International Journal of Electronics Communication and Computer Engineering
Volume 3, Issue 1, ISSN 2249 –071X

Microcontroller Based Solar Charge Controller for Power Application

Mr. Vikas Khare
E-mail : vikaskhare09@yahoo.co.in

Abstract — **Photovoltaic cell converts solar energy directly into electricity. This paper describes a design of microcontroller based solar charge controller for power application.[2] The work of the Paper is to charge a 12 volt battery by using a 50 watt solar panel with maximum power. This circuit regulates the charging of battery in a solar system by monitoring battery voltage and switching the solar or other power source off when the battery reached a preset value.[1] The microprocessor based charge control technique presented in this paper shows the assurance for charging the battery with the maximum power. Though the voltage of photovoltaic cell and the voltage of battery are different, the maximum power can be attained during battery charging from the photovoltaic cell through this technique. The voltages of the solar panel are different in different time and days.**

Key Words — **photovoltaic cell, MOSFET, Solar charge controller**

I. INTRODUCTION

Photovoltaic production becomes double every two years, increasing by an average of 48 percent each year since2002. For this reason it becomes the world's fastest growing energy technology. Photo voltaic efficiency is very important for solar application. There are three ways to increase the efficiency of a photovoltaic (PV) system. The first way is to improve the solar cell's efficiency. The second method is a solar panel tracking system to increase the efficiency of a PV system. Progress of solar panel tracking systems has been continuing for a number of years now. The third way is to maximize the energy conversion from the solar panel. A charge controller circuit can increase battery life by preventing over-charging which can Cause loss of electrolyte. The absence of a relay and its associated coil current makes this circuit efficient for small systems as well as for systems using larger current components. This charge controller was designed for high efficiency, use of common parts, and operation with common ground circuitry. The charge controller circuit has been used with solar power input. It also functions well as a battery Charger when used with any current limited DC power Supply such as small "wall wart" transformers or a high Current supply with a series resistor.

II. SYSTEM MODELING

During charging, current flows from the solar panel through diode D1, MOSFET transistor Q1, fuse F1, and into the battery. Power MOSFET transistor Q1 is the main switching device in the charge controller circuit. It connects the solar panel to the battery when it is in need of charging and power is available from the solar panel. As with the LVD circuit, Q1 is set up in a "high side" switch arrangement which allows for a common Ground circuit. This is helpful in automotive and other applications. Switching efficiency is very high due to the low "on" resistance of modern power MOSFETS, usually under 0.1½. Diode D1 is a Schottky device preventing back currents from flowing from the battery to the solar panel. A regular silicon diode may be used but a Schottky will have a lower forward voltage drop and resulting higher efficiency. Fuse F1 provides a safety limit on the current available from the battery in The event of a short. Comparator U2 is used to control power to the rest of the charge controller circuit. When the solar panel voltage is lower than the battery voltage, the rest of the circuitry is disabled, reducing night time idle current to the few milliamps consumed by U2 and its associated input circuitry. When the solar panel voltage rises above the battery voltage, the output of U2 goes negative switching on transistor Q2 which provides rest of the circuit. Resistor networks R1/R13 and R2/R4scale the battery and solar panel voltage to a range that is useful to U2. Capacitor C23 prevents oscillation in the comparator at start up. Voltage regulator U4 is used as a reference for the battery Reference points are adjusted via resistor network R11, R12, and R3. Comparators U1A and U1B monitor the battery voltage and switch states when the battery is fully charged (U1B) or has dropped to a voltage where charging should resume (U1A). The comparators drive a set-reset flip-flop circuit consisting of U3A and U3D. The comparator outputs are inverted logic, on is low and off is high. The output of the flip-flop is used to turn the oscillator consisting of U3B and U3C on and off. The flip-flop also drives the two LEDs used to indicate charging or battery full states. The oscillator generates a 10 kHz square wave that is stepped up to around 25Volts DC by the voltage doublers circuit of D5, D6, D7, and C7, C8, C21. The gate voltage is higher than the battery's 13

International Journal of Electronics Communication and Computer Engineering
Volume 3, Issue 1, ISSN 2249 –071X

Volts, and is used to turn Q1 on fully. Ferrite bead L2 is used to prevent oscillation inQ1.Resistor R9 discharges the voltage doublers when the oscillator is shut off. The technically picky may note that all of the ICs comparators are really common op-amps, not special purpose comparators. The op-amps are wired in a comparator configuration. The circuit is fairly dependent on the use of 741 and 1458 op-amp parts. Other op-amps may require changing the values of R1and R2. An equalize switch is included to allow for occasional over-charging of the battery by raising the threshold of the high voltage sensing comparator, forcing the charge current on. Equalizing helps bring lower voltage cells in the battery up to a full charge.

