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Bi-directional Inverter with DC-Bus Voltage Regulation and Power Compensation in DC-Micro Grid System

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Abstract: ***The objective of this paper is to propose single phase bi-directional inverter which will do DC bus voltage regulation and power compensation for DC microgrid applications. Due to defects of the traditional AC grid power supply DC microgrid is an effective solution to integrate renewable energy sources which are DC power supply with DC load & this system would be more efficient. In DC microgrid system it will required bi-directional inverter to control power flow between AC and DC grid and to regulate the DC bus voltage up to certain range. This bi-directional inverter has to full fill rectification and real power injection by reducing harmonics level. Experimental results obtained from 400VA single phase Bi-directional inverter.***

Keywords: Micro-grid system, dc-bus, MPPT, inverter

1. Introduction

Today the Energy efficiency has become a key element in the design and construction industry. Because of increased energy costs over the past several decades and the shift in philosophy to reduce the environmental impact that humans have on the world. Also, because of the cost of renewable, designers and owners are attempting to reduce energy usage in order to get the most out of limited resources. The concept of energy savings has shifted from the load to a global perspective, including the generation source and, distribution efficiency. Instead of increasing conversion efficiency, designers have removed the conversion processes and utilized a direct current distribution by increasing the DC loads in a technologically advanced society. Hence DC Micro-grid system is used which integrates all these energy to the demand sites economically. A micro-grid constitutes interconnected distributed energy resources, capable of providing sufficient and continuous energy to a significant portion of internal load demand. A heavy step load change will cause high dc-bus voltage variation and fluctuation. In dc micro-grid applications dc load may change abruptly, this will result in high dc-bus voltage variation and Power Compensation. To solve this problem dc-Bus Voltage Regulation and Power Compensation with Bi-directional Inverter in DC Micro-grid Applications proposed. For regulating the dc-bus voltage of a dc micro-grid system, the bi-directional inverter must operate in either grid-connection mode or rectification mode. Bi-directional inverter has to fulfill real power injection and rectification to regulate the dc bus within a certain range of 380 ± 20 V. The bi-directional inverter can adjust its current command and change its operational mode instantaneously to balance the power and tune the dc-bus voltage. The inverter controls the power flow between dc bus and ac grid, and regulates the dc bus to a certain range of voltages.

1.1 Bidirectional Inverter

A dc micro-grid power distribution system combining renewable DG with utility grid to supply power more efficiently has attracted a lot of attention. In dc-micro-grid applications, a bi-directional inverter has to fulfill real power injection (sell power or grid connection) and rectification (buy power) with PFC to regulate the dc bus within a certain range of 380±20 V [1] .The overall system configuration is shown in Fig. 1

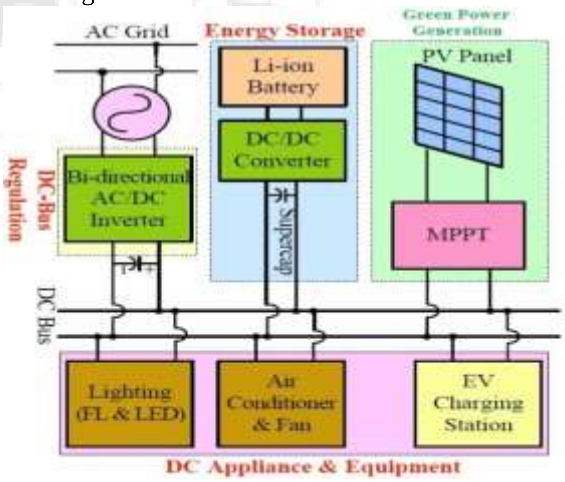


Figure 1: DC-Micro grid application system

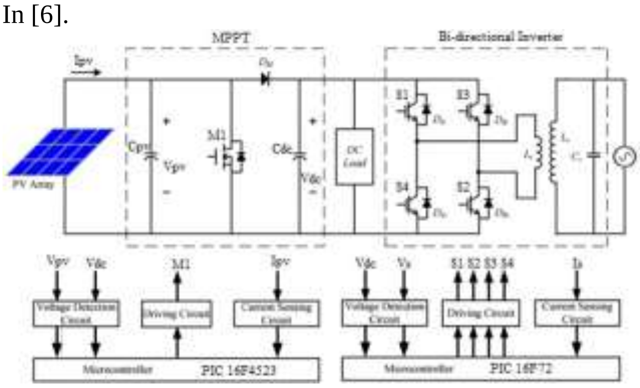
For regulating the dc-bus voltage of a dc-micro-grid system, the bi-directional inverter must operate in either grid-connection mode or rectification mode. In literature, a robust dc-bus voltage control scheme with a window average and an adaptive PI-like fuzzy logic controller for regulating a constant dc-bus voltage were proposed. However, a heavy step load change will cause high dc-bus voltage variation and fluctuation and the system might run abnormally or drop into under or over voltage protection. Bulky dc-bus capacitors can be adopt to increase the hold-up time which suppress the fluctuation of dc-bus voltage, but also increase the size and the cost of a PV inverter system significantly. For reducing the dc-bus capacitor size, reference uses an H-bridge in series with a bi-directional SR dc-dc converter. To operate the system more efficiently while without need of bulky dc-bus capacitors, an on-line regulation mechanism according to the inverter current levels. The bi-directional inverter can adjust its inductor current command and change its operational mode instantaneously to balance the power and tune the dc-bus voltage. It can enhance the dynamic performance on dc-bus voltage response but induce high current harmonic components. On the other hand, the current command can be updated at the zero-crossing of every line cycle to reduce harmonic currents, while it will result in high dc-bus voltage variation. Moreover, for meeting the requirement of reactive power compensation, the bi-directional inverter will adjust its output power factor and change the operational mode correspondingly.

