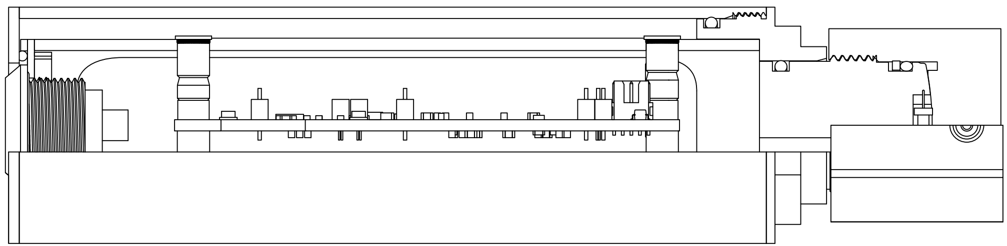
phase sensors

LUVD1 Viscosity and Density Sensor

User Manual



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LUVD1 Viscosity and Density Sensor

User Manual

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NOVEMBER, 2022

CONTENTS

SECTION 1
MECHANICAL INSTRUCTIONS

1.1 CONNECTING USER FLUID SYSTEM TO VISCOSITY AND DENSITY SENSOR

When connecting the measured fluid to the sensor, the following connection parts are necessary:

Consumer Items	Description	Qty.	Material	Supplier	Part Number
Cone Ferrule	40° metal cone 1/16”	2	Stainless Steel 316	Vici Valco	ZF1S6-10
Cone Nut	#10-32-1/2” Nut	2	Stainless Steel 316	Vici Valco	MZN1-10
Metal Tubing	1/16” OD, .022” ID	2	Stainless Steel 316	McMaster Carr	89785K911
Metal Tubing	1/6” OD, .006” ID	2	Stainless Steel 316	McMaster Carr	89785K912

***Note:** If flow through the .006” ID Tubing is difficult, use the .022” ID tubing instead.

When installing the cone fittings, ensure that the metal tubing is cut flush and there are no burs or blockages in the internal diameter. Place the nut behind the cone port and slide the 1/16” tubing through both. Insert two tubing/cone/nut assemblies into the corresponding tapped holes of the micro-cap. Gently push the tubing to ensure that it has bottomed-out at the seat in the microcap. Hand tighten the screw until the cone ferrule bottoms out in the seat of the micro-cap. Tighten the nut with a ¼” wrench one-quarter turn to seal. Refer to the diagram below:

