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DESIGNING AND IMPLEMENTATION OF BI - DIRECTIONAL ISOLATED FULL BRIDGE CONVERTER

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Abstract- In the renewable energy systems, the exchange of power from the source to the load and vice-versa have conventionally been implemented with two uni-directional converters; each processing the power in one direction. To improve the energy quality in such systems, bidirectional DC-DC converters are used to charge/discharge the energy storage systems. This paper proposes the bidirectional DC-DC converter which employs the two full single phase bridge converter configuration on the both sides of the isolating transformer. The high side converter is controlled as step down and the low side converter is controlled as step up. At a given instant of time, only one converter is controlled and other acts as diode bridge converter. The proposed system is characterized by good dynamic properties and high efficiency because of low switching losses. Using the same power components for achieving bidirectional flow of power in the symmetrical circuit topology provides a simple, efficient and galvanic ally isolated that is especially attractive for use in battery charging/discharging circuits.High frequency isolation transformer plays an important role in achieving galvanic isolation and also for reducing the system size, weight and cost. Power MOSFET switches, provided with snubber circuit and PI filter at the output side are employed to reduce the ripple and for voltage regulation in this proposed thesis.

Keywords –Converter, Inverter, Snubber Circuit, MOSFET, Switches.

I. INTRODUCTION

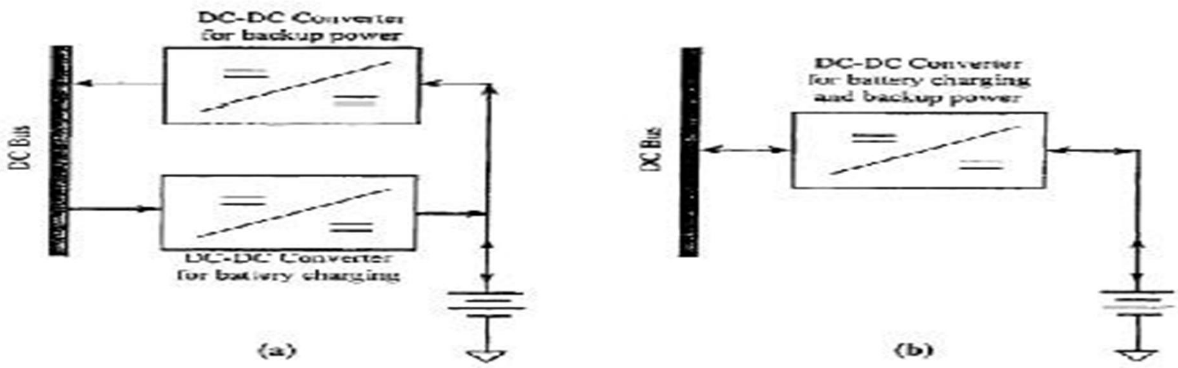
The preamble process of matching the energy supplied by the source to the load is done by a circuit called power converter by means of using semiconductor devices to control the voltage and current. The energy is usually available from the utility grid or from a bank of batteries with the applications ranging from high-power conversion equipment processing megawatts to low power equipment with requirements of a few mill watts.

The majority of the power converters are unidirectional with the power being supplied to load from the source. But, for a number of applications like motor drives uninterruptible power supplies, alternate energy systems, battery charger/dischargers, telecommunication and space systems require an additional exchange of energy from the load to the source. These applications require a power converter with bi-directional transfer properties.

Conventionally, bi-directional transfer of power is achieved using two independent unidirectional converters. The escalating cost of energy in recent years has resulted in growing emphasis on energy management due to the drain on natural resources and environmental pollution, and energy saving techniques are becoming essentially more important. The demand for the development of sophisticated, compact and efficient power systems has prompted research in the field of bi-directional converters providing the desired bilateral power flow which is capable of replacing the two unidirectional converters.

Bi-directional power flow is an especially attractive proposition in many DC power based systems such as telecommunication, space applications, and computer systems and etc., where the physical size and weight of the power processing modules are a critical aspect of design. Bi-directional dc-dc converters allows the transfer of power between two dc sources, in either direction with the ability to reverse the direction of current flow and the power, while maintaining the voltage polarity at either ends being unchanged. By nature, these converters are more complex than unidirectional converters. Extensive research has been conducted on unidirectional dc-dc converters topologies applicable for bi-directional Designing and Implementation of Bi- Directional Isolated Full Bridge Converter

Power flow in medium and high power applications with few topologies presented for low power applications. This thesis presents a bi-directional dc-dc converter for low power applications. General block diagram of converters operating in bidirectional is as shown in the Fig 1.1



The basic power topology of the proposed bi-directional converter is shown in Fig. 1.2. The bi-directional converter is seen to consist of a two full bridge DC-DC converter topology on the primary and secondary side of a high frequency isolation transformer. The DC bus is connected to the 1st bridge converter end and the battery is connected to the end of the 2nd bridge converter. Depending on the status of the DC mains, the converter can be operated in the forward/charging mode or the backup/discharging mode. All power switches are bi-directional and they are triggered according to the operating mode of the converter. The objective of this chapter is to describe the topology, modes of operation and the control principle of the proposed bi-directional DC-DC converter for a capacitor charger/discharger application.

