A MULTILEVEL TRANSFORMERLESS INVERTER EMPLOYING GROUND CONNECTION BETWEEN PV NEGATIVE TERMINAL AND GRID NEUTRAL POINT USING MOSFET

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ABSTRACT: In this paper a multilevel transformerless inverter using MOSFET switches provides a low cost and a total number of switches required are less. The proposed inverter topology gives a reactive power when it is connected to the grid. The Total Harmonic disortation are improved hence the filter required is of a small size. The levels can be increased by increasing two switches and one capacitor.

KEY WORDS: Multilevel inverter, Transformerless inverter, Common mode current. Photo voltaic (PV) system

INTRODUCTION

The multilevel inverters have drawn tremendous interest in the power industry. They present a new set of features that are well suited for use in reactive power compensation. It may be easier to produce a high-power, high-voltage inverter with the multilevel structure because of the way in which device voltage stresses are controlled in the structure. Increasing the number of voltage levels in the inverter without requiring higher rating on individual devices can increase the power rating. The unique structure of multilevel voltage source inverters allows them to reach high voltages with low harmonics without the use of transformers or series connected synchronised-switching devices. As the number of voltage level increases, the harmonic content of the output voltage waveform decreases significantly.

A multilevel inverter can eliminate the need for the step-up transformer and reduce the harmonics produced by the inverter. Although the multilevel inverter structure was initially introduced as a means of reducing the output waveform harmonic content, it was found that the dc bus voltage could be increased beyond the voltage rating of an individual power device by the use of a voltage clamping network consisting of diodes. A multilevel structure with more than three levels can significantly reduce the harmonic content. By using voltage clamping techniques, the system KV rating can be extended beyond the limits of an individual device. The intriguing feature of the multilevel inverter structures is their ability to scale up the kilovolt-ampere (KVA) rating and also to improve the harmonic performance greatly without having to resort to PWM techniques.

There has been significant drop in the price of PV modules in the last decade, hence the reduction of manufacturing costs of PV inverters becomes a necessity. PV inverters that employ an isolation transformer, are bulky and hard to install. Although by employing a high frequency transformer alongside a DC-DC converter can reduce the size of the inverter, it reduces the overall efficient due to the leakage in the high frequency transformer. As the name suggests, the transformer-less inverter are devoid of the bulky isolation transformer which not only makes them compact but also makes them cheaper and highly efficient. Therefore, the popularity of transformer-less PV inverters is increasing day by day. However, as there is no galvanic isolation between the PV panel and the grid, it can result in the flow of common mode leakage currents through the PV panel parasitic capacitance. This can compromise the safety of the consumer operating the inverter. It is mentioned that this leakage capacitance value depends on various factors; such as surface of cells, module frame, distance between cells, PV panel and frame structure, humidity and dust covering the PV panel and weather conditions[1].

The magnitude of these leakage currents between the panel terminals and ground depends mostly on the value of this stray capacitance and the amplitude and frequency content of the common-mode voltage variations that are present at the PV panel terminals[5].

