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1. **Aim of the experiment**: Studies on Rectifiers(Half wave rectifier, Full wave with center-tapped transformer, Full wave Bridge rectifier) , Zener diode voltage regulator.

2. **Tools used:**

   Half wave rectifier - AC Voltage source, step down transformer,inductors,capacitors,resistors,connecting wires,diode,zener diode,multimeter.

   Full wave with center-tapped transformer - AC Voltage source, step down transformer, inductors, capacitors, resistors, diodes, Zener diode, multimeter, connecting wires.

   Full wave Bridge rectifier - AC Voltage source, step down transformer, inductors, capacitors, resistors, diodes, Zener diode, multimeter, connecting wires.

3. **Background knowledge (brief):**

Half wave rectifier - Half-wave rectifiers transform AC voltage to DC voltage. A halfwave rectifier circuit uses only one diode for the transformation.

A halfwave rectifier is defined as a rectifier that allows only one-half cycle of an AC voltage waveform to pass while blocking the other half cycle.

Ripple factor determines how well a halfwave rectifier can convert AC voltage to DC voltage.

Full wave with center-tapped transformer - A center tapped full wave rectifier is a type of rectifier that uses a center tapped transformer and two diodes to convert the complete AC signal into a DC signal.

When an additional wire is connected across the exact middle of the secondary winding of a transformer, it is known as a center-tapped transformer. The upper part of the secondary winding produces a positive voltage $V_{1,}$ and the lower part has center-tapped a negative voltage V_2. When we combine these two voltages at output load, we get a complete AC signal.

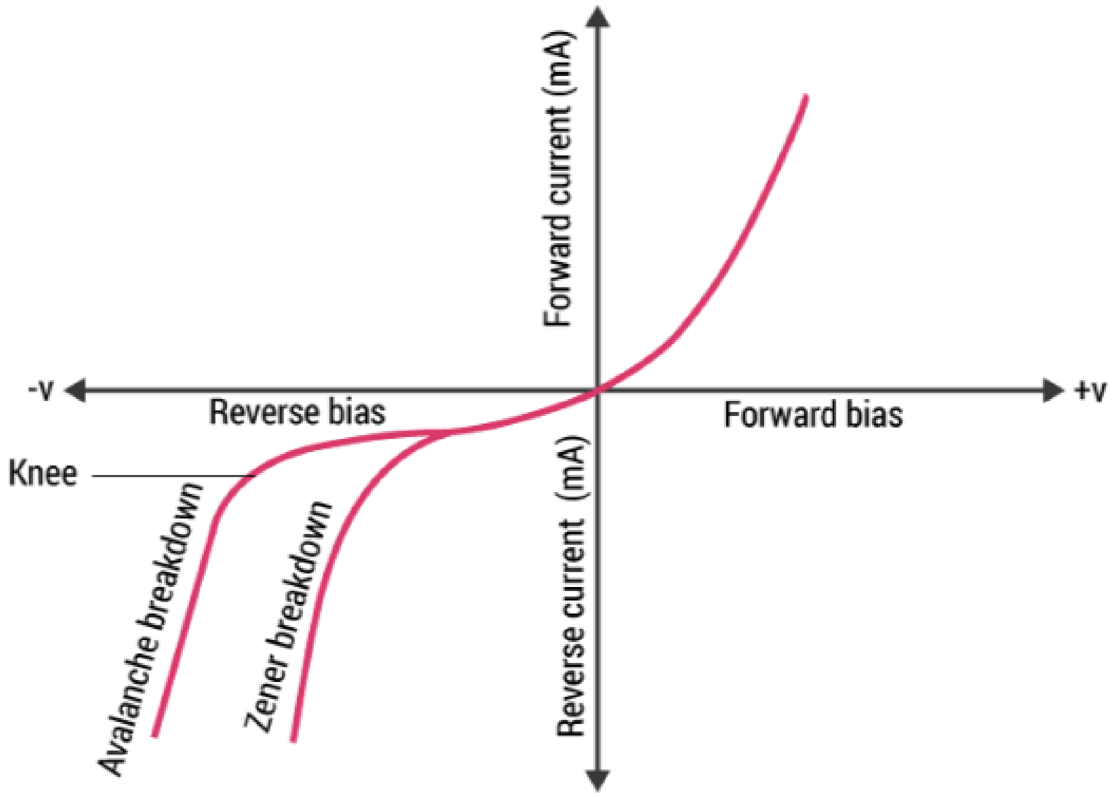
Full wave Bridge rectifier - Bridge rectifier circuit comprises four diodes D_1, D_2, D_3, D_4, and a load resistor R_L. The four diodes are connected in a closed-loop configuration to efficiently convert the alternating current (AC) into Direct Current (DC). The main advantage of this configuration is the absence of the expensive center-tapped transformer. Therefore, the size and cost are reduced.

The efficiency of the bridge rectifier is higher than the efficiency of a half-wave rectifier. However, the rectifier efficiency of the bridge rectifier and the center-tapped full-wave rectifier is the same.

Zener Diode, also known as a breakdown diode, is a heavily doped semiconductor device designed to operate in the reverse direction. When the voltage across the terminals of a Zener diode is reversed, and the potential reaches the Zener Voltage (knee voltage), the junction breaks down, and the current flows in the reverse direction.

Avalanche Breakdown - When a high value of reverse voltage is applied to the PN junction, the free electrons gain sufficient energy and accelerate at high velocities. These free electrons moving at high velocity collide with other atoms and knock off more electrons. Due to this continuous collision, a large number of free electrons are generated due to the electric current in the diode rapidly increasing.

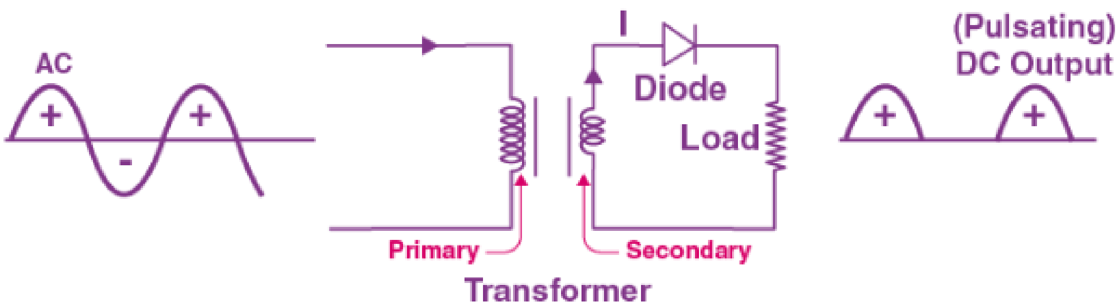
Zener Breakdown - When the applied reverse bias voltage reaches closer to the Zener voltage, the electric field in the depletion region gets strong enough to pull electrons from their valence band. The valence electrons that gain sufficient energy from the strong electric field of the depletion region break free from the parent atom. At the Zener breakdown region, a slight increase in the voltage results in a rapid rise of the electric current.



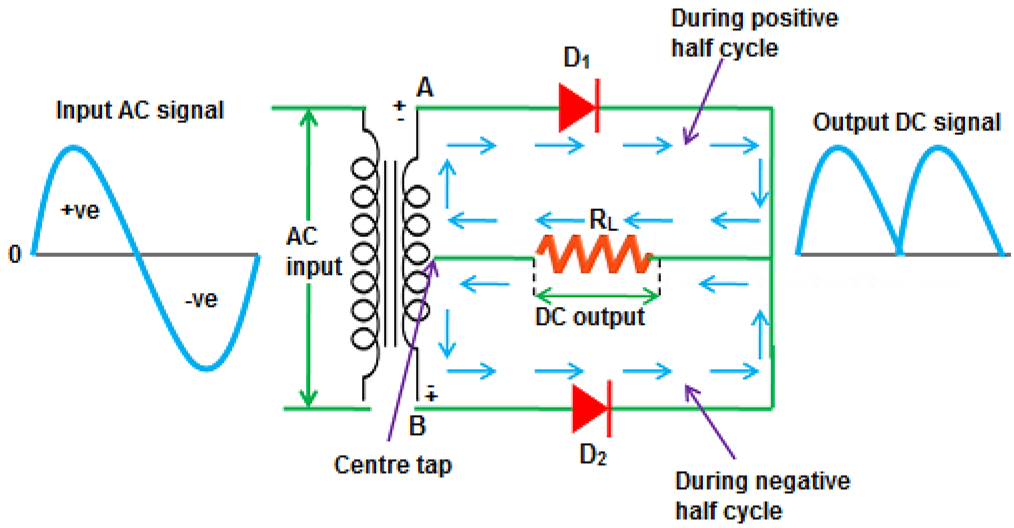
When reverse-biased voltage is applied to a Zener diode, it allows only a small amount of leakage current until the voltage is less than Zener voltage.

