



## **The Emergence of Brushless DC Motors Within Medical Applications**

Referred to by many design engineers as the ideal replacement for the more commonly used brushed DC motor, brushless DC (BLDC) motors are more frequently finding their way into an increasing number of medical applications every year. Challenges that once hindered BLDC motors from being designed into medical equipment such as the cost of drive electronics are being addressed by the electric motors and controls industry. Furthermore, customer push to develop more efficient, more compact, and more reliable medical equipment has subsequently led to the emergence of BLDC motors within medical applications.

### **WHAT IS A BLDC MOTOR?**

By definition, a brushless DC motor is a synchronous electric motor powered by DC power and is electronically commutated. BLDC motors are a derivative of the most common used DC motor, the brushed DC motor. Mechanically, BLDC and brushed DC motors are direct opposites. The windings of a BLDC motor are affixed to the motor's housing, whereas, the windings of a brushed DC motor are affixed to the motor's shaft. In addition, the magnets of a BLDC motor are affixed to the motor's shaft, whereas, the magnets of a brushed DC motor are affixed to the motor's housing.

Another primary difference between brushed DC and BLDC motors is the method in which each type is commutated. Commutation is the act of changing the motor phase currents at the appropriate times to produce rotational torque. Due to its mechanical structure, brushed DC motors use brushes to commutate the motor. BLDC motors do not have brushes and rely on electronics for commutation.



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### **SENSORLESS BLDC DRIVE TECHNOLOGY**

Ordinarily, BLDC motors utilize Hall Effect devices (HFD) to sense the rotor position which subsequently enables an electronic device known as a drive to commutate the motor. The development of lower cost yet highly intelligent sensorless BLDC drives is helping to increase the popularity of BLDC motors within the medical design community. The evolution of the sensorless brushless DC drive is widening the BLDC motor's appeal within the medical design community

Sensorless BLDC drives do not require HFD's to provide feedback from the motor. Instead, sensorless BLDC drives detect a motor's naturally produced back-EMF to determine the best method of commutation. The most common technique uses a ramp-up pattern to energize two motor phases while monitoring the third phase for back-EMF. This technique requires the drive to initially orient the rotor to a known position. Next, two phases are energized based on a ramp-up pattern such as AB-AC-BC-BA-CA-CB. As the motor increases speed, a proportionate amount of back-EMF is produced by the motor on the non-energized phase. When the amount of back-EMF becomes sufficient enough for the drive to sense, the drive will switch over from the ramp-up technique to a back-EMF, "zero-crossing", technique.

Sensorless BLDC drives have two primary disadvantages:

- The motor must rotate at a minimal speed to generate sufficient back-EMF for the drive to sense.
- Sudden changes in the load can cause the back-EMF loop to become out of sync and result in a loss of speed and torque.



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### **APPLICATION: SLEEP APNEA TREATMENT**

The treatment of sleep apnea requires the use of Positive Airway Pressure (PAP) respirators. Most PAP respirators use a BLDC motor to drive the blower fan. The blower fan creates positive airway pressure to aid the patient in breathing while they are asleep. In this application, the blower fan will increase or decrease the patient's airway pressure in response to their breathing pattern. When the patient inhales, the blower fan must increase the volume of air into the lungs, therefore the motor must accelerate. When the patient exhales, the blower fan must reduce the volume of air entering the lungs, therefore the motor must decelerate. Sensorless BLDC drives are ideal for blower fans used in sleep apnea equipment because the motor is never required to operate below the minimum threshold speed of the drive. In addition, BLDC motors are ideal for this type of application because there is no risk of a sudden change in load.

Motors used in hospital equipment or other patient-care facilities are required to comply with low noise level standards to endorse patient comfort and reduce anxiety. Nevertheless, motors used in sleep apnea equipment operate at high speeds and are expected to comply with even lower noise level standards. BLDC motors are ideal for noise sensitive environments because they do not have brushes, which emit audible noise during rotation.



