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A NEW MULTI-INPUT CONVERTER CONFIGURATION FOR RENEWABLE ENERGY SYSTEMS

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ABSTRACT

In renewable sources, such as wind and solar energy, the generated voltages often vary because of environmental changes. When the input voltage drops to the value lower than the battery, it will fail to charge. The cascaded buck-boost converters are conventionally used to step-up or step-down the input voltage, however it is relatively complex and costly. In this paper, a new battery charging system is proposed based on the non-inverting buck-boost converters. Circuit connected to wind turbine, for the low wind speed range, the control strategy is aimed to follow the wind turbines maximal power coefficient by adjusting the generator's rotational speed. For high wind speeds, the system power regulation is also made by controlling the generator speed. This control is made by the DC/DC power electronic converter, which modifies its input voltage, changing the machine voltage and consequently varying the generator's rotor speed. The model is validated through the simulation results of one and multiple sources with constant and variable input voltages .Test results show stable operating performances on both steady-state and transit conditions.

KEYWORDS: Buck-boost cascaded, fuel/stack energy system, Solar system, wind energy system**.**

INTRODUCTION

Multi-input inverter for the grid-connected hybrid photovoltaic (PV)/wind power system in order to simplify the power system and reduce the cost. The proposed multi-input inverter consists of a buck/buck-boost fused multi-input dc–dc converter and a full-bridge dc–ac inverter. The output power characteristics of the PV array and the wind turbine are introduced. The perturbation and observation method is used to accomplish the maximum power point tracking algorithm for input sources. [1]

Recently, the clean electric power generation systems have attracted a great deal of social attention to exploit the clean energy resources such as solar array, wind generator, fuel cell and so forth. In this case, the multiple-input dc-dc converter is useful to combine the several input power sources and to supply the regulated output voltage for the load. The novel solar cell power supply system using the buck-boost type two-input dc-dc converter is proposed, in which the solar array and the commercial ac line are exploited as power sources and they are combined by the two input windings of the energy-storage reactor. Also, its operation principle and performance characteristics are discussed.[2]

Renewable Energy development of today has a tendency towards still increasing power ratings for grid- connected systems. Substitute energy plants in case of lacking renewable instantaneous power are not directly considered because of grid connection. Stand-alone applications require well defined concepts for continuous energy supply providing a good balance between various energy sources and their capabilities and load requirements. Stand alone supplies of small power ratings cover local demands, e.g. one house or a small village in remote location. Multiple inputs for renewable energy are proposed in combination with high-efficiency power electronics for optimum power input into a DC bar directly connected to a battery.[3]

A controlled wind generation system for a standalone application is presented in this paper. A cascaded step-up/step-down power electronic converters topology is proposed to control the wind power system in the whole wind speed range. For the low wind speed range, the control strategy is aimed to follow the wind turbines maximal power coefficient by adjusting the generator's rotational speed. For high wind speeds, the system power regulation is also made by controlling the generator speed. This control is made by the DC/DC power electronic converter, which modifies its input voltage, changing the machine voltage and consequently varying the generator's rotor speed. [4]

PRINCIPLE OF OPERATION

The non inverting converter consists of only two Switches and two diodes. Buck and boost modes are sharing the same inductor, as shown in Fig I. The operating mode is controlled by only one

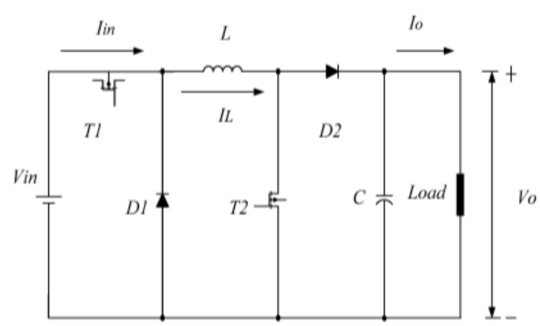

Fig.1 The Configuration of Non-Inverting Dc/Dc Converter

algorithm, depending on the value of the input voltages. If the input voltage is larger than the required output voltage, the converter works as a buck converter to step down

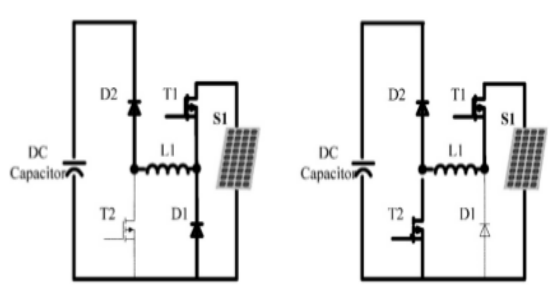

Fig 2.A) Buck Operation (B) Boost Operation

The input voltage, which is shown in Fig.2(a). As shown in Fig.2(b), if the input voltage is smaller than the required output voltage, the converter can be operated as a boost converter by simply switching T1 and T2. The non-inverting buck-boost converter with two switches can be used as three modes, which are buck, boost and buck-boost modes. The switching sequences are shown in Table.I for each modes

