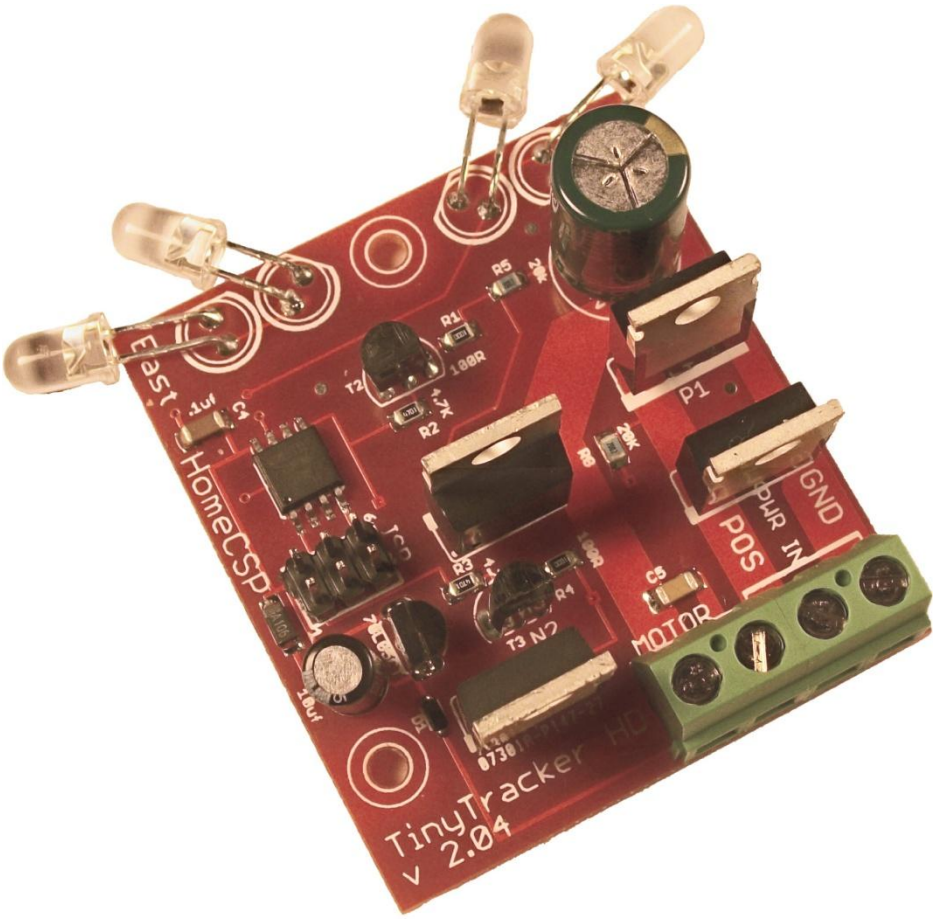

TinyTracker HD

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Important Notice:

PCB has been revised, connections may not match previous units!

