



Soilo Essence

Portable AI Soil and Water Testing Device

Soilo Essence is a portable field intelligence device for rapid soil and water testing, mobile data capture, geo-tagged records, dashboard reporting and agronomy recommendation workflows. It is designed for field teams, agronomists, distributors, FPOs, enterprises, institutions, carbon MRV teams and sustainability programmes that need structured ground-level data.



Item	Details
Product name	Soilo Essence
Device type	Portable AI-enabled soil and water testing device
Overall observed accuracy	Approx. 97% across tested parameters under defined comparative validation conditions
Core wireless module	Espressif ESP32-WROOM-32E
Battery	Rechargeable 2200 mAh single-cell Li-Po battery
Battery energy	8.14 Wh nominal calculated energy
Mobile app	Soilo mobile app with multilingual workflow support
Dashboard	Dashboard-ready data capture, traceability and reporting workflows
Warranty	3-year free replacement warranty by Soilo, subject to warranty terms

Accuracy and Validation Summary

Specification	Value
Overall device accuracy	Approximately 97% overall observed accuracy across tested parameters, based on comparative evaluation against reference testing values under defined validation conditions.
Validation basis	Readings compared with reference values obtained through standard soil and water testing methods across multiple samples and parameter ranges.
Parameter-level detail	Parameter-wise R2 Value, CV (%), detection range and QC status are provided in the validation table.
Calibration approach	Multi-point calibration approach using certified reference standards. Calibration curve fitted using ordinary least squares (OLS) regression, with R2 recorded before field measurement acceptance.
Field dependency	Field results may vary with sample type, soil type, moisture condition, calibration status, operator handling, probe condition and environmental conditions.

Battery and Power Details

Battery energy is stated in watt-hours because logistics teams and technical evaluators commonly use Wh to understand rechargeable battery capacity. The calculation below assumes a standard single-cell Li-Po nominal voltage of 3.7 V.

Battery item	Value / calculation
Battery chemistry	Rechargeable Li-Po battery
Cell configuration	1S single-cell Li-Po assumed for 3.7 V nominal battery pack
Rated capacity	2200 mAh = 2.2 Ah
Nominal voltage	3.7 V
Full charge voltage	4.2 V typical for a 1S Li-Po cell
Nominal energy	$2.2 \text{ Ah} \times 3.7 \text{ V} = 8.14 \text{ Wh}$
Practical usable energy	Approx. 6.9 to 7.3 Wh after 85% to 90% boost / regulator efficiency
5 V equivalent capacity	Ideal: $8.14 \text{ Wh} / 5 \text{ V} = 1.63 \text{ Ah}$. Practical: approx. 1.38 to 1.46 Ah after conversion loss
3.3 V equivalent capacity	Ideal: $8.14 \text{ Wh} / 3.3 \text{ V} = 2.47 \text{ Ah}$. Practical: approx. 2.10 to 2.22 Ah after conversion loss
Charging input	Type-C rechargeable battery system, final charging current depends on production charging circuit
Energy rating for documentation	8.14 Wh nominal battery energy

Estimated Runtime Calculation

The exact runtime must be measured on the final firmware and PCB. The calculation below is an engineering estimate for this class of ESP32, display and sensor-based field device.

Scenario	Estimated average device load	Estimated continuous runtime from 2200 mAh Li-Po
Light field use / mostly BLE sync	0.8 W	Approx. 8.6 to 9.2 hours
Typical active testing workflow	1.2 W	Approx. 5.8 to 6.1 hours
Heavy use with frequent wireless sync and display active	1.8 W	Approx. 3.8 to 4.1 hours

Power Budget Reference

Power item	Reference / estimate
ESP32-WROOM-32E RF active current	Official ESP32-WROOM-32E datasheet lists Wi-Fi TX average current from 165 mA to 239 mA depending mode, with peak up to 379 mA in 802.11b TX mode; Wi-Fi RX average current is listed around 112 mA to 118 mA.
Sensor and RS485 electronics	Estimated 0.1 W to 0.5 W during active measurement depending input regulation and sensor duty cycle. Final value should be measured on production PCB.
Display, indicator and control electronics	Estimated 0.05 W to 0.25 W depending display brightness, active time and firmware duty cycle.
Total practical device estimate	Approx. 0.8 W to 1.8 W during continuous active field use. Lower average power is possible when the device sleeps between tests.

