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A DISTRIBUTED CLUSTERING APPROACH FOR CANCER THERAPEUTICS BASED ON GENE EXPRESSION DATA

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Abstract
The development of technology should be an aid for human life to make it better. Hence a wide variety of motors are used in biomedical applications.A common type of motor employed is a BLDC motor. The BLDC can of slotless or slotted type. The slotless stator has a number of advantages such as reduced inductance and lower torque ripples. The responseof the machine is also improved. A comparative study of the slotted and slotless armature is done here. The results ensure that the slotless design provides a better performance as compared to the slotted design.
Keywords—Brushless DC motor, Slotted, Slotless

Introduction

A Brushless DC (BLDC) motor is a special electric machine having a permanent magnet rotor and the stator has three phase windings fed through an inverter. BLDC has all the characteristics of a conventional dc motor but does not have commutators or brushes. So it is maintenance free. BLDC motors can be substituted for conventional DC motors in umpteen applications. The AC supply required for the windings is generated by a pulse width modulated inverter fed by a DC source. BLDC motors are in arranged of powers ranging from biomedical applications to electric vehicles. While most applications use a three phase BLDC motor some application employ two phase machine also.

The BLDC motors are classified on the basis of output as sinusoidal and trapezoidal BLDC motor. The operations of these two machines are controlled by controlling the gating pulse provided to the inverter. Both applications mostly produce a constant load torque at the output.

The output torque of BLDC motors are greatly influenced by the back EMF in the machine. BLDC always produces a higher torque to weight ratio in the output hence making it suitable in applications where weight and torque are critical factors [1]. The slotless stator has a reduced electrical resistance, lower static friction, lower winding inductance and higher thermal efficiency. This is what makes it ideal for biomedical applications.

Though the trapezoidal waveform enables almost a constant output but practical applications show that there are waveform imperfections, current ripples and phase current commutation.

I. Slotless Vs. Slotted BLDC Motor

The BLDC motor has found its use in biomedical applications due to its properties such as great control range, higher efficiency and varied types of applications. A major hindrance in the

design is the fact that type of stator core prevents its size from minimizing hence limiting its range of applications. The windings also become a design issue as placing the windings becomes more difficult when the size is shrunk. The slotless motors use either a concentrated or distributed type of armature windings. These windings are fixed on the stator provides several design possibilities. This also enables an increased size of the rotor of the machine as resulting in a higher torque output for an identical machine size. The slotless design also ensures reduced noise and cogging in the machine can be eliminated. The elimination of noise also results in reduced machine vibrations.

In the slotless armature design the armature windings are wound in a cylindrical shape and then it's kept in such a way so as it is oriented with respect to the stator laminations and housing. This results in elimination of stator teeth. Cogging in any electrical machine is due to the locking between the stator teeth and rotor. Hence as the slotless design eliminates stator teeth the issue of cogging can completely be eliminated.

The elimination of slots also helps in the elimination of stator eddy currents. The increased distance between the rotor and stator further contributes to the elimination of stator eddy currents. The rotor is devoid of eddy currents as it is permanent magnet in construction.

The slotless stator also provides an advantage of reduced inductance in the in the airgap. The reduction of inductance ensures enables a smoother and quicker response of the machine. The teeth is one of the reason for inductance in the machine due to the effect of slotted machine. Due to the effect of self-inductance in the coil it results in a negative response and acceleration in the machine. This is also eliminated in the slotless design.

During the initial stages of development the slotted machine used to deliver power to the load efficiently as the iron as magnets were closer as teeth was present. This advantage has now been overcome due to the utilization of high energy, rare-earth magnets. The material now being employed is samarium cobalt and neodymium iron boron for magnets. By utilizing these magnets the slotless brushless motors has compensated for the greater air-gap distance in the machine. Higher performance of these magnets enables the better torque performance for slotless machine. The optimum power output is obtained from the machine by maximizing the electromagnetic field and by the aid of stronger magnets. The new age magnets also aids in reducing the number of coils in the stator. It also results in higher thermal efficiency, low electrical resistance and low winding inductance in the machine

Yet another design difference between a slotless and slotted machine is in the construction of rotor. Slotless machine are characterized by larger rotor diameter for identical outside diameter. This enables the generation of higher inertia as well as more magnetic material. The result of all these improvement is the production of a greater torque. Hence for applications requiring high inertia slotless design is used.

