Journal of Basic and Applied Engineering Research
p-ISSN: 2350-0077; e-ISSN: 2350-0255; Volume 2, Issue 23; October-December, 2015, pp. 2004-2008

http://www.krishisanskriti.org/Publication.html

Higher order Multipurpose DC-DC Converter for Agricultural System

Daniel T Varghese[1] and Arun S[2]

[1,2]Amal Jyothi College of Engineering
E-mail: [1]danibethelveedu@gmail.com, [2]sarun@amaljyothi.ac.in

Abstract—*The energy demand in our country is fast rising. The best possible solution to meet this issue is by promoting the use of renewable energy systems. Majority of the existing irrigation system in agriculture sector in our country is based on conventional fuels like diesel and kerosene. The project proposes a system which can replace all the existing diesel pump sets in the agricultural sector in the country. A higher order DC-DC converter is used for renewable energy application with single boost and multiple buck outputs. The converter is capable of producing simultaneous multiple buck output without affecting the boost operation. The proposed one is analyzed in detail using Simulink model of the proposed system in MATLAB. The entire control section of the proposed system is realized using PIC microcontroller. The system proposed is reliable, economical and convenient to use and has been validated using simulation results. The prototype of the system was setup and was subjected to lab testing.*

1. INTRODUCTION

The renewable energy sector is growing rapidly and it is becoming significant in the world today and in the future. Now in the current scenario every country is largely investing in this sector to meet the rising power demand. Wind energy conversion system and solar PV are the most important area in the field of renewable energy and has attracted lots of research. In the past years, wind energy and solar power generation systems have attracted attention due to the energy crisis and environment pollution. Power generation from these systems can mitigate effectively environmental issues such as the greenhouse effect and other environmental problems. One major problem with wind energy system and solar PV systems is that the electrical output power depends on the weather condition, these two source of energy are intermittent power sources [1]. Another major problem in this sector is that, due to this intermittent availability of energy there is lack of availability of continuous power, so a battery connected system is the best option. Thus stand-alone system is considered as effective method for small scale power production.

Wind energy as well as solar energy are clean renewable energy sources, and they are one of the most rapidly growing markets in all the countries [1]. Wind energy promises to be a significant contender in the near future, yet the variability of wind speed, and therefore the inability to control the amount of energy generated, remains a basic problem [1]. Similarly the availability of sunlight all time is also a major problem. All works in technological research areas are of public interest or a community's social issue. Many research are there in the field of agriculture, all these work in some way help the farmers. Similarly this work is also addressing a serious issue that the farmers are facing. One obvious issue that has risen in recent years is the over dependence of diesel pump for farming [2].

2. LITERATURE REVIEW

The fast depletion of fossil fuel and increasing pollution rate is a serious concern in the recent past. The use of renewable energy have become most effective source of energy. But the major challenge in integration of these renewable sources is its intermittent nature and cost. PV is one of the most effective renewable energy sources. But it is not available at night time. On the other side wind is also very intermittent [2]. However, the solution of this problem can be the use of hybrid systems like wind-solar, wind-hydro, solar-hydro etc. This ensures the requirement of two renewable energy sources. Therefore, to make this kind of hybrid system more reliable and cost effective, there must be some energy storage devices to store the available energy as much as possible. Battery and super capacitor are used for storage purposes. The important advantage of battery over super capacitor is its high energy density [2]. They can store at least 3 to 30 times more charge than super capacitor. Whereas, super capacitors are able to deliver hundred to thousand time more power than a similar sized battery. So battery is able to supply long term energy demand and super capacitors are essential to meet transient load demand.

3. EXTERNAL SURVEY

When considering the southern part of India, Tamil Nadu is the place where most people engage themselves in agricultural sector. Most of the people living there are farmers and have got large farm lands constituting large acres. Field surveys were conducted in three districts of Tamil Nadu, which

include Thirunelveli, Thoothukudi and kanyakumari. In and around 50 farmers where taken for surveys, personal in depth interviews were conducted with these farmers. The surveys report of the three districts which includes Thirunelveli, Thoothukudi and Kanyakumari is briefed in Table 2.1. There is a sole reason for choosing these three districts, first reason is the welcoming climatic condition for renewable energy system. For instance one of the field survey include areas of Arvalmozhi which is the second windiest place in India. And due to the topographical location of these district they are good source for utilization of solar energy. Let us see the separate survey reports of three district in detail.

