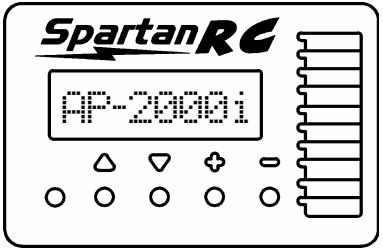
AP-2000i

3D Flight Stabiliser

Installation Guide



SpartanRC

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How to use this manual

This user guide covers the essential information required for the installation and configuration of the AP-2000i. It assumes that the model aircraft is correctly assembled and test flown and that the user is familiar with model helicopters and is a competent pilot. Please read this user guide entirely even if some sections may not appear applicable to your requirements. Some of the configuration options described in this user guide are applicable to firmware version 1.11 or higher.

Safety notes

Model helicopter are not toys and they have the potential to be very dangerous. Beginners who wish to use the AP-2000i as a learning aid should seek advice from a competent adult pilot.

CONTENTS

Overview

The AP-2000i is one of the most advanced aeromodelling avionics products available today. At its heart there are distinct several devices all housed in the same package.

- The AP-2000i's advanced Flight Stabiliser is able to interface with various types of analogue and digital sensor and provides fast model recovery and smooth hover. This feature can be individually disabled depending on the user's requirements.

- Our patent pending "digital cyclic ring" technology eliminates swashplate binding at extreme diagonal stick deflections. This feature can be individually disabled depending on the user's requirements.

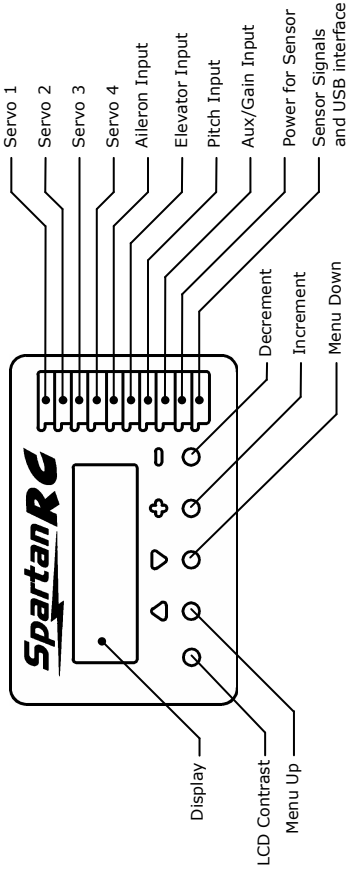
- The AP-2000i incorporates one of the most advanced electronic CCPM mixers. Designed with particular attention to the special requirements of scale and flybar-less helicopters it offers numerous swashplate options, phasing adjustment in 1 deg steps, fine trimming of servo mid-point of optimum geometry and adjustable endpoints for all servos.

- The built in battery monitor measures the battery voltage tens of times per second. It displays both the current voltage as well as the lowest voltage seen in flight while the battery was under normal operating load. This is the essential information every model pilot needs for making sure that his battery packs are healthy and up to the job.

- The build in glitch and frame error counters provide invaluable diagnostic information to users of PPM receivers which can help prevent loss of control due to locally generated interference.

- User adjustable failsafe ensures that AP-2000i will drive the aircraft controls to a predictable state should it fail to receive good signals from the radio system.

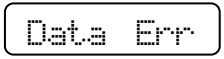
AP-2000i interconnections



Powering on the AP-2000i

The AP-2000i requires valid Aileron, Elevator and Pitch servo signals from the receiver before it begins to function. If any of these signals is not present the display will show:

The AP-2000i validates its programming every time it is powered on. Corruption of data is virtually impossible under normal use but it could happen if the AP-2000i is switched off while the programming is being modified. If corruption of data is detected the AP-2000i will not start operating and the following message will be displayed. If this case cycle power and reprogram the AP-2000i.



Configuration

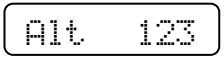
Configuration of the AP-2000i is performed via a simple menu system. First select the item you want to view or modify using the “Menu Up” and “Menu Down” pushbuttons; then use the “Increment” and “Decrement” pushbuttons to adjust the value as needed. To avoid accidental changes of the programming, the pushbuttons are recessed into the case and should only be pressed with a small Allen key or similar tool.

The first screen of the menu is referred to as “home” screen and displays a variety of easily accessible information about the AP-2000i internal operating state.