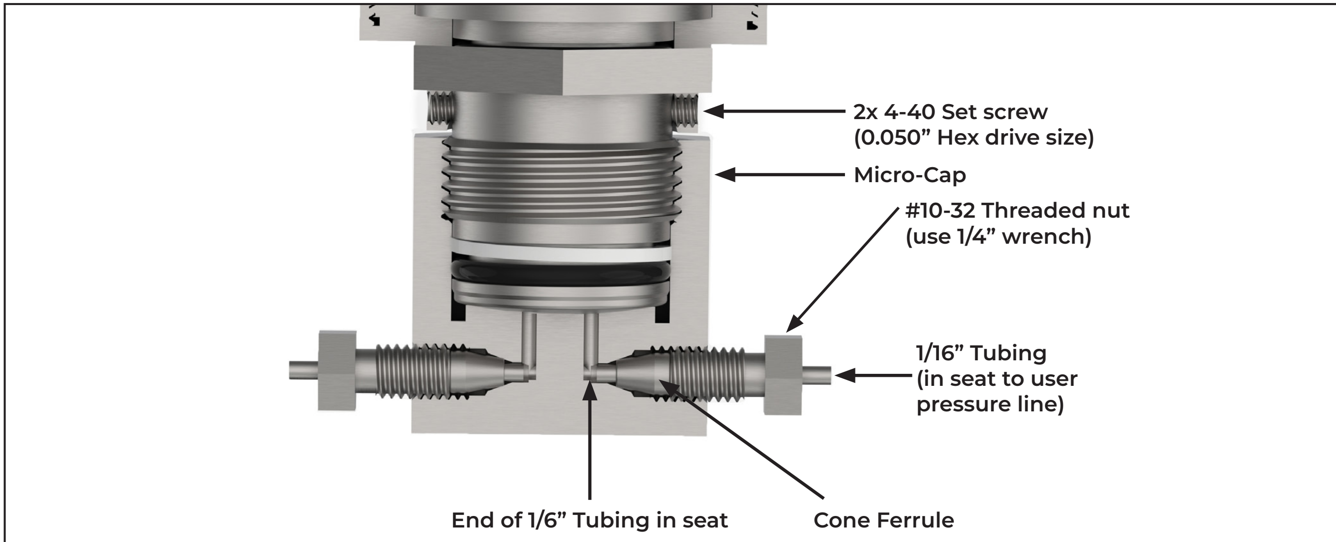

Figure 1-1. Installing Cone Fitting

1.2 CONSUMABLES

The following 0-rings may need to be replaced during the life of the sensor:

Number	O-Rings	Size	Qty.	Material	Supplier	Part Number
1	Diaphragm O-Ring	DN-016	1	90D Viton Fluoroelastomer	McMaster Carr	8297T126
2	Diaphragm Backup Ring	DN-016	1	55D PTFE	McMaster Carr	9560K43
3	Back O-Ring	DN-016	1	90D Viton Fluoroelastomer	McMaster Carr	8297T126
4	Front Housing O-Ring	DN-121	1	50A High Temperature Silicone	McMaster Carr	1173N121
5	Back Housing O-Ring	2mm wide, 18mm ID	1	75A Viton Fluoroelastomer	McMaster Carr	1295N244

The placement of the O-ring is shown below:

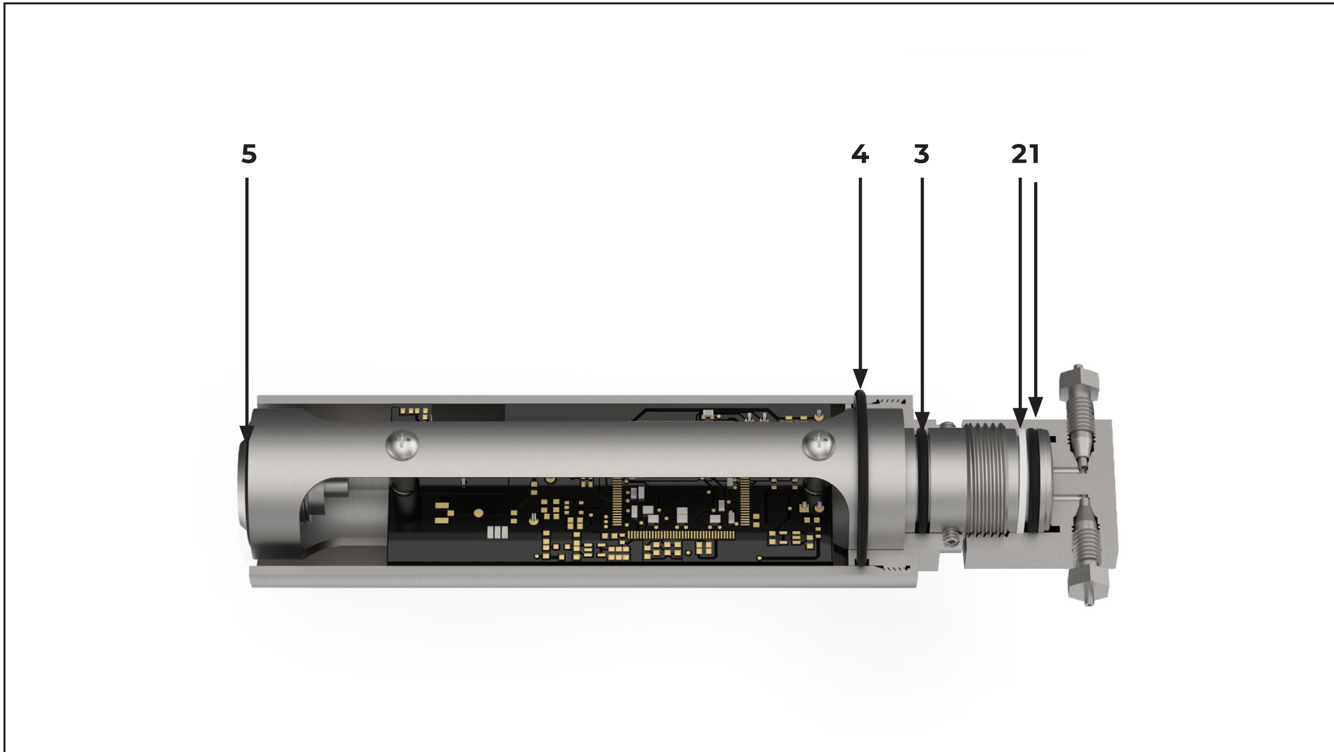

Figure 1-2. Placement of O-rings

1.3 MICROCAP ATTACHMENT

When removing or attaching the microcap to the pressure sensor, follow the procedures below:

Removal

1. Use a 1” hex wrench on the microcap and the included thin wrench on the sensor.
2. Turn the thin wrench counter-clockwise to loosen.
3. Once the threads are disengaged, hand turn the diaphragm hex while gently pulling the diaphragm away from the micro-cap for the O-rings to pass the threads.
4. Take care to ensure that you do not touch the quartz fork as it is fragile.
5. If cleaning is necessary, use Isopropanol or other solvent to rinse the quartz fork without contacting it. ***Note:** if using acetone, note that the specified diaphragm O-ring is not compatible with acetone and will be damaged.
6. Check all O-rings for damage and replace if necessary.

Attachment

1. Check all O-rings for damage and replace if necessary.
2. Engage the threads by hand using the thin wrench hex while gently pushing the sensor towards micro-cap for the O-rings to pass the threads.
3. Use a 1” hex wrench on the microcap and the thin 1” hex wrench provided on the sensor.
4. Turn the thin wrench clockwise. Tighten until the sensor face contacts the base of the micro-cap, but do not torque past the contact point. As this is an O-ring non tapered seal torque is not required to make it leak tight. High torque may gall threads and should be avoided.