TABLE 2.1: Field Survey Report Thirunelveli

Place	No of Farmers	Average Farmland	No of Diesel pump /acre	Type of crops
Karangulam	4	5-10 acre	2	Rice
Naguneri	7	3-5 acre	3	Banana
Panaikkudi	6	7-10 acre	2	Rice

4. EXISTING PRACTICE

Our Indian agricultural sector is still leaving in the past and there is not much developments in these areas basically because of the lack of knowledge of the farmers. Most of them are outdated systems. Here are some of the existing systems used in our agricultural fields.

Fig. 2.1: Diesel Pump in Rice Field

The Fig. 2.1 shows the schematic of the conventional system being used. The traditional system that is used in agriculture sector is a diesel pump sets for water pumping. It is purely an outdated system. During the survey on the three districts many farmers where identified who were using diesel pump sets. The Fig. 2.2 shows a Diesel pump set that is used in a rice paddy field and Fig. 2.3 shows s Diesel pump set in banana field. Likewise most of the farmers in India are using such kind of conventional outdated systems in their agricultural field. During the dry season the pumps are used for 24 hours for irrigating the fields. Some farmers use them intermittently depending upon the level of water in the field. Some farmers are cultivating seasonal crops so the use of pump for irrigating these fields are immense. So it is clear from the survey that these pump sets are to be replaced with some alternatives.

Thus after serious analysis and studies conducted on DC-DC converter the main problem has been identified for the DC-DC converter in our proposed system and it is as follows

An efficient upgradable converter with multiple output and multipurpose usage need to be developed for the proposed system. This is an up hilling and challenging task that need to be achieved with the help of new converters. Also the circuit should not compromise its efficiency for any aspect

The topology discussed provide one step-up and multiple step-down outputs. The topology is synthesized by replacing the control switch of a boost converter topology with series-connected switches and using the additional switch nodes to generate step-down dc outputs [14].

Compared with other converters, these topologies utilize a lower number of switches and are more reliable due to their inherent shoot-through protection. Analysis shows that the topologies exhibit similar dynamic behaviour as individual buck and boost converters. Hence, the control system methodology is the same as that of separate converters, with each output being precisely regulated.

5. HIGHER ORDER CONVERTER

The apt substitute for the diesel pump systems in the agricultural irrigation system is a solar PV renewable energy system with multiple battery charging system and a simultaneous boost output. The converter used for the system is a modified higher order converter. The following sections briefs the working of the higher order converter.

The Fig. 3.1 represent a schematic of the proposed system. It consists of basically four section

- Source: It can be either be wind or Solar depending on the climatic condition existing at the locality.
- Converter: This section constitutes the DC-DC converter , inverter and battery and this in this the main part is an efficient DC-DC converter, without which the entire system is an absolute failure, so detail study on this part is conducted in the coming sections.
- Loads: We can connect both AC and DC loads in the system. The preferable DC load is dryer system for the crops and the AC load will be Pump for the respective farm field.
- Controller: The main heart of the system is this control part which governs the operation of all the above system

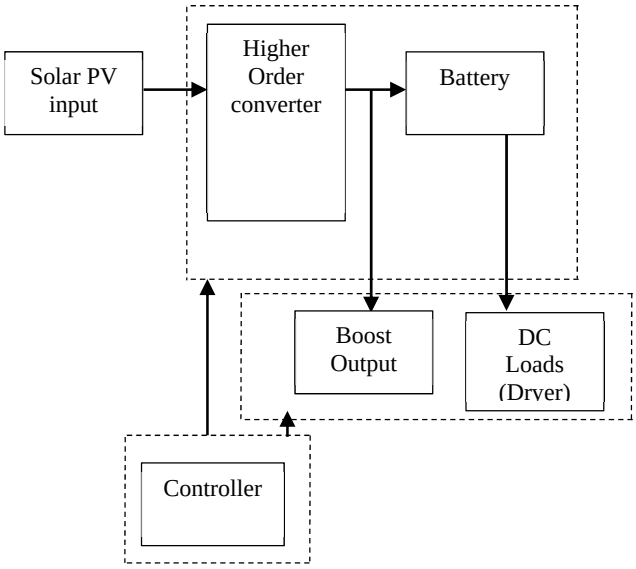

Fig. 4.1: Proposed Schematic

6. DC-DC CONVERTER

The modified higher converter is shown in Fig. 3.2.The circuit consists of one boost output and one buck output. The circuit is more reliable to give higher boost outputs.

