- ## **Abstract:**

The aim of this assignment is to simulate a chopper circuit supplying a highly inductive and a purely resistive load with an IGBT as a switch. Using PSpice to show the turn-on and turn-off transitions for the voltage, current and power loss in the IGBT. And by calculations the conduction and the switching power losses will be obtained.

- ## **Theory:**

A chopper is basically a dc to dc converter whose main function/usage is to create adjustable dc voltage from fixed dc voltage sources through the use of semiconductors. In other words, a chopper is a high speed switch which connects and disconnects the load from source at a high rate to get variable or chopped voltage at the output.

The Insulated Gate Bipolar Transistor (IGBT), is a power semiconductor device basically used as a switch, IGBT combines between a Bipolar Junction Transistor (BJT), and a Field Effect Transistor (MOSFET), and it has a simple gate-drive characteristics as MOSFETs with a high-current and low-saturation-voltage capability as BJT. To sum up, an IGBT combines an isolated-gate FET for the control input and a bipolar power transistor as a switch in a single device.

-The average switching power loss in the switch with highly inductive load is:

$Ps= 0.5*fs*Vd*Io*(tc(on) + tc(off))$

-Total average switching power loss with resistive load is:

$Ps= 1/6 *fs*Vd*Io*(tc(on) + tc(off))$

-The average power loss dissipation during conduction is:

$Pon= Von*Io*ton*fs$

- ## Calculations and Simulations:

First part (Highly Inductive Load):

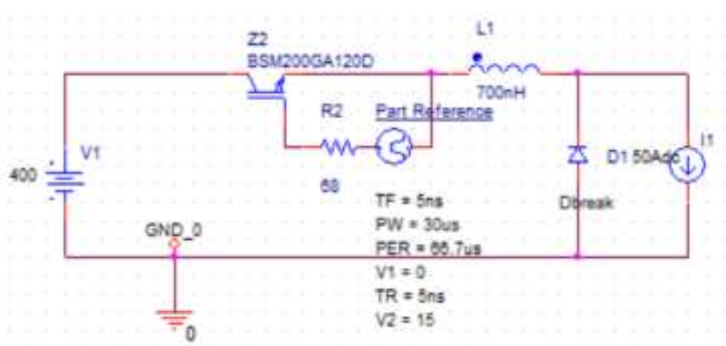
A chopper circuit supplying a highly inductive load and having an **IGBT** as a switch, has the following parameters: I_o=25A, V_d=400V, f_s=15kHz, L_s=700nH and t_{on}=30us. Assume linear voltage and current falls and rises during switching:

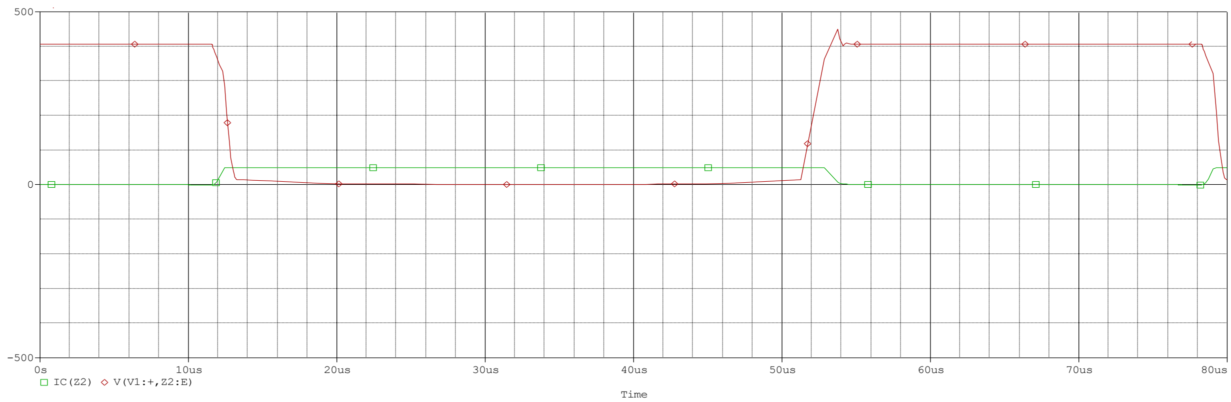
I. Calculate The conduction and the switching power losses if $t_{c(on)}$ =400ns, $t_{c(off)}$=600ns, assuming that V_{on}=2.5V using the appropriate derived formulas.