Parameter-wise Validation Table

The following table provides parameter-wise analytical method, R2 Value, CV (%), detection range and QC status from the evaluation report.

Parameter	Analytical Method	R2 Value	CV (%)	Detection Range	QC Status
pH	Potentiometric (ISFET)	0.9921	1.40%	3.5 - 9.5 pH units	PASS
Temperature	Thermistor (NTC)	0.9968	0.50%	0 - 60 deg C	PASS
Moisture	Capacitive TDR	0.9904	1.80%	0 - 100% VWC	PASS
Electrical Conductivity	Four-electrode probe	0.9887	2.10%	0 - 20 mS/cm	PASS
Salinity	Derived from EC (NaCl equiv.)	0.9871	2.30%	0 - 10 g/L	PASS
Organic Carbon	NIR Spectroscopy	0.9843	2.80%	0.1 - 12%	PASS
Nitrogen (N)	Ion-selective electrode	0.9856	2.60%	5 - 500 mg/kg	PASS
Phosphorus (P)	Colorimetric (Molybdate blue)	0.9834	2.90%	1 - 300 mg/kg	PASS
Potassium (K)	Flame photometry	0.9862	2.50%	10 - 1000 mg/kg	PASS
Boron (B)	Azomethine-H colorimetric	0.9741	3.80%	0.1 - 5 mg/kg	PASS
Zinc (Zn)	DTPA extraction / FAAS	0.9782	3.40%	0.1 - 20 mg/kg	PASS
Magnesium (Mg)	AAS (atomic absorption)	0.9851	2.70%	5 - 500 mg/kg	PASS
Copper (Cu)	DTPA extraction / FAAS	0.9763	3.60%	0.1 - 10 mg/kg	PASS
Molybdenum (Mo)	ICP-OES	0.9712	4.10%	0.01 - 2 mg/kg	PASS
Sulphur (S)	Turbidimetric	0.9836	2.80%	1 - 200 mg/kg	PASS
Iron (Fe)	DTPA extraction / FAAS	0.9813	3.10%	1 - 100 mg/kg	PASS

Interpretation of Validation Indicators

Column	Meaning
Overall accuracy	The report states approximately 97% observed accuracy across tested parameters under defined validation conditions.
R2 Value	Regression fit indicator recorded for the calibration curve. Higher values indicate stronger alignment between calibrated readings and reference values under the tested conditions.
CV (%)	Coefficient of variation. Lower values indicate better repeatability or lower relative variation under the tested conditions.
QC Status	Quality control status recorded in the evaluation table. All listed parameters show PASS status.

Sensor Measurement and Resolution Details

The integrated soil sensor supports rapid field readings over the following component-level ranges and resolutions. Overall device accuracy is stated separately as approximately 97% based on comparative validation.

Sensor item	Value
Measurement parameters	Soil conductivity (EC), temperature, moisture, pH, nitrogen, phosphorus and potassium
EC range	0 - 20,000 uS/cm
Temperature range	-40 deg C to 80 deg C
Moisture range	0 - 100%
pH range	pH 3 - 9
NPK range	0 - 2,999 mg/kg or mg/L
Resolution	EC: 1 uS/cm; temperature: 0.1 deg C; moisture: 0.1%; pH: 0.1; NPK: 1 mg/kg or mg/L
Sensor output	RS485, Modbus-RTU protocol
Default Modbus communication	Baud rate 4800; no parity; 8 data bits; 1 stop bit
Response time	< 1 second
Stabilisation time	<= 5 minutes

Probe and Physical Sensor Details

Item	Specification
Probe type	Five-pin soil multi-parameter sensor
Probe pin length	68 mm
Probe pin diameter	3 mm
Probe material	316L stainless steel
Sensor sealing material	ABS engineering plastic and epoxy resin
Waterproof grade	IP68 at sensor level
Sensor supply voltage	4.5 V to 30 V DC

Measured and Reported Parameters

Parameter group	Parameters
Core agronomic parameters	pH, electrical conductivity, moisture, temperature, salinity, nitrogen, phosphorus and potassium
Soil carbon and micronutrient indicators	Organic carbon, boron, zinc, magnesium, copper, molybdenum, sulphur and iron
Software workflow	Data capture, analysis, geo-tagging, record maintenance, recommendation generation and dashboard-based reporting

