Integration of Non-Conventional Energy Sources using Modified Full Bridge Converter

S. Banumathi, A. S. F. Subhamathi, V. Indra Gandhi

Abstract: ***Power system stability mainly involves the inputs from renewable energy sources and stand alone systems are playing major role in supplying electricity to remote areas. This paper displayed an altered full scaffold Triple port converter innovation to deal with the power stream between the sources and burden. Here the sun oriented PV board goes about as a principle source and it is upheld by a vitality stockpiling gadget battery providing capacity to the DC load. The proposed full scaffold Triple-port converter (FB-TPC) joins two converters (Buck-Boost) on the essential side of the transformer. The transformer inductors act as a filters and the power conversion and transformation operation involves only one step. This reduces the losses and increases the efficiency of the system. The zero voltage switching is involved in operating the switches. The principle of operation of the studied converter is analyzed thoroughly and the simulation output waveforms are compared between proposed FB-TPC and Modified FB-TPC.***

Index Terms**:** ***Buck-Boost Converter, Full Bridge Triple-Port Converter, Modified Full Bridge Triple-Port Converter.***

I. INTRODUCTION

In supplying electricity to rural areas Stand Alone Photo Voltaic system places a vital role [1] – [3]. The full bridge Triple port technology has been proposed in for this system in many articles [4]. A group of multiple port two directional DC to DC converters got a general topology is exhibited. Topology demonstrates coupling DC-link and magnetic coupling[5]. A work that manages structuring and measuring of a multiple-input power electronic converter which is suitable for an electrical vehicle drive circuit that incorporates a fuel cell (generator) & joined storage part. A storage unit is designed with a battery and an ultra capacitor tank, an ultra capacitors tank (UC) & battery unit used for design storage unit. MIPEC is taking care of power flow between the storage unit and vehicle. [6]. General topology and basic cells demonstrate a few potential outcomes to build a multiport converter for specific applications and furthermore, to offer a solution to constitute distinct sources inferable from their flexibility in structure is discussed[7]. W. Jiang and B. Fahimi proposed circuit coordinates distinctive sustainable power sources just as for storing energy. By incorporating sustainable power sources with factual expectancy to satisfy one another, the impact of the inconsistent nature can be significantly decreased. This incorporation will expand the unwavering quality and usage of entire system [8]. In triple port technology [9, 10], one input port is connected with the solar PV panel and the other input port is interfaced with battery. Output port and it is connected with the load. The expression of non isolated Triple-port DC to DC converters confirms the high efficiency because of single stage power transfer between solar PV, Battery and Load [11,12]. The Buck boost converter plays an important role that is it makes power flow between the ports depending upon the condition. The input supply voltage is available in a wide range and the converter has the control and makes the power balance in the circuit [13, 14]. A decoupled voltage regulation obtained by controlling, triggering order and triggering point on the interleaved converters [15]. By considering the above reviews and results a modified full bridge converter with Triple ports are proposed in this work and the simulation results have been discussed.

II. FULL BRIDGE TRIPLE-PORT CONVERTER

The proposed Full scaffold Triple-port converter is associated with PV source, Battery (input ports) and burden (yield port). The general square graph of proposed converter is given in Fig. 1. The circuit model of the converter exclusively with each info port is appeared in Fig. 2. The circuit comprises of four switches S1,S2, S3 and S4 and is playing out the task of two Buck Boost converter. Among these converters one Buck Boost converter involves the switch S1, S2 and inductance of T1and Lm1. The other circuit includes S3, S4, T2 and Lm2. The main difference between conventional full-bridge converter and the proposed converter is transformer is made into two transformers with magnetizing inductance. The inductance will act as a filter.

In the proposed circuit power transformation between any two ports is shown in Fig. 2 separately. Fig. 2 (a) shows the flow of power from solar photovoltaic to DC load; this has been done through a diode full bridge converter. Fig. 2 (b) shows the power flow from solar PV panel to storage device, which involves Buck-Boost converter operation with inductance on two transformers. The third

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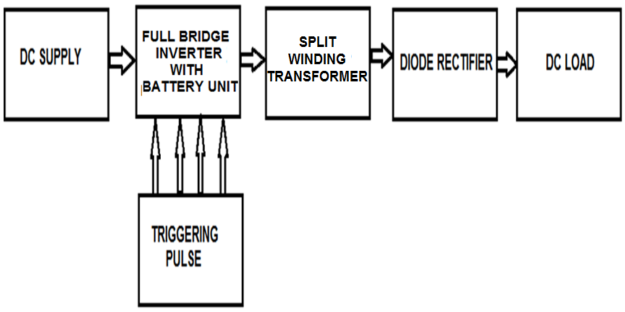

Figure 1 Block diagram of proposed converter

type power flow shown in Fig. 2(C) is between battery and load which takes place in the absence of PV source.

