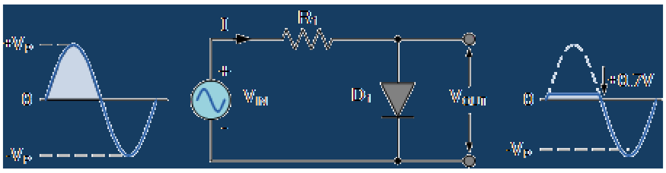

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Diode Clipping Circuits

The **Diode Clipper**, also known as a *Diode Limiter*, is a wave shaping circuit that takes an input waveform and clips or cuts off its top half, bottom half or both halves together.

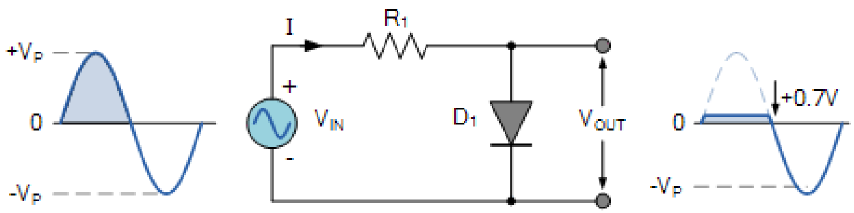
This diode clipping of the input signal produces an output waveform that resembles a flattened version of the input. For example, the half-wave rectifier is a clipper circuit, since all voltages below zero are eliminated.

But **Diode Clipping Circuits** can be used a variety of applications to modify an input waveform using signal and Schottky diodes or to provide over-voltage protection using zener diodes to ensure that the output voltage never exceeds a certain level protecting the circuit from high voltage spikes. Then diode clipping circuits can be used in voltage limiting applications.

We saw in the *Signal Diodes* tutorial that when a diode is forward biased it allows current to pass through itself clamping the voltage. When the diode is reverse biased, no current flows through it and the voltage across its terminals is unaffected, and this is the basic operation of the diode clipping circuit.

Although the input voltage to diode clipping circuits can have any waveform shape, we will assume here that the input voltage is sinusoidal. Consider the circuits below.

Positive Diode Clipping Circuits

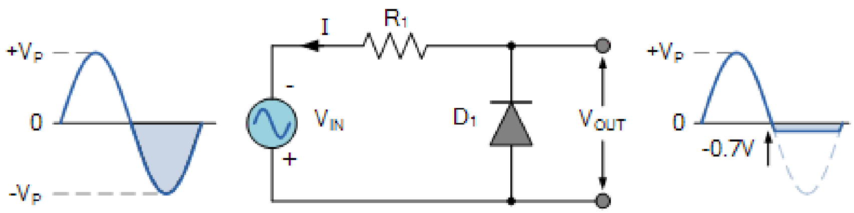


In this diode clipping circuit, the diode is forward biased (anode more positive than cathode) during the positive half cycle of the sinusoidal input waveform. For the diode to become forward biased, it must have the input voltage magnitude greater than +0.7 volts (0.3 volts for a germanium diode).

When this happens the diodes begins to conduct and holds the voltage across itself constant at 0.7V until the sinusoidal waveform falls below this value. Thus the output voltage which is taken across the diode can never exceed 0.7 volts during the positive half cycle.

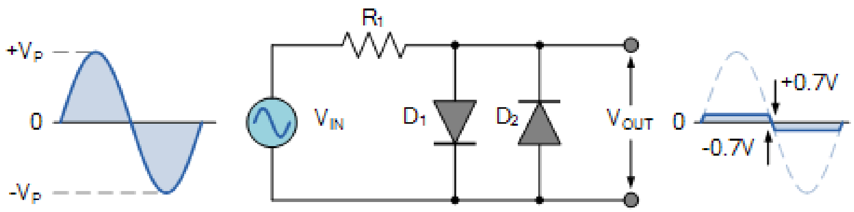
During the negative half cycle, the diode is reverse biased (cathode more positive than anode) blocking current flow through itself and as a result has no effect on the negative half of the sinusoidal voltage which passes to the load unaltered. Thus the diode limits the positive half of the input waveform and is known as a positive clipper circuit.

Negative Diode Clipping Circuit



Here the reverse is true. The diode is forward biased during the negative half cycle of the sinusoidal waveform and limits or clips it to –0.7 volts while allowing the positive half cycle to pass unaltered when reverse biased. As the diode limits the negative half cycle of the input voltage it is therefore called a negative clipper circuit.

