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Fuzzy Based Hybrid Wave, Photo Voltaic and Fuel Cells Power Generation System Dynamic Stability Analysis with Distributed Power Grid

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ABSTRACT:This Paper executes the mathematical model of the wavegenerator using the Linear Permanent Magnet Generator (LPMG) and integrates with the PhotoVoltaic(PV) and Fuel Cell power generation for a dynamic stability analysis of the grid connected hybrid generation system. The PV and the LPMG system is connected to the Point of Common Coupling (PCC) through a common DC link and a Voltage Source Converter(VSC) . This VSC is controlled in order to provide stable power to the power grid. This hybrid power generation system needs a Super Capacitor (SC) to smoothen power that is generated from both the power generation system before it is fed to the power grid. The control algorithm thus utilized in this hybrid grid integration system would maintain a constant voltage at the common DC link and also extracts the maximum power from the power generation system. Matlab/Simulink based implementation is carried out and this grid integration system has performed better with the proposed control algorithm.The control of the Maximum Power Point Tracking is utilized to develop a maximum power delivery from the hybrid system using Fuzzy Logic Controller(FLC).

KEYWORDS: Hybrid Power Generatin System, Wave Generator, Grid Integration,Maximum Power Point Tracking(MPPT)

I. INTRODUCTION

Since the depletion of the fossil fuel reserve on the earth , the need of usage of the renewable energy is of utmost importance in the current scenario. The renewable generation systems would be integrated to the bulk transmission line with the issues like the harmonics, synchronisation etc [1]. While large renewable energy generation is taking place[1] even the small scale renewable energy system is taken in to account in [2] and [3] for grid integration.A grid integration technique with the PV and the Wind Energy Conversion System(WECS) is carried out in the literature [4] which controls the VSC to provide a efficient grid integration applied. In [5] the microgrid kind of implementation is carried out which is a retrofitted PV and Wind hybrid system .In [6] the power management system which combines both the PV and the wind hybrid system is developed.

This paper takes up the wave generator using LPMG , PV and Fuel Cell power generation system for the grid integration with mathematical model of the LPMG developed and the grid integration carried out using the control technique which maintains the DC link voltage to be constant and the grid integration has dynamic stability.

II. IMPLEMENTATION OF THE PROPOSED HYBRID SYSTEM GRID INTEGARTION

The current implementation of the grid integration of the hybrid system which involves the combination of the LPMG and the PV connected to the the common DC link. The DC link is connected to the VSC and also to the bidirectional DC-DC converter that would be connected to the SC. The SC acts as a back for the power that is generated from the hybrid system and not useful for the grid integration. While SC would supply to the VSC along with the PV and the LPMG to supply the grid when the grid integration is active.The complete block diagram of the proposed grid integration system is as shown in the Figure 1.

