INTERNATIONAL RESEARCH JOURNAL IN ADVANCED ENGINEERING AND TECHNOLOGY (IRJAET) E - ISSN: 2454-4752 P - ISSN : 2454-4744
VOL 3 ISSUE 1 (2017) PAGES 1603 - 1607
RECEIVED : 15.01.2017 PUBLISHED : 07.02.2017

February 7, 2017

NOVEL MODULAR MULTIPLE-INPUT BIDIRECTIONAL DC–DC POWER CONVERTER (MIPC) FOR HEV/FCV APPLICATION

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ABSTRACT

This paper proposes PV (Photo-Voltaic) based multiple-input bidirectional dc–dc power converter to interface more than two dc sources of different voltage levels. This finds applications in hybrid electric cell vehicles, where different dc sources of unequal voltage levels need to be connected with bidirectional power flow capability. The converter can be used to operate in both the buck and boost modes with bidirectional power control. It is also possible to independently control power flow between any two sources when more than two sources are actively transferring power in either direction. Interleaved boost converter is used to step-up the PV voltage with low output current ripple. The proportional-integral-derivative (PID) controller provide required gate pulses to the transistor switches used in the bidirectional dc to dc converter.

Keywords: DC–DC power converter, fuel cell vehicle (FCV), hybrid electric vehicle (HEV), multiple-input converter.

1. INTRODUCTION

In fuel cell vehicle (FCV) systems, a dc–dc converter is used at the output of the fuel cell (FC) stack to obtain the required dc-link voltage to the inverter providing the power to the propulsion motor. To start the operation of the FC system and also to share the load, a battery unit that can supply power to the same dc link is used. The battery unit also helps to overcome the slower response time of the FC stack by providing peak power during the acceleration of the vehicle. In addition, the peak power transients during acceleration and regenerative braking can be avoided by the inclusion of a higher power density element such as an ultra capacitor. This can be used to store regenerative energy during deceleration to provide the supplemental power during acceleration. The ability of the ultracapacitor to handle higher power for higher number of charge/discharge cycles not only increases the life span of both the FC and battery but also improves the overall system efficiency. Based on the characteristics and dynamics of FC, the battery and ultracapacitor are optimally sized to achieve the required performance. A power electronic interface unit is required to match the voltage levels of the battery and the ultracapacitor units with the dc-link voltage Vdc of the inverter. The typical functional schematic of the power converter interface unit is shown in Fig. 1. The function of this multiple-input power converter is to interface these various sources with the dc link of the inverter and to regulate the power flow between the sources. A number of topologies are proposed in the literature to transfer the power from one source to another in hybrid electric vehicle (HEV) and microgrid applications. In multiple sources are interfaced using a common highfrequency transformer, where each source is connected through full-bridge cells utilizing 12 switches for three sources. Both phase shift and duty ratio modulations are proposed for controlling the converters.

