Analysis and Modelling of DC-DC Power Buck Converter

Pranali Jadhav
UG Student,
Department of Electrical Engineering,
JDCOEM, Nagpur,India.
jadhavpranali580@gmail.com

Sonali Wasnik
UG Student,
Deparment of Electrical Engineering, JDCOEM,
Nagpur,India.
wasniksonali218@gamil.com

Nagina Bhange
UG Student,
Department of Electrical Engineering,
JDCOEM, Nagpur,India.
naginabhange@gmail.com

Bhagyashree Wasnik
UG Student,
Department of Electrical Engineering,
JDCOEM, Nagpur,India.
bhagyashreewasnik08@gmail.com

Roshan Autkar
UG Student
Department of Electrical Engineering,
JDCOEM, Nagpur,India.
autkarr@gmail.com

Abstract— in present scenario DC to DC switching converter are generally used for modern application. Now a days design of power electronics circuitry are reducing the size, space and weights of converter or inverter circuit All this are possible because of the availability of new high switching frequency devices. This paper presents analysis and modelling of dc to dc power buck converter. A buck converter is a dc to dc power converters which step down the voltage from its input to its output. Sometimes, it is also called as step down converter. The proposed model of buck converter consists of two parts: 1].main converter circuit with the components like diode, inductor, capacitor and load. 2] Converter circuit with LM2576. To prove the propose model, the circuit is prepared and their experimental results were compared with result obtained by using LM2576.

Keywords— DC to DC buck converter, Integrated circuit (IC's), Inductor, Capacitor.

I. INTRODUCTION

DC to DC converter is a power converter. This converter are mostly used in switched mode power supply .It has light weight of highly efficient and it uses in a semiconductor switching element .In modern electronics system required small , lightweight and reliable. There are 5 types of DC to DC converter, Buck converter, Boost converter, Buck -Boost converter, Cuk converter and Full bridge converter .Out of this converter only 2 basic converter are used i.e., Buck and Boost converter. We can derive other converter by using this converter. Buck converter is used to stepping down the voltage from its input to the output load .It mainly consist of 2 semiconductors which can be either capacitor or inductor .It work based in the circuit where electrical isolation is not require. They are useful for performing a special task like converting the huge voltage to small voltage components like USB, CPU and DRAM.

Buck converter is step down converter which effectively reduces the level of voltage as per the required application. The DC to DC converter can operate into two distinct modes with respect to

inductor current .It consist of inductor, two switches (generally transistor switch (S) and diode (D) for controlling inductor and capacitor as Shown in figure (1).

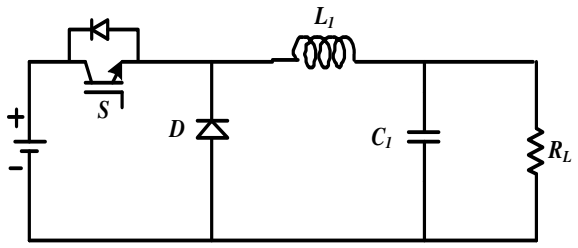

FIG .1. CIRCUIT DIAGRAM OF BUCK CONVERTER

CONTINUOUS CONDUCTION MODE

Under assumption that the state of converter in which the inductor current is never zero for any period of time is called as continuous conduction mode .In this mode when the switch is ON state (i.e. closed) as shown in fig2 (a) at t=0 the supply voltage changes the inductor current increases linearly. This current continuously increase till switch is ON and the freewheeling diode (D) acts as an open circuit that is the diode (D) is reverse biased. When the switch are open. There is some energy in the inductor, an inductor acts as a source and maintain the current through load resistor .During this period the energy stored in the inductor decreases and its current fall. As shown in fig 2(a) and (b).

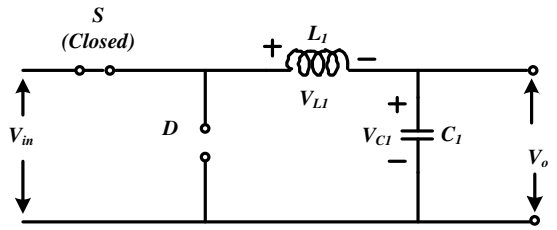

Fig 2(a). When switch is closed

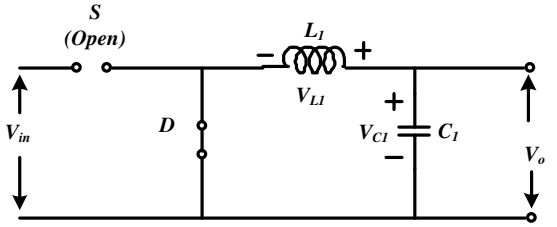

Fig2 (b). When switch is open.

