



M.Sc. In Electrical Energy Conversion and Power Systems



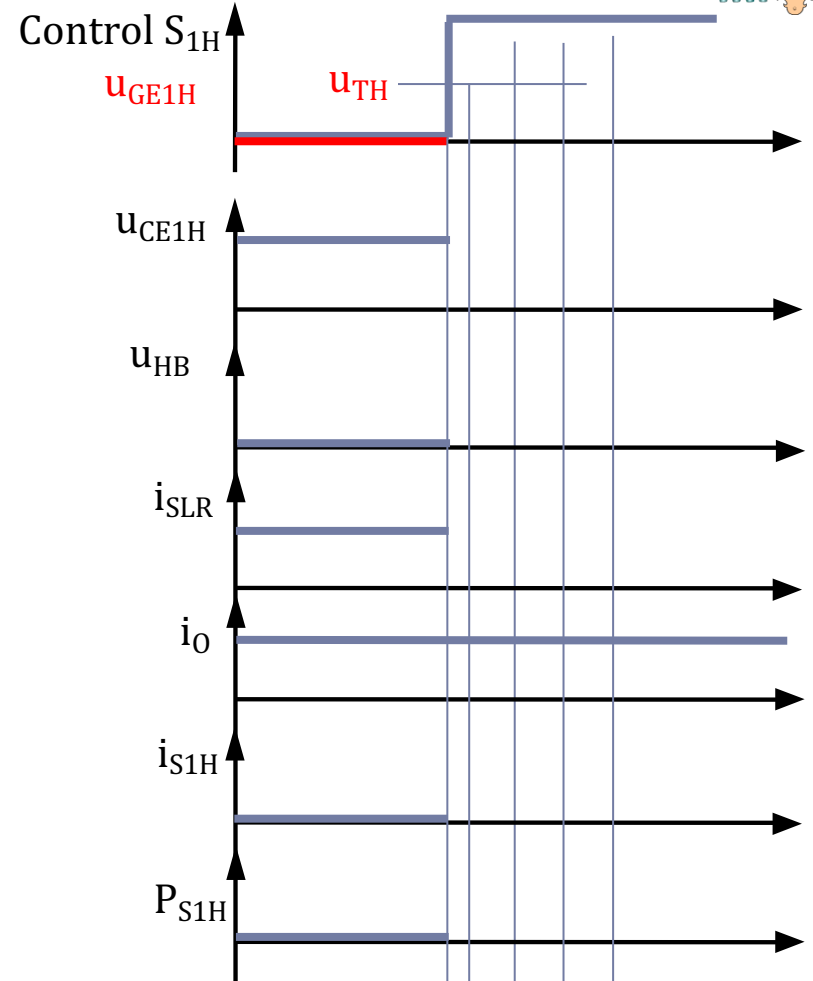
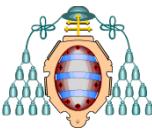
Seminar 3 – Switching of power converters

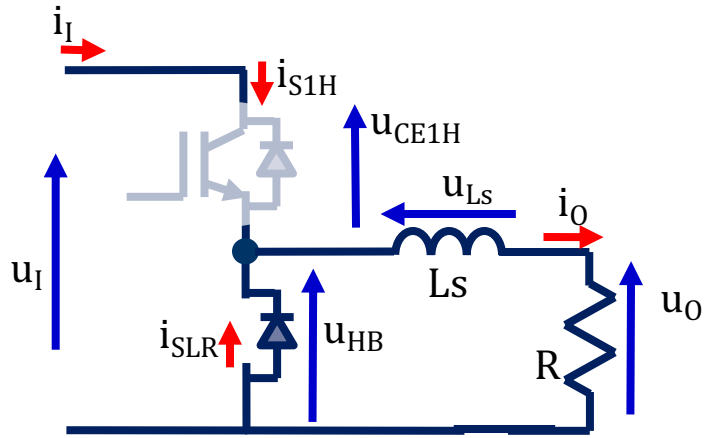
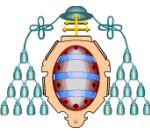
Semester 2 – Industrial electronics in renewable energy generation systems

Lecturer: Jorge García, garciajorge@uniovi.es

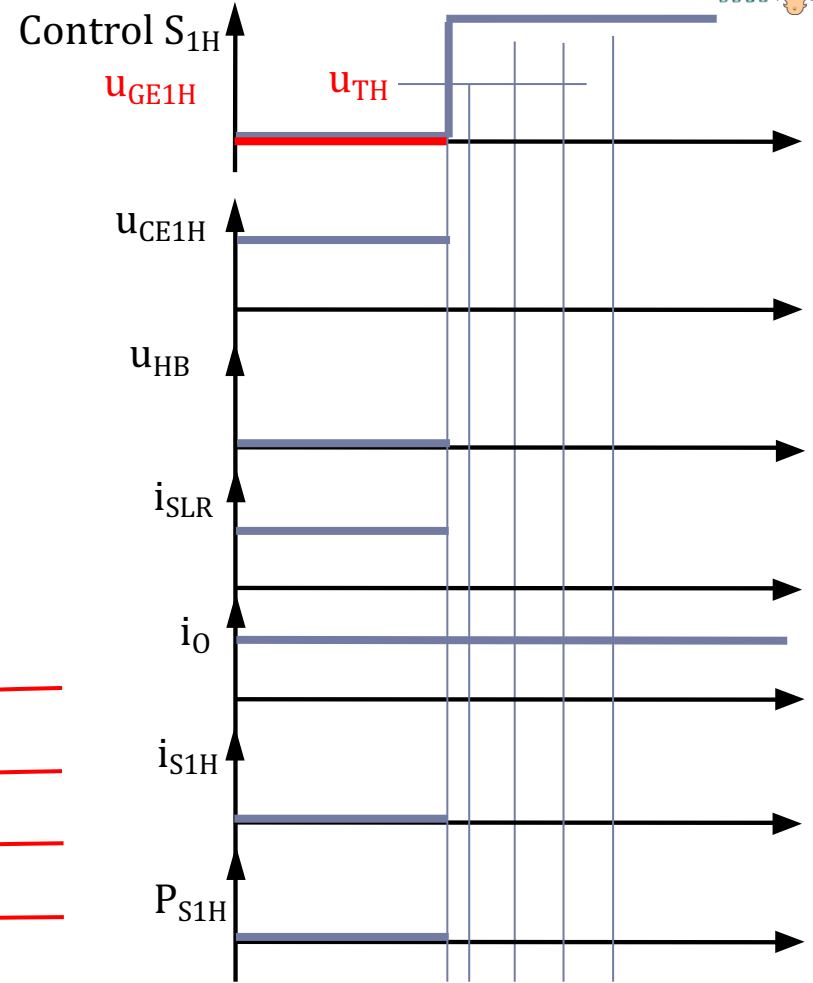
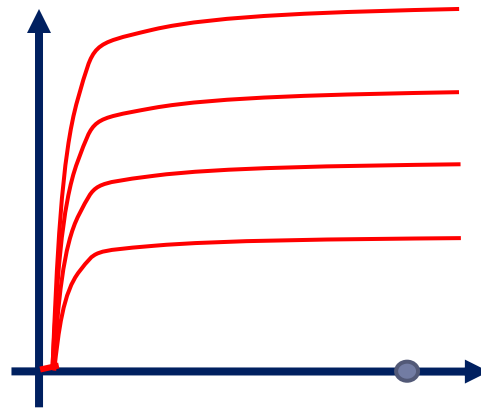
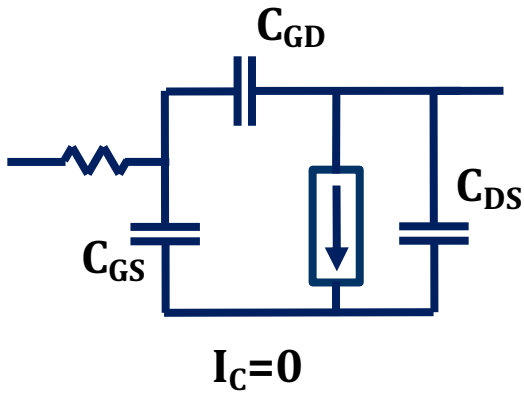


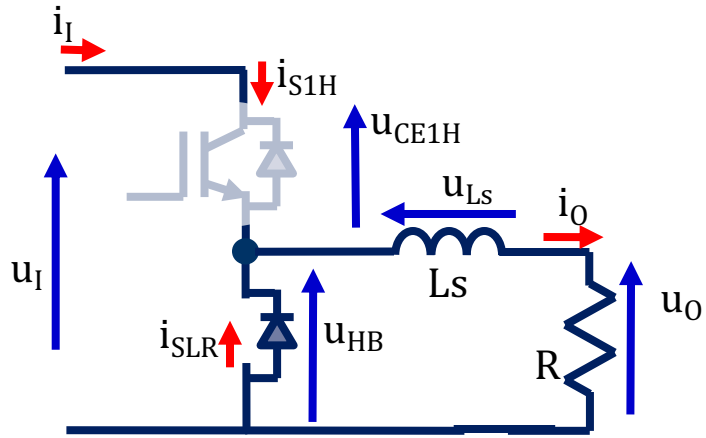
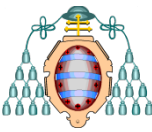
**HARD SWITCHING, HALF BRIDGE
TRANSISTOR TURN-ON
(HIGHER TRANSISTOR IS INITIALLY
TURNED OFF, WITH INDUCTIVE LOAD)**



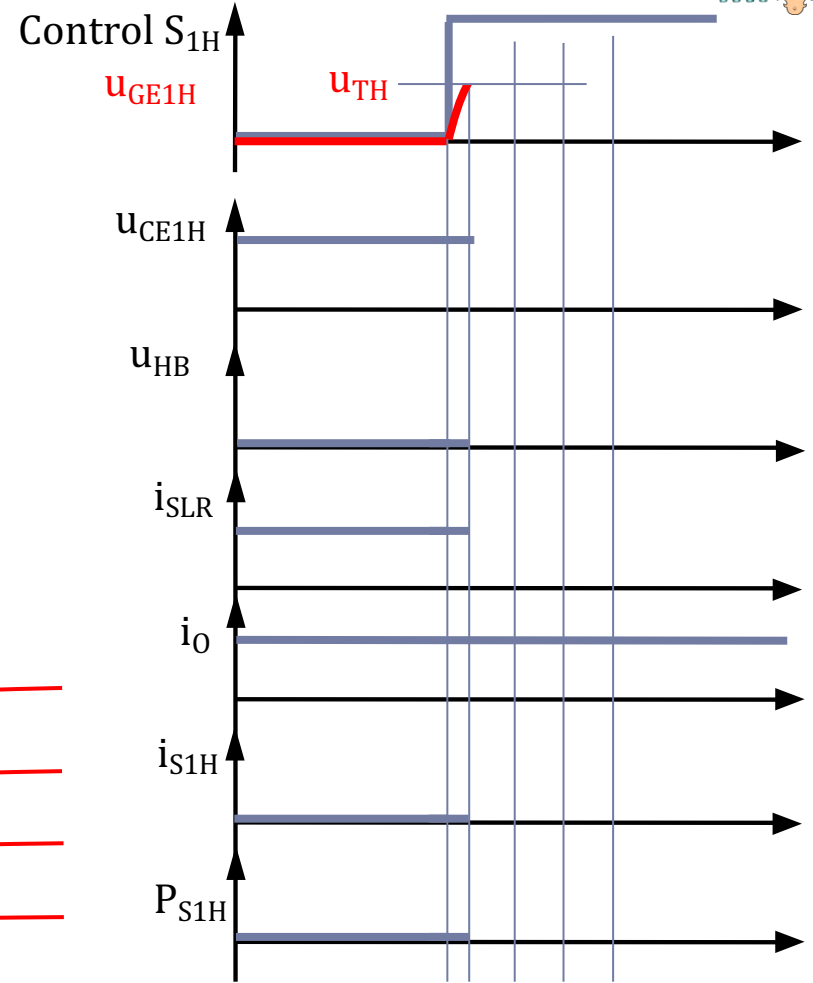
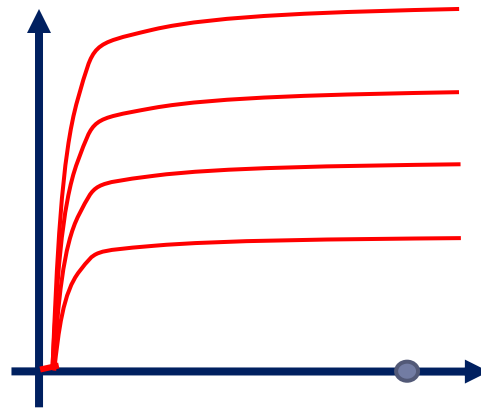
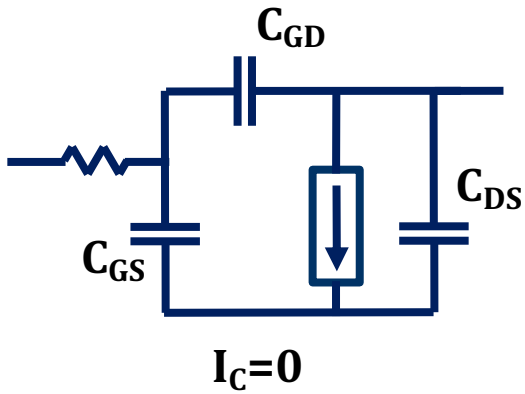


