LUNA CORROSION MONITORING

LUNA

CorRES™ | Operating Manual

CorRES^{TM} Corrosion Monitoring System Operating Manual

1. OVERVIEW

This document overviews the hardware and software setup for Luna's Corrosion and Coating Evaluation System (CorRES).

2. HARDWARE DEFINITION

The standard CorRES system setup involves a single docking platform (DP) continuously connected to a computer. The docking platform saves data internally and periodically transmits the logged data to connected computer according to user-selectable software preferences (See Section 5). The basic system hardware (Figure 1) is intended for indoor test applications, where the connected computer provides power to the docking platform through the USB port. An optional battery back enables long-term standalone operation where it is impractical to maintain a continuous computer connection, such as during outdoor exposure testing (Figure 2).
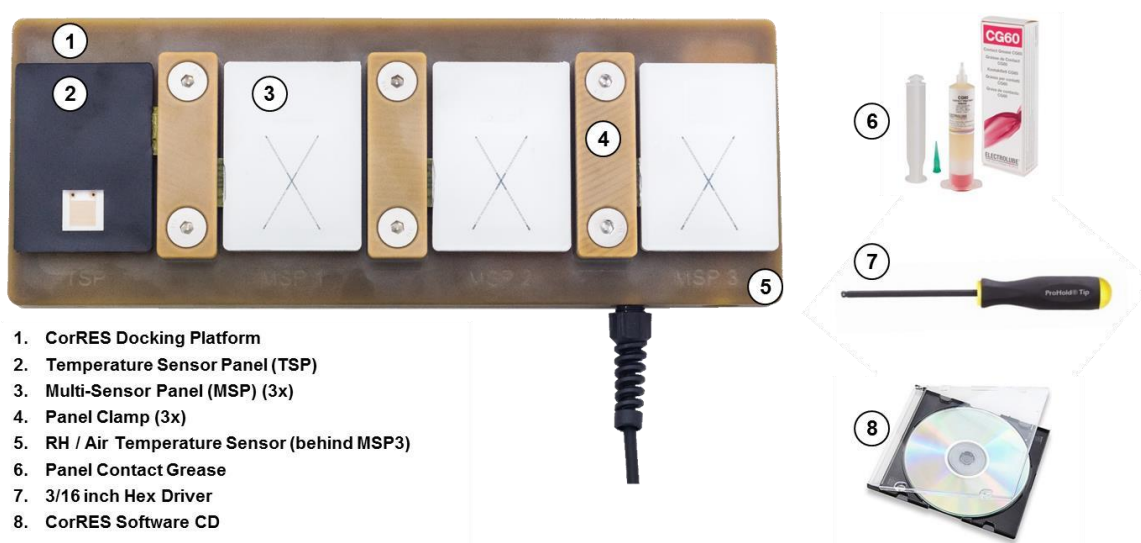

1. **CorRES Docking Platform**
2. **Temperature Sensor Panel (TSP)**
3. **Multi-Sensor Panel (MSP) (3x)**
4. **Panel Clamp (3x)**
5. **RH / Air Temperature Sensor (behind MSP3)**
6. **Panel Contact Grease**
7. **3/16 inch Hex Driver**
8. **CorRES Software CD**

Figure 1. Standard CorRES Hardware. TSP and MSPs are sold separately from the Docking Platform.
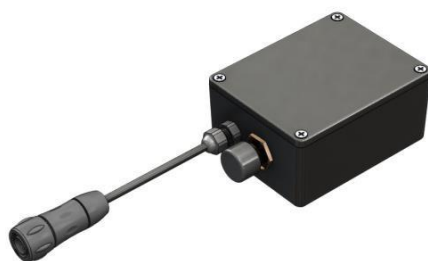

Figure 2. Optional CorRES Battery Pack for standalone operation. A separate communications cable and a battery charger (not shown) are needed for standalone operation.

The docking platform holds up to four sensor panels. The first panel is a temperature-sensing panel (TSP) with a gold interdigitated electrode (IDE) for sensing the solution conductance due to contaminants and moisture deposited on the surface. Three multi-sensing panels (MSPs) may be installed, each with a gold IDE to measure coating barrier properties, a free corrosion IDE to measure corrosion current of the sensor alloy, and a galvanic IDE to measure galvanic current of two coupled alloys. The following sections instruct how to install and remove panels and connect the system to a computer.

3. HARDWARE SETUP

This section describes the sensor panel preparation, installation, and removal procedures along with the mechanical and electrical connections required for system operation.

Panel Preparation, Coating, and Scribing

Typically, panel preparation involves surface cleaning or other treatment, coating application, and scribing to produce a known defect in the coating. Please consult Luna for specific advice on preparation of panels prior to testing for your application.

NOTE: In all cases, the TSP gold IDE sensor should remain uncoated.

NOTE: MSP/TSP serial numbers are handwritten on the connector tab in permanent marker. Newer panels also include a printed label on the back of the panel. For panels without printed labels, take precautions to not remove the handwritten labels and/or apply supplemental labeling that will withstand cleaning/painting processes and the test environment.

NOTE: For outdoor or other applications where solar irradiance is expected, Luna recommends applying the same coating to the temperature-sensing panels (TSP) that is being tested with the corrosion-sensing MSPs so that the TSP temperature accounts for the solar irradiance of the coating.

