Experiment 7

Diode Clipping and Clamping Circuits

Objectives:

In this experiment you will:

- Investigate diode clipping circuits, their characteristics, and applications.
- Investigate diode clamping circuits, their characteristics, and applications.

❶ In the figure below we apply a 2 V peak-to-peak, 1 KHz sinusoidal voltage, V_{IN}, and we carefully measure V_{OUT}, by the oscilloscope and place the two cursor bottoms on the peak and the trough of the curve and record both values. Note that the two recordings differ in the sign one is positive and corresponds to the peak value and the other is negative and that corresponds to the trough value.

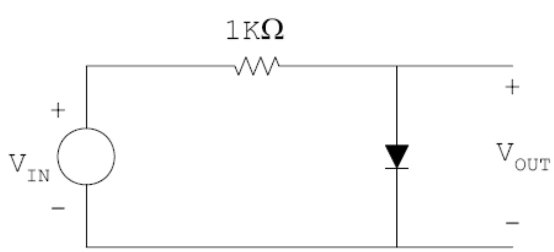


Fig. 1

❷ In the figure below with R = 1 KΩ we apply a 2 V peak-to-peak, 1 KHz sinusoidal voltage V_{IN}, using the function generator, and measure V_{OUT} by the oscilloscope (press the measure then read the peak-peak value).

When does clipping start?

Is the clipped waveform perfectly symmetrical?

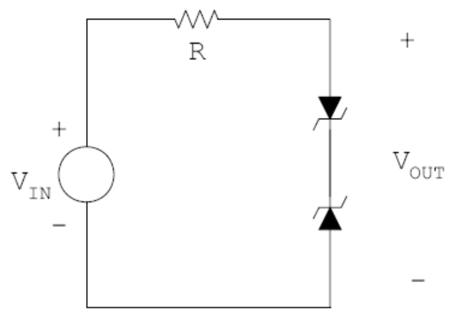
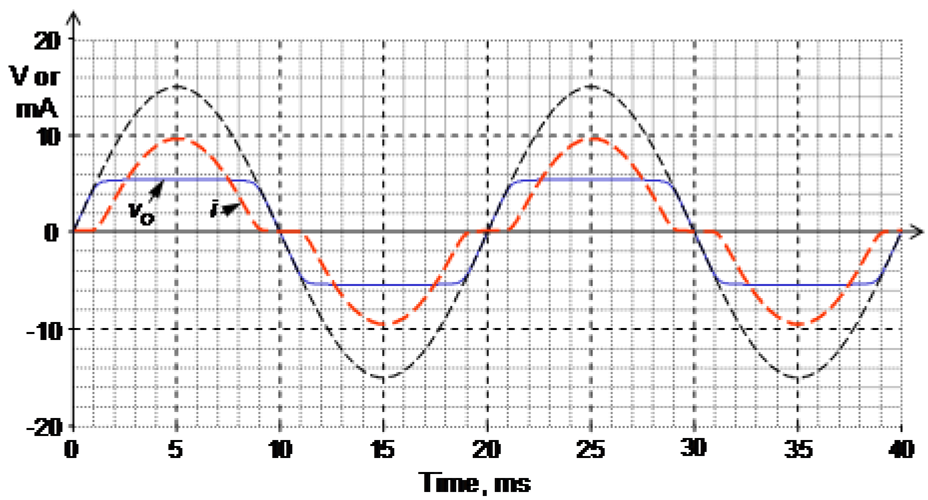


Fig. 2

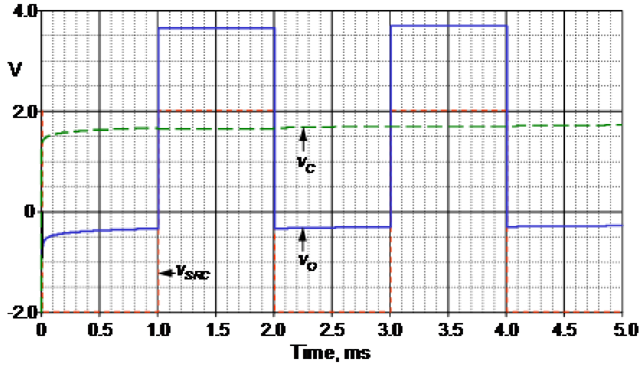
Notes:

- **Voltages are clipped at a certain level, voltage limiting circuits are also known as clipping circuits. In practice, the smooth variation of current with voltage in practical diodes results in gradual rather than abrupt clipping, as illustrated in Figure 1.5.4. Moreover, if r_D is not negligible compared to R_s, the clipped level varies somewhat with v_{SRC}.**



- **The input voltage is shifted in the positive direction so that the most negative level is at the zero level (Figure 1.6.1c).**

The circuit is a diode clamp, a clamping circuit, or a dc restorer.



