EE 351
Section AE

Lab Report 1

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Part 1: AC/DC Converter

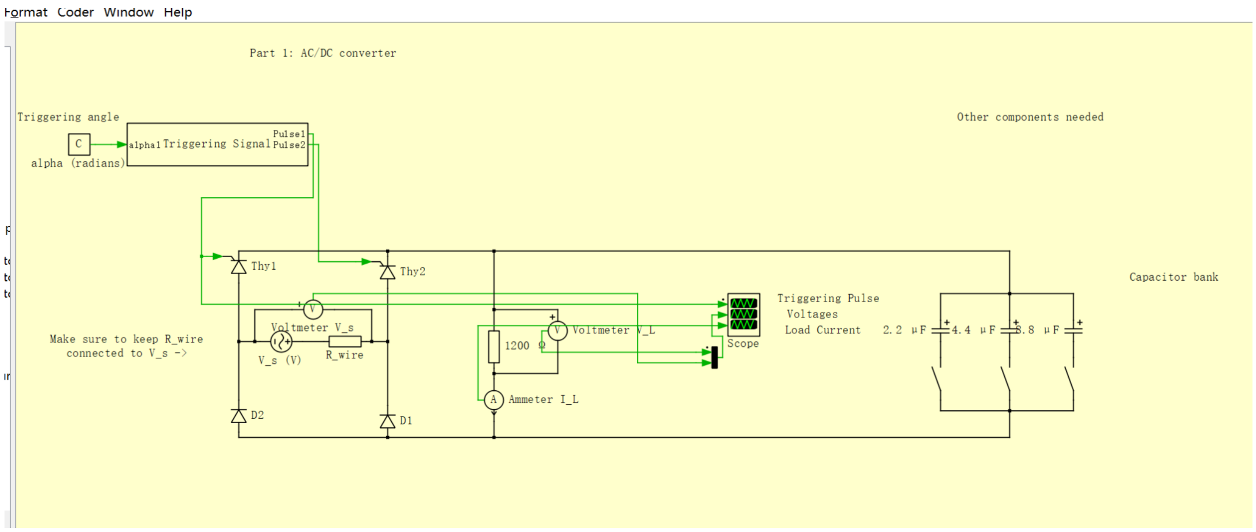

Fig. 1. AC/DC schematics

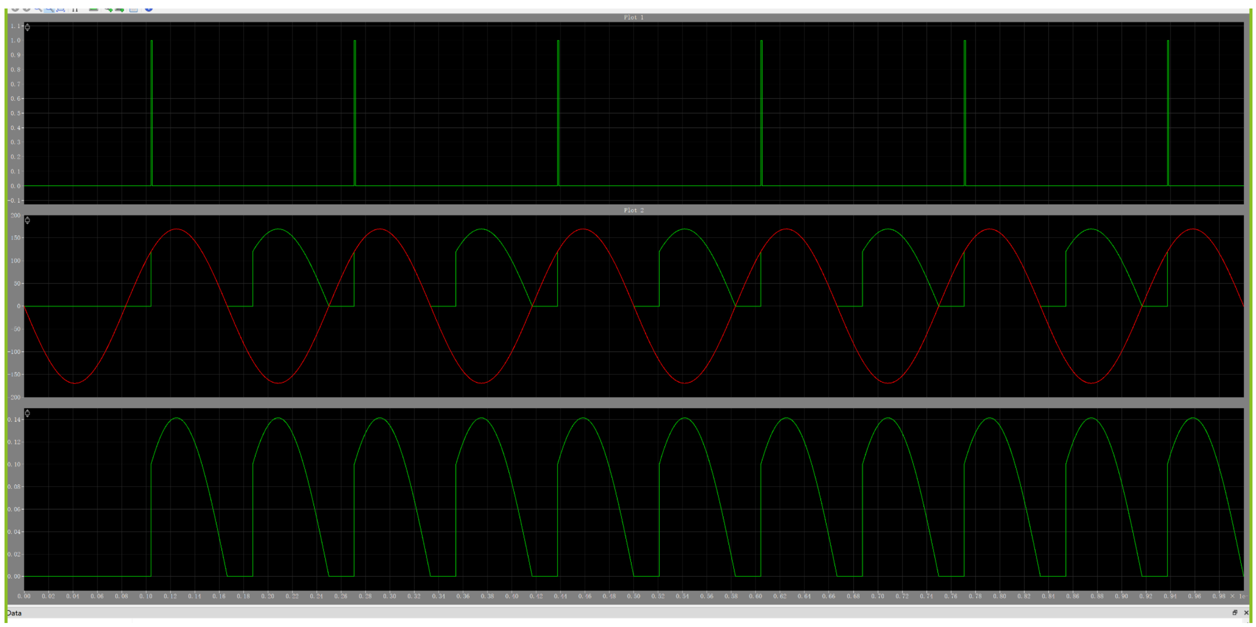

Fig. 2. Waveform when the triggering angles are 45 degrees

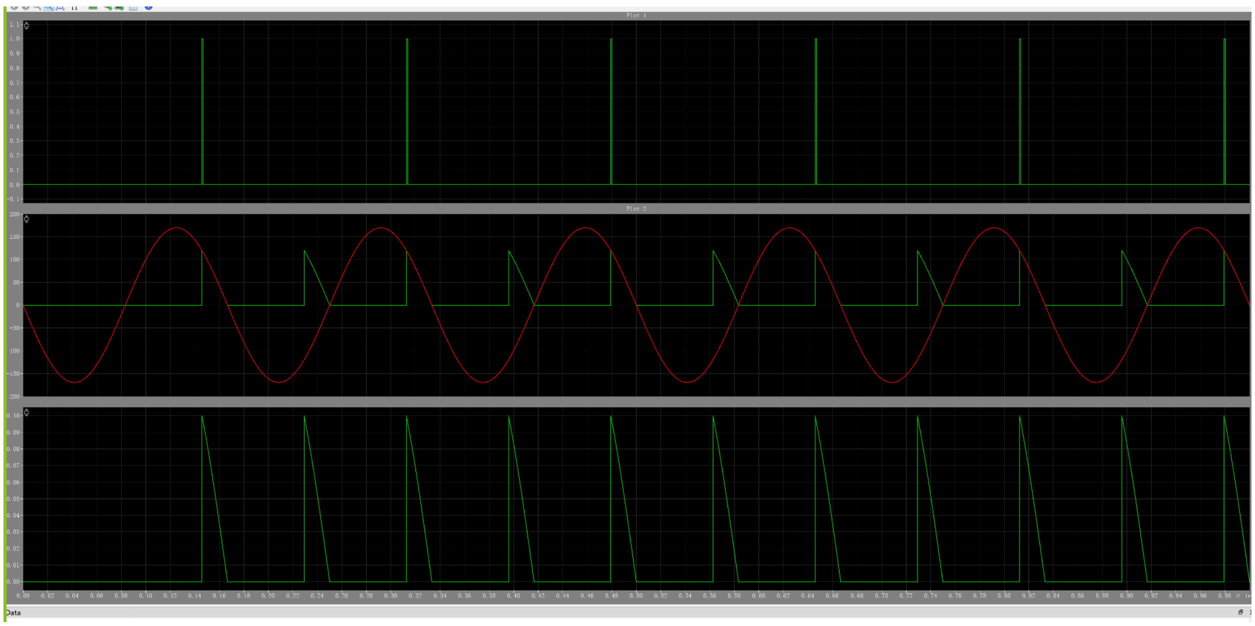

Fig. 3. Waveform when the triggering angles are 135 degrees

Comment: From Fig. 2 and Fig. 3, we can see that as we increase the triggering angle from 45 to 135 degrees, the waveforms of both load voltage and current will shrink (sharper).