Considering the above power flows between PV source, Battery and load, indicate the PV source power as Pin, Battery power as Pb and power delivered to load as Po. The power equation involving these Triple can be written as

$$Pin = Pin + Po \tag{1}$$

(c) Storage cell to load

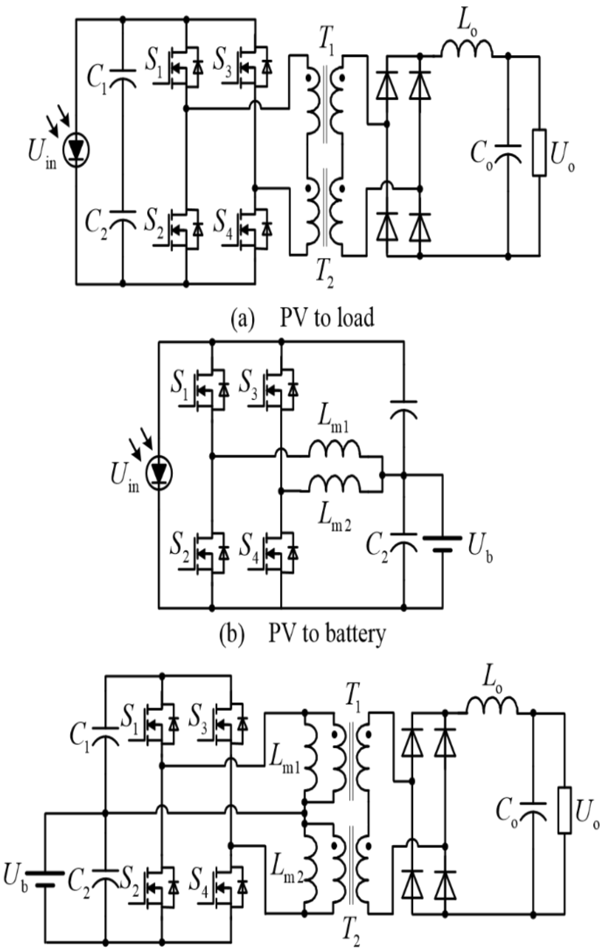

Fig.2 Equivalent Circuit Diagram of the
Converter with any two ports

and the circuit can operate in Triple modes:

Mode 1: When $P_{in}> P_o$, the excess power can be utilized to charge the battery and thus both load and battery obtain the power from solar panel. Since the battery is getting charged from solar PV supply the average value of input power is positive.

Mode 2: When $P_{in}< P_o$ and $P_{in}>0$, the additional power required by the load can be supplied with the help of battery. Mode 3: When Pin = 0, the load receives supply from battery. In mode 2 and mode 3 the storage cell discharges its supply to the load, it gives the negative average input power. In mode 1 and mode 2 all the Triple ports are involved so proper controlling of switches is necessary.

Each switching sequence is consisting of four states and the waveform of this sequence is give in Fig.3. Each state can be described as follows State t_0 : Switch S1 is triggered to on state, S2 is turned off on and switch S4 is already in conducting mode. Through this S1 and S4 primary winding of transformer T1 gets positive supply and primary winding of T2 receives negative voltage.

