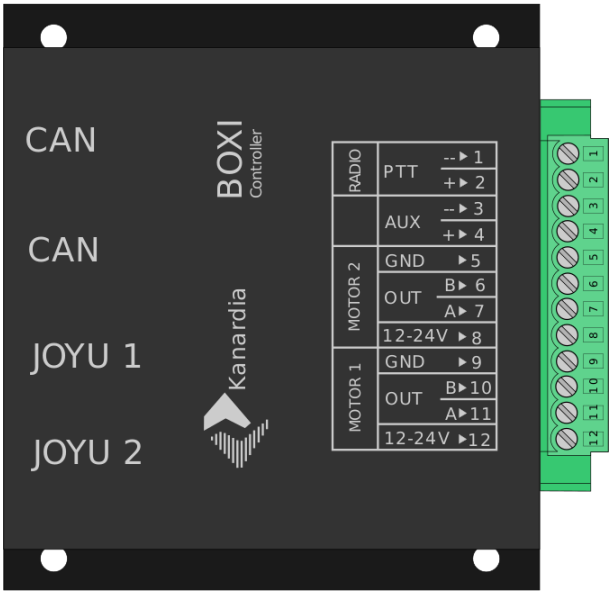


# Boxi — Manual

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Revision 1.2

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A lot of useful and recent information can be also found on the Internet. See <http://www.kanardia.eu> for more details.

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## Revision History

The following table shows the revision history of this document.

Rev.	Date	Description
1.0	July 2019	Initial release
1.1	Dec 2019	Connection of two separate relays added.
1.2	Aug 2020	Motor with external relay

# Contents

<b>1</b>	<b>Introduction</b>	<b>4</b>
1.1	General Description . . . . .	4
1.2	Technical Specification . . . . .	4
<b>2</b>	<b>Functional Description</b>	<b>5</b>
2.1	Control Logic . . . . .	5
2.2	CAN Interface . . . . .	5
2.3	Output Stage . . . . .	5
2.3.1	RADIO . . . . .	5
2.3.2	AUX . . . . .	6
2.3.3	MOTOR 1 and MOTOR 2 . . . . .	6
<b>3</b>	<b>Installation &amp; Maintenance</b>	<b>7</b>
3.1	Mounting Dimensions . . . . .	7
3.2	Connections . . . . .	7
3.2.1	CAN . . . . .	7
3.2.2	JOYU 1 and JOYU 2 . . . . .	7
3.2.3	RADIO - One Microphone . . . . .	8
3.2.4	RADIO - Two Microphones . . . . .	8
3.2.5	AUX . . . . .	9
3.2.6	MOTOR 1 and 2 . . . . .	9
3.3	High current motor connection with external relays . . . . .	10
3.4	Ray Allen T2 and T3 Trim Systems . . . . .	11
3.5	Maintenance . . . . .	11
3.6	Repair . . . . .	12
<b>4</b>	<b>Limited Conditions</b>	<b>13</b>
4.1	Warranty . . . . .	13
4.2	TSO Information . . . . .	14

# 1 Introduction

First of all, we would like to thank you for purchasing our device.

Boxi is an electrical actuator control box. It allows pilot to control airborne electrical actuators such as pitch and roll trims, landing gear actuators, radio transmission, electronic throttle, etc. via Joyu flight control stick.

This manual describes the technical description of the unit, installation and operation.

## 1.1 General Description

Boxi unit is an electronic power switch for controlling electrical loads via Joyu. It consists of one TTL level opto-isolated output, one 1 A open-collector bipolar transistor output and two 10 A H-bridge DC motor drivers.

The electronics listens for incoming CAN messages and based on the content controls the outputs. System has implemented several fail-safe mechanisms which sets the outputs in predefined state in case of disrupted CAN communication.

Due to safety reasons the electronics has implemented two electrically-isolated CAN buses; regular CAN bus and Joyu CAN bus. This feature also allows Boxi to be used as a communication switch between two electrically-isolated CAN buses.

One of the key advantages is the ease of installation. Boxi shall be installed close to power actuators which reduces length of power cables resulting in reduced both system weight and electrical interferences.

## 1.2 Technical Specification

Table 1 shows some basic technical specification of Boxi.