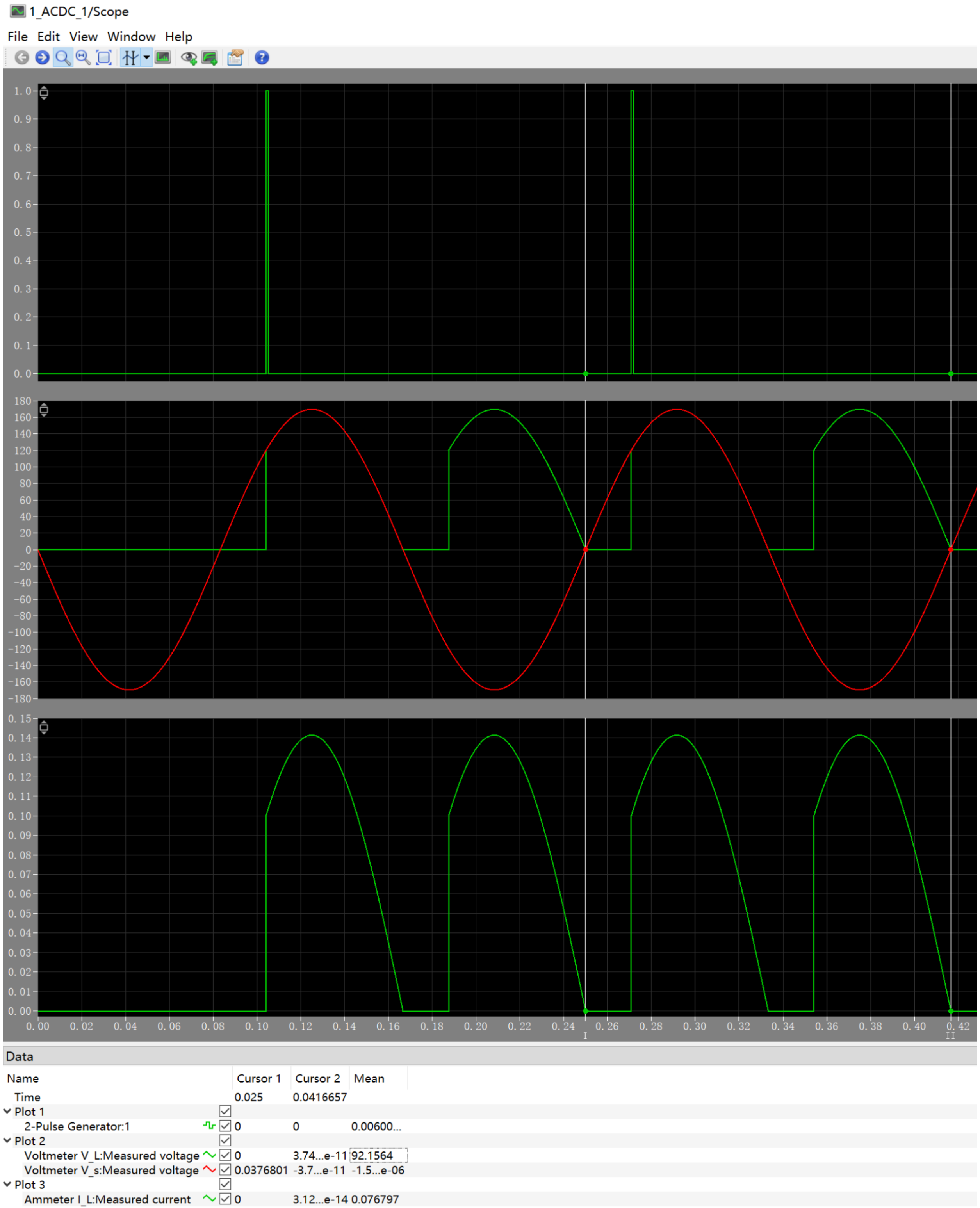

Fig. 4. Average voltage across the load measured by the simulation

From Fig. 4, At the triggering angle of 45 degrees, the average voltage across the load over one period is **92.1564V**. Calculated average load voltage is given by the full wave equation $Vave = (Vmax/\pi) * (1 + cos\alpha)$, which is equal to $(169.7/\pi) * (1 + cos(\pi/4)) = 92.213V$. The calculated value is the same as the measured value (92.1564 ≈ 92.213).

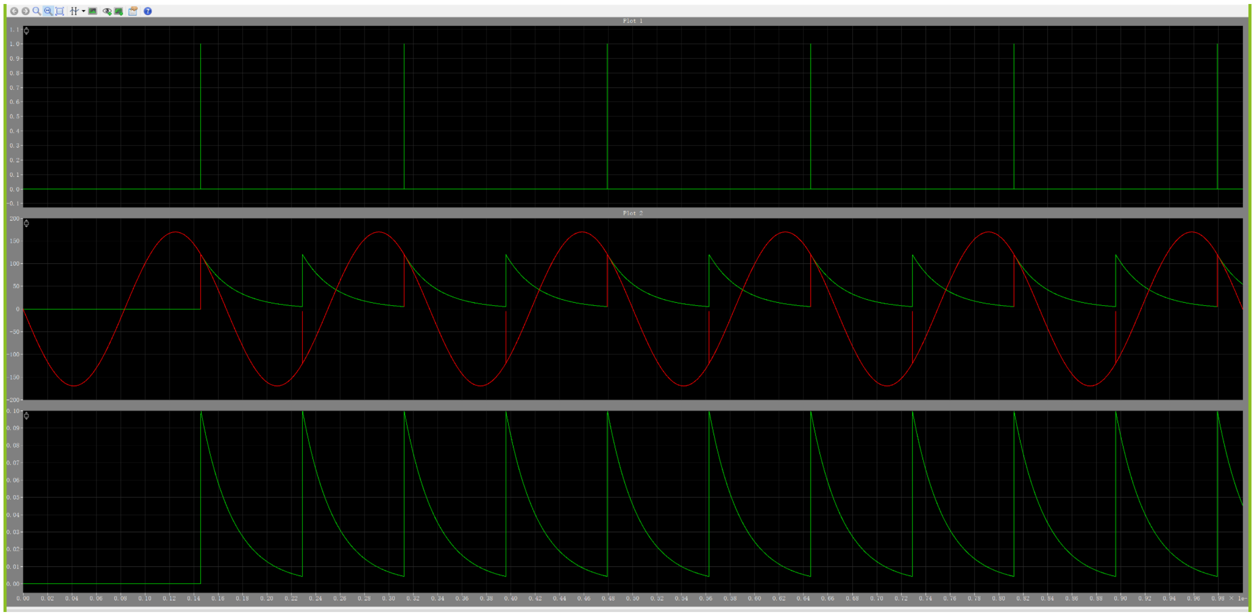

Fig. 5.Waveform when the triggering angle is 135 degrees and capacitance is set to 2.2μF

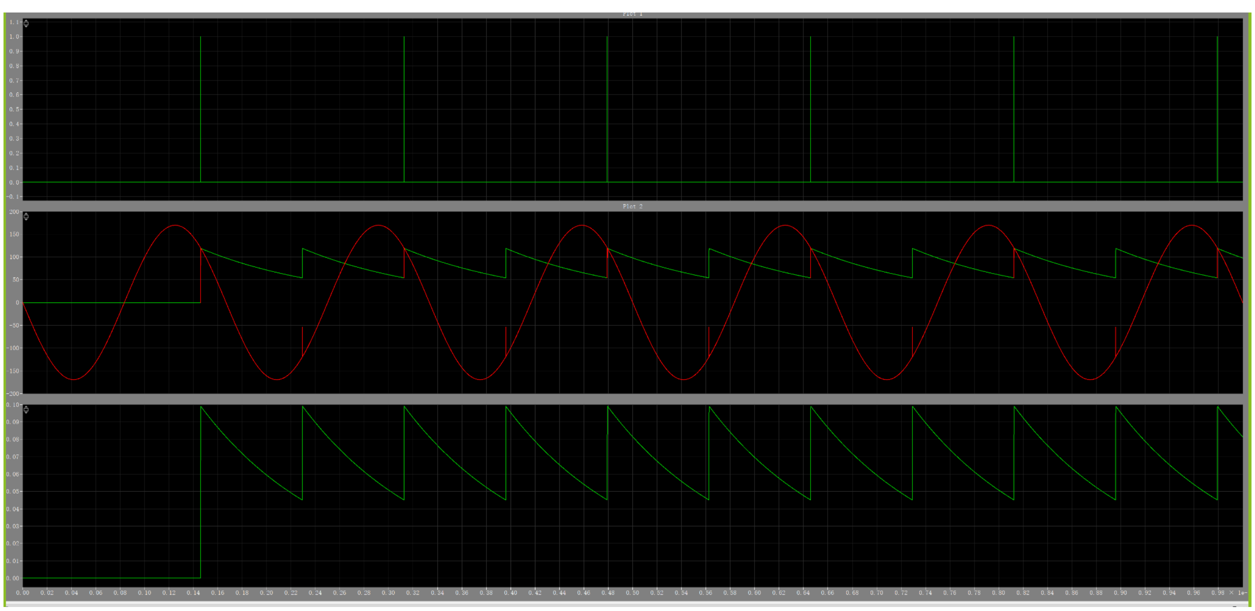

Fig. 6. Waveform when the triggering angle is 135 degrees and capacitance is set to 8.8μF

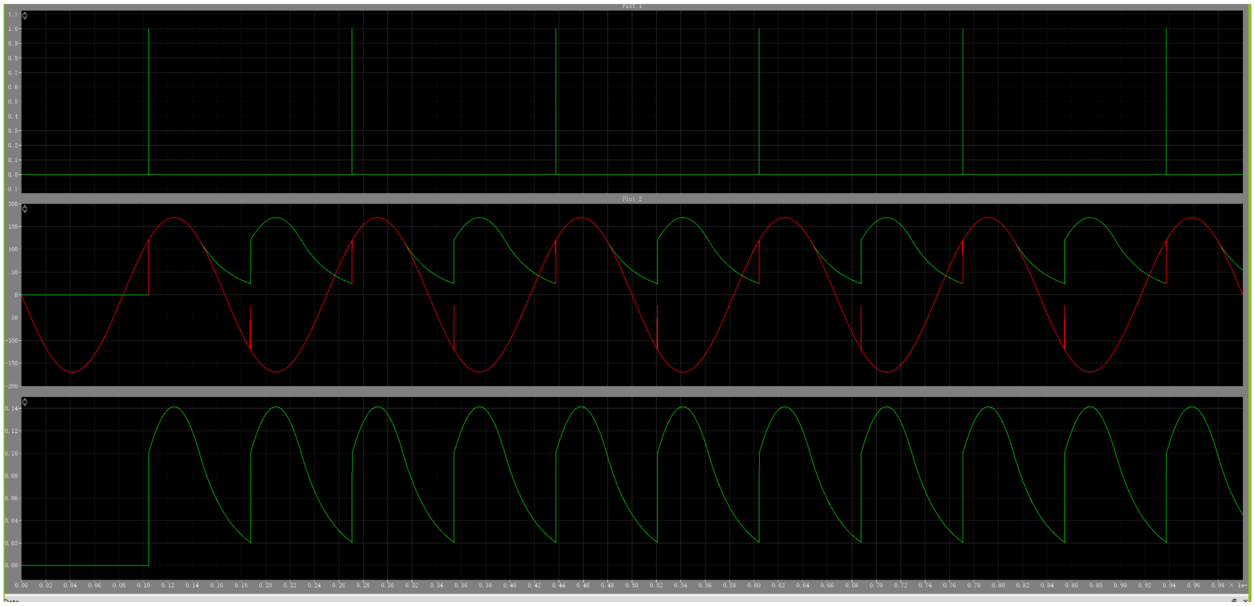

Fig. 7. Waveform when the triggering angle is 45 degrees and capacitance is set to 2.2μF

