Multi Coil Transformer Assymentrical Triple Portactive Bridge DC-DC Converter

S.Nivedha[1], S.Emimal[2], D.Karthigha[3], G.Indira[4]
[1, 2, 3, 4] Dept of Electrical and Electronics Engineering
[1, 2, 3, 4] Prince Shri Venkateshwara Padmavathy Enggineering College

Abstract*- Multi coil transformer based asymmetrical triple port active bridge converter is proposed to connect two different dc sources and load. Switches are turned on using by zero voltage switching.Multi coil transformer reduces circulating power between two ports. The proposed model reduces the magnetic short circuit by using multi coil transformer. The steady state losses, operating principle, different modes of operation are explained.*

Keywords- Multi-coil transformer, Zero voltage switching, Convertor, ports

I. INTRODUCTION

The requirement for adaptable energy management is developing along with the increase in renewable energy sources. In order to meet demands in such system, many power electronic devices are improved (MPC) owe to their upcoming applications in electric vehicles, renewable energy generation, micro grid, smart-grids, and uninterruptible power supplies. The significant attribute of MPCs are soft- switching, bi-directional power flow, flexible voltages at distinct ports. Among the available isolated MPC topologies, TAB is well-known methods that leads to most of the abovementioned basic features.MPC is mostly used link the sources and load whereas in electric vehicle TAB are used. On the other hand, TABs are Inappropriate for the application of two sources that are connected to supply and to the load. Due to the minute variation in the scale relating to high-frequency ac-voltages leads in high rotating power between the source-ports owing to small leakage inductance that between the interconnection of the transformer. Likewise, the higher circulating powers end in huge loss and weakening of the transformer core along with windings.

Further, in TABs, the ports can't be separated by operating its switching devices. Even though all switches of the connected to port converters of the TAB that are turned off, their anti-parallel diodes form the transmission pathways. A CLL resonant converter built MPC which contains two CLL-units, two HF transformers, and a Diode rectifier.

II. SYSTEM METHODOLOGY

Isolated ports are connected to two different sources in the transformer. Thus two different flux is created the total flux is the addition of these two fluxes. In interval t1 and t2, the polarities of V1 and V2 are positive and negative in interval t3 and t4 that tends to increase in electromotive force in the transformer. The transformer is connected to source ports with a high current that increases switching losses due to phase delay between V1 and V2.The short circuit tends to increase in inrush current of the transformer. The problems associated with the existing system for different phases are depicted. This section includes detailed flux analysis, losses and leakage inductance of both existing and proposed model.

III. EXISTING SYSTEM

The port 1 and port 2 are connected to two different sources as shown in the figure where RX and LX represent the leakage inductance associated with core and output of V1 and V2 produces the flux 1 and flux 2.

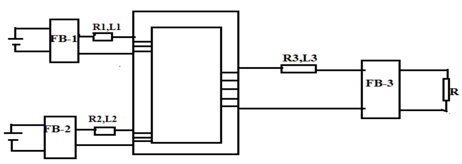

Figure 1(a) Transformer Winding connection of TAB

The resultant flux (ϕ)in the core is the summation of these fluxes.Figure 1 represents the leakage inductance of TAB which consists of flux leakage P11, P12,
P13

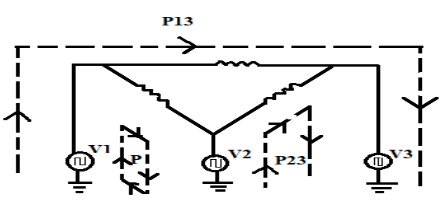

Figure 1(b) Equivalent circuit if TAB

It leads to increase in loss hence we prefer multi-coil transformer based TAB

IV. PROPOSED SYSTEM

The multi-coil transformer is used to mitigate current and switching losses. The principle of operation and steady-state operation are presented. The power flow, soft switching and output voltage are evaluated using Steady state operation.In figure 2(a) The flux is positive and negative in the interval (t1,t2) and (t3,t4).Thus the V1 and V2 have opposite polarity at these intervals. Thus flux decreases.

