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Multiphase Bidirectional Flyback Converter Topology for Induction Motor Drive

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***Abstract*—For hybrid electric vehicles, the batteries and the drive dc link may be at different voltages. The batteries are at low voltage to obtain higher volumetric efficiencies, and the dc link is at higher voltage to have higher efficiency on the motor side. Therefore, a power interface between the batteries and the drive's dc link is essential. This power interface should handle power flow from battery to motor, motor to battery, external genset to battery, and grid to battery. This paper proposes a multi-power-port topology which is capable of handling multiple power sources and still maintains simplicity and features like obtaining high gain, wide load variations, lower output-current ripple, and capability of parallel-battery energy due to the modular structure. The scheme incorporates a transformer winding technique which drastically reduces the leakage inductance of the coupled inductor. Finally the proposed converter is applied to a induction motor drive. Matlab/SImulink software and simulation results are presented.**

***Index Terms-* Bidirectional flyback converter, hybrid electric vehicle, leakage inductance, Induction Motor Drive.**

I. INTRODUCTION

Power electronics is an enabling technology for the development of electric or hybrid electric vehicles. For both ac and dc motor drives used in electric and hybrid electric vehicles, the basic requirement for efficient control is that the power electronic circuit should be capable of handling bidirectional power flow, i.e., energy transfer should be possible from battery to motor during motoring mode and motor to battery during regeneration. Now, the need for a bidirectional power converter should be properly examined. A battery can be used as a dc bus if the motor is rated for that voltage level. Thus, bidirectional power flow is not a problem because of the bidirectional power-handling capacity of a standard two-level three-phase inverter and also sinking and sourcing capacity of the battery. However, the traction motor should be rated for higher voltage to achieve higher efficiency for a given power rating. Therefore, the dc bus voltage should be maintained high enough to match the motor voltage rating in series. However, if too many batteries are connected in series, then the volumetric
efficiency of the battery comes down. Therefore, there is a need for a bidirectional converter which interfaces the low-voltage battery with a high voltage dc bus and maintains a bidirectional power flow.

Reference [2] shows the use of a bidirectional converter for a permanent-magnet ac motor- driven electric vehicle. Reference [3] shows the use of a cascaded bidirectional buck–boost converter for the use in dc-motor-driven electric vehicle. Both schemes emphasize the importance of bidirectional dc–dc converter for electric vehicle application. The dc–dc converters can be divided into hardswitching converters and soft-switching converters. Because of the low efficiency of hard-switching converters, recently, soft-switching techniques are getting popular. Reference [4] proposes ZVS techniques for different nonisolated dc–dc converters. There is a limit on the voltage gain that can be achieved using a buck–boost or a boost converter. It is not desirable to operate the boost or the buck–boost converter at very high duty ratio because of very high capacitor current ripple. Thus, the solution is to go for isolated topologies for getting the high voltage gain in between the battery and the dc bus.

Reference [6-10] proposes a coupled-inductor winding technique which reduces the leakage inductance to a very less value and without the use of any snubber, and that very less voltage spike be achieved during switching transients. Next, the paralleling of four batteries is done using a four-phase flyback topology, and outputs of all the four phases are connected to the same dc link. To reduce the current ripple through the dc-link capacitor, all the four phases are switched at a fixed 75% duty cycle with 90◦ (considering one switching period as 360◦) phase difference between subsequent phases. This configuration is also suitable for connecting multiple power sources. For battery charging from mains, a front-end converter is used which uses the same dc bus. Thus, the same flyback converter is used for battery charging. For series–parallel hybrid electric vehicles, the output of the synchronous generator can be connected to the same dc bus through a rectifier.