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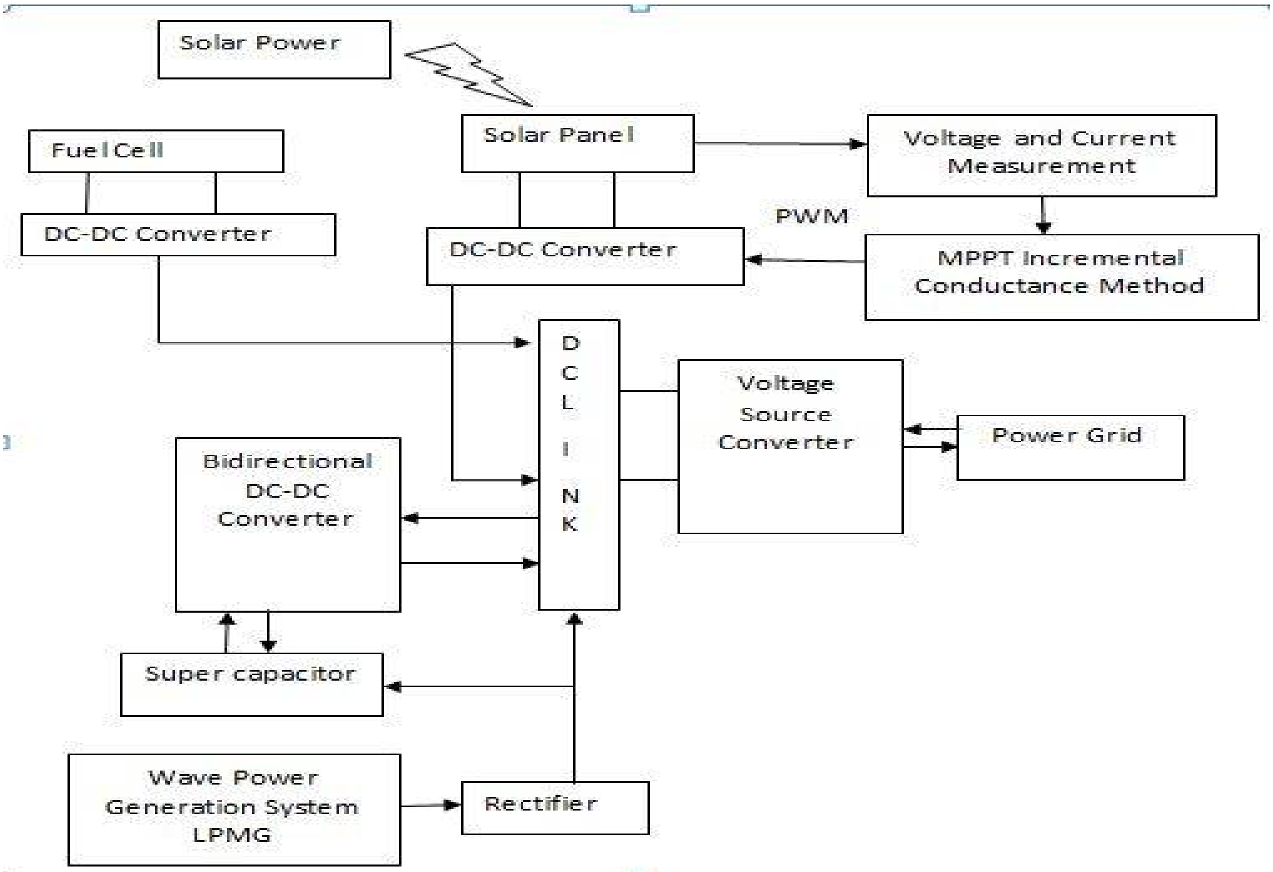

Figure 1. Overall Block Diagram

The block diagram explains the bidirectional flow of power in the supercapacitor. The power when has enough power to be fed to the power grid would use the power delivered from the super capacitor whereas the power delivered from the PV,Fuel cell and the LPMG is used to charge the super capacitor when the power generated is not used for grid integration.

Fuzzy rules table

Fuzzy logic is a very powerful method of reasoning when mathematical formulations are infeasible and input data are imprecise. These above problems are encounter in many control applications in which we know, how the system is behaving but find it difficult to express the derived behavior in terms of mathematical model are in analytical formula. In this case fuzzy logic is a powerful tool for designing the control system accurately. fuzzy logic application mainly to control is being studied throughout the world by control engineers. The result of these studies has shown that fuzzy logic is indeed a powerful control tool, when it comes to control system or process. Some studies have also shown that Fuzzy logic performs better when compared to conventional control PI. There are specific components characteristic of a fuzzy controller to support a design procedure. In the block diagram shown in fig.1.a, the controller is between a pre-processing block and a post-processing block.

