Power Electronics Lab (EE39006)

Autumn Semester 2021-22

Department of Electrical Engineering, IIT Kharagpur

Experiment-3

Title: Study of Thyristor (SCR) based Buck Converter consisting of Class-D Commutation Circuit.

General Instructions:

●Complete simulation model of part-A, and B within the first 1.5 hours. Please send the simulation model with File name: Expt3_Roll No_FirstName in MATLAB 2017a version (those who are using higher version) and submit to MS Teams assignment section within 3:30 PM.

● Complete taking the readings and observation tables from the reference simulation models sent by the TAs within the next 1.5 hours and save in pdf format with File name: Expt3_Roll No_FirstName and submit to the MS Teams assignment section within 5:30 PM.

● Submit the discussion answers with a complete lab report with readings and waveforms in the MS Teams assignment section within 7 days.

Monday Batch

Part-A: Simulate the ideal thyristor based buck converter in open-loop using following parameters, Input Voltage V_i = 1000 V, Output Voltage V_o = 600 V, Switching Frequency Fs = 500 Hz & Ts =1/Fs, Filter Capacitor C_f = 330μF, Filter Inductor L_f = 24mH, Load Resistance R_l = 30Ω, Commutation Capacitor Cc = 3 μF, Diodes and switches drops = 0V. Set the initial voltage of the Cc = +Vi (otherwise it would cause commutation failure)

[1] Choose the commutation inductor L_c in such a way that the peak current through the main thyristor remains at 120 A ($\pm 5\%$ is considerable).

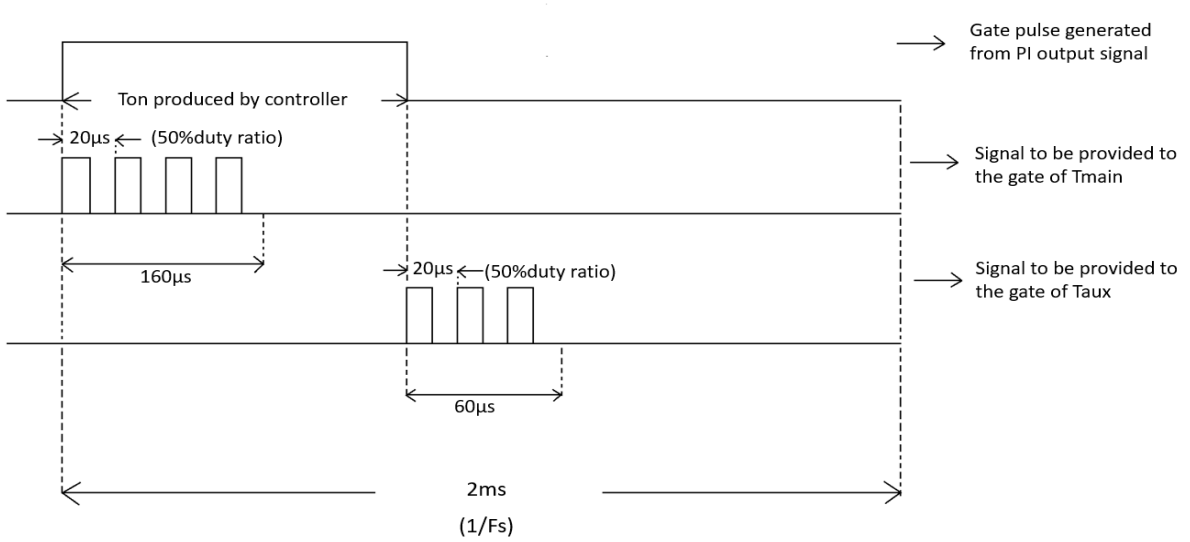
[2] Calculate the theoretical duty cycle value (the T_{on} time for steady state) & incorporate it to trigger both the thyristors in the proper way. Monitor the o/p voltage, whether it is coming 600 V or not. If it's not, then check the actual T_{on} time the main thyristor is having. Manipulate the theoretical T_{on} time (steady state) accordingly & recheck whether the o/p voltage is 600 V or not.

(i) Note the required turn on time manipulation to get 600V output voltage.

(ii) Note the circuit turn-off time of main & auxiliary thyristors.

(iii) Show the waveform of the voltage across the C_c (for 3 switching cycle in steady state).

