MANUAL WATERTIGHT COMPUTER PYPILOT WITH RF REMOTE CONTROLS RECEIVER

SUMMARY

OTHER SUPPLEMENTARY MANUALS

Profiles, gain adjustment:

- **See the manual "Pypilot – Profiles, gain adjustment and motor controller parameters"**

CU or CN cable option:

- **See §7 of this manual**

C6PxM connector and cable option:

- **See the manual: "Waterproof connector option with 6-conductor cable to the controller"**
- **See §5 and 6 of the "Pypilot manual for the 30A motor controller with clutch output by Navitop"**.

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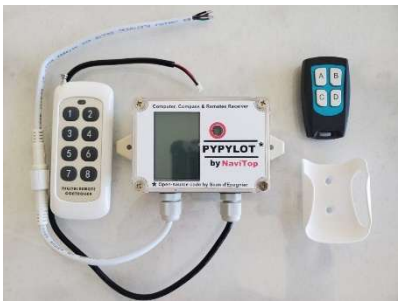

1. Presentation

This Pypilot computer, combined with a Pypilot motor controller, allows you to create a high-performance autopilot with very low power consumption. The four Pypilot controller models, with nominal output currents of 7, 10, 15, or 30 amps respectively, allow Pypilot to be adapted to all existing motors or rudder actuators.

It is ready to use with the latest stable version of the open-source software PYPILOT, conceived and designed by Sean D'EPAGNIER, along with the simplified Tinycore Linux system, available as an SD card image under the name TINYPILOT. With this file system, the Pypilot computer works perfectly with a small Raspberry Pi and can be safely switched 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, a 433MHz remote control receiver with its antenna, a decoder, an NMEA0183 port with galvanically isolated input, EMC surge protection, 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 integrated circuit directly installed on the printed circuit board with its interface circuits to the PI operating at 3.3V
- LCD display 128x64 with backlight automatically adjusted by an LDR cell
- 433MHz receiver and Arduino decoder for EV1527 rolling code remote controls
- EEPROM for automatic configuration of pypilot with the computer equipment
- 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)
- Watertight enclosure with cable glands (two to four cable glands depending on the options)
- Waterproof 4 pins connection to the motor controller
- Option CU: cable with USB-A female connector for data exchange allowing connection of NMEA0183 ou NMEA2000 > USB converter (not supplied) and possible USB multiplexer
- Option CN: cable NMEA0183 with waterproof 4 pins connection:
  - Galvanically decoupled input by optocoupler (version 1.3 and above)
  - Asymmetrical (default) or symmetrical TTL output protected against short circuits and overvoltage
- Dimensions: 85 x 58 x 33 mm (96mm between the fixing holes)

2. Installing the Pypilot computer

All Navitop autopilot computers with IMU and SD card come with the IMU's three accelerometers, and three magnetometers calibrated (scale and offset). They can be installed and mounted directly in the boat following the recommendations below. A sea trial is all that's needed to calibrate and compensate the compass.

Even though the latest version of the autopilot computer in the shop is housed in a waterproof case with cable glands, it's advisable to mount the autopilot computer and compass inside the boat to protect it from the marine environment and away from sources of magnetic interference often found on deck or in the cockpit. If you absolutely require buttons and an external display, several solutions exist, including the Pypilot radio keypad, a

high-brightness 7" waterproof Android 13 motorcycle console, or another computer with a small Raspberry Pi Zero used in "remote mode" with a display and buttons that will not be affected by magnetic interference.

To avoid any sudden and dangerous course deviations, it is essential to install the computer and its IMU away from any risk of magnetic interference. The computer's location must be chosen so that it is impossible to place any metallic or magnetic object within 15 cm of the computer and IMU. Therefore, the computer should not be directly under the deck, under or on the chart table, or in the saloon with the deck directly behind it. It should also be kept away from passageways such as the companionway, where a crew member passing by with a radio or tool could cause a sudden course deviation.

The computer should also not be installed too close to the bow, where the greatest shocks and accelerations occur, and near the engine if it generates significant vibrations.

The computer can be installed inside a steel boat because the permeability of steel does not prevent the Earth's magnetic field from passing through the boat. Pypilot will compensate for the boat's fixed metal masses if the computer is mounted at least 100 or 200 mm from the hull or steel bulkheads.

