老叶说事
《高阶会员专属-第7期》

IEEE Access 期刊跟一般IEEE期刊有何不同？

导读一篇論文並介紹軸向磁通電機！

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TABLE 1. Comprehensive and concise literature survey.

Topology	Adopted techniques	Motor type	Applications	Reliability	Torque ripple mitigation	Ref
Fault-tolerant control (FTC)	Sensory fault tolerance is improved by detecting the fault using discrete Fourier transform.	10 poles 3 phase BLDC	Industrial and commercial applications.	✓	--	[15]
Electromagnetic interference (EMI)	A LISN network is used in such a way that it reduces load parasitic elements.	4 poles 3 phase BLDC	Commercial applications.	✓	--	[16]
Torque ripple reduction using scalar control	Torque ripples are reduced by synthesizing the current wave of power supply.	4 poles 3 phase BLDC	Industry applications.	--	✓	[17]
Torque ripple reduction using vector control	Torque ripples are reduced by using MPC Scheme.	8 poles 3 phase BLDC	Industry applications.	--	✓	[18]
Torque ripple reduction using design topology	Torque ripples are reduced by optimizing the stator and rotor structure.	4 poles 3 phase BLDC	Industry applications.	✓	✓	[19]

TABLE 2. Comparison of the inner and outer rotor features.

BLDC motor physical design	Inner Rotor	Outer rotor
Stator	• Iron less core stator winding outside.	• Iron cored stator winding inside.
Speed	• High-speed motors are available.	• Low and medium speed motor available.
Inertia	• Low inertia	• High inertia
Noise	• Quickly changing direction makes noisy.	• Noise less.
Maintenance	• Less maintenance.	• High maintenance.
Efficiency	• High efficiency.	• Less efficiency compares to the inner rotor.
Torque	• Minimum torque.	• Produce more torque.
Power to weight ratio	• Compare to outer run less.	• High.
Gear box	• Gear box required.	• No gear box required.
Advantage	• Rotating shaft moment of inertia is small. • Heat dissipation efficiency high. • Reduce the downsize unit. • Compact size. • High output power.	• Increasing the torque capability and current. • Reducing heat dissipation. • Low cogging force. • Large airgap. • Increase torque.
Disadvantage	• Requires high magnetic flux density. • Need high-performance magnet. • High cogging force.	• Complex to design rotor embedded with magnets. • Mechanical stability. • Cooling stator winding.

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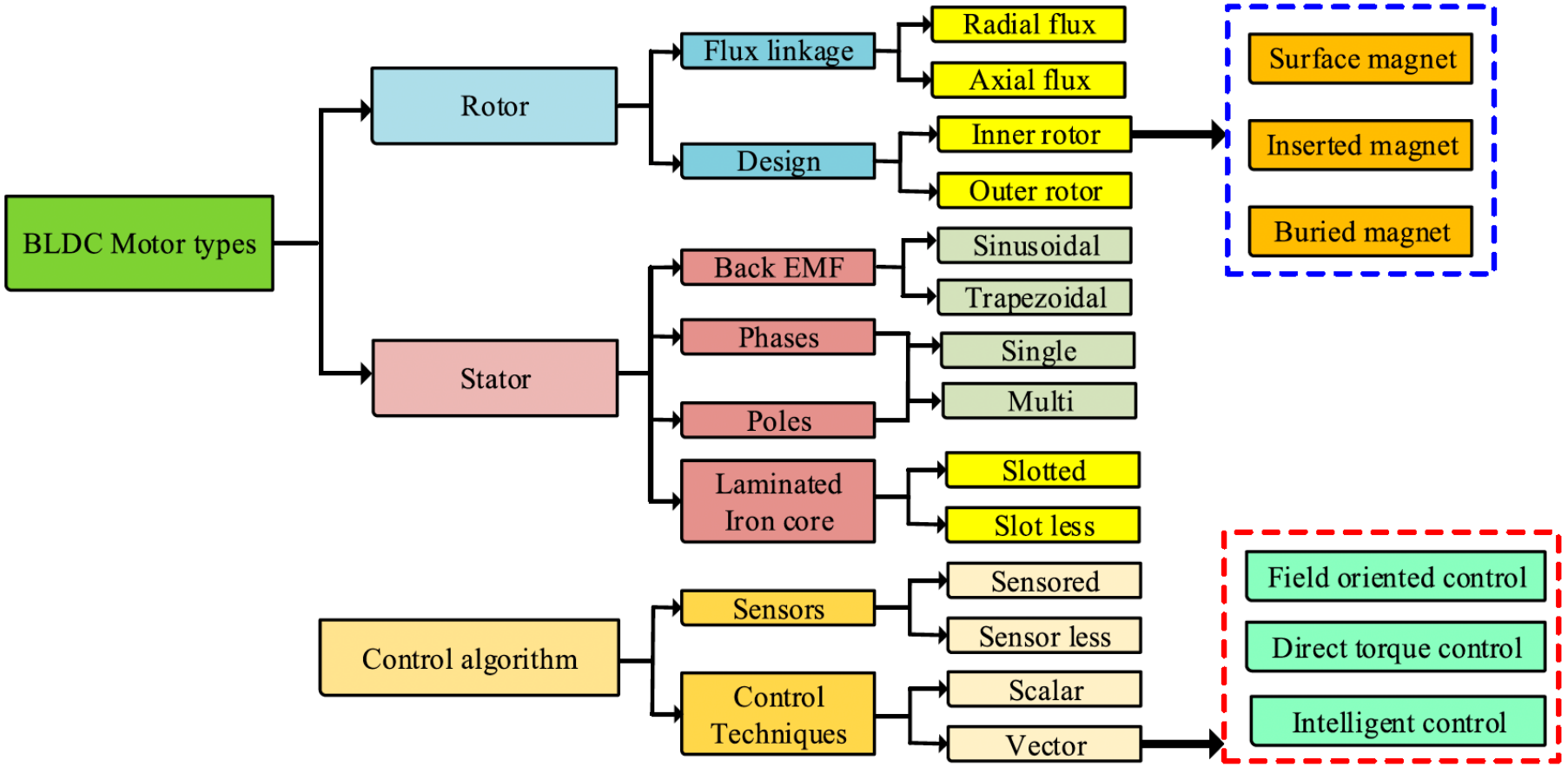

