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A Multi-Input Single-Control (MISC) Battery Charger for DC nano grids

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Abstract

The proposed topology is applicable where numbers of Renewable power sources occur. Because there we need number of converters to convert the energy into suitable form. Also we need to store the energy whenever required. For this purpose we need to use number of converters for different sources. Instead of this, we have proposed the concept called as multi input single control (MISC) battery charger for DC nano grids. This topology offers controlling and conversion of different sources and provides single boosted output. The converter varies the duty cycle based on optimum operation of the largest power where as the other smaller unidirectional sources act as slave. As per the characteristic of the source, the proposed converter works under various operating modes. The simulation and experimental results are analyzed for multi-input single control (MISC) converter. This topology presently available for low power applications, in future we can develop this converter up to megawatt application's

***Key words**- Multi Input Single Control (MISC), Battery Charging , Boost Converter,Multi-port , DC Nanogrid,*

I. INTRODUCTION

The DC nanogrid is a small residential supply system with capacity of 100W to few kilowatts which uses a DC voltage based power distribution to power various domestic loads. The reason is that, DC based nano grids are an attractive alternative for future domestic power systems. Typically a DC nanogrid is a standalone system. In classical model, An input solar source is interfaced to a DC distribution bus using a DC-DC converter. It uses a DC based distribution with various loads connected to it through dedicated point-of-load converters. The idea is basically inspired from computer power system. The renewable power sources are generally being DC forms. Due to the intermittent nature of renewable sources, even though the generated power is AC or DC form, they are converted to a DC and interfaced with storage before further processing. But for continuity in supply of power with renewable sources, a storage element is a must for storing necessary amount energy. It is advantageous to make the distribution voltage and battery voltage to be the same in a small power system like a nanogrid to improve efficiency of power usage. This will also eliminate an additional stage of conversion between the battery and the DC nanogrid. Another factor that improves efficiency is: more the distribution voltage less is the current for the same power level. Therefore, a boost stage between the solar panel and distribution bus is advantageous. In a 380 V based distribution is used and in a 144 V based distribution is used in realizing the nanogrid. The choice of voltage level is dependent on the power level of the nanogrid and available area for installation. In most implementations, a boost converter is used to interface the source with the nanogrid. DC nanogrid is preferred because: (a) Renewable sources are DC (b) future loads are more compatible with DC supply. Renewable Sources have varied characteristics, e.g., a solar array is a current source and a fuel cell is a voltage source. In order to interface all these sources to a single domestic supply grid, a converter has to be interfaced between the respective nodes. The converter takes care of the regulation and protection which arise because of the interfacing in a multiport converter. The multi-input series output concept is used to realize this interface which works at zero voltage switching (ZVS).

In the authors use various sources with its full bridge and the output of the full-bridges are connected to an AC link and then rectified. All the converters used to interface the sources and the grid are individually controlled. Most of the researches have addressed the multi-source power utilization problem by using individually controlled converters. That means, the source and grid have a dedicated converter between them. This option is quite good for higher power installations. However, in a nanogrid, where the power generation is limited and the sources have limited output, these options may not be the most efficient ones as more converters will degrade efficiency and reliability. This paper looks at an alternate circuit to realize a power electronic interface for nanogrids with multiple unidirectional input sources and a single output. The converter structure is realized using a single master control with multiple sources of relatively smaller power rating. The output of the converter is directly connected to DC loads. If the load is AC type means, voltage source inverter is connected to converter. Then AC power is given to the AC loads.

II. PROPOSED TOPOLOGY

The proposed topology of converter is given in fig.1.There is a Master source S 1 (can be voltage or current source) and N-l slave sources S2 to Sn are interfaced to the drain of the control switch through dedicated inductors. The converter topology is referred to as Multi Input Single Control (MISC) due to the fact that the master source is always in control of the duty. The Master Source S 1 fixes the duty cycle of switch Ml based on the MPP operating point of the input source, if input is a solar panel. [n this case the current is used to charge the battery as well as supply the loads connected to this bus. [n case of a voltage source, the output current of the boost can be controlled. The loads are connected to the battery bus directly or through an interface converter. As the converter topology is based on boost converter output voltage is always greater than input voltage for the operation of the converter. Depending upon the characteristics of the sources connected to the converter it can be classified either as a voltage or a current source. The possible combinations for a two input MISC Converter with current and voltage sources are as shown in Fig. 2.

