# A Single Switch Battery Charger with Active Power Filter

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*Abstract*—**This paper present the battery charger with active power filter for minimizing the input current distortion in a single phase system. The striking feature of this circuit is that it contains only a single switch. The active power filter here is use to mitigate the distortion current by injecting equal but opposite current to shape the pulsating of the supply current to a sinusoidal form that is in-time phase with the supply voltage. In this work, the single switch active power filter is used to reduce switching stress, losses and also the cost.**

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

## I. INTRODUCTION

Charging of batteries must be conducted with direct current. Alternative current or rotary current have to be transformed. Mostly semiconductor rectifiers are employed for this task [2]. Conventional battery chargers operating from mains can cause considerable current distortion and low power factor problems due to its input rectifier and filter capacitor. To overcome this, various techniques that include the use of an active power filter had been discussed. They are being used to eliminate both the lower order and higher order harmonic. The passive filter is normally designed to eliminate the bulk of load-current harmonic leaving the more complex problems to be solved by the actives power filter.

Active power filter normally operates using pulse width modulation inverter techniques to inject the required non-sinusoidal current requirement of nonlinear loads [6]. The proposed system introduces an active current-shaping technique to mitigate the distortion input current by injecting equal and opposite input current to shape the supply current to a sinusoidal form; in time and phase with the supply voltage.

The compensation circuit uses a boost regulation and PWM technique to injected current into the system.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 known as the pulse wave modulation (PWM) wave. A proportional integral (PI) control methods implement to aid response from the control which uses a supply current detection which is current sensor to achieve active power filter task.

## II. INPUT CURRENT DRAWN BY RECTIFIER

A rectifier in its simplest form consists of semiconduct diodes. Figure 1 shows the circuit diagram of a single- pha full wave diode rectifier with filter capacitor, which reduc the ripple present in output voltage. Although a filt capacitor significantly suppresses the ripple from the outp voltage, it introduces distortion in the input curre waveform. During the positive cycle of the input sign diode d1 and d4 conducts, supplying the load which battery and charging the capacitor. The capacitor is charg up to the maximum value of input voltage. This causes c and d4 to be reverse biased. Since the other diodes (d2 an d3) are also reverse biased, the load gets disconnected fro the supply voltage and the rectifier cease to draw any inp current.

During negative cycle diodes d1 and d4 are natural reversing biased. However, diode d2 and d3 also rema reverse biased due to the charge stored in the capacitor, unt through discharging output voltage falls below tl instantaneous amplitude of input voltage. So the rectifi draws input current only for a brief period of time when tl capacitor is charged either through diodes d1 and d4 (durin positive half cycle)or diodes d2 and d3(during negative ha cycle). This incident produces a distortion at the inp current drawn by the full bridge rectifier.

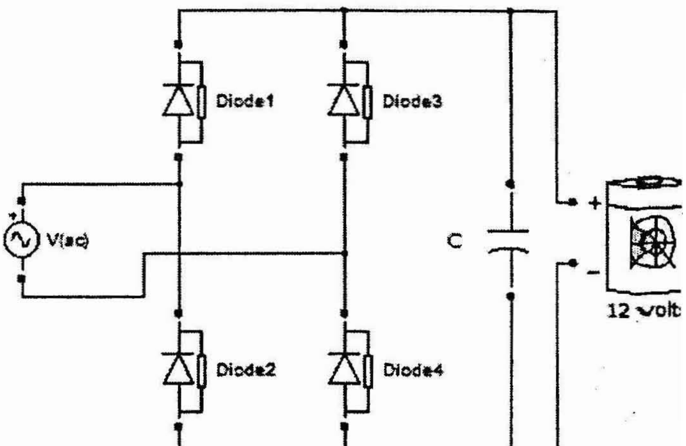


Figure 1: Full wave rectifier with filter and rechargeable battery.

