Sensata Technologies

HOW ADVANCED PRECISION MOTORS EMPOWER THE IOT AND INDUSTRY 4.0

WHITE PAPER

PROVIDING CRITICAL MOTION FUNCTIONALITY IN ADVANCED PORTABLE, REMOTE AND ROBOTIC DEVICES

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This is an exciting time for the electronic design industry as embedded electronic functionality spreads into every facet of modern society. The disruptive growth of the Internet of Things (IoT) and next-generation smart manufacturing, also known as Industry 4.0, is placing demands on designers to develop motion-enabled solutions that are powerful, small, precise and efficient.

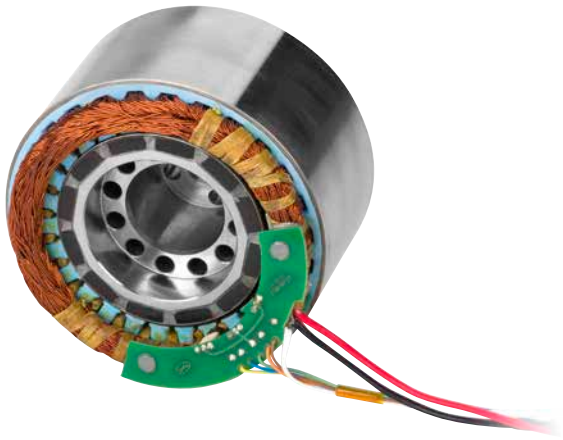
Electric motors have been around for over a century (the electric trolley has existed since the late 19th Century), but the first designs were inefficient, large and imprecise. The advent of rare-earth magnets and advanced brushless DC motor (BLDC) motor design has empowered a new range of motors small enough to fit into confined spaces, powerful enough to do real work, and efficient enough to be used in wireless or remote applications.

The pressure to make products that are both highly functional yet cost-effective means that an electronic engineer must draw the optimum performance out of every system they design. High performance BLDC motors can provide the levels of performance and economy that today's demanding applications require. This includes applications ranging from the appliances in a smart home, to self-propelled IoT devices, to industrial shop floors to 'down-hole' in oil and gas drilling and extraction operations.

INDUSTRIAL

When it comes to industrial applications, the motors in robotic handling and assembly systems must be extremely reliable, cost effective and space-efficient. Much of the technology that has enabled this new generation of motors had been previously used in various scientific and mil/aero applications, but these core technologies have now come down in cost and are being incorporated in a wide range of industrial solutions.

Figure 1



Frameless BLDC motor designs like Sensata's model DIP34 allow for the motor to be fully integrated within a given assembly.

One of the ways to streamline a package design is to incorporate the motor itself into the body of the product, instead of attaching it to an external movement point. A frameless BLDC motor design, also known as a rotor/stator part set, allows for the motor to become fully integrated within a given assembly, which results in the greatest torque-to-volume possible (Figure 2). For applications with restricted space constraints, developers have a choice of integration options and motor configurations. Depending on the application, either a regular cylindrical format or a flatter pancake-style motor can be used when the motion axis is space-restricted.

AUTONOMOUS VEHICLES

Most people think of aircraft or automobiles when the topic of unmanned or autonomous vehicles comes up, but the field reaches farther than that to the depths of the sea. Advancements in the remotely operated underwater vehicle (ROV) industry have created a market for the nimble machines to be used in applications such as search and rescue, maritime security, military, hydro industry, offshore oil rig inspection and scientific research.

Figure 2

BLDC motors like this housed model from Sensata Technologies are used on Inspection Class ROVs, which operate on less than 10 horespower and rely on compact thruster motors attached to the propeller for positioning.

The inspection-class ROVs that are used in such situations must be small and portable so they can be easily moved to and deployed at the locations where they are needed to ensure best operator performance and inspection results. Vehicles of this nature usually operate on less than 10 horsepower and use compact thruster motors attached directly to the propeller for positioning and navigation.

The motors used must present a low profile with the ability to operate reliably in water, oil and other liquids. The latest generation of advanced BLDC motors not only meet ROV Inspection Class requirements, but their small size, power and efficiency enable a streamlined design with low acoustic noise. Customizable motors serve this specialty market segment with compact designs in both housed and frameless mechanical configurations.

