K. J. SOMAIYA COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
ELEMENTS OF ELECTRICAL AND ELECTRONICS ENGINEERING
DIODE APPLICATION

Numerical 1: Simulate a half wave rectifier circuit with input amplitude = $150V_{peak}$, f = 50Hz and $R_L = 110\Omega$ using LTspice. Select diode as IN4148. Use 10:1 step down transformer. Find output peak value(V_m), output peak current(I_m), AC power, DC power, efficiency, PIV rating.
Plot the following using LTspice,
a] Primary peak voltage.
b] Secondary peak voltage.
c] Output voltage across resistor.
d] Output voltage across diode.
e] Current flowing through the circuit.

Solution:

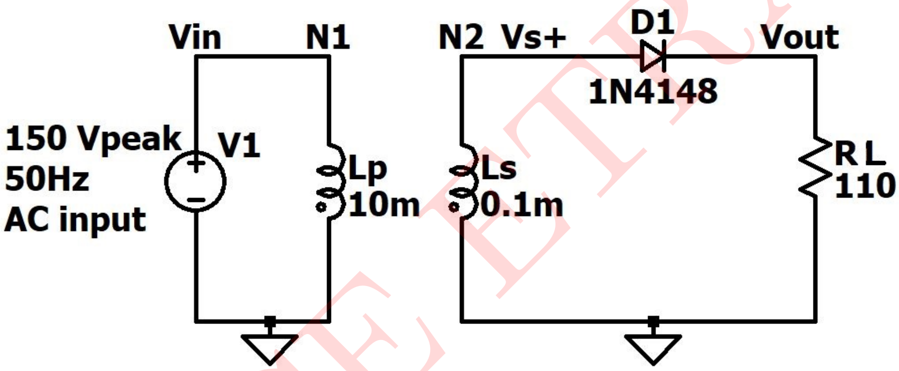

Figure 1: Circuit 1

i] We know that,

$$\frac{N_1}{N_2} = \frac{10}{1}$$

$$\therefore \frac{V_P}{V_S} = \frac{10}{1}$$

$$\therefore V_S = 150 \times \frac{1}{10}$$

$$\therefore V_S = 15V$$

ii] By KVL we get,

$$V_{in} - V_{DON} - V_{out} = 0$$

$$\therefore V_{out} = V_{in} - V_{DON} = 15 - 0.7$$

$$\therefore V_{out} = 14.3V$$

i.e $\mathbf{V_m = 14.3V}$

iii] $I_m = \dfrac{V_m}{R_S + R_L}$

Since, $R_S <<<< R_L$

$$\therefore I_m = \frac{V_m}{R_L}$$

$$\therefore I_m = \frac{14.3}{110}$$

$$\therefore \mathbf{I_m = 0.13A = 130mA}$$

iv] DC power $= \dfrac{V_m^2}{\pi^2 \times R_L}$

$\therefore$ DC power $= \dfrac{14.3^2}{\pi^2 \times 110}$

$\therefore$ **DC power = 0.1884W**

v] AC power $= \dfrac{V_m^2}{4 \times (R_S + R_L)}$

$\therefore$ AC power $\dfrac{14.3^2}{4 \times 110}$

$\therefore$ **AC power = 0.46475W**

vi] Efficiency $= \eta = \dfrac{P_{DC}}{P_{AC}} \times 100 = \dfrac{0.1884}{0.46475} \times 100$

$\therefore$ **Efficiency** $= \eta =$ **40%**

vii] Peak inverse voltage(PIV) rating $= -V_m = \mathbf{-14.3V}$

SIMULATED RESULTS:

The above circuit is simulated in LTspice. The results are presented below.

