Home CSP, Inc.

Trackers and electronics for home solar energy

www.homecsp.com

MEGA TRACKER 2A

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MEGA TRACKER 2A VERSION 1.0 REV B59

Thanks for purchasing your Mega Tracker from Home CSP Inc. The Mega Tracker provides the most comprehensive solution for single or dual-axis solar tracking with common satellite-dish style linear actuators and other various small DC motors. Please take the time to review this document and familiarize yourself with the features before installing and configuring your unit.

SPECIFICATIONS

Supply Voltage:	12v dc maximum, 6v minimum
# of Axis:	2, external motor drivers
Operating mode:	Automatic or Scheduled
Tracking mode:	Analog (light level), Digital (astronomical), or Combination
Position Feedback:	Pulse, Potentiometer, Inclinometer, or Accelerometer
# of input ports:	7 A/D, 2 digital, w/screw terminal connections
Display:	16x2 back lit blue LCD
Communication:	USB, wireless XBee
MCU:	Atmel MEGA2560 processor @ 16MHz
Clock:	RTC with battery backup
User input:	Sealed membrane keypad, remote serial commands
Enclosure:	Waterproof polycarbonate case.

OPERATIONAL THEORY

The Mega Tracker is named after the MEGA1280/2560 microprocessor which controls its operation. The MEGA2560 is an 8 bit microprocessor running at 16MHz with 128K of program memory, 4K of SRAM, and 4K of EEPROM. The motherboard is based on the Arduino Mega, while the custom daughter board includes a Real-Time-Clock, and various input/output connections in addition to the LCD display. The microprocessor is equipped with 10 bit analog to digital converters (ADC). In analog tracking mode the controller reads the voltage produced by light striking the LEDs. In digital mode, astronomical calculations are used to determine solar coordinates and actuator position feedback (pulse or potentiometer) is used to control axis drive motors appropriately. RJ-45 Ethernet style connectors are provided for two independent motor drivers.

All common mount types and actuator/drive linkage options have been included to be compatible with as wide as possible variety of solar trackers.

The Mega Tracker can monitor and log various analog and digital sensors with the various input ports. Each port may be assigned to any one of the various parameters available, which include: motor limit switches, analog feedback, and windspeed, as well as East, West, North, South, Volts, Temp, and Amps. Threshold conditions may also be defined to trigger park events.

Output ports may be configured based on parameter values and threshold conditions.

The optional XBee serial RF module provides wireless monitoring and remote command capability.

The extensive menu system allows full user control over various aspects of tracker behavior. The LCD may be configured to display any of the various parameter values.

The MegaTracker is the most sophisticated solar tracker available for the non-utility market, but it is simple to use.

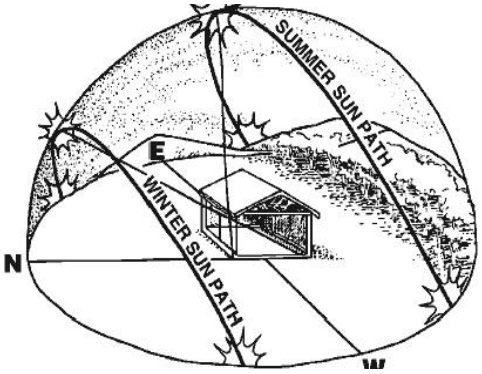
IMPLEMENTATION

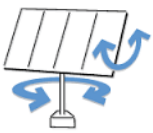
Connections should be made as per the illustrations and as appropriate for your system. Note that a fuse and/or power switch may be desirable or required in many applications. Consult with a professional electrician if you are unfamiliar with the concepts discussed here.

TRACKING MOUNTS

The sun traces an arc across the sky everyday that is essentially parallel to the celestial equator. Each day that moves a little north or south between the winter and summer solstice positions. The goal of a tracking mount is to accurately follow the sun each day.

There are many types of tracking mounts where the Mega Tracker 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.

Altitude-Azimuth – a dual-axis tracker where the panel elevation angle is adjusted throughout the day as needed in addition to rotation about the vertical azimuth axis.

Polar – the axis of rotation is tilted from horizontal to match your latitude and point at the celestial North Pole. Twice a year, on the spring and summer equinox dates, a single-axis polar tracker will follow the sun perfectly.

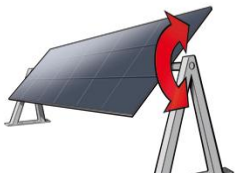
Order of rotation is important! This is the subtle difference between dual-axis polar and equatorial tracking mounts. While the difference is insignificant for PV tracking, CSP applications may be sensitive to the difference.

***** The Mega Tracker is the only controller that supports both Equatorial and Dip/Tilt semi polar systems*****

or 

Dip/Tilt semi polar – the east-west axis of rotation itself is tilted above or below the true polar axis to attempt to correct for seasonal movement. Note that this produces an arc which is no longer parallel to the celestial equator, and cannot accurately track the sun's path without motion throughout the day on both axis; however, this type of mount is easier to construct that an equatorial mount, and the panels can be kept close to the axis of rotation which minimizes static load conditions when rotated east west.

Polar Equatorial – so called because the primary axis (RA, right ascension) is parallel to the earth's polar axis, which makes it track parallel to the celestial equator. The secondary axis is called the declination and determines the tracking latitude relative to the celestial equator. Equatorial mounts are commonly used for astronomy because a single tracking motor can be used to keep objects in the field of view. The primary disadvantages of equatorial mounts are the increased complexity and the fact that the solar array has to be mounted at a distance from the polar axis to allow for declination movement. The larger the array, the farther the distance and that can substantially increase the load on the polar axis at low solar angles near the horizon. Counter weights are often required to compensate for this, which adds even more weight that the primary axis must support.



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.

MOTOR POSITION FEEDBACK

A wide variety of popular position feedback options are supported.

Pulse Standard actuator reed switch

Hall effect sensors - single channel (no quadrature reqd)

Optical encoders - single channel (no quadrature reqd)

Potentiometer used with some linear actuators. Provides an analog voltage signal .

Inclinometer Output current is linearly proportional to the measured angle.

Accelerometer 1, 2, or 3 axis sensors, output voltage is proportional to the Sin() of the measured axis angle.

1 or 2 axis sensors may be used for pitch or roll sensing, 3 axis sensors may be used for either or both.

Pulse feedback is relative to the starting point, whereas other systems provide a signal that indicates the absolute position of the system. Because of this, each time the system starts up, or experiences a power cycle, pulse feedback systems require that the motor is run to a limit switch where the count is then set to zero.

Potentiometer feedback gets connected to one of the available general purpose I/0 ports, as do inclinometer and accelerometer signals. Make note of the solderable pull-up jumpers for the I/0 ports., Pull-ups may be useful with potentiometer or inclinometer signals, but are inappropriate for accelerometer signals.

The M1 and M2 motor setup menus will present the appropriate calibration and configuration functions depending on the motor type and feedback options selected with the MODE command.

MOUNTING THE CONTROLLER

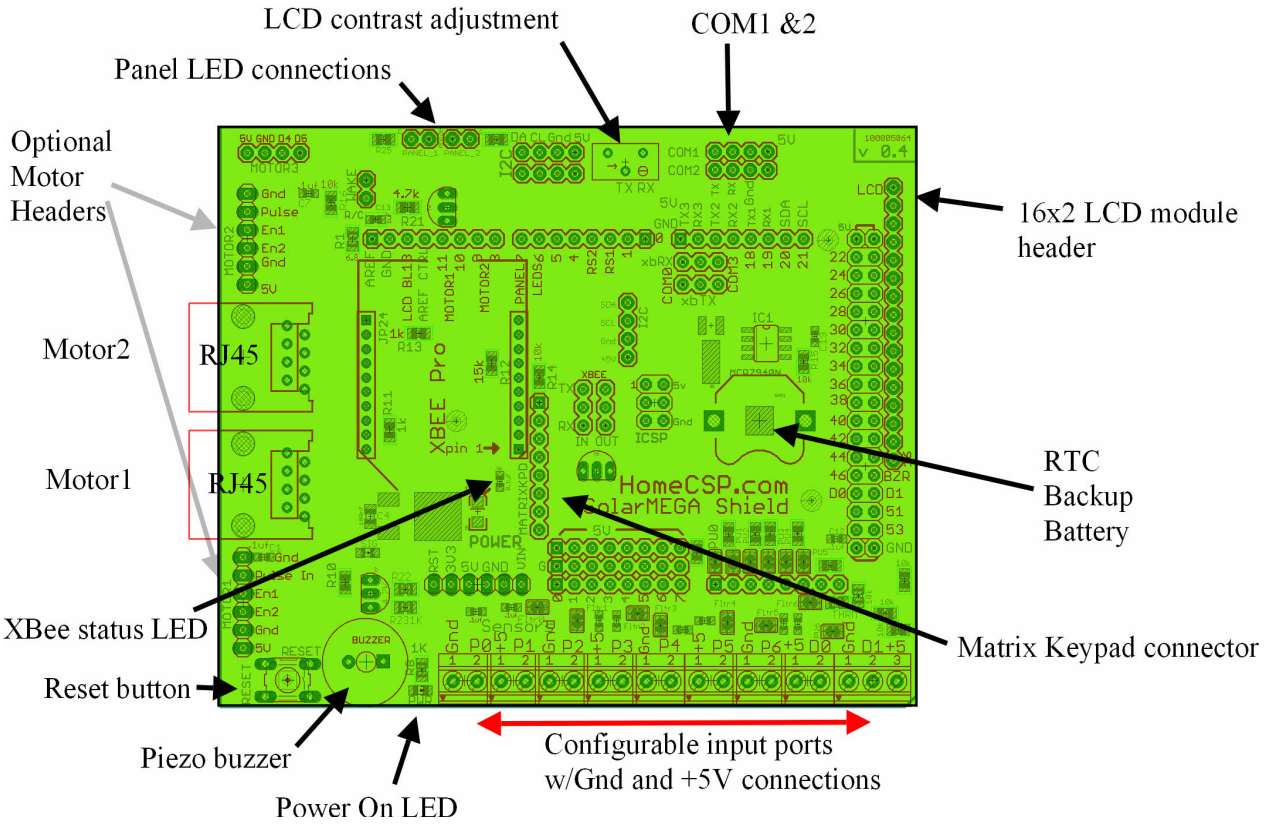
The Mega Tracker enclosure offers outstanding flexibility for locating the controller. While it provides full protection from rain and moisture, the unit should be mounted in a location that will not receive direct sunlight in order to keep the operating temperature from getting too high.

