COMPARATIVE STUDIES OF TERMINAL VOLTAGE TRANSFORMER-LESS PV INVERTER IN SINGLE-PHASE SYSTEM

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ABSTRACT: Photovoltaic (PV) now has an advanced technology [1] in energy generation, it is the most useful non-conventional energy source which is used in various areas for transferring energy from one medium to another medium. To reduce the use of transformers to avoid hazards and their various losses, high efficiency, and reduce leakage current to avoid problems we use transformer-less. Various types of transformer-less PV systems are optimized to eliminate the leakage current and reduce its cost, and size by using different types of inverter topologies. we discussed the different types of topologies and their design. We discussed how to affect the inverter the voltage ratio in input to output of the system. How the grid voltage is affected and which filter gives the most efficient result in different types of inverter topologies.

INDEX TERMS- Transformer less system, Photovoltaic system (PV), Topologies, common mode voltage (CMV), Vo (output voltage), Vn(neutral voltage), Vpv(source voltage)

INTRODUCTION - Renewable systems have gained popularity as power systems. Distributed grid-connected photovoltaics (PV's) are becoming an increasingly significant component of electricity grids. In a PV network, transformers are usually employed to reduce leakage currents by providing galvanic isolation. Large proportions, energy sources, and photovoltaic energy expensive price, and the possibility of weight loss are among its superfluous qualities.[1] Nevertheless, galvanic isolation between the input PV array and the system’s output is lost when the transformer is removed [1]. As a result, the system's built-in parasitic capacitances provide a direct conduit through the PV array for the leakage current to enter. Voltage source converters have [5]controllable dc-link voltage, to sinusoidal input current, a controllable power factor (leading, lagging, or unity), and restore energy. In the harmonic distortion between the ac, input is more it will be less to the conversion of the energy conversion process it has been occurring to use of nonlinear load. To eliminate the harmonics we use the filter (L-LC-LCL) type filters, especially LC and LCL filters used in the conversion process. A VSI, interfacing with the PV Module PWM inverters often utilizes fast switching, which produces high-frequency noise, with semiconductor switches [1]. Furthermore, all PWM mechanisms inherently create harmonics originating through high dv/dt and di/dt semiconductor switching transients [1]. These shortcomings lead to distortions in inverter output, leading to power quality concerns while connecting to the grid or serving an isolated AC load. Typically, passive filters were employed to eliminate harmonics from line current. Additionally, these passive filters increase the system's power factor [2]. It will be designed for the conversion of DC voltage in AC voltage to get more efficiency in the output.

2.1 TOPOLOGIES

2.1(a) Full Bridge Unipolar PWM Inverter Topology: The unipolar full bridge inverter topology is a type of PWM technique the signal is a comparison of two signal carriers and reference wave. IN PWM techniques it has a sinusoidal signal for the reference signal and have triangular signal for the carrier. There are two signals positive and negative. In the PWM technique unipolar is generated to 0-Vdc so the harmonic component is under operation. In this technique, switching has sw1sw2 and sw3 sw4 when sw1 and sw4 are conducted then sw2 and sw4 are off, and when sw3 and sw4 are conducted then sw1 and sw3 are off.

$$V_o = 0.5V_n + 0.5V_s$$

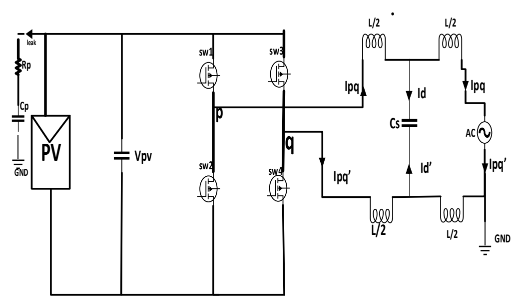

Figure 2.1 (a): Full bridge unipolar PWM inverter topology

2.1(b) Full Bridge Bipolar PWM Inverter Topology: This is an inverter topology which is a type of PWM technique it is has also two signal waves which are carrier and references in reference signals used as sinusoidal and carrier signals have a triangular signal which has negative and positive. it has generated to -Vdc - +Vdc so the harmonic component is over the operation and there are more harmonics rather than the unipolar PWM technique its switching operation is the same as the unipolar PWM technique.