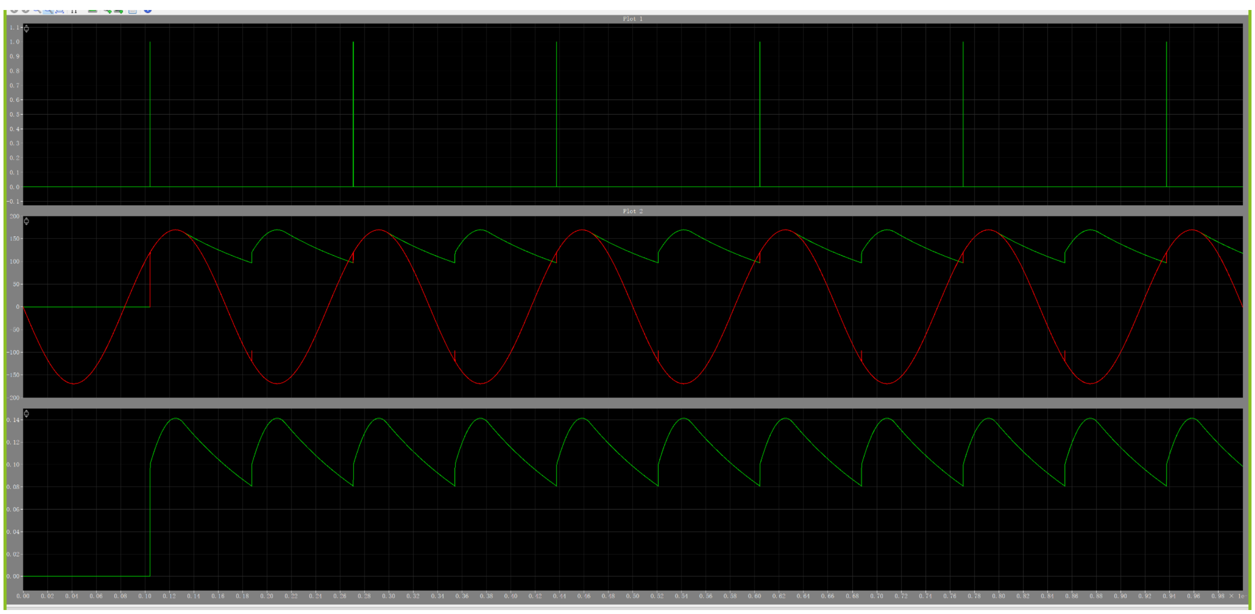

Fig. 8. Waveform when the triggering angle is 45 degrees and capacitance is set to 8.8μF

Comment: From Fig. 5 to Fig. 8, we can see that the bigger the capacitance connected parallel to the load at the same triggering angle, the waveform will be less steep, making the average voltage and current larger. Also, as triggering angle gets bigger at the same capacitance value, the waveforms of both load voltage and current will be sharper.

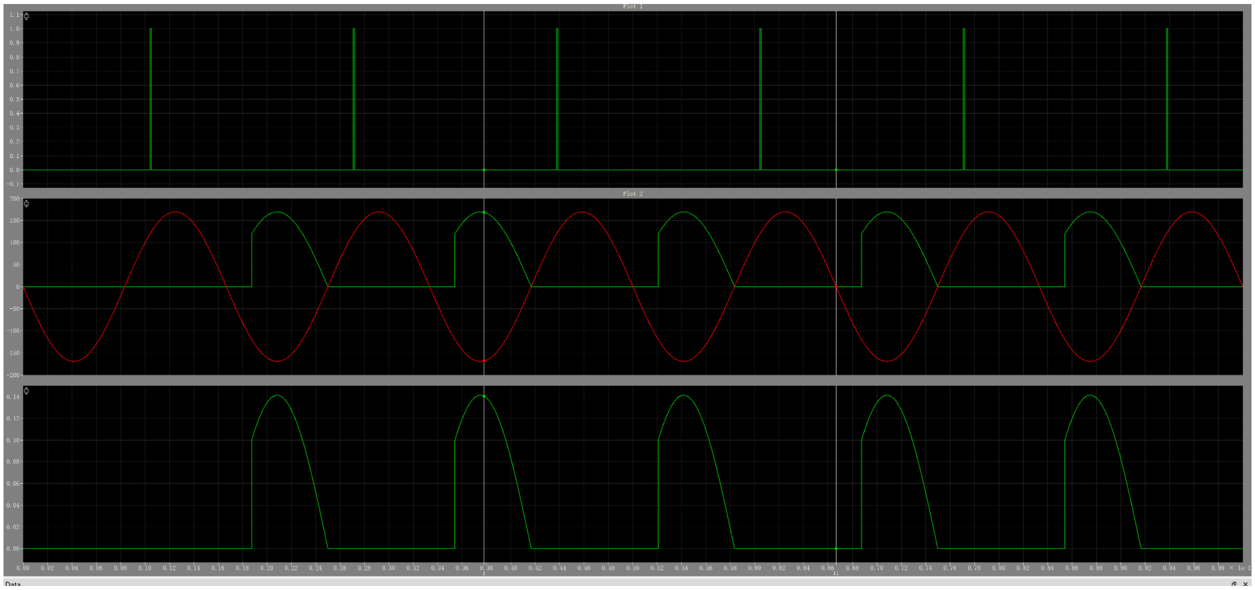

Fig. 9. Waveform when the triggering angle is 45 degrees and with diode D1 removed from the circuit

Comment: From Fig. 9, removing one of the diodes will half the number of pulses in the waveform of load voltage and current compared to Fig. 2. Removing one of the diodes is actuallying making the circuit a half wave rectifier, so the waveform is consistent with the equation of Average Voltage as V_{ave} should be halved in a half wave rectifier compared to a full wave rectifier.

Part 2: AC/AC Converter

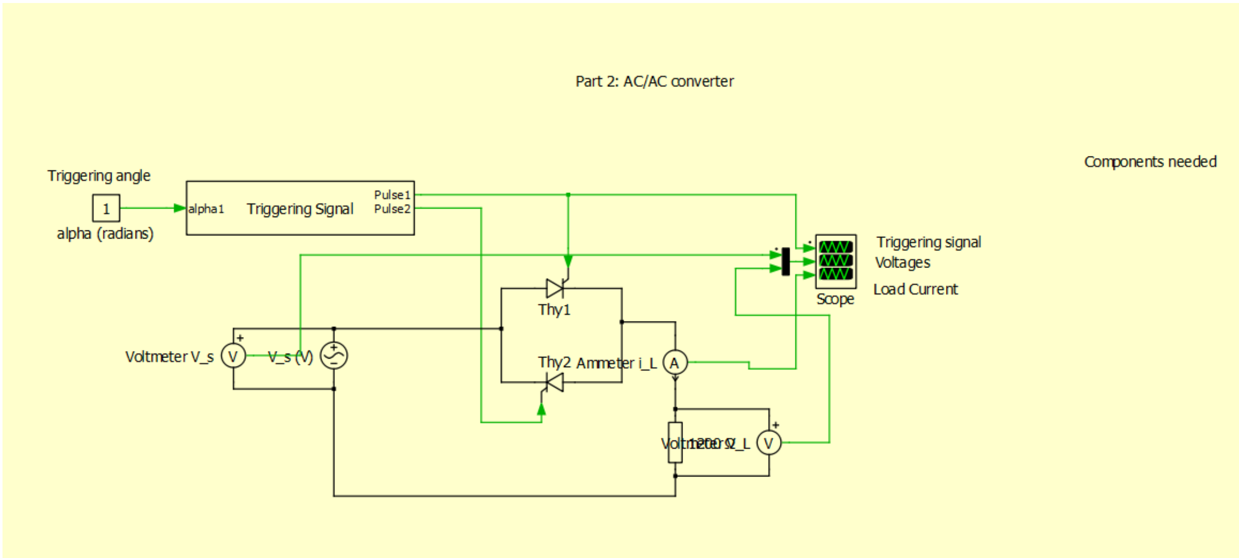

Fig. 1.AC/AC Schematics.

Experiment:

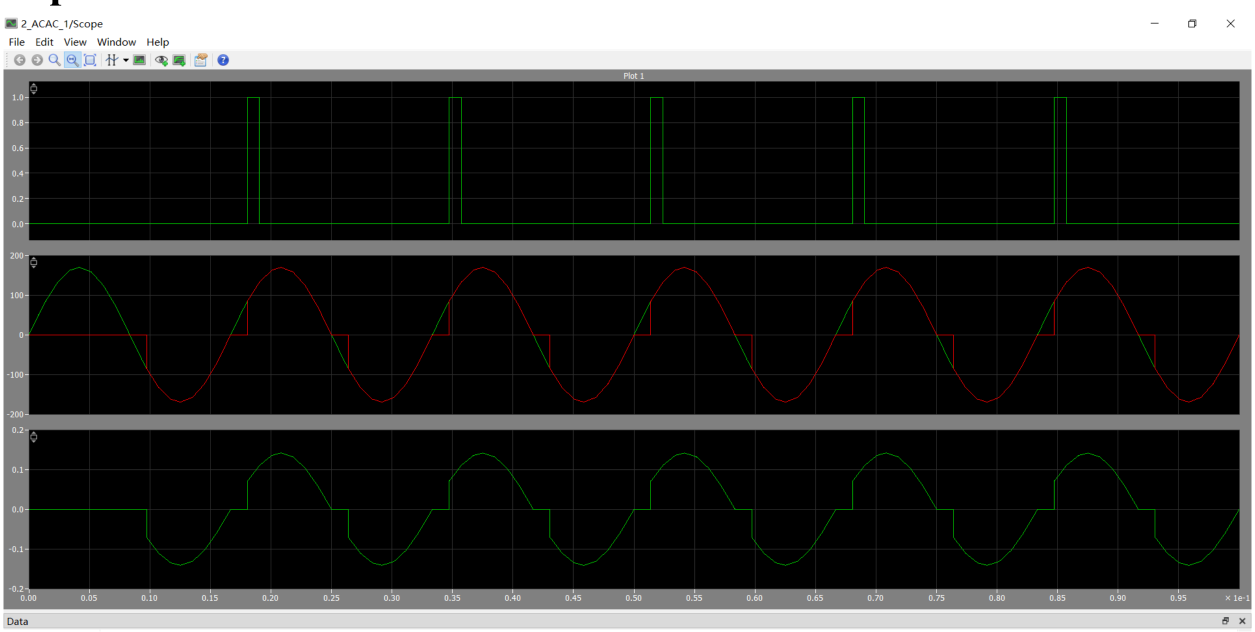

Fig. 2. Triggering signal/Voltage/Current vs.Time(30degree triggering angle)

