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A Solar Energy Framework: Solar System Design For Thermal Applications With Implementation of FPGA

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Abstract

The development goals of the government of Pakistan underscore the implementation of renewable energy resources to ensure environmental improvement for the future. Affordable energy, clean energy, and innovation in infrastructure are the pertinent development goals applied to the energy sector. Currently, digital technologies have significant potential to achieve the target of the effective use of renewable energy resources in the energy sector. With this motivation, this research aims to highlight the significance of different digital technologies used for energy system controllers in the industry, playing a pivotal role in the effective and efficient use of resources. Among renewable energy resources, solar energy stands out as an ideal choice for a country like Pakistan. In Pakistan, the cost of energy is escalating day by day, posing challenges for industries to remain competitive in the international market. Considering the primary export-based industries in Pakistan, such as textile and leather, which require a substantial amount of energy to meet their continuous demand for hot water and steam, there is a need to transition their systems to renewable energy sources like solar energy. To optimize the efficiency of a solar thermal system, a high-speed, efficient, and precise controller is essential. For this purpose, an FPGA control system is a robust candidate compared to other controllers or microcontrollers. During this research, an FPGA-controlled system was previously designed for a domestic heating system, revealing that an FPGA-controlled thermal system is more economical, efficient, flexible, and reliable to operate than other existing systems controlled by different digital technologies. Secondly, a solar energy framework is designed in line with the requirements of the textile and leather industry in Pakistan, where water heating and steam generation systems are extensively utilized. This is achieved by designing an efficient FPGA-based controller. The system is simulated using TRNSYS for thermal aspects, while Xilinx and Quartus are employed for the controller. It is specifically tailored for use in the textile and leather processing industry, particularly for water heating at 75℃ and steam generation at 150℃ and 220℃. A comprehensive design methodology for the water heating system and steam generation system is discussed, and simulation-based results are presented in this research. Simulations demonstrate the superior performance of the water heating system and steam generation system, exhibiting smaller deviations for disturbances and minimum overshoot.

Keywords
Solar Energy, Thermal Applications, FPGA Implementation.

Biography
Hafiz Usama Hashmat is currently enrolled for a Ph.D. degree in Mechanical Engineering at The University of Lahore, Lahore, Pakistan. He completed his M.S. Engineering degree in March 2013 from the University of Engineering and Technology Lahore. He completed his B.S. Engineering degree in 2008 from University of Engineering and Technology Lahore. His areas of current interest include automation, electronics and robotics. Hafiz Usama Hashmat has been teaching Electrical, Electronics and Mechanical Engineering subjects since January 2011.

His first appointment was at North East China International Electric Power Corporation (NEIE), Lahore as Project Engineer in June 2008. He worked for two years in Electrical Power Projects in the Northern areas of Pakistan. His first appointment in teaching was at the Electrical Engineering department, National University of Computer and Emerging Sciences, FAST-NU, Lahore campus in January 2011. His teaching experience includes nine months at National University of Computer and Emerging Sciences, FAST-NU, Lahore and more than seven years at The University of Lahore. He has been an Assistant professor in Faculty of Engineering and Technology at The University of Lahore, since June 2013. He has taught different courses and supervised undergraduate students during his teaching.