A SPLIT-TAPPED TOPOLOGY OF INTERIOR PERMANENT MAGNET SYNCHRONOUS MACHINE FOR ELECTRIC VEHICLES

IITM Technology Available for Licensing

Problem Statement

- **Multi-speed transmission technology** for electric vehicles (EVs) enhances **efficiency**, and optimizes **performance** across **varying speed modes.**
- **Conventional EVs** use either **mechanical gearboxes** or **single-inverter systems** to manage speed, torque, and performance adjustments. However, these systems are **bulky, complex and require higher battery voltage**, leading to **inefficiencies,** increased **costs**, and **reduced reliability**.
- There is a **need for an improved system that offers better torque-speed control**, lower voltage requirements, and enhanced reliability over traditional methods

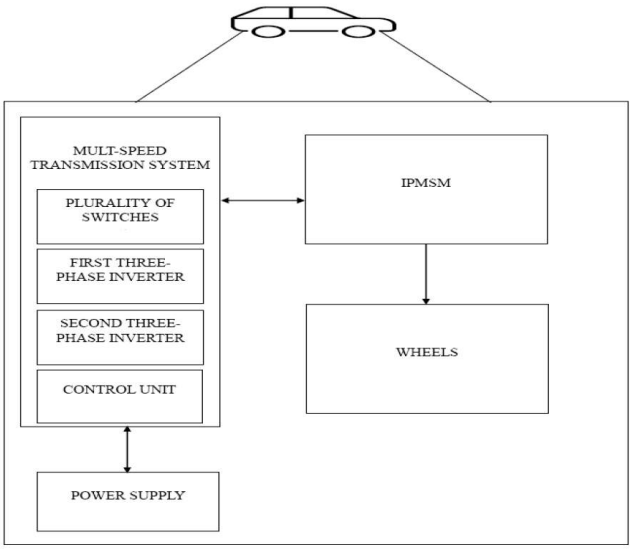

Figure: A block representation an electric vehicle configured to operate in multi-speed mode

Intellectual Property

- IITM IDF Ref 2935
- **IN 202441037588 Patent Application**

TRL (Technology Readiness Level)

TRL 4 Technology Validated in Lab

Technology Category/ Market

Category- Automobile & Transportation

Industry Classification:

Electric Vehicles; Powertrain Systems; Power Electronics

Applications:

Transmission for Electric Vehicles; Hybrid Electric Systems; Low-Voltage EV Systems

Market report:

The global electric vehicle (EV) transmission market size was valued at USD 11.32 billion in 2024 is projected to grow to USD 28.99 billion by 2032 exhibiting a CAGR of 12.2%

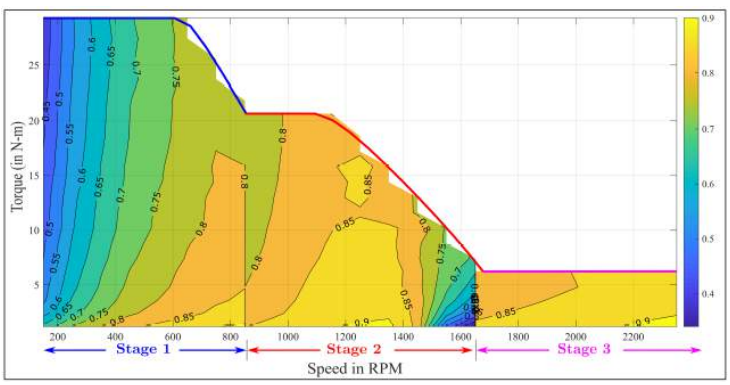

Figure: Experimental torque and efficiency plot. This highlights the Split Tapped Interior Permanent Magnet Synchronous Machine's (ST-IPMSM's) precise torque-speed characteristics, significant efficiency gains in the field-weakening region, and energy savings across diverse driving conditions. It demonstrates consistent performance under varying loads, ensuring reliability and adaptability offering reduced energy consumption and operational costs.

