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Bidirectional Conversion Techinque Using Active Power Filter for Vehicle to Grid (V2g) Applications

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ABSTRACT

The objective of the paper is reactive power compensation to optimize the power demand. Functions: to avoid the damages to generator due to overheating, minimize the loss in transmission, proper functioning of electrical equipment and to ensure reliability by avoiding voltage collapse its is indispensible to concentrate on voltage control in power Methods/statistical analysis: A bidirectional CUK converter is used for bidirectional current flow and to improve the system stability. This project results are shown in simulation using Mat lab software and by hardware. Findings: It is shown that the existing system has the drawback of higher cost and less efficiency. These drawbacks are over come in the proposed system by using the bidirectional CUK converter. Applications/Improvements: Improvement in efficiency and reactive power compensation is achieved and it is connected to the micro grid so that consumer gets benefited.

Keywords: Reactive power compensation, V2G, CUK Converter, micro grid.

1. INTRODUCTION

Oscillation of reactive power will be two times the rated frequency. So VAR generator are provide to avoid the circulation, hence voltage stability is enhanced. If VAR are connected in series are parallel, compensation of reactive power can be achieved [1]. Inorder to prevent this power being distributed to other parts of network compensation should be given close to compensation point [2]. Reactive power compensation enhance the stability of the ac system by maximizing the active power which is to be transmitted. Additionally it maintain a flat voltage profile, it also enhance HVDC (High Voltage Direct Current) conversion terminal performance, increases transmission efficiency, controls steady-state and temporary over voltages [1], In this paper shunt compensation technique is used to compensate reactive power.V2G serves the purpose of giving of extra power to grid while vehicle is idle there by it enhance the energy management [5-7], it also play the role of local compensation of reactive power which in turn improve the power quality [9]. Vehicle to grid concept plays an important role when there is a power demand [4]. This technique is introduced in micro-grid, which can be considered as a sub-station operated individually even when there is no connection among grid and main power station. Micro-grid can serve the electricity need for home appliances and for domestic purpose in a small location [10-11]. It is a more flexible and efficient as it encompass mixed micro power sources. Micro grid are typically used for energy storage system such as renewable energy sources like solar, wind, hydro, cogeneration technique in industrial area and one of the vehicle to grid applications[4]. The need of micro grid for the applications is to reduce transmission losses and as far as critical load it to yield reliable and quality supply.

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2. CONCEPT OF V2G

3. EXISTING SYSTEM

In existing system for conversion technique bidirectional uses switched mode power supply Buck-Boast converter to step up and step down the magnitude of voltage depending upon need. We can achieve wide range of input voltage by combining the buck boast common component to the control unit.

3.1. Existing System Block Diagram

The fig. 2 shows the outline of V2G it totally consist of 3 mode of operation which include compensation of reactive power mode, charging mode and grid connected mode.