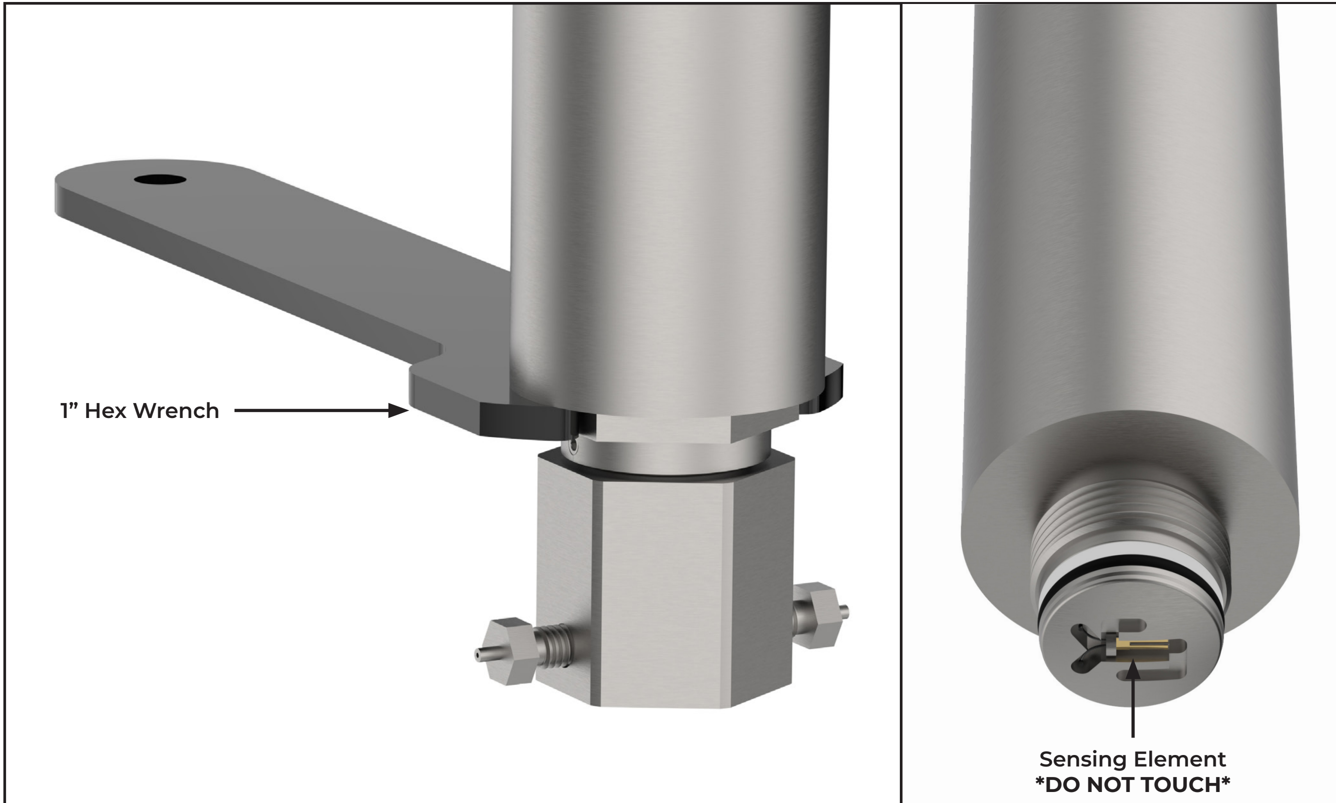

Figure 1-3. Microcap Attatchment

SECTION 2
LUVD1 SPECIFICATION SHEET

2.1 SPECIFICATION HIGHLIGHTS

CALIBRATED VISCOSITY RANGE	0.32cP<—>30cP
CALIBRATED DENSITY RANGE	0.65g/cc<—>0.85g/cc
VISCOSITY OPERATING RANGE	0.2cP<—>30cP
DENSITY OPERATING RANGE	0.2g/cc<—>0.85g/cc
CALIBRATED FLUID TEMPERATURE RANGE	30°C<—>80°C

2.2 MECHANICAL SPECIFICATIONS

WEIGHT	325 grams
HEIGHT	200 mm (7.86”)
MAXIMUM WIDTH	25.4 mm (1.0”)
MAX PRESSURE	103MPa (15,000psi)
DEADVOLUME	0.1 mL
HOUSING MATERIAL	316L STAINLESS / HASTELLOY C-276

2.3 ELECTRICAL SPECIFICATIONS

ELECTRONICS TEMPERATURE OPERATING RANG	-40°C<—>80°C
TEMPERATURE ACCURACY	0.1°C
VOLTAGE SUPPLY RANGE	3.5 V<—>6 V
CURRENT DRAW @ 25°C	100 mA
CURRENT DRAW @ 85°C	150 mA
OUTPUT	USB 2.0
ESD	IEC 61000-4-2 ±15 kV

2.4 FREQUENCY SPECIFICATIONS

NOMINAL REFERENCE FREQUENCY	170 MHz ± 10 PPM
NOMINAL TUNING FORK FREQUENCY	32.768 kHz ± 100 PPM
NOMINAL TEMPERATURE FREQUENCY	262 kHz ± 200 Hz

2.5 ENERGY STORAGE SPECIFICATIONS

INTERNAL OPERATING VOLTAGE	3.3 V
MAXIMUM CURRENT CONSUMPTION @ 25°C	100 mA
INTERNAL POWER CONSUMPTION @ 25°C	<= 0.33 W
TOTAL CAPACITANCE	37.7 μF
TOTAL INDUCTANCE	1.5 μH
LOWEST RESISTANCE ON-BOARD	300Ω