II. Maxwell Model Of Slotted And Slot less BLDC Motor

By analytical design the specifications of BLDC motor is found for modeling in Maxwell 2D. The specifications are shown in Table 1. The Maxwell model of slotted BLDC motor is shown in

TABLE I
SPECIFICATIONS OF THE ANALYSIS MODEL

Parameter	Value
Supply voltage	12 V
No.of phases	3
No.of poles	2
No. of slots	12
Axial length	31mm
Stator outer diameter	40mm

the figure 1.The windings are placed in the slots of stator

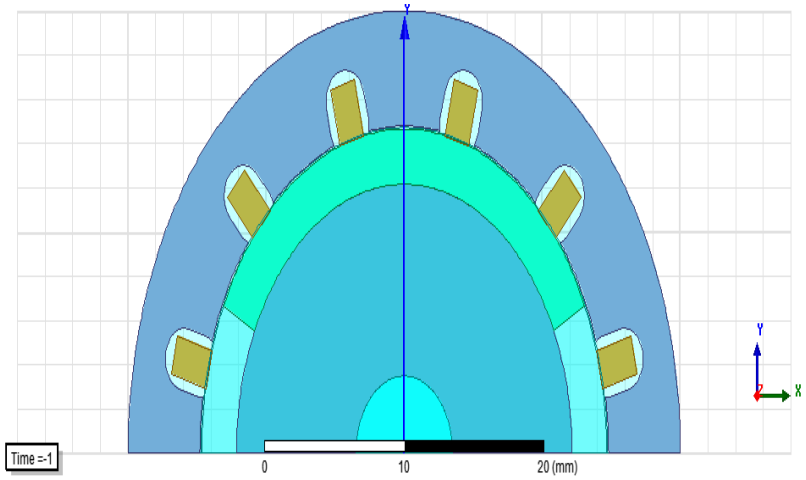

Fig. 1Slotted BLDC motor

The slotless model is developed by placing the windings in the air gap and not in slots as shown in the figure 2. For hardware development in practical applications a light former material is used in the air gap and windings are wound on it. This former is made of a material called derlin which is a non-electrical and non-magnetic material. It also gives an extra protection to the windings [2].