Panel Installation

To install a set of sensing panels:

1. Remove all clamp screws using the supplied 3/16-inch hex driver and remove the clamps from the docking platform.

    NOTE: Save the small fiberglass tabs shipped with the system. These tabs must be used as placeholders for any test conducted without a full complement of sensing panels to avoid corrosion damage to the electrical contacts.

2. Inspect o-ring seals for nicks or excessive deformation. Replace seals if necessary by carefully prying out the old seals with a small pick. One set of replacement seals is provided with the system (EPDM Shore 70A, size -012).

3. Apply a small amount of isopropyl alcohol (IPA) to a paper wipe and clean the gold-plated contact pads on the MSP/TSP.

    NOTE: *For panels that are only labeled with a permanent marker, take care not to remove these markings and/or add supplemental labeling.*

4. Using the supplied 3 ml syringe of contact grease, apply a small amount of grease to the middle of the contact pad area as shown (Figure 3, left). With the tip of the syringe, evenly distribute the grease across the contacts and surrounding area, roughly a circle large enough to cover all the pads (Figure 3, right). Once the panels are installed into the docking platform, the grease on the TSP/MSP will be sufficient to protect both sides of the connection.

    NOTE: Do not over apply grease to the TSP/MSP contacts as excessive amounts may affect docking platform spring contact performance. Likewise, do not apply grease directly to the docking platform contacts.

5. Observe the panel designations engraved on the outside of the docking platform:

T = TSP, 1 = MSP1, 2 = MSP2, 3 = MSP3

6. Align the panel mounting tab over the mating docking platform receptacle and gently install the clamp over the panel tab, making sure the clamp locating pins engage the panel locating holes (Figure 4).

   CAUTION: *Never install the panels by sliding them in from the side, as this could result in bent spring pin contacts and irreparable docking platform damage.*

7. Loosely install the clamp screws using the supplied 3/16-inch driver. Verify that all parts are still in alignment and tighten screws.

   NOTE: When installed properly, there should be no visible gap between the clamp and docking platform. If a large gap is visible, it is likely caused by alignment pins that are no longer mated with panel locating holes. Remove the clamp and repeat installation steps.

8. Repeat for all panels to be tested.

9. Install fiberglass tabs shipped with the system in any empty sensor panel slots to avoid corrosion damage to the spring contacts during the test.

Panel installation is now complete. Proceed with system setup outlined in Section "Hardware Connections".
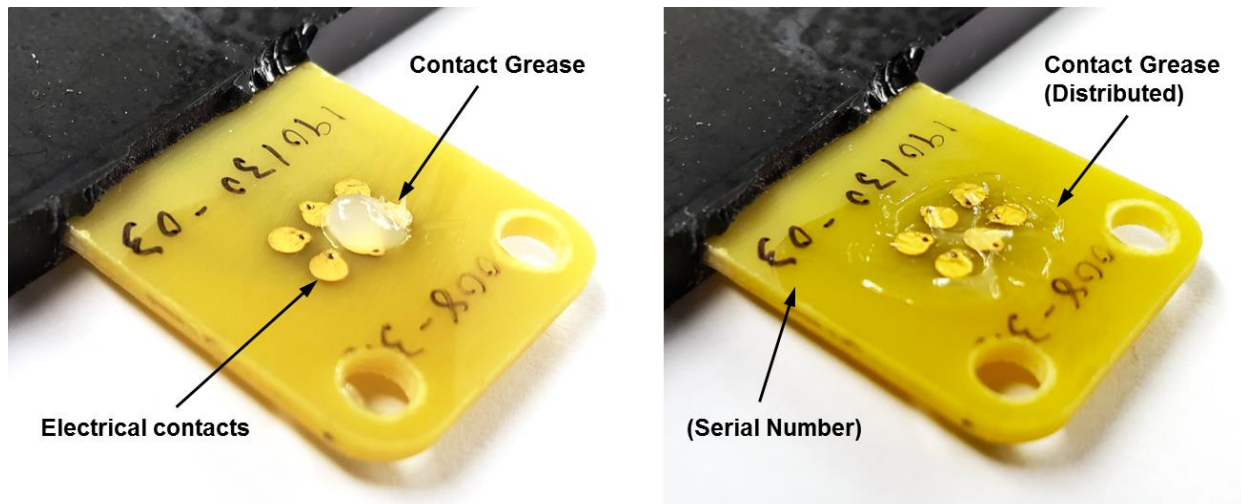

Figure 3. (left) Initial application of contact grease to MSP/TSP contacts. Do not apply excessive amounts of grease. (right) After distributing grease across all contacts and surrounding area.

