**IJCTA,** 9(36), 2016, pp. 01-18


# Power Factor Correction Using Type 1 Bridgeless Luo Converter with Optimal Genetic Algorithm in BLDC Motor

**V. Viji* and S. Arumugam****

***Abstract :*** In the recent times, the brushless dc (BLDC) motor drives have gained a significant progress in this modern world for different applications. For the purpose of improving for use in several helpful applications, in the existing system is proposed abridge less Luo (BL-Luo) converter-fed BLDC motor drive for the generation of the unity power factor. The already available topology comprises of filter, BL-Luo converter and Voltage Source Inverter (VSI) that offers only average performance. It considered the reference voltage and the speed control of the BLDC motor is performed by using single voltage sensor. It allows for lower frequency switching of the voltage source inverter for the BLDC motor electronic commutation. Nonetheless the available system has problems with inrush current, DC-link voltage and lesser degradation in the performance of power factor. With the aim of avoiding the above mentioned issues, in the proposed research, Type 1 Bridgeless-Luo converter with genetic algorithm is proposed. The proposed topology contains LC filter, Type I BL Luo and speed to be the reference parameter. The converter proposed is developed for operating in discontinuous inductor current conduction mode and electronic commutation with VSI operation is exploited for reducing the switching losses and for solving the dc link voltage issues. The speed PI converter with genetic algorithm is targeted over the improvement in the unity power factor from the BLDC motor. The type 1 Bridgeless-Luo converter in discontinuous inductor current mode is introduced for getting a leser inrush current and reduction in switching stress. The simulation results indicates that the novel drive has efficient performance making use of Type 1Bridgeless-Luo converter along with genetic algorithm. It attains an optimized power quality, speed parameter, and lesser inrush current, lesser switching loss at the ac mains considerably.

***Keywords:*** Type 1 bridgeless Luo (BL-Luo) converter, brushless dc (BLDC) motor, Genetic algorithm, Power factor correction, unity power factor.

## 1. INTRODUCTION

BLDC motors are widely used and are substituting for brush motors in several applications. Since the BLDC motor does not need commutator and owing to its great electrical and mechanical characteristics and its capacity to work in hostile conditions it is more trustworthy compared to the DC motor. The BLDC motor drive system comprises of a dc power supply switched to the stator phase windings of the motor by means of an inverter by power switching devices. The rotor position detection will decide regarding the switching sequence of the inverter. Three-phase inverters are usually employed for controlling these motors, needing a rotor position sensor for starting and then for rendering the suitable commutation sequence to the stator windings. These position sensors could be Hall sensors, resolvers, or absolute position sensors. Nevertheless, the Hall sensors will have a loss in its sensing capacity at the temperature above 125 °C. Hence the Hall sensors are not applicable in conditions of high temperature.

* Research Scholar, Department of EEE, St. Peters University, Chennai, Tamilnadu.
** Principal, GRTIET, Tirutani, Thiruvallur, Tamilnadu

The disadvantages of sensored motor control system are the raised expense and bulkiness of the motor, and require specialized mechanical arrangement for the mounting of the sensors. Another significant issue is with regard to the traditional controllers which are extensively employed in the industry owing to its simple control structure and convenience during implementation. But these controllers also suffer from hardships under the conditions of nonlinearity, load disturbances and parametric variations. Conventional control systems are on the basis on mathematical models where the control system is defined making use of one or more differential equations which define the system response and its inputs. In several cases, the mathematical model of the control process might not be present, or may be too costly with respect to computer processing power and memory, and a system dependent on empirical rules might be more efficient. Therefore a smart controller is necessary.

The BLDC motor offers a remarkable candidate for sensor less operation since the characteristic of its excitation intrinsically provides a low-expense means for extracting the rotor position information from motor terminal voltages. A Permanent Magnet (PM) brushless drive which does not need the position sensors but only electrical measurements is referred to as a sensor less drive [1]. For the case of three-phase BLDC motor at one particular time instant, just two among the three phases are the conducting current and in the no conducting phase the back-EMF is carried. In case the zero crossing of the phase back EMF can be measured, it can be known when the current has to be commutated. Fig.1. illustrates the block diagram of the BLDC motor drive system.

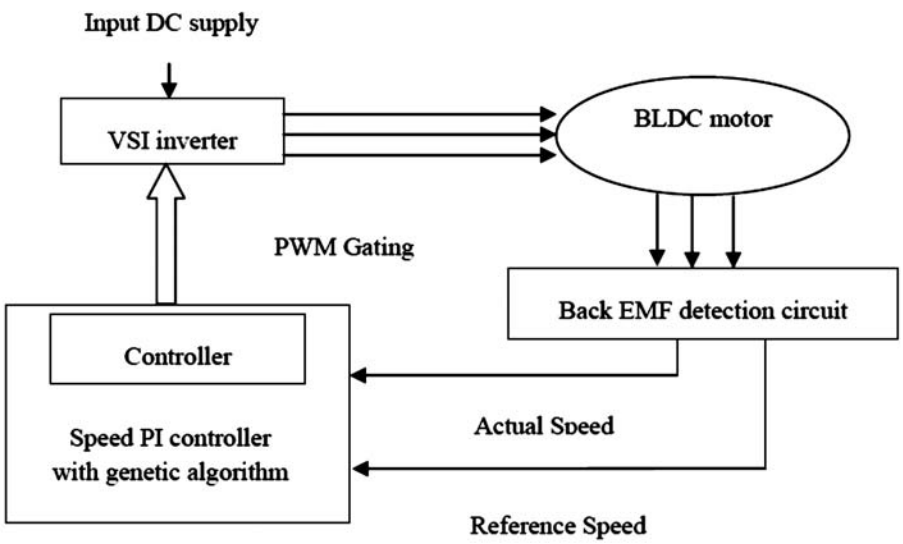



**Figure 1: Block diagram of sensor less control of the BLDC motor drive system**

The important problem in power transformer protection is with regard to avoiding the false tripping of the protective relays because of the misidentification of the magnetizing inrush current. Magnetizing inrush currents might have a greater magnitude that is differentiable from the conventional intrinsic fault currents. In order to avoid the unnecessary trip by magnetizing inrush current, the second harmonic component is generally utilizing for stopping the differential relay in power transformers. Generally, the important sources of harmonics in the inrush currents are (*a*) nonlinearities in the transformer core; (*b*) saturation of current transformers; (*c*) over-excitation of the transformers owing to dynamic over voltage conditions; (*d*) core residual magnetization; (*e*) switching instant [2].

The DC-link yields an additional spinning reserve facility for the wind system that can be utilized for sink or source of active power. A thought about variable dc-link voltage for the speed control of the BLDC motor is explained. In this work, in order to surpass the inrush current problems and changing DC-link voltage problems, Type 1 Bridgeless-Luo Converter in addition to the genetic algorithm is introduced. This work is aimed at reducing the switch losses and boost the unity power factor making use of the proposed technique.

The research work is organized as below: section 2studiesdifferent related works which have been carried out with regard to attaining a better inrush current and power factor correction in addition to the speed control. Section 3 deals with the proposed research scheme which is described in detail. Section 4 provides the results of this research work, got from the simulation environment. At last in section 5, the conclusion of the overall research along with their results.

## 2. RELATED WORK

This section presents the researches conducted by various researchers in the design, control and realization of several voltage and speed control methodologies of BLDC drives. Many researchers have implemented different control techniques for achieving lesser switching losses, inrush current and an enhanced unity power factor.

Chen et al [3] demonstrated the design of high power factor brushless motor drive. For the purpose of boosting the power factor of a BLDC drive, an active power factor controller is used for improving the high input current harmonics generated from the power diodes in addition to the inverters witching. The power factor controller and BLDC drive is then evaluated. The simulation validates the practicability of BLDC motor drive with the APFC controller designed. The results obtained of a BLDC drive in the presence and absence of APFC are compared and it indicated that the former's power factor correction capability is far better. But it suffers from high switching losses and it reduced the efficiency of the system on an overall.

Singh et al [4] illustrated a Cuk dc–dc converter in the form of a single-stage power-factor-correction converter for a permanent magnet(PM) brushless dc motor (PMBLDCM) powered through a diode bridge rectifier from a single-phase ac mains. It regulates the dc link voltage through capacitive energy transfer that leads to non pulsating input and output currents. The speed of PMBLDCM is observed to be in proportion to the dc link voltage and therefore a smooth speed control is noticed when regulating the dc link voltage. The PFC Cuk converter assured a near unity PF in an extensive range of the speed and the input ac voltage. But there are concerns with PQ, absence of speed control and inrush current issues.

Bist et al [5] studied regarding a PFC-based BLDC Motor (BLDCM) drive making use of a canonical switching cell converter. It is electronically commutated for low switching losses in voltage source inverter and CSC converter is utilized for getting the unity power factor and front-end CSC converter operates in discontinuous inductor current mode (DICM). A single sensor for dc-bus voltage sensing is employed for developing this new drive. It introduces the design of a reduced sensor-based BLDC motor drive for the purpose of low-power application. It is applied for achieving unity power factor at ac mains and the speed in performance is boosted. But it has problems due to higher switching losses.

Singh et al [6] discussed about PFC in BL-Luo converter-fed BLDC motor drive. The BLDC motor speed is regulated by a technique involving variable dc-link voltage that lets for a low-frequency switching of the voltage source inverter for electronically commutating the BLDC motor, there by rendering reduction in switching losses. The BL-Luo converter is modeled to be operated in DICM so as to function as an intrinsic power factor pre regulator. The front-end DBR is removed in this condition that again minimizes the conduction losses. It is employed for increasing the power quality though it has problems with inrush current and DC link voltage.

