ECE 4643

Power Electronics

Laboratory 2: AC-DC Controlled Power Electronic Converters

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Contents

Objective

The objective of this experiment was to understand of how full-wave single and poly phase controlled thyristors behave when supplied with static and dynamic loads. The observation will revolve around input and output currents, input and output voltages, harmonic, power factor, and efficiency.

Single Phase Full-Wave Rectifier

The circuit for the 1ϕ 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 current, voltages, and power were recorded while varying the firing angle. The waveforms and spectrums were also observed for each input and output currents and voltages with a 200 resistive load.

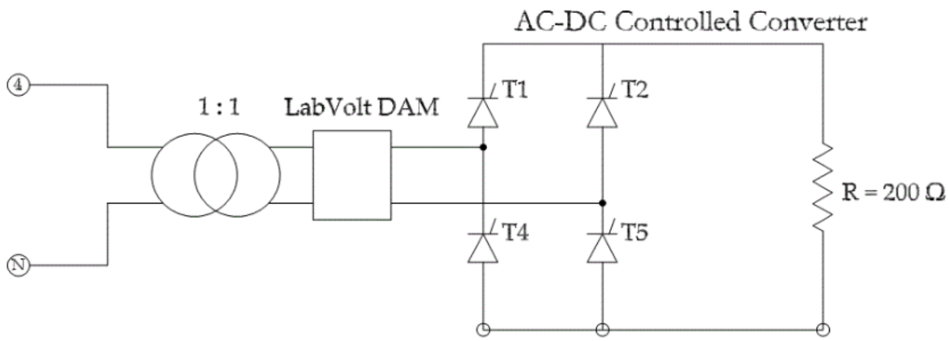

Figure 1: Single Phase full-wave rectifier with resistive load

Voltage and Current wave forms

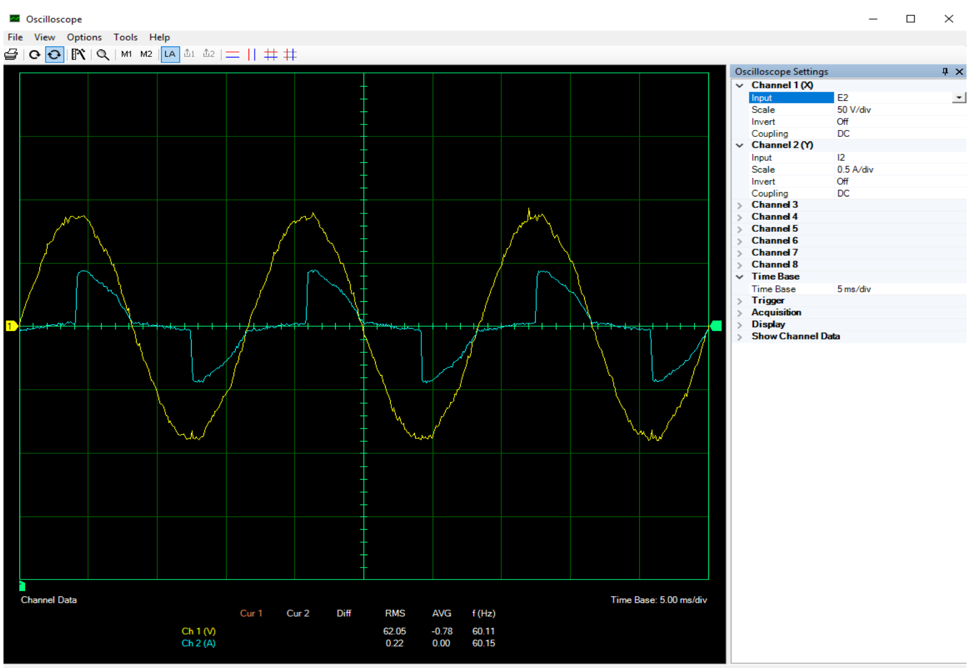

Figure 2: Input current and voltage waveforms (α=90°)

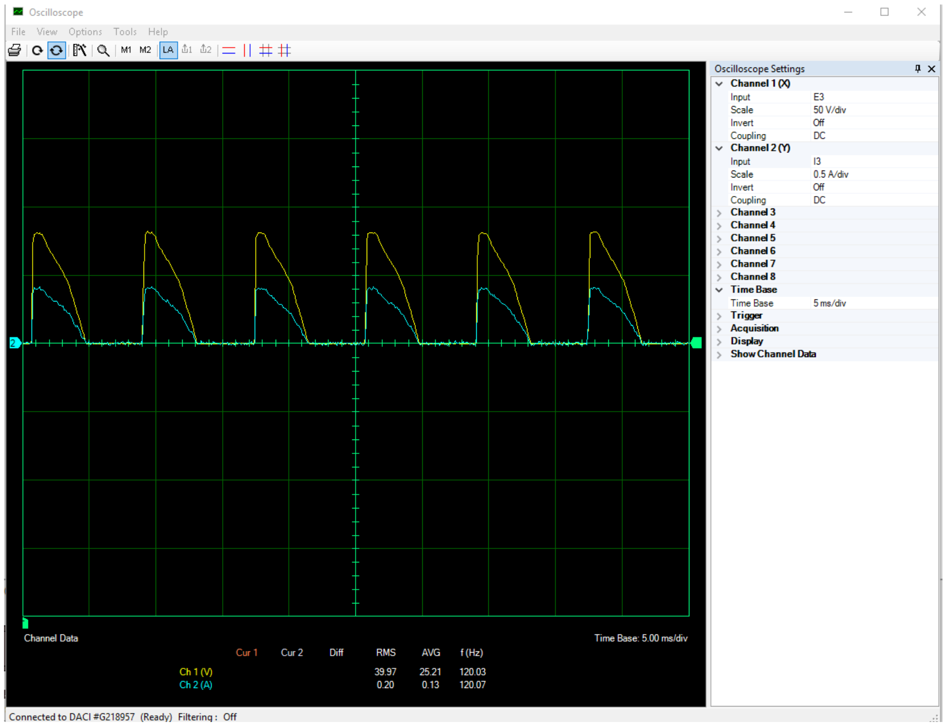

Figure 3: Output current and voltage waveforms (α=90̊)

