FORMULATION AND EXECUTION OF A DC TO DC BOOST CONVERTER WITH NON-CONVENTIONAL ENERGY RESOURCE

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Abstract - *As we all know, due to the distance between the generating power plant station and the demand, there are considerable losses in transporting electrical power. To limit these losses, we use distributed generation. The DG system generates electricity from both conventional and non-traditional sources. With efficiency ranging from 40% to 60%, hydrogen fuel cells are one of the non-conventional energy sources. We also know that hydrogen does not exist in nature, thus it must be created in laboratory. There are various ways to accomplish this. One of this is hydrogen production via the water electrolysis method. We also require power to produce hydrogen, which we obtain from solar panels. A DC-DC Boost Converter is used to accomplish voltage control, allowing the system to provide consistent power.*

Keyword: Distributed Generation (DG), Non-Conventional Energy Resources (NCER), solar power, Dc-Dc Boost Converter, IGBT.

1. INTRODUCTION

In summary, distributed generation (DG) based Non-renewable energy and renewable energy power production technology has achieved significant progress. However, most renewable energy power generating methods, such as wind power and solar power generation, are unpredictable and intermittent [1]. If such electricity enters the grid directly, the utility system's stability will be severely impacted, limiting the usage of connected-grid renewable energy and future development. As a result, several solutions to increase the economics and reliability of various energy conventional sources and renewable energy connected-grid power generating technologies are urgently needed. As an essential distributed power, various energy sources and renewable energy distributed generation should be incorporated in the entire work [2]. The expanding potential for DG to grid connections and decarburization of power systems throughout the world suggest that DGs, particularly renewable - based DGs like wind turbine, solar PV module, fuel cell, hydro power plant etc. might play a big role in power production's future. Policymakers, grid operators, power system developers, and consumers are the stakeholders whose interests must be addressed through DG integration. Despite the fact that integrating DG into the power grid provides advantages such as reduced line loss, increased grid flexibility, cost-effective energy generation, and a reduction in the inclination to invest in additional grid assets during capacity development [3]. Because of the diminishing supply of conventional energy resources, last 10 years have become more crucial for the per watt cost of solar energy devices. It is undoubtedly expected to become more affordable in the future, as technology improves in terms of both cost and applicability. Every day, the planet receives sunlight from above (about 1366W). This is an infinite supply of energy that is free [4]. The primary advantage of solar energy over other traditional power producers is that sunlight can be transformed directly into solar energy using the tiniest photovoltaic (PV) solar cells. The most significant benefit of solar energy is that it is free to the general public and accessible in vast volumes of supply when compared to the pricing of various fossil fuels and oils during the last ten years. Furthermore, solar energy requires less manpower than traditional energy production technologies [5].

DC/DC converters are critical components found in renewable energy conversion units as power electronic operating systems for power applications. Most renewable energy sources (RES), including photovoltaic (PV) systems and wind energy, have the lowest voltage output. They require booster circuits to give enough voltage at the output side. The size of the PV current ripple is a crucial aspect in determining the maximum power point (MPPT) [6].

A renewable energy system (RES) converts the energy contained in sunshine, wind, falling water, waves, geothermal heat, or biomass into a form that may be used, such as heat or electricity. Hydrogen-based renewable energy storage may solve the inherent weaknesses of battery-based energy storage technologies such as physical size, insufficient life duration, and the initial capital cost of the battery bank, as well as transportation, maintenance, and battery disposal difficulties [7]. When renewable resources exceed load demand, hydrogen would be created and deposited by water electrolysis. An electrolyzer, which converts water into hydrogen and oxygen, is employed as a fundamental component of RES for this purpose. When the load demand exceeds the renewable resource input, a fuel cell powered by stored hydrogen would provide the balance of electricity. Existing energy from various sources is connected to a low voltage dc bus to guarantee proper power transmission between system modules [8]. A direct dc bus connection to the electrolyzer is not recommended since it does not provide control of the power flow between the renewable input source and the electrolyzer. To connect the electrolyzer to the system bus, a power conditioning equipment, commonly a dc-dc converter, is required [9].

