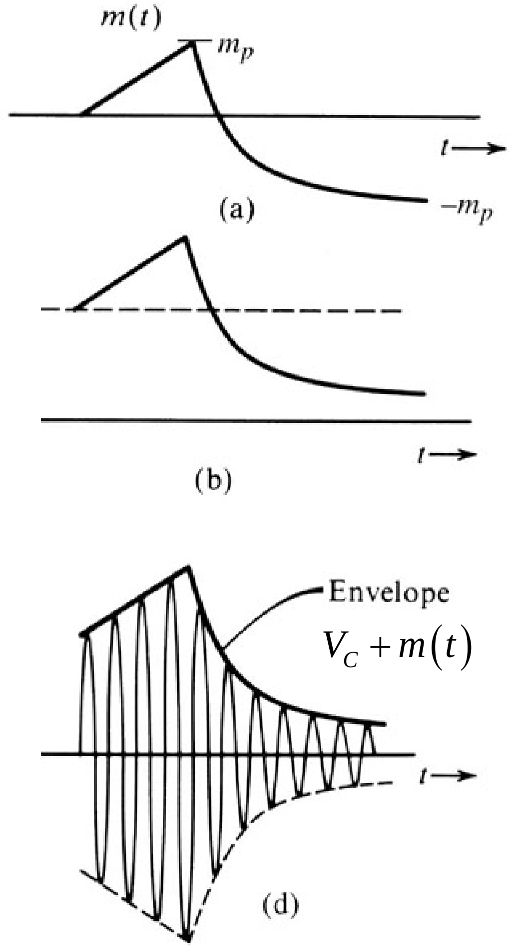
EE302 Lesson 9

Sources: (1) Course materials developed by CDR Hewitt Hymas, USN
(2) Frenzel, Principles of Electronic Communication Systems, 3rd ed., McGraw Hill, 2008

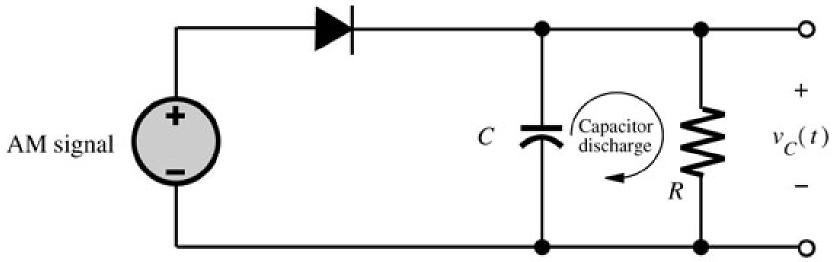
AM Demodulation Recall that in AM, our message signal (the information that we want to send) is impressed onto the amplitude of a high-frequency carrier.

As we have seen, the message signal exists as the envelope of the high-frequency carrier. In the picture below (taken from a different text—the notation is different but the concept is the same), we see our original message $m(t)$ at the top. The message is then raised by an amount V_C (middle picture) and then used to modulate a high-frequency carrier (bottom picture). The high-frequency waveform at the bottom is what arrives at the receiver. The important point: Our original message within the envelope of the high-frequency received message.



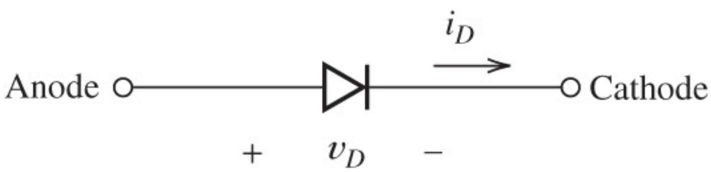
AM demodulation—done at the receiver—consists of extracting the envelope off of the received signal, thus recovering the original sent message $m(t)$. A *demodulator* (or detector) is a circuit that accepts modulated signals and recovers the original information.

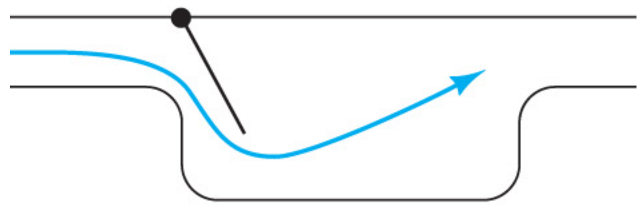
Diode Detector. The simplest and most widely used amplitude demodulator is the ***diode detector***.



