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Flyback Converter Controller by Arduino Uno

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Key words: Flayback converter, Arduino Uno, PI controller, MATLAB, open loop, close loop, IC2112

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Abstract: This study presented a flyback converter that regulates output voltage to give a desired value and can used in many application such as power supply. To give a regulated output voltage from flyback converter a feedback loop with Proportional-Integral (PI) controller is used. A simulation of flyback converter is employed by MATLAB/Simulink. Also a practical implementation is used microcontroller Arduino to control on the duty cycle through IC2112 driver at change in the input voltage or resistive load. The duty controller to create regulate output voltage by using voltage mode control.

INTRODUCTION

The DC-DC converter transforms a variable or constant DC voltage to regulated output DC voltage. Because of high efficiency and power density in addition to low cost, the switch mode power supplies is extended using than the linear power supplies. The DC-DC flyback converter are widely used, in power electronic application such as photocopy machines, plasma lamp and xenon flash lamps. It converts a fixed DC to variable DC voltage (Mohan *et al*., 2003; Rashid, 2004). There are many control method used for power converter such as linear control, fuzzy logic, PID, etc. PI control is used because of its simplicity in design and implementation (Sira-Ramirez, 1991; Verma *et al*., 2013). This study presents with a fly converter controller by Arduino Uno board. It has been selected because of its simplicity in use (Zulkifli *et al*., 2014; Badamasi, 2014). In this study, PI controller is achieve by programming of Arduino Uno board. The flyback converter is analysed as a feedback system in order to accomplish satisfying stability and time response.

MATERIALS AND METHODS

Flyback converter schematic: Figure 1 shows a flyback converter which contains of DC battery V_{in}, switch and output capacitor filter. Diode, transformer (ferrite core) to avoided saturation or two winding magnetic, inductor Lm and output resistance Rout (Erickson and Maksimovic, 2001). The flyback converter is essentially an isolated it operated buck or book. The flyback converter has low cost and simply circuit in addition to multi-output implementation. The transformation of the DC-DC flyback converter is through transformer or inductance by switch on or off. When switch on the the primary of transformer connected to input supply voltage. The primary current increased and energy stored in magnetizing inductance by switch on or off. When switch on the the primary of transformer connected to input supply voltage. The primary current increased and energy stored in wining of transformer. The voltage in the secondary wining has negative polarity, therefore, the diode is reverse biased. The output resistance is supplied from output capacitor. When switch off the primary current decreases and the secondary voltage has positive

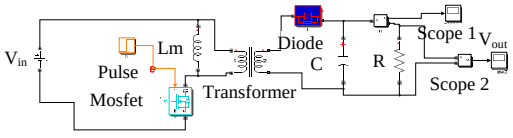

Fig. 1: A flyback converter which contain of DC battery

polarity, so that, diode is forward biased. The current flows in load and energy transforms from core of transformer to load. Figure 2 shows operated flyback in switch on and off. Operation of converter can be operated in both intervals. A microcontroller needed to generate the pulse width modulation for MOSFET. Arduino used as controller d evice and the output voltage is sensed). through R2 and R3 and sent to pin A2 of Arduino subsequently adjusted the output voltage (Xu *et al*., 2006). The driven switch is PWM through IC2112. Flyback converter can be control by digital or analog controller. A digital control will be selected here due to of its parameter changes adaptable such as desired output voltage, frequency of switch (MOSFET) and PI controller (proportional-integral parameter).

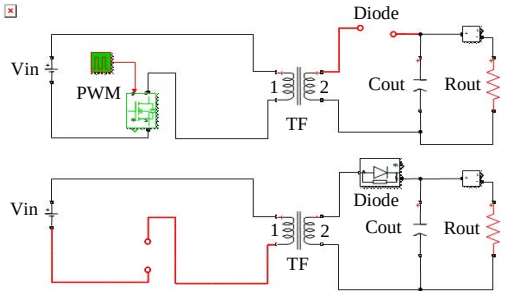

Fig. 2: Operated flyback

Feedback control loop by MATLAB: The flyback converter is operating in voltage mode control. The feedback loop of flyback converter is show in Fig 3. The output voltage is compared with reference voltage VREF and sent to PI controller to change duty cycle to adjust output voltage (Sucu, 2011).