1.2 Power Generation

Generation of system can be either AC or DC. In many cases, the AC sources will be converted to DC for distribution purpose. But more often in most of the cases two distribution systems are used in buildings. AC distribution is still relevant in buildings due to the need for plug loads. There is not a wide spread standard for DC plugs and many products are not manufactured that use these DC plugs as a standard power source. DC micro-grids use a single point of contact with the outside utility grid.

1.3 Particle Swarm Optimization

The proposed PV inverter system is shown in Fig. 2, which can fulfill grid-connection (sell power) and rectification (buy power) modes. The inverter senses current Is, dc-bus voltage Vdc and line voltage Vs, and uses the battery voltage or PV to determine a control for operating the inverter. When the output power from PV panels is higher than load requirement, the dc-bus voltage will get regulated to 12V; the inverter is operated in grid-connection mode. On the other hand, the inverter is operated in rectification mode with PFC to convert ac source to replenish the dc bus. Since the load may change abruptly and cause dc-bus voltage varying beyond the operating range, it requires a regulation mechanism to control the dc-bus voltage to a certain range. In [6].



Above figure 2 shows Configuration of a PV inverter system which includes MPPT and Bi-directional inverter connected to PV array and output voltage.

2. Simulated & Experimental Results

In this section, a proposed bi-directional inverter was simulated and implemented to verify its feasibility, of which the specifications and components are collected in Table 1.

Table 1: Specifications and components of the proposed inverter

Inverter Components	
Components	**Specification**
Inverter transformer	400VA
Power Connector	300AMP
Panel Mounting Fuse	5A
Sensing Transformer	6V
AC Capacitor	2.5µf/440V
Controller card /PCB	APD
Controller	PIC16F72
Optocoupler	6N137
OP-AMP	LM358
Power MOSFET	55V, 80A
Driver Stage Transistors	BC547/557
Driver Transistors for Relay/Buzz	BC547
Driver Transistors for fan	BD139
Zener Diode	6.2V
Switching Diode	1N4148
Relay	12V / 1 CO
Push to ON Switch	APD
ON/ OFF switch	APD
LED	5V
Resistance	MFR-1/4W
PCB Mounting fuse	40Amp
Battery	12V, 7Ah
AC Load	100W Bulb
Solar Panel	5W
Crystal	20MHz
Heat sink	APD

Table 2: Specifications and components of the MPPT

MPPT Components	
Components	**Specification**
Controller	PIC18F4523
LCD	20*4
Switch Push to ON	APD
Crystal	20MHZ
MOSFET IRFZ44	60V,50A
Controller card /PCB	APD
Resister Diodes	1N5408
Resister Diodes	1N4007
Box Capacitor	0.1µf/100V
Electrolytic Capacitor	1000µf/25
LCD Connector	APD
Power Connector	APD
Resister	100Ω, 1 W
Current Sensors	APD
DC Load	APD
DC Fan LED Strip Charging Station	12V 12V 5V

In this below figure 3 shows Photograph for the prototype of the designed bi-directional inverter and figure 4 shows the measured waveform,

Figure 3: Photograph for the prototype of the designed bi-directional inverter

Figure 4: Measured Waveform

Following are Experimental output of the Single-Phase Bidirectional Inverter

1. For Variable DC Load

Sr.No	Parameter	No Load	Load 1	Load 2	Load 3	Load 4
1	Battery Voltage	12.4	12.3	12.1	12.1	12.00
2	Battery Current	0.74	1.56	1.86	1.96	2.09
3	Solar Voltage	7.2	7.2	7.2	7.2	7.2
4	Solar Current	0.07	0.07	0.07	0.07	0.07
5	DC Bus Voltage	12.37	12.22	12.08	11.96	11.86

2. For constant DC Load (12 Volt, 1 Amp)

Sr. No	Output voltage of solar panel	No. of lamp on for radiation	DC Bus voltage	Output voltage of solar panel
1	14.7	100 W	12.50	14.7
2	16.3	200 W	12.46	16.3
3	17.1	300 W	12.45	17.1
4	17.7	400 W	12.46	17.7
5	17.9	500 W	12.42	17.9

3. Output for Variable AC Load

Sr.No	No. of lamp on (AC Load)	AC Voltage (Volt)	AC Current (Amp)
1	40W	230	0.2 A
2	100W	228 V	0.25 A
3	200W	226 V	0.75 A
4	300W	223 V	1.16 A
5	400W	217 V	1.7 A

Hence we have Verified Terminal voltage of DC Bus is maintain to constant level, though there is voltage drop occurs practically hence it is slightly decrease.

