

Design and Implementation of Single Output Flyback Converter for Navigation System

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Abstract— An electric device called a power supply is used to deliver electricity to an electrical load. A power supply's primary function is to transform electrical current from a source into the appropriate voltage, current, and frequency necessary to run the load. The common objective of any power supply design is to reduce the size, weight and to increase the efficiency and to reduce losses. Switch Mode Power Supplies (SMPS) are more effective at achieving these goals than linear power supplies. With its straightforward design and affordable cost, Flyback topology is a good option among different SMPS topologies for low to medium power applications. The design of a 6W single-output flyback converter with a low dropout regulator (LDO) on the secondary side is described in this paper. The Flyback Converter, designed for compact power delivery, achieves high efficiency by operating in Discontinuous Conduction Mode (DCM), making it suitable for applications requiring low power and stable output. The primary stage is responsible for energy conversion, while the secondary side LDO ensures precise voltage regulation, mitigating ripple and fluctuations from the converter. Key design considerations, including transformer selection, switching frequency, and LDO characteristics, are discussed to optimize both performance and efficiency. Experimental results show the converter's ability to deliver a stable 6W output with reduced thermal and electrical noise, proving its viability for cost-sensitive, low-power applications in various electronic devices.

Index Terms— DC-DC Converter, Flyback Converter, Operating frequency, UC2825 PWM IC, Voltage Mode Control.

I. INTRODUCTION

DC-DC converters are power circuits providing regulated output voltage and Power. Various applications involve telecom, industry, automotive, military and aerospace are served by DC-DC converters. The common objective of any power supply design is to reduce the size, weight and to increase the efficiency and also to reduce losses. Compared to linear power supplies, Switch Mode Power Supplies (SMPS) are more successful in accomplishing the aforementioned objectives. Due to its straightforward design, ease of adding numerous outputs, and affordability, Flyback topology is a great option for low to medium power applications among the various SMPS topologies. However, Flyback topology has few drawbacks such as high voltage stress across

MOSFET switch and poor cross regulation for multiple output topology. It is necessary to use snubber circuits to overcome the stress across the MOSFET switch.

The flyback converter operates in Discontinuous Conduction Mode (DCM) to achieve high efficiency, utilizing a transformer with optimal turns ratio to provide electrical isolation between the input and output. The LDO on the secondary side is employed to ensure precise output voltage regulation, compensating for any voltage fluctuations or ripple introduced by the converter. The design minimizes the need for additional passive filtering, offering a low-noise output ideal for sensitive electronic devices. The proposed converter is designed and realized with voltage mode control. Further, at the secondary side, Low Dropout Regulators (LDO) are employed to achieve better, line and load regulations.

II. BLOCK DIAGRAM

The block diagram depicts a flyback type DC-DC step down converter taking an input voltage of 28V to 40V and converts it to a regulated single output voltage of 15V with a current of 0.4A, providing 6W output power. The system undergoes part-by-part processing starting with an EMI filter suppressing the high frequency noise coming into the power supply and also radially out from the power supply. A startup circuit draws some amount of the input current to power the PWM IC by charging a capacitor, enabling the PWM controller to function. The bias circuit draws energy from an auxiliary winding of the transformer, can provide stable power supply for the controller allowing steady state operation.

The PWM IC turns ON a MOSFET switch and is controlled at a predetermined switching frequency of 450KHz. The duty cycle is modulated as feedback is provided, ensuring the output voltage remains stable. The flyback transformer separates the output from the input and serves to transfer energy from the primary to the secondary winding. During the ON state of the MOSFET, energy gets stored in the transformer's magnetic core. During the OFF state of the MOSFET, energy is released through the secondary winding.

The output of the transformer's secondary winding is high-frequency AC is converted into pulsating DC by the diode rectifier. An LDO (Low Dropout Regulator) used to smooth the pulsating DC, remove ripple and noise and regulate the output voltage to a precise 15V. The end result is an isolated, regulated source of 15V DC which can supply current up to 0.4A, capable of powering various electronic devices.

