Nautinect AUTOPILOT CONTROLLER

INSTALLATION & OPERATION MANUAL

Thank you for choosing Nautinect autopilot, you are now part of a large community of boat-tech enthusiast across the oceans. This product was designed by users for users with best in-class technologies, and it has proven its capabilities with thousands of miles under the hull.

This manual describes how to install the autopilot controller, how to integrate it into an existing autopilot system and how to operate. With proper care, your Nautinect autopilot should provide you with years of trouble-free operation.

IMPORTANT

READ ALL INSTRUCTIONS CAREFULLY BEFORE USING THE AUTOPILOT – It is the owner's responsibility to ensure the autopilot is properly used and properly installed to avoid accidents, injuries or property damages.

KEEP THIS MANUAL ON BOARD YOUR VESSEL — This manual contains important operating instructions for the autopilot and you should have access easily anytime during navigation.

MAINTAIN A PERMANENT WATCH - Always maintain a permanent watch, this will allow you to respond to situations as they develop. Failure to maintain a permanent watch puts yourself, your vessel and others at serious risk of harm.

ENSURE SAFE NAVIGATION - This product is intended only as an aid to navigation and must never be used in preference to sound navigational judgment. Only official government charts and notices to mariners contain all the current information needed for safe navigation, and the captain is responsible for their prudent use. It is the user's responsibility to use official government charts, notices to mariners, caution and proper navigational skill when operating this or any other Raymarine product.

WARNING

The autopilot is intended as a steering aid, and you should always remain at the helm. The autopilot is not aware of its surroundings and relies on sensitive instruments that may be subject to interference. The seller is not responsible for any damage, loss, or accidents resulting from the use of the autopilot. Use of the autopilot is entirely at the buyer's own risk. It is the buyer's responsibility to ensure that the device is suitable and safe for use on their specific boat and in their particular boating conditions.

DISCLAIMER

The autopilot is intended as a steering aid, and you should always remain at the helm. The autopilot is not aware of its surroundings and relies on sensitive instruments that may be subject to interference.

This autopilot is provided without any guarantee that it is free from errors or that it will operate correctly in combination with products manufactured or supplied by third parties.

The manufacturer accepts no responsibility for any loss, damage, or personal injury resulting from:

- the use of, or inability to use, this autopilot;
- interaction between this autopilot and third-party steering systems, actuators, or drive units;
- incorrect installation, sizing, configuration, or failure of third-party autopilot drive units.

This autopilot may be connected to steering actuators or drive units manufactured by third parties. Such equipment is supplied under the terms and conditions of its respective manufacturer. Unless explicitly stated otherwise, third-party drive units have not been tested, verified, or approved by the manufacturer of this autopilot.

The manufacturer has no control over, and assumes no responsibility for:

- the performance, reliability, or operation of third-party autopilot drive units; or
- (b) the installation practices, specifications, or safety characteristics of such equipment.

Any reference to third-party autopilot drive units in this documentation is provided for convenience only and does not constitute approval, recommendation, or endorsement.

All information in this manual is provided on the basis that, to the fullest extent permitted by applicable law, the manufacturer excludes all liability for any loss or damage arising from the use of, or reliance upon, this information.

Nothing in this manual excludes or limits liability for death or personal injury resulting from negligence, fraud, or any other liability that cannot legally be excluded.

PRECAUTIONS



- WARNING! Never connect the autopilot to an AC outlet. This may pose a fire hazard or result in an electric shock.
- WARNING! Never connect the autopilot to a power source of more than 36 V DC. This could cause a fire or damage to the controller.
- WARNING: Switch off power supply before installation or maintenance of this product.
- WARNING! Never reverse the DC power cable polarity when connecting to a power source. This could damage the controller.
- WARNING! Do Not install in a hazardous/flammable atmosphere such as engine rooms or near fuel tanks.
- WARNING! The Autopilot drive should never reach the end stop of the rudder. Protect this with a rudder position sensor or end switches An Hydraulic ram should stroke should never be greater than the rudder is allowed to turn.
- CAUTION - NEVER place the autopilot where normal operation of the vessel may be hindered or where it could cause injury.
- CAUTION Protect the power source by installation an adequately rated fuse or circuit braker.

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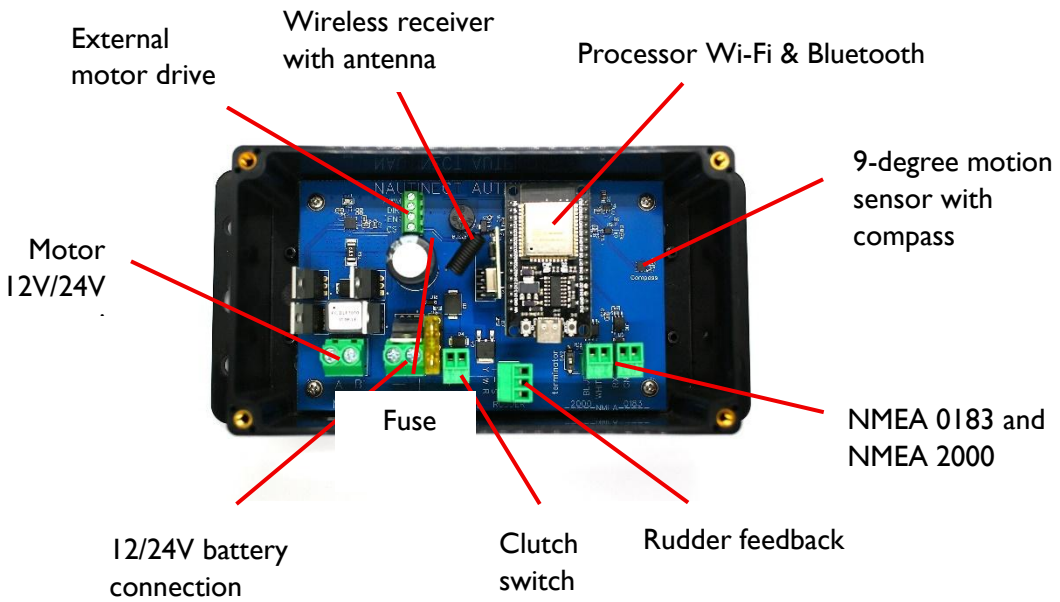
1 Introduction

