MODELLING AND FABRICATION OF ELECTRIC BIKE USING SOLAR ENERGY STAND ALONE PV SYSTEM USING ARTIFICIAL INTELLIGENCE FUZZY LOGIC CONTROL

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Abstract: This project describes the modeling, fabrication and analyzing the performance characteristics of electric Bike, and application of Brushless DC (BLDC) Hub motor technology in a solar energy powered electric Bike with illustrating special emphasis over MPPT technique using Fuzzy Logic Controller for effective operation of D.C. - D.C. Boost Converter in Stand-alone Photo Voltaic (PV) system for charging the Battery used in electric Bike through MATLAB.[1]

Key words: Electric Bike, Boost Converter, BLDC Motor, Solar energy, Battery.

1. Introduction

An E-bike powered by electricity from the solar energy will be one of the most efficient modes of personal and public transportation. The main reasons for selecting electric vehicle are the energy input provided to B.D.L.C Motor can be provided by solar energy and wind energy conversion systems and also combined Hybrid energy sources. And energy requirement for propulsion is minimum. The second reason is bio-fuels or regular cycling requires conversion of solar energy to chemical energy which is characterized by low energy conversion efficiencies related with solar energy conversion. There are several E-bikes. Some have been running for a years and some are recently started.

1.1 Objectives

- This project is to promote the utilization of renewable energy powered electric vehicles in human transportation as a personalized vehicle.
- To analyze software implementation of the Maximum Power Point Tracking using Fuzzy Logic Controller to obtain solar electric energy Current(I) - Voltage(V) and Voltage(V) – Power (P) characteristics of the Photo Voltaic Module in MATLAB Simulink to charge the Sealed Maintenance Free Battery.[2]
- To construct electric Bike model in ANSYS. And the modeled structure is designed and fabricated and all components are assembled.
- To run the simulation circuit and the output characteristics obtained are noted.
- To charge the battery full and run the electric bike for different rider loads till the battery gets complete discharged, and readings for every charge cycle for respective rider load weight are noted.
- To plot the characteristics for outputs obtained and analyze the complete system efficiency with various analysis.

2. Photovoltaic System

Photovoltaic cells consist of a silicon P-N junction that when exposed to light releases electrons around a closed electrical circuit. From this premise the circuit equivalent of a PV cell can be modeled through the circuit shown in Fig. 4.1 Electrons from the cell are excited to higher energy levels when a collision with a photon occurs. These electrons are free to move across the junction and create a current. This is modeled by the light generated current source. The intrinsic P-N junction characteristic is introduced as a diode in the circuit equivalent. The photocurrent generated in the PV cell is proportional to level of solar illumination, is the output current of photovoltaic cell, the current through the diode varies with the junction voltage and the cell reverse saturation current, is the output of the photovoltaic cell, and are the parallel and series resistances, respectively. Parallel resistance is very large while the series resistance is small. There are relevant mathematical equations expressing as following:

$$I=I_L-I_D-I_{sh} \quad (2.1)$$

$$I_{sh}=\frac{V_{sh}}{R_{sh}} \quad (2.2)$$

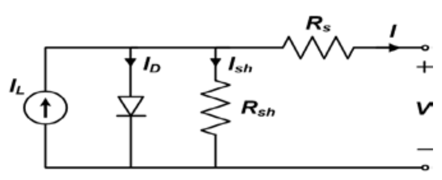

Fig.2.1 Single diode model of a PV Cell

From Diode Equation,

$$I_D=I_o(e^{qV_{sh}/kT}-1) \quad (2.3)$$

Then,

$$I=I_L-I_o\left(e^{qV_{sh}/kT}-1\right)-\frac{V_{sh}}{R_{sh}} \quad (2.4)$$

Applying Kirchhoff's voltage law,

$$V_{sh}=V+IR_s \quad (2.5)$$

The output current from the Photovoltaic array is

$$I=I_L-I_o\left(e^{q(V+IR_s)/kT}-1\right)-\frac{(V+IR_s)}{R_{sh}} \quad (2.6)$$

Where,

I =Output current from PV array

I_L=Cell Current (A)

I_o=Reverse saturation current of diode

I_D=Diode saturation current

R_s=Cell series resistance (ohms)

R_{sh}=Cell shunt resistance (ohms)

V=Output Voltage

V_D=Diode Voltage

q=($1.609*10^{-19}$coulombs) is the electron charge

k=($1.38*10^{-23}$J/K) is Boltzmann constant

A=Diode ideal factor

T=Cell working temperature

In order to model the solar panel accurately we can use two diode model but in our project our scope of study is limited to the single diode model.

