

FieldBonnet

Soil Moisture Sensor

THE PROBLEM

Tend Works Co. had a clear vision for a new kind of gardening tool. Their target market of hobbyist gardeners was tired of complicated apps, dashboards, and notifications. They wanted something that would simply sit in the soil and tell them when to water. No screens. No logins. Just an email.

But that simplicity masked real engineering complexity. The product had to measure soil moisture at root depth across four independent sensing zones, survive outdoors for months on a single charge, connect to home WiFi without requiring an app, aggregate data from multiple probes, and deliver a daily email with 15-day moisture trends. All of this had to ship at a \$29.99 consumer price point.

No off-the-shelf sensor platform met these constraints. The product needed to be designed from scratch: electrical hardware, mechanical enclosure, firmware, cloud backend, and packaging.

THE PROPOSED SOLUTION

We proposed a full product development program spanning feasibility study through production qualification, delivering a complete, market-ready IoT device. The architecture centered on an ESP32 wireless module driving a custom capacitive sensing probe with integrated battery management, paired with an AWS cloud backend for automated email delivery.

The program would execute in two major iterations. The first would produce a proof-of-concept with extra sensors and flexibility for user trials. The second would refine the design for manufacturing cost, aesthetics, and operational simplicity based on real-world feedback.

KEY DESIGN DECISIONS

- Capacitive sensing over resistive to eliminate corrosion and extend field life
- ESP32 for WiFi and deep sleep, enabling months of battery on a single charge
- Built-in hotspot for onboarding so users never download an app or create an account
- Daily email digest over push notifications to match the way gardeners actually live
- USB-C rechargeable lithium-ion battery to avoid disposable cells
- 26 plant profiles with tuned moisture thresholds, actionable out of the box

TECHNOLOGIES & EXPERTISE

- ESP32 microcontroller with WiFi, BLE, and ultra-low-power modes
- Custom 4-zone capacitive soil moisture probe design
- Environmental sensors: temperature, pressure, humidity
- Lithium-ion battery management system (BMS)
- AWS IoT / Lambda / SES for cloud email pipeline
- Injection mold tooling for production enclosure



FieldBonnet production unit. Capacitive 4-zone probe with dome housing and USB-C rechargeable battery.

PHASED APPROACH

Stage	Focus
Feasibility Study	Viability
Conceptual Design	Architecture
Front End Engineering	Specifications
Detailed Engineering	Build & Test
Initial Qualification (IQ)	Design Verify
Operational Qualification (OQ)	Performance
Production Qualification (PQ)	Mfg. Release
7 Stages	Concept → Production

DELIVERABLES

Electrical Hardware	Schematic · PCB · BOM
Mechanical Design	Enclosure · Packaging
Embedded Firmware	ESP32 · Deep Sleep
Cloud Infrastructure	AWS · Email Pipeline
Validation	IQ · OQ · PQ

From Proof of Concept to Production

ITERATION 1: PROOF OF CONCEPT

The first iteration prioritized flexibility over cost. We designed a probe with the full sensor suite, including four capacitive moisture zones plus temperature, pressure, and humidity, on a board with extra test points, diagnostic headers, and room to experiment.

This version went through user trials and beta testing with real gardeners. We learned which sensors mattered most, how often users wanted updates, what battery life they actually needed, and how the probe behaved across different soil types and pot sizes.

- Full ESP32 dev board with all environmental sensors
- Oversized enclosure for easy access during testing
- Configurable wake intervals and reporting frequency
- Beta firmware with verbose logging for field diagnostics
- Manual WiFi provisioning and email configuration

ITERATION 2: PRODUCTION REFINEMENT

Armed with field data, we refined everything. The probe was redesigned for injection molding. The enclosure shrank to a sleek dome-and-stake form factor. The board was optimized for manufacturing cost. The firmware was hardened for reliability and battery life was extended from three months to six-to-twelve months through aggressive power management.

The onboarding experience was simplified to a built-in WiFi hotspot and setup wizard that required no app download and no account creation. Twenty-six plant profiles were developed with tuned moisture thresholds so the product worked out of the box for everything from succulents to row crops.

- Production PCB layout optimized for automated assembly
- Injection-molded enclosure with splash-resistant seal
- Retail-ready packaging for direct-to-consumer fulfillment
- Hotspot-based setup wizard that works from any phone browser
- 26 pre-configured plant profiles with actionable thresholds
- AWS email pipeline: daily digest with 15-day trend and battery level

VALIDATION & QUALIFICATION

The product progressed through a structured qualification sequence before manufacturing release.

- Initial Qualification (IQ) to verify the design met all functional specifications
- Operational Qualification (OQ) to validate performance across operating conditions
- Production Qualification (PQ) to confirm manufacturing process repeatability



Production FieldBonnet. Four capacitive sensing zones visible along the probe body.

THE RESULT

Product	FieldBonnet FB-001
Retail Price	\$29.99
Battery Life	3–6 months
Sensing Zones	4-zone capacitive
Plant Profiles	26 built-in
Connectivity	WiFi, no app required
Status	In production

Now available for purchase at tendworks.co.