TECH TIPS

Helpful insights for designing with motion control from Chuck Raskin, PE, CMCS

#4: What 'Homing' is and how it happens.

A reader asked me exactly what I mean when I use the term "homing" a system, because it's a much misunderstood word, which often means different things to different people, and there are many ways to accomplish it.

Basically, to home a system simply means to provide a point of reference by which all future axis motion or programmed moves can be measured.

Sound complex? Let's try a simple homing procedure. Assume we have a single axis motion control system like that shown in Figure 1. The ruler indicates that there are twelve inches of available travel. Even though different rules apply, our motor can be a servo, or a stepper.

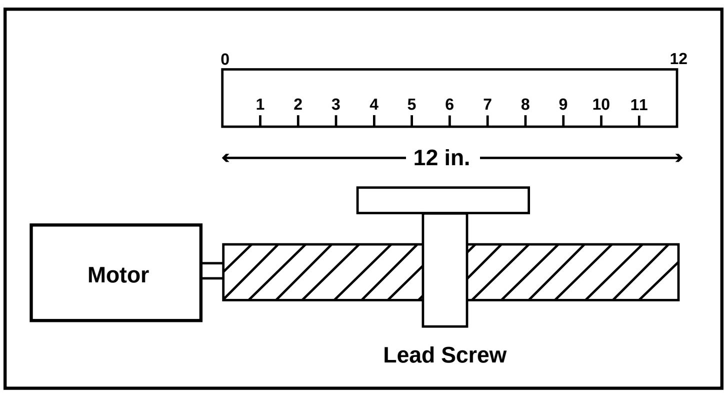

Figure 1: A lead-screw system

While we have five methods to choose from, the simplest home routine that we can do to zero the counters at the slide location. We'll start here.

Method 1: Simple Zero Counter

Sometime in your experience, you've probably seen a machinist operating a manual machine such as a mill or a drill press with both encoders mounted on the moveable axis slides and readout counters set up to show the slides' current actual positions. The machinist "homes" a machine axis simply by manually moving it to a reference position. Then he zeros a position counter. All subsequent axis movement is known and is measured relative to this preset zero position. We might consider this a crude homing method, but it is really effective.

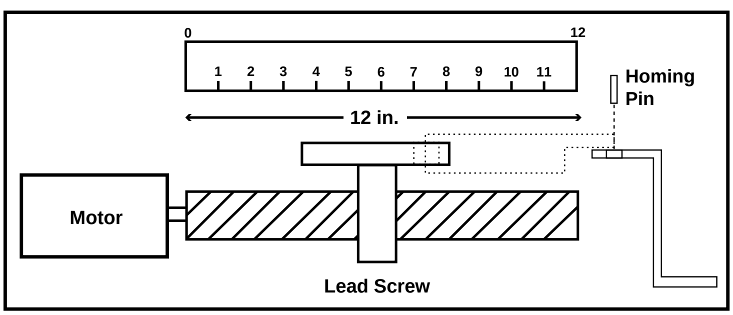

Figure 2: Zeroing a slide by pinning.

However, though effective, its accuracy leaves much to be desired. The ability of an operator to place the slide at precisely the same position every time the axis needs to be referenced is almost impossible to guarantee. Precision becomes especially important when the jig or clamp holding the part is physically mounted to the motion slide. An inability to consistently zero the position counters at the identical physical slide position can destroy very expensive parts.

To meet this challenge, some machines use a method of pinning the slide. The operator moves the axis slowly to a position where a steel pin or dowel can be inserted into a hole set. This aligns the slide with a reference point (see Fig. 2). Once the pin is placed into the hole set, the counters can be zeroed.

In the case of a motor-driven axis, the same method applies. Jog — or manually move — the axis as close as possible to the desired home position, and zero the counter. If the pinning method is used, jog the axis as close as possible to the pin position, power down the motor, and hand position the axis until the pin drops into place. Zero the counter(s), remove the pin, and reapply power to the motor.

It really doesn't matter how the zero reference is obtained as long as the reference position allows the production of parts within the customer specification.

Method 2: Referencing to a Switch Edge

Figure 3 illustrates one improvement over Method 1. A switch installed on the axis signals a control or counter when it is at home position. The home switch is actuated by the movable slide. It's not really important where the switch is located along the axis, as long as it is within reach of a moveable part of the axis. The physical switch trigger point, with respect to true home position, can be accounted for using a HOME_OFFSET software function. The HOME_OFFSET value will automatically reposition the computer's internal counters to the precise home position you desire.

