Acuity LS™ | Operating Manual

LUNA

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Acuity LS™ System Operating Manual

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1. Overview

This document provides an overview of the hardware and software setup for Luna's Acuity LS Corrosion Monitoring System. The Acuity LS system provides long duration, autonomous measurements of environmental and corrosion parameters. Acuity LS continuously collects and records air temperature, relative humidity (RH), surface contaminants, free corrosion of alloys and galvanic corrosion of dissimilar materials.

The Acuity LS device is battery-powered, small in size, light weight, and mounts directly onto structures. The battery provides approximately 4 years of operation without a replacement (assuming 60 min measurement intervals). The commercially available battery can be replaced by the user.

Acuity LS Interface software enables users to configure each Acuity LS device at startup and collect data.

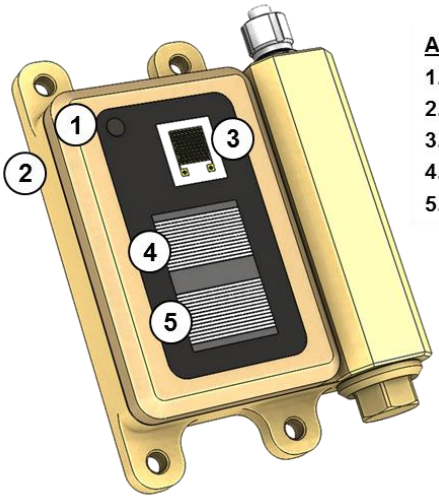
Acuity LS corrosion sensing elements are replaceable by the user. Replacement Acuity LS Lid Sensor Panels (LSP) may be purchased from Luna.

2. Hardware Definition

The Acuity LS system includes a multi-sensor data acquisition device that saves data internally, and when connected to a computer can transmit the stored data (see Section 5). The Acuity LS system hardware components are the battery-powered sensor device with a replaceable Acuity LS Lid Sensor Panel (LSP) and the RS-485 communications cable for computer connection (Figure 1). The Acuity LS sensor device comes complete with a base, single LSP and a single battery. The RS-485 cable and spare LSP items are sold separately. Spare batteries may be purchased online (via Amazon and others) or through Luna.

Figure 1. Standard Acuity LS hardware. The RS-485 communications cable and replacement LSPs are sold separately.

The LSP includes a gold interdigitated electrode (IDE) for sensing solution conductance, a free corrosion IDE to measure corrosion current of an alloy, a galvanic IDE to measure galvanic current of two dissimilar alloys, and a sensor to measure air temperature and relative humidity (Figure 2).



Acuity LS Sensing Elements

1. **Air Temp and RH**
2. **Surface Temp (bottom of case)**
3. **Gold IDE – Environmental Contaminants**
4. **Single Alloy – Free Corrosion Rate**
5. **Dissimilar Alloys – Galvanic Corrosion Rate**

Figure 2. Acuity LS sensing elements.

3. HARDWARE SETUP

This section describes the LSP installation and removal procedures, connections required for system operation, and coated panel preparation.

LSP Removal and Installation

The Acuity LS device is delivered fully assembled with LSP installed on base. The following instructions are only needed for replacement of an LSP. The replacement LSP is delivered with a new O-ring seal installed. For set up of new Acuity LS device please skip to next section "LSP Surface Preparation for Testing".

LSP removal:

1. Thoroughly rinse and dry the Acuity LS device to remove corrosive contaminants and salts, especially near LSP and base interface.
2. Remove all socket-head cap screws using 9/64” hex wrench. Take care to avoid sideways motion of the LSP as the screws are removed as this may damage the internal spring pin connector.
3. The LSP can then be removed from the base by lifting it straight up.
4. Once the LSP is removed, examine the base spring contacts for any corrosion or mechanical damage. Lightly press on the spring pins with a clean wipe (no fingers) and verify that they actuate smoothly and all return to the same position. The spring contacts on the base should have no signs of corrosion or mechanical damage. Please contact Luna if there is any evidence of seal leakage allowing contaminants into the device and connector.

LSP installation:

1. Ensure that the base and LSP mating surfaces are clean, dry, and free of any contaminants and obstructions that may prevent them from mating together and forming a seal.

2. Orient the LSP so that its two metal dowel pins align with the mating holes in the Acuity base (Figure 3).

   CAUTION: *Misalignment or using the wrong orientation of the LSP could result in bent spring contacts and irreparable damage to the Acuity LS based and LSP.*

3. Hold the LSP onto the base while reinstalling the six socket-head cap screws, applying only light torque until all screws are seated.

