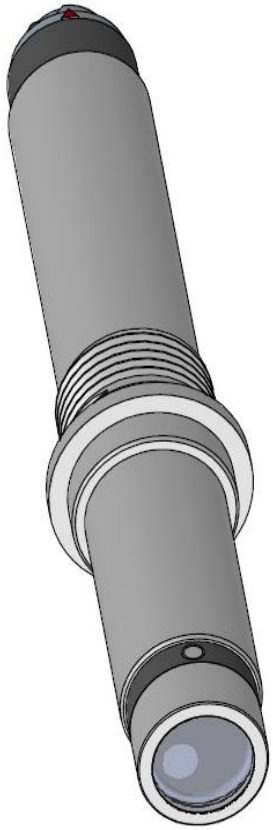
MagPi Enterprise

In-Line PTSA Fluorometer



- Real-Time PTSA Measurement
- Advanced Patent Pending Optics
- Bluetooth-Calibration and Diagnostics
- 4-20mA
- Automatic Temperature Compensation
- Ruggedized Design

MagPi Enterprise specializes in environmental water quality fluorescence instrumentation and application consulting. Applications include algal pigments, fDOM, Dye Tracing, hydrocarbon detection, industrial, biotech and custom appliations. P.O Box 230104 Centreville, VA 20120
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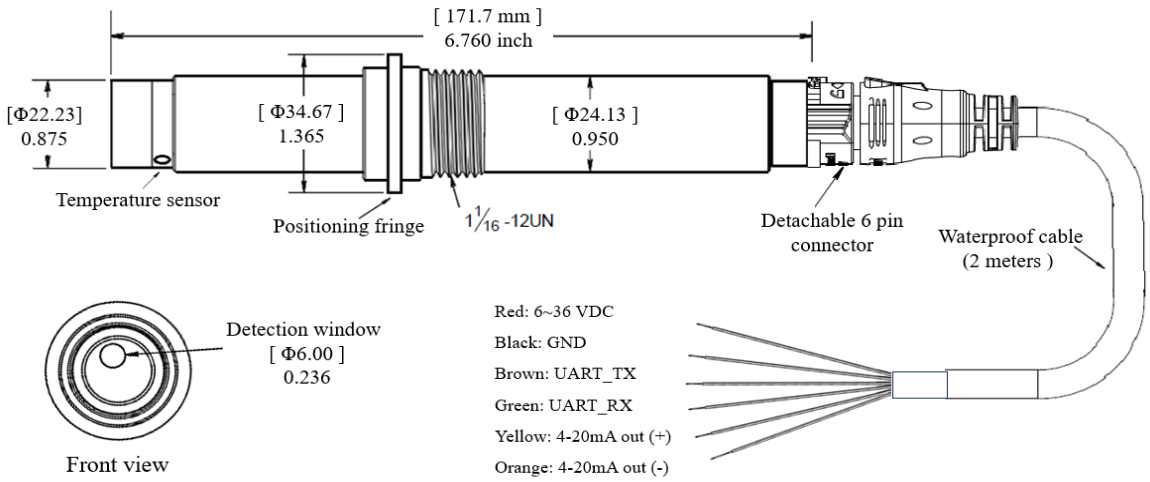
Introduction

The In-Line PTSA fluorometer was designed for monitoring PTSA (1,3,6,8-Pyrenetetrasulfonic acid) in closed loop systems to provide real-time monitoring of chemical levels tied to measurable concentrations of PTSA. This fluorometer uses state-of-the-art technology and is extremely user friendly and reliable. Bluetooth applications are available for both iOS and Android to allow for convenient maintenance checks, calibration and diagnostics. The unique and patent pending optic configuration allows for high precision operation and excellent turbidity rejection. The PTSA fluorometer also has onboard temperature compensation

Our PTSA fluorometer was designed to operate under a wide variety of conditions. The body is constructed of durable polyvinyl chloride and special glass and polymer materials that provide a high resistance to direct chemical exposure. The fluorometer accepts a wide range of 6-36 VDC input power and has a primary 4-20 mA signal output. The factory set range for the fluorometer is 0-300 ppb PTSA. Dimensions and wiring instructions are illustrated in Figure 1.



