ISSN (Online) : 2319 - 8753
ISSN (Print) : 2347 - 6710

International Journal of Innovative Research in Science, Engineering and Technology

Volume 3 , Special Issue 3, March 2014

2014 International Conference on Innovations in Engineering and Technology (ICIET'14)
On 21st & 22nd March Organized by

K.L.N. College of Engineering, Madurai, Tamil Nadu, India

Minimized Standby Power Scheme For Forward Converter With Isolated Output-Feedback

J.Arul sheeba [1], B.Pushpavanam [2]
[1] PG Scholar, EEE, PSNACET, Dindigul, India
[2] Assistant professor, EEE, PSNACET, Dindigul, India

ABSTRACT— A feedback network for forward converter that automatically reduces the current flowing through the opto-coupler under no-load condition is presented in this paper. Standby power is electricity used by appliances and equipment while they are switched off or not performing their primary function. On account of isolation requirements for safety concerns, feedback via optical coupling is very prevalent in the industry. The number of electronics products has continued to increase rapidly. As a result, the accumulated standby power loss caused by their power supply devices has gradually been a significant part of total electricity use. In order to reduce the standby power loss of the power converter the no-load condition should be kept as low as possible. The conventional feedback system uses TL431 Commercial programmable shunt regulator, which results in increased power loss at no-load. A Feedback network for forward converter that automatically reduces the current flowing through the opto-coupler nearly zero under no load condition is achieved by replacing TL431 by reverse type shunt regulator. This feedback network for isolated switch-mode power supply uses a reverse type shunt regulator to generate error signal for optical coupling and a modified PWM controller to receive feedback signal. Thus the current through the feed-back circuit is minimized nearly zero under no-load condition. In this paper, simulation is done using MATLAB/SIMULINK and experimental results are presented.

KEYWORDS— Feedback topology, forward converter, Pulse width modulation (PWM) controller, standby power, shunt regulator

I. INTRODUCTION

The need for electronics products are increasing day by day. As the result standby power associated with them also increases. Standby power is the power which is consumed by the device under no-load condition. Although standby power is important for instant-on, power a remote control receiver it should be minimized to improve their no-load efficiency.

As shown in Fig.1. A SMPS generally contains the following blocks. An EMI filter, a bridge rectifier, dc-dc converter, an isolated feedback network and a controller. It's well known that the major drawback of SMPS is electromagnetic interference which will degrade the performance of the circuit. To avoid this and make the circuit electromagnetic compatible EMI filter is used here. Diode rectifier will convert the ac input voltage into dc output voltage. Forward converter has been used for low output voltage and high current applications. It may be used to supply devices that require voltages ranging from 12V to 3.3V and current upto50A. Feedback circuit consists of an error amplifier to generate error signal that is used by control IC to generate switching pulses.

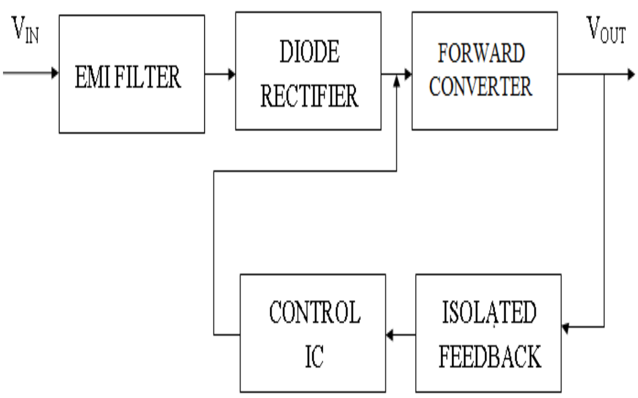


Fig.1. Block diagram of a SMPS

The losses of products are reduced using control IC ON/OFF [1], burst mode control[2] [3], pulse frequency modulation[4], pulse skipping modulation [5]

[6][7], pulse train modulation[8], in combination with the pulse width modulation technique. Using these techniques switching frequency at light-load and no-load conditions are reduced. The above mentioned techniques will reduce the switching loss associated with the converter. Unfortunately again the no-load efficiency is still poor because of the losses that take place in the feedback circuit. Although primary side current sensing [9] eliminates the need for feedback and results in low standby power loss it is applicable only for flyback topology.

