Growbud
elemental insight

Flo Controller

4-Zone Irrigation Controller · Modbus RTU · BACnet MS/TP & IP · LoRaWAN · Bluetooth LE

TECHNICAL MANUAL

DOCUMENT	REVISION	FIRMWARE	MODEL
FLO-TM-100	1.0 (July 2026)	v5.x	GROWBUD013

§ Contents

1 Safety Information

> **WARNING: ELECTRICAL**
> Disconnect all power sources before wiring. The 24 VAC input rectifies to approximately 35 V peak internally. Only qualified personnel should install this equipment. Do not exceed the rated input voltage ranges in §2.

> **WARNING: LOADS**
> Valve outputs are rated for solenoid valve coils only (0.6 A RMS per channel AC, 1.5 A peak DC pulses). Do not drive motors, pumps, or resistive heaters directly from valve outputs.

> **NOTE**
> The enclosure is IP-sealed when all M12/M8 connectors are mated or fitted with sealing caps and both antenna bulkheads are torqued. Unused ports must be capped for outdoor installations.

2 Product Overview & Specifications

The Flo Controller is a professional 4-zone irrigation controller for greenhouse, indoor, and field operations. Each of its four valve channels drives either a legacy **24 VAC solenoid** (triac output) or a **latching DC solenoid** (H-bridge pulse output), with per-channel automatic valve-type detection via harness ID. Connectivity spans **LoRaWAN**,

Bluetooth LE (commissioning and BLE-central sensor aggregation), and an industrial **RS-485 port** that operates as a Modbus RTU slave, a Modbus RTU master, or a BACnet MS/TP node. Amazon Sidewalk support is planned COMING SOON.

VALVE ZONES
4
24 VAC triac or latching DC H-bridge, auto-detected

POWER INPUT
USB-C PD / 12 VDC / 24 VAC
USB-C Power Delivery (up to 20 W) is the simplest supply; 12 VDC or 24 VAC also accepted, auto-detected at boot

RS-485 PORT
3 Modes
Modbus slave · Modbus master · BACnet MS/TP

WIRELESS
LoRaWAN + BLE
US915 (EU868 capable) · BLE 2.4 GHz

SCHEDULES
16
Stored on-board, run autonomously offline

OPERATING TEMP
–20…+70 °C
Sealed aluminum enclosure

2.1 Electrical Specifications

PARAMETER	VALUE	NOTES
USB-C input (USB-C PD)	5–20 V USB Power Delivery, up to 20 W	Primary power input; power only, no data. Negotiates PD; recommended when AC valve drive is not required
DC supply input (POWER IN pin 1)	9.0–16.0 VDC, nominal 12 VDC	PTC 2.5 A hold / 5 A trip; reverse protection (ideal diode); TVS clamp
AC supply input (POWER IN pins 3/4)	20–26 VAC RMS, nominal 24 VAC	PTC 3 A hold / 6 A trip; bridge rectified (~35 V peak); MOV + snubber
Supply mode selection	Automatic	Hardware-latched at boot; app selection is advisory only
Valve output, AC mode	0.6 A RMS per channel, 4 channels simultaneous (2.4 A total)	Triac-driven, opto-isolated gating
Valve output, DC mode	1.5 A peak per channel, 9–12 V pulses	Latching solenoid; channels fire staggered (one at a time)
Standby consumption	≤ 250 µA (DC supply) / ≤ 0.5 VA (AC supply)	
Real-time clock	Supercap-backed RTC	Retains time and schedules through power loss
Environment	–20 °C to +70 °C	CISPR 22/32 Class B; FCC Part 15; RoHS/REACH

