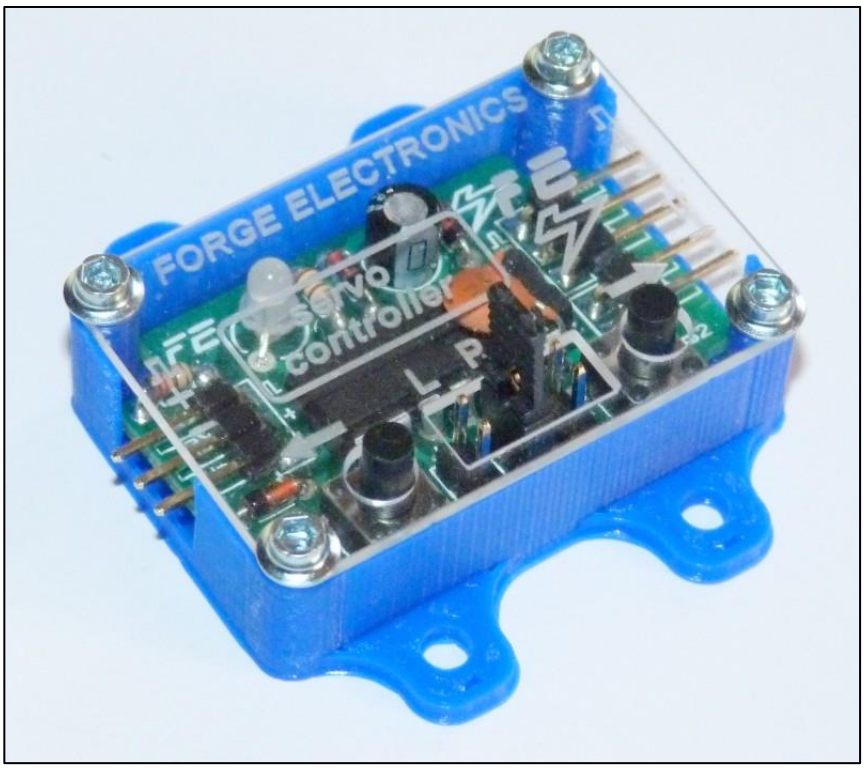
Servo Controller



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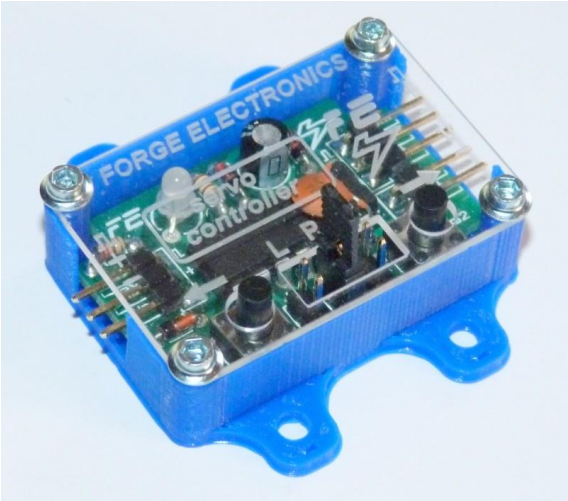


Many modellers choose to use a standard servo as the motive platform for a ship's guns, but driving the servo directly from a spare channel of the receiver has two main drawbacks. Firstly, it is very difficult to move the gun slowly and smoothly, especially if trying to operate other functions of the model at the same time and unrealistically rapid and/or jerky motion usually ensues. Also to maintain any position other than dead ahead, the transmitter joystick must be held at the equivalent position for the duration that the gun displacement is required. Secondly, the standard signal from an RC receiver can only move a servo through 90 degrees, whereas 180 degrees is ideally required to allow a gun to fire broadsides. Gearing up the servo shaft is an option, but only serves to increase the jerkiness and maybe introduces backlash too.

This servo controller module fits between the receiver and the servo to overcome the above problems. Firstly, joystick movement to either side of a centre dead-zone commences movement of the servo in the appropriate direction at a steady speed regardless of the size of the joystick displacement. Releasing the joystick to the central position causes the servo to halt and maintain the position achieved. The speed of travel is user adjustable from the slew rate of the servo (maybe a second or two from end to end) to around 30 seconds for a full traverse.

