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Fuzzy Based Dual-Axis Solar Tracking Technique

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ABSTRACT

The proposed technique is on dual axis solar tracking system based on fuzzy control. In this proposed research solar panel will move along horizontal as well as along vertical axis according to sun's daily movement and also follow its seasonal change in axis; motion of the panel will be determined by the fuzzy controller. The proposed technique is such that solar panel actually follows the motion of sun to get maximum power. Problem is the percentage of useful solar energy because it varies with time. Variation in it occurs because as we know sun keeps on moving so its incident radiation is not perpendicular to panel's surface all along the day. It has been observed that efficiency of solar panel is about 23% -25%. Generally, PV panels are fixed along one direction due to which as the sun moves, the angle of incident insolation varies, decreasing the amount of useful solar radiation and hence could not provide maximum power, there is need of a technique which can be used to solve out this problem.

Keywords: Enhancement of Power Output, Inclination, Mathematical Model

1. INTRODUCTION

Sun is renewable source of energy and energy obtained from sun is called solar energy. Generation of energy from sun is done by process called nuclear fusion. Hydrogen and Helium atoms are present in sun in plasma state. High temperature and pressure in sun results in separation of nuclei from electrons. Hydrogen nuclei fuses to form one helium atom and along this process radiant energy is released.

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$$^{2}_{1}H + ^{2}_{1}H = ^{3}_{1}He + energy$$

$$^{2}_{1}H + ^{3}_{1}H = ^{4}_{1}He + energy$$

At the earth's surface where the sunlight falls perpendicular at sea level, energy density of sun is found to be approximately 1000W/m^2. Increasing demand of electricity is also being fulfilled by converting solar energy into electricity with the help of PV modules. These modules are made of two types of semiconductor, n type and p type. Generally PV panels are mounted facing towards one direction but due to daily and seasonal motion of sun maximum power output is not achieved. For achieving maximum power output, some techniques are required. This paper is based on fuzzy dual axis solar tracking technique which helps in getting maximum power output [1-6].

1. 1. Effect of inclination on output power of the PV module

Performance of solar panels depends on intensity of light falling on it. Maximum energy transformation takes place when sunrays fall perpendicular to surface of panel. Hence, generated output power depends on angle by which panel is tilted.

