جامعة بيرزيت
BIRZEIT UNIVERSITY

Electrical and Computer Engineering Department

Power Electronics ENEE 3305

An Assignment on Power Devices Switching

Fall 2017

Student's name: Anas Abdelhalim Tomaizeh

Student's number: 1152325

Assign. #1

Power device switching

Dr. M. Adu-Khaizaran

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Abstract:

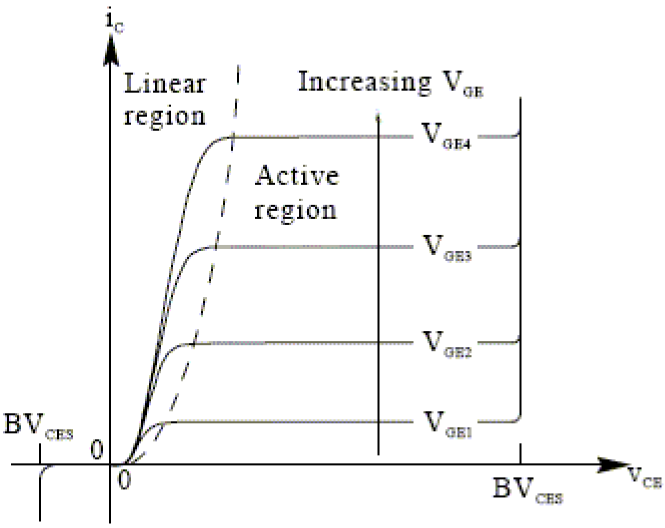
The aim of this assignment is to implemented ***IGBT*** in a chopper circuit, and to simulate it using ***ORCAD*** to graph the voltage, current and power charastaristics.

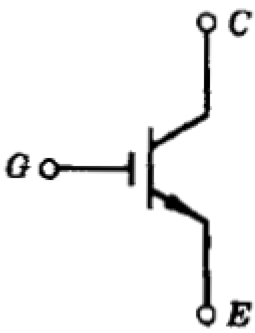
Theory:

- ## Insulated Gate Gipolar Transistor (IGBTs):
  - **The circuit sympol of IGBT is shown in the Fig. 1-a bellow, and i-v charastaristic is shown in the Fig. 1-b bellow.**

Fig. 1-a:

Fig. 1-b





- **Some advanteges of IGBT:**
  1) **Is batter than MOSFET and BJT.**
  2) **High input impadance so, it is required only a small amount of energy to switch the device.**
  3) **IGBT have turn-on turn-off on the order of 1µs.**

- **Some apllications of IGBT:**
  IGBT is finding increasing application in medum power application for example, DC motor and AC motor drives and power supply.

- ## Snubber Circuit:

The aim of the snubber circuit is to reduse the electrical stress placed on the device during swiching.

✓ ***More function of snubber circuit:***

1. **Limiting voltages applied to devices during turn-off transients.**

2. **Limiting device currents during turn-on transients.**

3. **Limiting the rate of rise *(dildr)* of currents through devices at device turn-on.**

4. **Limiting the rate of rise *(dvldt)* of voltages across devices during device turn-off.**

or during reapplied forward blocking voltages (e.g., SCRs during the forwardblocking state).

5. **Shaping of the switching trajectory of the device as it turns on and off.**

From the circuit topology perspective, there are three broad classes of snubber circuit:

1. Unpolarized series R-C snubbers used to protect diodes and thyristors by limiting

the maximum voltage and *dvldt* at reverse recovery.

2. Polarized R-C snubbers. These snubbers are used to shape the turn-off portion of

the switching trajectory of controllable switches, to clamp voltages applied to the

devices to safe levels, or to limit *dvldr* during device turn-off.

3. Polarized L-R snubbers. These snubbers are used to shape the turn-on switching

trajectory of controllable switches and/or to limit *dildt* during device turn-on.

- ✓ **Freewheeling diode:** when turn-on the swich the result is stored energy in the inductor, this energy will be dissipated in the form spark, so use a Freewheeling diode across the load to provide an alternative path for the current when the swich is off.