As feedback circuit is also concerned as a source of loss it should be designed to overcome this problem and must be able to adopt by all the converter topologies to improve no- load efficiency. Such a technique is introduced in this paper. As safety is concerned feedback via opto-coupling is adopted. Current that flows through the opto-coupler under no-load condition is too large in conventional circuit which will increase the standby power loss. So if this current is reduced nearly zero, standby power loss can be reduced and the no-load efficiency can be improved. The proposed circuit consists of an error amplifier that drives PMOS as a feedback circuit.

II. EXISTING FEEDBACK CIRCUIT

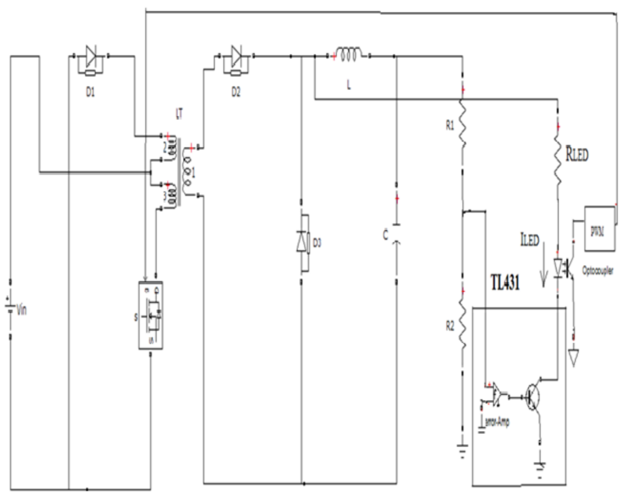


Fig.2. Existing circuit

In fig.2.The input voltage is obtained from the rectifier. According to the feedback information the MOSFET is turned ON/OFF by PWM controller. The feedback network consists of TL431 and an opto-coupler. Output voltage is divided by voltage divider R_1 and R_2. TL431 compares the divided output voltage with built-in reference voltage and error signal I_{LED} is drawn according to the difference. Opto-coupler transfers I_{LED} by current transfer ratio (CTR) to primary side and maintains galvanic isolation between primary and secondary sides. Induced primary current I_{FB} is converted into voltage V_{FB} by the controller and it is modulated by PWM modulator to generate gate-pulses. Thus lower output voltage will produce higher V_{FB} and I_{FB}, I_{LED} is lower. When load is disconnected V_{FB} drops to lower value and I_{FB}, I_{LED} becomes higher. This shows that when output power gets lower the power loss increases. Although it is a small value it will affect the no-load efficiency. It is against the energy saving point of view.

III.PROPOSED FEEDBACK CIRCUIT

The filtered ac input is given to the diode bridge rectifier where ac voltage is converted into fixed dc voltage. This is given as the input for the forward converter. Then the feedback network will produce the error signal and according to it the PWM modulator will produce the gate pulse.

The operation of the proposed feedback network differs from the existing one by replacing the bipolar junction transistor by pMOS. So the supply current I_Q supplying the amplifier and voltage reference will not flow through the opto-coupler.