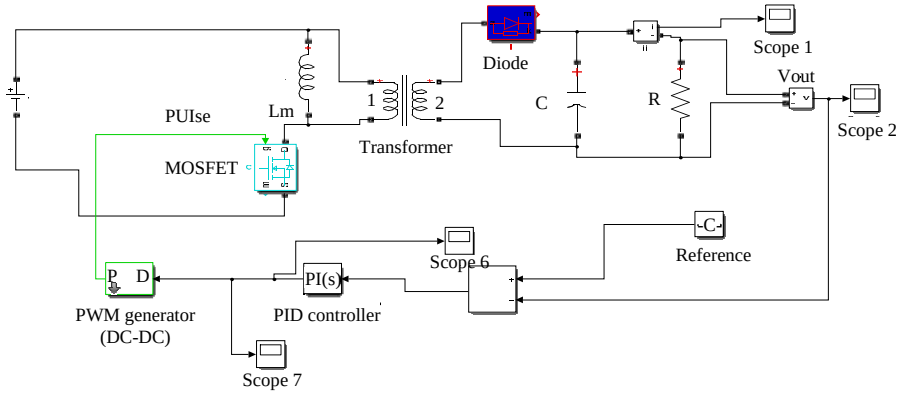

Fig. 3: Feedback loop of flyback converter

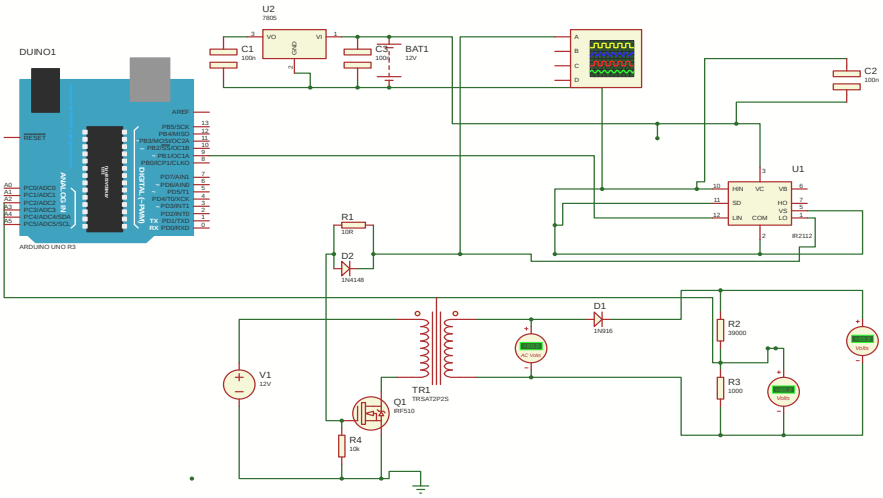

Fig. 4: Flyback converter with feedback loop

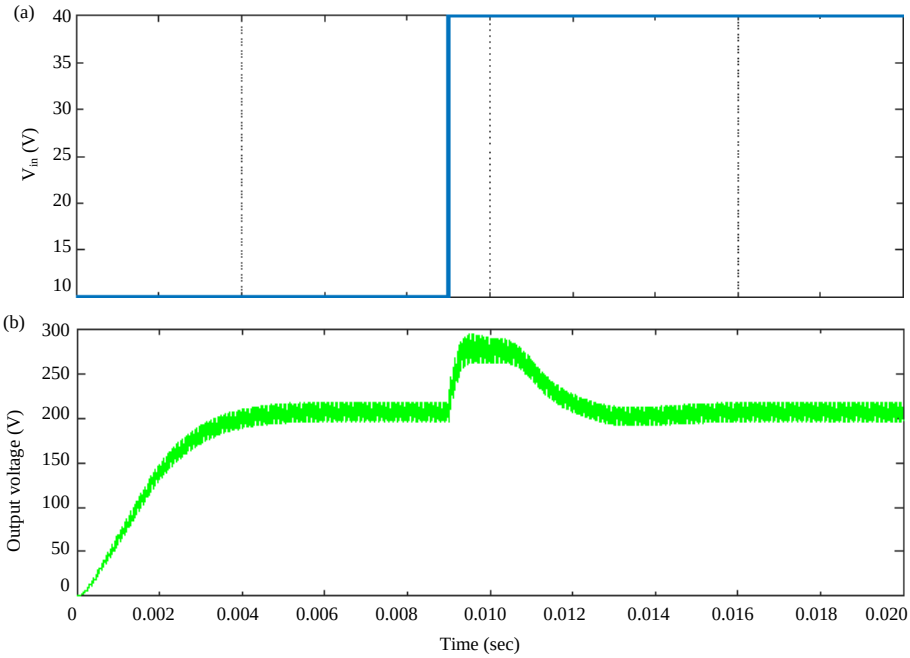

Fig. 5: Pulse width modulation and controlled on the output voltage

Table 1: Component

Variables	Values
Mosfet	IRF540
Capacitor	0.61 (μF)
V_{in}	12 (V)
V_{out}	200 (V)
R	800 (Ω)
Inductor	0.44 (mH)
Ic	2112
fs	20 (kHz)

Table 2:The output voltage constant with change in the input voltage

Input voltage	Output voltage	Output current
9	200.322	0.2504
11	200.366	0.25045
12	200	0.250
13	200.86	0.25107
14	200.98	0.25112

Table 3: The output voltage constant with change in load resistance

Load resistance in (Ω)	Output voltage in (V)	Output current in (amp)
500	200.222	0.4004
600	200.3256	0.3338
800	200.3451	0.250
900	200.877	0.2231
1000	200.9367	0.2009

Feedback loop regulation of flyback converter: The control part will be implemented by Arduino Uno board and all parameter circuit with feedback system show in Fig. 3 and 4. The pulse width generator delivers a rectangular signal at frequency 20000 khz and duty cycle D = 0.4 from Arduino Uno through IC2112 driver to supply gate of switch. The output voltage is measured through resistances R2, R3. The output voltage divider is sent to Arduino Uno to correct any change in the output voltage or input voltage of the converter. The output voltage divider should not exceed analog input voltage of Arduino Uno (5V). Figure 4 and 5 show flyback converter with feedback loop (Table 1-3).

Component: A DC voltage source used to supply the flyback converter. The fly back converter gives output voltage greater than input voltage, according to PWM produced by Arduino board. The pulse signal from Arduino v supples to semiconductor through IC2112 driver.

RESULTS AND DISCUSSION

The flyback converter is designed and simulated by using MATLAB R2017A. The Arduino provided pulse width modulation and controlled on the output voltage by increase or decrease the duty cycle. Figure 5 show when occurred change in input voltage from (10-40) V the microcontroller (Arduino Uno) corrected any change to give desired Voltage (200 V).

Hardware implementation: Figure 6 shows the hardware implement of flyback converter with Arduino controller. A PWM signal is generated by