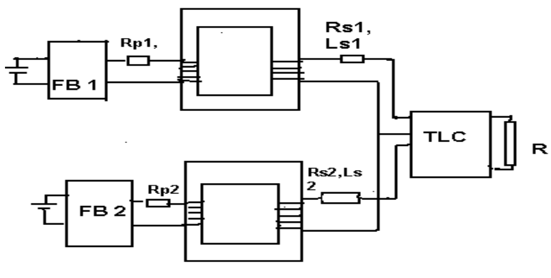

Figure 2(a) Transformer winding of MT-ATAB

In Fig. 2 (b) there is no additional leakage inductance as that of the existing system. Thus the flux intersection decreases and loss is reduced

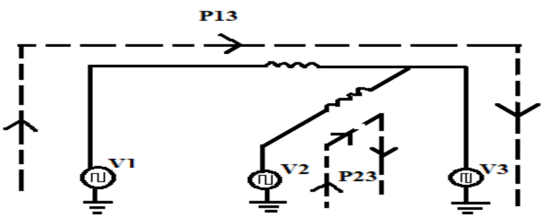

Figure 2(b) Equivalent circuit of MT-ATAB

OPERATION

MT-ATAB can be operated in two different modes of operations

1) Two-port mode

In this mode, any one of the source ports of DT-ATAB is active and other Source port is isolated from the process by applying turn-on and turn-off gate signals to some of the selected switches as shown . In the two port mode of operation, the MT-ATAB operates as a active bridge

2) Three-port mode

The MT-ATAB is supposed to operate primarily in the three-port mode of operation where all the ports are active. There are two different sources are connected to the ports -1 and -2 to supply the power to a load connected to the port -3output.

V. STEADY STATE ANALYSIS

The converter operation over a completeswitching cycle can be explained using six different time intervals. The corresponding equivalent circuits of the MTATAB showing the conduction status of switches and the closed loop paths for the transformer winding currents. It is assumed that before starting the new interval of our analysis, the secondary currents is1 and is2 are having negative values and the switches S12, S13, S22, S23, S32, S33, and S36 are turned on and all remaining switches are turned off.

Interval-1 [t0 - t1]

This period begins when S12 and S13 are turned off and the voltage vA1A2 (or vs1) changes its polarity from negative to positive. The current path for ip1 shifts from S12 and S13 to D11 and D14 naturally. Here, D11 and D14 represent the antiparallel diodes across S11 and S14,respectively.

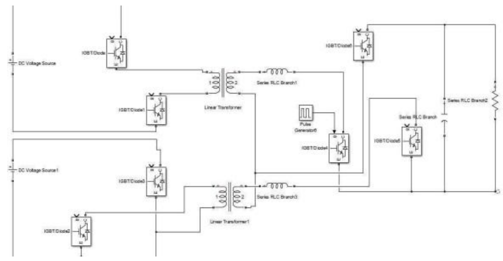

Figure 3(a) Interval 1

These switchesget turn-on after is becomes zero at zero voltage leading to the zero voltage switching. The closed-loop paths for the primary and secondary winding
Currents during this period.

Interval-2 [t1 - t2]

This period begins when S22 and S23 are turned off and the voltage vB1B2 (or vs2) shifts from negative to positive. The current path for ip2 shifts from S22 and S23 to D21 and D24 naturally. The switches S21 and S24 gets turn-on after is2 which becomes zero (denoted with t20) at zero voltage.

Active Ports	Switching conditions
Port 1 and 2	S21, S22, S23, S24, S35, and S36 are OFF
Port 2 and 3	S11, S12, S13, S14, S31, and S32 are OFF

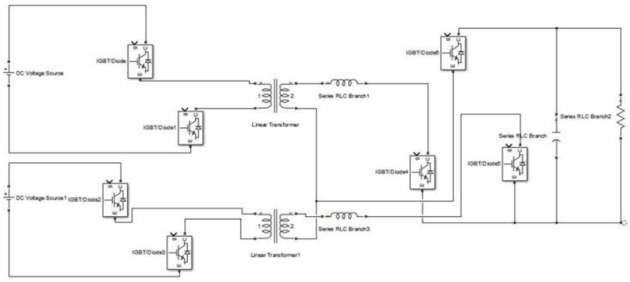

Figure 3(b) Interval 2

Interval-3 [t2 - t3]

This period begins when S32, S33, and S36 are turned off and the voltage vC1C2 and vC3vC2 shifts from negative to positive. The current path for is1 shifts from S32 and S33 to D31 and D34 and that for is2 shifts from S36 and S33 to D35 and D34 naturally. The switches S31, S34, and S35 get turn- on after the currents is1 and is2 become zero (denoted with t30) at zero voltage.