## III. ACTIVE POWER FILTER PERFORMANCE

This filter system use is active power filter for removing both high order and low order harmonic components. Figure 2 shows the arrangement of proposed active power filter and figure 3 shows the control components of active power filter.

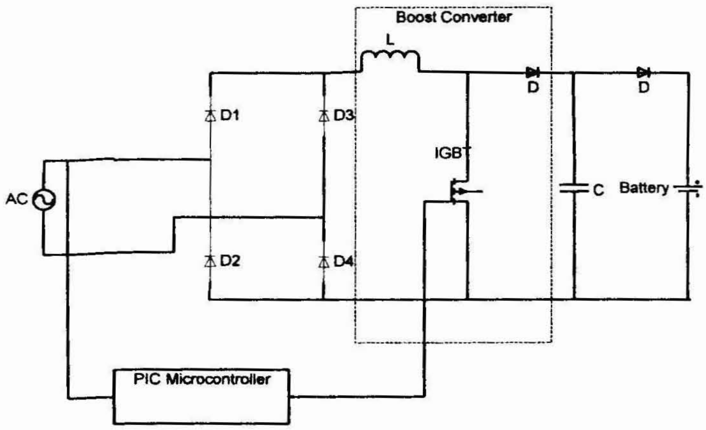


Figure 2: The arrangement of proposed system

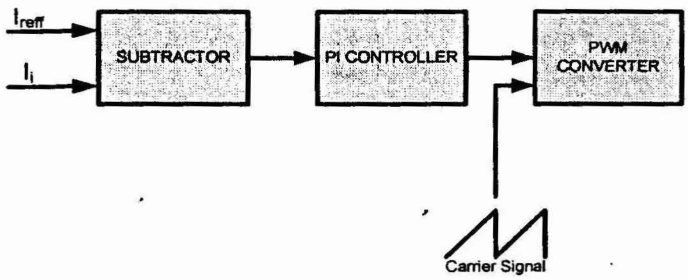


Figure 3: Control component of active power filter

The active power filter is used to inject current onto the system to mitigate the distortion current to a sinusoidal form, means that the current is in phase and time with the voltage supply. The topology consist a single switch (IGBT) in order to control circuit and reduce the switching stress.

The current sensor is used to detect the current waveform and sent the data to the subtractor. If the supply current is distorted, the switch controller will provide 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 use in the system.

The compensation uses a boost and PWM technique to generate the injected the current into the system. The active PWM is also known as active current wave shaping used for switching control [5]. This technique allow active comparison of the error signal with the carrier signal to ensure error is kept within the boundaries of the carrier peaks at all times. The active PWM operates by comparin the corrected signal with the carrier signal to produce th required PWM control as shown in Figure 4. When th sinusoidal signal has magnitude larger than or equal to th carrier signal, the comparator output (PWM sequence) i higher [4].

A proportional integral (PI) control algorithm is used t regulate the error. The main part of the PI control algorithı is the gain K.The gain K is determined by the proportion gain, Kp and integral gain, Ki value.Kp must be choose carefully in order to get best possible system response. If th value of Kp is low, system response becomes lower bı smother while if the value of Kp is high system respons become faster but may become overshoot. The intergr gain Ki, is put together with proportional gain t accumulated error signals encountered since compensate begin. The value of Ki also needs to be chosen well becaus if too low, the error will be corrected slowly, but if it is to high, the system becomes unstable.

