MODELLING AND SIMULATION OF HYBRID PHOTOVOLTAIC AND WIND ENERGY SYSTEMS USING FUZZY LOGIC CONTROLLER

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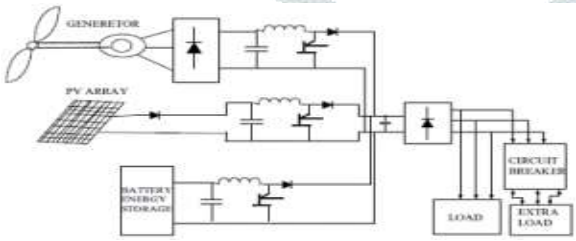
Abstract: As power requests round the field increment, the requirement for a sustainable power source resources as an approach to not harm the earth is lifted. The regular objective of sustainable power source frameworks is to pick up vitality with forceful esteem or even pick up as for other power assets. The surest plan of sustainable power source device can broadly improve the financially savvy and specialized execution of vitality convey. This paper presents the power organization control using Fuzzy Logic control strategy. In like manner, an aggregate logical showing and MATLAB/Simulink exhibit for the proposed the electrical bit of an aquaculture device is realized to tune the contraption execution. The reproduction impacts demonstrate the possibility of control technique.

Watchwords: Battery banks, fuzzy logic control (FLC), hybrid system, PV cluster, wind turbine.

1. INTRODUCTION

Elective vitality resources, for example, sun and wind energies, has pulled in numerous analysts and networks all through the world on the grounds that the "vitality catastrophe" of the 1973 [1]. Furthermore, the developing of intensity call for, high power charges, and also the developing circumstance on finished ecological elements, wellness and climate interchange ramifications of intensity related with sports affecting the expanding worries on elective power thinks about in bunches [2-6]. The high costs of quality is presumably due to incorporate the power structures which work for the most part on petroleum products and require enormous speculations for set up transmission and dispersion frameworks that may infiltrate remote locales [6]. Besides, the petroleum product ignition results inside the discharge of offensive gases which developing stresses in environmental change and different wellness dangers [7]. Traditional oversee calculations require a numerical rendition for the dynamic gadget to be controlled. The numerical form at that point used to build a controller. In numerous functional circumstances, be that as it may, it isn't generally constantly conceivable to accomplish a right numerical model of the controlled gadget. Counterfeit astute (AI) oversee offers a path managing displaying issues by actualizing etymological, non-formal communicated control laws got from master data [8]. This paper exhibits a scientific displaying of PV-wind half breed machine. Besides, a control machine the utilization of FLC controller is developed for achieving the coordination between the segments of a PV-Wind crossover framework and in addition control the power streams among PV, wind and battery. This view is accomplished for an aquaculture device in remote region in MersaMatruh, Egypt.

2. MODELING OF HYBRID SYSTEM COMPONENTS



Proposed Block Diagram

Figure 1: Proposed Block Diagram

The objective of this work is to reenact the activity of PV-wind battery half and half power framework as precise as attainable. To get this aim, one needs a settled of relative indicated models. In this stage, the individual numerical model for each issue is advanced in MATLAB.

Different displaying systems are advanced by specialists to form added substances of half and half inexhaustible power sources (HRES). Execution of man or lady added substances is either displayed by method for deterministic or probabilistic strategies. General approach for displaying HRES parts like PV, wind and battery is portrayed beneath.

