

# SDP/SI solves integration challenges with frameless brushless DC motors

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Invented in 1962, brushless DC (BLDC) motors are now commonly used in multiple applications such as robotics, industrial automation, autonomous ground vehicles and personal transportation devices. Standard-frame DC motors are usually integrated into several end products; however, situations may arise where constraints in weight, inertia, volume or packaging require use of alternative solutions, such as frameless BLDC motors. There are benefits and challenges for integrating frameless BLDC motors. SDP/SI is a worldwide developer, manufacturer and supplier of precision motion control systems and components with a partnership with Nidec Motion Control, an industry-leading manufacturer of frameless BLDC motors.

## BLDC motors

BLDC motors offer the flexibility to operate over a wide range of speeds and torques. By adding an in-line or right angle planetary gearset from 3:1 to 100:1 (Figure 1), BLDC motors can be used for an almost infinite number of motion control solutions that meet the most stringent and demanding requirements.

BLDC motors contain a permanent magnet (PM) rotor and coils that are fixed in place on the stator housed within a frame (Figure 2) with a cross-sectional view (Figure 3). Control of the speed, torque and direction of the motor rotation is accomplished by changing the current in the coils. This is done so by use of a switching controller that can sequence the proper charge through the stator coils (commonly known as commutation).

However, BLDC motors are not ideal for every application. The switching controller can be expensive and the need for additional closed-loop control of the commutation sequence results in a higher initial cost than a typical open-loop DC brushed motor. Furthermore, certain applications – such as medical devices or robotics – may require flexibility in the design to incorporate special mechanical features into the housing or rotor, such as a hollow central shaft to pass wiring and signal data. For these applications, it is often necessary to implement frameless BLDC motors.

## Frameless BLDC motors

Frameless BLDC motors (Figure 4) fit more easily into small compact machines that require high precision, high torque and high efficiency, such as robotic applications where low weight and inertia is critical. A frameless BLDC motor consists of two separate pieces: a wound



Figure 1. BLDC with 100:1 ratio planetary gearhead. Source: SDP/SI



Figure 2. Framed BLDC motor. Source Nidec

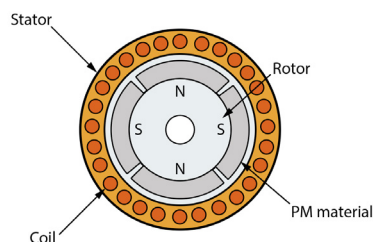


Figure 3. Cross-sectional view of framed BLDC. Source: SDP/SI

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coil stator with multiple poles, and a hollow shaft rotor consisting of rare earth neodymium magnets. The frameless BLDC motor omits the housing, front and rear end caps, bearings and hall sensor found in traditional framed BLDC motors. Frameless BLDC motors can therefore provide a reduction in size, mass and inertia, along with greater flexibility to route cables, electronics and optics through the motor centerline.

Integrating a frameless BLDC motor into a system design can be a daunting task with many concerns such as air gaps, concentricity or handling high-performance rare earth magnets with extremely strong magnetic fields. The size of air gaps and the concentricity of components must be carefully balanced with the strength of the magnetic fields to ensure problem-free operation of frameless BLDC motors.

### Air gap

The air gap refers to a physical gap in an electric motor that separates the moving rotor and the stator core. This gap is a necessary part of motor design, and the size of the air gap is one of the keys to motor performance and reliability. An uneven air gap over a full rotation will generate fluctuations of the magnetic force applied and create dynamic instability. Precision machining of the stator housing is usually required to maintain an even air gap.

### Concentricity

The positioning tolerances of the housing, bearings, shaft and rotor combinations are critical. Proper geometric tolerancing to maintain concentricity and air gap will ensure that there are no imbalances within the assembly. Imbalances within the assembly leads to decreased efficiency, excessive wear, reduced service life, or worse yet, catastrophic failure. Additionally, the concentricity should be carefully evaluated depending on the assembly method such as adhesive bonding, thermal fit, or mechanical clamping, length of the rotating shaft and operating conditions.

### Rare earth magnets

Rare earth neodymium magnets have very strong magnetic fields and are naturally brittle and prone to chipping and shattering. During assembly, it is necessary to avoid the collision of magnets and to keep magnets away from sensitive electronic components. To ensure personal safety, workers are required to use safety glasses when handling larger magnets and nearby personnel must be kept at a safe distance from assembly lines.

