A PV, Supercapacitor & PEM Fuel Cell based Fuzzy Logic Control for Energy Storage System for AC/DC Microgrids

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Abstract - Basically Energy storage is an important research area nowadays. Several storage systems have been made to store energy. In this paper, a photovoltaic, Supercapacitor and Proton Exchange Membrane based Fuel Cell (PV-SC/PEM Fuel Cell) based Hybrid Storage system for energy is implemented on MATLAB Simulink. The four sources are included PV arrays, PEM Fuel Cell, Supercapacitor and Battery, which are then fed on their respective dc-dc converters. After which tested on three phase load and DC load. The control system proposed is designed in such a way to reduce the fluctuations for output voltage and currents. The control system consists of fuzzy logic controller for error reduction and incorporation with previously existing PI and MPPT control for the PV arrays.

Keywords: PV, Fuel, PEM, Fuzzy, HESS, MATLAB

I. INTRODUCTION

Nowadays, Microgrids are the most rising as one of the promising answers for incorporate different sorts of conveyed sustainable power sources with the utility grid. [1] In spite of the fact that the current grids are AC grids, the present electrical burdens including power electronic based hardware's and appropriated sustainable power source age make DC micro grids increasingly attractive. [2] Consequently, AC/DC micro grid is by all accounts the best answer for dodge significant vitality misfortunes in numerous transformations. [3] Be that as it may, there are a few specialized difficulties in the basic execution of AC & DC combined micro grid, which should be tended to improve its efficiency. [4] These difficulties incorporate for the most part power the executives and its control. [5] Right now, present an idea of PV based and PEM fuel cell based AC/DC microgrid consists of the following representation as shown in Figure 1.

Both AC and DC microgrid are in a lot of demand and employing renewable energy sources in it, is in current research trends of power systems. [6][7] Microgrid basically constitutes small areas power supply, which may be required in the form of AC or DC voltage. [8] the protection of load standards in both AC and DC based microgrids are required. [9] The concept of hybrid microgrid consist of both AC and the DC output and for characterization of hybrid energy storage generally PV arrays and battery are used. [10]- [11]

Figure 1 shows the block representation of AC/DC microgrid with four sources, namely, battery, PV, Supercapacitor, PEM based Fuel Cell. All the Boost converters are fed to AC/DC link load line and VSC converts the DC to AC for a three phase load.

This paper on HESS is organized as the following outline: the first section of the paper briefs the introduction about the need of microgrid based HESS and literature survey. The second section shows the implementation of the proposed work on fuzzy based control modification. The third section includes the results of the simulations o MATLAB Simulink for HESS.

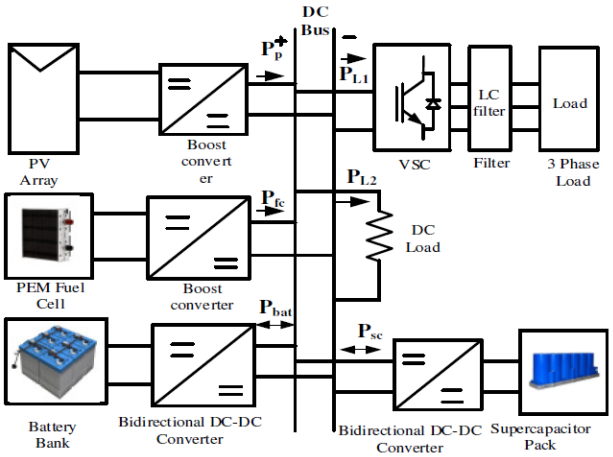

Figure 1: Block Representation of HESS (Hybrid Energy Storage Systems) [1]

II. IMPLEMENTATION

The block diagram as shown in Figure 1, is implemented on MATLAB Simulink, and the currently existing control system is also implemented. The implementation model is shown in figure 2.

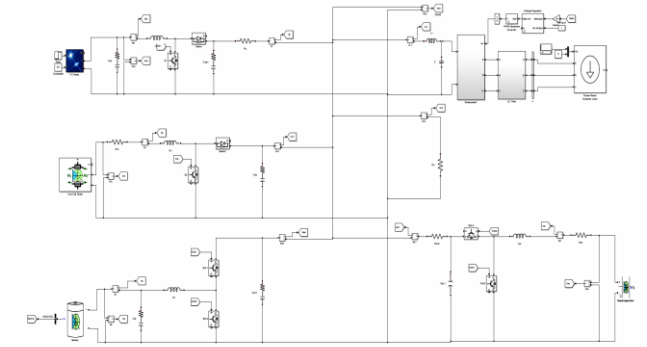

Figure 2: Circuit for Hybrid Energy Storage System

The existing control system for the circuit given in figure 2, consists of PI based controller for error reduction, this gives a lot of calculation complexities and a high noise at the output waveforms. The existing control system implementation is represented in figure 3.

