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Design And Development of Wind Charge Controller

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Abstract—Energy sources are broadly divided into to two main types renewable and non-renewable. A Sustainable/renewable energy sources are wind, water, solar energy which can be converted to electrical energy. Wind energy is converted to electrical energy with the help of turbines, but must be controlled before feeding to any grid or storage devices. To control the power generated from turbine to store or to feed any grid a system is needed which will stabilize the power generated. Wind charge controller is a device which will control the power generated from the wind and fed it to storage device such as batteries. Charge controller is the controller uses electronic means to regulate the incoming power and apply the correct charging voltage to the installed battery. Proposed controller will also monitor the battery/system voltage and supply power for load consumption and battery charging. As soon as batteries reaches to a fully charged state, the excess current from the generator will be transferred to a dump load heat element via solid state device called MOSFET.

Keywords*-component; Wind power, wind turbine charge controller, battery voltage conditioner, overcharge protection, wind turbine voltage regulator*

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I. Introduction

The electricity grid can provide households and communities with reliable, high quality, predictable and cheap electricity, but this is far from the norm for the majority of the world's population. Whilst being in the forefront of many governments stated development objectives, widespread electrification is still the dream rather than the reality for most.

In the part or areas without grid, some households use motorcycle, car or lorry batteries to power radios or TV. This small amount of energy can disproportionately improve the standard of living. When there is enough to also provide lighting, it can improve children's opportunities in later life by enabling them to study after dark. Such batteries are often charged in the nearest town, which can be costly in terms of money, time and convenience. At a suitably windy site small wind generators provide a better option for charging the batteries [1].

But the power generated from the wind energy cannot be used directly as wind is not constant throughout the day or season so to use that power it need to be stored and before that it need to be stabilized up to such a level that it can be stored to the batteries and that can be done by designing a Wind Charge Controller which will stabilize the power and convert it to suitable form and level so that it can be stored in the batteries. The proposed charge controller is to prevent damage to the batteries. If the batteries are near to full charge, but the wind is blowing strongly, the charging current needs to be reduced to prevent damage to the battery. The charge controller diverts some power from the generator away from the battery to a Dump load. This can be anything from a series of bulbs, heating coil or etc.

II. Literature Surve

A. Charge Controller Survey

1) It provides a central point for connecting the load, module and the battery.

2) It manages the system so that the harvested electricity is effectively used. Batteries are to be charged within a certain voltage range and regular undercharging or overcharging does not serve them well. So that a battery needs to be protected from damage due to overcharge, deep discharge and changing voltage level.

B. Types of Charge Controller

Charge Controller regulates the charge transfer and prevents the battery from being excessively charged and discharged. Three types of Charge Controller are commonly used viz;

1) Series charge Regulators
2) Shunt charge Regulators
3) DC-DC converter

Analog type charge controllers include operational amplifiers which indicate the battery status by glowing the LED. The status of battery can be known by LED. Most of the analog charge controllers glow RED LED for battery discharge and GREEN LED for battery charging.

ON/OFF charge controllers simply make ON and OFF the controlling element like MOSFET so that either full or no current will be passed to the battery.

(Pulse-width modulated) PWM charge controllers which charge the battery with constant voltage or constant current are also being used. They have a power device like MOSFET which is made ON and OFF. The efficiency of PWM charge controllers is higher than analog and simple ON/OFF charge controllers. PWM have ability to recover battery capacity, to increase charge acceptance of the battery. The PWM based charge controllers provide longer battery life, saves the cost by reducing size.

The (maximum power point tracking) MPPT types are newly introduced and are latest trend in market. They are more costly and better suited to large systems, when the investment in an expensive MPPT regulator gives quick returns. The MPPT charge controllers charges the battery at full power by maintaining efficiency of 90% to 93%. Among all discussed charge controllers in this report, the MPPTs provide excellent efficiency however they are costly [2].

