Astrosyn

Guide to Stepper Motor Drive Selection

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Introduction

Stepper motors require external drivers to control them, with components including a power supply, logic sequencer and switching components. In recent years circuit integration has enabled these to be included in a single unit, and control can now be fully programmable using digital signal processors. Simon Hunt of Astrosyn International Technology outlines the fundamentals of driving stepper motors.

Most hybrid stepper motors are designed for 2- or 4-phase operation, and for these there are two basic types of drives: unipolar and bipolar. Steppers designed for 3- or 5-phase operation are less commonly encountered; they require unique drives, which will not be covered in this review.

Lead wires

One of the confusing aspects of hybrid steppers is the number of lead wires, which can be four, five, six or eight! This relates to the motor design (unipolar or bipolar), and also to the flexibility that the user requires in selecting different drive techniques for the same basic motor.

The choice of drive mode is based on the torque-speed characteristics required to suit the application. For example, high torque may be needed at low speed; or perhaps relatively constant torque is better over a wide range of speeds. Cost also plays a major role; unipolar polar drives tend to be cheaper than bipolar models, but offer less flexibility and lower torque.

If all the coils in a bifilar wound motor are brought out separately, there will be a total of eight leads, which offers the most flexibility.

Eight lead stepper motors can be driven in bipolar series, bipolar parallel and unipolar modes. Many stepper motors are produced with **six leads**, where one lead serves as a common connection to each winding in the bifilar pair. In this case, the external windings cannot be connected in parallel, but these motors can be connected externally in bipolar series and unipolar modes.

Other motors have only **four leads**: these are not bifilar wound and therefore cannot be used with a unipolar drive. Internally, four wire motors may be manufactured with coils wound in series or in parallel; this will not be visible externally.

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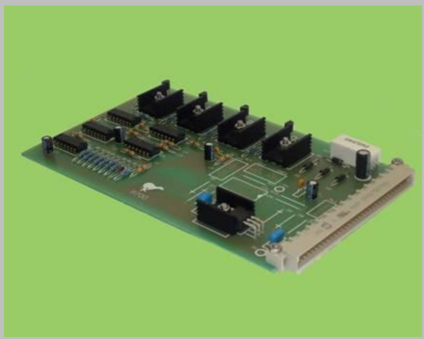
Five lead wire steppers are rare, and can only be used with unipolar drives.

Unipolar and Bipolar Drives

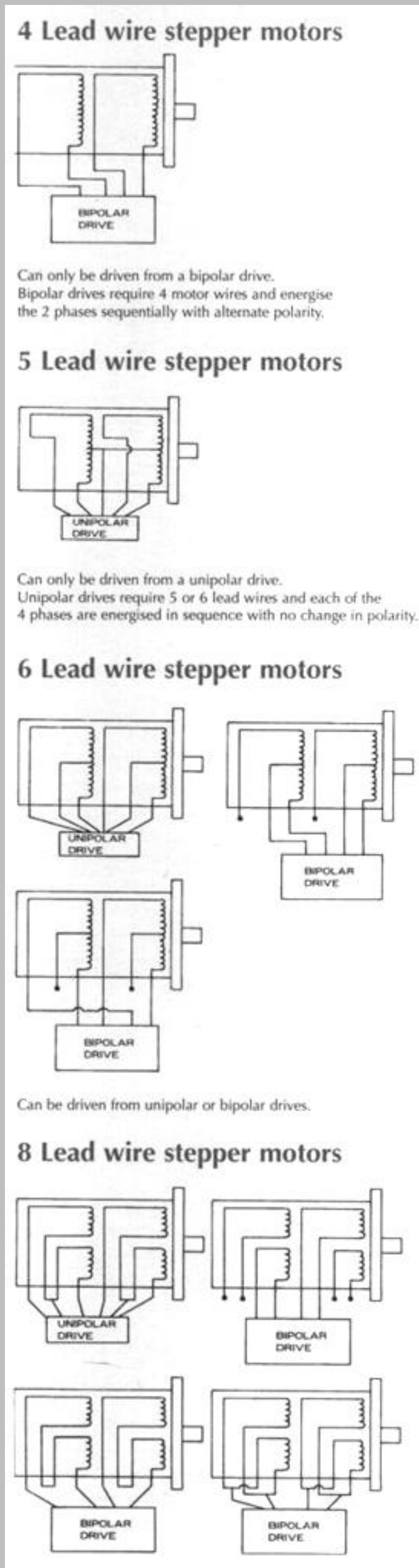
Unipolar drives are the simplest designs and as such they offer a robust, low cost solution for many undemanding applications. The input signals to the drive are the clock (speed) and direction (clockwise or counter-clockwise) pulses.



From these signals, the drive logic provides the output to control the motor.

Drive Mode	Number of Wires	Main Features
Unipolar	5, 6 or 8	Best at lower speeds Robust and simple Low cost drive
Bipolar Series	4 (internal series), 6 or 8	High torque at low speed Low torque at high speed
Bipolar Parallel	4 (internal parallel) or 8	Flatter torque-speed profile Higher torque at high speed

In unipolar motors, there are two identical sets of windings on each pole ("bifilar wound"), so that only one changeover switch is required. The driving current flows in only one direction through any particular motor terminal, and because not all coils are used simultaneously, the output torque is limited.



Bipolar drives can generate current flow in both directions in each motor coil, and this more efficient technique enhances performance. With bipolar designs there is only one field coil on each pole, which therefore requires two changeover switches to reverse the direction of current flow to cause the motor to move one step. The need for two changeover switches with bipolar motors requires a more complicated driving circuit, but the availability of integrated circuit designs means that this is not a disadvantage.

Having two sets of windings provides additional flexibility, and different connection modes can be used to give alternative torque-speed characteristics. Because the whole coil is used at the same time with bipolar devices, this enables them to have higher torque and a more compact size, which has led to their increased popularity today.

Many modern drives now offer microstepping, an electronic means of subdividing basic step angles by proportioning drive current between the windings. In some cases this may provide up to 51,200 steps per revolution, thereby offering extremely smooth rotation.

Digital signal processors

The use of DSP (digital signal processor) technology for the digital control of stepper motors offers a number of advantages over traditional microcontroller drivers. While microcontrollers are either general purpose or optimised for control functions, the strength of DSPs is that they are designed for high performance, numerically intensive tasks, which enables them to perform in software many functions that were previously carried out by expensive hardware. This leads to lower system cost, together with increased performance and power efficiency.

Furthermore, as DSP technology continues to advance, the chips are becoming so powerful that they have increasing amounts of spare processing capacity, so that they can take on additional ‘intelligent’ functions and background tasks.

Another advantage is ultra-smooth operation for stepper motors. A DSP can directly generate waveforms of the precise shape and frequency optimised for a particular motor design, without requiring any of the intervening analogue processing used in traditional designs. This ensures operation is smooth and quiet due to reduced jitter, and opens up the potential for stepper motors in a much wider range of applications.

These features are used in the Astrosyn range of DSP drives and motion controllers.

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Their diagnostic output can also be used to optimise stepper motor performance in real-time applications. This is achieved by providing continuous feedback to the drive power supply in order to optimise the electrical input to the motor windings. In the event that a failsafe shutdown is triggered, the diagnostic reporting will provide details of the failure. The nature of the error mode is reported by the diagnostic display, e.g., under voltage, over voltage, over temperature, over current, open circuit, phase short circuit, communications error.

The transition from analogue to digital control is enabling the characteristics of stepper motors and drives to be studied in more detail so that their performance can be refined, leading to a much broader range of motion control applications, in particular those requiring smooth, quiet and reproducible precision.

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