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DESIGN AND BUILDING OF MULTIPLE INPUT SINGLE OUTPUT DC-DC CONVERTER

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ABSTRACT
A multiple input DC-DC converter has been proposed in this paper to obtain power from several input sources. The structure of the proposed Multiple Input Converter (MIC) is simpler than the several available single input converters for each source. Due to the rapid depletion of the conventional energy the world is turning towards the renewable energy sources because of their abundance and distribution throughout the earth. Thus using different inputs from renewable sources this MISO DC-DC converter is designed. To show continuous output, two 12V batteries are connected as input sources to give a common regulated output. LTspice software is used in the designing of the converter. Hardware implementation of the converter is also done. Results are obtained from both software and hardware.

KEYWORDS: MISO,DC-DC Converter,.

INTRODUCTION
In the late 1880s when the world was moving towards the alternating current,Thomas Alva Edison promoted direct current instead of alternating current for electrical power distribution.Edison promoted DC over AC due to several reasons such as DC worked well with incandescent lamps and motors.Also batteries required a DC supply for providing backup in case of interruptions of generator operation.But due to long transmission problems AC was chosen a better option over DC.But now DC have gained a particular focus because of its various useful advantages over AC.Also the world is turning towards the renewable energy sources which have a DC output.So many studies are now being done for making DC useful for household purposes[1].Thus DC based local distribution power systems have become more attractive due to the increasing use of renewable energy sources.Using DC power systems have many advantages especially for local distribution.DC house may eventually provide electricity for people living in remote areas and this will help these areas not to completely stay dependent towards the grid.

Various researches have been conducted on methods to maximize energy collection from renewable sources.One common technique is Maximum Power Point Tracking(MPPT)[2] which is used in Photo-Voltaic(PV) systems to maximize the input power to the converter.To provide maximum amount of solar radiation to the solar panels or PV cells MPPT technique is used. Also mirrors are used to increase the solar intensity of the PV system. These techniques are used as the renewable energy sources available are not constant and their intensity changes with the climate.Thus these techniques prove useful for a DC house system[3].

For a populated country like India the consumption of electricity is growing at a very fast rate owing to the growing population and economic development.And in India the power is mostly generated using thermal and hydro power plants from which the thermal power plant is non-conventional and its fuel i.e coal is not forever.So India has tremendous energy requirements and intricacy in meeting those needs through conventional means of power generating.Our economy has been put forth to increasing challenges which our country as the energy supply is struggling to meet the consumer demands and there are energy shortages at many places in the country.This situation raises the issues of economic development of the country.So there is a need of more power generation which is clean as well as environment friendly.The environment friendly power generation could be done only through renewable energy sources which include fuel cell,wind energy,photo-voltaic etc.

Renewable energy sources such as solar and wind produce power intermittently according to the weather conditions rather than the power demanded[4].Various storage elements such as batteries should be used with these renewable sources to provide continuous uninterrupted supply.One major advantage of this renewable sources is that they are renewable and will never run out.Thus providing fuel for the power plant forever. Now such renewable plants have been installed in many places around the world which are then inter-connected with the grid thus maintaining the energy demands.

These renewable sources can be used for generating power in rural areas where there is no continuos power supply and are prone to various interuptions.But in some rural areas depending on any one renewable source does not serve the purpose of load demand.So there must a solution to this problem.Also distributed generating systems or micro-grid systems normally use more than one power source or more than one kind of energy source.Here comes the role of hybrid systems which requires more than one power source for serving the consumer load demand.But using many such inputs will make the system very much complex so here comes the role of Multiple Input Single Output (MISO) converters[5-6].MISOs are capable of converting power from various sources to a common load.Basically MISO was derived from from a buck converter by adding more DC input voltage sources in parallel with the original DC input voltage source. The various advantages of MISO over combination of several single input single output converters are reduction of cost,less floor space and greater manageability.Also MISO converters can save the amount of inductors,transformers and/or capacitors as compared to the several combinations of single input single utput converters.The various applications of MISOs are in air-space,EHVs,sustainable energy sources and micro-grid applications.Generally these MISOs are DC-DC converters.A DC-DC converter is an electronic ciruit that converts a DC voltage from one level to to another.

