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RESEARCH ARTICLE

DIGITAL CONTROL OF BUCK CONVERTER USING ARDUINO AND 8051 MICRO-CONTROLLER

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Abstract

The recent advancement in the domain of processors of embedded modules and integrated systems has put on the requirement of high performance, uninterrupted quality of power supply for its accurate and quality performance. For this accurate and quality power supply, the power electronic converters play a vital role. In this conversion process there is always a fluctuation in a voltage levels and this will affect the life span of electronic components along with quality of the result being produced. The DC to DC conversion plays vital in case of electronic components. This paper is going to discuss about one of the methods that will control or reconfigure the output from the converter. With the use of micro-controllers that maybe 8051 Micro-controller or by Arduino that contain ATmega328P digitally. Along with an improved efficiency of electronic components with durable life span.

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Introduction:-

The Power electronics is related to the use of electronic devices for processing of the electrical power. Switching converter is the key component for this conversion. And selection of these switching converters is all together based on their high frequency switching and power handling capacity. For faster response “Voltage mode” control is preferred over the other mode of control. The proposed DC-DC buck converter is controlled by using Arduino Uno and 8051 Micro-controller.

Eventually the regulation of the converters can be done by two methods:

Linear Regulator:
This is one of the simple and low cost modes of regulation, where the variable resistor is connected in series with load resistor and this resistance is varied with respect to the load. But, the major drawback of this method being less efficient due to power loss at resistor end.

Switching Regulator:
This is one of the high-power conversions efficiency methods with almost 90% of the efficiency, with great design flexibility. Here we use power switch, by turning On/Off will partly transfer the energy from source to load. And this switch is controlled by controller i.e., Arduino and 8051

So, this paper deals with Buck Converter modelling with switching regulator method and digitally controlling the unit. The future work includes practical implementation of feedback system using 8051 Micro-controller, which is successfully obtained with simulations.

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Buck Converter:
Buck converter (step-down) is a DC-DC converter that decreases the output voltage over the supplied input voltage. And reverse in case of current, where the supplied current is more than the output current. It is a class of switched-mode power supply (SMPS). As Switching regulator MOSFET is used and rectifying diode to allow the inductor current or inductor energy to discharge to zero.

Capacitor filters along with the inductor is used in order to reduce the ripple in the voltage. Capacitor filters can be used at input and at output to reduce the ripple at either end.

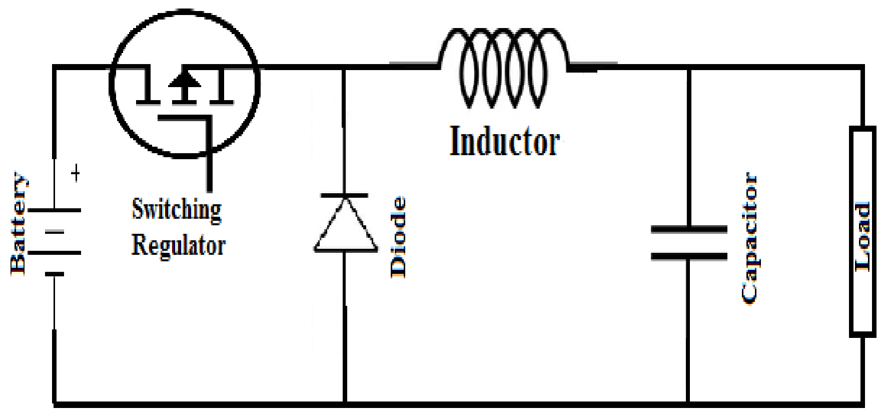


Fig 1:- Basic Buck Converter Design.

Fig 1 represents the basic buck converter circuit. In order to regulate the fluctuation at output DC voltage, let's incorporate feedback concept and maintain the fluctuation in voltage by Arduino and 8051 Micro-controller.

