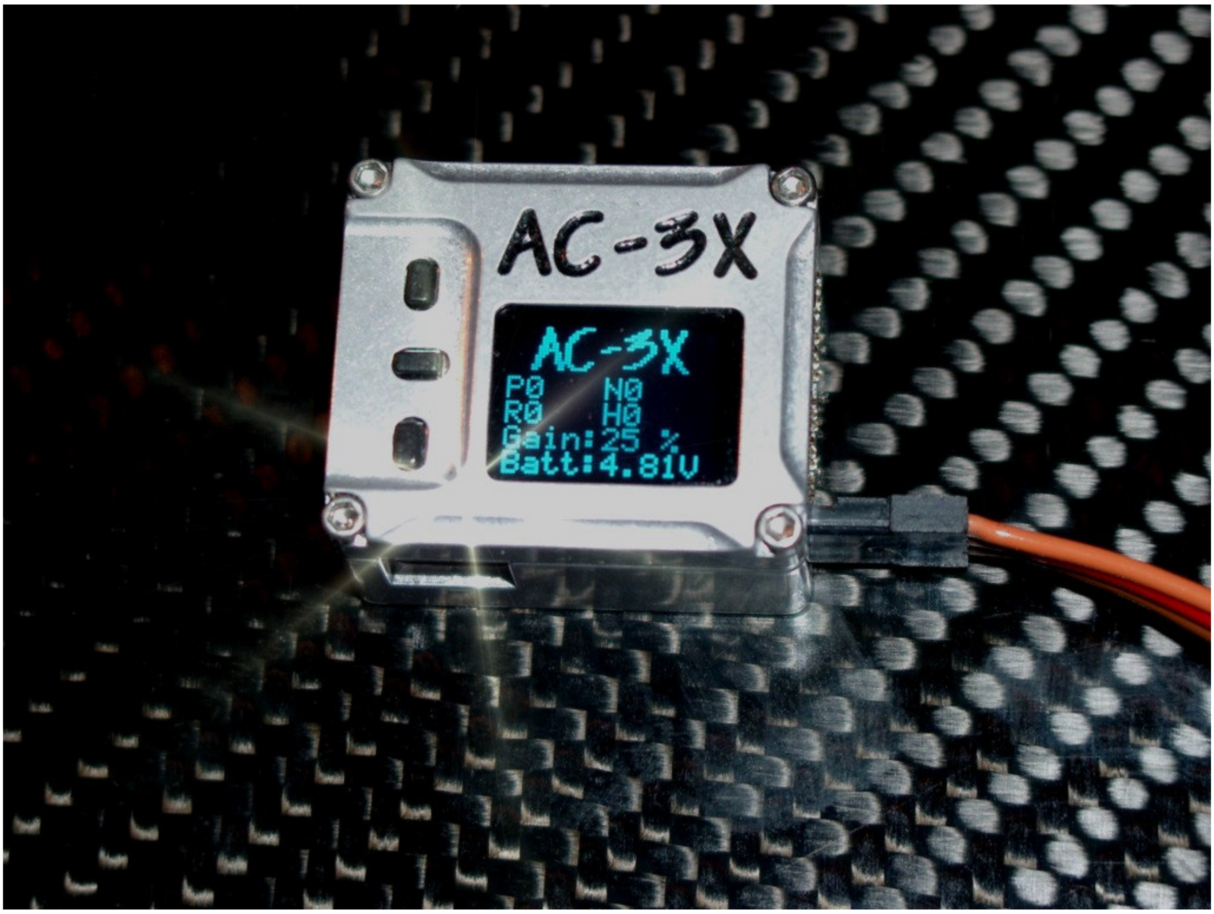
Manual

AC-3X

(ACRO Control - 3 Axis)

Software Version 4



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Software History AC-3X:

SW Version	Changes
2	- first officially released version
3	- optimized sensor calibration to prevent servo drifting on ground
4	- optimized tail algorithm - parameter switching for different flight conditions - Gain Lock function - USB-Port activated - simplified setup of gyro sense and the direction of the axis rotation - servo output directly after power up (Savox and Align servos are now supported) - synchronic swash plate rotation for all swash servos

1. Introduction

AC-3X is a synonym for Acro Control 3-Axis, a state of the art flight control stabilization for radio controlled helicopters. The goal of the development of AC-3X was to create a flight control stabilization for flybarless helicopters which ensures a flight performance far beyond a normal Bell Hiller rotor head, reachable with a minimum of adjustment effort. Beside this, the flight stability and neutrality of a good conventional rotor head should have been kept. The system should be small an light enough to be installed in small electric helicopters and the setup of the system should be possible without any other equipment but helicopter and transmitter.

AC-3X is using intelligent PI-control algorithms on all three axis which are fed by the signals of three SMM-Gyro sensors to control the helicopter motion. During the design of the control algorithms special focus was set on the stopping behavior from fast rotations. Without knowledge of the Eigenfrequencies of the helicopter the AC-3X algorithms are able to stop the helicopter from rotation without any oscillation tendency. The integrated tail gyro has an intelligent feed forward control to reduce torque effects.

A highlight of AC-3X is the calibrated and uncoupled sensor unit. Every individual AC-3X runs through a calibration process which ensures that the three axis (elevator, aileron and tail) are perfectly uncoupled and thus e.g. rolling figures are in line without any corrective steering inputs on elevator. The same is with pirouettes, the rotor disc stays very stable while pirouetting. Beside this the sensors are also temperature compensated so that even at very high temperature changes no drift effects are noticeable during flights.

As a result the AC-3X user obtains a high agility and a neutral and also very stable flight with one single setup. Thus an AC-3X controlled helicopter can be used for 3D aerobatics and smooth F3C-like flying without any modification on the helicopter.

AC-3X includes an universal 3-servo swash plate mixer so that no additional mixing in the transmitter is needed. As swash plate servos any servo with 1.5 ms neutral pulse length can be used. The swash plate servo framerate can be varied in a wide range from 50Hz to 200Hz.
The tail gyro supports all of the state of the art servos with 1.5ms neutral pulse width (standard digital servos), 960µs pulse length (Logitech) and 760µs (Futaba S9251/S9256 or BLS 251). The framerate for the gyro servo can be selected to be 165Hz or 330 Hz. The power concept of AC-3X ensures a save function even under low voltage conditions below 3V. AC-3X was developed with special regard on low electromagnetic emissivity so that AC-3X can be combined with any kind of RC-equipment without any influencing.

Sensors and controller of AC-3X are integrated in one single aluminum housing, no extra volume is needed for a processor unit. The user interface of AC-3X is realized with a blue OLED-display and three pushbuttons. The brightness of the display assures sufficient contrast even under bright daylight conditions. Via the integrated diplay the user can overview many important status informations like stick positions or the rc-battery voltage with a single look. The programming is very intuitive. After reading this manual once, you should be able to setup AC-3X without any further help.

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Technical Data AC-3X:

Weight	app. 20g without wiring
Size (LxWxH)	31mmx26mmx15,5mm
Supply voltage	3-9 Volt (including 2S Lipo)
current (typ.)	60 mA
Resolution of ADC for sensors	12 Bit
CPU	32 Bit 72MHz RISC

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2. Overview Setup menu AC-3X

In this chapter the user interface of AC-3X is described. The structure of the setup menu is shown in the flowchart in Figure 1.

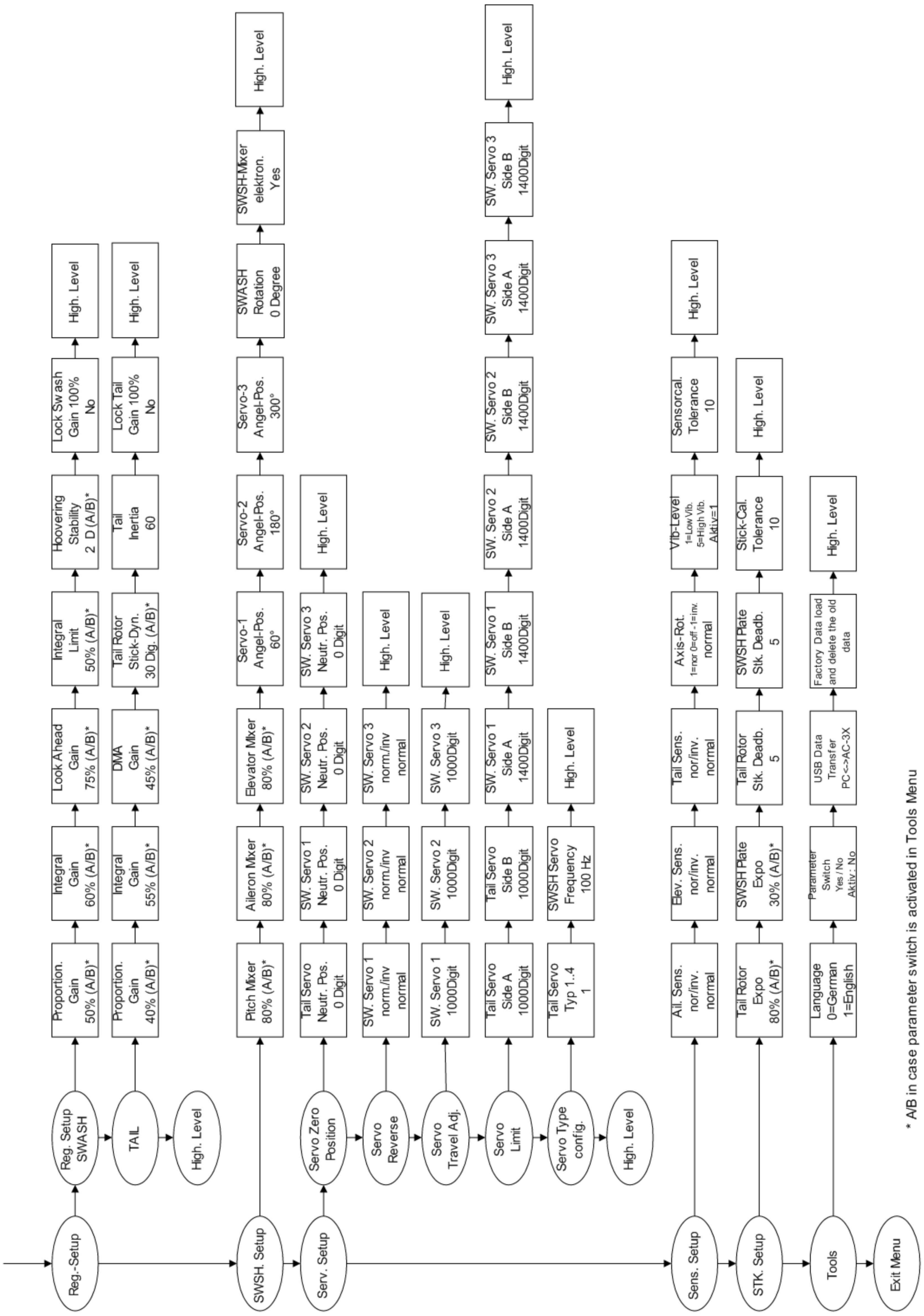

Figure 1: Flowchart AC-3X setup menu.

2.1. Navigation in the setup menu

There are two possibilities to enter the setup menu. When AC-3X is powered up one can press any of the three pushbuttons while the AC-3X Logo is shown and AC-3X will enter into setup menu. When AC-3X is already in operational mode the user can press on the uppermost button for at least one second and AC-3X will also go into setup mode. The structure of the setup menu is shown on the flow chart on the page before.

