ECE 4643: Power Electronics

Laboratory 2: AC-DC Controlled Power Electronic Converters

Objectives

The main objectives of this experiment are to investigate the performances of 1ϕ and 3ϕ full-wave controlled (thyristor-based) rectifiers when supplying different load types. The target performances include harmonic contents on the input and output sides of the converter, input power factor, controllability of the output DC voltage, and efficiency.

Review

AC-DC full-wave (bridge) controlled rectifiers offer converting AC voltages and currents into adjusted DC ones through sequential ON and OFF actions of groups of thyristors. These sequential ON and OFF actions performed by thyristors are of a single-pulse nature, that is the ON action is controlled through delaying the switching pulse of each thyristor, while the OFF action is determined by the natural (line) commutation. AC-DC controlled (1ϕ and 3ϕ) converters are non-linear due the fact that their inputs are sinusoidal voltages, but their input currents have distorted sinusoidals. The AC-DC bridge controlled rectifiers are constructed from power rated thyristors, which requires critical synchronization of the switching pulses. Such a requirement is critical since activating the thyristor is the control that can be employed (the OFF is made by line commutation). Finally, as per the latest standards and industrial codes, any power electronic converter (PEC) (1ϕ or 3ϕ) has to be connected to grid through a transformer. This mandate is made to reduce possible harmonic distortion on the grid side. In addition, the transformer can offer isolating the grid from the PEC, especially during faults on either side of the transformer. Such a transformer is commonly called *the grid-connection transformer*.

CAUTION:

Do not connect or disconnect any component, supply, device while the power switch is on.

Description of the Circuit

Instruments and Components

- AC variable voltage supply: In the lab bench with $ON - OFF$ switch, output pins 4, 5, 6 for 3ϕ supply;
- Resistive load (as a static load);
- Transformer (for 1ϕ and 3ϕ configuration);
- The DC machine configured as a shunt DC motor (as a dynamic load);
- 3ϕ thyristor AC-DC converter;
- The thyristor AC-DC converter firing angle controller;
- Connection Leads (different lengths);
- The LabVolt Data Acquisition Module (DAM)

Experimental Work

The AC-DC bridge 1ϕ and 3ϕ controlled rectifiers for this laboratory work are to be constructed using the controlled AC-DC converter module. The firing angle are generated by the firing angle module.

The 1ϕ ***Full-Wave Controlled Rectifier***

STEP 1: Construct the circuit shown in Figure 1.

STEP 2: Connect and prepare the data acquisition module (DAM) unit. Also, connect the converter module with the firing angle unit (remember to select 1ϕ).

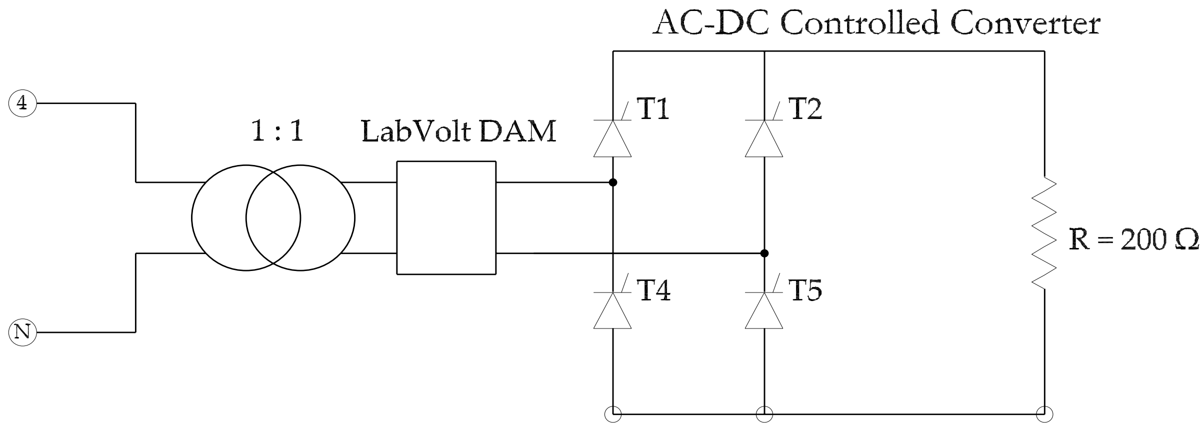

Figure 1: The 1ϕ full-wave controlled rectifier and both load types.

STEP 3: Connect the input voltage and current through the DAM. Also, connect the output voltage and current through the DAM unit.

STEP 4: Switch ON the power Supply, and increase the supply voltage to 60 V.

