Lab 04 – Wave Shaping Circuit

Toronto Metropolitan University

ELE404 – Electronics I

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Introduction:

In this lab experiment, we investigated a diode circuit's capacity to change an input signal into a desired waveform. This capability is found in a diode's nonlinear voltage-current characteristic, which sets it apart from linear circuits that depend on inductors, resistors, or capacitors. The diode's nonlinear characteristic allows it to alter the shape of an input signal toward a desired waveform, in contrast to these linear circuits, which show simple relationships between voltage and current. By utilizing their unique non-linear characteristics, this experiment seeks to comprehend and illustrate the waveform shaping potential of diode circuits.

Objective:

Gaining familiarity with diode circuit manipulation of input waveforms is the main goal of this lab. The purpose of this exercise is to improve our understanding of diodes' non-linear properties and how they are used in wave-shaping techniques. This lab also aims to enhance our abilities in circuit analysis and design, with a particular emphasis on comprehending and utilizing the fundamental ideas of wave-shaping circuits.

Circuit Under Test:

In this lab, we examine a wave-shaping circuit made out of a meticulously ordered collection of parts (Figure 3). It has four diodes, two of which are oriented in one direction and the other two in the other direction. A group of interconnected resistors arranged to create a voltage-dividing network completes this configuration. The purpose of this setup is to precisely and carefully modify the characteristics of an input waveform.
Figure 3, which has R1=R2=3.3k ohm, R3=470 ohm, and R4=R5=91 ohm, is the first circuit built.

