2023

Simulation Report for Dual DC Power Supply Design

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YOUR ID:

Introduction:

Project Overview:

This project involves the design and simulation of a dual DC power supply using LTSpice. The aim is to create a reliable power supply capable of generating ±15.0 V from a single-phase residential voltage source of 120 V (rms) at 60 Hz. The power supply is an essential component in electronic systems, providing stable DC voltages for various applications. The design incorporates transformers, diodes, resistors, and capacitors to achieve the desired output.

Objectives:

The primary objectives of this project are as follows:

Design a Schematic: Develop a comprehensive schematic diagram that includes all the necessary components for the dual DC power supply.

Transformer Turn Ratio Calculation: Determine the appropriate turn ratio for the transformer to step down the input voltage to the required levels.

Ripple Voltage Control: Calculate and implement components to keep the ripple voltage within the specified limit of ≤ 50 mV.

Resistor and Capacitor Selection: Choose suitable resistor values for voltage division and capacitor values for filtering to achieve the desired DC output.

LTSpice Simulation: Simulate the entire system using LTSpice to validate the design and compare the results with hand calculations.

Circuit Design:

Schematic Design and Components:

The circuit design includes the following components:

AC Source: Utilizing a single-phase residential voltage of 120 V (rms) at 60 Hz.

Center-Tapped Transformer: A transformer is used for stepping down the input voltage. The turns ratio and specifications are detailed in the subsequent section.

Diodes (1N4002): Four diodes are employed for full-wave rectification.

Capacitors:

Two 1000 μF capacitors

Two 10 μF capacitors

Two 0.1 μF capacitors

Transformer Turn Ratio Calculation:

The transformer turns ratio (N) was calculated based on the given specifications:

Primary Inductance (L1): 1 mH

Secondary Leakage Inductances(Ls1,Ls2): 40 μH each

Input Voltage: 230 V

Output Voltage at Secondary: 16 V

The calculated turns ratio is essential for stepping down the input voltage to the desired output level.

$$N = \sqrt{\frac{L_1 + L_{s1} + L_{s2}}{L_{s1} + L_{s2}}}$$

Substituting the given values:

$$N \approx \sqrt{\frac{1\,\mathrm{mH} + 70\,\mu\mathrm{H} + 70\,\mu\mathrm{H}}{70\,\mu\mathrm{H} + 70\,\mu\mathrm{H}}}$$

$$N \approx \sqrt{\frac{1.14\,\mathrm{mH}}{140\,\mu\mathrm{H}}}$$

$$N \approx \sqrt{8.1428}$$

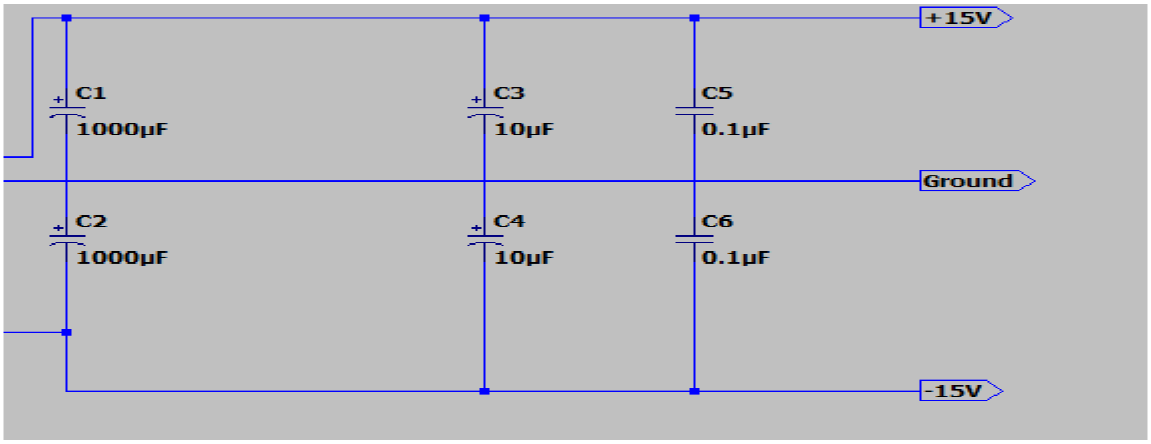
$$N \approx 2.855$$

The transformer turns ratio is approximately 2.855.

Ripple Voltage Calculation and Component Selection:

The ripple voltage calculation is crucial for determining the capacitor values. Based on the specified ripple voltage (Vr≤50mV) and the load current, appropriate capacitor values were selected to meet the design requirements.

I adjusted the capacitor values in the circuit to align with the calculated requirements and achieve the desired ripple voltage.



Simulation Setup and Parameters:

Circuit Schematic:

Include a screenshot or a drawing of the LTSpice schematic that corresponds to your designed circuit.

