AUTOPILOT CONTROLLER

INSTALLATION AND PILOT'S GUIDE

Revision table

Date	Revision	Comments	Section
March 3, 2022	**1.0**	First Revision	

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. Extended warranty is available for purchase on our website Please register your product online at: http://aviation.levil.com

IN NO EVENT, SHALL LEVIL AVIATION BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES, WHETHER RESULTING FROM THE USE, MIUSE 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.

1.0 INTRODUCTION

The Levil Auto Pilot Controller contains a small LCD and a knob to provide a panel mounted interface to the iLevil AP (sold separately). The AP Controller uses RS-232 communication to send and receive commands to/from the iLevil AP such as Altimeter Setting input, Heading Hold, Desired Altitude, and all the configurations required for the iLevil AutoPilot
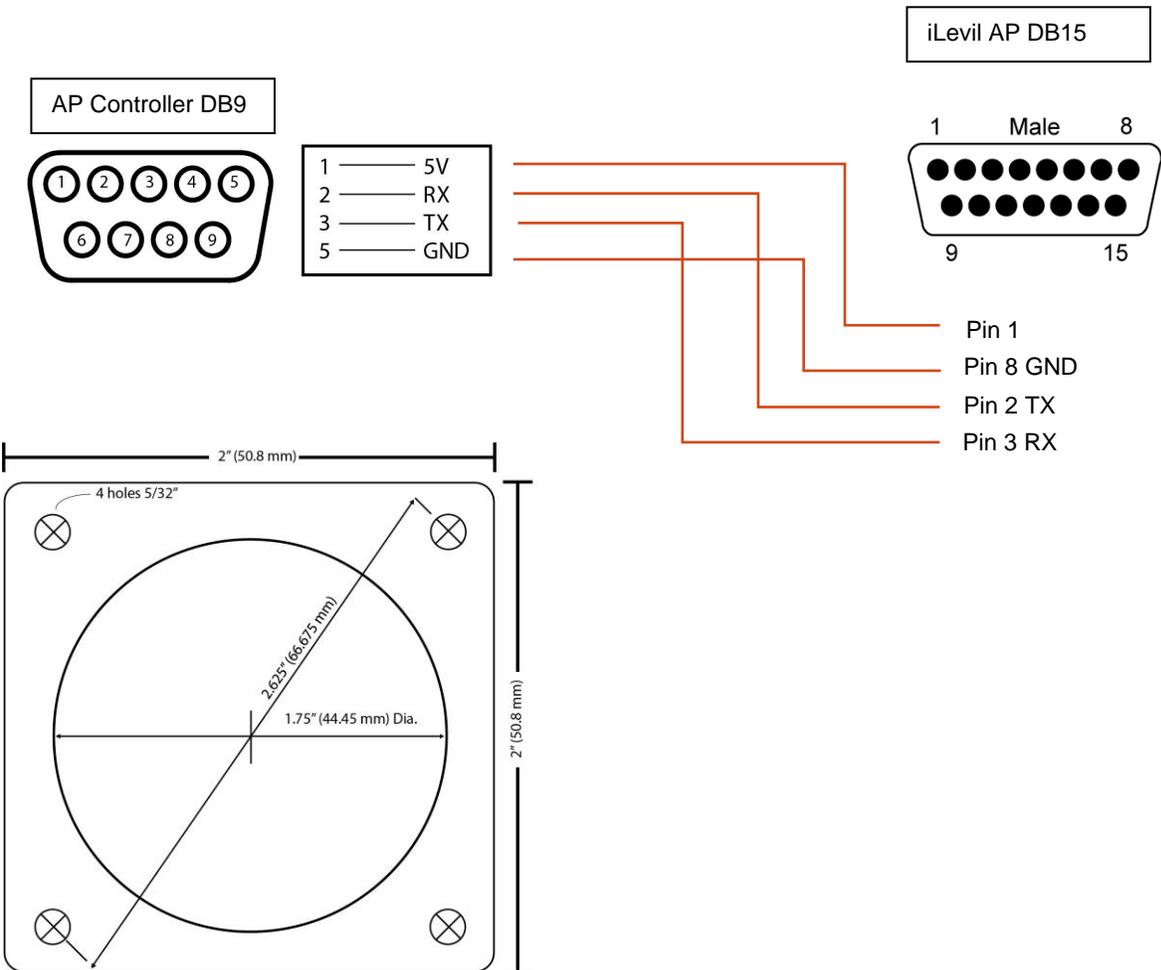
2.0 COMPLIANCE AND USE

