DATE : 08/02/2021

2EE603

ELECTRONIC SYSTEM DESIGN LABORATORY

EXPERIMENT - I

Submitted by :

Parth Patel(18BEE081)

Design of +12 V & -12 V Linear Power Supply.

Aim :-

Design, Fabrication and testing of IC based linear power supply and learning its merits and demerits.

Components :-

1. Centre-tapped Transformer.
2. Diode Bridge Rectifier.
3. IC 7812 & IC 7912.
4. Electrolytic Capacitor(1000uF and 10uF).
5. Oscilloscope.
6. LED(Checking purposes).
7. Wires.

Circuit Schematic :-

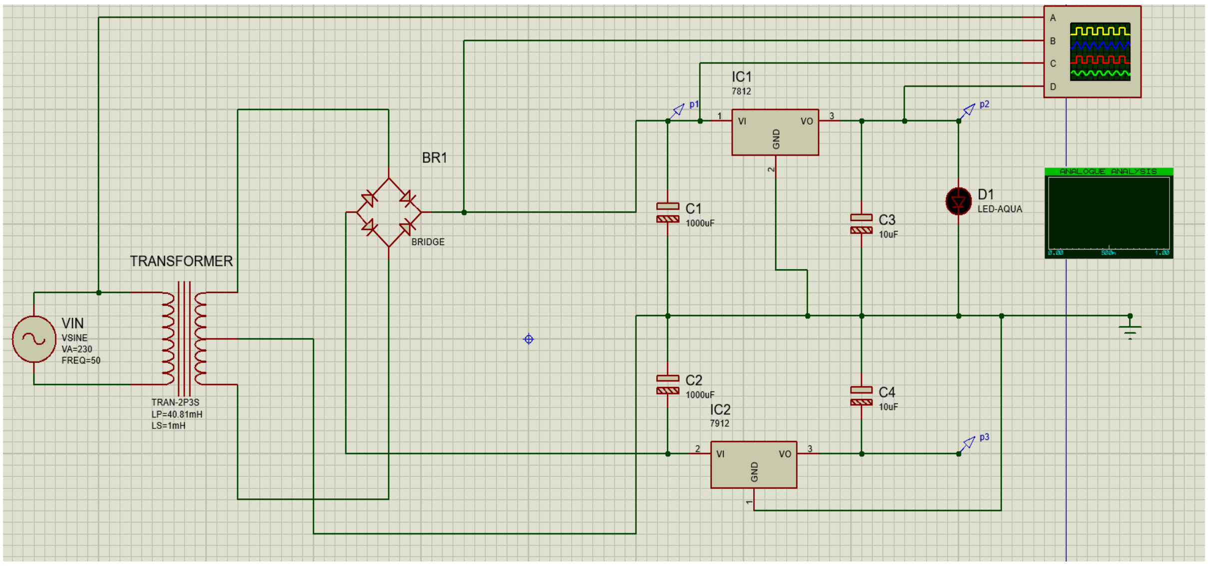

Fig. Circuit Diagram (PROTEUS software)

Calculations:-

Design Calculations

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* **Transformer selection :-**

- From the data sheet of IC 7812 & 7912, the minimum Voltage input required by the IC is 15V.
- We also have to consider drop across the diodes i.e. BRIDGE RECTIFIER.
- Hence to be on a safer side and as it is commercially available in market, "18-0-18" centre taped X'mer is chosen.
- The current consumed / drawn by the load is 1A.

Hence, rating of transformer = 18x1 + 18x1 = 36 VA

* **Turns Ratio Calculation :-**

As $L \propto N^2$ & X'mer = 230/18 V

Considering $L_2 = 1mH$, $\frac{V_1^2}{V_2^2} = \frac{L_1}{L_2}$

$\therefore L_1 = \frac{230 \times 230}{36 \times 36} = 40.81\ mH$

As X'mer secondary 18 V is rms, $\therefore V_m = 18 \times \sqrt{2}$

$V_m = 25.38\ V$

Date

Considering drop across diodes,

$$V_m = 25.38 - (0.7)(2) = \boxed{23.98\ V}$$

→ 23.98 V is the Voltage appearing across the Capacitor (cin)

★ Cin design :-

We know that $Q = CV$ & $Q = it$

$$C = \frac{It}{V}, \quad C_{in} = \frac{I_L t_d}{\Delta V}$$

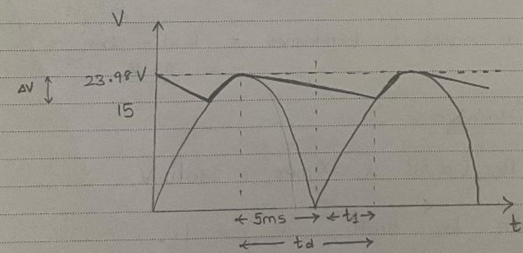


Fig. 1

$$V = V_m \sin\theta$$

$$\therefore \sin\theta = \left(\frac{V}{V_m}\right), \quad \theta = \sin^{-1}\left(\frac{V}{V_m}\right)$$

$$\therefore \theta = \sin^{-1}\left(\frac{15}{23.98}\right) = 38.72^\circ$$

We know that 360 degree ⇒ 20 ms

38.72 ⇒ ?

