SENS-LINK-RS485-V1 - Operating Instruction

1. Purpose and Principle of Operation

1.1 Purpose

`SENS-LINK-RS485-V1` is a dual-mode LTE-M/NB-IoT telemetry bridge for RS-485/Modbus field devices.

Primary integration interfaces: - RS-485 bus (`A` , `B` , `VCC` , `GND`) - digital inputs `IN1` and `IN2`

1.2 Scope of Application

- Legacy Modbus meter and controller integration
- Remote polling and cloud forwarding
- Hybrid deployments with mixed-vendor equipment

1.3 General Operating Algorithm

1. Device powers and initializes RS-485 subsystem on schedule.
2. Polling cycle reads configured Modbus registers from slave devices.
3. Results are buffered locally and sent over LTE-M/NB-IoT.
4. Communication statistics (timeouts/CRC failures) are tracked for diagnostics.

2. Specifications

Parameter	Value / Notes
Device type	`SENS-LINK-RS485-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

Main interface	RS-485 Modbus (`A`, `B`, `VCC`, `GND`)
Digital inputs	`IN1`, `IN2`
Service interfaces	Hall sensor trigger
Enclosure class	IP67/IP68 variant-dependent

3. Device Elements and Connections

3.1 Main Elements

1. Integrated cable harness (RS-485, power, and digital input leads)
2. LED indicators
3. Hall sensor zone

3.2 Wiring Notes

- Connect RS-485 with consistent polarity (`A-A`, `B-B`).
- Match bus settings (baud, parity, stop bits, slave IDs).
- Plan line termination and biasing for long/noisy segments.

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 module SKU and Modbus device list.
2. Verify shipped lead set for this variant (RS-485, power, and digital input channels as applicable).
3. Mount enclosure and route RS-485 and power cables.
4. Use supplied zip ties through top and bottom slots to secure to a stick/pole if required by the field layout.
5. Configure protocol parameters and register map.
6. Verify LED startup and run first polling session.
7. Confirm cloud telemetry and error counters.

6.2 Commissioning Recommendations

- Start with a low polling frequency and scale gradually.
- Validate each slave device independently.
- Investigate CRC/timeouts before production rollout.

7. Polling Strategy and Data Interpretation

7.1 Baseline Polling Strategy

Start with stable read windows and increase only when link quality remains healthy for at least two weeks:

Polling parameter	Baseline value	Adjustment signal
Read interval for slow-changing assets (energy/flow totals)	60-300 s	Decrease only when operations require faster visibility
Read interval for control-critical assets (VFD state,	5-30 s	Increase if timeout/CRC rate rises above target

alarms)		
Per-device request timeout	800-1500 ms	Increase for long cable runs or slow slave response
Retry policy	1 retry after 500-1000 ms	Add second retry only for high-value registers
Bus utilization target	< 40% average duty cycle	Reduce register count or split schedule if exceeded

7.2 Alarm Handling Workflow

1. Classify alarm source: transport (`timeout`, `CRC`) vs process (`out-of-range`, `state mismatch`).
2. Apply first-line action automatically:
   - transport alarm → one controlled retry and bus-health counter update
   - process alarm → create event with last known good value and context tag
3. Escalate when thresholds are exceeded:
   - transport errors > 3 consecutive cycles per slave
   - process alarms persistent for more than 2 configured windows
4. Create maintenance ticket with affected slave ID, register block, and recent quality metrics.
5. Confirm alarm clears after corrective action before closing incident.

7.3 Optimization KPIs

- Successful poll ratio by slave and shift
- Median/95th percentile response latency
- CRC and timeout alarms per 1000 requests
- Data freshness (age of last valid point) for control-critical registers
- Time-to-resolution from alarm trigger to stable telemetry recovery

8. Industrial Use Cases

Use case	Telemetry/control loop	Operational benefit
Power and utility meter consolidation	Periodic read of energy, flow, and pressure totals from legacy Modbus meters	Single remote visibility layer without replacing installed assets

VFD supervision in pumping or process lines	Poll speed/current/fault registers and correlate with run schedule	Early detection of inefficient operation and reduced unplanned downtime
HVAC and boiler/chiller controller monitoring	Read supply/return temperatures, operating modes, and alarm states	Faster response to comfort/process drift and energy optimization
Mixed-vendor production skid diagnostics	Unified register map and alarm normalization across multiple controller brands	Lower troubleshooting time and clearer cross-line comparisons
Remote compliance reporting	Scheduled capture of mandatory operating values with timestamp integrity	Improved audit readiness and reduced manual data collection

9. Operation and Maintenance

- Inspect terminal integrity and shielding/grounding policy.
- Review polling reliability and retry metrics monthly.
- Reconfirm protocol settings after field device replacement.
- Apply OTA updates through approved signed workflow.