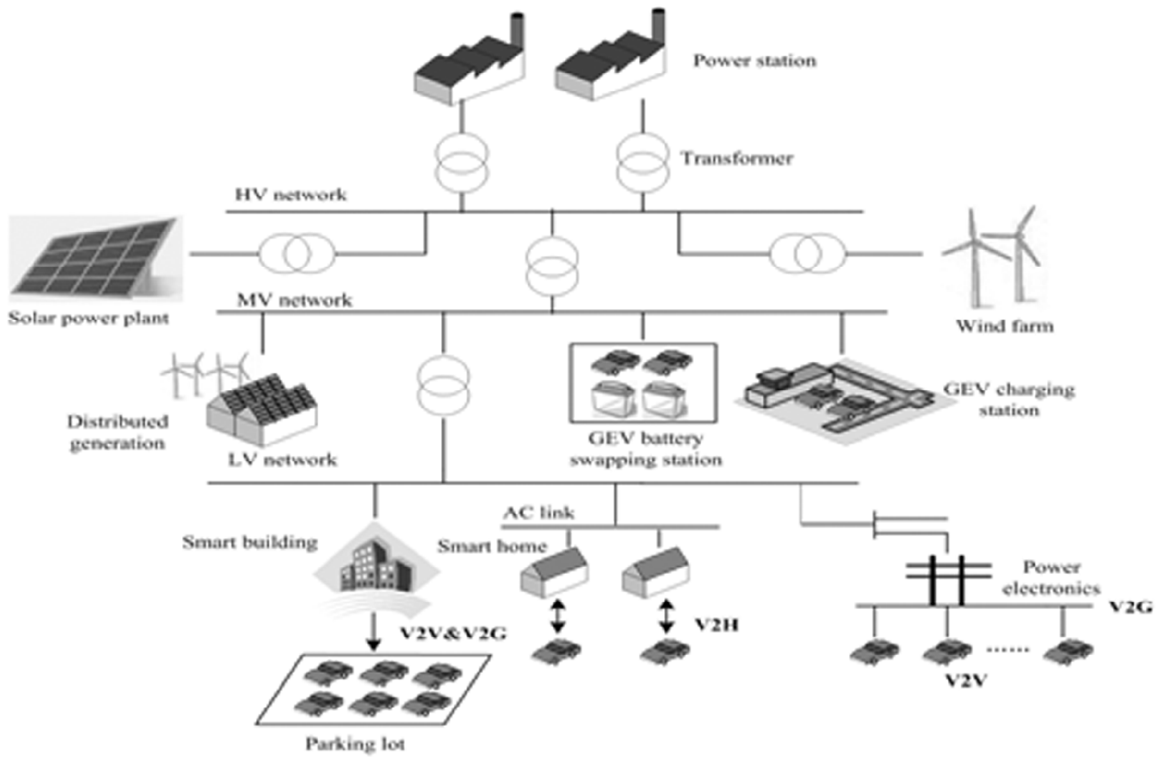

Figure 1: Framework of V2G

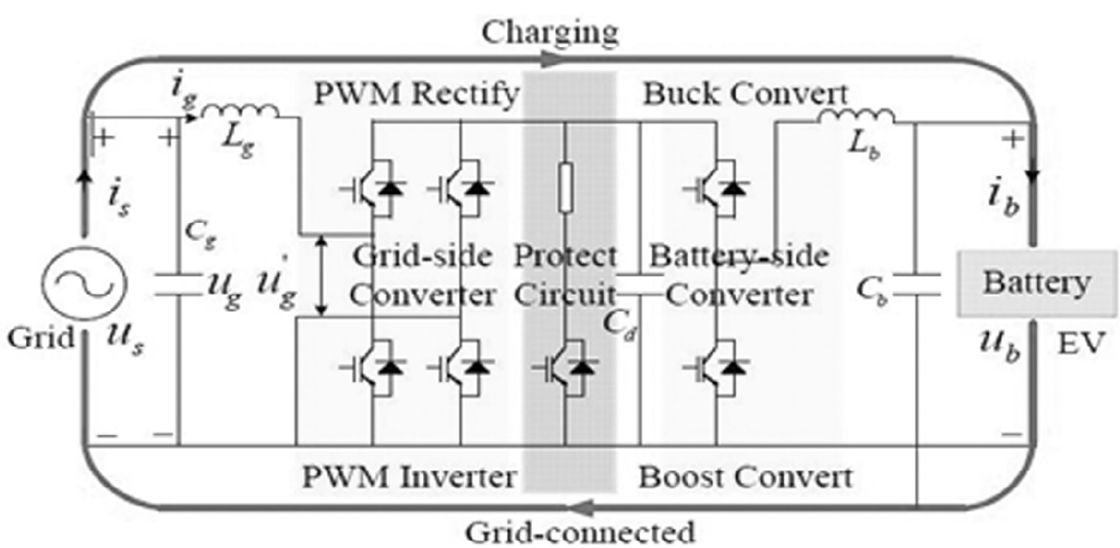

Figure 2: Block Diagram

Table 1
Mode of Operation

S. No	*Mode of operation*	*converter*	*role*
1	Charging mode	Battery side Grid side	Buck converter PWM rectifier
2	Grid connected mode	Battery side Grid side	Boost converter PWM inverter
3	Compensation of reactive power mode	Battery side Grid side	Boost converter. Reactive power compensator

4. PROPOSED SYSTEM

In proposed system CUK converter is used. CUK converter gives continuous input and output current. Energy is transferred when the switch is open and closed. Since the CUK converter uses LC filter the peak-peak ripple current of inductor are less. Main source of energy in this project is car battery and it is implemented when the cars are idle in the parking area.

These batteries are used as a storage unit and it is connected to the grid. Micro-grid as well as CUK converter. It is necessary to enhance the AC system performance by managing the efficiently the reactive power compensation. Active and reactive power transfer are control byPR controller between battery and Design formulae for CUK converter is given below.

