ON THE DISCONTINUATION OF THE PALM PLATFORM

Palm formally ceased production of handheld devices in February 2009. Due to the popularity of the Palm up until that time, Palm-compatible devices are still easily available as of this writing, though in many cases they are now used or refurbished. Despite its age, the Palm/infrared commanding approach satisfies a combination of objectives that is hard to achieve with current technology:

- Robust, inexpensive, handheld commanding unit for use in difficult field situations
- No cables
- No commanding sockets on Acousonde that could compromise reliability
- No prior pairing or other per-Acousonde setup necessary
- No need for, or conflict with, any existing network(s)
- Can communicate with a specific desired Acousonde easily, even with several other Acousondes nearby
- Commanding app only needs to be maintained for one platform
- Commanding app can be loaded onto a Palm directly from an Acousonde in the field without need for synchronization cabling, networking, or any other equipment
- User does not need to register for a vendor's app "ecosystem"; in fact user does not need network connectivity at all

Acoustimetrics has thus hesitated to change how the Acousonde is commanded, not only because of the development hurdles, but also because it has been difficult to identify a realistic concept that works as easily, as inexpensively, and as well.

Nevertheless, Palms will gradually become harder to find. Eventually an alternative must be pursued. A stopgap measure is simply to write a command-line app for a laptop computer

* This manual refers to any handheld computer compatible with the Palm Operating System (PalmOS) as a "Palm", although PalmOS compatibles were manufactured by several other vendors besides Palm, including Handspring and Sony.

mated with infrared hardware, and indeed this is already set up for in-house development and testing. If all Palms disappeared tomorrow this software could quickly be modified to replace the Palm functionality.

6.2 NAVIGATING AND USING THE ACOUSONDE PALMOS APP

The **Acousonde** app consists of several "pages" or "panes" for different topics of interaction with the Acousonde. One accesses the different pages using the menu selector; Figure 12 shows the drop-down menu that appears when pressing your Palm's menu icon or, in most Palm devices, the upper left corner of the screen.

Commanding the Acousonde via infrared involves navigating to the appropriate **Acousonde** app page, entering any information necessary, then pressing the (software) button that sends a command as an infrared packet to the Acousonde. For most commands, the Acousonde will respond by sending an infrared return packet, and the Palm will use that response to update/populate the relevant fields on the page. If an error occurred, the Palm will display an alert dialog.

Infrared communications between the Palm and the Acousonde depend on a short, uncontaminated optical transmission path between the two. At all times when using the Palm to interact with the Acousonde, be sure both devices are oriented so that their optical transceivers are pointed at each other and are less than 1 m apart, and keep other powered-up Acousonde units out of the line of sight. Note that some computer monitors and light fixtures emit significant infrared noise; consider moving away from such things or turning them off if communication problems arise.

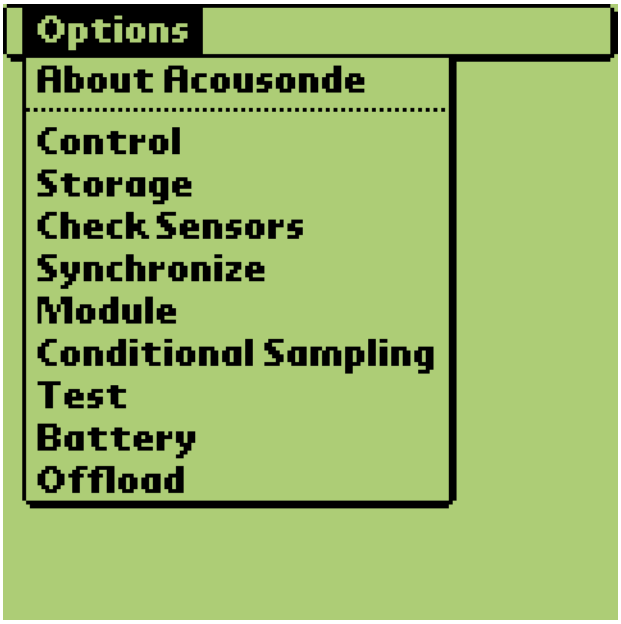

Figure 12. The Acousonde app menu.

6.3 CONTROL

The **CONTROL** page (Figure 13) provides the Acousonde with a sampling program, and starts and stops sampling. The following explains how to use the fields on the **CONTROL** page.

6.3.1 Title

The optional **Title** field, at the top of the page, provides a place to include essential information about the data, especially information that may not otherwise be embedded with the metadata. The provided text must be 80 characters or less, and will be embedded in all data-file headers.

For example, in Figure 13 the **Title** field notes a cruise identifier as well as wind speed and direction. Other things one could consider writing into this field are the iteration of this effort (e.g., "third attempt with magnesium release"), or a location (e.g., "SB Channel").

Note: The Acousonde automatically keeps information regarding date, time, unit serial number, and sampling rate in the metadata of every data file. There is no need to enter any of these items into the **Title** *field. The most effective use of this field is for notes that will help jog one's memory as to the recording circumstances.*

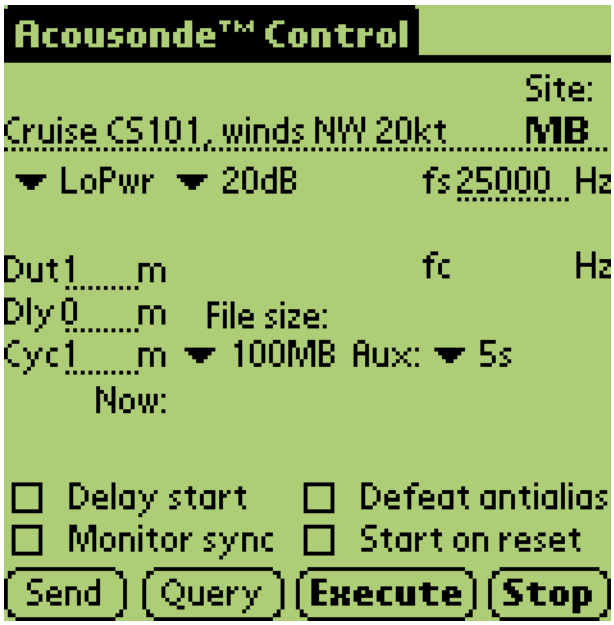

Figure 13. Example of a populated Control page.