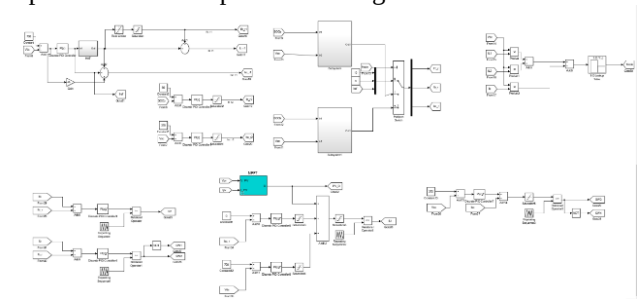

Figure 3: Proportional Integral (PI) based control system for Hybrid Energy Storage

Now, to basically improve the performance of the existing system, the fuzzy based control logic system is added as represented in the figure 4. By this improves performance by error reduction of the system. The fuzzy logic based block diagram is shown in figure 5.

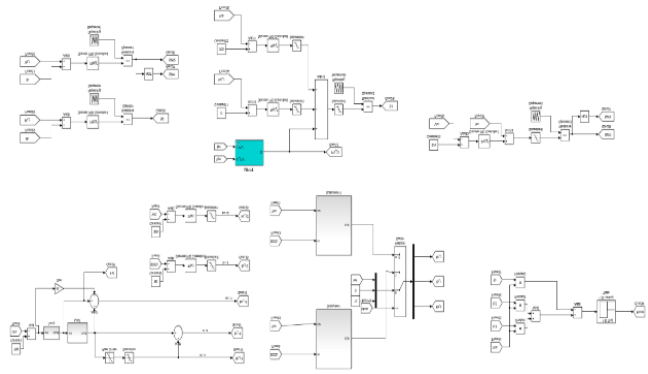

Figure 4: Proposed Fuzzy Logic HESS based control system

The proposed fuzzy logic based controller with combination of PI for HESS works with a set of rules, the two basic inputs of the fuzzy logic are error input and change in error input. The rule set used is mamdani and each input has 3 and output has 5 membership functions.

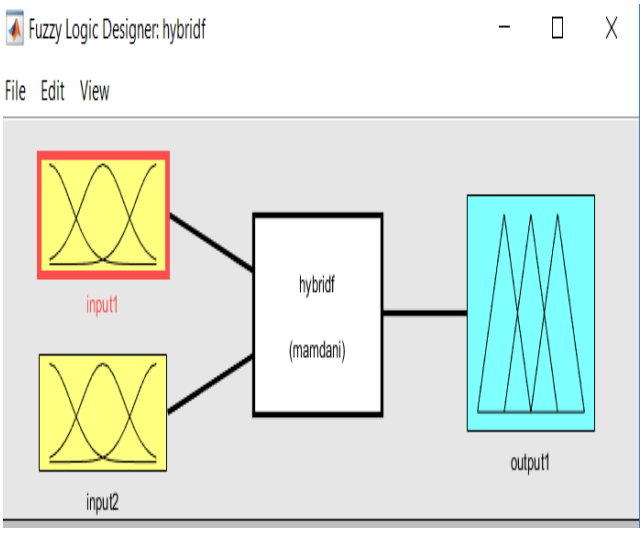

Figure 5: Fuzzy Block Diagram

The input membership function and output or chance based membership functions are shown in figure 6 and figure 7, the fuzzy set is applied on the set of rules to improve the overall performance of array of PV-SC/PEM based Fuel Cell HESS for AC & DC microgrids.

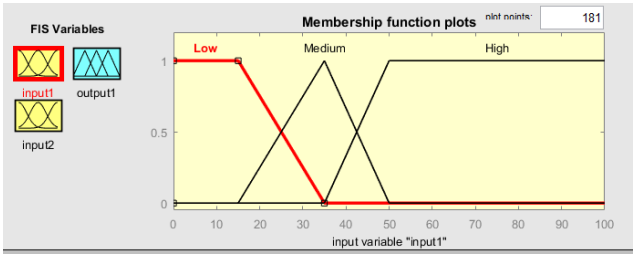

Figure 6: The proposed Input Fuzzy Membership Range Functions

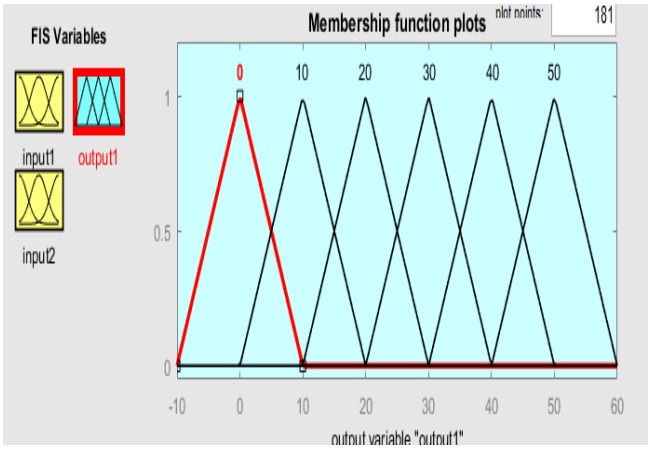

Figure 7: The proposed Output Fuzzy Membership Range Function

The diagram of figure 8 shows the surface view of the rules which improve the performance of PV, battery and

Supercapacitor, PEM Fuel Cell based on Hybrid Energy Storage System for mircogrids.