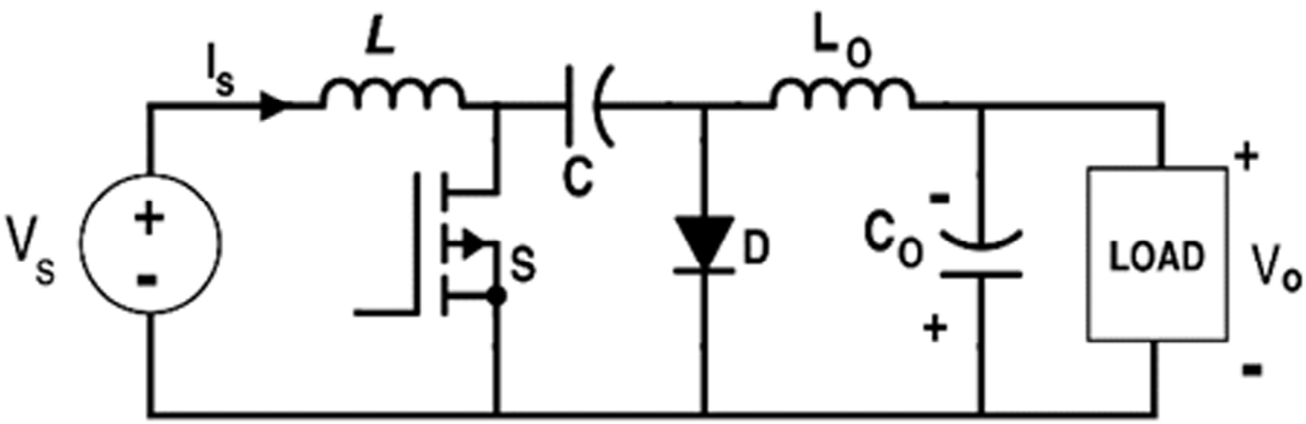

Figure 3: Conventional Cuk Converter

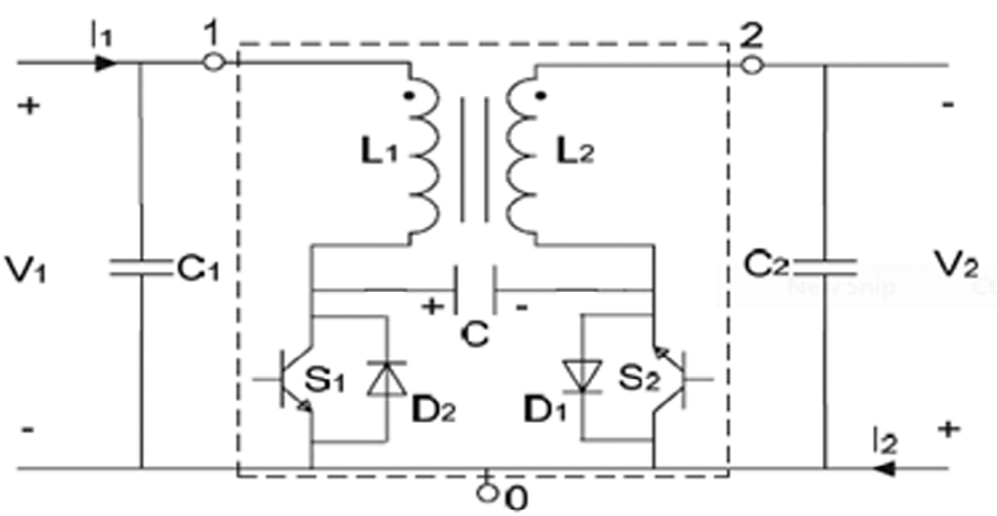

Figure 4: Bidirectional Cuk Converter

$$L_2 = \frac{V_S}{\Delta i_{L2(p-p)}} DT_S$$

$$C_2 = \frac{V_S}{8\Delta V_{C2(p-p)} L_2} DT_S^2$$

$$L_1 = \frac{V_S}{\Delta i_{L1(p-p)}} DT_S$$

$$C_1 = \frac{V_S}{8\Delta V_{C1(p-p)} L_1} DT_S^2$$

$$C = \frac{I_S(1-D)}{\Delta V_{C(p-p)}} T_S$$

$\Delta V_{C2(p-p)}$-peak to peak ripple voltage across capacitor C_2

$\Delta V_{C(p-p)}$-peak to peak ripple voltage across capacitor C

V_s-input voltage

$\Delta i_{L2(p-p)}$-the peak to peak ripple currents through inductor L_2

I_s-input current

$\Delta i_{L1(p-p)}$-the peak to peak ripple currents through inductor L_1

The CUK converter can replace two inductors with a coupled inductor. As this is two inductors wound in a single core, characteristically either one of the currents at the input and output is able to have zero ripple. Though this improves the input and output characteristics, this converter suffer from shortcoming such that step down and step down efficiency is low, input and output polarity is reversed.

5. TOPOLOGY VARIATION

The dotted box in Fig. 5 represents the switching cell that has 3ports to get various topologies by external connections to the bi-directional CUK converter in Fig. 4 Fig. 5(a) represents that the switch S2 of the converter turns off but S1 turns on, and in Fig. IV.A.1(b) represents that the switch S1 of the converter turns off but S2 turns on.

