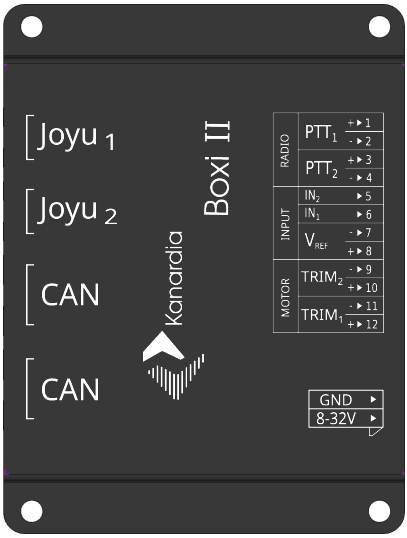
Boxi II — Manual

February 2022



Revision 2.1

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Revision History

The following table shows the revision history of this document.

Rev.	Date	Description
2.0	April 2021	Initial release
2.1	February 2022	Added configuration section, corrected relay connections.

Contents

1 Introduction

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

This manual describes the technical description of the unit, installation and operation. There are two hardware versions of Boxi device: Boxi and BoxiII. This manual is for Boxi II version only. Boxi II units are shipped from May 2021.

1.1 General Description

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

Other devices communicate with Boxi device via CAN bus. Boxi listens to incomming CAN messages and based on their content, controlls its outputs. Boxi has implemented several fail-safe mechanisms which sets the outputs in predefined state in case of disrupted CAN communication. Boxi also monitors the health of all outputs and is able to monitor two external analog inputs.

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

Boxi unit is powered over separated power connector. The electronics will operate correctly even if the main CAN bus is not active or is in error state.

One of the key advantages is the ease of installation. Boxi shall be installed close to power actuators. This reduces system weight and electrical interferences.

1.2 Technical Specification

Table 1 shows some basic technical specification of Boxi.

2 Functional Description

Boxi electronics consists of: CAN interface, control logic, power output and analog input. Boxi electronic is isolated from the main CAN bus to eliminate stray currents between power electronics and main communication bus.

[1] Electronics only, without outputs.

Description	Value
Weight	93 g
Size	100 x 76 x 21 mm
Operational voltage	6 to 36 V
Power consumption	0.45 W [1]
Current	36 mA @ 12 V [1]
PTT Outputs	Solid-State relay, max. 50V/0.5A
Motor Outputs	MOSFET full-bridge, max 36V/1.5A
Operating temperature	-20 °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.

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 a separate power supply connector.

Beside controlling the outputs the microprocessor is also monitoring the status of the outputs. In case of any problem detected it reports the error state to the main bus.

2.2 CAN Bus Interface

System consists of two 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 bus topology problems and to minimize the possibility for Joyu CAN bus malfunction.

Due to the topology used the Boxi and Joyu units will operate even in the case of severe problems on the main bus, or if there is no device connected to the main bus at all.

2.3 Analog Input

Analog input consist of two analog inputs and a reference voltage input/output. It is able to measure voltage from various sensors used for detecting trim and/or flap position.

Boxi outputs a weak reference voltage to be used with simple resistor divider sensors (potentiometer). However in the case of voltage divider powered by external source the reference voltage could be overridden by external reference voltage. The sensor voltage can therefore depend on internal reference, external reference or absolute voltage between $V_{ref}-$ and V_{in} inputs.

Input specifications are listed in table 2

Description	Value
Min voltage on any input	-3 V
Max voltage on any input	18 V
Reference output	3 V
Reference output resistance	2 kOhm
Input resistance	min. 100 kOhm

Table 2: Input characteristics.

2.4 Output Stage

Output stage consists of two pairs of output modules: Ptt and Motor.

2.4.1 Ptt1 and Ptt2

Ptt (Radio) outputs are mostly used to control radio transceiver push-to-talk input. Output is realized using electrically isolated solid-state relay. Its output terminals are routed directly to output terminals 1/2 and 3/4 respectively. Default output state is open (NO, normally open). Press on the PTT button shorts terminals 1, 2 or 3, 4 respectively.[2] Table 3 shows basic characteristics of solid-state relay used.

