



An Integrated Flyback Converter with an Advanced Version of Multilevel Inverter Powered By Renewable Energy Sources

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Abstract-There is an increasing demand of power and load shedding is preferred as a solution. An interruption for a few cycles of power supply results in loss of data, mal functioning of various sensitive equipments. A model is developed to provide uninterrupted power supply to the consumers in the event of failure of the main input source. The different modes of operation that has been developed are normal, back-up and charging. The output of the integrated flyback converter is given to the multilevel inverter. A cascaded H-bridge multilevel inverter is implemented using a single DC power source and capacitors. A standard cascaded multilevel inverter requires 'n' DC sources for '2n + 1' levels. Without requiring transformers, the scheme proposed allows the use of a single DC power source (e.g., a battery, a fuel cell stack or photo voltaic panel) with the remaining n-1 DC sources being capacitors. The DC voltage level of the capacitors can be maintained simultaneously and a fundamental frequency switching pattern can be chosen to produce a nearly sinusoidal output. The number of levels is increased up to fifteen by adding six bidirectional switches to a H-bridge inverter. The main objectives are to improve the power quality by reducing the total harmonic distortion to a very low value and the reduction of the per unit cost of electricity.

Keywords--- Multilevel inverter, flyback converter, H-bridge configuration, energy storage and management

I. INTRODUCTION

Now-a-days, we can hardly imagine the lifestyle without the provision and processing activities which use electrical energy, and its supply. In recent years, a lot of

research has been carried out on the design of uninterruptible power supply systems to provide clean and uninterruptible power to equipment in critical applications under normal or abnormal utility power conditions for which batteries or flywheels are incorporated in the UPS for this purpose. The power conversion is mainly accomplished using power electronics switches due to the advanced development of fast-switching and high current capabilities. [1]. A dc UPS is designed with high efficiency due to single voltage conversion. The system cost will also be reduced substantially due to removal of the redundant inverter and rectifier. It will have small size, which is slightly larger than a conventional switching power supply but much smaller than a UPS. So for only a few designs of such high frequency dc UPS had been reported in [2, 3]. All these designs have a common feature that a single power transistor is used for current switching in both normal and backup operations, while another transistor is used for battery charging. While this feature enables full utilization of the power transistor, the conversion efficiency in backup operation will be unacceptably low so we are proposing an integrated fly back converter for dc UPS application. The proposed converter accepts a high voltage main input and a low voltage backup battery input. With separated converter circuits for the main and battery inputs, the ratings of each switching device can be optimally selected, thus enabling the converter to achieve high conversion efficiency in normal, backup, and charging operations.

A cascade multilevel inverter is a power electronic device built to synthesize a desired AC voltage from several levels of DC voltages. Such inverters have

been the subject of research in the last several years [4] [5] [6] [7] [8], where the DC levels are considered to be identical and all of them were either batteries, solar cells or any other source. The advantages are waveforms with high power quality can be obtained, devices of low voltage rating can be used, low harmonic distortion, low switching frequency and switching losses, higher efficiency, reduction of dv/dt stresses etc. The popular MLI topologies are Diode Clamp, Flying Capacitor and Cascaded Multilevel Inverter (CMLI). In this paper we are using a CMLI that consist of an H-Bridge inverter. In [8], a multilevel converter was presented in which the two separate DC sources were the secondary windings of the two transformers are coupled to the utility AC power. In contrast, only one source is used without the use of transformers. A single DC power source is interfaced with a cascaded multilevel inverter where the other DC sources are capacitors. Currently, each phase of a cascade multilevel inverter requires n DC sources for $2n+1$ levels in applications that involve real power transfer. Here, a scheme is proposed that allows the use of a single DC power source (e.g., battery or fuel cell stack) with the remaining $n - 1$ DC sources being capacitors. It is shown that one can simultaneously maintain the DC voltage level of the capacitors and choose a fundamental frequency switching pattern to produce a nearly sinusoidal output.

II. INTEGRATED FLY BACK CONVERTER

The circuit of the proposed integrated fly back converter is shown in Fig.1.