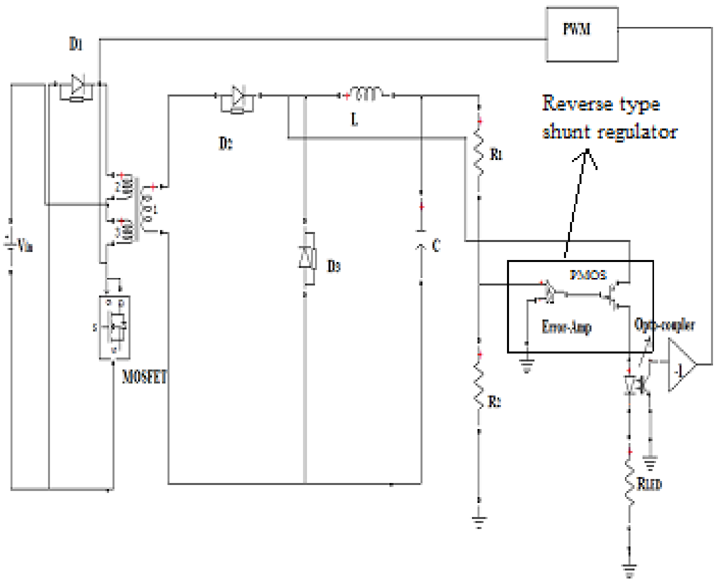


Fig.3. Proposed feedback circuit

This feedback network comprises of a built-in voltage reference voltage of 2.5V. On the primary side, the opto-coupler induces I_{FB} according to I_{LED} and I_{FB} is then converted into V_{FB}. Since the polarity of V_{FB} is same as that of the output voltage, using PWM modulator to directly modulate V_{FB} into switching pulses by forming positive feedback loop and cause malfunction. In order to avoid that inverting amplifier is introduced to reverse the phase of V_{FB} before giving it to PWM modulator which will form negative feedback.

This operation is similar to the conventional system but the difference is the phase of intermediate error signal for optical coupling. For higher output voltage the produces larger V_{FB} resulting in lower I_{FB}, $I_{LED.}$ Thus automatically the current through feedback circuit is reduced and improve the no-load efficiency. There is also no problem of instability.

IV.FORWARD CONVERTER DESIGN

Output voltage of forward converter is given by

$$V_{out} = \left(\frac{N_s}{N_p}\right) D V_{in} \qquad (1)$$

N_s/N_p is transformer turns ratio
D is duty cycle
Number of turns of single phase three winding transformer can be calculated by following equations:
Number of primary turns,

$$N_p = \frac{V_{inmin} D_{max}}{A_e \Delta B f} \qquad (2)$$

Where, V_{inmin} is minimum dc input voltage that can be given to the converter
D_{max} is maximum allowable duty cycle
A_e is effective winding area inside the core and can be calculated using,

$$A_e = \frac{1.2 P_{out}}{K_w K_p J_{max} f \Delta B \eta A_w} \times 10^4 \qquad (3)$$

B is flux density
f is the operating frequency of forward converter
Number of secondary turns,

$$N_s = N_p \left\{ \frac{V_{out} + V_F D_{max}}{V_{inmin} D_{max}} \right\} \qquad (4)$$

V_F is voltage drop of diode D_1
Number of tertiary turns,

$$N_d = \frac{N_p D_{max}}{1 - D_{max}} \qquad (5)$$

Value of output inductor,

$$L = \frac{\left[\left(\frac{N_s}{N_p} V_{in}\right)(1 - D_{max}) - V_F\right] D_{max}}{\Delta I_L f} \qquad (6)$$

Value of output capacitor,

$$C = \frac{\Delta I_L}{2\pi f \Delta V_c} \qquad (7)$$

V.SIMULATION RESULTS

To verify the proposed circuit simulation is done stage by stage in MATLAB/SIMULINK for no-load condition. The simulation results are shown below:

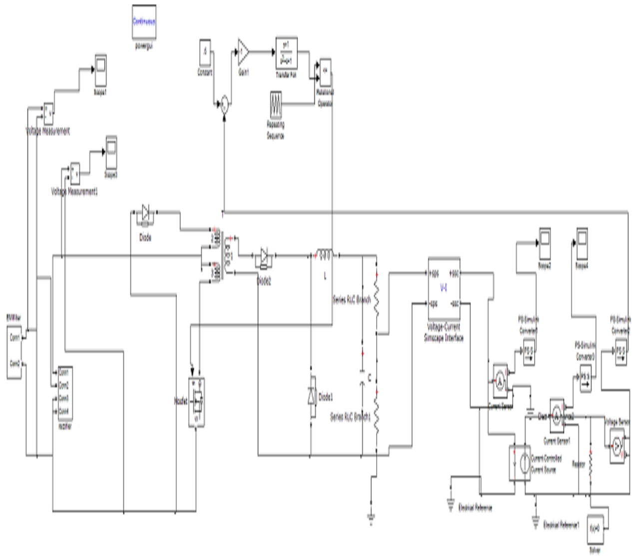
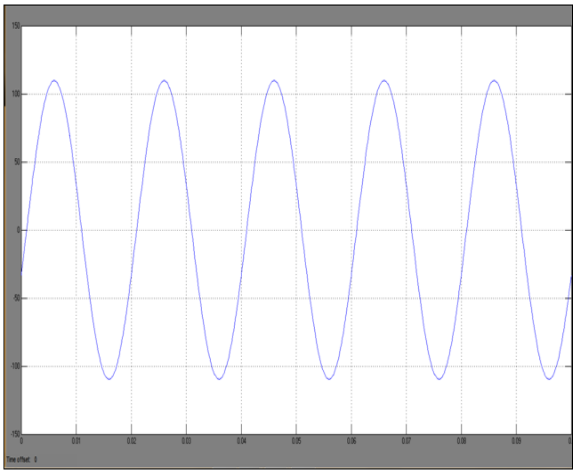


