A Review Paper on Health Monitoring With Different Types of DC-Dc Converter For Speed Control of BLDC Motor

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Abstract- *This paper present performance of BLDC motor using CUK, SEPIC, ZETA and Buck-Boost converter. DC voltage provided by battery contains high voltage ripple and it is not constant enough voltage, thus it is not applicable for most devices like electric-vehicle controller, dc charger, etc. DC-DC converters are employed to attenuate the ripple regardless of change in the load voltage. DC-DC converter are devices which convert direct current (DC) from one voltage level to another by changing the duty cycle of the main switch in the circuit. Brushless DC (BLDC) motor are gaining much importance these days in industrial and traction application because of its ease of control in all four quadrants. There are various converters designed for BLDC motor for varied application. This paper reviews the different types of such converters in BLDC motor used for varied application.*

Keywords- Brushless DC motor, Buck-Boost, Cuk Converter, Luo Converter, Sepic Converter, Zeta Converter.

I. INTRODUCTION

A brushless DC electric motor (BLDC), also known as electronically commutated motor. Brushless DC(BLDC) motors are extensively used now days due to their improved performance and lower maintenance. These motors are available in different power rating from small motors in hard disks to large motors electric vehicles, actuators, robotics, etc In conventional DC motors, the mechanical commutation is implemented using brushes which results in mechanical friction, noise, electric spark and radio interference. These drawback can be overcome by brushless DC motor (BLDC). Since permanent magnet are placed in the rotor, they are also known as permanent magnet brushless DC (PMBLDC) motors. The BLDC motor is developed on the basis of brushed DC motor.

DC –DC converters are power electronic circuits that convert a dc voltage to a different voltage level. There are different types of conversion method such as electronic, linear, switched mode, magnetic, capacitive. The circuits described in this report are classified as switched mode DC-DC converters. These are electronic devices that are used whenever change of DC electrical power from one voltage level to another is needed. To perform the conversion with the highest possible efficiency. DC-DC Converters are needed because unlike AC, DC can not simply be stepped up or down using a transformer. In many ways, a DC-DC converter is the DC equivalent of a transformer. They essentially just change the input energy into a different impedance level. So whatever the output voltage level, the output power all comes from the input; there is no energy manufactured inside the converter.

According to the applications, there are several DC to DC converters that are used to modulate the input voltage. Generally, there are two types of DC to DC converters which are isolated DC to DC converter and non-isolated DC to DC converter. The input and output of isolated DC to DC converter are isolated also depending on the electrical barrier. This is done by using high frequency transformer. Protecting the sensitive load is the major advantage of isolated DC to DC converter. Either positive or negative polarity can be used for configuring the converter output. The problem is it has high interference noise capability. The electrical barrier is absent in case of non-isolated DC to DC converter. The non-isolated DC to DC converters are low cost and simple design compare to the isolated DC to DC converters. Five types of non-isolated DC to DC converters are presented in this paper. To concerning reliable switching strategies control, higher efficiencies and fault-tolerant configurations, different topologies of DC to DC converters are developed and they based on renewable energy applications. The DC-DC converter plays a major role in determining the performance of the motor.

Buck-boost converters can be cheaper because they only require a single inductor and a capacitor. However, these converters suffer from a high amount of input current ripple. This ripple can create harmonics; in many applications these harmonics necessitate using a large capacitor or an LC filter. This often makes the buck-boost expensive. Another issue that can complicate the usage of buck-boost converters is the fact that they invert the voltage. Cuk converters solve both of these problems by using an extra capacitor and inductor. However, both Cuk and buck-boost converter operation cause large amounts of electrical stress on the components, this can result in device failure or overheating. SEPIC converters solve both of these problems

A. Buck-Boost Converter

It is a type of DC to DC converter and it has a magnitude of output voltage. It may be more or less than equal to the input voltage magnitude. The buck boost converter is equal to the fly back circuit and single inductor is used in the place of the transformer. There are two types of converters in the buck boost converter that are buck converter and the other one is boost converter. These converters can produce the range of output voltage than the input voltage. The following diagram shows the basic buck boost converter.