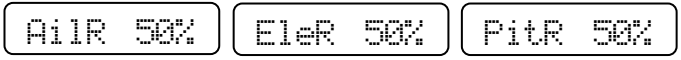
Typical views of the home screen are shown above. The first four characters of the screen show the stabilisation gain or they will display OFF when the stabiliser is switched off and CAL while the calibration request is being detected.

The remaining four characters show the receiver battery voltage. The number displayed toggles every few seconds between the current voltage and lowest voltage. While an upper case ‘V’ is shown the current voltage is being displayed. While a lower case ‘v’ is shown the lowest voltage is being displayed.

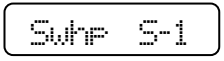
If any glitches or frame errors are detected during the flight, Gxx and Fxx will be also appear in rotation after the voltage display. In the above example G07 shows the number of glitches (7) and F03 shows the number of frame errors (3). Additional information is available in the “Glitch and frame error counters” section later in this guide.



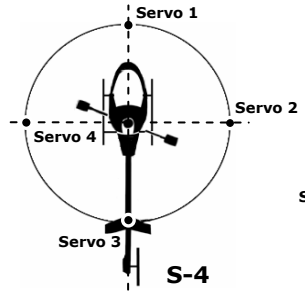
Pressing and holding down the Increment button at the home screen the display changed to the one shown above. At the end of the flight this screen shows the maxim altitude the aircraft has flown to. Please note that the optional FL-180 altitude sensor is required for this functionality.

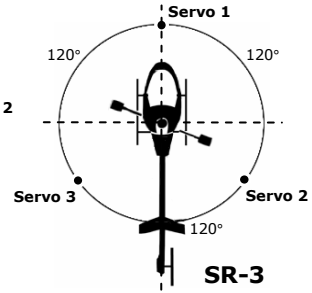


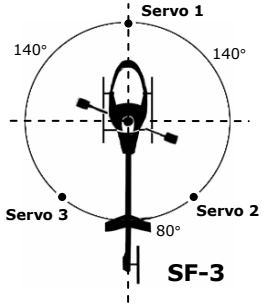
These are the Aileron, Elevator and Pitch Rate adjustment screens. Adjusting these values is functionally identical to adjusting the transmitter ATVs. However, in the interest of preserving system resolution it is advisable to make these adjustments on AP-2000i and keep the transmitter ATVs and dual rates in the 80-120% range. The factory default value is 50% which is suitable for CCPM mixing. If you are using the “S-1” type swashplate adjust these to 100%.

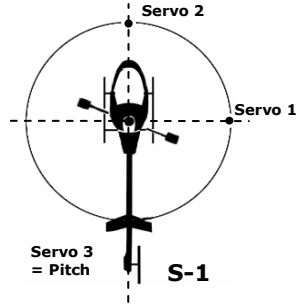


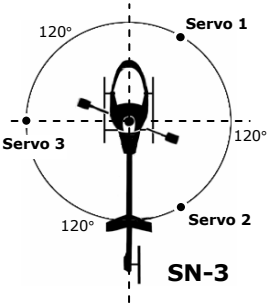
Use this menu screen to select your model’s swashplate type according to the graphs shown on the next page. The servo numbers shown on the graph match the ones on interconnection diagram of page 5. Also refer to the CCPM Setup section later in this user guide.

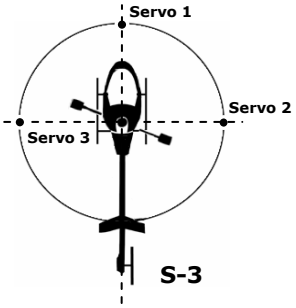


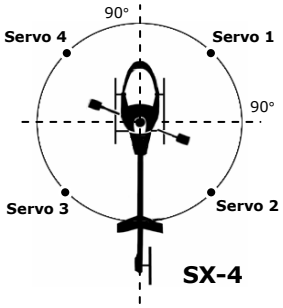


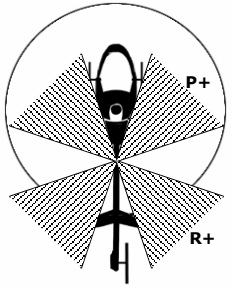




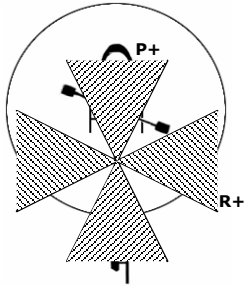








IRx for analogue sensor
IR* for digital sensor



IR+ for analogue sensor

Ring100%

Use the Digital Cyclic Ring ™ adjustment to avoid diagonal swashplate binding. Detailed information about this feature can be found at later pages of this user guide. The factory default value is 100% which corresponds to this feature being disabled.

