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AI-based solar fed single phase induction motor drive

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ABSTRACT

These days, induction motors will be employed in more applications, particularly in industries where items will be manufactured using induction motors. This project's primary objective is to use an effective controller and converter to feed solar energy to an induction motor. To get the solar panel's maximum power point (MPPT), we used fuzzy logic based on SEPIC converters in this project. This solar energy is given to the induction motor with help of the voltage source inverter. By taking the motor speed as feedback we can vary the voltage out of the SEPIC converter with the help of the Arduino Uno. Due to this the solar energy will be utilized with an efficient manner.

Keywords: *SEPIC, MPPT, PWM, VSI, SPWM*

I. INTRODUCTION

Nowadays induction motor will be used for industry as well as domestic purpose depending upon their application. to run this induction motor mostly utilize the supply coming from the grid. If the grid connection not available near means by paying amount to the office, we are taking grid line near our site. The main objective of this project is to save the grid energy as possible by utilize renewable energy source with an efficient manner and to reduce the harmonics present in the output in our project, we used solar energy and this can be used efficiently with the help of fuzzy logic controller and SEPIC converter, inverter.in this paper Section-1 we explain about the block diagram of proposed system. IN section- II explained about the design of SEPIC converter for making the MPPT it will necessary. In section-III explained about design of MPPT with SEPIC and fuzzy logic controller. In section-IV explained about the controlling the induction motor with help of voltage source inverter.

II. PROPOSED SYSTEM

The below figure shows the block diagram of the proposed system.

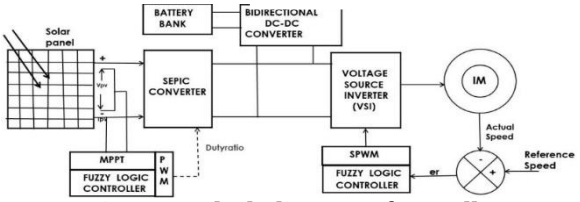


Figure 1: Block diagram of overall system

In this system the solar energy will be obtained from the solar panel is given to the MPPT at the same time to the SEPIC converter. Let's take V(pv) is the voltage coming from the solar panel and I(pv) is the current coming from the solar panel. This are given to MPPT at the same time to the SEPIC converter. The voltage V(pv) and current I(pv) is compared by the MPPT with help of fuzzy logic controller. After comparing this voltage and by fuzzy sets depending upon the V(pv) and I(pv) MPPT will be generate a duty ratio and this duty ratio is applied to the SEPIC Converter. SEPIC converter is a type of DC-Dc converter. This converter collects voltage V(pv) and current I(pv) from the solar panel set to be V(m) and I(m) respectively by taking the duty ratio coming from the MPPT. Due to this the maximum power will be obtained from the solar panel. this maximum voltage and current coming from the SEPIC converter are given to the battery with help of bi-directional dc-dc converter. This converter will give suitable voltage to the battery and charge the battery. Due to this converter at night times solar energy will not present and at same whether condition also solar energy will be reduced under this condition we can take supply from the battery through bi-directional dc-dc converter.

The output of the SEPIC converter will also send to the inverter. In this system we implemented SPWM based inverter. This inverter converts dc to ac voltage by taking the PWM signal coming from the Arduino. the output of this inverter is feed to the motor. Due to this the motor will drive the load. The speed of the motor will be sensed by the speed sensor and it's given to the Arduino. Depending upon the error signal coming from the motor will be analysed by Arduino and with help of fuzzy rules it will generate PWM signal to the inverter to control the output of the inverter. This is the operation of the proposed system.

III. DESIGN OF SEPIC CONVERTER

A SEPIC converter is a type of dc-dc converter.it can increase or decrease or maintain the input voltage as constant. This converter having non-inverting output unlike a buck-boost converter. The harmonic present in this converter output is also less because it contains two inductors, and two capacitors and ripples appear at output also less. SEPIC converter has higher efficiency than most of the other Dc-Dc converters. The below figure shows the circuit diagram of the SEPIC converter.

