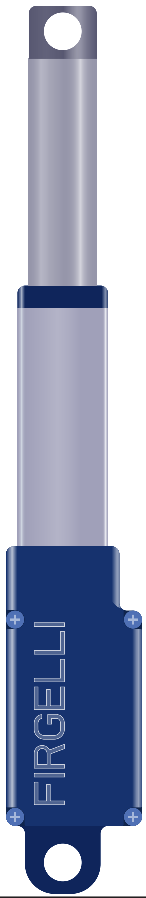


Miniature Linear Motion Series • L12

Firgelli Technologies' unique line of Miniature Linear Actuators enables a new generation of motion-enabled product designs, with capabilities that have never before been combined in a device of this size. These small linear actuators are a superior alternative to designing with awkward gears, motors, servos and linkages.

Firgelli's L series of micro linear actuators combine the best features of our existing micro actuator families into a highly flexible, configurable and compact platform with an optional sophisticated on-board microcontroller. The first member of the L series, the L12, is an axial design with a powerful drivetrain and a rectangular cross section for increased rigidity. But by far the most attractive feature of this actuator is the broad spectrum of available configurations.

Benefits

- → **Compact miniature size**
- → **Simple control using industry standard interfaces**
- → **Low voltage**
- → **Equal push / pull force**
- → **Easy mounting**

Applications

- → **Robotics**
- → **Consumer appliances**
- → **Toys**
- → **Automotive**
- → **Industrial automation**

L12 Specifications

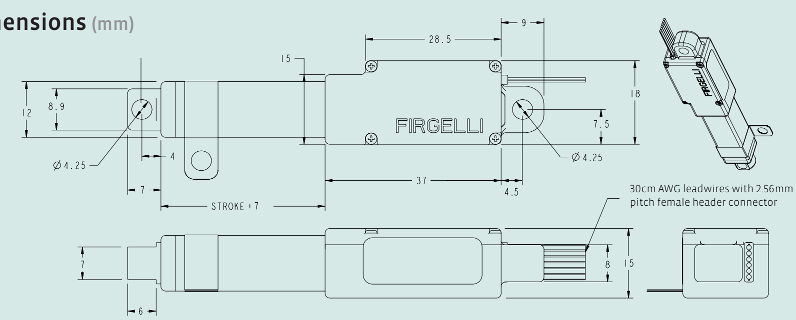
Gearing Option	50	100	210
Peak Power Point [1]	**12 N @ 11 mm/s**	**23 N @ 6 mm/s**	**45 N @ 2.5 mm/s**
Peak Efficiency Point	**6 N @ 16 mm/s**	**12 N @ 8 mm/s**	**18 N @ 4 mm/s**
Max Speed (no load)	**23 mm/s**	**12 mm/s**	**5 mm/s**
Backdrive Force [2]	**43 N**	**80 N**	**150 N**

Stroke Option	10 mm	30 mm	50 mm	100 mm
Weight	**28 g**	**34 g**	**40 g**	**56 g**
Positional Accuracy	**0.1 mm**	**0.2 mm**	**0.2 mm**	**0.3 mm**
Max Side Force (fully extended)	**50 N**	**40 N**	**30 N**	**15 N**

Mechanical Backlash	**0.1 mm**
Feedback Potentiometer	**2.75 kΩ/mm ± 30%, 1% linearity**
Duty Cycle	**20 %**
Lifetime	**1000 hours at rated duty cycle**
Operating Temperature	**–10°C to +50°C**
Storage Temperature	**–30°C to +70°C**
Ingress Protection Rating	**IP–54**
Audible Noise	**55 dB at 45 cm**
Stall Current	**450 mA at 5 V & 6 V, 200 mA at 12 V**

[1] 1 N (Newton) = 0.225 lb_f (pound-force)
[2] a powered-off actuator will statically hold a force up to the Backdrive Force

Dimensions (mm)



Firgelli

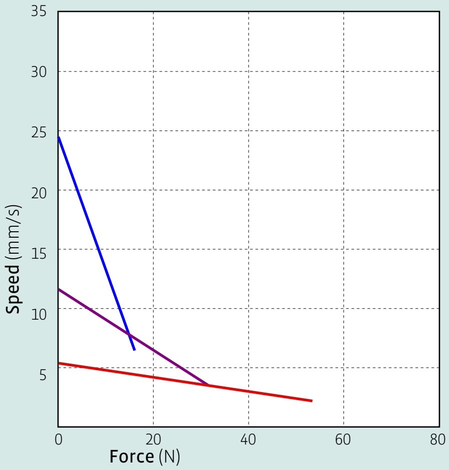
Firgelli Technologies Inc.
4585 Seawood Tce.
Victoria, BC V8N 3W1
Canada