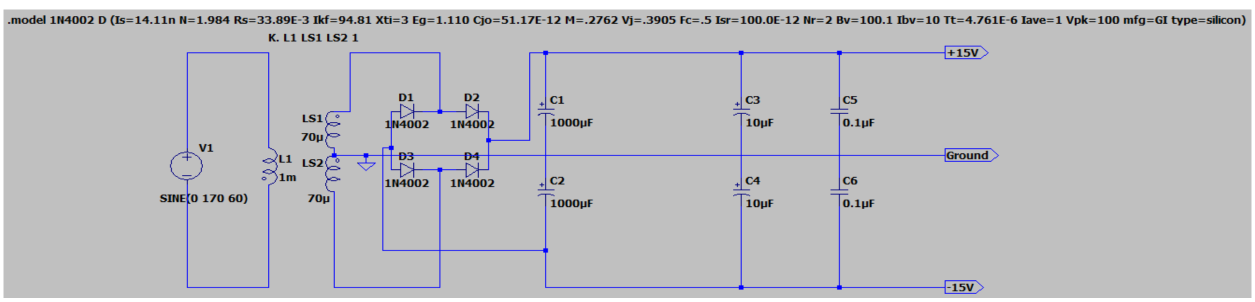


Figure 1: Circuit Diagram

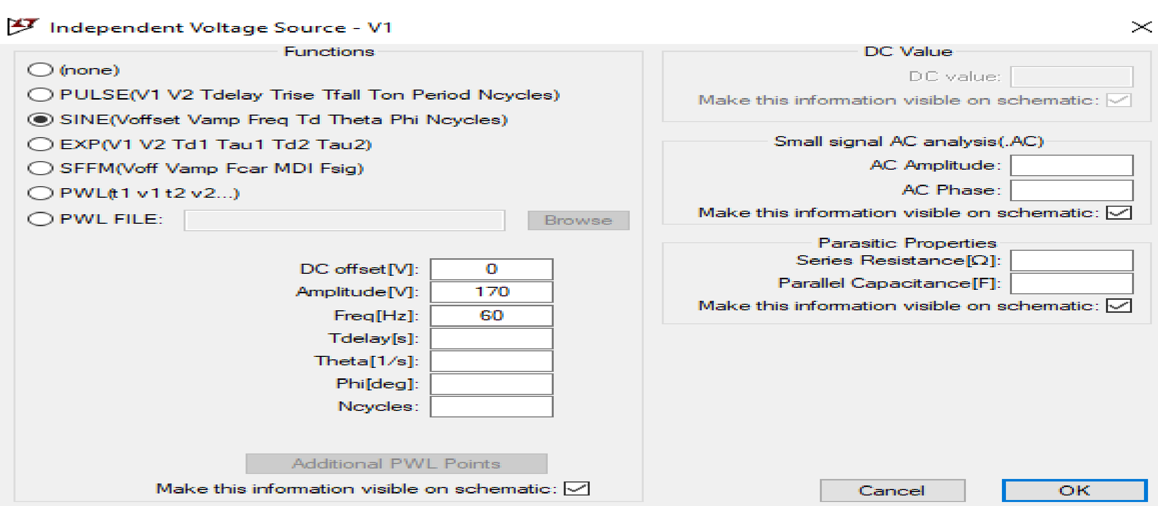


Figure 2: Input Parameters 120Vrms*0.7=170 and 60Hz frequency

Transformer Waveforms:

Waveform for the primary Voltage

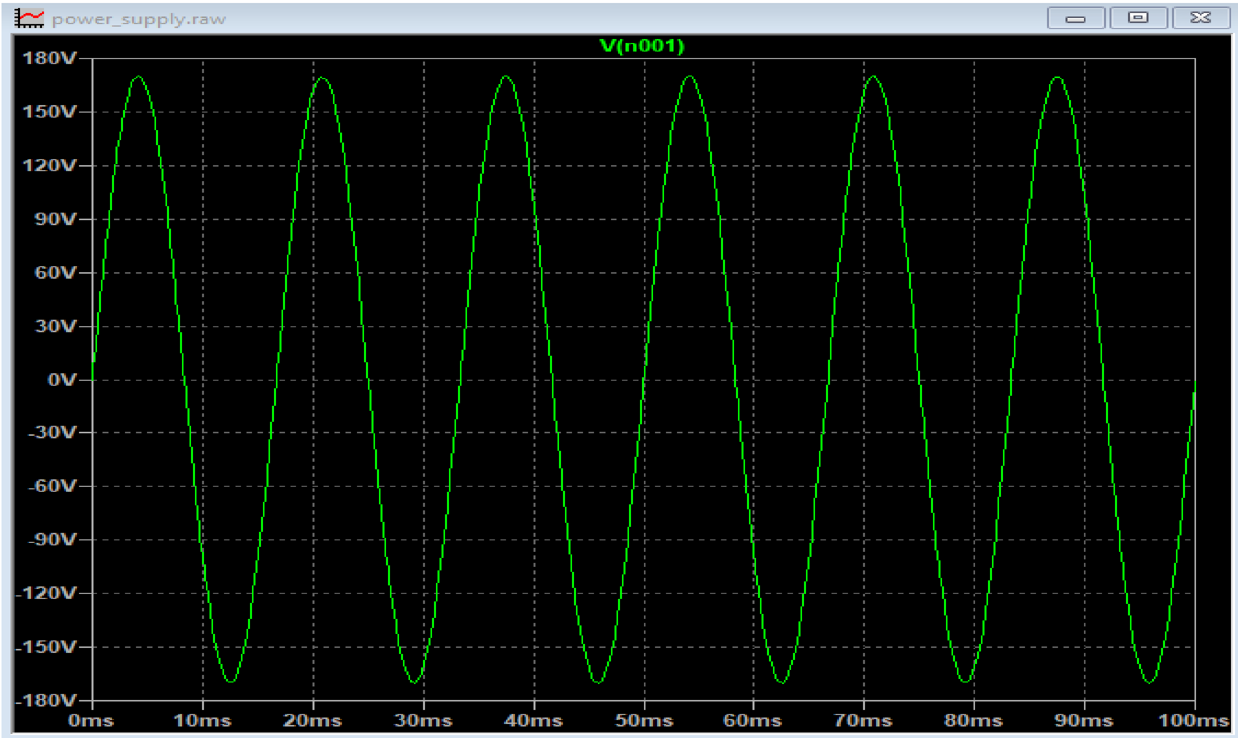


Figure 3: Primary Voltage

Waveform for the secondary Voltage

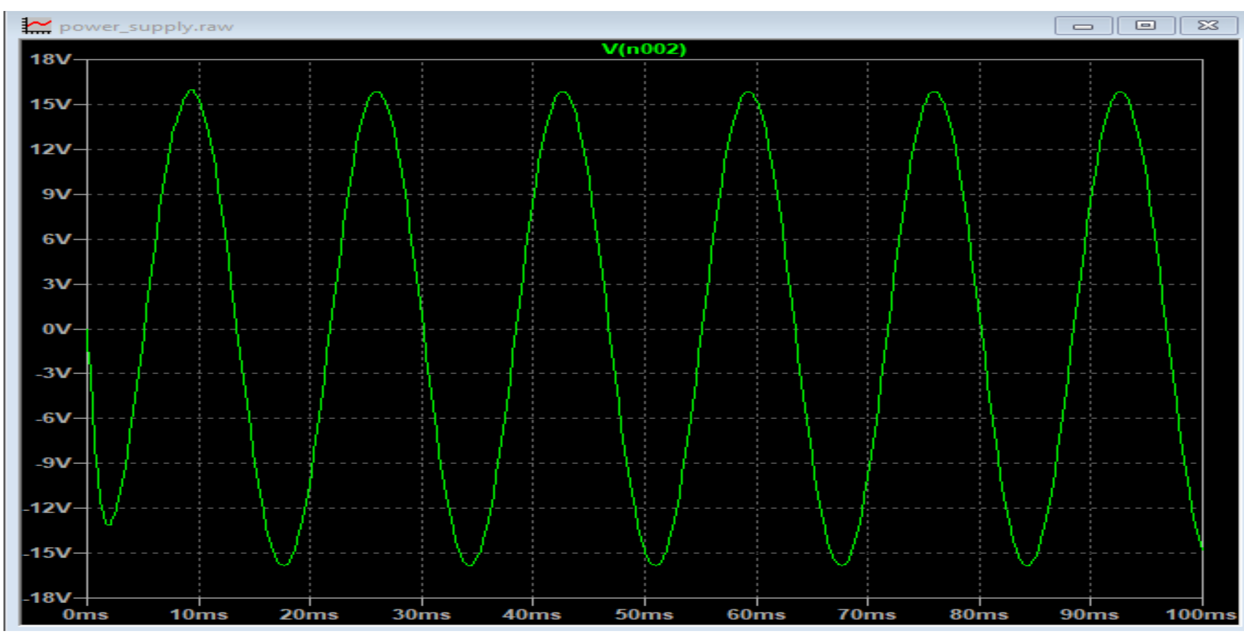


