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A Simplified PMSM Drive fed MIMO Boost Converter for Electric Vehicles

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ABSTRACT

A New Simplified transformer-less multi-input multi-output dc–dc boost converter fed PMSM Drive is proposed in this paper. This converter is applicable in hybridizing alternative energy sources in electric vehicles. In fact, by hybridization of energy sources, advantages of different sources are achievable. In this converter, the loads power can be flexibly distributed between input sources. The proposed converter has two outputs with different voltage levels which makes it suitable for interfacing to multilevel inverters and also for electric vehicles. The proposed converter has just one inductor. Depending on charging and discharging states of the energy storage system (ESS), two different power operation modes are defined for the converter. In this paper battery discharging mode is evaluated by effective control which is more efficient than conventional controllers. The Proposed Circuit is simulated using Matlab/Simulink.

KEYWORDS: DC–DC converters, electric vehicle, hybrid power system, multiple-input–multiple-output(MIMO).

1. INTRODUCTION

It has been well recognized that hybrid electric vehicles (HEVs) are much more efficient and cleaner than the vehicles powered by gasoline and diesel engine alone. The EVs can be used for environmentally friendly transportation application with the usage of clean and renewable energy sources such as fuel cell etc. Due to the slow power transfer rate and increased cost of fuel cell, they are used along with batteries and super-capacitors. To provide a specific voltage level for load and to control power flow between input sources, dc-dc converter is needed. In hybrid power systems, multiinput dc-dc converters have been used.

In this paper, a new multiinput multioutput nonisolated converter based on combination of a multiinput and a multioutput converter using simplified effective control is proposed. The proposed converter compared to similar cases has less number of elements. This converter can control power flow between sources with each other and load. Also, proposed converter has several outputs that each one can have different voltage level. The terminal output voltage is controlled by effective simplified controller which performs better than conventional controllers.

2. LITERATURE SURVEY

To address the issues of depletion of fossil fuels, rising gasoline prices, over-dependence on foreign energy, and growing greenhouse gas emissions, vehicle manufacturers have increasingly found electric vehicles as a solution. All-electric vehicles (EVs) run on electricity only. Electricity can be produced from renewable energy sources like fuel cell,etc[1]. sAs the usage of fuel cell alone have certain disadvantages, it is used along with energy storage systems such as batteries or super capacitors.

FC and ESSs such as battery and SC used in converter topologies have different voltage levels[2]. So, to provide a specific voltage level for load and to control power flow between input sources, using of a dc–dc converter for each of the input sources is need. Usage of a dc–dc converter for each of the input sources leads to increase of price, mass, and losses. Consequently, in hybrid power systems, multiinput dc–dc converters have been used. Multiinput converters are of two main types, isolated and nonisolated.

In isolated multiinput converters high frequency transformer is used for isolation and impedance matching between two sides of the converter[3]. These converters need inverters in the input sides and rectifier in the output side. So several switches are applied which increases the cost and losses[4].Hence non isolated multiinput dc-dc converters are widely used. Several nonisolated multiinput converter topologies were introduced[5].Most of these converters are having single output. In applications such as electric vehicles that several input energy sources like fuel cell and battery are employed, using of multiinput multioutput converters is favourable. Then several multioutput topologies which has just one inductor were proposed. Using of large number of switches is drawback of these converters which caused low efficiency[6]. Impossibility of energy transferring between input sources is another disadvantage of these converters.

In this paper, a new controlled multiinput multioutput nonisolated converter based on combination of a multiinput and a multioutput converter is proposed. The proposed converter compared to similar cases has less number of elements. This converter can control power flow between sources with each other and load.Also, proposed converter has two outputs that each one can have different voltage level.

