

# SENS-FLOW-CTRL-V1 - Operating Instruction

Installation, commissioning, operation, and diagnostics

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## 1. Purpose and Principle of Operation

SENS-FLOW-CTRL-V1 brings remote control and monitoring together for irrigation and fertigation infrastructure. It can drive external actuators while also tracking pulse or state signals through its digital inputs, so operators can manage flow-related equipment from a distance. This combination supports faster response to changing field conditions and better visibility into what is happening at each site. For distributed installations, it reduces the need for manual checks while making control actions easier to coordinate.

### 1.1 Purpose

SENS-FLOW-CTRL-V1 is a dual-mode LTE-M/NB-IoT field controller for irrigation/fertigation actuation and digital input telemetry.

Primary control and telemetry interfaces: - 12V output with reversible polarity for external actuator control - digital inputs IN1 and IN2 for pulse/state monitoring

### 1.2 Scope of Application

- Irrigation valve control
- Fertigation sequence automation
- Leak/anomaly monitoring using digital input events
- Remote operation of distributed flow infrastructure

## 1.3 General Operating Algorithm

1. Device monitors configured inputs and schedules.
2. Control actions are executed according to policy.
3. Events and measurements are buffered.
4. Data and state changes are sent through LTE-M/NB-IoT.

## 2. Specifications

| Parameter                      | Value / Notes                                 |
|--------------------------------|-----------------------------------------------|
| Device type                    | <b>SENS-FLOW-CTRL-V1</b>                      |
| 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                                         |
| Control output                 | 12V rail with reversible polarity             |
| Digital inputs                 | IN1, IN2                                      |
| 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 cable harness (power, control, and I/O leads)
2. LED indicators
3. Hall sensor zone

### 3.2 Wiring and Safety Notes

- Validate actuator voltage/polarity requirements before connection.
- Confirm IN1/IN2 signal type and debounce settings in configuration.
- Define fail-safe behavior for communication loss scenarios.

## 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                              |

| LED    | Pattern                                             | Meaning        |
|--------|-----------------------------------------------------|----------------|
| STATUS | 6 blinks [2 long + 0 shorts]<br>heartbeat every 3 s | MQTT connect   |
| STATUS | 7 blinks [2 long + 1 short]<br>heartbeat every 3 s  | MQTT subscribe |
| STATUS | 8 blinks [2 long + 2 shorts]<br>heartbeat every 3 s | Data publish   |
| STATUS | 9 blinks [3 long + 0 shorts]<br>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 module SKU and controlled actuator profile.
2. Verify shipped lead set for this variant (power, control output, and IN1/IN2).
3. Install enclosure and route the prewired harness to actuator and field wiring.
4. Verify startup LED sequence.
5. Use the supplied zip ties through top and bottom slots to secure the unit on a stick/pole if required.
6. Test safe monitor-only mode, then enable controlled actuation after telemetry validation.

### 6.2 Commissioning Recommendations

- Start with conservative operation windows.
- Configure anomaly alerts for repeated starts or long runtime.
- Validate command execution feedback before unattended operation.

### 6.3 Baseline Configuration for Reliable Operation

Set initial values and tune after 2-4 weeks of field telemetry:

| Parameter                           | Initial value                                         | Adjustment signal                                                       |
|-------------------------------------|-------------------------------------------------------|-------------------------------------------------------------------------|
| Max valve open time                 | 10-30 min by zone type                                | Decrease when runoff/waste appears; increase when soil deficit persists |
| Minimum off interval between cycles | 5-15 min                                              | Increase when pressure drops or pump over-cycling appears               |
| Input debounce (IN1/IN2)            | 200-500 ms                                            | Increase when noise generates false pulses                              |
| Leak alarm threshold                | 2-5 consecutive abnormal pulses while valve is closed | Lower for critical zones, raise for noisy hydraulic lines               |
| Command retry policy                | 1 immediate retry + alarm on second failure           | Increase retry delay if actuator needs longer settle time               |

## 7. Data Interpretation and Process Actions

### 7.1 Core Telemetry to Track

- `cmd_exec_ok_rate`: % of successful valve/open-close commands
- `valve_runtime_s`: accumulated open duration per cycle
- `input_pulse_count`: pulses from flow or state channel during a control window
- `unexpected_pulse_events`: pulses while actuator should be closed
- `retry_count`: number of command retries per day/zone

### 7.2 KPI Examples for Process Optimization

- Command success rate per zone and shift
- Water delivery per open-minute (pulse efficiency)
- Leak alarm frequency per 100 operating hours
- Average response time from leak alert to valve isolation
- Overrun minutes outside approved irrigation/fertigation windows

## 8. Industrial Use Cases

| Use case                         | Sensor/control signal value      | Optimization outcome                                    |
|----------------------------------|----------------------------------|---------------------------------------------------------|
| Multi-zone irrigation scheduling | Runtime + pulse feedback by zone | Reduced overwatering and more stable crop stress levels |

| Use case                                   | Sensor/control signal value                      | Optimization outcome                                     |
|--------------------------------------------|--------------------------------------------------|----------------------------------------------------------|
| Fertigation batch execution control        | Valve sequence confirmation + cycle timing       | Consistent nutrient dosing and lower chemical waste      |
| District valve sequencing for shared pumps | Coordinated open windows + minimum off intervals | Lower pump stress and reduced peak energy demand         |
| Leak isolation in remote branches          | Unexpected pulse events while closed             | Faster incident response and water-loss reduction        |
| Remote pumping window enforcement          | Command logs vs approved time windows            | Better compliance with utility tariffs and site policies |
| Seasonal retuning of water strategy        | KPI drift across weeks/months                    | Data-driven tuning of schedules and thresholds           |

## 9. Operation and Maintenance

- Inspect wiring terminals and seals each service cycle.
- Review event and command success metrics monthly.
- Revalidate fail-safe policy after firmware changes.
- Apply OTA updates through approved workflow.