Harmonic Analysis of the waveforms

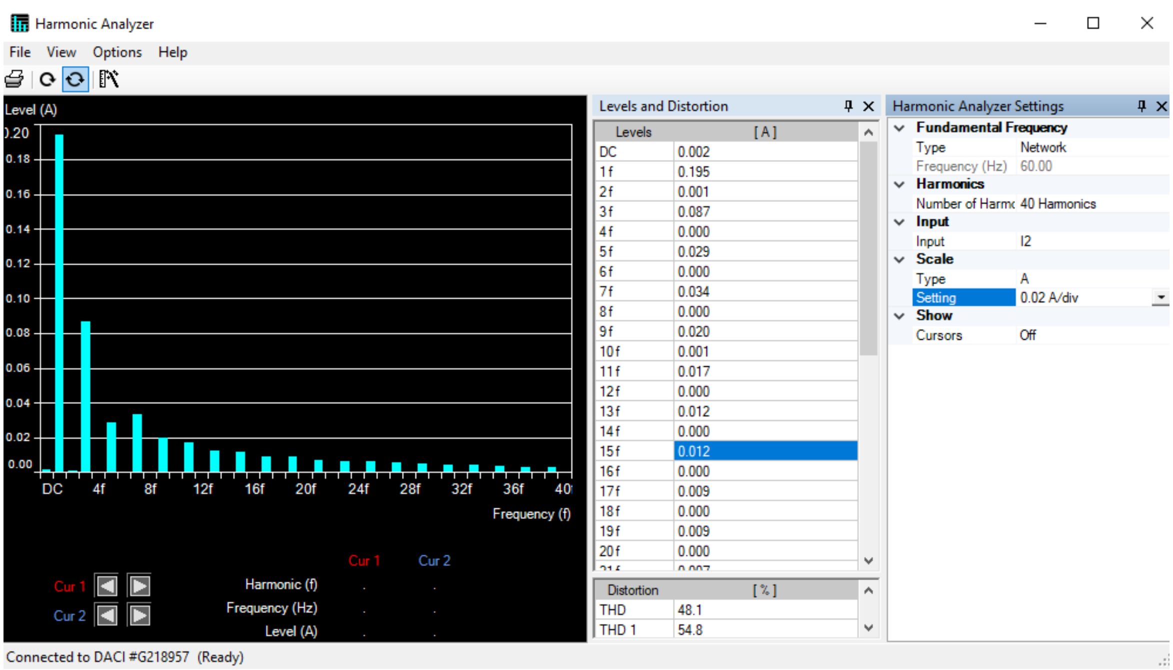

Figure 4: Input current spectrum (α=90̊)

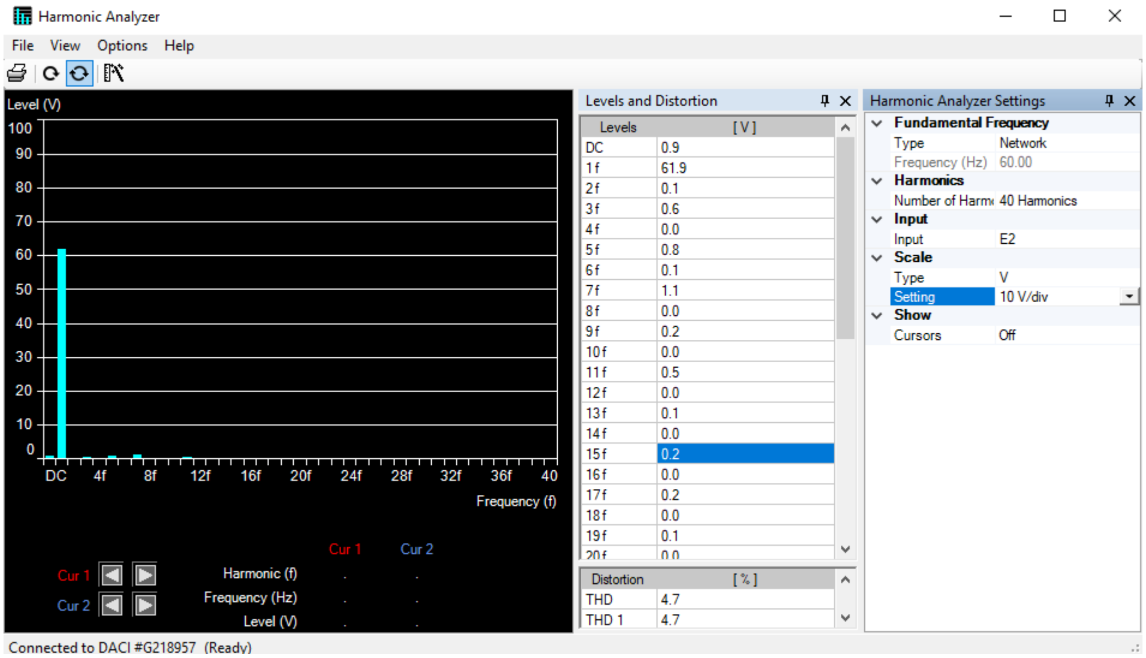

Figure 5: Input voltage spectrum (α=90̊)

