RESEARCH ARTICLE OPEN ACCESS

Development of Charge Controller for Small Scale Wind Energy Conversion Systems

R. Sujitha, K. R. Santhya, A. Vigneshwari, V. Varsha, Dr. K. Elango
(EEE, SRM Valliammai Engineering College, and Kattankulathur
Email: sujitharavi99@gmail.com)
(EEE, SRM Valliammai Engineering College, and Kattankulathur
Email: santhyakr77@gmail.com)
(EEE, SRM Valliammai Engineering College, and Kattankulathur
Email: avickyeee11@gmail.com)
(EEE, SRM Valliammai Engineering College, and Kattankulathur
Email: nalinivishwanathan81@gmail.com)
(Professer and Head, EEE, SRM Valliammai Engineering College, and Kattankulathur
Email: elangok.eee@valliammai.co.in)

--************************----------------------------------

Abstract:

This paper presents the development of charge controller for small scale wind energy conversion systems. It is designed using PIC 16F877A microcontroller, Silicon controlled rectifier (SCR), LCD display and other electronic components. Here, the microcontroller circuit controls the charging of the battery with the help of SCR and other components. The LCD is used to display the battery's voltage level. When the battery is fully charged the charging current is diverted to the dump load. An audible alarm circuit is also used to produce signal in case of full charge battery. This controller protects the battery from overcharging and deep discharging.

Keywords — **Renewable Energy, Controller, PIC, Wind Turbine.**

--************************----------------------------------

I. INTRODUCTION

Wind energy is a clean and renewable energy and one of the most economical forms of available alternative energy. The main components of wind energy conversion system includes the turbine, generator, controller and the power grid. The kinetic energy of the wind is converted to mechanical energy by means of a wind turbine. Then the mechanical energy is converted into electrical energy by the generator.

Wind energy applications often use batteries for storing excess energy such as in photovoltaic systems. Batteries are often prone to deep discharging and over charging. These phenomeno causes adverse effect in the life of the batteries. Thus in order to protect the batteries and to increase their life span, a charge controller should be used. In photovoltaic system the controller just disconnects the batteries from the generator.

This occurs in case of fully charged batteries and during deep discharging. This principle cannot be used in wind turbine applications. The charge controller proposed here prevents over charge, deep discharge and protects the battery.

II. PROPOSED SYSTEM

The charge controller is built using Silicon controlled rectifier (semi conductor switches) rather than relays (electro mechanical switches). This controller is used to control the battery over charging, to display the battery voltage continuously and to make an audible alarm when it is charged fully. Initially high current through the SCR is used in charging the battery. When the battery is charged near to its full terminal voltage high current charging is stopped and trickle charging (slow charging) starts and when the battery is fully charged, charging is entirely cut off by the control of micro controller. The current from the wind turbine through the converter is being diverted to a diversion load (e.g. lamp). Hence by this overcharging of the battery can be prevented. This charge controller can charge both 12v and 24v battery with 10 A of current.

