Using MATLAB Simulink, design and simulation of a fuzzy logic controller-based MPPT for a PV module

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***Abstract*—This work describes the use of Matlab-Simulink and a fuzzy logic controller to enhance the maximum power point tracking (MPPT) of a PV system. The KD230GX-LFB PV Module makes up the system. For the PV system to run at its maximum PowerPoint, the DC-DC boost converter circuit controller raises the voltage. This makes the PV system more effective. The fuzzy system is also less difficult to combine with the Matlab software. Under varying sun irradiance and temperature modules, the performance of the suggested technique has been simulated in Matlab-Simulink.**

***Keywords*—Boostconverter,MPPT,FuzzyLogic**

I. INTRODUCTION

Solar energy is now the most popular renewable energy source. Solar power is a clean, limitless source of energy. There are two different ways of solar energy consumption. Electricity was mostly produced by solar energy. However, it was employed to generate heat (Drying technology and hot water production technology). PV cells are the name for the solar energy technology used to produce electricity [1-3]. Solar cell technology hasn't, however, been fully employed. The majority of the issues are climate-related. The primary source of energy for the solar cells will be sunshine. The capacity to generate energy is diminished by the varying light intensity throughout the day. Solar cells hence require maximal power tracking [4-5]. Today, a variety of peak power tracking methods, such as voltage configuration and current configuration, are accessible, each with a different set of outcomes. The system can nevertheless trace the peak power using these approaches, but to a lesser extent [6–9]. A computational discipline known as fuzzy logic has seen a rise in popularity in computer science and has been used in a wide range of applications, including several studies involving tracking [10–13]. It will be more effective to monitor the solar cells' maximum power. This is so that the system can automatically adapt to the environment as it changes thanks to the fuzzy algorithm. Additionally, it makes more shrewd choices. In order to better understand the design and modelling of PV cells, our research focused on the KD230GX-LFB. The effectiveness of the solar system's power tracking was enhanced using Matlab Simulink.

II. FUNDAMENTALTHEORIESRELATEDTORESEARCH

A.PVSystem

Based on a P-N junction, which resembles a diode structurally, solar cell’s function. A solar cell thus faces the same current and voltage effects as a diode even if it is not activated by light. A hole forms in the valence band and free electrons arise in the conduction band when light strikes the connection. Electrons will flow to the right, against the electric field, as a result of the potential wall's effect on the electric field. The hole moves in the same direction as the electric field, to the left. If a suitable power source or load is supplied, this may cause an external current to flow [14]. The production of power in a solar cell is seen in Figure 1.

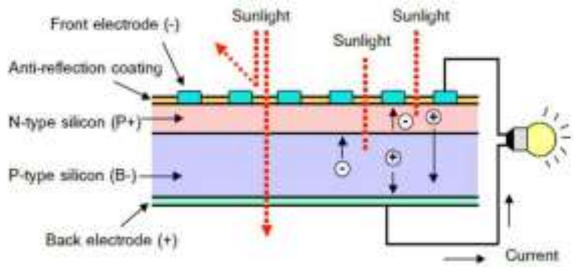


Fig1.Thegenerationofelectricityinsolarcells[14]

The operational point that the electric load imposes determines the PV power output. Therefore, a sophisticated control approach is required to enhance efficiency and produce the most power from the PV cell. Therefore, the Maximum Power Point Tracking (MPPT) was employed to increase the PV cells' efficiency. Additionally, the MPPT technique is used to operate the PV system, which results in a high-power output [15]. I-V, P-V, and MPP curve characteristics are displayed in Figure 2.

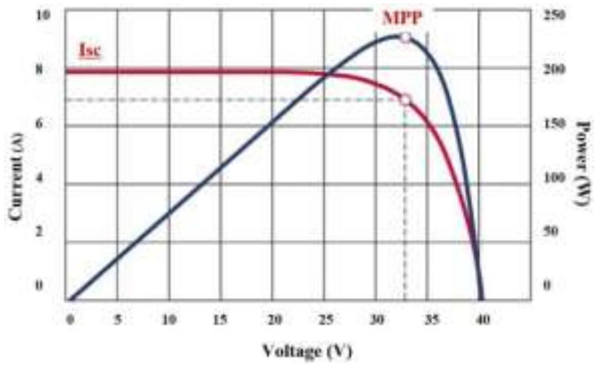


Fig2.I-VandP-VCharacteristiccurvesofPVcells 250W[15].

