IMPLEMENTATION OF NEW SINGLE PHASE MULTILEVEL INVERTER FOR PV POWER CONDITIONING SYSTEM

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Abstract: This project presents a high conversion ratio hybrid DC-DC converter fed single-phase low harmonic distortion nine-level photovoltaic (PV) inverter topology for PV power conditioning systems with a novel pulse width-modulated (PWM) control scheme. A digital PI control algorithm is implemented in microcontroller PIC16C7F88 to keep the current injected into the grid sinusoidal and to have good dynamic performance with rapidly changing atmospheric conditions. For low-voltage dc energy sources, a power conditioning system (PCS) is needed to convert the energy sources to a higher-voltage dc before making it to ac for grid tie applications. Fuel cells and Solar photovoltaic (PV) are perhaps the most well-known and prospective energy sources with low voltage dc output. A thermoelectric generator, a battery, and an ultra-capacitor are also examples of such low-voltage dc energy sources. Recently, numerous circuit topologies for the power conversion from low-voltage dc to high-voltage ac for grid-tie applications were proposed to deal with specific issues such as high efficiency, low cost, and safety.The whole system is constructed and simulated using MATLAB/SIMULINK environment. The power qualities under different conditions are given and compared. An experimental prototype of High efficiency power conditioning system was built and Experimental results are shown to verify the effectiveness of the proposed power conditioning topology.

I. INTRODUCTION

As The World is concerned with fossil-fuel exhaustion and environmental problems caused by conventional power generation, renewable energy sources, particularly solar and wind energy, have become very popular and demanding. Photovoltaic (PV) sources are used today in many applications because they have the advantages of being maintenance and pollution free. Solar-electric-energy demand has grown consistently by 20%–25% per annum over the past 20 years, which is mainly due to the decreasing costs and prices. This decline has been driven by the following:

- An increasing efficiency of solar cells;
- Manufacturing-technology improvements; and
- Economies of scale.

A PV inverter, which is an important element in the PV system, is used to convert dc power from the solar modules into ac power to be fed into the grid.

This project presents a multistring five-level inverter for PV application. The multistring inverter shown in Fig. 1 is a further development of the string inverter, where several strings are interfaced with their own dc–dc converter to a common dc–ac inverter. This is beneficial, compared with the centralized system, because every string can be controlled individually. Thus, the operator may start his/her own PV power plant with a few modules. Further enlargements are easily achieved because a new string with a dc–dc converter can be plugged into the existing platform.

A flexible design with high efficiency is hereby achieved. In this project, a nine-level inverter is used instead of a conventional three-level pulse width-modulated (PWM) inverter because it offers great advantages, such as improved output waveforms, smaller filter size, lower electromagnetic interference, lower total harmonic distortion (THD), and other. An auxiliary circuit comprising four diodes and a switch is configured together with a conventional full-bridge inverter to form this topology.

A novel PWM control scheme is introduced to generate switching signals for the switches and to produce seven output-voltage levels: zero, $+1/3V$dc, $2/3V$dc, Vdc, $-1/2V$dc, and $-1/3V$dc, $-2/3V$dc, $-V$dc, (assuming that Vdc is the supply voltage). This inverter topology uses two reference signals instead of one to generate PWM signals for the switches.

II.SOLAR ARRAY'S

Knowledge of the sun is very important in the optimization of photovoltaic systems. Solar energy is the most abundant renewable resource. The electromagnetic waves emitted by the sun are referred to as solar radiation. The amount of sunlight received by any surface on earth will depend on several factors including; geographical location, time of the day, season, local landscape and local weather. The light's angle of incidence on a given surface will depend on the orientation since the Earth's surface is round and the intensity will depend on the distance that the light has to travel to reach the respective surface. The radiation received by a surface will have two components one which is direct and will depend on the distance the rays travel (air mass). The other component is called diffuse radiation and is illustrated in figure 2.1. The range of wavelengths of light that reach the earth varies for 300nm to 400nm approximately. This is significantly different from
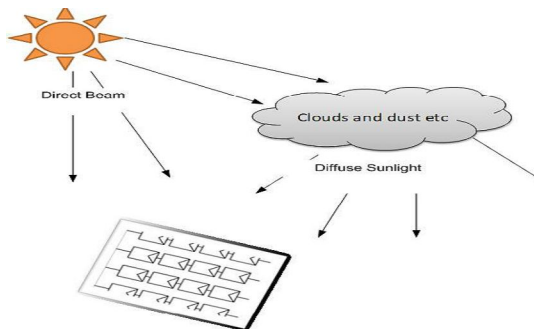

Fig:1Types of radiation from the sun

Nine level inverter
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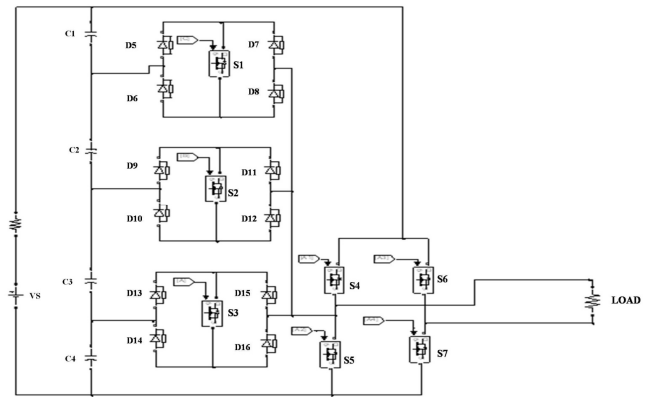

Fig:2 Nine level inverter

voltage source boosted by the dc–dc boost converters to exceed grid voltage Vg, and the voltage across the dc Combinations of PV strings are used as the input bus is known as Vpv.