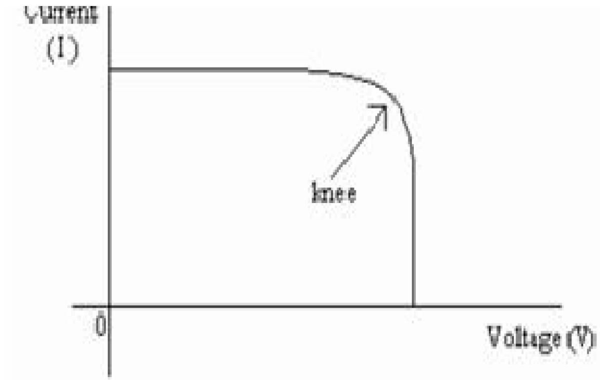

Fig. 1: V-I curve for a solar panel [2].

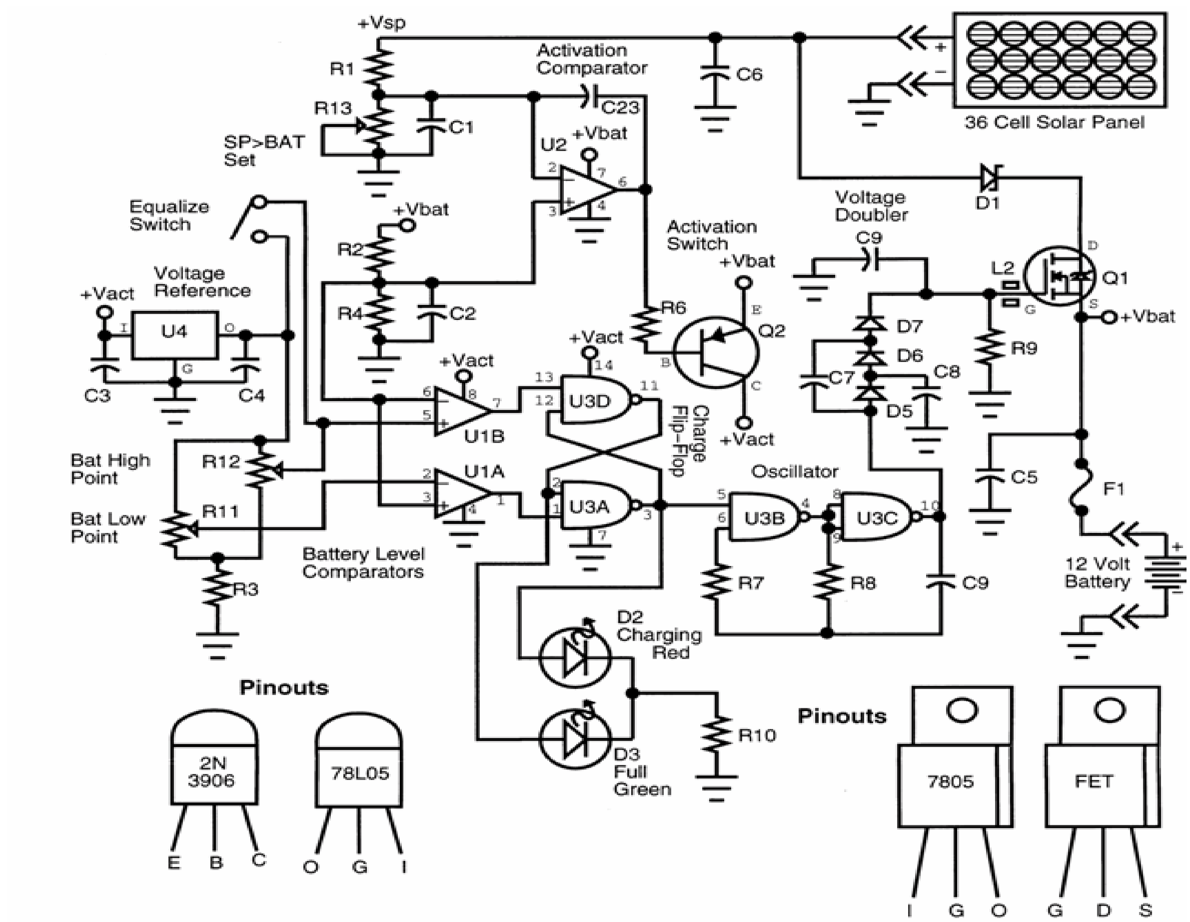

Fig. 2 Solar charge controller

III. Current Capacity

The current handling capacity of this circuit is determined by the MOSFET transistor Q1, diode D1, Fuse F1, and the current carrying wires in the path between the solar panel and the battery. An IRFZ34MOSFET is rated at 30 Amps max and should easily Handle 10 Amp charging currents. A heat sink should be used on the MOSFET and diode D1 if you are running currents higher than 2 or 3 Amps through the circuit. The peak current may be determined from the solar Panel specs. Diode D1 can be an IR 80SQ045 when the max current is less than 8 Amps. Higher current Diodes such as the GI MBR1045GI rated at 10 Amps May also be used with a heat sink. For efficiency, it is Important to use a Scotty barrier diode since it has a Voltage drop of around 0.4 Volts under load while a Regular silicon diode has a voltage drop of around 0.8 Volts under load. At 5 Amps, the silicon diode would Waste 4 Watts while the Schottky diode wastes only 2Watts. The circuit board version of this circuit can Handle about 8 Amps maximum if the proper Semiconductors are used. The fuse should be rated the same as the maximum current of the FET or diode D1, Whichever is lower. Part list of the system is given in appendix. Application of the system is Connect the solar panel to the solar panel terminals and the battery to the battery terminals and watch the battery charge up. When the LEDs alternately blink, the battery is charged. A load may be connected between ground and the fused C5-Q1 source junction if the load current is lower than the fuse rating. The circuit board has the companion LVD circuit connected in at this point. Be sure to use battery cables that can handle the load