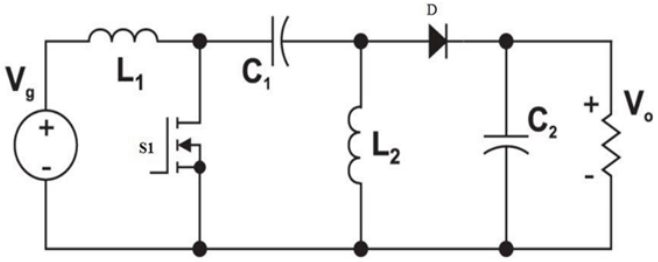


Figure 2: SEPIC converter circuit with MOSFET as switch

To Implement the SEPIC converter in for making MPPT application we have to design this converter depending upon the input and output voltage required for output.

The below shows some steps to design a SEPIC converter.in this we required to step down the 18V to 14V and at the same time the 6V voltage will be step up to the 14 v by using this converter. the input current for this converter will be 0.75 A.
Depending upon the above requirement we can design a SEPIC converter for MPPT applications. In this design we used coupled inductor. the coupled inductor not only provides a small footprint but also get same inductor ripple, requires only half of the inductance required for SEPIC with two separate inductors [4]

Steps for design a SEPIC converter

The below steps are used to design the SEPIC converter.
Step1: To design a SEPIC converter first we must calculate the maximum and minimum duty cycle of the SEPIC converter and minimum duty it can be calculated by using following equation (1) and Equation (2).

$$D(max) = \frac{Vout(max) + Vd}{VIn(min) + Vout(max) + Vd} \quad --- (1)$$

$$D(min) = \frac{Vout(min) + Vd}{Vin(max) + Vout(min) + Vd} \quad ---- (2)$$

Where:
Vd=potential across the diode (0.5)
Step2: After calculating the duty cycle depending upon this, we can calculate rating of the inductor. Before selecting inductor for our application, we have to select the ripple current Δir. the inductor ripple current will be 10% of input current [1].

Δi=10%ofIin ---------- (3)

$$L = \frac{Vin(min) \times D(max)}{\Delta io_{ma} \chi f_s} \quad \text{---} \quad (4)$$

Where,
Δir=ripple current.
fs=switching frequency of the of MOSFET.
Step3: for knowing the ratings of the inductor first we have to select the voltage ripple (Δvr) depending upon that we can calculate the ratings of the capacitor.

Δvr=2% of Vo ---------- (5)

$$C = \frac{i(out) \times D(max)}{\Delta Vr \times f_s} \quad \text{------} \quad (6)$$

Where,

ΔVr = voltage ripples.
fs = switching frequency of the MOSFET.
By using the above steps, we can design SEPIC conveter.in addiction to reduce the harmonic a LC filter is added at the output of the capacitor.
The simulation design of the above SEPIC is shown below.

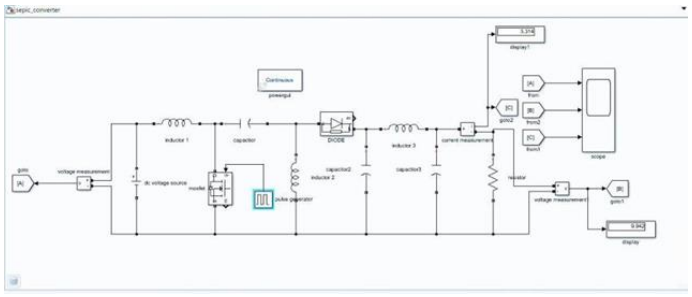


Figure 3: SEPIC converter with filter circuit.

The above figure shows the design of SEPIC converter with help of simulation and this converter also verified with maximum and minimum voltage and duty cycle as Shown figure below. Switch condition on the SEPIC can determined with pulse width modulation signal, like a 0 or 1 digital signal.

From the figure 4 we can observe that if we give a minimum voltage 10 with maximum duty cycle we obtained 16v. From the figure above we can observe that if we give maximum voltage 20v it gives output which reduced input voltage.

