Battery Charger With Active Power Filter

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Abstract :-**This paper present single phase battery charger with active power filter using simulation and hardware.The active power filter is used to mitigate the distortion current by injecting equal but opposite current to shape the pulsating of the supply current to sinusoidal form that is in phase with the supply voltage. Full bridge rectifier is converting AC to DC voltage. Capacitor at dc side to stored the voltage. A diode rectifier feeding capacitive-resistive load is considered as nonlinear load on ac mains for the elimination of harmonics by the proposed active power filter.**

Keywords-component; Rectifier, Boost converter, Pulse Width Modulation; Peripheral Interface Controller

I. INTRODUCTION

Battery charger is a device used to put energy into a secondary cell or (rechargeable) battery by forcing an electric current through it. Charging of batteries must be conducted with direct current . Alternative current or rotary current have to be transformed[1]. Mostly power electronic converters are employed for this task. For this project consists of transformer to step down voltage, full bridge rectifier, boost compensation, switching IGBT by using PWM technique and controller PIC 16F877A.

Firstly, full bridge rectifier are required to convert AC to DC voltage. When only one diode is used to rectify AC (by blocking the negative or positive portion of the waveform), the difference between the term diode and the term rectifier is merely one of usage, i.e., the term rectifier describes a diode that is being used to convert AC to DC[4]. The nature of rectifiers either it is conventional or switch mode types, all of them contribute to low power factor,high total harmonic distortion and low efficiency to the power system.

Mostly power electronics have a harmonics component. To eliminate harmonics must used active power filter. Active power filter normally operates using pulse width modulation inverter techniques to inject the required non-sonusoidal current requirement of non linear loads.

Beside that, the compensation circuit uses a boost regulation technique can overcome the problems mentioned above almost entirely. This technique involving fast switching of power electronics devices which are piloted by Pulse Width Modulation (PWM) technique. The error is computed from the different of instantaneous actual current signal with its reference signal, normally pure sine wave by subtractor. This error is then conditioned and processed by PI controller to obtain the required switching pattern[2].

Therefore, the insertion of power electronics devices alone would not help much if without closed loop control. In this paper a current control loop (CCL) is employed to provide for closed loop requirement.

II. CIRCUIT TOPOLOGY

A rectifier in its simplest form consists of semiconductor diodes. Figure 1.1 shows the circuit diagram of a single-phase full wave diode rectifier with filter capacitor, which reduces the ripple present in output voltage.

During the positive cycle of the input sine diode D1 and D4 conducts, supplying the load which battery and charging the capacitor. The capacitor is charging up to maximum value of the input voltage. This caused D2 and D3 to be reverse biased. Since the other diodes (D2 and D3) are also reverse biased, the load gets disconnected from the supply voltage and the rectifier to draw any input current.

During negative cycle diodes D1 and D4 are natural reversing biased. However, diode D2 and D3 also remain revese biased due to the charge stored in the capacitor, it through discharging output voltage falls below instataneous amplitude of input voltage. So the rectifier draws input current only for a brief period of time when capaciotr is charged either through D1 and D4 (during positive half cycle) or diode D2 and D3(during negative half cycle).

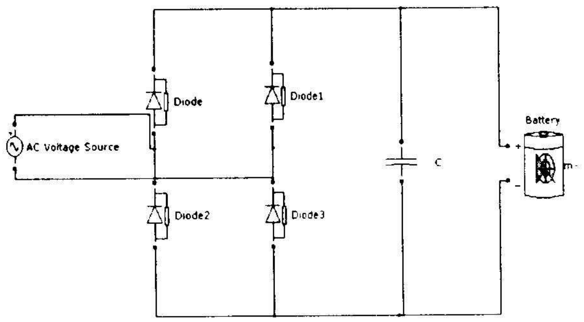

Figure 1.1 : Full wave rectifier with filter and rechargeable battery

A. Active Power Filter Perfomance

The figure 1.2 shows the flow chart operation of the overall circuit and its can divided into 5 stages. Firstly, the current sensor senses the continuous supply current and subtracted from the reference voltage. The next step is comparing the error signal with triangular signal (carrier signal) in the circuit and produce PWM waveform. The PWM waveform actually is a switching signal to turn on IGBT. Lastly, when the IGBT operate the supply current force to follow the reference voltage and improve the power factor system.