ⓘ *The AP Controller series is for use in Experimental and Light Sport Aviation only*.

You may only install the Beacon on aircraft with *Experimental Airworthiness Certificates*. For LSA owners, the installation must be performed in accordance with an applicable consensus standard (as an alteration) and authorized by the aircraft's manufacturer.
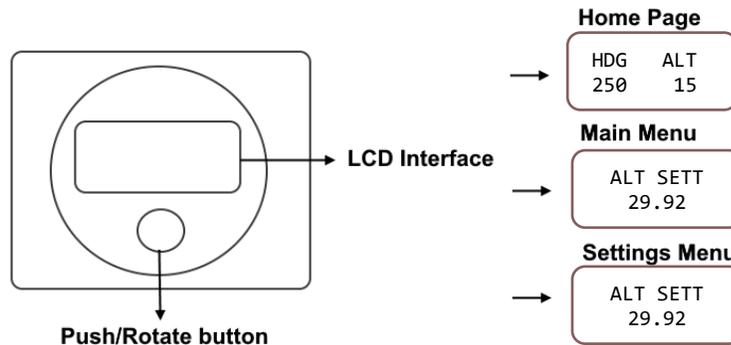
3.0 TECHNICAL SPECIFICATIONS

Specification	Description
Power	5V
Serial Communication	RS-232, 230400 baud rate
Temperature Range	-30 C to +70 C
Weight	4oz

4.0 INSTALLATION

5.0 LCD NAVIGATION

The LCD interface has one button (push and rotate) and has three different modes:

Home Page
```
HDG    ALT
250    15
```

LCD Interface

Main Menu
```
ALT SETT
  29.92
```

Settings Menu
```
ALT SETT
  29.92
```

Push/Rotate button

On power ON, the LCD interface will display the company name "LEVIL AVIATION", firmware and serial number, followed by a prompt to enter the altimeter setting. This is important as it configures the barometric pressure internal in the iLevil AP. After this, the AP will immediately go to the Home Page, unless no data is received, in which case it will say "NO DATA". Once in Home page, navigate between the screen modes using the button as follows:

Home Page -> PUSH and RELEASE to change between AP modes

Home Page -> ROTATE button to set a heading or Altitude value to follow

Home Page -> PUSH and ROTATE button to enter **Main Menu**

Main Menu -> Rotate the button to go through the *Menu Items*

Main Menu -> PUSH and RELEASE to enter a *Menu Items*

Main Menu -> Scroll down to "EXIT" to EXIT the **Main Menu**

Main Menu -> Rotate within the menu to access the **Settings Menu**

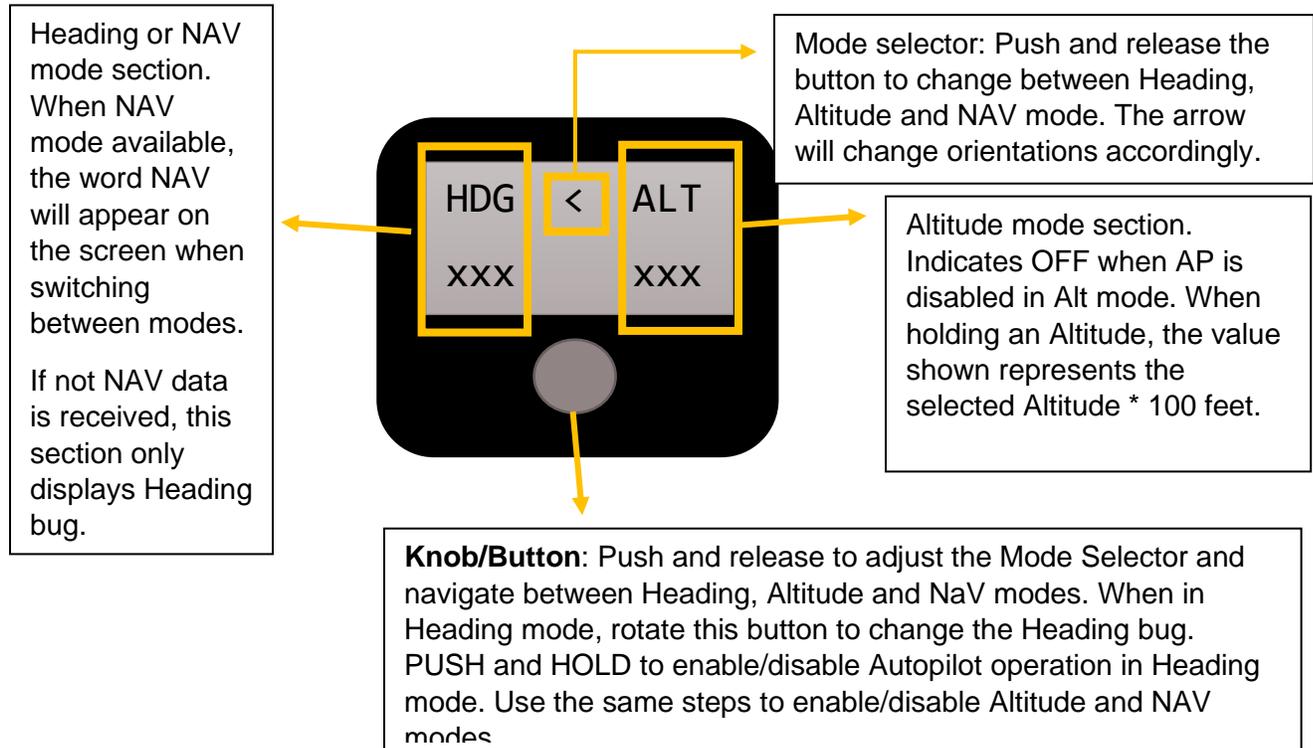**Settings Menu** -> Rotate the button to go through the *Menu Items*

Settings Menu -> Push and RELEASE to enter a *Menu Item*

Settings Menu -> Scroll down to "EXIT" to EXIT the **Settings Menu**

Menu Items -> Rotate the button to adjust settings, PUSH and RELEASE button to go to next character or exit

6.0 HOME PAGE

When in default screen or Home page, the AP controller displays the current state for Heading and Altitude and NAV (if available). If the AP is disabled for a certain mode, it will say "OFF", otherwise it will display the current value selected which the iLevil AP should follow. The arrow in the middle is the **Mode Selector.** Use the mode selector to control the autopilot accordingly:

Heading or NAV mode section. When NAV mode available, the word NAV will appear on the screen when switching between modes.

If not NAV data is received, this section only displays Heading bug.

Mode selector: Push and release the button to change between Heading, Altitude and NAV mode. The arrow will change orientations accordingly.

HDG < ALT

xxx   xxx

Altitude mode section. Indicates OFF when AP is disabled in Alt mode. When holding an Altitude, the value shown represents the selected Altitude * 100 feet.