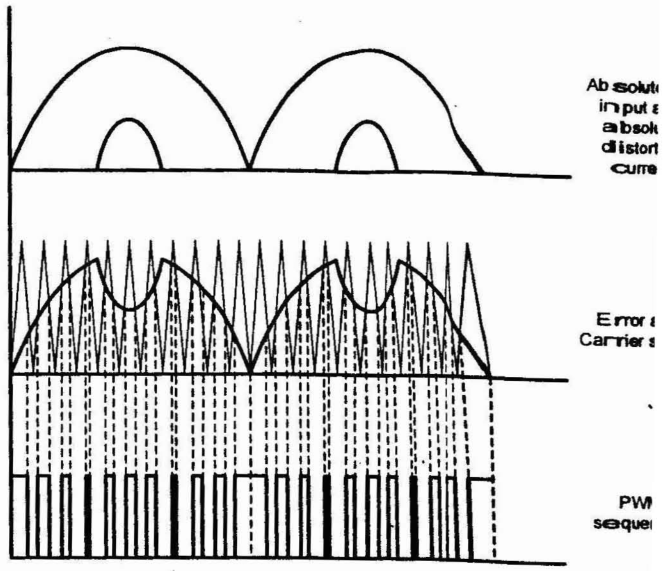

Figure 4: Switching pattern using PWM

## IV. IMPLEMENTATION OF BOOST CONVERTER AS A SWITCH

Boost converter is used because it can produce outpı voltage that is greater or equal to the input voltage [3].A illustrated in Figure 5, diode will reverse biased when th switch is turned ON. Thus the output stages isolated froı the system. This condition makes the current to flow t inductor and making it fully charge. The input suppli energy to the boost inductor that causes inductor current t increase linearly with ramp behavior from 0A until IGBT turned OFF. The energy stored in the inductor can be use for compensation purposes.

When the switch is turned OFF, diode is forward biase as shown in Figure 6. The current that flowing through th IGBT would now flow through inductor, diode, capacit and load which is a battery. However, the inductor voltag reverses its polarity in an attempt to maintain constant current. Due to the energy remains in the inductor, it is used to charging the capacitor and hence transfers the stored energy. As a result, output voltage is higher than input voltage.

