BIDIRECTIONAL ISOLATED FULL BRIDGE DC–DC CONVERTER WITH ACTIVE AND PASSIVE SNUBBERS FOR A RENEWABLE ENERGY SYSTEM

U. Pinky*1, K. S. S. Nagateja2

1M.Tech, Malla Reddy Engineering College (Autonomous), Hyderabad, Telangana, India.
2Asst. Prof, Malla Reddy Engineering College (Autonomous), Hyderabad, Telangana, India.

ABSTRACT

To improve the energy quality, most of the renewable energy systems include an energy storage element charged by the bidirectional DC–DC converter. This paper proposes the bidirectional isolated full bridge dc–dc converter with active and passive snubbers for renewable energy system. The low side converter is controlled as step up and the high side converter is controlled as step down. The proposed framework is portrayed by good dynamic properties and high efficiency because the converter transistors are switched in ZVS conditions. Theoretical analyses to provide relations for system design, and the MATLAB/Simulink model investigations to validate the system characteristic are given in the paper.

Keywords: Bidirectional converter, high conversion ratio, coupled-inductor.

1. INTRODUCTION

In rising oil costs and expanded conditions on remote oil, our vitality approaches have underscored to build the utilization of renewable vitality, particularly in the territory of sun based vitality assets. This paper depicts the application grew by using a renewable vitality innovation that sun powered vitality into a solitary or brought together power era framework. In the majority of the circumstances, sun oriented boards alone are not adequate to supply the force needs of numerous applications amid the winter months, essentially because of shorter sunshine time and weaker sun based radiation. Subsequently this sort of vitality is not suitable for discriminating applications. The proposed innovation tackles this issue by coordinating photovoltaic (PV) power era. Of all renewable vitality sources, sun based vitality utilizing photovoltaic board is chosen for our venture. The study was embraced to focus the capacities and to figure out whether the long haul sparing of power .The improvement of renewable vitality has been an inexorably discriminating point with the developing issue of a dangerous atmospheric deviation and ecological effects. With an improved examination, elective renewable sources have turn out to be progressively vital for electric force era.

These options incorporates sunlight based, wind, hydro, geothermal and biomass. They can be delivered today without harming their capacity to be created later on. Photograph voltaic (PV) is a strategy for changing over sun oriented vitality into direct current power utilizing semiconducting materials that show the photovoltaic impact. The most critical part of a sun oriented cell is that it produces sun based vitality straightforwardly to electrical vitality through the sun powered photovoltaic module. Silicon cells are utilized as a material to fabricate that voltaic cell. The yield of every cell is moderately low voltage. A sun powered photovoltaic module is framed by displaying the cells in arrangement.

Block Diagram of Proposed System
The flyback snubber can reuse the held importance which is orchestrated away in the propping capacitor CC, while without current encountering the standard switches. It can about lessen the voltage to a fancied respect just conceivably higher than the voltage over the low side transformer. Since the snubber current does not course through the fundamental switches, current strain can be diminished essentially under wide weight condition. Moreover, the flyback snubber can be controlled to precharge the high-side capacitor to keep up a vital separation from in-surge current amidst a start-up period. In any case, the low- and high-side switches are worked with hard exchanging side road, perceiving high-voltage spikes.

To handle the as of recently bestowed issue, we first present two fortify capacitors (Cb1 and Cb2) related in parallel with the upper legs of the voltage-bolstered addition, as showed in Fig. . With these two pad capacitors, the low- and high-side switches can work with fundamentally zero-voltage exchanging (ZVS) and zero present exchanging (ZCS). Regardless, when it is worked in attempt down change, these capacitors will resound with spillage inductance of the transformer, making EMI uproar and making exchanging setback. Besides, two withdrew capacitor–diode snubbers are proposed to supplement the part flyback snubber, as showed in Fig. . The proposed snubber arrangement can't just diminish the voltage spike brought on by the present capability between the spillage inductance and current-kept up inductor streams at any rate, additionally can calm the downsides of high-present and high-voltage maddens obliged on the standard switches at both turn-on and side road moves. Also, it can perform close ZVS and ZCS for the switches on both sides of the change.

