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Hybrid MPPT Charge Controller & Remote Monitoring for a Hybrid Solar and Micro Wind Power Generator

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Abstract— For Developing of culture, Industries and nation electric Power play an important role and obviously it is very important for the growth of economy. As per the present scenario there is a huge demand of electricity in all the sectors like industries, domestic & other commercial sector. Thus there is a great need to find out the alternate source of power. The use of renewable energy such as wind & solar energy is the best substitute of it. Aims of this paper is to optimize the hybrid power obtain from the sources such as solar & wind power. Another aim is to design the hybrid Maximum Power Point Tracking(MPPT) charge controller for the solar and micro wind turbine. One more thing is added to the system is that monitoring and diagnosis of system at the real time. Both features make it reliable to use this research in various purpose. Hybrid MPPT Algorithm used in the charge controller and monitoring algorithm used for the monitoring of the system is discuss in this paper.

Keywords— *renewable energy, hybrid MPPT & monitoring and diagnosis of system.*

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I. INTRODUCTION

Electrical Energy is most desirable for our day to day life. There are two different ways to generate the electrical power, either by conventional energy resources method or by non-conventional energy resources method. Major portion of the generated power is mainly from the Diesel power, Hydro power, coal, Nuclear.[1] The main concern is to increased the usage of power through the Hybrid sources. There are mainly two sources of renewable energy which available in plenty in nature. First and main source is solar energy & second is wind energy which is also available abundant & regularly in nature. Wind energy is the cheapest Renewable energy technology is present and has peaked the interest of scientists and educators around the world. Photovoltaic energy conversion from sunlight into direct current electricity. Photovoltaic gives you more advantages as compared to other renewable energy sources like no noise , and require almost no maintenance cost such as wind power required in energy conversion.[7]The analysis made here is mainly for the solar & wind energy sources. The basic fundamental of working of the hybrid MPPT charge controller is discuss through the algorithm which is implemented to the configuration. The concept of working of hybrid MPPT charge controller is illustrated with the help of line diagram through Fig.1.

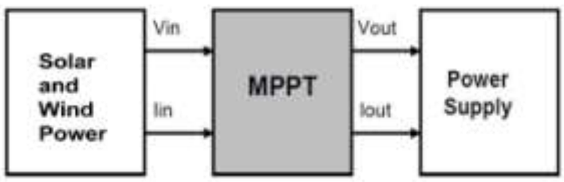

Fig.1.1Block diagram of proposed hybrid MPPT charge controller

Micro wind turbine which has been employed in the proposed research converts the kinetic energy in the wind into the mechanical or useful energy. This mechanical energy is then converted to the electrical power with the help of generator. Solar energy obtain from the solar radiation that is available on earth in huge amount and free of cost. It also has higher efficiency as compared to other energy sources. Solar PV cell directly convert the solar energy into the Direct Current (DC).

II. DEVELOPEDHYBRID MPPT TECHNIQUE& DIAGNOSIS

Hybrid energy term is stand for the combination of two different sources of energy. The proposed system uses Solar and micro wind power generator for the generation of electricity. In other word we can explain it by the sentence “system which is fabricated or designed to extract power by using two energy sources is called as the hybrid energy system.” Hybrid energy system has good reliability, efficiency, less emission, and lower cost.[6] Proposed system has equipped with the Hybrid MPPT charge controller which regulate the charging current and voltage as per the proposed algorithm. Proposed Hybrid MPPT method searches for the optimum relationship of system for solar and wind power and then regulates the output voltage and current according to the relationship results.

Mechanical power obtained from the wind energy is expressed with following relationship:

$$P_m = \frac{1}{2}\rho\pi r^2 v^3 C_p$$

Where P_m is maximum power extract from the wind energy, ρ is density of air (kg/m^3), r is radius of the turbine rotor (m), v is speed of wind (m/s) &C_p stand for the coefficient of performance. Theoretical value of C_p is maximum upto 0.59 for the best design. Practical range for this value is from the 0.40 to 0.45[1]. Coefficient of performance have the maximum value at some speed of wind. At this wind velocity value will be maximum for the coefficient of performance after this optimum wind speed coefficient of performance goes on decreasing either by increasing or decreasing the wind velocity.