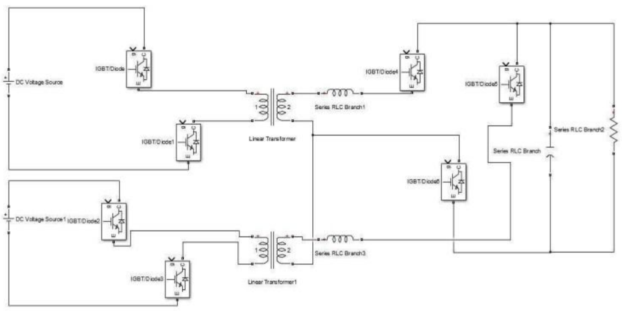

Figure 3(c) Interval 3

Interval-4 [t3 – t4]

This period begins when S11 and S14 are turned off and the voltage vA1A2 (or vs1) changes its polarity from negative to positive. The current path for ip1 shifts from and D13 represent the antiparallel diodes across S12 and S13, respectively. These switches get turn- on after is1 (or ip1) becomes zero) at zero voltage leading to zero voltage switching. The closed-loop paths for the primary and secondary winding currents during this periodS11 and S14 to D12 and D13 naturally. Here, D12 and D13 represent the antiparallel diodes across S12 and S13, respectively. These switches get turn- on after is1 (or ip1) becomes zero) at zero voltage leading to zero voltage switching. The closed-loop paths for the primary and secondary winding currents during this period

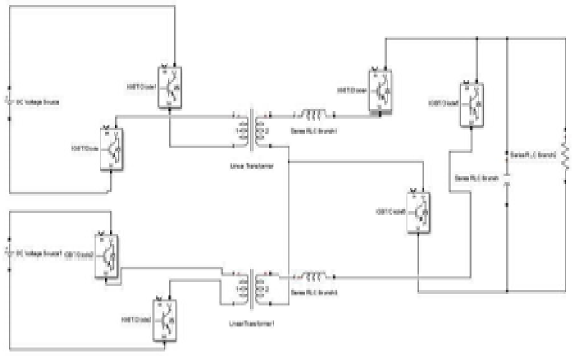

Figure 3(d) Interval 4

Interval-5[t4–t5]

ThisperiodbeginswhenS21andS24areturnedoffandthev oltage vB1B2 from negative to positive. The current path for ip2 tends to shifts from S21 and S24 to a D22 and D23 naturally. The switches S22 and S3 getsturn-on after is 2 and become zero(denoted with t20) at zero voltage.

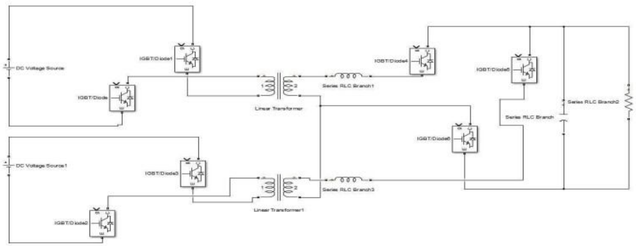

Figure 3(e) Interval 5

Interval-6 [t5 – t6]

This period begins when S31, S34, and S35 are turned off and the voltage vC1C2 and vC3C2 shifts from negative to positive. The current path for is1 shifts from S31 and S33 to D32 and D34 and that for is2 shifts from S33 and S35 to D36 and D34 naturally.

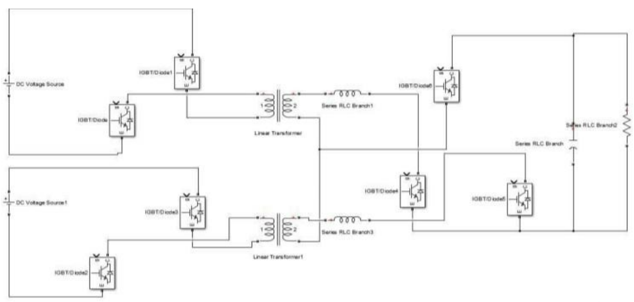

Figure 3 (f) Interval 6

The switches S31, S34, and S35 get turn- on after the currents is1 and is2 become zero (denoted with t30) at zero voltage.

VI. BLOCK DIAGRAM

In this block diagram the single phase inverter inverts dc source to ac source is the multi coil transformer. Multi coil transformer can be operated in two different modes of operations: two-port and three port. In the two-port mode, one port is completely isolated from the system and the remaining two ports are used for the power transfer operation.