Description	Value
Weight	95 g
Size	74 x 70 x 23 mm
Operational voltage	6 to 32 V
Power consumption	0.3 W <sup>1</sup>
Current	25 mA at 12 V <sup>1</sup>
PTT Output	Opto-isolated, 5 V TTL, max 50 mA
AUX Output	PNP, open-collector, max 0.5 A
Motor Outputs	D-MOS H-bridge, max 24 V / 2 A
Operating temperature	-30 °C to +85 °C
Humidity	30 % to 90 %, non condensing
Communication	CAN bus, 29 bit header, 500 kbit, Kanardia protocol

Table 1: Basic technical specifications.

<sup>1</sup> Electronics only, without outputs.

## 2 Functional Description

Boxi electronics consists of three blocks: control logic, CAN interface and power output stage. All outputs are galvanically isolated from the control electronics and CAN buses to eliminate stray currents between input communication lines and output power lines.

### 2.1 Control Logic

The heart of the unit is a microprocessor which has two primary functions: forwarding CAN messages between both CAN buses and controlling the outputs. It also implements several fail-safe mechanisms which defines output states in case of disrupted CAN communication or system failure. Control logic is powered from primary CAN bus.

### 2.2 CAN Interface

System consists of two electrically isolated CAN interfaces: primary CAN bus and Joyu CAN bus. All CAN messages from one bus are forwarded to the other bus. The main purpose of implementing isolated Joyu CAN bus is eliminating CAN line termination issues with longer Joyu cables.

### 2.3 Output Stage

Output stage consists of four output modules which are all galvanically isolated from control logic and CAN interfaces. Bellow is the description for each output module.

#### 2.3.1 RADIO

RADIO (PTT) output is dedicated to control radio transceiver. Output is realized with Darlington phototransistor optocoupler which collector and emitter terminals are routed directly to output terminals 1 (emitter) and 2 (collector). Default output state is open (floating). Press on the PTT button ‘shorts’ terminals 1 and 2.<sup>2</sup> Table 2 shows basic characteristics of phototransistor.

Description	Value
Isolation voltage	3.75 kV
Collector-emitter voltage	35 V (max)
Emitter-collector	6 V (max)
Collector current	Min: 6 mA Max: 75 mA
Collector-emitter saturation voltage	0.8 to 1.0 V
Floating capacitance	1 pF

Table 2: PTT output characteristics.

---

<sup>2</sup> Default configuration.

### 2.3.2 AUX

Aux output is designed to control external relays or small electrical loads (max. 15 W). Output is realized with combination of optocoupler and power PNP transistor. Optocoupler drives the base of power PNP transistor. Collector and emitter terminals of power PNP transistor are routed directly to output terminals 3 (collector) and 4 (emitter). Default output state is open (floating). Press on the AUX button ‘shorts’ terminals 3 and 4.<sup>1</sup> Table 3 shows basic characteristics of PNP power transistor.

Description	Value
Collector-emitter voltage	35 V (max)
Collector-emitter saturation voltage	2.0 to 4.0 V
Collector current	0.5 A (max)

Table 3: AUX output characteristics.

### 2.3.3 MOTOR 1 and MOTOR 2

MOTOR 1 (MOTOR 2) output stage is specifically designed to control DC motors. It consists of quad D-MOS switch driver with integrated short-circuit and overtemperature protection. Output stage can be configured either as two independent push-pull outputs or one H-bridge<sup>2</sup> output. H-bridge configuration is used for bidirectional driving of DC-motors (trim actuators, etc.) while the push-pull configuration allows controlling up to two loads (unidirectional motors, lights, etc.). Table 4 shows characteristics of D-MOS motor driver.

Description	Value
VCC voltage	6 - 35 V
Output current	3 A (max)

Table 4: Motor driver characteristics.

### 3 Installation & Maintenance

The device shall be installed away from:

- Any heat source.
- Radio, transponder, antennas and antenna cables.

When installing it in a location where it will be exposed to fluids or moisture, install it in a waterproof enclosure.

#### 3.1 Mounting Dimensions

The device is mounted using four screws type M4. It is highly recommended that the device is mounted using rubber shocks (rubber washers), which reduce the vibrations. Figure 1 illustrates mounting holes for the device.