current. If the circuit is to be connected to a high current source such as an automobile cigarette plug or a high current capable power supply instead of a solar panel, it will be necessary to use a high wattage series resistor between the positive power source and the charge controller solar panel input.

IV. Implementation of Charge Control Program

Flow Chart of the PWM Charge Control program is shown in fig.3. According to the flow chart a program is written in assembly language and loaded the program in to the microcontroller. Here, the microcontroller initially set a pulse which is appropriate for 14 volt at where the maximum power point was achieved from the experiments before. Microcontroller gets the solar panel's voltage through its one pin and digitizes it. It compares the digitized value with the stored value of 14 volt. If it matches, microcontroller maintains the pulse. But if the getting voltage is greater than 14 volt, decreases the pulse width, hence voltage will be increased and vice versa [8].

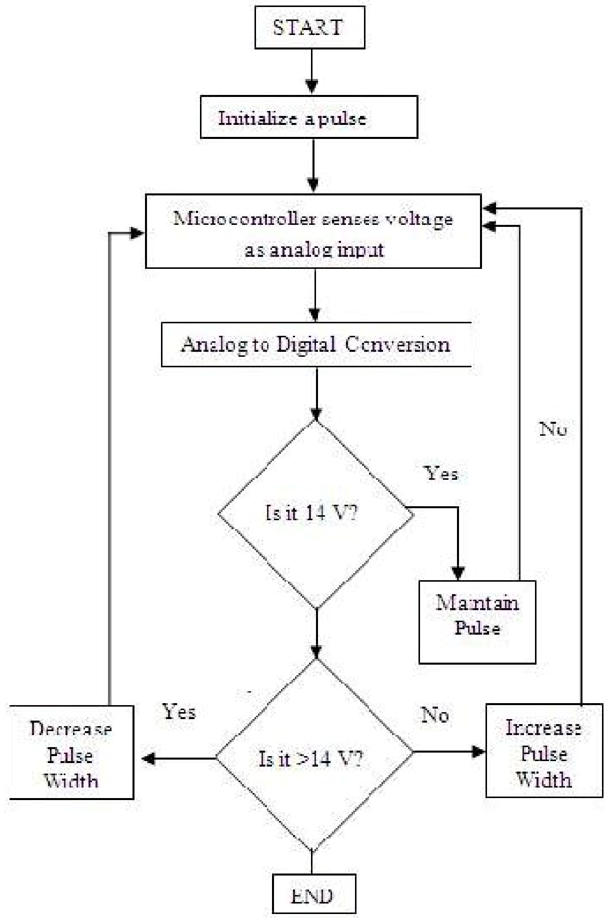

Fig. 3 Flow chart of change control program [8]

V. Conclusion

The microprocessor based charge control technique presented in this paper shows the assurance for charging the battery with the maximum power. Though the voltage of photovoltaic cell and the voltage of battery are different, the maximum power can be attained during battery charging from the photovoltaic cell through this technique. The voltages of the solar panel are different in different time and days. This depends on the solar cell's consumed sun light. When the sky is cloudy or there is no enough sun light, the voltage of the solar panel becomes low. In that case, by increasing the pulse width, the battery is charged with maximum power. For this reason, the battery is charged quickly and efficiently.

