NaviTop

NaviTop models: C30 or PC30

MANUAL PYPILOT CONTROLLER 30A WITH CLUTCH OUTPUT BY NAVITOP

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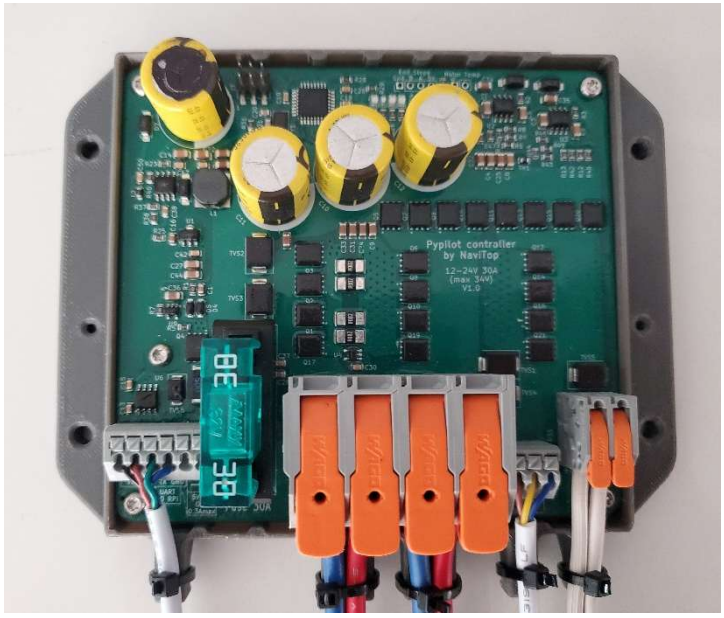


1 – Presentation and specification

Pypilot was conceived and designed by Sean D'EPAGNIER. Thanks to him for this fantastic boat autopilot.

This motor controller drives autopilot actuators with DC motors and electromagnetic clutches. It must be paired with a suitable autopilot computer such as **Tinypilot**, **OpenPlotter** or BBN running Pypilot.

- Supports 12 or 24 volts (10v to 34v maximum)
- Power input protected against reverse polarity, EMC Surges and a 32V 30A "MAXI" automotive fuse
- All outputs protected by electronic current limitation, including the rudder angle sensor and limit switch power supplies
- With pypilot, once the clutch is engaged, this controller allows to reduce the electrical consumption of the clutch only to what is sufficient to keep it engaged
- With pypilot, this controller allows you to adjust the acceleration, deceleration and speed of the motor
- Software over- current (stall) detection and over-temperature protection
- Voltage, current, temperature and rudder feedback
- Box allowing easy fixing of cables using nylon collars
- Power supply input and motor output with lever connection terminals Wago 66 amps for conductors up to 16mm²
- Clutch output with lever connection terminal Wago 32 amps for conductors up to 4mm² conductors
- Terminal blocks with push button for conductors 0.75 to 1.5mm² (strip length 8.5 to 9.5mm) for connecting:
    - Serial communication to Raspberry Pi (tinypilot or openplotter) with galvanic isolation, prevent ground loops and other electrical problems.
    - output 5V DC 0.3A max to powering tinypilot Pi Zero autopilot computer.
    - rudder feedback sensor
- 4 pins for connection to optional rudder end of stops (limit switches or proximity detectors 5V). As an option, a cable with a waterproof connector can be soldered (see §13)
- The controller's 5V DC power supply has been redesigned to be more robust and allow the pypilot computer, with Pi Zero W or Zero 2W, to be powered. All 5V outputs are short-circuit protected
- Intrinsic consumption about 5 mA (60 mW with 12V, 120 mW with 24V)
- PCB marinized with tropicalizing acrylic varnish
- The open-source Arduino software designed by Sean d'Epagnier is flashed. The processor can be reprogrammed using the ISP programming connector on PCB
- Dimensions :
    - Box : 146 x 132 x 50 mm
    - PCB : 107 x 117 x 43 mm

2 - Power Supply and Motor Connection - Power Cable Sizing

For the controller's power supply and connection to the motor, use a cable with a sufficient cross-section, whenever possible, so that its electrical resistance does not exceed the internal resistance of the motor controller. The goal is to have the actuator operate as quickly as possible with minimal heat loss in the wires.

