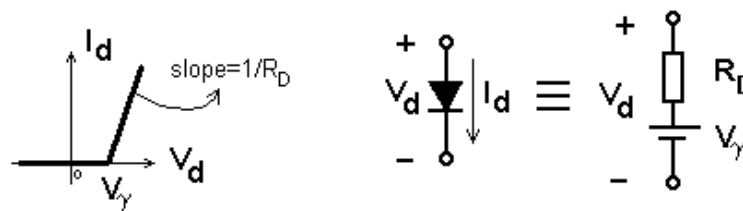


EXPERIMENT #2

DIODE CLIPPING AND CLAMPING CIRCUITS

Clipping networks are designed to limit the positive and/or negative parts of the input waveform to a predetermined value (which may be zero). Under clipping action, the shape of the input waveform is changed. Clamping circuits, however, set either the positive or negative excursion to a predetermined level, while preserving its original form. The set level may be positive, negative or zero.

The piecewise linear model of the diode is shown in the Fig. below:



where V_γ is the cut-in voltage (forward voltage drop) of the diode (which is about 0.6V) and R_D represents the equivalent dynamic resistance (a linear approximation to the real curve). Consider the circuit of Figure 1. If the diode is replaced by its piecewise linear model, the equivalent circuit shown in Figure 2 is obtained.

In addition to the use of diodes as rectifiers and voltage regulators, there are a number of other interesting applications. For example, diodes are frequently used in applications such as wave-shaping circuits, detectors, protection circuits, and switching circuits. In this experiment, two widely used applications of diode circuits are investigated, namely diode *limiter (clipper)* circuits and diode *clamping (DC Restorer)* circuits.

Often in the development of electronic circuits it is required that voltages be limited in some manner to avoid circuit damage. Furthermore, the limiting or clipping of voltages can be very useful in the development of wave-shaping circuits. A typical clipper circuit is shown in Fig. 1. In this circuit the output voltage can never be greater than 3 V. The ideal diode becomes forward biased at $v_o(t)$ equal to 3 V and this ties the output directly to the 3 V supply. The waveform can be clipped on the negative side by placing the series combination of a diode and power supply in parallel with the diode and power supply already shown.