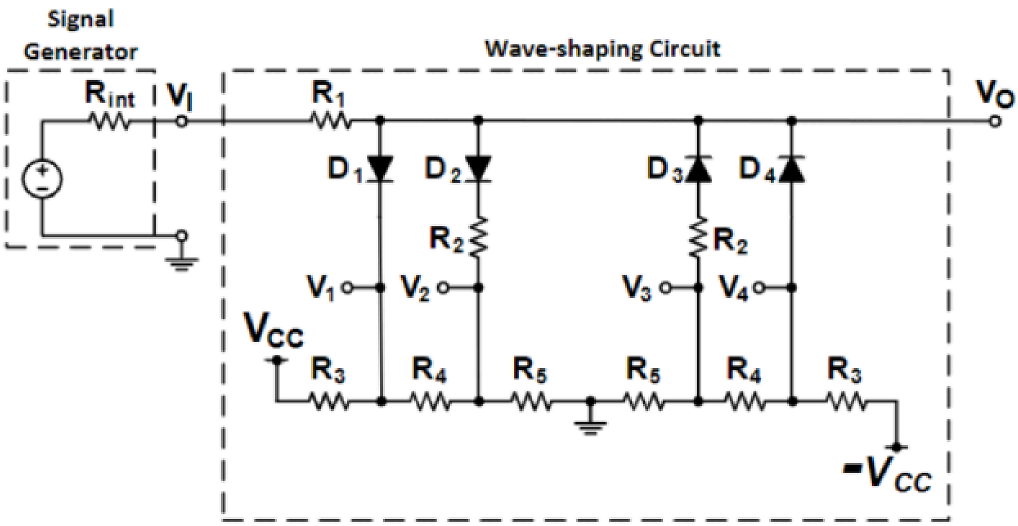
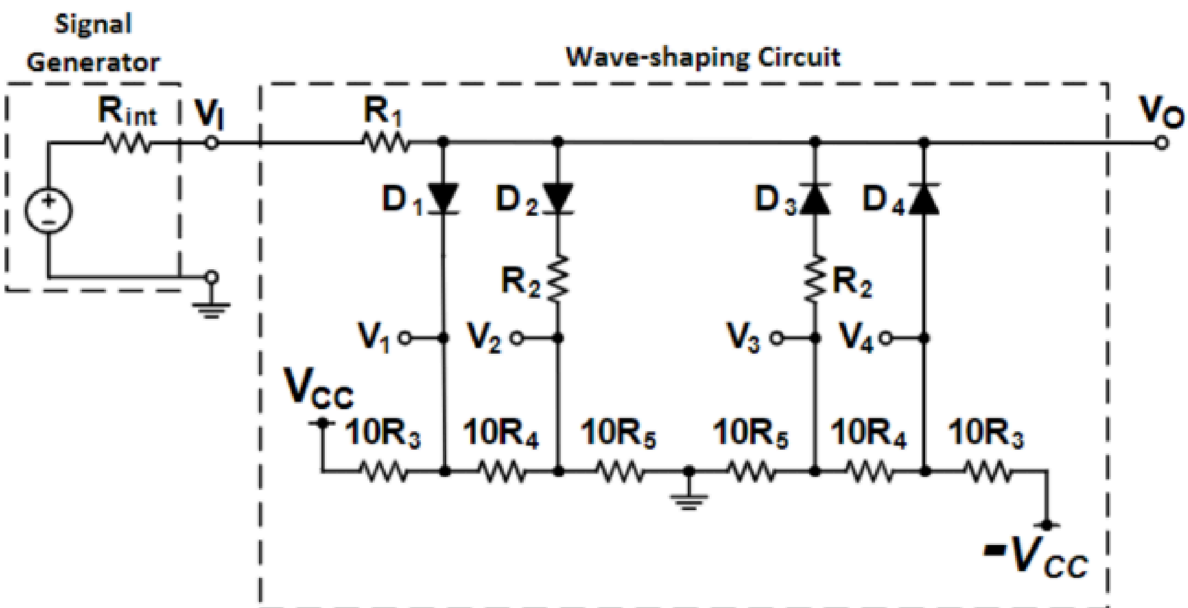
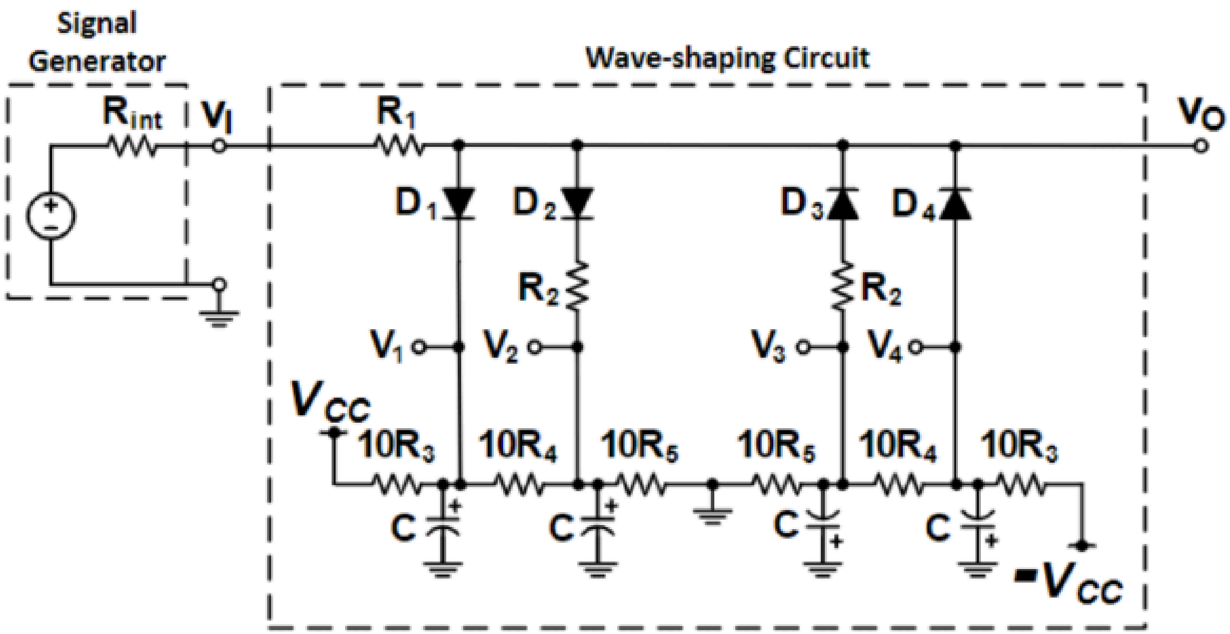


Figure 3. Wave-shaping circuit of Figure 1 in which the DC voltages are obtained from the voltage-dividing network of Figure 2.

The circuit configuration stays the same in the following stage of our experiment, but the voltage divider resistor values are increased tenfold, which affects how the circuit shapes waves.