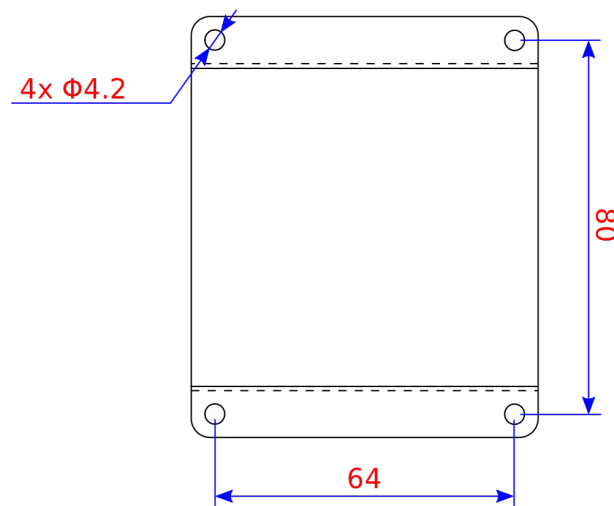


Figure 1: Device mounting holes. Note: Figure is not in scale.

#### 3.2 Connections

Figure 2 illustrates default connection of Boxi.

##### 3.2.1 CAN

Boxi must be connected to primary CAN bus in order to control Nesis via Joyu (refer to Figure 2). Use standard RJ45 ethernet cable to connect it with other Kanardia equipment. If this option is not needed, a special RJ45 power cable must be connected to one of Boxi CAN ports and the other end of cable must be connected to aircraft electrical supply (blue to GND and red to +12 V).

##### 3.2.2 JOYU 1 and JOYU 2

One or two Joyu units must be connected to RJ11 receptacles. Refer to Figure 2 for proper connection.

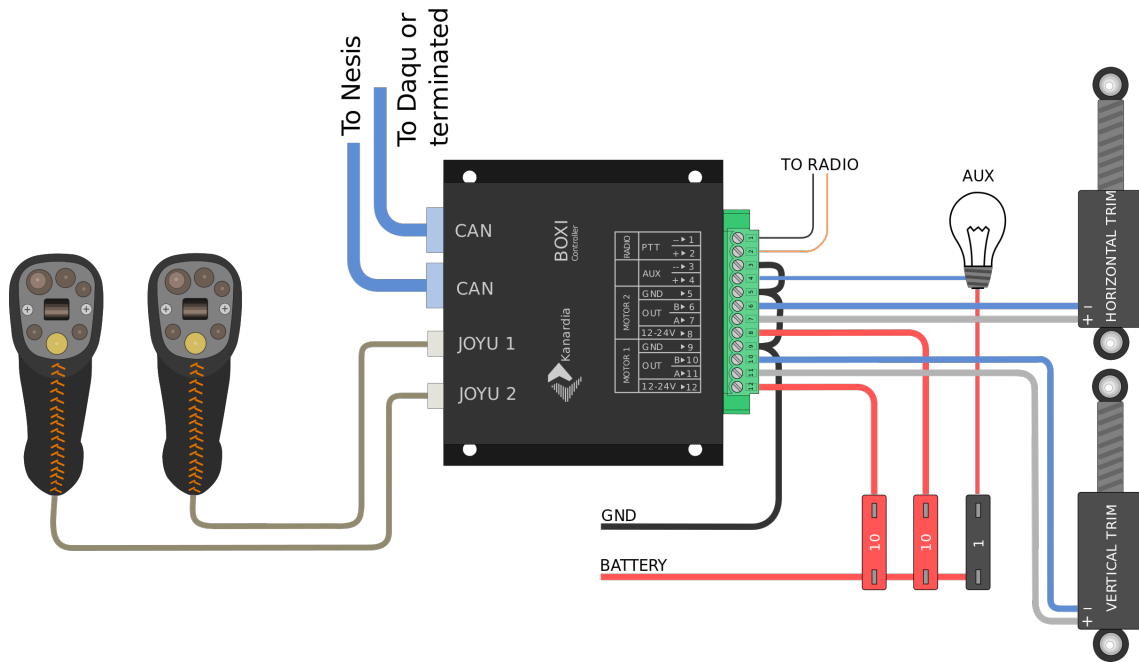


Figure 2: Default connection.

