ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization *Vol. 5, Special Issue 2, March 2016*

National Conference on Future Technologies in Power, Control and Communication Systems (NFTPCOS-16)

on 10, 11 and 12th March 2016

Organised by

Dept. of EEE, College of Engineering Perumon, Kollam, Kerala – 691601, India

Electrical Energy Generation from Solar Power by Using Seven Level Inverter

Reshma Ravi[1] , Sankaran Nampoothiri[2]

UG Student Dept. of EEE, Sree Buddha College of Engineering for women, Elavumthitta, Kerala, India[1]

Assistant Professor, Dept. of EEE, Sree Buddha College of Engineering for women, Elavumthitta, Kerala, India [2]

ABSTRACT: It is a new type of solar power generation system which consists of a dc/dc power converter and a new seven level inverter. A dc/dc boost converter and a transformer is present in the dc/dc power converter which convert the output voltage of the solar cell array into two independent voltage source. This new seven-level inverter consisting of a capacitor selection circuit and a full-bridge power converter, connected in cascade in order to provide seven level voltage. The main function of capacitor selection circuit is to convert the two output voltage of dc/dc power converter into three level dc voltage, then the full bridge power converter present in the circuit further convert this three level dc voltage into a seven level voltage. This system generates sinusoidal output current which is in phase with the utility voltage and fed into the utility. The important features of this seven-level inverter is that it only uses six power electronic switches for its operation and only one power electronic switch is switched at high frequency at any time.

KEYWORDS: Dc-Direct current

I.INTRODUCTION

Nowadays the use of fossil fuels such as coal, petroleum and natural gases lead to number of global problems like greenhouse emissions, global warming etc. Moreover, day by day the amount of fossil fuel is decreased due to the increasing number of vehicles; due to this the costs of the fossil fuels are rises very rapidly. In order to avoid the above mentioned problems, solar energy is used which produce less pollution and it also a non conventional energy source, which available in the nature very widely. Nowadays in particular residential application such as electricity generation in rural areas, small-capacity distributed power generation systems using solar energy are widely used. So in order to covert the output direct current produced by the solar array a power conversion interface is important to grid-connected solar power generation systems, the interface mainly consist of a dc-dc converter and a seven level inverter, this interface will convert the dc current generated in solar panel into ac current and it feed to the utility grid.

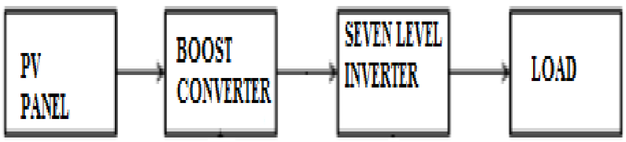


Fig 1:Block diagram of solar power generation system

The main components of this solar power generation system are solar photovoltaic panel, a dc-dc power converter and a modified seven level inverter. The solar cell array track light energy from the sun and it convert into electrical (direct current) energy then it is feed to a dc/dc converter connected to the solar panel, a fly back boost converter along with a transformer with turns ratio 2:1 is used as a dc/dc converter. The main function of dc–dc power converter converts the output power of the solar cell array into independent voltage sources with closed loop control

II. CIRCUIT CONFIGURATION

Fig.1.2 shows the circuit configuration of the proposed solar power generation system. The proposed system consists of a solar cell array, a dc–dc power converter, and a new seven-level inverter. The solar cell array is connected to the dc–

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization Vol. 5, Special Issue 2, March 2016

National Conference on Future Technologies in Power, Control and Communication Systems (NFTPCOS-16)

on 10, 11 and 12th March 2016

Organised by

Dept. of EEE, College of Engineering Perumon, Kollam, Kerala – 691601, India

dc boost converter that incorporates a transformer with a turn ratio of 2:1. Solar array refers to a panel designed to absorb the sun's rays as a source of energy for generating electricity or heating, it is also known as PV module. A PV module is a packaged, connected assembly of typically 6×10 solar cells. Solar PV panels constitute the solar array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications.