Buck Converter Operation:
The entire operation of buck converter will completely depends on the switching On/Off of the MOSFET. This switching of MOSFET is done using PWM technique. So, let us consider the above basic circuit of buck converter for understanding the switching operations.

It works on the two switching operations between zero and one levels of PWM. Let's see these two-switching operations to understand working in more detail.

On State:
Here we are representing On-state of switching regulator in for switch S1 and diode is in by-pass mode.

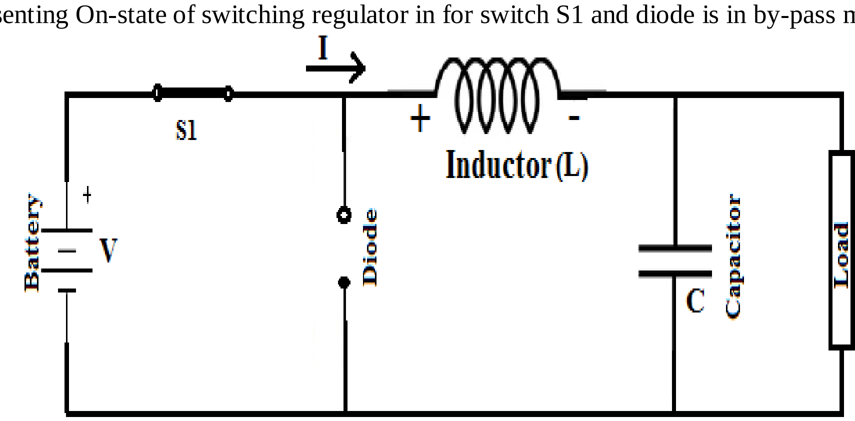


Fig 2:- On-State of Switching Regulator Buck Converter.

When the switch is closed the flow of current 'I' will increase through inductor 'L', resulting into increase of magnetic field across the inductor. And the energy is stored in this magnetic field and resulting into decrease in voltage across the inductor. Eventually the capacitor 'C' is also charged.

Off State:

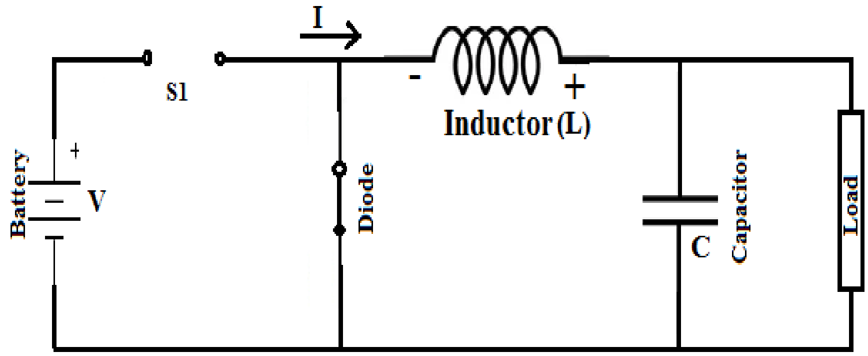


Fig 3:- Off-state of switching regulator in Buck Converter.

Here we are representing off-state of switching regulator with open switch and diode is inoperation mode. The current through inductor will decrease and so the magnetic field associated with it. Now the inductor start to act as current source and circulate the current as the diode is in operation mode.

If voltage across the inductor is more than that across capacitor, then the capacitor gets charged. Otherwise, both inductor and capacitor will discharge and resulting into higher current than at input end.

Duty Cycle Calculation Formula:

$$V_{OUT} = \frac{t_{ON}}{(t_{ON} + t_{OFF})} \times V_{IN}$$

The buck converters duty cycle can also be defined as:

$$D = \frac{t_{ON}}{(t_{ON} + t_{OFF})} = \frac{t_{ON}}{\text{Total Time}} = \frac{t_{ON}}{T}$$

$$\therefore D \approx \frac{V_{OUT}}{V_{IN}} \quad \text{or} \quad V_{OUT} = D V_{IN}$$

Project Flow:

The project is followed in two types, by implementing it with open-loop as well as closed-loop. This provides us the insight of effectiveness of the closed loop system over the open loop system. Along with that results are obtained with simulation along with practical implementation of the same.