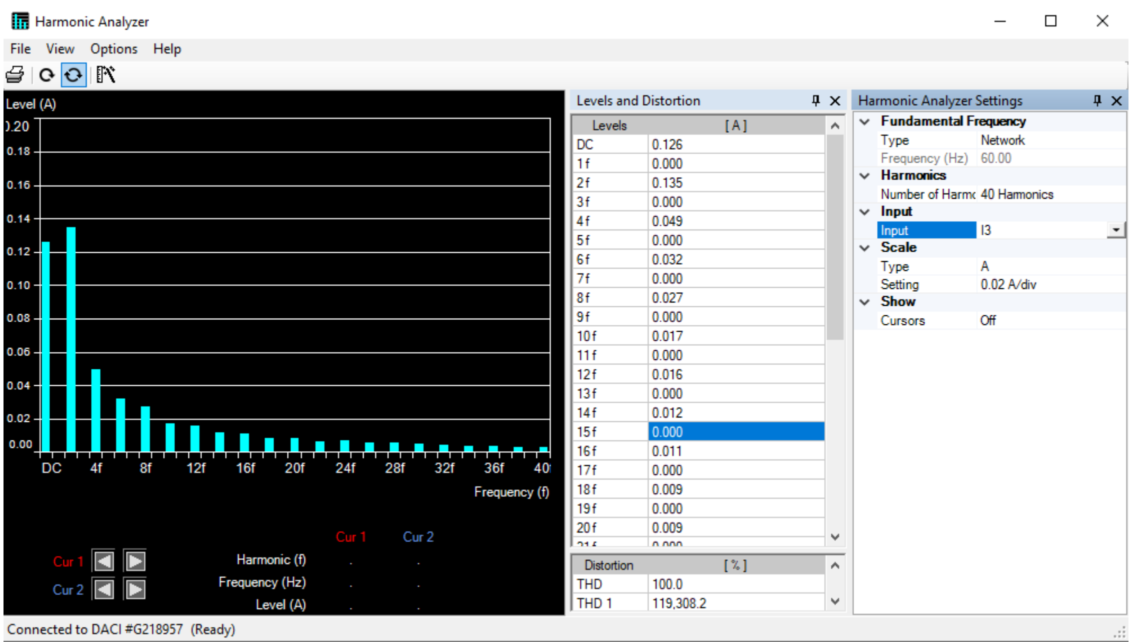

Figure 6: Output current spectrum (α=90̊)

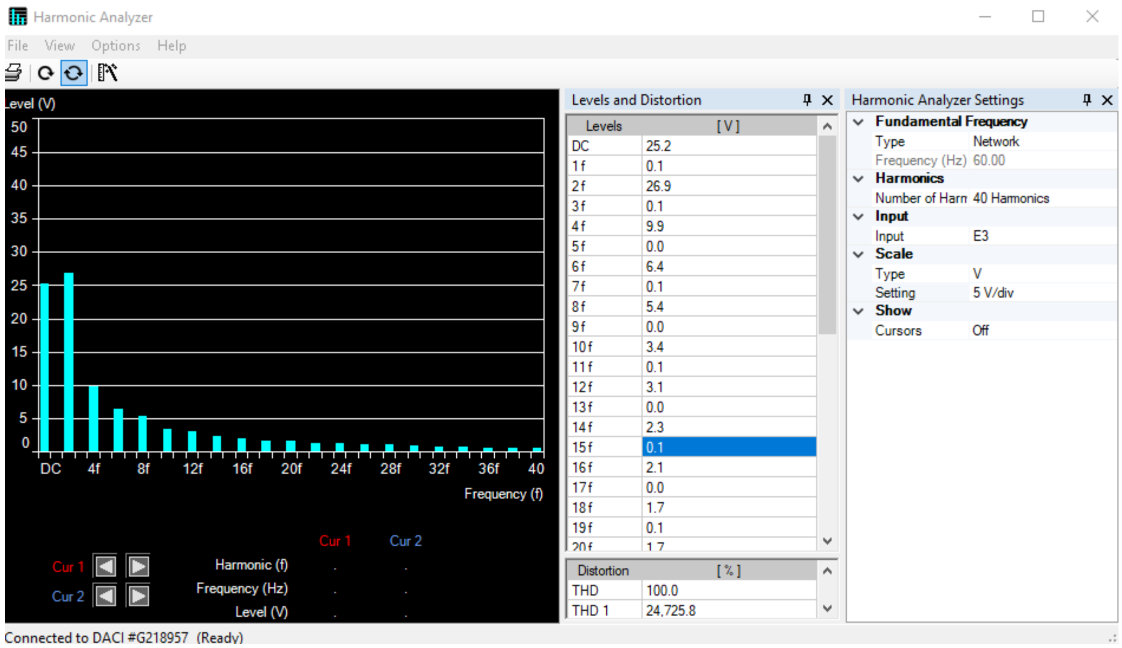

Figure 7: Output voltage spectrum (α=90̊)

Three Phase Full-Wave Rectifier

The second part of the lab was to perform the same analysis for 3 phase full wave controlled rectifier with DC motor load this time. The circuit was connected as per shown in the figure 8 below. Using the DAM we observed the input and output waveforms and harmonics of the voltage and current.