$$V_o = 0.5V_n + 0.5V_s$$

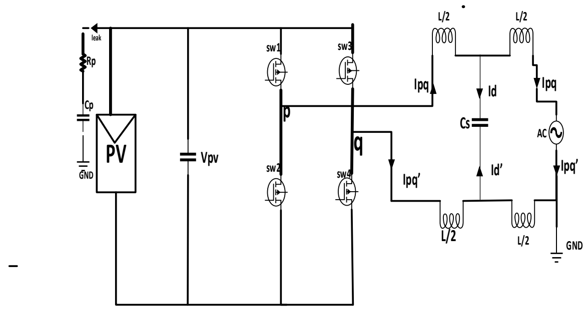

Figure 2.1(b) Full bridge bipolar inverter topology

2.1(c) H5 inverter topology: This topology has a high frequency and high leakage current inverter type it has 5 switching devices and generates less harmonics Device switching [2]. The full bridge with DC bypass is shown in Fig. 2.1(c). This procedure involves disconnecting the inverter from the grid [2]. This topology allows for continuous common mode voltage by severing the PV panel's connection to [6] the grid during current freewheeling periods [2]. A DC bypass switch and four switches (sw1, sw2, sw3, sw4) are seen in Figure 3. The switches SW1 and SW2 work at grid frequency, whereas SW3, SW4, and SW5 operate at high frequency [2]. During the current freewheeling phase, the sw5 switch is open, disconnecting PV panels from the inverter's full H-bridge [2].

$$V_o = 0.5V_n + 0.5V_s$$

At zero voltage cycle,

$$V_a = \infty$$

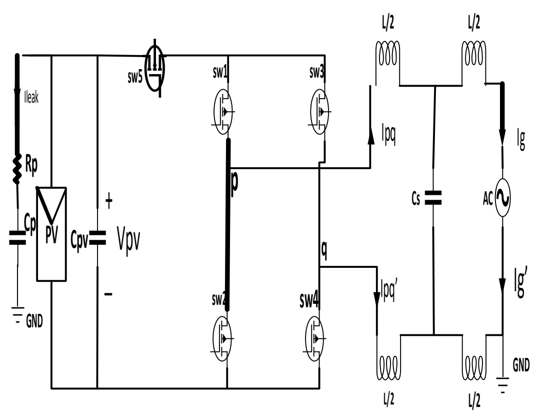

Figure 2.1(c): H5 Inverter Topology

2.1(d) H6 Inverter Topology: H6 inverter topology has the H type of inverter. It has high efficiency in voltage regulation it has 6 switching devices available which is directly connected with it in the positive grid path cycle it has sw1 sw4 and sw6 is operated and in the negative grid path cycle sw3 sw2 and sw5, it has connected with both positive as well as negative grid. In the positive grid path cycle s16 is always on and in the negative grid path cycle the sw5 switch is always on. H inverter topology has a very high efficiency and less leakage current generated.

$$V_o = 0.5V_n + 0.5V_s$$

At zero voltage cycle,

$$V_a = \infty$$

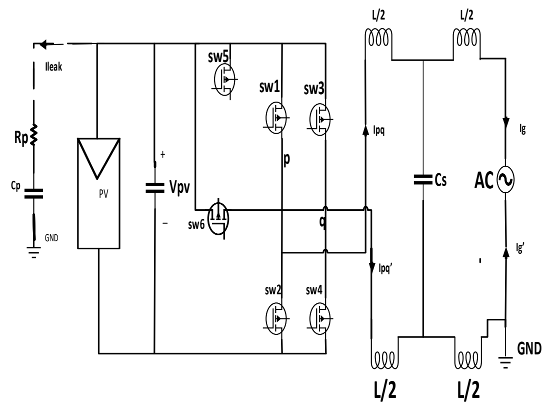

Figure 2.1(d): H6 inverter topology

2.1(e) HERIC Inverter Topology: Highly efficient and reliable inverter concept. As the high efficiency through reduced leakage current when it is transformer-less it has also six switches that help generate the path of the voltage in the HERIC inverter topology sw5 and sw6 are switched as complementary switches in the grid and sw6 and sw5 are turned on both the cycle on positive and negative cycle in the positive grid path cycle s11 and s14 are ON with sw6 and for negative path sw2 and s13 is ON with s15 at zero voltage.