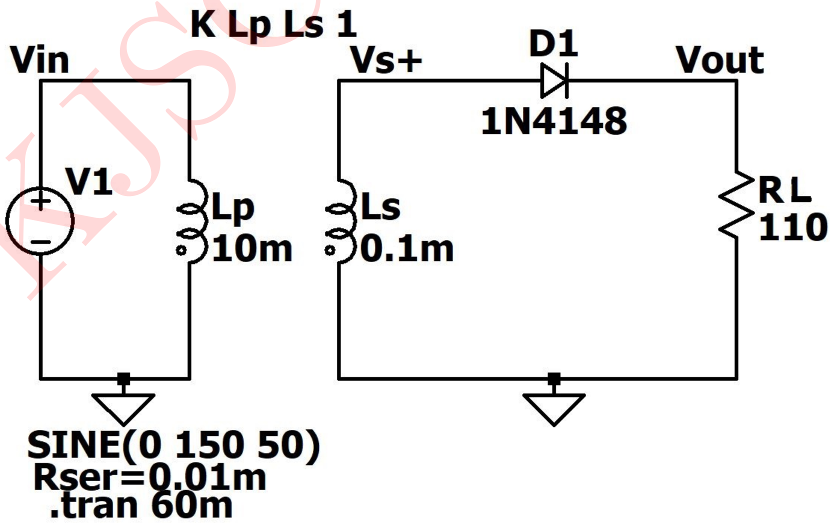

Figure 2: Circuit schematic

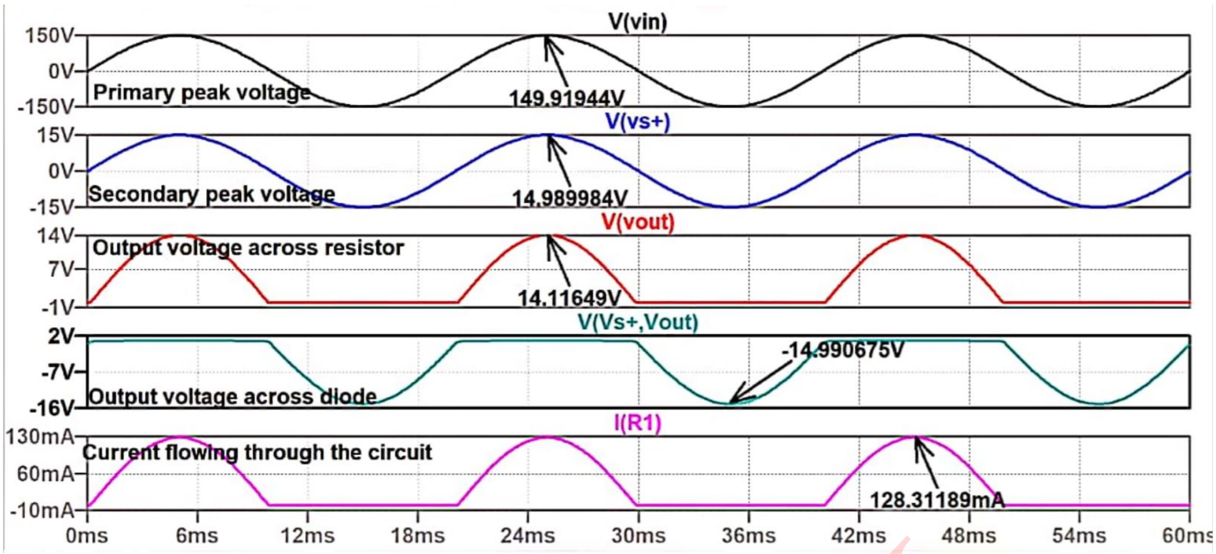

Figure 3: Simulated results

From graph we get,

Output peak voltage = 14.116V

Output peak current = 128.312mA

$$P_{AC} = \frac{V_m^2}{4 \times (R_S + R_L)}$$

$$\therefore P_{AC} = \frac{14.116^2}{4 \times (110)}$$

$$\therefore \mathbf{P_{AC} = 0.4528W}$$

$$P_{DC} = \frac{V_m^2}{\pi^2 \times R_L}$$

$$\therefore P_{DC} = \frac{14.116^2}{\pi^2 \times 110}$$

$$\therefore \mathbf{P_{DC} = 0.4528W}$$

$$\text{Efficiency} = \eta = \frac{P_{DC}}{P_{AC}} \times 100 = \frac{0.1835}{0.4528} \times 100$$

Efficiency = 40%

Peak inverse voltage(PIV) rating $= -V_m = \mathbf{-14.116V}$

Comparison table between theoretical and simulated values:

Parameter	Theoretical value	Simulated values
V_m	14.3V	14.116V
I_m	130mA	128.312mA
AC power	0.46475W	0.4528W
DC power	0.1884W	0.1835W
Efficiency	40.537%	40.52%
PIV rating	$-14.3V$	$-14.115V$

Table 1: Numerical 1

Numerical 2: Simulate a full wave rectifier circuit with input amplitude = $140V_{peak}$, f = 50Hz and $R_L = 110\Omega$ using LTspice. Select diode as IN4148. Use 10:1 step down center tap transformer. Find output peak value(V_m), output peak cirrent(I_M), AC power, DC power, efficiency, PIV rating.
Plot the following using LTspice,
a] Primary peak voltage.
b] Secondary peak voltage.
c] Output voltage across resistor.
d] Output voltage across diode.
e] Current flowing through the diode.
f] Current flowing through the circuit.