2.1. PV MATHEMATICAL MODEL

A PV framework comprises of numerous cells which associated in accumulation and parallel to give the favored yield terminal voltage and present day, and surely understood demonstrates a nonlinear I– V work [9-11]. The PV cell equal variant speaks to the dynamic nonlinear I– V

attributes of the PV gadget is characterized underneath [9-11]. The working condition of present day – voltage qualities of sun oriented cell underneath enlightenment impact is communicated by method for [12-14]

$$I_G = N_P I_{lg} - N_p I_O \left(exp\frac{(V+IR_S)}{V_t} - 1\right) \quad (1)$$

$$V_t = \frac{akT_p}{q} \quad (2)$$

Light generated current is given as:

$$I_{lg} = \frac{G}{G_r}[I_{lr} + m(T_C - T_r)] \quad (3)$$

Where reverse saturation current of PV cell is represented by

$$I_o = I_{or}\left({}^{T_a}/_{T_p}\right)^{3}/_{n}\, exp\left(-b\left[\left({}^{1}/_{T_p}\right) - \left({}^{1}/_{T_r}\right)\right]\right) \quad (4)$$

$$I_{or} = {}^{I_{scr}}\Big/\left[exp\left({}^{V_{ocr}}/_{V_{tr}}\right) - 1\right] \quad (5)$$

Cell temperature can be ascertained by utilizing the accompanying condition

$$T_c = T_{air} + \left[\left(\frac{\tau\alpha}{U_l}\right)\left(1 - \frac{n}{\tau\alpha}\right)\right] G \quad (6)$$

Wherein,

IG Output modern-day of PV exhibit, (A).

V Output voltage of PV exhibit, (V).

Ns Number of collection modules.

Np Number of parallel strings.

Il g Light generated modern, (A).

Io Revese saturation modern-day at running temperature, (A).

Isc Short circuit cutting-edge at 28°c and a thousand W/m 2 (=2.Fifty two A).

A, b Ideality elements (=1.Ninety two).

Tr Reference temperature (=301 K).

Tp Cell temperature (K).

Tc Cell temperature (°C).

k Boltzmann' s steady (=1.38×10 - 23 J/K).

G Cell light/m2.

Gr Reference light (=one thousand W/m2).

Ego Band jabber for silicon (=1.11 ev).

M Short circuit current temperature coefficient (=0.0017 A/°C).

Q Electron price (=1.602×10 -19C).

2.2. WIND TURBINE GENERATOR

There are a few present styles for the estimation of wind turbine control, including the straight form, the model essentially in view of Weibull parameters and the quadratic model [15]. Picking a suitable model could be exceptionally basic for wind turbine quality recreation. There are three critical elements that decide the yield power of a breeze turbine, i.E. The yield vitality bend (chose by utilizing streamlined power proficiency, mechanical transmission and changing over power execution) of an appointed breeze turbine, the breeze pace circulation of a chose site in which the breeze turbine is set up, and the pinnacle crest. The quality bend of the contraption shows the streamlined, transmission and period efficiencies of the machine in an included shape. Figure 2 demonstrates the run of the mill control bend of a far reaching wind turbine. The evaluated quality of the turbine is 3 KW. The given bend is a hypothetical one, and by and by we may likewise examine the speed control variation in a somewhat scattered example.

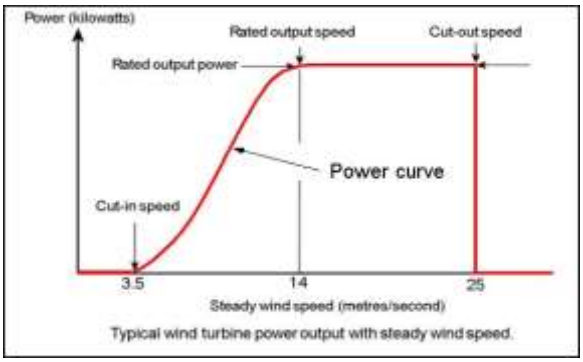


Figure 2: Power curve of wind turbine.