Calculation:

Part one: high inductive load:

1) **the average power losses during conduction in the IGBT**

Pon = Von*Io*Ton*Fs

= $2.5 * 25 * 30u * 15K$ = **28.125** watt

2) **The total avarege power losses during switching in the switch is:**

$P_s = 1/2 * F_s * V_d * I_o * (T_{c(on)} + T_{c(off)})$

= 0.5*15K*400*25*1000*10^{-9} = **75** watt.

Part two: resistive load:

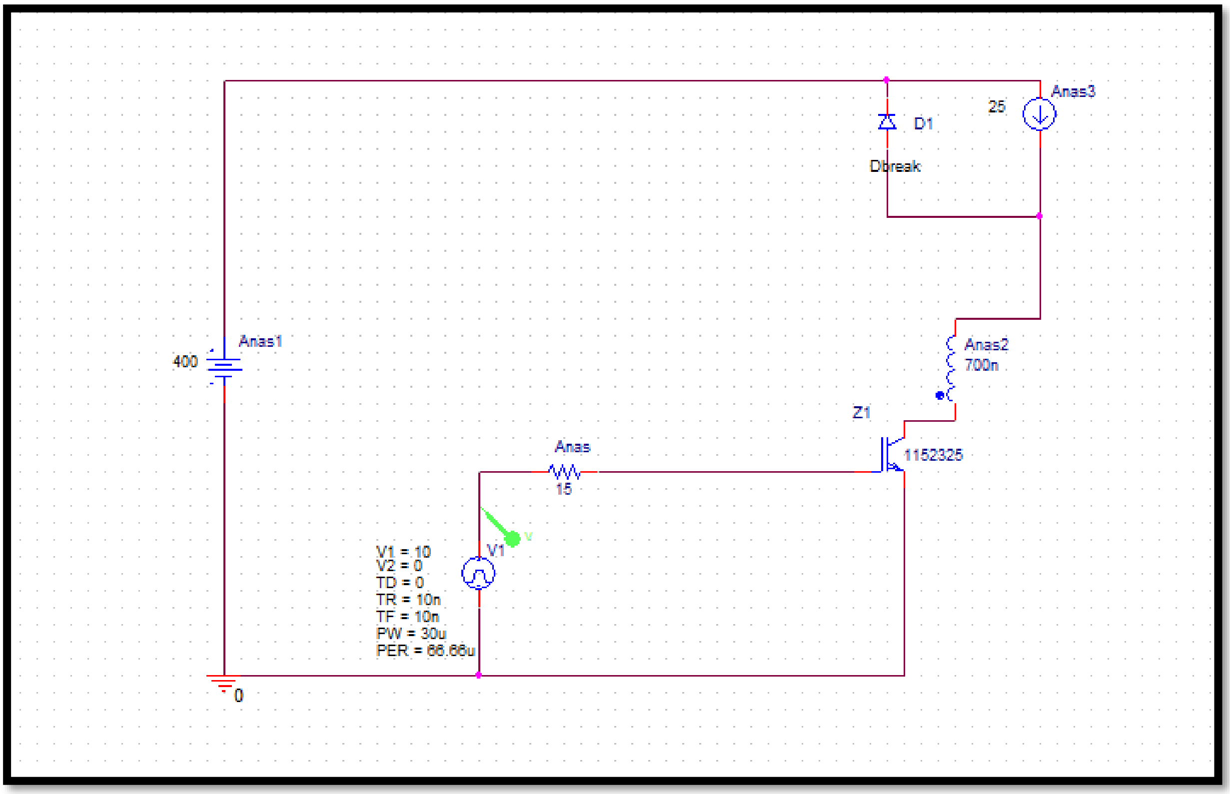
1) **The avarege conduction power loss is:**

   Pon=Von*Io*Fs*Ton
   =2.5* (400-2.5/15)*15K*30*10^-6 = 29.8125 watt.