- 3m length between the electrical panel and the motor = 2 x 5mm² (AWG10)
- 4m length between the electrical panel and the motor = 2 x 7mm² (AWG9)
- 6m length between the electrical panel and the motor = 2 x 10mm² (AWG7)

Strip 18 to 20 mm of insulation from the power and motor wires, then:

- Connect the + and – power wires to the WAGO + and – terminals marked "Power".

- Connect the motor wires to the Wago A and B terminals marked "Motor" on the circuit board. The two motor wires must be reversed if the driver corrections are made in the wrong direction.

3 - Clutch output and energy saving device

There are two terminals for powering a solenoid valve for hydraulic actuators, or a mechanically controlled solenoid clutch for other applications.

The output voltage for the clutch is the same as the power supply voltage of the motor controller.

Strip the wires between 9 and 11mm and connect them to the + and – terminals of the Wago terminal block marked “Clutch”.

To reduce power consumption, pypilot energizes the clutch coil at full power for 200-300 milliseconds, then the controller outputs pulse width modulated (PWM) pulses to keep the clutch engaged while reducing power consumption. This can be adjusted with pypilot parameter "servo.clutch_pwm" key (0-100%) accessible in the additional "pypilot client" settings. For a cylinder solenoid valve, a setting of 16% decreases the current by a ratio of 6.25 while keeping the cylinder fully engaged, which reduces consumption from 30Ah per day to 5Ah.

4 - Serial Data Connection to computer

Connection to Raspberry Pi (tinypilot, openplotter or BBN) via 4 Wago push-button terminal block contacts for conductors up to 1.5 mm² (strip length 8.5 to 9.5mm).

Wago terminal	Function	To raspberry pin
VCC	+3.3v	1
RX	Rx (to Tx)	8
TX	Tx (to Rx)	10
GND	0v, GND	6, 9

It is recommended to use telephone or Ethernet cable directly connected to the WAGO push-in terminals. This cable can be extended by more than 30 meters.

The controller's serial input and output are galvanically isolated to prevent ground loops and other electrical problems. The + wire powers the controller's galvanic decoupling circuit, which can be powered from +3V to +5.5V. The current consumption, in the order of mA, allows the use of a fine-wire cable. To facilitate connection to the autopilot computer, a 4-pin waterproof connector is provided and connected to the controller.

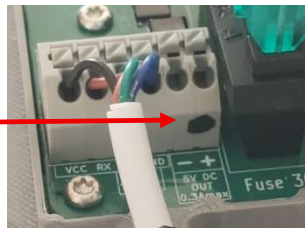
The serial cable can be extended by more than 30 meters with telephone or Ethernet cable. If you are particularly concerned about interference, you could use a shielded cable, but this is rarely, if ever, a concern in practice.

If you connect the motor controller directly to a Pi, we recommend installing TVS diodes on the Pi side to limit potential surges that could be induced by a nearby lightning strike, especially if this cable is more than a meter long (see diagram of a simple tinypilot in the documentation tab of www.navitop.fr).

5 - 5V DC output to power the Pi Zero autopilot

To the right of the four UART communication pins with the Raspberry Pi, there are two additional push-button terminals for powering the computer with a Pi Zero at 5V DC. Larger Pis draw too much peak current and should not be powered by the controller.

All Navitop computers (basic or with remote control) come with a 5V DC power cable approximately 45cm long. Strip 9mm of insulation from the red and black wires of the cable and insert them into the + and – 5V DC terminals of the controller.



The first 30A controllers have an output voltage of 4.95V. Controllers from version V1.2 onwards have a 5.23V output, as do the V1.1 controllers with a black dot on the terminal block.