II. FOUR PHASE BIDIRECTION FLYBACK CONVERTER

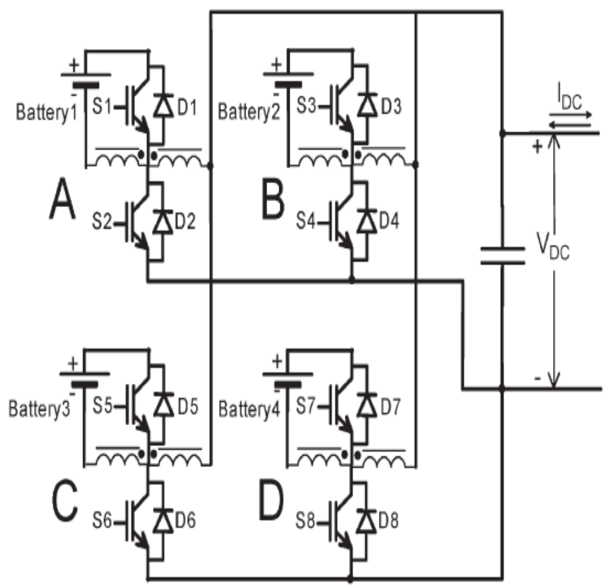

Figure-1 Fly Back Converter

If we consider the first converter, then, during forward power flow, S1 and D2 are active, and during reverse power flow, S2 and D1 are active as well. During forward power flow, active switches S1, S3, S5, and S7 get switching pulses of 75% duty cycle with 90◦ phase difference between subsequent phases, as shown in Fig. 2(a). During reverse power flow, active switches S2, S4, S6, and S8 get switching pulses of 25% duty cycle which are 90◦ phase shifted to each other, as shown in Fig. 2(b). Fig. 2(c) and (d) shows the ideal switch voltage and current waveforms assuming continuous conduction mode (CCM) for forward and reverse power flows, respectively.

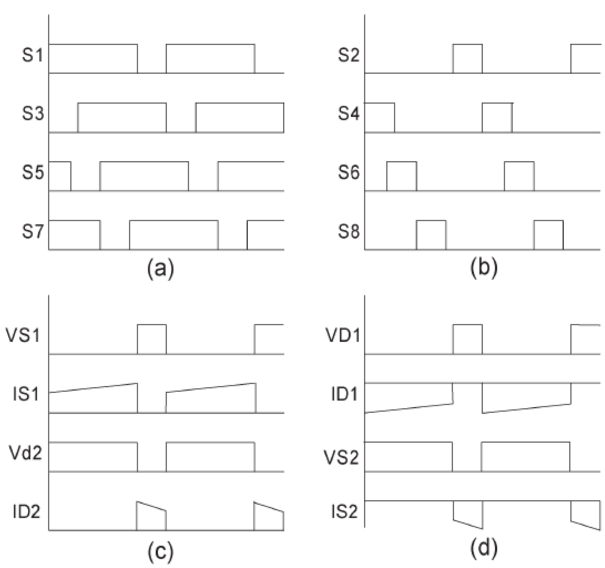

Figure-2 Gating Pulses

CCM is not the only conduction mode for this bidirectional converter. This can also operate in critical conduction mode (CRM) or discontinuous conduction mode (DCM), depending on the load. During forward power flow, if the load is very less, then the converter can go into CRM or DCM, similar to any standard flyback converter. However, for circuit design, only CCM is considered. As no snubber is used, circuit design involves the design of the inductor and the capacitor. The load connected at the output of the converter is a threephase inverter connected to the motor. Thus, the capacitor voltage ripple is dominated by the dc-link current ripple of the inverter, and capacitor value is decided depending on that ripple.

III. CONTROL SCHEME

Simple hysteresis voltage control is used for dc-link voltage regulation for power management in the proposed MPP scheme. During power flow in the forward direction, i.e., from the battery to the dc bus, the duty cycles of switching voltages of S1, S3, S5, and S7 are fixed at 75%, while switches S2, S4, S6, and S8 are permanently off. During reverse power flow, S1, S3, S5, and S7 are permanently off, and S2, S4, S6, and S8 are switched at 25% duty cycle. Therefore, during forward power flow, the voltage is boosted by a factor of three, and during reverse power flow, the voltage is stepped down by a factor of three. It is to be noted that this voltage boost is only due to duty-cycle operation. The coupled-inductor turns ratio is fixed in such a way that during full-load operation in forward mode, the converter output voltage is the rated dc bus voltage V_{dc}. For an operating condition with lesser load, the series voltage drop in the converter will be less. Thus, the dc-link voltage will get increased from the rated value because of fixed duty cycle of operation. At a voltage $V_{dc} + v_1$, the pulses to switches S1, S3, S5, and S7 are stopped. If the load is still drawing current, then it will discharge the capacitor. When the voltage reaches V_{dc}, again, the switching pulses are given to S1, S3, S5, and S7. Therefore, during light-load conditions, the voltage is maintained between V_{dc} and $V_{dc} + v_1$. If there is no load, then the voltage will also be maintained in between V_{dc} and $V_{dc} + v_1$. However, during regeneration, even if switches S1, S3, S5, and S7 are off, because of reverse power flow, the voltage will increase beyond $V_{dc} + v_1$. This is the time when energy should flow back to the battery. Thus, at a voltage $V_{dc} + v_1 + v_2$, switches S2, S4, S6, and S8 are pulsed, and because of the flyback action, current flows into the battery, and the battery gets charged.