1.1 General presentation

Nautinect autopilot is unique in its kind: simple to install, operate and maintain. It can operate any linear drive, wheel drive or hydraulic pump at it fits with any kind of boat. Autopilot is waterproof and can be used in any position. It is designed to work perfectly in combination with actuators from Nautinect, and it can be easily used as a replacement into any existing autopilot system in substitution of old/broken controllers.

1.2 Components

The circuit board of the autopilot unit include motor controller, 9-degree motion sensor with compass, Wi-Fi, Bluetooth, NMEA input and wireless receiver. It is protected by a robust waterproof black case (with transparent cover at request) with screw holes to install on board on your boat.



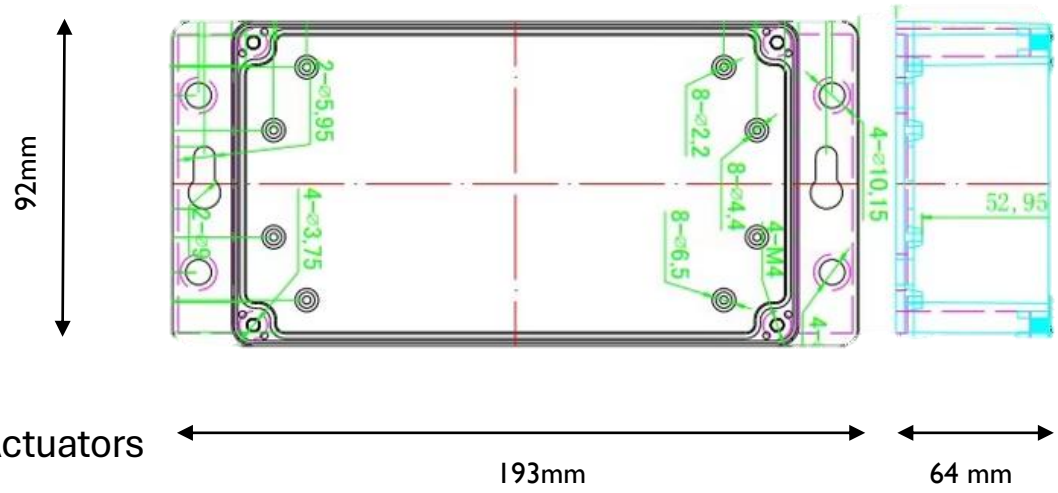


Cable glands and a silicone seal are provided to optionally make the box waterproof for outdoor placement.



1.3 Technical specification

Nominal supply voltage	12/24V DC
Operating voltage range	36VDC MAX
Current	30A continuous, 50A instantaneous
Power consumption standby	0.5W
Max motor consumption	40 Amps 12/24V
Operating temperature Range	-20 °C – 60 °C
Water proofing	IP66 with cable glands and seal installed
Wireless connectivity	WIFI 2.4GHZ n Bluetooth & BLE 5.0
Data connections	USB UART USB Serial NMEA0183 NMEA 2000
Onboard sensor	accelerometer, gyro, magnetic field 3 axes
Case material	ABS
Weight	400 grams
External size (box)	193 x 92 x 64 mm (L x W x H)



1.4 Actuators

Any Brushed DC motor can be used. When buying a linear actuator, one with end-limit switches is advised to avoid heat and burns when reaching the end limit. The autopilot on a straight course should not hit the end of the steering. However, there is a built-in protection that makes sure that the motor does not run for more than 5 seconds at full speed in a single direction to prevent too much heat generation. This duration can be changed in the settings.

2 Installation

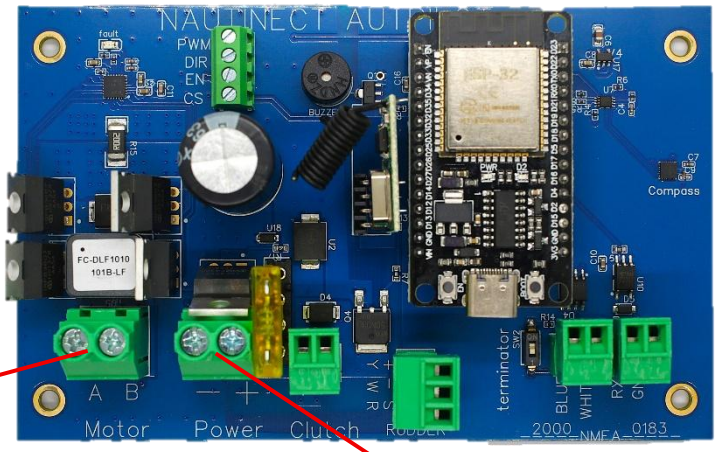
2.1 Positioning and mounting

The unit can be placed in any orientation as long as one side is facing to the sky with no more than 20 degree slant (while the boat is at rest). Upon start of the unit, the position is determined. If the unit is started or reset when the boat has significant heel or pitch, a wrong orientation is detected. Make sure it is not close to metal or wires conducting high currents. Place the unit 1 centimeter away for each Amp that a cable is running. The compass works on steel ships, but doesn't give an accurate reading because of the magnetic field deviation. It also may require recalibration trough the app.

