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ADVANCED MODELLING AND SIMULATION OF CONTROL OF RURAL SOLAR PV MICRO GRID USING FLC

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ABSTRACT:

This paper proposes an approach for the hybrid solar photovoltaic and Battery management for stand-alone applications. Battery charging process is non-linear, time-varying with a considerable time delay so it is difficult to achieve the best energy management performance by using traditional control approaches. A fuzzy control strategy for battery charging or discharging used in a renewable power generation system is analyzed in the paper. To improve the life cycle of the battery, fuzzy control manages the desired state of charge. A fuzzy logic-based controller to be used for the Battery SOC control of the designed hybrid system is proposed. This paper presents a general description of the implemented microgrid topology. The exact linearization theory adapted for power converters is applied to both a Single-Ended PrimaryInductor converter (SEPIC) to extract energy from PV modules and to a Boost converter to increase the voltage. The entire designed system is modeled and simulated using MATLAB/Simulink environment.

Keywords: SEPIC, Fuzzy, PV, Microgrid, DC-DC converter, THD.

INTRODUCTION

In the present scenario, the proliferation of energy call for of households and industries, create demanding situations and set a limit on the energy generation from the conventional strength assets [1]. the solution to this hassle lies someplace within the core of electricity through renewable energy resources (RES) [2], with efficient, cost effective and dependable generation via RES. the rural electrification is supplied by means of a standalone diesel generator and an integration of other RES in [3–7]. but, the setback for this technology is an RES intermittent nature. This leads to the factor over sizing while designing any hybrid renewable power primarily based microgrid (MG). This also will increase the preliminary price, operational value, and lifestyles cycle cost. these shortcomings open the window for hybridisation of RES to back up each other. however, this requires the top-rated integration of RES and various styles of hybrid systems. Philip et al. [8] have established the diesel engine driven generator, battery and photovoltaic (PV) array primarily based hybrid standalone MG. because of increasing gasoline prices and extended pollutants concerns, the diesel PV primarily based MG has confined scope. Furthermore, the topology supplied in the literature has the battery directly related to the direct current (DC) link. Due to this, the battery is uncovered to direct DC link voltage fluctuations. This reduces the battery existence. In the proposed topology, the battery is hooked up to the DC-link with a bidirectional DC–DC converter (BDDC). Therefore second harmonic modern is removed from the battery current. Grid attached RES are another elegance of topologies, which might be available in the literature [9]. Those topologies primarily based MGs are viable at the ones places, wherein grid availability is straightforward. But, the proposed topology is likewise possible in rural regions. Merabet et al. [10] and Prakash et al. [eleven] have mentioned the wind, PV and battery based totally MG. They have got installed the manipulate algorithm to appearance after the energy compatibility and strength control among different RES in the MG. Wind and PV both being of intermittent nature, gift a hassle to the most reliable sizing [12] of the strength storage. The minimal required battery size, depends at the critical load that the MG have to be able to feeding while each the sun and wind, are unavailable. On this way, the garage may be outsized. But, inside the proposed MG, hydro additionally supports the critical load, consequently the battery size is decreased. Moreover, initial and operational costs, are low and upkeep requirement is likewise much less. The small hydro electricity plant in faraway regions is regarded as a promising energy source to generate power. The small hydro system up to a hundred kW score does not require governor control based totally turbine prime mover and curtails down the cost of the turbine. The generator used in the small hydro has many variations. Synchronous generator Everlasting magnet synchronous generator, synchronous reluctance generator and self-excited induction generator (SEIG), are few to operate. But, the most fee effective, precise, rugged, and smooth to use generator within the small hydro machine is SEIG. Additionally, the renovation requirement is also much less as compared with its synchronous counterpart. Furthermore, SEIG has the downside that it demands reactive energy or magnetising current for generating the favored terminal voltage. consequently, an excitation capacitor financial institution provides magnetising modern for regulating the terminal voltage of the generator. The hydro-based totally generating device operates in nearly steady electricity mode in order that if the load adjustments, the frequency, and voltage also modifications from their reference values.

II RELATED STUDY

In this system, PV-battery-hydro primarily based MG is designed for low voltage, which substances strength to small wallet of clients. The proposed MG includes two energy assets specifically hydro and PV with BES. The hydro-based totally MG provides stiffness and inertia to the system voltage and also increases the reliability of the MG in comparison with the wind based MG. An integration of BES gets rid of the need for a dump load and provides to the functionality of the MG. This BES is controlled via a bidirectional converter, which reduces the capacity of storage and utilises the battery effectively. The era of solid, maximum and continuous energy from the PV array is executed through incremental conductance maximum energy point monitoring (MPPT) technique. Additionally, some supporting services are completed like contemporary harmonics mitigation, voltage harmonics discount and reactive power assist on the point of common interconnection (PCI).

