# Super Servo Driver Card

*Designed by Ian Armstrong*

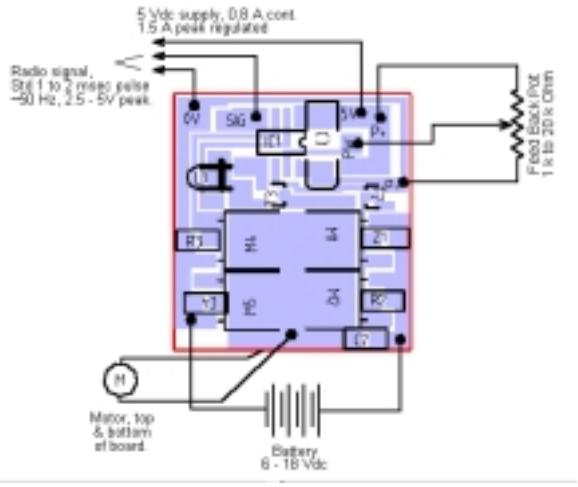
## General

The Super Servo Driver Card was designed to surpass all RC servos for power and efficiency, and with it's small size (28 x 30 x 9mm), represents probably the best power for size available.

## Features

- Small package (28 x 30 x 9mm)
- Wide voltage range (6 Vdc to 18 Vdc)
- Powerful, > 20 Amps continuous, up to 30 Amps cont. with additional heat sinking, giving a power output of 250 W cont. on 12 Vdc, or 375 W at 18 Vdc.
- 4 kHz PWM (pulse width modulation) output for greater efficiency, and less heat build up in drive motor and Super Servo.
- Full digital PD (Proportional/Differential) control circuit, for precise and accurate positioning.
- Reliable miniature micro-controller heart for minimum circuitry and maximum performance.
- Programmable Failsafe. Servo will return to a user pre programmed position with a failure of the signal pulse train (~1/2 second without signal)
- Spike and glitch rejection. Signals more than 10% outside normal range are ignored.
- Full buttonless programming, Programming of Proportional Gain, Differential Gain, Failsafe Position and Feed Back Range, that is required only once, but can be changed as often as required.
- In built Receiver Battery Eliminator Circuit (BEC) (5 Vdc 1.5 Amp peak, ~ 0.8 A cont depending on supply voltage)
- Feed back by potentiometer 0.5 kΩ to 20 kΩ. Uses same supply as A to D converter for accurate positioning precision.
- Three Programmable Feed Back ranges (full range, ½ range and ¼ range) allows for a number of possible feed back solutions.
- Full 8 bit positioning (256 steps) in all 3 feed back ranges, with high frequency sampling of servo position (~125 smaples/second)
- Signal requirements are as for std RC receiver output. i.e. 2.5V to 5V, 1 millisecond to 2 milliseconds pulse width at 50 Hz. (frequency can be from ~100 Hz to ~ 3 Hz, without effecting normal operation. However, parts of the programming sequence which are timed will vary inversely proportional to the frequency e.g. 10 Hz signal frequency will increase any specified times by 5x)
- Signal specifications could be changed if specifically required. Any pulse train, digital or pulse width or frequency could be accommodated, including variable voltage or variable current (eg 0-10V, 0-5V or 4 to 20 mA) at minimal extra cost.

## Connections




Please connect Super Servo according to the diagram at left.

1. Connect feed back pot to P+, P- & PW.
2. Connect drive motor to top and bottom of circuit board as shown.
3. Connect battery 6 to 18 Vdc to tracks on the edges of the board (top or bottom). But do not turn on power yet.
4. Connect pulsed signal between 0V and SIG. If peak signal voltage is over 5V, then add a resistor to the signal wire according to the following formula.

$$R_{min} = (V_{sig} - 5)/0.003$$

5. Connect 5 Vdc 0.8 Amp supply to receiver or signal generator if required.

## Mounting

The Super Servo Card should be mounted to avoid shorting any tracks or connections. Some ventilation is required if the output is to be close to maximum specifications.

The Card is fairly immune to contamination from dust and water, but corrosive substances and metallic particles should be avoided completely.

## Testing & Tuning

Super Servo has been tested to operate correctly, and therefore already has a temporary set up already programmed.

Turn on power momentarily, with or without receiver (or signal generator). Super Servo should centralise around the signal or the temporary Failsafe. If one of the following conditions occurred correct as instructed.

1. Servo runs to one of the ends without stopping. Swap motor + and – wires **or** swap pot P+ and P- wires and retest.
2. Servo travels in the wrong direction. (Can only be tested when connected to signal). Swap motor + and – wires **and** swap pot P+ and P- wires and retest.
3. Servo oscillates around the set point. Reprogram Super Servo with less proportional gain or more Differential gain. See Programming
4. Servo travel is too large or too small. Reprogram Super Servo with more suitable range. See Programming.
5. The LED flashed twice and Super Servo did not respond for 2 seconds (total). This is normal, Super Servo has indicated that the first condition required to enter program mode has been met, but not completed.

**An explanation of Proportional and Differential Gain**

If you are knowledgeable in this subject, you can skip to Programming.

A servo operates by driving a motor in some process to a position determined by the input signal. The motor runs till a feed back device (usually a potentiometer) produces a signal corresponding to the position determined by the input signal. When these two signals match the servo stops.

