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iLevil 3 AP Pilot's Guide

LEVIL AVIATION

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This is a controlled document; if any changes are made (even a single character) to any part of the document, it is considered an entirely different document. For this reason, a Revision Record page is provided, documenting every single change done to the document.

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AMENDMENT RECORD

This procedure is reviewed to ensure its continuing relevance to the systems and processes that it describes. A record of contextual additions or mission is given below:

Revision No.	Date	Responsible Person	Description of Change
1	08/12/2021	Ananda Leon	Initial release

Warranty

Levil Aviation warrants this product to the original purchaser to be free from defects in material and workmanship for a period of one year from the date of the original purchase. The following are not covered: software, damage resulting from accident, neglect, misuse, fire, or flood, improper voltage supply, or failure to follow operational guidelines supplied with this product. An extended warranty is available for purchase on our website.

Please register your product online at www.levilaviation.com

IN NO EVENT SHALL LEVIL AVIATION BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES, WHETHER RESULTING FROM THE USE, MISUSE, OR INABILITY TO USE THE PRODUCT OR FROM DEFECTS IN THE PRODUCT. SOME STATES DO NOT ALLOW THE EXCLUSION OF INCIDENTAL OR CONSEQUENTIAL DAMAGES, SO THE ABOVE LIMITATIONS MAY NOT APPLY TO YOU.

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1. Introduction

The ILEVIL 3 AP is an alternative to traditional autopilots that rely on heavy servos tied to the main controls. Instead, this revolutionary concept is designed to add flight comfort and safety by controlling small trim tabs to help the pilot maintain wings level, heading, and climb/descent to an altitude throughout the flight. This is all possible thanks to the integrated Autopilot controller, AD-AHRS, and PWM output.

The ILEVIL 3 AP is also a fully independent, all-in-one avionics device. Avionics include WAAS GPS, ADSB-in, Air Data (Altitude, Airspeed), AHRS (Attitude, Directional Gyro, Turn Coordination, rate of turn, VSI), and the ability to connect to other external hardware such as EIS systems. Once installed, the ILEVIL 3 AP connects via WiFi to a tablet inside the cockpit, and data can be displayed on multiple Apps thanks to its open protocol.

**Figure 1. ILEVIL 3 AP layout and features**

What makes the ILEVIL 3 AP special?
- Independent source of aviation-grade sensors, navigation, and ADS-B information that fits in the palm of your hand.
- An affordable and safe way to modernize your cockpit
- Able to drive small trim tabs for full AutoPilot capabilities without the need to install heavy servos.
- Wireless platform offering iOS/Android compatibility
- Multiple App compatibility. For a complete list of compatible apps, visit our website www.levilaviation.com
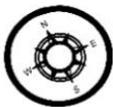
GPS   ADS-B IN   Wi - Fi   Air Data   AHRS   Data Recording

2. **Operating Limitations**

a) The ILEVIL 3 AP is not a required system and may not substitute for a certified aircraft system.
b) No operational credit may be taken for the installation of the ILEVIL 3 AP system.
c) No operational credit may be taken for such items as reduced approach speed and shorter landing distances.
d) The iLevil 3 AP can only report speeds higher than 30 kts and of up to 320 kts.
e) Although the ILEVIL 3 AP transmits AHRS Data, the data is not to be used as a substitute for the airplane's certified AHRS instrumentation. The AHRS supplied by the ILEVIL 3 AP is to be used only as supplemental information to the pilot.
f) Levil Aviation does not provide or endorse any carry-on device that displays the information sent by the ILEVIL 3 AP.
g) Ferrous Materials near the ILEVIL 3 AP may affect the compass reading.
h) When transporting or temporarily storing in an airplane or vehicle, the temperature range should be no less than 20 ° F (-12 ° C) and not more than 150 ° F (65 ° C)
i) Storing our device at temperatures higher than 170 ° F for extended periods (more than 2 hrs.) may cause damage to the battery and possible fire.
j) DO NOT disassemble, remodel, drop, or modify the ILEVIL 3 AP as this will invalidate the unit's warranty.
k) Do not use the ILEVIL 3 AP as an anti-collision system. Not all traffic is displayed using ADS-B in. In addition, any aircraft not currently ADS-B Out equipped will not be detectable by the ILEVIL 3 AP.

l) Levil Aviation does not provide a display for this unit. Any display the pilot chooses to integrate should comply with FAA certification requirements or qualify as a carry-on device. Under no circumstances should any display be placed in any way that it will obstruct the pilot's views of the aircraft flight instruments or the external view, which may be detrimental to the ability of the pilot to fight the aircraft.

m) Autopilot functions are designed for cruising speeds AND smooth air. Slow flight and approaches may exceed the speed limitations and affect the performance of your AP. Always turn OFF the autopilot during landings, take-off, slow flight maneuvers, or turbulent air.

n) Levil Aviation does not provide trim-tabs or servo components. Therefore, any trim-tab-servo solution the pilot chooses must be balanced and tested before activating the autopilot.

o) Before activating the Altitude Mode of the autopilot, the altimeter setting on the iLevil app MUST be set correctly.