4. <u>Circuit (hand-drawn/image):</u>

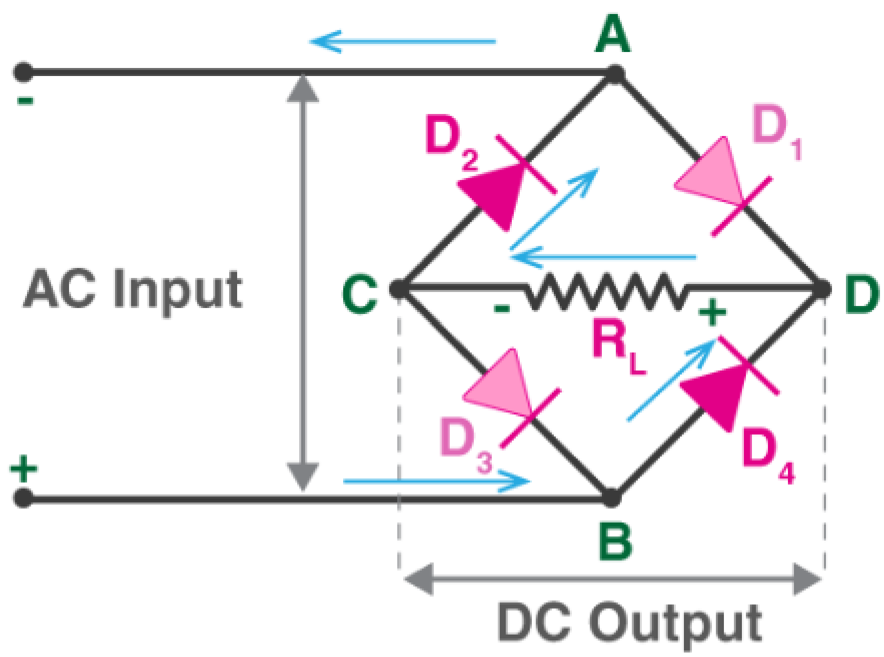
Half wave rectifier -



Full wave with center-tapped transformer -



Full wave Bridge rectifier -



5. <u>**Measurement Data (Tabular form):**</u>

Half wave rectifier -

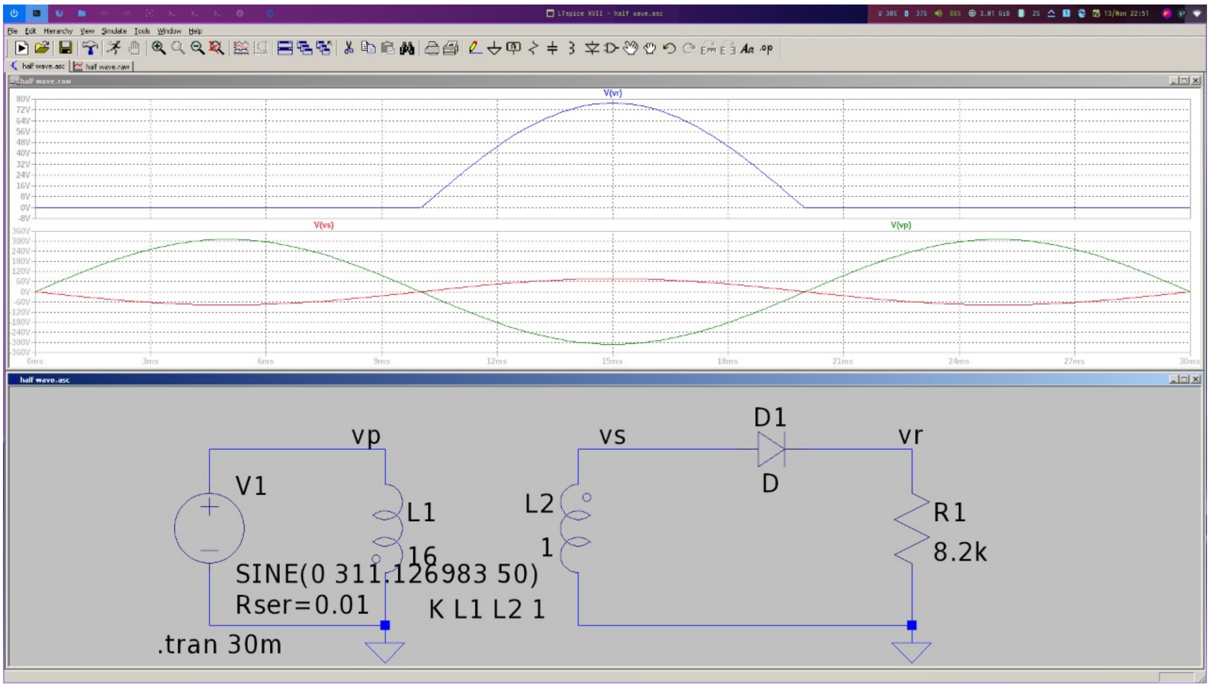
Full wave with center-tapped transformer -

Full wave Bridge rectifier -

6. Graph (Image)/Screenshots:

Half wave rectifier -

a)pulsatile dc



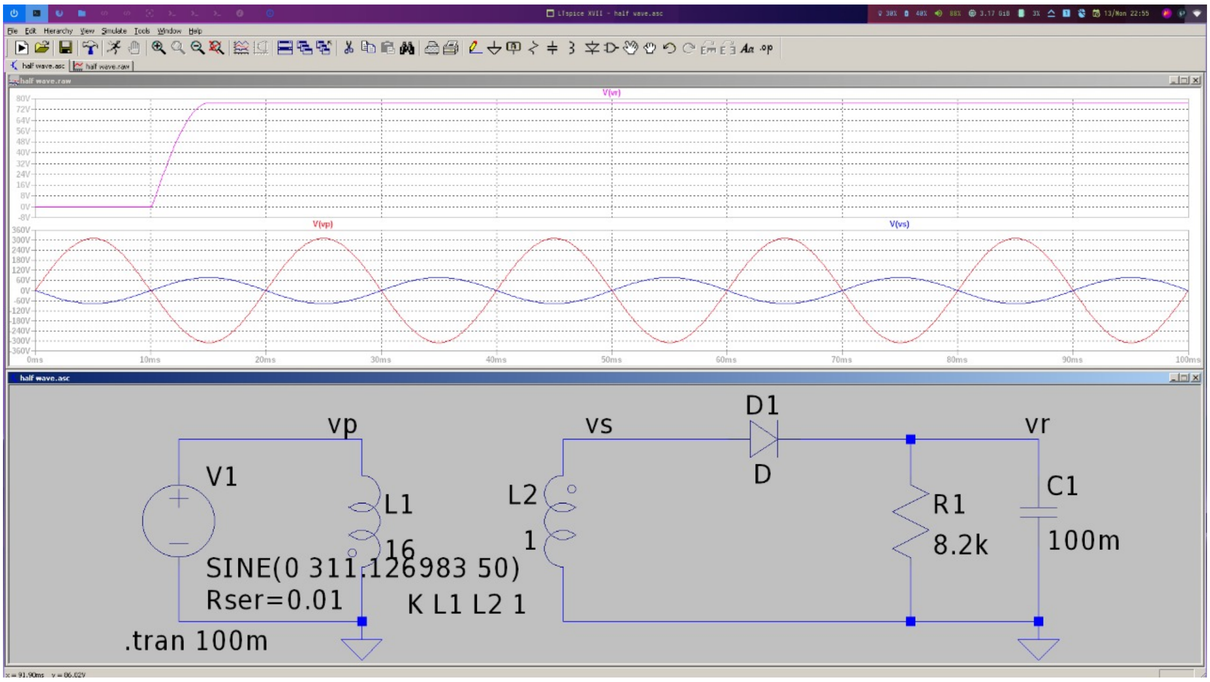
From the graph, Vm = 311.126V.

Ripple Factor Vr = ((Irms/Idc)e2 - 1)e0.5   (Irms = Im/2 , Idc = Im/π)

