BERZIET UNIVERSITY

Faculty of Engineering and Technology
Electrical and Computer Engineering Department

ANALOG ELECTRONICS
ENEE2360
PSpice project part1

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Abstract:

The aim of this project is to know how to use Pspice software to design and simulate a full wave center tap rectifier with filter, zener diode and transformer to change the voltage from Ac to Dc. Then, the comparison between the resulting values from the calculation process and the resulting values from the curves to find out the error percentage.

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1. Procedure and Discussion:

To complete the design of the circuit shown in Figure NO.1, by using the given values in Table NO.1:

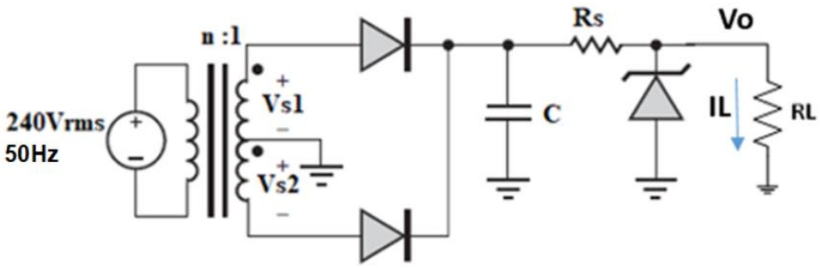

Figure NO.1: Circuit of Center Tapped Transformer Full-Wave Rectifier

Table NO.1 shows given values:

Load current	IL	0.14
Output voltage	Vo(avg)	20
Capacitor voltage	Vc(avg)	30
Pk-pk ripple at C	VLr,pp	4.8

Center tapped transformer: when an additional wire is connected across the exact middle of the secondary winding of a transformer, as shown in Figure NO.2:

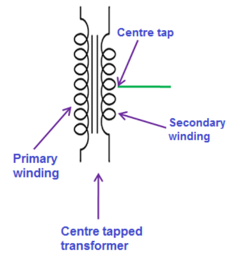

Figure NO.2: Center tapped transformer [1]

Center tapped full wave rectifier: is a type of rectifier which uses a center tapped transformer and two diodes to convert the complete AC signal into DC signal. It is made up of an AC source, a center tapped transformer, two diodes, and a load resistor, as shown in Figure NO.3:

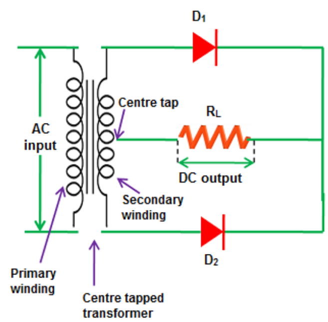

Figure NO.3: Center tapped full wave rectifier

The calculation before designing the circuit (from the given values):

- From Datasheet for 1N4728A-1N4764A Zener diodes [2]:
  $V_{ZT} = V_{o(avg)} = 20$ volt.
  $I_{Z(max)} = 45mA$.
  $I_{ZT} = 12.5mA$.
- By Ohm's Law: $V_{o(avg)} = R_L.I_L$, then $R_L = V_{o(avg)}/ I_L = 20/0.14 = 142.857 \cong 143$ volt.
- In steady state: $V_{mc} = V_{c(avg)} + (0.5*V_{Lrp,p}) = 30 + (0.5*4.8) = 32.4$ volt.
- Simplified/Knee/Practical model: Diode ON replaced by 0.7 volt battery:
  By KVL1: $V_{ms1} = V_{mc} + 0.7 = 32.4 + 0.7 = 33.1$ volt.
  By KVL2: $V_{ms2} = V_{mc} - 0.7 = 32.4 - 0.7 = 31.7$ volt.
- $V_{mp} = V_{rms}.\sqrt{2} = 240*\sqrt{2} = 339.4$ volt.
- By KCL: $I_s = I_L + I_{z(max)} = 0.14 + 45mA = 0.185$ A = 185 mA.
- To find C:
  $\Delta V = V_{Lrp,p} = V_{mc}/(2.f_o.R.C) = I_s/(2.f_o.C) \rightarrow 4.8 = 0.185/(2*50*C)$
  Then $C = 3.85416 * 10^{-4} = 385.4$ uF.
- $Rs = [V_{mc} - V_{o(avg)}]/I_s = (32.4 - 20)/0.185 = 67.027 = 67$ ohm.
- In linear/ideal transformer: $\frac{N1}{N2} = \frac{Vmp}{Vms1} = \sqrt{\frac{L1}{L2}} = \frac{n}{1} = \frac{339.4}{33.1} = 10.25377644 \cong 10.25$
  Assume L2 = 1mH, then L1 = 105.1399312 mH ≅ 105.14 mH. And coupling = 1 "always in simulation".
- In linear/ideal transformer: $\frac{N1}{N2} = \frac{Vmp}{Vms2} = \sqrt{\frac{L1}{L2}} = \frac{n}{1} = \frac{339.4}{31.7} = 10.70662 \cong 10.71$
  Assume L2 = 1mH, then L1 = 114.63181 mH ≅ 114.63 mH. And coupling = 1 "always in simulation".