6.3.2 Station/Subject

The optional two characters of the station/subject field become the leading characters of all resulting data files. These are arbitrary and can be anything you wish, although it is better to choose characters that will work correctly when used as part of a filename. Enter characters that can help you differentiate one deployment from another. In Figure 13, for example, "MB" refers to Monterey Bay, the location of the test. Other example station/subject codes might be "SB" for Santa Barbara, "Ne" for Newport, "S3" for subject number three, "T3" for test number three, "5k" for 5-km range, etc.

6.3.3 Primary channel selector

Use the primary-channel sampling menu (Figure 14) to select which primary channel, or combination of primary channels, to sample. Choices are as follows:†

LoPwr Sample acoustics from the low-power channel only. In units without the high-frequency option, this is the only acoustics channel. In units with that option, the low-power channel is typically (but not always) for lower-frequency recordings with sample rates up to 25 kHz (bandwidths up to 9.2 kHz).

HiFreq† Sample acoustics from the high-frequency channel only. Use this channel, if it is available in the unit in question, for sampling acoustics faster than 25 kHz (typically at 232 kHz).

LP[HF]† Alternate sampling, first for a number of minutes on the low-power channel, then for a different number of minutes on the high-frequency channel. The number of minutes to sample each channel is provided by the user during programming.

LP/HF† Alternate ("ping-pong") sampling between the low-power and high-frequency channels. **This feature is not yet supported.**

HF+HV† Sample acoustics from the high-frequency channel only, and at the same time, turn on the high-voltage supply internal to the Acousonde. Intended for specific custom applications with certain acoustic/seismic sensors.

Off Do not sample acoustics. Auxiliary sensors may be engaged with the **Aux** sampling menu elsewhere on the **CONTROL** page.

† Channels so marked are available only on units equipped with the high-frequency option.

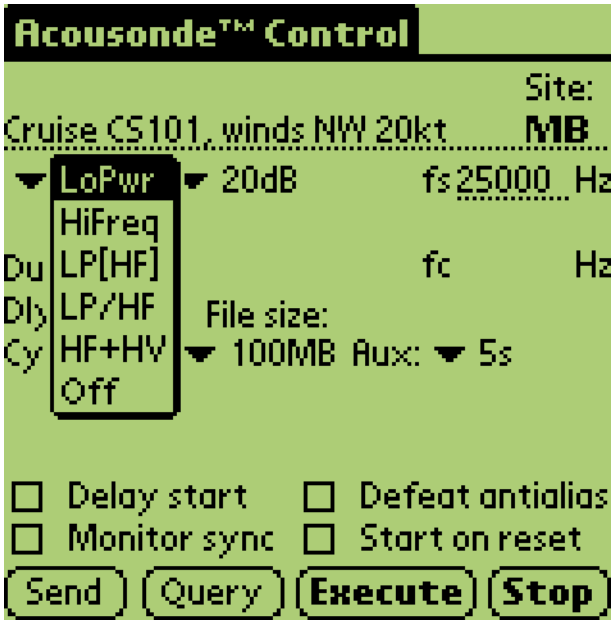

Figure 14. Selecting the primary-channel sampling program.

6.3.4 Primary sampling rate

The primary sampling rate (f_s) is the rate at which acoustics will be sampled. The Acousonde does not support arbitrary acoustic sampling rates, but it does support a broad selection of discrete rates up to 232 kHz (464 kHz is also possible and has been tested, but is not a guaranteed specification). Possible acoustic sampling rates are given precisely by the formula*

$$\frac{13008896 \text{ Hz}}{28 * \{1, 2, 3...\}}$$

For example, the fastest sampling rates available in hardware are

$$\{464.6 \text{ kHz}, 232.3 \text{ kHz}, 154.9 \text{ kHz}, ...\}$$

When you **Send** a sampling-program request with a desired sampling rate, the Acousonde will determine the next highest sampling rate it can accommodate and return this value in the confirmation packet it sends back to your Palm for display, along with the "cutoff" frequency (f_c) at which the anti-alias (low-pass) filter will be set.

Note: The "actual" sampling rate displayed on the Palm, as well as the rate embedded in the sampled-file metadata, will be an approximate truncation of an infinitely-repeating decimal.

* The given numerator is for standard applications that source the system clock from the real-time clocking system. For special applications that use the main oscillator to source the system clock, the numerator is 13000000 Hz instead of 13008896 Hz.

However, the log file available on the auxiliary filesystem the next time the Acousonde is mounted via USB (e.g. "B003A041.TXT") will list the integer numerator and denominator of the fraction representing the sampling rate. From these values a more precise value for sampling rate may be determined.

Note: Sampling rates over 26 kHz draw more heavily on the battery and may result in reduced recording duration.

6.3.5 Gain

Gain selects either 0 or 20 dB deployment-time amplification of the analog signal, after preamplification but before digitization. Applying deployment-time gain can increase the signal-to-noise quality of recorded data, but it also increases the risk that strong signals will saturate or clip the recording. Heavily clipped digital records can be nearly useless, so use this feature with care.

6.3.6 Multi-channel acoustic sampling using LP(HF)

When multi-channel acoustics are to be sampled using the **LP[HF]** primary sampling program, the **CONTROL** page will display two rows of acoustic sampling parameters instead of one (Figure 15). The upper row controls parameters for the low-power channel, and the lower row control parameters for the high-frequency channel. The number of minutes to sample each channel must be entered.

For power conservation it is usually best to rely on the LP channel most of the time and record the HF channel only a small fraction of the time.

6.3.7 Auxiliary program selector

The Acousonde's auxiliary sensor suite comprises all non-acoustic sensors, including temperature, pressure, 3-axis acceleration, 3-axis compass, and battery voltage. Acousonde 3B models also sense light level.

It is not possible to program an arbitrary user-specific sampling regime for the auxiliary sensors. However, the **Acousonde** app provides a suite of preconfigured auxiliary sampling programs for a range of applications. See the quick-start guide at the beginning of this manual for a description of the available auxiliary sampling programs.