2.1 I-V & P-V CURVES

Two important points of the current-voltage characteristic must be pointed out: the open circuit voltage V_{oc} and the short circuit current I_{sc}. At both points the power generated is zero. V_{oc} can be approximated. When the output current of the cell is zero, i.e. I=0 and the shunt resistance R_{sh} is neglected. [1]

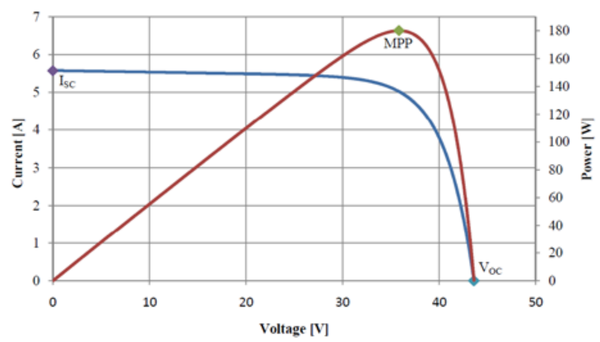

Fig.2.2 Standard I_{sc}-V_{oc} & P-V Curves

3. Modeling and Fabrication of Electric Bike

The project design was modeled in ANSYS. Secondly, the B.L.D.C. Hub Motor was connected to rear wheel, which is fitted on seat stay through nut and bolts on iron strips welded to seat stay of the Chassis.

- The fabrication was carried out by keeping in the mind of the maximum load and thus the rated motor was assembled to the chassis.
- Edge grinding was done to provide smoother surface finishing on freewheel and iron strips.
- All the fabricated parts were assembled and the Battery connections had been connected to the controller correctly.
- The Sealed Maintenance Free Battery was fully charged using Stand-alone Solar Photo Voltaic System.
- The throttle was powered by batteries which are fitted on the handle.
- The throttle gets powered through battery and sends signal to the B.L.D.C. Hub Motor.

4. Modelling of E-Bike project

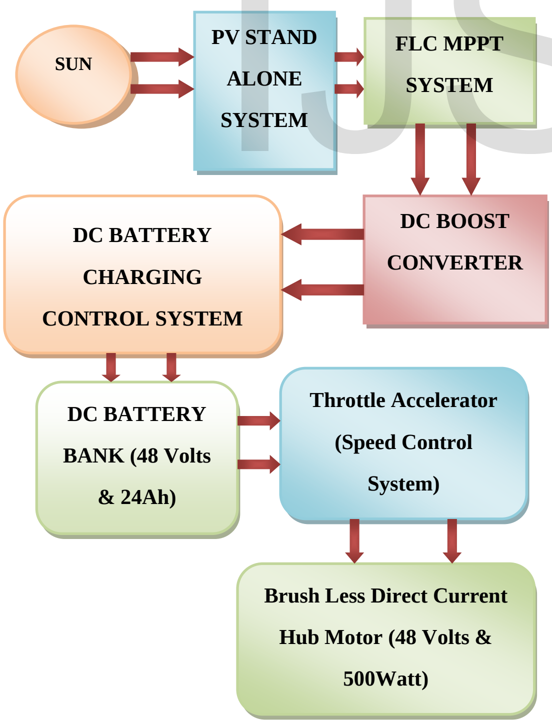

Fig.4.1 Block diagram of Project

This Project proposal illustrates the solar energy conversion technology with the help of MATLAB SIMULINK, [3] and the analysis of Stand-alone Photo Voltaic system was performed for various Temperature and Irradiance levels and VOLTAGE-CURRENT and VOLTAGE-POWER characteristics obtained are intended to charge the sealed proof maintenance free Battery practically assembled and connected with Electric Bike.[4,5,6]