Secondly, by increasing the range of the servo drive signal beyond the industry standard limits it is possible, depending on the actual servo used, to achieve up to 180 degrees of movement. Often, the servo mechanics are asymmetric and dictate that this range is achieved as eg 70 degrees one way and 110 degrees the other, so in this example the servo horn would need to be fitted displaced by 20 degrees from its normal position to achieve the +/- 90 degrees required by the gun. The servo end points are independently adjustable by push button anywhere within its possible operating range (see later).

An (active low) output has been added which is activated when the servo reaches either its clockwise or anti-clockwise limit – this is for the purpose of automatically initiating gunfire or some other appropriate sound from a suitable sound module. The Adafruit SFX and Sparkfun MP3 Trigger are recommended. This is a low current logic output direct from the chip and may not be suitable to operate sound units other than those named above. An LED also shows the status of the unit, being lit if the servo is at either of its end limits and flickering whilst the servo is in transit.

The final issue addressed is servo behaviour at power up. At any time during its operation, for anything more than a tiny error between its actual position and its commanded position a servo applies full power to correct that error. If that error is gross the servo will reach its full slewing speed whilst correcting it. So, if at power up the servo is not in alignment with its commanded position, a gun that is intended to move smoothly and majestically may jerk violently into position, which is undesirable – certainly aesthetically and maybe mechanically too. There are two options for the start-up position:-

1. USER - a starting position may be set which the servo will always assume at switch on, moving if necessary to achieve it. Rather than at centre, this starting position might be required to be at one extreme of movement in some applications. However, to avoid violent movement at switch on the user must have parked the servo at this position prior to switching off.

2. AUTO - the controller can monitor the servo position during normal operation and if it is found to be stationary for more than 5 seconds (my arbitrary value), it can store that position in the chip's non-volatile memory. Thus at switch on the controller can assert the last position that the servo was parked in and no movement occurs

Both the above options rely on the servo not being manually displaced during power down. Be aware that some inferior servos do 'twitch' at power up, so check your servo prior to blaming the controller!

Option 2 has a cost associated with it. The chip manufacturer only certifies re-writing of the chip's memory locations for a typical life of 100,000 times. Thus, if the servo were continually pausing for 5 seconds (causing a memory write) and immediately afterwards moving on only to pause again for a further 5 seconds then a chip failure *might* occur after some 138 hours of continuous operation in this mode. There again it may never happen, such is probability theory! However, the pot track of the servo would undoubtedly get equally distressed in such a worse case scenario!

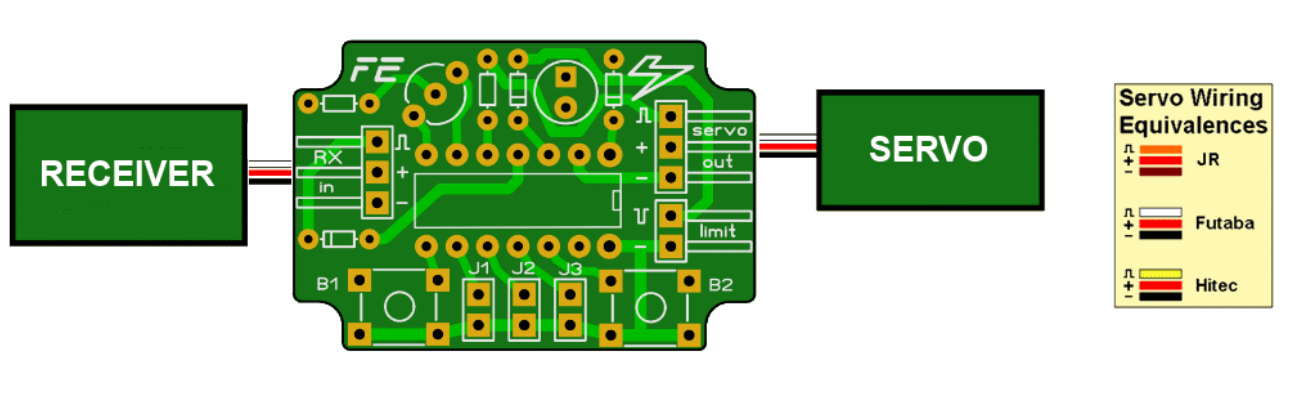
But note the memory is NOT written to **every** five seconds, but only when the servo position has changed from its last stable position to a new stable position. So if the servo then stays put for 5 minutes, no further memory writes occur. Thus with a more realistic operating scenario, the memory life prediction would be nowhere near as gloomy as suggested above. So with the above risk in mind, the user has the option to choose either mode of servo positioning at start-up.