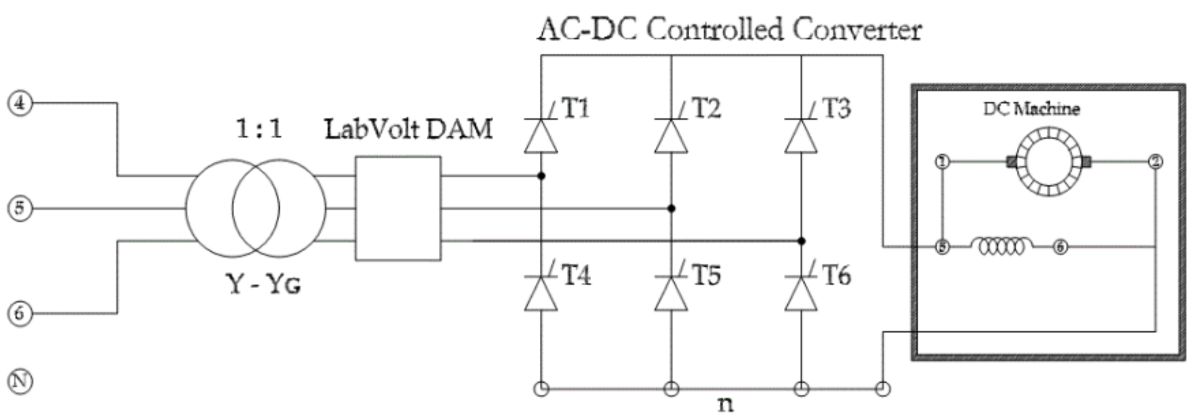

Figure 8: 3 Phase full-wave rectifier with DC motor load

Voltage and Current wave forms

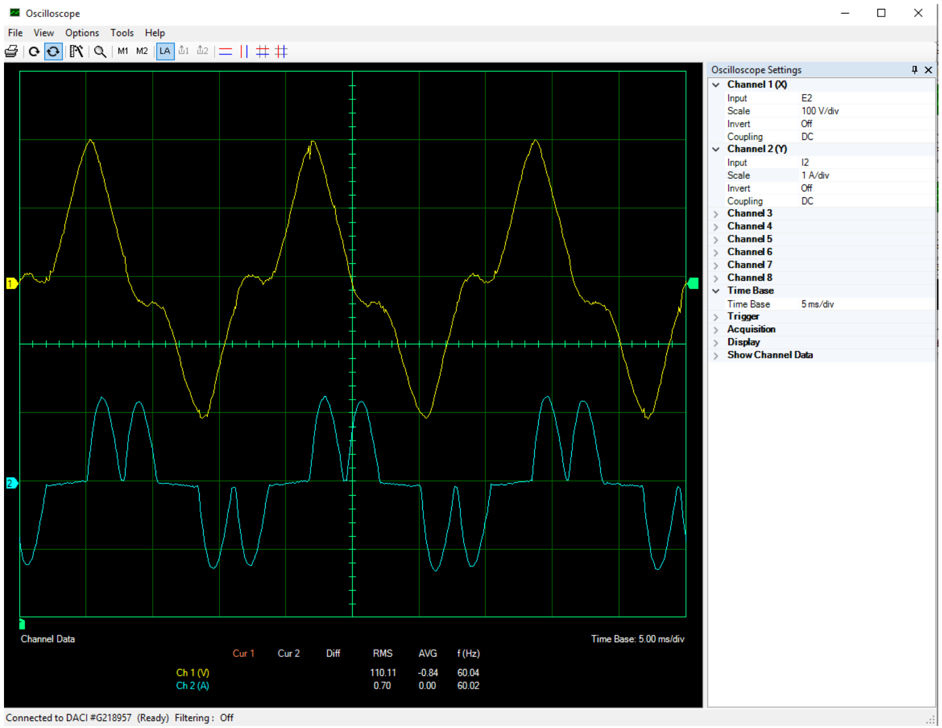

Figure 9: Input current and voltage waveforms (α=60̊)

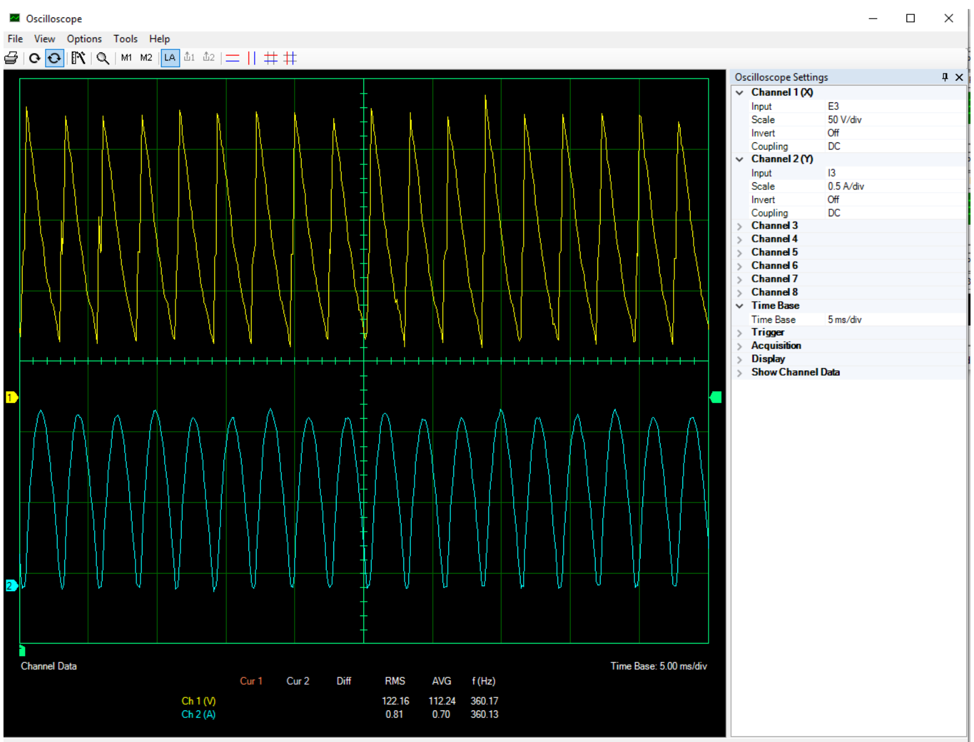

Figure 10: Output current and voltage waveforms (α=60̊)