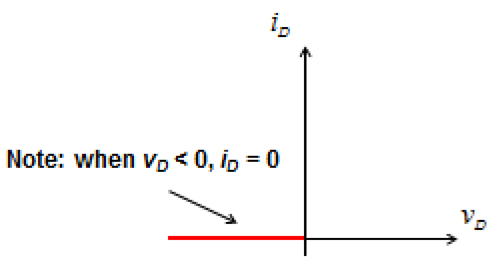
So, right off the bat, we see a new symbol we have not seen before: the diode. Let's talk about that first.

A diode is an electrical *check valve*. It allows current to flow in one direction only. It blocks current flow in the opposite direction. Specifically, current can only flow from the positive terminal (anode) to the negative terminal (cathode).





A diode can be either ON or OFF. If the voltage v_D across the diode (shown above) is negative—i.e., if the voltage on the cathode is in fact higher than the voltage on the anode—the diode is OFF and no current flows through it. The diode, in essence, acts as an open circuit in this case. So, we can start describing the characteristics of the diode by illustrating the fact that if $v_D < 0$, then $i_D = 0$.

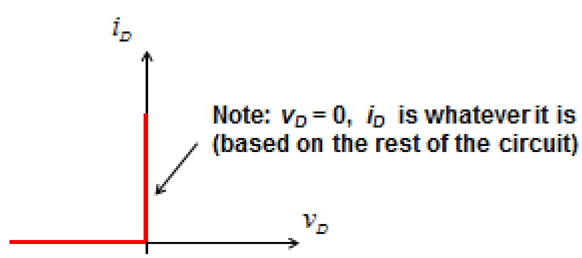


Now, if $v_D > 0$, the diode is ON. In this case the diode acts as a short circuit and current i_D can flow.

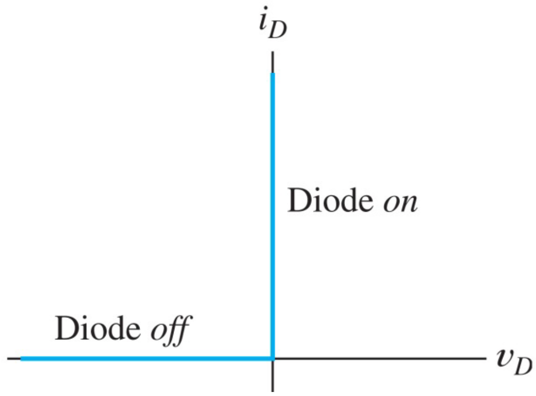
Question: If $v_D > 0$, what value of current i_D actually flows?

Answer: The current i_D that flows is determined by the rest of the circuit--i.e., the resistors, inductors, capacitors, and voltage sources that exist in the circuit when the diode is viewed as a short circuit.

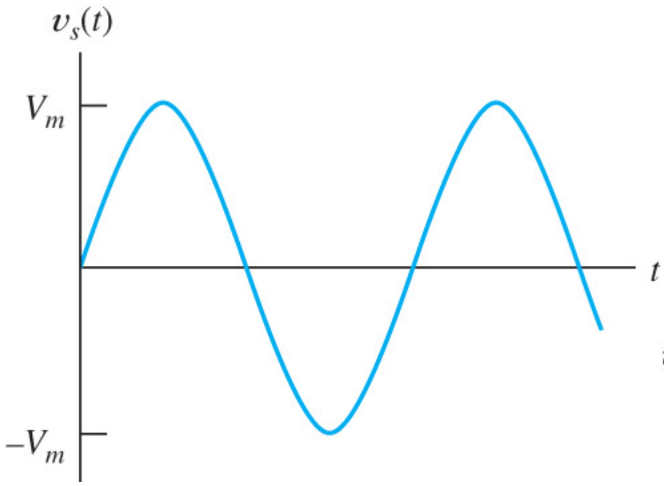
Now, think of how we would represent this behavior on the graph above. We basically want to say: "$v_D = 0$ since the diode acts as a short circuit, but the current i_D can be whatever value is determined by the rest of the circuit." We represent this behavior as shown below:

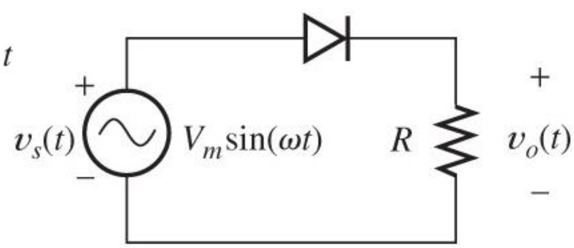


Putting this together, our diode behavior is:

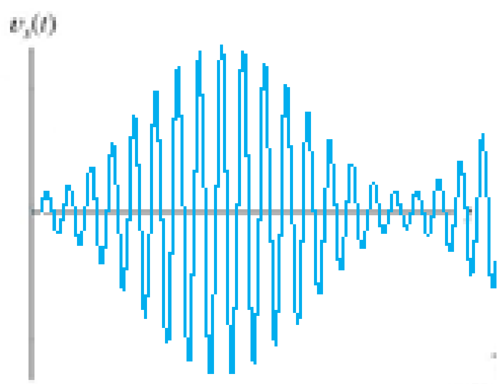


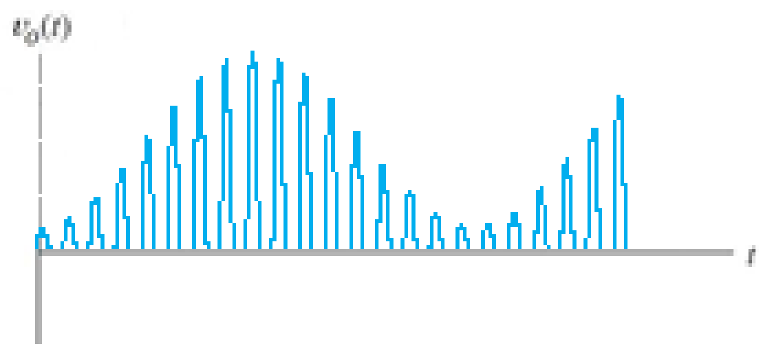
So, consider the circuit below with a sinusoidal input $v_s(t)$. Assuming an ideal diode, draw the output waveform $v_o(t)$.





Now consider the same circuit with an AM input $v_s(t)$. Again, assuming an ideal diode, draw the output waveform $v_o(t)$.

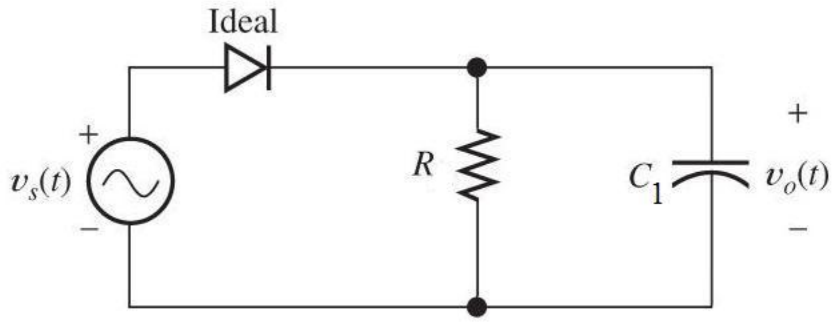




Since the diode only allows positive current to flow, it only passes the positive half-cycles of the modulated signal. The circuit is known as a **half-wave** rectifier.

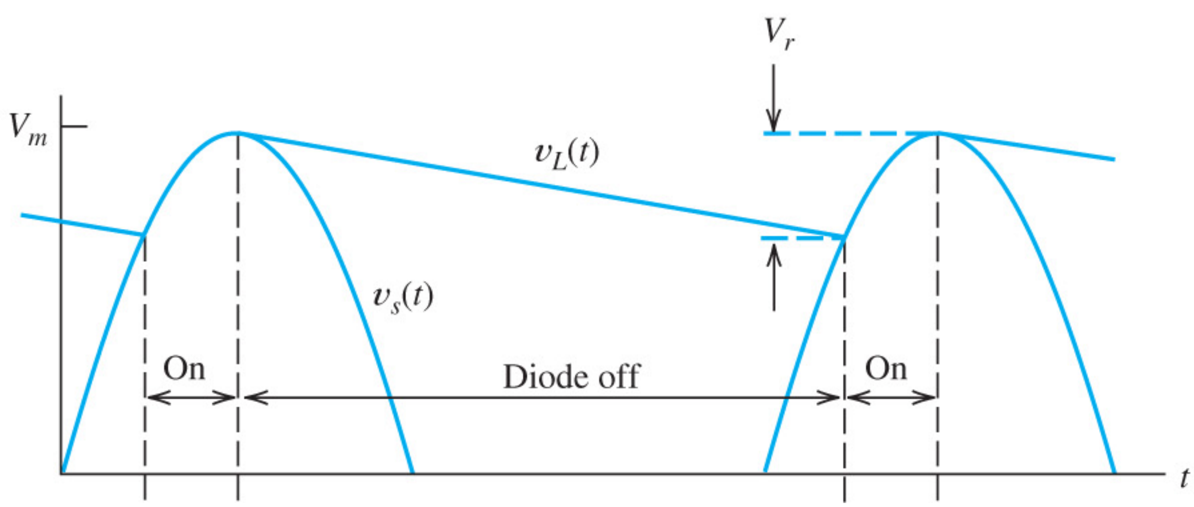
The signal on the above right is closer to the desired envelope, but now we need something to reduce the voltage peaks and recover the envelope. This is done by a *smoothing capacitor*.

