ECE 4643

Power Electronics

Laboratory : 1

AC-DC Uncontrolled Power Converter

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1 Objective

The objective of this experiment is to investigate the performance of single phase and three phase full wave rectifiers while supplying different load types. We will investigate the input and output harmonics of the AC-DC converter. We will record the efficiency of the system as well as the power factor of the full wave rectifier for the 1ϕ and 3ϕ systems.

2 1ϕ full wave rectifier

The circuit for the $1\,\phi$ full wave rectifier used in the lab is given in the Figure 1. In this experiment the DAM is used to monitor and record the input output voltages and current. The power and reactive power reading is also recorded from the DAM. Different harmonics for both input and output will be observed for both voltages and currents, which is expected due to the diodes involved in the rectification process. The experiment will be first conducted using a $200\,\Omega$ pure resistive load. Later, the resistive will be removed and it will be replaced using a DC motor. In the case of the resistive load the input voltage has to be increased to $60\,\mathrm{V}$ from $0\,\mathrm{V}$.While for the DC motor the input voltage is increased to a value of $110\,\mathrm{V}$

For the $1\,\phi$ full wave rectifier, the circuit is setup in the following configuration

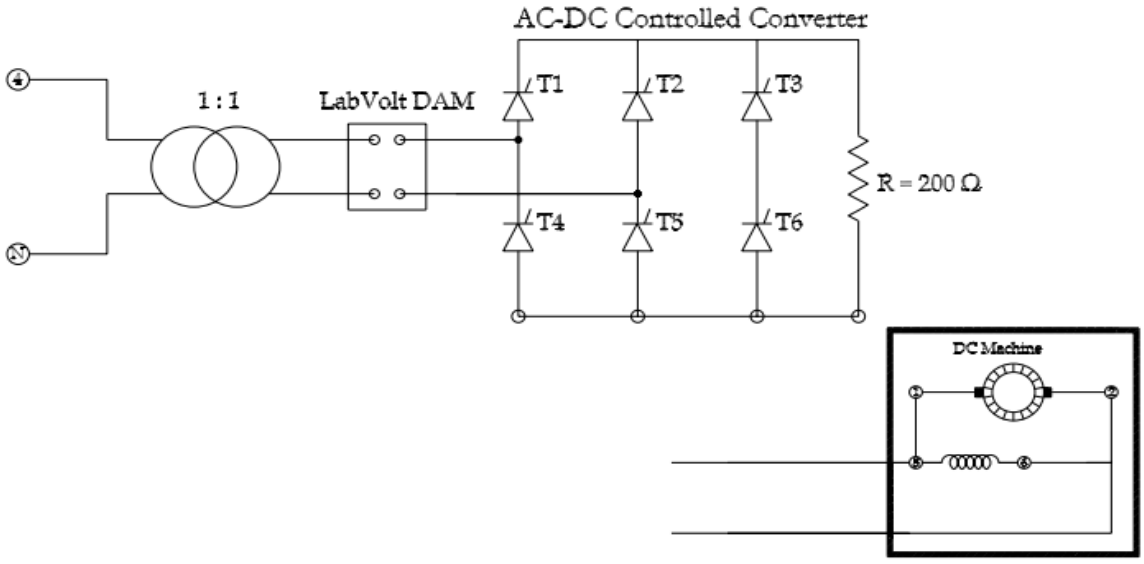

Figure 1: $1\,\phi$ full wave rectfier

2.1 Voltage and Current waveforms

2.1.1 200 Ω

Input voltage vs the input current waveform for the 200 Ω is given in the following figure.

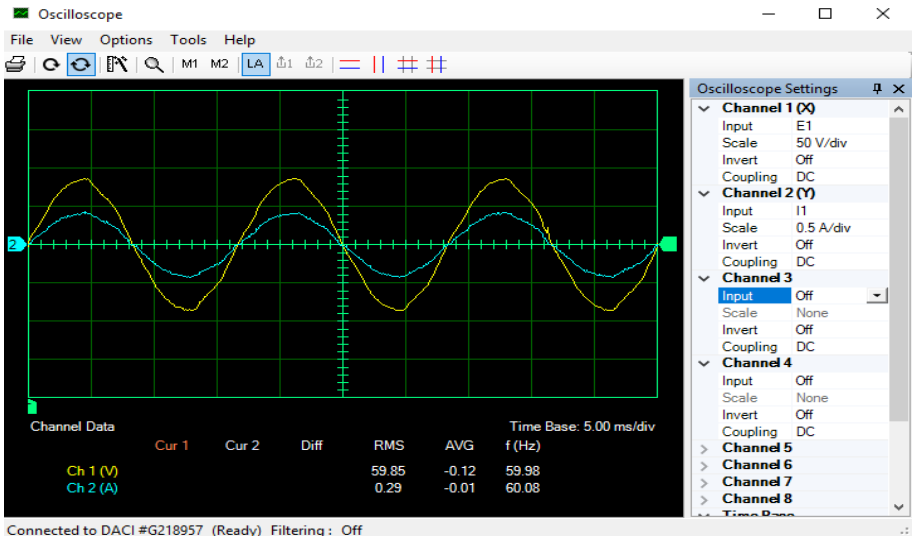

Figure 2: V_{in} vs I_{in} for 200 Ω

Output voltage vs the output current waveform for the 200 Ω is given in the following figure.

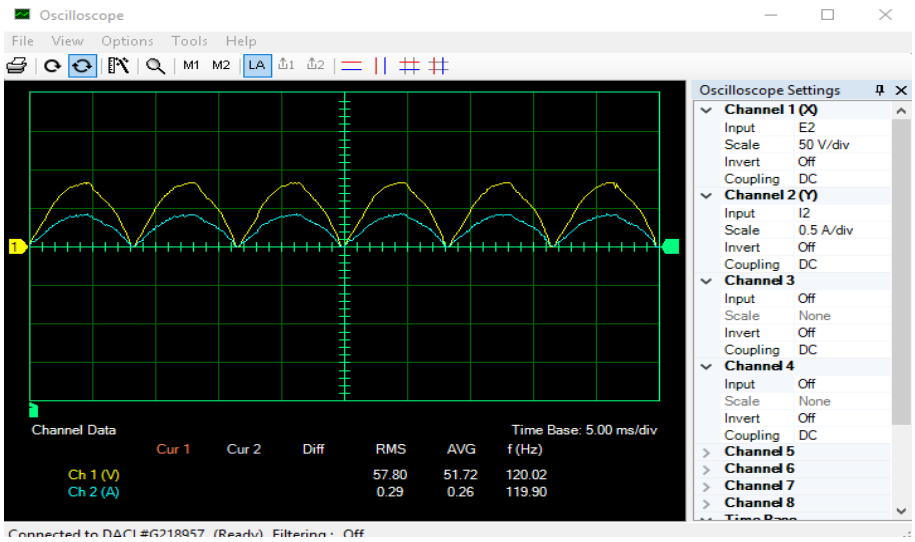

Figure 3: V_{out} vs I_{out} for 200 Ω

2.1.2 DC motor

Input voltage vs the input current waveform for the DC motor is given in the following figure.

