# PortaPilot

## One & Two Axis Clamp-On Autopilot

## Pilot's Guide


Revised: 10/28/21

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**Failure to comply with any of the following may lead to property damage, and serious injury including death.**

To reduce the risk of unsafe operation, users must read and understand all aspects of this Pilot's Guide. All operations and safety procedures must be thoroughly practiced prior to use, in a safe environment, and on the ground where applicable. Ensure all systems are fully operational, thoroughly inspect each component and perform an integrity check as part of every pre-flight check. Compare indications to aircraft instruments to ensure proper operation while in use.

Although the manufacturer has taken reasonable steps to test its product, the final determination as to its safety falls with the installer and pilot. Careful installation, and testing the system on the bench, as well as in the aircraft is crucial to safety.

The PortaPilot is not certified, endorsed, or recommended by the FAA or any other authority or agency, governmental or otherwise. Pilots agree to use the PortaPilot at their own risk, taking full responsibility for all consequences associated with its use.

This autopilot is designed for specific aircraft types and models only. Before installing or flying this autopilot, read this Pilot's Guide completely. If you have any questions or concerns about the installation, operation or use of this autopilot, E-mail, or call the PortaPilot support team before proceeding.

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# Specifications

| | |
|---|---|
| Operating Temperature | -15 ºC to +42ºC |
| Warm up time | 5 minutes |
| GPS data protocols | Aviation data and NMEA183 |
| Baud rate | 4,800 or 9,600 |
| NAV model weight | 21 Oz |
| VNAV model weight | 25 Oz |
| Maximum controllable airspeed | 200 KIAS |
| Altitude measurement range | 0 to 30,000ft |
| Vertical speed measurement range | ±5,000 feet/minute |
| Pitch and Roll angle measurement range | ±60º |
| Typical backup battery run-time (optional) | 2:00 |
| Typical backup battery run-time with portable GPS (optional) | 1:30 |
| Typical Heading accuracy | ±3º (calm air) |
| Typical Altitude holding accuracy (VNAV only) | ±200 feet (calm air) |
| Typical on course lateral accuracy | ±200 feet (calm air) |
| Supply voltage range | 11.5 to 15.5VDC |
| Typical NAV model current * | Typical 150mA |
| Typical VNAV model current * | Typical 200mA |

*** Typical current does not include power supplied to a portable GPS navigator**

## *Limitations of use*

No pilot may operate the PortaPilot unless the following conditions are met:

1. The pilot read this Pilot's Guide and understands clearly the installation, removal, and operating procedures
2. The flight is during day VFR conditions.
3. The aircraft indicated airspeed is at least 1.5 X Vs (Vs being the stall speed with flaps retracted).
4. Altitude is at least 2,000ft AGL.
5. Cross wind component is no greater than 35KTS.
6. Turbulence is no greater than light intermittent.
7. Flight limited to sparsely populated areas and at least 5miles from the nearest airport.
8. The pilot is current and has over 200 flight hours as PIC.

# Introduction

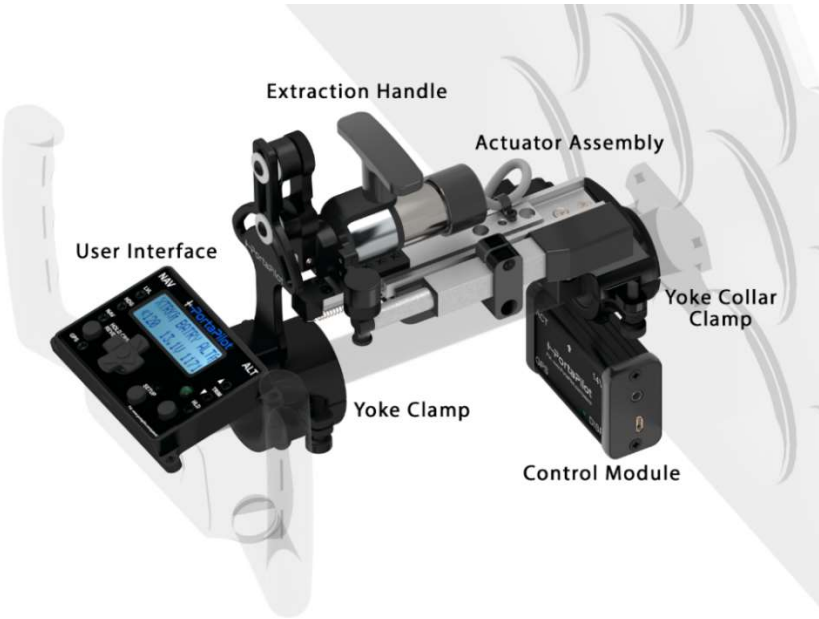


**Figure 1. PortaPilot Two Axis model (VNAV), typical installation on Cessna 152 and 172 models.**

PortaPilot is a clamp-on, quick-release autopilot which is intended as an aid to the pilot while at cruising speed and altitude, or to provide temporary help during an in-flight emergency. By utilizing one or two servo motors (Actuator Assembly), the PortaPilot can steer the aircraft by manipulating the flight controls. The Actuator Assembly (Figure 1) can be quickly snapped in and out during flight. It is designed for use in small, single engine aircrafts, such as Cessna 152, 172, 177 and similar aircraft which are included in the aircraft compatibility list. The PortaPilot is provided “as is”, as a use at own risk device, it is restricted for use at or above an altitude of 2,000ft AGL, in unobstructed airspace, and should only be used for daytime VFR operations. The PortaPilot is recommended for use by pilots with at least 200 hours in the type and model of aircraft it is being used on. Due to its portability, the PortaPilot components and cables are exposed and vulnerable to interruptions in operation, requiring pilot vigilance while it is in control of the aircraft. The PortaPilot is not designed to control the aircraft, but rather assist the pilot in flying it.

The PortaPilot provides the benefits associated with conventional built-in autopilots, without the complexities, inconvenience, and expense involved with installation. Other advantages include portability, serviceability, and

adaptability to multiple aircraft. The PortaPilot facilitates maintaining spatial orientation in an emergency, and reduces the pilots stress, workload, and fatigue.

**WARNING:** Prior to use, the pilot must complete at least two hours of flight instruction with the PortaPilot, from a certified flight instructor, or qualified co-pilot.

Key differences of the PortaPilot vs. conventional autopilot systems:

1) Only engaged with the aircraft controls while the Actuator Assembly is snapped in, which can be removed at any time.
2) Based on digital IMU technology, minimizing any drift or need for service.
3) Does not add resistance to flight controls while disengaged.
4) Not permanently installed in the aircraft.
5) Practical for use by aircraft renters, clubs, and owners.
6) May be adapted for use in different aircraft types and models, by changing some of its components.
7) May be powered by a compact, optional Backup Battery during in-flight electrical failure.
8) Compatible with a wide range of panel and portable GPS navigators.
9) Self-contained, doesn't rely on any aircraft instruments to operate.
10) Control parameters may be modified by the pilot to customize performance.
11) Easily serviceable, cost-effective maintenance.
12) Can serve as a backup autopilot when a built-in autopilot fails during flight.

The PortaPilot is available as either NAV (single axis) or VNAV (two axes) models. Both are self-contained and based on a built-in state of the art solid-state inertial platform (AHRS) incorporating a full suite of sensors, including but not limited to gyroscopes, accelerometers, and altimeter. This digital technology provides superior stability, leading to accurate, drift-free performance, and decreased cost of ownership as no periodic adjustments are required.

In addition to many hours of test flights over several years by the developers, the PortaPilot has undergone several flight tests by FAA test pilots and test flight engineers; However, the PortaPilot is not certified, endorsed, or recommended by the FAA or any other authority or agency, governmental or otherwise. Pilots agree to use the PortaPilot at their own risk, taking full responsibility for all consequences associated with its use.

# Warnings

**WARNING:** The pilot is responsible for the safe operation of the flight at all times, and must be constantly vigilant during flight. Ascertain the PortaPilot is properly mounted and connected, with couplers engaged, and all systems are functioning properly. Whenever in doubt, immediately remove the Actuator Assembly. Faults may be manifested without warning, be it electrical or mechanical disconnects and failures or locking of aircraft controls. It is not uncommon to have transients or intermittent aircraft electrical power causing the PortaPilot software to hang up. Additional causes may be wind gusts, or loosely attached components and/or cables. The PortaPilot does not have secured interconnects, it is therefore possible to have an electrical disconnect. Failing to monitor operation of the PortaPilot may result in unusual attitude or even a stall. If the Actuator Arm does not show any movement while in NAV active mode (**LVL**, **HDG**, **NAV and CR** modes, detailed in Table 1), it may be an indication of malfunction.

**WARNING:** Be sure to practice all operations and procedures of the PortaPilot in a safe environment, so that you will be prepared in case of an emergency. Familiarize yourself with its limitations and capabilities, at a safe altitude in daytime VFR conditions.

**WARNING:** Aircraft rigging must be as specified by the aircraft manufacturer. Improperly rigged ailerons and / or elevator controls may result in poor control characteristics of the aircraft, or control surface oscillation during PortaPilot active modes.

**WARNING:** Whenever in doubt, remove the Actuator then cycle power. Be aware that cycling power will set the current attitude of the aircraft as reference. Therefore, do it while flying straight and leveled.

**WARNING:** Do not attempt to manually fly the aircraft while the PortaPilot is engaged. Physically remove the Actuator Assembly to resume manual control of the aircraft. Either the pilot or the autopilot is flying the aircraft. Do not fight the PortaPilot. Whenever in doubt remove the Actuator Assembly.

**WARNING:** While not in use, keep the Actuator Assembly away from the aircraft magnetic compass as to prevent heading error. The PortaPilot magnetic components such as servo motors and couplers may introduce a significant interference and error to the aircraft magnetic compass. A GPS navigator may be use as a backup magnetic heading.

**WARNING:** It is the pilot's responsibility to ensure proper and safe operation of the aircraft while using the PortaPilot, which is consistent with the aircraft normal operation envelope as specified in the aircraft's POH, as well as compliance with the information provided in this Pilot's Guide.

**WARNING:** The Control Module (Figure 5) houses a three-axis inertial measurement unit (IMU), sensing orientation and motion of the aircraft. It is essential that it is securely mounted to a stable part of the aircraft panel. Moving it during flight will result in significant aircraft upset, or even causing unusual attitude – requiring a quick removal of the Actuator Assembly. Verify that it is fastened securely before each flight, and avoid moving or touching it during flight.

**WARNING:** Keep Away from anyone with a pacemaker. Neodymium magnets create strong magnetic fields which can interfere with pacemakers, ICDs and other implanted medical devices. This is because many of these devices are made with a feature that deactivates the device in a magnetic field.

**CAUTION:** The PortaPilot uses powerful magnets, which may snap together, pinch the skin, or cause serious injury.

**CAUTION:** Never insert the Actuator Assembly while on the ground. This is likely to result in damage, voiding product warrantee.

# Unboxing and Installation:

When receiving the **PortaPilot** inspect the box and make sure all components are included and in good condition.

Included Components:

- PortaPilot Main Assembly (NAV or VNAV Model)
  - Yoke Collar Clamp (**YCC**) set (aircraft specific)
  - Yoke Clamp (**YC**) set (aircraft specific)
  - Actuator Assembly (**AA**, one or two axis)
- Control Module
- User Interface (**UI**)
- UI cable
- Actuator cable (YCC to Control Module)
- Power cable
- GPS cable (bare wire to 2.5mm plug)

To separate the components, first pull apart the two clamp assemblies by grabbing the two clamp assemblies (YCC & YC) (Figure 2).