1 (206) 347-9684 *phone*
1 (888) 225-9198 *toll-free*
1 (206) 347-9684 *fax*

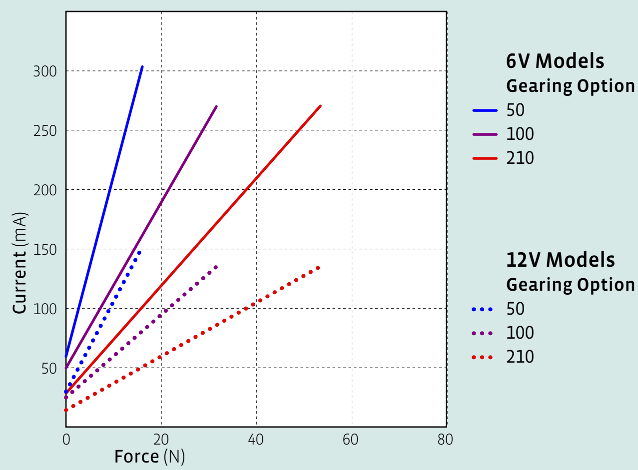
sales@firgelli.com
www.firgelli.com

L12 Specifications

Load Curves



Current Curves



Model Selection

The L12 has five configurable features. L12 configurations are identified according to the following scheme:

L12-SS-GG-VV-C-L

feature	*options*
SS: Stroke Length (in mm)	**10, 30, 50, 100** Any stroke length between 10 and 100 mm is available on custom orders, in 2 mm increments.
GG: Gear reduction ratio (refer to force/speed plots)	**50, 100, 210** Other gearing options may be possible on custom orders.
VV: Voltage	**06** 6 V (5 V power for Controller options B and P) **12** 12 V
C: Controller	**B** Basic 2-wire open-loop interface, no position feedback, control, or limit switching. Positive voltage extends, negative retracts. **S** 2-wire open-loop interface (like B option) with limit switching at stroke endpoints. **P** Simple analog position feedback signal, no on-board controller. **I** Integrated controller with Industrial and RC servo interfaces (see L12 Controller Options section). Not available with 10mm stroke length configurations. **R** RC Linear Servo. Not available with 10mm stroke or 12 volts.
L: Mechanical or electrical interface customizations	Custom option codes will be issued by Firgelli for custom builds when applicable.

Basis of Operation

The L12 actuator is designed to move push or pull loads along its full stroke length. The speed of travel is determined by the gearing of the actuator and the load or force the actuator is working against at a given point in time (see Load Curves chart on this datasheet). When power is removed, the actuator stops moving and holds its position, unless the applied load exceeds the backdrive force, in which case the actuator will backdrive. Stalling the actuator under power for short periods of time (several seconds) will not damage the actuator. Do not reverse the supply voltage polarity to actuators containing an integrated controller (I controller option).

Each L12 actuator ships with two mounting clamps, two mounting brackets and two rod end options: a clevis end and a threaded end with nut (see drawing on page 4). When changing rod ends, extend the actuator completely and hold the round shaft while unscrewing the rod end. Standard lead wires are 28 AWG, 30 cm long with 2.56 mm (0.1") pitch female header connector (Hi-Tec™ and Futaba™ compatible). Actuators are a sealed unit (IP–54 rating, resistant to dust and water ingress but not fully waterproof).

Ordering information

Sample quantities may be ordered with a credit card directly from www.firgelli.com.

Please contact Firgelli at sales@firgelli.com for volume pricing or custom configurations.

Note that not all configuration combinations are stocked as standard products. Please refer to www.firgelli.com/orders for current inventory.

L12 Controller options

Option B—Basic 2-wire interface

WIRING:

1	(red)	**Motor V+** (5 V or 12 V)
2	(black)	**Motor ground**

The –B actuators offer no control or feedback mechanisms. While voltage is applied to the motor V+ and ground leads, the actuator extends. If the polarity of this voltage is reversed, the actuator retracts. The 5 V actuator is rated for 5 V but can operate at 6 V.

Option S—Basic 2-wire interface

WIRING:

1	(red)	**Motor V+** (5 V or 12 V)
2	(black)	**Motor ground**

When the actuator moves to a position within 0.5mm of its fully-retracted or fully-extended stroke endpoint, a limit switch will stop power to the motor. When this occurs, the actuator can only be reversed away from the stroke endpoint. Once the actuator is positioned away from it's stroke endpoint, normal operation resumes. For custom orders, limit switch trigger positions can be modified at the time of manufacture, in 0.5mm increments.

Option P—Position feedback signal

WIRING:

1	(orange)	**Feedback potentiometer negative reference rail**
2	(purple)	**Feedback potentiometer wiper** (position signal)
3	(red)	**Motor V+** (5 V or 12 V)
4	(black)	**Motor ground**
5	(yellow)	**Feedback potentiometer positive reference rail**

The –P actuators offer no built-in controller, but do provide an analog position feedback signal that can be input to an external controller. While voltage is applied to the motor V+ and ground leads, the actuator extends. If the polarity of this voltage is reversed, the actuator retracts. Actuator stroke position may be monitored by providing any stable low and high reference voltages on leads 1 and 5, and then reading the position signal on lead 2. The voltage on lead 2 will vary linearly between the two reference voltages in proportion to the position of the actuator stroke.