3. Specifications

3.1 AHRS
- 360-degree pitch and bank operations
- GPS Independent Attitude
- 500°/sec max turn rates
- 6 G's max rating
- Output: Roll, pitch, magnetic heading, slip indicator, rate of turn, G meter, indicated airspeed (max 365kts), vertical speed (ft/min), Pressure altitude.

3.2 Internal Battery
- Operating Time after flight (if fully charged) <= 3.5 hrs.

3.3 WiFi
- Android and iOS compatible
- Support up to 5 devices connected simultaneously (UDP broadcast)
- Supports multiple protocols:
  - GDL90 (default)
  - iLevil Proprietary
  - NMEA

3.4 GPS
- Support WAAS
- Cold start < 60 sec. Typ. (open sky)
- 1 Hz output (5 Hz optional)

3.5 ADS-B in (978/1090 MHz)
- Receives regional and continental NEXRAD reports broadcasted by ADS-B towers within range: (Regional every 2.5 min. /Continental every 15 min.)
- Receives "GROUND TO AIR" traffic. (re-broadcast of traffic by ADS-B towers nearby)
- Receives "AIR TO AIR" traffic reports from other aircraft operating 978/1090 MHz transmitters: (978 MHz UAT ADS-B out and Mode-ES transponders with extended squitter)

3.6 Autopilot
- Heading Select, Heading Hold (1 deg resolution)
- Altitude Select, Altitude Hold (10 ft resolution)
- Straight and Level (roll and pitch)
- PWM output to RC servos (Pulses 1 to 2 ms every 20 ms)
- 14Hz refresh rate
- Navigation mode (flight tracking) available when connected to standard NMEA output $GPRMB waypoints via RS232 or WiFi
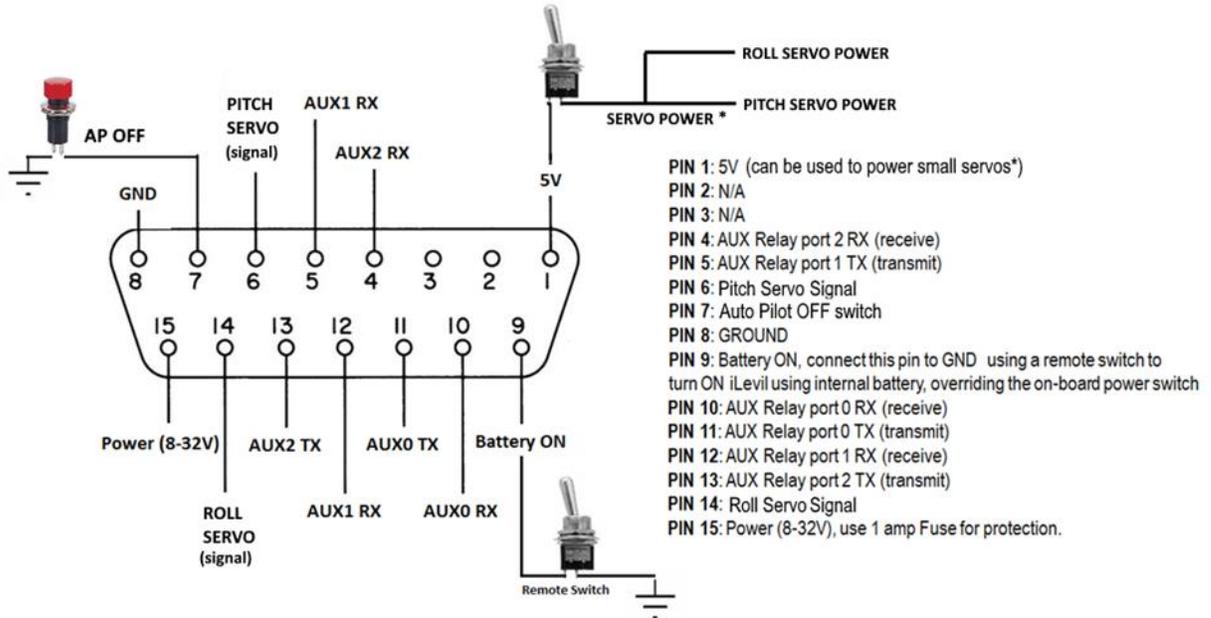
3.7 LED Indicators

LED	Status	Description
Power/GPS	Slow Blink Green:	Power ON/ No GPS Fix
	Solid Green:	Power ON/ GPS fix acquired
		Power Off
ADS-B	Slow Blink Green:	Traffic Received
	Solid Green:	Weather and traffic received
	Off:	No traffic or Weather received
Charging (with 5V USB power)	Solid Green:	Charging
	OFF (with power):	Battery 100% charged
	OFF (no power):	Not charging
Charging (with ship's power on Pin15)	No Charging Status available	

NOTE: iLevil3 has a charging temperature protection. If the battery is above 40°C (104°F) and the iLevil3 is connected to external power, the iLevil3 will continue to operate from external power, but the charging process will be disabled. In addition, the charging LED status will be set to OFF.