Beside standard configuration this outputs could be used for any other digital output function.

[2] Default configuration.

Description	Value
Maximum switch voltage	50 V
Maximum current	0.5 A
Switch resistance	2.5 Ohm

Table 3: PTT output characteristics.

2.4.2 Trim 1 and Trim 2

Motor output stage is used to control DC motors. It consists of MOSFET switch driver with integrated short-circuit and over-temperature protection. It also provides open load detection on the output stage.

Output stage can be configured either as two split push-pull outputs or one full-bridge[2] with PWM output. Full-bridge (motor) configuration is used for bidirectional driving of DC-motors (trim actuators, etc.), while the split mode allows controlling up to two loads (unidirectional motors, lights, relays, etc.). Table 4 shows characteristics of MOSFET motor driver.

Description	Value
Voltage	6 - 36 V
Current	1.5 A (max)
Switch resistance	250 mOhm
PWM frequency	12 kHz

Table 4: Motor driver characteristics.

In the motor mode the PWM switching also is implemented. Therefore it is possible to configure soft-start or to limit the maximum power of the motor. The user must configure start and finish PWM duty cycle and time to transit from start to finish value.

PWM mode works like quick switching the output to on and off. The duty cycle between on and off state can be changed. This way the power delivered to the load is reduced. The switching is fast and at fixed frequency.

With change of PWM duty cycle the soft start of motor is realized in Boxi II. On figure 1 the idea of soft start is presented. On keypress on Joyu the Trim output starts switching with cycle period. On the first PWM cycle the *Start PWM* duty cycle is used. On consecutive cycles the duty cycle is increased until

it reaches the *Max PWM*. The transition time from Start to max is marked as Time To Max.

On figure 1 the Start PWM is 30%, the Max PWM is 100%.

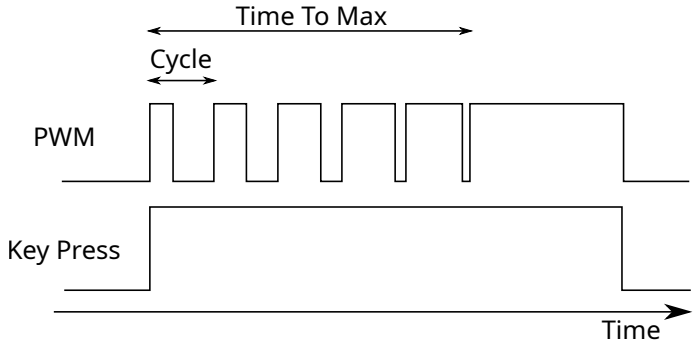


Figure 1: Pwm mode switching description.

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, it shall be installed 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 2 illustrates mounting dimensions for the device.

3.2 Maintenance

No special maintenance is required.

