Autopilot — Installation Manual

Kanardia d.o.o.

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Contact Information

Publisher and producer:
Kanardia d.o.o.
Lopata 24a
SI-3000
Slovenia

Tel: +386 40 190 951
Email: info@kanardia.eu

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Revision History

The following table shows the revision history of this document.

Revision	Date	Description
1.0	Aug 2015	Initial manual release.
1.1	Maj 2016	Tunning noted were added.
1.2	Jul 2016	Tunning table expanded.
2.0	Feb 2020	Complete Manual rework.

Contents

1 Introduction

First of all, we would like to thank you for purchasing our product.

This chapter describes the basic principle on which autopilot operates. After reading it, you will be familiar with basic knowledge you will need to properly install and tune the autopilot.

1.1 Minimal Configuration

Most modern light airplanes can be controlled during a stable flight by controlling elevator and aileron only. An autopilot function can be achieved using the following minimum configuration:

- Two servo motors that are mechanically connected with the airplane command system. One motor controls elevator and the other controls aileron.
- An AD-AHRS-GPS device which consists of many sensors and provides crucial information required by the autopilot system (airspeed, rate of climb, pitch, roll, position, direction, altitude, etc.)
- A display unit takes pilot inputs like required altitude and direction. It is also used to enter configuration parameters required to properly setup the autopilot system.
- A servo motor controller. It monitors the pilot instructions and information obtained from the sensors and controls the servo motor accordingly.
- A communication system that connects all devices and allow information exchange in real time.

In Kanardia autopilot case, the following minimal equipment is needed:

- Two SERU servo motors. SERU consists of a servo motor and an integrated controlling unit, which serves as a motor driver. One SERU controls elevator and the other controls aileron.
- Nesis III (or Aetos) primary display unit. The display has integrated AD-AHRS-GPS device, which provides all sensor data. The display has several buttons and a knob that allow pilot control over the system. In addition, touch screen can be also used on Nesis III.

- The devices are communicating using the CAN bus system. The CAN bus is integral part of almost all Kanardia devices. Simple RJ45 cables (a.k.a. Ethernet cables) are needed to connect them.

1.2 Principle of Operation

When autopilot is active, pilot selects requested altitude, direction and rate of climb or descend. AD-AHRS-GPS device provides current values for almost all flight parameters. Controller units compare the requested values with actual values and give appropriate commands to the servo motors. The PID controller principle is used together with the cascade control system.

The autopilot drives two separate controls: aileron and elevator. In general these two controls are independent, though minor dependency may exists.

Each control has two control loops[1]. Elevator control has pitch loop and vertical speed loop. The two loops are regulated by cascade. This means that requested altitude sets wanted vertical speed and the vertical speed loop sets wanted pitch. The pitch loop then controls the elevator by minimizing the difference between requested and actual pitch. Aileron works in a similar way. Requested direction sets the required roll angle and the roll loop controls the aileron trying to minimize the difference between requested and actual roll angle.

This means that autopilot has four loops: *pitch* and *vertical speed* loops are used for elevator, while *heading* and *roll* loops are used for aileron. All these loops must be properly tuned to achieve requested autopilot operation. Various experimental values in the form of tuning parameters are provided at the end of the document. These values represent good starting point for first autopilot tests.

2 Installation

This section provides information about the installation of autopilot servo motors (the SERU device) into an airplane. It contains important rules which must be obeyed to have a working and safe autopilot system. The installation information in this section is extremely important and must be clearly understood by the installer.

[1] The control loop is basic term from control theory. In simple terms – the control loop tries to move the actuator in such a way that difference between WANTED and ACTUAL value is minimal.

Improper servo installation or failure to observe and diagnose installation problems prior to flight can result in extremely serious consequences, including loss of ability to control the aircraft. If there are any questions on the part of the installer it is mandatory to resolve these questions prior to flight of the aircraft.

CAUTION: Improper installation could result in lost aircraft controls, injury or death!