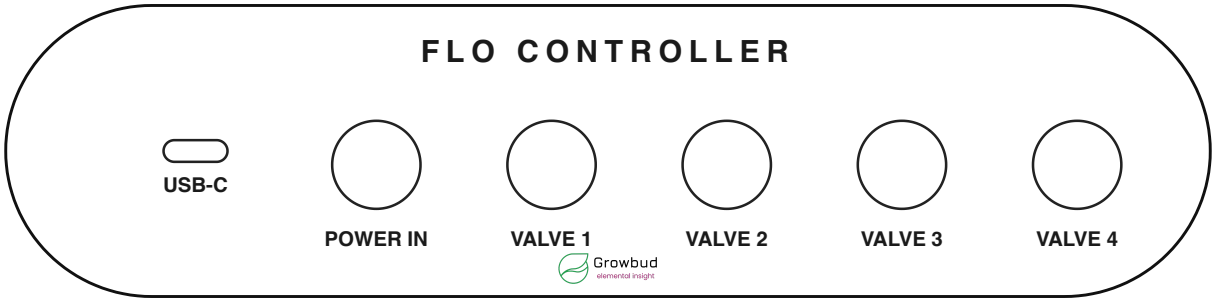
2.2 Mechanical

PARAMETER	VALUE
Enclosure	Obround extruded aluminum, 165 × 40 × 160 mm, gasket-sealed end panels
Panel A (power end)	USB-C power input, M12 POWER IN, 4× M12 valve ports (VALVE 1–4)
Panel B (data end)	M12 RS-485 port, 2× M8 sensor ports (SENSOR 1/2), USER button, 2× SMA antennas (BLE + LoRa)

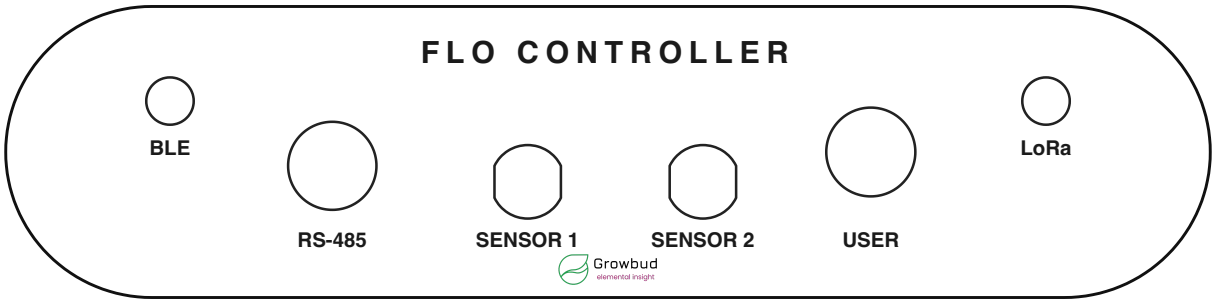
Connectors	M12 A-coded 5-pin (power, valves, RS-485); M8 3-pin (sensors); IP68 rated

3 Hardware & Connector Reference

PANEL A · Power & Valves · shown 1:1 layout, 165 × 40 mm



PANEL B · Data & Sensors · shown 1:1 layout, 165 × 40 mm



3.1 POWER IN (M12 A-coded, 5-pin)

PIN	SIGNAL	DESCRIPTION
1	+12 VDC	DC supply, 9.0–16.0 VDC
2	DC return / GND	DC return, chassis ground
3	24 VAC hot	AC supply, 20–26 VAC RMS
4	24 VAC return	Floating AC return (internal bridge rectifier)
5	Shield	Shield drain to ground

> **NOTE**
> Connect **either** the DC pair (1/2) **or** the AC pair (3/4); not both. The controller detects the powered rail at boot and latches the corresponding valve-drive mode globally for all four channels.

3.2 VALVE 1–4 Outputs (M12 A-coded, 5-pin each)

PIN	SIGNAL	DESCRIPTION
1	Valve Power A	Switched valve drive (relay COM1)
2	Harness ID	Valve-type identification input (pulled up to 3.3 V)
3	Valve Power B	Switched valve drive return (relay COM2)
4	Aux I/O	Flow sensor, leak detect, or auxiliary input
5	Shield	Shield drain to ground

Harness ID Coding

RESISTOR (PIN 2 → GND)	VALVE TYPE
2.2 kΩ	24 VAC solenoid
10 kΩ	Latching DC solenoid
Open (no resistor)	Unknown; channel reports a harness fault

3.3 RS-485 Port (M12 A-coded, 5-pin)

PIN	SIGNAL	DESCRIPTION
1	A (D+)	RS-485 non-inverting
2	B (D–)	RS-485 inverting
3	GND	Signal common
4	Shield	Shield to ground
5	Shield drain	Shield drain to ground

> **BUS DESIGN**
> The port includes on-board **120 Ω termination** and fail-safe bias (560 Ω pull-up on A, 560 Ω pull-down on B). The RS-485 connector carries **no power pin**; third-party Modbus sensors require external power. Half-duplex, up to 247-node addressing in slave mode.

3.4 SENSOR 1 / SENSOR 2 Ports (M8, 3-pin)

Two IP68 M8 ports accept Growbud wired sensor accessories (flow, leak, auxiliary probes). Refer to the sensor accessory datasheet for pinout.

