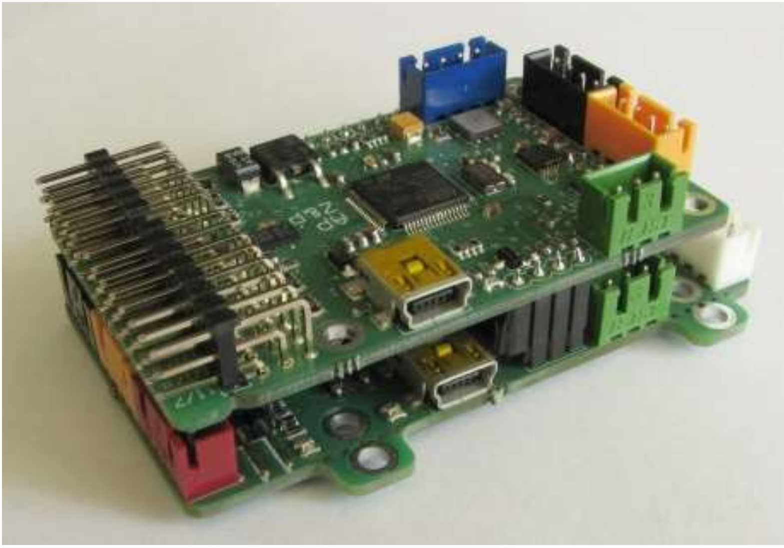
Electrical connection

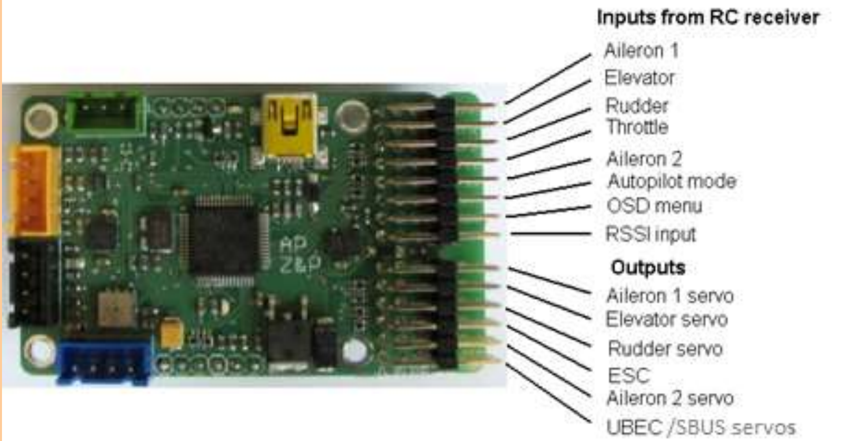
Autopilot works exclusively in combination with the OSD. All electrical connections between the OSD and autopilot PCBs are made through a dedicated connector on both PCBs. When purchasing a set, the two units are electrically and mechanically connected to each other.



Autopilot can be connected to a remote control in two ways, depending on the characteristics of the receiver and the autopilot settings.

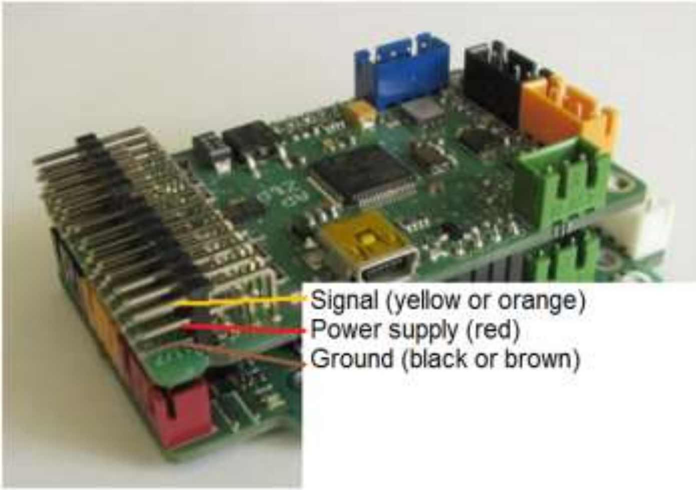
Parallel connection of the receiver

Remote control receivers with autonomous outputs of all signals (parallel) are connected with the autopilot in such a way that the outputs of appropriate channels of the receiver are connected with the corresponding input channels of the Autopilot.



NOTE: The remote control kits from different manufacturers may have different signal sequence-for specific control elements (ailerons, throttle, direction, altitude), so connecting further signals to the autopilot, you should pay attention to the meaning of the output from the receiver and inputs of the autopilot.

The receiver should be connected to all the control signals, and at least one ground and power supply wire (it is not necessary to connect all pins of the ground and the power supply). The autopilot should also be connected to the RSSI signal if the receiver is equipped with such output.



Serial connection of the receiver CPPM or S-Bus

If you use a receiver equipped with serial PPM output (CPPM) or S-Bus, connection of all channels to the autopilot can be made by a single signal cable. In this case, we connect to the receiver a ground pin, power, CPPM or S-Bus and RSSI signal if the receiver is equipped with such output.

If you connect Serial PPM signal (CPPM / S-Bus), it is necessary to set up this signal with FPV_manager applications on your PC. Please connect autopilot board to the computer (via USB) and in configuration application, choose the socket pin of the Serial Input PPM (CPPM) - Input #1 or #6 or S-Bus on input #1, and make an assignment of the other channels of signal to each function of the autopilot.

In serial mode, you can configure the unused PPM inputs as outputs of autopilot additional channels from serial signal (output Aux 2 to Aux 5). This eliminates the need to purchase an additional CPPM/S-Bus decoder.

NOTE: Additional Aux 4 and Aux 5 outputs offer additional filtering and option for simple gimbal control and are recommended for the control of a pan-tilt system (camera control)

RC signal diversity

To avoid problem with RC link on long distances the both serial inputs can be supplied by 2 independent RC receivers working as diversity. Receivers can work in CPPM (on both #1 and #6 input channels) or S-Bus mode (on #1 input channel). To work properly both receivers should have the same channel order.

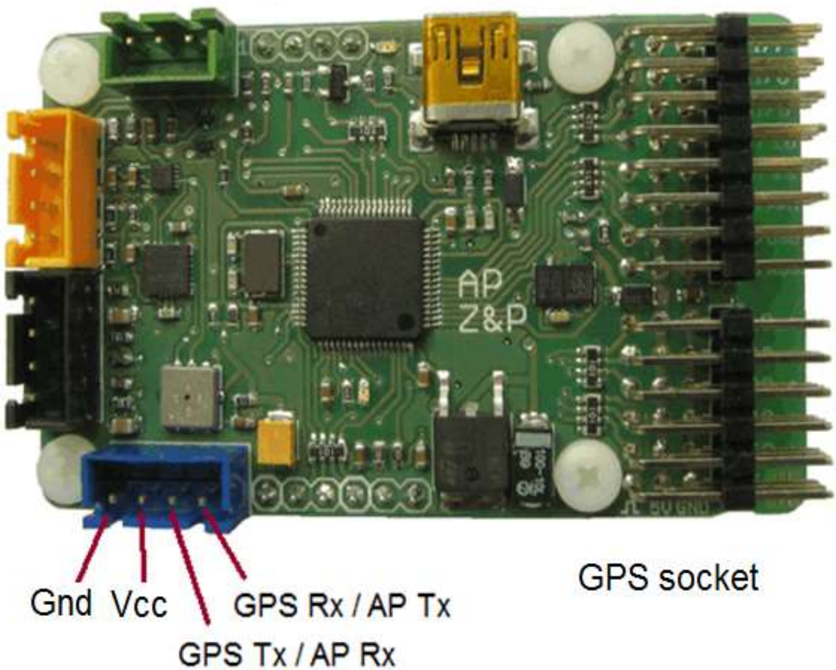
Document: Detailed description of diversity is described in separate document: “Diversity in PitLab FPV System”.

