Minimization of No-Load Power in AC/DC Adapter

V.J.SIVANAGAPPA[1] Assistant Professor
R.RANJANI[1] Assistant Professor
A.SHOBANA[2] Assistant Professor
S.MUTHARASU[2] Assistant Professor
Department of EEE, Vivekanandha College of Engineering for Women,
Thiruchengode, Namakkal- 637 205, India.
sivanagga@gmail.com en.ramsen@gmail.com sonasri@gmail.com mailtomuthu@rocketmail.com

ABSTRACT: **Now a days usage of electronic equipments have been increased, in most of these equipments have energy storage system. To store energy in the battery with a specified limit of power, certain switched power conversion circuits are needed. This conversion circuit delivers power even though the load is detached from the source. As our country's power demand is very high, the no load power minimization techniques has to be developed. A simple AC/DC adapter is proposed in this Paper. Conventional AC/DC adapters consume considerable amount of no load power . In proposed work, the power will get turned off in the source side itself when the load (i.e the battery) is removed from the system. By simulation results, the no load power is minimized to less than 0.5mW were the conventional system has standby power consumption of several 100mW. To verify the proposed adapter the simulation and modelling are proposed in MATLAB.**

Index Terms: **Standby Power, Energy Star Program, Buck converter.**

I.INTRODUCTION

No load power is the power wasted by the adapter circuit when the charger and adapters plugged into electrical sockets, but it's not connected with the appliances. The energy is wasted when the adapter is not getting connected with the respective devices. The recent survey on no load power describes the power waste under no load condition is nearly two third of mobile phones energy usage. So many research processes is going on under no load power minimization or no load power consumption to develop energy efficient appliances. These no load power wastage is commonly found out in the following devices like cell phones, laptop computers, handheld music systems and handheld gaming device. Enormous numbers of devices are used in the recent trends. Most of these portable devices work on the battery backup. When the system needs power, the respective device has to be connected to an adapter or charger to make the device charged. The system may get removed without switch off the main supply. In that case the adapter or charger begin to drain the energy and it will transfer to the system without analyzing the load condition whether load is get connected or not. At the time of unload condition, the power drained by the chargers are virtually useless. According to the survey and study, these types of energy losses fairly common, because users may leave the chargers plugged into a supply when not in use. The no load power of a single system may be small amount of energy, but while considering an area of power utilization where the usage of these kind of portable devices are high. If the numbers of devices are increased that time the integral of no load power over that particular area is high. So, there has been a tremendous development in the applications of AC/DC conversion systems. Most of these conversion systems work irrespective of the connectivity to the load system. The conversion adapter circuit wastes power without transferring power to load or battery. This kind of wastage in power circuit is known as no load power or standby power. About 10 – 20 % of electric power is wasted as standby power over a zone (residents, institutions, corporate etc). Leading concerns need to be more conscious about this no load power consumptions while producing their products having switched power conversion systems by having energy star program**.** So many techniques are developed to minimize the no load power. The burst mode, high voltage start up circuit and embedded battery are the some of the techniques commonly used in commercial AC/DC adapters. In this paper to reduce no load power consumption and to reduce the power loss under no load condition . Minimization of no load power in AC/DC adapter is proposed. The conventional system structure is complex because of monitoring of load connection block (MOLB) and control IC ON/OFF block (CIOB). Compared with conventional system the structure of proposed system is simple and cost effective.

II. PROPOSED ADAPTER TECHNIQUE

The proposed circuit has four sections which are EMI filter, diode bridge rectifier, buck converter, control circuit and load system .

A. OPERATION:

In proposed circuit [D1-D4] are rectifier diodes which will rectify the input 100V, 50Hz AC supply to pulsated DC, the Cdc is the DC capacitor which will smooth the DC voltage. The buck converter converters the supply voltage into desired charging voltage for the battery