The vitality bend of a breeze turbine is non-direct. The information is accessible from the maker and might be effortlessly digitized and the resulting work area might be utilized to recreate the breeze turbine execution. The outlet quality of a turbine will be ascertained from its capacity speed bend . The yield intensity of each WG unit instead of wind speed may be, constantly, given through maker and more often than not portrays the genuine quality exchanged from WG to DC transport. In this look at, Non specific Breeze turbine is thought about. It has an evaluated limit of three kW and offers 24 V DC on the yield. The capacity condition of wind generator is obtained with the guide of turning into the sensible yield include bend the use of a minimum rectangular minimization procedure. By utilizing bend getting to be to achieve a scientific demonstrating of nonlinear zone in control bend of wind turbine, the bend fitting condition of the yield capacity of wind generator might be communicated as [24]

$$P = \begin{cases} 0 & \text{if } V_s < V_i \\ aV_s^4 + bV_s^3 + cV_s^2 + dV_s + e & if\ V_i < V_s < V_r \\ P & if\ V_r < V_s < V_o \end{cases}$$

$$P_w = A_w \eta P$$

Where,

Vs	Velocity (m/s).
VI	Cut in speed (m/s).
VR	Rated speed (m/s).
VO	Cut out speed (m/s).
P	Output power thickness (W/m2).
Pr	Rated vitality thickness (W/m2).
Pw	Output quality of wind turbine (W).
A, b, c, d, e	Fitting parameters.
Aw	Total swept vicinity (m2).
η	Generator performance.

To specific the exact model that constitute the used of wind turbine electricity curve, the curve becoming using MATLAB toolbox has been used to extract the model. Linear model Poly4is used and the coefficient are (with 95% confidence bounds): a = zero.0005096, b = -zero.02656, c = zero.4564, d= -2.747, e = 5.362, SSE: 0.03718, R-rectangular: zero.998 and RMSE: 0.05566.

2.3. THE BATTERY STORAGE MODEL

The battery display depicts the association between the voltage, current and the nation of charge is said. The proportional electrical circuit of capacity battery is trailed by utilizing Figure 6.Four.The terminal voltage of a battery might be communicated as far as its open circuit voltage and the voltage drop all through the interior obstruction of the battery [25]:

$$V_B = V_r + I_B R_B$$

Where,

VB	Battery terminal voltage (V).
IB	Battery display day (A) (compelling when charging and awful while releasing).
Vr	Rest voltage (V).
RB	Internal obstruction of the battery (ohms).

The unwinding voltage, Vr, is communicated in expressions of cell temperature as

$V_r = 2.04[1 - 0.001(T_c - T_r)]$

The battery resistance during fee and discharge system.

3. THE FUZZY LOGIC CONCEPT

Fluffy sound judgment emerged from a decision to consolidate intelligent thinking and the instinctive basic leadership of an expert administrator into a computerized machine [8]. The objective is to settle on decision in light of some of discovered or predefined rules, instead of numerical computations. Fluffy practical insight contains manage base shape in endeavoring to settle on decisions [8]. Nonetheless, sooner than the rule base can be utilized, the enter data ought to be spoken to in the kind of route as to keep up which implies, even as, in any case remembering control.The fluffy govern portrayal depends on semantic [8]. In this manner, the info is a phonetic variable that compares to the kingdom variable under consideration. In fluffy sound judgment deal with, the day and age "etymological variable" alludes to whatever nation factors the gadget fashioner is curious about [8]. The fluffy variable is conceivably better portrayed as a fluffy semantic qualifier. Once, the semantic and fluffy factors had been correct, the entire deduction gadget can be characterized as building up a FIS and applying it to an oversee bother involves a few stages:

a. Fuzzification.

B. Fuzzy govern assessment (fluffy deduction motor).

C. Defuzzification.

4. ELECTRICAL SYSTEM CONTROL

The objective of PV wind battery half breed contraption controller is to guarantee the administration of the vitality that is conveyed by means of the cross breed framework to meet the heap and to rate the lead corrosive battery over the span of the length of additional produced quality. The power control technique flowchart is received in Figure 3. The square chart of controlling the PV wind battery mixture gadget the utilization of FLC is demonstrated in Figure 4.

