International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

Power Factor Correction Insepic Converter Fed Hub Motor for Electric Vehicle

A. Rameshbabu, V. Geetha, V. Sivachidambaranathan, D.N.S.Ravikumar

Abstract*: The paper deals with improvingthe power factor in permanent magnet HUB motor by using Bridgeless SEPIC converter. The input voltage of the HUB motor is controlled to ensure the smooth operation of electric motor. The wide range of input voltage is demonstrated by controlling the speed of the HUB motor using fuzzy controller. Comparative analysis of SEPIC and CUK fed HUB motor is simulated for power factor correction. A SEPIC converter with power factor of 0.939 is achieved and examined with an experimental setup.

Keywords: HUB motor, CUK , SEPIC converter, Power factor correction, THD.

I. INTRODUCTION

Now a day's using fuel like petrol, diesel in driving systems in the world is common. Combustion of fuels has a bad impact on our Environment and led to the pollution. The combustion of fuels produces greenhouse gases which led to the depleting of ozone layer faster which causes Global Warming.

Therefore in future fuel driving systems are converted to electric system. Electric vehicles are running without reek. The latest E-Vehicles are employed in individual motor drive system. A HUB of the E-Vehicle is incorporated with one motor.HUB motor is utilized in electric vehicle application due its high torque.

The maximum real power is achieved by using a power factor corrected converter. The reactive power of the electrical system is compensated by adding power factor correction converter.

The converter improves the reactive power to achieve close to unity power factor. Thus the new bridgeless PFC converter is introduced to reach 98%of efficiency and 0.99 power factors.

Revised Manuscript Received on February 28, 2020.
***** Correspondence Author

A. Ramesh Babu, Department of EEE,Sathyabama Institute of science and technology since 2007, Chennai, India. rameshbabuaa@gmail.com

V. Geetha*, Department of EEE, Sathyabama Institute of science and technology since 2007, Chennai, India. geethasendray28@gmail.com.

V.Sivachidambaranathan, HOD/EEE, Sathyabama Institute of science and technology since 1994, Chennai, India, sivachidambaram_eee@yahoo.com

D.N.S Ravi Kumar, Department of EEE,Sathyabama Institute of science and technology since 2007, Chennai, India, rk9980@gmail.com

The benefit of using this bridgeless converter is only two switches are used and in turn the conduction loss is lesser,

control circuit is simple, overall efficiency holds high[1],[2], [6].the different topologies are CUK,SEPIC,ZETA are controlling the DC voltage with only one switch which improves the power quality in AC mains [3].The low power factor and high THD of the power semiconductor is discussed in[4],[5].

The DC-DC Resonant converter for PFC using Half Bridge technique [7],[8].The Continuous Conduction Mode of Bridgeless SEPEIC Converter uses the Power Factor Correction Rectifier[9].

SRF Theory using active power filter for renewable energy in [10], quasi resonant converter with single switch and two stage quasi z source DC-DC converter technique discussed in[11],[12] resonant converter using hybrid switching scheme for DC – DC converter [13].

II. PRINCIPLE OPERATION OF PROPOSED SYSTEM

The Fig.1 indicates the circuit diagram for Bridgeless (CUK orSEPIC) converter fed HUB motor. It consists of Bridgeless rectifier, three phase inverter and HUB motor. The bridgeless rectifier connected from input ac supply.The converted output dc voltage is connected to input of sixpulse inverter circuit.

The Inverter circuit converts DC to AC voltage. The ACoutput voltage is given to the stator of the HUB motor.The output voltage of the inverter and bridgeless rectifier is controlled by using fuzzy system.

The fuzzy controller generatescontrol pulses to gate driver circuit. The basic circuit diagram for CUK and SEPIC converters are depicted in Fig.2 and Fig.3.

III. SIMULATION RESULT

Bridgeless CUK converter fed HUB motor simulation using MATLAB shown in fig 4. Normally CUK converter contains four inductors, four diodes and three capacitors and two MOSFET switches are used in the circuit.

The power factor of converter input side measured in the circuit. The bridgeless rectifier output voltage is given to inverter circuit. Inverter is connected to three phase HUB motor.

