EXPERIMENT 5

Clipping Circuits

OBJECTIVE

To calculate, draw, and measure the output voltages of series and parallel clipping circuits.

EQUIPMENT REQUIRED

Instruments
Oscilloscope
DMM

Components
Resistors
(1) 2.2-kΩ

Diode
(1) Silicon
(1) Germanium

Supplies
(1) 1.5-V D cell and holder
Function generator

EQUIPMENT ISSUED

<table>
<thead>
<tr>
<th>Item</th>
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<tr>
<td>Oscilloscope</td>
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<td>DMM</td>
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RESUME OF THEORY

The primary function of clippers is to "clip" away a portion of an applied alternating signal. The process is typically performed by a resistor-diode combination. DC batteries are also used to provide additional shifts or "cuts" of the applied voltage. The analysis of clippers with square-wave inputs is the easiest to perform since there are only two levels of input voltage. Each level can be treated as a DC input and the output voltage for the corresponding time determined. For sinusoidal and triangular inputs, various instantaneous values can be treated as DC levels and the output level determined. Once a sufficient number of plot points for the output voltage $v_o$ have been determined, it can be sketched in total. Once the behavior of clippers is established, the effect of the placement of elements in various positions can be predicted and the analysis completed with less effort and concern about accuracy.

PROCEDURE

Part 1. Threshold Voltage

Determine the threshold voltage for the silicon and germanium diodes using the diode-checking capability of the DMM or a curve tracer. Round off to hundredths place when recording in the designated space below. If the diode-checking capability or curve tracer is unavailable assume $V_T = 0.7 \text{ V}$ for the silicon diode and $0.3 \text{ V}$ for the germanium diode.

$$V_T(\text{Si}) = \quad \quad V_T(\text{Ge}) = \quad \quad$$

Part 2. Parallel Clippers

a. Construct the clipping network of Fig. 5.1. Record the measured resistance value and voltage of the D cell. Note that the input is an $8 \text{ V}_{pp}$ square wave at a frequency of $1000 \text{ Hz}$.

![Figure 5-1]

b. Using the measured values of $R$, $E$, and $V_T$ calculate the voltage $v_o$ when the applied square wave is $+4 \text{ V}$, that is, for the interval when the input is $+4 \text{ V}$. What is the level of $V_o$? Show all the steps of your calculations to determine $v_o$.

$$V_o \text{ (calculated)} = \quad \quad$$
c. Repeat Part 2(b) when the applied square wave is $-4 \text{ V}$.

\[ V_o (\text{calculated}) = \]  

\[ V_o (\text{calculated}) = \]  

d. Using the results of Parts 2(b) and 2(c) sketch the expected waveform for $v_o$ using the horizontal axis of Fig. 5.2 as the $V_o = 0 \text{ V}$ line. Use a vertical sensitivity of $1 \text{ V/cm}$ and a horizontal sensitivity of $0.2 \text{ ms/cm}$.

**Sketch of $V_o$ from calculated results:**

\[ \text{Figure 5-2} \]

\[ \text{Figure 5-2} \]

e. Using the sensitivities provided in Part 2(d) set the input square wave and record $v_o$ on Fig. 5.3 using the oscilloscope. Be sure to preset the $V_o = 0 \text{ V}$ line using the GND position of the coupling switch (and the DC position to view the waveform).

**Sketch of $V_o$ from measured results:**

\[ \text{Figure 5-3} \]

\[ \text{Figure 5-3} \]
How does the waveform of Fig. 5.3 compare with the predicted result of Fig. 5.2?

f. Reverse the battery of Fig. 5.1 and, using the measured values of \( R, E, \) and \( V_T \), calculate the level of \( V_o \) for the time interval when \( V_i = +4 \text{ V} \).

\[ V_o \text{ (calculated)} = \]

\[ V_o \text{ (calculated)} = \]

\[ V_o \text{ (calculated)} = \]

\[ V_o \text{ (calculated)} = \]

h. Using the results of Parts 2(f) and 2(g) sketch the expected waveform for \( v_o \) using the horizontal axis of Fig. 5.4 as the \( V_o = 0 \text{ V} \) line. Use the same sensitivities provided in Part 2(d).

*Sketch of \( V_o \) from calculated results:*

\[ \text{Figure 5-4} \]

i. Set the input square wave and record \( v_o \) on Fig. 5.5 using the oscilloscope. Be sure to preset the \( V_o = 0 \text{ V} \) line using the GND position of the coupling switch (and the DC position to view the waveform).

How does the waveform of Fig. 5.4 compare with the predicted result of Fig. 5.5?
Part 3. Parallel Clippers (continued)

a. Construct the network of Fig. 5.6. Record the measured value of the resistance. Note that the input is now a 4 V_{p-p} square wave at \( f = 1000 \text{ Hz} \).

\[ R_{\text{max}} = \quad \]

\[ 4 \text{ V}_{p-p} \text{ square wave} \]
\[ f = 1000 \text{ Hz} \]

b. Using the levels of \( V_T \) determined in Part 1 calculate the level of \( V_o \) for the time interval when \( V_i = +2 \text{ V} \).

\[ V_o \text{ (calculated)} = \quad \]

c. Repeat Part 3(b) for the time interval when \( V_i = -2 \text{ V} \).

\[ V_o \text{ (calculated)} = \quad \]

d. Using the results of Parts 3(b) and 3(c) sketch the expected waveform for \( v_o \) using the horizontal axis of Fig. 5.7 as the \( V_o = 0 \) V line. Insert your chosen vertical and horizontal sensitivities below:

Vertical sensitivity = 
Horizontal sensitivity = 

Sketch of $V_o$ from calculated results:

Figure 5-7

e. Using the sensitivities chosen in Part 3(d) set the input square wave and record $v_o$ on Fig. 5.8 using the oscilloscope. Be sure to preset the $V_o = 0$ line using the GND position of the coupling switch (and the DC position to view the waveform).