Connecting the servos and motor controller

Autopilot directly controls servos in the model, and the electric motor speed controller (ESC). These devices must be connected to the appropriate terminals, according to their description. Because the autopilot in stabilization and AUTO mode actively stabilizes the position of the model in response, among others to wind gusts or turbulence, it more intensively burdens the servos and makes them consume significantly more power during operation. Normally used linear voltage regulators built in motor speed controllers often are insufficiently efficient to meet the increased demand of current and are subject to overheating, which can lead to a malfunction of the system. For this reason, we recommend the use of external switching controllers (UBEC) rated for 3A or more (depending on the size of the model), or motor controllers with built-in switching UBEC. In the case of external UBEC please disconnect the red wire from the plug of motor controller.

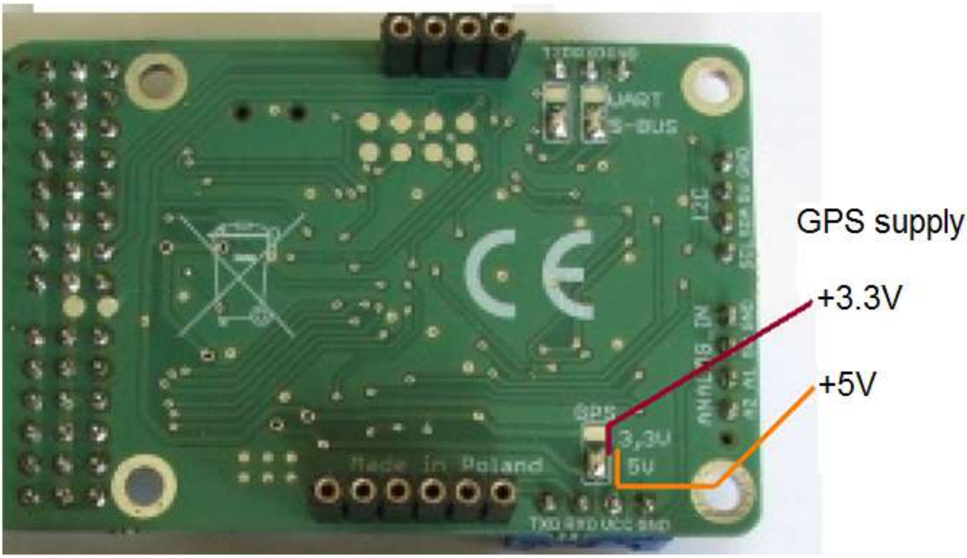
GPS Connection

Using the OSD -Autopilot set it is advisable to switch the GPS connector from the OSD board into connector on autopilot PCB. In such case the GPS system is supplied by a pulse-UBEC (like servos), relieving the linear regulator circuit on OSD (less heat is generated on the OSD board), and reducing the power consumption of the video set.



If you use your own GPS, connect it to the connector as described.

NOTE: Before you connect your GPS to the autopilot board you must verify and possibly change the value of the GPS supply voltage.



The changes are made by soldering respective fields with a drop of tin.

NOTE: This option may be changed only for 3-rd party GPS module. The default GPS voltage setting corresponds to GPSs available in the store and sold in a set, in this case no power supply voltage change is required.

RSSI

Autopilot does not use the RSSI signal, but for the convenience of connecting the receiver it has an input for connecting the signal to be sent directly to the OSD board. Requirements for RSSI signal have been escribed in the OSD manual.

NOTE: The OSD board in an earlier version (v2.1) does not receive an RSSI signal from the autopilot, in such case the RSSI signal from the receiver should be connected directly to the OSD terminal.

Location of autopilot board inside a model

Autopilot has an integrated inertial unit (IMU), which allows to determine the position of the autopilot board in three-dimensional space. This is a bank and inclination plate (relative to the vertical - the force of gravity), the direction the front of the plate is facing (compass direction), and the altitude above the airport (on the basis of changes in barometric pressure). Thanks to these properties, the autopilot can maintain (and stabilize) the levels of model flight, and provide the OSD with information of model tilt (artificial horizon).

However, in order for the information about the location of autopilot board to agree with the current position of the model, the autopilot board should be mounted in a suitable manner in a model, so that at the fixed level flight of the model, the autopilot board was horizontally facing the direction of flight.

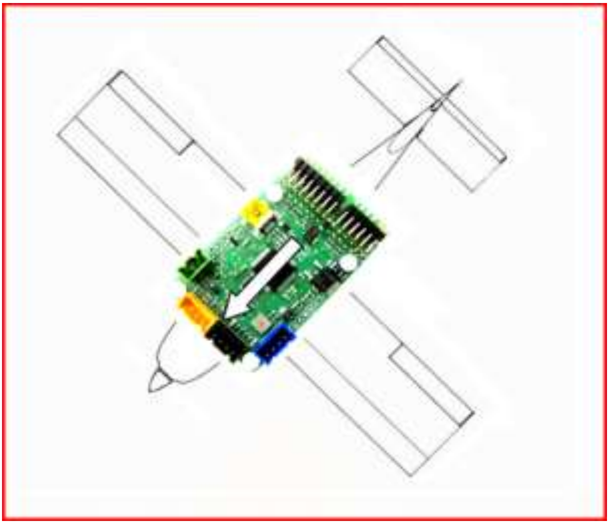


Figure 1 Correct locations of the autopilot inside the model

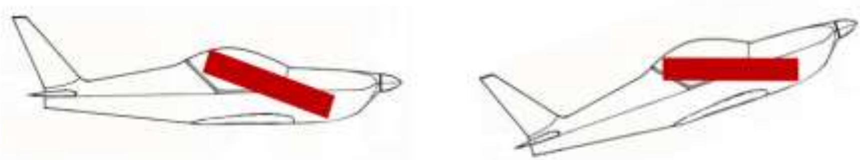


Figure 2 Impact of incorrect autopilot location on model flight

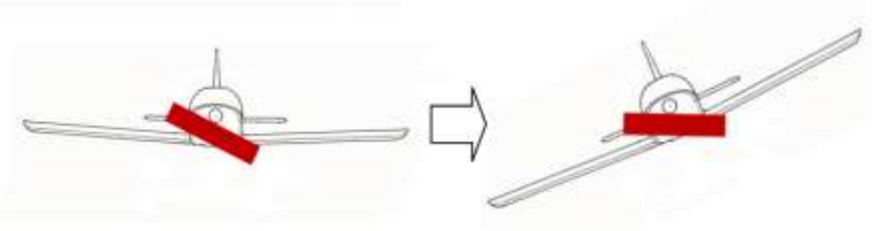


Figure 3 Impact of incorrect autopilot location on model flight

Small by few degrees autopilot position deviation can be compensated by settings OSD by **the horizon tilt** (compensation may also be made during the flight). Perfect location (or perfect compensation) occurs when properly trimmed, models flying straight and horizontal in autopilot OFF mode when you turn stabilization does not change the position a noticeably.
Autopilot board does not have to be fixed exactly in the model's center of gravity, we can choose other convenient place in the hull of the model.

Vibration protection

Autopilot should be protected against vibration (which affects the position sensors: accelerometers and gyroscopes). You can use the dumpers, sponge, or some other own patents. Dampers should dampen vibrations and resonances (do not use springs and rubber).

