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Anfis Controller Based Reconfigurable Solar Converter for Single Stage Power Conversion-PV Battery System

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Abstract - In this paper, analysis of Reconfigurable Solar Converter (RSC) based on Adaptive Neural Fuzzy Interface System (ANFIS) controller is presented for PV battery application. The major concept of RSC is to use single stage three phase grid tie solar PV converter system to perform both dc/ac and dc/dc operations. The conversion stages are decreased and cost, weight reduces. ANFIS controller improves the performance of the system. An effective Mat lab / Simulation result presents the attractive performance of proposed system.

Index terms- Photovoltaic (PV), Converter, ANFIS , Energy storage, SVPWM, RBFN.

I. INTRODUCTION

Non conventional energy sources such as Solar, water and wind plays a crucial role to generate electricity in the present scenario [1]. Generation of electricity from photo voltaic cells is variable throughout the day due to change in climate conditions [2]. Since the time varies the shading across the Photo Voltaic Cell varies [3]. Whenever shading across PV cells is high then the electrical output falls to a large extent. Mostly batteries, fuel cells are used to store energy [4, 5]. Batteries can be removed as per request [6]. Battery demand in PV method has increased [7]. The amalgamation of energy storage battery in solar PV is prepared in different ways [8]. Integration is used for better flexibility of solar PV-system. The aim of the paper is improving the efficiency of Reconfigurable Solar Converter (RSC) by using ANFIS Controller. RSC is used to perform single stage power conversion system in order to perform four modes of operation

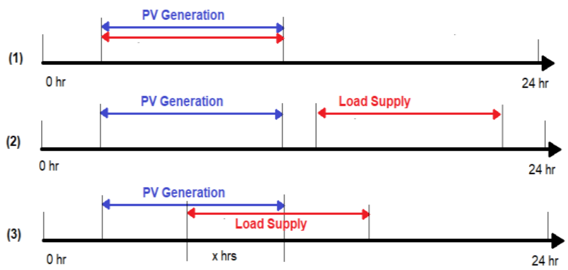

Fig1. Conditions of PV generation & load supply

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PV system performs four modes of operation PV-grid, PV-battery, battery –grid, PV/battery –grid. Fig1.Conditions of PV system generation & Load supply

In case (1), PV cell delivers energy to grid without any storage. Battery is not integrated. In (2) and (3) cases, energy is reserved in battery then to grid. To increase accuracy an Adaptive Neural Fuzzy Interface System (ANFIS) controller is used [9, 10]. To deliver maximum power from PV, MPPT (Maximum Power Point Tracking) strategy is used [11, 12]. RBFN based MPPT is used in this to get maximum output [13].

In this paper, Section (II) represents Photo Voltaic system. In Section (III) the configuration of RSC circuit, operation modes are introduced. Section (IV) introduces control strategy of RSC. Section (V), verifies experimental results which demonstrates best performance characteristics. In Section (VI), presents overviews and conclusion of paper.

II. PHOTO VOLTAIC SYSTEM

Symbolic representation and corresponding circuit of PV cell are represented in Fig 2.

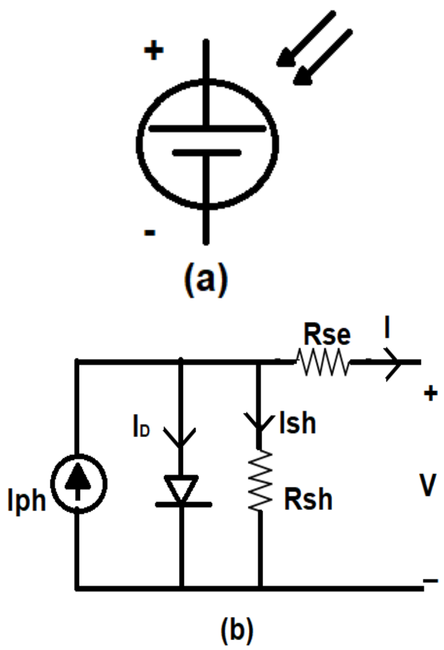

Fig 2. PV Cell (a) Symbol (b) Equivalent circuit

The Sun Power SPR-235NE-WHT-D PV module is used for analysis of RSC. PV cell has 200 strings in parallel connection and 15 series modules per string. Table1 represents PV cell parameters.

