DICKSON CHARGE PUMP CIRCUIT

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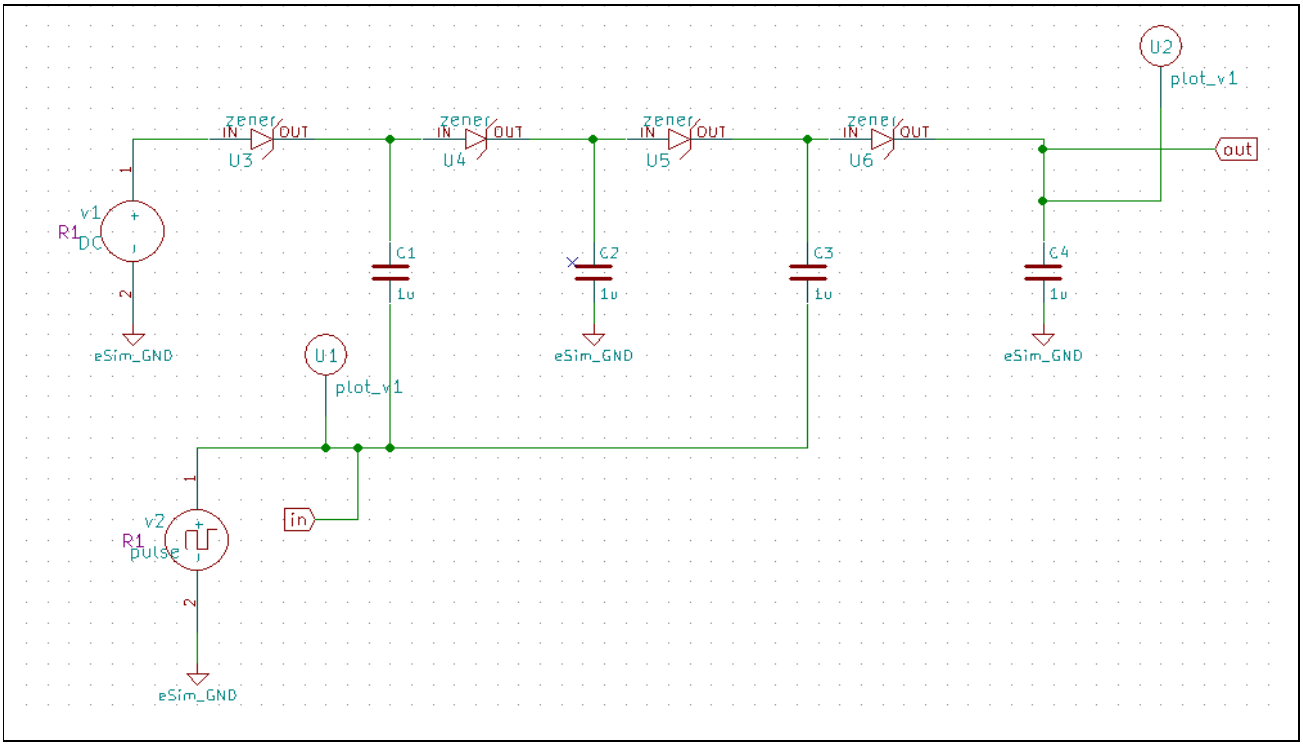
INTRODUCTION:

A Dickson charge pump is a type of voltage multiplier circuit that efficiently converts a lower DC voltage into a higher DC voltage using only diodes and capacitors as its main components. It operates on the principle of charge transfer, where capacitors are alternately charged and discharged through diodes under the control of a clock or switching signal. This circuit eliminates the need for inductors, making it highly suitable for integrated circuit (IC) implementation and compact power supply designs.

The Dickson charge pump provides advantages such as simple structure, low cost, and ease of integration, while delivering moderate efficiency for low to medium current loads. It is widely used in flash memory programming, EEPROMs, LCD bias generation, and RS-232 level shifters (like MAX232 ICs).

Typical characteristics include high voltage gain per stage, low ripple voltage, small size, and reliable DC conversion. Since the input to the Dickson charge pump is generally a low DC or pulsed signal, it is particularly useful in low-power electronic and energy-harvesting systems where compactness, stability, and efficiency are essential.

SCHEMATIC DIAGRAM:



TRANSIENT RESPONSE ANALYSIS:

PARAMETERS:

1.All the capacitors used in the circuit have a value = 1micro farad.

2.The input (DC) V1 is set at 5V.

3.The trigger(pulse) is set at 5V.

4.The output signal is observed across the capacitor(C4).

GENERAL EQUATION:

Ideal RMS Output:

$$\text{Ideal: } V_{out(RMS)} = V_{in} + N \cdot V_{clk(RMS)}$$

- V_{in}= DC input
- N= number of stages

- $V_{clk(RMS)}$= RMS of AC clock pulse

Key Point:

The practical RMS output is usually less than the calculated ideal value. It approaches the ideal only with large capacitors, high frequency clocks, and low load current.