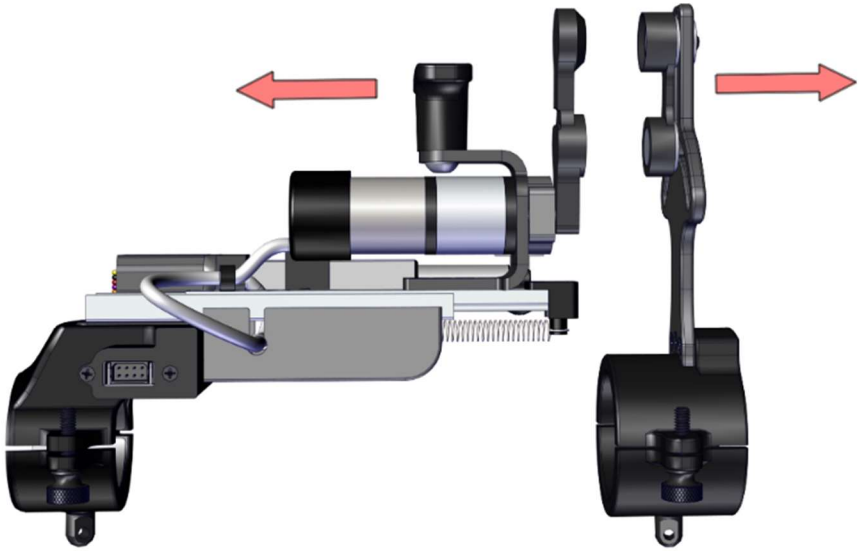

**Figure 2. The Yoke Clamp and Yoke Collar Clamp must be pulled apart to separate the two assemblies.**

Next, firmly grasp the Yoke Collar Clamp, and pull the Actuator Assembly apart by using the extraction handle (Figure 3).

## *Initial Testing & Configuration*

**WARNING**: Prior to using the PortaPilot, read the Pilot's Guide and the aircraft POH. Make sure you understand the PortaPilot operation and limitations, and are intimately familiar with methods to install, engage, disengage, and remove. Use Setup and Configuration to select your aircraft model, GPS navigator communications and other parameters.

After unboxing and prior to initial use, the PortaPilot must be configured. Arrange the components on stable surface such as a bench, with the Actuator Arm facing you. Connect the User Interface to the Control Module, and the YCC to the Control Module using the included cables. With the Control Module stable and standing upright, Power up the PortaPilot using an external 12V DC supply, such as a car cigarette lighter outlet, or optional AC adapter. The unit will light up and go through its self-test sequence. All tests must pass for the unit to be operable. At this point the PortaPilot will be in Control Wheel Steering (**CWS**) mode as indicated by the three **NAV** and the **HLD** indicators all extinguished.

Next, perform the following test:

1) Using the ◄ and ► buttons, rotate the Actuator Arm by about 45º to the left and right. Next press the **ENTR** button which should center the arm (neutral position).
2) With a **VNAV** model, use the ▼ button retract the slide to its limit, and the ▲ button to extend it. Verify total range of motion of about two inches. Next set it to mid extension (neutral).
3) With the Actuator Arm positioned vertically, enter **Setup** and select the **S&L Ref** and wait for it to terminate. This will establish roll and pitch references.
4) Using the **NAV** button select **LVL**. Slowly rotate the Control Module (**CM**) clockwise the around its vertical (yaw) axis to simulate aircraft motion. This should cause the Actuator Arm to rotate counter clock wise. Repeat this in the opposite direction, verifying that the Actuator Arm reacts properly to the motion.

Finally, configure the PortaPilot by using **Setup** and **Configuration** modes to ensure the appropriate **AIRCRAFT MODEL, GPS BAUD RATE** and **GPS PROTOCOL**, are selected. More detail is in the chapter titled **Setup & Configuration**.

If available, connect a portable GPS Navigator, preferably the one you intend on using in the aircraft. With the PortaPilot configured properly, the **GPS** indicator should illuminate within few seconds. If not, check the baud rate, data protocol and electrical connections. You may now separate the **Actuator Assembly** for further installation.

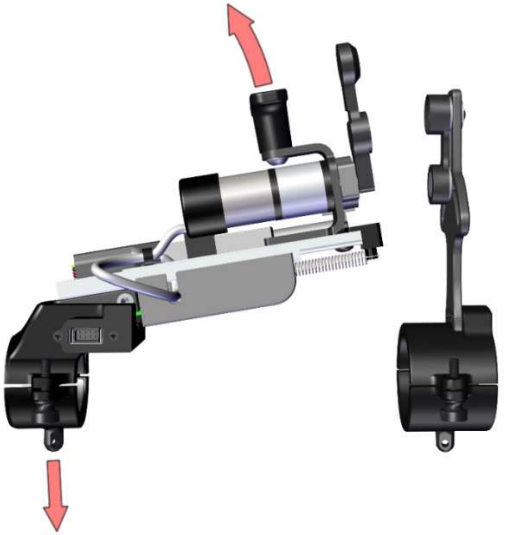

**Figure 3. Once the YC has been separated, grasp the Yoke Collar Clamp (YCC), and pull up on the extraction handle to separate the Actuator Assembly.**

## *Mounting and Removing the PortaPilot:*

Except for the **Actuator Assembly**, attach all the PortaPilot components while on the ground. With all cabling attached, ensure nothing interferes with any of the aircraft systems, and that you retain full range of motion of the controls, as well as unobstructed view of the aircraft instruments.

**WARNING**: The **Actuator Assembly** should **ONLY** be engaged during flight.

Attaching **Actuator Assembly** and engaging (allowing magnetic couplers to connect) while the aircraft is on the ground is likely to cause permanent damage to the PortaPilot, however, practicing insertion and removal of the **Actuator Assembly** on the ground is important, and should be done carefully while the yoke is supported in its full nose up position as to prevent the magnetic couplers from engaging. Alternatively, you may remove the **YC**.

**Mounting the PortaPilot on the ground:**

1. Attach the aircraft specific Yoke Collar Clamp (**YCC**) to the yoke collar, applying an equal rotation force onto both thumb-screws. It should be firmly fastened. Loose mounting will result in control instability. To prevent damage to the aircraft or PortaPilot, finger tighten the two thumb-screws. Do not use tools to tighten any of the thumb screws. Periodically inspect to avoid loosening.

**Figure 4. Yoke Collar Supports found on older Cessna 172's (Left), and 1971 and newer Cessna 172's (Right). See Appendix B for compatibility**

2. Attach the appropriate Yoke Clamp for the aircraft to its control yoke, such that the PortaPilot logo faces the pilot. Apply equal force onto both thumb-screws. Make sure it is firmly attached, and does not slip when applying reasonable rotational force. See section: Yoke Clamp **(YC)** on p. 39 for proper clamp alignment.

3. Attach the Control Module (**CM**) onto a stable and flat part of the aircraft panel, using Velcro, rubber bands (#64 Black Platinum Rubber) or other means. A good location in the Cessna 172 is on the panel just below the yoke collar (Figure 4). The **CM** must be mounted vertically (less than 5º in pitch and roll axis) on a stable surface. Using the provided cables, connect the **CM** to the Yoke Collar Clamp, the User Interface Module, aircraft 14V power, and GPS cable (Appendix D). The GPS cable is not required for all operations.

4. Attach the User Interface (**UI**) at an accessible part of the panel or onto the yoke facing the pilot, using Velcro or rubber bands. If the standard 18" cable won't reach the CM from your desired location, alternative lengths are also available.

Note: It is important to power up the PortaPilot prior to takeoff. This allows the system to initialize, perform its self-test, stabilize, and realign pitch and roll axes.


**Figure 5. Orientation of the CM with arrow pointing up and facing the pilot.**

***GPS Cable:***
If using a panel navigator, one of its unused serial data lines must be brought out to the panel. Portable GPS navigators require data port access. The data from the navigator must be set to a data rate of 4,800 or 9,600 baud, and NMEA183 or Aviation data protocol. Refer to the navigator's documentation for more details. A cable to connect the PortaPilot to your GPS navigator with bare wires is included.

Ensure that the PortaPilot is configured for the same data rate and protocol that your GPS navigator is set to.

**Engaging the NAV (one axis) Actuator during flight:**
Once stable, straight and level at a safe altitude of at least 2,000' AGL:

1. Line up the Actuator Assembly with the rear of the **YCC** opening, insert at a (approximately) 30º angle. Once fully inserted, rotate down to snap into position (Figure 6**,** Figure 7)
2. Select **LVL** mode, then use the handle to pull the actuator and engage the couplers. You may need to rotate the aircraft yoke to align. The wings should be leveled in a few seconds.
3. At this point you may select other **NAV** modes. The PortaPilot is **Active*** and engaged, in control of the and ailerons. The pilot is in control of the elevator and elevator-trim.

Verify that the aircraft is responding as expected to the selected settings.

* **Active** refers to modes in which the ailerons and / or elevator are being controlled and automatically responding to aircraft motion.

**NAV Active** modes include: **LVL, HDG, NAV, CR,** and **Suspended NAV**
**ALT Active** modes include: **HOLD** and **Suspended HOLD**

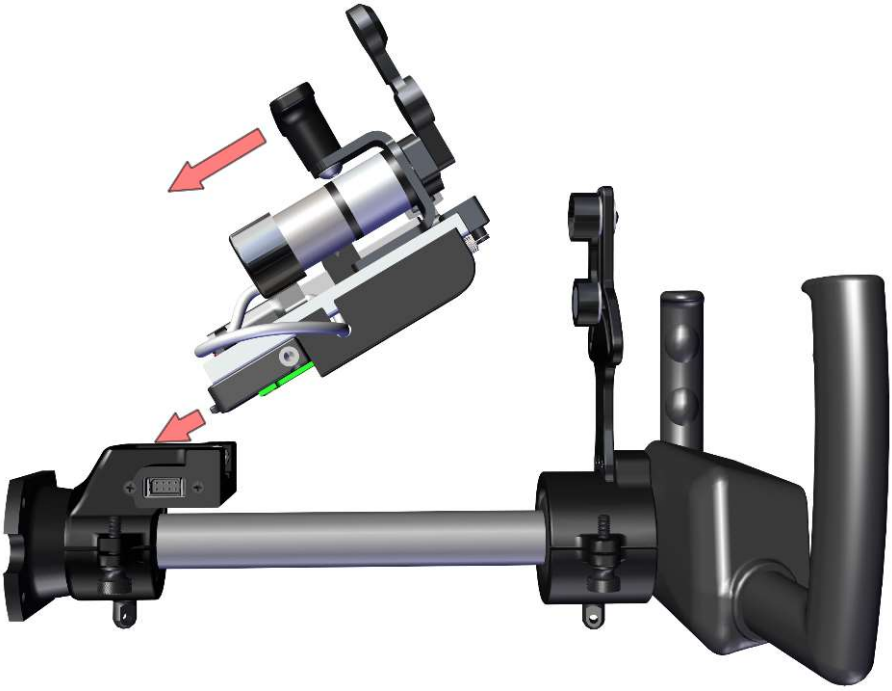

**Figure 6. Insert Actuator Assembly at a 30º angle towards rear of YCC. To prevent damage, avoid gold pins inside the YCC.**

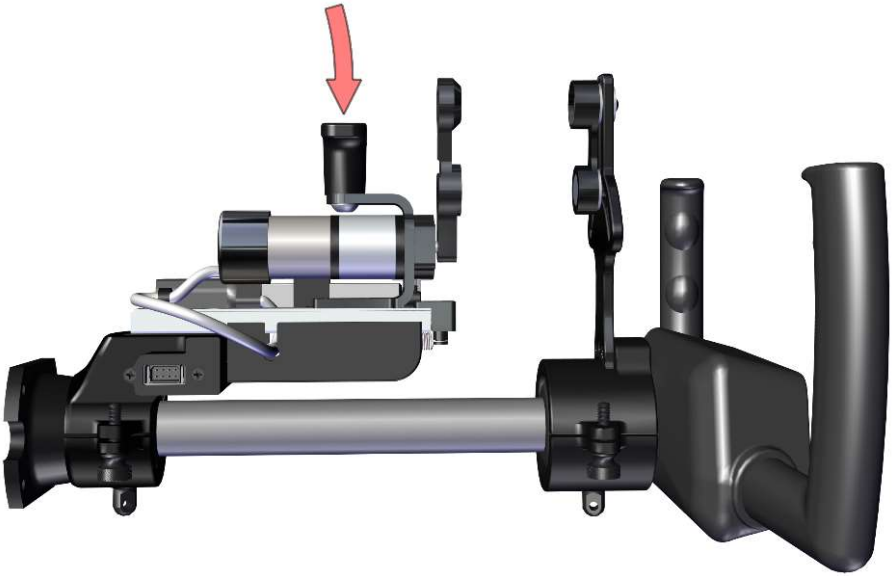

**Figure 7. Pivot the Actuator Assembly down and snap into place. Beware the YC Assembly will want to snap together to the Actuator Assembly at this point.**

**Engaging the VNAV (two axis) Actuator during flight:**

**WARNING**: On VNAV units, Once the **AA** is snapped in, the elevator actuator will retract. Disengage the elevator coupler prior to insertion.