Vishvanath et al [7] studied about PFC in SRM drives making use of bridgeless converters. The SRM, while powered by a DBR having a large value of DC-link capacitor leads to a hugely distorted supply current along with a poor power factor. PFC converter is developed to work in DICM in order to function as an intrinsic power factor corrector. The dc link voltage of the VSI is regulated for having the speed of the BLDC motor adjusted. The BL LUO converter is a blend of two dc-dc converters having one or two semiconductor switches present in the path of the current flow, thus decreasing the current stresses in the active and passive switches. It has problems with medium power level.

## 3. CONVENTIONAL PFC-BASED LDC MOTOR DRIVE

Fig. 2 illustrates the traditional boost-PFC for powering a BLDC motor drive. It operates under Continuous Conduction Mode (CCM), utilized for reducing the switch stress in PFC converter. BLDC motors are fed from single-phase ac mains via a diode bridge rectifier (DBR) along with smoothening DC capacitor and VSI [8]. Then the filter consists of capacitor, inductor or both. Capacitor filters are employed for lower power applications, whereas the inductor filters are utilized for high power applications. It imposes problems due to high switching loss because of larger switching frequency of PWM pulses for VSI. Reference Dc link voltage is provided as input for PFC and DC link voltage control, while the reference speed is provided as input for PW based speed also to current motor. PFC boost converter uses PFC and DC link voltage control and dc-link voltage is again provided to the PFC converter. It makes use of more number of sensors and hence imposes difficulty in control during its operation. Hence the overall system efficiency is affected dominantly.

In order to surpass the issues that are above mentioned, the BL converter is utilized in place of traditional boost converter in this research. In this circuit, DBR is eliminated, that actually is aimed at decreasing the conduction losses effectively [9] [10]. The Luo converter is used for multiple applications due to their original distinctiveness of voltage stimulation. A single-phase supply, which is followed by a filter and a BL-Luo converter is employed for feeding a VSI driving a BLDC motor. It operates at discontinuous inductor current mode. An input filter (L–C filter) is developed in order to prevent the high current ripple reflecting in the supply system. PFC based BL-Luo converter is modeled in order to achieve the power quality at AC mains for an extensive range of speed control. Voltage reference is provided for the closed loop of BL Luo converter. The speed of the BLDC motor is regulated via the dc-link voltage of VSI. The PFC based BL-Luo converter is connected serially and it comprises of the positive and negative half cycles of the supply voltage. In the BL configuration, the conduction loss is minimized by limiting the number of semiconductor components.

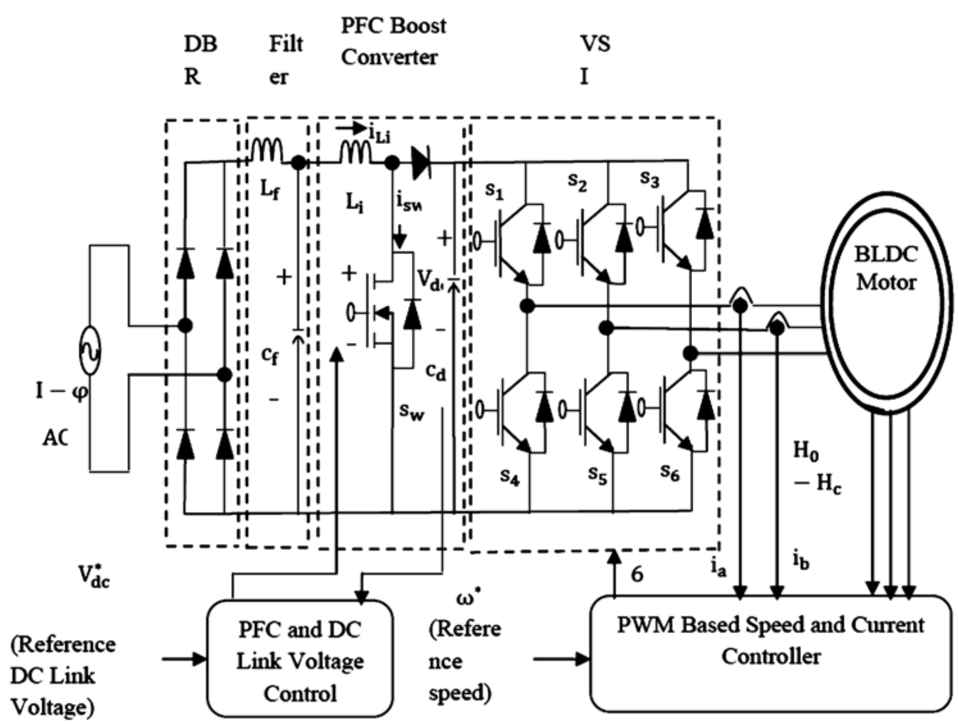



**Figure 2: Conventional PFC-based BLDC motor drives**

The control unit consists of a voltage controller, PWM generator, electronic commutation, saw tooth generator and reference voltage generator in it. Voltage controller and saw tooth generator is provided as input for the PWM generator. The switch Sw1 will be operating at positive half cycles and Sw2 will be operating at the negative half cycles in PFC based BL Luo converter. Diodes conduct during the negative half cycle of supply voltage. The BLDC motor is regulated by means of the PWM method in order to provide the correct commutations. The commutations sequence is maintained in correct order so that the inverter fulfills the functions of the brush and commutator in a classical DC motor, for generating a stator. VSI based BLDC drives the available AC supply which is converted into a pulsating DC by feeding it through a rectifier circuit and then this DC is converted back to the AC supply by employing an inverter. In the VSI method, inter linking capacitor is needed for the smoothening of the pulsating DC. This permits the VSI to function at fundamental frequency switching(i.e., electronic commutation of the BLDC motor) and therefore it yields lesser switching losses that are significantly large in a PWM-based VSI that feeds a BLDC motor.

**Disadvantages of existing system**

- Still it faces challenges with inrush current as the available topology has insufficient controlled power circuits. It results in high current flows and therefore the topology isrequired to be modified further.
- Changing DC link voltage is another important issue in research done.
- There is increase in the stator current ripples and the noise interference occurs in the output wave-forms.
- Optimized strategies are not taken into consideration in the previous researches and therefore it deteriorates the PF performance in some cases
- Greater switching stress is another important issue in the research done earlier.

## 4. PFC BASED TYPE 1 LUO CONVERTER

The important aim of Type I Luo converter is not just controlling the DC link voltage but also making the inverter to be operating at low frequency such that switching losses are reduced. The usage of Type 1 Luo converter boosts the power factor at AC mains and therefore the system expansive is decreased considerably. It is made to operate at low switching frequency, so that the near unity power factor is attained at ac mains. The speed of the BLDC motor is regulated by having a control over the DC link voltage of the boost converter. In addition, low frequency operation of VSI minimizes the switching losses. The Type I Luo converter is made to operate in discontinuous inductor current mode in the research proposed. The control of the boost converter is done by making use of the PWM signals to the converter switch that retains the necessary voltage level across the DC link capacitor. The CSC converter is developed and its parameters are chosen to operate the BLDC motor for getting a high-power factor at an extensive range of speed control.

### 4.1. Operation of Optimized PFC BL-LUO Converter-Fed BLDC Motor Drive

The proposed technique is BL-type 1-Bridgeless-Luo Converter based VSI fed BLDC motor drive. The DBR is removed in this BL- type 1-Bridgeless-Luo Converter; thus minimizing the conduction losses corresponding to it. A DBR, which is followed by a high value of the DC link capacitor powering a VSI based BLDC motor, obtains peaky current from the supply and feeds a huge amount of harmonics into the supply system. The expense of these converters is a significant parameter, determined primarily by the quantity of sensing requirement that is based on the mode of operation of PFC converter. This BL type 1-Bridgeless-Luo converter is developed to be operated in a discontinuous inductor current mode(DICM) so that the currents which flow through inductors Li1 and Li2 are discontinuous, while the voltage across the intermediate capacitors C1 and C2 stays continuous during a switching period. A mechanism of variable dc link voltage for regulating the speed of the BLDC motor is brought into use, and it is then electronically commutated for reducing the switching losses in the VSI.

The novel Type 1-Bridgeless-Luo Converter is aimed at generating a lesser inrush current and lower switching stress employing the genetic algorithm. The Bridgeless-Luo Converter comprises of two semiconductor switches in the path of the current flow and therefore it is utilized for reducing the current stresses over the switches. Circuit efficiency is enhanced compared to the traditional techniques with respect to lower switching losses, inrush current, noise interference and enhanced unity power factor, DC link voltage. The proposed diagram on an overall is illustrated in figure 3 that defines PFC based type 1 bridgeless Luo converter process. The proposed bridgeless converter is developed in such a way that two switches operate during the positive and negative half-cycles of the supply voltage. The working, design, and control of this kind of 1-Bridgeless-Luo converter fed BLDC motor drive are described in the sections to follow. The performance of the newly introduced drive is verified with the test results got on a prototype developed with enhanced power quality at the ac mains for an extensive range of speeds and supply voltages.