II. PROPOSED ALGORITHM

A. Selection of the appropriate power topology

For implementation of Bi-directional DC-DC converter, various power converter topologies can be considered. For the applications such as battery charging/discharging, a buck derived converter must be used for charging the low voltage battery from the high voltage DC bus. In back up mode of operation, battery supplies the power to the DC bus using a boost derived circuit to higher voltage at the DC bus. Designing and Implementation of Bi- Directional Isolated Full Bridge Converter.

B. Selection Full bridge topology

Full Bridge topologies are commonly used in the converter circuit where the voltage being fed from a rectified AC line or a high voltage DC bus. The OFF state voltage stress on the switches of full bridge topologies is equal to the DC input voltage and not to twice that as do the push-pull, single-ended and interleaved forward converter topologies. Voltage spikes on the primary of push-pull and the single-ended forward topologies due to leakage inductance in the transformer primary winding is absent in the bridge topologies. The primary leakage inductance spikes are clamped to the DC supply bus and this energy is stored in the leakage inductance which is returned to the bus instead of being dissipated in some resistive elements. This feature of full bridge allows for a high voltage DC bus with switches having lower voltage ratings that are inexpensive and easily available. The major inherent transformer saturation problem as seen in the converter such as push-pull is easily overcome in bridge topologies. Bridge topologies also provide a better utilization of the transformer windings and core than the conventional push-pull where only one half winding is used during each cycle.

In full-bridge topology, although the switches carry half the peak and RMS currents compared to the half-bridge, for the same output power, the number of switches is twice that in the half-bridge than in the full bridge. Thus, the full-bridge is usually used in higher power circuits.

C. Flux balancing in the full bridge topology

For al1 positive gating pulses, average volt-seconds applied to the primary winding is not exactly equal to that for al1 the negative going pulses the transformer flux density wil1 increase with each cycle and staircase into saturation. An unequal volt-second on Designing and Implementation of Bi-Directional Isolated Full Bridge Converter

In full-bridge implementations using MOSFETs as switching devices, such a situation may arise due to unequal voltage drops across the MOSFETs when they are in the ON state. The peak current is identical for each half cycle in Current-mode control when applied to the full-bridge is ensured. Use of a DC blocking capacitor in series with the transformer primary has been suggested, but this will cause a voltage to build up across it in a direction that reinforces the original volt-second asymmetry.

Objectives of transformer isolation are briefly listed below:

- Isolation of input and output ground connections,
- Reduction an former size of by incorporating high frequency isolation transformer inside converter

Minimization of current –and up or stepvoltage-down conversion ratio stresses is needed—use when a transformer turns ratio.

