EXPERIMENT E16: DIODE CLIPPING AND CLAMPING CIRCUITS

Related course: KIE1007 (Electronic Circuit I)

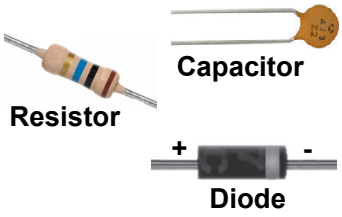
OBJECTIVES:
To construct diode clipping and clamping circuits and explain their operation

EQUIPMENT:
Oscilloscope; function generator; DC power supply; multimeter; breadboard; wires/jumpers; diode 1N4007 (1 unit); resistor 10kΩ (1); capacitor 0.01uF [103] (1)

INSTRUCTIONS:
1. Make sure that you have done **PRE-TEST** of Experiment E16 on your own before performing this experiment in the lab. Bring the simulation result along during the lab session. It will be used for comparison with the measurement result.
2. Record all your results and observations in a log book or on a piece of paper
3. Follow the demonstrator's instructions throughout the experiment

REFERENCES:
Refer to the main references of KIE1007

TESTS:
PRE-TEST: Simulation of Diode Clipping and Clamping Circuits
TEST 1: Diode clipping circuit
TEST 2: Diode clamping circuit



INTRODUCTION:

Diodes can be used to rectify power supplies, radio frequency detection, clipping and clamping signals. Both operations can be implemented with a diode and a few passive components. Clipping and clamping circuits find widespread use in audio and video circuitry.

Clipping is bounding a signal to limited amplitude. Clipping a signal is done to prevent its amplitude from exceeding a certain limit. Applications of clipping circuits are input protection and square wave generation. Some sensitive circuits can be damaged if large signals are applied to them. Clipping can be used to protect these circuits by limiting the signal amplitude. If a sine wave is clipped, the resulting waveform looks like a square wave.

Clamping is shifting the center of an AC signal to a different value. A clamping circuit is used to "clamp" a signal to a fixed DC level, known as "DC restoration." A capacitor in this circuit separates the voltage source from the load and the diode sets the clamping voltage level.

PROCEDURE:

PRE-TEST: Simulation of Diode Clipping and Clamping Circuits

1. Using PSpice, draw the circuit as shown in Figure 1. For diode, use D1N4002. For function generator, use VSIN. Set its VAMPL = 3, FREQ = 500 Hz and leave the rest unchanged.
2. Insert voltage probe  between VSIN and R and another one between R and diode.
3. Simulate the circuit by setting Final Time=0.01 and Step Ceiling=0.00001 under "Transient" (click "Analysis" –> "Setup" –> "Transient")

4. Paste the voltage curve result into Word.
5. Determine the pk-pk voltage, the maximum and minimum voltage of both waveforms.
6. Continued from the same circuit, reverse the diode polarity, i.e. the negative terminal of the diode is connected to the resistor. Simulate the circuit. Paste the voltage curve into Word. Determine the pk-pk voltage, the maximum voltage and the minimum voltage of both waveforms.
7. Continued from step 6, reverse the polarity of the DC power supply, i.e. the negative terminal of the DC power supply is connected to the ground. Simulate the circuit. Paste the voltage curve into Word. Determine the pk-pk voltage, the maximum voltage and the minimum voltage of both waveforms.
8. Repeat steps 1 to 7 for Figure 2.