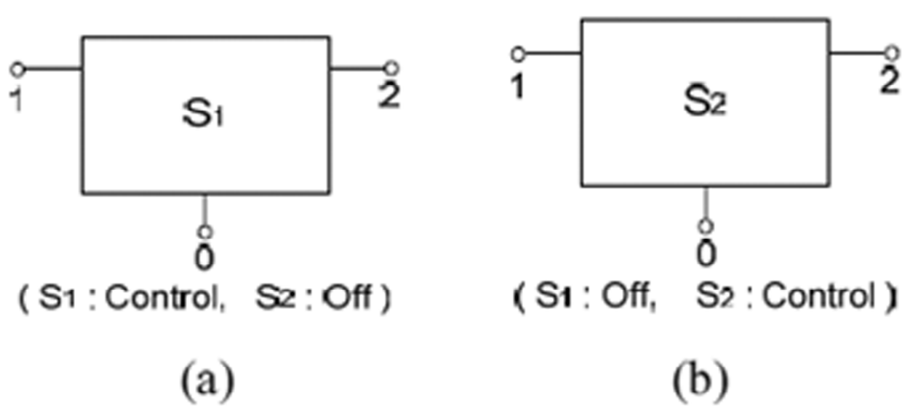

Figure 5: Switching Cell

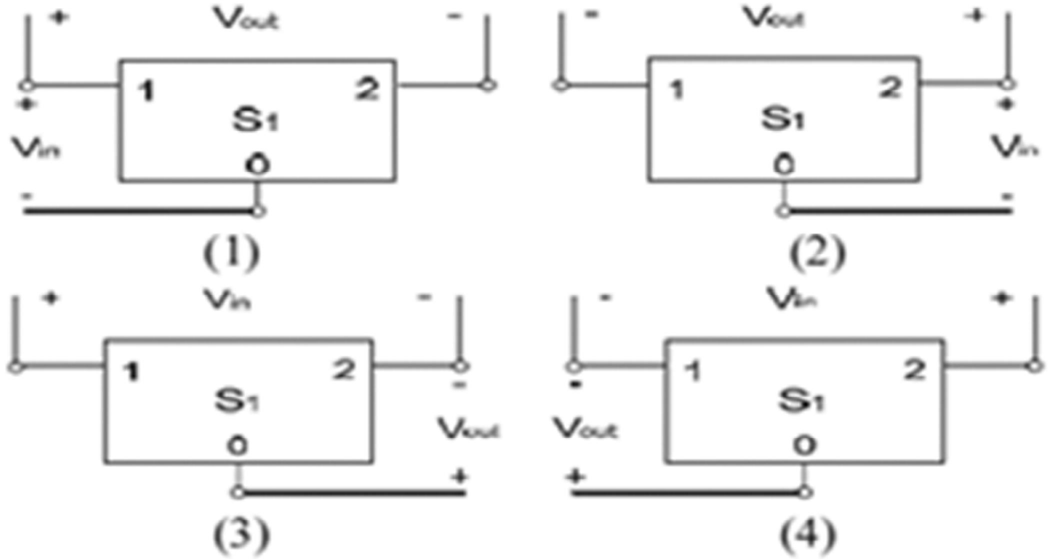

Figure 6: Topology by Switch 1

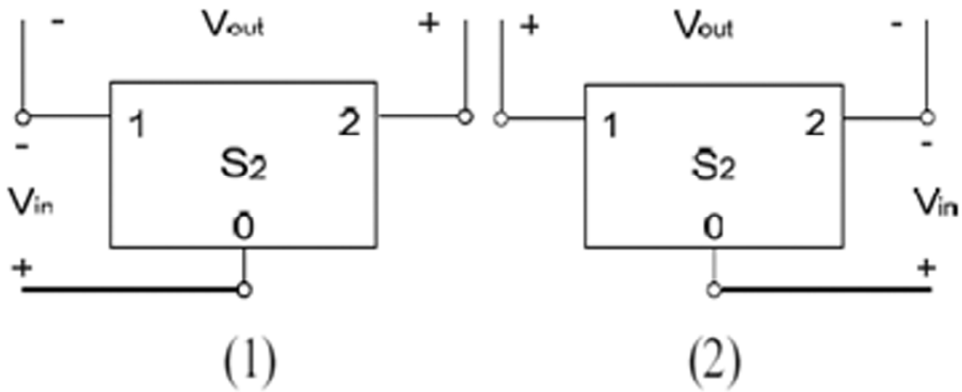

Figure 7: Topology by Switch 2

On the basis of the CUK switching cell controlled by the main switch (S1), Fig. 6 is the 2 step-up ((1) and (2)) and step-down ((3) and (4)) topology derived by executing the topology variation considering the property of capacitor (C) for energy transfer.

On the basis of CUK Switching cell controlled by the reverse switch (S2). The topology having the common ground at both input and output terminals among six topologies and reducing the energy loss during power conversion by executing the load power control with partially required energy and increasing the efficiency without adding the parts to the conventional DC/DC converter is the topology shown in Fig. 7(2) during the step-up mode and the topology shown in Fig. 6(3) during the Step-down mode.

