Technical Manual

S-Series S6PWM

Servo Motor Controller "SMC"

Rev F April 17, 2008

SMC Summary of Features:

- Digital signal processing for precise performance.
- High frequency (31.25 kHz) Pulse Width Modulation motor drive for smooth, quiet operation.
- All digital PID servo loop for accurate positioning.
- 12 bit resolution standard.
- Bio-Motion™ algorithms to produce life-like motion.
- 3 different jumper options for Bio-Motion selections.
- Jumper option to turn off napping
- Ignores invalid input pulse widths.
- 8 seconds soft start to prevent abrupt movements at power-up.
- Jumper option for R/C servo reversal.
- Built-in user selectable "self-test" mode which cycles the actuator slowly without any R/C input.
- Built-in, optional 0-5VDC voltage control input rather than pulse width, requiring only an external potentiometer for 12 bit position control.
- Deadband typically less than 0.001 msec.
- Fault indicator LEDs to simplify maintenance: *Red* LED indicates loss of input or presence of invalid pulse width. *Yellow* LED indicates overtemp or napping shutdown.
  Green LED blinks to indicate normal operation of the control system processor.
- *Opto isolator R/C input. Requires .7ma of input current.*
- Stores last valid input signal.
- RC input range of 1.00 to 2.00msec pulse widths @ 55Hz. *Bandwidth=.44to160Hz. Period from 6-23 msec.*
- Power supply voltage range of 12 volts (14V better) to 32 volts. Cut-off under 10V.
- Drives servos rated at up to 75 watts at 24 volts continuously, limited only by availability of heatsinking and/or cooling airflow for the servo controller.
- Designed to provide up to 3 amps continuous and 6 amps intermittent output with adequate heatsinking and/or cooling airflow for the servo controller.

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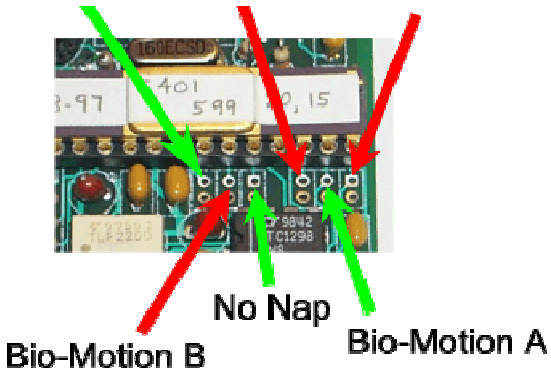
View of Jumpers **RC Reversal** **0-5V Enable** **Self Test Mode**



1.) Option Jumpers: The Series S Precision servo controller has several built-in features which may be controlled by wire jumpers, or could be connected to switches to dynamically alter the operation of the servo controller for special applications. The circuit board layout allows the use of standard 2 mm jumper headers.

The six option jumpers are:

RC Reversal Enable, for RC input function only:

Installing this jumper will reverse the direction of the R/C servo travel.

0-5 Volt or External Pot Enable:

Installing a jumper to connect these two pads will cause the servo to follow an external 0-5 Volt source, instead of the R/C signal. Do not use Reversal Enable with this function.

An external potentiometer wiper, or an analog input voltage, is connected to the card-edge connector pin A8. The bottom of the potentiometer or the ground reference of the analog input is connected to the card-edge at pins 9 or 10. The top of the potentiometer should be connected to the servo controller reference voltage on the card-edge connector pin B7. If a shielded cable is utilized, the shield should be connected to the card-edge connector ground on pin A10 or B10. The potentiometer resistance should typically be between 2K and 20K ohms for best performance.

For use with an external analog input, the maximum input voltage should be equal to the reference voltage on the servo controller card-edge connector pin B7. The maximum permissible current drain out of pin B7 is approximately 5 milliamps. The reference voltage is 5.0 ± 0.25 VDC. The minimum input voltage should be equal to the ground reference on the card-edge connector pin A9. The analog input is protected by a 10K ohm series resistor. The nominal input impedance is over 1 meg ohm.

Bio-Motion™ Options:

The Bio-Motion feature is designed to simulate inertia and serves to greatly reduce jerky motion, which is a valuable feature in animatronic applications. For example, a powerful motor moving the arm or leg of an animatronics creature will often move the limb much too abruptly, resulting in a very unnatural, jittery motion.