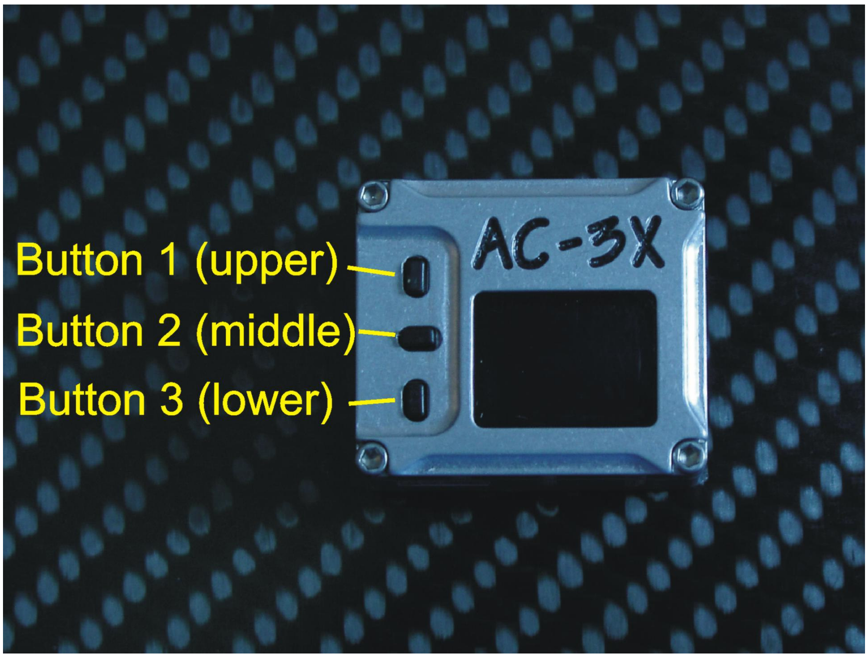

Figure 2: AC-3X navigation pushbuttons

The navigation through the menu is done with the upper and lower pushbuttons: Pressing the upper button leads to the next item in the menu, pressing the lower button to the item before. To enter in the underlying menu structure one has to press the middle button. In case one is already on the lowest layer of the menu where the parameters are changed, the middle button is used to select a parameter to modify it. When a parameter is selected, it is displayed in larger size and it's value can be increased by pushing the upper button or decreased by pushing the lower one. To safe the changes one has to press the middle button again and the changed value of the parameter is stored to the eeprom and the above lying menu is displayed. Every layer of the menu has one exit element (High. Level) which leads to the layer above. To select it, the user also has to press the middle button. When you are already on the highest level of the setup menu, the "High. Level"-Button leads to the active flight state of AC-3X where the control loops are active.

At this point one important note: please always take care that you never try to fly in setup mode. The control loops are inactivated in setup mode and thus the helicopter is not controllable!

After describing the use of the setup menu, I will describe the different menu items. Menu items marked with (A/B)* will appear twice when parameter switching is activated in the tools menu. The menu is structured in:

2.2. <u>Reg.-Setup (Regulator Setup)</u>

In this menu the parameters for the PI-controllers of the swash plate and the tail are summarized. It consists of two separate submenus, one including the swash plate parameters and the other including the tail rotor parameters.

2.2.1. Reg.-Setup SWASH

The parameters for the swash plate are.

<u>Proportional Gain:</u>
Proportional Gain produces an regulative action on the swash plate which is proportional to the measured rate error on the swash plate and thus proportional gain makes the aileron and elevator rate follow the rate commanded on the swash sticks. A to high proportional gain can cause a oscillating tendency on elevator in fast forward flight and also a bad stopping behavior on elevator rate changes. Abrupt stops of flips should be free of high frequency shaking. If this is not the case the proportional gain is to high!
To setup proportional gain one should increase it until one sees a wiggling tendency in fast forward flight. From this value one should decrease proportional gain by a quarter. Normally the default value of 50 is a good compromise which won't cause oscillations even with slow servos on the swash plate. With fast servos on swash plate one can increase proportional gain.

<u>Integral Gain:</u>
Integral gain is responsible that the helicopter keeps the direction under all circumstances. When wind forces the helicopter out of its direction, the integral gain is correcting this. Fast forward flight is also stabilized by the integral gain. Integral gain must be setup so that the helicopter stable during load changes on swash plate. When integral gain is set to high, the stopping behavior on swash plate is influenced negatively: the helicopter gets a tendency to slowly drift back after a hard stop. A to high integral gain has also bad influence on fast forward flight: The elevator control feeling becomes doughy and in extreme situations even slow oscillations (approx. 1 Hz) can appear. Thus one should start the first flights with the default value of 60 for the integral gain which is working even with very slow servos. With fast swash servos integral gain can be increased after the first flights in order to get more flight stability.

<u>Look Ahead Gain:</u> Look Ahead gains a parameter that determines the direct control of the swash plate. One should use a value which leads to 5-7° cyclic angle on the rotor head on full cyclic stick travel with inactivated proportional and integral gain (P=0, I=0). When this is the case, the helicopter can approximately follow the sticks without any assistance of proportional gain or integral gain and the proportional and integral controllers have only to compensate the difference to the commanded rate. Look ahead gain also changes the acceleration and stopping behavior on cyclic inputs. The more look ahead gain is used, the faster the helicopter corresponds to inputs. But be aware, very high look ahead gains result in a drift back tendency on cyclic stops. The default value is 75.

<u>Integral Limit:</u> Integral Limit is a parameter which influences the "nose up tendency" in fast forward flight. At high speeds the helicopter should keep trace on fast pitch changes. If this is not the case, one should increase the integral limit. The default value of 50 is ideal for a 1-

1.3m rotor diameter helicopter with neutral blades. For .90 sized helicopter one can decrease integral limit to around 30.

Hoovering Stability: The parameter Hoovering Stability can be setup in four steps (1-4). The larger the value, the more stable the helicopter behaves under windy conditions but the reaction of the helicopter on cyclic rate changes is also reduced. The default value 2 normally should not be changed

Lock TS Gain 100%: By activating this menu item, the swash plate gain is uncoupled from the gain channel and thus permanently set to 100%. When also the tail gain is locked, AC-3X can be operated without an RC gain input.

2.2.2. TAIL

Under TAIL the following parameters for the tail regulator setup are summarized:

Proportional Gain: Proportional Gain generates a steering signal on the tail servo which is proportional to the rate error. The higher proportional gain is, the more direct the tail follows the stick. To setup proportional gain one should increase it until the tail has a high frequency shaking tendency and the decrease it by one third. The default value is 45. The proportional gain depends strongly on the individual tail setup. Especially at larger helicopters with low tail power it can be increased by a factor of two.

Integral Gain: The Integral Gain corresponds to the heading hold gain of a normal gyro. It is used to produce an angular control of the tail. The higher integral gain is set, the more constant the tail rate will be. A to high value will result in a bad stopping behavior with a back drifting tendency. When integral gain is to low, the tail is unstable on heavy pitch inputs and can not hold the position. The integral factor is almost independent on the tail setup of the helicopter. Typical values are 50-60 (default 55).

DMA Gain: This parameter generates a torque feed forward on cyclic and collective steering inputs. The tail has to compensate all torque changes resulting from steering inputs on the main Rotor. This feed forward helps to reduce the corrective action on the P and I channel and thus generates a more stable tail. It can be either positive or negative (-100 to +100) depending on the tail geometry. To set up this parameter one should hoover and the suddenly give hard pitch inputs and watch the tail of the helicopter. While pitching it will shake following the torque of the rotor head. One hast to increase the value of DMA Gain until the tail movement on pitch inputs has a minimum. When the value is to high it can happen that the tail even moves against the torque! On my acrobat helicopters one can use the default value 45 unchanged. On other helicopters this value has to be adapted individually.

Tail Rotor Stick-Dyn.: This parameter limits the reaction on rate changes on the tail stick. The larger the value is set, the more dynamic is feed through to the tail servo. The default value of 20 is adapted to the maximum agility of my Acrobat Shark. For smaller helicopters one can increase this parameter to 25-30. In large scale helicopter with less power on the tail one should limit this parameter to 10-15.

Tail Inertia: This parameter represents the moment of inertia of the helicopter around the main shaft axis. When starting or stopping pirouettes the tail rotor has to accelerate against this moment of inertia. The default value of 50 is appropriate for all typical helicopters with a size larger than an Acrobat SE. In case that the tail has a visible bouncing during a stop from a fast pirouette, this parameter has to be adapted. For small helicopters it has to be reduced, for large one it might be necessary to enlarge it slightly.

Lock Tail Gain 100%: By activating this menu item, the tail gain is uncoupled from the gain channel and thus permanently set to 100%. When also the swash plate gain is locked, AC-3X can be operated without an RC gain input.

2.3. SWSH. Setup

Pitch Mixer: The Pitch Mixer determines the traveling path of the swash servos on pitch inputs. The default value is 80. To change the pitch direction the sign in the pitch mixer has to be changed. To change pitch values in AC-3X one has to use the Pitch Mixer **and not** the Servo Travel adjustment!

Aileron and Elevator Mixer: The Aileron and Elevator Mixers are used to setup the aileron and elevator rates of the helicopter. In difference to the Pitch Mixer the Aileron and the Elevator Mixer doesn't influence the servo travel on the cyclic inputs. This must be done via travel adjustment and the length of the servo levers. A change of sign in the Aileron and Elevator Mixer changes the direction of Aileron or Elevator. The default value on booth parameters is 80% and should be used for the first flights. 100% corresponds to relatively high agility comparable with a small helicopter with conventional rotor head.

Servo 1-3 Angel-Position: This three parameters determine the servo position on the swash plate. 0° corresponds to a linkage point which is oriented in flight direction. If one looks on the helicopter from above, the angels are defined clockwise. 60° is the default position for Servo 1 (right aileron servo on 120° swash plate), Servo 2 is at 180° (elevator servo on 120° swash plate) and Servo 3 at 300° (left aileron servo on 120° swash plate). The servo positions must be adapted to the individual helicopter.

Swash plate Rotation: With this parameter the swash plate can be rotated as a whole by +-90°. It is also operative when the electronic swash plate mixing is deactivated. The default value of this parameter is 0.

SWSH-Mixer Electron: This parameter activates the electronic swash mixing. When it is activated (1=default) the electronic mixing with the servo positions defined above is assumed. When it is not activated AC-3X assumes an mechanical mixed helicopter with servo 1 being pitch, servo 2 aileron and servo 3 elevator.

2.4. <u>Servosetup</u>

2.4.1. Servo Zero Position

<u>Tail Servo Neutral Position:</u> This parameter determines the neutral position of the tail servo. The lever should be mounted to the servo in a way that at 0 of this value the level is oriented almost perpendicular to the servo housing. The exact orientation can be done with this parameter.

<u>SW-Servo 1-3 Neutral Position:</u> This three parameters influence the neutral positions of the swash plate servos. The levers should be mounted to the servos whit this parameters set to 0. The levers must be oriented as good **perpendicular to the leverage** (not necessarily to the servo housing) to the swash plate as possible. Fine corrections then can be done with the neutral position parameters for each servo individually.

2.4.2. Servoreverse

<u>SW-Servo 1-3 norm./inv.:</u> With this three parameters one can change the direction of rotation of the swash servos.
A change of direction of the tail servo is not needed, the right direction is set via servo reverse in the transmitter.

2.4.3. Servo Travel Adjustment

<u>SW-Servo 1-3:</u> This parameters control the traveling path the swash servos do. The default value is 1000. When it is not possible to get a mechanical gear ratio from the servos to the blade grips that leads **with activated menu and default values in the swash mixer (Aileron 80, Elevator 80)** on aileron or elevator to an cyclic angle of 7°, than the swash Servo travel paths can be changed with this parameters. If the default value needs to be changed by more than 300 digits then the servo levers should be adapted! The swash regulator of AC-3X works better the closer the travel adjustment value is to 1000 to get the 7° cyclic on the blades!

2.4.4. Servolimit

<u>Tail Servo Side A:</u> This parameter limits the travel path of the tail Servo in direction A in order to avoid a mechanical blockage. Default value is 1000. The lever length on the tail Servo should be selected in a way that the limit lies between 900 and 1200.