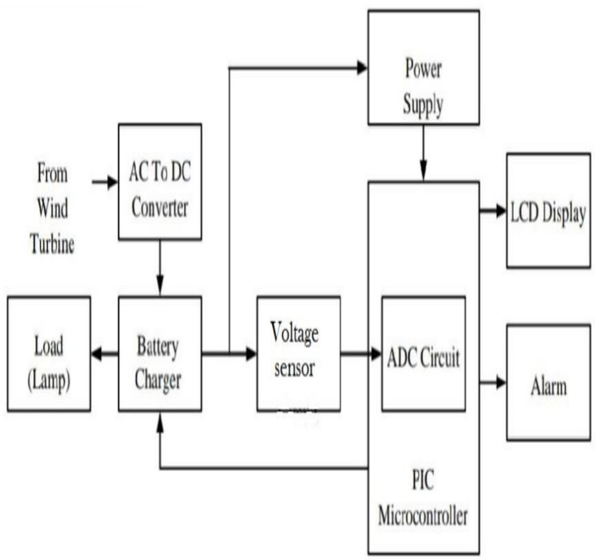
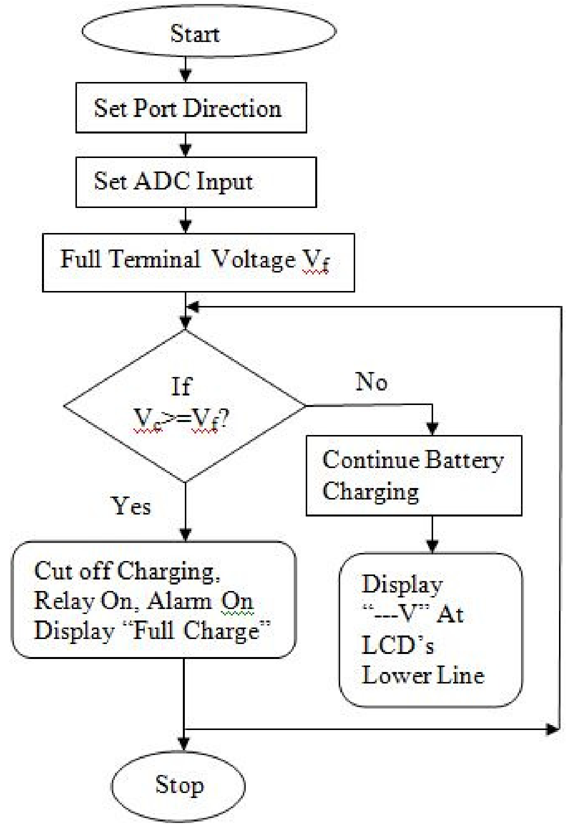


Fig. 1 The Block Diagram of the Charge Controller

III. FLOW CHART

The RA0 pin of the micro controller is configured as the ADC input pin and the reference voltage is assigned as +5V for the ADC. Here in this controller a 4 bit mode is used to display the message. The message "battery Voltage" is displayed in the upper line of the LCD module. The program checks the battery charging voltage at RA0. The charging continues if the battery voltage displayed is less than the full terminal voltage. Then the lower line of the LCD will display "full charge" when the battery charging is completely stop. Then the program will loop back to the start of the voltage comparison statement after waiting about one second.



IV. IMPLEMENTATION

The operation of the charge controller circuit is simple. It will charge the 24V battery untill its full terminal voltage is attained. Once the battery's full terminal voltage is attained, the controller changes from normal charging mode into the slow charging mode. At the end battery charging is totally cut off. This will lead the audible alarm to get activated. Therefore a battery is being saved from overcharging damage. At any time the difference in potential between the anode and cathode of SCR1 is the instantaneous value of the battery's voltage. The potential difference between the anode and cathode of SCR1 is high when the voltage of the battery is low.

When the battery voltage is high the voltage difference between the anode and cathode is low. This fact constitute the working of this charge controller. The current flows into the gate terminal of SCR1 through a resistor and diode namely R5 and D7 when the voltage of the battery is low. Thus, this will lead the SCR1 to conduct heavily and allows the battery to charge with large current. The serially connected resistor R3 and the preset resistor PR2 is used to sense the voltage of the battery. Thus the voltage divider circuit is formed by the resistor R3 and the preset resistor PR2. Thus the voltage divider equation can be used to calculate the voltage at the centre tap of the preset resistor PR2.