IV. MATLAB/SIMULINK MODELAND SIMULATION RESULTS

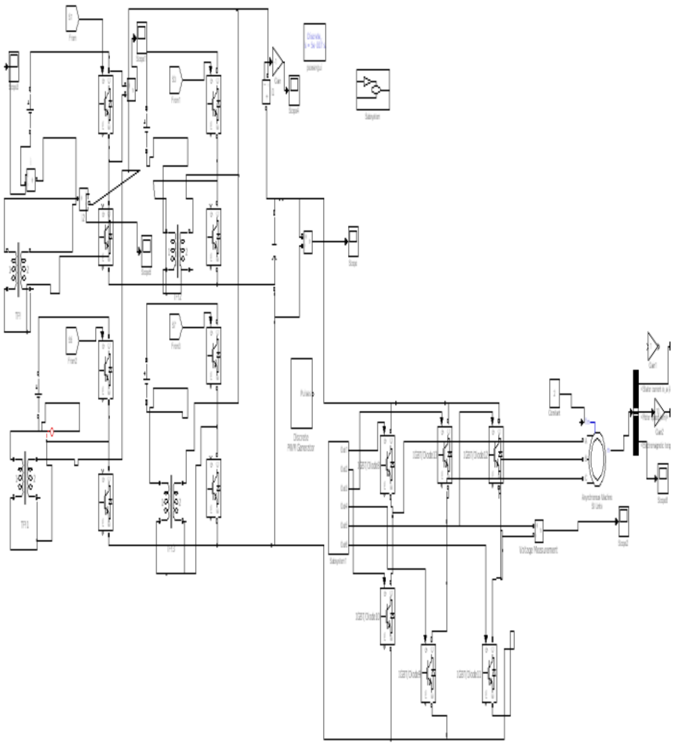

Figure-3 Fly Back Converter with Induction Motor Drive

Fig. 3 shows the Matlab/Simulink model of proposed flyback converter with induction motor drive. Here the motor is supplied with pwm inverter.

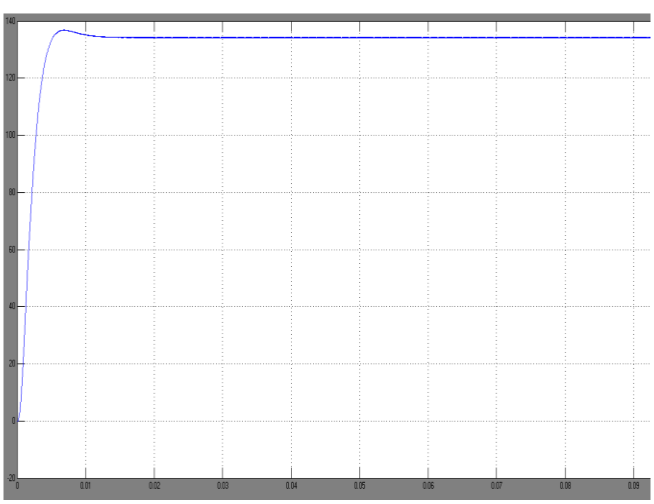

Figure-4 Fly Back Converter DC output voltage

Fig.4 shows the DC output voltage of flyback converter. Here output voltage is 400 v.

