EE4643: Power Electronics

Laboratory 1: AC-DC Uncontrolled Power Converters

Objectives

The main objectives of this experiment are to investigate the performances of 1ϕ and 3ϕ full-wave rectifiers when supplying different load types. The target performances include harmonics on the input and output sides of the converter, input power factor, and efficiency of the tested AC-DC rectifiers.

Review

AC-DC full-wave (bridge) rectifier circuits provide convert AC voltages and currents into DC ones through sequential ON and OFF actions of groups of power diodes. These sequential ON and OFF actions of the used power diodes take place without any control of their start or end. In general, AC-DC converters are non-linear in their nature due the fact that their input is sinusoidal voltages, but their input current is a distorted sinusoidal one. Their features and operational characteristics of AC-DC converters are helpful in providing general insight of practical more complicated power electronic converters that are employed in different industrial applications. AC-DC bridge rectifiers are constructed from power rated diodes commonly described by its two states ON (or forward-conducting) and OFF (reverse-blocking). Such features can be simply viewed as: If a forward current flow is attempted, the diode will turn on, and will exhibit only a small residual voltage drop, while, if reverse current flow is attempted, the diode will turn off and only a minuscule residual current will flow. 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 and/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 converters for this laboratory work are to be obtained using the controlled AC-DC converter module. The module is constructed from thyristors, and their firing angle are generated by the firing angle module. However, recall that setting the firing angle $\alpha = 0$ makes a thyristor behave like a diode. Finally, this laboratory work will investigate both 1ϕ and 3ϕ full bridge rectifiers, which will be constructed using the same module with a firing angle $\alpha = 0$.

The 1ϕ Full-Wave Rectifier

STEP 1: Construct the circuit shown in Figure 1.

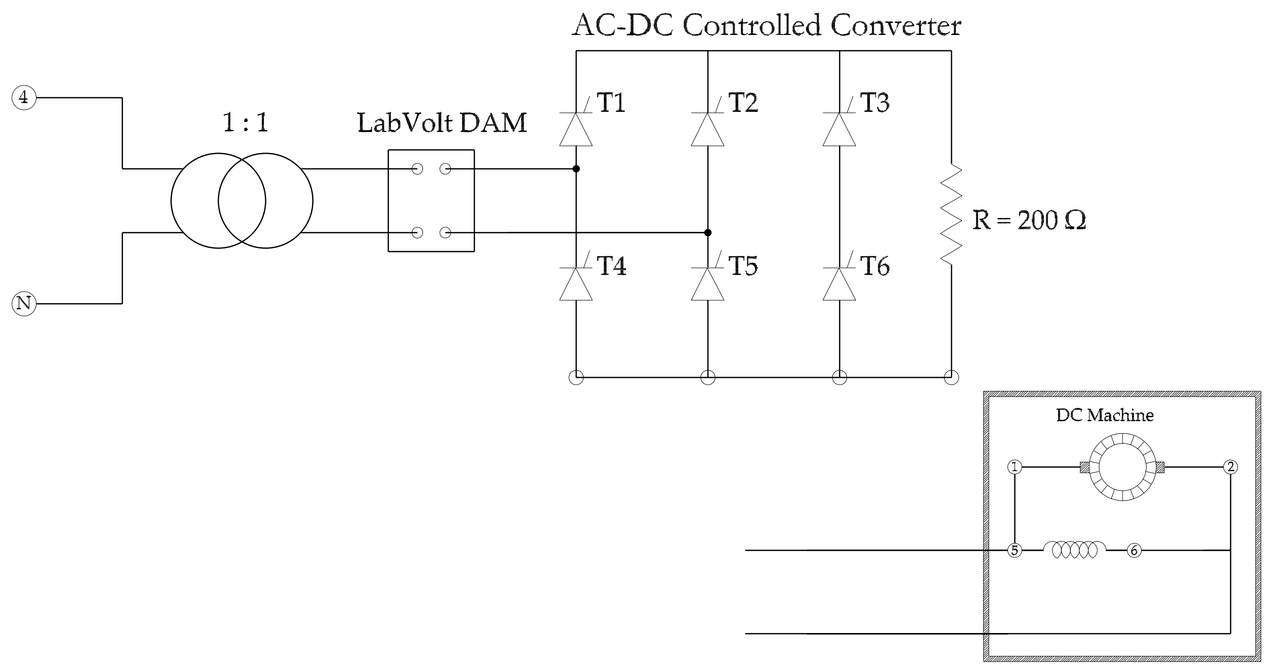

Figure 1: The 1ϕ full-wave rectifier and both load types.

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), and set the firing angle to $\alpha = 0$.

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: 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 6: Using the DAM measure the input active and reactive powers, along with the output active power.

