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Switching Algorithm for Leakage Current Reduction in a PV- No Transformer Inverter System

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Abstract

Electricity generation purposes renewable energy brings a important role especially Photovoltaic (PV) panels that can be covered our basic energy (electricity) needs. This photovoltaic panels cover a domestic level (solar power for home), commercially (solar power for commercial applications) or at the community level. Here used this photovoltaic panel as an input of PV-transformer-less inverter topology which has been compared with existed H6 transformer-less inverter topology. It's possible to reduce the leakage current with inclined the output voltage that has been shown here by using proposed topology. This topology is made by using two extra switches with filter. Moreover, overall system actually verified with Pulse Width Modulation (PWM) switching technique.

Keywords*: Photovoltaic (PV) panel, Electricity, PWM, Duty cycle, Leakage Current (LC), Inverter*

1. Introduction

Energy generated through the renewable such as solar, hydrogen, wind, biomass, geothermal, ocean energies are most reliable, and the sources do not suffer from the quandary of destruction [1]. Renewable energy sources especially wind [2, 3] and photovoltaic (PV) panels [4-6] which have been of interesting in government policies, academia and industry where application of off grid is well known for small wind turbines and photovoltaic systems. On the other hand, large scale wind farms and PV systems are widely used all over the world [7]. Meanwhile, it is not only environmentally beneficial but energy efficient as well. Wind and solar plants generate energy at different times of the day and, therefore, will supply a more stable energy to the grid. In addition, the transmission lines will be utilized more efficiently than by either wind or solar alone. Solar and wind are most important and efficient for electric power generation from above mentioning renewable sources of energy [1]. To produce electric power for various purposes such as residential, urban and so on, renewable energy is bringing a vital role especially solar energy solar energy [8]. Photovoltaic (PV) panel nowadays has been becoming part and parcel widely for distributed power generation. However, PV system is a bulky and susceptible to failure [9, 10]. These systems, as described, have several issues, namely cost, efficiency and size [8, 11]. On the other hand, it is really a combinations of solar cells that have many advantages such as non-polluting, inexhaustible and renewable energy and from few decades it gradually inclined in both topologies with and without transformer [11].
The no transformer based topologies such as H5, H6, Double Paralleled Buck, HB-ZVR, Karschny inverter, oH5, HERIC, Hybrid bridge, Step down converter [12-16] which are non-existent galvanic isolation. Hence, some advantages have been observed such as low cost, high efficiency, light weight and good performance as well [1]. However, here has been occurred a common problem which is leakage current through PV panel to ground. The common mode leakage current is a vital issue tending to develop between solar panel and ground side mainly in the cases of inverters using transformer-less topologies [17, 18]. Many researchers are busy working still trying to remove this current from the system for getting lost less power effective system. In this paper has been discussed the leakage current issues and

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reducing process with given proposed technique through the switching conditions in different on mode situation.

2. Leakage Current Reducing Process

In the common-mode issues of the PV-transformer-less inverter system, a voltage is generated around the parasitic capacitor helping the inverter to produce leakage current which is the causing to produce even electric shocks. This parasitic capacitor is generated in between PV panel to direct ground which is shown in Figure 1. Hence, the common mode voltage variations, the very reason for leakage currents, is to try using different approaches in newly reported topologies aimed at minimizing these currents.

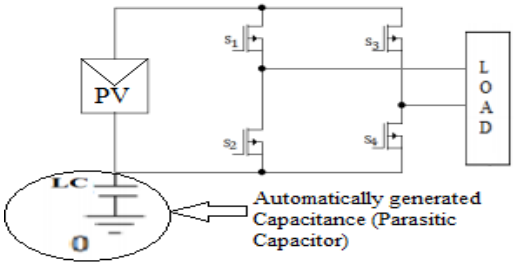

Figure 1. Indicated location of Parasitic Capacitance (PC)

3. Proposed Technique

In this approach shown in Figure 2 is a transformer-less topology, which is actually made by using H6 transformer-less inverter topology technique where uses extra two switches (S7 and S8). In total, in this proposed topology used eight switches where six switches are connected alternatively to make a inverting process smoothly. This idea actually achieved from H6 technique and compared this technique with proposed topology. Here used extra switches with filter to make a new transformer-less inverter topology. Meanwhile, in Figure 2 shows the leakage current path which is through parasitic capacitor that automatically created in between PV panel to ground.