(iv) For C_c = 1 μF & C_c = 0.2 μF, comment on the commutation failure of main thyristor for both the cases. (in the Simulink commutation failure of the thyristor can't be directly inspected, comment on it by analysing the voltage waveform across the main thyristor) [tq(main thyristor) = 30μs]



Discussion Questions:

1. Why is the commutation circuit required?
2. What will happen if we decrease the switch on period below thyristor turn-off time?
3. Can we use a polarised capacitor as the commutation capacitor (Cc) here? Justify your answer.

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Tuesday Batch

Part-A: Simulate the ideal thyristor based buck converter in open-loop using following parameters, Input Voltage V_i = 800 V, Output Voltage V_o = 480 V, Switching Frequency Fs = 500 Hz & Ts =1/Fs, Filter Capacitor C_f = 330μF, Filter Inductor L_f = 24mH, Load Resistance R_l = 30Ω, Commutation Capacitor Cc = 3 μF, Diodes and switches drops = 0V. Set the initial voltage of the Cc = +Vi (otherwise it would cause commutation failure)

[1] Choose the commutation inductor L_c in such a way that the peak current through the main thyristor remains at 95 A ($\pm 5\%$ is considerable).

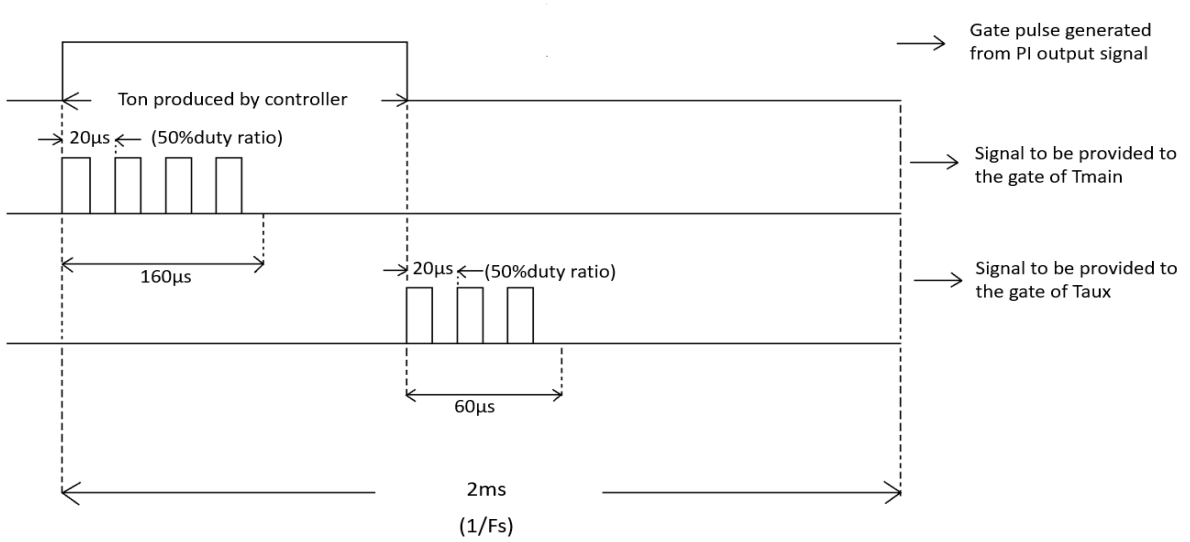
[2] Calculate the theoretical duty cycle value (the T_{on} time for steady state) & incorporate it to trigger both the thyristors in the proper way. Monitor the o/p voltage, whether it is coming 480 V or not. If it's not, then check the actual T_{on} time the main thyristor is having. Manipulate the theoretical T_{on} time (steady state) accordingly & recheck whether the o/p voltage is 480 V or not.

(i) Note the required turn on time manipulation to get 480V output voltage.

(ii) Note the circuit turn-off time of main & auxiliary thyristors.

(iii) Show the waveform of the voltage across the C_c (for 3 switching cycle in steady state).

(iv) For C_c = 1 μF & C_c = 0.2 μF, comment on the commutation failure of main thyristor for both the cases. (in the Simulink commutation failure of the thyristor can't be directly inspected, comment on it by analysing the voltage waveform across the main thyristor) [tq (main thyristor) = 30μs]



Discussion Questions:

1. What are the advantages and disadvantages of thyristor based buck converter over MOSFET based buck converter?
2. What will happened if the commutation capacitor voltage remains at zero throughout the operation?
3. While operating in an open-loop, why did we need to manipulate the Ton time of the converter to get desired o/p voltage?

