Growbud
elemental insight

Growbud Controller

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

TECHNICAL MANUAL

DOCUMENT	REVISION	FIRMWARE	MODEL
GBC-TM-100	1.1 (August 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 drive solenoid coils and other low-voltage loads (small pumps, fans, dosing heads, heaters) within the channel ratings: AC up to 1.35 A RMS per channel and 2.4 A across the controller; DC current-limited to a 3 A pulse, 1.35 A continuous per channel and 2.5 A total. For loads beyond these ratings, or any mains-voltage equipment, switch through a relay (a dry-contact relay coil is itself a valid output load). Every channel and both supply inputs carry self-resetting PTCs, but those protect the board, not the load. 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 Growbud 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), selected once per power cycle as a single global AC/DC drive mode. Connectivity spans **LoRaWAN**, **Bluetooth LE** (commissioning and BLE-central sensor aggregation), and an industrial **RS-485 / CAN** port that operates as a Modbus RTU slave, a Modbus RTU master, a CANopen master or slave, or a BACnet MS/TP node. Amazon Sidewalk support is planned.

VALVE ZONES

4

24 VAC triac or latching DC H-bridge, one global mode

POWER INPUT

USB-C PD / 12 VDC / 24 VAC

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

RS-485 / CAN PORT

5 Modes

Modbus slave/master · BACnet MS/TP · CANopen slave/master · 2 A fused sensor power

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

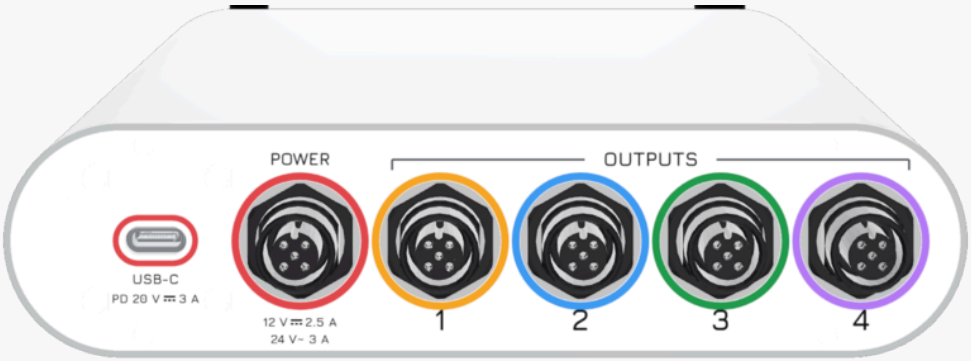
PARAMETER	VALUE	NOTES
Valve output, AC mode	Up to 1.35 A RMS per channel, 2.4 A total across all channels	Triac-driven, opto-isolated gating. A channel is bounded by its own 1.35 A PTC, the controller by the 3 A supply-input PTC; 2.4 A keeps margin for PTC derating at high ambient. Four channels at 0.6 A each is the all-on case, but any mix within the totals is valid, so several coils may share one output
Valve output, DC mode	Current-limited at 3 A pulse / up to 1.35 A continuous per channel, 2.5 A total, 9–16 V	H-bridge current regulation is set in hardware to 3 A, so pulse current is limited by the driver rather than by the coil. Continuous draw is bounded by the per-channel 1.35 A PTC and by the 2.5 A DC supply input, so 1.35 A is a single-channel figure and not four times over. Latching solenoids fire staggered (one at a time). Contact A is positive, B negative (§3.2)
Circuit protection	Regulated H-bridge current + self-resetting PTCs	DC pulse current is regulated at 3 A by the H-bridge. PTCs: 1.35 A per valve channel, 2.5 A on the DC input, 3 A on the AC input. Auto-reset: an overload clears once the fault is removed, with no fuses to replace.
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