This attempt can be connected with a photo voltaic centrality change structure at the information side which converters daylight based significance into force organize in connection of semiconductor benchmarks .This close to P & O MPPT (most dazzling power point taking after) count to get perfect power extraction.

Fig. 1: Proposed soft-switching bidirectional isolated full-bridge converter with an active flyback and two passive capacitor–diode snubbers

2. PV SYSTEM

A photovoltaic framework, additionally photovoltaic force framework, sun based PV framework, PV framework or coolly sun powered cluster, is a force framework intended to supply usable sun oriented power by method for photovoltaic. It comprises of a plan of a few segments, including sunlight based boards to retain and specifically change over daylight into power, a sun powered inverter to change the electrical current from DC to AC, and additionally mounting, cabling and other electrical assistants to set-up a working framework. It might likewise utilize a sun powered following framework to enhance the framework’s general execution or incorporate an incorporated battery arrangement, as costs for capacity gadgets are required to decrease. Entirely talking, a sunlight based cluster just incorporates the group of sun powered boards, the unmistakable piece of the PV framework, and does exclude the various equipment, frequently compressed as offset of framework (BOS). In addition, PV frameworks change over light straightforwardly into power and shouldn't be mistaken for other sun based advancements, for example, concentrated sun powered force (CSP) and sun oriented warm, utilized for both warming and cooling.
2.1 Solar Panel

Sunlight based boards are gadgets that change over light into power. They are called "sunlight based" boards and light power due to the effective accessibility of sun's radiation as both warmth and light. Photo voltaic innovation characterization into silicon crystalline innovation and slight film innovation. In this proposed system silicon crystalline is utilized. The crystalline silicon PV cell is one of numerous silicon-based semiconductor gadgets.

2.2 Maximum Power Point Tracking

Most extreme force point following (MPPT) is a strategy in which framework associated inverters, battery chargers and related gadgets are utilized to get greatest conceivable force from single or more voltaic modules. Photovoltaic sunlight based cells have a mind boggling relationship between sun powered irradiance, temperature and aggregate resistance that delivers a non-direct yield effectiveness which can be investigated in light of the i-v bend. The motivation behind the MPPT framework is to test the PV cell's yield and to apply the best possible resistance (burden) to get most extreme force at any given states of a situation. Transformation, sifting, and regulation of voltage or current for driving different burdens are given by MPPT gadgets which are normally incorporated into an electric force converter system. The change of the dc energy to air conditioning force should be possible by sun oriented inverters and may join MPPT. Such inverters test the yield power (i-v bend) from the sun powered modules and apply the best possible resistance (load) to get most extreme force. The result of the mppvoltage(Vmpp) and mpp current(Impp) will give mpp-most extreme force point esteem. The most extreme force point tracker (MPPT) is expected to streamline the measure of force acquired from the photovoltaic cluster to the force supply.

![Fig. 2: I-V curve](image)

The yield of a sunlight based module is portrayed by an execution bend of voltage versus present, called the i-v bend. The greatest force purpose of a sunlight based module is the point along the i-v bend that compares to the most extreme yield power workable for the module. Discovering the most extreme region under the current versus voltage bend gives bend esteem.

The yield of a sun based module is portrayed by an execution bend of voltage versus present, called the i-v bend. The most extreme force purpose of a sun oriented module is the point along the iv bend that compares to the greatest yield power feasible for the module. Discovering the greatest range under the current versus voltage bend gives bend value.

3. TOPOLOGY, CONTROL PRINCIPLE AND MODOES OF OPERATIONS

The proposed delicate exchanging bidirectional secluded full extension converter with a dynamic flyback and two aloof capacitor–diode snubbers is demonstrated in Fig. 4. It can be worked with two sorts of transformations: venture up transformation and venture down change. Fig. comprises of a current-nourished switch connect, a dynamic flyback snubber at the low-voltage side, a voltage-sustained switch scaffold, and a uninvolved snubber pair at the high-voltage side. Inductor Lm performs yield sifting when force stream from the high-voltage side to the low-voltage side, which is indicated as a stage down change. Then again, it meets expectations in the progression up transformation. In addition, snubber capacitor CC and diode DC are utilized to retain the present contrast between current-encouraged inductor current iL and spillage inductance current iP of detachment transformer TP amid exchanging compensation.
The flyback snubber is worked to exchange the vitality put away in snubber capacitor CC to support capacitors Cb1 and Cb2, and voltage VC can drop to zero. In this way, the voltage anxieties of switches M1 ~ M4 can be constrained to a lower level, accomplishing close ZCS side road. The fundamental benefits of the proposed snubber incorporate no spike current flowing through the switches and accomplishing delicate exchanging elements. Note that high spike current can bring about charge relocation, over current thickness, and additional attractive power which will disintegrate in MOSFET transporter thickness, channel width, and wire holding and, thusly, build its conduction resistance.