C. Efficiency Of Different Types Of Charge Controller

TABLE I
EFFICIENCY OF DIFFERENT CHARGE CONTROLLER

Sr. No.	Type of charge Controller	% Efficiency
1	Analog series/shunt mode charge controller	60%to70%
2	ON/OFF charge controller	65% to 75%
3	PWM Technique based charge controller	75% to 85%
4	MPPT Technique based charge controller	Above 90%

D. Disadvantages Of Existing Analog Charge Controller

The main disadvantage of this type of circuitry is the efficiency is very low as the circuits do not consider input power or output power. Thus any mismatch between input and output power may lead to loss of power resulting in low efficiency.

- The status of charged battery can be known only from LED displays.
- The system cannot be used for large current applications.
- No display has been connected so that actual battery voltage cannot be monitored.

To overcome disadvantages of above said system the proposed system is developed. This system will detect the full charged level of the battery and will give an indication in form of GREEN LED glow and allow to charge the battery up to further 20% i.e. 57.6V which is an preset value and after that, it will switch ON and OFF the MOSFET according to status of battery (Whether fully charged or discharged) to divert the extra current to the DUMP load. In addition it will also display the present voltage of battery indicating the actual status of battery [6].

E. Advantages of proposed charge controller over existing system

- The system uses MPPT algorithm hence the efficiency of the system is higher.
- The system shall be designed for large current ratings in Ampere.
- The system is user friendly hence can be easily operated by users.
- System will be compact and handy.

III. WIND ENERGY SYSTEM

The overall systems block diagram is shown in Fig. 1 which includes wind turbine for converting wind energy to the electric energy in charge controller circuit diagram there is three phase wind turbine generator which produces three phase out put.

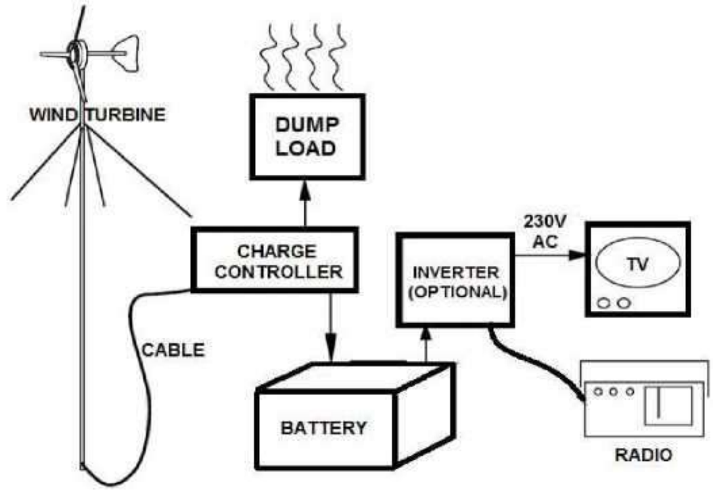


Fig. 1 Block diagram of wind energy system

from the wind turbine the AC three phase output is given to the charge controller where the charger controller includes three phase full wave rectifier which converts the AC output of the turbine to DC upto such level so that battery(48V) can be charged. Charge controller also detects the maximum charged level of the battery and give indication in form of blinking LED and if the battery get over charged up to 20% i.e. 57.6V then charging current needs to be reduced to prevent damage to the battery therefore charge controller diverts some power from battery to a Dump load. The stored power can be used directly by connecting to dc loads like Blowers, DC motors etc. or by connecting the output of battery to inverter for converting DC output to AC and use AC loads like TV, Radio etc.

IV. PROPOSED CHARGE CONTROLLER SYSTEM

To store the energy generated by the wind, wind-turbine needs a controller to adjust the generator voltage upto the battery voltage level. The alternating voltage generated is in the form of phase, and the battery voltage is continuous, so that converter is necessary and hence charge controller also comprises of converter circuitry (bridge rectifier) to convert AC to DC. A typical installation of wind charge controller is as shown in Fig.2. The system includes a wind turbine, Charge Controller, Divert Resistor, battery and an inverter. The inverter is additional and converts the battery DC power into standard AC power such that common mains powered appliances can be supplied [11].