3. CONVERTER STRUCTURE AND OPERATION MODES

In Fig. 1, the proposed converter with two-input two-output is shown. Four power switches Q_1 , Q_2 , Q_3 , and Q_4 in the converter structure are the main controllable elements that control the power flow and output voltages of the converter. In the proposed converter, source V_1 (fuel cell) can deliver power to source V_2 (battery) but not vice versa. Depending on the utilization state of the battery, two power operation modes are defined for proposed converter, charging mode and discharging mode. In each mode, just three of the four switches are

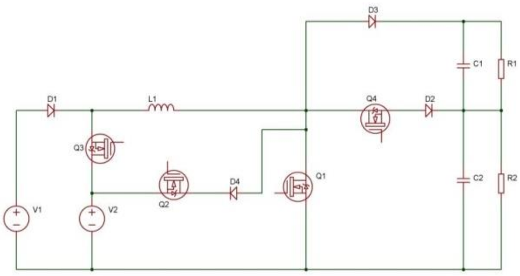

Fig.1 Proposed converter

active, while one switch is inactive. In evaluated using effective control.

3.1 Battery Discharging Mode.

Here, two input power sources V_1 and V_2 are responsible for supplying the loads. In this mode, Q_2 is OFF entirely and Q_1, Q_3 , and Q_4 are active. Q_1 is active to regulate battery current by controlling inductor current and Q_3 regulates total output voltage.Switching signals of switches and also voltage and current waveforms of inductor are shown in Fig. 2.

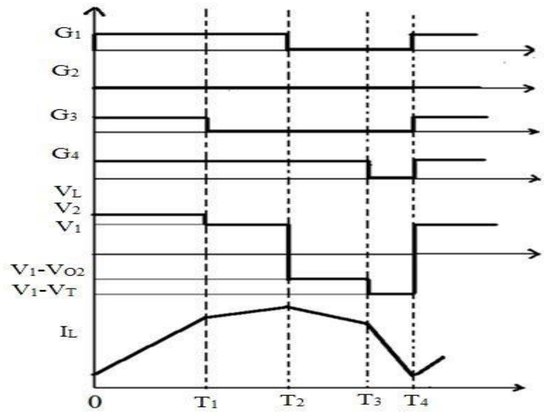

Fig. 2 Switching Waveforms

According to switches states, there are four different operation modes in one switching period as follows:

1) Mode 1 (0 < t < T1):

In this state, switches Q_1 and Q_3 are turned ON. Diodes D_2 ,D_3 and D_1 are reversely biased. Switch Q_4 is turned OFF. In this state, V_2 charges inductor L_1, so inductor current increases. Also, in this mode, capacitors C_1 and C_2 are discharged and deliver their stored energy to load resistances R_1 and R_2 ,respectively.

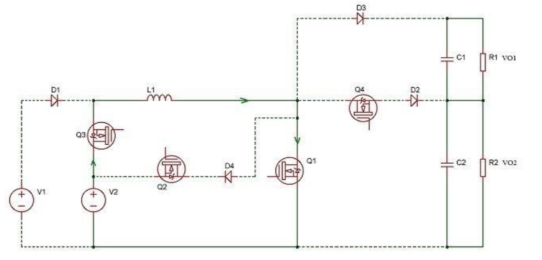

Fig.3 Mode 1 operation

2) Mode 2 (T1 < t < T2):

Here, switch Q_1 is still ON and Q_3 is turned OFF. Because Q_1 is ON, diodes D_2 and D_3 is reversely biased, so switch Q_4 is still OFF. In this state, V_1 charges inductor L_1, so inductor current increases. In addition, capacitors C_1 and C_2 are discharged and deliver their stored energy to load resistances R_1 and R_2 , respectively.

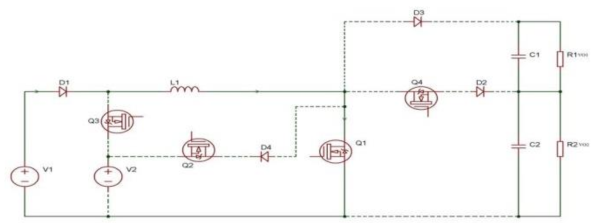

Fig.4 Mode 2 operation

3) Mode 3 (T2< t<T3):

Here, switch Q_1 is turned OFF and switch Q_3 is still OFF. Also, switch Q_4 is turned ON. Diode D_3 is reversely biased. In this state, inductor L_1 is discharged and delivers its stored energy to C_2 and R_2, so inductor current is decreased.