$$V_o = 0.5V_n + 0.5V_s$$

At zero voltage cycle,

$$V_a = \infty$$

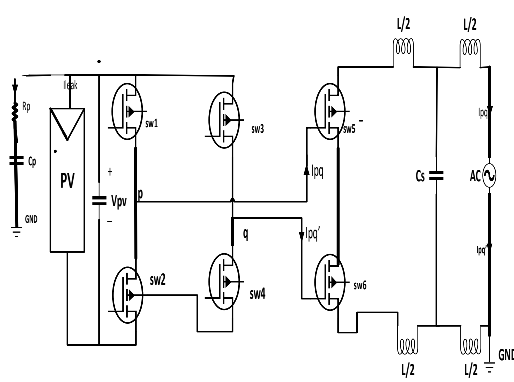

Figure 2.1(e): HERIC inverter topology

2.1(f) Novel H6 transformer-less PV Inverter Topology: Novel H6 transformer-less PV inverter has a reduced leakage current and conduction losses it has a high efficiency. this inverter is a modified H5 inverter topology it has 6 switches in the circuit that generate positive and Negative path cycles for voltage. For the positive path cycle, sw1 and sw5 are ON and for the negative Path cycle, sw4 and sw6 are ON, and switch sw4 is a complementary switch with the sw3 switch.

$$V_o = 0.5V_n + 0.5V_s$$

At zero voltage cycle,

$$V_a = \infty$$

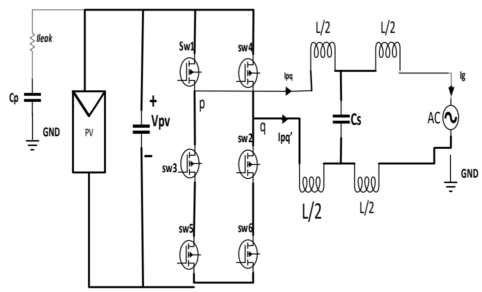

Figure 2.1(f): Novel H6 transformer-less PV inverter topology

2.1(f) NPC Full Bridge Inverter Topology: NPC (neutral point clamped) inverter topology works on the clamping diodes and it eliminates the CMC, reducing the filter requirement. It is a highly efficient and reduced leakage current inverter type it has 8 switches with 4 freewheeling diodes. This is a three-level inverter in the positive path cycle it has sw1 sw2 sw5 and sw6 on and during the negative path cycle sw3 and sw4 are on while during the zero- cycle as well as at the output current is freewheeled by the sw2, sw5, sw7, sw8.

$$V_o = 0.5V_n + 0.5V_s$$

At zero voltage cycle,

$$V_o = 0.5V_n + 0.5V_s$$

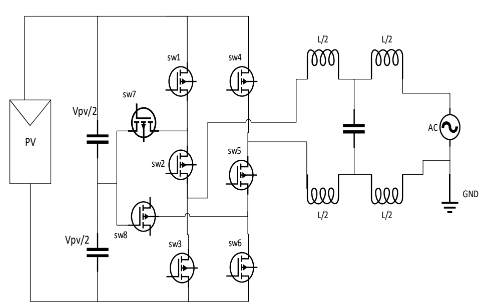

Figure 2.1(f): NPC full bridge inverter topology

2.1(g) Quasi-unipolar SPWM Full Bridge Inverter Topology: It is the inverter type with 8 switches with the AC bypass bridge, less conduction loss, and less leakage current inverter type inverter [6]. Where sw1 and sw4 are AC bypass switches and sw5 and sw6 are freewheeling diodes, sw1 and sw4 are on during the positive path cycle sw2 and sw3 are on during the negative path cycle, and current flows through freewheeling AC bypass sw5 and sw6 at 0 voltage cycle.