2.2 Wiring

To install the autopilot, you only need to connect 4 wires. Use 4mm^2 / 12 AWG wires and keep as short as possible covering the gap between to the motor and battery.

Wire **Power +** to the boat battery positive terminal, **Power -** to the boat battery negative terminal. The wires of your Motor/actuator should be connected to **Motor A&B.**



Motor connector A&B

12/24V connector to battery

Test if the rudder moves right when pressing on the +1 or +10 button (see chapter 3 for Basic Operation). If the rudder moves the wrong way, just switch the Motor wires. You can take the PCB out for easier installations. Make sure to tighten the cable glands to reduce stress on the terminals. If you place it on deck, insert the rubber seal ring in the lid for water proofing.

2.3 Clutch

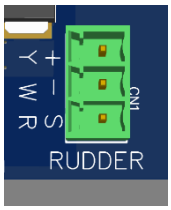
Many below deck autopilot drives feature a clutch mechanism to (dis)engage the autopilot in order to switch between manual and automatic steering. All clutches on the market are supported, both electromagnetic and hydraulic solenoid valves.
The clutch The GND (-) is switched on when the autopilot is turned on. The + terminal would read a positive voltage of 12v or 24v can be measured on the output terminal. After the 0.5 seconds when the autopilot is switched on, the voltage (and

thus current) is reduced by 50% to reduce current consumption. This settings can be changed in the app to either save more current or to increase holding power. The engaging of a clutch requires a higher voltage then holding the clutch. In this way, a 12V clutch in a 24V system can be used as well.

2.4 Rudder feedback

Connecting a Rudder Reference Unit (RFU) greatly improves the behavior of the autopilot steering. It way more precise with less corrections. This reduces current consumption and wear. A rudder sensor also prevents the motor from running to the end which could potentially cause damage. Many people use the controller without a rudder sensor which works well on course-steady (bigger) boats. For smaller boats and less-course steady boats I really recommend a rudder sensor.

The rudder sensors has 3 active wires which must be fed from my autopilot controller.



The + terminal is 3.3V and the – terminal is GND. The S(ignal) terminal can tolerate up to 3.3 Volts and is measured by the microcontroller and translated into a rudder angle. The power supply must come from the Nautinect autopilot to guarantee a stable power supply which won't cause too high voltage on the S pin to prevent damage the controller.

Analog rudder feedback sensor

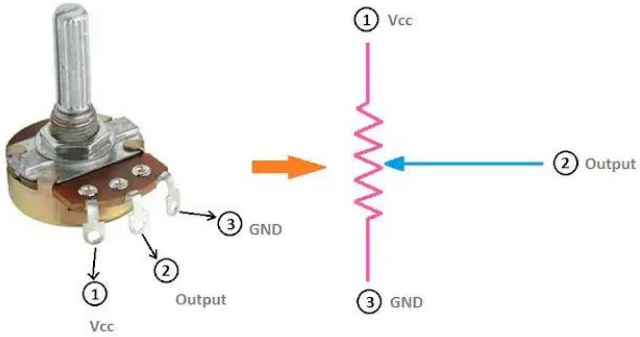
Wire the rudder sensor according to the diagram below and set in the app the rudder sensor to type "Voltage" or "Resistance based".

Wiring scheme

	+ 3.3V supply	- Ground	S (Signal 0-3.3V)	Shield	comments
Nautinect tiller drive	Yellow	White	Red		
Jovial rudder Sensor	brown	green	white	ground	
Raymarine Rudder sensor	red	green	blue	ground	
Generic			Potentiometer wiper	ground	
Garmin GRA 10	Red	Black	Yellow		Blue and white unused

For other rudder sensor, the correct wiring schema can be obtained by using a multimeter. A rudder sensor works with a variable resistor, called a potentiometer. A schematic is in the picture below. The resistance measured over pin 1 and 3 is mostly a nice number like 5000Ω (5k Ω) or 10.000 Ω (10k Ω). Let's say we have a rudder sensor with 5k Ω total resistance over pin 1 and 3. When this rudder sensor is in the middle, you would read 2.5k Ω between wire 1 and wire 2 and you would also read 2.5k Ω between wire 2 and 3. As you would rotate the rudder sensor the resistance will vary. Wire 2, is called the output or wiper and should be wired to the Signal port on the Nautinect controller. Now the other wires 1 and 3 should be connector to + and – and it doesn't matter which order that is as it will work either way.

NMEA2000 rudder sensors

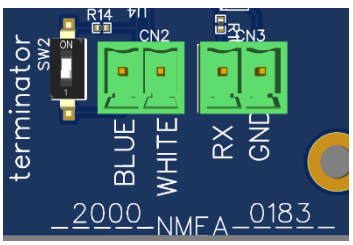


NMEA 2000 rudder sensors can also be used. Refer to rudder settings page to use the nmea rudder sensor.

2.5 NMEA installation

The Nautinect autopilot controller does not come with a standard NMEA2000 plug. Each NMEA wire has 4 cables inside with a shield. The Nautinect only used the blue and white cable, which contain the data. Cut the NMEA cable and stripe down the wires. Insert the light blue wire in the port labeled as blue on the circuit board an insert the white cable where it is labelled as white. Make Sure that the black, red and shield do not make contact with each other.