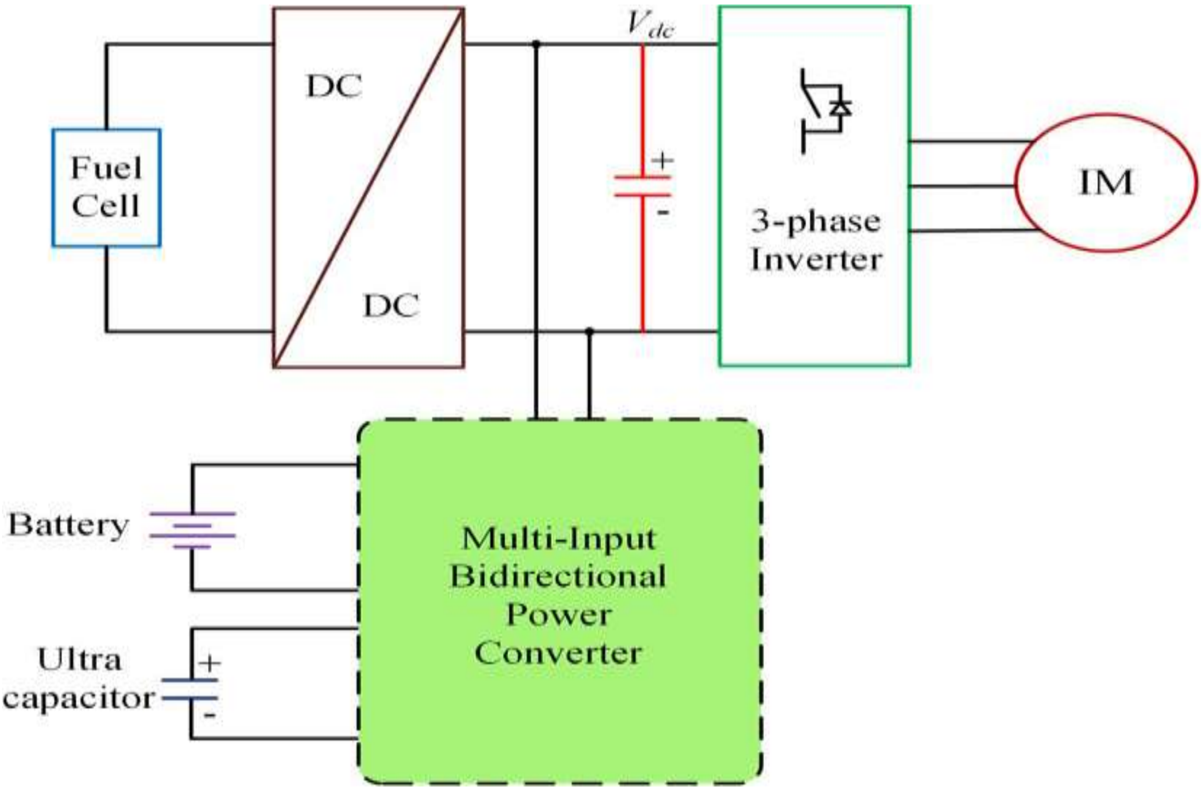

Fig. 1. Functional diagram of a hybrid FCV system

In PV (Photo-Voltaic) systems, a dc–dc converter issued at the output of the PV to obtain the required dc-link voltage to the inverter providing the power to the propulsion motor. To start the operation of the PV system and also to share the load, a battery unit that can supply power to the same dc link is used. The battery unit also helps to overcome the slower response time of the PV array by providing peak power during the acceleration of the vehicle. In addition, the peak power transients during acceleration and regenerative braking can be avoided by the inclusion of a higher power density element such as an ultra-capacitor. This can be used to store regenerative energy during deceleration to provide the supplemental power during acceleration.

2. PROPOSED SYSTEM

The ability of the ultra-capacitor to handle higher power for higher number of charge/discharge cycles not only increases the life span of both the FC and battery but also improves the overall system efficiency. Based on the characteristics and dynamics of FC, the battery and ultra-capacitor are optimally sized, to achieve the required performance. A power electronic interface unit is required to match the voltage levels of the battery and the ultra- capacitor units with the dc-link voltage Vdc of the inverter. The function of this multiple-input power converter is to interface these various sources with the dc link of the inverter and to regulate the power flow between the sources. A number of topologies are proposed in the literature to transfer the power from one source to another in hybrid electric vehicle (HEV) and micro grid applications.