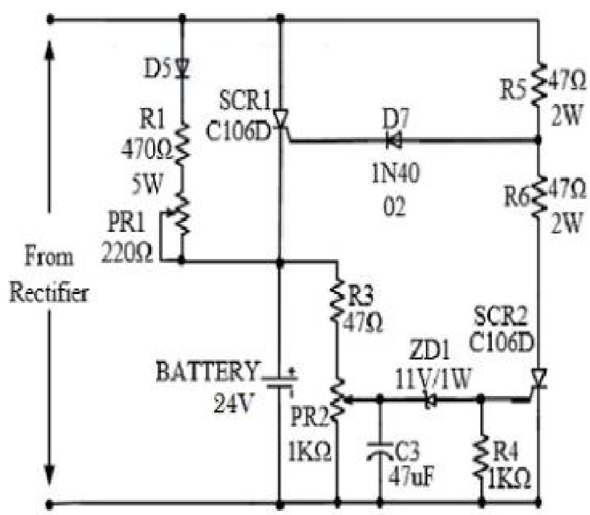


Fig. 2 The SCR Controlled Battery Charger Circuit

A zener diode ZD1 is being connected to the centre tap of PR2. The gate terminal of SCR2 has been connected to the anode of zener diode ZD1. If the voltage VC developed at the centre tap of the preset resistor PR2 is less than the voltage of zener diode, the SCR2 doesn't conduct. If the battery of the voltage increases due to the charging current the voltage VC will also become high. SCR2 will start conducting for every half wave cycles when the voltage VC becomes higher than the zener voltage. The SCR2 starts conducting at 90 degree of the positive half cycle. In other words this is the largest charging current position by SCR1 and therefore the charging current is shunt to the resistors namely R5, R6 and the SCR2.

During this stage SCR2 conducts earlier than SCR1. The heavy conduction of the SCR2 will reduce the potential drop across the terminals of SCR2.

This will lead to the decrease in voltage between the resistor R5 and R6 and reverse biasing the diode D7. This will stop the gate current of SCR1 stopping its conduction also. Thus charging through SCR1 is cut off. The power ratings of the resistors R5 and R6 should be chosen appropriately in order to withstand the current which is been passed through SCR2 during heavy conduction.

There is another charging current path to the battery even though there is no charging current through SCR1. The diode D5, resistor R1 and the preset resistor PR1 constitute this path which is nothing but the slow charging current path also known as trickle charging path. By this the battery is protected from being over charged. This slow charging current can be set by adjusting the preset resistor PR1. Preset resistor PR2 is adjusted to set the full terminal voltage of the battery.

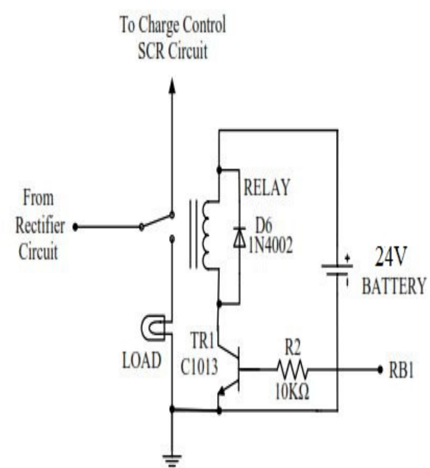


Fig. 3 Relay Circuit for Load Diversion

The RD1 pin is configured as the digital output pin in the micro controller. When the battery is charging, this RD1 pin will produce logic '0'. When the full terminal voltage is attained it will produce logic '1'.

This relay circuit for charging and load diversion consists of a transistor as in Fig. 3. The emitter of the transistor is grounded and the collector terminal is connected to the battery's positive terminal via the relay coil. The transistor is in off state during the charging state of the battery i.e. RB pin is at logic '0'. Under this condition there is no current through the relay i.e. the relay is not activated in this condition.

Several mA of current is needed to activate a relay coil. The transistor's current gain is nearly 100 therefore an assumption is made that 40 mA is required to activate the relay coil. Therefore the transistor is ON, the current passes through the relay coil. As seen in the circuit diagram Fig. 4, a load (e.g. lamp) is connected between the ground and the open terminal. Therefore the current coming from the rectifier circuit is passed to the ground through the load. Thus the current flowing from the rectifier circuit to the SCR controlled charger circuit is cut out. Therefore the battery is not charged any more preventing the battery from overcharging.

