NaviTop

NaviTop model: HS

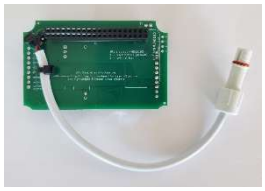
HAT PYPILOT WITH NMEA0183 PORT AND 8-BUTTON KEYPAD PINS

1 – Presentation

This HAT (Hardware Attached on Top) is an expansion board designed to fit the 40-pin GPIO connector of a Raspberry Pi.

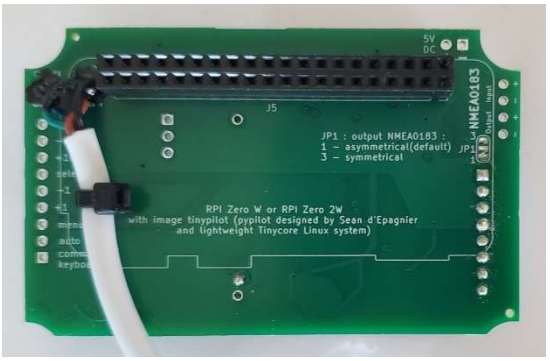
It allows you to transform the Raspberry Pi into a Pypilot boat autopilot computer integrating a high-performance compass using a state-of-the-art 9-axis IMU (inertial measurement unit).

Combined with a Pypilot motor controller, a Raspberry Pi Zero W and the Tinypilot-PYPILOT software installed on its microSD card, this HAT allows you to create a high-performance, low-power autopilot system.



Tinypilot-Pypilot is an SD card image that combines the free Pypilot software, conceived and designed by Sean D'EPAGNIER, with a simplified Linux system TINYCORE. This downloadable image can be installed on the Pi Zero's micro-SD card with an application such as Raspberry Pi Imager. With this file system, Pypilot works perfectly with a small Raspberry Pi Zero and can be safely turned on and off with a simple switch on the electrical panel.

There are three models of motor controller Navitop available to adapt Pypilot to all existing drive systems. You can either build your own or purchase one, keeping in mind that while the 12-24V 30A model with clutch control can be used with all existing drive systems, the 7A model without clutch output are only suitable for electric tiller steering systems.



This HAT integrates the LCD display, the IMU, the UART interface to the motor controller, an NMEA0183 port with galvanically isolated input, EMC surge protections and a GPIO connector allowing the use of a Raspberry Pi Zero 2W or Zero W.

The HAT is supplied with only one cable, which is used to connect the UART port to the controller.

Important: With a Pi higher than Zero, a GPIO spacer is needed to raise the HAT

- HAT and Raspberry Pi to be powered by 5V DC with a micro-USB socket connected to the Pi or directly on the PCB at the level of the 2 solder pads "Power Input 5V DC"
- TDK ICM20948 IMU integrated circuit directly installed on the printed circuit board with its interface circuits to the PI operating at 3.3V
- LCD display JLX12864G-086-PN 3.3V board
- Header 2X20 contacts for installing a Pi Zero W or Pi Zero 2W with tinypilot installed on the microSD card
- Wi-Fi interface (SSID: pypilot, no password required upon initial setup)
- Web server to allow control of pypilot from any device connected to the calculator's Wi-Fi network and equipped with a web browser (address 192.168.14.1)
- NMEA0183 port ttyAMA4 with TX and RX respectively connected to the GPIO12 and GPIO13 pins of the Raspberry Pi:
  - Galvanically decoupled input by optocoupler
  - Asymmetrical (default) or symmetrical TTL output protected against short circuits and overvoltage
- Pins on the PCB to connect an 8-button keypad
- The component side of the printed circuit board is marinized with tropicalizing polyurethane varnish, allowing for subsequent cable soldering
- Waterproof 4 pins connection to the motor controller
- Dimensions: 76 x 51 x 24 mm

2 - Installing the Pypilot computer

The boat's magnetic heading is determined by the Pypilot computer, which contains an IMU (Inertial Measurement Unit) with 9 sensors, including 3 magnetometers that are sensitive to magnetic fields. To minimize interference, it is essential to carefully follow the installation instructions in the Pypilot manual. It is imperative not to install the computer in the immediate proximity of any moving metallic or magnetic part and any electrical cable with significant variable currents (solar panel, winch, pump, actuator, etc.).