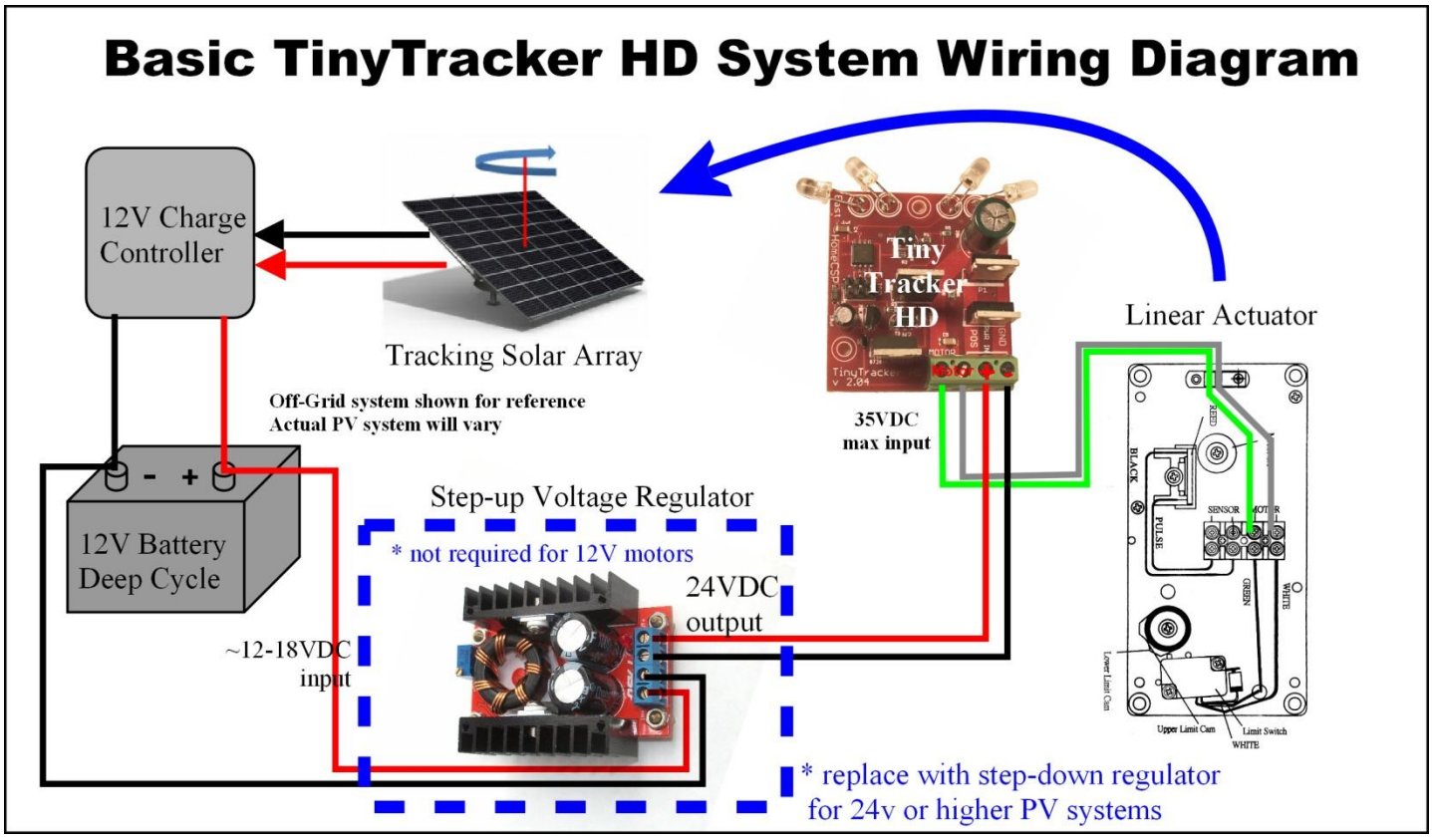
If you have a thru-hole processor rather than the new SMD unit pictured, then motor connections are now on the left, and Pos and Gnd connections are on the right side (opposite previous order) of the green terminal strip!