In this state, $C_2$is charged and C_1 is discharged and delivers its stored energy to load resistanceR_1.

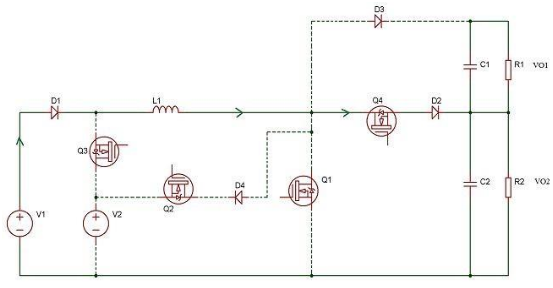

Fig. 5 Mode 3 Operation

4) Mode 4 (T3 < t<T4):

In this mode, all of three switches are OFF. So, diode D_3 is forward biased. Inductor L_1 is discharged and delivers its stored energy to capacitors C_1 , C_2 , and load resistances R_1 and R_2. Also, in this mode, capacitors C_1 and C_2 are charged.

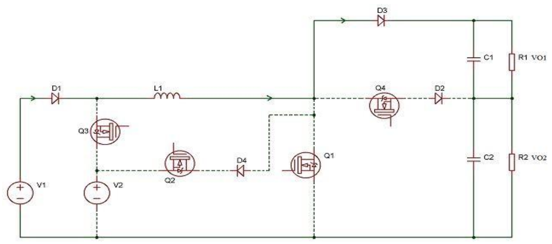

Fig. 6 Mode 4 Operation

4. SIMULINKMODEL

In order to verify the performance of the multi input multi output dc-dc boost converter, simulations have been done using Matlab/Simulink software in battery discharging mode.

There are two input sources and three outputs, voltage across the resistors R_1 and R_2 and the sum of the voltages across R_1 and R_2.In simulations, battery mode is used as input source 2.

As mentioned in previous sections, in this mode switches Q_1 , Q_3, and Q_4 are active.