In Open-loop operation the MOSFET is triggered by:

1. By Function generator.
2. Using mono-stable multi-vibrator.

In Closed-loop operation is performed by

1. Feedback system using PID controller.
2. Arduino Uno.
3. Micro-controller 8051.

The ratings of the components are as follows:-

COMPONENT	RATING
Input	12Volts
Inductor	5.83mH
Capacitor	0.4uF
Resistive load	500 ohms
Output	5 Volts

Table 1:- Components Rating.

Open-loop Simulations:
By Function Generator:
Input Voltage: 12 Volts Output Voltage: 5.32 Volts

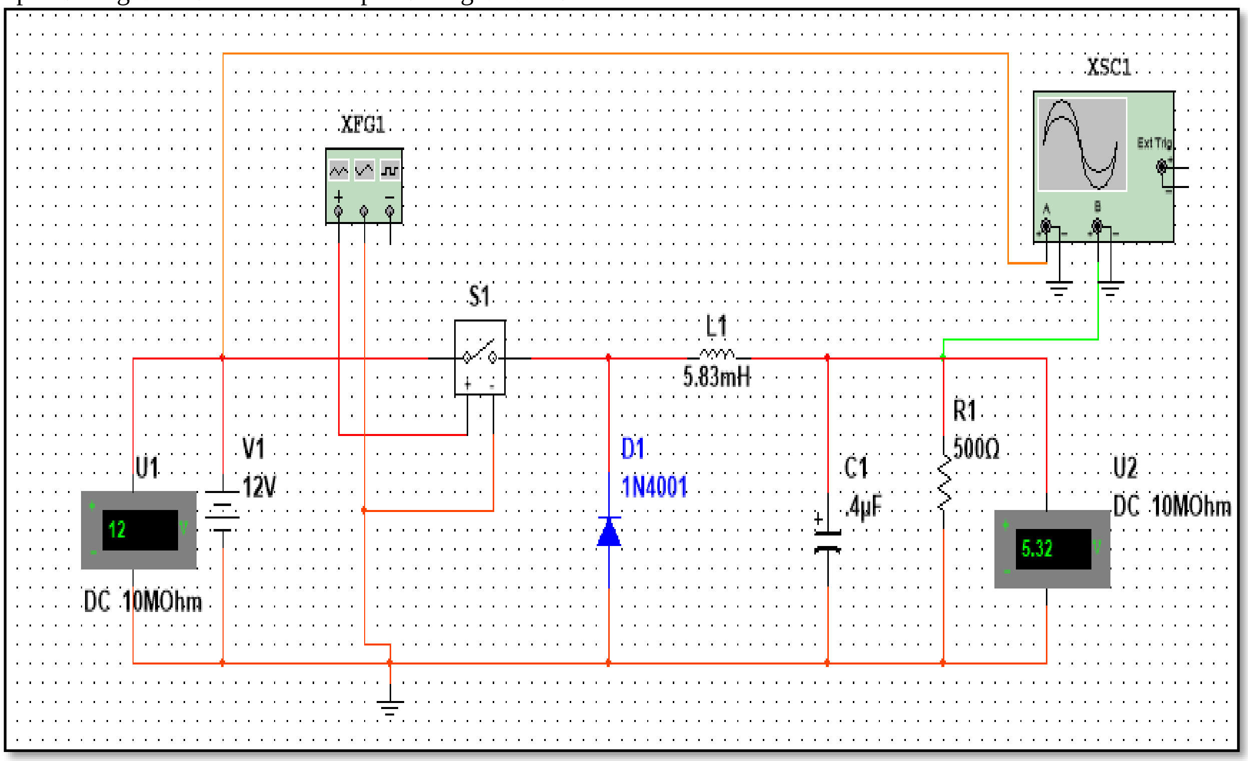


Fig 4:- Simulation by Function Generator.

