



Growbud Controller

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

TECHNICAL MANUAL

DOCUMENT	REVISION	FIRMWARE	MODEL
GBC-TM-100	2.1 (September 2026)	v5.x	GROWBUD013

§ Contents

1	Safety Information
2	Product Overview & Specifications
3	Hardware & Connector Reference
4	Installation & Wiring
5	Deployment Configurations
6	Commissioning & App Setup
7	Modbus RTU: Slave Mode Register Map
8	Modbus RTU: Master Mode (Third-Party Sensor Polling)
9	BACnet Integration (MS/TP & BACnet/IP)
10	LoRaWAN Configuration
11	On-Board Scheduling
12	Troubleshooting & Fault Codes
13	Compliance, Warranty & Support

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: in AC mode up to 1.35 A RMS per channel (about 0.95 A at 50 °C) and about 2.2 A across all four channels together, which is the shared-fuse ceiling and the one that bites first; in DC mode a 2.99 A peak pulse, one channel at a time. All four zones can be held on together as long as the coils sum to under that ceiling: about 0.5 A holding each, which most modern irrigation solenoids meet — see §2.1. 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 sealed to IP67 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. IP67 covers temporary immersion; it does not cover permanent submersion or pressure washing.

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. **Every one of those four ports is also a universal sensor input** — flow meter, 4–20 mA loop, 0–10 V or 0–3.3 V — and a port does both at once, so a zone's flow meter can share the port and cable with its valve. Firmware v5.x samples one sensor port at a time, selected at runtime along with its input mode (§3.2). Two identical **leak probe** ports round out the I/O. Connectivity spans **LoRaWAN**, **Bluetooth LE** (commissioning and BLE-central sensor aggregation), and an industrial **fieldbus** port that runs CAN (CANopen master or slave) or Modbus RTU / BACnet MS/TP over RS-485.

VALVE / SENSOR PORTS

4

Each port drives a valve (24 VAC triac or latching DC) or reads a universal sensor — firmware-selected per port

POWER INPUT

USB-C PD / DC / 24 VAC

USB-C PD (up to 20 W) is the simplest supply; 9–30 VDC or 24 VAC also accepted, auto-detected at boot

FIELDBUS PORT

CAN or RS-485

CAN (FD capable) / CANopen · or Modbus RTU slave/master · or BACnet MS/TP · plus switched 12 V / 0.75 A power out

LEAK PROBES

2

Two identical M8 ports; either port takes either probe

SCHEDULES

16

Stored on-board, run autonomously offline

WIRELESS

LoRaWAN + BLE

US915 (EU868 capable) · BLE 2.4 GHz

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)	9–30 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 — per	1.35 A RMS (about 0.95 A at 50 °C)	Triac-driven, opto-isolated gating. Set by that channel's own self-resetting PTC

PARAMETER	VALUE	NOTES
channel		
Valve output, AC mode — all four together	About 2.2 A at 50 °C	The real ceiling. All four channels and the board supply share one 3 A input PTC, and 2.2 A is what it passes once derated for a warm enclosure. Four zones at once is fine when the coils sum to less than this. See SIMULTANEOUS AC ZONES below
Valve output, DC mode	2.99 A peak, pulse only — 30–100 ms, one channel at a time	Set by the H-bridge current-trip threshold, not by a fuse, so the pulse is limited by the driver rather than by the coil. Latching solenoids fire one at a time. Contact A is positive, B negative (§3.2)
Circuit protection	H-bridge current trip + self-resetting PTCs	PTCs on each valve channel, on the shared AC input, and on the DC input. Auto-reset: an overload clears once the fault is removed and the part cools. No fuses to replace
PTC derating	Hold currents fall as the enclosure warms	Every PTC figure here is quoted at 50 °C, not at the 20–25 °C of a datasheet headline. A sealed aluminum enclosure in the sun runs well above room temperature, so design to the derated numbers
Sensor input (valve ports 1–4, pin 4)	Pulse / dry contact / hall-effect flow · 4–20 mA · 0–10 V · 0–3.3 V	Mode is firmware-selected at runtime. The sensor input is independent of the valve drive on the same port, so a port drives a valve and reads a sensor together. Firmware v5.x samples one sensor port at a time
Sensor excitation (valve ports 1–4, pin 2)	Switched 12 V	Powers the sensor on that port from the same cordset
Fieldbus power out (J14 contact 2)	12 V, up to 0.75 A	Switched in firmware, current-monitored, auto-reset fused (0.75 A hold / 1.5 A trip). The limit is set by fuse coordination with the supply-input protection, not by the load
Leak probe inputs	2 × two-electrode conductivity probe	J16 and J18 are identical; either port takes either probe
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