### 3.2.3 RADIO - One Microphone

RADIO (PTT) output acts as a switch between terminal 1 and 2 of output connector where the voltage potential on terminal 1 must be lower than voltage potential on terminal 2. Figure 3 illustrates wiring example for KRT-2 VHF Transceiver radio. Please refer to your radio user manual for proper connection. Note: some transceivers requires an external pull-up resistor on PTT control line (refer to radio user manual).

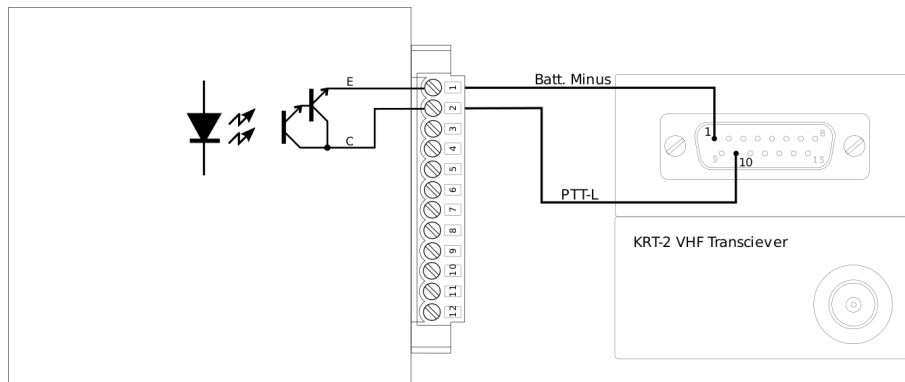


Figure 3: Connection example for controlling PTT on KRT-2 VHF Transceiver with one microphone connected.

### 3.2.4 RADIO - Two Microphones

When two microphones are connected to the radio, the radio must distinguish between microphone in use. Radio will open microphone for which the buttons is pressed and suppressed the other one. So, two switches are needed in Boxi, PTT and AUX.

Figure 4 illustrates wiring example for KRT-2 VHF Transceiver radio for two microphones.



Please refer to your radio user manual for proper connection. Note: some transceivers requires an external pull-up resistor on PTT control line (refer to radio user manual).

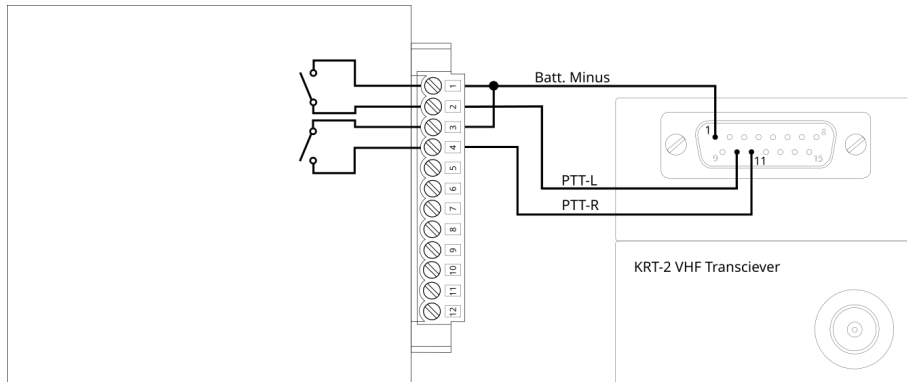


Figure 4: Connection example for controlling PTT and AUX on KRT-2 VHF Transceiver with two microphones connected.

### 3.2.5 AUX

AUX output acts as a switch between output connector terminal 3 and 4 where the voltage potential on terminal 3 must be lower than voltage potential on terminal 4. Figure 5 illustrates wiring example for connecting external power relay to AUX output terminals. A1 terminal of power relay is connected to positive battery lead, A2 is connected to terminal 4 of output connector and terminal 3 of output connector is connected to negative (GND) battery lead.