Figure 4: Secondary Voltage at above terminal of transformer

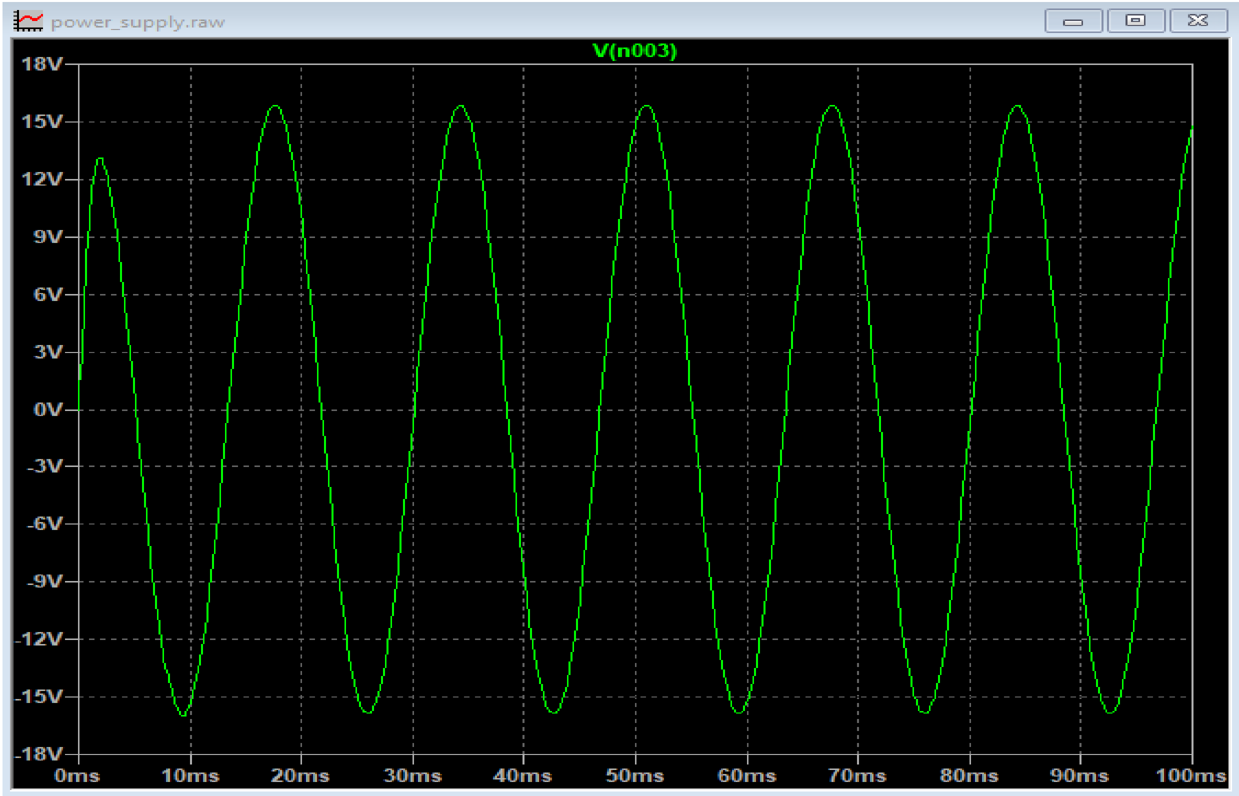


Figure 5: Secondary voltage at bottom terminal of center tapped transformer

Input and Output Voltage:

Input Voltage:

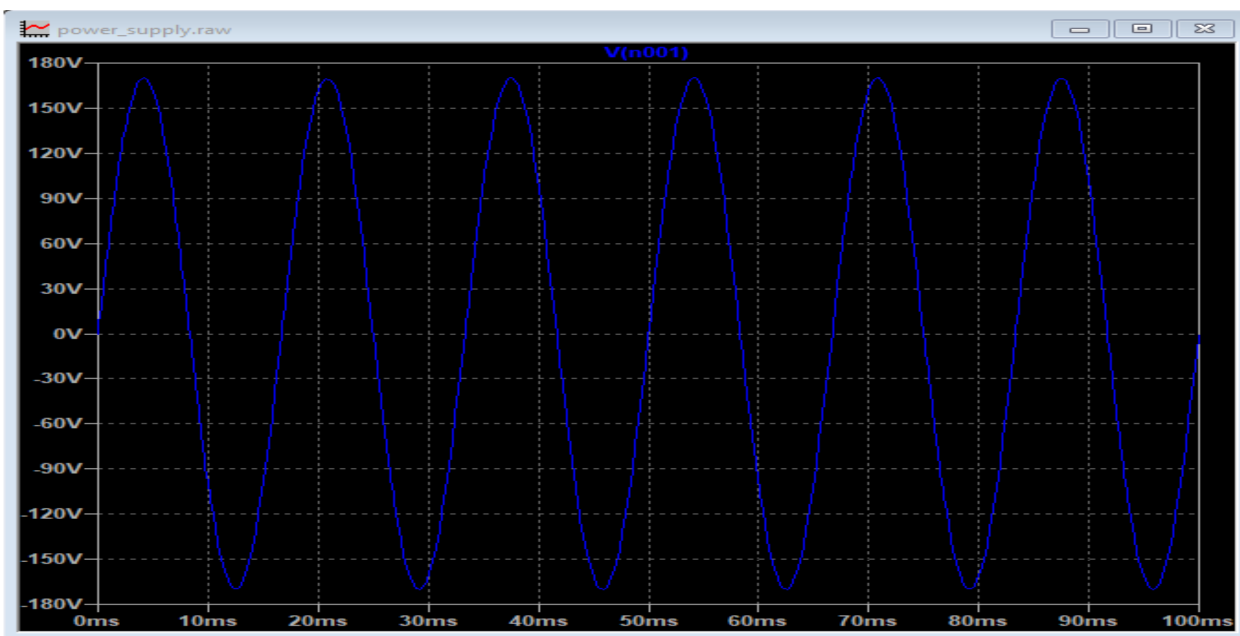


Figure 6: Input Voltage AC

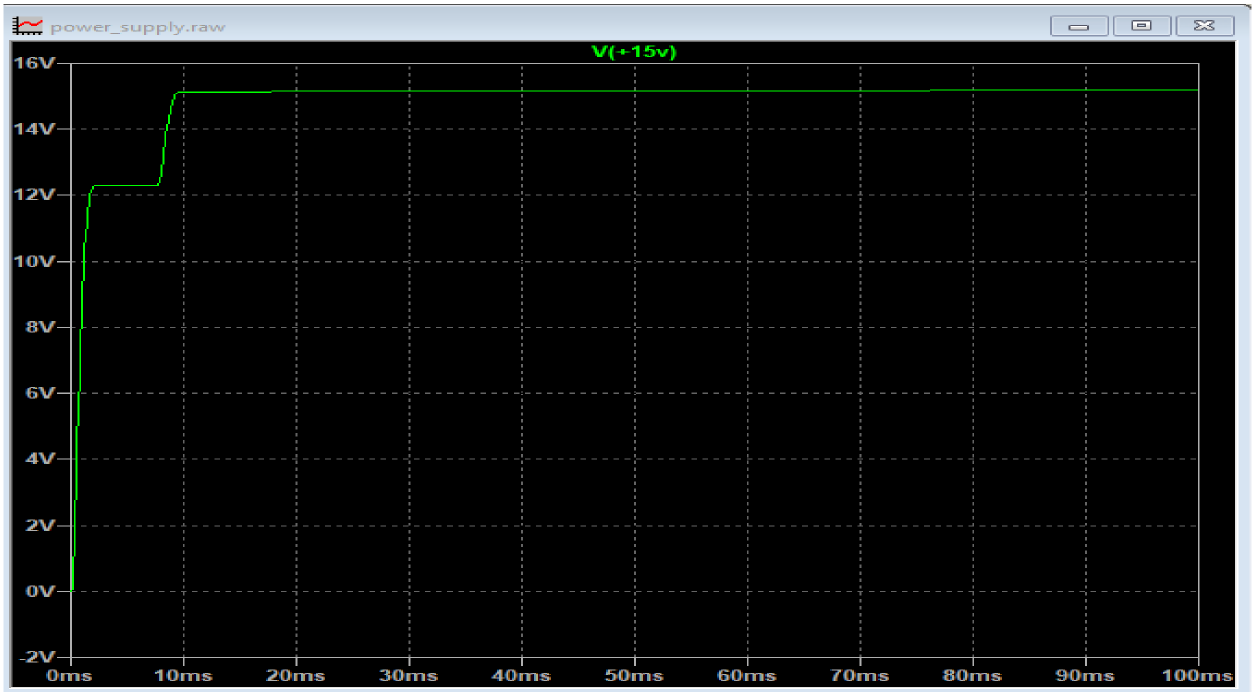


Figure 7: output Voltage Dc

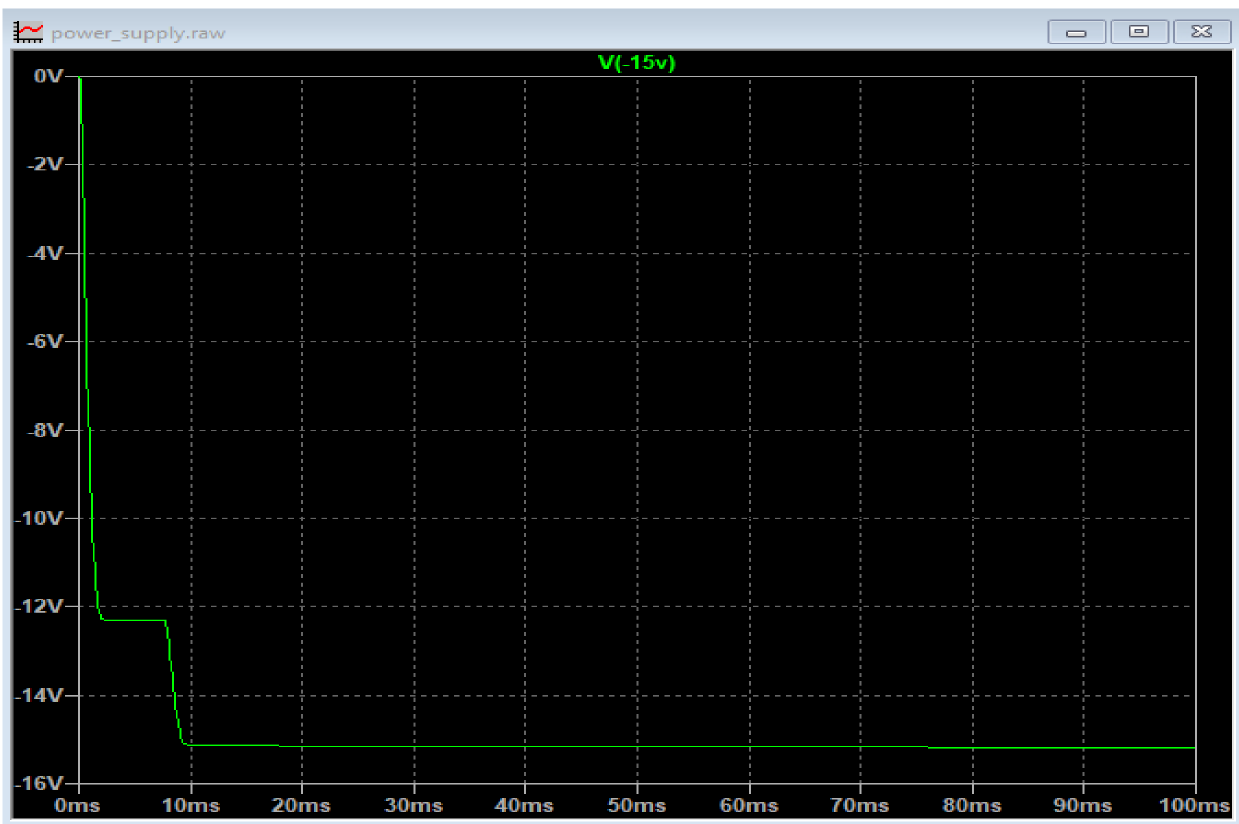


Figure 8: Output voltage -15V Dc