2.6 ADDITIONAL SPECIFICATIONS

STORAGE TEMPERATURE	-65°C<—>85°C
REPEATABILITY	1% of reading
PRESSURE RANGE	15,000psi
SAMPLING RATE	10 S<—>300 S

***Note:** Greater accuracy will be achieved by running at a longer sampling rate.

***Note**: Greater accuracy will be achieved by holding the sample temperature constant.

2.7 LUVD1 SPECIFICATION DRAWING

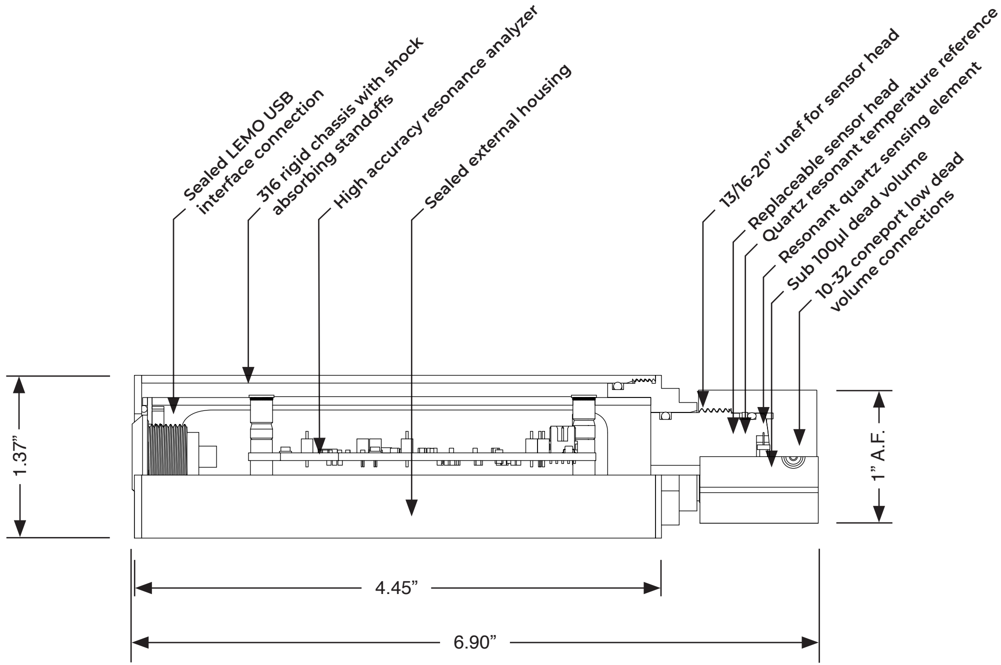

Figure 2-1. LUVD1 Sensor Specification Drawing

SECTION 3
ELECTRICAL WIRING SPECIFICATIONS

3.1 OPERATION OF DEVICE IN HAZARDOUS ENVIRONMENT AND USB ISOLATOR

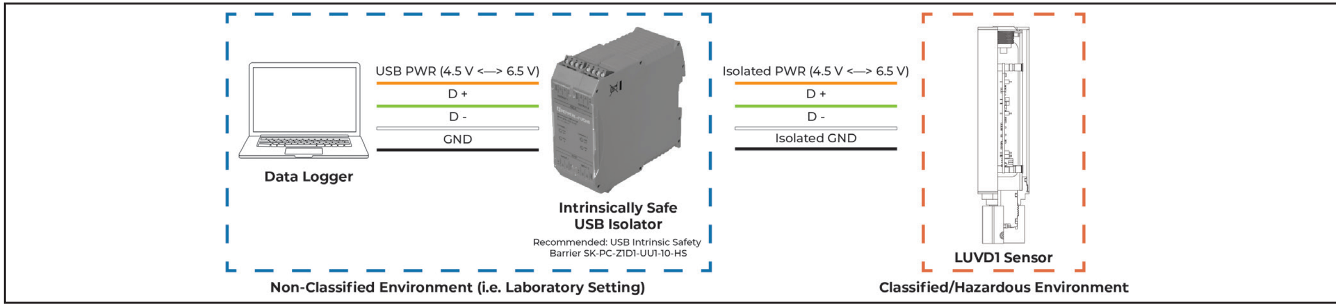

Figure 3-1. LUVD1 Sensor & USB Isolator in a Hazardous Environment

Figure 3-1. represents a use case where the device has been placed inside a hazardous environment and the data logger resides in a safe environment. A USB-A male to wire cable is used to connect the data logger to the USB isolator's 4 screw terminals on the input side of the isolator. A custom-built high temperature cable assembly comprising of a 4-pin LEMO male connector to wire is used to connect the Output Side of the Isolator to the Female 4-pin LEMO connector located on the Viscosity Density Device. Energy Storage specifications of the device can be found on Page 9 (LUVD1 Specification Sheet - 2.3 and 2.5 Electrical Specifications).