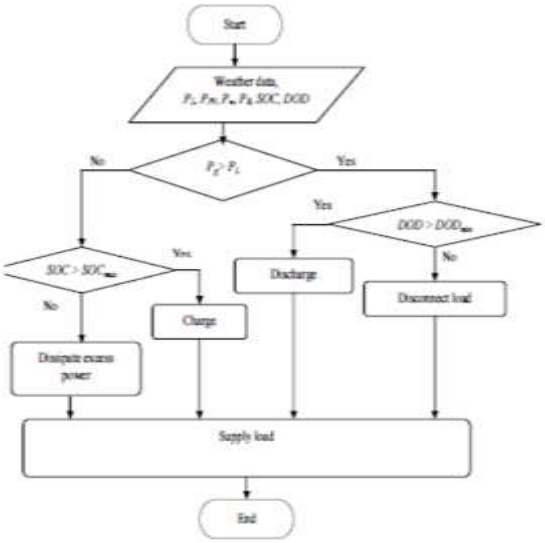


Figure 3: Power management of PV wind hybrid system.

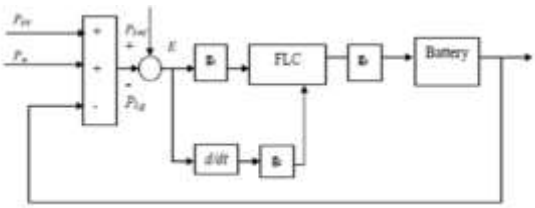


Figure 4: Square graph of FLC for PV wind battery half breed framework.

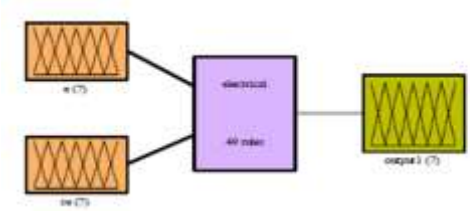


Figure 5: Square graph of FLC for electrical framework.

The reference stack is when contrasted with the created vitality with deliver the mistake sign which utilized as info sign to FLC. Enrollment trademark esteems are doled out to the etymological factors, the utilization of seven fluffy subsets: NB (appalling enormous), NM (poor medium), NS (poor little), ZE (zero), PS (invaluable little), PM (pleasant medium), and PB (positive tremendous). The charge of enter mistake (e) and substitute of botches (ce) are standardized through an information scaling thing.

The triangular type of the participation normal for this course of action presumes that for any one of a kind contribution there's most straightforward one predominant fluffy subset. The structure activity is the method by which the controlled yield is created. The Max– Min technique is utilized. The yield club highlight of each control is given by the Base. Table 1 recommends the rule base of the FLC. As a device more often than not requires a non fluffy cost of deal with, a defuzzification level is required. Defuzzification for this device is the center of gravity technique which is straightforward and fast. The standard gadget SIMULINK square graph is offered in Figure five. The square graph of FLC unit worked in MATLAB SIMULINK is appeared in Figure 6. The triangular enrollment trademark utilized as a part of this oversee configuration condensed in Figure 7.

Table 1. Rule base of fuzzy logic controller.

		CHANGE OF ERROR (CE)						
		NL	NM	NS	ZE	PS	PM	PL
Error (e)	NL	NL	NL	NL	NL	NS	NS	ZE
	NM	NL	NL	NL	NM	NS	ZE	PS
	NS	NL	NL	NL	NS	ZE	PS	PS
	ZE	NL	NM	NS	ZE	PS	PM	PL
	PS	NS	NS	ZE	PS	PL	PL	PL
	PM	NS	ZE	PS	PM	PL	PL	PL
	PL	ZE	PS	PS	PL	PL	PL	PL

