ACCURACY AND RESOLUTION

Step motors by and large are used in open loop positioning and velocity applications. There is no feed-back transducer to set the ultimate accuracy of the system. Consequently it falls on the motor and the drive's precision and behavior to determine the accuracy of the application.

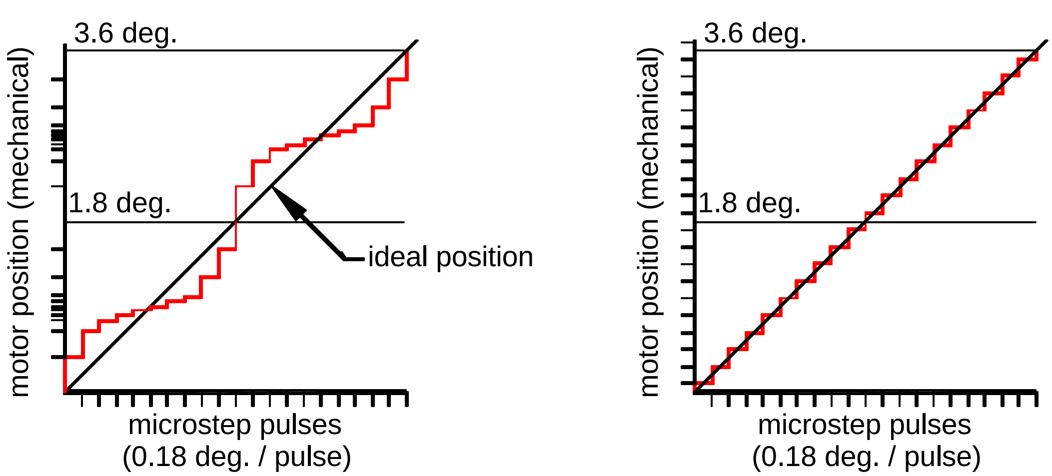
Through micro-stepping, 2^{nd} order damping and precision sine / cosine current references, the drive has cured the step motor of its inherent vices to make it a viable candidate for precision motion control applications. Neglecting the drive, the motor still has characteristics that must be considered in regards to ultimate accuracy in any application.

A step motor is a mechanical device that is manufactured to a certain tolerance. Typically a standard motor has a tolerance of +/- 5% non-accumulative error regarding the location of any given step. This means that any step on a typical 200 step per revolution motor will be within an .18-degree error range. Stated otherwise, the motor can accurately resolve 2000 radial locations. Coincidentally this is the resolution of a 10 microstep drive.

Any microstep resolution beyond 10, such as 125, yields no additional accuracy, only empty resolution. By analogy, a voltmeter having a 6 digit display while having a 1% accuracy would have meaningful information only in the first two digits. There are two exceptions justifying higher resolutions; the step motor is being run in a closed-loop application with a high-resolution encoder or the application requires smooth operation at very low speeds (below 5 full steps per second).

Another factor affecting accuracy is motor linearity. Motor linearity refers to how the motor behaves between its ordinal step locations. Ideally a 1.8 degree per step motor should move exactly 0.18 degrees for every step pulse sent to a 10 microstep drive. In reality all step motors exhibit some non-linearity, meaning the microsteps bunch together rather than being spread evenly over the span of a full step. This has two effects; statically the motor position is not optimum and dynamically low speed resonances occur because of the cyclic acceleration where the microsteps are spread apart and deceleration where they bunch up. The figures below show a motor with terrible linearity and a motor with excellent linearity.

bad vs. good motor linearity



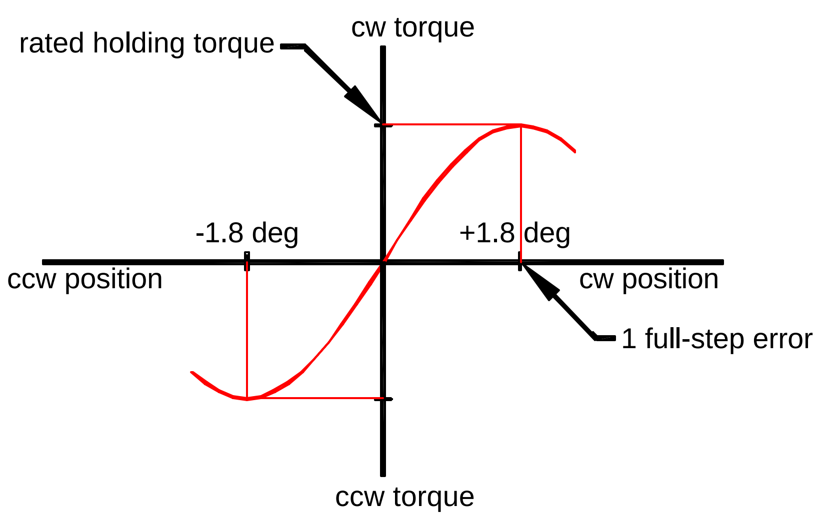
Finally, the static or frictional load applied to the motor affects accuracy. A stopped step motor, which has 100 oz/in of holding torque, is fundamentally different than a break that has the same holding torque.

The break will not turn at all until its holding torque is exceed. However a step motor only generates restoring torque if it is displaced from its rest position. Using the brake analogy, think of the output shaft being connected to the break with a torsional spring. Now when applying a load, the output shaft has to be radialy displaced to apply torque to the break.

When torque sufficient to overcome the holding torque is applied to a step motor, the shaft will jump to the next stable location, which is 4 full steps ahead or behind the original one, depending on which direction the load is applied. Peak restoring torque occurs a full step ahead or behind the original location, beyond which it weakens and reverses at the 2 full step position to attract the shaft to a 4 full step location ahead or behind the original one.

The relationship between restoring torque and shaft error angle is approximately sinusoidal as shown below.

shaft position vs. applied torque



From this one may approximate that a static torque load equal to 15 percent of the holding torque will displace the motor shaft 1/10 of a full step about the origin.