In the progression up change, switches M1 ~ M4 are controlled, and the body diodes of switches M5 ~ M8 serve as a rectifier. In the progression down transformation, switches M5 ~ M8 are controlled, and the body diodes of switches M1 ~ M4 work as a full-connect rectifier. To rearrange the relentless state examination, a few suppositions are made as takes after.

1) All parts are perfect aside from that the transformer is connected with spillage inductance.
2) Inductor Lm is sufficiently huge to keep the current IL steady more than an exchanging period.
3) Snubber capacitor CC is much bigger than the parasitic capacitance of switches M1 ~ M8.

A. Step Up Conversion

In the progression up change, switches M1 ~ M4 are worked like a help converter, where switch sets (M1, M2) and (M3, M4) behavior to store vitality in Lm. At the high-voltage side, body diodes D5 ~ D8 of switches M5 ~ M8 will direct to exchange energy to CHV. At the point when switch sets (M1, M2) and (M3, M4) are changed to (M1, M4) or (M2, M3), current distinction iC (∼ iL − iP) will charge capacitor CC until iP ascends to iL, and capacitor voltage VC will be cinched to VHV • (NP/NS), accomplishing close ZCS side road for M2 or M4. Meanwhile, high-side current iS has the need moving through one of the two uninvolved capacitor–diode snubbers, and either Cb1 or Cb2 will be completely released before diode D5 or D7 conducts. At the point when switch pair (M1,M4) or (M2,M3) is changed back to (M1,M2) and (M3,M4), switch M2 or M4 can have close ZCS turn-on highlight because of spillage inductance L11 restricting the di/dt of high-side diode-reverse-recuperation current. The flyback snubber works at the same time to release snubber capacitor CC and exchange the put away vitality to support capacitors Cb1 and Cb2. With the flyback snubber, the vitality assimilated in CC won't move through switches M1 ~ M4, which can decrease their present hassles drastically when the spillage inductance of the separation transformer is noteworthy.

The key voltage and current waveforms of the converter worked in the progression up transformation are indicated in Fig.2. An itemized portrayal of the converter operation more than a half exchanging cycle is exhibited as takes after.

Mode 1 [t0 ≤ t < t1]:

Before t0, the greater part of the four switches M1 ~ M4 are turned on. Inductor Lm is charged by VLV. At t0, M1 and M4 stay directing, while M2 and M3 are killed. At that point, clipping diode DC conducts, and snubber capacitor CC is charged by the present distinction iC. In this mode, the flyback snubber still stays in the OFF state. The comparable circuit is indicated in Fig. 4(a).

Mode 2 [t1 ≤ t < t2]:

In this mode, spillage inductance current iP will begin to track current iL, and cradle capacitor Cb1 will begin to discharge vitality. At time t2, current iP is equivalent to current iL, the voltage of switches M2 and M3 and capacitor CC will achieve the most extreme esteem all the while, and its equal circuit is demonstrated in Fig. 4 (b) A close ZCS delicate exchanging is along these lines achieved amid t0 to t2.

Mode 3 [t2 ≤ t < t3]:

Before t3, the vitality put away in cushion capacitor Cb1 is not completely released yet. Hence, the capacitor won’t quit releasing until Vb1 drops to zero. The comparable circuit is demonstrated in Fig. 4(c).
Mode 4 \([t_3 \leq t < t_4]\):
At the point when the vitality put away in Cbil has been totally discharged to the yield at \(t_3\), diode D5 will lead. The circuit operation over this time interim is indistinguishable to a general side road condition of a traditional current-encouraged full-connect converter. The identical circuit is demonstrated in Fig. 4(d).

