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Review on Multiple Input Multiple Output Dc-dc Converter for E-vehicle System

Jaydip.K. Ranva, Prof. Manan.M. Desai, Dinesh. A. Chavda
Dr. Subhash university, junagadh khamdhrol road

***Abstract*: For a considerable amount of time, switch-mode power converters have been an essential component of modern electronics technology, found in a wide range of sectors such as consumer, utility, commercial, and industrial. These days, low-power DC/DC conversion-based applications most commonly use three primary types of power converters: buck, boost, and buck-boost. Due to their widespread use in several industrial applications, DC/DC converters are a crucial topic of research in the fields of power electronics and energy drives Numerous high-tech applications, such as radar systems, DC distribution systems, data centers, and the exploitation of renewable energy, use high voltage gain converters. In the case of renewable energy applications, this is particularly important since high voltage gain DC/DC converters make it possible to enhance the voltage so that it is adequate for integration with the distribution system. DC distribution is the favored option for a wide range of applications because it has several benefits, such as fewer conversion units, lower cost, and improved power quality. The DC-DC converter is the only converter that is used for both energy production as well as consumption. Such converters of power electronics may also have different input and output configurations as single or multi-input and output. Various configurations such as Multi-Input Multi- Output (MIMO), Single Input Single Output (SISO), Single Input Multi-Output (SIMO), and Multi-Input Single Output (MISO) converters are used to cater to different applications requiring specific output levels. By using multiple input sources, energy efficiency and losses are reduced. Typically, such a converter allows in integration of many resources that directly generate DC electricity.**

***Index terms:* DC to DC converter, multi-input converter, multi-output converter, SISO, SIMO, and MIMO**

1. INTRODUCTION

The world is currently looking to electric cars (EVs) to address the pollution issues brought on by vehicles that run on fossil fuels. The growing demand for power production, the decrease in fossil fuel consumption, the need to protect the environment, electrical limitations, and fuel availability have all led to the consideration of new energies. The demand for renewable energy sources is very great in today's society. Most electrical systems are powered by a single kind of energy source, such as utility line electricity, solar, wind, etc. Periodically, systems may draw power from two sources, such as a UPS (Uninterruptible Power Supply). Future systems will have to communicate with various energy sources, including renewable energy sources. Systems of the future will have to connect with several energy sources, with renewable energy sources being especially important. Integrating several sources leads to increased flexibility, dependability, and utilization of chosen energy sources.

In most cases, one source is preferred over the others, or for optimal resource utilization, many sources should be combined simultaneously. This calls for the use of a multiple-input power converter. This new system will be made up of many energy input sources that are combined using multi-input power electronics converters. These converters can handle a range of input sources and combine their benefits to provide a controlled output for a variety of applications.

An electromagnetic circuit makes up a DC-DC converter. This circuit's primary function is to change one voltage differential level that is, voltage to another possible differentiation level. There are periodic variations in both the direct input and output power. For the most effective use of resources, one source is typically preferred over all others, or it is ideal to mix multiple sources at once. For this reason, a multiple-input power converter is required. A DC- to-DC boost converter is a type of power converter that increases the voltage of a lower DC input togenerate a higher DC output. The boost converter stores energy in an inductor when a switching transistor is active and releases it when the transistor is off. A DC-to-DC boost converter with multiple input sources and numerous output loads is known as a multiple input multiple output (MIMO) converter. As a result, the converter can use various power sources and divide the output power across various loads.

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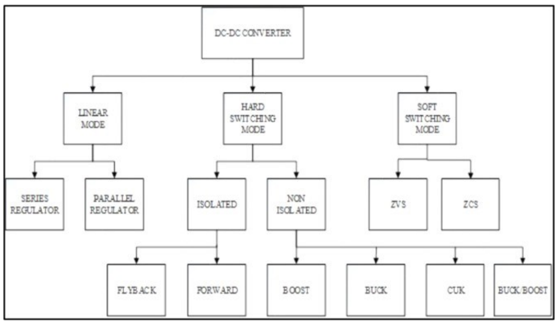

FIGURE 1.TYPES OF DC-TO-DC CONVERTER

2. DIFFERENT TOPOLOGIES OF DC-DC CONVERTER:

DC-DC converters are quite extensively used in alternative energy systems to provide regulated and controlled energy from an unpredictable and uncontrolled source of renewable energy. DC power supply is used for many applications that require a constant voltage. The DC supply sources are Photovoltaic cells, thermocouples, and capacitors [1]. A DC-to-DC converter converts the supply voltage to another DC voltage level required by the load. There are different forms of conversion in the power converters: Electronic conversion and magnetic conversion.