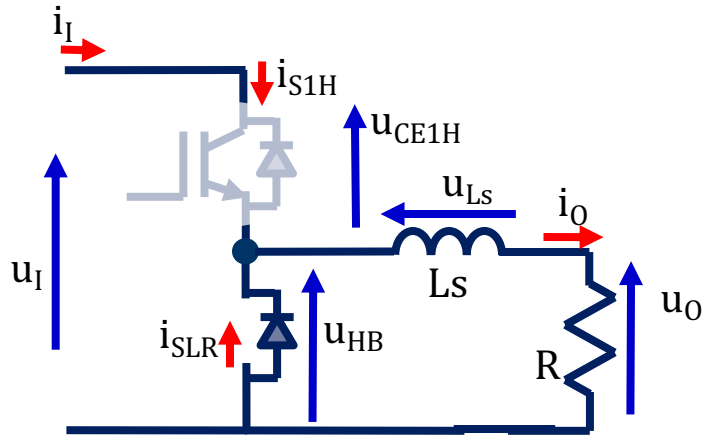
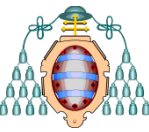
Assuming Diode ON, Switch OFF.



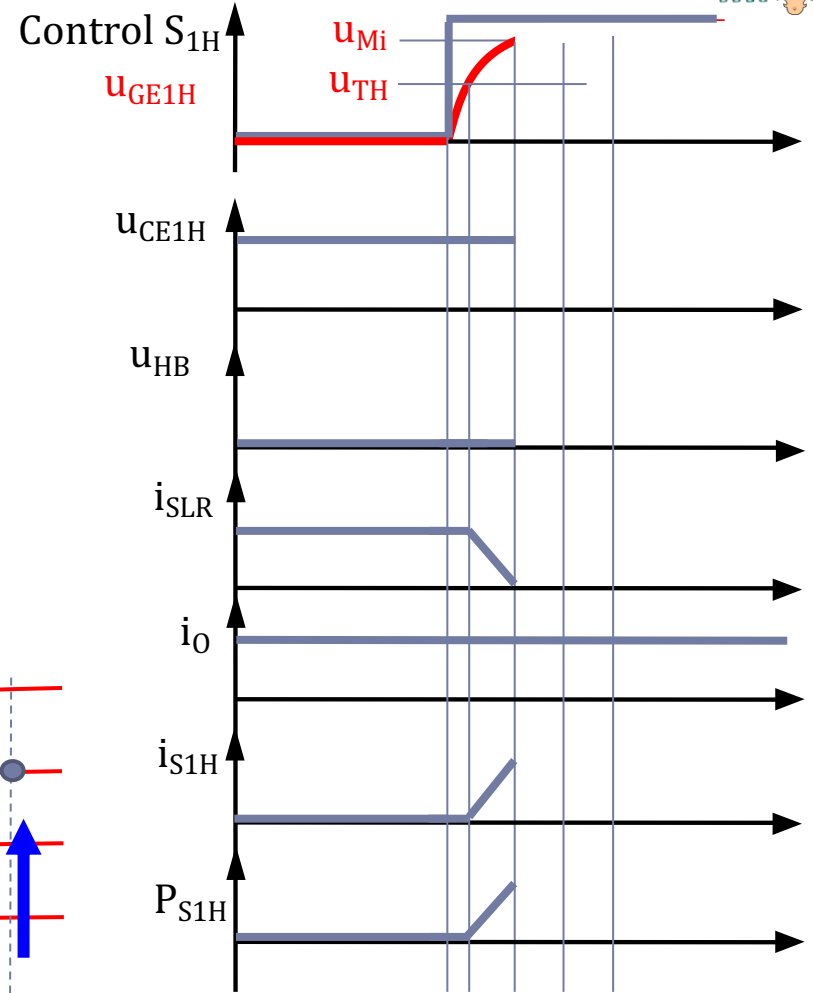
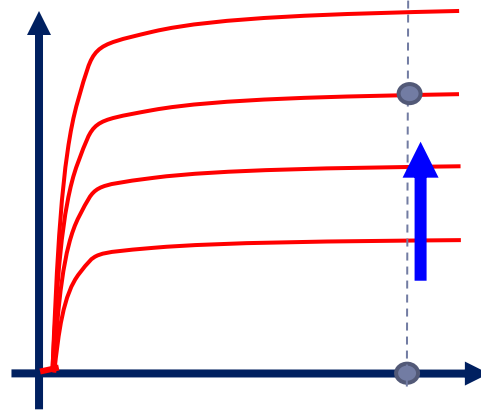
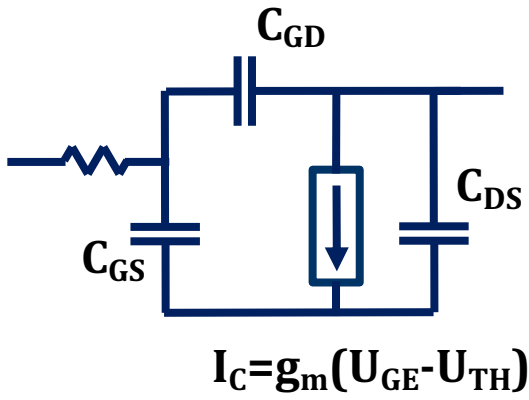


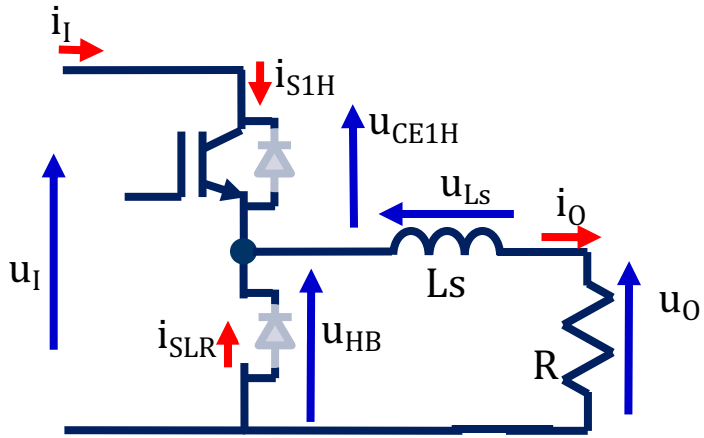
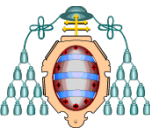
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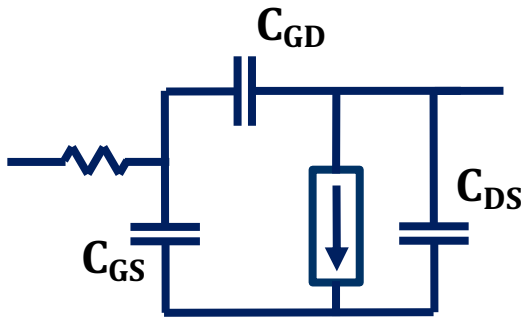


Assuming Diode ON, Switch OFF.

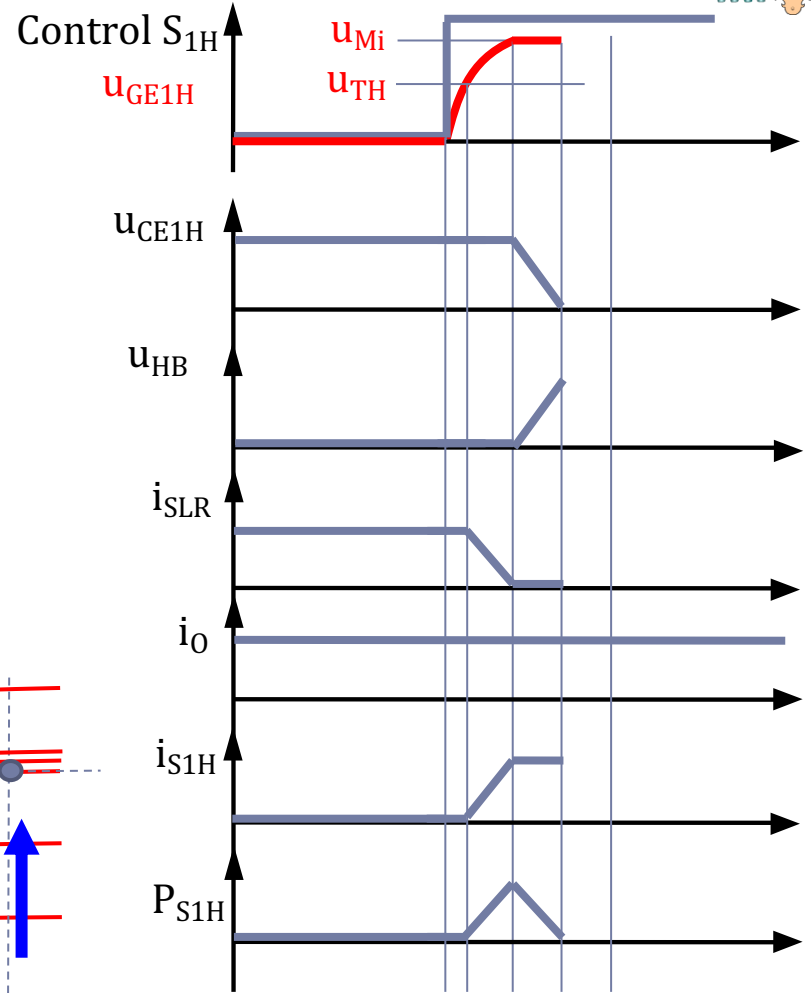
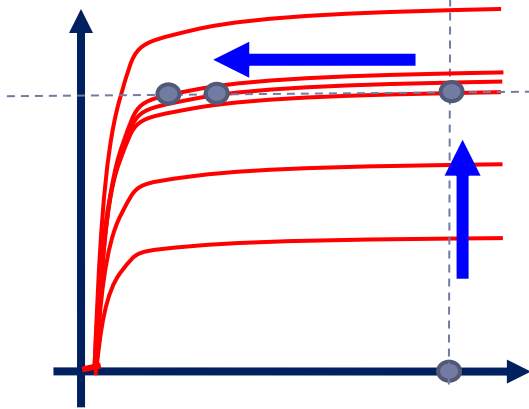


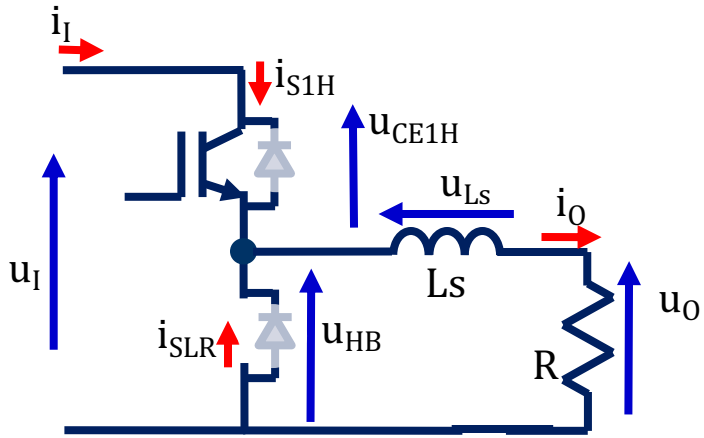
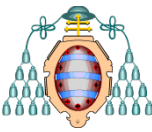


Assuming Diode ON, Switch OFF.