Table:1. Operating Modes

Operating Mode	Switching sequences	
	T1	T2
Buck converter	PWM	OFF
Boost converter	ON	PWM
Buck-boost converter	PWM	ON

Generally, the buck-boost mode is not taken into consideration since it has high sensitivity of duty cycle variations. In addition, large switching loss is another main drawback. Therefore, only buck and boost modes are commonly used. For the buck mode shown in Fig.2, if the battery voltage is smaller than the input voltage, TI is ON and T2 is OFF. Thus, the converter works as a buck converter, except that there is an additional diode drop due to D2. In order to block the reverse current flow when the panel voltage drops below the battery voltage, diode D2 is quite necessary for the proposed configuration. The voltage range of the input source must lie equal or above to the battery for the buck mode.gain value is given by

$$V_o = V_{in} \bullet d_1 - V_{d1} \bullet \left(1 - d_1\right) - V_{d2} \tag{1}$$

The boost-converter mode is presented in Fig.2(b). If the converter operates as the boost mode, T I is ON and T2 is used for PWM modulation. The output voltage is given by

$$V_o = \frac{V_{in}}{1 - d_2} - V_{d2} \tag{2}$$

THE PROPOSED MULTIPLE INPUT TOPOLOGY

The proposed configuration In the proposed topology, different renewable energy sources are connected in parallel to form a multiple input system for charging batteries, as shown in Fig.3. As batteries can be considered having big capacitor inside, the proposed topology deletes the capacitors of the non-inverting coveters to achieve cost-optimality. In order to deliver the maximum power to the battery side, Perturbation and Observation (P&O) algorithm is employed in the proposed system.

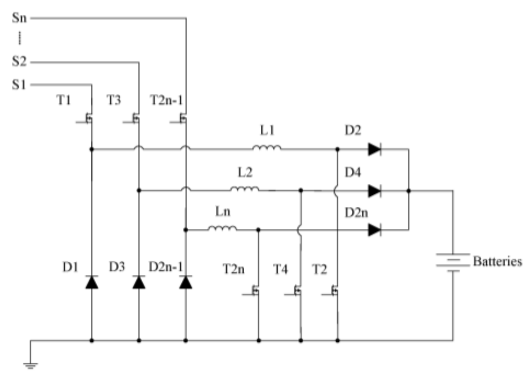

Fig 3. Multiple Input Topology

For the multiple input configuration, more renewable sources can be connected to the proposed system by simply adding more legs. The multiple inputs can deliver power simultaneously to the battery side without any time share operations. Since the non-inverting converter can operate as both buck and boost modes, the different PV sources can be operated in the voltage above or below the battery voltage. Due to the parallel connection, the system will not be diminished if one of the input sources failed.

The flow chart of buck/boost-mode selector is presented in Fig.6. The mode is determined depending on values of the PV and battery voltage. If the PV voltage is smaller than the battery voltage, the "sel" is set as -1, otherwise the "sel" is 1. By reading the value of "sel", switches TI and T2 are controlled to regulate the desired voltage and current.

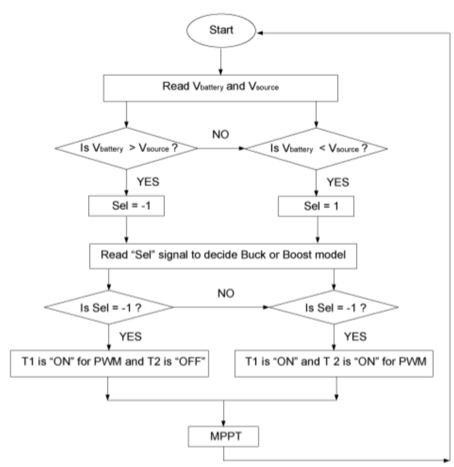

Fig 5. Flow Chart of Buck/Boost -Mode Selector

Table:2. Circuit Parameters

Parameters	Value	Unit
Input voltage	0-24	V
Battery voltage	12	V
Maximum load current	5	A
Switch frequency	100	kHz
Voltage ripple	50	mV
Maximum current ripple	0.5	A
Inductor	150	µH

CONTROL LOOP FOR WIND ENERGY CONVERSION & FUEL CELL

The proposed cascaded power converter is composed of an input boost converter plus an output buck converter. Each power converter is controlled in an independent and complementary way. To control the DC voltage, a feed-forward strategy is used. A selector allows the converters complementary operation. For this, the DC voltage measurement at the boost converter input (diode bridge output voltage) is used. This voltage is proportional to the AC voltage at generator terminals, which is approximately proportional to the system rotor speed.