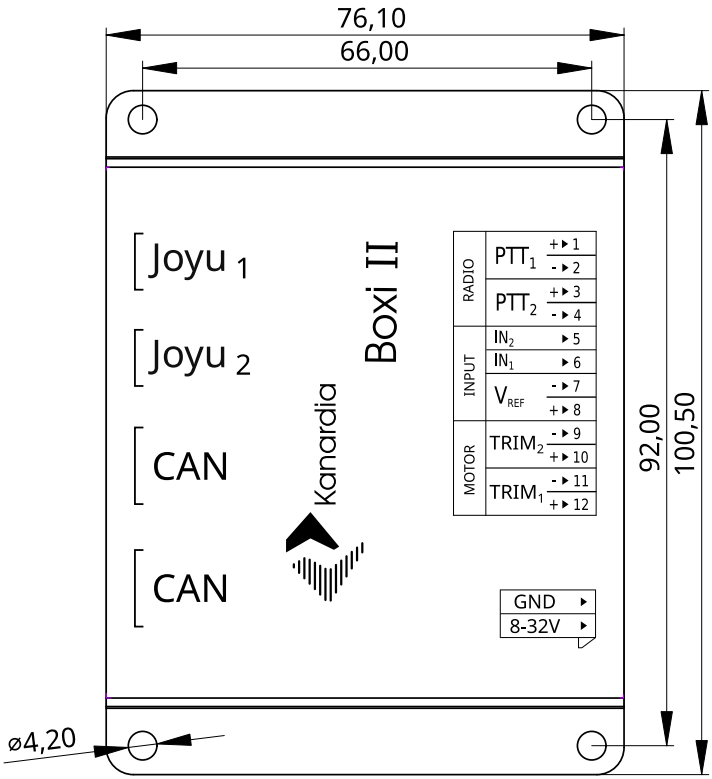


Figure 2: Device mounting dimensions. Note: Figure is not in scale.

4 Connections

Boxi connects different devices together to ease the installation. Figure 3 illustrates connection of standard devices to Boxi.

4.1 Power

Boxi shall be connected to the aircraft power supply. Because Boxi controls essential devices like PTT for the radio it should get a power supply as soon as the master switch of the aircraft is turned on. In this case it will be able to control outputs before any other avionics is switched on.

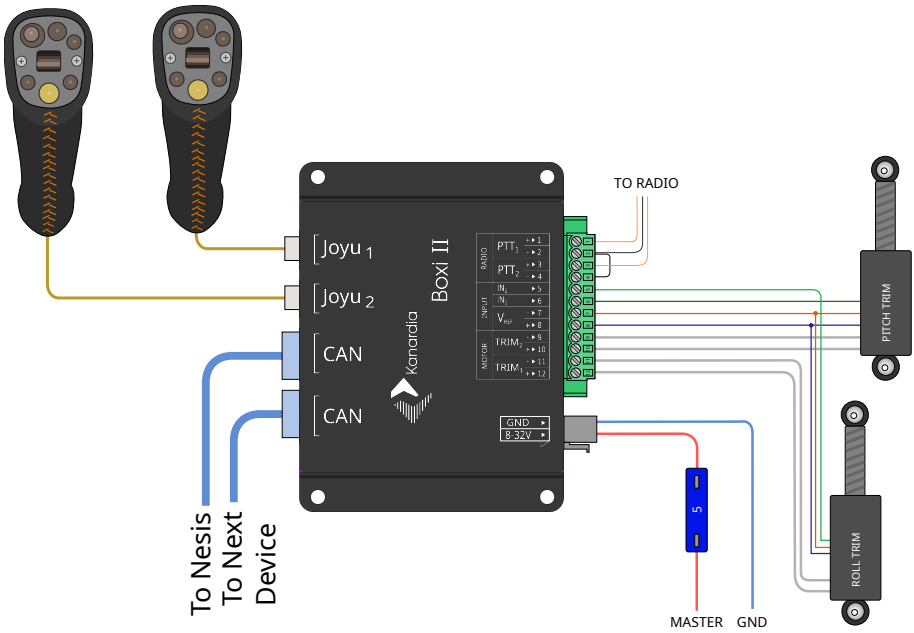


Figure 3: Default connection.

Boxi power supply shall be protected with a fuse of a proper rating. The recommended current rating of the fuse is 5A.

4.2 CAN

Boxi must be connected to primary CAN bus in order to control any supported Kanardia device via Joyu (refer to Figure 3). Use standard RJ45 ethernet cable to connect it with other Kanardia devices.

Two identical CAN ports are present on the Boxi device. If the Boxi is the first or last device on the bus use termination plug on the remaining port.

4.2.1 BLU

If there are no devices present and you want to configure Boxi and Joyu devices with BLU (Bluetooth CAN interface) you shall use a special RJ45 power cable for powering the BLU device. The cable connects 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). This cable shall be used only if BLU is used and no other device is powering the main CAN bus. The cable also includes the CAN bus termination resistor.