However, it is essential to ensure that the computer is always kept away from moving magnets (moving magnet compasses, speakers, VHF radios, etc.) as well as moving metal parts (tool drawers, etc.).

Be aware that some stainless steels are magnetic and can be magnetized. They can interfere with the compass.

The computer and its IMU should also not be installed too close to electrical cables carrying significant and variable current (solar power, etc.). A simple rule of thumb is to move it 2 cm away for every amp flowing through the wire. It is also possible to twist the power supply wires passing near the computer to Reducing Magnetic Interference Generated by Wires

The biggest problem to consider during installation is magnetic interference. The effect is cubed, so proximity is the biggest issue. This effect can be easily tested by comparing the displayed heading readings while intentionally applying interference via wires or other means to get an idea of the sensitivity. Generally, the effect is only problematic when objects are placed within a few centimeters of the computer's IMU sensor.

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

Remote commands can be configured using your web browser from the Pypilot configuration page, or directly at: http://192.168.14.1:333333

There are many different functions (-1, +1, -10, +10, menu, etc.) that can be assigned to a specific button on the radio remote control, as well as by pressing several buttons simultaneously.

All assignable functions are listed. The first seven functions are related to the LCD menu interface (see §3.3 of the PyPilot manual). Their function depends on the display state. Therefore, they are intended for use with a radio remote control or keypad positioned within sight of the screen. Assigning these functions to remote controls that do not allow the user to view the screen is not recommended.

Each time a remote control button is pressed, the blue indicator light on the computer should illuminate, and the following information will be displayed in the middle of the remote control configuration page:

- Key: The code of the remote control button
- Action: the function already programmed, or NONE if no function has been assigned to that button

After pressing the button you want to program or modify, click on the function you want to associate with it in the list on the remote control configuration webpage. It's best to double-click on the function.

A simple radio remote control with four buttons configured with the functions -1, +1, "menu," and "mode" is sufficient to navigate the LCD menu. This can be useful, for example, to reset the Wi-Fi connection if you have forgotten the password.

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 -1, +1, “engage”, and “standby” buttons to start and stop the autopilot more safely than with an "auto" button. The -1 and +1 buttons allow the actuator to be retracted and extended when the pilot is not engaged.

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

All Navitop autopilot computers with IMU and SD card come with the IMU's three accelerometers, and three magnetometers calibrated (scale and offset).

The following steps must be performed in the order given:

- Install the computer following the instructions in §2
- Check that the 6-wire waterproof connector of the optional cable to the controller is securely locked
- Turn on the autopilot
- Connect a device with a web browser to the pypilot Wi-Fi network and enter the web address 192.168.14.1 in the browser's address bar
- With the boat horizontal and stable, you must tell the computer that the boat is level. This is essential because the Pypilot computer can be installed in any orientation. 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. Optional USB or NMEA0183 cable(s) for NMEA0183 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 USB/CAN (NMEA2000) converter (not included) or an USB/RS422 (NMEA0183) converter (not included), and even multiple converters using a hub USB. The advantage of the USB port is that it allows automatic detection of NMEA exchange parameters. USB/RS485-RS422 converter can also be used for NMEA0183.

- **NMEA0183 Cable (CN Option)**

This optional NMEA0183 cable, connected to the serial port of the Arduino on the computer, allows data to be received* or transmitted via a receive port and a transmit port.

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 soldering 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.

Function of the different wires of the NMEA0183 cable, which has a transparent sheath:

- Brown metal wire : A or Input + or RA
- Blue metal wire : B or Input – or RB
- Black metal wire : Y or Output + or TA
- Metal wire : Z or Output – or TB

8. Use of external data - Provision of data (USB port or NMEA0183 ports 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.

9. 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, tighten each cable gland until its cable is securely locked.

10. Backing up calibration data, remote controls, and settings

It is strongly recommended to keep a copy of the Linux directory on the SD card:

- piCore_TCE/.pypilot

and in particular the following files:

- pypilot.conf (calibration, configuration, and profiles of parameters and gains)
- hat.conf (hardware configuration and parameters of the HAT, associated remote controls)

It is also wise to make a copy of the SD card itself.