SIMULTANEOUS AC ZONES — SIZING SOLENOIDS

All four zones can run at the same time. Firmware places no limit on how many channels are energised together; the limit is electrical. All four AC channels and the board supply draw through one shared input PTC, which passes about **2.2 A** once derated for a warm enclosure, so the four holding currents must sum to less than that: about **0.5 A per coil**. Most current irrigation solenoids from the major brands hold at 0.2–0.4 A, so four of them together is well inside the limit. Older or heavy-duty coils that hold at 0.6 A or more come to roughly 2.4 A for four, which is over it: for those, stagger the zones (the on-board scheduler does this for you, §11) or choose lower-current solenoids. If the sum is exceeded the PTC trips: the zones drop out, and it resets by itself once the

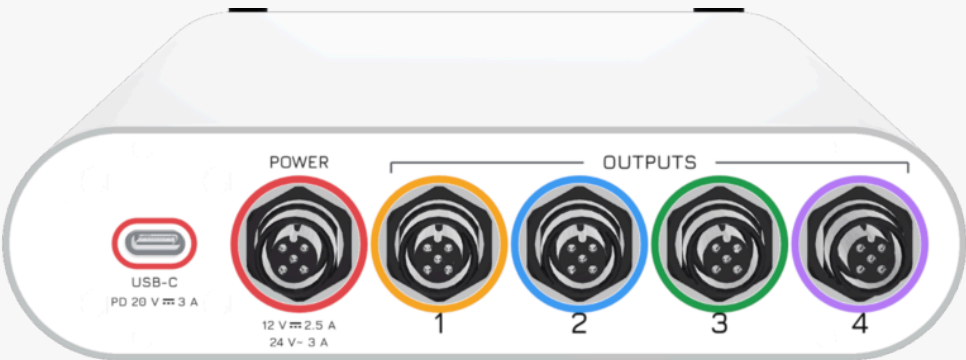
part cools. That is a nuisance trip, not a failed board — report it rather than replacing anything. Check the holding current on the solenoid you actually buy.

2.2 Mechanical

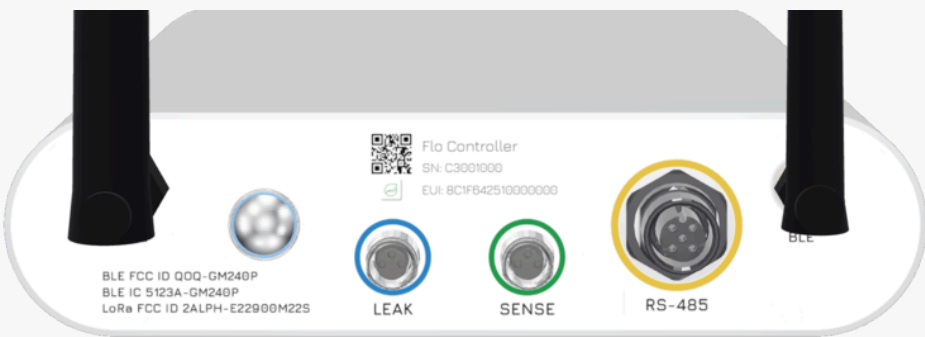
PARAMETER	VALUE
Enclosure	Oround extruded aluminum, 165 × 40 × 160 mm, gasket-sealed end panels; IP67 with all ports mated or capped
Panel A (power end)	USB-C power input, M12 POWER IN, 4× M12 valve / sensor ports (VALVE 1–4)
Panel B (data end)	M12 fieldbus port, 2× M8 leak probe ports, USER button, 2× SMA antennas (BLE + LoRa)
Connectors	M12 A-coded 5-pin (power, valve/sensor, fieldbus); M8 A-coded 3-pin (leak probes); IP67 mated