   CAUTION: *Do not cross-thread or overtighten the screws, this could cause irreparable damage to the Acuity LS LSP.*

4. Using a torque-limiting driver, tighten all screws to 15 lbf-in [1.7 N-m].

5. Verify functionality of the new assembly using the Acuity LS Interface software. The “System Check” function in Section 5, "Operating the User Interface" will confirm the LSP is in good contact by displaying reasonable measurements for air temperature and relative humidity.

LSP installation is now complete.

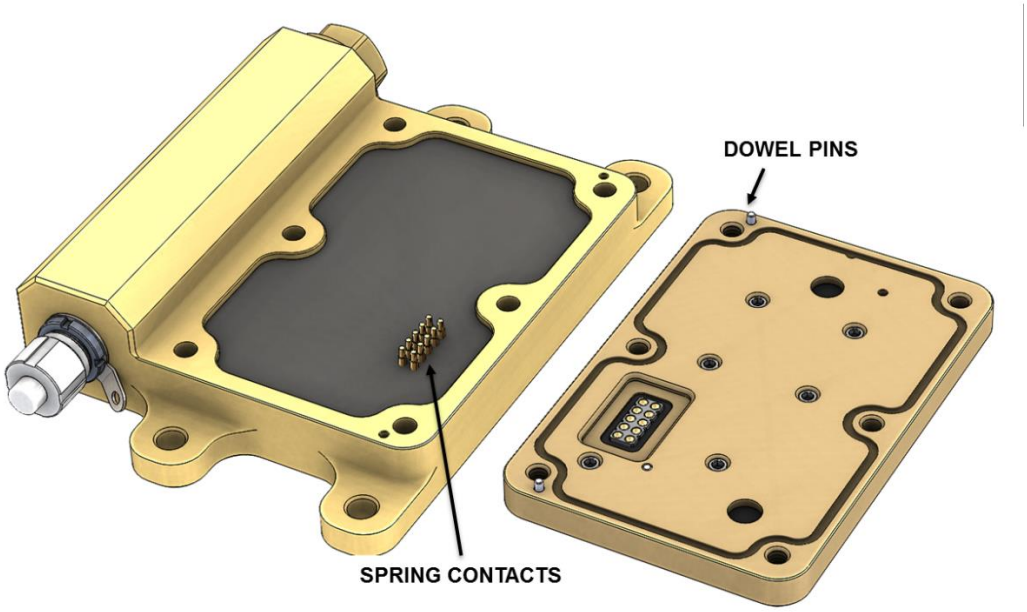


Figure 3. Acuity LS base (left). Electrical spring contacts connecting base to LSP (right). NOTE: LSP O-ring seal not shown.

LSP Surface Preparation for Testing

The LSP is delivered in a clean condition ready for use.

If the surface is contaminated, water rinsing can be done to the conductance, free corrosion, and galvanic corrosion sensors. If organic contaminants need to be removed, wiping of the sensors with mild solvent (isopropyl alcohol) using a non-abrasive foam or cotton swab can be done.

CAUTION: *Do not immerse the Acuity LS device or flood the filter cap area that houses the relative humidity and temperature sensor with solvent, this could affect the temporary operation of these sensors or cause permanent damage.*

CAUTION: *Contact time of the sensors with solvent should be kept to a minimum. Prolonged contact with solvents may soften and damage the polymer sensor materials.*

The Acuity LS device and LSP can be used with coatings. Please contact Luna for specific instructions for coating the LSP and using the Acuity LS device to measure coating performance.

Battery Replacement

The low-power electronics in the Acuity LS ensure long life, battery powered operation. When the battery is depleted, it may be swapped out without removing the Acuity LS device from a structure. Battery replacement is outlined below.

1. Source a new Saft LS17500 primary-cell battery from Luna or an authorized Saft distributor. *NOTE: Substituting a different battery type is strictly prohibited. Device damage and safety hazards may result from unauthorized battery usage.*

   WARNING: TEMPERATURES IN EXCESS OF 100 °C MAY CAUSE BATTERY FIRE, EXPLOSION, AND SEVERE BURN HAZARD.

2. Using a 5/8" box end wrench or socket, remove the battery cap (Figure 4).
3. Remove the metal battery contact tube and the battery.
   - For sensors mounted with battery cap facing up, the battery is more difficult to extract.
   - In these situations, it may be possible to extract the battery by quickly pulling the battery tube from the device to create a vacuum around the battery.
   - If this is unsuccessful, a small jet of compressed air (i.e., canned air) directed between the battery and the housing is sufficient to extract the battery in these situations.
   - It is for this reason that Luna does not recommend mounting the sensor directly vertical with the battery cap on top.
4. Visually check the contact faces on the metal tube to ensure that there is no evidence of corrosion or other damage.
5. Install a new battery into the metal tube **using the polarity shown below** (Figure 4).
6. Install battery and tube into the device housing.
7. Inspect battery cap O-ring seal for damage. If none, reinstall battery cap by hand until seated. Ensure that O-ring remains in its groove during this step.
8. Using a torque-limiting driver, tighten battery cap to 30 lbf-in [3.4 N-m]. *NOTE: Consult Luna if tooling recommendations are needed.*
9. Verify functionality of the new assembly using the Acuity LS Interface software.