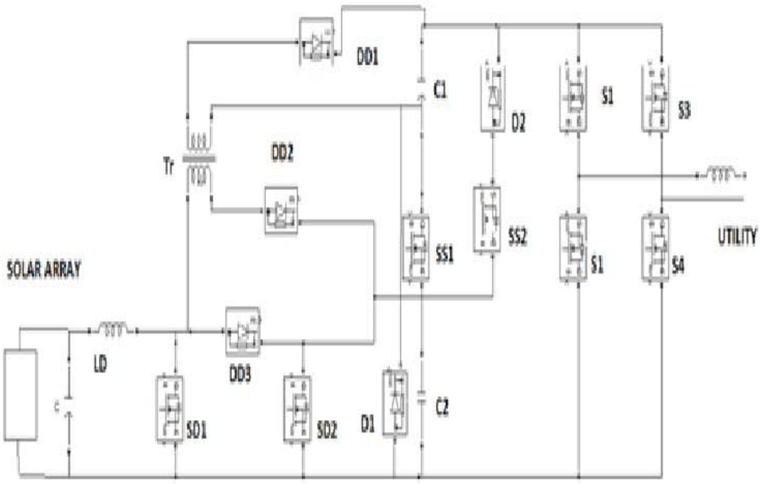


Fig 2 :Configuration of proposed solar power generation system

Each module is rated by its dc output power under standard test conditions, and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. There are a few solar panels available that are exceeding 19% efficiency. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring. By using some technique known as MPPT (maximum power point tracking) we were track the solar energy and the solar array convert it into electrical energy. This electrical energy is given to a dc/dc converter for boosting and a seven level inverter for converting boosted dc (direct current) into ac (alternating current).

III. DC-DC POWER CONVERTER

The boost converter is consisting of an inductor L_D, a power electronic switch S_{D1}, and a diode, D_{D3}. The boost converter charges capacitor C_2 of the seven-level inverter. In a boost converter, when the current ramps up in the primary, energy formed in the transformer core.

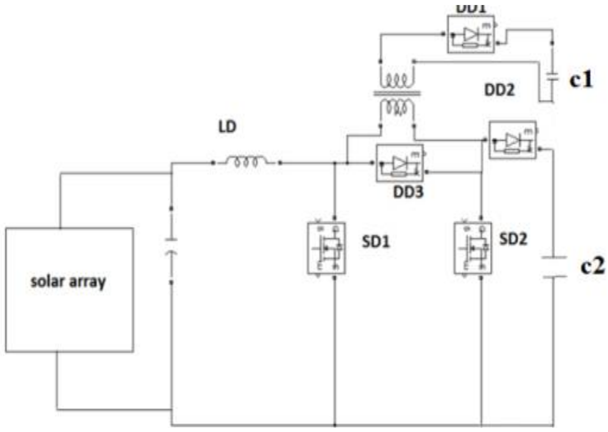


Fig 3 :Dc-Dc power converter

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization Vol. 5, Special Issue 2, March 2016

National Conference on Future Technologies in Power, Control and Communication Systems (NFTPCOS-16)

on 10, 11 and 12th March 2016

Organised by

Dept. of EEE, College of Engineering Perumon, Kollam, Kerala – 691601, India

When the switch is in off condition, the energy is passed into the secondary side of transformer. This makes the current flow current to flow in the secondary, so the primary current reduced to zero. This effect made to rise a current in the secondary side of a transformer, after that the current in the secondary side goes down linearly as it discharges voltage from the capacitor to the load. When the switch is in off condition the secondary side is equal to the peak value of the primary and is determined by the turn's ratio. The behaviour of most transformer-isolated converters can be adequately understood by modelling the physical transformer with a simple equivalent circuit consisting of an ideal transformer in parallel with the inductance. The magnetizing inductance behaves in a way of all the inductor behaves; in particular, volt-second balance must hold when the circuit operates in steady-state. The average voltage given across every winding of the transformer must be zero.The current-fed forward converter is composed of an inductor L_D, power electronic switches S_{D1} and S_{D2}, a transformer, and diodes D_{D1} and D_{D2}. The current-fed forward converter charges capacitor C_1 of the seven-level inverter. The inductor L_D and the power electronic switch S_{D1} of the current-fed forward converter are also used in the boost converter. The dc-dc converter has mainly two modes of operation.