<u>Tail Servo Side B:</u> This parameter limits the travel path of the tail Servo in direction B in order to avoid a mechanical blockage. Default value is 1000. The lever length on the tail Servo should be selected in a way that the limit lies between 900 and 1200.

<u>SW Servo 1-3 Side A:</u> This values limit the maximum travel path of each swash servo in direction A. In case of mechanical limitations it can be used to avoid an blockage. The default value is 1400

<u>SW Servo 1-3 Side B:</u> This values limit the maximum travel path of each swash servo in direction B. In case of mechanical limitations it can be used to avoid an blockage. The default value is 1400

2.4.5. Servo Typ Config.

Tail Servo Typ 1-4: With this parameter the neutral pulse length and the framerate of the tail servo is choosen. The following four setups are supported:

	Framerate	Center Pulse length	Examples
Typ1	165Hz	1500 µs	Standard tail servos (Futaba 9253/4/7, DS8700 etc.)
Typ2	330Hz	1500 µs	same, but operated at high framerate
Typ3	330Hz	760 µs	Futaba 9251/9256/BLS251
Typ4	330Hz	960 µs	Logitech tail servos

Typ 1 is default.

SWSH-Servo Frequency: This parameter controls the framerate with which the swash plate regulator algorithm is calculated and the swash servo signals are updated. Values from 50-200 Hz are possible. Most digital Servos can handle 200 Hz (e.g. Futaba). With analog servos the SWSH frequency should be limited to 50-80 Hz. The update frequency has a big influence on the grade of the swash plate stabilization. The higher the frequency is, the better the swash plate is stabilized. The default value is 100 Hz. Note: Some digital servo types can not handle frequencies up to 200 Hz. If your servos behave somehow strange or get very warm, please reduce the frequency until this misbehavior vanishes!

2.5. Sensor Setup

Ail. Sens. Norm/Inv.: This parameter can change the direction of the sensor on the aileron axis. The sensor direction must be set in a way that the regulator compensates the swash plate movement when the helicopter is tilted around the aileron axis. In this menu all stick inputs in AC-3X are deactivated so that the servos only react on the sensors. The servos do not automatically go back to the center position!

Elev. Sens. Norm/Inv.: This parameter can change the direction of the sensor on the elevator axis. The sensor direction must be set in a way that the regulator compensates the swash plate movement when the helicopter is tilted around the elevator axis. In this menu all stick inputs in AC-3X are deactivated so that the servos only react on the sensors. The servos do not automatically go back to the center position!

Tail Sens. Norm/Inv.: With this parameter one can invert the direction of the tail stabilization. It must be set in a way that tail movements are damped. When the helicopter is rotated around the main shaft, the tail blade rear ends must move to the same direction in which the tail is moving. In this menu all stick inputs in AC-3X are deactivated so that the servos only react on the sensors. The servos do not automatically go back to the center position!

Axis-Rot Nor./ Off/ Inv.: This parameter controls the rotation direction of the swash plate in pirouettes. When entering to this menu item, all stick inputs are deactivated and the swash plate tilts into forward or backward direction (depending on the servo geometry). When you now turn the helicopter by 90° around the rotor axis, the swash plate tilt should rotate into opposite direction than the helicopter. E.g. rotating the helicopter counterclockwise, the swash plate tilt should rotate clockwise so that in principle the position of the swash plate doesn't change with respect to the room. One also can deactivate the swash plate rotation in this menu.

Vib-Level 1=Low Vib. 5=High Vib.: With this parameter one can influence the vibration sensitivity of the sensors. When a drift on one of the three axis appears under high vibrational conditions, then changing this parameter from 1 (default) to a higher value will help to overcome this problem. The Vib. Level Parameter should be choosen as low as possible as the lower it is, the higher the sensor resolution is. When one can not get rid of drifts by changing the Vib Level parameter, then the AC-3X should be mounted softer or even with a little ballast plate sticked right below AC-3X which shifts the resonances of the mounting to lower frequencies.

Sensorcal. Tolerance: The calibration of the sensors works in the following way. First a reference value for the sensor signal on each axis is measured, then the controller waits some time and then a second measurement is done which is compared with the first one. When the deviation is larger than the Sensor Calibration Tolerance value setup in this parameter, the calibration is done once again. The default value is 10. with this value after approx. 10s the calibration is usually finished when the helicopter is on the ground and without any movement. When one reduces this value, the calibration is more accurate but might take longer. Values below 4 should not be used as the calibration effectively won't be finished in reasonable time.

2.6. STK.-Setup

Tail Rotor Expo: This parameter is used to adjust expo feeling on the tail stick. With the default value of 80 the stick feeling should be like an Futaba GY in F3C mode. The higher this value is, the less the tail reacts around midstick.

SWSH Plate Expo: This parameter is used to adjust expo feeling on cyclic inputs. With the default value of 30 the stick feeling should be like with an normal Bell Hiller Head without Expo. The higher this value is, the less cyclic reacts around midstick.

Tail Rotor Stk Deadb.: The stick deadband sets a limit on the tail stick inputs below which the input are ignored. The default value of 5 corresponds to 0.5% of a full stick travel. When the transmitter has no poti drifts, one can set this parameter to 0.

SWSH Plate Stk. Deadb.: Also on cyclic a lower limit for the stick inputs can be set to suppress very small steering inputs. The default value for this parameter is 5. With good transmitter potis this value can be set to 0.

Stick-Cal. Tolerance: The calibration of the middle position of the sticks on cyclic and tail works in the same way as the sensor calibration: two values are taken on each channel an compared with each other. The maximum acceptable deviation is set with this parameter. The Default value is 10. With good transmitter potis it can be lowered. But be careful, a too low value will lead to very long calibration times or will even cause an RC-calibration failure.

2.7. Tools

Language: With this parameter the language can be changed from German to English and vice versa.

Parameter Switching: In this menu item a mode can be activated in which one can choose between two sets of control parameters by switching the gain input (see Figure 3). When it is activated all items marked by (A/B)* in the flowchart in Figure 1 appear twice, once for the parameter set A and once for the parameter set B. When activating parameter switching, all parameters from set A are copied to parameter set B. This is done in order to avoid that non fitting parameters can cause a damage of the helicopter. The parameters then can be edited individually. But be careful: by deactivation of parameter switching all changes done on set B will be lost as with the next activation of parameter switching, set A will be copied to set B once again!

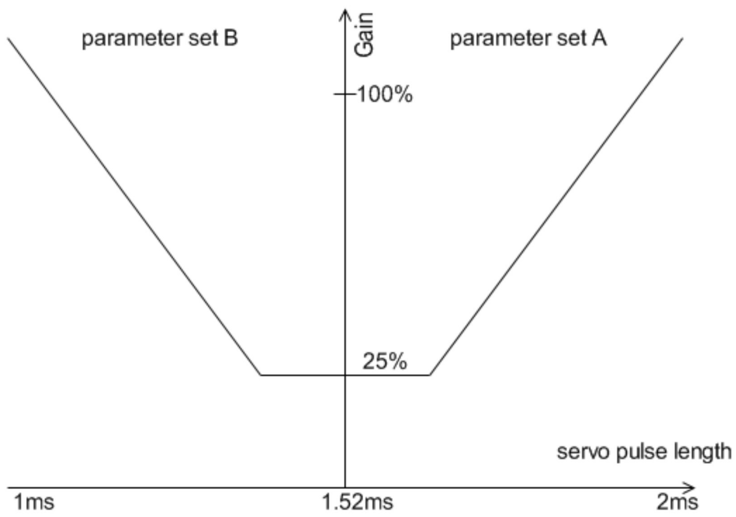

Figure 3: Switching between parameter sets

USB Data-Transfer: In this menu item the USB communication of AC-3X can be activated. A Software to store the AC-3X parameters on a PC will be available until Summer 2009.

Load Factory data and delete old data: This function sets all parameters to factory data. **All configurations will be lost!**

3. First flight in 7 Steps

This chapter describes how AC-3X is integrated into a helicopter and how the transmitter should be programmed to get good flying performance with. In comparison to an normal rigid helicopter without electronic swash plate stabilization with AC-3X one can get a neutral helicopter with almost any rotor blade. To get optimum performance it is important to do the basic setup in the workshop very accurate. Thus I recommend to follow all the steps described in this chapter and to assure yourself after every step that you have reached the step as described. When you do so, you will get good flying performance without major programming effort on the flying field.

3.1. Preparation of the Helicopter

First let me point out some basics to be kept in mind when operating a helicopter with an electronic swash plate stabilization.

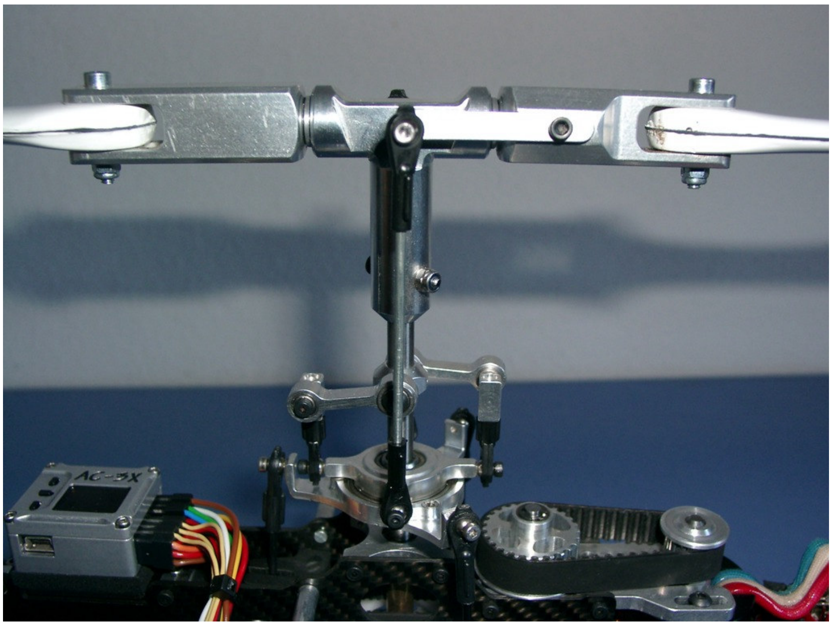

Figure 4: Side view linkage rigid head

The adaptation of you rotor head should be done in a way that the linkage from the swash plate to the blade grips is as stiff as possible and has no mechanical tolerance. The linkage should be realized either without Delta 3, which means that the linkage is done exactly 90° advanced to the axis of the spindle. Or alternatively the linkage can be done with 2-3° of delta 3 like in my Acrobat helicopters where the linkage is less than 90° in advance (see Figure 4 and Figure 5).

The mounting points on the servo levers of the swash plate servos usually must be shifted a little bit to the servo axis. For the Acrobat SE an ideal value is **11-13mm,** for the Acrobat Shark it is **16mm**.