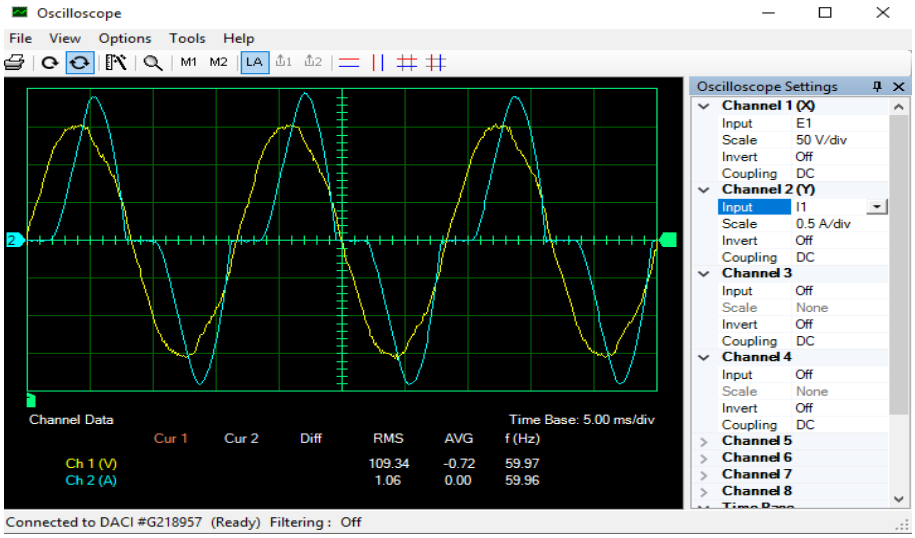

Figure 4: V_{in} vs I_{in} for DC motor

Output voltage vs the output current waveform for the DC motor is given in the following figure.

