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HYBRID SOLAR AND WIND ENERGY SYSTEMS WITH CONVERTER DESIGN

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***Abstract*— In the context of increasing demand for energy and regarding the availability of conventional energy sources renewable plays a crucial role in nowadays, But we can't assure continuous supply from these renewable as their performance totally depends on the weather conditions. So, in order to overcome these problems to some extent hybrid systems are used. This work addresses a new concept in a hybrid system i.e., the photovoltaic cells are placed on the wind blades. Thus, this model signifies the reduction in design, optimizes the cost, and to shows the new development in renewable. This paper explains darrieus model of vertical-axis wind turbines (VAWTs) accompanied by polycrystalline solar cells. This system is connected to 555 timer astable mode of operation of the boost converter and a protected model of charge controller for the battery. So, to exploit the energy efficiently by this hybrid model i.e. extract of solar energy from panels and wind energy from darrieus wind turbine at a time helps to meet the concept of uninterrupted supply on besides the discontinuity of nature. A small working model is also developed basing on this concept and it is performance curves of the wind and solar are obtained.**

***Keywords*— Hybrid system, Poly solar cells on darrieus VAWT, Converter, Charge controller, Battery**

1. INTRODUCTION

Use of renewable sources of energy is encouraged due to fast reduction in conventional non-renewable energy sources. Interconnected microgrid system enhance reliability and reduce spinning reserve due to higher redundancy the most important sources of such types of resources of energies can be Wind and Solar energies which are most the efficient relatively. Solar panels can generate the electrical energy required during the day while wind turbines can compensate and meet the needs in the night through wind energy. In present times electricity usage is so high because of advancement of technology so that the load demand is so high and the generation is not up to the mark. To meet the requirements we must go with renewable energy systems like solar and wind as these energies are economic and environmental friendly[5,6].

Mostly the solar and wind systems occupy more space but here we are reduced the size by placing the solar cells on to the blades of the wind system. As mono-crystalline solar cells are efficient than poly-crystalline we use mono-crystalline cells [4]. But on taking in account of

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various advantages of VAWT over Horizontal-axis wind turbine (HAWT) most of the developed countries making more researches on VAWT's or its better usage and also many upcoming countries represents VAWT as a suitable alternative in extraction of wind power [2,3]. By using slip rings we can acquire the solar energy and the wind energy to the converters and from the converters to the energy storage systems like batteries to store the hybrid energy obtained by solar and wind.

2. MAJOR COMPONENTS AND ITS SPECIFICATIONS

2.1. Wind Turbine

Design of wind turbine is of two types HAWT and VAWTs . HAWTs occupies a vast part in wind energy system as because of its design simplicity but VAWTs has numerous advantages over HAWT. One of the specific features of to that the maintenance and construction cost of VAWTs are easier as the generator and gear box implanted at ground level. Reckoning these reasons, the researchers of VAWTs are rejuvenation recent years.

Darrieus –type approach of VAWTs

As if the VAWTs is by aerodynamic lift it is known as darrieus type VAWT. Darrieus design consists of symmetrical arranged aero foils so that they have zero rigging angle. Thus this makes the turbine to be rotated with the wind face on no matter with the direction of wind blowing. The blowing wind across these airfoils moves them in a circular path, which contours the blade causes an aerodynamic lift which actually makes the blades to pull along with them. This action is known as angle of attack (AOA), which develops a net force diagonally towards the blades creating a certain line of action. This created force is projected towards the axis of turbine, endowing a positive torque for the shaft, thus makes it to revolve in its direction as before. If the aerofoil direction changes to the back of the system, the angle of attack shows opposite sign but in the created force is in the same sign direction, as because of the symmetry of wings and zero rigging angle. Thus this generated energy is converted into useful power with the help of electrical generator.

TABLE I. Different Speeds of Wind in this Location

	10 am	**11 am**	**12 pm**	**1 pm**	**2 pm**	**3 pm**	**4 pm**	**5 pm**	**6 pm**
Temprat- -ure	30ºC	32ºC	34ºC	36ºC	35ºC	34ºC	32ºC	31ºC	29ºC
Wind direction	South West	South West	South West	South West	South West	South West	South West	South West	South West
Wind speed	14 Km/hr	12 Km/hr	11 Km/hr	13 Km/hr	17 Km/hr	20 Km/hr	20 Km/hr	19 Km/hr	17 Km/hr

We designed a VAWT system which is darrieus model of 3 blade system because to make the solidity of the system to greater than 0.4, so that it can be a self-started turbine and the design parameters are Length of the blade is 75 cm, The radius of the turbine is 28 cm and the chord length of the blade is 20 cm with three blades. In our project model we use a PMDC generator so the output was a pure DC therefore there is no need of conversion and any commutation circuit which reduces the cost.