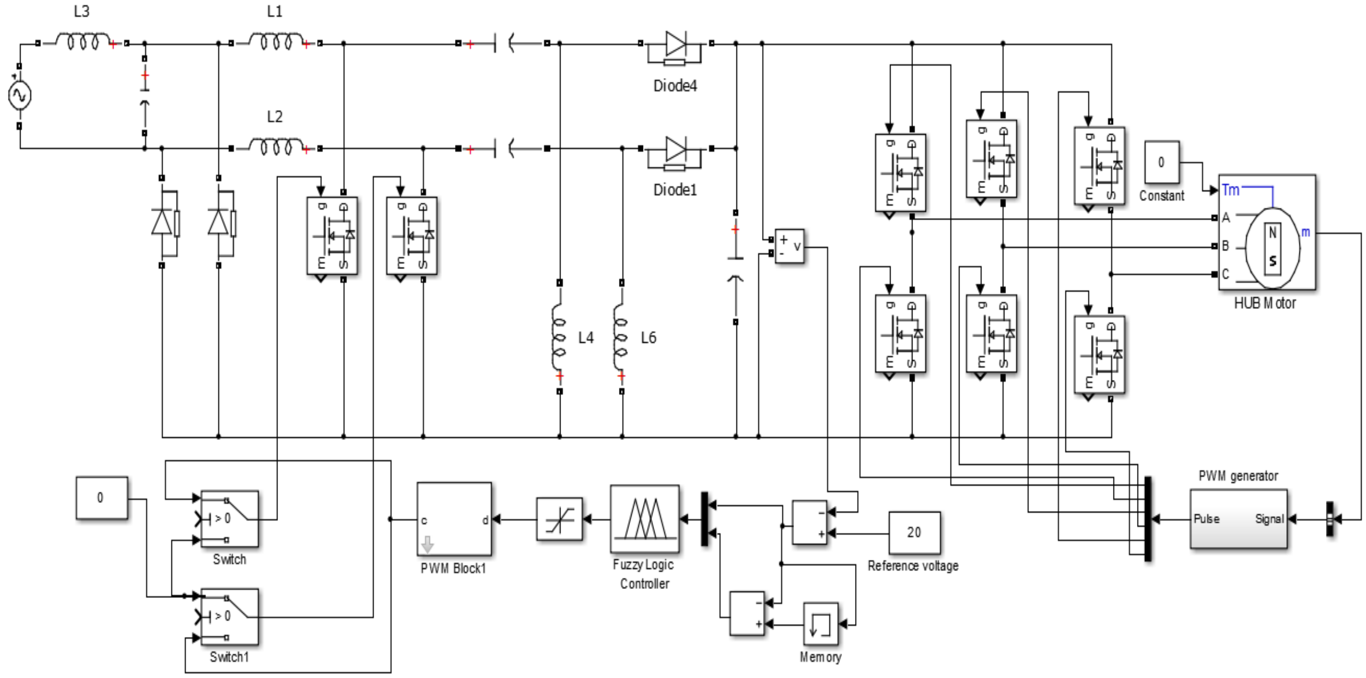

Fig.1 Circuit diagram for SEPIC fed HUB motor

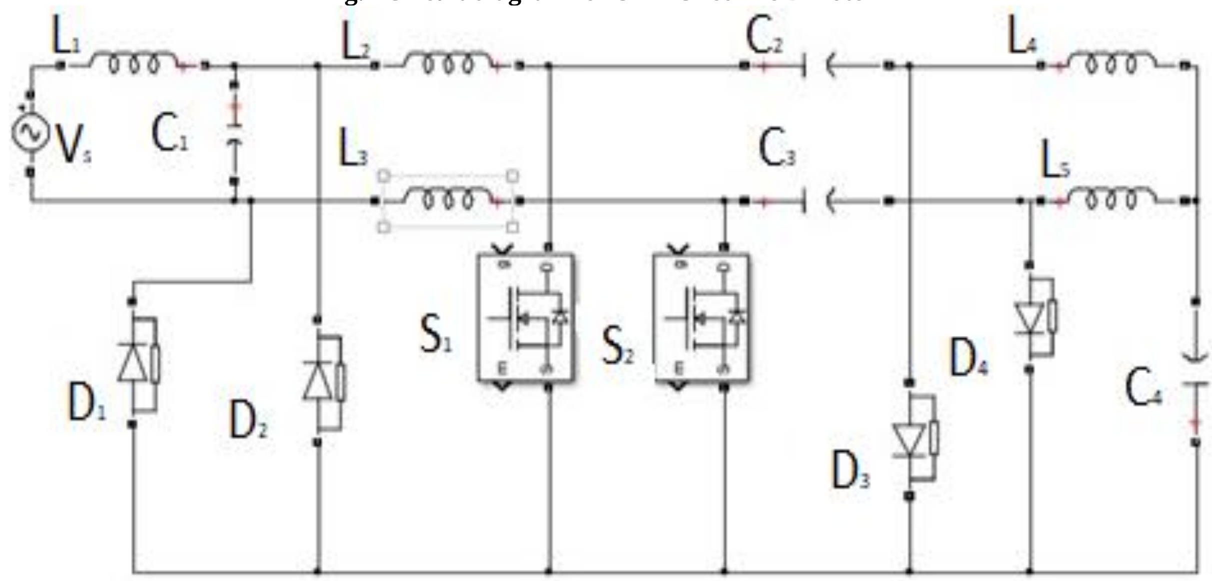

Fig. 2 CUK converter circuit diagram

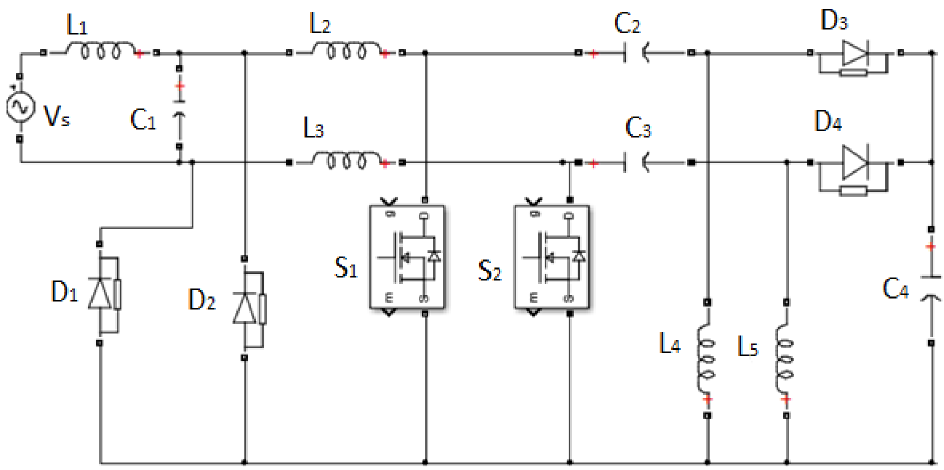

Fig.3. Circuit diagram for SEPIC converter

International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

The fig.5 represents the input waveforms of the bridgeless CUK converter. Simulation of CUK converter is carried out and fig .6 shows the output voltage waveform and voltage across the capacitor is also measuredfor the proposed bridgeless CUK converter.

The intermediate output of the six pulse inverter is depicted in fig.7. The above mentioned figure 8 represents the power factor measured in the proposed converter. The power factor was found to be 0.8 for the system developed.