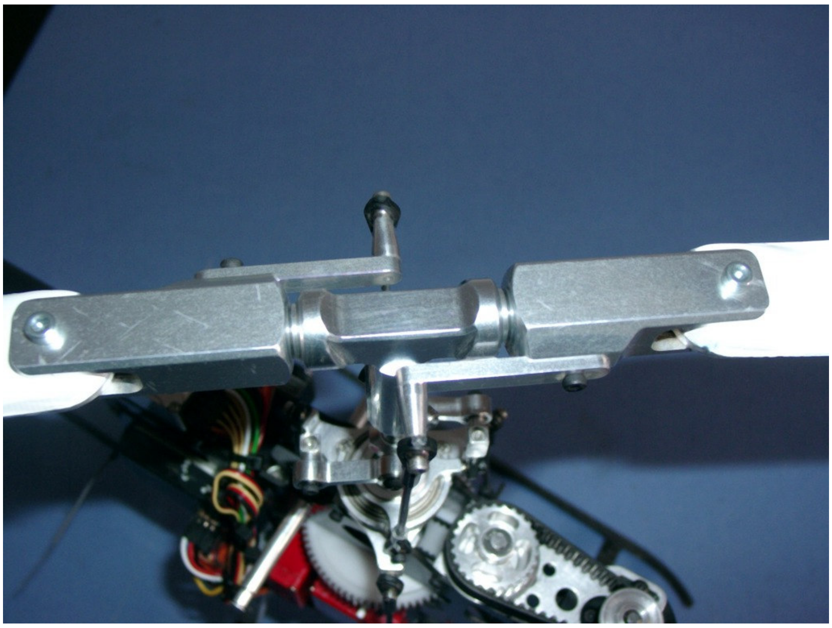

Figure 5: Rigid Rotor head Acrobat SE

When operating a rigid helicopter it is important that the swash servos have a reasonable traveling path. When the servos travel a to large angle, differentiation effects become very severe, when the used angle is to low, the resolution of the servos might limit the reachable flight performance. There is a further import thing to be kept in mind: the swash plate transfers collective inputs directly with a ration of 1:1 to the bald grips while cyclic inputs are reduced by the ratio of the diameter of the outer swash ring to the diameter of the inner ring. A typical and recommended value for this reduction is 1.5:1 which means that cyclic inputs are reduced by one third in comparison to collective (see Figure 6). The adjustment of the mechanics is explained in chapter 3.4 in detail.

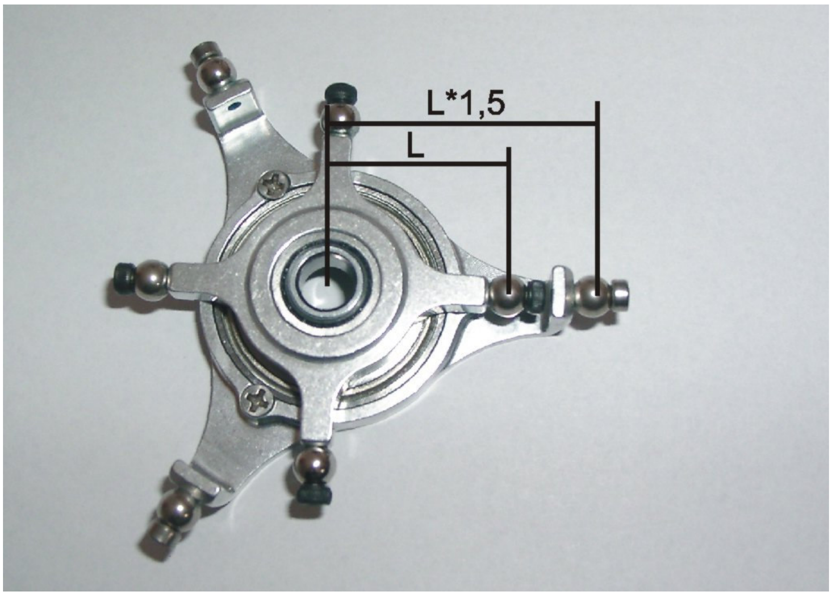

Figure 6: Acrobat SE swash plate, reduction ratio 1.5:1

I want to point out some more differences of an electronically stabilized rotor head in comparison to a conventional one: Due to the electronic regulation the servos have a little more servo action than in an conventional helicopter. A servo noise like on a normal Tail servo also on swash is normal and no reason to worry. One could filter out this micro movements but this would limit the regulation bandwidth of the swash plate stabilization which is the reason why I do not filter. Beside this the more direct linkage of the bald grips also increases the power consumption of the servos. With “normal” swash servos the power consumption with an electronic swash stabilization is doubled in comparison to an unstabilized rotor head. Thus please check your receiver battery especially during your first flights with AC-3X

During the development of AC-3X I tested several different types of servos. On first sight there are to main parameters for a good swash plate servo for an electronic swash plate stabilization: it must be fast and powerful. During my test I additionally realized that the best suited servos are the ones which have a smooth regulation free of artifacts and overshooting tendencies. Unfortunately there are Servos on the market which are optimized on fast acceleration and thus have a not negligible overshooting tendency and thus are not suited for an electronic swash plate stabilization although they are fast and powerful. They lead only to medium performance but extraordinary power consumption.

The following medium sized servos turned out to be good suited for an electronic swash plate stabilization: MPX Titan Digi 4, Futaba S9451 and the new Futaba BLS 451. ThunderTiger DS1015 servo is a fast Servo but nevertheless doesn’t lead to a good performance. Graupner JR 8822 lead to a good performance but needs twice the energy than the Futaba S9451.

On the mini servo market the Robbe FS 550 Carbon and the Futaba S9650 are very good suited. The Polo Digi 4 servos I used up to now in my Acrobat SE, also work on AC-3X.
For normal flying and simple aerobatics without fast load changes they are fine but for harder 3D one should use Futaba 9650 in the Acrobat SE.
The FS 550 Carbon also guarantee good performance but need more power than the Futaba S9650. The Power consumption is to high for the BEC of the Jazz 80-6-18. To avoid an overload with this servos one should use an extra RX-battery or one should use the Kontronik Jive esc.

I also tested a lot of tail servos. The state of the art servo at the moment is the Futaba BLS 251.

3.2. <u>Mounting in the Helicopter</u>

With the delivered two stripes of double side tape AC-3X is mounted to the gyro platform of the helicopter. The display must be oriented up and the connectors must show either to the front or the tail of the helicopter. It is very important to align AC-3X as parallel as possible to the helicopter axis in order to get best performance without any coupling between the axis.

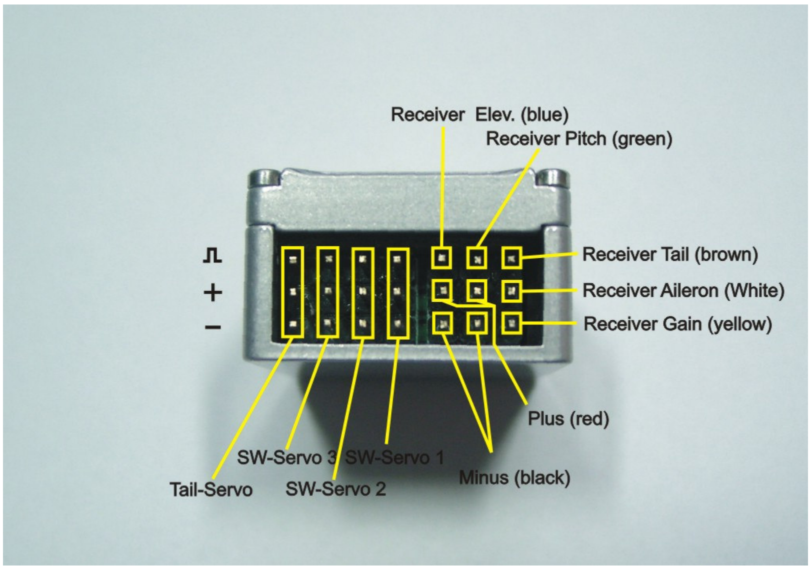

Figure 7: Pin assignment of AC-3X

Now AC-3X is connected to the receiver and the servos. For this purpose we first connect the receiver wiring to AC-3X. The pin assignment of AC-3X is shown in Figure 7. Looking on the connector side of AC-3X the wiring is connected to the 9 most right pins. The wiring must be oriented in a way that the brown, white and yellow cables are on the most right pin row. On the second row from the right there is the connector with the green, red and black cables, on the third row from the right the connector with the blue, red and black cable.

The right orientation of the receiver wiring is very important. A wrong orientation might cause a short circuit of the RC-voltage supply!

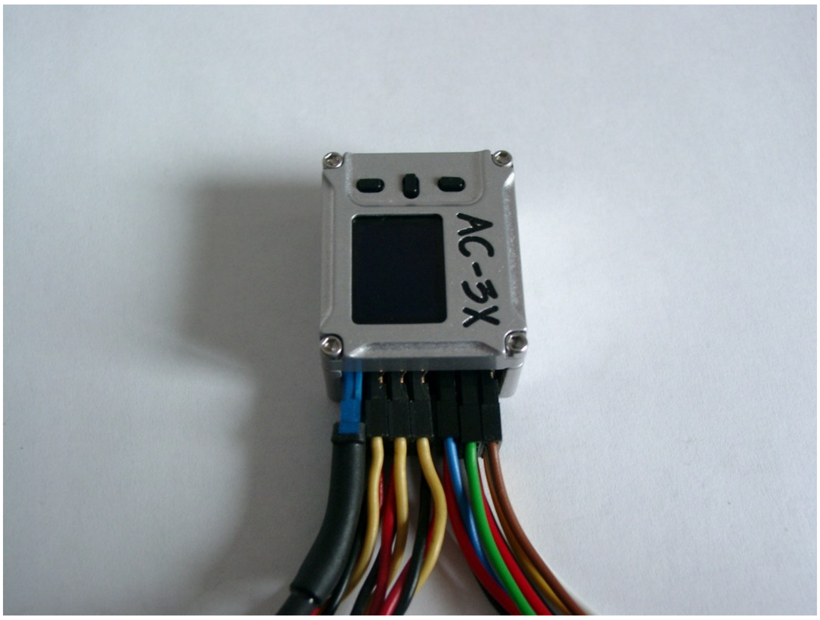

Figure 8: AC-3X with receiver wiring and 4 Servos connected

Now the receiver wiring is connected to the receiver. The cables and connectors are color coded. This is the

Channel assignment of AC-3X:

impulse cable colour	function
blue cable	elevator
green cable	pitch
white cable	aileron
brown cable	tail
yellow cable	sensitivity

Depending on the receiver type it might be necessary to secure the receiver connectors in the receiver with a stripe of tape.

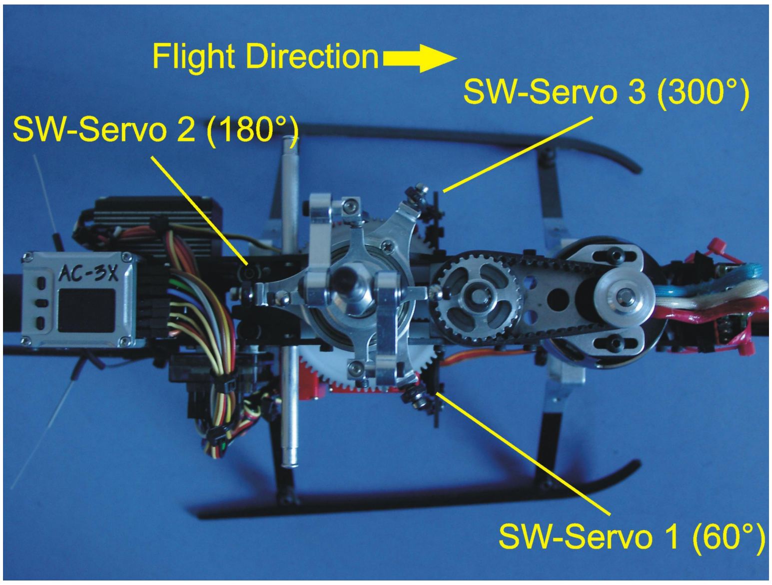

Figure 9: Servo orientation (factory defaults)

Now the servo cables are connected to AC-3X. The connector next to the receiver wiring is for swash servo 1, the next for swash servo 2 and the third for swash servo 3. The fourth connector at the edge of the housing is for the tail Servo. All four connectors have to be oriented with minus cable to the lower side (Impulse cable oriented to the display). The default orientation of the three swash plate servos in the helicopter is shown in Figure 9. The servo positions can be edited in the swash plate setup. The orientation is given in degrees relative to the helicopter axis. The 0°-position is looking forward. The angle is increasing clockwise (see Figure 8).
All cables should me fixed without any tension and with a small radius as shown in Figure 10. It is important that the fixation of the cables doesn't influence the orientation of AC-3X which is mounted on a tape!

Important note: Do not mount anything to AC-3X itself. This influences the frequency response of the mounting and thus also the functional properties of AC-3X!

