ANB Sensors

ANB Sensors, AQ² pH Sensor

Analytical Performance of the AQ²: Validation Through Laboratory Testing

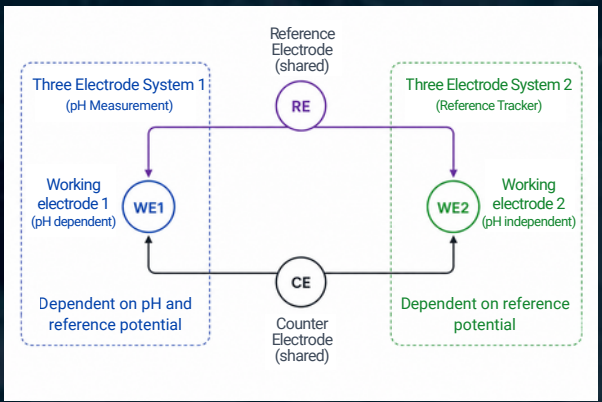
Electrochemical pH Measurement Principles

Electrochemical pH sensors traditionally rely on a glass membrane electrode that develops a potential difference across a hydrated glass layer in response to hydrogen ion activity. This potential is measured relative to a reference electrode and follows the Nernst equation, with the voltage changing predictably with pH. While glass pH sensors are well established, they require frequent calibration, are susceptible to drift, need to be stored wet, and can suffer from fouling, dehydration, and mechanical fragility in field deployments.

In contrast, electrochemical redox-based pH sensors measure pH by tracking the potential of a pH-sensitive redox-active molecule at a working electrode within a three-electrode configuration (working, counter, and reference electrodes). When a potential sweep is applied, the redox peak position shifts as a function of hydrogen ion concentration, providing a robust electrochemical proxy for pH. The resulting current and potential signals depend on analyte concentration, electrode surface properties, and mass transport, while the reference electrode provides a stable potential baseline for accurate measurement. However, without secondary corroboration of the reference electrode potential these measurements fall foul of reference electrode drift.

ANB's Dual Working Electrode Architecture for Calibration-Free pH Measurement

ANB's pH sensor employs a novel architecture featuring two working electrodes that share a common counter and reference electrode, effectively forming two parallel three-electrode systems. One working electrode is functionalised with a pH-responsive redox-active molecule whose redox potential shifts with hydrogen ion concentration, enabling pH measurement via the observed peak potential. The second working electrode contains a pH-independent redox molecule that serves as a reference tracker, providing a stable electrochemical signal that reflects only the reference electrode potential.



By measuring this reference tracker signal prior to each pH measurement cycle, ANB compensates for any reference drift in real time, enabling highly stable and calibration-free pH sensing.

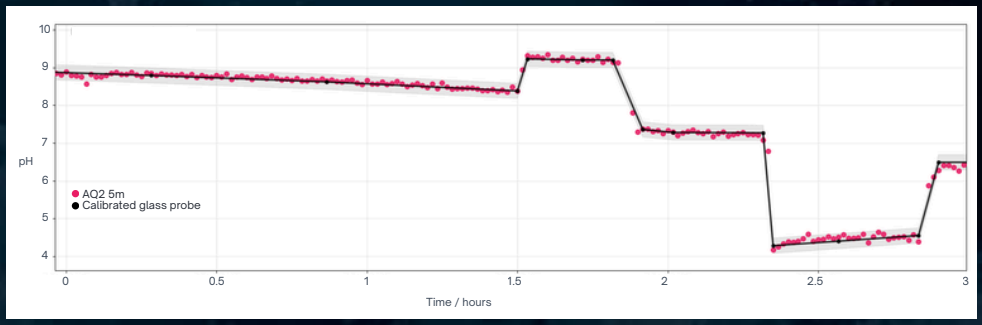
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Experimental Validation & Performance Comparison

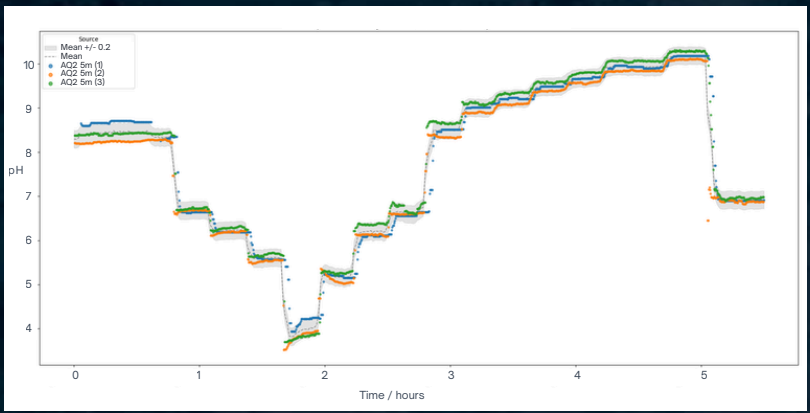
In April 2026, we launched the second-generation calibration-free pH sensor - the AQ^2 - representing a significant advancement in sensor performance, measurement reliability, and data quality. The AQ^2 incorporates an updated measurement methodology that delivers stable pH readings every 5 seconds, providing substantially improved temporal resolution. A redesigned measurement and calibration framework enhances accuracy across a broader range of environmental conditions, with particularly improved performance in low-salinity waters. Sensor stabilisation time has also been significantly reduced, enabling reliable measurements to be obtained more rapidly following deployment or sensor abrasion.