3.5 USB-C Power, Antennas, and Button

- **USB-C:** primary power input. Supplies the controller from any USB-C Power Delivery source (wall adapter, battery bank, or PoE-to-USB injector) up to 20 W. This is power only; the port carries no data. Use it whenever you do not need to drive 24 VAC valves, which most installations will not.
- **SMA (LoRa):** attach the supplied 915 MHz antenna (US ISM band).

- **SMA (BLE):** attach the supplied 2.4 GHz antenna.
- **User button:** illuminated momentary button; used for commissioning (§6) and status indication.

4 Installation & Wiring

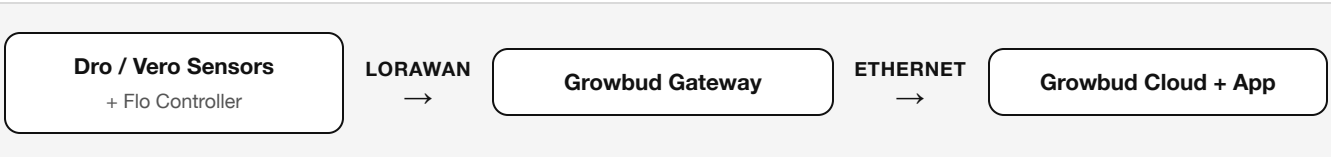
1. **Mount** the enclosure in a sheltered or exposed location (IP-sealed with all ports mated/capped), valve panel facing your irrigation manifold.
2. **Attach both antennas** to the SMA bulkheads on Panel B before applying power.
3. **Wire the valves.** Connect each solenoid to a valve port (VALVE 1–4) using a Growbud valve harness. The harness ID resistor tells the controller whether the valve is 24 VAC or latching DC; all four valves must be of the **same type**, since the AC/DC drive mode is global.
4. **Wire RS-485 (optional).** Daisy-chain A/B/GND with shielded twisted pair. Terminate the far end of the bus with 120 Ω (the Flo end is already terminated).
5. **Apply power.** The simplest option is a USB-C Power Delivery adapter (up to 20 W); this powers the controller for latching DC valves, RS-485, and all wireless functions. If you need 24 VAC valve drive, supply the POWER IN connector instead, using either 12 VDC (pins 1/2) or 24 VAC (pins 3/4). The controller auto-detects the supply and latches AC or DC valve-drive mode for this power cycle.
6. **Verify:** the panel button illuminates and the device appears in the Growbud app for commissioning (§6).

> **WARNING**
> A mode mismatch (e.g., DC valves detected while on AC supply drive mode) raises fault code 12 (§12) and the affected channels are interlocked off.

5 Deployment Configurations

The Flo Controller supports two primary system topologies. Choose one per site; both are managed from the Growbud app.

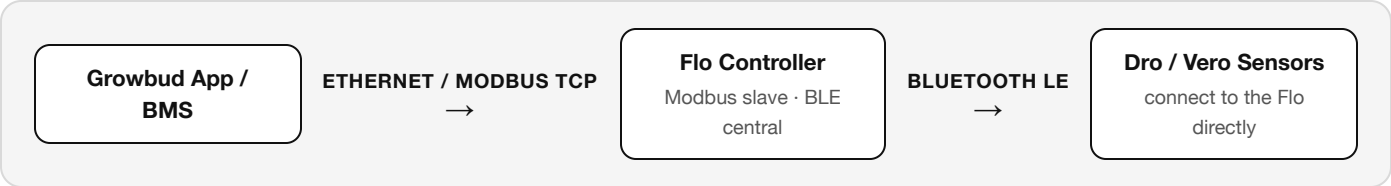
5.1 Configuration A: Wireless LoRaWAN Network



The Flo joins your Growbud gateway over LoRaWAN exactly like Dro and Vero sensors; same commissioning flow, same network. Valve commands, schedule sync, and telemetry travel over LoRaWAN (Class A/C, §10). On-board schedules continue autonomously if connectivity drops.

- Best for: fields, greenhouses, and sites already running a Growbud LoRaWAN network.
- Range: miles per gateway; no wiring beyond power and valves.

5.2 Configuration B: Wired Modbus + BLE Sensor Aggregation



The Flo operates as a **Modbus slave** (register map in §7) and is controlled over Ethernet/TCP directly from the Growbud app or your BMS; no gateway required. In this configuration the Flo also runs in **BLE-central mode**: it scans for and connects to nearby Growbud sensors by itself, aggregating their readings locally and exposing them alongside its own telemetry.

