

ADDRESS YOUR COMMERCIAL AEROSPACE APPLICATION NEEDS WITH AN IDEAL DC MOTOR



In commercial aerospace, the application areas for motors are wide and varied, each with their own unique requirements. From electric vehicle take-off and landing (eVTOL) air taxis to business jets to long-haul commercial transport aircraft, DC motors must endure various environmental conditions like extreme temperatures, shock and vibration, atmospheric pressures and signal interference. These applications may also demand motors that provide a fast response, high power or torque density. In addition to these requirements, the aerospace industry perpetually calls for lightweight materials and smaller installation spaces. Taken together, it can be very difficult to specify and buy a reliable motor for mission-critical equipment.

This article will present common commercial aerospace applications that pose performance and environmental challenges for DC motors along with a summary of the stringent aerospace industry standards that the motors must satisfy. It will also provide an overview of BLDC and DC motor types, the attributes to look for when specifying motion control components for various commercial aerospace applications, and customization options to ensure optimal reliability and a long lifetime.

COMMON COMMERCIAL AEROSPACE APPLICATIONS AND THEIR CHALLENGES

Brushless (BLDC) and coreless DC motors are an attractive choice for many commercial aerospace systems, primarily because they offer exceptional efficiency in a lightweight form factor. Common applications include:

- **Propulsion and Fuel Systems.** Propulsion systems, like jet engines and propellers, convert fuel into the mechanical energy that thrusts an aircraft through the atmosphere, while fuel systems employ motorized pumps and valves to regulate the flow of fuel to the engines. The performance, range and reliability of aerospace vehicles depend on optimum, efficient fuel delivery and pressure to the engine via these mission-critical systems. Motors in these systems should be compact, optimized for power and torque density, and constructed to withstand extreme conditions that occur outside the cabin, especially vibration, shock, altitude and wide temperature ranges. Motion

components must also be tested and qualified to satisfy rigorous standards for a gamut of aircraft. Previous generation designs frequently used brush DC motors, but given the increased focus on efficiency and control, smart valves designed around brushless DC motors have become the norm for next-generation technology.

- **Flight Control Systems.** These systems are vital for maintaining aircraft stability, maneuverability and safety. New aircraft depend less on cumbersome hydraulic equipment, instead incorporating intricate electric systems comprising sensors, computers and actuators that enable precise control of flight parameters such as heading and attitude. Electronic flight control systems aim to give more accurate feedback to the pilot, reduce human workload and optimize the aircraft's overall operational efficiency and safety. The wide range of possible applications for precision DC motors in flight control systems includes stick units and yokes, autopilot actuators and flight control surfaces, as well as the smart trim actuators located throughout the aircraft. Each presents specific requirements that must be considered.

Many flight control systems respond to constant inputs from the sensors or the pilot, so the motor you choose must also be highly responsive. Because these electronic systems can be complex, small-size and lightweight motors are particularly desirable. Additional requirements include precise speed or position control when paired with Hall sensors, encoders or other feedback devices. Like many other components in aerospace applications, the motors need to withstand harsh conditions. High power density is the primary driver for these applications, so brushless DC motors are the go-to technology.



Figure 1: BLDC motors are essential to flight control system precision

- **Environmental Control Systems (ECS).** Pivotal for creating and maintaining a controlled, safe and comfortable atmosphere within the aircraft cabin for passengers and crew, ECSs manage temperature, humidity and cabin pressure. Precision motors used for these applications must be compact and lightweight with optimized power and torque density to boost the aircraft's fuel efficiency, provide control for proper positioning and valve actuation, as well as operate reliably. Onboard HVAC systems particularly benefit from efficient motors that both prevent undue strain on the plane's overall power system and resist refrigerants and other caustic substances. Given the precise control required, ECS systems frequently use BLDC stepper motors.

- **Cabin Experience Systems.** In-flight entertainment, comfort and connectivity go a long way to create a pleasant flying experience for passengers and crew. A wide range of motorized amenities — such as window shades and seat actuation systems — require compact and lightweight motors that provide smooth, precise motion and operate quietly and efficiently for optimal passenger comfort. Keep in mind that electromechanical systems in these applications may also cause unwanted electromagnetic disturbances to other systems, requiring motors that minimize EMI and EMC issues. System performance and reliability can also be enhanced with gearboxes, encoders, EMI/EMC protection, thermal fuses, gearheads and brakes. DC motors are frequently used due to their price to performance attributes. However, more dynamic applications will frequently require brushless DC motors.



