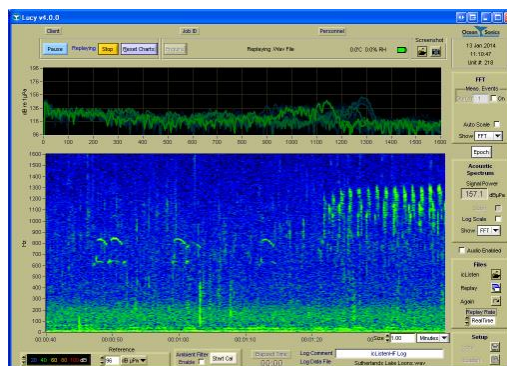


icListen LF User Guide

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icListen LF Smart Hydrophones



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1 icListen Smart Hydrophones

The concept of the **icListen** Smart Hydrophone has been in development since 2005. Smart Hydrophones take the work out of gathering acoustic data in the ocean. They supply data in real units, processing it as needed before it is stored or sent to the operator.

These hydrophones are ideal for a range of passive acoustic applications, such as

- *Environmental assessments of underwater acoustic noise*
- *Monitoring for marine life, including sea mammals and spawning fish*
- *Laboratory reference hydrophone*
- *Locating sound sources, such as malfunctioning equipment, or flight data recorders*
- *Locating leaks in underwater pipes, and identifying machine noises*

Users communicate with **icListen** through a PC program called **Lucy**. **Lucy** allows users to view instrument data in real-time, retrieve and play stored data, and perform housekeeping functions, such as checking the status & configuration. Ethernet **icListen** models also contain a web interface which can be used for device configuration.

We hope you enjoy your experience with **icListen LF**, and look forward to receiving your feedback.

2 Features of icListen LF

The **icListen LF** combines high signal integrity, data storage capacity, low power and small size with the ability to process sound data in real-time.

The **icListen LF** can be used in a tethered mode, or as an acoustic data logger.

In tethered mode, real-time waveform or spectral data can be continuously acquired by a PC running the **Lucy** program.

As a data logger, the **icListen LF** can be configured using **Lucy** or its web interface, then left for extended periods under water to collect waveform or spectral data, storing it internally.

The amount of recording time is dependent upon the sample rate, as seen in the following table.



Figure 2-1: icListen LF

How Sample Rate Affects Storage Time		
Sample Rate	MB per day	Days with 32 GB
250 S/sec	65	492 (16 months)
500 S/sec	130	246 (8 months)
1000 S/sec	259	123 (4 months)
2000 S/sec	518	61 (2 months)
4000 S/sec	1037	30 (1 month)

Note that storage time can be increased significantly by using event detection only when certain conditions are detected.

Waveform data is logged in the standard “.wav” format, making it accessible from a wide range of software programs. Spectral data is in .FFT format, detailed in the **icListen Log File Formats** document. The **Lucy** program is ideal for viewing stored waveform or spectral data.

Spectral analysis of data is optionally performed in the instrument, and can be averaged to reduce the quantity of data transferred or stored.

2.1 LF – Feature Summary

- Frequency Range: 1.0 to 1600 Hz, can be extended to 6400 Hz
- Low power, less than 100 mW
- Flexible power input requirement for Ethernet and RS232/RS485: 12 - 24 VDC
 - USB requires: 5 VDC
- Supplies real-time waveform and processed data, in tethered mode
- Processed data in FFT format (detailed in the **icListen Log File Formats** document)
- Waveform data in WAV format, with meta data stored in file header
- Stores up to 32GB in autonomous mode
- Monitors internal temperature and humidity
- Event detection, up to 5 bandwidth configurable triggers
- Seconds can be aligned to falling edge of PPS
- Maximum depth: 3500 meters
- Interfaces - RS232/RS485, USB (legacy), Ethernet (legacy)
- Size: 45 mm dia., 230 mm long (excluding connector)
- Depth rating: 200 or 3500 meters

3 Quick Start – Bench Setup

It is important to test **icListen** when it is first unpacked, and before each deployment for best results.

The hydrophone works in air well enough to provide a good functional test. Arrange a work surface large enough to hold the hydrophone, cables and the PC used to run the **Lucy** software.

3.1 Checklist

1. Hydrophone to be tested (note its serial number).
2. A PC (ideally the same portable one used to deploy the hydrophone), with the **Lucy** software previously installed. Ensure the PC has a suitable data port interface for the **icListen** instrument.

3.2 Steps

1. Connect the **icListen** to the link cable, and the data link to the PC.
2. Start up the **Lucy** program on the PC.
3. Click the icListen Setup button in the lower right. In the popup window, select the Link tab and chose the appropriate connection type. To find your **icListen**, click “Find All Units”. To connect double click the unit from the found units list.