2.1 Servo Motor

The servo motor must be installed in a fixed position. It must be attached with all four mounting screws. The motor mount should be provided by aircraft manufacturer and has to be adapted to specific airplane model. The motor should be oriented parallel with longer edge regarding control rod connected to the servo arm. The servo schematics is given in Figure 1. It defines three important elements:

(1) Safety pin,

(2) Arm movement limiter,

(3) Arm.

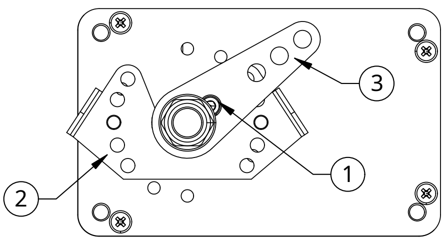

Figure 1: Safety pin, limiter and arm.

2.2 Servo Arm

Servo arm has multiple holes for mounting control rod. The hole in use should be chosen to maximize the arm rotation. Servo arm should not be removed or replaced without Kanarida advise. The removal of servo arm includes removal of safety pin. Please contact Kanarida before replacing safety pin for latest instructions.

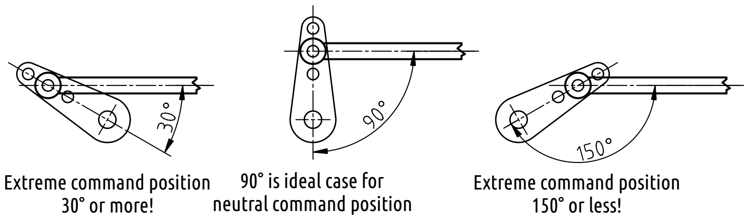

Figure 2: Main servo dimensions.

Figure 2 illustrates valid relative positions between command rod and servo arm. When command is in neutral position, the angle between rod and arm shall be 90° or at least very close to this ideal case. When command is in its extreme position the angle between the command rod and the arm must never be more than 150° or less then 30°.

Under no circumstances the servo arm is allowed to come into position called *over center* – the position at which the primary aircraft control would lock up and can result in fatal crash. A mechanical stops must be applied to prevent this to happening. Mechanical stops must limit the arm movement at least 30° before the over center situation.

2.3 Servo Arm Limiter

To protect against control lock up, a mechanical arm limiter is supplied with servo. The limiter is drilled so that it can be mounted at different angles as required (18° intervals).

The limiter must not prevent aircraft command movements. Always make sure that the controls can have their full travel and they never reach the servo limiter.

2.4 Servo Arm Safety Pin

Safety pin is a safety mechanism which prevents blocking of the aircraft command system for the case of blocked servo motor. If servo blocks the command system, pilot must apply high force on the command stick. This force will break the pin and release the servo from command system. Once the pin is broken, the autopilot system is not operational until the pin is replaced.

If safety pin is broken or it gets slack the whole autopilot system must be checked. Only after the cause of the problem was found and corrected, safety pin can be replaced with a new pin. Always use original safety pin.

The safety pin is made from high grade steel and it is intentionally weaken to break at specific torque applied on servo arm.

The airplane command system must be capable to withstand the forces in the command system required to break the safety pin.

3 Electrical Installation

Servo motor has two electrical connections. The first one provides power for the electrical motor and the second one connects controlling device with the CAN bus. (The controlling device is hidden inside the servo motor).

3.1 Electrical Power

The autopilot servo motor must be connected to a 12 V DC standard aircraft power source. It is also possible to use 24 V DC power. The maximum current consumption for one servo motor is 1.5 A (at 12 V). Always protect servos with an automatic/replaceable fuse and a switch. The fuse protects against over-current and the switch allows quick disconnect by taking power from the motor. Figure 3 shows typical connection.

The *autopilot switch* must be easily accessible by the pilot. The pilot must be able to reach it in any moment.