B.BootsConverter

The Step-up converter circuit, also known as Boost converter, is a circuit to increase the voltage to suit the application[16].ThestructureofthecircuitisshowninFigure 3; the boots converter has few components, which makes its structure reliable and straightforward [17].

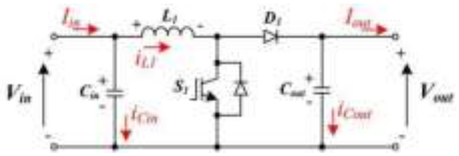


Fig3.BoostConverterEquivalentCircuit[16]

The input voltage source (V_{in}) of the boost converter is connected to an inductor(L_1), and a capacitor (C_{in}) is connected inparallel. The solid-state device, which operates as a switch(S_1), is connected across the source (S_1in boost converter circuit uses a MOSFET or IGBT). The second switch used is a diode(D_1). The diode is connected to a capacitor(C_{out}),andtheloadisconnectedinparallel,asshown in Figure 4 [18].

Theoperationoftheboostconverter(BoostConverter)in each mode (Mode) working according to the switch's on-off switch is as follows.

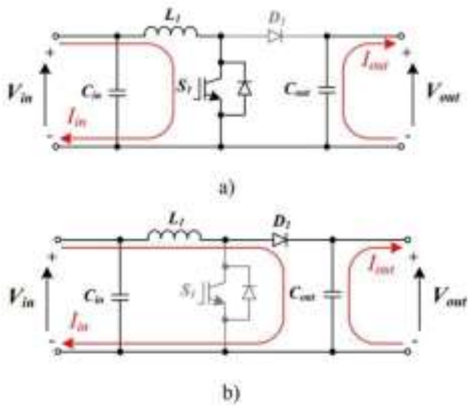


Fig4.Boostconvertersa)whenS_1isonandb)whenS_1isoff

Figure4-ashowsthatwhentheboostconverterison-state (switch $S_1$is on), the current in the boost inductor increases linearly,andthediodeD_1isoffatthattime.Figure4-bshows thatwhentheboostconverterisoff-state(S_1isturnedoff),the energystoredintheinductorisreleasedthroughthediodeto the output RC circuit [19].

Determinationofthemostnegligibleinductance(L_{min})of a boost converter circuit is shown in equation 1.

$$L_b = \frac{(1-D)^2 DR}{2f} \quad (1)$$

The minimum value of the filter capacitance (C_{min}) that results in the voltage ripple $V_r$is given by

$$C_{min} = \frac{DV_O}{V_r Rf} \quad (2)$$

C.FuzzyLogic

Fuzzy logic (FL) is a methodology designed to allow computerstoareasonsimilartohumanreasoning.Formaking decisions that are not just YES and NO. Computers usually returnTRUE and FALSE answers, and humans tend to have clearanswersYESandNO.However,humanresponsesmay not be YES and NO, but maybe expressed as Level values, such as low, medium, or very high, are called "Linguistic values." If we look back at computers in general, besides returning TRUE and FALSE, we can also return numeric values,suchastrueintegers,etc.Therefore,wecancontinue toapplythisknowledge[20-22]. AnArchitectureofa Fuzzy Logic System is shown in Figure 5.

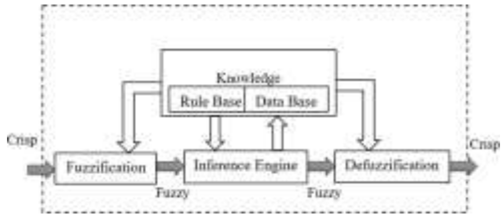


Fig5.AnArchitectureofFuzzyLogicSystem[20]

III. DESIGNANDSIMULATION

The fuzzy Logics controller is designed to track the maximumpowerpointofthePVcellsunderchangingweather conditions. Fast-changing solar radiationistaken into account while designing a fuzzy rules base. In this work, only the simulation part was presented by simulation through the Matlab program.