To control the DC voltage, relations between DC voltages (diode bridge DC voltage VDC and output battery voltage VBatt) are considered (3).

$$V_{batt} = A_v . V_{dc} = f(D) . V_{dc} \qquad (3)$$

The voltage gain Av of buck and boost converters for Continuous current mode are defined by (4) and (5) respectively

$$A_{v\,Buck} = \frac{V_o}{V_i} = D$$

$$A_{v\,Boost} = \frac{V_o}{V_i} = \frac{1}{1-D}$$

(4) (5)

So, as the battery voltage –which is the wind energy system output voltage– remains nearly constant and when boost converter is on stand-by mode (switch open, diode in forward mode), the control variable when buck converter is regulating is (6). The voltage reference value $V_{DC\,REF}$ is obtained from generator speed control.

$$D_{Buck} = \frac{V_{Batt}}{V_{DC\,REF}}$$

(6)

When boost converter is controlling the DC voltage for maximal power output, the buck converter is now in the steady state value of the control variable for the step up converter is

$$D_{Boost} = 1 - \frac{V_{DC\,REF}}{V_{Batt}} \quad (7)$$

Figure 6 shows the proposed open loop control scheme for the cascaded DC converter, based on a pulse

width modulation (PWM) scheme, where the duty cycle for each converter is calculated and converted into gate signals. The DC voltage reference is compared to battery voltage to define which converter will operate and a simple digital circuit completes the task.

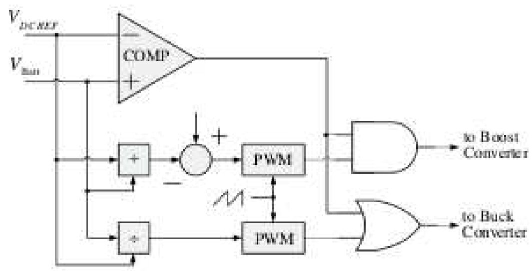

Fig 6. Control Circuit for Wind Generation and Fuel Cell

The AND function is used to control the boost converter because it operates as DC/DC converter only when DC voltage reference is lower than battery voltage. The power transistor must remain open elsewhere. The OR logic function allows controlling the buck converter when required DC voltage is higher than battery voltage. The power transistor must remain closed when the boost converter operates

PROPOSED BLOCK DIAGRAM

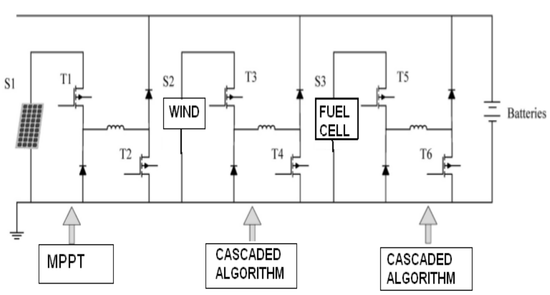

Fig. 7 Block Diagram of Proposed System

The proposed block diagram shows that the DC-DC converter discussed above cascaded and the inputs are given form solar, wind and Fuel cells. So the power will be given from the three renewable resources. In summer the power is generated from solar and in windy season wind power generator gives power and in mean while we can use fuel cells to store the energy.

SIMULATION & RESULTS

The simulation for the proposed charger (cascaded DC-DC converter) was simulated using matlab. The circuit parameters are taken from the table I. And simulation results are shown in the below figure