IMPORTANT NOTE: There are cable who do not follow the official nmea wiring colours. If the colours are not exactly light blue, white, red and black, do not use the wire. Double check that red is 12V and black is GND. The light blue and white wires are the data lines

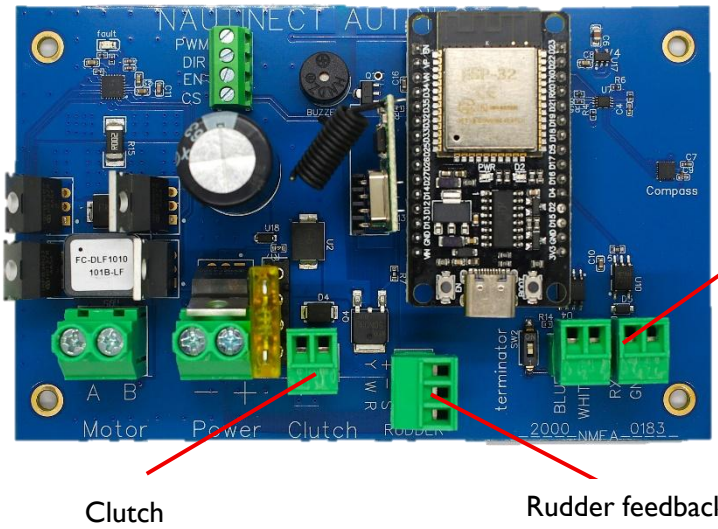


The terminator switch should be off when the Nautinect controller is placed inside a NMEA2000 network. Each NMEA network backbone should have a terminator enabled at its end to prevent the data for continuously bouncing around.

The current supported messages for read NMEA2000 are wind, compass, waypoints and rudder sensors.

The Nautinect controller sends rudder, magnetic heading, rate of turn, attitude, pitch and roll over the NMEA2000 network.

The Nautinect controller can receive NMEA0183 with 4800 baud rate. Current only wind angles, true and apparent, are supported. The NMEA0183 network is too slow to utilize compass and rudder data.



2.6 App download and pairing

The app serves as a remote control for the autopilot. Tuning and other settings can be adjusted with ease. Updating the autopilot is a breeze, so you will enjoy our continuous improvements. The app is available for both **Android** and **iOS**, you just need to download from the store, install and launch. Make sure Bluetooth is active on your phone. The app finds and pairs with the autopilot. Do NOT pair manually.

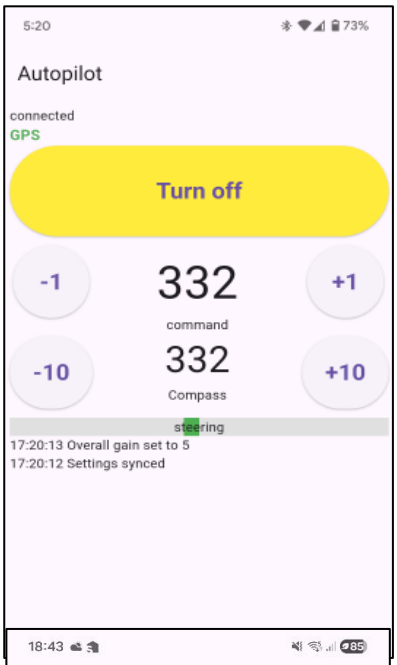
2.7 Software updates

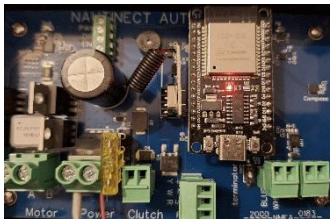
Once connected to the phone and paired via Bluetooth, the app will automatically check for software updates and will inform you in case of new firmware version. Just follow the instructions on your device to update the software.

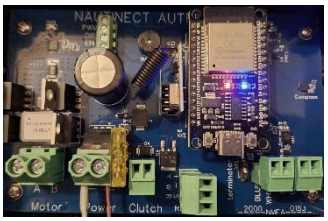
3 BASIC OPERATION

3.1 Operation with APP

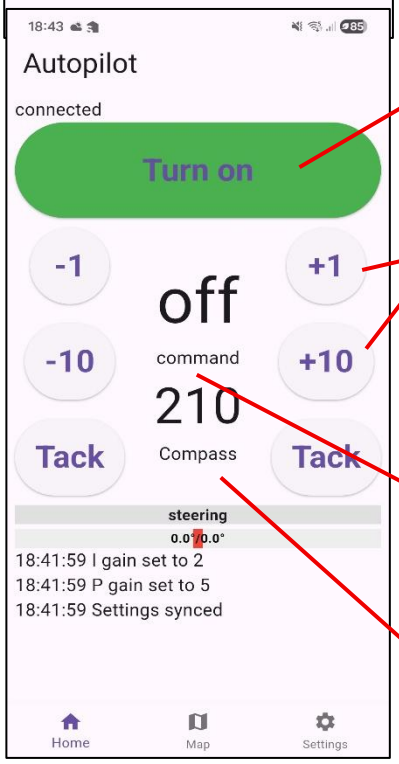
Launch the App on your mobile device. It will start automatically to search for Bluetooth devices. Once the controller is found, the App will connect automatically to it and you will see the notification "**connected**".







NOTE: If you have chosen the transparent lid, you can see visually on the board if the app **is not connected** (red light only), or if **it's connected** (red and blu).



Push **Turn on/off** button to **engage/disengage** the autopilot.

Choose your compass **direction** using **-1+1/-10+10** buttons. When the autopilot is off, the buttons move the rudder manually.

