

# Xroute RV Smart Controller - Hardware Overview

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## System Summary

Xroute is a rugged, feature-rich RV smart controller designed for modern campervans. It manages power, lighting, sensors, and automation with advanced protections and monitoring. Built to handle 12V and 24V systems, it's OTA upgradeable and expandable.

- Processor: 32-bit dual-core @ 240 MHz (main controller unit)

### 1. Power System

- Input Voltage: 9V-24V DC
- Idle Consumption: ~1.8W (150mA @12V)
- 4-pin Connector: 2 power + 2 battery sampling
- Internal 16A Thermal Fuse (auto-reset)
- Reverse polarity protection
- External fuses required: max 15A

### 2. Relay Outputs

- 16 Galvanically Isolated Outputs (12 standard, 4 motor control relays)
- 20A @12V DC, 4A @220V AC
- Signal control supported (inverter, heater, etc.)
- PWM Relay Control: high switching power, low hold current
- Dynamic adjustment based on input voltage

### 3. Dimmer Outputs

- 7 channels, 4A each
- Powered from main input
- Internal protection & alerts
- 24-bit PWM resolution
- Power limiting & PWM half mode for 12V LEDs
- RGB calibration for channels 5-7

### 4. Measurement Inputs

- Voltage: VBAT+ and PV+ (12-bit differential)
- Water Level: 3x 0 $\Omega$ -400 $\Omega$  floaters (calibrated)
- Supports LPG/resistive sensors
- PT100 Temp: -40 $^{\circ}$ C to +100 $^{\circ}$ C, calibration supported
- Analog 2-40mA sensor input for precision level sensing

### 5. Digital Sensor Ports

- 3x RJ45 Ports
- Modules: Temp/Humidity, Gas, Shunt Current Sensor (50A, 100A, 200A)
- Fuel gauge features for AGM, LiFePO4, etc.

### 6. Environmental Sensors

- Altitude Sensor
- 3-Axis Accelerometer: spirit level, pitch/roll orientation

### 8. Communication & Expandability

- Bluetooth to mobile/tablet
- OTA firmware updates
- RS485 for future Modbus RTU (by request)

### 9. LED Indicators

- Green Power LED
  - RGB Status LED for operational states (blinking/color-coded)
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# Port Names

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## Top Side Port Labeling (Left to Right)

- Dimmer Outputs (DIRS1-DIRS7):**
  - **Dim 1 + / -**
  - **Dim 2 + / -**
  - **Dim 3 + / -**
  - **Dim 4 + / -**
  - **Dim 5 + / - (Red)**
  - **Dim 6 + / - (Green)**
  - **Dim 7 + / - (Blue)**→ These are your **7 protected dimmer channels**.
- Sensor Inputs:**
  - **Su 1** – Water Level Sensor 1
  - **Su 2** – Water Level Sensor 2
  - **Su 3** – Water Level Sensor 3
  - **PT100** – Temperature Sensor Input (PT100)
- RJ45 Digital Sensor Ports:**
  - **Humidity & Temperature** – Temp + Humidity sensor (RJ45)
  - **Gas sensor** – Gas sensor (RJ45)
  - **Amper meter (shunt)** – Current sensor/shunt input (RJ45)
- Status Indicators & Communication:**
  - **RGB LED** – multi-color status LED for system feedback
  - **Antenna** – External antenna (for Bluetooth)

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## Right-Side Terminal Block (Vertical):

This block handles **voltage sensing and power input**:

- **PV+** – Solar Panel Voltage Sense Input
- **VBAT+** – Battery Voltage Sense Input
- **Bat-** – Battery Negative Sense (thin wire)
- **Bat+** – Battery Positive Sense (thin wire)
- **12- / 12+** – Main power input (thick wires, for powering device and dimmers)

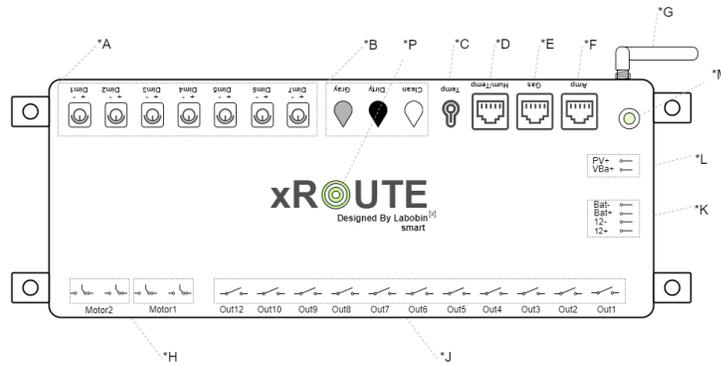
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## Bottom Side (Relay Outputs):

Labeled “Out”:

- **Motor 2** – 2x Relay outputs for Motor 2 (H-bridge)
- **Motor 1** – 2x Relay outputs for Motor 1 (H-bridge)
- **Output 12 to Output 1** – General-purpose Relay Outputs 1-12  
→ All 16 relays can be used flexibly (12 + 4 motor, or all 16 for devices)

# Port Locations



## **A** — Dimmer Outputs (DIM1–DIM7)

7 dimmer channels for PWM lighting control (white/RGB), each rated up to 4A. Protected and software calibrated.