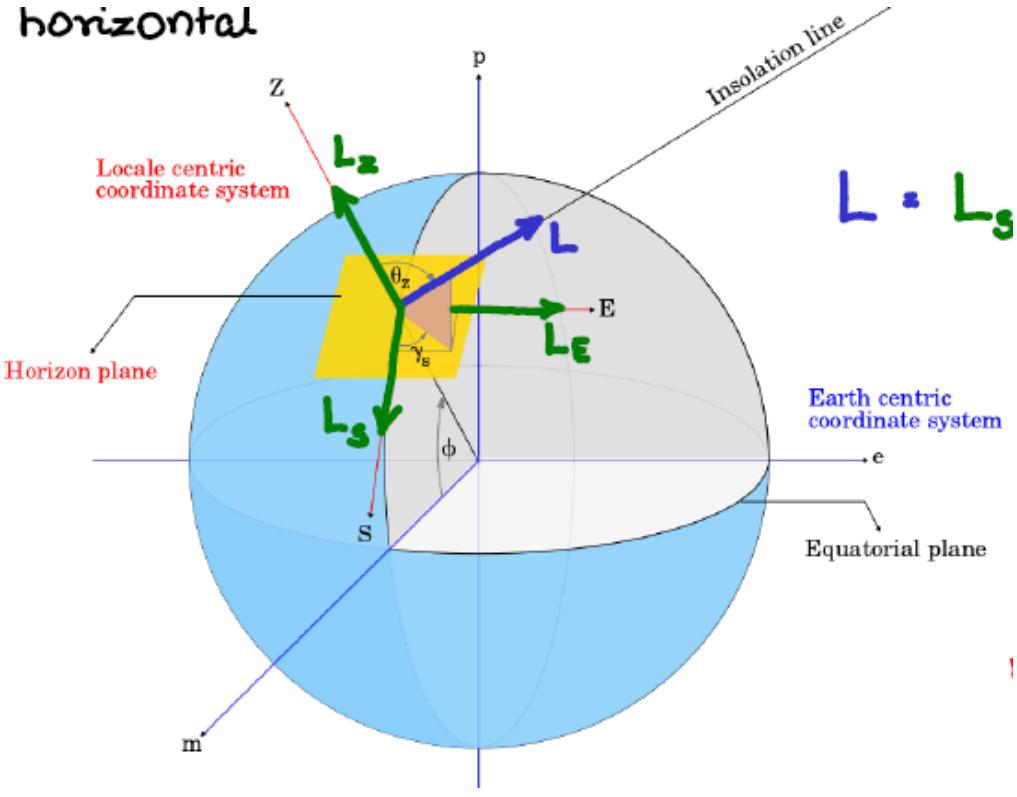


Figure 1. Insolation on a horizontal flat plate

$$L = L_S + L_Z + L_E$$

$$L_S = L\, sin\theta_z cos\gamma_s$$

$$L_Z = L\cos\theta_z \text{ (Normal Incidence)}$$

$$L_E = L\sin\theta_z \sin\gamma_s$$

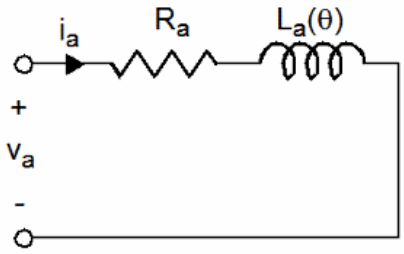
2. MATHEMATICAL MODEL

2. 1. Stepper motor

The stepper motor block puts into effect the characteristic model that constitutes two types of stepper motors:

1) Variable-Reluctance stepper motor
2) Permanent magnet stepper motor

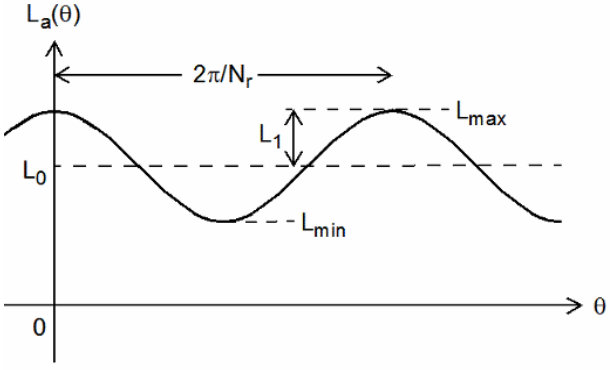
Circuit diagram of variable-reluctance stepper motor is show below.



(a)

Figure 2. (a). Circuit Diagram of Variable reluctance stepper motor

In this circuit diagram, R_a and L_a (θ) represent the resistance and the inductance of phase "A" winding respectively.



(b)

Figure 2. (b). Inductance curve of Variable reluctance stepper motor

Circuit diagram of permanent-magnet stepper motor, is shown below.

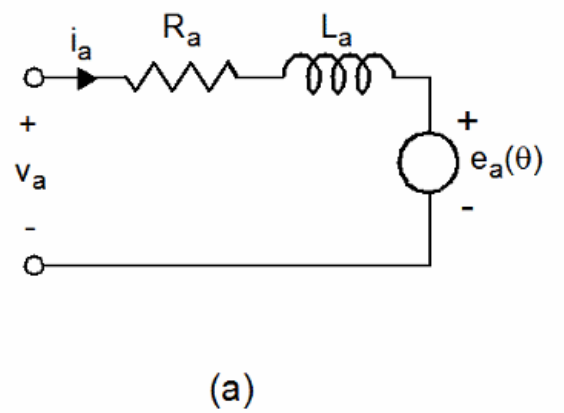


Figure 3. (a). Circuit Diagram of permanent magnet stepper motor

In this circuit diagram, $R_a$and $L_a$represent the resistance and inductance of A-phase winding respectively. As the magnets introduce large air gap, hence the winding inductance can be assumed independent of rotor position. The voltage source $e_a(\theta)$ represents the motor back EMF (electromotive force) which is a

Sinusoidal function of the rotor position.

