

EVERYTHING YOU WANTED TO KNOW ABOUT STEPPER MOTORS BUT DIDN'T KNOW WHO TO ASK!

This is a short essay in layman's terms (even I might understand it but then that's because I wrote it) of what happens inside your motor and your GeckoDrive when you are implementing a small motion system. Firstly let's investigate the various types of stepper motors available.

Stepper drives are often classified as 'unipolar' or 'bipolar', simply put this means that the current running through the coils of your motor is either able to travel in only one direction (unipolar) or in both directions (Bipolar). Unipolar motors are much easier to drive as you simply switch each coil on sequentially and the rotor will move to its next detent position, four simple transistors and a little logic circuitry will achieve this easily. Bipolar on the other hand requires that the current be allowed to flow in both directions through the coils and this often requires an 'H bridge' type power device, two in fact, one for each phase. The logic to drive this is a little more complex and the 'H bridge' power device is more expensive.

Internally a stepper motor is little more than coils of wire wrapped around an iron lamination, this is common to nearly all stepper motors. The rotor or armature is usually different and can be divided into three categories:

1. Soft iron or so called low reluctance, often a material such as ferrite is used- usually higher speeds but lower torques. These motors spin quite freely when turned by hand.
2. Permanent magnet, the rotor is made of a magnetic material some of which can be quite exotic- usually higher torques but lower speeds. These motors have a very pronounced detent when turned by hand.
3. Some motor are a combination of the two, these are called 'hybrid' and in an attempt to get 'the best of both worlds' stepper motor manufacturers combine materials in the rotor to get high torques and high speeds. These motors have a less pronounced 'detent' when turned by hand.

Most stepper motors have 4 coils internally and one type has only two. So let's look at the various types of motors identified by the number of wires coming from it. (If you can count to ten then the next section is easy!)

1. If your motor has 4 wires coming from it, this is a typical 2 phase, bipolar motor (two coils internally) and can only be driven with a bipolar drive. These motors are commonly found in high end industrial applications where it has been designed or

specified for a specific job. Nice if you can find them as the performance is usually very good.

2. If your motor has **5** wires then the ends of all 4 coils have been connected internally and you are only able to drive in unipolar mode. These motors are often used for uncritical, cost sensitive applications. Usually they are not large and the performance is poor or moderate. You could try to open the motor and break out the connection point but this operation is not easy (the wires are very thin) and don't remove the rotor, it will lose its magnetic strength.
3. If your motor has **6** wires then both ends of a pair of coils have been connected internally. This motor is able to be driven in unipolar mode (connect the two centre taps together) or bipolar mode with either the two coils in series (connect the power across the ends and ignore the centre tap), centre tap to one end and ignore the other coil. Note that it is not possible to connect the ends together and use the two coils in parallel, as internally the two coils will be in opposition and the mutual inductance will be zero, this smokes drives very quickly! Trust me I know this!
4. If your motor has **8** wires (the best kind) then you are able to drive this motor in any method that you choose! Should you decide to run it in unipolar mode connect the correct end of each coil together and connect the remaining 4 wires to your drive. You could also run it in bipolar mode with just a pair of coils connected or the pairs in series or parallel. The series connection will allow you to run at a lower current setting, 0.7 of the unipolar current, parallel connection will allow you to use 1.4 times the unipolar current. Note that it is vitally important that you get the orientation of the phases correct for both series and parallel connections. Use the manufacturers' data sheet; trial and error will cost you a lot of money!

[Read the section on installing your Geckodrive to learn more!](#)

There are also 3phase and 5 phase stepper motors available but as these are very manufacturer specific we will not discuss them here.

Now that we know a little about stepper motors, what about stepper drives? The first thing you need to know is that your Geckodrive is a "Bipolar, chopping, 2 phase stepper motor drive!" Now repeat after me, "My Geckodrive is a Bipolar, Chopping, 2 phase stepper motor drive!" Good, remember to hold your head up high, shoulders back when you tell your friends that you only use the very best!

The most common stepper drive is usually a single chip that runs the motor in unipolar mode; it is little more than 4 output devices for switching the coils on or off and a little embedded logic to drive these, nothing more. There are a number of stepper systems that can be driven straight from the printer port, the power devices are discreet and driven by output signals in the printer port directly, all the logic is handled in the PC. These systems are very simple and easy to use but the performance is often poor or moderate, as the old law states "You pay your money and you take your pick!" Don't think that these systems are inferior, they are suitable for the requirements and designed accordingly but if you want more... "Please Sir, may I have some more..."

The second category of stepper drives are bipolar drives, here usually the performance offered far exceeds the unipolar drives for a number of reasons, we will look at some of them. As we learnt earlier, stepper motors are coils of wire wrapped around a core, their behavior is that of an inductor, i.e. very resistant to changes in the current flow. Think of an inductor as a flywheel, difficult to start and difficult to stop but quite happy to carry on spinning at its present speed. If we want to get this motor to turn faster we need to start the current flowing in the coil and stop it as quickly as possible to allow it to move to the next step quickly, that way we can get higher power outputs from our motor. "Ah, but how do we do that!" Easy, we do it two ways, we use much higher voltages, often ten to twenty times the nameplate voltage to switch the current on, i.e. we try to turn the flywheel harder. This sounds simple enough but in so doing we open another can of worms, the current through the coils will also increase and so will the heat generated by the coil resistance, this can be overcome.

[Read the section on current control and over driving to learn more!](#)

So we increase the voltage to build the coil field up quicker, but how do we break it down quicker? Easy, we reverse the voltage on the coil instead of simply switching it off and allowing the energy to dissipate naturally by its own resistance. This means the field will collapse twice as fast as it might have on its own. Running at these higher voltages, or overdriving motors as we 'commoners' would say, improves the speed of your motor and hence the power it can deliver.

"Ah," you say, "I see it now, clear as mud! We use the high voltages to build up and break down the magnetic fields created by the coils as quickly as possible and we limit the current to stop the motor from overheating, why didn't I think of that!" Fortunately GeckoDrive already has and we can use the benefit of all their hard work.

Well now you know what you don't know about stepper motors and drives, read the following sections and you can learn more.

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