Length of the blades (L) =75 cm
Radius of the wind turbine (R) = 28 cm
Air density (ρ) = 1.13 kg/m3
Chord length (c) = 20 cm

Number of blades (N) = 3;

Speed of wind in rajam having latitude- 18.4555839 and longitude- 83.64938059999997 and an elevation of 80m on 25th March, 2019.

TABLE II. The Wind Turbine Parameters

Parameter	**Formulae**	**Value**
Swept area	2RL	1.2 m2
Wind power	0.5ρAVo3	43.39 W
TSR	Vt/Vw	0.87
Solidity	Nc/R	2.14
Aspect Ratio	L/R	2.68
Torque	(Pt*30)/πn	
Power Coefficient	Pt/Pw	

2.2. Generator Specification (Pmdc)

Output power	250 W
Supply Voltage	25 V
Speed	2650 RPM
Full load current	13.7 A
No load current	2.2 A
Weight	1.92 Kg
Rated torque	0.80 N.m
Stall Torque	5 N.m
Efficiency	>= 78%

Fig. 1 PMDC generator used in the system

2.3. Solar Cells

We used solar cells charge of material poly crystalline it was able to generate efficiency of 17.8% of the solar radiation which is reached to it and can make the voltage of 0.17 watt for each cell we take these solar cells in a sequence so that we can achieve a maximum output and the output generated is required to maintain the load and tries to balance it demand and we joined these cells by a single lead wire of very less diameter we taken the strands of a conducting wire the diameter might be nearer to our hair thickness, as this is an Integrated system these solar cells were placed on the blades of the wind turbine as our idea is to reduce the occupancy of area. The connections we made are like we take 14 solar cells of rating as mentioned above we connect these cells in series which can gives an output of 7 to 7.7 volts and these 14 cells makes a row than we place 2 rows on one blade so the arrangement is like 6 rows were connected in parallel and to make sure that there should be no reverse currents we placed a diode in series with the solar cells row so that it was unidirectional. It gives an output of 2 to 5 watts. Based on the climatic and surrounding conditions we get the results which are not the same values which were specified by the supplier and the solar output is

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mainly based on the solar intensity and the incident angle, as these cells were placed on the wind blades we cannot provide with MPPT techniques so the angle of incident is constant based on the wind blade design[4].

Specification of solar cell

Rated values	: 0.5 V; 340 mA; 0.17 W
Efficiency	: 17.8
Model Number	: JS-5219100
Material	: Poly crystalline Silicon
Nominal Capacity	: 0.15 A
Max. Power	: 0.17 W
Size	: 52*19mm
Thickness	: 200um
Colour	: Blue
Model	: Photo voltaic cell

TABLE III. DC Boost Converter Parameters

S. No	Component	Value	Quantity
1	Resistor	1k	1
2	Resistor	50k pot	1
3	Capacitor	0.1 μf, 0.01 μf, 100 μf	1
4	Inductor	13 μH	1
5	MOSFET	IRFZ44N	1
6	555 timer	NE555	1
7	Diode	IN5817	1

Fig. 2 Array of solar cells

2.4. Dc Boost Converter

The design of this converter is to boost up the output voltage up to 25 V as the output of wind is not much we are using it for boosting to 15V the integrated system should be paralleled so the voltage should be common to make it a parallel operation. We get the results in CRO. We used a PWM technique for switching operation by a 555 timer. The switch is a n-channel MOSFET for to vary the frequency we used a 50K resistor pot and the designed circuit has been shown below.