Option I—Integrated controller with industrial and RC servo interfaces

WIRING:

1	(green)	**Current input signal** (used for 4–20 mA interface mode)
2	(blue)	**Voltage input signal** (used for the 0–5V interface mode and PWM interface modes)
3	(purple)	**Position Feedback signal** (0–3.3 V, linearly proportional to actuator position)
4	(white)	**RC input signal** (used for RC-servo compatible interface mode)
5	(red)	**Motor V+** (+6 Vdc for 6 V models, +12 Vdc for 12 V models)
6	(black)	**Ground**

The –I actuator models feature an on-board software-based digital microcontroller. The microcontroller is not user-programmable

The six lead wires are split into two connectors. Leads 4, 5 and 6 terminate at a universal RC servo three-pin connector (Hi-Tec™ and Futaba™ compatible). Leads 1, 2 and 3 terminate at a separate, similarly sized connector.

When the actuator is powered up, it will repeatedly scan leads 1, 2, 4 for an input signal that is valid under any of the four supported interface modes. When a valid signal is detected, the actuator will self-configure to the corresponding interface mode, and all other interface modes and input leads are disabled until the actuator is next powered on.

0–5 V Interface Mode: This mode allows the actuator to be controlled with just a battery, and a potentiometer to signal the desired position to the actuator – a simple interface for prototypes or home automation projects. The desired actuator position (setpoint) is input to the actuator on lead 2 as a voltage between ground and 5V. The setpoint voltage must be held on lead 2 until the desired actuator stroke position is reached. Lead 2 is a high impedance input.

4–20 mA Interface Mode: This mode is compatible with PLC devices typically used in industrial control applications. The desired actuator position (setpoint) is input to the actuator on lead 1 as a current between 4 mA and 20 mA. The setpoint current must be held on lead 1 until the desired actuator stroke position is reached.

RC Servo Interface Mode: This is a standard hobby-type remote-control digital servo interface (CMOS logic), compatible with servos and receivers from manufacturers like Futaba™ and Hi-Tec™. The desired actuator position is input to the actuator on lead 4 as a positive 5 Volt pulse width signal. A 1.0 ms pulse commands the controller to fully retract the actuator, and a 2.0 ms pulse signals full extension. If the motion of the actuator, or of other servos in your system, seems erratic, place a 1–4Ω resistor in series with the actuator's red V+ leadwire.

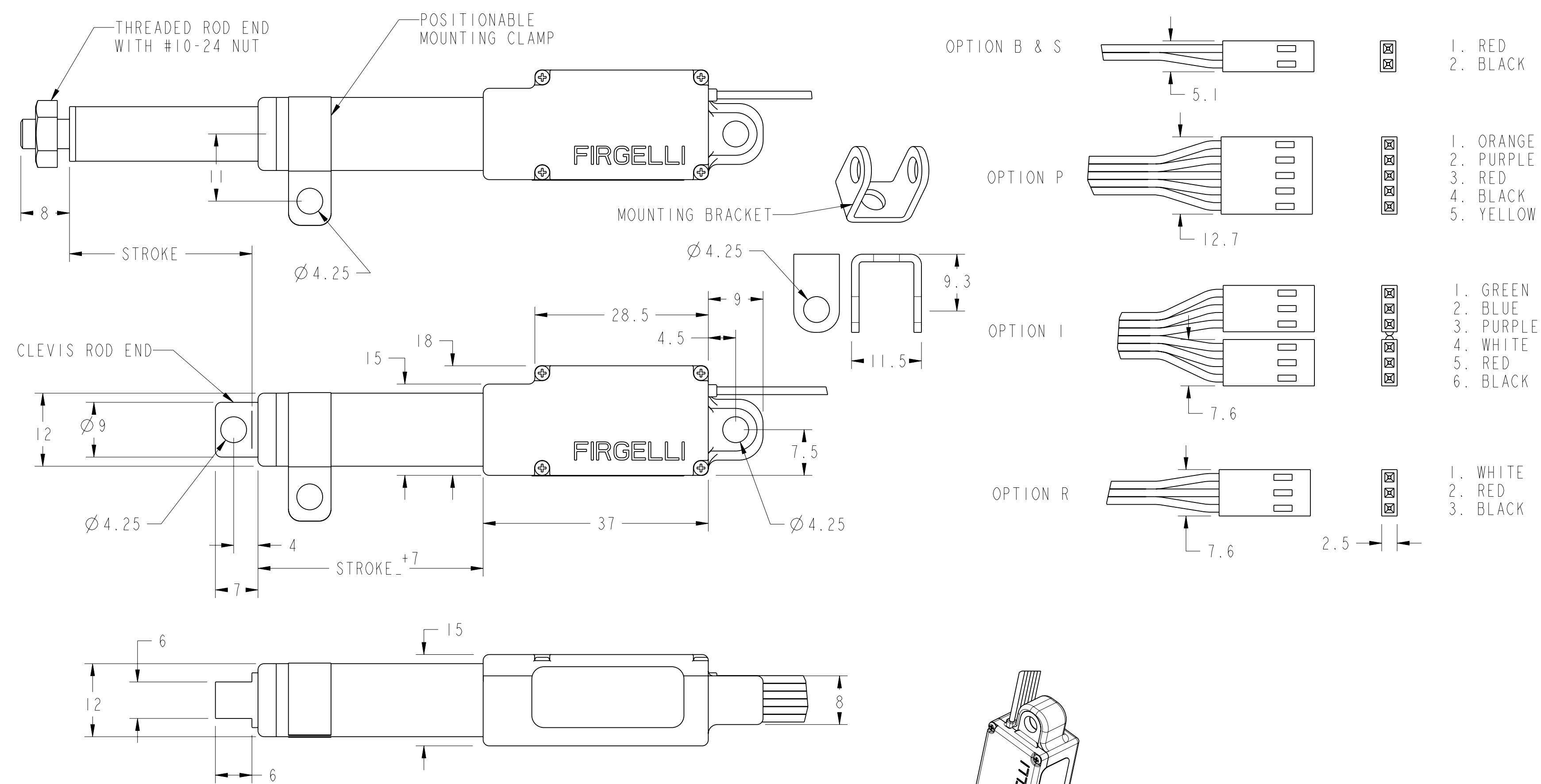
PWM Mode: This mode allows control of the actuator using a single digital output pin from an external microcontroller. The desired actuator position is encoded as the duty cycle of a 5 Volt 1 kHz square wave on actuator lead 2, where the % duty cycle sets the actuator position to the same % of full stroke extension. The waveform must be 0V to +5V in order to access the full stroke range of the actuator.