- Best for: indoor facilities with existing wired automation or BMS infrastructure.
- BACnet MS/TP or BACnet/IP (§9) can be used instead of Modbus where the BMS requires it.

5.3 Amazon Sidewalk COMING SOON

A future firmware release will add Amazon Sidewalk support, enabling gateway-free wireless coverage in urban and suburban deployments. No hardware change is required.

6 Commissioning & App Setup

6.1 Unboxing

- **What's included:** Flo Controller, LoRa antenna (915 MHz), BLE antenna (2.4 GHz), and sealing caps for unused ports.
- **Check for damage:** inspect the enclosure, connectors, and antennas for any transit-related issues before installation.

6.2 App Download & Account

- **Get the Growbud app:** search "growbud" in the Apple App Store or Google Play Store, or use the web app in any browser at **www.growbud.app**.
- **Create an account:** an account is required to save your device configuration and telemetry.
- The same app manages your Dro and Vero sensors, gateways, and the Flo Controller from one dashboard.

6.3 Pairing the Flo

1. Apply power (§4) and confirm the panel button illuminates.
2. Press the panel button once; the Flo enters pairing mode and advertises over BLE. The button blinks while pairing mode is active.
3. In the app, choose **Add Device** and select the discovered Flo Controller. As with Growbud sensors, the button press is only needed for this one-time pairing.
4. Name the device and assign it to a room or zone, just like a sensor.

6.4 Configuration

1. Choose the deployment configuration (§5) and the RS-485 port role: **Modbus Slave**, **Modbus Master**, or **BACnet MS/TP** (mutually exclusive).
2. The app pushes the full commissioning package (Modbus, BACnet, LoRaWAN, and schedule configuration) over the BLE config-transfer channel and the device applies it on-board.
3. Assign each valve zone a name and, if fitted, its flow or leak sensor input.
4. **Verify:** use the app to toggle each valve once and confirm the corresponding zone actuates. Live valve state, rail voltages, and board temperature appear on the device page.

> **NOTE**
> Protocol configuration tables (Modbus master maps, BACnet commissioning, LoRaWAN class settings) are currently held in RAM and re-pushed by the app after a power cycle. Persistent on-device configuration storage arrives in a firmware update.

7 Modbus RTU: Slave Mode Register Map

7.1 Protocol Conventions

ITEM	VALUE
Register width	16-bit, big-endian on wire
Addressing	0-based register addresses
Function codes	0x03 Read Holding · 0x04 Read Input · 0x06 Write Single · 0x10 Write Multiple
Slave address	1–247 (configurable at holding register 0x0000); broadcast not supported
Layout	Global block `0x0000`–`0x000F` · per-channel blocks at `0x0010 + ch×0x10` (ch 0–3) · schedule block `0x0050`–`0x005F`

7.2 Input Registers (Read-Only, FC 0x04): Global Block

REGISTER	NAME	TYPE	DESCRIPTION
`0x0000`	fw_version	uint16	Firmware version, e.g. `0x0502` = v5.2
`0x0001`	mode_configured	enum	0 = unknown, 1 = AC, 2 = DC
`0x0002`	mode_detected	enum	0 = unknown, 1 = AC, 2 = DC, 3 = both-rails fault
`0x0003`	device_fault	enum	Device fault code (§12); 11 = leak detected, 12 = mode mismatch
`0x0004`	vboost_mv	uint16	VBOOST rail voltage, mV
`0x0005`	vbus_mv	uint16	VBUS / 24 V rail voltage, mV
`0x0006`	board_temp_c_x10	int16	Board temperature, 0.1 °C units (352 = 35.2 °C)
`0x0007`	schedule_active	bool	1 if any on-board schedule is currently firing
`0x0008`–`0x000F`	reserved	-	Read as 0

7.3 Input Registers: Per-Channel Blocks (base `0x0010 + ch×0x10`)

OFFSET	NAME	TYPE	DESCRIPTION
+0	state	enum	Channel output state
+1	fault	enum	Channel fault code (§12)
+2	level_pct	uint16	Output level, 0–100 %
+3	current_ma	uint16	Measured channel current, mA
+4…+15	reserved	-	Read as 0

Channel bases: ch0 = 0x0010, ch1 = 0x0020, ch2 = 0x0030, ch3 = 0x0040.

