Transformerless Grid Connection Technique.

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Abstract—Now a days renewable energy sources are most commonly used energy source. When a renewable energy source is directly connected to a grid, but the renewable energy source output is varies with the input. The grid needs a constant transmission voltage and frequency. A high power high voltage step up DC-DC converter are required to deliver the produced electrical energy to HVDC grid, the step up DC-DC converter not only transmit electrical but also isolate or buff kinds of fault conditions.Converter companies introduced a boost converter but its efficiency is relatively low due to large reverse recovery loss of diode and switching loss under high voltage condition, also it has low voltage ratio and not giving soft switching, so we have to introduce a novel resonant converter to achieve the large voltage ratio, zero current and soft switching.

Index Terms—Transformerless, HVDC, DC-DC coverter

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1 INTRODUCTION

Now a day's, most of the renewable energy sources are utilized with the form of AC power. The generation equipments of the renewable energy sources and energy storage devices usually contain DC conversion stages and the produced electrical energy is delivered to the power grid through DC/AC stages, resulting in additional energy loss. The common problem of the renewable energy sources, such as wind and solar, is the large variations of output power, and the connection of large scale of the renewable sources to the power grid is a huge challenge for the traditional electrical equipment, grid structure and operation. DC grid, is one of the solutions for these issues.

The voltage in the generation equipments of the renewable energy sources are relatively low, hence high power high voltage step up DC-DC converters are required produce electrical energy to HVDC grid.The first grids were based on direct current (dc). Without appropriate equipment to change the voltage level dc distribution suffered from high losses and was soon ruled out by more efficient ac technology, which used transformers to step up the voltage. However, today as a result of considerable technical progress in the field of high-power semiconductor devices and cable technology, high-voltage point-to-point direct current (HVDC) transmission has merged into power systems for several decades now.

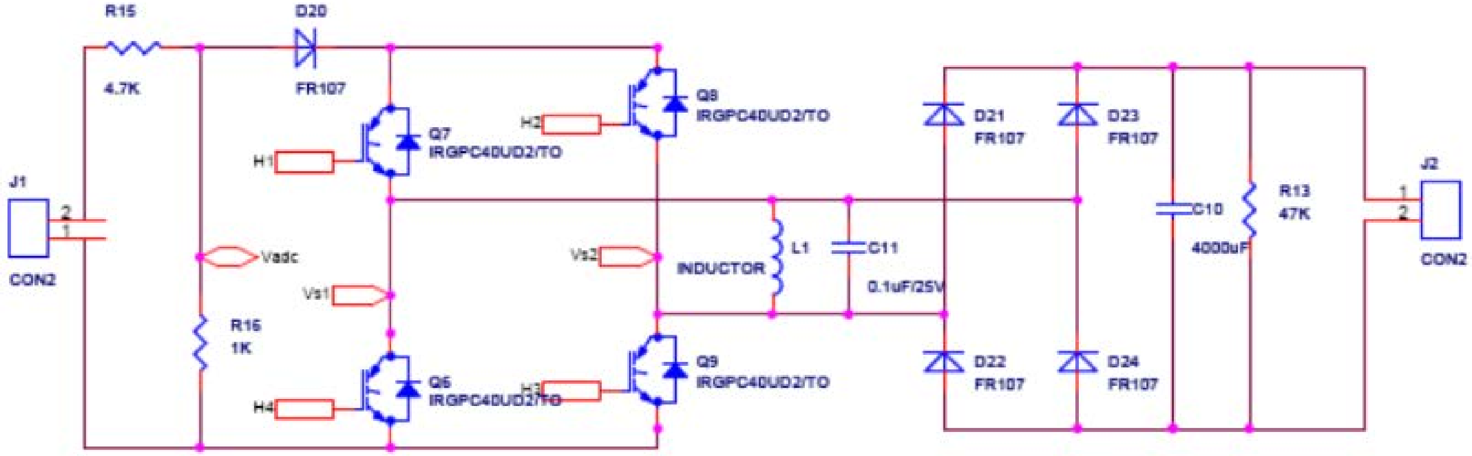


Fig 1. Resonant step-up converter

Boost converter is adapted by researchers of Converteam company to transmit energy from ±50kV to ±200kV, the efficiency of Boost converter is relatively low due to large reverse recovery loss of diode and switching loss under high-voltage condition, and Boost converter is usually used for the application where voltage-ratio is less than six [2]. There were different studies related to this DC-DC conversion [3].