Phas 0°

This menu screen allows adjustment the rotor phasing for multi-bladed helicopters. Adjustment range -90 to +90 degrees. Factory default: 0 degrees. Also refer to the Rotor Phasing section later in this user guide.

Stab IRx

Selection of the stabilisation sensor type and orientation. Changes of this adjustment are not operational immediately. Power cycle for changes to take effect. The shaded area on the graphs below shows the infrared sensor's field of view. See dedicated chapter for sensor installation and pre-flight checks later in this guide. Select the "OFF" option if you are using AP-2000i as a CCPM mixer only without a stabilisation sensor.

Ail5 NOR Ele5 NOR

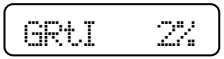
Select the required Aileron and Elevator Stabilisation Reversing. When stabilisation is active the swashplate should move in such direction that:

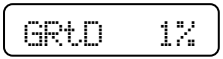
- inertial sensor: corrects any tilt or roll
- infrared sensor: tilts away from a heat source such as a hand or hot cup of coffee placed near the sensor

SCal OFF

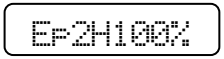
The Stabilisation Calibration screen allows selection of the type of calibration to be performed. The actual calibration will only tale place when requested by the pilot by reduced the gain input well below the OFF position. Calibration is not essential but if not done the aircrafts trim may slightly vary when the stabiliser is turned on/off. See the calibration section for additional information. Available options:

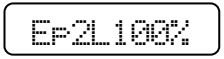
OFF = No calibration to be performed. Default values to be used.
P-R = Pitch and Roll calibration

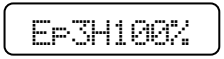


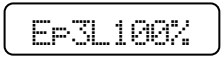


The Gain Rate Increment and Decrement screens control how fast the stabiliser gain tracks the pilots demand. 0% equals instantaneous change and larger values result to a softer switch on/off of the stabiliser. This helps prevent the rapid and jerky jump to the hover position when the stabiliser is switched on. However it also reduces the stabilisers response it is to be used as an emergency bailout from an unsuccessful 3D manoeuvre. Typically a GRtI of 1-2% offers a good compromise between response speed and soft switch on. GRtD is less critical and can be much faster. You can observe the effects of GRtI and GRtD on the gain display of the home screen.

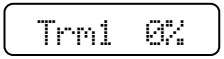


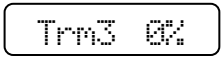




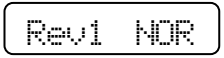


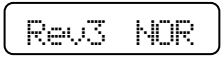
High (H) and Low (L) Endpoint adjustment for each of the four servos. This is the absolute limit that a servo is allowed to travel.

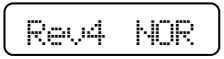




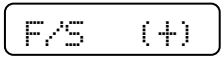
Adjusts the servo mid-point for optimum linkage geometry.







Servo direction reversing for each of the four servos.



Press the Increment button to memorise the current Aileron, Elevator, Pitch and Aux/Gain inputs as failsafe positions. These will take effect should the AP-2000i fail to receive good signals from the radio system. Users of PCM systems should also program the failsafe feature of their radio system since it takes priority over the AP-2000i's failsafe. For further information see the Failsafe section at later pages of this user guide.

CCPM Setup

1. Switch stabilisation off before commencing with CCPM setup as stabilisation corrections can crate confusion while setting up CCPM mixing and almost certainly will effect the neutral potion of servos, thus affecting the geometry of your CCPM setup.
2. Turn the transmitter's CCPM mixing off.
3. Set the swashplate type on the AP-2000i
4. Move the collective pitch stick up/down and reverse servos as needed on the AP-2000i so that the swash travels up/down while remaining flat.
5. If the aileron, elevator or pitch direction need reversing, do this at the transmitter.

Glitch and frame error counters

The glitch and frame error counters monitor the four inputs of the AP-2000i and count any signals that fall outsize the normal operating limits. Users of PPM receiver are advised to inspect these values regularly as part of their post flight checks as these can provide early warning of interference problems which could imminently result in loss of control.