A. Voltage Mode Control

Voltage mode control is a common practice in DC-DC converters. Output voltage is controlled by adjusting the duty cycle of the switching element using voltage feedback. The output voltage is monitored using a resistor divider and compared with a reference voltage by an internal error amplifier within the PWM controller. The voltage error produced is processed within a comparator comparing with a fixed frequency sawtooth or ramp waveform in order to generate a PWM signal. The signal determines the ON and OFF periods of the MOSFET adjusting the energy delivered through the transformer and the output voltage is stabilized. The presented converter operates at a fixed switching frequency of 450 kHz. Voltage mode control maintains the output at 15V for input voltage fluctuations between 28V and 40V. The technique uses a single control loop ensures stable and predictable switching and good output regulation. The approach may be slower to respond to fast load changes than current mode control.

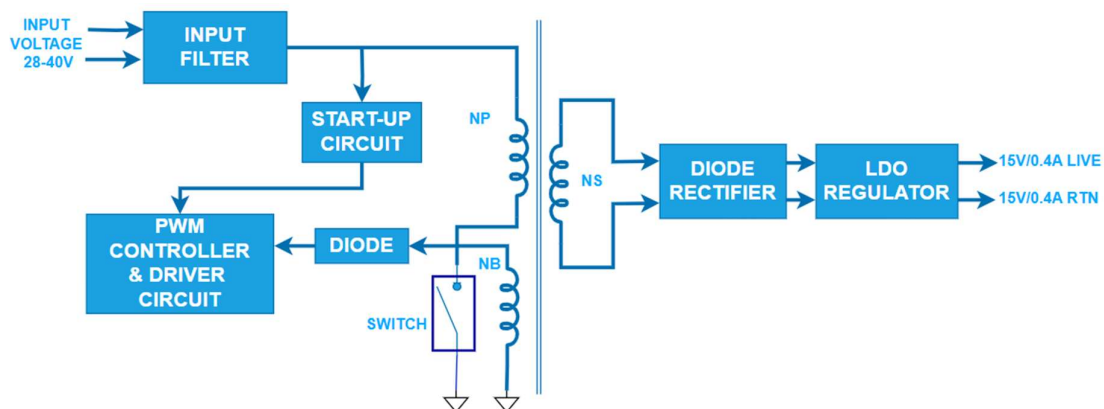


Figure 1. Block Diagram of Proposed Flyback Converter

III. HARDWARE PROPOSAL

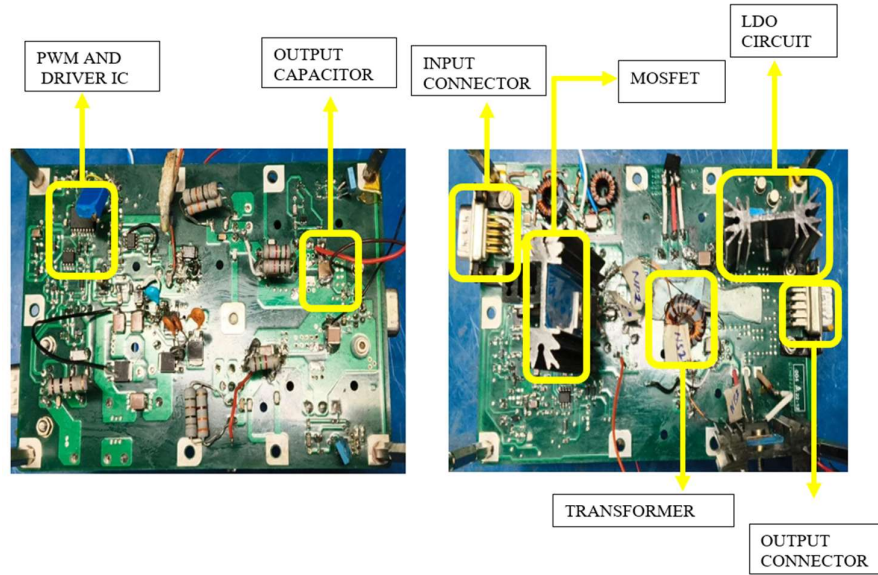


Figure 2. Hardware Module of the Proposed Flyback Converter