A 3-LEVEL TRANFORMERLESS INVERTER CIRCUIT

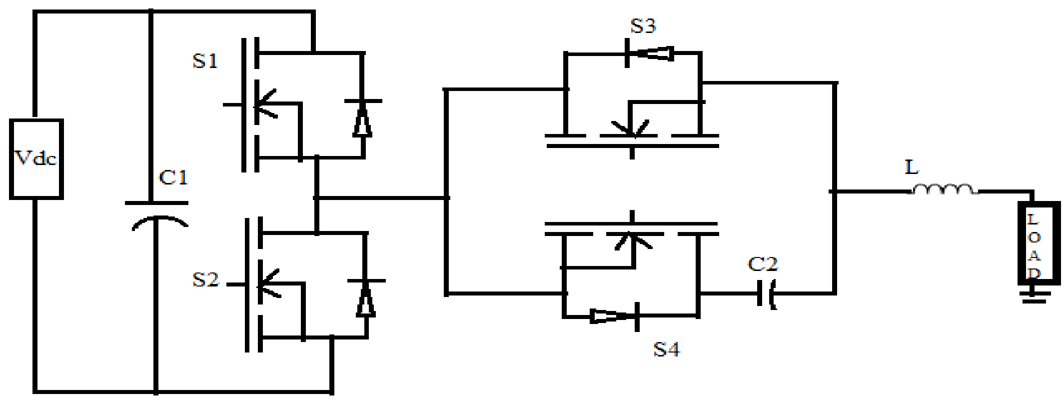

Fig. 1: 3-Level inverter circuit

A basic 3 level transformerless inverter circuit is shown in Fig.1 The proposed inverter circuit is a H4 topology consisting of two half bridges with switches S1, S2 and capacitor C1 forming one half bridge and switches S3, S4 and capacitor C2 forming the other half bridge. When switch S1 and S4 are on and conducting, the current flows from source to load. The output will be 0 because the capacitor C2 get charged, when switch S4 is off the current will be flowing from source to load and at S3 will be providing path and output will be Vdc(input). When switch S2 and S3 are on and conducting, the current flows from source to sourcload. The output will be 0, when switch S3 is off the current will be flowing from load to source and at S4 will be providing path and output will be -Vdc.

5-LEVEL TRANSFORMERLESS INVERTER CIRCUIT

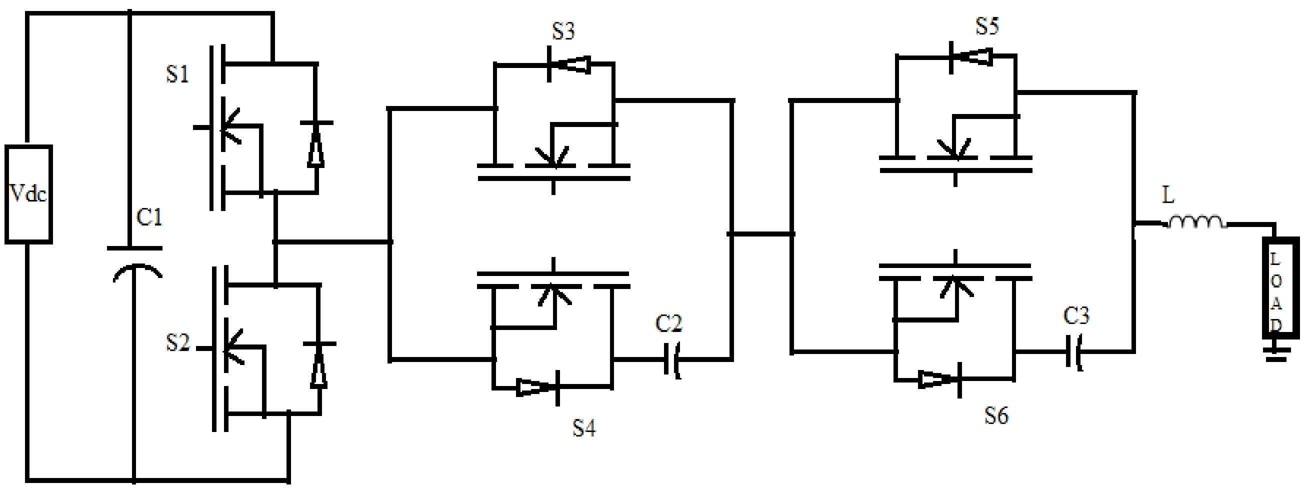

Fig.2: 5-level transformerless inverter circuit

The 5-Level circuit is modular, thus by adding another half-bridge module to the proposed 3-level circuit, a five level transformerless inverter circuit is obtained, which is shown below Fig2. The proposed 5-level circuit is first of its kind multilevel inverter which eliminates the CM leakage current with less than seven power switches. When switch S1,S4 and S6 are on and conducting, the current flows from source to load. The output will be 0 because the capacitor C2 and C3 get charged, when switch S6 is off the current flows from source to load and at S5 diode will be providing path and output will be Vdc/2.when switch S4 is off and at S3 diode will be providing path and output will be Vdc. When switch S2, S3 and S5 are on and conducting, the current flows from load to source, The output will be 0, when switch S5 is off and at S6 will be providing path and output will be –Vdc/2. When switch S3 is off and at S4and S6/ will be providing path and output will be -Vdc.

7-LEVEL TRANSFORMERLESS INVERTER CIRCUIT

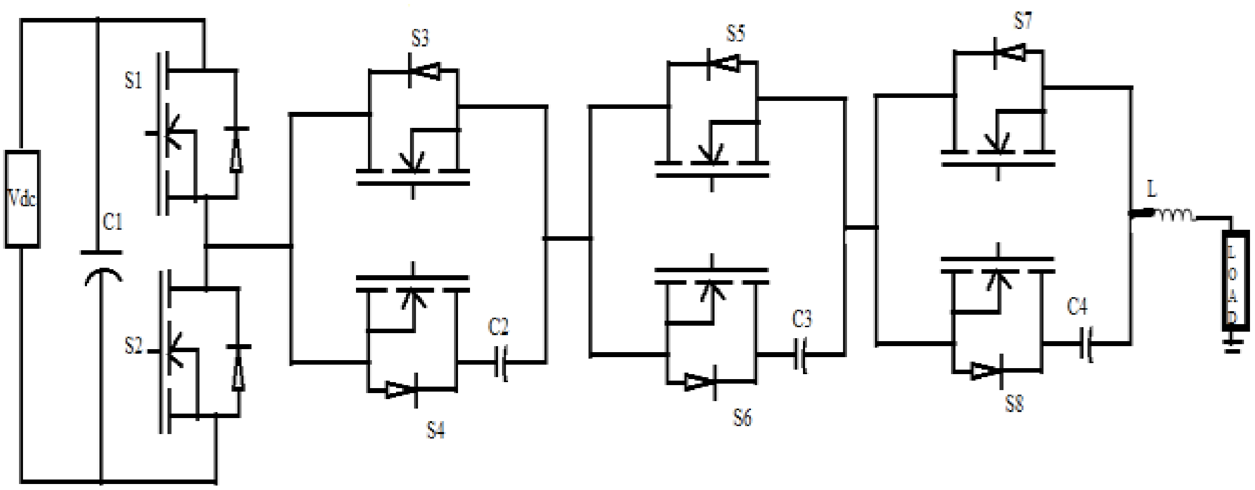

Fig.3: 7-Level transformer less inverter circuit

The 7-Level circuit is modular, thus by adding another half-bridge module to the proposed 5-level circuit, a seven level transformerless inverter circuit is obtained, which is shown below Fig3. The proposed 7-level circuit is first of its kind multilevel inverter which eliminates the CM leakage current with less than nine power switches. When switch S1, S4, S6 and S8 are on and conducting the current flows form source to load. The output will be 0 because capacitor C2, C3 and C4 get charged. When switch S8 is off and at S7 will be providing path the output will be Vdc/3. When switch S6 is off and at S5 and S7will be providing path the output will be Vdc/2. When switch S4 is off and S3, S5 and S7 will be providing path and output will be Vdc. When switch S2, S3, S5 and S7 are on and conducting the current flows from load to source, the output will be -Vdc. When switch S7 is off and S8 provides path and the output –Vdc/3. when switch S5 is off and S6 and S8 provides path and output will be -Vdc/2. When switch S3 is off and S4, S6 and S8 provides path and output will be 0.

CONTROL STRATEGY

The inverter is operated in current control mode. The block diagram of control strategy is shown in Fig.4 The reference current Iref is obtained via MPPT. Incremental conductance algorithm is used for MPPT calculation. Proportional Resonant (PR) control is used to control the grid current.Transfer function of PR control is given by below equation. The output of PR controller is the modulation index 'm' and it acts as an input to sine triangle PWM block.

$$G_c(s) = K_p + K_i \frac{s}{s^2 + \omega^2}$$

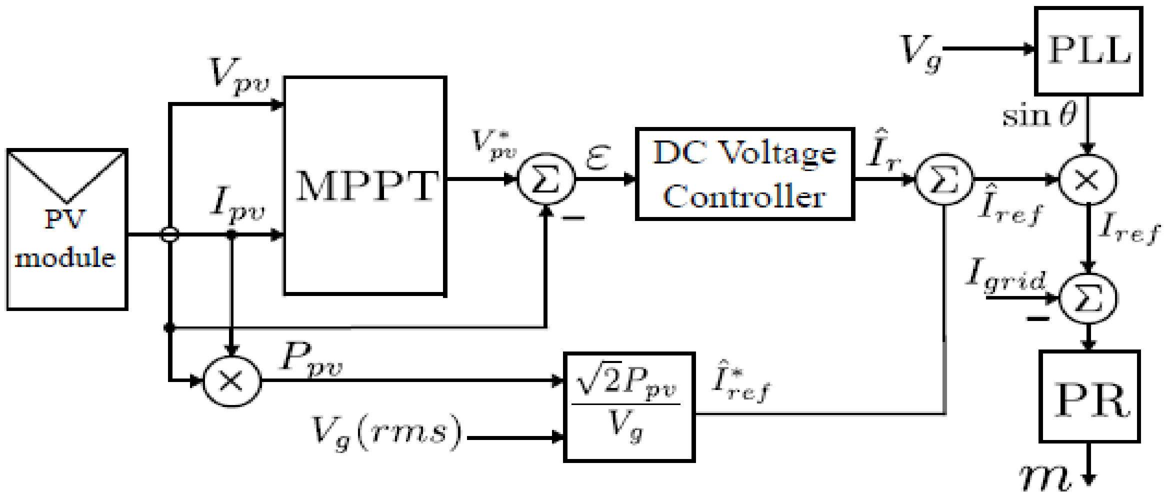

Fig.4: current control for proposed inverter

7- Level transformer less inverter simulation circuit diagram

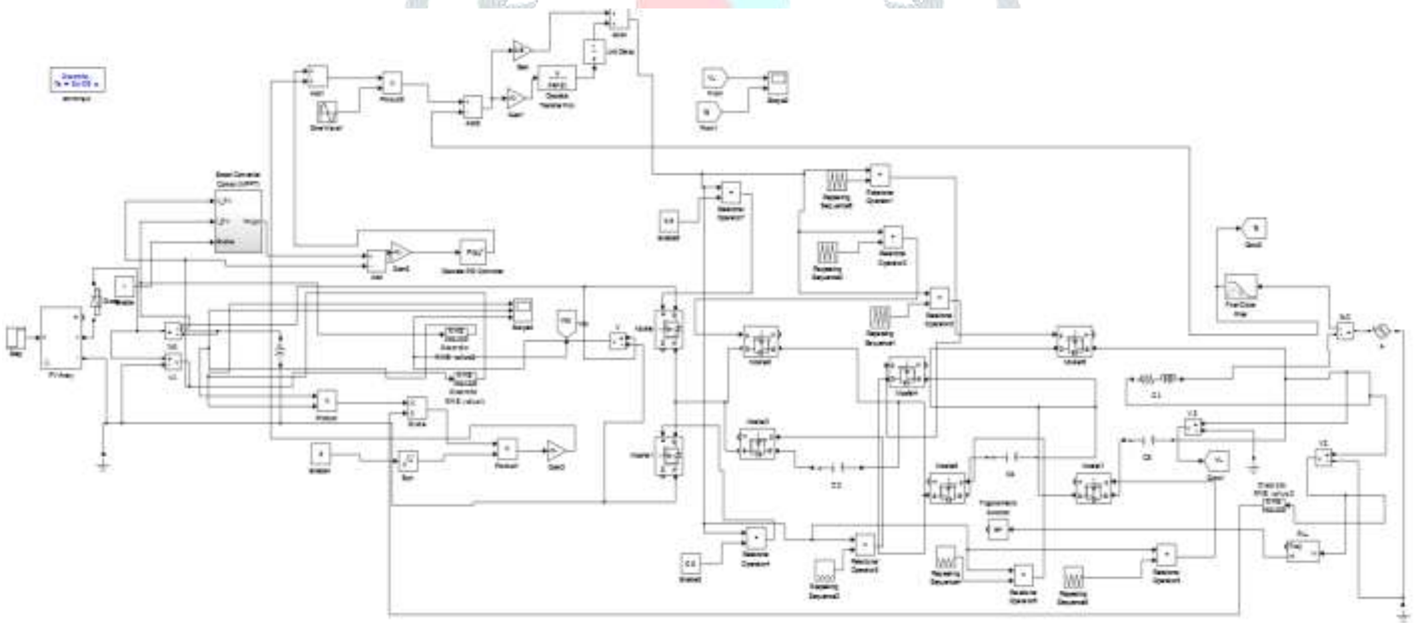

Fig.5: 7-level transformer less inverter

RESULT

Simulation results

(a) Output Voltage (b) Output current of a 3- Level inverter

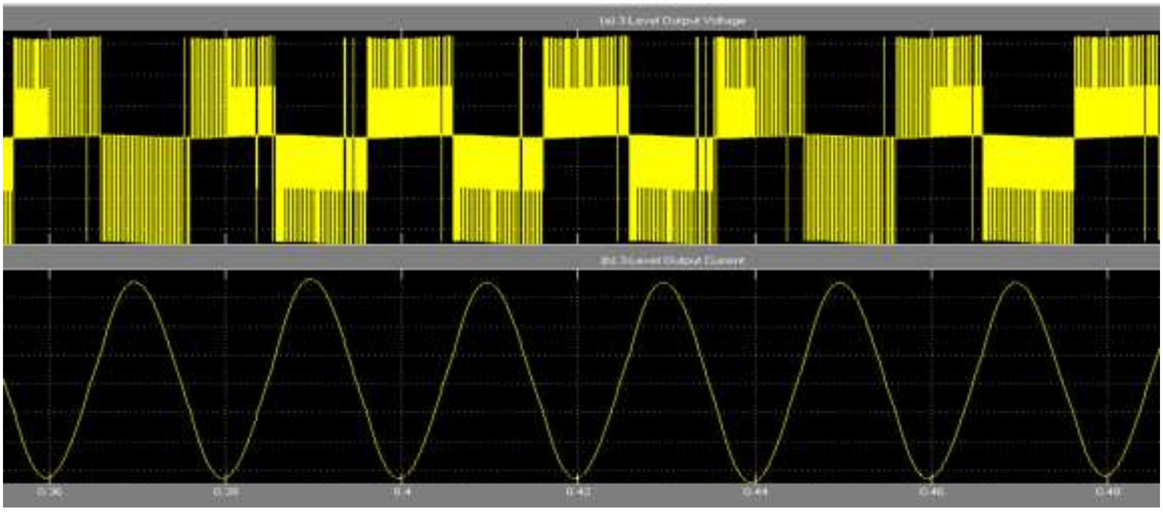

Fig. 6: Simulation results of 3-level inverter

(a) Output Voltage (b) Output current of 5- Level inverter

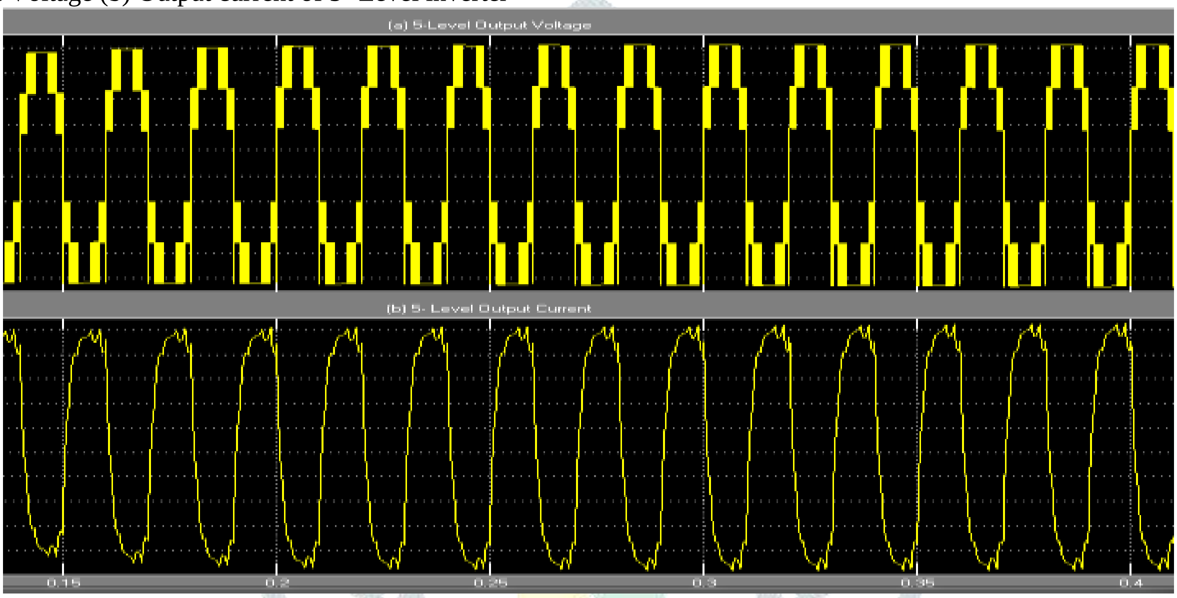

Fig.7: Simulation results of 5- Level inverter

(a) Output voltage (b) Output Current of 7- Level inverter

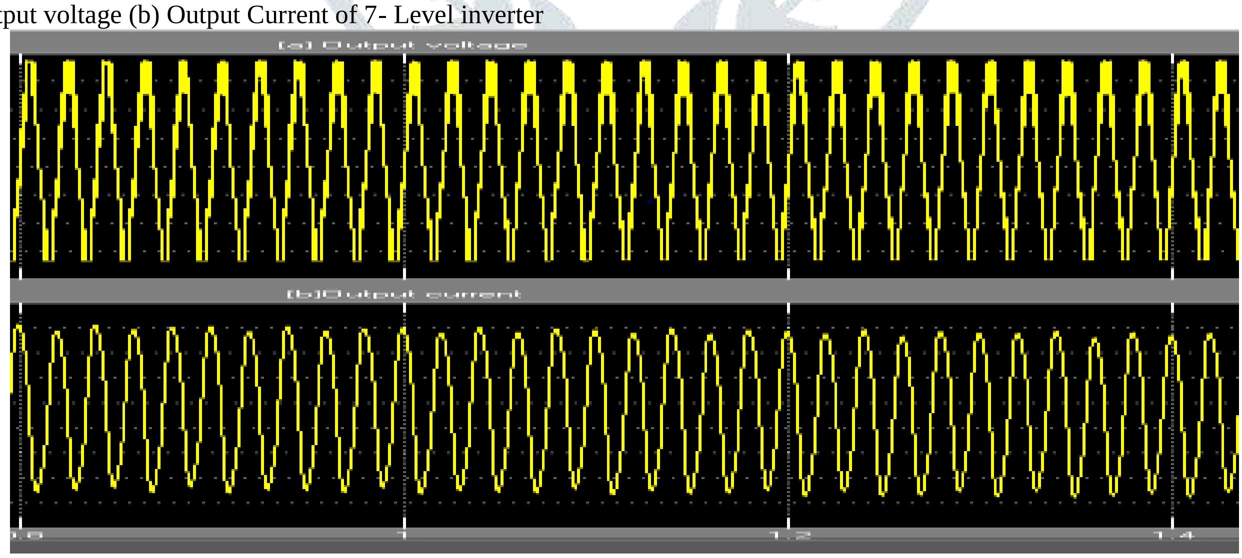

Fig.8: Simulation results of 7- Level inverter

CONCLUSION

1. The proposed inverter is modular in nature and hence can be extended to get n-level output by adding two more switches and capacitor appropriately
2. CM leakage current can be reduced by grounding
3. It is LVRT capable and it can provide reactive power to the grid
4. As the number of level increases the THD decreases and we can get improved outputs

5. Small size filter is required
6. The number of switches required are less

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