Ripple voltage

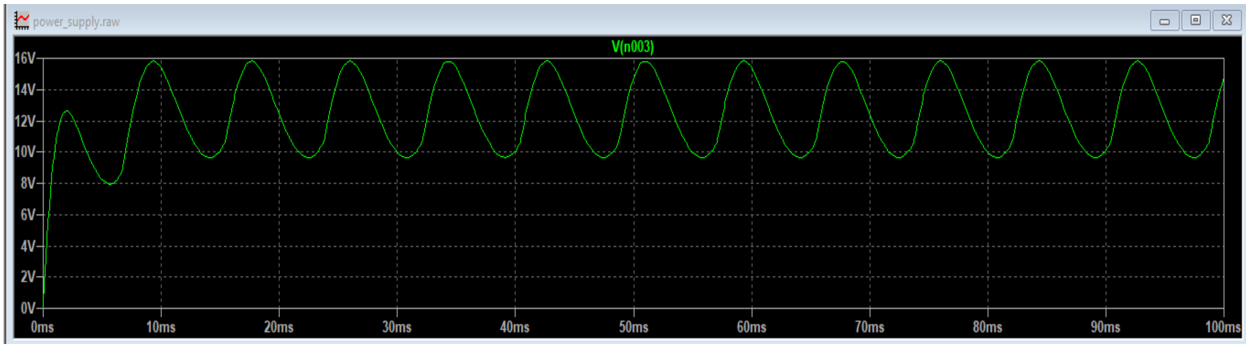


Figure 9: Ripple voltage first half diode

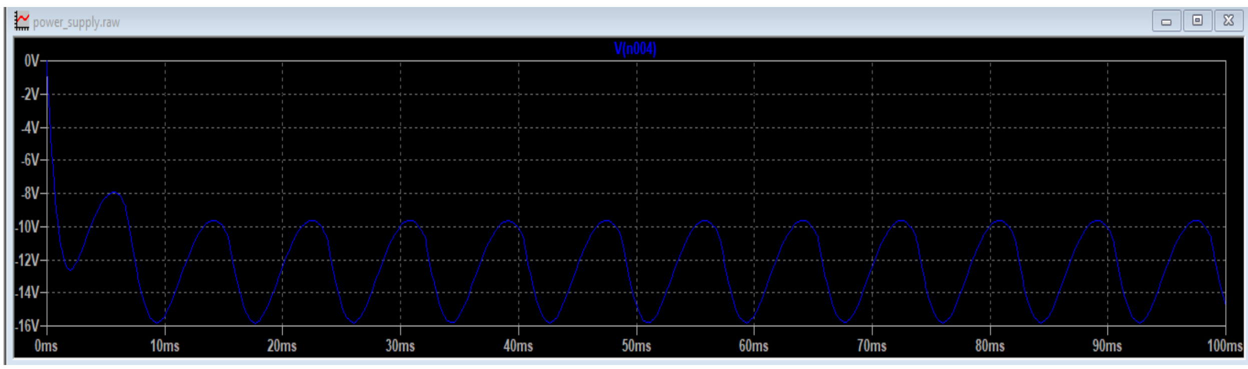


Figure 10: Ripple Voltage at 2nd half diode circuit