TABLE-I PV PANEL PARAMETERS

Maximum power	234.9W
Maximum current	5.8A
Maximum voltage	40.5V
Temperature	35^0C
Irradiation	1000
S.C current	6.18A
O.C voltage	48.4A

III. RSC

The proposed RSC is shown in Fig 3. Alterations to conventional three phase inverter are done to represent RSC. A diode is linked with PV cell in series to maintain unidirectional current flow. If voltage across the battery is higher than voltage of PV cell the current from battery is blocked by this diode.

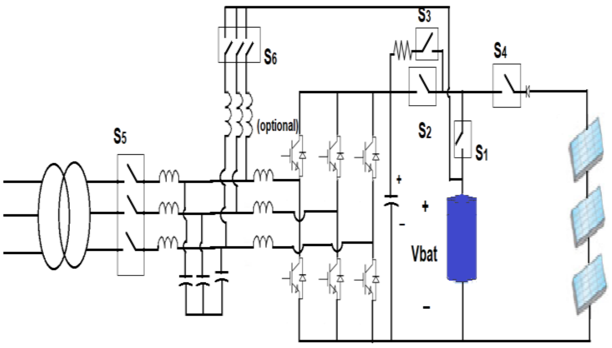

Fig 3-Schematic representation of RSC

A. Modes of Operation of RSC

RSC circuit executes four operation modes depending up on irradiance value of PV system. Different modes are illustrated below.

1) Mode 1

The operation PV – grid is given in Fig 4(a). MPPT technique implements maximum output power from PV system. In this condition PV system is adequate to fulfill grids requirement. Switches S_2 and S_4 are closed to achieve dc/ac operation.

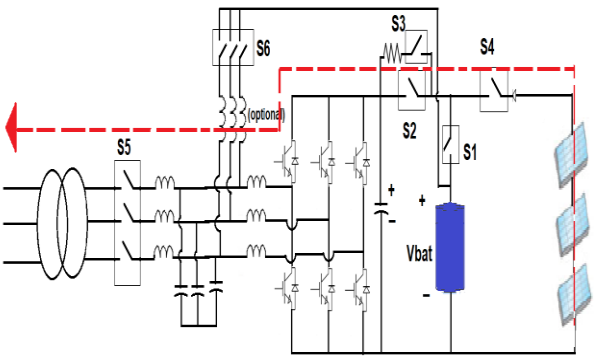

Fig 4(a) PV cell to grid

2) Mode 2

In Mode 2, the power is given from PV – battery shown in Fig 4(b). Energy is stored in battery, then battery supplies power to the grid. Switches S_1, S_4 are closed to perform chopper operation. At some cases an optional circuit acts as Boost Converter and one inverter switch acts as boosting switch.

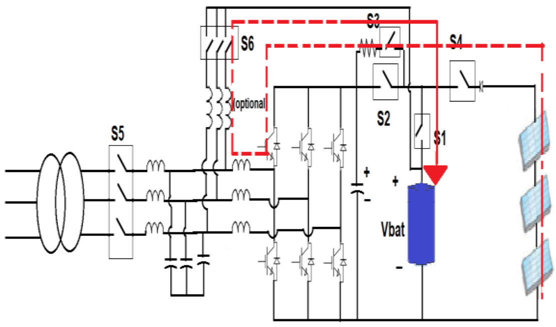

Fig 4(b) PV cell to battery

3) Mode 3

In Mode 3, the power to grid is supplied from PV/battery. Fig 4(c) represents this operation. S_1, S_2 and S_4 are closed. Both PV, battery feed power to grid depending up on SOC of battery, irradiance of PV system.