In the proposed system we have observes that increasing the speed of wind will continuously increases in the current and voltage extract from the wind power.

For practical applications of solar PV array it is observed that efficiency and IV Characteristics curve of solar system continuously vary with the variation of the isolation and temperature of the cell, solar radiation, solar inclination angle and panel direction facing to the sun always keeps on changing. Thus the algorithm used in the research work would determine the Maximum point in IV Characteristics curve where solar PV array withdraw maximum power at a particular voltage and current. In general case it is found that solar PV array withdraw maximum voltage around 19 V at 25°C and it drops to around 15V on very hot day. The proposed coding for the MPPT technique is stored in the microcontroller which switch the integrated circuits (ICs) and find out the maximum power point on IV characteristics curve. i.e. at voltage where it gives the maximum power, given the output from the solar array and the wind power. Pulse Width modulation Technique is used to regulate the output voltage. The hybrid MPPT technique id developed specially for the hybrid energy system which convert DC to DC current from solar PV module and micro wind turbine and then this DC input is exchanging to AC and changing this current back to the acceptable range of DC voltage and current to precisely matches the PV module and wind turbine to the battery.

The specifications of the Hybrid MPPT Charge Controller Design:

Features	Hybrid MPPT Algorithm is used for optimized battery charging current, Buck and boost charge controller for solar PV module and for Wind Turbine.
Input	Input voltage from Solar panel is 19 V Input current from Solar panel is 2.00 A Input voltage from Wind Turbine is 24 V Input current from Wind Turbine panel is 1.8 A
Battery Rating	Lead acid Battery, 12V Maximum charging current – 1.6 A (10% of the battery capacity)
Boost Driver Rating Mode	88.23 % of Pulse with modulation
Floating Driver Rating Mode	19.16 % of Pulse with modulation
LED Indicator for the indication of status of the system	Like, Boost Mode, Float Mode, Battery Low, Power Available.

Charge Controller:
Maximum power point tracking with Pulse width modulation (PWM) technologies makes the charge controller more electronically reliable, efficient and sophisticated by regulating charging current amounts depending on the battery's voltage level and to permit charging current nearer to its maximum capability. when its voltage goes down the predefined level of the voltage. Charge controllers will monitor and read the temperature of the battery to avoid overheating. The designed charge controller will also display the data and transmit data regarding the system to the remote area of display.