FLOW CHART

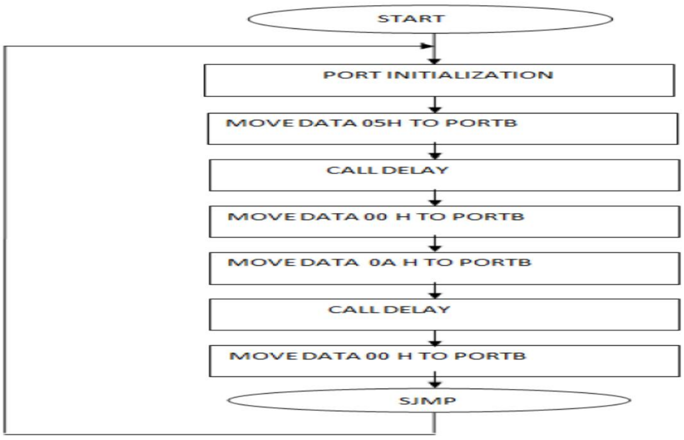


Fig - Flow chart of main program

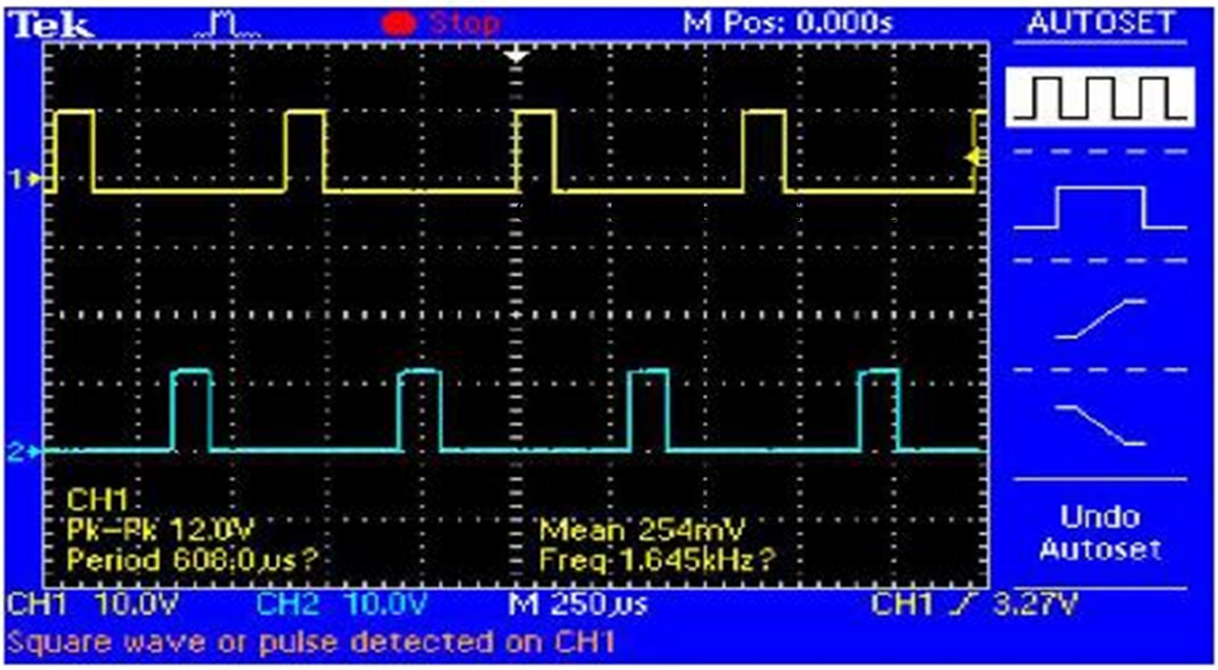
IV. HARDWARE IMPLEMENTION RESULT

The simulation of the proposed topology shows that the power is transferred between two bridge converters in both direction. The hardware implementation of the same was undertaken to verify the simulation results in practical conditions. The implementation is in three parts.

Three sets of circuits are designed and implemented in the proposed thesis.

- Power circuit
- Control circuit
- Power convert circuit

The waveforms of the gating signals to the converter software is MATLAB and SIMULINK, the rectified output voltage in forward conduction mode and the output voltage in reverse conduction mode are shown.



A. Forward mode of operation:

To give the input supply to the power circuit, a step down transformer (230/15V) is used.

Pure DC voltage is obtained by removing the ripple in the DC voltage, using the filter capacitors.

A 15V AC supply is rectified into 15V pulsating DC voltage using the diode bridge rectifier.

For voltage regulation, the positive terminal of the capacitor is connected to the 7812 regulator.

12V DC voltage from the output of 7812 is fed to 7805 pulse amplifier.

The input 5V to microcontroller is provided by the output of 7805 amplifier.

A LED in series with the resistor, is connected to the same output pin of the 7805 to indicate that the power is on.

12V DC is converted to 5V DC voltage in the driver circuit IRF2110. This 5V DC is required to trigger the MOSFET switches.

The Pic-Microcontroller is programmed in such a way that the switching pattern

The output of 15V pulsating AC is obtained in the 0 delay where S1, S2 in 1st bridge and S'1 and S'2 in the 2nd bridge are conducting while other switches are OFF.

25% duty cycle is provided for each switch and are operated in 1.6 kHz.

Since the transformer is designed for 1:2 ratio, step up voltage of 30V AC is obtained.

Designing and Implementation of Bi-Directional Isolated Full Bridge Converter

The same steps are repeated in the next operating cycle where S3 & S4 in 1st bridge and S'3 & S' 2nd bridge are turned on with all other switches in OFF condition.

The output readings are taken across the resistive

The output voltage is approximately 30V DC. Filter circuits are included in the converter for removing the ripple in the voltage. So pure DC voltage is obtained.

