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# EEE419 Project Part 1

**Introduction:**

A flyback converter with input voltage $V_d$=6V and output voltage $V_o$=27V is designed.

**Methodology:**

- The chosen $T_S$ value is 10µs
- $i_{peak}$ value is chosen as 1.1A
- $R_{SC}$ value is calculated as 0.3Ω
- $R_C$ value is calculated as 200Ω, but used 150Ω in the simulation
- Zener diode voltage is chosen as 30V, so the sum $V_d$+$V_Z$=36V
- Chosen $V_{OR}$ value is 9V
- D+$\Delta_2$=0.8
- D is calculated as 0.48 from the equation

$$D = \frac{D + \Delta_2}{1 + {V_d}/{V_{OR}}}$$

- $\Delta_1$ value is calculated from the following formula:

$$\Delta_1 = D\frac{V_d}{V_z - V_{OR}} * \frac{kL_1}{L_1} = 0.0137$$

- $L_1$ value is calculated from the following equation:

$$L_1 = \frac{DT_sV_d}{i_{peak}} = 26.2\mu H$$

- The turns ratio $N_1/N_2$ is calculated as 1/3 by the ratio $V_{OR}/V_O$.
- The value of the $L_2$ is calculated by using the following formula:

$$L_2 = \frac{L_1}{({N_1}/{N_2})^2} = 236\mu H$$

- The number of turns for the primer side $N_1$ is calculated as 12.8 turns

$$N_1 = \sqrt{\frac{L_1}{A_L}}$$

- Using the above formula, $N_2$ value is calculated as 38.4 turns
- $t_{OFF}$ value is calculated as 5.2µs
- $C_T$, timing capacitor value is determined as 2nF, but used 1.2nF in the simulation.
- To obtain 2.5V as the reference voltage of the shunt regulator, $R_1$ and $R_2$ values are chosen as 4.7KΩ and 47KΩ respectively.
- In order to obtain a voltage between 1.1V and 1.25V, $R_4$ and $R_5$ values are chosen as 3.6KΩ and 15KΩ respectively.
- $R_{load}$ is determined as 2KΩ
- To calculate the maximum theoretical output power and efficiency, following formulas are used to find $I_O$, $P_Z$, $P_O$, $I_d$, $P_d$, and η:

$$I_O = \frac{1}{2T_S} {i_{peak}}^2 \left( \frac{L_M}{V_{OR}} - \frac{L_L}{V_Z - V_{OR}} \right) \frac{N_1}{N_2} = 0.0504A$$