Solution:

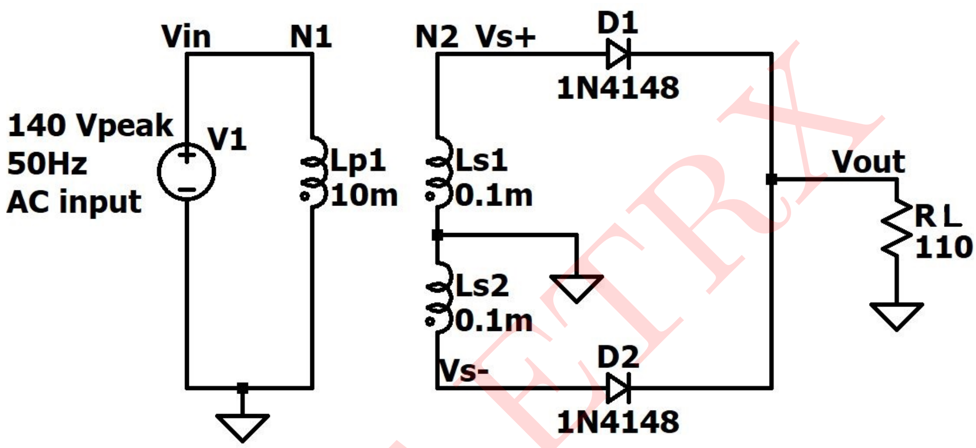

Figure 4: Circuit 2

i] We know that,

$$\frac{V_P}{V_S} = \frac{N_1}{N_2} = \frac{10}{1}$$

$$\therefore \frac{V_P}{V_S} = \frac{10}{1}$$

$$\therefore V_S = 140 \times \frac{1}{10}$$

$$\therefore V_S = 14V$$

ii] By KVL we get,

$$V_{in} - V_{DON} - V_{out} = 0$$

$$\therefore V_{out} = V_{in} - V_{DON} = 14 - 0.7$$

$$\therefore V_{out} = 13.3V$$

i.e $\mathbf{V_m = 13.3V}$

iii] $I_m = \dfrac{V_m}{R_S + R_L}$

Since, $R_S <<<< R_L$

$\therefore I_m = \dfrac{V_m}{R_L}$

$\therefore I_m = \dfrac{13.3}{110}$

$\therefore \mathbf{I_m = 0.1209A = 120.9mA}$

iv] DC power $= \dfrac{4 \times V_m^2}{\pi^2 \times R_L}$

$\therefore$ DC power $= \dfrac{4 \times 13.3^2}{\pi^2 \times 110}$

$\therefore$ **DC power $=$ 0.6517W**

v] AC power $= \dfrac{V_m^2}{2 \times (R_S + R_L)}$

$\therefore$ AC power $\dfrac{13.3^2}{2 \times 110}$

$\therefore$ **AC power $=$ 0.8040W**

vi] Efficiency $= \eta = \dfrac{P_{DC}}{P_{AC}} \times 100 = \dfrac{0.6517}{0.8040} \times 100$

$\therefore$ **Efficiency $= \eta =$ 81.06%**

vii] Peak inverse voltage(PIV) rating $= -2V_m =$ **$-$26.6V**

SIMULATED RESULTS:

The above circuit is simulated in LTspice. The results are presented below.