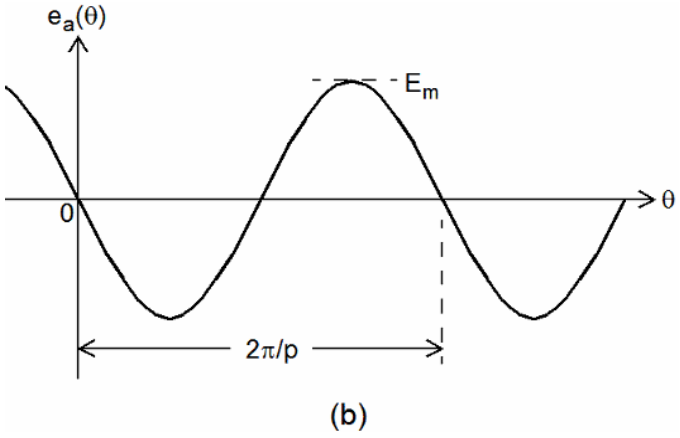


Figure 3. (b). E.M.F. curve of permanent magnet stepper motor

Note that at the reference position ($\theta = 0$), the North Pole on the rotor is fully aligned with A-axis pole so that the A-phase back EMF is then zero.

2. 2. PV module

Now, here is the relation between incident insolation, energy generated and inclination of solar panel (or indirectly one can say angle of incident insolation).

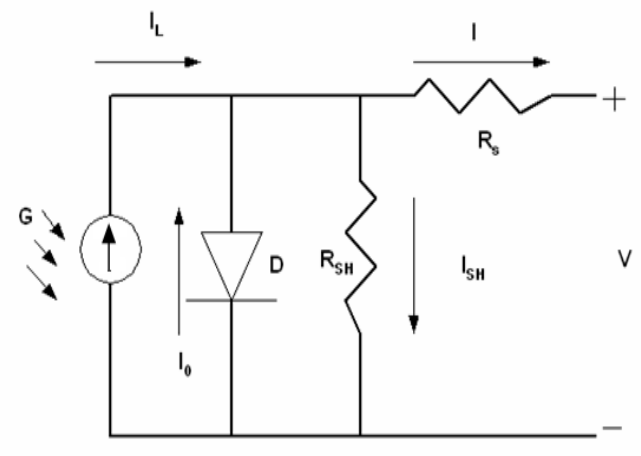


Figure 4. Circuit diagram of PV module

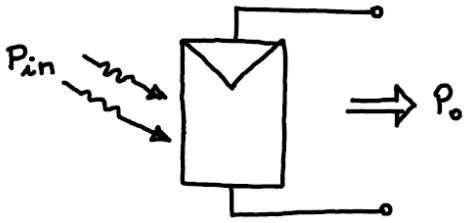


Figure 5. Incident Energy

The relation is written as follows:

$$\eta = \frac{P_o}{P_{in}} = \frac{V_m I_m}{LA} = \frac{V_m I_m}{(L_i cos\Theta)A}$$

From this it can be seen that Efficiency is inversely proportional to "$cos\Theta$".

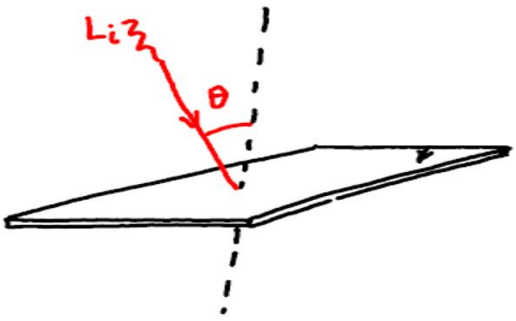


Figure 6. Incident insolation at an angle at solar panel due to its tilt

3. FUZZY LOGIC MODELLING

The below shown flow chart shows the whole process of this system.