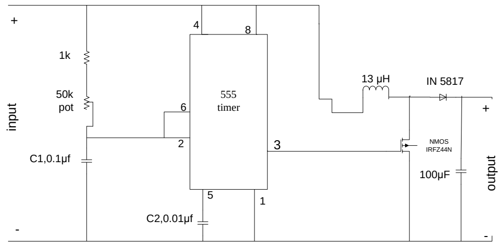

Fig. 3 DC Boost Converter

We have made the circuit based on what we needed. The frequency is set by the circuit for the 555 timer and the components are explained below. In this boost converter the minimum voltage should be 3 to 5 V because it has minimum voltage to apply to the 555 pin so that the timer could turn on and creates the pulse that can turn on the MOSFET.

2.5 Charge Controller

A typical charge controller consists of 5 basic features:

1. Low voltage protection
2. Over voltage protection
3. Battery cut off circuit
4. Back current protection
5. Over discharge protection

The first part of our charge controller is a N-channel MOSFET in forward bias condition to stop the flow of current to battery from the solar panels. During the sunrise whenever the panel voltage reaches 10v and the wind system also provides an output of 10v then ultimately the 10v zener diode starts conducting thus turning on the MOSFET which ultimately turns on the relay and the battery starts charging. This is known as low voltage protection. Whenever the current reaches 15V the other zener diode turns on thus brings the MOSFET to change in conducting state, negative voltage flows through it thus turns off the MOSFET[1, 8]. Then the battery is not being charged, which leads the current flows through the battery to zero. Now the case of over charge protection Here, when the battery is fully charged less current flows through it; which ultimately turns off the second MOSFET and then it trips the second relay. This cycle repeats whenever the battery reaches to a minimum value. So this is how a solar and wind charge controller actually works. Our present circuit can handle a current upto a max. of 10A, however it can be upgraded to a higher value. Since our hardware model source gives an output of 1 to 3 Amps.

3. SCHEMATIC DIAGRAM AND WORKING PRINCIPLE

This project describes the production of energy through the integration of wind and solar in an effective manner using the power electronic devices. First of all in this project using a darrieus type vertical axis wind turbine and connected this blades to a shaft through a base of circular wooden plates and this shaft is coupled to a dc generator and on the free space of the blades of darrieus type wind turbine a series of thin solar cells are connected and placed on it. due to the continuous rotation of wind blades, the solar cells will also rotate so the power which is coming from the solar cells will be collected through the slip rings and this is connected to a converter which steps up the voltage to the required level simultaneously the slip rings output will be given to another converter for step up the voltage and these converter outputs will be given to charge controller which is connected before the battery preventing it from under and over voltages.

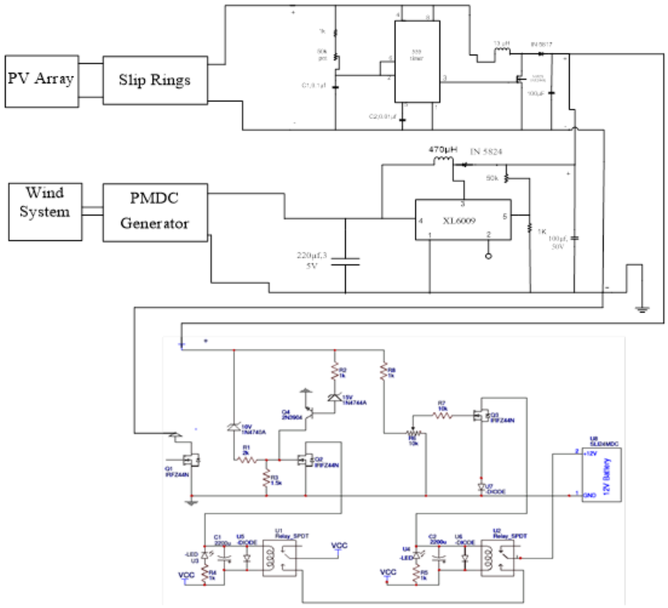

Fig. 4. Schematic Diagram of Proposed work

TABLE V. Solar output for different voltage and current

S. No	**V (V)**	**I (mA)**	**P (W)**
1	7.4	0	0
2	7.2	63	0.4536
3	7	102	0.714
4	6.9	120	0.828
5	6.8	121	0.822
6	5.6	140	0.784
7	2.4	160	0.384
8	0	220	0

4. RESULTS

4.1. PV OUTPUT

Solar radiance in rajam having latitude - 18.4555839 and longitude - 83.64938059999997 and an elevation of 80m on 27th MARCH, 2019. Is shown in Table IV below.