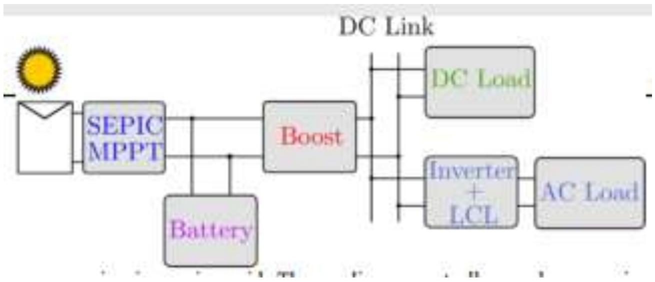

Fig.1. Proposed model diagram.

The energy source used in this work is solar PV, which implies the use of DC/DC converters to raise or lower the input voltage depending on the case. There are different power converter topologies used in the conversion of PV energy, which can be divided into non-isolated and isolated converters. In the first group there are converters such as Buck, Boost, Cuk, Sepic and Zeta. In the case of isolated converters, the Flyback, Forward, Push Pull, Half-Bridge and Full-Bridge converter can be highlighted. A non-isolated converters use a smaller number of components than isolated converters, which makes them more economical. However, they have a larger size compared to isolated converters. In terms of control, the most important objectives in PV converters are the current and voltage control, maximum power point tracking (MPPT), synchronization with the electrical network,power quality,anti-islandedprotection,energy storage and monitoring of PV modules. Regarding the control techniques of the fundamental electrical variables (voltag current), works such as present the strategies that allow meeting the objective of control and maximization of the use of photovoltaic energy. In this context, works such describe the use of a voltage-current cascade loop to control the energy extracted and injected into the electrical grid. Compares the most used maximum power point tracking algorithms, concluding that the classical methods are more reliable under uniform irradiance conditions, while the intelligent algorithms present a better performance under different irradiance conditions thanks to the increased speed of tracking, sensing and data storage.

III WORKING METHODOLOGY

The SEPIC and Boost converters can be controlled by the exact linearization technique. The idea behind exact linearization is to redefine the power converter's input as a function of variables and parameters to find a linear relationship between a new input and the output. In this method is not required to consider the dynamics of other variables except those of interest, therefore no reduced model is needed. The linearization can be found by two main ways: input states linearization and input-output linearization. The result obtained with the exact linearization is a transfer function that allows the use of a linear controller such as a simple PI controller, highly simplifying the task of controlling the nonlinear DC/DCconverter.Inthiscontext,papers such validate the implementation of the exact linearization technique applied to the control of a Buck-Boost converter. The exact linearization is applicable to PV systems (and other energy sources), where an algorithms is used to track the maximum power point, such as Perturb and Observe (P&O) or Incremental Conductance (IC). In this implementation, the P&O algorithm is used with a modification, which consists of providing the current as a reference to be followed by the control, instead of the PV module. The novelty of this work is in the application of the exactlinearizationtechnique for a SEPIC and Boostconverter in a simple and systematic way, obtaining the same models thanks to the generality of the method. Together with the exact linearization, the use of a power balance technique is proposed, with the aim that the converters can operate with different types of loads into the entire power converter's operating region. The final result is reflected in the versatility and robustness of the algorithm for microgrids.

Microgrid is an important and necessary part of the development of smart grid. A microgrid is a low-voltage and small network connected to a distribution grid through the point of common coupling (PCC), and contains both distributed generations and loads. Several types of distributed energy resources (DERs) are used in a microgrid, such as microturbine (MT), fuel cell (FC) and energy storage system (ESS) as controllable units. Due to uncertainties of the renewable energy availability, battery storage is adopted. So the electricity energy will be saved to the battery when the excessive electricity is generated and the stored energy will supply electricity to the load. Many Countries count on coal, oil and power being generated. As we know, frequent charging and discharging will shorten the life time of a battery. With such a system, the problem is how to determine when the battery should be charged to provide the best energy efficiency and to prolong the life time. The proposed fuzzy control is to optimize energy distribution and to set up battery state of charge (SOC) parameters. A control strategy based on fuzzy control theory has been proposed to achieve the optimal results of the battery charging and discharging performance, and compared with a classical PI controller for performance validation.