By choosing the appropriate amount of Bio-Motion acceleration processing, it is possible to produce much more realistic motion, with smoother, more life-like movement and a visual impression of a system having a realistic amount of inertia.

The Bio-Motion algorithm also smoothes the R/C signal and provides gentle transitions between the abrupt jumps in the R/C pulse widths. The Bio-Motion algorithm is calculated in 32 bit floating point math for ultra high resolution.

There are four possible Bio-Motion jumper combinations:

Jumper A **(or connector pin A7)**	**Jumper B**	**Bio-Motion Result**
none	none	Fast acceleration Bio-Motion
Installed	none	Medium acceleration Bio-Motion
none	Installed	Slow acceleration Bio-Motion
Installed	Installed	Full speed, no Bio-Motion

Bio-Motion digital acceleration processing currently is available in three different values. The speed numbers indicate the maximum acceleration. The currently available values are 30, 10, & 5. The jumpers for the Bio-Motion processing for Fast (default), Medium and Slow acceleration are installed by the end user. Also jumper A is on the connector (A7) so you can switch it "on or off" via switch on the fly. Switch to signal gnd. pin A8 or B9 on the connector. Play with these options; it's a must if you are doing animatronics.

Self-Test (Demo Mode) Enable:

Installing a jumper to connect these two pads will cause the servo controller to repeatedly move between 25% of travel and 75% of travel. Alternatively, a jumper, or switch may be connected to the card-edge connector from pin A6 to the ground on pin A10 or pin B10. The range of motion, velocity and the duration of the pause at each end point may be customized at the time of manufacture of the servo controller.

Nap Mode:

Nap mode is designed to allow the motor to turn completely off whenever the commanded position and servo position are not changing. As soon as either the command position of the servo position change, normal operation is immediately restored.

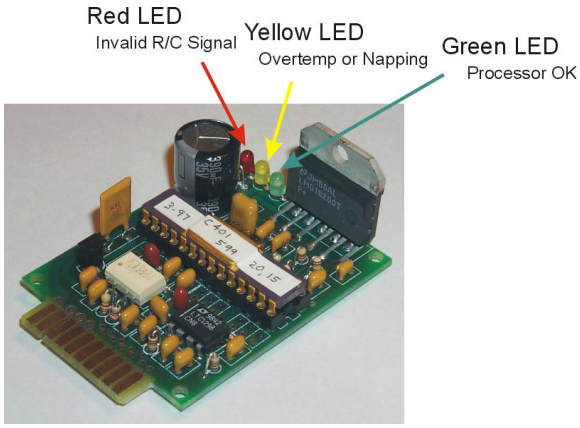
In some situations, this napping mode can reduce power consumption, thereby allowing both the motor and the servo controller to run cooler.

The nap feature is not useful with servos that creep or can be back-driven, because when the motor power is turned off, the back driven servo will change position, and immediately turn the controller back on and kick the position back to null.

The nap mode should only be used when there is a need to save battery power.

Installing a jumper in the "No Nap" location will disable the nap mode.

The controller will typically enter the napping condition when either the R/C command or the servo position has changed less than 125 counts in the preceding one second time period. For an actuator using the full pot travel which is measured digitally as 4096 counts, this means that during movement slower than 32 seconds end-to-end travel of the actuator, the napping mode may be actuated. The controller will awaken instantly when either the R/C command or the servo position changes 2 counts.



2.) LED Indicators:

Green LED:

System OK. Flashes green about 7 times per second to indicate that the processor is operating properly.

Yellow LED:

Over temp. Lights yellow continuously to indicate that the controller has overheated and may be shutdown.