Mode 5 \([t_4 \leq t < t_5]\):
At \(t_4\), the majority of the four switches M1 – M4 are turned on once more, and switch MS of the flyback snubber is turned on synchronously. Switches M2 and M3 accomplish a ZCS turn-on delicate changing element because of L1, and current ip drops to zero steadily. In the flyback snubber, the vitality put away in capacitor CC will be conveyed to the polarizing inductance of transformer TS. The proportionate circuit is demonstrated in Fig. 4(e).

Mode 6 \([t_5 \leq t < t_6]\):
At the point when switch MS is killed at \(t_5\), capacitor voltage VC drops to zero, and the vitality put away in the polarizing inductance will be exchanged to cushion capacitor Cbil. In this mode, the time interim of driving sign Vgs(Ms) is marginally more than the releasing time of capacitor CC. The reason for existing is to guarantee that the vitality put away in capacitor CC can be totally discharged, making a ZCS operational open door for switch M2 or M4 at the following side road move. The equal circuit is demonstrated in Fig. 4(f).
Mode 7 \([t_6 \leq t < t_7]\):

At \(t_6\), the vitality put away in the polarizing inductance of transformer TS was totally exchanged to cradle capacitor \(C_{b1}\), and the circuit operation is indistinguishable to a normal turn-on condition of an ordinary

Fig. 4: Operation modes of the step-up conversion (a) Mode 1 (b) Mode 2# (c) Mode 3 (d) Mode 4 (e) Mode 5 (f) Mode 6 (g) Mode 7
current-sustained converter. Its proportionate circuit is indicated in Fig. 4(g). The circuit operation stops at \( t_7 \) and finishes a half-exchanging cycle.

**Fig. 5: Key voltage and current waveforms of the proposed converter operated in the step-down conversion**

**B. Step-Down Conversion**

In the examination, the spillage inductance of the transformer at the low-voltage side is reflected to the high-voltage side in which proportionate inductance \( L^{*}\text{eq} \) levels with \((L_{lh} + L_{ll} \cdot N_{2s}/N_{2p})\). In the movement down change, switches \( M_5 \sim M_8 \) are worked like a buck converter in which switch sets \((M_5, M_8)\) and \((M_6, M_7)\) substitute guiding to trade power from capacitor CHV to battery BLV. For lessening spillage inductance affect on voltage spike, switches \( M_5 \sim M_8 \) are worked with stage development control, achieving ZVS turn-on parts. Yet there is no convincing motivation to hold the present difference amidst \( i_L \) and \( i_P \), capacitor \( C \) can help snap the voltage ringing in light of \( L^{*}\text{eq} \) and the parasitic capacitance of \( M_1 \sim M_4 \). With the two detached capacitor-diode snubbers, switches \( M_6 \) and \( M_8 \) can achieve close ZCS side street.

The key voltage and current waveforms of the converter worked in the movement down change are shown in Fig. 7. An unmistakable depiction of its operation more than a half-trading cycle is displayed as takes after.

**Mode 1 \([0 \leq t < t_1]\):**

In this mode, switches \( M_5 \) and \( M_8 \) are turned on, while \( M_6 \) and \( M_7 \) are in the OFF state. The high-side voltage \( V_{HV} \) is crossing the transformer, and it is, to be perfectly honest, crossing the equivalent inductance \( L^{*}\text{eq} \) and drives current \( i_S \) to climb with the inclination of \( V_{HV}/L^{*}\text{eq} \). With the transformer current extending toward the load current level at \( t_1 \), the body diodes \((D_1 \text{ and } D_4)\) are prompting trade power and the voltage over the transformer terminals on the low-voltage side changes right away to reflect the voltage from the high-voltage side. The equivalent circuit is shown in Fig. 6(a).