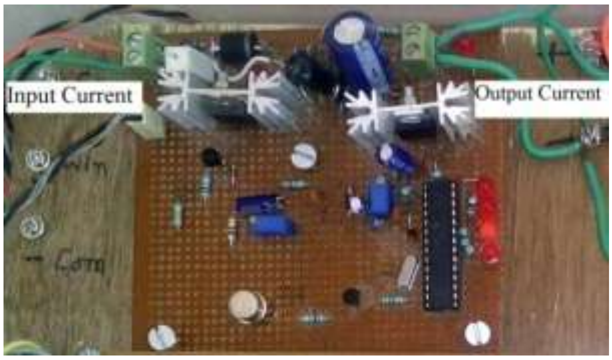

Fig.2.1 Diagram of the MPPT circuit for the solar system

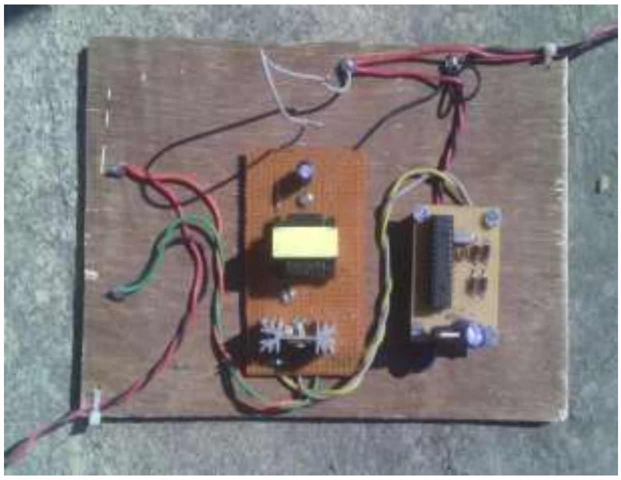

Fig.2.2 Boost mode MPPT charge controller for the micro wind turbine or ferrite circuit

Pulse Width Modulation (PWM) :
Pulse Width Modulation (PWM) controls alters the duty cycle ratio of the switches as the input voltage changes to generate a constant voltage output. The DC voltage obtain from the solar and wind turbine is converted to a square-wave signal by changing between fully on and zero. Thus the analog circuits is controlled digitally with the help of the Pulse Width Modulation (PWM).The cost of the system and consumption of power is extremely minimizes with the PWM. In nowadays there are so many microcontrollers which is already include on-chip PWM controllers, thus making application easy. Briefly, Pulse Width Modulation is

a technique of encoding the analog signal levels to in the form of digitally.

The determination of set points be determined by pattern of usage, battery types and the battery capacity.

Determine the duty cycle, D to obtain required output voltage.

$$D = V_o/Vi$$

For the Boost mode Duty Cycle is 88.23%
For the Float mode Duty Cycle is 19.60%

Calculation :
Range of the Pulse Width Modulation is 0 to 255. PWM is of 8 bits

8 bits	= 2^8	=	256
In Boost mode		=	(225/255)×100
		=	88.23%
In Float mode		=	(50/255)×100
		=	19.60%

Where:
D = Duty cycle
V_o = Output Voltage
V_i = Input Voltage

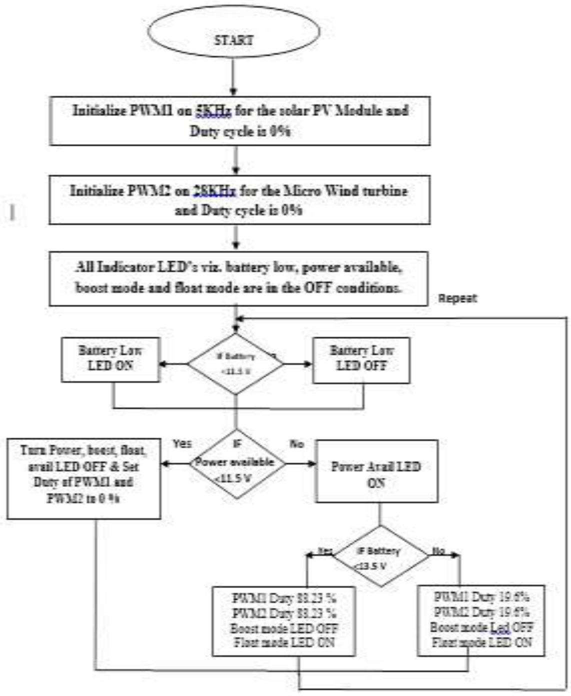

Fig.2.3 Flow diagram of proposed algorithm

Interfacing of DAQ Card

One most necessary thing in remote monitoring of hybrid solar and micro wind power generator is to interface between the DAQ card and the visual studio 2010 edition. The DAQ card received the information from the anemometer and hybrid MPPT charge controller and transfer the data to the computer or to the GUI unit in the digital form. To perform the remote monitoring we have used the RX 232 Receiver and Transmitter Module. Interfacing of RX 232 Module.