1. Insert, engage, and activate Actuator Assembly as described in "Engaging the NAV (one Axis) …" section (p. 10)
2. Fly straight and level at the desired altitude (at least 2,000' AGL). Allow airspeed to stabilize, and properly trim aircraft to achieve vertical speed of less than 50fpm.
3. Slowly raise the lower coupler, Use ▼, ▲ to align couplers prior to letting them connect (Figure 8).
4. Use the **HLD** button to hold the current altitude (HLD indicator illuminates).

At this point you may adjust the altitude and/or select other NAV modes. The PortaPilot is **Active** and engaged, in control of both, the elevator and ailerons. Allow several minutes for the altitude to settle, trimming elevator as indicated.

Verify that the aircraft is responding as expected to the selected settings.

**Making altitude adjustments:**

1. While in altitude hold, Use ▼, ▲ buttons to initiate a desired vertical speed (Suspended Altitude mode, **HLD** indicator flashing).
2. Upon reaching the desired altitude, press the **HLD** button to lock in altitude.
3. Allow a few minutes for the altitude to be captured.

Be sure to manage power and trim throughout these procedures.

**Emergency Removal of Actuator Assembly (AA)**:
In an emergency, or when there is an urgent need to remove the Actuator Assembly; Forcefully pull the extractor handle up and towards you with one hand, while holding the aircraft controls with the other.

**Removing the Actuator Assembly during flight:**
If the situation allows, first disengage, and retract (Temporary Disengagement) before removing the Actuator Assembly as follows:

Push forward on the extractor handle (If still engaged), then pull up and towards you. This will extract the Actuator Assembly from the YCC. Apply sufficient force in order to overcome the catches and magnetic couplers if they are still engaged. Stow away from the aircraft panel to avoid magnetic interference with instruments.

**Temporary Disengagement of the Actuator Assembly:**
**VNAV models**: First, Disengage the Elevator Actuator magnetic couplers by rotating the lower magnet down (Figure 8) then proceed with the following:

**NAV models**: While holding the control yoke with one hand, push the Actuator Assembly forward towards the panel by using the extractor handle to disengage the magnetic couplers (Figure 2). The Actuator Assembly will be held in this forward position by the retraction spring.

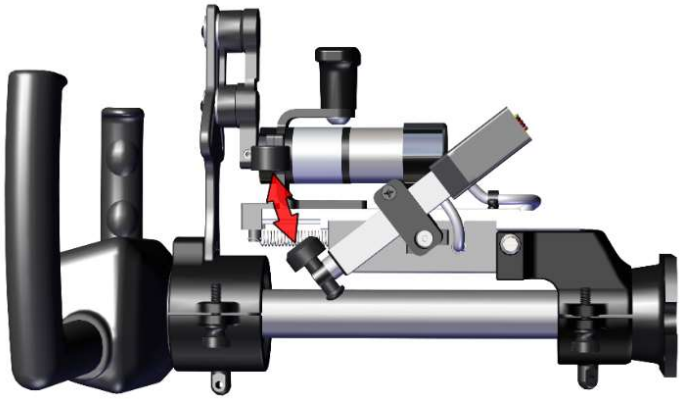

**Figure 8. Rotation of elevator actuator to engage / disengage magnetic coupler**

**Figure 9. The VNAV model Actuator Assembly includes an Elevator Linear Actuator, shown here disengaged, with couplers separated**

# Operating Modes

Roll axis modes are selectable by pressing and releasing the **NAV** button , available with both NAV (single axis) and VNAV (dual axis) models


**Figure 10. User Interface in NAV mode with GPS navigator connected.**

**Table 1. Roll axis modes of operation.**

| Mode | Active [1] | ◄,► buttons | Details |
|---|---|---|---|
| CWS [2] | | Direct ailerons control | Manual control of ailerons deflection. Default mode, at power up. |
| LVL | √ | Suspended mode: commands a turn | Wing Leveler operation. |
| HDG | √ | | Hold magnetic heading [3] |
| NAV | √ | | Track active flight plan or Direct-To [3] |
| Course Reversal [4] | √ | | Make approximately 180º turn to the left, with or without GPS navigator. |

[1] Automatic control of ailerons is active.
[2] Control Wheel Steering
[3] In the absence of GPS signal, the PortaPilot automatically reverts to LVL mode.
[4] Course reversal is initiated by holding down the **NAV** button.

Pitch axis modes are selected by pressing and releasing the **HLD** button, only available with VNAV model

**Table 2. Pitch axis modes of operation (VNAV model of the PortaPilot only)**

| Mode | Active [1] | HLD indicator | ▲,▼ buttons | Details |
|---|---|---|---|---|
| CWS [2] | | OFF | Direct elevator control | Manual control of elevator deflection. Default mode, entered at power up. |
| HOLD | √ | ON | Select suspended mode, setting vertical speed | Hold current altitude. |
| Suspended | √ | FLASHING | Control vertical speed in 50fpm steps | Command a climb or descent rates. **HLD** button resumes **HOLD** mode. |

[1] Automatic control of elevator is active.
[2] Control Wheel Steering

The PortaPilot Pitch and Roll axes systems are independent of each other and may be selected and operated independently.

The built-in altimeter sensor is sufficiently accurate for use by the PortaPilot as relative altitude reference. However, the pilot must monitor and rely on all relevant aircraft instruments including the altimeter.

With either **Setup** or **Configuration** selected, the PortaPilot's display and buttons are dedicated to these operations, and are no longer available for adjustments to pitch (**ALT**) or roll (**NAV**) axes mode selection and monitoring. During Setup or Configuration, the PortaPilot continues to control the aircraft in the background, processing GPS data and adjusting pitch and roll in accordance with the selected mode.

For maximum elevator authority with either VNAV or NAV models, the Actuator Assembly should be near mid extension while cruising. This may be displayed on VNAV models **(Setup→CENTER DISPLAY→Elevator Extensn)**.

# Roll Axis (NAV) Modes

Except for the **CWS** (roll axis Control Wheel Steering) mode, the PortaPilot provides gyro stabilized roll axis control. The roll axis steering modes are selected using the **NAV** button, each press will cycle through each mode sequentially through the following:

**LVL: Wing Leveler** (**LVL** indicator illuminated)

**HDG: Heading Hold** (**HDG** indicator illuminated)
**NAV: Flight Plan Tracking** (**NAV** indicator illuminates)
**CWS:** (**Control Wheel Steering**, all **NAV** indicators extinguished)

Pressing the **ENTR** button (press D-Pad down, Figure 10) forces both the roll and pitch axes to their **CWS** mode while the system is in normal operation (not in **Setup** or **Configuration**).

During **Active** mode and in the absence of a GPS signal, the PortaPilot automatically reverts to **Wing Leveler** operation. The GPS indicator is illuminated to confirm a valid GPS signal is connected. The correct baud rate and data protocol must be selected in configuration. The GPS indicator blinks to confirm valid data packet reception. This rate depends on the data update rate of the connected GPS navigator.

The Control Module (Figure 5) houses a three-axis inertial measurement unit (IMU), sensing orientation and motion of the aircraft. It is essential that it is securely mounted to a stable part of the aircraft panel. Moving it during flight will result in significant aircraft upset, or even causing unusual attitude – requiring a quick removal of the Actuator Assembly. Verify that the control module is fastened securely before each flight, and avoid moving or touching it during flight.

While in active roll mode (**LVL**, **HDG**, **NAV**), monitor the **Clamp Rotation** parameter on the center field of the display (**Setup→CENTER DISPLAY→Clamp Rotation**). This provides an indication of proper Yoke Clamp position, and required rotation relative to the yoke. This value is affected by both cross-wind, and aircraft rigging. See Appendix 'E' Yoke Clamp Alignment. This is typically only performed once on an aircraft.

**WARNING:** In **NAV** mode the PortaPilot expects the aircraft to respond to its roll commands. If the aircraft does not, such as when the Actuator Assembly is inserted but not engaged with the Yoke Clamp, it will be interpreted as rotation error which accumulates in attempt to correct. This will result in large deflection of the Actuator arm. To prevent this, select **CWS** mode whenever the Actuator is inserted but not engaged.

**NOTICE:** For proper autopilot operation the minimum indicated airspeed must be greater than 1.5 x Vs (Vs is the stall speed with flaps retracted).

## *Control Wheel Steering, Ailerons (CWS)*

This is the default aileron control mode which is selected when the PortaPilot powers up. While selected, the three **NAV** indicators are extinguished.

Pressing the **ENTR** button (press D-Pad down) while the system is in normal operation, forces both the roll and pitch axes to the **CWS** mode.

In this mode, the pilot has a direct control over the ailerons deflection by using the ◄, ► buttons. The ◄ button causes the aircraft to bank to the left and the ► button causes a bank to the right.

In this mode the left field of the display indicates the rate of turn (ROT), as measured by the PortaPilot.

## *Wing Leveler (LVL)*

Engaging **LVL** (Wing Leveler) operation is confirmed by the illumination of the **LVL** indicator. In this mode the PortaPilot controls ailerons deflection as to resist turns, resulting in leveled wings. In the presence of cross-wind, bank angle will be maintained which is proportional and opposite the cross-wind. Some nominal drift is to be expected. This mode does not maintain a precise ground track or heading. The left field of the display indicates the measured rate of turn (ROT) in degrees per second. For stability, in the absence of GPS navigator, the pilot should enter the aircraft indicated airspeed (**Setup→INDCTD AIRSPEED**).

Pressing the ◄ or ► button while in **LVL** mode will engage the **Suspended NAV** mode, providing means to command a turn to the left or right, respectively, as confirmed by blinking of the **LVL** indicator. The value of the commanded turn is displayed in the left field (**TROT**). It is useful for adjusting aircraft heading while in **LVL** mode, or diverting the flight path. Repeated button inputs change turn rate in 1dps steps, up to 3dps. Pressing the **NAV** button while in **Suspended NAV** mode will resume **LVL** operation. This mode is available in all three active **NAV** modes.

## *Hold Heading (HDG)*

Engaging **HDG** (Heading Hold operation) is confirmed by the illumination of the **HDG** indicator. In this mode, the built-in GPSS (GPS steering) is enabled, holding the current heading (GPS ground track). Pressing the **SETUP** button invokes the heading bug (**Setup→HEADING SELECT)**. This function provides means to select a heading with one degree resolution. If GPS data is lost during **HDG** mode, the PortaPilot reverts to **Wing Leveler** (**LVL**) operation, confirmed by blinking of the **HDG** indicator. Restoration of GPS signal automatically resumes **HDG** mode, holding the previously held heading.