Note:

- A label is included on each wire of the pigtail cable for rapid I/O verification
- *Two data wires TX (green) and RX (white) are used for digital access, which can be retained or cut depending on the user's applications and needs.*

FIGURE 1: Fluorometer Mechanical Information

The fluorescent measurement is measured at a 0° angle. Both the fluorescence excitation and emission pass through the detection window to obtain better linearity, stability and less interference from light scatter. (see the Front view in the lower left part of Figure 1). A special Tee Fitting was designed for in-line applications. Calibration should be completed for both the blank and standard with the plumbing tee installed. Calibrating with the tee ensures that the test distance is accurately controlled within a very small tolerance, as shown as **X** in Figure 2A. For convenience, users can use two Tee Fittings, one is permanently installed at the monitoring spot, and the other is used for calibration. Because the measurement results are not affected by flow rate, the probe equipped with the Tee Fitting can be calibrated directly in the beaker and then installed back to the monitoring spot. Trapped air will generate errors in measurement and calibration. Ensure that all air bubbles are dislodged before proceeding with operation or calibration.

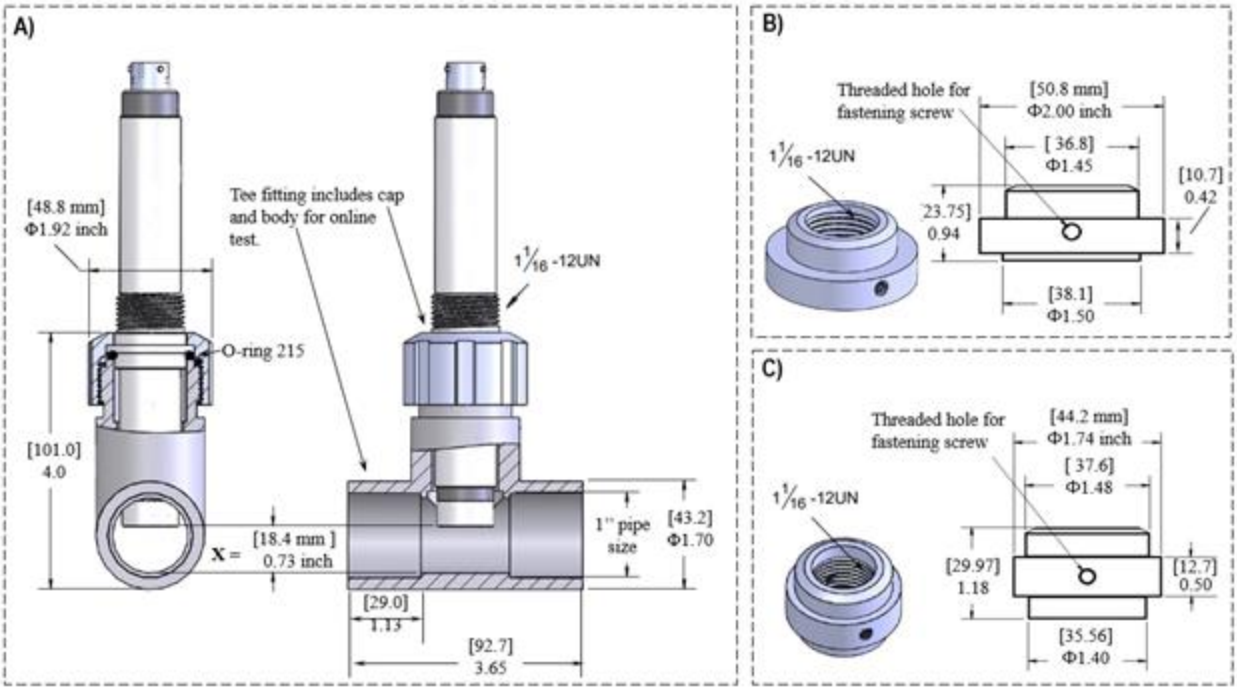


FIGURE 2: A) Fluorometer with our standard Tee fitting; B) and C) Adapters for other Tee fittings.