3.2 CAN Bus

Servo motor must also be connected to the CAN bus. The controller module is built in the servo housing. The controller exchanges the information over the CAN bus. In addition, CAN bus is also used to power the controller. This means that controller works even when servo motors are without power.

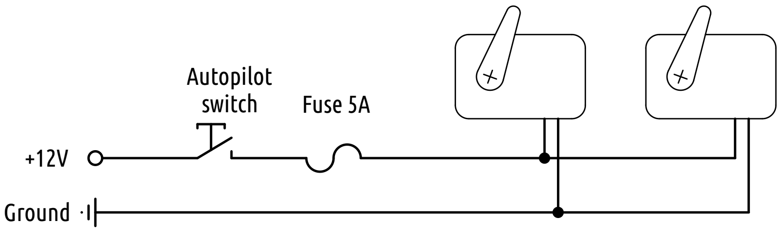

Figure 3: Typical connection of servo motor electrical power.

Figure 4 shows CAN bus connections for the minimal autopilot configuration. In reality more devices can be connected to the CAN bus. The CAN bus goes trough Nesis or Aetos, where it is internally connected to AD-AHRS-GPS module. On the servo side, T junction is needed and a short connection is made from T to the servo controller.

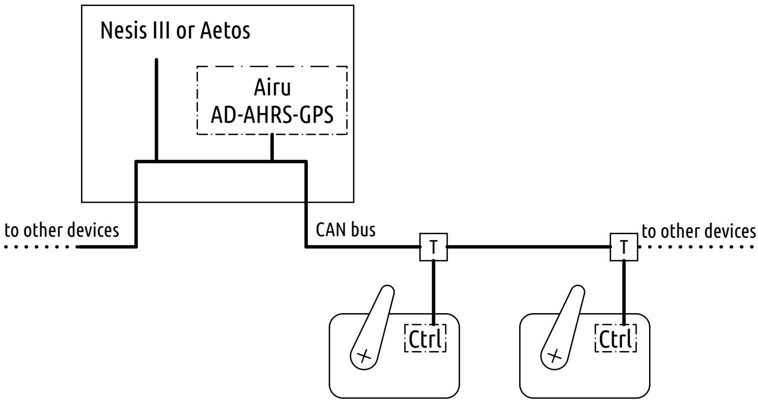

Figure 4: Typical CAN bus connection for minimal autopilot configuration.

Please note that CAN bus must be terminated with a 120 Ohm terminator on both ends of the main line. Terminators are not shown on Figure 4.

3.3 External Button For Autopilot Disconnect

It is advisable to install an external push button, which allows for quick autopilot disconnect command. The push button shall be installed on the command stick, where it is easily accessed by pilot. Two wires from the push button must be connected to the Nesis/Aetos service port. The connection details are given in the Nesis/Aetos installation manual, see *External Push Button* section.

Nesis/Aetos must be then configured to react on the push button event. When the button is pushed, the autopilot disconnect command is sent via CAN bus to both servo controllers, which will cut power of both servo motors.

Alternatively, Joyu command stick can be also used. Joyu has multiple programmable buttons and one of this buttons can be assigned to disconnect the autopilot.

4 Configuration And Tuning

For the autopilot to operate properly, controllers inside the servo motors must be configured properly. Once the initial configuration is complete, the whole system must be also tuned for every specific type of airplane. Both operations are done with the Nesis/Aetos.

The tuning of the autopilot requires flight testing. The flight test should be conducted on a clear, VFR day. Before commencing the flight test, ensure that you have adequate altitude, enough fuel, clear weather, no traffic, no obstructions in the flight path, great visibility, no airspace conflicts, etc.

4.1 Configuration

Autopilot settings are accessible from *Service options* page in the display. Special password (provided with the instrument) must be entered to access the Service options page. The password can be also found under the *Info* icon. Figure 5 shows the main autopilot settings menu.

The following options are available:

`Servo` is used to configure servo motors.

`Motor test` is used to test servo motors on the ground. It allows to identify correct control movements.

`Limits` is used to define operational limits of the autopilot.