NOTE: Do not apply grease directly onto the docking platform spring pins.
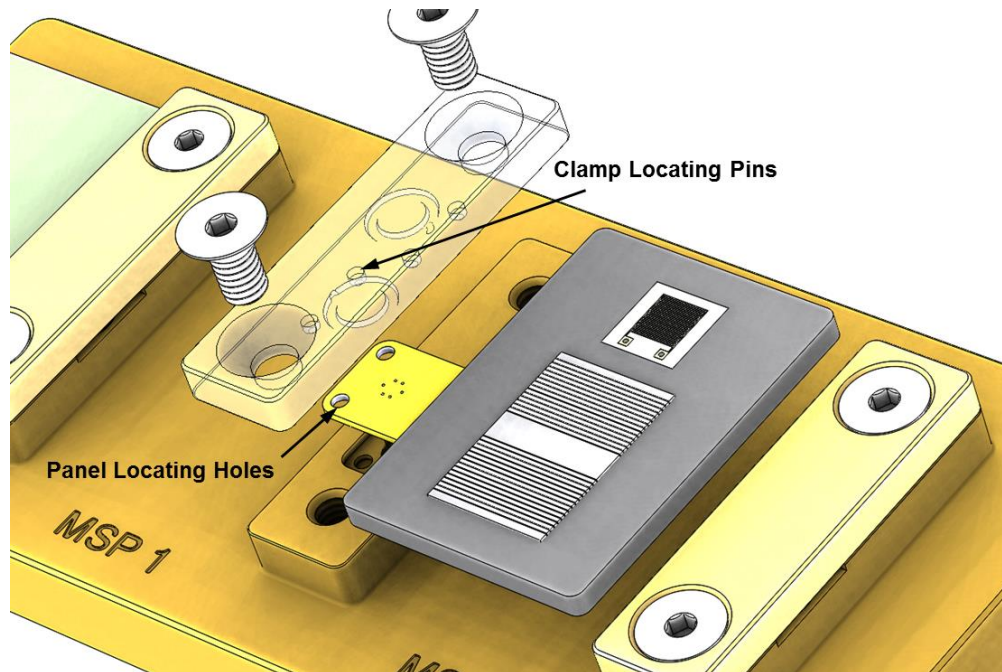
Figure 4. Installing sensor panel onto docking platform. Each clamp has two locating pins that retain the sensor tab in the correct position after assembly. Ensure pins are properly aligned in the panel locating holes before tightening the clamp screws.

NOTE: Always install panels in a way that vertically compresses the spring contacts in their intended direction of travel, never side-loading them as this may bend the contact pins. Bent spring contacts will render the docking platform inoperable and likely irreparable.

Panel Removal

This section covers the process for removing the sensor panels.

Removing panels after a test:

1. Thoroughly rinse the docking platform to remove corrosive contaminants and salts, especially in the areas around the riser to sensor panel interfaces.

2. Allow the system to dry to avoid trapped water running into the contact areas.

3. Loosen the clamp screw and remove the panel.

4. Remove the clamp and visually verify that no liquids or contaminants have entered the connector and that the pins move freely.

5. Loosely reinstall the clamp hardware for storage until the next test.

Removing panels during a test (e.g., for troubleshooting):

1. Locally rinse the riser interface of the panel to be removed.

2. Dry the area as well as possible within the constraints of the test apparatus.

3. Loosen the clamp screws and remove the panel.

4. Remove the clamp and visually verify that no liquids or contaminants have entered the connector and that the connector pins move freely.

5. Reinstall panel according to Section "Panel Installation".

Hardware Connections

In most indoor laboratory applications, CorRES system(s) will be continuously powered during a test by the host computer's USB port(s). In cases where continuous laptop connectivity is impractical, such as most outdoor applications, an optional battery pack is available to provide the required electrical power for system operation. CorRES docking platforms are distinguished as either "indoor" or "outdoor" types, as follows:

- *"Indoor" CorRES docking platforms* source power from a PC USB port or USB powered hub. They have a USB Type-A male connector that is not ruggedized for harsh environments.

- *"Outdoor" CorRES docking platforms* source power from a rechargeable accessory battery pack. All of their connections are hardened for long-term outdoor exposure. Communication is made through a USB cable that is easily removed when not in use.