A nylon zip-tie or similar strap may be attached to the top of the enclosure for a simple hanging mount, or mounting holes may be drilled in the back of the enclosure to facilitate fixed mount on a panel.

The 3/4" conduit fitting may be connected to either rigid or flexible PVC conduit to protect all connecting wires and maintain weather-resistance for reliable operation.

CONNECTIONS

DAUGHTER BOARD LAYOUT



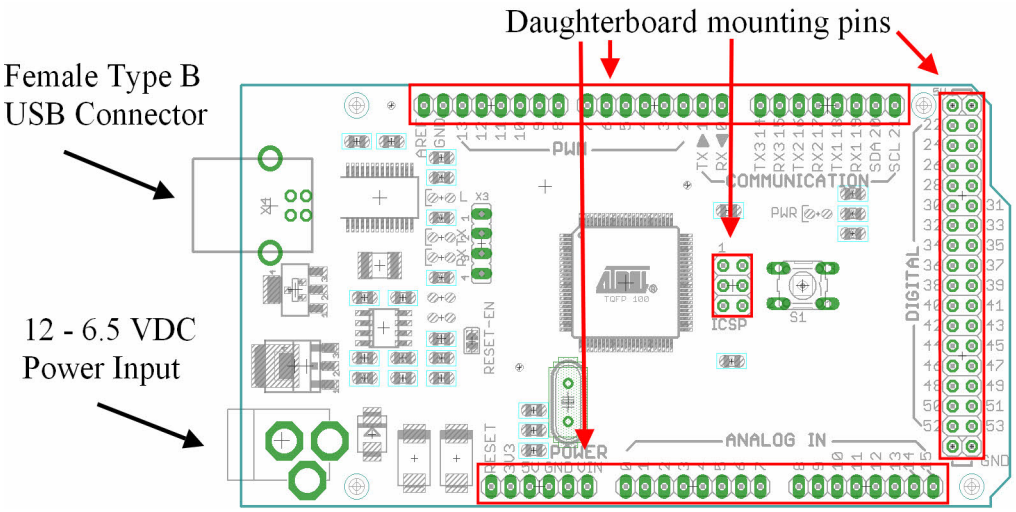
DAUGHTERBOARD CONNECTION

The Mega Tracker daughter board sits on top of a standard Arduino Mega mother board.

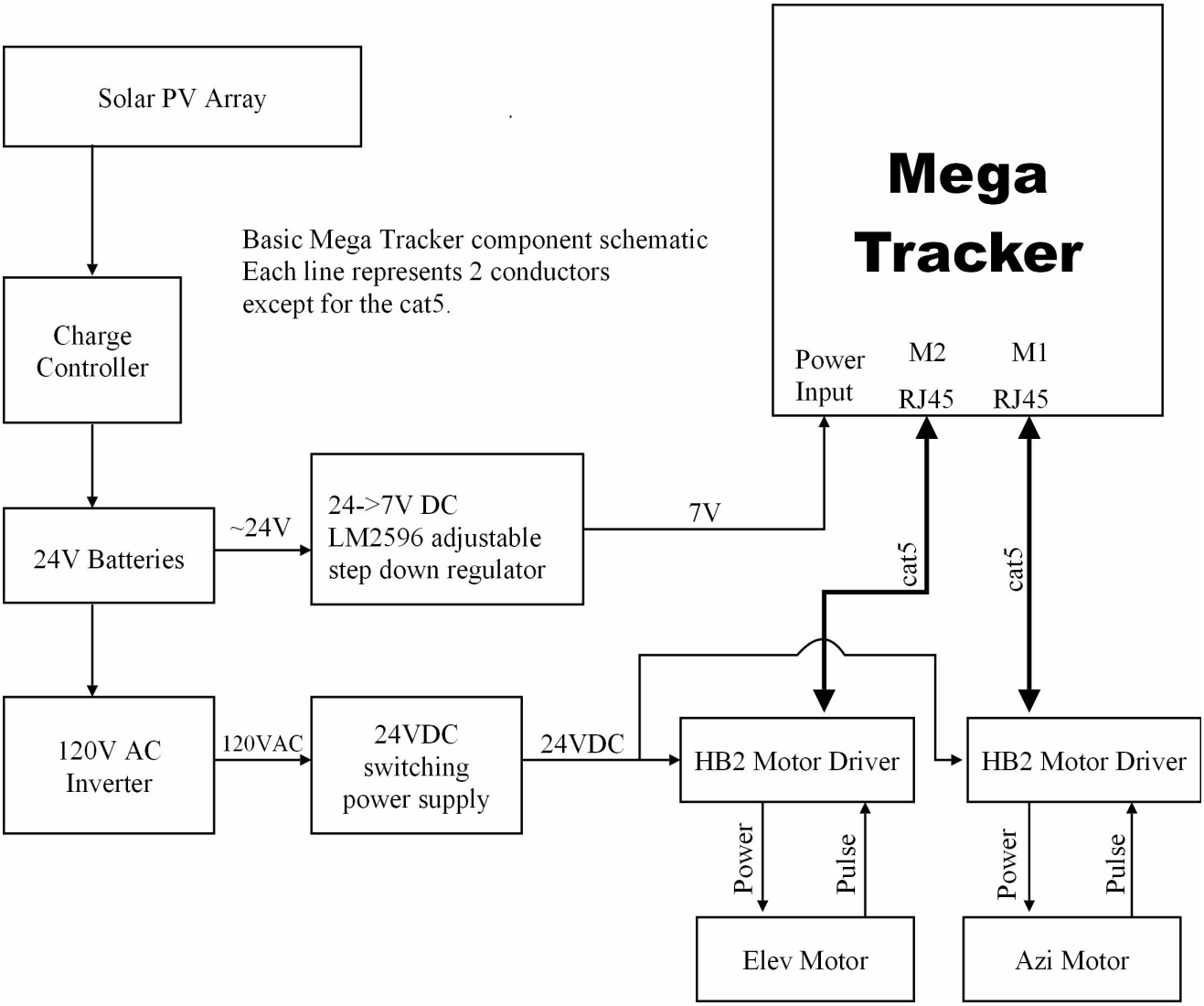
Exercise caution when separating the boards. Pressure should be applied to the Arduino Mega while lifting the daughter board in order to avoid over-stressing the mounting stand-offs. Carefully move each end and side a little bit at a time till the boards easily separate. Avoid accidentally bending the connecting pins.

When replacing the daughter board, first align the row of double pins at the end before carefully mating the boards and firmly pressing them together.

MOTHERBOARD LAYOUT



SAMPLE 24 SYSTEM BLOCK DIAGRAM



POWER CONNECTION

DC power is connected directly to the Arduino Mega motherboard with a standard barrel style power connector. A 12” pigtailed power cable is supplied with the Mega Tracker.

KEYPAD CONNECTION

The keypad ribbon cable connects to the marked header on the Mega daughter board in a straightforward fashion with no twists. Only the 6 pins closest to the analog input ports are utilized (some boards may have 8 pins).

- Exercise caution opening the enclosure door to not damage the keypad ribbon cable.
- Enclosure door must be partially closed to facilitate connection of keypad ribbon cable.

MOTOR DRIVER CONNECTIONS

Either the 6 pin headers or standard 8-pin RJ45 connectors may be used to connect the motor drivers.