`Tune` is used during in-flight tuning of PID regulator inner and outer loops.

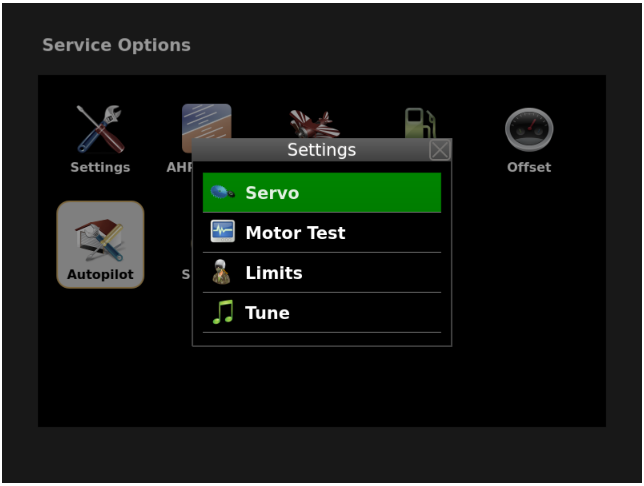

Figure 5: Main autopilot settings menu.

When setting up autopilot system a step by step approach is used. First check and adjust servo motor configuration, after this proper limiting values shall be entered and autopilot tuning shall be done at the end. Section 6 reveals the workflow for airplanes where autopilot parameters are already known.

4.1.1 Servo Motor Settings

Figure 6 shows and example of servo motor settings. Servo motors are identified by their serial number. We recommend that you write down which serial number is used for aileron and which for elevator.

In general, `PPR`, `Reduction` and `Top speed` shall not be adjusted and preconfigured values shall be kept. Change them only after contacting Kanardia support team if they give you instructions to do so.

The window allows configuration of following parameters:

`PPR` tells how many pulses are needed for one rotation of internal stepper motor (always 200 for current servos).

`Reduction` is the gearbox reduction factor between the arm and stepper motor. (This factor is 4.57 for recent servos. But factors between 4 and 5 are also in use.)

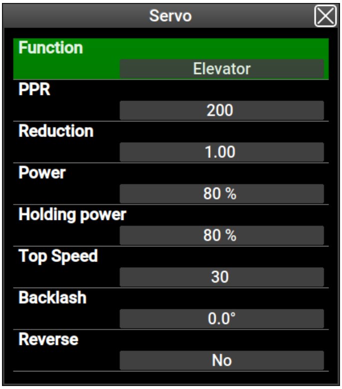

Figure 6: An example of servo settings window.

`Power` defines the relative value of electrical current, which flows through motor. This level defines the torque of the motor. A value of 100% yields maximum torque that motor can deliver.

`Holding power` defines how much torque is used when motor is not moving. This value depends on the power value above. If it is set to 50% this means that motor will use 50% of the torque set with the power parameter. For example, if power is set to 70% and holding power is set to 50%, the motor will use 35% of maximal torque at standstill.

`Top speed` is the maximum speed at which servo moves the arm. It is expressed in *deg/s*. This value is usually set between 30 and 60 deg/s.

`Backlash` defines the amount of command system *free* travel. In ideal circumstances this shall be zero.

`Reverse` is used to reverse the direction of the motor movement. Set this to `Yes` if the motor is moving in the wrong direction.

4.1.2 Operating Limits

Autopilot is allowed to operate only when airplane is withing operating limits of approved autopilot use.

The limits shall be defined by the airplane producer. The autopilot limits are much, much stricter than airplane capabilities. The limits are set around stable, coordinated flight at the economy cruise speed.

As soon as any parameter goes out of the limits, autopilot will be disconnected. The following limits must be set:

`Maximum IAS` ... set this slightly above the cruising speed. This shall be significantly less than VNE.

`Minimum IAS` ... set this slightly below the cruising speed. This shall be significantly more that stall speed. In fact, this shall be set above VFE.