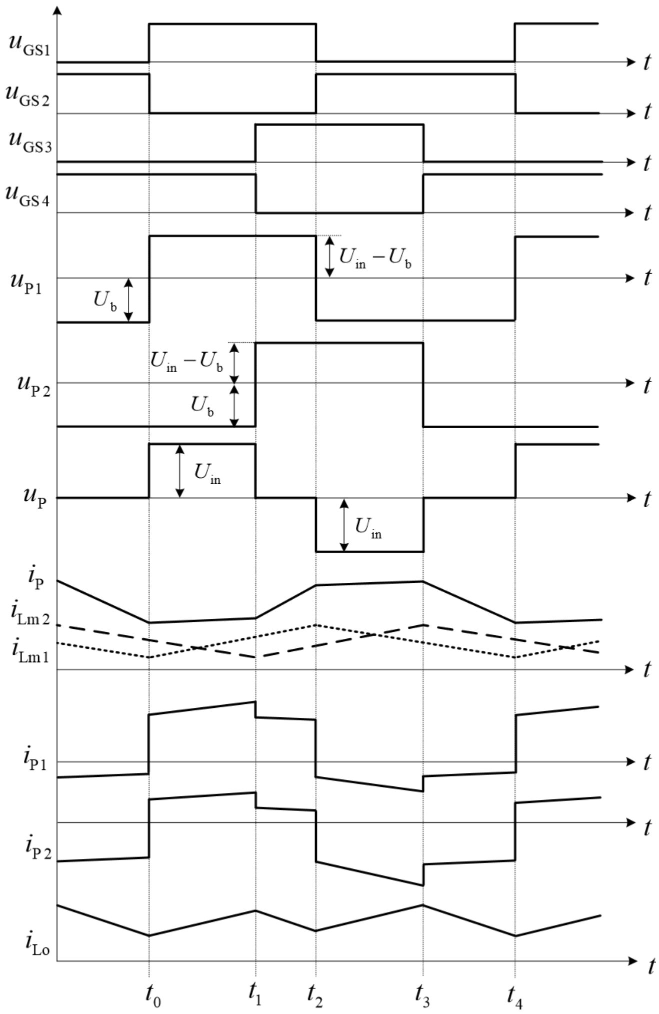

Fig.3 Key waveforms of Full Bridge –Triple Port Converter

$$\frac{diLo}{dt} = \frac{(nVin - Vo)}{Lo} \tag{2}$$

State t_1 : Switch S3 is triggered to conducting state, S4 is commutated and switch S1 is already in conducting mode. Conduction takes place through S1 and S3 and both transformers receives positive supply. iLm_1, iLm_2 and iL_o freewheel through S_1 and S_3.

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$$\frac{diLo}{dt} = \frac{-Uo}{Lo} \quad (3)$$

State t_2: Switch S2 is triggered to on state, S1 is turned off and switch S3 is already in conducting mode. Conduction takes place through S2 and S3, primary winding of transformer T1 gets negative supply and primary winding of T2 receives positive voltage

$$\frac{diLo}{dt} = \frac{(nVin - Vo)}{Lo} \quad (4)$$

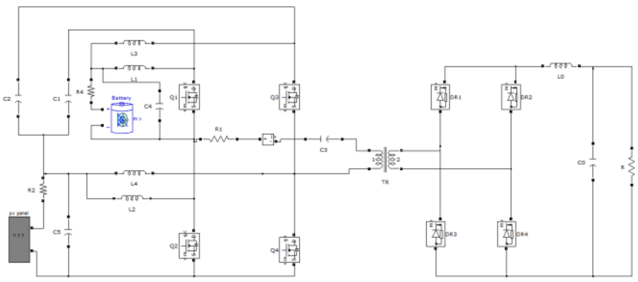

Fig.4 Proposed Full Bridge Triple - Port Converter circuit

State t_3: Switch S4 is triggered to conducting state, S3 is commutated and switch S2 is already in conducting mode. Transformer T1 and T2 supplied with negative voltage. iL_{m1}, iL_{m2} and iL_o freewheel through S_2 and S_4.

$$\frac{diLo}{dt} = \frac{-Uo}{Lo} \quad (5)$$

III. SIMULATION MODEL

A. Full Bridge Triple-Port Converter

Control signal of the converter can chosen in such a way that to maintain power equilibrium among solar power and the battery. The input side of the converter circuit consists of two Buck Boost converters. The switches S1, S2 & T1, Lm1 makes one converter and the switch S3, S4 & T2, Lm2 makes another converter circuit. The converter circuit can work in any mode which was discussed earlier. The load is connected after the conventional diode bridge rectifier. The simulink diagram of the planned Full Bridge Triple-Port Converter is given in Fig. 5.