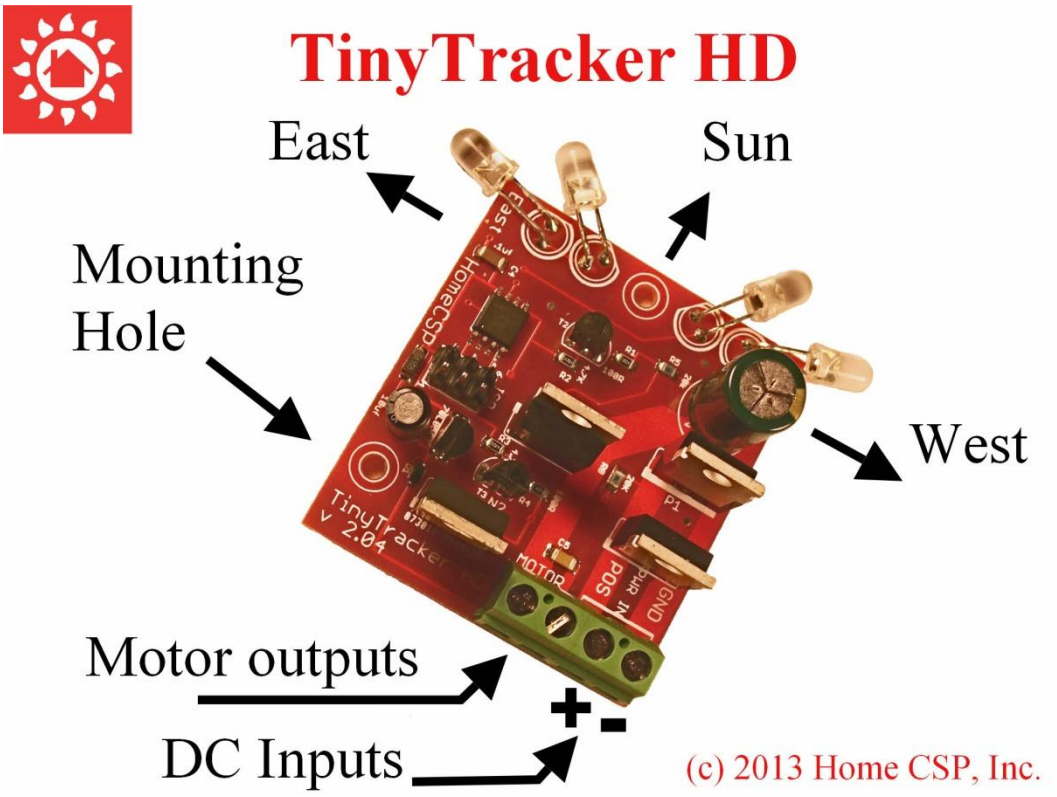
Please observe labeling on your board carefully when making connections.

Thanks for purchasing your TinyTracker from Home CSP Inc. The TinyTracker HD provides a simple but effective solution for single-axis solar tracking with common satellite linear actuators and other various small/medium DC motors. **When first turned on, the TinyTracker will momentarily run the connected motor west, then east. Reverse motor leads if necessary to obtain proper behavior. The unit will pause for 10 seconds to read the light levels before beginning regular tracking operation.**

Specifications

Voltage:	30v dc max, 12-27 recommended
Tracking Period:	3 minutes
Max Motor Run:	3 minutes
Sample Period:	0.5 seconds
East Return Delay:	10 minutes
Max Motor Current:	8A





Connections should be made as per the illustrations for your system. Power is supplied to the TinyTracker HD and the motor outputs are connected to your linear actuator (or similar) motor. No external sensor connections are used.18 AWG wire is recommended for use with the TinyTracker HD.

Note also that a fuse and/or power switch may be desirable or required in many applications. Consult with a qualified licensed electrician if you are unsure of your skills or proper wiring procedures.

There are many types of tracking mounts where the TinyTracker can be used here are just a few:

Azimuth – these are the most common type of pole tracker. Rotation is about the vertical axis, and the PV panel is usually set at a fixed angle. The TinyTracker should preferably be positioned at the same angle as the panel, but may also be positioned vertically as best appropriate for your application.

Altitude-Azimuth – a second TinyTracker can be added to an Azimuth tracker to create a dual-axis tracker where the panel elevation angle is adjusted throughout the day as needed.

Polar – the axis of rotation is tilted from horizontal to match your latitude and point at the celestial North Pole. This is ideal for the TinyTracker.

Horizontal – this is a simplified version of the polar mount with a horizontal north-south axis. These are popular on flat rooftops and along north-south roof ridges. These work best at lower latitudes.

New Features in Firmware Revision G

The RevG firmware includes nearly all the features of our previous custom firmware configurations, and stores all tracking parameters in EEPROM so that it can be customized for almost any application.

Tracking parameters stored in EEPROM:

- BALANCE – used to adjust East/West balance
- DAYLIGHT – used to control night park light threshold
- SUNLIGHT – defines minimum light level for tracking, minimizes seeking in cloudy conditions

- MAX_TRACK – maximum run time during normal tracking event
- MAX_RUN – maximum motor run for actuator reset, east-return, etc.
- TRACK_PERIOD – interval between tracking updates
- EAST_INHIBIT – prevents Eastward movement during normal tracking updates.
- PWM – pulse width modulation for adjusting motor speed
- ALT_AXIS – for elevation axis use, this reverses the normal east-return direction to make the elevation axis park in a horizontal position at night.