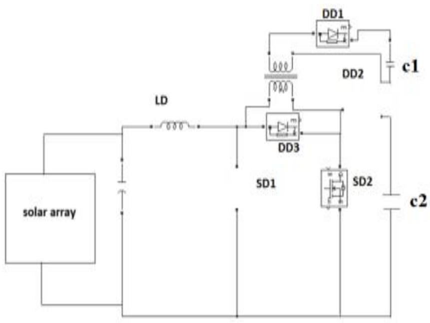


Fig 4: Mode 1 operation

S_{D1} is turned on and S_{D2} is turned off, so the solar cell array supplies charge to the inductor. The diodes D_{D1} ,D_{D2} are reverse biased and diode D_{D3} is forward biased so the current flows through the transformer primary and we get a voltage across capacitor C_2 .

The voltage across the capacitor C_2 is $V_{c2}=(1/(1-D))*V_s$

Where,

V_s:output voltage

D: Duty cycle

The output voltage of mode1 can be represented as " $V_{out}= V_{solar}$"

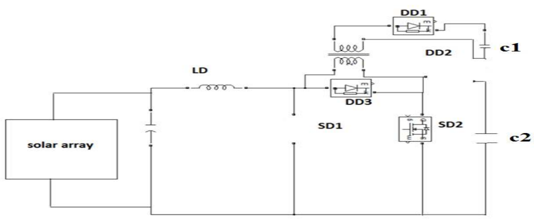


Fig 5: Mode 2 operation

In the boost converter capacitor C_1 is connected to the capacitor C_2 in parallel through a transformer having turns ratio 2:1. So the energy of the inductor L_D and solar cell array charge capacitor C_2 through D_{D3} and charges the capacitor C_1 through the transformer and D_{D1} during the off state of S_{D1} . Since capacitors C_1 and C_2 are charged in parallel by using the transformer, the voltage ratio of capacitors C_1 and C_2 is same as that of the turn's ratio of the transformer. Therefore the voltage of C_1 and C_2 have multiple relationships. The boost converter is operated in continuous conduction mode (ccm).

In mode 2 we get output voltage across both the capacitor C_1 and C_2

$V_{c2}= (1/ (1-D))*V_s$

$V_{c1}= (1/2(1-D))*V_s$

The output voltage of mode 2 can be represented as " $V_{out}= V_{solar}+V_{LD}$ "

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization | Vol. 5, Special Issue 2, March 2016

National Conference on Future Technologies in Power, Control and Communication Systems (NFTPCOS-16)

on 10, 11 and 12th March 2016

Organised by

Dept. of EEE, College of Engineering Perumon, Kollam, Kerala – 691601, India

It should be noted that the current of the magnetizing inductance of the transformer increases when S_{D2} is in the ON state. Conventionally, the forward converter needs a third demagnetizing winding in order to release the energy stored in the magnetizing inductance back to the power source. However, in the proposed dc–dc power converter, the energy stored in the magnetizing inductance is delivered to capacitor C_2 through D_{D2} and S_{D1} when S_{D2} is turned OFF. Since the energy stored in the magnetizing inductance is transferred forward to the output capacitor C_2 and not back to the dc source, the power efficiency is improved. In addition, the power circuit is simplifies because the charging circuits for capacitors C_1 and C_2 are integrated. Capacitors C_1 and C_2 are charged in parallel by using the transformer, so their voltages automatically have multiple relationships. The control circuit is also simplifies.