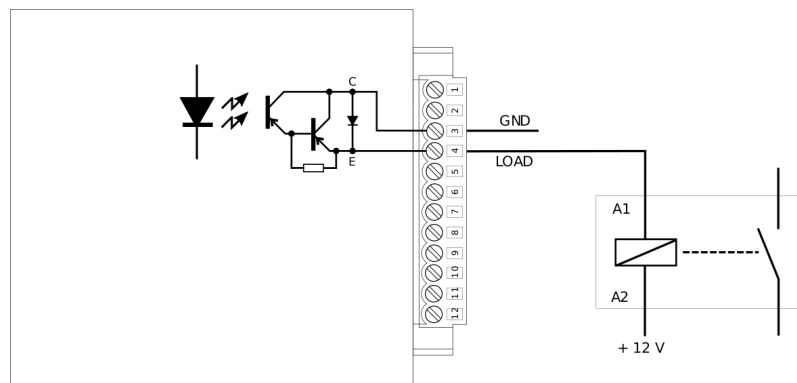


Figure 5: Connection example for controlling external power relay.

### 3.2.6 MOTOR 1 and 2

MOTOR 1 and 2 outputs can be configured either as a single bidirectional DC motor driver or two independent push-pull drivers. Figure 6a illustrates an example of connecting DC-motor (trim actuator), figure 6b illustrates an example of connecting two light bulbs and figure 6c illustrates an example of connecting two independent relays and protection (freewheel) diodes to MOTOR output stage.

The Output stage will output VCC to the selected output pin according to Boxi configuration. If function Motor X+ is selected then the output Motor X+ will go high and Motor X- will remain low. If function Motor X- voltage is selected output Motor X- will go high and Motor

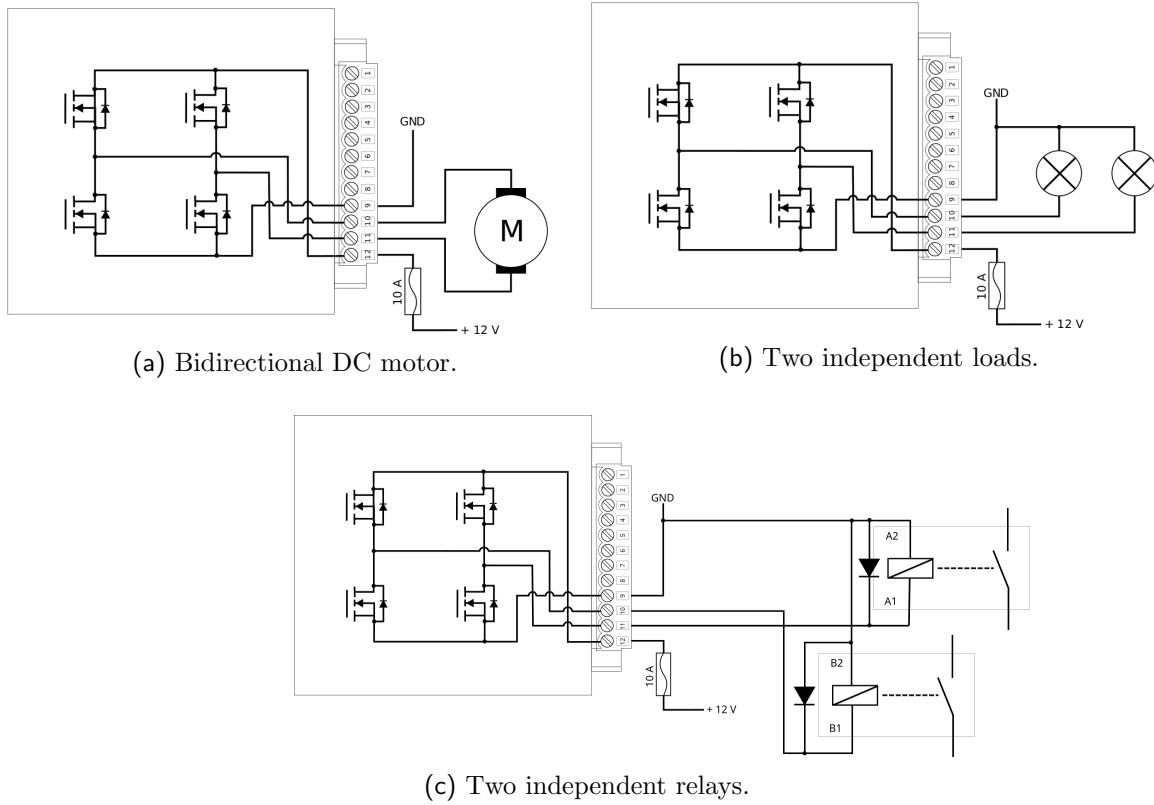


Figure 6: Connection examples for MOTOR 1 output.

