iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: VI Month of publication: June 2022

DOI: https://doi.org/10.22214/ijraset.2022.44004

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VI June 2022- Available at www.ijraset.com

Design and Implementation of Synchronous Buck converter for Space Applications

Latha G[1], Dr. Umavathi M[2], Bhoopendra Kumar Singh[3], Dr Ravichandran C[4], Prasanna Kumar R[5]

Abstract: The synchronous Buck converter is used to step down voltage from higher to lower level. Now a days, Efficiency is the major concern in designing any converters hence power converter design must be optimized to increase the performance of converter and to meet the requirement of load demand. The proposed work aims at design and Implementation of 6W synchronous buck converter using LT3845 synchronous step-down controller IC which is suitable for High Efficiency application. The compactness of device is also a major concern for proposed work, hence the current mode topology makes the power converter module more compatible and efficiency. The proposed work is designed for output power 12V/0.5A(6W) for an Input voltage from 24-30V.The system frequency of converter is 150Khz.The results are obtained for Hardware Implementation using LT3845 IC.

Keywords: Synchronous buck converter, LT3845 step down controller IC, Switch mode power supply, Current mode control.

I. INTRODUCTION

In recent times, Switch Mode Power Converters (SMPS) are playing a prominent role in various applications due to their high efficiency solutions. These converters can be found in power supplies, electric tools, televisions and other electronic devices. The most popular converter among the other converters is the buck converter. Buck converter is one of the DC-DC converters which steps down the direct current (DC) voltage from one level to another level, this voltage level which is stepped down is used for particular applications and it is designed accordingly.

It is considered because of its simple construction. The peak current rating selected for the device should be minimum 1.5 times higher than the maximum output current. In a conventional buck converter, the diode will not conduct, if the main switch is on. When the switch is turned off the diode starts conducting, due to this there is a voltage drop across the diode and this drop is considered as loss. The conduction loss in diode might affect the efficiency of the buck converter[1]. Therefore, to enhance the efficiency and to minimize the conduction losses, Synchronous Buck converter using integrated chip (IC) LT3845 can be implemented. This paper focuses on design and analysis of synchronous buck converter using IC LT3845 at switching frequency of 150 kHz.

II. SYNCHRONOUS BUCK CONVERTER TOPOLOGY

As shown in figure, the basic circuit diagram of a synchronous buck converter. The two switches S1 and S2 in Synchronous converter are operated such that there is no overlap that is during the ON time of one switch the other one will be OFF. This introduction of second switch in place of a diode, decreases the voltage drop from about 1V to about 0.3V [2]. In addition, this enhances the efficiency of the converter considerably [2].

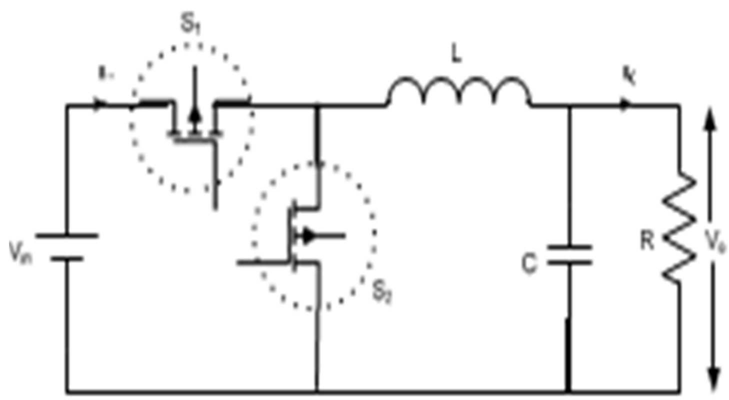

Figure 1: Synchronous Buck Converter

There are two cases in which synchronous buck converter operates. In case 1, switch 1(S1) is turned 'on' while the switch 2(S2) is turned 'off'. During this the inductor and capacitor gets charged. In case 2, switch 2(S2) is turned 'on' while the switch 1(S1) is turned 'off'. During this the inductor discharges through the body diode of S2. In case 2, on-state power loss is less because of the synchronous switch which is as shown in figure 2 [3-6].