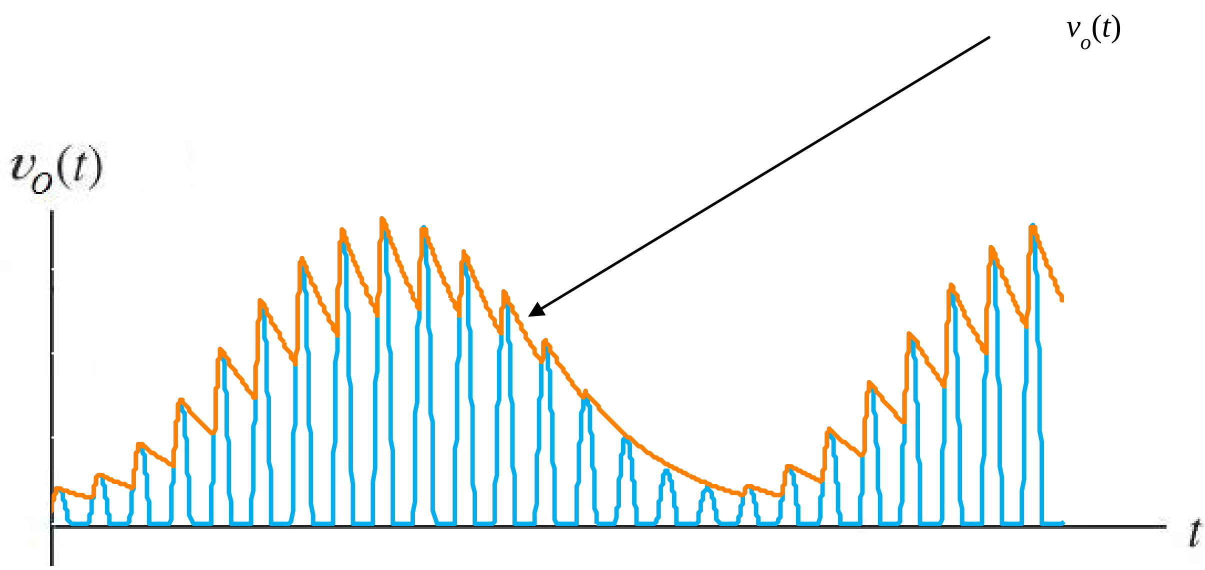
Smoothing Capacitor



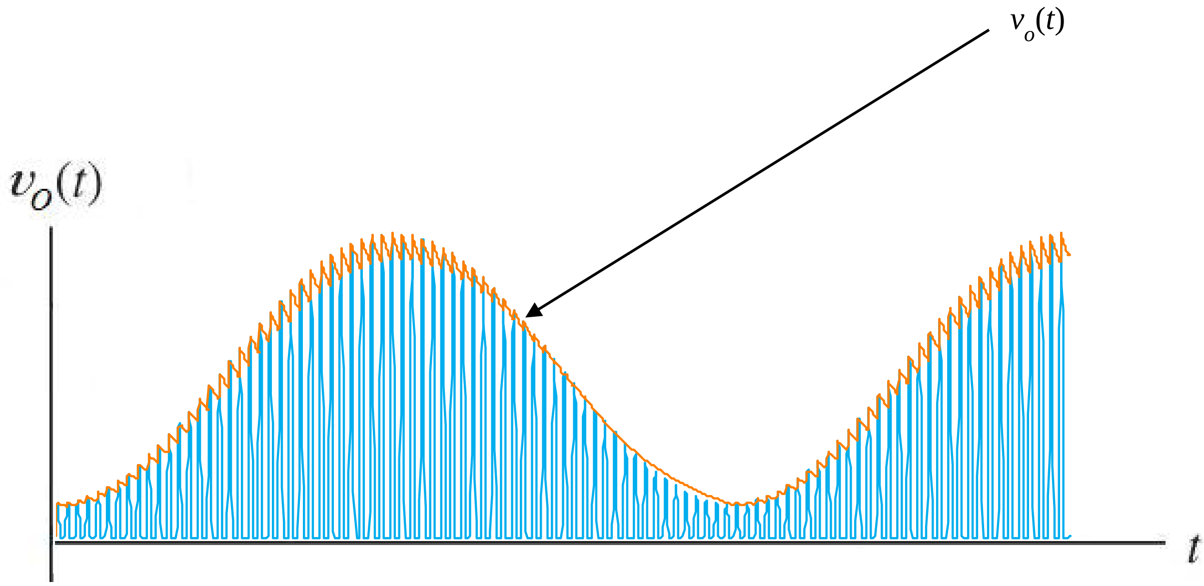
C_1 charges rapidly when the diode is on.

C_1 discharges slowly through R when the diode is off.

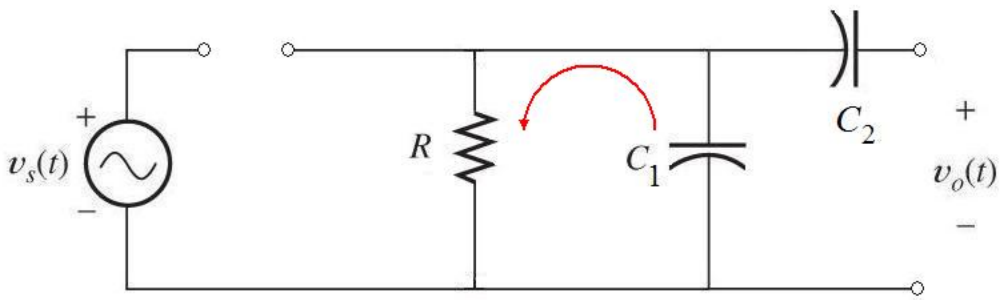