## **B** — Water/Fluid Sensor Inputs

Three resistive level inputs labeled:

- **Clean, Dirty, and Grey**  
Use 0–400Ω sensors. Can support other resistive gauges like LPG sensors.

## **P** — (LED indicator)

This indicator shows the current state of connection and device errors. More on this later.

## **C** — PT100 Temperature Sensor Input

For -40°C to +100°C temp monitoring. Includes software calibration.

## **D** — RJ45: Temp & Humidity Sensor

Plug-and-play, no calibration needed.

## **E** — RJ45: Gas Sensor

For LPG/propane leak detection. Can trigger safety relays or alerts.

## **F** — RJ45: Current Sensor (Shunt)

For 50A/100A/200A range current sensors. Enables battery monitoring and fuel gauge functions.

## **G** — Bluetooth Antenna

Used for wireless connection with mobile app and OTA updates.

## **H** — Motor Relay Outputs

Two motor controllers (Motor 1, Motor 2), each with 2 relays for H-bridge logic. Used for rooftop lifts, windows, etc.

## **J** — Relay Outputs (Out1–Out12)

General-purpose relay outputs, rated up to 20A DC or 4A AC. Used for device switching or signal control.

## **K** — Main Power Input

- **12+ / 12-**: Main input (9–24V DC)
- **Bat+ / Bat-**: Battery sense lines (for voltage monitoring only)

## **L** — Voltage Monitoring Inputs

- **PV+**: Solar panel voltage sense
- **VBAT+**: Battery voltage sense  
12-bit differential input measurement

## **M** — Green Power LED

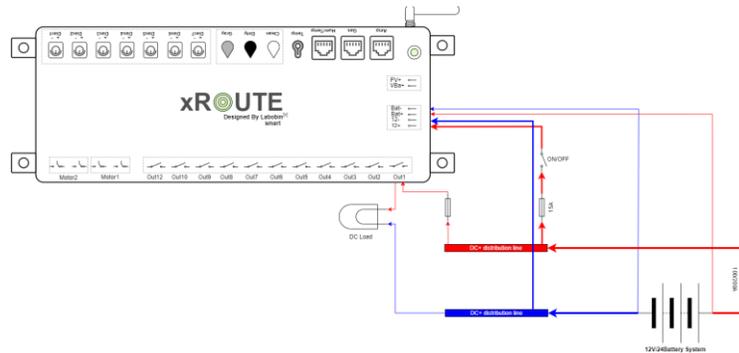
Turns on when power is supplied to the device.

## **N** — RGB Status LED

Multicolor indicator showing system state through blinking/color patterns (e.g., normal, pairing, error).



## ⚙️ Example: Controlling a Simple DC Load



Once the Xroute controller is properly powered through the distribution bars, you can begin wiring your devices to the **relay outputs**.

In this example, a **DC Load** is connected to **Relay Output 1 (Out1)**.

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### 🔧 How It Works:

- The **red line** carries switched positive voltage from **Out1**.
- The **blue line** provides the ground (negative) return path, connected directly to the **DC- distribution bar**.
- When **Relay 1** is activated by the controller (via app, automation, or manual input), it closes the internal contact and allows current to flow to the connected device.
- The relay operates as a standard **normally open switch**, closing only when triggered.

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### ✅ Use Cases:

This wiring method can be used for:

- Water pumps
- LED lighting
- Ventilation fans
- Signal-level DC devices
- Actuators or solenoids

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### 🔒 Protection & Best Practice:

- Each relay output should have an **external fuse** rated for the connected load (not shown here but recommended).
- The relay output is **galvanically isolated**, allowing flexible control without sharing power grounds with sensitive electronics.
- You can mix AC and DC loads across different relays safely, thanks to this isolation.

## External Sensor Modules for Xroute



The Xroute Smart RV Controller supports multiple external sensors via its dedicated RJ45 and PT100 ports. These sensors expand the functionality of your system, allowing precise monitoring of environmental conditions and system safety.

### Temperature & Humidity Sensor (RJ45)

- Measures **ambient temperature and humidity**
- No calibration needed – **plug-and-play**
- Compact, ventilated enclosure with **status LEDs**
- Connected via **RJ45 port** on Xroute
- Ideal for **indoor climate monitoring** and **automatic ventilation control**

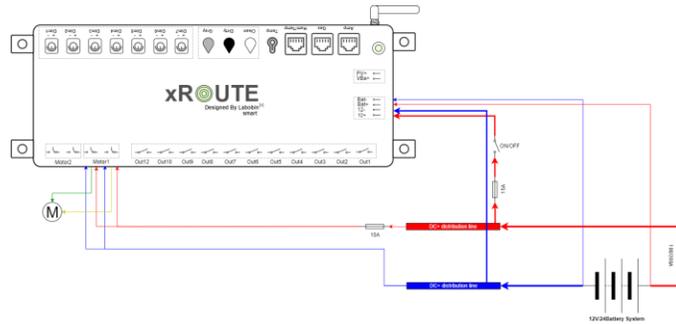
### Gas Sensor (RJ45)