Failsafe

In the event of a radio lockout while the AP-2000i stabilisation is active the helicopter could fly very long distances without any pilot inputs. It is therefore recommended that failsafe is set to descent the helicopter. Always set the failsafe feature according to your radio system manufacturer's and local aeromodelling authority's guidelines. BMFA recommends that engines are brought to slow idle and electric motors stopped. For this purpose users of PPM receivers are advised to use an additional failsafe device on the throttle channel.

Infrared stabilisation

If infrared (horizon sensing) stabilisation is required the following sensors may be connected to the AP-2000i:

1. FMA CPD4SENUNIT utilising the AP-2000i's analogue sensor mode. An optional adaptor cable is required.
2. Spartan RC HL360 horizon sensor utilising AP-2000i digital sensor interface.

Our sensor cables come with two coloured J-type connectors. The red plug provides power to the sensor and the black plug delivers the sensor signals to the AP-2000i. The infrared sensor must be installed away from the exhaust fumes and heat sources at a location where the sensing elements can have unobstructed view of the horizon.

Calibration

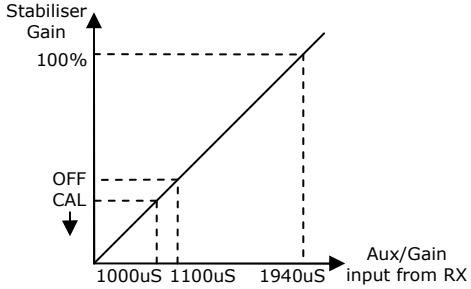
The purpose of calibration is to minimise day to day variations in trim and gain. Calibration is not essential, but if not done the aircraft's trim may slightly vary as the stabilisation gain is increased and a small amount of trimming may be required. We recommend that a slider is used to control the gain so that the pilot can easily adjust the gain as needed.

There are two distinct types of infrared calibration: The Pitch and Roll calibration memorises the current pitch and roll attitude of the aircraft as the ideal hover point therefore improving the aircrafts trim. The gain calibration memorises the temperature difference between ground and

sky and scales the gain signal accordingly. The AP-2000i's "SCal" menu offers the following calibration options that arising from the above two calibration types:

OFF = No calibration is desired
P-R = Pitch and Roll calibration
GAI = Gain calibration only (to be available if future f/w release)
PRG = Pitch, Roll and gain calibration (to be available if future f/w rel.)

The "SCal" menu is only for selection of the desired calibration type. The actual calibration is will be performed when requested by the pilot by the use of the Aux/Gain input channel. Calibration is not performed when the "Stab" adjustment is set to OFF. The following diagram illustrates how the AP-2000i translates the Aux/Gain input to gain % and calibration request.



In practical terms, adjust your transmitters AVTs so that the gain display on AP-2000i home screen changes from OFF to 100% when the slider is moved from end to end. Additionally program a mixer to be activated via the use of a switch. The mixer should be configured to offset on the Aux/Gain channel enough to reach the calibration point. If offset adjustment is not available on your radio, simply mix the Aux/Gain channel with itself. With the gain slider at the OFF position adjust the mixing percentage. When the AP-2000i senses the calibration request the home screen will change from OFF to CAL.

First flight

The following procedure is recommended for the first flight.

1. Confirm the swashplate moves correctly to the pilot's controls.
2. Use an easily accessible slider for gain.
3. Take off and with the stabiliser off trim your aircraft as accurately as possible.
4. Activate the calibration switch for approximately 1 second.
5. Fly to a safe height (15-20 feet) and hover.
6. Slowly increase the stabilisation gain using the slider until you achieve the desired degree of stabilisation. If at any point you feel uncomfortable with the flight characteristics, reduce the gain to the off position.

Digital Cyclic Ring

The use of cyclic rings is a highly debated subject between helicopter pilots. This chapter explains what diagonal cyclic binding is and why the digital cyclic ring is essential when a flight stabiliser is used.

Let's assume the scenario where the swashplate is set for maximum roll (aileron) and pitch (elevator) through. Individually the roll or pitch controls do not cause any binding. However, when the cyclic stick is placed at the furthest possible diagonal position in most cases the underside of the swashplate binds with the main shaft. In same helicopters the increased diagonal through also causes binding to other linkages on the head which can be checked by slowly turning the rotor.

Some pilots prefer to address this binding by separately lowering the aileron and elevator through enough to prevent diagonal binding. Undoubtedly this reduces the roll and flip capability of the aircraft. The alternative solution is to install a plastic ring around the joystick. The ring restricts the operating area of the joystick within a circle allowing the best roll/flip performance in all stick directions while avoiding diagonal binding.