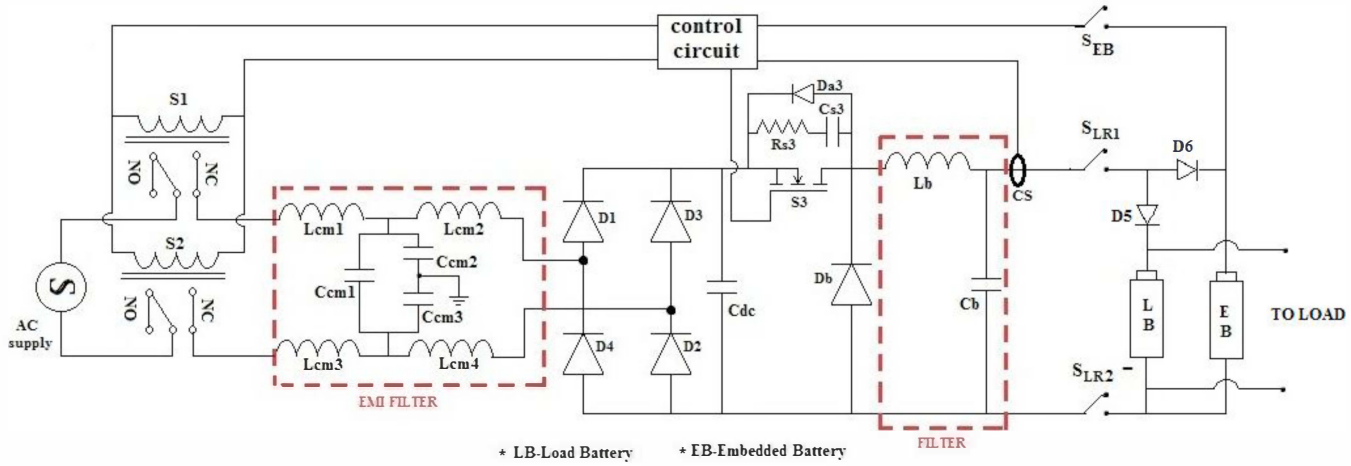


Fig.1. Circuit Diagram of Proposed adapter

were Lb and Cb are the filter of respective converter. The output power from the buck converter is fed to the load (i.e the battery here).The detachment of load from the power conversion system is represented by the Load Rejection Switches ($S_{LR}1$ and $S_{LR}2$).CS is the current sensor which sense the current flow to the load, this signal is fed to the control circuit.

When the load is detached from the system, the signal to the control circuit through current sensor will cut off. This results in turning off the whole power circuit through switching off the main switches S1, S2 and S3. The power to the control circuit is fed by a 5V battery and it gets charges when there is power flow in the main circuit. Control circuit consists of voltage regulator LM78M05, 5V battery, logic gate. When the detached load is once again attached to the system, the control circuit gets power from the embedded battery. In addition with load rejection switches ($S_{LR}1$ and $S_{LR}2$) one more switch S_{EB} is added, to control the connection between embedded battery and control circuit. The signal from embedded battery is fed to control circuit, in control circuit logic gate is used to identify the load connection. The attachment, detachment of load and respective input signals, output signals are expressed in Table.1.

B. SNUBBER DESIGN:

Snubber circuit is used across the switch to reduce voltage stress across the switch to attain a good damping condition Cs value should be chosen twice the sum of the output capacitance of the switch and reverse transfer capacitance. Rs is selected by the ratio of output voltage to the current. The initial voltage when current flow through Rs should not be greater than clamped output voltage.

$$R_S = \frac{V_O}{I_O} \qquad \text{(Eq.1)}$$

$$C_S = 2[C_{OPS} + C_{rrS}] \qquad \text{(Eq.2)}$$

Power dissipation at given switching frequency is given by

$$P_{diss} \approx C_S V_O^2 f_S \qquad \text{(Eq.3)}$$

C. FILTER DESIGN

The filter design process can be described as an optimization problem where each requirement contributes with a term to an error function which should be minimized.

$$\Delta V = \frac{V_{in}\,\delta(1-\delta)}{8LCf^2} \qquad \text{(Eq.4)}$$

$$C = \frac{1-\delta}{16Lf^2} \qquad \text{(Eq.5)}$$

III. MODELING AND SIMULATION OF PROPOSED ADAPTER

The proposed adapter technique is simulated by using MATLAB. The operation of the proposed adapter is same as that of conventional AC/DC adapter. The simulation and modelling of the proposed adapter is shown in the Fig.2 and Fig.3. Function of the control circuit and the simulation results are described in the following section. The power converter model is time-varying in nature because of the switching action. This leads to the complication of system analysis and design. Several approaches based on an averaging technique are commonly used to eliminate the switching behaviour to achieve time-invariant model. Then, the classical method can be easily used for system analysis and design.