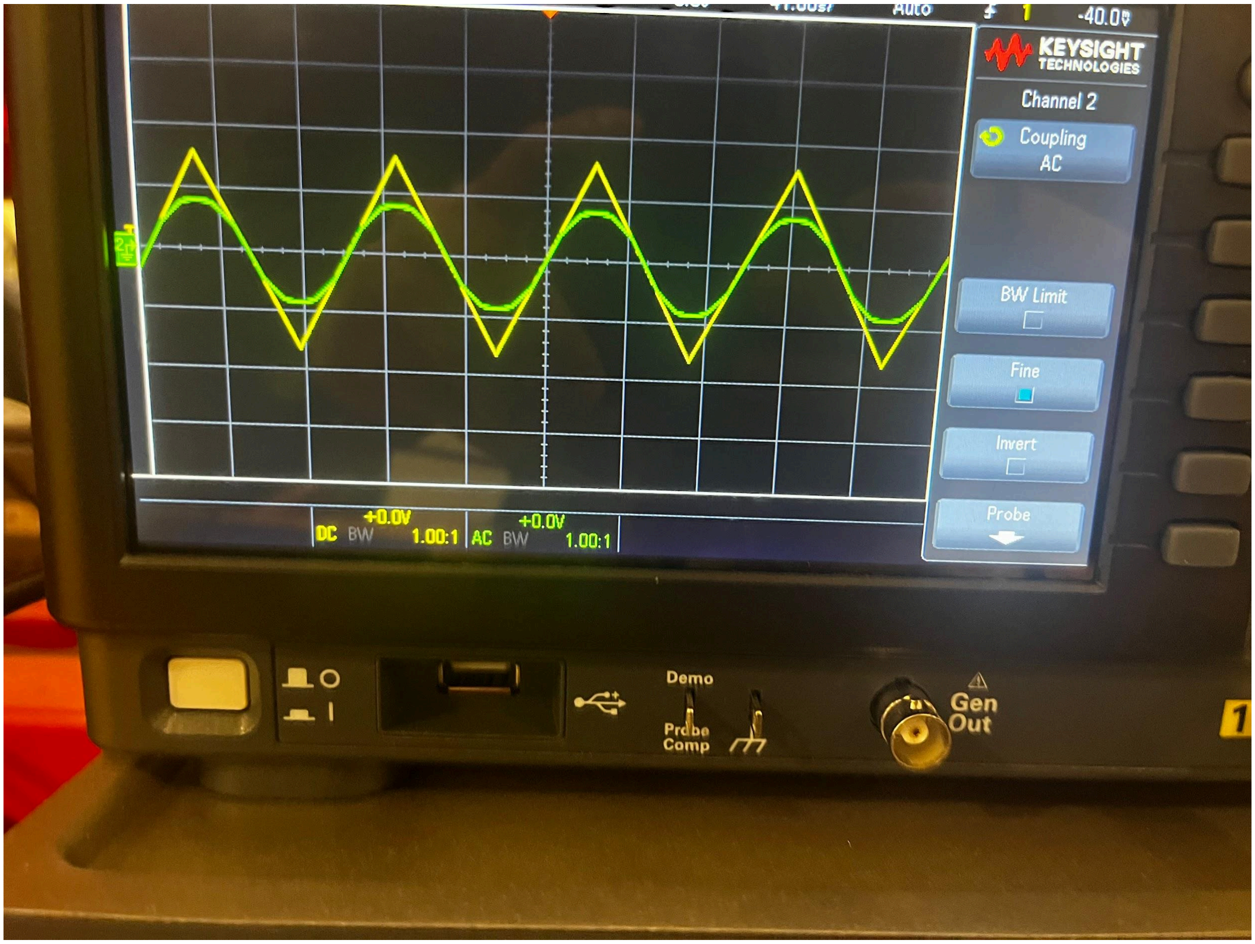
In the final experiment stage, we put a capacitor between each voltage divider node and connected them to ground. Because improper connections could harm the circuit and result in burning or even an explosion, we also made sure the capacitor's connected polarity was accurate.