The previous trace does not look smooth due to the unrealistically low carrier frequency. In reality the carrier frequency will be much higher that the information frequency.

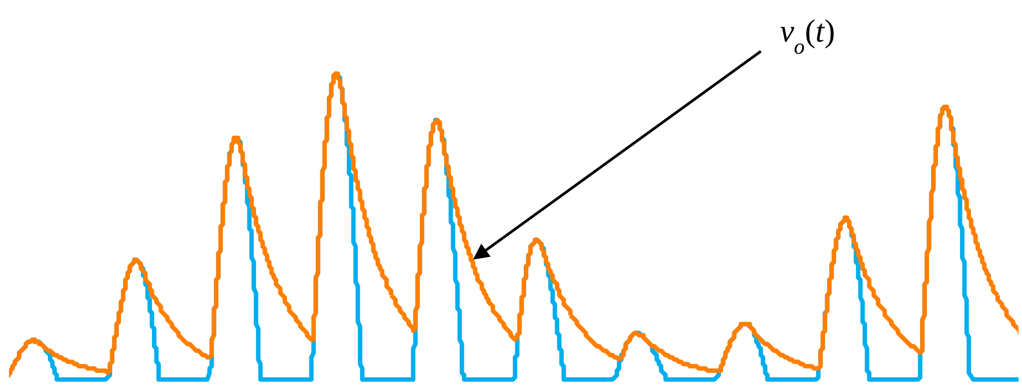


Note that when the diode is not conducting (OFF), the capacitor C_1 discharges through R.