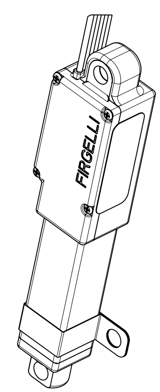
Option R—RC Linear Servo

WIRING:

1	(white)	**RC input signal**
2	(red)	**Motor V+** (6 VOC)
3	(black)	**Ground**

The –R actuators or 'linear servos' are a direct replacement for regular radio controlled hobby servos. Operation is as above in RC servo interface mode (option I). The –R actuators are available in 6 volt and 30, 50 and 100 mm strokes only.





SCALE 1:1

NOTES:

1) WHEN CHANGING ROD ENDS, EXTEND ACTUATOR COMPLETELY AND HOLD THE ROUND SHAFT WHILE UNSCREWING THE ROD END PLUG

2) Ø4.25 MOUNTING HOLES WILL FIT M4 OR UN #8 SIZE SCREWS

3) TWO MOUNTING CLAMPS, TWO MOUNTING BRACKETS, ONE EXTRA THREADED ROD END WITH NUT AND #8-32 HARDWARE, IS INCLUDED WITH EACH ACTUATOR.

4) STANDARD LEAD WIRE LENGTH IS 300mm. 28AWG STRANDED RIBBON WIRE. CONNECTORS ARE 2.54mm PITCH FEMALE HEADER CONNECTORS

FIRGELLI	
L12 ACTUATOR FAMILY INTERFACE DIMENSIONS	SCALE 3:2

wwww.PerihelionDesign.com

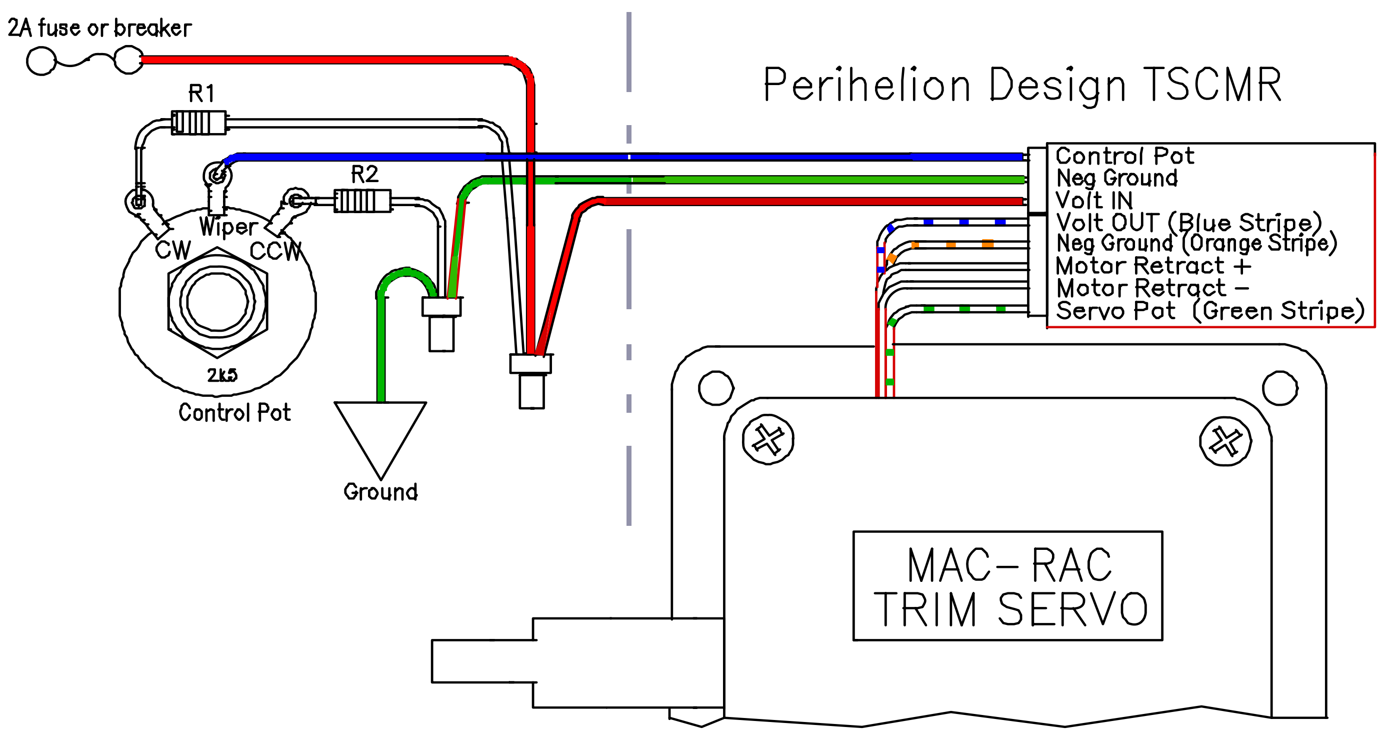
Eric M. Jones
113 Brentwood Drive
Southbridge MA 01550-2705
508-764-2072
emjones@charter.net

True Servo Conversion for M.A.C.-R.A.C. "Sort-of-Servos"

True servos read a control signal and move a motor or mechanical part as commanded. Some feedback is required to complete the control loop. Usually, servos mimic mechanical control systems, but allow remote operation or magnified forces.

The standard MAC-RAC controls the motor with two pushbuttons and uses the visual feedback from their LED bar graph as well as the pilot's sense of stick forces. So it is really a "*Sort-of-Servo*". The MAC-RAC would be a *real* servo if its internal potentiometer wiper voltage (indicating its position) were fed back to a logic controller to drive the motorized mechanism to a desired position automatically.