$$\therefore t_1 = 2.15ms$$

→ From fig. 1, total $t_d = 5ms + 2.15ms$
$= 7.15ms$

Thus, $C_{in} = \frac{(1)(7.15 \times 10^{-3})}{(23.98 - 15)} = \boxed{796\ \mu F} \approx 1000\ \mu F$

→ Thus the nearest & easily available electrolytic Capacitor of Value 1000 μF is Choosen.

★ Cout :-

$$V_{ripple} = \frac{I_{load}}{2f C_{out}} \quad \text{[for bridge Rectifier]}$$

or $C_{out} = \frac{I_{load}}{2f\, V_{ripple}}$ or $C_{out} = \frac{1}{100} C_{in}$

→ The Cout is mainly used to suppress the noise signals & Provide neat DC waveform. Hence it's value is chosen as 10 μF.

Simulation diagram :-

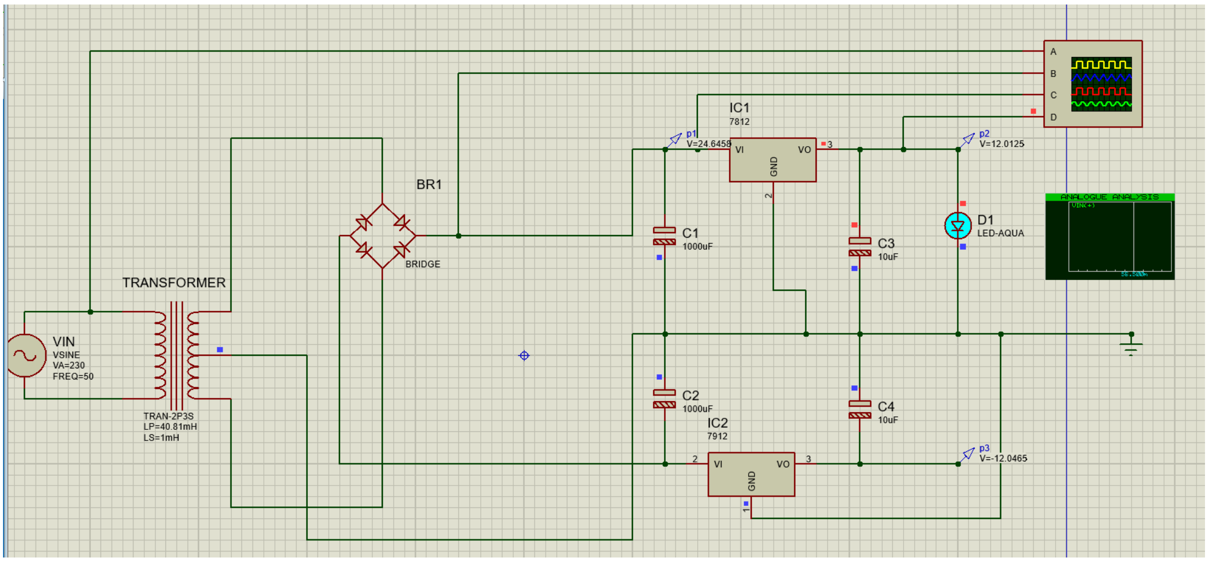


Fig. **Circuit Diagram in ON condition (PROTEUS software)**

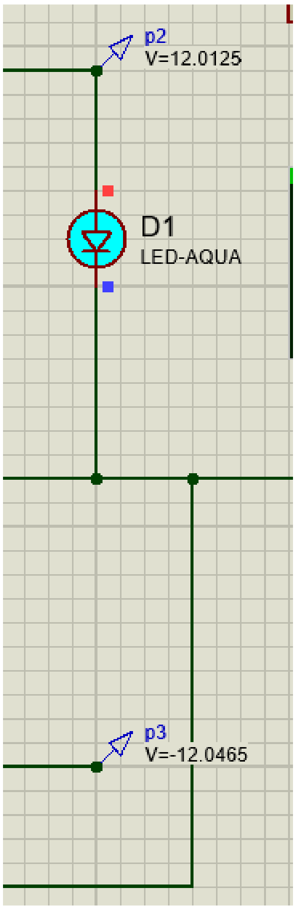


Fig. **+12V & -12V OUTPUT (PROTEUS software)**

Results (Waveforms) :-

- To obtain results and waveforms oscilloscope and Analogue Analysis is carried out.