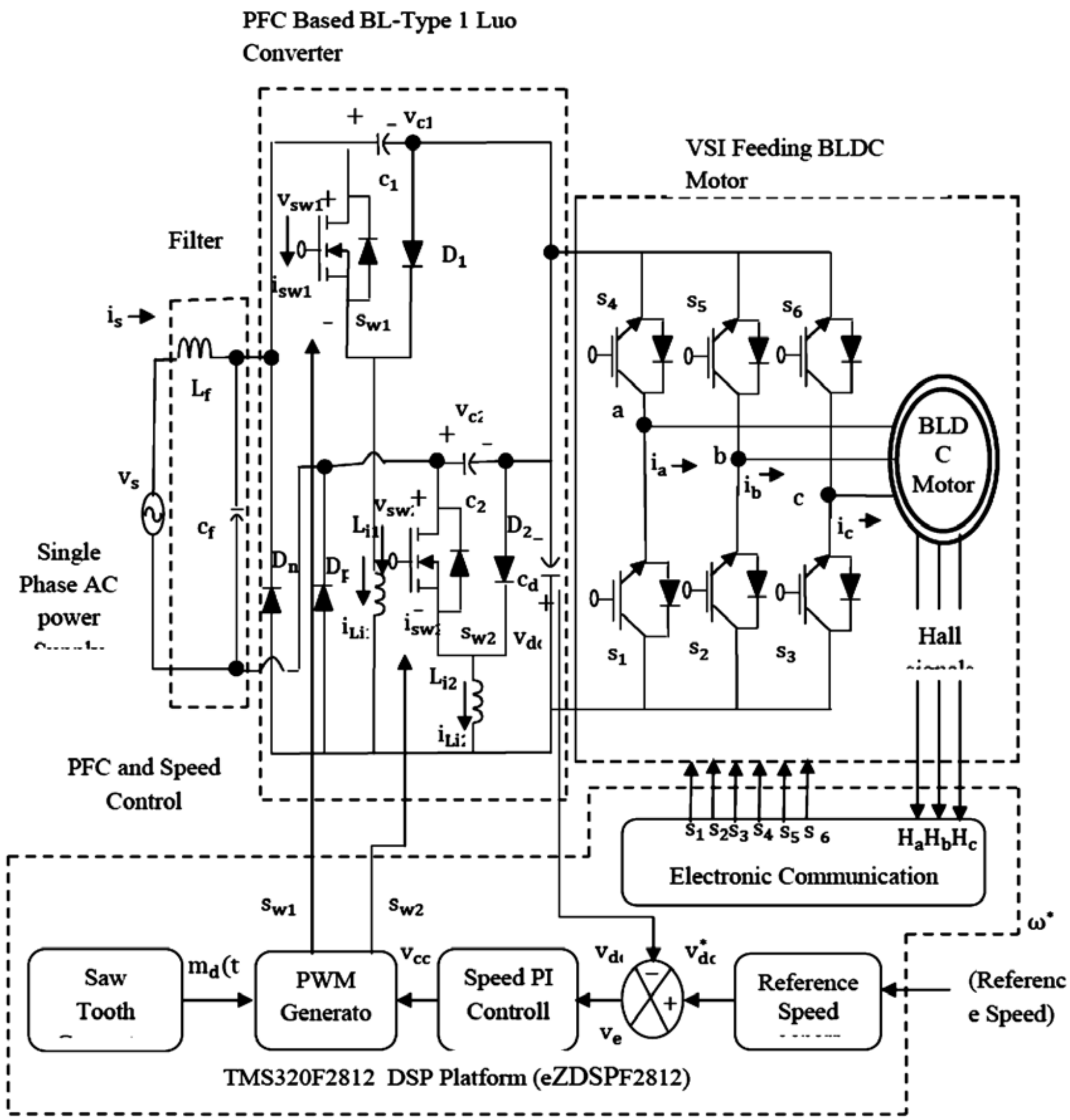



**Figure 3: Proposed topology of Type 1 Bridgeless-Luo converter with optimized method**

The LC filter is exploited for reducing the basic output ripple and it comprises of an inductor and a capacitor. PFC based type 1 BL Luo converter gets the input frequency from the PWM generator. It is modeled so that it is parallel connected and the inrush issue is resolved optimally by making use of type 1 BL Luo converter with genetic algorithm during the operation of discontinuous inductor current mode. It is interconnected with VSI feeding BLDC motor in addition to six switches and this switching frequency is got by means of electronic commutation. It is largely applied for decreasing the switching loss. Speed reference is provided as input to the reference speed generator and it is provided as input to the speed PI controller. Saw tooth generator and speed PI controller is provided as input to the PWM generator that does the generation of two switching frequency to the Type 1 BL Luo converter. The closed loop topology leads to an enhanced power factor by making use of speed PI controller with genetic algorithm.

The comparison between the newly introduced type 1 BL Luo converter with genetic algorithmic addition to the already available bridgeless converter configurations is summarized in Table I. It shows the total number of elements (Switch— Sw, Diode—D, Inductor—L, and Capacitor—C) and the elements that are conducting during every half-cycle of supply voltage. The bridgeless buck [11] and boost converter [12], [13] configurations are not appropriate for the necessary application because of the high voltage conversion ratio (*i.e*., voltage bucking and boosting) required for regulating the speed over a broad range. In comparison with the different bridgeless configurations of Cuk [14]–[16], SEPIC [17], [18], and Zeta converters [19], this novel type 1 BL Luo converter consists of considerably lesser number of components and the least number of conducting devices during every half-cycle of the supply voltage, while the proposed configuration reveals minimal conduction losses owing to the conduction of reduced number of components during every half line cycle.

**Table 1**

**Comparative Analysis of the Proposed Type 1 Bl- Csc converter with Existing Configurations**

| *Configuration* | *No. of Devices* | | | | | *½ Period Cond* |
|---|---|---|---|---|---|---|
| | $S_W$ | *D* | *L* | *C* | *Total* | |
| BL-Cuk [27] | 2 | 3 | 3 | 2 | 10 | 8 |
| BL-SEPIC [29] | 2 | 3 | 2 | 2 | 9 | 7 |
| BL-Zeta [30] | 2 | 4 | 4 | 3 | 13 | 7 |
| Proposed type 1 BL-CSC | 2 | 4 | 2 | 3 | 11 | 6 |

Fig. 4(*a*) illustrates the waveforms of supply voltage with inductor currents (iLi1 and iLi2) and intermediate capacitor voltages(VC1 and VC2). The proposed converter operates in DICM, *i.e*., the inductor currents (iLi1 and iLi2) are irregular, and the voltages across the intermediate capacitor (VC1 and VC2)stay constant with an allowed amount of voltage ripple in an entire switching period.

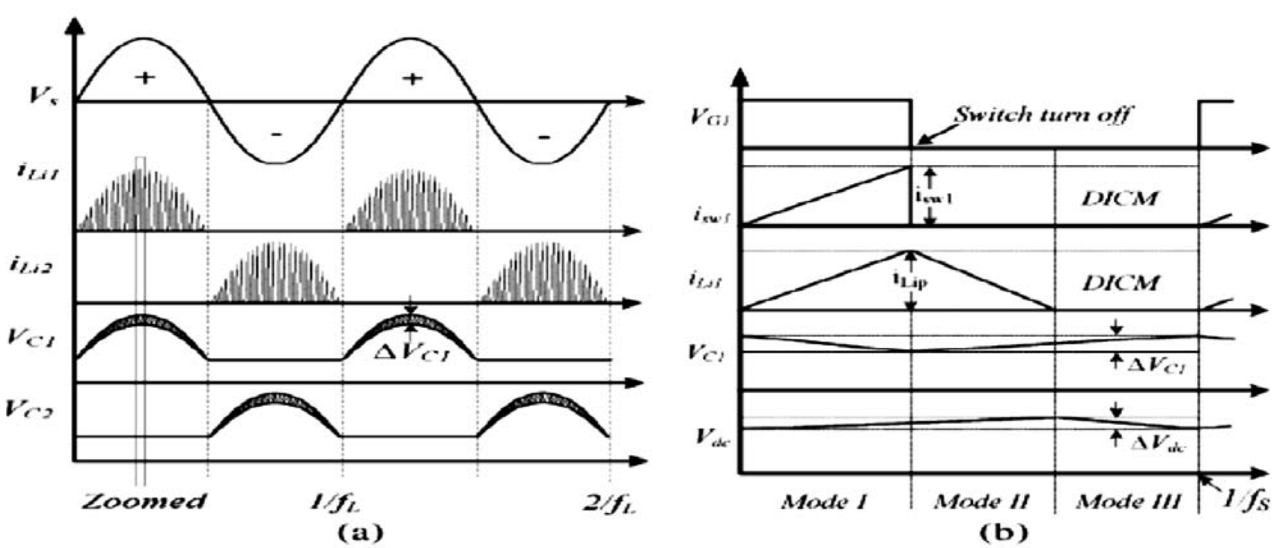



**Figure 4: Waveforms in different modes of operation of the proposed converter**

## Operation During Complete Switching Period

The new Type 1 BL-CSC converter is modeled to work in DICM in such a way that current in inductors Li1 and Li2 tend to become discontinuous for a switching period. Fig. 5(*a*)–(*f*) illustrates the various modes of operation during a whole switching period for the corresponding positive and negative half-cycles of the supply voltage. Fig. 5(*b*) illustrates the respective waveforms during the three modes of operations.