### The SDP/SI frameless BLDC solution

SDP/SI can help their customers overcome numerous design and integration challenges to successfully integrate their frameless BLDC motors into several different applications. This is enabled with a dedicated design and engineering staff and access to their full line of power transmission and motion control options, including a variety of gears, timing belts and pulleys, bearings, shafts, couplings and more.

Sizing a motor based only on power input/output, size and duty cycle without consideration of the entire application can lead to increased costs due to over or under engineering. For example, the proper choice of gears or pulleys that can increase the mechanical advantage within the drivetrain can save costs by allowing for the use of a smaller motor. Similarly, the proper choice of bearings, shafts and couplings can ensure proper mechanical fits, extend product life, reduce dynamic loads, compensate for axial misalignments and imbalance loads.

Specifically, SDP/SI can provide engineering and technical support in four distinct areas:

- The selection of bearings that provide low friction and appropriate axial and radial load ratings
- The selection of stator and rotor mounting materials that provide the best conductive heatsinking path and structural integrity
- The recommendation and design of appropriate stator and rotor mounting methods, including adhesive bonding, thermal shrink fits or axial clamping
- The recommendation and design of mounting methods to enable the proper axial alignment of the rotor

This can ensure an optimum integrated frameless BLDC motor design with high reliability and minimal development time. SDP/SI designers, engineers and technicians can assist customers by performing calculations and designing custom mounting fixtures, brackets, adaptors and motor and gearhead assembly combinations.

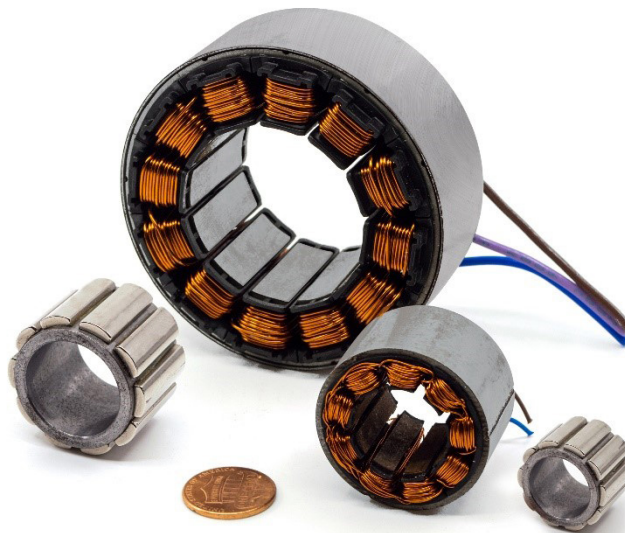


Figure 4. Frameless BLDC motor. Source: SDP/SI

## SDP/SI

SDP/SI has been a worldwide developer, manufacturer and supplier of precision motion control systems and components since 1950. Headquartered in Hicksville, New York, they have been a one-stop source for engineering development and manufacturing of precision mechanical components. With world-class CNC machining, milling and turning equipment, they are capable of producing precision gears and high-quality mechanical components using materials such as alloy steel, stainless steel, bronze, brass, acetal, nylon, aluminum, inconel and titanium. Other services include heat treating, anodizing, zinc plating and painting. This has enabled SDP/SI to produce over 87,000 products that are used in numerous applications in the medical and dental, aerospace, defense, recreational and robotics industries.

SDP/SI is ISO 9001 + AS9100 registered, ITAR compliant, DDTC registered, RoHS and REACH compliant, Boeing BQMS certified and can supply DFARS-compliant components as required. Experienced engineers provide customer support for product development, design for manufacturability, customization and part selection, oftentimes leading to design improvements, cost and time savings. More information can be found on the [SDP/SI website](#).

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### ABOUT STOCK DRIVE PRODUCTS & STERLING INSTRUMENT - SDP/SI

Established in 1950, Stock Drive Products/Sterling Instrument (SDP/SI) is the company engineers and OEMs depend on for high-quality components, subassemblies, and engineering expertise. As a company founded and managed by engineers we understand and respond to the developing needs of our customers better than anyone. Over 100,000 components are available off-the-shelf for fast turnaround. When a standard part won't meet your requirements we can provide alternative solutions through custom design and manufacturing. Our engineering and manufacturing teams will partner with you throughout the entire process. By providing design, development, manufacturing, assembly, and testing in one location we can ensure the end product will meet your expectations. For prototype and small to large production runs you can rely on SDP/SI.