These operating principles are proposed inverter is to generate seven output-voltage level. As auxiliary circuit that consists of twelve diodes and a switch S1, S2, S3 is used between the dc-bus.Proper switching control of the auxiliary circuit can generate half level of PV supply voltage, four reference signals Vref1, Vref2, Vref3 and Vref4 will take turns to be compared with the carrier signal at a time. If Vref1 exceeds the peak amplitude of carrier signal Vcarrier, then Vref2 will be compared with the carrier signal until it reaches zero. Switch S2-S7 is on condition.[+Vs/2] . Switch S4-S7 is on condition.[+3Vs/4]. Repeated the process in negative side.

9-Level Switching pattern

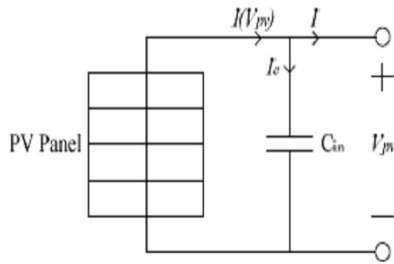| S1	S2	S3	S4	S5	S6	S7	Vout
OFF	OFF	ON	OFF	OFF	OFF	ON	+VS
OFF	ON	OFF	OFF	OFF	OFF	ON	+2VS/4
ON	OFF	OFF	OFF	OFF	OFF	ON	+VS/2
OFF	OFF	OFF	ON	OFF	OFF	ON	+3VS/4
OFF Or OFF	OFF Or OFF	OFF Or OFF	OFF Or OFF	ON Or ON	OFF Or OFF	ON Or ON	0
OFF	OFF	OFF	OFF	ON	OFF	ON	-VS
ON	OFF	OFF	OFF	OFF	ON	OFF	-2VS/4
OFF	ON	OFF	OFF	OFF	ON	OFF	-VS/2
OFF	OFF	ON	OFF	OFF	ON	OFF	-3VS/4

MATHEMATIC MODEL

Fig 3.Dynamic PV panel.

The equations that describe the electric behavior of the PV panel under constant irradiance and temperature are:

$$I(V_{pv}) = \frac{I_x - I_x e^{\left(\frac{V_{pv}}{bVx} - \frac{1}{b}\right)}}{1 - e^{\left(-\frac{1}{b}\right)}}$$

$$V_{pv}(I) = bV_x \ln\left[\frac{I_x - \left(I - Ie^{\left(\frac{1}{b}\right)}\right)}{I_x}\right] + V_x$$

$$P(V_{pv}) = V_{pv}I = \frac{V_{pv}I_x - V_{pv}I_x e^{\left(\frac{V_{pv}}{bVx} - \frac{1}{b}\right)}}{1 - e^{\left(\frac{1}{b}\right)}}$$

The output current of the PV panel is taking to be equal to the average input current of the DC-DC converter. Capacitor current is given by,

$$\frac{dV_{pv}}{dt} = \frac{1}{C_{in}}[I(V) - I]$$

Where I is the PV panel current, Vpv is the PV panel voltage, Vx is the PV panel open circuit voltage (Voc), Ix is the PV panel short circuit current (Isc), b is the PV panel characteristic constant and P is the PV panel output power.

Determining the derivative of the PV panel output power with respect to its voltage, gives the following:
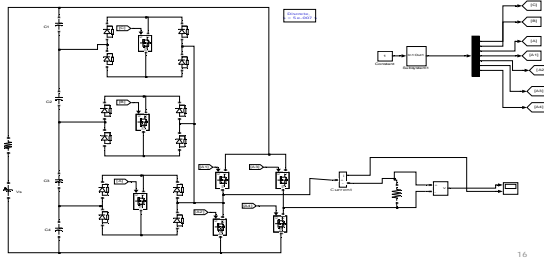
SIMULATION CIRCUIT OF NINE-LEVEL INVERTER

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Fig.4 Simulation circuit of nine-level inverter
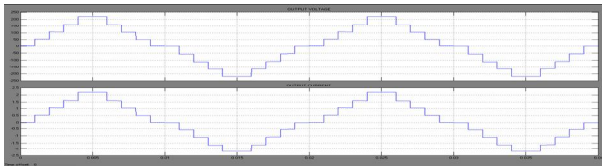
SIMULATION OUTPUT FOR NINE-LEVEL INVERTER

Fig.5 Simulation output for nine-level inverter

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