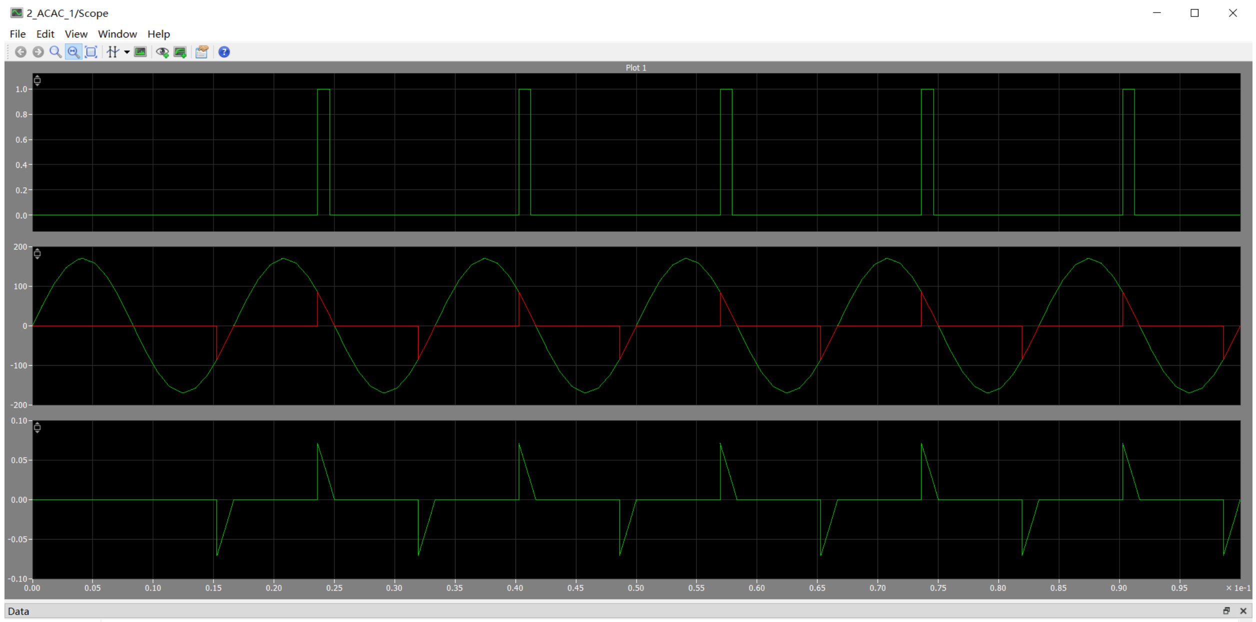

Fig. 3. Triggering signal/Voltage/Current vs.Time(150degree triggering angle)

Problem2:

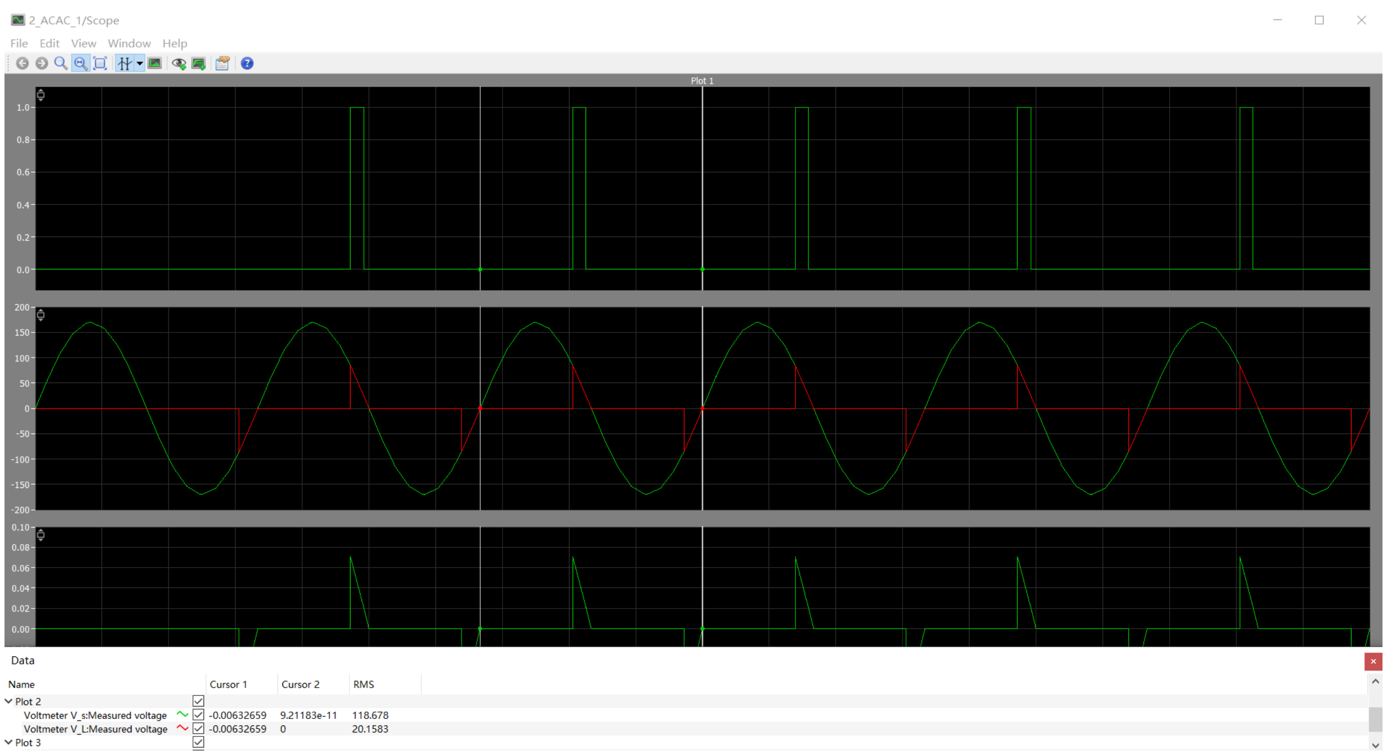

Fig. 4. RMS Voltage Over One Period(150degree triggering angle)

According to the graph above, V_rms = 20.1583 V over one period.
Using the formula to compute the V_rms:

$$V_{rms} = 120\sqrt{[1 - \frac{2.618}{\pi} + \frac{sin(300)}{2\pi}]}$$

We get V_rms = 20.3753 V. As a result, the V_rms we measured(20.1583 V) is very close to the theoretical value(20.3753 V).

Discussion on the outcomes:
From figure 2 and figure 3 we can see that, we can vary the waveform of output voltage by varying the triggering angle. Both the time it lasts and the average of the output voltage shrinks as we change the triggering angle from 30 to 150 degree. As a result, the load current has a similar behavior.

Part 3: DC/AC Converter

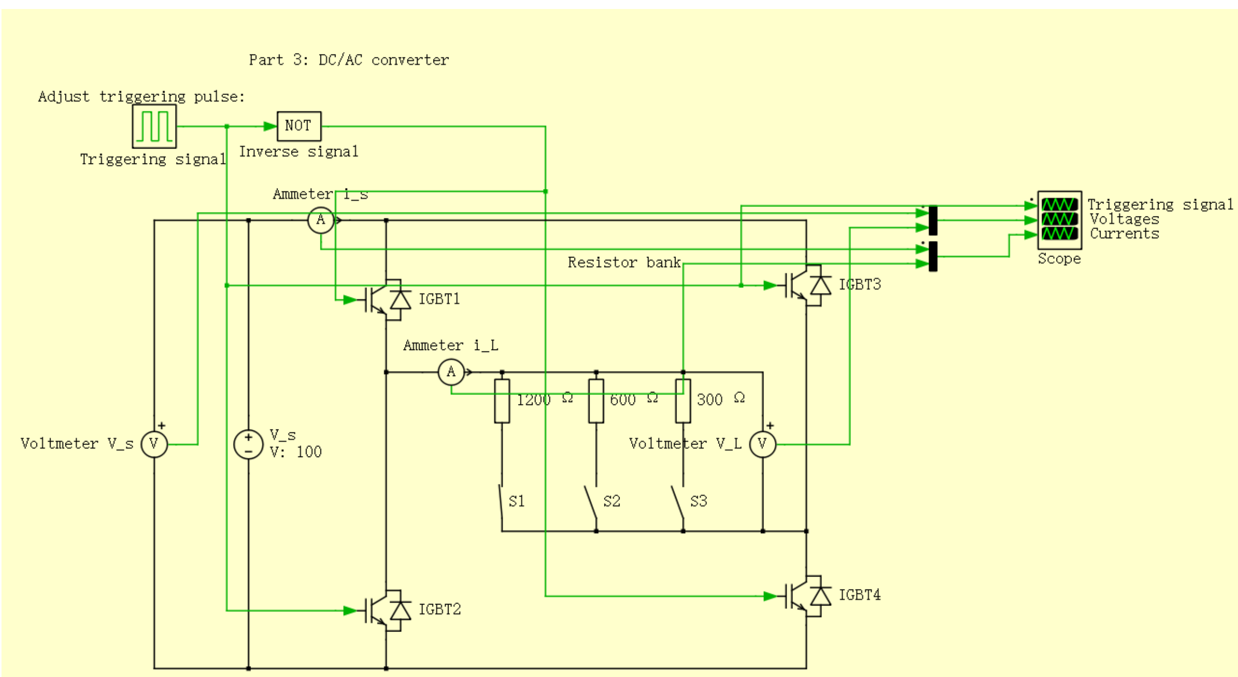

Fig. 1. Schematics.
Comment: Using triggering signal with frequency 150Hz, resistor with resistance 1200 ohm.