6.3.8 Auxiliary sampling capacity

The Acousonde's auxiliary storage capacity dictates how long auxiliary data channels may be sampled, and at what rate, before auxiliary storage fills and auxiliary sampling ends. Depending on an Acousonde's hardware, its auxiliary storage capacity may be 256, 512, or 2048 MiB. To determine the auxiliary storage capacity of an Acousonde, mount it as a USB

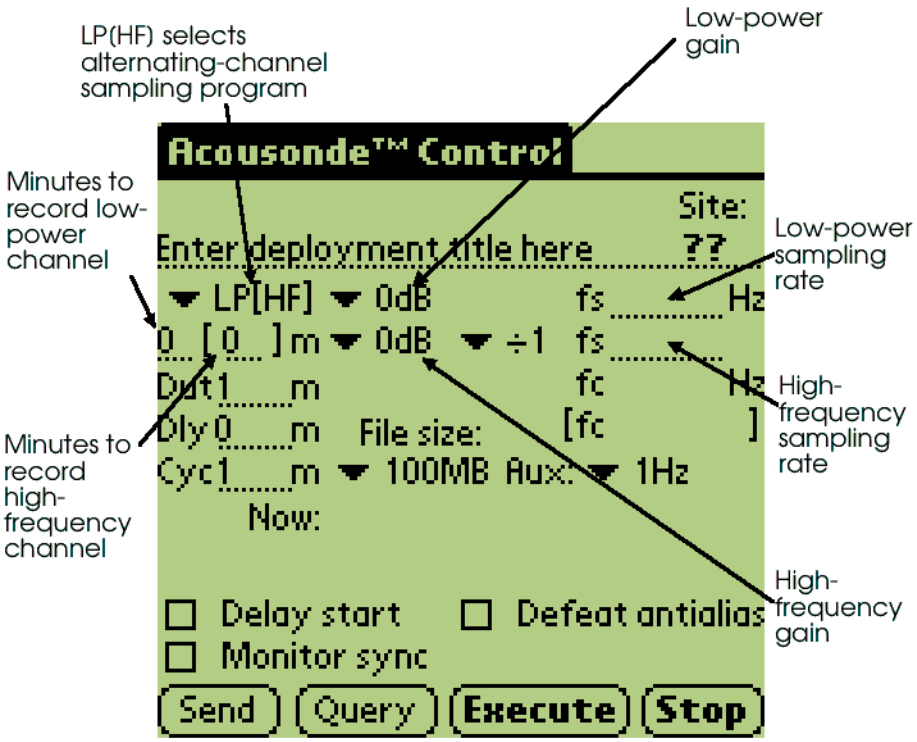

Figure 15. Additional fields display to support multi-channel acoustic sampling.

drive and examine the .HTM configuration report located on the auxiliary volume. The report provides the value under “Auxiliary storage capacity (raw)”.

Table 3 lists the approximate theoretical maximum recording durations for different auxiliary sampling selections and auxiliary storage capacities. Many of the values shown are unrealizable on battery power, that is, the battery will fail long before auxiliary storage capacity is exhausted.

If auxiliary storage fills, deployment logging and all auxiliary recording will cease. Conditional acoustic sampling, if active, will stop functioning and acoustic recording will no longer change state depending on auxiliary sensor readings. In typical deployments these are undesired effects, and it is best to select a conservative auxiliary sampling scheme that avoids this result.

6.3.9 Acoustic Duty/Delay/Cycle

Acoustics may be sampled periodically rather than continuously. Periodic recording, also known as “duty-cycled” recording, may be programmed by entering the desired minutes of “on period” (**Duty**) out of the minutes of total “cycle period” (**Cycle**).

Table 3. Approximate theoretical auxiliary sampling capacities.

Select	bytes/s	Time to fill auxiliary storage (days) 256 MiB	512 MiB	2048 MiB
5s	3.6	(2.3 years)*	(4.6 years)*	(18 years)*
1Hz	18	(170)*	(340)*	(3.7 years)*
5(1)Hz	66	47	(94)*	(1 year)*
10(1)Hz	126	24	48	(192)*
10Hz*	160	19	38	(155)*
10/100	700	4.4	8.8	35
20/200	1360	2.2	4.5	18
20/400	2560	29 hours	2.4	9.7
40/800	5080	14 hours	29 hours	4.8
Tilt	6	(1.4 years)*	(2.8 years)*	(11 years)*
Batt	0.8	(10 years)*	(21 years)*	(85 years)*

(value)* – Unobtainable without external power; typical battery will not support this.

For example, if **Duty** is set to 10 minutes and **Cycle** to 60, acoustic recording will take place for 10 minutes out of every hour, that is, in a repeating pattern of 10 minutes on and 50 minutes off.

Duty cycle windows are aligned with the time of day. This means that, for example, a cycle of 120 minutes will start at the top of each evenly-numbered hour, a cycle of 60 minutes will start at the top of each hour, a cycle of 30 minutes at the top of each half-hour, and so forth.

To offer a more specific example, consider a duty cycle of 5 minutes out of every 120, with the Acousonde's initial wakeup programmed by the user for 9 AM. The Acousonde would not actually record acoustics until 10 AM, when it would be active from 10:00 to 10:05, then again from 12:00 to 12:05, etc.

Aligning the recording cycle with the time of day this way is known as *synoptic recording*. Doing so ensures that multiple units operating with the same duty cycle will record the same snapshot of time, provided their clocks are adequately synchronized.

The **Delay** value, also in minutes, specifies by how much the recording window should be offset within the duty cycle. A **Delay** of zero minutes causes recording to begin at the top of the duty cycle. In the above example, had the user additionally specified **Duty** of, say, 15 minutes, then recording would occur from 10:15 to 10:20, then again from 12:15 to 12:20, etc.

Cycle should be a value that divides evenly into a day (1440 min). **Cycle** may not be larger than 1440 minutes. This means that any duty-cycled program must engage sampling at least once per day.

The default duty/delay/cycle is 1/0/1, which requests continuous acoustic sampling. A duty/cycle of 0/1 may also be selected, which is another way of turning acoustic data collection off.

Regardless of the acoustic duty/cycle chosen, auxiliary data channels such as pressure and temperature will be sampled continuously until the program is stopped or onboard storage fills (unless auxiliary sampling has been explicitly disabled using the **Auxiliary** drop-down menu).