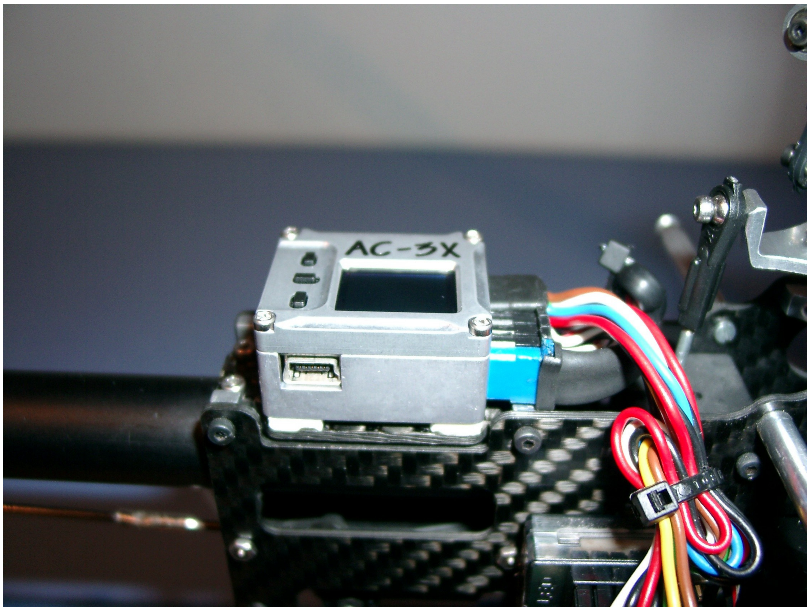

Figure 10: Mounting AC-3X on an Acrobat SE

3.3. Transmitter Setup

Now first the transmitter and afterwards the receiver is switched on. AC-3X will display the start up screen with AC-3X logo and serial number. In a second step AC-3X calibrates the middle stick impulse lengths for aileron, elevator and tail. During this stick initialization the sticks may not be moved as otherwise the initialization will not succeed. A successful initialization is acknowledged by a status screen. In a third step the neutral voltages of the three rate sensors are calibrated and after a successful finish of the calibration this is confirmed and AC-3X switches to operational mode with the normal status screen. The servo output is now enabled. Before the successful finish of the calibration AC-3X does not react on the transmitter sticks! The operative status screen displays the actual values of the 4 control channel, the gain value set from the transmitter, the used flying condition (only if parameter switching is activated in the tools menu) and the receiver battery voltage (Figure 11).

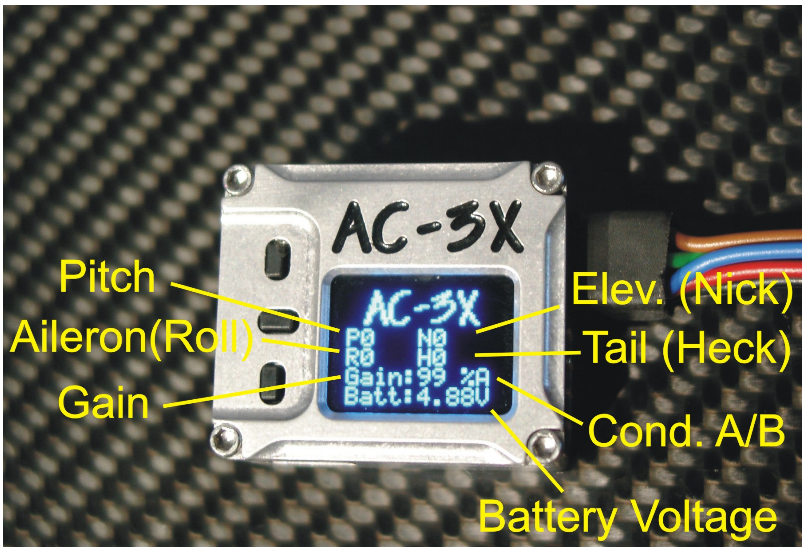

Figure 11: Status screen of AC-3X after successful calibration

Now the basic setup of the transmitter is done. **First we select the helicopter mode with mechanical swash plate mixing and deactivate all mixing functions which might be preselected in the transmitter. All mixing required for the swash plate is done inside AC-3X!** When the transmitter sticks are move independently only a single value displayed by the AC-3X may change! If this is not the case it is obvious that there are still mixers activated on the transmitter side. Now AC-3X should be switched off and one again. In case that during the last startup some mixers were still activated, the zero position calibration might be faulty and thus it is better to reinitialize again.

In case you are not using an Futaba transmitter with 1.52ms neutral pulse length you should subtrim your pitch channel in the transmitter so that at middle stick position of pitch P=0 is displayed by AC-3X. Now for all channels (P = Pitch, N=Nick (German) =Elevator, R=Roll (German) =Aileron, H=Heck (German)=Tail) the travel adjust in the transmitter is adapted to get exactly -100 to +100 as minimum and maximum values displayed by AC-3X.

The right sense of direction for the four steering channels is the following: Positive Pitch corresponds to positive P values in the display, aileron right corresponds to positive R values, elevator forward corresponds to positive N values and tail right corresponds to positive H

values. If you do not have this senses of direction please use the servo reverse function of your transmitter to correct. **After correcting it please check once again that middle stick is still 0 and that you still have stick travels of -100 to +100.**
Depending on whether you are installing AC-3X in a new helicopter where no setup is existing or whether you already have a setup for your helicopter type, set the sensitivity channel to a Gain value of **60%** for unknown setups or **100%** for known setups (see Figure 12). This can be done either in the gyro menu of your transmitter or via travel adjust. For unknown setups it might be better to start with reduced sensitivity in order not to take the risk of getting oscillations in the first flight. Now AC-3X should be switched off again.

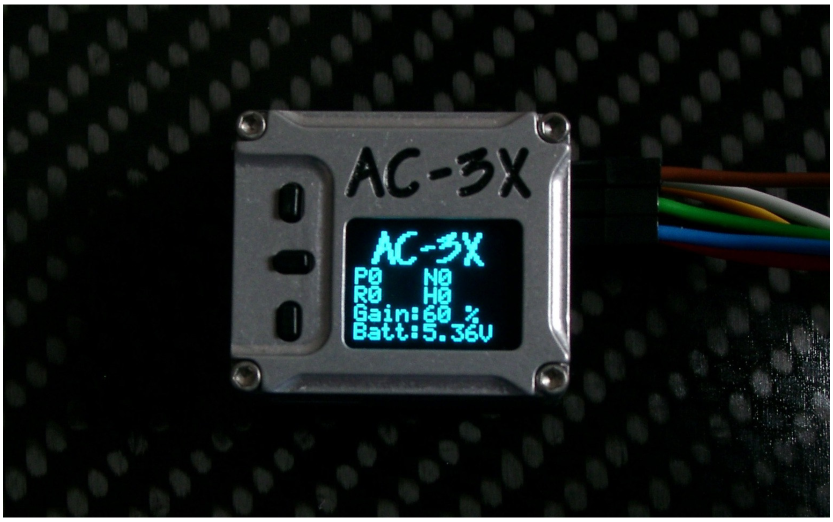

Figure 12: AC-3X at 60% Gain

3.4. Basic Setup of the Helicopter

All adjustment described in this chapter should be done in the AC-3X setup menu if not explicitly stated different! Only in the setup menu the flight control regulators are inactive and the setup of servo zero positions and servo travel is possible.
First the used servo types must be selected in the servomenu. For the tail servo four different modes are possible which are different with respect to framerate and neutral pulse width:

Supported tail servos:

Type	Framerate	Center Pulse length	Examples
1	165Hz	1500 µs	standard tail servos (Futaba 9253/4/7, DS8700 etc.)
2	330Hz	1500 µs	same, but with higher framerate
3	330Hz	760 µs	Futaba 9251/9256/BLS251
4	330Hz	960 µs	Logitech tail servos

After choosing the tail servo type, the correct servo direction must be selected. In the setup menu the RC signal is directly routed to the servo so that one can directly observe the tail servo direction when moving the transmitter stick. If this is not the case, please change the servo direction with servo reverse in your transmitter. Now the middle position of the servo is adapted. **For this purpose you must got to the menu item "Servo Zero Pos." as only here the torque feed forward on tail is deactivated!** Now the tail servo lever is mounted to the servo. Take care that it is already oriented as perpendicular as possible to the tail linkage. The fine adjustment then is done via the tail servo zero position calibration function until linkage and lever are perfectly perpendicular as shown in Figure 13.

Figure 13: Orientation of the tail servo lever.

After finishing this, the length of the tail linkage is adapted so that the lever at the tail gearbox is also perpendicular to the linkage. The tail blades now should have 5°-10° pitch against the torque direction. Now the servo limits A and B for the tail servo are adapted in the menu servolimits. The full travel path of the tail slider should be covered as can be seen in Figure 14. To get optimum tail stabilization performance the limits on both sides should be between 900 and 1200. If the are smaller, please shorten the servo lever, if they are larger please use a longer lever.

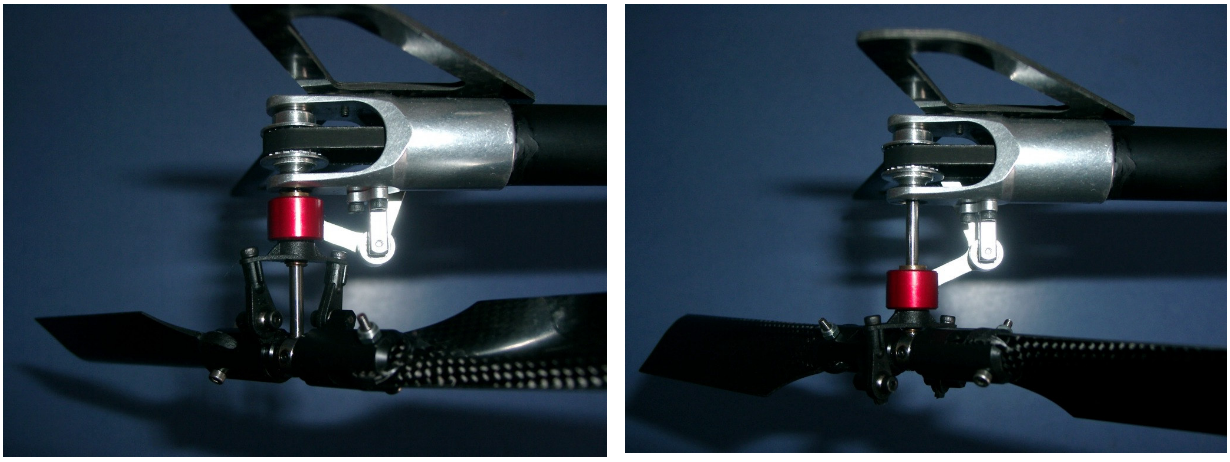

Figure 14: Position of the tail pitch slider - full tail left and right

Now the framerate for the swash plate servos must be selected in "Servo Typ Configuration – SWSH-Servo-Frequency". For most digital servos you can go up to a framerate of 200 Hz. With analog servos the framerate should not be larger than 80 Hz. The stabilization performance becomes better with larger framerate. But be careful, there are some servos on the market which do not work with the framerates stated above. So in case you observe some abnormal servo action or extra noise, please reduce the framerate until the servos work smooth again.
The right servodirections can be set in the menu item "Servoreverse" for the servos 1-3. First choose the directions in a way that all servos are running synchronously on pitch action. If you have managed this, the direction of aileron, elevator or pitch might be still reversed. This direction can be changed in the "SWSH. Setup" menu by changing the direction of the relevant inputs from 80% to -80%.