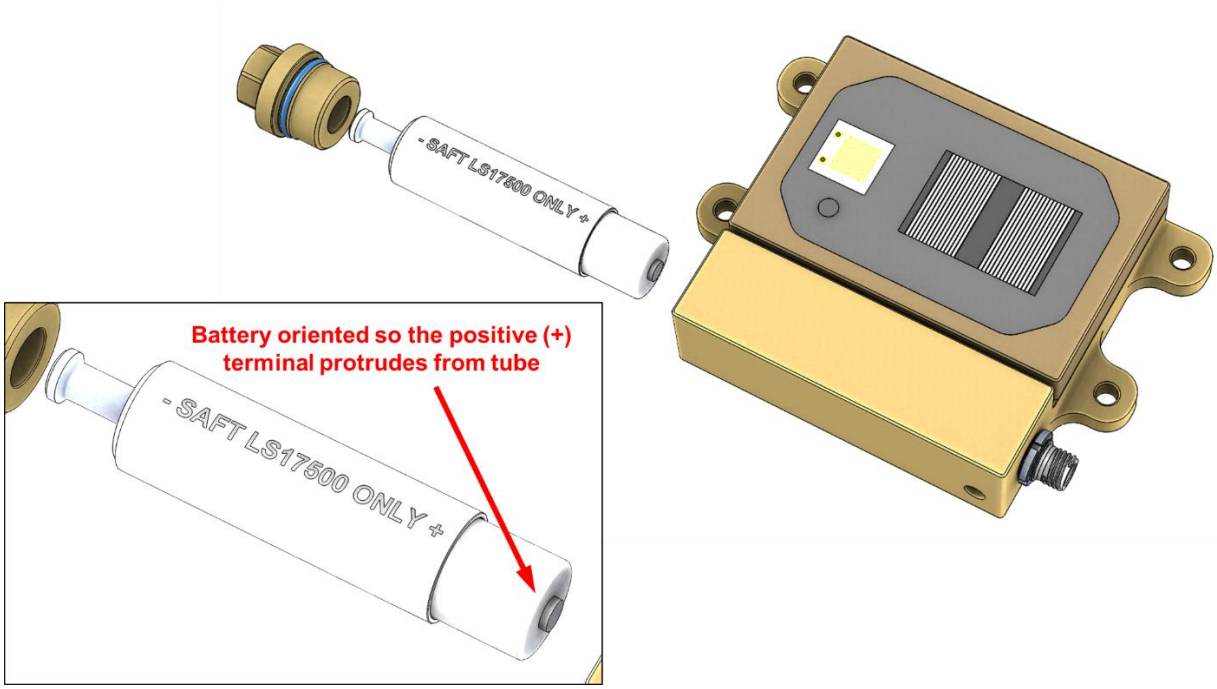


Figure 4. Battery removal. The metal tube around the battery serves to provide electrical contact to the negative side of the battery. NOTE: Older model shown, but battery replacement is the same.

System Restart

To perform a system restart of the Acuity LS device, remove the battery and wait 10 seconds, then install the battery per the instructions above. Performing a system restart has no effect on the data; all data will remain stored on the Acuity LS device. *NOTE: consult Luna if there are questions concerning the system restart.*

4. Software and Driver Installation

This section provides instructions for installing the software and drivers needed to communicate with Acuity LS. Please ensure that your computer meets these basic system requirements:

- Laptop or desktop computer with Windows 7, 8, or 10 (64 bit)
- 500 MB available hard drive space
- One (1) available USB port

Acuity LS User Interface Software and USB Driver Installation

NOTE: Do not plug the Acuity LS RS-485 communications cable into the computer until after the drivers are installed on the computer, otherwise Windows may attempt to install incorrect drivers automatically.

1. Insert the CD or USB flash drive that was provided with the Acuity LS product shipment. If these are not available, please contact Luna for copies of the software and drivers.
2. Use Windows file explorer to navigate to the media drive. (shortcut: Windows file explorer can be accessed with “Windows” + “E” keys)

3. Open folder “Acuity LS Interface Installer” → ”Volume” and double-click on file “setup.exe”.
4. Select the default for all prompts. The user software installation will take several minutes to complete.
5. Once software is installed, the user will be prompted by Windows to install the FTDI drivers for USB driver operation. Select the defaults for all prompts.
6. Reboot the computer if prompted.
7. Software and USB driver installation is complete. The computer is now ready to interface with Acuity LS device.

