Using the DMON2 with a Slocum glider

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The instructions below will allow you to use the DMON2 instrument running either record-only or marine mammal detection/classification application firmware. Specifically, the instructions describe how to:

A. Install DMON2 communication software
B. Connect the DMON2 and a PC and install new firmware
C. Configure recording parameters for record-only firmware
D. Test the firmware and hydrophone prior to glider deployment
E. Charge the DMON2 battery
F. Prepare the DMON2 for deployment
G. Deploy a DMON2-equipped glider
H. Recover a DMON2-equipped glider
I. Offload DMON2 files after recovery
J. Access recorded audio in DMON2 wav files
K. Install new _boot.bin and _reboot.bin files

Additional information about the following topics are included:

L. DMON2 lithium-ion batteries
M. DMON2 hydrophone information
N. Tips and best practices
O. Troubleshooting the DMON2
P. Changing the DMON2 clock speed

When testing, you may find it useful to have software that allows you to listen to recorded audio and view spectrograms. Raven Lite is a free program offered by Cornell University's Center for Conservation Bioacoustics that works very well for this purpose. You can find it here: https://ravensoundsoftware.com/software/raven-lite/. Record-only application firmware comes standard with the DMON2 instrument. Marine mammal detection firmware, such as the low-frequency detection and classification system (LFDCS), is available only through collaboration with Mark Baumgartner (mbaumgartner@whoi.edu), as data from those systems must flow through the Robots4Whales system (robots4whales.whoi.edu).

Please note: The DMON2 is an instrument developed and built by the Woods Hole Oceanographic Institution (WHOI), a non-profit marine research, engineering and education organization. The instrument is produced and sold at cost and made available to the marine community in an effort to proliferate a technology that is useful for the study and conservation of marine mammals. As a non-profit, WHOI does not benefit financially from the sale of the DMON2. Support is provided for users of the DMON2, but please be patient with us, as we have day jobs as scientists and engineers.

Operating principle

The DMON2 consists of a printed circuit board that is attached to (1) a hydrophone head containing low-, mid- and high-frequency hydrophones, (2) a rechargeable lithium battery, (3) an external power source, and (4) external devices via USB and serial lines (e.g., PC, glider science bay motherboard). The DMON2 draws power for its operation from the lithium battery, and any external power source or USB power that is attached is used to charge the lithium battery when needed. Should a user ever need to reset a DMON2 board, simply disconnect it from all power sources, including the lithium battery.

The DMON2 operates in 3 principal modes:

1. Hibernation mode. When in hibernation mode, nearly all of the DMON's components are powered down except a few that are designed to monitor for signals that indicate the DMON2 should emerge from hibernation mode. The DMON2 enters hibernation mode when application firmware shuts down or when the user exits d3host and chooses to enter hibernation mode. All LEDs on the board will be extinguished in hibernation mode except the red LED, which may be very dim (indicating that the lithium battery is not charging) or bright (indicating that the lithium battery is charging using power from either the attached USB cable or external power).

2. Host mode. When in host mode, the DMON2 runs the host firmware (_boot.bin) that is designed to interact with the d3host software running on a PC and allow the user to offload files, download new firmware, set the clock, etc. Host mode is initiated when the DMON2 is in hibernation mode and a USB cable is used to connect the DMON2 directly to a PC. Upon connection with the USB cable, the DMON2 will wake up and enter boot mode where it expects d3host to send it the host firmware. If the user launches d3host on the PC, d3host will send the host firmware, which the DMON2 will run to service requests from the d3host software. The green LED will be illuminated on the DMON2 board when in host mode. ***Importantly, if the user disconnects from the DMON2 while the DMON2 is in boot mode (i.e., the user has connected and disconnected the USB cable without launching d3host on the PC), the DMON2 will remain in boot mode, which draws much more power than hibernation mode; if the DMON2 is left in this state, it can deplete the lithium battery in a matter of days.*** When exiting d3host, the user has the option to run the application firmware (i.e., enter application mode) or enter hibernation mode. The chosen mode will be initiated when the USB cable is disconnected.

3. Application mode. When in application mode, the DMON2 is running application firmware that has been loaded previously using d3host (option 7). Application mode can be initiated from host mode by exiting from d3host and choosing to run the application firmware immediately. Application mode can also be initiated from hibernation mode in two ways: (1) external power is applied via the external power source or (2) a wakeup pin in one of the connectors is brought to ground (this method is not used for Slocum gliders). Application firmware can carry out various functions depending on the application, and the DMON2 is capable of running different firmware much like a PC can

run different software. The two main types of firmware used on Slocum gliders include (1) a record-only application that allows the user to record audio from the different hydrophones using user-specified recording parameters (record-only firmware typically begins with “LF” or “mcrec”), or (2) a detection and classification application that allows both recording and real-time detection and classification of marine mammal sounds (this firmware typically begins with “ptracker”). The blue and green LEDs on the DMON2 board will flash multiple times during startup of the DMON2 in application mode, and for most applications, the blue LED will flash once every 5 seconds after startup is complete. The DMON2 will exit application mode and enter hibernation mode in two ways: (1) power is provided via the USB cable connected to either a PC USB port or an A/C outlet, or (2) the command $ADSTOP is issued to the DMON2 via its serial port. Upon successful shut down of the application firmware, which takes on the order of 15 seconds during which the blue and green LEDs on the board typically illuminate, the DMON2 will enter hibernation mode.

A. Install DMON2 communications software

1. *Do not* attach the DMON2 to the PC via the USB cable yet.
2. Unzip the dmon2 distribution in a folder on your PC.
3. Inside this folder, run the zadig_2.2.exe application.

4. Under the "Device" menu select "Create New Device". See Figure 1.
5. In the top field, enter the name of the device: “DMON_Boot”. See Figure 2.
6. In the first two fields of USB ID, enter 0451 and 9001. Leave the last USB ID field blank.
7. Above the “Install Driver” button, ensure that WinUSB is selected “WinUSB (v6.1.7600.16385)”
8. Click the “Install Driver” button.

9. Under the "Device" menu select "Create New Device". See Figure 1.
10. In the top field, enter the name of the device: “DMON_Host”. See Figure 3.
11. In the first two fields of USB ID, enter 0C55 and 1235. Leave the last USB ID field blank.
12. Above the “Install Driver” button, ensure that WinUSB is selected “WinUSB (v6.1.7600.16385)”
13. Click the “Install Driver” button.