This is the compass direction you have chosen and settled for your route (it appears "off" when in stand by and no route is engaged)

This is the current heading source which can be compass, gps or wind

3.2 Operation with Remote Controller

The Remote Controller gives you the opportunity to control the Autopilot without depending on your smartphone. With the Remote, your Autopilot will operate fully standalone* using its internal compass and motion sensors.



Press & hold +1 to engage the autopilot (autopilot on)
Press & hold -1 to disengage the autopilot (autopilot off)

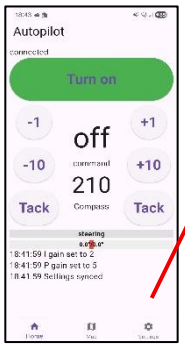
When the autopilot is on: the -1 +1/-10 +10 buttons change the heading that the autopilot will maintain.
When the autopilot is off: the -1 +1/-10 +10 buttons move manually the rudder.

The CR2032 battery will last for many years and can be easily replaced if needed. The range is max 30-50 meters but depends heavily on the number of obstructions.

*NOTE: To calibrate the Autopilot, a smartphone with Nautinect app is needed. The Remote Controller is useful to operate the Autopilot but is not capable of any single setting or calibration.

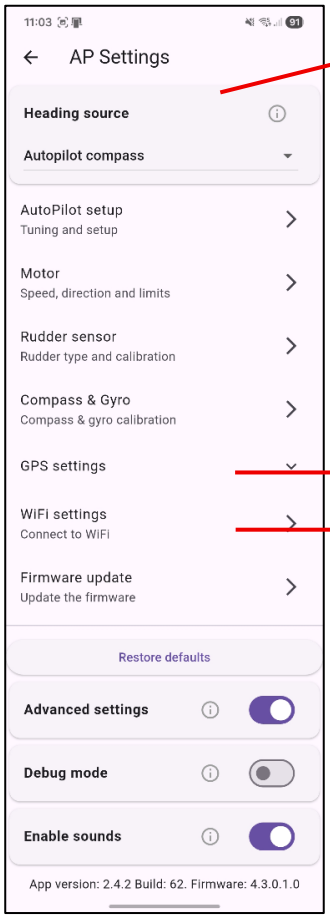
4 Autopilot settings

4.1 Enter Settings menu



Enter in Autopilot Setting page by touching the button at the bottom of the screen

4.2 Heading source selection & setup sub-sectors menu



Choose your preferred **heading source**. You can choose between: Autopilot on board **compass**, phone compass, **phone gps** (if available), Apparent wind angle, True wind angle. NMEA compass and NMEA GPS.

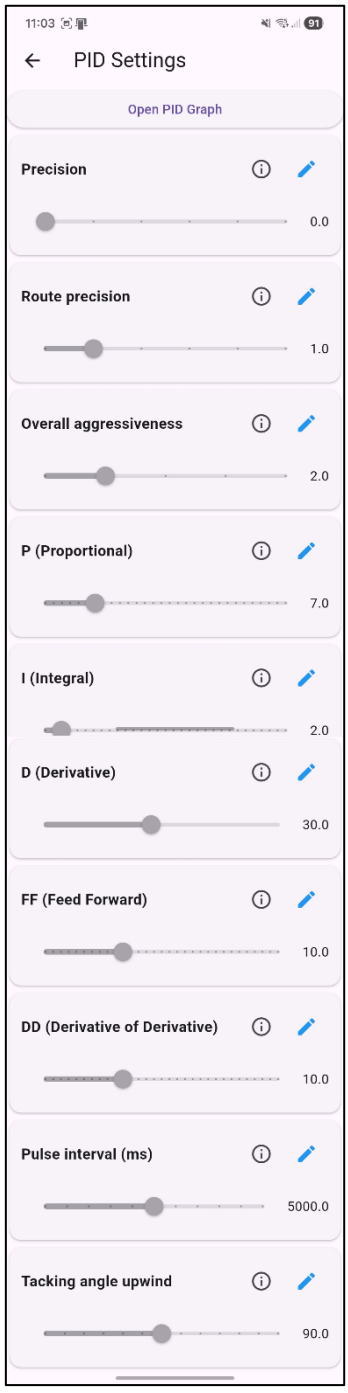
Enter in sub-menu for setup Autopilot, Motor actuator, rudder sensor and compass & Gyro (see next chapter sections)

Enter WiFi settings to exchange information with other instruments

Enter Firmware update to check for new software and to launch updates of the controller firmware.

Enter Advanced settings: this area is indicated for advanced users. It is firmly discouraged to enter to non expert).

4.2 Autopilot tuning



Tuning the behaviour

The default settings are mostly doing ok for most boats but tuning can improve it further more. Without a rudder sensor, the boat will always oscilate arround the setpoint. The easiest performance improvement is adding a rudder position sensor. Start by only adjusting the P and D values, those are the most important.

Let's start with the maths, but skip this part if you don't like it and go straight to the part where what to do in a few situations is explained.

The PID algorithm has the following Algorithm.

$$\text{Rudder angle} = A * \frac{P+I+D+DD+FF}{20}$$

P for example is the difference between the target heading and the current heading. For example if you want to sail 10 degrees on the compass, but the current heading is 20 then P = 10. Now what you do with the settings are called gains, it means by how much we would have to mulitply P. So if you set the P setting (gain) to 5, the value in the formula above becomse 5*10 = 50 and results in a 50/20=2.5 degree rudder angle.