Oscilloscope Results

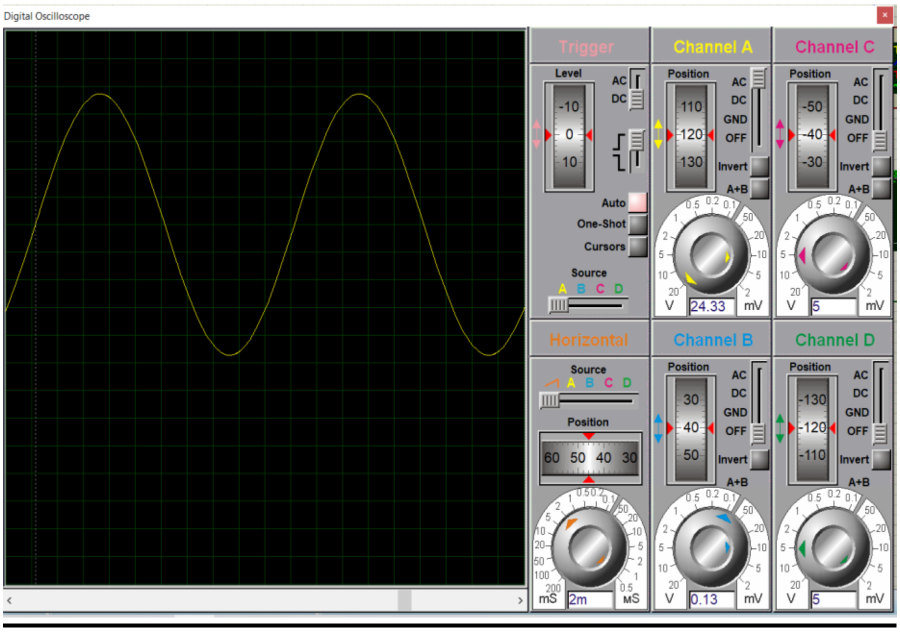


Fig. **Supply waveform measured at AC Supply mains(230V,50Hz)**

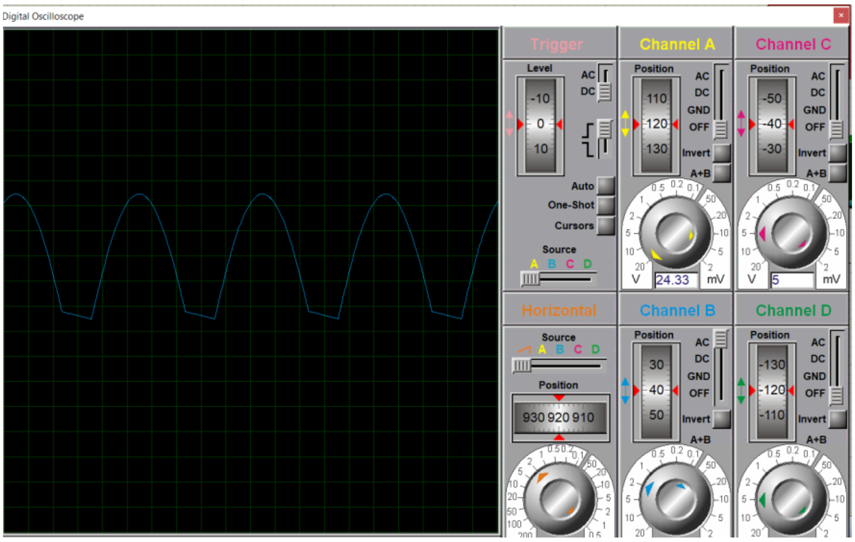


Fig. **Pulsating DC obtained after DIODE BRIDGE RECTIFIER**

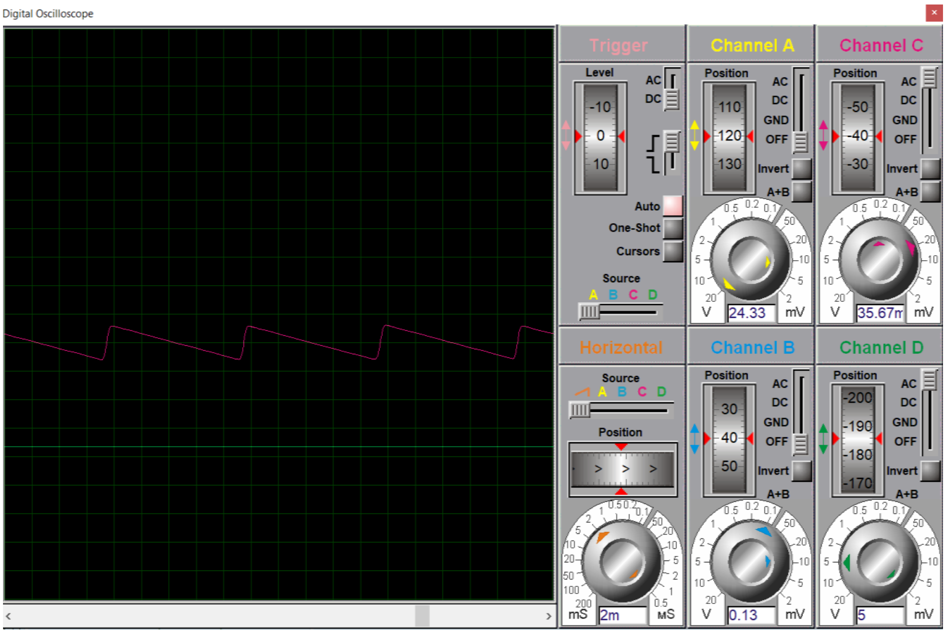


Fig. **Voltage across Capacitor is shown by pink and DC voltage at output is shown by green**

Analogue Analysis

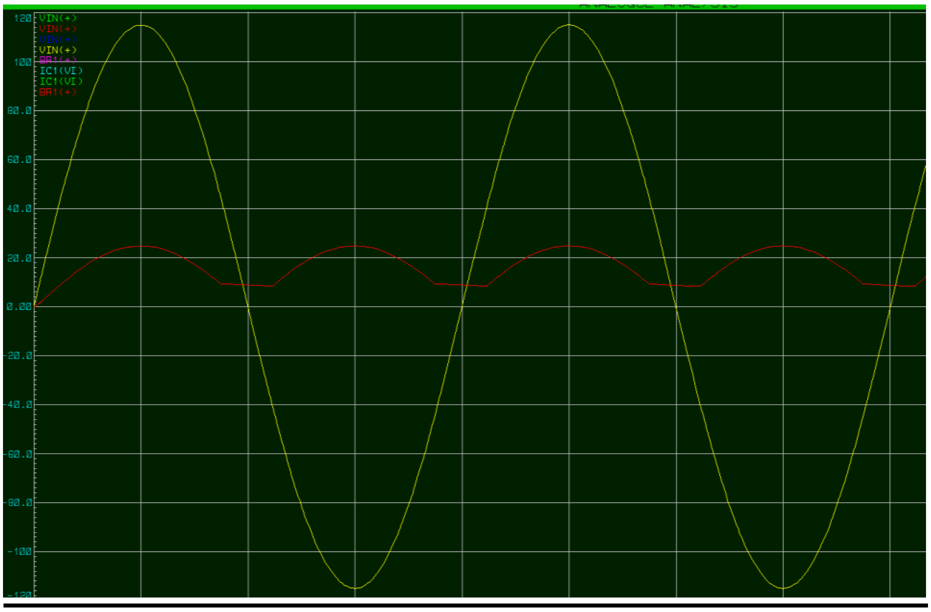


Fig. **Supply waveform(yellow) and pulsating DC(red) obtained after Rectification**

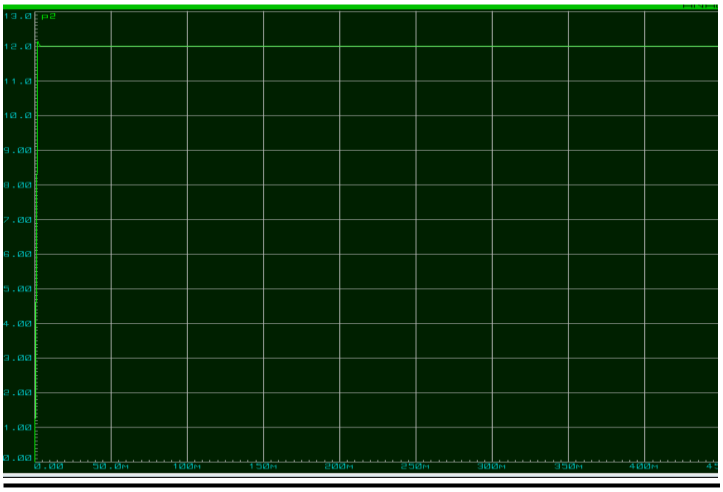


Fig. **+12V output obtained in DC form**

Analysis :-

In linear power supply first of all the input of AC main supply is taken to Centre tapped Transformer rated as 36VA and secondary of 18-o-18 V. Here the step down of voltage takes place from 230 V AC TO 36 V AC. As it is known that as it is centre-tapped transformer the tap is considered as ground(reference) and from that it would be considered as +18 V & -18 V. Now the 18 V AC is supplied to the Diode full Bridge Rectifier which converts the AC signal into pulsating DC signal as shown in the waveform results.

As seen from the waveform analysis the waveform is pulsating DC and not a constant and hence for a neat DC we need to use filter Capacitor. This capacitor converts the pulsating DC to constant but as seen, the there are some ripples present in the waveform even after the filter capacitor. This DC waveform with ripples is then given to or provided to IC 7812 which works as a voltage regulator. After passing through this regulator a clean DC is obtained. To reduce some noise signals present in the waveform further a smoothening capacitor is put to eliminate this signals. Hence the Vout obtained is a clean and neat +12 V signal which is then provided to LED for checking purposes. The same phenomena occurs with -12 V supply design.