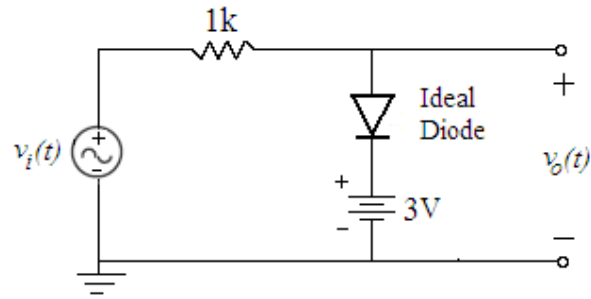


Fig. 1. Diode clipper circuit

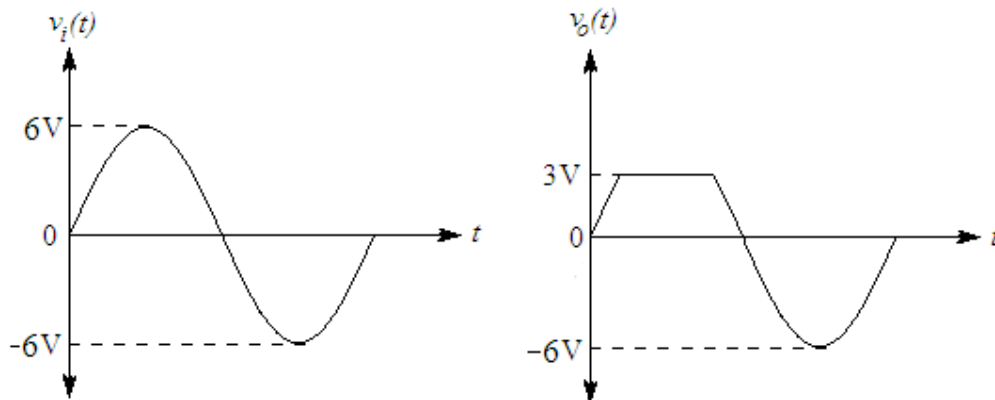


Fig. 2. Input and output waveforms of the diode clipper in Fig. 1

While clipper circuits are concerned primarily with limiting or cutting off part of the waveform, clampers are used primarily to shift the DC level. For example, if we have a clock signal that swings between 0V and 5V but our application requires a clock signal from -5V to 0V, we can provide the proper DC offset with a passive clamper circuit. A typical clamper circuit is shown in Fig. 2. For this circuit to work properly the pulse width needs to be much less than the RC time constant of 10ms. The input square wave with a frequency of 1 KHz and a pulse width of 0.5ms meets this requirement. The diode and power supply as shown will prevent the output voltage from exceeding 3 V (i.e., all of the region above 3 V can be viewed as a forbidden region for output voltage). Because of the time constant requirement the voltage across the capacitor can not change significantly during the pulse width, and after a short transient period the voltage across the capacitor reached a steady state offset value. The output voltage is simply the input voltage shifted by this steady state offset. Also, observe that the peak-to-peak output voltage is equal to the peak-to-peak input voltage. This is true

because the voltage across the capacitor can not change instantaneously and the full change of voltage on the input side of the capacitor will likewise be seen on the output side of the capacitor.

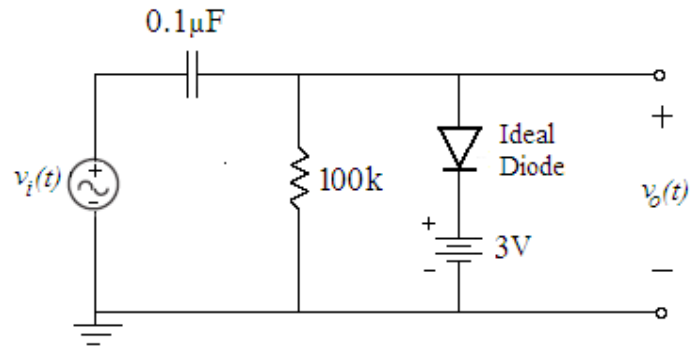


Fig. 3. Diode clamper circuit

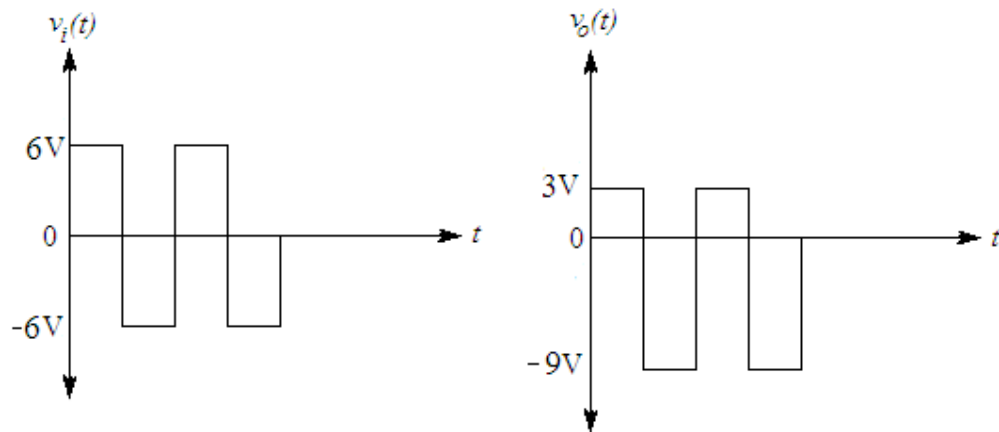


Fig. 4. Input and output waveforms of the diode clamper in Fig. 3

As stated above, the clamping circuit has three elements: a capacitor, a resistor and a diode. R and C are chosen so that the RC time constant is large enough to ensure that the capacitor voltage remains practically constant during one period of the input waveform. In order to obtain a distortionless output signal, the source resistance should be very small compared to the resistor R .