Using the ◄ or ► button while in **HDG** mode engages the **Suspended NAV** operation which allows temporary heading diversion. While in this mode, pressing the **NAV** button resumes **HDG** operation, holding the present heading. While in **HDG** mode, crosswind and other error sources

have minimal effect on the ground track. Unlike **NAV** mode, **HDG** does not follow a course, and may have some drift. It is more accurate in maintaining heading than **LVL**, but it is not as accurate as following a GPS flight plan or Direct-To in **NAV** mode.

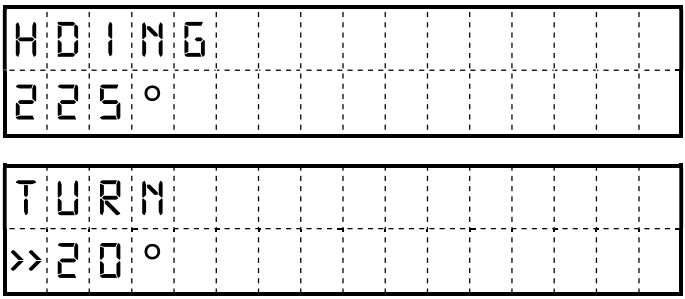


**Figure 11. In HDG mode, the left field alternates between desired heading and the required turn.**

There are several methods to select a heading in this mode, all of which require GPS data:

1) Selecting **HDG** mode while in **LVL** mode, locking current heading.
2) Change the heading using **Suspended HDG**, then pressing the **NAV** button.
3) Commanding a numeric heading using **Setup→HEADING SELECT**.

## *Tracking GPS Flight Plan or Direct-To (NAV)*

Pressing the **NAV** button while in **HDG**, selects **NAV** mode (GPSS), which is confirmed by the illumination of the **NAV** indicator. In this mode, the PortaPilot follows a GPS navigator's active flight plan, or Direct-To, using its built-in GPSS. The aircraft will intercept the current active segment then track it, by sequencing way points and making the required turns. If the aircraft is off course, it will intercept and capture the currently active course segment using an intercept angle proportional to both, ground speed and distance to the active segment. The aircraft must be within 10NM of the active course segment to intercept it.

While in **NAV** mode, loss of GPS signal will result in extinguishing of the **GPS** indicator, blinking of the **NAV** indicator and the left side of the display alternating between "NO GPS" and "WING LVLR". With a valid GPS signal but no active flight plan or Direct-To, the **GPS** and **NAV** indicators will flash, while the left side of the display will alternate between "NO F-PLN" and "WING LVLR". In either case the PortaPilot will automatically revert to **LVL** operation. Once GPS signal is restored and flight plan or Direct-To data is received, the PortaPilot will resume **NAV** tracking.

## *Suspended NAV mode*

While in any active **NAV** modes (**LVL, HDG**, **NAV**), pressing the ◄ or ► button will command a turn to the left or right. This will suspend the currently selected **NAV** mode (**Suspended NAV** mode), and the mode's indicator will blink.

In this mode the ◄ and ► buttons command a turn rate between 1 to 3dps (degrees per second). A setting of 0dps is equivalent to using **LVL** mode. While in **Suspended NAV** mode, the left side of the display indicates commanded turn rate. Pressing the **NAV** button while in **Suspended NAV** resumes the currently selected **NAV** mode.

While in **LVL, or HDG,** entering **Suspended NAV** mode provides means to controllably turn the aircraft to a new heading. Resuming **LVL** mode causes the aircraft to maintain level wings (0dps) and the **LVL** indicator stops blinking. Resuming **HDG** mode causes the aircraft to hold the current heading, and the **HDG** indicator stops blinking.

While tracking a flight plan or Direct-To in **NAV** mode**,** entering **Suspended NAV** provides means to temporarily divert the aircraft heading, suspending way-point sequencing. Resuming **NAV** operation (**NAV** button), results in intercepting and recapturing the currently active course segment, way-point sequencing, and the indicator will stop blinking

Pressing the **ENTR** button (press down D-Pad) at any time will set both the roll and pitch axes to **CWS** (Control Wheel Steering) operation.

Complying with ATC vectors: To comply with ATC vectors while tracking a flight plan, select **HDG** mode (three **NAV** button actions) and dial in the heading (**SETUP→HEADING SELECT)**. In response to "resume own navigation", a single click of the **NAV** button resumes **NAV** mode, re-intercepting and tracking the flight plan, provided the aircraft is within 10NM of the active course segment.

## *Course Reversal (CR)*

**CAUTION**: Course Reversal cannot be engaged while in **Setup** mode. Ensure **Setup** is not active by verifying the indicator is not illuminated.

There are several methods the PortaPilot can turn the aircraft to the direction opposite of its current course:

1. With the **Actuator Assembly** engaged in NAV mode and following a flight plan, invert the flight plan in the GPS navigator.
2. While in **HDG** mode, dialing in an inverted heading will turn the aircraft to this heading.

3. In **LVL** mode, three clicks of the ◄ button will initiate a turn to the left. In this case the pilot needs to monitor the aircraft Heading Indicator, and arrest the turn (**NAV** button).

However, the fastest way is using the Course Reversal (**CR**) operation to automatically execute a left turn of approximately 180º. This operation is performed by pressing and holding the **NAV** button until all three **NAV** indicators rapidly flash (about three seconds). While active, the three **NAV** indicators are illuminated. **CR** is available regardless of the currently selected **NAV** mode. In the absence of GPS signal, a turn will be performed, and **LVL** mode will be automatically selected on completion of the turn, maintaining leveled wings. With active GPS navigator connected, accuracy will be increased, and **HDG** mode will be automatically selected on completion of the turn, holding the reversed course. Pressing any button during **CR** will terminate the turn. The turn takes about a minute to complete.

Unless in **Altitude Hold** mode (**VNAV** models), the aircraft will lose altitude in the turn. Therefore, the pilot should apply appropriate power and/or elevator pressure and/or trim to minimize altitude loss.

During the turn, approximate remaining turn amount and time are displayed. The remaining turn amount is of particular importance.

The primary objective of this procedure is to provide simple means to steer the aircraft out of inadvertent penetration into IMC, resulting in spatial disorientation emergency. As with all PortaPilot operations, for safe operation during this procedure, the pilot must monitor and verify all relevant aircraft instruments such as AI, HI, Turn & Bank, Altimeter and Vertical Speed indicators. It is the pilot's responsibility to make sure the turn is conducted safely. For additional information view the YouTube video titled "178 Seconds to Live".

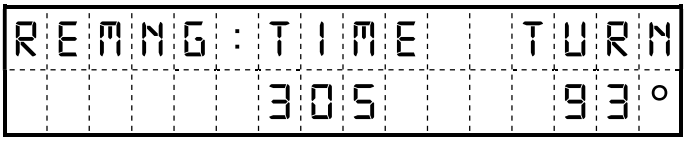


**Figure 12. Display showing remaining time and turn amount during CR procedure.**

Practice: Whenever using **CR** operation, the pilot should note the current heading and calculate the reverse heading. Once the turn is complete, the ◄ and ► buttons may be used to adjust the heading.

**NAV system check:**

While flying through calm air, the **Actuator** movements may be very small and infrequent. To verity the PortaPilot is operational; apply a gentle tap

on the rudder. This should cause the **Actuator** arm to respond to counter the rudder input.

## *Emergency during an IFR approach*

The PortaPilot is neither capable nor does it meet the certification requirements for coupled instruments procedures, including coupled approaches. **Safety first!** Do not perform this procedure unless you have practiced at a safe altitude, and built familiarity and confidence.

In an emergency the pilot may use any means they see fit in order to preserve life and property. There are several factors to consider while encountering an emergency during an IFR flight. The nature of the emergency may be due to spatial disorientation related to partial panel, equipment failure, pilot incapacitation, or other disabling causes. In these cases, it is of great importance to confess and declare the nature of the emergency to ATC. As stated, the PortaPilot is neither certified nor capable of executing coupled instruments procedures. However, the pilot may choose to use it as a last resort during an emergency, to assist with control of the aircraft. There are few PortaPilot capabilities that may be deployed on some of the approach segments. This relies on having an IFR certified navigator capable of providing a GPS overlay (magenta line) of the selected approach. In such case the PortaPilot may be deployed to guide the aircraft through some segments of the approach. In an emergency, a pilot experienced with the PortaPilot may use it to track the overlay.

It must be noted that there are significant segments of an approach that the PortaPilot is ***not*** capable of executing automatically, including:

1) Entering and tracking Holding Patterns.
2) Flying Procedure Turns or Course Reversals.
3) Tracking a glide slope.

Entering and tracking a holding pattern during an emergency may be accomplished by the pilot alternating between **HDG**, **NAV** and commanding turns. As an example, once the navigator has the approach loaded and active, **NAV** may be used to fly the aircraft to the hold waypoint. Next **HDG** may be used to control the entry part of the procedure. **NAV** may be utilized on the inbound segment, while **HDG** provides control over the outbound segment.

To terminate the hold and proceed to the FAF, on the in-bound segment set the navigator to cancel the hold and resume waypoint sequencing. The PortaPilot should respond by guiding the aircraft to the FAF and to the

runway, providing the lateral part of the final approach. The pilot must control the glide slope manually.

If flying Vectors to Final, use **HDG** to comply with ATC vectors. Once established (localizer in active range) select **NAV** to intercept and fly the GPS overlay to the FAF, and MAP. Whenever using **HDG** mode, incrementally adjust the heading to ensure a turn in the intended direction, avoiding the 180º ambiguity.

# Operating Without GPS Navigator

The PortaPilot may be operated without a GPS navigator. This limits the roll axis active modes to **LVL** and **CR** (Course Reversal). Without a GPS navigator, both **HDG** and **NAV** automatically revert to **LVL** operation.

Note: Some inexpensive GPS devices, such as the Garmin GPS-35LP, GlobalSat BR-355, or most automotive GPS receivers that have NMEA183 serial data port, are sufficient to provide **HDG** functionality. A portable or panel aviation GPS navigators allow the full range of capabilities of the PortaPilot. The PortaPilot may be wired to provide aircraft power (14V) to power most portable GPS navigators.

Some of the GPS navigators the PortaPilot is compatible with include: Garmin III Pilot, Garmin GPSMap 196 and 396, Garmin 695, Garmin AERA 500, 660, and 760, Garmin 795/796, Garmin GPS20A, Garmin GNS 430/530, GTN 650/750 series panel GPS navigators, and others. Panel type navigators require connections to an available serial port, and must be configured for Aviation or NMEA183 protocol.

# Pitch Axis (VNAV) Modes

**WARNING**: To control altitude, the PortaPilot adjusts the aircraft pitch (nose attitude) by means of elevator deflection rather than elevator trim tab adjustment. The pitch attitude is adjusted regardless of the aircraft speed, AOA (angle of attack), power, altitude, CG, etc. Due to this, in attempt to maintain altitude the PortaPilot may set the aircraft for unusual attitude, stall, or exceed safe speed. Therefore, it is ***always*** the pilot's responsibility to remain vigilant, monitor aircraft performance, and to take the necessary actions to remain within safe operating envelope as indicated in the POH. Whenever in doubt, remove the PortaPilot's **Actuator Assembly**.

The ▲, ▼, and **HLD** buttons as well as the **HLD** and **TRIM** indicators are involved in controlling the aircraft pitch axis. The **HLD** button toggles between pitch **CWS** and **Altitude Hold** operation. During normal operation (while the **SETUP** indicator is extinguished), The **ENTR** button (press D-Pad down) sets both the **ALT** and **NAV** systems to **CWS** operation.

Following power up, the PortaPilot roll and pitch systems are in **CWS** mode.

## *Control Wheel Steering, Elevator (CWS)*

With the **HLD** indicator extinguished the pitch system is in **CWS** mode. While the elevator couplers are engaged, the ▲ and ▼ buttons adjust the elevator deflection for nose up and nose down attitude, respectively. It is critical for the pilot to monitor aircraft airspeed, attitude, and vertical speed, and adjust power and elevator trim, making sure the aircraft operates within normal operation envelope. Since trim indication is disabled during this mode, large deflection may result in an **Elevator Actuator** disconnect.

