Amplitude Modulation: Demodulation

Demodulation

Q: What is demodulation?

Demodulation is recovering the original message signal. Also known as detection.

Q: What is a demodulator?

It is a circuit that accepts a modulated signal and recovers the original message signal.

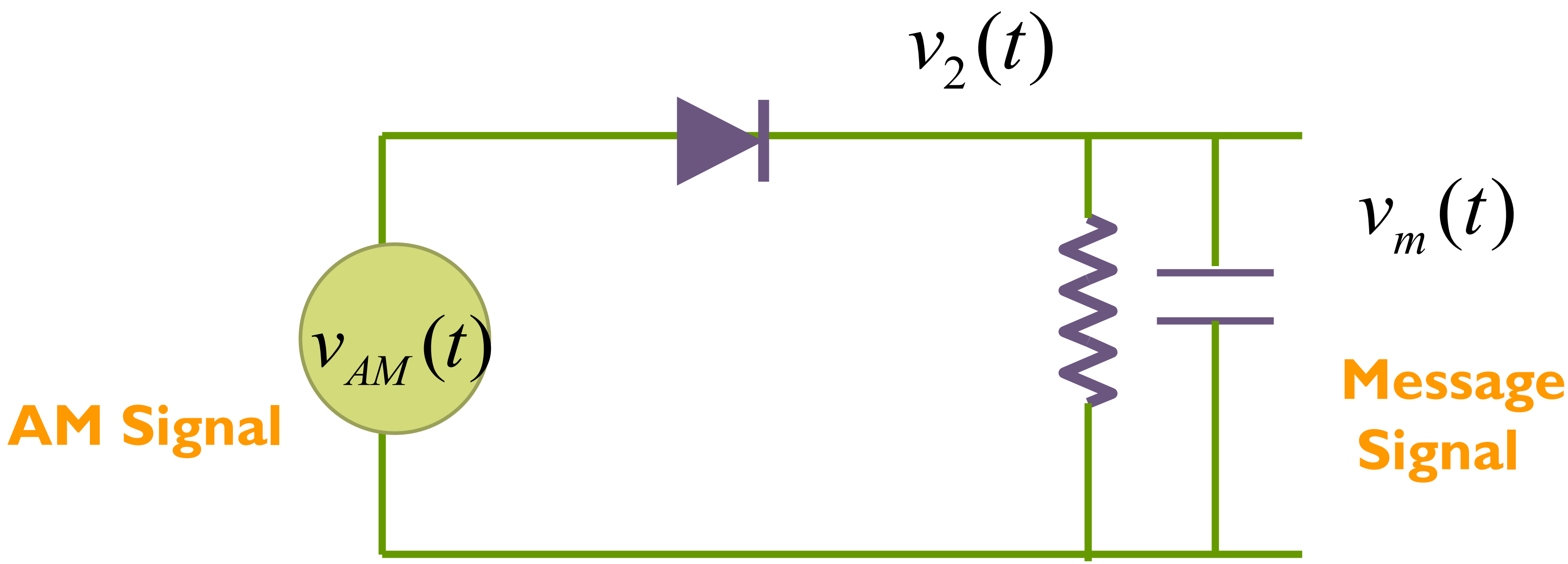
AM Demodulator

Q: What is an AM Demodulator?

A simple AM demodulator is an Envelope detector. It is circuit that detects the envelope of an AM signal, which is the information signal.