14. Exit the program. You can now attach the DMON2 via the USB cable and launch d3host.

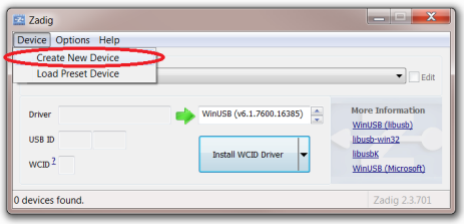


Figure 1. Create new USB device in Zadig

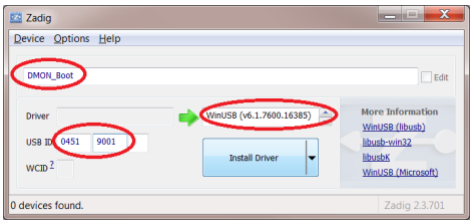


Figure 2. Create DMON_Boot device

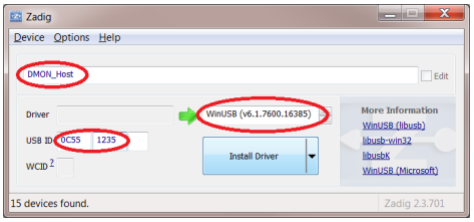


Figure 3. Create DMON_Host device

B. Connect to the DMON2 from the PC and download new firmware

1. Make sure the glider is shut down.
2. On the PC, make sure the caps lock is off (d3host is case sensitive) and turn up the speaker volume so you can easily hear the USB connect sound.
3. Connect the USB cable to the 8-pin bulkhead connector in the stiffener ring of the glider.
4. Plug the other end of the USB cable into the PC.
5. You should hear the USB-connect sound (two tones in rapid succession or a 4-note tune, depending on which version of Windows you are using) shortly after the USB cable is plugged into the PC.
6. If you don't hear the USB-connect sound, try the following:
    a. Plug the cable into a different USB port on the PC. Try each USB port in succession. Be sure to wait 10-15 seconds before unplugging, as the computer may be slow to recognize a new device on the USB port. Once you find a USB port that works, always connect to the DMON2 using that port.
7. Launch d3host.exe on the PC.
8. If d3host cannot find the DMON2 right away, it will display the message "DMON2 not found: try again?" Wait until you hear the USB connect sound a second time, then press "y" and d3host should connect to the DMON2. Upon connection, a message reading "Connected to DMON2 id xxxxxxxx" will be displayed, along with a menu of actions.
9. Select option 7 – "Download firmware" to put application firmware in flash memory.
    a. When prompted for the filename, type in the full pathname (e.g., C:\Baumgartner\NJ0420\LF2_HF240d1_15min.bin). Alternatively, if you copied the binary firmware file to the same directory where you launch d3host, you can just enter the filename (e.g., LF2_HF240d1_15min.bin).
    b. You should see "Erasing code space 100%", then "writing to FLASH……" several times, "Checking firmware in flash……", and finally "Successful firmware download!" if all goes well. You will see "Unable to open file XXXX" if the file cannot be found.
    c. Downloading the firmware need only occur once. The firmware is held in non-volatile memory, so it can be accessed every time the DMON2 starts up.
10. Select option 8 – "Current firmware" to verify the correct firmware was downloaded. Check that the correct binary file name is displayed, and the file/download times are appropriate.
11. If using a record-only application, use the instructions in section C to configure the recording parameters.
12. Select option "q" – "Quit" to quit d3host.
    a. When prompted, select "h" to initiate hibernation mode upon disconnect from USB.

C. Configure recording parameters for record-only application firmware

If you are using a record-only application firmware that starts with the letters "mcrec" (for multi-channel recorder), then you will need to save your desired recording parameters prior to running the firmware. These recording parameters are saved in non-volatile (EEPROM) memory, so they will be retained between startups even if you completely power off the DMON2 board. If you have firmware that starts with any other letters (e.g., "ptracker", "LF"), the recording parameters are hard coded in the firmware and are not user selectable.

1. Use the instructions in section B above to connect the PC to the DMON2 via the USB cable and launch the d3host program.
2. Select option "b" – "Parameter tables", and then select option "1" – "Recording parameter table". You will be asked a series of questions for each of the low-frequency (LF), mid-frequency (MF) and high-frequency (HF) hydrophones (see section M for a description of these hydrophones).
    a. "Record from hydrophone?" – answer "y" or "n" if you would like to record this hydrophone. You can record from multiple hydrophones if you'd like.
    b. "Enter sampling rate index" – choose from the listed sampling rates (2-500 kHz) for this hydrophone.
    c. "Enter recording duration in seconds" – choose how long a recording session will last. Entering "0" will result in a continuous recording.
    d. "Enter recording interval in seconds" – choose how often to initiate a recording session. If continuously recording (i.e., you entered "0" for the recording duration), this will indicate how often a $DUTY message is generated.
3. Once these parameters are set, they will be saved in EEPROM and will therefore be accessible to the DMON2 every time it boots up (i.e., there is no need to set these prior to every deployment).
4. To check the recording parameter values, choose option "b.1" again – d3host will display the current recording parameter values and ask if you would like to change them.

D. Test the application firmware and hydrophone prior to glider deployment

1. Make sure the glider is shut down.
2. Use the instructions in section B above to connect the PC to the DMON2 via the USB cable and the d3host program.
3. Select option 3 – "Erase files" in d3host to clear the flash memory prior to testing.
    a. When asked "Are you sure you want to erase recordings?", respond "y".
    b. Select "a" to erase all files.
4. Select option "q" – "Quit" to quit d3host
    a. Upon quitting, select "r" to initiate application mode and run the application firmware upon disconnect from USB.
5. Disconnect the USB cable from the PC. The firmware will now begin to run on the DMON2. Depending on the application, the red LED may flash inside the hydrophone head every 5 seconds for 30 minutes after the DMON2 is started. After 30 minutes, the LED will stop flashing, but the firmware will continue to run. The flashing LED is intended to provide an external indicator that the firmware is running after startup.
6. Over the next few minutes, provide audio to the hydrophone that you will later recognize in the recordings (e.g., talk, play music, clap your hands, tap gently on the hydrophone, etc.). At the very least, tap gently on the hydrophone in some recognizable pattern (e.g., heartbeat: thump-thump-pause-thump-thump-pause …), as this signal will be recognizable later regardless of the background noise present.
7. After about a minute or so, reconnect the USB cable to the PC to initiate shutdown of the application firmware and to enter hibernation mode. You should *not* hear the USB-connect sound when you connect the USB cable to the PC this first time. No USB connection will be made. Wait 30 seconds for the shutdown to complete, then unplug the USB cable from the PC.
8. Plug the USB cable into the PC again. This time you should hear the USB-connect sound.
9. Launch d3host.
10. If you wish, select option "5" to change the directory into which offloaded files will be written. If you do not select this option, the files will be written into the same directory that contains d3host.exe. Once you select a new directory, it will be saved and all future offloads will be written to this directory.
11. Select 2 – "Offload files"
    a. Select "a" to offload all files (there should only be one file for this test)
    b. When prompted to "Enter filename base", type "XX" (or whatever you wish). The DMON2 will proceed to copy the data in flash memory to the file XX001.dtg. If there are multiple files, it will offload the first to XX001.dtg, the second to XX002.dtg, the third to XX003.dtg, and so on.
12. Select "q" – "Quit".
    a. When prompted, select "h" to initiate hibernation mode upon disconnect from USB.
13. Launch the PC program d3read.exe.
14. The program will display the directory where it thinks you are offloading DTG files. Verify that this directory is where you just put the offloaded XX001.dtg file. If it is not correct, type "y" when prompted to change. If the directory is correct, type "n".
15. When prompted for the "Input filename base", type "XX"