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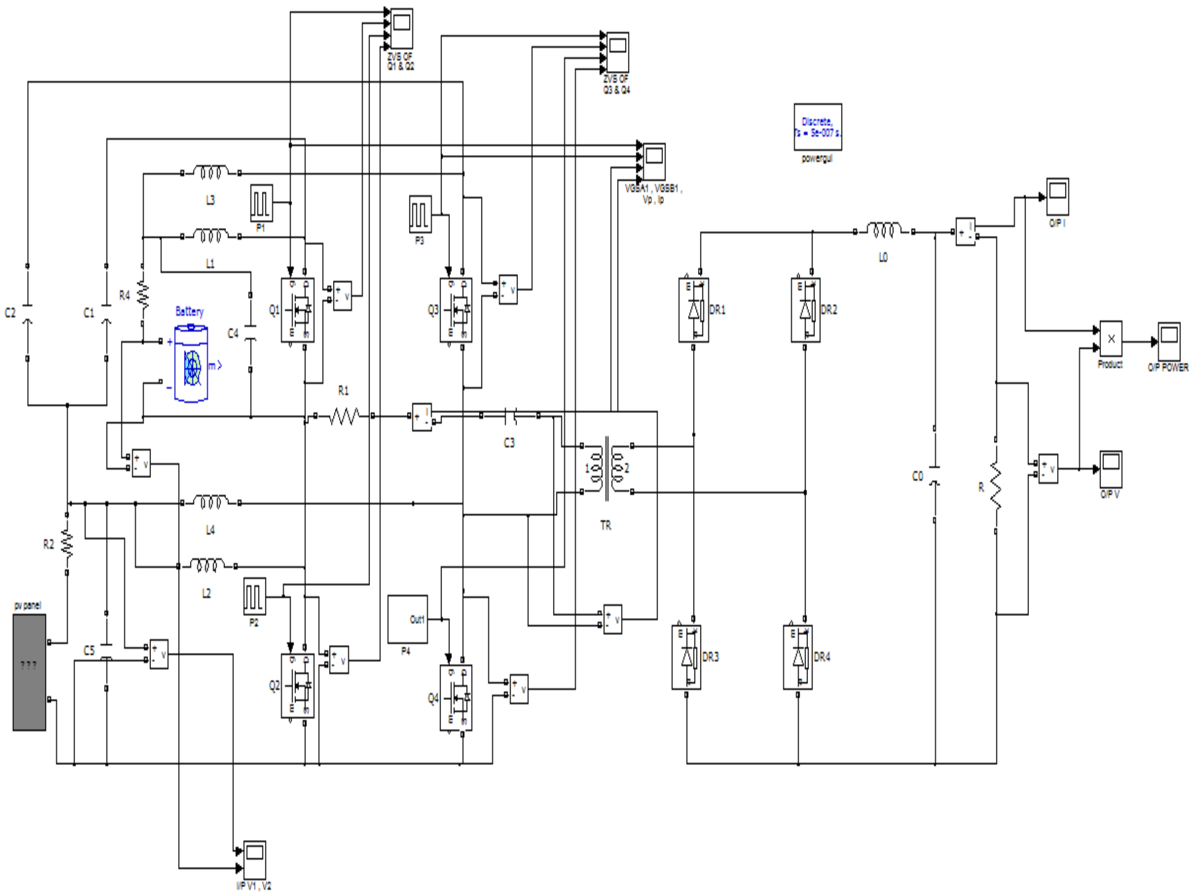