2. LITERATURE REVIEW

Neha bhagat et al. created a supply circuit for an electrolyzer process that produced hydrogen using a dc to dc boost converter. To achieve the highest output voltage level, they employed ideal switches for quick switching response and ZVS (zero voltage switching) pulse topology. Input supply voltage of 40 volts was used from the PV module and boosted it to 60 volts [9].

At the matlab simulation tool, Prasanna Kumar et al. took a step toward the modification of a typical dc to dc boost converter by substituting MOSFETs and diodes with four IGBTs and two inductors. They created a circuit that took 48 volts input from a PV module and boosted it to 222.5 volts, achieving 91% circuit efficiency.[10].

Antônio Alisson Alencar Freitas et al. created a high-voltage gain dc-dc converter that operated in dependent chip mode (DCM) and does not require electrolytic capacitors to accomplish MPPT in PV systems. An inductor, a capacitor, and a diode were used for the circuit. The presented topology had several significant advantages, including a low component count, decreased dimensions, and inherent simplicity. The converter efficiency was around 87.5%, with a passive regeneration that was employed to reduce the switching losses. The input voltage is 17 volts, whereas the output voltage was observed to be 311 volts. At rated conditions, the average input current I_{in} = 5.82 A, which was much more than the average output current I_{out} = 322 mA [11].

Chou et al. proposed the work to enhance energy efficiency and hydrogen flow rate in the electrolysis process, new evolving DC-DC converters and power management technologies were suggested for implementation. Finally, Pulse width modulation (PWM) change topologies to address power quality, current control, and dynamics response time challenges. Authors suggested that it must be confined to medium voltage application to ensure the maximum power efficiency [12].

3. MODELING OF PHOTOVOLTAIC (PV) ARRAY

Solar energy was instantly turned into electricity by the cells. It is made up of a variety of semiconductor materials. Positive charge and negative charge are the two different kinds. Solar cells with high conversion efficiency and cheap cost are created using this cell technology. When a solar-powered cell absorbs photons, silicon atoms' electrons are broken loose and dragged away by a grid of metal conductors, which forces an electric current to flow. A PV module is the fundamental component of a PV system and is made up of solar cell circuits sealed in an ecologically friendly laminate. To accommodate the energy demand, several PV modules are often stacked in series and parallel. [13] Following are the specification of PV module used in circuit:-

Table -1: PV Panel Parameters

S.No.	MODEL PARAMETER	
1	Maximum Power (W)	200.112
2	Cell Per Module (Ncell)	54
3	Open Circuit Voltage (V_{OC})	32.9
4	Short Circuit current (I_{SC})	8.21
5	Voltage at Maximum Power Point (V_{MP})	26.4
6	Current at Maximum Power Point (I_{MP})	7.58
7	Light Generated Current (I_L)	8.2311
8	Shunt Resistance (R_{SH})	126.9934
9	Series Resistance (R_S)	0.32653

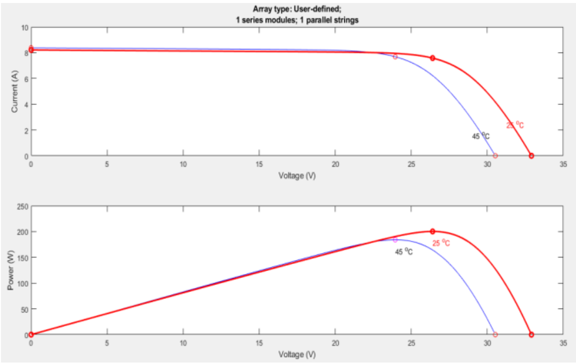

Fig -1: I-V and P-V Characteristics of PV array Model

I-V and P-V characteristics of the PV array is helps to determine the MPPT or sometime just power point tracking (PPT) of the panel.

3.1. Design and construction of the suggested IGBT module work

The circuit for the MATLAB simulation of a DC to DC boost converter is shown in the figure. Tracking the output voltage and current waveforms at full load condition is the circuit's goal. The circuit has a 32.69V input voltage and a 226.5V output voltage. The simulation model's source of input voltage is a solar panel with a 200.112 watt power rating, which is a renewable source of electricity.