Experiment:

1. Simulation waveform with duty cycle of 20% as shown in Fig. 2-4.

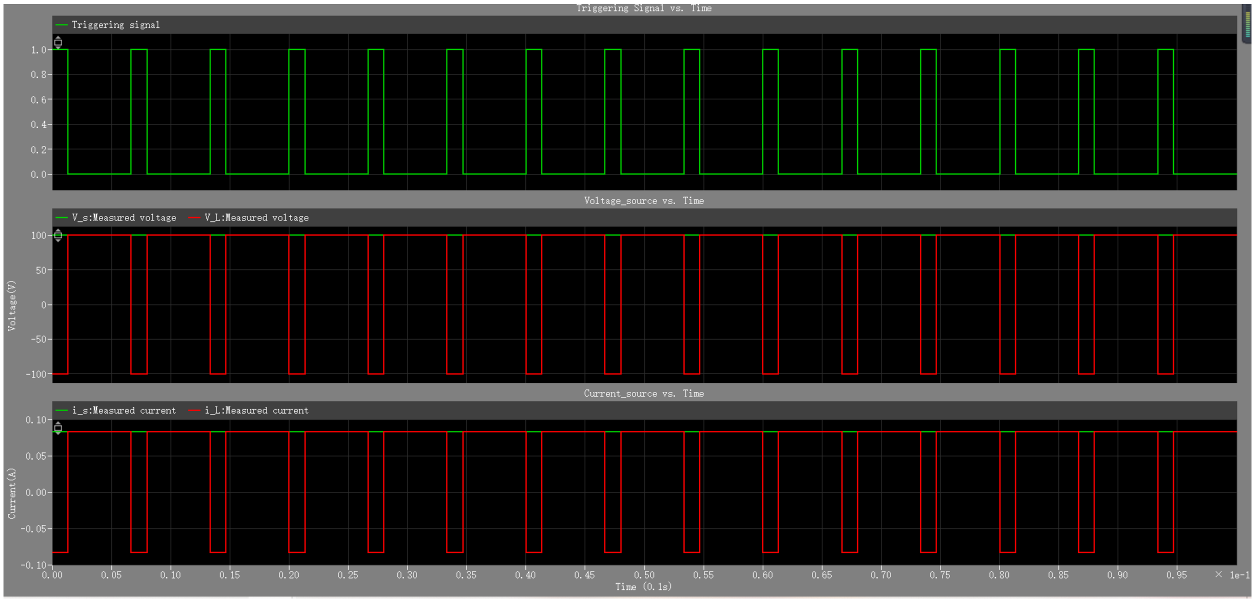

Fig. 2. Triggering signal/Voltage/Current vs.Time

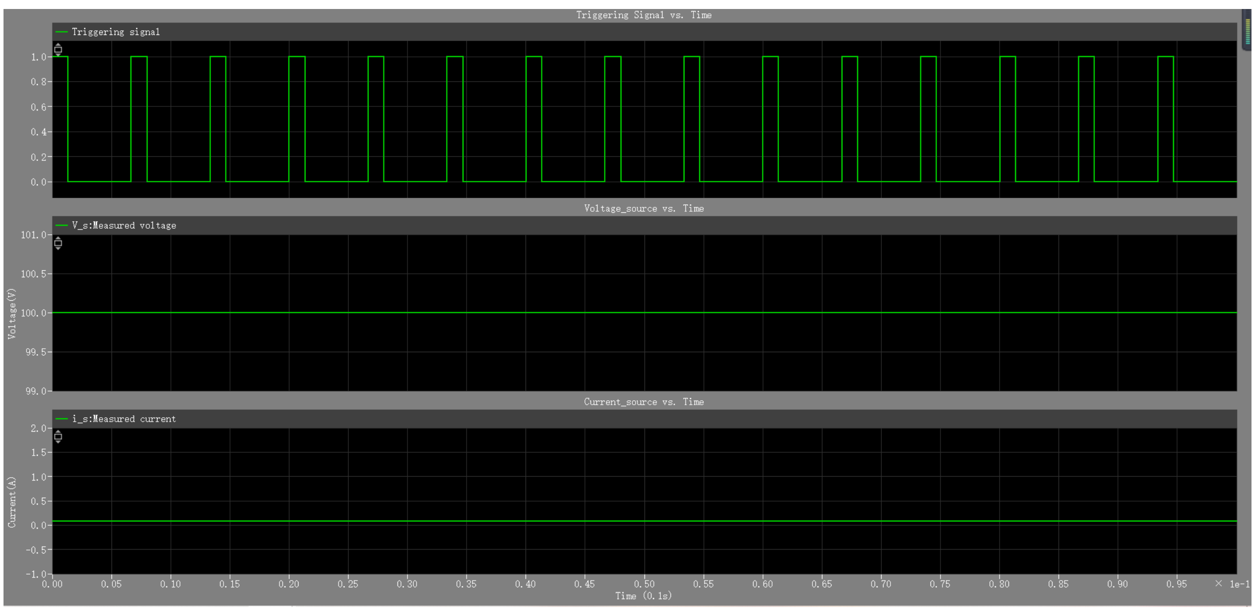

Fig. 3. Triggering signal/Voltage_source/Current_source vs. Time

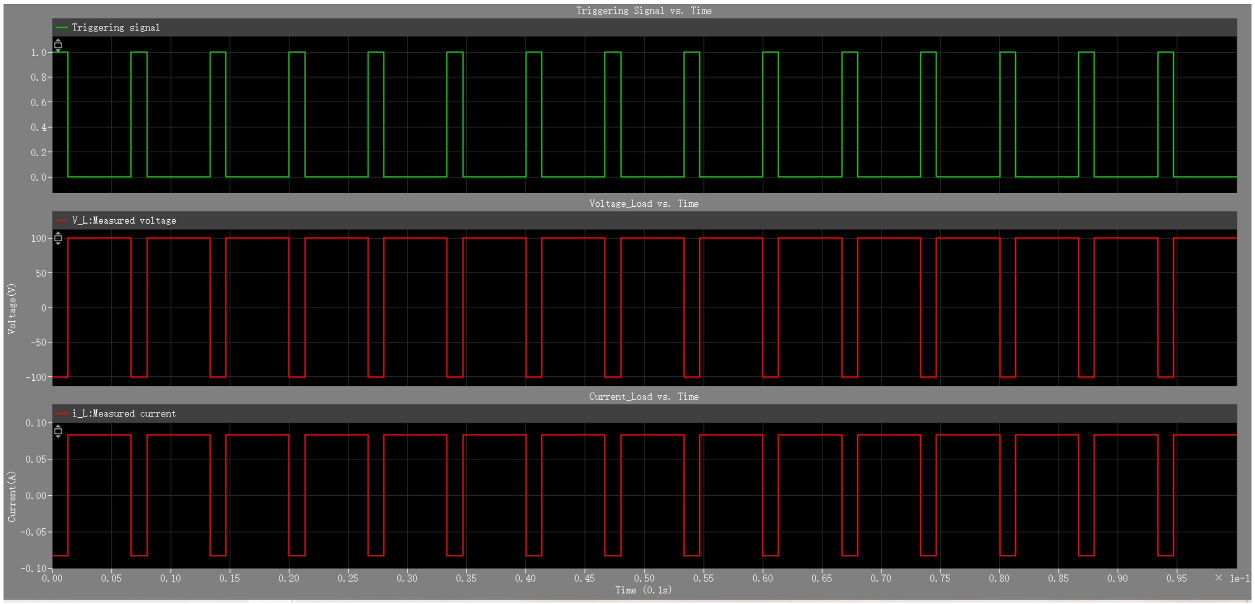

Fig. 4. Triggering signal/Voltage_load/Current_load vs. Time

2. Simulation waveform with duty cycle of 50% as shown in Fig. 5-7.

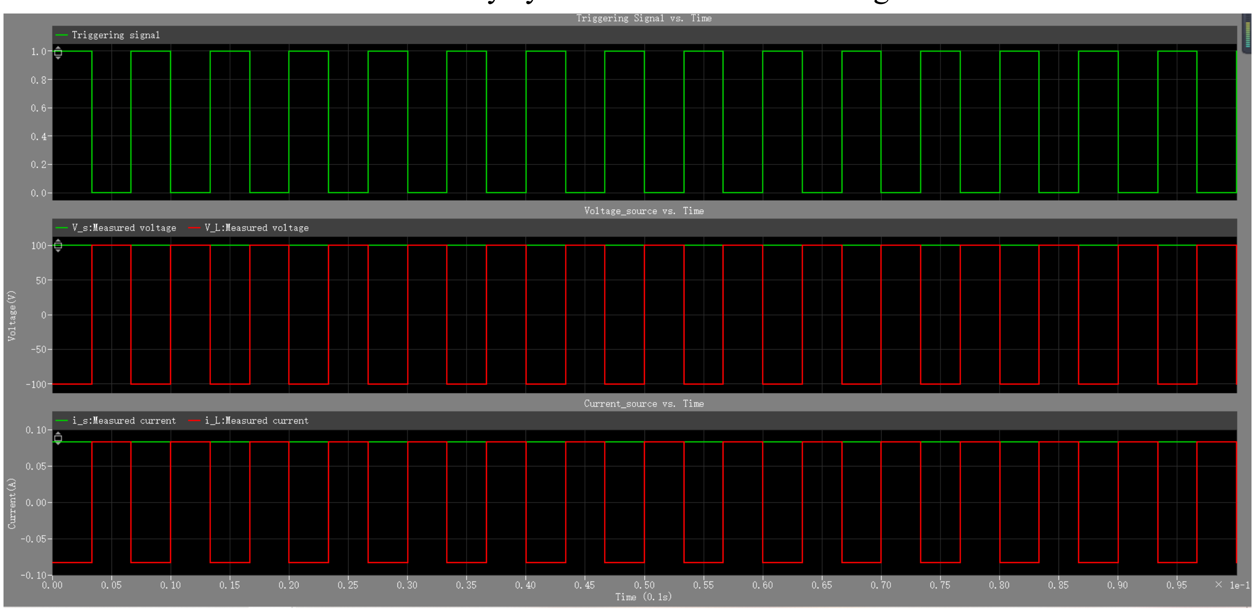

Fig. 5. Triggering signal/Voltage/Current vs.Time

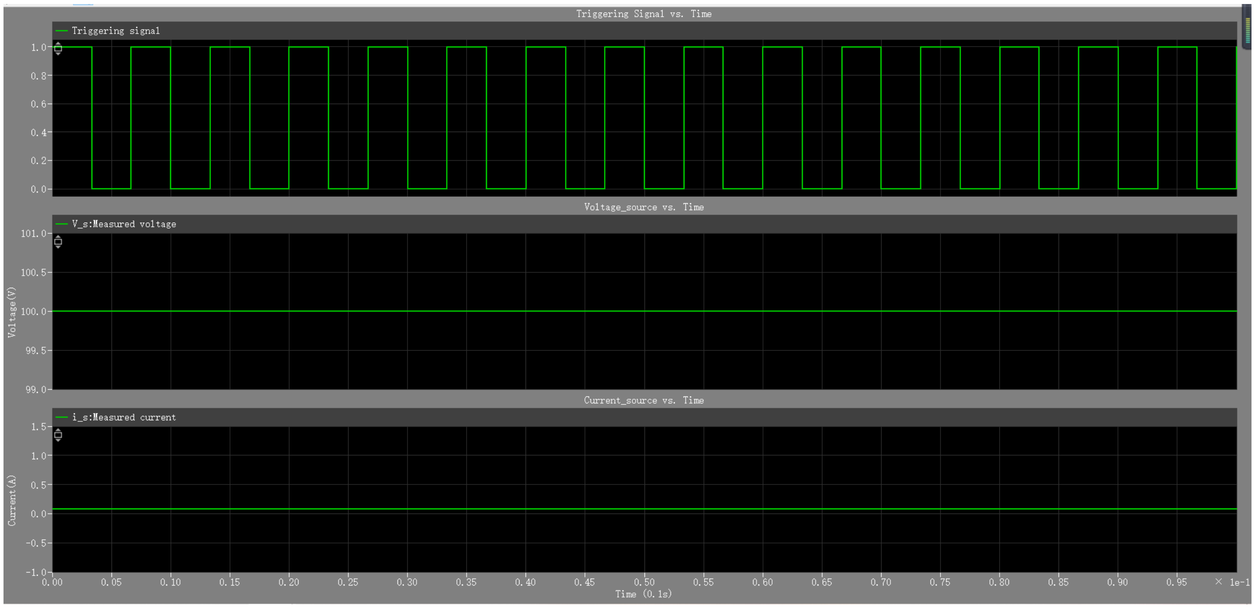

Fig. 6. Triggering signal/Voltage_source/Current_source vs. Time

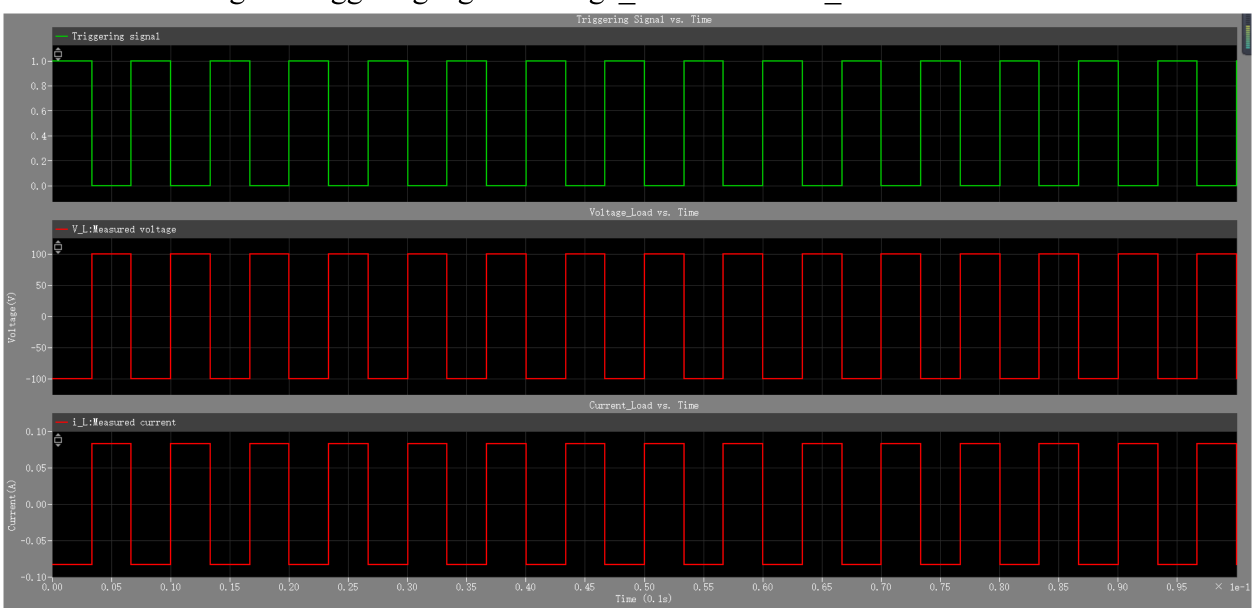

Fig. 7. Triggering signal/Voltage_load/Current_load vs. Time

Comment: from Fig.2-7, we can see that the voltage waveform and current waveform has the same shape as the triggering signal. The load voltage is formed by the negative triggering signal being amplified by the source voltage, thus is affected by the properties of the triggering signal, such as duty cycle. The current is equal to voltage divided by the resistance, thus, since the load resistance is consistent, the current has the same shape as the voltage, except the amplitude. Also, we can see that as the duty cycle increases, the positive period of the load voltage decreases, the negative period of load voltage correspondingly increases.

3. The measured RMS voltage across the load is shown in Fig. 8. as V_L under RMS.

Data