**Mode 2 \([t_1 \leq t < t_2]\):**

At \( t_1 \), switch \( M_8 \) stays driving, while \( M_5 \) is slaughtered. The body diode of \( M_6 \) then starts coordinating the freewheeling spillage current. The transformer current \( i_S \) accomplishes the load current level at \( t_1 \), and \( V_{AB} \) rises to the reflected voltage \((V_{HV} \cdot N_{P}/N_{S})\). Cutting diode \( DC \) starts driving the full current of \( L^{*}\text{eq} \) and the parasitic capacitance of \( M_1 \sim M_4 \). In the meantime, switch \( MS \) of the flyback snubber is turned on and starts...
trading the imperativeness set away in capacitor CC to support capacitors Cb1 and Cb2. The technique closes at t2 when the resonation encounters a half resonating cycle and is discouraged by securing diode DC. With the flyback snubber, the voltage of capacitor CC will be cut to a needed level just fairly higher than the voltage of Vds(M4). The corresponding circuit is shown in Fig. 6(b).

Mode 3 \( [t_2 \leq t < t_3] \):
At t2, the body diode of switch M6 is coordinating, and switch M6 can be turned on with ZVS. The indistinguishable circuit is demonstrated in Fig. 6(c)

Mode 4 \( [t_3 \leq t < t_4] \):
At t3, switch M6 stays coordinating, while M8 is executed. Support capacitor Cb2 is discharging by the freewheeling current. Right when Cb2 is totally discharged, a nearby ZCS side street condition is hence accomplished, and the body diode of M7 then starts driving the freewheeling current. The corresponding circuit is demonstrated in Fig. 6(d).

![Fig. 6: Operation methods of the progression down change (a) Mode 1 (b) Mode 2 (c) Mode 3 (d) Mode 4 (e) Mode 5](image-url)
Mode 5 \([t_4 \leq t < t_5]\):

At \(t_4\), with the body diode of switch M7 coordinating, M7 can be turned on with ZVS. Over this time interval, the dynamic changes change to the following pair of switches, and the voltage over the transformer pivots its furthest point. The circuit operation stops at \(t_5\) and completes a half-trading cycle. The relative circuit is shown in Fig. 6(e).

4. SIMULATION RESULTS

Simulation is performed using MATLAB/SIMULINK software. Simulink liabrary files include inbuilt models of many electrical and electronics components and devices such as diodes, MOSFETS, capacitors, power supplies and so on. The circuit components are connected as per design without error, parameters of all components are configured as per requirement and simulation is performed.

Six 36-cell strings

‘Si’ material
Array Open Circuit voltage=50V
Array Short Circuit current =7.34A
Wattage=369W
Operating Temp=25.1C
Radiation=1000W/m2
Source side inductance \(L_m=500\mu H\)
Capacitance \(C_c=100nF\)
Diode ratings:
\(R_{ON}=0.001\) Ohm
\(V_{fD}=0.8V\)
Snubber: \(R_s=500\) Ohm; \(C_s=250nF\)

Flyback transformer ratings:
100VA 50Hz
\(n=1/4.25\)
Winding-1: \(R=4.3\) Ohm, \(L_1=0.4H\)
Winding-2: \(R=0.793\) Ohm, \(L_2=0.08H\)
\(R_m=1Mohm; L_m=2866H\)

Active snubber parameters:
\(L_i=500\mu H\)
\(C_c=100nF\)
Three Winding Transformer
100VA, 50Hz
Winding-1 : 50V, \(R_1=4.3\) Ohm, \(L_1=0.45H\)
Winding-2: 150V, \(R_2=0.793\) Ohm, \(L_2=0.084H\)
Winding-3: 150V, \(R_3=0.793\) Ohm, \(L_3=0.084H\)
Turns ratio, \( n = 1:3 \)

Simulation Circuit

Bidirectional isolated full bridge dc–dc converter with active and passive snubbers for a renewable energy system

PV Boost Converter

PV Cell Model
Waveforms

a) Input voltage

b) Output voltage

Calculations

Input voltage from PV=800V

Output voltage at HV side =1700V

Therefore, conversion ratio \( M = \frac{V_o}{V_{in}} \)

\[ M = \frac{1700}{800} = 2.1 \]

5. CONCLUSION

Thus a bidirectional isolated full bridge dc–dc converter with active and passive snubbers for renewable energy system like PV system is employed here. This converter is designed for high voltage gain so that the low dc voltage from PV is stepped up to suitable ratio. This is studied using MATLAB/ SIMULINK study.

REFERENCES