❸ In the figure below with C = 0.1 µF. We apply a 10 KHz, 2 V peak-to peak sinusoidal voltages and observe the V_{OUT} waveform from the oscilloscope (peak- to- peak value is the input voltage and the output voltage is the mean value read on the oscilloscope after pressing the measure bottom).
What is the relationship between the input and output waveforms. We repeat with the diode reversed.

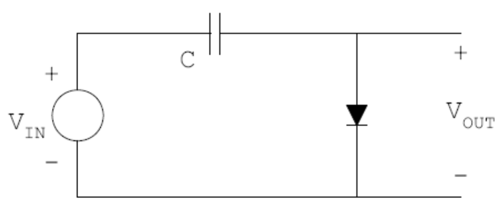


Fig. 3

❹ Connect a 10 KΩ resistor in parallel with the diode in Fig. 3, and measure the DC shift of V_{OUT} by reading the mean value at the oscilloscope. Repeat with a 1 KΩ resistor.
Explain the effect of the load resistor on the DC shift.

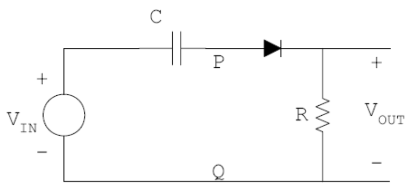


Fig. 4

Concept: When a capacitor is alternately charged and discharged, then in the steady state, the charge gained in the charging phase is equal to the charge lost in the discharging phase

❺ *W*e connect the circuit of Fig. 4 with C = 0.1 μF and R = 10 KΩ and apply a 10 V peak-to-peak, 1 KHz sinusoidal input. We observe V_{OUT}, similarly from the oscilloscope first without the diode then with the diode.
What is the effect of the diode on V_{OUT}? Why?
Connect a 1 KΩ resistor across PQ and observe V_{OUT}.
What is the effect of this resistor?
When we did not connect the resistor across PQ, the output was zero because the capacitor couldn't discharge, and so the capacitor could be considered as an open circuit.
When we plugged the R- 1K resistor across PQ, the capacitor started to discharge into the resistor. Therefore a measurable output voltage was created. Dividing the circuit of figure 4 into two parts that are:
1) A capacitor and a resistor thus the circuit will conduct a sine wave across the resistor.
2) A diode and a resistor, thus the circuit will act as a half-wave rectifier circuit. The input will then be a sine wave measured in the resistor. As a result, the output voltage will be a half-rectified sine wave.

❻ *D*iodes may be used for overload protection of meters. How would you protect the meter against reversal of polarity?

To protect the meter against reversal of polarity, we have to add a LED or an ideal diode with zero V offset in parallel with the connected one but in opposite direction. This would allow all the reverse current to flow through this diode and not through the coil.

❼ *a* diode is sometimes connected across a relay coil to protect a switch from excessive voltage due to induced e.m.f. Explain the operation of the circuit. What is the maximum voltage across the switch upon opening? How does the diode affect the pick-up and release times of the relay?

When the switch is closed, the diode is reverse biased, and thus is not conducting. When the switch is open, the coil discharges in the diode (forward biased), therefore the diode limits the voltage across the coil to V_d, and I_L will keep flowing through the switch and thus the voltage across the switch would be V_{swtich}=Vin+V_d. This voltage would damage the switch. However, if we connect the diode as in the figure above, the diode won't have any effect during the closure of the switch since the diode would be reversed biased. Yet, when the switch is opened, it would give the coil a path through which it discharges without creating an infinite emf and thus, the switch won't be affected by an infinite voltage, and would thus be protected. The diode slightly delays the pick-up and release times of the relays because the coil will discharge in an additional circuit whose time constant is slightly higher than if there were no diodes at all. This extra time needed is very small since the resistance in this additional circuit is very small.

❽ **Modify the circuit of Fig. 2 so as to have symmetrical clipping, using a single Zener diode and a diode bridge.**

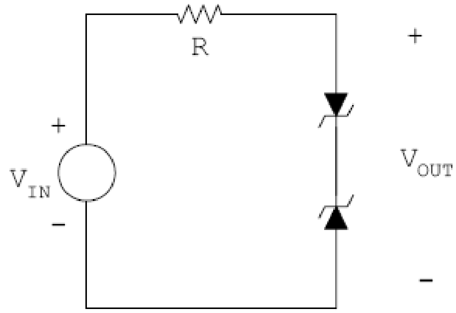


Fig. 2