Fig. 5 Simulation circuit for Proposed Full Bridge Triple - Port Converter

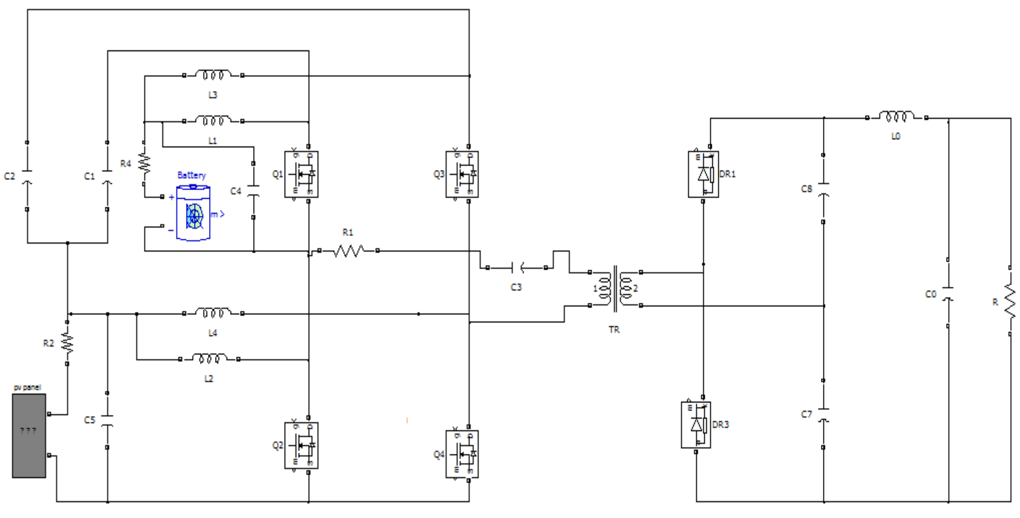

Fig.6 Modified Full Bridge Triple - Port Converter circuit

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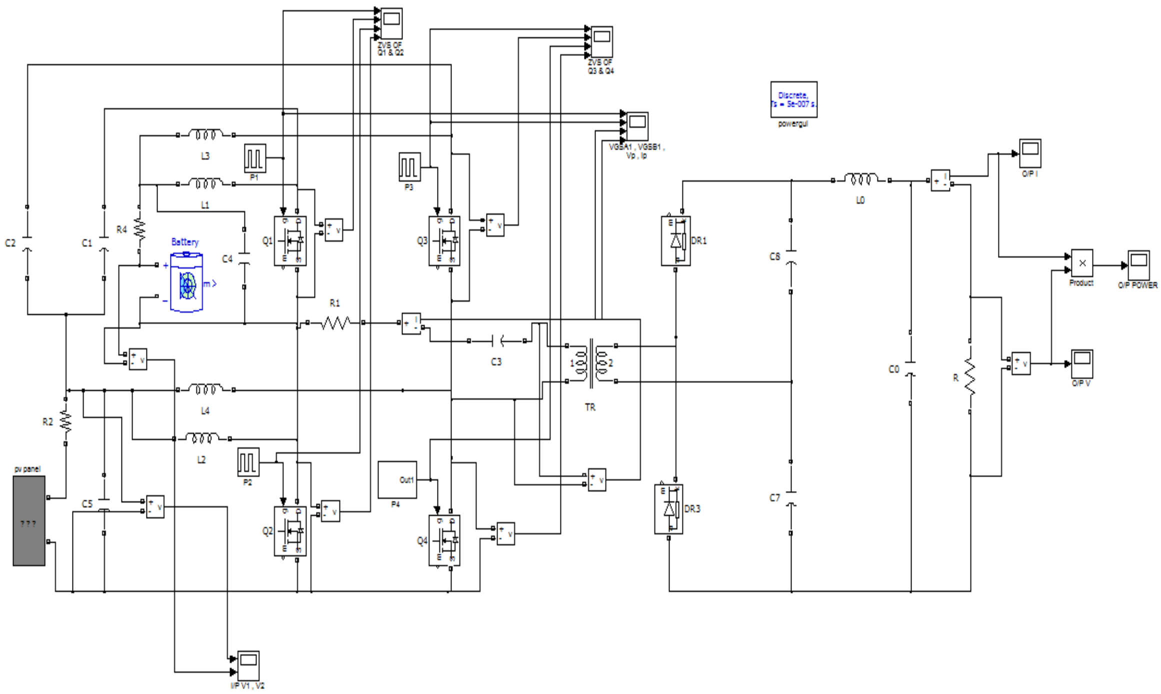

Fig.7 Simulation circuit for Modified Full Bridge Triple - Port Converter

IV. SIMULATION RESULT AND DISCUSSION

This chapter discusses about the simulation results obtained from proposed Full Bridge Triple - Port Converter and Modified Full Bridge Triple - port converter. The voltages waveforms obtained from the PV source Vin1 and Battery source Vin2 are given in the figure 8 & figure 9 for Proposed FB-TPC and Modified FB-TPC respectively. Since the primary side converter circuit and its operation are same in both the converters, the output wave form is more or less same. The main dissimilarity is the modified FB-TPC takes