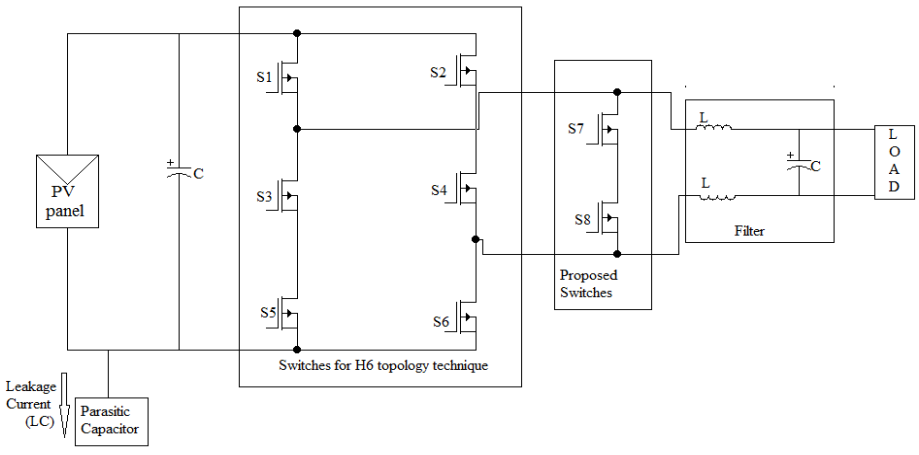

Figure 2. Proposed Transformer-less inverter topology

4. Result and Discussion

4.1. Switching Conditions

In Figure 2 has been shown the proposed topology and it will be compared with H6

topology. In below mentioning Table 1 and Table 2 are the tables where show the values of leakage current and output voltages for both H6 and proposed technique.

In the case of 30% duty cycle in Table 1 when switch S1 and S4 is in on S2 and S3 is in off mode that works is in opposite direction and S5 and S6 is the H6 switches and it connects alternatively to work accurately. After using the six switches in 30% duty ratio, output voltage can be got around 11V, but the leakage current is occurred more that varies from 180.325pA to 10.143uA. On the other hand, this leakage current is varies from 32.59m to 5.257u for H6 transformer-less inverter topology and the output voltage also around 10.5V. Here selected only one leakage path.

Table 1. 30% on mode condition the leakage current and output voltages for both H6 and proposed technique

S1	S2	S3	S4	S5	S6	S7	S8	LC(A) (Proposed)	LC (A) (H6)	V_{OUT} (V) (Proposed)	V_{OUT} (V) (H6)
ON	OFF	OFF	ON	OFF	ON	ON	ON	3.259n	32.59m	10.69	10.05
OFF	ON	ON	OFF	ON	OFF	OFF	OFF	18.025p	5.257u	11.02	10.52
ON	OFF	OFF	ON	OFF	ON	OFF	ON	180.325p	220.698u	10.88	10.63
OFF	ON	ON	OFF	ON	OFF	ON	OFF	10.142u	1.2353m	11.01	10.55

In the case of 50% duty cycle when leakage current has occurred through one path that has been shown in Table 2 for when switches S1 and S4 is in on mode than the switches S2 and S3 is in off mode that works is in opposite direction and S5 and S6 is the H6 switches and it connects alternatively to work accurately that fixed in 50% duty ration and rest of the two switches which are proposed switches are fixed in 50% duty cycle, output voltage can be got more than 11.5 V which is more that which is achieved for 30% duty ration but the leakage current is occurred which is reduced from the 30% duty ration that varies from 37.021p to 28.695f Amp.

Table 2. 50% on mode condition the leakage current and output voltages for both H6 and proposed technique

S1	S2	S3	S4	S5	S6	S7	S8	LC(A) (Proposed)	LC (A) (H6)	V_{OUT} (V) (Proposed)	V_{OUT} (V) (H6)
ON	OFF	OFF	ON	OFF	ON	ON	ON	40.29f	302.129u	11.62	11.05
OFF	ON	ON	OFF	ON	OFF	OFF	OFF	37.021p	50.367u	11.85	11.08
ON	OFF	OFF	ON	OFF	ON	OFF	ON	28.695f	20.618p	11.58	11.23
OFF	ON	ON	OFF	ON	OFF	ON	OFF	29.39p	11.024u	11.54	11.10

4.2. Wave Shapes

The Leakage current (LC) has occurred in different places and in this paper has been considered only one path. It has been simulated through PSpice software after constricting the circuit together. The value of leakage current for PV panel to ground is changed from when we consider in one path that has been shown in above in a tabular form. Below is shown the considering path where leakage current is occurred. Meanwhile, the leakage current wave shapes are shown for both 30% and 50% duty cycle as well.

In Figure 3 is shown the wave shape of the leakage current after considering the automatically occurred parasitic capacitance is 1nf and the selected switching condition is 50% duty cycle.

In Figure 4 is shown the wave shape of the leakage current after considering the automatically occurred parasitic capacitance is 1pf and the selected switching condition is 50% duty cycle. Here shows the increment of leakage current compared to selected 1nf parasitic capacitance.

In Figure 5 is shown the wave shape of the leakage current after considering the automatically occurred parasitic capacitance is 1nf and the selected switching condition is 30% duty cycle. The leakage current actually occurred in the time of switched on/off.