At switch on, there is a five second delay, counted down by the LED flickering. This is to allow 2.4Ghz receivers to 'boot-up' and assert their correct outputs rather than those dictated by their 'failsafe' condition during the boot which could cause unintended movement of the servo.

CONNECTING UP

As can be seen from the photo above the unit housed in a small custom designed 3D printed box which will afford protection against accidental shorting and/or accidental splashing – *but it is certainly NOT waterproof!*

As shown below, the control channel of the receiver connects to the RX IN header using the male/male RC lead supplied. Similarly the servo plugs into the SERVO header. Be sure to insert the leads observing the polarities shown in the table.



If a sound trigger is to be used, simply plug a male two pin lead onto the “limit” header and connect the other end to the appropriate trigger input you wish to use. Be sure to mate the “-“ contact of the “limit o/p” header with the 0v contact on the sound trigger unit. Detailed instructions about using the latter are beyond the scope of this document and you should consult the sound unit manufacturer’s documentation.

OPERATION

The Option Links J1, J2, J3 are continuously sampled (rather than just at switch on) so they may be adjusted at any time, having immediate effect.

Normal Operation

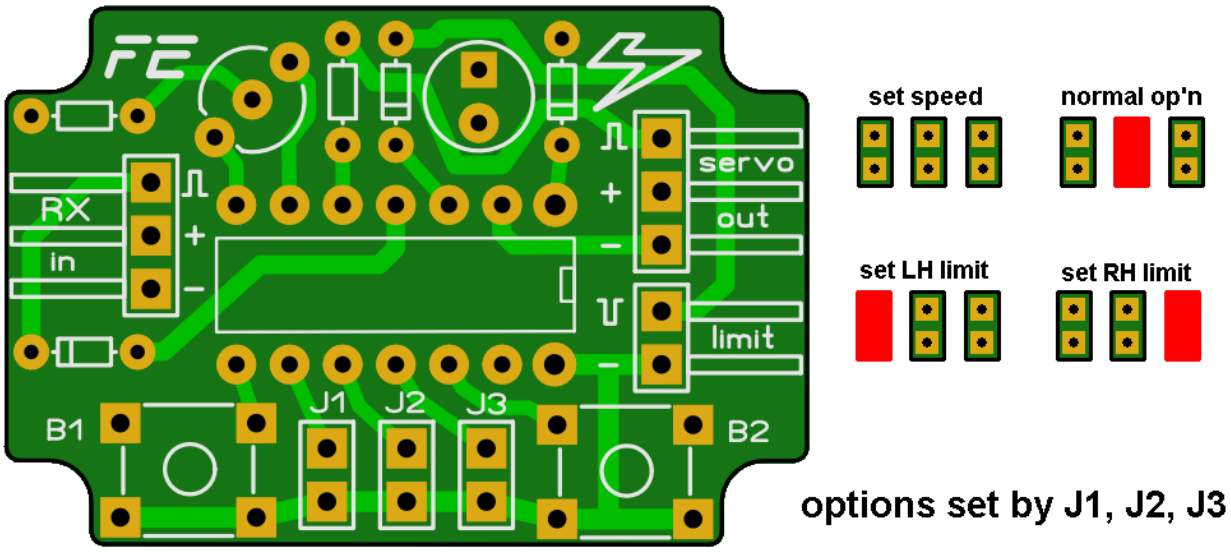
This occurs with the black jumper link in the centre position.

- **The LED Indicator** shows GREEN at all times during normal operation. Faint green to signify the unit is powered, bright green to indicate the limits of movement have been reached, and rapidly flickering green any time the servo is in transit. If the servo start up position is set to AUTO the LED will briefly flash RED each time a memory write occurs.

- **Anti-Clockwise Movement** occurs by displacing the joystick in one direction which causes continual movement of the servo until the joystick is released to its centre position. The servo then holds the position it achieved at release of the joystick. If the servo reaches the limit of its anti-clockwise rotation, the LED is lit, the 'limit' output goes low (for as long as the joystick is held displaced) and no further movement occurs.
- **Clockwise Movement** occurs in a similar fashion as above, but by displacing the joystick in the other direction instead.
- **Gunfire (**or some other user defined sound) can be set to sound automatically at the extreme limits of movement - provided the unit's "limit" output is connected to a sound trigger unit. The "limit" output is asserted for as long as the joystick is held displaced at the clockwise or anticlockwise limit, which allows the gun to fire repeatedly. The firing repetition rate is governed by the length of silence following after the 'shot' on the sound file recording. Alternatively, releasing the joystick to centre position once the gun starts to fire cancels the "limit" output so a single shot results.