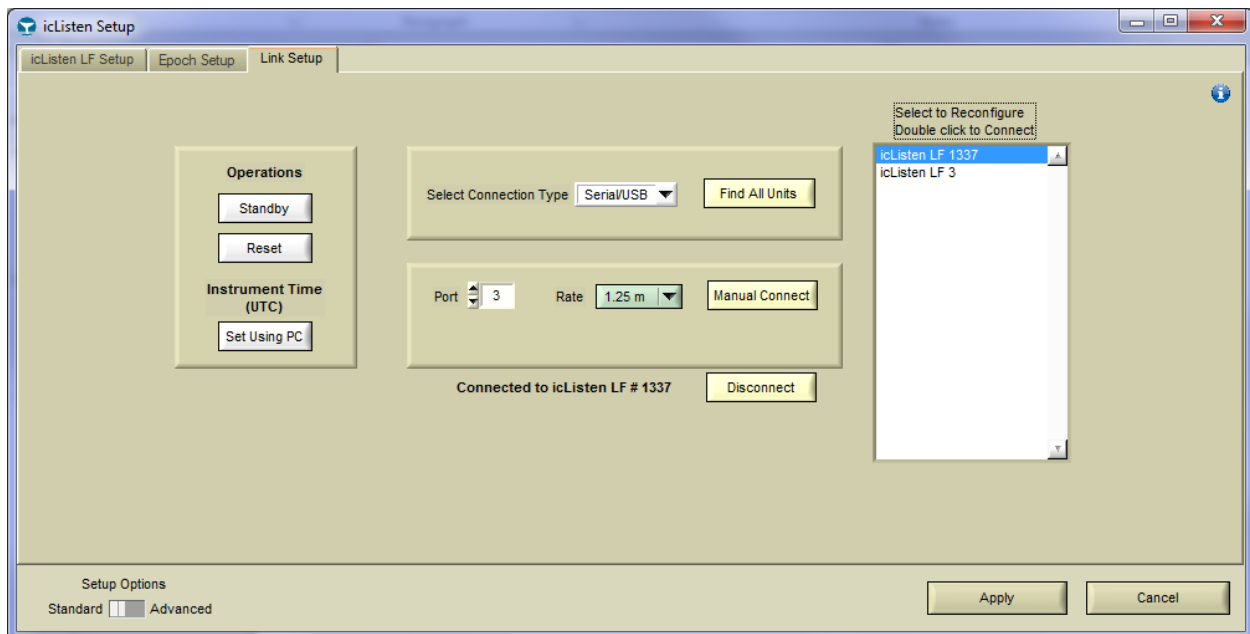


Figure 3-1: Lucy USB/RS232 connection display

- Click the 'Enquire' button in the middle top of the display. A message to the right will display if enquire is successful. Note the serial number in the displayed message to ensure it matches the number on the hydrophone. The message also displays the sensor temperature (which may be slightly different from that outside the instrument), and the internal humidity.

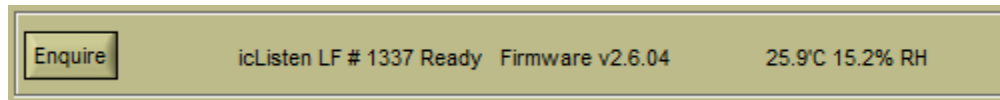


Figure 3-2 : Lucy status display

- The humidity is an indication of the seal quality. A humidity reading of 50% or less is acceptable. Higher readings indicate a possible leak in the seal. Contact Ocean Sonics if the humidity is higher than 80%. Close the Setup window if it is still open.
- Click the 'Start' button in the top left corner. The display should begin to show data in the charts. Gently tap the hydrophone, or whistle near it, to cause a change in the display. If the display is black/red, change the reference setting on the bottom left until blue or green is visible.
- If a changing data display is seen, the hydrophone is ready to put in the water. Events will show up on the display approximately 1 second after they have occurred. See the following display for an example.

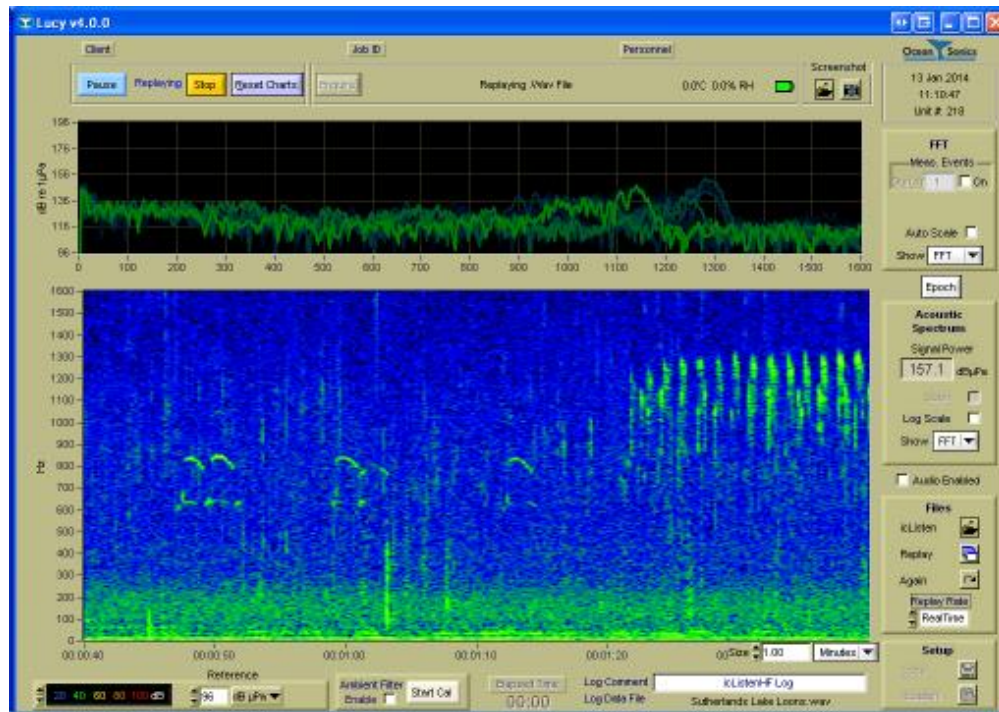


Figure 3-3: Lucy example display

4 Ocean Sonics' Lucy™ Software

The PC software used to talk to the **icListen** hydrophones is called **Lucy**. It presents data to the operator in a graphical and numerical format.