This mode is intended primarily for alignment of the elevator couplers.

## *Altitude Hold*

**Altitude Hold** mode is optimized for cruising altitudes and speeds. When selected, the aircraft holds the current altitude. Prior to selecting this mode, the aircraft must be stabilized and trimmed for leveled flight at the desired altitude, with both the power and speed settled, and vertical speed less than 50fpm. Only then should the elevator actuator coupler be engaged and **HLD** button pressed. The PortaPilot holds altitude by adjusting pitch attitude, relying on its barometric altimeter and pitch sensors. Prior to holding altitude, make sure the PortaPilot and aircraft altimeters are synchronized.

When powered up, on the ground or in flight, a reference pitch and roll attitude are established. It is important that the aircraft is on a flat and level tarmac or flying straight and leveled when powering up, alternatively **Straight & Level** operation must be performed.

There are three methods to terminate **Altitude Hold**:

1. Press **HLD** button
2. Press **ENTR** button
3. Remove **Actuator Assembly**.

Flying through areas of varying barometric pressure requires periodic adjustments to both the aircraft and PortaPilot altimeters (**Setup→SET ALTIMETER)**. Proper elevator trim must be applied periodically. Failing to adjust elevator trim may result in couplers disconnecting and subsequently, significant pitch excursion. The aircraft altimeter must be relied on for altitude indication. For instance, if the PortaPilot target altitude is set to 4,500', and the aircraft altimeter indicates 4,400', correct the PortaPilot barometer. If the error persists increase the target altitude (**SET ALTIMETER**) value by 100'.

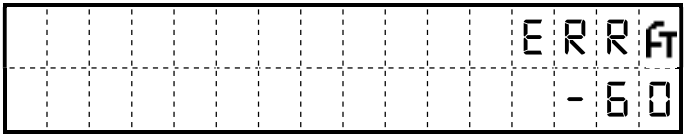


**Figure 13. Display during Altitude Hold indicating altitude error.**

**Altitude Hold Practice:**

1. Hand-fly the aircraft to the desired altitude.
2. Set aircraft power and elevator trim for strait-and-level flight, and wait for both, the RPM (power) and speed to stabilize.
3. Align the upper and lower elevator couplers (▲ & ▼ buttons)
4. Rotate and engage elevator actuator, then press the **HLD** button.
5. Wait for a few minutes for the altitude to stabilize.

It is very important maintain constant RPM (or power) while holding altitude. Any upsets to the held altitude, such as a gust, turbulence, change in power or a turn will result in reacquisition of this altitude, which may take several minutes.

## *Suspended Altitude Hold*

While holding altitude, pressing either, the ▲ or ▼ button will enter **Suspended Altitude Hold**, commanding vertical speed. This is confirmed by flashing of the **HLD** indicator. Each additional click of these buttons will command an additional 50fpm of vertical speed. The maximum allowable vertical speed should not exceed the aircraft performance envelope. On reaching the desired altitude, pressing the **HLD** button will resume **Altitude Hold**, holding the current altitude. It may take several minutes to acquire the altitude. Always rely on the aircraft instruments for vertical speed and altitude.

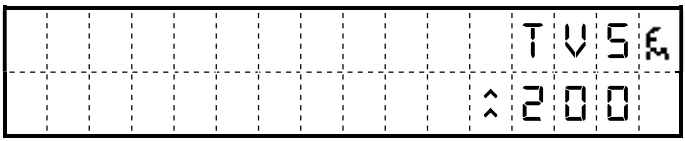


**Figure 14. Suspended Altitude Hold indicating commanded vertical speeds.**

During **Altitude Hold** and **Suspended Altitude Hold,** make sure the elevator trim is properly adjusted, and maintain appropriate RPM (power).

**Aircraft Power During Altitude Hold:**

While cruising, it is important to maintain constant power, whether RPM or manifold pressure. Even as small as a 50 RPM change will introduce altitude and pitch errors which may take several minutes to correct, and require multiple pitch trim adjustments. While the PortaPilot commands a

descent or a climb, appropriate aircraft power and elevator trim must be set, followed by progressive readjustment of both when closing in on the destination altitude.

Consult with a performance table (Table 3), or create one for your aircraft, which is consistent with the POH. At all times the pilot is responsible for monitoring all relevant aircraft instruments. The sample performance table below is for C172 with 180hp engine at 3,000'.

**Table 3. Example Cessna 172, 182HP Engine aircraft performance table.**

| Performance Table: Cessna 172, 180HP Engine | | | |
|---|---|---|---|
| **Operation** | **Power (RPM)** | **Airspeed (KIAS)** | **VS (f/m)** |
| Cruise Climb | Full | 90 | 800 |
| Cruise | 2500 | 110 | 0 |
| Descent | 2200 | 110 | -500 |
| Leveled Approach | 1900 | 90 | 0 |
| Precision Approach | 1750 | 90 | -500 |
| None Precision Approach | 1600 | 90 | -800 |

Appropriate power management and frequent elevator trim are essential, particularly during climbs and descents. Failure to do so will result in poor response and accuracy, and potentially control surface oscillation, pitch hunting or coupler disconnect.

## *Elevator Trim Indicators*

The **VNAV** models of the PortaPilot incorporate elevator trim sensing, and indicators which show both direction and amount of elevator trim required. This function is active while in **Altitude Hold** or **Suspended Altitude Hold**. Out-of-trim condition is indicated by illuminating the corresponding trim indicator. With the **ELEV. TRIM** parameter set to 60 (**Config→ELEV. TRIM LEVL** ↵), elevator force greater than about one pound will result in steady trim indicator illumination. The indicator will flash if elevator force is two times this amount. Both indicators are extinguished when the elevator is properly trimmed. Unless trim indicator flashes, limit trim corrections to about "half a notch" in a typical single engine Cessna. Large corrections will cause hunting of both altitude and pitch. For efficient trim correction, make trim adjustments following trim force measurement (indicated by a short flashing of both indicators).

With **TRIM UP** indicator illuminated (upper indicator), adjust the aircraft elevator trim control for nose up attitude. With **TRIM DOWN** indication adjust the aircraft elevator trim for nose down. Trim until both indicators are extinguished. Illumination of both trim indicators implies that elevator actuator is at the limit of its travel range, or a failure of the elevator linear

actuator is detected. An intermittent indication is normal during turbulence or while turning. Failure to properly trim the elevator will result in excessive forces imposed on aircraft elevator and PortaPilot components. Such forces may result in disconnection of the elevator coupler; further consequence is an out of control nose up or down excursion.

# PortaPilot Operating Parameters

The PortaPilot is a limited authority autopilot, and in addition to the parameters specified in the aircraft POH, these parameters must also be adhered to:

1. Airspeed range: **1.5 X Vs to 2.7 X Vs (KIAS)**
2. Maximum yoke rotation: **±30º**
3. Maximum yoke travel (pitch axis): **±1”**
4. Maximum in flight cross-wind component: **35KTS**.
5. Actuator Assembly must be removed below: **2,000 ft AGL**
6. Maximum allowed turbulence: **Light, intermittent**
7. **NEVER** insert the Actuator Assembly during ground operations.
8. Manually overriding the PortaPilot is discouraged in order to prevent damage.
9. Removing the Actuator Assembly using the Extraction Handle is recommended whenever possible.
10. The pilot must be strapped-in prior to using the PortaPilot
11. The PortaPilot is limited for use in small single engine aircraft, with aircraft-specific components which are not interchangeable.

On power up the PortaPilot enters **CWS** modes, and the ▲,▼,◄, ► buttons control the deflection of the elevator and ailerons. Anytime the Actuator Assembly is inserted and engaged, it is in control of the aircraft, and fighting it could result in damage to its components. It is essential for the pilot to be confident in inserting and removing the Actuator Assembly. With the single axis (**NAV**) model, engaging the Actuator Assembly retains free pitch axis control, which allows pushing and pulling the aircraft flight controls, or via elevator trim adjustment.

## *Takeoff and Initial Climb*

### Roll Motor Torque

During climb out the aircraft engine is developing high thrust at high angle of attack, resulting in P-Factor force and high torque. The PortaPilot does not have sufficient torque to overcome these forces, therefore the pilot must make sure the aircraft is flown coordinated (ball centered).

### Crosswinds and Turbulence

Forces imposed by turbulence and/or crosswind may exceed the capability of the PortaPilot roll torque. The torque limit of the PortaPilot may be adjusted by the pilot (**Configure→AILERONS TORQUE**) to handle these forces. However, increasing the value may result in coupler disconnect under these forces, particularly in turns.

### Power Considerations

The PortaPilot requires 14VDC to operate. A minimum of 11.5V is required to operate properly. During power up sequence the PortaPilot displays battery voltage. A voltage between 13.3V and 14.4V is usually an indication that the aircraft charge system is properly operating. This can be monitored in the center display field (**Setup→CENTER DISPLAY)**.

# Setup and Configuration

**Setup** is intended for in-flight use, while **Configuration** is intended for use on the ground. The **SETUP** button is used to select either one of these modes, as well as step through the available menu items. Adjusting a selected parameter involves the use of ▲,▼,◄, ► (D-Pad). While the **SETUP** indicator is illuminated, the PortaPilot is in either **Setup** or **Configuration** mode, and both the display and buttons are unavailable for normal control of the lateral (**NAV**) and vertical (**VNAV**) navigations. The **NAV**, **HLD**, and **ENTR** buttons will terminate **Setup** or **Configuration** operations, restoring normal operation.

Any item followed by an enter symbol (↵) requires pressing **ENTR** to permanently store the parameter to memory. Other parameters are temporary, and are only available while the PortaPilot is powered.

While the **SETUP** indicator is illuminated**,** the PortaPilot continues to control the aircraft in the background.

**NOTICE:** Do not disconnect power to the PortaPilot while the **SETUP** indicator is illuminated. Doing so may corrupt the data in its memory, which may require factory reconfiguration.

## *Setup*

Press the **SETUP** button momentarily to activate **Setup** mode, confirmed by illuminating the **SETUP** indicator. The display shows the currently selected **Setup** menu item. The following list contains the parameters and operational items included in **Setup**. Parameters which are indicated as **Immediate** are set as they are being edited, effecting operation

immediately. Keep a log of any parameter changes for future reference, particularly if using the PortaPilot on multiple aircraft.

Some menu items are context sensitive. For instance, **HEADING SELECT** is only available while the PortaPilot is in **HDG** mode with the GPS indicator lit.

**Setup** mode includes the following items:

**1. STRT & LEVL:** Pressing the **ENTR** button while this item is displayed sets a straight and level attitude reference, where the aircraft's current pitch and roll references are set to zero. This takes five seconds to complete and will subsequently exit **Setup**. This operation should only be performed while flying unaccelerated, strait and level, with or without the Actuator Assembly in place.

This operation is automatically performed every power up, and only needs to be performed if the aircraft was not on a flat surface during power up. You may also perform this operation during flight to realign the reference. Keep in mind that the aircraft reference pitch varies with altitude, power setting, weight, and center of gravity.

**2. ROLL GAIN (Immediate) ↵ :** The default roll gain is set when the aircraft model is selected (**Configuration→AIRCRAFT MODEL**). This value may be modified by up to 50% in order to tune the roll axis characteristics. Edit this parameter while the PortaPilot NAV system is in one of its active modes (**LVL**, **HDG**, or **NAV**). This parameter is actively applied while being edited. Great care must be taken while changing this parameter since it affects both, the stability, response time and damping (overshoot or undershoot) of the roll axis. Higher gain values will result in faster roll, more accurate tracking and reduced hunting of the course line or heading, however, too high a value will cause twitchy roll response (particularly in turns), overshoot of the intended course, or even uncontrolled roll oscillations. This parameter must be adjusted in small steps, followed by verification. An acceptable value should result in accurate tracking, pleasant turn entry and course corrections, as well as minimal S-turns or hunting. If set too low, this will result in sluggish response, poor tracking, and poor response to wind and turbulence. Use the **ENTR** button to save the edited value to permanent memory location. Press **NAV** or **HLD** to cancel changes and exit **Setup**. Press **SETUP** to cancel changes and step to the next menu item.