Differential equation of buck converter

$$\frac{uV_S - i_o R}{L} = \frac{d_{iL}}{dt} \qquad \text{(Eq.6)}$$

$$\frac{dV_c}{dt} = \frac{i_L}{C} - \frac{V_o}{RC} \qquad \text{(Eq.7)}$$

IV. CONTROL CIRCUIT OPERATION

When the load is disconnected from the from the adapter it mean that the load rejection switches ($S_{LR}1$ and $S_{LR}2$) and the switch (S_{EB}) between embedded battery and control circuit are get open. Control circuit consists of voltage regulator, current sensor and OR Logic. The embedded battery is connected to one of the OR Logic gates terminal through voltage regulator. The

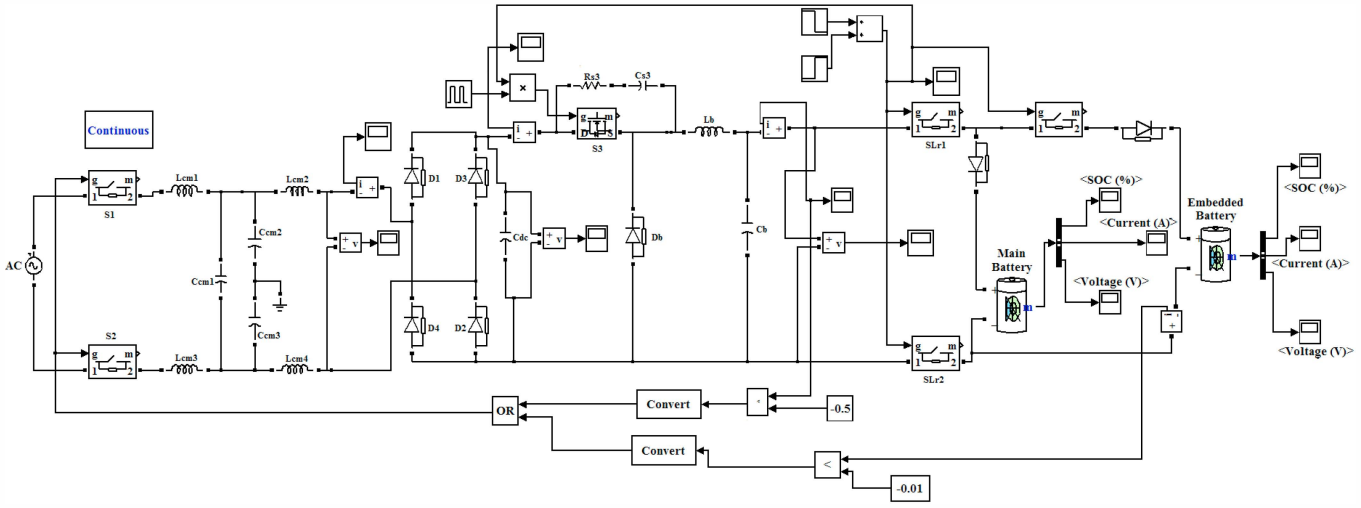


Fig.2 Simulation of Proposed adapter in MATLAB

signal from the current sensor which is connected in adapter circuit is the second input for the logic gate. The adapter is get turn OFF when the load is detached from the adapter circuit based on the output signal from the OR Logic gate. Condition of battery and input signal for the OR Logic is based on the following conditions

(i) Battery may fully utilized and there is no more power, i.e Empty load battery.

(ii) Battery is not utilized completely, there is some power in the battery but still need to charge a battery for future use.

In both of the cases embedded battery won't discharge completely because it is not connected with load side. The adapter circuit ON/OFF controls are made through a relay, which is connected in between AC power and rectifier circuit. The signal from the logic gate is fed to the relay circuit. Control circuit gets input signal from the embedded battery and current sensor in the adapter circuit. When signal enable in OR Logic gate it turns ON the relay otherwise the relay gets OFF, it leads to turn OFF the whole circuit. The working of control circuit is described in Table.1. switching of the power circuit (ON/OFF) depends on the output signal from the control circuit. This output signal from the control circuit is fed to the relay which is connected in between AC Source and power conversion circuit.