IV. SEVEN LEVEL INVETER

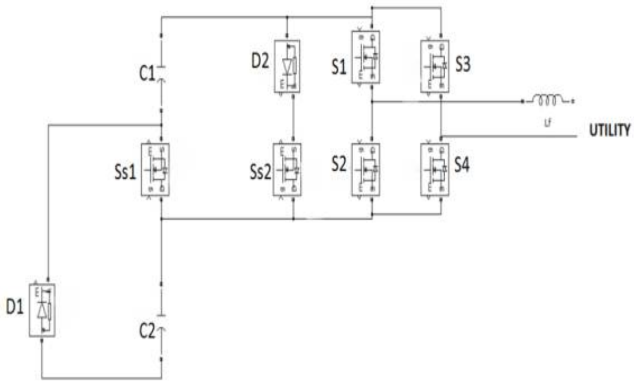
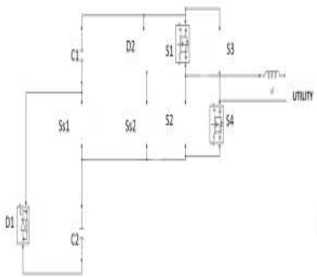


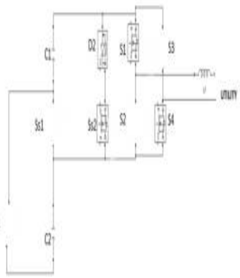
Fig 6: Seven level inverter

Fig 6 shows the seven-level inverter is composed of a capacitor selection circuit and a full-bridge power converter, which are connected in cascade. The operation of the seven- level inverter can be divided into the positive half cycle and the negative half cycle of the utility. The five levels multi-string inverter will have lot of drawbacks like large size filter, high harmonics and high electromagnetic interference. This can be reduced by using 7 levels multi-string inverter. For ease of analysis, the power electronic switches and diodes are assumed to be ideal, while the voltages of both capacitors C_1 and C_2 in the capacitor selection circuit are constant and equal to $V_{dc}/3$ and $2V_{dc}/3$, respectively. Since the output current of the solar power generation system will be controlled to be sinusoidal and in phase with the utility voltage, the output current of the seven-level inverter is also positive in the positive half cycle of the utility.

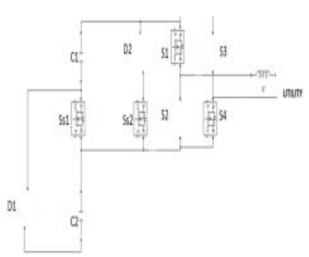
The seven-level inverter is consists of a capacitor from converter and a full-bridge power converter, which are connected in cascade. Here converter itself acts as a capacitor selection circuit. For ease of analysis, the power electronic switches and diodes are assumed to be ideal, the output current of the solar power generation system will be controlled to be sinusoidal and in phase with the inverter bus voltage, the output voltage and current of the seven-level inverter is also positive in the positive half cycle of the load. The seven level inverter has mainly 8 modes of operation, four modes in the positive half cycle and four modes in the negative half cycle.



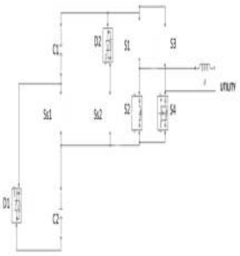
Mode 1



Mode2



Mode3



Mode 4

Mode 1: Both S_{S1} and S_{S2} of the capacitor selection circuit are OFF, so C_1 is discharged through D_1 and the output voltage of the capacitor selection circuit is Vdc/3. S_1 and S_4 of the full-bridge power converter are ON.At this point, the output voltage of the seven-level inverter is directly equal to the output voltage of the capacitor selection circuit, which means the output voltage of the seven-level inverter is $V_{dc}/3$.

Mode 2: In the capacitor selection circuit, S_{S1} is OFF and S_{S2} is ON, so C_2 is discharged through S_{S2} and D_2 and the output voltage of the capacitor selection circuit is $2V_{dc}/3$. S1 and S_4 of the full-bridge power converter are ON. At this point, the output voltage of the seven-level inverter is directly equal to the output voltage of the capacitor selection circuit which implies that the output voltage is equal to $2V_{dc}/3$.