Harmonic Analysis of the waveforms

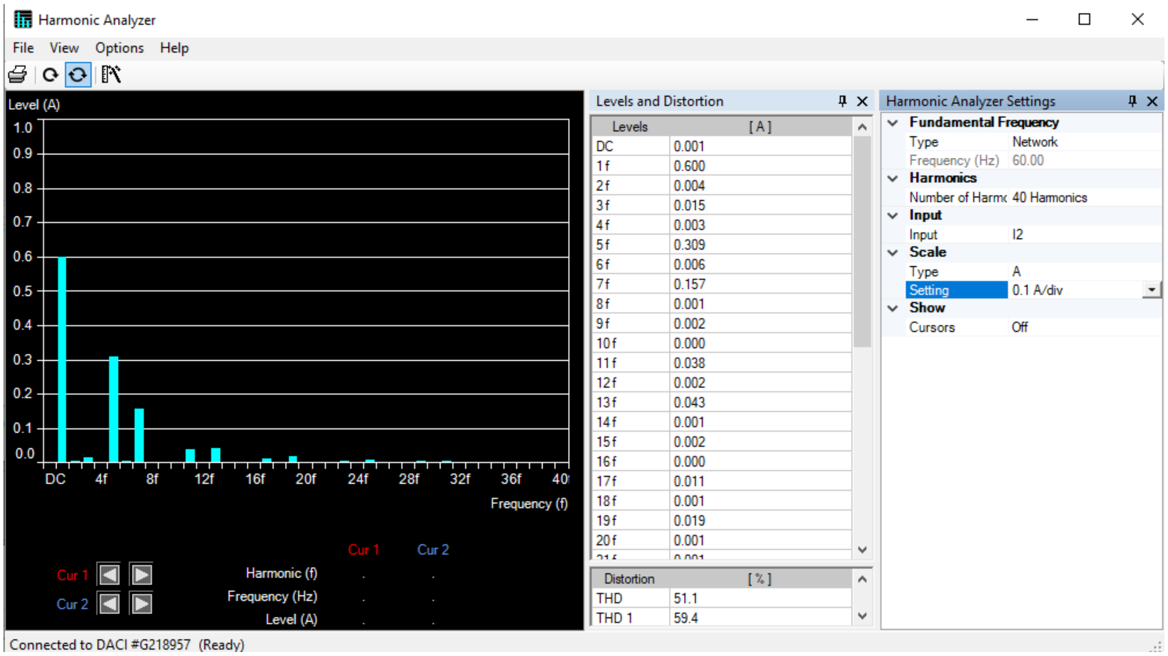

Figure 11: Input current spectrum (α=60̊)

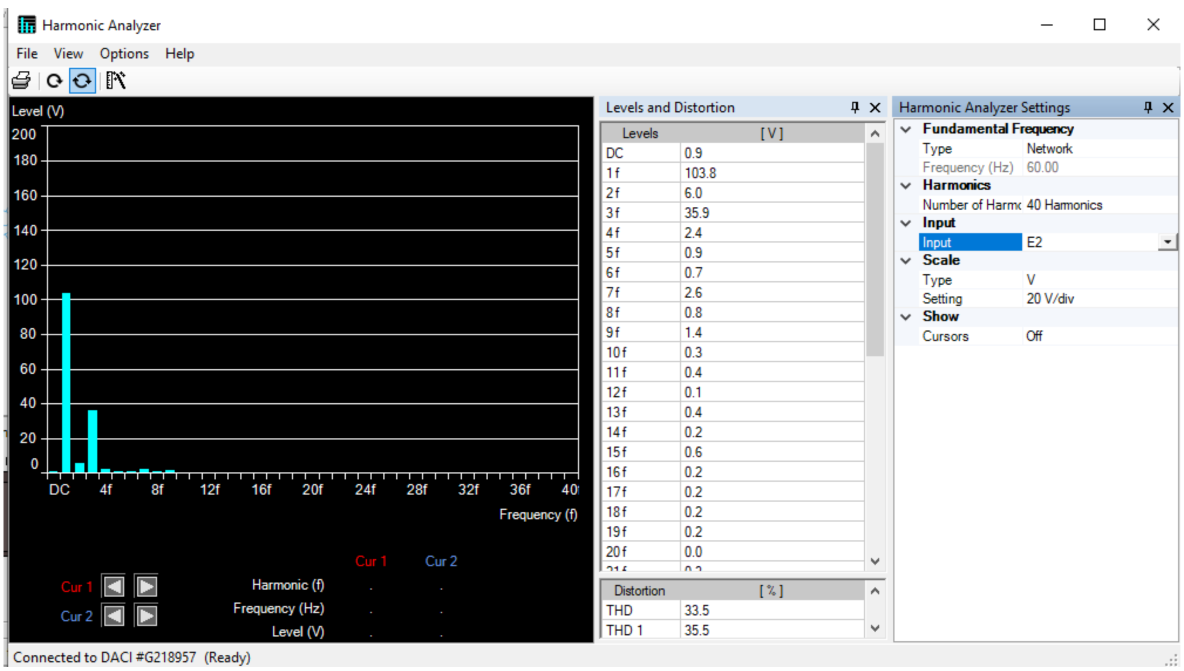

Figure 12: Input voltage spectrum (α=60̊)