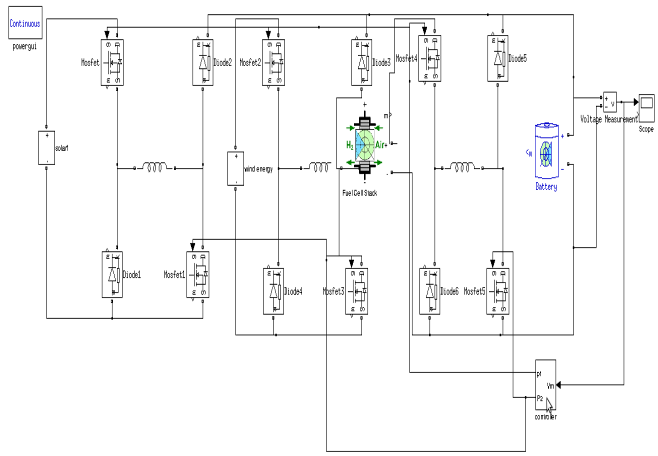

Fig. 8 Complete Simulation Diagram

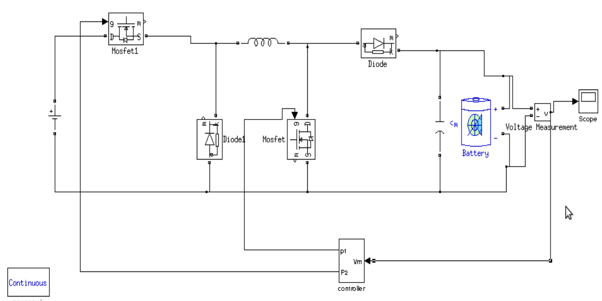

Fig 9. Single Circuit Connected to Solar System

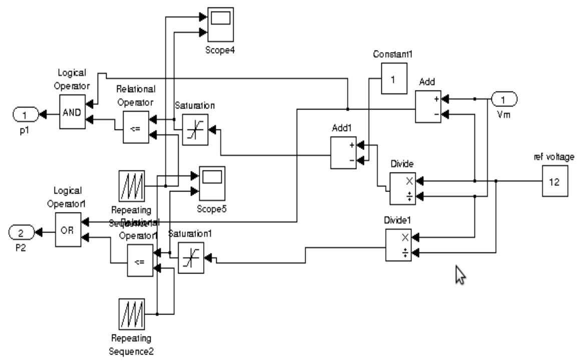

Fig 10 Cascaded Circuit Diagram

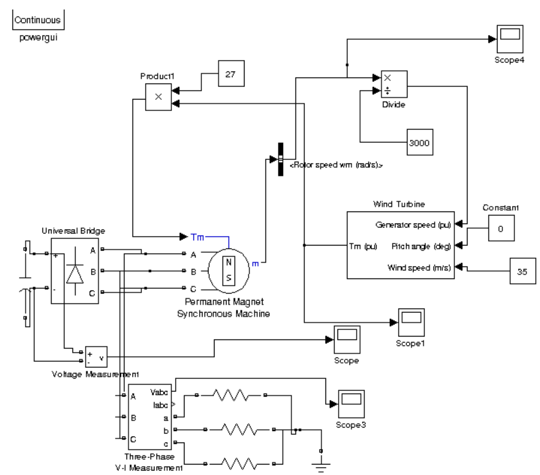

Fig 11. Wind Energy System with PMSM

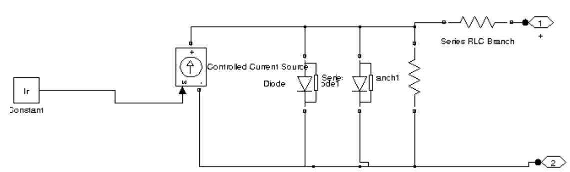

Fig 12. Solar Panel Modelling

RESULTS

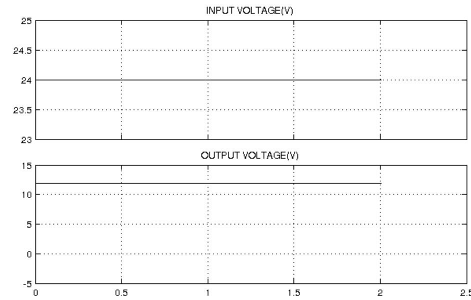

Fig 11. Output Voltage Maintained Constant When the Input Give is 24V-Converter Acts as Buck Converter.

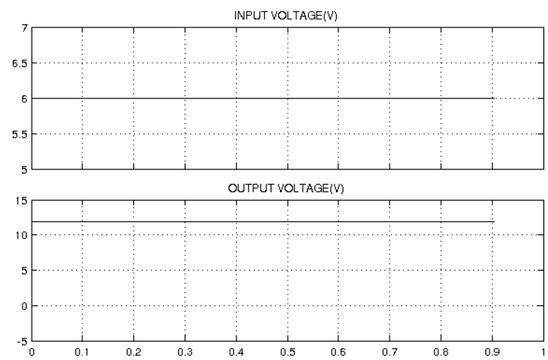

Fig 10. Output Voltage Maintained Constant When the Input Given is 6V Converter Acts in Boost Mode

The above figure shows the control circuits and the main proposed circuit with the output waveforms.

CONCLUSIONS

A novel multiple-input configuration is proposed for connecting multiple PV sources. The proposed system has the advantage of low cost because of the reduced components in converter. The principle of converter operation is explained. P&O MPPT algorithm is employed to track the MPP. The PMSM based wind energy system and fuel-cell are connected as input to the circuit . The proposed system can either step-up or step-down the PV source voltages to charge batteries with a satisfied MPPT and cascaded control algorithm. Solar system, wind energy gives energy seasonally and fuel cell gives when the fuel is available.

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