Knob/Button: Push and release to adjust the Mode Selector and navigate between Heading, Altitude and NaV modes. When in Heading mode, rotate this button to change the Heading bug. PUSH and HOLD to enable/disable Autopilot operation in Heading mode. Use the same steps to enable/disable Altitude and NAV modes

6.1 Heading Mode:

When the Mode Selector is pointing at HDG, the user can adjust the heading bug (even if HDG follow is disabled. Rotate the Knob to select a desired heading. If the HDG is enabled, the Autopilot will engage to this new desired heading after 2 seconds. If HDG is disabled, the value will say "OFF", however, rotating the knob will allow the user to pre-select a heading bug. Once the desired heading is selected, PRESS and HOLD the button to enable heading following. To turn OFF Heading following, PRESS and HOLD the button until it says "OFF".

6.2 Altitude Mode:

When the selector is pointing at ALT, the user can adjust the altitude bug. Rotate the knob to pre-select al altitude when ALT mode is not engaged. If ALT mode is engaged, rotate

the knob to climb/descend to a new Altitude. The Autopilot will engage this new command after 2 seconds of no registered movement on the knob. To Enable/disable Altitude Mode PRESS and HOLD the knob until "ON" or "OFF" is registered on the screen accordingly.

6.3 NAV mode:

When the iLevil AP is receiving NAV data (NMEA or Aviation data) from an external navigation source, it will alert the AP controller and a new option will appear on the HOME PAGE. When pressing the button to navigate between modes, the NAV mode will be visible.

If NAV mode is disabled (i.e flight plan not activated) the NAV mode will indicate "OFF". On the contrary, if the iLevil AP is following a flight plan, the NAV mode will alternate between the name of the destination waypoint (ie KSFB) and the distance in Nautical Miles to that waypoint. The screen will flash between these two values. In order to activate flight following on the Autopilot, PRESS and HOLD the button until "ON" is seen on the screen. To disable NAV mode, PRESS and HOLD the button, or to change to HDG mode, change the mode selector to HDG mode and then PRESS and HOLD the button.

- If the autopilot was in NAV mode, and the Navigation data was cut off, the autopilot will remain engaged to the last bearing sent by the flight plan.

7.0 MAIN MENU

To enter the Main menu PRESS and ROTATE the knob. The following menu items will be available as you keep rotating the knob:

- **Altimeter setting**: Needs to be adjusted for the autopilot to properly maintain the correct altitude.
- **VSI**: Allows to adjust the vertical speed that the autopilot will use to climb to or descend to the desired altitude.
- **Roll Trim**: Allows the pilot to adjust the Neutral position of the roll servo. This option will only be available when HDG mode is not engaged.
- **Pitch Trim**: Allows the pilot to adjust the Neutral position of the pitch servo. This option will only be available when ALT mode is not engaged.
- **CAGE**: Use this option once after initial installation to offset any errors in pitch and roll. To use this command, fly straight and level, with the aircraft trimmed to neutral position and use the Cage option. The AP controller will send the command to the iLevil AP to cage the horizon. You might see the horizon adjust to roll = 0 deg and pitch = 0 deg when connected to an iPad/iPhone.
- **Settings Menu**: Contains a sub-menu with the commands necessary to configure AP settings such as servo direction, K values etc.
- **EXIT**: Exit to Home page.

8.0 SETTINGS MENU

Following menu items will be available as you keep rotating the knob when inside the settings menu:

- **K Proportional Roll**: Amplification value that determines how much input the roll servo will provide to the tab to maintain
- **K Proportional Pitch:** Amplification value that determines how much input the pitch servo will provide to the tab
- **Roll Angle:** Maximum roll angle allowed when making a turn to reach a heading, or used by the safety envelop protection feature to keep aircraft within certain attitude boundaries.
- **Pitch Angle:** Maximum pitch angle allowed when making climbing or descending to an altitude, or used by the safety envelop protection feature to keep aircraft within certain attitude boundaries.
- **K Proportional Heading**: Amplification value that determines how much input the autopilot will provide to reach a heading
- **K Integral Heading**: Amplification value that fine tunes the heading following, accounting for wind direction and other measures over a period of time. Adjusting this value will not have an immediate effect or response on the autopilot.
- **K Proportional Altitude**: Amplification value that determines how much input the autopilot will provide to reach an altitude
- **K Integral Altitude**: Amplification value that fine tunes the altitude following, accounting for trim position and other measures over a period of time. Adjusting this value will not have an immediate effect or response on the autopilot.
- **Roll Servo Direction**: Orientation of the servo to indicate LEFT / RIGHT turn direction
- **Pitch Servo Direction**: Orientation of the servo to indicate UP/DOWN direction