However, both of the above solutions only limit the pilot's inputs. A flight stabiliser is not aware of any limits set on the transmitter side (mechanical or programmed) and it can still generate large diagonal corrections in certain conditions. For example if it was to trying to quickly recover the model from an unknown attitude.

The digital cyclic ring is therefore required to ensure that neither the pilot nor the flight stabiliser can cause anything to bind. Adjusting it is a very simple and straightforward procedure. Slowly move the cyclic joystick towards the full diagonal point while observing the gap between the swashplate and the main shaft on the underside of the swashplate. If binding exists lower the ring value a few steps and try again. Once you have confirmed the swashplate does not bind, hold the cyclic at full diagonal and slowly turn the rotor while observing for any linkage binding on the head. If anything appears binds lower the ring value a bit more until it stops. You may also confirm the diagonal adjustment by increasing the stabilisation gain too 100% and placing your hand near infrared the sensor to cause the swashplate to tilt.

Rotor Phasing

This section is applicable to flybar-less and multi-blade helicopters only. You may omit reading it if your helicopter uses a standard flybar type rotor design but ensure that the "Phas" adjustment in the menu is set to 0 degrees.

When the pitch of a rotor blade is increased, the blade does not immediately rise but has to rotate for approximately another 90 degrees before it reaches the highest flapped position. This 90 degree phase lag is attributed to blade inertia and gyroscopic factors, between the point at which the pitch is increased or decreased and the point where the full effect registers on the blade. As a result of this phase lag any fore-aft cyclic input would make the helicopter roll. To compensate for this most helicopters offset the control linkages from the swash plate to the blade by approximately 90 degrees. In model helicopters this phase adjustment is typically designed into the commonly used Hiller or Bell-Hiller (flybar) mixer. With flybar-less and multi-blade heads small phase adjustments can be made by rotating the swashplate lock. However, mechanical

restrictions often make it impossible to achieve the required 90deg phase correction.

The AP-2000i offers an electronic phase adjustment that operates by offsetting the phase of the pilot's controls in order to achieve the correct relationship between cyclic stick and helicopter rotor. The step by step instructions below describe how to correctly set the phasing of your rotor.

1. If the model uses CCPM mixing configure this first. Refer to the CCPM Setup section for step by step instructions.
2. Ensure that the swashplate responds correctly to cyclic inputs. Fore cyclic input should make the swashplate tilt forward.
3. Adjust the swashplate lock according to the helicopter's or head manufacturer's recommendation. If no recommendation is give find the position that gives the optimum linkage geometry. Typically this will be when the linkages from the swashplate to the blade grips are parallel with the main shaft.
4. Place any blade parallel over the tail boom and apply a large fore and aft cyclic input while observing the blade for pitch changes. Adjust the "Phas" menu screen until you find the number that result to no pitch change on this blade. Keep in mind that the adjustment range is +/-90 degrees and the value you need may be negative.
5. While keeping the blade parallel over the tail boom, apply full right cyclic. For a clockwise rotation head the pitch on the blade should increase. For a counter-clockwise rotation head the pitch of the blade should drop.

For the first flight spool up and without taking off carefully apply a very small and gentle cyclic input. Watch which way the rotor tilts. If you observe any difference between cyclic and the direction at which the rotor tilts fine tune the "Phas" adjustment as needed until you the rotor tilt is identical to the direction of the cyclic stick.

Using gyroscopes

When using gyros in conjunction with the AP-2000i to enhance the stability of your aircraft, these need to be connected between the receiver

and AP-2000i's the aileron and elevator inputs. Pay particular care to the mounting of these gyros and ensure that each gyro senses the rotation it controls. The roll sensing gyro should therefore control the aileron channel and the pitch sensing gyro should control the elevator. Furthermore, ensure that the gyro reversing and gain is correctly set as incorrect adjustment of either can render the aircraft uncontrollable. Excessive gain will almost certainly result to violent oscillations with possible loss of control. For the first flight adjust the gyro gain to around 10% and slowly increase in subsequent flights until the desired level of stabilisation is achieved. Finally ensure that the AP-2000i internal stabiliser is set to "Stab OFF" when such gyros are used.