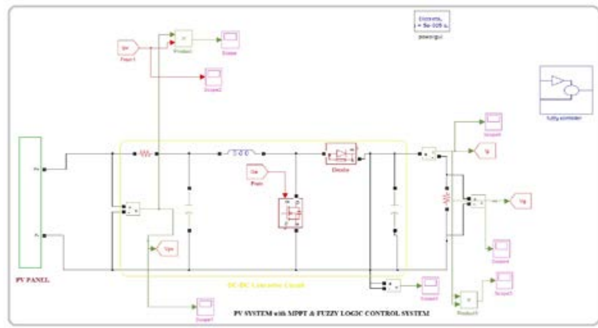

Fig. 4.2 MATLAB SIMULINK OF PV SYSTEM

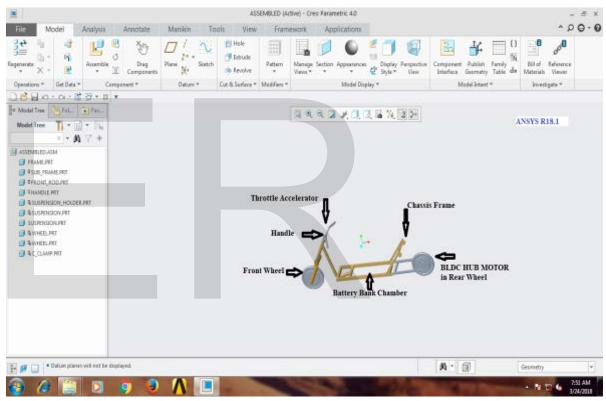

Fig. 4.3 E-Bike model in ANSYS R18.1

Fig. 4.4 Fabricated Project Model

Fig. 4.5 (12Volt x 4 = 48Volt, 24Ah) Battery Bank

5. RESULTS

5.1 PARAMETERS SPECIFICATION

Table 5.1 Project experiment apparatus parameters specification

S.No	Parameter	Variable	value
1	Constant Temperature	T□ C	25□ C
2	Solar Irradiance	G_o	1kWh-m^2
3	PV Panel MPPT Maximum Power	P_m	428 Watt
4	PV Panel MPPT Maximum Voltage	V_m	145 Volt
5	PV Panel MPPT Maximum Current	I_m	2.75 Amp
6	PV Panel Open Circuit Voltage	V_{oc}	50 Volt
7	PV Panel Short Circuit Current	I_{sc}	4.35 Amp
8	Cells in series	N_s	4
9	Cells in Parallel	N_p	1
10	Battery terminal Voltage	V_t	12 x 4=48 Volt
11	Battery Ampere Hour (Ah)	I_t	24 Ah
12	Energy stored in fully charged Battery	$E_{full} = V_t \times I_t$	48x24=1152Watt hour
13	Battery fully Charging Time	$t_{charging} = (E_{full} / P_m)$	(1152/428) = 2hours, 20 minutes
14	Average Battery Discharging Time (60kg load)	$t_{discharge}$	2 Hours
15	Brushless D. C. Motor input power	P_{in}	500 Watt
16	Motor terminal Voltage	V_{in}	48 Volt
17	Motor Full Load Current	I_{FL}	10.41 Amp
18	Motor Rated Speed	N_{rated}	750 RPM
19	E-Bike weight	W_B	80Kg
20	Best Load on E-Bike	W_R	60Kg
22	E-Bike Maximum Speed	S_{max}	45Kmph
23	Maximum Distance travelled in E-Bike	D_{max}	60Km
24	Radius of wheel	R	0.25m

Table 5.2 E-BIKE TEST READINGS PARAMETERS

Parameters	Values						
Rider Weight (Kg)	60	68	75	80	90	100	120
Maximum Speed (Kmph)	44.96	42.99	41.8	41.06	40.11	32.45	26.7