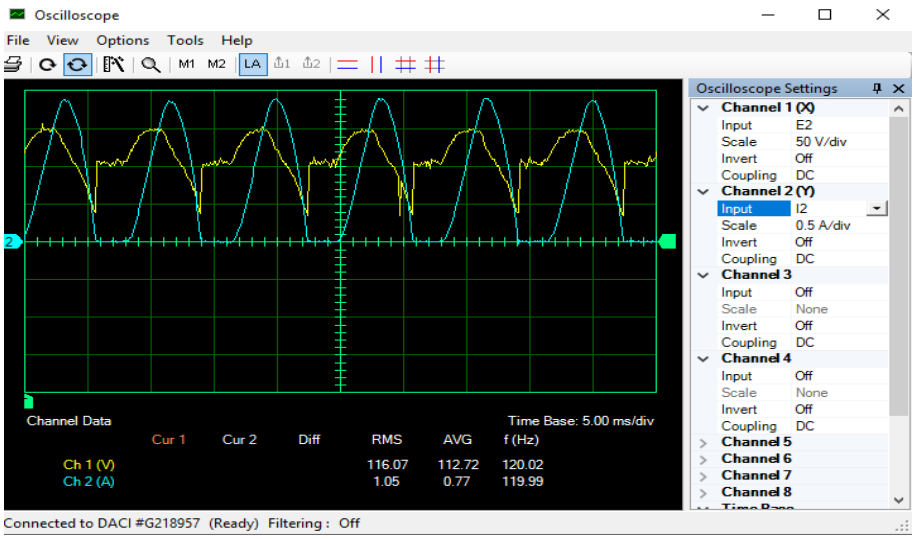

Figure 5: V_{out} vs I_{out} for DC motor

2.2 Harmonic Analysis of the waveforms

2.2.1 200 Ω

Harmonic analysis for the input voltage in the case of 200 Ω

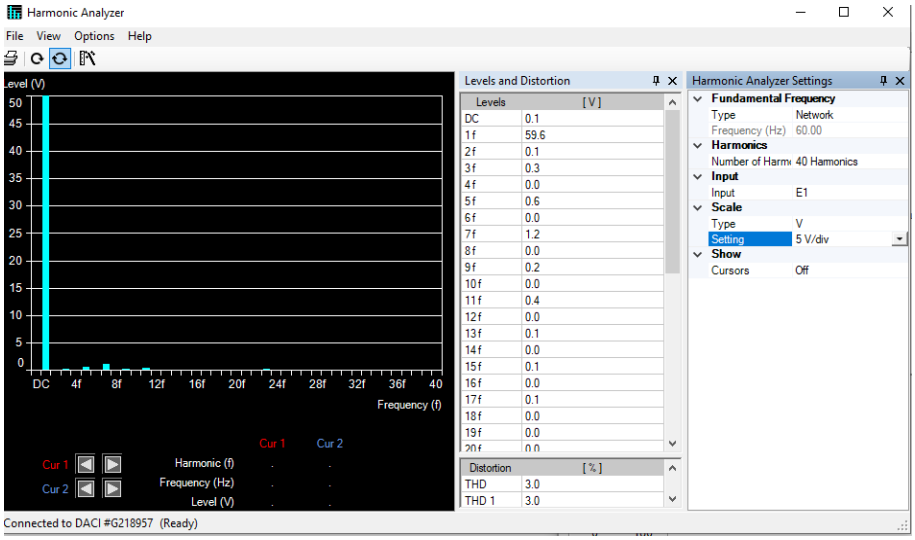

Figure 6: V_{in} Harmonics for 200 Ω

Harmonic analysis for the output voltage in the case of 200 Ω

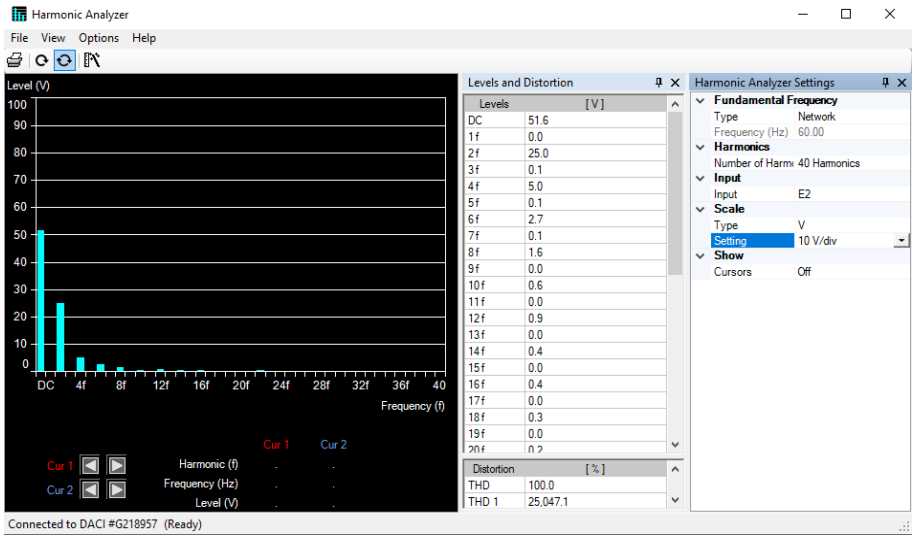

Figure 7: V_{out} Harmonics for 200 Ω

Harmonic analysis for the input current in the case of 200 Ω

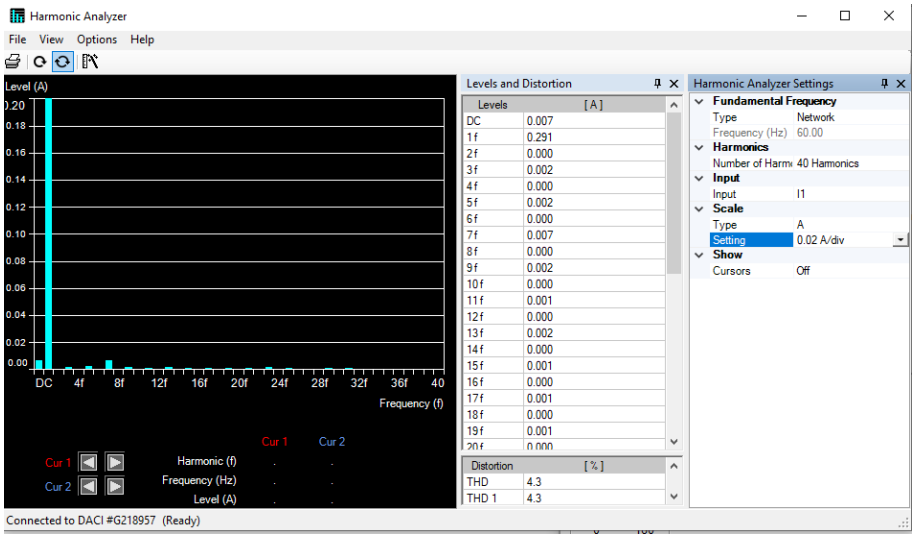

Figure 8: I_{in} Harmonics for 200 Ω

Harmonic analysis for the output current in the case of 200 Ω

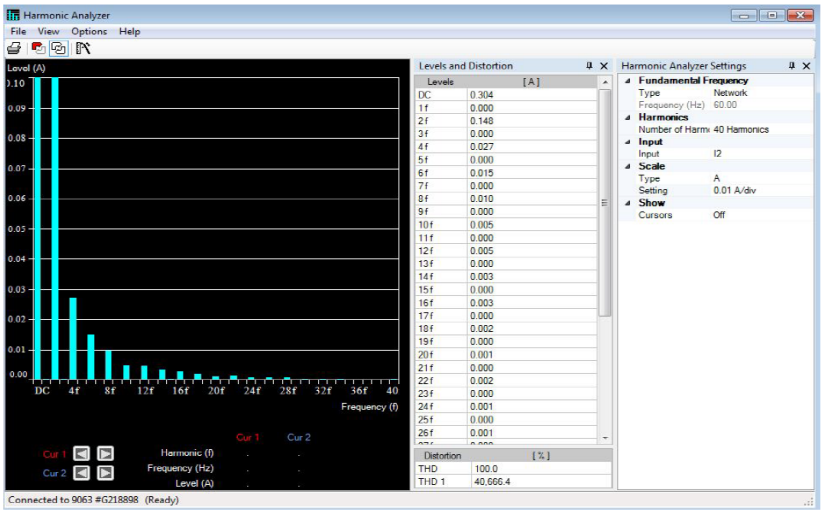

Figure 9: I_{out} Harmonics for 200 Ω

2.2.2 DC motor

Harmonic analysis for the input voltage in the case of DC motor

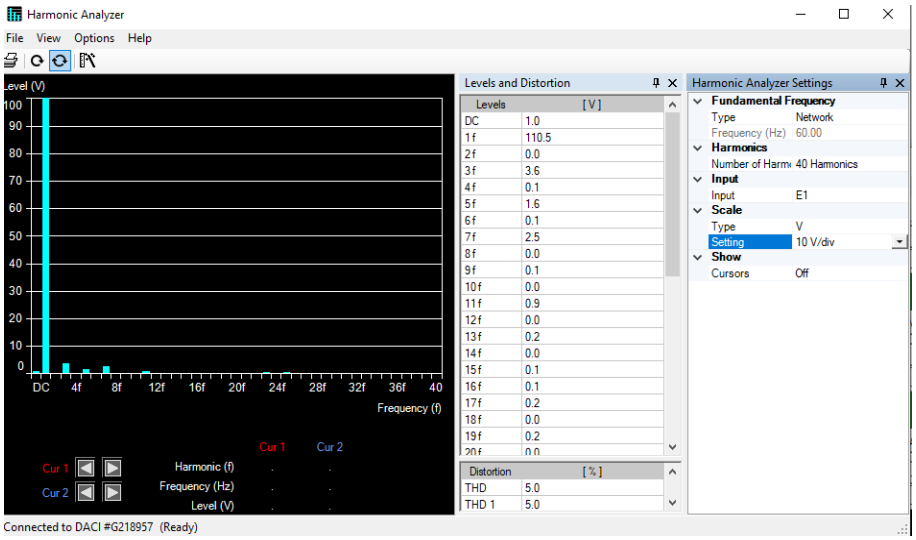

Figure 10: V_{in} Harmonics for DC motor