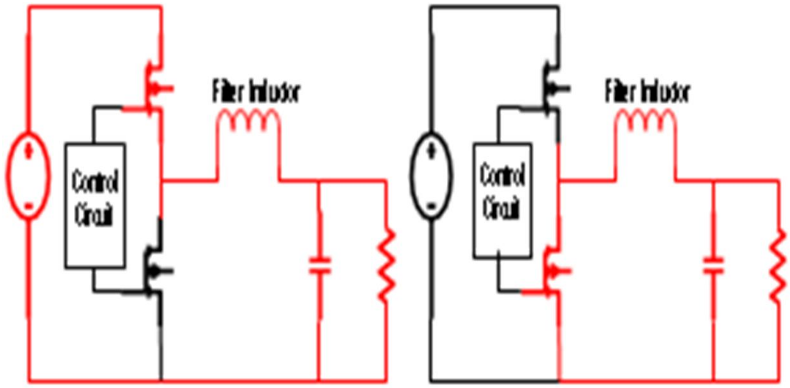

Figure 2: Operation of synchronous buck converter in both Cases

III. SYNCHRONOUS BUCK CONVERTER'S DESIGN AND HARDWARE IMPLEMENTATION

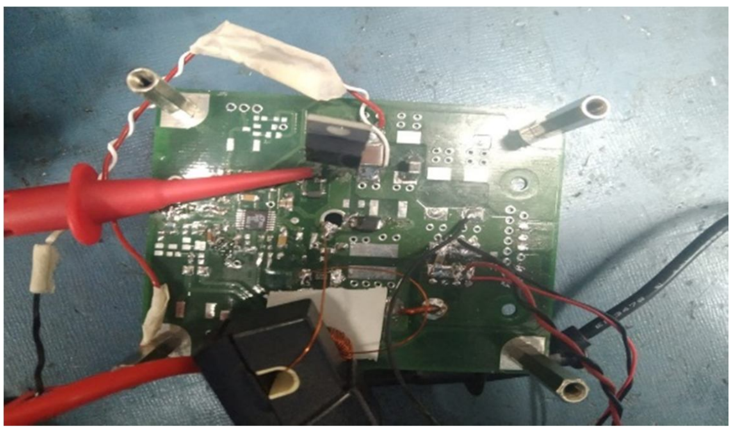

Figure 3: synchronous buck converter

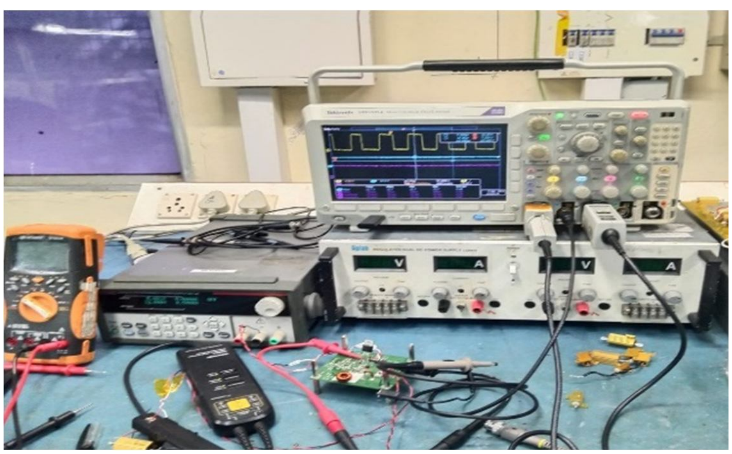

Figure 4: Prototype model setup of Synchronous Buck Converter

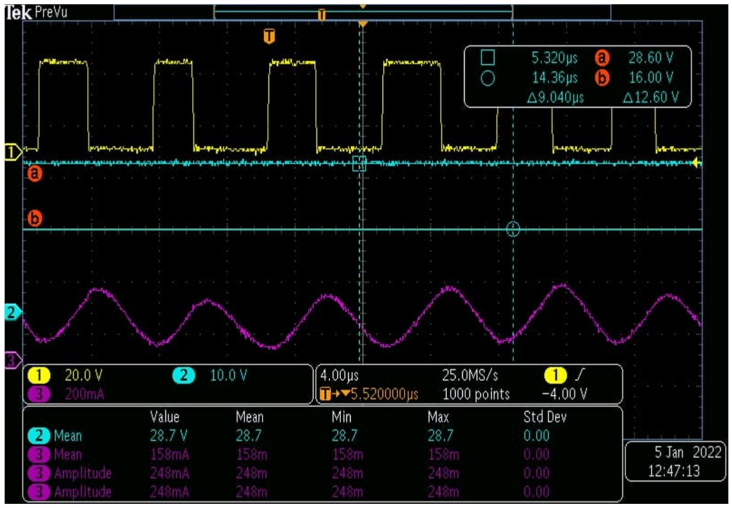

Figure 5: Hardware Input Waveforms: Yellow-Gate-source Voltage, Blue-Input Voltage, Purple-Input Current