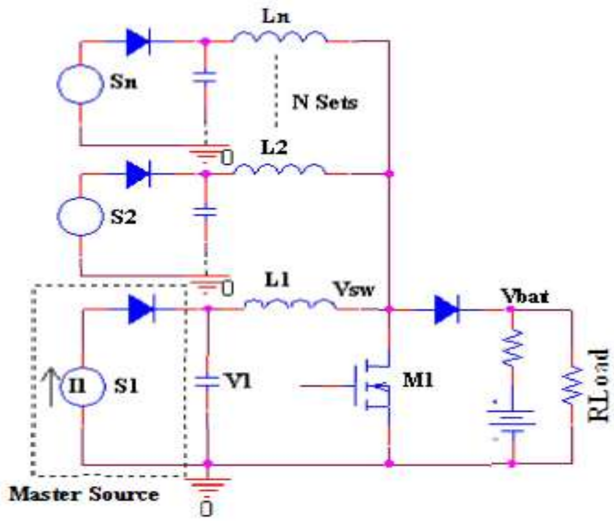

Fig 1: proposed circuit diagram [1]

All the common renewable sources are unidirectional in nature and should be interfaced with a diode. When a current source is interfaced to the converter, a capacitor is used at the input terminal as can be seen from Fig. 2. This capacitor is required to meet the ripple requirements of the converter input current. When the source has a voltage source property, an input capacitor is avoided as it will invariably force the capacitor voltage to become equal to the master source terminal voltage due to duty constraint.

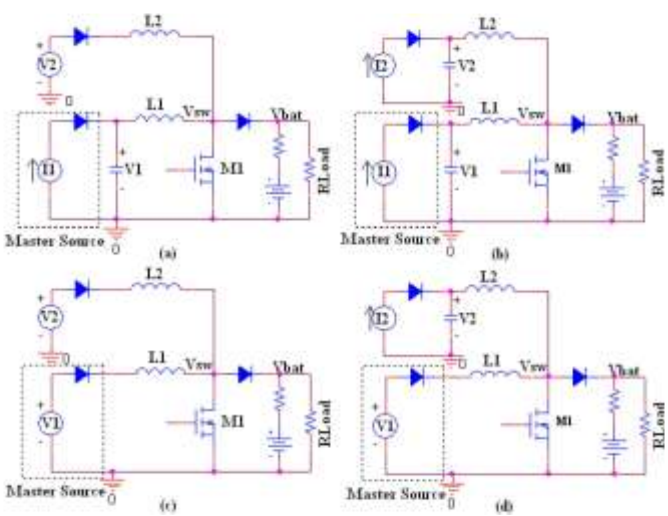

Fig. 2. (a) Current and Voltage Source Inputs, (b) Current and Current Source Inputs, (c) Voltage and Voltage Source Inputs, and (d) Voltage and Current Source Inputs.

MODES OF OPERATION FOR VOLTAGE SOURCE VOLTAGE SOURCE.

The different modes of operation of MISC converter can be performed as shown in fig.2. but our experiment , we need only one mode of operation i.e. voltage source voltage source (VSVS) mode operation. The inputs of MISC converter are connected to voltage sources as shown in Fig. 2 (c). In this mode of operation there are two sub-modes possible which are given below. The duty ratio for this mode is fixed by the master source.

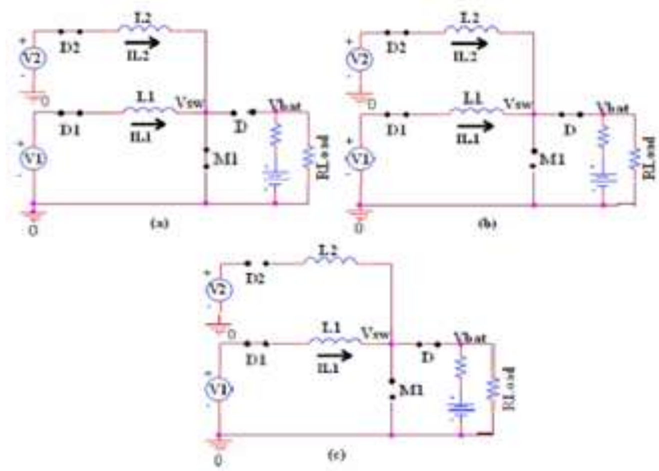

Fig. 3. Operating Intervals when both inputs are voltage sources: (a) when MI is on, (b) when D is on, and (c) when input diode D2 is off.