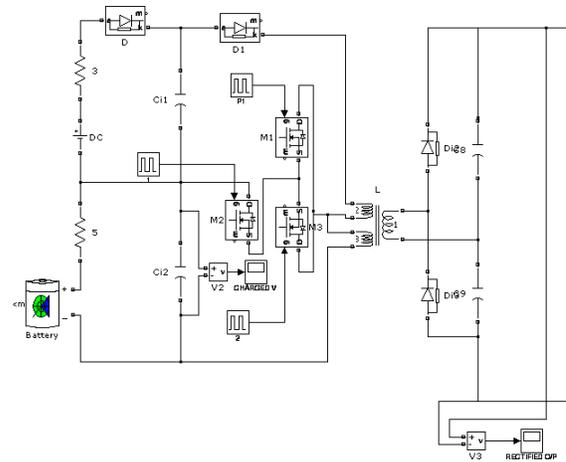


Fig.1 Circuit diagram of integrated flyback converter

The switch SW1 is used to select the mode of operation. When the main power input V_{AC} is functioning properly, the switch SW1 will be closed and MOSFET Q2 turned off to operate the converter in normal mode. The equivalent circuit of the converter in normal mode is shown in Fig. 2. The battery voltage V_B should be chosen to be higher than $V_c n_2/n_1$ to prevent diode D2 from conducting when Q1 is turned on. Such choice will make the backup converter (V_B , Q2, D2 and n_2) idle, thus disconnecting it from the equivalent circuit during normal-mode operation.

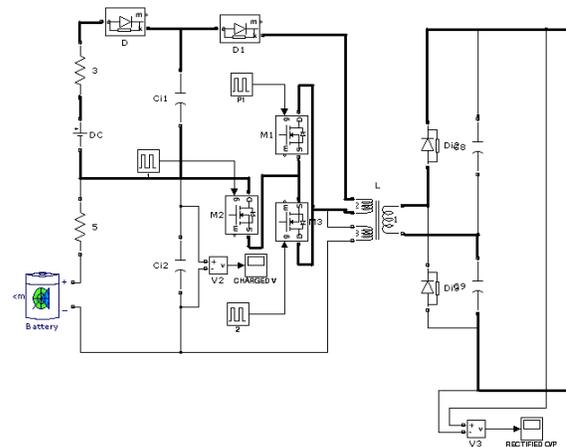
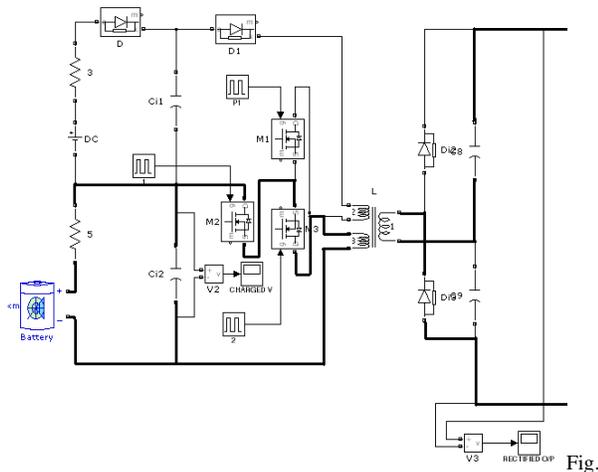


Fig. 2 Normal mode

When input power failure is detected, MOSFET Q1 will be switched off and switch SW1 will be closed to operate the converter in backup mode. The equivalent circuit of the converter in backup mode is shown in Fig.3.



3 Back up mode

As the battery voltage VB is much lower than main input voltage VC1, the switch current iQ2 in backup will be much higher than the switch current iQ1 in mode normal. Therefore a low-voltage, low-RDs (on) MOSFET should be chosen for Q2. The number of turn's n2 in the primary of backup converter should be chosen to be much smaller than n1 in the main converter and with much higher current winding used. When the main power input VAC is functioning properly, SW1 can be opened to operate the converter in the charging mode. The equivalent circuit of the converter in the charging mode is another flyback converter as shown in Fig.4.