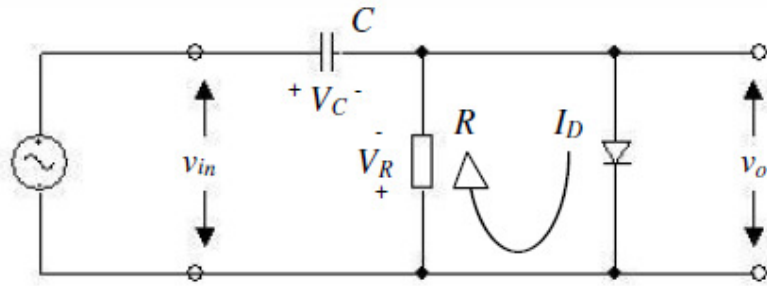


Fig. 5. Diode clamper circuit

In Fig. 5 a negative clamping circuit is formed. Assuming an ideal diode and an ideal voltage source, the drop across the diode is zero when forward biased. Therefore the output cannot rise above zero and is clamped to this level.

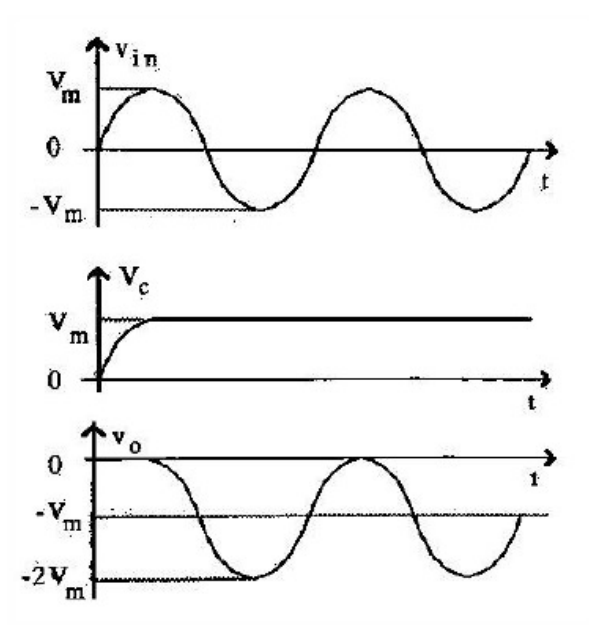


Fig. 6. Input and output waveforms of the diode clamper in Fig. 5

Components Required

1N4001 (or similar) diodes

1k Ω resistor

47k Ω resistor

47 μ F capacitor

1 μ F capacitor

Procedure

- a.** Set-up the circuit of Fig.7. Set the input voltage signal to a sinusoid with 1kHz frequency and 20V peak-to-peak amplitude with $R=1\text{k}\Omega$ and $R_L=47\text{k}\Omega$. Obtain and plot the input and output voltage waveforms. (in DC coupling mode).