- $V_{in} = 5$ V, $V_{clk(RMS)} = 3.5$ V.
- $N = 4$, $V_D = 0.7$ V, $C = 1\ \mu F$ load.

$$V_{out(RMS)} \approx 16.2 \text{ V (ideal without load drop)}$$

- With 1 µF load → **practical RMS drops to ~12.6 V**
- Output rises gradually → **takes several clock cycles** to reach steady RMS

SIMULATION OUTPUT:

Ngspice plot-input:

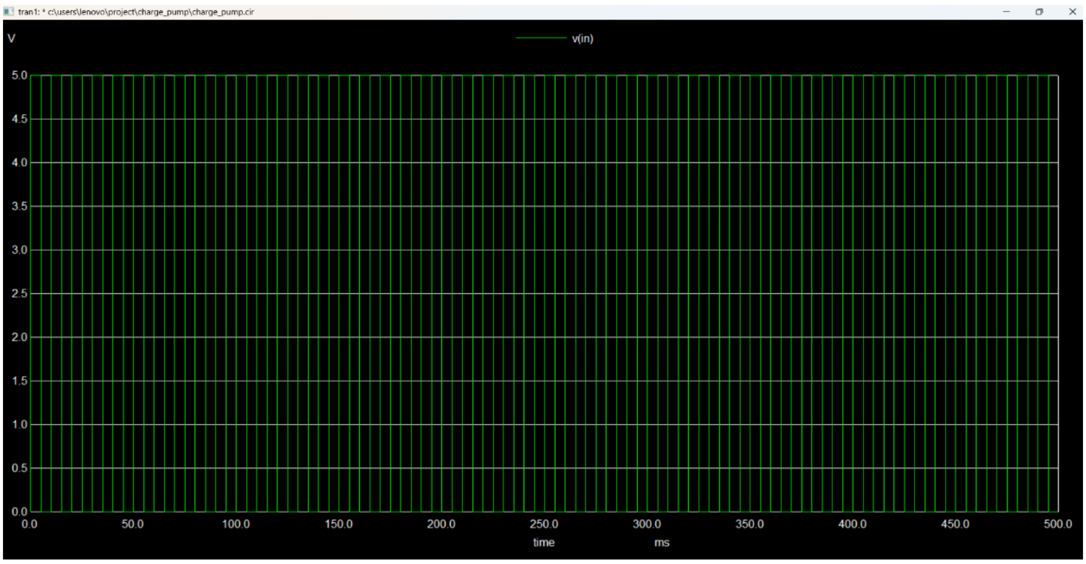


Figure 1. Pulse(5V), RMS=3.5V.

<u>Ngspice plot-output:</u>

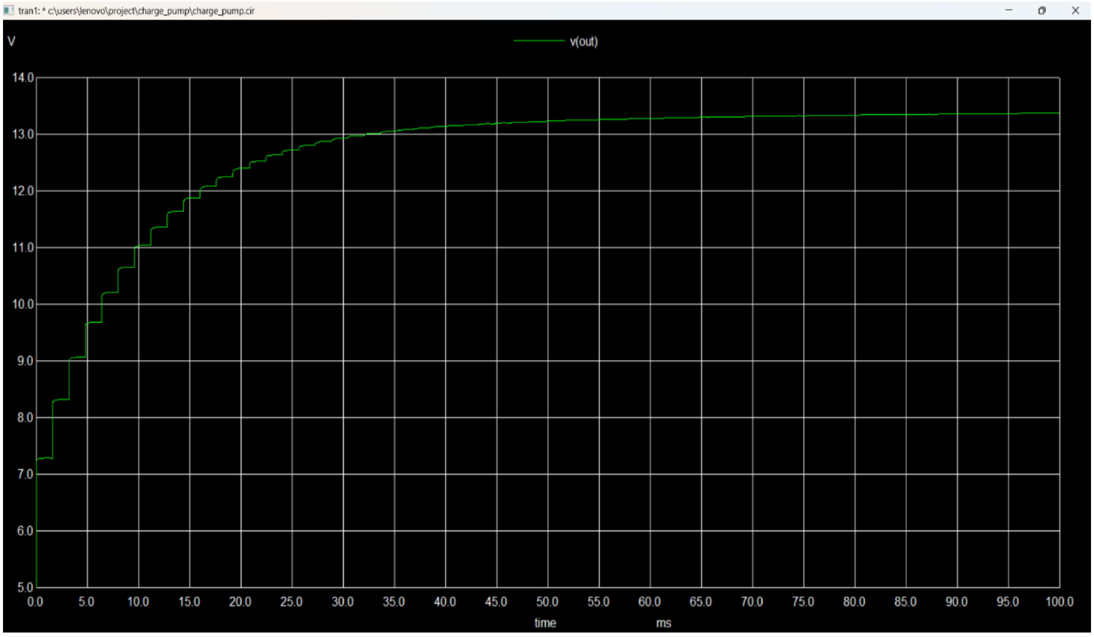
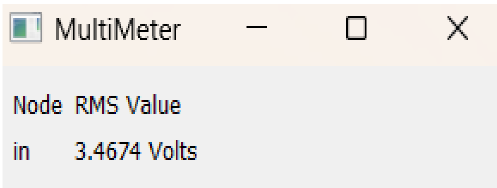
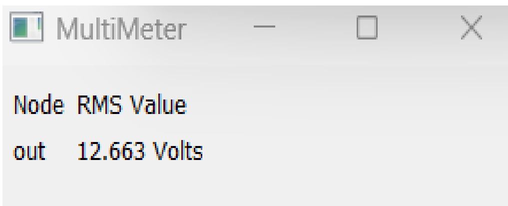