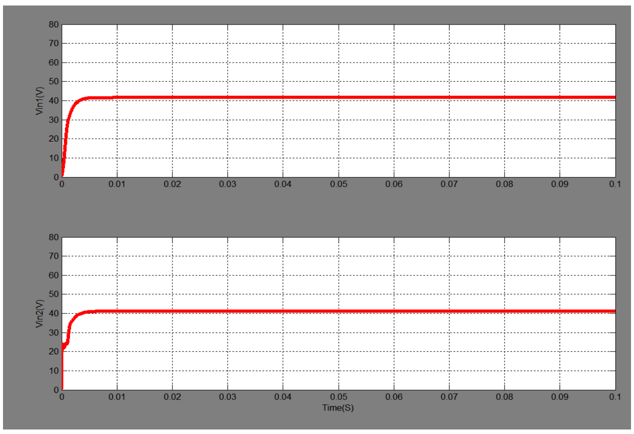

Fig.8 Simulated output for input voltage of Proposed FB TPC

more time to reach its steady state value when compared to planned Full Bridge Triple - Port Converter

In modified Full Bridge Triple - Port Converter, load side diode bridge rectifier is replaced by two diodes and two capacitors which improve output voltage, current and power. The simulated output waveforms like voltage, current and Power of Proposed Full Bridge Triple - Port Converter and Modified Full Bridge Triple - Port Converter respectively are shown in figure 10 & figure 11. From the output waveform it is very clear that the output voltage of Proposed FB-TPC is around 95 V and for Modified FB-TPC it is 150 V. The output current also improved from 1.7 A to 2.9 A and the output power value also shows the improvement from 160 watts to 450 watts.

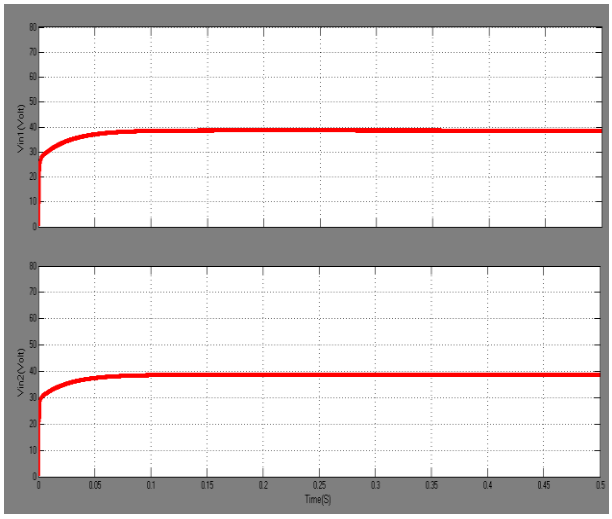

Fig.9 Simulated waveform of input voltages of a Modified FB TPC

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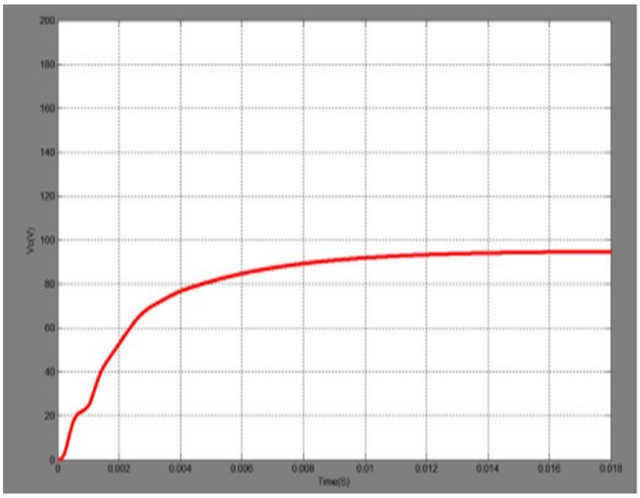