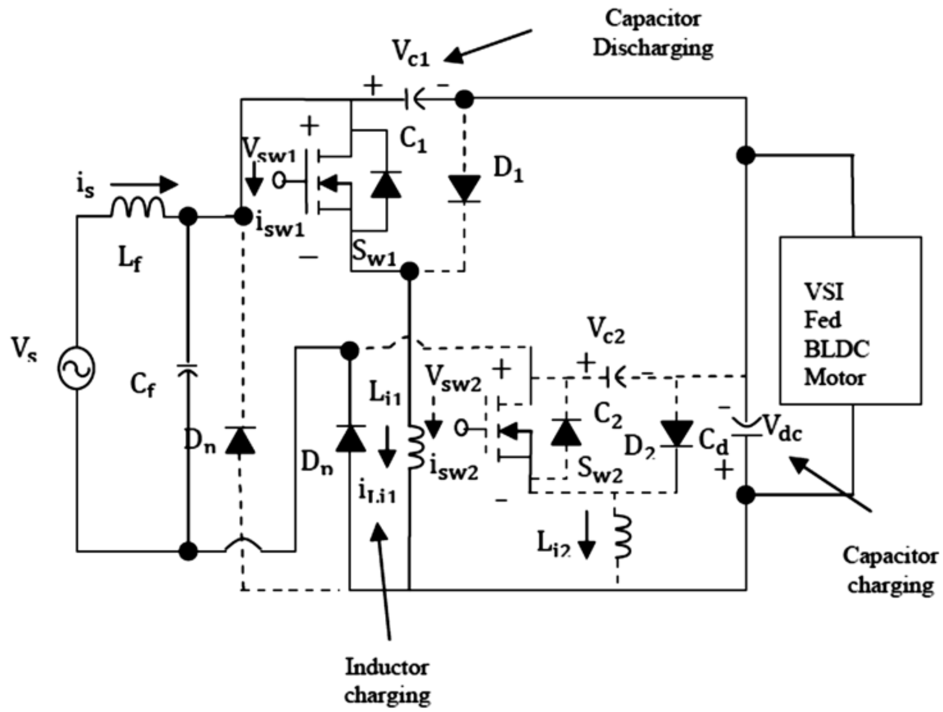



**Figure 5: (*a*)**

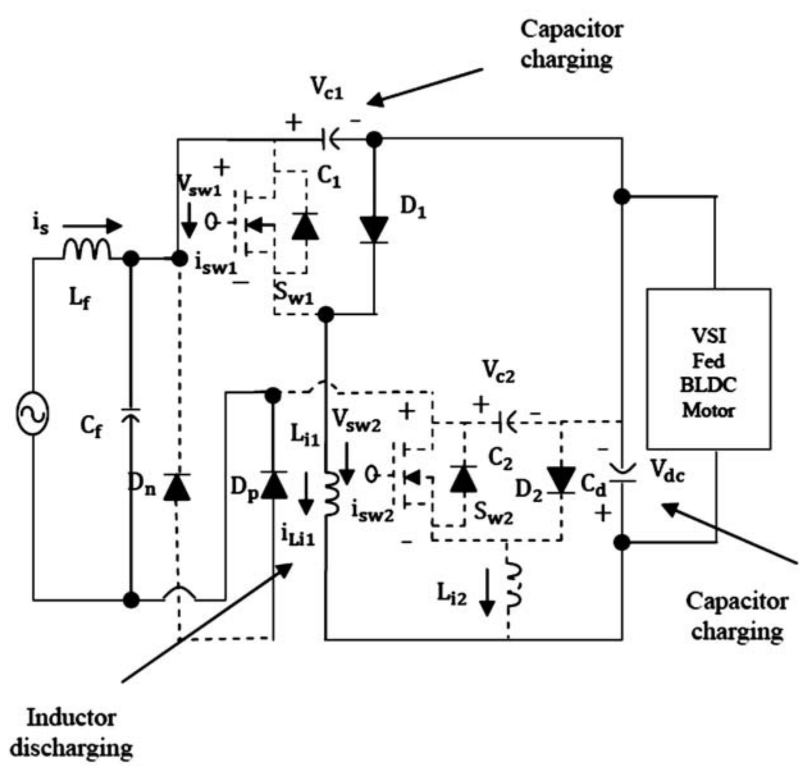



**Figure 5: (*b*)**

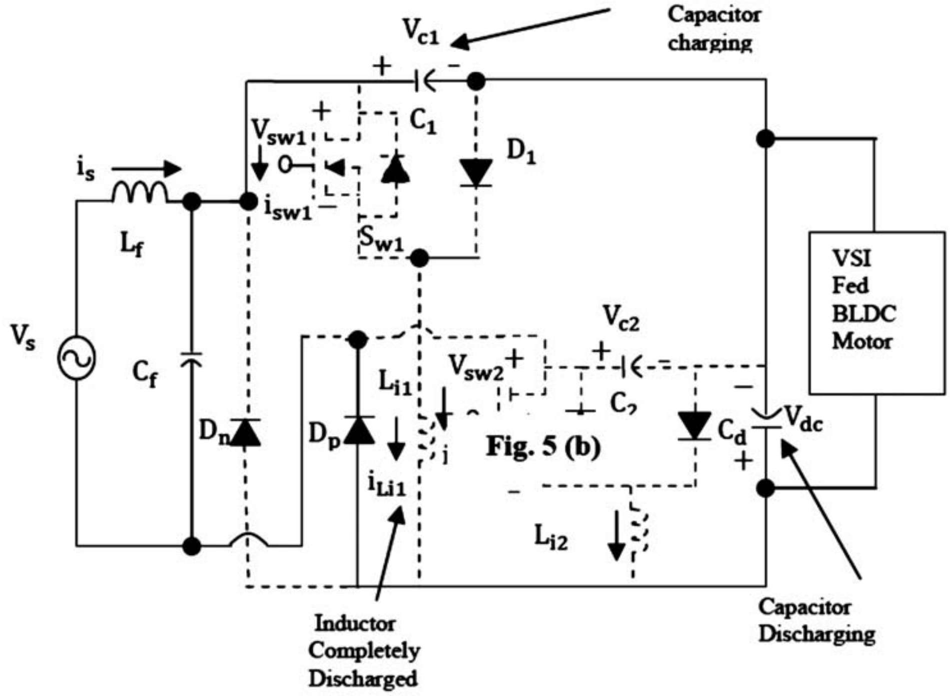



**Figure 5: (*c*)**

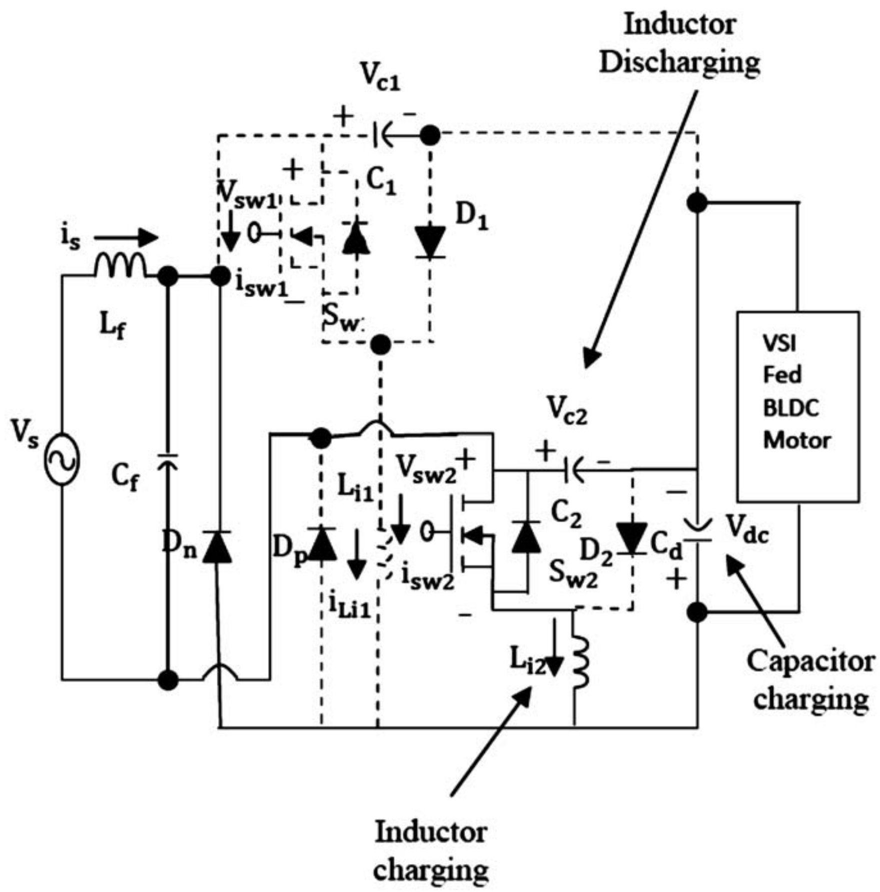



**Figure 5: (*d*)**

**Mode I-A *:*** As illustrated in Fig. 5(*a*), when switch Sw1 is turned on, the input side inductor Li1 begins to charge through diode Dp, and current Ili increases, capacitor Cd. Hence, the voltage across intermediate capacitor VC1 reduce, while the dc link voltage Vdcgets increased.