2.1 ELECTRONIC CONVERSION:

Electronic conversion is known as a no isolated circuit. DC-to-DC converters adopt switching technology in electronic circuits The switched DC- DC converter transforms the DC voltage rate by briefly storing the input energy and then releasing it at a specific voltage output. Power conversion is achieved through the components of the magnetic field, such as an inductor, transformers, or elementsof the electrical field such as capacitors. This method of conversion can increase or decrease the voltage level. Conversion switching is more energy-efficient than control of linear voltage, which dissipates unnecessary heat power. A switched-mode converter's high efficiency decreases the necessary heat sinking and improves portable equipment'sbattery endurance. Efficiency has increased with using power FETs that can more rapidly switch to higher frequencies with lower flipping errors, and use less sophisticated drive electronics than power rectifier diodes. Another improvement in DC-DC converters is to use a power FET to replace the flywheel diode with synchronous rectification that has a much lower ' on-resistance,' which reduces the loss of switching [2]. The performance of theconverter is improved by the use of power FETs,which can shift more effectively at higher frequencies with lower switching losses than power bipolar transistors and less complicated drive structures [3]. Many DC-DC converters are intended to move unidirectional from input to output. Switching regulator topologies also be designed for bidirectional power flow by replacing all diodes with separately different controls in regenerative automobile braking, for example, where energy is transferred whendriving to the wheels, but when the tires are provided for braking. Therefore, a bi-directional conversion is more advantageous [4].

2.2 MAGNETIC CONVERSION:

Magnetic conversion is known as an isolatedcircuit. In these DC-DC converters, the energy in a frequency range of 300 KHz to 10MHz is regularly collected and released in an inductor or transformer from a magnetic field. By adjusting the charge voltage's duty cycle, the amount of power transferred to a load can be controlled more efficiently. Thiscontrol can also apply to the input current, the output current, or to keep constant power [4]. The transformer-based converter can insulate the input and output [4]. In general, the DC-DC converter applies to the converters mentioned below. Such circuits are the backbone of the switched-mode powersupply. In general, there are two types of DC-DC converters in the applications of renewable energyapplications.

3. NON-ISOLATED CONVERTERS:

The following are in this category the different types of converters.

- Step-down converter (buck converter)
- Step-up converter (boost converter)
- Buck-boost converter
- Cuk converter

3.1. DC-DC STEP DOWN(BUCK) CONVERTER:

Step down converter is also referred to as a buck converter shown in Fig 2. For generating a lower voltage than the input, a step-down circuit is [4]. The polarities in the input are the same. A switching regulator (break-down converter) is a DC- to-DC power converter that increases the voltage from its input (supply) to its output (load) [5,6]. The switch turns on and, trying to charge it up, allows the flow of electricity to the output capacitor. Since the voltage across the capacitor cannot increase immediately, and since the inductor limits the charge current, the voltage across the capacitor during the switching process is not the power source's maximumvoltage [7]. Now the light is switched off. Since the current cannot quickly change in an inductor, the inductor produces a voltage across it. When the switch is powered off, this voltage is allowed to charge the capacitor and power the load through the diode, maintaining current output throughout the switching cycle [8].