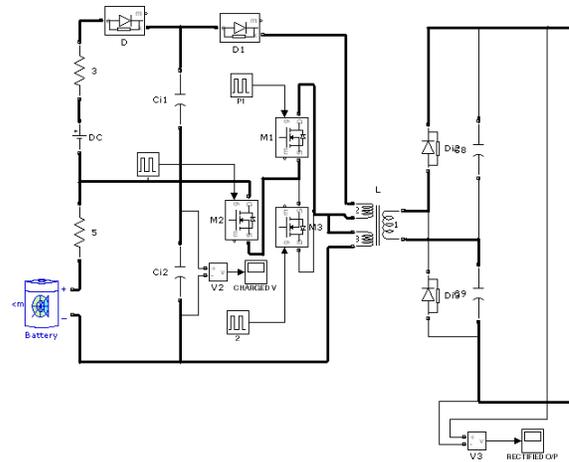


Fig. 4 Charging mode

As the battery VB is in series with the main input VC1, the battery charging current -IB will be equal to the averaged input current IQ1 from VC1. A disadvantage of the proposed converter is that the charging current is load-dependent and cannot be controlled independently. The converter thus cannot provide battery charging when there is no load. Battery charging is instead controlled by charging time, i.e. the duration the converter operates in charging mode.

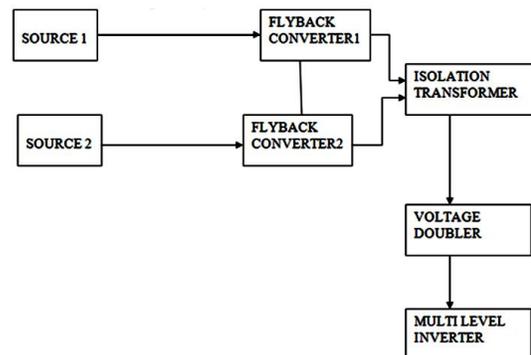


Fig. 5 Block diagram of the integrated flyback converter

III. MULTILEVEL INVERTER ARCHITECTURE

To operate a cascade multilevel inverter using a single DC source, it is proposed to use capacitors as the DC sources for all but the first source. The multi level inverter comprises of a single-phase conventional H-bridge inverter, six bidirectional switches, and a capacitor voltage divider formed by C1, C2, C3, C4, C5, C6, C7. The H-bridge topology is significantly advantageous over other topologies, i.e., less power switches, power diodes, and less capacitor for inverters of the same number of levels. It generates an almost sinusoidal waveform voltage while switching only one time per fundamental cycle. The output voltage waveform of a multilevel inverter is composed of the number of levels of voltages, typically obtained from capacitor voltage sources. The so-called multilevel inverter starts from three levels. As the number of levels reach infinity, the output THD approaches zero. The number of the achievable voltage levels, however, is limited by voltage imbalance problems, voltage clamping requirement, circuit layout, and packaging constraints. When analyzed we arrived at fifteen modes of operation for the multilevel inverter.

S9&S4 on capacitors C1-C5 are charged. In mode 3 ($3V_{dc}/7$) operation, switches S8&S4 are turned on and capacitors C1-C4 are charged. In mode 4 ($4V_{dc}/7$) operation, switches S7&S4 are turned on and capacitors C1, C2 and C3 are charged. In mode 5 ($5V_{dc}/7$) operation, switches S6&S4 are turned on and capacitors C1 and C2 are charged. In mode 6 ($6V_{dc}/7$) operation, switches S5&S4 are turned on and capacitor C1 is charged. In mode 7 (V_{dc}) operation switches S1&S4 are turned on. In mode 8 ($-6V_{dc}/7$) operation, switches S10&S2 are turned on and capacitor C7 is charged. In mode 9 ($-5V_{dc}/7$) operation, switches S9&S2 are turned on and capacitors C7 and C6 are charged. In mode 10 ($-4V_{dc}/7$) operation, switches S8&S2 are turned on and capacitors C7, C6 and C5 are charged. In mode 11 ($-3V_{dc}/7$) operation, switches S7&S2 are turned on and capacitors C7, C6, C5 and C4 are charged. In mode 12 ($-2V_{dc}/7$) operation, switches S6&S2 are turned on and capacitors C7-C3 are charged. In mode 13 ($-V_{dc}/7$) operation, switches S5&S2 are turned on and capacitors C7-C2 are charged. In mode 14 ($-V_{dc}$) operation, switches S2&S3 are turned on. The duration and the number of gate pulses are calculated and supplied accordingly.