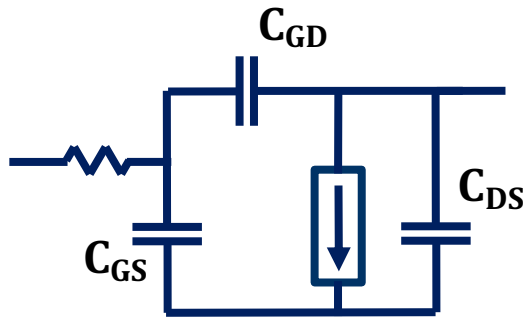


$$I_C = g_m (U_{GE} - U_{TH})$$

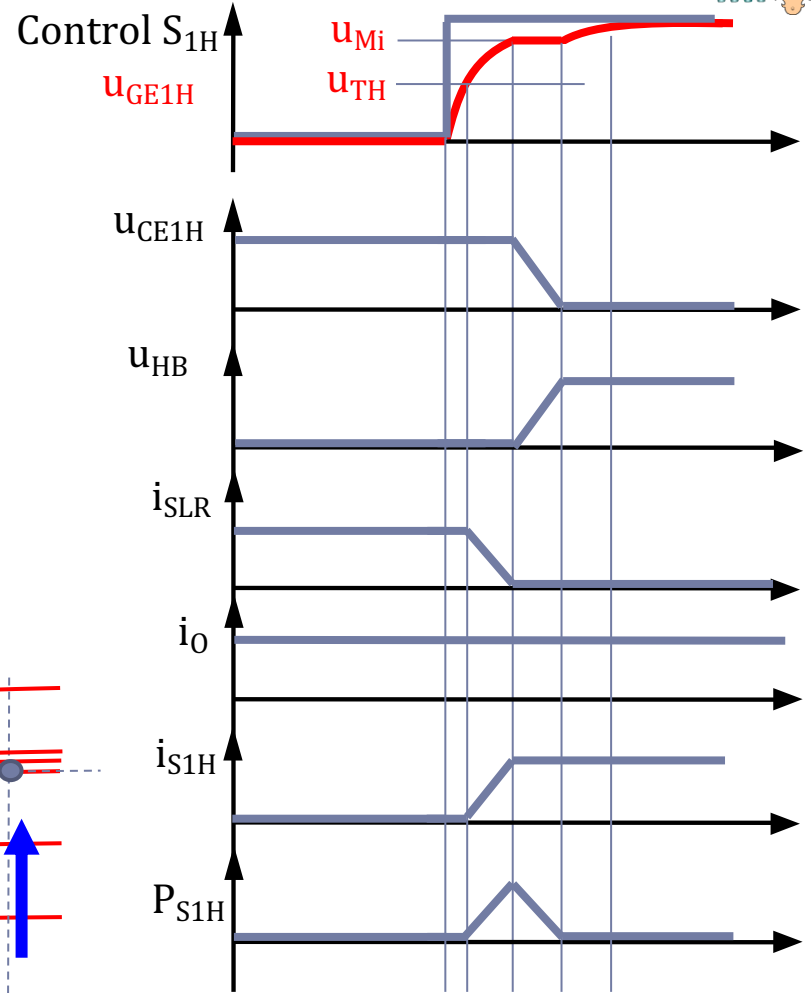
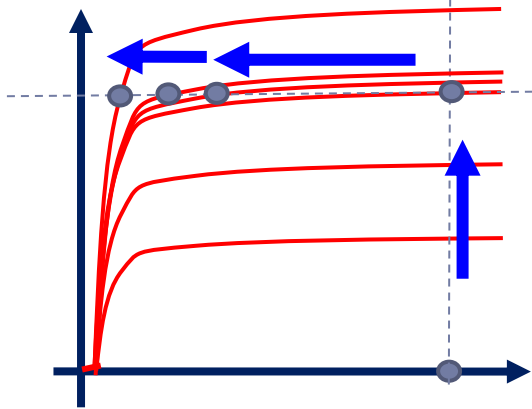




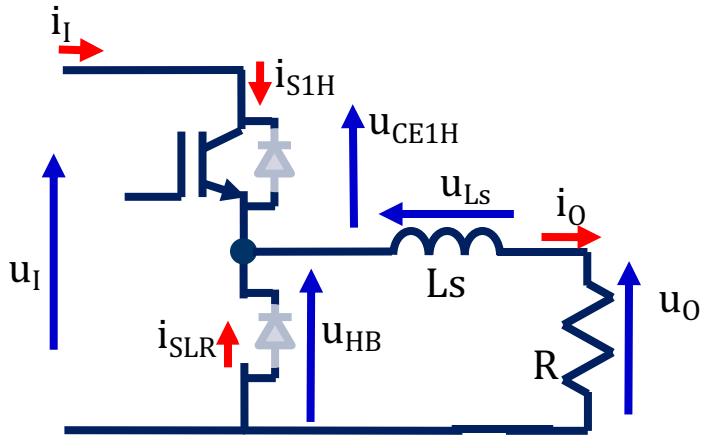
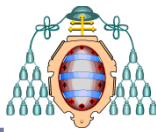
Assuming Diode ON, Switch OFF.



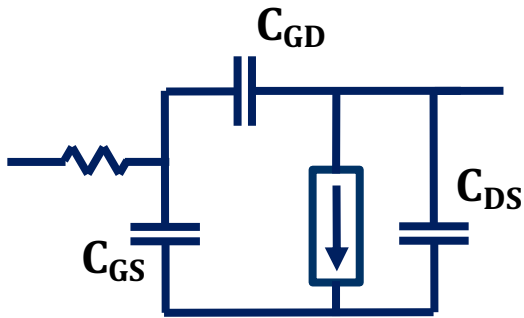
$$I_C > g_m(U_{GE} - U_{TH})$$



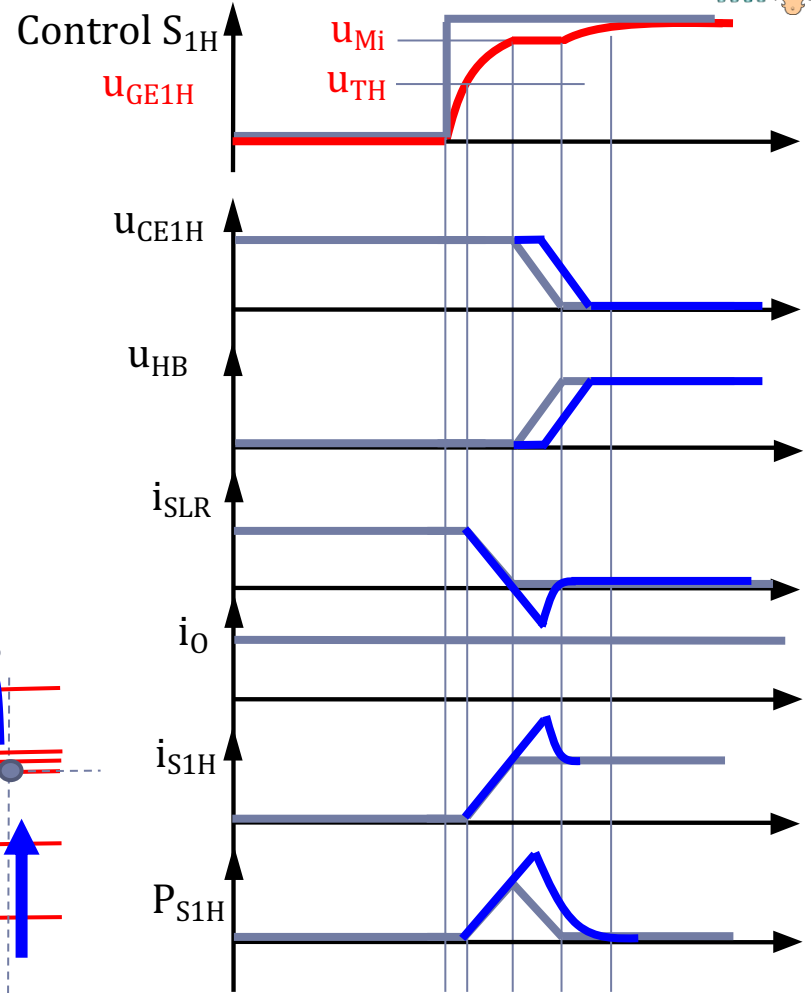
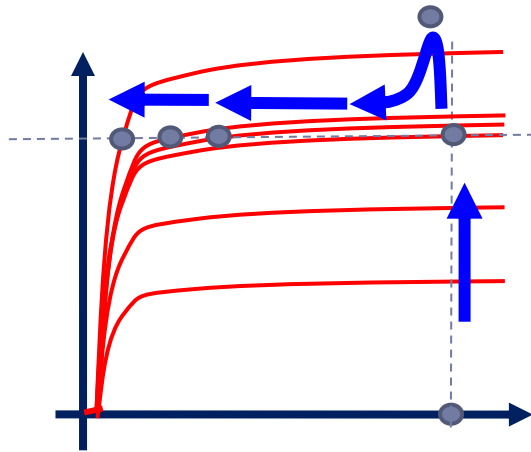
Hard Switching, Hard Turn-on Losses in transistor



Assuming Diode ON, Switch OFF.