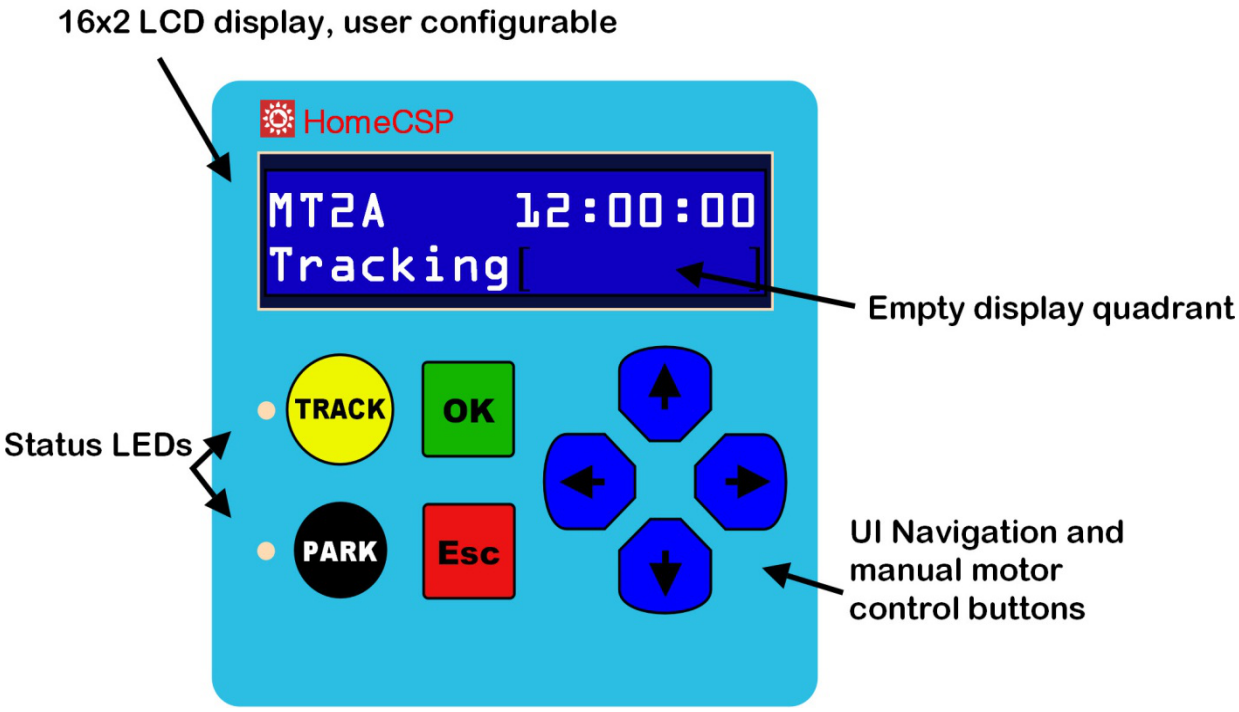
RJ45 T568A Wiring		**TSA568B**	**Signal**
#	**Color**	**Color**	**Signal**
1	W/Gr	W/Or	GND
2	Gr	Orange	Pulse
3	W/Or	W/Gr	EN1
4	Blu	Blu	EN2
5	W/Blu	W/Blu	EN3
6	Or	Gr	MIS
7	W/Brn	W/Brn	GND
8	Brn	Brn	+5V

I/O SENSOR PINS

Analog pins are labeled 0-6. Two additional digital pins are labeled D0 and D1. Analog pins may also be utilized for digital logic signals. Depending on installed Mega firmware, all pins may be utilized for either input or output signals. Inputs can be used to trigger Park events, and Outputs can reflect various system parameters.

Each pin has an adjacent GND and +5V signal available. Where necessary two adjacent pins may share GND or +5V terminals. There are also 10K pull-up resistors for pins 0-6 (labeled PU0-PU6) available for each pin (which are commonly needed for various input devices). These must be enabled or disabled with a soldering iron.

FRONT PANEL FEATURES



The membrane keypad provides access to all of the Mega's versatile features while also remaining fully weatherproof.

Key features:

- LCD – has 2 modes: IDLE and COMMAND. When idle the display is divided up into 4 quadrants, and each quadrant is assigned a user selectable display parameter with the SHOW command. Pressing the OK, ESC, or arrow keys while in IDLE mode will put the display into COMMAND mode and display the Root menu. The display back light will automatically fade after a couple minutes of inactivity to reduce power consumption.
- Track Button – puts unit into Tracking mode, when in Manual mode this also toggles between degrees and pulse.
- Park Button – puts unit into Park mode. If unit is already in Park mode, then park position configuration is invoked.
- OK Button – used to select menu commands and confirm user input values.
- Esc Button – used to cancel menu commands, or go back one menu level. While in COMMAND mode, Esc button will switch to IDLE mode.

Important Note: The Esc button can also be used as a safety switch to stop motor operation at any time.

SERIAL COMMAND OPERATION

Nearly all UI commands are also available at a command line level using a USB or XBee serial connection. Default baud rate is 9600 (8-N-1). Any standard serial monitor program should be compatible. It is generally helpful to turn **Local Echo ON** so that your keyboard input is visible.

- The Mega Tracker's COM0 is used for USB serial data.
- COM3 should be selected for Xbee operation.
- Enter "?" for a list of available commands.
- Enter a command followed by a "?" for command syntax explanation.
- Separate parameters with a space character
- Start a command line with "#" to invoke a sub-menu command from the root menu. For example if we were in the INFO submenu the command "#SETUP TIME" would show the current time and leave us in the SETUP submenu.
- DUMP is a special serial command for examining various variables and parameters.
    - The DUMP command may be accompanies by the following keywords:
        - ALL – complete dump of all data sets
        - PARMS – all I/o port parameter values
        - PORTS – all I/o port configuration information
        - M1 or M2 – dumps motor class data set
        - SOL – solar position calculation related values
- Any command may be preceded by "ID=### " to direct the command at a specific tracker Unit number.

  Example: "ID=1 ?" – gets a list of the current commands from Unit number 1.
- POLL is a special command used to poll the various Mega Tracker controllers available on a given Xbee network. Each controller's response is delayed proportional to the Unit number so that responses are naturally ordered and non-overlapping.
- The PARK command is always available regardless of current submenu context.

GETTING STARTED - FIRST TIME OPERATION

Until the alignment procedure has been completed for at least one axis, the MegaTracker will continue to present the First Time Setup prompt upon startup. The First Time Setup procedure simply implements the recommended order of operations for going about system setup. Each of the setup procedures may be accomplished separately by selecting the appropriate Setup Menu items.

Clock – If the clock is not already set then the first prompt is to set the clock (this is done initially at the factory). Do not use Daylight savings time!

GPS – Longitude and Latitude input for local coordinates. Northern latitudes and Eastern longitudes are positive.

Mode – Single or Dual Axis operation, Digital/Analog tracking, Smart PV tracking, and Automatic tracking selection.

Motor Mode – actuator drive , axis and linkage options.

Limit – test/configure actuator motion limit

PPU – input/measure/test actuator position sensor pulses per unit length

Trig – enter measurements to allow calculation of angles

Align – define reference positions for determining relative angles

If you select Dual-Axis operation then the motor configuration steps must be repeated for the second axis.

For finishing an incomplete First Time Setup, Limit, PPU, and Trig steps if previously completed may be skipped by using the ESC_KEY without aborting the rest of the scripted setup procedure.

Once setup is complete, the main menu will be presented and the Mega Tracker may begin normal operation.

MENU SYSTEM

MAIN MENU

TRACK/PARK - turns TRACKING on when PARKED. Parks unit when TRACKING already on

MCTRL– manual motor control using navigation keys on keypad. Stops Tracking mode, clears Park flag.

INFO- invokes Info submenu

SETUP- invokes Setup submenu

SHOW – configures display options. The display is broken up into four quadrants. Use the cursor to move to the selected quadrant and press OK

SCHED- invokes Schedule submenu

WASH – move array to pre-defined wash position, and sets tracker mode to WASHING. Invoking this command when already in WASHING mode will allow the option of setting the wash position.

LOG – invokes regular transmission of status and input parameters via serial port/xbee

RESET – resets configuration values to original defaults (must do first-time setup again after this)

INFO MENU

STAT - displays status: auto-rise, dual-axis

TEMP - displays on-board temp

SOLAR - displays solar position, sunrise, sunset

POSI - displays current motor position information

POWER -calculates potential solar power based on current coordinates, panel area, and incident angle. Calculation is based on the “Bird Clear Sky Model for Direct and Diffuse Insolation on Horizontal Surfaces.”

VERS - displays software version

MODEL - displays hardware version

AREA - displays/configures tracker array area (in square meters) for power calculations

SCHEDULE MENU

AUTO - Select Automatic or Scheduled operation

LIST – List/Edit scheduled tracker events

ADD – Add a scheduled tracker event

DEL – Delete a previously scheduled tracker event

RISE – Set minimum sunrise elevation for tracking operation

SET - Set minimum sunset elevation for tracking operation

SETUP MENU

MODE - Dual-Axis? M1 Digi, M2 Digi, Smart PV mode, Auto-rise?

Smart PV tracking mode is a new feature which combines digital tracking under sunny conditions with analog photo tracking under cloudy conditions. External E/W/ N/S sensors are required for this.

PARMS - sub menu

M1 – primary axis sub menu

M2 – secondary axis menu

PORTS - sub menu

COMM - sub menu

TIME - set clock time, and adjustment calibration factor. Calibration factor is added/subtracted just after midnight each day.

ZONE - set time zone relative to GMT, must adjust time zone (-1) if using Daylight Savings Time !

GPS - set Latitude and Longitude. Western longitudes are between 0 and -180, Eastern values are positive. Northern latitudes are positive, while Southern ones are negative.