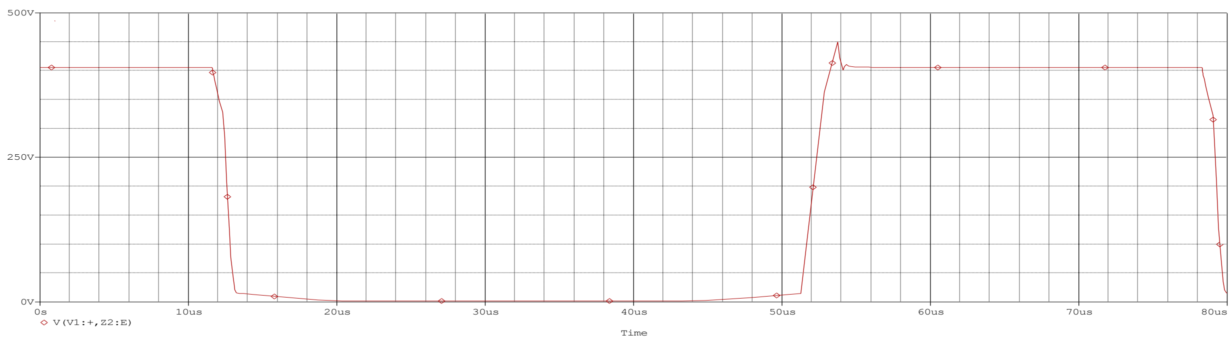
$P_{switching} = (½)*f_s *V_d *I_o *(t_{c,on} + t_{c,off})$
= (½)*(15k)*(400)*(25)*(1000n)
= 75 Watt
$P_{on,conduction} = f_s *V_{on} *I_o *t_{on}$
$= (15k)*(2.5)*(25)*(30*10^{-6})$
= 28.125 Watt

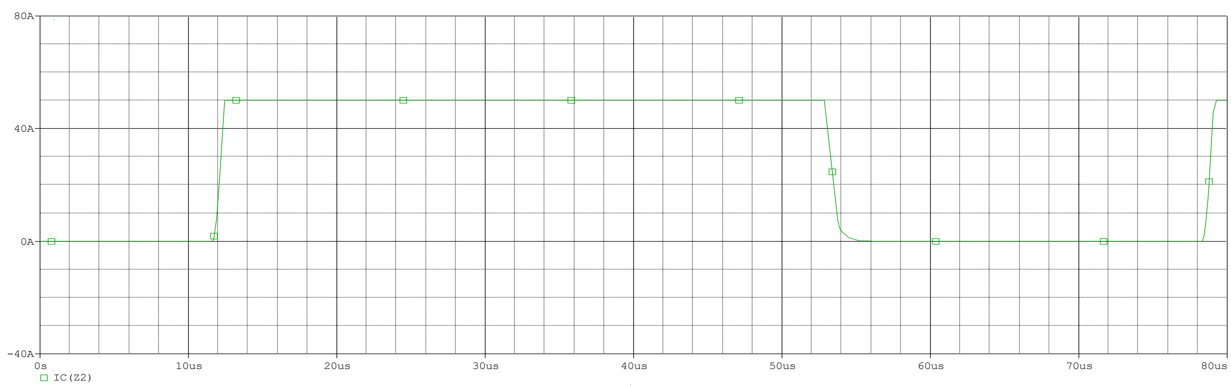
III. The total average power losses in the IGBT:
$P_{Total} = P_{switching} + P_{on,conduction} =$ 103.125 Watt