NOTE: The greater the mass of an isolated element, the vibrations are more effectively limited, so it is best to mount flexibly the whole "sandwich" OSD + autopilot, and not the autopilot board only.

The vibration level is checked with the engine running - if overload and vibration exceed 2g a digit will appear on the screen showing the current number of overload (2g, 3g, up to 8g).

Excessive vibration causes tilting ("passing out") of the artificial horizon on the OSD, despite the fact that the model is still level. The sensors, and algorithms of the autopilot should ensure the proper operation of up to the overload of 5 g, but keep in mind that during the fly, there are additional overloads (turbulence, the centrifugal force, etc.), and generally the lower the vibration, the more accurate is the work of the autopilot. You must therefore strive to achieve a minimum level of vibration from the engine.

Transmitter and autopilot configuration

First RC transmitter have to be properly configured for manual steering (without autopilot). User should properly set all mixers (e.g. flying wing or V-tail), neutral positions (trims), servo reverses and servo travel end points. All transmitter settings may be verified when autopilot is in OFF (manual) mode. In this mode autopilot just transfers all RC signals from receivers into servos, without any modifications.

Next step is to set proper mixers and reverses into autopilot to allow proper work of autopilot in STAB and AUTO mode when autopilot takes full control over airplane and need to know how to proper use steering surface.

The simplest and recommended way is to use OSD menu option **Autopilot->Mixers->Easy Setup**. This wizard will guide user through setup process with simple steps:

Step1: Left all sticks neutral with throttle low and then press **Enter** on OSD keyboard

Step2: Move aileron stick an your transmitter to the right and keeping it in this position press **Enter**

Step 3: Move elevator surface up (move elevator stick backward or down), and keeping it in this position press **Enter**

Step 4 for flying wing (delta): Left all sticks neutral and press **Enter**

Step 4 for other airplanes: Move rudder stick on your transmitter right, and keeping it in this position press **Enter**

NOTE: If you use transmitter settings to limit servo travel (EPA function), you should connect autopilot board to PC with USB cable and in

FPV_manager application use Autopilot | Radio | EPA / Servo travel function to store EPA values into autopilot.

Manual autopilot’s mixer configuration

There is an option for manual setup of mixers and servo reverses in autopilot. In this option user can also verify existing settings.

The first step is to select the type of model tail in OSD menu autopilot -> Mixer

When one rod is attached to two servos and two control surfaces (delta, tail V, flaperons), we can choose between two options of servos concurrency, (in line) and (anti in line), depending on whether for the proper control the opposite – or non-opposite movement of servos is required.
In the second step, for each side of the rudder we set the correct channel under OSD autopilot -> Mixers

Check the proper settings for servo and reverse concurrency after stabilization mode is off, observing the behavior of the control surfaces on bank and inclination of the model. When reverses and concurrency are positioned properly, by tilting or pitching the model they must be set in such a position that during the flight they counteract such deviation of the model.

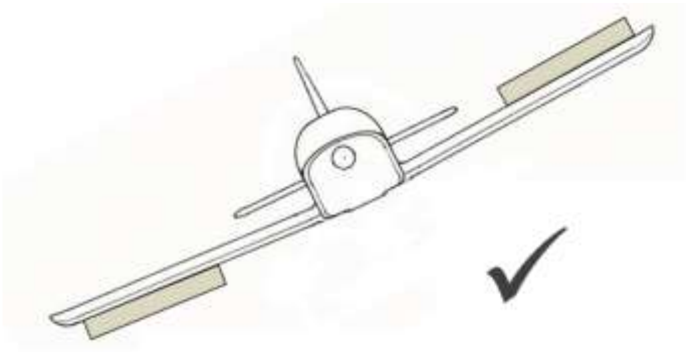


Figure 4 The correct setting of concurrency and servos reverses

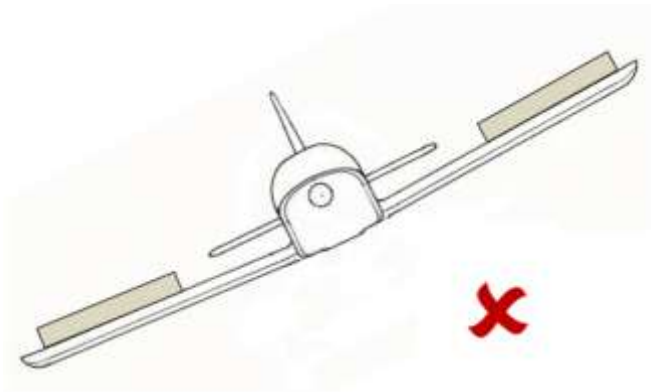


Figure 5 incorrectly set servos concurrency

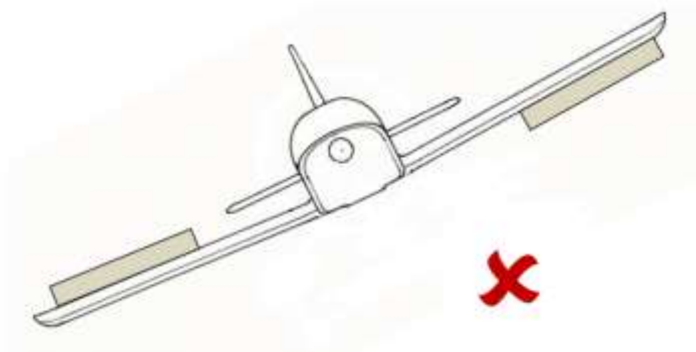


Figure 6 Incorrect setting of the reverse (correct concurrency setting)

Since the rudder does not participate in the stabilization of flight, it is not possible to set its reverse on the basis of observation of the behavior of the model at tilts. Therefore, after any change to reverse of the rudder the autopilot for about 1 second swings the rudder like to turn to the right. If after the change of the reverse you see the rudder turn left, it means that the reverse is not valid.

Autopilot modes

Autopilot mode control is done by a three-state RC channel connected to the PPM "6" output, as follows:

- Channel for minimum (PPM pulse duration less than 1.2 ms): OFF - autopilot off.
- The center-channel (pulse duration 1.3 ms to 1.7 ms): STAB - stabilization mode
- Channel for maximum (pulse duration more than 1.8 ms): AUTO - autonomous flight

Furthermore, in the autonomous flight mode you can select one of the three throttle control position:

- Throttle at a minimum: AUTO - back to the starting point.
- Throttle in the middle: WP - flight on waypoints along the route (a more detailed description contained later in this manual)
- Throttle to maximum: (*) - circulation over the current GPS point.

Current autopilot mode is indicated on the OSD screen next to the pilot icon.

In order or the model to automatically return to the starting point if you have problems with a range of RC circuit, FailSafe mode must be correctly set in the RC receiver :

- duty cycle of operation mode channel to maximum (AUTO)
- duty cycle of throttle at minimum (back to the starting point).

Document: The development of FPV System made to increase number of sub-modes. Detailed description of all sub-modes is in separate document: “Navigation modes in the Pitlab & Zbig FPV System”.

Turning the autopilot off

In the OFF mode, all RC input signals are transmitted to the output without any interference (except for disregarding false PPM pulse outside the acceptable range of 0.8 ms to 2.3 ms).

If the autopilot is connected to only one aileron signal (input # 1 "aileron 1"), the autopilot transmits the same signal on both ailerons outputs - works as a "Y" cable, making it easy to control two servos from one RC channel.

Stabilization of model

Stabilization of model is essential in order to prevent unexpected or uncontrolled changes of model position. Proper configuration of stabilization mode is also required for the correct operation of autonomous flight mode.