COMM SUB MENU

WIND - enable serial wind data input

NAME - define/edit unit name

XBEE – set XBee PAN, Channel, ID, and DestAddress

PORT - select serial port for communication (USB =COM0, XBEE=COM3)

BAUD - select data speed for the selected data port

PORTS MENU

AREF – configure Analog Reference Voltage for ADC conversion

DEFAULT – standard 5v reference

INT_2V56 – internal 2.56V reference. Useful for ADXL335 accelerometer measurements

INT_1V1 – internal 1.1V reference.

EXTERNAL – utilizes the Aref pin on the Mega (requires modification of daughterboard). Most commonly use is for 3.3v reference from the Xbee 3.3v voltage regulator.

ADC0 – default East external light sensor

ADC1 – default West external light sensor

ADC2 – default North external light sensor

ADC3 – default South external light sensor

ADC4 – configurable analog input

ADC5 - configurable analog input

ADC6 - configurable analog input

DIG1 - configurable digital input

DIG2 - configurable digital input

Assigned ports will display customized label values in PORTS menu for easy identification of port assignments.

The following device types are supported: "LED","Thrmst","Amp","Volt","LM35","DS18","LDR","Dew","Flow","Analog"

M1 OR M2 SUB MENU

MANU – allows manual control of each motor using arrow keys on keypad

MODE – configuration procedure for setting actuator mode

CAL – accelerometer calibration for tilt sensing

LIMIT – configuration procedure for setting max pulse count associated with pulse & potentiometer feedback systems or min/max angles for tilt sensing feedback.

PPU – configuration procedure for determining and setting actuator pulse-per-inch value. Only used with pulse and potentiometer feedback.

TRIG – configuration procedure for dimensional values used in axis angle calculation. Not shown for Gear drive or tilt sensor axis.

ALIGN - configuration procedure for axis angle calculation

PWM – configures pulse-width modulation setting for motor speed control

STALL – configures motor pulse stall period

ZERO – returns motor to fully retracted position and zeroes pulse counter. Not applicable to tilt sensor feedback.

PARMS MENU

FREQ – tracking update frequency (technically the period) expressed in minutes between updates (1-60)

SUN – set sADC value for sunlight threshold (used in Inhibited mode analog tracking)

NIGHT – sets ADC value for night threshold used to end TRACKING mode and trigger axis return function

ELEV – set minimum East and West elevation (in whole degrees) for tracking (this is the same as the Rise and Set commands available under the Schedule menu.

INHIB – sets reverse-solar inhibition (East Inhibit) function for M1

BIAS - sets East/West AND North/South tracking bias used in Analog tracking mode

WTIME – tracking inhibit time (in minutes) after high wind trigger

RTIME – sets motor run time limits (in minutes)

FOCUS – is used to optimize tracking motions by only moving when off focus by the specified number of degrees. The system calculates the effective degree resolution per pulse of the motors, and the lowest value (highest resolution) determines the minimum focus value. Maximum focus value is 5 degrees.

I/O PORT CONFIGURATION

The configurable I/O ports are a powerful feature of the Mega Tracker controller. Besides light and wind sensor inputs, they also allow the Mega Tracker to respond to temperature, voltage, current, and other sensors. Using outputs for relay control or logic inputs to CHP system or other controller provides system integration capabilities not found in other solar tracking controllers.

*** Please refer to the Appendix for Pull-up resistor jumper configuration information**

The I/O ports are located along the right side of the Mega Tracker controller with a long line of terminal connectors that provide +5v and GND signals interspersed with the I/O ports.

Ports configured for output can provide status signals for other devices based on the assigned parameter.

Ports configured for input are assigned to a parameter that may either be used strictly for monitoring, or as input to an output port. They can also be used to trigger park events based on input signals. For example a dew sensor could be used to park in the rain, or a high temp level could make a CSP dish go to a safe park position.

Both input and output ports may use inverted logic for conditional versatility.

After selecting a port the first prompt asks if the port configuration should be cleared to inactive values.

- If you answer YES, then you are returned to the ports menu after the port values are reset.
- If you answer NO, then the port configuration procedure begins.

- **Holding any key down on the the membrane keypad while starting the Mega Tracker will cause ALL ports to be reset to inactive/default values**.

The second step is selecting Input or Output mode for the port. Input mode is used for reading sensor data and assigning it to one of the available port parameters appropriate for the given sensor..

INPUT DEVICE TYPES

The next step involves selecting Analog or Digital input operation.

The **LM35** and **DS18B** one-wire devices are the only Digital input devices available at this point. Pull-up jumper should be enabled for these devices (see appendix).

The following analog device types are supported: ActPos, LED, Thrmst, Amp, Volt, LDR, Analog, Wind, Dew

ActPos – analog actuator position feedback, usually from a poteniometer, alternative to pulse-feedback and cannot be used with pulse feedback.

Wind – is intended for analog anemometer wind speed measurement where the input value is proportional to a measured reference voltage at zero wind speed. Standard slope value is 1.6v/32.4m/s.

Volt – is intended for DC voltage measurement where the input value is proportional to a measured voltage source. The Home CSP Voltage Divider module with Zener protection diode is recommended for this purpose.

Amp – is intended for Hall-effect current sensors with an analog output voltage from 0 to 5v in proportion to current. Min and Max scale value parameters are provided for use in value calculation.

Limit - switches are considered Digital due to their binary nature.

LDR – Light Detecting Resistors may be used similar to LED's for analog light sensors.

LED – is intended for LED based light sensors. The use of multiple LEDs in parallel is recommended. LED devices are assigned to either EAST, WEST, NORTH, or SOUTH parameter values for use with analog tracking mode.

Dew – may be used to inhibit tracking and is based on TTL logic levels rather than analog input measurements.

Thrmst – is intended for 10K NTC thermistor devices. Single Beta parameter configuration is provided for temperature calculation. Default Beta value is 3950 (check the specs for your device). Pull-up resistor should be enabled (see appendix).

Analog – is provided for generic analog signals within 0 to 5v DC max not covered by the above device categories.

OUTPUT PORTS / PINS

Output ports are limited to using 5v signal logic, and with all but the Park and Dew parameters (which are Boolean) the output signal is based on a comparison of the assigned port parameter value with a threshold value associated with the given output port. Inverted logic is also selectable on each output port for the desired signal logic.

Port Parameters

The first step for setting up an Output port is to select the Parameter that the Output port is to be associated with. The selection list is tailored to the device type that has been selected.

See the **SHOW** command section for a list of all the parameter available.

Ports assigned to EAST, WEST, NORTH, or SOUTH are special values that are used if photo-tracking is enabled. The SUN, NIGHT, and BIAS commands under the SETUP | PARMS menu are used to adjust for their input values. The following I/o port settings do not apply to those with one of these parameter assignments.

Park Trigger

If an input value is not selected as a park trigger, then it will be used strictly for monitoring purposes. Inputs used as park triggers generally are compared to a threshold value to determine if the trigger condition is met. Hysteresis value is subtracted when considering clearing the trigger. Normal threshold logic is value>=threshold. This result may be inverted (for an effective value<threshold test condition) to meet signal application requirements.

With the DEW and PARK parameters inverted logic means that the output logic will be HIGH (5v) when there is no dew, or the unit is not parked.

With the DEW and PARK parameters there are no other values to set besides the Name.

Threshold Value

All other parameter selections must specify a threshold value to be used in determining the logic state of the associated output port. Inverted logic these parameters will effectively change the output condition to a “less than” comparison rather than the “greater than or equal to” comparison that is done with the threshold value and the relevant parameter value.

Hysteresis

A hysteresis value may be specified to prevent unwanted output chatter. Select 0 for no hysteresis function. The hysteresis value is subtracted from the threshold value when determining if the park trigger should be cleared when set.

I**nverted Logic**

The next to last step is to select whether Inverted Output logic is desired.

Name

The last step for port configuration is to customize the label used to identify the port in the ports menu.

COMM PORT CONFIGURATION

Serial Communications ports can be used for command and data logging, wired or wireless via XBee, and also for wind speed monitoring.

Wind – Wind speed data is used by the Mega Tracker to automatically move the mount to the set park position at a desired threshold. It is currently compatible with Peet Bros. weather stations operating in Data Logger mode.

- Port — Any of the available serial ports (0-3) may be assigned to read incoming weather data.

  For instance COM3 can be used with an XBee for wireless weather data reception.

  RS232 to TTL conversion may be necessary for use with COM2 , COM1, and COM0 (USB).
- Park Speed — Threshold wind speed for automatic parking is expressed in whole units. Tracking activity will be inhibited for 30 minutes following any wind speed measurement over the set level

Name – User defined name is transmitted with data logging and may also be shown in idle mode on the LCD panel.

XBEE – Allows configuration of XBee wireless communication parameters

NetworkID	Specified in Hexidecimal. 0x0000 – 0xFFFF) are the allowable values.
Channel	Specified in Hexidecimal. 0x0B – 0x1A are the acceptable channel values.
Device ID	(UnitNo) Trackers should be numbered seqentially from 1. Zero is used for the base station ID
DestAddress	This should be the device ID of your network router (base station), while the base station device should have DestAddress set to 0xFFFF to broadcast to all devices at same time.

PORT – Defines general I/O COM port used for serial command input and/or data logging output.

For Xbee communication COM PORT 3 must be selected.

For USB communication COM PORT 0 must be selected.

BAUD – sets desired communication rate on the selected I/O COM port for serial data. The default value is 9600.