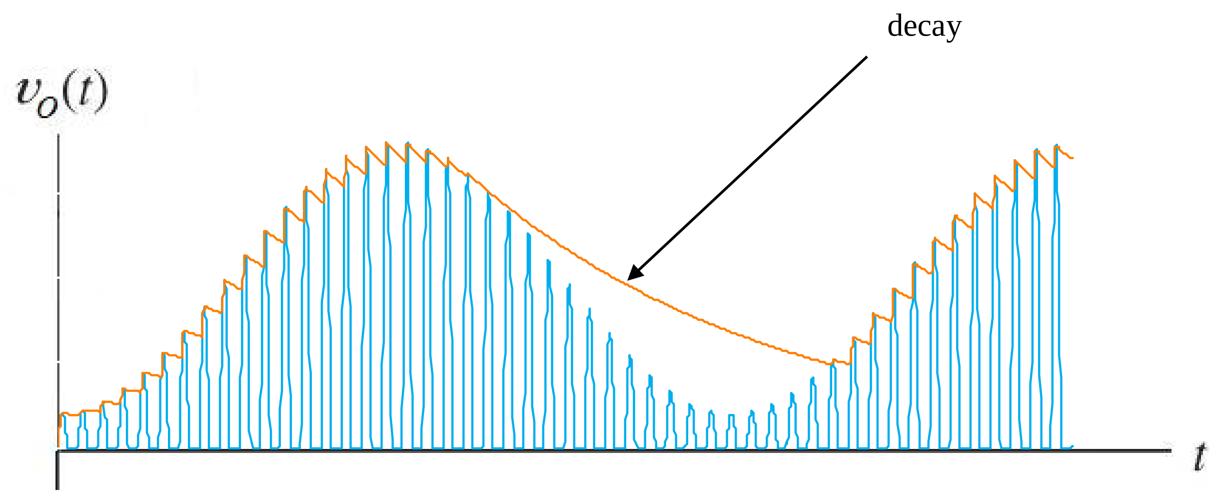


Recall from EE301 that this rate of discharge is given by a time constant: the product RC_1.

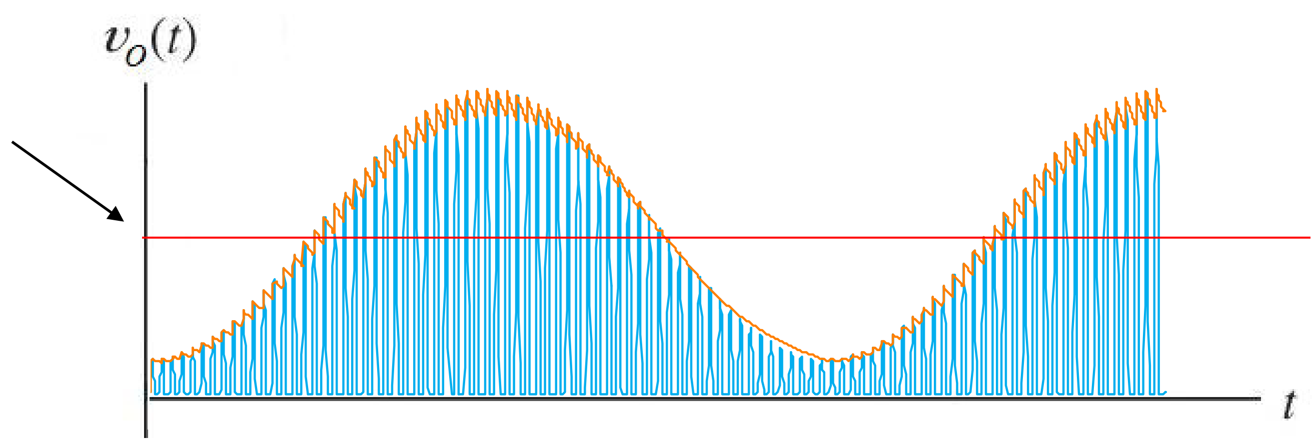
Careful consideration must go into the choices for R and C_1. If the product RC_1 is too small, the capacitor will discharge very quickly, and the response will not be a smooth envelope:



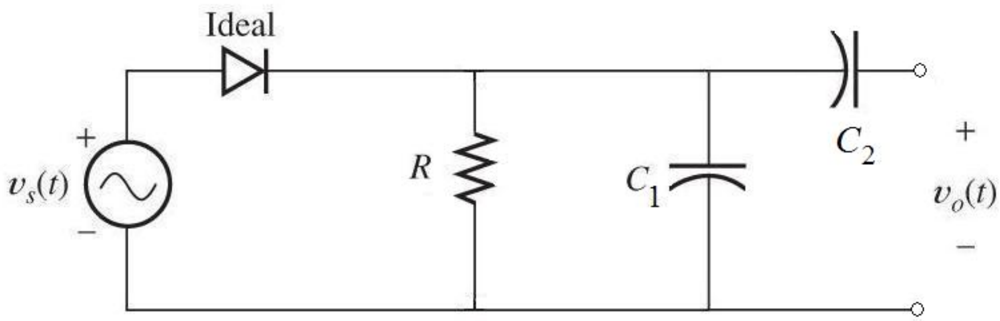
On the other hand, if the product RC_1 is too large, the capacitor will discharge very slowly, and the response will also not follow the envelope. In this case the capacitor discharge will be too slow to follow the faster changes in the modulating signal. This is referred to as **diagonal distortion** or **diagonal clipping**.

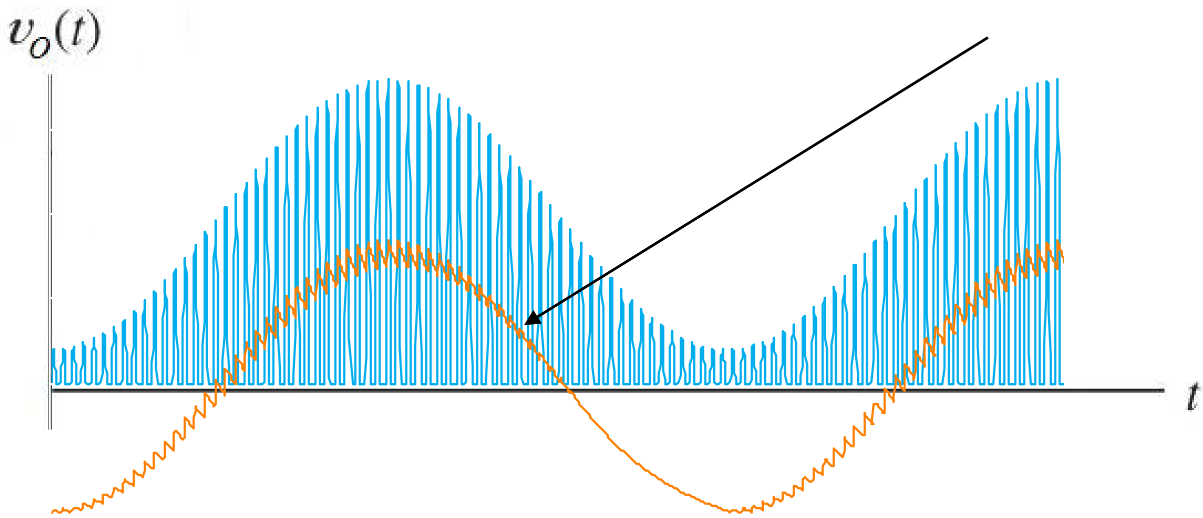


<u>Blocking Capacitor</u> Notice that $v_o(t)$ has a non-zero average value. This is due to the addition of V_C to our signal at the transmitter, before multiplying our signal by the carrier.

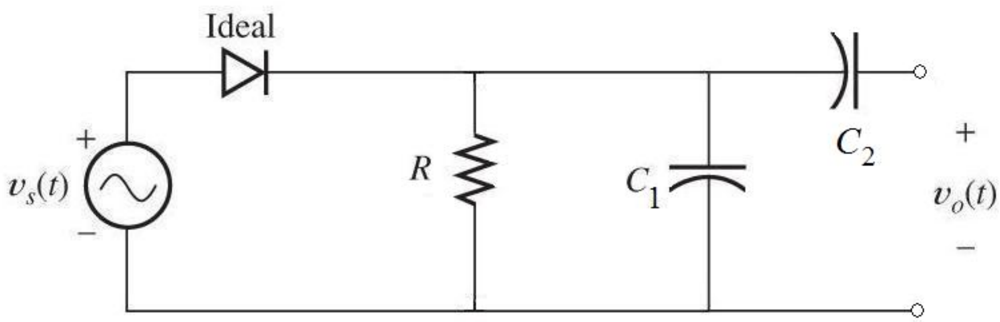


To get rid of the average value (dc component) we can use a blocking capacitor C_2.





To summarize, our circuit for demodulation of an AM signal is:



You should feel comfortable explaining the operation of this circuit to a friend (or to a friendly instructor on an exam!)