16. From the list of "Found files", select the file(s) that were previously offloaded (in this case, select XX001.dtg), or select "a" for all files if you want to unpack and decompress multiple files.
    a. Several files will be unpacked from any one DTG file. For the file XX001.dtg that you just created, d3read should unpack XX001.log, XX001.err, XX001.wav, and XX001.xml (there may be XX001_LF.wav, XX001_MF.wav and/or XX001_HF.wav files as well, depending on the firmware you are using). The wav files have the recorded audio, the log file has messages stored by the DMON2 in an encoded format, the err file reports runtime errors, and the xml file has metadata.
17. Open XX001.log with a text editor and you should see something very much like the following (note, you may see other messages or the messages may look differently depending on the firmware you are using):

```
1663867326,244536,$INIT,RTCRETRIES,0,0,0
1663867326,246063,$INIT,AUDIO,1,INIT_OK,AUDIO_ON,CHAN_ON,VTH_ON,VTH_OK,0021
1663867326,247580,$INIT,AUDIO,2,INIT_OK,AUDIO_ON,CHAN_ON,VTH_ON,VTH_OK,0021
1663867326,249101,$INIT,AUDIO,3,INIT_OK,AUDIO_ON,CHAN_ON,VTH_ON,VTH_OK,0021
1663867326,258587,$INIT,HEADINIT,INIT_OK,38,38,0
1663867326,258681,$INIT,HEADRETRIES,0
1663867326,265070,$INIT,CHANINIT,2,OK,2000
1663867326,270740,$INIT,CHANINIT,4,OK,240000
1663867326,270824,$INIT,ALLJOBINIT,OK
1663867326,270997,$INIT,IICRETRIES,159,0,0
1663867328,7154,$START,632C99C000000E231E2C00010000*1B
1663867362,96,$DUTY,632C99C00004632C99DF00052000000010000F618*0A
1663867364,6209,$END,632C99E400060E231E2C1*20
1663867366,38,LOGEND,0000000000……0000000000
1663867366,274,LOGEND, 0000000000……0000000000
1663867366,390,LOGEND, 0000000000……0000000000
1663867366,1072,LOGEND, 0000000000……0000000000
1663867366,1188,LOGEND, 0000000000……0000000000
```

    a. The first two fields indicate the time, so these will be different for your test.
    b. The important thing is that the XX001.log file has $INIT strings, a $START string (or an encoded string that starts with the letter "A"), and an $END string (or an encoded string that starts with the letter "B"). There will be a number of LOGEND strings at the end of the file with lots of zeroes at the end of each string. The number of LOGEND strings will likely change if you do this test again and again. This is not a problem.
18. Open each of the wav files with a media player and play the audio. You should recognize the sounds you made/played to the glider hydrophone (note that they will sound muffled because of the hydrophone's urethane housing, which is acoustically transparent in water but not in air). If you examine the sound using software that allows you to plot spectrograms (e.g., Raven), do not be alarmed if there is a tremendous amount of noise in the recording. Ships and some labs are notoriously noisy (both acoustically and electrically), so there may be lots of noise present in the recording. This test is simply to make sure signals from the hydrophone are being recorded by the DMON2 firmware. Any

local noise will, of course, disappear once the glider is in the water. The multi-channel recorder firmware will produce wav files with the following suffixes: _LF.wav for recordings from the low-frequency hydrophone, _MF.wav for recordings from the mid-frequency hydrophone, and _HF.wav for recordings from the high-frequency hydrophone. Note that every time the red LED flashes (for the first 30 minutes after startup), there will be a corresponding impulsive noise in each recording caused by electrical noise. This is normal and one of the reasons the red LED only flashes for the first 30 minutes.

E. Charge the DMON2 battery

1. Make sure the glider is shut down.
2. Use the instructions in section B above to connect the PC to the DMON2 via the USB cable and the d3host program.
3. Once connected in d3host, select 4 – "Battery".
4. Make sure "Battery connected" is reported and note the battery voltage displayed just to the right of "Battery connected". If the battery voltage is less than 4 volts, keep the USB cable attached to the hydrophone, which will allow the DMON2 battery to charge via the USB port on the PC. Depending on how depleted the battery is, it may take several hours to fully charge the battery. If possible, set the computer up to charge the DMON2 battery overnight. Make sure your computer does not go to sleep during the charging process, as this will almost surely turn off the power to the USB port. Alternatively, you can attach the USB cable to a USB charger that plugs into an electrical outlet (e.g., the same chargers that are used with smartphones) and leave it plugged in overnight. This is okay to do in a pinch, but it is not the recommended method of charging the DMON2's lithium battery. Charging via the PC USB port with d3host launched (i.e., with the host firmware running) will put the DMON2 charger into a high-current mode and charging will be faster; charging while connected to an A/C wall outlet will be much slower. ***Importantly, if you charge with a charger attached to an A/C wall outlet, you will put the DMON2 into boot mode which will draw a great deal of power from the battery once the USB cable is disconnected; be sure to connect to the DMON2 with d3host and put the DMON2 into hibernation mode after doing this or you risk fully depleting your lithium battery.***
5. Check the battery voltage at any time in d3host using option 4 – "Battery".
6. When fully charged, the battery will have a voltage of 4.1 V or more. A depleted battery will have less than 3.8 V. It is good practice to fully charge the DMON2 battery prior to deployment. This is not necessary, but the glider's battery capacity will be reduced (i.e., wasted) by charging up the DMON2 battery when it is first deployed. It is recommended that the DMON2 battery have a voltage of 4 V or more prior to deployment.
7. When done charging, select option "q" – "Quit" in d3host and when prompted, select "h" to initiate hibernation mode upon disconnect from USB.

Note that during the glider mission, the DMON2 will occasionally charge its lithium battery from the glider's battery. When this happens, you may see the voltage of the main battery drop for the duration of the charging, and you will see an associated reduction in the glider's battery capacity (measured by the coulomb counter in amp-hours). This is normal.

F. Prepare the DMON2 for deployment

1. Make sure the glider is shut down.
2. On the PC, set the computer time zone to GMT, and then set the computer time to the exact GMT time. This can be done with a time server using the "sync time" feature in a PC's "Adjust date/time" window. Before exiting, you will set the DMON2 clocks using the PC clock, so you will want to ensure that the PC clock is accurately set to GMT time.
3. Use the instructions in section B above to connect the PC to the DMON2 via the USB cable and the d3host program.
4. Select option 3 – "Erase files" in d3host to clear the flash memory prior to deployment.
    a. When asked "Are you sure you want to erase recordings?", respond "y".
    b. Select "a" to erase all files. The DMON2 should have no files in flash memory prior to deployment.
5. Select option 4 – "Battery" to verify that the battery is at least 4 V.
6. Select option 8 – "Current firmware" to verify the correct firmware will be used for the deployment. Check that the correct binary file name is displayed, and the file/download times are appropriate.
7. Select option 9 – "Set real-time clocks" to set the onboard and Dallas real-time clocks to match the PC's clock.
8. Select option "q" – "Quit" to quit d3host.
    a. When prompted, select "h" to initiate hibernation mode upon disconnect from USB. The DMON2 will remain in hibernation mode until external power is applied to the DMON2 board by the glider science bay computer, which typically happens when the glider is started and the house elf runs for the first time. In this way, the DMON2 will automatically exit hibernation mode, enter application mode and run its application firmware without any user intervention.
9. Disconnect the USB cable and attach the dummy plug to the bulkhead connector. The DMON2 is now ready for deployment.