`Maximum Vario` ... set maximal allowed rate of climb or descent.

`Maximum Roll` ... maximal allowed roll for autopilot operation. Set this to 30° or less.

`Maximal Pitch` ... maximal allowed pitch for autopilot operation. Set this to 12° or less.

All limits must be checked with a flight test after the tuning has been completed.

4.2 Motor Direction Test

The motor test options are used to check correct servo motor movement on the ground. Figure 7 illustrates available options.

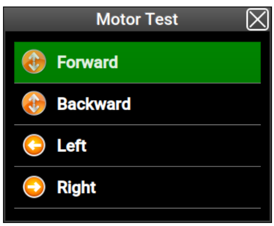

Figure 7: Motor test movement options.

`Forward` shall move the command stick slightly forward (nose down). Make sure that command stick is not fully forward before this command is issued.

`Backward` shall move the command stick slightly backward.

`Left` shall move command stick slightly to the left.

`Right` shall move command stick slightly to the right.

If any of the movements appear in wrong direction or it moves wrong command, you probably have to change the *Reversed* parameter or the *Function* parameter.

4.3 Tuning

After basic settings for autopilot operation were defined you may proceed with autopilot tuning. The `Tune` option activates the menu shown on Figure 8.

We recommend to tune elevator first and once the autopilot is able to hold the altitude correctly advance to the aileron.

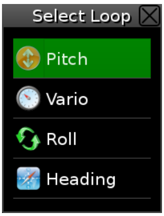

Figure 8: Selection of the loops.

Each servo has two loops. The elevator servo has *Pitch* inner loop and *Vario* outer loop. The aileron servo has *Roll* inner loop and *Heading* outer loops. You should always start with the inner loop first. The outer loops depends on the inner loop.

After the loop selection a new menu pops-up, which consists of two or three options, see Figure 9.

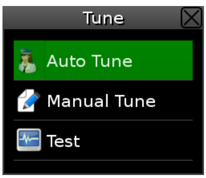

Figure 9: Tuning options for each selected loop.

4.3.1 Auto Tune

On Roll/Pitch controllers you also have the *Auto Tune* option. The automatic option can be used to quickly find workable tuning parameters. However these parameters are not always good and the *Manual Tune* shall be used afterwards.

4.3.2 Manual Tune

The *Manual Tune* window is used to set loop controller parameters. Figure 10 shows an example. The most important one is `P-term` a.k.a *gain*. You must keep changing it until the controller works appropriately. The loop adjustments must follow one important rule: One small change at one time.

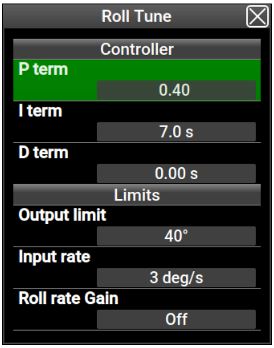

Figure 10: Example parameters of the Roll loop controller.

In manual tuning dialog you are able to change following parameters:

`Reference IAS` is reference IAS for parameter estimator (for time being it should be set to 100km/h or 60kts).

`P term` a.k.a *gain* defines controller's proportional part. **This is the main tuning parameter.** This parameter tells how much the servo arm should move proportional to the difference between reference and actual value of the controlling parameter.

`I term` is the integration time of the PID controller. It tells how fast the controller is trying to eliminate the steady-state error.

`D term` is the derivative time constant of the controller.

`Output limits` represents the maximum output value of the controller. For example, the output limit of heading controller is the maximum roll angle during the turn.

`Input rate` is the input rate limit of the controller. For roll loop this is maximum rate of change for bank angle reference. If the outer loop – heading control loop asks for a quick change in bank angle, the controller will limit the speed of change to the value entered here. The airplane will therefore make a smooth transition.

The last option is special and varies depending on the loop type. Heading loop is an exception and does not have any special option

`Roll rate gain` This value is normally disabled. When enabled, the roll control loop goes into special experimental mode, where the loop is based on angular rate rather than the roll angle.