3.8 DB15 PIN Description

PIN 1: 5V (can be used to power small servos*)
PIN 2: N/A
PIN 3: N/A
PIN 4: AUX Relay port 2 RX (receive)
PIN 5: AUX Relay port 1 TX (transmit)
PIN 6: Pitch Servo Signal
PIN 7: Auto Pilot OFF switch
PIN 8: GROUND
PIN 9: Battery ON, connect this pin to GND using a remote switch to turn ON iLevil using internal battery, overriding the on-board power switch
PIN 10: AUX Relay port 0 RX (receive)
PIN 11: AUX Relay port 0 TX (transmit)
PIN 12: AUX Relay port 1 RX (receive)
PIN 13: AUX Relay port 2 TX (transmit)
PIN 14: Roll Servo Signal
PIN 15: Power (8-32V), use 1 amp Fuse for protection.

* Servos connected to Pin 1 can only draw 500mA combined. If servos require current > 250ma each, do not connect to Pin 1.

4. Installation

Please follow the iLevil 3 AP Pilot's Installation guide available on the website.

5. User Interface

5.1 Connecting to your favorite app
- Turn ON your aircraft's power or use the manual ON/OFF Switch to turn the ILEVIL 3 AP ON.
- Go to your tablet's "WiFi Settings."
- Connect to an SSID called iLevil-XXXX, where XXXX is the serial number for the device.
- Open your favorite app; most apps will connect automatically. Others require further setting configuration within the app.

NOTE:

- *Other apps may require subscriptions, and some offer more features than others.*
- *Some Apps may not support all the features of the ILEVIL 3 AP.*
- *You may choose to use one Navigation App or a combination of apps on multiple devices depending on your flying needs.*
- *For a complete list of compatible apps, go to www.levilaviation.com*

5.2 Levil Aviation App

Levil Aviation developed a free app that makes the use of the ILEVIL 3 AP easy and reliable for pilots. The Levil Aviation App is an application that displays the ILEVIL 3 AP data graphically and numerically and runs on iOS devices only (iPad /iPhone). This utility App is designed as a tool to help the pilot troubleshoot and calibrate the required systems and as an aid for instrumentation display. Pilots can download the app directly to their iOS devices from the App Store. Installers are recommended to use this app when installing the ILEVIL 3 AP to set the tilt and configure the autopilot settings.

5.3 Navigation and third-party Apps

The ILEVIL 3 AP is designed to be compatible with various Apps on both iOS and Android platforms by offering an open broadcast of data. Navigation Apps can use the GPS data and ADS-B data streamed by the iLevil AP to provide navigation functionalities on your tablets. However, there are no restrictions on how or what data they can display. Refer to a table of compatible Apps on Levil Aviation's website to determine the capability of each app available. Combining the level Aviation App and some Navigation Apps simultaneously when using an iPad as a display is also possible.

NOTE:

- *Other apps may require subscriptions, and some offer more features than others.*
- *Some Apps may not support all the features of the ILEVIL 3 AP.*
- *For a complete list of compatible apps, go to www.levilavaiation.com*

5.4 Autopilot Interface

The iLevil AP is meant to be used with the Levil Aviation App as the primary interface when using autopilot. You can download this app directly from the Apple Store free of charge.
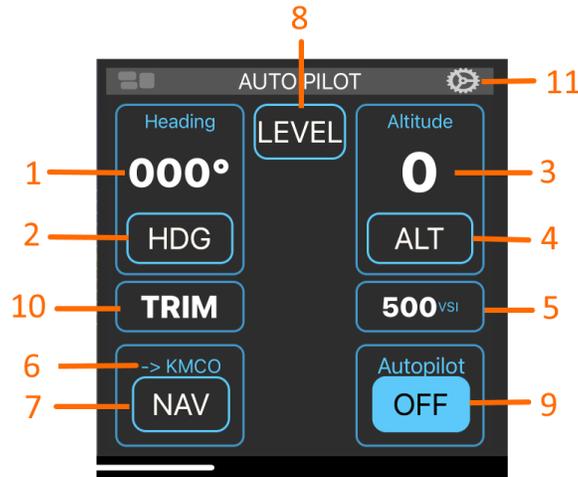
Once connected to the app, you can find the autopilot window under the main menu:

Inside the autopilot window, you'll find the following options:

1	**Heading Select**	Click to change the Heading Bug
2	**Heading Activate**	Click to turn ON Autopilot in Heading mode. The aircraft will hold the heading selected above. This button will illuminate BLUE when Active
3	**Altitude Select**	Click to change the Altitude Bug.
4	**Altitude Activate**	Click to turn ON Autopilot in Altitude mode. The aircraft will hold the altitude selected above. NOTE: Set your altimeter setting on the EFIS before activating! This button will illuminate BLUE when Active
5	**Vertical Speed Select**	Click to change the speed at which the AP will climb or descent to an altitude.
6	**Current Flight Plan**	Shows the current active Flight Plan being sent to the autopilot. This data comes from a navigation source such as iFly GPS or Garmin 430.
7	**NAV activate**	Click to turn ON Autopilot in NAV mode. The aircraft will follow the waypoints sent from your navigation source. This button will illuminate BLUE when Active
8	**Straight and Level Activate**	Click to turn ON autopilot in Heading and Altitude mode. The aircraft will hold its current heading and current altitude.
9	**Autopilot OFF**	Turns OFF autopilot functionalities. Servos will return to the previous trim position.
10	**Trim Select**	Opens the Trim Window
11	**Configuration**	Opens the autopilot settings window