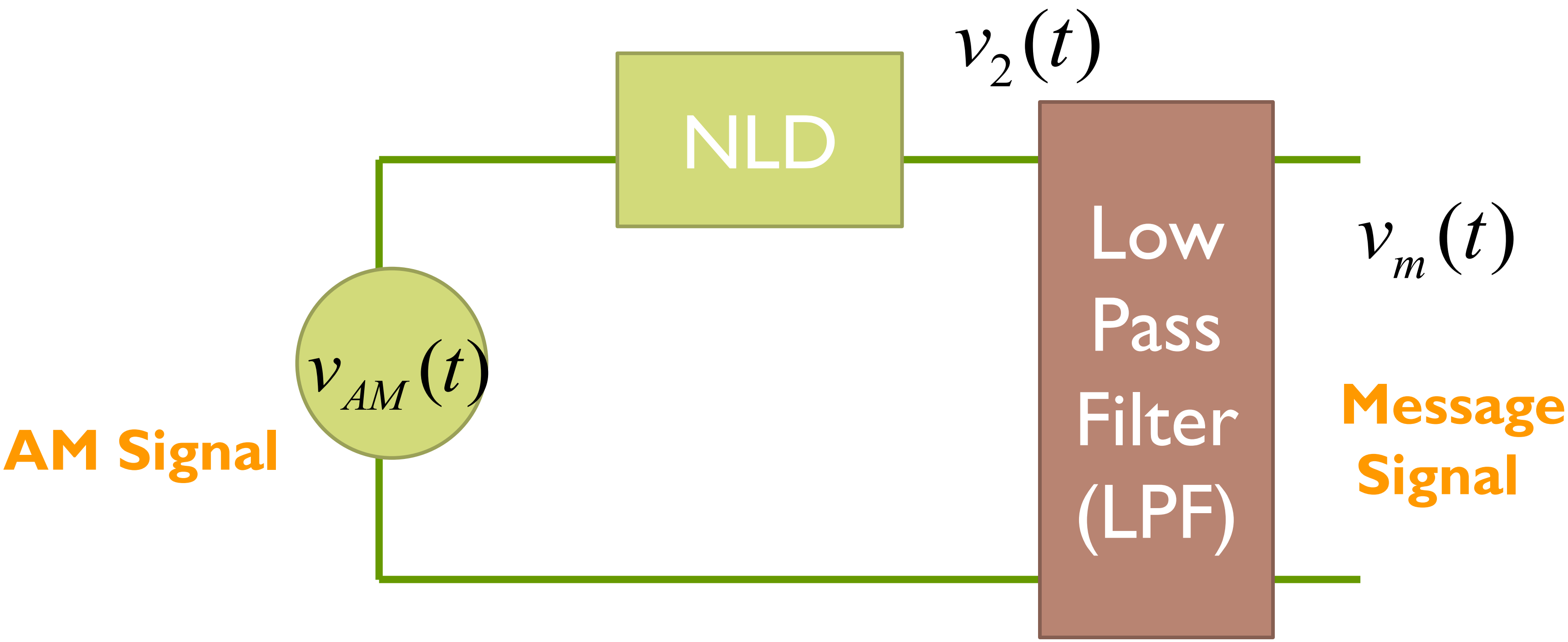
Envelope Detector

Q: What is a half wave envelope detector?



Envelope Detector

Q: What is a half wave envelope detector?