IV. HARDWARE SETUP

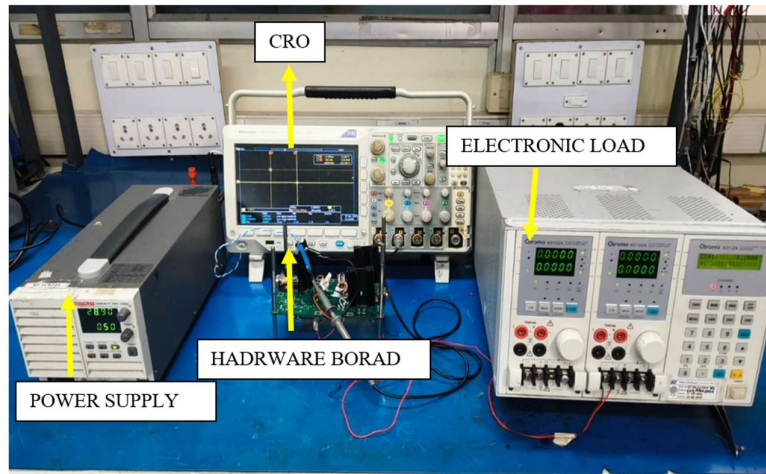


Figure 3. Hardware Setup of Proposed Flyback Converter

TABLE I: SPECIFICATION

Input Voltage	28V-40V DC (32V Nominal Voltage)
Topology	Flyback Converter
Switching Frequency	450KHz
Output Voltage and Current	15V/0.4A
Efficiency	58%
Line Regulation	<1%
Load Regulation	<0.5
Minimum Duty Cycle	<50%
Output Power	6W
Output Voltage Ripple	50mVpp at Full Load
Spike	100mVpp

Time Period $T_s = \frac{1}{F_{sw}} = 2.222 \times 10^{-6} \text{ sec}$
Efficiency = 0.58%
Duty cycle = 0.5
Total Output Power = $V \cdot I = 15 \cdot 0.4 = 6 \text{ Watt}$
TRANSFORMER DESIGN CALCULATION:
 $J = 4 \text{ amp/mm}^2$, $K_w = 0.3$, $B_m = 0.1 \text{ tesla}$
 $A_p = \frac{L_p \cdot I_{pp} \cdot A_{p0}}{K_w \cdot J \cdot B_m \cdot 10^{-6}} = 48.66 \text{ mm}^4$
Selection Core: 55025A2, $A_c = 15 \text{ mm}^2$, $A_w = 45 \text{ mm}^2$
 $A_c = 15 \text{ mm}^2$, $A_w = 45 \text{ mm}^2$
 $A_p = A_c \cdot A_w$, $A_p = 675 \text{ mm}^4$
 $AL = 124 \cdot 10^{-9} \text{ H}$
 $N_{pri} = \frac{L_p \cdot I_{pp}}{A_c \cdot B_m \cdot 10^{-6}} = 10.37704$ $N_{pri} = 10$
Turn ratio $N_{s1} = 0.56$
 $N_{sec} = \text{Turn ratio } N_{s1} \cdot N_{pri} = 5.60$ $N_{sec} = 6$