3 – Wi-Fi Connection

Upon initial setup, the autopilot computer is configured as a Wi-Fi router (master) with the SSID pypilot and no password. Wi-Fi settings can be modified via the pypilot web server configuration page or the LCD menu. If the password is lost, the LCD menu allows you to reset the Wi-Fi settings to their initial values.

4 - Controlling and Configuring the Pypilot Autopilot

This Pypilot computer offers numerous control and configuration options. The Pypilot web server is accessible at 192.168.14.1 from the web browser of any tablet, computer, or phone connected to the pypilot computer's Wi-Fi network. You can also use several 433MHz radio remote controls (EV1527 rolling code), whose buttons can be assigned to a wide variety of functions.

From another device connected to the autopilot's Wi-Fi network, it is also possible to control pypilot using:

- The pypilot plugin for the OpenCpn application,
- Pypilot client scripts installed with a software suite such as OpenPlotter or Bareboat Necessities (BBN).

VERY IMPORTANT: The main script, or "pypilot" server script, must only run on the Raspberry Pi to which the motor controller and autopilot IMU are connected. With TinyPilot, it always starts automatically when the pypilot computer is powered on. This "pypilot" script is essentially the table of all the data used by the autopilot and the pypilot client scripts.

However, the pypilot client scripts, such as "pypilot_control", "pypilot_scope", and "pypilot_calibration", can be run simultaneously on multiple computers. If these computers are connected to the same Wi-Fi network as the autopilot, these scripts will automatically synchronize with it.

It is convenient to install pypilot on other computers on board to automatically install all the pypilot scripts. However, it is imperative never to enter the "pypilot" command in the Linux command prompt of these computers. Make it a habit to systematically run a pypilot client script, for example "pypilot_control".

5 - Configuring the Radio Remote Controls

The remote controls can be configured via the web interface on the Configuration page, or directly using the address: http://192.168.14.1:333333

Many different functions can be assigned to a specific button on the radio remote control, as well as to combinations of multiple buttons pressed simultaneously.

All available functions are listed. To assign a function to a remote control button, simply press that button. The blue LED should light up. On the remote control configuration screen, the following should be displayed:

- Key: The code of the remote control button
- Action: NONE if no function is assigned to this button

Simply click on a function in the remote control configuration web page to associate it with the remote control button.

The first 7 functions are related to the LCD menu interface. Their function depends on the display status. Therefore, they are intended for use with a remote control or radio keypad that allows the user to see the screen. It is not recommended to assign these functions to remote controls that do not allow the user to see the screen. Their functions are described in section 3.3 of the pypilot manual. Note that a 4-button radio remote control, configured with the functions -1, +1, menu and mode, allows you to navigate the LCD menu. Feel free to configure such a remote control and attach it near the computer to be able to reset the Wi-Fi connection in case you forget your password, as well as configure Pypilot if you don't have a device with a web browser.

Further down, you'll find functions that can be used without needing to view the LCD display of the control unit, and which are intended to be used with handheld remote controls or wireless keyboards located remotely on the boat. For example, there are the "engage" and "standby" buttons, which can serve as alternatives to the "auto" button.

With a tiller linear actuator, it is advisable to attach a remote control with the -10, +10, “engage”, and “standby” buttons to start and stop the autopilot more safely than with an "auto" button. The -10 and +10 buttons allow the actuator to be retracted and extended when the pilot is not engaged. They can also be used to avoid an obstacle when the pilot is engaged.

6 - Essential steps to perform before using PyPilot to automatically control your boat

The following steps must be performed in the order given:

1) 5V DC powered computer not attached to the boat

- Accelerometer calibration, already performed on the computers with an SD card from Navitop. A new calibration is recommended after each SD card image change. This is preferably done on land, on a horizontal surface such as a table. See Pypilot manual
- Magnetometer pre-calibration, already performed on computers equipped with a Navitop SD card. A new pre-calibration is recommended after each image change on the SD card. The computer must be slowly rotated in all directions. It can also be rotated on several of its sides. Pre-calibration is complete when the measurement points are still on the sphere and the compass calibration date is reset.