TEST 1: Diode clipping circuit

1. Connect the function generator, 10 kΩ resistor, diode and the DC power supply in series on a breadboard, as shown in Figure 1. For diode, the negative terminal is shown by the grey stripe on its body.
2. Connect the probe hook clip of the oscilloscope CH1 at the output of the function generator (labelled CH1 in Figure 1). Connect the CH1 ground lead (black croc clip) to the ground of the function generator (its black croc clip).
3. Connect the probe hook clip of the oscilloscope CH2 between the 10 kΩ resistor and the diode (labelled CH2 in Figure 1). Connect the CH2 ground lead (black croc clip) to the ground of the function generator (its black croc clip).
4. Switch ON the DC power supply and set to +2V DC. Switch ON the function generator and set the voltage amplitude to 6V pk-pk, sinusoidal, frequency 500 Hz. You can check the voltage amplitude and frequency of the function generator from CH1 waveform on the oscilloscope screen by pressing MEASURE button.
5. Set the oscilloscope to display both CH1 and CH2 clearly by adjusting the VERTICAL and HORIZONTAL settings (try 1V/div and 500 μs/div). Make sure that the offset of both signals is 0V. Adjust trigger level if necessary. Can you see that the output signal is bounded to limited amplitude or “clipped”? Save the oscilloscope screen in a pendrive or capture the screen using a camera.
6. Record the pk-pk voltage, the maximum voltage and the minimum voltage of the CH1 waveform. The maximum and minimum voltage can be measured using ‘Cursor’ button on the DSO. These values are from the function generator or the input signal of the clipping circuit. Then, compare these values with the simulation results.
7. Record the pk-pk voltage, the maximum voltage and the minimum voltage of the CH2 waveform. These values are the output of the clipping circuit. Then, compare these values with the simulation results.
8. Switch OFF the function generator and DC power supply.
9. Continued from your circuit in Figure 1, reverse the diode polarity, i.e. the negative terminal of the diode is connected to the resistor. Repeat steps 4 to 8. What is the difference between the output signal in step 9 and step 5?
10. Continued from step 9, reverse the polarity of the DC power supply, i.e. the negative terminal of the DC power supply is connected to the ground (or to the black clip of the function generator). Repeat steps 4 to 8. What is the difference between the output signal in step 10 and step 5?