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### **OPTIMIZING POWER DENSITY**

The continuing development and improvement of medical technologies in the areas of disease detection, prevention, and treatment; coupled with a double digit increase in the number of people requiring medical care over the last decade, has created a strain on the world's medical analysis and testing service providers. The worldwide increase in demand for medical analysis and testing services has resulted in the need to develop medical analysis and testing equipment with greater throughput and of high reliability.

To accomplish this goal, a machine's drive train components must be capable of providing a greater amount of torque over a larger speed range and perform at higher duty cycles.

When compared to brush DC motors, brushless DC motors provide exactly that:

- **Greater amounts of torque over a larger speed range and capable of performing at higher duty cycles**

### **HEAT TRANSFER EFFICIENCY**

While increasing the overall throughput of medical equipment is the primary objective for many design engineers, there is also an increasing market trend to reduce the cost of existing designs. Reducing cost often creates additional challenges for design engineers such as a reduction in the amount of space available for the drive train and electronics. The majority of heat transferred from a motor occurs at the surface of its housing by the mode of convection. As the volume of air surrounding the motor is reduced, the temperature gradient between the motor and the surrounding air diminishes at a proportional rate. The heat transfer efficiency of a motor directly impacts its performance characteristics such as rated torque and duty cycle.



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When compared to their brushed counterpart, brushless DC motors have:

- **Higher heat transfer efficiency which allows them to run cooler in crowded spaces**

There is a direct correlation between the location of a motor's windings and the rate in which heat is dissipated from a motor. For optimal heat dissipation, the ideal location for the windings is affixed to the motor's housing. Being that the windings of BLDC motor are affixed to the motor's housing, the BLDC motor is very efficient at transferring heat away from the motor.

### **MORE RELIABILITY = NO BRUSHES**

Medical applications typically require motors to long life. BLDC motors are more reliable than brushed DC motors because they do not have any brushes to wear out and replace. The life expectancy of BLDC motors is over 10,000 hours, whereas brushed DC motors have life expectancies of 2,000 to 5,000 hours.

### **APPLICATION: MEDICAL ANALYZER**

Medical analyzers are multi-function machines used to test human bodily fluids such as blood and urine. In a medical analyzer, fluid samples are transported from station to station to conduct various tests. Generally, medical analyzers are totally enclosed and the temperature within the machine will rise to well above ambient temperature during periods of peak operation. Medical analyzers are designed to test thousands of samples per year and to run a minimal of eight hours per day.



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Today, stepper motors, a close relative of the BLDC motor, are the most common type of motor used in medical analyzers. Stepper motors are also considered to be “brushless DC” motors. However, the major difference is the construction and pole count of its rotor assembly. Stepper motors have a higher pole count than that of a BLDC motor. The more poles a motor has, the lower its top speed.

The need to develop machines with higher throughput requires the motor to rotate at speeds above the capability of stepper motors. BLDC motors are ideal for medical analyzers because they combine the characteristics of high speed operation, high heat transfer efficiency, and they have long life expectancies.

### **Conclusion**

The BLDC motor will continue to emerge within medical applications.

As sensorless BLDC drives continue to develop and costs are reduced, the attractiveness of BLDC motors will continue to increase. Customer demand for medical equipment capable of handling even higher throughput and of higher reliability than the machines of today will continue to challenge the capabilities of brushed DC motors. Lastly, the trend of reducing the size of medical equipment will require the motor’s overall size to continue to become smaller.

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About NMB Technologies Corporation - NMB Technologies Corporation, a Minebea Group Company, is the world's largest manufacturer of miniature precision ball bearings and a volume leader in the design and manufacturing of precision electro-mechanical components, including cooling fans, precision small motors and mechanical bearing assemblies, among others. NMB products can be found in the personal computing, networking, telecommunications, home entertainment, home electronics, automotive, medical and industrial markets.

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