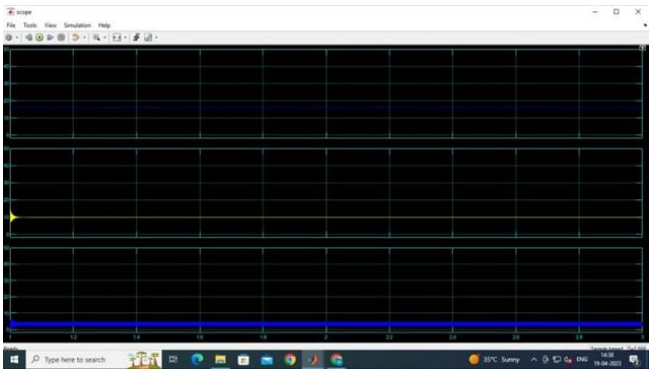


Figure 4: simulation result for minimum input with maximum duty ratio

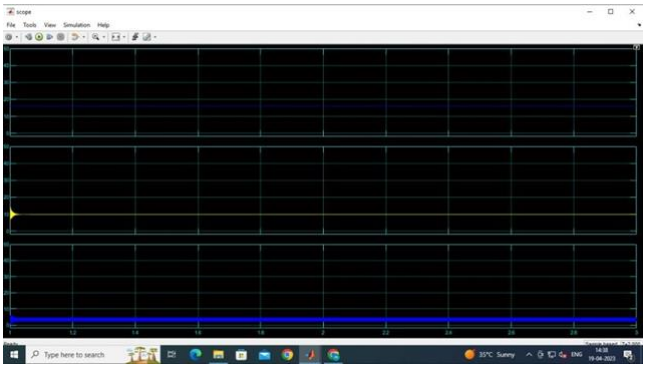


Figure 5: simulation result for maximum input with minimum duty ratio

After designing SEPIC converter next we have to design a MPPT with help of this converter.

IV. DESIGN OF MPPT

MPPT is a type of DC-DC converter with the help of this we can made the solar panel to operate at which maximum power point. MPPT perform this operation by Matching the impedance of source and the load. A dc-dc converter is used for to do this application [7].in this proposed system we used SEPIC type dc- dc converter. because of it provides less harmonic compared to other converters.

3.1 Block diagram of MPPT

Below figure shows the block diagram of MPPT. the input coming from the solar panel is given to the voltage divider circuit. Arduino read the voltage coming from the solar panel by the help of voltage divider circuit. the voltage and current coming from the solar panel are compared by the Arduino and generate a PWM signal with help of fuzzy logic rules. this PWM signal are given to the SEPIC converter to obtain the maximum power.

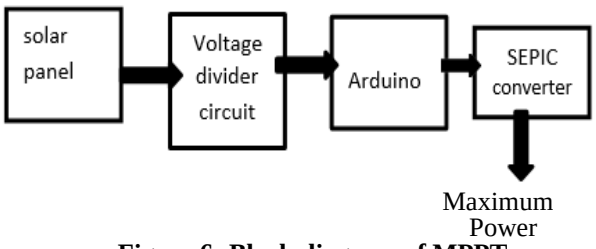
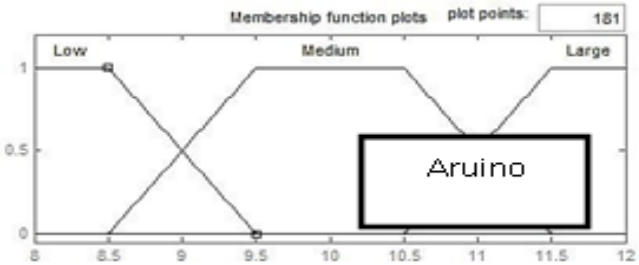


Figure 6: Block diagram of MPPT

Steps to design fuzzy logic MPPT

Irradiance, temperature and current drawn from the cell control the are the main factors of the of power drawn from the solar panel change any of this Terms causes change in power [2].By placing source impedance equal to the load impedance we can get maximum power from the source[5] .fuzzy logic controller can provide faster and stable tacking maximum power as compared to another controller [6].