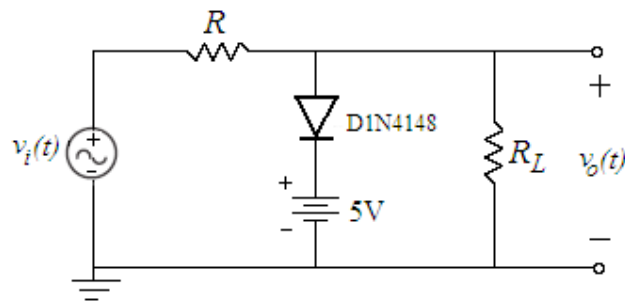
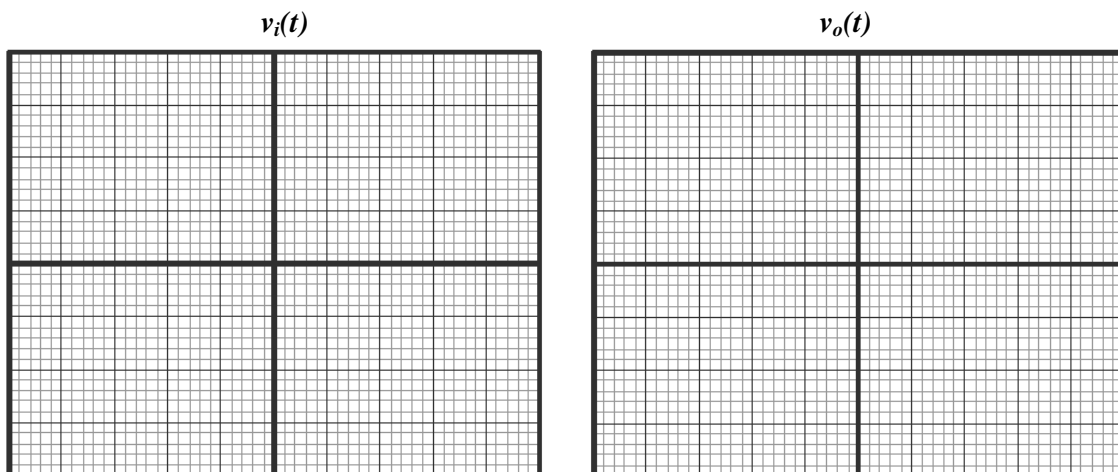
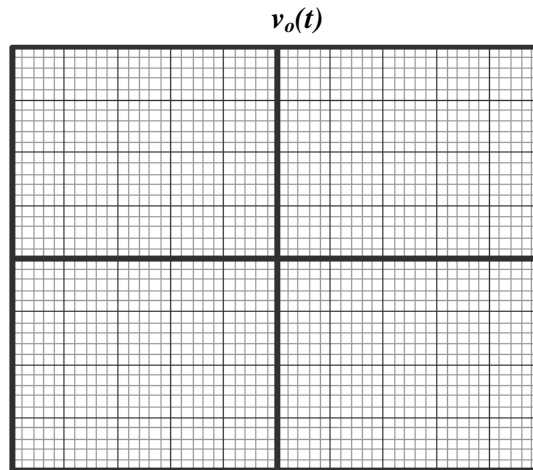


Fig. 7. Diode clipper circuit



- b. Reverse the diode and replace the positive DC supply with negative DC supply and repeat step 1.a. Does the output voltage waveform change? Why? (Explain Briefly)



2. a. Setup the circuit of Fig.8. Set the input voltage signal to a sinusoid with 100 Hz frequency and 20V peak-to-peak amplitude with $C=1\mu\text{F}$. Obtain and plot the input and output voltage waveforms.

