SENS-SOIL-BASIC-V1 - Operating Instruction

1. Purpose and Principle of Operation

1.1 Purpose

`SENS-SOIL-BASIC-V1` is a dual-mode LTE-M/NB-IoT telemetry module for soil condition monitoring.

The module is intended for periodic collection and transmission of: - soil temperature - soil moisture - pH - EC - optional GPS position metadata

1.2 Scope of Application

- Precision irrigation scheduling
- Soil chemistry trend monitoring
- Multi-zone field diagnostics
- Remote telemetry from distributed agricultural plots

1.3 General Operating Algorithm

1. The module reads connected soil sensing channels according to schedule.
2. Data is buffered in non-volatile memory.
3. Data is transmitted through LTE-M/NB-IoT at configured intervals.
4. If network is unavailable, data remains buffered and is sent in a later successful session.

2. Specifications

Parameter	Value / Notes
Device type	`SENS-SOIL-BASIC-V1`
Connectivity	LTE-M (Cat-M1), NB-IoT (Cat-NB1/NB2)
Network transport	LTE-M/NB-IoT with fallback and retry policies
Operating temperature	-20 to +85 °C
Standby current (battery mode)	150mk
Dimensions	250 x 30 x 30 mm

Weight	183 g
Sensors	Temperature, moisture, pH, EC
Positioning	GPS profile supported
Service interfaces	Hall sensor trigger
Enclosure class	IP67/IP68 variant-dependent
Firmware updates	OTA supported

3. Device Elements and Connections

3.1 Main Elements

1. Integrated sensor harness (factory-connected)
2. LED indicators
3. Hall sensor zone

3.2 Field Integration Notes

- Keep sensor cable routing separated from high-current switching lines.
- Use stable probe depth and placement per zone for comparable trend analysis.
- Use sealed cable glands to preserve ingress protection.

4. Hall Sensor Actions

Magnet hold time	Action
1-2 s	Show last diagnostics code
2-4 s	Trigger measurement cycle
4-6 s	Trigger cloud communication
6-8 s	Trigger GPS-only cloud communication
15-20 s	Enter warehouse mode
>25 s	Reset storage and device model

Note: A hall sensor interaction also opens the BLE service window for the configured settings timeout.

5. LED Indication

Indicator	Meaning
`INFO`	State and error code patterns
`STATUS`	Cloud connection stage heartbeat

Firmware LED patterns:

LED	Pattern	Meaning
`INFO`	1 blink	Device wake-up/initialization complete
`INFO`	3 blinks (every 60 s)	Warehouse mode active
`INFO`	5 blinks [1 long + 2 shorts]	Entering warehouse mode
`INFO`	10 blinks [3 long + 1 short]	Exiting warehouse mode
`STATUS`	1 blink heartbeat every 3 s	Initialization and SIM/APN checks
`STATUS`	2 blinks heartbeat every 3 s	Requesting full functionality (`CFUN=1`)
`STATUS`	3 blinks heartbeat every 3 s	Network registration
`STATUS`	4 blinks [1 long + 1 short] heartbeat every 3 s	DNS resolution
`STATUS`	5 blinks [1 long + 2 shorts] heartbeat every 3 s	MQTT open
`STATUS`	6 blinks [2 long + 0 shorts] heartbeat every 3 s	MQTT connect
`STATUS`	7 blinks [2 long + 1 short] heartbeat every 3 s	MQTT subscribe

`STATUS`	8 blinks [2 long + 2 shorts] heartbeat every 3 s	Data publish
`STATUS`	9 blinks [3 long + 0 shorts] heartbeat every 3 s	GNSS-only flow

Blink encoding for values above 3 uses mixed long and short blinks:

- short blink: 20 ms ON, 100 ms OFF
- long blink: 100 ms ON, 300 ms OFF

6. Installation and Commissioning

6.1 Installation Sequence

1. Confirm selected module SKU and planned installation point.
2. Follow the RS-485 soil sensor installation procedure from the hardware repository for placement depth and field handling.
3. Install the enclosure and secure it to a stick/pole using the supplied zip ties through top and bottom slots.
4. Keep the factory-connected sensor harness intact and verify only LED/Hall access is needed in routine deployment.
5. Trigger measurement and communication using the Hall sensor.
6. Confirm data in backend dashboard.

6.2 Commissioning Recommendations

- Baseline first 7-14 days before threshold tuning.
- Apply crop and irrigation-zone metadata at commissioning.
- Keep sampling interval stable during baseline period.

7. Data Interpretation and Optimization Guidance

7.1 Baseline Threshold Framework

For the publishable normalization rules used by the Sensorius platform, see the SENS-SOIL-BASIC-V1 Normalization Guide.

Without the Sensorius platform pipeline, exported readings are raw telemetry values and are not automatically normalized. Use these starting bands and adjust by soil type, crop stage, and local

climate:

Parameter	Initial operating band	Adjustment signal
Soil moisture	18-30% VWC (crop/soil dependent)	Raise lower bound during heat stress; lower when drainage risk increases
Soil temperature	12-28 C (crop dependent)	Tighten control around germination and flowering periods
pH	5.8-7.2	Correct with amendment/fertigation when drift persists for >3 samples
EC	1.0-2.5 mS/cm (context dependent)	Lower with flush strategy when salinity trend rises outside target
Sampling interval	15-60 min in active season	Increase frequency during irrigation events or extreme weather windows

7.2 KPI Suggestions for Field Teams

- Moisture-in-target-band time per zone (% of day)
- Irrigation efficiency index (soil moisture gain per applied irrigation minute)
- pH stability (daily/weekly variation vs target range)
- EC deviation events per week and mean recovery time
- Zone anomaly rate (number of outlier zones per 100 zone-days)

8. Agronomic and Industrial Use Cases

Use case	Data-driven control loop	Practical benefit
Precision irrigation scheduling	Moisture trend + forecast window drives start/stop decisions	Reduced water waste and more stable crop stress profile

Greenhouse climate-irrigation balancing	Soil temperature/moisture coupling with ventilation and irrigation routines	Lower root-zone stress during heat and humidity swings
Zone-level anomaly detection	Cross-zone pH/EC/moisture comparison with outlier alerts	Faster detection of leaks, clogging, and uneven nutrient delivery
Fertigation quality guardrail	pH/EC trend checks before and after feed cycles	Better nutrient consistency and reduced corrective interventions
Seasonal transition retuning	Weekly KPI drift review to update irrigation parameters	Smoother adaptation to climate and crop-stage changes

9. Operation and Maintenance

- Inspect sealing and cable strain relief at each service cycle.
- Track battery and communication quality monthly.
- Apply OTA updates using approved release workflow.
- Record firmware version and intervention log after each service visit.