Conclusion :-

Hence after performing simulating and analysing this experiment in proteus software we conclude that this linear power supply despite of changing or varying the supply mains gives a constant DC waveform and voltage without any interruption to the Load and is simple to design.

DATE : 29/04/2021

2EE603

ELECTRONIC SYSTEM DESIGN LABORATORY

EXPERIMENT - IV

Submitted by :

Parth Patel (18BEE081)

Design of Closed Loop Buck Converter as per Required Specifications.

Aim :-

Design, fabrication, and testing of a switched mode power converter (non-isolated dc-dc converter), and comparing its performance with linear power supply.

Specifications :-

$V_O = 5$ V	|	$V_{in} = 12 \pm 15$ %
$I_O = 5$ A	|	∴ $V_{in\ max} = 13.8$ V
$f_s = 40$ KHz	|	∴ $V_{in\ min} = 10.2$ V

Components :-

1. DC Voltage Source.
2. MOSFET Switch.
3. Diode.
4. Inductor, Capacitor & Resistor.
5. Voltage Sensor.
6. Voltmeter & Ammeter.
7. Control Circuitry.
8. Wires.

Circuit Schematic :-

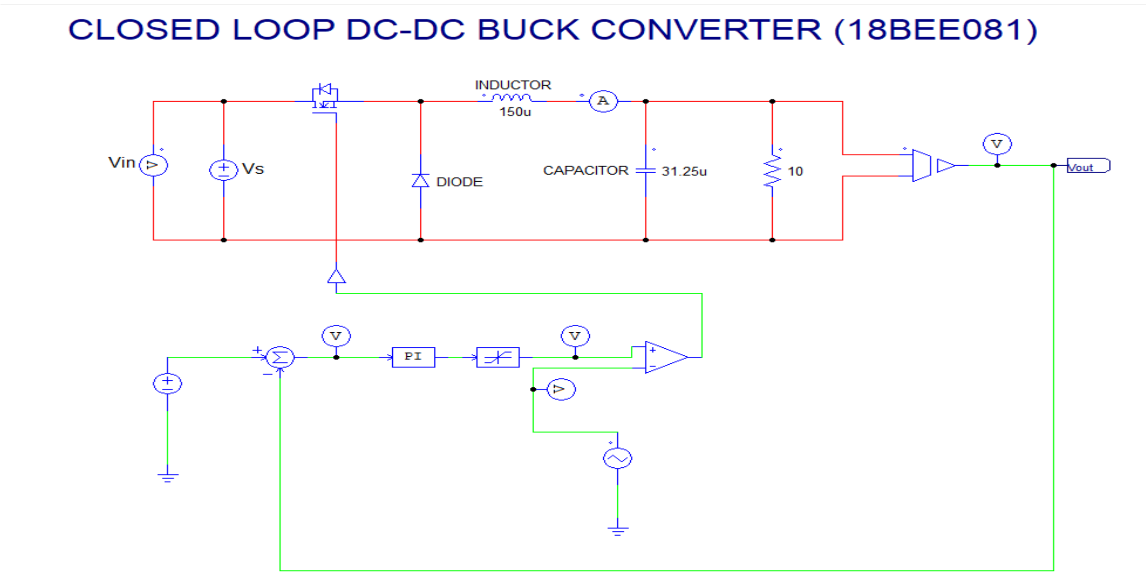


Fig. **Circuit Diagram (Psim software).**

Results (Waveforms) :-

- The Obtained Results and Waveforms are shown below ;

