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Solar Based Three Level T-Type Converter For Low Voltage Application

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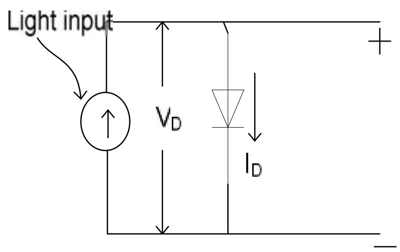
Abstract: Our future energy sources are renewable energy sources, one of the renewable energy is solar energy, so there is need to convert these energy forms into electrical energy efficiently. Generally solar to electrical energy conversion efficiency is very less. The conversion process has different stages at each stage there will be some energy loss. In solar system dc-ac conversion is one of the stages in these paper three level T-Type converter is used. The three level T-Type converters have very good efficiency because less number of switches is present in the conduction path. The two level converters have the advantage of less conduction losses and three level converters have the advantage of less switching losses. The proposed topology in this paper has the advantages of both two level voltage converters and three level voltage sources. The $3LT^2C$ has different control topologies among those SVPWM gives less THD but it is very complicated to implement. The SPWM can be easy to implement and also give better results.
Key words: Photo voltaic (PV) cells;Three level T-type converter ($3LT^2C$); SPWM; THD.

INTRODUCTION

Currently, the use of renewable energy is gaining increased amounts of attention due to environmental issues. Moreover, while the cost of the fossil fuels has increased, the cost of photovoltaic (PV) generation has decreased. Therefore, PV generation is becoming a viable solution in the event of an energy crisis. For example, multi-megawatt PV plants are common in many places [1]-[3]. There are many topologies for connecting PV modules to the grid [4]. Among these, the centralized inverter is preferred in large-scale PV applications for practical reasons [3]. However, in terms of maximum power point tracking (MPPT), the centralized inverter may not be the best topology with which to maximize the power generation, as all of the PV modules are rigidly tied to a single inverter [5]. It would be desirable to consider the mismatches in PV modules [6]. For better MPPT, additional DC-DC converters can be used to connect split PV modules to the centralized inverter [4], [7], [8]. However, although this structure may be helpful to deal with partial shade, the conversion efficiency may be degraded due to multiple conversions. Moreover, the installation and maintenance costs increase. Therefore, it is worth augmenting the degree of freedom for MPPT while the number of conversion stages does not increase. Recently, three-level inverters have been discussed for implementing a centralized PV inverter, as the conversion efficiency can be increased by reducing switching losses and the output harmonic property can be improved. In particular, the T-type three-level inverter shown in Fig. 1 is preferred because conduction losses are further minimized by reducing the average number of switch modules on the current paths [8]. Inherently, the three-level inverter has a split DC-link, who’s. The voltages of the split DC-link are supposed to be symmetric they can be regulated asymmetrically. If the asymmetric regulation applies to the split PV connection in Fig. 1, separate MPPTs on the PV modules become possible without an increment in the conversion stage**.**

PHOTOVOLTAIC CELL

Solar cells are semiconductor devices which convert solar energy utilizing the photovoltaic effect. Photovoltaic energy conversion is based on a quantum mechanical process by which incident photons free charge carriers from their otherwise bound conditions within a semiconductor. In a solar cell, a p-n junction collects the freed charge carriers and forces them through an externally connected electric load. Solar cell covers are transparent plates that shield the solar cells from excessive damage by space environments and otherwise enhance the power output capability of the solar cells.



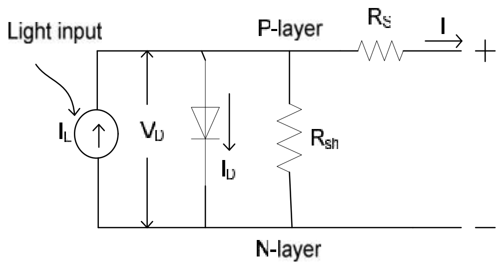


Figure1.a: Ideal PV device **1.b:** Practical PV device

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Solar cell and array I-V characteristics are typically show in the first quadrant i-v the voltage (abscissa)-current (ordinate) coordinate system Fig 2. This presentation is consistent with the theoretical solar cell model in which current is a function of voltage. It is equally consistent with electrical measurement techniques where positive voltage, current, and power output are obtained from the cell working into a positive conductance load. Some earlier presentations of the I-V curve in the fourth quadrant of the same coordinate system led to negative current, positive voltage, and hence confusingly, to negative power output from the cell into a negative conductance load.