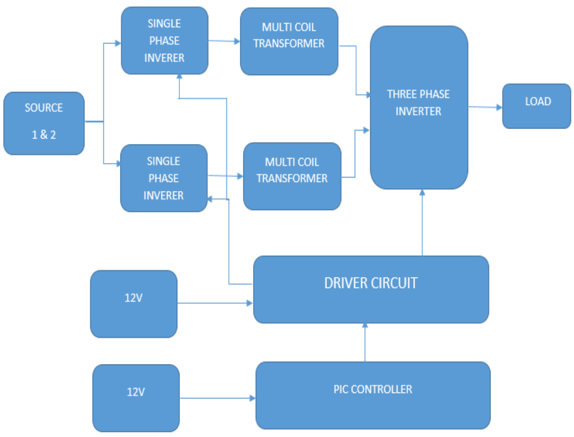

Figure 4 Block Diagram

In the three-port mode, port-1 and port-2 of the multi coil transformer –asymmetrical active bridge dc to dc converter are connected to two different dc-sources and a load is connected to the port-3 terminal. And the pic controller is used for the control the gate terminals in the switches. The driver circuit is used for thegiven pulse to another switch in the MT-ATAB.

VII. CIRCUIT DIAGRAM

The circuit diagram of MT-ATAB is shown. It consists of two FBs, TLC, and two HF transformers.The circuit diagram of MT-ATAB is shown in Fig. 5. It consists of two FBs,TLC, and two HF transformers. As all switches of MT-ATAB are active and the bidirectional power flow operation can be achieved between the source and load.complementarily with a duty ratio of 0.5 to achieve the maximum power operationports.In each bridge arm of MT-ATAB the active switches are turned on and turned off

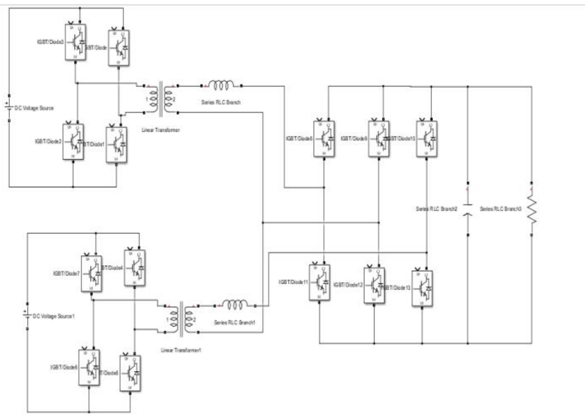

Figure 5 Circuit Diagram

The hardware circuit of MT-ATAB is shown below which is implemented and analysed by proteus software with pic micro controller to control the switching operation.

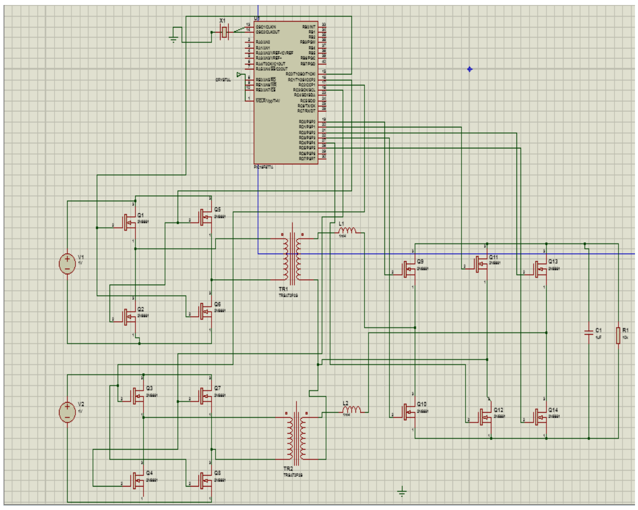

Figure 6 Hardware Circuit

VIII. SIMULATION AND RESULT

In the efficiency analysis, both dc source voltages are maintained. The losses of the isolated bi-directional converters decrease with the output poweroverall up to certain power limitandthenincreaseswiththepowertheMT-ATABoffersanadmirableefficiencyascompared to theexistingisolatedMPCsandcanbeapromisingtoolforthehighpowermulti-source power applications.