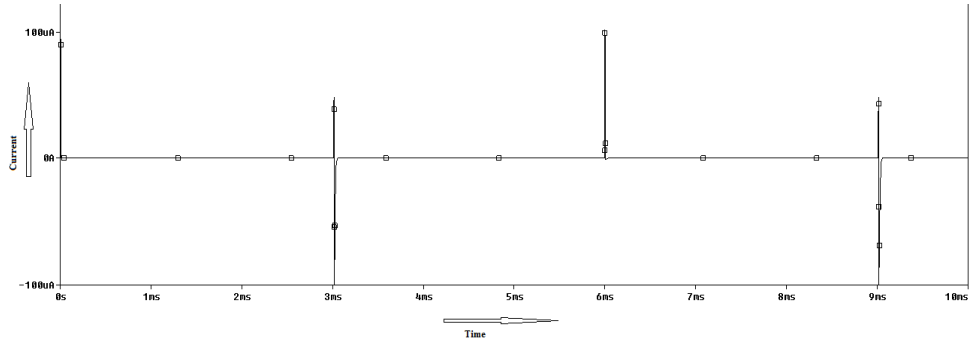

Figure 3. Leakage current for considering 1nf parasitic capacitance when 50% duty cycle considered

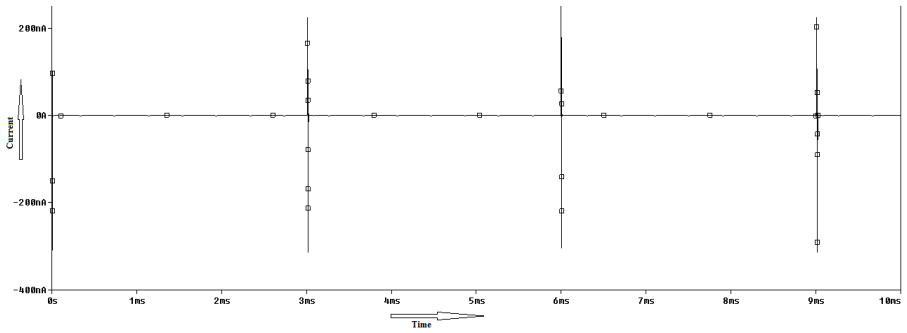

Figure 4. Leakage current for considering 1pf parasitic capacitance when 50% duty cycle considered

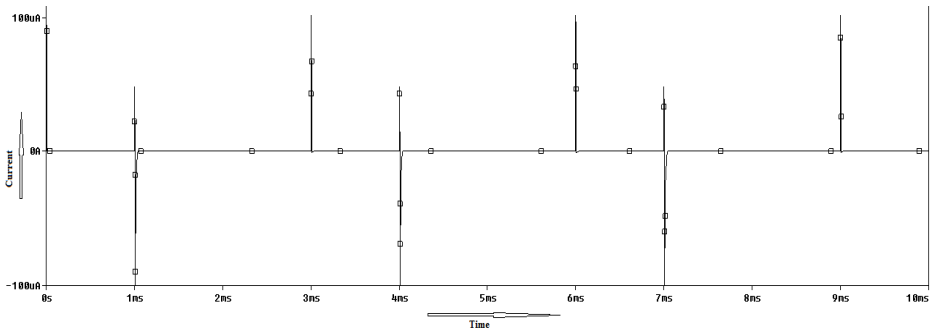

Figure 5. Leakage current for considering 1nf parasitic capacitance when 30% duty cycle considered

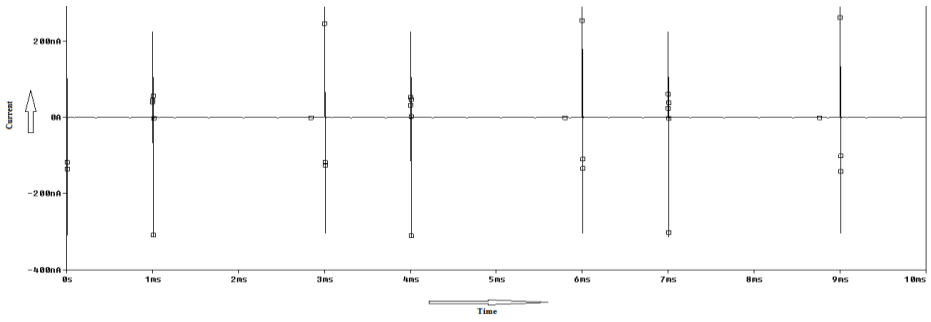

Figure 6. Leakage current for considering 1pf parasitic capacitance when 30% duty cycle considered

In Figure 6 is shown the wave shape of the leakage current after considering the automatically occurred parasitic capacitance is 1pf and the selected switching condition is 30% duty cycle.

5. Conclusion

Throughout the world, the demand of power is increasing dramatically where photovoltaic system is becoming a vital role especially, transformer-less inverter topology. In additionally, limitations of using PV-no transformer inverter system are high cost. This system is reduced in size as well as weight, which is its benefit whereas it is associated with a very common problem of common mode voltage development; hence leading to having leakage current and power loss as a result—this is a power loss component as well safety concern. In the decreasing the cost of photovoltaic panel system for transformer-less inverter system most important part is reduction of leakage current in the system, hence inclined the power efficiency. In this paper has been addressed the issue of leakage currents and proposed a new technique for reducing this leakage current with output voltage development through the PWM of varying Duty Cycle for switching devices.

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