A) Sub-Mode lll(A): VI > V2: When input voltage of master source is greater than the slave source voltage there will be three operating intervals as shown in Fig. 3 (a), Fig. 3 (b), and Fig. 3 (c). The slave voltage source will be forced to operate in OCM as the gain required is more. As the power generated from the source is not very high, interfacing separate converter for power extraction is not necessary and OCM operation can be used for extraction of the available power. The input current waveforms is as shown in Fig.4(a).

B) Sub-Mode III (B): VI = V2: In this sub-mode of operation the input inductor currents I L I and I L2 ideally should operate in CCM. The corresponding operating intervals of MISC converter is as shown in Fig. 3 (a) and Fig. 3 (b). As the duty ratio is fixed by master source, when input voltage of master source is less than or equal to the slave source voltage it will have a higher gain than required due to higher duty ratio. Output current from slave source increases till it reaches its current limit which is the equilibrium point of operation for the source. The input inductor IL2 current waveform before the slave source reaches the current limit is as shown in Fig.4 (b). When source reaches the current limit the operating waveform will depend of source characteristics such as source type, source impedance etc.

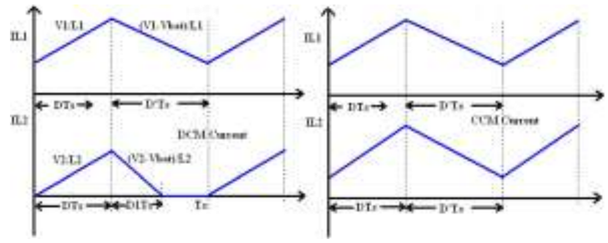

Fig. 4 Inductor Current Waveforms (a) Sub-Mode III(A), and (b) Sub-Mode III(B).

III. SOFTWARE IMPLEMENTAION

Simulink includes a comprehensive block library of toolboxes for both linear and nonlinear analyses. Models are hierarchical, which allow using both top-down and bottom-up approaches. As Simulink is an integral part of MATLAB, it is easy to switch back and forth during the analysis process and thus, the user may take full advantage of features offered in both environments. The main advantage of SIMULINK over other programming software's is that, instead of complication of program code, the simulation is build up systematically by means of basic functional blocks.

IV.A. Simulation for proposed system

Fig.5 shows the simulation diagram for the proposed system using MATLAB Simulink R2010a version by using different Sim power system components.

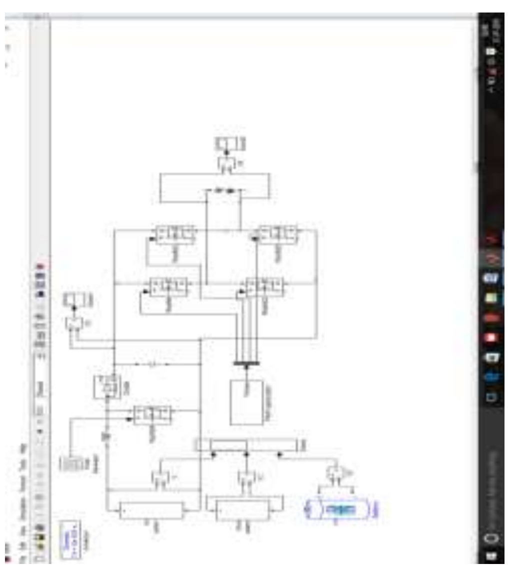

Fig.5 Simulation model of proposed inverter

IV.B. Simulation results

Simulation model is tested and fabricated using MATLAB R2010a software. Table 1 shows the input voltage value and corresponding output DC and AC voltage values.

TABLE 1 sum of inputs and corresponding DC and AC outputs

SL NO.	Sum of Input voltage(V)	AC output voltage(V)	DC output voltage (V)
01	270	210	252

And the snap charts of input and output voltages are taken. These waveforms are shown in fallowing figures,