Observations

We have been observed the maximum voltage and maximum current by connecting a load across it on the day as we have seen on the internet correspondent readings on the net and the open and short circuit values have calculated by using the multi meter and we noted the readings. We plotted the graph for voltage and current as well as for power and voltage and at that point of time as the results obtained. The curve deviates at maximum voltage so we can know that from the graph the maximum power point is that particular region. Solar observation table for different loads and the v-I and p-v graphs are shown below Table V.

We have been observed the maximum voltage and maximum current by connecting a load across it during the mid-day light time which has maximum irradiance on the day as we have seen on the internet and the open and short circuit values have calculated by using the multi meter and we noted the readings. By varying the 50K pot we obtained the PV characteristics of solar cell. We plotted the graph for voltage and current as well as for power and voltage and at that point of time as the results obtained. The curve deviates at maximum voltage so we can know that from the graph the maximum power point is that particular region.

TABLE IV. Output of Solar Voltage for One Day

S. No	**Time**	**V_{oc} (V)**	**V_{mp} (V)**	**I_{sc} (mA)**	**I_{mp} (mA)**
1	9:05	4.3	3	100	90
2	11:10	7.4	6	200	180
3	12:30	7.5	7	230	195
4	13:30	7.62	7.2	260	210
5	14:30	7.4	7.1	230	190
6	15:30	7.2	6.9	180	160
7	17:00	6.9	5	120	90
8	18:00	3.75	1.2	55	19

4.2. WIND OUTPUT

Design parameters:

L=75 cm; R= 28 cm; ρ = 1.13 kg/m3; c = 20 cm N=3; RPM= 120

The wind output is maintained by the wind speed. We measure the wind speed by surfing in the internet and in the day duration 2 to 6 PM the wind speed is good, we perform this duration and the results are obtained like according to wind speed. As the generated is directly coupled to shaft of the wind turbine, at different wind speed the output generation is tabulated in table VI [7].

TABLE VI. Wind Output for Different Wind Speeds

S. No	**Wind Speed (m/sec)**	**RPM**	**V (V)**	**I (A)**	**P (W)**
1	4.1	190	1.8	0.89	0.712
2	2.6	138	1.14	0.49	0.5586
3	Manual	356	3.22	1.85	5.95

4.3. Boost Converter

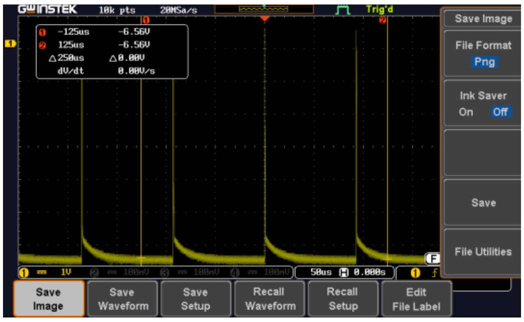

Fig. 5. When the pot is at minimum position

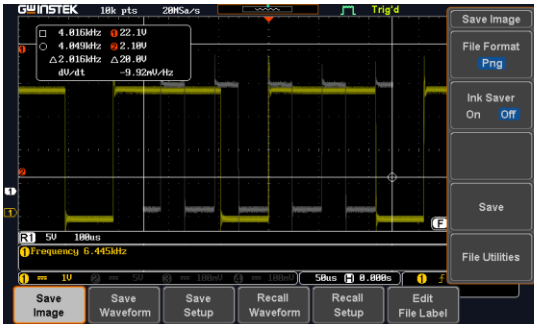

Fig. 6. When the pot is at intermediate position

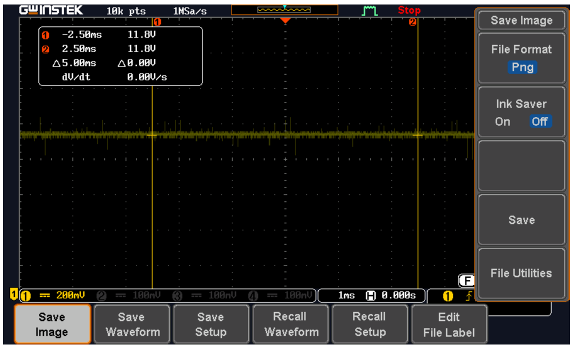

Fig. 7. Output of the solar Boost converter

As by varying the pot we vary the pulse width of the pulse generated by the 555 timer the results were at minimum at the pot and the input given is a 4 v DC which gives an output of 11.4 V.