Fig.10 (a) Simulated output of voltage of Proposed FB TPC

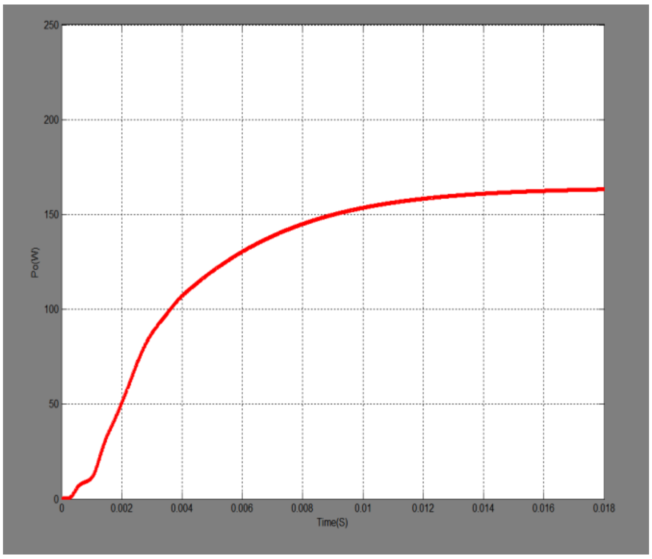

Fig.10 (b) Simulated output of current of Proposed FB TPC

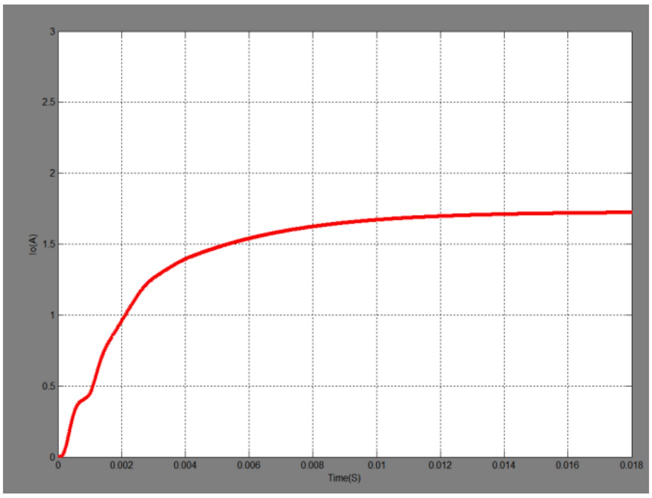

Fig.10 (c) Simulated output of Power of Proposed FB TPC

V. CONCLUSION

Modified full bridge Triple - port converter for integration of non-conventional energy source is planned in this work. Operation of Full bridge Triple port converter connected to solar source, DC (input ports) & load (output port) discussed. The modified FB-TPC the load side diode bridge rectifier circuit is replaced by two diodes and two capacitors. The simulation diagram and simulation results of input and output voltages, output current and output power are discussed and compared between two converter circuits. The power transformation between any of the port includes just single stage, so effectiveness of the framework is high and the activity is controllable. The changed full-connect Triple-port converter can be executed for all intents.