The focus of this study is to design and build a Multiple Input Single Output(MISO) DC-DC converter in which two voltage sources are interfaced as multiple inputs to get a single isolated DC output.As mentioned earlier,these MISOs will serve a better purpose in rural areas where these DC systems would be more advantageous and efficient by utilizing renewable energy resources such as solar, wind and hydro energy.As these systems will their purpose through lifetime, so these are comparatively cheaper solution and this is the purpose of the DC house project.A laboratory prototype is also built with two input DC voltage sources to verify the theoretical analysis and design of the converter.

DESIGN CONFIGURATION

Renewable sources can be connected in different patterns. One of the easy methods is to connect all sources in parallel on a single DC voltage bus. Overall power on the DC bus can be adjusted by connecting or removing sources on the DC bus. Setting up a DC input bus is simple,but all renewable sources on the DC bus will become dependent to one another.The total power on the DC bus will drop to zero when one of the sources is shorted to ground. Since most of the renewable sources depend on their resources which are not always simultaneously available; therefore, this is not practical to apply this solution on the proposed multiple input single output converter.The addition of power can be performed inside the core of the transformer Instead of connecting all renewable sources in parallel on a single DC bus by the produced magnetic flux.The output voltage can be adjusted using the turns ratio of the primary and secondary windings.

There are various advantages in designing this MISO converter.This MISO converter is designed using fly-back topology which requires only one switch and one winding per input.Thus reducing the number of switches,material and space.

Controller

Choosing the right controller was the main challenge in designing this MISO converter.Finally LT3748 IC was chosen as the controller to do the job due to its flexibility in adjusting the maximum output power based on the components used for the MISO converter.The operation of LT3748 is done in Boundary Conduction Mode (BCM) to increase the efficiency of the fly back.The circuit diagram of the LT3748 is shown in fig.1.

Fig.1:-Circuit diagram of LT3748

Operating frequency of the controller is set by load current and transformer magnetizing inductance.It monitors the output voltage across the primary winding of the transformer and thus regulates the output voltage,hence providing complete isolation between primary and secondary sides of the circuit without the use of more costly opto-isolator or third winding.

Looking at the figure.1 a couple of resistors have to be determined for LT3748 to regulate the output voltage.But before that the transformer turns ratio has to be determined.Determining the turns ratio of the transformer is bit tricky because there are two limitations to be considered.One is the current and the other is the voltage limitation which have to be balanced.If we use 1:N turns ratio then there will be current requirement in the primary winding.However,if N:1 is used then the current will not be as high.However the voltages seen across the switches will be higher without considering the voltage spike.Therefore 1:1 transformer is used for this MISO converter.

In the circuit diagram shown above both pin 1 and pin 16 are connected by the biasing circuit,which indicates that the voltage at the pin 1 is reflected at the pin 16 due to the PN junction charecteristics.On the other node where,the R_{fb} is connected, the primary winding and the drain of the MOSFET meet and has a voltage of $V_{in}+V_{out}$ .Thus the voltage across the R_{fb} circuit is V_{out} .

Circuit Design

The circuit diagram of the proposed MISO converter is designed in LTSPICE software.This software is provided by the Linear Technologies company which provides a variety of custom design simulation tools and device models to allow even novice designers to quickly and easily evaluate circuits using high performance switching regulators, data converters, filters,amplifiers and more. LTspice is high performance SPICE simulator,waveform viewer and schematic capture with enhancements and models for easing the simulation of switching regulators.New enhancements to SPICE have made simulating switching regulators extremely fast compared to normal SPICE simulators, allowing the users to view waveforms for most switching regulators in just a few minutes.

The design of the proposed MISO converter is shown in figure.2.

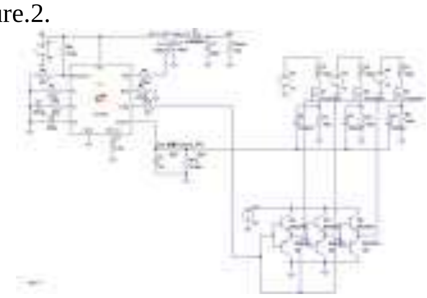

Fig.2:-Schematic of the proposed MISO converter

In the above schematic diagram there are two input voltages which are provided through batteries of 12V supply.

We get an output of 12V isolated which is obtained through the transformer.Since the proposed converter is designed for two input sources full bridge transformer requires only two primary windings in total which occupy less winding area and thus minimize the transformer size.