The current sensor is used to detect the current waveform and sent data to the subtractor. If the supply current is distorted, the switch controller provided desired current waveform in term of switching signal to the IGBT. Then, the injected current from IGBT itself will compensate the distorted supply current into a sinusoidal form. The unipolar switching is proposed due to the power switch is used in the sytem. In PWM control, the converter switches are turned-on and off several times during a half cycle and the output voltage is controlled by varying the width of pulse. The gate signals are generated by comparing triangular wave with a DC signal. Figure 1.3 shows the subsystem that consists the controller. The control electronics is combination of analogue and digital circuits. The analogue element is consists of currents sensor, reference signal and absolute circuit are used. The digital system used peripheral interface controller (PIC) that contains the operation of subtractor, PI controller and comparator[6].

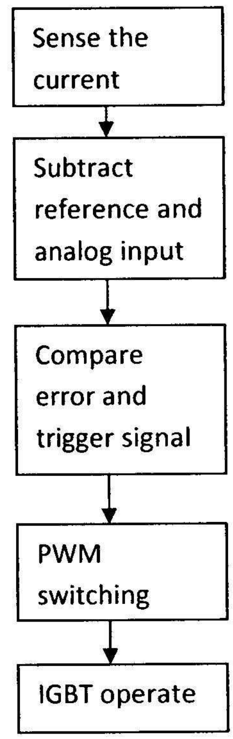

Figure 1.2 : The flow chart of circuit operation

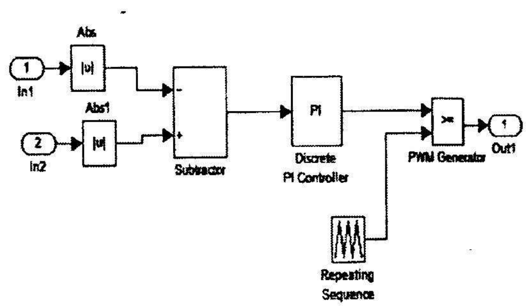

Figure 1.3 : The subsystem that consists the controller

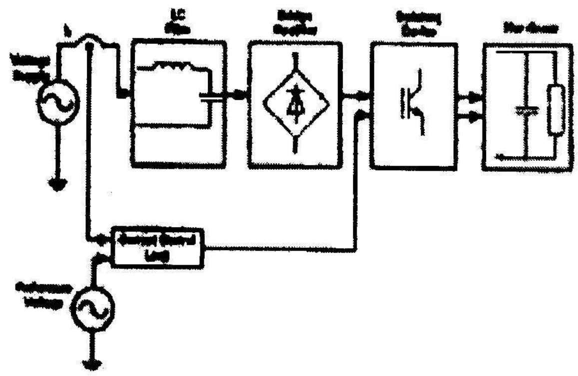

Figure 1.4 : The overall operation

Only one active power switching device IGBT is used. The PWM technique is used to synthesize the injection current. The controlling output is used to provide the switching functions to compensate the distorted supply current into sinusoidal form.

A propotional integral (PI) control algorithm is used to regulate the error. The main part of the PI control algorithm is the gain K. The gain K is determined by the proportional gain, Kp and integral, Ki value. Kp must be chosen carefully in order to get best possible system response. The value of Kp is low, system response becomes lower smoother while if the value of Kp is high system response become faster but may become overshoot. The integral gain, Ki is put together with proportional gain accumulated error signals encountered since compensation begin. The value of Ki also need to be chosen well because if too low, the error will be corrected slowly, but if it is high, the system becomes unstable[3,5]. Figure 1.5 shows the switching pattern for comparing error and carrier signal to generate PWM.