5. Software Operation

This section provides instructions for connecting an Acuity LS device to a computer and operating the user interface software.

Establishing Communication

To establish communications between the Acuity LS and the computer:

1. Remove the protective cap (Figure 1, item 4) and install the RS-485 cable (Figure 1, item 5). The other end of the cable plugs into any USB 2.0 compliant serial port. *NOTE: When finished communicating with the device, ensure that the protective cap is reinstalled by snugging down hand tight (no tools).*
2. In the Windows start menu, locate the Acuity LS Interface folder and select the program (Figure 5).

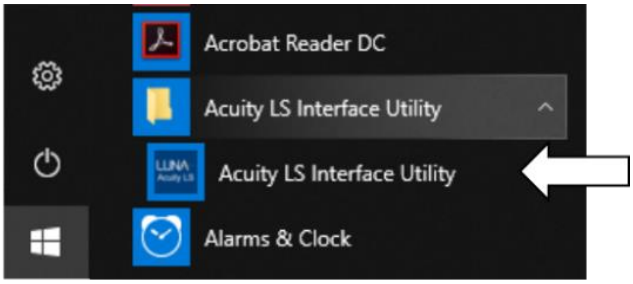


Figure 5. Starting the Acuity LS Interface program.

3. The communications (COM) port selection window will appear first (Figure 6, left). This step is required to tell the computer how to communicate with the Acuity LS communications cable.
4. To select the COM port, verify that the communications cable is plugged into the computer and click the small arrow beside the “COM1” label to get the drop-down menu. This shows a list of the available serial communications ports (Figure 6, right).

   NOTE:

   a. *“COM1” and “COM3” are usually reserved by the system and are not associated with Acuity LS.*

b. *The computer automatically assigns a unique COM port to the communications cable when it is plugged into the computer. COM4 is most often the port assigned to the Acuity LS communications cable.*
c. *The computer remembers the COM port assigned to a specific communications cable. If you are using several different cables with the same computer, each will have a unique COM port assigned.*
d. *The assigned COM port does not depend on which physical USB port is used.*

Figure 6. Configuring the communications (COM) port.

5. Select a COM port (e.g., “COM4”) and click the “OK” button.

a. If the correct COM port has been selected, the software will verify communications with the Acuity LS and automatically advance to the main screen (Figure 8).

b. If the incorrect COM port has been selected, an error message will be displayed along with some troubleshooting instructions (Figure 7).

i. For item 4 in Figure 7 please refer to "System Restart" in Section 3.

ii. If there is no connection after following all the instructions, please contact Luna for support.

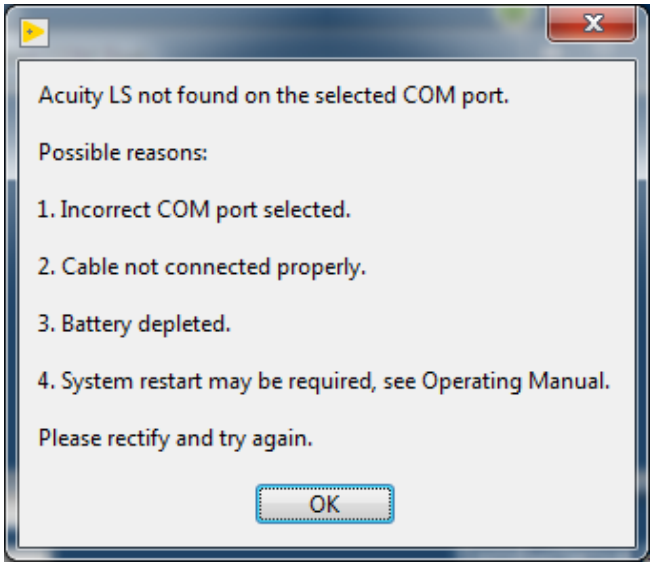


Figure 7. COM port error message.

Operating the User Interface

The Acuity LS user interface main screen appears once communications are established (Figure 8).