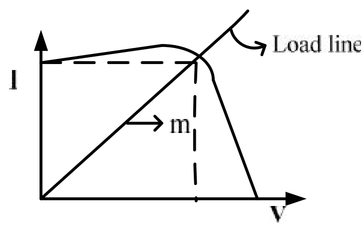


Figure2: I-V Characteristics of solar cell.

$$\text{Power} = IV \ldots\ldots\ldots\ldots(1)$$

$$m = I/V = G_L \ldots\ldots\ldots\ldots(2)$$

$$\text{load current} = I, \quad I = I_L - I_{sh}\{\exp(\frac{e(v+IRs)}{AKT}) - 1\} - V/R_s \ldots\ldots\ldots\ldots(3)$$

PHOTOVOLTAIC SYSTEM

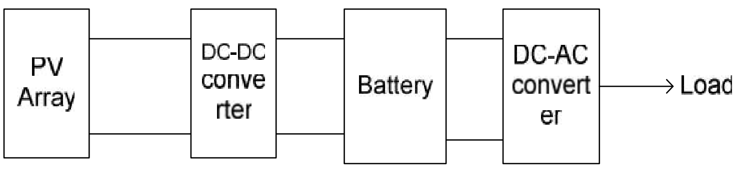


Figure 3: Block diagram representation of Photovoltaic system

This photovoltaic system consists of three main parts which are PV module, balance of system and load. The major balance of system components in this systems are charger, battery and inverter. The Block diagram of the PV system is shown in Fig. 3.