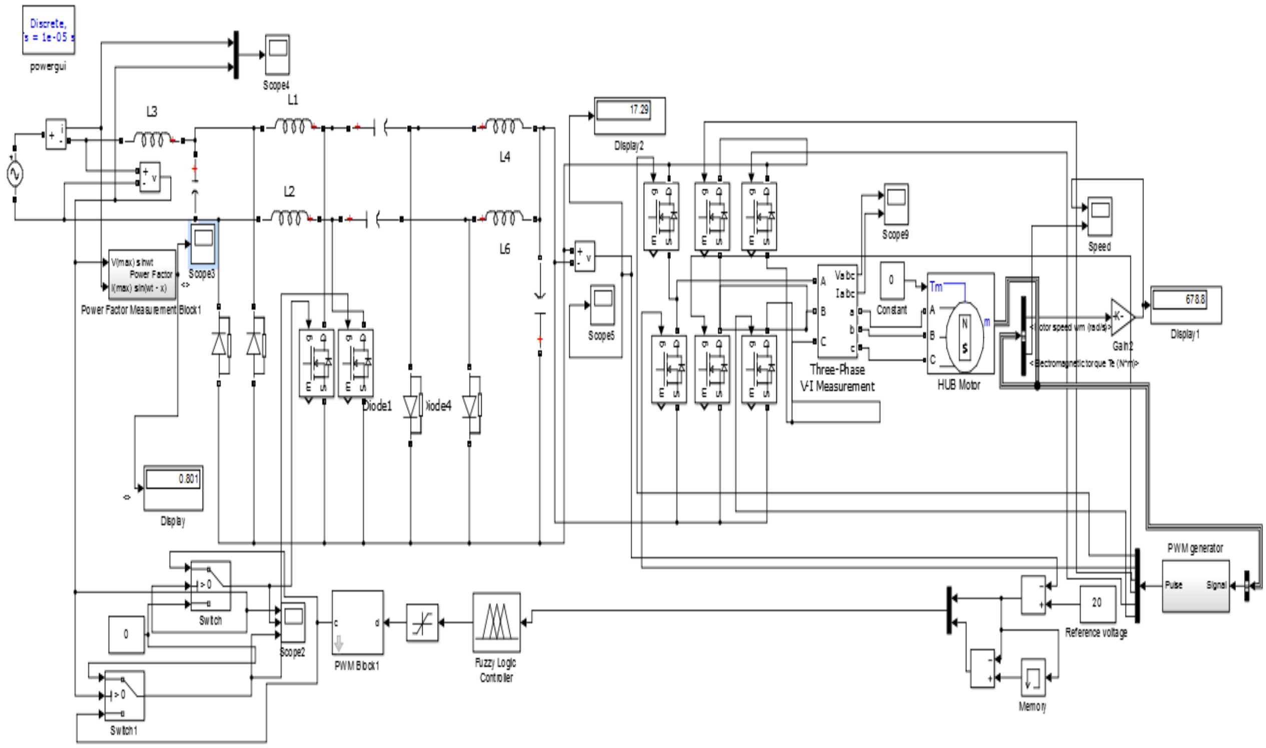

Fig.4. Simulation diagram for CUK fed HUB motor

The Bridgeless SEPIC converter is simulated using MATLAB shown in fig.9. Normally SEPIC converter contains four inductors, four diodes and three capacitor two MOSFET switches are used in the circuit. The power factor is converter input side measured in the circuit. The converter output voltage is given to inverter circuit. The Inverter is connected to three phase HUB motor.

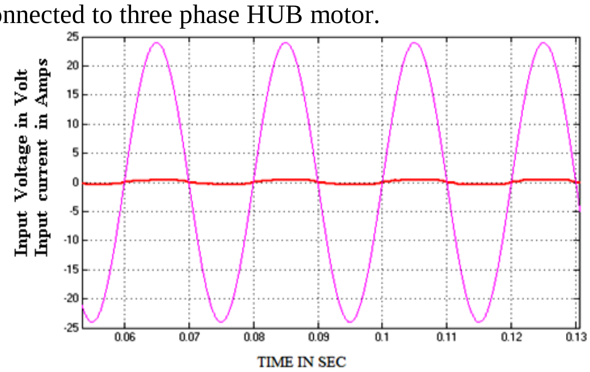

Fig.5 Input waveforms of the Bridgeless CUK converter

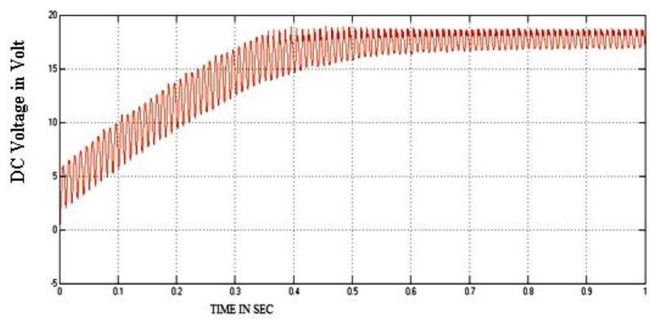

Fig.6 Output voltage for bridgeless CUK

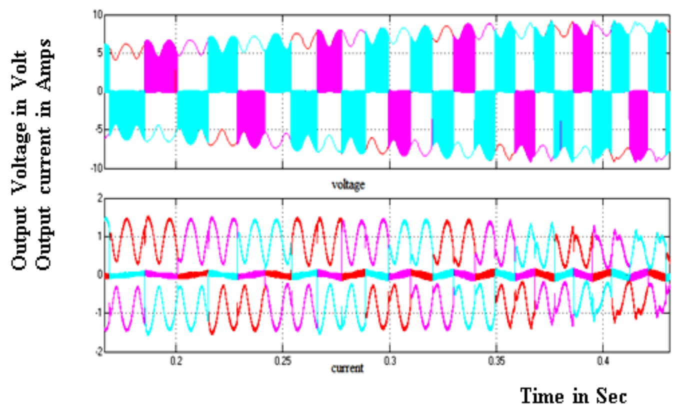