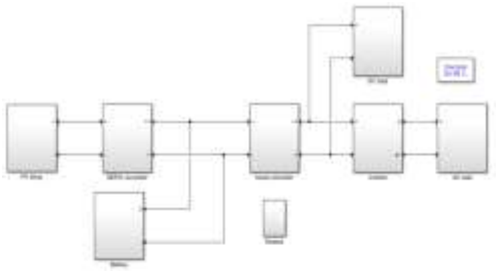

Fig.2. Simulation circuit

The motivation for the work presented in this paper is to include renewable energy in rural microgrids, where the energy may be required in AC or DC form at different voltage levels (12/24 V and 110/220 V). In the proposed topology indicates that the SEPIC converter charges the battery, tracks the maximum power point (MPP) and supplies the Boost converter. The Boost converter is required increase the voltage to the needed AC level. Additionally, once the DC link voltage is well regulated by the Boost converter, the inverter can be used to supply AC loads. All of the power converters used in this paper are nonlinear, and therefore the control is not necessarily an easy task. Thus, the exact linearization-based control is proposed to be able to manipulate and control the variables in the entire operating region avoiding the intrinsic nonlinearities of these power converters.

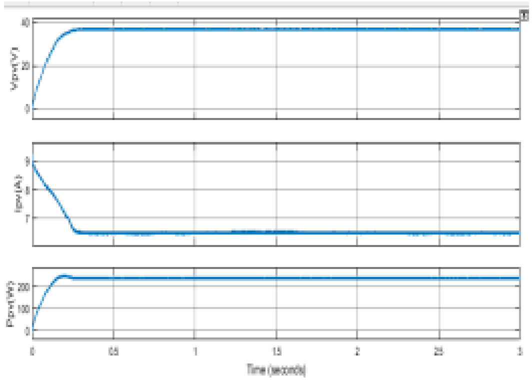

Fig.3. SEPIC converter output

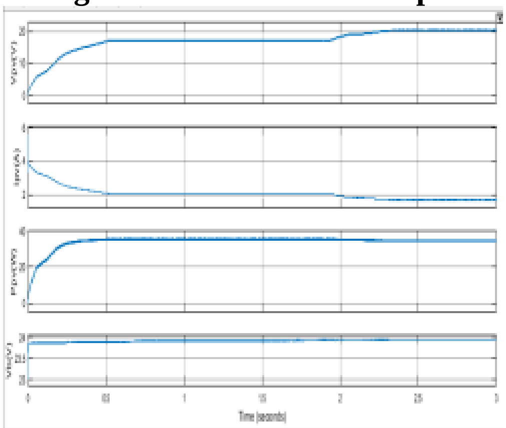

FIg.4. MPPT without fuzzy

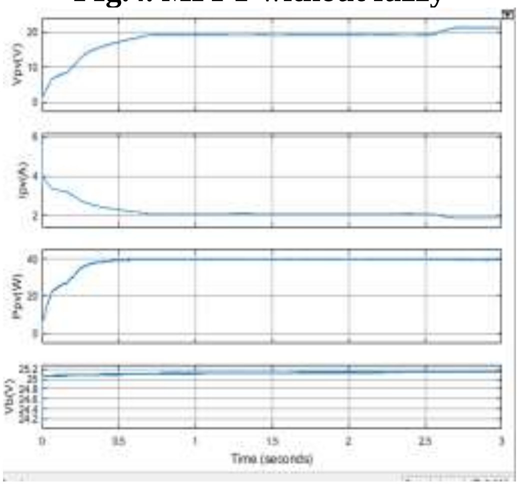

Fig.5. MPPT with fuzzy

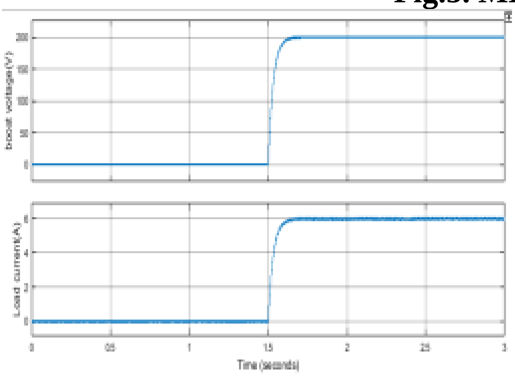

Fig.6. BOOST CONVERTER using without fuzzy

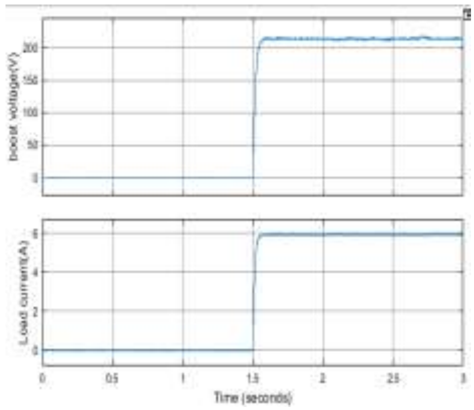

Fig.7. BOOST CONVERTER using with fuzzy

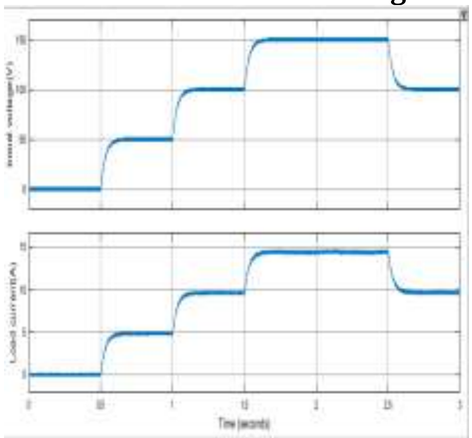

FIg.8. BOOST CONVERTER STEP REFERENCE without fuzzy

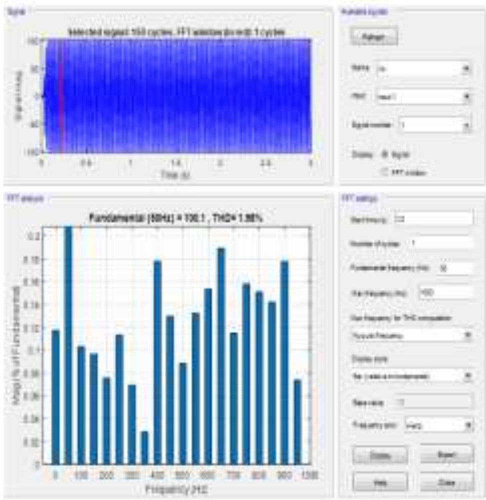

Fig.9. THD values.

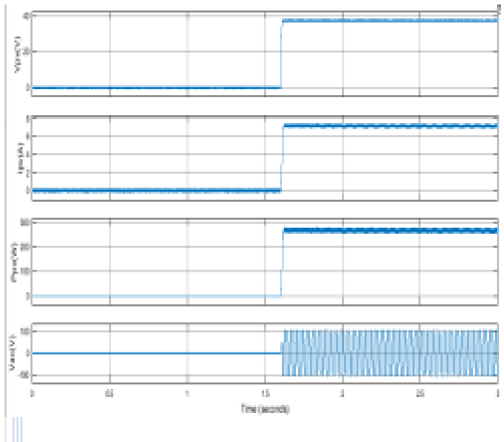

Fig.10. MPPT and inverter waveform Without FLC.

Results in table

SEPIC CONVERTER

	V_{pv}(V)	I_{pv}(A)	P_{pv}(W)
Without fuzzy	38	4	250