Harmonic analysis for the output voltage in the case of DC motor

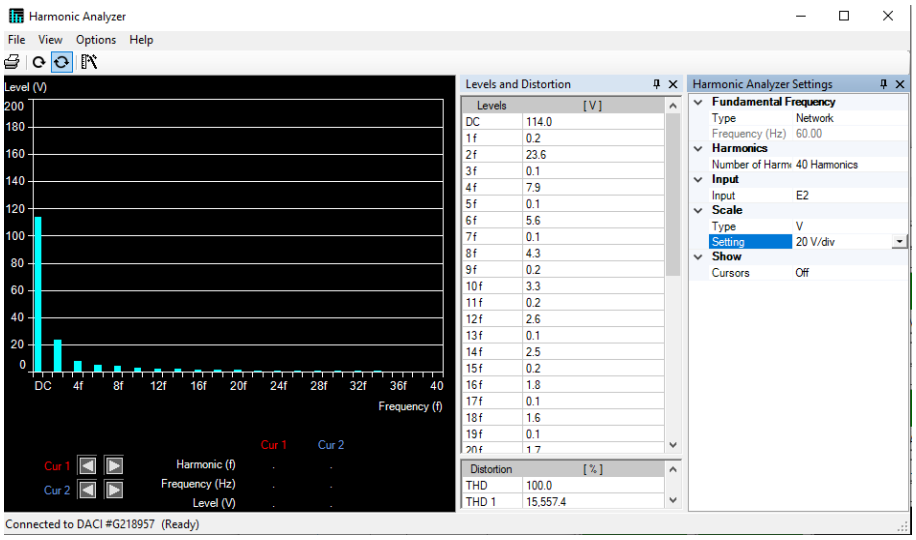

Figure 11: V_{out} Harmonics for DC motor

Harmonic analysis for the input current in the case of DC motor

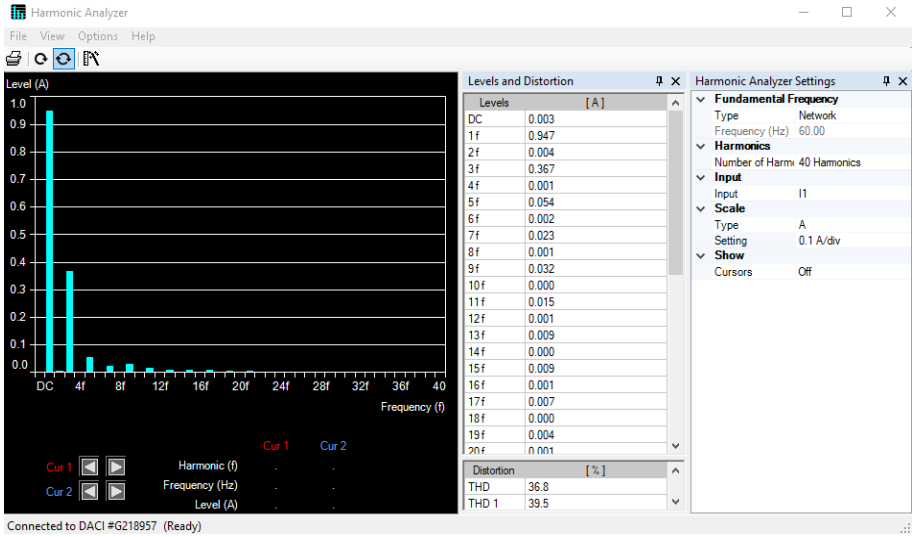

Figure 12: I_{in} Harmonics for DC motor

Harmonic analysis for the output current in the case of DC motor

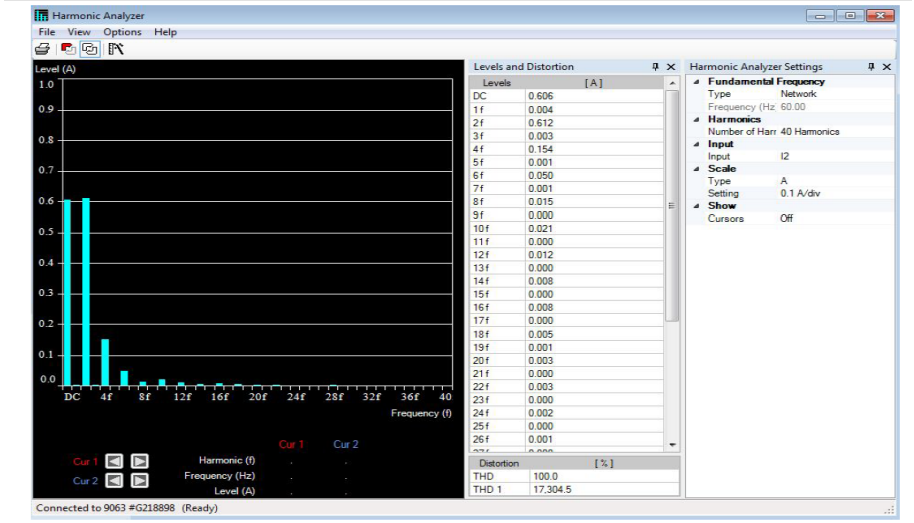

Figure 13: I_{out} Harmonics for DC motor

3 3ϕ full wave rectifier

The circuit for the 3ϕ full wave circuit is taken from the lab manual and given in the page below. The circuit is connected as shown in the figure below. Using the DAM we will monitor the input and output waveforms and harmonics of the voltage and load. The experiment will be conducted as the same as previous. It will be repeated for a 200 Ω and then later for a DC motor.