`Vertical speed` This value sets the default climb/descent rate when autopilot is operating in altitude mode. Usually the 500 ft/min or 2.0 m/s rate is used here.

`Roll feed forward` is used by the pitch loop. This parameter is used in cases where aircraft pitches down in turns. Usually the value used here is between 0.2 and 0.5. If the aircraft does not loose altitude in turns, set this parameter to 0.

4.3.3 Tune Test

When the *Test* mode is activate current loop set point can be compared with the actual value. The chart shows time series of both parameters.The reference value is an actual set-point for the loop currently tuned. For the pitch loop the autopilot is expected to follow the pitch angle. For the roll loop it must follow the roll (bank) angle, etc.

Figure 11 gives the graphical (chart) representation of two values. The red line is the input value or reference of the controller. This is the value we want the controller to follow as much as possible. The blue line is an actual flight parameter.

For Pitch tuning the red line is the wanted pitch (current set point) and blue line is the actual pitch. When the window opens the current observed value is set as a reference. For example, if heading loop is being tested and the current heading is 250° the reference is set to 250° and the autopilot is activated to track this angle.

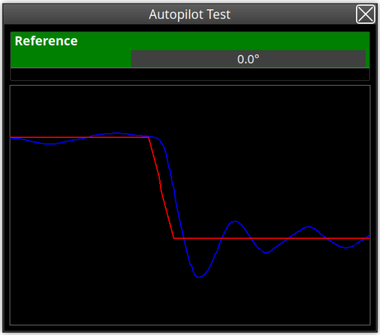

Figure 11: An example of test window for the roll loop. Red line is reference, which has changed from 5 to 0 °and the blue line is airplane response.

A click on the *Reference* item opens a new window. The window enables change of the reference value. The newly entered value becomes a new reference value immediately after the change and it reflects on the time series chart.

4.4 Tuning

The tuning of the autopilot requires flight testing. The flight test should be conducted on a calm, VFR day. Before commencing the flight test, ensure that you are at the safe altitude, you have enough fuel, clear weather, no traffic, no obstructions in the flight path, good visibility, no airspace conflicts, etc. It is recommended that clearing turns are performed before executing each procedure.

It is highly recommended that you bring someone along on the first autopilot test flight. At many points the pilot's attention will be divided between documentation, tuning autopilot, and maintaining situational awareness.

The operator has to tune (guess) the optimal values for four (4) controlling loops: roll, pitch, vario (rate of climb/descent) and heading. From experience it is rarely needed to tune vario and heading loops because default values are usually good enough. Default values can be also kept for the limits and reference IAS. The operator usually needs to tune only two loops with three parameters inside each loop: P term, I term and D term. But also for this three parameters only P term *gain* is usually tuned. In many case, default values for I and D terms can be used.

4.4.1 P-term of Pitch And Roll

The operator will be switching between the *Manual Tune* and the *Test* windows. Parameters will be changed in the *Manual Tune* and the controller response will be observed in the *Test* window.

First the sign of P-term for *Pitch* and *Roll* control loop shall be established:

1. Go to `Manual tune` and set the P-term to a suitable value taken from a similar airplane. See section 4.4.2.
2. Go to `Test` and enter a reference set-point (for pitch enter zero). The aircraft should try to follow 0 pitch angle (reacting slowly or oscillating up and down). Both responses are correct at this stage. You can skip to *P-term* tuning.
3. If airplane just pulls up or down until the autopilot exceeds the limits (without any other action), the sign of the P-term has to be reversed. Go to *Manual tune* and change `Reverse` from `No` to `Yes` or vice versa.

Once the sign of the P-term has been determined, P-term value must be found. Note: This is just a precaution. The correct direction should be already checked by procedure described in section 4.2.