FLOU-TEE in Figure 2A is our standard Tee Fitting, and the In-Line PTSA fluorometer can be directly installed in it. Unique adaptors have been developed to assist customers who are replacing an existing fluorometer system. The In-Line PTSA fluorometer can be installed into an existing fluorometer tee by using one of the adapter fittings depending on which brand of fluorometer you are replacing. Image B illustrates the Turner fluorometer tee adapter. Image C illustrates the Pyxis fluorometer tee adapter.

The In-Line PTSA fluorometer is Bluetooth-enabled so users can set up, calibrate and transfer data via the related application of mobile phone, both iOS and Android.

Wiring and Installation

1) Installation and operation should only be conducted by properly trained and authorized professionals. Proper caution and safety protocols must be adhered to when working on energized electronics and electrical equipment. The In-Line Fluorometer is a sophisticated opto-electronic instrument, the user should read the manual carefully, follow the instructions, and integrate them into the final measurement and safety procedures to ensure the fluorometer is installed and operating within normal conditions. Failure to follow the operating instructions may result in damage to the instrument and invalidate the warranty.
2) Prior to applying power, check all wired connections. Make sure the detachable pigtail is securely seated and there are no exposed conductors.
3) Once power is applied to the fluorometer, it will being measuring. The In-line PTSA fluorometer uses a UV light as an excitation for the PTSA. Do not look directly at the optic face of the fluorometer while powered. In order to verify operation, remove the fluorometer from the plumbing tee and place the

powered fluorometer < 1" from a white piece of paper. If the fluorometer is operating properly, you will see a faint blue light on the paper which indicates that the LED is functioning correctly.

4) If the In-Line PTSA Fluorometer is being used without the plumbing tee, the calibration should be completed in an environment that replicates the distance from the optic face of the fluorometer to the bottom of the sample area.

Preliminary Specifications

Range: **PTSA**: 0 to 300 ppb (µg/L), factory setting **Operating Temperature**: 0 to 50°C. **Storage Temperature**: 0 to 50°C. **Maximum Bearing Pressure**: 100 PSI.	**Linearity/Resolution/Accuracy** / **PTSA linearity:** $R^2 > 0.999$. **PTSA accuracy:** 0.1 ppb. **Current resolution**: 0.050 mA/ppb. **Temp. accuracy**: ± 0.4 °C with Tee fitting.
Response Time: **PTSA:** < 200 ms; measured value for T_{100} is 2 ~ 5s (depending on controller or software). **Temperature:** T_{90} ~ 5 minutes with Tee fitting.	**PTSA Compensation Factors:** **Temperature:** automatic, full range. **Turbidity**: Optional (0 to 500 NTU).
Optic/Input /output/protocol: **Excitation**: ~ 365 nm. **Emission:** ~ 400 nm. **Input:** 6 - 36 V DC. **Consumption:** 760 mW. **Output:** 4-20 mA / Bluetooth	**Others:** **Size:** Φ22.2mm X 172mm; **Weight:** ~ 100g **Waterproof:** IP68 **Materials:** Grey PVC, Delrin and Epoxy. **Cable**: 2 m (options exist) waterproof cables and detachable connector.
Calibration and Influencing factors: **Calibration point:** 2-point (Zero and PTSA standard solution). **Calibration frequency**: Recommended 6 month intervals or as needed. **Position dependent:** The plumbing tee should be installed in a vertical orientation so that the water flows in a way that will prevent air from being trapped in the plumbing tee. **Color dependent.:** If there is significant dissolved material in your water system that is interfering with the measurements, it may be necessary to recalibrate using "clean" system water without treatment product or PTSA present and a calibration standard generated with a mixture of system water and known MagPi Calibration PTSA standard. Contact MagPi Enterprise technical support for further information.	

Bluetooth Connection

App Installation

The App used for Bluetooth connection with this product is **XCITE Measure**, which can be downloaded directly from Google Play or Apple Store.

After XCITE is successfully installed, the following operations are required to proceed and are stored for future App sessions.

- Grant Bluetooth permissions.
- Accept the End User License Agreement (EULA, scroll to the bottom of the EULA page and click Accept)

Dashboard Overview

As shown in the leftmost part of Figure 3, the Home or Dashboard offers access to:

- **Connect to Bluetooth Device**: Establish a connection with your XCITE-compatible device.
- **Real-Time Measurement**: Begin live data collection.
- **Access your saved Files**: View and manage your files.
- **Adjust your Settings**: Customize themes, languages, and other app preferences.