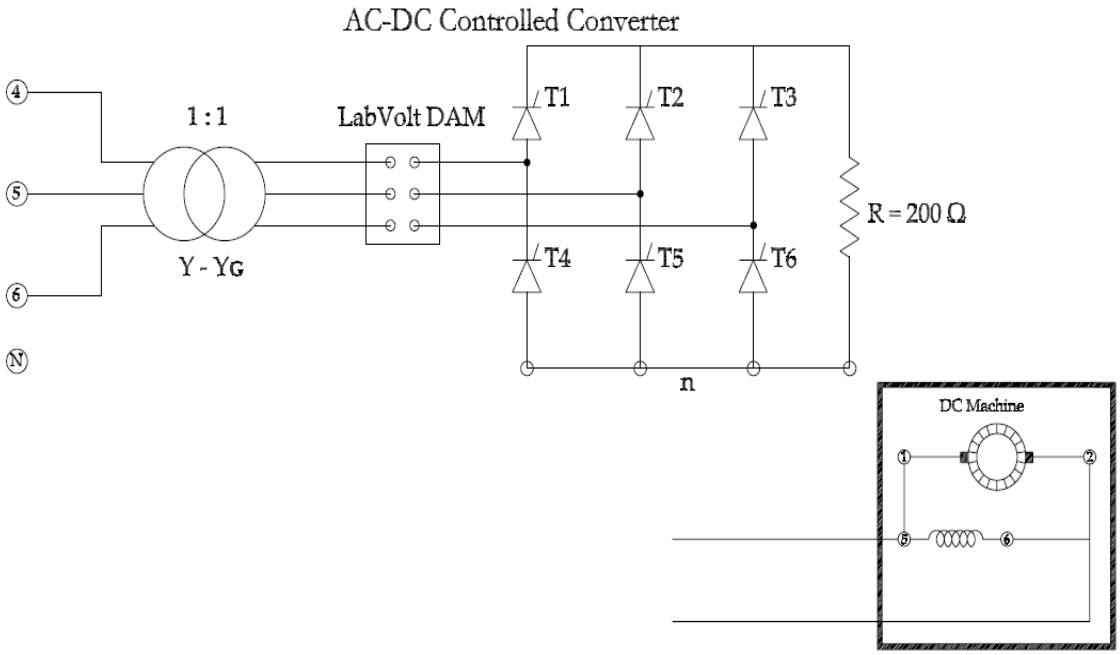

Figure 14: 3ϕ Full wave rectifier

3.1 Voltage and Current waveforms

3.1.1 200 Ω

Input voltage vs the input current waveform for the 3ϕ circuit with the 200 Ωis given in the following figure.

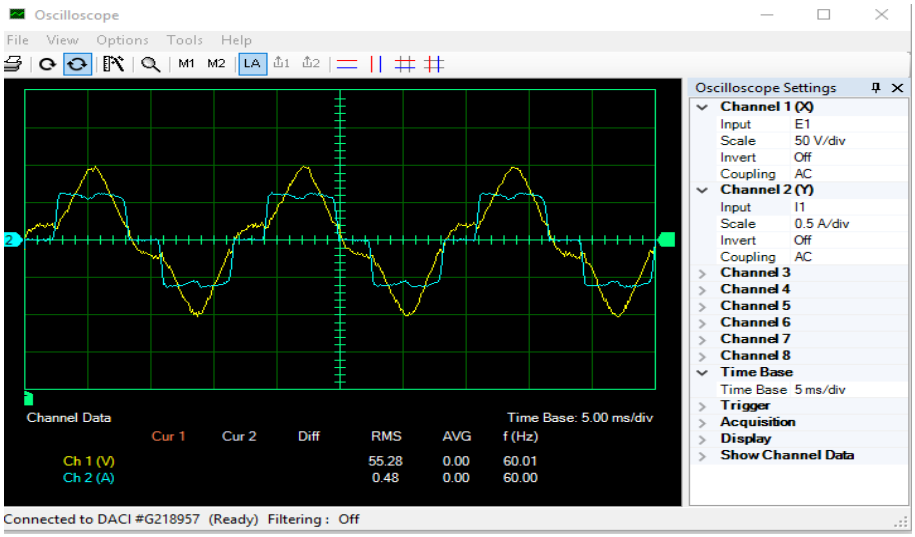

Figure 15: V_{in} vs I_{in} for 200 Ω

Output voltage vs the output current waveform for the 3ϕ 200 Ω is given in the following figure.

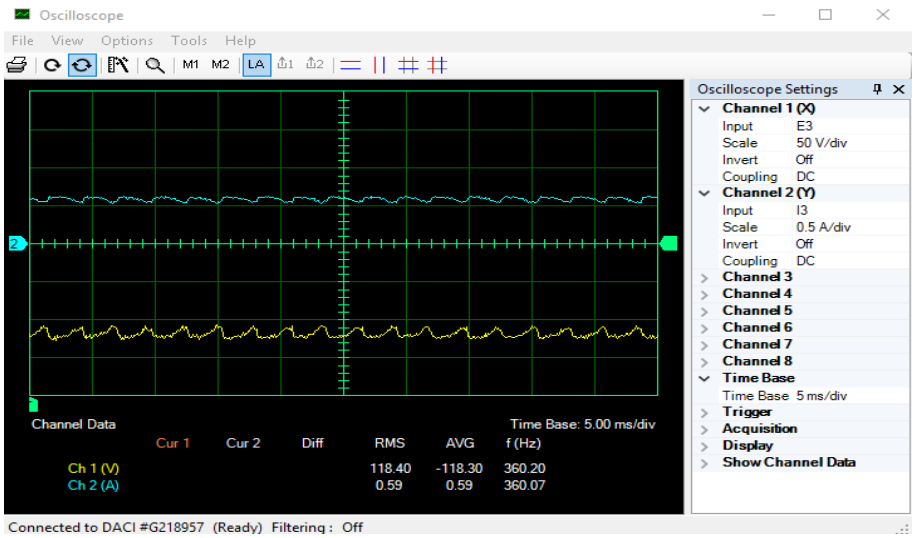

Figure 16: V_{out} vs I_{out} for 200 Ω

3.1.2 DC motor

Input voltage vs the input current waveform for the DC motor is given in the following figure.

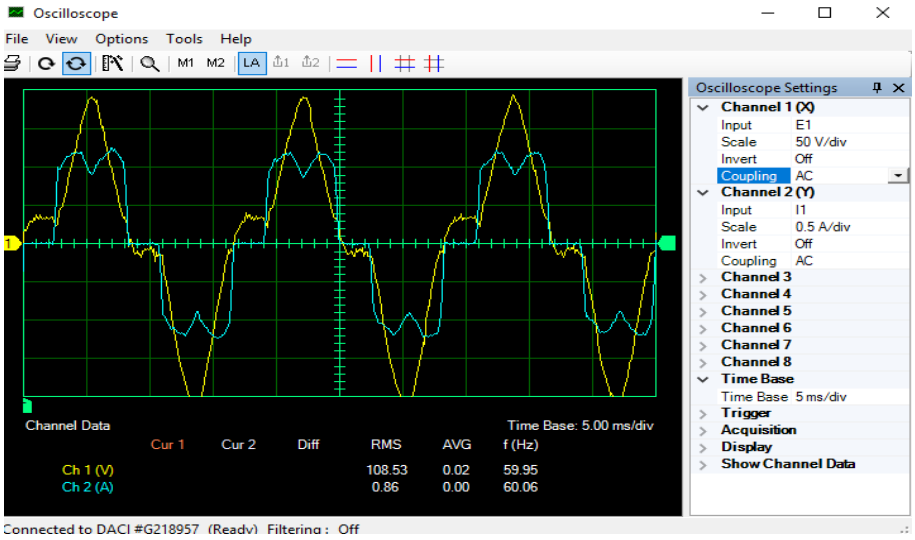

Figure 17: V_{in} vs I_{in} for DC motor

Output voltage vs the output current waveform for the DC motor is given in the following figure.