Figure 6: Hardware Input Waveforms: Yellow-Gate-source Voltage, Blue-Input Voltage Purple-Input Current

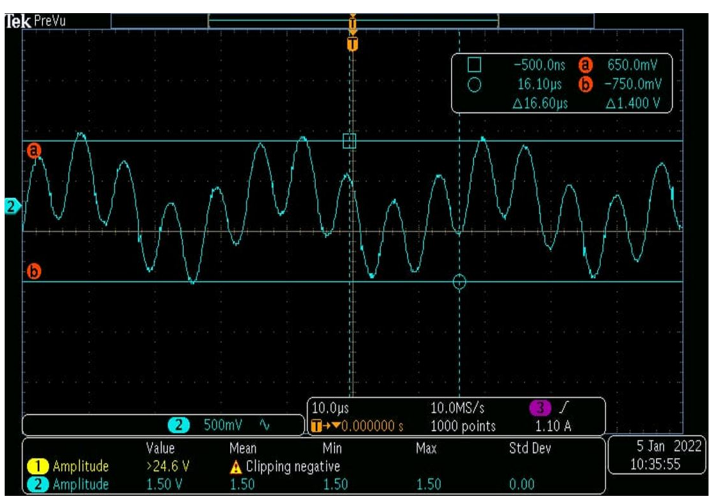

Figure 7: Ripple Waveforms

IV. DESIGN STEPS FOR SYNCHRONOUS BUCK CONVERTER

A. Input

Minimum input voltage Vin_min := 24 Volts
Maximum input voltage Vin_max := 42 Volts
Nominal input voltage Vin_nom := 28 Volts
Switching Frequency Fsv := 150.10^3 Hz
Ts := $\frac{1}{Fsv}$
Ts = $6.6667.10^{-6}$ Second

B. Output Voltage & Current

Vout := 12 Volt
ΔVout := 30.10^{-3} Volt
Iout_max := 0.5
Iout_min := 0.1

C. Duty Cycle Calculation

D_max := $\frac{Vout}{Vin\_min}$ = 0.5
D_min := $\frac{Vout}{Vin\_max}$ = 0.2857
D_nom := $\frac{Vout}{Vin\_nom}$ = 0.4286

D. Output Resistance Calculation

Rout_min := $\frac{Vout}{Iout\_max}$ = 24
Rout_max := $\frac{Vout}{Iout\_min}$ = 120
Nominal := 40

E. Input & Output Power Calculation

Pout_max : = Vout . Iout _max = 6
Pout_min : = Vout . Iout_min = 1.2
η : = 0.85
Pin_max : = $\frac{Pout\_max}{\eta}$ = 7.0588
Pin_min : = $\frac{Pout\_min}{\eta}$ = 1.4118

F. Input Average Current Calculation

Iin_max_min : = $\frac{Pin\_max}{Vin\_min}$ =0.2941
Iin_max_nom : = $\frac{Pin\_max}{Vin\_nom}$ =0.2521
Iin_max_max : = $\frac{Pin\_max}{Vin\_max}$ =0.1681

Iin_min_min : = $\frac{Pin\_min}{Vin\_min}$ =0.0588
Iin_min_nom : = $\frac{Pin\_min}{Vin\_nom}$ =0.0504
Iin_min_max : = $\frac{Pin\_min}{Vin\_max}$ =0.0336
Pk -Pk ripple factor @ Vmax K : = 0.2
Iripple := k . Iout _max

G. *Output Inductor Selection*

L : = Vout . $\frac{(Vin\_max - Vout)}{Fsv \,.\, Vin\_max \,.\, Iripple}$ = 0.0006(667 micro) **Note** : Select L greater than the calculated value

OUTPUT CAPACITOR ESR CALCULATION

ESR_max := $\frac{(\Delta Vout \,.\, L \,.\, Fsv)}{Vout \,.(1-\frac{Vout}{Vin\_max})}$

ESR_max = 0.3

ESR_max := 0.02

H. *Output Capacitor Selection*

C_out := $\frac{Iripple}{8.(\Delta Vout - Iripple \,.ESR\_max).Fsv}$ =$2.9762.10^{-6}$