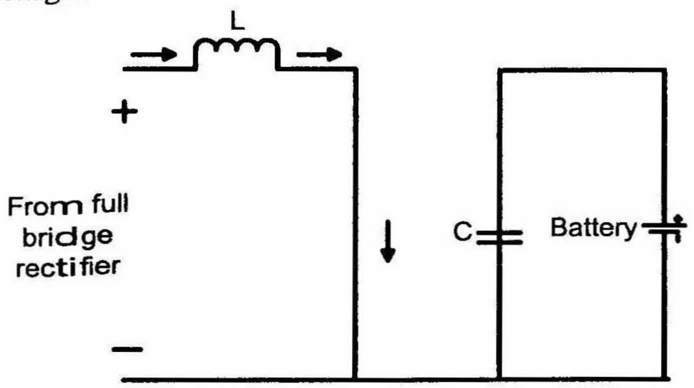


Figure 5: Switch at ON state

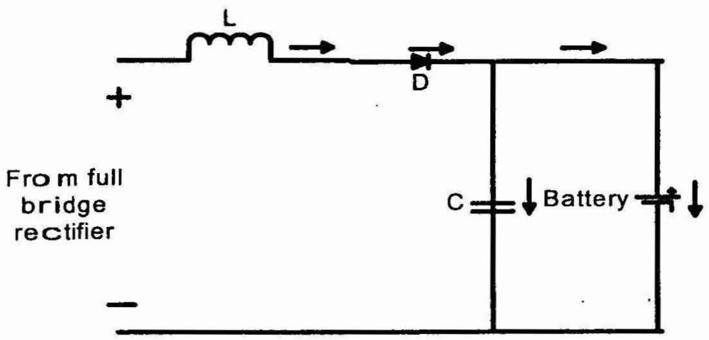


Figure 6: Switch at OFF state

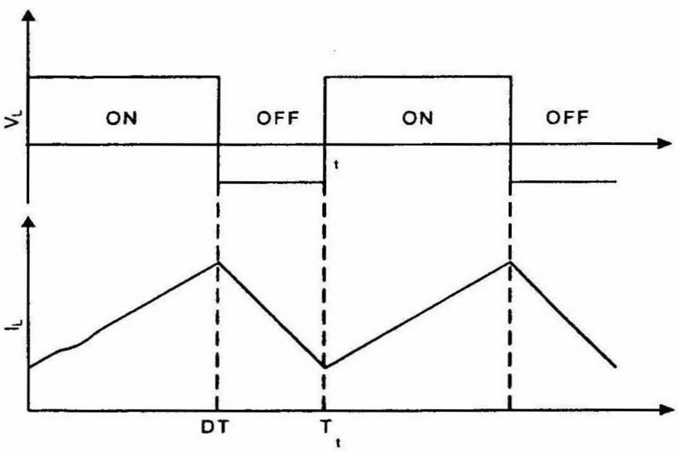


Figure 7: The behavior of inductor current when switch is turn ON and turn OFF

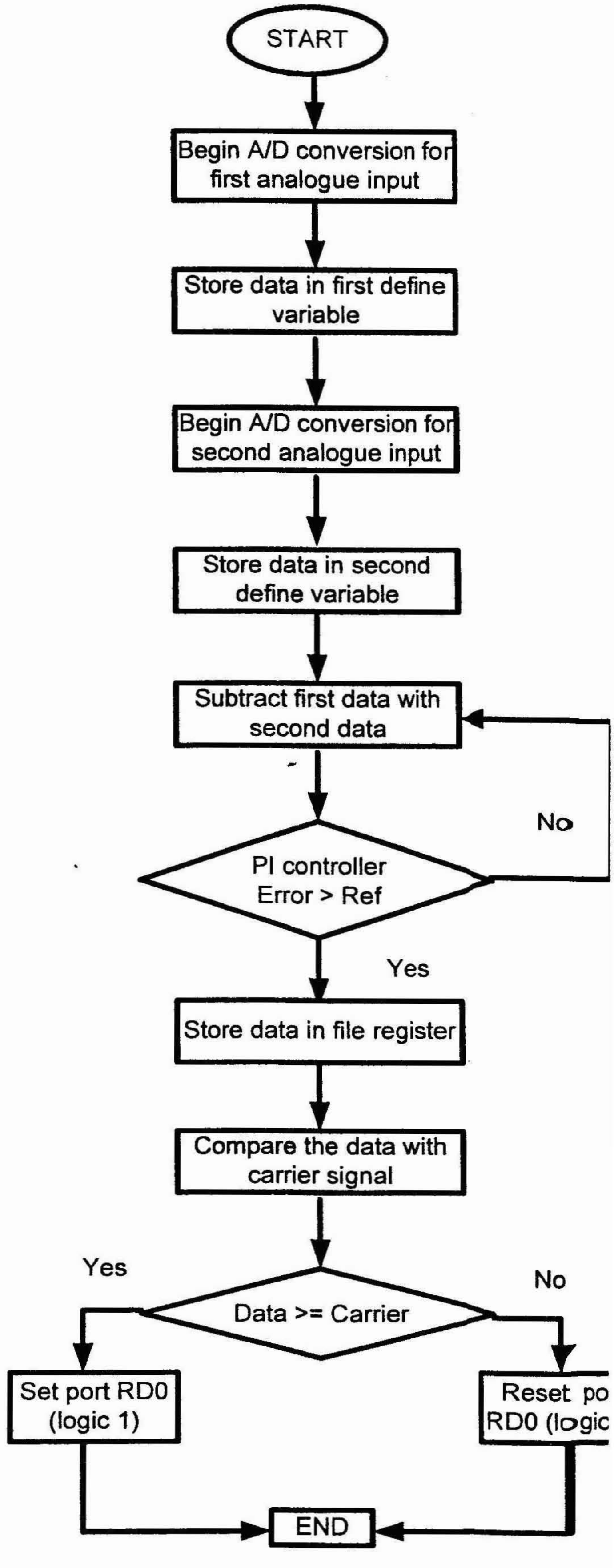


Figure 8: Flowchart for PIC programming

## RESULTS

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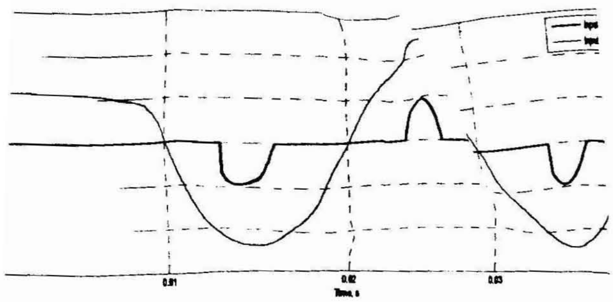