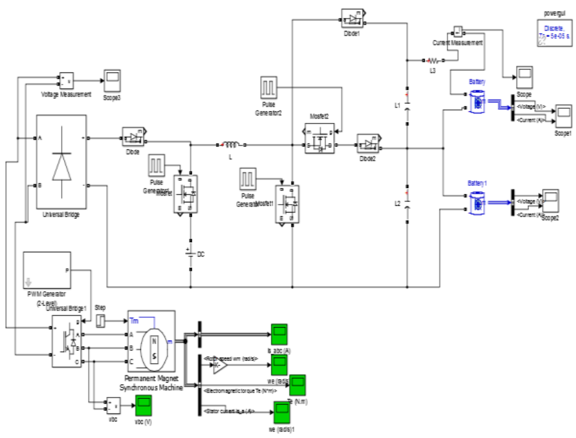

Fig 7 Matlab Simulation Circuit

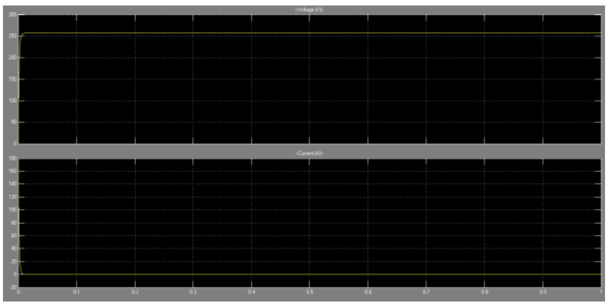

Fig 8 Battery1 Voltage And Current

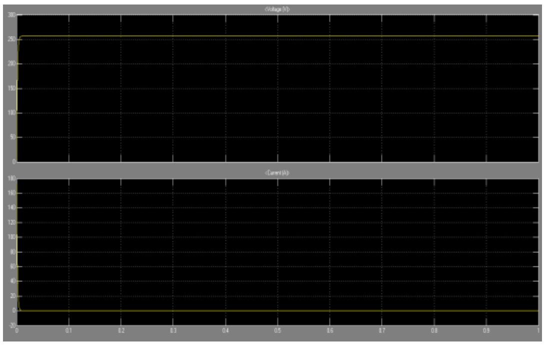

Fig 9 Battery2 Voltage And Current

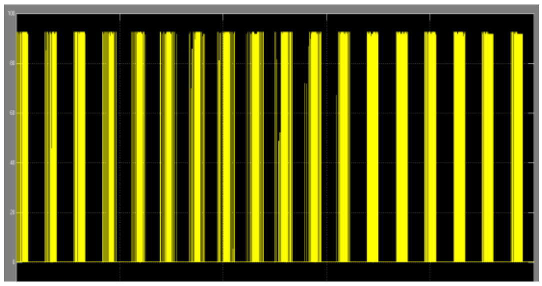

Fig 10 inverter Output Voltage

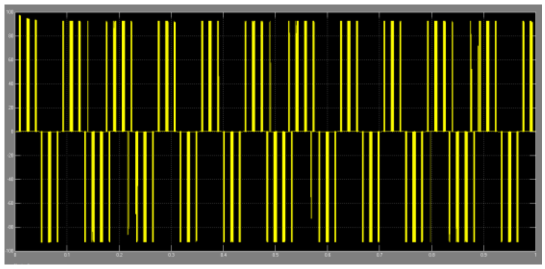

Fig 11 3-level Output Voltage

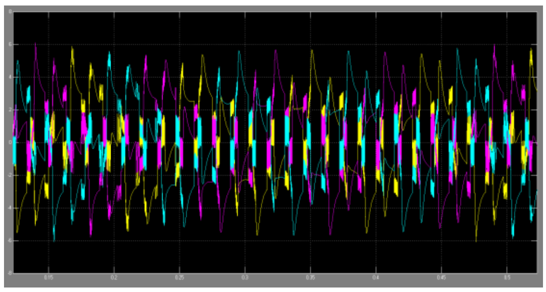

Fig 12 stator Output Current Of PMSM

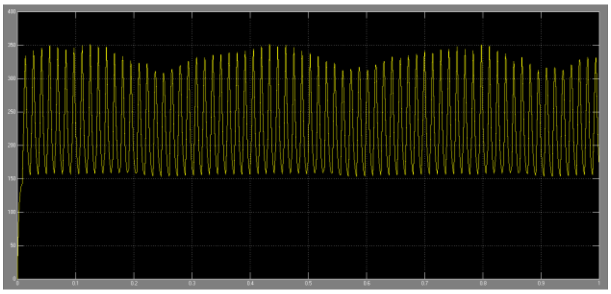

Fig 13 Motor Speed

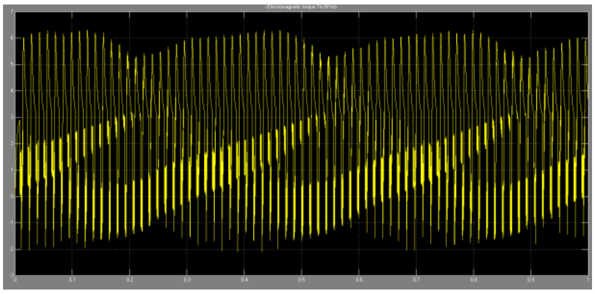

Fig 14 PMSM Motor torque

CONCLUSION

A New Simplified control transformerless multiinput multioutput dc-dc converter in battery discharging mode fed PMSM Drive is implemented in this paper. The converter has two inputs and two outputs .The different dc voltage levels at the output can be fed to the input of a multilevel inverter and can also be used for electric vehicle applications. The Simplified controller provides fast response, better settling time and reduced overshoot than conventional controllers.

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