# Technology Comparison Summary

## A comparison of stepper and servo motor technologies

Stepper motors, DC brush servos and brushless servos each have their respective benefits and drawbacks. No single motor technology is ideal in every application, despite what some manufacturers may claim. This section reviews the relative merits of each technology and lists the application types most appropriate to each.

## Stepper motor benefits

- Lowest-cost solution
- A stepper motor will always offer the cheapest solution. If a stepper will do the job, use it.

### Rugged and Reliable

Steppers are mechanically very simple and apart from the bearings (like in servos) there is nothing to deteriorate or fail.

### No Maintenance

There are no brushes or other wearing parts requiring periodic checking or replacement.

### Industry-standard ranges (Nema or metric)

Steppers are produced to standard flange and shaft sizes so finding a second source is not a problem.

### Few environmental constraints

A stepper may be used in just about any environment, including in a vacuum. Special magnets may be needed if there are very large magnetic fields around, e.g. in evaporation chambers. Watch heat dissipation in a vacuum (there is no convection cooling).

### Inherently failsafe

There are no conceivable faults within the drive to cause the motor to run away. Since current must be continually switched for continuous rotation most faults cause the motor to stop rotating. A brush motor is internally-commutated and can run away if continuous current is applied. A brushless servo relies on the feedback signal. If the signal is damaged, or absent the motor will run away.

### Not easily demagnetized by excessive current

Owing to the perpendicular planes of the permanent magnet and alternating flux paths stepper motors will more often melt the windings before demagnetizing the permanent magnet, as would happen in a brushed motor.

### Inherently stable at standstill

With DC flowing in the winding, the rotor will remain completely stationary. There is no tendency to jitter around an encoder or resolver position. This is useful in applications using vision systems.

### Can be stalled indefinitely without damage

There is no increase in motor current as a result of a stall or jam as in a servo system. There is no risk of overdriving a stepper system due to large loads, or high speeds.

### High continuous torque in relation to size

Compared with brushed servos of the same size, a stepper can produce greater continuous torque at low speeds.

### Only 4 leads required

This minimizes the installed cost, particularly important in applications where connections are expensive (e.g. vacuum chambers).

## Stepper motor drawbacks

### Ringing, resonance and poor low speed smoothness

These are criticisms generally leveled at full-step drives. These problems may be almost wholly overcome by the use of a higher-resolution drive.

### Undetected position loss in open loop

This should only occur under overload conditions and in many applications it causes few problems. When position lost must not go undetected, a check encoder may be fitted which then results in a very secure system. The encoder is not needed for positioning, only for confirmation. If a positioning encoder is desired a servo system should be used.

### Uses full current at standstill

Since current is needed to produce holding torque, this increases motor heating at standstill.

### Noisy at high speeds

The 50-pole rotor has a magnetic frequency of 2.5 kHz at 3000 rpm. Magneto-striction causes a correspondingly high-pitched sound.

### Excessive iron losses at high speed

Again due to the high pole count, hysteresis and eddy current losses are higher than in a servo. A stepper is therefore not recommended for continuous operation at speeds approximately above 2000 rpm.

## Brush Servo benefits

### Low Cost

Brush servo motors are well developed an are inexpensive to produce.

### Smooth rotation at low speeds

Brush motors are available which are specially designed for low speed smoothness with a large number of commutator segments. Brushed motors are the smoothest of the three discussed motor technologies.

### Low cost drive

A DC brush drive can be made very economically since only a single bridge circuit is required.

### No power used at standstill

With no static loads on the motor, no current is required to hold position.

# Technology Comparison Summary (continued)

### High peak torque available
In intermittent duty applications, particularly when positioning mainly-inertial loads, the motor can be overdriven beyond its continuous rating.

### Flat speed-torque curve
Gives optimum performance with easily generated linear acceleration ramps.

### Wide variety of types available
Brush motors are produced in many styles including very low inertia types for high dynamic applications.

### High speed attainable
Brush servos are typically good for speeds up to 5000 rpm.

## Brush servo drawbacks

### Brush Maintenance
Not necessarily a problem if the motor is easily accessible, but a nuisance if the motor is not. Brushes also create dust as they wear; therefore limiting their use in clean rooms, and other environments where brush dust is not acceptable.

### Problems in hazardous environments or a vacuum
Arcing at the brushes is fundamental to their operation.

### Commutator limitations
Arduous duty cycles promote wear, and the mechanical commutation limits top speed. Very short repetitive moves, less than one revolution of the motor, may wear part of the commutator.

### Poor thermal performance
All the heat is generated in the rotor, from which the thermal path to the outer casing is very inefficient.

### Can be demagnetized
Excessive current can result in partial demagnetization of the motor.

### Increased Installed cost
The installed cost of a servo system is higher than that of a stepper due to the requirement for feedback components.

## Brushless servo benefits

### Maintenance free
The lack of a commutator and brush system eliminates the need for periodic maintenance.

### Good thermal performance
All the heat is generated in the stator where it can be efficiently coupled to the outside casing.

### Very high speeds possible
There is no mechanical commutator to impose a speed limit, small motors are typically rated at up to 12,000 rpm.

### Virtually no environment constraints
Due to the absence of brush gear, a brushless servo can be used in almost any environment. For high temperature operation, the use of a resolver feedback avoids any electronics buried in the motor.

## Brushless servo drawbacks

### Higher motor cost
This is largely due to the use of rare earth magnets

### Drive more complex and costly
Six state, or trapezoidal drives, are not much more expensive than DC brush drives, but the higher performance sine wave drive can cost several times that of the DC brush drive.

## Which technology to use?
The following section gives some idea of the applications that are particularly appropriate for each motor type, together with certain applications which are best avoided. It should be stressed that there is a wide range of applications which can be equally well met by more than one motor type, and the choice will often be dictated by customer preference, previous experience or compatibility with existing equipment.

With the increased requirement for intelligent drives, the real cost differential between brush and brushless servo systems is diminishing. In the majority of new applications the choice is therefore between stepper and brushless servo.

Cost conscious applications are always worth attempting with a stepper, as it will generally be hard to beat on cost. This is particularly true when the dynamic requirements are not severe, such as “setting” type applications like periodic adjustments on printing machines.

**High Torque, low speed,** continuous duty applications are appropriate for direct drive servos and frequently also for stepper motors. At low speeds the stepper is very efficient in terms of torque output relative to both size and input power. A typical example would be a metering pump for accurate flow control.

**High torque, high speed,** continuous duty applications suit a servo motor, and in fact, a stepper should be avoided in such applications because the high speed losses can lead to excessive motor heating. A DC motor can deliver greater continuous shaft power at high speeds than a stepper of the same frame size.

**Short, rapid repetitive moves** may demand the use of a servo if there are high dynamic requirements. However the stepper will offer a more economic solution when the requirements are more modest.

**Positioning applications** where the load is primarily inertia rather than friction are efficiently handled by a servo. The ability to overdrive a servo motor in intermittent duty allows a smaller motor to be used where the main torque demand only occurs during acceleration an deceleration.

**Very arduous applications** with a high dynamic duty cycle or requiring very high speeds will normally require a brushless servo.

**Low speed, high smoothness applications** are appropriate for a microstep system or a direct drive servo.

**Applications in hazardous environments** cannot normally use a brush servo. Depending on the demands of the load, use a stepper or brushless servo. Bear in mind that heat dissipation can present a problem in a vacuum.