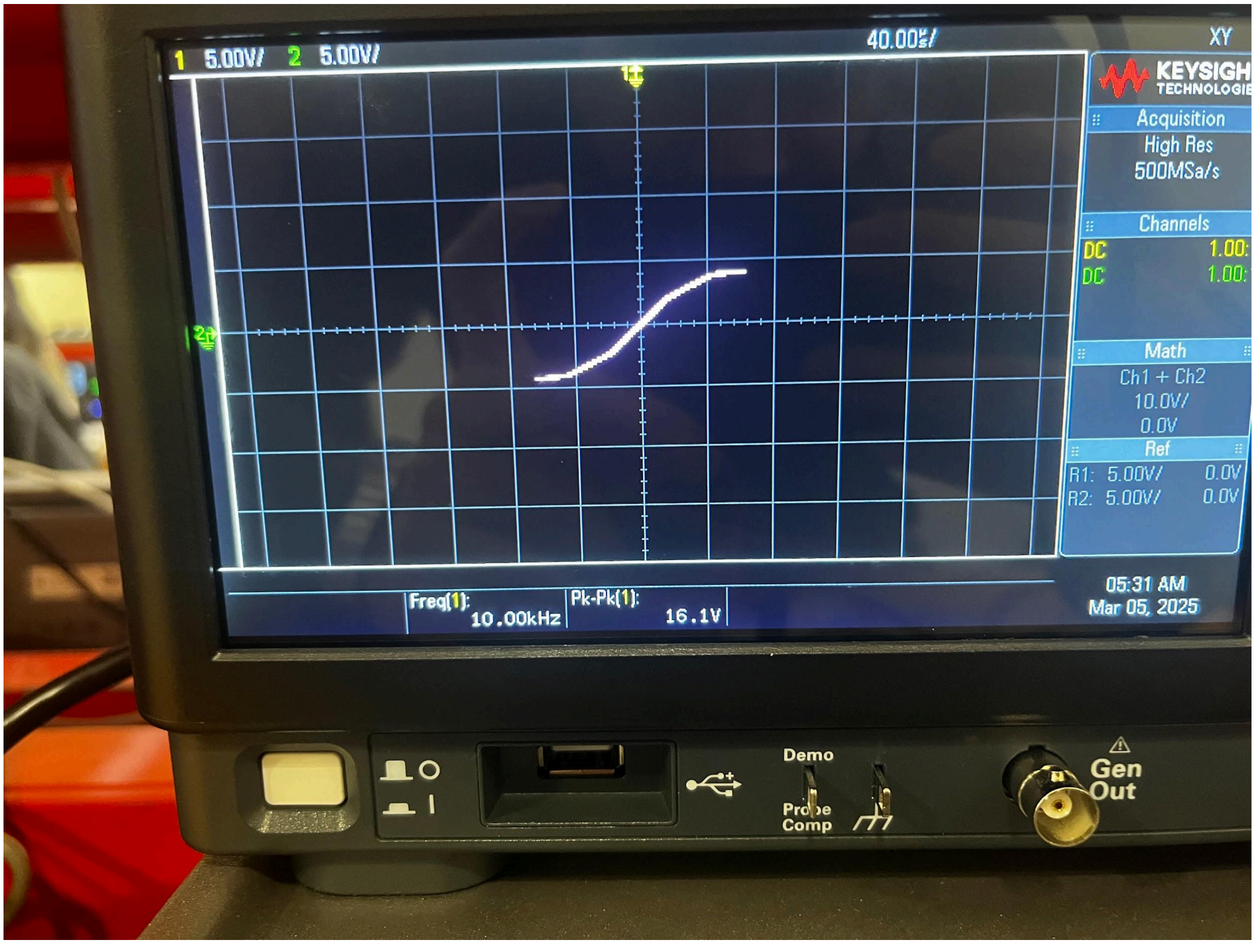
Experimental Results:

We had to construct three wave-shaped circuits that matched P5, P6, and P7 for this experiment. R1 = R2 = 3.3 kΩ, R3 = 470 Ω, and R4 = R5 = 91 Ω were regular resistors in the first circuit. In the second circuit, we increased the factors of specific resistors by a factor of 10 (R3 = 4.7 kΩ and 10R4 = 10R5 = 910 Ω). We connected a 10-µF electrolytic capacitor to the ends of the resistors (r3, r4, and r5) for the final circuit. These three circuits' graph shapes and appearances are shown below.