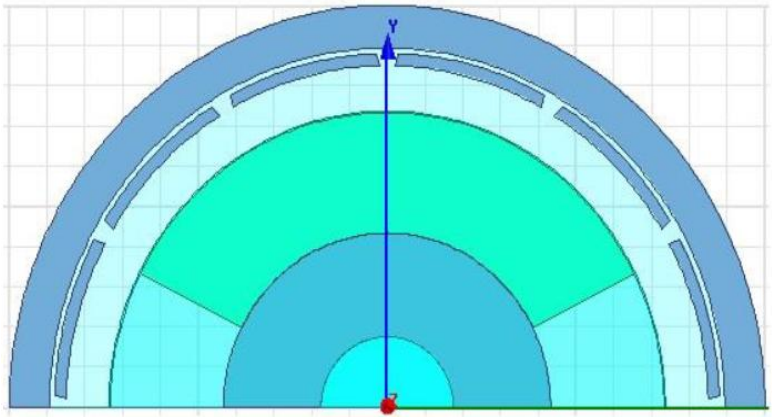

Fig. 2 Slotless BLDC motor

II. PERFORMANCE COMPARISON OF SLOTTED AND SLOTLESS BLDC MOTOR

The torque produced by the slotted BLDC motor is shown in the Figure 3

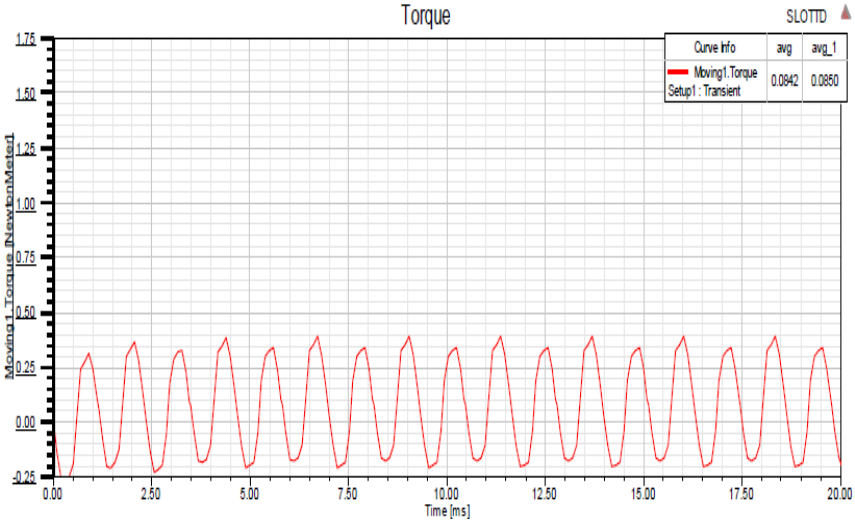

Fig. 3 Output torque of slotted BLDC motor

The output torque of the sloltess BLDCmotor is shown in the Figure 4.

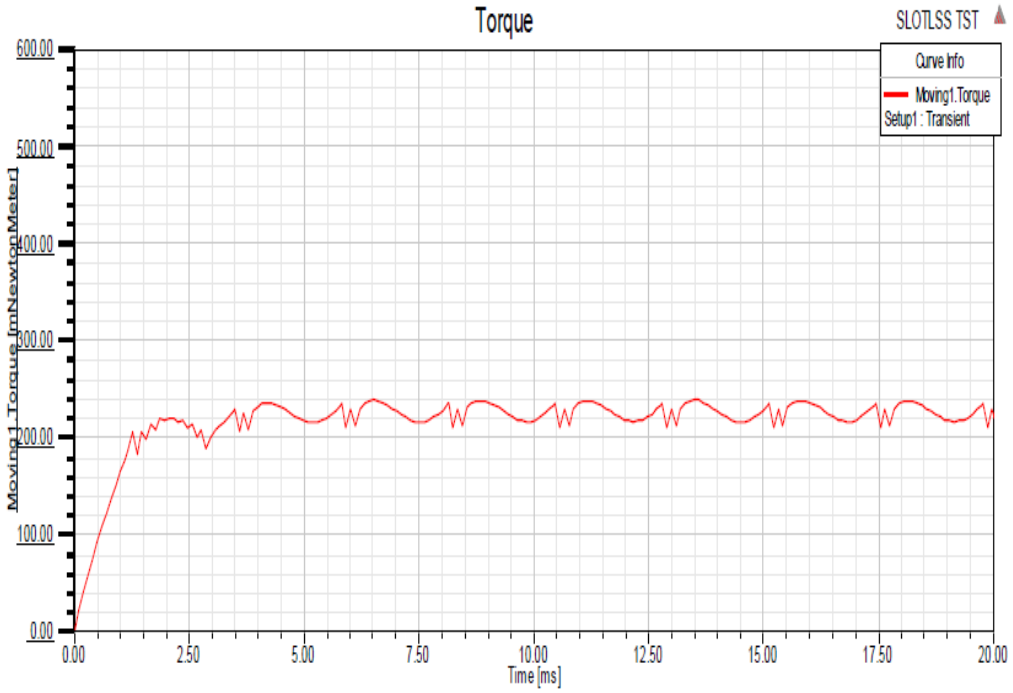

Fig. 4 Output torque of slotless BLDC motor

From the graph of output torque of slotted and slotless BLDC motor it is clear that the average output torque of a slotless BLDC motor is higher than slotted BLDC motor. Also the torque ripples in slotless motor is very minimum compared to slotted BLDC motor

The cogging torque of both motors is obtained in Maxwell. Cogging torque is caused due to the variation of magnetic energy in the air gap. Simply this torque ripple is due to the interaction between the rotor magnetic flux and the variation of stator. Cogging torque of slotted BLDC motor obtained is shown in Figure 5.