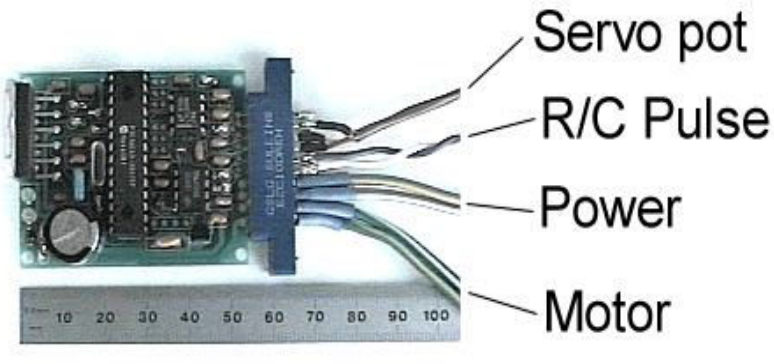
Napping. Yellow LED flashes in sync with the green LED to indicate that the controller is napping. Napping mode is used to save power, but should only be used with servos that are not subject to being backdriven. In napping mode, whenever the controller detects that the servo motion has stopped and power could be saved, the motor current is turned off.

Red LED:

Invalid R/C input pulse. Lights red to indicate that the R/C pulse width is either outside of the permissible range of 0.920 msec to 2.120 msec or that the R/C pulses are entirely missing.

The full range of travel of the servo corresponds to R/C pulse widths from 0.988 msec to 2.012 msec. Pulse widths from 0.920 msec to the lower limit of 0.988 msec will be treated as if they were 0.988 msec. Similarly, pulse widths from the upper limit of 2.012 msec to 2.120 msec will be treated as if they were 2.012 msec. Pulse widths below 0.920 or above 2.120 will be completely ignored and treated as if they had never occurred.

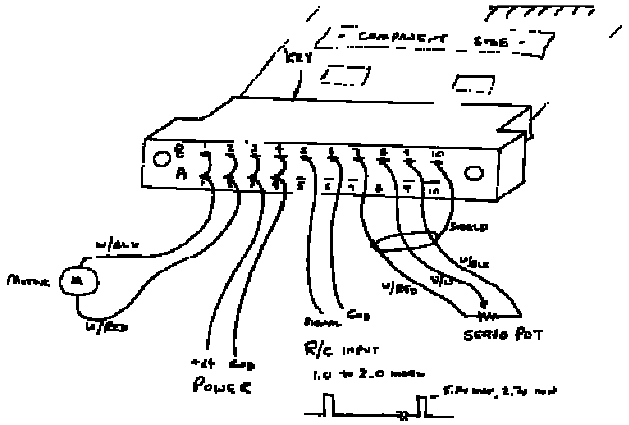
3.) Wiring:



Connector:

The Precision Servo Driver is designed with a gold plated "card-edge connector", which allows quick and easy replacement and troubleshooting of the system. The connector is also available with pc board pins, so that a system motherboard can be created. Note that a connector key is used between pins 2 & 3 contacts to prevent incorrect insertion of the circuit board.

CONNECTOR *WIRING*: A= Bottom side of PCB. B = Top side of PCB.



Function	**Connector Pin**
Motor -	A1 and B1
Motor +	A2 and B2
+ DC Power	A3 and B3
Power Gnd	A4 and B4
Mfg. test	A5 n/c
Self-Test	A6 n/c
Bio"A" Enable	A7
0-5V In or Ext pot wiper	A8 *(0-5v input option)*
Ext pot Gnd	**A9**
Common Gnd	**A10**
R/C pulse input	B5
R/C ground	B6
+5V ref.	B7 *(pots +5V ref.)*
Servo pot wiper	B8
Servo pot *gnd*.	**B9**
Common Gnd	**B10**

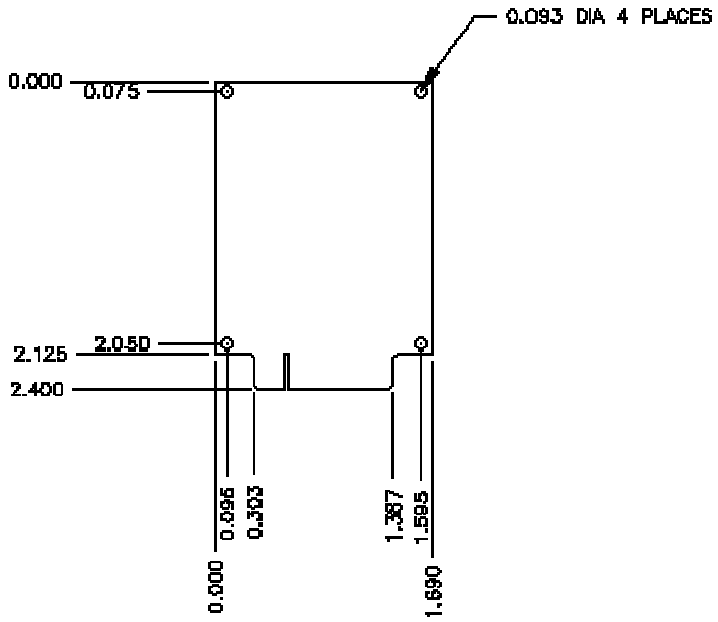
4.) Heat-Sinking and Cooling:

In general, for small motor currents, somewhat below 1 amp, there is no need for any heatsinking or forced airflow. As the motor current increases above 1 amp, the power output stage of the controller will need to get rid of some heat, which may be accomplished by heatsinking or by providing some cooling airflow. The output stage may safely be run at temperatures around d 150 deg F, but higher temperatures should be avoided.

- Drives servos rated at up to 75 watts at 24 volts continuously, limited only by availability of heatsinking and/or cooling airflow for the servo controller.
- Drives servos rated at up to 150 watts at 24 volts intermittently, limited only by availability of heatsinking and/or cooling airflow for the servo controller.
- Designed to provide up to 3 amps continuous output with adequate heatsinking and/or cooling airflow for the servo controller.
- Designed to provide up to 6 amps intermittent output with adequate heatsinking and/or cooling airflow for the servo motor *controller pcb.*

5.) Mechanical Specifications:

Dimensions: The following illustrations show the outline dimensions of the circuit board as well as the location of four corner mounting holes that are available. Also note that there is a keying slot between the second and third connector fingers which prevents improper insertion of the circuit board into the mating connector.



6.) Controller Notes

Motor Heating and Ratings:

In order to avoid overheating and permanently damaging the actuator motor, it is very important to understand how the motor heating is related to the "actuators load, duty cycle and motor start commands". Every time a dc motor is turned on from a stopped position, it will use close to its stall current for a few milliseconds. Rapid, small position change commands, even with no load, can exceed the motors continuous current rating. It is advised to keep your update rates within the motors current limits.

For example, the L1621-16-2/2 mini actuator motor is rated at a continuous current of 0.336 amps. In that actuator, a motor current of 0.336 amps will produce a force of about 8 pounds. Therefore, for continuous operation, the actuator load cannot exceed 8 pounds.

At a 50% duty cycle and a 16 lb. load the motor current will be about .620 amps. The average continuous current would be .310 amps .That is less than its maximum continuous current rating.

However, in many cases it is satisfactory to consider the average motor current over a short period of time. For example, L1621-16-2/2 could produce a force up to 50 pounds for a few seconds if the load was then reduced to essentially zero for an equal time period, to keep the average current at, or under, the .336 amp rating.

Smoothness:

There are several actuator properties which often lead to lack of smooth servo operation. Two of the most severe are gear backlash and static friction.

When the gear train has backlash, the motor position is somewhat disconnected from the servo position, leading to a lack of smoothness. For smooth, accurate operation, the backlash must be minimized.

When the actuator requires significantly greater motor current to overcome the static friction than is required to overcome the dynamic friction, the actuator will become jumpy, particularly at extremely low speeds where the actuator momentarily stops and the actuator loading is over a few pounds.

For example, the L1621-10-2/4 high speed mini actuators have a very high ratio of static friction to dynamic friction. The motor current required to dynamically move 10 pounds is around 0.65 amps, but once the actuator stops momentarily, it requires as much as 0.90 amps to overcome the static friction and begin to move again.

Output IC Overheating:

The PWM output amplifier IC contains built-in thermal protection, intended to protect the IC from some types of overloads. However, it has been observed in some cases that the thermal shutdown may result in driving the actuator to either end of travel at full power. This has been a rare occurrence and seems to be a flaw in the IC design.