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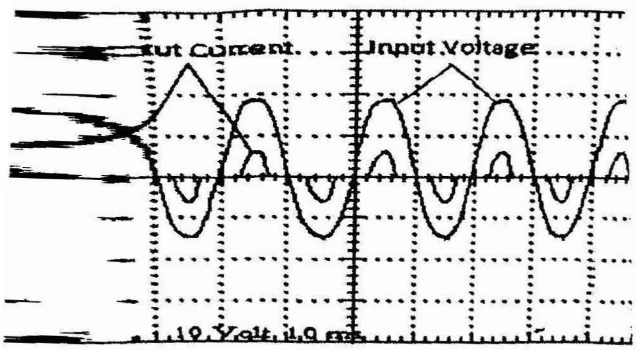


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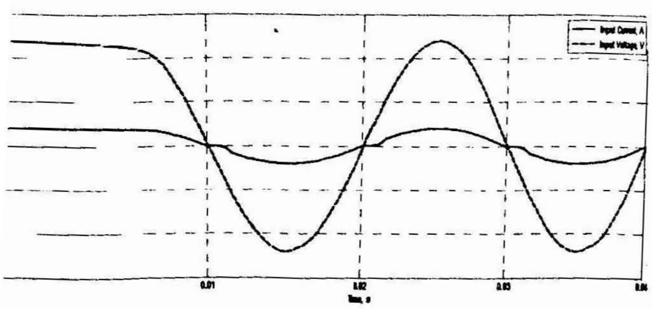
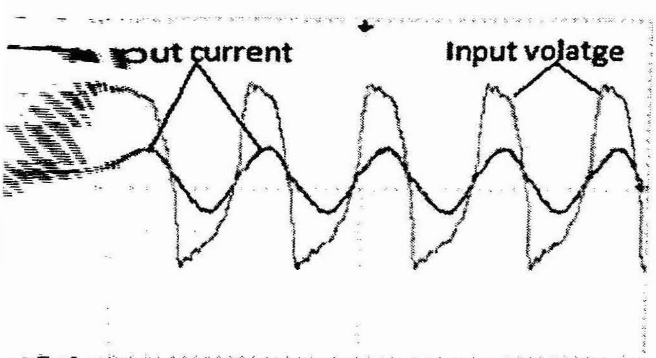


Input current and voltage after compensated with APF (Simulation)




re 12: Input current and voltage after compensated with APF (Experiment)