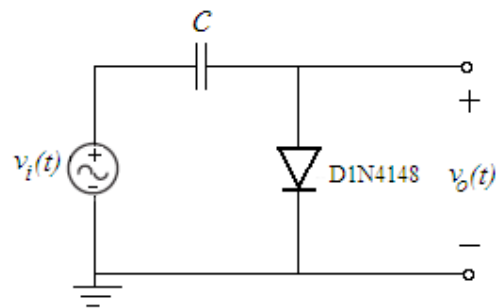
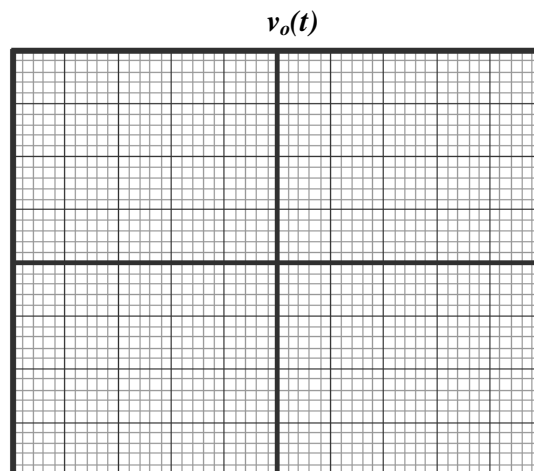
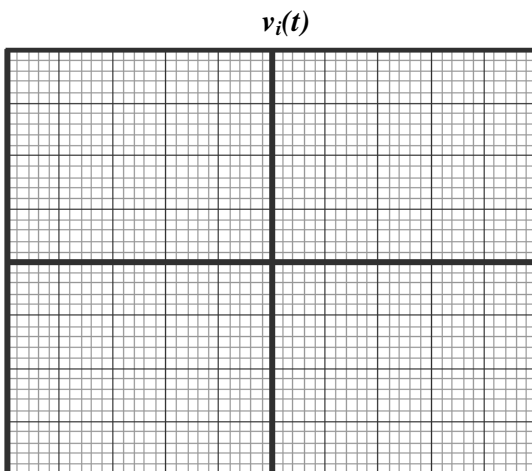


Fig. 8. Diode clamper circuit



b. Setup the circuit of Fig.9. Set the input voltage signal to a sinusoid with 1kHz frequency and 20V peak-to-peak amplitude with $C=47\mu\text{F}$. Obtain and plot the input and output voltage waveforms.

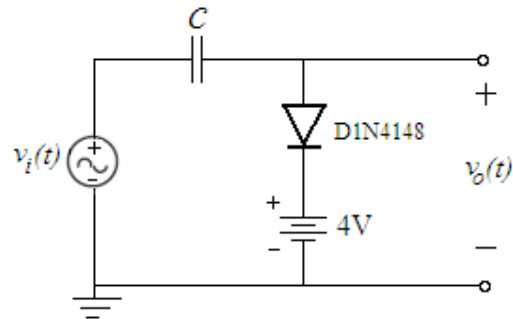
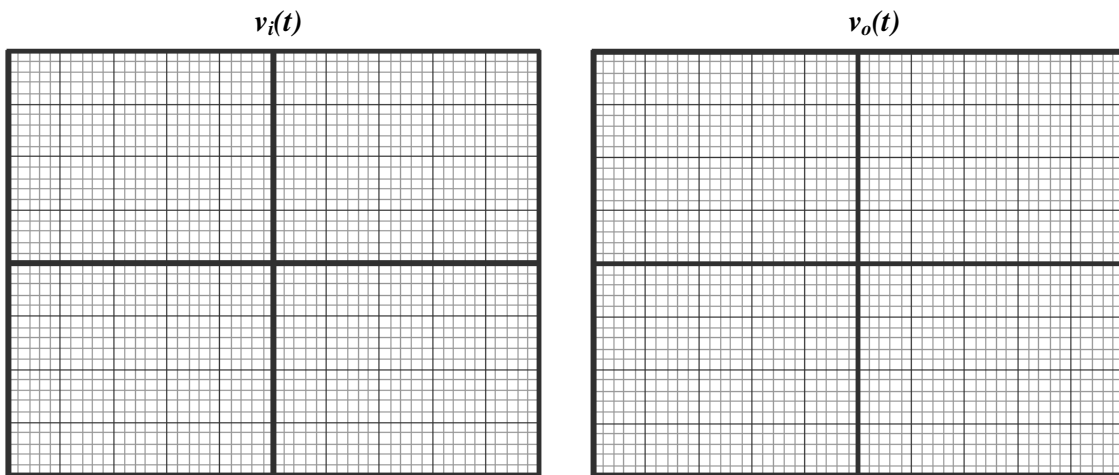


Fig. 9. Diode clamper circuit



c. Reverse the diode and replace the positive DC supply with negative DC supply and repeat step 2.b. Does the output voltage waveform change? Why? (Explain Briefly)