3 Hardware & Connector Reference

PANEL A | POWER + VALVE / SENSOR PORTS



PANEL B | FIELDBUS + LEAK PROBES



The renders above are pre-production and some panel legends differ from the shipping product: both M8 ports are leak probe inputs, and the M12 port marked RS-485 is the dual CAN / RS-485 fieldbus port. Follow the pin tables in this section rather than the legend in the render. The illuminated push button beside the M8 ports is USER.

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

PIN	SIGNAL	DESCRIPTION
1	DC in	DC supply, 9–30 VDC
2	DC return / GND	DC return and circuit ground
3	24 VAC hot (R)	AC supply, 24 VAC. 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.

PIN	SIGNAL	DESCRIPTION
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.

CABLE SHIELDS

Contact 5 is unconnected by design, and so is contact 1 on the fieldbus port (§3.3). A cable shield terminates at **one end only, off the controller**; the controller does not ground shield pins. Do not land a drain wire on either contact expecting a ground path.

3.2 VALVE / SENSOR Ports 1–4 (M12 A-coded, 5-pin each)

Each of the four ports does two jobs at the same time. It drives a valve on contacts 1/3, and it reads a sensor on contact 4 with switched 12 V excitation on contact 2. The two halves are electrically independent, so the usual arrangement is a zone's solenoid and that zone's flow meter on one port and one cable. The sensor input mode is **selected in firmware at runtime**, and in firmware v5.x **one sensor port is active at a time**: you choose which of the four ports is sampled and what is wired to it. The other ports still drive their valves. There is one board: no build variants, no jumpers, no per-port stuffing options.

PIN	SIGNAL	DESCRIPTION
1	Valve conductor A (+ in DC)	Switched valve drive terminal A; positive in latching-DC mode. Brown conductor.
2	Sensor power	Sensor excitation, 12 V nominal. One switched supply feeds contact 2 on all four ports; it is turned on whenever a voltage or 4–20 mA input is configured. White conductor.
3	Valve conductor B (– in DC)	Switched valve drive terminal B; negative in latching-DC mode. Blue conductor.
4	Sensor input	Universal sensor input; mode selected in firmware. Black conductor.
5	GND	Sensor ground. Not required for valve connection: the valve drive is fully on contacts 1 and 3, and a DC solenoid negative goes to contact 3, not here. Grey conductor.

3.2.1 Sensor input modes

MODE	USE IT FOR
Pulse / dry contact	Reed or open-collector outputs, rain switches, tank float switches
Hall-effect flow meter	Flow metering; the pulse frequency is proportional to flow rate. Specify a meter of roughly 500 pulses/litre or below
4–20 mA loop	Industrial pressure, level, EC and pH transmitters
0–10 V	Industrial analog transmitters on the 0–10 V standard
0–3.3 V	Low-voltage analog sensors and ratiometric outputs

VALVE AND SENSOR TOGETHER

A port drives its valve on contacts 1/3 and reads its sensor on contact 4 at the same time; neither disables the other. Enable the valve driver per port and pick the active sensor port and its input mode in the Growbud app (§6.4). Firmware v5.x reads one sensor port at a time. Both are runtime settings, so a port can be repurposed in the field without opening the enclosure. There are no build variants and no jumpers: mode is firmware only, and every unit ships able to do all of it.

SPECIFYING A FLOW METER

Pulse inputs are serviced through an I/O-expander interrupt, which sets a ceiling on pulse rate. **Specify meters at or below roughly 500 pulses per litre.** A high-K meter — some are 5880 pulses/litre — will produce more edges than the input can service, and the reading will run low at high flow. This is a standing design limit, not a firmware gap: a hardware prescaler was designed for this input and deliberately not fitted. At 500 pulses/litre and below, volume totals stay exact across the controller's full flow range.