8.0 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)

8.1 Adjusting servo direction (Roll)

This configuration needs to be performed on the ground. First, verify autopilot is OFF.
- Go to Main Menu by pressing and rotating the button simultaneously.
- Once in Main menu, rotate the button until you see "TRIM ROLL" on the Screen and press the button to confirm
- Using the button rotate to TRIM LEFT and TRIM RIGHT to verify the following:

  o 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, explained below)
  o If the servo is installed on the LEFT aileron, when you trim RIGHT, the trim tab should move up
  o 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, explained below)
  o If the servo is installed on the RIGHT aileron, when you trim RIGHT, the trim tab should move down

Wrong Servo Direction? If the trimtab does not follow the rules above, you can go to Main Menu -> Settings Menu -> Roll Servo Dir 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.

8.2 Adjusting servo direction (Pitch)

This configuration needs to be performed on the ground. First, verify autopilot is OFF.
- Go to Main Menu by pressing and rotating the button simultaneously.
- Once in Main menu, rotate the button until you see "TRIM PITCH" on the Screen and press the button to confirm
- Using the button rotate to TRIM UP (rotate counter clockwise) or DOWN (rotate clockwise) 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

Wrong Servo Direction? If the trimtab does not follow the rules above, you can go to Main Menu -> Settings Menu -> Pitch Servo Dir 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.

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

8.3 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
Maximum Roll Angle: 25

Pitch:
K Proportional: 20
Maximum Pitch Angle: 15

Heading - DISABLED
K Proportional: 0
K Integral: 0

Altitude - DISABLED
K Proportional: 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 Main Menu -> CAGE the horizon to offset any minimal installation errors. After caging, the horizon should be close to pitch zero and roll zero:

4. Now turn ON Autopilot in Heading Mode by PRESSING and HOLDING the button when in Heading mode until it says "ON". Since the K values for Heading are disabled, the aircraft will not attempt to follow the heading set, but it will try to keep the aircraft from rolling.

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 **<u>K Proportional</u>** 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. Activate the Altitude mode by PRESSING and HOLDING the button when in Altitude mode until it says "ON". Since the K values for Altitude are disabled, the aircraft will not attempt to climb or descend, but it will try to keep the attitude at pitch = 0.

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 before the next step

8.4 Heading Track Test

Once you are satisfied with the responsiveness of the autopilot, you can enable the Heading Mode by increasing the **K Proportional** of the heading. 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)

    Heading

    K Proportional: 60
    K Integral: 60

2. Select a desired Heading on the autopilot window

3. Activate Heading mode by PRESSING and HOLDING the button when in Heading mode until it says "ON". 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 over time. You can start with a value of 50. This constant takes time to calculate the error, therefore, allow few minutes to evaluate.

8.5 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)

   Altitude

   K Proportional: 45
   K Integral: 0

6. Update the altimeter setting by going to Main Menu - > Alt Setting ! Otherwise the AP may climb or descend to an altitude different from that of your reference altimeter.
7. Select a desired vertical speed on the Main Menu as well.
8. Exit to the main screen and pre-select a desired Altitude by rotating the knob. Mostly an altitude within 700 ft for testing purposes
9. Activate Altitude mode by PRESSING and HOLDING the button when in Altitude mode until it says "ON". 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.