As seen in the Fig.2 that the charge controller system is not a single unit i.e. it's not a stand-alone system. It basically comprises of wind turbine, charge controller, battery bank dump load, circuit breaker(break switch maintenance purpose), inverter and various loads.

Therefore from Fig.2 the main components of wind charge controller system are as followings:-

- Wind turbine
- Charge controller

- Battery bank
- Dump load

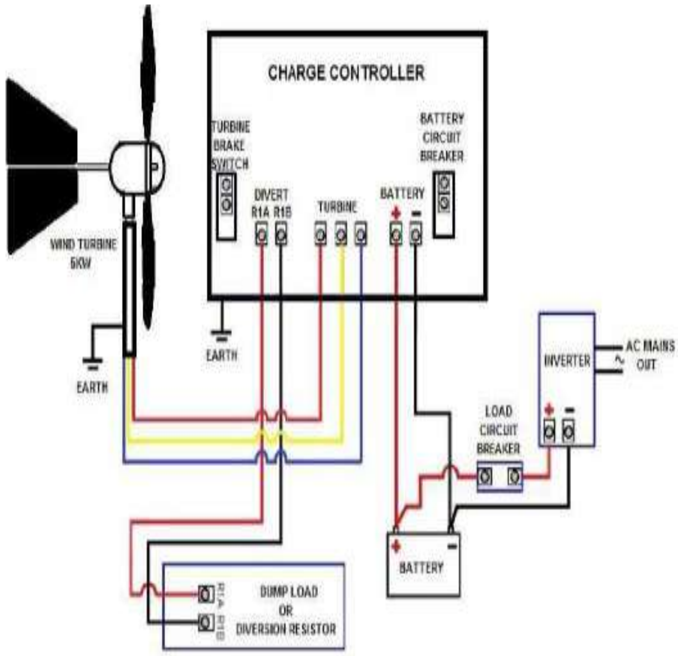


Fig. 2 Wind charge controller connected to dumpload and battery

A. Wind turbine

The synchronous machine is characterized in that the relationship between engine speed and frequency is always constant and is a function of the number of pole pairs. The output voltage is independent of the rotational speed for the wound rotor synchronous motor, but for the permanent magnet, the output voltage is proportional to speed.

The synchronous machines have very good characteristics to use as a generator:

- In isolated systems can independently control the frequency (in from of velocity) and the amplitude of the voltage (current from excitation).
- For network connection, you can independently control powers active (from the prime mover) and reactive from the excitation current.

The synchronous machine dominates the market for electricity generation, both large as small power plants and in isolated systems. Note that the synchronous machine is less usual use as a motor, although it is interesting to use in some applications where a power necessary large volume. Therefore synchronous machines are used for generation applications by providing permanent magnet rotor. As synchronous machines built with permanent magnet has a smaller volume compared to the others [3].

B. Charge controller

Basically, battery is the main component in renewable energy system. Energy generated from different renewable energy sources such as wind and solar, however the frequent charging and discharge the battery will lead the battery to have short term. Thus, the important of using charge controller is the main concern in keeping the battery life longer and optimize the system [4].The wind charge controller is suitable for wind turbines with brushless permanent magnet generators or hydro systems with brushless permanent magnet generators, which has a three phase AC output within the corresponding voltage range. It rectifies and regulates the generator's three phase alternating current in order to be able to charge battery banks in a smooth and safe way. The charge controller also protects the batteries from over-charging by transferring the charging current to dump load. It includes the main switch which short- circuits the three phase of the generator when in OFF position (break switch) for maintenance purpose.