Note: Each time a duty-cycled 'on" period ends, acoustic sampling will continue until the current internal sampling buffer is full. Depending on the acoustic sample rate, the recorded "on" period may continue into the nominal "off" period by up to several seconds. As a result, the top-of-the-minute LED status flash may indicate that acoustic sampling is still active even as the first minute of the "off" period begins.

6.3.10 Delayed start

If you want the Acousonde to begin sampling at some specified time in the future, select **Delayed start**. This will cause a soft key labeled **Wake** to appear, which will allow you to select your desired wakeup time. Neither acoustics nor auxiliary data will be sampled until the Acousonde wakes up.

Enabling **Delayed start** and selecting a start date and time programs the Acousonde, but does not "arm" it. To tell the Acousonde that you are through adjusting its programming and wish it to execute the sampling program, with or without a delayed start, you must send **Execute**. Otherwise the Acousonde will remain in standby and will not perform the desired sampling program.

6.3.11 Monitor sync

Monitor sync causes the Acousonde to make a timestamped entry in its log every time it observes a certain kind of brief infrared transient pulse ("synchronization pulse"). It is intended to allow assessment of the Acousonde's internal clock accuracy.

6.3.12 Defeat antialias

Digital sampling systems typically place an analog *antialias filter* before the digitizer, to ensure that frequencies above the Nyquist frequency are not reflected (*aliased*) into the passband during the digitization process. With unusual recording conditions and narrowly targeted scientific requirements, however, aliased data may be of less concern, and there may be value in bypassing the Acousonde's anti-alias filters using the **Defeat antialias** feature. Doing so will increase the digital self-noise present in the resulting recording.

6.3.13 Start on reset

Selecting the **Start on reset** checkbox has two effects. First, as long as power is not lost for more than a few seconds, the programmed sampling regime will automatically restart after the Acousonde resets (caused either by the magnetic switch or by a momentary power interruption). Second, the programmed sampling regime will be permanently remembered as the default, meaning that a **Query** sent immediately after unit power-up will obtain this default

regime rather than the factory default. Should the user **Execute** sampling immediately after power-up without first providing a sampling regime, this new default will be used.

Start on reset provides assurance that sampling will continue even in the face of momentary power failures or other expected or unexpected factors that might induce a system reset.

Start on reset may be also used in conjunction with deep power-down. It will cause the Acousonde to begin sampling when it is restarted from deep power-down by a magnet swipe or by a brief power interruption. Note that a restart, whatever the cause, will require the usual start-up time before the Acousonde is ready to acquire data.

6.3.14 Send

The **Send** soft key sends your sampling program to the Acousonde. You should continue to keep the Palm and Acousonde positioned for infrared communication, because the Acousonde will respond to a **Send** command by returning the sampling program it was able to accept.

Caution: Sending a sampling program does not cause it to execute! It programs the Acousonde but does not activate the program. To start sampling requires the* Execute *button.

6.3.15 Query

Query requests that the Acousonde transmit its current sampling program. Use **Query** to verify that the Acousonde has been set up properly.

6.3.16 Execute

When you are satisfied that the Acousonde has been set up with the desired sampling program, use **Execute** to engage the program. If you have not requested **Delayed start**, the Acousonde will flash the alert LED and sampling will begin about 15 seconds later.

If you have requested **Delayed start**, the Acousonde will pulse the alert LED upon receiving the **Execute** command. It will then sleep until the preset wakeup time, pulsing the alert LED at the top of each minute until then.

6.3.17 Stop

Use **Stop** to request that the Acousonde cease any sleep or sampling that may be in progress.

6.3.18 Icons denoting conditional sampling and/or an active module

Before sending **Execute**, it is often useful to review the complete status of the sampling program from the **CONTROL** page. However, the sampling program may be strongly influenced by the presence of an active module and/or active conditional sampling programmed from the **MODULE** and **CONDITIONAL SAMPLING** pages, respectively.

Two icons provide feedback via the **CONTROL** page as to the status of any module and/or conditional sampling (Figure 16). These help confirm the active status of these systems without necessitating a double-check of the other pages.

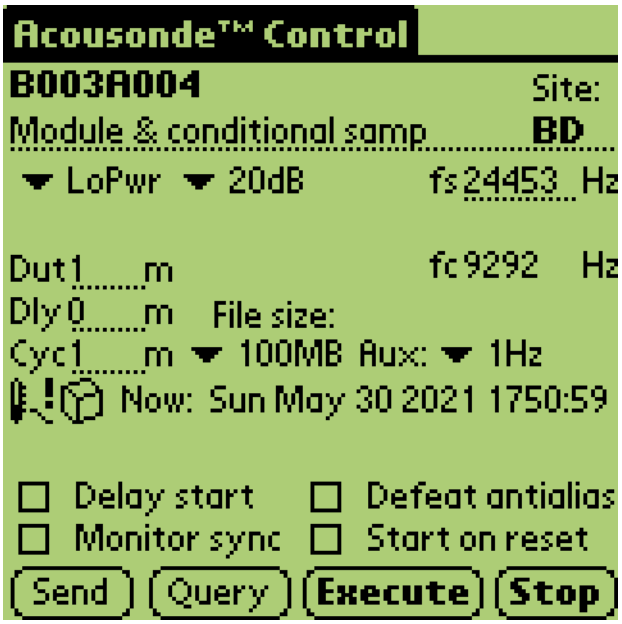

Figure 16. Icons denoting conditional sampling and an active module. In this example, active conditional sampling is denoted by the icon of a thermometer and exclamation mark; an active module is denoted by the icon of a cube.

6.4 MODULE

AcOS 3 introduced support for user-programmable software *modules*. Modules are extensions or plugins that can be developed and loaded separately from the operating system, allowing Acousonde users to create their own modules or to use modules written by third parties. Module programming is detailed in the Acousonde Module Developer Kit (MDK). Any Acousonde running AcOS 3 or later can host a module. Unless otherwise arranged, however, the Acousonde does not come with any module loaded.

An active user module will bypass the built-in handling for onboard data streaming from the acoustic and auxiliary sensors. Normally, built-in data handling simply reads the incoming sensor data and writes it out to the Acousonde's built-in mass storage. A user module, if one is present and active, likewise receives the incoming sensor data; but then it processes and digests the data prior to storage and/or telemetry. An active module may also customize the rules for conditional acoustic sampling with more flexibility than is available through the deployment-time conditional-sampling user interface.