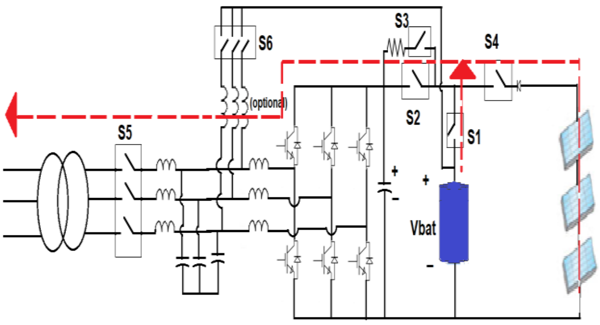

Fig 4(c) PV cell/ battery to grid

4) Mode 4

The power supply from battery to grid is represented in Fig 4(d). In this mode PV cell is completely dead (night). Battery itself provides power to grid. Switches S_1, S_2 are closed to perform this operation.

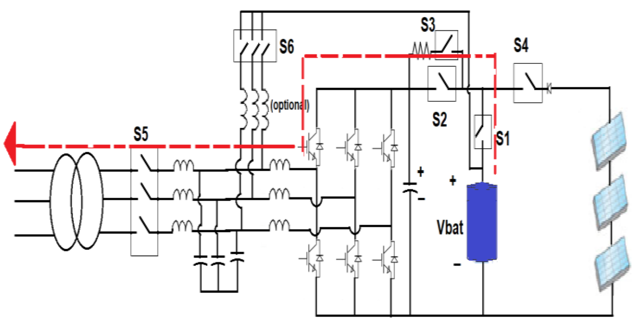

Fig 4(d) Battery to grid

IV. CONTROL OF RSC

A. DC to AC conversion modes

The dc to ac operation is executed by RSC whenever the power is supplied to grid by PV cell, battery or PV/ battery. Radial Basis Function Network (RBFN) based MPPT is used to get more output from PV. ANFIS gives better accurateness. Fig 5 represents presents diagram of RSC with control block. Transformation of 3-ph stationary to 2-ph rotating is used to apply control technique easily.SV- PWM technique reduces the Total Harmonic Distortion (THD)..

1) ANFIS Controller

Adaptive Network Based Fuzzy Interface System (ANFIS) is a fuzzy interface system. It is the unification of fuzzy and neural network. The toolbox of fuzzy logic in MATLAB gives membership functions. These parameters traces the input, output data. Later they are tuned by Back Propagation algorithm. Total inputs are sent to neural network which presents the standard output. The input/output in neural network are trained. These trained data as input is given to fuzzy system. IF THEN rules and membership functions usage frames better output. This neuro adaptive learning is Sugeno-type Fuzzy Interference System. In this 7 membership functions are specified to every input and 49rules are established in Table 2. The output obtained can be either constant or linear variables. The rules of FIS are as follows:

Rule 1: If e-NB and de is NB then output is NB
Rule 2: If e-NM and de is NM then output is NB.
Rule 3: If e-NS and de is NS then output is NM.

Table -II Rules of interference system

e/de	NB	NM	NS	EZ	PS	PM	PB
PB	Z	PS	PM	PB	PB	PB	PB
PM	NS	Z	PS	PM	PB	PB	PB
PS	NM	NS	Z	PS	PM	PB	PB
EZ	NB	NM	NS	Z	PS	PM	PB
NS	NB	NB	NM	NS	Z	PS	PM
NM	NB	NB	NB	NM	NS	Z	PS
NB	NB	NB	NB	NB	NM	NS	Z

B. DC to DC conversion mode

In this mode, the RSC is used to deliver utmost energy from PV cell to battery.RSC acts as boost converter in dc to dc operation. Lithium-ion battery is used because it requires an algorithm maintaining sustained voltage and current. The stable control of maintaining constant voltage, current based on state of charge (SOC) of battery is done by using dc to dc converter. RBFN based MPPT is used in chopper operation to maximize output power from PV to battery. The block diagram of chopper operation is shown in Fig 6.