Clipping of Both Half Cycles



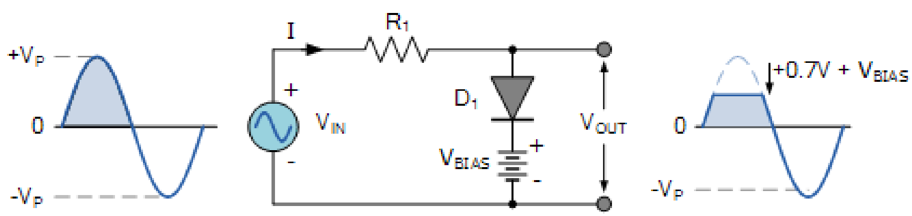
If we connected two diodes in inverse parallel as shown, then both the positive and negative half cycles would be clipped as diode D_1 clips the positive half cycle of the sinusoidal input waveform while diode D_2 clips the negative half cycle. Then diode clipping circuits can be used to clip the positive half cycle, the negative half cycle or both.

For ideal diodes the output waveform above would be zero. However, due to the forward bias voltage drop across the diodes the actual clipping point occurs at +0.7 volts and –0.7 volts respectively. But we can increase this ±0.7V threshold to any value we want up to the maximum value, (V_{PEAK}) of the sinusoidal waveform either by connecting together more diodes in series creating multiples of 0.7 volts, or by adding a voltage bias to the diodes.

Biased Diode Clipping Circuits

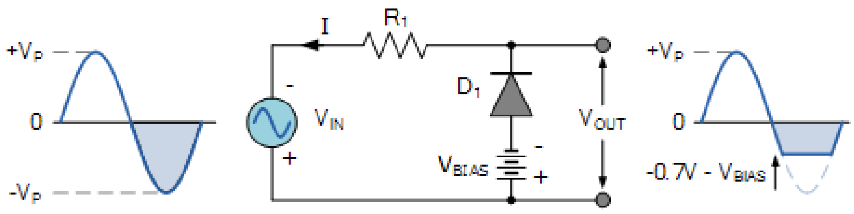
To produce diode clipping circuits for voltage waveforms at different levels, a bias voltage, V_{BIAS} is added in series with the diode to produce a combination clipper as shown. The voltage across the series combination must be greater than V_{BIAS} + 0.7V before the diode becomes sufficiently forward biased to conduct. For example, if the V_{BIAS} level is set at 4.0 volts, then the sinusoidal voltage at the diode's anode terminal must be greater than **4.0 + 0.7 = 4.7 volts** for it to become forward biased. Any anode voltage levels above this bias point are clipped off.

Positive Bias Diode



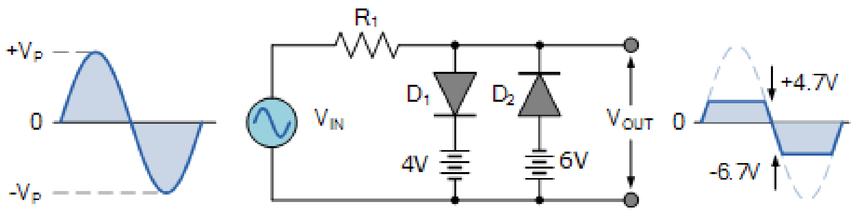
Likewise, by reversing the diode and the battery bias voltage, when a diode conducts the negative half cycle of the output waveform is held to a level $-V_{BIAS} - 0.7V$ as shown.

Negative Bias Diode



A variable diode clipping or diode limiting level can be achieved by varying the bias voltage of the diodes. If both the positive and the negative half cycles are to be clipped, then two biased clipping diodes are used. But for both positive and negative diode clipping, the bias voltage need not be the same. The positive bias voltage could be at one level, for example 4 volts, and the negative bias voltage at another, for example 6 volts as shown.

Diode Clipping of Different Bias levels



When the voltage of the positive half cycle reaches +4.7 V, diode D_1 conducts and limits the waveform at +4.7 V. Diode D_2 does not conduct until the voltage reaches –6.7 V. Therefore, all positive voltages above +4.7 V and negative voltages below –6.7 V are automatically clipped.

The advantage of biased diode clipping circuits is that it prevents the output signal from exceeding preset voltage limits for both half cycles of the input waveform, which could be an input from a noisy sensor or the positive and negative supply rails of a power supply.