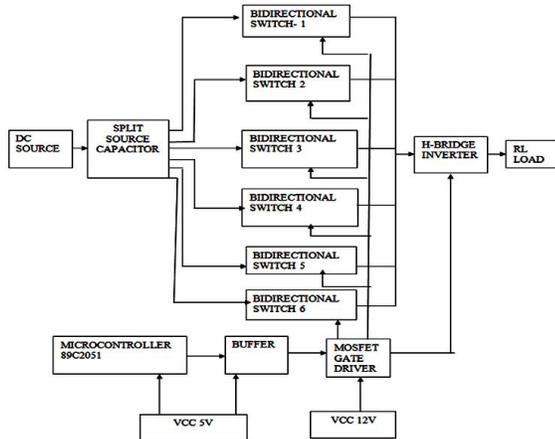


Fig.6 Block diagram of the fifteen level inverter

In case of mode 0 operation the switches S3&S4 are turned on and capacitors C1-C7 are charged. In mode 1 ($V_{dc}/7$) operation switches S10&S4 and capacitors C1-C6 are charged. In mode 2 ($2V_{dc}/7$) operation switches

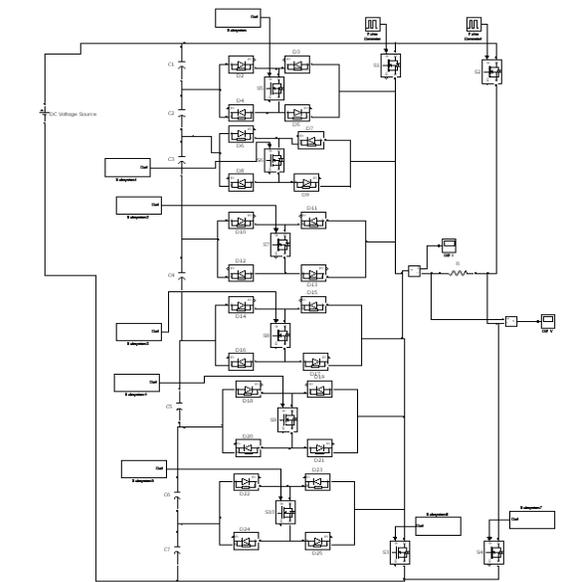


Fig.7 Circuit diagram of the fifteen level inverter

IV.SIMULINK MODEL OF THE PROPOSED CIRCUIT DIAGRAM

The simulation has been done with the help of Simulink in Matlab.

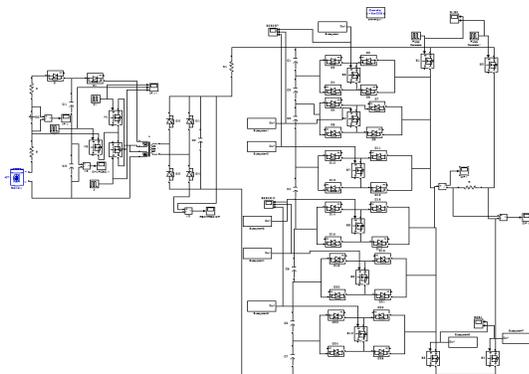


Fig.8 Simulink model of the circuit

V.SIMULATION RESULTS AND DISCUSSION

The fig. 9 shows the simulated input voltage which is supplied by the renewable energy source

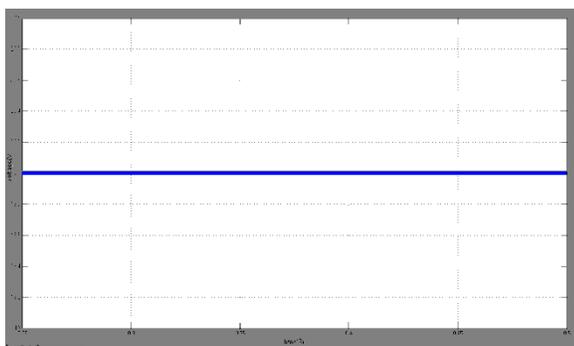


Fig. 9 Input voltage

The fig 10 shows the simulated voltage across the capacitor connected in parallel to the battery (auxiliary source)

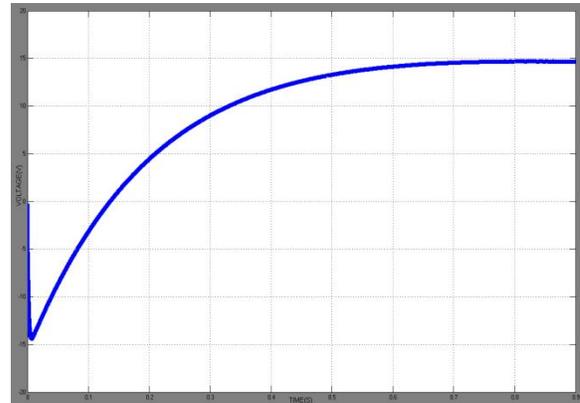


Fig. 10 Voltage across capacitor (charged voltage)

The fig 11 shows the simulated output of the voltage doubler which is the input to the multilevel inverter.