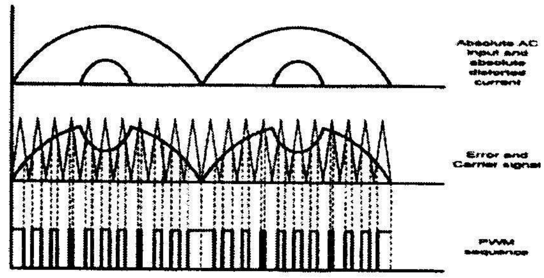

Figure 1.5 : The switching pattern for comparing error and carrier signal to generate PWM

B. Implementation of Boost Converter As a Switch

Compensation using boost rectifier technique can improve the system. Boost converter is used because it can produce output voltage that is greater or equal to the input voltage. In the On-state, the switch S (see figure 1.6) is closed, resulting in an increase in the inductor current. Beside that, in the Off-state, the switch is open and the only path offered to inductor current is through the flyback diode D, the capacitor C and the load battery. Due to the energy remains in the inductor, it is used charging the capacitor and hence transfers the stored energy. As a result, output voltage is higher than input voltage. Figure 1.6 shows the two configurations of a boost converter, depending on the state of the switch S.

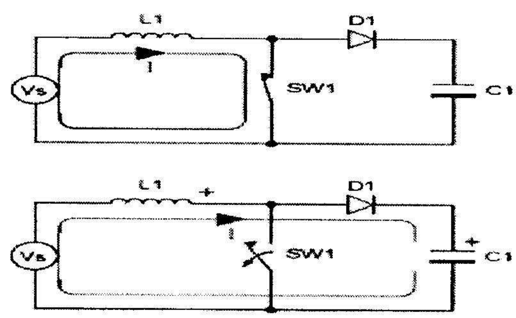

Figure 1.6 : The two configurations of boost circuit

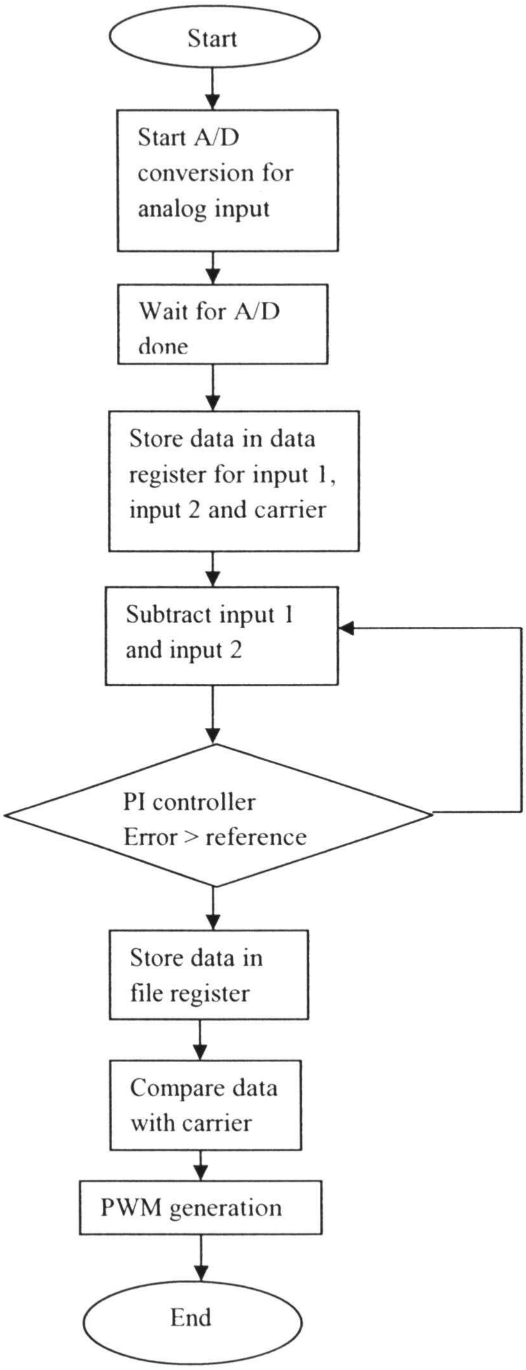

Figure 1.7 : Current Control Loop flow chart to generate PWM

III. RESULTS

A. MATLAB Simulink Simulation

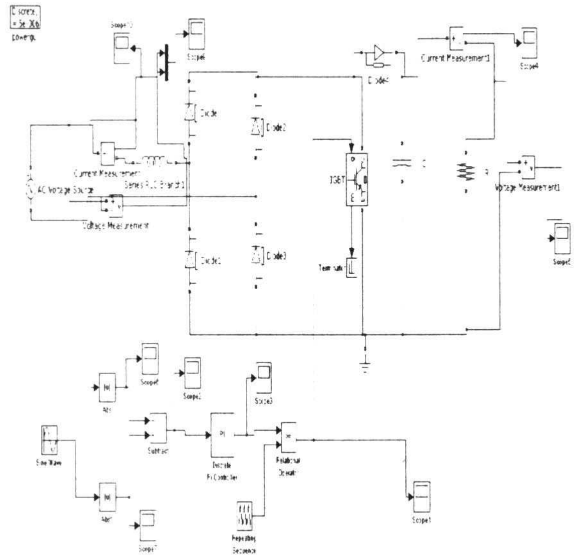