Actuator Travel:

In order to avoid hitting the internal end stops in the actuator and/or hitting any noisy runoff area of the servo pot, the controller is normally set to move the actuator from *1% to 99%* of the servo pot. *This range of motion limit can be set to custom values during manufacturing if the standard travel is not suitable for a specific application. The W-Series actuators are set at 25% to 75% because only 50% of the pot travel is used. At half stroke the pot is factory set to 50% of its travel.*

7.) EEPROM codes for 16F876 processor

Unless otherwise noted, the 24v actuators are tuned for use up to 28 vdc, and the 12v actuators are tuned for operation at 14 vdc. It is best to run the 12 vdc actuators at 13.5 vdc. *Beyond those voltages, the controller may allow some slight overshoot.*

Each of the controller programs has a unique code name. For example, the meaning of code "F1A" is as follows: The "F" denotes that this program is intended for the 16F876 flash memory. The "1" denotes a sequential number that is assigned for each different actuator. The "A" denotes the current revision level of the code. All F codes are rev A.

CPU Code Chart

L16 12V Actuators

12V 2" Stroke	Code	Alts.	12V 3" Stroke	Code	Alts.	mfg.ref
L1609-03-2/12	F4A		L1609-03-3/12	F4A		4.4/.250
L1609-06-2/6	F 4A		L1609-06-3/6	F4A		4.4/.125
L1609-10-2/4	F4A		L1609-10-3/4	F4A		5.4/.125
L1609-12-2/3	F26A	F3A	L1609-12-3/3	F3A		4.4/.062
L1609-16-2/2.3	F3A		L1609-16-3/2.3	F26A		5.4/.062
L1609-20-2/2	F3A		L1609-20-3/ 2	F3A		5.4/.050
L1609-25-2/1.5	F3A		L1609-25-3/1.5	F3A		19/.125
L1609-40-2/.7	F3A		L1609-40-3/.7	F3A		19/.062
L1609-50-2/.6	F3A		L1609-50-3/.6	F3A		19/.050
L1609-65-2/.56	F3A		L1609-65-3/.56	F3A		24/.062
L1609-75-2/.5	F3A		L1609-75-3/.5	F3A		24/.050
L1609-100-2/.35	F3A		L1609-100-3/.35	F3A		29/.050

L16 24V Actuators

24V 2" Stroke	Code	Alts.	24V 3" Stroke	Code	Alts.	mfg.ref
L1621-03-2/12	F2A	F4A	L1621-03-3/12	F2A	F4A	4.4/.250
L1621-06-2/6	F2A	F4A	L1621-06-3/6	F2A	F4A	4.4/.125
L1621-10-2/4	F2A	F4A	L1621-10-3/4	F2A	F4A	5.4/.125
L1621-12-2/3	F3A	F26A	L1621-12-3/3	F26A		4.4/.062
L1621-16-2/2.3	F1A		L1621-16-3/2.3	F1A		5.4/.062
L1621-20-2/2	F1A		L1621-20-3/2	F1A		5.4/.050
L1621-25-2/1.5	F26A		L1621-25-3/1.5	F26A		19/.125
L1621-40-2/.7	F1A	F26A	L1621-40-3/.7	F1A	F26A	19/.062
L1621-50-2/.6	F1A	F26A	L1621-50-3/.6	F26A	F1A,F3A	19/.050
L1621-65-2/.56	F3A		L1621-65-3/.56	F3A		24/.062
L1621-75-2/.5	F3A		L1621-75-3/.5	F3A		24/.050
L1621-100-2/.35	F3A		L1621-100-3/.35	F3A		29/.050

W-Series

W1012 12V	Code	Alts.	W1024 24V	Code	Alts.	W7024 24V	Code	Alts.
W1012-25-2	F6A		W1024-25-2	F18A		W7024-50-2	F7A	
W1012-40-2	F20A		W1024-40-2	F7A		W7024-100-2	F21A	
W1012-75-2	F19A		W1024-75-2	F7A		W7024-150-2	F21A	
W1012-25-4	F17A		W1024-25-4	F14A	F10A	W7024-50-4	F22A	
W1012-40-4	F16A		W1024-40-4	F5A		W7024-100-4	F23A	
W1012-75-4	F15A		W1024-75-4	F5A		W7024-150-4	F23A	
W1012-25-6	F13A		W1024-25-6	F10A	F14A	W7024-50-6	F22A	
W1012-40-6	F12A	F5A	W1024-40-6	F5A		W7024-100-6	F23A	F11A
W1012-75-6	F11A		W1024-75-6	F11A	F5A	W7024-150-6	F23A	