MODE CONFIGURATION

The **SETUP | MODE** command is used for several important tracking mode parameters:

Dual-Axis – M2 motor functions will not be enabled unless Dual-Axis is selected. Reasons to not use dual-axis include using a Horizontal, Azimuth, or Polar tracker without motorized elevation control.

Digital Mode – Astronomical (digital) tracking or Photo tracking (analog) is configurable for each axis independently. Analog tracking requires assigning configured Input Ports to EAST, WEST, NORTH & SOUTH parameters.

Smart PV – This mode combines digital mode tracking for highest accuracy when light levels are above the configured sunlight threshold, then uses analog photo tracking at other times during the day to still maximize power output.

Auto-Rise – When this feature is enabled, the Mega Tracker will automatically begin tracking operation after sunrise; otherwise, you must manually invoke a Track command or use a scheduled Track event. When disabled, it's sort of like putting the unit in standby mode.

Other important configuration parameters like mount type are found in the **SETUP | M1 | MODE** command as well as in the **SETUP | PARMS** sub menu.

MOTOR CONFIGURATION

SETUP: MOTOR: MODE COMMAND

The Motor Mode command is begins the first-time setup procedure.

```
1. Driver Type      - HB2 or Custom
2. Motor Linkage    - Arm or Gear
3. Which axis       - Azimuth, Dip/Tilt, Polar, or Horizontal
4. East/West Return - Which way start?
5. Feedback         - Pulse, Potentiometer, Inclinometer, or Accelerometer
```

The Home CSP HB2 motor driver defaults are easily selectable; however full control over motor driver output pin assignments is given when NO is chosen in response to the question to use the HB2 settings.

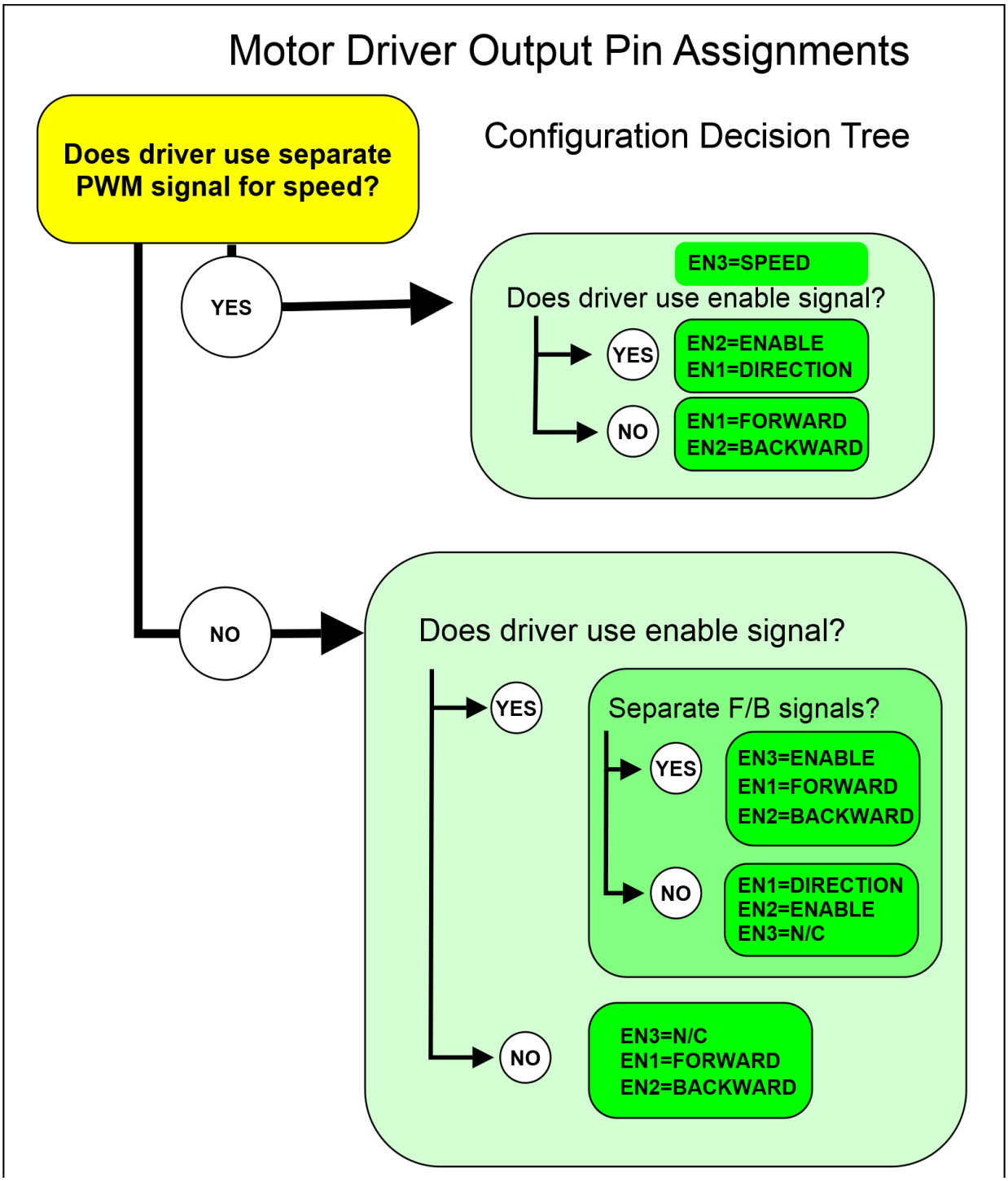
SETUP: MOTOR: MODE: MOTOR DRIVER CONFIGURATION

Step one involves selecting the proper motor driver signal configuration for your motor driver hardware. Default values are available for our HB2 motor driver. The available options for customization should support most motor drivers.

Warning: Selecting the wrong driver pin assignments may cause damage to your motor driver!

After configuring the 3 motor driver output pins (EN1-3), the option is presented as to whether to apply inverted logic to the signals (many motor drivers have pull-up resistors on the control signals and go active when that signal gets pulled to ground by the controller). If your driver does not use 5v TTL signal levels then you must use a relay interface system.

The “IS” (which stands for current sensing) alarm input pin is configured last and supports current/voltage sensors output as well as 5v TTL alarm signals for suspending motor operation.



Possible Pin Assignment Configurations *** indicates PWM usage**

EN1	EN2	EN3
FW	BK	SPEED*
DIR	ENABLE	SPEED*
FW	BK	ENABLE*
DIR	ENABLE*	N/C
FW*	BK*	N/C

FW/BK These control motor direction by their logic state and are generally never in the same logic state which would burn out most H-Bridge motor drivers (including the standard Home CSP HB2 driver).

DIR The logic state of the DIR signal determines the motor direction. PWM when used in this configuration is applied to the ENABLE pin (or SPEED if present).

ENABLE ENABLE is used as a Start/Stop signal based on the logic state. When not present motion will start as soon as direction is set.

SPEED PWM signal for motor speed regulation is often isolated from other inputs on its own signal rather than being combined with the direction or ENABLE signal.

N/C No connection – not used.

IS Pin Configuration

Some motor drivers are equipped with an output signal for either current sensing purposes or alarm indicators. Alternatively you may wish to use some other signal to suspend motor operations like the voltage of your motor power supply (processed through an appropriate voltage divider for 0-5v signal level).

Does driver have alarm output?

NO – Pin will not be used. IS=N/C

YES – Is it an analog signal(current sensing)

YES – you are asked to enter the alarm threshold value

NO - it is a digital TTL signal

Invert logic? Treat low condition as alarm (such as for a motor power supply voltage monitor)

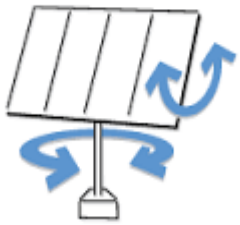
LINKAGE

While the vast majority of linear actuators are implemented with a control arm setup, this not only limits the maximum rotation to about 150 deg, but also has an effective range of only about 120 degrees, and has a non-linear rate of rotation which reduces accuracy at each end. Besides slewing gear drive systems, a linear actuator can be connected to a belt or chain and connected to a pulley or gear in such a way as to result in a constant rate of rotation that doesn't depend on arm position, and has whatever range of rotation is desired.

AXIS

The supported mount types are also covered in the introductory Tracking Mounts section.

Azimuth – axis of rotation is vertical. Secondary elevation axis (commonly called Altitude or Alt) allows this mount type to easily aim at a variety of positions, and easily support large arrays. The Home CSP Solibrium mount is an example of this mount type. Their only draw back is the zenith position at which azimuth angle suddenly reverses and a long tracking movement must be made.



Dip/Tilt - the “dip” of the semi-polar axis is adjusted and then the polar axis is rotated (“tilted”) east/west.

Polar – aka true Equatorial: the primary axis of rotation stays pointed at celestial North/South, i.e. at 90 deg – latitude.

Horizontal – axis of rotation is parallel to the ground, aligned North/South.

RETURN DIRECTION

This refers to the orientation of the axis when the actuator is fully retracted. Depending on whether the actuator has been mounted on the left or right side of the mount, it will face east or west for example. Likewise, the elevation axis may zero out the pulse count at either a vertical or horizontal position.

FEEDBACK

A wide variety of feedback options are supported to support possible scenarios.

