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Linear Actuators in Solar Tracking Systems

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Objective:

Solar trackers require actuators to move the tracker around either a single or dual axis. For both types of trackers, a linear actuator provides a cost effective solution for controlling a tracker's elevation.

Background Information:

There are two methods commonly employed for the control of solar trackers. One is to use an optical sensing system, and the other is to use a mathematical equation. Both types of systems usually employ a microprocessor based controller which directs a motor to operate one way or the other.

The optical method will only work on clear skies, and it is not unusual to see such a tracker pointing in the wrong direction after a cloud cover has disappeared. Similar results can also occur with dirt accumulating on the optical eye. Finally; optical systems usually have no remote accountability.

Using a mathematical approach to controlling solar trackers solves many of the optical problems, but also carries a few of its own. Namely; the pointing accuracy is only as good as the positional feed-back information. The solar tracker industry typically uses one of two methods to provide elevation feed-back. The first is to use a combination of limit switches and motor encoder counts, and the other is to use the method as invented by Richard J. Carlton (in US Patent #4,445,030) - an inclinometer.

Linear Actuators:

One of the leading US linear actuator manufacturers is Venture Manufacturing Company. Their actuators include a 24V DC motor, encoder, and limit switches, making it a great fit for solar tracker elevation control.

Calculating Inclination using a Kinematics Equation:

The basic principle behind the Kinematics method is to rely on the actuator’s limit switch as an indicator of an absolute inclination position. From that coordinate point, one can now count the encoder feed back, which translates into the actuators linear extension, and calculate the tracker’s inclination by using a kinematics equation. Fortunately, most solar trackers can be described by the mechanical linkage like this:

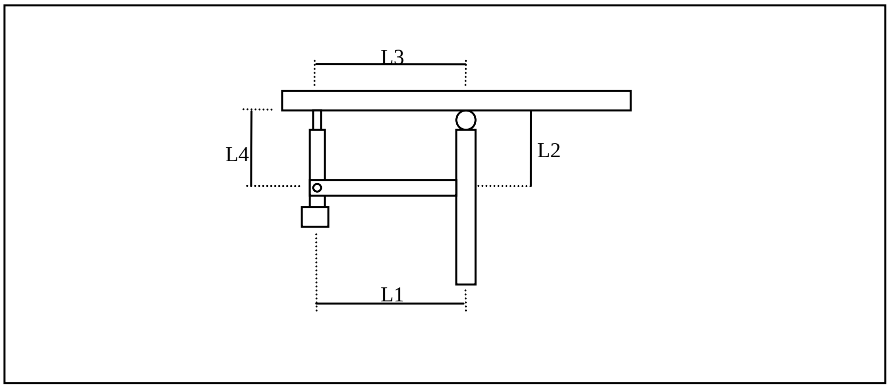

Figure 1: Graphical Representation of Generic Elevator Attachment

Using trigonometry, a simple function can be derived which will yield the elevation as a function of the actuator’s extension.

Measuring Inclination using an inclinometer:

The most popular electronic inclinometers are based on Micro Electro Mechanical Systems (MEMS) technology. A MEMS based inclinometer is really an instrument measuring acceleration, and in the case of a solar tracker, the acceleration is caused by gravity.

Inclinometers are sold in two varieties, as a stand-alone and as a PCB based package. To save cost, the Lauritzen Sif solar tracker controller has an integrated inclinometer. The Sif would typically be mounted directly underneath a tracker’s plane, from where the inclination can be measured. Most other inclinometer based solutions require an external inclinometer, which adds additional cost due to additional package and interface requirements.

Since inclinometers measure acceleration, they will inevitably record noise while a tracker is moving. Thus proper filtering has to be applied in order to eliminate moving noise. A popular method is to “stop and measure”, while another is to estimate encoder clicks to target based on recent motor moves.

Control of Actuator's DC Motor:

Brushed DC motors are very popular, inexpensive and easy to interface to. However, frequent start and stop operations can cause prematurely brush wear. Fortunately a couple of techniques can be applied to reduce such wear. The first is to control motor acceleration and deceleration, while the second is to keep the move period as large as possible.

