NaviTop

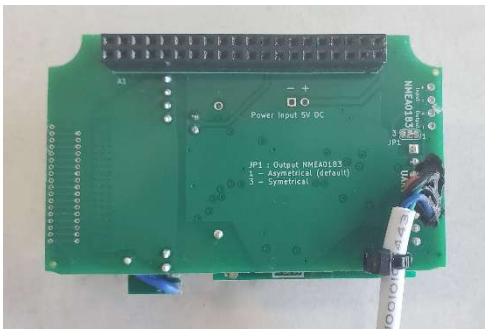
NaviTop model: HR

HAT PYPILOT WITH RF REMOTE CONTROLS RECEIVER AND INPUT/OUTPUT NMEA0183

1 - Presentation

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

It allows you to transform the Raspberry Pi into a Pypilot boat autopilot computer integrating a radio receiver for remote control and 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 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 12V 7A model without clutch output is only suitable for electric tiller steering systems.

This HAT integrates the LCD display, the IMU, the UART interface to the motor controller, a 433MHz remote control receiver, a decoder, an NMEA0183 port with galvanically isolated input, EMC surge protections and a GPIO connector allowing the use of a Raspberry Pi Zero W or Zero 2W. The 433 MHz receiving antenna is integrated on the printed circuit board. It is also equipped with an EEPROM memory that automatically configures Pypilot according to the HAT hardware.

The Arduino and the EEPROM are already flashed.

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
- 433MHz receiver and ATmega328P decoder for EV1527 rolling code remote controls
- EEPROM for automatic configuration of pypilot
- Header 2X20 contacts for installing a Pi Zero W or Pi Zero 2W
- NMEA0183 port connected to the AtMega328 (Arduino) decoder:
  - Galvanically decoupled input by optocoupler
  - Asymmetrical (default) or symmetrical TTL output protected against short circuits and overvoltage
- 433MHz reception antenna internal to the enclosure
- Component side of the PCB marinated with tropicalizing polyurethane varnish allowing soldering
- Waterproof 4 pins connection to the motor controller

2 - Dimensions

- 76 x 51 x 24 mm

3 - 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 essential to keep the computer away from any moving metal or magnetic parts and any electrical cables carrying power (solar panel, drive, etc.).

4 - Pypilot Autopilot Control

This Pypilot computer offers many control options such as 433MHz radio remote controls (code EV1527) or the pypilot web server accessible via wifi at the address 192.168.14.1 from the web browser of any tablet, computer, or phone. Pypilot allows you to configure multiple remote controls that can be used at the same time.

From another computer on the same wifi network, it is also possible to control pypilot with:

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

Simply run Pypilot client scripts such as "pypilot_control", "pypilot_scope", "pypilot_calibration", etc., from the Linux command line.

It's important to remember that the the "pypilot" server should only run on the autopilot computer to which the motor controller and the IMU used by pypilot are connected. "pypilot" server script is the central hub for all data used by pypilot and its various client scripts.

For this reason, the main "pypilot" script should never be run on any other machine, even though it's often useful to install pypilot on other machines so that you can run pypilot client scripts, such as "pypilot_control," from the Linux command line. It's always remarkable to see how well pypilot is designed when you see these client scripts automatically connecting to the pypilot-tinypilot computer.

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 and 2000)

The NMEA serial port of this computer uses the serial output of the ATmega328P (Arduino) decoder. You need to check the NMEA Arduino option in the settings, enable the input and output ports, and configure the baud rate.

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

- Input + or A
- Input – or B

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
- Output – or B or Z

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.

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

The NMEA0183 connections are either on serial ports, usb port with NMEA0183>USB converter, or via wifi with port TCP 20220. 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 wifi.