Functional schematics for both system types illustrate how they are connected for operation depending on the docking platform type and intended application (Figure 5). A functional description of each follows. Please connect the system according to the desired configuration type.
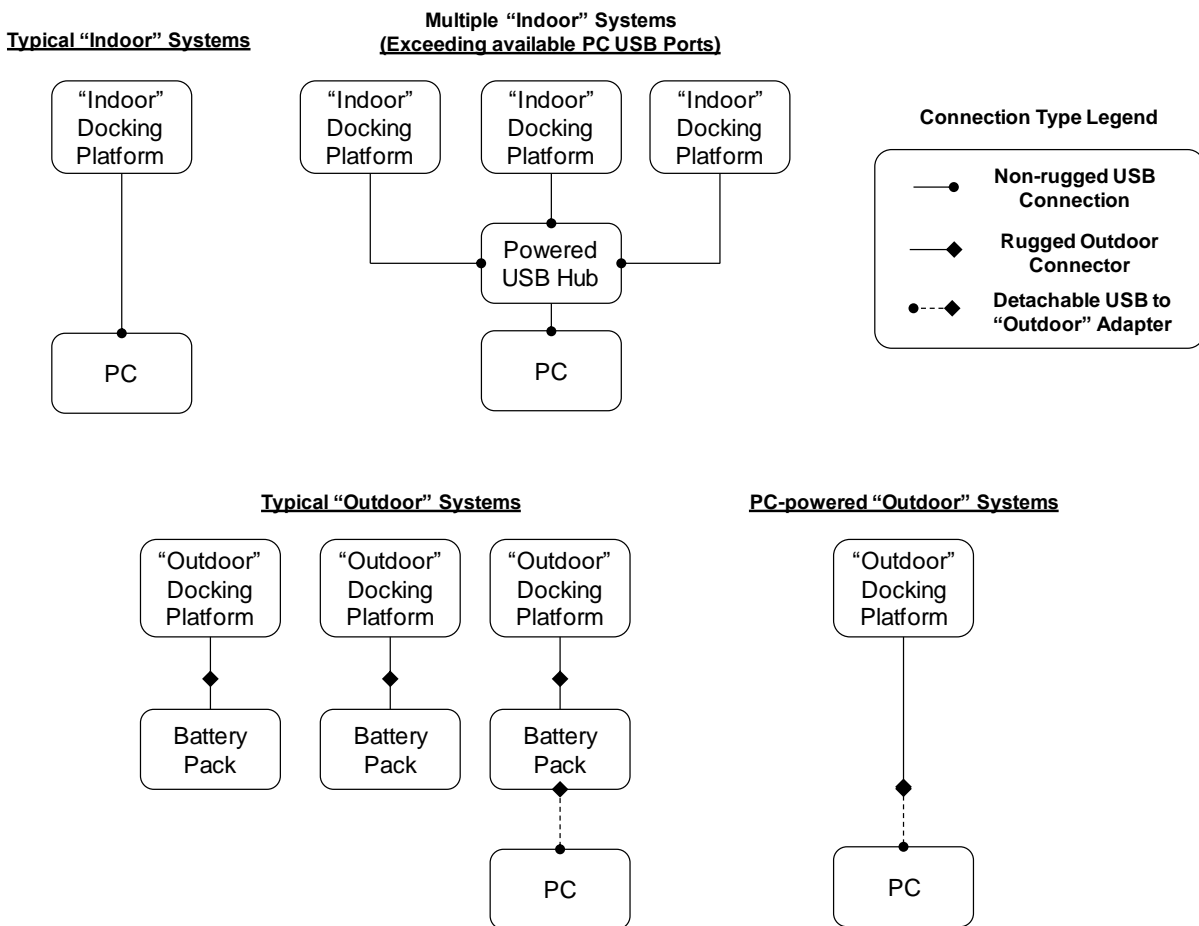

Figure 5. Electrical connections for "Indoor" and "Outdoor" CorRES docking platforms.

- *Typical "Indoor" systems* connect to a PC through the docking platform built-in USB cable. Although not shown, multiple docking platforms may be serviced by a single PC provided it has sufficient USB ports to support the desired number of docking platforms.

- *Multiple "Indoor" systems* may also be connected through a powered USB hub if there are insufficient ports available on the PC.

- *Typical "Outdoor" systems* draw power from an external battery pack and include a ruggedized electrical connector in place of the standard USB connector used for the "Indoor" systems. A PC is temporarily connected with a detachable cable (dotted line) to configure the system, start/stop testing, and download stored data. While the PC is connected, the docking platform draws power from the PC USB port and will function even if the battery pack is depleted.

- *PC-Powered "Outdoor" systems* may also be operated without a battery pack by simply connecting the detachable USB adapter to the ruggedized connector on the docking platform. This configuration is functionally equivalent to the typical "indoor" setup.

   CAUTION: "Outdoor" systems are suitable for indoor laboratory use, provided the battery pack is not subjected to severe conditions (e.g., accelerated corrosion chambers).

   WARNING: Exposure of the battery pack to temperatures exceeding the stated range, presents a serious health and safety risk. See Section 6 for temperature ranges.

   CAUTION: "Indoor" systems may not be used outside as their USB connector is unprotected from the environment. For converting an "Indoor" system to an "Outdoor" configuration, please contact Luna.

   NOTE: In all configurations, cable length between docking platform and PC is approximately 15 ft. (4.5 m).

4. SOFTWARE AND DRIVER INSTALLATION

This section provides instructions for installing the software and drivers needed to communicate with CorRES. 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

- (1) available USB port

CorRES User Interface Software and USB Driver Installation

1. Insert the CD or USB drive that was provided with the product shipment. If these are not available, please contact Luna for replacements.

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 "CorRES Interface Installer" → "Volume" and double-click on file "setup.exe".

4. Select the default for all prompts. 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 operation. Select the defaults for all prompts.

6. Reboot the computer if prompted.

7. Software and USB installation is complete. The computer is now ready to interface with CorRES docking platforms.

5. SOFTWARE OPERATION

This section provides instructions for connecting the CorRES to the computer and operating the user interface software.

Establishing Communication

To establish communications between the CorRES and the computer:

1. Plug the communications cable into an available USB port on the computer.

2. In the Windows start menu, locate the CorRES Interface folder and click on the program (Figure 6).

3. The communications (COM) port selection window will appear first (Figure 7, left). This step is required to tell the computer how to communicate with the CorRES 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 7, right).   A few useful things to note:

    a. "COM1" and "COM3" are usually reserved by the system and are not associated with CorRES.
    b. The computer automatically assigns a unique COM port to the communications cable when it is plugged in. COM4 is most often the port assigned to the CorRES 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.