Electronics and Connectivity

Item	Specification
Core wireless module	Espressif ESP32-WROOM-32E
Wireless support	2.4 GHz Wi-Fi, Bluetooth and Bluetooth LE
Processor	ESP32 series SoC with Xtensa dual-core 32-bit LX6 processor, up to 240 MHz
Memory variants	4 MB, 8 MB or 16 MB flash variants depending on module configuration
Operating temperature range of module	Standard ESP32-WROOM-32E variants: -40 deg C to 85 deg C; selected high-temperature variants up to 105 deg C depending on ordering code
Module dimensions	ESP32-WROOM-32E module: 18.0 mm x 25.5 mm x 3.1 mm
Internal sensor communication	RS485 / Modbus-RTU sensor interface through device electronics
Mobile workflow	Bluetooth-based field workflow with Soilo mobile application

Software, Dashboard and Data Workflow

Software item	Details
Mobile application	Soilo mobile app for test capture, result viewing, sample records and field workflows
Multilingual support	Multilingual mobile application support available for field teams and farmer-facing workflows
Geo-tagging and records	Supports location-linked data capture, traceability and structured records where enabled
Dashboard	Dashboard-ready data for programme monitoring, agronomy workflows and reporting
Recommendations	Digital crop and agronomy recommendation support through connected software platform
Enterprise integrations	API, dashboard and reporting integrations available for enterprise deployments where configured

Typical Applications

Application area	Use case
Farm advisory	Rapid field-level soil and water testing for advisory and recommendation workflows
Distributor-led services	Soil testing service delivery through distributor, retail and field teams
Institutional programmes	Large-scale soil health, water testing and field data collection programmes
Precision agriculture	Soil monitoring, irrigation planning, nutrient management and field condition tracking
Sustainability and Carbon MRV	Ground-level environmental data collection, evidence records and monitoring workflows
Research and trials	Field screening, experimental plots and comparative field monitoring

Operating Guidance

Guidance	Details
Probe insertion	Insert the probe fully into soil during measurement to reduce operational error and improve consistency.
Hard soil and stones	Do not force the probe into stones or very hard soil to avoid damaging the probe pins.
Removal	Do not remove the sensor by pulling directly on the cable or connected wiring.
Calibration	Use prescribed operating procedure and periodic calibration. Calibration frequency depends on soil type, moisture, salinity, pH, probe condition and field usage.
Field result dependency	Readings may vary with soil heterogeneity, moisture level, insertion depth, compaction, temperature, calibration status and operator handling.

Warranty and Support

Item	Details
Warranty	3-year free replacement warranty by Soilo, subject to warranty terms, eligible usage conditions and non-man-made damage policy.
Training	Training and onboarding support available based on deployment size and commercial agreement.
Support	Support and ticketing workflow available for device usage, deployment and software assistance.
Important distinction	Component-level supplier warranties may differ from Soilo warranty terms. Soilo warranty terms apply to the final Soilo Essence device purchased from Soilo or its authorised channel.

Notes

Soilo Essence is intended for rapid field-level soil and water intelligence, monitoring and digital advisory workflows. For statutory, dispute-related or laboratory-grade certification purposes, results may be supplemented with standard laboratory testing wherever required.

Battery runtime is an engineering estimate based on 2200 mAh, 3.7 V Li-Po energy and practical regulator efficiency assumptions. Final runtime should be verified on the production firmware, charging circuit, display duty cycle, wireless sync behaviour and final PCB configuration.

Specifications may be updated as Soilo improves hardware, firmware, mobile application and dashboard features. Final commercial terms, integrations, regional language support, report formats and enterprise workflows are defined in the quotation, purchase order or agreement.

Reference Documents Used

Reference	Use in datasheet
ICAR Soilo Device Report, dated 29.08.2025	Overall observed accuracy, evaluation language, parameter-wise validation table, R2 Value, CV (%), detection range and QC status.
Five-pin soil multi-parameter sensor manual	Sensor measurement ranges, resolution, Modbus communication, probe material, sensor output and operating guidance.
Espressif ESP32-WROOM-32E / ESP32-WROOM-32UE Datasheet	Wireless module, Wi-Fi, Bluetooth, Bluetooth LE, processor, dimensions, temperature variants and RF active current reference.