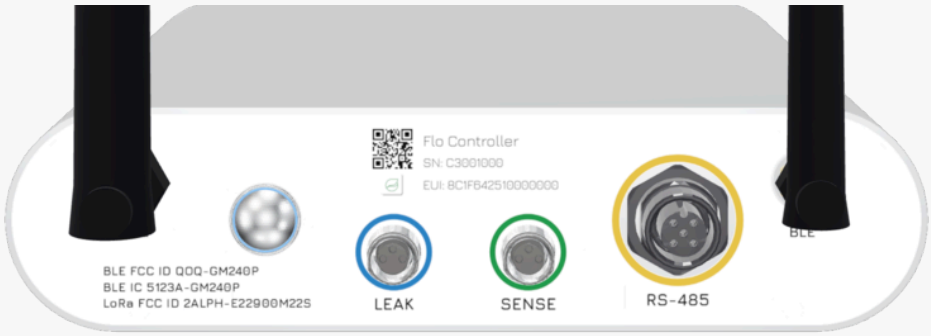
PARAMETER	VALUE
Enclosure	Obround extruded aluminum, 165 × 40 × 160 mm, gasket-sealed end panels
Panel A (power end)	USB-C power input, M12 POWER IN, 4× M12 valve ports (VALVE 1–4)
Panel B (data end)	M12 RS-485 port, 2× M8 sensor ports (LEAK / SENSE), USER button, 2× SMA antennas (BLE + LoRa)
Connectors	M12 A-coded 5-pin (power, valves, RS-485); M8 3-pin (sensors); IP68 rated

3 Hardware & Connector Reference

PANEL A | POWER + OUTPUTS | PRODUCTION UNIT



PANEL B | DATA + ACCESSORIES | PRODUCTION UNIT



Printed markings are authoritative: LEAK and SENSE are the M8 accessory inputs; the adjacent push button is USER.

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

PIN	SIGNAL	DESCRIPTION
1	+12 VDC	DC supply, 9.0–16.0 VDC
2	DC return / GND	DC return and chassis ground
3	24 VAC hot (R)	AC supply, 20–26 VAC RMS. In HVAC terms this is the red R power leg.
4	24 VAC return (C)	Floating AC return (internal bridge rectifier). The HVAC C common.
5	NC	Not connected

> **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 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 conductor A (+ in DC)	Switched valve drive terminal A; **positive** in latching-DC mode. Brown conductor.
2	NC	Not connected
3	Valve conductor B (– in DC)	Switched valve drive terminal B; **negative** in latching-DC mode. Blue conductor.
4	NC	Not connected
5	NC	Not connected

> **DC SOLENOID POLARITY**
>
> In latching-DC mode, contact A (pin 1, brown) is positive and contact B (pin 3, blue) is negative. On a typical DC latching solenoid this is **RED TO BROWN, BLACK TO BLUE**. Reversed polarity will not damage the solenoid, but it swaps which pulse opens the valve and which closes it: the zone runs inverted, and the controller reports OPEN while the valve is actually shut. If a zone behaves backwards, swap A and B.

> **AC MODE**
>
> In AC mode polarity does not apply. The output is simply energised or de-energised, so A and B may be connected either way round. Only latching-DC drive depends on wiring order for open versus closed.

> **GLOBAL DRIVE MODE**
>
> The controller selects one global AC/DC valve mode for all four outputs. Contacts 2, 4 and 5 are not connected; standard 5-conductor cordsets work, with the white, black and grey conductors unused.

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

One wired port, two buses. Pins 4/5 carry either the RS-485 pair or the CAN pair depending on the configured mode, on the industrial-standard CAN pin assignment, so off-the-shelf CAN cordsets wire in directly on a colour-equivalence basis (see CORDSET COLOURS). Wired modes are mutually exclusive: Modbus RTU master, Modbus RTU slave, BACnet MS/TP, or **CANopen (master or slave)**.

PIN	SIGNAL	DESCRIPTION
1	NC	Not connected
2	V_OUT (V+)	Sensor power out: 9–16 V, up to 2 A, auto-reset fuse. White conductor (IEC).

