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CALCULATION OF THD VALUES OF FIVE LEVEL MULTI-LEVEL INVERTER FOR SOLAR PANNEL USING SEPIC CONVERTER

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ABSTRACT: The challenges with solar energy extraction are addressed in the proposed approach through development and demonstration of multilevel inverter architecture and the associated control algorithms. The proposed multilevel inverter topology along with the control algorithms for solar photovoltaic (PV) systems increases the overall energy capture from the sun. Multilevel inverters are mostly used in medium and high power applications because of their robustness and reliability.

PV (photovoltaic) system with single-ended primary-inductor converter (SEPIC) and maximum power point tracking (MPPT) using fuzzy logic controller are presented here to solve the harmonic problem of PV system. Fuzzy logic controller shows high precision in current transition and gives crisp output to the SEPIC converter for buck/boost the output voltage of PV array.

FLC based on P&O method and gives duty cycle to the SEPIC converter for boost up the output voltage of PV array so SEPIC converter also known as dc to dc converter or buck/boost converter, inverters are used for conversion of dc to ac but for reduction of harmonics, multilevel inverter is used in this paper because, it gives near to sine wave with less harmonic output.

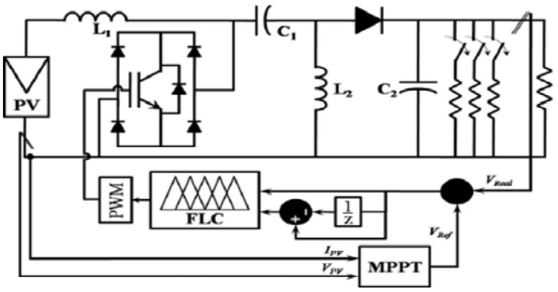
1. INTRODUCTION

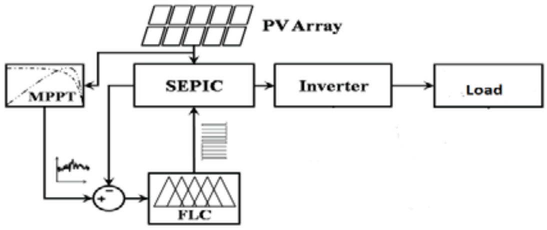
In Last few years solar energy improves its share in production of electricity or electrical power for this purpose photovoltaic cells are used their output power generation can be varied according to irradiation or sunlight & temperature beneficial to get output power which is maximum, MPPT is used with single ended primary induction inverter that is also called SEPIC converter. This SEPIC converter is used as Direct Current to Direct Current mechanism. Here the benefit of this SEPIC converter is output of SEPIC converter changes in accordance with the fuzzy logic controller and the adoption of converter mainly depends upon key component such as price, effectiveness and pliability (means how output varies with input). Buck-boost converter mainly ability to increase and decrease the applied potential difference levels. So with use of these converters energy transfer is possible at different radiation levels.

SEPIC and CUK converters mainly converts levels of voltage output it may be either more or less as compared to input. The output curve of photovoltaic cells is exponential curve where P_{max} occurs at bow of curve. A well known method is P&O method that is called perturb and observe method the beauty of these method is they finds the maximum point of output this is possible only with the use of MPPT. Today researchers used a new technique to reduce THD levels that is total harmonic distortions that is use of five level inverter which is possible by implication of PI controllers for DC-DC converters. THD level does not comes to lower level as expectation because system cost in increased with the use of five level converter. Experts applied optimization for maximum power point tracker using PI controller in which on cycle is controlled. PI controllers are used by system designers with MPPT but some of the limitations were seen they are highly sensitive with the variations in parameter and condition of weather so to overcome such problem a converter is needed which works on all occurs uncertainty.

2. PROPOSED SYSTEM

Output of photovoltaic array is increased by use of Direct Current to Direct Current mechanism which improves Photo-Voltaic output and this output voltage is given to the inverter. In this Thesis the level of voltage output is varied according to the PWM duty cycle and the level of output voltage depends upon maximum power obtained, this output signal is then matched with sinusoidal reference signal to generate signals with zero error, To gain highest power SEPIC output is matched with the sinusoidal reference signal . Shape of this reference signal varies according to the environmental conditions so it can be said that reference signal is adaptive in nature. The output signal which is SEPIC is matched with this reference signal which is adaptive in nature to supply the inverter. As it is desired that the output which we are getting from inverter should be smooth in nature but the output of SEPIC has no smooth signal so this becomes a problem to make the SEPIC result smooth normal filters as adopted for the system.