G. Deployment

1. No special action is required when the glider is powered up. Once the glider science bay supplies power to the DMON2, it will enter application mode and begin running the application firmware. If the firmware supports it, upon startup the LEDs inside the hydrophone head will begin to flash once every 5 seconds. They will continue to flash for the next 30 minutes, after which they will stop flashing; even though the LEDs are no longer flashing, the firmware is still running. The LEDs are intended to provide an external indicator that the firmware is running after startup.
2. During typical pre-deployment glider checkout, you can verify that the glider and the DMON2 are capable of bi-directional serial communications by using u4stalk (or uart on G3s) on the science computer:
    a. In GliderDOS, type "consci" to switch to the science computer
    b. Type "u4stalk X 9600 Y" where X and Y are the UART and power bit reported in proglets.dat. The "9600" refers to the baud rate to communicate with the DMON2.
    c. Once in u4stalk, type one of the following commands. u4stalk will probably not echo these characters back to you, so you will be typing them blind. If you make a mistake, just press enter and start over.
        i. If using older firmware for real-time detection/classification, type "$ADRUN,0" (omit the quotation marks) and hit return
        ii. If using newer firmware for real-time detection/classification or record-only firmware, type "$HELLO" (omit the quotation marks) and hit return
    d. As soon as you hit enter after typing the command, you should see the DMON2 answer back with some text that might look something like this (it's okay if it doesn't look exactly like this; as long as the DMON2 answers back with some text, you're in good shape):

MXpnS8wC2CCRBRFJVTiww43
DXpnS8wC3XpnScgAAAAAAgQAXAA……
EXpnS8wC4DiMeLA/UAAAQAAAApE……

    e. If you see a response, you know that the DMON2 is able to receive serial data from the glider, and the glider is able to receive serial data from the DMON2.
    f. Hit ctrl-C to exit u4stalk, and type "quit" to get back to GliderDOS.
3. From the perspective of the DMON2, the glider is now ready to deploy.
4. Once deployed and on mission, the glider will store DMON2 serial messages sent from the DMON2 to the glider in a segment file ending in .asc. These data can be offloaded from the glider during each Iridium communication session if desired.

H. Recovery

Note that the DMON2 will not shut down when the glider is shut down. If the glider is shut down, the DMON2 will happily continue running its application firmware using power from its lithium battery. It will continue to do this until the lithium battery voltage drops below 3.8 V or you shut it down.

1. Once the glider is recovered but before it has been shut down with the "exit" command, you can turn off the DMON2 using u4stalk. Turning off the DMON2 now is optional; you can do it with a USB cable later if you wish (described below).
    a. In GliderDOS, type "consci" to switch to the science computer
    b. Type "u4stalk X 9600 Y" where X and Y are the UART and power bit reported in proglets.dat. The "9600" refers to the baud rate to communicate with the DMON2.
    c. Once in u4stalk, type "$ADSTOP" (omit the quotation marks) and hit return. u4stalk will probably not echo these characters back to you, so you will be typing them blind. If you make a mistake, just press enter and start over.
    d. After a few seconds, you should see the DMON2 reply with a message that starts with "$END" or it will reply with an encoded message that starts with the letter "B" depending on what firmware you are using. This is alerting to you that the DMON2 has begun its shutdown sequence and will be entering hibernation mode shortly.
    e. Hit ctrl-C to exit u4stalk, type "quit" to get back to GliderDOS, and then type "exit" to shut the glider down. If the house elf runs before you type "exit" to shut the glider down, the DMON2 may be started again, in which case you will need to use u4stalk to shut it down again.

Note that while the glider is on mission, there are times when you may wish to shut down the science bay and the DMON2 prior to recovery. Shutting down the science bay (e.g., "use – science_super) will not turn off the DMON2. There is no harm in letting the DMON2 continue to run, as it will no longer draw power from the glider batteries because the science computer will no longer supply power to the DMON2. The DMON2 can continue to operate on its internal lithium battery, which will last a few days more until the battery voltage falls below 3.8 V, at which point the DMON2 will shut down and enter hibernation mode. Of course, you will not receive any more messages from the DMON2 in this mode, but if you're going into power-savings mode, you probably don't care about those messages anyway. If you wish to shut the DMON2 down prior to shutting down the science computer, just use the same procedure above using u4stalk over Iridium. In step (e) above, hit ctrl-C to exit u4stalk, type "quit" to get back to GliderDOS, and then type "use – science_super" to take the science computer out of use. If the house-elf runs before you shut down the science computer, you will need to use u4stalk to shut the DMON2 down again.

2. If you wish to shut the DMON2 off with the USB cable, bring the glider to a sheltered area where you can safely attach the USB cable to the hydrophone and have a PC nearby.
3. Connect the DMON2 to the PC via the USB cable to signal the DMON2 to begin its shutdown sequence and enter hibernation mode. You should *not* hear the USB-connect sound when you connect the USB cable to the PC this first time. No USB connection will be made. Wait 30 seconds, then unplug the USB cable from the PC.

I. Offload DMON2 files after recovery

1. Use the instructions in section B above to connect the PC to the DMON2 via the USB cable and the d3host program.
2. If you wish, select option "5" to change the directory into which offloaded files will be written. If you do not select this option, the files will be written into the same directory that contains d3host.exe. Once you select a new directory, it will be saved and all future offloads will be written to this directory.
3. Select 2 – "Offload files"
    a. Select "a" to offload all files
    b. When prompted to "Enter filename base", enter the name of your mission. The DMON2 will use this as the file prefix (e.g., if you enter "nj0420_", then the DTG files will be saved as "nj0420_001.dtg", "nj0420_002.dtg", "nj0420_003.dtg", etc.).
    c. The DMON2 will likely take a long time (several hours) to offload all the files from a several week- to several month-long deployment.
4. Select "q" – "Quit".
    a. When prompted, select "h" to initiate hibernation mode upon disconnect from USB.
    b. *It is recommended that you do not erase the files from the DMON2 until all the data are backed up elsewhere. Even then, leave the data on the DMON2 until they absolutely have to be erased.*
5. Launch the PC program d3read.exe.
6. When prompted for the "Input filename base", type the same filename base you used when offloading the data in d3host (e.g., "nj0420_" in the example above).
7. Select "a" for all files to unpack and decompress multiple files.
    a. Unpacking and decompressing will also take a long time (several hours).
8. Backup all files (*.wav, *.log, *.xml) to an external hard drive as soon as possible.

J. Accessing recorded audio from DMON2 wav files

The DMON2 application firmware saves data (e.g., audio, logs, configuration information) to flash memory in chunks as they are generated in real time, and d3host assembles those chunks into .dtg files that are then unpacked into .wav, .log, .xml and .err files by the d3read program. Audio may be recorded continuously or on a duty cycle. Record-only applications store timing information for the audio in the .log file in $DUTY messages; however, for continuous recordings from a single hydrophone (typical of some firmware that does real-time detection/classification), the user can more simply pull timing information from a "CUE TIME" message in the .xml files.

Software written in IDL is provided to rename .wav files and/or extract and save recording sessions contained within the .wav files using the appropriate timing information; renamed files will contain the start date/time of the recording in the filename. The program is called "reformat_dmon_wav_files.sav" and requires an IDL runtime license to run on Windows, Mac or Linux operating systems. Once the IDL runtime license is installed, the user just double-clicks the "reformat_dmon_wav_files.sav" file icon and selects (1) the folder in which the DMON2 .wav files currently reside and (2) a folder in which the newly extracted and renamed .wav files will be saved. Once these folders are selected, the user hits the "Go!" button to start the processing. This program saves you the effort of developing your own software to access the audio in the .wav files. The following text describes in detail how audio timing information is saved by the DMON2 application firmware, but is not necessary to know/understand if you are using the "reformat_dmon_wav_files.sav" program.