Lucy allows a user to fully configure, monitor status, and retrieve live and logged data from **icListen**. It is also capable of logging live data as it is retrieved and later viewing and analyzing logs created either by **icListen** or **Lucy**.

The interaction of the software has been designed for field operations personnel, making it simple to use once configured.

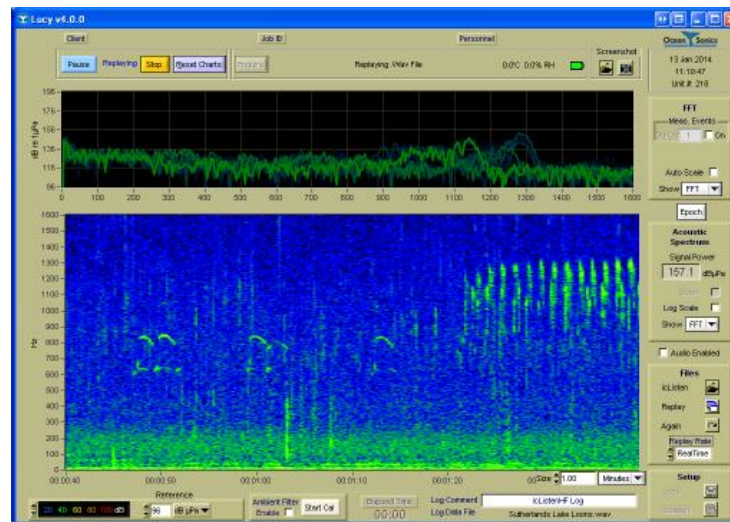


Figure 4-1: Lucy main display

Please refer to the **Lucy User's Guide** for instructions on operating the **Lucy** software.

5 Processing in icListen

One thing that makes **icListen** hydrophones smart is their ability to process data. Several types of processing are available to **icListen** devices, all of which add value to the data.

icListen is capable of transmitting real-time waveform data, and storing this data for later analysis as well. All **icListen** smart hydrophones can convert incoming data to power spectrum frequency data. This data can be processed in different ways, transmitted in real-time, stored, or used to trigger different effects in Epoch mode.

5.1 Waveform (Time Domain) Data

Waveform data represents the raw signal detected by a hydrophone. Acoustic data is converted from analog to digital, where it can then be processed by **icListen**.

5.1.1 Real-Time Data

icListen LF is capable of transmitting real-time waveform data to users, using software such as **Lucy**. Along with the digital waveform data, **icListen** will also transmit information on how the unit was configured when the data was collected, which can be used to convert the received numbers to voltage or pressure measurements.

5.1.2 Stored WAV Data

Waveform data may also be stored by **icListen LF** in standard uncompressed WAV files. This makes data recorded by **icListen** readable by many third party sound editing programs and analysis tools, as well as by Ocean Sonics' **Lucy** software.

In addition to the waveform data, **icListen** will store additional metadata in the WAV file's LIST chunk, which can prove to be useful for analysis. For more information on the WAV file format, and the additional information provided in the LIST chunk, please refer to the ***icListen Log File Formats*** document.

Files may be retrieved from **icListen LF** over the communications channel using Ocean Sonics' **Lucy**.

5.2 Power Spectrum (FFT) Data

One of the most powerful processing features of **icListen** smart hydrophones is their ability to provide power spectrum frequency data. Looking at data in the frequency domain, rather than the time domain, provides a clearer picture of what's going on within a sound, and can dramatically reduce the storage and bandwidth requirements of an operation.

5.2.1 Real-time Data

All **icListen** models are capable of providing real-time frequency data. This data provides a clear picture of what's happening in a sound. Transmitting frequency data rather than waveform data reduces the bandwidth requirement dramatically as well, which saves on transmission costs, and improves reliability.

This data is also accompanied by information on how the unit was configured when the data was collected, as well as scaling information which can be used to convert the data from voltage to pressure measurements.

5.2.2 Stored FFT Data

icListen LF is capable of storing processed power spectrum data in .FFT format files. This is a binary file format, similar to the WAV file format used for waveform data.

Storing spectrum data can provide a much more compact form of data storage than waveform data, allowing for faster data retrieval and analysis, and means that the unit can store data for longer periods of time between data retrievals.

These files also store additional sensor data (such as temperature and humidity), hardware information, and setup information, which can be used to aid in analysis. For a more in depth discussion on the FFT file format, please refer to the ***icListen Log File Formats*** document.

Files may be retrieved from **icListen LF** over the communications channel using Ocean Sonics' **Lucy**.

5.2.3 Windowing

icListen makes use of the Hann window function, in order to reduce spectral leakage, when converting data from time to frequency domain.

5.2.4 FFT Processing Options

Not all applications require data to be processed in the same way. For this reason **icListen** has been designed to allow multiple options for power spectrum data processing.

5.2.4.1 Overlap

It is often useful to have some overlap in the waveform data used to compute frequency data. This helps to improve the time resolution of the resulting data, and assists in ensuring we do not miss data that may otherwise be filtered out by the Hann windowing operation. The figures below show an example waveform data set, divided into sections which are used to compute frequency data. These figures show the data used with no overlap (0%), 50% overlap, and 75% overlap.

An overlap can be used in combination with mean, peak value, and filtered (exponential moving average) processing.