Using Mono-stable Multi-vibrator:
Input Voltage: 12 Volts Output Voltage: 4.98 Volts

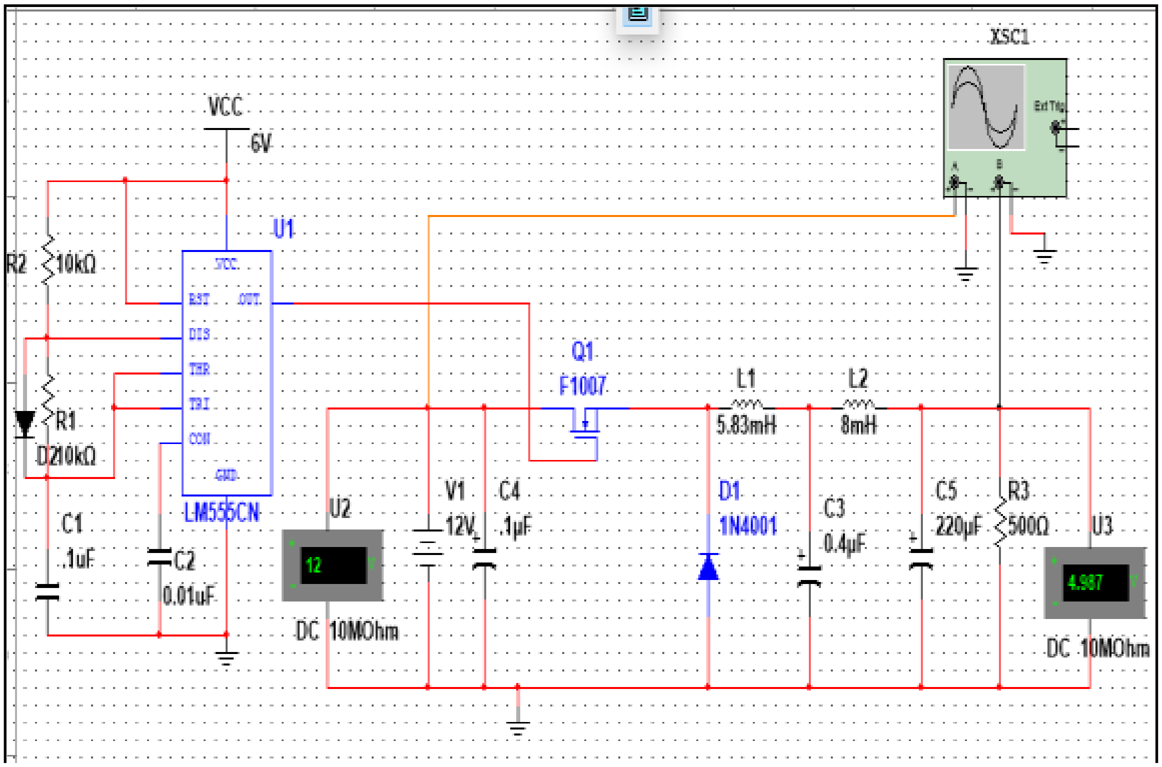


Fig 5:- Simulation Using Mono-stable Multi-vibrator.