4.2.2 Joyu 1 and Joyu 2

One or two Joyu units shall be connected to 4-pin RJ connectors. Refer to Figure 3 for proper connection. Both outputs are short circuit protected. Failure of one Joyu device does not influence operation of Boxi and other Joyu. If any problem is detected by the Boxi it is reported to the user.

4.3 Ptt 1 and Ptt 2

Ptt 1 and Ptt 2 are two separated and completely isolated switches. Both + and - teminals shall be connected. In this section we will explain most common connections for Ptt outputs.

4.3.1 One Microphone

Ptt output acts as a switch between terminal 1 and 2 of the output connector. Figure 4 illustrates wiring example for KRT-2 VHF 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).

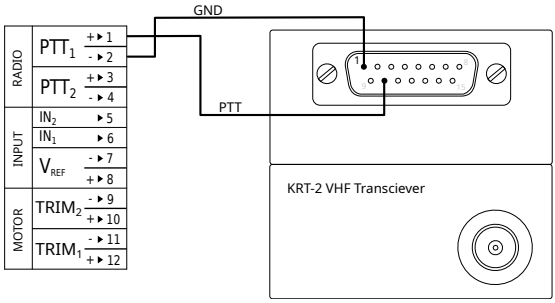


Figure 4: Connection example for controlling PTT on KRT-2 VHF radio with one microphone connected.

4.3.2 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 button is pressed and suppressed the other one. So, two switches are needed in Boxi, Ptt1 and Ptt2.

Figure 5 illustrates wiring example for KRT-2 VHF radio for two microphones. Please refer to your radio user manual for proper connection. Note: some transceivers require an external pull-up resistor on PTT control line (refer to radio user manual).

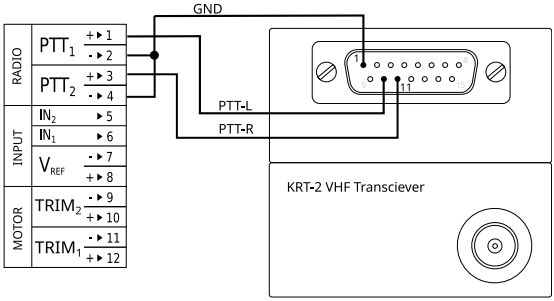


Figure 5: Connection example for controlling PTT-1 and PTT-2 on KRT-2 VHF radio with two microphones connected.

4.3.3 PTT as Auxiliar Output

Ptt output can also act as auxiliar switch for triggering some external device. Figure 6 illustrates wiring example for connecting external power relay to Ptt2 output terminals. A1 terminal of power relay is connected to positive battery lead, A2 is connected to terminal 3 of output connector and terminal 4 of output connector is connected to negative (GND) battery lead.

In case of inductive loads (relays, small motors) user shall install freewheeling diode in parallel to inductive load. Also please make sure that maximum voltage and current are not exceeded.

4.4 Trim 1 and Trim 2

Each motor output can be configured either as a bidirectional DC motor driver or as two independent push-pull drivers. Figure 7a illustrates an example

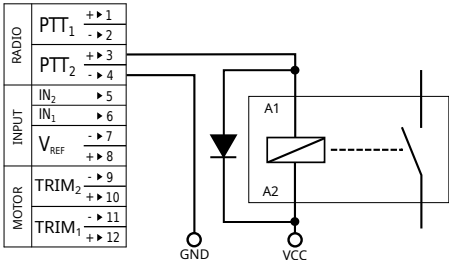
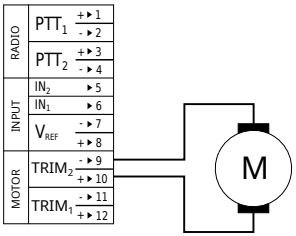
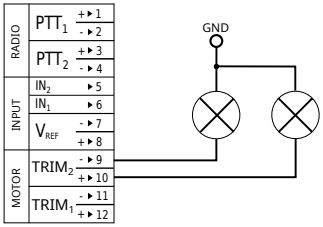


Figure 6: Connection example for controlling external relay.

of connecting DC-motor (trim actuator), figure 7b illustrates an example of connecting two light bulbs.