Here are some examples of different autopilot states:

Heading Mode Active, 250 deg Heading:
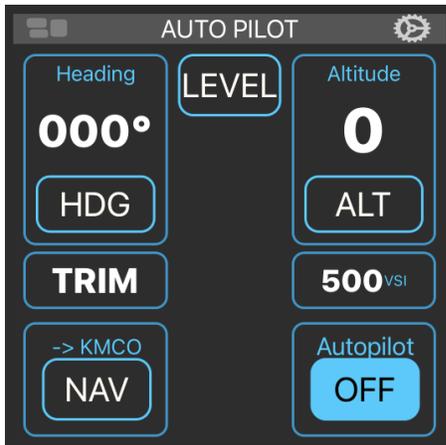

Heading Mode Active and Altitude mode Active:
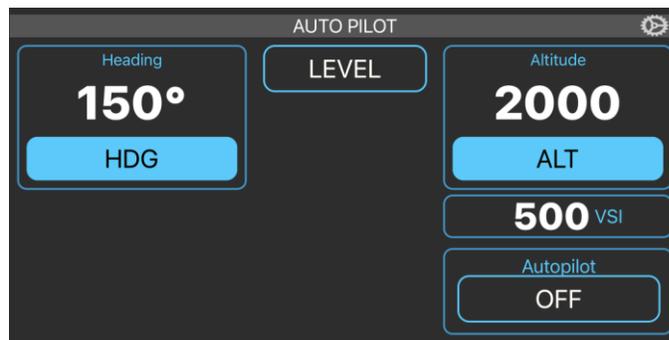
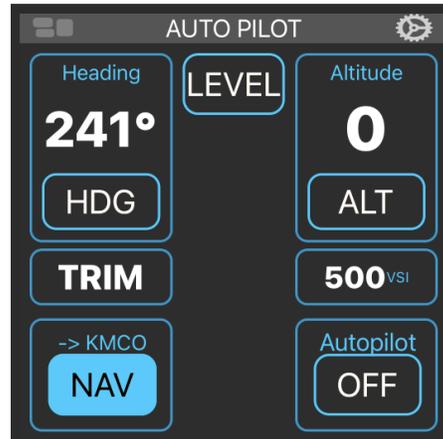**Heading Mode Active and Altitude Mode Active reflected on both screens:**
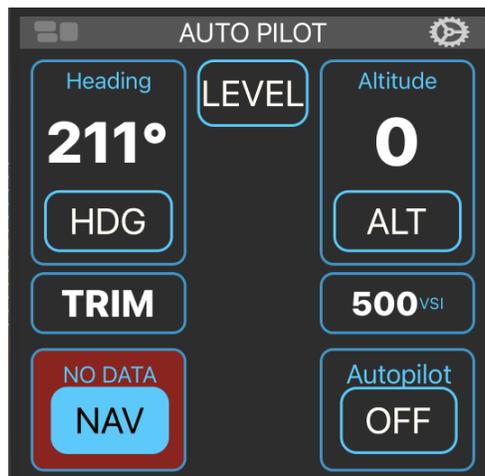

autopilot status

AutoPilot OFF, NAV mode available, but not active:
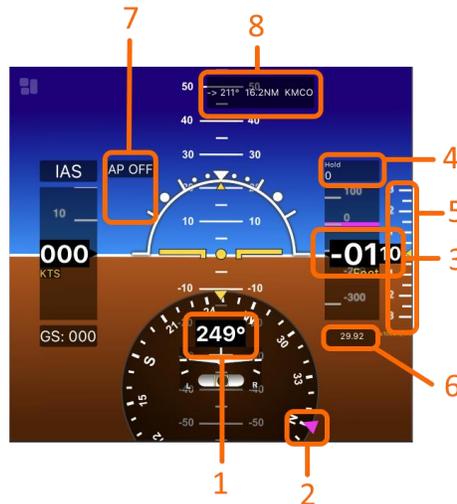

NAV Mode Active, destination MCO:

NAV Mode Active, but Navigation data is no longer available from the external device. The aircraft will continue flying its current course until further pilot input.

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It is also possible to control the autopilot directly from the EFIS view:

|		
1	**Heading Select**	Press and hold for three seconds to change the Heading Bug. You can activate and de-activate Heading mode using the on/off switch on the pop-up window
2	**Heading Bug**	This is the selected heading to be followed by the autopilot when Heading mode is activated. When AP Heading mode is Active, the Heading Bug will be green. Otherwise, it will be magenta.
3	**Altitude Select**	Press and hold for three seconds to change the desired altitude. Then, you can activate and de-activate Altitude mode using the on/off switch on the pop-up window. NOTE: Set your altimeter setting on the EFIS before activating!
4	**Desired Altitude**	This is the selected altitude to be followed by the autopilot when in Altitude mode is activated. When AP Altitude mode is activated, the Altitude Hold text will turn green; otherwise, when altitude is not active, the text will be magenta.
5	**Vertical Speed Select**	Press and hold for three seconds to change the Vertical Speed at which the autopilot will attempt to climb or descend to the hold altitude.
6	**Altimeter Setting**	When activating the Altitude mode, it is MANDATORY to update the Altimeter Setting so that the autopilot can follow the correct altitude.
7	**Autopilot Status**	This box will update the pilot about the status of the autopilot.
8	**Flight Plan**	When coupled with a NAV source such as iFlyGPS or Garmin 430, the current active flight plan will be displayed in this box. The first value contains the "Destination Heading," the second field is the "Distance To," and the third field is the "Destination ID."