THE THREE LEVEL T-TYPE TOPOLOGY

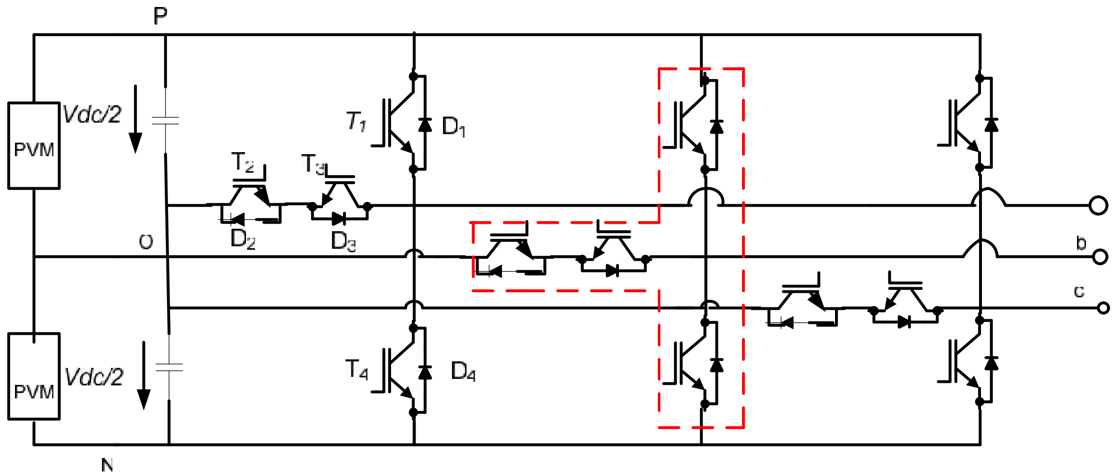


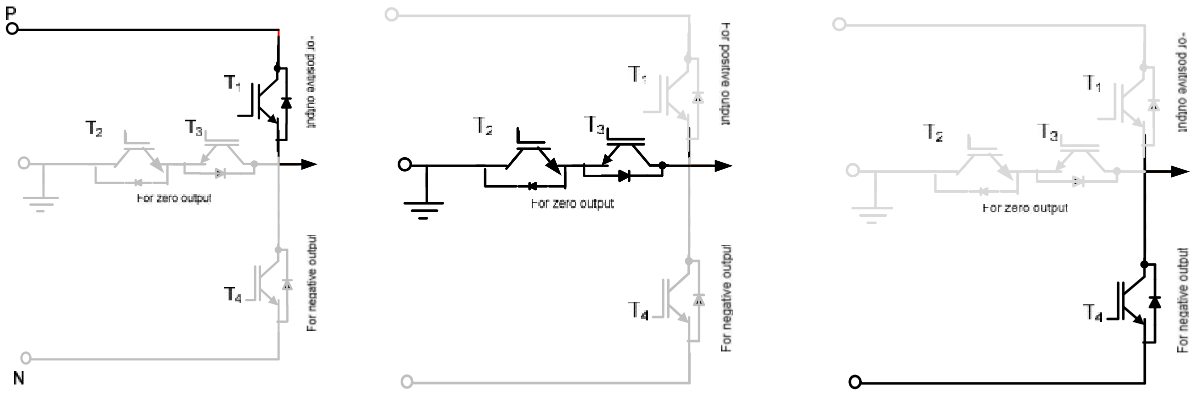
Figure 4: Circuit diagram of Three level T-Type converter

The basic topology of three level T-Type converter is depicted in fig 4. The conventional two level voltage source converter topology is extended with an active, bidirectional switch to the dc-link midpoint In these conduction is takes place in the form of T shape to give the three level output voltage.

The high side and the low-side switches (T1 /D1 and T4 /D4) would usually be implemented with 1200-V IGBTs/diodes as the full dc-link voltage has to be blocked. Differently, the bidirectional switch to the dc-link midpoint has to block only half of the dc-link voltage. It can be implemented with devices having a lower voltage rating, in the case at hand two 600-V IGBTs including antiparallel diodes are used [16]. Due to the reduced blocking voltage, the middle switch shows very low switching losses and acceptable conduction losses, although there are two devices connected in series. An Additional benefits related to using single 1200-V devices to block the full dc-link voltage are reduced conduction losses, if bipolar devices are considered. Whenever the output is connected to (P) or (N), the forward voltage drop of only one device occurs, contrary to the NPC topology where always two devices are connected in series [11]. The conduction losses are considerably reduced making the $3LT^2C$ an interesting choice even for low switching frequencies.

A. Switch Configuration

For positive output switch T1 is ON, for negative output switch T4 is ON , for zero output switch T3 and T4 is ON.



I II III

Figure: 5 Current Commutation during the switching transition for different levels (I)Positive output (II)Zero output ,(III) Negative output.

Operation of the other legs also same as this, they have the phase displacement of 120 degrees each.

B. Switching stages

Table: 1 switching states

State	**V_{out}**	**T_1**	**T_2**	**T_3**	**T_4**
P	$V_{dc}/2$	On	Off	Off	Off
O	0	Off	On	On	Off
N	$-V_{dc}/2$	Off	Off	Off	On

C. Modulation

The modulation strategies known from the three-level NPC converter can also be applied to the $3LT^2C$. The modulation strategy is an important point for the converter efficiency [10] [12]. In this paper we used phase displacement pulse width modulation scheme to simulate the circuit. Control signal generation is shown in the figure: 6 .Universal control scheme is used to implement the control circuit. For N level output we require (N-1) carrier signal ,here output is three level so the required carrier signal are two, triangular wave is taken as the carrier signal and sinusoidal wave is taken as the reference wave with an amplitude 0.85. Here we considered the dc-link voltage as symmetrical and constant, but most of the cases the dc-link is asymmetrical the control of asymmetrical voltage is difficult, several attempt to control the DC-Link voltages asymmetrically in multi-level inverters have been reported [13]-[15]. They can be differentiated according to their pulse width modulation (PWM) schemes

NOMENCLATURE

A=an arbitrary curve fitting constant between 1 and 5
R_s=cells series resistance, R_{sh}=shunt resistance, I= cell's output current,
I_L=light-generated current, I_o=diode saturation current, e = electronic charge,
v= cell's terminal voltage, K= Boltzmann's constant, T=absolute temperature

RESULTS

The PV arrays output is gives as input to the inverter and Fig 7 shows the I-V Characteristics of the solar cell here Alternate phase opposition displacement Sinusoidal Pulse Width Modulation Scheme is used to generate the control signals for the inverter Fig 6 shows the modulation scheme diagram.