In the case of model deviations from the desired position, stabilization system forces appropriate control surface deflection to eliminate these deviations. Proportionality of steering surfaces deflection in relation to the position deviation is defined by setting in the OSD menu Autopilot->Roll stabilization and Autopilot->Pitch stabilization.

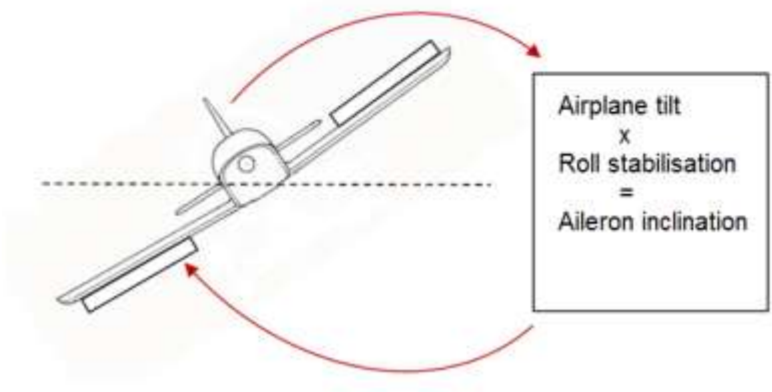


Figure 7 Illustration of operation of banking stabilization algorithm

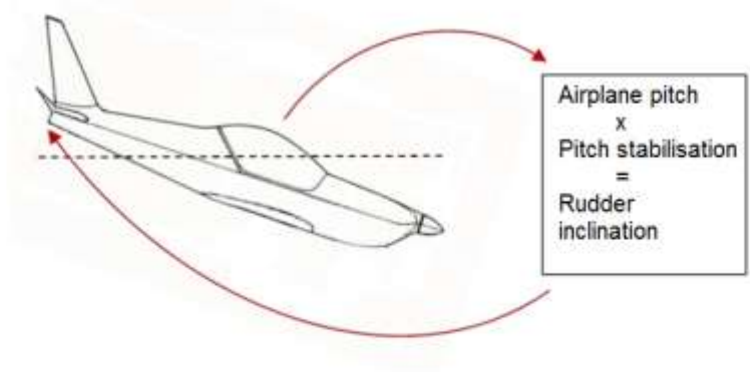


Figure 7 Illustration of operation of inclination stabilization algorithm

The correct setting of the stabilization of the model is necessary to work in autonomous mode of the autopilot.

We set the highest value of the roll stabilization force at which the model is flying steadily without falling into oscillation. Too high stabilization value is manifested by rapid fluctuations in the wings - especially with increasing speed.

Too low roll stabilization force could prevent proper flight in AUTO mode (unstable flight, too small or too great banking of model during turns)

We choose the mean pitch stabilization force, with which the model aimed sharply down, after releasing the elevator stick gets back to the level without pumping , and cutting the throttle airplane glides without deceleration and stall, and after the addition of throttle attains altitude, but also does not take up too hard.

Small values of pitch stability may cause pumping of the model and with the model with a strong drive too rapid pulling up of the model on throttle.
Too high pitch stabilization force can cause quick, short oscillating up and down, especially at higher speeds, and also cause stall of the model without throttle, and poor ascending on throttle (model accelerates, without ascending), causing problems in autonomous flight. Autopilot in stabilization mode does not hold directly the setpoint direction of flight, but by keeping the level of the model largely eliminates the unplanned deviations from the current model course.

Autonomous flight mode

In autonomous mode, the autopilot controls the model flight alone, maintaining the right direction and altitude, as well as preventing too rapid model banking, which could cause loss of control (framing the wing, corkscrew, etc.).
In autonomous mode, the autopilot is flying to the point specified by the position of the throttle stick (channel). Also the distance and the course displayed on the OSD are always relative to the currently selected destination (base, waypoint or point of circulation).

- Throttle at a minimum: AUTO - back to the starting point.
- Throttle in the middle: WP n - flight to the route number 'n'.
- Throttle to maximum: (*) - circulation over the current GPS point.

Banking limit

In order to maintain control over the model it is necessary to determine the maximum (and safe) allowed model banking during maneuvers in autonomous mode. Make the settings in the OSD Autopilot-> Banking Limit

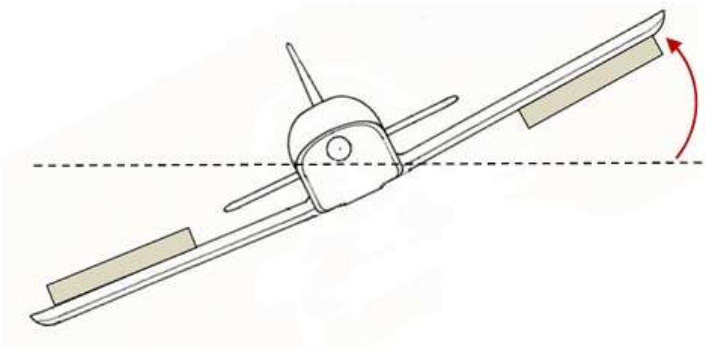


Figure 9 Maximum banking of the model in autonomous flight

Too small value of the maximum banking increase the turn radius, or may even prevent it from turning in strong wind. Too large values can cause problems with the stability of the model in the air can cause the loss of altitude during the turn, and cause significant deviation (delay) of the course provided by the GPS in relation to the real course of the model, so the model when turning to the base and starts "poking" flying to the base.

NOTE: For models with a large agility (large aileron deflections) or with set lower stabilization force it may be necessary to adjust the lower limit of the banking angles.

Force of getting back on course

When in the autonomous fly the current course of the model is different from the desired course to the base (or waypoint) the autopilot makes a turning maneuver performed in order to return to the right course. Accuracy of staying the course, and the deflection of the ailerons and rudder in case of deviation from the course is defined by OSD parameter **Autopilot-> Force of getting back on course**. This is illustrated in figure:

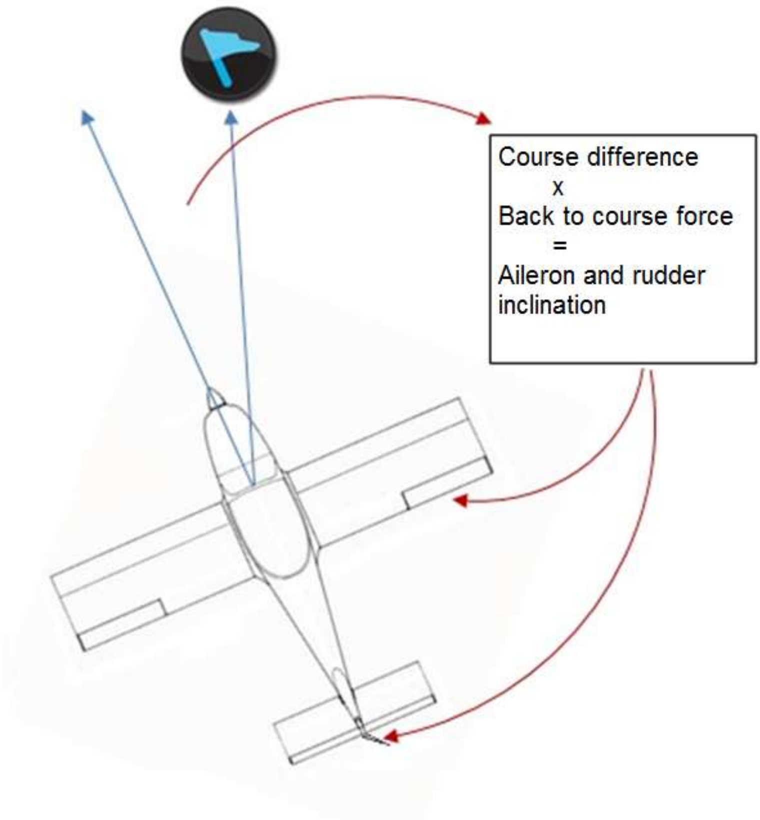


Figure 10 Illustration of the algorithm to maintain the course

The greater the deviation of the course, the stronger the swing of ailerons and rudder causing getting back on course. This means that if deviation of the course is high, then also the turning speed of the model is high, and with getting closer to the expected course the speed of turn decreases.