(a) Bidirectional DC motor.



(b) Two independent loads.

Figure 7: Connection examples for motor output.

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

4.4.1 High current motor

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 one SPST and one DPDT 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.

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

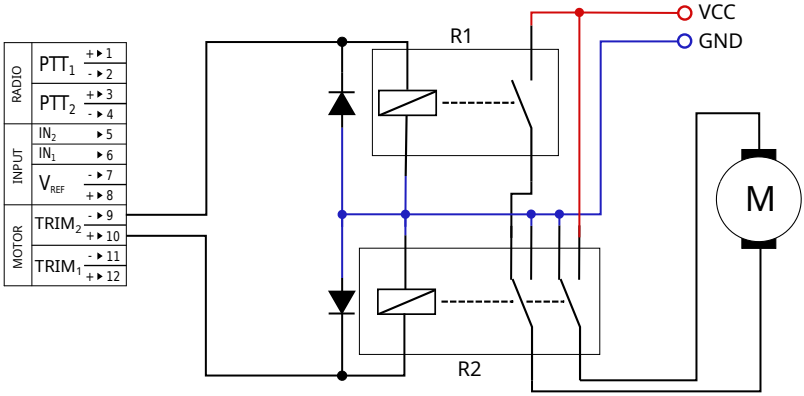


Figure 8: Connection of external relay for driving high current motor.

4.5 Position Input

The Boxi II includes also two analog inputs for position sensors. Most of the position sensors are simply variable resistors - potentiometers, which work as a voltage divider. The voltage divider must be connected to a voltage source which we will refer to as a reference voltage. Boxi is able to handle different types of connections which will be described in this section.

The connection used must be selected in a way that simplifies the installation. Please note that Input 1 and Input 2 can be configured in a different way, however not every possible combination is possible. The reason for this is that only one V_{ref} input is present.

4.5.1 Internal Reference

This is simplest way of connecting the position sensor to the Boxi. The installer shall connect three wires from position sensor directly to the Boxi. Please refer

to figure 9 for detailed connection example.

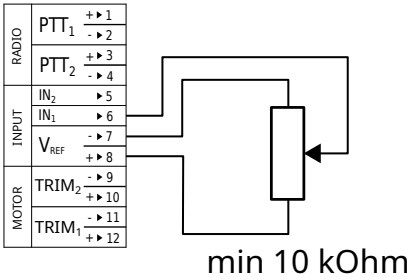


Figure 9: Position sensor with internal reference.

However with this connection it is not possible to connect any external position display to the same sensor.

4.5.2 External Reference

External reference connection is using external voltage applied to the V_{ref} input. Installer shall connect external reference to V_{ref} input and to the position sensor.

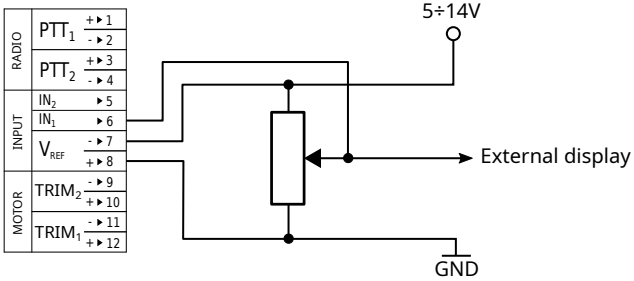


Figure 10: Position sensor with external reference.

This voltage can be stabilised or not. In the case the voltage is stable the please see next section. In the case of unstablized reference voltage the relative ratio must be chosen during configuration.

4.5.3 No Reference

If the voltage on the position sensor is stabilised via some sort of voltage regulator it is not necessary to connect $V_{ref}+$ input. However $V_{ref}-$ must still be connected. In this way the Boxi measures absolute voltage on input. The user must define maximum and negative values in volts, rather in relative ratio.