The **MODULE** page (Figure 17) controls module functionality. When first brought up, the **MODULE** page offers three buttons:

Query	Inquire if a module is loaded, and if so, return its name, copyright holder, and version. If a module is found, the **Preset** selector and **Auto-activate on reset** checkbox will be shown.

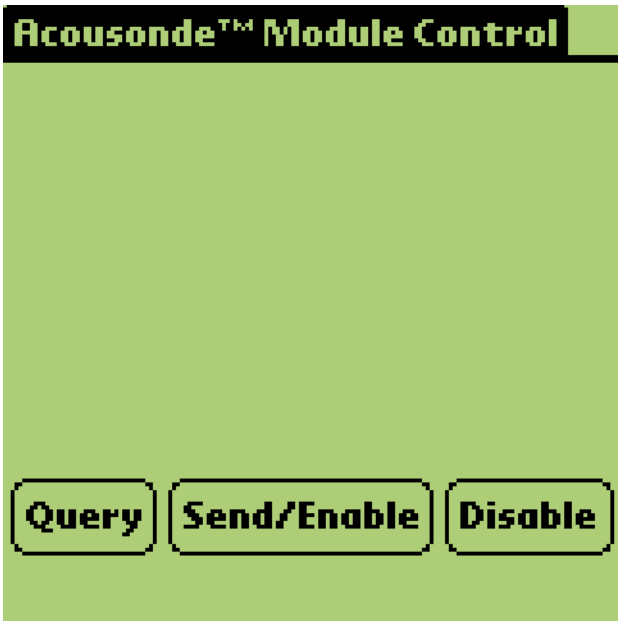

Figure 17. The Module page before interaction with the Acousonde.

Send/Enable	Send the current selections for **Preset** and **Auto-activate on reset**, and activate/engage the module for future data handling (if **N/A** is selected for **Preset**, the module will retain its current preset setting).
Disable	Deactivate and disengage any module that is present and restore default data handling. The module is not erased, but remains on the Acousonde for future use.

Typically, one begins interaction with the module using the **Query** command to determine whether a module is present and, if so, whether it has been set to auto-activate and what preset it will use. If no module is present on the unit interrogated, an error dialog will appear (Figure 18). If a module is present, it will be either *active* or *inactive*.

6.4.1 Inactive modules

A module is inactive if it has been loaded on the Acousonde but will not be used in any way. After a **Query**, an inactive module will display with the warning

<Module available but inactive>

displayed at the top of the Module page (Figure 19). The module may be activated using the **Send/Enable** button.

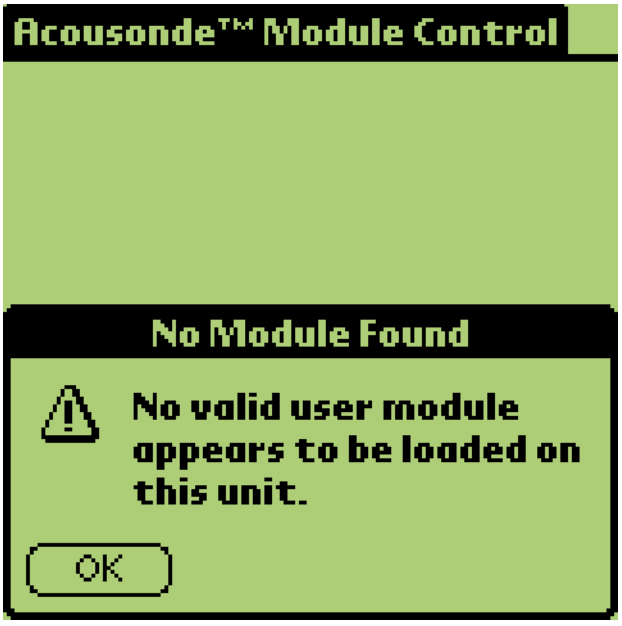

Figure 18. Alert showing that no module has been loaded on the interrogated unit.

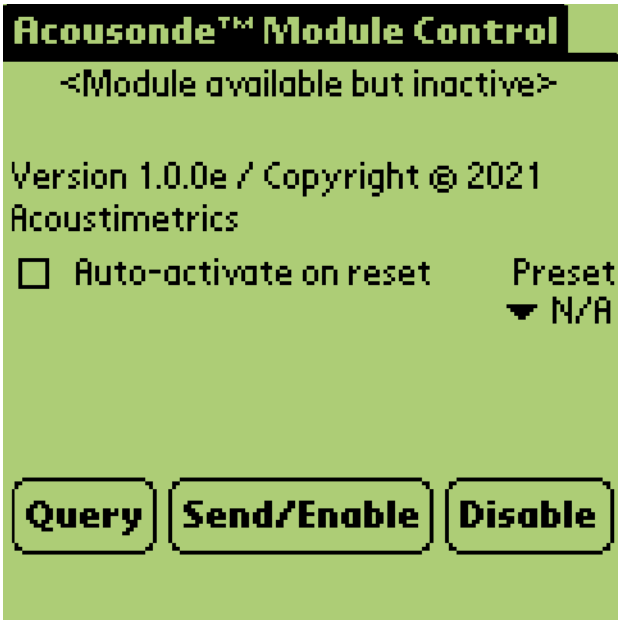

Figure 19. Module page noting a module that is present, but inactive. The **Send/Enable** button will enable the module.

One may check the **Auto-activate on reset** box and/or select a **Preset** as desired before using **Send/Enable** to activate the module. The selections will be passed to the module after it is activated and the module's responses returned. Alternately, one may simply activate the module first with **Send/Enable** and adjust its configuration, after it has been activated, using additional **Send/Enable** commands as necessary.

6.4.2 Active modules

If the module is active, the notice

Module Active

will display at the top of the Module page (Figure 20). This indicates that the installed module will actively bypass built-in data processing when the sampling program is executing.