PIN	SIGNAL	DESCRIPTION
3	GND	Power and bus return. Blue conductor (IEC).
4	RS485_A / CAN_H	RS-485 A in Modbus / BACnet modes; CAN_H in CANopen mode. Black conductor (IEC).
5	RS485_B / CAN_L	RS-485 B in Modbus / BACnet modes; CAN_L in CANopen mode. Grey conductor (IEC).

> **CORDSET COLOURS**
> Standard IEC A-coded cordsets: white (2) is V+, blue (3) is GND, black (4) is A / CAN_H, grey (5) is B / CAN_L. On CAN cable with DeviceNet-style colours the equivalents are red to pin 2, black to pin 3, white to pin 4, and blue to pin 5.

> **SENSOR / ACTUATOR POWER**
> Pin 2 supplies up to 2 A behind an auto-reset fuse, so a bus sensor or CANopen actuator can run from the same cordset with no separate supply.

> **BUS DESIGN**
> Fit the 120 Ω termination jumper only when the controller sits at the end of the bus; CAN and RS-485 both require termination at the two bus ends. RS-485 is half-duplex with up to 247-node addressing in slave mode. In CANopen mode the controller runs as an NMT master commanding actuators and remote I/O, or as a slave device on an existing industrial network.

3.4 SENSE / LEAK Ports (M8 A-coded, 3-pin)

PIN	SENSE (UNIVERSAL INPUT)	LEAK (PROBE)
1	12 V switched excitation; 0.2 A PTC	Probe electrode A (pulsed excitation)
3	Sensor return / GND	GND; unused by 2-wire probe
4	0–10 V, pulse/contact, or 4–20 mA	Probe electrode B (conductivity sense)

> **NOTE**
> SENSE input mode is set during commissioning. LEAK is a dedicated two-electrode detector; it is not a second universal input and does not provide sensor power.

3.5 USB-C Power, Antennas, and Button

USB-C: primary power input from any USB-C Power Delivery source up to 20 W. Power only, no data. Use it whenever you do not need to drive 24 VAC valves.

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.

3.6 Connector Pinout Reference

Front (mating-face) views of each receptacle. Pin fills show IEC 60947-5-2 conductor colours for standard A-coded cordsets: 1 brown, 2 white, 3 blue, 4 black, 5 grey. The keyway at 12 o'clock orients the plug.

GROWBUD CONTROLLER · J1

Power input

M12 A-coded input · separate DC and floating AC pairs

DEVICE FRONT VIEW — looking into the female receptacle; cable plug face is mirrored

TOP / A-CODE INDEX

M12 A-coded · 5-contact female receptacle

Contact numbers are physical connector numbers

PIN	SIGNAL	FUNCTION / LIMIT
1 BROWN	VDC_IN +12 VDC	9–16 VDC input
2 WHITE	GND DC return	DC return / circuit ground
3 BLUE	VAC_HOT 24 VAC hot	20–26 VAC RMS input
4 BLACK	VAC_RETURN 24 VAC return	Floating AC return; not DC ground
5 GREY	SHIELD Cable drain	Shield drain tied to controller GND

INSTALLATION NOTES

- IEC blue normally means 0 V. On J1 it does not — contact 3 is 24 VAC hot. Never treat the blue conductor here as a return.
- Never bond contact 4 to contact 2 in the cable; the AC input is differential.
- Use either the DC pair (1/2) or the AC pair (3/4), not both supplies at once.

Generated from the product connector template · R&D pinout review — 2026-08-03

Do not wire from the cable-side view without mirroring

GROWBUD CONTROLLER · J10 / J11 / J12 / J13

Valve outputs 1–4

M12 A-coded valve output · AC or latching-DC mode

DEVICE FRONT VIEW — looking into the female receptacle; cable plug face is mirrored

TOP / A-CODE INDEX

M12 A-coded · 5-contact female receptacle

Contact numbers are physical connector numbers

PIN	SIGNAL	FUNCTION / LIMIT
1 BROWN	VALVE_A_n Valve conductor A	Switched valve drive terminal A
2 WHITE	NC Not connected	Not connected
3 BLUE	VALVE_B_n Valve conductor B	Switched valve drive terminal B
4 BLACK	NC Not connected	Not connected
5 GREY	SHIELD Cable drain	Shield drain tied to controller GND

INSTALLATION NOTES

- The controller selects one global AC/DC valve mode for all four outputs.