Depending on the wire gauge of the cable, the output voltage of the controller, and the type of Pi Zero, we advise you never to exceed the following cable lengths:

		Pi Zero 2W and USB accessories consuming 1W		Pi Zero W and USB accessories consuming 1W	
Cable wires		Output 4.95V	Output 5.23V	Output 4.95V	Output 5.23V
2 x 24AWG	2 x 0.2mm²	1.5 m max	3.6 m max	2.2 m max	5.4 m max
2 x 22AWG	2 x 0.3mm²	2.4 m max	5.7 m max	3.6 m max	8.6 m max
2 x 20AWG	2 x 0.5mm²	3.8 m max	9 m max	5.7 m max	13.6 m max

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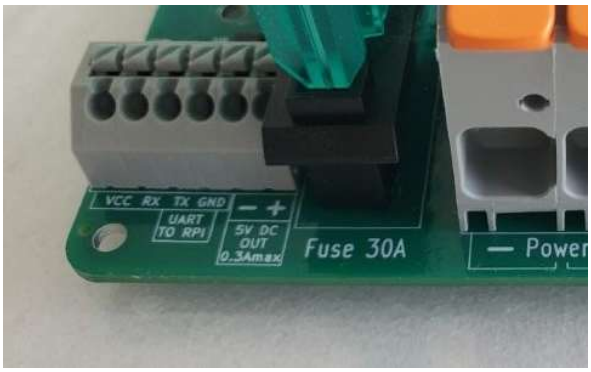
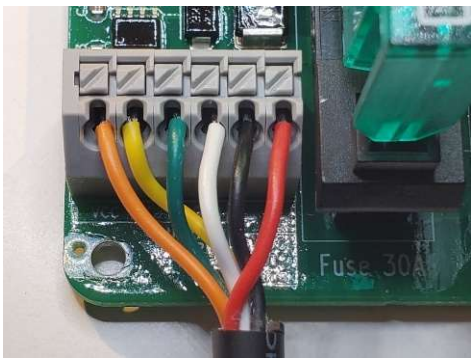
Adhering to these maximum cable lengths ensures that the Raspberry Pi Zero is powered within the normal voltage range defined by the Raspberry Pi Foundation, between 4.75V and 5.25V.

Going below 4.65V will reset the Pi, which can disrupt and prevent it from booting.

6 - Connection to the ECU with a single cable (option C6P3M, C6P5M or C6P9M)

The computer can be optionally equipped with a connector and a single 6 x 20AWG cable to the controller. Depending on the option chosen, the cable length can be 3m (C6P3M), 5m (C6P5M) or 9m (C6P9M).





The functions, wire colors, and corresponding terminals of the controller are listed in the table below:

Function	Wire color	Controller terminal
UART +3.3V	Orange	UART VCC
UART RX (TO TX)	Yellow	UART RX
UART TX (TO RX)	Green	UART TX
UART GND	White	UART GND
POWER +5V	Black	5V DC -
POWER GND	Red	5V DC +

7 - Adjusting the current consumption limit for the motor

All brushed motors have low no-load current. As the motor becomes under load, the current increases until it reaches the maximum current specified by the manufacturer, which corresponds to the maximum force or maximum pressure in the case of a pump.

Pypilot instantly stops the actuator motor when the current drawn by the motor exceeds the Pypilot servo.max_current setting. The motor is then no longer powered until the computer requests that the motor be restarted in the opposite direction. This is sufficient to effectively limit the stroke and force of many actuators.

All Pypilot controllers are equipped with a precise measurement of the current drawn by the motor. The servo.current variable, directly in amperes, is accessible via the Pypilot client (configuration page) or with the pypilot_scope script.

The servo.max_current parameter should be set between 12 and 20 amps with large actuators or hydraulic pumps. If this current limiting setting is set too low, "OVERCURRENT_FAULT" messages will appear constantly and prevent the actuator from moving. If the value is too high, the actuator could continue to operate dangerously even at its limit.

The actual current drawn by the motor in amps is available in real time with the Pypilot servo.current variable. This can be viewed in the configuration page using the Pypilot client. It is also possible to visualize the current draw with a graph using the pypilot_scope script.

8 - Rudder Feedback sensor

First, without a rudder feedback sensor, Pypilot will steer the boat without any noticeable decrease in autopilot performance.