While there are still fossil fuel-powered autonomous vehicles in aerial and wheeled applications, more and more manufacturers are migrating to all-electric systems because of smaller sizes, and ease of integration. Electrical systems' advantages over fossil fuel also include a reduced carbon footprint, less acoustic noise and lower emissions. The lack of emissions and noise is beneficial to many other applications such as police and military solutions that require a minimal size and acoustic signature.

Another overlooked advantage to electrical vs. fossil fuel systems of any nature is the ability of an electrical system to safely operate in almost any human environment, even clean rooms. Such an ability is impossible with a system that emits exhaust of any nature. Automated forklifts, mobile equipment carts and parts bins, shop-floor scooters and other self-driven gear also operate much more quietly when driven by electric motors, making integration into the workplace easier as well.

BATTERY LIFE

A powerful electric motor operating at a relatively high duty cycle places strict demands upon its energy delivery and storage system. Additionally, the power infrastructure must be as cost-effective as possible. An efficient electric motor reduces those demands.

Maximizing battery life is a decisive factor in a variety of mission-critical systems, where the reliability and longevity of the equipment involved can affect the outcome of that mission.

In battery-operated medical devices as well as in remotely piloted military vehicles, the ability to last a few minutes longer in a demanding situation can make a significant difference. This need isn't restricted to critical systems. Increasing the life of any battery-operated system is now a key initiative for equipment manufacturers, from phones to cars.

In order to address this demand, the latest frameless brushless DC Motors are available in multiple configurations, with designs that provide extremely high operational efficiencies in excess of 90%. This enables an extended battery life over legacy designs. For battery-dependent applications, the efficiency of the motor is often the deciding factor, not the battery size, in achieving the longest operating time in a given application before the battery (or supercapacitor or reflow cell) needs to be charged.

HARSH ENVIRONMENTS

In applications where a housed BLDC motor is used in harsh environments like oil and gas applications, there are additional demands placed on the design. To properly

address these needs, motors for these applications must be rated to perform at up to 205°C and 30,000 PSI, with the ability to withstand shock loads in excess of 1000g and with a vibration resistance of 25g RMS.

Figure 3

High Pressure High Temperature BLDC motors like Sensata's model DII-15-60 can handle extreme ambient temperatures and pressures.

For example, the brushless DC motor in Figure 3 is designed for the most extreme ambient temperature and pressure environments. This BLDC motor has been validated under some of the most extensive environmental test protocols available to ensure performance at those high ambient temperatures and pressures, while handling high shock and vibrational loads in extreme applications. These motors have a proprietary design that is highly customizable for specific needs, are available in a wide range of torques and speeds and can be configured for gearboxes or other feedback systems.

Down-hole

One aspect of the growth in advanced oil and gas drilling and extraction methods is the need for highly reliable and high performing motors that can survive and operate 'down the hole'. This requires a rugged brushless DC (BLDC) motor specifically developed to withstand the harshest possible conditions found in drilling operations.

The integrated motors used in drilling equipment for the extraction of oil must continue to operate reliably, regardless of the conditions, because oil and gas extraction is an industry where one hour of downtime can cost upwards of $100,000. Replacing a motor, or any integrated equipment, in a drilling rig can take hours or even days, depending on the situation.

In this case, a high pressure and temperature brushless DC motor can directly address those severe down-hole applications such as mud pulser valves, caliper deployment and sensor positioning. Motors of this nature have been successfully tested to operate under continuous duty in temperatures up to 205°C and pressures up to 30,000 psi.

A custom design with winding variations is often needed to create a motor that not only meets a wide range of controller voltages and currents, but that can endure the most extreme environmental conditions while still working optimally with a gearbox or other feedback device.

The motor's robust design can also serve other demanding applications in a diverse range of severe and hostile environments where failure or poor operation is not an option.

The spread of advanced automation technology in manufacturing is rapidly advancing, with facilities both old and new implementing the latest in smart manufacturing and intelligent robotic systems. The need for precise motion control is driven by many demands now placed on the line, from moving products around on the manufacturing floor to a variety of work stations to the logistics of moving the finished product through a facility. Having the proper motion solution can greatly reduce this pressure for the designer.