C_out = $2.9762.10^{-6}$

ΔVin := 0.1

I. *Input Capacitor Selection*

C_IN (BULK) :=Iout_max. $\frac{Vout}{\Delta Vin \,.\, Fsv \,.Vin\_min}$ =$1.6667.10^{-5}$

I_CIN (RMS) := Iout_max . $\sqrt{\frac{Vout \,.(Vin\_max - Vout)}{Vin\_max\,\hat{}\,2}}$ =0.2259

J. *R Sense Calculation*

R_Sense := 70 . $\frac{mV}{Iout\_max}$ = 0.14 V

R_Set calculation

R_set (KΩ) := (8.4) . 10^4 . Fsv $^{(-1.31)}$

Rset := 118.KΩ

V. HARDWARE IMPLEMENTATION RESULTS

Table1: synchronous Buck converter Hardware results

Input Voltage(V)	Input current(I)	Input power(W)	Output voltage(V)	output current(I)	output power(w)	Efficiency n (%)
24	0.156	3.7	11.963	0.299	3.5769	95.513
25	0.150	3.75	11.963	0.299	3.5769	95.36
26	0.144	4.277	11.963	0.299	3.5769	95.51
27	0.139	4.3065	11.963	0.299	3.5769	95.28
28	0.134	4.3372	11.963	0.299	3.5769	95.31
29	0.129	4.3645	11.963	0.299	3.5769	95.59
30	0.125	4.3920	11.962	0.299	3.5769	95.36

The Hardware Implementation of synchronous buck converter using LT3845 was carried out for the given specifications and the results and waveforms are given below[6-7]. The output voltage, output current and efficiency is as shown in Table 1. The resulted waveform of Synchronous buck converter for 28V input is shown in figures. Efficiency of the converter is also tested for 24V and 30V inputs and it is shown in Table-1.

VI. CONCLUSION

Current mode controlled high efficiency synchronous buck converter is designed. Hardware results are verified, the load of the converter is 40 ohms, with an input voltage range of 24 to 30V. Efficiency of more than 95% is obtained by using LT3845 Synchronous stepdown controller IC.

VII. AKNOWLEDGEMENT

Authors are grateful to the Management, BMS Educational Trust, Principal and Vice-Principal, BMS College of Engineering.

REFERENCES

[1] J. Sreedhar, Dr. B. Basavaraju, "Design and Analysis of Synchronous Buck converter for UPS Application", 2016 2nd International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB).

[2] Zafar Iqbal, Usman Nasir, Muhammad Tahir Rasheed, Kashif Munir, "A Comparative Analysis of Synchronous Buck, Isolated Buck and Buck Converter", 2015 IEEE 15th International Conference on Environment and Electrical Engineering (EEEIC).

[3] Linear technology, High Voltage Synchronous Current Mode Step-Down Controller with Adjustable Operating Frequency,LT3845-datasheet:https://www.analog.com/media/en/technical-documentation/data-sheets/3845fd.pdf, http://cds.linear.com/docs/en/datasheet/rh3845mkfc.pdf.

[4] UMAVATHI M, & Udhayakumar K "Simulation and Analysis of Solar-Wind Hybrid System Using an Efficient Multi-Port DC-DC Converter 'Journal of Advanced Research in Dynamical and Control Systems' Spl.pp.1910-1918, ISSN 1943-023X (Received Best Paper Award in Conference), May 2017

[5] Nishanth B Kulkarni, Sukumar J P, B K Singh "Multiple Output Fly Back Converter with primary side current mode control for defense Applications". Smart Grids, Power and Advanced Control Engineering Conference, 2017.

[6] Umavathi M, Udayakumar K & ISHWARYA K. "Combined wind and PV residential energy system with single DC-DC (CUK) converter and 1-phase inverter to power grid" Journal of Electrical Engineering, vol.17, no.3, pp.118-129,2017.

[7] Sudeep E, Rachappa, B. K. Singh "Design and Implementation of Current Mode Controlled 150W Miniature Forward Converter for Defence application" 2016.

[8] Chaitra G. Satyaraddi, A. Usha, Bhoopendra Kumar Singh, Vinod Chippalktti. "Design and Implementation of Multiple Output Interleaved Flyback Converter with Post Regulators", 2019 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT), 2019.