K. J. SOMAIYA COLLEGE OF ENGINEERING
DEPARTMENT OF ELECTRONICS ENGINEERING
ELECTRONIC CIRCUITS
DIODE APPLICATIONS

Numerical 1: Simulate a half wave rectifier circuit with input Amplitude = 220V peak, f = 50Hz and R_1 = 95 Ω using LTspice. Select diode as IN4148. Use 10:1 step down transformer. Plot the following using LTspice:
a) Primary peak voltage.
b) Secondary peak voltage
c) Output voltage across resistor
d) Output voltage across diodes
e) Current flowing through the circuit
Also calculate the efficiency of the Half wave rectifier circuit.

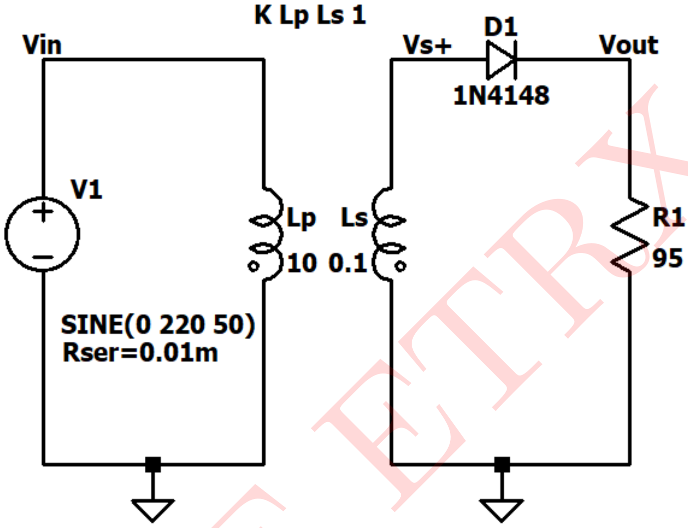

Figure 1: Circuit 1

Given:

$R_1 = 95\ \Omega$
$R_S = 0.01\text{m}\ \Omega$
$V_{in} = 220\text{V}$
f = 50Hz

Solution:

Since, $V_{in} = 220\text{V}$

$\therefore$ **Primary peak voltage = 220V**

Also, turn ratio is 10:1

$\therefore V_m = \dfrac{220}{10}$

$\therefore V_m = 22\text{V}$

$\therefore$ **Secondary peak voltage = 22V**

Current:

$$I_m = \frac{V_m}{R_1 + R_S}$$

$$\therefore I_m = \frac{22}{95 + 0.01 \times 10^{-3}}$$

$$\therefore I_m = 0.231578$$

$$\therefore I_m = \mathbf{231.578mA}$$

DC output power:

$$P_{DC} = \left(\frac{I_m}{\pi}\right)^2 R_1$$

$$\therefore P_{DC} = \left(\frac{231.578 \times 10^{-3}}{\pi}\right)^2 \times 95$$

$$\therefore P_{DC} = \mathbf{0.489W}$$

AC output power:

$$P_{AC} = \left(\frac{I_m}{2}\right)^2 (R_1 + R_S)$$

$$\therefore P_{AC} = \left(\frac{231.578 \times 10^{-3}}{2}\right)^2 \times (95 + 0.01 \times 10^{-3})$$

$$\therefore P_{AC} = \mathbf{1.27367W}$$

Efficiency:

$$\eta = \frac{P_{AC}}{P_{DC}} \times 100$$

$$\therefore \eta = \frac{1.27367}{0.489} \times 100$$

$$\therefore \eta = \mathbf{40.5}\ \%$$

PIV rating of diode:

PIV rating $= -V_m$

$\therefore$ **PIV rating** $= \mathbf{-\ 22V}$

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

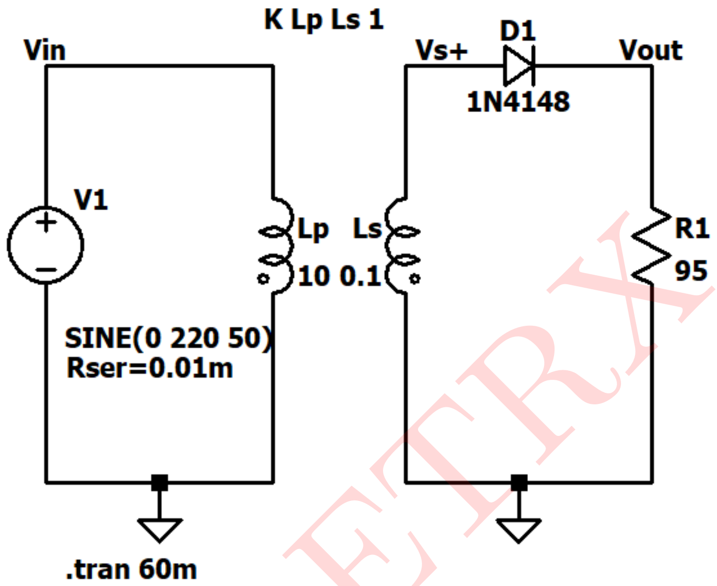

Figure 2: Circuit Schematic and Simulated Results

The waveforms are shown in figure 3

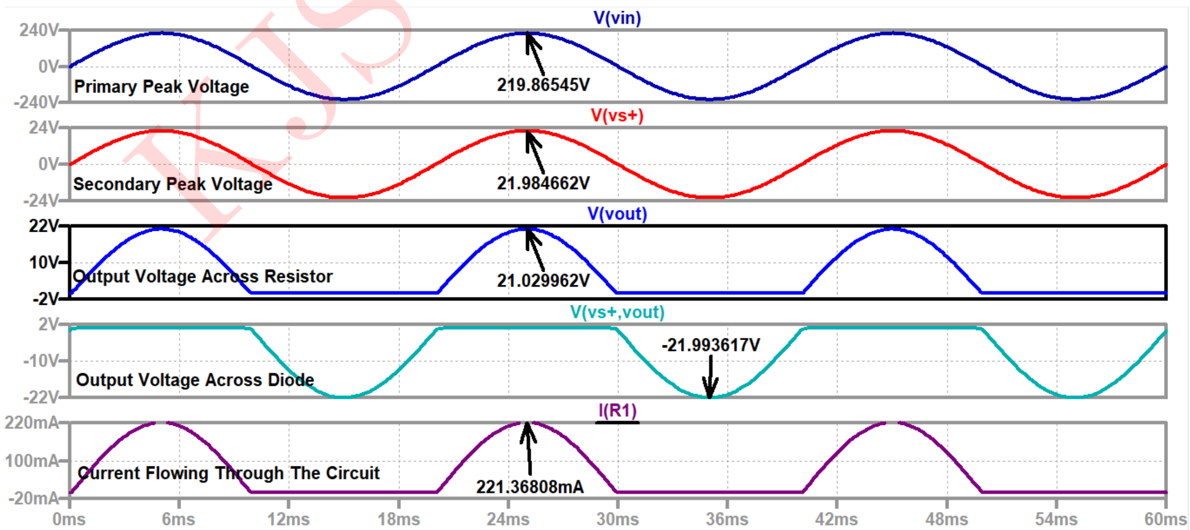

Figure 3: waveforms obtained

Calculation:

DC output power:

$$P_{DC} = \frac{{V_m}^2}{\pi^2 R_1}$$

$$\therefore P_{DC} = \frac{21.0299^2}{\pi^2 \times 95}$$

$$\therefore P_{DC} = \mathbf{0.471W}$$

AC output power:

$$P_{AC} = \frac{{V_m}^2}{4(R_1 + R_S)}$$

$$\therefore P_{AC} = \frac{21.0299^2}{4(95 + 0.01 \times 10^{-3})}$$

$$\therefore P_{AC} = \mathbf{1.1638W}$$

Efficiency:

$$\eta = \frac{P_{AC}}{P_{DC}} \times 100$$

$$\therefore \eta = \frac{1.1638}{0.471} \times 100$$

$$\therefore \eta = \mathbf{40.5282}\ \%$$

PIV rating of diode:

PIV rating $= -V_m$

$\therefore$ **PIV rating = − 21.984V**

Comparison of theoretical and simulated values:

Parameters	Theoretical Values	Simulated Values
Output peak value (V_m)	22V	21.0299V
Output Peak current (I_m)	231.578mA	221.368mA
AC power	1.2736W	1.1638W
DC power	0.489W	0.471W
Efficiency	40.5 %	40.52 %
PIV rating	− 22V	− 21.9846V

Table 1: Numerical 1

Numerical 2: Simulate a Full wave rectifier circuit with input Amplitude = 220V peak, f = 50Hz and $R_1 = 90\ \Omega$ using LTspice. Select diode as IN4148. Use 10:1 step down transformer. Plot the following using LTspice:
a) Primary peak voltage.
b) Secondary peak voltage
c) Output voltage across resistor
d) Output voltage across diodes
e) Current flowing through the diodes
f) Current flowing through the circuit
Also calculate the efficiency of the Full wave Center tapped rectifier circuit.

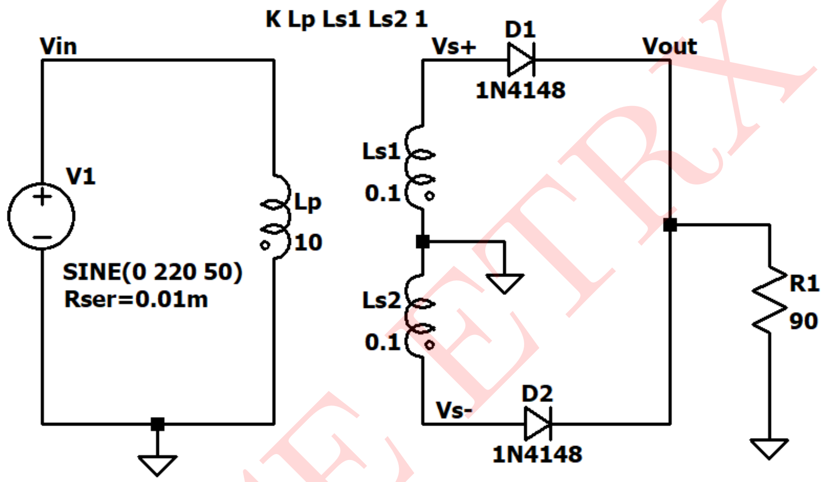

Figure 4: Circuit 2

Given:

$R_1 = 90\ \Omega$
$R_S = 0.01\text{m}\ \Omega$
$V_{in} = 220\text{V}$
f = 50Hz

Solution:

Since, $V_{in} = 220\text{V}$

$\therefore$ **Primary peak voltage = 220V**

Also, turn ratio is 10:1

$\therefore V_m = \dfrac{220}{10}$

$\therefore V_m = 22\text{V}$

$\therefore$ **Secondary peak voltage = 22V**

Current:

$$I_m = \frac{V_m}{R_1 + R_S}$$

$$\therefore I_m = \frac{22}{90 + 0.01 \times 10^{-3}}$$

$$\therefore I_m = 0.244444$$

$$\therefore I_m \mathbf{= 244.444mA}$$

DC output power:

$$P_{DC} = \left(\frac{2I_m}{\pi}\right)^2 R_1$$

$$\therefore P_{DC} = \left(\frac{2 \times 244.444 \times 10^{-3}}{\pi}\right)^2 \times \times 90$$

$$\therefore P_{DC} \mathbf{= 2.1795W}$$

AC output power:

$$P_{AC} = \frac{I_m^2}{2}(R_1 + R_S)$$

$$\therefore P_{AC} = \frac{\left(244.444 \times 10^{-3}\right)^2}{2} \times (90 + 0.01\times\ 10^{-3})$$

$$\therefore P_{AC} \mathbf{= 2.6888W}$$

Efficiency:

$$\eta = \frac{P_{AC}}{P_{DC}} \times 100$$

$$\therefore \eta = \frac{2.1795}{2.6888} \times 100$$

$$\therefore \eta \mathbf{= 81.05}\ \%$$

PIV rating of diode:

PIV rating $= -2V_m$

$\therefore$ **PIV rating of Diode** D_1 **= − 44V**
$\therefore$ **PIV rating of Diode** D_2 **= − 44V**

SIMULATED RESULTS:

The given circuit is simulated in LTspice and the results obtained are as follows:

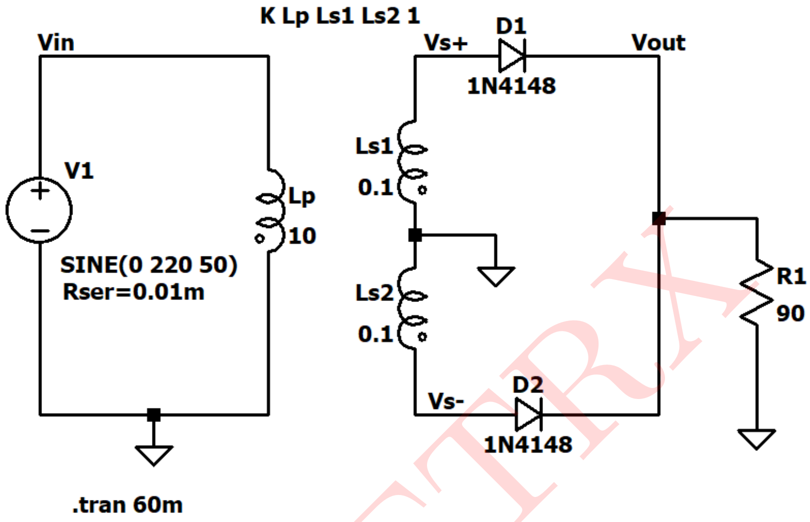

Figure 5: Circuit Schematic and Simulated Results

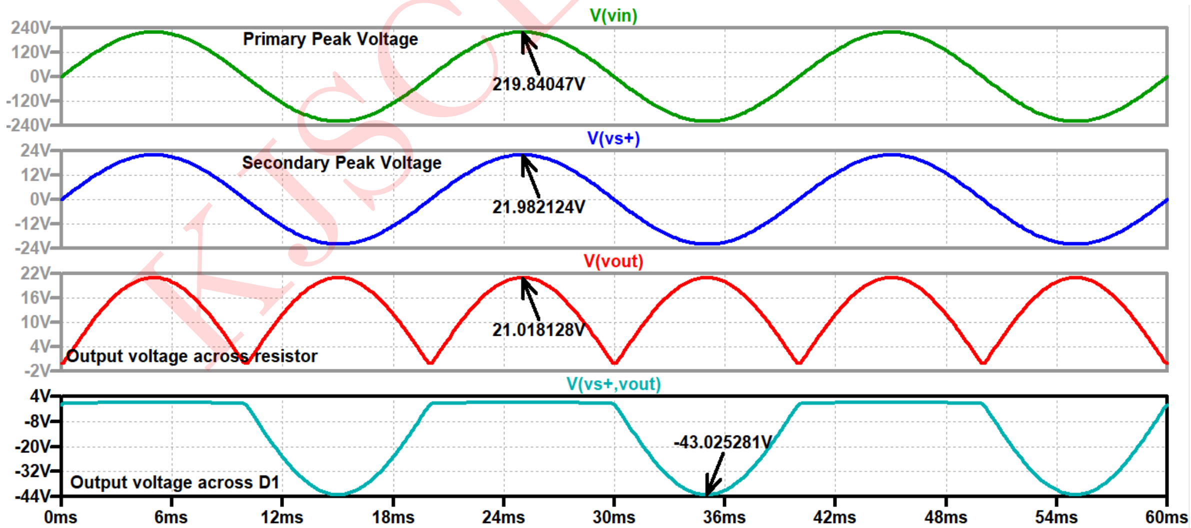

Figure 6: Waveforms obtained

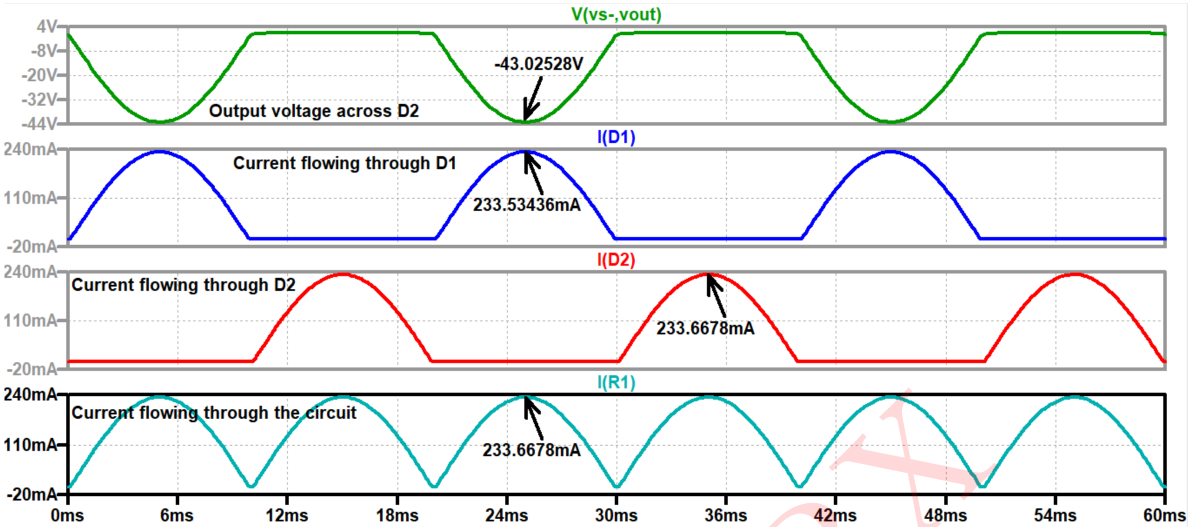

Figure 7: Waveforms obtained

Calculation:

DC output power:

$$P_{DC} = \frac{4{I_m}^2 R_1}{\pi^2}$$

$$\therefore P_{DC} = \frac{4 \times (233.6678 \times 10^{-3})^2 \times 90}{\pi^2}$$

$$\therefore P_{DC} = \mathbf{1.9915W}$$

AC output power:

$$P_{AC} = \frac{{I_m}^2}{2}(R_1 + R_S)$$

$$\therefore P_{AC} = \frac{(233.6678 \times 10^{-3})^2}{2}(90 + 0.01 \times 10^{-3})$$

$$\therefore P_{AC} = \mathbf{2.457W}$$

Efficiency:

$$\eta = \frac{P_{AC}}{P_{DC}} \times 100$$

$$\therefore \eta = \frac{1.9915}{2.457} \times 100$$

$$\therefore \eta = \mathbf{81.05659}\ \%$$

PIV rating of diode:

PIV rating $= -2V_m$

$\therefore$ **PIV rating of D_1 = − 43.025V**
$\therefore$ **PIV rating of D_2 = − 43.025V**

Comparison of theoretical and simulated values:

Parameters	**Theoretical Values**	**Simulated Values**
Output peak voltage (V_m)	22V	21.018V
Output peak current (I_m)	244.444mA	233.667mA
AC power	2.688W	2.457W
DC power	2.179W	1.9915W
Efficiency	81.05 %	81.05 %
PIV rating	− 44V	− 43.025V

Table 2: Numerical 2