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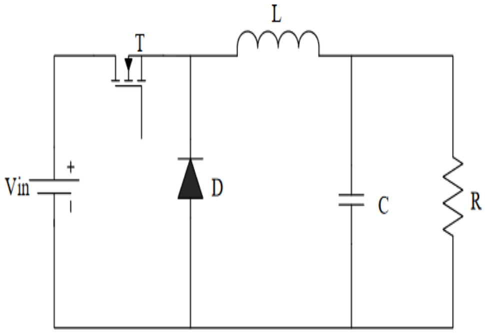

FIGURE 2. BUCK CONVERTER

3.2 DC-DC STEP-UP (BOOST) CONVERTER:

A step-up circuit is used to produce a higher voltage than the input voltage. The input polarities are the same. An inductor in a boost converter can endure current changes by generating and removing a magnetic field [9]. For a boost converter (Fig 3), the output voltage is usually higher than the input voltage [10]. When the switch opens, the current flows through the inductor in the clockwise direction and produces a magnetic field. The magnetic field on the left side of the inductor is positive. Because the impedance is higher, once the switch is released, the current will be decreased [11]. The magnetic field previously made will be lost to hold the current to theload. It reverses the polarity (meaning the left side of the inductor is negative). As a result, two sources in series, creating a higher voltage, will charge the capacitor through diode D.

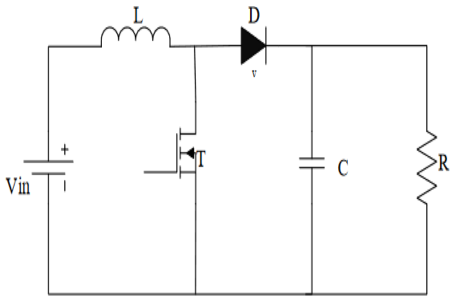

FIGURE 3. BOOST CONVERTER

3.3.DC-DC BUCK-BOOST CONVERTER:

The maximum output in the Buck-Boost Converter (Fig 4) can be increased or reduced, particularly in comparison to the input voltage. This converter either raises the voltage or reduces the voltage [12]. The frequent use of this converter is to reverse the polarity. The source of input voltage is directly connected to the inductor (L)[13]. This leads to energy accumulation in L. At this point, the capacitor is supplying energy to the output load. When in the off-state, the inductor is connected to the output load and condenser, transferring power from Lto C and R.

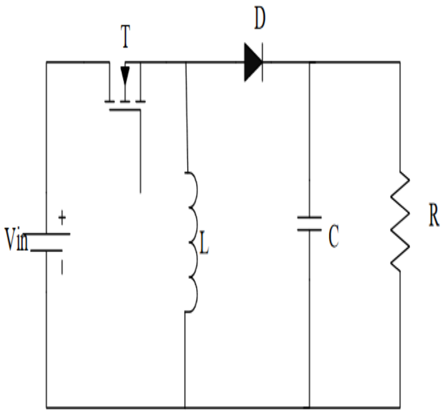

FIGURE 4. BUCK-BOOST CONVERTER

3.4. DC-DC CUK CONVERTER:

In a non-isolated cuk converter (Fig 5), thereare two inductors, two capacitors, a switch (usually a transistor), and a diode. The figure displays the diagram. It is an inverter, so in terms of input voltage, the output voltage is the opposite. The capacitor C is used to transmit energy and is connected alternatelyto the converter input and output by transistor and diode switching [14]. The two inductors L1 and L2 are used simultaneously to convert the origin of input voltage (Vi) and output voltage source (Co) into current sources. In a short time scale, an inductor can be viewed as a current source that holds a constant current [15,16]. This conversion is essential because if the capacitor were attached directly to the source ofthe voltage, the current would be limited only by the parasitic resistance, resulting in a high energy loss [17]. Charging a capacitor with a current source (the inductor) prevents the resistive current from being restricted and the resulting energy loss.

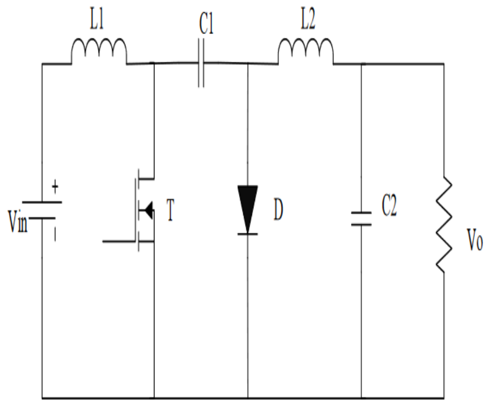

FIGURE 5. CUK CONVERTER

4. DIFFERENT INPUT AND OUTPUT CONFIGURATION:

The non-isolated converter is simple in structure and does not require any isolation. The non- isolated converters are classified into various input and output configurations, Single Input Single- Output (SISO), Single-Input Multi-Output (SIMO),Multi-Input Single Output (MISO), Multi-Input Multi-Output (MIMO).