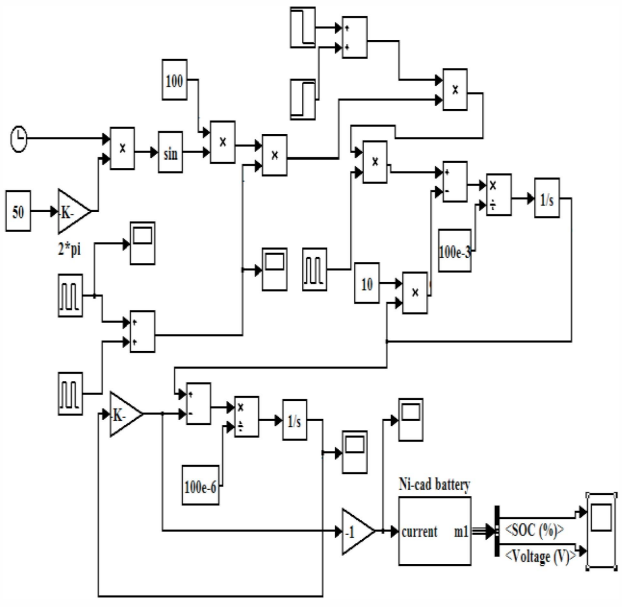


Fig.3 Modeling of proposed adapter

SIMULATION RESULT

To verify the proposed Minimization of No-Load Power in Ac/Dc Adapter techniques, the simulation is made in MATLAB . The Fig.4(a)-(f) shows the simulation waveform of the proposed adapter.

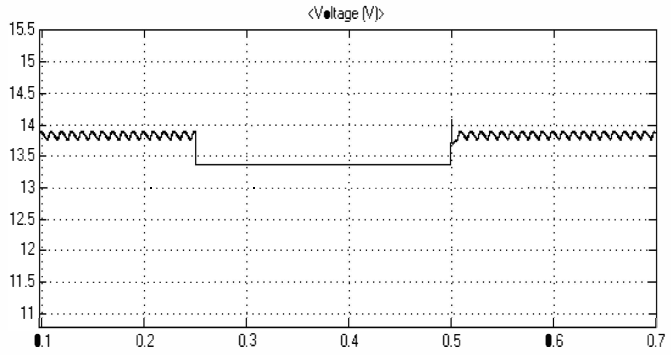
In which the first 0.25sec is considered as the load is connected with the adapter circuit. The next interval from (0.25-0.5)sec the system is considered as under No-Load condition. The response of voltage, current, state of charge characteristics are obtained. After disconnection of load the voltage level of the battery remains constant.

According to the simulation results, the adapter conversion circuit is switched off i.e the overall system get turned off when there is no battery or load connection. When the load connected to adapter the embedded battery switch ON the relay that leads to turn ON the adapter. The figure shows the proposed adapter is totally turned ON/ turned OFF whenever the load is connected/disconnected from the adapter. In the conventional adapter, the efficiency of the adapter is lower on peak load as well as light load condition due to the losses of the CIOB and the MOLB Block. The efficiency of the proposed adapter in different load conditions are shown in Fig 5

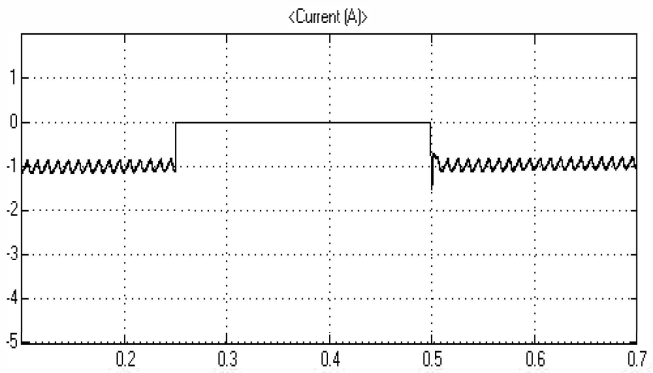
From the analytical report the average efficiency of the proposed adapter is over 92.3%. The proposed adapter satisfies the average efficiency of the AC/DC adapter 87% in the last energy star program.

