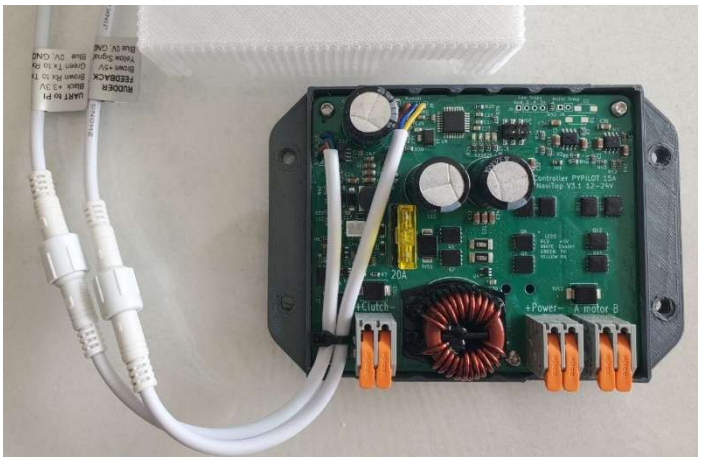
PYPILOT CONTROLLER 15A* WITH CLUTCH OUTPUT by Navitop



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 (10.5v to 34v maximum)
- Can drive most existing autopilot drive units with electromagnetic clutch (4A max)
- 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 to 5.5V with galvanic isolation, prevent ground loops and other electrical problems.
- Waterproof 3 pins connection to optional rudder feedback
- Pins to connect 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)
- Internal electrical resistance < 25mΩ
- Power and output with lever connection terminals Wago 32 amps for 4mm² conductors
- The 5V DC power supply has been redesigned to improve reliability and allow reliable powering of the pypilot computer with an optional micro-USB cable. The 5V outputs are each protected from short circuits
- EMC has been improved with EMC filters including a common mode toroidal filter added to the power supply input.
- Tropicalized with Tropicoat acrylic varnish
- Open source software based on Arduino installed (ISP connector).
- Optional waterproof connection to end of stops
- Optional 90cm micro-USB cable to power a Pi Zero tinypilot computer (0.3A max)

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.

Dimensions

- PCB : 104 x 70 x 25 mm
- Enclosure : 133 x 98 x 34 mm with 4 fixing holes for 4mm screw (120 x 48 mm)

Power connection and sizing of power cables

The power + and - wires connect to the + and - terminals of the Wago terminal block marked "Power".

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.
- 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)

Motor Connection

The motor connects to Wago terminals block marked “Motor”. These may need to be reversed if the autopilot makes corrections in the wrong direction.

Clutch output

This usually either activates a solenoid (hydraulic) or a mechanical clutch controlled by a solenoid for the other actuators.

The clutch + and – wires 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 ms, 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.

Serial Data Connection

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 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).

Rudder travel limiter switches

The connection on the motor controller PCB is labeled "End Stops". The square pin is GND, the second pin is Limit Switch B, the third pin is Limit Switch A, and the last pin is the +5V power supply. If you choose to use proximity switches or logic hall sensors, the power supply +5v is used to power them. Pin A or Pin B, shorted to ground (GND), prevents any further movement in the corresponding direction.

With pypilot, rudder travel limiter switches are optional. They can be useful to reduce the forces applied to the rudder system if the current limiter does not limit the force, as with some hydraulic drives, or if the rudder feedback device becomes misaligned (rod bent or disconnected). When one of the switches closes, the controller prevents any further movement of the motor in that direction.

In all cases, care must always be taken to ensure that the limit switches remain electrically closed when the rudder is fully travelled, beyond the angle at which they are set to stop the actuator motor.

An optional cable with 3 wires can be used for optional end stops.

Cable type 1	Cable type 2	Cable type 3	purpose
Red	Brown	Red	End A – Rudder travel limiter switch with boat to port (left)
Yellow	Blue	Black	End B – Rudder travel limiter switch with boat to starboard (right
Black	yellow	Blue	0v, GND

Rudder Feedback

First, with pypilot, the rudder feedback is optional. It can be disconnected while underway and pypilot will continue to steer. It is generally used to report the rudder angle on a display and avoid relying on end-of-travel stop by intensity limitation. It also may be used by certain pilot algorithms to enhance steering, but the basic pilot algorithm does not require it. To be

clear, corrections needed in moderate conditions are 10 or more times that of the errors due to integration from not knowing the rudder position, so the potential improvement in steering performance from rudder feedback is not huge.

A potentiometer with 3 wires can be connected to the controller. The potentiometer should range from 1k ohms to 100k ohms. Recommend 10k. You can also connect a Hall effect sensor 5v with analog output to these 3 wires.

The connection on the motor controller PCB is labeled "Rudder". The square pin is GND, the middle pin is the measurement pin, and the last pin is the 5V power supply.

It is not critical that the voltage increases or decrease with rudder angle as the rudder feedback calibration takes care of the direction.

A potentiometer with only 2 wires can connect GND and measurement pins. A resistor must then be added from 5V pin to measurement pin.

The optional rudder angle sensor connects to the cable with waterproof connector and 3 conductors which can be of three types depending on the manufacture and the color of the three wires :

Cable type 1	Cable type 2	Cable type 3	purpose
Red	Brown	Red	+5v
Yellow	Blue	Black	voltage for angle
Black	yellow	Blue	0v, GND

When the rudder feedback sensor is installed, you can check the rudder calibration page to read the value and make sure it is working.

The rudder feedback must be calibrated. You must manually turn the rudder to port range, starboard range, and center and press each button for each position. The order is not important, but once all 3 operations are complete, the scale, offset, and nonlinearity must be calculated. The "Rudder Range" field must be manually set to indicate the actual angle at each range position and to limit the autopilot movement beyond that position. It is possible to set the "rudder range" to say 35 degrees and calibrate the rudder by moving it to 35 degrees in each direction and later set it to 30 degrees to further constrain the range the autopilot can move the rudder. So, to be clear, the "rudder range" is for calibration and whatever the value is when the button is pressed, but in operation it specifies the maximum angle the motor controller can move the rudder to.

Note: It should also always be remembered that using the rudder angle sensor to limit the actuator travel may disable the autopilot if the rod connecting the rudder is accidentally bent or disconnected. Properly installed limit switches or a good adjustment of the current limiter will often be more reliable in limiting the forces on the rudder system.

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.

JST connector to power the Pi Zero autopilot

The 5V 0.3A output for powering a Pi Zero is via a JST PH2 connector (see photo opposite). It is recommended to connect it with a cable equipped with a microUSB connector that connects directly to the Pi Zero.