Design procedure of multiple input converters

Kavita Tamboli[1], Naveen Goel[1]

[1]*Dept. of Electrical and Electronics Engineering, SSTC Bhilai, CG, India*

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Abstract: - It is suggested to use a multiple input boost converter with high voltage gain. The photovoltaic uses for this converter are possible. This converter allows the simultaneous extraction of continuous current from multiple sources. The converter's steady state analysis is presented. To take in the most electricity possible from each solar panel both individually and collectively, the MPPT algorithm is used. The converter under consideration may increase voltage by up to 20 times while keeping input current constant. In a simulation environment, the proposed converter's open loop steady state operation is verified.

Keywords— Boost converter, multiple-input converter (MIC), transformer-less converter, DC-DC converter.

1. INTRODUCTION

The use of renewable energy sources and the development of power electronics systems for harnessing related energy sources have seen a surge in interest over the last 10 years. Common renewable energy sources include solar energy, wind energy, and hydropower. In that they can be employed simultaneously to maintain continuous power delivery to the demand, several of these sources are mutually complementing. It turns out that different independent single-input converters can link different renewable energy sources to a common dc bus, and such configurations have been proposed for hybrid power systems [1], [2]. However, the design becomes very complex and expensive when many single-input converters are used. In order to simplify and reduce the cost of hybrid power systems, the use of a multiple-input converter (MIC) in favour of several single-input converters has recently attracted a lot of attention. II. Converter Topology Synthesis A single load can receive electricity from a number of power sources through the MIC. The fundamental MIC was developed by deriving it from a buck converter and connecting multiple dc-input voltage sources in parallel with the original dc-input voltage source [3], [4]. Because the available dc voltage sources have various magnitudes and cannot therefore be directly connected in parallel, only one power source is allowed to deliver energy to the load at a time. This prevents more than two dc voltage sources from being connected in parallel. Instead, a series-connected active switch is used to connect the dc voltage sources in parallel. Flyback, forward, and buck-boost converters have all exploited this connection of the dc-input voltage sources [5, 6, 7], [8]. The multiple-input forward converter can be thought of as an isolated multiple-input buck-derived converter with an isolation transformer. The primary windings of each dc-input voltage source are different, but they all share a secondary winding with active switches connected in series. It is possible to compare the isolated buck-boost converter with multiple inputs to the flyback converter with multiple inputs. Such MIC controls frequently start with a time-multiplexing technique. In order to get over the constraints of the time-multiplexing approach, some MICs have been devised that may be used to transport power from the various voltage sources to the load individually or concurrently. In order to minimise the amount of passive components, the MIC suggested in [9]–[11] combines a buck converter and a buck-boost converter while sharing an inductor and capacitor between the two converters. The MICs suggested in [12]-[14] are built on a foundation of boost converters and buck-boost converters that are connected in parallel at their outputs. The advantages of having fewer devices and elements are absent in such MICs. However, the isolated multiple-input full-bridge boost converters [15]–[18] and the multiple-input half-bridge boost converter [19] share the output rectifier using a multiplewinding transformer. A thorough process for creating MIC topologies was laid out in [20]. The six basic nonisolated converters—the buck, boost, buck-boost, Cuk, Zeta, and SEPIC converters—were used as pulsing source cells (PSCs), and the concepts of pulsating voltage-source cells (PVSC) and pulsating current-source cells (PCSC) were introduced. The recommended approach includes including these PSCs alongside the six basic non-isolated converters. The input sources of the resulting nonisolated MICs can deliver the energy to the load separately or simultaneously. The topologies generated by this method do not provide isolation, nor do they take into consideration topologies having a time-multiplexing control scheme.

For identifying the potential input cells that realise MICs from their single-input converters, a number of assumptions, limitations, and requirements were put out in [21]. Based on these assumptions, limits, and conditions, the extended set of nonisolated single-input converters provided in [22] was validated, and the viable input cells were found. These viable input cellswere used to create a number of MICs. The resulting MICs were managed using the time-multiplexing techniques.

The purpose of this article is to offer a methodical approach to MIC creation. We examine two distinct MIC kinds. The first only allows one power source to transfer energy to the load at a time, but the second allows all input sources to supply power to the load either concurrently or individually.

Additionally, the connections between the current MICs will be made clear.

The structure of this essay is as follows. The fundamental cells for creating dc-dc converters are covered in Section II. The rules for connecting PSCs are presented in Section III, and Section IV generates the MICs using these criteria. In Section V, conclusions are provided.