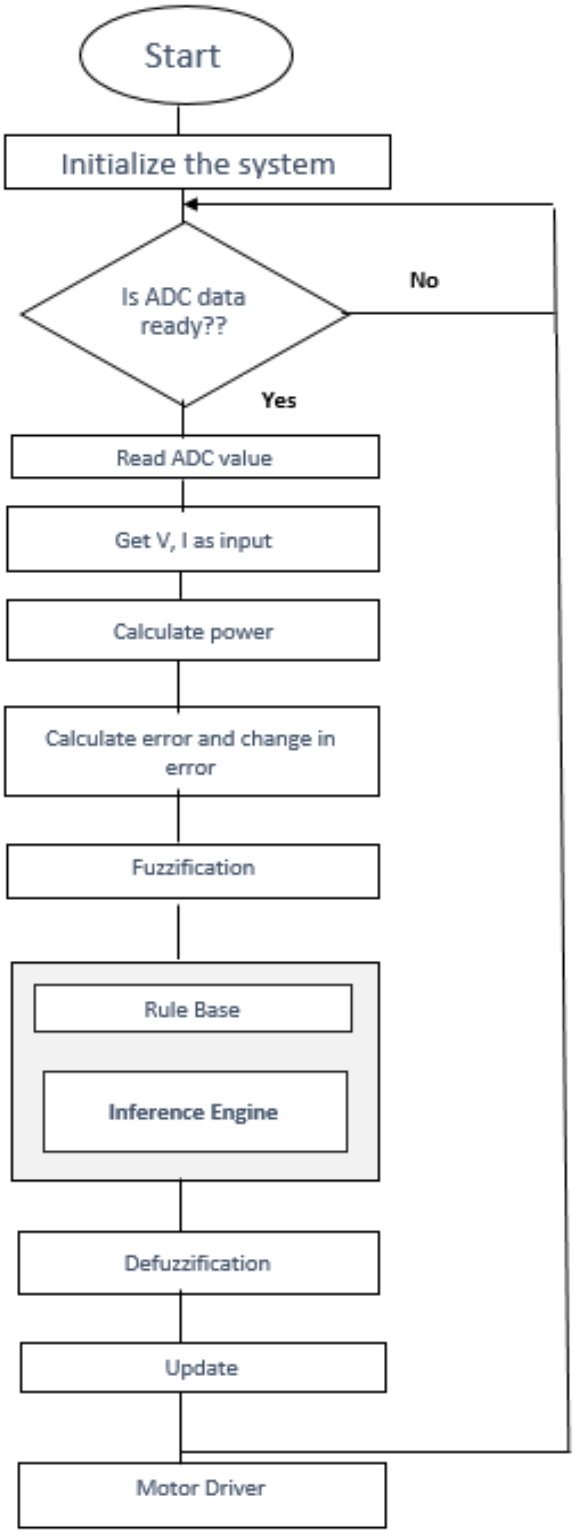


Figure 7. Process flow chart

We define fuzzy variables voltage, current as input and motor (start/stop) as output. Fuzzification is the process that converts crisp values into grade of membership of fuzzy set members. Membership function provides a measure of the degree of similarity of elements in the universe of discourse of fuzzy set. Fuzzy inference combines the fact obtained from the Fuzzification with the rule base and conduct the fuzzy reasoning process. Output obtained from the Defuzzification block which converts the fuzzy set back into the crisp values.