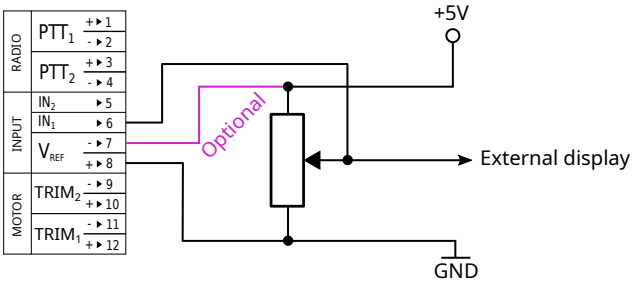


Figure 11: Position sensor with stabilised outside voltage source.

4.6 Ray Allen T2/T3 Trim Motor

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

In this section we are using 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.

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 12 illustrates how to connect a Ray Allen servo as motor 1. Connect white leads to ports Trim+ and Trim- respectively. The same principles apply also for connection to motor 2 position.

Test the servo and make sure that it runs in proper direction. If direction is wrong, white leads shall be reversed. It is also possible to reverse the direction in software configuration.

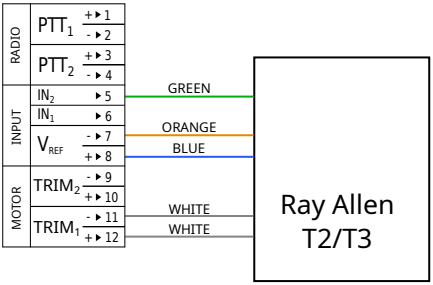


Figure 12: Connection of Ray Allen T2/T3 servo as Trim 1.

5 Configuration

The Boxi device can be easily configured with any Nesis/Aetos type of device with at least software version 3.8.5.

5.1 Overview

For Boxi configuration the dialog in Figure 13 is used. With the use of menu on the left side of the dialog it is possible to configure both Boxi output and both input channels. On the right side of dialog current state of boxi outputs and inputs are shown in raw format. Also the power consumption of both Joyu units can be monitored.

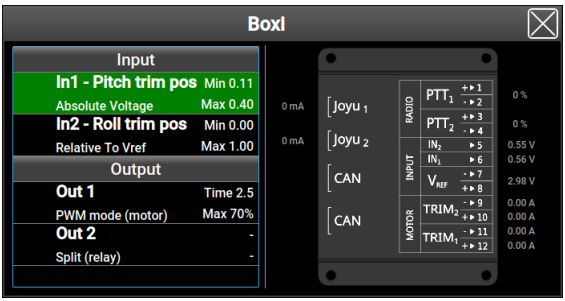


Figure 13: Boxi configuration dialog with status information.

5.2 Outputs

The output type can be selected when operator selects one of the output channels. There are two types of output behavior present: Pwm and Split. Depending on the selection of the type different options are shown.

5.2.1 Pwm

Pwm mode of output is suitable for direct connection of the electric DC motor. In this mode the Boxi is using pulse width modulation to control the power output to the motor. With output configuration dialog several values could be adjusted. Please see figure 1 for more information about pwm switching.

- Time To Max - This is the time needed to transit PWM dutty cyle from *Start PWM* to *Max PWM*. If this value is set to 0 seconds, the *Start PWM* is ignored and *Max PWM* is used from the start of button press to release. The duty cycle transition increases lineary with time.
- Start PWM - This is PWM duty cycle at push button press event. For most motors it should be arround 50% because of the faster reaction to push button event.
- Max PWM - This is maximum PWM this output channel is using. If it is set to 100% then the output is constantly on and no PWM switching is occurring.

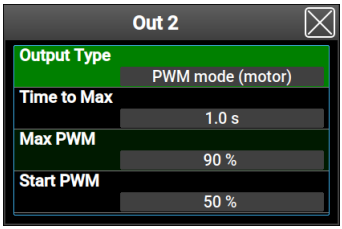


Figure 14: Configuration dialog for PWM type of output.