If your application firmware records audio continuously from a single hydrophone, then the time stamp of the first sample in each .wav file is contained in a message that starts with "CUE TIME" in the corresponding .xml file. For example, if file XX001.xml has the following "CUE TIME" record:

<CUE TIME="2021,6,17,12,22,27" ID="13" SUFFIX="wav" SAMPLE="0"> 0.007868 </CUE>

then the first sample in XX001.wav was recorded on June 17, 2021 12:22:27.007868 (note the fractions of a second are reported at the end of the "CUE TIME" record). There may be encoded duty messages in the log file

If your application firmware records audio from multiple hydrophones and/or uses duty cycling, then the timing information for each recording session from each hydrophone can be found in the $DUTY messages in the .log files. Duty cycled audio is defined by a recording session of some specified duration that occurs on some specified regular interval (e.g., a 1-minute recording session that occurs every 15 minutes, which means recording occurs for 1 minute and is followed by 14 minutes of no recording). Recording sessions from the same hydrophone are concatenated in the corresponding wav files for that hydrophone. For example, say the low-frequency hydrophone was sampled at 2 kHz for 1 minute every 5 minutes. In the subsequent *_LF.wav file, the first 120,000 samples (i.e., 2000 samples per second for 60 seconds) will be the audio from the first recording session, and the next 120,000 samples will be the audio from the second recording session, which started 5 minutes after the start of the first recording session. There is a $DUTY message in the .log file for each recording session that describes which hydrophone the

audio comes from, the date and time of the first sample in the recording session, the date and time of the last sample in the recording session, how many samples were recorded in the recording session, and the recording session number (a sequential number starting with 1).

For a multi-channel record-only application, it is possible to have a hydrophone sampled continuously while other hydrophones are simultaneously sampled with different recording parameters. In such cases, $DUTY messages will still be generated for the hydrophone that is sampled continuously. The user can use those $DUTY messages to access timing information for the audio, or they can use the "CUE TIME" records in the .xml file; either approach will provide the same timing information.

For record-only applications, $DUTY and other messages sent from the DMON2 to the glider and also saved in flash memory in the .log file are formatted in NMEA-like strings, with a "$" at the beginning, followed by a message name (e.g., START), followed by a data payload ending in "*", and finally a checksum. The payload consists of human-readable hexadecimal numbers comprising several data fields that are concatenated. Message formats and examples are shown and decoded below.

*$START,632C99C000000E231E2C00010000*1B*

- 632C99C0 – date/time (seconds since January 1, 1970 00:00:00)
- 0000 – milliseconds after whole second value
- 0E231E2C – DMON2 board id
- 00010000 – flash memory size in MB
- 1B – checksum

*$DUTY,632C99C00004632C99DF00052000000010000F618*0A*

- 632C99C0 – start date/time of recording session (seconds since January 1, 1970 00:00:00)
- 0004 – milliseconds after whole second value
- 632C99DF – end date/time of recording session (seconds since January 1, 1970 00:00:00)
- 0005 – milliseconds after whole second value
- 2 – hydrophone (1 – mid-frequency, 2 – low-frequency, 3 – high-frequency)
- 00000001 – sequential recording session number
- 0000F618 – number of samples recorded

*$END,632C99E400060E231E2C1*20*

- 632C99E4 – date/time (seconds since January 1, 1970 00:00:00)
- 0006 – milliseconds after whole second value
- 0E231E2C – DMON2 board id
- 1 – shutdown code
- 20 – checksum

K. Installing new _boot.bin and _reboot.bin

Use these instructions to upgrade the host firmware (_boot.bin) and the firmware used by the DMON2 to launch the application firmware (_reboot.bin).

1. Copy _boot.bin and _reboot.bin files to the same folder with d3host.exe.
2. Use the instructions in section B above to connect the PC to the DMON2 via the USB cable and the d3host program.
3. Select option 6 – “Enter expert mode”
4. Select option 6 – “EEPROM write”
5. Enter _reboot.bin when prompted for the filename
6. Enter 0 when prompted for the address
7. Select option “i” to return to the user menu
8. Select option “q” to quit and when prompted, select “h” to initiate hibernation mode upon disconnect from USB.
9. Disconnect USB cable from PC.

L. DMON2 lithium-ion batteries

The DMON2 has an integrated lithium-ion rechargeable battery that powers the DMON2 during all modes of operation (hibernation, host and application modes) and is recharged from either an external source or USB power. When the DMON2 is in hibernation mode, it will draw a very small amount of power from the lithium battery to keep some basic wake-up and clock functions operational. Some users have experienced depleted batteries after storage of a few weeks to months. This is most likely caused by users leaving the DMON2 in boot mode, which occurs when the DMON2 is attached to USB power (either to a PC USB port or to a USB charger brick that plugs into an A/C wall outlet) and then detached from USB power without first running d3host. Attaching the DMON2 to USB power puts the board in boot mode, which wakes the DSP to await the delivery of host firmware via the USB connection from d3host. If d3host is not launched and USB power is subsequently detached from the board, the DMON2 will remain in boot mode, which consumes much more power than hibernation mode and will deplete the lithium battery in a matter of several days. The solution to this problem is to always use d3host to put the DMON2 into hibernation mode prior to any kind of long-term storage.

If the lithium battery does become depleted, d3host will report that there is no battery connected to the DMON2. In such cases, the battery may be able to be revived with a lithium-ion battery charger, such as a Tenergy TB6B. You can test the lithium battery at its connector by measuring the voltage across the red and black wires that are positioned opposite one another in the connector body. Be VERY CAREFUL when doing this to NOT short the battery (i.e., connect the red and black wires). Note that one of the black wires will come from the thermistor taped to the side of the battery – do not use this as ground to test the battery voltage). Based on the voltage, do the following:

~ 0.0 V – battery protection board is not passing voltage (see below)
< 2.5 V – discard
2.5-3.6 V – revive with Tenergy TB6B battery charger
> 3.6 V – charge with DMON2

The lithium battery has an attached battery protection board (beneath the tape at the end of the battery from which the wires emerge) that does not allow any voltage to pass if the battery is below 2.5 V. If you test the voltage on a battery and get 0 V, it is very likely that the battery protection board is not passing voltage. Such a battery may still be tested and possibly revived if you remove the protective tape and expose the gold and silver tabs that attach to the battery protection board. Test the voltage across these tabs, and if it is not too low, try to recharge the battery using a Tenergy TB6B battery charger (or equivalent).

If recharging a depleted battery, it is recommended that you not leave the battery charger unattended. Once the battery voltage is brought to 3.6 V or higher, you can reattach the battery to the DMON2 and let it recharge the battery. The DMON2 does not need to be attended during charging.

M. DMON2 hydrophone information

The following are the factory sensitivities and bandwidths of the 3 DMON2 hydrophones:

Low-frequency: -203 dB re: V/µPa rms, 10 Hz – 7.5 kHz
Mid-frequency: -200 dB re: V/µPa rms, 100 Hz – 50 kHz
High-frequency: -206 dB re: V/µPa rms, 1 kHz – 160 kHz

For each hydrophone, there is a gain of 33.2 dB (20 dB preamp gain, 13.2 dB main board gain), the zero-to-peak V_{adc} is 1.5 V, and the system is 16 bits. That should be all you need to calculate sound pressure level and/or power spectral density from the digital recordings using the equations in the following publication (and supplemental material):

Merchant, N.D., Fristrup, K.M., Johnson, M.P., Tyack, P.L., Witt, M.J., Blondel, P. and Parks, S.E. (2015), Measuring acoustic habitats. Methods in Ecology and Evolution, 6: 257-265. https://doi.org/10.1111/2041-210X.12330.