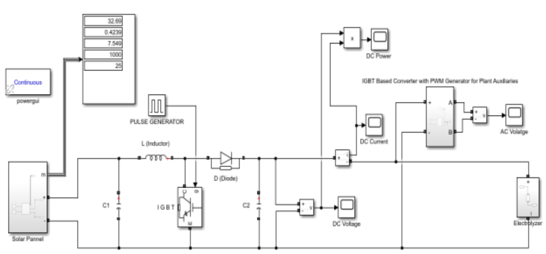

Fig -2: RES System model using PV module

Figure 2 shows how the analysis for the minimal input voltage V_{in}, min = 32.69V under no load conditions with an output voltage V_o = 226.5V predicts the performance of the RES model. In the experiment, boost inductor L = 0.02 H and resonant capacitors C_1 = 0.006 F and C_2 = 0.006 F were utilized as passive parts. Steps increase output voltage by displaying various waveforms captured at no load with a low input voltage 32.69 V. The output voltage decreased from 226.5 to 180.8V when a full load was supplied to the circuit, while the solar panel voltage decreased from 32.69V to 26.29V. Because the solar panel is current source so the current in panel is constant and voltage is variable and it will be near about 20%. We know that water is a pure resistive load, thus we employ resistance as the electrolyzer load.

Graphically Representation of No Load DC and AC Voltages

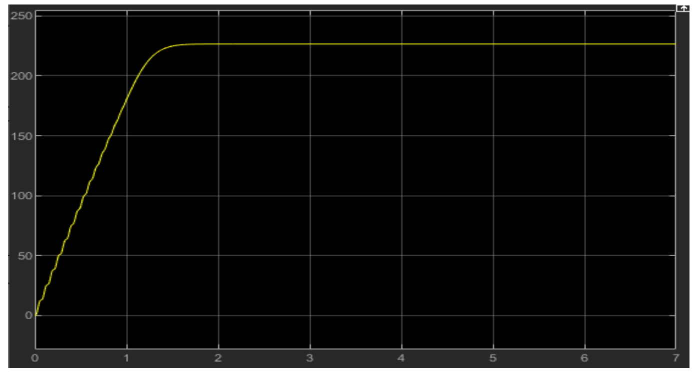

Fig -3: Step up DC voltage. X-axis = Time, Y-axis = DC voltage.

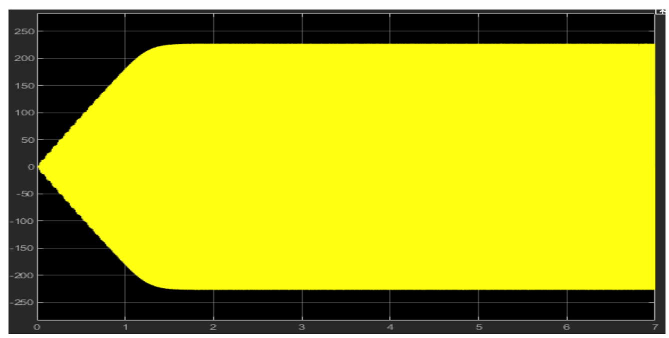

Fig -4: Step up AC voltage. X-axis =Time, Y-axis = AC voltage.

Graphically Representation of DC, AC Voltages, DC Current at Full Load Condition.

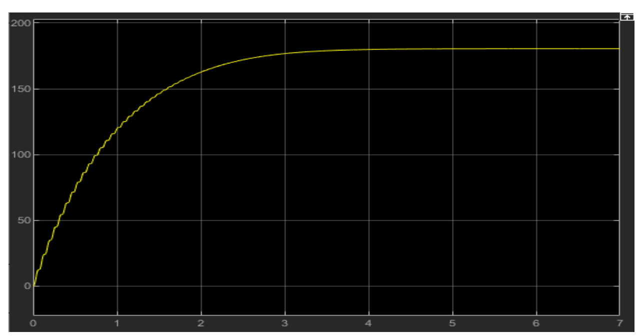

Fig -5: DC Voltage at Full-load. X-axis = Time, Y-axis = DC voltage.