PID graph shows you the values of the components in a graph. If the a component line is right of the center, it contributes to steering to the right and vice verssa. If you observe the graph and boat behaviour simultationously and you would think, now the boat should give rudder to the left, check with component is at the left side and increase that setting (gain)

Precision: (alias deadband)
The unit is in degrees. So if it is set to 1, the rudder wont be adjusted when the target heading is 1 degree from the current heading.
Route precision: The precision when following a waypoint route.

Overall aggresiveness(A) is the term used for how much rudder is applied. Increase this for light weight performance boats and challanging conditions. When setting it higher, more rudder corrections are applied which results in more power consumption

Proportional (P) increasing this value would determines how fast we steer to the target heading when we are of course. P is measured as the difference between the target heading and set heading. If we sail a compass course of 100 and we want to sail a compass course of 90, this value is 10.

Integral (I) Is the correction factor for a wheather or lee helm or a offset in rudder position sensor midpoint calibration. This value is only used when using a Rudder sensor. If we are 10 degrees of course, after one second I becomes 10. If we are one second later 9 degrees of course, I become 10+9=19. So this would add up until we are on course.

Derivative(D). Determine how much rudder is applied when the boat is turning (Rate of Turn in degrees per second). If the rate of turn is 6 degrees per second, it takes 360/6=60 seconds for a complete turn.

Feed Forward (**FF)** is only active when a change in target heading is set by the user. Because in most situation where you would adjust it, you would like to see it a little faster. The effect only last for a few seconds.

Drivative order Derivate (DD) correctly called the second order derivative is when the boat starts to rotate (D) faster or slower. This determines then how fast the autopilot reacts to quatering waves and gusts. In a Gust or Wave, the boat is starting to rotate which should be counteracted by giving rudder.

Pulse interval is only used when not using a rudder sensor. The autopilot applies a certain motor power within a timeframe (pulse interval). If the pulse interval is set the motor turns longer hence providing more rudder angle per correction. If the corrections are too large, lower this value.

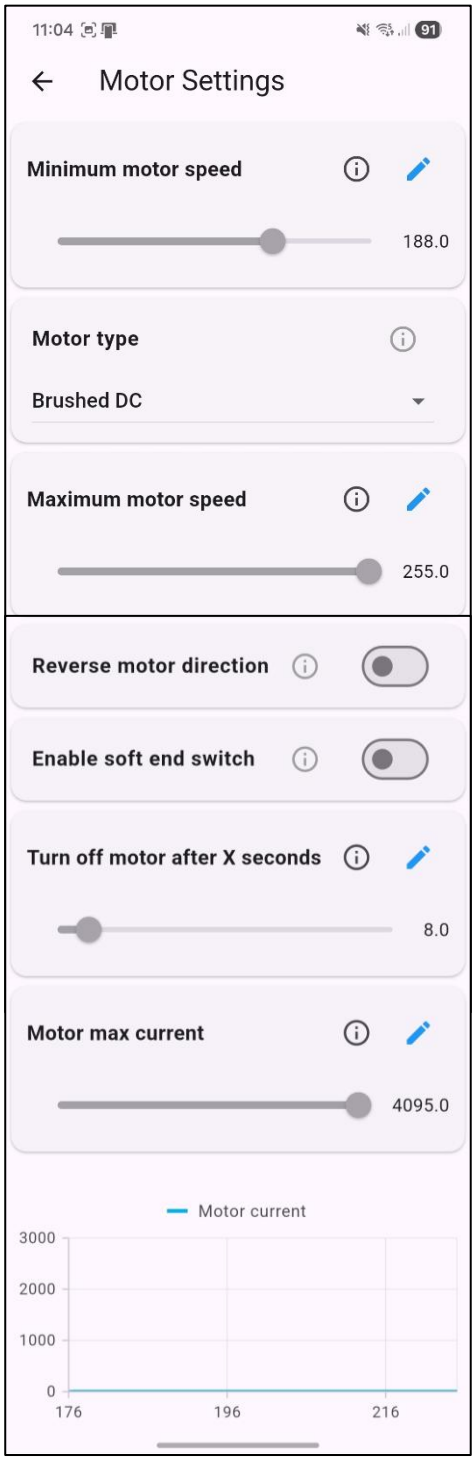
Example scenario's without rudder feedback

All regular example scenario's apply also to the no-rudder feedback setups. Dialling in the settings for a setup without rudder feedback is harder. The boat will always oscillate a bit but getting it within -2 to 2 degrees is the goal.

Boat oscillates around the target. If the burst of the motor movement gives too much rudder, lower the pulse duration to lets say 3000. Alternatively, you can lower the minimum motor speed if you think the speed is too high.

Boat cannot hold course in waves or gusts. Increase DD as that parameter only is active during big changes in rate of turn. Also increase the Overall aggressiveness. Increasing D would also yield a better result

4.3 Motor Settings



Minimum motor speed is the setting on which speed the motor should run in slow mode. Slow mode is used when small rudder corrections are needed. This reduces the sound and wear on the system. Set the value such that your motor moves at roughly 50% speed compared to full speed.

Motor type can be switched if you use a different motor. 99% of all autopilots are Brushed DC motors which 2 wires coming out.

Maximum motor speed is only used when your motor turns your helm too fast. Leave it at 255 for almost all autopilots.

Reverse motor direction is highly discouraged to use but is offered for some edge cases where it was necessary. Preferably switch the motor wires A & B to achieve the same effect.

Enable soft end switch will enable the feature "turn off motor after X Seconds". It is default off because it could cause unexpected behaviour but I highly recommend turning it on to protect your system. If you do not have physical end switches or a rudder reference sensor, this setting must be used!