If this value is too low, the model will be turning slowly and will not be coming to the course to the base. Too high a value causes the model to perform a quick turn also when the deviation of the course is low, so that the model significantly exceeds the course and oscillates around the course flying zigzag.

Mixer ailerons-> direction

Turn of the model is generally obtained by ailerons, but it is also possible to add steering with the rudder. This is done by the mixer set in the OSD menu options Autopilot-> Mixers-> mixer ailerons- direction, that helps to turn the model. In models with ailerons its use and value is at the discretion of the pilot. Too large values of the mixing can cause excessive model banking in relation to the value of the banking limit set in autopilot menu.

NOTE: in aerobatic models where the ailerons do not turn the model, we should set high values of aileron-direction mixer, and a small banking value limit.

The slowdown in turn

Since small values of the maximum model banking can cause problems in the event of strong winds, it is necessary to use average values of the banking limit, aided by dynamic constraint (slow down) of the turn speed, which prevents problems with GPS course.

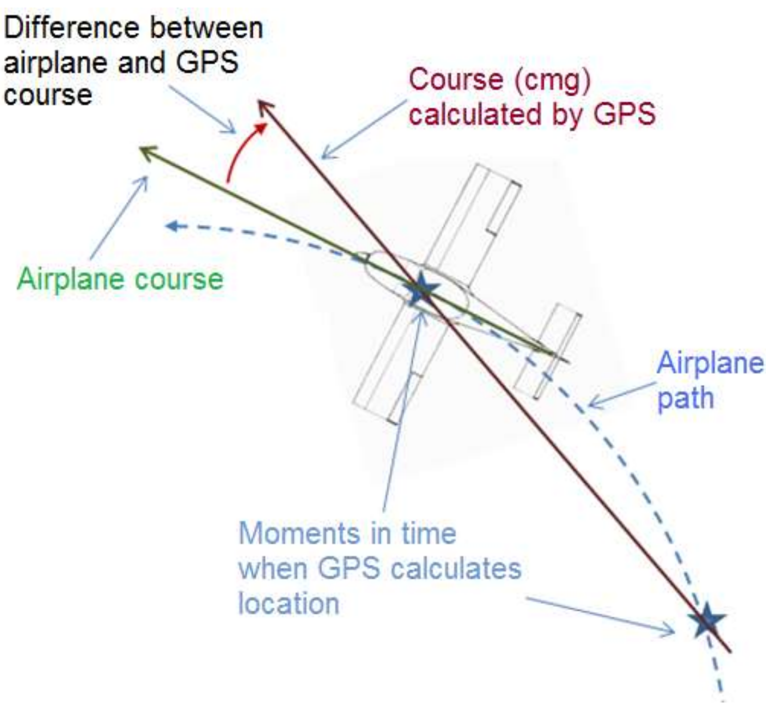


Figure 11 The error of indication of the course during a quick turn GPS model

The slowdown in turn can be set in the OSD Autopilot-> turn slow-down.

NOTE: When using the magnetic heading it is not necessary to slow down the bend more, as the used magnetometer has a sufficient speed and precision of operation, even with a stronger heel and high-speed turns.

Compensation of crosswinds

If some factor, such as crosswind (but also bad trimming or bad position compensation of autopilot) causes the model is still relegated from the course and does not pull to the course to the base, this error is constantly monitored and if it does not disappear, the autopilot is steadily increasing aileron deflection to compensate for this error. It takes a relatively long time (up to several seconds or even longer) and makes systematic "pulling" the autopilot to the correct course.

Compensation is selected at the discretion of pilot, keeping in mind that too high a value may result in exceeding the line of the course by the model and a slow return to the course (or zigzag flight or a slow change in the course), because the adjustment changes slowly.

Maintaining the altitude

Maintaining the altitude of the autonomous flight is performed by throttle, so the model should ascend as the throttle increases.

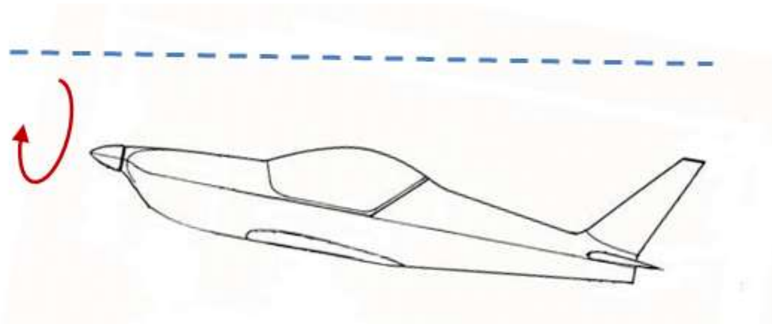


Figure 12 ascending of the model - engine flight and the free fall of the model with the reduction (or shutdown) of throttle.

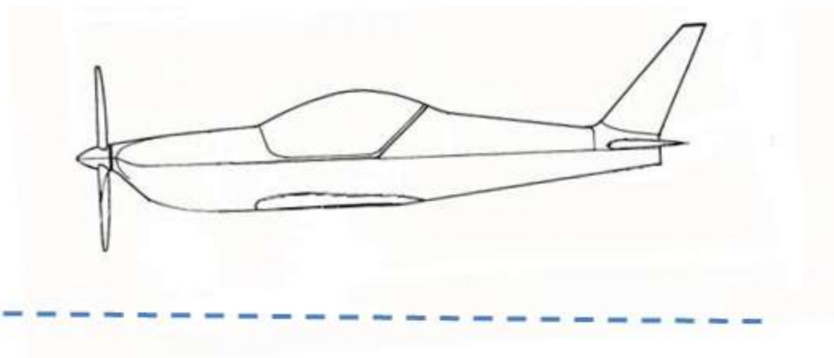


Figure 13 Lowering the cruising altitude - free glide without engine

In certain situations, such as descent from a very high altitude and the forced flight with much throttle, autopilot also uses the elevator to lower the altitude.

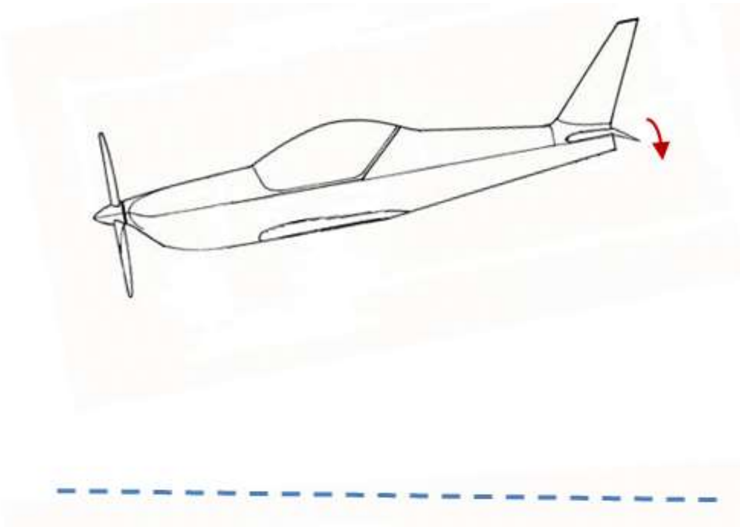


Figure 14 The use of the elevator during descent from a great altitude

Throttle limit

Throttle limit sets the maximum value of the throttle (power) which the autopilot can use in AUTO mode. Reducing throttle allows for a more economical flight and limits the maximum cruise speed in models with a strong drive, including the elimination of the risk of overheating the motor or speed controller (ESC) during the autonomous flight after a long tour. Too low limit may cause problems when flying in a strong wind. Throttle limit must be sufficiently large to ensure that the ascent of the model under adverse temperature conditions (such as "strangling" by the downdraft).