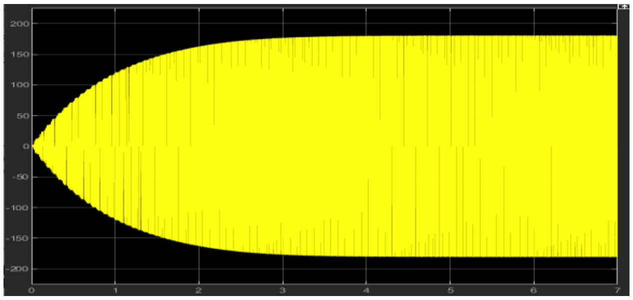

Fig -6: AC Voltage at Full-Load. X-axis = Time, Y-axis = AC voltage.

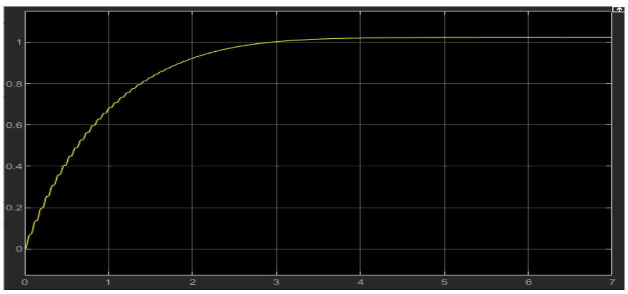

Fig -7: DC Current at full-load. X-axis = Time, Y-axis = AC Current.

Table -2: Result at Various Load Level

S. No	V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	η%	V.DROP	R_L
1	32.69	0.4237	226.5	0.0045	13.85	1.026	7.41	0.00	Open Circuit
2	1.155	8.201	1.143	1.143	9.476	1.307	13.79	99.50	1
3	3.309	8.184	17.13	1.142	27.08	19.56	72.23	92.44	15
4	5.751	8.165	34.03	1.135	46.96	38.62	82.24	84.98	30
5	7.987	8.147	50.74	1.129	65.07	57.27	88.01	77.60	45
6	10.29	8.129	67.24	1.122	83.65	75.45	90.20	70.31	60
7	12.57	8.111	83.54	1.116	102	93.19	91.36	63.12	75
8	14.96	8.092	99.62	1.109	121.1	110.05	90.88	56.02	90
9	17.02	8.076	115.5	1.103	137.5	117.4	85.38	49.01	105
10	19.37	8.055	131.2	1.096	156	143.8	92.18	42.08	120
11	21.49	8.028	146.5	1.088	172.5	159.5	92.46	35.32	135
12	23.52	7.969	161	1.076	187.4	173.3	92.48	28.92	150
13	25.23	7.822	173.2	1.053	197.3	182.4	92.45	23.53	165
14	26.29	7.609	180.8	1.022	200.1	184.7	92.30	20.18	177

As per simulation result this circuit gives 92.3 % maximum efficiency using signal IGBT with PWM technique and voltage drop up to 20.18%.

4. CONCLUSION

This work is the first phase in the investigation of the electrolyzer supply circuit utilizing IGBT switching techniques. The electricity for the electrolyzer supply is supplied by renewable energy resources in the form of a PV array. The PV array produces 32.69V and has a power rating of 200.112 Watt. Using the IGBT-based boost converter in the MATLAB Simulation Tool, we increase the voltage level to 226.5V DC. The circuit consumes 13.85 watts of power in no load condition. After stepping up the DC voltage, we convert it to AC voltage using an IGBT-based converter with PWM generator that consumes 1.029Watt at no load. These alternating current voltages are used for plant auxiliaries. As we know, the elctrolyzer works on step-up dc voltage, therefore when we apply full load to it, the output DC voltage drops to 180.8 V. We measure a total of 20.18% voltage loss in the circuit, with a maximum efficiency of 92.35%.

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