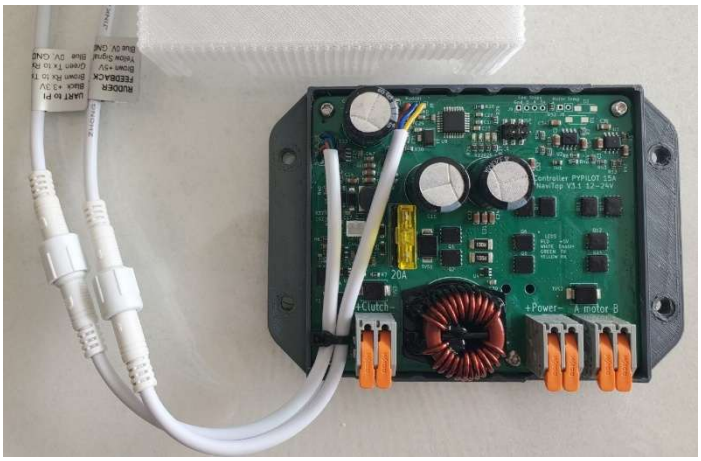
NaviTop

NaviTop models: C15 or PC15

PYPILOT CONTROLLER 15A WITH CLUTCH OUTPUT
by Navitop



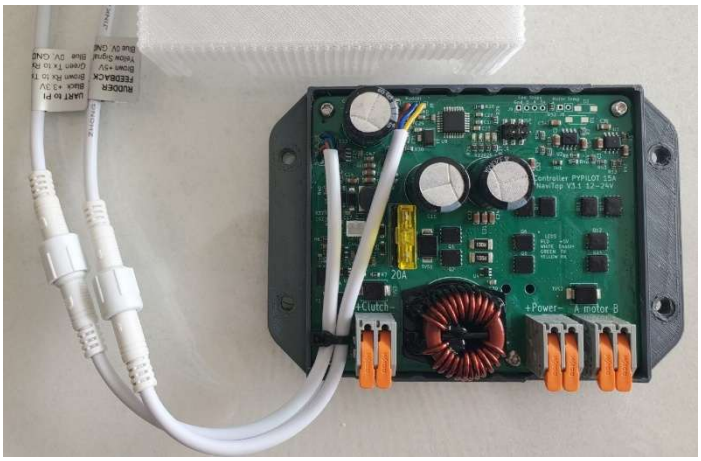
Summary:

1. Presentation and characteristics 2
2. Precautions for removing and replacing the cover 2
3. Power Supply and Motor connection – Power cable Sizing 3
4. Motor Connection 3
5. Clutch output with energy saving device 3
6. Serial Data Connection to computer 3
7. Adjusting the current consumption limit for the motor 4
8. Rudder Feedback sensor 4
9. Rudder travel limiter switches 4
10. JST connector for powering tinypypilot computer with Rapberry Pi Zero 5
11. Motor Temperature Sensor 5

NaviTop

NaviTop models: C15 or PC15

PYPILOT CONTROLLER 15A* WITH CLUTCH OUTPUT by Navitop



1. Presentation and characteristics

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

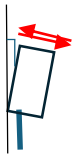
* Motor current is the amount of amps drawn by the motor at maximum torque, allowing the rudder to move freely. It is not the current with the motor stalled. The peak current of this controller can be 25A.

This motor controller needs to be paired with a suitable autopilot computer such as **Tinypilot** or **OpenPlotter** running pypilot.

- Supports 12 or 24 volts (34v maximum)
- With pypilot, this controller allows you to adjust the acceleration/deceleration and speed of the motor
- 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
- Over-temperature, over-current (stall) detection
- Waterproof 4 pins connection to Raspberry Pi (tinypilot or openplotter) by serial communication 3.3 or 5.5V with galvanic isolation, prevent ground loops and other electrical problems.
- Pins to connect optional rudder feedback, optional port/starboard end of stops switches or proximity detectors 5V
- Voltage, current, temperature and rudder feedback
- Reverse polarity protection and fuse ATC 20A
- Intrinsic consumption about 5 mA (60 mW with 12V, 120 mW with 24V)
- Power and output with lever connection terminals Wago 32 amps for 4mm² conductors (for 6.6mm², see paragraphe 11)
- The controller's 5V DC power supply has been redesigned to be more robust and allow the pypilot computer (only with Pi Zero) to be powered (0.8A peak). All 5V outputs are short-circuit protected. EMC has been improved with EMC filters including a common mode toroidal filter added to the power supply input.
- Printed circuit board marinized by applying several layers of tropicalizing acrylic varnish
- open-source software based on Arduino installed (ISP connector)
- JST PH2 connector for connecting the 5V power cable of Navitop computers or a Pi Zero via its micro-USB Power port with the optional CUP cable
- Dimensions:
  - PCB : 104 x 70 x 25 mm
  - Box : 133 x 98 x 34 mm with 4 fixing holes for 4mm screw (120 x 48 mm)
- Variants:
  - C15 : Pypilot motor controller 12-24V 15A by Navitop with case
  - PC15 : Pypilot motor controller 12-24V 15A by Navitop without case
- Options available:
  - CS3R: Cable with 3-contact waterproof connector for rudder angle sensor
  - CS3S: Cable with 3-contact waterproof connector for rudder limit switch contacts
  - CS4: Cable with 4-contact waterproof connector for proximity detectors requiring a 5V power supply
  - CUP: Cable to directly power a Pi Zero via its micro-USB Power port from the controller's JST output 5V

2. Precautions for removing and replacing the cover

To remove and replace the cover, tilt the top of the cover while keeping the bottom of the cover pressed against the bulkhead.