In this paper, a novel resonant step-up DC-DC converter is proposed. In this we provide the input form a solar panel, and the input voltage to the converter is around 16V. We experimentally found that we got the output of 32V with a load of 24V 5W bulb and around 100V output without load.

2 OPERATION PRINCIPLE

The solar panel output is onnected to the input of the input of the converter. The operation principle can be explained with 4 modes.Fig. 1 shows the proposed resonant step-up DC-DC converter and its key waveforms are depicted in Fig. 2. During the operation *Q*2 and *Q*3 are tuned on and off simultaneously, *Q*1 and *Q*4 are tuned on and off simultaneously, there are 12 modes in a switching period and its equivalent circuits are illustrated in Fig. 3.

(1) Mode 1 [t_0, t_1] [Fig. 3(a)]

At t_0, Q_1 and Q_4 are turned on, the voltage across resonant capacitor C_r v_{Cr}=V_{in}, V_{in} is applied on resonant inductor L_r and L_r absorbs energy from V_{in}. The resonant inductor current i_{Lr} increases linearly from I_0. The load is powered by Co. At t_1, i_{Lr} reaches I_1.

$$I_1 = I_0 + \frac{V_{in}T_1}{L_r} \qquad (1)$$

Where $T1$ is the time interval of $t0$ to $t1$. The energy delivered from $Vin$to $Lr$is

$$E_{in} = \frac{1}{2}L_r(I_1^2 - I_0^2) \qquad (2)$$

(2) Mode 2 [t_1, t_4] [Fig. 3(b)

At t_1, Q_1 and Q_4 are turned off and after that $L_r$resonates with Cr, v_{Cr}decreases from V_{in}andi_{Lr}increases from I_1 in resonant form. At the same time, the voltage of node A $v_A$declines from V_{in}, the voltage of node B $v_B$increases fromzero. Due to the parasitic capacitor of main switch is much smaller than C_r, the voltage increase of the parasiticcapacitor is very small during the turn-off time of Q_1 and Q_4, hence, Q_1 and Q_4 are turned off with zero-voltage.

At t_2, v_{Cr}decreases to zero, i_{Lr}reaches its maximum magnitude, v_A=v_B=$V_{in}/2$. After that, v_{Cr}increases in negative direction, i_{Lr}declines in resonant form, $v_A$declines from $V_{in}/2$and $v_B$increases from $V_{in/2}$.

At t_3, v_{Cr}= -V_{in}, v_A=0, v_B=V_{in}, the voltages across Q_2 and Q_3 both reduce to zero and then Q_2 and Q_3 can be turned on with zero-voltage. After t_3, $L_r$still resonates with Cr, v_{Cr}increases in negative direction from -V_{in}, i_{Lr}declines in resonant form. The input reverse-blocking diode $D_i$will withstand voltage and $v_B$continues to increase from V_{in}. At t_4, v_{Cr}= -$V_o$andi_{Lr}reduces to I_2. It can be seen that during t_1 to t_4 the whole energy stored in LC resonant tank is unchanged.