- Identical enclosure to the temperature & humidity sensor
- Detects **LPG, methane, or other gas leaks** (depending on model)
- Plug-and-play via **dedicated RJ45 port**
- Triggers **alerts or automated cutoffs** when gas is detected
- Important for **camper safety systems**

### PT100 Temperature Sensor

- High-precision temperature sensor using a **resistive platinum element**
- Measures from **-40°C to +100°C**
- Includes 2-wire connector for the PT100 port on Xroute
- Ideal for measuring **water tanks, external environment, or engine area**
- Calibration is supported via Xroute software for accurate readings

## ⚙️ Example: DC Motor Connection (Bidirectional Control)



In this example, a **DC motor** is connected to **Motor1 relay group**, which consists of two relays internally configured as an **H-Bridge**. This allows full **bidirectional motor control** (forward and reverse).

### □ How It Works:

- **Motor1** relay group uses **4 terminals**:
  - Two positive outputs (red, yellow)
  - Two negative outputs (blue, green)
- The Xroute controller activates the relays in pairs to **reverse the polarity** across the motor:
  - One direction = red + blue
  - Opposite direction = yellow + green
- This switching method allows precise **reversible motion control**, ideal for:
  - Pop-up roofs
  - Electric steps
  - Venting windows
  - Linear actuators

### 🔧 Power Flow:

- The **DC motor** is powered directly from the main **DC+ / DC-** distribution lines.
- An **inline 10A fuse** protects the motor's power feed. Fuse value should match the motor's rated current.

### 🔒 Safety Notes:

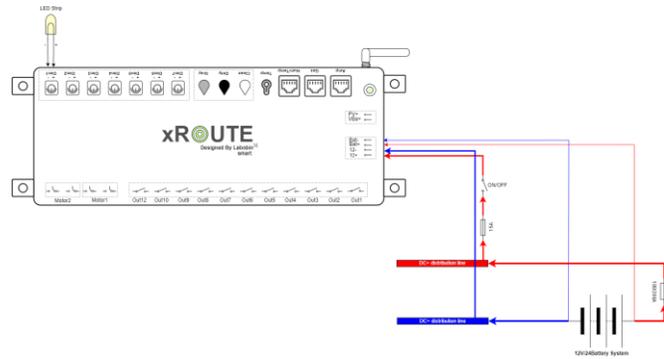
- Relays used in H-bridge mode must not be triggered both ways simultaneously — the Xroute controller handles this logic safely via firmware.
- Always fuse your motor line according to the stall current and wire gauge.
- For inductive motors, an internal flyback protection mechanism is handled by the relay hardware; no external diode is needed.

### 🔧 Customization Tip:

In software, you can configure the relay behavior as:

- Timed motor runs (e.g. 10s up, 10s down)
- Limit switch logic (if external feedback is wired)
- Manual or app-based controls

## 💡 Example: LED Strip Connection (Dimmer Control)



This schematic shows how to connect a **single-color LED strip** to one of Xroute's **dimmer outputs** for smooth brightness control.

### 🔧 Connection Overview:

- The **LED strip** is connected to **Dimmer Channel 1 (Dim1)** on the controller.
  - + (positive) terminal receives PWM-controlled voltage
  - - (negative) terminal returns to ground
- The dimmer draws power directly from the main **12+ / 12- input**, which is supplied through the previously established **DC distribution system** (red and blue bars).
- The LED's brightness is controlled by the Xroute controller using **24-bit PWM**, allowing ultra-smooth transitions with no flickering.

### ⚙️ Use Case Scenarios:

- Interior ambient lighting
- Bed strip lighting
- Ceiling or under-cabinet lighting
- Reading lights with brightness adjustment

