# NaviTop

NaviTop models: C7 or PC7

## PYPILOT MOTOR CONTROLLER 7A* by NaviTop

### 1 - Presentation and specification

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 15A

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

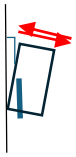
- Voltage 12V DC (10.5 to 17V)
- Can drive most existing autopilot drive units without electromagnetic clutch such as tillerpilot and wheel pilot.
- With pypilot, this controller allows you to adjust the acceleration/deceleration and speed of the motor.
- Over-temperature, over current (stall) detection.
- Waterproof 4 pins connection to Raspberry Pi (tinypilot or openplotter) by serial communication with galvanic isolation, prevent ground loops and other electrical problems.
- Pins to connect optional rudder feedback and/or port/starboard end of travel input switches
- Voltage, current, temperature monitoring.
- Fuse ATC 10A and reverse polarity protection.
- Intrinsic consumption 10mA
- Internal resistance < 50mΩ
- Power and output with lever connection terminals Wago 32 amps for 4mm² conductors
- PCB marinized with tropicalizing acrylic varnish
- Open source software based on Arduino installed (ISP connector)

### 2 - Dimensions

- PCB : 76 x 57 x 25 mm
- Enclosure : 105 x 69 x 32 mm

### 3 - 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.



### 4 - Power Connection

The 12V + and – wires, striped between 9 to 11mm, connect to the + and - terminals of the Wago terminal block marked "12V".

### 5 - 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.

**6 - 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 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).

**7 - End stops**

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.

The connection on the motor controller PCB is labeled "End Stops". The square pin is GND, the middle pin is End A pin, and the last pin is End B pin.

**8 - Motor Current Measurement and Limiting**

All pypilot controllers are equipped with a motor current measurement function that allows you to determine the current drawn by the motor in amps using the servo.current variable, visible in the pypilot client (configuration page) or with the pypilot_scope script.

**Important**: The pypilot servo.max_current parameter must be set appropriately for the motor and the controller installed on the boat. Pypilot detects the end of travel by stopping the motor in one direction when the measured current (servo.current) exceeds the pypilot servo.max_current setting. If this current limiting setting is set too low, "OVERCURRENT_FAULT" messages will constantly appear and block the actuator from moving. If the value is too high, the actuator could continue to output power even when the actuator is at its limit.

For tiller actuators, a setting of 3.5 to 7 amps is generally correct..

Using the pypilot_scope script can be useful to know the actual consumption curve of the motor during operation and at full throttle.

**9 - 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.

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 proper adjustment of the current limiter can often limit rudder loads more reliably.

**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 – Navitop 12V 7A Motor Controller Designations**

- C7 : Pypilot motor controller 12V 7A by Navitop with case
- PC7 : Pypilot motor controller 12V 7A by Navitop without case