Generated from the product connector template · R&D pinout review — 2026-08-03

Do not wire from the cable-side view without mirroring

GROWBUD CONTROLLER · J14

RS-485

M12 A-coded half-duplex RS-485 service / expansion bus

DEVICE FRONT VIEW — looking into the female receptacle; cable plug face is mirrored

TOP / A-CODE INDEX

M12 A-coded · 5-contact female receptacle

Contact numbers are physical connector numbers

PIN	SIGNAL	FUNCTION / LIMIT
1 BROWN	RS485_A Bus A	Non-isolated RS-485 line A
2 WHITE	RS485_B Bus B	Non-isolated RS-485 line B
3 BLUE	GND Bus reference	Circuit-ground reference
4 BLACK	SHIELD Shield / drain	Tied to controller GND
5 GREY	SHIELD Cable drain	Redundant shield drain tied to GND

INSTALLATION NOTES

- J14 does not provide sensor power; an RS-485 sensor needs a separate supply.
- Fit the 120 Ω termination jumper only when the controller is at the end of the bus.

Generated from the product connector template · R&D pinout review — 2026-08-03

Do not wire from the cable-side view without mirroring

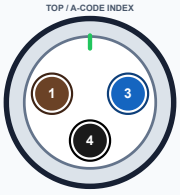
GROWBUD CONTROLLER · J16

Universal sensor input

M8 A-coded input · analog, pulse/dry-contact, or 4–20 mA

DEVICE FRONT VIEW — looking into the female receptacle; cable plug face is mirrored

TOP / A-CODE INDEX



M8 A-coded · 3-contact female receptacle

Contact numbers are physical connector numbers

PIN	SIGNAL	FUNCTION / LIMIT
1 BROWN	SENSOR_PWR Switched excitation	12 V nominal; 0.2 A-hold PTC
3 BLUE	GND Sensor return	Circuit-ground return
4 BLACK	SENSOR_IN1 Universal signal	0–10 V, ≤300 Hz pulse/contact, or 4–20 mA

INSTALLATION NOTES

- Input mode is configured by stuffing/firmware; do not assume all modes simultaneously.
- 4–20 mA mode switches in a 150 Ω burden: 0.6–3.0 V at the input and 0.18–0.90 V after the ADC divider.
- Dry-contact/open-collector mode uses a 3.3 V pull-up; the sensor closes to GND.

Generated from the product connector template · R&D pinout review — 2026-08-03

Do not wire from the cable-side view without mirroring

GROWBUD CONTROLLER · J18

Leak probe

M8 A-coded dedicated two-electrode leak detector

DEVICE FRONT VIEW — looking into the female receptacle; cable plug face is mirrored

TOP / A-CODE INDEX

M8 A-coded · 3-contact female receptacle

Contact numbers are physical connector numbers

PIN	SIGNAL	FUNCTION / LIMIT
1 BROWN	LEAK_EXCITE Probe electrode A	Microamp-class pulsed excitation
3 BLUE	GND Cable reference	Circuit ground; normally unused by 2-wire probe
4 BLACK	LEAK_PROBE_SENSE Probe electrode B	Dedicated conductivity-sense input

INSTALLATION NOTES

- J18 is not a second universal sensor input and does not provide SENSOR_PWR.
- Connect the two passive probe electrodes to contacts 1 and 4.

Generated from the product connector template · R&D pinout review — 2026-08-03

Do not wire from the cable-side view without mirroring

> **CAUTION · POWER IN (J1)**
>
> IEC blue normally means 0 V. On J1 it does not: contact 3 (blue) is 24 VAC hot. Never treat the blue conductor at the power inlet as a return, and never bond contact 4 to contact 2 in the cable.