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4.1. SINGLE INPUT MULTI OUTPUT (SIMO) CONVERTER:

Overall, different single-input DC-DC converters with varying gains of voltage merged to meet the requirements of varying voltage levels, making their system control more complicated and making the corresponding cost more expensive. A single-input multi-output (SIMO) converter (Fig 5) to improve conversion efficiency and voltage gain, and to minimize voltage gain. It took more than three switches, however, for one output This system is only appropriate for the implementation of low voltageand power usage, and hard switching operation degenerates the power conversion. They suggested a new multi-output DC-DC boost converter that can share total output between different low- and high-power output voltage series. The proposed converter utilizes one power switch to execute the high-efficiency conversion targets, high step-up ratio, and varying output voltage levels. In the proposed SIMO converter, the strategies of soft switching and voltage clamping were developed to minimize the conduction and switching losses via the usage of a low-voltage-rated power switch [18]. The power switch to switch on the ZCS property and the leakage inductor effect may mitigate the loss caused by the reverse recovery current. Nevertheless, in the conventional boost converter, the problems of stray inductance energy and reverse recovery currents inside diodes can also be solved so that high-efficiency power transfer.

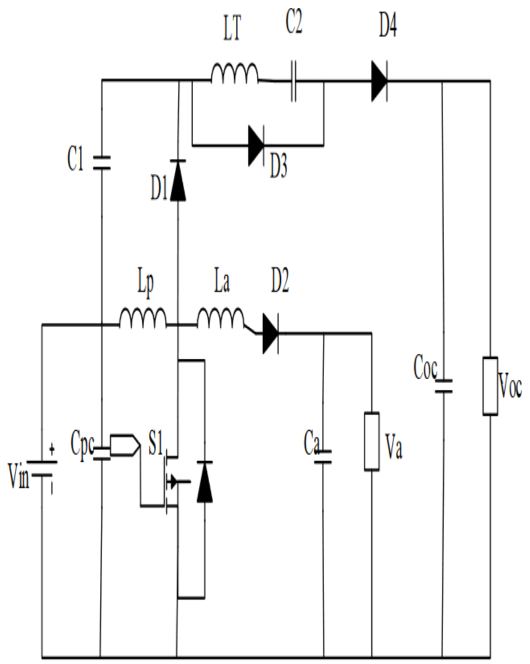

FIGURE 6. SINGLE INPUT MULTI OUTPUT CIRCUIT

4.2. MULTI INPUT SINGLE OUTPUT (MISO) CONVERTER:

Alternatively, MISO converters are designed for parallel yields. Fig 6 represents the MISOconverter. The most critical leeway of these systems is to have free power rates. Nevertheless, for remote control, they have to use such a large number of inductors and switches. It is a significant disservice to related parallel MISO systems. Therefore, structures of the MISO converter are rendered using a single inductor, and subsequently, sources of voltage are worked on consecutively [19]. In this way,sometimes, control of these structures is given. A significant drawback to these systems is the use of power sources that have a typical voltage standard.

Also, the control mechanisms are confused, and the use of a single MISO inductor converter increases enthusiastically. Three power layers limit the use of the MISO converters to acquire the high voltage gain, the generated voltage, and the power stream with two sources of information. By regulating the power flow of inductors connected with input sources, the generated voltage is set to the reference [20]. Constant power flow from input sources cannot be given for this situation as they are employed successively. Luo converters are specially used for high voltage gain, which is expanded byusing a converter layer for each info source. Unlike conventional Luo converters, the immateriality of Luo multi-input converters is more enthusiastic because they need multiple latent components that operate with high voltage rates. The use of DC/air conditioning inverters is another strategy to defeat theinteroperability problem. In these systems, the inverter yields of each source of information associated with a first multi-winding transformer. In this way, the transformer is connected to separate power sources [21]. Different inverters provide power control [5]. The transformer's voltage changes to DC, and then the entire output voltage is moved to DC transport. An extraordinary transformer's prerequisite, however, stands apart as a significant burden on these frameworks.