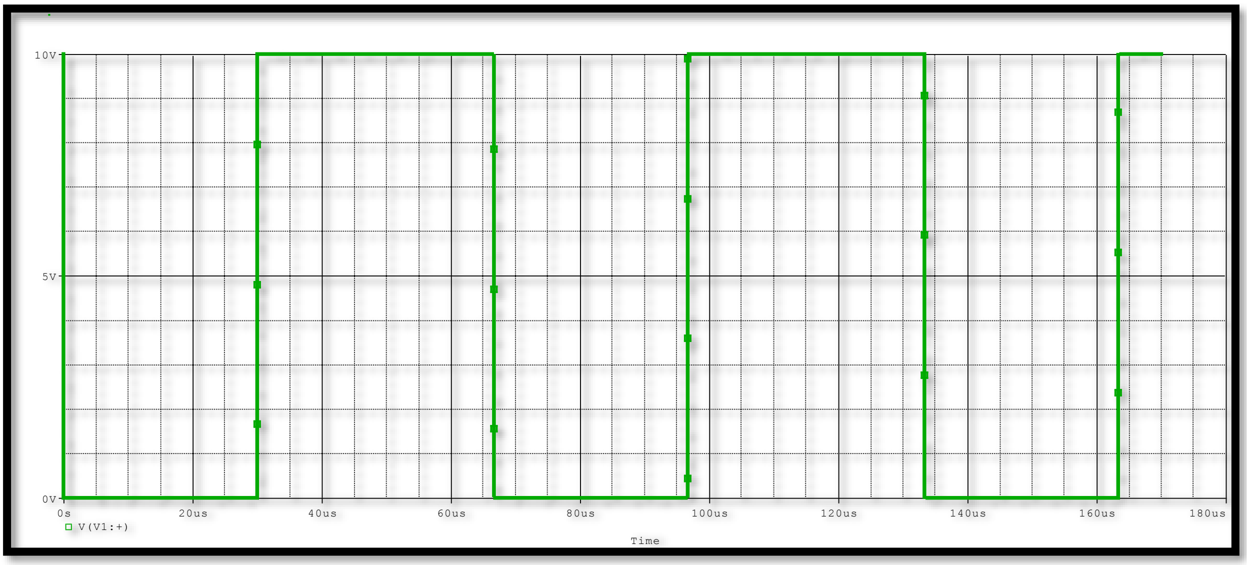
2) **Total average switching power loss with resisteve load is:**

   Ps=1/6*Fs*Vdc*Io*(Tc'on'+Tc'off')
   = 1/6*15K*400*(400-2.5/15)*(1000*10^{-9}) = 26.5watt.

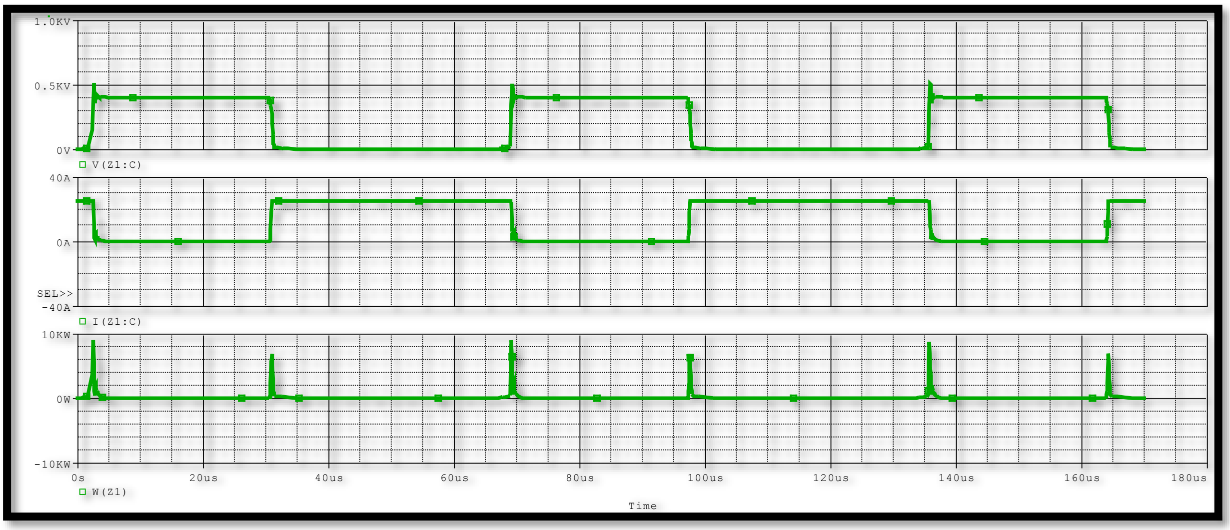
For high inductive load: **Circuit diagram:**