Closed-loop Simulations:
Feedback system using PID controller:
Input Voltage: 12 Volts Output Voltage: 4.99 Volts

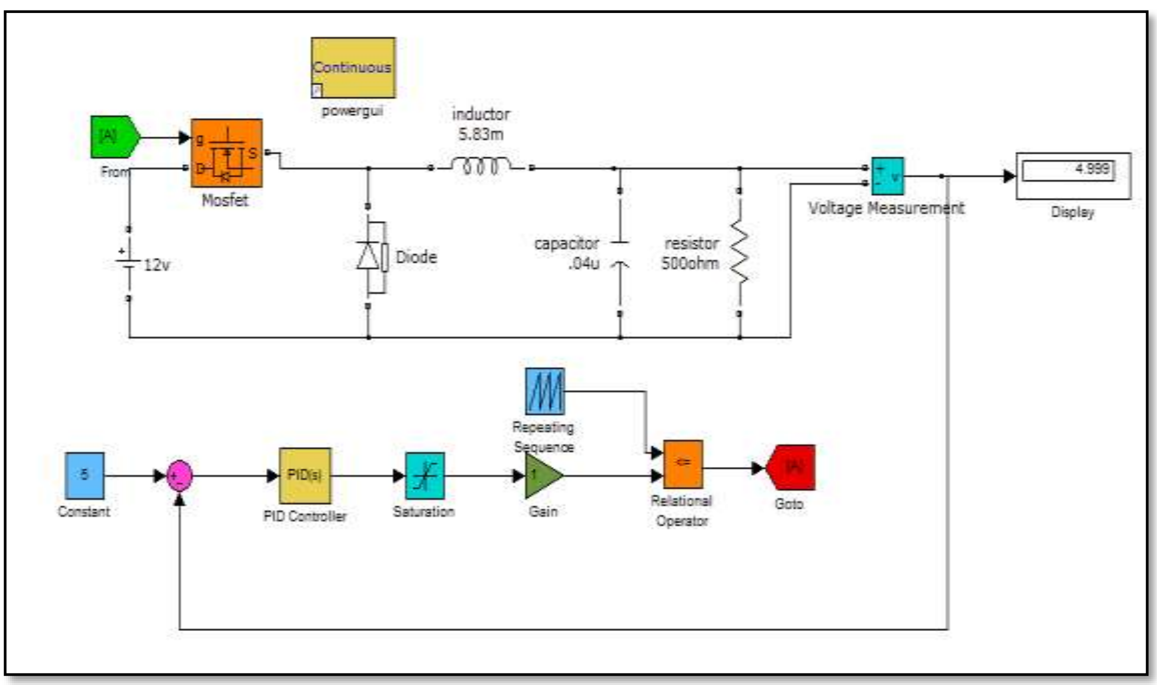


Fig 6:- Feedback system using PID controller.