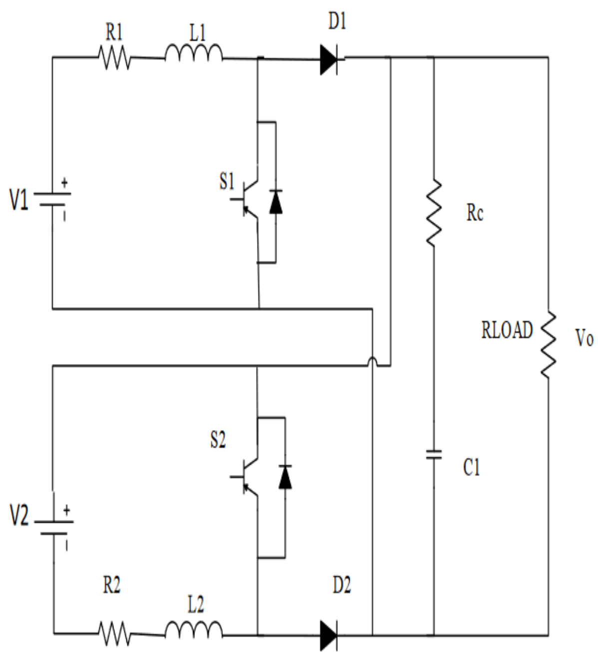

FIGURE 7. MULTI-INPUT SINGLE OUTPUT CONVERTER

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4.3. MULTI INPUT MULTI OUTPUT (MIMO) CONVERTER:

The problem of multiple inputs interfacing for reliable supply can be solved by MISO circuits. There is another problem of load diversity, different loads operate on different voltages thus multiple outputs are also required. This concludes the requirement of a MIMO DC-DC converter. The MIMO ensures a smooth switching of power betweenloads dividing the current of sources which ultimately distributes the power accordingly. And also. High step-up ability, Simple control, Low per-unit peak voltage stress (PPV), and Low voltage gain.

A MIMO converter has numerous DC contributions of various voltages and consolidates other MISO circuits to give different levels [20]. The sole reason for this kind of converter is to run the differentiated burdens.

4.3.1 TOPOLOGY OF MULTIE INPUT MULTIPLE OUTPUT:

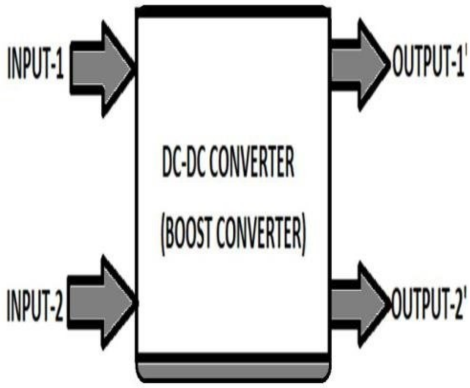


Figure 8. Dc-dc converter blockdiagram

The fundamental design of a DC-DC converter with multiple inputs and multiple outputs isdepicted in Fig. 7. This topology has two input sources (input-1 and input-2) and two output loads. (Outputs 1' and 2'). The boost converter is composed of an inductor (L), a switch (S), a diode (D), and a capacitor (C). Similar to a boost converter with asingle input, the MIMO boost converter operates in the same way.

When the switch S is closed, the inductor L charges up and stores the energy from the input sources. The diode D and the capacitor C allow the energy stored in the inductor L to be transmitted to the output loads Vo1 and Vo2 when switch S is opened. The duty cycle of switch S affects the voltagegain of the converter. To ensure that each input source contributes evenly to the output power when there are many input sources, the converter can be adjusted to balance the power between the inputs.The converter can also be managed to balance power between outputs and make sure that each output load receives the necessary voltage and current in the case of numerous output loads.