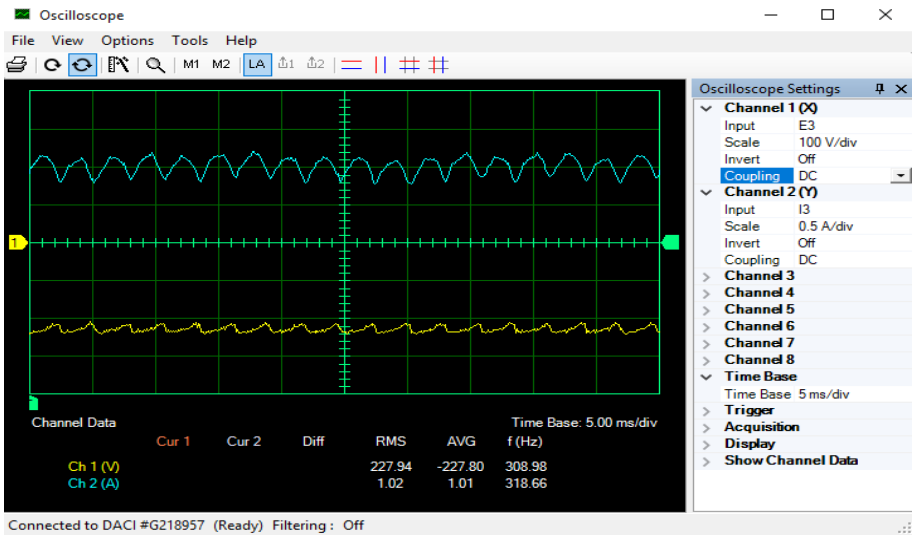

Figure 18: V_{out} vs I_{out} for DC motor

3.2 Harmonic Analysis of the waveforms

3.2.1 200 Ω

Harmonic analysis for the input voltage in the case of 200 Ω

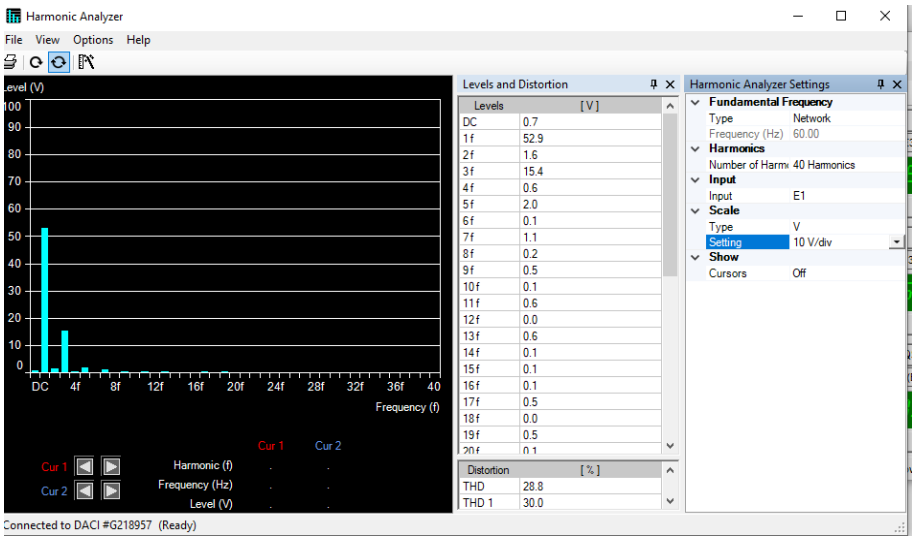

Figure 19: V_{in} Harmonics for 3ϕ 200 Ω

Harmonic analysis for the output voltage in the case of 200 Ω

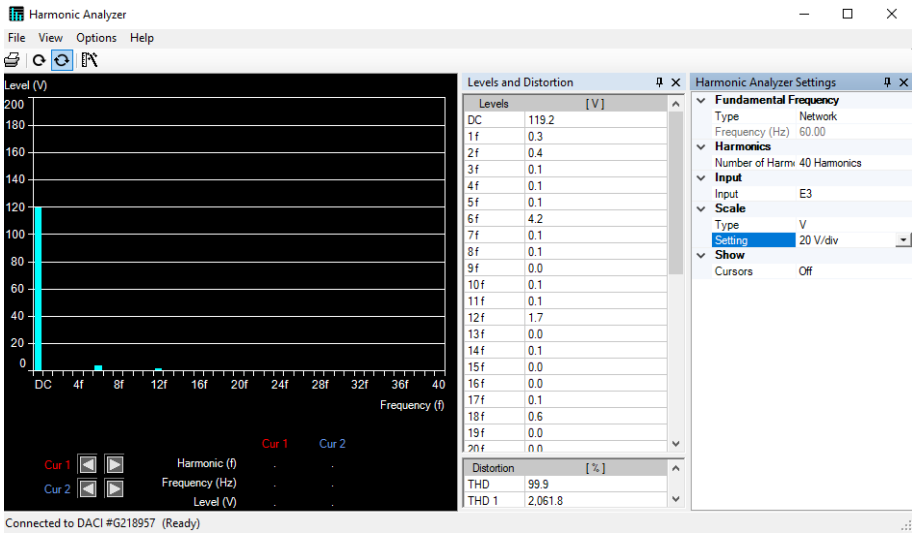

Figure 20: V_{out} Harmonics for 3ϕ 200 Ω

Harmonic analysis for the input current in the case of 200 Ω

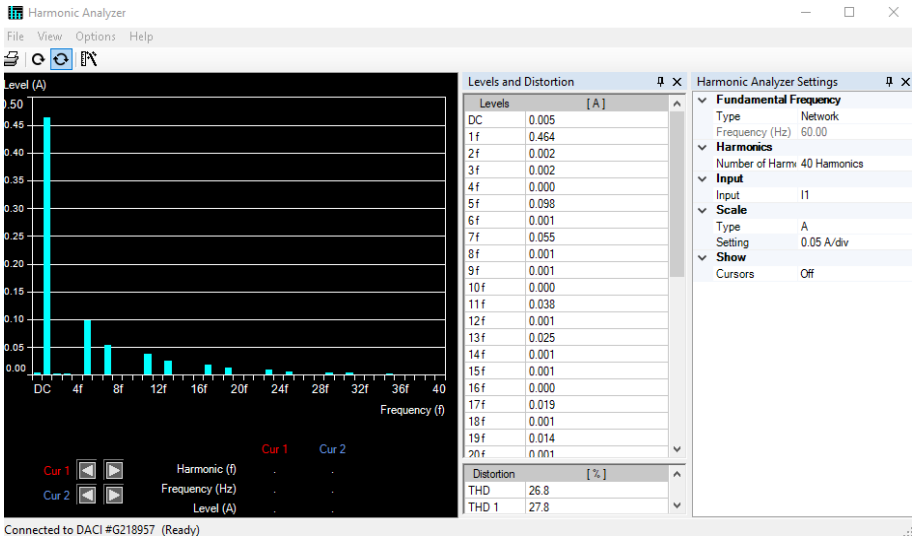

Figure 21: I_{in} Harmonics for 3ϕ 200 Ω

Harmonic analysis for the output current in the case of 200 Ω

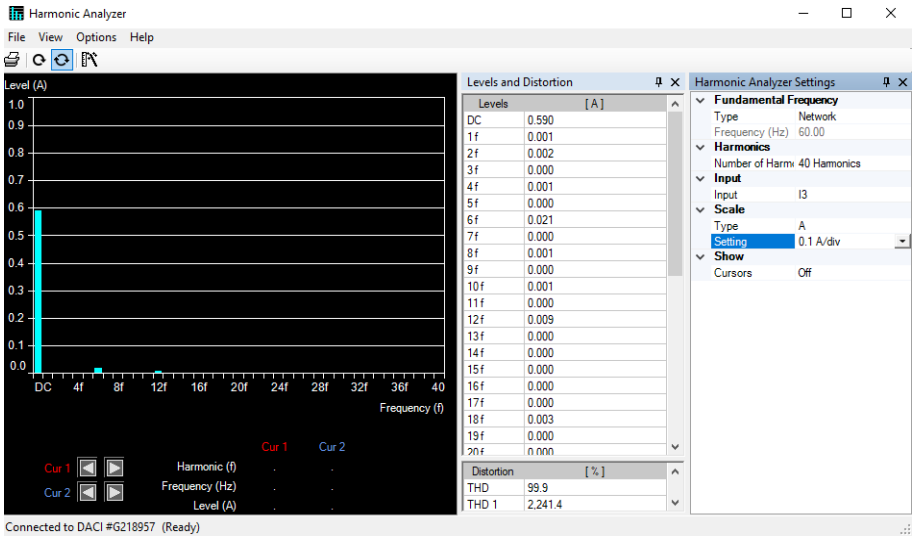

Figure 22: I_{out} Harmonics for 3ϕ 200 Ω

3.2.2 DC Motor

Harmonic analysis for the input voltage in the case of DC motor

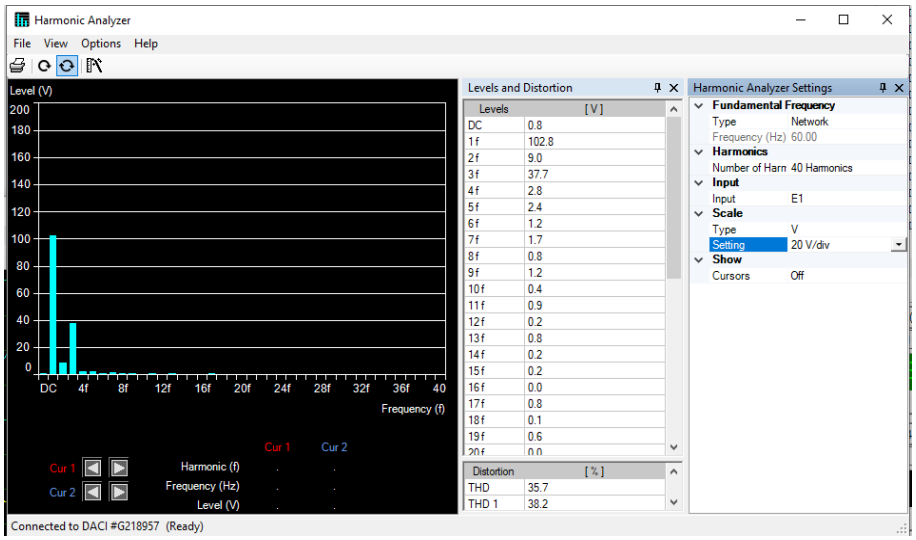

Figure 23: V_{in} Harmonics for 3ϕ DC motor

Harmonic analysis for the output voltage in the case of DC motor

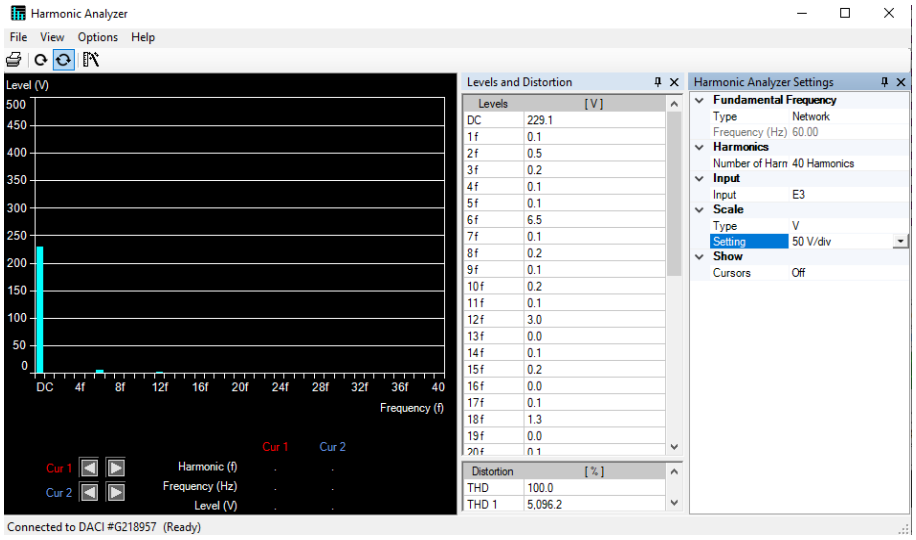

Figure 24: V_{out} Harmonics for 3ϕ DC motor

Harmonic analysis for the input current in the case of DC motor

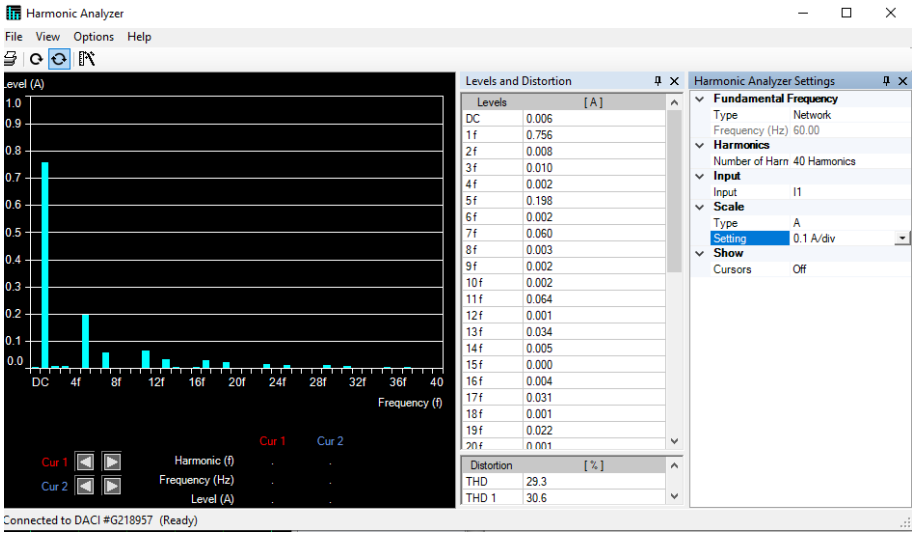

Figure 25: I_{in} Harmonics for 3ϕ DC motor