Using Arduino Uno:
Input Voltage: 12 Volts Output Voltage: 5.012 Volts

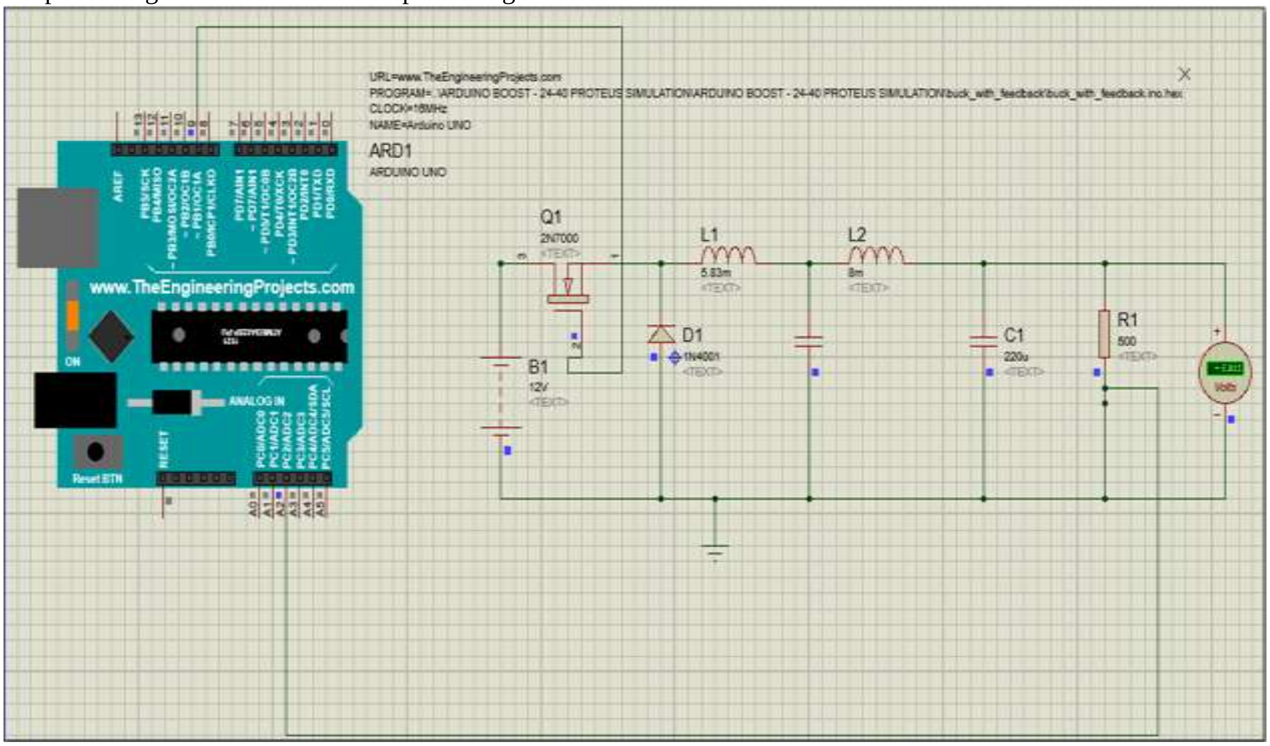


Fig 7:- Simulation using Arduino Uno.

Using Micro-controller 8051:
Input Voltage: 12 Volts Output Voltage: 6.8 Volts.