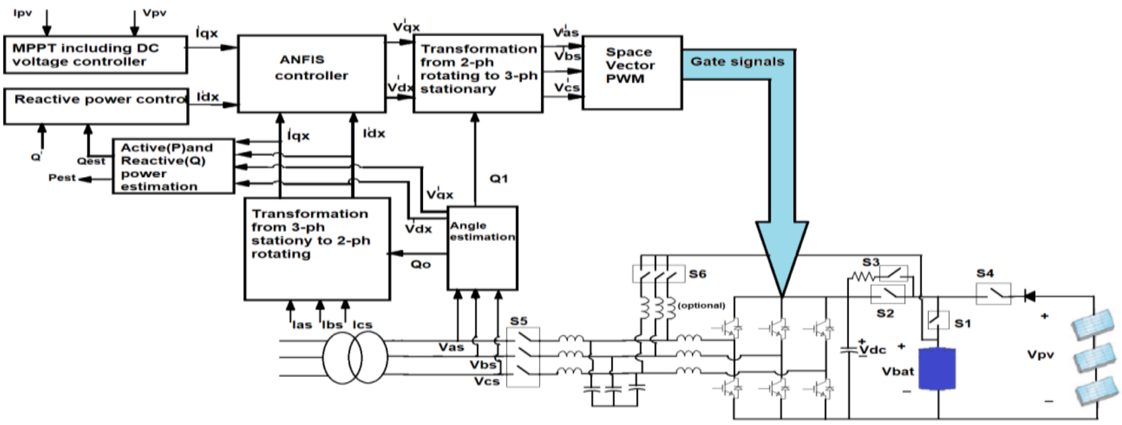

Fig 5- Block diagram of RSC for dc/ac operation.

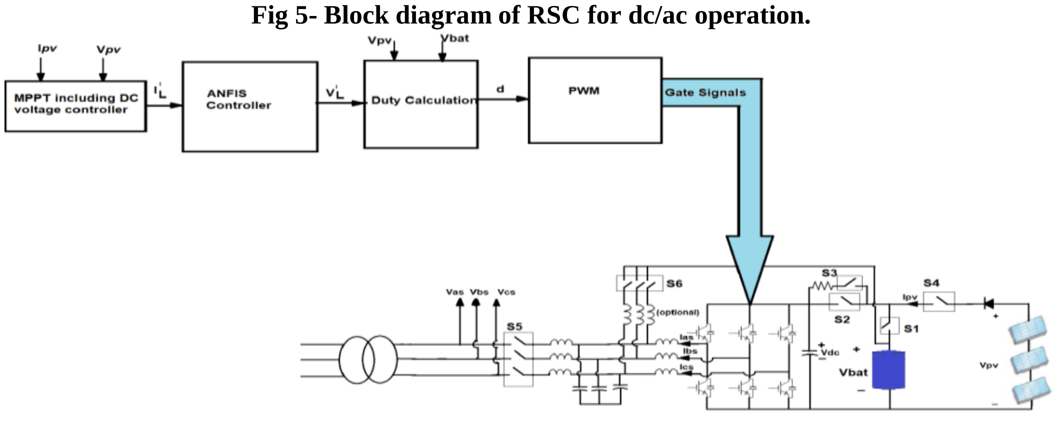

Fig 6- Block diagram of RSC for DC/DC operation

V. SIMULATION RESULTS

The ANFIS control and RBFN based MPPT is tried on RSC. The proposed concept simulation is executed in SIMULINK/MATLAB. The simulation diagram of RSC is shown in Fig 7.