3.2 OPERATION OF DEVICE WITH THE "PROBE" CONFIGURATION

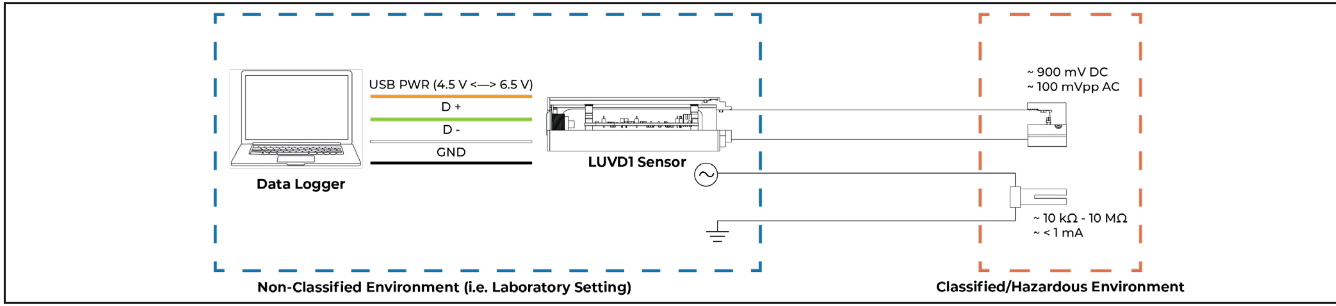

Figure 3-2. LUVD1 Sensor with "Probe" in a Hazardous Environment

Figure3-2. represents a use case where the device has been purchased with a probe configuration. This allows the electronics of the device to remain inside a safe environment while the test fluid and resonating tuning fork are located inside the hazardous environment.

The electrical signals passing between the environments are 100mVpp AC biased about 900mV DC in respect to the grounded housing of the device. These signals are passing through a glass-to-metal feedthrough in order to interact with the test fluid and vibrate the quartz tuning fork. A USB-A male to 4-pin male LEMO connector is used to connect the data logger to the viscosity density device.

SECTION 4
WINDOWS INSTALL INSTRUCTIONS

4.1 WINDOWS INSTALL INSTRUCTIONS

Python Installation

The LUVD1 sensor is a USB device with a device-specific API. Python scripts are available to drive the sensor and can be used directly or as a reference for custom software developed by the end-user. The scripts are all based on Python 3, which needs to be installed on the host machine as follows:

****

* TBD

* I typed “python3” in a Windows command prompt and this took me to the

* Microsoft store where I could click “Get” for Python 3.10. It installed and

* then “python3” was available at the command prompt.

****

libusb Installation

In order for the Python scripts to be able to talk to the sensor, the libusb library must be installed. The libusb library provides an interface for the standard Python USB library, pyusb, to be able to talk to standard WinUSB devices. The LUVD1 sensor conforms to the WinUSB protocol, so with libusb installed this enabled Python to talk to the sensor:

1. Download the latest .7z release from:
   https://github.com/libusb/libusb/releases
   At the time of this writing, libusb 1.0.26 is the latest available release.
2. Extract the .7z into a convenient location.
3. Check whether your version of Windows is 32- or 64-bit by navigating to the Windows "Settings > System > About" panel.
4. For a 64-bit operating system, copy the libusb file "VS2015-x64\dll\libusb-1.0.dll" into the "C:\Windows\System32\" directory.
5. For a 32-bit operatiny system, copy the libusb file "VS2015-Win32\dll\libusb-1.0.dll" into the "C:\Windows\System32\" directory.

Final Package Installation

The Python scripts depend on a few Python packages that need to be installed before we are able to actually use the sensor. These can be installed from a command prompt using the pip tool that is bundled with Python:

```
python3 -m pip install pyusb btype scipy matplotlib
```

This may take a moment to install; once it is complete navigate to the Phase Sensors source repository and then we should be able to discover any LUVD1 sensors that are connected via USB to the system.