Figure 2: Automated window shades and seat actuation rely on power-dense DC motors to ensure patient comfort

DC MOTOR TECHNOLOGIES FOR COMMERCIAL AEROSPACE APPLICATIONS

Several DC motor technologies and form factors are appropriate for the harsh conditions and special requirements of aerospace applications. Among them, brushless DC (BLDC) motors are characterized by their exceptional speed and position control, long life and high torque density, while brush DC motors come in small sizes boasting high power density, excellent speed-to-torque performance and minimal iron losses. BLDC motors can be implemented as stand-alone units or as part of a more complete motion system that includes a custom housing with integrated gear train for easy installation. Both the stand-alone motor and the overall system often require modifications to meet the application's temperature and vibration requirements. Here is an overview of common DC motors along with their advantages for commercial aerospace applications:

- **Slotted BLDC motors** have coils inserted in the slots of the stator and offer a balance of a combination of benefits that includes high torque density and maximum speed, long life, low inertia, efficiency and protection against shock and vibration. These powerful motors are designed with thicker teeth inside the copper windings, thereby creating a smaller air gap between the iron and the magnets. Slotted BLDC motors laminated with stacked steel offer high efficiency and power density with low losses and the ability to withstand high peak torque. Portescap slotted BLDC motors are designed with windings that are placed in slots cut axially along the inner periphery for easier customization. Additional benefits include the ability to withstand harsh environments and greater motor lifetime without mechanical commutation.
- **Slotless BLDC motors** use a cylindrical ironless coil made in the same winding technique as ironless DC motors. Using high energy permanent neodymium iron-boron or samarium cobalt magnets, motors with a slotless stator design exhibit acceptable core losses and stable operation at high speeds. They have a larger air gap than slotted BLDC motors, which minimizes cogging torque while also reducing noise and vibration. Slotless BLDC motors generate lower EMI, making them appropriate for applications where interference with other avionic devices is a concern, as well as those requiring high speeds and fast accelerations.
- **BLDC slotted motors** with a flat outer rotor are both compact and flat for applications with tight space requirements. This rotor configuration delivers high continuous torque for exceptional power density and smooth output. These attributes, as well as easy customization, make BLDC slotted motors with a flat outer rotor particularly desirable for aerospace applications.
- **DC coreless motors** offer many of the same features of a BLDC motor in a compact, coreless brushed unit. Without a core, these motors are inherently smaller and more lightweight than typical DC motors. They also accelerate faster, produce less EMI and ambient noise, while exhibiting smooth operation. In addition, coreless brushed-type DC motors are not subject to iron losses and offer lower Joule heating, resulting in exceptional efficiency. Portescap's Athlonix™ family has two series designed to meet specific power, torque, lifetime and size requirements, with a host of customization options.



Figure 3: Portescap's product portfolio features a variety of slotted and slotless BLDC motors



Figure 4: Portescap's 45ECF flat slotted motor



Figure 5: Portescap's 16N78 brush DC motor

	BLDC Slotted	BLDC Slotless	BLDC Slotted Flat Outer Rotor	DC Coreless
Torque density	+++	+++	+++	++
No load losses	+	+	+	+++
Max speed	+++	+++	+	+
Cogging torque	+	+++	+	+++
Lifetime	+++	+++	+++	+
Inertia	+++	++	+	++
Robustness (shock & vibration)	+++	++	+	++

DC motor technology comparison.

SPECIFY MOTORS THAT COMPLY WITH AEROSPACE INDUSTRY STANDARDS

Aerospace environments present some of the most challenging and unique environmental operating conditions for motion components, and compliance with industry regulations is a critical aspect of product selection. Two sets of standards — RTCA DO-160G and AS9100 — offer designers the assurance of knowing that their motion systems can endure and operate safely in harsh aerospace environments.

DO-160G for Airborne Equipment

The Radio Technical Commission for Aeronautics (RTCA) established test procedures and criteria for equipment susceptible to harsh conditions aboard the full spectrum of aircraft from light general aviation aircraft and helicopters through the largest jets, as well as those capable of supersonic speeds. Known as RTCA DO-160G, the test standard’s 26 sections cover several common environmental conditions for motors aboard commercial aircraft.