= ((π/2)e2 - 1)e0.5

= 1.21

b) Low pass filter included

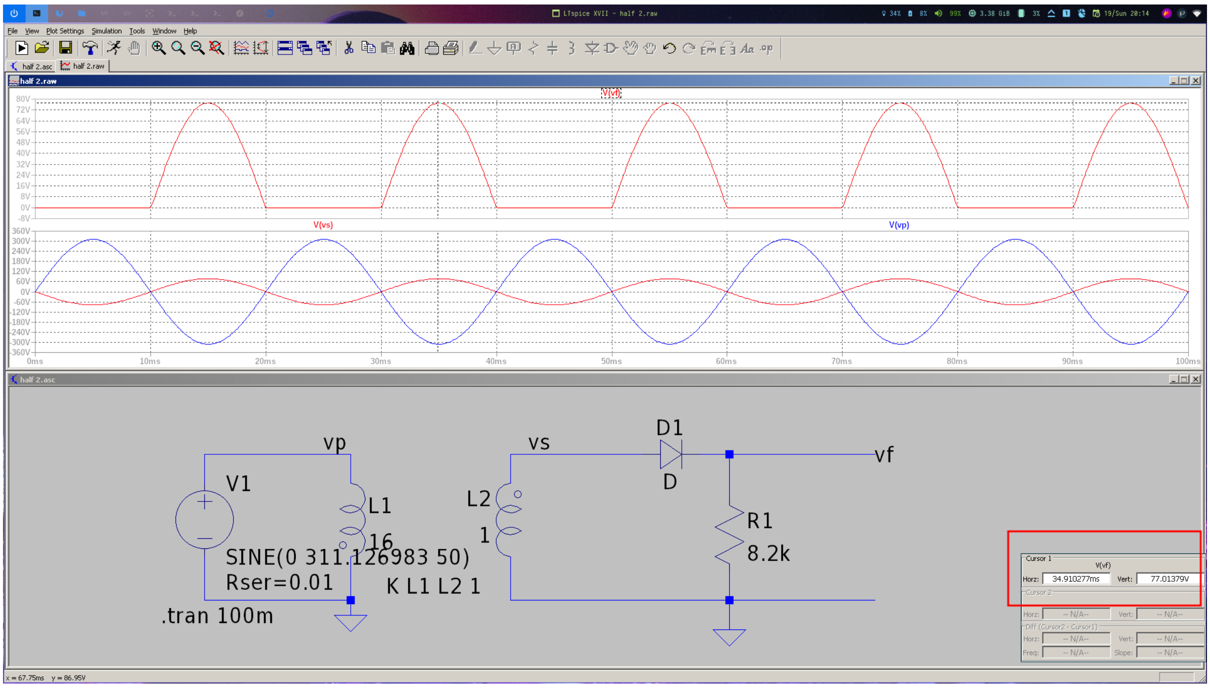


Ripple Factor Vr = $1/2\sqrt{3}fRC$ = 1 / (2 * 50 * 8200 * 100e-3 * $\sqrt{3}$)

= 7.04 * 10e-6.