6. BLOCK DIAGRAM

7. DESCRIPTION

The power generated at the power system is in KV and it is step downed in several stages before distributed among the consumer. When we consider the example of malls and industries if the load is linear, the condition will be in resonance and we will get the output what was provided as an input, else if the load is non-linear, then the resonance condition will not occur. In order to attain the resonance condition the reactive power compensation is essential. Here the current and potential transformers are used to sense the high current and voltage at the generating station. Then the sensed current and voltage parameters are fed

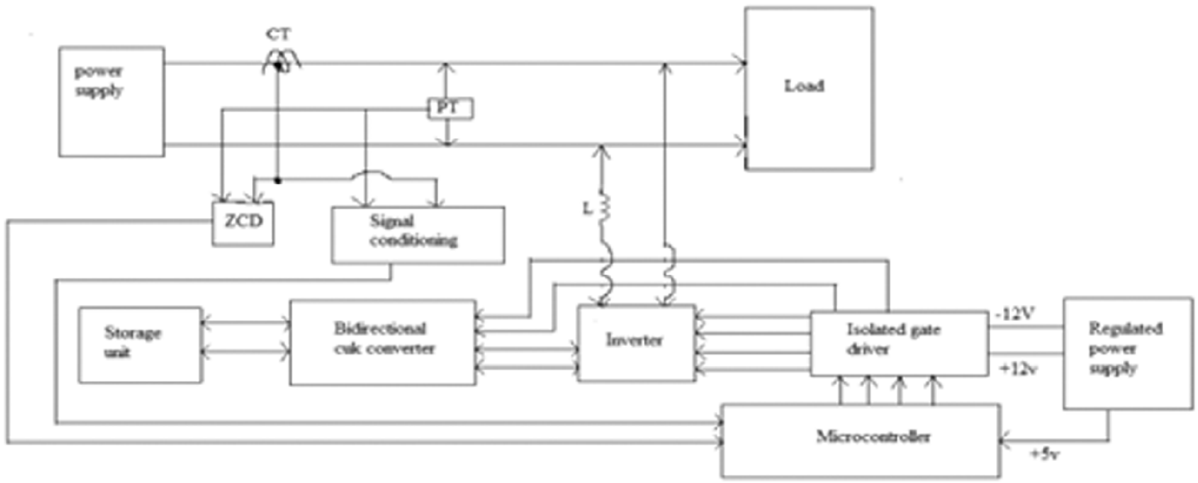

Figure 8: Hardware Block Diagram

into the zero cross detector which detects where the current and voltage are in in-phase are not. Simultaneously the signal conditioning converts the analog signal into digital signals which is acceptable by the microcontroller. The maximum input to the microcontroller is 5v hence the signal conditioning converts the analog signal to digital equals to the quantity of analog signal. The regulated power supply is provided to supply power to microcontroller and isolated gate driver.

The microcontroller gives the sufficient signal for the attainment of resonance condition to the isolated gate driver and bidirectional CUK converter, so that switches are triggered. Low power input are amplified to high current input for triggering. The MOSFET gate drives on to coupler which reduces the consumption of power by providing smaller. Thus the MOSFET produces the high current and that will be given to the battery from which voltage is extracted and that will be given to the CUK converter to boost it. Once the voltage is boosted then it is forwarded to the inverter, for converting the voltage into AC signal and then fed to the micro-grid where the reactive power compensation is achieved. Power will be extracted from grid when maximum power flow is detected. The AC supply is converted into DC and it is stepped down using CUK converter and then stored in the battery**.**

8. CONTROL SCHEME

8.1. For Grid Side Inverter

The improved V-I double-loop control scheme is employed in the grid-side converter control.

During charging mode Steady state error in grid current is stopped by PR controller. Tracking error is reduced by voltage feed forward, thus it improves the dynamic performance.

During grid connected mode zero steady state error is achieved by PR controller in steady frame, more reliably than PI controller, gain of PR controller is given as.

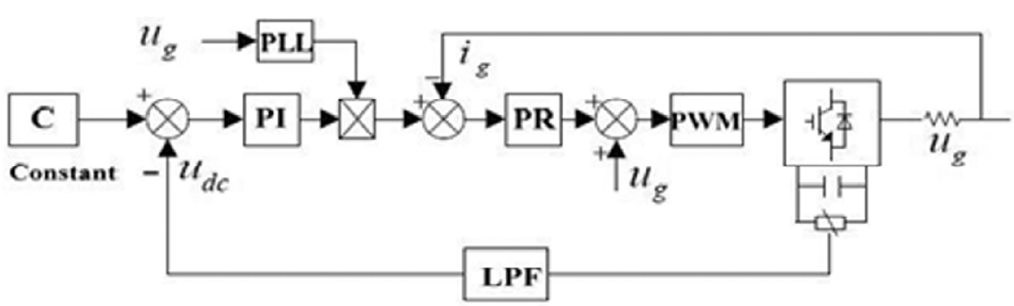

Figure 9: Improved Bidirectional Control Approach For Inverter Of Grid Side

$$G_c(s) = K_p + K_i * \frac{2\omega_c S}{S^2 + 2\omega_0 s + \omega_0^{\ 2}}$$

Where,

K_p – proportional constant
ω_c – cut off frequency
ω_o – resonant frequency
K_i – integral constant

large gain in selected frequency archives zero steady state by PR control, Dc link voltage oscillation are expelled by LPF (Low pass filter).

