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Summary Report

Project Title: Mitigation of Adverse Effect of E3 HEMP on Power Transformers by Intelligent Controller Based Variable Resistor.

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Summary: This research was conducted as an undergraduate design project, where three undergraduate students registered for the Energy Conversion class project in the Fall 2023 semester. The project was continued until the Spring 2024 semester. The goal of the project is to design a novel and cost-effective method of mitigating the adverse effects of E3 high altitude electromagnetic pulse (HEMP) on transformers by using a nonlinear and intelligent controller based variable resistor which is connected in parallel to the transformer neutral. A switch will be connected in series with the transformer neutral. Under normal operating conditions, almost no current flows through the neutral of a transformer, therefore the switch remains in a closed state and activation of the variable resistor is not required. Under E3 HEMP conditions, any current flow through the neutral of the transformer will be detected by the proposed controller, which would then send a signal to the switch to get it opened. The variable resistor will be in the circuit and will impede the flow of current through the neutral, thereby protecting the transformer from getting overheated. Some noteworthy features of the proposed solution are: i) It is simple and cheap; and ii) In addition to mitigating the adverse effects of E3 HEMP, it can also suppress the flow of geomagnetically induced current (GIC) and zero sequence current caused by unbalanced faults as well as triplen harmonics in the power network, through the neutral of transformers.

Design Testing and Results: For this design project, the power system model as shown in Figure 1 was considered. A fuzzy logic controller was developed for the proposed variable resistor. Figure 2 shows the simulation results indicating the effectiveness of the proposed controller based variable resistor.

Conclusion: The proposed project has potential impact on the relevant field and application. The proposed intelligent controller based variable resistor can be a new method to suppress the adverse effects of E3 HEMP and GIC. Moreover, the proposed solution can be useful to electric power utilities and transformer manufacturing companies. Thus, the invention has a great commercial potential.

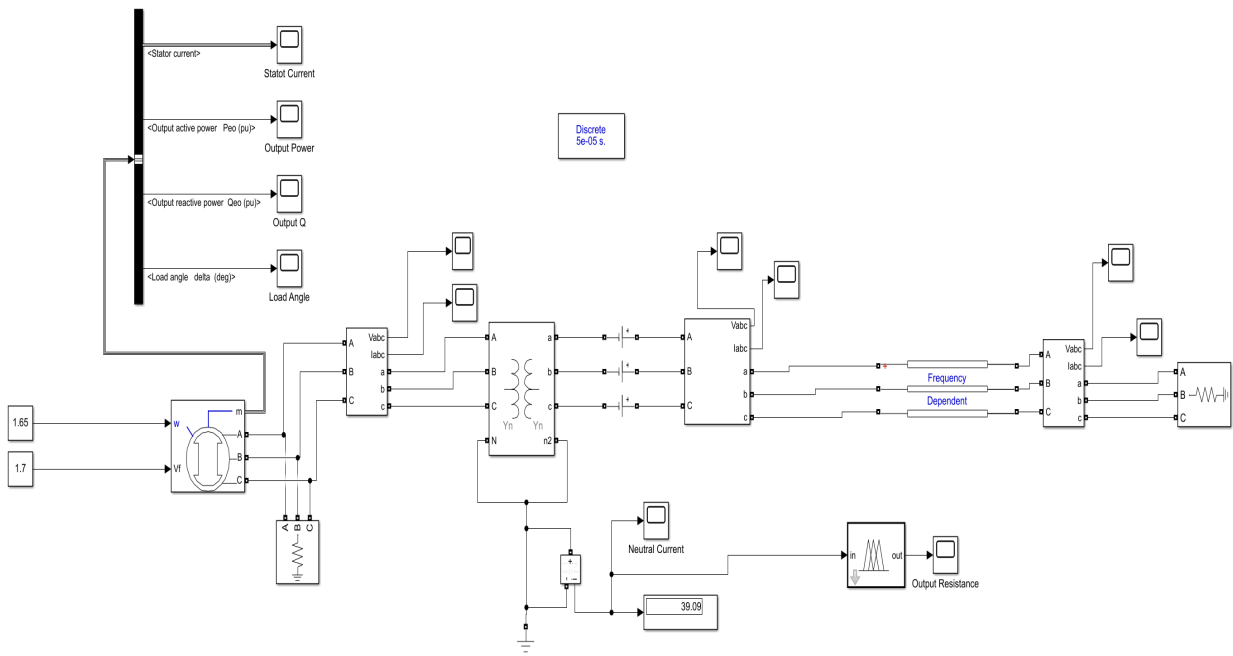


Figure 1. Power system model.

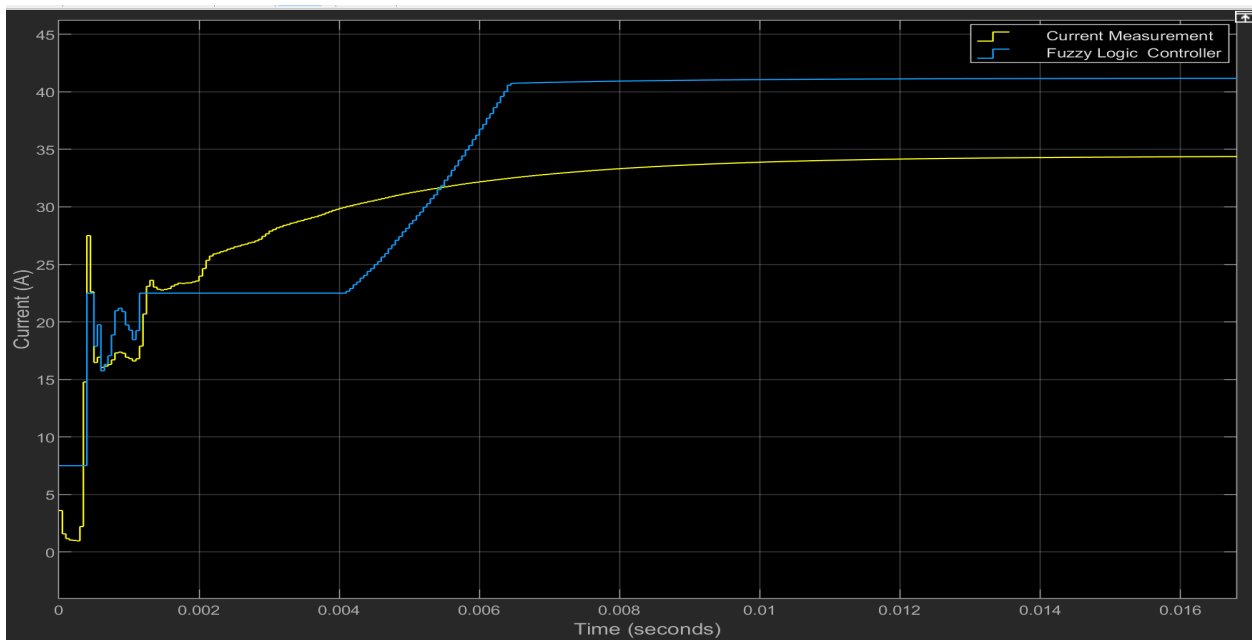


Figure 2. Performance of fuzzy logic controller.