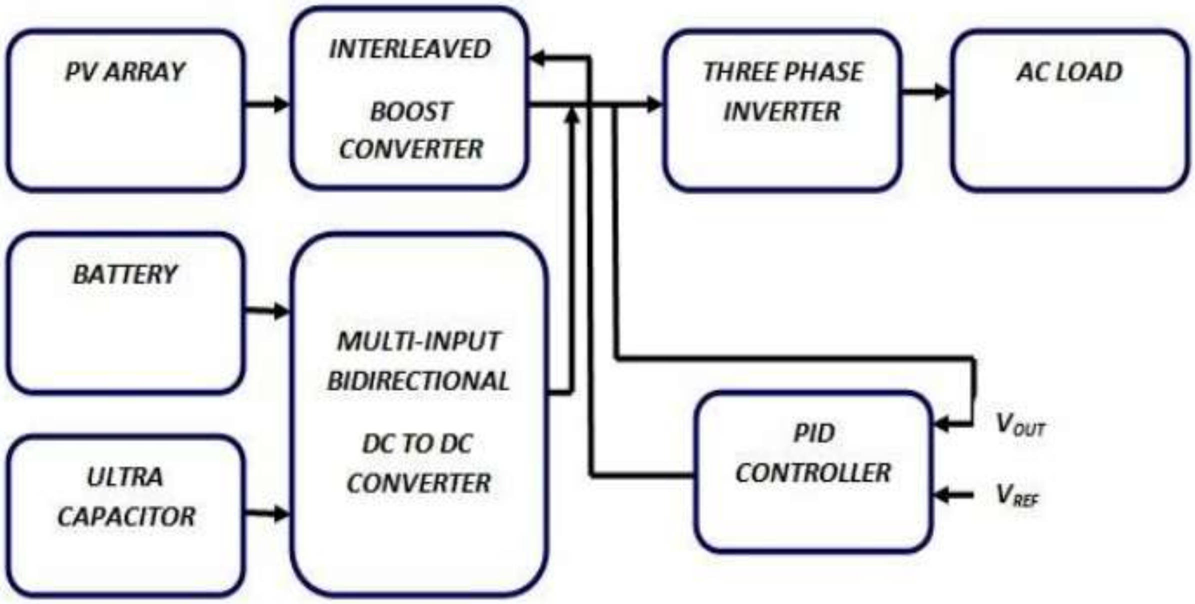

Fig.2. Block Diagram of Proposed System

In this system PV array converts light energy into dc electrical energy using photo-voltaic effect. The interleaved boost converter is a voltage step-up and current step-down converter. Here it boosts the dc voltage obtained from fuel cell and it gives necessary voltage to the dc link. Interleaved boost converter is designed by connecting two boost converters in parallel so it reduces ripples in the output current.

3. RESULT ANALYSIS

Battery and Ultra-capacitors are bidirectional devices because both devices have charging and discharging characteristics.Multi-input bidirectional dc to dc converter acts as buck converter during battery and ultra-capacitor charging,it acts as boost converter during battery and ultra-capacitor discharging. This converter maintains the power flow between dc link and battery, ultra-capacitor. Proportional-Integral-Derivative (PID) controller provide gate pulses to the transistor switch used in multi-input bidirectional dc to dc converter via driver circuit to maintain the desired value at the output.

MATLAB is a high-performance language for technical computing. It integrates computation, visualization, and programming in an easy-to-use environment where problems and solutions are expressed in familiar mathematical notation. Typical uses include

- Math and computation.
- Algorithm development.
- Data acquisition.
- Modeling, simulation, and prototyping.
- Data analysis, exploration, and visualization.
- Scientific and engineering graphics.

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Application development, including graphical user interface building. MATLAB is an interactive system whose basic data element is an array that does not require dimensioning. This allows you to solve