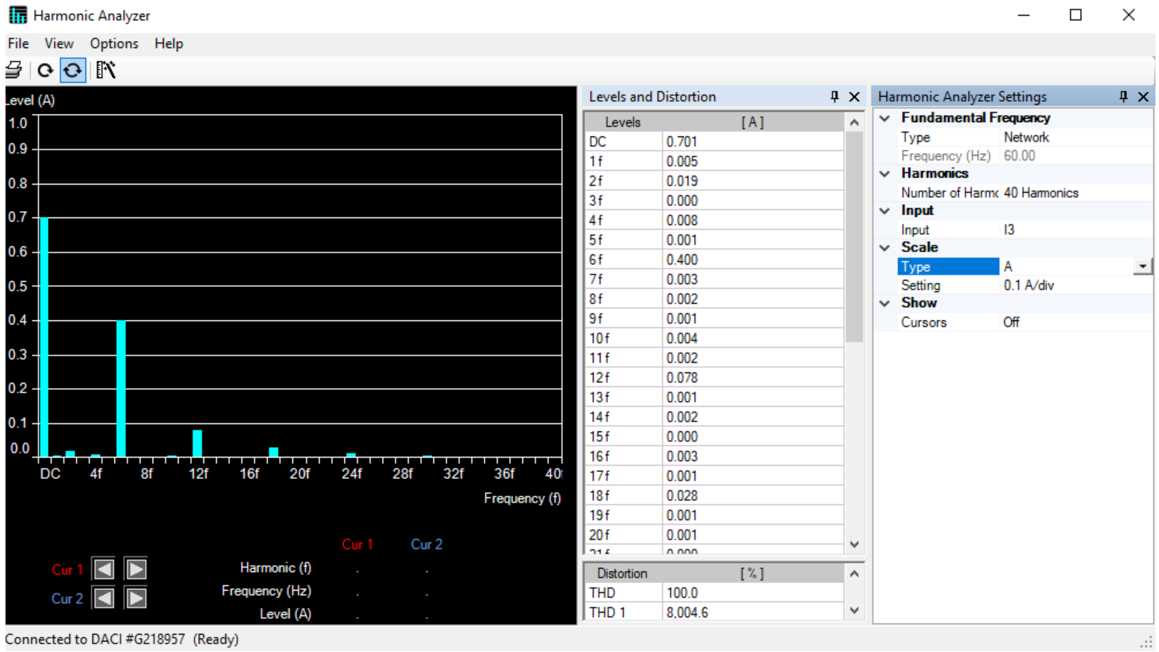

Figure 13: Output current spectrum (α=60̊)

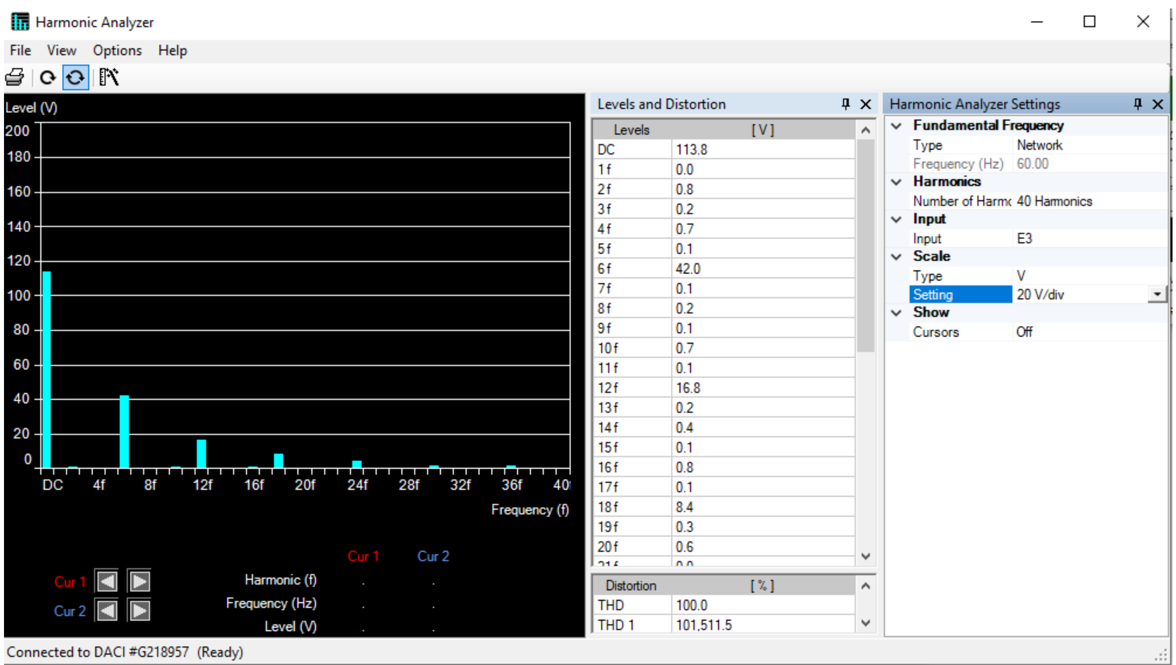

Figure 14: Output voltage spectrum (α=60̊)

Calculations and Questions

Single Phase

α	$(I_A)_{rms}$	P_{in}	Q_{in}	V_{dc}	I_{dc}	P_{dc}	PF	HF	n
0	0.305	18.68	1.277	50.88	0.253	16.16	0.997		86.5%
30	0.302	16.77	2.732	47.34	0.236	15.65	0.977		93.3%
60	0.278	15.17	5.625	38.03	0.19	12.88	0.887		84.9%
90	0.223	9.86	6.93	25.22	0.125	7.97	0.717		80.8%
120	0.143	4.46	5.34	12.36	0.061	3.01	0.507		67.4%
150	0.061	1.69	2.49	3	0.015	0.418	0.423		24.7%
180	0.029	1.19	1.25	0.19	0.001	0	0.37		0%