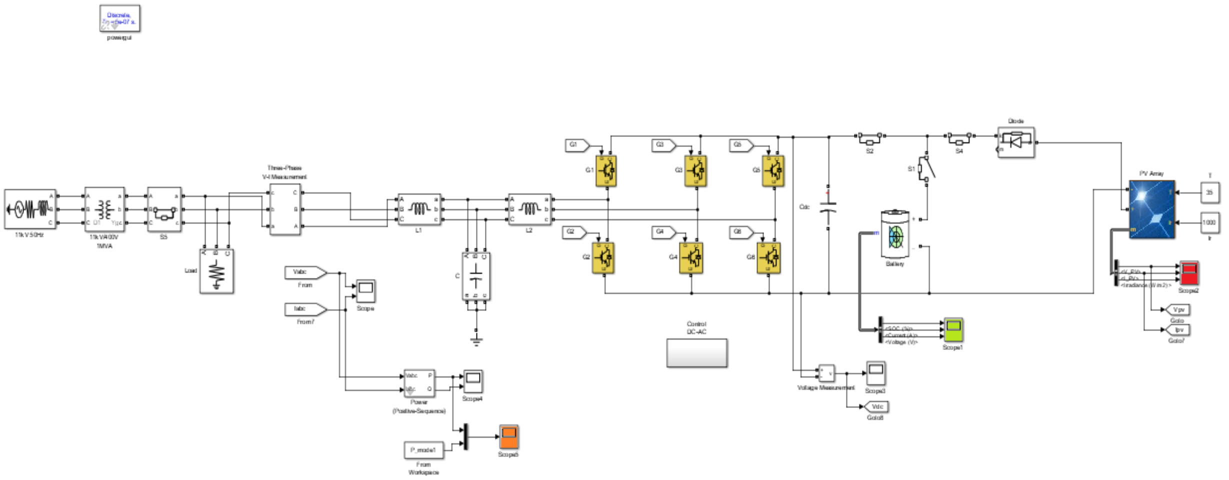

Fig 7. Simulation diagram of RSC with control block

TABLE-III-BATTERY PARAMETERS

Battery capacity	51.2kWhr
Nominal voltage	600V
Fully charged voltage	698.3V
Nominal discharge current	22.2609A
Cut off voltage	450V

The Vpv , Ipv , Irradiance of PV panel are given in Fig 8. The Power-Time characteristics of Mode1, Mode 3 and Mode4 (dc to ac operation) are exposed in Fig 9a, Fig 9b and Fig 9c.The settling time is decreased by ANFIS controller. The power gain is higher at grid by using ANFIS control.

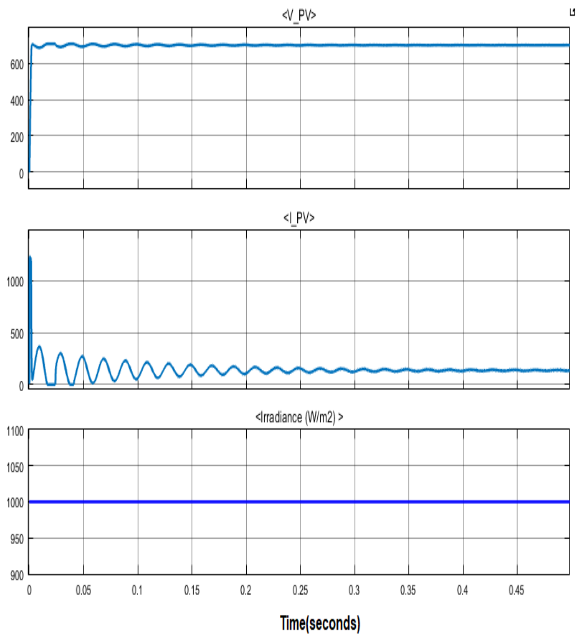

Fig8. Voltage, Current, Irradiance of PV

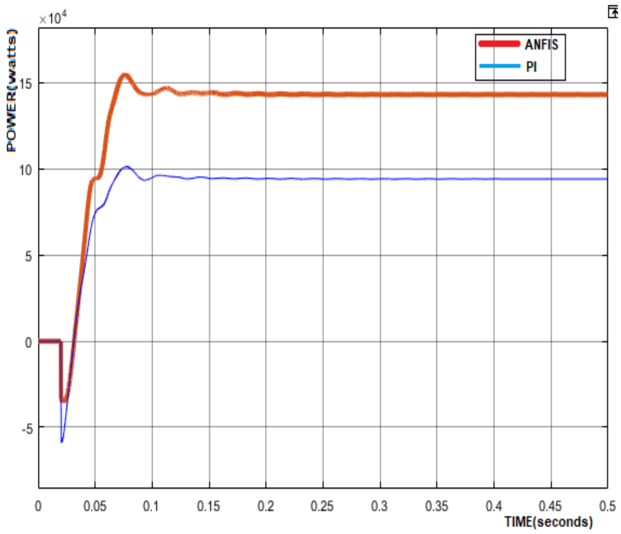

Fig 9(a) MODE 1 (PV - grid)