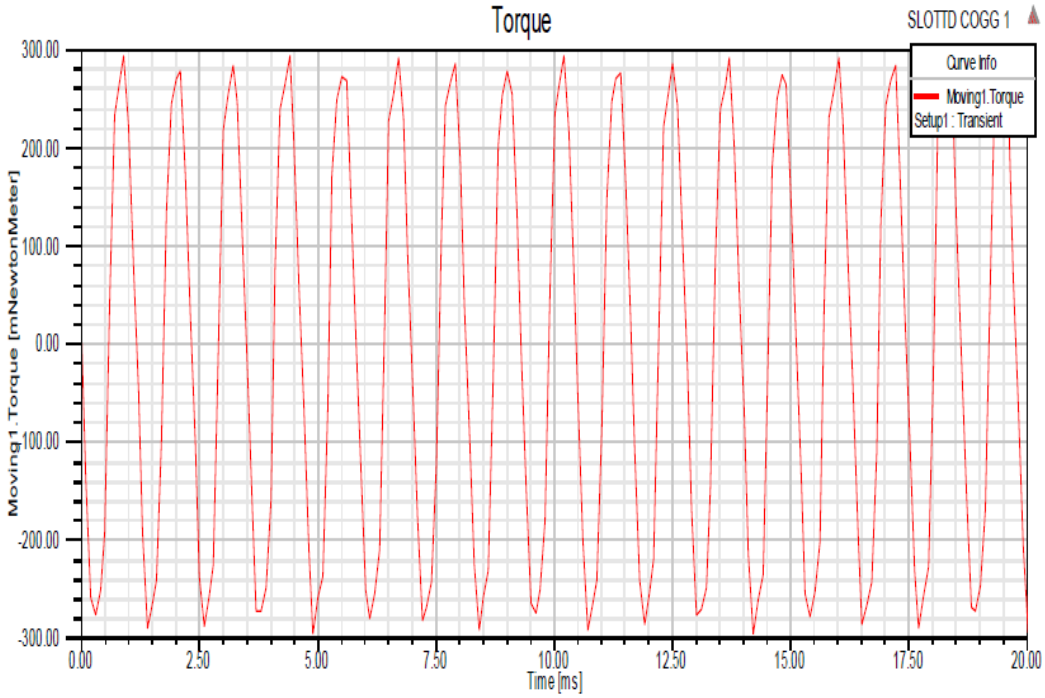

Fig. 5 Cogging torque of slotted BLDC motor

The cogging torque obtained for slotless BLDC motor is shown in Figure 6. This cogging torque waveform clearly shows the torque ripple minimization.