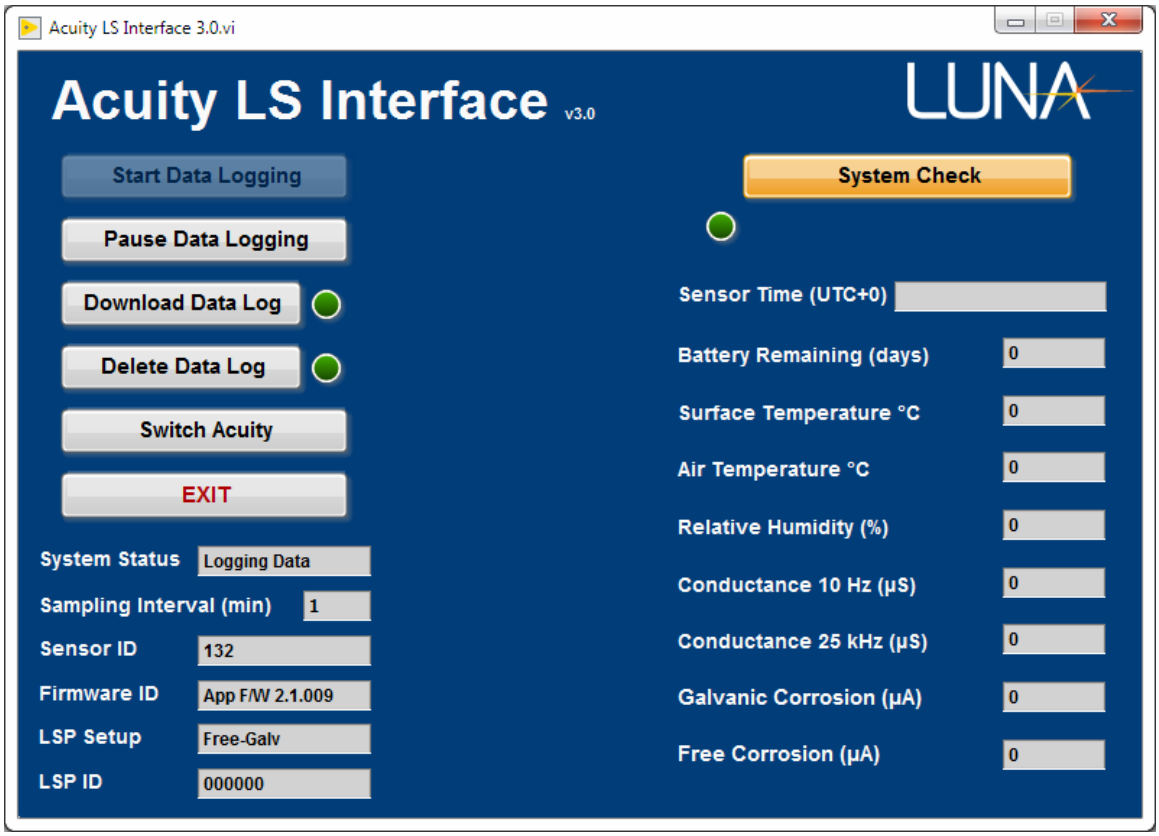


Figure 8. Acuity LS user interface main screen appears once communications are established.

The interface main screen provides the following information and functions:

- System Status – Indicates whether the connected Acuity LS device is currently logging data.
- Sampling Interval – Displays the sampling interval in minutes currently set for the device.
- Acuity LS Device ID – Displays the serial number of the connected Acuity LS device. This number should match the label on the outside of the device.
- Firmware ID – Displays the current device firmware version.
- LSP Setup – Displays whether the sensor lid has dual galvanic (Dual-Galv) or free corrosion and galvanic (Free-Galv) setup
- LSP ID – Displays the current sensor lid ID
- Start Data Logging – Commands the Acuity LS device to start automatic data logging. The software will also prompt the user to set the correct date and time for the device as well as the desired sampling interval.

- Pause Data Logging – Suspends automatic data logging and instructs the Acuity LS device to remain in low-power sleep mode.

- Download Data Log – Retrieves all stored data from the Acuity LS device. Selecting this button will open a dialog window to save the downloaded data. The default filename includes the Acuity LS device serial number, date, and time of the download. The green indicator will blink while the data transfer is in progress. This may take several minutes.

- Delete Data Log – Permanently deletes all stored data on the Acuity LS device. Selecting this button will open a dialog window so that the user may confirm or cancel this request. The green indicator will blink until the deletion is complete. This may take several minutes.

  NOTE: this command has no effect on other stored settings, such as system time, logging interval, etc.

  ***CAUTION:** this command will permanently erase all test data from the Acuity LS device.*

- Switch Acuity LS Device – Allows the user to connect a different Acuity LS device without restarting the interface utility software.

- System Check – Instructs the Acuity LS device to immediately take a set of measurements and display the results in the parameter fields below in the main screen. This command is used to verifying system operation. System check can be used to confirm if time is correct, check remaining battery life, and verify sensor responses. This process takes about 20 seconds to complete. Points collected using this command are stored in the Acuity LS memory, but otherwise this command does not affect data logging.