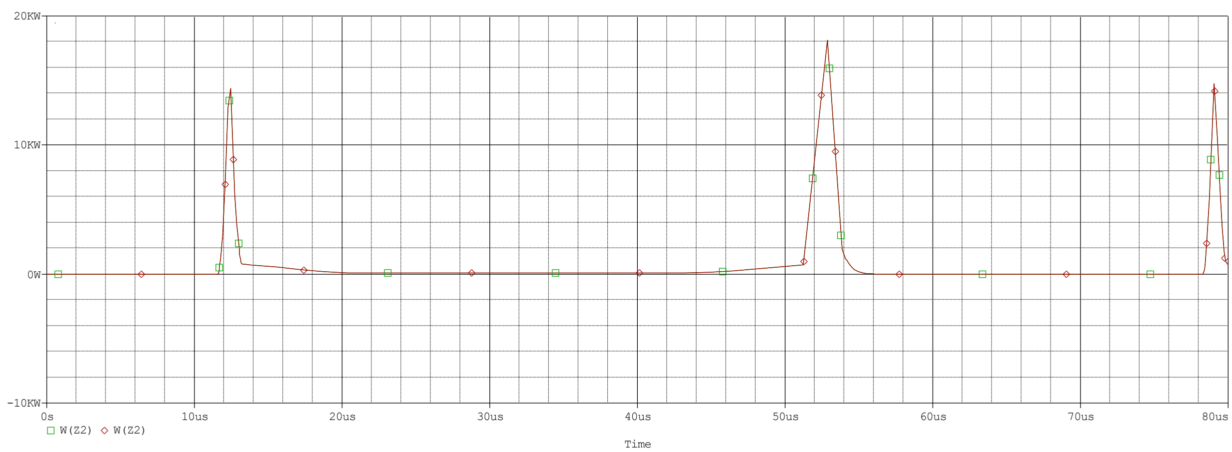
II. In ORCAD/PSPICE, simulate a chopper circuit implementing an IGBT (BSM150GB50D) as a switch to supply a highly inductive load which has the following parameters: Io=25A, Vd=400V, fs=15kHz, Ls=700nH and ton=30us. In the results, show the turn-on and turn-off transitions (magnified) for the voltage, current and power losses in the IGBT.




500
0
−500
0s
10us
20us
30us
40us
50us
60us
70us
80us
IC(Z2) V(V1:+,Z2:E)
Time


500V
250V
0V
0s
10us
20us
30us
40us
50us
60us
70us
80us
V(V1:+,Z2:E)
Time


80A
40A
0A
−40A
0s
10us
20us
30us
40us
50us
60us
70us
80us
IC(Z2)
Time


20KW
10KW
0W
−10KW
0s
10us
20us
30us
40us
50us
60us
70us
80us
W(Z2) W(Z2)
Time

Second Part (Resistive Load):

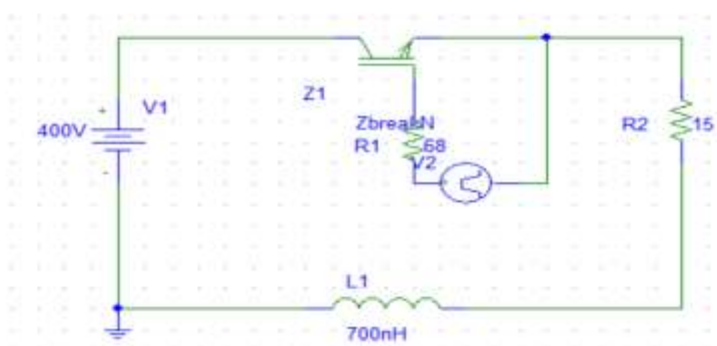
If the chopper circuit is now supplying a purely resistive load of 15 Ohms (no parallel diode) and implementing the IGBT model. Assume linear voltage and current falls and rises during switching to:

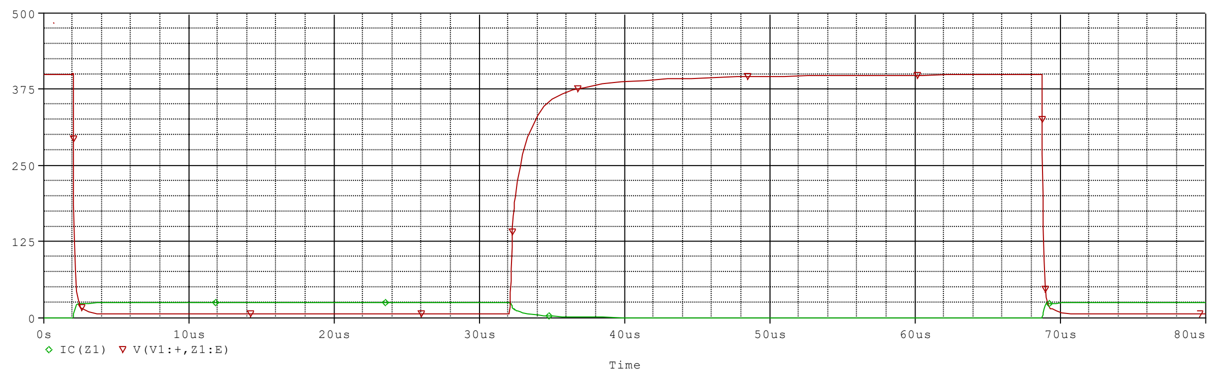
a) Calculate the conduction and the switching power losses if Vd=400V, fs=15kHz, ton=30us, tc(on) =400ns, tc(off)=600ns, Ls=700nH and Von=2.5V using the appropriate derived formulas.

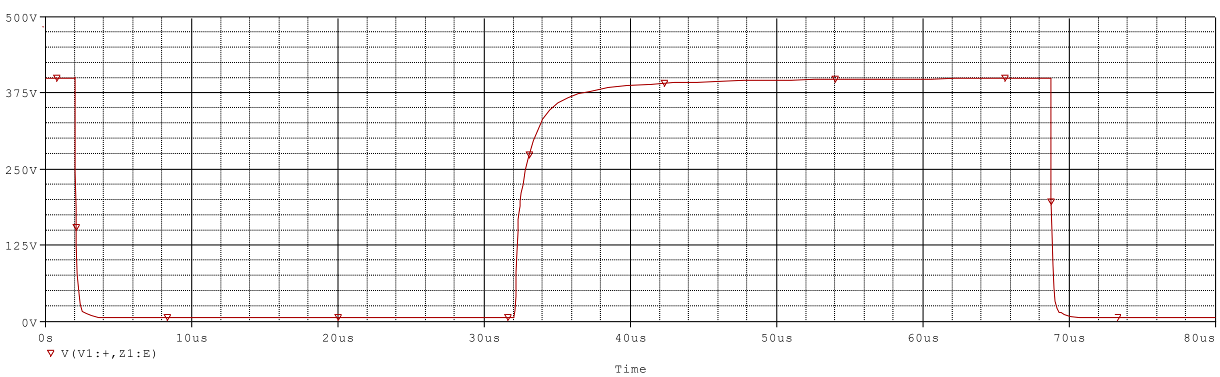
$P_{switching} = (1/6)*f_s*V_d*I_o*(t_{c,on} + t_{c,off})$
$= (1/6)*(15k)*(400)*(25)*(1000n)$
$= 25$ Watt
$P_{on,conduction} = f_s*V_{on}*I_o*t_{on}$
$= (15k)*(2.5)*(25)*(30n)$
$= 28.125$ Watt