Fig.4.Simulation diagram

OUTPUT VOLTAGE OF EMI FILTER

Voltage (volts)



Time (seconds)

Fig.5.Output voltage

OUTPUT VOLTAGE OF DIODE RECTIFIER

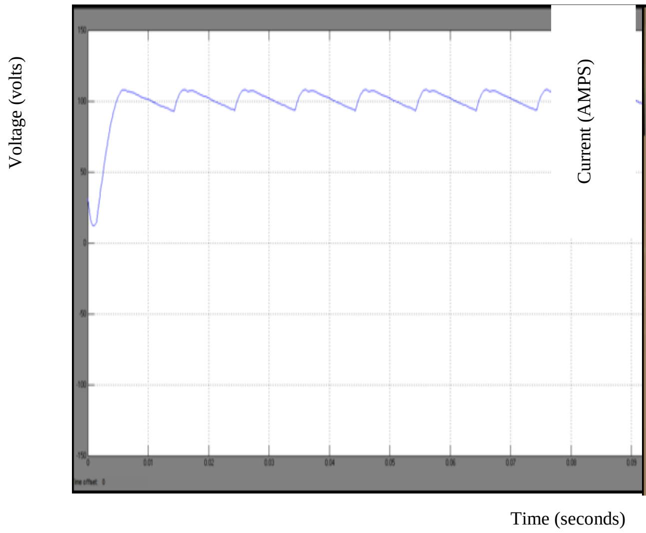


Fig.6.Output voltage

CURRENT THROUGH THE OPTO-COUPLER

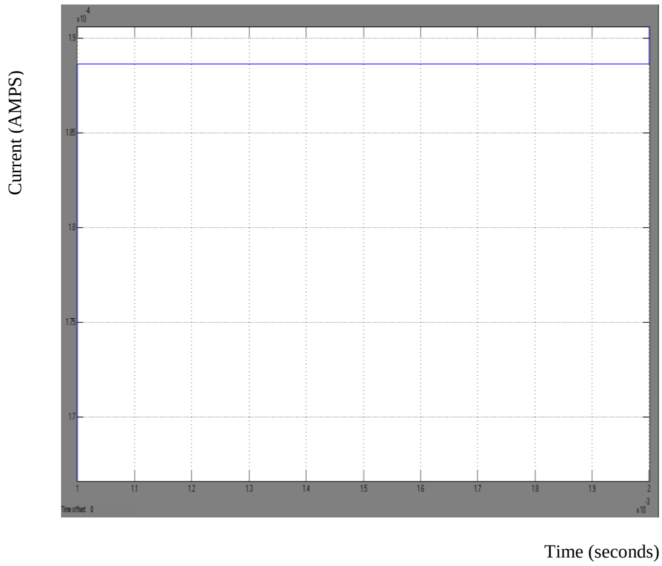


Fig.7.Output current

CURRENT THROUGH THE SHUNT REGULATOR

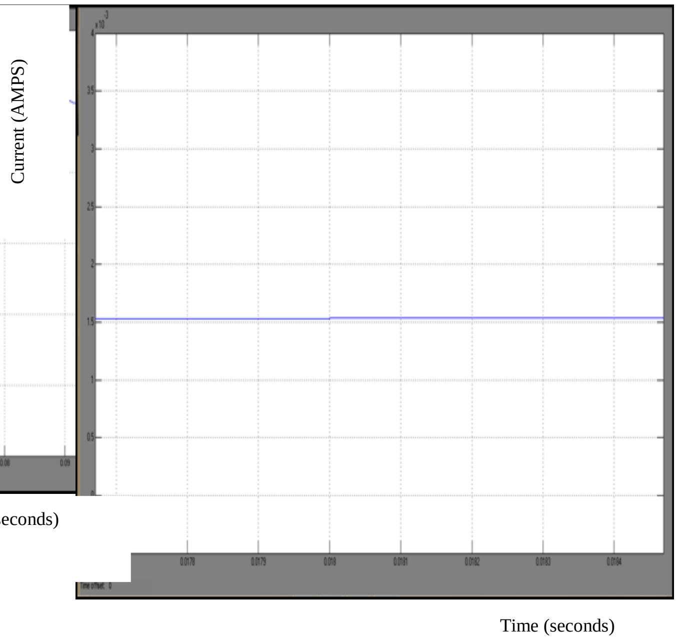


Fig.8.Output current

VI .CONCLUSIONS

An isolated feedback scheme with low-standby power for forward converter has been proposed. By this method under no-load condition opto-coupler consumes current nearly equal to zero i.e. 1.85×10^{-4}A. Thus the standby power consumption is reduced to .6mW. Simulation result show significant improvement in no-load efficiency of the forward converter. It can be used for other converter topologies also. It's application may include ATX power supplies for computers, low voltage battery chargers, server power supplies.

REFERENCES

[1] B.-H. Lee *et al., "No-load power reduction technique for ac/dc adapters," IEEE Trans. Power Electron., vol. 27, no.8, pp. 3685–3694, Aug. 2012.*

[2] S.-Y. Cho *et al.*, "A new standby structure based on a forward converter integrated with a phase-shift full-bridge converter for server power supplies," *IEEE Trans. Power Electron., vol. 28, no.1, pp. 336–346, Jan.* 2013.

[3] J.-H. Choi, D.-Y. Huh, and Y.-S. Kim, "The improved burst mode in the stand-by operation of power supply," in *Proc. IEEE Appl. Power Electron. Conf. Expo., 2004, vol. 1, pp. 426–432.*