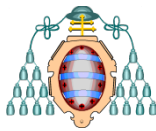


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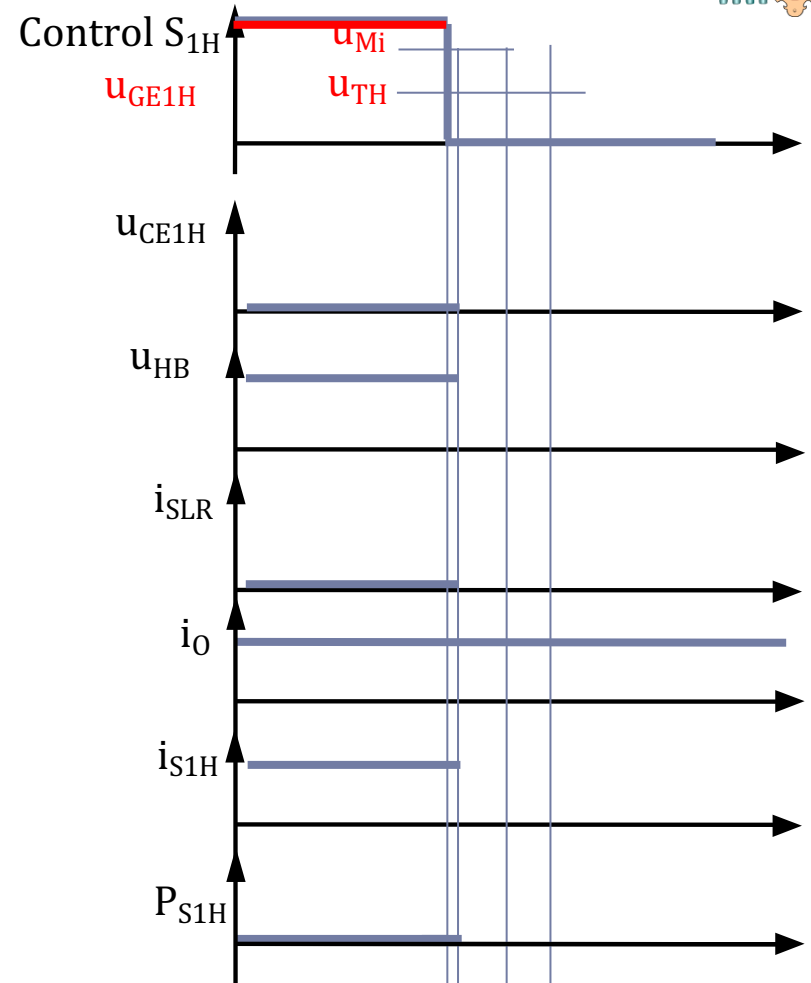


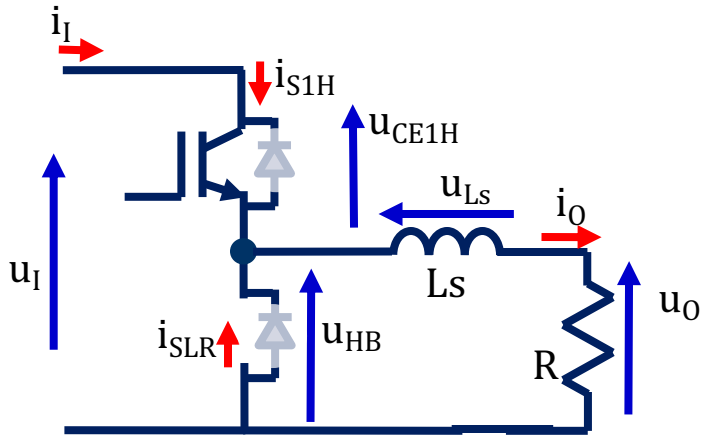
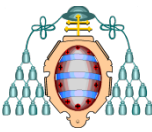
Hard Switching, Hard Turn-on Losses in transistor

Even worse, as diode reverse recovery peak increases Turn on Losses!!!

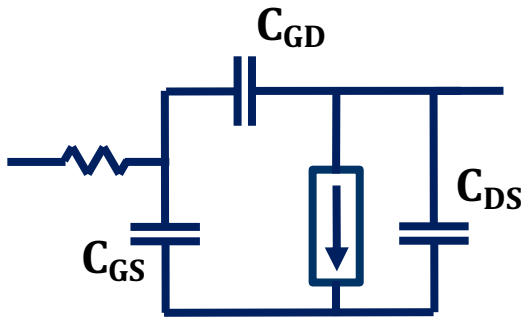


**HARD SWITCHING
HALF BRIDGE
TRANSISTOR TURN-OFF
(HIGHER TRANSISTOR IS
INITIALLY TURNED ON, WITH
INDUCTIVE LOAD)**

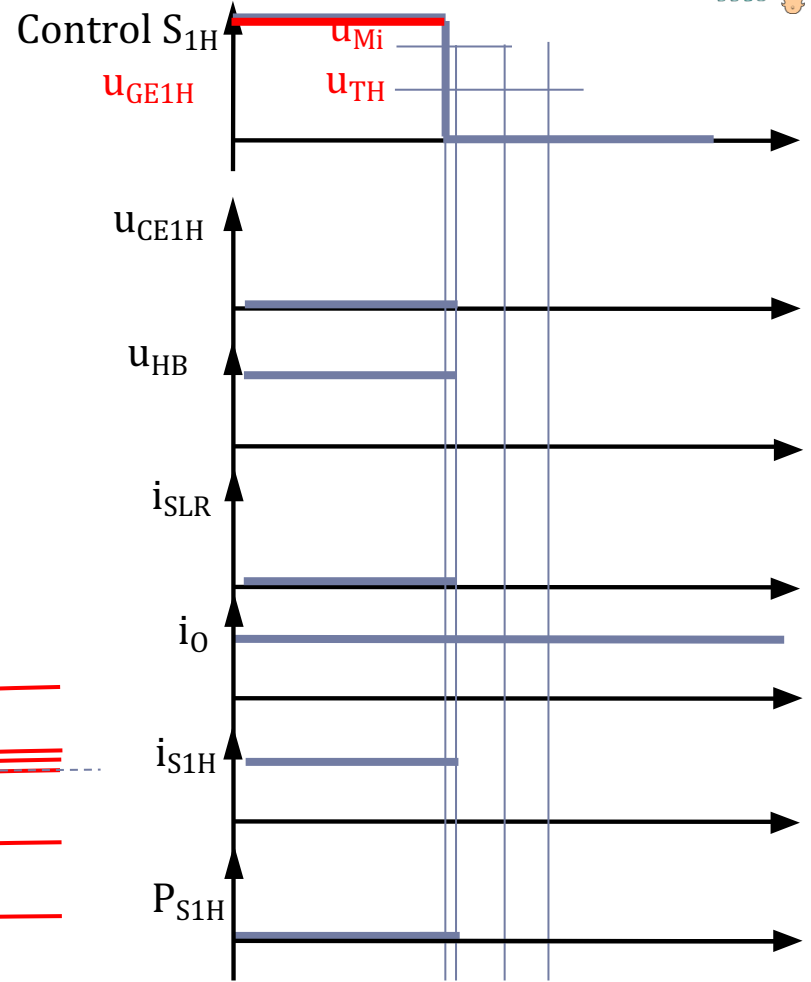
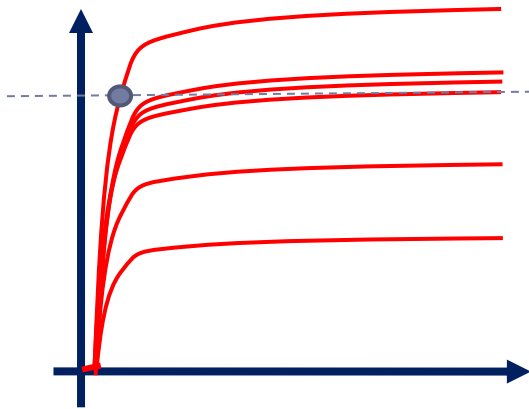


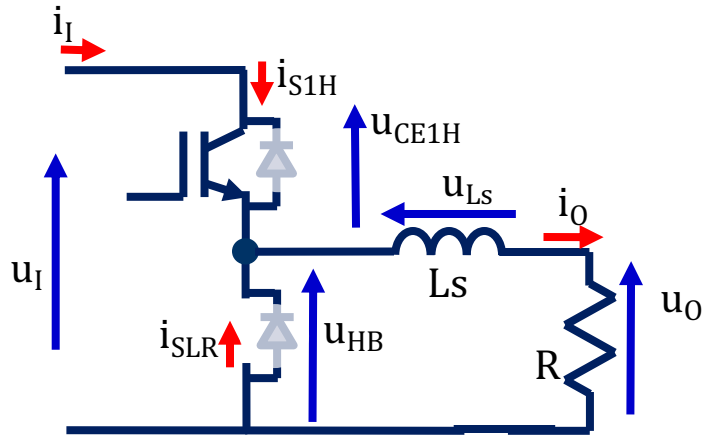
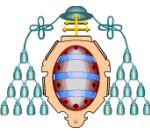


Assuming Diode OFF, Switch ON.

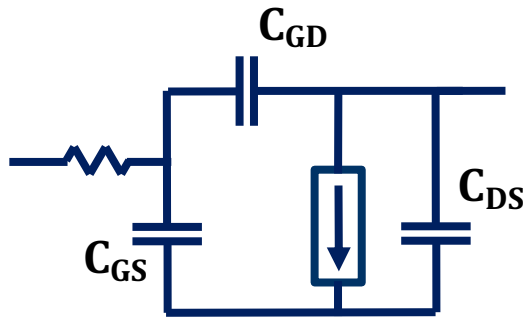


$$I_C > g_m (U_{GE} - U_{TH})$$

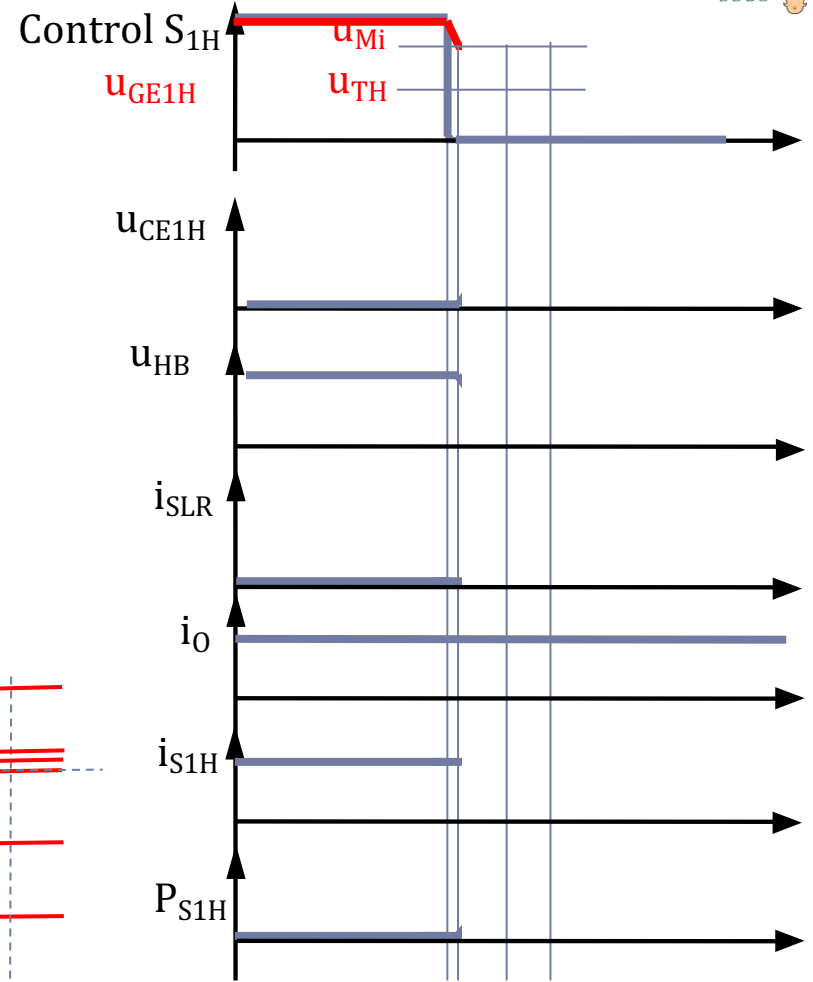
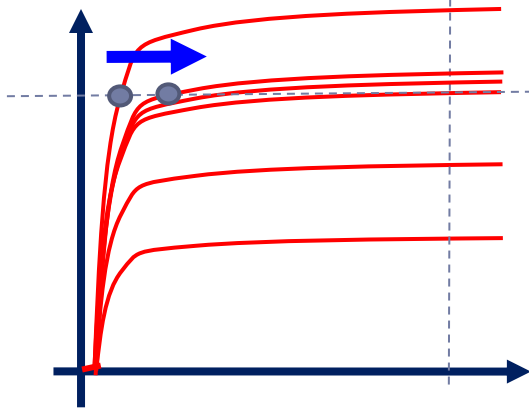


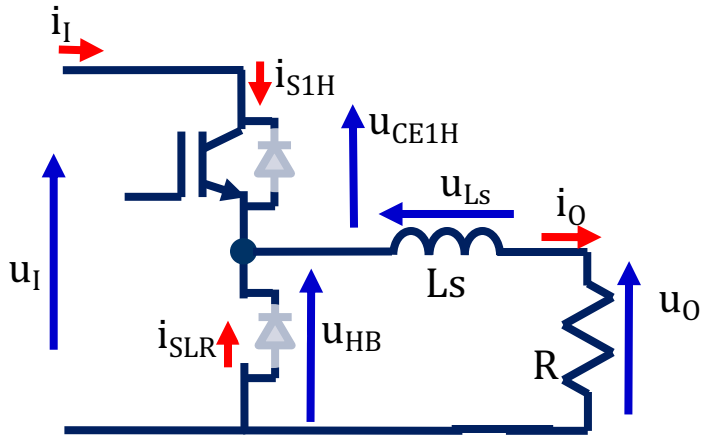
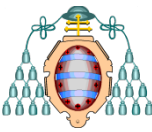


Assuming Diode OFF, Switch ON.