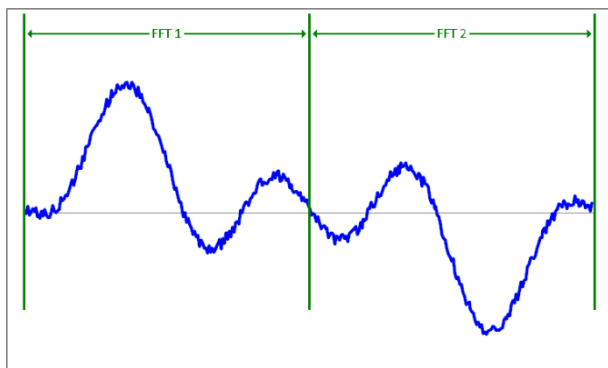


Figure 5-1: FFT's with 0% Overlap

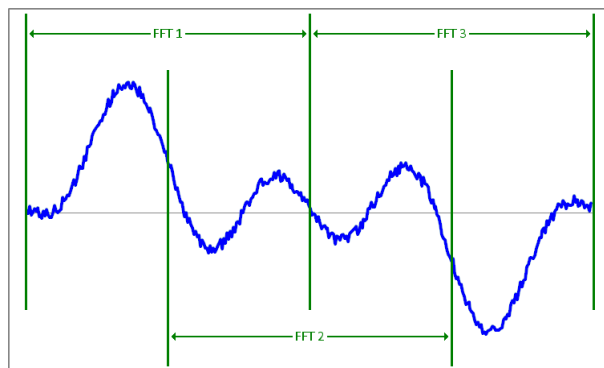


Figure 5-2: FFT's with 50% Overlap

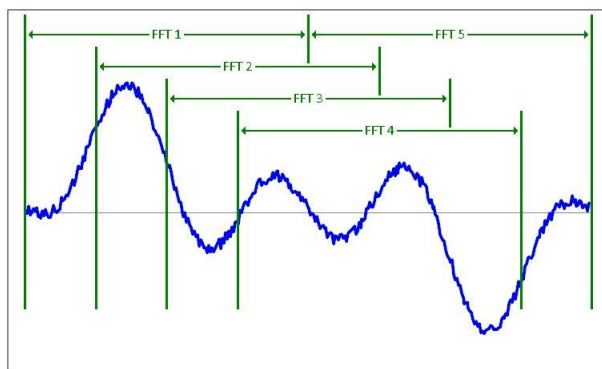


Figure 5-3: FFT's with 75% Overlap

5.2.4.2 Mean Average

This form of processing will calculate the mean average power found at each frequency, over a configurable averaging period. The averaging period is the number of FFT data sets over which the average is calculated.

The mean value for each frequency bin is calculated as follows:

$$Y_i^2 = \frac{1}{N} \sum_{j=0}^{N-1} |C_{i,j}|^2$$

Where:

N = Averaging Period

Y_i^2 = Signal Power of frequency bin

$C_{i,j}$ = FFT Coefficient

i = Frequency Bin Number

j = FFT Data Set Number

5.2.4.3 Peak Value Detect

Peak value detect processing keeps track of the maximum power level found at each frequency. This can be configured to be done over a set number of FFT data sets, or configured to reset the detected peak value only when data is retrieved from the unit.

5.2.4.4 Filtered

This form of processing performs infinite impulse response (IIR) filtering on the power levels detected at each frequency. The type of filter used is an exponential moving average. The weighting of the average, as well as how frequently the **icListen** will transmit results are both configurable in this mode. This has the effect of smoothing new data with the previous FFT results.

The filtered data for each frequency is calculated as follows:

$$Y_{i,j}^2 = \frac{(N - 1) \times Y_{i,j-1}^2 + |C_{i,j}|^2}{N}$$

Where:

N = Weighting Factor

$Y_{i,j}^2$ = Signal Power of frequency bin

$C_{i,j}$ = FFT Coefficient

i = Frequency Bin Number

j = FFT Data Set Number

5.3 Epoch Mode

In Epoch mode, **icListen** can be configured to detect specific signals in the real-time data, and perform a number of tasks based on those signals. An **icListen** can check the data for 5 independent triggers.

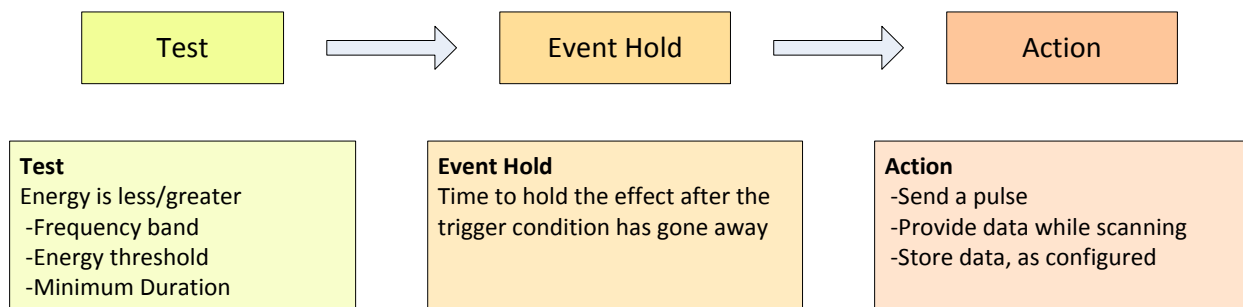


Figure 5-4: Epoch Triggers

Epoch triggers consist of 3 settings. The first setting is the signal conditions required to activate the trigger. This is called the test. Secondly there is the event hold, which is how long the action lasts after the triggering signal disappears. Finally there is the action which **icListen** takes when triggered. The actions available to **icListen LF** are: sending a signal pulse, logging data, or preparing data to send when scanned.

icListen LF begins sending or logging data immediately after the event is detected.