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Wednesday Batch

Part-A: Simulate the ideal thyristor based buck converter in open-loop using following parameters, Input Voltage V_i = 600 V, Output Voltage V_o = 360 V, Switching Frequency Fs = 500 Hz & Ts =1/Fs, Filter Capacitor C_f = 330μF, Filter Inductor L_f = 24mH, Load Resistance R_l = 30 Ω, Commutation Capacitor Cc = 4.7 μF, Diodes and switches drops = 0V. Set the initial voltage of the Cc = +Vi (otherwise it would cause commutation failure)

[1] Choose the commutation inductor L_c in such a way that the peak current through the main thyristor remains at 75 A ($\pm 5\%$ is considerable).

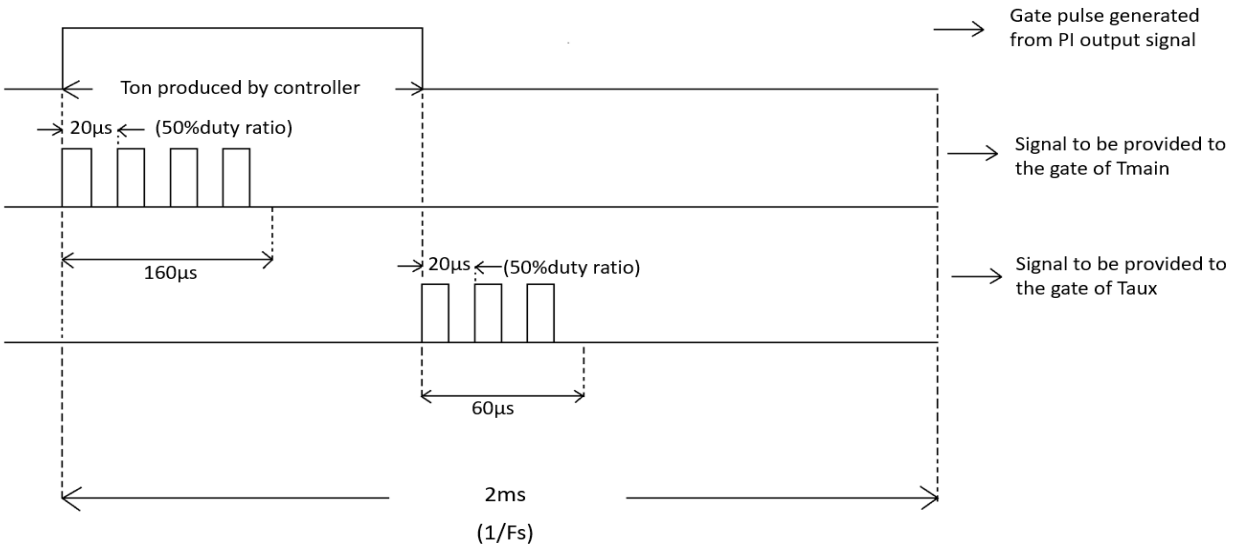
[2] Calculate the theoretical duty cycle value (the T_{on} time for steady state) & incorporate it to trigger both the thyristors in the proper way. Monitor the o/p voltage, whether it is coming 360 V or not. If it's not then check the actual T_{on} time the main thyristor is having. Manipulate the theoretical T_{on} time (steady state) accordingly & recheck whether the o/p voltage is 360 V or not.

(i) Note the required turn on time manipulation to get 360V output voltage.

(ii) Note the circuit turn-off time of main & auxiliary thyristors.

(iii) Show the waveform of the voltage across the C_c (for 3 switching cycle in steady state).

(iv) For C_c = 1 μF & C_c = 0.2 μF, comment on the commutation failure of main thyristor for both the cases. (in the Simulink commutation failure of the thyristor can't be directly inspected, comment on it by analysing the voltage waveform across the main thyristor) [tq(main thyristor) = 30μs]



Discussion Questions:

1. Explain the phenomenon if commutating thyristor is not fired properly.
2. If the circuit turn-off time is 100 microseconds. What can be the maximum switching frequency (assuming the minimum duty ratio is 0.2)?
3. What is the reason behind feeding pulse trains instead of continuous pulses or just a single pulse to the thyristor?