X+ will remain low. This enables user to use Boxi output for controlling DC motor or it can be used as a two channel independent driver.

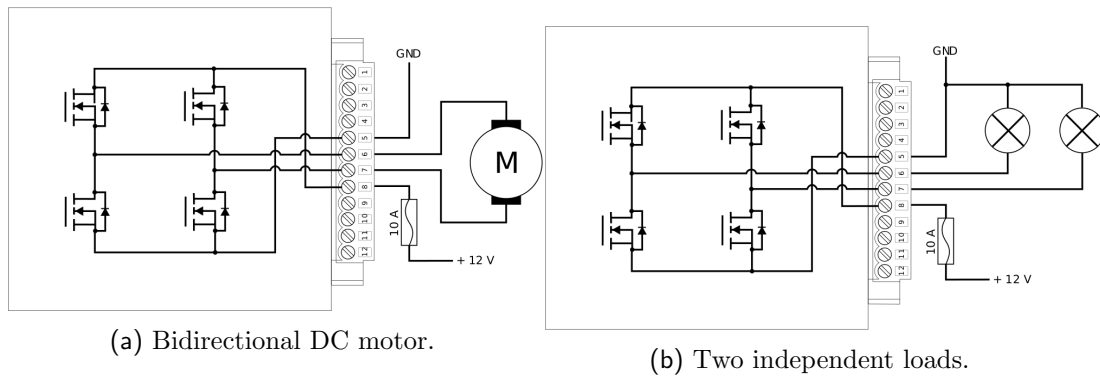


Figure 7: Connection examples for MOTOR 2 output.

### 3.3 High current motor connection with external relays

Sometimes the power output of Boxi is not adequate to handle big DC motors. In this case we propose solution with two external relays.

Figure 8 illustrates how to connect two DP-DT relays (double pole, double throw) to drive high current DC motor in both directions. This connection guarantees that no shortcut can occur even if both relays are engaged at the same time in the case of Boxi malfunction.

CAUTION: Make sure that relays can handle enough current for motor operation under full load.

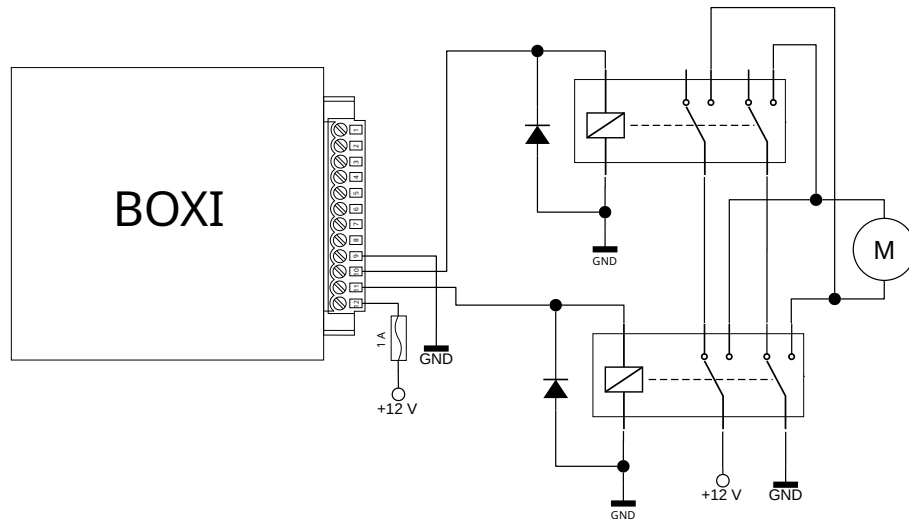


Figure 8: Connection of external relay for driving high current motor.

### 3.4 Ray Allen T2 and T3 Trim Systems

Ray Allen T2 and T3 servo motors are very popular. These servos behave as bidirectional DC motors.

In this section we took color codes from the *Ray Allen Installation Instructions for T2/T3 Trim Systems* manual. Please double check that color coding of your Ray Allen servo matches the coding from the manual.

CAUTION: Do not connect the Ray Allen RS2 rocker switch in parallel to Boxi! This may create a shortcut and may cause severe damage to the wiring and the system.

