DESIGN AND PERFORMANCE OF SOLAR TRACKING SYSTEM USING FUZZY LOGIC CONTROLLER

Ms.S.Shivanija, PG Scholar, Department of EEE, Sona College of Technology, Salem
Dr.K.S.Yamuna, Assistant Professor, Department of EEE, Sona College of Technology, Salem
Mr.D.Kesavan, Assistant Professor, Department of EEE, Sona College of Technology, Salem

---***---

ABSTRACT: This work presents the design and construction of PV tracking system to improve the efficiency of solar output power. Here, single axis solar tracking technique is implemented to track the azimuth angle which enables the movement of solar panel in according to the sun's illumination. FLC topology is utilised to control the position of a panel. Simulation have been made through Matlab/Simulink. The obtained results reveals that the proposed solar tracking improves the efficiency of PV array output power comparatively than a fixed position.

Keywords: Solar tracking system, Fuzzy controller, Azimuth angle.

1.INTRODUCTION

The depletion of fuel such as coal etc, which are utilized for power production has made the world to move towards solar energy for electric power production. As solar energy is abundantly available, it is easier and exhibits lower cost of production than other RES. Hence, it becomes widespread. However, its efficiency is only about 20% when it is converted into electrical energy. Similarly, partial shading of PV module also reduces the amount of power obtained from the system[1]. Thus to overcome this problem, tracking systems have been implemented. Many researches have been carried out to obtain sun says perpendicular to panel using variety of controllers [2]. Figueiredo et al 2008 formulated SCADA based system to track optimal power from the solar. As a result, generation of power increases when compared to other non-tracking system. For a real time tracking, PLC and stepper motor are utilized.

Similarly in 1990, microprocessor based tracking controller was designed in India, It exhibits both controlling and monitoring applications [4]. Nopporn et al 2005 has introduced a controller for tracking system with respect to environmental conditions. Ghassami et al 2013 introduced a FLC based controller to find peak power under varying environmental condition. Bawa and patil 2013 introduces an Arduino based tracking system using PLC. But it exhibits only 33.416% increased efficiency when compared to non- tracking system.

From the above survey, it is observed that the tracking system designed so for matches the tracking with irradiation value and temperature of the environment [6,14]. So only the basis of changes in irradiation value, the tracking system functions. Thus, the sensors should be maintained in a proper condition. If it fails down, then exact tracking application cannot be obtained. Hence, in order to overcome this drawback, the proposed work formulated the tracking system using azimuthal angle of the sun's position based on time. It also utilizes FLC to control the position of tracking unit [9-14].

2. MATERIALS AND METHODS

2.1. SYSTEM BLOCK DIAGRAM

The block diagram of the proposed system is represented in Figure 1.

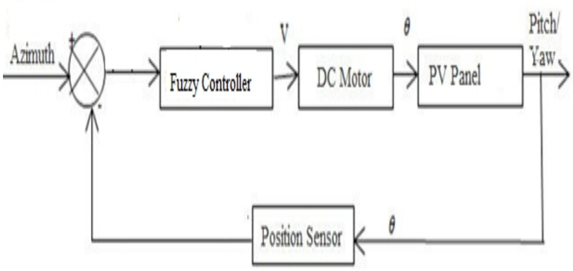


Figure 1. Block diagram representation of the proposed topology

In this proposed topology, the time, longitude / latitude details of the specific location is obtained using NOAA solar position calculator. This generated database comprises exact position of sun in terms of altitude / azimuth angles. For the azimuth motion control, the panel should be rotated either in clockwise or in anticlockwise direction. Finally, at the end of the day, the PV module returned to its zero position [15,16].

Thus, the equations utilised for calculating azimuth, γ and altitude, α is explained as follows

$$\gamma = cos-1((\sin\delta.\cos\emptyset - \cos\delta\sin\emptyset)/\cos\alpha) \quad (1)$$

$$\alpha = \sin-1(\sin\delta.\sin\varphi + \cos\delta.\cos\varphi.\cos\partial) \quad (2)$$

$$C = 360/365.(d-81) \quad (3)$$

$$LSTM = 15^{\circ}.\Delta T_{GMT} \quad (4)$$

$$\delta = 23.45^{\circ}.\sin C \quad (5)$$

Where
α - Altitude angle,
γ - Azimuth angle,
δ - Declination angle,
d – No. of days the numbers of days in year,
λ - Longitude,
GMT - Greenwich Mean Time -
LSTM - Local Standard Time Meridian.