STEP 5: Using the metering feature of DAM, measure the input current, active power and reactive powers, and output DC voltage, current and active power. Complete the data in Table 1. Note that input PF, HF, η need to be calculated.

Table 1: *DATA FOR THE* 1ϕ *FULL-WAVE CONTROLLED RECTIFIER.*

α	$(I_A)_{rms}$	P_{in}	Q_{in}	V_{dc}	I_{dc}	P_{dc}	PF	HF	η
0									
30									
60									
90									
120									
150									
180									

STEP 6: for $\alpha = 90$, observe and record the waveforms of the input voltage and current, as well as the the output voltage and current. Save an image for each spectrum, and

attach it to your report

STEP 7: Decrease the supply voltage to 0 V, and switch OFF the power Supply.

The 3ϕ Full-Wave Controlled Rectifier

STEP 1: Construct the circuit shown in Figure 2.

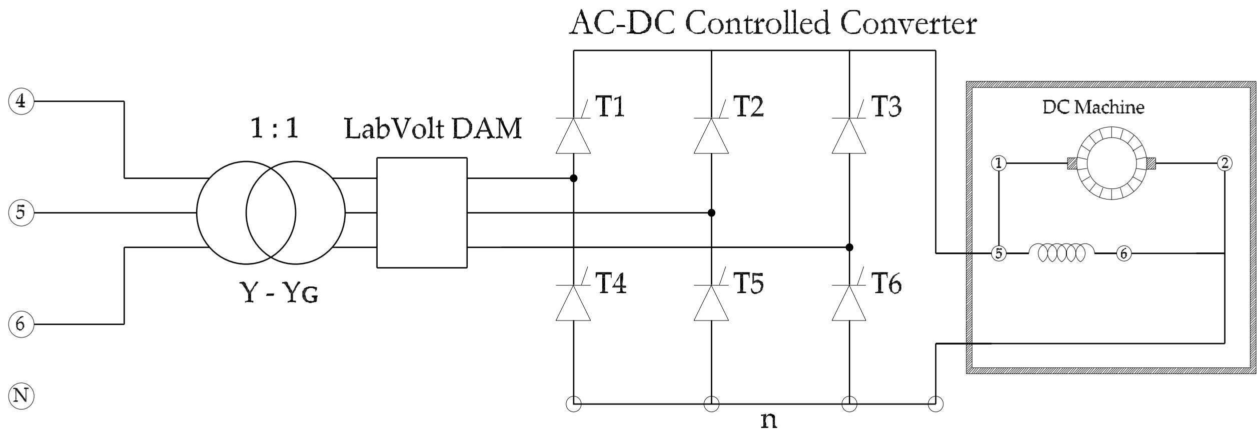

Figure 2: The 3ϕ full-wave controlled rectifier and load.

STEP 2: Connect and prepare the data acquisition module (DAM) unit. Also, connect the converter module with the firing angle unit (remember to select 3ϕ).

STEP 3: Connect the input voltage and current through the DAM. Also, connect the output voltage and current through the DAM unit.

STEP 4: Switch ON the power Supply, and increase the supply voltage to 110 V.

STEP 5: Using the metering feature of DAM, measure the input current, active power and reactive powers ($P_1 + P_2 + P_3$, and $Q_1 + Q_2 + Q_3$), and output DC voltage, current and active power. Complete the data in Table 2. Note that input PF, HF, η need to be calculated.

Table 2: *DATA FOR THE 3ϕ FULL-WAVE CONTROLLED RECTIFIER.*

α	$(I_A)_{rms}$	$(P_{in})_{3\phi}$	$(Q_{in})_{3\phi}$	V_{dc}	I_{dc}	P_{dc}	PF	HF	η
0									
30									
60									
90									
120									

STEP 6: for $\alpha = 60$, observe and record the waveforms of the input voltage and current, as well as the the output voltage and current. Save an image for each spectrum, and attach it to your report

STEP 7: Decrease the supply voltage to 0 V, and switch OFF the power Supply.

STEP 8: Decrease the supply voltage to 0 V, and switch OFF the power Supply.

Calculations and Questions

Q1– From the data in Table 1, create graphs for α vs V_{dc}, α vs PF, and α vs η.

Q2– Comment on the graphs created in Q1.

Q3– From the data in Table 2, create graphs for α vs V_{dc}, α vs PF, and α vs η.

Q4– Comment on the graphs created in Q3.

Conclusions

The last part of the report has to be the conclusions. In this part, has to be a summary of the observations made during the experimental work. Also, it should reflect on the agreement or disagreement between the theoretical (calculated) and measured values.