Mean speed (Kmph)	29.84	26.44	25.48	25.23	25.00	23.18	20.62
Voltage V Volts	48	48	48	48	48	48	48
Current I Amps	5.8	6.4	7.0	7.3	8	8.8	9.5
Power P Watts	278.4	307.2	336	350.4	384	422.4	456
Total Distance travelled (Km)	60	58.5	57.6	55.45	50	43.54	28
Total Discharging Time (t_d) minutes)	120	112	105	98	95	85	60
Energy Consumed per Kilometer (Wh/Km)	19.2	19.69	20	20.77	23.04	26.45	41.14
Torque N-m	0.3715	0.428	0.48234	0.512	0.574	0.781	0.912
Speed in (S/t)RPM	749.3	716.5	696.6	684.33	668.5	540.833	500

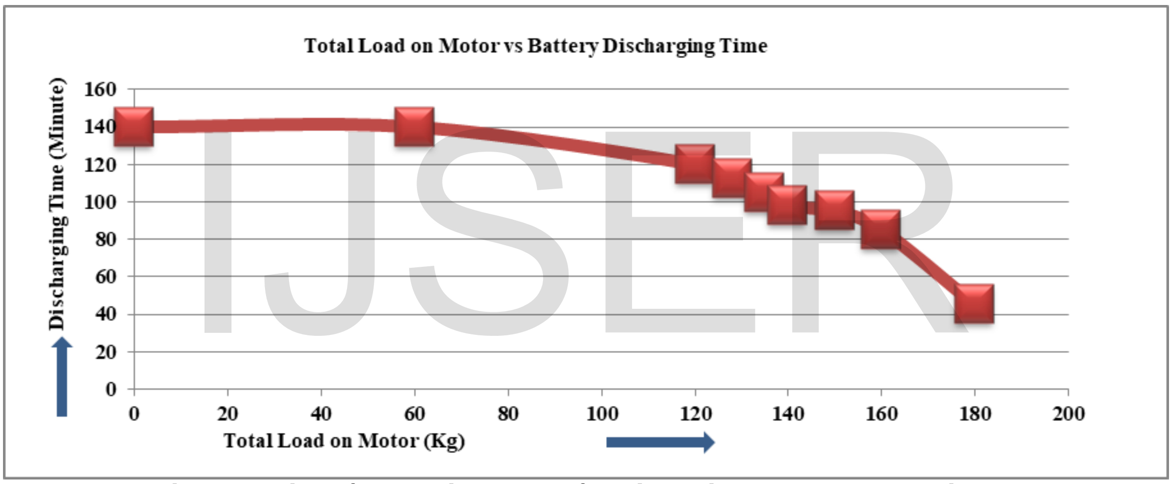

Chart 5.1 E-Bike performance characteristics for Rider Load on Motor vs Battery Discharging Time

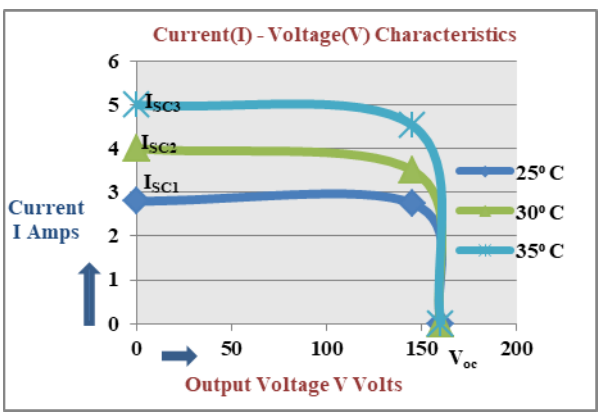

Chart. 5.2 I-V Characteristic curves of Photo Voltaic Module at constant Irradiance (1000Wh-m^2) and varying Temparature (T□ C)

TEMPARATURE (T)□ C	VOLTAGE (V) Volts	CURRENT (I) Amps
25□ C	0	2.8 (I_{sc1})
	145	2.75
	160 (V_{oc})	0
30□ C	0	4 (I_{sc2})
	190	3.5
	160 (V_{oc})	0
35□ C	0	5 (I_{sc3})
	230	4.53
	160 (V_{oc})	0

Table. 5.3 Measured readings for I-V Characteristic curves of PV system at DC-DC Converter for constant Irradiance (1000Wh-m²) and varying Temperature (T□ C)