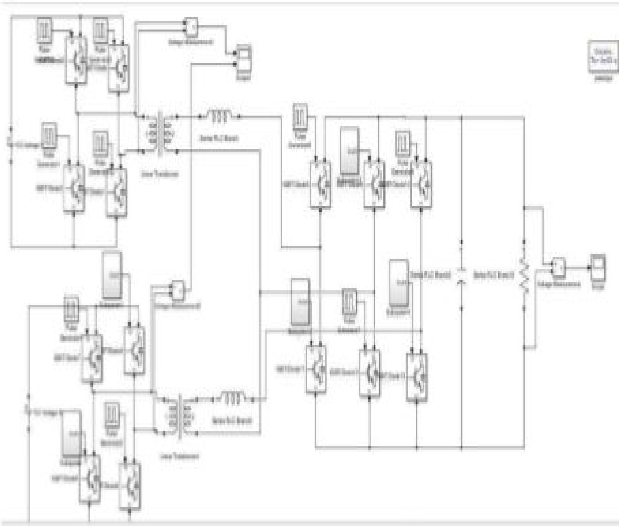

Figure 7 Simulation Circuit

The voltage versus time curve is shown in figure. The efficiency is increased to 20 percent compared to the existing model. The pulse width is varied corresponding to efficiency.

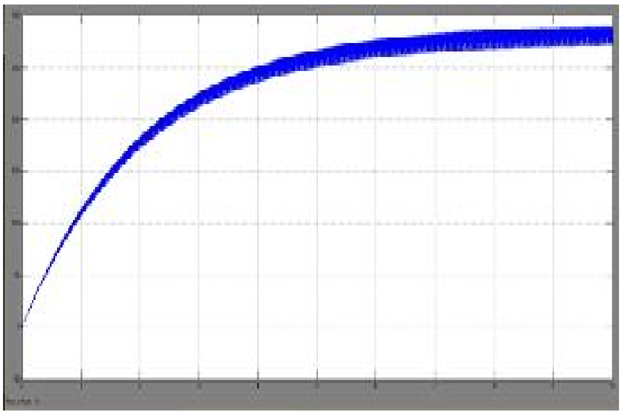

Figure 8 Output Waveform

IX. EXPERIMENTAL ANALYSIS

A laboratory prototype of MT-ATAB as shown in Fig4.4 is implemented. The port-1 and port-2 converters are implemented and the port-3 converter is implemented. The leakage inductances of the transformers are used as the boost inductors. In order to avoid short-circuiting of dc-buses, a dead-band of 2 µs is used between the switches of each arm of MT-ATAB. That both the input sources sharing the loadpower equally as their corresponding voltages and current.

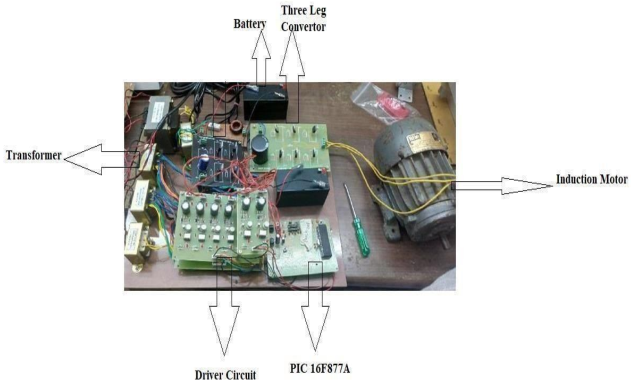

Figure 9 Hardware Snapshot

X. CONCLUSION

The system uses isolation between two ports , Switches are turned on by ZVS.Bidirectional power flow operation, reduced circulating powers, mitigation of magnetically short circuiting conditions, etc. This can be operated over a wide-ranging phase shift ratios between the source port converters to achieve the substantial choices of the output voltage and power. The efficiency of the proposed converter is verified using the simulation and experimental studies. The illustrated studies show that the proposed Multi coil transformer using active bridge dc-dc convertor can be used as a promising MPC topology capable of versatile power.

XI. FUTURE SCOPE

In order to maintain a desired voltage at the output and to regulate the powers flowing from the source ports, a closed loop control can be usedHere, the port-1 converter is operated to maintain the output voltage at desired level and the port-2 converter is operated to supply the desired power from the source connected at port 1 Therefore, the remaining power consumed at the output will be suppliedsource connected to port -1. Here, D13 is obtained by applying a proportional-integral (PI) regulator to the difference between the reference and actual values of the output voltage. Similarly, D23 is obtained by applying a PI regulator to the difference between the reference and actual powers supply from the port.