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, and the valve type is a configuration setting you enter during commissioning.

3.3 Fieldbus Port (M12 A-coded, 5-pin)

One wired port, two buses. Contacts 4/5 carry either the CAN pair or the RS-485 pair depending on the configured mode, on the standard CANopen / DeviceNet contact assignment, so off-the-shelf CAN cordsets wire in directly on a colour-equivalence basis (see CORDSET COLOURS). The port runs **CAN (FD capable)** or **Modbus RTU over RS-485**, firmware-selected — **never both at once**. The wired roles are mutually exclusive: CANopen master, CANopen slave, Modbus RTU master, Modbus RTU slave, or BACnet MS/TP.

PIN	SIGNAL	DESCRIPTION
1	NC	Not connected. Brown conductor (IEC) unused.
2	V+ out	12 V output, up to 0.75 A — switched, fused, current-monitored. White conductor (IEC).
3	GND	Power and bus return. Blue conductor (IEC).
4	CAN_H / RS485_A	CAN_H in CAN modes; RS-485 line A in Modbus / BACnet modes. Black conductor (IEC).
5	CAN_L / RS485_B	CAN_L in CAN modes; RS-485 line B in Modbus / BACnet modes. Grey conductor (IEC).

CORDSET COLOURS

Standard IEC A-coded cordsets: white (2) is V+, blue (3) is GND, black (4) is CAN_H / A, grey (5) is CAN_L / B; brown (1) is unused. On CAN cable with DeviceNet-style colours the equivalents are red to contact 2, black to contact 3, white to contact 4, and blue to contact 5.

BUS POWER OUT

Contact 2 is a switched 12 V output rated **0.75 A**, so a bus sensor or CANopen actuator runs from the same cordset with no separate supply. Firmware switches it on and off and monitors its current, so the controller can cut a shorted or overloaded bus device without dropping the bus. The 0.75 A ceiling comes from coordinating this output's auto-reset fuse with the supply-input protection — a bigger load does not trip it sooner, it trips the wrong fuse. Power anything hungrier from its own 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 LEAK Probe Ports (M8 A-coded, 3-pin) — two off

The controller has **two leak detector inputs**, on the two M8 ports labelled **LEAK 1** and **LEAK 2**. Either one closes the valves; the app, Modbus register 0x000F and BACnet BI:23/BI:24 say which one is wet. They are electrically identical: the same probe and the same cable work in either port, so there is no wrong way round.

CONTACT	SIGNAL	DESCRIPTION
1	Probe excite	Probe electrode A — excitation. Brown conductor (IEC).
3	GND	Circuit ground; normally unused by a 2-wire probe. Blue conductor (IEC).
4	Probe sense	Probe electrode B — conductivity sense. Black conductor (IEC).

A 3-pole M8 numbers its contacts **1, 3 and 4** — there is no contact 2. That is the IEC 61076-2-104 three-wire arrangement (L+ / L- / signal), and it is why a stock 3-wire M8 cordset is brown, blue and black. Match the contact numbers, not the count of wires.

NOTE

Connect the two passive probe electrodes to contacts 1 and 4. Neither leak port supplies sensor power. For a powered sensor, use a valve / sensor port (§3.2), which provides switched 12 V excitation.

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.

These diagrams are generated from `flo/docs/connector-pinouts.json` by `tools/connector_pinouts/render.py`. The same source renders `flo/docs/CONNECTOR_PINOUTS.md`.