NOTE: Saving the trim (OSD menu “Autopilot” -> “Save trims”) with tilted throttle rod can cause incorrect handling of throttle by the autopilot (e.g., exceeding the set limit of throttle). Writing a non-zero position of the throttle is needed for combustion models, allows you to save the position of rpm speed (minimum) of the motor.

Throttle mode

Autopilot has three throttle operating modes, allowing the autopilot to customize the behavior to specific model and the modeler's expectations.

On-off mode is designed to glider models. In this mode the motor is switched on with the throttle level defined by the throttle *limit* parameter and after attaining additional 50-70m the motor is cut off and the model glides freely until the loss of altitude, whereupon the process is repeated.

In **Fixed throttle** mode, the engine has constant throttle level determined by the *throttle limit* parameter. This mode is recommended when a fast return to base and fast performance of the flight route points is required, particularly in strong or variable wind, and in models of poor gliding, with a tendency to stall.

Dynamic mode is recommended for most models. In this mode, the throttle is set to a value at which the model maintains a constant altitude. This allows for the most economical flight of the model with a moderate wind. In this mode the maximum value of the throttle used by the autopilot is determined by the *throttle limit* parameter.

Cruising altitude

During autonomous return to base and circulation over the current GPS point the autopilot maintains altitude at which the AUTO mode was turned on.

During the autonomous flight along the points of the route, the autopilot flies at an altitude given in the specification of each waypoint along the route, or at the actual altitude (at the time of activation of the autonomous mode) - If the definition of the route does not specify the cruising altitude.

For autonomous flight we can specify the minimum and maximum cruising altitude that guarantees safe flight. Setting of the cruising altitude limit set in the OSD menu “Autopilot”-> “Altitude”:

Minimum altitude: If at the AUTO mode activation the current altitude of the model is less than the specified value, the autopilot will rise model to the preset minimum altitude and will continue to fly at that altitude. This allows a return to the base at a safe altitude, for example, above the trees or other obstructions.

NOTE: Disabling a minimum altitude allows for a flight at points along the route below the starting point (e.g. when taking off from the hill)

Maximum altitude: If at the AUTO mode activation the current altitude of the model is above the specified value, the autopilot will not maintain this level, but will lower the flight by elevator and in dynamic throttle mode the engine will not start until the model will reduce the flight to the set maximum and then will continue to fly at this altitude (maintain this altitude). This setting allows for the safe return of the model to an area where it will be possible to regain lost range of the control RC, video link or visual contact with the model.

Minimum speed of the GPS

For flights in strong winds there is a risk that the model gliding into the wind stands still or moves backward (free glide speed is less than the wind speed), and when the model goes back , the course indicated by the GPS becomes the opposite to the direction the model is heading. The result is that the autopilot is doing a circle, trying to get back on the correct course. These phenomena can make the autopilot to be unable to return to base.

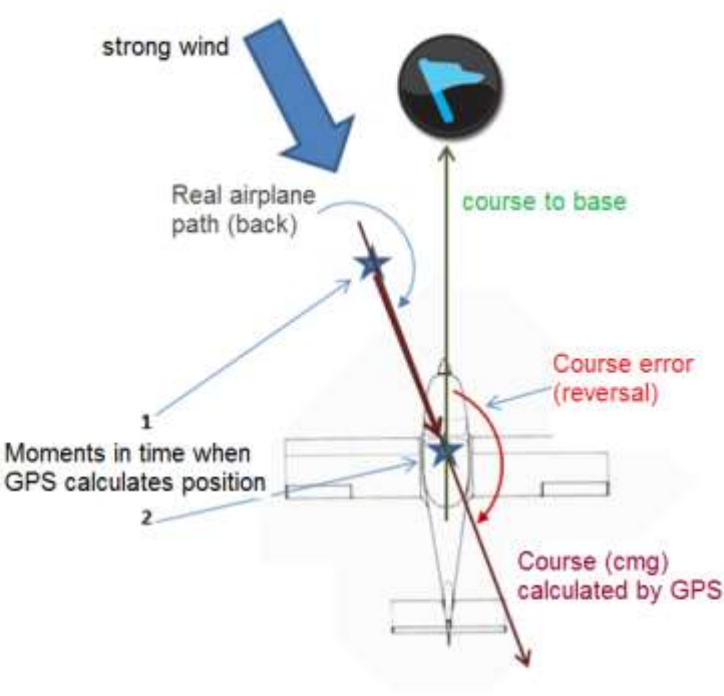


Figure 15 Reversal of GPS course when backing up the model in strong winds

Setting the minimum speed of the GPS (speed vs. ground) causes the autopilot to start the engine whenever the current GPS speed is below this speed, eliminating the risk of model regression (getting away from the base), and turning with the wind.

NOTE: In order to increase the speed (above the set minimum GPS speed) the autopilot can also use the value of the throttle set above the limit of throttle. The algorithms applied are designed solely to eliminate the risk of model regression against the wind, the control of throttle may not be smooth, and the algorithms for altitude keeping can work less effectively.

Saving the trimmers

Before the first flight, and after each change of trim model, save for the autopilot linkage positions (PPM signal values) corresponding to level flight of the model. Use this option in the OSD autopilot-> save trimmers.

Saving the trimmers is important from the point of view of the autopilot, as in AUTO mode the autopilot takes over the role of RC transmitter and needs to know the PPM signal values (modulation of servos) corresponding to free flight in a straight line, with no banking and no stall of the model. Changing the trim without saving it in the autopilot will result in banking and turning of model in STAB mode, and a worse operation of autonomous flight mode (asymmetric turns and, in extreme cases, stall or problems with maintaining altitude).

Saving the trim can be done both on the ground and in flight. Trimming the model on the fly should be made in OFF mode (with stabilization off) in order to correctly observe the behavior of the model in free flight.

NOTE: saving the trim should always be made with the throttle set at a minimum. The throttle trimmer saving is significant in models with combustion engines, allowing for maintaining appropriate minimum engine speed during flight in autonomous mode.

Choosing between GPS or magnetic course

Autopilot allows you to select the method of determining the course to base by a built-in GPS or by electronic compass. The choice is made in the OSD menu **Service settings-> course**.

GPS determines the course on the basis of the position of the model calculated in the consecutive points in time. So it is always the actual direction of movement of the model, including pushing the model away by the wind. This is called the Course Made Good CMG . Autopilot using GPS course goes to the base in a straight line, along the shortest route, but during the flight with side wind the model body is deflected from the direction of the base direction so as to compensate for model drift by wind. This deviation may be up to about 90 degrees, with a very strong wind. For the pilot who observes view from a model camera for the first time, this can be a surprise and may cause confusion, because the model gives the impression of flying in the wrong direction (too much into the wind).