Note: Different events can have different result actions.

5.4 Gain

Applying gain affects the dynamic range of the instrument, by increasing the minimum amplitude signal which can be detected by an instrument, and decreasing the maximum amplitude signal which can be measured by the instrument. This behavior makes increasing gain desirable in quiet environments where important information could be otherwise lost, but undesirable in loud environments where data would be lost due to “clipping” of the signal if gain were applied.

6 Additional Features of icListen

icListen also contains some additional features that can aid with troubleshooting, deployment, and operation of the device.

These features include: monitoring temperature, humidity, acceleration and magnetic field, time synchronization, and network device discovery options for Ethernet **icListen** devices.

6.1 Temperature and Humidity

Temperature and humidity values are continuously measured internally in all **icListen** models.

The internal temperature of an **icListen** will generally be slightly warmer than the outside temperature (more so when the unit is out of water). It is useful for determining if any temperature shocks are experienced during testing. Rapid changes in temperature can result in a DC offset being introduced to waveform data. In some cases the offset can be great enough to “clip”/“max out” the data. This effect is expected and temporary, and knowing the temperature changes that the device experienced can help in determining if this is occurring.

The relative humidity reading can be used to determine the seal quality of the instrument. A humidity reading of 50% or lower is acceptable. If the reading is higher than this, it may indicate a leak in the seal.

6.2 Acceleration and Magnetic Field

Accelerometer and magnetometer readings are available for **icListen LF**. These values can be used to monitor changes in the orientation of the instrument once it has been deployed.

6.3 Time Synchronization

icListen LF is capable of having its time of day set over the command & control connection to the device. This can be done using Ocean Sonics’ **Lucy** software.

Data can also be synchronized to the falling edge of a pulse per second (PPS) signal, allowing synchronization between multiple units.

6.4 Network Discovery

In order to make finding your **icListen** on a network easier, some network discovery protocols have been implemented on Ethernet units. **icListen LF** Ethernet models have UPnP (Universal Plug and Play) enabled, and make use of Ocean Sonics Marco/Polo protocol to discover IP addresses (as of web interface v1.2).

6.4.1 UPnP (Universal Plug and Play)

UPnP is a set of networking protocols, which allows a device to automatically be discovered by any computer which has UPnP services enabled on the same subnet as the device.

UPnP is enabled by default on Windows 7 and Vista, and UPnP devices can be found under “Network”. When UPnP is enabled on Windows XP, UPnP devices can be found under “My Network Places”. UPnP is not enabled by default in Windows XP (visit support.microsoft.com for details on how to enable this feature).

6.4.2 Marco/Polo

A pair of programs (**Marco** and **Polo**), are used to discover **icListen** units on a network. **Marco** is the application used by the end user on a PC which scans the network for devices, while **Polo** exists on the **icListen** unit and responds to messages from **Marco**. Using **Marco**, a unit can be discovered on a local network, or through a direct connection to a device, even when not on the same subnet. **Marco** also allows the network settings of the **icListen** unit to be reconfigured.

A copy of the **Marco** software is provided on the data stick supplied with all **icListen** units. As of version 3.6, Ocean Sonics’ **Lucy** software is also capable of finding **icListen LF** units using the same message protocol.

7 Logged Data Retrieval

Data logged in an **icListen LF** is retrieved over the command and control connection to the instrument. This can be done using the **Lucy** software's file utility. This is activated by pressing the "icListen" button in the "Files" section of **Lucy**'s main display window, while connected to an **icListen LF**. For a more detailed description, please refer to the ***Lucy User's Guide***.

8 Care and Maintenance

To get the best performance and longest service life possible out of your **icListen**, it is important to properly care for and maintain your unit. Here are a few things which should be remembered when using your **icListen**.

8.1 Firmware Updates

Occasionally, Ocean Sonics may provide firmware updates for **icListen**.

The firmware for **icListen LF** is updated over the command and control communications channel, and can be done using Ocean Sonics' **Lucy**. For more detail on this update procedure, please refer to the ***Lucy User's Guide***.

8.2 File System Care

To maintain optimal performance, Ocean Sonics recommends that logging be disabled, and all files be cleared from the system when the instrument is not in use. This will prevent accidentally deploying an instrument that has no storage capacity remaining.

For **icListen LF**, files can be cleared by deleting them using the file utility provided by **Lucy**.

8.3 Connector Care

Ensure that the mating surfaces of the connector are fully seated before deploying the instrument. Failure to do this could result in shorted connections when the unit is placed in the water.

Never use excessive force to seat connectors. This may result in the pins being broken or bent, which could result in down time while the connectors are being replaced. If a connector is tough to get in place, lubricate the rubber parts of the connector sparingly using **Molykote 44 Medium** lubricant.

Never use the backshell/fastening nut to force the connector into place. This could result in damage to the connector or backshell, and may result in the connectors not being fully seated in place.

The connector should not be exposed to extended periods of heat or sunshine. Should this occur and the connectors become very dry, they should be soaked in fresh water before use.

Any accumulation of sand or mud in the female contact should be removed with fresh water. Failure to do so could result in the splaying of the female contact and damage to the O-ring seals.

Disconnect by pulling straight, not at an angle. Do not pull on the cable, and avoid sharp bends at cable entry.