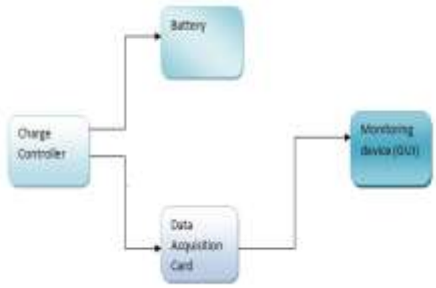

Fig.2.4 Block Diagram for remote monitoring and diagnosis

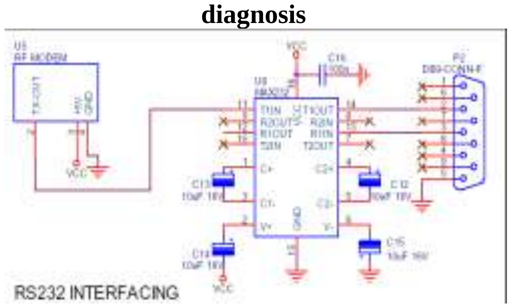

Fig.2.5 RX 232 Interfacing at Receiving End

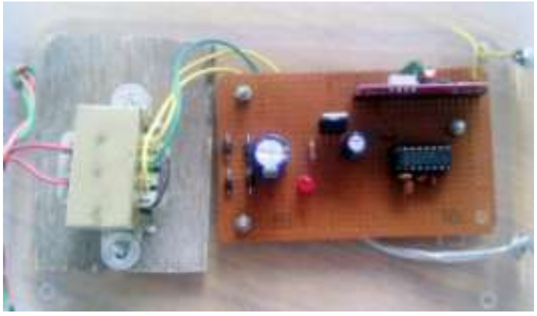

Fig.2.6 RX232 Receiver module

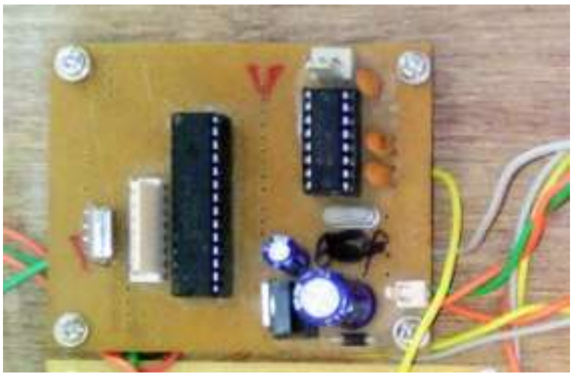

Fig.2.7 Diagram of SM TX transmitter module

Remote monitoring is done to measure the velocity of wind, wind speed has measured with the use an IR LED and phototransistor in the anemometer, these arrangement is count the number of rotation of anemometer and made the pair witch ON and OFF. With this information its easy to calculate the wind speed.

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Fig.2.8 Anemometer to measure the wind speed through IR sensor

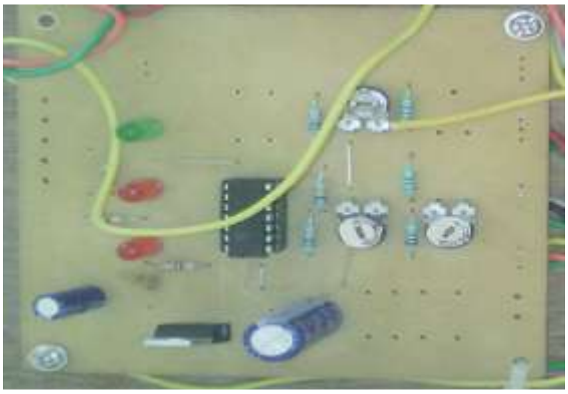

Fig.2.9 Circuit indicate the IR sensor ON and OFF

Calculation used to Calibrate the Anemometer = *(CF × RPM) × Circumference of the Anemometer) / 60*