3. SOLAR PHOTO-VOLTAIC SYSTEM

A solar photo-voltaic systems is a system that collects irradiance as a input and provides output as a voltage but this process is mainly divided into two parts, one is production of electron-hole pairs which is due to sunlight absorption and other one is separation of electron hole pair which is done by the module structure as movement of electron towards (–) terminal and hole towards (+) terminal.

A potential difference is generated because of separation of electrons and holes.

4. MULTI-LEVEL INVERTERS

Basically multilevel inverter is universally adopted technique in more power medium voltage applications many industrial applications use multilevel inverters for higher power apparatus.

The multilevel inverter consist of several ON-OFF switches that may be IGBT , BJT , SCR or many more and also number of lower voltage DC sources. Power switches commutation helps to get the higher output voltage form lower DC voltage sources where rating of lower DC voltage sources helps decides the rating of power semiconductor switches. The multilevel inverter uses high frequency pulse width modulation (PWM) switching which makes it higher advantageous as compared to the two level inverter. The major advantages are listed below

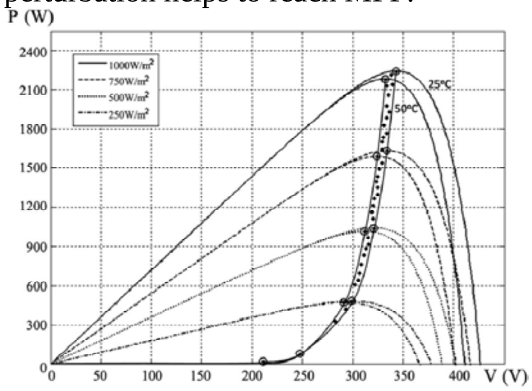
1. Better stepped waveform means lower dv/dt.
2. Smaller common mode voltage.
3. Low input current distortion.

The another quality of multilevel inverter is that it can operate on switching as well as high switching frequency PWM which confirms greater efficiency and lower switching loss. The expense increases in multilevel inverter as it uses number of power semiconductor switches and each switch need separate gate driver circuit but important thing is lower voltage rating switches can be used to reduce the expense. Three different multilevel inverter will be introduced in this chapter as they are widely used in recent years they are listed below-

1. Clamped Diode
2. Clamped Capacitor
3. Separate dc sources Cascaded multi-cell

5. MAXIMUM POWER EXTRACTION

As we all know that solar irradiation varies throughout the day so the available energy varies throughout the day nonlinearly. So without measuring the panel temperature and solar irradiation available solar energy estimation is very difficult. With the help of sensing element still very difficult to calculate. Clouding and shading continuously affects the performance of the panel, also with the time solar performance goes down, so inverter must be so designed that it adjusts itself with the variation of power availability. So MPPT is an important part of solar irradiation system. Many MPPT algorithm developed to capture maximum power for that many literature are reviewed but among all the methods hill climbing or perturb & observe method (P&O) algorithm found effective MPPT method. In the P&O method perturbing of inverter duty ratio is done which is connected to the panel which then perturbs the PV array current which will finally perturb power output. To reach the MPP, if there is an increment in power perturbing should be done in the same way, if power decreases perturbing should be reversed. Till the MPP attained process continues. In order to reduce oscillation during the process step size of perturbation is reduced. A smaller step size of perturbation helps to reach MPP.



Power-Voltage curve for the prescribed Photo-voltaic array

6. SEPIC CONVERTER

In order to meet design requirements, it is essential to maintain a consistent and precise input to various sub-circuits. If a check a comparison of alternating current to alternating current transformation transformer is best choice but if a discussion is made on direct current to direct current conversion it becomes a little complex. Diodes and voltage bridges can be used to decrease voltage by a fixed amount, but these methods can be inefficient. Voltage regulators are used to establish a reference voltage and control the voltage in a circuit. It is important to note that battery voltage decreases as the battery discharges, which can lead to several issues in the absence of voltage control. The most effective way to regulate voltage in a circuit is through the use of a DC-DC converter. There are five main types of DC-DC converters-

1. Buck Converters (which only decrease voltage)
2. Boost Converters (which only increase voltage
3. Buck-boost, Cúk, and SEPIC converters (which can either improve or reduce voltage).