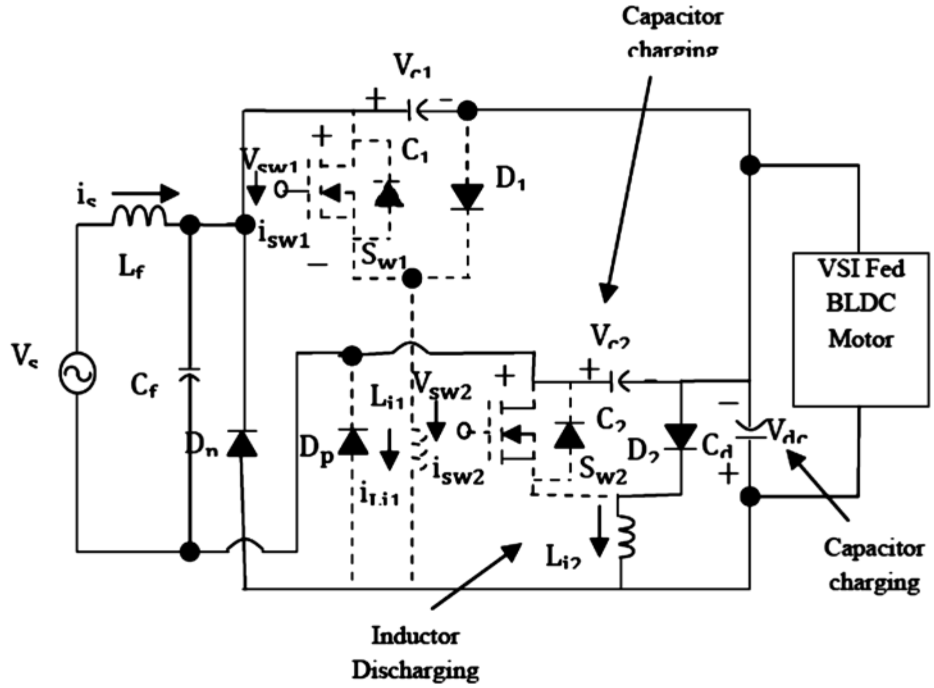



Figure 5: (*e*)

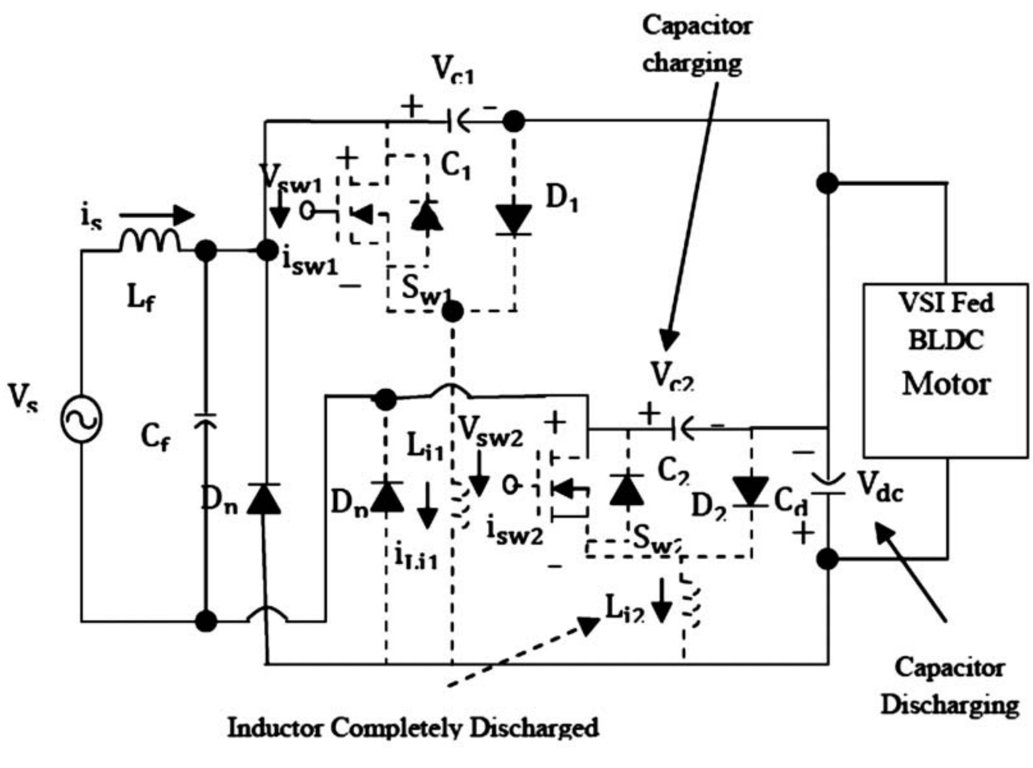



Figure 5: (*f*)

**Figure 5: Different modes of operation of the proposed BL-CSC converter (*a*) Mode I-A (*b*) Mode I-B (*c*) Mode I-C (*d*) Mode II-A (*e*) Mode II-B(*f*) Mode II-C**

**Mode I-B:** When the switch Sw1 is turned off, the energy saved in inductor Li1 gets discharged to dc link capacitor Cd through diode D1, as illustrated in Fig. 5(*b*). The current iLidecreases, while the dc link voltage continues to rise in this mode of operation. Intermediate capacitor C1 begins to charge, and voltage VC1 increases, as illustrated in Fig. 5(*b*).

**Mode I-C:** This mode is actually the DCM of operation since the current in input inductor Li1 reaches zero, as indicated in Fig. 4(*c*). The intermediate capacitor C1 remains to store energy and sustains its charge, while the dc link capacitor Cd provides the necessary energy to the load. The same behavior of the converter is implemented for the other negative half-cycle of the supply voltage. An inductor Li2, an intermediate capacitor C2, and diodes Dn and D2 also conduct in a similar manner, as illustrated in Fig. 5(*d*)–(*f*).

Fig. 5(*a*)–(*f*) illustrates the working of the novel type 1 BL Luo converter for the respective positive and negative half-cycles of the supply voltage. As indicated in Fig. 4(*a*)–(*c*), during the positive half-cycle of the supply voltage, the input side current passes through switch Sw1, inductor Li1, and a fast recovery diode Dp. Likewise, switch Sw2, inductor Li2, and diode Dn conduct for a negative half-cycle of the supply voltage, as indicated in Fig. 5(*d*)–(*f*).

## 4.2. Design of Proposed Topology

### *4.2.1. Input Inductor*

The inductor $L_{ic}$ is obtained from the magnetic field around a current-carrying conductor; the electric current passing through the conductor produces a magnetic flux.

The input inductor is expressed as

$$L_{ic} = \frac{V_{in}(t)D(t)}{2l_{in}(t)f_s} \tag{1}$$

Where $R_{in}$ indicates the input resistance, $f_s$ refers to the switching frequency, and Pi stands for the instantaneous power. A lesser value of inductance leads to an increase in the current stress on the PFC converter switch in DICM operation. Hence, the switching frequency is chosen and the losses in addition to current stress of PFC converter switches are less, and it also satisfies the required performance.

### *4.2.2. Intermediate Capacitor*

It is used for enabling the filtering of signals and the proposed PF regulation technique, along with a correctly designed input line capacitor, can assure a unity PF all through the wholerange of speed. The intermediate capacitance (C1 and C2) is expressed as

$$C_1 = C_2 = \frac{V_{dc}D(t)}{\Delta V_C(t)f_s R_L} = \frac{V_{dc}D(t)}{\eta\{V_{in}(t) + V_{dc}\}f_s R_L} \tag{2}$$

Where η refers to the permitted ripple voltage across intermediate capacitors ($C_1$ and $C_2$), $V_C$ indicates the intermediate capacitor's voltage, $R_L$ and stands for the emulated load resistance and is formulated as $RL = V_{dc}^2 / P_i$ .

### *4.2.3. DC Link Capacitor*

DC link capacitors are employed as intermediate device between the power systems input and output sections for filtering the unnecessary signals and for offsetting the impacts of inductance.

The value of dc link capacitor is computed as

$$C_d = \frac{1_{dc}}{2\omega\Delta V_{dc}} = \left(\frac{P_i}{V_{dc}}\right)\frac{1}{2\omega k V_{dc}} \tag{3}$$

Where *k* indicates the permissible ripple in dc link voltage

### *4.2.4. LC Filter*

It is applied for avoiding the noise or ripple in the system and it is calculated as below

$$C_{max} = \frac{I_m}{\omega_L V_m} \tan(\theta) \quad (4)$$

Where $I_m$ refers to maximum current and indicates maximum voltage

#### *4.2.5. VSI Feeding BLDC Motor*

In this new topology, the voltage source inverters are used in the rotor circuit for making the drive system to be able to operate in the motoring and generating modes above and below synchronous speed. It comprises of six switches ON and OFF mode in addition to electronic commutation. It considers the speed parameter to be reference to the PFC unit in the topology proposed.

The newly introduced topology drives have achieved significantly in the recent designs owing to power quality enhancements which have also lead to remarkable performance in comparison to other available drives. The benefits of the new topology are better efficiency, greater reliability, ruggedness, less EMI issues and better performance over an extensive range of speed control which have developed this motor. The BLDC motor is suitable for several low and medium power applications. BLDC motors are synchronous motors that have permanent magnets on the rotor, and three phase windings on the stator. An electronic commutation which is based on the rotor position, that is sensed by Hall Effect sensors is utilized that removes the problems which is associated with the available BLDC motors like sparking, noise, electromagnetic interference (EMI) and maintenance issues. Hence, power factor correction (PFC) converters are utilized for boosting the power quality at the AC mains. These converters have lesser number of components and therefore have lesser switching losses associated.

