A NOVEL REDUCED SWITCH COUNT BIDIRECTIONAL CONTACTLESS CHARGING SYSTEM FOR EVS AND PHEVS APPLICATIONS

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INTRODUCTION

- A novel Reduced Switch Count Bidirectional Contactless Charging System (BCCS) suitable for Electric Vehicles (EVs) and Plug-in Hybrid Electric Vehicles (PHEVs) applications.
- The proposed topology has half the number of switches and diodes compared to the conventional full bridge topology. This results in reduced control complexity, losses and converter cost.
- The operation and performance of the reduced switch count BCCS topology has been investigated bidirectional power flow.
- A reduced switch count BCCS scheme has been designed for a 2kW system and is tested by simulation to check its bidirectional power flow functionality.

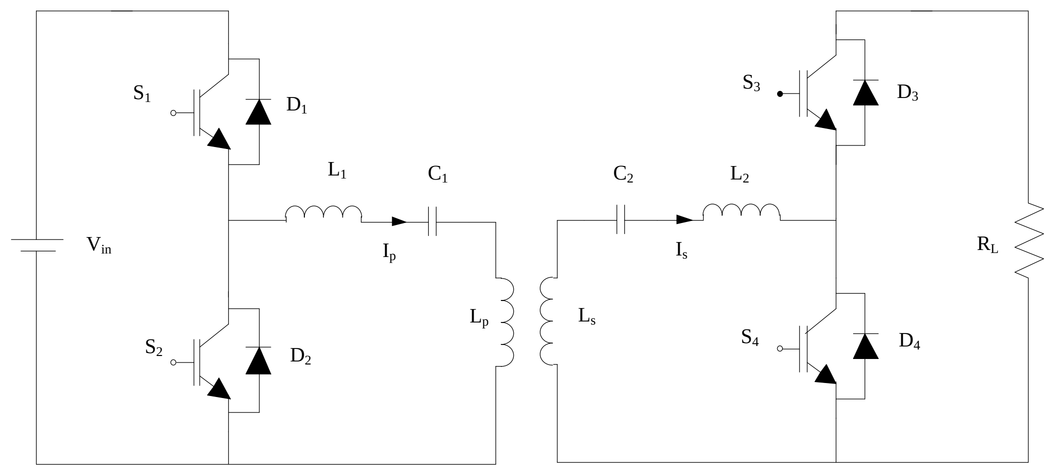
INTRODUCTION (Contd.)

- Electric Vehicles (EVs) and Plug-in Hybrid Vehicles (PHEVs) are widely accepted as an effective solution to overcome the problems of pollution, depletion of fossil fuels and rising petrol cost.
- Although EVs are primarily considered as a method of clean transport, they can also be used as a potential source of energy by supplying power back to the grid.
- This process is coined as Grid-to-Vehicle (G2V) and Vehicle-to-Grid (V2G) technology, where G2V implies charging the EV batteries from the grid and V2G means EVs deliver electricity into the grid.
- The V2G and G2V services are provided through EV charging systems with bidirectional power flow functionality. Hence, recent research is targeted towards developing an effective bidirectional charging systems for EVs and PHEVs.

Circuit Diagram

- The proposed topology is less expensive due to reduced number of switches and has a simple control strategy with similar functions like conventional charging systems.

Fig. 1 Power circuit of contactless coil with reduced switch converter.



- Basically the bidirectional contactless unit needs a converter topology on its either side, which must be able to generate High Frequency (HF) voltage - for power transfer from EV battery to Grid and vice versa.

Working principle – G2V

- Fig. 1 shows the schematic of the proposed contactless coils with reduced switch count converter on either side of the coils connected with a constant dc source.
- The main components of the converter are the inductor (L_1, L_2), the capacitors (C_1, C_2), the power switches (S_1, S_2, S_3 and S_4) and diodes (D_1, D_2, D_3 and D_4).
- The proposed converter has two operating modes: rectification and inversion.
- The converter works on the aspect of energy balance in a resonant network. The resonance in the circuit is maintained by free oscillation and energy injection control.

Working principle-G2V (Contd.)