Output Ripple Voltage for Full Load

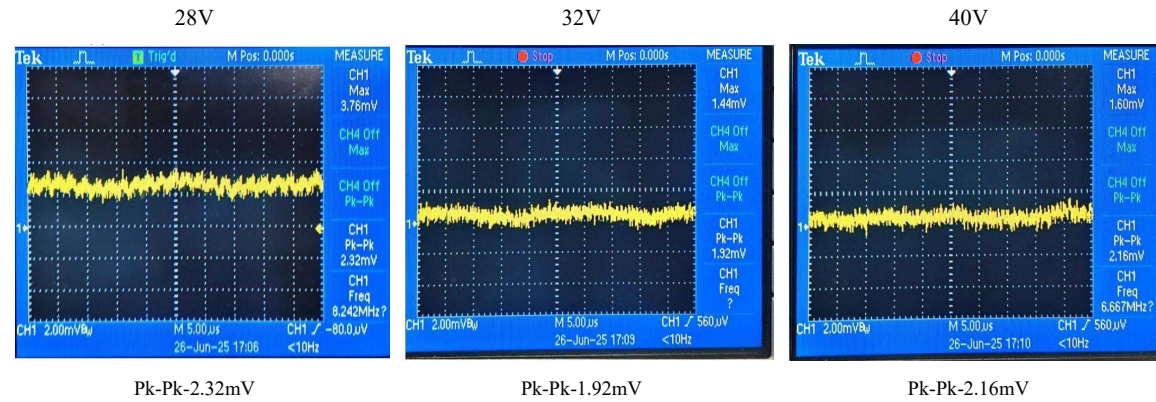


Figure 4. Output Ripple Voltage Waveform for Full Load

Drain-Source Voltage for Full Load

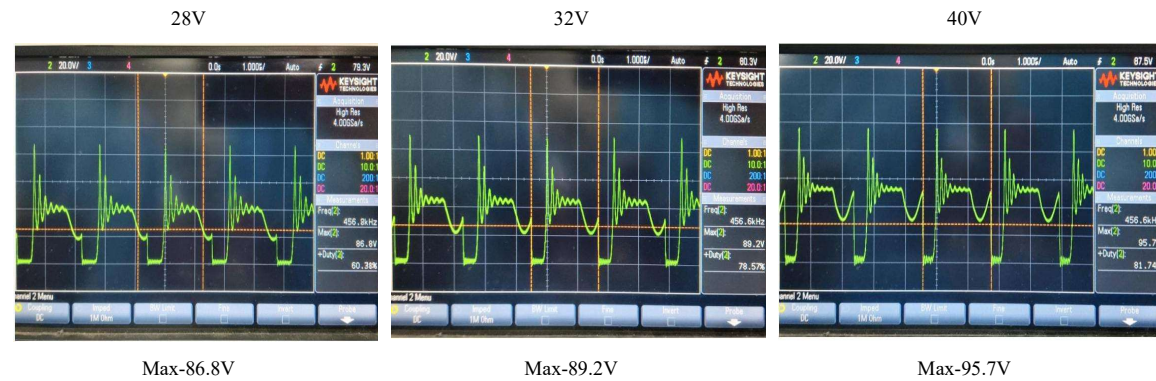


Figure 5. Drain-Source Voltage Waveform for Full Load

TABLE II: OUTPUT VOLTAGE FOR 10% LOAD

$V_{in}(V)$	$I_{in}(A)$	$V_{out}(V)$	$I_{out}(A)$	$P_{in}(W)$	$P_{out}(W)$
28	0.14	14.961	0.04	3.92	0.598
32	0.12	14.949	0.04	3.84	0.597
40	0.12	14.956	0.04	4.80	0.598

Output Voltage Waveforms for 10% Load

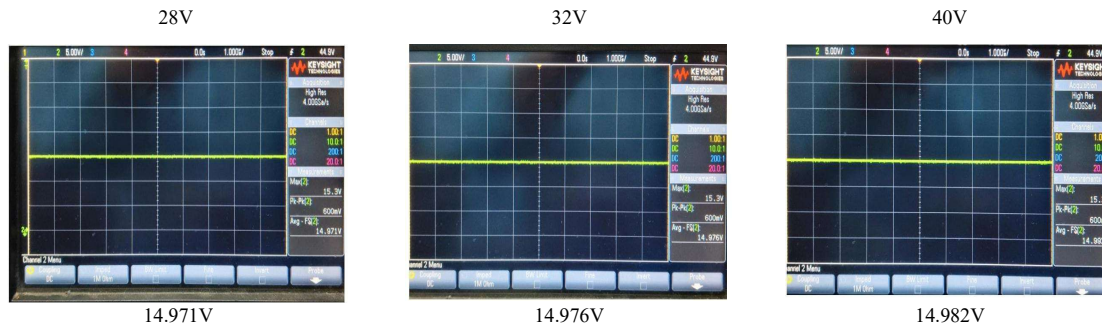


Figure 6. Output Voltage Waveform for 10% Load

TABLE III: OUTPUT VOLTAGE FOR 50% LOAD

$V_{in}(V)$	$I_{in}(A)$	$V_{out}(V)$	$I_{out}(A)$	$P_{in}(W)$	$P_{out}(W)$
28	0.14	14.961	0.04	3.92	0.598
32	0.12	14.949	0.04	3.84	0.597
40	0.12	14.956	0.04	4.80	0.598