Thus, to minimize the movement of motor and to obtain maximum energy gain (ie., azimuth motion), a FLC was utilized. This azimuth angular set point is obtained from the generated database. Based on the difference between the set point of azimuth angle and the current angular position, FLC controls the tracking motor. For this, DC motor is utilised in this work.

2.2 DESIGN OF DC MOTOR

The model of DC motor utilised in this work is portrayed in figure 5 and its transfer function is represented in equation 6

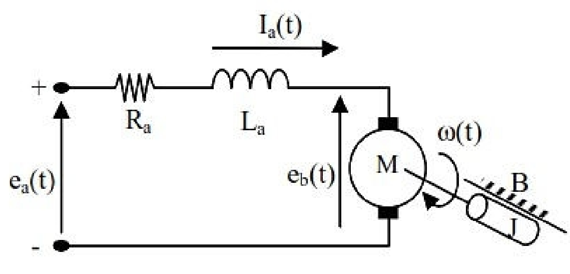


Figure 2. Motor DC Circuit

$$\frac{\omega(s)}{V(s)} = \frac{Kt}{[La.Jm.s^2 + (Ra.Jm.La.BM)s + (Ra.Bm.+Kb.Kt)]} \quad (6)$$

3. RESULT AND DISCUSSION

Hence, to verify the proposed control strategy, an extensive simulation is carried out using MATLAB/Simulink. In this simulation, azimuth control over PV panel is carried out. Hence, to find out the efficiency of the proposed system, different set points (60 and 90) are fixed as a reference for proposed controller. In this type, the set point acts as reference position for the controller.

Thus the proposed FLC is written off as follows

- Five fuzzy sets (NB, NS, ZE, PS, PB) for each input and output variables.
- Triangular membership function is utilised.
- Mamdani-type min-operator implemented for Implication.
- centroid method is adopted for Defuzzification.

Figure 3 displays the MF of FLC.

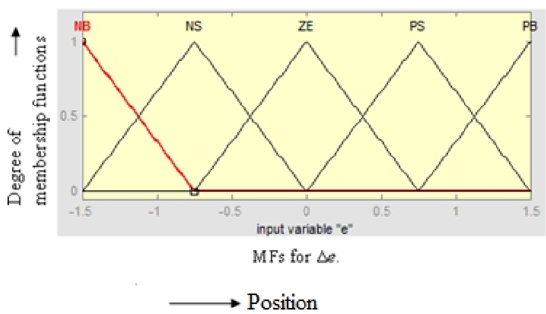


Figure 3a Membership functions for *e*

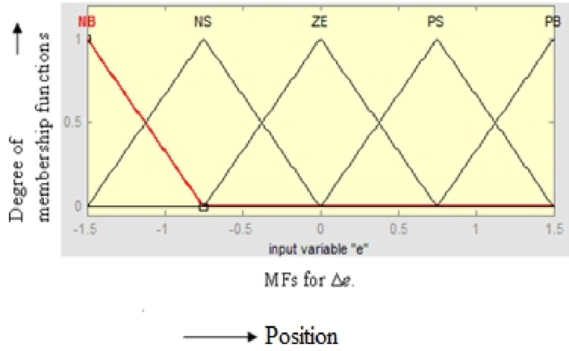


Figure 3b Membership functions for Δ*e*

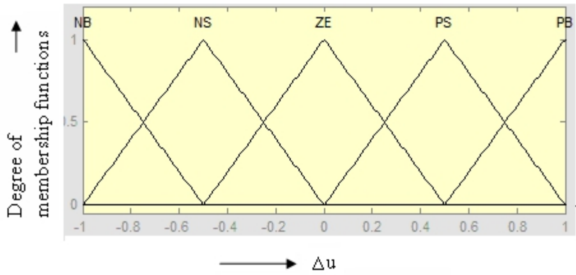


Figure 3c Membership functions for Δu

Thus the position control of dc motor using FLC for the azimuth angle about 60° is depicted in figure 4.