Fig.7 Output voltage and current waveform

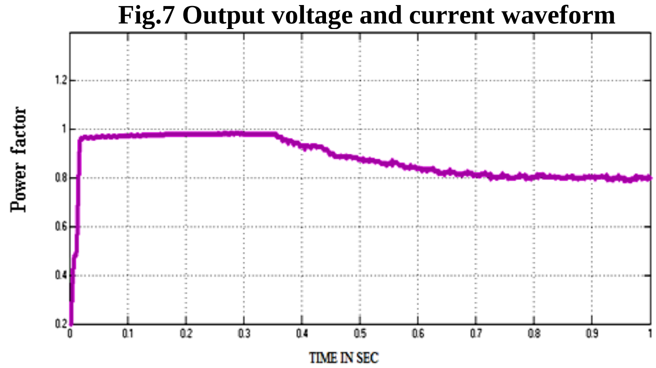

Fig.8 Power factor of bridgeless CUK converter

A) SEPIC fed HUB motor

SEPIC converter input ac voltage waveform is shown in fig.10.simulation of SEPIC converter input voltage is set 24VAC.From the circuit is current is low level in the input side. Simulation of SEPIC converter output voltage is shown in fig .11 this voltage is measured converter across the capacitor. Bridgeless SEPIC converter using simulation output voltage and current waveform shown in fig.12. This Output voltage and current has converted from six pulse inverter. Bridgeless SEPIC converter performance for measured power factor is pf=0.9 is shown in fig.13