Harmonic analysis for the output current in the case of DC motor

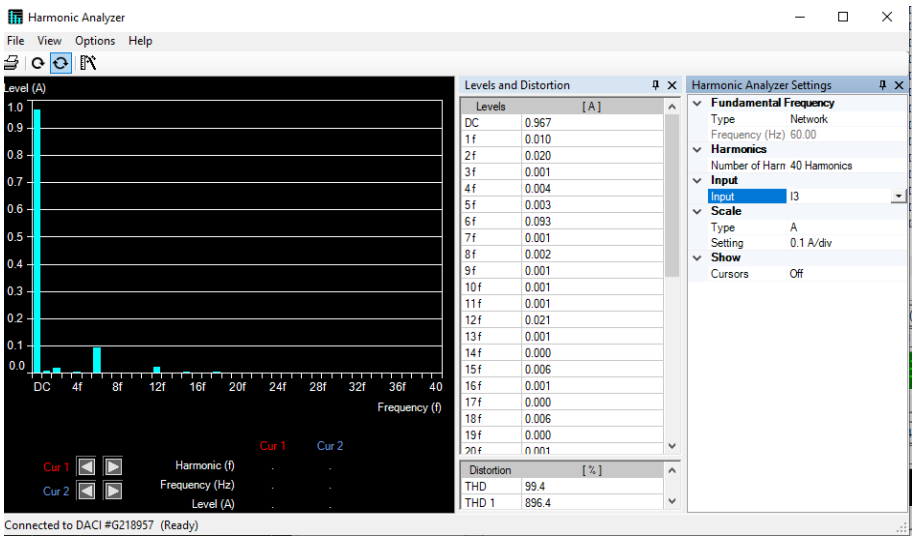

Figure 26: I_{out} Harmonics for 3ϕ DC motor

4 Calculations and Questions

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

Circuit	Load	P	Q	A	PF
1ϕ Converter	$200\,\Omega$	17.16	-0.2	17.17	0.9994
	DC motor	94.83	44.43	104.72	0.9055
3ϕ Converter	$200\,\Omega$	72.57	6.48	75.84	0.9568
	DC motor	228.93	18.24	229.65	0.9968

Table 1: Load power factor calculation

- Calculate the efficiency as : $\eta = \frac{P_{dc}}{P_{in}}$ for both the 1ϕ and 3ϕ load types

Type	Load	P_{dc}	P_{in}	η
1ϕ Converter	$200\,\Omega$	16.71	17.16	0.9737
	DC motor	90.00	94.83	0.9490
3ϕ Converter	$200\,\Omega$	69.62	72.57	0.9593
	DC motor	219.90	228.93	0.9605

Table 2: Load efficiency

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

  The three phase rectifier is more efficient than the single phase. For both load types the three phase efficiency is higher than the single phase. For both loads the efficiency of the three phase converter is higher than that of the single phase with a $200\,\Omega$ load.

- Calculate the power losses for both the 1ϕ and 3ϕ load types

Type	Load	P_{dc}	P_{in}	P_{loss}
1ϕ Converter	$200\,\Omega$	16.71	17.16	0.45
	DC motor	90.00	94.83	4.83
3ϕ Converter	$200\,\Omega$	69.62	72.57	2.95
	DC motor	219.9	228.93	9.03

Table 3: Load power loss

5 Discussions and Conclusion

1ϕ and 3ϕ full wave rectifiers are individually tested in this experimental setup. Different types of voltages had different effects on the load setup of the experiment as the η of the whole system varied for the setup of the experiment. Increasing the voltage increased the efficiency of the experiment which is valid for the 3ϕ full wave rectifier while for the 1ϕ full wave rectifier it is not seen. From the table:3 it can be seen DC motor is having power losses which may origin from the motor core or due to the inductive behavior of the motor itself . We can see from the previous table:3 3ϕ full wave rectifiers are more efficient than the 1ϕ full wave rectifier in case of the DC motor . Switching the load to DC motor from the $200\,\Omega$ resistive load decreased the η for 1ϕ . Based on the experiment we can tell that the η of the full wave rectifiers is related to the applied voltage and type of load supplied by the rectifier circuit.