6. Autopilot Configuration

Depending on specific aircraft aerodynamics, servos used, the trimtab size used, etc., the autopilot will behave differently and thus, needs to be appropriately configured before use. BEFORE activating and configuring the iLevil 3 AP for autopilot use, verify the following:

- iLevil 3 AP was installed following the guidelines established on the iLevil 3 AP Installation Manual available on the website.
- Trimtabs were balanced and will not create flutter
- Control surfaces (aileron and elevator) were balanced after installing servo and trim tabs
- Trimtab responsiveness was tested during flight not to overpower the pilots' inputs on the control surfaces. (see the video tutorial on how to test trim tab responsiveness on the website)
- iLevil Aviation App is installed on your Apple device.
- Setup the App to display GPS Heading: Menu -> Settings -> Heading Source -> GPS
- Setup the App to display Pressure Altitude: Menu->Settings-> Altitude Source-> Pressure.

6.1 Adjusting servo direction (Roll)

This configuration needs to be performed on the ground. First, verify your iPad/iPhone is connected to the iLevil 3 AP, and that autopilot is OFF.
Using the TRIM window, you can click on the TRIM LEFT and TRIM RIGHT to verify the following:
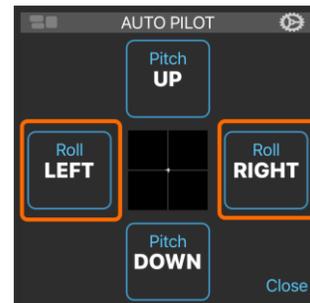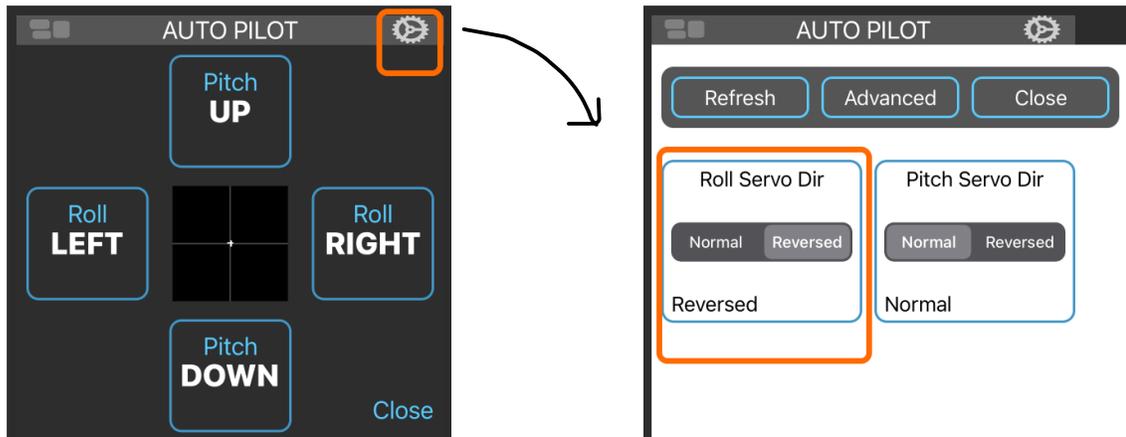

- If the servo is installed on the LEFT aileron, the trim-tab should move down when you trim LEFT. (If it doesn't, change the servo direction on the app)
- If the servo is installed on the LEFT aileron, when you trim RIGHT, the trim tab should move up
- If the servo is installed on the RIGHT aileron, the trim-tab should move up when you trim LEFT. (If it doesn't, change the servo direction on the app)
- If the servo is installed on the RIGHT aileron, when you trim RIGHT, the trim tab should move down

If the trimtab does not follow the rules above, go into Autopilot settings, and change the roll servo configuration to the opposite value. For example, if it says Normal, change to Reverse or vice versa:

Verify the trimtab follows the correct orientation when trimming left and right and proceed to the pitch servo configuration.

