fieldkit

H41S-2013

Caldor: the in-situ calibration system

The design and implementation of a user-friendly, app-based environmental sensor calibration architecture for use in a wide variety of environments from the field to the lab. Designed with flexibility in mind, including multiple regressions, modalities, and traceable standards.

Introduction

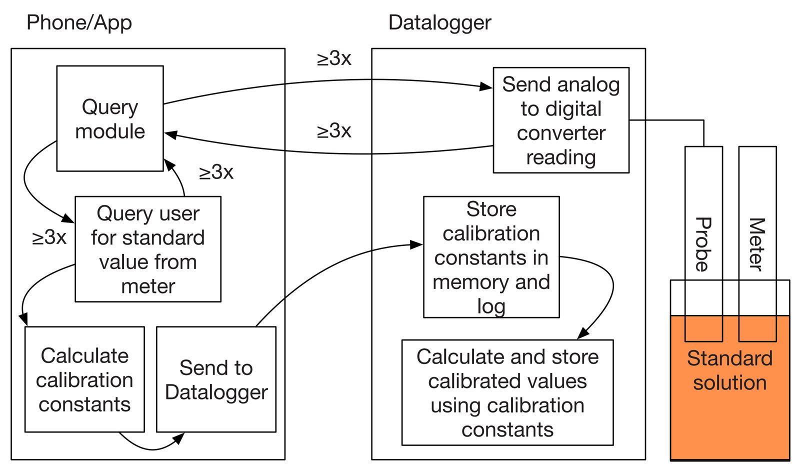
In the realm of field instrumentation, calibration is always necessary[1,2,3]. However, having to take instruments and equipment out of the field and into the lab to undertake required calibration procedures and protocols can cost valuable time and data[4]. As an answer to this problem, a system was developed to allow for calibration to take place in the field using proper traceable calibration standards and creating calibration functions from the data recorded from both them and the in-field instruments being calibrated.

- First system in a datalogger to allow in-field calibration with external standards
- First two-part system that allows calculation of calibration functions in an app and stores them on the datalogger, specifically on its module(s)
- Scalable implementation of linear and exponential regressions (with options on more functions as needed) for sparse calibration datasets
- Adds traceability to measurements
- Can be implemented in app, server-side, and/or firmware

Materials and Methods

Hardware: Calibration standards and test equipment, datalogger, Android/iOS Phone

Software: App with integrated Caldor library compatible with data logger firmware.

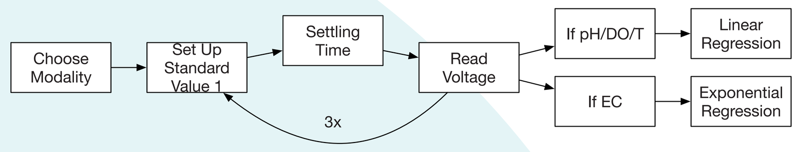


Calibration system

Calibration begins with gathering calibration standards and test equipment for the relevant modality. For example, water temperature requires boiling water, ice water, and a thermometer. Electrical conductivity requires the relevant standards (e.g. 82 µS/cm, 1,600 µS/cm, 12,000 µS/cm) and an optional EC meter for checking standard degradation.