REFERENCES

[1] H. Matsuo, Wenzhong Lin, F. Kurokawa, T. Shigemizu, and N. Associate Professor in the Department of Electrical Engineering. His Watanabe, "Characteristics of the multiple-input DC-DC converter,"research interests include power electronic converters for HVDC and IEEE Trans. on Indust. Elect., vol. 51, no. 3, pp. 625-631, June 2004. FACTS

applications, grid integration of renewable energy sources,

[2] Yaow Ming Chen, Yuan-Chuan Liu, and Feng-Yu Wu, "Multi-input solid state transformers, hybrid and solid-state circuit breakers andDC/DC converter based on the multi-winding transformer for renewable electric drives.energy applications," IEEE Trans. Indust. Appl., vol. 38, no. 4, pp. 1096- Dr. Shukla is a recipient of the Young Engineer Award (2011)1104, Aug. 2002. conferred by the Institution of Engineers, India.

[3] S.V. Kulkarni and S.A. Khaparde, "Transformer Engineering: Design and Practice," CRC Press, pp. 367-387, May-2004.

[4] E. Asa, et al., "Asymmetrical Duty-Cycle and Phase-Shift Control of a Novel Multiport CLL Resonant Converter," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 3, no. 4, pp. 1122-1131,2015.

[5] M. N. Kheraluwala, R. W. Gascoigne, D. M. Divan, and E. D. Baumann, "Performance characterization of a high-power dual active bridge DC- to-DC converter," IEEE Trans. on Indust. Appl., vol. 28, no. 6, pp. 1294-1301, Nov/Dec 1992.

[6] H. Wu, L. Chen and Y. Xing, "Secondary-Side Phase-Shift-ControlledDual-Transformer-Based Asymmetrical Dual-Bridge Converter With Wide Voltage Gain," IEEE Trans. Power Elect., vol. 30, no. 10, pp.5381-5392, 2015.

[7] V. N. S. R. Jakka, A. Shukla, and G. Demetriades, "Three-winding transformer based asymmetrical dual active bridge converter," IET Power Electronics, vol. 9, no. 12, pp. 2377-2386, 2016.

[8] A. Ganz, "A Simple, Exact Equivalent Circuit for the Three-Winding Transformer", IRE Trans. Component Parts, vol. 9, no. 4, pp. 212-213, Dec 1962.

[9] C. Mi, et al., "Operation, design and control of dual H-bridge-based isolated bidirectional DC-DC converter," IET Power Elect., vol. 1, no4 2008

[10] T. Zhao, et al., "Voltage and Power Balance Control for a Cascaded H- Bridge Converter-Based Solid-State Transformer," IEEE Trans. Power Elect., vol. 28, no. 4, pp. 1523-1532, 2013.

[11] S. Inoue and H. Akagi, "A Bidirectional DC–DC Converter for an Energy Storage System With Galvanic Isolation," IEEE Trans. Power Elect., vol. 22, no. 6, pp. 2299-2306, Nov. 2007.

[12] R. L. Steigerwald, at el., "A comparison of high power DC-to-DC soft- switched converter topologies," IEEE Indust. Appl. Society Annual Meeting, pp. 1090-1096, vol. 2, Oct. 1994.

[13] T. Hirose and H. Matsuo, "Standalone Hybrid Wind-Solar Power Generation System Applying Dump Power Control Without Dump Load," IEEE Tran. Indust. Electro, vol. 59, no. 2, pp. 988-997, Feb. 2012.

[14] D. Boroyevich, I. Cvetkovic, et. Al. "Intergrid: A Future Electronic Energy Network?," IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 1, no. 3, pp. 127-138, Sept. 2013.

[15] K. Filsoof and P. W. Lehn, "A Bidirectional Multiple-Input Multiple- Output Modular Multilevel DC–DC Converter and its Control Design," IEEE Trans. Power Elect. vol. 31, no. 4, pp. 2767-2779, 2016.

[16] M. McDonough, "Integration of Inductively Coupled Power Transfer and Hybrid Energy Storage System: A Multiport Power Electronics Interface for Battery-Powered Electric Vehicles," IEEE Trans. Power Elect, vol. 30, no. 11, pp. 6423-6433, Nov. 2015.

[17] Switching Full-Bridge Three-Port Converter for Renewable PowerSystems," IEEE Trans. Indust. Elect., vol. 62, no. 11, Nov. 2015.

[18] X. Liu, et al. "A Compact Three-Phase Single-Input/Dual-Output Matrix Converter," IEEE Trans. Indust. Elect., vol. 59, no. 1, pp. 6-16,Jan.2012.