But of course…! Perihelion Design has developed the TSCMR for builders who want to use their MAC-RAC as a true servo, to trim the elevator, ailerons, or rudder or for simple jobs such as controlling heater or air vents, opening a baggage or dipstick door, and other tasks.



Advantages---True servo operation allows the pilot to position a control knob or wheel and have the servo go to the commanded position and stop.

Differences between Perihelion Design's EGPNMSC and TSCMR Servo Controllers---

Perihelion Design's EGPNMSC (Extremely General Purpose Non-MAC Servo Controller) is designed to drive Futaba and other servos that require a pulse-width modulated signal as well as a 6VDC power source.

Perihelion Design's TSCMR (True Servo Controller for MAC-RACs) controller is designed to drive MAC and RAC trim controllers. The TSCMR converts the system that uses pushbuttons and LED an bar graph to a true servo system. The bar graph could still be used if desired by teeing off the lines previously used for this purpose (see next page).

The TSCMR is used in the Perihelion Design Trim Wheel Assembly too.

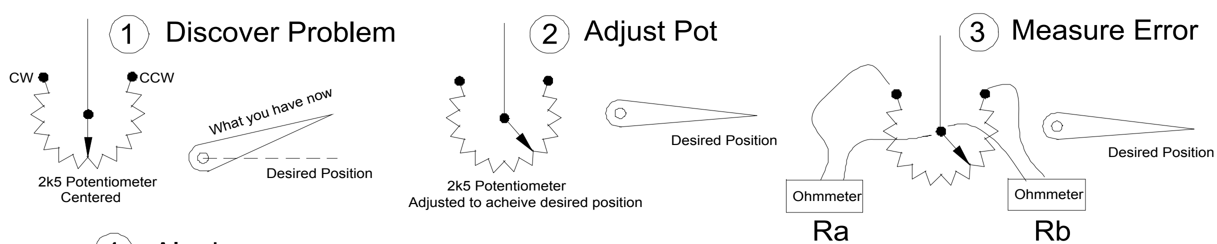
TSCMR Features:

- Reverse voltage protection
- Over-voltage shutdown
- Over-current shutdown
- Sets servo position according to signal voltage.
- Ideal for adapting to many flap and trim control types
- EZ Computer control via D/A converter
- Servo cannot lose synchronization.
- No pushbuttons (common cause of runaway trim).

Specifications:

- Input voltage 14.5 VDC
- 1A guaranteed output current
- Size: 0.30 W; 1.4 L; 0.82 H
- Weighs less than 1/2 oz (14 g)

(Nerd Stuff) How to set optional R1 or R2



4 Algebra

Convention: 2k5 = 2500 etc.