FIGURE 4. Types of BLDC motor and control algorithms.

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Content	Surface magnet	Inserted magnet	Buried magnet
PM rotor structure			
Torque/weight ratio	• Very good.	• Very good.	• Very good.
High-speed running capability	• Less preferred for high-speed operation.	• Compared to surface mounted it has a good affinity towards high-speed operations.	• It shows the best performance at high speed.
Power factor	• Power factor obtained is less.	• Power factor obtained is less.	• Power factor obtained is good.
Efficiency	• Less compared to buried.	• Less compared to buried type.	• Very high compared to the other types.

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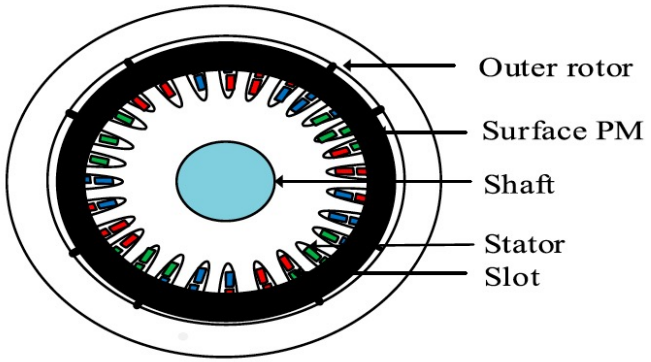

FIGURE 5. Outer rotor (Hub motor).

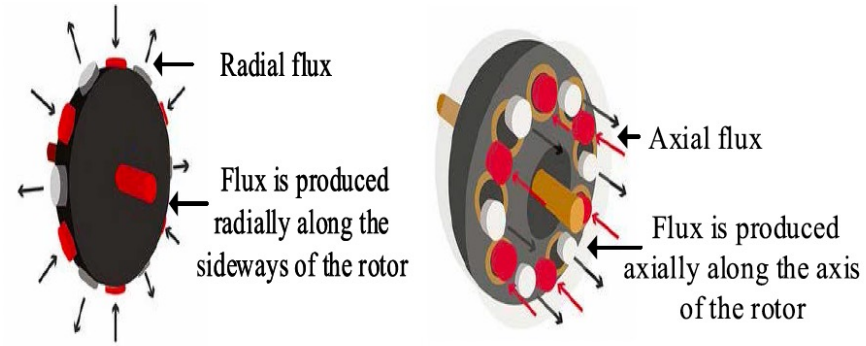

FIGURE 6. Radial and axial flux.

TABLE 4. Electromagnetic axial and radial flux path difference.

Magnetic flux direction	Axial flux	Radial flux
Flux direction strength	• Flux-path is shorter.	• Flux-path is longer.
Magnetic field	• Strong	• weak
Efficiency	• High	• Compare to axial low.
Power density	• High	• Minimum.
Direction	• Flux unidirectional path.	• 2D dimensional path.
Iron loss	• Decreasing iron loss.	• Iron loss maximum.
winding	• Minimum heat conductivity.	• Low thermal conductivity.
diameter	• High	• Medium
Active length	• Minimum	• High
Mass	• Low	• High
Output voltage	• High	• Low.
Outer rotor	• High torque.	• Less torque.

single-phase and three-phase motors are used. Three-phase, five-phase, and seven-phase motors are preferred for dynamic

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TABLE 5. BLDC stator slotted and slotless structure features.

Stator structure	Slotted	Slotless
Advantages	• Uneven magnetic pull. • High power density. • Higher order spatial harmonics. • Easier to protect.	• High power density. • Low cogging torque • Better overload capacity. • Limit the operational noise. • Increase operating frequency.
Disadvantages	• Volume of the machine size is big. • Poor overloading. • High cogging torque. • Enables to operate at high speed. • Less efficiency. • Increasing noise and vibration.	• Low inductance to control motor is challenging. • Not suitable for harsh environmental conditions.