### 4.3. Control of the PFC Type 1 Luo Converter

The proposed PFC Type 1 Luo converter fed BLDC motor drive's control comprises of two important components. This consists of the control of the PFC converter for the electronic commutation and the speed control of BLDC motor.

#### *4.3.1. Electronic Commutation*

It is well-known fact that in a D.C. motor there exists stationary electromagnets that supply the magnetic field. The static inverter along with the shaft positions-sensitive controller can be considered to be an electronic commutator. This enables the operation of the synchronous motor in the form of a versatile-speed drive similar to a D.C. motor with no mechanical commutations and brushes. Hall-effect position sensors are employed for sensing the rotor position for achieving electronic commutation of BLDC motor. It is utilizing for this trapezoidal back electromotive force (EMF) BLDC motor, in which only two stator phases are conducting at any given point of time. With the assistance of rotor position information, the switches in the VSI are switched ON and OFF to guarantee aright direction of current flow in the corresponding windings.

Commutator is utilized in direct current (DC) machines: dynamos (DC generators) and several DC motors in addition to universal. In a motor, the commutate or injects the electric current onto the windings. Through the reversal of the current direction in the rotating windings every half turn, a steady rotating force (torque) is generated. In a generator, the commutator picks up the current that is generated in the windings, then reverses the direction of the current with every half turn, functioning as a mechanical rectifier to transform the alternating current obtained from the windings to unidirectional direct current in the external load circuit.

#### *4.3.2. Speed Control*

Generally, the speed control of the DC motors is vital. This new system offers a very accurate and efficient speed control system. In this new topology, a speed control system is designed for a BLDC motor by closed loop control method. The speed controller unit comprises ofspeed error generator, PWM generator, the speed PI controller, saw tooth generator, reference speed generator and Hall signals for the BLDC motor drive. The speed control of the BLDC motor is achieved by changing the duty cycles (PWM Pulses). In the closed loop speed control the original speed is measured and then compared with the reference speed for finding the error difference. This error difference will then be provided to the PI controller. The output obtained from the PI controller supplies the necessary period cycle.

For speed control (closed loop speed control)

Speed_start_referencerefers to the starting reference value of the voltage.

$$\text{Speed\_start\_reference range } [0\text{–}K_{Hall}] = \frac{\text{Speed\_start\_reference}}{K_{hall}} * 2^{15} \tag{5}$$

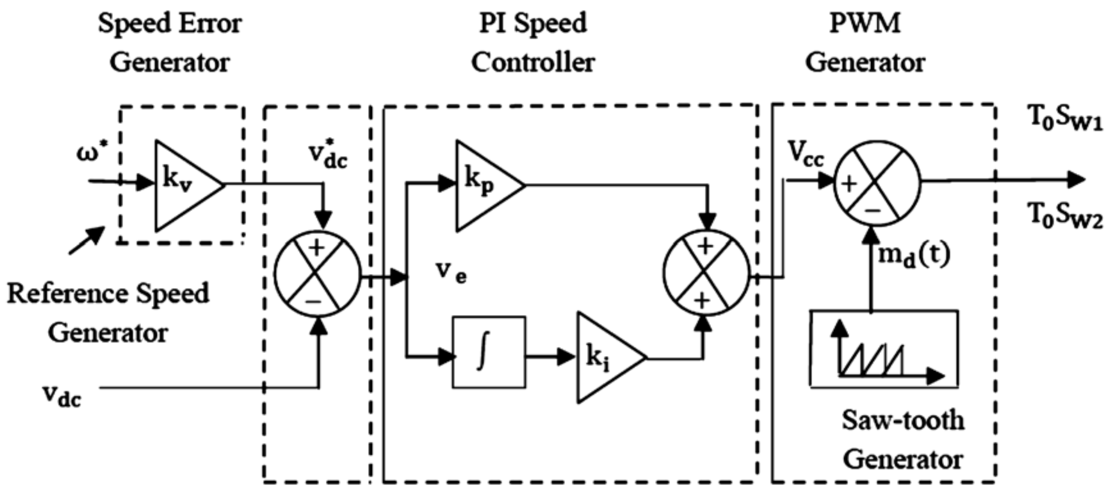



**Figure 6: Control of the PFC based type 1 BL-Luo converter feeding BLDC motor drive**

A single voltage sensor is necessary for controlling the dc link voltage for speed controlof BLDC motor, and intrinsic PFC is attained at the ac mains. It is accomplished with efficiency by using the proposed Type 1 Luo converter. It consists of the components such as saw tooth generator, PWM generator, speed PI controller and reference voltage generator.

## Genetic Algorithm (GA) with Type 1 Bridgeless Luo Converter

The genetic algorithm is employed for optimizing the inrush current issues and DC link voltage control, utilized for generating lower switching losses through the selection of the optimal chromosomes. Genetic algorithm is basically a computational model which resolves optimization problems by replicating genetic processes along with the theory of evolution. It replicates the biological evolution by making use of genetic operators like reproduction, crossover, mutation, etc. The crossover, mutation and accept operations are exploited for improving the unity power factor and the less amount of overshoot stator current. Therefore it is hybrid with Type 1 Bridgeless Luo converter that is utilized for increasing the motor speed in an optimal manner and noise interferences are minimized considerably. Optimization in GA refers to maximization. In the cases in which minimization is necessary, the negative or the inverse of the function which has to be optimized is utilized.

The objective function lower inrush current and higher unity power factor

Inrush Current formula is expressed below

$$I_c = \frac{\sqrt{2V}_m}{Z_t} * K_w * K_s * \left( \sin(\omega t - \varphi) - e^{\frac{-(t-t_0)}{\tau}} \sin\alpha \right) \tag{6}$$

Where $V_m$ refers to the maximum applied voltage, $Z_t$ stands for the total impedance under inrush, φ indicates the energization angle, $t_0$ refers to the point at which the core is saturated, τ refers to the time constant of transformer winding under inrush scenarios.

Therefore the speed PI converter along with genetic algorithm is employed for generating the enhanced unity power factor. The optimized genetic algorithm increases the system efficiency on an overall in the type 1 BL Luo converter. The electronic commutation along with VSI produces lesser switching losses and enhances the varying dc link voltage in the BLDC motor. The discontinuous inductor current mode with type 1 BL Luo converter is introduced for reducing the inrush current problems and switch stress. The results demonstrated that the new type 1 BL-Luo converter showed reliable performance.

## 5. SIMULATION RESULT

The performance and the parameters of the system are discussed in this section. It is evaluated under steady state and dynamic condition making use of available and the new BLDC motor drives. The performance parameters that are considered are the input voltage, input current, power factor, inrush current, DC link voltage (Vdc), motor speed (ω), stator current and overshoot. The results illustrate the MATLAB-Simu link model of the system and the motor parameters are tabulated in Table 1.

**Table 2**

**Comparative Analysis of the Proposed Type 1 Bl-Csc converter with Existing Configurations**

| *Configuration* | *No.of Devices* | | | | | *½ Period Cond* |
|---|---|---|---|---|---|---|
| | $S_W$ | *D* | *L* | *C* | *Total* | |
| BL-Cuk [27] | 2 | 3 | 3 | 2 | 10 | 8 |
| BL-SEPIC [29] | 2 | 3 | 2 | 2 | 9 | 7 |
| BL-Zeta [30] | 2 | 4 | 4 | 3 | 13 | 7 |
| Proposed type 1 BL-CSC | 2 | 4 | 2 | 3 | 11 | 6 |

Figure 6 illustrates the simulation setup of the novel research work. Figure 6indicates the modules and functions that are associated with the newly introduced research topology that gives optimal speed control and a better unity power factor.

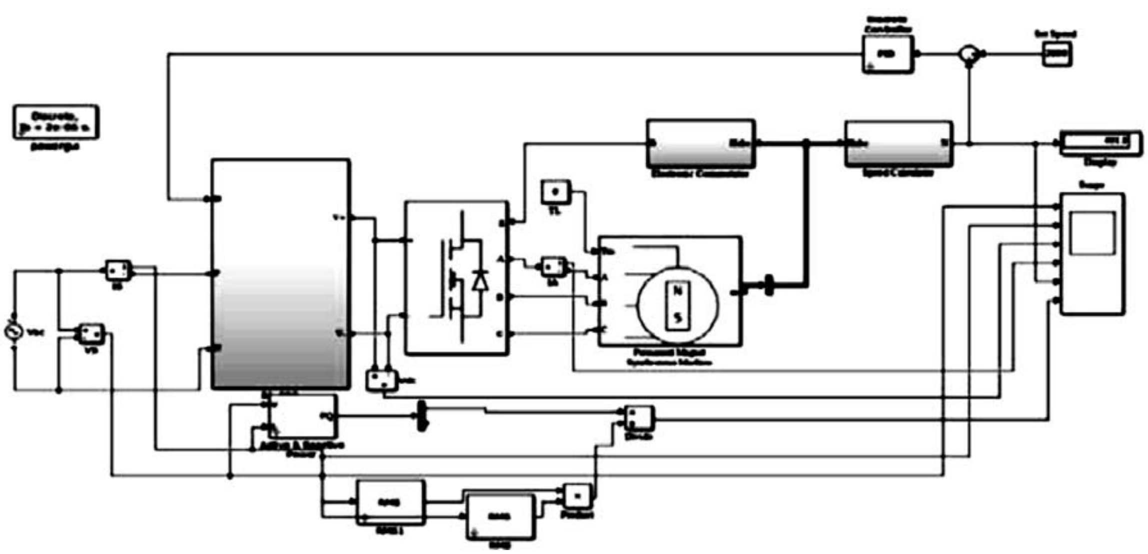
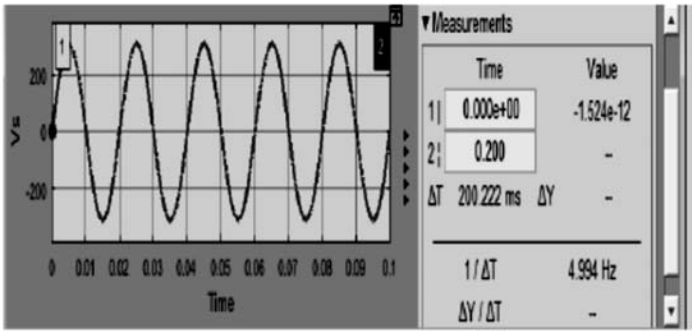


**Figure 7: Simulation setup**

It can be proved from the analysis that the novel optimized mechanism offers more reliability and the objective function is got for different input values. The speed control of the BLDC motor is calculated and frequency of the input current demonstrates the operation of the BLDC motor at various speeds. Experiments are conducted for various voltage conversion, current ratios and for various values of switching frequencies for each half cycle.