- During G2V operation, the primary side converter performs inversion operation and converts dc voltage to HF ac voltage by controlling S_1 and S_2.
- When S_1 is controlled on, when capacitor (C_1) is fully charged from -CV_p to +$CV_{p.}$
- S_3 is turned off, when the capacitor fully charged (upto +CV_s) and S_4 is turned on. The current flows in the reverse direction (S_3, L_s, C_2), when capacitor discharges completely (+VC_p to -VC_p).
- The secondary side converter performs HF ac voltage to dc by D_3 and D_4.
- The positive half cycle, diode D_3 is forward biased. The current flow through C_2, L_2, D_3, R_L and L_s. The load voltage is +V_s
- The negative half cycle D_3 is not conduct and D_4 is conducting, the current flow through C_2, L_2, D_4 and L_s. The load voltage is Zero.

Modes of operation

(a) Mode 1

(b) Mode 2

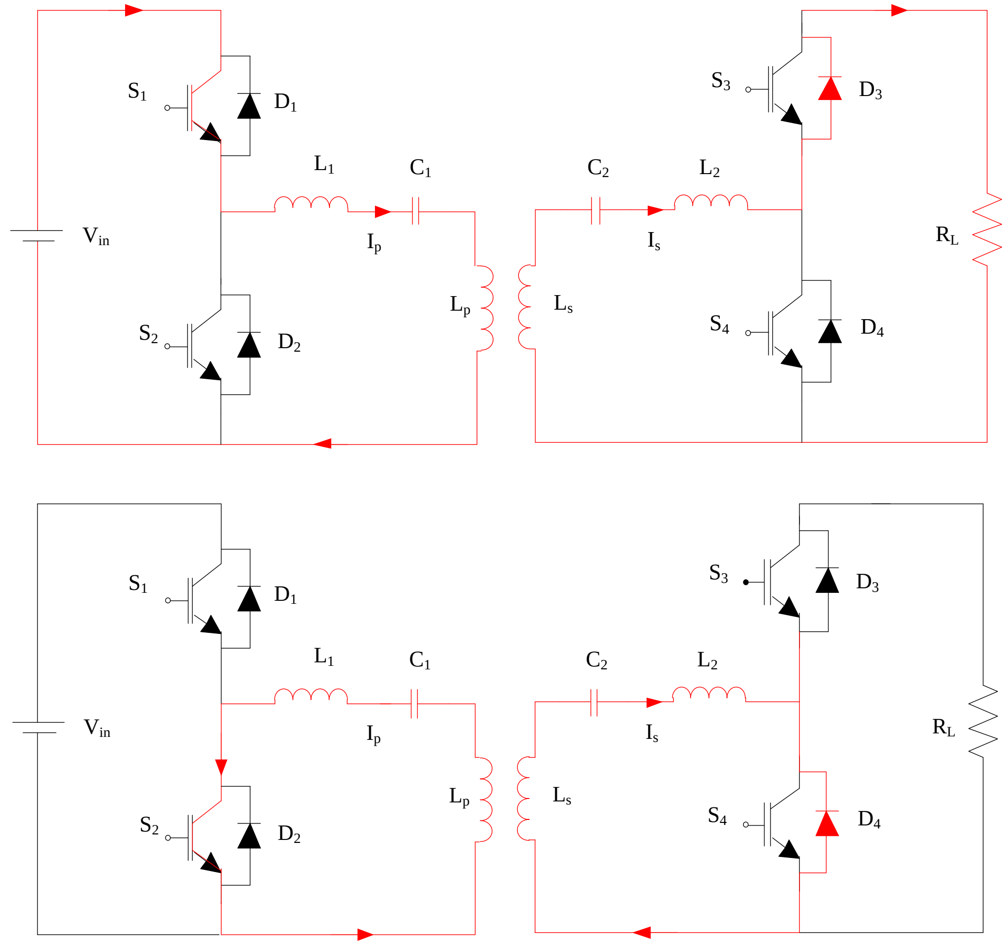


Fig. 2 Modes of operation – dc to HF ac and ac to dc conversion

Output waveforms

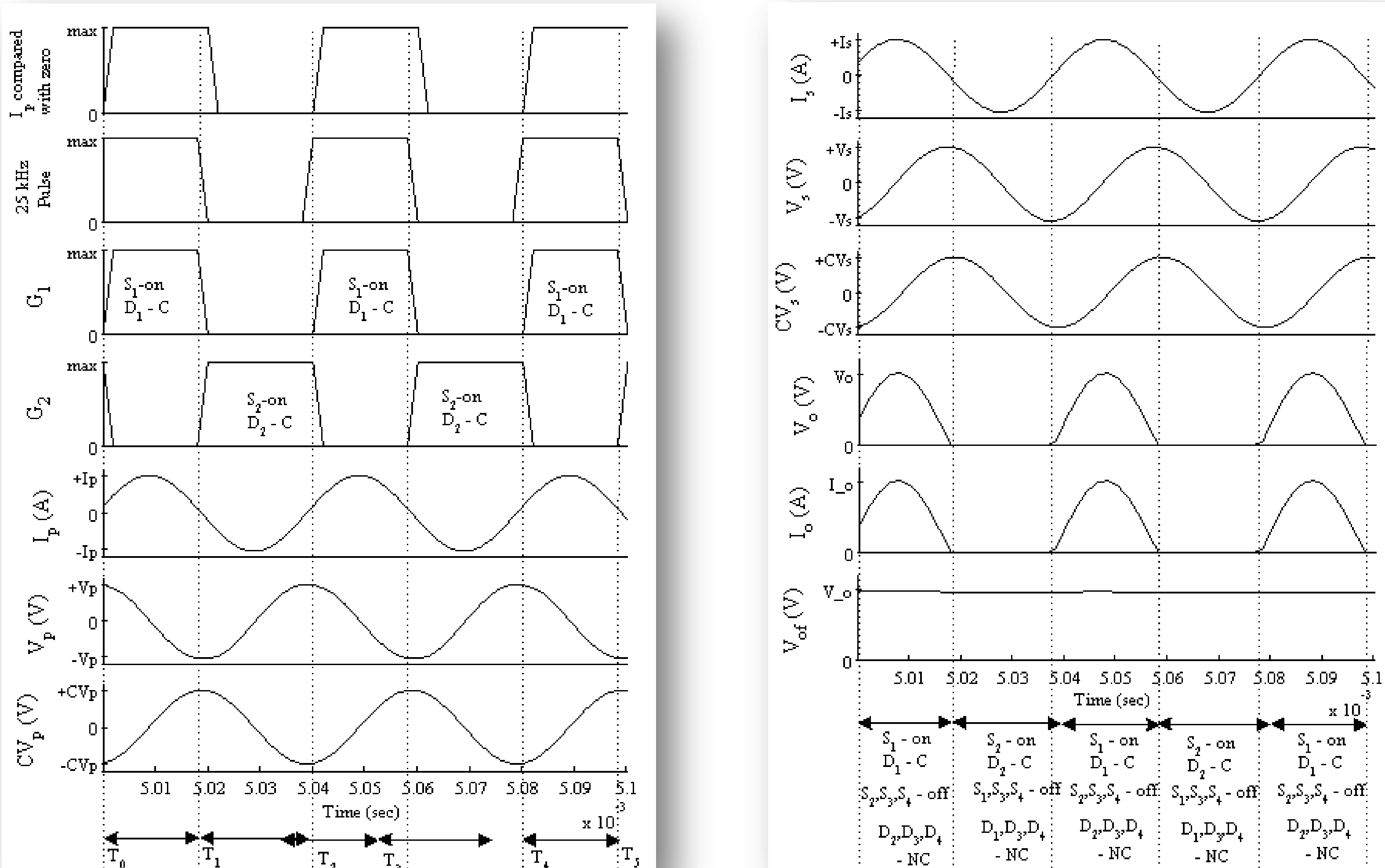


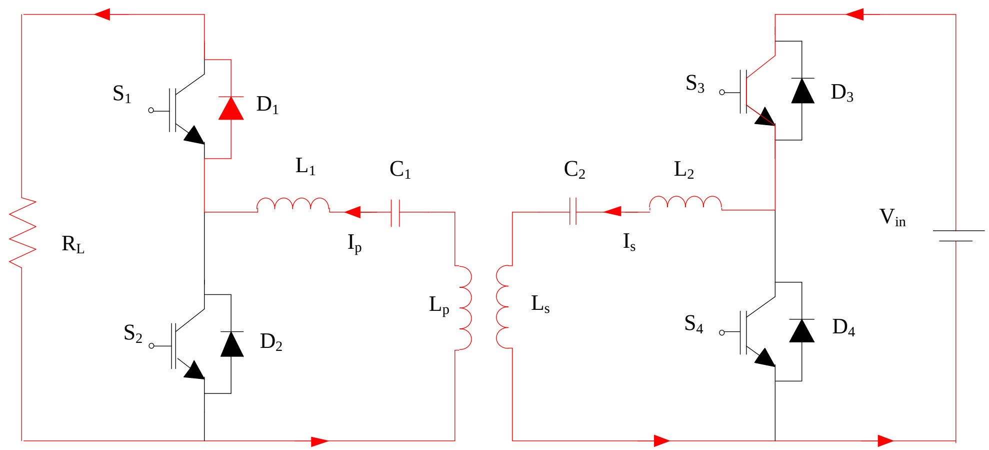
Fig. 3 primary and secondary side output waveforms

Working principle – V2G

- During V2G operation, the secondary side converter, converts dc voltage to HF ac voltage by controlling S_3 and S_4. The primary side diodes (D1 and D2) convert HF ac to dc voltage.
- When S_3 is turned on, the capacitor (C_2) is fully charged from $-CV_p$ to $+CV_{p.}$
- S_1 is turned off when the capacitor fully charged ($+CV_p$) and S_2 is turned on. The current flows in the reverse direction (S_2, L_s, C_2), when capacitor discharges completely ($+VC_s$ to $-VC_s$).
- The secondary side converter performs HF ac voltage to dc by D_1 and D_2. The positive half cycle, diode D_1 is conduct. The current flow through C_1, L_1, D_1, R_L and L_p. The load voltage is $+V_s$.
- The negative half cycle D_1 is not conduct and D_2 is conducting, the current flow through C_1, L_1, D_2 and L_p. The load voltage is Zero.