8.4 Retrieval and Storage

When your **icListen** is being retrieved, it is important to rinse off the unit with fresh water. This will avoid corrosion and keep salt crystals from forming on the connectors. Failure to do this could result in the need to have the instrument serviced, to replace the connectors.

If your unit is battery powered by using a shorting plug, ensure the shorting plug has been disconnected from the unit after retrieval. This will help reduce running down of the battery, and accidentally logging data while in storage. Failure to do this can result in lost time while the battery is being charged, or while clearing unnecessary log files from the unit.

8.5 Deployment

When deploying an **icListen**, it is a good idea to apply some gentle soap, such as dishwashing liquid, to the surface of the hydrophone. This will help to break the surface tension, avoiding bubbles forming on the hydrophone surface, which could have adverse effects on the signal quality.

If your **icListen** will be internally logging, make sure that the file system is ready (see *File System Care*).

8.6 Long Term Deployment

For long term deployments, contact Ocean Sonics for support.

9 Troubleshooting icListen

9.1 Instrument not communicating

- Check wiring. If externally powered, ensure power is functional using a multimeter. Re-seat plugs and connectors.
- Check data link interface on PC with another device to ensure PC interface is working.
- If using RS-232 option, ensure the baud rate is correct, or use the auto-detect option in **Lucy**. If the cable was recently wired up or modified, ensure that the TX and RX lines are not reversed.

9.2 I need to find out the icListen firmware version and serial number

- The instrument's serial number is printed on the side of instrument, and its carrying case.
- The firmware version and serial number can be retrieved by sending an Enquire command to **icListen**. This can be done in **Lucy** by clicking the 'Enquire' button and noting the response to the button's right, or by connecting to the unit using the "Link" panel.

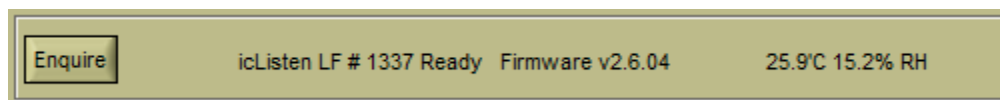


Figure 9-1: Lucy status bar

- This information is also available on the "Home" section of the web interface.

9.3 The information displayed on the web interface is blank or not updating

- Your web browser may be displaying the page from a cached version.
- For most browsers, holding Ctrl while pressing F5 will force all files in the cache to be discarded, and refresh the page (this is often not done when using the refresh button, or pressing F5 without holding Ctrl). Some pages on the web interface also include a "Refresh" button, which will also clear browser cache.
- If this fails you may need to manually clear all browser cache to remedy the issue (Ctrl + Shift + Delete on most browsers).

9.4 I can't connect to my Ethernet icListen's IP address

- Do not add leading 0's to any part of the IP address. Many applications will treat address fields with leading 0's as base 8 numbers instead of base 10. For example, if your address is 10.11.12.1, and you type 010.011.012.001 into your browser or **Lucy**, you will not be able to connect to the instrument (010.011.012.001 will be interpreted as 8.9.10.1).
- If this fails to fix the problem, make sure that your computer is on the same network as your **icListen**. If your icListen and computer are on separate private networks, it will not be possible to connect to it. If your web interface version is v1.2 or newer, Ocean Sonics' **Marco** or **Lucy** (v3.6 or newer) can be used to reconfigure the device's network settings, to make the instrument accessible. For older web interface versions, your computer network settings must be adjusted in order to allow it to communicate with **icListen**.

10 Functional Block Diagram

The drawing below shows the **icListen LF** key functions. The Blocks on the left of the diagram represent connector functions. Not all interface functions are available on all instruments.

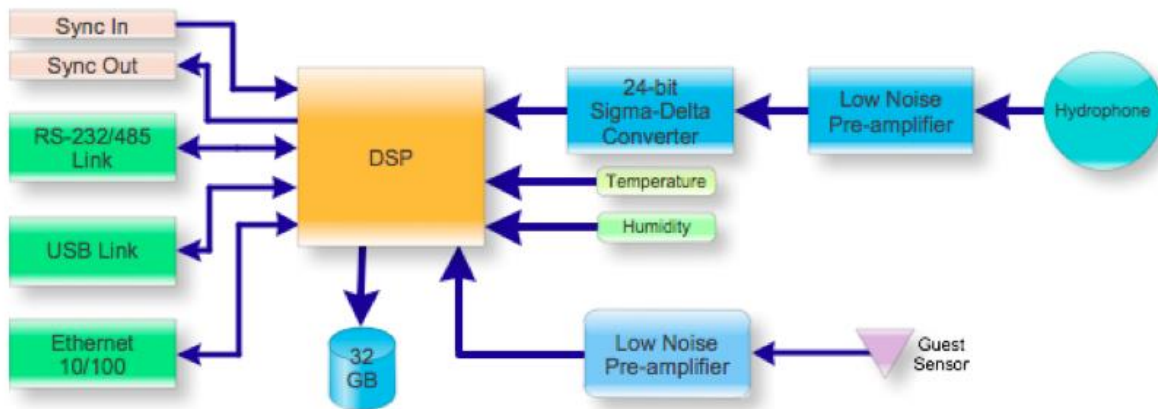


Figure 10-1: Functional block diagram

11 Instrument Performance

- The charts on the following pages show the frequency and noise response of the **icListen LF** instrument at the 250Hz and 4000Hz sample rates. The first chart shows a conventional voltage and ADC count response versus frequency, over the bandwidth of the instrument.
- The second chart shows the instrument dynamic range, as a function of the maximum signal and the measurement noise floor.