Figure 2. Output plot

<u>INPUT Vpulse- in RMS:</u>

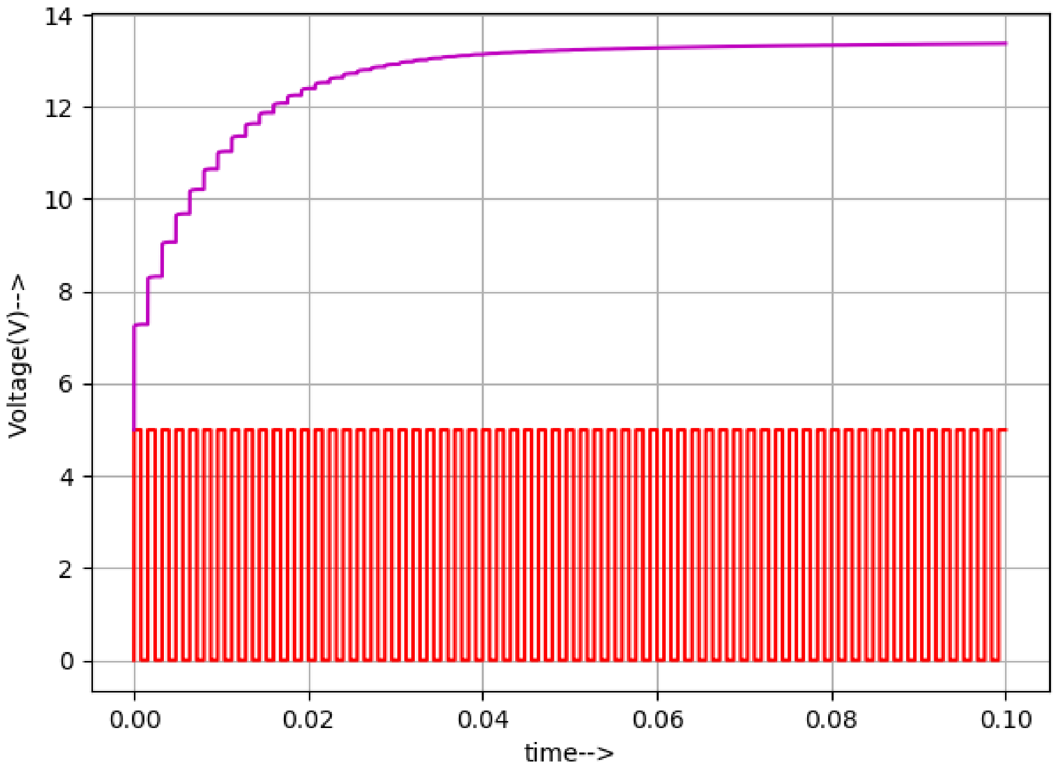


<u>OUTPUT RMS VALUE:</u>



The output increases because the charge pump transfers charge from the AC clock pulses to the capacitors stage by stage, stacking the voltage. Each stage adds part of the AC RMS voltage (minus diode drops) to the previous stage, so the final output builds up from the input 5 V DC + 3.56 V RMS clock to 12.6 V RMS.