CASE 1 : Input Voltage Vin = 12 V ,

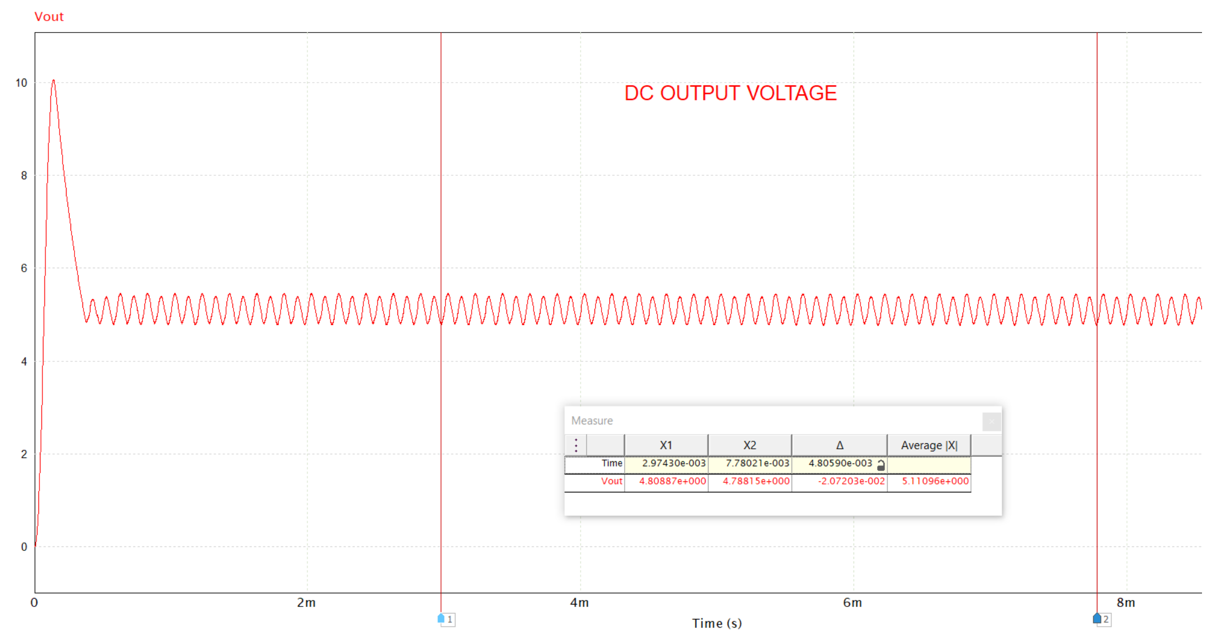
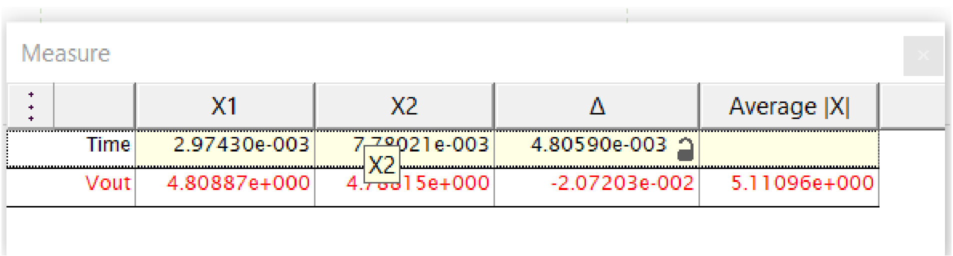


Fig. **DC-DC Output Voltage where V_{in} = 12 V (Psim software).**



Measure

	X1	X2	Δ	Average |X|
Time	2.97430e-003	7.78021e-003	4.80590e-003	
Vout	4.80887e+000	4.78815e+000	-2.07203e-002	5.11096e+000