5.2.2 Split

In split mode type of the output there are no further options for configuration. In the split mode the output behaves as a simple switch.

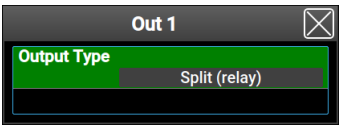


Figure 15: Configuration dialog for Split type of output.

5.3 Inputs

In Boxi configuration dialog also the input channel configuration can be done. After selecting appropriate channel the action dialog is shown as on figure 16.

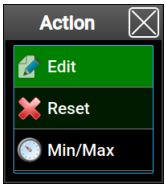


Figure 16: Action dialog for input channel configuration actions.

The following action can be done for each channel:

1. Edit - Edit the function and other parameters of selected channel.
2. Reset - Reset selected channel function to not used.
3. Min/Max - Set the minimum and maximum values of the channel.

5.3.1 Edit

When entering Edit dialog as on figure 17 is shown. Within Edit dialog the following parameters can be set:

1. Function - that this channel represents. Usually this is one of the trim position indicators, but it can be used also for flap position, etc...
2. Sensor - Describes the connection type of the sensor and its reference voltage. Please see section 4.5 for more details.
3. Report Time - How often the information is sent from Boxi to other units on CAN bus. For position reports this should be set to 0.2 seconds.

4. Filter - Time constant for internal digital filter. It controls how fast the input reacts to sensor changes.

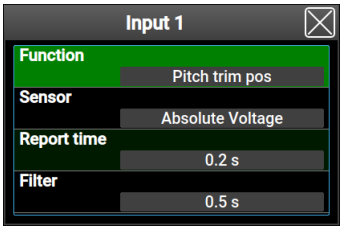


Figure 17: Configuration dialog for Input channel.

5.3.2 Min/Max

In Min/Max dialog the values that represent limiting values of the sensor shall be set. For pitch trim the limits are full “Nose” trim and full “Tail” trim, for roll trim position the full “left and ”right“ values shall be set. In figure 18 Min/Max dialog for Roll Trim is shown. There are three different values shown:

- Left - value of the sensor input at full left position.
- Right - value of the sensor input at full right position.
- Sensor - current value of the sensor input.

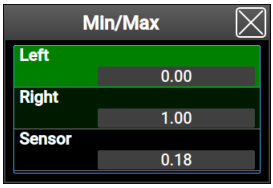


Figure 18: Configuration dialog for Min/Max settings.

5.4 Status

Within Boxi configuration dialog as on figure 13 the status of Boxi can be monitored.

1. Power consumption of Joyu 1 and 2 ports.
2. State of Ptt1 and Ptt 2 outputs. The 0% means open contact, 100% means closed contact.
3. Voltage between In1 and In2 inputs and Vref-.
4. Voltage between Vref+ and Vref-.
5. Current flowing from Boxi VCC to the Trim 1+, 1-, 2+ and 2- terminals.

5.5 Ray Allen

When using Ray-Allen T2/T3 motors set the Boxi configuration to proposed values. The proposed settings will enable the use of soft start of the trim motor, with quick input signal response. Please select appropriate input and output channel and set them as follows.

5.5.1 Input

- Function - Pitch, Roll or Yaw trim position
- Sensor - Internal reference
- Report Time - 0.2s
- Filter - 0.5s

5.5.2 Output

- Output type - PWM
- Time To Max - 1.0s
- Start PWM - 50%
- Max PWM - 100%

6 Repair

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

7 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.

7.1 Warranty

Kanardia d.o.o. warrants the Product manufactured by it against defects in material and workmanship for a period of twenty-four (24) months from retail purchase.