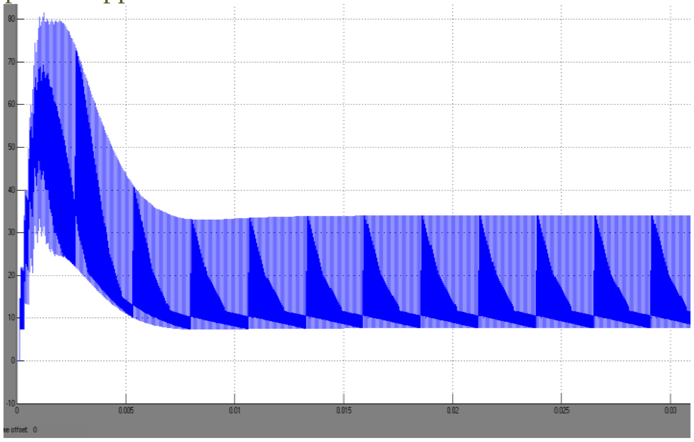

Figure-5 Coupled Inductor current

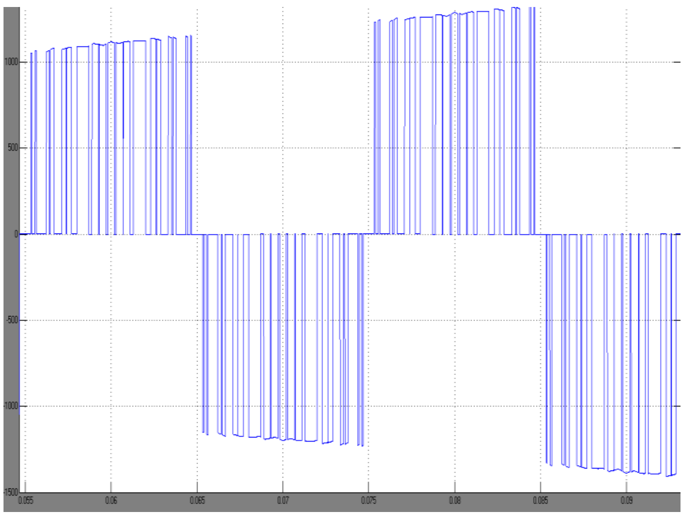

Figure-6 PWM Inverter output

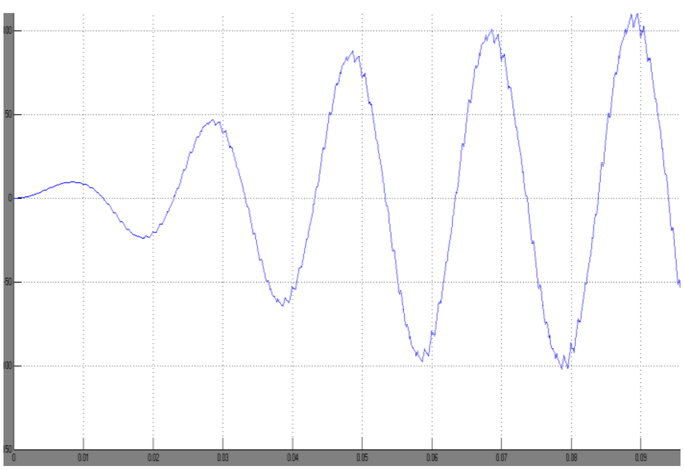

Figure-7 Induction Motor Stator current

Fig 5 shows the coupled inductor current. Fig 6 shows the PWM ac output of the inverter. Fig 7 shows the induction motor stator current.