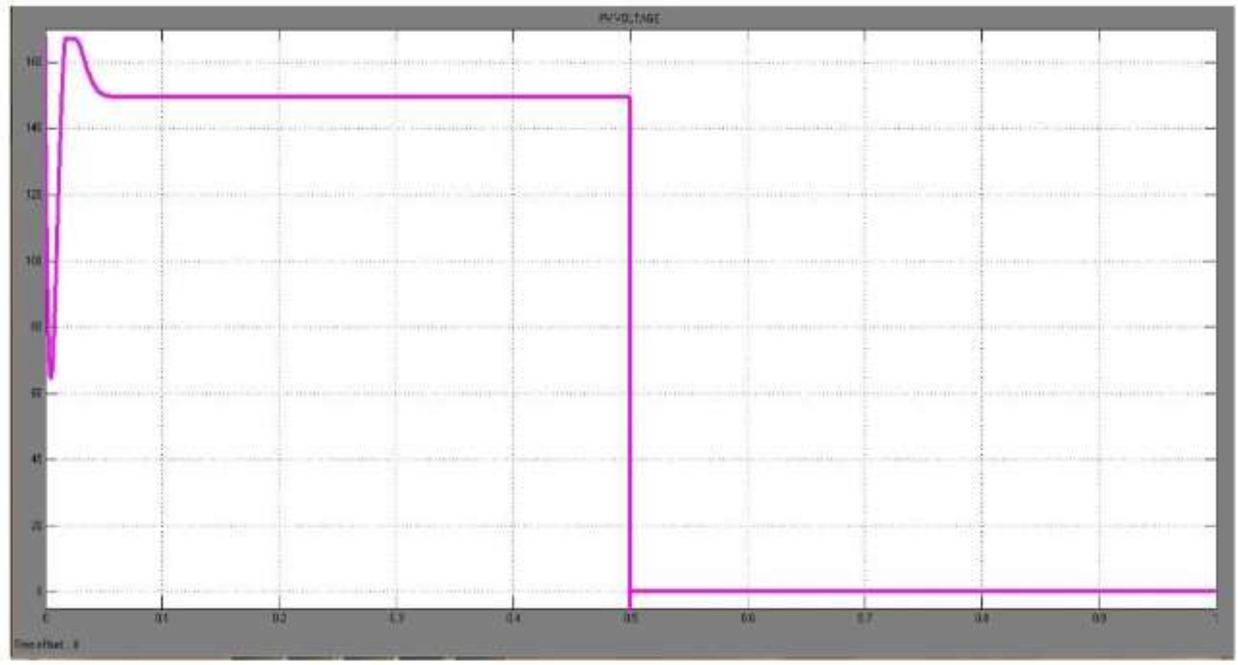

Fig.3. Output voltage

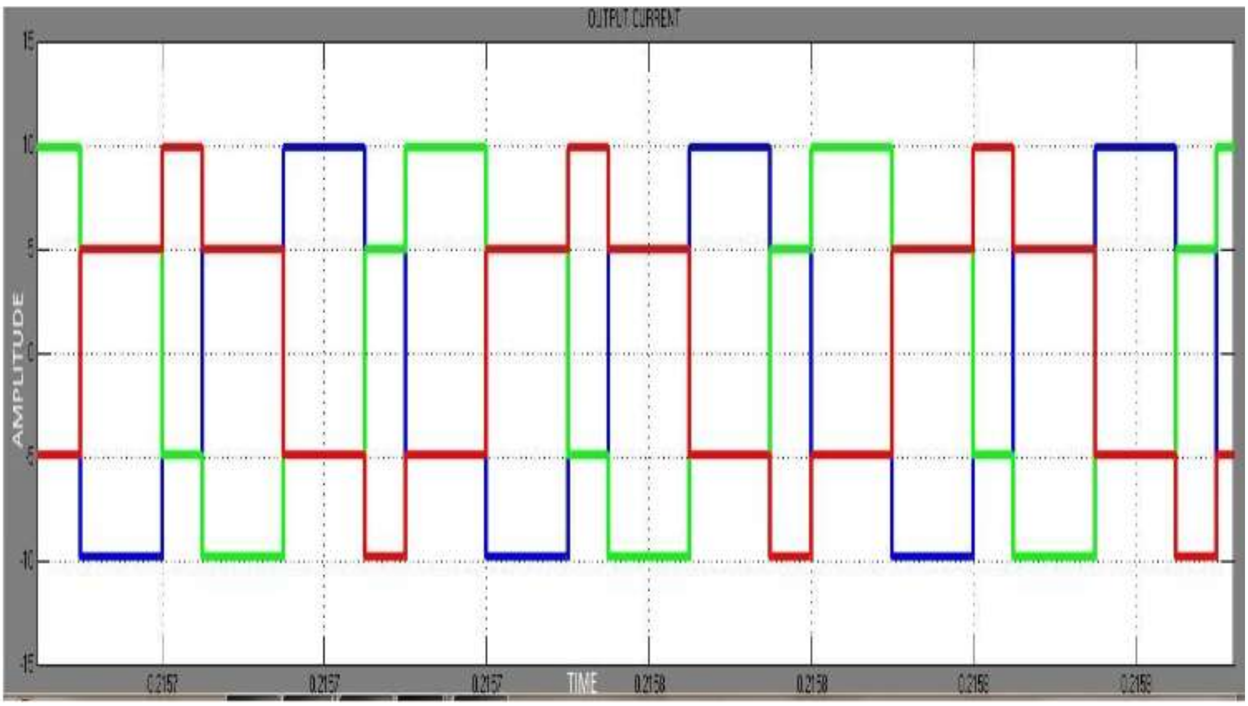

Fig.4.Output Current

many technical computing problems, especially those with matrix and vector formulations, in a fraction of the time it would take to write a program in a scalar non interactive language such as C or FORTRAN.

CONCLUSION

This system has proposed a multiple-input bidirectional dc–dc converter to interface more than two sources of power/energy operating at different voltage levels. The converter can be operated either in buck mode or boost mode in either directions of power flow. It is possible to control the power flow between each pair of sources independently when more than two sources are active. This system gives detailed analysis, modulation, and operation of the converter for various modes. In each mode, the relationship between the sources is derived which assists in the implementation of the controller. The design of the converter for a typical hybrid FCV has been explained where the dc link of the inverter, lithium-ion battery bank, and ultra capacitor tank are being interfaced together. Typhoon-based HIL realtime system has been used to emulate the designed converter to validate the performance.

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