Clock Synchronization

Each Acuity LS device has an internal real-time clock that maintains device time using Coordinated Universal Time (UTC+0).

NOTE: User should make sure the connected computer time is accurate before synchronizing the Acuity LS clock.

The user is prompted to synchronize the Acuity LS device time with the computer time whenever starting a data log or downloading data (Figure 9). Use the Acuity LS interface program to synchronize the Acuity LS device clock with the connected computer clock.

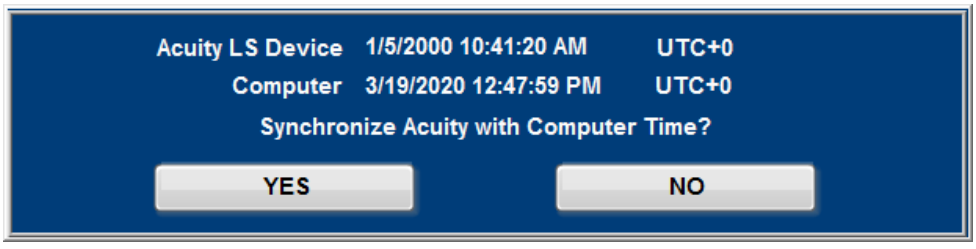


Figure 9. Acuity LS device and computer time comparison window when starting the data logging or downloading data.

Starting Data Logging

1. Establish communications between the computer and Acuity LS device. Refer to “Establishing Communication” above.
2. Select “Start Data Logging”.
3. Synchronize clock. Refer to “Clock Synchronization” above.
4. Set the sampling interval. Select "Yes" to keep current sampling interval, or select “No” and enter a new sampling interval (Figure 10, left). Once new sampling interval is entered, select “OK” (Figure 10, right).

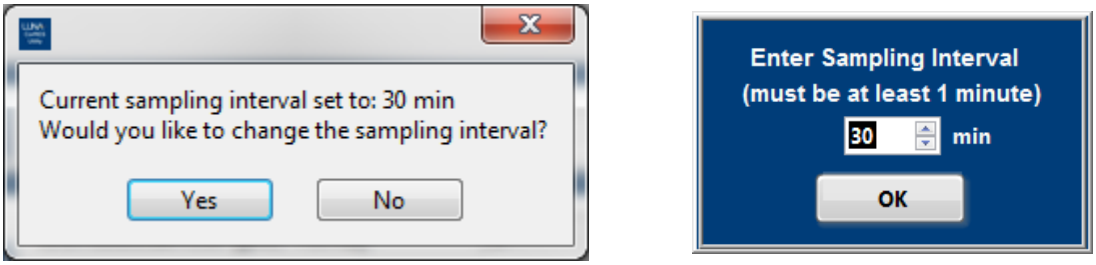


Figure 10. Indication of current sampling interval, and prompt for changing sampling interval (left). Sampling interval input window (right).

5. Use the Installation Description window to enter aircraft/asset, Acuity LS device, and LSP information (Figure 11).

   CAUTION: *DO NOT use any “,” or carriage return (enter key) characters in the provided text boxes.*

   - The Aircraft/Asset window can be used to enter specific information and notes about the aircraft, asset, or structure being monitored.
   - The Acuity LS device window can be used to enter specific LSP or other information about the materials and condition of the LSP, such as coating information if used.
   - Within the Acuity LS device window, answer the question, "Coating applied to gold IDE?". The default answer is "No". If a coating is applied to the gold sensor then "Yes" can be selected from the drop-down menu.
     i. For "No" coating applied to the gold IDE, the high frequency gold conductance (Au 25kHz, Column F in the data file) is a measure of surface contaminants.
        1. The low frequency gold conductance (Au 10Hz, Column G in the data file) should not be used for analysis when operating with "No" coating.
     ii. "Yes" should only be selected if a coating is applied to the gold IDE. For “Yes”, both the low and high frequency measurements can be used to quantify coating barrier properties.

