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A NEW MULTI INPUT ISOLATED THREE-LEVEL CONVERTER FOR RENEWABLE AND SUSTAINABLE ENERGY SYSTEMS ADOPTING HIGH DC LINK VOLTAGE

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Abstract—Power electronics solutions based on multiple converter configurations offer cost-effective solutions by integrating a number of components at input or output power stages. This project proposes a new multiinput isolated three-level converter for renewable and sustainable energy systems adopting high dc link voltage. Multiple dc sources are integrated to the three-level dc/dc converter before the isolation stage, resulting in reduced part-count, determining dc link voltage level and allowing flexibility in transformer design. The proposed architecture eliminates two boost switches which are present in the two-stage counterpart. The input inductors are operated in discontinuous conduction mode; thus, power can be shared between input sources through proper selection of input inductors. A low voltage prototype has been designed to serve as a proof of concept.

Keywords:THREE-LEVEL INVERTER, DC/DC CONVERTER, MULTIPLE CONVERTERS.

INTRODUCTION

multiinput converters providing galvanic isolation, majority of the work has been devoted to phase-shifted full bridge converters. In, two identical current fed full-bridge converters are connected in parallel to interface a common output rectifying diode-bridge. Similar concept has been applied using individual output rectification stages but sharing an integrated transformer. Two current fed bridges are controlled in a phase-shifted manner. The parallel connection of multiinput cells are first identified as pulsating voltage-source cell and pulsating current-source cell, and various topological combinations have been presented. However, majority of the isolated multiinput converters presented in the literature are proposed as individual converters or shares only the output stage on the secondary side of the transformer. In, the concept of paralleling multiple input sources at the primary side of the transformer has been proposed.In this study, a new multiinput converter based on three-level structure for renewable energy systems is proposed, as shown in Fig. 1. Following the concept proposed in, pulsating current-source (PCC) cells are integrated to the same bridge before the isolation stage, while the adopted bridge offers utilizing low voltage rated upper and lower switches due to the three-level structure. The control of PCCs is integrated to the operation of the three-level bridge converter. Thus, the control complexity of the proposed converter is similar to that of a three-level dc/dc converter. On the other hand, the proposed converter provides reduced part-count and lower

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voltage stress across the upper and lower switches. The input inductors are operated in discontinuous conducting mode (DCM), which allows autonomous power sharing between input sources with proper selection of input inductors.

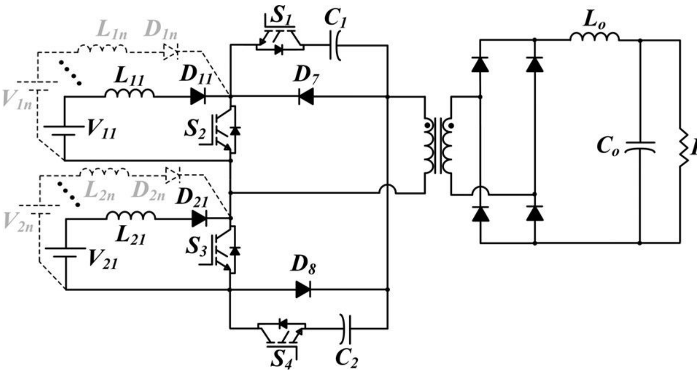


Fig. 1. Proposed multiinput isolated three-level dc/dc converter

MULTIINPUT ISOLATED THREE-LEVEL DC/DC CONVERTER

The proposed multiinput converter is essentially based on the operation of the three-level isolated dc/dc converter. The secondary side rectifier can be either a half-bridge rectifier accompanied by a tapped winding for low output voltage application, or a full-bridge rectifier for high output voltage applications as shown in Fig. 1. Since the PWM scheme here is similar to that in three-level converters, the control complexity is not intensive. The boost inductors, connected to the input sources of different voltages, are charged when S2 and S3 are turned on, respectively. When the related switch (S2 or S3) is turned off, the energy stored in the inductor is transferred to the load. The excess or insufficient energy is either absorbed or compensated by the dc link capacitors. At the same time, S1 to S4 are switched to apply Vdc/2, –Vdc/2, and zero voltage across the primary side of the transformer. In comparison with the two-stage counterpart, two active switches and boost diodes are eliminated, while two blocking diodes are added to block the reverse current from the dc link capacitors.

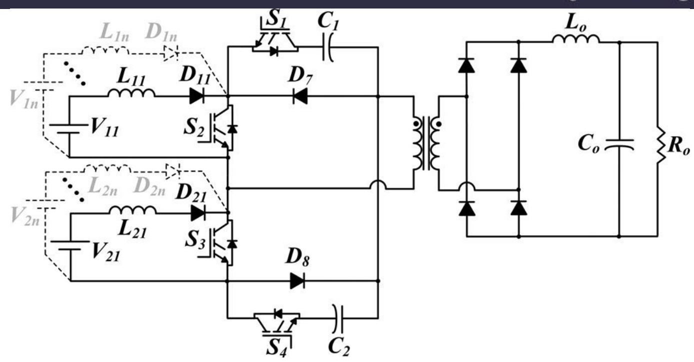
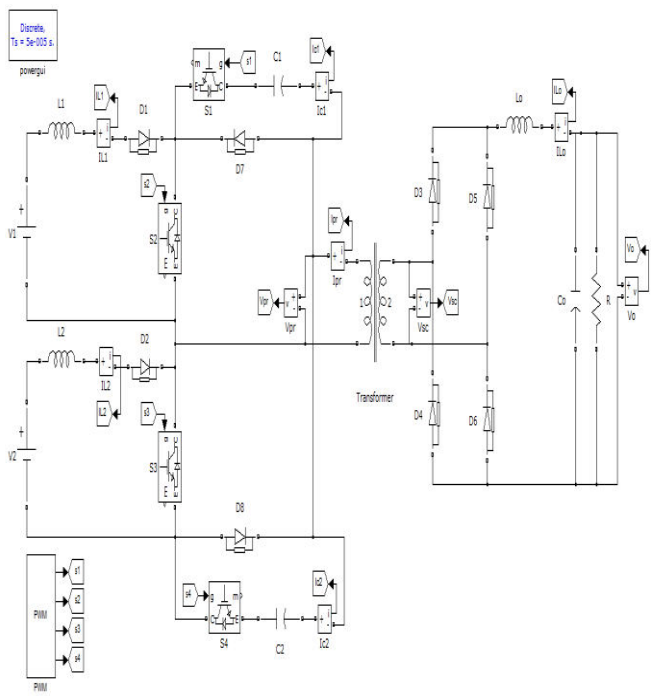