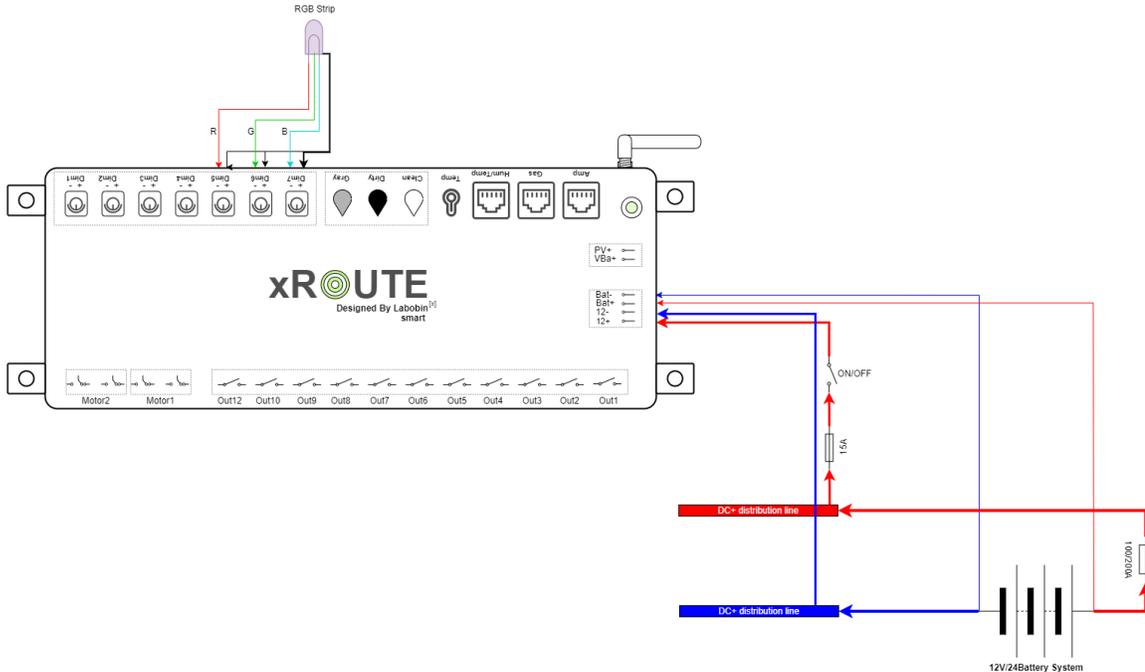
### 🔒 Safety & Notes:

- Dimmer outputs are internally protected with thermal fuses and short circuit detection.
- No external dimmer or controller is needed—the brightness and effects are fully managed through the Xroute app.
- Up to **4A** of current per channel is supported.
- You can limit power output from the software to extend LED lifespan or match LED strip rating.

### 🔧 Tip:

If using **12V LED strips on a 24V system**, you can enable the "**PWM Half Mode**" from the software to safely drop the average power level and prevent overvoltage damage.

## Example: RGB LED Strip Connection (3-Channel Dimmer Control)



This schematic shows how to wire a **standard 4-wire RGB LED strip** to Xroute's **dimmer outputs** to control Red, Green, and Blue channels independently for full color control.

### Connection Overview:

- The RGB strip uses:
  - **Red wire** → connected to **Dim5**
  - **Green wire** → connected to **Dim6**
  - **Blue wire** → connected to **Dim7**
  - **Common Positive (Black)** → connected to **DC+ distribution line**
- Each color channel receives a **PWM-controlled signal** from the corresponding dimmer output.
- Xroute uses **24-bit PWM resolution**, ensuring smooth color transitions and flicker-free blending.

### Software Features:

- Use the Xroute mobile app or tablet interface to:
  - Choose colors using a color picker
  - Set fade-in/out effects and transitions
  - **Save custom scenes (e.g., night mode, warm mode)**
- **RGB White Calibration:**
  - Xroute allows white balance correction by tuning each color's maximum output.
  - Useful when LED strips have uneven brightness across R/G/B channels.

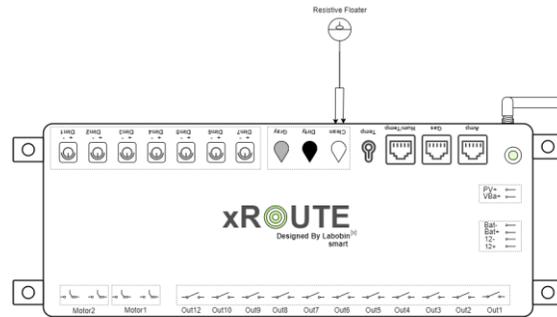
### Load & Protection:

- Each dimmer output supports up to **4A**, suitable for medium-to-long LED strips.
- Internally protected against short circuits and overheating.
- No need for external fuses or dimmer modules.

### Tips & Notes:

- If you're using **12V RGB strips** in a **24V system**, enable "**PWM Half Mode**" from the software to safely reduce average power without risking overvoltage.
- Always match your strip's connection labels (R, G, B, +) to avoid color confusion or reverse polarity.

# 🔹 Example: Water Tank Level Monitoring Using a Resistive Floater



This schematic shows how to connect a **resistive float-type level sensor** to the Xroute controller, allowing it to monitor the fluid level in a tank (e.g., clean water, grey water, or black water).

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## 🔧 Connection Overview:

- The **resistive floater** is connected to one of the dedicated inputs:
  - In this example, it's wired to the “**Clean**” sensor terminal.
- The sensor typically varies resistance depending on the float position:
  - Common range: **0Ω (empty)** to **400Ω (full)**, or reversed.
- The controller reads this resistance value and translates it into a percentage using calibration.

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## 📱 Software Features:

- Each input can be individually calibrated from the mobile/tablet app.
  - You define **minimum and maximum resistance** values.
  - You can **invert direction** if needed (e.g., 0Ω = full).
- Supports **upside-down floaters** or sensors mounted at an angle.
- Calibrations are stored in firmware and persist through power cycles.