DISCONTINUOUS CONDUCTION MODE

When average value of output current is low, the converter may enter the DCM .In this mode, the inductor depletes its stored energy completely before completion of switching cycle. i.e., the current through inductor goes to zero and reverse current does not flow.

DC voltage transfer function for buck converter defines as the ratio of the output voltage to the input voltage is.

$$\Delta I_{L(ON)} + \Delta I_{L(OFF)} = 0$$

$$\frac{V_S - V_O}{L} DT + \frac{-V_O}{L}(1-D)T = 0$$

$$V_O = DV_S$$

$$D = \frac{V_O}{V_S} \quad (1)$$

Where V_O is the output voltage, D id duty cycle, and V_S is the input voltage .The range of duty cycle lies between 0 - 1 ($0<D\leq 1$) so output voltage is always less than or equal to supply voltage.

Critical value of inductance for buck converter.

$$L_c = \frac{(1-D)R}{2f} \quad (2)$$

Critical inductance Lc is the minimum value of the inductor for a given D, f and R before the converter enter the discontinuous conduction mode of operation.

Critical value of capacitance

$$C_{min} = \frac{(1-D)}{16 f^2 L} \quad (3)$$

Where C_{min} is the minimum capacitance Where D refers duty cycle, f is frequency of switching, L and C refers to inductor and capacitor respectively,

DESIGNING 5V BUCK CONVERTER CIRCUIT USING LM2576

There are many types of buck regulators. These regulators attempt typical features like input voltage capacity, switching frequency, and high efficiency operation. And these devices are available in fixed output voltage of 3.3V, 5.0V,

12V, 15V, and an adjustable output version. It has some distance advantages like resulting in poor efficiency, wasted power and continuous heat generation. The main disadvantage is that, their maximum continuous output current rating is limited to just a few amperes or so.

1] WHERE TO USE LM2576 BUCK CONVERTER IC.

The LM2576 is a voltage Regulator IC. A regulated voltage is very important for smooth functioning of many digital electronic devices. It uses the Buck converter type to step down regulate higher level voltage value to lower level voltage. This is fixed output voltage type and varible output type coverters are available with the same IC.

2] HOW TO USE LM2576 IC.

Using the LM2576 is very easy. It requires some additional components including an inductor which is placed in series with the output. The value of the inductor can range from 47uH to 330uH based on the output required. The circuit diagram of 5V buck regulator based on the LM2576 is shown below.

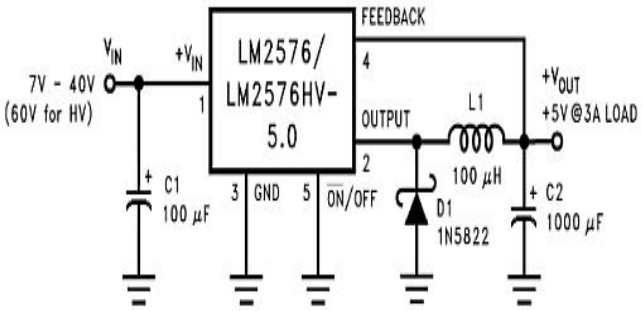

Fig.3. buck converter eith LM2576

3] APPLICATIONS OF LM2576

Simple High Efficiency Step down regulator. Power supply for battery charge. Used in small SMPS cirsuits and Positive to Negative converter.

DESIGNING BUCK CONVERTER CIRCUIT USING SWITCHING REGULATOR.

When higher output voltage or current power supplies are required switching regulators are use. Switching regulator commonly known as switch mode power supply. A buck switching regulator is a type of switch mode power supply that is designed to reduce DC voltage from a higher voltage to a lower voltage. For example a buck converter can convert 8 volts to 5 volts. The basic circuit of buck converter using arduino and N-channel MOSFET as shown in fig4. The major advantage of the switch mode power supply is its higher efficiency, and this is achieved by power MOSFET.

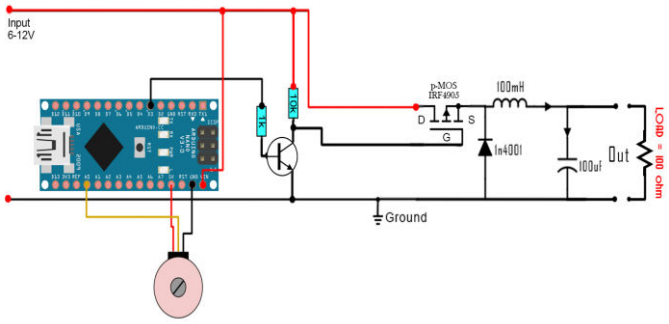

Fig4. Control of buck converter using switching regulator.