The Circuit of Full wave Center Tab rectifier in Pspice:

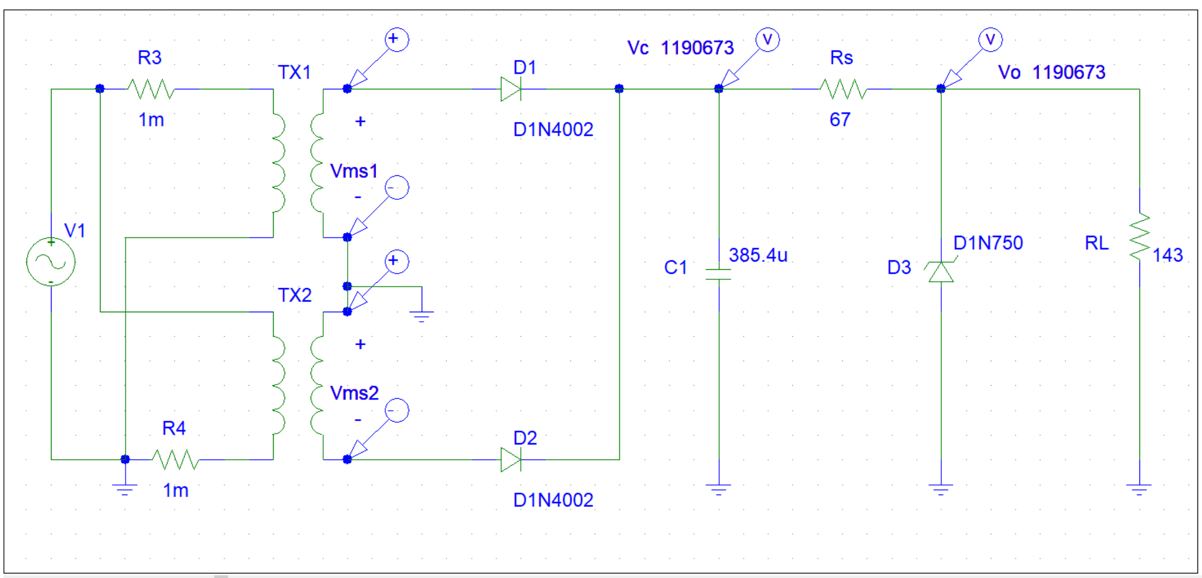

Figure NO.4: Circuit of Center Tapped Transformer Full-Wave Rectifier in Pspice

Plot Vo(t) from circuit Simulation: Vo curve in yellow, Vo = 20.006 volt from the simulation and Vo = 20 volt from given.