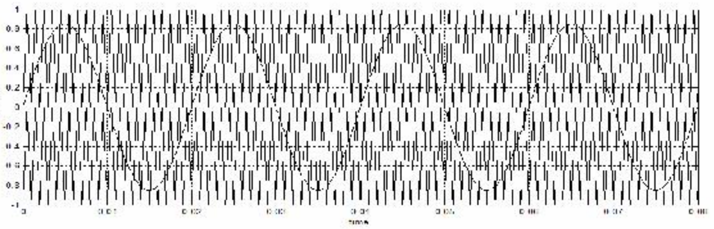


Figure: 6 Pulse generation circuit waveforms of the single leg, carrier signal frequency is 1 KHz, reference wave signal frequency is 50Hz Modulation index m=0.8

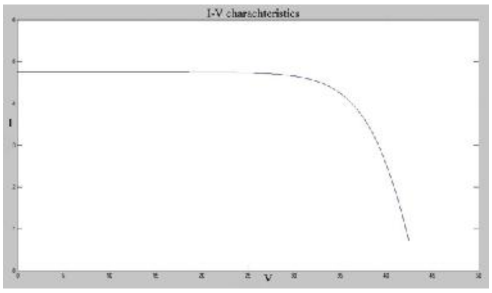


Figure: 7 Current and Voltage (I-V) Characteristic of the solar cell

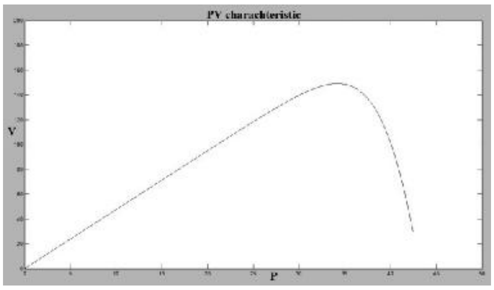


Figure: 8 Power and Voltage (P-V) Characteristic of the solar cell

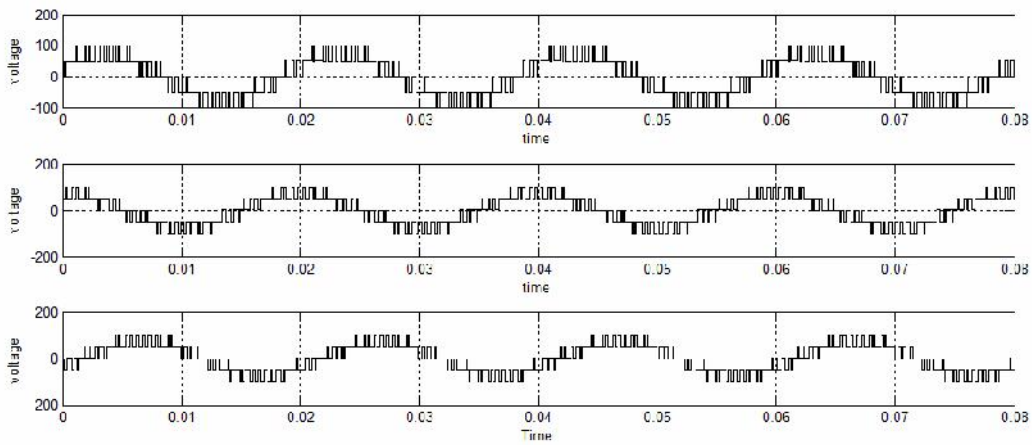


Figure: 9 Output voltage waveform of three level T-Type converter

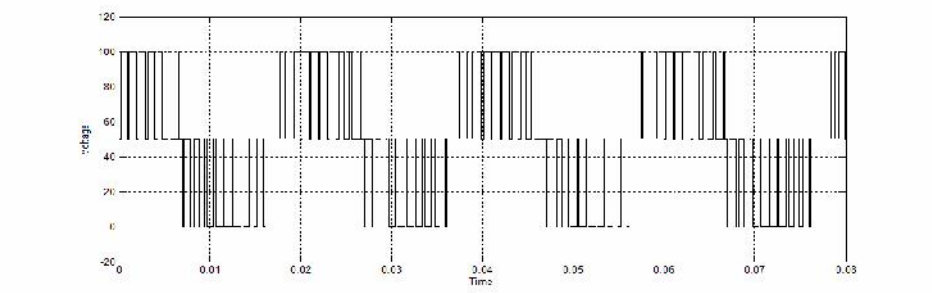


Figure: 10 Waveform of voltage across the switch T_1

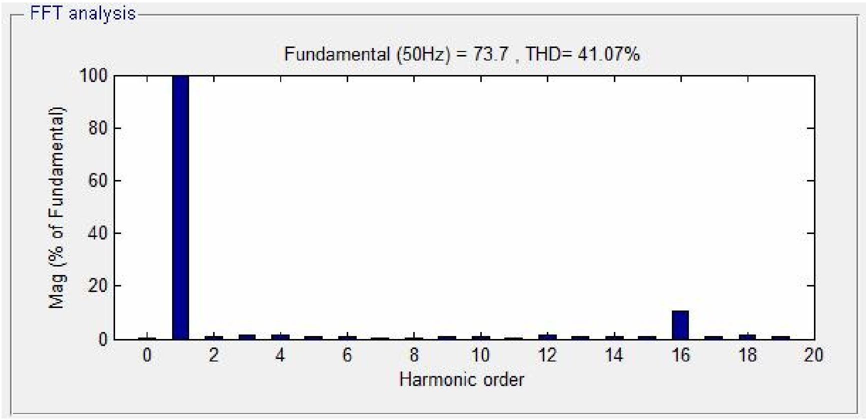


Figure 11: Total harmonic distortion of the three level T-type converters for phase displacement sinusoidal pulse width modulation, for switching frequency f_s=1 KHz, reference wave frequency f_r =50hz