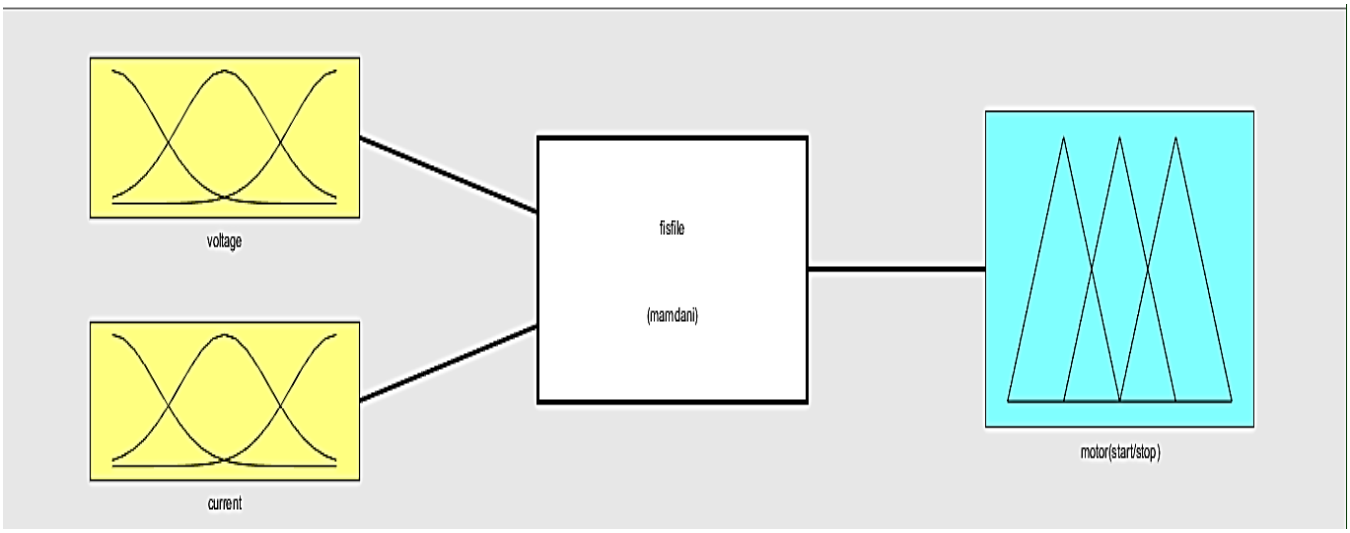


Figure 8. System Model

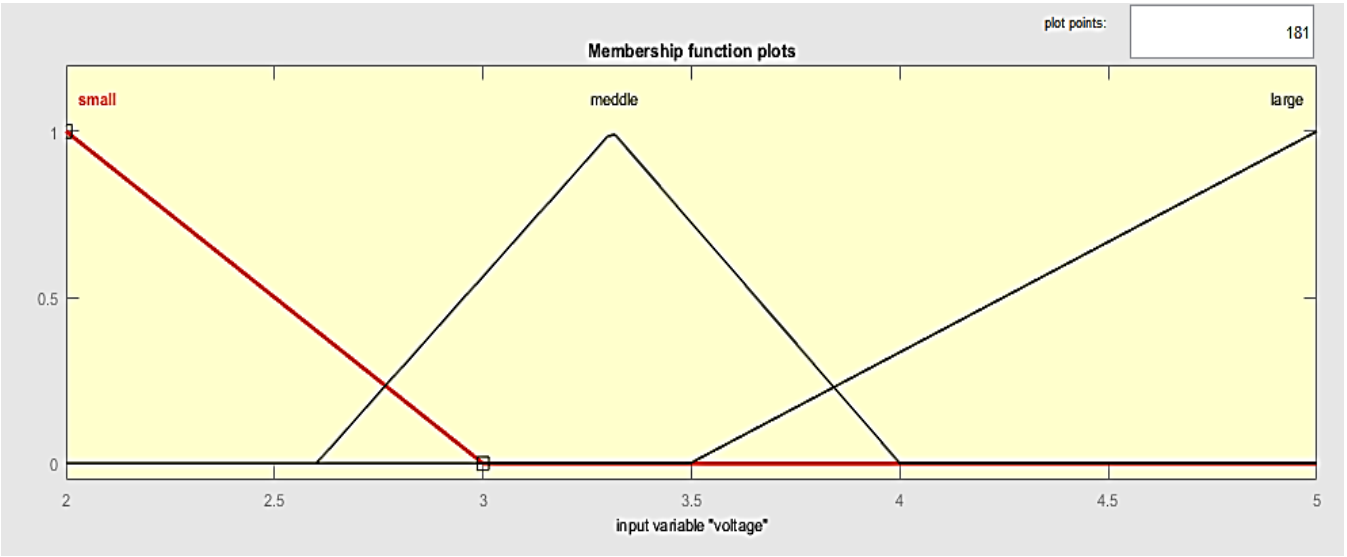


Figure 9. Input variable “Voltage”