2. BASIC CELLS OF SINGLE-INPUT CONVERTERS

As shown in Fig. 1, each fundamental single-input dc-dc converter can be divided into two basic cells: a PSC and an output filter cell (OFC) (a). PVSCs and PCSCs are the two different types of PSCs. Given that the PVSC produces pulsating voltage, the corresponding OFC should be a voltage-type low-pass filter, which is essentially composed of an inductor and a capacitor. LC-OFCs are this type of OFCs. Similar to how the PCSC supplies pulsating current, the corresponding OFC should be a current-type low-pass filter, which is simply achieved by a capacitor. One variety of OFC is the COFC. The arrangements of a PVSC followed by an LC-OFC and, accordingly, a PCSC followed by a COFC, are shown in Figs. 1(b) and (c).
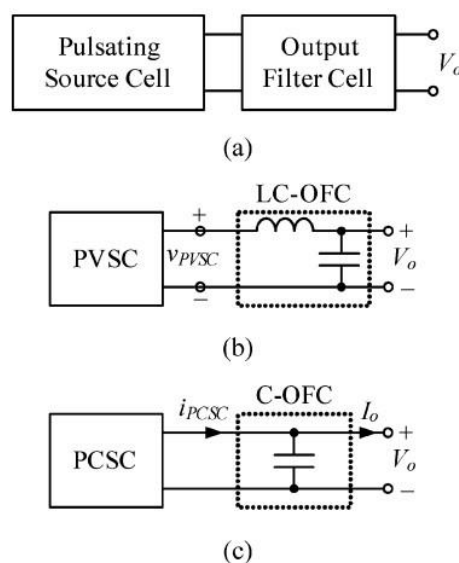

Fig.1 Configurations of single-input converter. (a) General configuration. (b) PVSC followed by LC-OFC. (c) PCSC followed by C-OFC.

3. BASIC RULES FOR CONNECTING PSCS AND OFCS

We begin by going through the two main limitations that Kirchhoff's rules place on integrating independent sources [24]. First off, parallel connections between two or more independent voltage sources are not possible due to Kirchhoff's voltage law. Second, it is impossible to connect two or more independent current sources in series, in defiance of Kirchhoff's current law. Any synthesis regulations for MICs that mix multiple PSCs will be subject to these fundamental limitations.

A list of the synthesis procedures is provided below.

Combination of Pulsating Sources

The kind of pulse sources being brought together determines the proper Kirchhoff's law, which is then utilised to define the connection style. Basically, many PCSCs, which are primarily current sources, can be connected in parallel, and many PVSCs, which are primarily voltage sources, can be connected in series (b). It is clear that depending on the switching configuration, PVSCs in series and PCSCs in parallel can both produce electricity simultaneously.

Furthermore, as PVSCs are switching source cells, connecting them in parallel is possible without breaking Kirchhoff's rules, provided that they are not simultaneously delivering power, which would result in a direct parallel connection of voltage sources. In other words, assuming the appropriate switching configuration is in place, PVSCs can also be connected in parallel, as shown in Fig. 2. (c). Similar to this, as PCSCs are switching source cells, they can theoretically also be connected in series.

Given that the PCSCs do not provide power concurrently, current sources can be connected directly in series without deviating from Kirchhoff's principles. The current sources in PCSCs, including the independent and intermediate storage ones, are achieved by an inductor behind a voltage source, despite the fact that they are not perfect current sources. For instance, we would need to turn on Q so that the input voltage would charge the inductor to saturation and destroy the boost PCSC in order to stop the boost PCSC in Fig. 3(a) from sending energy to the load. Therefore, it is impossible to connect PCSCs in series in practise. We can offer the following potential relationships as a conclusion.

Connection Rule 1: Several PVSCs can be connected in series to give power concurrently or one at a time, whereas several PCSCs can be connected in parallel. The resulting MICs enable the supply of power from all input sources to the load either singly or concurrently, as was already described.

Connection Rule 2: With the appropriate switching configurations, several PVSCs can be linked in parallel and give electricity one at a time. A diode connected in series with the switch or a switch that is explicitly unidirectional must be used in a nonisolated PVSC.

The several linked PVSCs in Fig. 2(a) and (c) can be seen as a single PVSC, it should be highlighted.. The numerous connected PCSCs depicted in Fig. 2(c) can also be viewed as a single PCSC.

In actuality, more than one PCSC can be connected in parallel to a PVSC, and this PSC configuration acts as a

voltage source. However, each parallel-connected PCSC would not function independently if the PVSC or combined circuit failed. Similar to a current source, a series connection between multiple PVSCs and a PCSC behaves similarly and would fail if the PCSC failed. As a result, such PSC combinations do not result in efficient MICs.