8.2. Control Approach For The Compensation of Reactive Power

Infinite gridis considered, in which current and voltage are

E_a – grid side voltage
I_a – grid side current
E_i – voltage of converter
I_i – current of converter
E_z – load side voltage
I_z – load side current

$I_a = I_i + I_z$ and

$E_a = E_i = E_z$

Reactive power compensation is done by the converter in grid side and converter near battery act as boast converter Fig. 11 display theoretical circuit and phaser diagram of inductive load connected EV system

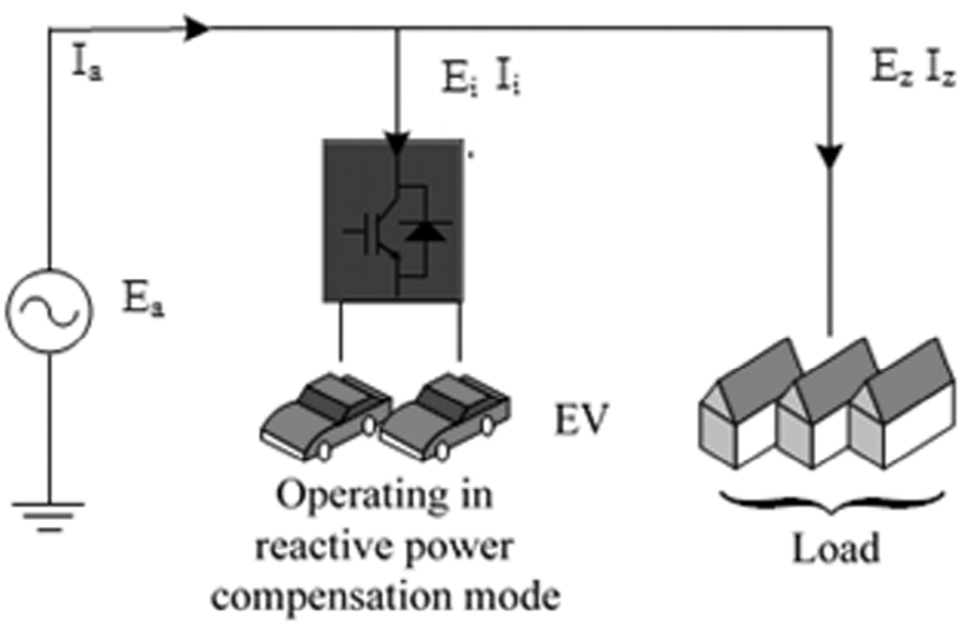

Figure 10: Basic Domestic Single Phase Supply System

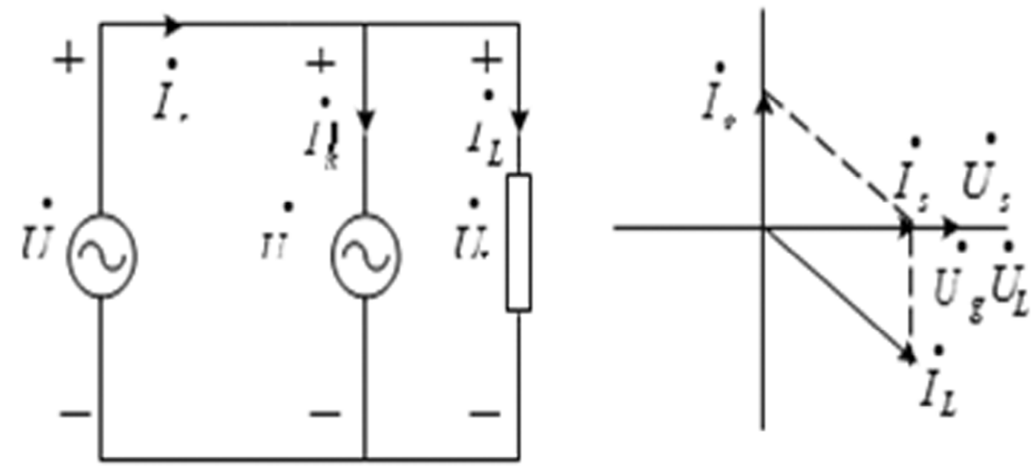

Figure 11: Theoritical Circuit and Phaser Diagram of Inductive Load Connected EV System