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## ✅ Use Case Examples:

- Fresh/Clean water tank
- Grey water tank
- Black water or wastewater tank
- LPG/Gas bottle level (if using resistive gauges)

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## 🔧 Tips & Best Practice:

- **If floaters behave non-linearly (e.g., tanks with unusual shapes), software can compensate by applying custom scaling.**
- You can install multiple sensors (Clean, Dirty, Grey) simultaneously—Xroute supports 3 separate inputs.
- Use twisted pair cable to minimize noise over long runs.

## ⚡ Battery Current Sensor (Shunt Type)



This high-precision current sensor is designed to measure **charging and discharging currents** of the battery using an external shunt. It connects to the Xroute smart controller via a dedicated **RJ45 port** and enables full battery monitoring and fuel gauging functionality.

### 🔍 Features:

- Compatible with **50A, 100A, or 200A** shunt ratings
- **Bidirectional current sensing** for both charge and discharge
- Enables:
  - Accurate **real-time current monitoring**
  - **State of charge (SoC)** and **battery health** estimation
  - Deep analysis of **battery usage trends**
- Works with **AGM, Lead-Acid, Li-ion, and LiFePO4** batteries
- **Software calibration required** for precise readings

### ⚙️ Calibration Procedure:

To ensure accurate operation, the sensor must be calibrated via the **Xroute software interface** at two key points:

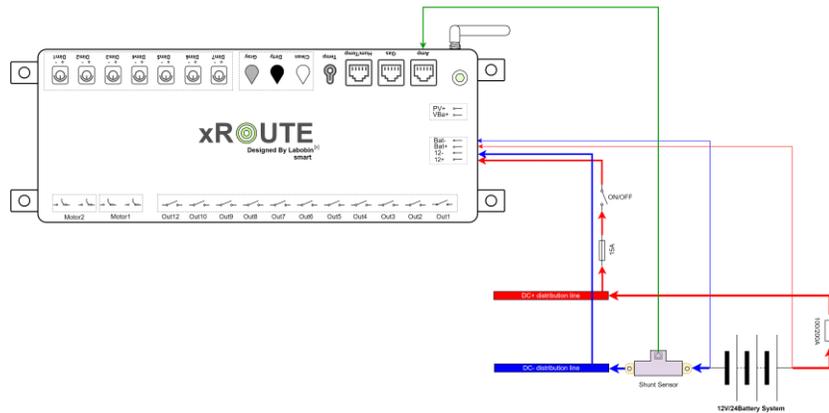
1. **Zero Current Point**
  - Performed with **no current flowing** through the shunt
  - Establishes a stable baseline for zero
2. **High Current Reference Point**
  - Performed while a **known current** is flowing through the shunt (e.g., turning on a large load or charger)
  - Used to calculate the exact scaling factor based on the shunt rating

Once both points are calibrated, the system provides **precise and reliable current measurements** and accurate charge/discharge tracking.

### 🔧 Installation & Connection:

- Mount the shunt on the **negative line** of the battery system
- Plug the sensor's RJ45 cable into the **Shunt input port** on Xroute
- Perform calibration via software, then begin using the system immediately

# Shunt Sensor Wiring Diagram



The diagram above shows the correct method for wiring the **battery current sensor (shunt)** to the Xroute smart controller. This configuration enables precise monitoring of current flow into and out of the battery system.

## Wiring Explanation:

### Battery Side:

- The **negative terminal** of the 12V/24V battery system is connected directly to **one side of the shunt sensor**.
- The **positive terminal** of the battery is connected to the **DC+ distribution line** (red).

### Shunt Sensor:

- The **shunt sensor** is installed on the **negative line** of the battery system.
- Ensure the **direction of current flow** matches the expected orientation (battery to load).
- The sensor's **RJ45 cable** is plugged into the **“Amp” port** on the Xroute device.

### Important Notes:

- The **DC- distribution line** (blue) originates from the **other side of the shunt**, ensuring that all current passes through the shunt for accurate measurement.
- The **DC+ line** includes a **15A fuse** and an optional **ON/OFF switch** for protection and control.
- The current sensor must be **calibrated in software**:
  - First at **zero current**
  - Then at a **known high current** for accurate scaling

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 *This setup enables Xroute to calculate charge and discharge currents, estimate battery percentage, and track long-term battery performance.*



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#### ⚡ Electrical Connections:

- The gas valve is powered via Relay Out1, protected by a 15A fuse
- The valve receives power from the DC+ distribution line
- The gas sensor uses the dedicated RJ45 port and communicates directly with Xroute
- All gas appliances are downstream from the valve, ensuring no gas reaches them unless the valve is opened intentionally