LOAD CONNECTION STAGES	A. Signal from embedded battery to control circuit. **(INPUT I to OR Logic gate)**	B. Signal from current sensor which is in adapter circuit. **(INPUT II to OR Logic gate)**	C. Signal fed to the relay circuit. **(Output from OR Logic gate)**
STAGE - I	**ZERO** (There is no connection between embedded battery and control circuit) (Load detached from the adapter circuit)	**ZERO** (No current flow in adapter circuit)	**ZERO** (Relay OFF)
STAGE - II	**ONE** **(** When load is connected to adapter, embedded battery will get connected to the control circuit **)**	**ZERO** **(** When load is connected to adapter, initial stage there is no current flow in adapter circuit **)**	**ONE** (Relay ON)
STAGE - III	**ONE** **(** When load is connected to adapter, embedded battery will get connected to the control circuit **)**	**ONE** **(**Current will flow in adapter circuit when the load is connected after the stage- II **)**	**ONE** (Relay ON)

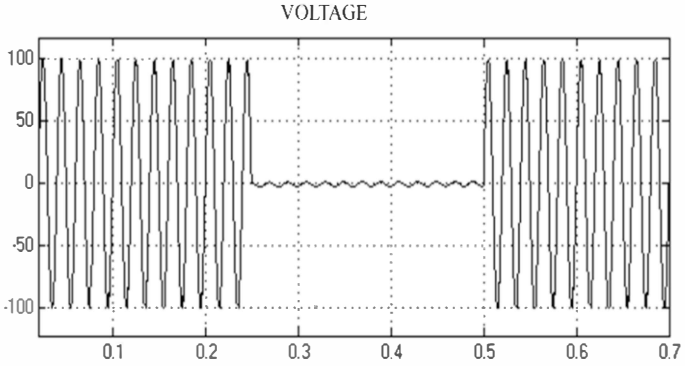
Table .1 Stages of relay position during load connection



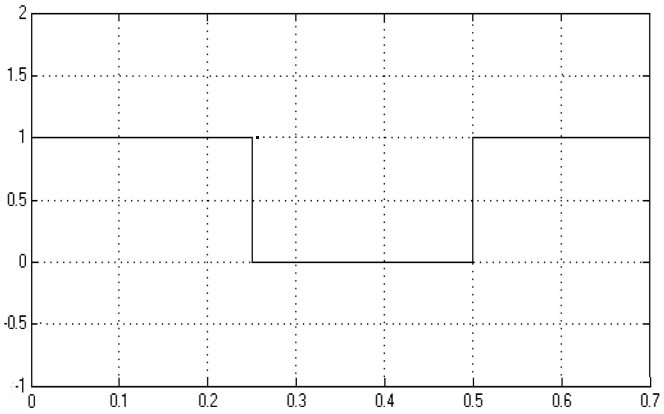
(a)



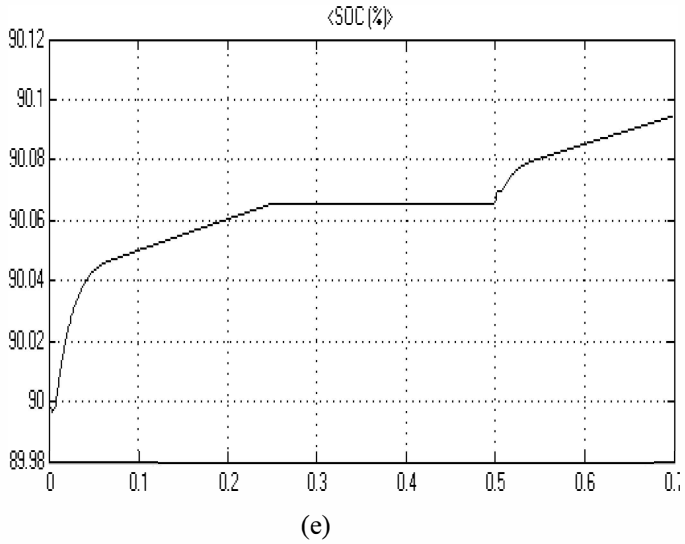
(b)



(C)