4 Installation & Wiring

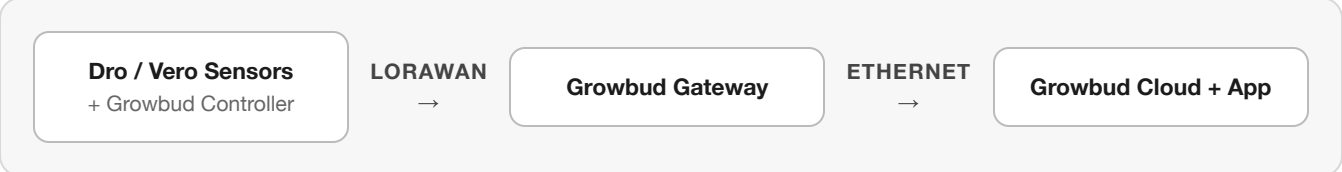
1. **Mount** the enclosure in a sheltered or exposed location (IP-sealed with all ports mated/capped), valve panel facing your irrigation manifold.
2. **Attach both antennas** to the SMA bulkheads on Panel B before applying power.
3. **Wire the valves.** Connect each solenoid to a valve port (VALVE 1–4) using a Growbud valve harness. The controller drives all four valves in one global AC/DC mode; there is no per-port sensing, so all valves must be of the same type, never mixing 24 VAC and latching DC on one unit. **For latching DC solenoids observe polarity:** contact A (brown) is positive and contact B (blue) is negative, so a typical solenoid wires red to brown and black to blue. Getting it backwards is not damaging, but it reverses open and close (§3.2). Polarity is irrelevant in AC mode.
4. **Wire the bus (optional).** Daisy-chain pins 4/5 plus GND with shielded twisted pair — RS-485 A/B for Modbus or BACnet, CAN_H/CAN_L for CANopen. Terminate both bus ends with 120 Ω (fit the controller's termination jumper only at the bus end). Pin 2 can power a bus device: 9–16 V, up to 2 A, auto-reset fused.
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 Growbud Controller supports two primary system topologies. Choose one per site; both are managed from the Growbud app.

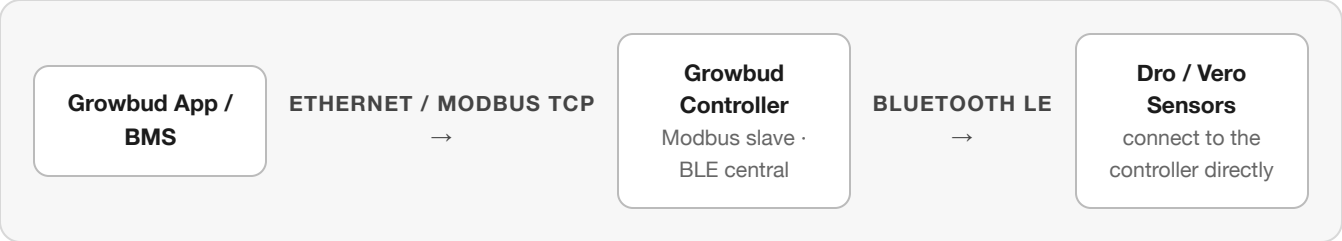
5.1 Configuration A: Wireless LoRaWAN Network



The controller 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 controller 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 controller 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:** Growbud 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 Growbud Controller from one dashboard.

6.3 Pairing the Controller

1. Apply power (§4) and confirm the panel button illuminates.

2. Press the panel button once; the controller 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 Growbud 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 wired port role: Modbus Slave, Modbus Master, CANopen Master, CANopen Slave, 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

OFFSET	NAME	TYPE	DESCRIPTION
+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

OFFSET	NAME	DESCRIPTION
+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 controller polls up to 128 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 controller 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

FIELD	VALUES / RANGE	DEFAULT
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 probe on the LEAK (J18) input asserted	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

SYMPTOM / CODE	CAUSE	ACTION
Channel output fault	Open or short detected on the valve output	Check valve wiring and coil (§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