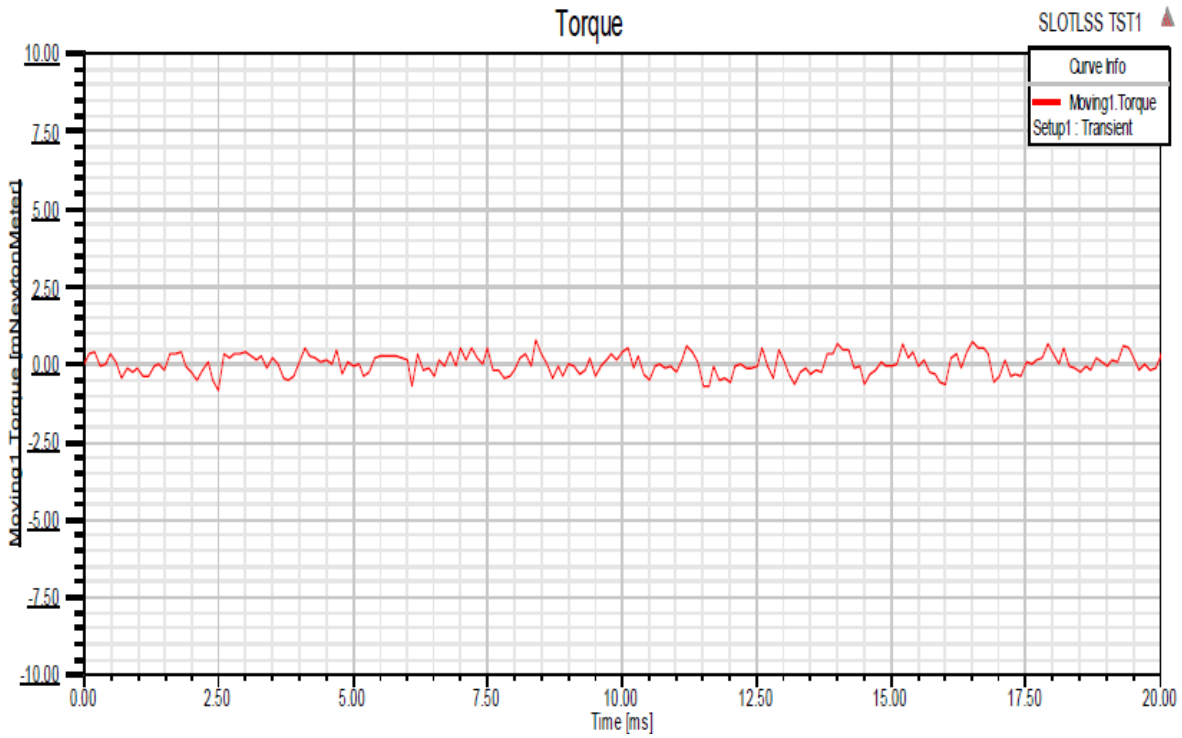

Fig. 6 Cogging torque of slotless BLDC motor

By comparing the cogging torque waveforms it is clear that the cogging torque is high in slotted BLDC motor and is almost zero in slotless BLDC motor. So the slotless BLDC motor has less vibrations and heating problems. These advantages make it suitable for biomedical applications.

The inductance variation in the air gap is an index showing the current response of the motor. The inductance variation in slotted BLDC motor is shown in Figure 7.

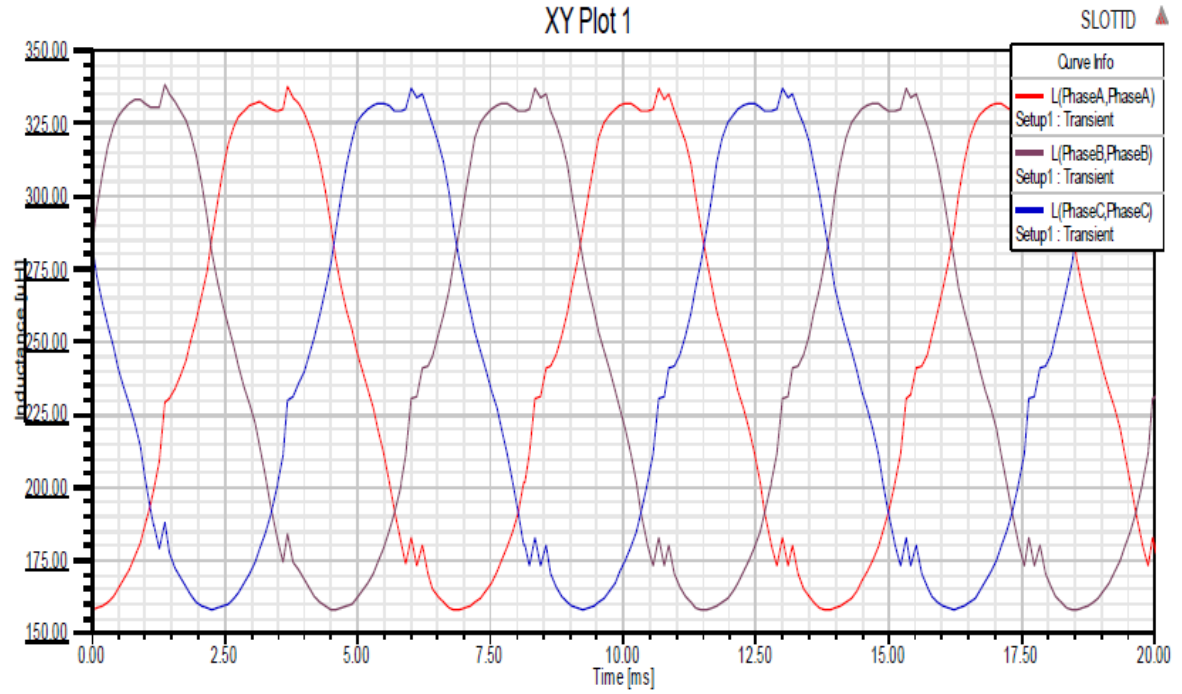

Fig.7 Inductance variation of slotted BLDC motor

The variation of inductance of slotless BLDC motor is shown in Figure 8.