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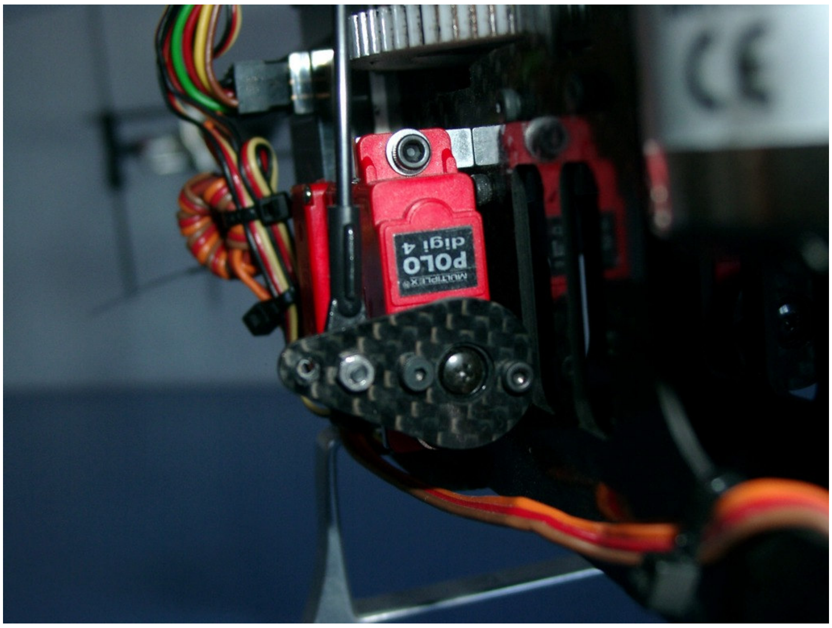

Figure 15: Servo lever at 0° pitch perpendicular to SWSH-linkage

After the servodirections of the swash plate servos are now correct the servo levers have to be aligned in a way that at 0° pitch position **the linkages going from the servo levers to the swash plate are perpendicular to the levers (compare Figure 15).** To reach this situation please first preadjust the level by mounting it in the nearest position and then do a fine adjustment for each servo via the AC-3X subtrim function for the SWSH-servos 1-3.

Figure 16: Cyclic angle of 7° at full swash stick input

In a next step we check if the helicopter mechanics is properly setup and adapted to an electronic swash plate stabilization like AC-3X. **This check must be done in the setup menu**

and the swash mixer must be set to a value of + or - 80% on aileron and elevator! Now please check the mechanical travel at the blade grips when you go from a neutral swash stick position to a maximum steering input on swash plate. This cyclic angle should be approx. 7°. The travel on pitch should be 8-12° to both sides (compare Figure 16 and Figure 17) .

In principle one could adapt the cyclic and collective travel via the travel adjust menu in the servo setup and the pitch mixer in the swash setup menu electronically. But I recommend to do this only by a few %. If the servo travel adjust had to be adapted by more than 30% with respect to the default value of 1000 units to get 7° cyclic or the pitch mixer had to be adapted by more than 20% with respect to the default value of 80% to get 8-12° of pitch then the servo levers should be adapted on their length as otherwise the resolution of the servos will limit the flight performance. The main focus should be on cyclic as the algorithm in AC-3X assume to have 7° cyclic and are optimized on this value. Pitch is not actively controlled and thus a bigger change on the pitch mixer only results in a not optimal reaction on pitch but has no effect on the flight stability.

Figure 17: Full pitch, 10° on the blade grips

After setting up cyclic and collective like described above, one should also check if the swash plate is running straight up when the pitch stick is moved. It might be that there is also some cyclic admixture. This is due to different servo travels. During my tests with AC-3X I realized that even with servos bought at the same time the servo travel might vary up to 10%. To correct this one should adapt the servo travel for each swash plate servo individually until the collective movement is perfectly free of any cyclic admixture.

Now we have to check for the correct directions of the swash plate- and the tail gyro. To do this please go into the Sensor Setup of AC-3X. In the Sensor Setup menu of AC-3X the sticks are deactivated and the servos are only reacting on the integrated signals of the gyro sensors. Now take the helicopter and rotate it around the aileron axis and watch the swash

plate. The swash plate must rotate in the opposite direction than the helicopter. If this is not the case, change the direction of the aileron sensor in the Sensor Setup.
Now check the elevator axis. Here it is the same: when you tilt the helicopter around the elevator axis, the swash plate must tilt in opposite direction than the helicopter. In case this is not so, change the sensor direction for the elevator sensor.
Finally also check for the correct direction of the tail gyro, it must damp a rotation around the helicopter main shaft which means that the back ends of the tail blades should move into the direction in which you move the tail of the helicopter. If this is not the case, change the tail sensor direction in the sensor setup.

The next step is to check for the right direction of the integrated torque feed forward on the tail. The direction of the DMA feed forward must push against the torque of the main rotor when the absolute value of collective or cyclic on swash plate is increased. **Note:** There are helicopters on the market like Aligns or Logo 500/600 which require an inversion of the DMA direction.

Before you can start the first flight with AC-3X you should also check the direction of the integrated pirouette correction. To do this, go to the axis rotation menu. The swash plate will tilt into forward or backward direction. Now turn the helicopter around the main shaft axis by 90°. The swash plate tilt direction should stay unchanged in this maneuver. Relative to the helicopter the tilt direction of the swash plate should have turned by 90° in opposite direction than the direction you have turned the helicopter. In case that this is not the case and the swash plate turned into the same direction as the helicopter then please invert the "axis rotation" direction. "Axis rotation" can also be deactivated. This might be useful if you are using analog servos which can be operated with a framerate of only 50 Hz. In this case, the axis rotation might lead to a tumbling of the helicopter in fast pirouettes during dynamic flight.

3.5. First Flight

Now we can go out for the first flight with AC-3X. The default parameters are adapted to an Acrobat SE with Polo Digi 4 servos with 13mm levers on swash plate and a BLS 251 with 13.5 mm level on the tail. In case you have an helicopter for which a setup is listed in the next chapter, then you should use these parameters. For all other helicopters the default setup should be a good start. For very small helicopter like the Trex 450 I recommend to reduce the look ahead gain on swash plate to 45. In case you have installed AC-3X on a very large helicopter or in case that your helicopter has an extraordinary low headspeed or a multiblade head, I recommend to also read the FAQs on such systems in chapter 0.
Before the first take off please check the direction of the gyros on all three axis once again. In case that the gyros are inversed, the helicopter is uncontrollable and thus a danger for the spectators. Also do never fly in the setup menu, here the gyros are inactive and thus the helicopter might also be uncontrollable.
When you are convinced that everything is correct you can start for the first flight.

But be careful:

- The **take off with an electronic swash plate stabilization is different to a conventional Bell Hiller rotor head**. If the helicopter is spinning up an the stick are moved while the helicopter is still on the ground an cannot move, the swash plate will tilt up to the maximum possible swash plate angle. If pitch is increased to suddenly now, the helicopter might tilt and the blades might hit the ground. To avoid this, one should spin up the system with 0° Pitch (P=0 in the AC-3X Display) and not give large steering inputs on swash plate so that the swash plate is kept horizontal. When the right headspeed is reached pitch should be increased rapidly to lift off.

- The cyclic agility of a rigid rotor head can be very high. In AC-3X the cyclic agility is set up in the swash setup via the aileron and elevator mixer. The default values of 80% will lead to an agility comparable to an agile conventional rotor head. If you are used to fly bigger and less agile helicopters then you should reduce the aileron and elevator mixer values to 60% in order to reduce the agility of the helicopter for the first flight (but be careful, do not change the sign of the aileron and elevator mixers as otherwise steering directions are inverted)

The helicopter should hover without any permanent osscilations. **Depending on the type of helicopter it might be that the helicopter is a little bit lethargic on steering inputs and that the stopping behavior is not optimal. This is due to the fact that we set the gain to 60% before.** If the helicopter is drifting into on direction, one should correct this by tilting the swash plate mechanically by changing the lengths of the linkages from the servos to the swash plate. Do not compensate such a drift by trimming! During the transmitter setup we set the gyro gain to 60% in case that the helicopter is unknown an no setup is already existing. Normally the default parameters should not lead to any oscillations so that **we can go up to 100% gain in the AC-3X display now and then finalize the setup.**

3.6. Tail Rotor Setup

To achieve optimum flight performance we have to adapt some parameters on the helicopter. First we will take a look at the tail rotor. There are five parameters in the tail setup which have already been described in chapter 2.2.2..

To optimize them one should start with a look at the stopping behavior of the tail. If the tail is stopping relatively soft with a tendency to drift back after the stop, then one should increase proportional gain until a high frequency oscillation of the tail can be observed. When this level is reached, proportional gain should be reduced by one third. Now one should fly at moderate speed and start some pirouetting. If the pirouetting rate is constant, than the integral gain is set high enough. In case that the pirorate is not constant but changing due to wind effects, then the integral gain should be increased. For the Acrobat helicopters the default integral gain of 55 should be sufficient to get a constant pirorate so that integral gain mustn't be changed. The next parameter to be fine tuned is the Tail Stick Dynamic. To optimize it one should pirouette with high speed in the direction of the of the main rotor torque and then change the pirouetting direction as fast as possible. The tail drive may not be upset by this maneuver. Especially on a belt driven tail, the belt should not slip. In case that the tail drive is overloaded, the tail stick dynamic should be reduced. For pilots who are not able to fly such a fast piro direction change I recommend to fly with the default value of the tail stick dynamic of 20 which is a value which is adapted to a normal 700 size helicopter. The parameter tail inertia usually doesn't need to be adapted. The default value of 50 fits to helicopters from 500 size to 700 size. This parameter should only be adapted in case the tail is bouncing back. When this is the case, the parameter schould be decreased on small helicopter and increased on large ones.

The maximum pirorate is adjusted with the travel adjust function of the transmitter. 100% RC-value on tail displayed by AC-3X corresponds to a pirorate of 600° per second. To give exponential on the tail in order to be more sensitive around midstick, this can be done in the "Stick Setup - Tail Rotor Expo". The default value of 80% will lead to an stick feeling similar to an Futaba GY 601 in F3C mode.

To finalize the tail setup the DMA Gain parameter for the torque feed forward on tail can be adapted, although the default value of 45 should fit for most helicopters.
The procedure how to adapt this parameter is described in chapter 2.2.2. Be aware that the DMA Gain has the right sign so that the torque feed forward compensates the main rotor torque.

3.7. Swash plate Optimization

After the tail setup one should fine tune the swash plate gyro parameters described in chapter 2.2.1.
Similar to the tail rotor setup we start with optimizing the stopping behavior from flips by adjusting the proportional (P) and integral (I) gain. The goal is to make the helicopter follow the stick as neutral as possible especially during hard rate changes. On should start with increasing P and I synchronously. Doing this one should observe that first the stopping is becoming crisper but with increasing both parameters more and more some bouncing back appears. One hast to find the point of the crispiest or most neutral stopping. Once having found it, one should do a fast forward flight an then give a short kick on elevator an observe how the helicopter reacts. If the helicopter doesn't start to oscillate periodically then the right balance of P and I is already found. If the helicopter starts to oscillate, then one should reduce P until the oscillation in fast forward flight stops.
Now we should have a lock on the behavior of the helicopter around midstick. If the helicopter behaves to sensible on elevator and aileron, one should reduce the "Look Ahead Gain" parameter. Especially on small machines like Trex 450 at high RPM, the default value of the "Look Ahead Gain" of 75 might be to high.

Now we again start some fast forward flight and check how the helicopter react on pitch changes. If the helicopters nose goes up when pitch is increased quickly, one should increase the "Integral Limit". If there is no reaction on the elevator axis during pitching, one can reduce the integral limit.