Note that tilt sensors are ineffective for an Azimuth axis (rotation around a vertical axis). Single axis sensors may be used with horizontal tracking systems, but dual axis provide better resolution across the range of movement. Dual axis sensors may not be used for both pitch and roll measurement (3 axis is required for both).

Pulse feedback is most common with actuators and Hall effect sensors from slewing gear systems. The pulse input is held “high” (5v) by a 10k resistor (and also has a 0.1uF capacitor for debouncing). A magnetic reed switch is typically used to short the signal to ground and release it, resulting in a 5v pulse signal that is counted by a special interrupt routine that increments or decrements the count based on the motor direction. A Hall effect sensor uses a NPN transistor on it’s output for a similar pulse signal.

*NOTE: use of direct pulse signal from brushless motors may require the use of a frequency divider circuit.

Potentiometer feedback produces an analog voltage that is linearly proportional to actuator arm movement, and is less common than pule feedback. It has the advantage of not requiring a reset, but may not have the same accuracy as pulse feedback. **Signal must not exceed 5v.**

You will be prompted to select one of the available I/O ports for the potentiometer signal.

Inclinometers are industrial tilt sensors (such as Turck) which produce a current linearly proportional to the measured angle. A shunt resistor is employed to produce an analog voltage measured by the Mega Tracker. Multi axis inclinometers are not currently supported. Current support is for horizontal trackers only.

You will be prompted to select one of the available I/O ports for the inclinometer signal.

Analog Accelerometer sensors produce an output voltage proportional to the sin() of the measured angle. For increased accuracy a second or third axis is usually measured as well.

Select: Number of Axis (1, 2, or 3) – this pertains to the accelermeter device itself, not your tracking mount.

I/O port – inputs for multi-axis sensors must be in the succeeding consecutive I/O ports.

Pitch – when configuring M1 for accelerometer use (measuring roll) with a 3-axis sensor, you will be prompted whether the same sensor should also be used for M2 pitch measurements.

Accelerometer calibration may be performed next, or performed when ready using the CAL command.

SETUP: MOTOR: CAL COMMAND

This is used exclusively for accelerometer and inclinometer device calibration, and is a prerequisite procedure before the device is mounted and then finally calibrated on the tracking system using the ALIGN command.

The sensor device must not be mounted for this procedure. You should also have a flat level surface upon which to place the device during calibration.

For each axis of your sensor (X,Y, and Z)

> **Measure minimum signal** (-1G) output – rotate device by hand. Minimum value is displayed on left hand side of LCD while the current value is displayed on the right. If the device is accidentally shaken and a false minimum value is measured, then the UP arrow key may be used to reset the minimum to the current reading. Press OK once you have measured a satisfactory value.
>
> **Measure maximum signal** (+1G) output – rotate device by hand. Maximum value is displayed on left hand side of LCD while the current value is displayed on the right. If the device is accidentally shaken and a false maximum value is measured, then the DOWN arrow key may be used to reset the maximum to the current reading. Press OK once you have measured a satisfactory value.

Zero calibration (pitch and roll)

Tiny errors in alignment of the accelerometer chip on the PCB, and alignment of the pcb in the sensor enclosure need to be measured and compensated for best tracking accuracy. The device should be placed on a flat level surface, with no vibrations for 10 seconds while this procedure is performed.

Alarm values: You will be prompted to enter minimum and maximum threshold values used to detect proper signal values. Should any values outside this range be detected, the controller will go into a safe mode and not perform any tracking movements.

SETUP: MOTOR: PPU COMMAND

In order to accurately calculate actuator position, the Mega Tracker needs to know how many pulses-per-unit-of-length are sent by the actuator position sensor. Inches or centimeters are the recommended units. Whichever you choose, all other motor/arm measurements must be in the same unit. Empirical measurement of actuator behavior provides the most reliable means of configuring this parameter which is essential for DIGITAL tracking mode.

```
Step1: Measure arm length
Step2: Select # of pulse to test
Step3: Move arm, measure again
Step4: Distance & PPU calculated
```

After confirming that you want to proceed with PPU configuration, the active motor will be reset to its starting position.

Once the motor has been reset, the program will pause for user input of the current starting arm length. The important thing for the process to determine is the net travel so you can choose any particular reference point on the actuator arm that is convenient for measuring to.

Selection of the number of pulses over which to perform the test is the next step. Any number between 100 (300 default) and 1000 may be used. Larger values may help reduce the effect of measurement inaccuracy.

Next the Mega Tracker will engage the actuator motor till the set number of pulses have been counted, then pauses to allow the second arm length measurement. The program will calculate the differential between the two measurements and divide by the set number of pulses to calculate the PPU.

The program will pause to display the net actuator travel and final PPU value. The motor configuration is automatically saved to EEPROM upon completion of this command.

NOTES FOR POTENTIOMETER FEEDBACK:

When using potentiometer (analog) feedback instead of pulse-feedback, the PPU value is calculated during the LIMIT command procedure. The value may be edited directly if needed, but use of the LIMIT command is preferred.

SETUP: MOTOR: LIMIT COMMAND

Careful setup of limit switches is essential to safe and optimal tracker operation. Improperly set limits can result in damage!

```
Step1: Adj Min - Length if needed
Step2: Set Max - Motor Position
Step3: Adj Limit - switch (r/cover)
Step4: Test - Save result
```

At the start of the procedure, the motor will be reset to its retracted position. At this time the saddle clamp should be adjusted as necessary to position the array at the desired angle. Be mindful of selecting a starting position which will allow the desired symmetry of motion.

The Manual Motor control mode is then used to allow the operator to drive the unit to the desired opposite limit. This is an ideal time to follow the limit switch adjustment procedure for your actuator as well.

Once Manual Motor control is exited, the motor pulse count is displayed, and if the value is confirmed, then the motor configuration is saved to EEPROM.

NOTES FOR POTENTIOMETER FEEDBACK:

When using potentiometer (analog) feedback instead of pulse-feedback, you must configure a corresponding I/O port as ACTPOS device type, and assign that port to the corresponding motor parameter. Analog to digital values are assigned between 0 and 1023 by the microprocessor's 10-bit ADC. The minimum feedback value is measured and stored when the actuator is fully retracted, and a base measurement is taken for the actuator length. Once the actuator is fully extended then the maximum value is feedback is also measured and stored, and a second measurement is made of the actuator length in order to determine the effective stroke length. The difference between the minimum and maximum feedback values then is divided by the stroke to calculate the effective PPU value which is then stored.

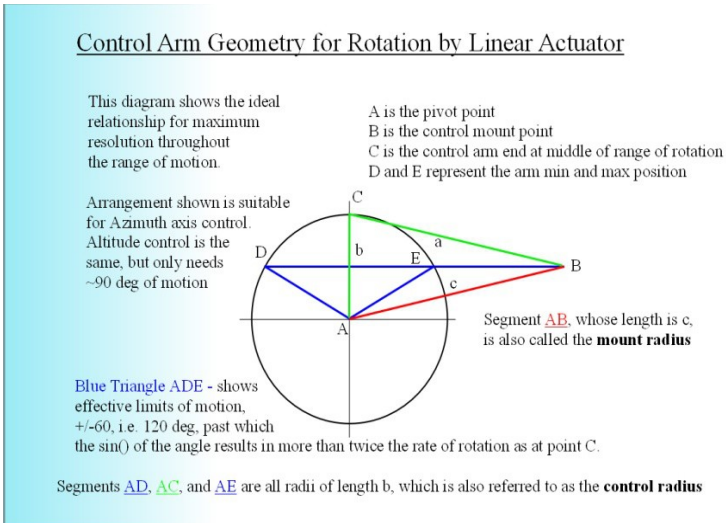
SETUP: MOTOR:TRIG COMMAND

This command is used to configure the following actuator dimensional values. The Trig command is not used in Linear motor mode. In order to achieve optimum accuracy, it is very important to measure these values as carefully as possible.

The measurements taken also need to go to/from the middle of the various points.

When measuring to a bolt, measure the diameter of the bolt, and then add ½ of the diameter to the measurement to the bolt.

When measuring to the saddle clamp for Side A, measure the width of the saddle clamp, and then add ½ of the width to the distance to the arm end.



Step 1: Side A - Min Arm length

The position of the Saddle Clamp mount on the actuator tube will determine the minimum arm length.

The program will prompt to ask if you need to reset the actuator arm to the fully retracted position prior to measurement.

Example calculation: Saddle clamp width 2.25”, Bolt diameter 0.5” (on end of arm), measurement from bolt to clamp is 10.25”

Side A = 2.25/2 + 0.5/2 + 10.25 = 1.125 + 0.25 + 10.25 = 11.625

Step 2: Side B - Arm Mnt->Pivot

This is also often referred to as the control arm length. As before, it is important to account for the diameter of the hinge and actuator arm bolt.

Step 3: Side C - Motor Mnt->Pivot

The next to last value is the distance of the actuator saddle clamp mount bolt to the hinge point.

Step 4: Side M - Motor Mnt Offset

The last step accounts for the fact that the actuator arm is actually one side of an acute triangle whose hypotenuse connects the actual motor mount and the actuator arm end. Side M is determined by the saddle-clamp Heim joint offset from the center of the actuator tube. For our standard satellite dish actuators, M=1.5 inches.