(Ra+Rb)=2k5 Ω
Ra'=1k25 Ω
Rb'=1k25 Ω
R1=X

$$\frac{Rb}{(Ra+Rb)} = \frac{Rb'}{(X+Ra'+Rb')}$$

Solve for X

Rb (X+Ra'+Rb') = Rb'(Ra+Rb)

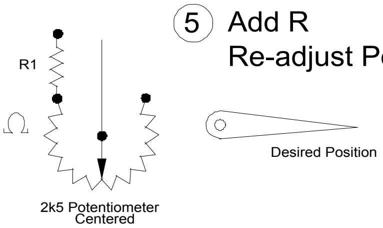
Fill in the values and simplify

Rb(X+1k25+1k25) = 1k25 (2k5) Ω

Rb(X+2k5) = 3M13 Ω

$$R1 = X = \left(\frac{3M13}{Rb}\right) - 2k5\ \Omega$$

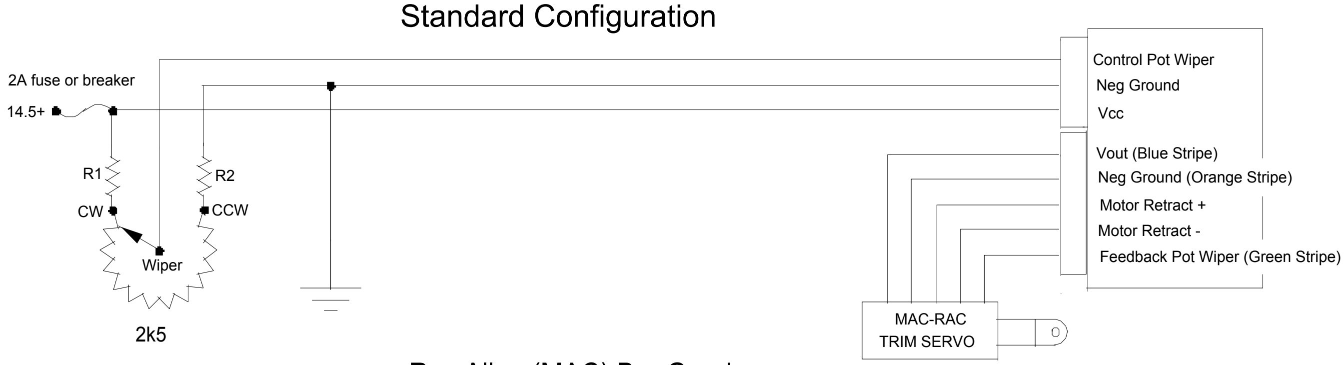
5 Add R
Re-adjust Pot



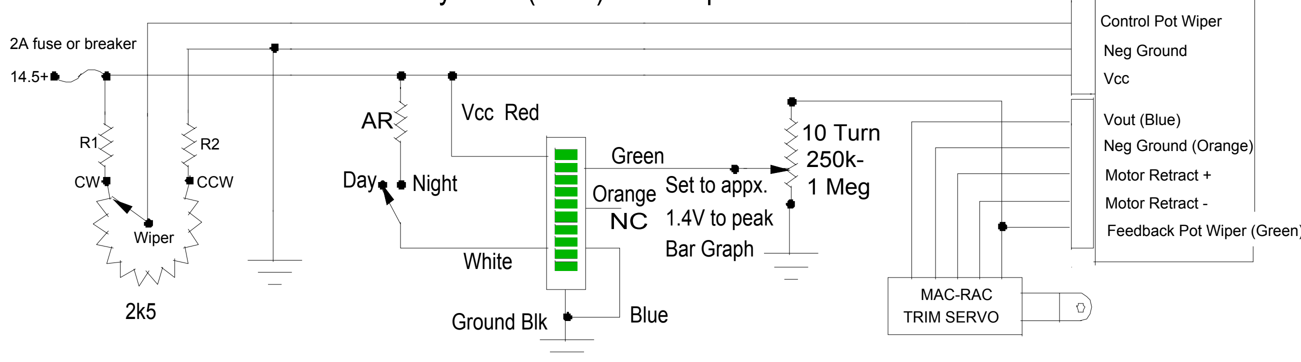
If the resistance is negative, it would be on the other side (R2)
For this example if Rb = 1k ohms, then R1 = 625 (a 620 ohm 1/4W will do)
Usually corrections will be less than 500 ohms.