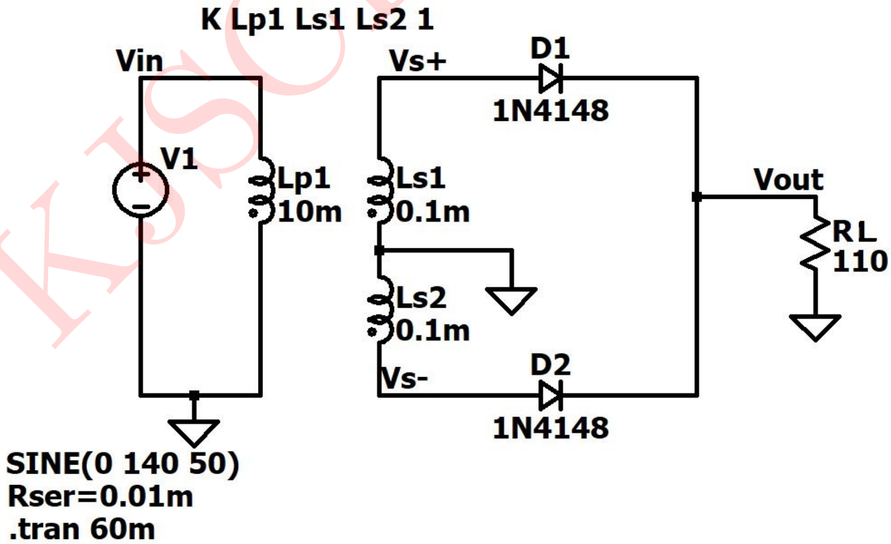

Figure 5: Circuit schematic

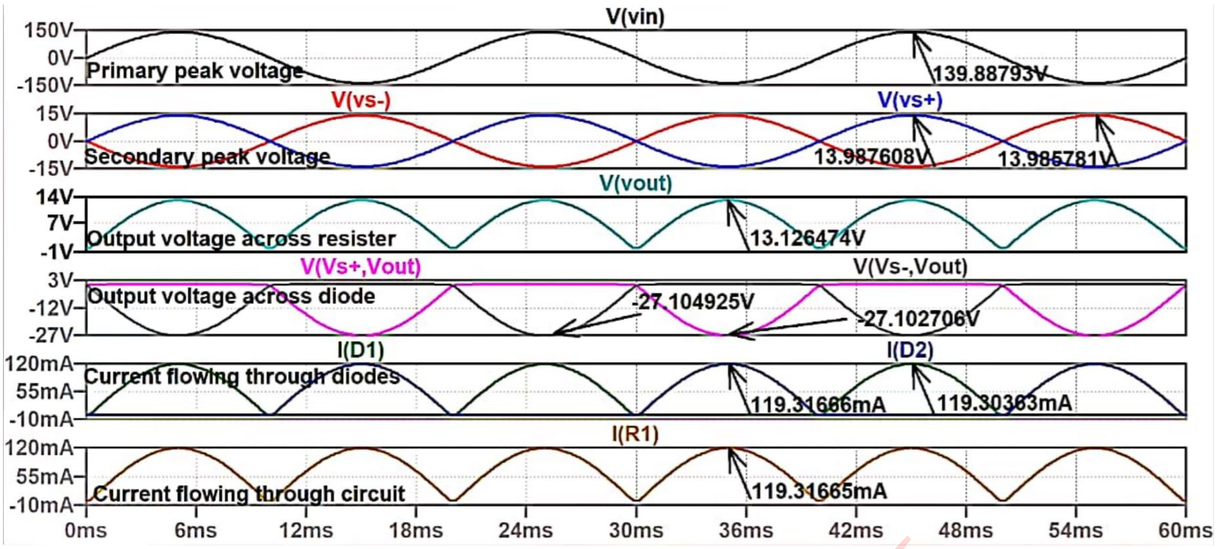

Figure 6: Simulated results

From graph we get,

Output peak voltage = 13.1264V

Output peak current = 119.3165mA

$$P_{AC} = \frac{V_m^2}{2 \times (R_S + R_L)}$$

$$\therefore P_{AC} = \frac{13.1264^2}{2 \times (110)}$$

$$\therefore \mathbf{P_{AC} = 0.7832W}$$

$$P_{DC} = \frac{4 \times V_m^2}{\pi^2 \times R_L}$$

$$\therefore P_{DC} = \frac{4 \times 13.1264^2}{\pi^2 \times 110}$$

$$\therefore \mathbf{P_{DC} = 0.6348W}$$

$$\text{Efficiency} = \eta = \frac{P_{DC}}{P_{AC}} \times 100 = \frac{0.6348}{0.7832} \times 100$$

Efficiency = 81.052%

Peak inverse voltage(PIV) rating $= -2V_m = \mathbf{-26.2528V}$

Comparison table between theoretical and simulated values:

Parameter	Theoretical value	Simulated values
V_m	13.3V	13.1264V
I_m	120.91mA	119.3165mA
AC power	0.8040W	0.7832W
DC power	0.6517W	0.6348W
Efficiency	81.057%	81.052%
PIV rating	$-26.6V$	$-26.2528V$

Table 2: Numerical 2