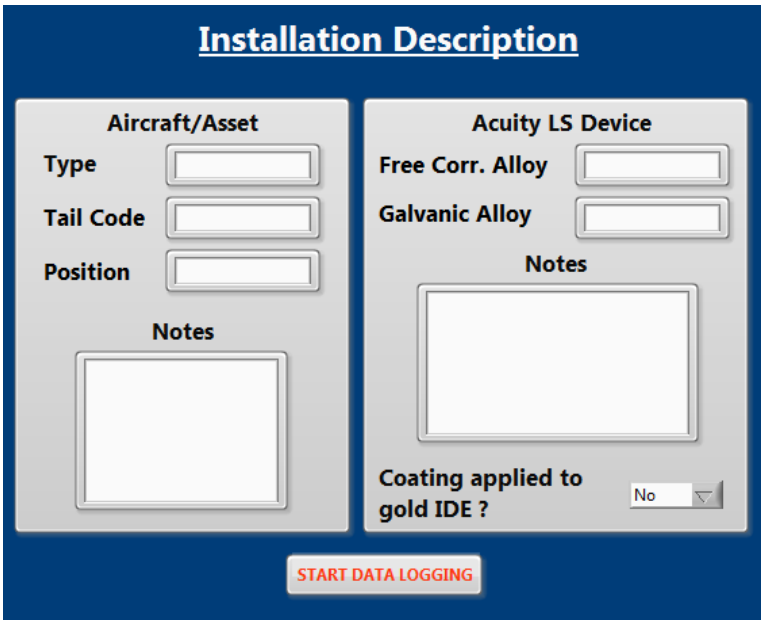


Figure 11. Installation Description window. ***CAUTION:*** *DO NOT use any "," or carriage return (enter key) characters in the provided Notes text boxes.*

6. Select "START DATA LOGGING" to begin Acuity LS device data collection and storage. A dialog box will appear indicating that the Acuity LS device data logging has started (Figure 12).

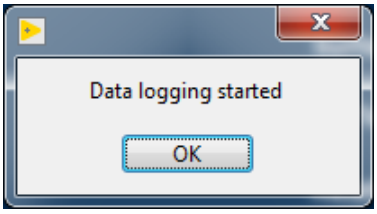


Figure 12. Window indicating Acuity LS device data logging started successfully.

7. Select "OK" to return to the main screen.
8. Once data logging has started, the "System Status" on main screen will indicate "Logging Data" and displays the selected "Sampling Interval" and "Gold IDE Setup".

Download Data Log

1. Refer to "Establishing Communication" above for connection to computer.
2. Select "Download Data Log" and save the file. The default filename includes the Acuity LS device ID, date, and time. Data download may take several minutes.
3. When download is complete, the UTC time synchronization window will appear (Figure 9). Refer to "Clock Synchronization" above.
4. Acuity LS device will resume operation according to the previously selected sampling interval and setup.

5. The “System Status” on main screen will indicate “Logging Data” and display the selected “Sampling Interval” and "Gold IDE Setup".

Suspending Operation (Pause Data Logging)

1. Refer to “Establishing Communication” above for connection to computer
2. Select “Pause Data Logging” to suspend operation.
3. On the main screen, verify that the “System Status” displays the message “Not Logging Data”.

Data File Format

Data files are stored to the computer using a comma-separated values (.csv) file format. These files can be imported by standard data handling software (e.g., Microsoft Excel, MATLAB, etc.). The data file column headers and brief descriptions are given below (Table 1).

Table 1. Data file column definitions and descriptions.

Column	Measurement (Units)	Description
A	Unix Time (s)	Number of seconds since midnight Jan 1, 1970 (UTC+0) See “Unix Timestamp Conversion” below for more details
B	Test Time (h)	Time in hours since first sample in data file
C	Air Temp (°C)	Temperature of the ambient air in degrees Celsius
D	RH (%)	Percent relative humidity of the ambient air
E	Surface Temp (°C)	Temperature of the structure in degrees Celsius
F	Au 10Hz (µS)	Gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 10 hertz excitation signal (only for coated gold IDE - Yes)
G	Au 25kHz (µS)	Gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 25 kilohertz excitation signal
H	Galv Corr (µA)	Galvanic corrosion current in microamperes using a ZRA
I	Free Corr (µA)	Free corrosion current in microamperes using a 20 mV peak-to-peak, 0.5 hertz excitation signal
J	Tot Au 10Hz (C/V)	Gold IDE time-integral of conductance to obtain total charge passed per unit voltage (only for coated gold IDE - Yes). Units of coulombs per volt
K	Tot Au 25kHz (C/V)	Gold IDE time-integral of conductance to obtain total charge passed per unit voltage. Units of coulombs per volt
L	Tot Galv Corr (C)	Time-integral of galvanic corrosion current to obtain total charge passed. Units of coulombs.
M	Tot Free Corr (C)	Time-integral of free corrosion current to obtain total charge passed. Units of coulombs.

NOTE: The total time-integral data in columns J – M are calculated using all stored data on the Acuity LS device. If new total time-integral data starting at zero is desired, all data must be deleted from the Acuity LS device using "Delete Data Log" in the user interface main screen (see Section 5, Figure 8).

> ***CAUTION:*** *The "Delete Data Log" command will permanently erase all test data from the Acuity LS device.*

UNIX Timestamp Conversion

Timestamps in the downloaded data files are presented in terms of the "UNIX time", or the number of seconds that have elapsed since 12:00 am, January 1, 1970 (UTC+0). UNIX time may be readily converted to other time and date formats using the methods in Table 2 or this time converter - https://www.epochconverter.com/.