Mode 3: In the capacitor selection circuit, S_{S1} is ON. Since D_2 has a reverse bias when SS1 is ON, the state of S_{S2} cannot affect the current flow. Therefore, S_{S2} may be ON or OFF, to avoiding switching of S_{S2}. Both C_1 and C_2 are discharged in series and the output voltage of the capacitor selection circuit is V_{dc}. S_1 and S_4 of the full-bridge power converter are ON. At this point, the output voltage of the seven-level inverter is V_{dc}.

Mode 4: Both S_{S1} and S_{S2} of the capacitor selection circuit are OFF. The output voltage of the capacitor selection circuit is $V_{dc}/3$. Only S4 of the full-bridge power converter is ON. Since the output current of the seven-level inverter is positive and passes through the filter inductor, it forces the anti parallel diode of S_2 to be switched ON for continuous conduction of the filter inductor current. At this point, the output voltage of the seven- level inverter is zero.

Therefore in positive half cycle, the output voltage of the seven level inverter has four levels: V_{dc}, $2V_{dc}/3$, $V_{dc/3}$ and zero.In the negative half cycle, the output current of the seven level inverter is negative. The operation of the seven level inverter is also further divided into four modes; the operation of the capacitor selection circuit in negative half cycle is same as that of the positive half cycle.The output voltage of seven level inverter during negative half cycle are $–V_{dc}$, $-2V_{dc}/3$, $-V_{dc}/3$ and zero.

V. ADVANTAGES AND DISADVANTAGES

ADVANTAGES

1. They are able to generate high output voltage with very low distortion and lower $\frac{dv}{dt}$
2. They are able to bring in input current with very low input distortion.
3. They can be functioned with a much lower switching frequency.
4. Conduction and switching losses are minim um.

DISADVANTAGES

1. It requires isolated voltage sources or a band of series capacitor for voltage balancing.

2. Very difficult to the practical

VI.CONCLUSION

This paper proposes a solar power generation system to convert the dc energy generated by a solar cell array into ac energy that is fed into the utility. The proposed solar power generation system is composed of a dc–dc power converter and a seven- level inverter. The seven-level inverter contains only six power electronic switches, which simplifies the circuit configuration. Furthermore, only one power electronic switch is switched at high frequency at any time to generate the seven-level output voltage. This reduces the switching power loss and improves the power efficiency.

ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

An ISO 3297: 2007 Certified Organization Vol. 5, Special Issue 2, March 2016

National Conference on Future Technologies in Power, Control and Communication Systems (NFTPCOS-16)

on 10, 11 and 12th March 2016

Organised by

Dept. of EEE, College of Engineering Perumon, Kollam, Kerala – 691601, India

The voltages of the two dc capacitors in the proposed seven-level inverter are balanced automatically, so the control circuit is simplifies. The proposed solar power generation system can generate a seven-level output voltage and outputs a sinusoidal current that is in phase with the utility voltage, yielding a power factor of unity. In addition, the proposed solar power generation system can effectively trace the maximum power of solar cell array.

1. implementation of a multilevel inverter.

REFERENCES

[1] Z.Zhao,M.Xu,Q.Chen,J. S.JasonLai,and Y. H.Cho,"Derivation,analysis,and implementatin of a boost–buck converter-based high-efficiency pv inverter," IEEE Trans. PowerElectron., vol. 27, no. 3, pp. 1304–1313, Mar. 2012.

[2]] R. A. Mastromauro, M. Liserre, and A. Dell'Aquila,"Control issues in single-stage photovoltaic systems: MPPT, current and voltage control," IEEE Trans. Ind. Informat., vol. 8, no. 2, pp. 241–254, May. 2012.

[3] M. Hanif, M. Basu, and K. Gaughan, "Understanding the operation of a Z-source inverter for photovoltaic application with a design example," IET Power Electron., vol. 4, no. 3, pp. 278–287, 2011.

[4] J.-M. Shen, H. L. Jou, and J. C. Wu, "Novel transformer less grid- connected power converter with negative grounding for photovoltaic generation system," IEEE Trans. Power Electron., vol. 27, no. 4, pp. 1818– 1829, Apr. 2012.