[4] B. Sahur and G. A. Rincon-M´ora, "An accurate, low-voltage, CMOS switching power supply with adaptive on-time pulse-frequency modulation (PFM) control," *IEEE Trans. Circuits Syst. I, Reg. Papers*, vol. 54, no. 2, pp. 312–321, Feb. 2007.

[5] S. Kapat, S. Banerjee, and A. Patra, "Discontinuous map analysis of a dc-dc converter governed by pulse skipping modulation," *IEEE Trans. Circuits Syst. I, Reg. Papers*, vol. 57, no. 7, pp. 1793–1801, Jul. 2010.

[6] Y. Ye *et al.*, "PWM/PSM dual-mode controller for high efficiency dc-dc buck converter," in *Proc. Power Energy Eng. Conf.*, 2010, pp. 1–4.

[7] S. Kapat, A. Patra, and S. Banerjee, "Achieving monotonic variation of spectral composition in dc-dc converters using pulse skipping modulation," *IEEE Trans. Circuits Syst. I, Reg. Papers*, vol. 58, no. 8, pp. 1958–1966, Aug. 2011.

[8] M. Telefus *et al.*, "Pulse train control technique for flyback converter", *IEEE Trans. Power Electron.*, vol. 19, no. 3, pp. 757–764, May 2004.

[9] J. Zhang, H. Zeng, and T. Jiang, "A primary-side control scheme for high power-factor LED driver with TRIAC dimming capability," *IEEE Trans. Power Electron., vol. 27, no. 11, pp. 4619–4629, Nov. 2012.*

[10] Willi sansen, "Feedback Voltage & Transconductance Amplifiers".

[11] [Thesis] Ching-Shan Leu "Improved Forward Topologies for DC-DC Applications with Built-in Input Filter".

[12] [Thesis] Compact Isolated High Frequency DC/DC Converters Using Self-Driven Synchronous Rectification.

[13] [Thesis] "Integrated EMI Filters for Switch Mode Power Supplies", by Rengang Chen.