### 5.1. Supply Voltage



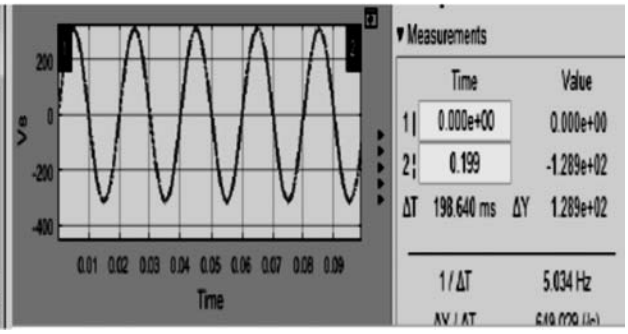
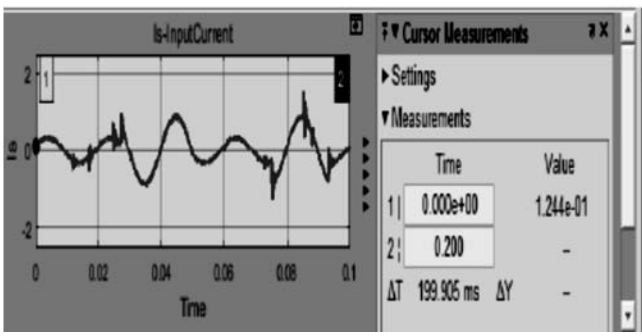




**Figure 8: (*a*) Exiting supply voltage as 220 V** **Figure 8: (*b*) Proposed supply voltage as 220 V**

The figure 8(*a*) and 8billustrates that the input supply voltage for the available techniques and the newly introduced motor. The Type 1 BL-Luo converter with genetic algorithm proposed is employed for performing the input voltage efficiently. The voltage is supplied at 220V for both of the existing and proposed technique. Figure 7 indicates the supply voltage comparison values of both the available and the newly introduced research techniques during the same time span.

### 5.2. Input Current



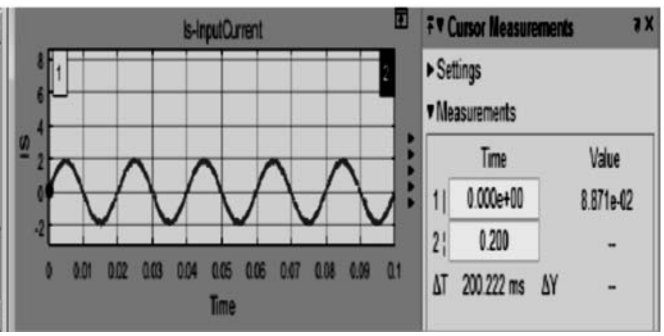
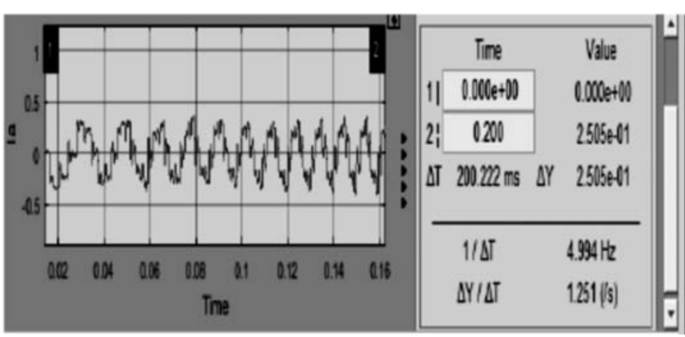




**Figure 9:(*a*) Exiting input current** **Figure 9:(*b*) Proposed input current**

Figures9(*a*) and 9billustrates the input current for the already available technique and the proposed motor. The proposed Type 1 BL-Luo converter with genetic algorithm is used to perform the input current efficiently. The input current has ripple problems while in the proposed, the input current has unity input current.

### 5.3. Inrush Current



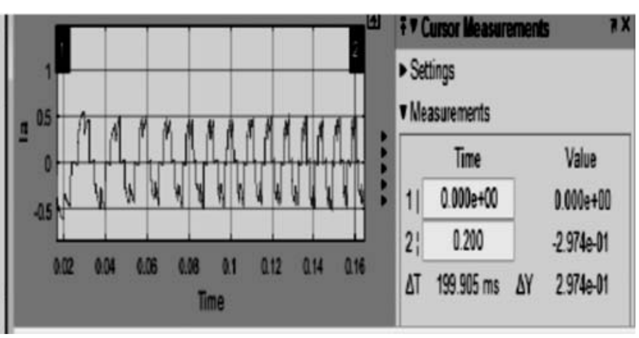




**Figure 10: (*a*) Exiting inrush current** **Figure 10: (*b*) Proposed inrush current**

Figures 10(*a*) and 10(*b*) gives the inrush current values got from the already existent research and the proposed research of BLDC motor. Inrush current is an important challenge in the earlier research. It is predicted from these figures that the research technique proposed is aimed at providing an improved inrush current rate to the motor along with decreased fluctuation compared to the existing research scheme that gives more fluctuation in the inrush current rate. In the earlier technique, the inrush current consumes some time for running while, on the contrary, in the proposed topology, the inrush current begins to run with speed. Therefore a less amount of inrush in stator current is seen by the improved varying dc link voltage. The Type 1 BL-Luo converter with genetic algorithm attains optimal inrush current considerably. The earlier inrush current had noise problems while in the proposed topology, in the inrush current the noise is effectively eliminated.

### 5.4. DC-Link Voltage

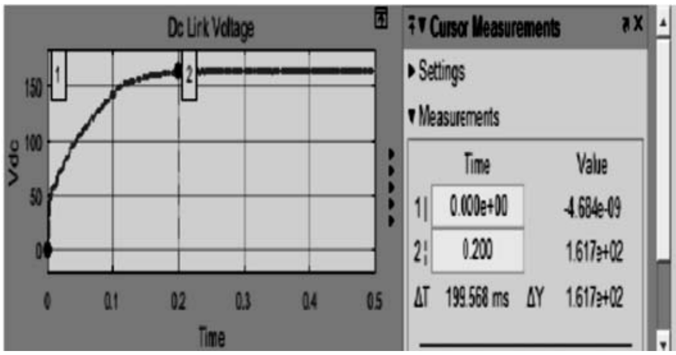



**Figure 11: (*a*) Exiting DC link voltage**

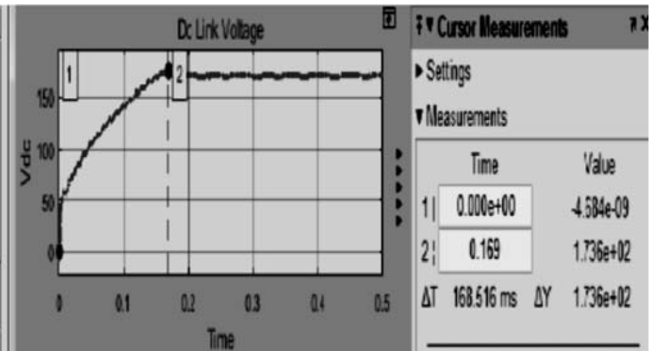



**Figure 11: (*b*) Proposed DC link voltage**

Figures 11(*a*) and 11(*b*) illustrates the performance of the drive proposed at rated condition of supply voltage with dc link voltages of 200V. The speed of the new BLDC motor is regulated by changing the dc link voltage of the VSI with more efficiency. It can be noticed from the above figures that the earlier dc-link voltage consumes longer time to produce a constant voltage while in the proposed topology, the dc-link voltage takes lesserms time for the generation of the constant voltage. Therefore it reveals that the dc link voltage is optimized in a better manner in comparison with the earlier technique.