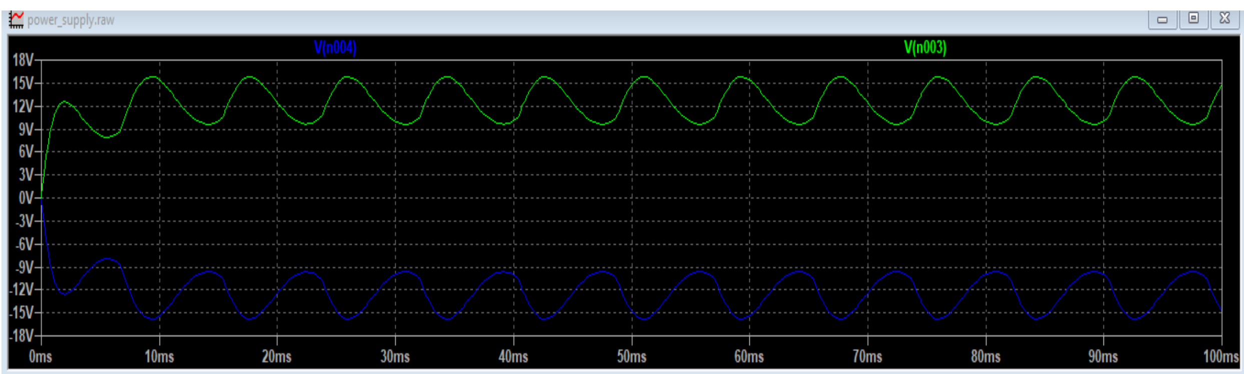


Figure 11: Both waveforms

Current waveforms through the diodes

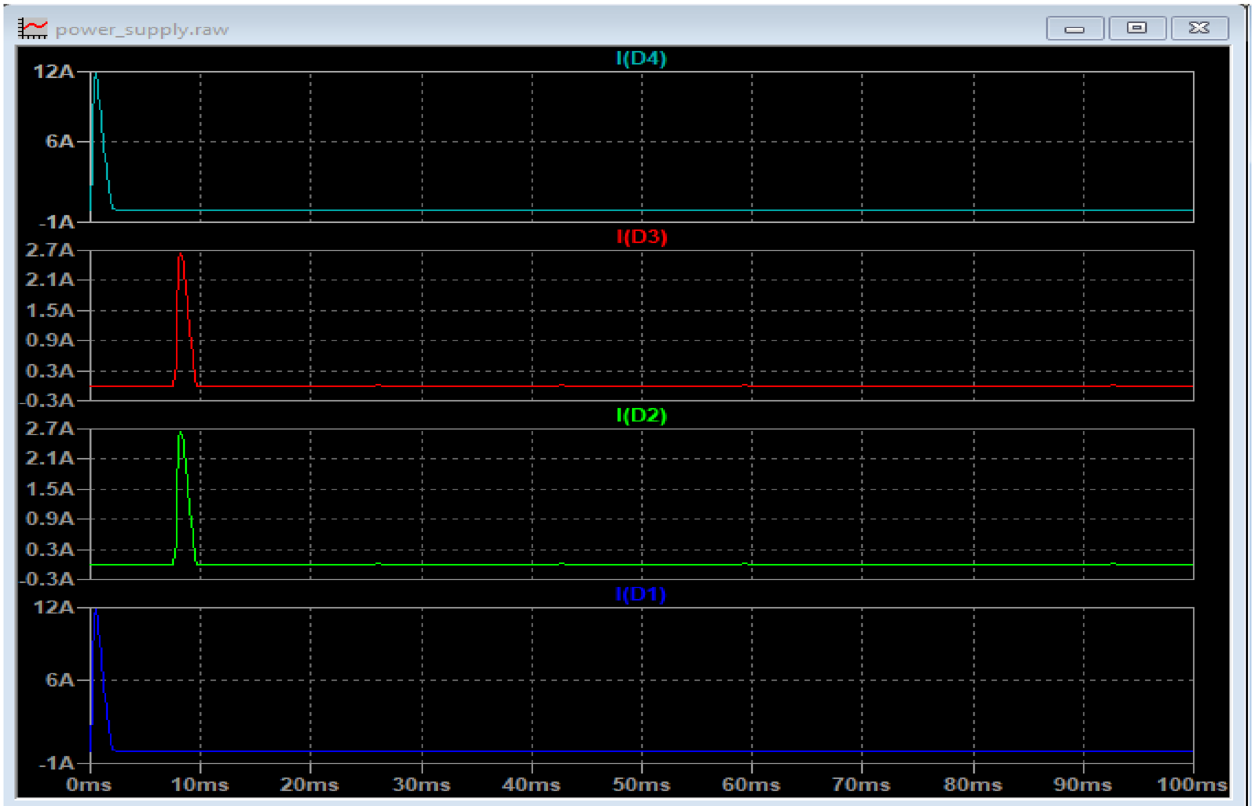


Figure 12: Current waveforms of 4 diodes

current waveforms align with our expectations.