Warranty Coverage

Kanardia's warranty obligations are limited to the terms set forth below:

Kanardia d.o.o. warrants the Kanardia-branded hardware product will conform to the published specification when under normal use for a period of twenty-four months (24) from the date of retail purchase by the original end-user purchaser ("Warranty Period"). If a hardware defect arises and a valid claim is received within the Warranty Period, at its option and as the sole and exclusive remedy available to Purchaser, Kanardia will either (1) repair the hardware defect at no charge, using new or refurbished replacement parts, or (2) exchange the product with a product that is new or which has been manufactured from new or serviceable used parts and is at least functionally equivalent to the original product, or, at its option, if (1) or (2) is not possible (as determined by Kanardia in its sole discretion), (3) refund the purchase price of the product. When a refund is given, the product for which the refund is provided must be returned to Kanardia and becomes Kanardia's property.

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This Limited Warranty applies only to hardware products manufactured by or for Kanardia that have the "Kanardia" trademark, trade name, or logo affixed to them at the time of manufacture by Kanardia. The Limited Warranty does not apply to any non-Kanardia hardware products or any software, even if packaged or sold with Kanardia hardware. Manufacturers, suppliers, or publishers, other than Kanardia, may provide their own warranties to the Purchaser, but Kanardia and its distributors provide their products *AS IS*, without warranty of any kind.

Software distributed by Kanardia (with or without the Kanardia's brand name including, but not limited to system software) is not covered under this Limited Warranty. Refer to the licensing agreement accompanying such software for details of your rights with respect to its use.

This warranty does not apply: (a) to damage caused by use with non-Kanardia products; (b) to damage caused by accident, abuse, misuse, flood, fire, earthquake or other external causes; (c) to damage caused by operating the product outside the permitted or intended uses described by Kanardia; (d) to damage caused by service (including upgrades and expansions) performed by anyone who is not a representative of Kanardia or an Kanardia Authorized Reseller; (e) to a product or part that has been modified to significantly alter functionality or capability without the written permission of Kanardia; (f) to consumable parts, such as batteries, unless damage has occurred due to a defect in materials or workmanship; or (g) if any Kanardia serial number has been removed, altered or defaced.

To the extent permitted by applicable law, this warranty and remedies set forth above are exclusive and in lieu of all other warranties, remedies and conditions, whether oral or written, statutory, express or implied, including, without limitation, warranties of merchantability, fitness for a particular purpose, non-infringement, and any warranties against hidden or latent defects. If Kanardia cannot lawfully disclaim statutory or implied warranties then to the extent permitted by law, all such warranties shall be limited in duration to the duration of this express warranty and to repair or replacement service as determined by Kanardia in its sole discretion. Kanardia does not warrant that the operation of the product will be uninterrupted or error-free. Kanardia is not responsible for damage arising from failure to follow instructions relating to the product's use. No Kanardia reseller, agent, or employee is authorized to make any modification, extension, or addition to this warranty, and if any of the foregoing are made, they are void with respect to Kanardia.

Limitation of Liability

To the extent permitted by applicable law, Kanardia is not responsible for indirect, special, incidental or consequential damages resulting from any breach of warranty or condition, or under any other legal theory, including but not limited to loss of use; loss of revenue; loss of actual or anticipated profits (including loss of profits on contracts); loss of the use of money; loss of anticipated savings; loss of business; loss of opportunity; loss of goodwill; loss of reputation; loss of, damage to or corruption of data; or any other loss or damage howsoever caused including the replacement of equipment and property, any

costs of recovering, programming, or reproducing any program or data stored or used with Kanardia products and any failure to maintain the confidentiality of data stored on the product. Under no circumstances will Kanardia be liable for the provision of substitute goods or services. Kanardia disclaims any representation that it will be able to repair any product under this warranty or make a product exchange without risk to or loss of the programs or data. Some jurisdictions do not allow for the limitation of liability for personal injury, or of incidental or consequential damages, so this limitation may not apply to you.

7.2 TSO Information — Limited Operation

This product is not TSO approved as a flight instrument. Therefore, the manufacturer will not be held responsible for any damage caused by its use. The Kanardia is not responsible for any possible damage or destruction of any part on the airplane caused by default operation of instrument.