N. Tips and best practices

Hydrophone head

Be very careful when handling the hydrophone head. It is best to treat it as if it is a Fabergé egg – delicate, expensive and difficult to replace. The amber dome is made of urethane, which encapsulates the three ceramic hydrophones that are suspended above the preamplifier board by thin wires. These wires between the ceramics and the preamp board are delicate and can easily be broken if the hydrophone head is jarred or twisted in any way. It is recommended to never grab or twist the amber dome in any way; in fact, don't touch it at all unless you are gently tapping on it to make an audio signal for testing. It may look like a convenient handle during glider recovery, but immediately prior to recovery it is helpful to remind yourself and your ship mates not to grab the amber dome. If installing the hydrophone head in a science bay ecopuck port, push it into place using your thumbs to press down on the plastic base. If you need to rotate the head in the ecopuck port to line up the retaining screws, apply pressure to the plastic base, never to the amber dome.

The base of the hydrophone head has a wiring harness emerging from it, and it is important not to tug on this wiring harness or ever carry the hydrophone head by the wiring harness. Hold the hydrophone by its plastic base whenever handling it (see above about treating the hydrophone head like a Fabergé egg). Prior to installation or when troubleshooting, inspect the connector at the end of the wiring harness to make sure all the pins are secured with retaining tabs (see discussion about connectors in the Section O).

It is possible to protect the hydrophone head in a cage that attaches to the base of the head, which is available from WHOI should you need one. However, flow noise caused by the cage will contaminate low-frequency recordings, and it is therefore not recommended for work with species that produce low-frequency calls. The cage can be removed prior to deployment and reattached after recovery should you wish to use the cage to prevent damage during transport, in the lab, or during routine maintenance or refurbishment by you or the glider manufacturer.

Lifting bails or cleats

Gliders with a cleat or any other obstruction just forward of the hydrophone head will be susceptible to flow noise interfering with low-frequency recordings. It is recommended not to place anything immediately in front of the hydrophone head. The Ocean Tracking Network at Dalhousie University have developed a clever lifting bail that can be attached to the stiffener ring just aft of the hydrophone head that accommodates the bulkhead connector mounted on that same stiffener ring; this bail can be used as a replacement for the standard cleat.

LEDs

The DMON2 has a red, green and blue LED on the board that light as follows:

The red LED is used to indicate the charge status of the DMON's lithium battery. If the LED is very dimly lit in hibernation mode, the DMON's charger is inactive and the battery is fully charged. If the LED is brightly lit, the DMON's charger is actively charging the lithium battery from either the attached USB cable or the external power source.

In host mode, the green LED is used to indicate that the host firmware is running on the DMON. In application mode, the green LED is typically only used during startup and shutdown to indicate progress; the meaning of the sequence of flashing LEDs during startup and shutdown is known only to the firmware programmer.

The blue LED is used both in host and application mode during startup and shutdown to indicate progress; the meaning of the sequence of flashing LEDs during startup and shutdown is known only to the firmware programmer. In application mode, the blue LED is typically flashed once every 5 seconds after startup to indicate the firmware is operating correctly.

There are also red, green and blue LEDs in the hydrophone head that are used sparingly when the DMON2 is in application mode and never when in hibernation or host mode (flashing the LEDs causes noise in the recorded audio; hence the sparing use). In most applications (but not all), the red LED will blink every 5 seconds within the first 30 minutes of the application firmware starting. The red and green LEDs will also often illuminate when the DMON2 shuts down its application firmware and enters hibernation mode.

Fuses and connectors

The DMON2 fuses and connectors are user-replaceable and can be ordered on-line (e.g., from Digikey). It is extremely rare to need to replace fuses, although they are very easy to replace if you need to. The fuses are as follows:

F1, F2: Littelfuse Inc. 0157002.DR (2A)
F3: Littelfuse Inc. 0157003.DR (3A)

It is more commonplace to need to replace connectors. The connectors are as follows:

Comms (J1): Amphenol ICC (FCI) 90311-022LF
External power (J2): Amphenol ICC (FCI) 90311-006LF
Lithium battery (J3): Amphenol ICC (FCI) 90311-008LF
Hydrophone (J4): Amphenol ICC (FCI) 90311-020LF

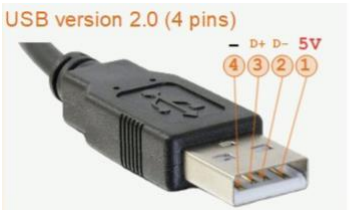
O. Troubleshooting the DMON2

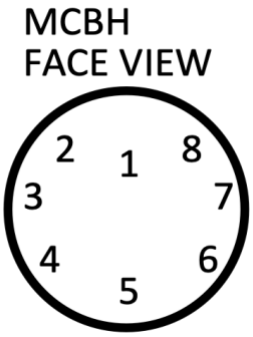
If you are having trouble connecting to the DMON2 using the USB cable, here are some things to check…

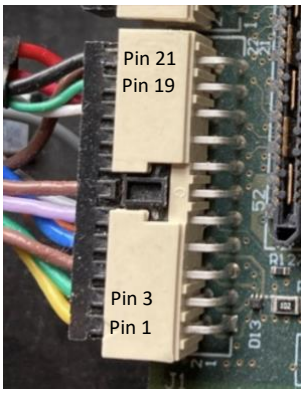
- Are you using a USB extender cable? If so, try connecting to the DMON2 without it.
- It is possible your cable is damaged or the wiring between the bulkhead connector and the DMON2 board inside the science bay is not correct. To test the cable, measure pin-to-pin connectivity. Here is the pinout to go from the USB connector (Type A) to the glider bulkhead connector in the stiffener ring (MCBH) to the DMON2 board (receptacle J1):

Pinout for USB to bulkhead connector to DMON2 *wiring*

Function	USB (Type A)	Bulkhead connector (MCBH)	DMON2 (J1)
PWR	1	7	20
PWR (Bootmode)	1	8	18
D-	2	6	17
D+	3	5	19
GND	4	2	21







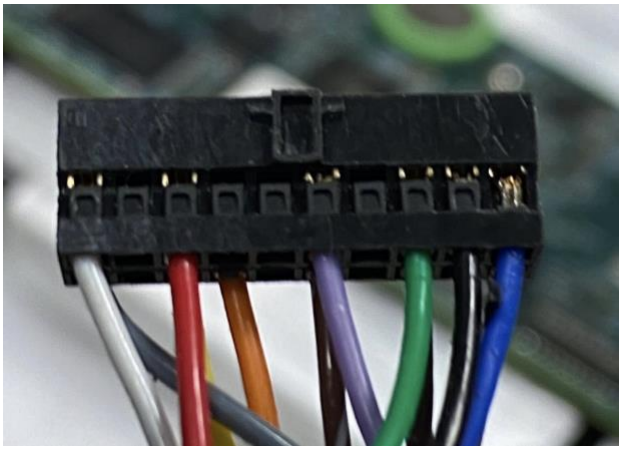
- Did you load the DMON2 USB device driver using Zadig?
- Try using different USB ports on your PC.