6.4.3 Auto-activate on reset

By default, the Acousonde operating system will not activate a module, even if one is present, unless explicitly requested with the **Send/Enable** button. However, if **Auto-activate on reset** is checked, the currently-loaded module will be activated every time the Acousonde is powered up or otherwise rebooted. This setting is nonvolatile; the module will automatically activate whenever a battery is inserted, even if the unit has been depowered for an extended period. Further, the module will be activated with the same preset it was given when the last time **Send/Enable** was used with **Auto-activate on reset** checked.

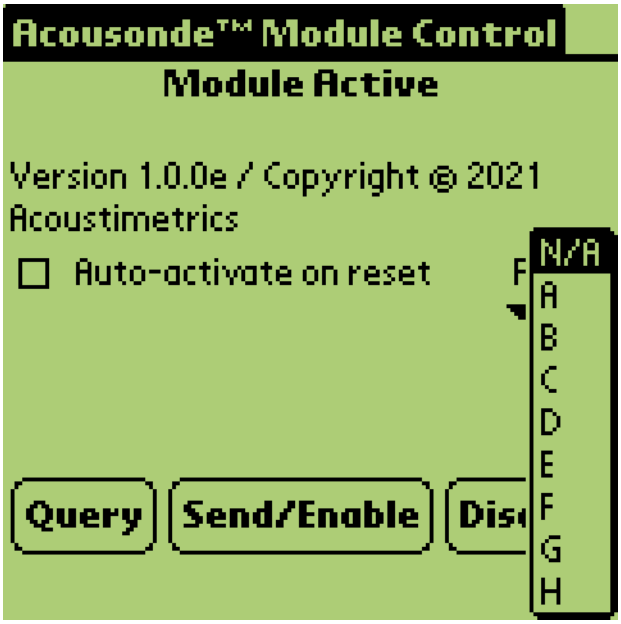

Figure 20. The Module page showing that a module is active, with the preset menu displayed. The list of presets is offered by the user interface, not the module itself. A given module may support only a subset of the presets listed, or it may not support presets at all.

6.4.4 Selecting a module preset

If suitably programmed, modules may support one or more **Presets** that can alter their functionality. The availability and behavior of presets depends entirely on the module. The **MODULE** page supports up to eight presets labeled **A** through **H**, plus the option of no preset available and/or selected (**N/A**).

Modules that support presets are typically programmed with a default preset. To avoid changing the default, select **N/A** from the **Preset** menu before using the **Send/Enable** button. If a module responds to interaction with the **MODULE** page with a **N/A** preset, that means the module does not support presets. If a module responds with a preset other than **N/A**, that is the preset to which the module is currently set.

The **MODULE** page has no way of knowing what presets a given module will support, if any. It also cannot know how different presets will change the module's behavior. It is essential to review the module's documentation to determine which preset to apply.

6.5 CONDITIONAL SAMPLING

AcOS 3 introduced support for user-selectable *conditional sampling*, that is, sampling of acoustic data when selected auxiliary data meet specified conditions. The **CONDITIONAL SAMPLING** page enables and controls this feature.

Navigate to the **CONDITIONAL SAMPLING** page and check the **Conditional acoustic sampling** box to enable parameter entry. Drop-down menus and parameter fields will appear, described as follows.

Note: The **CONDITIONAL SAMPLING** *page allows access only to a limited subset of conditional-sampling features. More complete and configurable access is possible via a custom module, such as in the* **m003_demo_conditions** *demonstration module.*

Caution: The conditional sampling system relies on operation of the auxiliary sampling system. If the sensor channels to be monitored for conditional sampling are not available in a given hardware unit, or are not being recorded, or if the auxiliary sampling system is disabled, then conditional sampling will not take place.

Caution: Conditional sampling will fail if and when auxiliary storage fills, since that will result in cessation of auxiliary sampling. For this reason, be careful when selecting both fast accelerometry (accelerometer sampling rates of 100 Hz or faster) and conditional sampling, as fast accelerometry will fill auxiliary data storage much more rapidly.

6.5.1 Execution Type

Execution Type (Figure 21) selects whether conditional analysis determines the *initial starting conditions* ("to start if") or the *perpetual conditions* ("only while") for acoustic sampling. Selecting "to start if" means that, once conditions are satisfied the first time, acoustic sampling will be enabled and no further conditional evaluation will take place. Selecting "only while" means that conditional evaluation will continue indefinitely, with acoustic sampling enabled or disabled depending on whether current auxiliary data satisfy conditional thresholds.

If the **Execution Type** is "only while", an additional field appears on the page to allow hysteresis to be specified. This will be discussed shortly.

6.5.2 Evaluation Type

Evaluation Type (Figure 22) selects how the samples from a given auxiliary data stream are to be evaluated to determine if the conditional succeeds or fails.

Before evaluation, the auxiliary data stream is averaged as necessary to achieve an effective sample rate no faster than 1 Hz; the finer time resolution of any channels sampled faster than 1 Hz is not used by the conditional-sampling system. The resulting 1-Hz samples are kept in a ring buffer. Once each second, the buffered samples covering the most recent evaluation period (to be discussed shortly) are processed and compared with the evaluation threshold. If the comparison succeeds, acoustic sampling changes state.

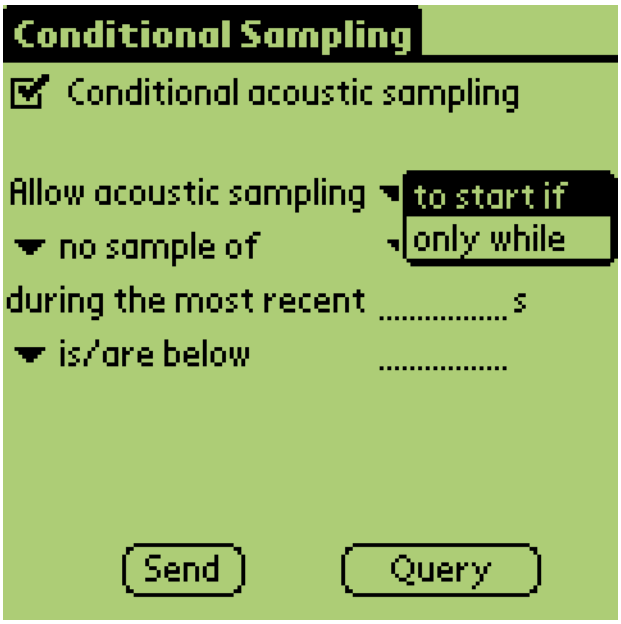

Figure 21. The Conditional Sampling page with the Execution Type menu displayed.