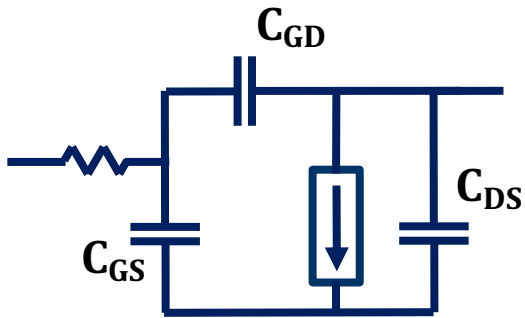


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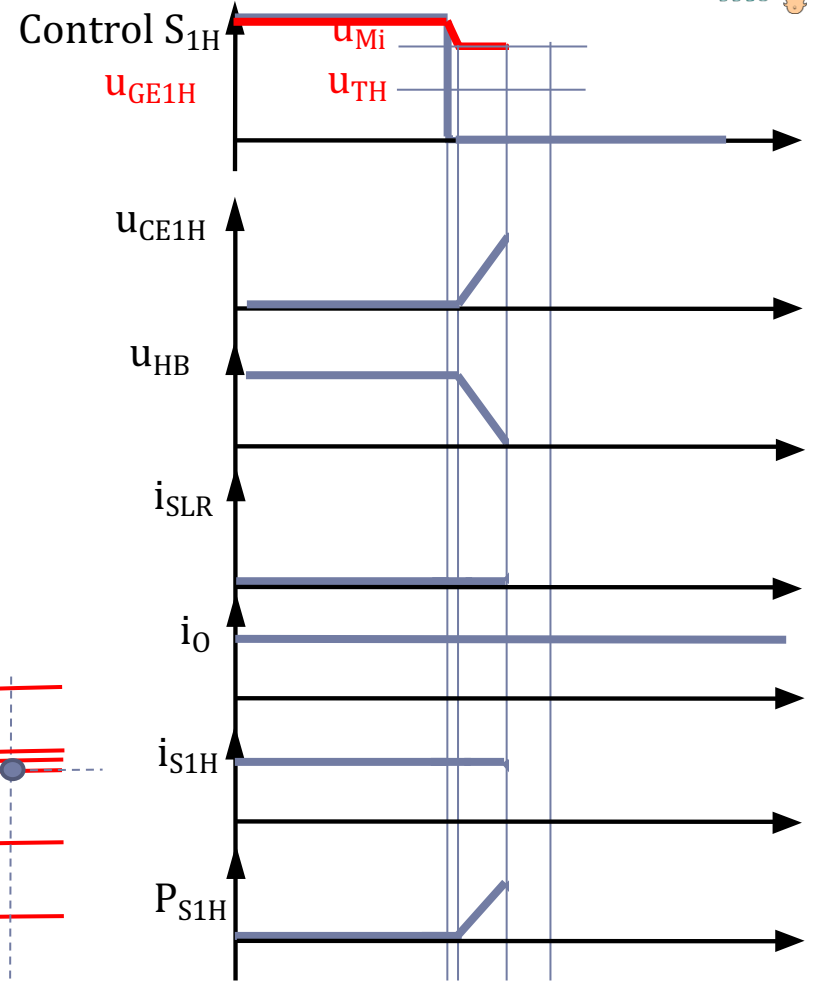
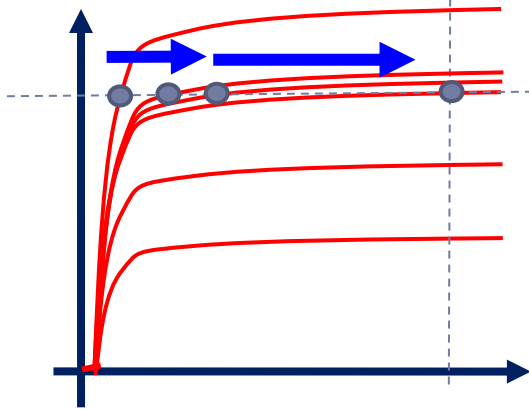


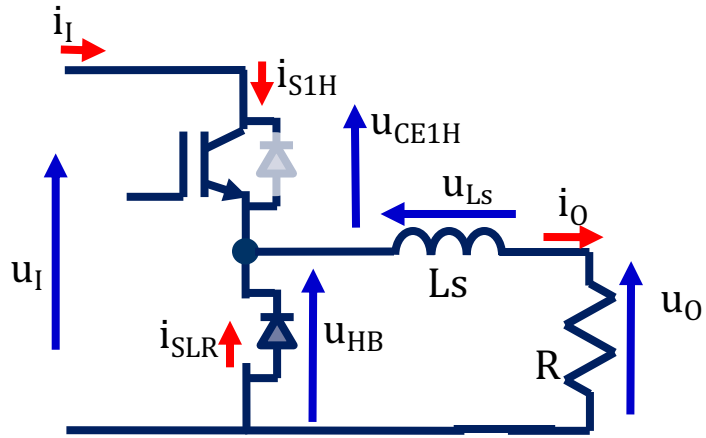
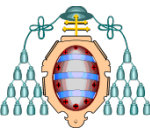


Assuming Diode OFF, Switch ON.

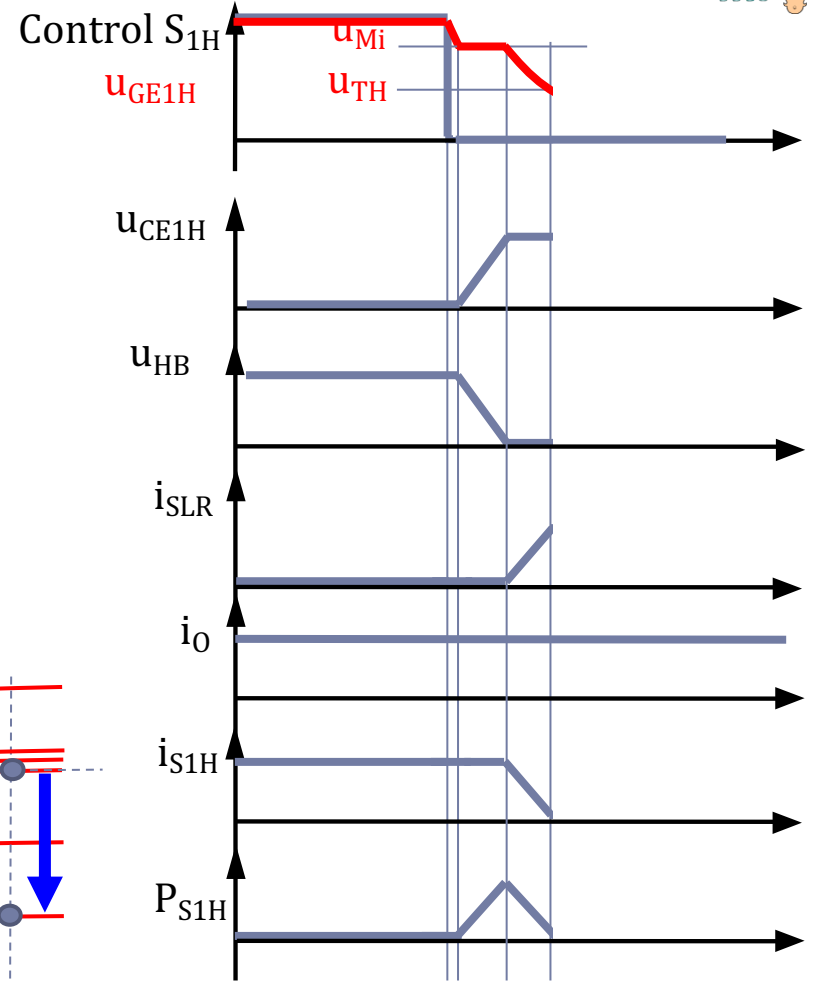
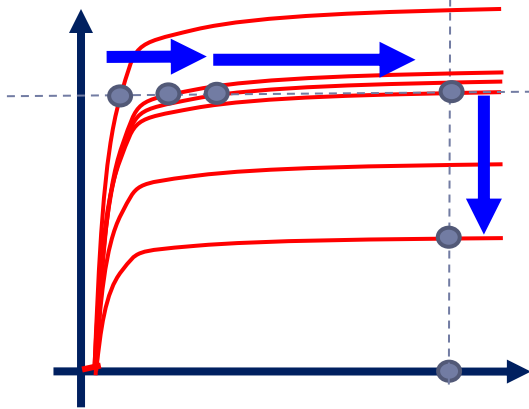
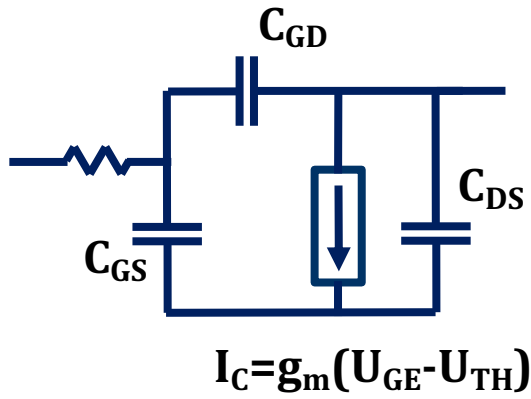