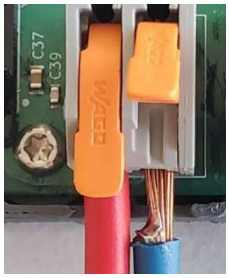
3. Power Supply and Motor connection – Power cable Sizing

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 3.3mm² (AWG12)
- 4m length between the electrical panel and the motor = 2 x 5.2mm² (AWG10)
- 6m length between the electrical panel and the motor = 2 x 6.6mm² (AWG9)

Strip 9 to 11 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.



However, the cross-section of a 6mm² conductor can be halved over a few millimeters of length without overheating or increased electrical losses. To connect 6.6mm² (AWG9) wires to a Wago 32A terminal, simply cut slightly less than half of the strands along the stripped length. Ideally, a spot solder should be applied at the cut to ensure a good electrical connection with all the strands (see photo opposite).

4. Motor Connection

The motor wires, striped between 9 to 11mm, connect to Wago terminals block marked “Motor”. These may need to be reversed if the autopilot makes corrections in the wrong direction.

5. Clutch output with 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.

The clutch + and – wires, striped between 9 to 11mm, connect to + 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.

6. Serial Data Connection to computer

Cable type 1	Cable type 2	Cable type 3	purpose	raspberry pin
Red	Brown	Black	+3.3v	1
Green	White	Brown	Rx to Tx	8
Blue	Blue	Green	Tx to Rx	10
Black	Black	Blue	0v, GND	6, 9

Note: wire colors of cable will be one of 3 possibilities depending on the manufacturing.

This serial data connection is galvanically decoupled. The + wire is used to power the controller's galvanic decoupling circuit, which can be powered by +3.3V (Pi) or even +5V if you want to connect the controller to an Arduino driver. The power consumption in the mA range allows for the use of a cable with thin wires.

This 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 protection diodes on the RX, TX and +3.3V lines to clip any overvoltage that may be induced by an electrical transient nearby, especially if this cable is more than one meter long (see diagram of a simple tinypilot in the documentation tab of the website www.navitop.fr).

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.

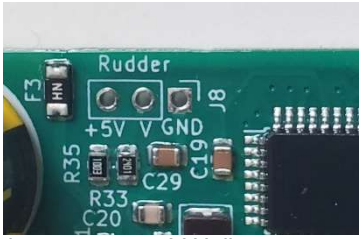
Pypilot instantly stops the actuator motor when the current drawn by the motor exceeds the Pypilot servo.max_current setting. The motor is no longer powered until the computer requests that the motor be restarted in the opposite direction. This is sufficient to effectively limit the stroke and force 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 3 and 7A for tiller actuators and 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 on the configuration page using the Pypilot client. It is also possible to visualize the current drawing 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.

The connection on the motor controller's PCB is labeled "Rudder." The square pad is GND, the middle pad is the measurement, and the last pad is the 5V supply. It is not critical for the voltage to increase or decrease with rudder angle, as the rudder sensor calibration controls the direction. To determine the color of the three corresponding wires, visually check their connection on the PCB.

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 PCB is labeled "End Stops." The square pad is GND, 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.

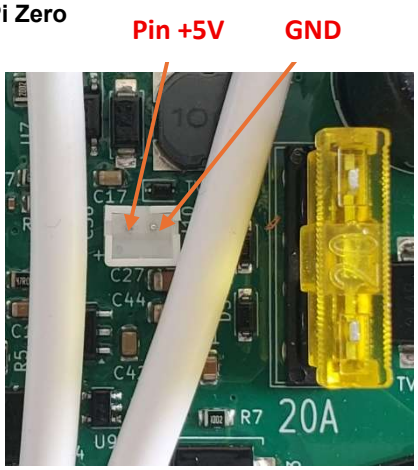
After connection, test to ensure that when the motor rotates in one direction, the limit switch corresponding to that direction stops the motor. If this is not the case, the End A and End B wires must be reversed.

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. JST connector for powering tinypypilot computer with Rapberry Pi Zero

This allows a tinypilot computer with a Pi Zero to be powered with 5V DC. Larger Pis draw too much peak current and should not be powered by the controller.



All Navitop computers (simple or with remote control) come with a 5V DC power cable approximatively 45cm long pre-equipped with a JST PH2 connector to power them with this controller.

For those building their own ECU, the Navitop store offers a 90cm cable with a JST connector on one end and a micro-USB male plug on the other. This plug connects to the Pi Zero to power the computer.

If you wish to position the controller further from the computer, we recommend specifying this when ordering to obtain a controller with a 5.23V output instead of 5V.

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

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.

11. 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.