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 CorRES and automatically advance to the main screen (Figure 9).

    b. If the incorrect COM port has been selected, an error message will be displayed along with some troubleshooting instructions (Figure 8). If there is no connection after following all the instructions, please contact Luna for support.

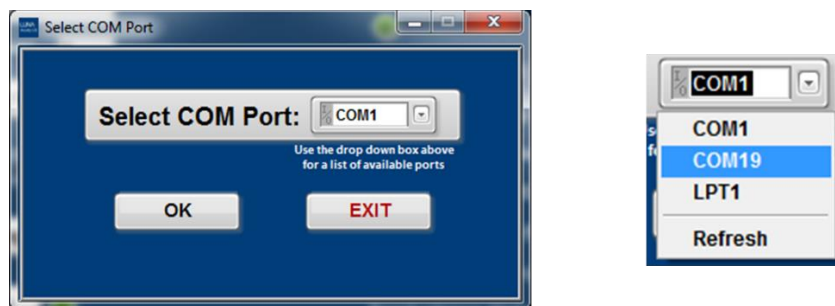*Figure 6. Starting the CorRES Interface program.*

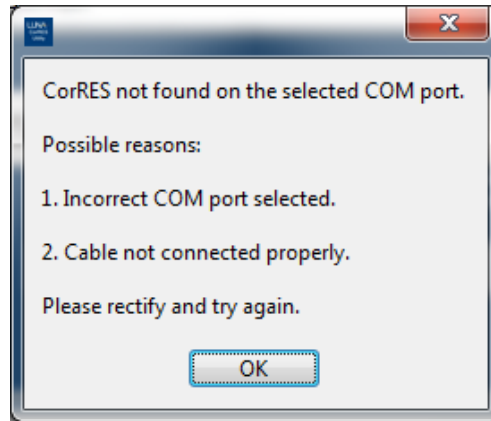*Figure 7. Configuring the communications (COM) port.*

Figure 8. COM port error message.

Operating the Interface

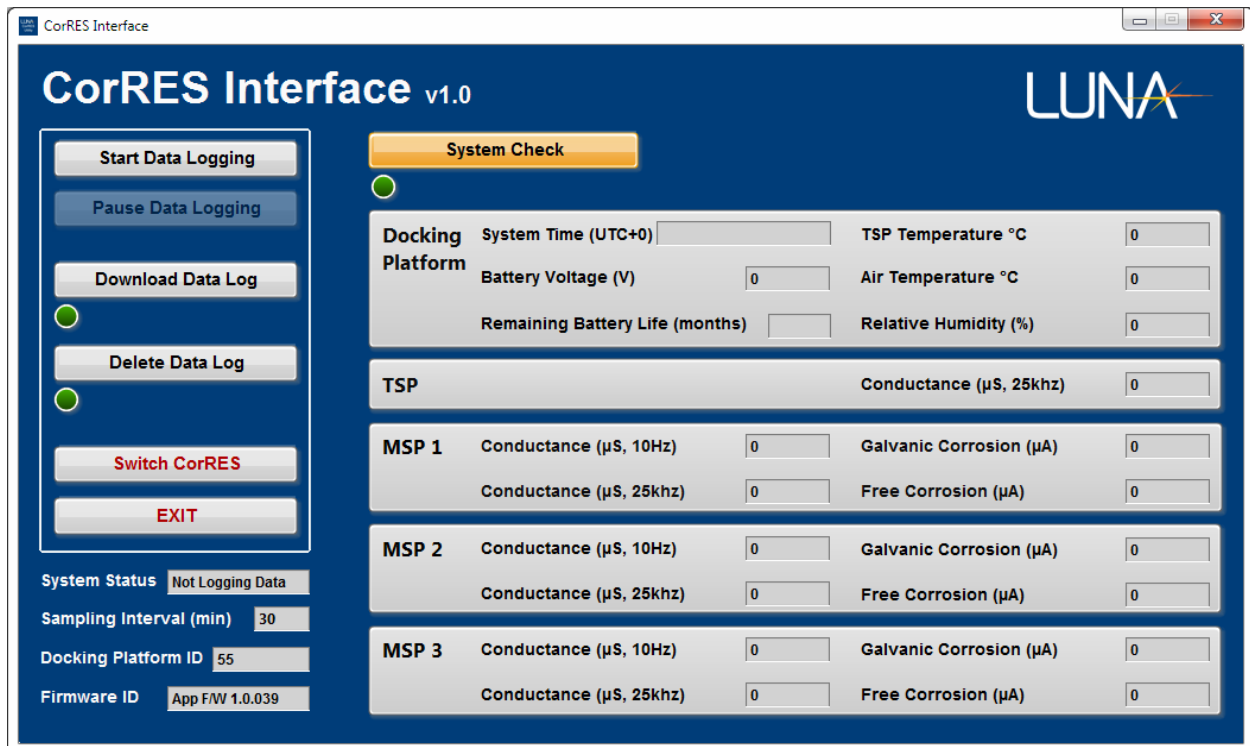The CorRES user interface main screen appears once communications are established (Figure 9).

Figure 9. CorRES Interface Utility main screen appears once communications are established.