1. Go to `Test` mode and enter a reference value. A typical reference value for pitch is between -5 and +5 degrees. Start with zero degrees. Observe the response:
   - If the response is lazy the P-term has to be increased.
   - If the response is jumpy (the airplane is oscillating) the P-term has to be decreased.
2. Go to the `Manual Tune` and change the P-term. Increase or decrease it by approximately 20% in one step (from 0.5 to 0.4 for example).
3. Go back to point (1) until satisfying result is obtained. Only after parameters of one loop has been obtained, the operator should move to the next one. It is recommended to make notes of values and comments about responses during the test flight.

4.4.2 Parameters For Known Airplanes

Tables in this section list the tuning parameters for autopilots we have installed in different airplanes.

Some loops given below are using special values. RFF means Roll Feed Forward, VS is Vertical Speed, RRG means Roll Rate Gain.

Table 1: Ekolot Topaz

Parameter	Pitch	Vario	Roll	Heading
P-term	1.0	0.018	0.8	0.75
I-term	14.0	19.0	10	28
D-term	0.16	0.16	0.02	0.3
Output limit	40°	12°	40°	20°
Input rate	10.0°/s	1.5 m/s^2	3°/s	0°/s
Special	(RFF) 0.0	(VS) 3 m/s	(RRG) Disabled	-

Table 2: Pistrel Sinus

Parameter	Pitch	Vario	Roll	Heading
P-term	0.5	0.02	0.5	1.0
I-term	7.0	12.0	8.0	25
D-term	0.16	0.2	0.02	0.2
Output limit	40°	12°	40°	20°
Input rate	5.0°/s	1.5 m/s^2	3°/s	0°/s
Special	(RFF) 0.0	(VS) 3 m/s	(RRG) Disabled	-

Table 3: Legend 540

Parameter	Pitch	Vario	Roll	Heading
P-term	0.65	0.017	0.9	0.6
I-term	4.0	15.0	6	26
D-term	0.2	0.32	0.16	0.2
Output limit	40°	10°	40°	20°
Input rate	5.0°/s	1.0 m/s^2	3°/s	0°/s
Special	(RFF) 0.2	(VS) 3 m/s	(RRG) Disabled	-

Table 4: Eurostar EV97

Parameter	Pitch	Vario	Roll	Heading
P-term	0.4	0.025	0.7	0.9
I-term	7.0	12.0	8	26
D-term	0.0	0.2	0.2	0.2
Output limit	40°	12°	40°	20°
Input rate	3.0°/s	1.5 m/s^2	5°/s	0°/s
Special	(RFF) 0.3	(VS) 3 m/s	(RRG) Disabled	-

Table 5: Aerospool Dynamic WT9

Parameter	Pitch	Vario	Roll	Heading
P-term	1.2	0.017	0.6	0.6
I-term	6.5	15.0	4.5	26
D-term	0.52	0.32	0.4	0.2
Output limit	30°	10°	30°	20°
Input rate	3.0°/s	1.0 m/s^2	3°/s	0°/s
Special	(RFF) 0.2	(VS) 2.5 m/s	(RRG) Disabled	-

Table 6: Roko NG-6

Parameter	Pitch	Vario	Roll	Heading
P-term	1.2	0.017	0.6	0.6
I-term	6.5	15.0	4.5	26
D-term	0.52	0.32	0.4	0.2
Output limit	30°	10°	30°	20°
Input rate	3.0°/s	1.0 m/s^2	3°/s	0°/s
Special	(RFF) 0.2	(VS) 2.5 m/s	(RRG) Disabled	-

Table 7: A22 and A32

Parameter	Pitch	Vario	Roll	Heading
P-term	1.9	0.020	0.45	0.45
I-term	5.0	20.0	5.0	22
D-term	0.2	0.2	0.16	0.3
Output limit	30°	10°	40°	20°
Input rate	4.0°/s	1.0 m/s^2	5°/s	0°/s
Special	(RFF) 0.2	(VS) 2.5 m/s	(RRG) 2.0	-

5 Safety Measures

> Autopilot system is not terrain or traffic aware and it will not make any avoidance action or issue any terrain warning!