6.2 Adjusting servo direction (Pitch)

This configuration needs to be performed on the ground. First, verify your iPad/iPhone is connected to the iLevil 3 AP, and that autopilot is OFF. Using the TRIM window, you can click on the TRIM UP and TRIM DOWN to verify the following:
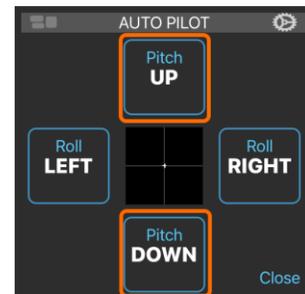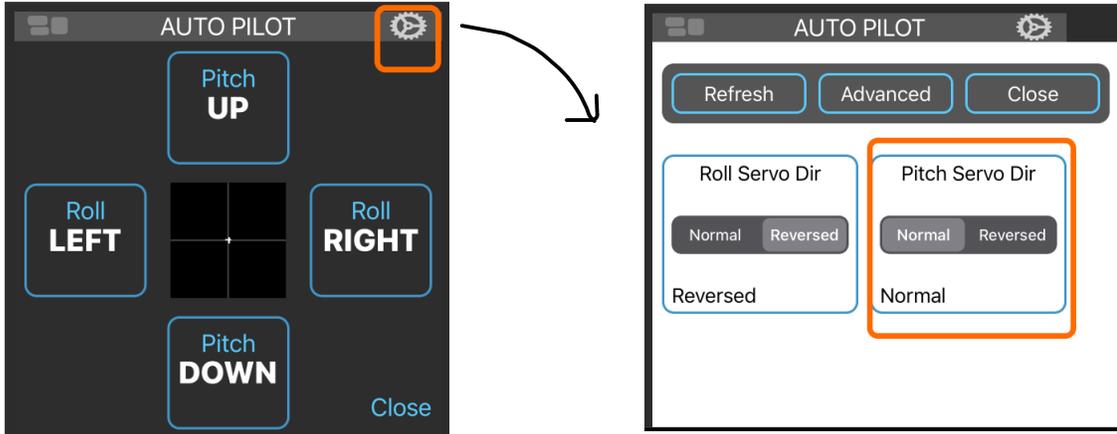

- o When you trim UP, your trim-tab should move down. (If it doesn't, change the servo direction on the app)
- o When you trim DOWN, your trim-tab should move up

If the trimtab does not follow the rules above, go into Autopilot settings, and change the pitch servo configuration to the opposite value. For example, if it says Normal, change to Reverse or vice versa:

Verify the trimtab follows the correct orientation when trimming up and down and proceed to the pitch servo configuration.

NOTE
- iLevil AP is not designed for V-tail aircraft
- For Canard type aircraft, the pitch direction is reversed

6.3 WING LEVELER Test flight

Once the servo directions are set correctly, you are ready for the first test flight. First, we will set up the autopilot as a "WING LEVELER" to better fine-tune the responsiveness of the trim-tabs. For this, the HEADING, ALTITUDE, and AIRSPEED hold functions will be disabled to test the wing leveling capabilities.

IMPORTANT: Some of the tasks require a co-pilot! We highly advise finding a person to accompany you on your test flights to help you configure the settings while the other person has the controls.

1. On the ground, configure the Advanced parameters as follow:
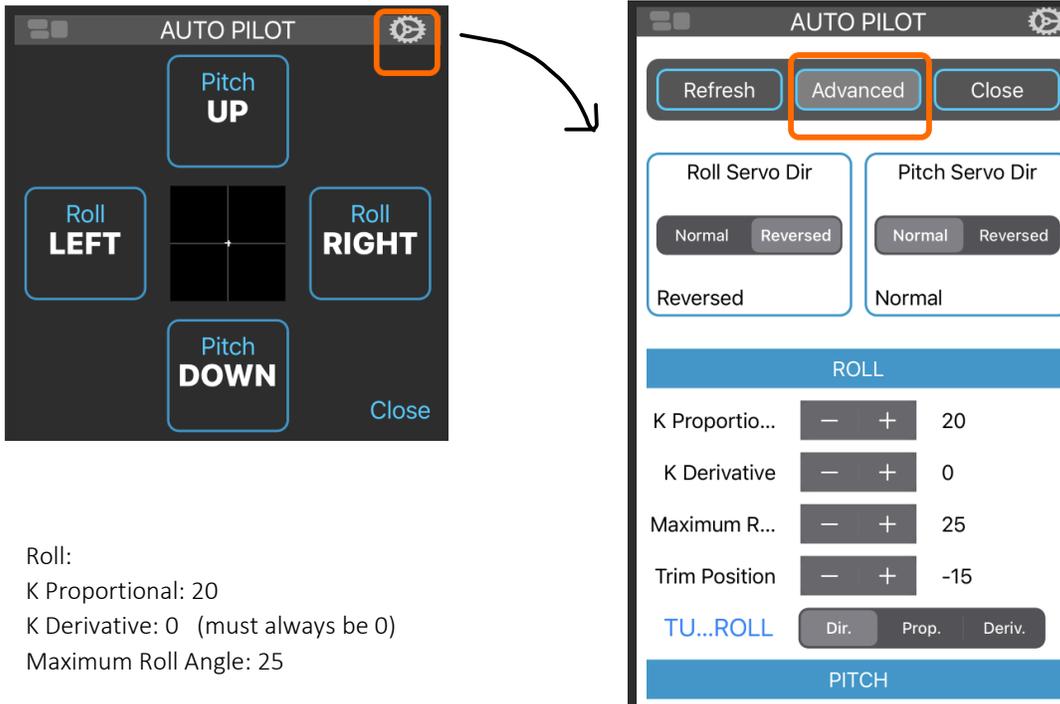
Roll:
K Proportional: 20
K Derivative: 0   (must always be 0)
Maximum Roll Angle: 25