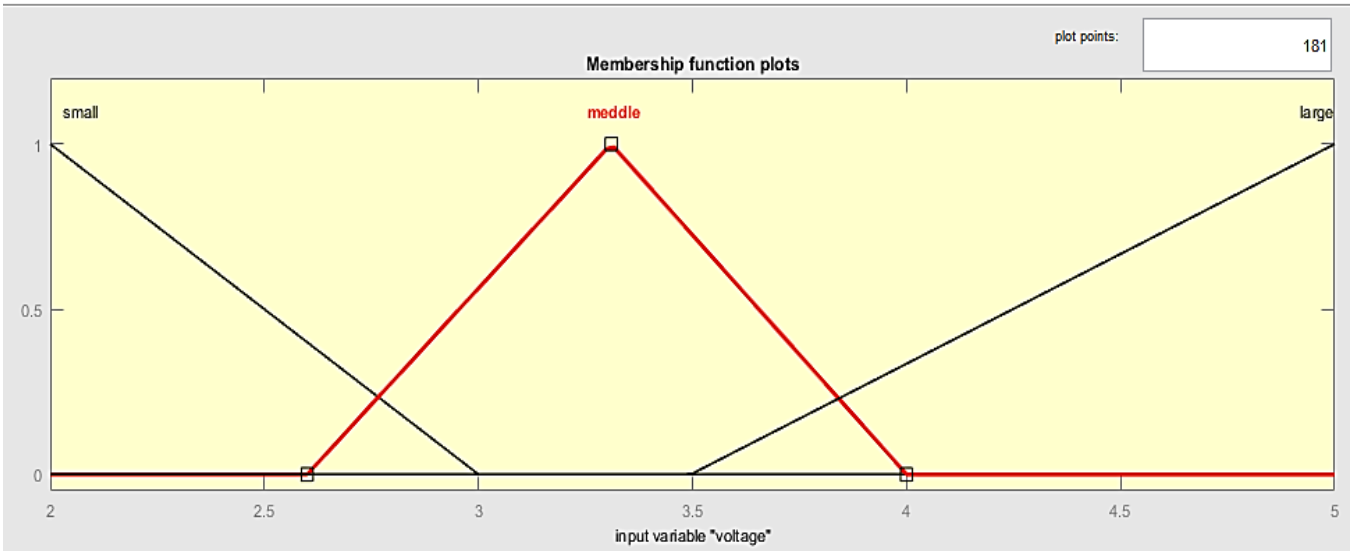


Figure 10. Input variable “current”