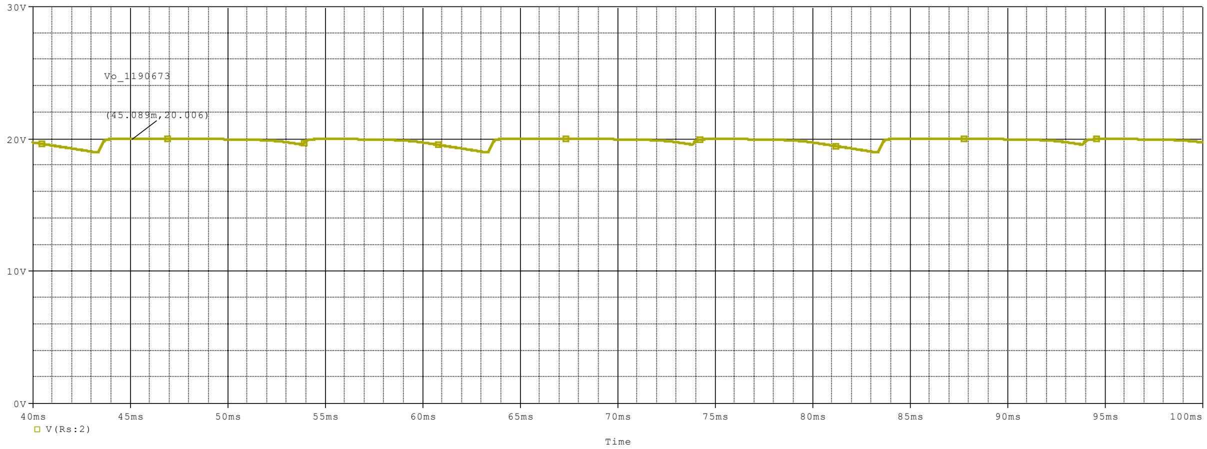

Figure NO.5: Vo(t) from circuit Simulation in Pspice

Plot Vc(t) from circuit Simulation: Vc curve in pink, Vc(max)=32.239 volt and Vc(min)=27.83 volt, then $\Delta V = V_{Lrp,p} = V_{c(max)} - V_{c(min)} = 32.239 - 27.83 = 4.409$ volt from the simulation and $\Delta V = V_{Lrp,p} = 4.8$ volt from given.

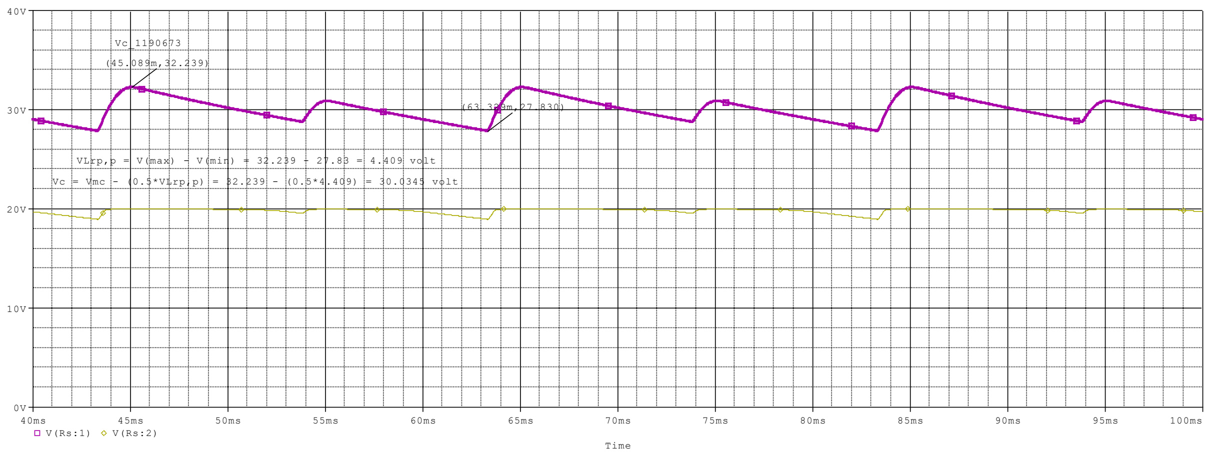

Figure NO.6: Vc(t) from circuit Simulation in Pspice

Plot Vms1(t) from circuit Simulation: Vms1 curve in green, Vms1 = 33.099 volt from the simulation and Vms1 = 33.1 volt from the calculation.

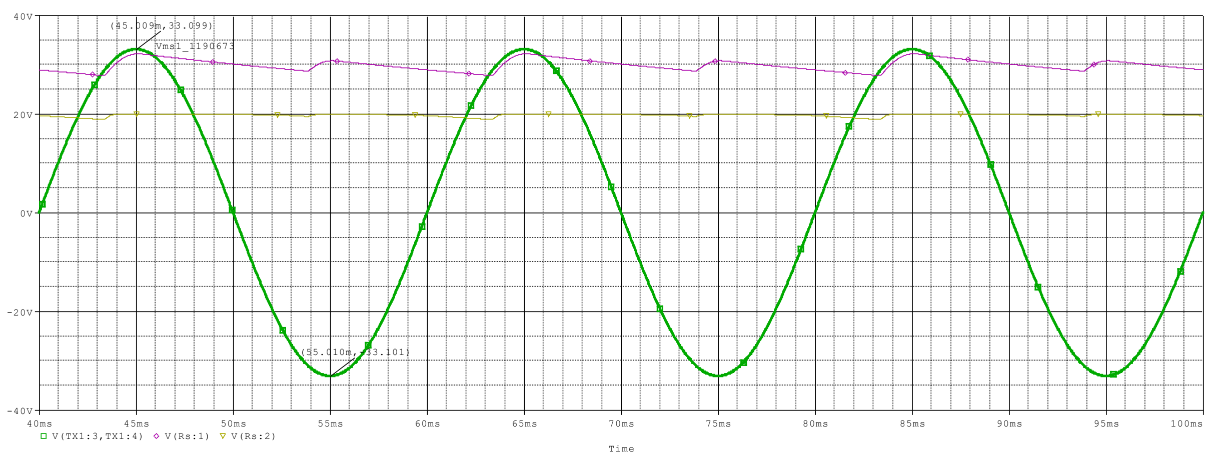

Figure NO.7: Vms1(t) from circuit Simulation in Pspice

Plot Vms2(t) from circuit Simulation: Vms2 curve in blue, Vms2 = 31.699 volt from the simulation and Vms2 = 31.7 volt from the calculation.