Research Lab

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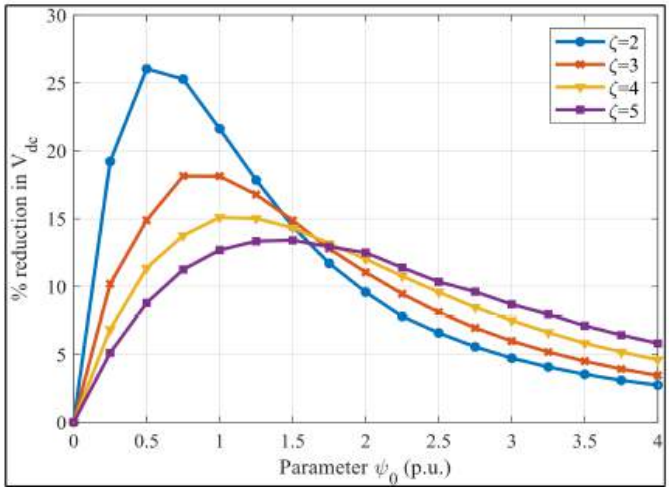

Figure: Reduction in V_{dc} as a function of ψ_0 . The extent to which the reduction of V_{dc} is obtained has been generalized for all IPMSMs and shown in the figure. It is observed that with a careful design of the machine, approximately 26% reduction in V_{dc} can be obtained for the chosen gear ratio.

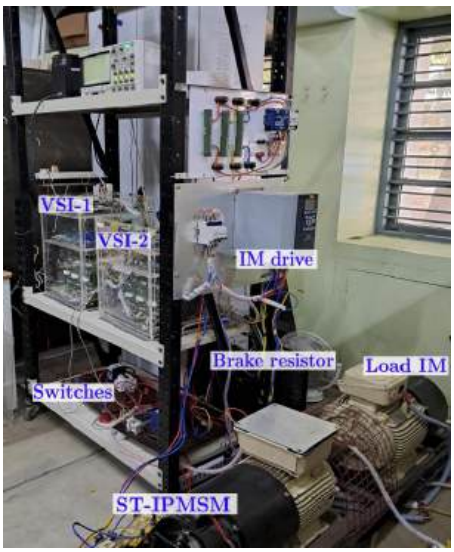

Figure: The proposed concepts have been validated on a 3.7kW IPMSM setup.

Technology

The Split-Tapped Interior Permanent Magnet Synchronous Motor (ST-IPMSM) offers a 3-speed transmission system for electric vehicles, utilizing split winding configurations and two voltage source inverters for precise torque-speed control and enhanced efficiency.

Split ratio and tap ratio define winding configurations, with tested values of 0.75 and 0.667, respectively. The motor operates with a common DC bus voltage of 320V, reducing voltage requirements by up to 26%.

Achieves higher power factor and efficiency in the field-weakening region, ensuring optimal energy usage across speed stages. The system supports flexible torque ratio based on application requirement.

Two independent inverters allow uninterrupted power during stage transitions, enabling reliable operation and fault tolerance. Smooth winding change-over ensures continuous operation even under demanding conditions.

Reduces mechanical complexity, operational costs, and energy consumption. Supports diverse EV applications with customizable torque-speed profiles, providing superior adaptability, scalability, and significant long-term cost savings for manufacturers.

Key Features / Value Proposition

- The ST-IPMSM achieves higher efficiency, especially in the field-weakening region, by leveraging split winding configurations and dual inverters, reducing energy losses compared to conventional single-inverter or mechanical transmission systems.
- The system reduces DC bus voltage by up to 26%, lowering battery and inverter specifications. This minimizes costs and enhances compatibility with lower voltage systems compared to conventional tapped winding or multi-phase topologies.
- Dual inverters provide redundancy, enabling uninterrupted operation during faults or stage transitions. Conventional systems lack this feature, making them less reliable in real-world applications.
- The invention supports precise torque-speed ratios tailored to specific vehicle requirements, unlike traditional systems that lack flexibility or require oversizing motors for broad application ranges.
- By eliminating mechanical gearboxes and utilizing efficient winding reconfiguration, the ST-IPMSM reduces mechanical complexity, maintenance needs, and manufacturing costs compared to gear-based or complex inverter-driven systems.

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