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For example, using the method shown in Figure 2, the switch will trigger at about the 11.5-inch ruler position. Since we want the true home position to correlatewith the ruler markings, we simply tell the control that the home offset is +11.5 inches. By doing this, the next RETURN_TO_ZERO command issued by the control will send the axis slide to the left-most or home position. Since the switch does not physically move, the home offset position will always reflect the true home position, provided that the switch is repeatable. Since most switches activate and deactivate at different physical positions (a phenomenon known as switch hysteresi), and since most switches are not 100 percent repeatable at a given trigger position, this homing method may require conditioning to ensure an acceptable level of accuracy and repeatability.

Method 3: Referencing to a Switch Center Point

If a switch provides the only homing criterion and if the axis position repeatability requirement is tighter than the switch can provide, then the following homing method might be necessary.

Figure 4 illustrates a switch used in an axis homing routine. The switch hysteresis in this case is 0.030 inches, typically with a +0.005 inch tolerance. The switch repeatability is +0.005 inches. Therefore, the objective is to home the axis within +0.005 inches.

We follow these steps:

1. We move the axis forward until the switch activates and record the position.
2. We reverse the axis until the switch deactivates, and again we record the position.
3. Next, we repeat steps 1 and 2 above, recording the positions until the central point of the switch can be mathematically determined and is within the required operating specifications.

This method can significantly increase the time it will take to reference the axis. If the machine were reasonably complex with multiple axes, it could take several minutes to complete the homing sequence. In addition, the amount of time necessary to home is be directly proportional to the quality of the switch being used.

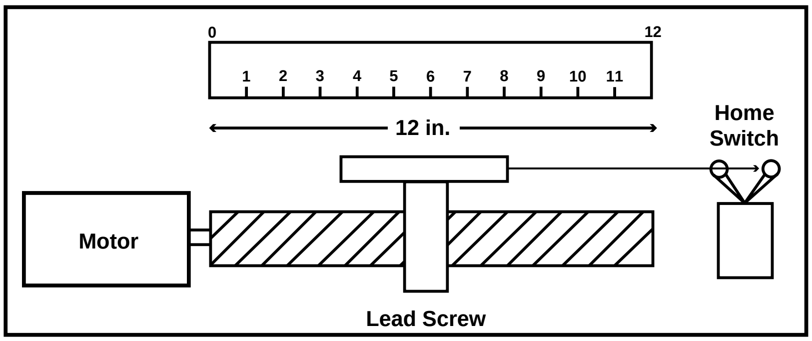

Figure 3: Using a switch to signal home.

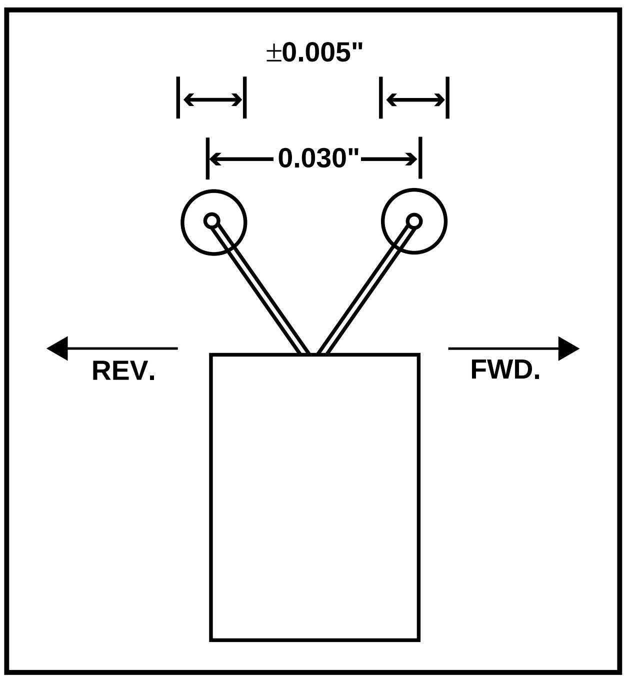

Figure 4: Referencing to a switch center point

Method 4: Referencing to an Encoder Index

Referencing to an encoder signal is the most accurate and repeatable method to obtain an axis zero point.