As in DC frameworks, there are such sorts of difficulties that require various voltages and flows to run, so by acquiring different yields from a single converter, they can run effectively The MIMO system mainly depends upon the MISO technology. The design is pretty simple, and there is a need to select an output find the duty cycle of a switch, and distribute it accordingly.

Fig 6 shows the circuit diagram of the MIMO converter [21]. The higher s voltage, the lesser the duty cycle. The design is like it's a combination of three MISO converters from the samesource. As of late, miniaturized scale networks with amix of various vitality stockpiling units and sustainable power sources have changed the exploration enthusiasm because of the natural contemplations and unwavering quality prerequisite.

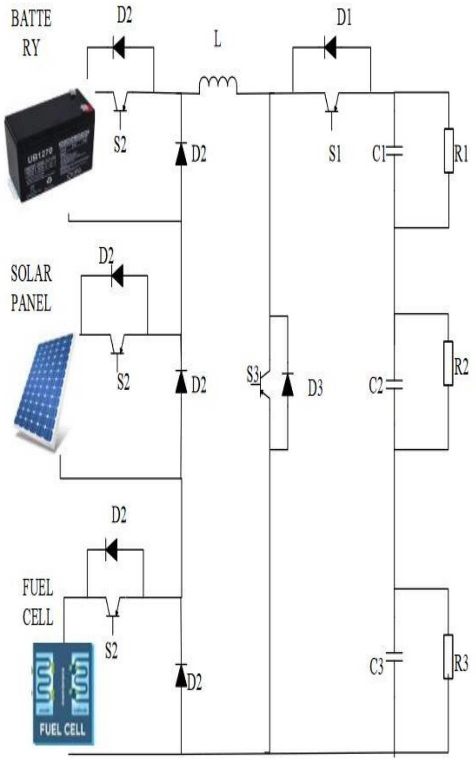


Figure 9. Circuit diagram of mimo converter.

In such conditions, Multi-Port Converters (MPC) assume a crucial job in interfacing and incorporating these vitality sources to supply the heaps. Every subclass is additionally isolated into MISO, SIMO, and MIMO. In the past barely few years, a great deal of research has been done on MPCs. The majority of the specialists propose the MISO converter to join the diverse vitality sources at various voltage levels. The issue in these convertersis that just one source can supply capacity to the heap at a time. A portion of these examines show that their topologies have specific highlights like the MISO can spending plan the power between various vitality sources.

4.3.2. PROPOSED CONVERTER:

The recommended MIMO converter is shown in Figure 6. This image illustrates the input sources (Vi1 and Vi2), output sources (Vo1 and Vo2), and output loads (Ro1 and Ro2). The recommended converter consists of three inductors (L1–L3), four capacitors (C1, C2, Co1, Co2), twoswitches (S1, S2), and four diodes (D1, D2, D3, Do1, Do2).