9. COMPARSION OF EXSISTING BUCK BOOST CONVERTER AND PROPOSED CUK CONVERTER

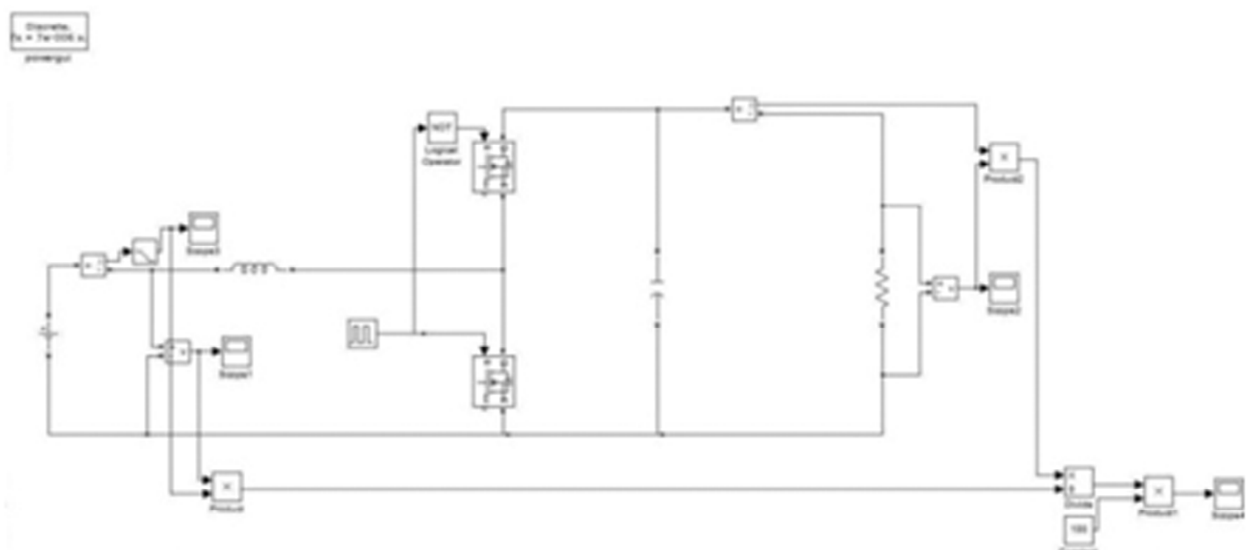

Figure 12: Buck Boost Converter

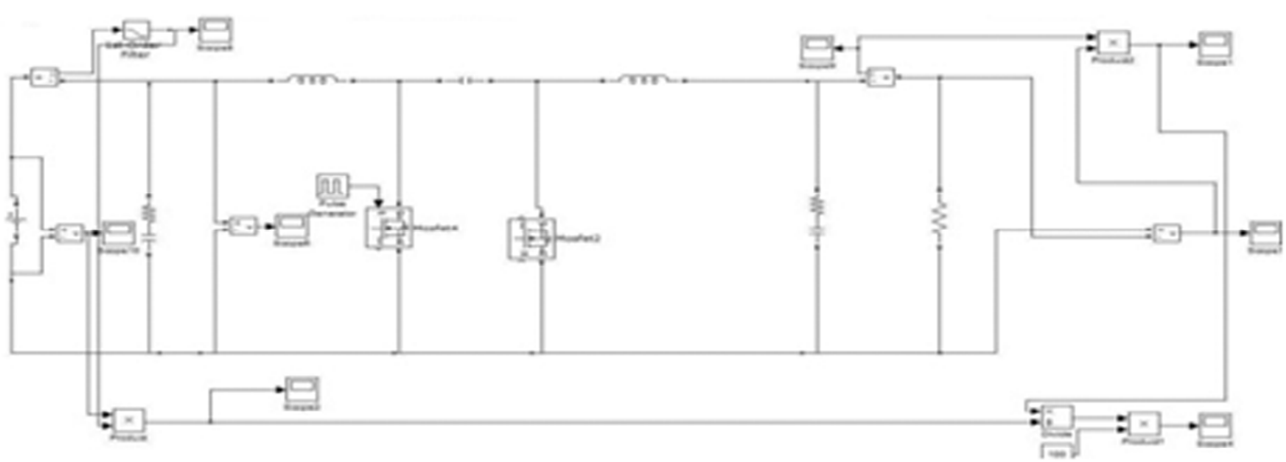

Figure 13: Cuk Converter

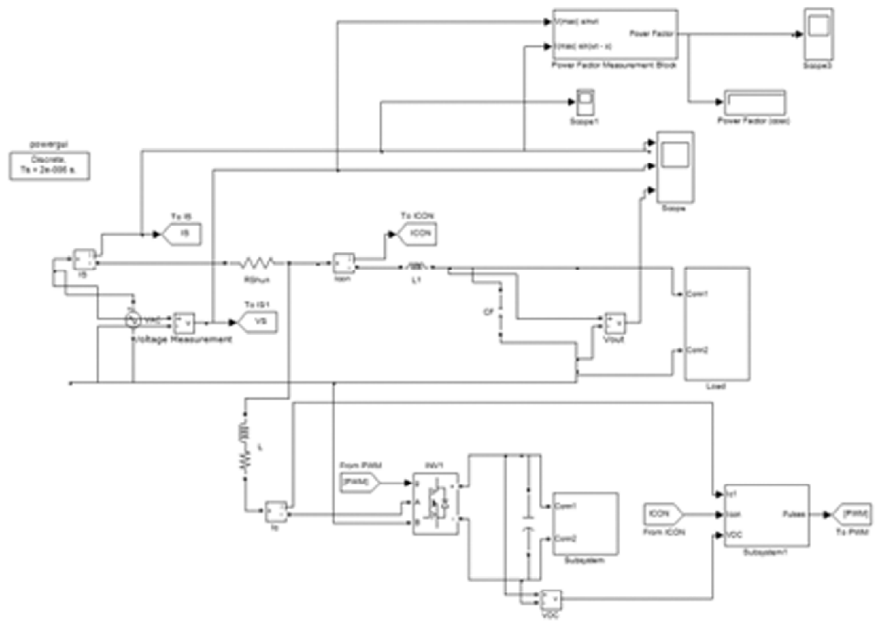

Figure 14: Final Simulation

10. SIMULATION RESULTS

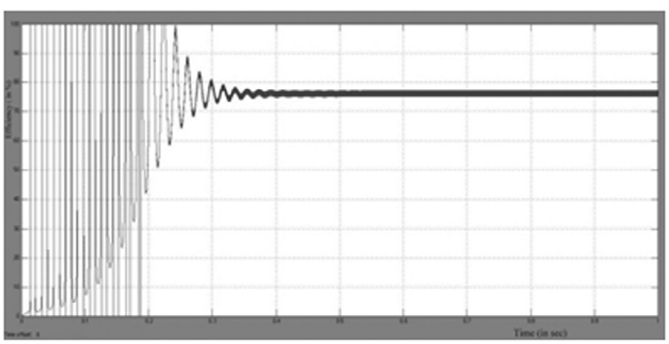

Figure 15: Efficiency Of Buck Boost Converter

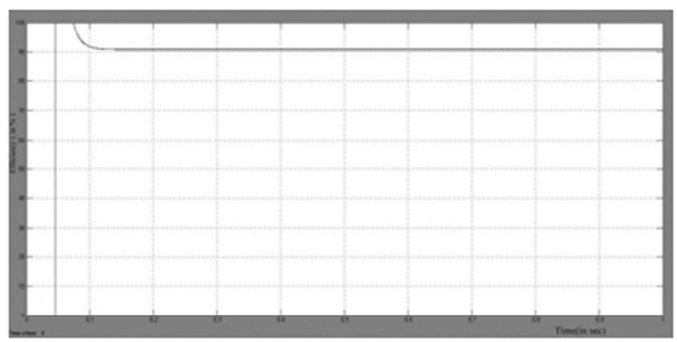

Figure 16: Efficiency Of Cuk Converter

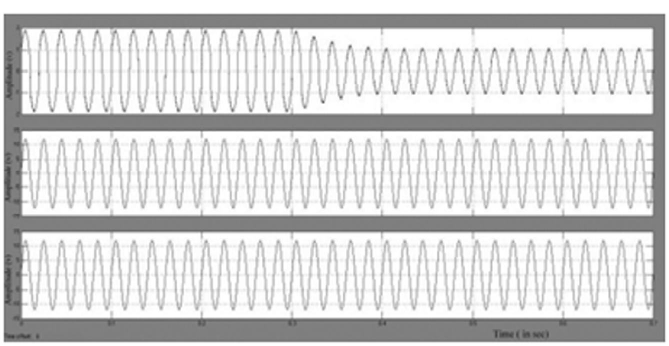

Figure 17: Reactive Power Compensation

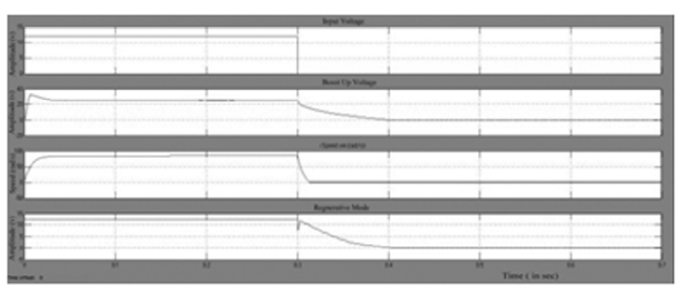

Figure 18: Input and Output Waveforms

11. CONCLUSION

From the simulated result we can clearly infer that cuk converter based vehicle to grid provide a reliable bi directional topology for compensating the reactive power in addition to that result proves that the design is more reliable for multi function operation alone with reactive power compensation bi-directional transformation in V2G.

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