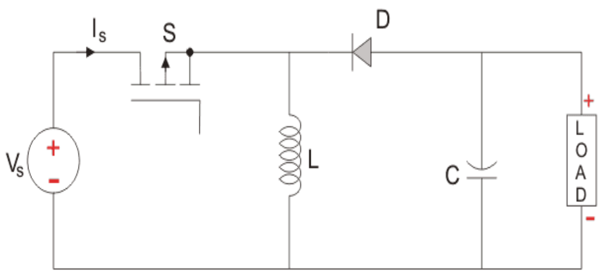

Fig. 1. : Buck-Boost Converter

The controlled switch is turned on and off by using Pulse Width Modulation (PWM). PWM can be time based or frequency based. Frequency based modulation has disadvantages like a wide range of frequencies to achieve the desired control of the switch which in turn will give the desired output voltage. Time based Modulation is mostly used for DC-DC converters. It is simple to construct and use. The frequency remains constant in this type of PWM modulation. The buck-boost converter has two modes of operation. The first mode is when the switch is on and conducting.

Mode I :Switch is ON, Diode is OFF

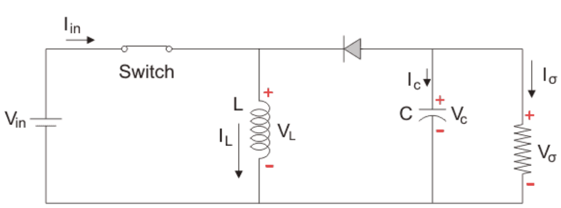

Fig. 1.mode I : Buck-Boost Converter

The Switch is ON and therefore represents a short circuit ideally offering zero resistance to the flow of current so when the switch is ON all the current will flow through the switch and the inductor and back to the DC input source. The inductor stores charge during the time the switch is ON and when the solid state switch is OFF the polarity of the Inductor reverses so that current flows through the load and through the diode and back to the inductor. So the direction of current through the inductor remains the same.

Let us say the switch is on for a time T_{ON} and is off for a time T_{OFF}. We define the time period, T, as T= $T_{ON} + T_{OFF}$ and the switching frequency, $F_{switching} = \frac{1}{T}$

Let us now define another term, the duty cycle, D = $\frac{Ton}{T}$, Let us analyse the buckboost converter in steady state operation for this mode using KVL.

$$\therefore Vin = Vl$$

$$\therefore Vl = l\frac{di\ l}{dt}$$

$$\frac{dil}{dt} = \frac{\Delta il}{\Delta t} = \frac{\Delta il}{DT} = \frac{Vin}{L}$$

Mode II : Switch is OFF, Diode is ON

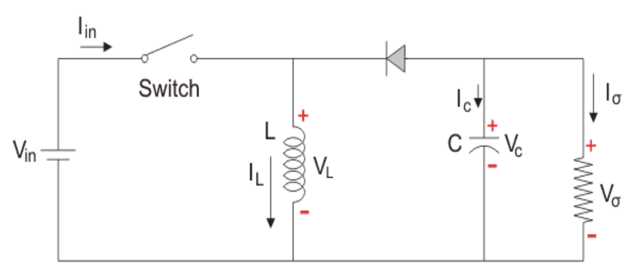

Fig. 1.mode II : Buck-Boost Converter

In this mode the polarity of the inductor is reversed and the energy stored in the inductor is released and is ultimately dissipated in the load resistance and this helps to maintain the flow of current in the same direction through the load and also step-up the output voltage as the inductor is now also acting as a source in conjunction with the input source. But for analysis we keep the original conventions to analyse the circuit using KVL.

B. CUK Converter

Cuk converter is using the capacitor and inductor as power storing device. The converter has the continuous input and continuous output current. The main drawback of the dc motor is ripples for eliminating that the capacitor has been used and it eliminates the ripples in both input and output side.

There is no need of external filter is used. The inductor on the output side is used for better output current characteristics and on input side is used for boost the voltage level.

SW is the power electronic switch MOSFET has been used, D is the freewheeling diode, L1, L2, C1, C2 are inductors and capacitors which are used for energy storing purpose. When the input voltage is turned on the MOSFET switch will be turned off, were the diode D is the forward biased the capacitor C1 has charged through the L1.