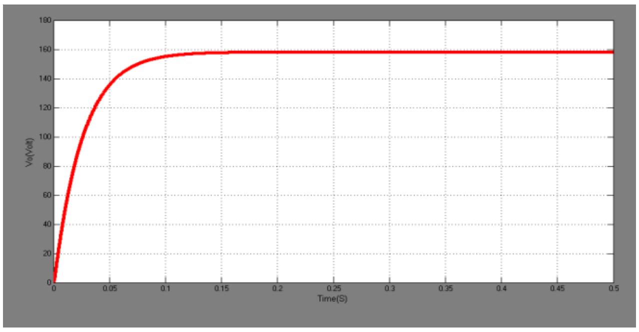

Fig.11 (a) Simulated output of voltage of Modified FB TPC

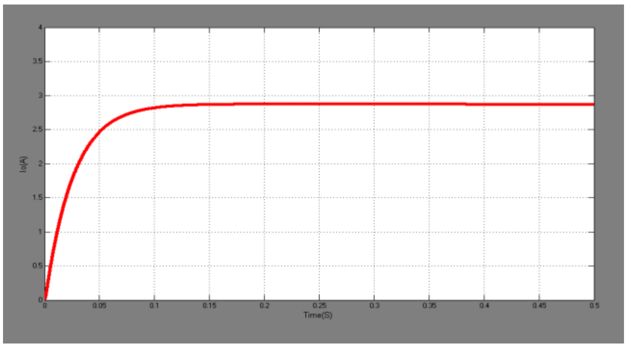

Fig.11 (b) Simulated output of current of Modified FB TPC

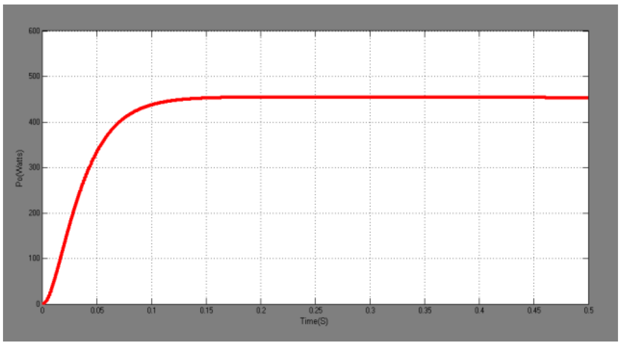

Fig.11 (c) Simulated output of Power of Modified FB TPC

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REFERENCES

1. Hyun-Jun Kim, Eun-Suk Shin, Yoon-Seok Lee, Jae-Hyuk Kim, Byung Moon Han, "Smooth Operation Transition Scheme for Stand-Alone Power System With EG and BESS-PV Panels", IEEE Transactions on Smart Grid, Vol. 8, No. 4, 2017, pp. 2042-2044.
2. Tanmay Rout, Manoj Kumar Maharana, Ankit Chowdhury, Sarita Samal, "A Comparative study of Stand-alone Photo-Voltaic System with Battery storage system and Battery Supercapacitor storage system" , *4th International Conference on Electrical Energy Systems (ICEES)*, 2018, pp. 77-81.
3. Indragandhi V, B Keerthi Vardhan, Arunkumar. G ; Raja Singh R Banumathi. S, "Implementation of a DC Micro-Grid for House Hold Applications", *8th International Conference on Power and Energy Systems (ICPES*), 2018, pp. 141 – 145.
4. Junjun Zhang, Hongfei Wu , Xiaoqing Qin , Yan Xing, "PWM Plus Secondary-Side Phase-Shift Controlled Soft-Switching Full-Bridge Triple-Port Converter for Renewable Power Systems", *IEEE Transactions on Industrial Electronics, Vol. 62, No.11, 2015, pp. 7061-7072.*
5. Hongfei Wu, Runruo Chen, Junjun Zhang, Yan Xing, Haibing Hu, Hongjuan Ge., "A Family ohf Triple-Port Half-Bridge Converters for a Stand-Alone Renewable Power System", *IEEE Transactions on Power Electronics*, Vol. 26, No.9, 2011, pp. 2697-2706.
6. Hongfei Wu, Runruo Chen, Junjun Zhang, Yan Xing, Haibing Hu, Hongjuan Ge., "A Family of Triple-Port Half-Bridge Converters for a Stand-Alone Renewable Power System", *IEEE Transactions on Power Electronics*, Vol. 26, No.9, 2011, pp. 2697-2706.
7. Zhan W, Hui L., "An Integrated Triple-Port Bidirectional DC-DC Converter for PV Application on a DC Distribution System", *IEEE Trans. on Power Electronics*, Vol. 28, No. 10, 2013, pp. 4612-4624.
8. W.Jiang and B. Fahimi, "Multi-Port Power Electric Interface for Renewable Energy Sources," *in Proc. IEEE 2009 Appl. Power Electron. Conf*., 2009, pp. 347-352.
9. Wu H, Sun K, Ding S, Xing Y., "Topology Derivation of Non Isolated Triple-Port DC-DC Converters from DIC and DOC", *IEEE Trans. on Power Electronics*, Vol. 28, No. 7, 2013, pp. 3297-3307.
10. Hongfei Wu, Kai Sun, Runruo Chen, Haibing Hu, Yan Xing., "Full-Bridge Triple-Port Converters with Wide Input Voltage Range for Renewable Power Systems", *IEEE Transactions on Power Electronics*, Vol.27, No.9, 2012, pp. 3965 – 3974.
11. PL.Somasundaram, V.Jayakumar, "Computation of short run marginal cost in open access transmission system" Journal of chemical and Pharmaceutical Science, ISSN: 0974-2115, Special issue1, pp 275 -279, Feb 2017.
12. R Karthikeyan, GN Sachin Amreiss, PV Based Interleaved Boost Converter for Pumping Applications, Internationall Conference on Intelligent and Advanced System, https://doi.org/10.1109/ICIAS.2018.8540613 , Kuala Lumpur, Malaysia
13. Karthikeyan R, Chenthurpandiyan S, Generalized Space Vector PWM Algorithm for Minimizing THD in Hybrid Multilevel Inverters, International Review of Electrical Engineering, 6(5), 2011, 2094 - 2099.
14. Karthikeyan R, Pandian SC, An Efficient Multilevel Inverter System for Reducing THD with space Vector Modulation, International journal of computer applications, 23(2), 2011,0975-8887.
15. Jayakumar V, "Single Phase Fifteen Level Inverter using Seven Switches for Industrial Applications" Journal of Advances in Chemistry, ISSN 2321-807X, Volume 12 Number 21, pp 5355 – 5364, Dec 2016.

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