SETUP: MOTOR: ALIGN COMMAND

This command is used to teach the Mega Tracker where the various reference positions are, and is usually the final step in motor configuration. The standard manual control interface is used to maneuver through the various reference positions. While the Mega tracker could theoretically operate based on a single reference position, the incorporation of multiple alignment points, improves tracking accuracy through interpolation.

MAIN AXIS – M1

- Azimuth trackers will have due North as a reference for 0 degrees
- Polar and Horizontal trackers will use a vertical down vector 0 degree reference

LINEAR ROTATION RATE (PULLEY/GEAR DRIVEN) AXIS CONFIGURATION.

A1 Step 1: East - Move to 90 deg

A2 Step 2: South/North - Move to 180/0 deg

Noon position. Installations in the northern hemisphere will point in a southerly direction, those in the southern hemisphere will face towards the north. Horizontal trackers will face straight up (zenith).

A2 Step 3: West - Move to +270 deg

CONTROL ARM (LINEAR ACTUATOR DRIVEN) AXIS CONFIGURATION

AZIMUTH AXIS CONFIGURATION STEPS:

Northern Hemisphere

A1 Step 1: East - Move to 135 deg
A2 Step 2: South - Move to 180 deg
A3 Step 3: West - Move to 225 deg

Southern Hemisphere

A1 Step 1: East - Move to 45 deg
A2 Step 2: North - Move to 0 deg
A3 Step 3: West - Move to 315 deg

POLAR AXIS CONFIGURATION STEPS:

```
A1   Step 1: East  - Move to 135 deg
A2   Step 2: South - Move to 180 deg
A3   Step 3: West  - Move to 225 deg
```

SECONDARY AXIS – M2

In order to minimize the effects of pitch and roll inherent with mount alignment, the first step of secondary axis configuration is to center the M1 axis at the North/South/noon position.

- 0 degrees reference is a vertical panel position
- 90 degree reference is horizontal panel position (facing straight up)

POLAR MOUNT – DECLINATION

Northern Hemisphere

```
A1   4)South Solstice = 90-Lat-23.4     winter position
A2   Step3: Equinox   = 90-Lat          Matches polar angle
A3   2)North Solstice = 90-Lat+23.4     summer position
```

Southern Hemisphere

```
A1   2)North Solstice = 90+Lat-23.4     winter position
A2   Step3: Equinox   = 90+Lat          Matches polar angle
A3   4)South Solstice = 90+Lat+23.4     summer position
```

Actual target angle values for each step are calculated based on the configured Latitude information.

AZIMUTH MOUNT – ELEVATION

```
A1   Step2: 0 degrees – Panel Vertical
```

After moving to the minimum elevation possible (without going below horizon), the actual angle achieved must be entered. This accommodates those mounts which lack the ability to tilt that far.

```
A2   Step3:           - Move to 45 deg
A3   Step4: Zenith    – Panel Horizontal
```

After moving to the maximum elevation, the actual angle achieved is entered as with the first alignment point. This position should never be past 90 degrees.

While an inclinometer is useful, a simple level is adequate for most elevation alignment operations.

Azimuth and polar axis can be more challenging and the best technique may involve some creativity based on the particulars of your mount design. In some cases it may be as simple as holding a standard speed square against the frame to check the angle; however, often this is not practical. A useful technique is to use a small cross-hair laser to facilitate measuring changes in the angular position. For an Azimuth axis, aim the laser at the ground. Even though the laser cross-hair will most likely not remain stationary as the axis rotates, it is still easy to measure the relative angles. Using a 12x12 or larger square tile as a reference makes this very easy.

For example: at 0 degrees line the tile up so that the laser line goes diagonally across at a 45° angle. For the +/-45° steps, use a stick & tape measure to make sure that the laser line is parallel to the side of the square tile.

SETUP: MOTOR: PWM COMMAND

This command is used to configure motor speed control features. **Because speed control uses a high frequency modulation of the output voltage, it should never be used when it will be a relay input trigger.**

- PWM stands for pulse width modulation. NOTE: this has nothing to do with the pulse-feedback used for positioning.
- A value of 255 (the default) is full on with no modulation
- A value of 0 would be fully off (and you should never use that!)
- There are only two actual motor speeds used:
    - **PWM_MAX** value which is defines the *fast* speed (255 by default, don't change this unless your mount is rotating too fast. Should generally never be less than 127 in order to leave room for slow speed)
    - **PWM_MIN** defines the *slow* speed, and must always be less than the *fast* speed
    - **DECEL** stands for deceleration and this value defines the number of motor pulses from the target position which the slow speed setting will be automatically engaged. A value of 0 effectively disables the *SLOW* speed option

Procedure:

Step 1: Input maximum speed pwm value (default 255=full speed, 191=3/4 speed, 127=half-speed)

Step 2: PWM setting is tested by moving motor 3 seconds forward and backward again

Step 3: Accept value or repeat step 1

Step 4: Input minimum speed pwm value (will automatically be limited by maximum speed selected)

Step 5: Test and accept, or repeat step 4

Step 6: Input deceleration pulse count value (0 = off, if PPU is 32 then DECEL=16 will engage slow speed when within 0.5 length units (inches or centimeters or whatever you are using).

Step 7: Everything gets automatically saved to EEPROM

SETUP: MOTOR: STALL COMMAND

Stall protection is required to ensure both that the motor itself is not in a stall condition (not rotating but with power applied), and that the controller has proper feedback signals. A stall condition may be caused by too much load, a weak power supply, or problems with the motor or motor driver circuit themselves. In any of these cases the smart thing to do is quickly turn the power off rather than cause damage to various components from high currents that can be caused during a stall condition.

The actual way that stall protection works **depends on the** motor position **feedback** type used. In each case a period of time is defined within which a certain minimum movement must be detected before the controller assumes a stall condition has occurred.

Pulse Stall defines the maximum period (0-2.55 seconds) that may elapse before a pulse signal should be received.

Pot Stall defines the maximum period (0-2.55 seconds) that may elapse before the ADC signal should change.

Inclinometer & Accelerometer

For compatibility, the measured angle is multiplied by 10 and the integer portion is then stored with the same pulse count variable used with pulse feedback. From this operation the minimum movement required to avoid a stall condition is 1/10th of a degree; however this also needs to be larger than 5 times the resolution of your sensor (which is done to help ensure that minor sensor fluctuations are not mistaken for movement).

OPERATION

PARK COMMAND

Invoking the Park command moves the mount to the predetermined park position. Typically the Mega tracker should be configured to orient the mount facing north or south towards the equator with the array in a horizontal position. The park command first engages the secondary/elevation axis since this typically has the most effect on wind exposure and azimuth movement may take a couple minutes.

SETTING THE PARK POSITION

Pressing the Park button when the unit is already in park mode will give you the opportunity to use the navigation buttons to manually orient the mount as desired and then have that position saved for use.

MANUAL CONTROL

Convenient manual control of each axis is available through this command. Pressing the navigation arrows on the keypad controls the motor and direction. Pulse count or angle value for the currently operated motor is displayed on the LCD. In addition to being useful for maintenance, the manual control routine is used by many of the motor configuration commands so please take a moment to familiarize yourself with the manual control functions:

Left Moves M1 in the Eastern direction.

Right Moves M1 in the Western direction.

Down Moves M2 to reduce tilt (vertical panel represents no tilt at 0 degrees, horizontal is fully tilted at 90 degrees).

Up Moves M2 to increase tilt.

OK Exits manual control. When manual control interface is being used by a configuration procedure, this will select the current position.

Esc Exits manual control. Does not select current position, may abort procedure.

Track Toggles between Pulse Count and calculated Angle display.

If PWM has been configured, then the slow pwm setting will be engaged for about 2 seconds when a button is pressed and then advance to the fast pwm value. This is to facilitate manual fine positioning.

The display will show a warning in the event of a motor stall condition (no pulses received in 0.5 sec) and a beep will sound. This is also a normal condition when the limit switches are activated. After a second, operation may be resumed.

SHOW COMMAND

The Mega Tracker allows data displayed on the LCD to be configured to display whatever information you want to see at a glance.

The display is broken up into four quadrants (7 characters wide on the left side, 8 wide on the right). To change the display field in a given quadrant, use the cursor to move to the selected quadrant and press OK.

In addition to the unit **Name**, solar **Azi**muth and **Alt**itude angles, **Time**, **Date**, and **Status**, the list of available display fields includes the following sensor and motor parameters:

- **East, West, North, South** – these are light sensor readings when using the optional light sensor
- **Temp1, Temp2** , **BTemp** – any desired temperature sensors or the pcb board temperature
- **Amps, Volts, Dew,** or **Flow** – additional sensor types supported

- **Windspeed** – anemometer signal
- **Park** – an input signal for triggering park or allowing tracking when off
- **Roll, Pitch, M1Pos, M2Pos** – the angular position or pulse count values for M1 and M2
- **M1Lim0, M1Lim1, M2Lim0, M2Lm1** – the status of soft limit switches for M1 and M2

The navigation keys are used to cycle through the available fields, and pressing OK selects the current option.

SCHEDULE SUB-MENU

AUTO COMMAND

The Mega Tracker can either be configured for automatic operation according to scheduled events. Scheduled operation is either ON or OFF. This is distinct from the Auto-Rise feature (Mode command) which effectively schedules track events each day. Park events are automatically issued at sunset when tracking and need not be separately configured unless desired.