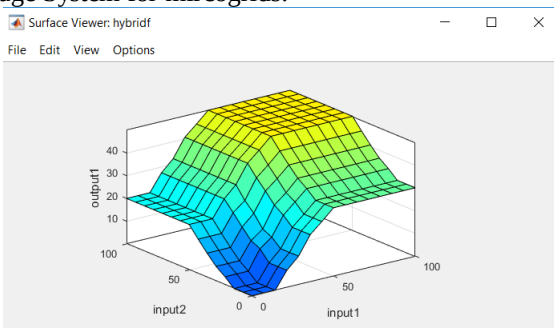

Figure 8: Surface View of Fuzzy Rules

The next section will present the results of the simulation implementation in MATLAB Simulink software.

III. RESULTS

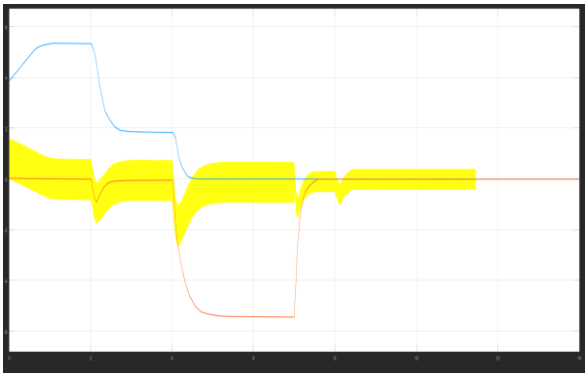

Figure 9: Results for variation of Super Capacitor, Fuel Cell and Battery Currents with PI Controller

Comparing figure 9 and 10, shows that the fuzzy logic one is improved one and causes less fluctuations based on error reduction and its uncertain logic benefits.

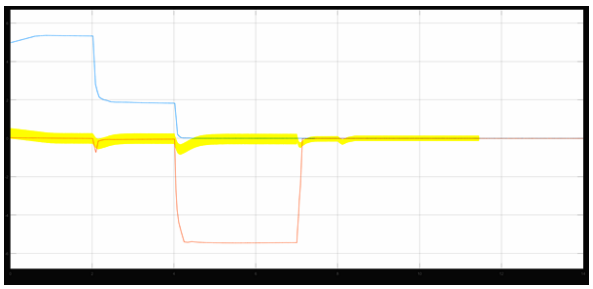

Figure 10: Proposed Results for variation of Super Capacitor, Fuel Cell and Battery Currents with Fuzzy Logic

Now, complete results of the simulation will be shown in this figure 11 and Figure 12.

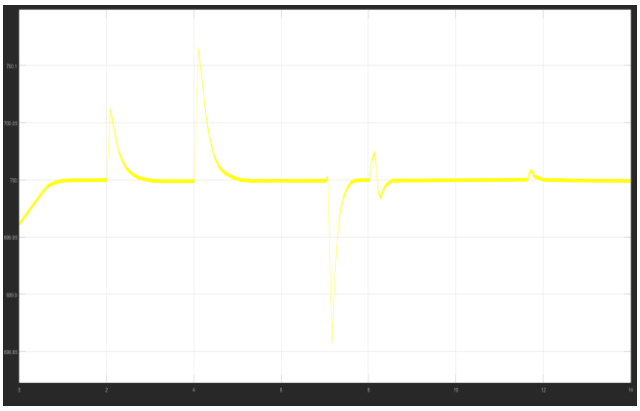

Figure 11: DC Voltage Output

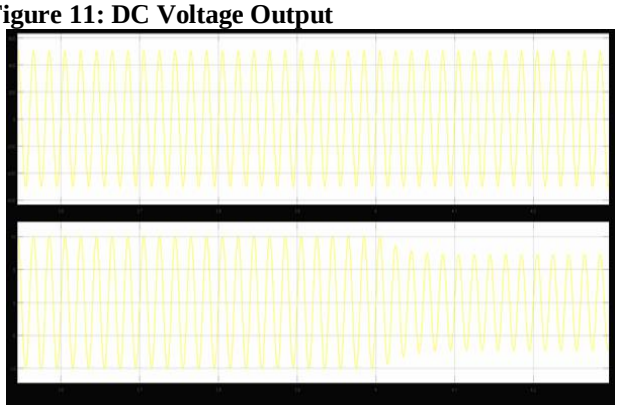

Figure 12: Vabc and Iabc Output

IV. CONCLUSION

Hence, the hybrid energy storage system (HESS) with PV, SC, Battery and PEM Fuel cell for grid is implemented on MATLAB tool based Simulink Software. The output simulation results accurately show that the output achieved with the use of fuzzy logic controller combined with previous PI controller, with MPPT gives better output. The fluctuations and noise is reduced to provide better output to the loads for AC and DC. Microgrids are very promising solutions for hybrid energy storage and supplying of both AC and DC load drives. The future scope of this work may include wind energy concept to convert under more renewable sources.

V. REFERENCES

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