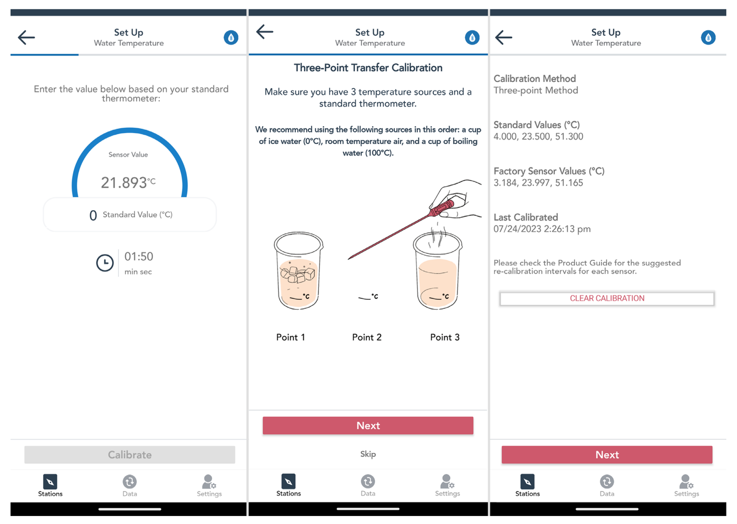
The datalogger is then powered on and connected to via the app. The user selects the modality to be calibrated and is walked through the calibration process, which includes modality specific washing/preparation instructions (See figure).

After the final reference, the app applies the appropriate regression for the modality and sends the calibration coefficients and metadata to the datalogger. The datalogger records this in the log and the sensor module's EEPROM and applies the curve to all future readings.

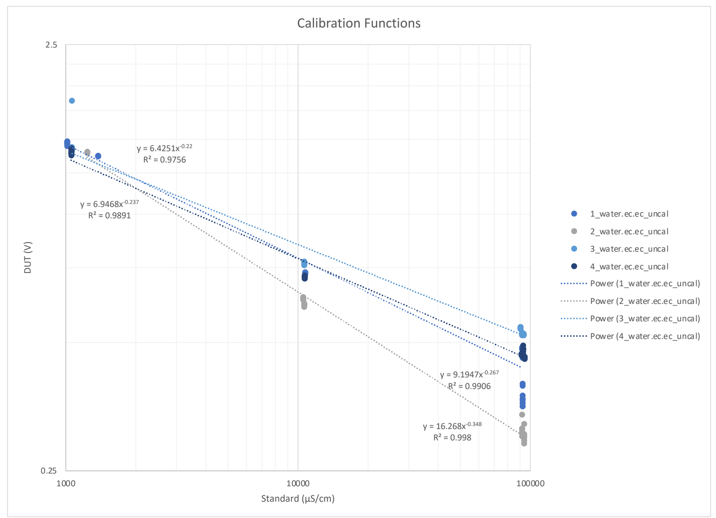


Calibration process

Results



A sampling of screens from the app showing a calibration being performed. From left to right, a timer counts down to allow the reading to settle; the Calibrate button will become available as soon as the timer expires and a new reading is collected. Another screen shows protocol instructions to guide the user, and a final screen shows a portion of the calibration metadata for record keeping, with the ability to clear the calibration should another be necessary.



Electrical conductivity calibration functions across a number of units and a number of calibrations. Of particular note is the repeatability of each calibration, resulting in tightly clustered points for each of the four units being tested.

Discussion

Having a standard data format for representing calibration data and a flexible approach to generating that data goes a long way toward simplifying the expansion of the repertoire of modalities, comparing approaches to calibration, and understanding previously executed calibrations. By developing these libraries and schemas in the context of a variety of modalities and more than one physical datalogger, much of the heavy lifting toward future proofing has been accomplished. There are ways the current metadata could be expanded, for example, including identity of the calibrator and any other environmental metrics easily available from the datalogger being used to perform the calibration (e.g. ambient temperature). Automated cataloging of all calibrations and the unique identifiers of the probes and hardware is also strongly desired.

Conclusion

Flexible Implementation: The flexibility to implement the system in an app or directly in the firmware makes it adaptable to a wide range of field instruments and data loggers. This flexibility ensures that the system can be tailored to meet the specific needs of different applications and environments. The system is open source and available on GitLab: https://gitlab.com/fieldkit/libraries/caldor

Traceability of Measurements: By adding traceability to measurements, the system enhances the credibility and reliability of the data collected. Traceable calibration standards mean that the data can be linked back to recognized international standards, crucial for scientific research, environmental quality enforcement, and industrial applications.

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Scan for FieldKit's GitLab

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