The performance of the AQ^2 was validated through controlled laboratory testing against a daily calibrated and verified laboratory-grade glass pH electrode, which has a stated accuracy of ±0.2 pH units immediately following calibration. This benchmark provides a robust reference for assessing the accuracy, consistency, and stability of the calibration-free sensor, demonstrating that the second-generation design delivers high-quality pH measurements without the need for routine user calibration.

- AQ^2 sensor
- 10 ppt water
- Acid & base additions
- Spot measurements with calibrated glass probe



- Multiple AQ^2 sensors
- Tap water
- Acid & base additions



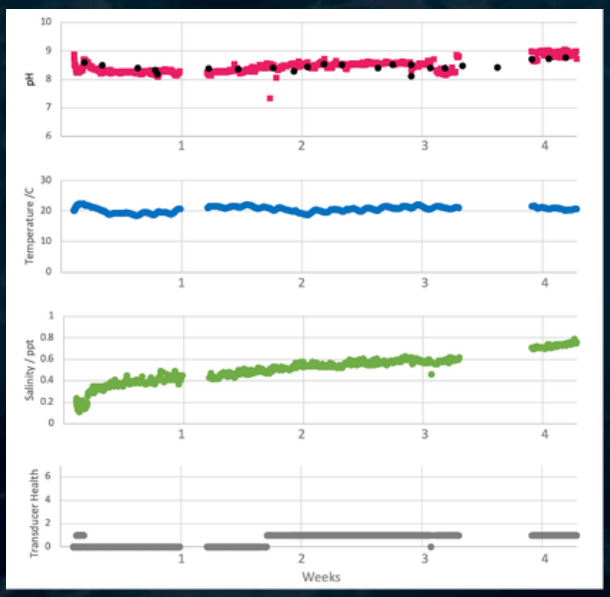
ANB AQ^2 sensor tracks dynamic pH transitions with rapid response and stable signal behaviour. Spot measurements taken with a freshly calibrated glass probe at discrete time points show excellent agreement with the ANB sensor, confirming ±0.2 pH accuracy across the tested pH range.

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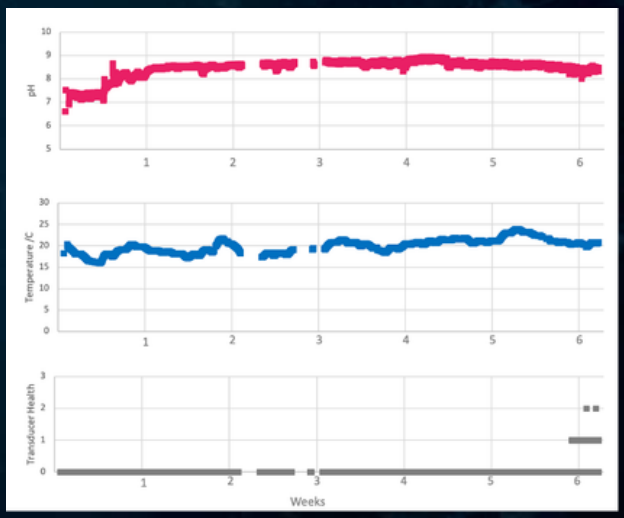
Performance in Different Salinity Conditions

Sensor performance was further evaluated using sensors deployed in both high- and low-salinity solutions over extended periods.

Freshwater | 1hr measurement intervals | 4.5 wks



Seawater | continuous monitoring | 6 wks



Lower salinity environments are inherently more challenging for electrochemical sensors because reduced ionic strength decreases solution conductivity, increases solution resistance, and can distort electrode potentials and current responses. Despite these challenges, the ANB sensors maintained stable and accurate pH measurements across salinity regimes, demonstrating robustness to variations in ionic strength and suitability for both marine and freshwater monitoring applications.

By comparison, the accuracy of conventional glass pH electrodes in field conditions is often uncertain unless the probe has been recently calibrated, as drift, fouling, and reference junction degradation can introduce unknown offsets between calibration events. In practice, the true accuracy of a glass electrode between calibration events is typically unknown, whereas the ANB sensor continuously tracks and compensates for reference drift in situ.

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Tailored pH-Active Chemistry & Calibration Approach

A key element of ANB's intellectual property is the design and selection of pH-responsive redox-active molecules specifically tailored for low-buffer-capacity environments. Unlike conventional glass pH electrodes, which are optimised and routinely calibrated in standard laboratory buffer solutions, ANB's electroactive chemistry is engineered to operate in weakly buffered media where hydrogen ion activity and proton-coupled redox equilibria more closely reflect real environmental conditions.