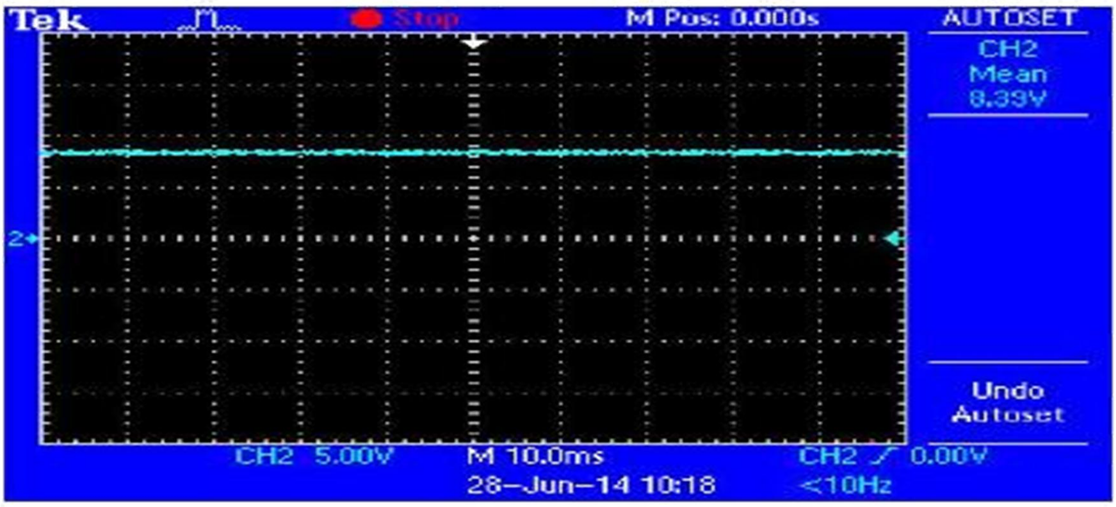


Fig- Forward Conduction Mode Voltage

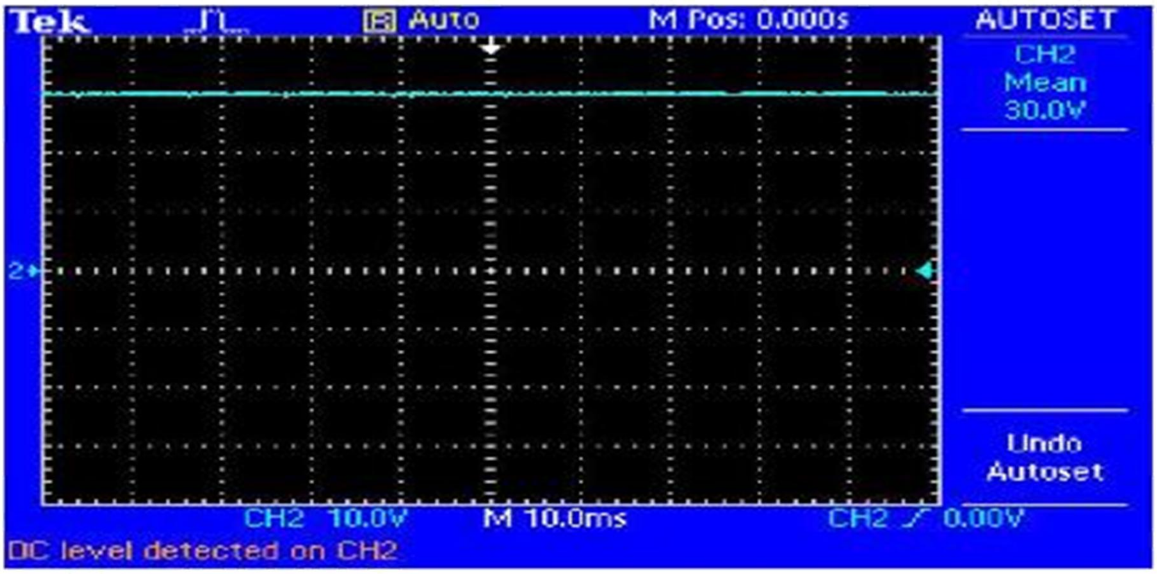


Fig -Reverse Conduction Mode Voltage

B. Reverse mode of operation:

In this back up mode, the power has to flow in the reverse direction. This process in the hardware circuit is as explained.

15V AC from the 230V /15V transformer is rectified by the bridge rectifier.

The switching pattern is as per the table 3.3.5

The operation of power and driver circuit in the reverse direction is same as they worked in the forward mode.

Rectified 15V DC is inverted in the 2nd converter forming 15V pulsating AC.

Power is made to flow in 1st bridge via transformer. The voltage is reduced to half of its value i.e to 7.5V in the step down transformer

7.5V AC is processed in the 1st bridge and converted into DC component approximately 7.5V DC.

The output voltage and current is measured across t

The hardware circuit and the obtained output waveforms as shown below

V.CONCLUSION

In this proposed work, two isolated single phase full bridge converters are designed and implemented for battery charging /discharging application. The theoretical and experimental analysis reveals that battery can be successfully charged to the rated maximum voltage from the DC supply voltage and feeds back the stored energy to the source in the back up mode. This topology can also be used in the renewable energy systems, since the circuit size, weight and cost are less compared to other DC-DC converter topologies used for bidirectional power flow as, symmetrical converter construction makes gate pulse generation pattern simple, low conduction and switching losses due to high frequency switching and filter design is simple as compared to other topologies which also provides Galvanic isolation.

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