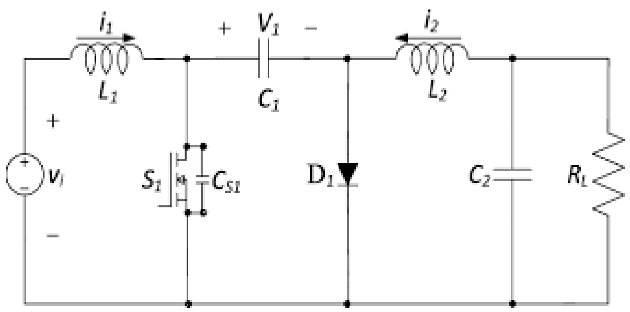

Fig. 1.B : Cuk Converter

The cuk converter operation has divided into two modes.

Mode-1: Here the MOSFET switch is used and is turned on when t=0. At that time the flow of current by the inductor L1 is increases. Then the capacitor voltage will be reverse bias and the diode D will get turn off. The energy of the capacitor will be discharge and the current flow will be like these C1-C2-Load-L2.

Mode-2: When time t=t1 the MOSFET switch will be turned off. The input supply is giving the supply to capacitor for getting charge and the load get energy from the stored energy of. Here the medium will be the capacitor because it transfers the energy from the supply to load

C. Luo Converter

luo converter is the developed converter derived from the buck-boost converter.

Here the MOSFET as power electronic switch as S, the D as freewheeling diode, L1, L2, C1, C2 are inductor and capacitor which are used for energy storing elements and R as Resistive load. The positive output luo converter operation can be explained in two modes.

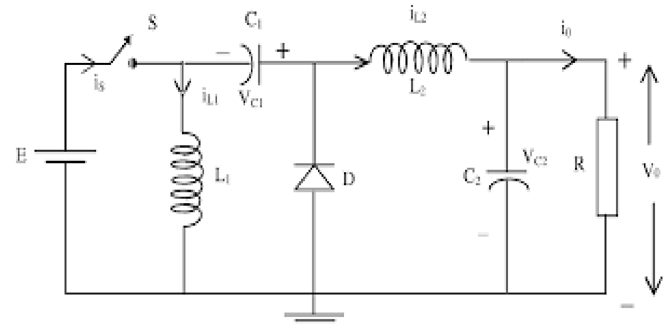

Fig. 1.C. : Luo Converter

Mode-1: When the MOSFET switch is turned on, the supply voltage E is given to inductor and it is get charged. Then the inductor L2 will absorb the energy from the Direct Current and from the Capacitor C1. The resistive load will get supply from the capacitor C2.

Mode-2: The MOSFET switch is turned off, and the current from the source will start to become zero. The capacitor C1 will get charge from the current that flow through the freewheeling diode. The current flows through the capacitor C2 and resistive load R and the freewheeling diode D is going to make it as continuous.

D. Zeta Converter

A Zeta converter is a fourth-order DC-DC converter made up of two inductors and two capacitors and capable of operating in either step-up or step-down mode

It comprises of a switch, a diode, two capacitors $C1$ and $C2$, two inductors $L1$and $L2$ and a standing resistive load.

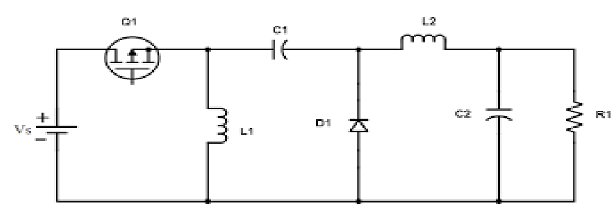

Fig. 1.D : Zeta Converter

The operation of zeta converter is designed in Continuous Conduction Mode (CCM) and the circuit operation can be defined by two modes of operation are shown in Fig1. D.