Some off-the-shelf motion systems can fall short of meeting RTCA DO-160 test criteria, so it pays to collaborate with a motion component supplier who has the technical expertise to custom-engineer a DC or BLDC motor that satisfies DO-160G standards and application-specific requirements. For example, here are some design considerations for common harsh aerospace conditions along with examples of customizations that a consultative motion specialist like Portescap can provide:

- Shock and vibration. Defined vibration curves can guide design decisions in various aircraft applications and help ensure that the overall system as well as each of the subcomponents meet long-term reliability requirements and survive crash impacts. Motion systems can be fortified against vibrations using various approaches such as potting for slotted designs and advanced manufacturing techniques like laser welding during component assembly.
- Temperature. Specify motors, bearings and gearboxes that can perform reliably across a wide -55 to +125°C operating temperature range typically required for aerospace environments. Be sure that bearings and gearboxes use lubricants that are formulated for extreme temperatures. Bearings should also be treated to prevent outgassing.
- Humidity and salt fog. A commercial aircraft will endure many environmental cycles when traveling back and forth from elevations of over 30,000 feet. This temperature cycling can cause moisture buildup on surfaces and lead to oxidation and damage to electrical components. To combat corrosion, specify corrosion-resistant material for metallic components as well as special conformal coatings for PCB protection.

AS9100 Quality Management Standard

AS9100 is the internationally recognized defining standard for Quality Management Systems (QMS) in the aerospace industry. It outlines a set of rigorous requirements that aerospace suppliers must meet to ensure the quality and safety of their products and services. Companies that earn AS9100 certification must prove their operations continually meet these requirements in order to indicate their products and services are safe and reliable to use in the industry.

Portescap miniature motors are of the highest quality and are manufactured in accordance with the latest industry requirements. Our off-the-shelf miniature motors are tested both internally and externally to meet RTCA DO-160G standards, and we recently expanded our motor design capabilities to also produce custom motion products to satisfy DO-160. In addition, we also obtained AS9100:D certification in 2023 for our production plant in Mumbai, India. Taken together, Portescap customers can be certain we meet the aerospace industry's rigorous standards for quality and reliability.

OPTIMIZE YOUR MOTOR TO MEET YOUR SPECIFIC REQUIREMENTS

While many motion component suppliers offer designers a host of standard products, finding the DC motor that meets your exact requirements while also addressing the inherently tough conditions and unique requirements of commercial aerospace applications is seldom easy. When it comes to customized DC motors, there are certain attributes to look for in a supplier. They include:

- A consultative approach to motor system design
- Support for integrated solutions
- Flexible design capabilities to create systems that operate reliably in harsh environments

Although you may know Portescap for our lineup of quality miniature, precision motors, we're also a trusted partner when it comes to specialty motor systems that meet tough commercial aerospace challenges. Not only do we offer these capabilities, we leverage state-of-the-art advanced tools and deep application engineering expertise to design, develop and optimize a DC motor to meet your exact needs.

Examples of our customization capabilities for aerospace include:

- Special lubricants suitable for temperatures down to -55°C and across the operating range in both the bearings and the gearbox
- New manufacturing methods to ensure survivability against shock and vibrations, such as laser welding the bearings to the shafts to improve motor reliability
- A selection of corrosion-resistant materials for machined components like the sleeve, end bells and shaft
- Applying a conformal coating to electrical components as protection from moisture



Figure 6: Portescap's AS9100 Certification

THE PORTESCAP DIFFERENCE

Portescap has a 40-year history of providing innovative precision motors and motion control products to the aerospace and defense industry. With many suitable motor technologies and manufacturing locations throughout the world, we provide both off-the-shelf and custom precision DC motors that resist thermal and mechanical extremes while delivering the power and long life that commercial aerospace applications demand — all in a compact, lightweight envelope.

If an application calls for a customized motion system, we consult with our customers to create a tailor-made motor that is end-to-end tested to meet the system's exact requirements for reliability and performance. By manufacturing motion products using controlled processes and procedures that comply with AS9100 QMS, we are able to deliver products of the highest quality that adhere to the latest industry standards. **P**

For more information, visit our website.

FOR MORE INFORMATION:

110 Westtown Road
West Chester, PA 19382
T: +1 610 235 5499
F: +1 610 696 4598
portescap.sales.america@regalrexnord.com
www.portescap.com

CONTACT AN ENGINEER:

www.portescap.com/en/contact-portescap

Julian Del Campo
Senior Industry Manager
Portescap
A REGAL REXNORD BRAND