V-Pulse

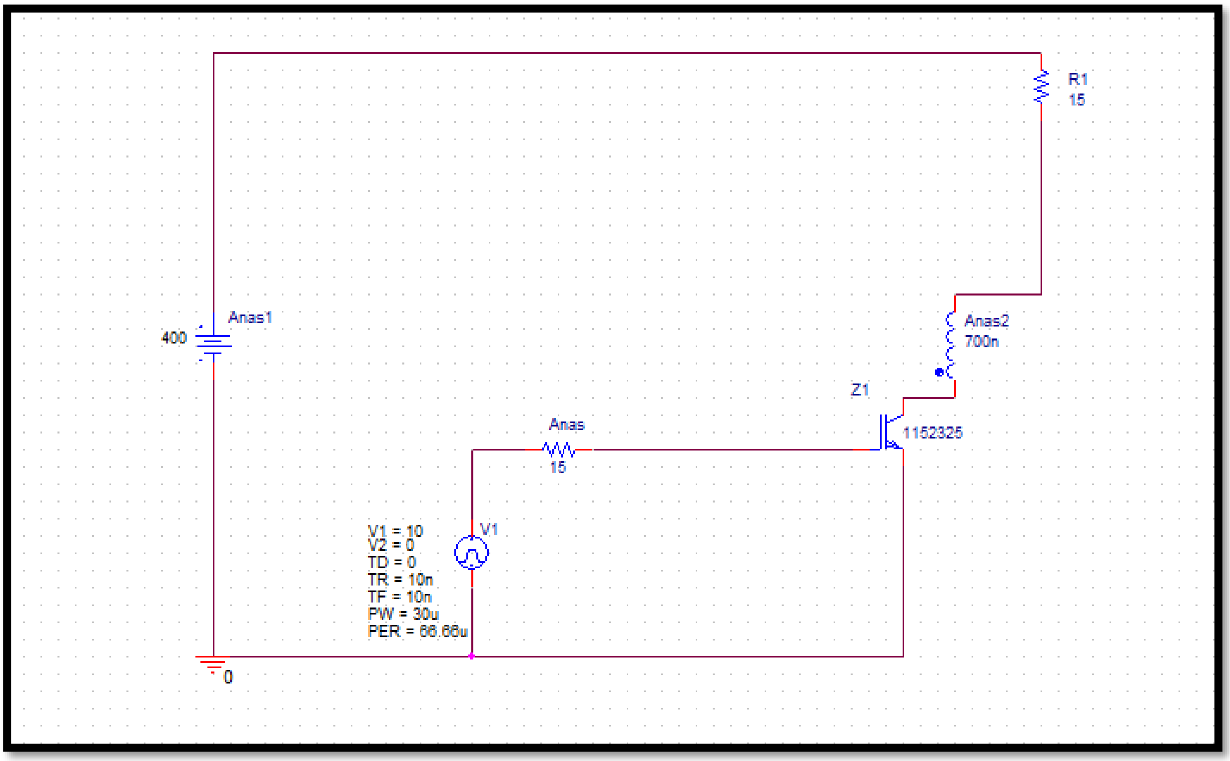


The results:

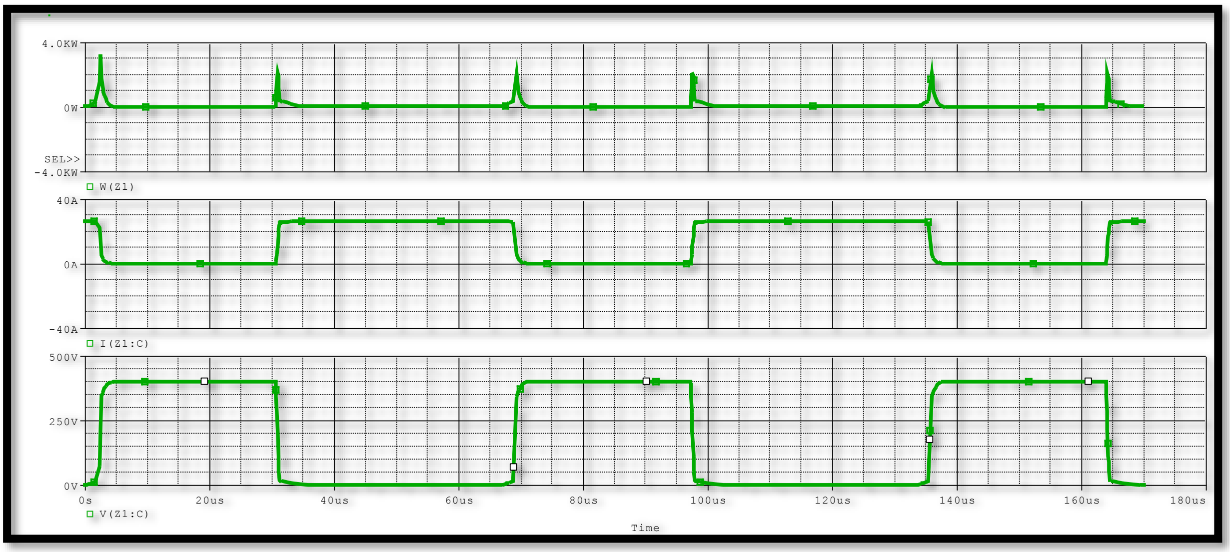


For resistive load:

Circuit diagram:

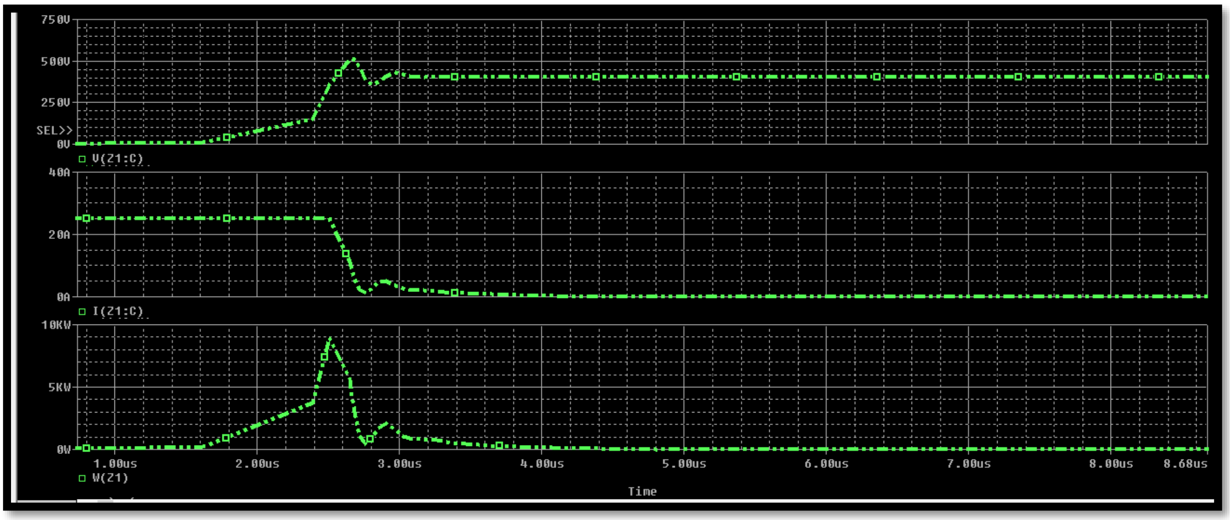


The result:



Conclusion:

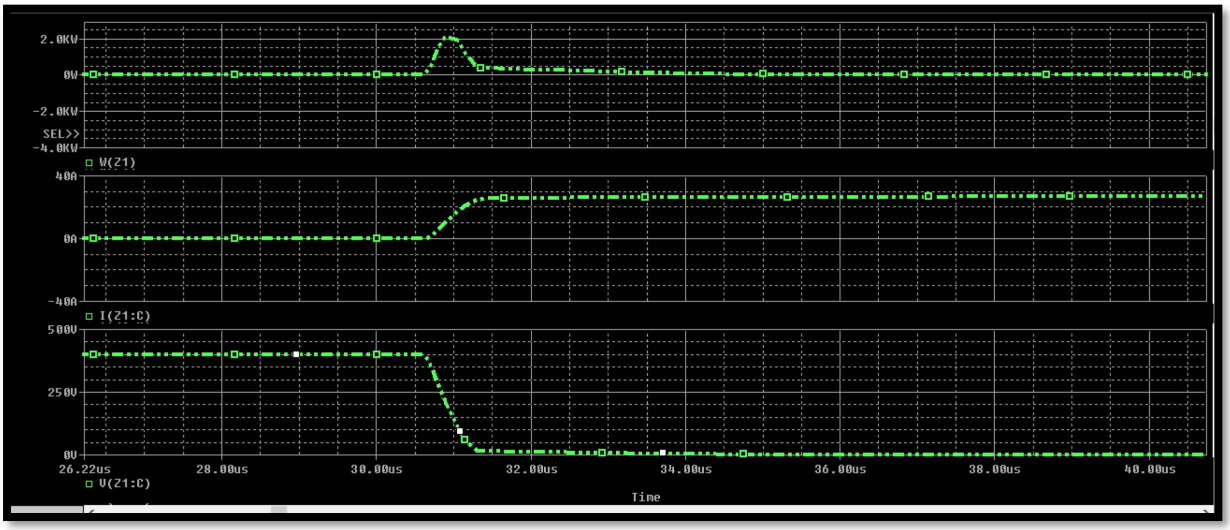
Zoom for part one: high inductive load:



According to the graph 'zoom for part one, shown above' note that:

- There is an over shoot in the voltage curve, since there is a voltage drop across the stray inductance at turn-on state.
- The tail current shown in the current curve, since that the IGBT turns off as an open Base BJT.
- The voltage start increasing when the current is still unchanged, but it is got in a few microsecond, so no need to snubbers' circuit to protect the power electronics device.
- In this case, we use a Freewheeling diode because the inductance load stored the energy when the switch is on, so to protect the device from the spark we use this diode.

Zoom for part two: resistive load:



According the graph 'zoom for part two, shown above' note that:

- **The voltage begins increasing when the current starts decreasing at the same time , but it is got in a few microsecond (less than in high inductive load), so no need to snubbers circuit to protect the power electronics device.**
- **We didn't use a Freewheeling diode in this case because no energy stored in the resistive load.**

NOTE THAT: The error in simulation: the power dissipated in IGBT in the ideal case is equal: $V_d * I_o$ = 400*25=10KW but in the graph the result is about 9KW and that is because the stray inductance which makes a over-shot in the voltage and in the current, also the power dissipated in IGBT when it is connect with resistive load is 1/3 of power dissipated when it is connect with high inductive load.

References:

1) **Muhammad H. Rashid 'Power Electronics: Circuits, Devices and Applications', 4th edition Prentice Hall 2013.**

2) **Ned Mohan, Tore M. Undeland, and William P. Robbins 'Power Electronics: Converters, Application, and Design', 3rd edition 2003.**

3) **Lecture note, Dr. M. Abu-Khaizaran.**

Failer try to solve the assign, use MATLAB SIMULINK.