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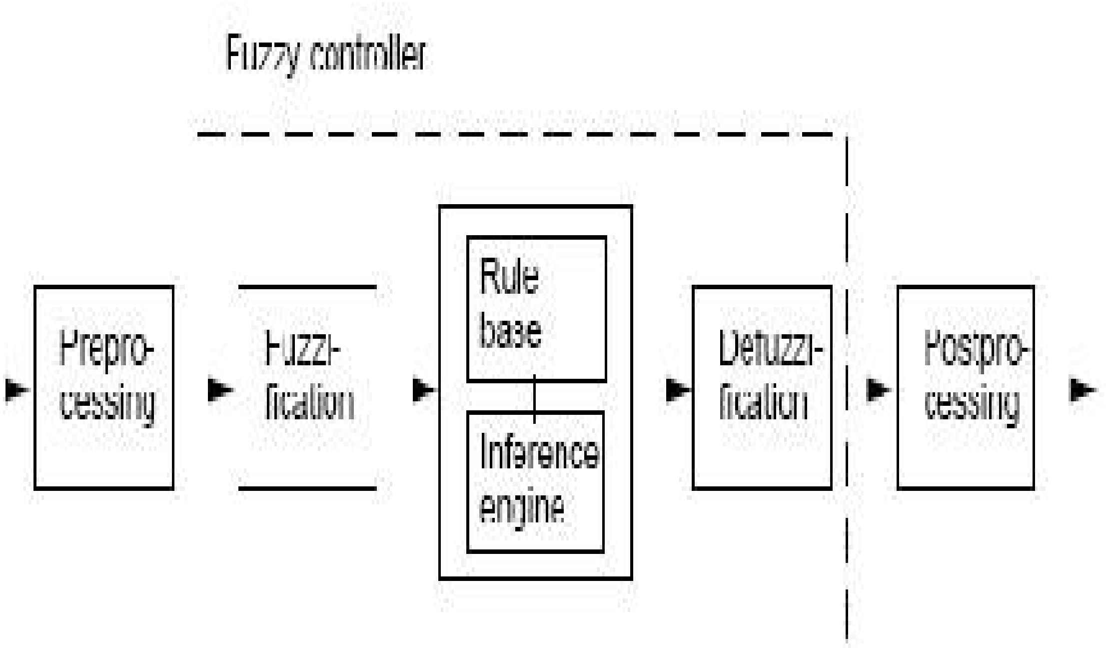

Fig 1a Block diagram of fuzzy logic controller

Here fuzzy is used in the place of PI controller in Dc regulator for performance improvement. It is trained with artificial intelligence technique.

Table: 1 : fuzzy rules

err \ ch_err	MF1	MF2	MF3	MF4	MF5	MF6	MF7
MF1	MF1	MF2	MF3	MF4	MF5	MF6	MF7
MF2	MF8	MF9	MF10	MF11	MF12	MF13	MF14
MF3	MF15	MF16	MF17	MF18	MF19	MF20	MF21
MF4	MF22	MF23	MF24	MF25	MF26	MF27	MF28
MF5	MF29	MF30	MF31	MF32	MF33	MF34	MF35
MF6	MF36	MF37	MF38	MF39	MF40	MF41	MF42
MF7	MF43	MF44	MF45	MF46	MF47	MF48	MF49

III. RESULTS AND DISCUSSION

Matlab based implementation of the PV,Fuel Cell and Wave generation based hybrid power generation system is developed and the grid integration is developed by the control of the VSC PWM controller.

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Fuzzy controller results:

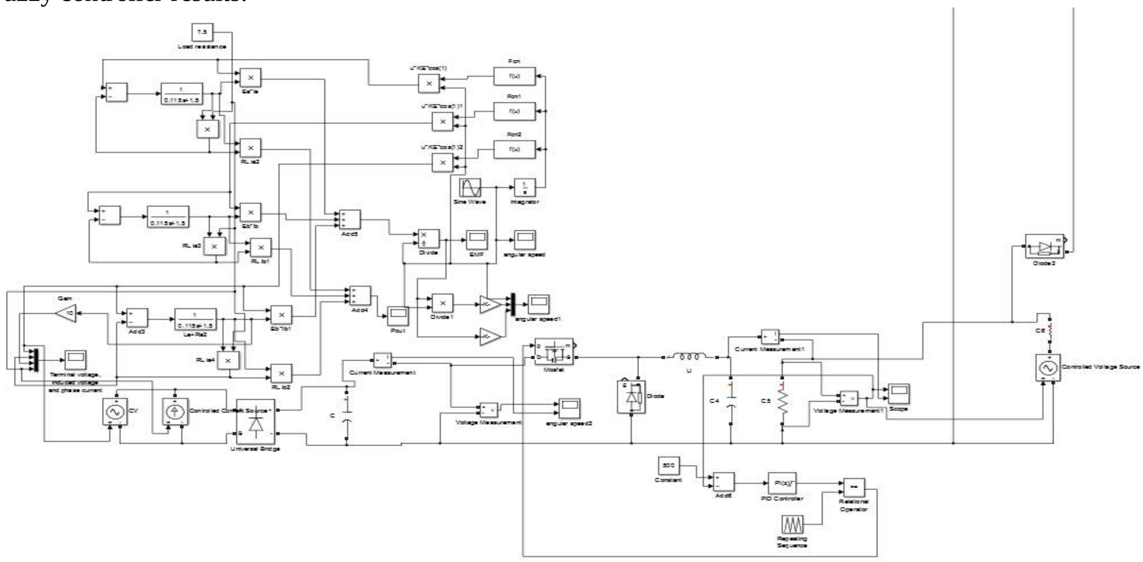

Fig.2 wave generator mathematical model with buck converter and controller

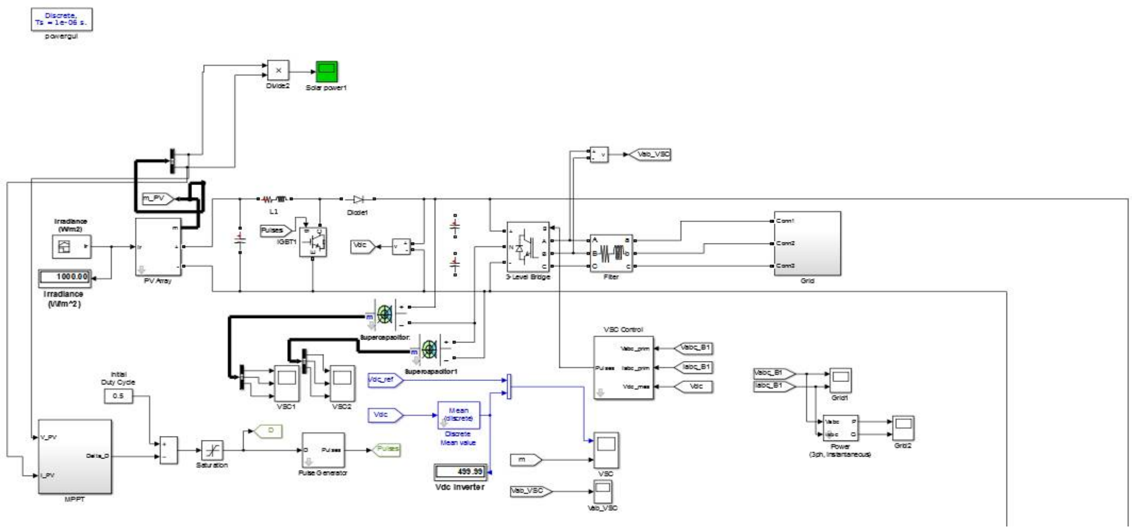

Fig.3 Solar energy generator with MPPT and super capacitors

The solar power generation and wave generator are connected as cascaded and hybrid then it is connected to grid. The powers generated by river and solar are connected to grid for supplying power. The super capacitors are used for stabilizing the DC supply.

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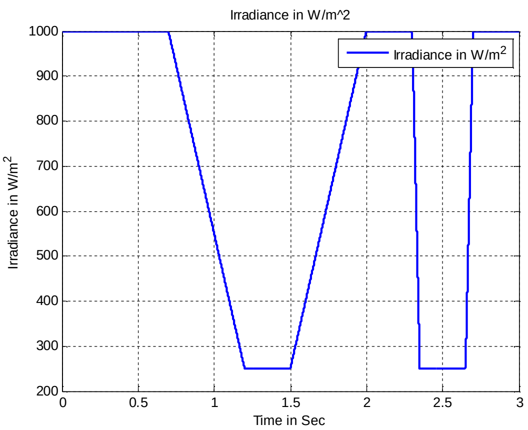