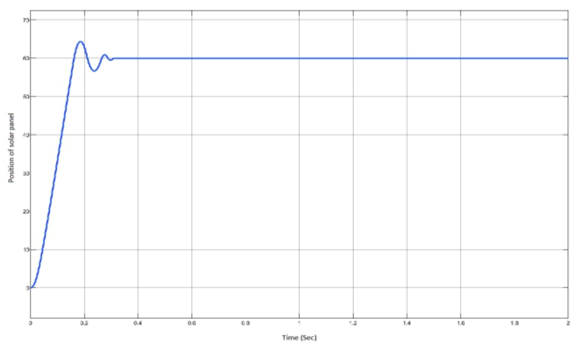


Figure 4. Position of the DC motor

Finally, the performance of the proposed controller is evaluated using the performance Indexes namely Rise time (Tr), Settling time (Ts), Maximum overshoot and Ess.

TABLE 2. Performance Indexes @ 60°

Performance Indices	Proposed FLC	PI
Tr	0.81	0.96
Ts	0.36	0.65
Maximum overshoot	11.4	14.63
Ess	0.06	0.09

From the figure 4 and table 2, it is concluded that solar tracking with fuzzy controller exhibits faster response than PI controller.

Table 3. Comparison Analysis

Model	Power Output from PV
Fixed position	60 watts
Tracking control using fuzzy logic	70 Watts

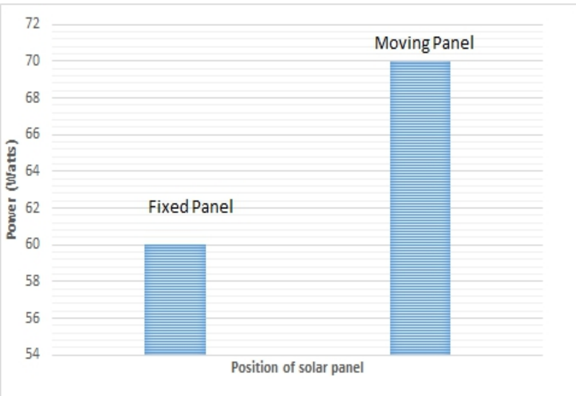
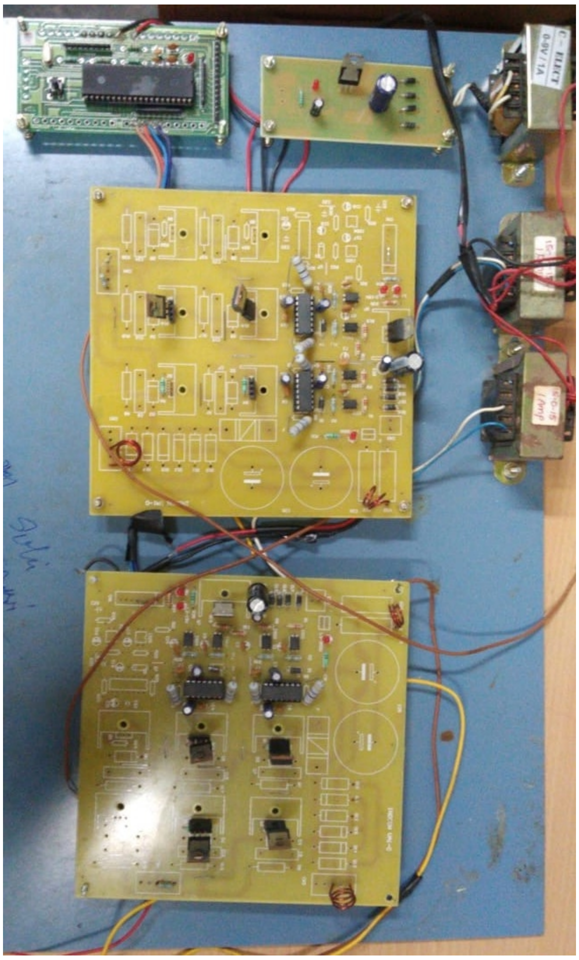


Figure 5. Power Output (under Moving and Fixed Panel)

The above table depicts the power output obtained from PV panels while implementing proposed solar tracking system using FLC and panel at fixed position. From the results, it is observed that the proposed FLC based tracking system exhibits higher output power than the fixed system. Based on the figure, the energy enhancement of moving panel is about 10 KW higher than that of fixed system.