11.1 Response at 4000 Samples/sec

The following charts show the **icListen LF** performance, for its default sample rate of 4000 Samples/sec. Note that the bandwidth at this sample rate is 1600 Hz.

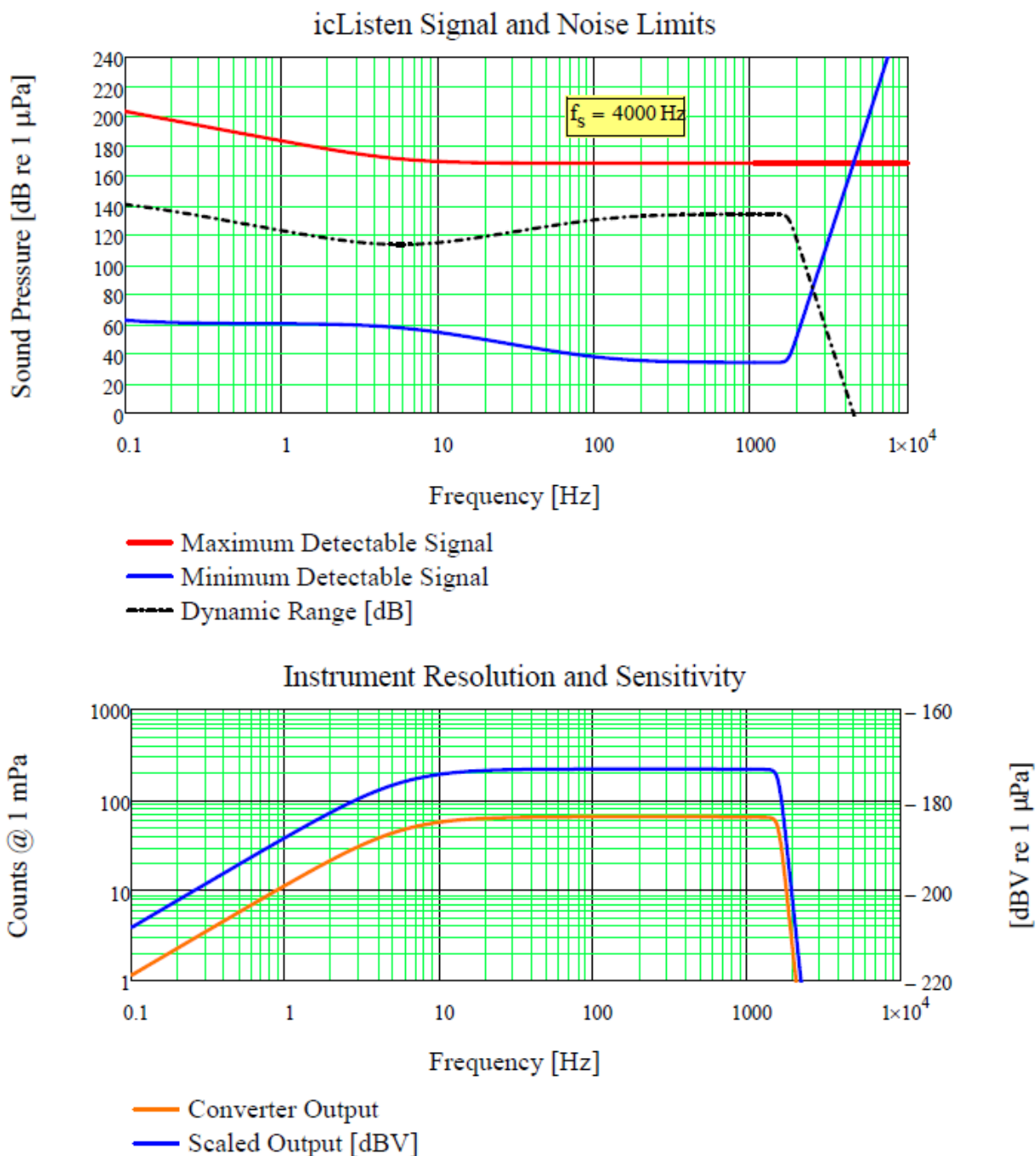


Figure 11-1: Noise response at 4 kHz sample rate

11.2 Response at 250 Samples/sec

The following charts show the **icListen LF** performance for its default sample rate of 250 Samples/sec. Note that the bandwidth at this sample rate is 100 Hz.