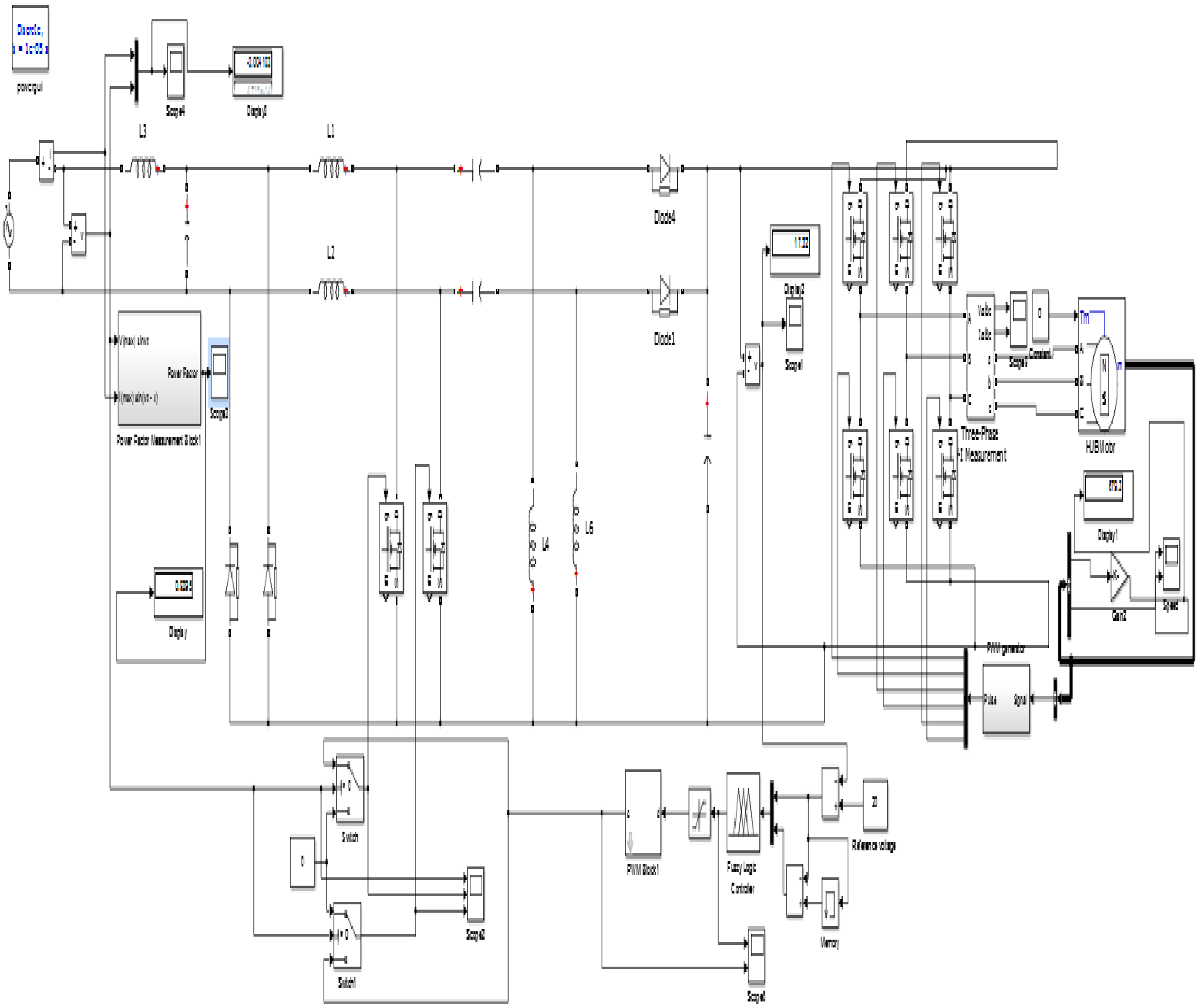

Fig.9.Simulation diagram for SEPIC converter fed HUB motor

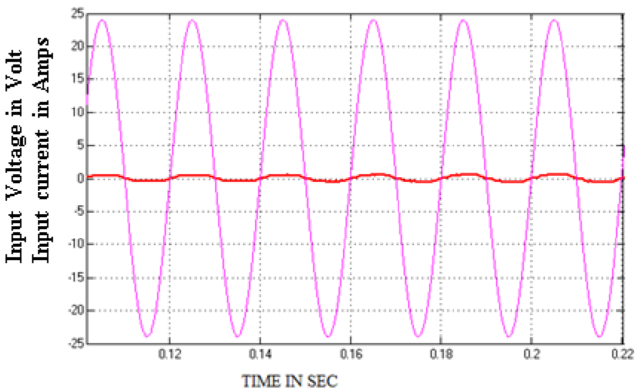

Fig.10 Input waveform for bridgeless SEPIC

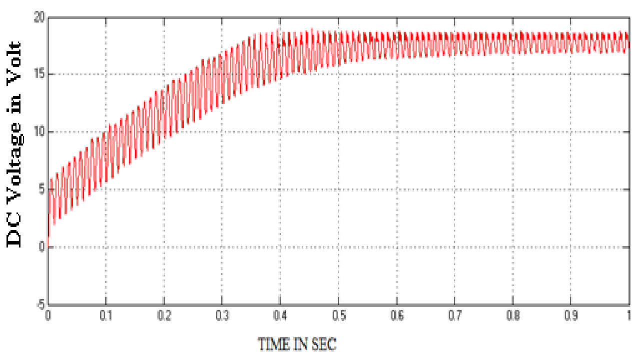

Fig.11Output voltage for bridgeless SEPIC

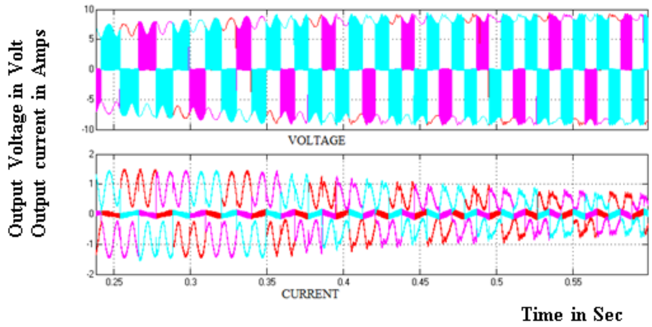

Fig12. Output voltage and current waveform

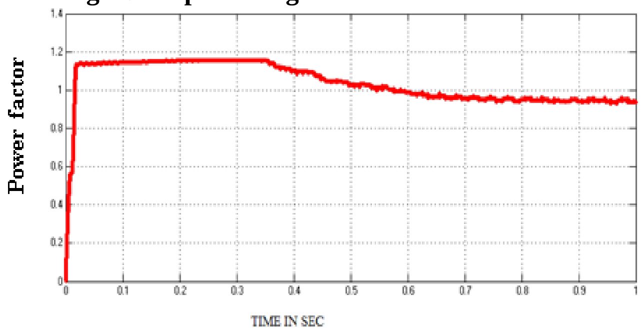

Fig.13 power factor for SEPIC converter

B) Comparison Results for CUK and SEPIC

The performance comparison of the CUK and SEPIC converter is made in table.1. The comparison is made with the performance parameter such as input voltage, power factor, Motor RPM, converter output voltage. The SEPIC based Motor converter provides the better power factor compared to the CUK converter.

Table 1 Performance comparison of CUK and SEPIC

Parameter	CUK Converter	SEPIC Converter
Input Voltage	24VAC	24VAC
Reference Voltage	20VDC	20VDC
Powerfactor	0.8	0.939
Motor RPM	678.7	679.9
Converter Output	17.28VDC	17.32VDC

C) Hardware Result

The 230V AC power is converted to 20 VDC supply using the bridgeless PFC SEPIC converter. The SEPIC converter output DC voltage is fed to the inverter. The inverter is used to convert DC voltage to three phase AC voltage. The AC supply is fed to HUB motor. The PWM signal for the SEPIC converter is produced based on the input voltage and current of the SEPIC converter. At the same manner PWM signals for the inverter is made by SEPIC output voltage sensing. The PWM signals are generated from ANFIS controller is fed to converter through gate driver. The developed hardware photo copy is shown in fig.15.