Figure 2.0 : Circuit model in simulation

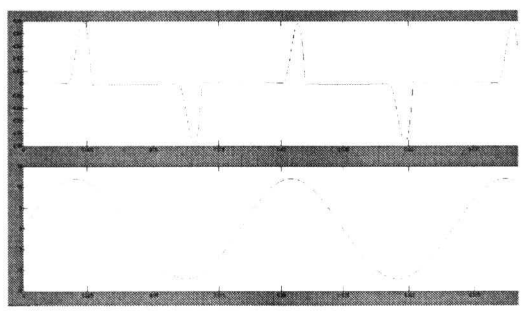

Figure 2.1 : The input current and voltage supply

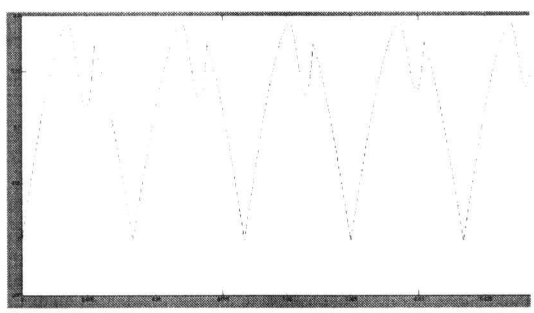

Figure 2.2 : The error signal after compare reference and input signal

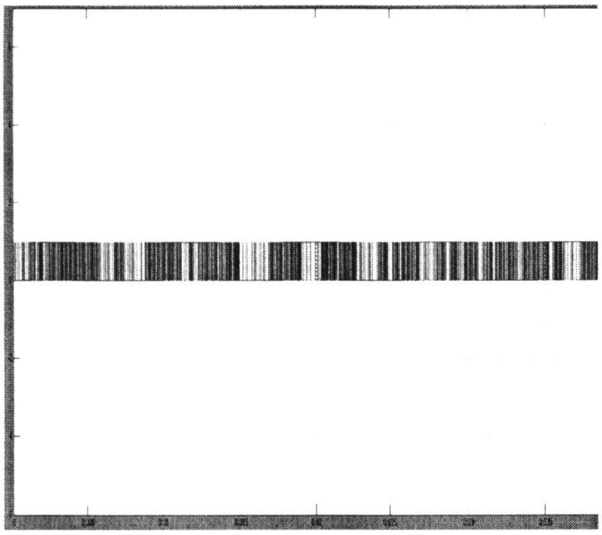

Figure 2.3 : The switching pattern PWM sequence

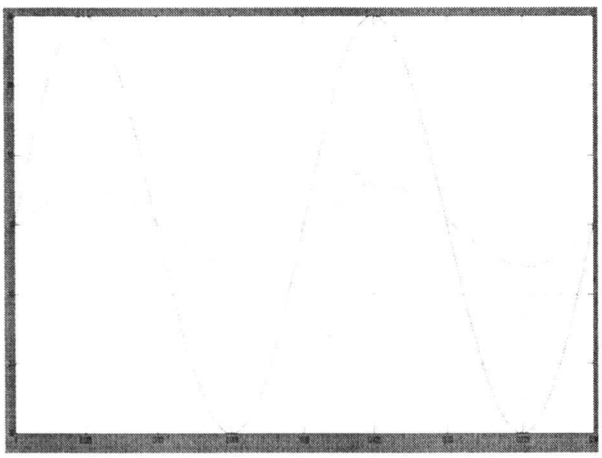

Figure 2.4 : Supply current and voltage waveform after compensated APF

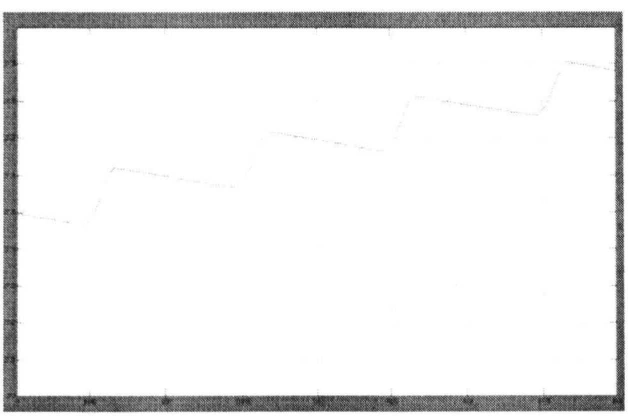

Figure 2.5 : Voltage at non-linear load

B. Laboratory Experiments

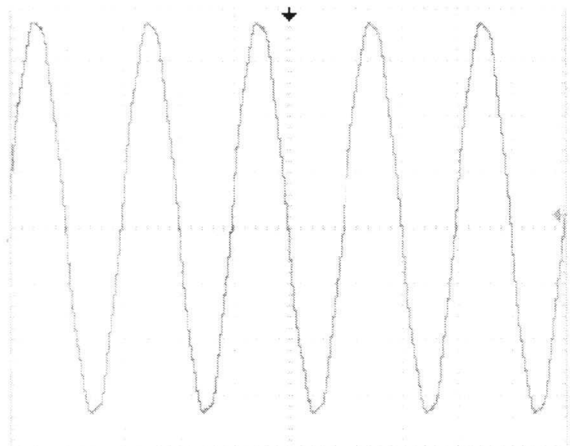

Figure 2.6 : The input voltage before compensated

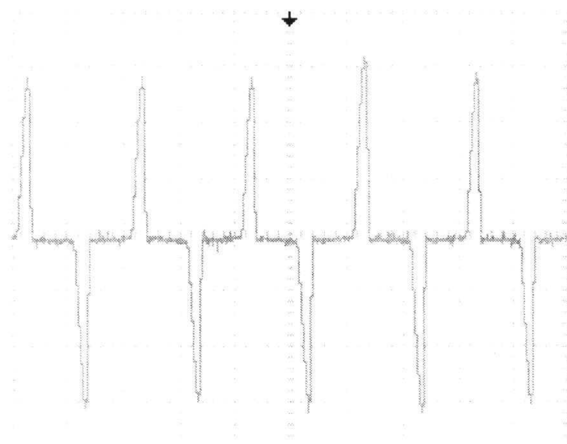

Figure 2.7 : The input current before compensated

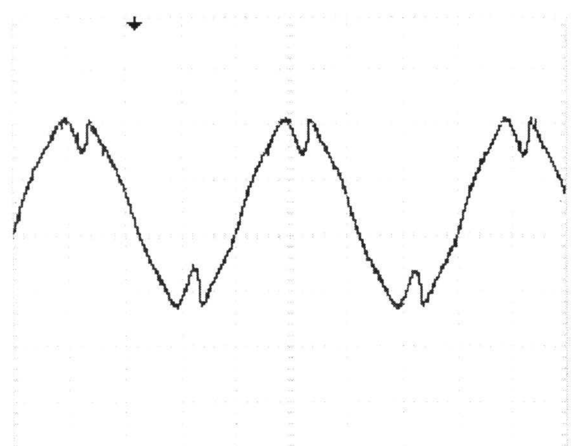

Figure 2.8 : The error signal after compare reference and input signal

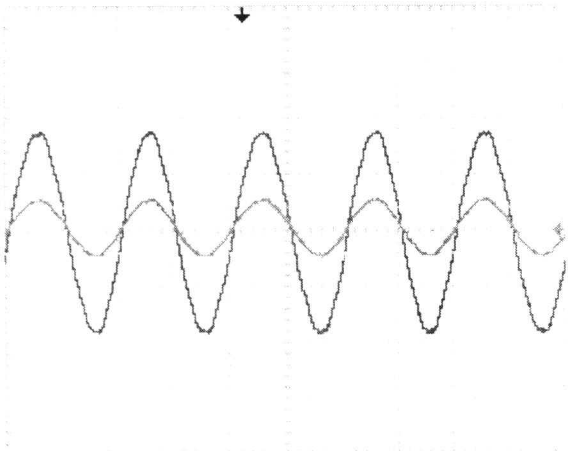

Figure 2.9 : Supply current and voltage waveform after compensated APF

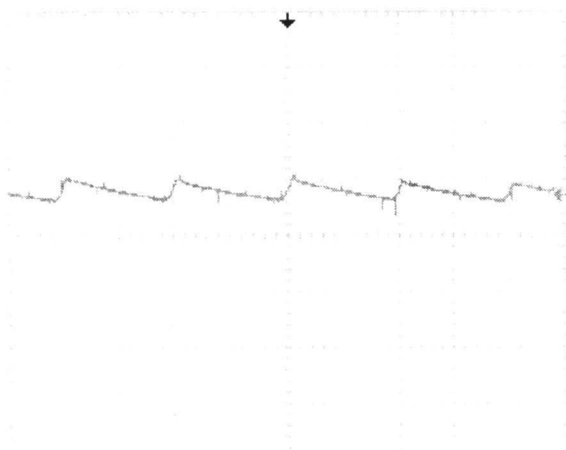

Figure 2.10 : Voltage at non-linear load

IV. DISCUSSION