ARDUINO

The Arduino UNO is a low cost microcontroller board based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller, power to it with an AC to DC adapter or battery to get started. The MATLAB also supports the arduino and communicate through the computer serial port. The arduino has a 5v linear voltage regulator that will lower efficiency of the circuit. The main function of the arduino is to learn how the circuit, the feedback and the PWM signal work in order to achieve the desired output. The buck converter parameters are connected as shown in fig. we have a potentiometer connected to the analog input A0. With this potentiometer we will choose the output value.

COMPARISION OF LINEAR REGULATOR (LM2576) AND SWITCHING REGULATOR (MOSFET)

1. LINEAR REGULATOR

Linear regulators are uses for low powered devices. Even they are easy to use, simple and cheap, it is normally insufficient because the difference between the input voltage and regulated output voltage is continually dissipated as heat.

2. SWITCHING REGULAROR

Switching regulators are highly efficient and wide input and output range internal compensation. Complexity is medium to high. Waste heat is low.

DESIGN

Specifications with LM2576

Input voltage = 12V
Output voltage = 5V
Switching frequency = 52 kHz fixed frequency
L1: 100 uH
D1: 1N5822
C1: 100uF
C2: 100uF

Specification with switching regulator

N-channel MOSFET
Inductor: 100 uH
Capacitor: 47uF
Resistor: 10kohm, 100ohm
Schottky diode
Arduino UNO
Potentiometer: 10kohm

SIMULATION RESULT

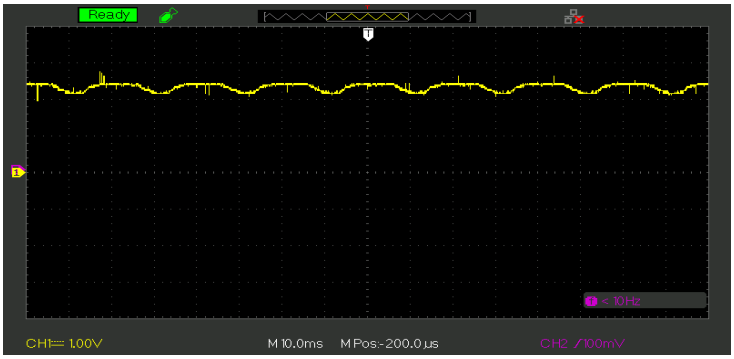

Fig5 (a). Input of buck converter with LM2576

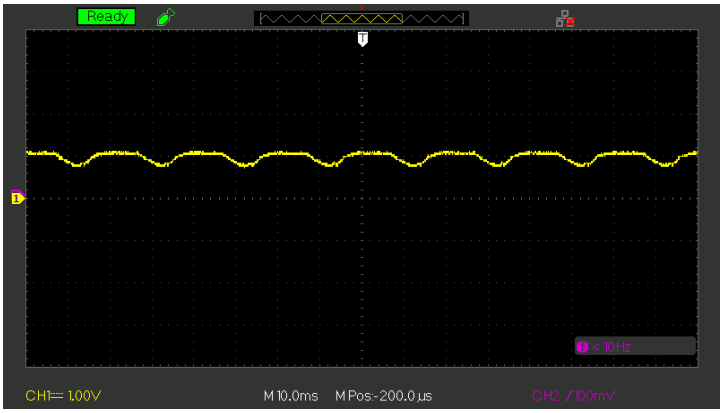

Fig5 (b). Output of buck converter with LM2576

Fig5 (c). Input of buck converter using switching regulator.

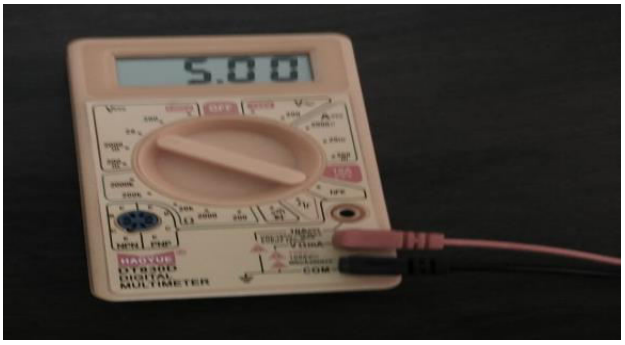

Fig5 (d). Output of buck converter using switching regulator.