The firmware incorporates a special tracking algorithm to limit extraneous motor operation caused from "seeking" in cloudy/partial-sun conditions. When first started up, the firmware will allow the motor to run for up to 3 minutes (MAX_RUN), this run time decreases over the next ten tracking updates till only 3 seconds (MAX_TRACK) of motor operation is allowed each tracking period. Just in case something happens like the sun comes out from clouds in the afternoon, once per hour a 4x longer motor period is allowed. These features result in a much more plant like heliotropic motion in a wide variety of conditions, and result in less wear and tear on actuator components for extended actuator life.

Theory

The TinyTracker HD is named after the ATtiny85 microprocessor which controls its operation. The ATtiny85 is an 8 bit microprocessor with 8K of program memory, and is configured to run on its internal clock at only 1MHz to save power. The microprocessor is equipped with 10 bit analog to digital converters (ADC) which read the voltage produced by light striking the LEDs. Two digital outputs are utilized to control a standard H-Bridge motor driver circuit based on TIP-12X Darlington transistors. This allows the microprocessor to control the direction of the current through the motor in an attempt to achieve a position where the voltage produced by the East and West LEDs is equal.

While it is commonly know that LED's produce light from electricity, hence their name, it is less commonly known that they also produce a voltage in response to normal light striking the diode. Due to their size, LEDs produce an insignificant amount of power, but the voltage is easily read by a microcontroller. As it turns out, green LEDs tend to give the best output, and these have been used in the TinyTracker design. Two LEDs at a 90 degree angle to each other form the core of the light sensor, while two additional LEDs provide a wider field of off-center light detection to help enable solar target acquisition.

Since the power from the LEDs is very small and there is virtually no load, there is a need to smooth out the data from the ADC for reliable operation. This is accomplished by a digital single-pole low-pass filter which is implemented in the firmware.

Use of a microcontroller allows a minimum of electrical components and also enables the TinyTracker to be extremely energy efficient. The ATtiny85 chip draws less than 0.5 mA when the motor is not operating. By updating the motor position according to the Tracking Period, extraneous motor movements are avoided: reducing wear and also conserving energy.

TinyTracker operation may be affected by various environmental factors such as trees, clouds, ground color, reflections, and other extraneous light factors. The voltage from the LEDs and the 10bit resolution of the ADCs limit the theoretical resolution to slightly better than 0.5 degrees. The TinyTracker is primarily intended for PV tracking, and due to the factors mentioned, no minimum accuracy is appropriate.

Once light levels have fallen to "nighttime" levels, the TinyTracker will wait about 10 minutes (to make sure it's not a solar eclipse or something else transitory), and then engage the "east-return" function. This causes the motor to run in an eastern direction until the limit switch is tripped. As the microprocessor has no knowledge of the actual array position, the east-return function runs for the specified Max Motor Run period. As long as your motor can at least return 50% from its western limit in this time, the TinyTracker should be able to reacquire the sun the following day.

Also note that the pulse output connections for positional sensing common to many linear actuators are not used by the TinyTracker. It is completely dependent upon limit switches stopping the flow of current to the motors when mechanical constraints prevent the unit from achieving the desired orientation, and the LEDs for determining what that orientation is.

With a large PV array the TinyTracker usually returns itself to a middle azimuth position (and horizontal panel position when used for elevation control) following sunset, and will acquire the sun the next day without issue. However, depending on the power and arrangement of your PV panels, the TinyTracker may go to sleep at various degrees of return from western maximum if battery power is not also supplied in order to enable the east-return function, as needed.

Details

Light Vane: Use of light vane is optional according to your requirements. A properly designed external light vane can increase tracking accuracy. A longer vane will cause more of a shadow to fall on the LEDs which will increase sensitivity. A short strip of black tape on the enclosure between the LED sensors casts a shadow and makes a simple but effective vane for most purposes.

LEDs: the two LEDs that are 180 degrees apart (East and West) are intended to help increase the effective field of vision. This can help the tracker re-orient itself in the morning if the east-return function did not work due to lack of power after sunset (if the tracker is powered by PV instead of batteries); however, in some circumstances this may not be desirable. For instance: with a dual-axis controller using the TinyTracker for elevation control (rather than Azimuth or Right Ascension angle), movement will be 90 degrees maximum. In this situation using a piece of tape to cover the outside LEDs will improve performance.