Fig. 4 Solar irradiance

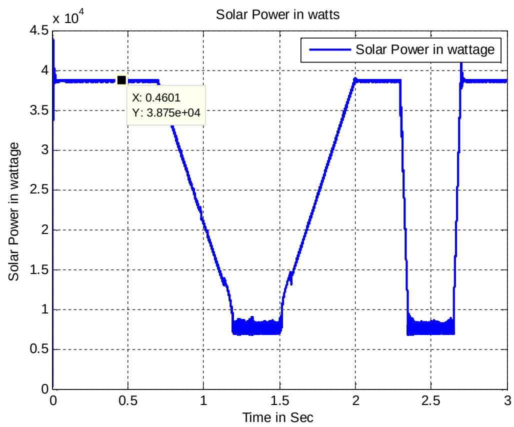

Fig.5 Solar power in watt

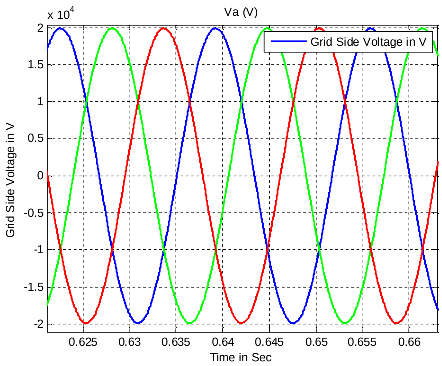

Fig.6 Voltage in Grid in V

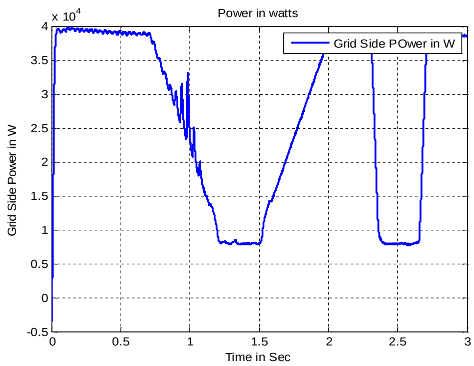

Fig.7 Power at grid

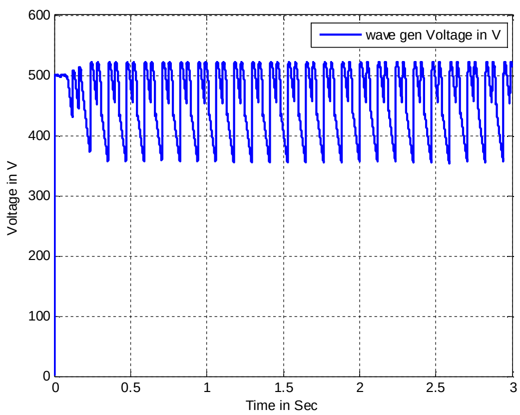

Fig.8 Voltage of wave generator (rectified)

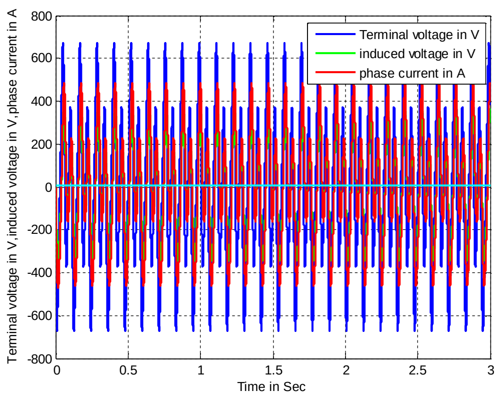

Fig.9 Terminal Voltage in V, Induced Current in A, Phase current in A of wave generator

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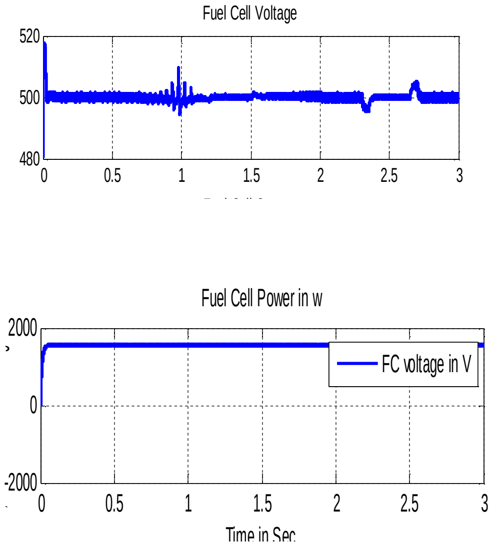