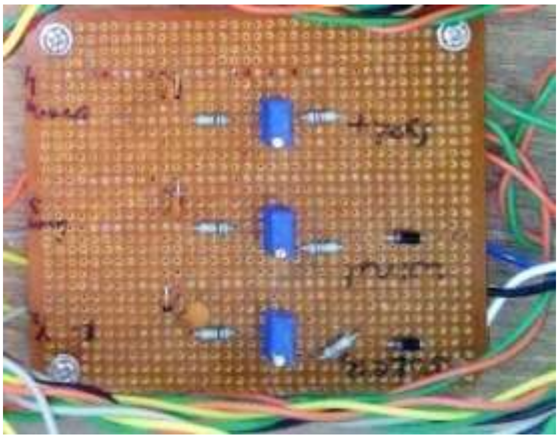

Fig.2.10 Circuit Diagram of measuring wind speed, voltage &current of solar and wind

III. OBSERVATION

There are different types of instrument are used while taking the reading for different parameter. Whole reading are taken at equal interval of 30 minutes.

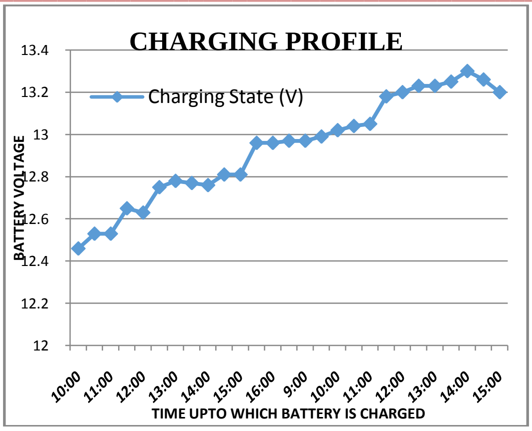

Fig.3.1 Charging profile of battery with Hybrid MPPT charge controller

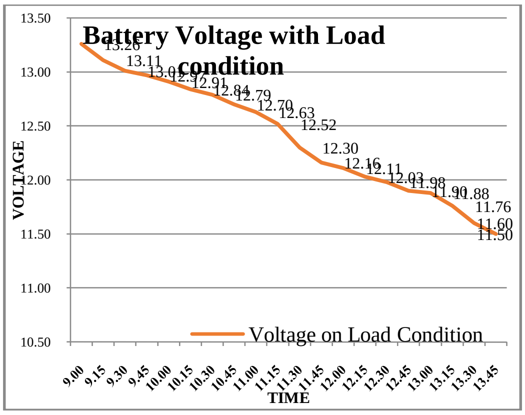

Fig.3.2 Voltage while discharging with Load Condition

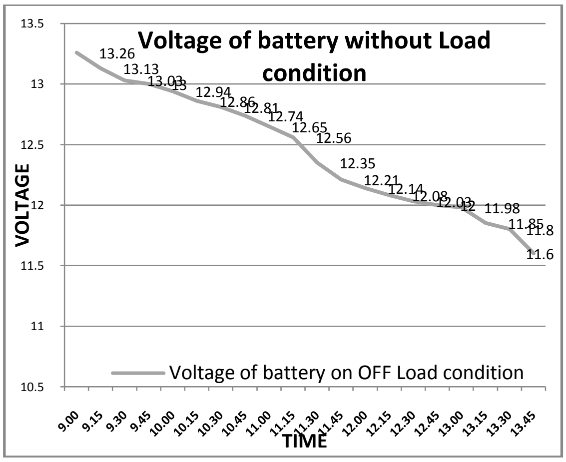

Fig.3.3Voltage while discharging without Load Condition

Solar Panels Characteristic

There is a point on the I-V Curve where the maximum power output is obtain and this point is known as the Maximum Power Point (MPP). The voltage and current at this Maximum Power Point are designated as V_{mp} and I_{mp}. The rated power of the PV / Solar Module in Watts (P_{max}) is derived from the above values of voltage V_{mp} and current Imp at this Maximum Power Point (MPP):