Transient Analysis:

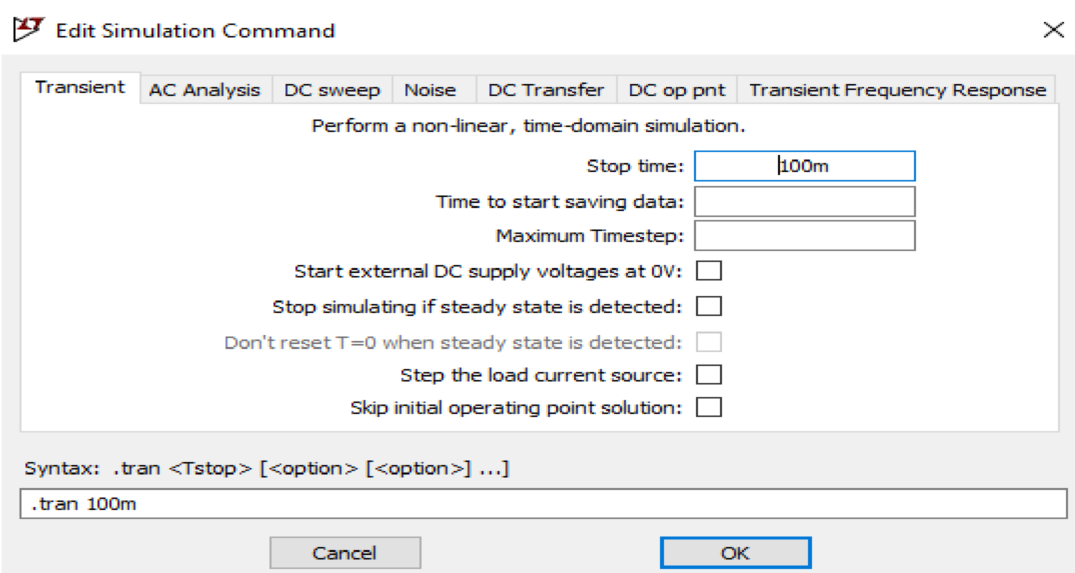


Figure 13:Transiet Analysis simulation parameters

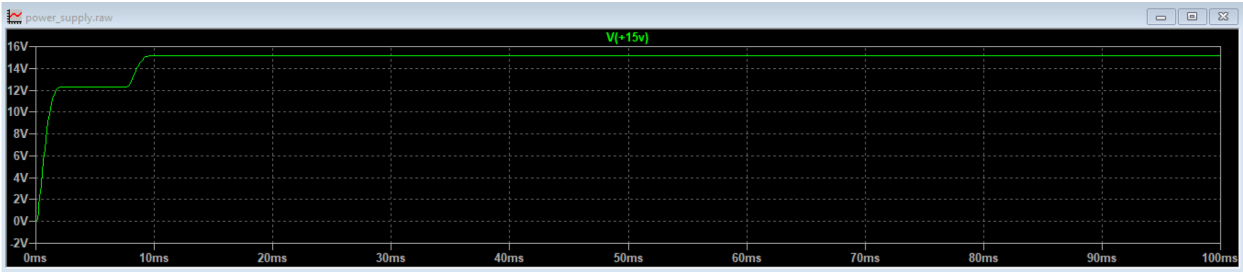


Figure 14: Voltage stabilizes after 9ms

Conclusion:

In conclusion, the design and LTSpice simulation of the dual DC power supply yielded valuable insights into transformer turns ratio calculation, ripple voltage considerations, and overall circuit performance. The adjusted secondary leakage inductances resulted in a calculated turns ratio (N) of approximately 2.855, crucial for effective voltage transformation. The meticulous adjustment of capacitor values ensured alignment with the specified ripple voltage requirements (Vr ≤50mV), indicating stable and reliable performance. The LTSpice simulation successfully validated the design, confirming expected output voltages and transformer waveforms. Noteworthy insights from the project include the sensitivity of the transformer design to secondary leakage inductances, the importance of considering component tolerances in practical implementations, and the inherent trade-offs involved in power supply design. The project underscores the significance of simulation tools, such as LTSpice, in predicting and refining circuit behavior. These findings will serve as valuable considerations in future power supply designs, contributing to the ongoing refinement of power electronics systems.