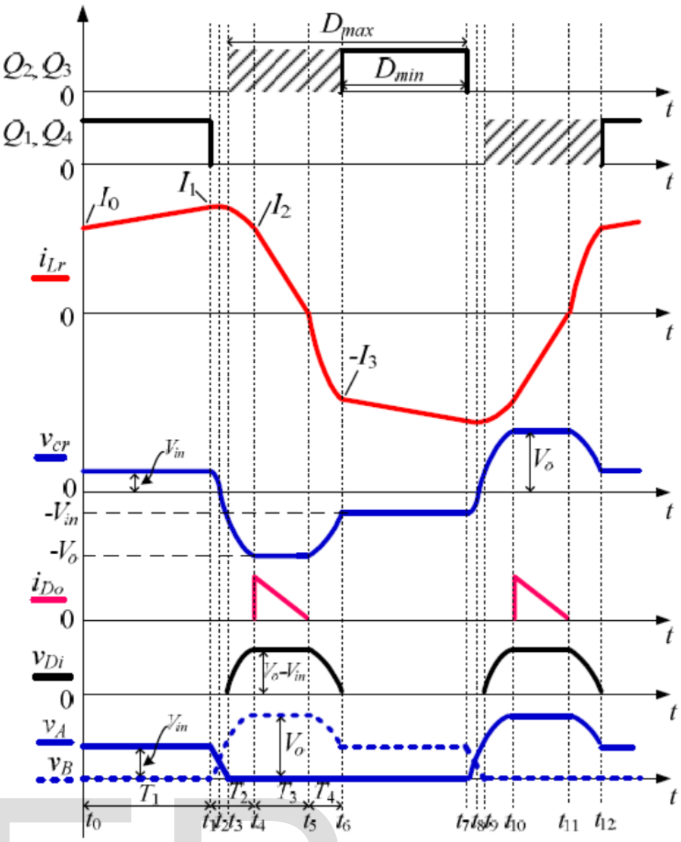


Figure 2. Key waveforms

(3) Mode 3 [t_4, t_5] [Fig. 3(c)]

At $t4$, vCr= -Vo, $DR1$ and $DR4$ conduct naturally, Co is charged by iLrthrough $DR1$ and $DR4$, v_{Cr}keeps unchanged, i_{Lr} decreases linearly. At t_5, i_{Lr}=0. The time interval of t_4 to t_5 is

$$T_3 = \frac{I_2 L_r}{V_0} \qquad (3)$$

The energy delivered to load side in this method is

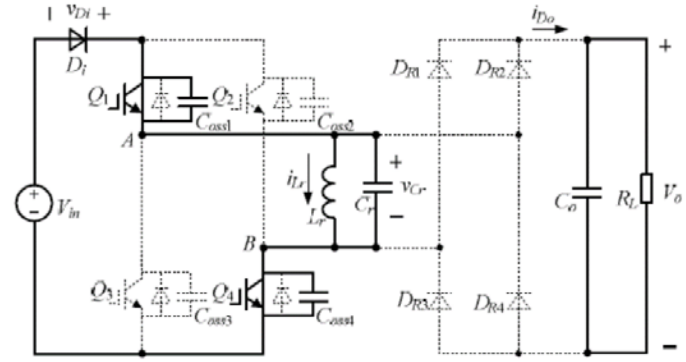
$$E_{out} = \frac{V_0 I_2 T_3}{2} \qquad (4)$$

The energy consumed by the load in half switching period is

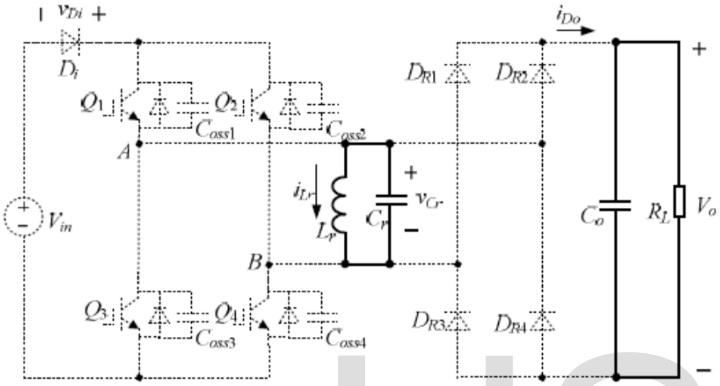
$$E_R = \frac{V_0 I_2 T_3}{2} \qquad (5)$$

Where T_5 is the switching period.
According to the energy conversation rule,in half switching period,