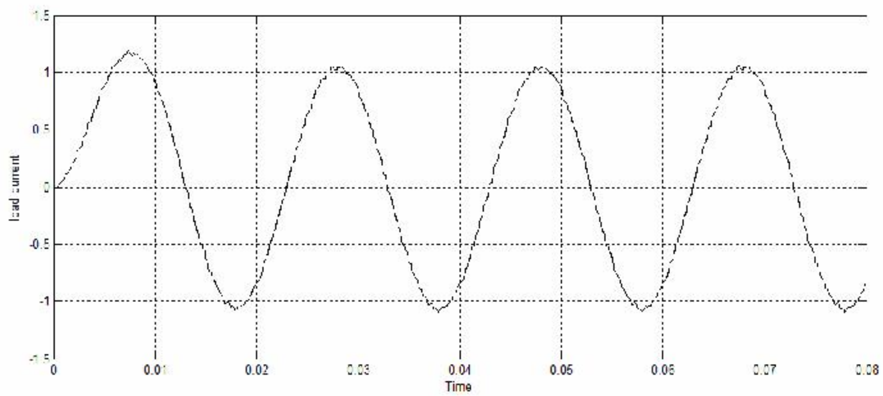


Figure 12: Load current waveform for R=20ohms, L=1H

CONCLUSION

In this paper the main advantage comes from the halved commutation voltage which reduces the switching losses compared to the two-level topology. The conduction losses do not change considerably. And the voltage stress decreases across the switches and the THD will improve by using the Space Vector Pulse Width Modulation than SPWM. Even though three level multilevel inverter had the advantages due to the cost it is not got the market penetration. This three level T-type converter had the advantages of both two level VSC and Three level NPC so it’s the best alternative for the existing three level multilevel inverter and two level VSC.

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