The roll axis performance is affected by the center of gravity, load, speed, configuration, altitude, temperature and more. This parameter is accessible to the pilot as means to optimize the roll axis characteristics during flight.

Wings rocking, or oscillation while in one of the roll axis active modes (**LVL**, **HDG** or **NAV)**, particularly during a turn**,** could be caused by several factors, including: wind, turbulence, altitude, or speed. Adjusting this parameter may alleviate this, since stability is significantly affected by **ROLL GAIN**. The PortaPilot does not have access to the aircraft airspeed indicator, it relies on GPS ground speed. Therefore, when the aircraft indicated airspeed (KIAS) differs by more than 10KT from the GPS ground speed, or when a GPS signal is not available, it is essential to enter the aircraft indicated airspeed using the **Setup→ENTER AIRSPEED** rather than change **ROLL GAIN**.

Loose PortaPilot components such as **YCC** and **YC**, **Actuator** and its arm will be manifested as poor roll axis stability, particularly noticeable while entering a turn. Reducing **ROLL GAIN** under such circumstances may alleviate this condition, but will also hide the problem at the cost of reduced tracking accuracy and poor responsiveness. The same holds for sloppy aircraft ailerons rigging and yoke linkage, such as loose control wheel U-Joint or improper control cables tension.

**Flying through turbulence**: While cruising in turbulent conditions, the aircraft may exhibit excessive roll fluctuations. Temporarily reducing **ROLL GAIN** (by 10% to 20%) is likely to result in a more pleasant ride.

**Optimizing performance:** While in **LVL** mode at cruising speed and safe altitude, follow each **ROLL GAIN** adjustment with a short rudder application (left then right). Observe the response of the aircraft, such as roll overshoot, fluctuations in bank angle, and time to reach leveled wings. Aircraft should settle within three to five bank excursions, and with minimal residual roll oscillations. Repeat the above with opposite rudder, followed by making 90º turn to the left then to the right. If the coupler disconnects during any of these maneuvers, reduce the torque limit by about 20 and try again (see **AILERONS TORQUE** item in **Configuration** below).

**3. PITCH GAIN (Immediate) ↵ (VNAV Only):** The default pitch gain is set when the aircraft model is selected (**Configuration→AIRCRAFT MODEL**). This value may be modified by the pilot by up to ±50% in order to tune the pitch axis characteristics. This parameter is actively applied while being edited. This parameter can be adjusted during flight to optimize the dynamic performance of the pitch axis, and only has effect while holding altitude, or during **Suspended Altitude Hold**. High values may cause jittery pitch and vertical speed response, and/or an overshoot of the commanded altitude. Extremely high values will result in pitch oscillations or porpoising. Low values will result in a sluggish response, and altitude error. Extremely low values will result in poor response, poor accuracy, and pitch oscillations. The **ENTR** button saves the edited value

to permanent memory and exits **Setup**. Press **NAV** or **HLD** to cancel changes and exit **Setup**. Press **SETUP** to cancel changes and step to the next menu item.

**Testing pitch axis stability:** While holding altitude at cruise speed and a safe altitude, reduce aircraft power and speed by reducing power by about 100RPM if fixed pitch aircraft. Observe how the aircraft responds to the change in terms of pitch, vertical speed variations, and captures the commanded altitude. Repeat by increasing power by about 100RPM. Observe overshoots and undershoots in altitude, pitch angle and vertical speed fluctuations and the time it takes to restore altitude, as well as altitude accuracy. Keep in mind that it takes several minutes for the pitch axis to settle.

**4. INDCTD AIRSPEED (Immediate):** Enter indicated airspeed in knots (KIAS). Indicated airspeed is the ram airspeed shown by the aircraft airspeed indicator, without temperature and altitude compensation. This value is not saved permanently, and defaults to zero at power-on.

With this default setting, GPS ground speed is used, which works well in the absence of significant wind (over 7KT). For greater accuracy, enter KIAS manually.

Be sure to enter your KIAS if no GPS signal is available, otherwise the factory default aircraft cruise speed will be used.

Erroneous KIAS may result in marginal performance; unaccounted Tail wind tends to degrade roll axis stability, while unaccounted head wind results in sluggish control.

When entering KIAS, the display also shows the calculated KTAS (true airspeed). Use ▲,▼,◄, ► to enter a value of 0 to 350KT. The entry is set immediately. Press **ENTR**, **NAV** or **HLD** to exit **Setup**. Press **SETUP** to step to the next menu item. For quick zeroing use the ▼ button while cursor is on the 100KT digit.

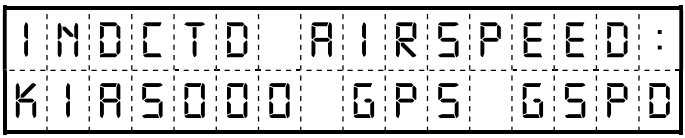


**Figure 15. Display showing GPS ground speed is being used.**

Figure 15 depicts a typical situation with KIAS at a default of 0, with a GPS navigator connected. The aircraft speed being used by the PortaPilot is the navigator's ground speed, indicated by "GPS GSPD". Without GPS,

the display will show "ENTR SPD" to urge the pilot to enter the correct indicated airspeed. Manually entering correct KIAS will also take priority over GPS. This will be indicated on the lower line of the display, as "KIASXXX KTASXXX".

**5. SET ALTIMETER (Immediate) ↵ :** Set local barometric pressure of the built-in pressure altimeter between 28.00 - 31.00 inHg. Actively applied while being edited, and essential to the accuracy of the built-in altimeter. This setting effects PortaPilot altitude and vertical speed. The sensor measures the pressure inside the aircraft cabin which is slightly different than outside pressure, resulting in altitude error. **ENTR** saves the edited value to permanent memory and exits **Setup**. Press **NAV**, or **HLD** to cancel changes and exit **Setup**. Press **SETUP** to cancel changes and step to the next menu item.

**WARNING (VNAV Models Only)**: While holding altitude, changing PortaPilot Barometric Pressure is interpreted as abrupt changes in both altitude and vertical speed. This may cause significant climb, descent, or even unusual attitude or a stall. Adjust barometric pressure in small 0.02" steps at 10 seconds intervals while holding altitude.

**VNAV example**: Assuming **Altitude Hold** is engaged at 4,500' with a PortaPilot altimeter setting of 29.75". The barometric pressure 200 NM from the departure airport is 29.95". Setting this value in the PortaPilot will result in altitude indication of 4,700'. To recapture the 4,500' altitude hold, the PortaPilot will apply significant nose down pitch and rapidly descend to correct for the perceived climb rate.

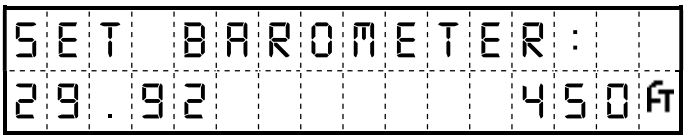


**Figure 16. Barometric Pressure setting also displays the corrected altitude.**

**6. CENTER DISPLAY ↵ :** This menu item allows the pilot to select a parameter to be displayed on the center field of the display. Use ▲,▼ to select an item from the list. The **ENTR** button saves the value to permanent memory and exits **Setup**. Press **NAV** or **HLD** to cancel changes and exit **Setup**. Press **SETUP** to cancel changes and step to the next menu item.

**Pitch angle:** this is the pitch angle of the aircraft in degrees. Accuracy is dependent on **Straight & Level** operation.

**Vertical speed:** Measured vertical speed in feet per minute (fpm). Derived from the PortaPilot built in VSI, and is similar in operation to the aircraft vertical speed indicator.

**Elevator Extensn (VNAV Only):** Measured extension amount of the elevator actuator in percent. Fully extended (nose up) is displayed as 100%, and fully retracted (nose down) as 0%. Nominally this value should be approximately 50% extension while cruising.

**GPS Altitude:** Altitude indicated by the GPS navigator.

**Rate of Turn:** Measured rate of turn in degrees per second (dps). Should not differ by more than about 0.5dps from the aircraft Turn & Bank indicator.

**Clamp Rotation:** Amount and direction of required rotation of the Yoke Clamp (relative to the aircraft yoke). Only valid while the aircraft is in one of the active **NAV** modes (**LVL**, **HDG**, or **NAV**). If this value is greater than 15, adjust the mounting of the **Yoke Clamp**. A '>>' symbol indicates a clockwise rotation of the clamp is required, '<<' indicates counterclockwise rotation. This value changes slowly. Allow several minutes to settle. It is helpful to mark the rotation of the Yoke Clamp (**YC**) onto the yoke for subsequent flights.

Note: To avoid damaging PortaPilot components, only rotate the Yoke Clamp while it is disengaged from the Actuator Assembly.

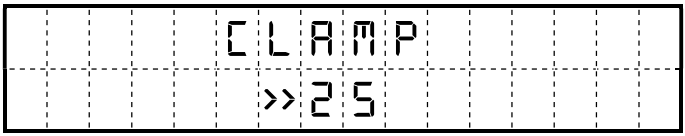


**Figure 17. The required Clamp Rotation is indicated in center field of the display.**

**Ground Track:** Magnetic ground track of the aircraft. Requires GPS signal.

**Desired Track:** Desired magnetic track of the aircraft while following an active flight plan or a Direct-To. Requires GPS signal.

**Distance to Next:** Distance in nautical miles from the aircraft current position to destination or next waypoint in flight plan. A GPS navigator with an active flight plan or Direct-To must be connected. Distance to destination (DDST) will be displayed with Aviation data protocol, or distance to next waypoint (DWPT) with NMEA 183 protocol.

**Time to Destin.:** Time from current position to destination, or next waypoint. GPS with an active flight plan or Direct-To must be present. With Aviation protocol in use, a flight plan will result in displaying of the total time to destination (TDEST), and Direct-To will result in time to next waypoint (TWPT). With NMEA protocol, time to next waypoint (TWPT) will be displayed.

**Supply Voltage:** Measured battery voltage. Can be used to monitor the aircraft electrical system condition; High voltage (>14.3V) may indicate an aircraft regulator failure. Low voltage (<12.5V) may indicate a battery, alternator, regulator, or other failure. May also be used to determine when to connect the optional backup battery, as well as to monitor its charge level.

**7. HEADING SELECT (Immediate)**: Only available while in **HDG** mode and valid GPS data is received. Serves as a digital "Heading Bug". The aircraft responds immediately to changes. Use ▲,▼,◄, ► to change heading from 0º to 359º. This value is not saved to permanent memory. Pressing the **NAV**, **HLD** or **ENTR** buttons will exit **Setup,** saving the value temporarily. Pressing the **SETUP** button selects the next menu item. It is convenient to remain in this selection while anticipating frequent changes in heading. The aircraft will always turn in the shortest direction towards the entered heading.

Following the selection of **HDG** mode, **HEADING SELECT** will be the selected menu item when entering **Setup**.

There are three ways to turn to a heading:

1) Select **HDG** mode, then select **Setup** and dial in a desired heading.
2) While in **HDG** mode, turn to the desired heading (◄ or ► to enter Suspended NAV). On reaching the desired heading, press the **NAV** button to hold this heading.
3) While in **LVL** mode, turn to the desired heading (◄ or ► to enter Suspended NAV). On reaching the desired heading, press the **NAV** button twice to select **HDG** mode.

**Example 1**: While on a 340º heading, the pilot is instructed to turn right, heading 030 by ATC. Use ◄, ► to select the second digit (10º increment) and press ▲ five times, resulting in 350º, 000º, 010º, 020º, then 030º. The aircraft begins to respond immediately commencing a turn to the right.