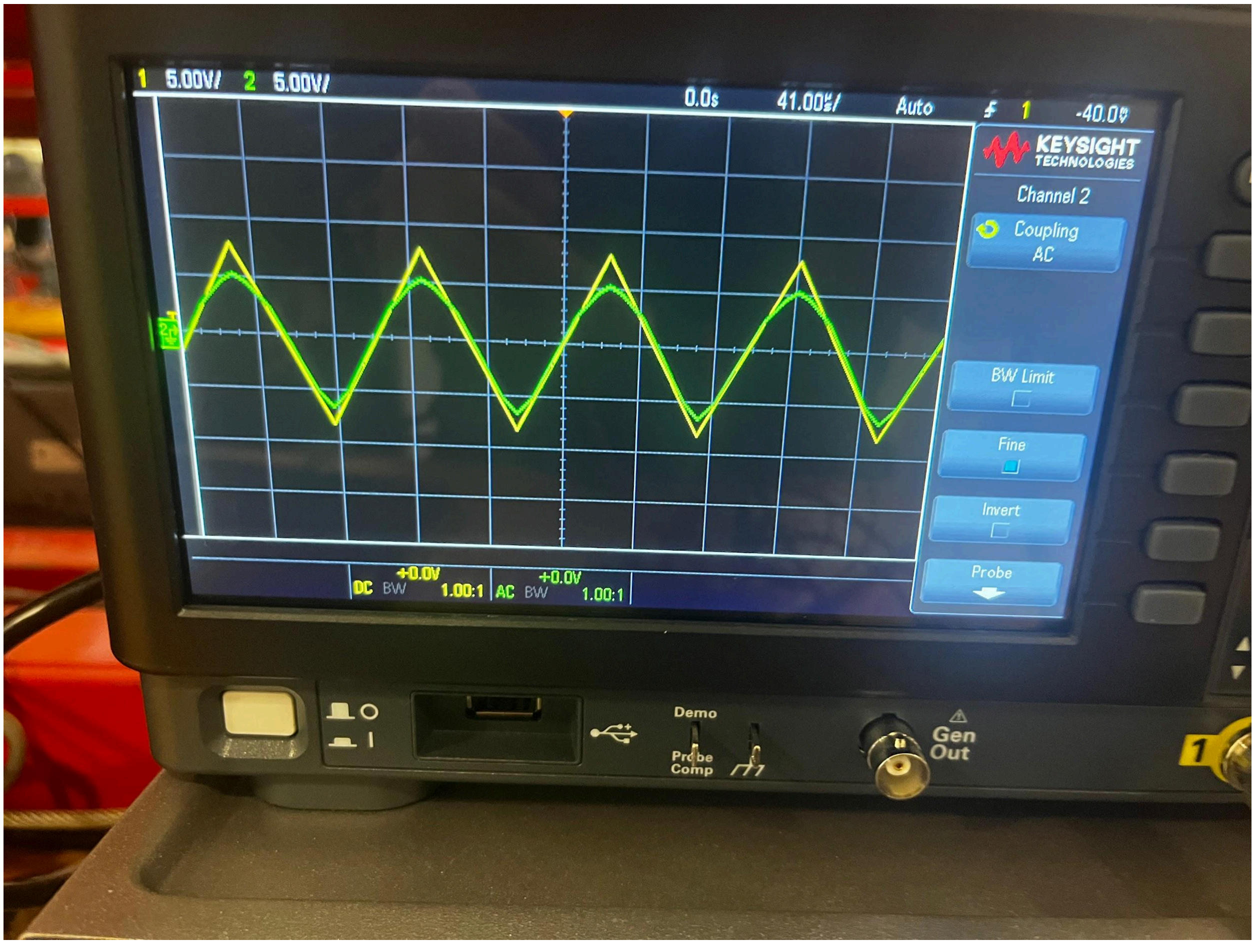
E1.



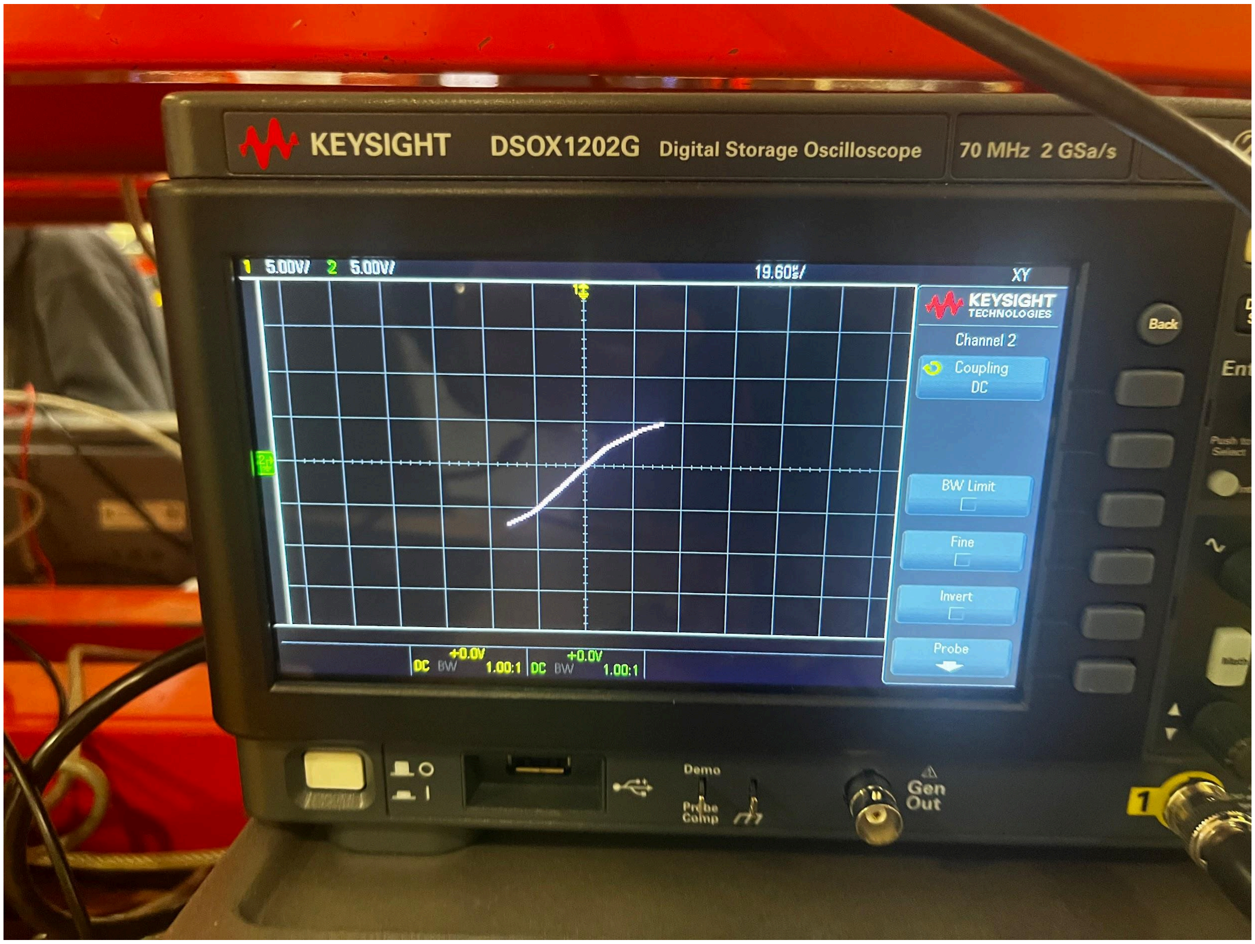
Auto
-40.0V
KEYSIGHT TECHNOLOGIES
Channel 2
Coupling
AC
BW Limit
Fine
Invert
Probe
+0.0V
DC BW 1.00:1
+0.0V
AC BW 1.00:1
Demo
Probe Comp
Gen Out