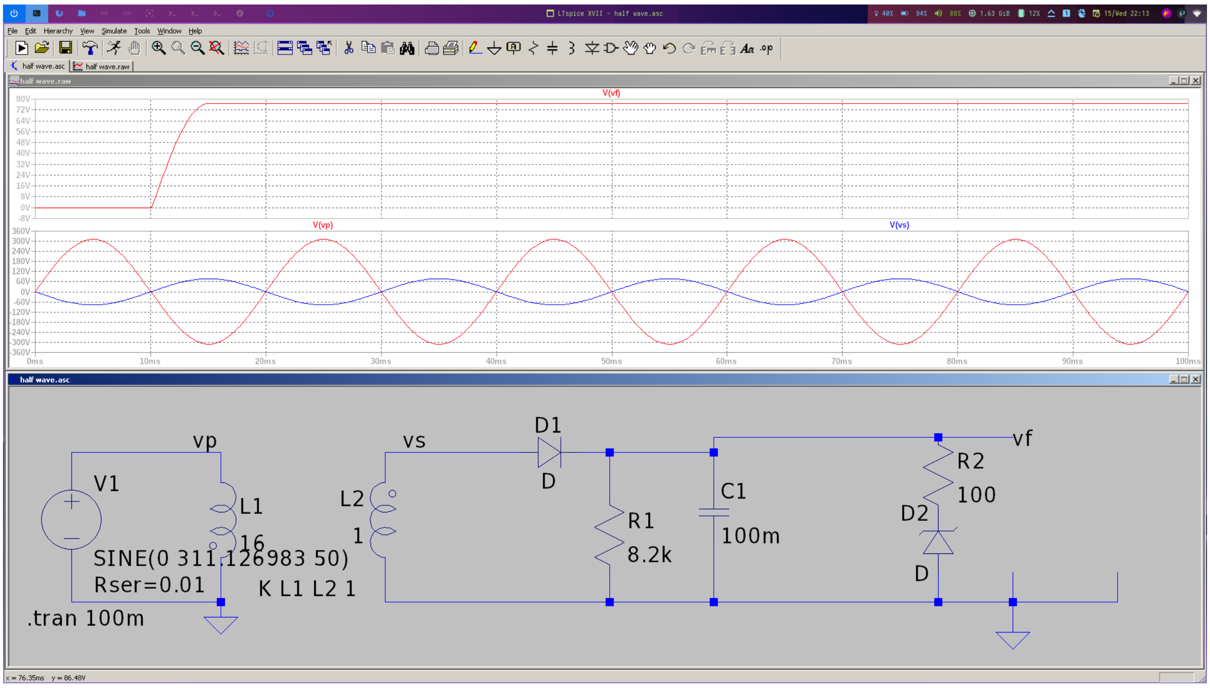
c)Voltage regulator included

1)No load is connected

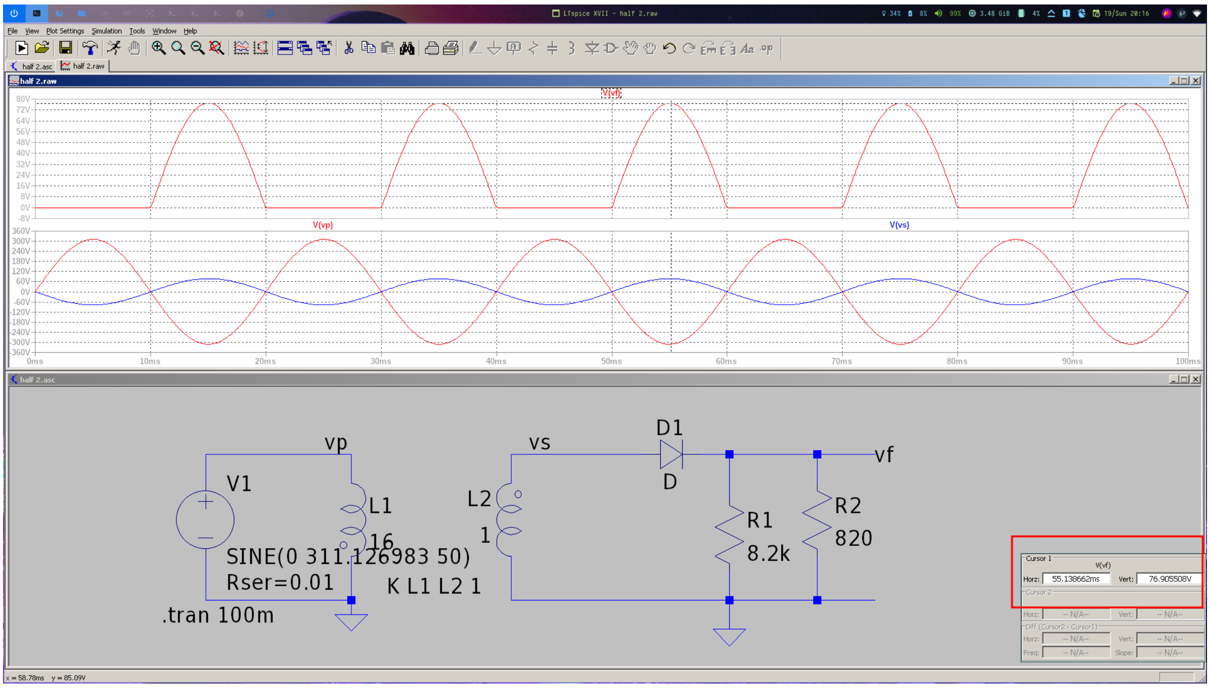


From Graph , VNL = 77.013V

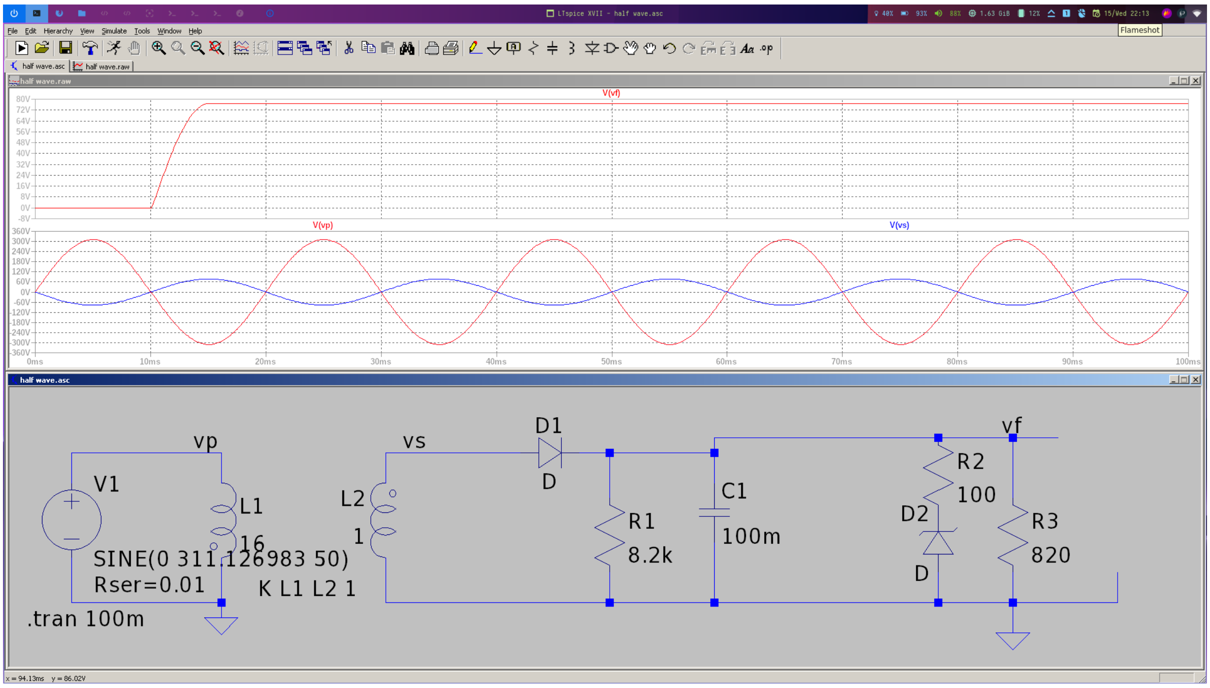
With Filter



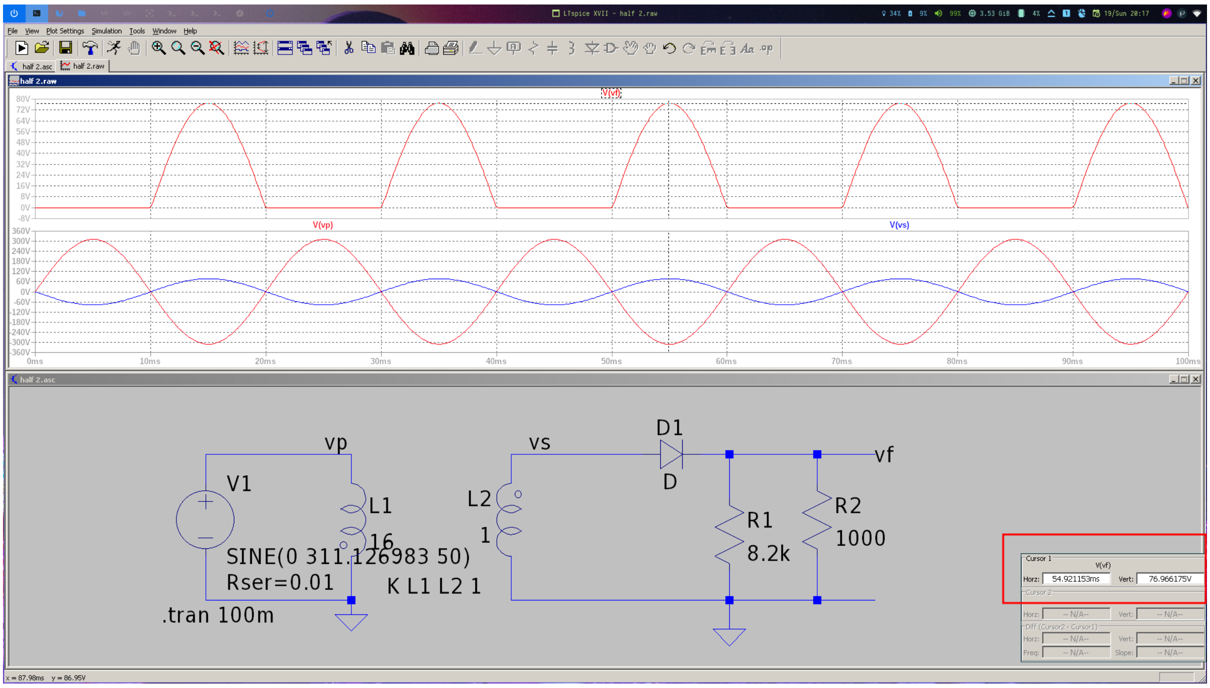
2)Load 1 is connected



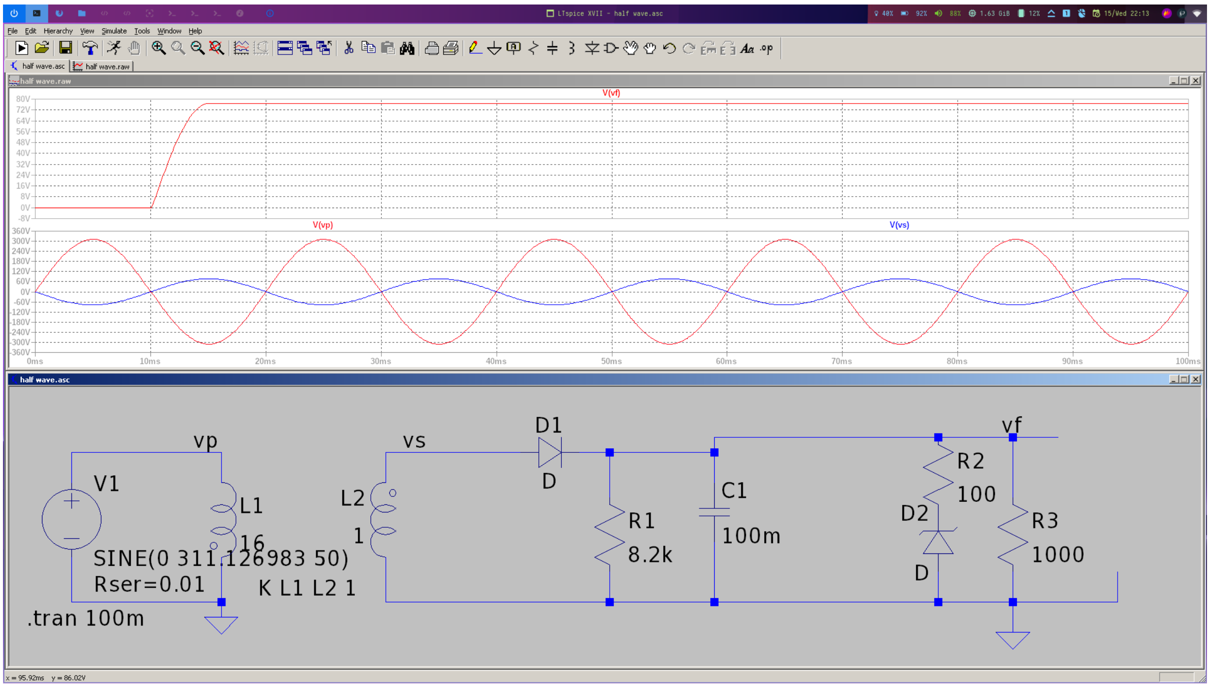
With Filter



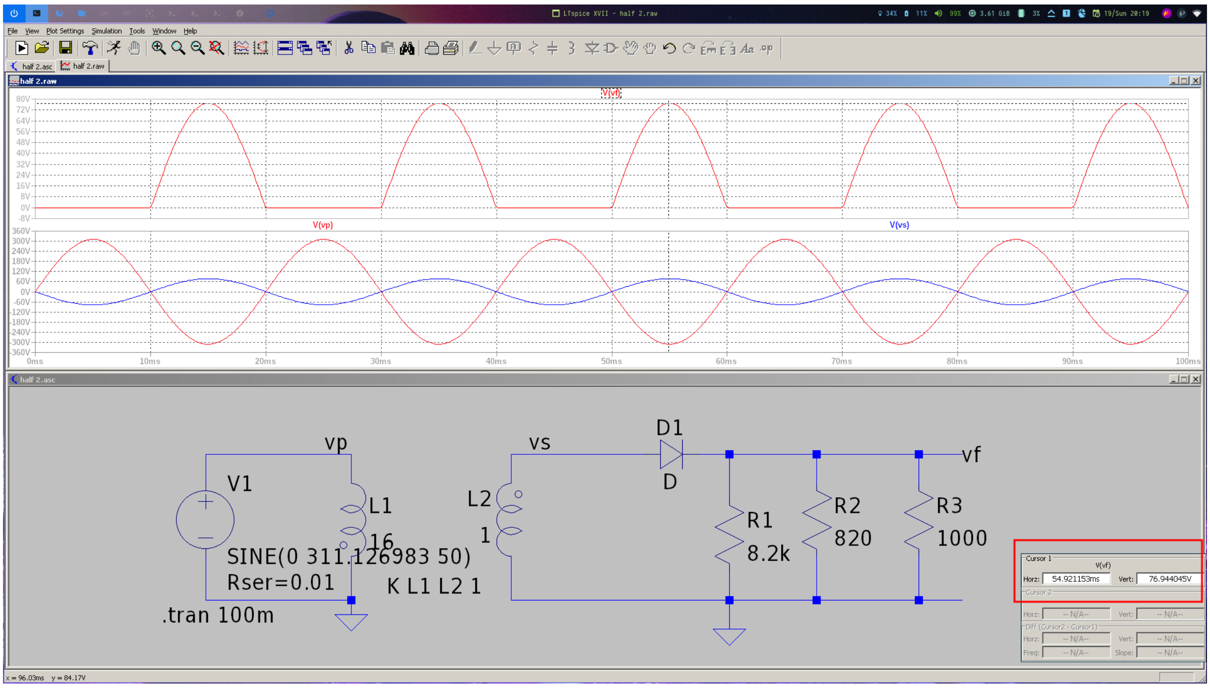
3)Load 2 is connected



With Filter