Name	Cursor 1	Cursor 2	Delta	RMS
Triggeri...	1	1	0	0.447214
Voltage_Loa...				
V_s:Me...	100	100	0	100
V_L:Me...	-100	-100	0	100
Current_Loa...				
i_s:Mea...	0.0833333	0.0833333	0	0.0833333
i_L:Mea...	-0.0833333	-0.0833333	0	0.0833333

Fig. 8. Measured RMS value for each data.

Vrms_measured: 100V

Vrms_calculated:

$$RMS\ Value = \sqrt{1/T \int_0^T f(x)^2\, dx}$$

Based on the formula of rms value, we see that T = 1/f = 1/150Hz, f(x) = V_L. Thus, after $(f(x))^2$, the -100V in the V_L will become +100V, $(v\_load)^2$ will be the same as $(100)^2$, which is the same as V_s, thus makes Vrms_calculated = 100 V.

Thus, the calculated Vrms and the measured Vrms have the same value, the simulation is working ideally.

Outcome: From Fig. 2-7 we can see that the DC-AC converter works ideally under the simulation setting, which can also be proved by Fig.8 the measured rms value matching with the calculated rms value. We also observe that the output AC voltage is controlled by the triggering signal's duty cycle, it's positive period happens at the negative period of triggering signal and negative period happens at the positive period of triggering signal. The output AC voltage is also determined by the DC voltage's amplitude, as it is what determines the maximum amplitude of AC voltage.

Part 4: DC/DC Converter

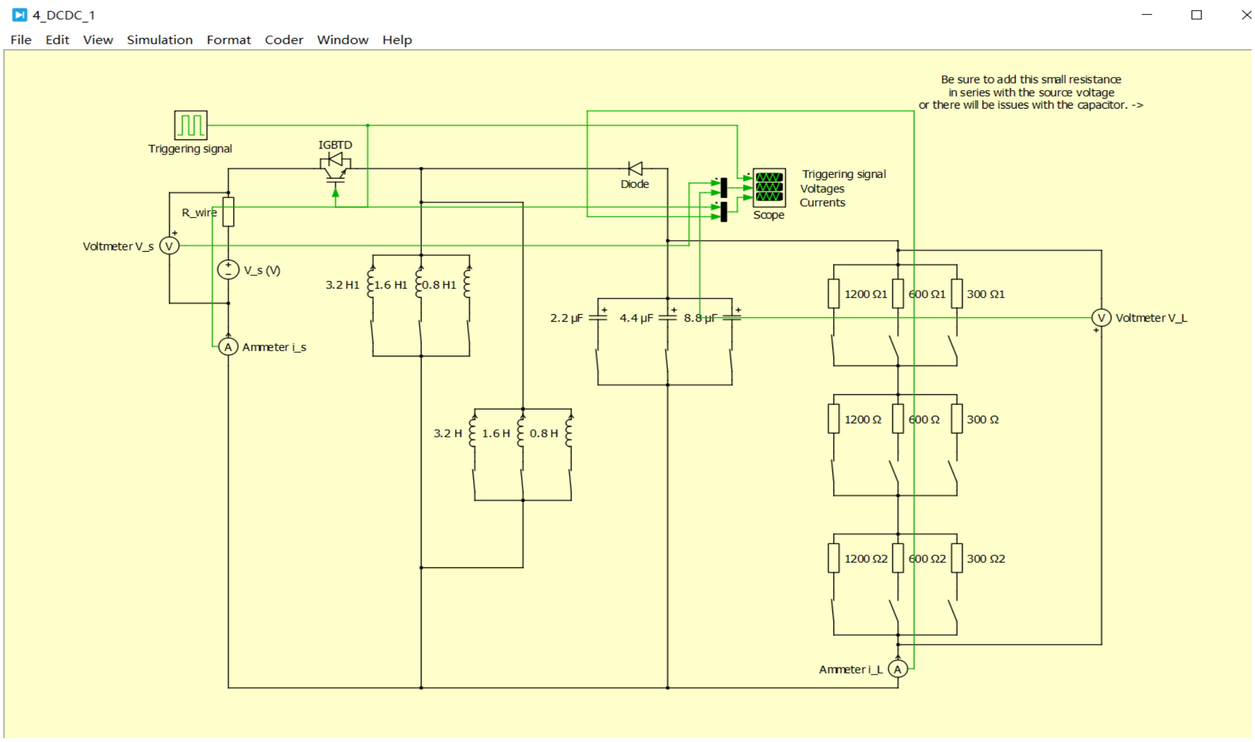

Fig. 1.DC/DC Schematics.

Experiment:

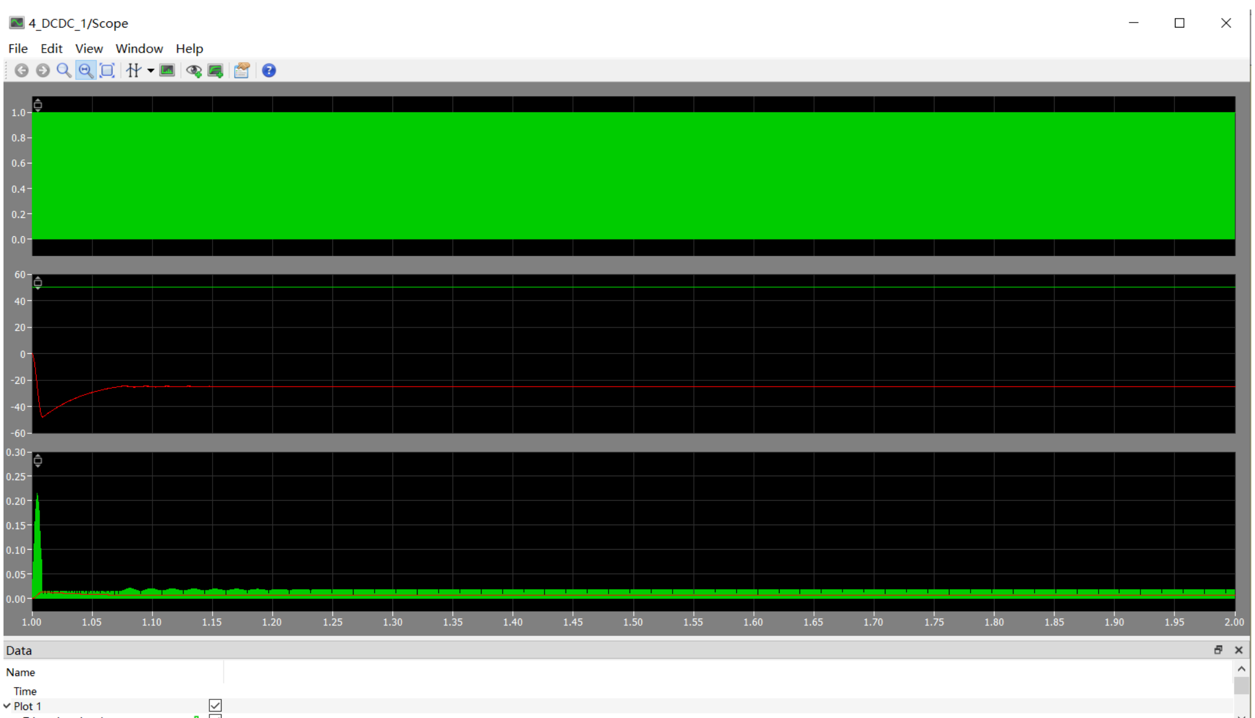

Fig. 2. Triggering signal/Voltage/Current vs.Time(t_on/t_off = 50%)