3. Conclusion

In this paper a modulated digital control for a 1ϕ bidirectional inverter has been designed and implemented along with MPPT which is having capabilities:-
1) To charge through solar input power
2) To charge through AC mains

Its output can be used for 12V DC appliances. eg- LED, fan, charging. Its output can also be used for 230 V AC appliances. eg- household appliance. Bidirectional inverter here working in in Rectification mode & Grid connection mode also & actual selling of power to the grid is possible when isolation transformer is connected to the AC side of inverter via net metering. Here care is taken for harmonic generation due to switching frequency by AC capacitor at output.

References

[1] Tsai-Fu Wu, Senior Member, IEEE, Kun-Han Sun, Chia-Ling Kuo, and Chih-Hao Chang, Predictive Current Controlled 5-kW Single-Phase Bidirectional Inverter With Wide Inductance Variation for DC-Microgrid Applications, IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 25, NO. 12, DECEMBER 2010, pp. 3076-3084.
[2] Kuo-Yuan Lo, Yaow-Ming Chen, Senior Member, IEEE, and Yung-Ruei Chang, Member, IEEE, Bi-Directional Single-Stage Grid-Connected Inverter for Battery Energy Storage System, IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS 2016, pp. 0278-0046.
[3] Tsai-Fu Wu, Senior Member, IEEE, Chia-Ling Kuo, Li-Chiun Lin, and Yu-Kai Chen, Member, IEEE, DC-Bus Voltage Regulation for a DC Distribution System With a Single- Phase Bidirectional Inverter, IEEE JOURNAL OF EMERGING AND SELECTED TOP- ICS IN POWER ELECTRONICS, VOL. 4, NO. 1, MARCH 2016, pp.210-220.
[4] Fei Wang, Student Member, IEEE, Jorge L. Duarte, Member, IEEE, and Marcel A.M. Hendrix, Member, IEEE, Grid-Interfacing Converter Systems With Enhanced Voltage Quality for Microgrid Application Concept and Implementation, IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 26, NO. 12, DECEMBER 2011, pp.3501-3513.
[5] Ming-Hao Wang, Student Member, IEEE, Kwan-Tat Mok, Student Member, IEEE, Siew-Chong Tan Senior Member, IEEE, and S. Y. (Ron) Hui, Fellow, IEEE, Multifunctional DC Electric Springs for Improving Voltage Quality of DC Grids. IEEE accepted for publication in a future issue of this journal 2016,pp. 1949-3053.
[6] Xiangzhen Yang, Yan Du, Jianhui Su, Liuchen Chang, Senior Member, IEEE, Yong Shi and Jidong Lai,' An Optimal Secondary Voltage Control Strategy for an Islanded Multi-bus Micro-grid', IEEE. Pp. 2168-6777.
[7] Daolian Chen, Senior Member, IEEE, and Sheng Chen.' Combined Bidirectional Buck- Boost DC-DC Chopper-Mode Inverters with High-Frequency Link', IEEE

TRANSAC- TIONS ON INDUSTRIAL ELECTRONICS, VOL. 61, NO. 8, AUGUST 2014, pp. 3961-3968.

[8] 8.Tan Ma, Mehmet H. Cintuglu, Student Member, IEEE, and Osama A. Mohammed, Fellow, IEEE,' Control of Hybrid AC/DC Microgrid Involving Energy Storage and Pulsed Loads', IEEE,p.p- 0093-9994.

[9] Bo Yang, Wuhua Li, Member, IEEE, Yi Zhao, and Xiangning He, Fellow, IEEE, Design and Analysis of a Grid-Connected Photovoltaic Power System, IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 25, NO. 4, APRIL 2010, pp. 992-1000.

[10] Fei Wang, Student Member, IEEE, Jorge L. Duarte, Member, IEEE, and Marcel A. M. Hendrix, Member, IEEE,' Grid-Interfacing Converter Systems With Enhanced Voltage Quality for Microgrid Application-Concept and Implementation', IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 26, NO. 12, DECEMBER 2011, pp. 3501-3513.

[11] Tsai-Fu Wu, Senior Member, IEEE, Chia-Ling Kuo, Kun-Han Sun, Yu-Kai Chen, Yung-Ruei Chang, Member, IEEE, and Yih-Der Lee, Member, IEEE,' Integration and Operation of a Single-Phase Bidirectional Inverter With Two Buck/Boost MPPTs for DC-Distribution Applications', IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 28, NO. 11, NOVEMBER 2013, pp. 5098-5106.

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