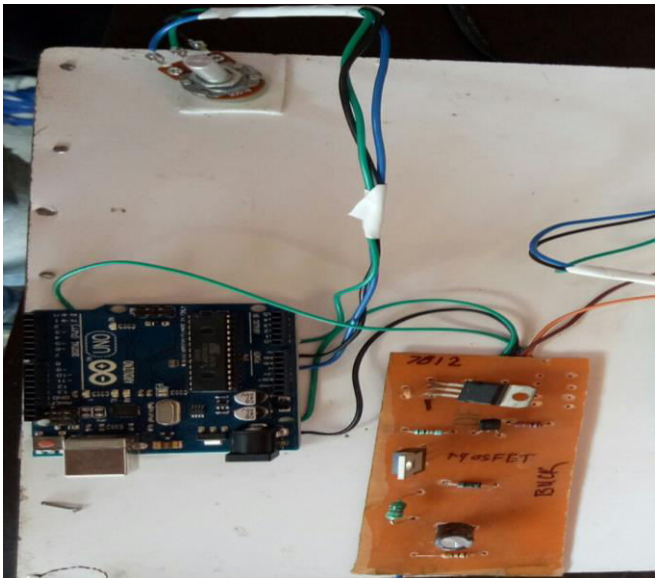

Fig5 (f). Hardware setup of buck converter with arduino.

HARDWARE IMPLEMENTATION

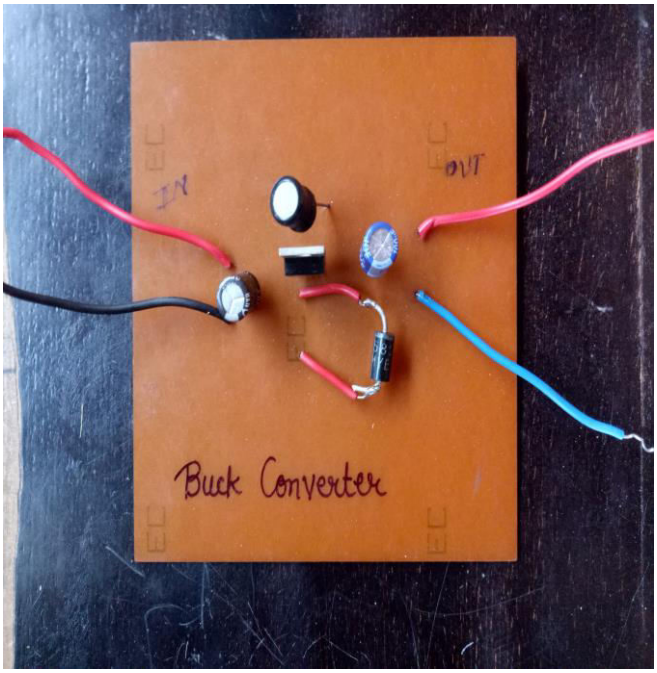

Fig5 (e). Hardware of buck converter with LM2576.

CONLUCTION

In this paper, buck converter is designed and simulated in both with LM2576 and without and hard ware also implemented for both with LM2576 and without by using Arduino microcontroller for low power applications, and most of the electronics systems. Since arduino is used for better flexibility in control system for any change in supply voltage and load. And as compare to linear regulator switching regulator is better.

REFERENCES

[1] Muhammad H. Rashid, "Power electronics :circuit ,devices and application" 3rd edition ., pearson publisher,2003

[2] K. Bendaoud, J. LaassiriC. Deekshitha and K. L. Shenoy, "Design and simulation of ,synchronous buck converter for LED application," *2017 2nd IEEE International Conference on Recent Trends in Electronics, Information & Communication Technology*

(RTEICT), Bangalore, 2017, pp. 142-146., S. Krit and L. El Maimouni,

[3] " Design and simulation DC-DC power converters buck and boost for mobile applications using Matlab/Simulink," *2016 International Conference on Engineering & MIS (ICEMIS)*, Agadir, 2016, pp. 1-6.

[4] ARDUINO.CC "Arduino - Introduction", 2015 [Online] Available: http://arduino.cc/en/Guide/Introduction. [Accessed: 25-Feb – 2015].

[5] Arduino.cc, 'Arduino - Products,' 2015. [Online] .Available: http://arduino .cc/en/Main/Products. [Accessed: -25- Feb-2015].

[6] "Adjustable regulator," LM2576 Datasheet. Available on www.it.com> lit > symlink > lm2576.

[7] " linear versus switching regulator ," Available on https://www.renesas.com > products> lin…

[8] http://en.wikipedia.org/wiki/Buck_converter.

IEEE conference templates contain guidance text for composing and formatting conference papers. Please ensure that all template text is removed from your conference paper prior to submission to the conference. Failure to remove template text from your paper may result in your paper not being ublished.