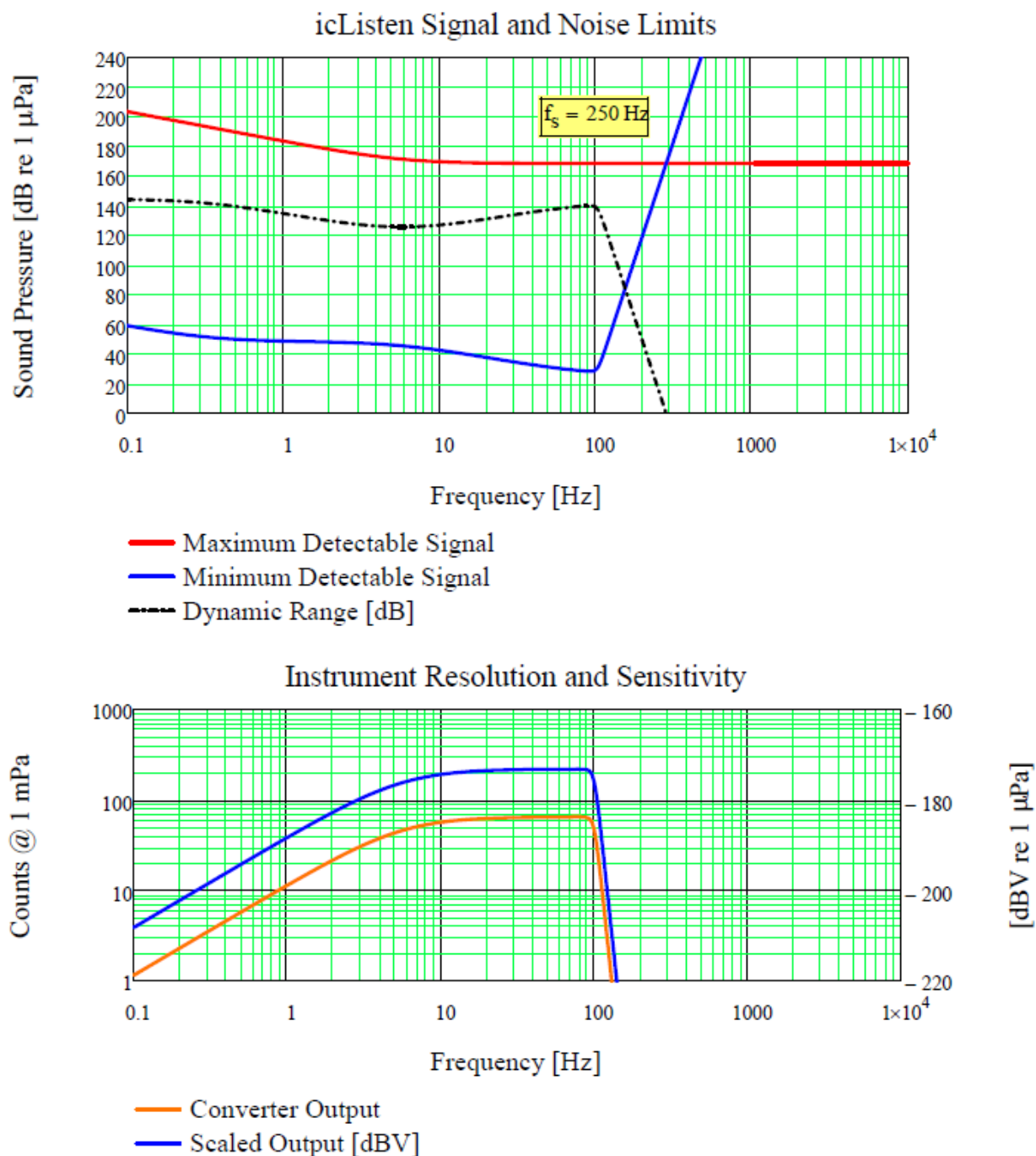


Figure 11-2: Noise response at 250 Hz sample rate

12 Options and Configurations

The configuration options for **icListen LF** are listed in the table.

Spec	Standard	Options
Depth	200 meters	3500 meters
Connection	Male 8-pin bulkhead	-
Frequency	1.0 Hz - 1600 Hz	-
Use	Tethered / Mooring with battery	Autonomous with internal battery

13 Wiring Tables for icListen

The following are standard pinouts used with molded cables and shorting jumpers provided by Ocean Sonics. As your application may have specific requirements, please refer to the wiring table provided with your unit. Drawings of the molded cables are available by request from Ocean Sonics.

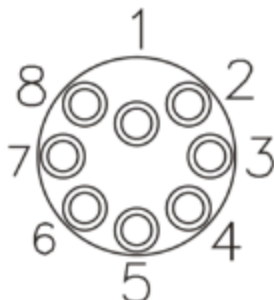


Figure 13-1: Subconn MCBH8M male face

13.1 icListen LF RS-422 Interface

Subconn	Signal
MCBH8M	Name
1	DC-
2	COM
3	TX-
4	TX+
5	RX-
6	RX+
7	DC+
8	SYNC

13.2 icListen LF RS-232 Interface

Subconn	Signal
MCBH8M	Name
1	DC-
2	COM
3	N/C
4	TXD
5	GND
6	RXD
7	DC+
8	SYNC

13.3 icListen LF Shorting Jumper

To run **icListen LF** in battery mode, a shorting jumper is used to connect the power pins to the battery voltage.

Subconn Shorting Jumper		
Pin #	Circuit Name	Wire Colour
1	A	Not Defined
2	A	
3	B	
4	B	
5	C	
6	C	
7	D	
8	D	

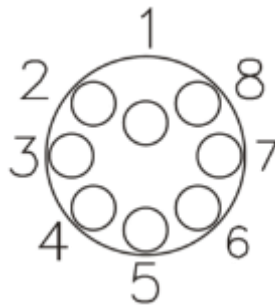


Figure 13-2: Subconn MCDC8F female face

14 Recommended Connectors

The following table lists all the connectors used by **icListen**. Please ensure you check the number of pins and the connector gender before ordering connectors or whips from another vendor.

All listed are rated to 3500 M depth.

Connection	Maker	Pins	Part #	Thread	Mate & Backshell	Dummy/Short Plug
Bulkhead - Male	Subconn	8	MCBH8M	$\frac{7}{16}$ " x 20	MCIL8F & MCDLSF	MCDC8F

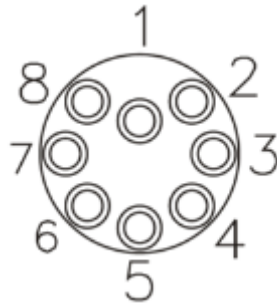


Figure 14-1: Subconn MCBH8M male face