The autopilot is directly linked with aircraft commands thus it presents high risk if something fails or goes wrong. Kanardia autopilot is using following safety measures in order to reduce this risk to a minimum.

- Automatic disable when aircraft is outside safe operating limits.
- Multiple Manual disable options.
- Servo power switch immediately cuts the power of servo motors.
- Motor override – the servo motor can be safely overridden, but the commands are jerky.
- Safety pin will break if the motor or gears inside is mechanically blocked.
- Mechanical limiter limits the movement of the motor lever preventing mechanical lock-up.

The servomotors are designed to be over-driven with external force from command stick with no damage.

5.1 Automatic Disable

The Autopilot will disengage automatically and immediately when any of the following values is out of the range:

- minimum autopilot IAS,
- maximum autopilot IAS,
- maximum autopilot vertical speed,
- maximum autopilot roll angle,
- maximum autopilot pitch angle.

This values must be configured correctly and they depend on the type and performance of the aircraft. See section 4.1.2 for limit details.

5.2 Manual Disable

The following ways may be used to disable autopilot system manually:

1. Select the *Disable* option from the autopilot menu of Nesis/Aetos.
2. Press the *User* button when the autopilot menu is active (double click on user button).
3. Make a long press on the *User* button – the long press function must be properly configured.
4. When an external push button is installed on a command stick, press the button to disable the autopilot. Nesis/Aetos must be properly configured.
5. When *Joyu* is connected to the CAN bus and its buttons are properly configured, press (or long press) the corresponding button on Joyu.
6. When *Amigo* is connected to the CAN bus, press the top knob to disconnect aileron servo and bottom knob to disconnect the elevator servo.
7. On Nesis only, make a long touch on autopilot status window.

5.3 Electrical Disable

The autopilot motors are disconnected as soon as power supply is removed. Therefore it is essential that the power to the servo motors can be cut with removable fuse or with a separate switch. See section 3.1 for more details.

5.4 Mechanical Disable

The servo motor torque is small enough that it can be overridden by higher force in the command stick even when servo is operating with 100% torque. However, the commands feel jerky and precise steering is a bit challenging.

Safety pin is the inserted between the servo arm and the servo motor shaft. In the very unlikely case of blocked motor or blocked gears, pilot can use force on the command stick, which will break the pin and release servo motor shaft from the command system.

6 Quick Configuration

This is a quick reminder of Nesis/Aetos commands inputs required to configure the autopilot system for a know airplane.

6.1 Configure Servos

Define which servo is used for elevator and which for aileron. Write down their serial numbers.
Options ⇒Service Mode ⇒Autopilot ⇒Servo ⇒Select Serial number.

Now configure the motor as *elevator* or as *aileron*. Other values are:

- PPR : 200
- Ratio: 4.5
- Power: 80%
- Holding power: 80%
- Reversed - select `Yes` or `No` depending on the results of the *Direction Test*.

6.2 Direction Test

Options ⇒Service Mode ⇒Autopilot ⇒Test.

Press move forward, backward, left, right. The yoke/stick should move in the correct direction. If the movement is opposite, change the `Reversed` parameter in Servo Configuration.

6.3 Operating Limits

Options ⇒Service Mode ⇒Autopilot ⇒Limits.

- Minimum IAS: 140 km/h
- Maximum IAS: 200 km/h
- Maximum vario: 6 m/s

- Maximum Roll: 30°
- Maximum Pitch: 12°

Values shown above are given for example only – use appropriate limits for your airplane. If the aircraft exceeds this limits the autopilot will disengage immediately and the reason will be shown on the display.

6.4 Tuning

Enter values from tables given in section 4.4.2.
Options ⇒Service Mode ⇒Autopilot ⇒Tune and then:

- Pitch ⇒Manual tune,
- Roll ⇒Manual Tune,
- Vario ⇒Manual Tune,
- Heading ⇒Manual Tune,