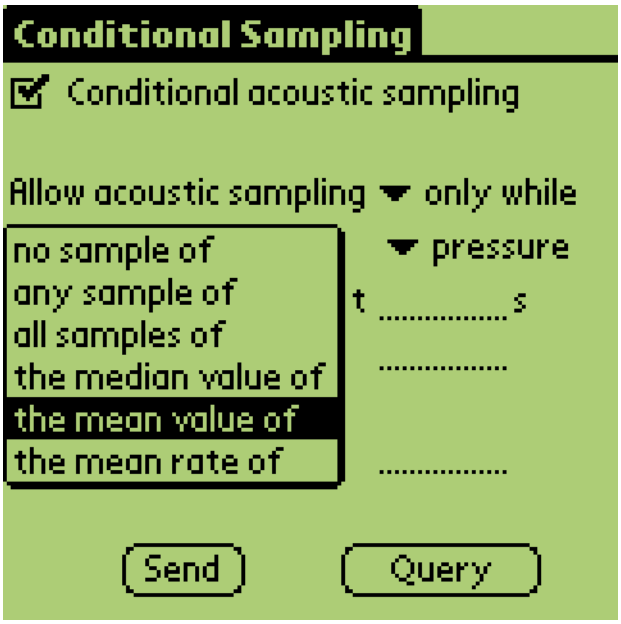

Figure 22. Choices for Evaluation Type. The Evaluation Type setting determines how the 1-Hz samples over the Evaluation Period will be evaluated for comparison with the Evaluation Threshold.

6.5.3 Channel Selector

The **Channel Selector** (Figure 23) identifies which auxiliary channel is to be monitored for conditional acoustic sampling. Only a subset of auxiliary channels is available via the Palm interface. Much more flexibility is provided via the software module interface, for example as demonstrated in the **m003_demo_conditions** module.

6.5.4 Comparison Type

Comparison Type (Figure 24) selects the arithmetic comparison. The conditional evaluation will return true if the evaluation result is *above* or *below* a specified threshold criterion, or *within* or *outside* a range established by a pair of threshold criteria (if a range comparison is selected, a second threshold field appears to allow entry of the additional criterion).

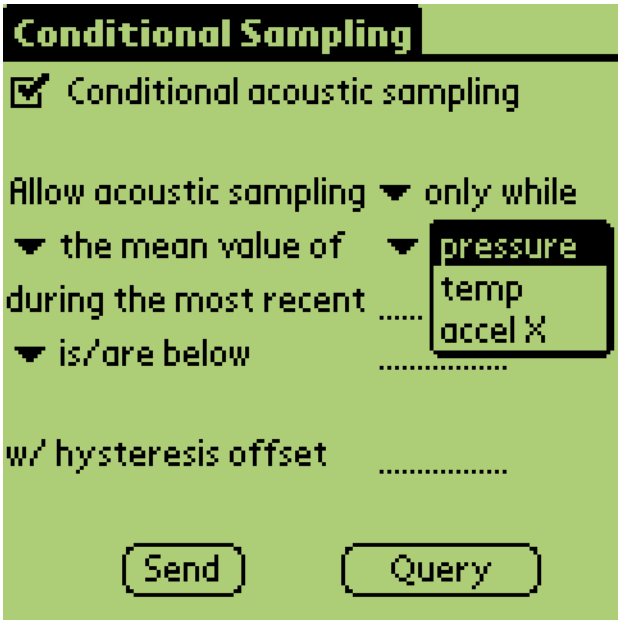

Figure 23. Conditional channel selection.

6.5.5 Evaluation Period, Threshold, and Hysteresis Offset

To complete the conditional-sampling program, one must fill the **Evaluation Period**, **Threshold**, and **Hysteresis** fields (Figure 25) as follows:

Evaluation Period — "During the most recent _____ s" establishes the time window, in seconds, of most-recent samples to be evaluated.

Threshold — If the Comparison Type is **above** or **below**, the **Threshold** is a single parameter establishing the calibrated threshold for condition success. If the Comparison Type is **within** or **outside**, a second threshold parameter must be entered to establish the range of included or excluded (respectively) qualifying values. Threshold parameter(s) must be provided in the units with which the specified channel is calibrated, e.g. dbar, m*g*, etc. (or dbar/s, m*g*/s, etc. if the **Evaluation Type** is **mean rate**).

Hysteresis Offset — The value by which the **Threshold** will be offset when evaluating if the specified condition is no longer true. The Acousonde will apply the **Hysteresis Offset** intelligently so that the turn-off condition is always in the "other direction" from the turn-on condition, including for range thresholds. This parameter must be specified in the same units as the **Threshold**.

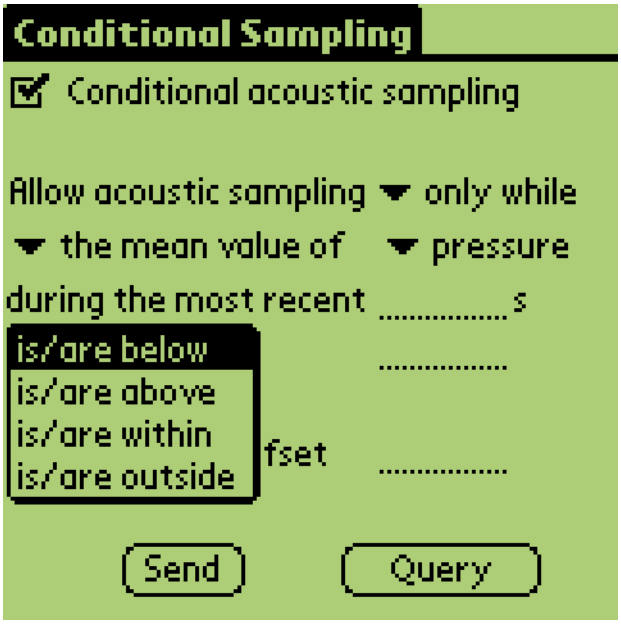

Figure 24. Conditional comparison selection.