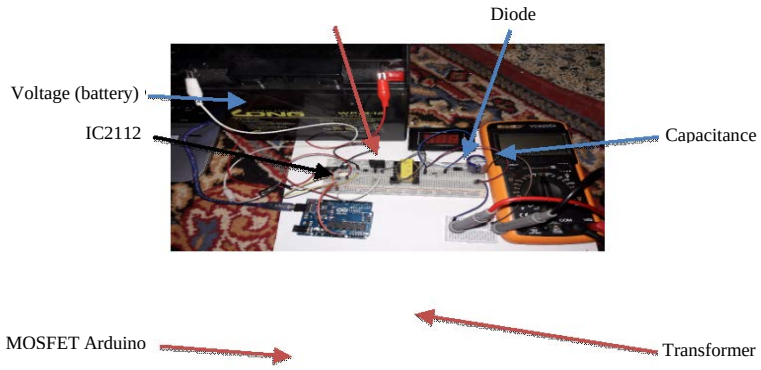

Fig. 6: The hardware circuit

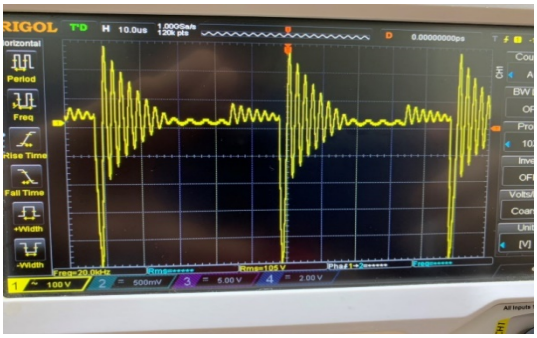

Fig. 7: The output voltage from transformer

Fig. 8: The waves at primary

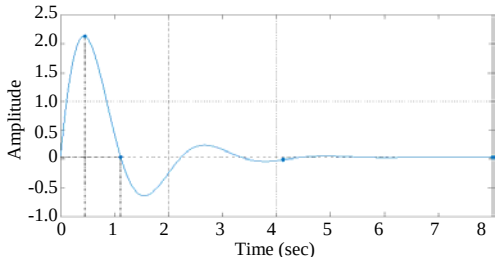

Fig. 9: Step response

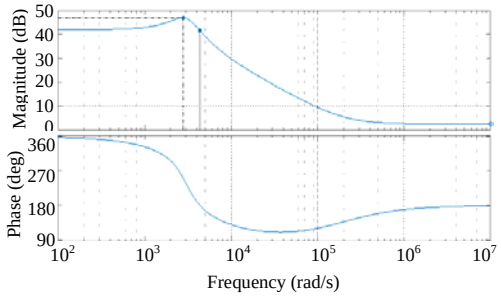

Fig. 10: Bode plots (V_{out}/V_{in}:from:d, To: vo)

Arduino in order to trigger the switch through IC driver (IC2102). The frequency of the PWM is the same that in the simulated circuit.

State space of flyback converter: Obtained transfer function of the flyback converter to determine the Bode plots and step response and ensure the system in stable, show in Fig. 8 and 9. We can find state space from (Sucu, 2011; Ramanarayanan, 2006; Chen *et al*., 1999). During switch on:

$$A1 = \begin{bmatrix} 0 & 0 \\ 0 & \frac{1}{RC} \end{bmatrix}, B1 = \begin{bmatrix} \frac{1}{Lm} \\ 0 \end{bmatrix}, C1 = \begin{pmatrix} 0 & 1 \end{pmatrix}$$

During switch off:

$$A2 = \begin{bmatrix} 0 & -\frac{n}{Lm} \\ \frac{n}{Cout} & \frac{1}{RCout} \end{bmatrix}, B2 = \begin{bmatrix} 0 \\ 0 \end{bmatrix}, C2 = \begin{pmatrix} 01 \end{pmatrix}$$

$$A = A1*d+A2(1-d)$$
$$B = B1*d+B2(1-d)$$
$$C = C1*d+C2(1-d)$$
$$E = E1*d+E2(1-d)$$

$$\frac{\text{Vout}}{\text{Vin}} = c(\text{SI-A})^{\tau}(-1)$$

$$B = \frac{0.0495\,s^2 + 9902\,s + 2.475\text{e}05}{s^2 + 2050\,s + 8.96\text{e}06}$$

CONCLUSION

The flyback converter controlled by microcontroller (Arduino Uno board) is achieved. Arduino Uno is used to control on flyback converter by generated PWM. The flyback converter is implemented by PI controller which accomplished by Arduino Uno board. PI controller used to reduce over shoot and steady state errors and gave desired output voltage.

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