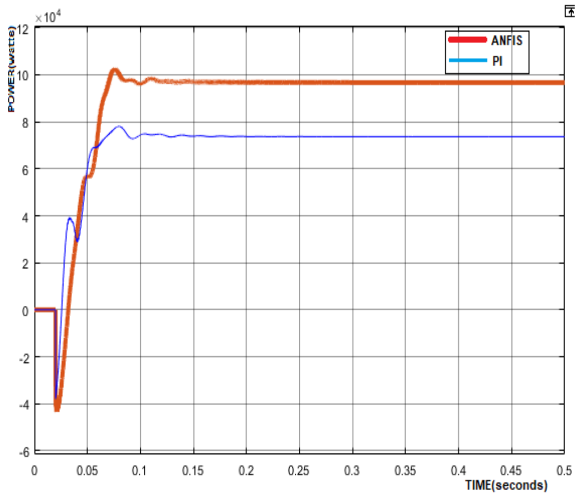

Fig 9(b) MODE 3 (PV/battery - grid)

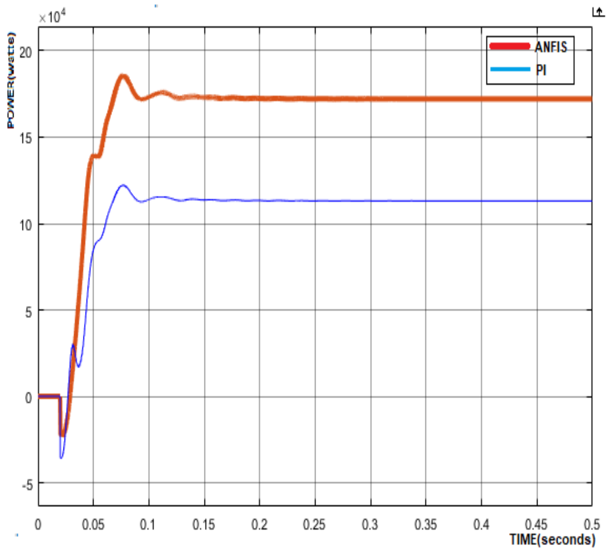

Fig9(c) MODE 4 (battery - grid)

In Mode 2 the power is transferred from PV cell to Battery.Battery initial SOC of the battery is 100%.The SOC comparison of battery using PI and ANFIS controller is exposed in Fig 10.

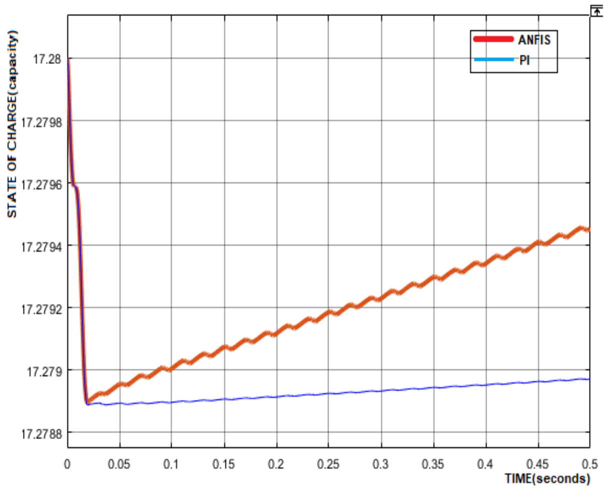

Fig10. MODE 2 (PV-battery)

VI. CONCLUSION

This paper implements ANFIS controller to RSC for appliance of PV battery. By using RSC, single conversion stage is used to perform dissimilar operations.The estimated converter reduces the cost and volume . ANFIS control which has better learning ability is used and it can handle non linear systems. The output power has fast settling time with certain improvement by using ANFIS controller. RBFN MPPT improves tracking efficiency of the PV panel. The output power is increased and it takes less time to settle down by using Adaptive Neural Fuzzy Interface System controller. The results authenticate the attractive performance demonstrated by ANFIS controller.

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