WATERTIGHT COMPUTER PYPILOT-TINYPILOT

1 – Presentation

This pypilot computer, combined with a pypilot motor controller, creates a high-performance autopilot with very low power consumption. The three pypilot controller models, each with a nominal output current of 7, 15, or 30 amps, allow pypilot to be adapted to all existing motors or rudder actuators.

This computer uses the free PYPILOT software, conceived and designed by Sean D'EPAGNIER, combined with the simplified TINYCORE Linux system, available as an SD card image under the name TINYPILOT. With this file system, the pypilot ECU works perfectly with a small Raspberry Pi and can be safely turned on and off with a simple switch on the electrical panel.

The fully waterproof case provides excellent protection for the Pi Zero and its connections to the microSD card and HAT. It includes a printed circuit board integrating 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 computer is equipped with a cable for a 5V DC power supply; this cable has a JST connector that connects to the 12-24V 10A or 15A Pypilot motor controllers by Navitop; with the Navitop 30A controller, the connector must be cut and the wires stripped to connect them to the two DC 5V OUT push-button terminals on the controller; with the Pypilot or Navitop 12V 7A controllers, a 12-24V DC to 5V 1A minimum converter must be connected to this cable
- TDK ICM20948 IMU chip directly installed on the HAT printed circuit board
- LCD display JLX12864G-086-PN 3.3V
- Pi Zero 2W with tinypilot installed in the microSD card (Pi Zero W on request)
- WiFi interface (SSID: pypilot, no password required during initial setup)
- Web server to allow control of pypilot from any device connected to the computer's Wi-Fi network and with a web browser (address: 192.168.14.1)
- NMEA0183 port (ttyAMA4):
    - Input galvanically decoupled by optocoupler (version 1.3 and above)
    - Asymmetrical (default) or symmetrical TTL output protected against short circuits and overvoltages
- Pins on the PCB to connect an 8-button keypad
- Waterproof autopilot computer enclosure with waterproof cable glands
- Waterproof 4 pins connection to the motor controller
- Optional 4 pins waterproof connection to input and output NMEA0183 or connector with USB-A female socket for connecting a NMEA0183-USB or NMEA2000-USB adapter
- Enclosure: 85 x 58 x 33 mm (96mm between the two fixing holes)

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 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 - 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

6 - Optional USB or NMEA0183 cable(s) for NMEA data exchange

The watertight computer is supplied as standard without a USB or NMEA0183 cable because it can receive and transmit data via Wi-Fi using the TCP20220 port. Upon request, the computer can be equipped with one or two additional cable glands with the following optional cables:

- **USB cable (CU Option)**

For exchanging NMEA data, this optional cable, equipped with a USB-A female connector, allows you to connect an not included USB-CAN (NMEA2000) converter or an not included USB-RS422 (NMEA0183) converter, and even multiple converters using a hub USB. The advantage of the USB port is that it allows automatic detection of NMEA exchange parameters.

- **NMEA0183 Cable (CN Option)**

The optional NMEA0183 cable of this computer uses the port ttyAMA4 with TX and RX respectively connected to the GPIO12 and GPIO13 pins of the Raspberry Pi.

The RX input, functional from version 1.3 onwards, is protected against overvoltage and uses an optocoupler for galvanic isolation. The 5V TTL output is protected against short circuits and overvoltage. By default, it is asymmetrical with the negative output connected to GND, which is suitable for almost all applications. If necessary, it can be made symmetrical so that the negative wire is at +5V when the positive wire is at 0V. To do this, the printed circuit board must be modified to break the jumper of JP1 between pins 1 and 2, and then solder pins 2 and 3 together.

The NMEA0183 connector is supplied with a cap. If you are not using the NMEA0183 cable, disconnect it to prevent short circuits and put the cap on the connector.

9 - Use of external data - Provision of data (USB port or NMEA0183 port 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 (CU option) using NMEA0183 (RS422) or NMEA2000 (CAN) to USB converters, or via the NMEA0183 serial port (CN option). If the connection is a serial port or a virtual communication port, it will be detected with a baud rate of 4800 or 38400 baud. Sentences received via USB or serial that are not used by the autopilot will be relayed to devices connected to Wi-Fi.

With the NMEA0183 cable (CN option), you need to check NMEA arduino in the pypilot configuration and activate the ports (input and output) as well as set the speed.

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

If you are not using the NMEA0183 cable, disconnect it to avoid short circuits.

10 - Opening the watertight case to access the SD card

To avoid damaging the internal cable connections, it is essential to begin by completely loosening all cable glands. Ensure that all cables slide freely before removing the circuit boards from the case. The microSD card is inserted on the left side of the Pi Zero.

After reassembly, securely tighten all cable glands.