Modes of operation

(a) Mode 1



(b) Mode 2

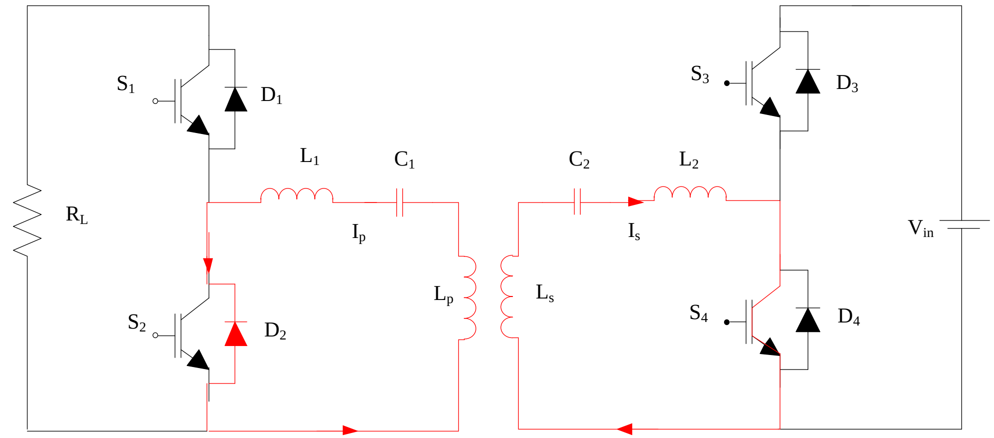


Fig. 4 Modes of operation – dc to HF ac and ac to dc conversion

Output waveforms

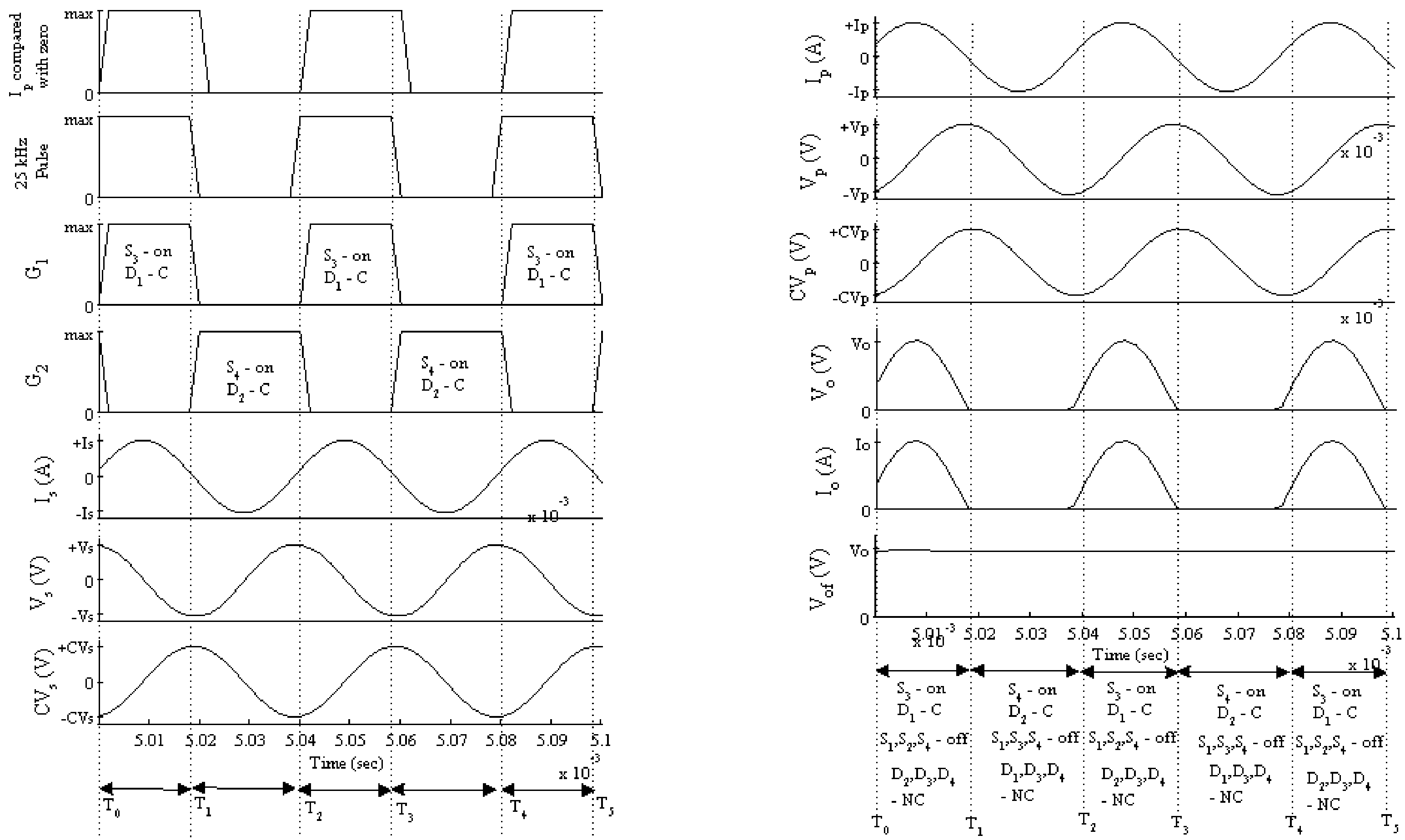


Fig. 5 primary and secondary side output waveforms

Conclusion

- A reduced switch count Bidirectional Contactless Charging System (BCCS) has been proposed.
- The proposed topology employs half the number of switches and diodes comparing to the conventional full bridge topology.
- Suitable closed loop controllers are developed to control the power flow in both the direction.
- The complete model of reduced switch count BCCS unit is analyzed for V2G and G2V operation.

Thank You