In few cases, it is necessary to have a converter that can both increase and decrease the voltage, and buck-boost converters are often used for this purpose. However, these converters can be expensive and inefficient due to high input current ripple and harmonics, which may require additional components such as large capacitors or LC filters. Furthermore, buck-boost converters invert the voltage, which can cause complications. Cúk converters address these issues by utilizing an additional capacitor and inductor, but they still subject components to high electrical stress, potentially leading to overheating or failure. SEPIC converters, on the other hand, can overcome both of these issues.

7. FUZZY LOGIC

The system that we have adopted in our study control scheme is already discussed in previous chapters. To design FLC controller very basic thing is identification of control variable and preparation of set of variable that helps to define linguistic variable values. The structure of fuzzy logic controller is already shown in the previous chapter in which some of the variable like input variable, output voltage error and also rate of change of output voltage error that is (e_ (n)). The output that we will get of FLC is

(d(n)) PWM signal duty cycle

Pulse Width Modulation basically controls the value of output voltage. To make calculation easy functions having triangular membership are preferred for fuzzy logic controller as a input and output it is shown below in figures.

Linguistic variable values are the set of 5 fuzzy terms described below-

1. Negative big (N-II)
2. Zero (Z)
3. Positive small (P-I)
4. Negative small (N-I)
5. Positive big (P-II)

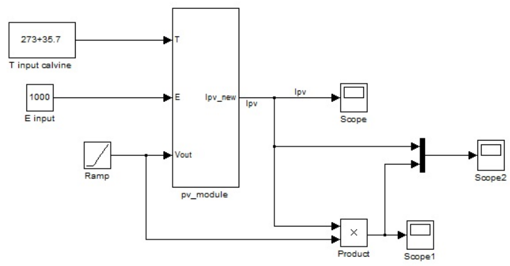
Output variable membership functions are the set of 9 fuzzy terms described below all the variables having triangular shapes-

1. Negative very big (N4)
2. Negative big (N3)
3. Negative small (N2)
4. Negative very small (N1)
5. Zero (Z)
6. Positive very small (P1)
7. Positive small (P2)
8. Positive big (P3)
9. Positive very big (P4)

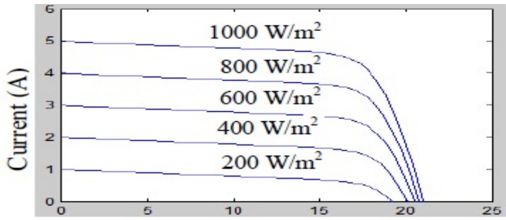
For Fuzzification P&O fuzzy inference method is used where a technique called maximum and minimum composition is used and for De-fuzzification inference and the center-of-gravity method is preferred.

8. SIMULATION IMPLEMENTATION

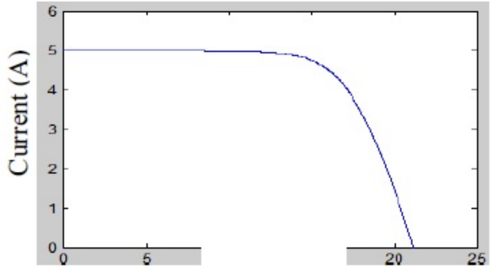
To validate the THD value of the output waveform, simulation was carried out using MATLAB/SIMULINK. This section begins with a discussion of the simulation of the photovoltaic characteristics. The PV module produces non-linear P-V and I-V curves that are contingent on the solar irradiation conditions of the PV array.