4.4. Charge Controller

We designed a charge controller to charge a battery of voltage 12 V, 1.32 mAh battery this has the ability to save the battery from overcharge and undercharge protection.

Specification

Input : 10 to 15 V (relay trips if voltage is below 10V and above 15V)

Current : 0.5 to 10 A

Output : 10 to 14 V

4.5. Output of the whole system

In this setup we are using two individual boost converters one for PV unit and one for wind system (their individual outputs are shown above) and after connecting the solar and wind inputs to corresponding converters and then to the charge controller we are getting the following results

TABLE VII. Solar Output of the Whole System

S. No	**V (V)**	**I (mA)**	**P (W)**
1	9.6	0	0

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2	11.2	0.9	10.8
3	13.4	1.1	14.74
4	14.1	1.9	26.79

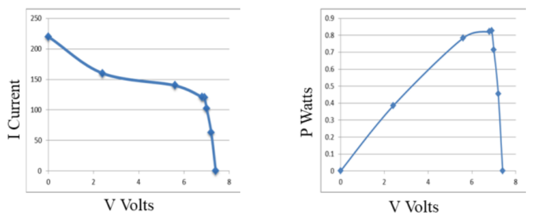

Fig. 8. VI and PV Characteristics of solar

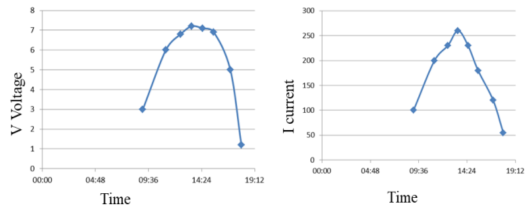

Fig. 9. V & I Vs Time curves of solar cell

Fig. 10. Setup of complete prototype

5. CONCLUSION

In this modern world emerging with the new technologies attaining uninterrupted power supply is a big issue, also the space required for the installation of renewable source plays a keys role. This hybrid technology provides continuity in power supply and also solves the problem of space. This paper optimizes the space and also makes the solar cells are fixed on the wind blades, so we can attain the energy from both the renewable collectively. This concept might helpful in installation of systems in which solar is difficult in hilly areas. So here we have made a small try to integrate two renewable sources to bring out some good amount of energy and make it useful for the society and our existing environment. This new idea which has much of innovativeness in it shows how the potential of renewable energy sources can be used to get the best out of it. An prototype proposed system is fabricated and the desired output is achieved.

6. REFERENCES

[1] C. J. Sudhakar; Avinash V. Deshpande; Diwakar R. Joshi, " Charge controller for hybrid VAWT and solar PV cells", Pages: 343 – 347, IEEE Conference 2017.

[2] E.A.D. Kumara, N.K. Hettiarachchi and K.G.R.M. Jayathilake, " Review Paper: Overview of the Vertical Axis Wind Turbines", ISSN: 2313-3759, Vol. 4 No. 8; August 2017.

[3] N. C. Batista, H. Sintra; R. Melício, V. M. F. Mendes, H. M. I. Pousinho, " Innovative design on technology of urban Darrieus VAWT: Field tests", Pages: 1 – 6, IEEE Conference 2015.

[4] Damala Rajesh Babu, M.T. Naik and A. Jaya Laxmi " A Prototype Model of Augmented Solar Tracking System for Electric Vehicles " International Journal of Control Theory and Applications" Volume 10 Issue 16 Pages 23-31, 2017

[5] M .Andriollo, M. De Bortoli, G. Martinelli, A. Morini, A. Tortella, " Control strategies for a VAWT driven PM synchronous generator", Pages: 304 – 308, IEEE Conference 2014

[6] Sandeep Kumar, Vijay Kumar Garg, "A Hybrid model of solar-wind power generation system", IJAREEIE, vol. 2, no. 8, August 2013.

[7] Piyali Ganguly, Akhtar Kalam, Aladin Zayegh,"Solar–wind hybrid renewable energy system: current status of research on configurations, control, and sizing methodologies", Hybrid-Renewable Energy Systems in Microgrids. Elsevier Ltd, 2018.

[8] https://easyeda.com/Aatik/solar_charge_controller-788dc735e2ad4e0897d3790693144692