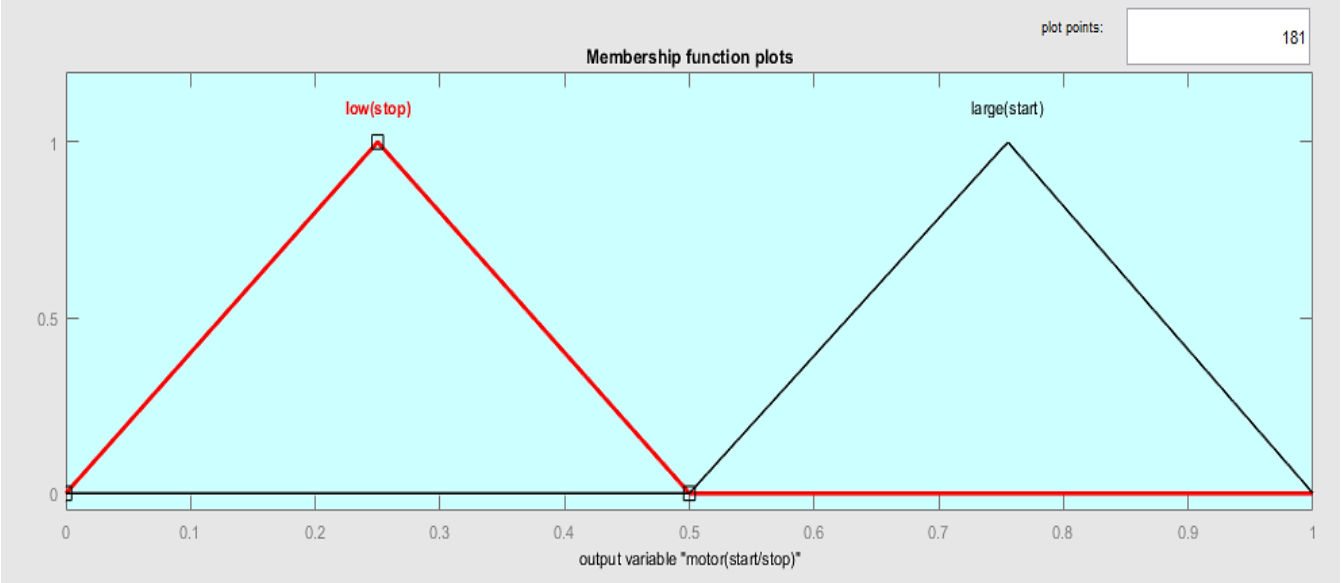


Figure 11. Output variable “Motor (Start/Stop)”

3. 1. Rule-Base

- 1. If (voltage is small) and (current is small) then (motor(start/stop) is high(start)) (1)
- 2. If (voltage is small) and (current is middle) then (motor(start/stop) is high(start)) (1)
- 3. If (voltage is small) and (current is large) then (motor(start/stop) is low(start)) (1)
- 4. If (voltage is middle) and (current is small) then (motor(start/stop) is low(start)) (1)
- 5. If (voltage is middle) and (current is middle) then (motor(start/stop) is large(start)) (1)
- 6. If (voltage is middle) and (current is large) then (motor(start/stop) is low(start)) (1)
- 7. If (voltage is large) and (current is small) then (motor(start/stop) is low(stop)) (1)

- 8. If (voltage is large) and (current is middle) then (motor(start/stop) is low(stop)) (1)
- 9. If (voltage is large) and (current is large) then (motor(start/stop) is low(stop)) (1)