At this point **two important notes concerning the parameters on the swash plate:**

- If the helicopter has a tumbling tendency when either elevator or aileron is moved and both axis seem to be somehow coupled, then usually the swash plate has not the right orientation and thus the axis are coupled (see Figure 4)
- When increasing P and I synchronously it might happen that the helicopter doesn't start to oscillate on elevator. In this case only a fast shaking back at high gain can be observed and the helicopter feels somehow undefined in the stop. This undefined stopping might be misinterpreted as a to low gain but increasing it further more won't help to overcome this phenomena. Thus when you feel that the stopping is still soft and increasing gain is not helping to overcome this problem, that reduce P and I by at

least one third and then try again to find the point of the most neutral stopping. In general it is more comfortable to operate AC-3X at a to low P- and I-Gain than at to high values of this parameters.

To finalize the Swash setup one should adapt the cyclic rates to the own habits. This can be done in the “Swash Setup” via the “Aileron-Mixer” and the “Elevator-Mixer”. A reduction of these two values corresponds to a reduction of the rates on the axis and vice versa. If you like expo feeling on cyclic, you can use the „Swash plate Expo“ parameter in the “Stick Setup”. The default value is 30 which should generate almost the same stick feeling like the Bell Hiller head on the Acrobat SE.

<u>Using different flight conditions</u>

With AC-3X you can change the gyro gain on all three axis synchronously via the sensitivity channel from the transmitter. This can be of big use if you want to fly with different headspeeds or with different flight conditions. During the transmitter setup we set the gain on 60% in the AC-3X Display and then changed this value to 100% after the first flight. The gain value can be set at 25% in minimum and up to 150% as maximum and thus this parameter can be used to adapt the overall gyro sensitivity to the rpm like the gyro gain in a conventional gyro.

In software version 4 of AC-3X it is now also possible to lock the gain for the tail gyro or the swash plate gyros individually. This can be done in "Lock Tail Gain 100 %" and "Lock Swash Gain 100 %". If one of this parameters is activated, the corresponding gain is locked to 100% and does no longer vary with the RC input.

Also new in SW version 4 is the option to switch between two sets of control parameters. To use this option, one has to activate “parameter switching” in the tools menu. The parameters marked by a “*” in Figure 1 are then doubled in the menu and can be set individually for two flight conditions. To switch between both parameter sets the gain channel is used (see Figure 3). The active condition is displayed on the AC-3X main screen when parameter switching is activated.

The setup of AC-3X is now finished. My experience is, that after the first flights one observes things that need to be optimized. The detailed effect of all parameters is thus described in chapter 2.

In the following chapter setups for different helicopters are collected.

4. AC-3X Setups

In this chapter AC-3X setups for different helicopters with different servo types are listed. I only list the gyro parameters for the swash plate and tail gyro but not the servo an sensor parameter which are helicopter and installation specific and thus need to be setup individually in the workshop. I also do not list the stick parameters which have to be adapted to the pilots preferences.
With every setup a headspeed with which the parameters have been flown is given. When a higher headspeed shall be used the overall gain in the AC-3X has to be reduced and when you want to use a lower headspeed you usually can increase the overall gain above 100%.

During my test flights I observed that unfortunately there are some servos on the market which have a certain spread in their parameters. Especially the servo travel might be different also the servos are of the same type. This has also an effect on the setups as if a servo is doing a larger travel one effectively has a larger gain than with a servo with smaller travel. But when the basic setup described in chapter 3 is done carefully the mechanical necessarities for a goof setup should be met and thus with the setups below good flying should be reached. It might be, that with the own individual servos the swash plate travel adjust values after the basic setup of the helicopter are different from those in the tables. In this case please use your own individually adapted values.

The tail gyro parameter are listed for tail servo limit of 1000 units. Is the tail linkage done in a way, that you can use larger tail servo limits, than this means that also the parameters listed for P- , I- and DMA-gains should be increased by the same factor. When the Servo limits are e.g. 1300 instead of 1000, this means that the gains above need to be multiplied by 1.3.

4.1. Acrobat SE Setups

All Acrobat SE setups have been flown at 2000 rpm with a total gain of 100% in the AC-3X display.

Setup:	**Acrobat SE & FS 550 Carbon**			
Swash plate Setup:			**Tail Setup:**	
Servos	Robbe FS 550 Carbon		Servo	Futaba BLS251
Lever length	11mm		Lever length	13,5 mm
Travel Adjust SW	1000		P – Gain	45
P – Gain	60		I – Gain	50
I – Gain	70		DMA Gain	45
Look Ahead Gain	70		Tail Stick Dyn.	25
Integral Limit	60		Tail Inertia	50
Hoovering Stabilit.	2			
Power Consumpt.	Relatively high, with Jazz 80-6-18 BEC must be supported			

Setup:	**Acrobat SE & Futaba S9650**			
Swash plate Setup:			**Tail Setup:**	
Servos	Futaba S9650		Servo	Futaba BLS251
Lever length	13 mm		Lever length	13,5 mm
Travel Adjust SW	800		P – Gain	45
P – Gain	60		I – Gain	50
I – Gain	70		DMA Gain	45
Look Ahead Gain	65		Tail Stick Dyn.	25
Integral Limit	60		Tail Inertia	50
Hoovering Stabilit.	2			
Power Consumpt.	low, Jazz 80-6-18 BEC sufficient			

Setup:	**Acrobat SE & Multiplex Polo Digi 4**			
Swash plate Setup:			**Tail Setup:**	
Servos	Multiplex Polo Digi 4		Servo	Futaba BLS251
Lever length	13 mm		Lever length	13,5 mm
Travel Adjust SW	800		P – Gain	45
P – Gain	50		I – Gain	50
I – Gain	60		DMA Gain	45
Look Ahead Gain	65		Tail Stick Dyn.	25
Integral Limit	60		Tail Inertia	50
Hoovering Stabilit.	2			
Power Consumpt.	low, Jazz 80-6-18 BEC sufficient			

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4.2. Acrobat Shark Setups

All Acrobat Shark setups have been flown at 1800 rpm with a total gain of 100% in the AC-3X display.

Setup:	**Acrobat Shark & Futaba S9451**			
Swash plate Setup:			**Tail Setup:**	
Servos	Futaba S 9451		Servo	Futaba BLS251
Lever length	16 mm		Lever length	13,5 mm
Travel Adjust SW	1000		P – Gain	70
P – Gain	60		I – Gain	50
I – Gain	60		DMA Gain	45
Look Ahead Gain	70		Tail Stick Dyn.	20
Integral Limit	45		Tail Inertia	60
Hoovering Stabilit.	2			
Power Consumpt.	approx. 230 mAh per 6 minute flight			

Setup:	**Acrobat Shark & Futaba BLS 451**			
Swash plate Setup:			**Tail Setup:**	
Servos	Futaba BLS 451		Servo	Futaba BLS251
Lever length	16 mm		Lever length	13,5 mm
Travel Adjust SW	1000		P – Gain	70
P – Gain	55		I – Gain	50
I – Gain	60		DMA Gain	45
Look Ahead Gain	70		Tail Stick Dyn.	20
Integral Limit	45		Tail Inertia	60
Hoovering Stabilit.	2			
Power Consumpt.	approx. 260 mAh per 6 minute flight			

Setup:	**Acrobat Shark & Multiplex Titan Digi 4**			
Swash plate Setup:			**Tail Setup:**	
Servos	Multiplex Titan Digi 4		Servo	Futaba BLS251
Lever length	16 mm		Lever length	13,5 mm
Travel Adjust SW	1000		P – Gain	70
P – Gain	60		I – Gain	50
I – Gain	60		DMA Gain	45
Look Ahead Gain	70		Tail Stick Dyn.	20
Integral Limit	45		Tail Inertia	60
Hoovering Stabilit.	2			
Power Consumpt.	approx. 250 mAh per 6 minute flight			

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Setup:	**Acrobat Shark & Graupner JR DS 8822**			
Swash plate Setup:			**Tail Setup:**	
Servos	Graupner JR DS 8822		Servo	Futaba S9256
Lever length	17 mm		Lever length	13,5 mm
Travel Adjust SW	1000		P – Gain	70
P – Gain	55		I – Gain	50
I – Gain	60		DMA Gain	45
Look Ahead Gain	70		Tail Stick Dyn.	20
Integral Limit	45		Tail Inertia	60
Hoovering Stabilit.	2			
Power Consumpt.	approx. 440 mAh per 6 minute flight			

4.3. Logo Setups

At first I want to give some advice on the use of AC-3X in Mikado Logo Helicopters. This helicopters may produce strong static discharges between the tail belt drive and RC-components. Thus, in case AC-3X shall be used in a Logo, it is very important to assure an electrical connection between the tail shaft, the boom and some discharge plate which is mounted in the main chassis very close to the belt in the area where the belt leaves the boom. In case the tail servo has a metal housing, it can also be sufficient to establish an electrical connection between the tail shaft, the boom and the tail servo housing. Without such an electrical grounding of the belt, AC-3X in a Logo might be disturbed or even damaged by electric discharges.

The following Logo 600 setup has been flown at 2050 RPM headspeed with 100% gain in the display.

Setup:	**Logo 600 & Graupner JR DS 8822**			
Swash plate Setup:			**Tail Setup:**	
Servos	Graupner JR DS 8822		Servo	Futaba BLS251
Lever length	17 mm		Lever length	13,5 mm
Travel Adjust SW	1000		P – Gain	80
P – Gain	65		I – Gain	50
I – Gain	70		DMA Gain	-70
Look Ahead Gain	85		Tail Stick Dyn.	20
Integral Limit	50		Tail Inertia	50
Hoovering Stabilit.	2			
Power Consumpt.	approx. 350 mAh per 6 minute flight			

4.4. Trex 250 Setup

This is a setup for a Trex 250 with Align CFK main rotor blades at a headspeed of 4500 RPM. To fly it rigid, the flybar has been removed and the mixing arms which were attached to the flybar mount before where screwed to the main rotor hub into the threads of the flybar mount. Then the blade gripes where linked from the rear side via the mixing arms. The mechanical ratio of 1:2 of this linkage is ideal for a flybarless setup. When using AC-3X on the Rex 250 it is very important to mount AC-3X on a stable platform. The original gyro mount of the Trex is not stiff enough and thus can shake which limits the performance of AC-3X severely!

Setup:	**Trex 450 SE & Hitec HS 65**			
Swash plate Setup:			**Tail Setup:**	
Servos	Align DS410		Servo	Futaba S9257
Lever length	10.5 mm		Lever length	6.5 mm
Travel Adjust SW	1000		P – Gain	30
P – Gain	50		I – Gain	35
I – Gain	50		DMA Gain	-40
Look Ahead Gain	65		Tail Stick Dyn.	25
Integral Limit	65		Tail Inertia	30
Hoovering Stabilit.	2			
Power Consumpt.	Low, no problem for Align ESC BEC			

4.5. TRex 450 SE V2 Setups

This is a setup for a Trex 450 SE V2 flown at 2700 RPM headspeed with 100% Gain in the display of AC-3X. The blade grips were modified in a way that the distance between both linkage points at the blade grips is 40mm. In case that a higher headspeed is needed you should reduce the Look Ahead Gain on swash plate further as otherwise the Trex behaves to nervous on cyclic inputs. The framerate for the HS 65 should not exceed 65Hz as it is an analogue servo which was not designed for electronic swash plate stabilization. Although I publish this setup here, I recommend the digital Hitec HS 5065 servo for better performance in 450 helicopters.

Setup:	**Trex 450 SE & Hitec HS 65**			
Swash plate Setup:			**Tail Setup:**	
Servos	Hitec HS 65		Servo	Futaba S9257
Lever length	10 mm		Lever length	10 mm
Travel Adjust SW	1000		P – Gain	50
P – Gain	50		I – Gain	50
I – Gain	45		DMA Gain	-50
Look Ahead Gain	55		Tail Stick Dyn.	20
Integral Limit	40		Tail Inertia	40
Hoovering Stabilit.	2			
Power Consumpt.	Low, no problem for Jazz 40-6-18 BEC			

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The second setup for the Rex 450 is a setup for the digital Hitec HS5065 MG servos at 3000 RPM (100% Gain in the AC-3X display). This servos can handle 200 Hz swashservo framerate which enhances the control performance by far in comparison to the analogue HS65. The mechanic setup again was done in a way that the two linkage balls on the blade grips have a distance of 40mm to each other.