Pitch:
K Proportional: 20
K Derivative: 0   (must always be 0)
Maximum Pitch Angle: 15
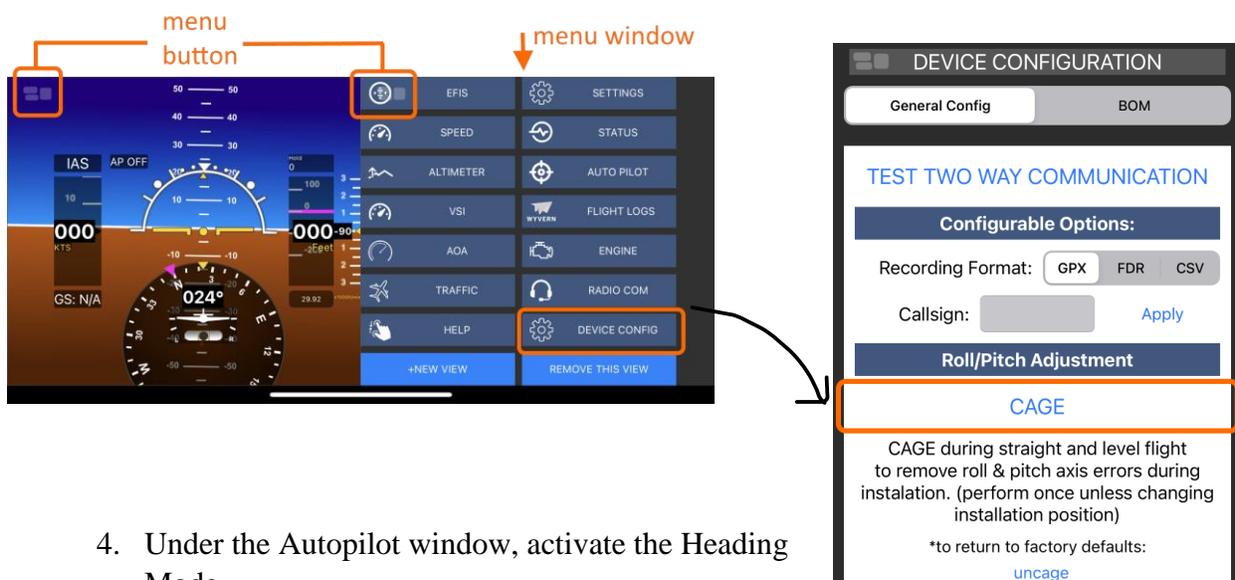
Heading
K Proportional: 0   (Heading track functionality disabled when 0)
K Derivative: 0   (must always be 0)
K Integral: 0

Altitude
K Proportional: 0   (Altitude hold functionality disabled when 0)
K Derivative: 0   (must always be 0)
K Integral: 0

Airspeed:
K Proportional: 0   (airspeed track functionality disabled when 0)
K Derivative: 0   (must always be 0)
K Integral: 0

2. Once in the air, Trim the aircraft for straight and level flight as you normally do
3. During straight and level flight, go to Device Configuration and CAGE the horizon to offset any minimal installation errors. After caging, the horizon should be close to pitch zero and roll zero:

4. Under the Autopilot window, activate the Heading Mode
5. Apply a force to the left or right on the yoke and verify the autopilot can return to level position comfortably and without oscillating. You can increase the **K Proportional** value for the **roll** to increase the responsiveness of the autopilot. Never to exceed a value that promotes oscillations (rocking of the wings). You should feel the aircraft return to roll level within 2-3 seconds for a roll deflection of 30 deg
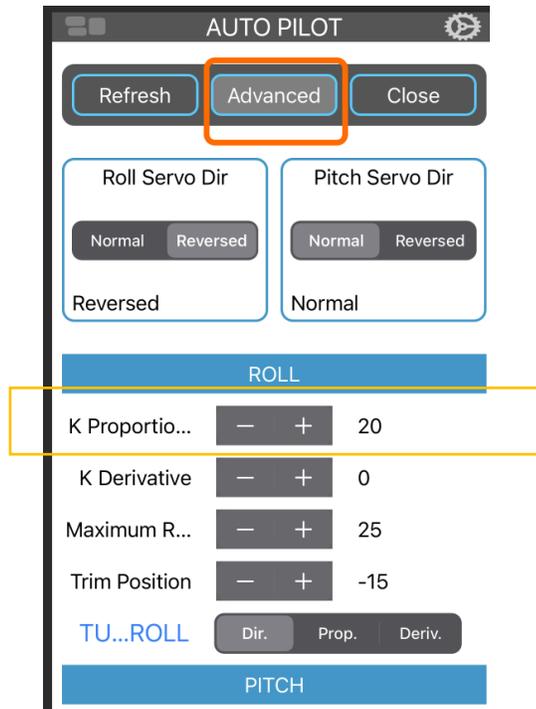
6. Once satisfied, proceed to repeat the same steps for pitch. Go back to the Autopilot window. Activate the Altitude Mode.
7. Apply a force up or down on the yoke and verify the autopilot can return to level position without oscillating in the pitch axis. You can increase the **K Proportional value for the pitch** to increase the responsiveness of the autopilot. Never to exceed a value that promotes oscillations (rocking back and forth)
8. Turn Autopilot off