STEP 7: Using the DAM, obtain and record spectra for the input current, output voltage, and output current. Save an image for each spectrum, and attach it to your report.

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

STEP 9: Disconnect the resistive load form the output side of the converter, and connect the DC motor.

STEP 10: Switch ON the power supply, and increase the voltage slowly to 110 V.

STEP 11: Repeat the previous measurements.

STEP 12: Decrease the supply voltage to 0 V, and switch OFF the power Supply.

The 3ϕ ***Full-Wave Rectifier***

STEP 1: Construct the circuit shown in Figure 2.

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), and set the firing angle to $\alpha = 0$.

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

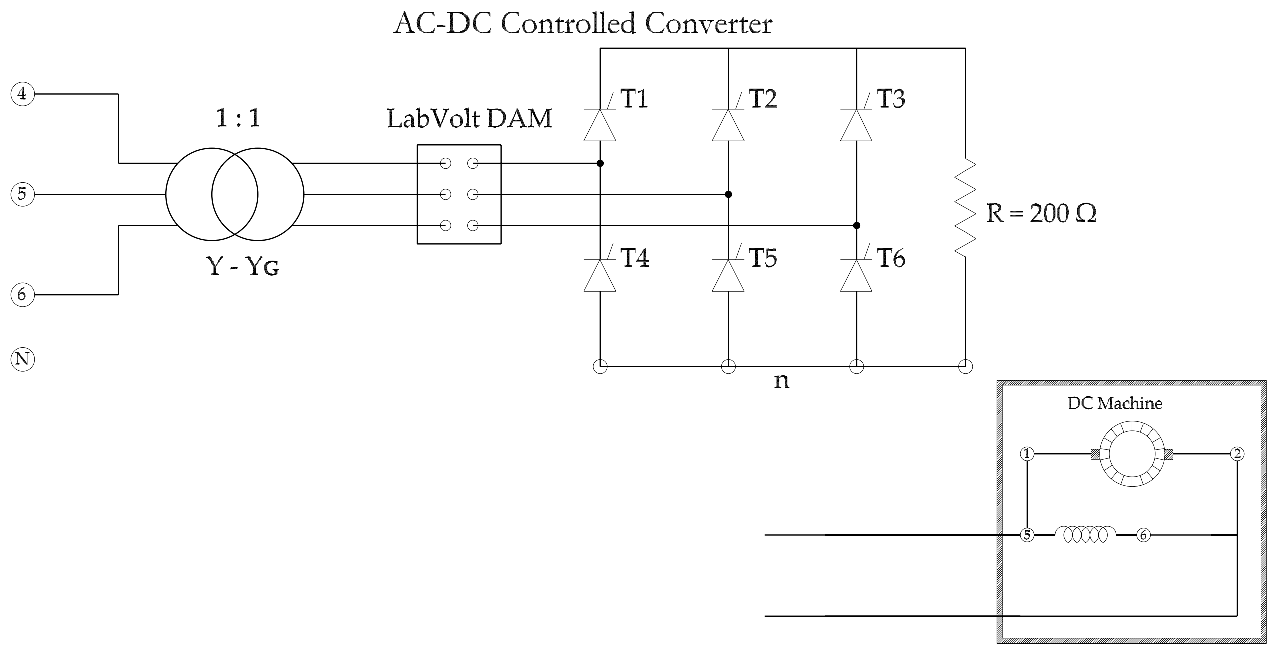

Figure 2: The 3ϕ full-wave rectifier and both load types.

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

STEP 5: Observe and record the waveforms of the input voltage (V_{AN} and current I_A, as well as the the output voltage and current. Save an image for each spectrum, and attach it to your report

STEP 6: Using the DAM measure the total input active and reactive powers ($P_1 + P_2 + P_3$, and $Q_1 + Q_2 + Q_3$), along with the output active power.

STEP 7: Using the DAM, obtain and record spectra for the input current I_A, output voltage, and output current. Save an image for each spectrum, and attach it to your report.

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

STEP 9: Disconnect the resistive load form the output side of the converter, and connect the DC motor.

STEP 10: Switch ON the power supply, and increase the voltage slowly to 110 V.

STEP 11: Repeat the previous measurements.

STEP 12: Decrease the supply voltage to 0 V, and switch OFF the power Supply.

Calculations and Questions

Q1– Calculate the input power factor for both 1ϕ and 3ϕ converters for both load types.

Q2– Calculate the efficiency as:

$$\eta = \frac{P_{dc}}{P_{in}}$$

for both 1ϕ and 3ϕ converters for both load types.

Q3– Compare the the efficiency of the 1ϕ and 3ϕ rectifiers and comment on the impact of load type on the obtained efficiency values.

Q4– Calculate the power losses for both 1ϕ and 3ϕ converters for both load types.

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.