A typical encoder index signal with quadrature signals A and B is shown in Figure5. The index signal is shown to be an active-high pulse, lasting for a period of 90 electrical degrees. This index typically occurs only once in a complete encoder rotation of 360 physical degrees. Under no circumstances should an index signal remain active for a period exceeding 360 electrical degrees.

The reason for this restriction is because homing can generally be accomplished from either direction. Also, the current position with reference to the index might need to be recorded for count referencing. If the index is 720 electrical degrees, it would be recorded at two different physical positions four quadrature counts apart. If our system is in a home sequence, depending upon encoder direction a different physical zero reference position would be selected. This could ruin the product and and the day!

The major drawback to this method is that, when using a rotary encoder, the index pulse is repeated every encoder revolution. Therefore, with a complete encoder revolution translated to 0.1 inch of linear travel with a 12-inch system, 120 index pulses occur as the axis moves toward home position. It is then necessary to somehow jog the axis close to the desired index position, and to then command the system to zero reference. This can be bothersome, inaccurate, and time-consuming, with low-encoder count/high-resolution systems.

Method 5: Referencing to a switch, then to the encoder index

This is the preferred method of referencing. We ge the best compromise by

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implementing a combination of Methods 2 and 4. You can high-speed move to a course zero position via a switch. Then you slowly move in the proper direction to the actual home position via the index signal.

With any of these methods, once the axis is zeroed, the appropriate home offset value can be inserted. The reason for the home offset value is to allow accurate axis homing whether or not the switch or index pulse can be positioned precisely at absolute true zero.

Servo and Stepper Homing Considerations

Knowing the difference between stepper and servo motors can greatly reduce the costs involved when dealing with stepper system homing. A stepper motor is a torque device that maintains a constant phase current requirement, whether in motion or otherwise. Therefore, if a stepper motor is driven into a hard stop, such as a machine part at the axis end-of-travel is, the stepper motor will draw the same current as during the move. On the other hand, servo current will increase, as the computer attempts to correct for following error.

Because of this difference, it becomes apparent that the servo motor must be controlled at all times, by means of switches, feedback devices, and other components.

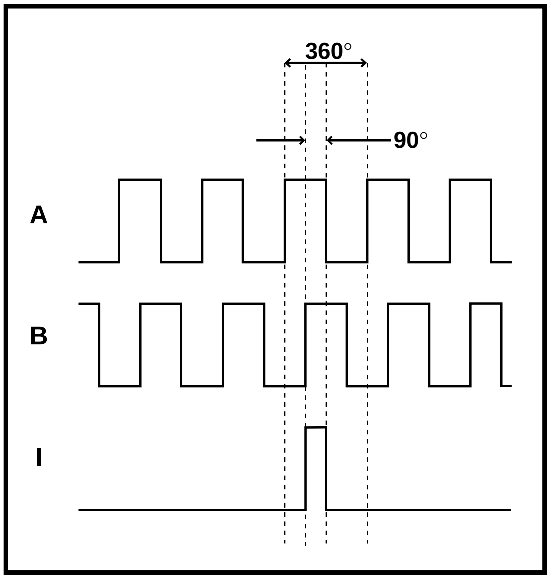

Figure 5: Quadrature encoder waveform relationships.

We do this to prevent the motor from burning out or damaging the machine as the motor is moved from one position to another. However, steppers can legitimately, though carefully, be forced into a hard stop, and the system counters zeroed or preset to some home offset value.

One caution: When you drive any motor into a hard stop situation, you must ensure that your system can withstand the resulting shock!

Since the basis for homing is to reference the system counting mechanisms to some predefined axis position, the notion that absolute position encoders do not require a homing sequence is a common misconception. This will only be the case if one revolution of the absolute encoder reflects a complete system cycle in which one revolution of a rotary axis represents one revolution of the absolute encoder. However, if the absolute encoder is required to rotate more than once to produce the total feedback information for a complete axis cycle, then we may be required to do an axis home sequence. Remember that position feedback of an absolute encoder device is only guaranteed to give true position information within one physical revolution of that device.

About the Author:

In his more than two decades in the industry, **Chuck Raskin, PE, CMCS**, has contributed to many industry publications, including ***Motion, Motion Control,* & *PCIM***, and is currently working on the fourth edition of the ***Designing with Motion Handbook***. Chuck is currently the manager of technical services for Technology 80 and a board member of the American Institute of Motion Engineers (AIME).

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