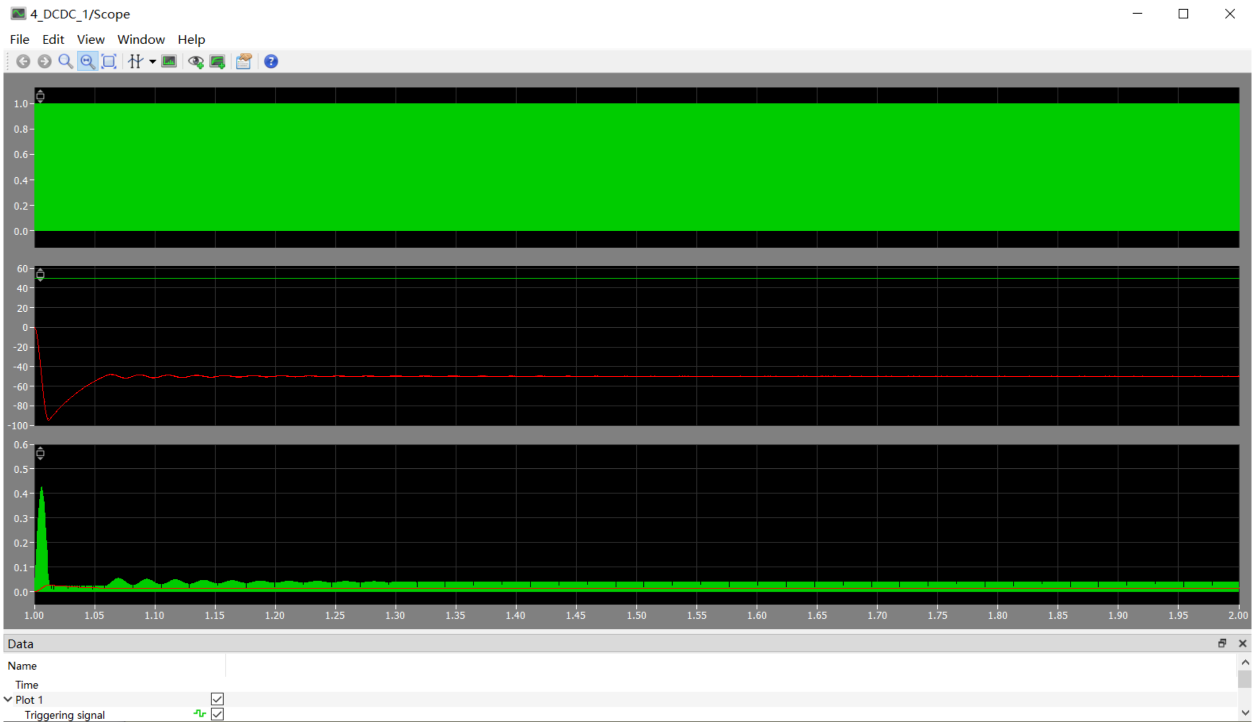

Fig. 3. Triggering signal/Voltage/Current vs.Time(t_on/t_off = 100%)

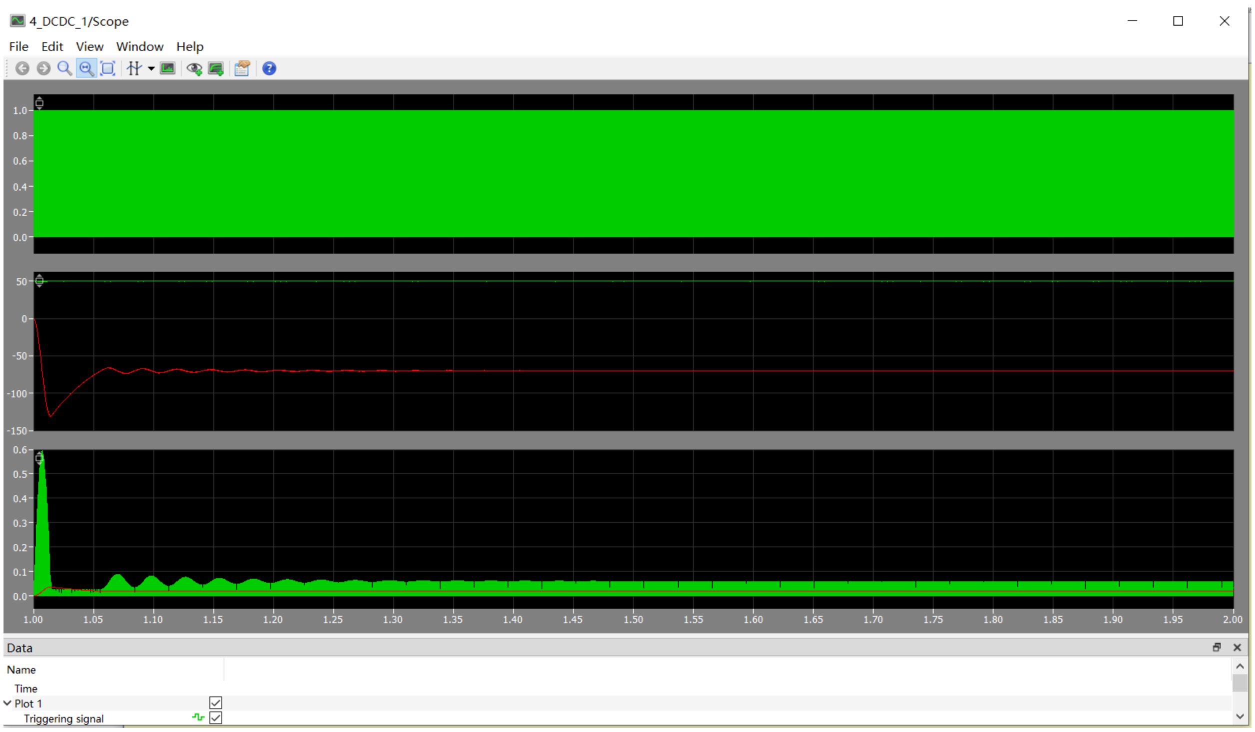

Fig. 4. Triggering signal/Voltage/Current vs.Time(t_on/t_off = 140%)

Problem 2:

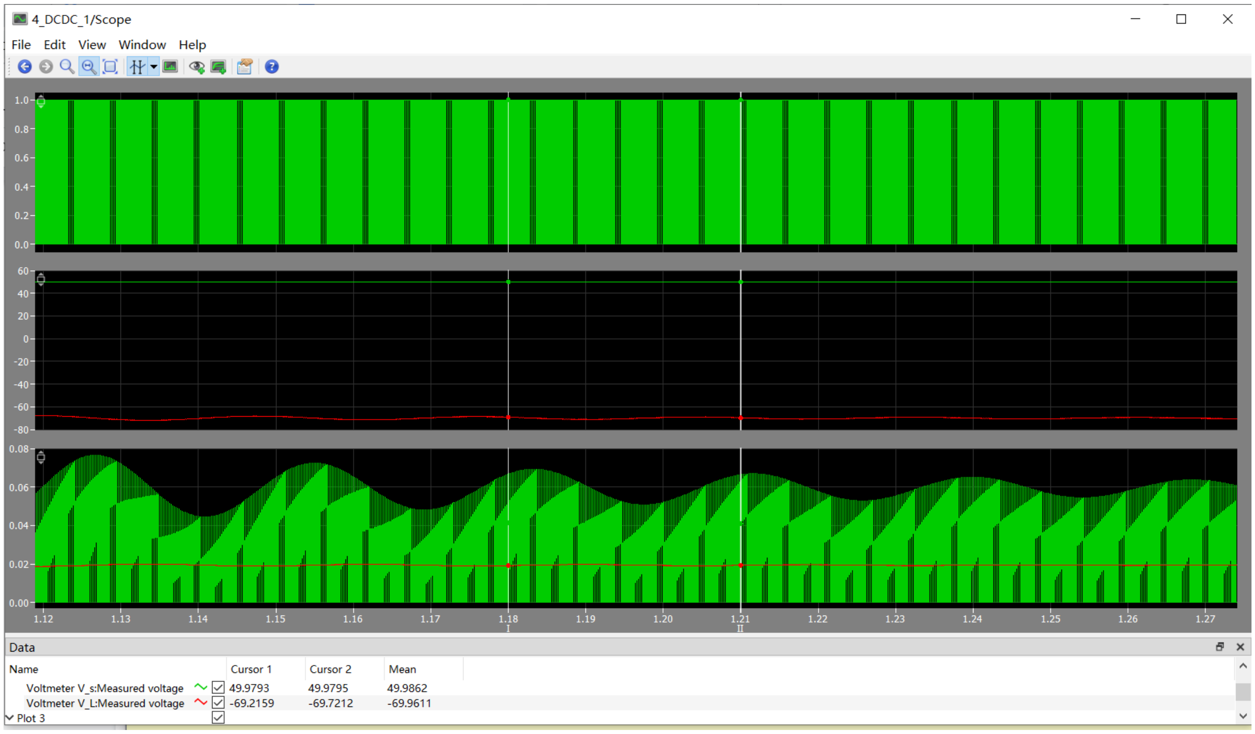

Fig. 5. Average Load Voltage Over One Period(t_on/t_off = 140%)

According to the graph above, V_avg = -69.96 V
When t_on/t_off = 140%:

$$V_{avg} = -V_s \frac{t_{on}}{t_{off}} = -70V$$

As a result, the V_avg we measured(-69.96 V) is very close to the theoretical value(-70 V).