Fig.3 shows Wind charge controller with its essential components

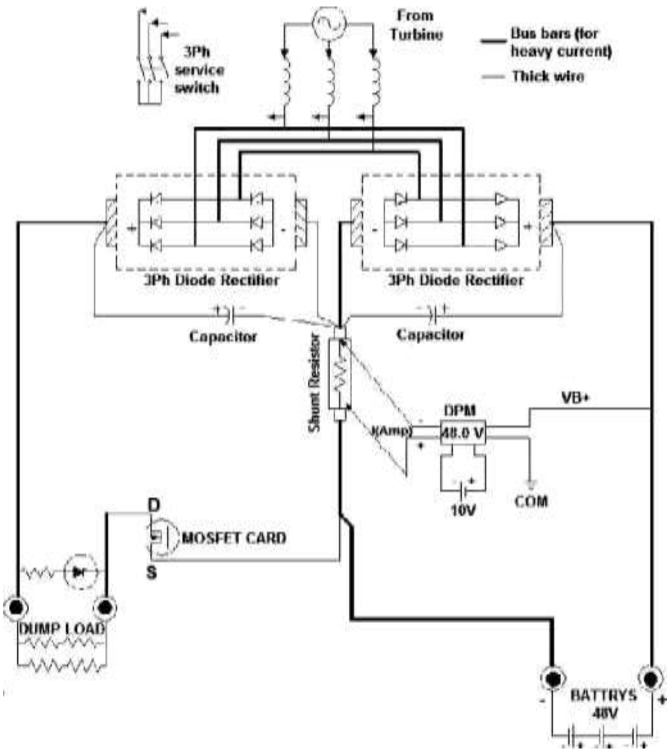


Fig. 3 Wind charge controller's internal blocks

1) Full Wave Rectifier Bridge: The wind turbine generator is a three phase synchronous motor with permanent magnets six pairs of poles. As can be seen, the turbine produces a phase current at different frequencies, as the air, which is the driving force of the motor is variable. For continuous tensions, it must rectify the voltage generated by the wind turbine. The most effective way to move from AC to DC voltage, is using a diode bridge (single phase) or three-phase rectifier. This type of semiconductor employed as the rectifier diode. They are called this way because you can control the output power, i.e. for a fixed input voltage output voltage is also fixed. In an uncontrolled three-phase rectifier circuit 6 pulse, diodes are listed in the order of the driving sequences and each conducted for 120° of the period. The driving sequences for the diodes are D1-D2, D3-D4, D5-D6, and D1-D6.

2) Smoothing Capacitors: This capacitor makes sure that the voltage output from rectifier is a smooth. The heavier the load (higher current), the faster capacitor will discharges, thus there will be more ripple. We want an input voltage (to the load) as smooth as possible because sometimes the device acts weirddue to a power supply with large ripple [10]

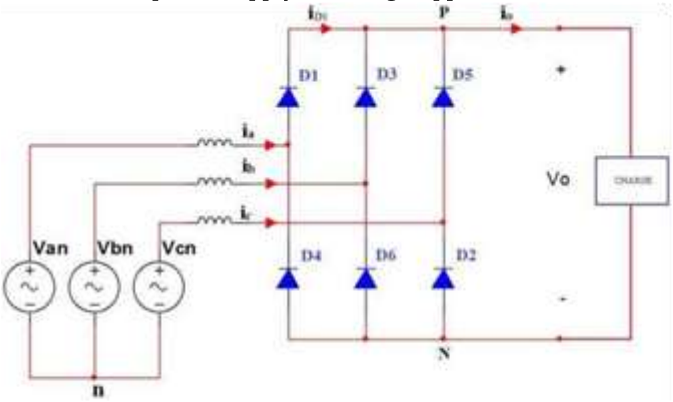
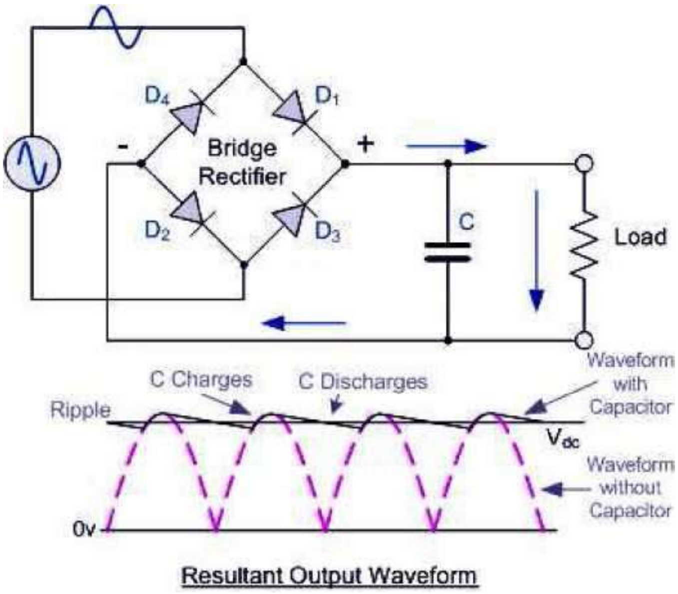