The interface main screen provides the following information and functions:

- Docking Platform ID – Displays the serial number of the connected CorRES. This number should match the label on the outside of the CorRES.

- Firmware ID – Displays the current CorRES firmware version.

- System Status – Indicates whether the connected CorRES is currently logging data.

- Sampling Interval – Displays the sampling interval in minutes currently set in the CorRES.

  Note: The software can be used to change the sampling interval whenever a data log is started or resumed.

- Start Data Logging – Commands the device to start automatic data logging. The software will also prompt the user to set the correct date and time for the CorRES as well as the desired sampling interval.

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

- Download Data Log – Retrieves all stored data from the CorRES. Selecting this button will open a dialog window to save the downloaded data. The default filename includes the CorRES docking platform 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 CorRES. Selecting this button will open a confirmation 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 <u>all</u> test data from the CorRES.*

- System Check – Instructs the CorRES to immediately take a set of measurements and display the results in the parameter fields below. This command is used to quickly verifying system operation. System check can be used to confirm if time is correct, check remaining battery life (outdoor unit only), and verify sensing element response. This process takes about 50 seconds to complete. Points collected using this command are stored in the CorRES memory, but otherwise this command does not affect data logging.

  NOTE: For outdoor unit only, the estimated battery life is based on the selected sampling rate.

- Switch CorRES – Allows the user to connect a different CorRES docking platform without restarting the interface utility software.

Clock Synchronization

CorRES features an internal real-time clock that maintains system time using Coordinated Universal Time (UTC+0).

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

The user is prompted to synchronize the CorRES time with the computer time whenever starting a data log or downloading data from the CorRES (Figure 10). Use the CorRES interface program to synchronize the CorRES clock with the connected computer clock.
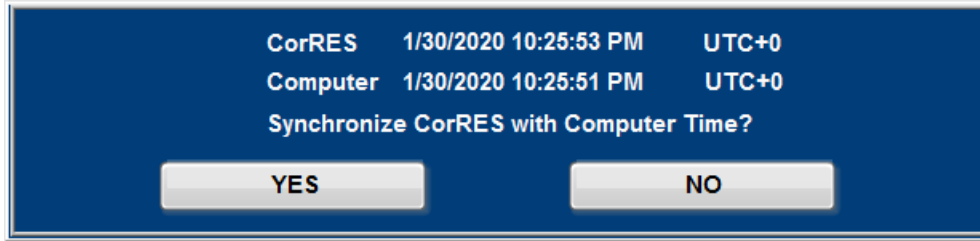
Figure 10. CorRES and computer time comparison window when starting a data log or downloading data.

Starting Data Logging

1. Establish communications between the computer and CorRES. 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 11, left). Once new sampling interval is entered, select "OK" (Figure 11, right).

5. Use the Test Description window to enter MSP and test information (Figure 12).

   - The user can select coated or uncoated for MSP1, MSP2, or MSP3 in the drop down menu.

   - The MSP text box can be used to input notes for each MSP.

   - The Test Notes text box can be used to input additional test information.

6. Select "START TEST" to begin CorRES data logging. A dialog box will appear indicating that the CorRES data logging has started. Select "OK" to return to the main screen.

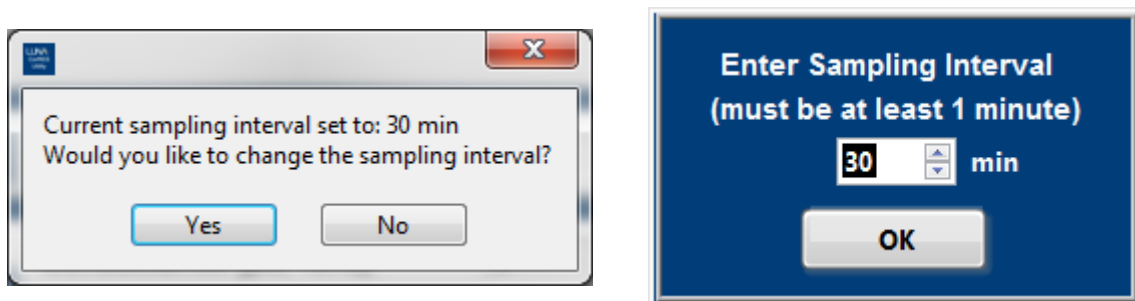7. The "System Status" on main screen will indicate "Logging Data" and selected "Sampling Interval".

Figure 11. Indication of current sampling interval, and prompt for selecting a different interval (left). Sampling interval input window (right).
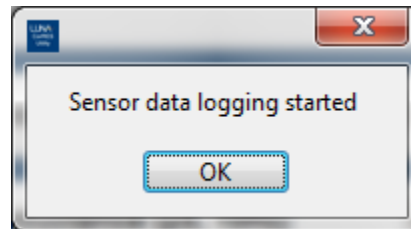
Figure 12. New test description window.

Figure 13. Window indicating CorRES data logging started successfully.

Download Data Log

1. If the computer is not already connected refer to "Establishing Communication" above, otherwise go to next step.

2. Select "Download Data Log" and save the file. The default filename includes the CorRES docking platform serial number, date, and time. Data download may take several minutes.

3. When download is complete, the UTC time synchronization window will appear (Figure 10). Refer to "Clock Synchronization" above.