APPENDIX

1. U1 1458 dual op-amp
2. U2 741 op-amp
3. U3 4011 CMOS quad nand gate IC
4. U4 78L05 or 7805 voltage regulator IC
5. Q1 IRFZ34 power MOSFET, see text
6. Q2 2N3906 PNP silicon transistor
7. D1 80SQ 045, or MBR1045GI Schottky diode, see text
8. D2 Red LED
9. D3 Green LED
10. D5-D7 1N4148 silicon switching diode
11. C1-C8,C21,C23 0.1mF ceramic disc capacitor
12. C9 0.001mF ceramic disc capacitor
13. C20 100mF 16V electrolytic capacitor
14. R1-R3,R7 100KW 1/4w resistor
15. R4 39KW 1/4w resistor
16. R6, R10 2.2KW 1/4w resistor
17. R8 47KW 1/4w resistor
18. R9 1MW 1/4w resistor
19. R11-R13 100KW 10 or 15 turn trimmer potentiometer
20. F1 DC fast blow fuse, see text
21. L2 ferrite bead or 3 turns #24 wire on a 22 W 1/4w resistor
22. Heat Sink TO-220 finned heat sink on Q1for greater than 3A capacity (don't ground the Q1 tab, it's hot)
23. Battery 12 Volt lead acid flooded or gel cell battery
24. Solar Panel 36 cell photovoltaic panel, see text about maximum current.

REFERENCES

[1] Wikipedia,http://en.wikipedia.org/wiki/Photovoltaic
[2] Robert Weissbach, Isaac Auks', AC 2007-1213: A MICROCONTROLLER-BASED SOLAR PANEL TRACKING SYSTEM, American Society for Engineering Education, 2007
[3] Why PWM, Morning Star Corporation, USA, www.morningstarcorp.org allows.
[4] Pico, Z.G. Park, J.M. Kim, J.H. Cho, G.B. Beak, H.L., "A study on the tracking photovoltaic system by Program type, Electrical Machines and Systems, 2005. ICEMS 2005. Proceedings of the Eighth International Conference on, 27-29 Sept. 2005, page(s): 971 - 973 Vol. 2.
[5] Chanchiang Hula and Chiming Sheen, "Comparative study of peak power tracking techniques for solar storage system," Applied Power Electronics Conference and Exposition, 1998. APEC '98. Conference Proceedings1998, Thirteenth Annual, Volume 2, 15-19 Feb. 1998 Page(s):679 – 685.
[6] Saxena, A.K.; Dutta, V., "A versatile microprocessor based controller for solar tracking," Photovoltaic Specialists Conference, 1990., Conference Record of the Twenty First IEEE, 21-25 May 1990, Page(s):1105 -1109 vol.2.
[7] Dobson, F., Lugo, A., Mender, J., Valera, P., Osuna, R., Acosta, L., and Magical, G.N., "First results of the tetra-track system and control electronics," Photovoltaic Energy Conversion, 2003. Proceedings of 3rd World Conference on, 12-16 May 2003, Page(s):2050 - 2053 Vol. 2.
[8] Design & construction of microcontroller based maximum power point PWM charge controller for photo voltaic application Gazi Mohammad Sharif, S. M. Mohaiminul Islam, Khosru Mohammad Salim.
[9] Dobon, F., Lugo, A., Monedero, J., Valera, P., Osuna, R., Acosta, L., and Marichal, G.N., "First results of the tetra-track system and control electronics," Photovoltaic Energy Conversion, 2003. Proceedings of 3rd World Conference on, 12-16 May 2003, Page(s):2050 - 2053 Vol. 2.
[10] Yousef, H. A., "Design and Implementation of a Fuzzy Logic Computer-Controlled Sun tracking System,"Proceedings of the IEEE International Symposium on Industrial Electronics, ISIE '99, Volume 3, 12 – 16 July 1999, pp. 1030 – 1034.
[11] Pritchard, D., "Sun tracking by peak power positioning for photovoltaic concentrator arrays," IEEE Control Systems Magazine, Volume 3, Issue 3, August 1983, pp. 2 – 8.
[12] Urbano, J.A.; Matsumoto, Y.; Asomoza, R.; Aceves, F.J.; Sotelo, A.; and Jacome, A., "5 Wp PV module-based stand-alone solar tracking system," Photovoltaic Energy Conversion, 2003. Proceedings of 3rd World Conference on, 12-16 May 2003, Page(s):2463 - 2465 Vol. 3.

AUTHOR'S PROFILE

Mr. Vikas Khare

Assist. Professor in SGSITS, Indore. His completed B.E. in Electrical and M.Tech in energy management.

Email: vikaskhare09@yahoo.co.in