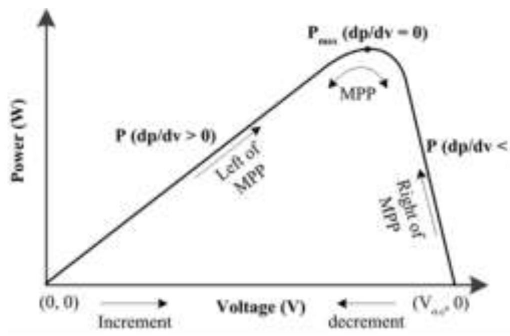


Fig6.TheconceptprincipleofMPPTfuzzylogic controller[23]

Five fuzzy logic levels are used for all input and output variables: NB is Negative big, NS is Negative small, ZE is Zero,PSisPositivebigand,PBisPositivesmall.Arulebase used in the fuzzy logic controller is shown in Table 1.

Figure 7 shows a functional diagram of a fuzzy logic controlleralgorithmtotrackthemaximumpowerofanMPPT solar cell.

ISSN: 2278-4632
Vol-10 Issue-11 No.03 November 2020

TABLEI. RULEBASEUSEDINTHEFUZZYLOGICCONTROLLER

ΔV \ ΔP	NB	NS	ZE	PS	PB
NB	PB	PS	NB	NS	NS
NS	PS	PS	NB	NS	NS
ZE	NS	NS	NS	PB	PB
PS	NS	PB	PS	NB	PB
PB	NB	NB	PB	PS	PB

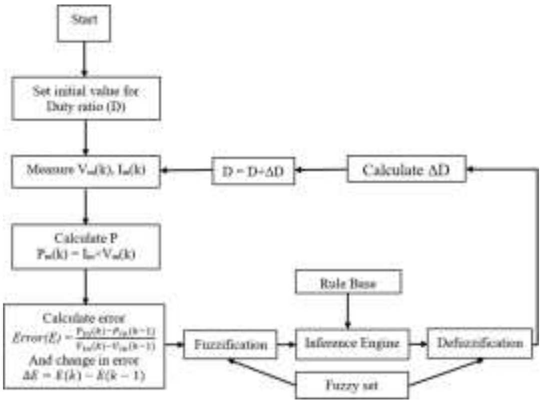


Fig7.Flowchartoffuzzylogiccontrolleralgorithm MPPT[24]

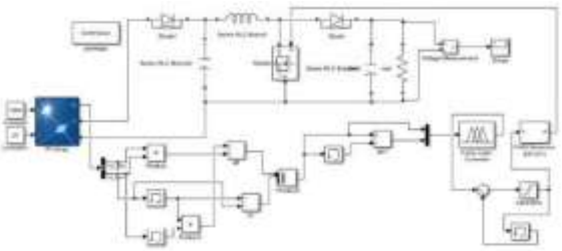


Fig.8ProposedfuzzylogiccontrolbasedMPPTin MATLAB/Simulink

The inputs of the Fuzzy logic controller system are the outputvoltageofthe PVcells(ΔV) andoutputpowerofthe PV cells ΔP that change each time,which be related to the modulation signal used to the Pulse Width Modulation modulator to produce the pulses switching in DC-DC boost converter.The Proposed fuzzylogic control-based MPPT in MATLAB/SimulinkisshowninFigure8,andFigure9shows the surface viewer of the Fuzzy rule.

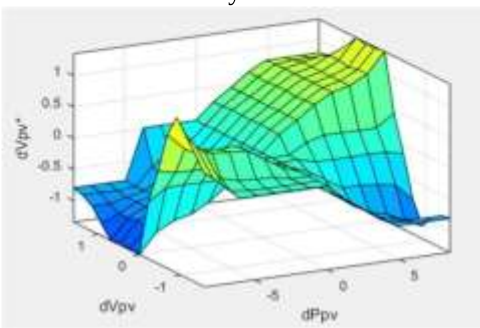
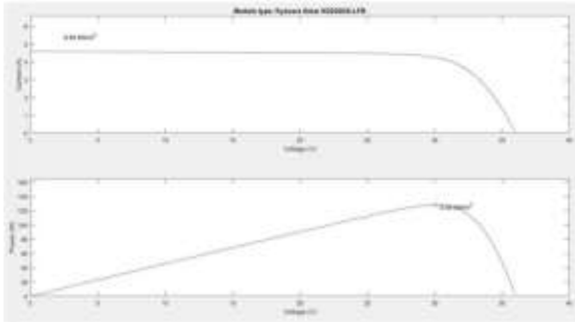