7.4 Holding Registers (R/W, FC 0x03/0x06/0x10): Global Block

REGISTER	NAME	TYPE	DESCRIPTION
`0x0000`	slave_address	uint16	1–247; new address applies immediately
`0x0001`	role	enum	RS-485 role: 0 = MASTER, 1 = SLAVE
`0x0002–0x000F`	reserved	-	Writes return ILLEGAL_DATA_ADDRESS

7.5 Holding Registers: Per-Channel Blocks

OFFSET	NAME	DESCRIPTION
+0	cmd_onoff	0 = off, non-zero = on (subject to interlocks)
+1	cmd_level	0–100 %; values > 100 return ILLEGAL_DATA_VALUE
+2	cmd_pulse	Bits 0–14 = pulse duration (ms); bit 15 = polarity (0 = OPEN, 1 = CLOSE)
+3…+15	reserved	Writes return ILLEGAL_DATA_ADDRESS

> **INTERLOCK CHAIN**
> Every Modbus write is routed through the on-board command dispatcher, so hardware interlocks (mode mismatch, over-current, leak detection) gate all external commands identically to app and schedule commands. A refused command returns exception 0x04 (SLAVE_DEVICE_FAILURE).

7.6 Schedule Block: `0x0050–0x005F` (Stage-then-Commit)

Schedules are edited one entry at a time: select an entry with `sel`, stage its fields, then write `commit`.

OFFSET	NAME	DESCRIPTION
+0	sel	Schedule entry selector, 0–15
+1	enabled	0 = disabled, 1 = enabled
+2	ch	Target channel, 0–3
+3	days_mask	Bit 0 = Sunday … bit 6 = Saturday
+4	hour	0–23
+5	minute	0–59
+6	action	0 = ON, 1 = OFF, 2 = PULSE, 3 = LEVEL
+7	duration_s	Action duration, seconds
+8	level_pct	0–100 (LEVEL action)
+9	polarity	0 = OPEN, 1 = CLOSE (PULSE action)
+10	commit	Write-only; commits the staged entry
+11…+15	reserved	-

7.7 Exception Codes

CODE	MEANING
0x01	ILLEGAL_FUNCTION: unsupported function code
0x02	ILLEGAL_DATA_ADDRESS: reserved/unknown register
0x03	ILLEGAL_DATA_VALUE: value out of range
0x04	SLAVE_DEVICE_FAILURE: command refused by interlock

8 Modbus RTU: Master Mode (Third-Party Sensor Polling)

In master mode, the Flo polls up to **8 third-party Modbus devices** on the RS-485 bus, with up to **16 register entries per device**, and forwards engineering-unit values into Growbud telemetry. Register maps are pushed from the Growbud app as a versioned configuration (full-table atomic replacement; a new table must carry a version greater than the current one).

8.1 Per-Device Configuration

FIELD	RANGE / VALUES	NOTES
address	1–247	Slave address of the polled device
baud	e.g. 9600–115200	Applied to the UART per poll session
parity	none / even / odd	Stored for documentation; current firmware operates 8N1
stop_bits	1 / 2	Stored for documentation; current firmware operates 8N1

8.2 Per-Register Entry

FIELD	VALUES	DESCRIPTION
reg_addr	uint16	Register address on the target device
func	0x03 / 0x04	Holding or input register read
word_count	1 / 2	16-bit or 32-bit value
dtype	U16, I16, U32, I32, FLOAT	FLOAT = IEEE-754 single
word_order	ABCD / CDAB / BADC / DCBA	32-bit word/byte ordering
scale, offset	float	engineering value = raw × scale + offset
poll_interval_ms	uint32	Per-register poll period

8.3 Behavior

- **Retries:** 3 attempts with linear 20 ms backoff on timeout/CRC error. A Modbus exception response is terminal (no retry).
- **Framing:** inter-frame silence (t3.5) enforced via UART idle detection.
- **Acknowledgement:** the applied configuration version is echoed in Growbud telemetry so the app can confirm delivery.
- **Power:** the RS-485 port provides no power; externally power all polled sensors.

9 BACnet Integration (MS/TP & BACnet/IP)

The Flo exposes its valve channels as native BACnet objects, either directly on RS-485 as a **BACnet MS/TP** node (ANSI/ASHRAE 135 Clause 9), or as **BACnet/IP** via the Growbud gateway (Annex J). MS/TP occupies the RS-485 port exclusively; it cannot run simultaneously with Modbus modes.