It would be impossible to let the motor operate at full power till the set position is reached, as inertia would cause the servo to go straight past. Being on the other side of the set point, the servo would then go full reverse in the opposite direction and again pass the set point. Uncontrolled oscillations would result. In a simple analogue servo the power of the motor is reduced as the set point is approached, in fact the motor power is proportional to the distance the servo is from the set point. The amount the offset distance is multiplied to give motor power is called *Proportional Gain.* The gain is high if the motor reaches full power at a small distance from the set point, and is lower if it is further away.

Proportional only systems are prone to oscillations and normally run reduced gains to counter this problem. However, low proportional gain means that the servo can be more easily driven from its set point because the servo has to move further for the motor to increase in power.

One solution to this problem is to subtract the speed the servo is travelling from the calculated proportional motor power. This only has a major effect when the power to the motor from the proportional gain is small, i.e. when the servo is close to the set point. In fact, if the servo is very close but still travelling with some speed, the power to the motor will be reversed, which will stop the motor quickly.

Because on a position/time graph the slope represents the speed the servo is travelling, and in maths this can be found by the differential (dx/dt) of the equation, the amount of speed feed back used in the calculation is called *Differential Gain*.

A digital controller samples the feed back at specific time intervals (~125 times/sec. in Super Servo). Differential gain can be derived by subtracting the previous feed back value from the current value (the difference).

Differential Gain has the effect of trying to keep the servo at rest, and is extremely effective in stabilising a proportional only servo.

## Programming

There are four specific things to program in Super Servo. When you enter programming mode all 4 are programmed, and all in sequence. The sequence is :- Enter program mode, save off Failsafe Position, Pulse count for Proportional gain, Pulse count for Differential Gain, Pulse count for Feed Back Range.

Note :- During programming, output to the motor is disabled, and, after programming the LED serves no purpose other than to tell which direction the motor is being driven.

Entering Programming Mode

1. Before turning on the servo adjust signal input to above 1.75 mS pulse width. This will be close to full up or right stick if using a Radio Control unit (unless the directions have been reversed)
2. Turn on Super Servo. After ½ second the LED should flash twice (1/4 second flashes, with ¼ second gap). If Super Servo goes straight into normal operation then try more trim, or try holding the controls in the opposite direction, or reversing control direction. Repeat from start.
3. Immediately after the initial 2 flashes, move the control in the complete opposite direction and then back again. (Signal pulse width has to go below 1.25 mS and return above 1.75 mS). This sequence has to be completed in 1 second, otherwise normal servo operation will be resumed.
4. The LED flashes twice more to confirm programming mode has been entered.

Failsafe Position

5. You now have 2 seconds to position the control to the position of Failsafe. Super Servo saves the last signal received at the end of the 2 seconds.
6. The LED flashes three times.

Proportional Gain

7. During the next 1 second move the control to full again. SS will turn on the LED and count 1 in Proportional Gain. (You can hold the control in this position indefinitely)
8. Release the control till the LED turns off (below 1.75mS) and reapply if you want more proportional gain. Each time the LED comes on SS counts 1 to a maximum of 20 counts when SS will step to the next sequence regardless.
9. 

Differential Gain

10. During the next 1 second move the control to full again. SS will turn on the LED and count 1 in Differential Gain. For both Proportional and Differential Gain, no counts are adjusted to 1count.
11. Pulse control as before to program up to a maximum of 16 Counts.
12. Release the control for 1 second.
13. The LED again flashes three more times.

Feed Back Span

14. Adjust Span as per proportional or differential gain. 0 counts = ¼ of full pot travel, 1 count = ½ of pot travel, and 2 counts = full pot travel.
15. Release the control for 1 second.
16. The LED again flashes three more times.
17. SS returns to normal operation but using the new settings.

**Programming suggestions**

The programming sequence may have to be repeated a number of times till all parameters have been adjusted to their optimum values. It would be a good idea to keep note of all values so that if one or more need to be changed in the future, then the others will not have to be found by experimentation.

The textbook procedure in adjusting the parameters would be :-

1. Ignore failsafe position till the end of programming and decide on the pot span required. This would normally be 1 pulse for a rotary servo, and 2 for a linear positioner.
2. Adjust Proportional gain to about 4 and differential to 0 (defaults to 1). Initial Prop. Gain can be much higher on a slow servo (>2 seconds response).

3. Test operation of servo. Continuous oscillations will require a reduction in Prop. Gain.
4. Adjust Prop. Gain till the servo overshoots a step response by about 5-10% and oscillates 2-3 times before settling.
5. Increase Differential Gain till stable operation is achieved.
6. Adjust failsafe position.

A quicker way to get reasonable results is to start with Prop. Gain of 6 and Diff. Gain of 4, and adjust from there.

## Increasing Power Output

Output power could be increased by approximately 25% by soldering approx. 5 $cm^2$ of thin copper sheet to the tabs of drive mosfets on both sides of the circuit board. The mosfet tabs are soldered to the large piece of track in the middle of both sides of the circuit board where the motor wires are attached. It is **important** that the heatsinks do not contact any other tracks on the circuit board, as circuit failure will result.

**Warranty** ► The Super Servo Card is warranted for life against faulty parts or workmanship. Abuse, short circuits accidental or otherwise, reverse connections & exceeding maximum ratings is not covered. Repairs and/or claims can be arranged by using the contact below. All freight and packaging expenses will be at the owner's responsibility.

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## Disclaimer

*Although great care was taken in designing, programming and assembly of this controller, the manufacturer/designer will not be held liable for any damage or injury caused by any device containing this controller. Due to the nature of radio control, no guarantees can be given as to the safe use of this product.*