Setting Up

This is achieved by appropriate movement of the black jumper link and use of the two push buttons. All the link options are illustrated in the layout diagram below.



- **The LED Indicator** shows RED at all times during set-up operations. Bright red to indicate the limits of movement have been reached, and rapidly flickering red any time the servo is in transit.

- **Anti-Clockwise (LH) Limit** is set by moving the black jumper link to the left hand position. The servo will then travel from its current position to the previously set anti-clockwise limit position and the LED will light to show when it has been reached. Now use the two push buttons B1, B2 to increase or decrease the limit position as desired. A short press of the button will move the servo one step at a time, whereas if the button is held down then after a short delay the servo will move steadily in the commanded direction until the button is released.
- **Clockwise (RH) Limit** is similarly set by moving the black jumper link to the right hand position to set the clockwise limit of movement.

Care must be taken in setting the end limits as the unit has sufficient range to drive the servo into its mechanical end stops and if the servo is commanded to attain a position beyond these and is held stalled by its mechanical end stops then a heavy motor current will flow, eventually burning out the motor and/or the servo's drive electronics. When the mechanical end stop of the servo is reached (no further movement occurs in response to button presses) be sure to back off the position until the servo is seen to move again. YOU WERE WARNED!

- **Traverse Speed** of the servo is set by removing the black jumper link altogether and waiting - after about 3 seconds the servo will commence to sweep between the two end limits previously set. Now use the two push buttons to increase or decrease the speed of traverse as required. When increasing the speed, at some stage the slew rate of the servo will be reached and no further increase of speed is possible - in this situation the end limits may not be reached either as the servo drive might reverse prior to the servo having had time to reach the set end point. Replace the black jumper link in the mid position to resume normal operation again. The LED, which normally flickers RED to signify servo movement, will show solid RED when the upper or lower limits of traverse speed adjustment have been reached.

- **Servo Start Position Mode** can be set to USER (a fixed user position) or AUTO (the last stable position). The chosen mode is indicated during the 5 second power-up delay by the LED either flickering green (USER) or red (AUTO). To change between modes, press and hold either the left or right hand button *before* powering the unit. The left button selects USER and the right button selects AUTO. When the LED lights red or green as appropriate, the button may be released and the start-up sequence will commence.

- **Servo Start Position USER** can only be set during normal operation (ie the jumper link must be in the centre position) and provided that the USER mode of servo start position has been invoked. It is set by pressing *both* of the pushbuttons whilst the servo is stationary in the desired position. The LED will show red for the duration of the simultaneous button press to indicate that this position has been written to memory for use at the next power up

- **Servo Start Position AUTO** only functions during normal operation (ie the jumper link must be in the centre position) and provided that the AUTO mode of servo start position has been invoked. The servo start-up position is saved automatically once the servo has been stationary for in excess of 5 seconds. The LED will briefly flash RED each time that a memory write occurs.

- **Servo Start Position Conflicts**. If after setting the servo start position the user later adjusts a limit position to be less than the start position then a conflict could occur at the following power up, when the unit would try to set the servo starting position somewhere outside the user limits. This conflict condition could also occur during AUTO operation if after making a limit adjustment the user powers down the unit prior to the 5 second stable position checking has occurred.

  So to avoid this conflict condition, at power up the unit checks to see if the servo start position lies beyond the user set limits and if so it modifies the previously saved position to match the limit that was exceeded. The LED which normally shows red during set-up operations will briefly flash green to signify that the start-up position has been automatically modified.

- **Default Settings**. When shipped, the unit is in the USER mode for servo start position and programmed to start the servo midway between the two end points which are set to values of +/- 45 degrees from centre (equating to 1.0, 1.5 and 2.0mSec).

Signal loss / Signal out of range

In the event of total loss of signal from the receiver, the LED will alternately flash red/green, each cycle taking approximately one second.

Signals outside the range 0.8mSec to 2.2mSec are ignored and have no effect on the servo position.