Additional Design Examples using the TSCMR

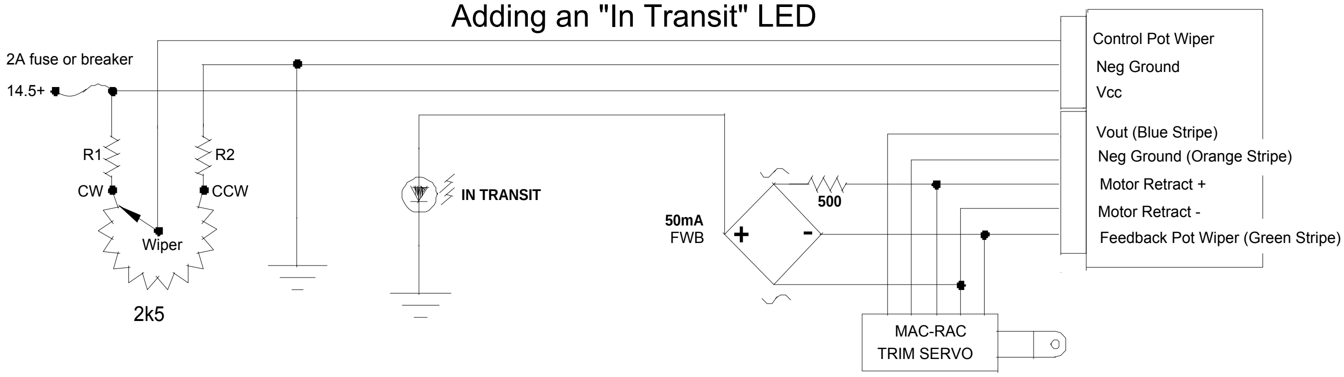
Standard Configuration



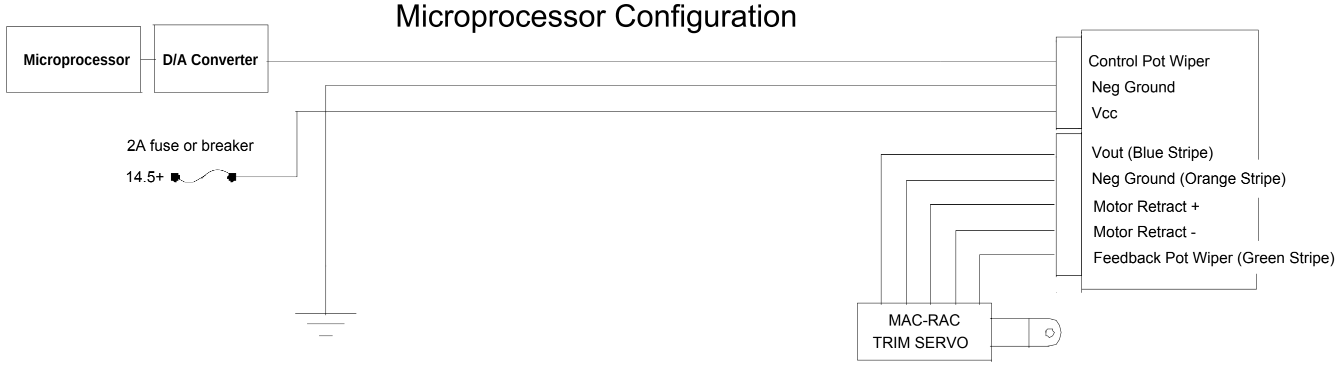
Ray Allen (MAC) Bar Graph



Adding an "In Transit" LED



Microprocessor Configuration



Installation

The Perihelion Design TSCMR accepts the wire leads from the MAC-RAC controller and the wires to the control pot. It is convenient to mount the TSCMR on the MAC-RAC servo box near the wire entrance.

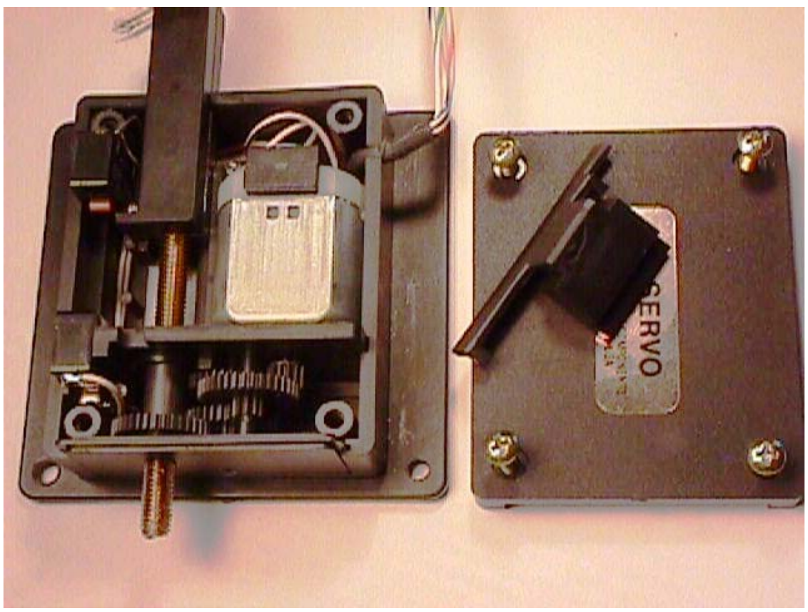
IMPORTANT: Initially power the identical white "Motor Retract –" and "Motor Retract +" leads from the MAC-RAC trim box (perhaps with a 9-volt battery) to determine their identities. Mark or label the lead that will retract the actuator arm when attached to the + terminal. This is the "Motor Retract +"

Wire the leads as shown. Weatherproof and stabilize the wire joints with silicone rubber sealer/adhesive.