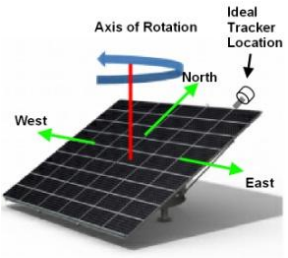
Supply Voltage: The TinyTracker is designed to handle a wide range of input voltage to allow operation from unregulated 12v PV panel output; however, unregulated 24v PV output may exceed the maximum rating (30vdc) for the MOSFETs. The actual voltage used will depend upon the requirements of your motor. The TinyTracker features a blocking diode to prevent damage from accidentally reversed DC polarity; however the MOSFETs may still be damaged. ALWAYS VERIFY POLARITY before connecting power.

If you are using an AC adapter power supply instead of PV or battery, then a 24vdc 5.0 amp rating is recommended.

Motor Amperage: The motor driver is limited to 16A maximum under ideal conditions, but continuous current should not exceed 8 A in practice. Inside a hot enclosure in the sun is not ideal, and obviously those conditions will vary. More important than actual amps, are the watts used by your motor (Volts x Amps = Watts) as this will determine the actual heat dissipation factor for the electronics. The maximum wattage recommended is 240. Remember we're trying to make more energy, not use it all up with the tracker! The PMA linear actuators sold by HomeCSP draw slightly less than 0.4A at 24vdc. Heavy duty linear actuators typically draw 5-8A max under load, and the TinyTracker HD can easily handle that. Solar tracking motors should move slowly. Your motor should take at least a minute to go from one side to the other. Use of a power supply rated at 10 amps or less is one good way to avoid damage to the motor driver.

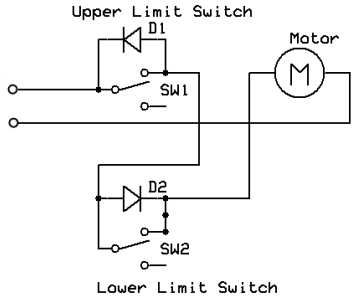
PWM versions of the TinyTracker firmware are available by request. Pulse Width Modulation is used to control motor speed and also reduces the average current level; however the breaking design of the MOSFET circuit causes significantly increased heat dissipation. The braking feature of the motor driver makes PWM control even more effective at slowing speed but this comes at the cost of converting the motor energy into heat. Consequently PWM is NOT RECOMMENDED with the Tiny Tracker HD.

Enclosure: Painted or opaque enclosures with a clear window tend to function as small solar ovens and increase the operating temperature for the electronics, and are not recommended. The recommended enclosure for the TinyTracker is a clear PET plastic jar or similar container. The TinyTracker is easily fastened to the lid with a small stand-off, and this provides excellent weather protection and visibility for the tracker. Make sure the enclosure is water tight: silicone sealant may be required. Waterproof conduit fittings are recommended, and a small desiccant package of silica gel may help prevent dew point condensation on the inside of the enclosure. For adjustment and alignment, make sure that you can rotate the enclosure as needed about an axis parallel to that which the TinyTracker will be controlling.



Location: For a south facing panel in the northern hemisphere, the north-east corner of the array is the generally preferred location to mount the TinyTracker. In the southern hemisphere, this becomes the south-east corner.

Limit Switches: Most linear actuators come with built in limit switches. These prevent the motor from destroying itself or the mechanical components by moving the actuator too far. Rocker switches are normally used and are configured in a Normally Closed manner. They are also used in conjunction in blocking diodes to allow the motor to reverse direction while the limit switch is open. If you are using a motor without built-in limit switches it is essential that you incorporate these into your design. A basic limit switch schematic is shown below for reference purposes



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Appendix

I. Software Updates

New software updates and versions may be released from time to time by Home CSP. These binary releases will be made available to registered TinyTracker owners for free in the Home CSP website store (use voucher code FIRMAT85), and may be installed through the 6 pin ISP header. An AVR ISP programmer and AVRdude software is required to upload the new firmware. AVRdude is freely available, and is part of the Arduino development environment. AVR ISP programmers are commonly available on eBay and other from other sources such as www.adafruit.com. Visit the Home CSP website for firmware upload instructions.

II. Circuit Schematic Diagram: