GRID CONNECTED ELEVEN LEVEL INVERTER WITH RENEWABLE ENERGY SOURCE

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Abstract
Implementation of an eleven level inverter is designed and input for the inverter is given by PV panel (renewable energy). Alternative phase opposition disposition pulse width modulation (APODPWM) method is used for driving the gate pulses for the switch. Filter is used for filtering purpose to obtain the pure sign wave. The inverter output voltage is step up to higher value and is connected to grid through transmission line parameters. The simulations of a PV connected eleven level inverter to grid are done in MATLAB/Simulink.
Keywords: Pulse Width Modulation (PWM).

I. INTRODUCTION

Power electronic devices play a major role in the conversion and control of electric power, especially to extract power from renewable energy sources like photovoltaic array and wind energy. Conversion of DC to AC power can be done with the help of inverters (single phase or three phases). Conventional bipolar inverters produce alternating staircase waveforms with higher harmonics. Thus, the multilevel inverters (MLI) were developed.[1]. Fundamentally Inverter is an arrangement that converts DC power to AC power at desired output voltage and frequency. Drawbacks of inverter are less efficiency, high THD, and high switching losses. To overcome these drawbacks, we are going to use multilevel inverter. The duration Multilevel instigated with the three-level converter. The conception of multilevel converters has been announced since 1975.
The cascade multilevel inverter was first suggested in 1975, in recent years multilevel inverters are used for high voltage and high power applications. Modular multilevel converters have abundant potential in high power applications, such as dc interconnections, Off-shore, and dc power grids wind power generation are in power conversion in order to reduce both their environmental impact and their operating costs [2].
Power grids, in terms of voltage (v) and frequency (f).Multilevel inverters are considered today as the state-of-the-art power-conversion systems for high power and power quality demanding applications. Multilevel inverters are currently considered as a better industrial solution for high dynamic performance and power-quality demanding applications, covering a wide power range. Cascaded H-bridge multilevel inverter has been researched for high voltage applications since it has advantages in number of components, high reliability, and modularity. One of the demerits of cascade multilevel inverter is that as the number of level increases, the number of H-bridges also increases. These new types of inverters are suitable or high voltage and high power applications due to their ability to synthesize waveforms with better harmonics spectrum. [3], [4]. The number of applications of multilevel power inverters in the field of medium and high voltage has increased. This gives birth to greater attention on multilevel topologies. The most common multilevel converters use symmetric topologies such as diode clamp multilevel converters (DCMC), flying capacitor multilevel converters (FCMC) and cascade cell multilevel converters (CCMC). Asymmetrical multilevel inverters have received increasing attention

because it is possible to synthesize voltage waveforms with reduced harmonic content, even using a few series-connected cells [5].

Conventional pulse width modulation techniques (PWM) used in symmetrical inverters could be used in asymmetrical inverters. The most widely used techniques for implementing the pulse width modulation (PWM) strategy for multilevel inverters are sine-triangle PWM (SPWM) and space vector PWM (SVPWM). The concept of power quality and power-electronics based custom power devices are of utmost importance nowadays. A large variety of nonlinear loads are used in the industry for various operations which in turn induce harmonic distortion and reactive power problems in the supply network [6-7]. Harmonics in the supply are responsible for various adverse effects like transformer losses, power factor reduction, measurement errors, heating losses, and reduction in efficiency. They also affect the other consumers linked to the same supply network [8].

There are many inverter topologies in which cascaded inverter have some advantages compared to other multilevel inverters such as reduced harmonics but they have drawbacks also such as many heat losses, more switches, high cost. In this three different pulse width modulation techniques can be used. [9-10].

PWM techniques are used gating pulses. The proposed configuration has many advantages, i.e., reduced cost reduced harmonics, pure sine output, reduced gate control, very less heating losses.[11-14]. This new inverter regulates DC link voltage as well as active and reactive power injected to the grid through the distribution transformer in order to set the grid PF at a target value established by the user (utility)[15].Renewable energy is used for the distribution system by using this we can reduced the total cost of the system. Eleven level inverter is used for DC to AC conversion by using this we can reduced the total harmonic distortion of the systems less THD losses will produce less losses. Filter is used to remove the unwanted signal and to get the pure ac is stepped up to higher value by using step up transformer and is transferred to grid for the distribution system. In this we used two transformers one is used for isolation purpose to provide safety for the inverter side. From grid we can distribute the energy to the load.

II. MODULATION TECHNIQUE

A. Alternate Phase Opposition Disposition PWM (APODPWM)

Alternative Phase Opposition Disposition (APOD) method each carrier of this method is phase shifted by 180° from its adjacent one. This method gives almost the same results as the POD method. The major differences are the larger amount of third order harmonics which is not important because of their cancellation in line voltages. Thus, this method results in a better THD for line voltages when comparing to the POD method.

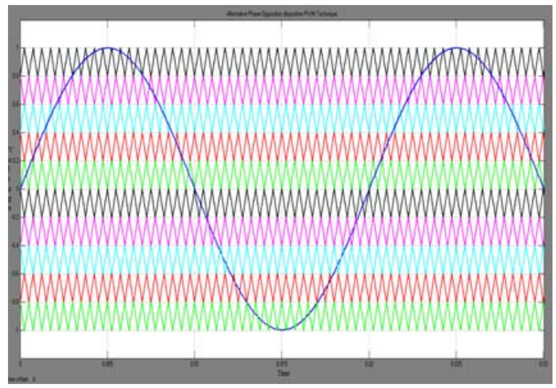

Fig.1: Alternate Phase Opposition Disposition PWM (APODPWM)

III.MULTILEVEL INVERTER

The inverter structure consists of twenty switches, ten upper and ten lower switches. The typical structure of a MMC is shown in Fig.2. Each SM is a simple cell composed of two IGBT switches (T1 and T2). The configuration with T1 and T2 both ON should not be considered because it determines a short circuit. Also the configuration with T1 and T2 both OFF is not useful as it produces different output voltages depending on the current direction. In a MMC the number of steps of the output voltage is related to the number of series connected SMs.

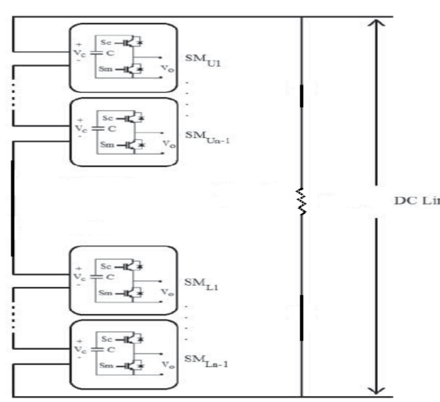

Fig 2: Single-phase MMC inverter structure.

Fig 3: Eleven level output voltage waveform indicating voltage levels

The eleven level inverter consists of different voltage levels of 5vdc, 4vdc, 3vdc, 2vdc, vdc, 0,-vdc,-2vdc,-3vdc,-4vdc and -5vdc.Wavefoem of these voltage levels is shown in Fig.3.The operating regions and the voltage levels of eleven level inverter is depicted in Table 1.

Table 1: Operating regions of eleven level inverter

Voltage level	Status	Gates	Vout
1	Vr>=Vc1	U1a.U1b	5Vdc
2	Vr>=Vc2	U2a,U2b	4Vdc
3	Vr>=Vc3	U3a,U3b	3Vdc
4	Vr>=Vc4	U4a,U4b	2Vdc
5	Vr>=Vc5	U5a,U5b	Vdc
6	Vr>=Vc5,Vr>=Vc6	U5a,L5a	0
7	Vr>=Vc6	L5a,L5b	-Vdc
8	Vr>=Vc7	L4a,L4b	-2Vdc
9	Vr>=Vc8	L3a,L3b	-3Vdc
10	Vr>=Vc9	L2a,L2b	-4Vdc
11	Vr>=Vc10	L1a,L1b	-5Vdc

Inverter consists of 20 numbers of switches 10switches are considered for positive cycle and remaining 10 switches are used for negative cycle. As number of levels increased the total harmonic distortion will be reduced in the system output. The output of the inverter consist different voltage levels these are given in Table 1.Based on that the generated gate pulses of 1 carrier and sign is given to the switches such that first carrier and sign comparison gives the output U1a, U1b that is connected to upper switch 1 and 2 will results the output voltage of 5Vdc.Similarly other levels of output can be obtained from table 1.

IV. SIMULATION RESULT

Generation of PWM pulses

No of carrier pulses = N-1

N=number of levels for Inverter N=11

N=11-1=10 carrier waves are required to get the eleven level output

$$F = \frac{1}{T} \quad T = \frac{1}{F} \qquad 1$$

For sine wave frequency is 50Hz

$$T = \frac{1}{50} = 0.02sec$$

For carrier wave frequency is 2 KHz

$$T = \frac{1}{2000} = 500e^{-6} \quad T = 500e^{-6} * 40 = 0.02sec$$

APODPWM

Carrier wave amplitude =0.2V

Ten carrier wave Frequency=2000Hz

Inverter

Number of switches =20

Voltage levels =

$$^{5Vdc}/_{10}, ^{4Vdc}/_{10,} ^{3Vdc}/_{10,} ^{2Vdc}/_{10,} ^{Vdc}/_{10}, 0$$
$$-^{5Vdc}/_{10}, -^{4Vdc}/_{10}, -^{3Vdc}/_{10}, -^{2Vdc}/_{10}, -^{Vdc}/_{10}$$

R=25Ω

PV Pannel

Number of cells per module=36V

Number of series-connected modules per string=9

Number of parallel strings=10

Table 2: Simulation Parameters

Transformer 1	Primary Voltage:1000V Secondary Voltage:1000V
Transformer 2	Primary Voltage:1000V Secondary Voltage:12000V
Transmission line parameters	Resistance: 1Ω Inductance :15mH
AC grid voltage	Peak Voltage: 12000V Frequency:50Hz
Filter	Inductance:5mH Capacitance:100µF

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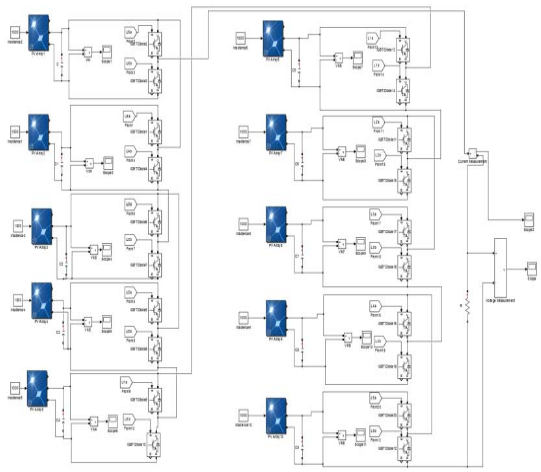

Fig.4: Simulink Model of eleven level inverter with PV panel

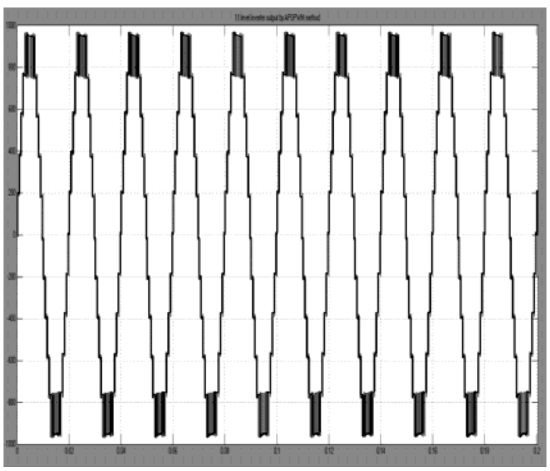

Fig.5: Simulated output voltage of eleven level inverter

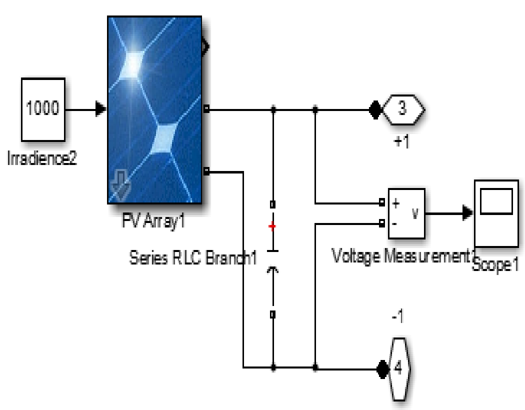

Fig.6: Simulink model of Solar PV Panel

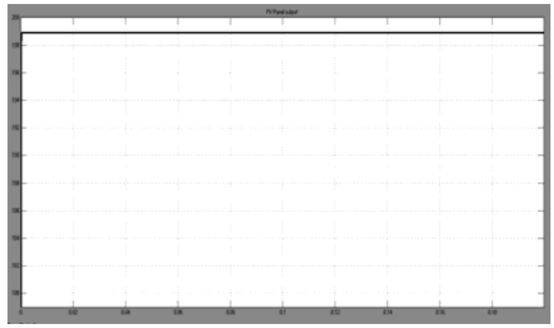

Fig.7: Simulated Output Voltage of One Solar panel

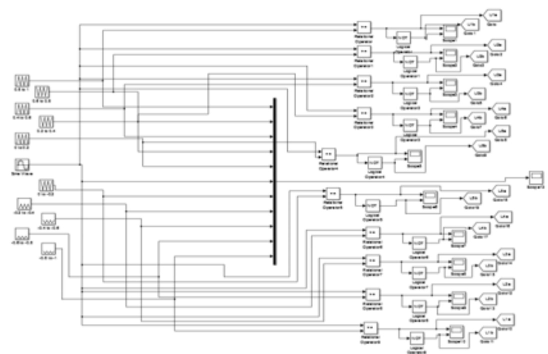

Fig.8: Simulink model to generate gate pulses using APODPWM technique

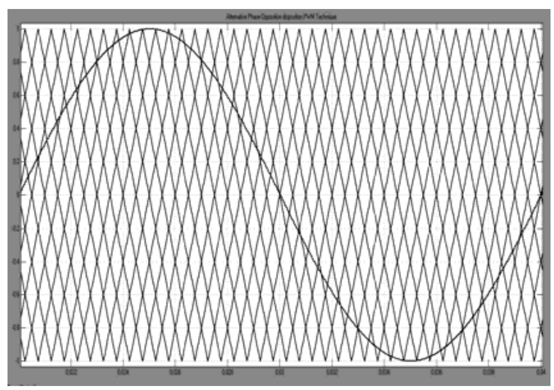

Fig.9: Comparison of Carrier and Reference wave for Alternate Phase Opposition Disposition PWM (APODPWM)

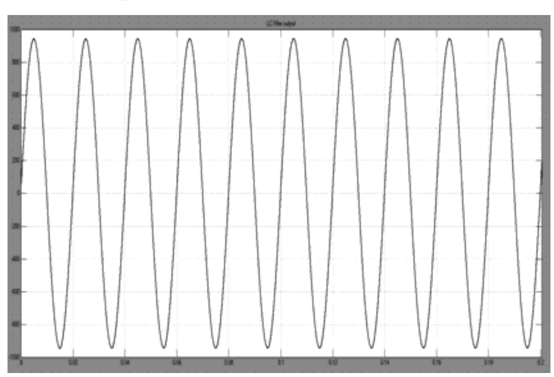

Fig.10: Simulated Inverter output voltage by using Filter

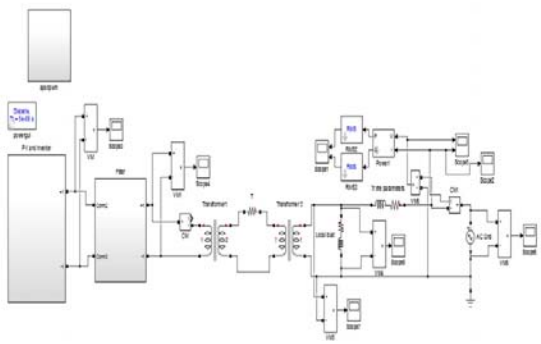

Fig.11: Simulink Model of Grid Connected inverter with PV panel

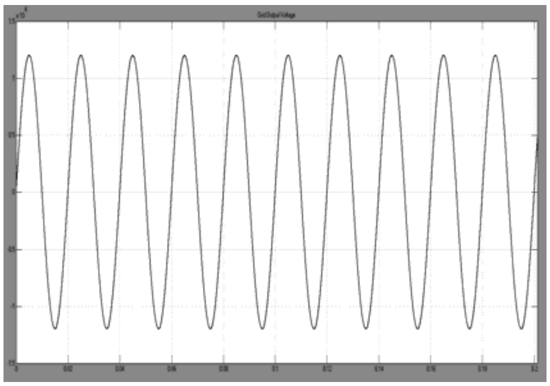

Fig.12: Simulated output Voltage of grid

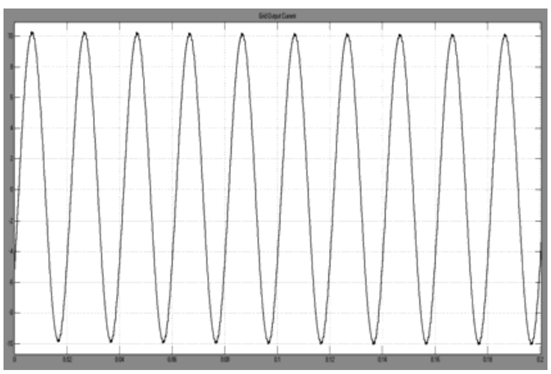

Fig.13: Simulated output Current of grid

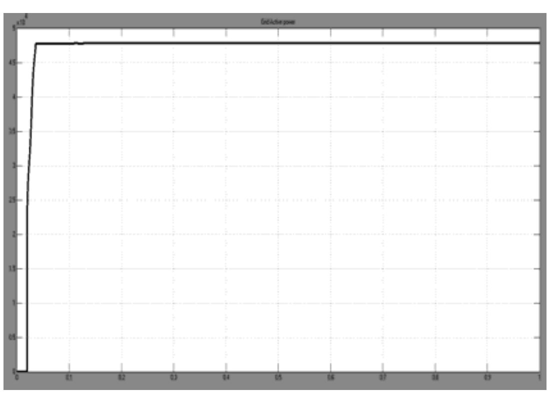

Fig.14: Grid active power

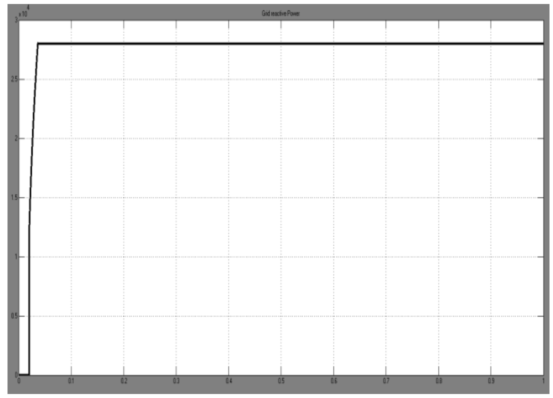

Fig.15: Grid reactive power

PV panel gives 1000 V Dc is converted to AC and is given to transformer to step up the voltage for the grid to a value 12000V. From the grid we can use the required amount of power to loads.

V. CONCLUSION

Implementation of an eleven level inverter is designed and simulated .PV panel is used input for inverter. Alternate phase opposition disposition pulse width modulation (APODPWM) is used. Here two transformers are used first transformer is ideal one for isolation purpose to keep the inverter side safety purpose. Simulated inverter output voltage is filtered using LC filter and step up transformer is used to step up the voltage and given to the grid through local load. The required voltage is obtained from the grid. The simulations of a PV connected eleven level inverter to grid are done in MATLAB/Simulink.

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