1 5.00V/ 2 5.00V/
40.00s/
XY
KEYSIGHT TECHNOLOGIES
Acquisition
High Res
500MSa/s
Channels
DC 1.00:
DC 1.00:
Math
Ch1 + Ch2
10.0V/
0.0V
Ref
R1: 5.00V/ 0.0V
R2: 5.00V/ 0.0V
Freq(1): 10.00kHz
Pk-Pk(1): 16.1V
05:31 AM
Mar 05, 2025
Demo
Probe Comp
Gen Out

E2.

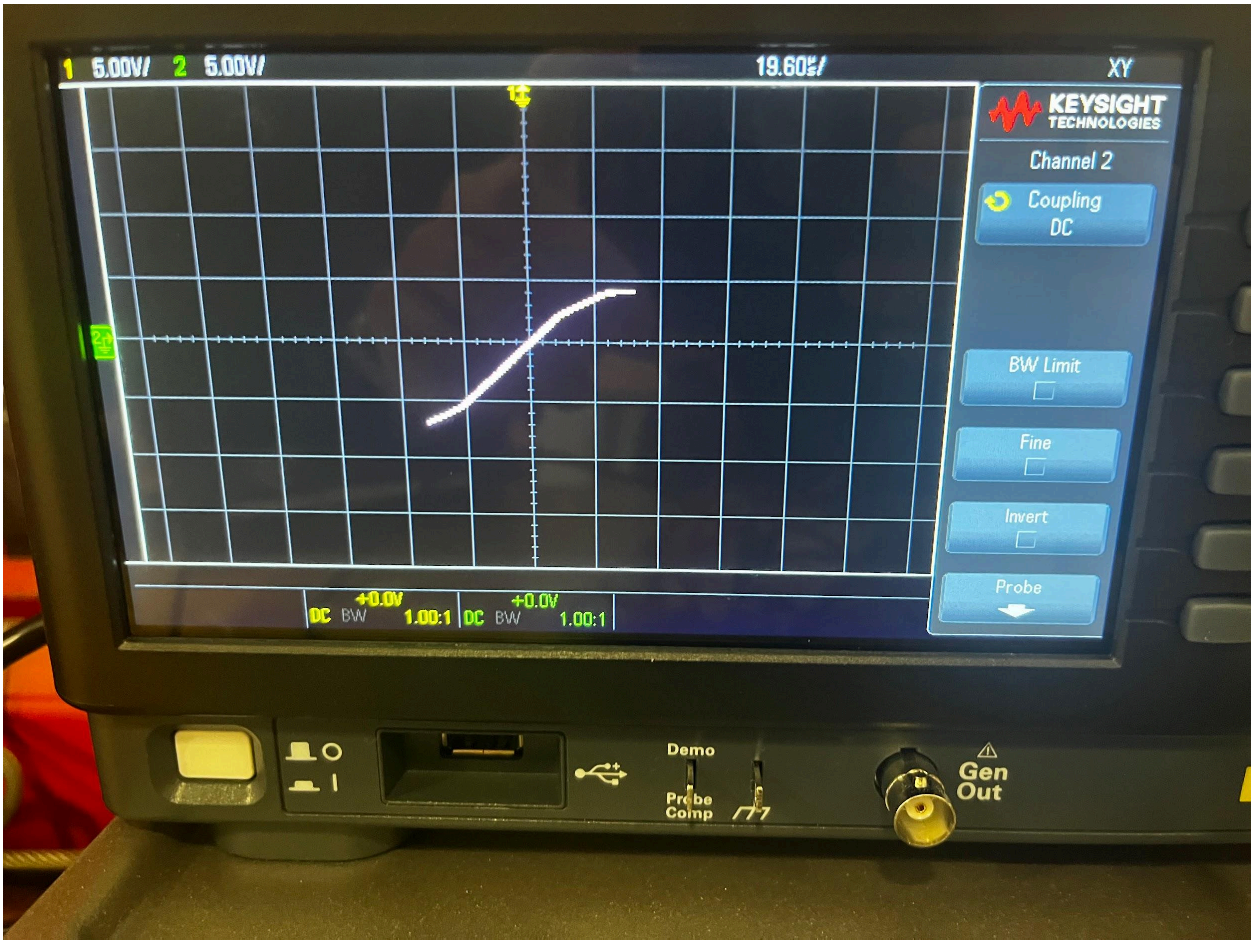


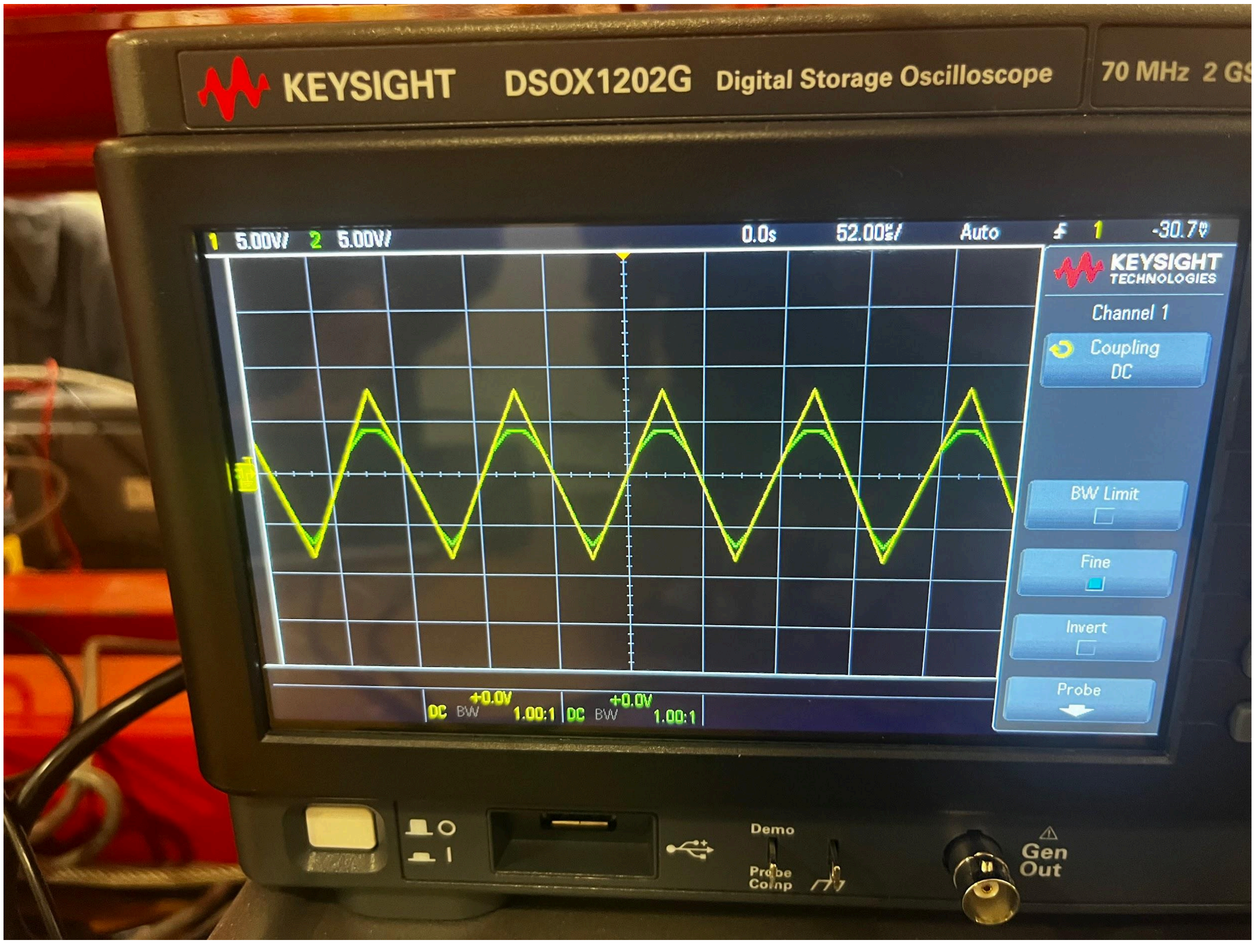
1 5.00V/ 2 5.00V/
0.0s 41.00µs/ Auto
1 -40.0V
KEYSIGHT TECHNOLOGIES
Channel 2
Coupling AC
BW Limit
Fine
Invert
Probe
DC BW +0.0V 1.00:1
AC BW +0.0V 1.00:1
Demo
Probe Comp
Gen Out