4 Installation & Wiring

1. **Mount** the enclosure in a sheltered or exposed location (IP67 with all ports mated or 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 / sensor port (VALVE 1–4) on contacts 1 and 3. The controller drives all four valves in one global AC/DC mode and you declare the valve type during commissioning, so all valves must be of the same type — never mix 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. **For AC solenoids, add up the holding currents of the zones that run together:** all four channels share one fuse that passes about 2.2 A when warm. Four coils at 0.5 A or less run together without issue; coils at 0.6 A or more need staggered zones (§2.1).
4. **Wire the sensors (optional).** Every port reads a sensor alongside its valve. Land the sensor signal on contact 4, its supply on contact 2 (switched 12 V) and its return on contact 5, then select that port as the active sensor port and set its input mode in the app (§6.4). Firmware v5.x samples one sensor port at a time, so wire the sensor that matters most: a flow meter on the master or main-line port confirms every zone, or a 4–20 mA tank level transmitter. Any port will do, valve or no valve. The sensor supply on contact 2 is one shared switched rail, on whenever a voltage or 4–20 mA input is configured.
5. **Wire the leak probes (optional).** Plug a probe into either M8 port; the two are identical. Electrodes go to contacts 1 and 4.
6. **Wire the bus (optional).** Daisy-chain contacts 4/5 plus GND with shielded twisted pair — CAN_H/CAN_L for CAN, RS-485 A/B for Modbus or BACnet. Terminate both bus ends with 120 Ω (fit the controller's termination jumper only at the bus end). Contact 2 can power a bus device from the switched, current-monitored 12 V output (up to 0.75 A). Terminate the cable shield at the far end only; the controller does not ground shield pins.
7. **Apply power.** The simplest option is a USB-C Power Delivery adapter (up to 20 W); this powers the controller for latching DC valves, the fieldbus, and all wireless functions. If you need 24 VAC valve drive, supply the POWER IN connector instead, using either DC (contacts 1/2) or 24 VAC (contacts 3/4). The controller auto-detects the supply and latches AC or DC valve-drive mode for this power cycle.
8. **Verify:** the panel button illuminates and the device appears in the Growbud app for commissioning (§6).

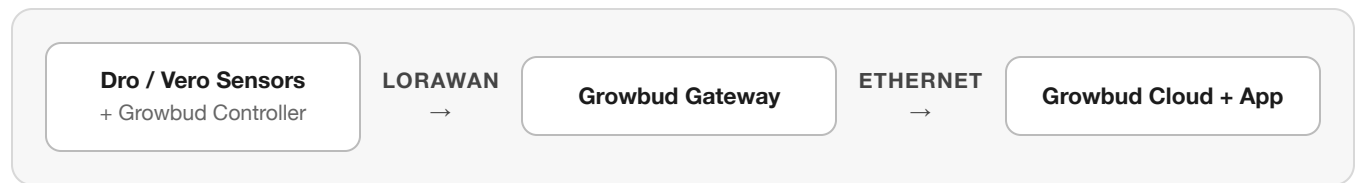
WARNING

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.

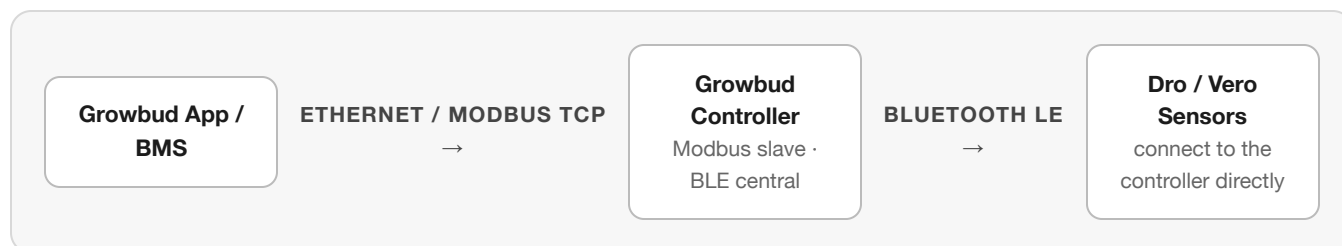
5.1 Configuration A: Wireless LoRaWAN Network



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.