Table 1: Single Phase full-wave rectifier

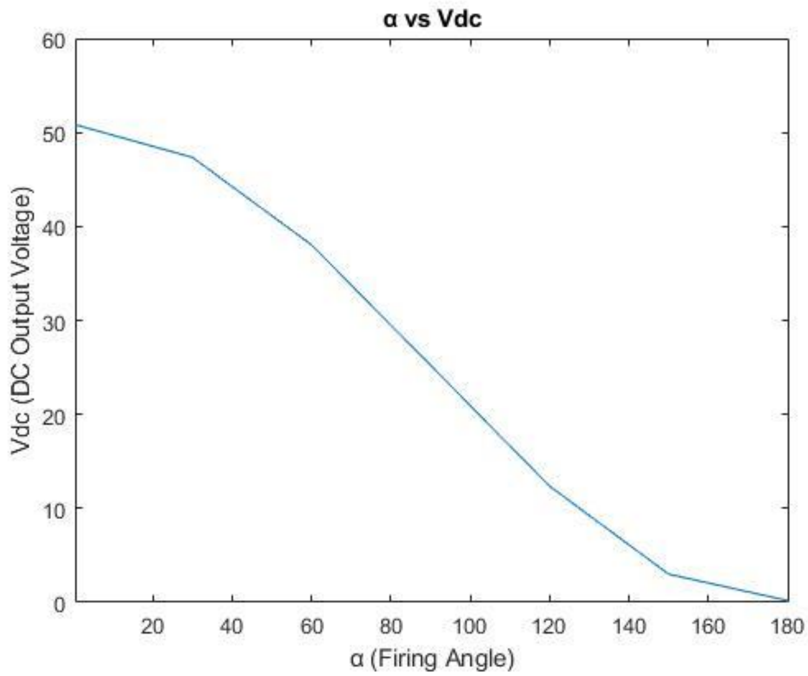

Figure 15: Firing Angle vs. Output Voltage (DC)

Figure 15 shows the decrease in output voltage as the firing angle increases. Since the conduction will take place in thyristor with the increasing firing angle, it was expected to observe a decay in output voltage.

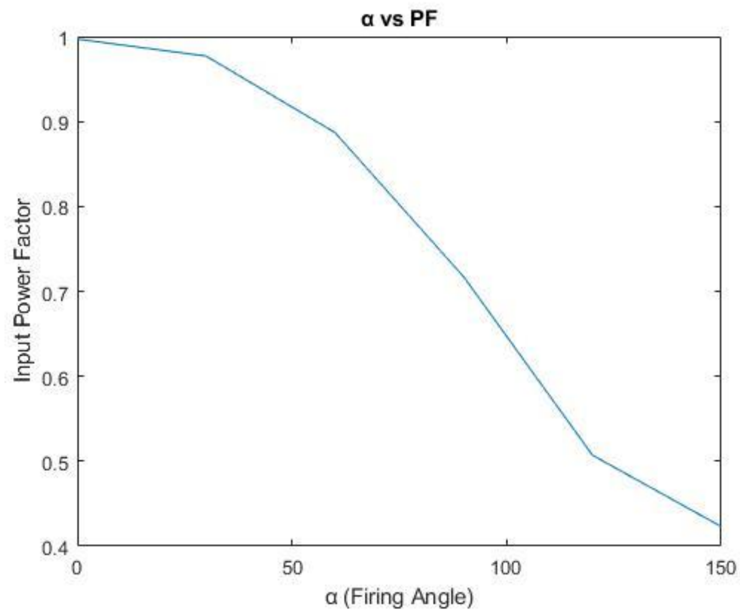

Figure 16: Firing Angle vs. Power Factor

Power factor is defined as how efficiently the electrical system is working. As can be seen from figure 16, the lower the firing angle, the better the power factor is. Thus, the system is operating under best conditions with zero firing angle.

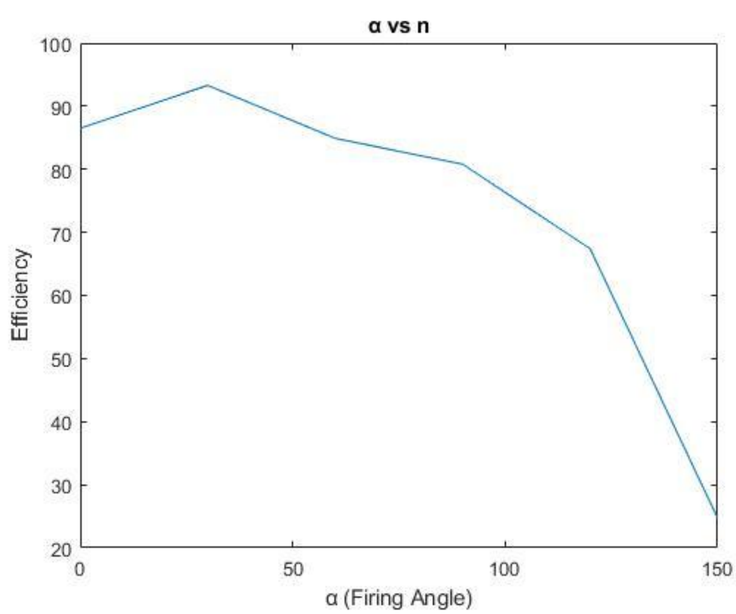

Figure 17: Firing Angle vs. Efficiency

As can be seen in figure 17, the efficiency drastically drops after100 degrees. As the waveform moves towards 180 degrees, Induction starts increasing and the system is no longer efficient.

Three Phase

α	$(I_A)_{rms}$	P_{in}	Q_{in}	V_{dc}	I_{dc}	P_{dc}	PF	n
0	0.88	281.43	32.1	219.7	1.08	237.7	0.996	84.46%
30	0.856	221.82	117.39	194	0.936	187.8	0.764	84.66%
60	0.683	106.11	144.75	113	0.684	80.25	0.47	75.62%
90	0.527	23.76	135	4.9	0.53	5.37	0.132	23.6%
120	0.034	7.95	6.51	0.004	0.001	0	0.710	0%