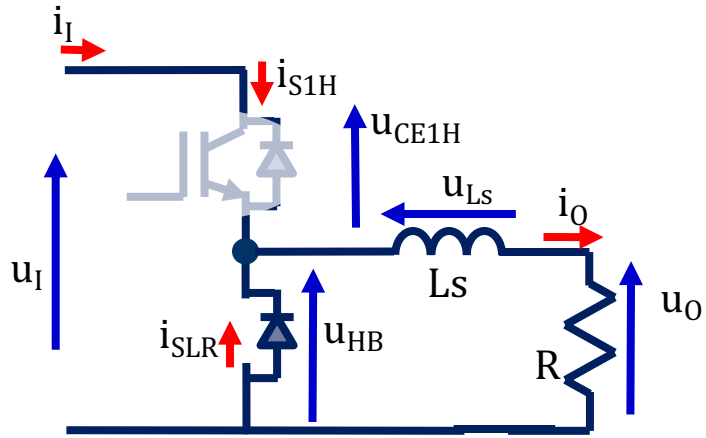
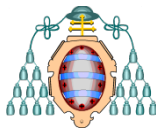
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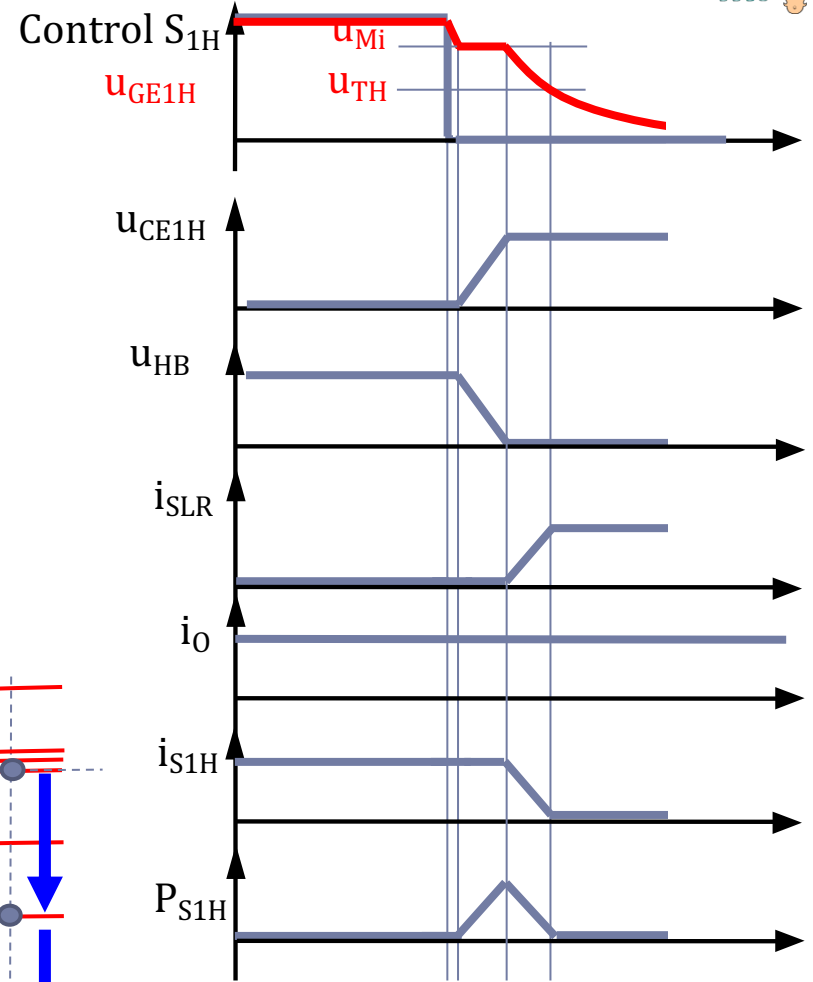
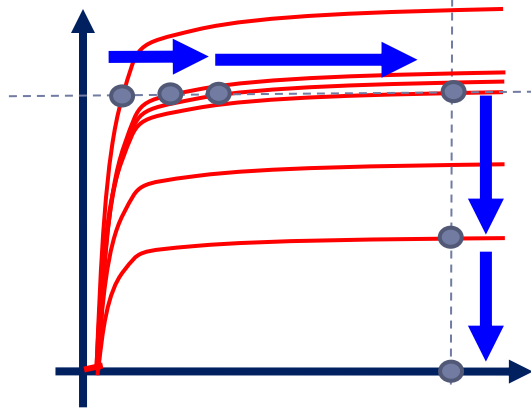
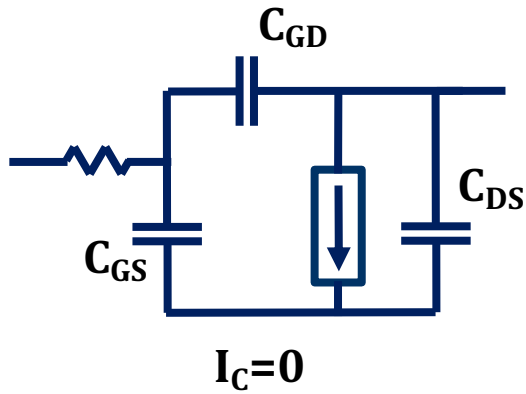


Assuming Diode OFF, Switch ON.

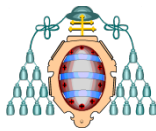




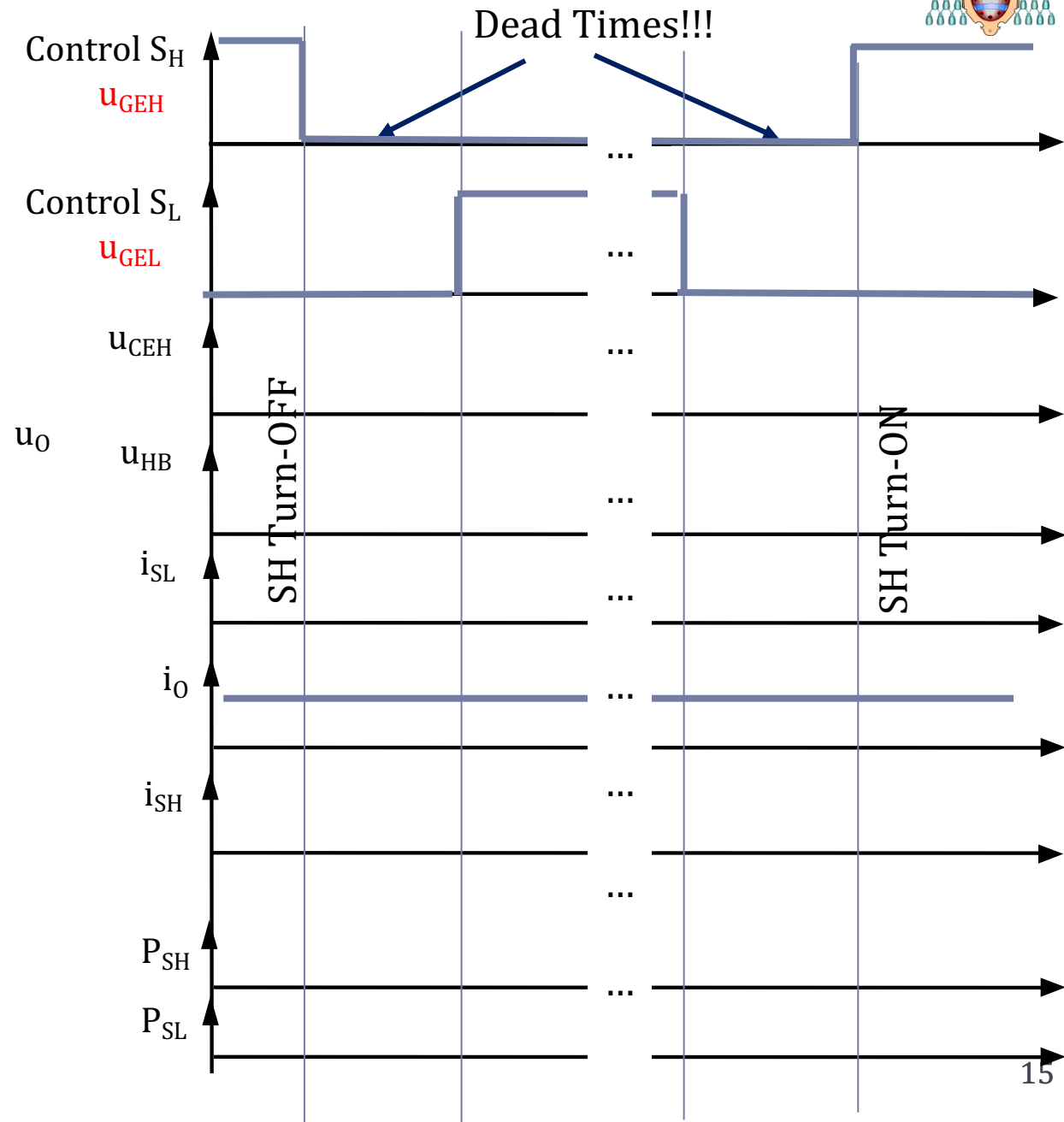
Assuming Diode OFF, Switch ON.



Hard Switching, Hard Turn-on Losses in transistor

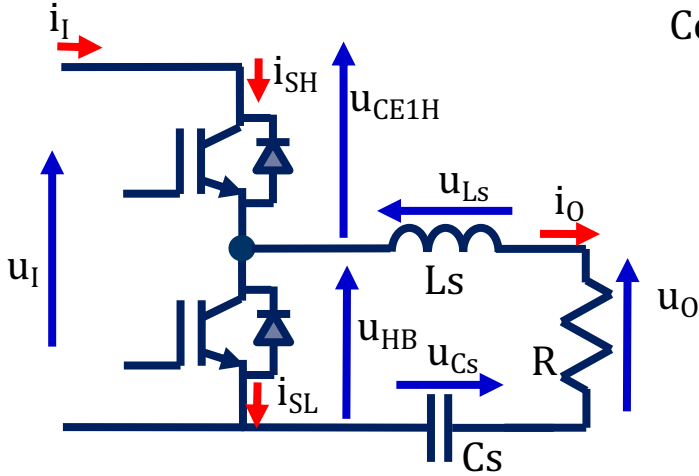


**HARD SWITCHING
HALF-BRIDGE,
TRANSISTOR SH
TURN-OFF/ON,
DEAD TIMES,
INDUCTIVE LOAD**

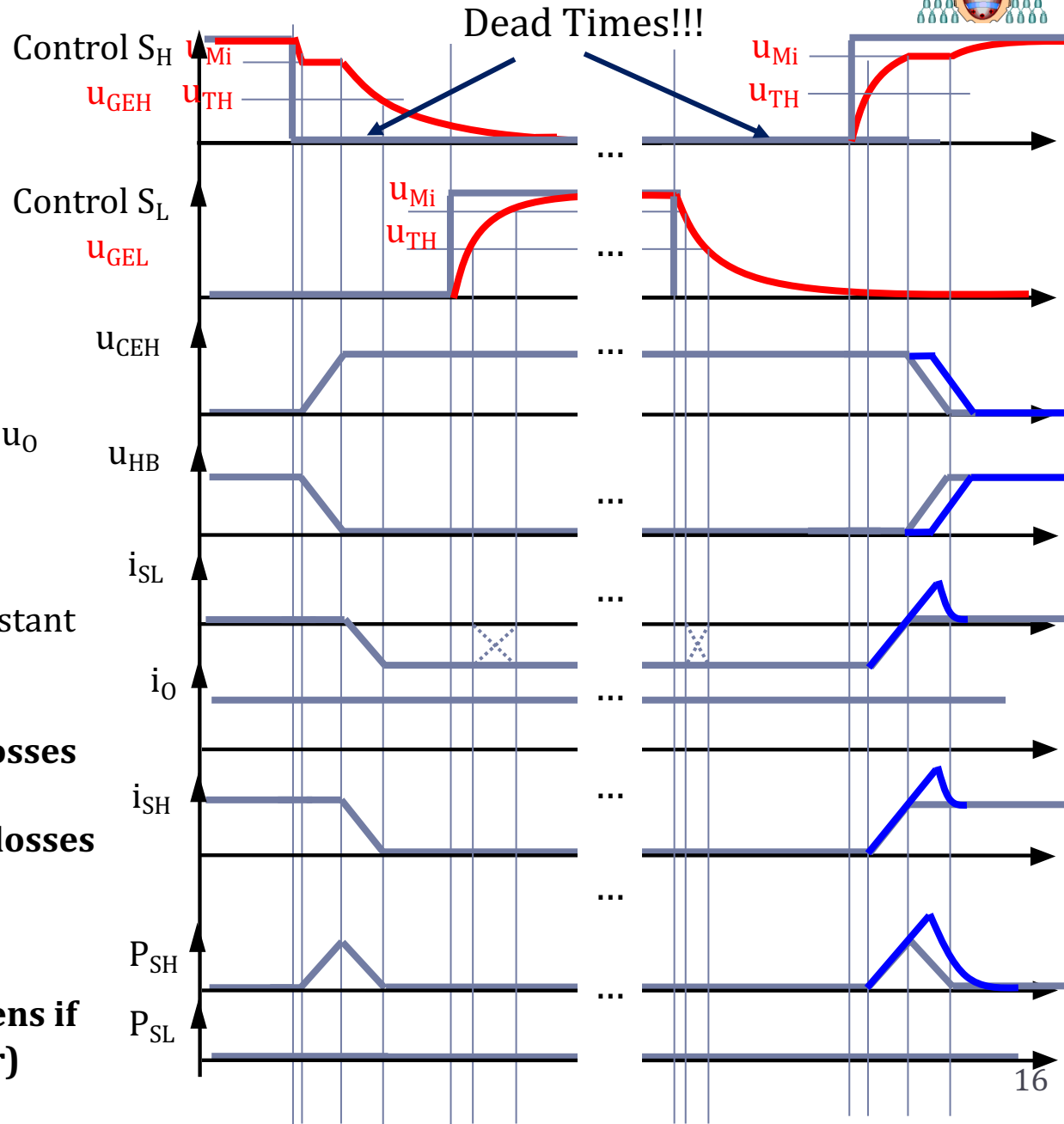
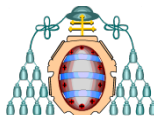