Figure 9 illustrates how to connect a Ray Allen servo as motor 1. Connect 12V power lead via 10 A fuse to port 12 and black GND lead to port 9. Connect gray and white leads to ports 10 and 11 respectively.

Test the servo and make sure that it runs in proper direction. If direction is wrong, gray and white leads shall be reversed.

The same principles apply also for connection to Motor 2 position. Figure 10 illustrates connection schematics.

### 3.5 Maintenance

No special maintenance is required.

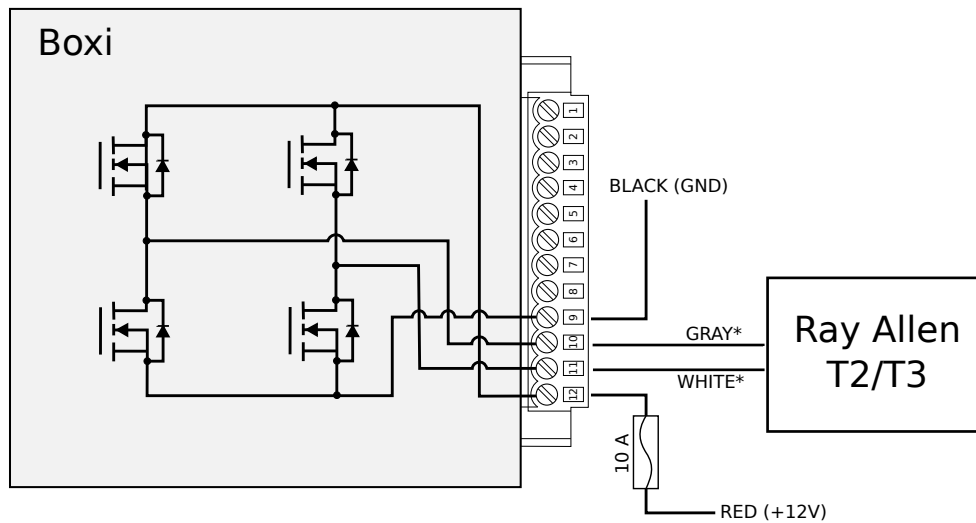


Figure 9: Connection of Ray Allen T2/T3 servo as motor 1.

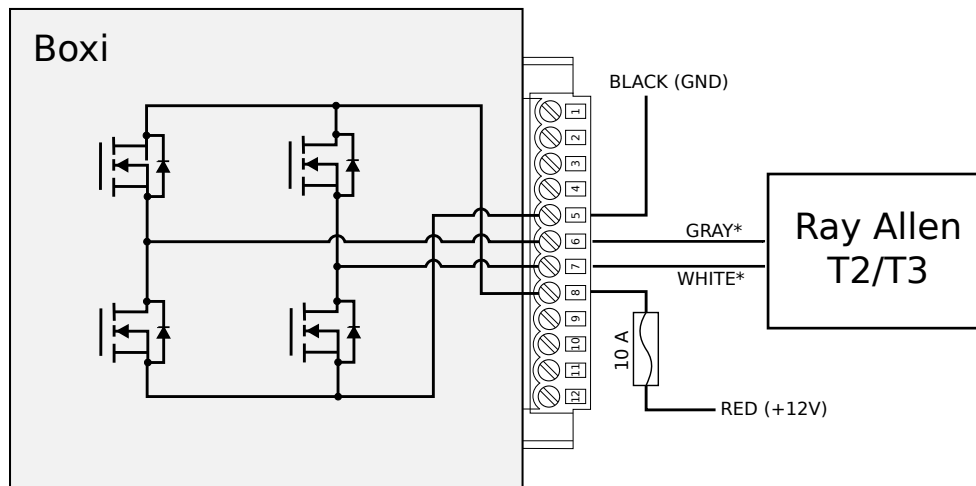


Figure 10: Connection of Ray Allen T2/T3 servo as motor 2.

### 3.6 Repair

The Boxi has no serviceable parts inside. In the case of malfunction, it must be sent to factory for a repair.

## 4 Limited Conditions

Although a great care was taken during the design, production, storage and handling, it may happen that the Product will be defective in some way. Please read the following sections about the warranty and the limited operation to get more information about the subject.

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