3.2 Cascade of PSCs and OFCs

We begin by assuming that the OFC is the last cell to supply the load with constant dc voltage. We have two basic types of OFCs, the LC-OFC and C-OFC, as discussed in Section II.

When a voltagesource-capacitor loop is closed or opened, switching creates an incompatible boundary state that
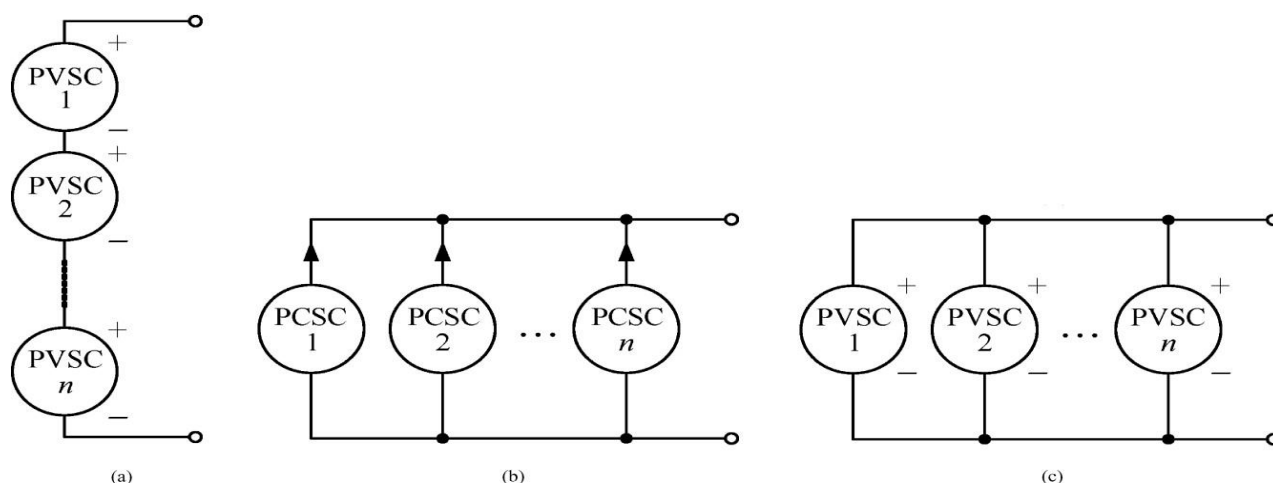

Fig. 2 Configurations of (a) multiple PVSCs in series, (b) multiple PCSCs in parallel, and (c) multiple PVSCs in parallel with appropriate switching arrangement to ensure each PVSC delivering power individually.
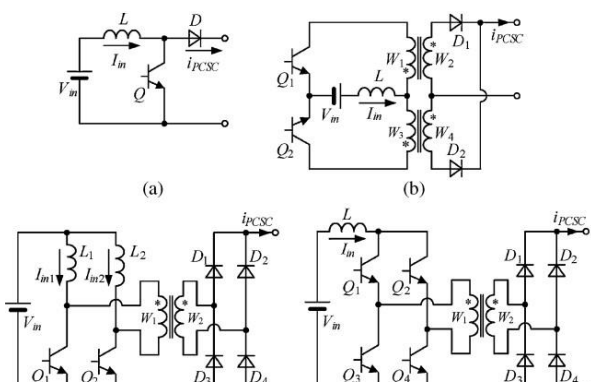

Fig.3 Configurations of single-input converter. (a) General configuration. (b) PVSC followed by LC-OFC. (c) PCSC followed by C-OFC.

leads to unending current or voltage impulses, according to fundamental circuit theory. Pulsing sources should be connected to the right kind of buffer cell in order to transfer power without creating incompatible switching conditions (storage element). Switched current can only interact with capacitive storage to prevent switching a current-source-inductor cutset, and switched voltage can only interface with inductive storage to prevent switching a voltage-source-capacitor loop.

The LC-OFC should be used to filter the voltage delivered from a PVSC and the C-OFC should be used to filter the current delivered from a PCSC when connecting a PSC with an output filter.

The potential links between PSCs and output filters are outlined in the following rule
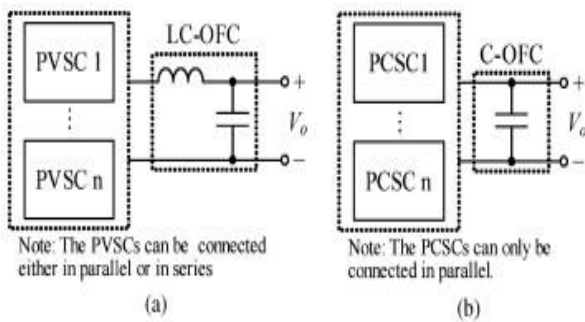

Fig.4 Block diagram of MIC topologies. (a) Combined PVSCs followed by LC-OFC. (b) Combined PCSCs followed by C-OFC.

