Determining Correct Encoder Resolution

If you purchased your encoder installation from JMI, you received documentation on the correct resolution for each axis and, if included in the purchase, the computer was set to the proper values. For any other installations you can use the following information to determine the correct resolution to enter in the computer's Setup mode.

The Goal
The goal of the following exercise is to get the correct encoder resolution in the MAX computer by matching the degrees shown in the Encoder mode display with the actual degrees of movement of your scope.

Calculating for Gears and Pulleys
There should be a sticker with a number on the housing of each encoder (e.g. 2160, 4000, 4096, or 8192). If you are using gears or pulleys, simply multiply this number by the ratio of teeth on the telescope shaft to the number on the encoder shaft.

$$\text{encoder tics} \quad X \quad \frac{\text{teeth on telescope shaft}}{\text{teeth on encoder shaft}}$$

For example, a 4000 tic encoder using a 100-tooth gear on the telescope shaft and a 50-tooth gear on the encoder shaft would yield a total of 8000 tics per revolution (4000 x 100/50).

Calculating for Friction Drives
If you have a friction drive where calculating the ratio of telescope shaft movement to encoder shaft movement is impractical, you can use the following formula to determine the tics per revolution:

$$\text{new resolution} \quad = \quad \frac{360 \times \text{old resolution}}{\text{angle}}$$

Enter an estimated resolution for the axis using the Setup mode. This accuracy of this initial number is not important but it should be placed in the above formula as the *old resolution*. Using the Encoder mode and starting with a display of zero degrees, determine what angle is displayed after exactly one rotation of the axis. Use this number for *angle* in the formula. Be sure to add 360 to the angle displayed for each time the display passes 359º, if any. Replace the initial number you entered into the computer with the answer (*new resolution*) and repeat the above procedure so that the *new resolution* now becomes the *old resolution*. This process should be repeated until the result stabilizes (usually two or three iterations). If the telescope cannot be moved through 360º of rotation you will need to adjust the formula. For instance, if you can only move 180º the displayed angle should be multiplied by two.

Here is an example. Your right ascension resolution is set to 4096 in the computer. After rotating the right ascension axis 360º while in Encoder mode the display shows an angle of 12º. Observing the display during rotation showed that the angle passed 359º one time so the true angle is 360º + 12º or 372º. Therefore, the formula would look like this:

$$\text{new resolution} \quad = \quad \frac{360 \times 4096}{372}$$

The *new resolution* is 3964. This number should be entered into the computer and into the formula (as the *old resolution*) and the process repeated until the number does not change. At this point 360º of telescope axis rotation will translate to 360º on the display (showing 0º after full rotation).

For a more accurate calculation you can rotate the axis through several complete revolutions and divide the angular result by that number of turns to determine the *angle* to plug into the formula. For example, if five revolutions shows a result of 2º and the display passed 359º five times, the total degrees would be 1802º (360º x 5 + 2). Dividing 1802 by 5 gives 360.4º which should then be used for *angle* in the formula.

Digital Nature of Encoders
It should be noted that pointing error is always greater than the encoder resolution. The problem stems from the digital nature of the encoder steps. The encoder may be positioned on the verge of a step during the star alignment, then on the opposite edge of a step when the target star is sighted. With ideal encoders, perfect mechanical installation and perfect alignments, the fundamental error can be three times the encoder step angle. Fortunately, this rarely happens.

Maximum Practical Encoder Resolution
If you wish to increase the resolution, keep in mind that while the maximum possible encoder resolution is 32767, in most cases the practical limits are much lower. This is due to the computer's sampling rate and display resolution. We target 10000 tics-per-revolution for our systems. To put it simply, higher resolution requires slower telescope movement because the computer's *sampling rate* determines how fast it can read the data sent by the encoder.

Further Reading
For more information, refer to the document library on our web site at jmitelescopes.com.