Sketch of $V_o$ from measured results:

Figure 5-8

How does the waveform of Fig. 5.8 compare with predicted result of Fig. 5.7?

Part 4. Parallel Clippers (Sinusoidal Input)

a. Rebuild the circuit of Fig. 5.1 but change the input signal to an 8 Volts pp sinusoidal signal with the same frequency (1000 Hz).

b. Using the results of Part 2 and any other analysis technique sketch the expected output waveform for $v_o$ on Fig. 5.9. In particular find $V_o$ when the applied signal is at its positive and negative peak and zero volts. Also list the chosen vertical and horizontal sensitivities below:
Sketch of $V_o$ from calculated results:

$$V_o \text{ (calculated) when } V_i = +4 \text{ V is } \_\_\_\_\_\_\_\_\_.$$
$$V_o \text{ (calculated) when } V_i = -4 \text{ V is } \_\_\_\_\_\_\_.$$
$$V_o \text{ (calculated) when } V_i = 0 \text{ V is } \_\_\_\_\_\_.$$
Vertical sensitivity = \_\_\_\_.
Horizontal sensitivity = \_\_\_\_.

Figure 5-9

Using the sensitivities chosen in Part 4(b) set the input sinusoidal waveform and record $v_o$ on Fig. 5.10 using the oscilloscope. Be sure to preset the $V_o = 0 \text{ V}$ line using the GND position of the coupling switch.

Sketch of $V_o$ from measured results:

$$0 \text{ V}$$

Figure 5-10

How does the waveform of Fig. 5.10 compare with the predicted result of Fig. 5.9?

Part 5. Series Clippers

a. Construct the circuit of Fig. 5.11. Record the measured resistance value and the DC level of the D cell. The applied signal is an $8 \text{ V}_{pp}$ square wave at a frequency of 1000 Hz.
b. Using the measured values of $R$, $E$, and $V_T$ calculate the voltage $V_o$ for the time interval when $V_i = +4$ V.

\[ V_o \text{ (calculated)} = \]

\[ V_o \text{ (calculated)} = \]

\[ V_o \text{ (calculated)} = \]

c. Repeat Part 5(b) for the time interval when $V_i = -4$ V.

\[ V_o \text{ (calculated)} = \]

d. Using the results of Parts 5(b) and 5(c) sketch the expected waveform for $v_o$ using the horizontal axis of Fig. 5.12 as the $V_o = 0$ V line. Insert your chosen vertical and horizontal sensitivities below:

**Sketch of $V_o$ from calculated results:**

![Sketch of Vo](image)

**Vertical sensitivity =**

**Horizontal sensitivity =**

e. Using the sensitivities chosen in Part 5(d) set the input square wave and record $v_o$ on Fig. 5.13 using the oscilloscope. Be sure to preset the $V_o = 0$ V line using the GND position of the coupling switch (and the DC position to view the waveform).
Sketch of $V_o$ from measured results:

![Figure 5-13](image)

How does the waveform of Fig. 5.13 compare with the predicted result of Part 5(d)?

f. Reverse the battery of Fig. 5.11 and using the measured values of $R$, $E$, and $V_T$ calculate the level of $V_o$ for the time interval when $V_i = +4$ V.

$$V_o \text{ (calculated)} = \_\_\_\_\_\_\_$$

g. Repeat Part 5(f) for the time interval when $V_i = -4$ V.

$$V_o \text{ (calculated)} = \_\_\_\_\_\_\_$$

h. Using the results of Parts 5(f) and 5(g) sketch the expected waveform for $V_o$ using the horizontal axis of Fig. 5.14 as the $V_o = 0$ V line. Use the following sensitivities:

Vertical: 2 V/cm
Horizontal: 0.2 ms/cm
i. Using the sensitivities provided in Part 5(h) set the input square wave and record \( v_o \) on Fig. 5.15 using the oscilloscope. Be sure to preset the \( V_o = 0 \) V line using the GND position of the coupling switch (and the DC position to view the waveform).

How does the waveform of Fig. 5.15 compare with the predicted pattern of Fig. 5.14?

Part 6. **Series Clippers (Sinusoidal Input)**

a. Rebuild the circuit of Fig. 5.11 but change the input signal to an \( 8 \text{ V}_p\text{-p} \) sinusoidal signal with the same frequency (1000 Hz).

b. Using the results of Part 5 and any other analysis technique sketch the expected output waveform for \( v_o \) on Fig. 5.16. In particular, find \( V_o \) when the applied signal is at its positive and negative peak and zero volts. Use a vertical sensitivity of 1 V/cm and a horizontal sensitivity of 0.2 ms/cm.
Sketch of $V_o$ from calculated results:

![Figure 5-16]

$V_o$ (calculated) when $V_i = +4$ V is =

$V_o$ (calculated) when $V_i = -4$ V is =

$V_o$ (calculated) when $V_i = 0$ V is =

c. Using the sensitivities provided in Part 6(b) set the input sinusoidal waveform and record $v_o$ on Fig. 5.17 using the oscilloscope. Be sure to preset the $V_o = 0$ V line using the GND position of the coupling switch.

Sketch of $V_o$ from measured results:

![Figure 5-17]

How does the waveform of Fig. 5.17 compare with the predicted result of Fig. 5.16?