Fig.10 Fuel Cell voltage and power

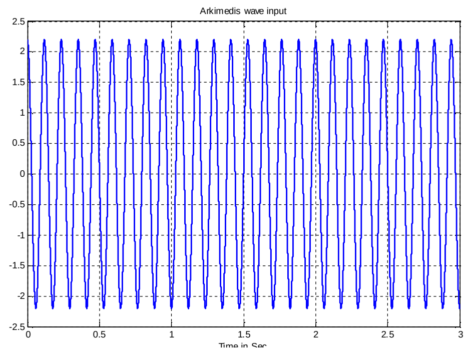

Fig.11 Archimedes wave input

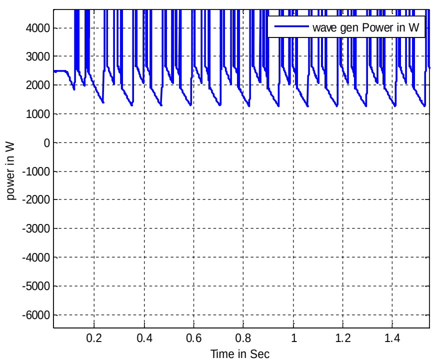

Fig.12 shows Wave Generator Power in wattage.

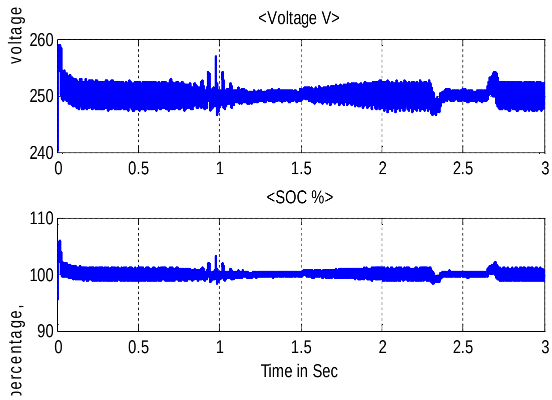

Fig.13 shows Super Capacitor (V and % of SOC).

Fig.2 shows wave generator mathematical model with buck converter and controller. Fig.3 shows Solar energy generator with MPPT and super capacitors. Fig. 4 shows Solar Irradiance Fig.5 shows Solar power in watt. Fig.6 shows Voltage in Grid in V. Fig.7 shows Power at grid. Fig.8 shows Voltage of wave generator (rectified). Fig.9 shows Terminal Voltage in V, Induced Current in A, Phase current in A of wave generator. Fig.10 shows Fuel Cell voltage and power. Fig.11 shows Archimedes wave input. Fig.12 shows Wave Generator Power in wattage. Fig.13 shows Super Capacitor (V and % of SOC).

By seeing fig 7, 10, 12, at 0.5sec**38.75Kw** is generated and sent with fuzzy controller. Due to the change in waves and solar irradiance the power change is created.

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Table 2: Specifications

Solar details	parameters
Module type	sunpower SPR-305-WHT
Number of cells/module	96
number of series connected module/string	5
number of parallel strings	17
Voc (V)	64.2
Isc (A)	5.96
Vmp (V)	54.7
Imp (A)	5.58
Fuel cell details	
Vnom (V)	45
Inom (A)	133.3
Number of cells	65
Power in Kw	6
wave generator details	
Voltage in V	500
Current in A	8
Power in Watts	2000

IV. CONCLUSION

Matlab Simulink model of the hybrid power generation system involving the PV, LPMG and fuel cell is developed and the power delivery optimization is carried out. Matlab Based implementation of the dynamic control of the grid integration system by the use of Fuzzy control is carried out and the results are inferred. The Fuzzy controller had performed better. The amount of power delivered by the Fuzzy controller is more than that of the PI controller base grid integration implementation. The Fuzzy based MPPT algorithm is the cause of the increase in the power delivery.

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