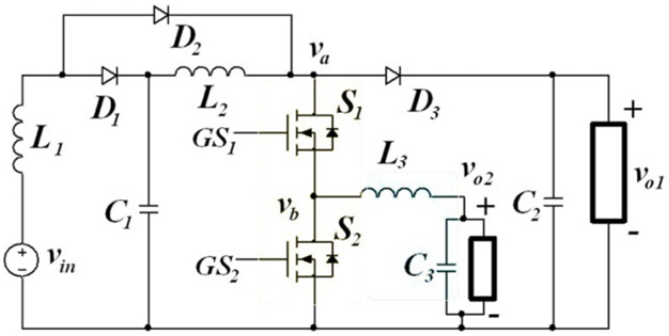

Fig. 5.1: Higher Order Converter

The circuit operation is explained with the help of three operating modes which are Mode 1(S1,S2 ON), Mode 2 (S1 ON S2 OFF), Mode 3 (S1, S2 OFF).

Mode 1: S1 and S2 ON

This interval is similar to conventional boost mode. Now in the cascaded section double boosting occurs the two inductors charge to a higher value and makes in getting high voltage gain. This mode can be analysed further by making use of a cascaded boost converter analysis.

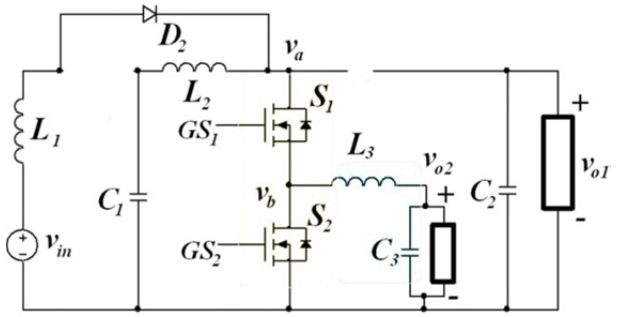

FIG. 5.2: Mode 1

Mode 2: S1 ON S2 OFF

During this interval, the current from the cascaded section is distributed into two components: One is flowing through diode D3, and the other portion is equal to the buck inductor. The step-down converter draws energy from the source during this interval.

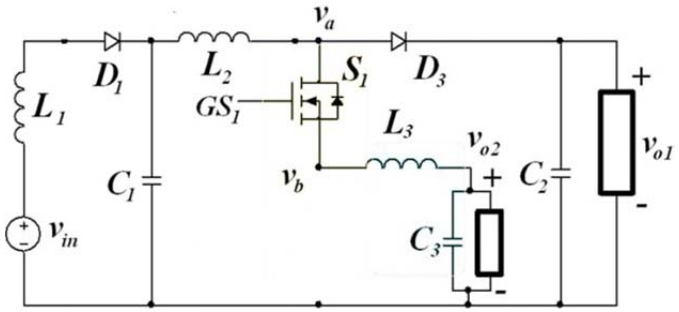

Fig. 5.3: Mode 2

Mode 3: S1 OFF S2 OFF

In this interval, the inductor current in buck inductor L3 freewheels through switch S2 or through its antiparallel diode (if S2 is not being gated). This interval is thus analogous to the free wheel period associated with conventional buck converters, either the lower switch conducts in synchronous switching scheme or the diode conducts. Diode D3 conducts the boost inductor current. Hence, both inductors give out their energy to their respective outputs.

$$\frac{V_{02}}{V_{in}} = \frac{V_{02}}{V_{01}} * \frac{V_{01}}{V_{in}} = \frac{D_2}{(1-D)^2}$$

7. HARDWARE SETUP

A prototype of the existing integrated converter and the proposed higher order converter were developed. The two systems where tested under lab setup and analysis were conducted and the comparative studies are explained below.

For Hardware analysis the two circuits were subjected to two conditions open circuit and under load condition. The testing

was also carried out with 20W solar PV panel as source.The two prototypes were made to work under load conditions and open load conditions with PV source as input. The following Fig. 6.1 shows the prototype of the Higher Order converter.

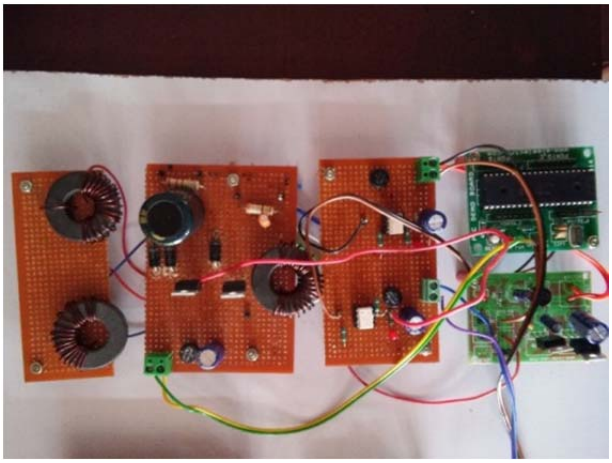

Fig. 6.1: Hardware of Higher Order Converter

The circuits where subjected load and the analysis where carried out in that perspective. The Fig. 6.2 shows the circuit testing under load condition. A 12V battery was connected as buck load and incandescent bulb as boost load.