Fig. 4 Three phase rectifier

When the load is heavy, at that time the ripples are too large, in such conditions use a bigger capacitor, because that smooth's the line voltage more efficiently in Fig.3 there are two smoothing capacitors used one for supplying battery and another is for the Dump load. During the normal operation when battery is charging at that time capacitor connected to battery is in the working condition and when battery get over charged at that time capacitor connected to Dump load provides supply to Dump load..



3) *Shunt Resistor & DPM (Digital Panel Meter):* Shunt resistors are used to measure the DC current in any line and DPM is the digital panel meter which is used to display the electrical parameters such as current and voltage. As mentioned charge controller also need display battery present status i.e. present voltage and current for that Shunt resistor is used to measure the current and as DPM is connected across the battery it will also measure the battery voltage and display it on the LCD screen mounted on the panel of charge controller.

4) *MOSFET Bank:* MOSFET is used as the power electronics switch which switches the charging current from bat- tery to the dump load. MOSFET bank is an PCB card on which circuitry for switching the dump load is there which includes the comparator circuitry, voltage regulator circuitry for supplying OPAMP and DPM is there basically it is called as an heart of any charge controller [7].

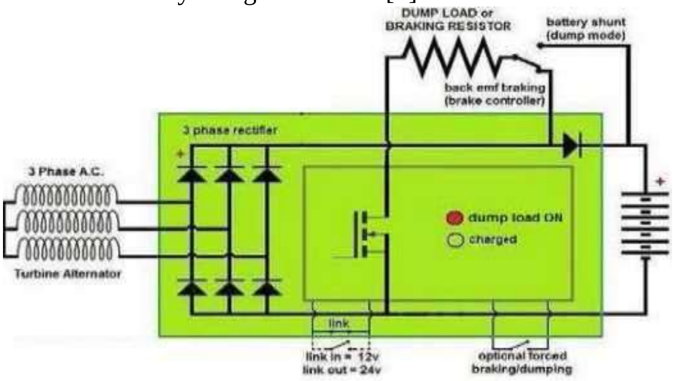


Fig. 6 MOSFET as switch for controlling switching of dump load

5) *Dump-Load:* When the battery has reached a fully charged state, the excess current from the generator is transferred to a dump load heat element via solid state MOS-FETs. The filament of dump load is made of ***NiCr*** material, which prevents the humming noise during operation, which is a typical characteristic of ferrite-based heating elements [4]. A blocking diode protects the batteries from alternating DC currents, which has a lifetime decreasing effect on the batteries. A capacitor permits the disconnection of the battery terminals in all circumstances [8].

Fig. 7 Dump load

V. Conclusion

The charge controller in the proposed circuit can now be able to detect the full charged level of the battery by giving an indication in form of a blinking GREEN light and allow to charge the battery further upto 20% i.e. 57.6V and when the battery reach to the predefined value of 57.6V the MOSFET bank switches the charging current form battery to the dump load and this will prevent the battery to charge further upto danger level and also prevents the batteries life to degrade bay over charging.

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