Fig. **Average of Output Voltage (Psim software).**

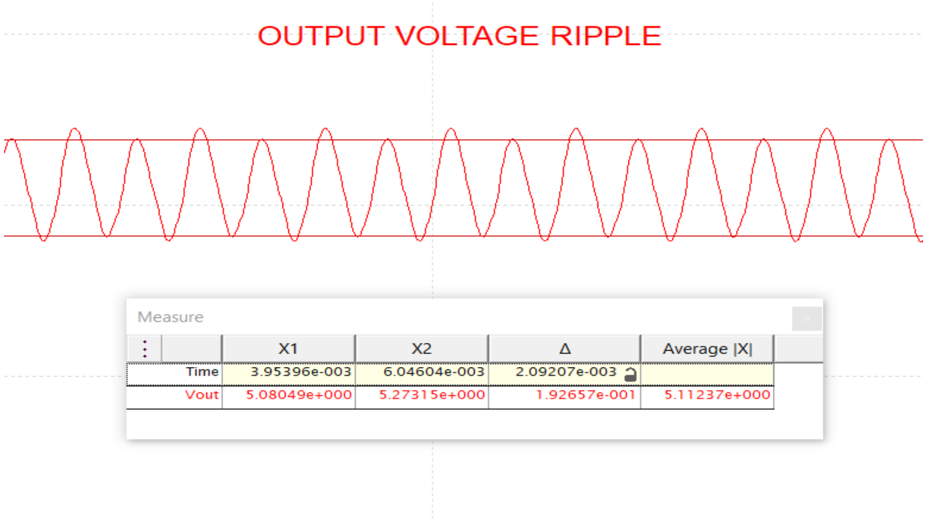


Fig. **Output Voltage Ripple (500mV) (Psim software).**

CASE 2 : Input Voltage Vin = 10.2 V considering Tolerance ,

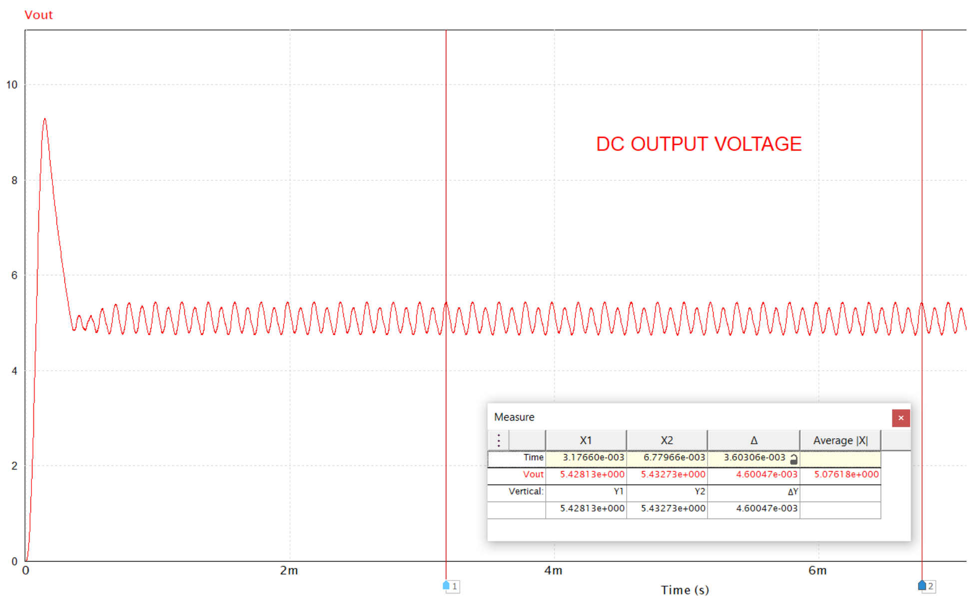
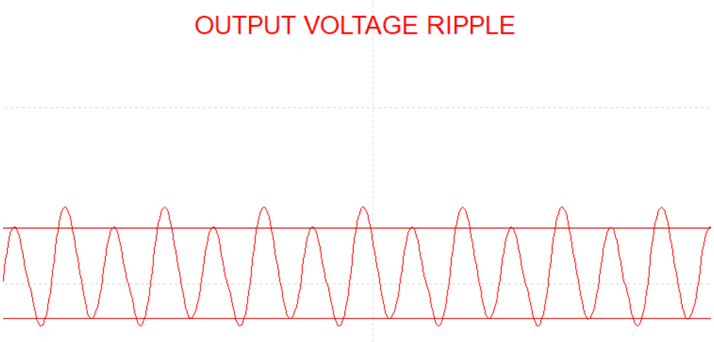


Fig. **DC-DC Output Voltage where V_{in} = 10.2 V (Psim software).**

Measure

	X1	X2	Δ	Average |X|
Time	3.17660e-003	6.77966e-003	3.60306e-003	
Vout	5.42813e+000	5.43273e+000	4.60047e-003	5.07618e+000
Vertical:	Y1	Y2	ΔY	
	5.42813e+000	5.43273e+000	4.60047e-003	

Fig. **Average of Output Voltage (Psim software).**



Measure

	X1	X2	Δ	Average |X|
Time	3.94303e-003	6.03510e-003	2.09207e-003	
Vout	4.83634e+000	4.80119e+000	-3.51553e-002	5.07814e+000
Vertical:	Y1	Y2	ΔY	
	4.80250e+000	5.31599e+000	5.13498e-001	