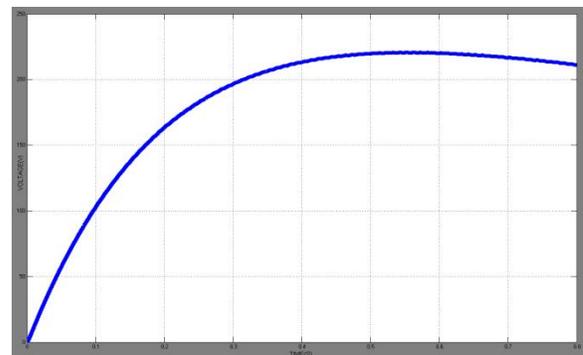


Fig. 11 Input to multilevel inverter

Fig. 12 shows the simulated output voltage of the fifteen level inverter.

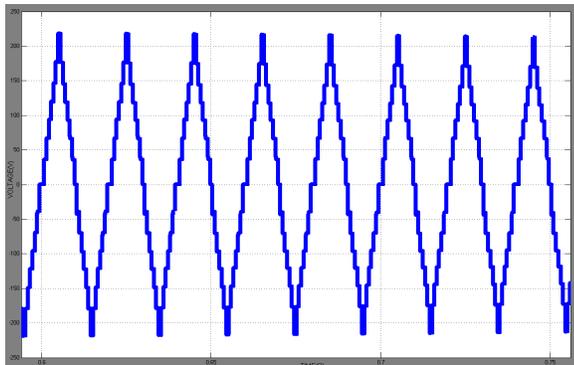


Fig. 12 Output voltage of the fifteen level inverter

The fig13 shows that the simulated 15 level output current for the proposed circuit.

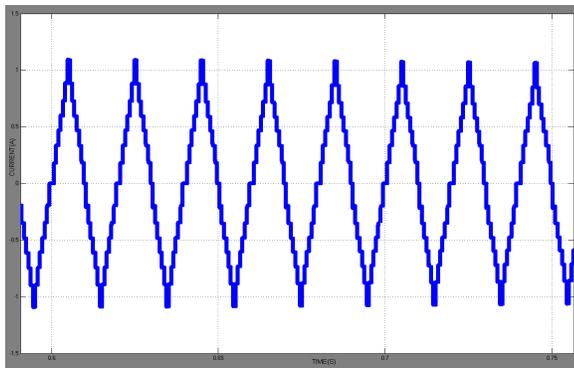


Fig. 13 Output current of fifteen level inverter

The harmonic analysis was simulated and was found to be 16.35%. The fig. 14 shows that the simulated THD of output current for the proposed circuit.

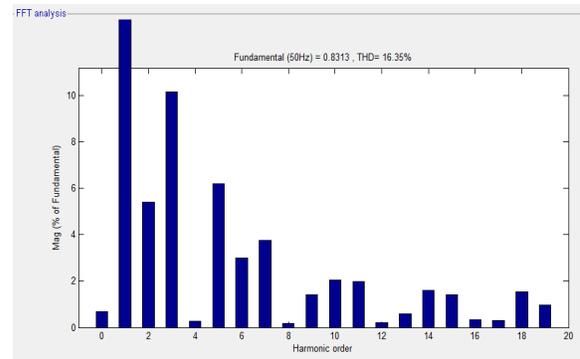


Fig. 14 THD of output current

VI.CONCLUSION

The operation and design of an integrated flyback converter is explained in detail. The converter features a simple circuit with high efficiency, small size, and low cost when compared to the conventional switching power supply. A cascade multilevel inverter topology has been proposed that requires only a single DC power source. The objectives of the proposed method are harmonic reduction, high efficiency, less isolation and balanced voltage transfer. The applications include AC drives, Static var compensator and satellite power supplies.

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