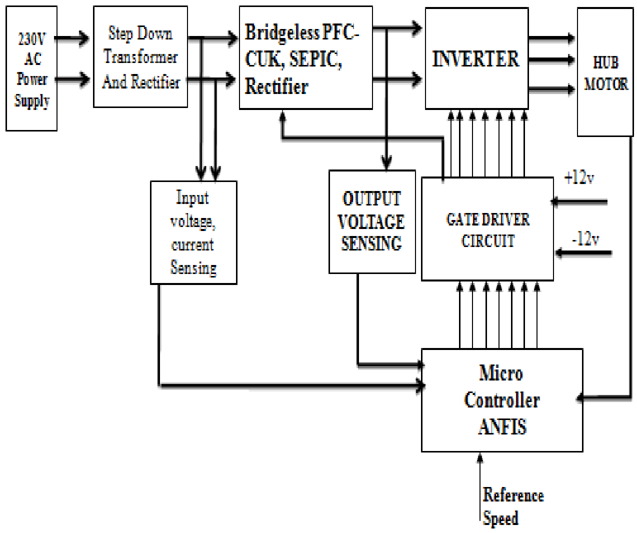

Fig14. Block diagram for power factor correction in CUK and SEPIC converter

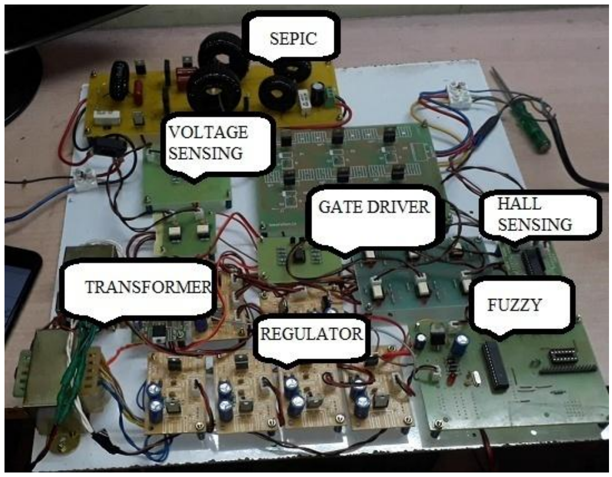

Fig.15 Hardware diagram for SEPIC

After inverting voltage for SEPIC converter output voltage is shown in fig.16 the output voltage is controlled by the controller. Voltage and current are in phase shown in fig.17.Input reference voltage is given the controller output has same voltage are coming the hardware results.

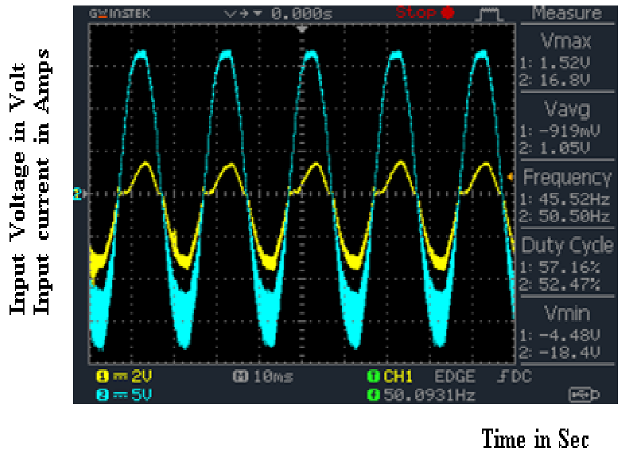

Fig16.Output voltage for SEPIC converter

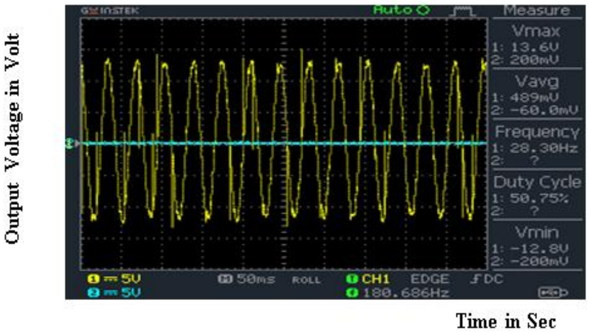

Fig.17. Input voltage and current waveform

IV. CONCLUSION

The Bridgeless SEPIC and CUK based Converter fed HUB motor is presented. The simulation results bridgeless CUK and SEPIC converter for HUB motor is presented. The performance parameters are compared for both the converter out of that SEPIC fed HUB motor provides better power factor that is 0.939 which is nearly unity power factor. The other parameters are such as motor RPM, Motor output voltage are remains same in both the converter. The prototype model of SEPIC fed HUB motor is developed for validate the simulated result.