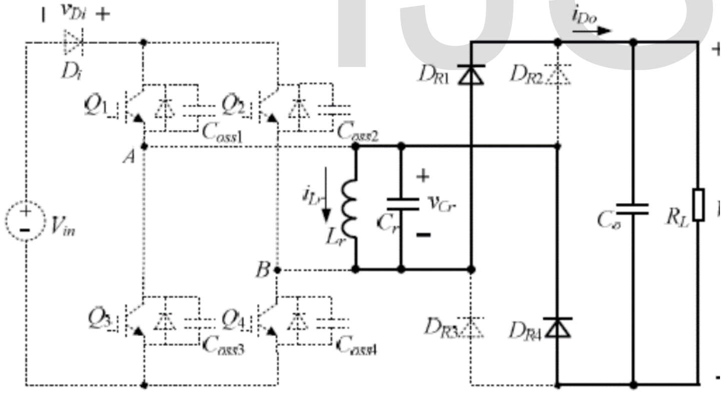
$$E_{in} = E_{out} = E_R \qquad (6)$$



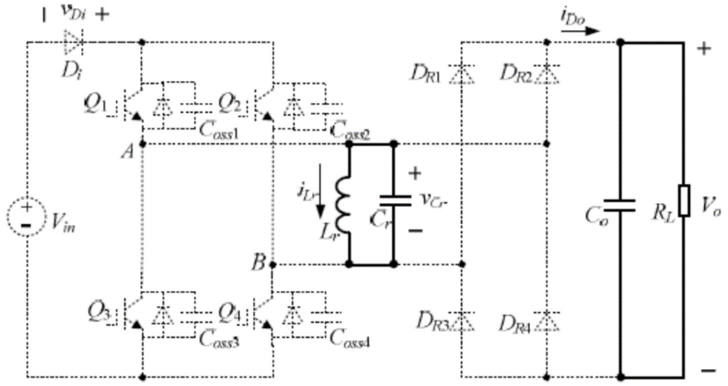
3(a) [t_0, t_1]



3(b) [t_1, t_4]



3(c) [t_4, t_5]



3(d) [t_5, t_6]

(4) Mode 4 [$t5$, $t6$] [Fig. 3(d)]

At $t5$, iLrdecreases to zero, $DR1$ and $DR4$ is turned off naturally. After $t5$, Lrresonates with Cr, Cr is discharged through Lr, vCrincreases from $-Vo$ in positive direction, iLr increases from zero in negative direction. Meanwhile, vB declines from Vo. At $t6$, $vCr= -Vin$, $iLr= -I3$. In this mode, the whole energy stored in LC resonant tank is unchanged.

If $Q2$ and $Q3$ are turned on before $t6$, then after $t6$, $Lr$is charged by Vinthrough $Q2$ and $Q3$, iLrincreases in negativedirection, the mode is similar to Mode 1. If $Q2$ and $Q3$ are not turned on before $t6$, then after $t6$, Lr will resonate with Cr, vAwill increase from zero and vBwill decay from Vin, Zero-voltage condition will be lost if $Q2$ and $Q3$ are turned on at the moment. Therefore, $Q2$ and $Q3$ must be turned on before $t6$ to reduce switching losses.

3 EXPERIMENTAL SETUP

Fig4 show the experimental setup of the converter**.** Input of 12V is provided from a 15W solar panel. The singnal is passes to the diode (here S306) and then to 4 FETs.there is an inductor provided it provides high oscillation for stepup. 2 windings are provided in the inductor, primary is thick and has less number of turns (here 60), secondary is thin and have large number of turns (here 100). A 16*2 matrix display is provided see the input voltage and a 12V 5W bulbe is provided on the load side.Pic 16F877A is used for the program.

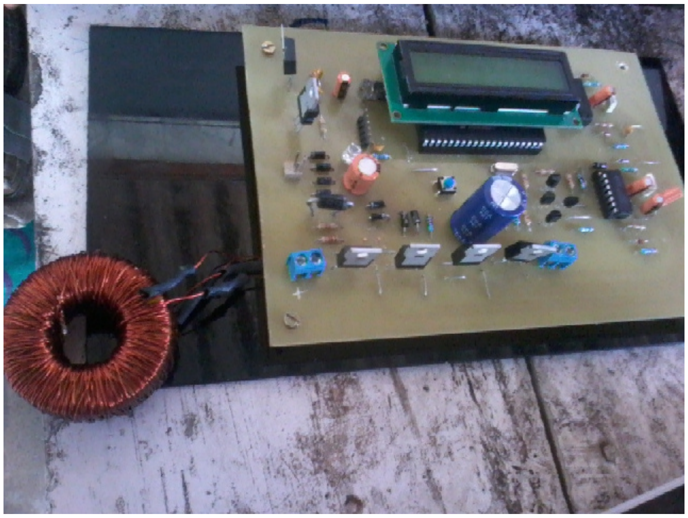


Fig 4: Experimental setup

4CONCLUSION

From the experimental setup we can obtain the steppedvoltage value. We provided the input as 16V DC from a solar panel and we obatained a 32V DC as an output with a load of 5W 12V bulb and 100V DC output without load.

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