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 fieldbus port role: Modbus Slave, Modbus Master, CANopen Master, CANopen Slave, or BACnet MS/TP (mutually exclusive).
2. **Declare the valve type** (24 VAC or latching DC). It is a configuration setting and it applies to all four ports.
3. **Configure the valve / sensor ports.** Enable the valve driver on each port with a solenoid. Then choose the active sensor port (one of the four in firmware v5.x) and its input mode: pulse / dry contact, hall-effect flow meter, 4–20 mA, 0–10 V, or 0–3.3 V (§3.2.1). The shared sensor supply switches on automatically for voltage and 4–20 mA inputs. A port can carry a valve, a sensor, both, or neither.
4. The app pushes the full commissioning package (port roles, Modbus, BACnet, LoRaWAN, and schedule configuration) over the BLE config-transfer channel and the device applies it on-board.
5. Assign each valve zone a name, and name any sensor and leak probe you have fitted.
6. 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

Slave mode is how the controller ships. Out of the box it answers a Modbus master on the fieldbus, so an RS-485-to-Ethernet adapter, a PLC or a building system can run all four outputs, the on-board schedules, leak detection and the sensor input with no app, no account and no gateway. A factory reset returns it to this state. Master mode (§8), which polls third-party sensors, is a choice you make; one RS-485 port cannot be both at once.

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	leak_state	bool	1 while either leak probe is wet — the condition the interlock acts on. Reads 0 when detection is off, which leak_enabled distinguishes from dry

REGISTER	NAME	TYPE	DESCRIPTION
0x0009	leak_enabled	bool	1 when leak detection is switched on (holding 0x0002)
0x000A	input_mv	uint16	General-purpose input, millivolts at the sampled port
0x000B	input_pulses_lo	uint16	Pulse totaliser, low word. Free-running; take differences
0x000C	input_pulses_hi	uint16	Pulse totaliser, high word
0x000D	input_config	uint16	Packed input configuration, same layout as holding 0x0003
0x000E	comms_loss_active	bool	1 while the comms-loss interlock is holding outputs closed
0x000F	leak_detail	bits	Which probe: bit 0 = LEAK 1, bit 1 = LEAK 2, as labelled on the end panel. 0x0008 says whether to act; this says where to look

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	device_type	enum	How the channel is commissioned; 0 = unconfigured, and an unconfigured channel refuses every command
+5... +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	leak_enable	bool	Switch leak detection on (1) or off (0). Off by default
0x0003	input_config	uint16	General-purpose input: bits 0–1 kind (0 = 0–10 V, 1 = 4–20 mA, 2 = pulse), bits 2–3 port (0–3)
0x0004– 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	device_type	Commission the channel: 0 = unconfigured, 1 = DC pulse valve, 2 = solenoid valve, 3 = relay, 4 = pump, 5 = fan, 6 = light. Set bit 15 to acknowledge continuous DC drive
+4	stroke_ds	Latch stroke in 10 ms units, DC pulse valve only; 0 keeps the default
+5... +15	reserved	Writes return ILLEGAL_DATA_ADDRESS

COMMISSION BEFORE YOU COMMAND

A channel ships unconfigured and refuses every command with exception 0x04. Write the device type to offset +3 first. On a DC rail every type except the latching pulse valve holds current and will burn a latching solenoid, so those types need the same acknowledgment the app asks for: set bit 15 of the value.

Channel edits are ordered by time, and the newest wins. A controller whose clock has not been set has no time to order by, so a commissioning write from the fieldbus is accepted as a repeat of the last edit. Set the clock first if a channel must not be changed from the panel.

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 Device Block: 0x00E0–0x00EF

Identity, the wall clock, and the settings a standalone install needs. The controller's schedules run on wall-clock time, so a controller that never meets the Growbud cloud must be given the time here or its schedules never fire.

OFFSET	INPUT REGISTER	HOLDING REGISTER
+0	serial_lo	reserved
+1	serial_hi	reserved
+2	hardware_rev	reserved
+3	clock_lo	clock_lo — writing this applies the clock
+4	clock_hi	clock_hi — staged, no effect on its own
+5	clock_valid	reserved
+6	comms_timeout_min	comms_timeout_min
+7	schedule_count	reserved
+8	channel_count	reserved
+9...+15	reserved	reserved

WRITE THE CLOCK HIGH WORD FIRST

The low word is what applies. Writing high then low makes the pair land as one instant, so the scheduler never sees half a value. A time before 2020 is refused. clock_valid tells a clock nobody set apart from a clock set wrong: until it reads 1, the on-board schedules do not run.