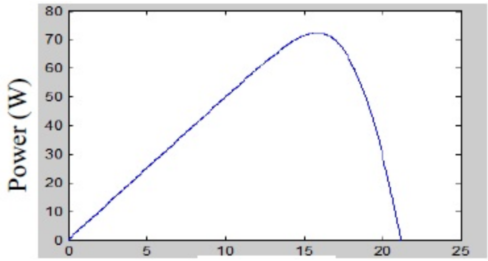
PV module



Current & voltage characteristics for different irradiation

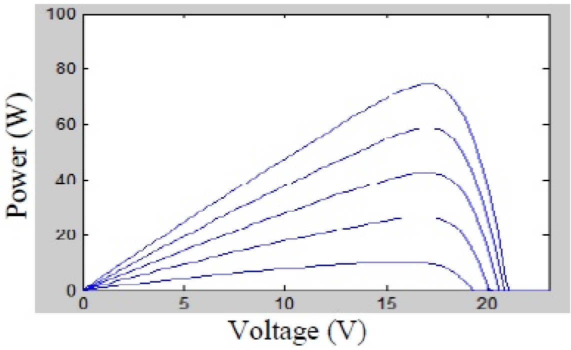


Current & voltage characteristics



Power & voltage characteristics

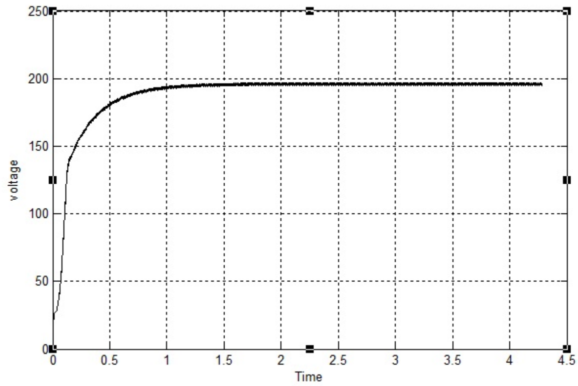
The curves depicted in Figure 9(a) are non-linear and rely on the irradiation and temperature conditions. Meanwhile, Figure 9(b) exhibits the non-linear I-V curve, while Figure 9(c) displays the voltage and power characteristics, which are instrumental in identifying the maximum power point.



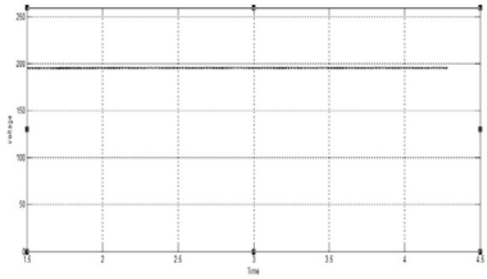
Power & voltage characteristics at different irradiation level

9. RESULTS AND DISCUSSION

Figures displays the output waveform of the SEPIC converter, and the corresponding figure, shows that the observed output voltage is 265 V.



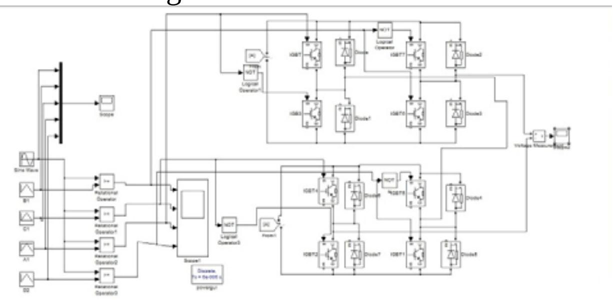
DC output of SEPIC converter



DC output of SEPIC converter

Simulation of Five Level Inverter

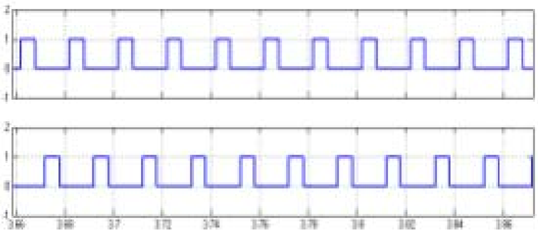
The MATLAB/SIMULINK model of a five-level inverter, which converts DC to AC, is presented in Figure