4)Load 1 + Load 2 are connected

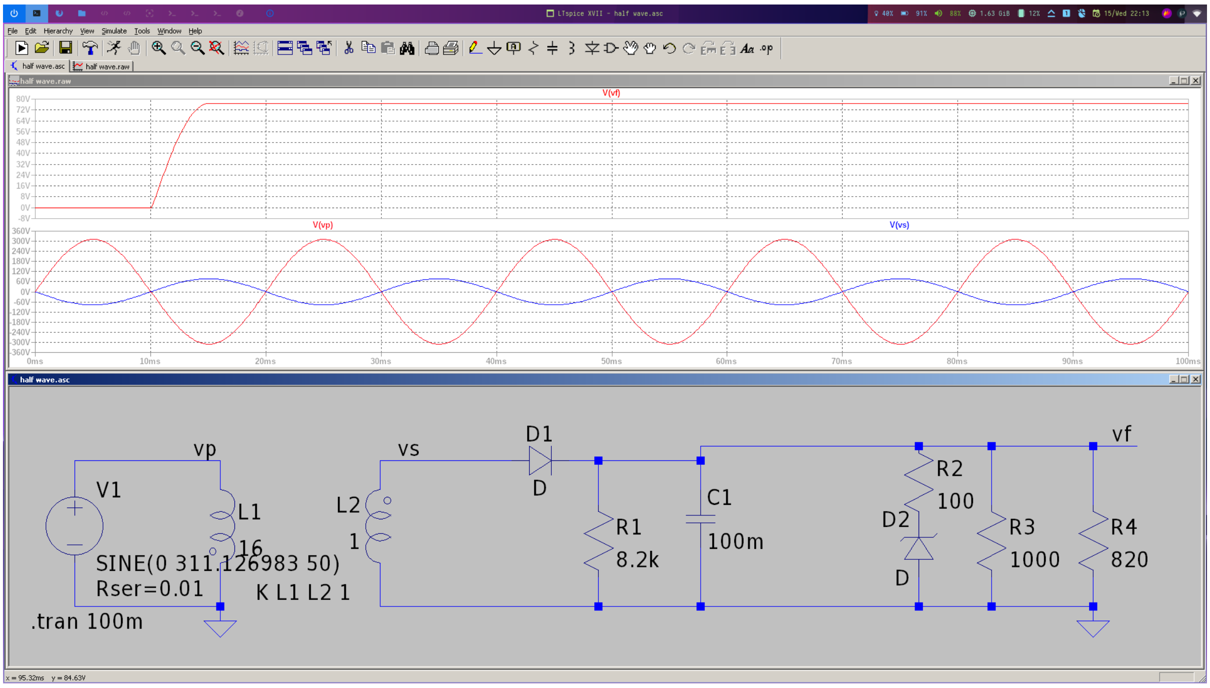


From the Graph , VFL = 76.944V.

Voltage Regulation V.R = (VNL - VFL)/VFL = (77.013 - 76.944)/76.944

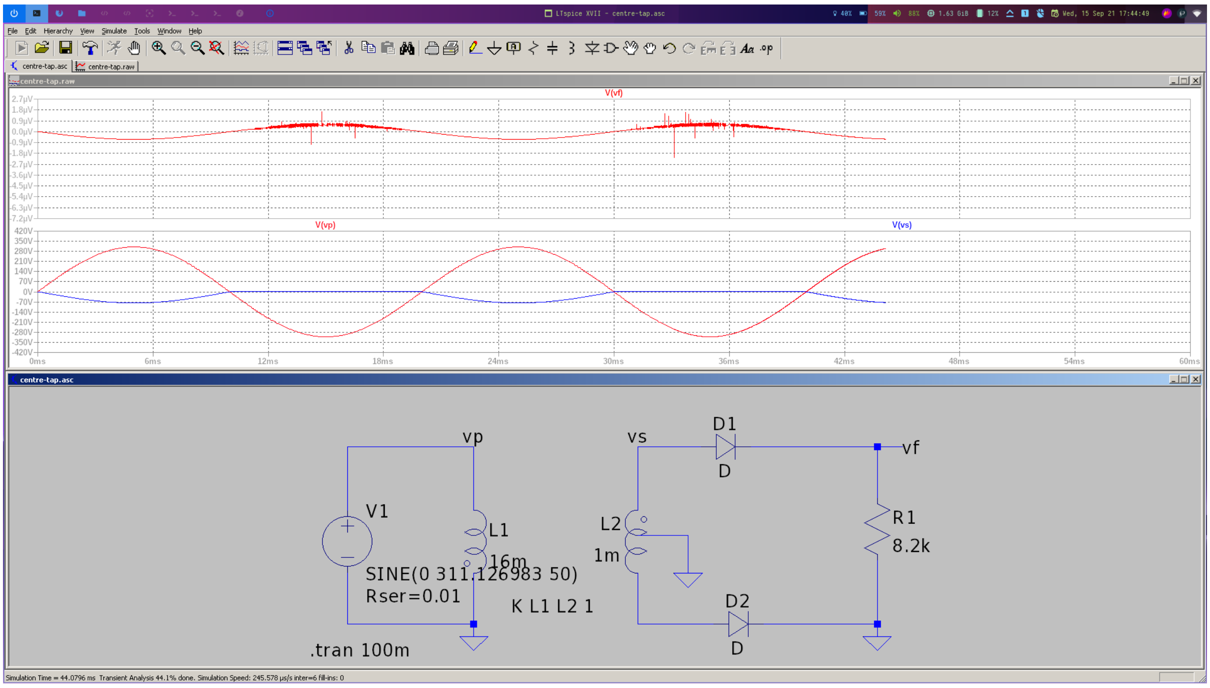
= 0.000896

With Filter



Full wave with center-tapped transformer -

a)pulsatile dc



From the graph, Vm = 311.126V.

Ripple Factor Vr = ((Irms/Idc)e2 - 1)e0.5 (Irms = Im/√2 , Idc = 2Im/π)