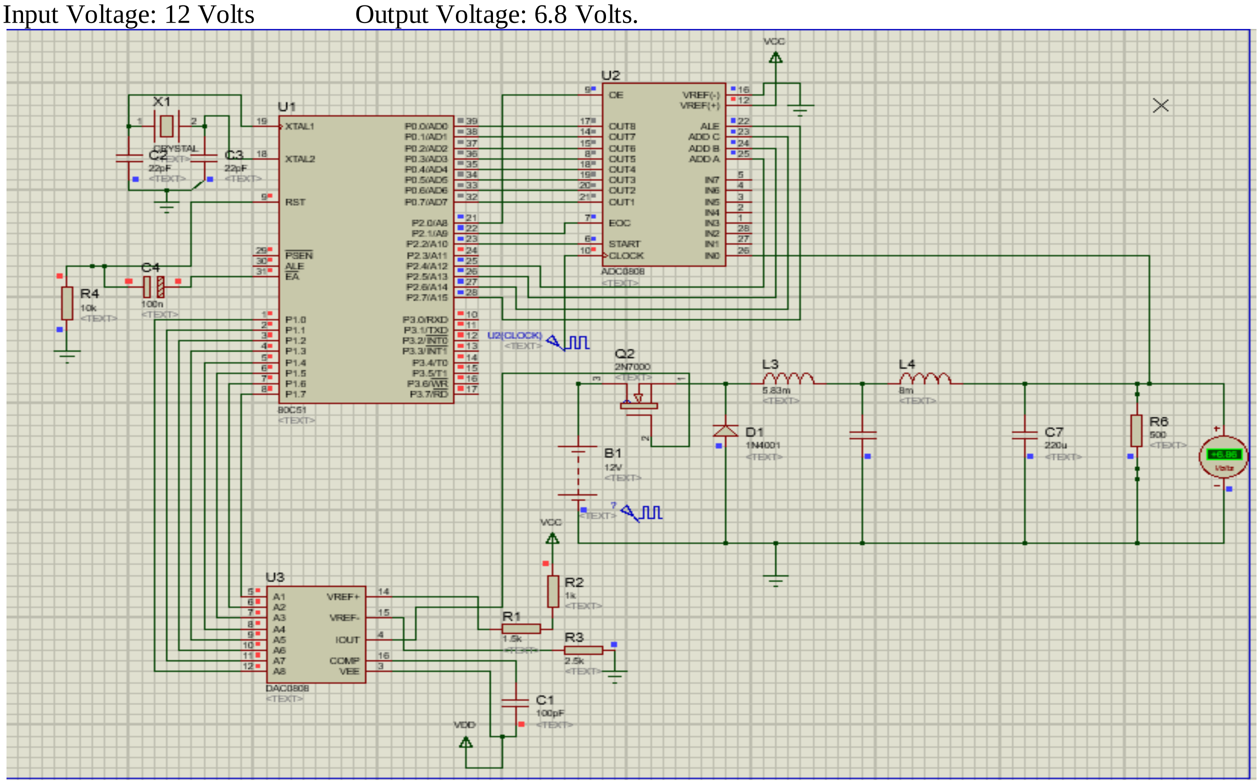


Fig 8:- Simulation Using 8051 Controller.

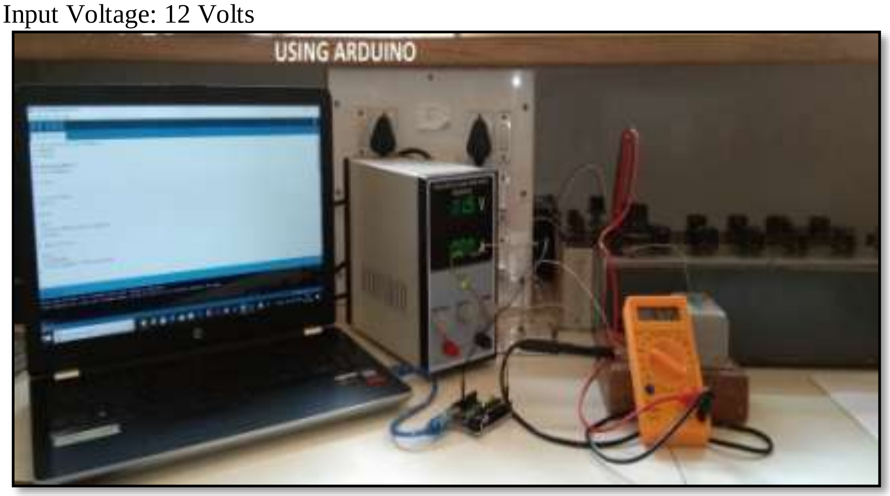
Open-loop practical implementation:
By Mono-stable Multi-vibrator
Input Voltage: 12 Volts

Output Voltage: 3.90 Volts

Fig 9:- MOSFET triggering with Mono-stable multi-vibrator

In case of Mono-stable multi-vibrator triggering to MOSFET it was observed that there was wide range of voltage fluctuation at output end. The fluctuation was almost ±1 volts.

Closed-loop practical implementation:
By Arduino Uno
Input Voltage: 12 Volts



Output Voltage:8.1 Volts

Fig 10:- MOSFET triggering with Arduino with feedback system.

Here in case of feedback system with aurdino triggering to MOSFET, the voltage fluctuation at output end was quite constant within the range of ± 0.2 volts.

Results:-

Type of Triggering MOSFET	Simulation Results	Practical Results
Function Generator	**5.32 Volts**	**--------**
Mono- stable Multi-vibrator	**4.98 Volts**	**3.90 Volts**
PID Controller	**4.99 Volts**	**--------**
Arduino UNO	**5.012 Volts**	**4.81 Volts**
8051 Micro-controller	**6.8 Volts**	**--------**

Table 2:- Simulation and Practical Results.

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