Rated power in Watts, $P_{max} = V_{mp} \times I_{mp}$

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I_{sc} = 1.42 A

Voc = 18.19 V

Maximum Power Point is as follow

I_{mp} = 0.75 A

V_{mp} = 14.5 V

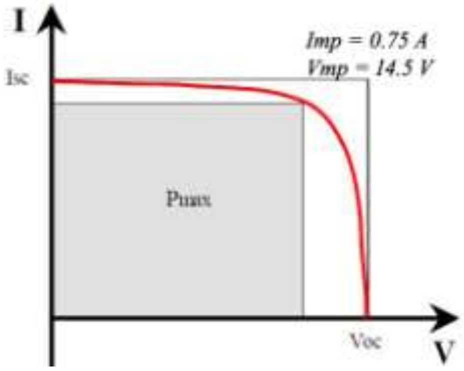

Fig.3.4 The maximum power obtained by the solar PV module, P_{max} is the maximum area of the power obtain

The efficiency of a solar cell is defined as the ratio of the electrical power which is obtain to the Solar radiation power incident on the cell. Maximum efficiency is obtain when power delivered to the load is P_{max}. Incident solar radiation power is normally specified as the solar power on the surface of the earth is approx 1000W/m^2.

IV characteristics curve of the solar cell is used to find the efficiency of the system.

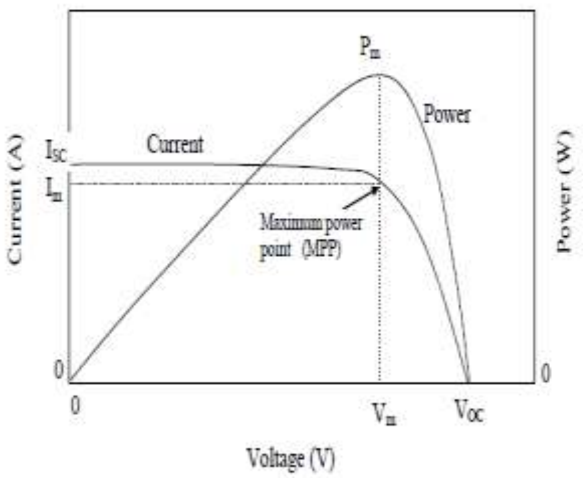

Fig.3.5 IV Characteristics of Solar Panel

Efficiency of the solar panel is stand for the total electrical power output per unit of area of the module *(W/m²)*.The incident solar irradiance flux is the amount of solar power that comes to the earth's surface in Watt/metre^2.

$$\eta(Efficiency) = \frac{P\ (Output\ Power)}{E\ (Solar\ Radiation) \times A_c\ (Area\ of\ Collector)}$$

Collector Area = 0.25 m^2

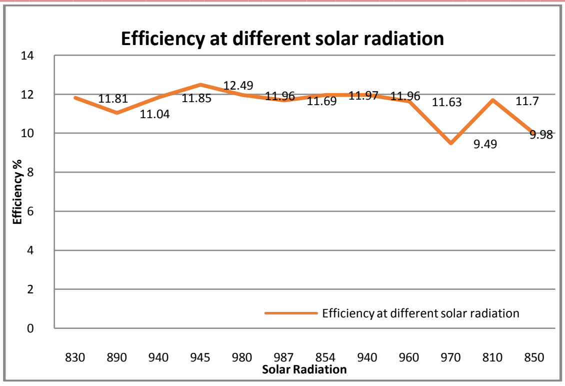

Fig.3.6 Efficiency at different solar radiation

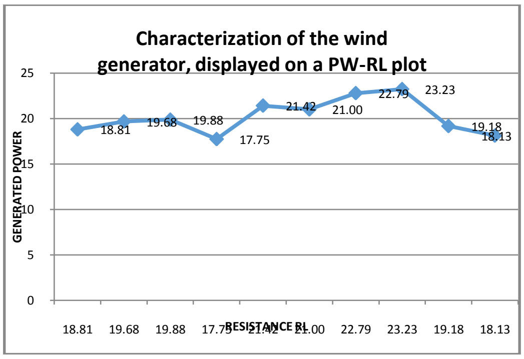

Fig.3.7The data acquired from the characterization of the wind generator, displayed on a PW-RL plot