7.7 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

OFFSET	NAME	DESCRIPTION
+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	-

7.8 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 fieldbus port's contact 2 is a switched 12 V output (§3.3), so a polled sensor can run from the bus cordset. Power anything beyond that output externally.

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

The controller exposes its 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.

No configuration is needed to start. A controller that has never been given a fieldbus role ships answering Modbus RTU as a slave, and switches itself to BACnet MS/TP the first time a BACnet master addresses it — every MS/TP frame opens 0x55 0xFF, which no Modbus request can. Two frames are required, so a corrupted Modbus frame cannot move a working bus, and the choice is stored. Setting the role explicitly, from the app or from Modbus holding register 0x0001, turns the detection off for good.

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

With no object list configured the controller exposes the set below, so a building system finds a usable device without any commissioning step:

OBJECT	INSTANCES	ACCESS	FUNCTION
Device	configurable (default 300001)	-	Device identity; Who-Is / I-Am supported
Binary Output (BO)	BO:0 – BO:3	Commandable	Channel on/off, full 16-slot priority array
Analog Output (AO)	AO:0 – AO:3	Commandable	Channel output level, 0–100 %
Analog Input (AI)	AI:0 – AI:3	Read-only	Measured channel current, mA
Analog Input (AI)	AI:10, AI:11	Read-only	General-purpose sensor input: millivolts, pulse count
Analog Input (AI)	AI:12	Read-only	Board temperature, °C

OBJECT	INSTANCES	ACCESS	FUNCTION
Analog Input (AI)	AI:13, AI:14	Read-only	Boost rail and bus rail voltage, mV
Analog Input (AI)	AI:15	Read-only	Number of schedules stored
Binary Input (BI)	BI:20, BI:21	Read-only	Leak detected; comms-loss interlock active
Binary Input (BI)	BI:23, BI:24	Read-only	LEAK 1 wet; LEAK 2 wet — the ports as labelled on the end panel. BI:20 is either
Binary Input (BI)	BI:22	Read-only	Clock set. Schedules do not run until this reads 1
Binary Value (BV)	BV:30	Writable	Leak detection on or off
Analog Value (AV)	AV:31	Writable	General-purpose input kind and port
Analog Value (AV)	AV:32	Writable	Comms-loss timeout, minutes
Analog Value (AV)	AV:33, AV:34	Writable	Wall clock, high word then low word

SETTING THE CLOCK OVER BACNET

Write AV:33 then AV:34. A BACnet REAL is a 32-bit float and cannot hold a UNIX second exactly, so the clock is carried as two 16-bit halves. AV:34 is what applies; writing it without a staged AV:33 is refused rather than setting the clock to some instant in 1970.

The value objects are settings, not commandable points. They have no priority array and no relinquish: the last accepted write is the setting.

A commissioned object list replaces this set entirely rather than adding to it.

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	A probe on either leak input asserted	Inspect the zone; clear condition, then re-enable the channel

SYMPTOM / CODE	CAUSE	ACTION
Sensor reads zero / no pulses	A different port is selected as the active sensor port, or wrong input mode	Select the port and input mode in the app (§6.4); the sensor supply on contact 2 switches on with voltage and 4–20 mA modes
Flow reads low at high flow	Meter K-factor above the supported pulse rate	Fit a flow meter of roughly 500 pulses/litre or below (§3.2.1)
Bus device dead, controller fine	Fieldbus 12 V output switched off or current-limited	Check the port power setting in the app; inspect the bus device for a short
mode_detected = 3	Both AC and DC rails energized	Disconnect one supply pair at POWER IN
Several AC zones drop out together, then recover on their own	The shared AC input PTC tripped — too many channels energised at once (about 2.2 A when warm)	Not a failure: the PTC resets as it cools. Stagger the zones or fit lower-current solenoids (§2.1). Report it; do not replace the board
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