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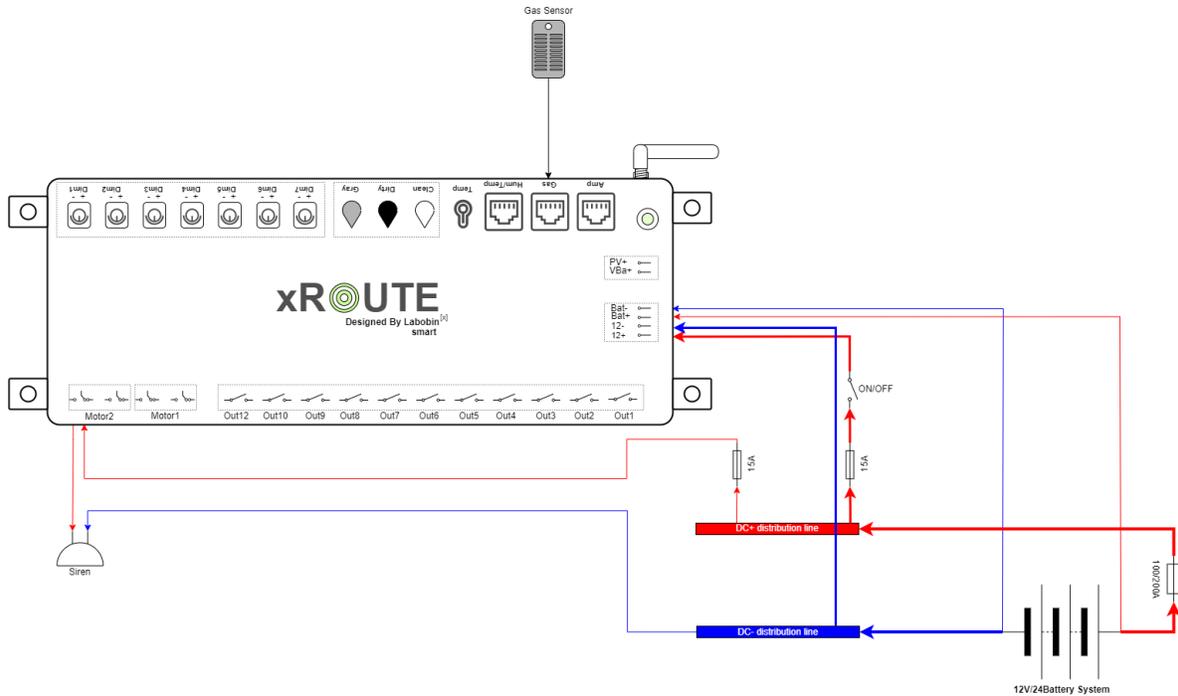
#### 🛡️ Safety Behavior:

- In the event of a system failure, reset, or power loss, the valve closes automatically (fail-safe)
- Ensures no accidental gas leakage
- Simple and secure design with automatic safety handling

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📖 *Use this section in your manual under "Gas Safety System" alongside the illustrated wiring diagram for clear user understanding.*

# Gas Leak Alarm with Siren



In this setup, a 12V siren is added to the gas safety system. The siren acts as an immediate audible alert when a gas leak is detected, ensuring safety even if the user is not looking at the display or mobile app.

## System Overview:

### Gas Sensor

- Connected to the “Gas” RJ45 port on the Xroute
- Continuously monitors the air for gas leaks

### Siren Output

- Wired to the Motor2 output of the Xroute controller
- Siren is powered by the system’s DC+ and DC- distribution lines
- Activated automatically by the software when a gas leak is detected

## Behavior & Safety Logic:

1. Under normal conditions, the siren remains off.
2. When the gas sensor detects a leak, Xroute performs these actions:
  - Cuts power to the normally closed gas valve (closes gas flow)
  - Activates Motor2 output, powering the siren
  - Optionally notifies the user via app or interface
3. The siren remains active until:
  - Gas levels return to safe thresholds
  - Or the system is manually reset (depending on configuration)

## Electrical Details:

- The siren connects to Motor2, which acts as a protected high-side switch
- Xroute controls it via software, allowing timed or conditional activation
- Power is drawn from the main 12V/24V battery system, protected via a 15A fuse
- Siren activation is independent of user input — it’s purely event-driven for safety

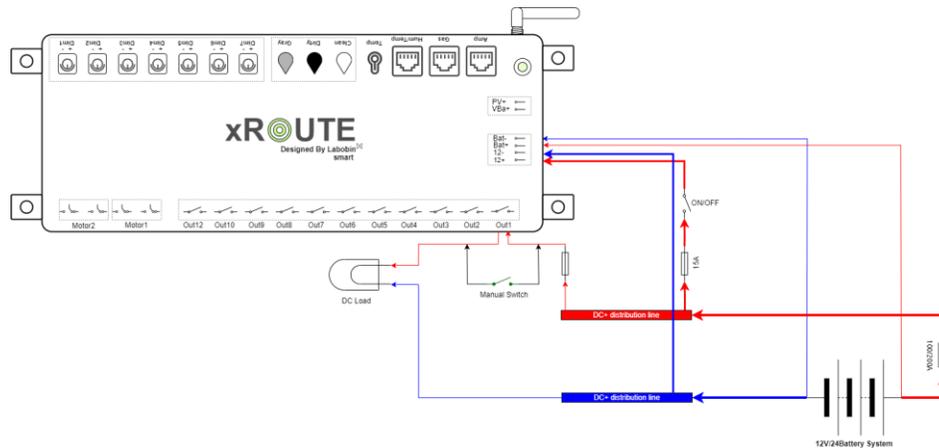
## Best Practices:

- Mount the siren in a central or audible location inside the camper

- Test the siren regularly using the Xroute test function in the app
- Consider configuring snooze or reset logic if using the alarm in sleeping areas

**📖 Include this section under “Gas Leak Alert System” in your manual along with the diagram, to clearly demonstrate how Xroute handles emergency gas events both visually and audibly.**

## □ Optional Manual Control (User Preference & Emergency Flexibility)



### □ Optional Manual Control (User Preference & Emergency Flexibility)

While the Xroute Smart Controller is designed to manage all outputs reliably and intelligently, some users prefer the option to have direct manual control over certain circuits — especially for critical loads like fans, lights, or communication systems.