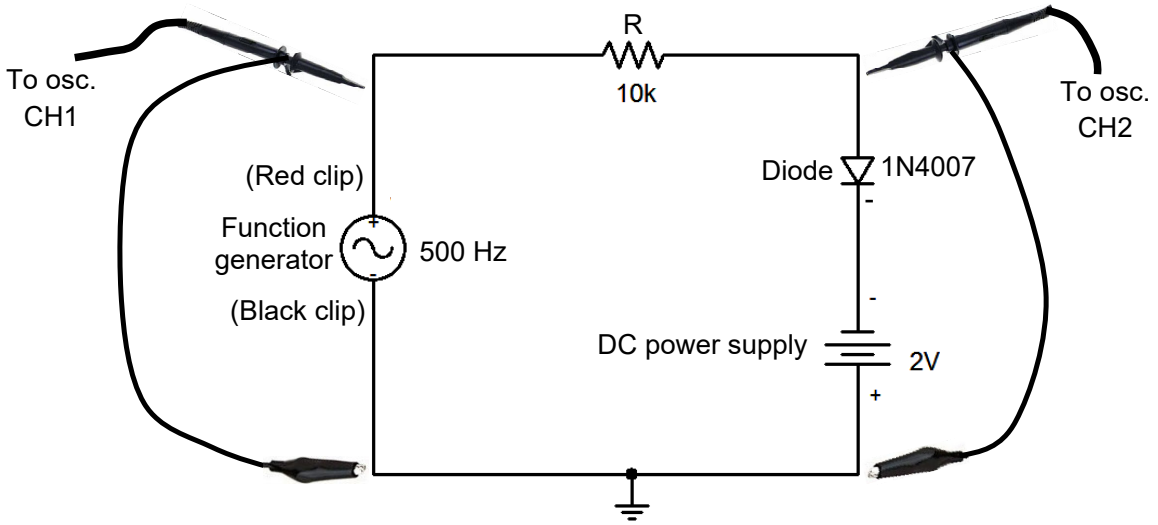


Figure 1: Diode clipping circuit

TEST 2: Diode clamping circuit

1. Connect the function generator, 0.01 uF capacitor, diode and a DC power supply in series on a breadboard, as shown in Figure 2. For diode, the negative terminal is shown by the grey stripe on its body.
2. Connect the probe hook clip of the oscilloscope CH1 at the output of the function generator (labelled CH1 in Figure 2). Connect the CH1 ground lead (black croc clip) to the ground of the function generator (its black croc clip).
3. Connect the probe hook clip of the oscilloscope CH2 between the capacitor and the diode (labelled CH2 in Figure 2). Connect the CH2 ground lead (black croc clip) to the ground of the function generator (its black croc clip).
4. Switch ON the DC power supply and set to +2V DC. Switch ON the function generator and set the voltage amplitude to 6V pk-pk, sinusoidal, frequency 500 Hz. You can check the voltage amplitude and frequency of the function generator from CH1 signal on the oscilloscope screen by pressing MEASURE button.
5. Set the oscilloscope to display both CH1 and CH2 clearly by adjusting the VERTICAL and HORIZONTAL settings (try 2V/div and 500 µs/div). Make sure that the offset of both signals is 0V. Adjust trigger level if necessary. Can you see that the output signal is shifted to a different value or “clamped”? Save the oscilloscope screen in a pendrive or capture the screen using a camera.
6. Record the pk-pk voltage, the maximum voltage and the minimum voltage of the CH1 waveform. The maximum and minimum voltage can be measured using ‘Cursor’ button on the DSO. These values are from the function generator or the input signal of the clamping circuit. Then, compare these values with the simulation results.
7. Record the pk-pk voltage, the maximum voltage and the minimum voltage of the CH2 waveform. These values are the output of the clamping circuit. Then, compare these values with the simulation results.
8. Switch OFF the function generator and DC power supply.
9. Continued from your circuit in Figure 2, reverse the diode polarity, i.e. the negative terminal of the diode is connected to the capacitor. Repeat steps 4 to 8. What is the difference between the output signal in step 9 and step 5?

10. Continued from step 9, reverse the polarity of the DC power supply, i.e. the negative terminal of the DC power supply is connected to the ground (or to the black clip of the function generator). Repeat steps 4 to 8. What is the difference between the output signal in step 10 and step 5?

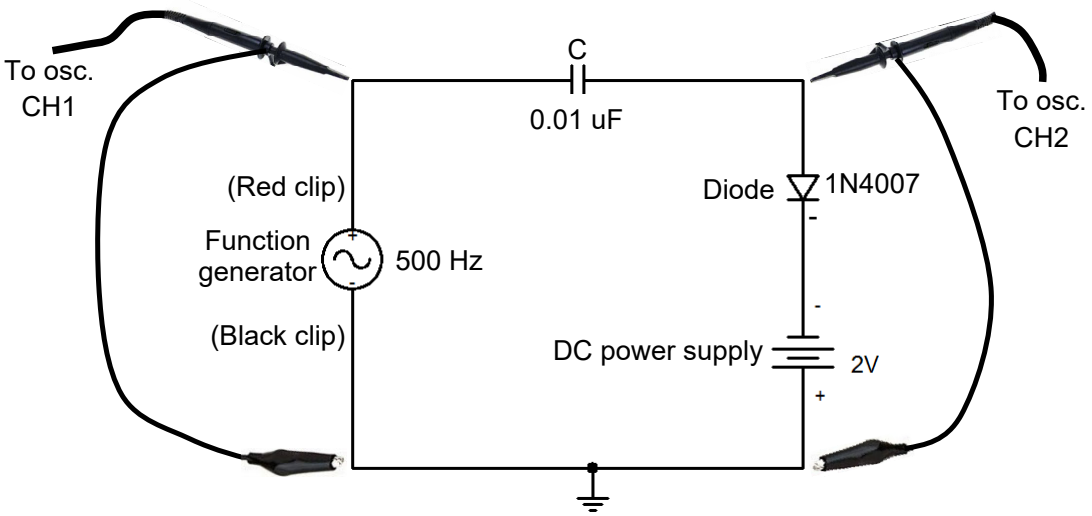


Figure 2: Diode clamping circuit

DISCUSSION:
Compare the waveform at CH2 in both circuits between your simulation results (PSpice circuits) and manual calculation. Do they almost equal to each other? If they are not, identify what factors which may cause the difference between them.

END OF EXPERIMENT