If the diode clipping levels are set too low or the input waveform is too great then the elimination of both waveform peaks could end up with a square-wave shaped waveform.

Zener Diode Clipping Circuits

The use of a bias voltage means that the amount of the voltage waveform that is clipped off can be accurately controlled. But one of the main disadvantages of using voltage biased diode clipping circuits, is that they need an additional emf battery source which may or may not be a problem.

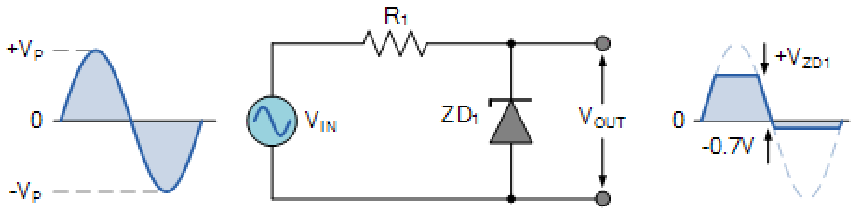
One easy way of creating biased diode clipping circuits without the need for an additional emf supply is to use **Zener Diodes**.

As we know, the zener diode is a another type of diode that has been specially manufactured to operate in its reverse biased breakdown region and as such can be used for voltage regulation or zener diode clipping applications. In the forward region, the zener acts just like an ordinary silicon diode with a forward voltage drop of 0.7V (700mV) when conducting, the same as above.

However, in the reverse bias region, the voltage is blocked until the zener diodes breakdown voltage is reached. At this point, the reverse current through the zener increases sharply but the zener voltage, V_Z across the device remains constant even if the zener current, I_Z varies.

Then we can put this zener action to good effect by using them for clipping a waveform as shown.

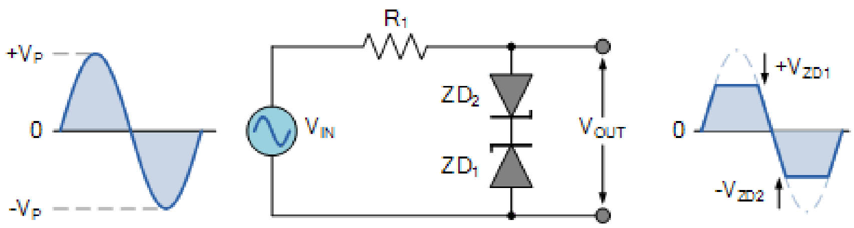
Zener Diode Clipping



The zener diode is acting like a biased diode clipping circuit with the bias voltage being equal to the zener breakdown voltage. In this circuit during the positive half of the waveform the zener diode is reverse biased so the waveform is clipped at the zener voltage, V_{ZD_1}. During the negative half cycle the zener acts like a normal diode with its usual 0.7V junction value.

We can develop this idea further by using the zener diodes reverse-voltage characteristics to clip both halves of a waveform using series connected back-to-back zener diodes as shown.

Full-wave Zener Diode Clipping



The output waveform from full wave zener diode clipping circuits resembles that of the previous voltage biased diode clipping circuit. The output waveform will be clipped at the zener voltage plus the 0.7V forward volt drop of the other diode. So for example, the positive half cycle will be clipped at the sum of zener diode, ZD_1 plus 0.7V from ZD_2 and vice versa for the negative half cycle.

Zener diodes are manufactured with a wide range of voltages and can be used to give different voltage references on each half cycle, the same as above. Zener diodes are available with zener breakdown voltages, V_Z ranging from 2.4 to 33 volts, with a typical tolerance of 1 or 5%. Note that once conducting in the reverse breakdown region, full current will flow through the zener diode so a suitable current limiting resistor, R_1 must be chosen.

Diode Clipping Summary

As well as being used as rectifiers, diodes can also be used to clip the top, or bottom, or both of a waveform at a particular dc level and pass it to the output without distortion,. In or examples above we have assumed that the waveform is sinusoidal but in theory any shaped input waveform can be used.

Diode Clipping Circuits are used to eliminate amplitude noise or voltage spikes, voltage regulation or to produce new waveforms from an existing signal such as squaring off the peaks of a sinusoidal waveform to obtain a rectangular waveform as seen above.

The most common application of a “diode clipping” is as a flywheel or free-wheeling diode connected in parallel across an inductive load to protect the switching transistor form reverse voltage transients.

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