9.1 MS/TP Data Link Settings

PARAMETER	RANGE	DEFAULT
MAC address	0–127	1
Baud rate	9600 / 19200 / 38400 / 76800	38400
Max master	1–127	127
Max info frames	configurable	1

9.2 Device & Object Model

OBJECT	INSTANCES	ACCESS	FUNCTION
Device	configurable (default 300001)	-	Device identity; Who-Is / I-Am supported
Binary Output (BO)	BO:0 – BO:3	Commandable	Valve channel on/off, full 16-slot priority array
Analog Output (AO)	AO:0 – AO:3	Commandable	Channel output level, 0–100 %

Supported services (v1): Who-Is / I-Am, ReadProperty (Present_Value), WriteProperty with priority array per ASHRAE 135 Clause 19.2.3. Writes flow through the same interlock dispatcher as Modbus and app commands. Max APDU 1476, segmentation not supported. ReadPropertyMultiple and COV subscriptions are planned.

9.3 Commissioning Configuration

BACnet settings are pushed from the Growbud app as a versioned commissioning package:

FIELD	VALUES / RANGE	DEFAULT
enabled	on / off	off
transport	BACnet/IP or MS/TP	-
device_instance	0 – 4194302	300001
device_name	up to 32 characters	-
udp_port (IP)	UDP port	47808 (0xBAC0)
bbmd_enabled / bbmd_address (IP)	BBMD registration	disabled
mstp_mac / mstp_baud / mstp_max_master	see §9.1	1 / 38400 / 127
points	up to 32 mapped points (AI / AO / AV / BO)	-

Validation rejects writable flags on non-commandable object types (AI/AV) and duplicate (object type, instance) pairs. Vendor ID is provisional pending ASHRAE registration.

10 LoRaWAN Configuration

PARAMETER	VALUE
MAC version	LoRaWAN 1.0.3
Activation	OTAA (DevEUI, JoinEUI/AppEUI, AppKey)
Region	US915, sub-band 2 (channels 8–15 + 65); EU868 configurable
Device class	Class C (continuous receive, default) or Class B (ping slots ≤ 8 s)
Uplink interval	Default 60 s, minimum 15 s, configurable
Uplink types	Confirmed and unconfirmed; downlinks dispatch valve/schedule/config commands

Device identity (DevEUI) is printed on the product label and surfaced in the Growbud app during commissioning. Class and uplink-interval configuration is versioned and acknowledged in telemetry, like the Modbus and BACnet packages.

11 On-Board Scheduling

Sixteen schedule slots run directly on the controller against the supercap-backed real-time clock, so irrigation continues through network outages. Each entry defines: target channel, weekday mask, start time (hour:minute), action (ON / OFF / PULSE / LEVEL), duration, level percentage, and pulse polarity.

- Schedules can be managed from the Growbud app (any deployment configuration), over Modbus (§7.6), or via LoRaWAN downlink.
- The global input register `schedule_active` (0x0007) reports when any schedule is firing.
- Committed schedules persist on the device.

12 Troubleshooting & Fault Codes

SYMPTOM / CODE	CAUSE	ACTION
Fault 12: mode mismatch	Detected supply (AC/DC) conflicts with connected valve type	Match supply and valves; power-cycle to re-latch drive mode
Fault 11: leak detected	Leak input asserted on a valve Aux I/O pin	Inspect the zone; clear condition, then re-enable the channel
mode_detected = 3	Both AC and DC rails energized	Disconnect one supply pair at POWER IN
Channel harness fault	Harness ID open / unrecognized resistor	Check valve harness pin 2 ID resistor (§3.2)
Modbus exception 0x04	Interlock refused the command	Read device_fault (0x0003) and channel fault registers

No Modbus response	Wrong role, address, or wiring	Verify role (holding 0x0001), slave address, A/B polarity, termination
MS/TP token loss	Baud or max_master mismatch	Align baud (9600/19200/38400/76800) and max_master across bus
No LoRaWAN join	Wrong sub-band or keys	Confirm gateway on US915 sub-band 2; re-check OTAA keys in app
Config lost after power cycle	Protocol config tables are RAM-resident in current firmware	Keep the Growbud app connection active; it re-pushes config automatically

13 Compliance, Warranty & Support

- **EMC:** CISPR 22/32 Class B; FCC Part 15.
- **Materials:** RoHS and REACH compliant.
- **Radio:** 902–928 MHz US ISM (LoRa) and 2.4 GHz (BLE).
- **Warranty:** 1-year limited warranty; 90-day return policy.
- **Support:** support@growbud.io · growbud.io/guides