= ((π/2√2)e2 - 1)e0.5

= 0.48

b) Low pass filter included

c)Voltage regulator included

1)No load

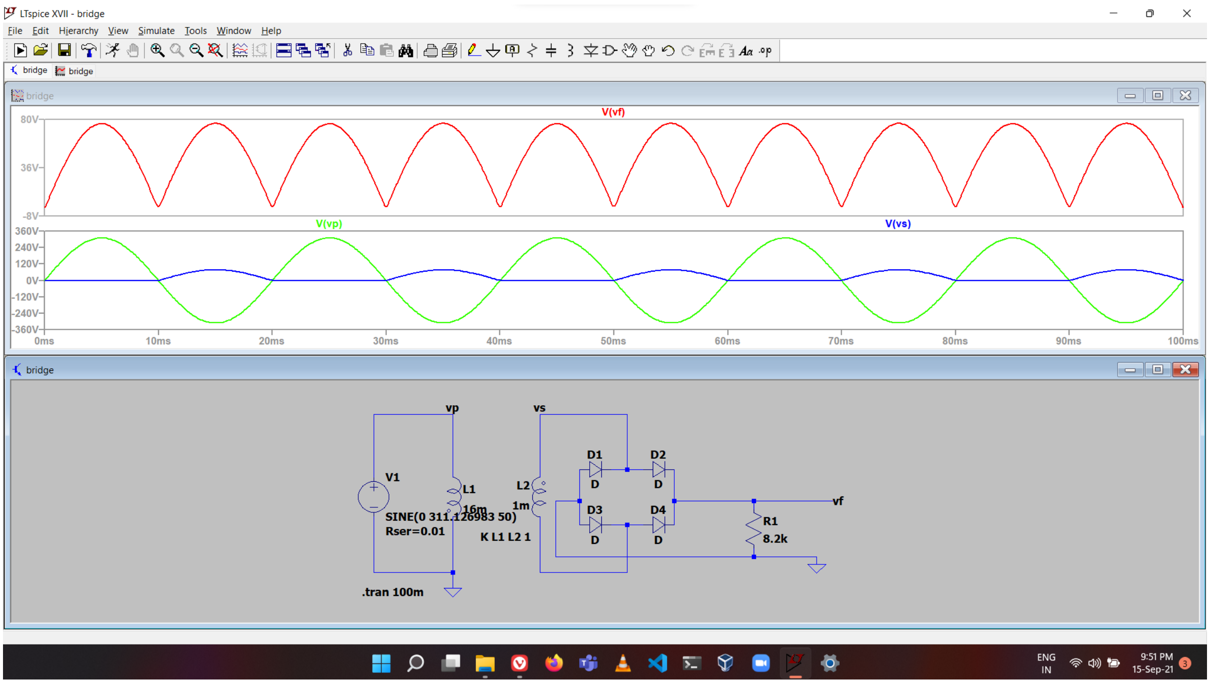
2)Load 1

3)Load 2

4)Load 1 + Load 2 are connected

Full wave Bridge rectifier -

a)pulsatile dc



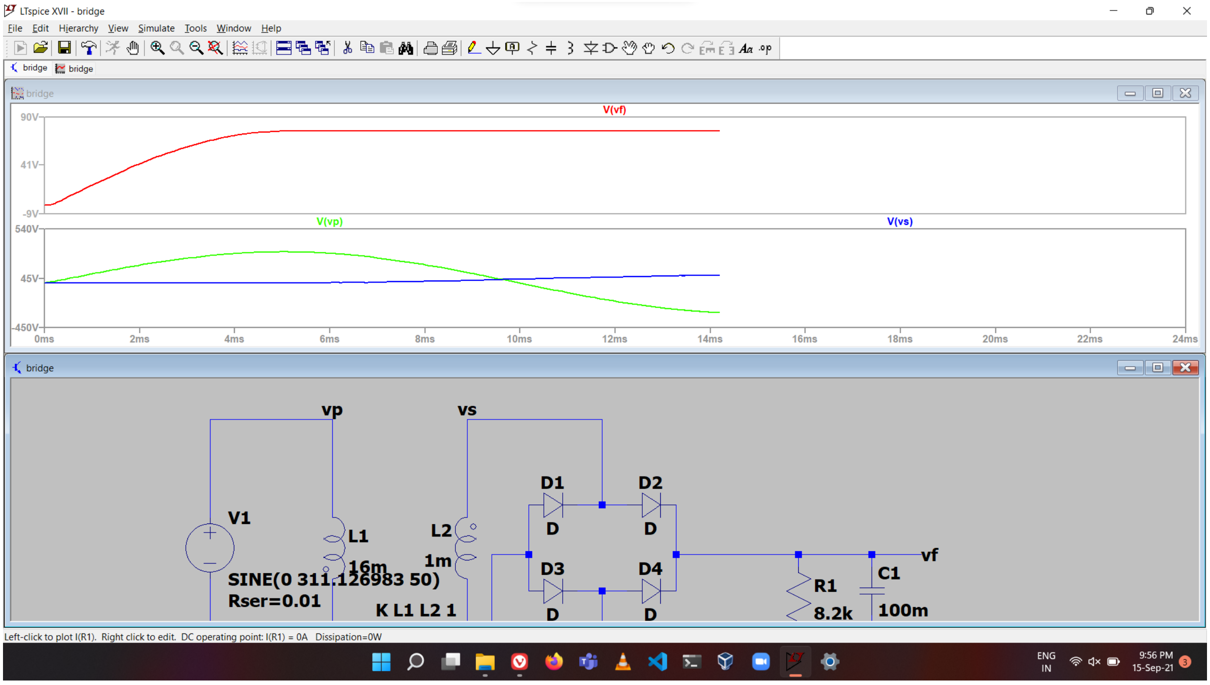
From the graph, Vm = 311.126V.

Ripple Factor Vr = ((Irms/Idc)e2 - 1)e0.5 (Irms = Im/√2 , Idc = 2Im/π)

= ((π/2√2)e2 - 1)e0.5

= 0.48

b) Low pass filter included

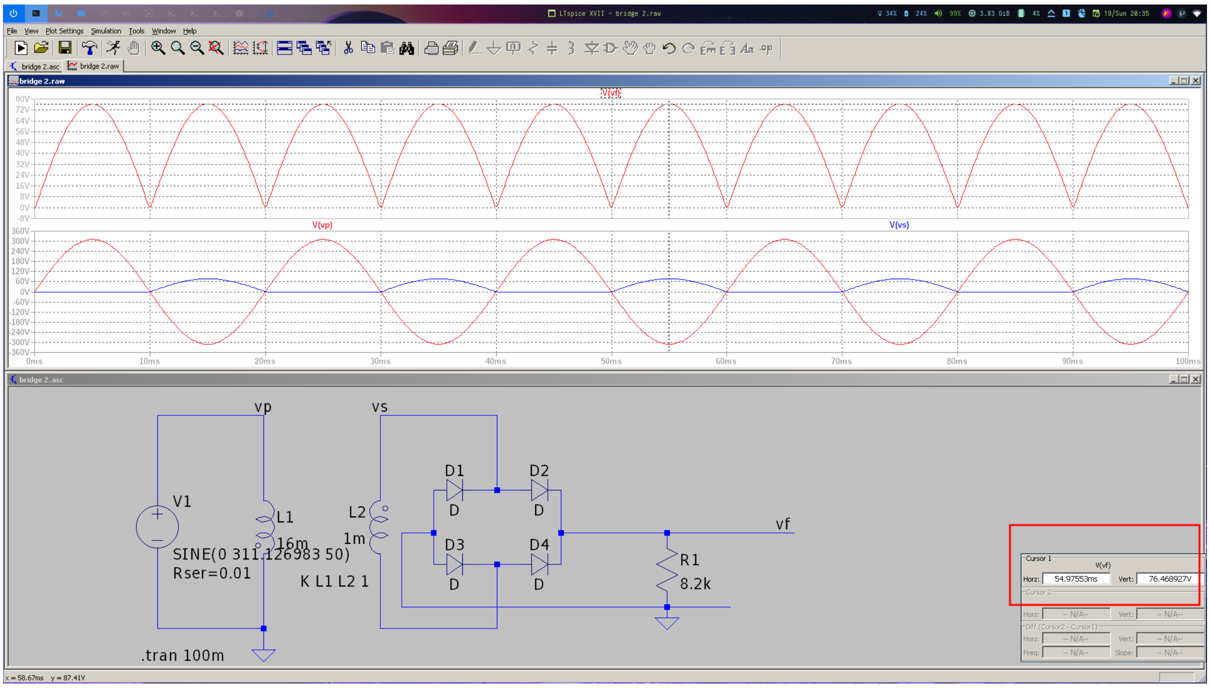


Ripple Factor Vr = 1/4√3fRC = 1 / (4 * 50 * 8200 * 100e-3 * √3)

= 3.52 * 10e-6.