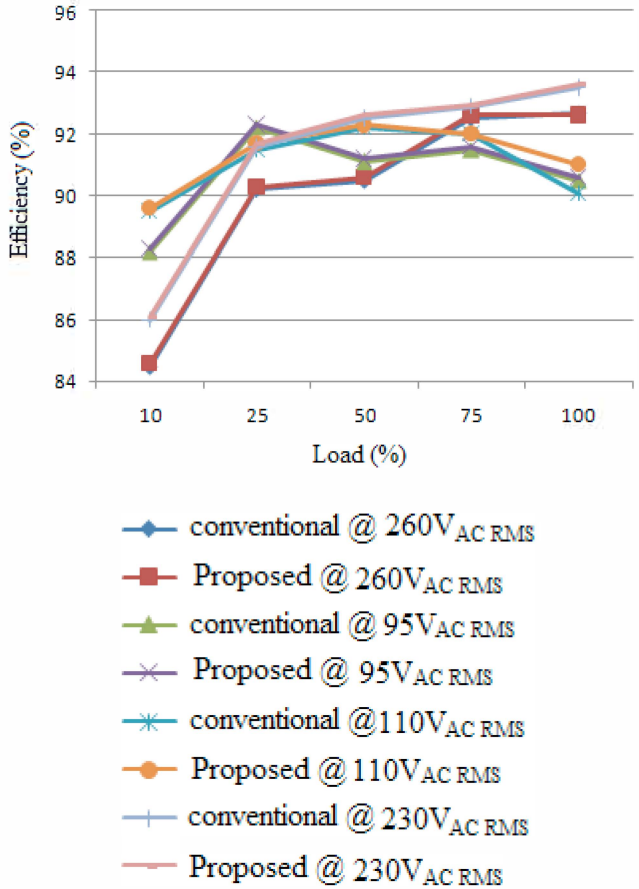


(d)



(e)

Fig.4. Simulation Result (a)Voltage across the battery (b)Battery Current (c) input AC voltage (d) Control signal to relay from control circuit (e) State of charge characteristics of battery (SOC)



V. CONCLUSION

The no load power minimization techniques with embedded battery and logic gate is proposed in this paper. When the load is disconnected the entire adapter circuit is get turned OFF by turning OFF the relay through OR gate signal. Likewise the load connection also gets identified by the same OR gate signal. The relay acts like a main switch, if the relay is getting turned OFF it mean that the power supply to the system is terminated. So there is no NLP (No Load Power) in the proposed adapter technique. This proposed adapter is simple in structure and expected to be widely used for no load power minimization.

REFERENCES

[1] Muhammed H.Rashid, "Power Electronics Circuits, Devices and Applications" , Third Edition, 2009.

[2] P. S. Bimbhra, Power Electronics, Khanna Publishers 2010.

[3] Byoung-Hee Lee and Gun-Woo Moon, "Zero No-Load Power AC/DC Adapter For Electronic Equipment With Embedded Battery"

[4] Y. K. Lo, S.C. Yen and C.Y. Lin, "A High-Efficiency AC-to-DC Adaptor With a Low Standby Power Consumption", *IEEE Trans.Industrial Electronics*. vol. 55, no. 2, pp. 963-965, February 2008.

[5] All About EMI filters, http://electronicproducts.com electronic products, October 2008.

[6] Fu-Yuan Shith, Dan Y.Chan, Yan-Pei Wu and Yie-Tone Chen, "A Procedure for Designing EMI Filters for AC Line Applications" IEEE Trans, Power Electronics. Vol. 11, pp. 170-181, January 1996.

[7] http://m.wisegeek.com/what-is-no-load-power.htm

[8] K. Y. Lee and Y. S. Lai, "Novel circuit design for two-stage AC/DC converter to meet standby power regulations", *IET Power Electronics.* vol.2, no. 6, pp. 625-634, November 2009.

[9] B. Y. Chen and Y. S. Lai, "Switching Control Technique of Phase-Shift-Controlled Full-Bridge Converter to Improve Efficiency Under Light-Load and Standby Conditions Without Additional Auxiliary Components", *IEEE Trans. Power Electronics*, vol. 25, no. 4, pp.1001-1012, April 2010.

[10] B. H. Lee, Y. D. Kim and G. W. Moon, "Single Switching Double Powering Converter for Reducing Power Consumption of AC/DC Adapter In Standby Mode", in *Proc. IEEE 8th International Conference on Power Electronics and ECCE Asia (ICPE & ECCE)*, 2011, pp. 199-204.