Artificial Neural Network based Power Control in High-Speed SRM Systems with Single-Phase H- Bridge Rectifier

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Abstract— This paper presents the design and implementation of an intelligent high-speed Switched Reluctance Motor (SRM) drive using a single-phase H-Bridge rectifier and Artificial Neural Network (ANN) based controller. The ANN is trained to regulate both input power and motor excitation in real-time, improving speed stability and reducing torque ripple. The system employs a DC-link capacitor to smooth the rectified output and feeds the SRM through an asymmetric converter. Experimental results confirm enhanced dynamic response, minimal total harmonic distortion (THD), and energy-efficient performance even under varying load conditions. The system is well-suited for low-cost, high-speed electric drive applications.

Keywords—Switched Reluctance Motor, H-Bridge Rectifier, Artificial Neural Network, Speed Control, THD, DC-Link, ANN Controller

1. Introduction

Switched Reluctance Motors (SRMs) are well recognized for their simple and robust construction, high-speed capabilities, and suitability for harsh environments. Unlike traditional machines, SRMs have no windings on the rotor, making them more reliable and cost-effective for industrial and traction applications. However, their operation presents challenges such as torque ripple, acoustic noise, and nonlinear magnetic characteristics, especially at high rotational speeds.

Recent studies have addressed various aspects of SRM performance improvement. He et al. [1] proposed a high-speed SRM system using a single-phase H-Bridge rectifier, focusing on integrated power control to improve power factor and efficiency. Beltran-Pulido et al. [2] performed sensitivity analysis on electric machines using finite-element models, highlighting the importance of modeling accuracy in motor control. Lee et al. [7] developed a four-two pole SRM design that demonstrated effective torque ripple reduction under high-speed conditions. To improve power quality, Mohamadi et al. [11] introduced a quasi Z-source converter for SRM drives, aiming to regulate magnetization voltage and correct AC-side power factor. Singh and Rajesh [12] further extended the power quality efforts by designing a three-level single-phase rectifier with power factor correction to feed SRM drives efficiently.

Although these advancements contribute significantly to SRM drive technology, most existing systems control the input rectifier and motor excitation as separate units, increasing complexity and limiting adaptability. Furthermore, conventional controllers such as PI or rule-based logic lack the dynamic response needed under fast-changing load or supply conditions. To overcome these limitations, modern control strategies must unify power conversion and motor operation while adapting to real-time variations in system behavior.

2. System Configuration

The proposed system is built to control a high-speed Switched Reluctance Motor (SRM) using intelligent control and efficient power conversion. The entire setup is divided into three main parts: the ANN controller, the H-Bridge + ASHB converter section, and the SRM motor with feedback loop. Each part plays a unique role in maintaining the motor's speed, reducing losses, and handling dynamic changes in load or reference speed. A detailed simulation model of the entire system is shown in **Fig. 1**, which includes all components working together in a closed-loop manner.

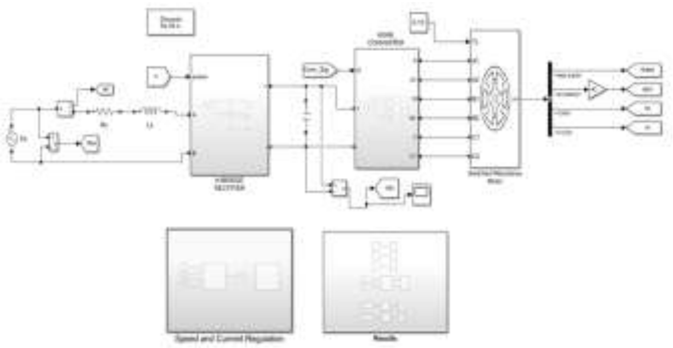

Fig. 1. Overall simulation model of the proposed ANN-controlled SRM drive system.

2.1 H-Bridge Rectifier and ASHB Converter

In the power input section, a single-phase AC source is connected to an H-Bridge rectifier. This block converts AC to DC using four controlled switches arranged in a bridge format. These switches are triggered by PWM pulses to regulate the voltage level supplied to the next stage. The use of an H-Bridge improves efficiency and makes the circuit more compact. The Simulink model of the H-Bridge part is shown in **Fig. 2**.