6.4 Heading Track Test
Once you are satisfied with the responsiveness of the autopilot, you can enable the Heading Mode by increasing the K Proportional. As a rule of thumb, the **Heading K proportional** will be similar or higher than the **Roll K proportional**

1. Copy the same Roll parameters obtained on your previous Wing Leveler test flight to the Heading section under Advanced parameters:

Roll

K Proportional: 60 (obtained during wing leveler flight, for example)

K Derivative: 0   (must always be 0)

Heading

K Proportional: 60
K Derivative: 0   (must always be 0)
K Integral: 0

2. Select a desired Heading on the autopilot window
3. Activate Heading mode on the autopilot window. The aircraft should go to the desired heading and hold it. You can modify the K proportional of the heading to increase or reduce responsiveness accordingly.
4. Increase **Heading 'K Integral'** to get better heading accuracy. You can start with a value of 50. This constant takes time to calculate the error, therefore, allow few minutes to evaluate.

6.5 Altitude hold Test

You can enable the Altitude Mode by increasing the K Proportional. As a rule of thumb, the K proportional for the altitude will be similar to the Pitch K proportional

5. Copy the same Pitch parameters obtained on your previous Wing Leveler test flight to the Altitude section under Advanced parameters:

Pitch

K Proportional: 45 (obtained during wing leveler flight, for example)
K Derivative: 0   (must always be 0)

Altitude

K Proportional: 45
K Derivative: 0   (must always be 0)
K Integral: 0

6. Update the altimeter setting on your EFIS window!
7. Select a desired Altitude on the autopilot window. Mostly an altitude within 700 ft for testing purposes
8. Select a desired vertical speed

9. Activate Altitude mode on the autopilot window. The aircraft should climb or descend to the desired altitude and hold it. You can modify the K proportional of the altitude to increase or reduce responsiveness accordingly.
10. Increase **Altitude 'K Integral'** to get better Altitude accuracy. You can start with a value of 50. This constant takes time to calculate the error, therefore, allow few minutes to evaluate
11. Your autopilot is ready for use at this point.

7. **Magnetic Heading vs. GPS Track**

There are two ways to obtain heading information from the ILEVIL 3 AP. Depending on the navigation App of choice, you may choose between the following:

- True-Track: Heading information based on GPS track. This is the heading used for autopilot track; thus, we recommend using this one.
- Magnetic Heading: Heading information determined by a combination of a 3-axis magnetometer and gyros that form part of the internal AHRS inside the ILEVIL 3 AP.

7.1 When using Magnetic Heading, it is crucial to be aware of the following:

- Magnetic fields caused by other things, such as Magnetic Compasses, may affect the AHRS heading.
- Verify your magnetic heading after following alignment and installation procedures: using the AHRS Utility App → options → Heading → Use magnetic
- In case of a magnetic deviation, the internal AHRS will slowly learn your aircraft configuration during the flight to compensate. This learning process requires the aircraft to turn both clockwise and counter-clockwise for at least 40 seconds.
- After turning, or at the end of your flight, verify the magnetic heading again using the AHRS Utility App. If the AHRS was able to compensate for errors successfully, you might store this data inside the ILEVIL 3 AP, and it will use this new configuration on the next power cycle: Using the AHRS Utility → Device Config → Enable Configuration → Save Mag Data
- ERASE Magnetic data using AHRS Utility before moving the ILEVIL 3 AP to a different aircraft or environment.

8. Data Recording

The ILEVIL 3 AP will automatically begin recording once the unit is powered on and has acquired a GPS fix.

8.1 Save files

- The filename will be saved as follows iLevilxxxx-yyyymmddThhmmss
- The ILEVIL 3 AP will have three file formats in which to choose from to record (.gpx, .csv, .fdr)
    - .gps – Google Earth, CloudAhoy, etc.
    - .fdr – Xplane flight simulator.
    - .csv Microsoft Excel (ASCII file)
- Data retrieval may be performed wirelessly using the app under the Flightlog's window
    -
- .csv (comma separated values) will be the default format from the factory and can be changed before flying using the Levil Aviation App.

8.2 How to change the recording format

- Open the Levil Aviation App
- Tap on any of the menu buttons on the top left
- Select the Device config option
- If prompted, enter the 4 digit serial number (available in the network name)
- Under General configuration, find the recording option
- Select desired extension and click apply
- Reset power to your iLevil 3 AP

8.3 How to change Callsign

- Open Levil Aviation App
- Tap on any of the menu buttons on the top left
- Select the Device config option
- If prompted, enter the 4 digit serial number (available in the network name)
- Scroll down to find Callsign
- Tap and type the desired Callsign
- Press Apply

9. Helpful Tips

- If you encounter WiFi connection problems, try resetting the device's WiFi (disable/enable)
- If using Apple devices, you may use our free Levil Aviation App to see battery percent, GPS signal power, ADS-B Diagnostic, etc.
- In most locations, it is not possible to receive ADS-B information from ground towers unless you are airborne (typically above 2000 feet) with a line of sight to the tower
- The Internal AHRS has a max rate of a turn of 300°/sec. Most likely, you will exceed this limit (or "tumble" it) when playing with the ILEVIL 3 AP in your hands. If this is the case, and the AHRS did not recover, you might "tumble" it again and set it on a level surface. It will recover within 4 secs.