$$P_O = V_O I_O = 1.36W$$

$$P_Z = \frac{1}{2T_s} {i_{peak}}^2 L_L \frac{V_Z}{V_Z - V_{OR}} = 0.226W$$

$$I_{in} = \frac{i_{peak}}{2} D = 0.264A$$

$$P_{in} = V_{in} I_{in} = 1.584W$$

$$\eta = \frac{P_O - P_Z}{P_{in}} * 100 = 71.6\%$$

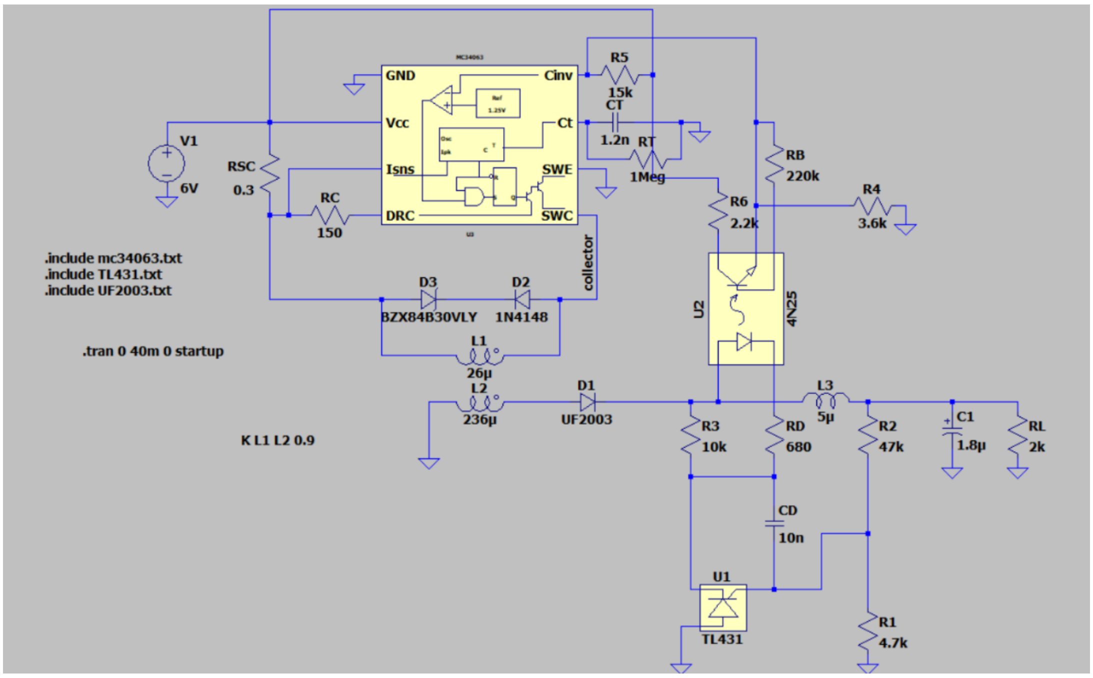


*Fig. 1: Designed Circuit Schematic*

**Analysis:**

Fig. 2 shows the output votlage graph. As seen, the cşrcuit reached its maximum and stayed at a constant voltage.

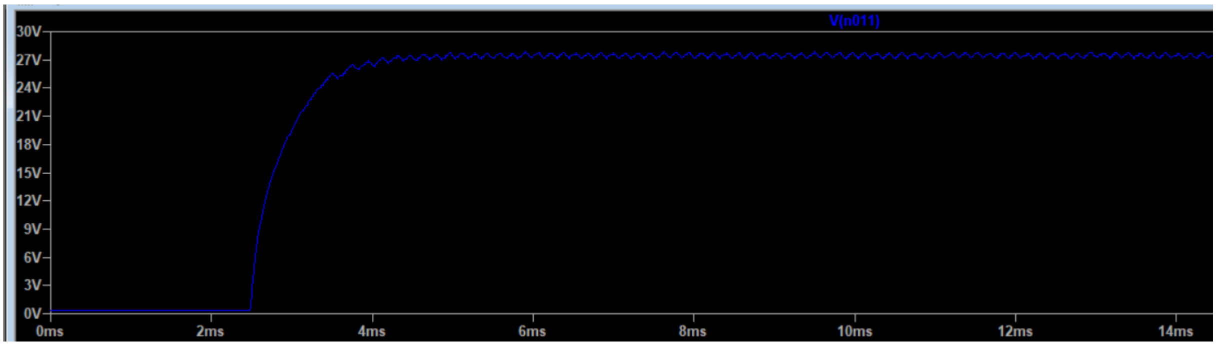


*Fig. 2: Output voltage value*

In Fig. 3, the ripple of the output voltage can be observed. With $C_O$=1.8µF, the ripple is mesaured as 676mV. The ripple can be reduced by increasing the output capacitor value $C_O$. As mentioned in the lab manual, to reduce the simulation time, capacitor value is chosen small. Therefore, the ripple is higher than the desired value, 300mV. In the real life trial, the output capacitor value will be chosen a higher value than 1.8uF to reduce the output ripple.

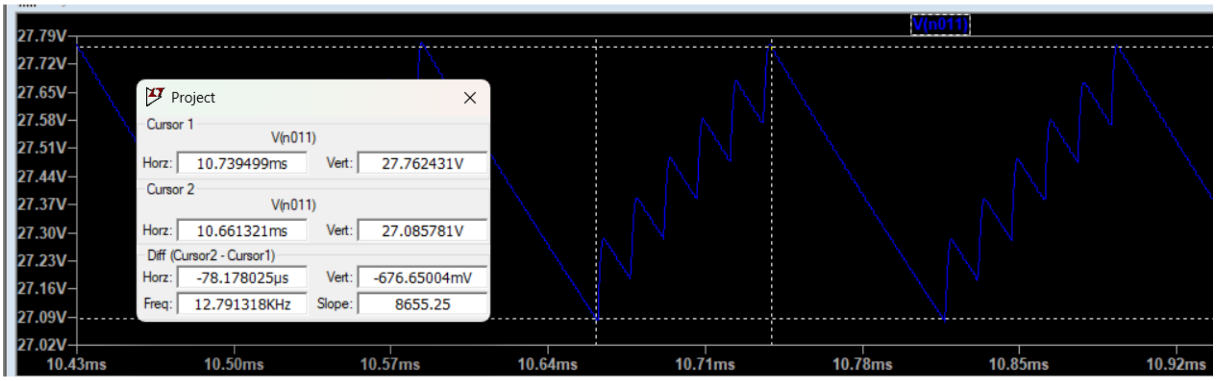


*Fig. 3: Output voltage ripple*

Fig. 4 shows the output voltage value, which has to be 27V. In the simulation, the average of the output voltage value is measured as 27.42V, which lies between the ±5% interval.