4. CorRES device will resume operation according to the previously set sampling interval.

5. The "System Status" on main screen will indicate "Logging Data" and selected "Sampling Interval".

Suspending Operation (Pause Data Logging)

1. If the computer is not already connected refer to "Establishing Communication" above, otherwise go to next step.

2. Select "Pause Data Logging" to suspend operation.

3. On the main screen, verify that the "CorRES 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 log 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 TSP in degrees Celsius
F	TSP Au 25kHz (µS)	TSP gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 25 kilohertz excitation signal
G	MSP1 Au 10Hz (µS)	MSP1 gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 10 hertz excitation signal
H	MSP1 Au 25kHz (µS)	MSP1 gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 25 kilohertz excitation signal
I	MSP1 Galv Corr (µA)	MSP1 galvanic corrosion current in microamperes using a ZRA
J	MSP1 Free Corr (µA)	MSP1 free corrosion current in microamperes using a 20 mV peak-to-peak, 0.5 hertz excitation signal
K	MSP2 Au 10Hz (µS)	MSP2 gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 10 hertz excitation signal
L	MSP2 Au 25kHz (µS)	MSP2 gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 25 kilohertz excitation signal
M	MSP2 Galv Corr (µA)	MSP2 galvanic corrosion current in microamperes using a ZRA
N	MSP2 Free Corr (µA)	MSP2 free corrosion current in microamperes using a 20 mV peak-to-peak, 0.5 hertz excitation signal
O	MSP3 Au 10Hz (µS)	MSP3 gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 10 hertz excitation signal
P	MSP3 Au 25kHz (µS)	MSP3 gold IDE conductance in micro-Siemens using a 20 mV peak-to-peak, 25 kilohertz excitation signal

Column	Measurement (Units)	Description
Q	MSP3 Galv Corr (µA)	MSP3 galvanic corrosion current in microamperes using a ZRA
R	MSP3 Free Corr (µA)	MSP3 free corrosion current in microamperes using a 20 mV peak-to-peak, 0.5 hertz excitation signal
S	TSP Tot Au 25kHz (C/V)	TSP gold IDE time-integral of conductance to obtain total charge passed per unit voltage. Units of coulombs per volt
T	MSP1 Tot Au 10Hz (C/V)	MSP1 gold IDE time-integral of conductance to obtain total charge passed per unit voltage. Units of coulombs per volt
U	MSP1 Tot Au 25kHz (C/V)	MSP1 gold IDE time-integral of conductance to obtain total charge passed per unit voltage. Units of coulombs per volt
V	MSP1 Tot Galv Corr (C)	MSP1 time-integral of galvanic corrosion current to obtain total charge passed. Units of coulombs.
W	MSP1 Tot Free Corr (C)	MSP1 time-integral of free corrosion current to obtain total charge passed. Units of coulombs.
X	MSP2 Tot Au 10Hz (C/V)	MSP2 gold IDE time-integral of conductance to obtain total charge passed per unit voltage. Units of coulombs per volt
Y	MSP2 Tot Au 25kHz (C/V)	MSP2 gold IDE time-integral of conductance to obtain total charge passed per unit voltage. Units of coulombs per volt
Z	MSP2 Tot Galv Corr (C)	MSP2 time-integral of galvanic corrosion current to obtain total charge passed. Units of coulombs.
AA	MSP2 Tot Free Corr (C)	MSP2 time-integral of free corrosion current to obtain total charge passed. Units of coulombs.
AB	MSP3 Tot Au 10Hz (C/V)	MSP3 gold IDE time-integral of conductance to obtain total charge passed per unit voltage. Units of coulombs per volt
AC	MSP3 Tot Au 25kHz (C/V)	MSP3 gold IDE time-integral of conductance to obtain total charge passed per unit voltage. Units of coulombs per volt
AD	MSP3 Tot Galv Corr (C)	MSP3 time-integral of galvanic corrosion current to obtain total charge passed. Units of coulombs.
AE	MSP3 Tot Free Corr (C)	MSP3 time-integral of free corrosion current to obtain total charge passed. Units of coulombs.

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

Limits of Operation

The docking platform continuous operating temperature range is from -40 °C to 85 °C

> NOTE: Use of the system outside this temperature range may cause permanent damage to the CorRES system.

Battery pack temperature range should not exceed -20 °C to 60 °C continuous.

> ***WARNING: Exposure of the battery pack to temperatures exceeding the stated range, presents a serious health and safety risk.***

Limits of Measurement

Table 3. CorRES sensor measurement limits.