Fig. 1 Proposed multiinput isolated three-level dc/dc converter

The switching scheme of the converter is given in Fig. 2. The switches S2–S3 and S1–S4 have 180° phase shift with respect to each other. The duty cycle of the middle switches should be greater than 50% such that they allow a freewheeling path for the transformer primary side current. The switching scheme is as follows: S1 is turned on right after S3 is turned off, and similarly, S4 is turned on when S2 is turned off. A dead-time should be inserted in between the turning on instant of S1 and turning off instant of S3, and likewise between switching of S2 and S4 to avoid short circuit.

SIMULATION RESULTS



simulation diagram of proposed multi-input isolated three-level dc/dc converter

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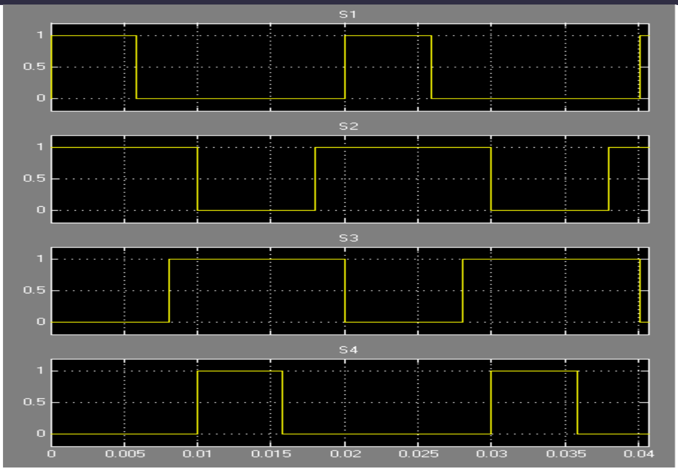
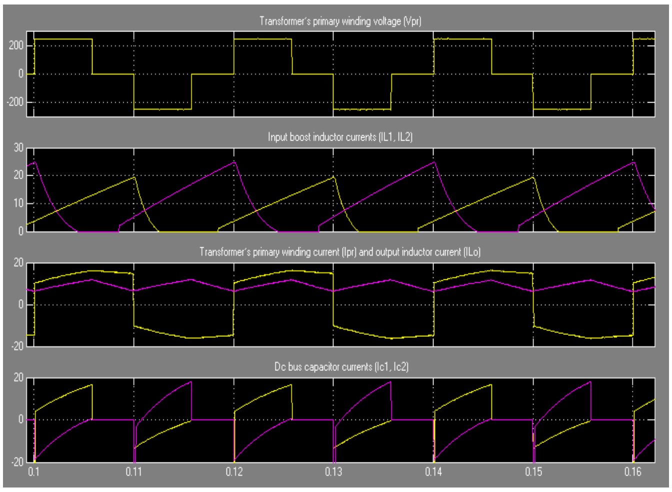
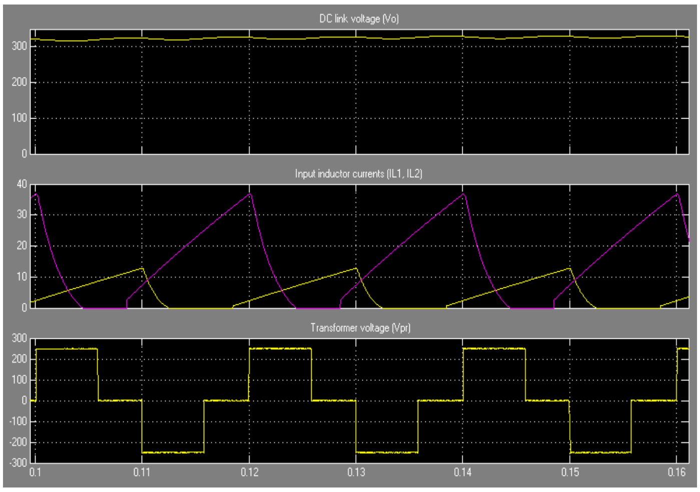


gating signals



Simulation waveforms when V1 = V2 = 150 V, L1 = 200 μH, L2 = 100 μH.



Simulation results of dc link voltage, transformer voltage, and input inductor currents

CONCLUSION

In this project,a new multiinput dc/dc converter having same number of active switches as of three-level isolated dc/dc converter without introducing additional switching actions is proposed. The circuit analysis and design consideration has been provided in detail. With proper selection of input inductors, autonomous load sharing can be achieved. To verify the operation of the converter, simulations of different parameters have been performed. A low voltage laboratory built prototype has been designed and tested under varying input voltages and duty cycles. The results prove the effective integrated operation of input sources with three-level isolated dc/dc structure, through operating four switches in a phase-shifted manner without introducing control complexity.

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