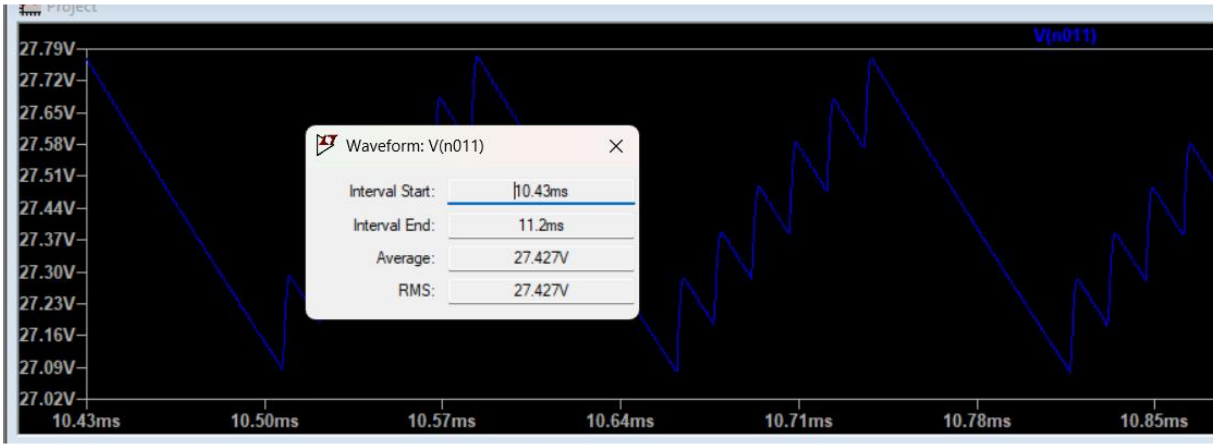


*Fig. 4: Output voltage*

Fig. 5 shows the switch voltage graph. The idle period is more than the expected, to lower the idle period, $C_T$ value can be lowered, but the simulation time increases significantly. When soldering the components, a lower $C_T$ value will be chosen.

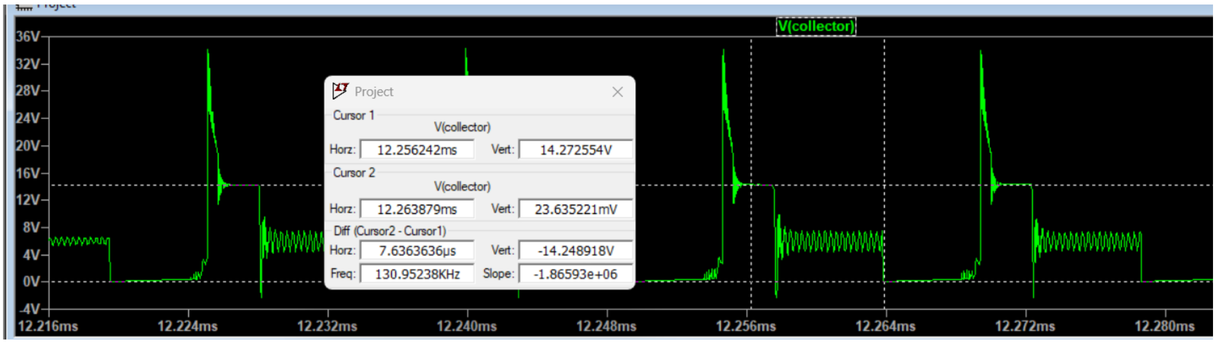


*Fig. 5: Switch voltage graph*

The cursor value shows the $V_{OR}$+$V_d$ value which is measured as 14.27V. The theoretical value is 9+6=15V. The results are close with a slight error due to the losses and other components in the circuit.