Firmware Update

Like all microcomputer systems the AP-2000i operation is based on factory preinstalled software, known as firmware. Spartan RC is committed to the continuous improvement of our products and from time to time we produce new firmware versions offering optimisations and/or new functionality. These new firmware releases are published on our website. To support such firmware updates the AP-2000i has a robust built in firmware update utility (firmware loader). It is designed so that the AP-2000i can always be brought back to operating state even if the update process fails to complete. However, for a smooth update always ensure that the receiver battery is sufficiently charged.

In order to install a new firmware you will need:

- A Flash-Link USB cable (can be purchased form Spartan RC and our distributors)
- The Windows firmware loader application (available on our website).
- The new firmware hex file (available on our website).

The firmware update procedure is as follows:

- First check if the AP-2000i's firmware needs updating by comparing the firmware version shown in the engineering/service menu with the version published on our website.
- Connect Flash-Link to the PC and confirm that it has been correctly

detected by Windows.

- Power-on the AP-2000i, enter the engineering/service menu, select the "Ldr" menu and press the "Increment" button. The message "*LOADER*" will be shown in the LCD.
- Connect the other end of the Flash-Link cable to AP-2000i's USB interface connector.
- Run the firmware loader application on the PC.
- Select the COM port where the AP-2000i is connected. If unsure select the listed ports sequentially. When the correct port is found the message "AP-2000i detected" will be displayed at the lower left corner of the window.
- Click on "Open" and select the new firmware hex file.
- Click on "Send" and wait until the update is complete.
- When the firmware update is complete successfully the AP-2000i will display "ChkModel".
- Power off the AP-2000i then back on and confirm that all controls operate correctly.

If the firmware update fails for any reason the AP-2000i will not function. However, the firmware loader will remain active. You may repeat the update as described above but keep in mind that no messages will be displayed on the LCD. The firmware loader will be automatically invoked.

If an incorrect or partial firmware is loaded on AP-2000i you may not be able to automatically invoke the firmware loader and the AP-2000i will appear to malfunction. In such rare cases the firmware loader can be forcibly invoked by holding down the "Menu Up" and "Decrement" buttons while powering on the AP-2000i. No messages will be shown on the LCD but you may proceed with the firmware update as described above.

Engineering/Service Menu Screens

The AP-2000i also has a number of hidden menu screens available via a secondary engineering/service menu. These menu screens are of no value to the end user and therefore they were separated from the primary menu

to avoid cluttering. The engineering menu items will not be described in detail in this document but a few notes are given later in this document for the curious modeller.

To access the engineering menu press both "Menu Up" and "Menu Down" buttons simultaneously while the AP-2000i is operating.

"SN: 1234" shows the electronic serial number of the device
"Ver 1.00" shows the firmware version.
"Ldr v1.0" shows the version of the firmware loader. Pressing the Increment button invokes the loader.
"Ail", "Ele", "Pit", "Aux" show the sampled pulse width for the corresponding input in uSec.
"Sv1", "Sv2", "Sv2", "Sv4" show the computed servo positions for each output.
"ADC1", "ADC2", "ADC3" show the values read form analogue stabilisation sensors (range 0-1023)
"OfsP" and "OfsR" show the sensor calibration offsets for the Pitch and Roll axis.
"RngZ" shows the sensor signal range. This is the maximum possible signal generated by the sensor minus the minimum possible signal.
"Alt" shows the current altitude when an FL-180 altitude sensor is connected.
"T°C" shows the temperature measurement provided from the FL-180 altitude sensor.
"Frm" shows the PPM/PCM frame period.
"Load" shows the computation time to process one frame. Pressing "Inc" shows CPU load as a %.
"*RESET*" Pressing "Inc" clears all user setting and loads the factory defaults. You will first be asked to confirm this by pressing "Inc" once more.

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Disclaimer

Because Spartan RC and their distributors have no control over the installation and use of this product, no liability may be assumed nor will any liability be accepted for any damages resulting from the use of this product. Under no circumstances will the buyer be entitled to consequential or incidental damages. By act of installing this product, the buyer accepts all resulting liability.

Specification

- Compatibility: All PCM/PPM radio systems using digital or conventional servos.
- Servo signal resolution: 1800 steps
- Operating voltage: 4 - 10 Volts, current draw <15mA
- Compact design measures: 55mm x 36mm x 13mm
- Weight: 30 grams
- Operating conditions: 0 to 50 deg C, 32 to 122 deg F, 20 to 85 % humidity not condensing.
- Storage: -20 to 70 deg C, -68 to 158 deg F, 20 to 90 % humidity not condensing.

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