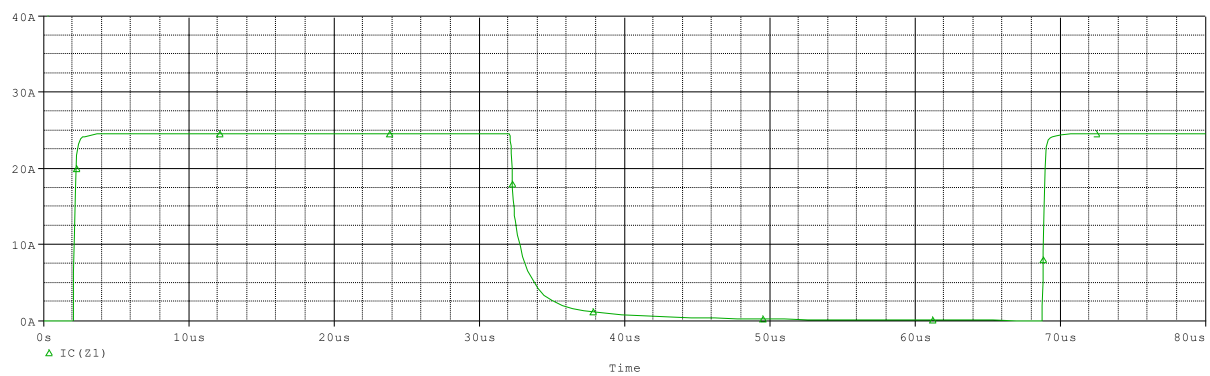
c) calculate the average power losses in the IGBT
$P_{Total} = P_{switching} + P_{on,conduction} = 53.125$ Watt

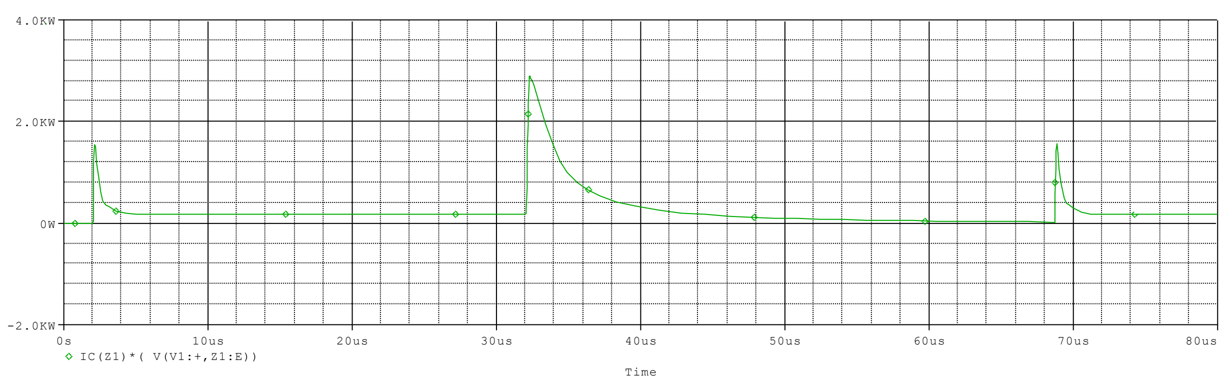
b) simulate the circuit in 2) using ORCAD/PSPICE and plot the magnified turn-on and turn off transitions of the voltage, current and power loss in the IGBT.




500
375
250
125
0
0s
10us
20us
30us
40us
50us
60us
70us
80us
IC(Z1) V(V1:+,Z1:E)
Time


500V
375V
250V
125V
0V
0s
10us
20us
30us
40us
50us
60us
70us
80us
V(V1:+,Z1:E)
Time


40A
30A
20A
10A
0A
0s
10us
20us
30us
40us
50us
60us
70us
80us
IC(Z1)
Time


4.0KW
2.0KW
0W
-2.0KW
0s
10us
20us
30us
40us
50us
60us
70us
80us
IC(Z1)*(V(V1:+,Z1:E))
Time

- **Conclusion:**

The results obtained from the simulations and calculations show that the power loss in case of a purely resistive load is less than the power loss in case of an inductive load.

By the end of this assignment, a full understanding of chopper circuits was achieved.