4.HARDWARE KIT



5. CONCLUSION

In this work, a smart solar tracking system is designed to improve performance of PV panel. The modelling of solar tracker based on fuzzy controller has been performed and also simulated to obtain the control performance indexes and the energy efficiency. From the results, it is evident that the proposed controller exhibits higher energy efficiency than fixed model topology.

References

1. Green, M. A., Emery, K., King, D. L., & Igari, S. (2000). Solar cell efficiency tables. *Progress in Photovoltaics: Research and Applications, 8*, 187–196.
2. Irina, T., & Cătălin, A. (2010). A study on the tracking mechanisms of the

photovoltaic modules. *Fascicle of Management and Technological Engineering, IX*, 59–66.

3. Figueiredo, J. M. G., & Costa, J. M. G. S., (2008). Intelligent sun-tracking system for efficiency maximization of photovoltaic energy production. In *ICREPQ'08—international conference on renewable energies and power quality symposium, Santander*.
4. Saxena, A. K., & Dutta, V. (1990). A versatile microprocessor based controller for solar tracking. In *21 IEEE photovoltaic specialists conference, Kissimmee*.
5. Nopporn, P., Premrudeepreechacharn, S., & Sriuthaisiriwong, Y. (2005). Maximum power point tracking using adaptive fuzzy logic control for grid-connected photovoltaic system. *Renewable Energy*, *30*(11), 1771–1788.
6. Li, D. H. W., Cheung, G. H. W., & Lam, J. C. (2005). Analysis of the operational per- formance and efficiency characteristic for photovoltaic system in Hong Kong. *Energy Conversion and Management, 46*, 1107–1118.
7. Ghassami, A. A., Sadeghzadeh, S. M., & Soleimani, A. (2013). A high performance maximum power point tracker for PV. *Journal of Electrical Engineer- ing, Electrical Power and Energy Systems, 53*, 237–243.
8. Bawa, D., & Patil, C. Y. (2013). Fuzzy control based solar tracker using Arduino Uno. *International Journal of Engineering and Innovative Technology, 2*(12), 179–187.
9. Peri, V. M., & Simon, D. (2005). Fuzzy logic control for an autonomous robot. In *Fuzzy Information Processing Society, 2005. NAFIPS 2005. Annual Meeting of the North American*, IEEE, 26-28 June 2005.
10. Takagi, T., & Sugeno, M. (1985). Fuzzy identification of systems and its applications to modelling and control. *IEEE Transactions on Systems, Man and Cybernetics, 15*(1), 116–332.
11. Punithaa, K., Devaraj, D., & Sakthivel, S. (2013). Development and analysis of adaptive fuzzy controllers for photovoltaic system under varying atmospheric and partial shading condition. *Applied Soft Computing, 13*, 4320–4332.
12. Hamed, B., & Mohammed, S. E., (2012). Fuzzy controller design using FPGA for photovoltaic maximum power point tracking. *International Journal of Advanced Research in Artificial Intelligence*, *1*(3), 14–21.
13. Abdallah, S., & Nijmeh, S. (2004). Two axes sun tracking system with PLC control. *Energy Conversion and Management, 45*, 1931–1939.
14. Arghira, N, & Iliescu, S. S. (2013). Design and implementation of a solar-tracking algorithm. In *Proceedings of the 24th DAAAM international symposium on intelligent manufacturing and automation*.
15. Visek, E., Mazzrella, L., & Motta, M. (2014). Performance analysis of a solar cooling system using self-tuning fuzz-PID control with TRNSYS. In *2013 ISES solar world congress energy procedia* (Vol. 57, pp. 2609–2618).
16. Al-Mohamad, A. (2004). Efficiency improvements of photovoltaic panels using a sun-tracking system. *Applied Energy, 79*, 345–354.