### 5.5. Power Factor

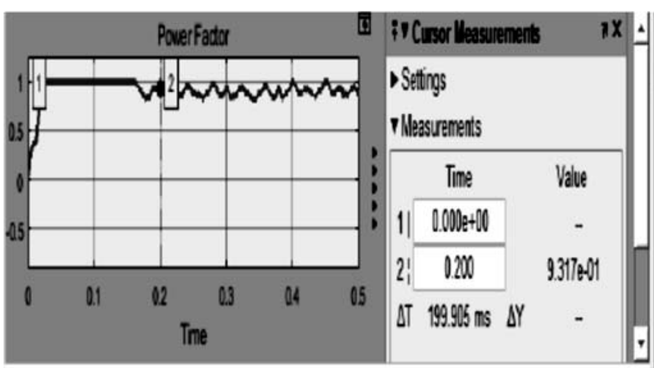



**Figure 12: (*a*) Exiting power factor**

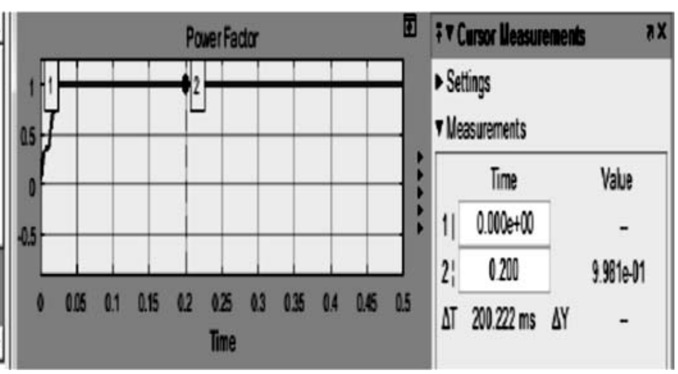



**Figure 12: (*b*) Proposed power factor**

Figure 12(*a*) and 12(*b*) illustrates the power factor values. This figure shows the existent power factor and the new power factor. It is noticed from this figure that the research work proposed can help in providing the unity power factor and better constant time. It is revealed from these figures that the new power factor values that are produced are unity having a lesser fluctuation rate in comparison to the existent research topology that generates more fluctuation in the power factor values. The existent technique takes up longer time to generate a constant power factor whereas the proposed technique consumes lesser time for generating a constant power factor. The result show that the new optimized approach yields a better unity power factor employing the genetic algorithm.

### 5.6. Speed

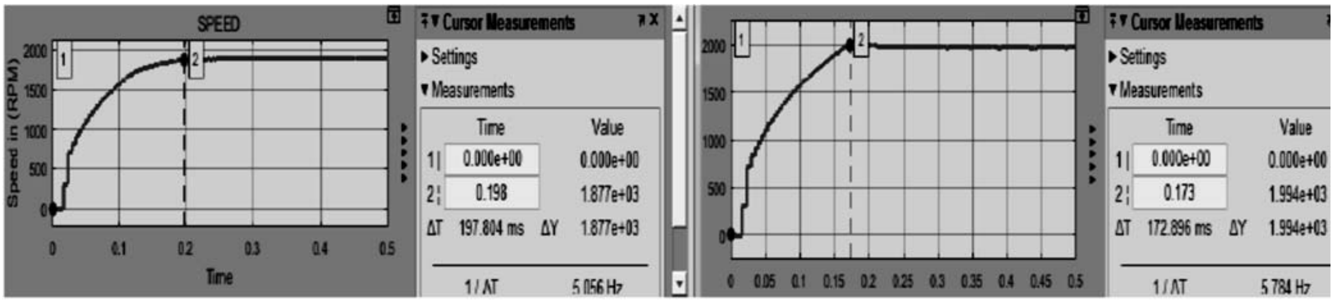



**Figure 13:(*a*) Exiting speed parameter** **Figure 13: (*b*) Proposed speed parameter**

Figure 13(*a*) and 13(*b*) illustrates the speed parameter for the available and the proposed techniques. It is observed from this figure that the new work renders high speed rpm values compared to the earlier research. It is shown from this figure that the speed parameter was generated with better acceleration in the proposed research, while the available system has problems with lesser acceleration speed. This figure indicates that the proposed research scheme yields a constant speed in much reduced running time though the earlier research consumes long time to generate the constancy in speed. Therefore the proposed Type 1 BL-Luo converter with genetic algorithm has more reliability compared to the earlier techniques.

## 6. CONCLUSION

This section deals with the proposed Type 1 BL-Luo converter along with genetic algorithm which offers enhanced power quality at the ac mains. The newly introduced PFC based Type 1 BL-Luo converter-fed BLDC motor generated at discontinuous inductor current conduction mode. Electronic commutation with BLDC motor has achieveda lesser switching loss in the VSI. The speed of the BLDC motor is controlled by means of the control over the dc link voltage. The optimized genetic algorithm with the speed PI converter achieves the improved unity power factor. The type 1 BL-Luo converter is utilized for reducing the inrush current issuesin an optimal manner and minimized the switching stress considerably. Lower switching frequency of PWM is got with VSI in six solid state switches. Changing switching frequency in VSI is exploited for controlling the dc link voltage. This way, the system efficiency is boostedlargely and in addition, the switching loss is minimized significantly. Therefore the simulation result concludes that the proposed techniques yields a robust performance through optimal unity power factor, speed parameter and lesser switching loss, noise, changing dc link voltage, inrush current in comparison with the other approaches. The proposed approach of optimized converter attains better system efficiency and PF through the elimination of the noise interference in addition to the inrush current issue. On a futuristic approach, the BLDC motor performance can be enhanced by making use of hybrid converter approaches along with optimized methods.

## 7. REFERENCES

1. J.C. Gamazo-Real, E. Vázquez-Sánchez and J.Gómez-Gil, "Position and speed control of brushless DC motors using sensorless techniques and application trends," Sensors, vol. 10, no. 7, pp. 6901-6947, 2010.
2. O.A. Youssef, "A wavelet-based technique for discrimination between faults and magnetizing inrush currents in transformers," IEEE Transactions on Power Delivery, vol. 18, no. 1, pp. 170-176, 2003.
3. T.Y. Ho, M.S. Chen, L.H. Yang and W.L. Lin, "The design of a high power factor brushless DC motor drive," In Computer, Consumer and Control (IS3C), 2012 International Symposium on, pp. 345-348, 2012.
4. S. Singh and B. Singh, "A voltage-controlled PFC Cuk converter-based PMBLDCM drive for air-conditioners," IEEE transactions on industry applications, vol. 48, no. 2, pp. 832-838, 2012.
5. B. Singh, V. Bist, A. Chandra and K. Al-Haddad, "Power quality improvement in PFC Bridgeless-Luo converter fed BLDC motor drive," In Industry Applications Society Annual Meeting, IEEE, pp. 1-8, 2013.

6. Wireless sensor network Attacks and Key Management Authentication "Presented in National conference on Networking and computing Technologies Organized by Dept of MCA,CSE & IT ,Vel Tech MultiTech Dr.Rangarajan Dr.Sakunthala Engg college, Chennai on 10.08.2012
7. V. Bist and B. Singh, "A Unity Power Factor Bridgeless Isolated Cuk Converter-Fed Brushless DC Motor Drive," IEEE Transactions on Industrial Electronics, vol. 62, no. 7, pp. 4118-4129, 2015.
8. F. Firdaus, Belim, K. Chirag, Vibhakar, B. Bharti, Parmar and J. Kishan, Bhayan, "Improve power quality of BLDC motor using buck dc-dc converter," International Journal of Application or Innovation in Engineering & Management (IJAIEM), 2013.
9. Y. Jang and M.M. Jovanovi´c, "Bridgeless high-power-factor buck converter," IEEE Transactions on Power Electronics, vol. 26, no. 2, pp. 602–611, 2011.
10. A.A. Fardoun, E.H. Ismail, A.J. Sabzali, and M.A. Al-Saffar, "New efficient bridgeless Cuk rectifiers for PFC applications," IEEE Transactions on Power Electronics., vol. 27, no. 7, pp. 3292–3301, 2012.
11. Y. Jang and M.M. Jovanovi´c, "Bridgeless high-power-factor buck converter," IEEE Transactions on Power Electronics, vol. 26, no. 2, pp. 602–611, 2011.
12. L. Huber, Y. Jang and M.M. Jovanovic, "Performance evaluation of bridgeless PFC boost rectifiers," IEEE Transactions on Power Electronics, vol. 23, no. 3, pp. 1381–1390, 2008.
13. A.A. Fardoun, E.H. Ismail, M.A. Al-Saffar, and A.J. Sabzali, "New "real" bridgeless high efficiency ac–dc converter," In 2012 Twenty-Seventh Annual IEEE Applied Power Electronics Conference and Exposition, pp. 317–323, 2012.
14. A.A. Fardoun, E.H. Ismail, A.J. Sabzali, and M.A. Al-Saffar, "New efficient bridgeless Cuk rectifiers for PFC applications," IEEE Transactions on Power Electronic., vol. 27, no. 7, pp. 3292–3301, 2012.
15. B. Singh and V. Bist, "An improved power quality bridgeless Cuk converter-fed BLDC motor drive for air conditioning system," IET Power Electronics, vol. 6, no. 5, pp. 902–913, 2013.
16. M. Mahdavi and H. Farzaneh-Fard, "Bridgeless CUK power factor correction rectifier with reduced conduction losses," IET Power Electronics, vol. 5, no. 9, pp. 1733–1740, 2012
17. Methods for spectrum Assignment ,Pricing and Sensing Mechanism" in International Journals of Golden research thoughts in Vol 1,Issue III,Sep 2011
18. M. Mahdavi and H. Farzanehfard, "Bridgeless SEPIC PFC rectifier with reduced components and conduction losses," IEEE Transactions on Industry Applications, vol. 58, no. 9, pp. 4153–4160, 2011.
19. Automatic detection of lung cancer nodules by employing intelligent fuzzy cmeans and support vector machine Biomedical Research.