The simulations results on the operation of the battery charger with active power filter are presented. The perfomance of the battery with both filter are investigated. From results, it can be seen that the supply current was not in phase with the supply voltage for uncompensated system. It is just not in phase with the supply voltage but it is also can approaching zero due to the battery feature. The battery obtains the dc current and dc voltage but it is not filter yet. So, this will have an effect on the baterry performance, short life span and dangerous to the user if the charger is not filtered well. Duirng compensation active power filter, the distorted supply current was injected by active power filter to mitigated become a sinusoidal input current and in phase with the supply voltage.

V. CONCLUSION

A single switch battery with active power filter has been implemented. The analysis and MATLAB/simulink of the boost converter has been carried out. Expected sinusoidal supply current that in phase and time with the supply voltage can be obtained by inject opposite current to shape the pulsating supply current into sinusoidal form and in time and phase with the supply voltage.

VI. ACKNOWLEDGEMENT

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REFERENCES

[1] Baharom,R;Hamzah, M.K; Hamzah N.R; MohdKasim,L.;"Boost rectifier using single matrix converter with bipolar output",*IEEE 2nd International Power and Energy Conference,2008. Pecon2008 1-3 Dec 2008* Page(s):1141-1146

[2] Baharom,R; Hamzah, M.K; Saparo,A.;Ibrahim I.R.;"Studies on Control electronics implementation of single phase Matrix converter operating as AC-DC converter with active power filter",*IEEE 2nd International Power and Energy conference, 2008.* PECon 2008. Page(s) 758-763

[3] Bhim Singh, Brij N. Singh, Ambrish Chandra Kamal Al-Haddad, Ashish Pandey, Dw rka P.Kothari., "A Review of Single-Phase Improved Power Quality AC-DC Converters," *IEE Transactions on industrial electronis,* Vol. 50, No.5, October 2003.

[4] T. C. Chen and C. T. Pan, "Modelling and design of a singlephase AC to DC convertor," *Electric Power Applications, IEE Proceedings B,* vol. 139, pp. 465-470, 1992.

[5] K. C. Umeh, *et al.*, "Comparing the harmonic characteristics of typical single-phase nonlinear loads," in *Power Engineering Conference, 2003. PECon 2003. Proceedings. National*, 2003, pp. 383-387.

[6] I.Daut,R.Ali,S.Taib;"Design of a Single-Phase Rectifier with Improved Power Factor and low THD using Boost Converter Technique",*American Journal of Applied Sciences 3*,2006,pp 1902-1904