A common question is how accuracy is assured without calibration in standard buffers; instead of traditional buffer-based calibration, ANB sensors are validated and referenced using traceable electrochemical methods and comparison to calibrated glass electrodes under controlled conditions, as well as internal reference tracking to compensate for reference drift in situ. This approach shifts calibration from periodic manual buffer-based adjustment to intrinsic electrochemical self-referencing, enabling reliable long-term deployment in real-world, low-buffer aquatic environments where conventional calibration paradigms are impractical.

Limitations of Glass Electrode Calibration

To illustrate the limitations of conventional calibration-based pH sensing, two commercial glass pH probes were calibrated using standard pH 4, 7, and 10 buffer solutions and subsequently deployed in freshwater and seawater test tanks. Despite identical calibration procedures, the probes produced significantly different readings in both environments, with discrepancies of up to 0.24 pH units in freshwater and 0.11 pH units in seawater. This variability arises from multiple sources inherent to glass electrode calibration, including electrode ageing, reference junction effects, temperature mismatch, ionic strength differences between buffers and real samples, and uncertainties in the buffer solutions themselves [1]. Even certified calibration buffers carry intrinsic uncertainties [2] (typically ±0.02 pH for commercial technical buffers [3]), and these uncertainties propagate directly into subsequent measurements. Furthermore, repeatability limitations in industrial pH systems often constrain achievable accuracy to ~0.1 pH units straight after calibration [4], even under controlled laboratory conditions.

These results highlight that conventional buffer-based calibration does not guarantee accurate or reproducible pH measurements in real-world waters, particularly when probes are transferred between laboratory buffers and low-buffer-capacity environmental samples. In contrast, ANB's calibration-free electrochemical approach is designed to operate directly in low-buffer aquatic environments and incorporates internal reference tracking to mitigate drift, reducing reliance on external calibration procedures that can themselves introduce systematic error.

1. https://nvlpubs.nist.gov/nistpubs/Legacy/SP/nbsspecialpublication260-53e1988.pdf
2. https://www.yokogawa.com/eu/library/resources/white-papers/basics-of-ph-theory
3. https://www.mt.com/us/en/home/library/tips-and-tricks/lab-analytical-instruments/comparison-pH-buffer-accuracy.html
4. https://www.controlglobal.com/network/wireless/article/11380171/instrumentation-maximize-ph-response-accuracy-and-reliability

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Immersion Detection & Smart Power Management

The ANB sensor platform incorporates an integrated immersion detection mechanism that enables intelligent measurement control based on the presence of fluid at the sensing interface. When the sensor detects that it is not immersed in liquid, measurements are automatically suspended and the system enters a low-power sleep state for five minutes before rechecking for immersion. This prevents unnecessary measurements in air, protects the sensing surface, and significantly reduces power consumption during intermittent or splash-exposed deployments. In contrast, conventional glass pH electrodes require continuous hydration and cannot be stored or operated dry without degradation, limiting their suitability for intermittent monitoring scenarios.

The ability to safely tolerate dry conditions and autonomously manage measurement cycles expands the range of applications for the ANB sensor, including event-driven sampling, intermittently submerged environments, and low-power remote deployments where maintenance access is limited.

Maintenance of the AQ² Sensor

Maintenance of the ANB sensor is simple and robust, consisting of a light abrasion of the transducer surface. Over time, the surface molecules become less responsive after numerous electrochemical scans, and this gentle abrasion refreshes the active surface to restore optimal performance. Crucially, the sensor provides a built-in health indicator that informs the user when maintenance is required, removing guesswork and preventing unnoticed sensor degradation. This contrasts with conventional glass pH electrodes, which provide no feedback on sensor health and may continue reporting plausible values even when damaged or malfunctioning.

The required maintenance interval is dependent on measurement frequency, as surface wear is related to the number of scans performed rather than elapsed time. Unlike fragile glass probes, the ANB sensor is mechanically robust, allowing the surface to be abraded without risk of breakage, making it well suited for long-term and field-deployed monitoring applications.

Conclusions

Laboratory testing shows that the AQ² delivers accurate, stable pH measurements without routine user calibration. Against a freshly calibrated glass electrode, the AQ² tracked rapid pH changes from acid and base additions and agreed to within ±0.2 pH across the range tested, in both 10 ppt water and tap water and across several sensors. Extended deployments of 4.5 weeks in freshwater and 6 weeks in seawater confirmed that this performance holds in both low- and high-salinity conditions.

These results come from a different way of measuring pH. ANB's dual working electrode architecture checks the reference electrode before every reading, so drift is corrected in situ rather than building up unseen between calibrations. Our own tests show how much that matters: two glass probes calibrated identically in standard buffers disagreed by up to 0.24 pH in freshwater. For glass, accuracy is known only just after calibration. For the AQ², it is maintained for the whole deployment.

Together with dry-tolerant immersion detection, low-power operation, a built-in health indicator and simple abrasion-based maintenance, this makes the AQ² well suited to long-term, remote and intermittent monitoring. It is a practical choice for coastal and ocean observation, rivers and estuaries, aquaculture and industrial water, where regular calibration is impractical and unknown drift is not acceptable.