REFERENCES

1. De Pelecijn, Elly, and Michiel SJ Steyaert. "A Fully IntegrateSwitched-Capacitor-Based AC-DC Converter for a 120 VRMS Mains Interface." IEEE Journal of Solid-State Circuits (2019).
2. Stern, Léo, Othman LADHARI, Jean-Paul Ferrieux, David Frey, and Pierre-Olivier Jeannin. "Direct conversion switched-mode AC/DC converter." U.S. Patent 10,250,158, issued April 2, 2019.
3. R.D Middle brook and Slobodan CUK, "A general unified approach to modeling switching converter powerstages",IEEE Power Electronics Specialists Conference,June8-10 1976
4. Kim, Sooa, Bong-Hwan Kwon, and Minsung Kim. "Highly-Efficient Bridgeless Dual-Mode Resonant Single Power-Conversion AC-DC Converter." IEEE Transactions on Power Electronics (2019).
5. Davidson, Christopher Donovan. "Single stage isolated AC/DC power factor corrected converter." U.S. Patent 10,263,508, issued April 16, 2019.
6. M. Mahdavi h. farzaneh-fard," Bridgeless CUK power factor correction rectifier with reduced conduction losses," IET Power Electron., 2012, Vol. 5, Iss. 9, pp. 1733–1740.
7. Sivachidambaranathan.V & S.S.Dash (2010), "Simulation of Half Bridge Series Resonant PFC DC to DC Converter", IEEE International Conference on "Recent Advances in Space Technology Services & Climate Change – 2010" (RSTS&CC-2010), Sathyabama University in association with Indian Space Research Organization (ISRO), Bangalore and IEEE, ISBN 978-1-4244-9184-1, November 13-15, IEEE Explore pp 146-148.
8. Geetha.V and Sivachidambaranathan.V (2018), "A single switch parallel Quasi resonant converter topology for induction heating application", International Journal of Power Electronics and Drive System (IJPEDS) (ISSN 2088-8694) – Vol. 9, No. 4, December 2018, pp. 1718 - 1724.
9. Babu, A. Ramesh, and T. A. Raghavendiran. "Analysis of non-isolated two phase interleaved high voltage gain boost converter for PV application." In Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014 International Conference on, pp. 491-496. IEEE, 2014.
10. Babu, A. Ramesh, and T. A. Raghavendiran. "Performance analysis of novel three phase High step-up dc-dc interleaved boost converter using coupled inductor." In Circuit, Power and Computing Technologies (ICCPCT), 2015 International Conference on, pp. 1-8. IEEE, 2015.
11. K. Selvamuthukumar, M. Satheeswaran and A. Ramesh Babu," Single phase thirteen level inverter with reduced number of switches using different modulation techniques" ARPN Journal of Engineering and Applied Sciences, Vol. 10, No 22, ISSN 1819-6608,pp 10455-10462, Dec. 2015.
12. Saravanan, M., and A. Ramesh Babu. "High Power Density Multi-Mosfet-Based Series Resonant Inverter for Induction Heating Applications." International Journal of Power Electronics and Drive Systems (IJPEDS) ISSN: 2088-8694, Vol. 7, No. 1 pp. 107-113, March 2016.
13. Babu, A. Ramesh, and T. A. Raghavendiran. "High voltage gain multiphase interleaved DC-DC converter for DC micro grid application using intelligent control." Computers & Electrical Engineering, ISSN: 0045-7906, Vol.74, pp.451-465, March 2019.

AUTHORS PROFILE

A.RameshBabu born in Virudhunagar District, Tamilnadu State, India in 1980, received B.E. degree in Electrical and Electronics Engineering from the Manonmaniam Sundaranar University and the M.E. degree in Power Electronics and Industrial Drives and Ph. D. from the Sathyabama University, Chennai, India in 2001, 2008 and 2018 respectively. He is life member of Indian Society for Technical Education (ISTE). He is a reviewer of various Scopus and SCI Journals. He has organized several conferences, Seminars, Workshops and Faculty development programs.

V,Geetha has received her B.E degree in Electrical and Electronics Engineering from Anna university, Tamilnadu, India in 2005 and M.E degree in Power electronics and industrial drives from Sathyabama institute of science and technology, Tamilnadu, India in 2008. She is pursuing her Ph. D under the faculty of Electrical and Electronics Engineering at Sathyabama Institute of Science and Technology from 2015. Her research interest includes Fuzzy logic controller, Artificial Neural network and Power Electronic Converters for induction heating application**.**

Dr,V.Sivachidambaranathan has received his M.E.,Power Electronics and Industrial Drives from Sathyabama Institute of Science and Technology, Chennai in 2005 and obtained his Ph.D. degree in the Faculty of Electrical Engineering from Sathyabama institute of science and technology Chennai in the year 2013. He is currently working as Associate Prof. and Head of the Department of Electrical and Electronics Engineering, Head - Internal Exam Cell, at Sathyabama Institute of Science and Technology, Chennai. His research interest includes power converter, drives and control and renewable energy sources.

D.N.S Ravi Kumar has completed his M.Sc.(Applied Electronics) in the year 2003 from Bharathiyar University Coimbatore ,India and M.E ((Applied Electronics) in the year 2006 from Sathyabama Institute of Science & Technology Chennai India.He is pursing PhD in the field of Vehicular Communication (Distributed Embedded Systems) from Sathyabama Institute of Science and Technology since 2015,Chennai India.His field of intrests includes Embedded Systems ,Vehicular Communication and Robotics. He is currently working on Smart car Technology (V2V).Apart from research an innovator to spark startup ideas to implementation .which contains their education details, their publications, research work, membership, achievements, with photo that will be maximum 200-400 words.