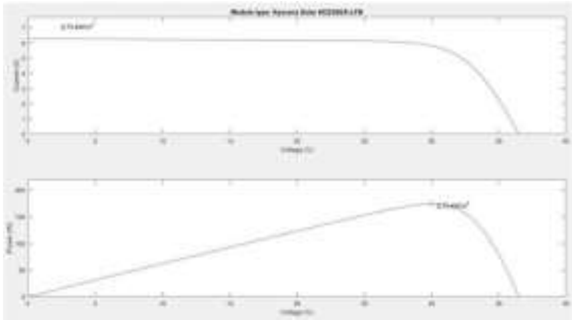
Fig9.ThesurfacevieweroftheMPPTFuzzyrule.

IV. RESULTSANDDISCUSSION

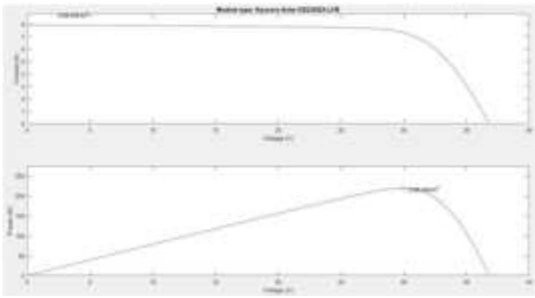
This research improves a PVsystem's maximum power pointtracking(MPPT)withafuzzylogiccontrollerusing Matlab-Simulink. The maximum power tracking MPPT systemworkby,thePVoutputpowerismonitored,compared tothevoltage,andthencorrectedforwhichpoweristhebest that the PV module can produce to charge the voltage and convert it to a voltage, that is best to get the maximum PV current. TheexperimentalresultssimulatethePVcells'output power, current, and voltage output.



a.)550W/m^2



b.)750W/m^2



c.)950W/m^2

Fig.10I-VandP-VcurveofPVatadifferentsolar irradiance

Energygainedbytheproposedtechniqueisgivingbetter efficiency than the conventional technique. Figure 10 a-e showstheperformanceofthePVsystemusingaFuzzylogic controller under changing solar irradiance. The irradiance values are a.) 550, b.)750, and c.) 950 W/m^2, respectively.

TABLEII.MAXIMUM EFFICIENCY OFTHE POWER TRACKING CIRCUITWITH A FUZZY LOGIC CONTROLLER.

No.	Irradiance (W/m^2)	Temperature (°C)	Power Output (W)	Efficiency (Ƞ)
1	1000	30	196.09	85.26
2	1000	50	176.08	76.56

Table2 shows the efficiencyofPV module MPPT fuzzy logic controller simulation using Matlab Simulink. Performance was measured with temperature settings intwo cases: 30 degrees and 50 degrees, and irradiation at 1000 W/m^2.Thesimulationresultshowsthatthecircuitefficiency is85.26%at30degrees,andthecircuitefficiencyis76.56% at 50 degrees, respectively.

V. CONCLUSION

Theinstabilityofsolarradiationatdifferenttimesresults ininsufficientpowerfromthephotovoltaicpowergeneration system. Therefore, PV systems require a maximum power point tracking (MPPT) system. In this article, the Maximum Power Point Tracking (MPPT) controller is a fuzzy logic control to identify MPPs. The fuzzy logic controls are presentedandusedinaMatlab-Simulinkenvironment.Then the boost converter circuit increases the voltage of the PV system for the PV to produce maximum power.

ACKNOWLEDGMENT

The authors thank the Bangkokthonburi University, Suranaree University of Technology, and the Rajamangala University of Technology Rattanakosin, Thailand, for providing the laboratory and financial support.

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