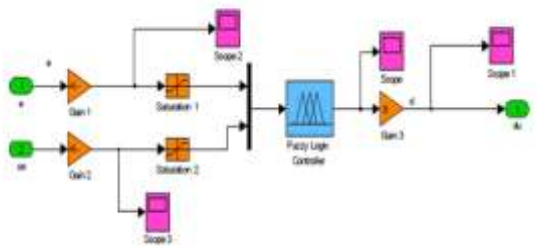


Figure 6: Simulink diagram of FLC

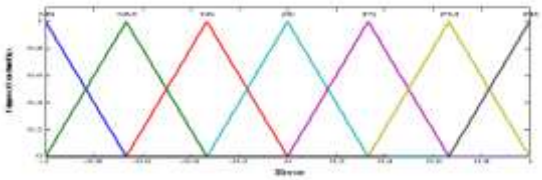


Figure 7: Membership functions

5. SYSTEM SIMULATION

The electrical subsystem includes several gadgets, PV array and wind generator units as primary sources of strength, battery bank unit as auxiliary supply of energy, load unit and manage unit. By making use of FLC as manage method which is developed to control the electricity management among one of a kind assets and the load, The PV-wind-battery hybrid device SIMULINK block diagram the use of FLC is given through Membership Function. The PV unit implementation the use of MATLAB SIMULINK is depicted in Results. The PV unit has two input parameters affected PV generator performance; the sun irradiance and the air temperature at the same time as the outputs are PV modern (IPV), PV voltage (VPV) and PV strength (PPV). The wind turbine unit has the wind speed as enter sign and the wind modern (IW) and the strength (PW) as output alerts.

The battery bank SIMULINK version implementation is illustrated in Figure nine. The battery has the air temperature and the charge current as enter variables, and offers the battery voltage at some stage in price (VBC) and discharge (VBD) method, the electricity (PB), the country of price (SOC) and the depth of discharge (DOD).

The oversee unit connected with the guide of FLC is intended to administer the battery current in accordance with the supplement of the weight with the coveted vitality. FLC has two sources of info and one yield. The inverter unit is utilized to change the DC created vitality from sustainable power assets to encourage the weight with the required air conditioning quality.

6. MATLAB/SIMULINK RESULTS

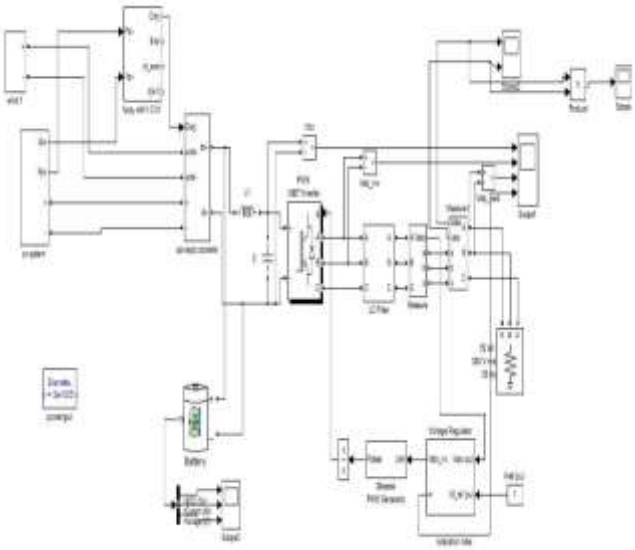


Figure 8: Simulation Diagram

Results:

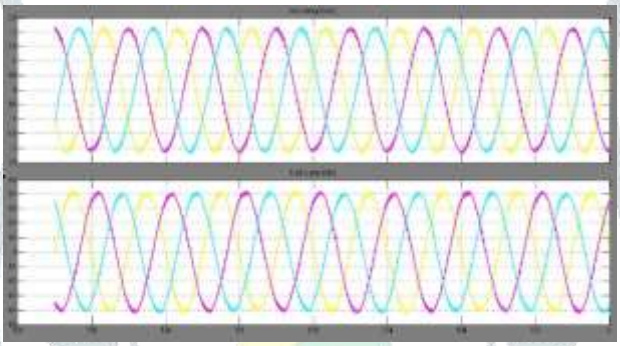


Figure 9: LOAD Voltage and Current

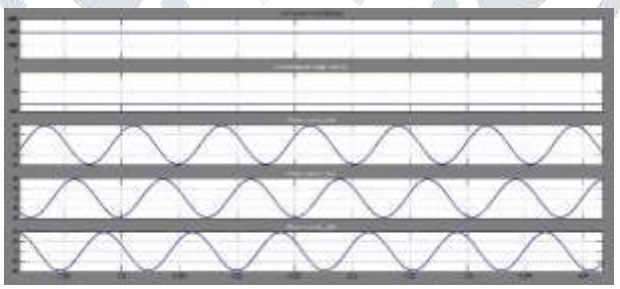


Figure 10: Permanent Magnet Synchronous Machine Measurements

Figure 11: SOLAR POWER

Figure 12: SOLAR VOLTAGE

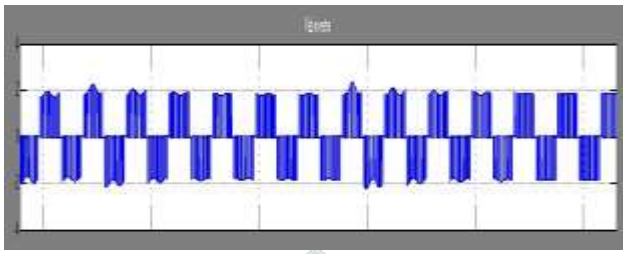


Figure 13: INVERTER VOLTAGE

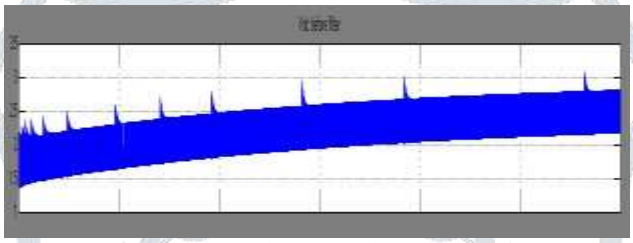


Figure 14: Vdc BEFORE FILTER

Figure 15: Vdc AFTER FILTER

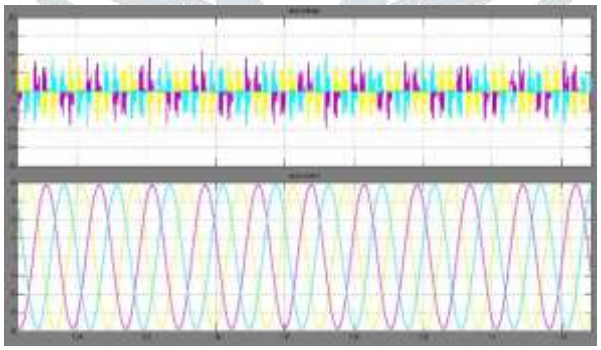


Figure 16: WIND Voltage and Current

Figure 17: Battery SOC, Voltage and Current

7. CONCLUSION AND FUTURE SCOPE

The investigated PV-wind hybrid device is designed to be totally self fulfill the weight during the operation duration. The machine is simulated to expect its overall performance below different environmental situation earlier than carried out in far flung location. The energy management between PV array, wind generator, battery bank and the burden become managed the use of FLC. The gadget overall performance using FLC had excessive applicability of FLC approach for this utility. The simulation consequences the use of MATLAB SIMULINK showed the excessive overall performance of the proposed gadget.

SCOPE FOR FUTURE WORK

The following aspects may be investigated as an extension of this work in future.

1. The optimization and reliability estimation for an hybrid combination of a photovoltaic (PV), wind energy conversion system and diesel system.

2. Optimization of hybrid system by considering maximum power point tracking cost of externalities and future demands to minimize the capacity of battery and excess power generated.

3. Practical difficulties associated with the implementation of hybrid system in rural areas.

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