EVENT COMMANDS

List – Navigate a list of scheduled events. Use the OK button to select an event to edit the parameters or delete the record. Events are automatically sorted by DOW and TIME fields. Serial command also shows recno and index values.

Add – Creates a new event record.

DOW Individual days (SUN-SAT) or ALL days. (for serial commands All=0, Sun=1, Mon=2...SAT=7)

TIME Event time (for serial commands this is given in minutes since midnight)

TYPE Event types include:

Park Puts unit into park position and park mode

Track Puts unit into track mode for automatic tracking

Clean Puts unit into wash position and park mode

Dump* Moves elevation to minimum angle then wags back and forth once to help dump snow loads.

Zero* Sometimes pulse-feedback sensor errors build up and the motors need to be moved back to the limit switch so the pulse count can be set to zero.

*** Does not change tracking mode!** If already tracking, tracking will automatically resume immediately afterwards.

RANK Priority to resolve conflicting events.

Del – delete an existing event with DOW-TIME key or record number. Serial command only (use List command for UI)

RISE

Set the minimum solar elevation (in degrees) for initiating digital tracking after sunrise. This is very useful when solar visibility is limited. **Note**: duplicate command to **SETUP | PARMS | ELEV**

SET

Configure the minimum solar elevation for continuing digital tracking before sunset. **Note**: duplicate command to **SETUP | PARMS | ELEV**

WASH COMMAND

The Wash command is useful for moving the mount to a position for array cleaning or other maintenance.

As with the Park command, invoking the Wash command when the unit is already in Wash mode allows the wash position to be customized utilizing the standard manual control functions with the keypad navigation arrows.

LOG COMMAND

Serial data logging of all parameters is available either by USB connection or optional XBee wireless module. All values are logged once per second when enabled.

Data fields are separated by commas, and each record is terminated with a carriage return. The data is suitable for standard CSV import into Excel.

Data records have the following format:

UnitNo, HH:MM, MM/DD/YY, BoardTemp, port0_name, port0_value…, port8_name, port8_value

Note: data stream may also include notifications of other tracker processes.

INFO SUB-MENU

STAT - displays auto-rise, dual-axis status

TEMP - displays on-board temp

SOLAR - displays solar position (Alt/Az), as well as sunrise, and sunset times

POSI - displays current motor position. Pulse count and angular position values are displayed for both motor axis.

POWER -calculates potential solar power based on current coordinates, area, and incident solar angle. A lookup table is used to facilitate transmittance calculation based on the Bird Clear Sky Model for Direct and Diffuse Insolation on Horizontal Surfaces. Power calculation depends on surface area configured separately.

VERS - displays software version

MODEL - displays hardware version

SERNO - displays unit serial number

AREA - displays/configures tracker array area for power calculations. Area uses square meter units only

DETAILS

External Light Sensor: In ANALOG TRACKING mode, a pair of orthogonal (90 degrees apart) external sensors is used to detect light levels for the given axis. Green or Blue LEDs are typically used for this purpose. The small surface of the LED diode junction acts as a miniature solar panel and generates a voltage that can be read by the Mega Tracker. CdS based light detection circuits which produce a voltage between 0 and 5v may also be used.

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.

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

Supply Voltage: The Mega Tracker requires a DC power supply between 12 and 6V. Operation from an unregulated 12v PV panel output will damage the unit. The external motor driver voltage used should be isolated from the Mega Tracker.

The Arduino Mega board features a blocking diode to prevent damage from accidentally reversed DC polarity, and resettable poly-fuse for current protection.

If you are using an AC adapter power supply instead of PV or battery, then a 6-9vdc 1.0 amp rating is recommended. Our LM2596 step-down regulator is recommended for operation from 12v DC PV systems.

Motor Amperage: is limited by your external motor drive circuit.

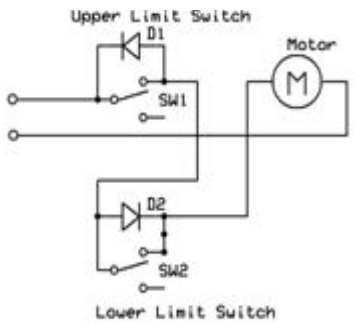
Pulse Width Modulation is used to control motor speed and also reduces the average current level. PWM utilizes a base 490Hz modulation frequency.

Enclosure: the Mega Tracker is fastened inside the polycarbonate enclosure with small Delrin stand-offs. Care should be taken to avoid damage when removing daughter board. Waterproof conduit fittings are recommended to keep the unit watertight, and a small desiccant package of silica gel may help prevent dew point condensation on the inside of the enclosure.

Limit Switches: Most linear actuators come with built in limit switches. These are called hard limit switches because they are purely mechanical and don't require software to operate. They prevent the motor from moving the actuator too far and destroying itself or other mechanical components. 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 highly recommended that you incorporate an equivalent into your design. The Home CSP SSR Limit Controller is ideal for this purpose.

The Mega tracker supports soft-limit switches which will trigger the controller software to stop motor movement. These are implemented through the general purpose I/O ports that are available. A primary benefit of soft limit switches is that the switches can operate at 5v logic level with minimal current and are both cheaper and more reliable than hard limit switches that have to deal with arcing while switching heavy motor loads.

A basic hard limit switch schematic is shown below for reference purposes.



APPENDIX

I.SOFTWARE UPDATES

Software updates may be released from time to time by Home CSP Inc. These binary releases are available to registered Mega Tracker owners for free upon request, and may be installed through the USB port. Alternate firmware with additional features may also be available for purchase. Download Russe Motto's Xloader program from: http://russemotto.com/xloader/XLoader.zip for the easiest way to upload .HEX files to the Mega Tracker. Visit the HomeCSP.com website for the latest information about Mega Tracker firmware updates.

II. PORT CUSTOMIZATION

Analog input ports feature optional pull-up resistors. Depending upon desired usage these may be enabled by using a soldering iron to bridge special solder jumper pads on the Mega Tracker PCB. Likewise, they may be disabled by removing the solder.

- Pull-up resistor jumpers are labeled PU0-PU6

The 10K pull-up resistors are particularly useful for thermistors, but are also useful for many other situations where the analog or digital device is pulling the signal down towards 0V .

External Analog Reference Voltage

If a 3.3v analog reference signal is desired for ADC operations, the voltage regulator for the Xbee radio module may be used. This is the approximately 1cm x 1cm black component on the right side of the Xbee sockets. The tab base of this component is the 3.3V output and provides an easy solder point. From the voltage regulator, the jumper should be attached to the Aref pin on the lower left other side of the Xee sockets. **It is important that the AREF command is used to first enable the EXTERNAL reference voltage before attaching the 3.3V or any other external voltage jumper for AREF**.

III. TROUBLESHOOTING

Issue	Cause	Solution
Motor runs momentarily but stops		
	Stall condition is detected	
		Double check pulse-feedback connections
		Edit motor configuration and increase **STALL** period
Motor runs wrong direction		
	Return direction configuration	
		Use motor **MODE** command to set return-direction
	Motor wiring	
		Verify motor driver reverse/ccw indicator comes on during motor reset
		Reverse motor polarity at motor driver terminal connection.
Motor stops before reaching limit switch		
	Pulse count has reached limit	
		Edit motor **LIMIT** value
		If Limit is greater than maximum allowed you will need a pulse frequency divider
Tracking does not start in the morning		
	Auto-rise must be enabled	
	Min-East Elevation	
First-time setup appears each time unit is started		
	Configuration has not been completed	
		SETUP | M1 | ALIGN procedure must be completed
Scheduled events don't happen		
	Automatic events have not been turned on	
		Use **SCHED | AUTO** command to turn on events.

III. MEGA TRACKER SETUP WORKSHEET

Unit#_____

GPS Latitude: _____ Longitude: _____

Mode: Single-axis Dual-axis

Axis #1: Azimuth Polar Horizontal

Track Mode: Digital Analog

Orientation: East-return West-return

Motor Mode: Arm (Radial) Gear (Linear)

Driver Type: FW/BW EN/DIR EN/F/B EN/F/B/Is

PPU:

Min. Length _____ Length Units: inch / cm / mm

# of pulses _____

Max. Length _____

Delta length: _____ Calculated PPU: _____

Limit:

Max Pulses: _____ Max PWM: _____

Trig:

Min PWM: _____

Min Arm Length A: _____ Decel: _____

Control Arm B: _____

Mount Distance C: _____

Mount Offset M: _____

Alignment:

Degrees: -45° 0° 45°

Count A1P: _____ A2P: _____ A3P: _____

Axis #2: Altitude

Track Mode: Digital Analog

Orientation: Up-return Down-return

Motor Mode: Arm (Radial) Gear (Linear)

Driver Type: FW/BW EN/DIR EN/F/B EN/F/B/Is

PPU:

Minimum Length _____ Length Units: inch / cm / mm

# of pulses _____

Maximum Length_____

Delta length: _____ Calculated PPU: _____

Limit:

Max Pulses: _____ Max PWM: _____

Trig:

Min PWM: _____

Min Arm Length A: _____ Decel: _____

Control Arm B: _____

Mount Distance C: _____

Mount Offset M: _____

Alignment Points:

Axis Mode

Declination:	Southern Solstice	Equinox	Northern Solstice
Elevation:	0°	45°	90°
Count	A1P: _____	A2P: _____	A3P: _____