In-Line PTSA Fluorometer Connection

The connection operations are shown in the Figure below.

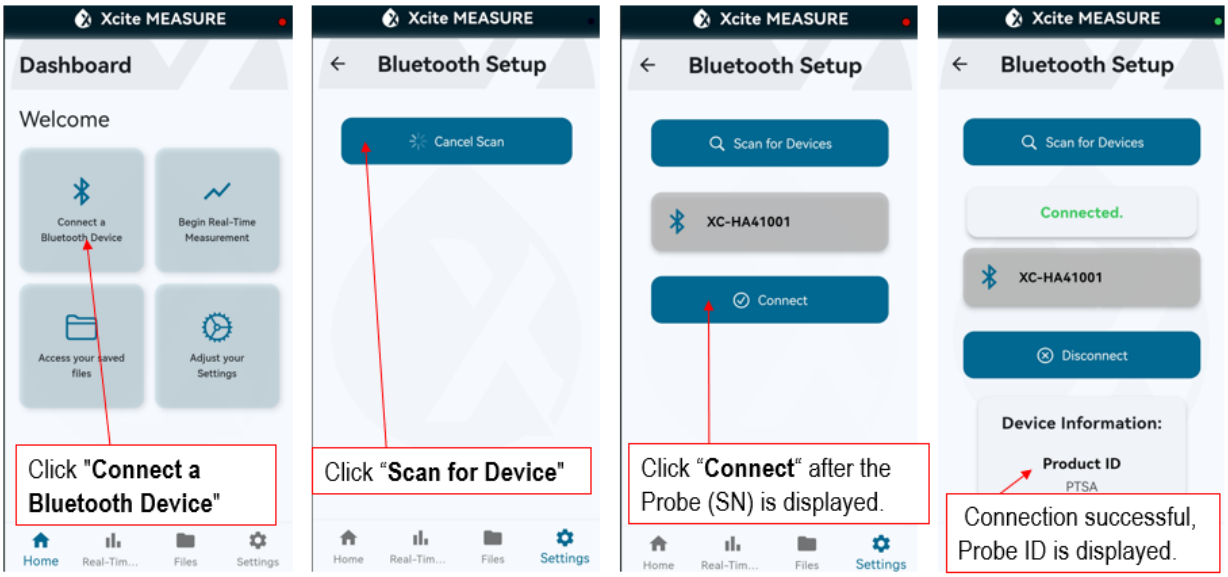


FIGURE 3: Connection Operations

Note:

- The connection distance should be within 5m (16.5 feet).
- If multiple probes are found, please select one of them. The connection is one-to-one, and it is not possible for one probe to be connected to two mobile phones at the same time, vice versa.

- A timeout occurs if the connection is unsuccessful (~ 30 seconds) and cancel the scan by clicking the Scan button again.
- If the connection always fails, please restart the app and try again.
- The indicator in the upper left corner contains the following status:

Red: Not ready for streaming.
Flashing Blue: Scanning for
Flashing Yellow: Connecting.
Green: Successfully connected.

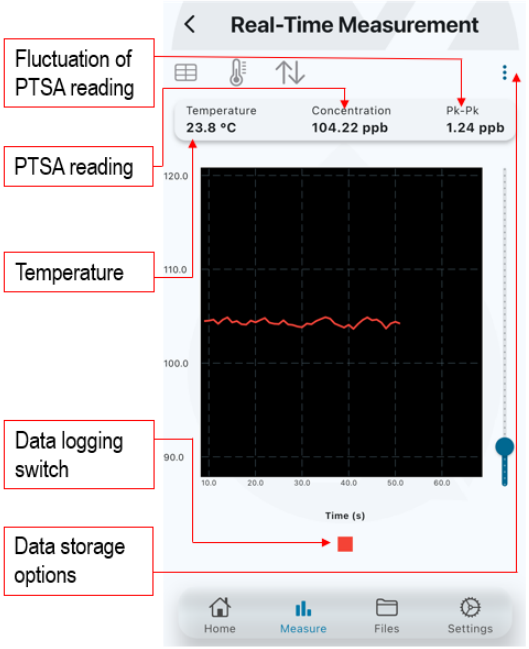
Measurement and Calibration

Real-Time Measurement on Mobile App

After the connection is successful, click the Icon of Column Chart (Real-Time Measurement) on the bottom navigation bar to access the Measurement Page as shown in the picture below, in which the main reading areas and function keys are given.

Note:

- Ensure the connection is OK; otherwise, a connect message will be prompted.
- Fluctuation of PTSA is the difference between maximum and minimum readings within a given time. The smaller the PK-PK, the more stable the PTSA reading.
- The Chart will appear if the Data logging switch is clicked, otherwise only the data in the upper reading area will be displayed and updated.
- Use the slider on the right to adjust Y-Axis of Chart.
- Drag left or right to view data in the Chart
- To zoom in and out, use a two-finger motion when data logging is stopped.



Data Storage

Data can be saved or shared when data logging is stopped. As shown in the Figure above, tap the three-dot menu to have the following two options:

- **Take Snapshot**: Share data via email, text, or AirDrop.
- **Save Data**: Export recordings as CSV files.

After the data are saved, additional options become available:

- **Table View**: View data in tabular format.
- **Toggle Temperature**: Show or hide real-time temperature.
- **Peak-to-Peak View**: Show or hide peak-to-peak values.

The stored data can also be viewed and processed in File Section, which is on the bottom navigation bar. To delete invalid or outdated files, please tap the three-dot menu under a file, then confirm deletion.

Calibration via Mobile App

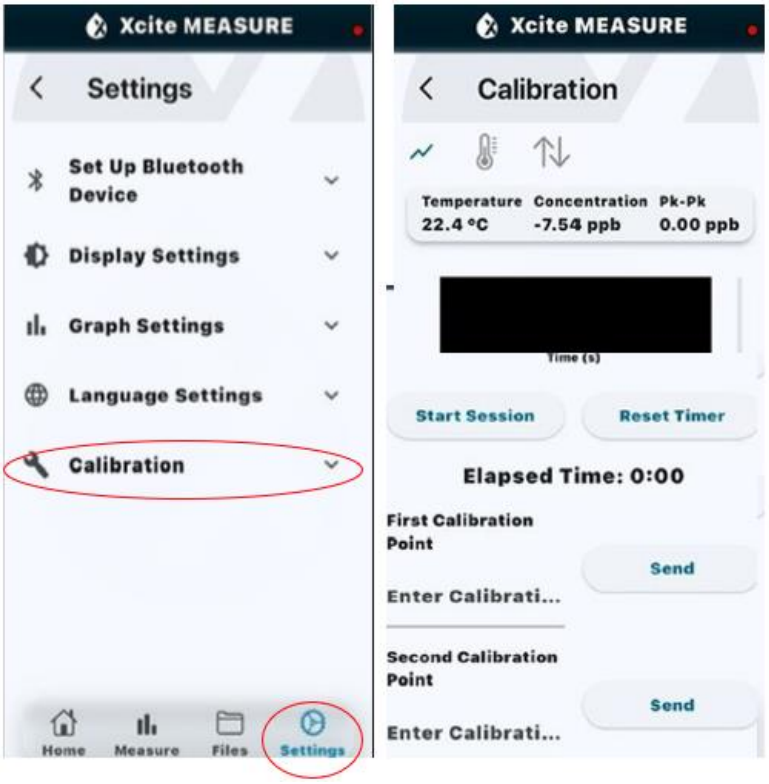
Although the probes have been calibrated at the factory, timely calibration on the users' side is also necessary. Because the zero point and slope of the probe may change due to the following reasons.

i) The test distance or Tee fitting is different.
ii) Changes in water quality, like color and turbidity.
iii) Difference or error of the standard solutions.
iv) Performance degradation of emitting light sources (LED)
v) Natural drift due to the decline in the mechanical or other optical components of the probe.

It is recommended that the probe needs to be calibrated when first used and then calibrate weekly for up to a month to ensure the probe reaches a stable. After that, calibration can be performed every 6 months, and users can extend or shorten the calibration cycle based on actual measurement results and desired accuracy requirements.