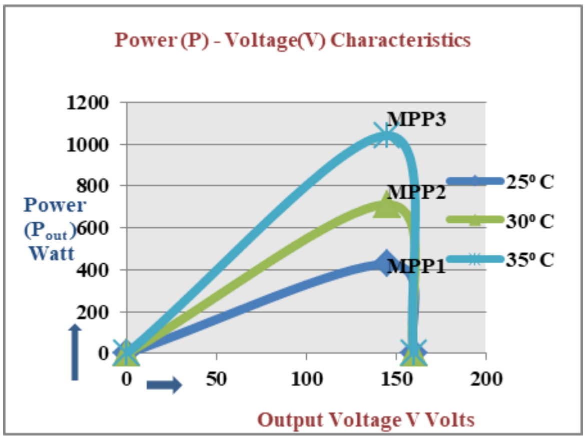

Chart. 5.3 I-V Characteristic curves of Photo Voltaic Module at constant Irradiance (1000Wh-m²) and varying Temparature (T□ C).

TEMPARATURE (T)□ C	VOLTAGE (V) Volts	POWER (W) Watts
25□ C	0	0
	145	428 **(MPP1)**
	160 **(V_{oc})**	0
30□ C	0	0
	190	712.5 **(MPP2)**
	160 **(V_{oc})**	0
35□ C	0	0
	230	1042 **(MPP3)**
	160 **(V_{oc})**	0

Table. 5.4 Measured readings for P-V Characteristic curves of PV system at DC-DC Converter for constant Irradiance (1000Wh-m²) and varying Temperature (T□ C)

7. Conclusions

Thus the E-Bike is designed by optimizing body weight of bike and powered by Stand-alone Photo Voltaic systems. And obtained the performance characteristics for the I-V and P-V characteristics for stand-alone PV system for different Temperature conditions by considering real values in MATLAB SIMULINK present in table.6.3. and table.5.4. are plotted in chart.5.2. and chart.5.3. [3]. and the Electric-Bike was loaded with different riders of ascending weight of load in Kilograms and the bike was driven for complete discharge cycles at various loads. And the characteristic curves were plotted against Total time of Discharge of Battery for different Load weights in Kilograms obtained from the test and the readings from table.5.2. in the chart.5.1. from the characteristic curve we observed that the load increase causes the fast discharging of battery. Finally, the project conclusion is that the renewable energy conversion system are required mandatorily to reduce and conserve the non-renewable energy sources.[5,6].

Acknowledgments

We wish to express our deep sense of gratitude to my guide **Ms. Dr. K. Kalyani Radha, M.Tech. Ph.D,** Assistant Professor, Department of Mechanical Engineering, JNTUA College of Engineering Ananthapuramu. for her kind help and support in doing Project with a lot of encouragement.

References

[1] Shilpa Sreekumar, Anish Benny, "Maximum Power Point Tracking of Photovoltaic System using Fuzzy Logic Controller Based Boost Converter", *International Conference on Current Trends in Engineering and Technology*, Coimbatore, vol. 2, no. 7, pp. 275-280, July 3, 2013.

[2] S.Gomathy, S.Saravanan , Dr.S.Thangavel "Design and Implementation of Maximum Power Point Tracking(MPPT) Algorithm for a Standalone PV System", *International Journal of Scientific & Engineering Research*, vol.3, issue 3 , pp. 1-7, March 2012 .

[3] R.Mahalakshmi, Aswin Kumar.A and Aravind Kumar," Design of Fuzzy Logic Based Maximum Power Point Tracking Controller for Solar Array for Cloudy Weather Conditions", *Power and Energy Systems: Towards*

ISSN 2229-5518

Sustainable Energy, vol. 1, no.8, pp. 120-124, August 2014.

[4] Atkinson, D., 2012. 2013 e-Bikes roundup - hub motors, shaft drives and more.... [Online] Available at: http://road.cc/content/news/66564-eurobike-2012-e-bikes-roundup [Accessed 24 February 2014].

[5] Electricbike.com, 2013. Torque Sensors on Electric Bikes. [Online] Available at: http://www.electricbike.com/torque-sensors/ [Accessed 27 March 2014]

[6] Bosch, 2014. Bosch eBike Systems. [Online] Available at: http://www.bosch-ebike.de/en/produkte_neu/intuvia_1/intuvia_2.php [Accessed 27 March 2014].