The Sif controller has integrated Pulse Width Modulation, and current sensing, and will through a combination of those two provide soft motor start and stop using the actuator encoder as motor velocity feed-back. In addition to the soft start and stop, it is also capable of detecting a motor-stuck or actuator-at-limit condition.

Non-concentration solar PV (PV) trackers do not require a position accuracy of much better than a few degrees. In that case, the motor-move-frequency can be reduced to a move per degree or two, which equates to one start/stop per 5-10 minutes. Concentrated PV (CPV) trackers on the other hand may require much higher accuracy, and it is not uncommon to see a 15 second move interval.

Lauritzen is currently conducting life time testing of brushed DC motors in Solar Tracker applications, and expect to publish those results toward the end of 2009. Preliminary results indicate a brush lifetime expectancy of well above 10 years for CPV systems.

Accountability:

Using the feedback mechanism provided by the Lauritzen Sif controller, it is possible to view the performance of a solar tracker in either a graphical or event form. Here is a picture of the elevator position of a dual-axis solar tracker:

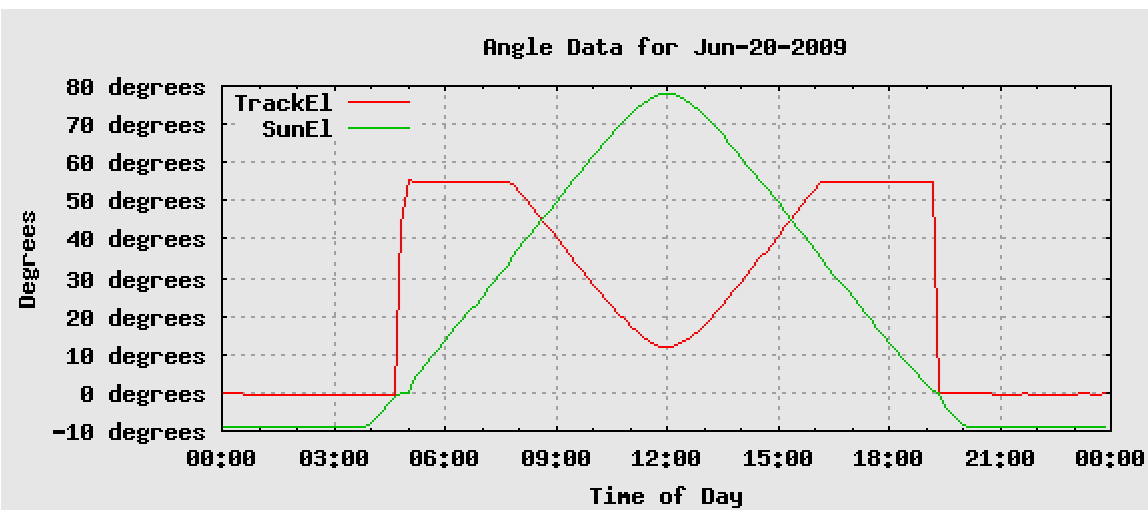

Figure 2, Graphical view Daily Solar Tracker Elevation

The sun's elevation is measured as 0 degrees at horizon, and 90 degrees directly overhead. The tracker's elevation is directly opposite of that. Thus a tracker's elevation of 0 degrees indicates a horizontal position, and 90 degrees would be vertical.

The tracker is stowed at horizontal (0 degrees) at night. At 5:00 the sun is above the horizon at which point the tracker exits stow position, and enters operational tracking mode. For mechanical reasons, this particular tracker has its maximum elevation set to 55 degrees, and it remains at that elevation until about 8:00 at which time it is possible to aim the tracker directly perpendicular to the sun.

Conclusion:

A linear actuator provides a cost effective method to control 1) a single axis solar tracker, or 2) the elevator in a dual-axis solar tracker. Together with the Lauritzen Sif Solar Tracker Controller, it is possible to construct a reliable, accountable, controllable and accurate solar tracking system.