Linearity of XC-PTSA201-AC is very good in the given range, and thus, the conversion equation can be easily determined by a 2-point calibration. Usually, a zero point and a non-zero point are adopted, and the latter should be in the range of interest to the user. The calibration can first be performed in XCITE. Users can access the calibration process in the Settings Page as shown on the left in the Figure below.

After entering the calibration window, users can operate as follows



1. Place the probe in DI water (for zero calibration).
   Note: If a Tee fitting is used during measurement, then the Tee fitting is also required during calibration.
2. After 30 seconds, tap **Start Session** button, and then the "Elapsed Time" starts
3. Observe Pk-Pk value (stability).
4. If Pk-Pk is < 0.3 ppb within 60 seconds, input the zero in the dialog box of "First Calibration Point" and then tap "Send".
   Note:
   - If it is > 0.3 ppb, tap "Reset Timer" to restart the timer and pk-pk display until the stability requirement of PTSA reading are met.
   - The value entered for the zero calibration must be in the dialog box of "First Calibration Point".

- Zero calibration is done. The sign of success is that the PTSA reading is equal or close to 0.
- If the user's application does not involve low PTSA measurements (< 10 ppb), the zero calibration (Steps 1-4 above) can be omitted, and the user can proceed directly to a non-zero calibration (Steps 5-8).

5. Place the probe in PTSA Standard Solution.
6. After 30 seconds, tap **Start Session** button, and let the "Elapsed Time" start.
7. Observe Pk-Pk value.
8. If Pk-Pk is < 0.3 ppb within 60 seconds, input the standard concentration in the dialog box of "Second Calibration Point" and then tap "Send".
   Note:
   - If it is > 0.3 ppb, tap "Reset Timer" to re-observe Pk-PK until the stability meets the requirements.
   - If the zero calibration is omitted, the user actually performs a 1-point calibration at a non-zero point. At this time, the standard value still needs to be entered in the dialog box of "Second Calibration Point".
   - A successful calibration is indicated by a PTSA reading that is equal or very close to the input value.

Since probe accuracy depends on the calibration and the related standard solution, the following precautions need to be carefully considered.

1) The accuracy of the blank and standard solution is critical.
2) Allow the In-Line Fluorometer three minutes for warm-up time.
3) Do not calibrate the probe until the probe reading is stable.
4) Do not calibrate the probe if the environment conditions (temperature, turbidity or color and more) are unstable.
5) Keep the probe head at least 4 inches from the bottom of the container if the Tee fitting is not used.
6) If possible or necessary, use zero-PTSA water from the measurement application for zero calibration, and then use it to dilute or prepare the standard solution for non-zero calibration. This will eliminate most interference factors.
7) Users need to calibrate the probe when the following happens.

   i. The water sample has obvious color (visible to the naked eye）.

   Note: PTSA emission is blue violet light, which will be absorbed more or less by the soluble colored substances, leading to a lower result. If this is case, please consider using the similar color water (zero-PTSA) to prepare PTSA standard solution and deduct the color effect with calibration

   ii. If Tee fitting is not used while the distance between the probe head and container bottom (or wall) gets changed and it is less than 10 cm (or 4 inches).
   iii. Calibrate probe whenever its reading looks different from expectation.

Calibration on User's Controller

The **zero-point** output of XC-PTSA201-AC is **4mA**, while the **20mA** output represents **320ppb**. (Leave a margin of 20 ppb to ensure that the probe's range can be maintained at 0-300 ppb). Users can use the above values to let the related analyzer/meter/controller calculate the slope and offset of the conversion equation. Since there is a certain error between the actual output current of the probe and the current measured by the

user's instrument, if the user needs a more accurate result, a 2-point calibration is needed to correct the slope and zero point. As shown in Eq.1, the user needs to record the probe's output in DI water and a standard solution, respectively for correcting the zero point and the slope. If the variation of the zero-point can be ignored, the user actually only needs one point calibration at a non-zero point. And then, the conversion equation can be obtained as shown in Eq.2.

$$\textit{Slope} = \frac{\textit{Output of non-zero point (mA)} - \textit{Output of zero point (mA)}}{\textit{The concentration of the standard solution (ppb)}} \quad \text{Eq.1}$$

$$\textit{PTSA (ppb)} = \frac{\textit{Output at any point (mA)} - \textit{Output of zero point (mA)}}{\textit{Slope}} \quad \text{Eq.2}$$