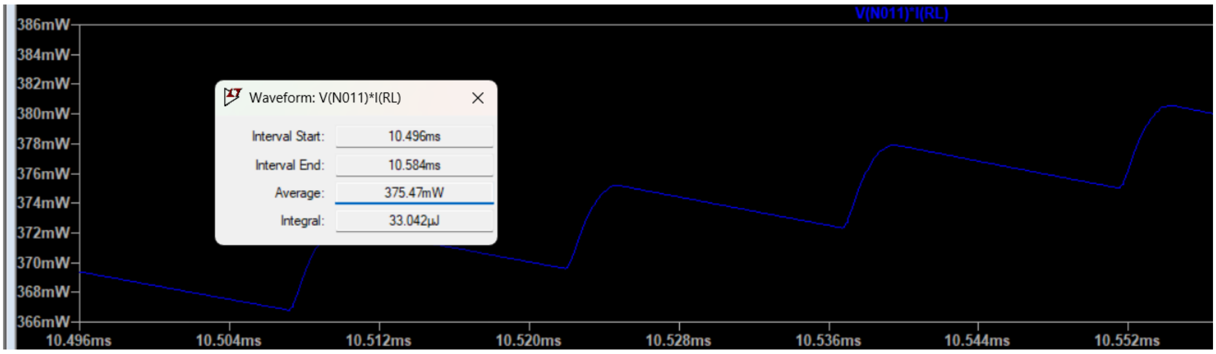


*Fig. 6: Output power*

Fig. 6 shows the output power measured from the simulation, 375mW. The calculated theoretical value is 1.36W. There is a big difference between two values but I think it is because of the diodes, switches, and other components' losses.

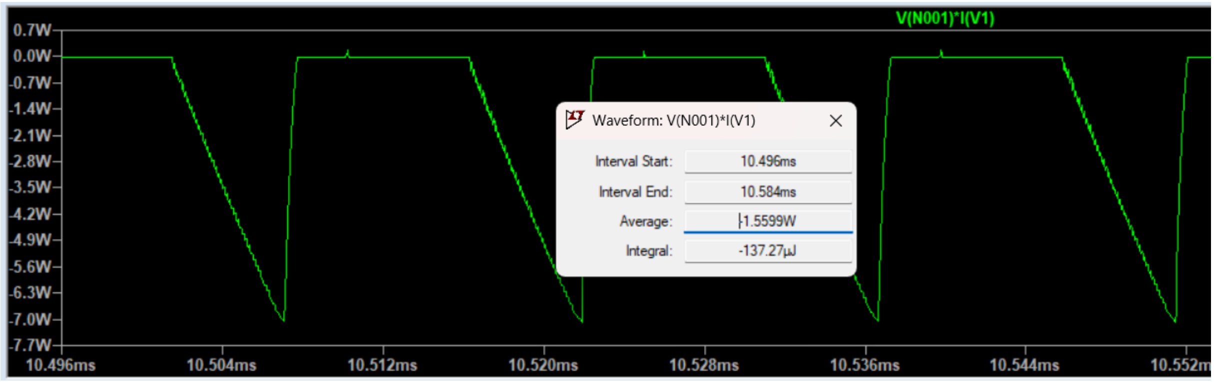


*Fig. 7: Input power*

The input power value can be seen in the Fig. 7. The theoretical calculated input power value is 1.584W, where the measured value is 1.56W. The values are close to each other with a slight error.

From the simulation results, the efficiency of the circuit is calculated as 24.03%. Whereas the theoretical efficiency is calculated as 71.6%.


*Fig. 8: Primer winding of the inductor*

As seen from the Fig. 8, I made 14 winding to achieve 25.71µH value for the primer side of the transformer. The theoretical calculated value is 26µH. The series resistance of the primer is measured as 0.3Ω. The $T_S$ value is 10µs, which is 100KHz. All measurements are made with f=100KHz.


*Fig. 9: Seconder winding of the inductor*

Fig. 9 shows the inductor value for the seconder side of the transformer. There are 41 windings in order to achieve 237.5µH value. The theoretical calculated value is 236µH. The series resistance of the seconder is measured as 0.4Ω.

To find the k (coupling coefficient) value, first, the primer and seconder windings are connected in series with the same dotting notation, the inductance value is measured. Then the dot pathing of the primer is reversed and again connected to seconder and measured the inductance. The difference between two value gives 4M. Below is the formula for calculating the coupling coefficient (k).

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

The M value is calculated as 72.1µ. Therefore, the corresponding k value is 0.923