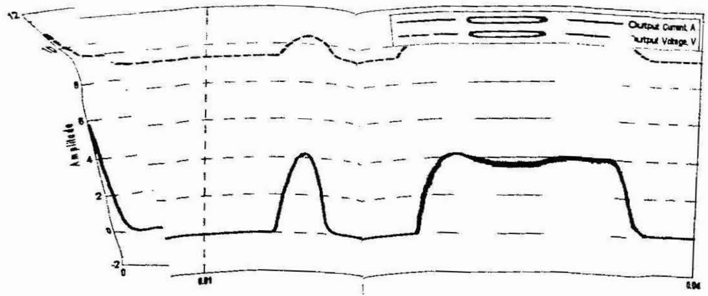



Figure 13: current and voltensate with APF (Simul

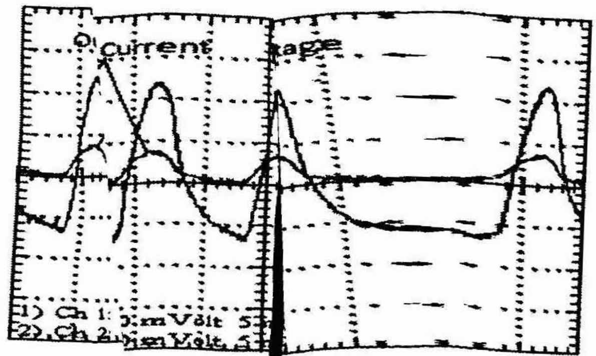



Figure 14: Output nt and voltag mpensated with APF (Experin

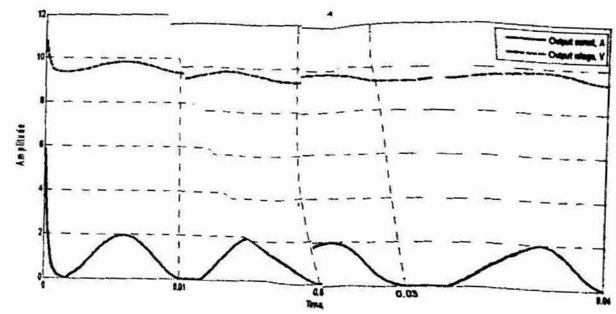



Figure 15: Output current and voltar compensated with APF (Simulat

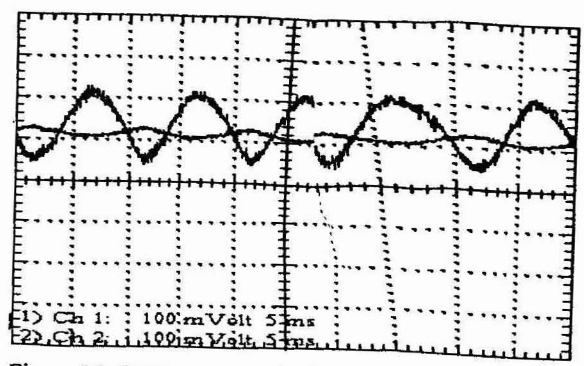
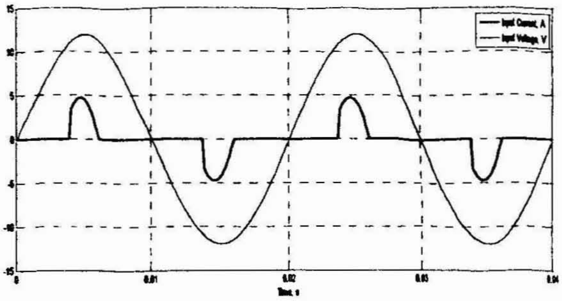


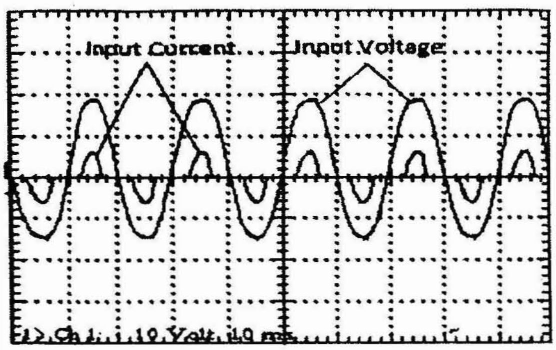

Figure 16: Output current and voltage after compensated by APF (Experiment)

## V. RESULTS

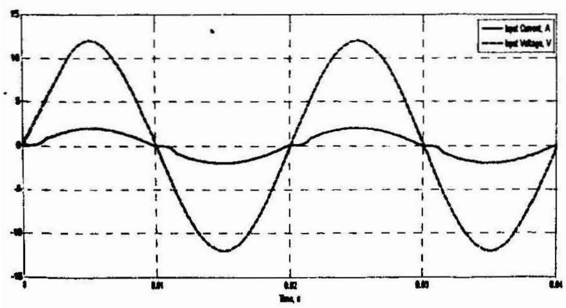
this project, MATLAB/Simulink was use to analyze -formance of the system.