Test. Correct the trim position if necessary as detailed above.

Additional suggestions:

The MAC-RAC series of trim boxes is actually a reasonably rugged and tested design. Some improvements can easily be made to enhance the design further---

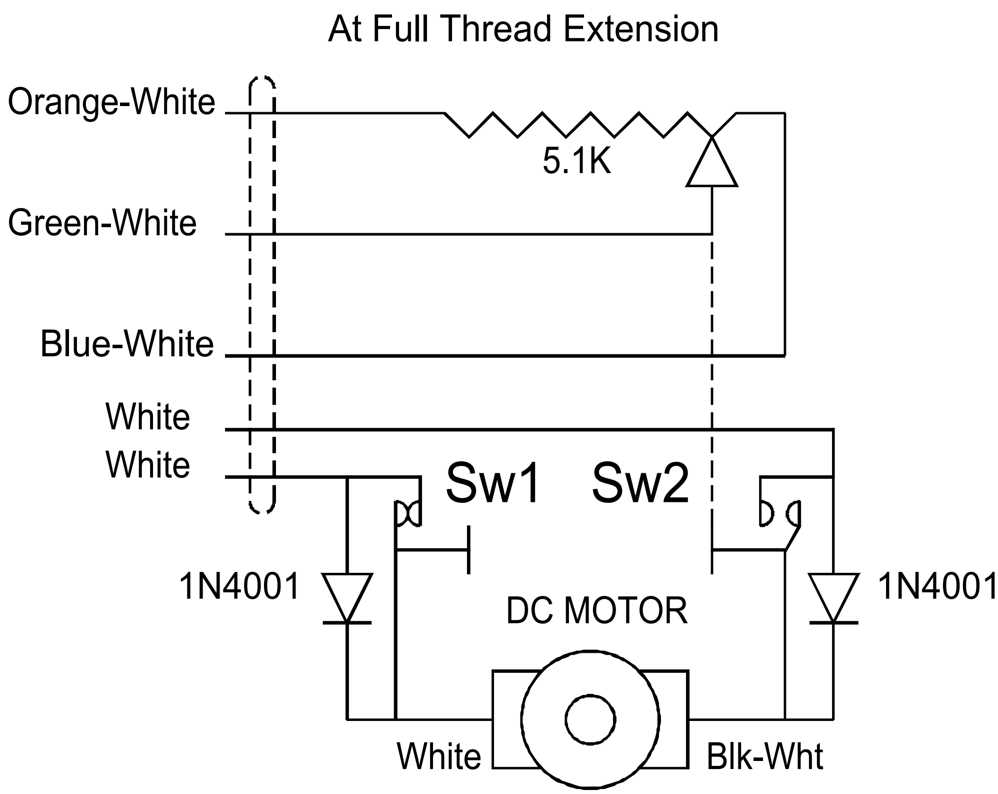


The MAC controller has a couple of possibilities for improvement:

1) Cover the actuator screw: This takes a part which could be made from a ball-point pen cap or any other minor piece of plastic (or aluminum) glued onto case to cover the screw, which extends 1-1/8 inches out from the housing (for the MAC8A). This seals one of several possible entries for dirt, water and corrosion. It is axiomatic that excluding dirt from the servo is a very good way to extend its service life.
2) Bondo the trough in the bottom of the square rod. Same reason.
3) Cover the actuator square rod: A small extensible boot can be fashioned to cover this part. Otherwise a wiper made from Gortex, little brushes, etc., could be made for it. Same reason.
4) Seal the cover: A little (very little) non-hardening gasket seal. Tape on the seam would technically be better because no sealant could get into the parts.
5) Run the cover screws through the body. This is a minor point; but some improvement can be made by using metal inserts in the case.
6) Squash the motor EMI capacitor at the motor. The standard method of handling this is to put a small (0.01 µF ceramic) across the motor leads and 0.1 µF ceramic caps from each motor lead to ground. This should be done right at the base of the motor and the capacitor leads should be very short. Then the motor case should be grounded. The TSCMR does have a similar approach onboard but is less efficient at quieting the EMI because it is some distance from the motor.

7) Other changes to the inside...? Well, I pored over this and believe the inside is actually pretty good. There is no way to know how tough the plastic parts are, but there is good reason to believe they are fine. Time will tell.

How long will the motor brushes last? Who knows? But it would be nice to be able to see them.



MAC8A Schematic

Here's a simple electronic schematic that shows how the MAC-RAC works: The servo is shown at the position where the brass actuator thread is fully extended (the square rod is fully retracted). The limit switch SW2 has opened, allowing ONLY movement in the opposite direction. The 1N4001 diode conducts only until the limit switch SW2 again closes (almost immediately). The motor can drive the rod all the way to the other end so that the other switch SW1 opens, or the motor can stop anywhere in between