The rudder feedback sensor is primarily useful for displaying the rudder angle on a screen and/or limiting the actuation travel to prevent it from forcing the rudder stops.

A 3-wire potentiometer can be connected to the controller. The potentiometer's resistance range should be between 1 kΩ and 100 kΩ. 10 kΩ is recommended. You can also connect a 5V Hall effect sensor with an analog output to these 3 wires.

If an existing rudder sensor with only two wires is connected, a 1 kΩ resistor must be added between the 5V pin and the measurement pin.

If a rudder feedback sensor is connected, you can consult the calibration page to read the sensor measurement and verify that it is working. To calibrate it, you must manually turn the rudder to port, starboard, and center and clicking the button corresponding to each position. The order does not matter, but once all three positions are clicked, the scale, offset, and non-linearity are calculated. The "rudder range" field must be manually set to indicate the maximum angle of rotation from the center. This setting also allows you to automatically limit the autopilot's movement beyond this position. For example, with a rudder turning ±35°, you would enter 35 in the "rudder range" field to calibrate the sensor by moving the rudder to port, starboard, and then center. By then decreasing the value of the "rudder range" field to 30 degrees, the autopilot's travel is limited to 30°, or 5° before the rudder stops.

9 - Rudder travel limiter switches

Electrical limit switches are not required with Pypilot.

With a powerful actuator, installing limit switches to stop the motor is the safest way to prevent the actuator from overexerting the mechanical rudder stops. Limit switches are less prone to malfunction than a rudder feedback sensor whose rod can bend or detach. A bent or detached rod of a rudder feedback sensor can prevent the actuator from turning the rudder in one direction, thus rendering the autopilot inoperative.

GND is the common wire for both switches. Connecting wire A or wire B to GND prevents any motor movement in the corresponding direction.

The connection on the PCB is labeled "End Stops." The square pad is GNDZero, the second is End B, the third is End A, and the last pad is the +5V power supply, used only if you are installing proximity switches or Hall effect logic sensors requiring a 5V power supply.

After connection, test to ensure that when the motor rotates in one direction, the limit switch corresponding to that direction stops the motor. If this is not the case, the End A and End B wires must be reversed.

Upon request, we can supply and solder a cable with a waterproof connector:

- CS3S: optional 3 pin waterproof connector (End A = yellow, End B = brown, GND = blue)
- CS4: optional 4 pin waterproof connector (+5V = brown, End A = green, End B = blue, GND = black)

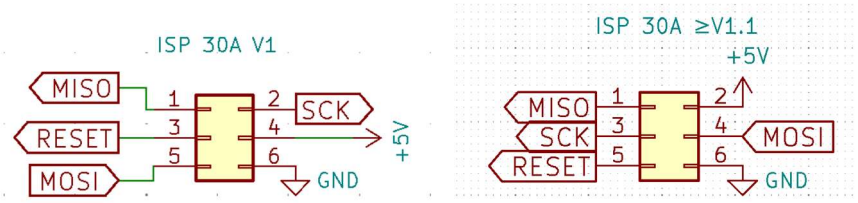
10 - Motor Temperature Sensor

Optional 10k NTC (2 wires) for temperature of the electric motor.

This is generally not needed because most motors will not overheat unless stalled for prolonged periods. It can be used to prevent the motor from overheating and burning out.

11 - ISP connector

Important: The ISP programming connector in PCB version V1 is special. The ISP connector is normal from version V1.1



12 – Navitop 12-24V 30A Motor Controller Designations

- C30 : Pypilot motor controller 12-24V 30A by Navitop with case
- PC30 : Pypilot motor controller 12-24V 30A by Navitop without case

13 – List of options available with Navitop Motor Controller 12-24V 30A

- CS3S - Waterproof 3 pin connector for rudder limit switches
- CS4 - Waterproof 4 pin connection for rudder inductive limit switches
- C6P3M – Waterproof 6 pin connector and single 3m cable to the controller 30A
- C6P5M - Waterproof 6 pin connector and single 5m cable to the controller 30A
- C6P9M - Waterproof 6 pin connector and single 9m cable to the controller 30A