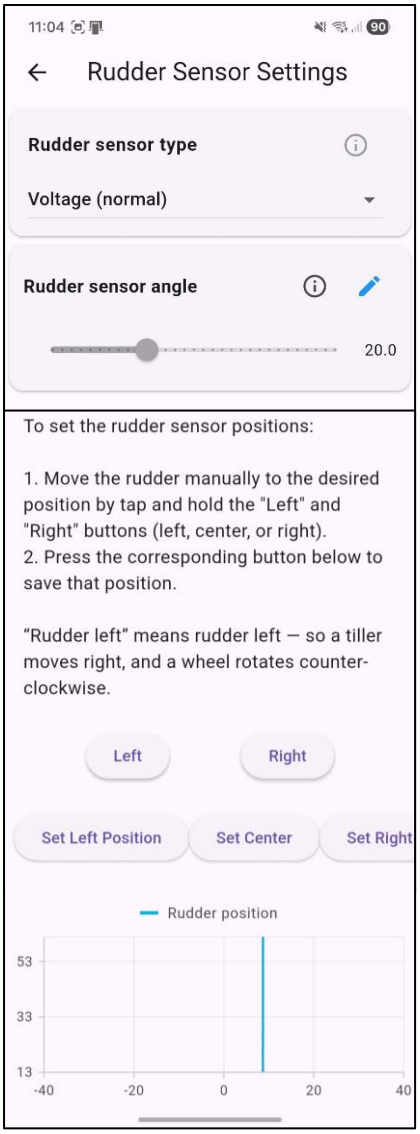
Turn of motor after X seconds is used the Soft end switches are enabled. If the value is 8 seconds, than the motor cannot turn in one direction at full speed for more than 8 seconds. Set this setting twice the time it takes your rudder to go from center all the way to a side.

Motor max current Is set to an arbitrary value and will stop the motor for turning in that direction when the current limit is exceeded. There is a huge current rush when the motor stalls, for example when the rudder reaches the end. There is also a current spike of a fraction of a second when the motor starts moving. To check which value you need, use the remote to press +10 to move the rudder all the way to the right. Now when it is at the end, press +10 again and watch peak value in the graph. Now set the motor max current to the maximum value

minus 20%. So if your reading is 1500 at the peak, the entered value should be 1200. But 1200 should be higher in normal operating conditions. If it is not, put the limit higher.

4.4 Rudder sensor settings

A rudder sensor greatly improves the performance of the autopilot. The Nautinect autopilot is compatible with almost all rudder sensors.



Rudder sensor type can be set to voltage, encoder and NMEA. Encoder is not used by any brands . So, a rudder sensor usually has 3 or 4 wires and utilize a variable resistor (potentiometer).

The Nautinect autopilot is designed to fit the most common rudder feedback sensors out of the box. The Nautinect autopilot does not support a 2-wire rudder feedback sensor default. it can be used with additional resistors.

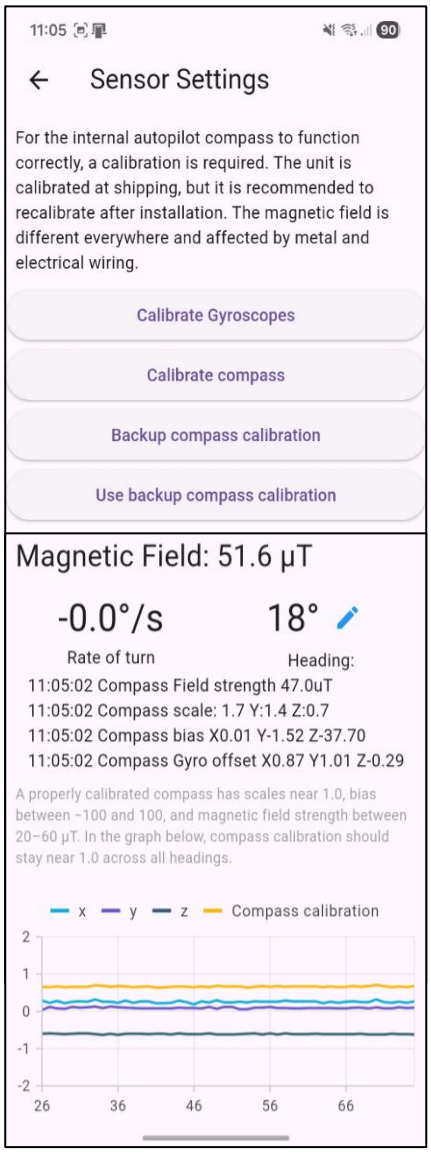
Rudder sensor angle is the angle from the rudder centre position to the left position or right position. Boats normally have a total rudder angle of 60°-70°. So, for a total rudder angle of 70, you set this value to 35.

The tiller drive with integrated sensor you must enter the angle which the autopilot can make at its minimum and maximum stroke. For the Nautinect autopilot with 300mm stroke mounted at 450mm from the rudder axis, the value is TAN (150/450) = 18°

To calibrate the rudder sensor, move the rudder all the way to the left by hand. If you have an tiller drive with integrated rudder sensor, you can use the buttons below the graph. If the rudder is at its end, press “Set Left Position”. Now move the rudder all the way to the right using the Right button and hit “Set right position”. Now move to the middle and set the centre position. Setting a good centre position is hard to judge by the eye. The most accurate method is to motor straight in calm waters. Manually move the rudder until your boat is going straight, then hit centre.

Note: if you want to build in some safety margin, you can set the left and right position before the end, but please do so symmetrically for the left and right position.

4.5 Compass & Gyro calibration



The Nautinect autopilot comes pre-calibrated and a re-calibration should only be done when necessary.