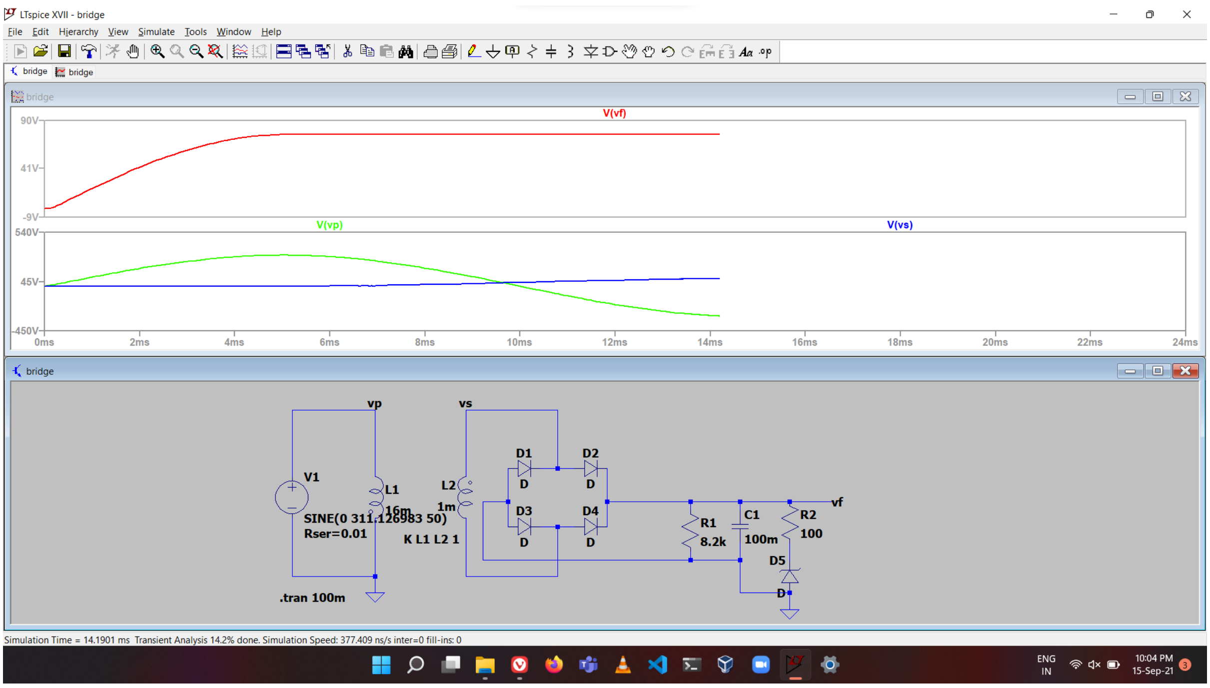
c)Voltage regulator included

1)No load

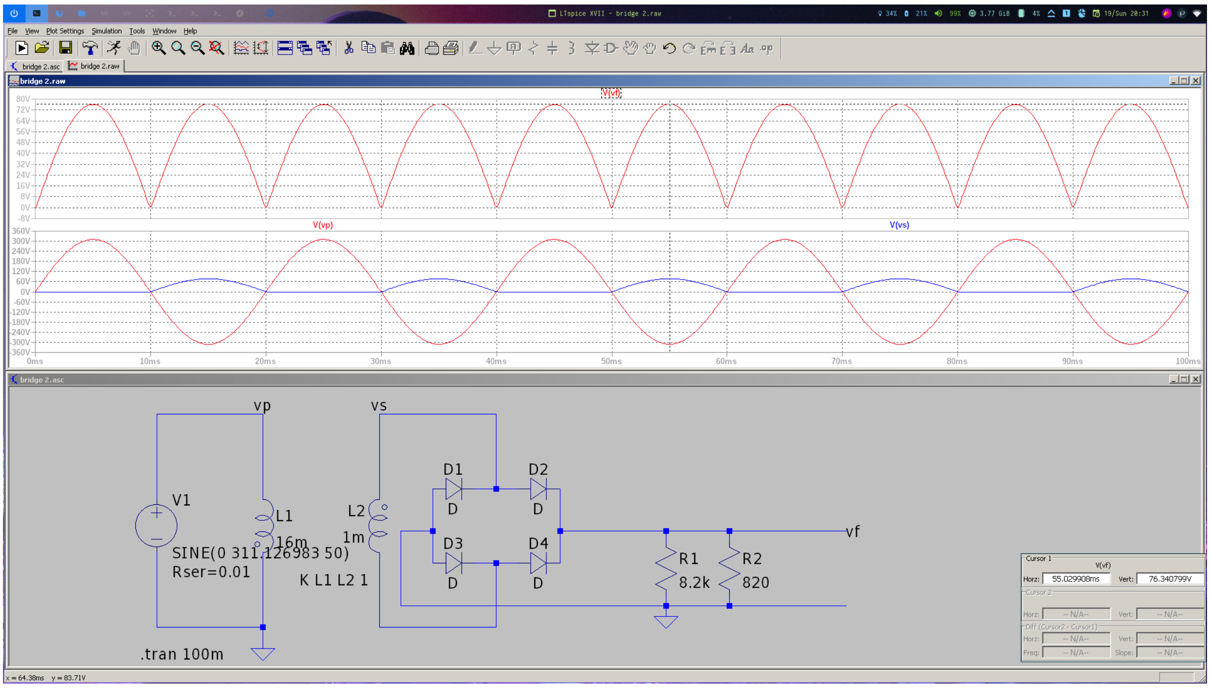


From the Graph , VNL = 76.468V.