ure 9: Input current and voltage before compensated with APF (Simulation)




ure 10: Input current and voltage before compensated with APF (Experiment)



gure 11: Input current and voltage after compensated with APF (Simulation)

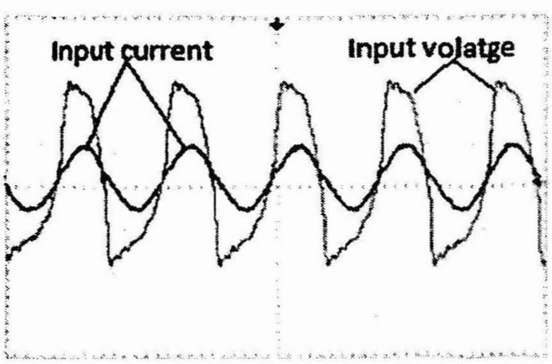



Figure 12: Input current and voltage after compensated with APF (Experiment)

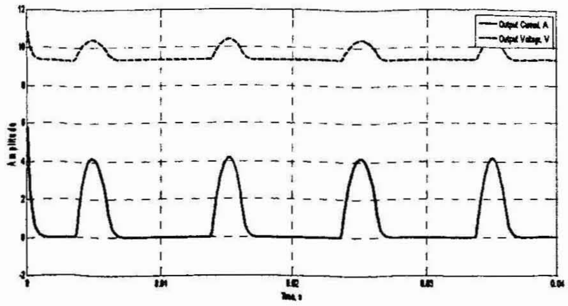


Figure 13: Output current and voltage before compensated with APF (Simulation)

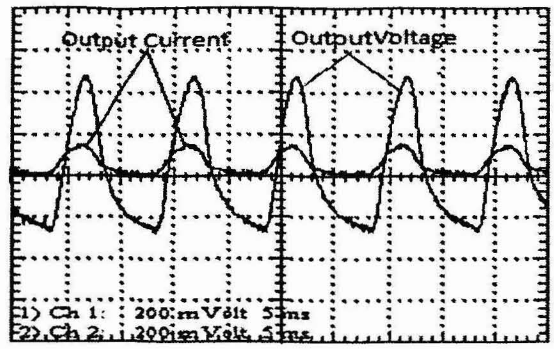



Figure 14: Output current and voltage before compensated with APF (Experiment)

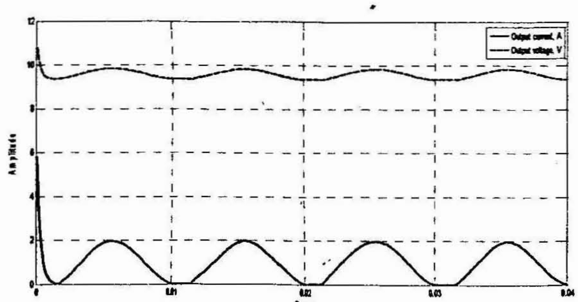


Figure 15: Output current and voltage after compensated with APF (Simulation)

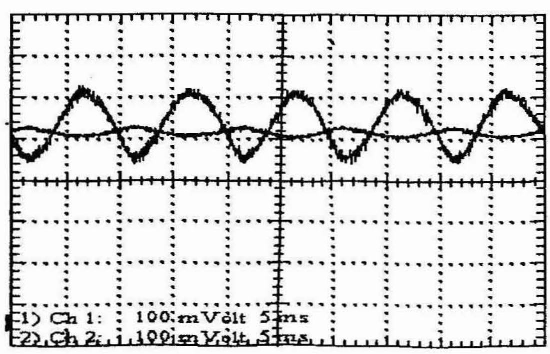



Figure 16: Output current and voltage after compensated by APF (Experiment)