HARD Switching of HB Converter, SH TURN OFF

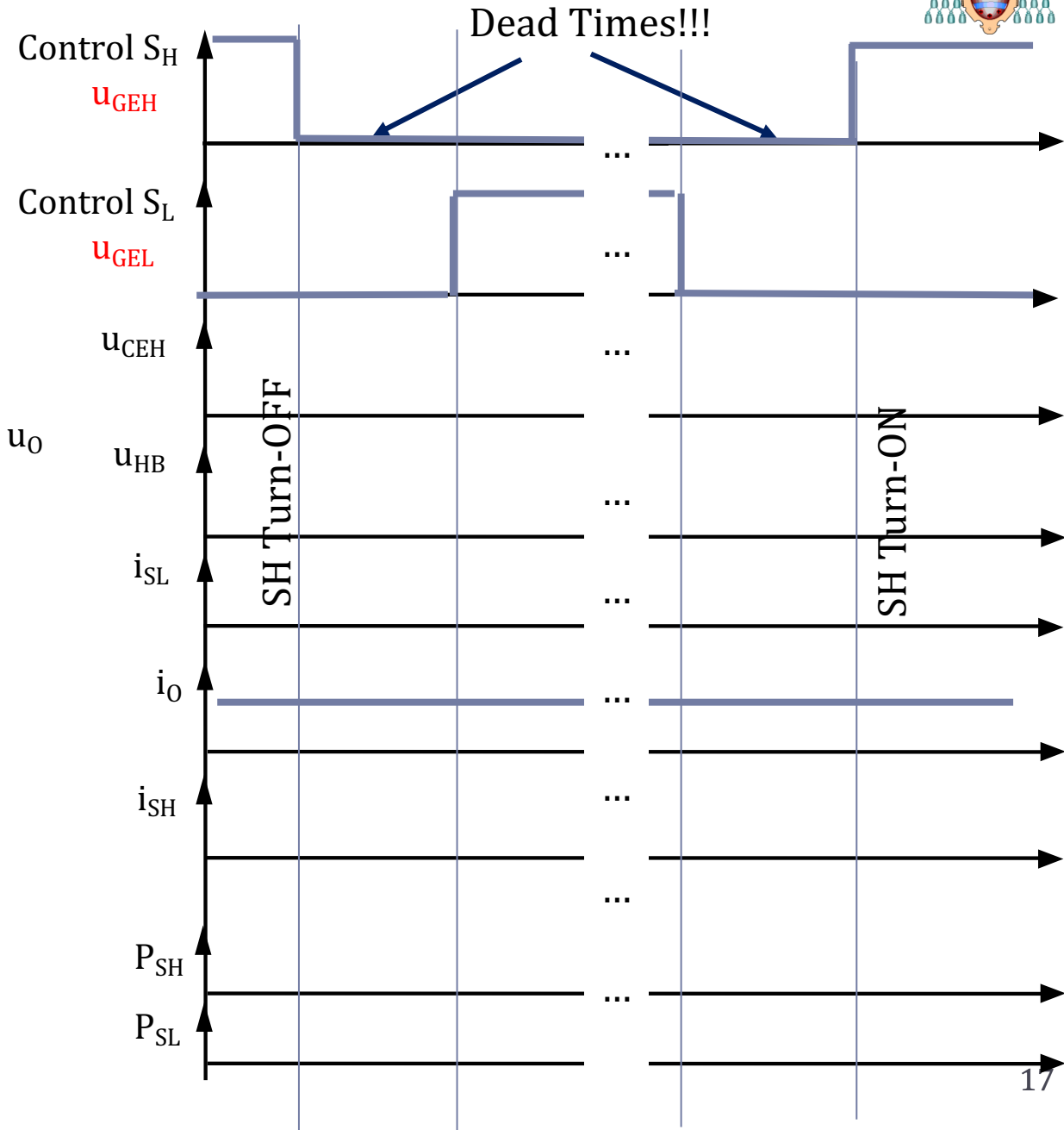
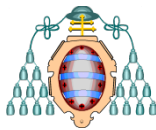
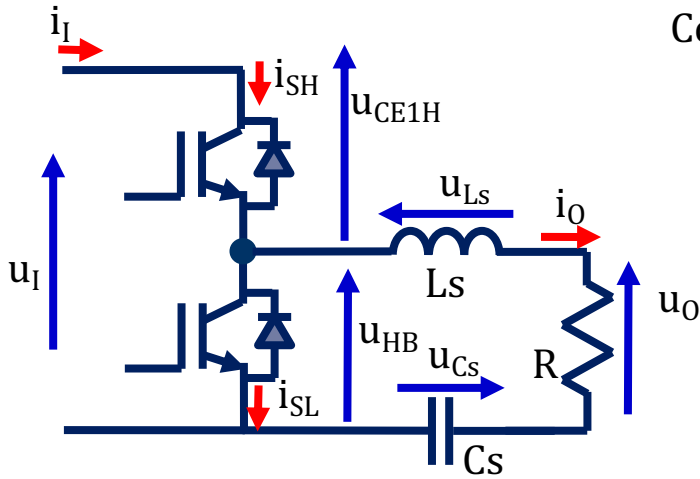


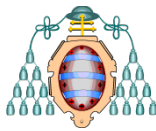
- Consider inductive load (i_o constant during switching period)
- **At Switch SH turn off, some losses at the transistor SH.**
- **At Switch SH turn on, higher losses at SH.**
- **Very Low losses at SL (ZVS).**
- **The opposite situation happens if $i_o < 0$ (bidirectional converter)**





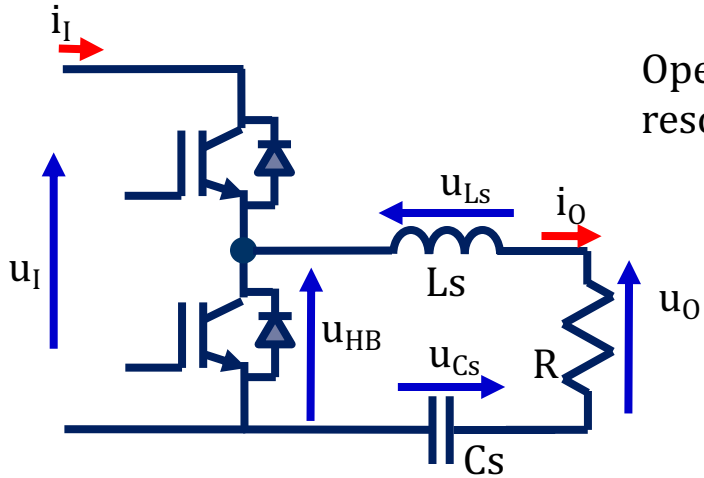
RESONANT SWITCHING HALF-BRIDGE, RESISTIVE BEHAVIOUR



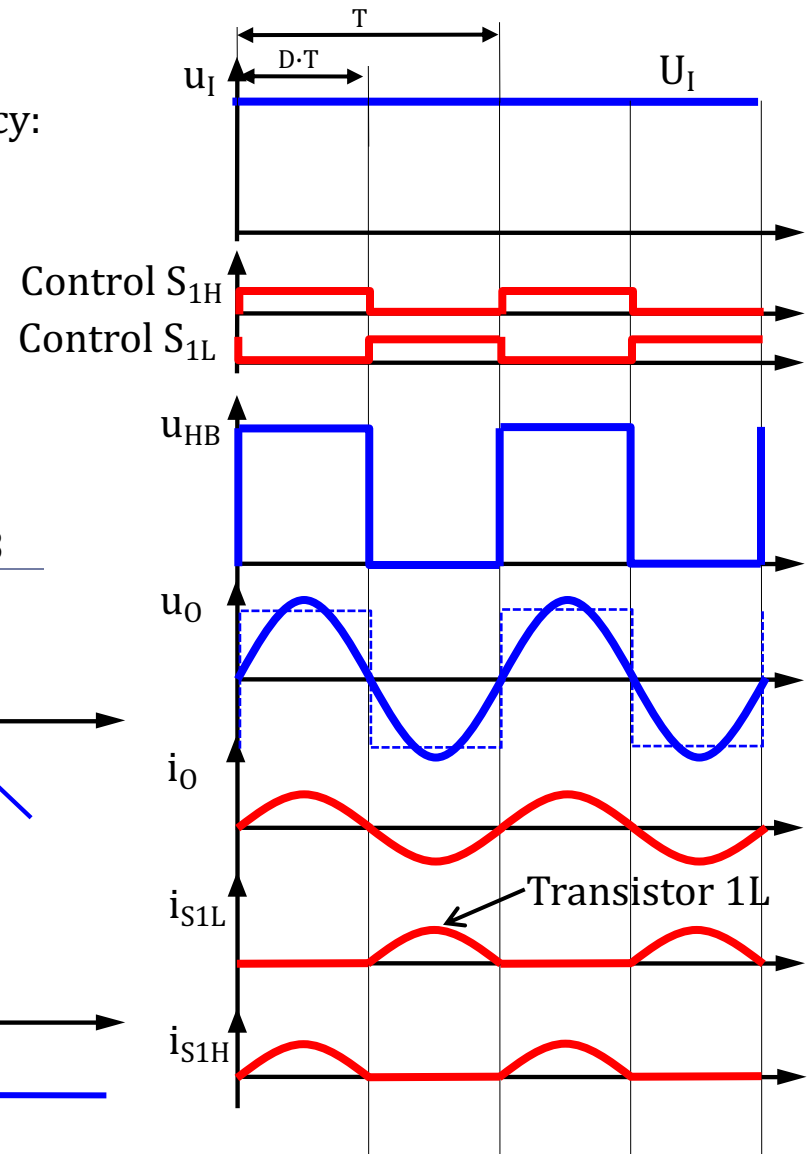
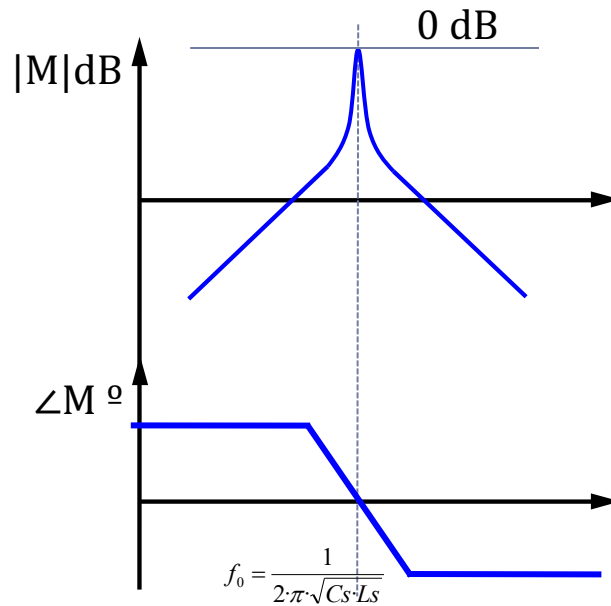


The HB inverter

Operation at resonant frequency:

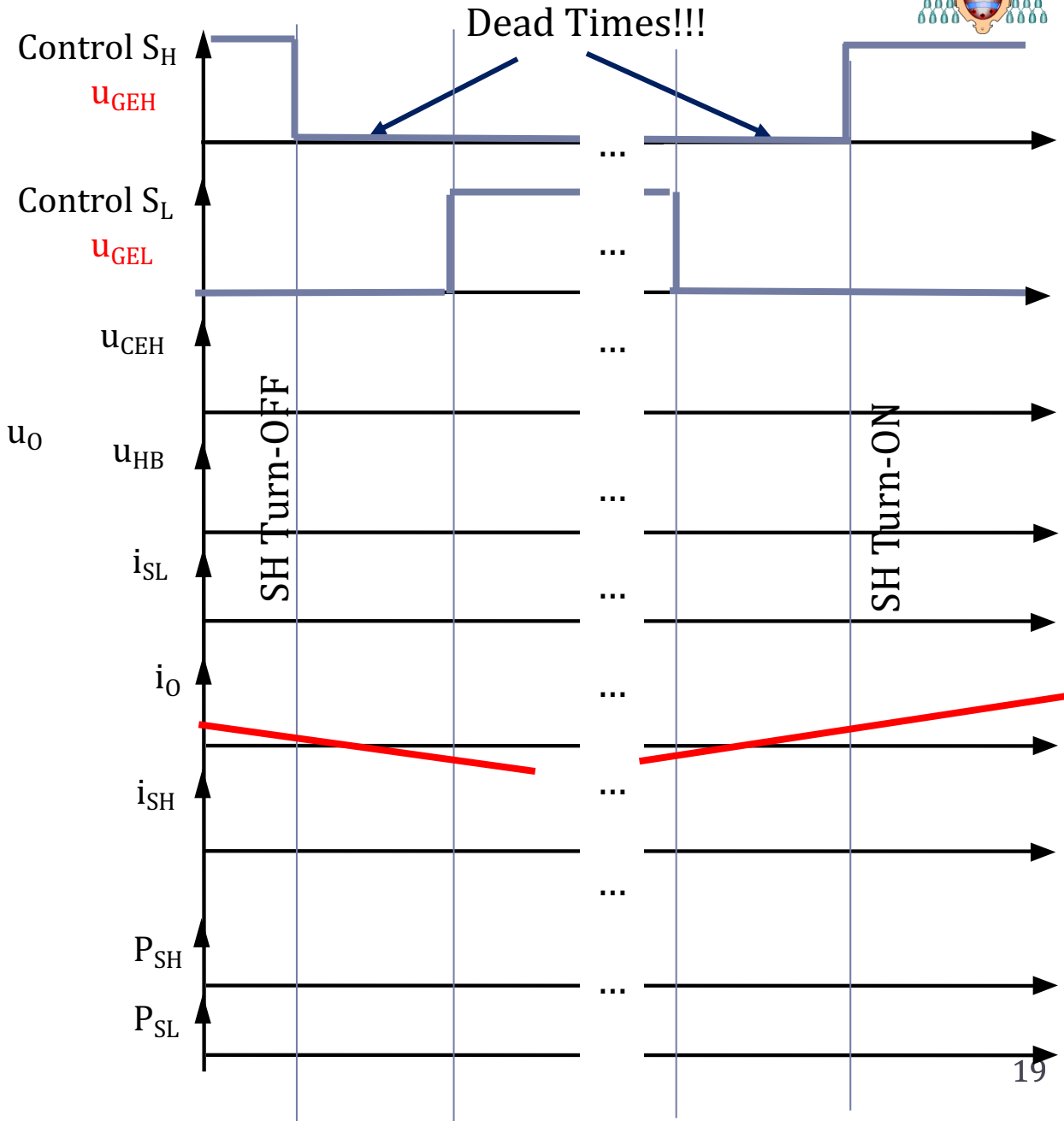
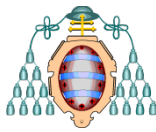
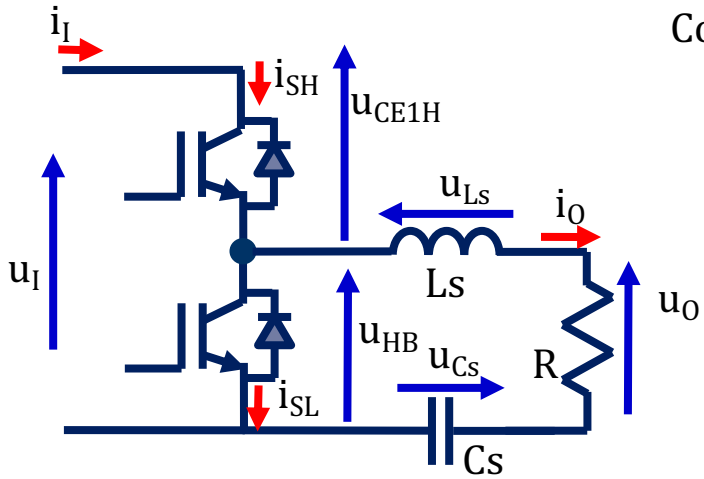


- Selective Filter: Only the harmonics close to f_0 are present at the load!!!!
- DC component also filtered.



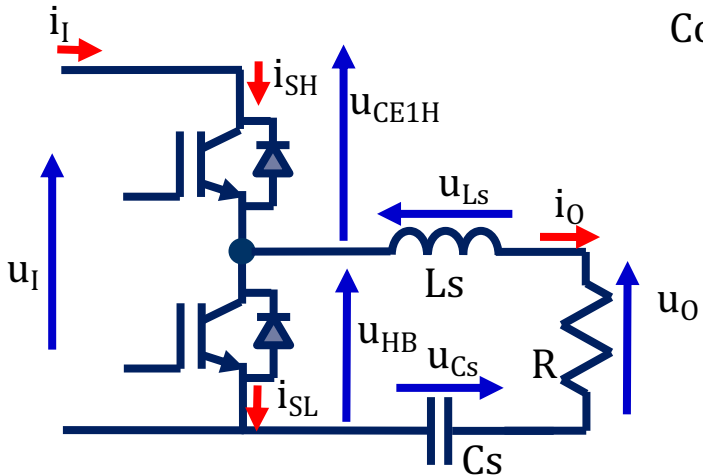


RESONANT SWITCHING HALF-BRIDGE, RESISTIVE BEHAVIOUR



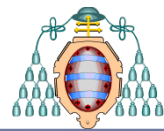
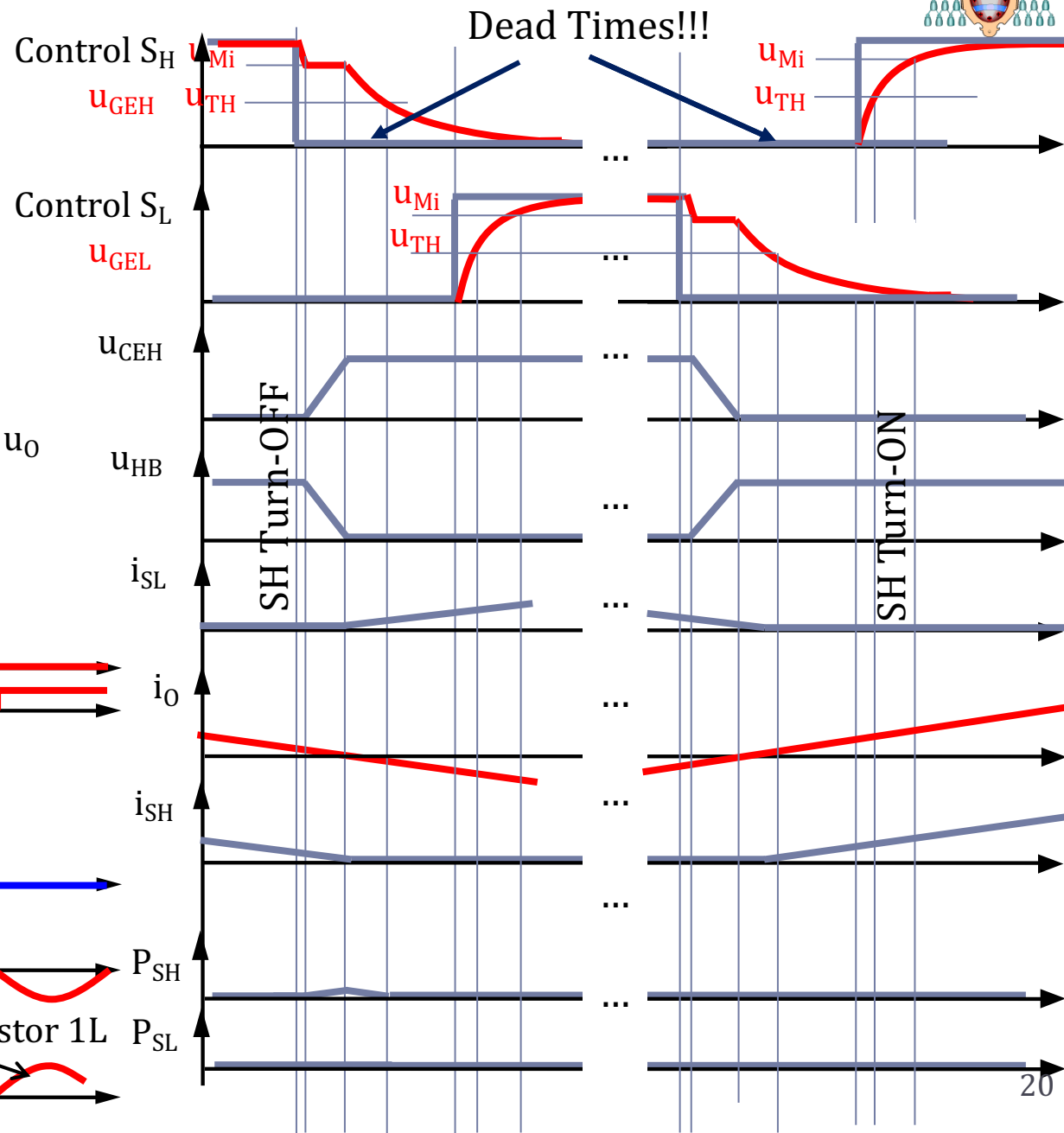


RESONANT SWITCHING HALF-BRIDGE, RESISTIVE BEHAVIOUR



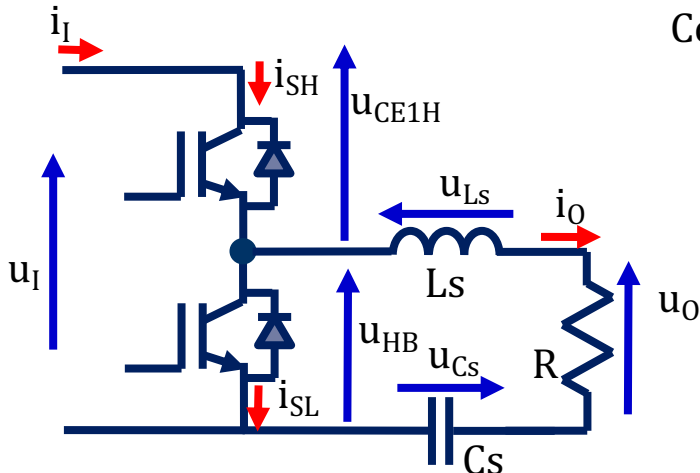
Current evolves naturally to zero just when the transistor is turned off/on

OVERALL LOSSES MUCH LOWER (increase design frequency up to MHz)





RESONANT SWITCHING HALF-BRIDGE, INDUCTIVE BEHAVIOUR



Current evolves naturally to zero just when the transistor is turned off/on

OVERALL LOSSES MUCH LOWER (increase design frequency up to MHz)