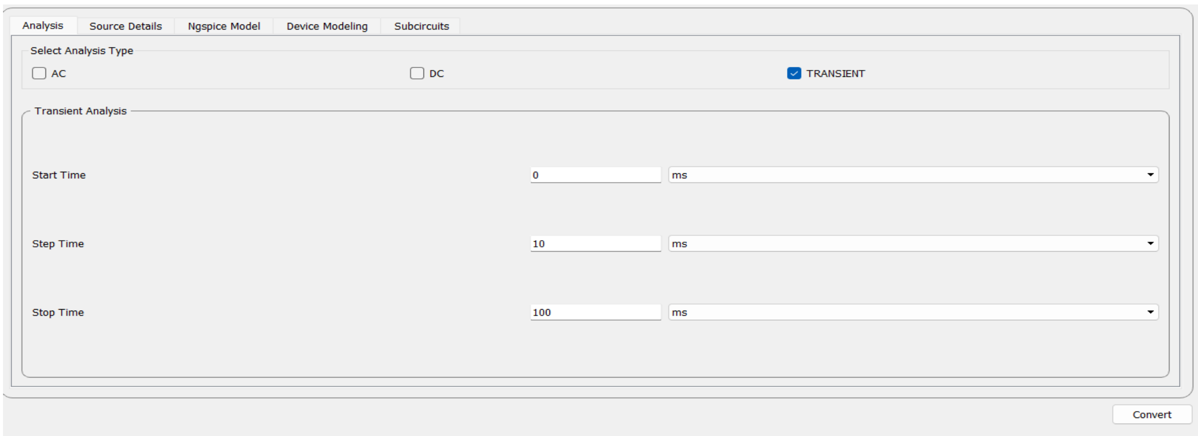
PYTHON PLOT:



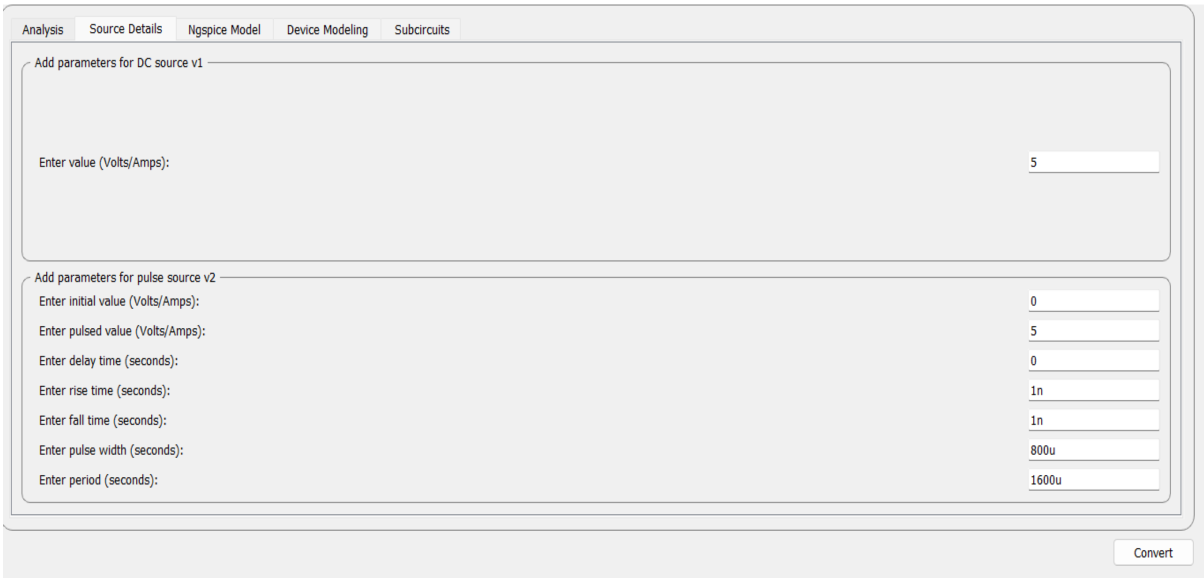
RED- PULSE PROVIDED.

PURPLE-OUTPUT.

TRANSIENT ANALYSIS:



SOURCE DETAILS:



CONCLUSION:

1. **Voltage Boosting:** The charge pump effectively increases the DC voltage by stacking AC clock contributions stage by stage.
2. **RMS Behaviour:** Output RMS voltage depends on the input DC, AC clock RMS, number of stages, diode drops, and load.
3. **Transient Response:** Output rises gradually from the input voltage to steady-state due to capacitor charging; rise time depends on capacitance and switching frequency.
4. **Practical vs Ideal:** Practical output is lower than the ideal calculation because of diodes voltage drops, limited capacitor size, and load effects.

5. **Load and Frequency Effects:** Increasing stage capacitance or clock frequency improves the output voltage closer to the calculated value.
6. **Stage Contribution:** Each stage adds a portion of the AC clock to the output; more stages give higher output but also increase losses.
7. **Application:** Charge pumps are suitable for generating higher voltages without inductors, useful in low-power ICs, sensors, and biasing circuits.

REFERENCE:

T. Tanzawa and T. Tanaka, "A dynamic analysis of the Dickson charge pump circuit," IEEE - ieeexplore.ieee.org/abstract/document/604079