MPPT For Wind Power Generator

The MPPT algorithm used for the wind power generator is the boost converter. It will step up the voltage up to 13.5 V at the output side at all the time either we get the less voltage at the input of the circuit. Data taken during the experiment is as follow:

TABLE.1 Observation taken on 8th Sept 2015

Time	Wind voltage before the circuit(V)	Wind current before the circuit (A)	Wind voltage after the circuit	Wind current after the circuit(A)	Wind speed (m/s)
10:00	18.7	1.09	12.11	.109	5.8
10:30	15.8	0.96	12.11	.096	4.3
11:00	18.9	1.02	12.18	.102	5.6
11:30	16.5	0.91	12.18	.091	4.2
12:00	20.5	1.2	12.20	.120	6.2
12:30	15	0.95	12.21	.095	4.2
13:00	17.5	1.02	12.21	.102	4.9

13:30	17	0.99	12.25	.099	5.2
14:00	18.5	1.12	12.24	.112	5.9
14:30	16.5	0.95	12.24	.095	4.0
15:00	17.4	0.97	12.29	.097	4.3
15:30	16.5	0.93	12.30	.093	4.1
16:00	18.5	0.98	12.32	.098	5.8

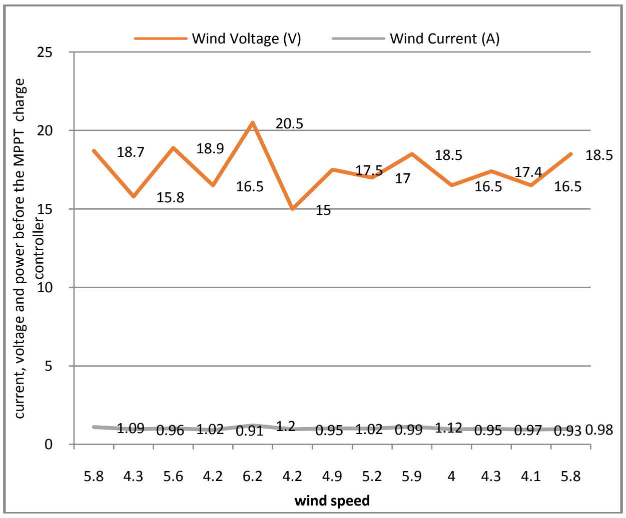

Figure.3.8 Graph between wind speed, current and voltage before the MPPT charge controller

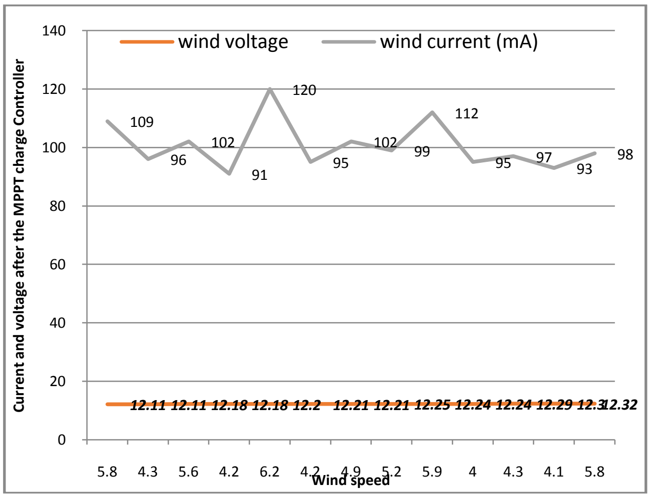

Fig.3.9 Graph between wind speed, current and voltage after the MPPT charge controller

Laboratory Analysis Test Observation For PWM:
The pulse show the value of the duty cycle that is needed to charge the battery. At the different level Pulse Width Modulation1 (PWM1) for solar and PWM2 for wind adjust to control the rate of charging the battery current.