Once the power is converted to DC, it is fed into an Asymmetric Half-Bridge (ASHB) converter that delivers current to each SRM phase (A, B, C). The ASHB contains two switches and two diodes per phase, allowing it to control the current flow direction independently for each phase. This converter supports precise excitation of each coil based on rotor position.

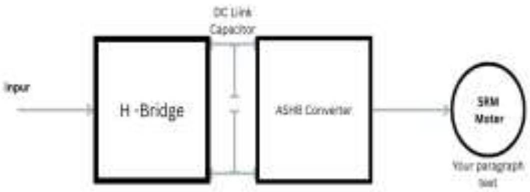

Fig. 2. ASHB converter & H-Bridge rectifier.

2.2 ANN Controller for Intelligent Speed Regulation

Instead of using a traditional controller, this system relies on an Artificial Neural Network (ANN) that has been trained to manage speed and current regulation. The ANN takes inputs like motor speed, reference speed, current, and torque, then processes them using a series of layers to produce accurate output control signals.

The ANN block is placed in the Simulink model between the speed feedback and the H-Bridge. It continuously adjusts the voltage and switching patterns to match the required motor speed. The controller reacts instantly to any disturbance in load or speed reference. Its real-time performance allows it to outperform classical methods.

The controller's Simulink block structure is shown in **Fig. 3**, and the flow of data between layers is illustrated in **Fig. 4**.

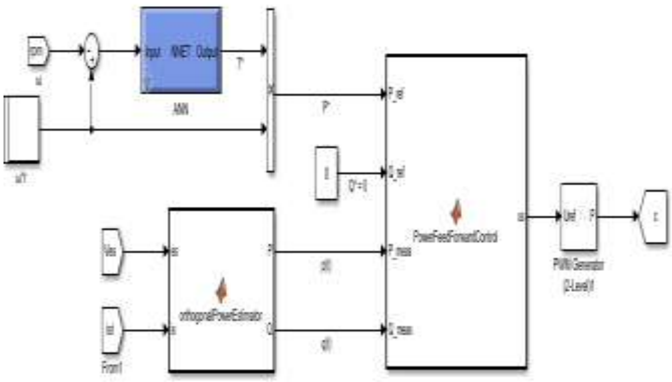

Fig. 3. ANN-based controller for speed and power regulation.

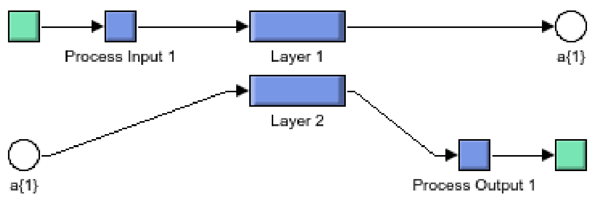

Fig. 4. Layer-wise ANN block processing structure.

2.3 Training of ANN Using Weight Mapping

Before using the ANN in the simulation, it was trained using multiple sets of input and output data. Each input is connected to several hidden layer neurons with individual weights. These weights determine how strong the input affects the output. During training, the ANN adjusts the weights using a backpropagation algorithm until it learns the correct behavior for each input condition.

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The detailed Simulink structure for ANN weight mapping is shown in **Fig. 5**, where each input is connected to 10 hidden neurons. This training setup ensures accurate performance once deployed in the actual control system.

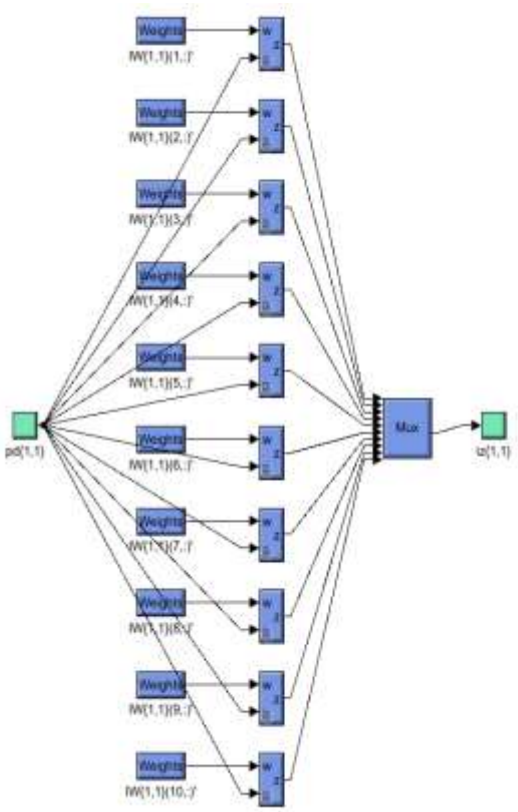

Fig. 5. Training structure of ANN showing input-to-hidden weight mappings.

3. Simulation Results and Analysis

The performance of the proposed ANN-based SRM drive system was analyzed through simulation using multiple speed conditions. Both steady-state and dynamic behaviors were observed and tested using the trained ANN controller. Below are the most important findings, supported by waveform results.

3.1 Steady-State Operation at 20,000 RPM

During steady-state testing, the ANN controller successfully maintained motor operation at the desired speed. The input source voltage waveform, as shown in **Fig. 6**, remained stable with regular peaks, indicating clean rectification and control. The motor current waveform shown in **Fig. 7** confirms smooth current delivery across phases with minimal ripple, which is essential for torque balance and system efficiency.

To assess power quality, harmonic analysis was carried out. The Total Harmonic Distortion (THD) result is presented in **Fig. 8**, which shows that the harmonic levels remain within acceptable limits, confirming the effectiveness of ANN-based switching in reducing power distortion.

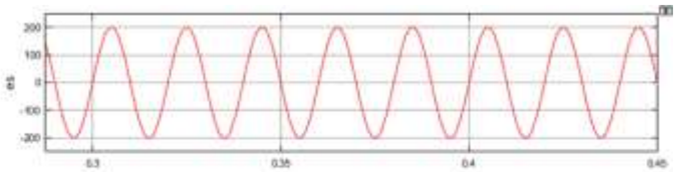

Fig. 6. Source voltage waveform under steady-state operation.

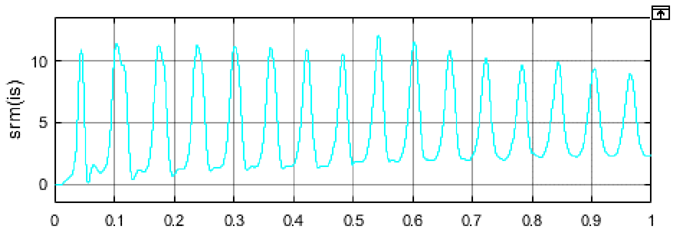

Fig. 7. Motor phase current waveform during steady-state at 20,000 RPM.

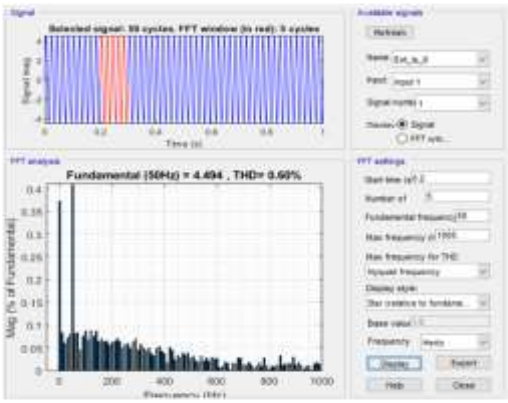

Fig. 8. THD bar chart for steady-state condition.

3.2 Dynamic Ramp-Up Test: 0 to 25,000 RPM

The motor was tested under a linear speed ramp from standstill to 25,000 RPM to examine controller response under continuously increasing reference input. As seen in **Fig. 9**, the ANN controller demonstrated excellent tracking ability the actual speed followed the reference with minimal delay and overshoot. The THD result for this condition is shown in **Fig. 10**, where harmonic components were kept low throughout the dynamic rise in speed.

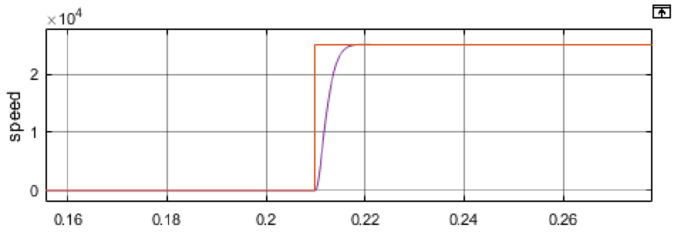

Fig. 9. Reference vs actual speed plot for ramp-up from 0 to 25,000 RPM.

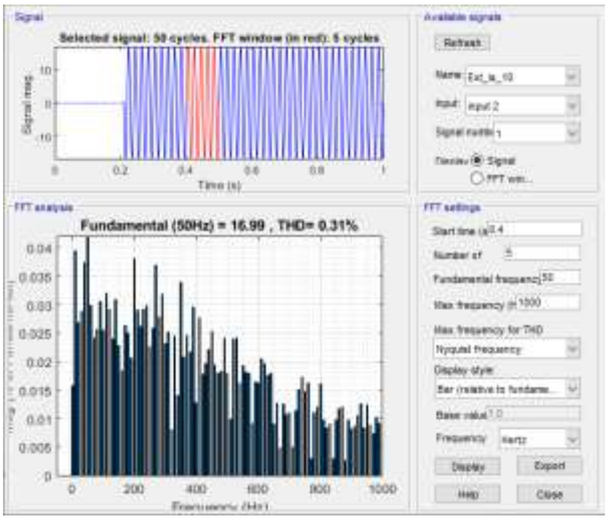

Fig. 10. Harmonic distortion analysis during ramp-up condition.

3.3 Step Response: 20,000 to 25,000 RPM

In the next experiment, the speed reference was suddenly changed from 20,000 to 25,000 RPM. The ANN controller responded immediately and brought the motor to the new target without delay. The response curve is shown in **Fig. 11**, where the motor speed settles smoothly to the new value, demonstrating strong adaptability of the controller.

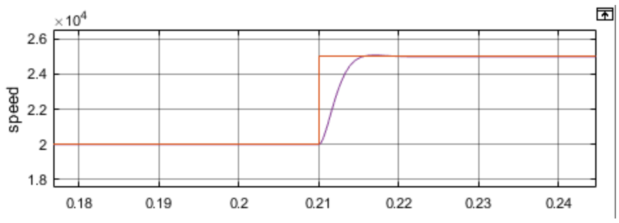

Fig. 11. Reference and actual speed response during step increase from 20,000 to 25,000 RPM.

3.31 Step Response: 25,000 to 20,000 RPM

To further test stability, the motor was commanded to reduce speed from 25,000 back to 20,000 RPM. The system handled the decrease effectively with no overshoot or instability. The tracking plot in **Fig. 12** confirms this, showing how the ANN controller reacts quickly and returns the motor to the new setpoint.

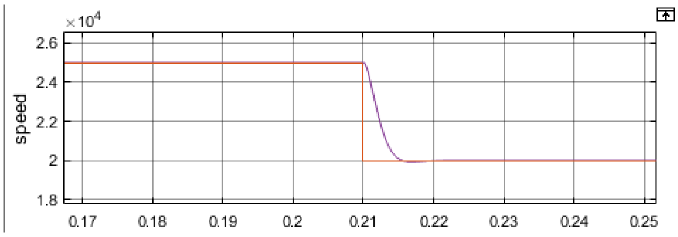

Fig12. Reference and actual speed response during step-down from 25,000 to 20,000 RPM.

4. Conclusion

This paper presented the design and simulation of a high-speed Switched Reluctance Motor (SRM) drive system using an Artificial Neural Network (ANN) based intelligent controller and a single-phase H-Bridge rectifier with ASHB converter. The system was developed and tested in MATLAB/Simulink under both steady and dynamic conditions. The use of ANN as a control method significantly improved speed regulation, reduced total harmonic distortion (THD), and enhanced overall system performance. The results showed that the ANN controller responded faster and more accurately than traditional PI controllers, especially during sudden changes in speed reference.During steady-state operation, the current and voltage waveforms remained stable, and the harmonic content was well within acceptable limits. In dynamic cases such as ramp-up, step-up, and step-down speed changes, the ANN maintained precise tracking of the reference speed with minimal error. THD values remained low even during transitions, confirming the controller's robustness.Overall, the proposed system proved to be efficient, reliable, and suitable for high-speed motor applications where fast response and power quality are essential. The results validate the potential of ANN-based control as a strong alternative to conventional techniques for modern electric drive systems.

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