Output Voltage Waveforms for 50% Load

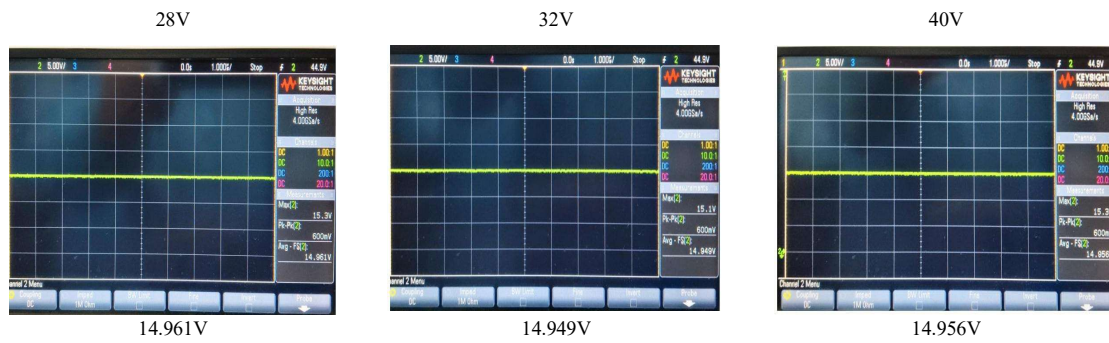


Figure 7. Output Voltage Waveform for 50% Load

TABLE IV: OUTPUT VOLTAGE FOR 100% LOAD

$V_{in}(V)$	$I_{in}(A)$	$V_{out}(V)$	$I_{out}(A)$	$P_{in}(W)$	$P_{out}(W)$	Eff (%)
28	0.36	14.764	0.4	10.08	5.905	58.58
32	0.33	14.764	0.4	10.56	5.905	55.91
40	0.29	14.899	0.4	11.60	5.959	51.37

Output Voltage Waveforms for 100% Load

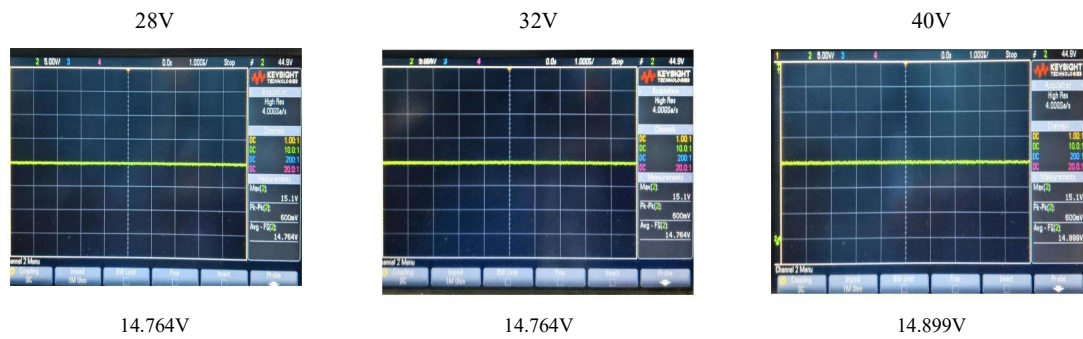


Figure 8. Output Voltage Waveform for 100% Load

TABLE V: LINE REGULATION

Input Voltage	Output Voltage	Line Regulation (%)
28V	14.764	0.91
32V	14.764	
40V	14.899	

$$\text{Line Regulation} = \frac{V_{out(\text{Max})} - V_{out(\text{min})}}{V_{out(\text{nom})}} = \frac{14.899 - 14.764}{14.764} = 0.91$$

$$\text{Load Regulation} = \frac{V_{out(\text{Max})} - V_{out(\text{min})}}{V_{out(\text{nom})}} = \frac{14.976 - 14.956}{14.956} = 0.005$$

TABLE V: LOAD REGULATION

Load	Vout (V) When Vin=28V	Vout (V) When Vin=32V	Vout (V) When Vin=40V
100%	14.764	14.764	14.899
50%	14.951	14.949	14.956
10%	14.966	14.971	14.976
Load Regulation (%)	0.013	0.013	0.005

VII. CONCLUSION

The proposed Flyback DC-DC converter works with an input voltage span of 28V to 40V, providing a steady 15V output at a current draw of 0.4A, translating to 6W output power. A flyback converter with an LDO voltage regulation method was designed and tested for use in a navigation system. The system operates at a switching frequency of 450 kHz. Hardware results show the converter achieves 58% efficiency. It also maintains excellent voltage stability, with load and line regulation below 1%. The results depict the design works effectively in real-world conditions and is well-suited for applications requiring a reliable and accurate power supply.

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