Fig. **Output Voltage Ripple (500mV) (Psim software).**

CASE 3 : Input Voltage Vin = 13.8 V considering Tolerance ,

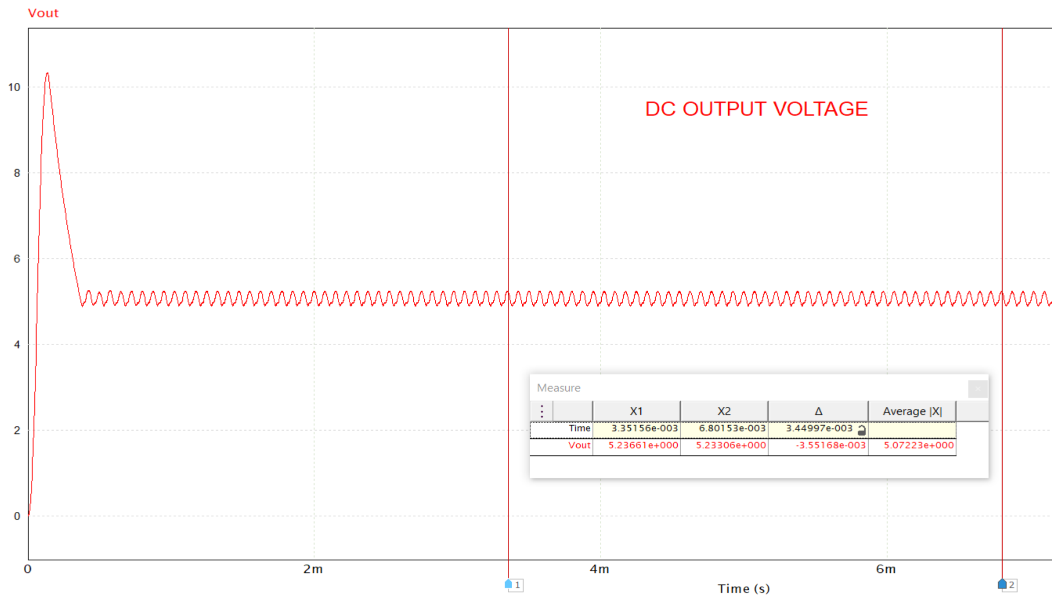
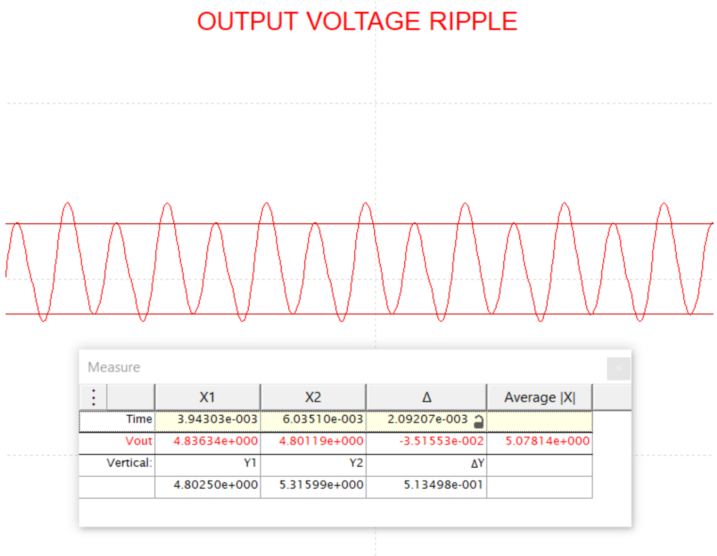


Fig. **DC-DC Output Voltage where V_{in} = 13.8 V (Psim software).**

Measure

	X1	X2	Δ	Average |X|
Time	3.35156e-003	6.80153e-003	3.44997e-003	
Vout	5.23661e+000	5.23306e+000	-3.55168e-003	5.07223e+000

Fig. **Average of Output Voltage (Psim software).**



	X1	X2	Δ	Average |X|
Time	3.94303e-003	6.03510e-003	2.09207e-003	
Vout	4.83634e+000	4.80119e+000	-3.51553e-002	5.07814e+000
Vertical:	Y1	Y2	ΔY	
	4.80250e+000	5.31599e+000	5.13498e-001	

Fig. **Output Voltage Ripple (500mV) (Psim software).**

Analysis :-

In the Switched Mode Power Converter more accurately non isolated DC-DC buck Converter Switching techniques are used. Initially DC voltage is taken from the source and is given to the Switching Device. Here we have considered MOSFET switch as a switch. Moreover Suitable value of Inductor along with Capacitor is calculated and placed in the simulation software package. A load resistor of 10 Ohms is also considered for checking the desired output voltage as per specification.

If we talk about open loop control of buck converter then things are quite easy. By just controlling the duty cycle of the Gate pulse Generator we can get the desired output easily. The main parameter here, which is driving the circuit is Duty Cycle Ratio.

But here we have considered closed loop buck converter so we need to have another control circuitry which is provided to the gate terminal of MOSFET which controls the duty ratio.

For the control circuit, a reference wave is provided into the summer block along by sensing the voltage at the output side of converter. We know that there are ripples present into the output voltage but we are considering it a pure DC signal. The reference wave is a proper DC signal. To reduce steady state error PI controller is used along with current limiter. Moreover a carrier wave (triangular) is also compared with the output wave of current limiter and hence duty cycle is generated which is then given to switch for turning ON/OFF as per input voltage fluctuation.

Comparison of Performance of Linear Power Supply & Switched Mode Power Converter :-

We have already analysed both the supplies in different experiments and hence we conclude the following points :

- The switched Mode Power Converter has higher efficiency of up to 80% which is quite higher than linear power supply which is of 60%.

- Switched mode power converter is more reliable compared to Linear power supply as the switching here depends on transistors.

- The switched mode power converter is closed loop circuit it means error is generated and according to that duty cycle is varied but in case of linear power supply no switching is required hence works in linear region.

Conclusion :-

Hence after performing simulating and analysing this experiment in Psim software we conclude that the switched mode power converter or non-isolated DC-DC buck converter based on our design gives the desired output irrespective of change in input voltage considering specific tolerance. We have also analysed that how pertaining to input voltage variation or line variation the duty cycle is adjusted with the help of control circuitry in order to have a constant DC output voltage.