

FPGA-Based PWM Controller for Motor Speed Control on Xilinx Spartan-7

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Abstract

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Abstract:

This paper presents an FPGA-based pulse-width modulation (PWM) controller designed for precise motor speed control using a Xilinx Spartan-7 board. Leveraging the parallel processing capabilities of FPGAs, the proposed system implements a high-resolution PWM generation algorithm using hardware description languages, enabling efficient and reliable control over motor dynamics. A comprehensive literature survey identifies existing methods and their limitations, underscoring the need for improved performance in terms of response time, energy efficiency, and system scalability. The design process is rigorously developed and validated through simulation and synthesis using the Vivado Design Suite. Key metrics such as timing analysis, resource utilization, and critical path performance are examined to ensure the robustness of the controller. Experimental results, obtained from simulation waveforms and real-time motor testing, reveal that the FPGA-based approach delivers superior performance compared to conventional analog or microcontroller-based PWM controllers. A detailed comparative analysis highlights enhancements in switching accuracy, dynamic response, and overall system efficiency. The contributions of this work include a novel implementation strategy for PWM signal generation on Spartan-7 devices and an in-depth evaluation of its practical performance in motor control applications. The insights gained from the design trade-offs and performance metrics provide a valuable reference for future research and development in the domain of digital control systems and embedded motor drive applications.

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