Fig. 6.2: Hardware Testing

The following Table 6.1 shows the observations of Higher Order converters under load conditions.

Table 6.1: Hardware Observations

Irradiance (W/m^2)	P_{in} (W)	P_{out} (W)	Efficiency (%)
116	18.69	19.53	95.6
150	17.53	18.92	92.6
250	16.5	18.87	87
396	16.93	19.1	88
681	15.8	19.1	82

Thus from the above analysis under load and no-load condition the higher order converter is more efficient than the integrated converter.

8. CONCLUSION

The alternative system which works on renewable energy source is the best suited replacement for diesel pump sets which are now used in various farm fields of south Tamil Nadu. The heart of the project lies on the multiple output and multipurpose DC-DC converter which is an integrated high end converter which can be used for other industrial applications as well. The converter suits all the customer requirements.

It can be regarded as the best in the present class of existing converter due to the following reasons

- The wide operating range and effective load handling capabilities.
- The higher voltage gain of the higher converter improves the boost output and make the system more efficient for the boost output.
- And due to the improved voltage gain of the boost system it has improved the system overall capacity to work at multiple buck output voltage levels which are respectively used for the charging of batteries.
- The converter has less amount of ripple in the output voltage so less filter requirement.

Thus we can conclude that the objective to have an economical and efficient multiple output multipurpose converter for small wind and solar powered system have been rightly achieved.

REFERENCES

[1] V I Cherian, Daniel T Varghese,, " Analysis and study on small hydro wind systems" International Journal For Technological Research in Engineering, Vol 2, No:8, April 2015

[2] Chetan Singh Soalnki:, " Solar Photovoltaics" PHI Learning Pvt Ltd, Fourth edition, Haryana,2013

[3] E. Koutroulis and K. Kalaitzakis:," Novel battery charging regulation for Photovoltaic systems" IEEE Proc.-Electr. Power Appl., Vol. 151, No. 2, March 2004.

[4] M. Druga, C. Nichita:, " Stand Alone Wind power System operating with specific storage structure", International Conference on Renewable Energies and Power Quality, April 2009

[5] Herminio Martínez-Garcia, Haritha Eachempatti :,"On Chip SIDO Buck converter with independent outputs" Conference on the Design of Circuits and Integrated Systems, Nov 2013

[6] Massimiliano Belloni, Edoardo Bonizzoni:,"Single inductor multiple output DC-DC converter"

[7] Olive Ray, and Anil Prasad Josyula, "Integrated Dual output converter," *IEEE Trans. Ind. Electron.*, vol. 62, no. 1, pp. 4500–4511, Jan 2015.

[8] F.L. Luo and H. Ye:, “Postive output cascaded boost converters” IEE Proceedings, Sep 2003.

[9] P. Shamsi and B. Fahimi, “Dynamic behavior of multiport power electronic interface under source/load disturbances,” *IEEE Trans. Ind. Electron.*, vol. 60, no. 10, pp. 4500–4511, Oct. 2013.

[10] A. Emadi, Y. J. Lee, and K. Rajashekara, “Power electronics and motor drives in electric, hybrid electric, plug-in hybrid electric vehicles,” *IEEE Trans. Ind. Electron.*, vol. 55, no. 6, pp. 2237–2245, Jun. 2008.

[11] P. Shamsi and B. Fahimi, “Dynamic behavior of multiport power electronic interface under source/load disturbances,” *IEEE Trans. Ind. Electron.*, vol. 60, no. 10, pp. 4500–4511, Oct. 2013.

[12] C. N. Onwuchekwa and A. Kwasinski, “A modified-time-sharing switching technique for multiple-input DC–DC converters,” *IEEE Trans. Power Electron.*, vol. 27, no. 11, pp. 4492–4502, Nov. 2012.

[13] R. Adda, O. Ray, S. Mishra, and A. Joshi, “Synchronous reference frame based control of switched boost inverter for standalone DC nanogrid applications,” *IEEE Trans. Power Electron.*, vol. 28, no. 3, pp. 1219–1233, Mar. 2013.

[14] A. V. Stankovic, L. Nerone, and P. Kulkarni, “Modified synchronous buck converter for a dimmable HID electronics ballast,” *IEEE Trans. Ind. Electron.*, vol. 59