In a command prompt, type the following:

```
python3 -m xtalx.tools.z_sensor.discover
```

and you should see output similar to the following:

```
  Product: XtalX TinCan4
Sensor SN: TCDC-5-2000004
 git SHA1: 37829693dc89c6a3e063048682cd72491b655dd7
  Version: 0x0098
```

This indicates that a LUVD1 sensor was discovered and that we are able to communicate with it via USB.

Full List of Installed Software

1. python3 - https://www.python.org
2. libusb - https://libusb.info
3. pyusb - https://github.com/pyusb/pyusb
4. btype - https://github.com/tgree/btype
5. scipy - https://scipy.org
6. matplotlib - https://matplotlib.org

SECTION 5
WINDOWS & MACOS SOFTWARE/COMMUNICATIONS

5.1 WINDOWS LAUNCH INSTRUCTIONS

The track_mode.py Python script is used to interface with the sensor and display density and viscosity measurements over time. This script is launched from the command prompt and takes a number of arguments. A typical invocation looks like this:

```
python3 -m xtalx.tools.z_sensor.track_mode -r 150000 --pga 3 --freq-0 33000 --freq-1 25000
```

This will launch the software, search for the resonator's measurement peak in the range of 25000 to 33000 Hz and use the largest PGA resistor (with a nominal value of 150000 Ohms) to perform the measurement. This combination of parameters may need to be adjusted depending on the end-user's use case; future software updates will provide more automation in this area.

Other optional parameters to the track_mode.py script are visible by using the --help option:

```
python3 -m xtalx.tools.z_sensor.track_mode --help
```

The track_mode.py graphical user interface is as follows:

<rest of existing section 5 goes here>

5.2 USER INTERFACE

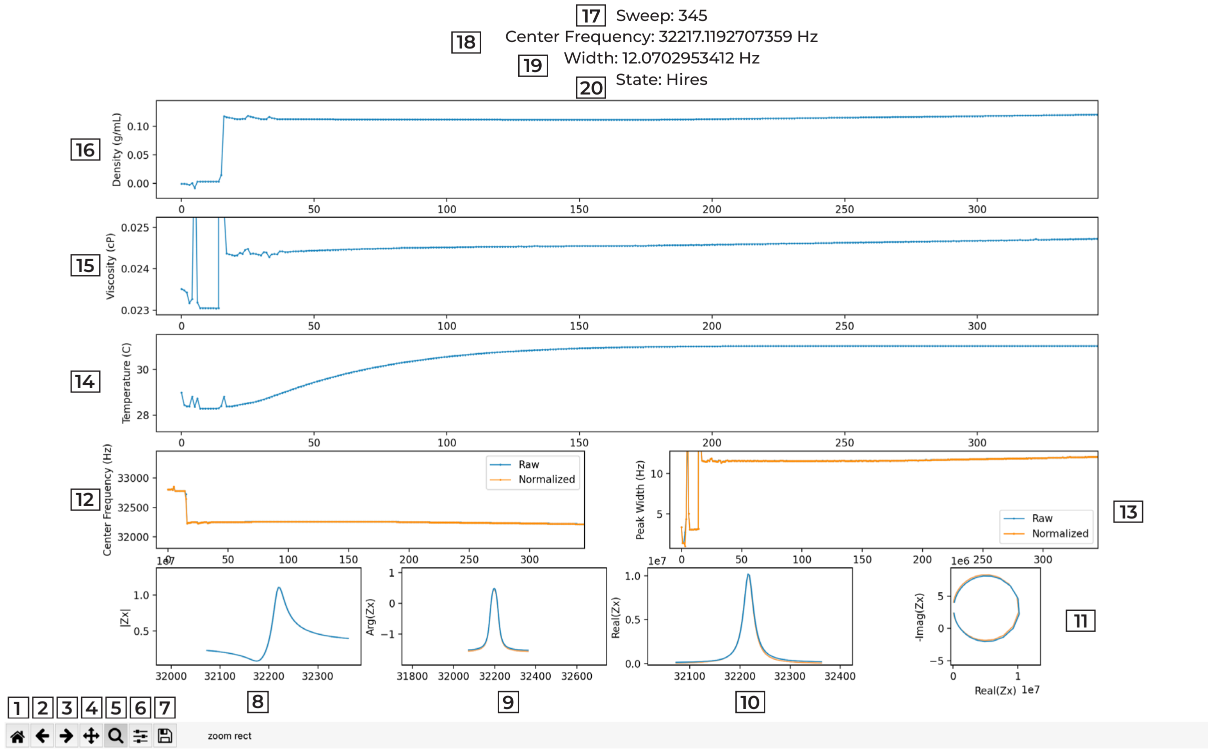

Figure 5-1. User Interface Screen Capture

5.3 USER INTERFACE OVERVIEW

1. Home Button
   Clicking on the home button returns the view windows to their original scales
2. Back Button
   Clicking on the back button returns the view windows to the previous window scales
3. Forward Button
   Clicking on the forward button changes the view windows to the next available view, think of button 2 and button 3 as the previous and forward buttons on a windows browser
4. Pan/Zoom
   This button allows the user to hold left-click (primary click) on a view window and pan the data to a desired location in the xy range. Hold right-click (secondary click) and hold on a view window allows the user to shrink or enlarge the data in the xy range. Note: Panning or zooming data that has sample number in the X axis (12,13,14,15,16) will also pan and zoom data in all other graphs of a similar type with respect to the X axis.
5. Rectangle Zoom
   This button allows the user to click and drag over a specific range in a view window to determine the new view window's x and y scale. Note: Similar to button 4, adjusting on x-axis will also adjust the other similar type graphs.

6. Adjust
   This button allows the user to adjust the ratio of empty space with respect to the graphs, as well as adjusting font size for ease of use.
7. Export
   This button allows the user to export a screenshot of the visible data in a PNG format.
8. Absolute Magnitude of Impedance
   This graph shows the absolute magnitude of impedance of the quartz tuning fork on the y-axis (Ω) and the corresponding frequencies on the x-axis (Hz).
9. Argument of Impedance
   This graph shows the Argument (phase angle) of the Quartz Tuning Fork on the y-axis (rad) and the corresponding frequencies on the x-axis (Hz).
10. Real Impedance
    This graph shows the real component of impedance of the quartz tuning fork on the y-axis (Ω) and the corresponding frequencies on the x-axis (Hz).
11. Nyquist Plot:
    This graph shows a combination of the graphs 8 and 9, showing the absolute impedances at their corresponding phase angles with respect to the origin. The imaginary impedance is displayed on the y-axis (-jΩ) and the real impedance is displayed on the x-axis (Ω).
12. Center Frequency
    This graph shows the extracted center frequency of the quartz tuning fork on the y-axis (Hz) for the corresponding sweep on the x-axis.

13. <u>Peak Width</u>
    This graph shows the extracted Peak Width of the quartz tuning fork on the y-axis (Hz) for the corresponding sweep on the x-axis.
14. <u>Temperature</u>
    This graph shows the temperature of the sensor head in celsius on the y-axis for the corresponding Sweep on the x-axis. Note: This measurement is useful when trying to attain stable conditions for your experiment.
15. <u>Viscosity</u>
    This graph shows the estimated viscosity of thetest fluid in cP on the y-axis for the corresponding sweep on the x-axis. Note: This measurement may be inaccurate outside of the device’s calibrated range.
16. <u>Density</u>
    This graph shows the estimated density of the test fluid in g/cc on the x-axis for the corresponding Sweep on the x-axis. Note: This measurement may be inaccurate outside of the device’s calibrated range.
17. <u>State</u>
    This field indicates the status of the device. “hires” indicates “high resolution” mode where the peak has been discovered and is being monitored closely in subsequent sweeps. “search” indicates the “search” mode where the device is sweeping the initial wide frequency range input by the user and is always the initial mode of operation when launching the software.

Note: The device can go from “hires” mode to “search” mode when the fluid properties change quickly. Note 2: If the device never leaves search mode, change the initial guess parameters to a wider frequency range, it is possible that the peak is outside of the initial guess parameters.

18. Width Field

    This fied displays the extracted width of the most recent sweep.

19. Center Frequency Field

    This field displays the extracted center frequency of the most recent sweep.

20. Sweep Field

    This field displays the last successful sweep number and increments up with time.