Connector issues

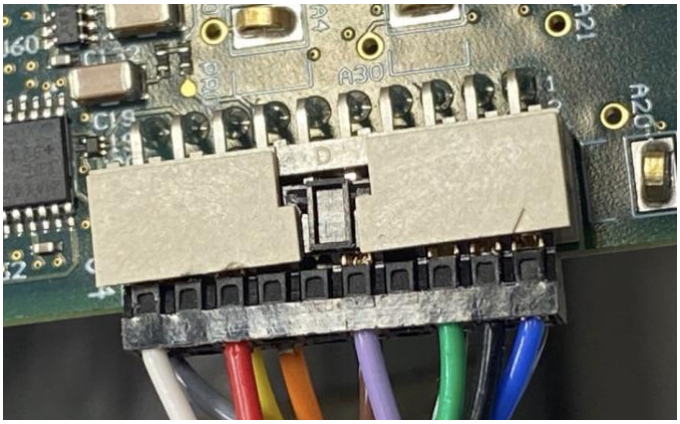
- It is always good practice to check on the condition of your connectors, as they are a frequent source of failure in almost any electronic system. The connectors for the DMON2 board are designed to fit very tightly, which is great when the glider is at sea, but hard on technicians that need to remove them. When doing so, do not pull on the wires, but instead coax the connector out of its receptacle with your fingernail until it is far enough out to grip the connector and pull. When you remove a connector, check to make sure the pins inside the receptacle are not bent; if they are, they are easily pushed

back into place (use a plastic mechanical pencil with the lead retracted to push the pin gently back into place).

- If you see any retaining tabs that have broken off on a connector, replace the entire connector (see part numbers above). Pin 1 (the one with the arrow just above it and the blue wire inserted into it) has a missing retaining tab in this picture:



- Replacing a connector is very quick and very easy, so definitely don't chance using a connector with a broken retaining tab. The pin will mostly likely not make contact or worse yet, will make intermittent contact, so it may look like it is working in the lab, but then fail at sea.
- To replace a connector body, order some replacements with the part numbers above, then take a picture of both sides of the old connector before you pull any pins out (just so you have a record of what the wire colors were). Use a small pick (e.g., a dental pick) to pry up the small plastic retaining tab for a single wire, pull out the wire, and insert it into the same socket in the new connector body. Do this one at a time for each of the wires. Compare your newly wired connector to the pictures of the old one, just to be sure they match.
- Before gently pushing the connector into its receptacle, double-check to make sure none of the pins in the receptacle are bent. The tab on top of the connector body ensures that you can't push it in upside down. Be sure the connector is pushed in all the way. Connectors like the one in the picture below are a recipe for trouble:



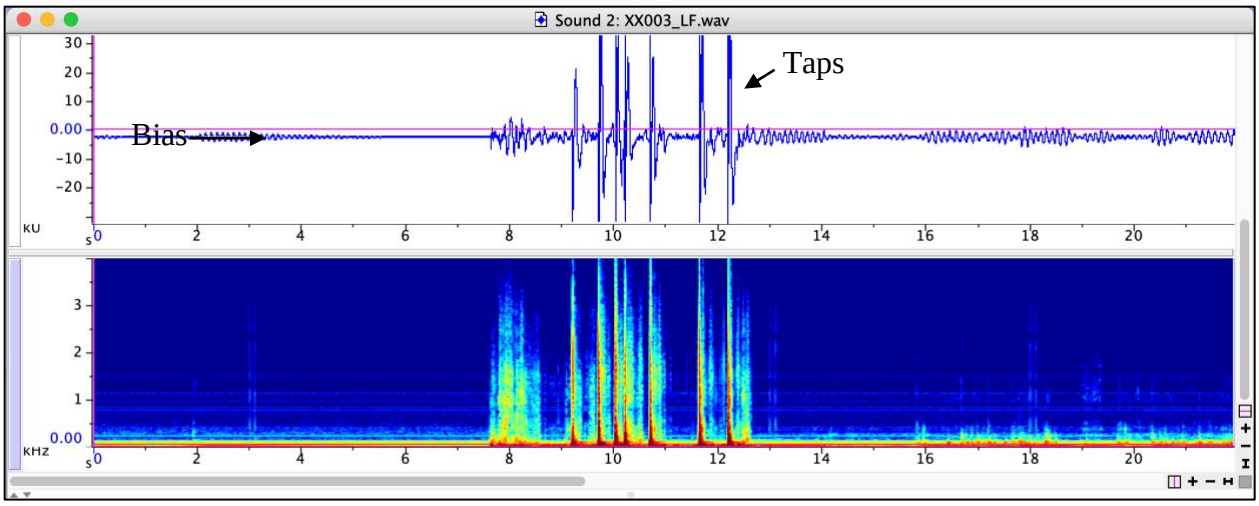
How do I know if the DMON2 is working?

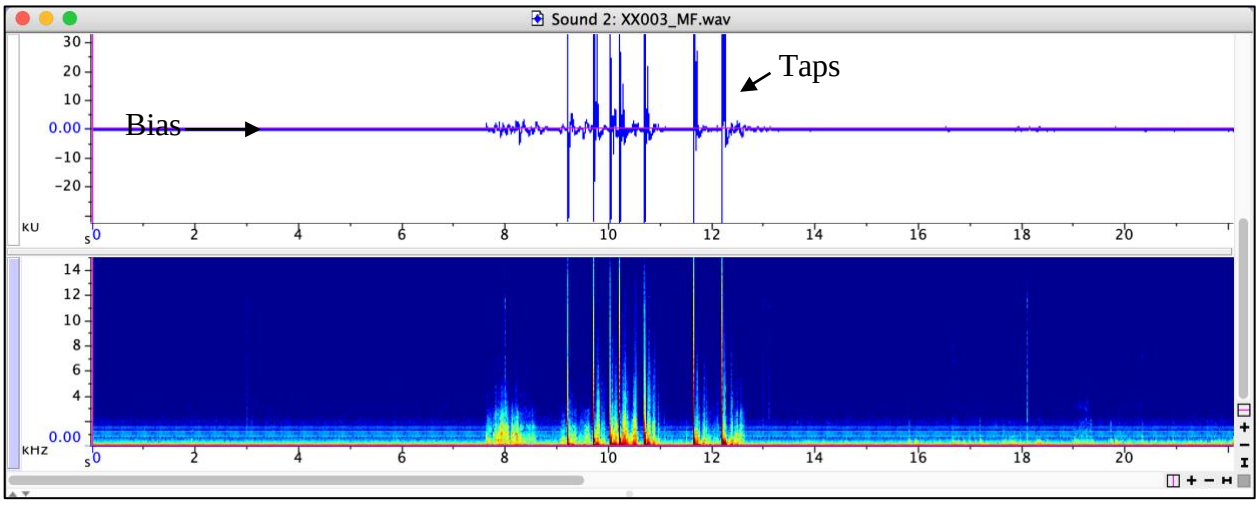
- Test each hydrophone using the record-only application firmware (e.g., mcrec2409.bin) and the procedures in section D of this document.
- Set up the application to record each of the hydrophones as follows (see section C):
    - Continuously record LF channel at 8 kHz
    - Continuously record MF channel at 30 kHz
    - Continuously record HF channel at 120 kHz
- When the firmware is running, tap gently on the hydrophone head in a known pattern (e.g., shave-and-a-haircut-two-bits, heartbeat)
- When you play back the audio or look at the spectrograms of the audio, you should be able to easily identify the tapping sounds.
- If you look at the waveforms (the time series of the audio), the LF channel should have a small negative bias of around -2000 digital values, the MF channel should have almost no bias, and the HF channel should have a positive bias of around 2000 digital values.
- If you do not hear/see the taps, and you do not observe these biases in the waveform, then there are a few things to check…
    - In the .log file produced during your test, there should be an $INIT message that looks like this:

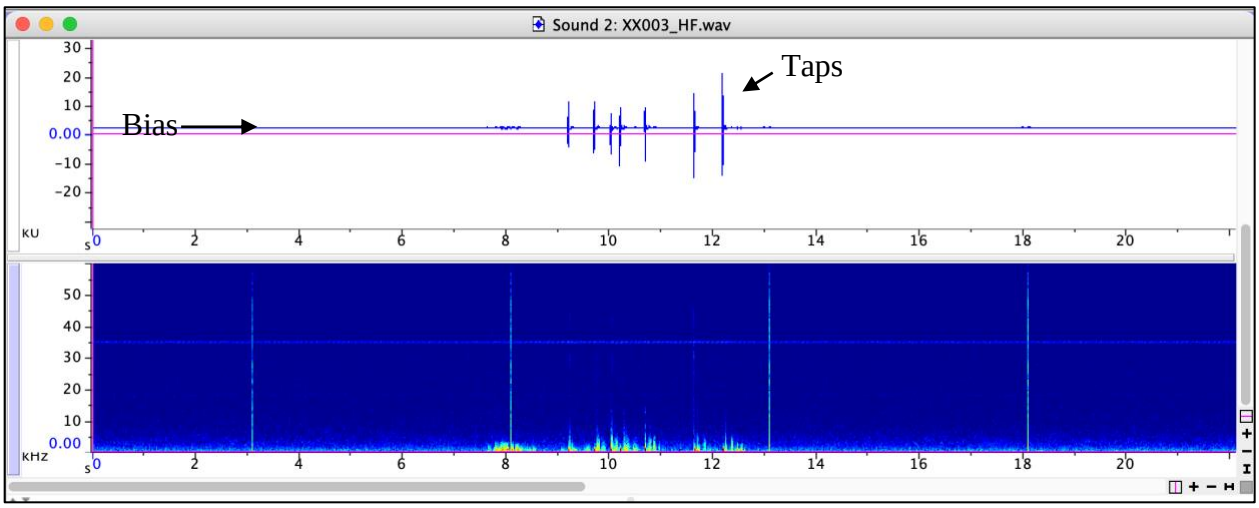
      $INIT,HEADINIT,INIT_OK,38,38,0

    - If you see "INIT_FAIL" instead of "INIT_OK", then the hydrophone head is not initializing correctly, which can be caused by a poorly seated connector, a bad connector or a damaged hydrophone head
    - If you see "INIT_OK", this means the DMON2 can power and communicate with the preamplifier board (which is good). Then the problem lies with the lines for the 3 hydrophones.
    - Open up the science bay and inspect the connector. Is it not seated well? Does it have one or more missing retaining tabs? When you remove the connector, is one of the pins in the receptacle severely bent, as if the pin was already bent before you removed the connector? If so, fix these and try the tap test again. The connector with the missing retaining tab shown in the photograph above is a hydrophone connector, and Pin 1 is the LF hydrophone line, so it is no surprise that this system was not recording the LF hydrophone correctly.
    - If you can find nothing wrong, then it is likely that the one or more of the ceramics have become disconnected from the preamplifier board because of some trauma experienced by the amber dome after it left WHOI.

The images below show snapshots from Raven of a successful DMON2 benchtop test. The waveform and spectrograms of audio recorded from the low-frequency (top; sampled at 8 kHz), mid-frequency (middle; sampled at 30 kHz) and high-frequency (bottom; sampled at 120 kHz) hydrophones in a DMON2 hydrophone head on the bench in the lab are shown. At 9 seconds into the recording, the "shave and a haircut, two bits" rhythm was gently tapped on the hydrophone head. The results are for a correctly functioning hydrophone head.


Sound 2: XX003_LF.wav
Taps
Bias
KU
KHz


Sound 2: XX003_MF.wav
Taps
Bias
KU
KHz


Sound 2: XX003_HF.wav
Taps
Bias
KU
KHz

P. Change DMON2 clock speed for record-only applications

The following section is an advanced function and is best done in consultation with Mark Baumgartner (mbaumgartner@whoi.edu). It is much easier for Mark to do this for you on his own DMON2 development board rather than you doing it on your DMON2 that is installed inside a glider science bay.

The record-only DMON2 firmware specifies that the DMON2 digital signal processor (DSP) run at 48 MHz clock speed by default. There are circumstances where you may want to decrease or increase this speed. A faster clock speed uses more power, so reducing the clock speed as low as a particular set of recording parameters will allow will save on power consumption. However, if the recording parameters require the DMON2 to sample and process faster than the present clock speed will allow, then the clock speed needs to be increased. When this occurs, the DMON2 will boot up from hibernation mode, but then immediately shut down and no recordings will be made. It is possible that the DMON2 will become unresponsive when this happens, and it can only be revived by disconnecting and reconnecting its lithium battery (hence, it is likely easier for Mark to do this than you doing it on a DMON2 installed inside a glider science bay). If you experience this problem, you can try changing the clock speed as follows.

1) Use the instructions in section B above to connect the PC to the DMON2 via the USB cable and launch the d3host program.
2) Select option "b" – "Parameter tables", and then select option "2" – "Clock speed parameter table".
3) Choose either 12, 24, 48 or 96 MHz for the clock speed.

One way to minimize the clock speed (and therefore power consumption) is to choose the slowest clock speed and try to run the firmware to record audio. If the firmware does not run, choose the next highest clock speed from the menu, and try to run the firmware again. Keep doing this until the firmware runs successfully. As mentioned above, it is possible that if the firmware cannot run, it will put the DMON2 into a mode where it cannot communicate via d3host any longer. It is best to try this "tuning" of the clock speed when the science bay is open and you have access to the DMON2. If the DMON2 does become unresponsive, reset the board by disconnecting and reconnecting the lithium battery connector.

The record-only firmware starting with "mcrec" also includes the capability to monitor several important metrics of processing load: the minimum number of calls to the idle job, the minimum number of free jobs available, and the minimum number of memory blocks available over a period of time. These metrics ought to be well above zero. The idle job is called by the DMON2 job scheduler when there is nothing left to do (i.e., all processing for the last batch of incoming audio is finished and the processor is just waiting for the next batch of audio), and the number of times the idle job is called is a measure of how busy the processor is. The DMON2 keeps track of how many jobs are scheduled, and there can be a serious backup of jobs if the processor is not fast enough to process them in real time. The DMON2 also has a finite amount of memory that is allocated dynamically as needed based on how much audio remains to be processed. When the system is so overloaded with incoming audio that it uses up all of the available memory, the system will crash. By increasing the clock speed, the DMON2 will process the audio faster such

that it will not use up all of the available memory (i.e., it can keep up with the speed at which the audio is being sampled). The minimum number of available memory blocks is a measure of how much memory the system leaves unused; if this number reaches zero, the system will crash. To monitor these metrics, do the following:

1) Start the firmware and monitor the console on COM1. If the DMON2 is attached to a glider, do this with the u4stalk (uart) program on the science computer.
2) In the console, type the following command: "$ADIDLE"
3) The console should start to output $IDLE messages every few seconds in the following format:

$IDLE,67CB1AB8,00E5,0061,000F,0010,0006,0009,0005,000F,0017,*58

- 67CB1AB8 – date/time (seconds since January 1, 1970 00:00:00)
- 00E5 – minimum number of calls to the idle job (in hexadecimal)
- 0061 – minimum number of free jobs available (in hexadecimal)
- 000F,0010,…,000F,0017 – minimum number of available dynamic memory blocks for each memory size category (in hexadecimal)
- 58 – checksum

4) The number of calls to the idle job, the minimum number of available free jobs, and the minimum number of available large memory blocks for the largest memory size category (reported as the last number before the checksum; 0017 in the example above) should be well above zero.
5) Type $ADIDLE to stop outputting these messages on the console