Setup:	**Trex 450 SE & Hitec HS 5065 MG**			
Swash plate Setup:			**Tail Setup:**	
Servos	Hitec HS 5065 MG		Servo	Futaba S9257
Lever length	10 mm		Lever length	10 mm
Travel Adjust SW	1000		P – Gain	50
P – Gain	50		I – Gain	50
I – Gain	50		DMA Gain	-50
Look Ahead Gain	55		Tail Stick Dyn.	20
Integral Limit	40		Tail Inertia	40
Hoovering Stabilit.	2			
Power Consumpt.	Low, no problem for Jazz 40-6-18 BEC			

4.6. TRex 500 Setup

This is a setup for a Trex 500 flown at 2700 RPM headspeed with 100% Gain in the display of AC-3X. The blade grips were modified in a way that the distance between both linkage points at the blade grips is 50mm. If you want to fly the Rex 500 with only 2200 RPM headspeed, then I recommend to increase Tail-P-Gain to 80-90 as the aerodynamic tail performance of the Rex 500 drops severely when RPM is decreased. Thus P-Gain should be adapted

Setup:	**Trex 500 & Futaba S9650**			
Swash plate Setup:			**Tail Setup:**	
Servos	Futaba S9650		Servo	Futaba S9253
Lever length	13 mm		Lever length	13 mm
Travel Adjust SW	1000		P – Gain	65
P – Gain	60		I – Gain	50
I – Gain	60		DMA Gain	-60
Look Ahead Gain	75		Tail Stick Dyn.	25
Integral Limit	50		Tail Inertia	50
Hoovering Stabilit.	2			
Power Consumpt.	Low, no problem for Jazz 80-6-18 BEC			

4.7. Revolution Setup

This is a Setup for the Revolution of Heli-Professional flown at 1800 RPM with 100% Gain in the AC-3X display. The linkage from servos to the rotor head was done in the way described in the Heli-Professional Rigid modification manual.
When setting up the tail servo please got to the setup menu and position the pitch stick to 0°. Now adjust the servo in a way that the side of the lever at the tail facing towards the tail gear housing is parallel to the surface of the tail gearing housing. When this is the case, the right tail pitch value for 0° pitch is adjusted. Please set the tail servo limits to 1250 on both sides. This amount of travel is sufficient to reach the maximum tail pitch values which are aerodynamically reasonable!

Setup:	**Revolution & Futaba S9351**			
Swash plate Setup:			**Tail Setup:**	
Servos	Futaba S9351		Servo	BLS251
Lever length	7.5 mm (Push Pull with 15mm distance between the linkage balls)		Lever length	-
Travel Adjust SW	1100		P – Gain	90
P – Gain	65		I – Gain	60
I – Gain	65		DMA Gain	60
Look Ahead Gain	75		Tail Stick Dyn.	20
Integral Limit	50		Tail Inertia	60
Hoovering Stabilit.	2			
Power Consumpt.	Jive HV BEC sufficient			

4.8. Three Dee Rigid Setup

This is a setup for the TDR with the CR Rigid Blades flown at 1700 RPM with 100% Gain in the AC-3X display. All linkages where done as explained in the TDR-Manual. For Speed flight at 1900 RPM, I recommend to lower the overall gain to 85%, for soft flying at 1400 RPM you should increase gain to 115%.

Setup:	**TDR & Futaba BLS451**			
Swash plate Setup:			**Tail Setup:**	
Servos	Futaba BLS451		Servo	BLS251
Lever length	18mm		Lever length	10.5mm
Travel Adjust SW	800		P – Gain	55
P – Gain	60		I – Gain	50
I – Gain	60		DMA Gain	-70
Look Ahead Gain	55		Tail Stick Dyn.	22
Integral Limit	50		Tail Inertia	55
Hoovering Stabilit.	2			
Power Consumpt.	Jive HV BEC sufficient			

5. Frequently Asked Questions – FAQs

In this chapter I want to collect a list of questions and answers which came up to me several times.

<u>Why does AC-3X does not have different parameter sets to switch between during flight?</u>:
Due to the whishes of many of my customers SW Version 4 now is able to switch between two sets of parameters. Nevertheless, in my opinion, this is parameter switching is not mandatory. Let me shortly explain why:
The goal of an electronic flight control is to control the helicopter in a way, that it follows the stick inputs as precisely as possible. The control gain on the different axis needed to meet this requirement of course depends on the headspeed of the helicopter as the aerodynamic effect of the rotors depends on the RPM. So to stay on the optimum working point for the gain, the gain has to be adapted rpm dependend. To do this one single overall gain parameter is sufficient. Like in conventional Gyros also in AC-3X this parameter is designed as an RC-input to be set from the transmitter. An adaptation of individual control parameters for the swash plate or the tail is not needed! If a pilot in addition to this wants to change the reaction of the Helicopter to his steering inputs for different flight situations, he can do this by using different flight conditions in the transmitter. With Dual Rate the maximum rates on the different axis are adaptable, with exponential the reaction around the midstick position can be modified.
Nevertheless in the new tail SW of SW 4 it might be of use to decrease the parameter "Tail Stick Dynamic" at low rpm. This parameter limits the reaction of the helicopter on tail stick inputs and thus at low rpm when the tail is less powerful, it can improve tail performance to reduce this parameter!

<u>The tail rotor performance is worse since I changed to AC-3X, Why?</u>
The AC-3X factory settings for the tail parameters are optimized on the Acrobat SE tail rotor. The SE is operated with very low proportional gain on the tail as otherwise the tail becomes shaky. The tail setups of most other commercial helicopters are a little bit different so that they need much higher proportional gain. So on most helicopters (e.g. Logos, Trex 500-600, TD NT, TD MP,...) a good start value for the optimization of the tail performance is an proportional gain of 80 but you should not mind if you even need p gain of above 100.

<u>What is the SW Version of my AC-3X?</u>
During the booting up phase of the AC-3X the version number of AC-3X, e.g. 1.3, is displayed. The first digit represents the hardware revision of AC-3X, 1 in this case, the second is the SW- Version, 3 in this case.

<u>Are there special setup aspects for helicopters with low rpm or multiblade rotor heads?</u>
In principle you can setup any rotor system with the setup procedure described in chapter 3. Nevertheless the aerodynamic behavior of a multiblade rotor is different to a normal two blade system and thus the cyclic pitch travel has to be adapted. In order to be sure that the rotor head geometry is correct, I recommend to proceed in the following way:
Reduce the P- and I-Gain in the Swash regulator setup to 0 and set the Look Ahead Gain to 100. The swash plate is now controlled directly from the sticks. Then leave the setup menu

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and verify that the swash gyros are inactive and the swash plate can be steered like on an conventional RC-helicopter. Modify the linkage to the rotor head in a way that the cyclic travel on the blade grips is approximately 4°. Having done this, you can do the first hoovering attempts. Without forward speed, with this cyclic travel, the helicopter should hoover like a normal Bell Hiller head. If this is not the case, something is wrong with the linkage ratio of the rotor head and even an electronic regulator won't be able to stabilize the helicopter perfectly. Thus you should modify the linkage. When the helicopter reacts too nervous on stick inputs, the linkage has to be modified in a way that the cyclic travel on the blade grips is reduced, when the helicopter is reacting to slow, the cyclic travel should be increased. When the hoover is stable one again checks that the overall RC-Gain value in AC-3X is at 100% and than one increases P- and I-Gain in the Swash Regulator setup synchronously in steps of 10. After every step one should check whether the hoover flight is more stable or not. In case that hoovering is more indifferent, this indicates that the gyro sense on one of the axis is wrong and you should correct this. Normally one should increase P- and I-Gain to approximately 50 without any problems. Having done this, one can optimize the setup as described in chapter 3.6 and 3.7.

What is the reason when the helicopter is drifting around one axis although the initialization of AC-3X finished without any problems?

This might be caused by two things: there might be heavy vibrations in the system which influence the gyros in AC-3X. In this case AC-3X should be mounted softer e.g. with two layers of the mounting tape. A further reason might be a drift of the transmitter potis. When they are drifting, one can already observe this on the ground when e.g. the tail slider is slowly drifting to one side although the motor of the helicopter is switched off. When this is the case please increase the stick deadbands in the stick menu until this phenomena vanishes!

Why do the servos move so slow when beeing in flightmode?

This is due to the control algorythms working in AC-3X. When the helicopter is on the ground and cannot follow the steering inputs, the swashservos will travel slowly to their maximum limits when giving steering inputs. The tailservo will also behave "strange", it is not moving at constant speed and might even stop in the middle of the travel range. To check for correct servo function please go to the setupmenu where the control algorythms are disabled!

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6. Error Messages during Operation.

Like with every technical device also with AC-3X malfunctions are possible. To avoid that the helicopter is damaged due to some error of AC-3X during the initialization of AC-3X several self tests are done. AC-3X only goes to the operative state when all of them have been passed without problems. In case that a test failed, AC-3X gives a note in the display. Possible error messages are:

RC-Calibration Error: When AC-3X can not calibrate the midstick positions correctly, AC-3X indicates this by a RC-calibration error. Normally in this case the receiver is not giving correct pulses. So the user should check all connection to the receiver and then switch on AC-3X again. The RC-calibration error message can be suppressed by pressing on the upper button. By doing this, one can go to the setup menu without transmitter. **But be careful**: when RC-Calibration did not succeed (the error message appeared and was acknowledged by the button!) no correct flight operation is possible!
If the RC-calibration doesn't work although all cables to the receiver are connected correctly, then it might be than the "Stick-Cal. Tolerance" in the Stick menu is to low and it should be increased.

Error during Sensor calibration: When the helicopter is moving in the initialization phase it might happen that the sensor calibration screen is not disappearing. Thus the helicopter should be left on the ground after switching AC-3X on for at least 10 seconds. If nevertheless the sensor calibration is not finishing, the "Sensor Cal. Tolerance" in the sensor menu is too low and should be increased.

Sensor Defect: The gyro sensors of AC-3X are also checked during the initialization phase. If one of the sensors seems to have an defect, this is also displayed by AC-3X. If this is the case AC-3X should be send back to me! Please do not fly with a defect sensor!

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7. Important Security Notes and Disclaimer

AC-3X may only be operated when it is assured that due to the operation of an AC-3X equipped helicopter neither persons or things are endangered.
When flying with an AC-3X equipped helicopter an adequate safety distance to persons, animals or buildings must be kept.
Keep always in mind that a component of the helicopter might fail and the helicopter gets uncontrollable! For damages resulting from such a situation, I have to disclaim the liability. The responsibility for the save operation of AC-3X takes the user!

Keep AC-3X dry otherwise a safe function of the electronics inside can not be guaranteed

When using AC-3X in helicopter with nitro engine, take care that no exhaust pollutes AC-3X as otherwise the function of AC-3X might be affected.

When AC-3X is damaged due to a crash, please do not operate it anymore. You can send it back to me for a function check.

AC-3X is intended to operate in an area without electrostatic discharges!

Any damages due to failure of AC-3X cannot be claimed!

For personal injury or damages of things and their consequences resulting from my delivery or work, I cannot accept any liability as I have no control on the usage and handling of my product.

General:

This manual represents my current state of experience with AC-3X. It might be updated to include new experiences. The current version of the manual will be downloadable at www.acrobat-helicopter.com.

EG-Konformitätserklärung:

For AC-3X I approve that is in line with the following EMV-regulations:

EG-Richtlinie Elektromagnetische Verträglichkeit:	2004/108/EG
Emission :	EN 55011 Klasse B (Wohnbereich)
Störfestigkeit:	EN 61000-6-1 (Wohnbereich)

The EAR registration code for AC-3X is

WEEE-REG. Nr.: DE29755000

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