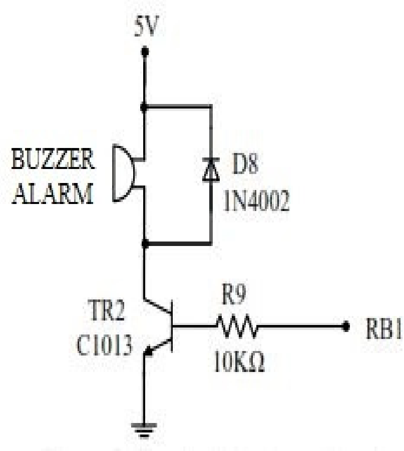


Fig. 4 Buzzer Alarm Circuit

There is an another transistor TR2, a diode D8, a buzzer and a current limiting resistor constituting the audible alarm circuit. When the battery reaches it's full terminal voltage the transistor TR2 is turned on and this leads the buzzer to produce audible alarm.

V. RESULT AND DISCUSSION

Since the wind speed velocity varies randomly with time, weather conditions, climate it is convenient to test the developed charge controller with a step down AC transformer instead of a AC generator of the wind electric power generator with the same power rating. The voltage of the battery is displayed in the LCD module for every second while the battery is charging. When the battery is in the charging state of 10V, the LCD module's first line will display "BATTERY VOLTAGE" and V(b) = 10V is displayed in the second line. When the battery is completely charged i.e. 24V, the first line of the module shows "BATTERY VOLTAGE" and "FULL CHARGE" message is displayed in the second line and the power from the generator is diverted to the dump load.

VI. CONCLUSION

The main objective of this work was to develop a charge controller dedicated to small scale wind energy conversion systems. The charge controller developed here can control a maximum charging current of about 15 A which is enough to charge a battery of about 150 to 200 Ah. To ensure long life span and to avoid damage of the battery due to overcharging and deep discharging, a charge controller has to be implemented.

VI. REFERENCES

1. Kuldipsinh. I. Rathod, Mahipalsinh.B.Jhala & A.D.Patel, " Modeling and Simulation of Wind Turbine Connected to PMSG for Wind Mill Application", International Global Journal For Research Analysis, Vol. 3, No. 3, March 2014, pp. 41-44.
2. Prerna Badoni and S. Bhanu Prakash, "Modelling and Simulation of 2MW PMSG Wind Energy Conversion System", IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), e-ISSN: 2278-1676, p-ISSN: 2320-3331, Vol. 9, No. 4, Ver.1, Jul-Aug. 2014, pp.53-58.

3. L. Maharjan, S. Inoue, H. Akagi, and J. Asakura, "State-of-charge (SOC) balancing control of a battery energy storage system based on a cascade PWM converter," IEEE Trans. Power Electron., vol. 24, no. 6, Jun 2009, pp. 1628-1638.
4. M.A. Abdullah, C.W. Tan, A.H.M. Yatim, M.R.D. Al- Mothafar and S.M. Radaideh, " Input Current Control of Boost Converters using Current-Mode Controller Integrated with Linear Quadratic Regulator ", INTERNATIONAL JOURNAL OF RENEWABLE ENERGY RESEARCH, Vol. 2, No. 2, 2012, pp. 262-268.
5. Amit Kumar Singh, Abhishek Kumar Agrawal, Simran Vohra, Shailendra Singh Thakur and Gajendra Patel, "Solar Charge Controller", International Journal Of Academic Research And Development, Vol. 2, No. 6, November 2017, pp. 994-1001.
6. V. Sharmila Deve and S. Karthiga, "ADVANCED CONTROL TECHNIQUES IN VARIABLE SPEED STAND ALONE WIND TURBINE SYSTEM", International Journal of Advances in Engineering & Technology, March 2012. ©IJAET ISSN: 2231-1963 Vol. 3, No. 1, pp. 549-557.