Mode 1: In this mode, the switch $Q1$ is ON and the diode $D1$ is reverse biased. Inductors $L1$ and $L2$ is charged from the source and the inductor current $IL1$ and $IL2$ increases linearly. Also, discharging of $C1$ and charging of $C2$ take place

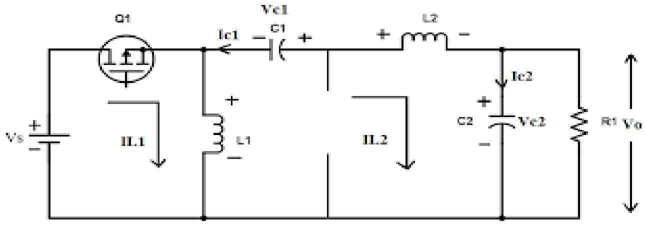

Fig. 1.D : Zeta Converter

Mode 2 : In this mode, the switch $Q1$ is OFF and the diode $D1$ is forward biased. During this interval, previously charged inductor $L1$ starts to discharge. So stored energy in $L1$ and $L2$ are discharged through capacitors $C1$ and $C2$. Therefore, the inductor currents iL1 and iL2 decrease gradually.

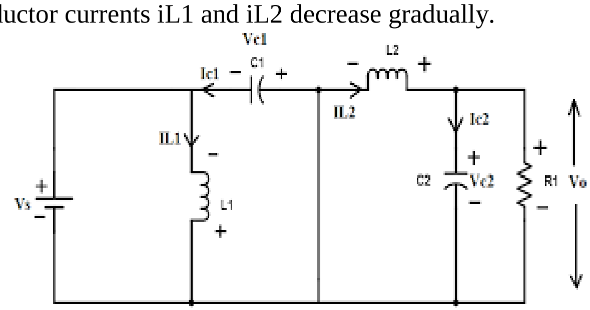

Fig. 1.D mode II: Zeta Converter

E. SEPIC CONVERTER

The SEPIC converter allows a range of dc voltage to be adjusted to maintain a constant voltage output.

All dc-dc converters operate by rapidly turning on and off a MOSFET, generally with a high frequency pulse. What the converter does as a result of this is what makes the SEPIC converter superior. For the SEPIC, when the pulse is high/the MOSFET is on, inductor 1 is charged by the input voltage and inductor 2 is charged by capacitor 1. The diode is off and the output is maintained by capacitor 2. When the pulse is low/the MOSFET is off, the inductors output through the diode to the load and the capacitors are charged. The greater the percentage of time (duty cycle) the pulse is low, the greater the output will be. This is because the longer the inductors charge, the greater their voltage will be. However, if the pulse lasts too long, the capacitors will not be able to charge and the converter will fail as shown infig. 1.E : Sepic Converter.

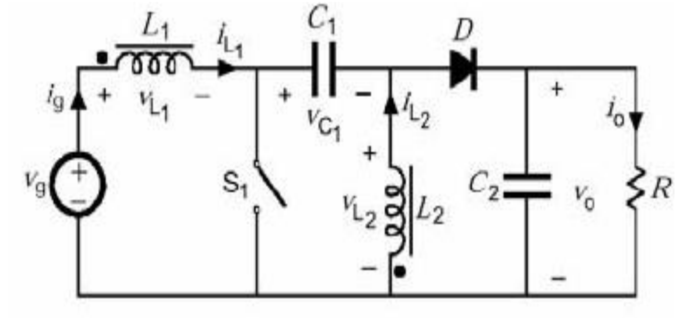

Fig. 1.E : Sepic Converter

Applications of BLDC motor

The cost of the Brushless DC Motor has declined since its introduction, due to advancements in materials and design. This decrease in price, coupled with the many advantages it has over the Brush DC Motor, makes the Brushless DC Motor a popular component in many different applications

1. Heating and ventilation
2. Industrial automation
3. Motion control
4. Positioning and actuating system
5. Aero modeling
6. Cooling fan

Application of DC-DC converter

Dc converters can be used in regenerative braking of dc motors to return energy back into the supply and this feature results in energy savings for transportation system with frequent stops. As for example :

a) Traction motor control in electric automobiles
b) Trolley cars
c) Marine Hoists
d) Forklift trucks
e) Mine Haulers

II. CONCLUSION

Thus comparative studies of different types of converters are discussed in this paper. Use of basic switching converters like Boost and Buck Converter significantly reduces the switching loss and cost thereby increasing the speed and efficiency of the BLDC motor drive system but it causes high input current ripple that produces harmonics. Cuk converters solve these problems by using an extra capacitor and inductor. However, both Cuk and buck-boost converter operation cause large amounts of electrical stress on the components, this can result in device failure or overheating. SEPIC converters solve both of these problems.

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