With Fuzzy	41	5	290

MPPT

	V_{pv}(V)	I_{pv}(A)	P_{pv}(W)	Vb(V)
Without fuzzy	20	1.8	38	23
With Fuzzy	22	1.9	40	25

BOOST CONVERTER

	Boost voltage(V)	Load Current(A)
Without fuzzy	200	5.9
With Fuzzy	215	6

BOOST CONVERTER STEP REFERENCE

	Boost voltage(V)	Load Current(A)
Without fuzzy	150	14
With Fuzzy	165	15

AC OUTPUT VOLTAGE

	Total Harmonic Distortion(THD)
Without fuzzy	1.98%
With Fuzzy	0.98%

MPPT AND INVERTER WAVEFORM

	V_{pv}(V)	I_{pv}(A)	P_{pv}(W)	V_R(V)
Without fuzzy	38	7	280	100
With Fuzzy	39	8	290	100

CONCLUSION

In the proposed MG, an integration of hydro with the battery, compensates the intermittent nature of PV array. The proposed machine uses the hydro, solar PV and battery strength to feed the voltage (Vdc), solar array current (Ipv), battery voltage (Vb) and battery current (Ib). while the weight is accelerated, the load call for exceeds the hydro generated energy, considering that SEIG operates in consistent strength mode situation. This system has the capability to adjust the dynamical strength sharing a number of the exclusive RES depending at the availability of renewable electricity and load demand. A bidirectional converter controller has been a hit to hold DC-link voltage and the battery charging and discharging currents. PV-based isolated microgrid using FLC. The improved power sharing between storage systems are achieved considering the SOC of the battery and power difference between total load and renewable generation. The FLC is able to adjust the droop coefficient according to the energy available in the battery and deficient and surplus power in the system.

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