2) After attaching the calculator to the boat

- This 3D pre-calibration is essential to ensure rapid automatic compass compensation at sea.
- After installing the computer on the boat, with the boat level and stable, inform the computer that the boat is level. See the Pypilot manual. This is essential because the computer case can be installed in any orientation. In fact, Sean has designed it so that the display orientation can be reversed using the LCD menu.
- Check the motor rotation direction. Pressing the +1 button should turn the rudder to rotate the boat clockwise (reverse the two motor wires if necessary).
- Calibrate the rudder angle sensor (if present) (see the controller manual).
- Adjust the current limit for the motor (see the controller manual)
- Calibrate the magnetic compass by slowly rotating the boat at sea. One full rotation is sufficient if the magnetometer pre-calibration was performed correctly before mounting the PyPilot computer on the boat.
- Align the PyPilot compass with the magnetic compass by entering an offset if necessary.
  - If the PyPilot unit is mounted on a bulkhead on the port side, along the centerline of the boat, the offset should be around 0 degrees.
  - If the PyPilot unit is mounted on a bulkhead towards the bow, perpendicular to the centerline of the boat, the offset should be around -90 degrees.
  - If the PyPilot unit is mounted on a bulkhead on the starboard side, along the centerline of the boat, the offset should be around 180 degrees.
  - If the PyPilot unit is mounted on a bulkhead towards the stern, perpendicular to the centerline of the boat, the offset should be around 90 degrees.
- Verify that no movable magnetic objects on board are interfering with the compass sensor of the computer

7 - NMEA0183 Computer serial port and USB port for NMEA exchanges (0183 or 2000)

The NMEA serial port of this HAT uses the port ttyAMA4 of the Raspberry Pi with TX and RX respectively connected to the GPIO12 and GPIO13 pins.

The RX input, protected from surges, is provided by an optocoupler providing galvanic isolation.

- Input + or A (metal and brown wire)
- Input – or B (metal and blue wire)

The 5V TTL output is provided by a UA9638 circuit protected from short circuits and surges. It is asymmetrical by default, with the - output connected to GND, which is suitable for almost all cases. If necessary, it can be symmetrical so that the - wire is at +5V when the + wire is at 0V. To do this, break the bridge of JP1 between 1 and 2 and then connect 2 and 3 with solder points.

- Output + or A or Y (metal and black wire)
- Output – or B or Z (metal wire)

To exchange NMEA data with Pypilot, it is also possible to use the micro-USB connector marked "USB" on the Raspberry Pi Zero by connecting a NMEA2000-USB converter or a NMEA0183-USB adapter (excluding supplies). The second micro-USB connector marked "Power In" does not allow data exchange.

8 - Use of external data - Provision of data (NMEA0183 or WIFI)

Without external data, pypilot only works in Compass mode. To use Apparent Wind mode, you must provide pypilot with NMEA data from a wind vane. To use True Wind mode, which is useful downwind, as well as GPS mode, you must also provide NMEA data from a GPS.

Sean, the designer of pypilot, advises using a conventional wind vane that can provide data that is as unfiltered as possible so that pypilot, which performs very fast calculations, can accurately determine the true wind, even with heel and waves.

NMEA data exchange is established either via Wi-Fi using TCP port 20220, via USB using NMEA0183 or NMEA2000 to USB adapters, or via the NMEA0183 serial port. If the connection is a serial port or virtual comm port, it will be detected with a baud rate of 4800 or 38400. Sentences received over usb/serial not used by the autopilot will be relayed to devices connected to Wi-Fi.

The following sentences can be received and used by pypilot:

- MWV : apparent and true wind
- VWR : apparent wind (alternative legacy)
- VWT : true wind (alternative legacy)
- APB : autopilot bearing for route following
- VWH : water speed
- LWY : leeway
- RMC : gps
- RSA : rudder angle (for faster action of the stroke limiter, however, it is advisable to connect the sensor directly to the motor controller)

The following sentences can be output:

- MWV : afteer calibrated
- RSA : rudder angle
- RMC : if gps filter combines IMU and GPS data this can provide a high speed output for speed/track
- XDR : Pitch and roll
- HDM : magnetic heading
- ROT : rotation rate