Simulation results waveforms for input voltages

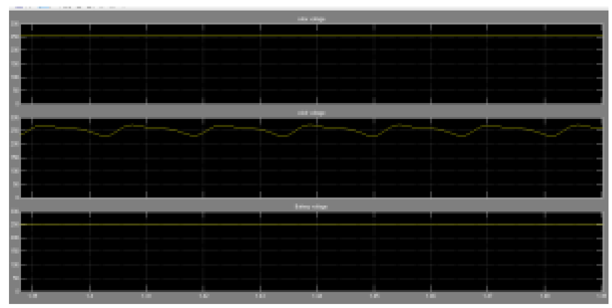

Fig 6, waveforms of input voltage for solar, wind and battery

Simulation result of DC output voltage

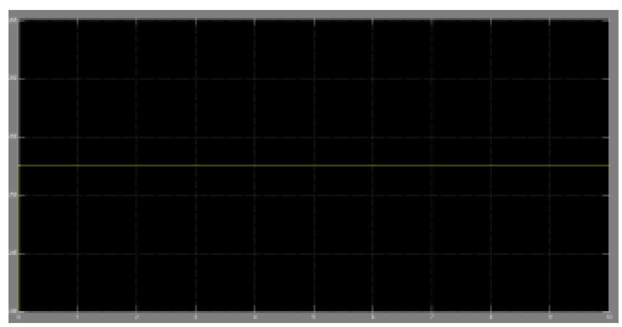

Fig.7 DC output voltage waveform for inputs

Simulation result of AC output voltage

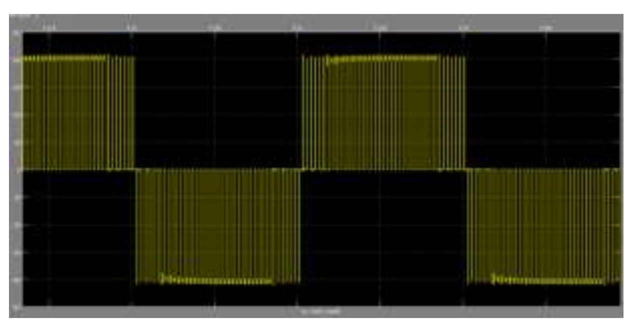

Fig. 8 AC output voltage for input

IV. HARDWARE IMPLEMENTATION

The Multi-Input Single-Control (MISC) Battery Charger for DC nano grids Topology system is done and the developed hardware is tested with constant load. The proposed hardware system is implemented by PIC-microcontroller 16F877A.The developed hardware system is tested in power electronics laboratory. The test is carried out on an resistive load. The output results of DC voltage and AC voltage waveforms are taken. Figure 9 shows the photograph of the proposed system.

Fig. 9 hardware setup of the proposed system

Table 2 sum of input voltages and correspond output DC and AC voltages

SL NO.	Sum of Input voltages(V)	AC output voltage(V)	DC output voltage (V)
01	12	60	40

After testing the hardware setup, required hardware results are obtained, they are shown in above table 2. And corresponding waveforms are taken as shown in following figures.

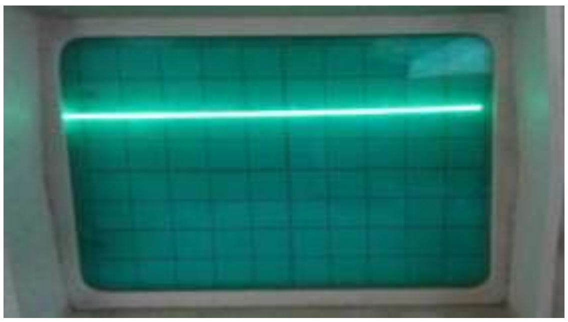

Fig.10 DC output voltage

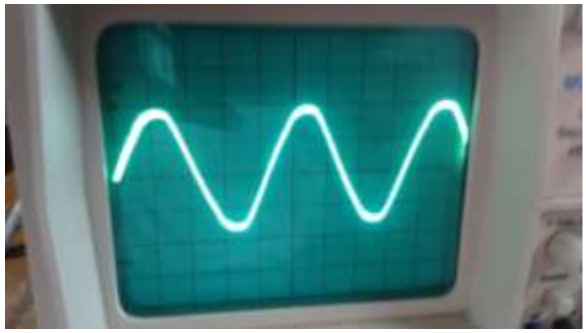

Fig.11 AC ouput voltage

Advantages:

- Eliminates switching losses.
- Switching losses are less and neglected
- Reduces the input current ripple.
- Low conduction losses

Applications:

- We can be used it in DC fans.
- This can be used in LED lighting system.
- Battery charging application.
- Dc nano grid applications

CONCLUSION

This paper proposed a Multi-Input-Single Control (MISC) converter for controlling multi inputs and providing single output. And it will boost the voltage to charge a battery using a single control. A fixed duty cycle based on the highest power source (Master source) characteristics is used to control the circuit. The simulation and hardware results are analyzed and verified. The entire smaller sources act as slave and supply the power that can be extracted from it. Depending upon the interfaced source characteristics different modes of operations are possible. Presently this concept is used and adapted in smaller grids. We can employ this concept for high power grids in future.

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