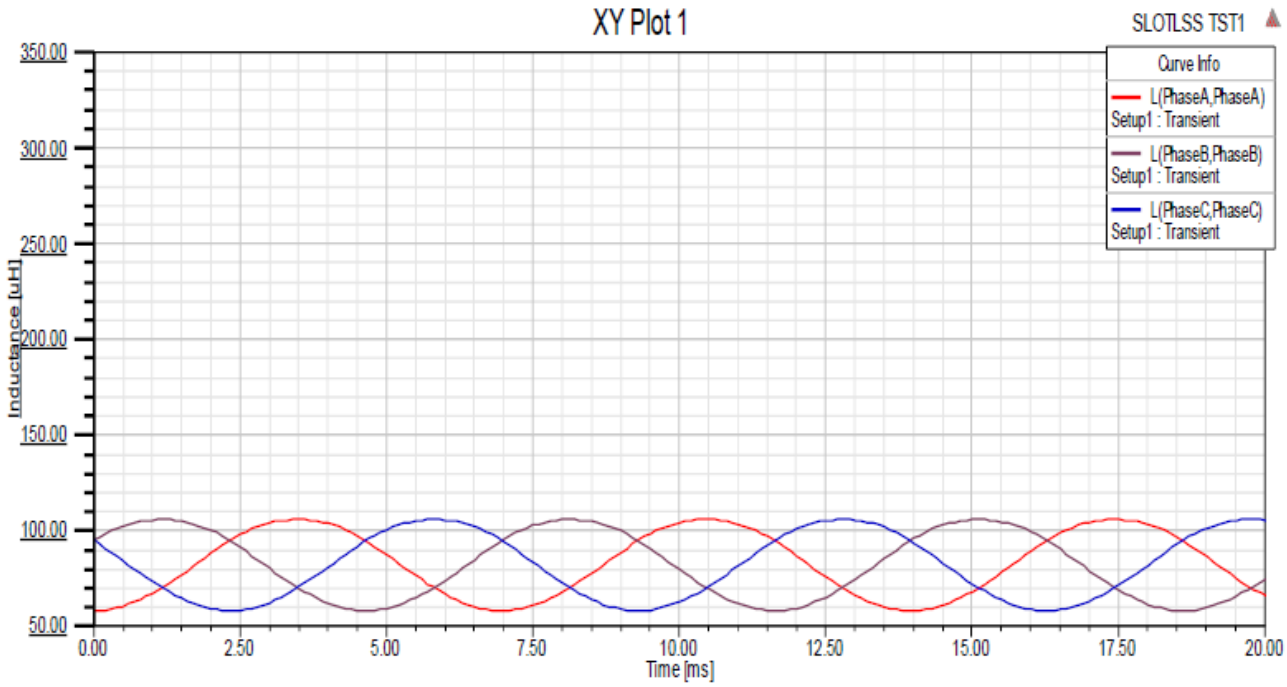

Fig. 8 Inductance variation of slotless BLDC motor

By comparing the inductance variation of both motors it is clear that the inductance of slotless BLDC motor is very less than the slotted BLDC motor. A lower inductance means faster current response. So the slotless BLDC motor gives faster response than slotted BLDC motor.

III. Conclusions

In this paper the comparison of performances of slotted and slotless BLDC motor is done and discussed. The slotless BLDC motor gives a higher output torque; the cogging torque is almost zero in slotless BLDC motor whereas it is high in slotted BLDC motor so the vibration and noises are very less for slotless BLDC motor. Also the inductance variation of slotless BLDC motor is very less compared to slotted BLDC motor so it gives a faster current response than slotted BLDC motor. It verifies that the slotless BLDC motor is the better choice for biomedical applications

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