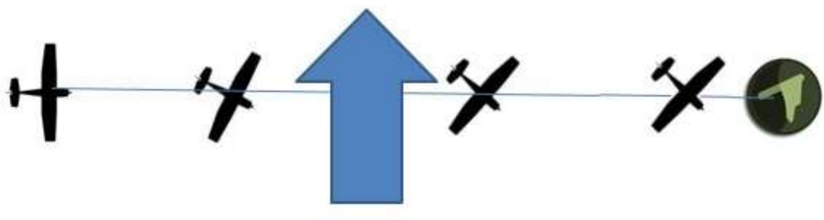


Figure 16 flight in strong winds according to GPS (cmg)

During the flight with the magnetic course the body is always in line with the base direction, and the pilot observing a view from camera on board should see destination point (base) directly in front of the model, but the model is constantly pushed away by the wind, and despite turning all the time in the direction of the base flies in an arc and at the end of the flight is always hitting the base against the wind. In this case, the distance traveled by the model is longer than the optimum. The advantage of magnetic heading is also that, regardless of whether the model is moving forward or in a strong wind gusts moves back it is always directed towards the base.

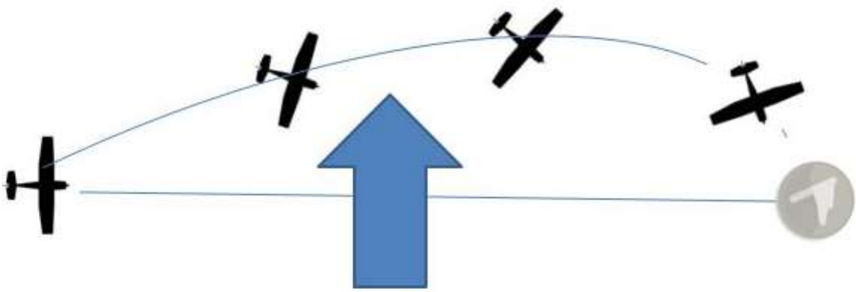


Figure 17 flight in strong winds according to magnetic course

NOTE: The magnetic field sensor (electronic compass) is sensitive to any kind of disturbance of the magnetic field caused by the presence of the magnets (e.g. magnetic latches of cabin, neodymium magnets inside motor), the magnetic fields generated by flowing current (power cables to the motor) and metal (magnetic) objects near the sensor, such as plates, brackets, bayonets, etc. Therefore, you should check if the directions indicated by the electronic compass of the Autopilot coincide with the actual geographic directions.

Choosing GPS or barometric altimeter

Autopilot allows you to select the type of altimeter, which is used to maintain altitude in AUTO mode and indicates the altitude of on-screen display.

Barometric altimeter is recommended for most flights. It provides high precision of determining the altitude and its change, which can provide information about the speed of descent or ascent of the model (variometer) with accuracy of 0.1 - 0.2 m / s, but it is sensitive to changes in atmospheric pressure, so during the flight and after landing the altitude indicated by the altimeter can change within a few meters in comparison to the initial value.

GPS altimeter is insensitive to weather conditions and provides a small percentage error at high altitudes, however, poses a significant absolute error of indications and its height can change unexpectedly and jump up and down even in tenth of meters. Therefore, when using altitude from GPS the variometer that indicates the rate of ascent / descent is not available. GPS altitude can be used in high or prolonged flights in changeable weather conditions.

Waypoints

OSD allows you to define up to nine points of the route, which can be used for a flight on a particular route, both in controlled flight and autonomous flight.

Waypoints managing takes place in the OSD menu Waypoints. Waypoints are described by GPS coordinates (altitude and latitude), and the cruising altitude to the waypoint (in relation to the altitude of the starting point).

Selection of the flight starting from the first defined waypoint is accomplished by selection OSD Waypoints-> Set flight according to points along the route.

You can also choose to fly starting from any point along the route, choosing the desired waypoint and then selecting from the submenu: flight from the selected point.

After selecting the initial waypoint the navigation switches (indicating the target course) to the first point of the route, and the autopilot display in the info box is WP displayed (called a waypoint) and the number of the current waypoint.

NOTE: The setting of flight along points along the route of flight in the manual operation mode (STAB and OFF) switches navigation (indicating the distance and course deviation) to the selected route (waypoint), and not to return to base. This allows manual flight to the selected destination, it should be borne in mind, and before returning to the base you need to switch navigation in OSD menu Waypoints-> Set: Return to base.

After approaching a waypoint at a distance of less than 50m the waypoint is “checked” and navigation switched to the next waypoint.

NOTE: empty (not filled in) waypoints are ignored, and next defined waypoint is selected.

Autonomous flight along the points along the route is activated by a change in autopilot mode to AUTO and lifting the throttle stick to the middle position. With throttle position at minimum , the autopilot always performs navigation and return to the starting point.

At any time you can stop navigating (and flight) along points along the route, choosing the OSD menu Waypoints-> Set: Return to base.

During the flight you can save your current GPS position of the model as a new waypoint. To do this, select the waypoint at which you want to save the current GPS position of the model, and then select the command **Use the GPS position**. This way you can remember for example the highest achieved flight distance or location of the point of interest along the route, and then check its location in Google Maps.

NOTE: The most convenient way of trajectory planning is to use PC application FPV_manager.exe, manage waypoints against the map service Google Maps, and send points to the OSD via a USB connection.

PC application configuration

Autopilot can be configured and updated via the USB port using **FPV manager** software, running on a computer that is running Windows XP, Vista, Win7 and Win8, in both 32 and 64 bit versions.

Configuration application (executable file FPV_manager.EXE) requires to operate the. NET Framework software version 3.5, which is shipped with the new versions of Windows and does not require any additional installation. But it is possible that with the older versions of Windows XP, the software is not available, then it must be downloaded from the Microsoft and installed on your system:

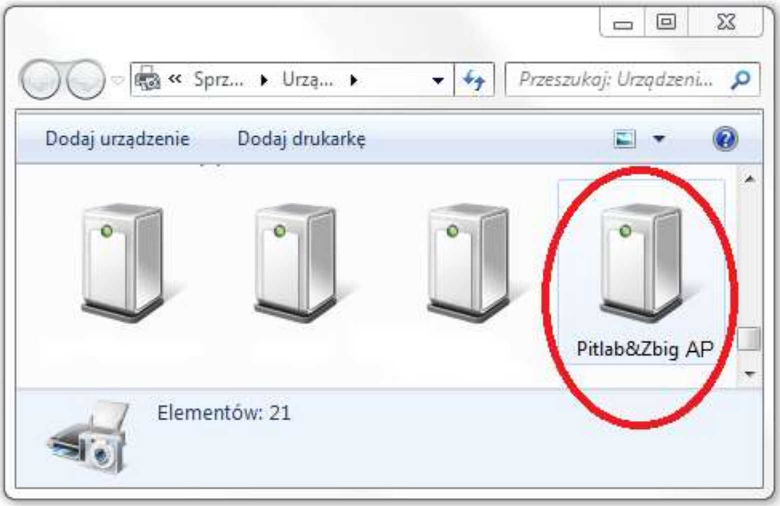
http://www.microsoft.com/downloads/pl-pl/details.aspx?FamilyID=333325fd-ae52-4e35-b531-508d977d32a6

The latest version of the configuration software can always be found on the manufacturer's website:

https://www.pitlab.com/fpv-system/download.html

The configuration application is ready for use immediately after downloading to a local drive or removable drive and does not require installation on Windows. The application can be run from anywhere, even from removable media such USB flash drive or directly from a network location, on any Windows computer.

The application communicates with the controller pad via USB and standard mini-USB cable. Windows automatically recognizes the connected device, without the need to install additional drivers. The device is seen in Windows as Pitlab & Zbig AP.