Table 2: Three Phase full-wave rectifier

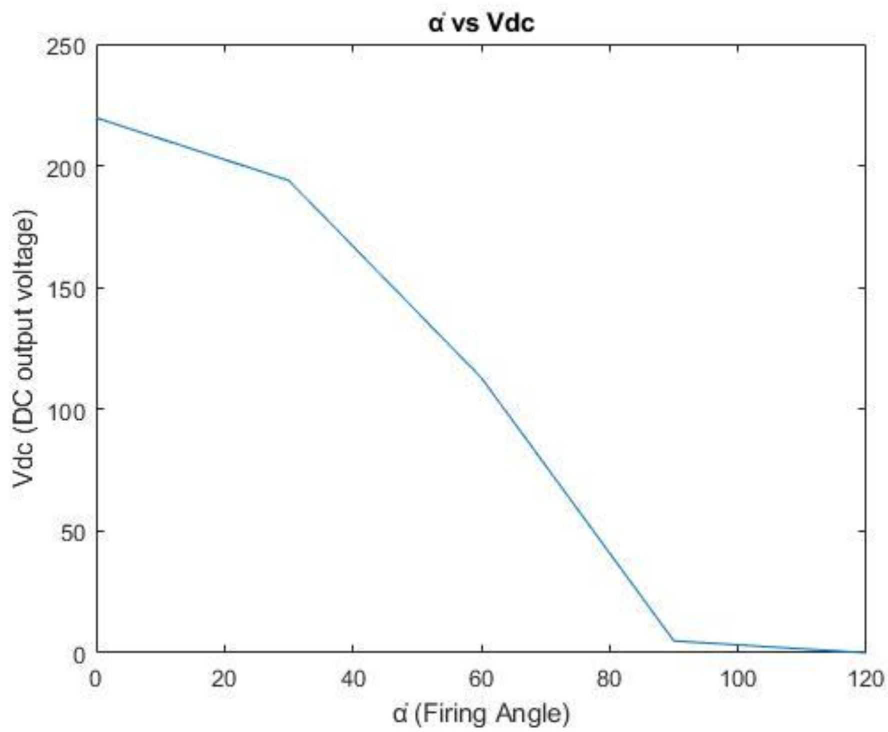

Figure 18: Firing Angle vs. Output Voltage (DC)

As it can be seen with the increasing firing angle the output voltage decreases. With this increasing delay, as the firing angle reaches 80 degrees, the motor stops running.

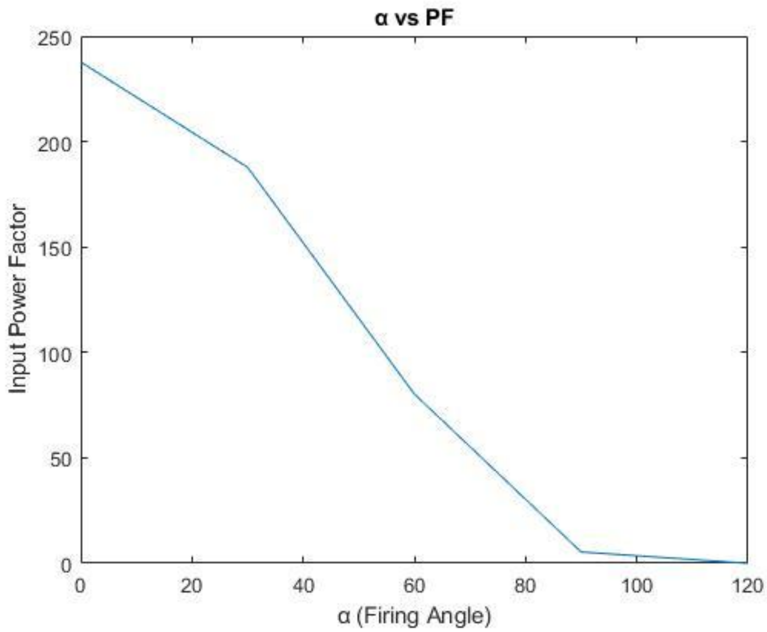

Figure 19: Firing Angle vs. Power Factor

The power factor is decreasing as well with increasing firing angle because of the delayed current. The greater the delay the more the current lags.

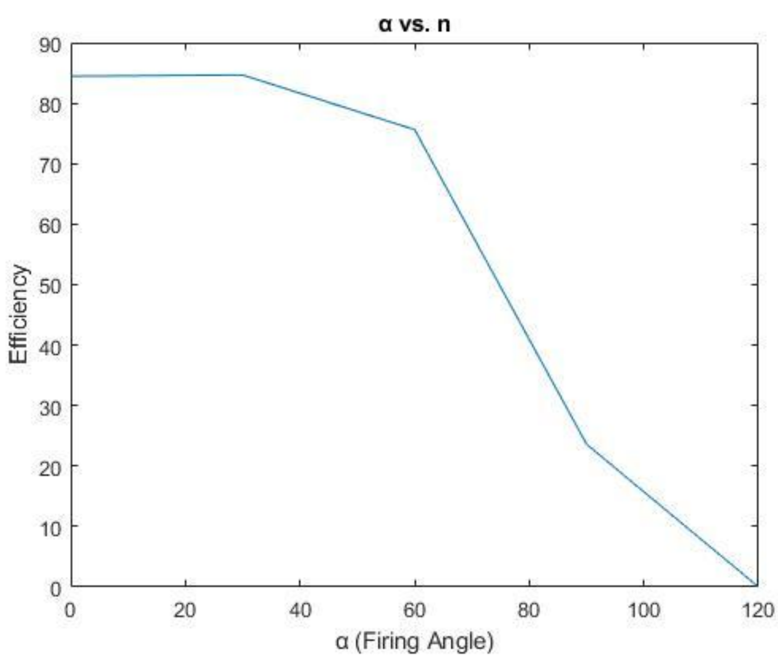

Figure 20: Firing Angle vs. Efficiency

With the increasing firing angle, the harmonics are also generated into the system. The increased conduction spot on the waveform of the thyristor decreases the overall efficiency.

Conclusion

For this experiment full wave controlled rectifier was evaluated for two different cases. The first scenario was static load and the next scenario was dynamic load. The load was a dc shunt motor. The ON and OFF sequence was performed using controlled gate pulsed from the thyristor firing angle controller. From our experiment we can conclude that thyristor firing angle plays a significant role in the AC-DC rectification and it was analysed in details and the relationship was clearly seen in figures above. It was clearly noted for increasing the firing angle, there was significant drop in efficiency, power factor and V_{dc}.