Relationship Rule 3: A component of an MIC that is required is an output filter. Power from a PVSC should be filtered using an LC-OFC, and power from a PCSC should be filtered using a C-OFC.

4. SYNTHESIS OF MULTIPLE-INPUT CONVERTERS

A PSC is first connected to each power source. After that, several PSCs are aggregated and electricity is sent to the load via an output filter. In Fig. 4, a block diagram is displayed.

Three types of MICs can be derived for the two different PSCs, namely the basic and hybrid PSCs, by connecting the resulting voltage or current to the right output filter. To make things simpler for the example, MICs are created by combining just two PSCs.

4.1 Synthesis of MICs With Basic PSCs

The synthesis procedure of this type of MICs takes the following steps.

Step 1: Choose PSCs from Figs. 2 and combine them according to connection rules 1 and 2.

Step 2: Cascade the combined PSCs with the appropriate output filter, according to connection rule 3.

Three groups of MICs are produced from the aforementioned procedure, depending on the connection style of the PSCs, as shown in Fig. 2.
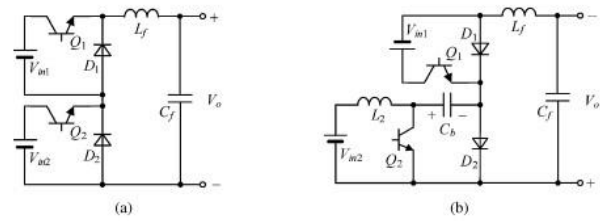

Fig.5 Typical derived MICs generated by seriesconnection of (a) two buck PVSCs, (b) one buck PVSC and one Cuk PVSC
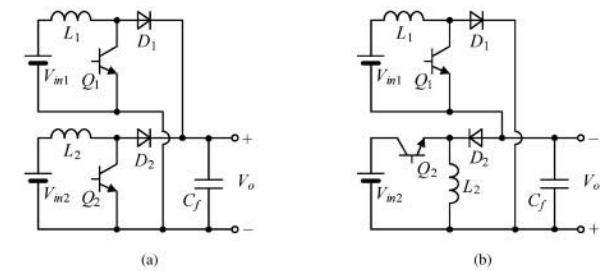

Fig.6 Typical derived MICs generated by parallel connection of (a) two boost PCSCs, (b) one boost PCSC and one buck–boost PCSC.

As illustrated in Figs. 2-4, there are many basic PVSCs that can be coupled in series with one another or other PVSCs to create a variety of MICs. Six representative MICs are shown in Fig. 5.

The first two MICs are shown in [20], and the remaining two are produced by connecting a buck PVSC in series with another buck PVSC, a Cuk PVSC, and a full-bridge PVSC, respectively.
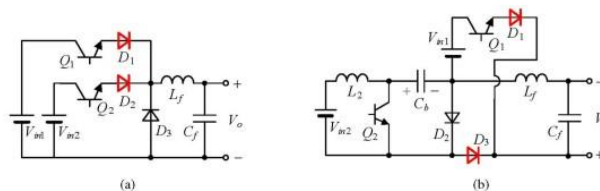

Fig.7 Typical derived MICs generated by parallel connection of (a) two buck PVSCs, (b) one buck PVSC and one Cuk PVSC.

The basic PCSCs can also be coupled in parallel with one another or other PCSCs, as shown in Figs. 5-7, to create a variety of different MICs. Six typical MICs are shown in Fig. 6. The ones shown in Fig. 6(a)–(b) are produced by connecting two identical PCSCs in parallel, such as two flyback PCSCs, two half-bridge PCSCs, and two full bridge PCSCs.

Six exemplary MICs produced by paralleling two PVSCs are shown in Fig. 7. The PVSCs only retain one freewheeling diode; the others can be removed because they are superfluous. A diode should be placed in series with each switching network in line with connection rule 2 to prevent voltage sources from being connected directly in parallel. In Fig. 7(a), two buck PVSCs and one freewheeling diode D3 are connected in parallel, and the diodes D1 and D2 are added in series with Q1 and Q2, respectively. In Fig. 7(b), a buck PVSC and a cuk PVSC are linked in parallel, with D2 acting as the freewheeling diode and D1 and D3 acting as the buck PVSC and cuk PVSC's respective series diodes, respectively..