If the conversion equation cannot be directly entered in the analyzer/meter/controller software, please first set the zero-point value at 4mA as calculated by Eq. 3 below. But sometimes this may not be necessary in some controllers, since its OFFSET function may be able to complete the zero point calibration. The user just needs to ensure that the probe is placed in DI water when performing zero point adjustment. After that, the user can set the full-scale point value at 20 mA as calculated based on Eq.4 below. If the zero point does not change much, the calibration is resetting the full-scale point of the meter. This point is initially 320 ppb in fluorometer side, but at the user's meter side, it may be close to this value or may be significantly different. It doesn't matter, since it should be subject to the latest calibration.

$$\textit{Zero point} = \frac{\textit{4 mA} - \textit{Output of zero point (mA)}}{\textit{Slope}} \quad \text{Eq.3}$$

$$\textit{Full scale point (ppb)} = \frac{\textit{20 (mA)} - \textit{Output of zero point (mA)}}{\textit{Slope}} \quad \text{Eq.4}$$

Additional Notes of Mobile App

The following are some additional notes and features of the XCITE Measure APP, mainly involving the "File" and "Setting" sections.

Files Section

1) Viewing Sessions
    - The default view displays a list of all sessions.
    - Clicking a session shows metadata such as:
        Start and end time.
        Duration.
        Time zone.
        Firmware and hardware version.

Product ID and serial number.

2) Navigation Buttons
    - Sessions: Lists all sessions.
    - Files: Displays saved files.
    - Sort: Organize files by date or type (images/recordings).
    - Filter: Narrow files by:
        All files.
        Images or recordings.
        Recent files (today, last 7 days, last 30 days).

Settings Section

1) Bluetooth Setup: Access the Setup Bluetooth Device section to manage connections.
2) Display Settings:
    - Switch between Light and Dark mode.
    - Choose a theme (if available).
3) Accessibility Options:
    - Adjust text size (Large, Normal, Small).
    - Revert graph colors to default settings.
4) Language Selection: Select your preferred language (varies by distribution).

Interference Factors and Compensation

Temperature, turbidity and the presence of background fluorescence all have a large impact on fluorescence measurements. Fluorescence measured in liquid is inversely related to the temperature of the liquid. As the temperature increases, the fluorescence will decrease. Also, if the temperature decreases, the fluorescence will increase as the molecules draw closer together and generate more fluorescence in a smaller space. The Temperature coefficient for PTSA is relatively small (~1.5%/℃).

The In-Line PTSA fluorometer has built-in temperature sensor, and the temperature effect can be automatically compensated by the sophisticated algorithms in the firmware. However, for the effect of the turbidity and the color, this fluorometer cannot automatically compensate for the time being. In actual operations, the best compensation for these two interference factors is to use the same or similar water sample to prepare the PTSA standard solutions and then calibrate the probe. In addition, we studied the relationship between the fluorometer readings and turbidity changes, so that users can perform manual turbidity compensation or realize automatic compensation when the fluorometer is combined with a turbidity sensor in the case of a multi-parameter sensor. The compensation method is as follows

$$PTSA\ Reading_{\ Final} = \frac{PTSA\ Reading_{\ Initial}}{K}$$

$$K = 0.0093\,x^3 - 0.1404x^2 + 0.4656x + 0.5151$$

$$x = \ln\ (turbidity\ reading)$$

Here, PTSA Reading $_{\text{Initial}}$ and PTSA Reading $_{\text{Final}}$ represent the readings before and after turbidity compensation, respectively. *K* is the compensation factor, and *x* is the natural logarithm of the turbidity value in the current testing environment. The user can perform compensation manually or input the algorithm into the controller for automatic compensation, when a turbidity sensor is connected.

Maintenance

This optical sensor is easy to maintain without complex operations, and most precautions are common sense for protecting an electronic product and optical sensor as below.

1) Caution should be used when handling or making electrical connections. Check for proper electrical connections before applying power.
2) If any contaminants or residue are present on the window, please use water or alcohol with a wipe to clean.
3) Avoid window contact with hydrofluoric and concentrated phosphoric acid.
4) When the probe is not in use, please store dry.