WHY STEPPER MOTORS

By Alan Buckman, AWR Technology, MAY 2013

In this modern age what decides the motor and drive type that are ideal for use in astronomy.

Synchronous motors. Traditional use in astronomy because they run at a constant speed locked into the AC supply frequency. These are generally 110 / 240 Volt operation and generally plugged straight into the mains. They can be bi-directional. Downside is they rotate quite fast and need a large reduction to be of use. Motor cost with the gearbox now around 100 GBP. Very few manufacturers left offering controls for these products.

DC Motors. Have no speed control. When you increase the voltage the motor will run and changing the load will change the speed. Electronic solutions (PWM) can make it run slowly but feedback in terms of an encoder is required to keep the speed constant. All sorts of problems with the output torque constancy. The lowest cost motors are under 10 GBP but the implementation suitable for astronomy raises it to several 100's GBP. All DC motors are very noisy in operation, the last thing you want if you are near to neighbours. They are typically used for low cost Focus motors.

DC Servo Motors. This is a DC motor with servo loop control, usually by optical encoder but can be other means. As a main drive motor in astronomy the encoder needs to return many pulses a second. The electronics to control this need to be quite elaborate and an amount of processing power is required just to keep it tracking. The reason why it is so widespread is that the hardware is cheap and it is reasonably easy to get a large dynamic speed range, however more powerful processing is required pushing the cost into the design time. The more expensive mass produced scopes use skew wound motors in order to even out the torque somewhat, getting over the uneven rotation with a very expensive motor. The commonly used small motors, even with the feedback, change the motor speed many times per second from stop to double speed in some of the systems I have investigated.

Direct Drive Motors. DC servo motors under a different name but with no gearbox they need to be huge to develop the required torque, but you still need many pulses per second of encoder feedback. These solutions are employed on the biggest telescopes. There are a few implementations on the very top end of mounts available to amateurs. The implementation cost - many thousands.

Stepper Motors. A hybrid between a DC and a Synchronous motor. It pulses in steps determined by the geometry of the motor, typically 200 steps per revolution for a hybrid motor type, 48 steps per rev for a permanent magnet type. The hybrid type can be made to deliver constant torque at many

intermediate positions between the full step – called microstepping – and it can be characterised to provide a linear movement per microstep. There are many microstepping drivers in the range 250 to 500 GBP that offer solutions for many motors, bipolar and unipolar wound with working current up to 5 amps per phase at a few volts. Generally these would be used with a 40 Volt supply and operate in constant current chopper mode to limit the current the motor sees. As you can see by the terms I have used there are many variations of stepper motors and stepper motor drivers. These systems, if properly designed with the mechanics, can give open loop control without any problems. Dynamic speed range determined by the overall reduction ratio as they can only spin up to 10 revs per second or thereabouts depending on the electronics. However if you have 12800 steps per rev as you do in the AWR systems then you can track the stars at 50 microsteps per second and still get several degrees per second slew rate. They are quiet in operation. There is less complication in the electronics as there does not need to be feedback. The main benefit is extremely smooth operation, provided you offer enough pulses per second out of the motor.

Intrinsic backlash. I am going to labour the point that it is impossible to get any motor system to operate without backlash. To get power out (torque) of the motor it is necessary to have a small angle between the electric / magnetic field and the rotor. The maximum loading (in terms of a stepper motor) is up to half a step position in lag. So when you swap the rotation direction the lag is reversed and there is the backlash.

Other Issues. If you can get the best out of your motor in terms of smoothness and evenness of torque, you still need the rest of the reductions to be operating smoothly, without tight spots and introducing very little extra backlash. At the working end the forces get quite large and the impossible can happen, like plates sliding even though they are done up with three off M5 screws. It is very important to get everything tight with anti-slip measures in place and to keep checking that it is working correctly. AWR offer several unique gadgets to help in this respect, the SEEKER and the PULSE ANALYSER, both operating into the Autoguider input port on the mount. There are also various guides available to help you.

For further information of what AWR can offer please go to the website
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