Problem 3:

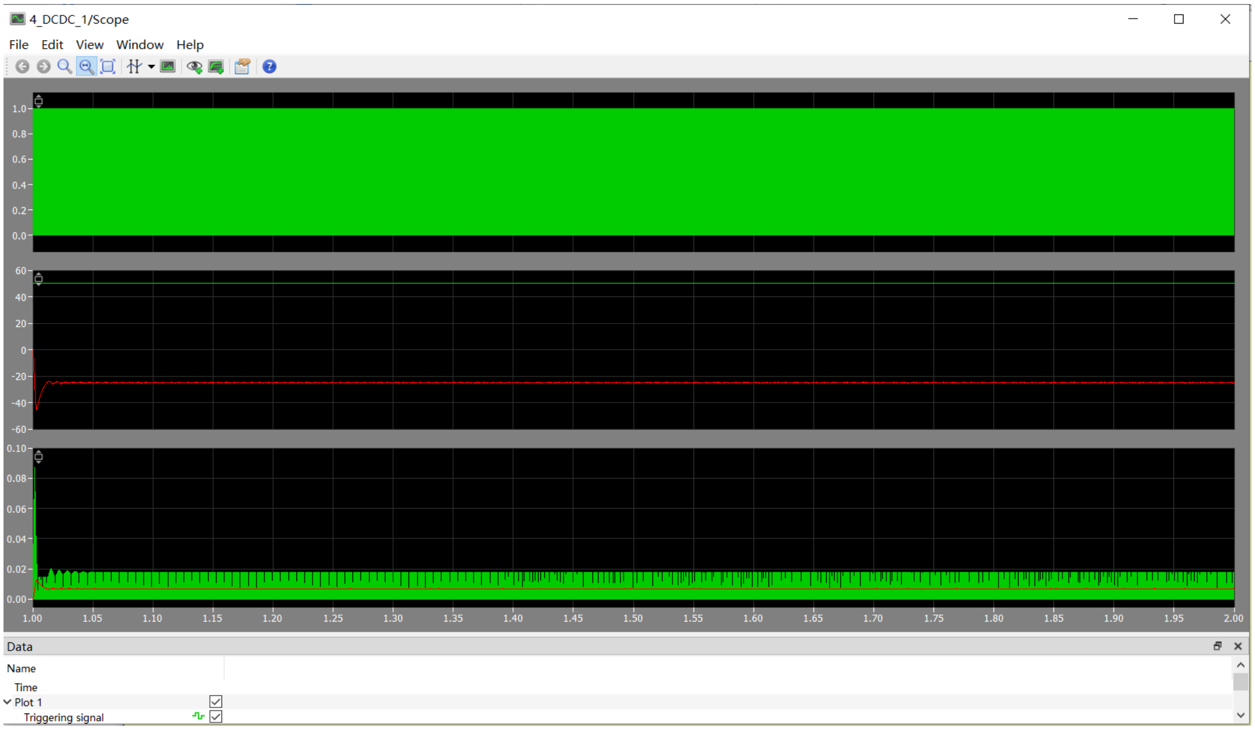

Fig. 6. Triggering signal/Voltage/Current vs.Time(t_on/t_off = 50%, C = 2.2μF)

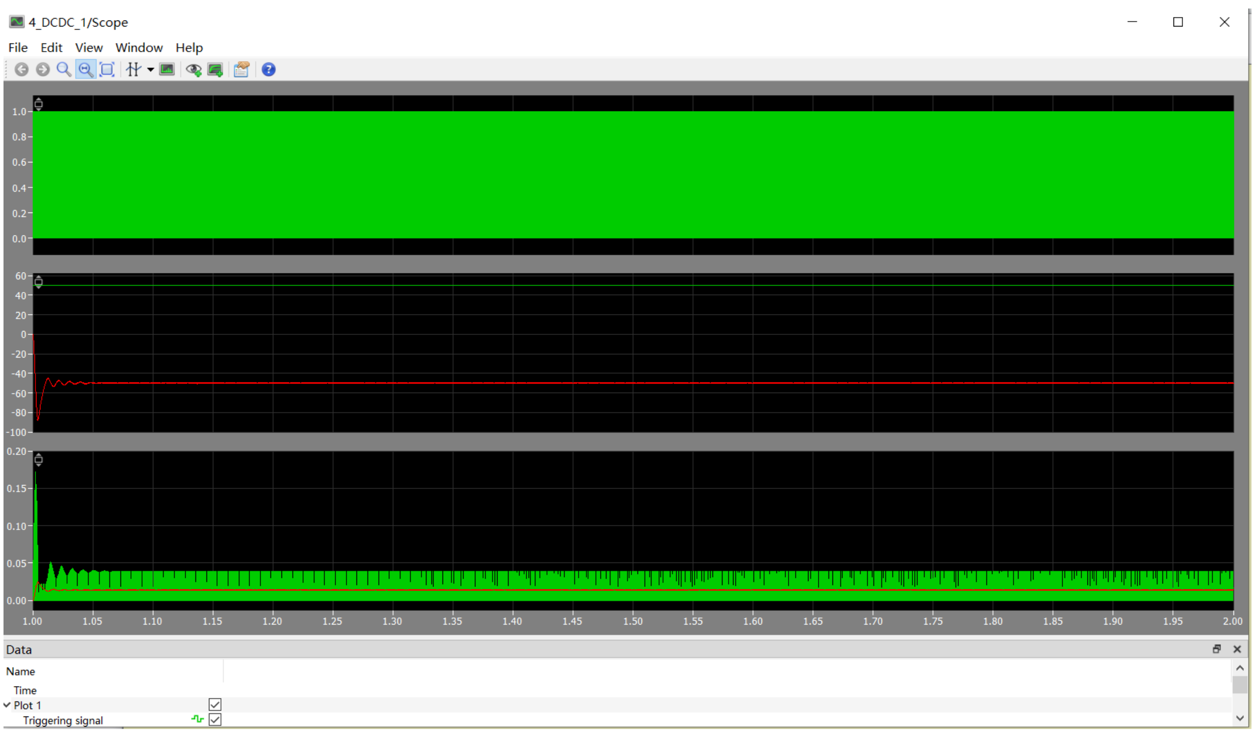

Fig. 7. Triggering signal/Voltage/Current vs.Time(t_on/t_off = 100%, C = 2.2μF)

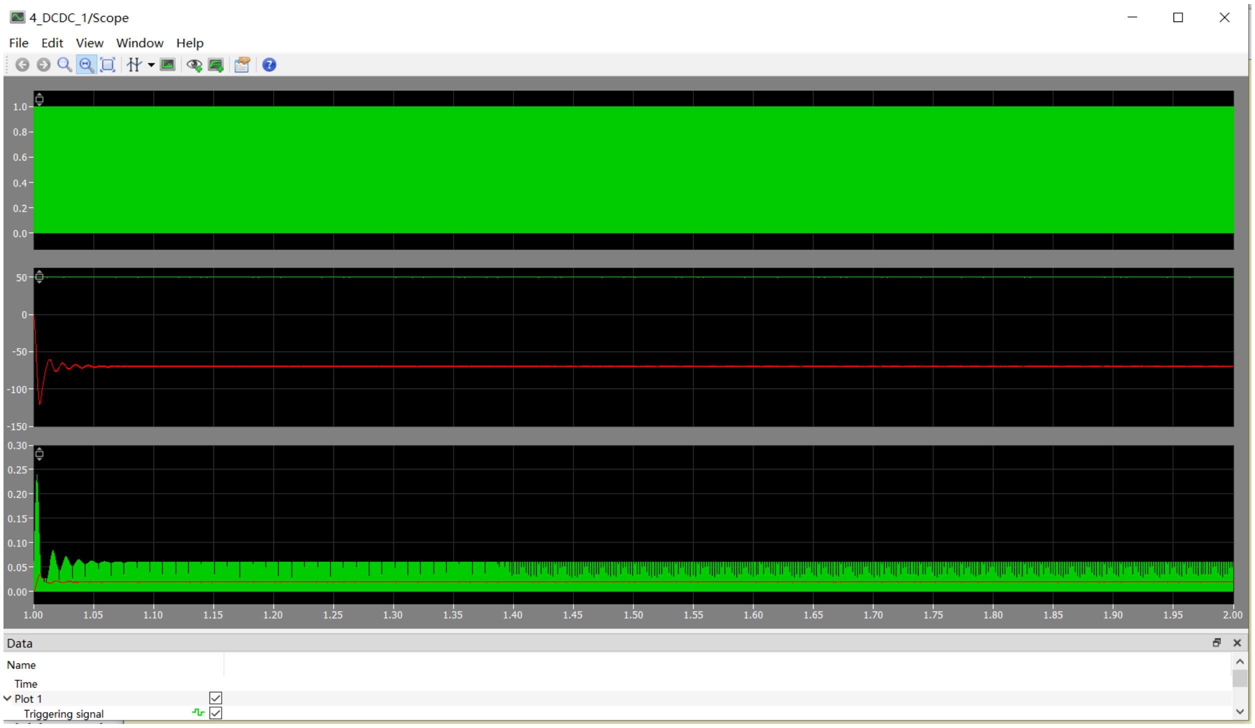

Fig. 8. Triggering signal/Voltage/Current vs.Time(t_on/t_off = 140%, C = 2.2μF)

Discussion on the outcomes:
From figure 2 to figure 4 we can see that as the ratio of t_on/t_off increases, the magnitude of the output voltage increases as well. From class we know that the inductor is used to store the charges when the switch is on and release the charges when the switch is off. The capacitor is used to reduce the voltage ripples across the load. From figure 6 to figure 8 we can see that with a smaller capacitor, the load voltage stabilized faster but the ripple voltage is larger.

Contribution:

Experiments: **Fan Yang, Simon Chen, Cynthia Li**
Analysis of the results: **Fan Yang, Simon Chen, Cynthia Li**
Preparation of the report: **Fan Yang, Simon Chen, Cynthia Li**