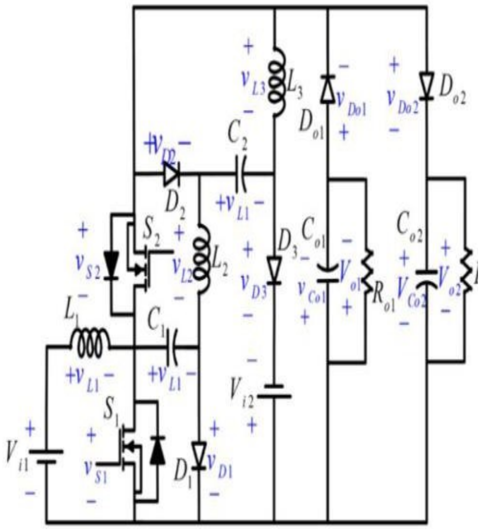


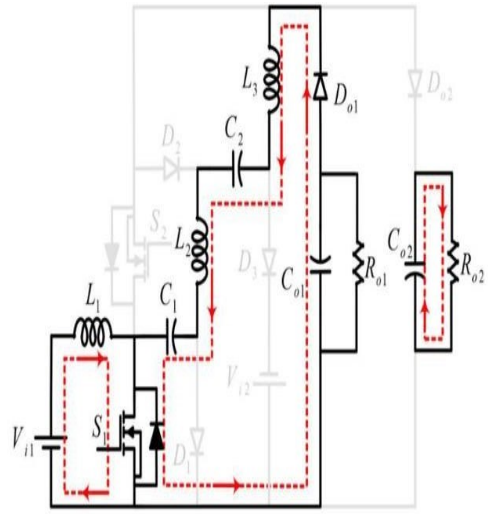
Figure 10. Mimo dc to dc converter

The PWM approach is used to activate the switches, which are arranged in opposition to oneanother. To make the calculations easier, the following assumptions are made: Every diode and switch functions in a steady-state manner; the output voltages (Vo1, Vo2) are constant; the values of L2 and L3 are equal (L2 = L3); all capacitors have constant voltages due to their high capacitance.

4.3.1.1. DIFFERENT MODE OF CONVERTER:

1. First Mode of operation
2. Second Mode of operation

1. FIRST MODE OF OPERATION:



IGURE 11. THE FIRST MODE OF OPERATION

At the start of this time interval, switch S1 conducts, and switch S2 remains non-conducting. As of right now, the related Tone is used to illustrate a time interval. The inductor L1's current increases linearly as a result of its direct connection to the first input voltage source (Vi1), increasing the quantity of energy stored in L1. Do1 is directly biassed, while thediodes D1, D2, and D3 are also reverse biassed. Consequently, the output load currents are suppliedby the inductors L2 and L3, which are coupled in series by capacitors C1 and C2, and they also charge the output capacitor Co1. C1, C2, L2, and L3 progressively release less of their stored energy to do this.

2. SECOND MODE OF OPERATION:

In this configuration, switch S2 is conducting and switch S1 is off. From now on, the previously indicated time frame is denoted as To f. The two input sources for the circuit, Vi1, and Vi2, supply power to the circuit in this mode. Do1 is the only diode that is not directly biased.

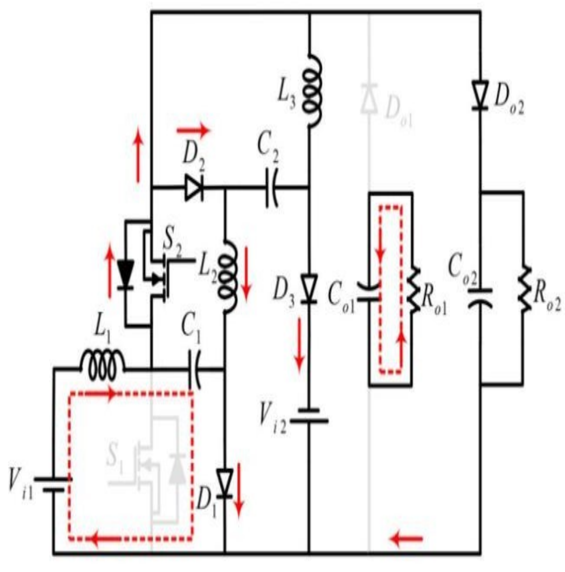


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Figure 12. The second mode of operation

Consequently, the inductors L1, L2, and L3 as well as the capacitors C1, C2 are connected. The result is a dramatic drop in current from the peak value to the bottom value as the energy that waspreviously stored in L1 is transferred to the inductors L2, L3, and capacitors C1, and C2. Therefore, the current flowing through L2 and L3 increases dramatically from its lowest value to its maximum value.

5. CONCLUSION:

This paper aims to review the wide varietyof multi-input DC-DC converters in different aspects. These converters are used especially for providing continuous power supply to various applications like hybrid vehicles, DC microgrids, nano grids, battery chargers, etc. Among many converters as discussed in this paper, Multi-input and Multi- output converters have different features and are widely used in many applications efficiently. In the MIMO converter, a single inductor and the least number of switches have been used to increase efficiency and reduce size and cost. The multiple inputs are various renewable sources so that energy consumption from non-renewable energy has been reduced. This converter boosts the input and pretends the battery acts as input or output. The construction and advantages over other converters have been discussed in this paper. This type of multi-input DC-DC converter would be used for empirical research and commercial applications.

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