This wiring setup includes a manual bypass switch in parallel with the smart relay output, offering instant, hands-on control whenever desired.

#### 🔧 Why Use Manual Mode?

- Peace of mind – Know you can power important devices even if the system is updating or turned off
- User control – Ideal for those who prefer physical switches alongside app or screen controls
- Installer/testing convenience – Quickly test or activate circuits without using the app
- No dependency – Manual mode gives flexibility, not because it’s needed, but because it’s preferred by many users

#### ⚙️ How It Works:

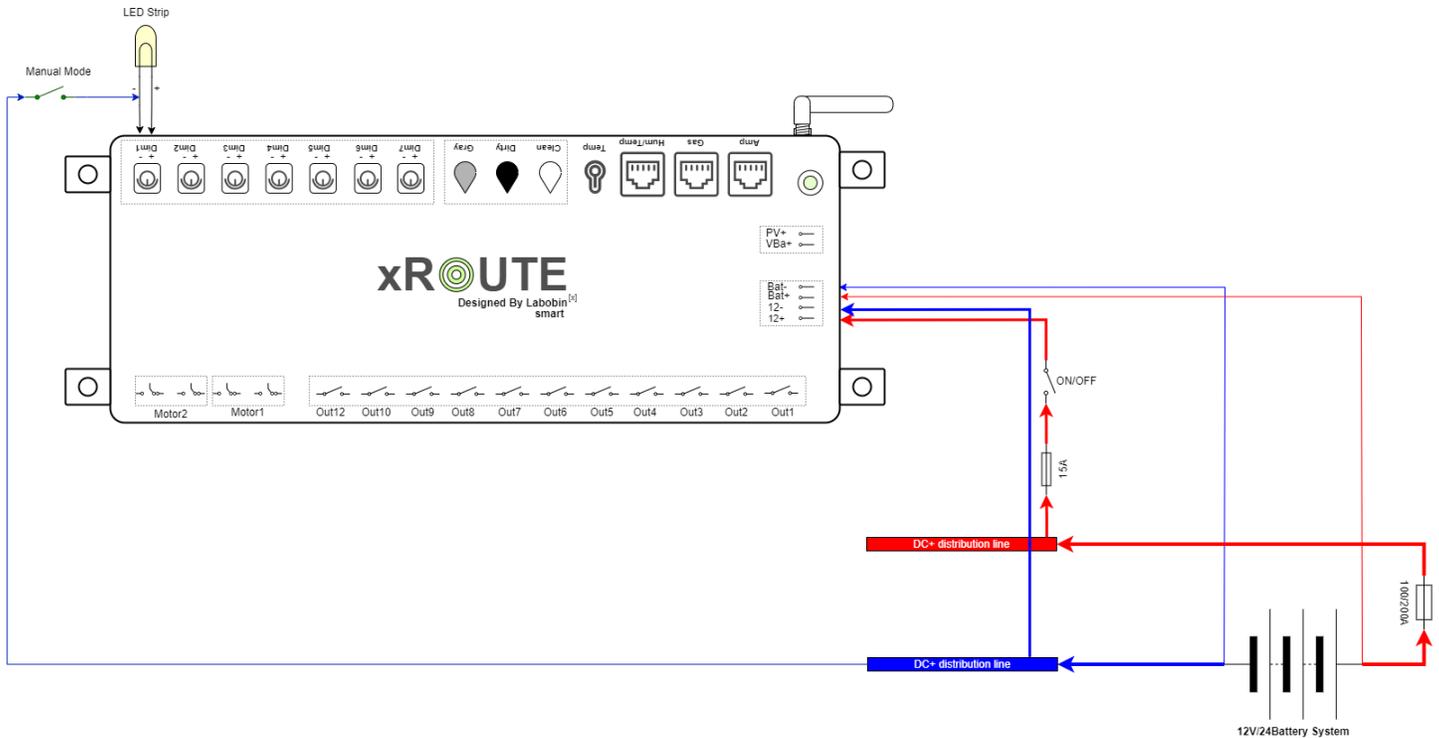
- The manual switch connects directly between the DC+ distribution line and the load (e.g., light)
- It works alongside the smart control system, not instead of it
- When the switch is on, the load is powered regardless of software state — ensuring total control when you need it

#### 🛡️ Safety First:

- All lines are protected by appropriate fuses
- The load remains powered only when either the relay or manual switch is active
- Perfect for use in RV environments, where preferences vary across users

**📖 Include this section under “Advanced User Preferences” in your manual for users who appreciate hands-on options and total control over their RV systems.**

# 💡 Manual Lighting Control (Optional Override for User Preference)



Xroute's lighting system offers both **smart control through software** and **optional manual override**, giving users the freedom to activate key lighting — like an LED strip — without needing to access the app or interface.