Table 2. Converting UNIX time to other date and time conventions.

Package	Conversion Command
MS Excel	`((Unix Time Value)/86400)+25569` *NOTE: Format the cell for date/time*
MATLAB	`datestr(719529 + UnixTimeValue / 86400,'dd-mmm-yyyy HH:MM:SS')`

6. General Specifications

The below sections provide limits of operation, measurement ranges, and Acuity LS device dimensions (Table 3 and Figure 13).

Limits of Operation

The Acuity LS device continuous operating temperature range is from -40 °C to 85 °C

> ***CAUTION:*** *Use of the system outside this temperature range may cause permanent damage to the Acuity LS system.*

> ***WARNING: TEMPERATURES IN EXCESS OF 100 °C MAY CAUSE BATTERY FIRE, EXPLOSION, AND SEVERE BURN HAZARD.***

Limits of Measurements

Table 3. Acuity LS device measurement limits.

Acuity LS Measurement	Symbol	Range Min	Range Max	Units	Sensor Excitation
Surface Temperature	T_S	-40	+85	ºC	DC current
Air Temperature	T_a	-40	+85	ºC	-
Relative Humidity	RH	0	100	%	-
Conductance (Low Freq)	G_H	0.005	1	µS	20 mV_{pp}, 10 Hz
Conductance (High Freq)	G_L	5	10,000	µS	20 mV_{pp}, 25 kHz
Free Corrosion	I_c	0.005	100	µA	20 mV_{pp}, 0.5 Hz
Galvanic Corrosion	I_g	0.01	100	µA	ZRA

Dimensions

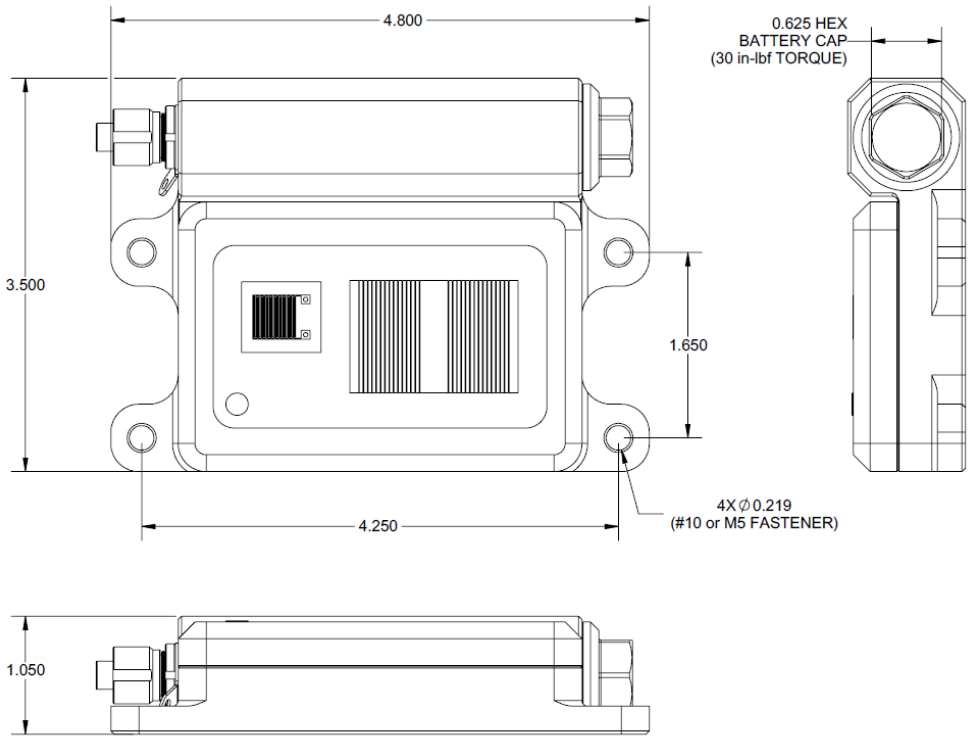


Figure 13. Acuity LS device dimensions, units in inches.

7. List of Acronyms

Acuity LS™	Acuity LS Corrosion Management System
CD	Compact Disk
COM	Communications
FTDI	Future Technology Devices International
ID	Identification
IDE	Interdigitated Electrode
IPA	Isopropyl Alcohol
LSP	Acuity LS Lid Sensor Panel
PC	Personal Computer
RH	Relative Humidity
USB	Universal Serial Bus
UTC	Coordinated Universal Time
ZRA	Zero Resistance Ammeter