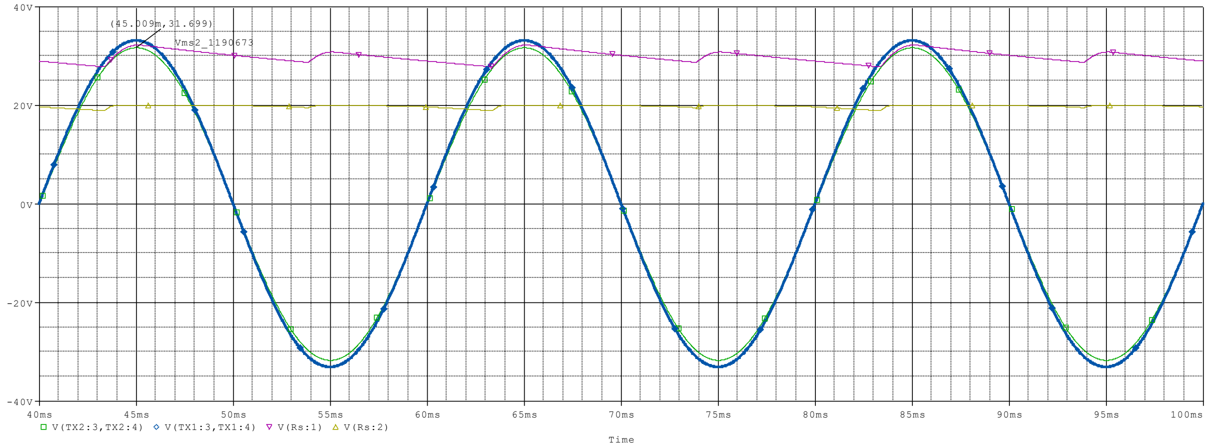

Figure NO.6: Vms2(t) from circuit Simulation in Pspice

The calculation after designing the circuit (from the curve):

- From first curve: Vo = 20.006 volt.
- From second curve: V(max) = 20.32.239 volt and V(min) = 27.83, then $\Delta V = V_{Lrp,p} = V_{c(max)} - V_{c(min)}$ = 32.239 – 27.830 = 4.409 volt.
- From third curve: Vms1 = 33.099 volt.
- From fourth curve: Vms2 = 31.699 volt.
- $V_{mc} = V_{(max)} = V_c + (0.5*V_{Lrp,p})$, then $V_c = V_{mc} - (0.5*V_{Lrp,p})$ = 32.239 – (0.5*4.409) = 30.0345 volt ≅ 30 volt.

2. Conclusion:

Comparison of the results between simulated values of Vo(t), Vc(t), and the ripple voltage to hand calculations, as shown in Table NO.1:

Name of voltage	simulated values	Hand calculations values
Vo(t)	20.006 volt	20 volt
Vc(t)	30.0345 volt	30 volt
Ripple voltage V_{Lrpp}	4.409 volt	4.8 volt
Vms1(t)	33.099 volt	33.1 volt
Vms2(t)	31.699 volt	31.7 volt

From the previous table, it was found that the values of Vo(t), Vc(t), Vms1(t) and Vms2(t) were very similar, while the value of the ripple voltage differed by a very small amount. It could be that the value of C was not calculated correctly 100% because we considered that the current passing through the zener diode = Iz(max), then the value of Vc was not accurate 100%.

Error percentage in Full wave Center Tab rectifier:

Error percentage = [Vc (simulation) – Vc (given)] / Vc (given) * 100 % = (30.0345 – 30) / 30 * 100 % = 0.115 very small percentage, so it's accepted.

3. References:

1. " Full wave rectifier," 24 NOV 2021. [Online]. Available: https://www.physics-and-radio-electronics.com/electronic-devices-and-circuits/rectifier/fullwaverectifier.html.
2. "1N4747A Datasheet," 22 NOV 2021. [Online]. Available: https://pdf1.alldatasheet.com/datasheet-pdf/view/972142/ZSELEC/1N4747A.html.
3. "lecture notes," 20 NOV 2021. [Online]. Available: https://drive.google.com/drive/folders/1BMOtKtk_tsWvnqLaALTTrSv28DYf2cHz.