

## Analysis and performance evaluation of PD-like fuzzy logic controller design based on Matlab and FPGA

### ABSTRACT

This paper presents an analysis and performance evaluation of the proportional-derivative (PD) fuzzy logic controller design by using Matlab and field programmable gate array (FPGA). The fuzzy logic controller consists of a Fuzzifier, inference engine and Defuzzifier; the Fuzzifier block accepts two PD inputs. Two types of controller are designed; the first one is using fuzzy logic toolbox in Matlab. The second type is designed using VHDL language for implementation on FPGA. Mathematical models of robot arm and bench-top helicopter are used for the purpose of simulation with the first type. This controller is used with a unity feedback control system in Matlab Simulink, in order to control these systems and to generate the simulation results. The best response with the robot arm has 0.02 errors and zero overshoot, and the best response with the bench-top helicopter has 0.01 error with 0.001 overshoot. Altera Quartus II and ModelSim simulation program are used to generate the simulation results of the second type. A mathematical model that represents industrial processes, such as temperature, pressure, pH, and fluid-level controls with unity feedback control systems and subjected to 0.2 step input is used to generate these results. This FPGA-based controller is able to produce a fast response ranging from 0.3 s, even with time delay added with the plant model.

**Keyword:** Bench-to helicopter; Field programmable gate array; Fuzzy logic controller; Industrial processes; Robot arm