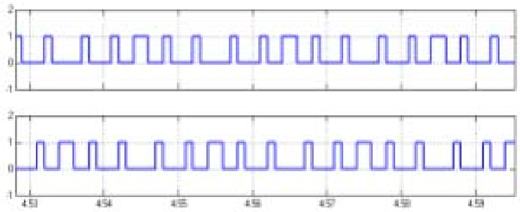
Five level inverter

Simulation result

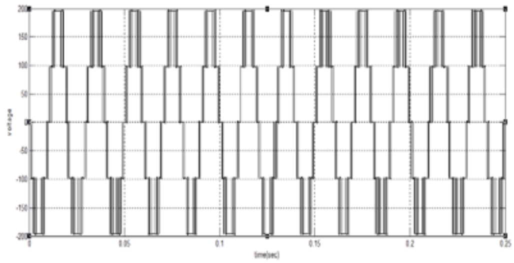
Figure depicts the output voltage of a five-level inverter, which yields a nearly sinusoidal waveform. As illustrated in Figure, the total harmonic distortion value for this waveform is 1.27%.



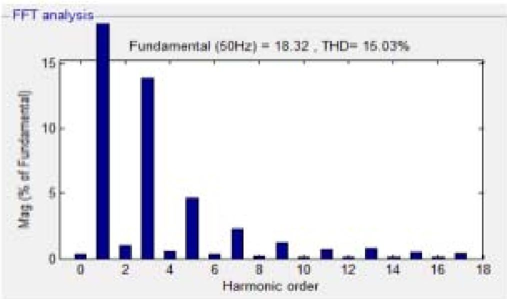
H-Bridge 1 pulses



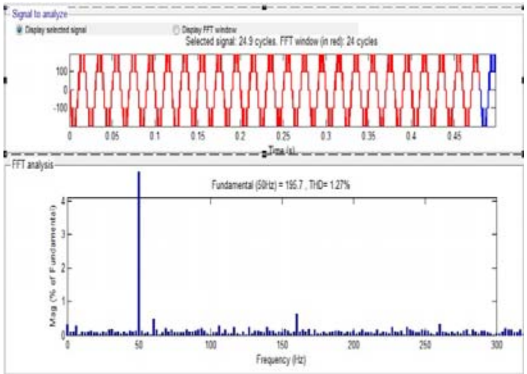
H-Bridge 2 pulses



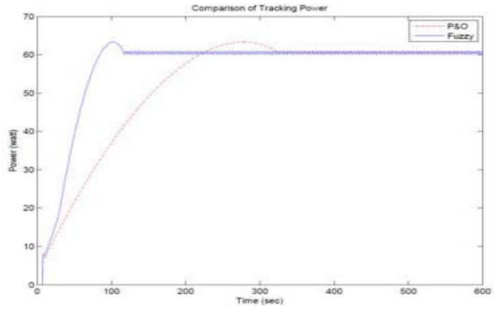
Multi level inverter output



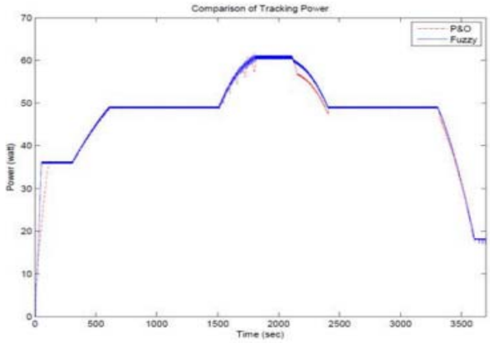
Output current spectrum study of frequency



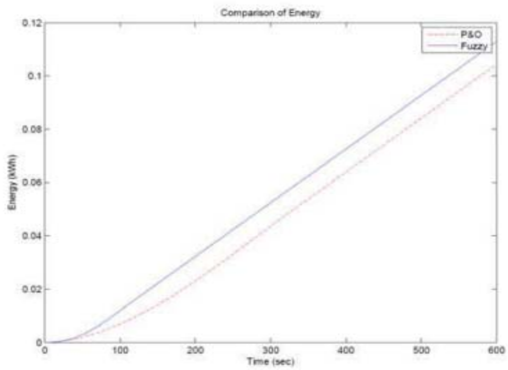
THD Value of Five Level Inverter



Power curve tracking by FLC Algorithm



MPPT curve tracking by FLC Algorithm



Energy curve tracking by FLC Algorithm and P&O Method

Comparison of THD

DEVICES	THD VALUE
PV-MODULE-WITH-SINGLE-PHASE INVERTER[1]	4.2%
PV-MODULE WITH FIVE LEVEL INVRTER	1.27%

10. REFERENCES

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