This is especially appreciated in **emergency scenarios, camp setup**, or by users who simply prefer the **feel of a physical switch**.

## 🔧 How It Works:

- The LED strip is connected to one of the **dimmer outputs** (e.g., Dim1)
- A **manual switch** is connected in **parallel** with the dimmer's control line (between the power source and the LED strip)
- When the manual switch is ON, the LED receives power directly — regardless of the software state

## 🕒 When to Use Manual Mode:

- **Quick access** to lights upon entering the vehicle or during system boot
- For users who prefer a **physical wall switch** alongside digital control
- As a **failsafe** or convenience option in cabins, storage areas, or entrances

## 🧩 Smart & Manual Together:

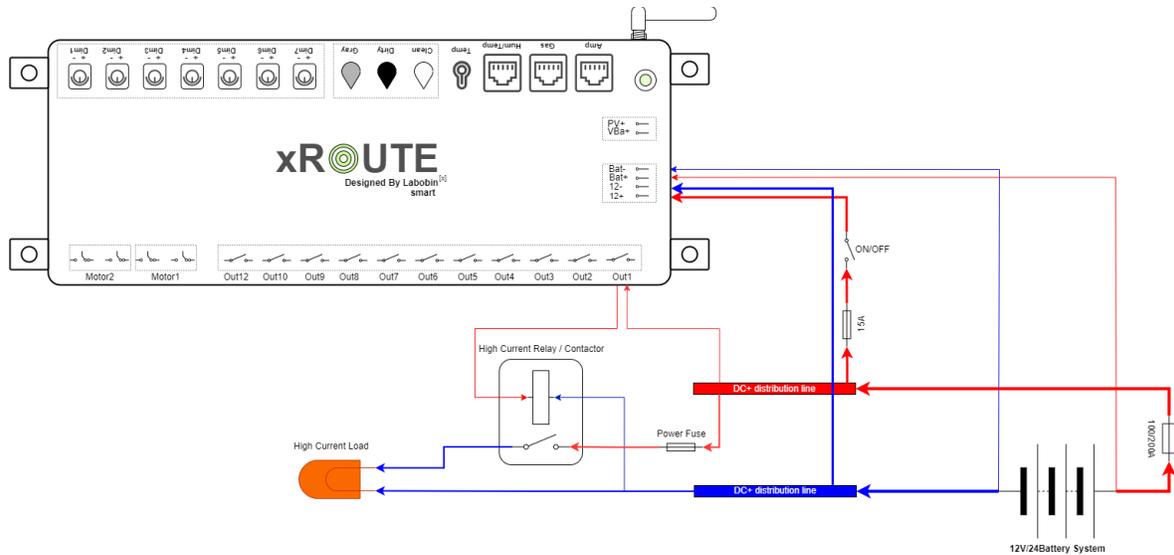
- The system doesn't replace smart control — it simply adds a **user-controlled shortcut**
- Users can still adjust **brightness and automation** through the app
- When the switch is OFF, the light behaves **fully under Xroute's smart control**

## ⚡ Electrical Notes:

- The LED is still powered from the **DC+ distribution line**, protected by fuses
- The manual switch only completes the circuit in a **safe and isolated way**
- This mode is compatible with both **12V and 24V** lighting setups

📖 Include this section under "Lighting Control Options" in your manual to explain how users can blend high-tech and hands-on control for maximum comfort.

# ⚡ High-Current Load Switching via External Contactor



The Xroute Smart Controller can control high-current loads safely and efficiently by using a dedicated external relay or contactor. This allows you to switch loads that exceed the onboard relay capacity (20A), while maintaining full system intelligence and safety.

## 🔧 How It Works:

- Xroute controls a high-current contactor using one of its standard outputs (e.g., Out1)
- The contactor is rated for heavy loads (e.g., 50A, 100A or more), and switches power directly to the load
- This output only drives the coil of the contactor, which consumes minimal current
- The main power lines to the high-current device are handled separately with appropriate gauge wire and a dedicated fuse

## 🔗 Use Cases:

- Large inverters
- High-power DC heaters
- Water pumps or air compressors
- Any equipment drawing more than 20A

## 🛡️ Safety & Protection:

- The high-current path is fused with a dedicated power fuse close to the battery
- Control wiring is thin and isolated, protecting the Xroute from high current stress
- The contactor opens instantly when Xroute disables the output, just like a built-in relay

## ✅ Key Benefits:

- Protects Xroute while expanding power capabilities
- Retains full software control via app, timer, automation, or manual override
- Supports both 12V and 24V systems
- Enables use of high-efficiency or high-load devices in your camper setup

📖 *Use this setup when integrating heavy equipment with your Xroute system, and place this section under “Advanced Power Integration” in your manual for installers or power users.*

# Dimensions