A properly calibrated compass will have the yellow line in the graph stable (flat) when you turn the autopilot controller (or boat) in any direction. A difference of 20% is acceptable.

A compass readying shows the heading to the magnetic north pole which is not the same as geographic north pole. This is called magnetic declination or variation and is different everywhere on the world. The magnetic north pole moves every year. The declination in popular waters is ±25°

For operation of the autopilot, it does **not** matter is the heading shown is incorrect, the only important thing is that if you turn the boat 90°, then the heading should also turn 90° (±2). For convenience, you can set a compass offset to show the correct compass heading. Hit the pencil icon behind the compass heading and enter the correct heading.

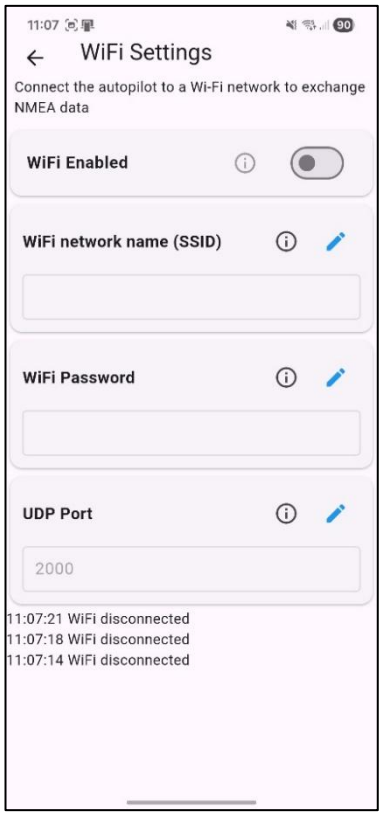
The autopilot works on steel boats but often 90° change of course won't show you an 90° change of the compass reading, but this can be 70°-110°. This is not an issue for course holding but it is for tacking.

To calibrate the compass you must rotate, pitch and heel the autopilot controller (and boat) to get readings in every direction. This is done much easier with the controller in your hands. On a boat, you would have to turn into a circle while mean while pitching and rolling the boat using waves.

Once you hit the button "calibrate compass" a circle will appear indication on which points of sail you have taken enough samples. Make sure every part of the circle will become green and then controller will calculate the biases and offsets for calibration. You have 3 minutes to complete the circle. On glass fibre boats, the scales should be between 0.5 and 2.0 and biases between -100 and 100. The Compass field strength should be between 40 and 60 and is different everywhere on the world. The calibration corrects the magnetic field readings for any metal and other magnetic sources nearby.

Gyroscopes are the most important sensors for the autopilot but are very easy to calibrate. Just make sure the autopilot controller (and boat) is dead still and hit the button "Calibrate gyroscopes". It will calculate the offsets which are usually less than 1° (reading as degrees per second). Do not every calibrate the gyroscopes when under way because the autopilot will behave very weird!

4.6 NMEA settings



4.6.1 NMEA over wifi

Many boats broadcast their NMEA data over Wi-Fi so that various applications can receive this data. The Nautinect controller can receive NMEA0183 data over Wi-Fi.

Enable Wi-Fi and set the Network name and password.

Currently only the UDP protocol is supported. Enter the port to listen on.

4.6.2 NMEA Emulation

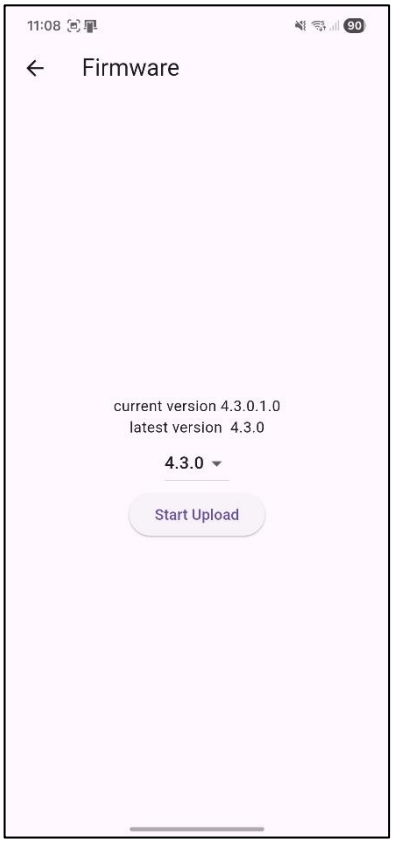
An experimental mode is added to be able to control the autopilot From a Raymarine, B&G, Simrad or Lowrance chartplotter. The feature has been tested on a Raymarine AXIOM running Lighthouse 3,4 or 5 and on a B&G Vulcan running Version 18.3

After setting the correct emulation mode, reboot the autopilot first and then the chartplotter or both simultaneously.

For B&G, check the following settings.

1) Settings→Advanced Settings→ Features →→ make sure Autopilot is checked
2) Settings→Network→Device List →Autopilot →→make sure Nautinect is checked

4.7 Firmware update



Nautinect often updates the software so please regularly use the app to check for an update. Please update the app once in a while to make sure the app and autopilot will stay aligned and can communicate with each other.

Select the version you want to upload and click “Start Upload” once. A progress bar will appear. Make sure the phone is nearby and the power supply won’t be interrupted. After the upload, the Nautinect autopilot will be reboot and the app connects again. The current version should then show you the just upload version.

Going back a version is not recommended and ruin the settings and calibration of the autopilot. So, if you need to go back a version, check all the settings again and check if they are good.

Nautinect

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