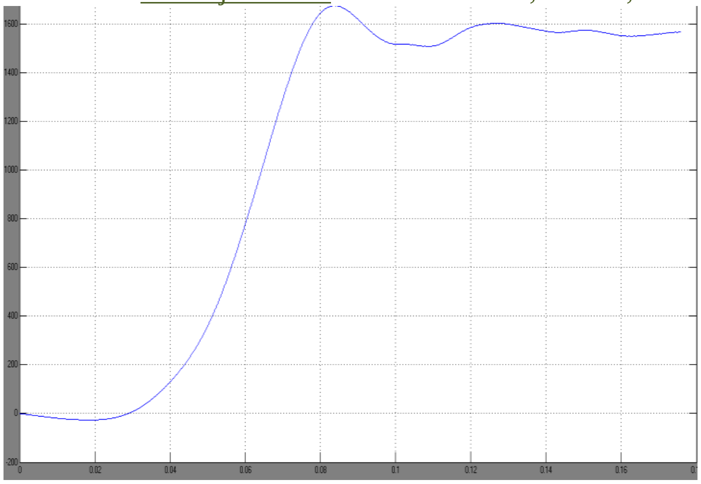

Figure-9 Induction motor speed

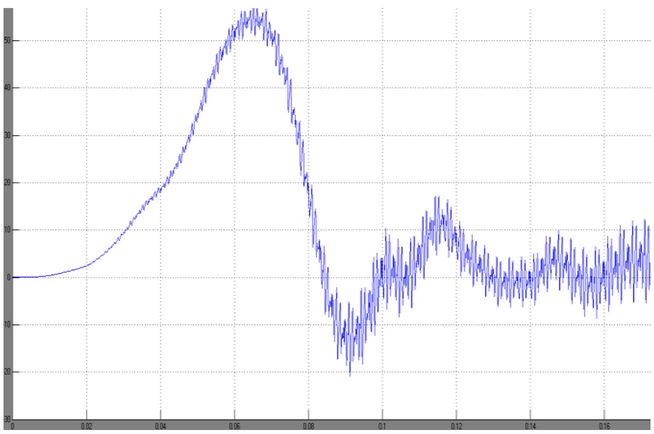

Figure-8 Induction Motor Torque

Fig.9 and 10 shows the induction motor speed and torque performance respectively. Here the motor is reaching a steady state speed of 1500 rpm.

V.CONCLUSION

This paper proposes a four-phase bidirectional flyback dc–dc converter which serves the role of an MPP interface for electric and hybrid electric vehicle applications. The bidirectional nature of the converter allows battery charging during regeneration and also from mains. The multiple phases give the flexibility of paralleling multiple batteries. Simple hysteresis control is used for converter control. Because of the four converters operating with 90◦ phase shift with fixed 75% duty cycle of operation, the capacitor ripple current is also reduced. The novel transformer design technique drastically reduces the leakage inductance and eliminates the requirement of snubber. Furthermore, it should be noted that the MPP interface could be made between any given battery voltage and dc-link voltage by only tuning the turnsratio of the flyback transformers. A SIMULINK based model is developed and Simulation results are presented.

VI.References

[1] A. Emadi, Y. J. Lee, and K. Rajashekara, “Power electronics and motor drives in electric, hybrid electric, and plug-in hybrid electric vehicles,” *IEEE Trans. Ind. Electron.*, vol. 55, no. 6, pp. 2237–2245, Jun. 2008.

[2] F. Caricchi, F. Crescimbini, G. Noia, and D. Pirolo, “Experimental studyof a bidirectional DC–DC converter for the DC link voltage control and the regenerative braking in PM motor drives devoted to electrical vehicles,” in *Proc. IEEE APEC*, Orlando, FL, Feb. 1994, vol. 1, pp. 381–386.

[3] F. Caricchi, F. Crescimbini, F. G. Capponi, and L. Solero, “Study of bi-directional buck–boost converter topologies for application in electrical vehicle motor drives,” in *Proc. IEEE APEC*, Feb. 1998, vol. 1, pp. 287–293.

[4] C.-M. Wang, “Novel zero-voltage-transition PWM DC–DC converters,” *IEEE Trans. Ind. Electron.*, vol. 53, no. 1, pp. 254–262, Feb. 2006.

[5] B.-R. Lin and F.-Y. Hsieh, “Soft-switching zeta–flyback converter with a buck–boost type of active clamp,” *IEEE Trans. Ind. Electron.*, vol. 54, no. 5, pp. 2813–2822, Oct. 2007.

[6] F. Z. Peng, H. Li, G.-J. Su, and J. S. Lawler, “A new ZVS bidirectional DC–DC converter for fuel cell and battery application,” *IEEE Trans. Power Electron*, vol. 19, no. 1, pp. 54–65, Jan. 2004.

[7] H. S.-H. Chung, W.-L. Cheung, and K. S. Tang, “A ZCS bidirectional flyback DC/DC converter,” *IEEE Trans. Power Electron*, vol. 19, no. 6, pp. 1426–2434, Nov. 2004.

[8] O. Garcia, P. Zumel, A. de Castro, and J. A. Cobos, “Automotive DC–DC bidirectional converter made with many interleaved buck stages,” *IEEE Trans. Power Electron.*, vol. 21, no. 6, pp. 578–586, May 2006.

[9] L. Solero, A. Lidozzi, and J. A. Pomilio, “Design of multiple-input power converter for hybrid vehicles,” in *Proc. IEEE APEC*, vol. 2, pp. 1145–1151.

[10] M. Michon, J. L. Duarte, and M. Hendrix, “A three port bi-directional converter for hybrid fuel cell systems,” in *Proc. IEEE PESC*, Aachen, Germany, Jun. 2004, pp. 4736–4742.