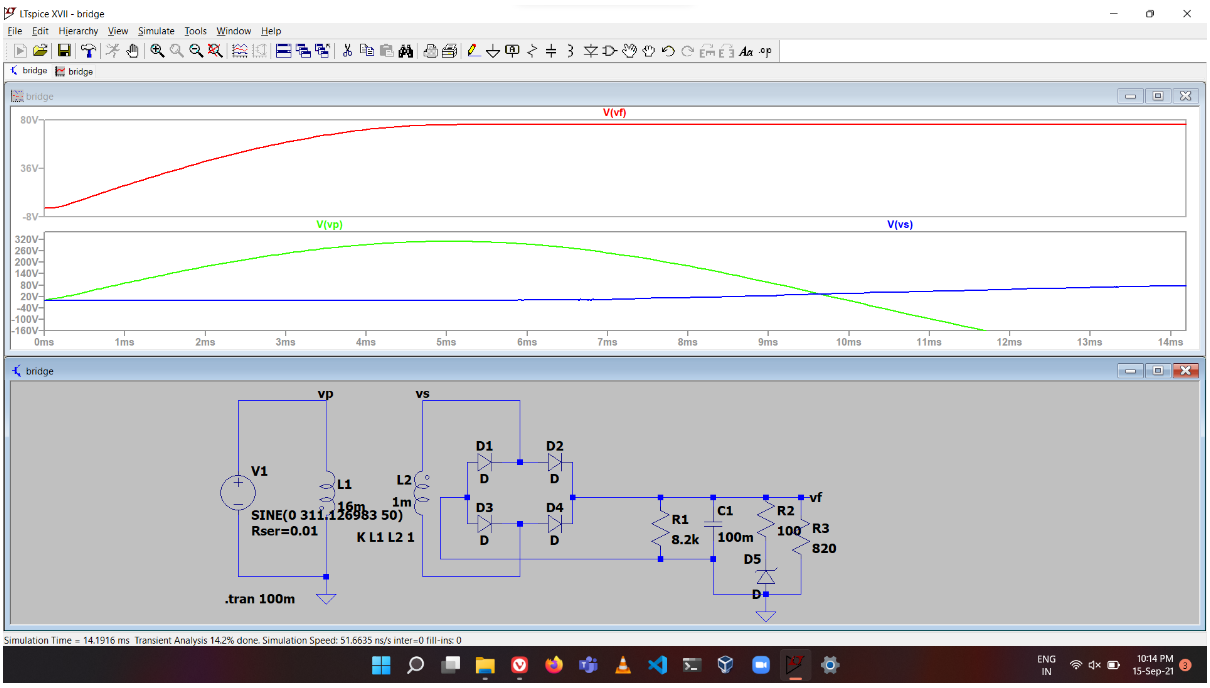
With FIlter



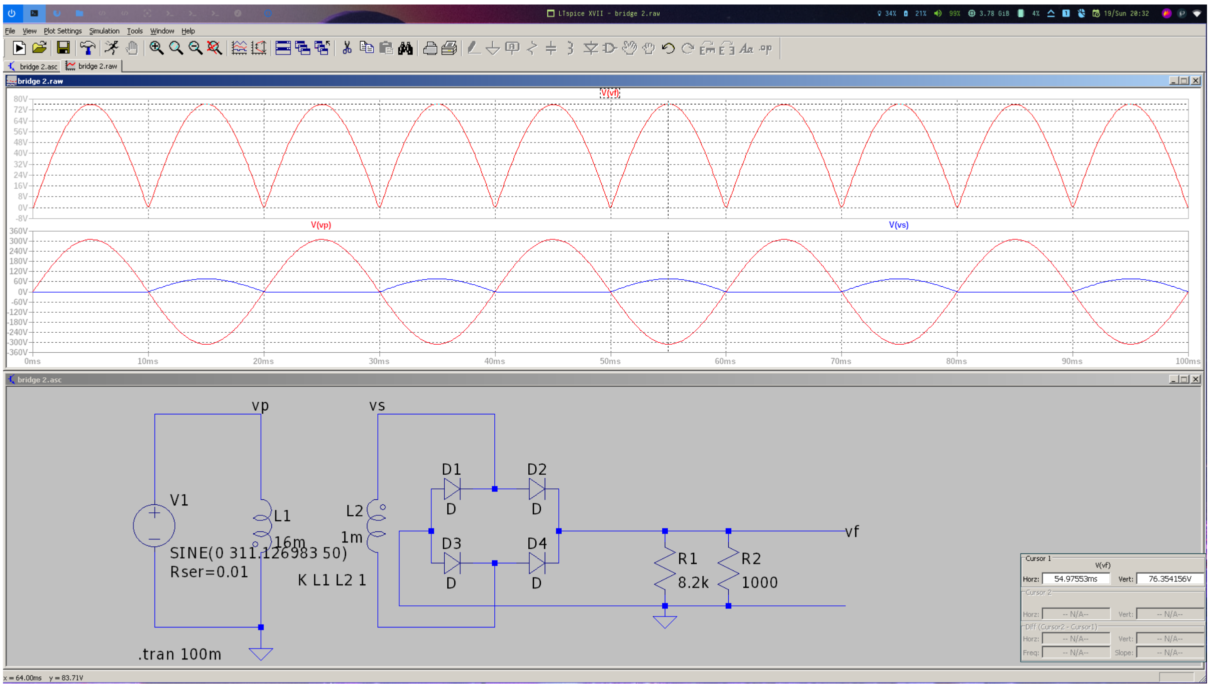
2)Load 1



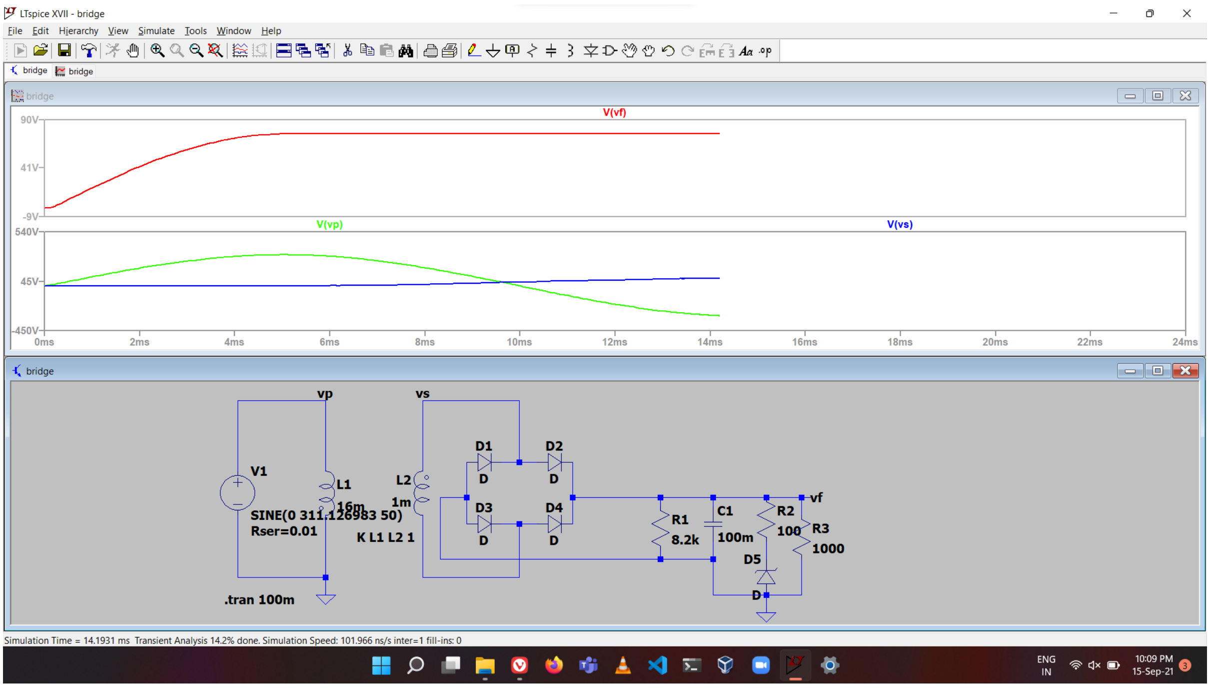
With Filter



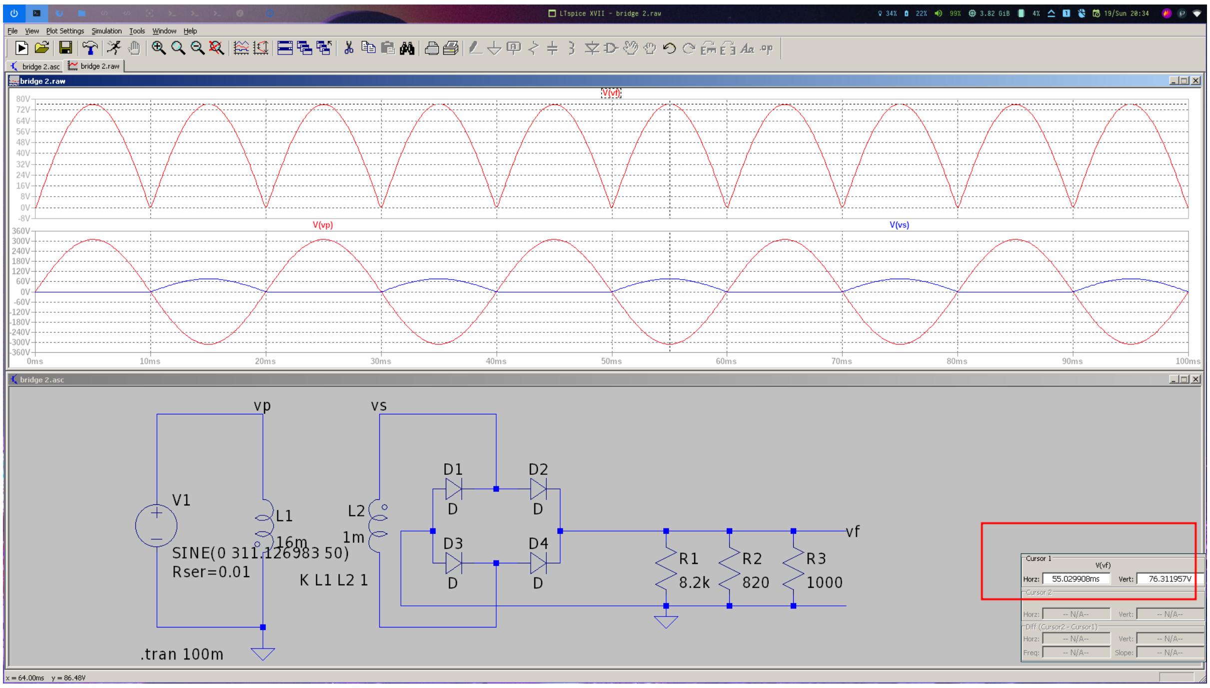
3)Load 2


V(vf)
V(vp)
V(vs)
vp
vs
V1
L1
16m
L2
1m
SINE(0 311.126983 50)
Rser=0.01
K L1 L2 1
D1
D2
D3
D4
R1
8.2k
R2
1000
vf
.tran 100m

With FIlter


LTspice XVII - bridge
V(vf)
V(vp)
V(vs)
vp
vs
V1
L1
16m
L2
1m
SINE(0 311.126983 50)
Rser=0.01
K L1 L2 1
D1
D2
D3
D4
R1
8.2k
C1
100m
R2
100
R3
1000
D5
vf
.tran 100m

4)Load 1 + Load 2 are connected

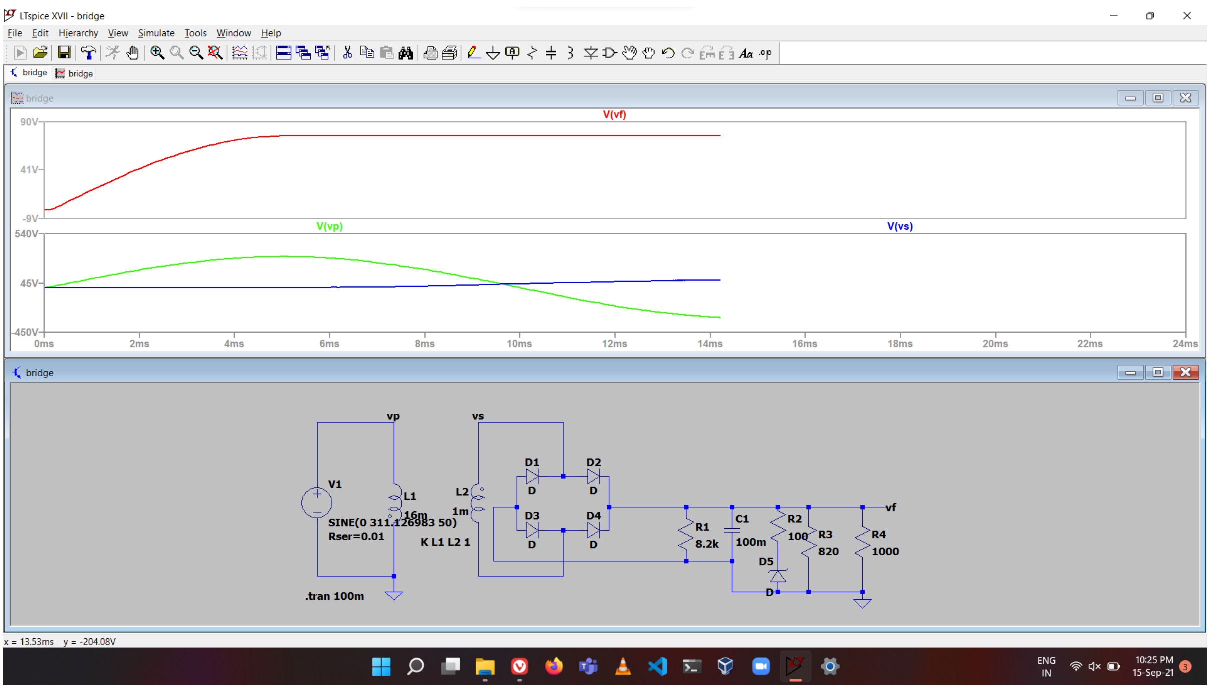


From the Graph , VFL = 76.311V.

Voltage Regulation V.R = (VNL - VFL)/VFL = (77.468 - 76.311)/76.311

= 0.0151

With Filter



7. Conclusion:

Half wave rectifier - In this case, the first half cycle of a sinusoidal waveform is positive, and the inclusion of a reverse-biased diode makes the current not flow to the negative side of the wave.

Full wave with center-tapped transformer - Same as Bridge Wave Rectifier . Both center tap and bridge have their own merits and demerits.

Full-wave Bridge rectifier - It is evident that the output is obtained for both the positive and negative half-cycles. It is also observed that the output across the load resistor is in the same direction for both the half cycles.

8. Discussions:

Half wave rectifier - Low cost.Easy to use and understand the circuit. They only allow a half cycle through per sinewave, and the other half cycle is wasted. This leads to power loss. They produce a low output voltage.

Full wave with center-tapped transformer - The ripple factor is much less than that of a half-wave rectifier. It is expensive to manufacture a center-tapped transformer that produces an equal voltage on each half of the secondary windings. The output voltage is half of the secondary voltage, as each diode utilizes only one-half of the transformer's secondary voltage.

Full wave Bridge rectifier - The need for a center-tapped transformer is eliminated. If stepping up or stepping down of AC voltage is not needed, it does not even require any transformer. The transformer is less costly as it is necessary to provide only half the voltage of an equivalent center-tapped transformer used in a full-wave rectifier. It requires four semiconducting diodes. Two diodes in series conduct at a time on alternate half-cycles. This creates a problem when low DC voltages are required. This leads to poor voltage regulation.