Since MOSFET drivers on the controller are designed to drive two switches on the bridge, Totem Pole is needed to boost the signal. In a totem pole output, two transistors are stacked one above the other and one transistor will be used in a common emitter configuration while the other is used as an emitter follower. Drive signal is sent to the base of both transistors and the output of totem pole is supplied by the 12V source. Using totem pole to drive MOSFETs draws less current from the controller so that the same signal can be used to drive more MOSFETs. In figure 2, totem pole is used to drive the low side MOSFETs which is the input side.

In order to reduce proximity effect between primary and secondary windings inside the transformer, primary and secondary windings in the MISO transformer are constructed in sandwich winding pattern to achieve high efficiency. The sandwich pattern Np/Ns/Np/Ns is used so that when all windings are loaded, the proximity effect between adjacent windings is minimized.Also the transformer is constructed using ferrite core.Ferrite core type is a material which is not really a metal or not even a bonded powered metal product which is used for the cores. It is a ceramic which is magnetic in its nature. Such transformer using ferrites for the core construction are called ferrite core transformers. The ferrite core produces a lower price to performance ratio.

The ferrite cores used in the transformer are of manganese iron oxide which are very hard, brittle and dark grey or black in colour. The ferrites have high permeability. The ferrites appear in numerous shapes like bar,rods, hollow pots, torroids, cross format, E_s etc. Hence the transformers using ferrite cores can be easily mounted in the circuit board. The ferrites have low leakage inductance.One of the properties of high resistivity of the ferrites keeps the eddy current losses very small, at high frequencies. This eliminates the need of the ferrites to keep the eddy current losses minimum, at high frequencies. This eliminates the need for laminated construction for the cores, in case of ferrites core transformers.[12]

RESULTS AND DISCUSSION

The simulation results of the schematic design are shown below.

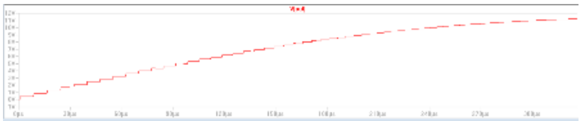

Fig.3:-Output voltage

Figure 3 shows the output voltage in a stepped waveform.This waveform has the minimum ripple content.

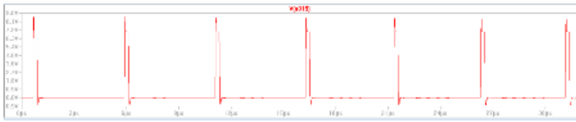

Fig.4:-Gate pulses

Figure 4 shows the gate pulses given to the gate of the MOSFETs.

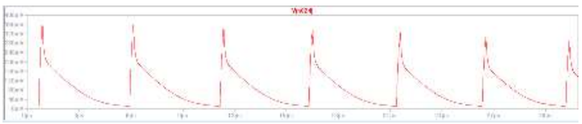

Fig.5:-Sensing pulses

Figure 5 shows the sensing pulses taken across the sensing resistor and ground.It shows the charging and discharging of the capacitor which is connected across the sensing resistor.

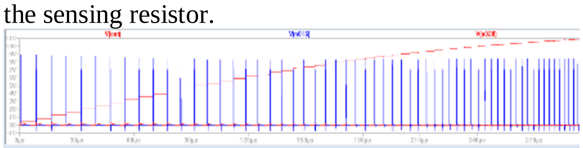

Fig.6:-Combined result

Figure 6 shows the combined result of the above three figures which includes the output voltage,gate pulses and sensing resistor pulses.It shows that with constnt gate pulses and reducing charging voltage across the capacitor the output voltage becomes steady at a particular time with low ripple content.

Fig.7:-Hardware of the schematic

To prove the theoretical results, a laboratory prototype has also been made which is shown in figure 7.Here two 12v batteries are used as input source.An electric motor is used as a load.The motor runs simultaneously with individual input sources.The motor also runs when both the inputs are turns ON.In the later case the motor runs very smoothly.

CONCLUSION

This paper entails the design and construction of the Multiple Input Single Output DC-DC converter for use with multiple input sources supplying power to a common DC bus.The proposed converter have some promising advantages such as the circuit design in very simple as only one controller IC3748 serves the purpose well,also the ferrite core transformer used for multiple inputs has high permeability, less weight and no eddy current losses.

The MISO converter supplies power to the load either individually or simultaneously from the input sources.MISO reduces the system size and system cost.Overall, the MISO converter proves to be a viable soltution for multiple input single output aplications.

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