CRO Observation for No Charging.

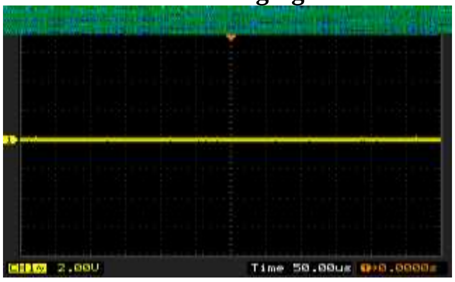

Fig.3.10 No Charge Wave Form

When the solar and wind voltage is below the 11.5 Duty cycle of the PWM1 and PWM2 is 0%.

CRO Observation for Boost Mode Charging.

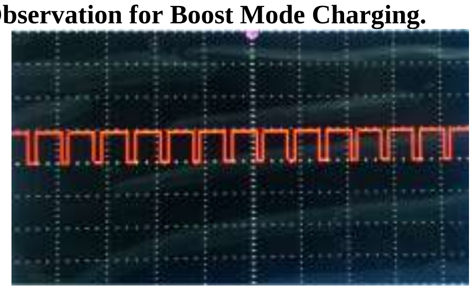

Fig.3.11 Boost Mode Charging Wave Form

When the battery voltage is below the 13.5V.
Duty cycle of the PWM1 and PWM2 is 88.18 approx 90%.

CRO Observation for Float Mode Charging.

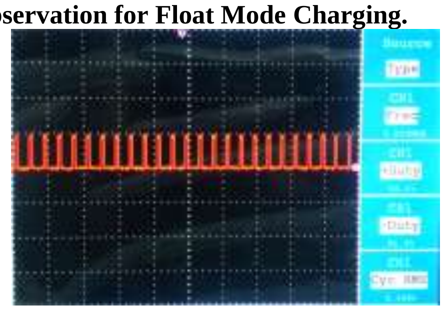

Fig.3.12 Float Mode Charging Wave Form

When the battery voltage is above the 13.5V.
Duty cycle of the PWM1 and PWM2 is 18.19%.

Interface of the DAQ Software:

Fig.3.11 Snapshot of data logging getting to the display

Data send by RX 232 transmitter module to RX 232 receiver module were arranged in the log book.

IV. EXPERIMENTAL SETUP

Experimental set is proposed for the setup of series of 10 Hybrid solar PV Module and 24 Micro wind power generator. Maximum Power which is developed from the system is to aim upto 40W.

Fig.4.1 Proposed System for Hybrid MPPT charge controller and Diagnosis.

V. RESULTS & CONCLUSION

Hybrid MPPT Charge controller, withdraw the maximum power from the hybrid sources like solar and wind energy, has its main motive. With the implementation of MPPT charge controller to setup there increase in the power generation. In this research paper proposed Hybrid solar and Micro wind power generator is tested in the real time at the average speed of wind 4-5 m/s and solar radiation 700-800 W/m^2. To decrease the shutdown time of system we have implemented remote monitoring for the setup and receiving the data of wind speed, solar voltage, solar current, wind voltage, wind current, battery voltage & battery charging current at the display unit to continuously diagnosis the system. The Proposed MPPT charge controller and remote monitoring increases the output power and decrease the shutdown time of system respectively.

VI. RECOMMENDATION AND FUTURE WORK

The proposed system need more modification and upgraded technology to increase its efficiency and make it reliable for the use. Hybrid MPPT charge controller increases the power output but it will not correct the orientation of the system according to the sun and wind speed thus it is better area of modification in this research work as a future work.

1. Tracking for the orientation control of the system according to the power sources.
2. Diagnosis is made to the system but if the problem occurred in the setup there would be mechanism to rectify it.
3. Separate control of wind turbine blade according to the speed of wind this modification will guard the system from the high wind speed.

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