Below shows the steps to design fuzzy logic based MPPT.

Step1:design a membership function for inputs as shown below

Current/voltage	Low	medium	High
Low	High	high	Medium
Medium	Medium	high	Medium
High	Medium	medium	Medium

Table 1: fuzzy logic rule

Step3: from the above logic rules table we can design an if-then rules for the Arduino.
The rules in the table above are as follows:
1) If (current is low) AND (voltage is low) then (D is high)
2) If (current is low) AND (voltage is medium) then (D is high)
3) If (current is small) AND (voltage is high) then (D is medium)
4) If (current is medium) AND (voltage is low) then (D is high)
5) If (current is medium) AND (voltage is medium) then (D is high)
6) If (current is medium) AND (voltage is high) then (D is medium)
7) If (current is high) AND (voltage is low) then (D is medium)
8) If (current is high) AND (voltage is medium) then (D is medium)
9) If (current is high) AND (voltage is high) then (D is medium)
Where D is duty cycle that represents the output of fuzzy controller.
By using the voltage, current and duty cycle range obtained from the from SEPIC converter design is taken and by he helps of this value we can write the code for Arduino.
By using the above Rules, the Arduino will generate a PWM pulse at pin 9 of the Arduino. This PWM signals are given to the MOSFET of the Arduino due to this it will control the SEPIC converter for obtain the maximum power from the source.

V. WORKING

The output voltage coming from the inverter is that will be givento the 12-230v boost transformer and this inverter is controlled by using Arduino with SPWM signal .to generate a SPWM usedthe Arduino. in Arduino we can give duty cycle to it from 0- 255.to generate a maximum duty cycle we have to write 255 in analog write function. Suppose we have to generate a 50% dutycycle means we in code we have to write 127 in the code.by using this process we can generate a SPWM signal for the Arduino to obtain the ac output 230v.

By taking the speed as Feedback we control the PWM pulses generating from the Arduino. Due to this motor drive the load.todo the above we can used fuzzy logic rules.by the help this we can control the speed of motor with efficient.

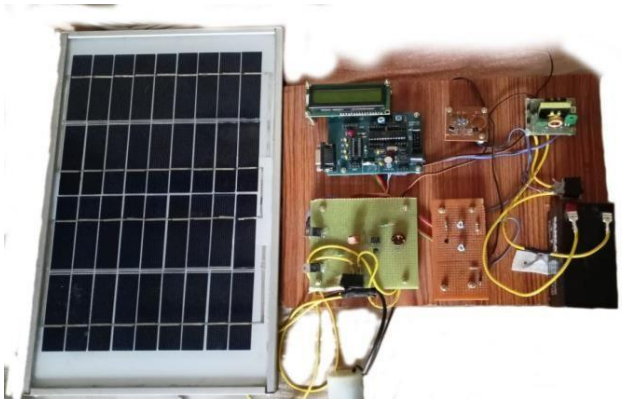


Figure 8: Prototype of proposed System

The diagram of this voltage source inverter is shown in figure 8 below it consists of two MOSFET and gate pulse given to this pin with help of the Arduino. compared to other inverter voltagesource inverter will give better sine wave.to improve the quality of power we have added capacitor at the output of this voltage source inverter. This capacitor rating is 1k250VAC.due to this the power factor also be increased.

The above figure shows the overall circuit of the proposed system. The voltage coming from the solar is displayed with thehelp of LCD display and also it displays the how much voltage will be getting from the SEPIC converter.

VI. CONCLUSION

From the above we can observe that for the motor is fed by fuzzy logic based MPPT and also the total harmonic distortion also reduced due quality of the power will be increases. we can protect the motor also from this scheme by taking voltage feedback and comparing it with the help of reference. Compared to the other controller fuzzy logic has less rise time due to this it rectifies the fault with less time.

VII. ACKNOWLEDGEMENT

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