**Example 2**: While on a 340º heading, the pilot wishes to fly a 040º heading. The ◄, ► buttons are used to select the third digit (100º increment) then ▼ is pressed three times, resulting in 240º, 140º, then

040º. The aircraft turns left towards 240º (100º left turn) then turns right towards 140º (160º right turn) and 040º (060º right).

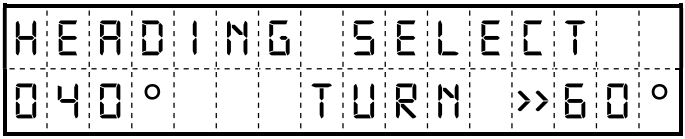


**Figure 18. Selecting a heading indicates direction and amount of turn.**

**8. ALTITUDE SELECT (Immediate) (VNAV Only):** Only available with **VNAV** models while holding altitude. Commands a target altitude to hold. The aircraft responds immediately while this value is changed, with vertical speed of 500fpm or less. Allows the pilot to make small altitude adjustments of no more than 500' from the current altitude. This target altitude value is set when engaging altitude hold.

Use ▲,▼,◄, ► to enter desired altitude with 1, 10, or 100 ft steps. This value is not saved to permanent memory. Pressing the **NAV**, **HLD** or **ENTR** buttons will exit **Setup,** saving the value temporarily. Pressing the **SETUP** button selects the next menu item.

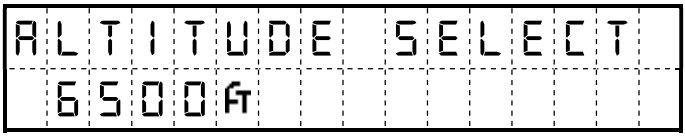


**Figure 19. Altitude select menu item.**

## *Configuration*

**NOTICE:** The PortaPilot must be restarted following any configuration changes for them to be applied.

To enter **Configuration**, Press and hold **SETUP** button until the **SETUP** indicator flashes rapidly (followed by steady illumination). Configuration parameters are normally modified on the ground once, or infrequently. Some parameters are editable, while others select or display information. Any menu item followed by an enter symbol (↵) gets saved to permanent memory when the **ENTR** button is pressed. The following are the parameters included in **Configuration**:

**1. GPS BAUD RATE ↵ :** 4,800 or 9,600 Baud may be selected. Must be the same as the GPS navigator being used. Factory default: 9,600. Use ▲,▼ to choose baud rate, followed by the **ENTR** button, to save the selection and exit **Configuration**.

**2. GPS PROTOCOL ↵ :** NMEA183 or Aviation protocol may be selected. Older and portable units usually use NMEA183, while newer units and panel units use Aviation protocol. Factory default: NMEA183. Use ▲,▼ to select protocol, followed by the **ENTR** button, to save the selection and exit **Configuration**.

**3. MAX CLIMB (FPM) ↵ (VNAV Only):** May be set to a value between 200 to 2,000fpm, in 50fpm steps. Editing this parameter overrides the default value loaded when **AIRCRAFT MODEL** is selected. This value is used to limit climb and descent rate entered by the pilot during **Suspended Altitude Hold** mode, and it must adhere to aircraft performance. Consult the aircraft POH for climb and descent at various pressures, altitudes, and temperatures. Use ▲,▼ to select the desired **MAX CLIMB** rate in fpm, followed by the **ENTR** button, to save the selection and exit **Configuration**. The maximum descent rate is set to twice the value of the **MAX CLIMB** rate. For instance, entering 750fpm Max Climb, results in maximum descent rate of 1,500fpm.

**4. SET CONTRAST (Immediate) ↵ :** Display contrast adjustment. Use ▲,▼ to set to a value that will yield the best contrast, followed by the **ENTR** button, to save the selection and exit **Configuration**.

**5. AIRCRAFT MODEL:** Select specific aircraft to load default parameters including **Roll Gain**, **Pitch Gain**, **MAX CLIMB**, **AILERONS TORQUE**, etc. If any of these parameters were previously modified, make sure to keep a record prior to using this operation. Use ▲,▼ to select model, followed by the **ENTR** button, to save the selection and exit **Configuration**.

**6. AILERONS TORQUE ↵ :** Maximum allowed rotation torque applied onto the yoke. Should be set in small steps and verified by making significant turns. Reduce this value if the magnetic coupler tends to disconnects during turns, keeping in mind that disconnection is normal in response to turbulence. The default value is loaded when selecting aircraft model. It is not typically necessary to adjust this value.

If this value is set too high, it will increase the likelihood of YC coupler disconnects. If set too low, this will result in lack of roll authority. Changing this value may also require adjustment to the **ROLL GAIN** value.

**7. ELEV TRIM LVL ↵ (VNAV Only):** Elevator trim indicator sensitivity adjustment. Changes force at which the trim indicators illuminate. The default value is loaded when selecting aircraft model. It is not typically necessary to adjust this value.

**8. ABOUT:** Displays information related to the PortaPilot, including serial number, H/W version, manufacturing date, S/W version, model, and installed features. Use ▲,▼ to scroll through entries.

## *Turning and Intercepting Considerations*

As no rudder control is applied by the PortaPilot, turns are uncoordinated, resulting in steeper bank angles. For instance, with a standard turn rate (3dps), and true airspeed (TAS) of 100KTS, a coordinated turn results in about 15º bank, while uncoordinated turn will result in nearly 25º bank.

A further consequence of uncoordinated steeper banks is altitude loss in the turn. The pilot may apply appropriate rudder pressure in the turn to coordinate it, which will result in a shallower bank angle and a reduced altitude loss.

With the **NAV** models of the PortaPilot, the pilot must use elevator pressure and trim and/or power to minimize altitude loss during a turn. While holding altitude with **VNAV** models, the PortaPilot adjust the nose pitch attitude which reduces altitude loss in a turn.

Intercepting an active course segment while following GPS navigator flight plan, the PortaPilot calculates heading by using ground speed, cross-track error, and other flight parameters. Beyond a calculated cross-track distance, the intercept angle is 45º. Closer to the desired course, the intercept angle diminishes asymptotically for smooth intercept. The cross-track error must be within 10NM to accomplish this.

**GPS Navigator Course Reversal**

While tracking a flight plan (**NAV** mode) it is sometimes required to perform course reversal (180º turn). When a course reversal is initiated using the attached GPS Navigator, the PortaPilot will respond by turning the aircraft in the direction resulting in the shortest turn. For instance, if the current ground track of the aircraft is 89º and the new desired course is 270º, it will execute a 179º turn to the left rather than 181º to the right. The pilot may control the turn direction by applying rudder in the desired direction just prior to activating the course reversal on the GPS Navigator. When making near 180º turns, there is an ambiguity where the aircraft turns in the opposite direction of the GPS navigator guidance due to minute differences in ground track caused by delays and algorithms.

# PortaPilot Components

The PortaPilot consists of five separate assemblies which are attached electrically and/or mechanically to each other. If planning to use the PortaPilot during flight, mount all its components on the ground prior to

takeoff, except for the Actuator Assembly. The PortaPilot should be powered up prior to takeoff.

**WARNING:** Before flight, the integrity of the mounted components and interconnects of the PortaPilot must be inspected. The PortaPilot is not hard wired and is temporarily installed on the aircraft. Due to this, it is vulnerable to disconnects, loose hardware, and loose or damaged cables. Prior to each flight the pilot must inspect and verify that all components and connections are firmly attached and working properly. The **AA** in particular should be carefully inspected for damage or loose components. Do not mount or use if any issues are found.

**WARNING:** Keep ferrous & magnetic objects, and sensitive electronics (such as pace makers) far away from the various Magnetic Couplers which contain powerful magnets. Keep magnets clear of debris.

## *Yoke Collar Clamp (YCC)*

The Yoke Collar Clamp (Figure 20) mounts to the aircraft frame near the instrument panel, providing a leverage point for the Actuator Assembly. YCC's are aircraft-specific. Electrical signals are connected to the Control Module via the included cable.

Protect while not in use by slightly loosening the two thumb screws and removing the Actuator Assembly. Avoid contact with the delicate gold-plated pins inside the YCC opening.

**WARNING:** Be sure to inspect the position of the spring plungers: gold slot head screws on the upper left and right sides of the YCC. If tightened too much, snapping in the Actuator Assembly will require excessive force and may become locked into place. These are set precisely from the factory and should not be adjusted.

**Figure** 20**. Yoke Collar Clamp (YCC) for Cessna 172.**

## *Actuator Assembly (AA)*

The **Actuator Assembly** contains one (NAV, Figure 21) or two (VNAV, Figure 9) servos which provide the steering input. The Actuator Assembly snaps into the Yoke Collar Clamp during flight and gets power and signal from the Control Module.

Only insert and remove the Actuator Assembly during flight. When removed, the PortaPilot does not affect the flight controls. Store it as far as practical from the aircraft magnetic compass to reduce errors.

Protect while not in use by avoiding contact with the gold-plated contact pads on the bottom. Keep far from objects which can snap together and shatter the installed magnets. Avoid touching or pulling on cables.

**Figure 21. NAV model Actuator Assembly, mid extension position.**

## *Control module (CM)*

The Control module contains a microprocessor which runs autopilot algorithms. Using the various on-board sensors, servo controllers, and GPS communication circuitry, it steers the aircraft with instruction from the User Interface. It has an integrated AHRS (attitude heading reference system), which incorporates 3-axis accelerometers, 3-axis gyroscopes, and a barometrically corrected pressure altimeter.

Since all environmental sensors are located inside the **Control** module, it is essential that it is attached firmly and at the correct orientation. Attach it to a stable location on the aircraft panel where it will not move or detach during flight. Touching it during flight, while it is in one of the active modes, will cause the aircraft to shudder, or enter an unusual attitude, requiring

quick release of the Actuator Assembly. Improper orientation will result in an error message: "CONTROL MODULE MOUNTING ERROR". Orientation should be within five degrees in the pitch and roll axis relative to flat and level tarmac. Mount the CM with the arrow pointing up and facing the pilot.

The CM receives its power from the aircraft cigarette-lighter port, or from an optional back up battery. Power is then distributed to the other modules, as well as to portable GPS if connected.

## *User interface (UI)*

**CAUTION**: The **UI** cable is subject to movement during flight, making it the most likely cable to disconnect, requiring a power cycle of the PortaPilot.

The User Interface module (Figure 10) comprises of an alphanumeric display, a Directional Pad (D-Pad), two buttons (three for VNAV model), and eight indicator lights. It connects to the Control Module and provides means for the pilot to control the PortaPilot operation, configure various parameters, and display data and status. Display and indicator light intensity is adjusted based on ambient light levels.

During normal operation the display is divided into three fields. The left filed displays **NAV** system data, and on the right is **ALT** system data. The center field is configurable. During **Setup** or **Configuration**, the display and buttons do not affect normal PortaPilot operation.

## *Yoke Clamp (YC)*

The PortaPilot Yoke Clamp (**YC**) conveys motion from the Actuator Assembly into the flight controls by using magnetic coupler(s) to attach to the Actuator Assembly Arm's coupler. It attaches onto the yoke via two thumb screws. The VNAV model has a dual magnet coupler, while the NAV model has one. The **YC** is not interchangeable between NAV (single magnet coupler) and VNAV (dual magnet coupler) models, and is also aircraft-specific.

**Alignment Procedure:** While flying straight and level, after selecting **LVL** mode an initial turn tendency is an indication that the Yoke Clamp is not properly aligned. The PortaPilot will gradually correct this error while remaining in this mode for a few minutes. Monitoring the Clamp Rotation value (center display field) will provide direction and amount of rotation required of the Yoke Clamp to alleviate this error. You must disengage the Actuator Assembly (retracted toward dash) prior to loosening and rotating the Yoke Clamp in small steps (2º-5º rotation). Repeating until the clamp rotation value settles below 15. Once aligned, mark the position of the Yoke Clamp index on the aircraft yoke for subsequent flights.