KEYSIGHT
DSOX1202G Digital Storage Oscilloscope
70 MHz 2 GSa/s
1 5.00V/ 2 5.00V/
19.60s/
XY
KEYSIGHT TECHNOLOGIES
Channel 2
Coupling
DC
BW Limit
Fine
Invert
Probe
DC BW +0.0V 1.00:1
DC BW +0.0V 1.00:1
Back
Demo
Probe Comp
Gen Out

E3.


1 5.00V/ 2 5.00V/
19.60s/
XY
KEYSIGHT TECHNOLOGIES
Channel 2
Coupling DC
BW Limit
Fine
Invert
Probe
+0.0V DC BW 1.00:1
+0.0V DC BW 1.00:1
Demo
Probe Comp
Gen Out


KEYSIGHT
DSOX1202G
Digital Storage Oscilloscope
70 MHz 2 GS
1 5.00V/ 2 5.00V/
0.0s
52.00㎲/
Auto
1 -30.7mV
KEYSIGHT TECHNOLOGIES
Channel 1
Coupling
DC
BW Limit
Fine
Invert
Probe
DC BW +0.0V 1.00:1
DC BW +0.0V 1.00:1
Demo
Probe Comp
Gen Out

Conclusion & Remark:

C1

You can determine the output voltage waveform created from a symmetrical periodic triangular input voltage by looking at Graph P3(b). According to Graph P3(b), as the input voltage rises to 4 volts, the output voltage remains constant. Additionally, as the input voltage drops according to Graph P3(b), the output voltage stays constant when the voltage drops to -4 volts. Thus, the output voltage would be 4 volts at its highest point and 8 volts from its lowest point to its highest point.

C2

The output voltage remains constant when the voltage hits -4 or +4 volts, according to a comparison of the transfer characteristics in Graphs P1 and P3(b). Additionally, the form and curve of both transfer qualities are comparable.

C3

Because the resistance in Graph P6B is amplified by 10 in comparison to Graph P5B, the two graphs may initially appear to be comparable. On closer inspection, though, these graphs show distinct circuit behaviors. While graphs P5B and P6B have nonlinear sections because of the addition of a voltage-dividing resistance that intensifies non-linearity in the Vo vs. Vi graph, graph P1 shows linear relationships. Diodes in the circuits are responsible for the non-linear behavior seen in Graphs P6B and P5B, where changes in input voltage result in non-linear variations in the output voltage. Thus, even if Graphs P5B and P6B are similar, they come from different circuits and have different features.

C4

Graph P1's transfer characteristics are completely different from those of Graphs P6(b) and P7(b). In contrast to Graph P1, Graph P6(b) is larger and lacks a true, consistent trend.
In contrast to Graph P1, Graph P7(b) is in the negative zone and lacks a true, consistent trend. These graphs differ greatly because of the bypass capacitors, which have the primary function of determining the precise charges even in the absence of the diode.

C5

It is clear from comparing graphs E1(b), E2(b), and E3(b) that they all exhibit the circuit's limiting behavior by sharing a common general pattern. An ascending line with horizontal lines at both ends is what defines this. Graph P1 has a linear component that is bounded by two complete flat lines, as can be seen when comparing it to these graphs. However, as we move from E1 to E3, the flat portions of these graphs get less flat (they tend to shift higher). The little variations between the graphs may be the consequence of variations in the performance of the resistors, diodes, and capacitors, or they may be the consequence of graph P1's hand-drawn accuracy not matching that of the digitally produced graphs E1(b), E2(b), and E3(b).

Remark

In this lab, we recognize and make use of a diode circuit's capacity to bend an input signal toward a distinct waveform in order to provide transfer characteristics. This aided in determining a diode's nonlinear voltage-current characteristic. This made it easier to teach more complex and novel real-world applications for diodes.