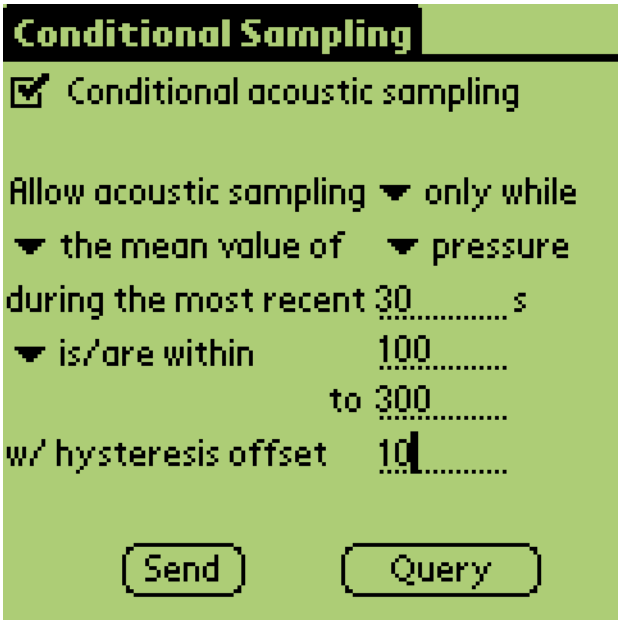

Figure 25. Conditional sampling menu completed and ready to send.

6.5.6 Conditional sampling example

For tutorial purposes, a full analysis of the conditional acoustic sampling program specified by Figure 25 follows.

This example uses the **only while** Execution Type, so acoustic sampling will be turned on and off throughout the deployment (or until auxiliary or primary data storage fills, or power fails) according to the specified conditional parameters. The **only while** Execution Type adds the **hysteresis offset** parameter field (it would not be necessary if the **to start if** Execution Type had been selected instead).

The "mean value" **Evaluation Type** and 30-s **Evaluation Period** will cause the most recent 30 s of samples to be averaged together before being compared with the **Evaluation Threshold**. The selection of the **pressure** channel means that the threshold and **Hysteresis Offset** parameters will be specified in decibars (essentially meters of ocean depth). A range comparison ("is/are within") has been selected instead of a single-threshold comparison, causing an additional threshold field to appear ("to 300") to allow specification of the other end of the threshold range.

With these specifications, this program will cause acoustic sampling to turn on when average depth over the preceding 30 seconds measures between 100 and 300 meters, and, due to the **Hysteresis Offset** of 10 meters, to turn off when that same average depth measures shallower than 90 meters or deeper than 310 meters.

6.6 CHECK SENSORS

The **CHECK SENSORS** page (Figure 26) allows inspection of current measurements from the Acousonde's auxiliary sampling system. After sending an Acousonde a request using the **Read** button, the Acousonde will respond with current measurements, calibrated according to the instrument's onboard calibration data. You may also ask for the upper bound of each auxiliary channel (also in calibrated units) using the **Clips@** button.

Sensor data from the acoustic channels will not be shown. If requesting **Clips@**, however, the maximum instantaneous peak level (in dB re 1 μPa 0-pk) recordable by the acoustics channels will be displayed. To calculate these values, the Acousonde will assume 0-dB deployment-time gain. If additional gain is applied at deployment time, the clip levels of the acoustic channels will be correspondingly less.

6.6.1 Zeroing the pressure offset

Like most pressure/strain gauges, the Acousonde's depth sensor may accumulate minor offsets with the passage of time. The **Zero** button on the **Pressure** data row instructs the Acousonde to re-zero its onboard pressure calibration for current conditions. This changes the Acousonde's calibration data to consider the currently measured pressure as "zero pressure." It is best to do this when the Acousonde is at or near deployment temperature, in order to minimize the effects of temperature-induced offset drift.

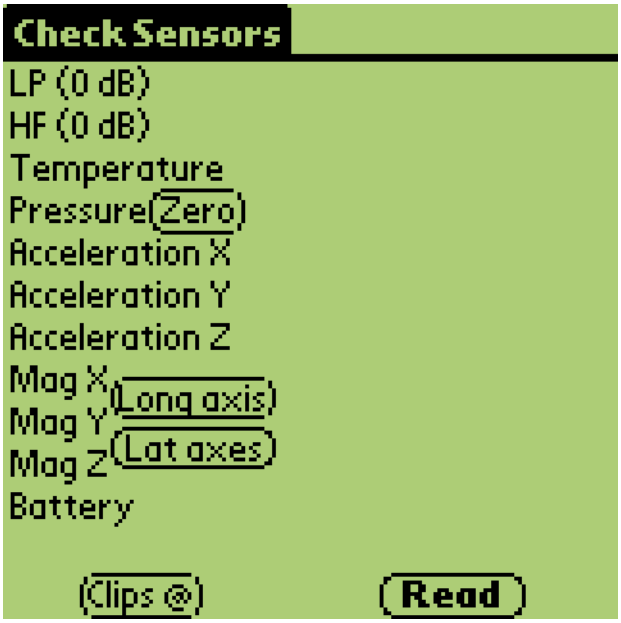

Figure 26. Checking current calibrated sensor readings. The **Clips@** command returns the maximum levels/reading possible for each channel.

It is especially useful to zero the pressure transducer if one plans to use absolute depth as part of a conditional acoustic sampling program.

6.6.2 Compensation for thermally-associated pressure drift

The Acousonde has the capability to adjust for thermally-associated drift in the pressure transducer offset. This drift is assessed and characterized at the factory and entered into each Acousonde's per-unit calibration data. Thermal drift compensation is active if the thermal-compensation icon (Figure 27) displays in the **Pressure** data row. If this icon does not display after sensor data have been read into the **CHECK SENSORS** page, no thermal drift calibration data are present and no compensation is taking place.

Once active, thermal drift compensation affects all pressure measurements. Unlike other aspects of calibration, thermal drift compensation is applied before acquired data are stored; the digital pressure samples recorded by the Acousonde are not identical to the "raw" samples originally acquired by the analog-to-digital converter. Measurements besides pressure are not affected by zero-drift compensation.

Figure 27. Icon indicating thermal-drift pressure compensation is active. The icon will display in the **Pressure** row of the **CHECK SENSORS** page after current sensors readings have been retrieved from the Acousonde.