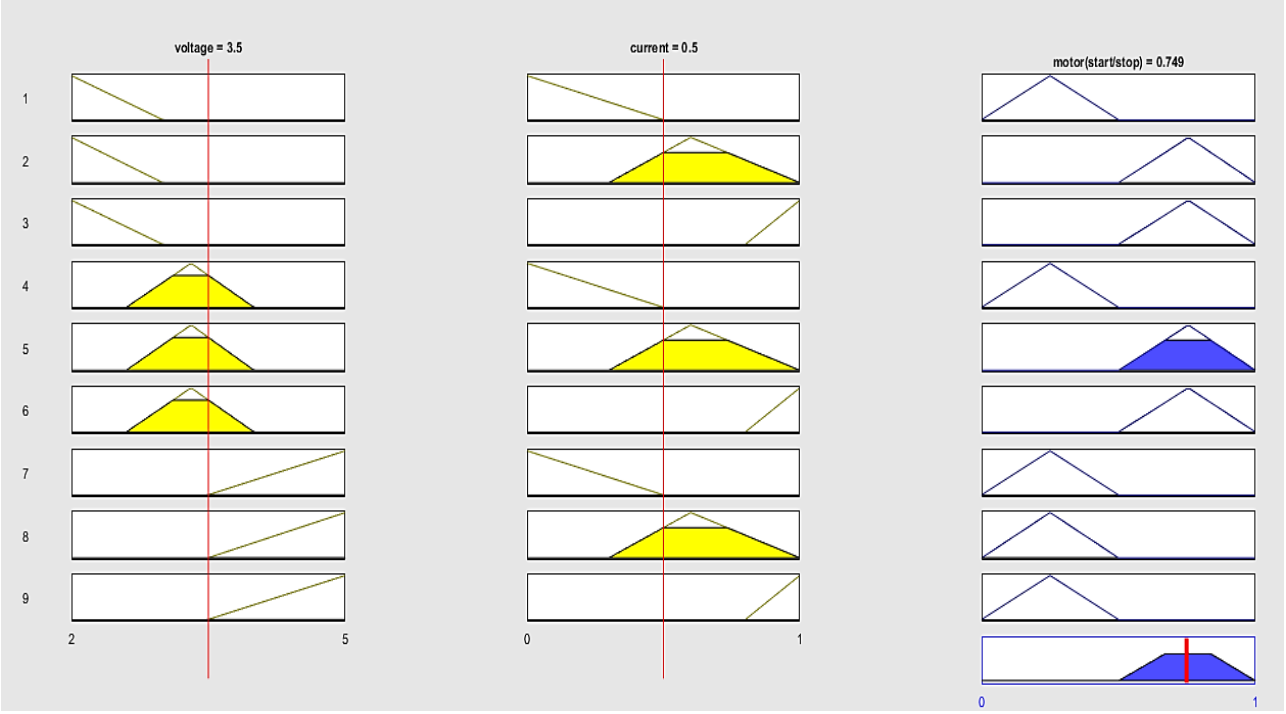


Figure 11. Rules

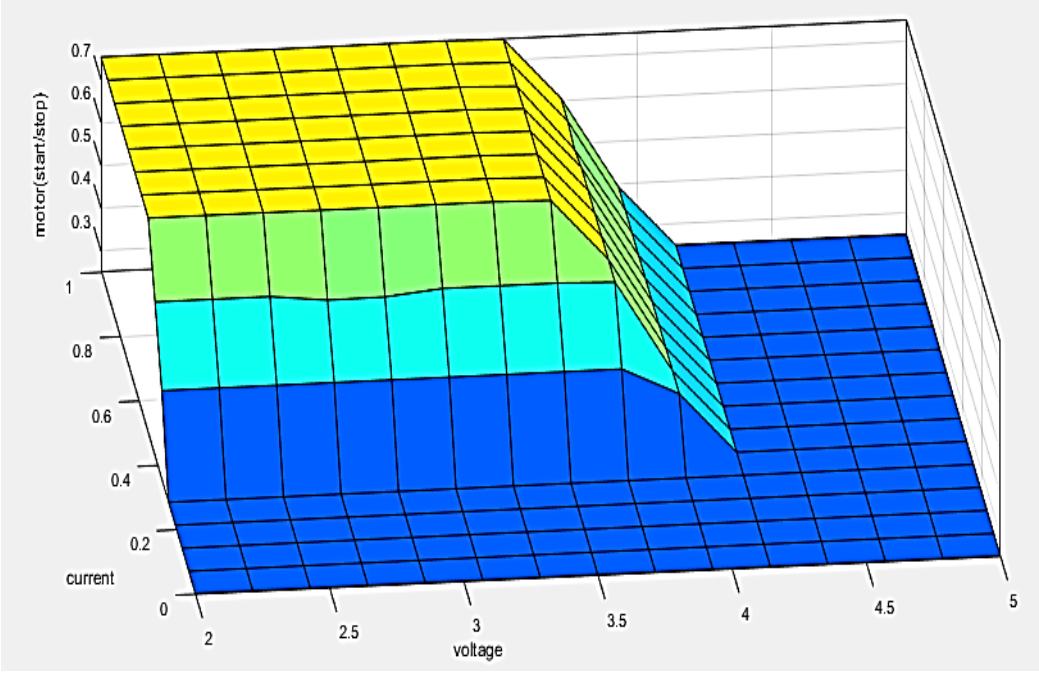


Figure 13. Surface view of the rules

4. CONCLUSIONS

Through the above research we find that fuzzy control gives faster response and good conversion of solar energy into electricity and increases the efficiency of overall system. By this method increase demand of electricity can be fulfilled. Degradation of non-renewable source of energy can be minimized.

Sufficient amount of power can be obtained in those rural or hilly area where there is no transmission line for electricity

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