While no computer failure has corrupted SD cards to our knowledge, an incorrect 5V power supply to the computer has sometimes caused the Pi Zero to constantly reset at startup (white screen) and, in exceptional cases, damaged files that prevented it from booting. The configuration files have always been recoverable in such cases.

11. Installing a new image on the SD card or replacing the SD card

When you want to install a new image on the SD card or replace the SD card, it is recommended to first back up the configuration files mentioned above.

It is then possible to install them in the newly installed image to retrieve the calibration and settings.

However, if the new version of Pypilot has new settings in the configuration files, it is best to keep the new configuration files and redo the pre-calibrations and configurations before installing the computer on the boat.

Accelerometer calibration should be performed on a horizontal table, and magnetometer calibration should be done away from any magnetic interference so that the magnetometers only have the Earth's magnetic field to calibrate their scale and offset. A 5V DC power supply for the computer is required for this.

It is often simpler to configure the remote controls, settings, and profiles before going to the boat and then perform the operations described in §6.

12. Pre-installed tuning profiles (pilot gains and motor controller parameters)

The Tinypilot-Pypilot image tinypilot_2024_07_17.img.xz , available for download online, was created by Sean d'Epagnier using a Tinycore system incompatible with the Pi Zero 2W.

For the Pi Zero 2W and Pi 3+, Stellian (Pypilot forum), created the image http://popies.net/pypilot/tinypilot13-20240915.img.xz of the latest Pypilot version with a compatible Tinycore system.

However, Stellian's image contains configuration files specific to his boat in the pypilot directory. It has a single "default" settings profile. The nmea0device configuration file for the USB port is not present. Furthermore, the excellent 7- or 8-button radio control units sold in the Pypilot shop are not pre-configured like in Sean's image.

From February 27, 2026, Navitop computers equipped with a Raspberry Pi 2W will be supplied with the Stellian image, modified with Sean's configuration files and an additional "stellian" calibration profile identical to the default one included with the Stellian image.

You can modify, create, or delete calibration profiles. Upon receiving your computer, you will have access to the 5 profiles listed below, available in the "profile" dropdown list on the "Calibration" page.

The LCD display indicates the currently active profile by showing the first two letters of the profile name after the capital letter P (for Profile).

Source	Sean d'Epagnier				Stellian
Profile	**default**	**light**	**downwind**	**upwind**	**stellian**
Pilot	basic	basic	basic	basic	basic
P	0.0027	0.0056	0.0033	0.0055	0.0023
I	0	0	0	0	0
D	0.062	0.0431	0.0715	0.0473	0.1169
DD	0.0532	0.0288	0.0666	0.0288	0.1036
PR	0.0048	0.0048	0.0048	0.0048	0.0051
FF	0.333	0.333	0.333	0.333	0.5
*Servo.max_current**	*6.37 A*	*6.37 A*	*6.37 A*	*6.37 A*	*4.20 A*
*Servo.max_slew_slow**	*26.378*	*26.378*	*26.378*	*26.378*	*26.378*
*Servo.max_slew_speed***	*19.0394*	*19.0394*	*19.0394*	*19.0394*	*19.0394*
truewind.offset	0	0	0	0	0
wind.offset	0	0	0	0	0
ap.tack.angle	100 deg	100 deg	100 deg	100 deg	100 deg
ap.tack.delay	0 s	0 s	0 s	0 s	0 s
ap.tack.rate	5 deg/s	5 deg/s	5 deg/s	5 deg/s	20 deg/s
ap.tack.threshold	55%	51%	49%	49%	50%
servo.period	0.4 sec	0.4 sec	0.4 sec	0.3 sec	0.4 sec
servo.speed.max	100%	100%	100%	100%	100%
servo.speed.min	100%	100%	100%	100%	91%

* , ** These first three motor controller settings are common to all profiles

** The Servo.max_slew_speed parameter of the latest pre-installations is that of Sean's profiles, whereas it was the Stellian parameter, namely 35.04, that was installed previously.

Caution : The default Servo.max_current value in amps is 6.37. This is too high for an ST4000 linear actuator without a rudder feedback sensor or limit switches. However, it is likely too low if you have a 15 or 30A motor controller. With a hydraulic actuator, you will probably need a setting between 10 and 20 amps...