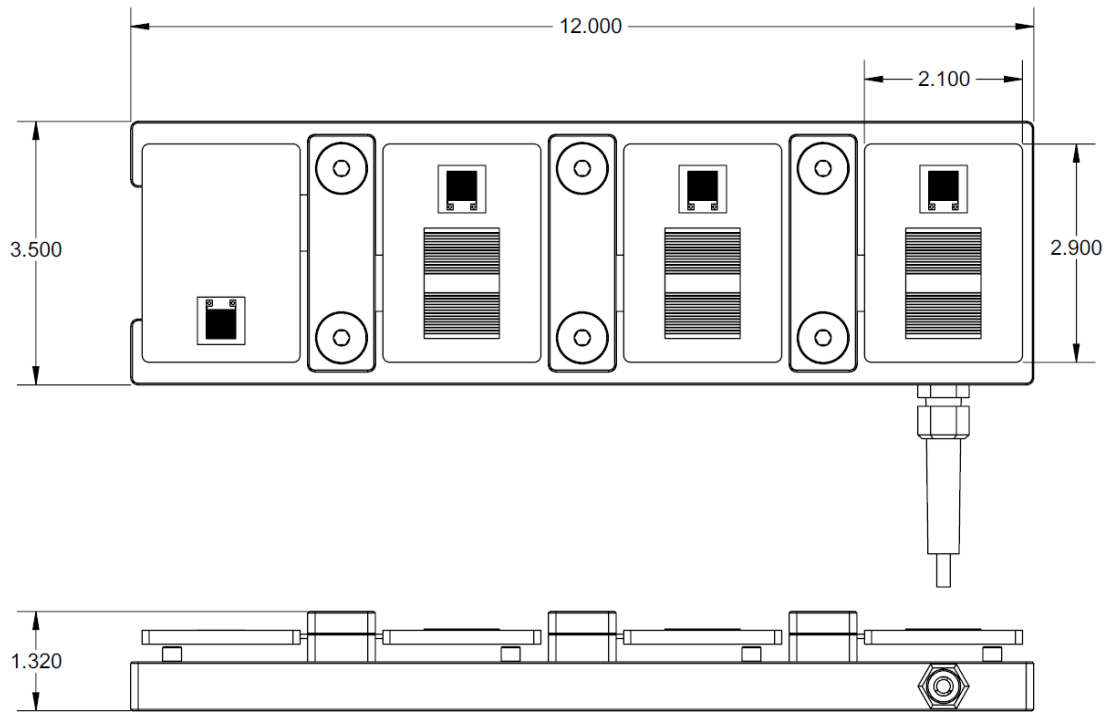| CorRES Measurement	Symbol	Range Min	Range Max	Units	Sensor Excitation
Surface Temperature	T_s	-40	+85	ºC	DC current
Air Temperature	T_a	-40	+85	ºC	-
Relative Humidity	RH	0	100	%	-
Conductance (Low Freq)	G_H	0.005	1	μS	20 mV$_{pp}$, 10 Hz
Conductance (High Freq)	G_L	5	10,000	μS	20 mV$_{pp}$, 25 kHz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

Dimensions

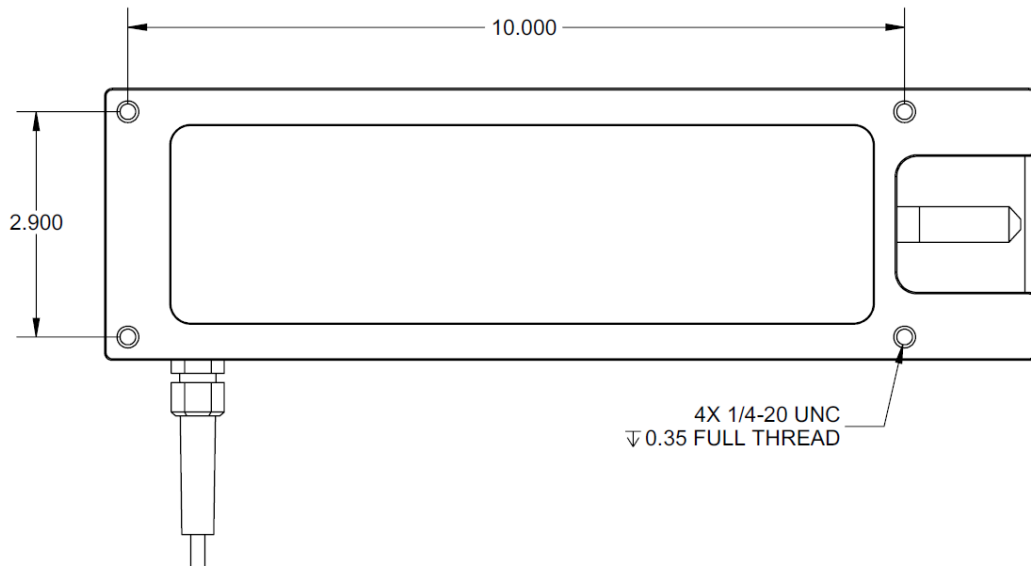*Figure 14. Docking platform and sensor panel general dimensions in inches.*

Figure 15. Mounting bolt pattern on rear side of docking platform with dimensions in inches. The mounting screws provided with the system are suitable for mounting plates up to 0.16 inches (4 mm) thick and use the same 3/16-inch hex wrench as the MSP/TSP clamp bolts.

7. LIST OF ACRONYMS

CD	Compact Disk
CorRES™	Corrosion and Coating Evaluation System
DP	Docking Platform
ID	Identification
IDE	Interdigitated Electrode
IPA	Isopropyl Alcohol
MSP	Multi-Sensor Panel
PC	Personal Computer
TSP	Temperature Sensor Panel
USB	Universal Serial Bus
UTC	Coordinated Universal Time
ZRA	Zero Resistance Ammeter