Once the FPV manager application is started, go to the Autopilot tab. If the device is connected to your computer, it be the automatically identified and the subpage Firmware displays basic information about the device.

Software Update

Manufacturer makes updated Autopilot software (firmware) available on its website, including functional enhancements and fixes. To update the software, the file with the new firmware version (with. AP extension) should be copied to the local disk, and then click Upload Firmware button and select the new firmware file. The update process takes from a few to several seconds, and the progress is indicated by a progress bar in an application FPV manager.

RC Setup

Configuration and the correct connection of the receiver verification can be made in the FPV_manager application, Autopilot tab-> Radio PPM.

In the PPM Input frame current signal levels from each receiver channel or serial signal decoded PPM (CPPM) are presented.

In the PPM Output frame current output signals of autopilot: control servos and motor controller are presented.

In the **PPM Input mode and mapping** frame you can find settings for cooperation with RC receiver through parallel connection (parallel inputs), or one of the two Serial PPM (CPPM)inputs - Input 1 or 6. Here we make the appropriate channel assignments of the CPPM signal to the autopilot function, and additional PPM Aux2 to AUX5 outputs.

Calibrations

Autopilot is factory calibrated and ready to operate, and you will not need to calibrate the device on your own.

However, there can be special circumstances in which it will be necessary to re-calibrate the system if there are problems with its proper operation. Problems may arise as a result of strong mechanical or thermal shocks, or natural aging of electronic components. This FPV_manager application allows you to perform additional Autopilot calibration (in order to shorten the maintenance of the device), but before using any calibration function you should contact the manufacturer to determine the nature and cause of the problem, and obtain instructions on how to calibrate it properly.

Calibrating Gyroscope

The gyroscope is very important sensor for flight stabilization. It detect rotation speed in all 3 axis. Due to complex electro-mechanical nature of the principle of measurement, it is exposed for offset error (detecting zero speed) depending mainly from temperature change and mechanical tension. Although gyroscope is fully factory calibrated, in some cases (change of mechanical tension, excessive temperature change or strong mechanical shock) it needs to be re-calibrated by the user.

Because gyroscope measures rotation speed during calibration process the autopilot (or whole plane with it) has to be very stable, not exposed to any movement nor vibration. Position of autopilot during calibration is not important.

The principle of calibration is to determine the current offset for a given temperature for all axis. It require to determine offset in 3 different temperatures: “low”, “mid” and “high”, to estimate individual curve of drift change in function of temperature.

The “mid” (or room) temperature should be close to 25°C. The “low” and “high” temperatures should cover (or be close to) range of temperatures in which autopilot will be used. If you are planning to operate in extremal condition: very hot or very cold, you may extend the temperatures of calibration. The factory calibration is done at “low” temperature -10°C, “mid” equal 25°C and “high” equal 40°C.

The calibration can be done by 2 ways: using FPV Manager or using OSD menu operated via 3-key keyboard (operation via RC channel don't support calibration for safety reasons). Calibration using OSD menu is more natural for assembled planes, but require correct sequence of cooling and heating. Calibration via FPV Manager require connecting USB cable, but give freedom in calibration sequence.

To calibrate via FPV Manager select “Autopilot” → “Calibration”.

Well calibrated gyroscope should has values “Axis X”, “Axis Y” and “Axis Z” near zero. It may fluctuate, but it's value should be not bigger then +/-10 units. If offset is bigger on any axis, it means the gyroscope require calibration.

First autopilot board need to be cooled (e.g. in refrigerator, covered with plastic bag). When board is stable, press button “Write min”. Next allow to slowly warm up board to room temperature (close to 25°C) and press button “Write mid”. Finally heat the board using hair dryer or other safe heat source and press “Write max”.

For cooling can be used outdoor temperatures in winter, ice cube in foil bag or specialized cooling spray. Using ice or sprays please cover the electronics with thin tissue to absorb water condensing from air. Correct sequence: first cooling, next heating allow to evaporate potentially condensed moisture.

To calibrate via OSD menu go to OSD menu “Service” → “IMU calibration” → “Thermal calibration” and follow instruction on the screen. First you will be asking for calibrate “mid” temperature and don't moving the model while calibration, next cooling and calibrating “low” temperature. Finally heating and calibrating “high” temperature.

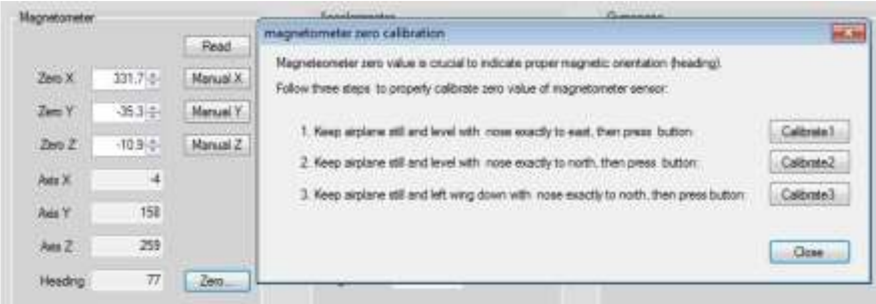
Calibrating magnetometer

Principle of magnetometer calibration is to find minimal and maximal magnetic field value for all axis. To do it, the autopilot board (or whole plane with it) should be oriented to the magnetic north direction in 3 different position to calibrate all 3 axis.

The calibration can be done via FPV Manager at office condition or via OSD menu outdoor. The outdoor conditions are recommended, because inside building the magnetic field can be highly distorted by iron used in building construction. In both ways of calibration, user is asked to keep the autopilot oriented to described direction in 3D space. To do it precise the magnetic compass will be useful to precise determine north direction before calibration.

Note: The compass is also the source of magnetic field, so when is kept in close distance to magnetometer on autopilot's board, it may distort the Earth magnetic field. Take it away from board during calibration.

To calibrate using FPV Manager use “Autopilot” → “Calibration”. In “Magnetometer” section, press “Zero” button and follow instruction displayed in window. Place autopilot board or whole plane in requested position and press the button “Calibrate 1”. Follow the same operation for next 2 steps in any order.



To calibrate using OSD menu (using keyboard instead RC channel as a input) call menu “Service” → “IMU calibration” → “Magnetometer calibration” and follow commands displayed on the screen.

The quality check of magnetometer calibration can be done by observing heading displayed on OSD screen while slowly rotating around own axis. The displayed magnetic scale should cover with real magnetic directions and should change with the same speed as rotating speed. Bad calibration may cause some course values will not exist and slowly rotating the plane with autopilot, the displayed course value will skip some values and extend other.

Calibrating accelerometer

The accelerometer in IMU is used to point direction to Earth by it's gravity vector and compensating slowly growing error of artificial horizon position caused by gyroscope drift. Principle of operation is quite simple and not influenced by so many errors like in cause of gyroscope or magnetometer, so it not require correction of temperature drift. Calibration is limited to find value of zero gravity for all axes and use it as a reference point.

Correctly calibrated accelerometer in FPV Manager → "Autopilot" → "Calibration" → "Accelerometer" should indicate "g-force" equal 1.0. Also plane placed levelled in position in flight should have values "Axis X" and "Axis Y" close to zero and value of "Axis Z" close to 4096.

To calibrate accelerometer first place plane or autopilot board (much easier) in perfectly levelled position and next press "Zero X,Y" button. To calibrate Z axis first enter 0 into "Zero Z" field and press "Manual Z" button. Next rotate the autopilot by 90° to be laying on side (plane should have one wing down, another up (not important which one) so the Z axis should indicate no gravity. Remember the value in "Axis Z" field and rewrite it to "Zero Z" field and save using "Manual Z" button.