cycle when all of the controllers are off.

$$V_o = 0.5V_n + 0.5V_s$$

At zero voltage cycle,

$$V_o = 0.5V_n + 0.5V_s$$

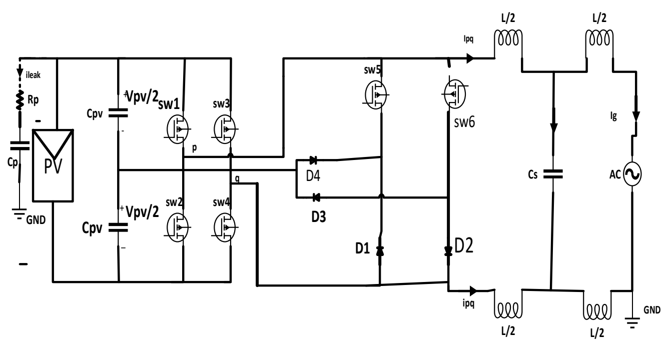

Figure2.1 (g) Quasi unipolar SPWM full bridge inverter.

DISCUSSION:

Inverter Topology	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
H5	unequal	No	3	5	1.92	0.2	3	3	19.614	2	3	1	1	12.87	Yes	3
HERIC	equal	No	2	6	1.92	0.2	2	2	13.2	2	2	1	1	8.58	Yes	3
H6	unequal	Yes	3	6	1.92	0.2	2	2	14.189	2	2	1	1	8.58	Yes	3
NPC full bridge	unequal	Yes	4	8	1.92	0.2	2	2	19.578	4	2	2	2	9.66	No	3
Bipolar	equal	No	2	4	3.31	1e-2	4	4	17.672	-	2	0	0	17.16	No	2
Unipolar	equal	No	2	4	1.99	5.75	4	4	17.672	2	2	0	0	17.16	No	3
Quasi unipolar	unequal	No	2	6	1.92	0.2	4	4	17.636	2	2	0	0	17.16	no	3
H6 transformer-less	unequal	No	3	6	1.92	0.2	3	3	19.578	2	3	1	1	12.87	Yes	3

Table 1: Comparison between different Topologies

A -Losses distribution in the four H-bridge inverters switching.

B- Irregularity in the inverter function over the +ve and -ve equal cycle of the system voltage.

C- Count of switches and diodes conducting during the negative equal cycle of the grid voltage.

D--Count of S used.

E-%Total Harmonic Distortion of the system current.

F- leakage current in peak value, A.

G-Count of S utilized at the excessive frequency during the +ve half cycle of the system voltage.

H- Count of switches operating at the excessive frequency during the -ve equal cycle of the system voltage.

I-Entire S loss for the inverter topology.

J- Count of S and D conducting during zero voltage cycle in system voltage.

K-Count of S and D conducting during -ve voltage cycle in system voltage.

L- Count of S operating in the grid at fundamental frequency voltage during the +ve half-cycle.

M-Count of S operating in the grid at fundamental frequency voltage during the -ve half-cycle.

N-Total conveying loss for the inverter.

O- output voltage in the undetermined states.

P-Count status of the terminal voltage.

In this paper, we discussed every one of the switching devices of each different topology. It has been seen that all the switches work on PWM and SPWM techniques it has all Hybrid inverters have low leakage current and low conduction losses, and in there has NPC full bridge inverter has reduced the filter requirement it has the all are the good inverter type solution. and the Unipolar PWM technique is better in the switching operation less losses in switching and less amplitude voltage compared to the bipolar PWM technique. The Heric is better in the loss distribution and the switching action is good in all the operations. Quasi-unipolar PWM technique inverters have also had less leakage current and high efficiency.

CONCLUSION: It is concluded that all of the inverters have the same type of operation the switching method and their viability is different in the same manner they have all eliminated the leakage current, reduced the consumption losses, and increased the overall efficiency. It seems that this paper helps to make the switching action easy and has a variant of the result found. the basic information of all of the above topologies is given in the paper.

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