Turning error may also be caused by slack in the aileron's linkage, improper cable tension, loose yoke U-joint, or other rigging issues. **Proper rigging is essential whenever using any type of autopilot including the PortaPilot**. If significantly out of rig, even light turbulence can trigger wing shake oscillations.

Protect while not in use by slightly loosening the two thumb screws. When detached, stow as far as practical from the aircraft magnetic compass. Keep far from objects which can snap together and shatter the installed magnets.

**Figure 22. VNAV model Yoke Clamp (dual magnet coupler). Only compatible with VNAV Actuator Assembly**

# Attitude Reference

When the **STRT & LEVL** operation is executed (automatically during power up or manually), Roll & Pitch angles are set to zero. Perform the **STRT & LEVL** operation, on level ground, or in the air while flying straight and leveled. On the ground is typically adequate, as most tricycle gear aircraft's attitude is similar to cruising attitude. Cycling or powering up the PortaPilot while in a climb or descent will introduce a significant error.

## *Display Field Examples*

The PortaPilot display contents change depending on the mode, and GPS data availability.

**Examples:**

While both the **NAV** and **ALT** systems of the PortaPilot are in **CWS** mode, roll axis rate of turn (ROT), and altitude will be displayed.

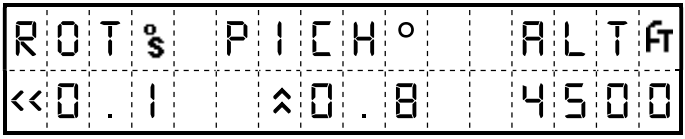


**Figure 23. NAV and ALT in CWS mode. Display indicating 4,500' altitude, 0.8º nose up attitude and 0.1dps left turn.**

In **HDG** mode, the left display alternates between the currently selected heading and the required turn to reach it. Figure 24 indicates a desired heading of 225º and a required turn of 20º to the right to reach it.

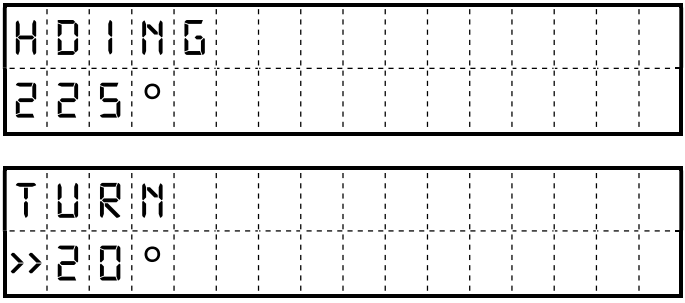


**Figure 24. Heading mode with 225º bug and current heading of 205º**

While tracking a GPS flight plan, the left field of the display provides an indication of cross track error "XTRK" in nautical miles, or feet if error is less than 0.09NM (Figure 25). The right field indicates altitude of 10,500ft.

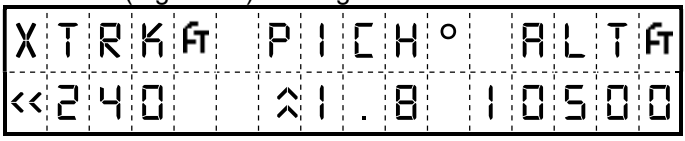


**Figure 25. GPS flight plan showing tracking error of 0.04NM (240 ft).**

While in any of the active **NAV** modes, pressing ► suspends the currently selected NAV mode, introducing a turn to the right, which results in the left field of the display (Figure 26) showing the commanded / target rate of turn (TROT). Press the button again to progressively change the ROT as desired. Both ◄ and ► buttons may be used to set a turn rate of 0 to 3dps to the left or right.

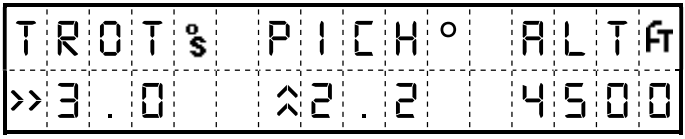


**Figure** 26**. Suspended NAV operation allows a diversion of heading, in this case a 3dps turn to the right.**

# Appendix

## *Appendix A: Instrument Redundancy*

Although not certified as such, in an emergency the PortaPilot may be used as a backup indicating instrument for Altimeter, Rate of Turn, and Vertical Speed. Other parameters available for display include battery voltage, Pitch Angle, and more. Use **Setup → CENTER DISPLAY** to select the desired parameter. For long flights, displaying voltage to monitor the aircraft electrical system can provide peace of mind.

## *Appendix B: Aircraft specific information*

Cessna 150/152, 172:
To use the PortaPilot, the aircraft must have Yoke Collar Support (also known as Cessna L/H Control Tube Support, or Yoke Collar). This is the pilot side Yoke Collar Support, through which the ¾" diameter control column is located. It includes two holes for gust lock onto which the compatible YCC is mounted:

C172YCCB is compatible with C172A through early C172L
C172YCCA is compatible with later C172L through 172S

Newer C172 such as more recent 172N and 172P, Q, R have a 28V electrical system, requiring an optional 28V to 14V converter, or use of the backup battery.

More aircraft are planned for future releases.

## *Appendix C: Optional Accessories*

**Backup Battery**: The optional backup battery may be connected to the PortaPilot in case of an aircraft electrical power failure, or any other case preventing aircraft power from powering the PortaPilot such as in 28V aircraft. It can power the PortaPilot for about two hours of continuous use while not providing additional power to GPS. While using a portable GPS navigator which is powered by the PortaPilot, expect about one hour of operation due to additional power draw.

The optional BB1 includes battery, cable, and power line charger. Only the approved BB1 battery should be used in order not to damage the PortaPilot or portable GPS navigator.

# *Appendix D: Connecting to a GPS Navigator*

Connecting a GPS Navigator requires wiring the RS-232 data out to the PortaPilot GPS port using a four conductor 2.5mm mini jack (included). If using a portable GPS navigator, it may be wired to provide fused aircraft power (14V DC). Ensure compatibility with your GPS to prevent damage. Cut and insulate the unused wire(s).

**Using Panel Mounted GPS Navigators**

With panel installed GPS Navigators, data lines must be brought to the panel in order to connect them to the PortaPilot. For instance, in the case of a GNS 430/530, GTN650/GTN750 and many other similar navigators, an aviation technician may connect one of the unused RS-232 Out lines to a two-position connector on the panel and configure it for sending Aviation data.

**Using Portable GPS Navigators**

Some older portable GPS Navigators use 4,800 baud and NMEA-183, while newer units also provide 9,600 baud. For instance, to configure a Garmin AERA 660 portable navigator, select **Tools→Setup→Interface**. In **Serial Port** choose **Serial Port 1** (assuming you are using port 1 connection), in **Serial Data Format** Select **NMEA Out 9,600 baud,** and in **NMEA Output Mode** select **Fast (1s updates)**.

**Table 4. PortaPilot 2.5mm GPS port connection to typical portable GPS navigator.**

| PortaPilot GPS port | GPS Navigator Connections |
|---|---|
| Pin 1 - Ground | Ground (Black) |
| Pin 2 - 14V Out | 14V In (Red) |
| Pin 3 - GPS Data In | Data out (TX1 or TX2) (white) |
| Pin 4 - Factory use | No connection allowed (green) |

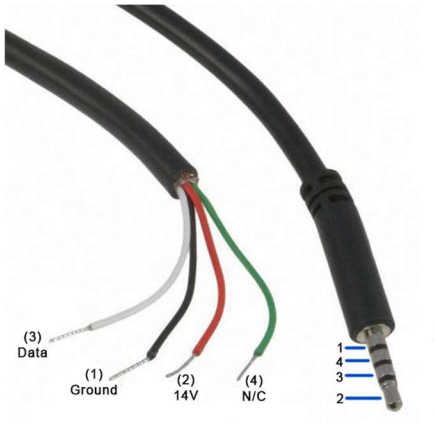


**Figure 27. Provided GPS cable with 2.5mm plug. Do not connect the N/C wire.**

# *Appendix E: Troubleshooting*

Do not press any buttons during PortaPilot power up sequence while it checks each of its systems and verifies proper operation. Initially all indicators are illuminated one at a time, followed by testing of each on-board function. If a failure is detected, the error description is indicated on the display and an indicator associated with the fault flashes. The following is a list of faults and their associated indicators:

**Table 5. Error codes**

| Flashing indicator | Failure |
|---|---|
| HDG | Error while reading the flash memory. [1] |
| NAV | Alphanumeric display |
| TRIM UP | Keyboard |
| TRIM DOWN | Gyroscopes |
| HLD | Accelerometers |
| GPS | Altimeter |
| SETUP | Temperature sensor |
| LVL | None recoverable flash memory failure. [2] |

[1] Flash memory error; flash memory loaded with defaults
[2] The flash memory is permanently damaged.

When a flash memory read error occurs, it is considered fatal and necessary to discontinue the use of the PortaPilot until repaired.

## *Appendix F: Warnings and error messages*

Several warnings and errors are displayed in the form of flashing indicators as well as text. These indications are not available while the PortaPilot is in **Setup** or **Configuration** mode (**SETUP** indicator illuminated).

1. "EXCESSIVE PITCH" or "EXCESSIVE ROLL": Flight envelope warning message, and flashing of the indicators occurs anytime the aircraft pitch and roll exceed 20º in pitch or 35º in roll
2. "CONTROL MODULE MOUNTING ERROR": Indicates faulty mounting of the Control Module. It is mounted at an angle exceeding the allowed range of 12º in the pitch and/or roll axes.
3. "NO ACTUATOR": Indicates that the Actuator Assembly is either not inserted, or a component such as the actuator cable is not making contact. The message remains until any button is pressed.
4. "SUPPLY VOLTAGE LOW" Indicates the battery voltage fell below 12.5V. This is an indication to the pilot that either there is poor connection of the power plug, or the aircraft battery is low, in which case you may wish to connect the optional backup buttery.
5. "FAIL GYRO COMMUNICATION" Indicates the built-n PortaPilot gyroscope failed.
6. "FAIL ACCELEROMETR COMMUNICATION" Indicates the built-in accelerometer failed.
7. "FAIL ALTIMETER COMMUNICATION" Indicates the built-in barometric altimeter failed.
8. "ROLL MOTOR OVER CURRENT": Indicates excessive aileron servo current is detected. If this persists longer than several seconds, the Actuator Assembly must be removed and repaired. If this message is intermittent, it could relate to temporary overload of the aileron servo due to abrupt condition such as sharp turn or turbulence.
9. "ELEVATOR MOTOR OVER CURRENT": Indicates excessive current is detected. If this persists longer than several seconds, the Actuator Assembly must be removed and repaired. If this message is intermittent, it could relate to temporary overload of the elevator actuator due to abrupt condition such as sharp turn or turbulence.
10. "! NO ROUTE !": Indicates no flight plan or direct-to are active in the GPS navigator while tracking a route or direct-to in NAV mode.
11. "! NO GPS !": Indicates no GPS signal received while attempting to select HDG or NAV modes.

12. "LOW SPEED ALERT": Indicates that GPS ground speed is over 10kt, and below 55% of cruise speed (aircraft speed at 65% power setting and 3,500' MSL altitude). All indicators will flash.
13. "ELEVTR EXTENSION OUT OF RANGE": Indicates that VNAV elevator actuator is at the limit of its range. To resolve this, terminate the hold (**HLD** extinguished) and move the elevator actuator to its active range using the ▲▼ button.
14. If an indicator on the **Control Module** is illuminated red for longer than ten seconds following power up, it is an indication the PortaPilot is failing and should not be used.

## *Appendix G: Revisions*

10/21 - Clarification of Indicated Airspeed, and engaging VNAV. Added power cycling note on configuration change.