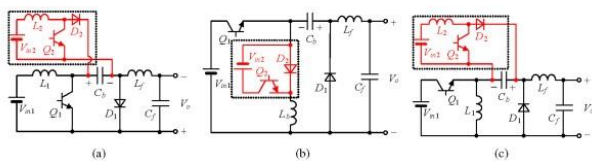The MICs in Fig. 14 allow all input sources to send power to the load either separately or simultaneously, in contrast to the MICs in Figs. 5 and 6, which only allow one power source to transfer energy to the load at a time.

It should be noted that there are additional alternatives for choosing voltage conversion ratios in the MICs created by Types II and III PCSCs or Types II and III PVSCs. The fundamental advantage of these MICs is that the output voltage can differ from the input voltage in either direction.

4.1 MIC Synthesis using Hybrid PSCs

The same synthesis process can also be used to create MICs with hybrid PSCs. A hybrid PSC with two input sources and one output filter is required to produce a two-input converter topology. As depicted in Fig. 8, the hybrid PSC feeds power to the load through an output filter. Such MICs were suggested in [20].
hybrid PSCs all have at least four input sources. C. Basic PSC and Hybrid PSC Synthesis of MICs

Connection rules 1 and 2 also allow for the creation of new MICs by combining a number of basic PSCs and a number of hybrid PSCs. The circuit designs for MICs depicted in Fig. 10 are made by connecting a buck PVSC in series with two more PVSCs—a boost-and-Cuk PVSC and a buckand-Zeta PVSC, respectively—and finishing each with a cascade LC-OFC stage.

The boost PCSC is connected in parallel with the buck-and-buck-boost PCSC, the boost-and-boost-SEPIC PCSC, and each is completed with a cascade C-OFC stage to produce MICs.

Fig.8 MICs generated by one (a) boost-and-Cuk PVSC, (b) buck-and-Zeta PVSC, (c) boost-and-Zeta PVSC.

Fig. 10 Circuit configurations of MICs generated by series connection of one buck PVSC and one boost-and-Cuk PVSC.
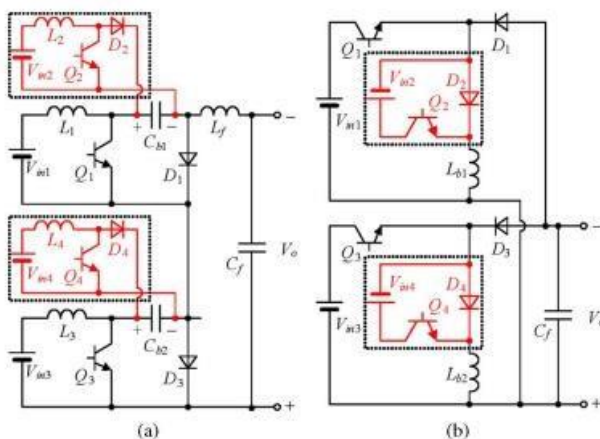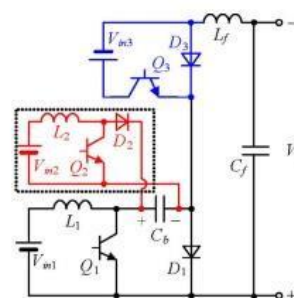
Fig.9 MICs Circuit (a) two boost-and-Cuk PVSCs in series connection and (b) two buck-and-buck–boost PCSCs in parallel connection

Similar to the synthesis of MICs using basic PSCs, several hybrid PSCs can be coupled to produce MICs in line with connection rules 1 and 2. Fig. 9 shows the configuration of a MIC created by two boost-and-Cuk PVSCs coupled in series with an LC-OFC (a). A C-OFC stage, two parallel-connected buck-and-buck-boost PCSCs, and a MIC are shown in Fig. 9(b) setup. Because the hybrid PSC contains various input sources, the MICs generated by different

where the diodes D1 to D4 act as the rectifier diodes, freewheeling diodes, and series diodes. Therefore, no other freewheeling diode is needed.

VII. CONCLUSION

An organized process for creating various input converters has been outlined in this study. The building blocks for the synthesis of multiple-input converters have been proposed as a collection of basic and hybrid PSCs, as well as output

filters. A collection of connection rules that can be used to methodically derive multiple-input converters is proposed. Although they are more complicated than multiple-input converters without intermediate storage, converters with intermediate storage have the advantage of having a wider range of voltage conversion ratio options. Additionally, multiple-input converters with isolation can be made simpler, which improves their functionality and usability.

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BIOGRAPHIES

Kavita Tamboli
M.Tech student in [1]Dept. of Electrical and Electronics Engineering, SSTC Bhilai, CG, India