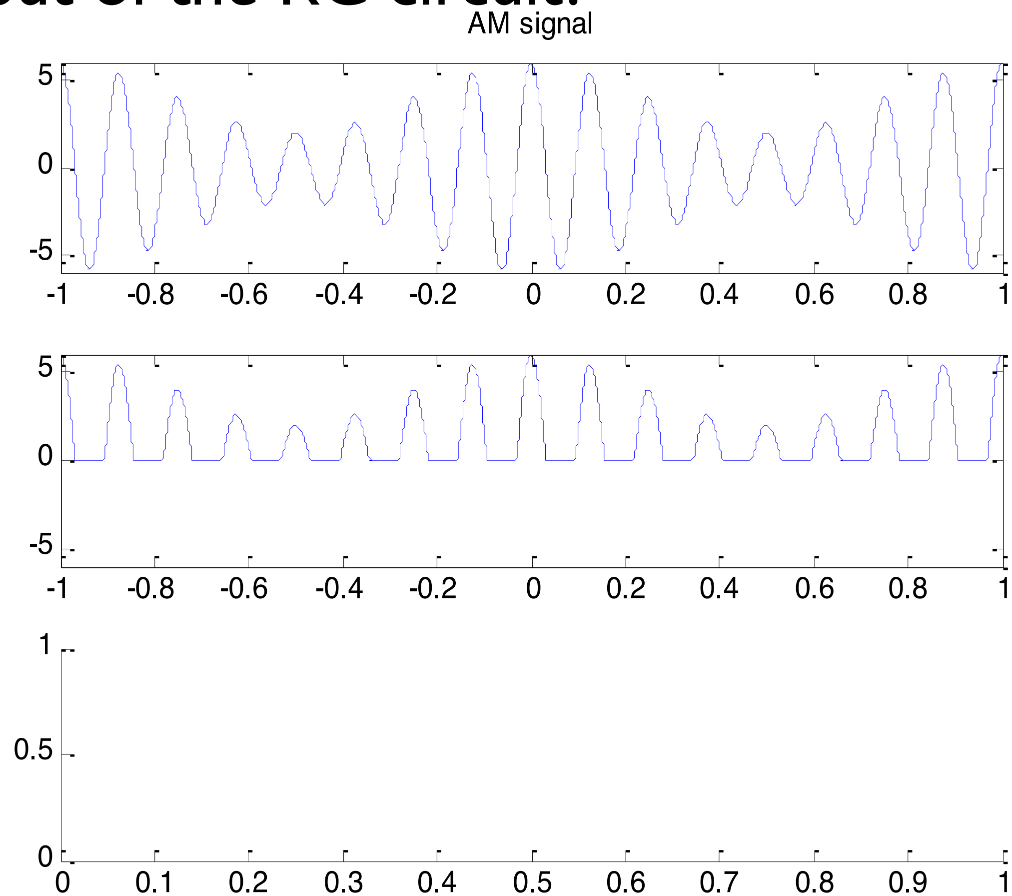
Envelope Detector

Q: What is the output of the RC circuit?

AM Signal

After Diode

After RC circuit

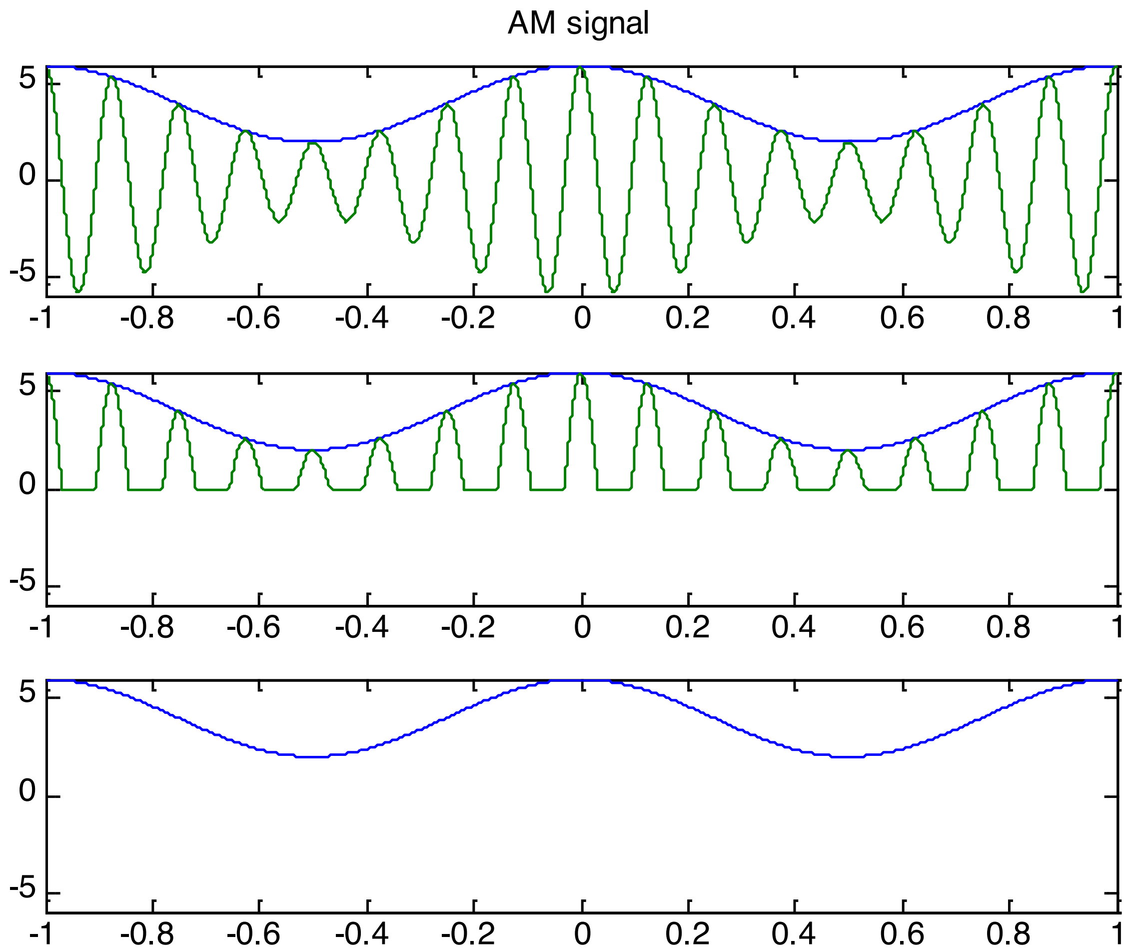


Envelope Detector

AM Signal

After Diode

After RC circuit



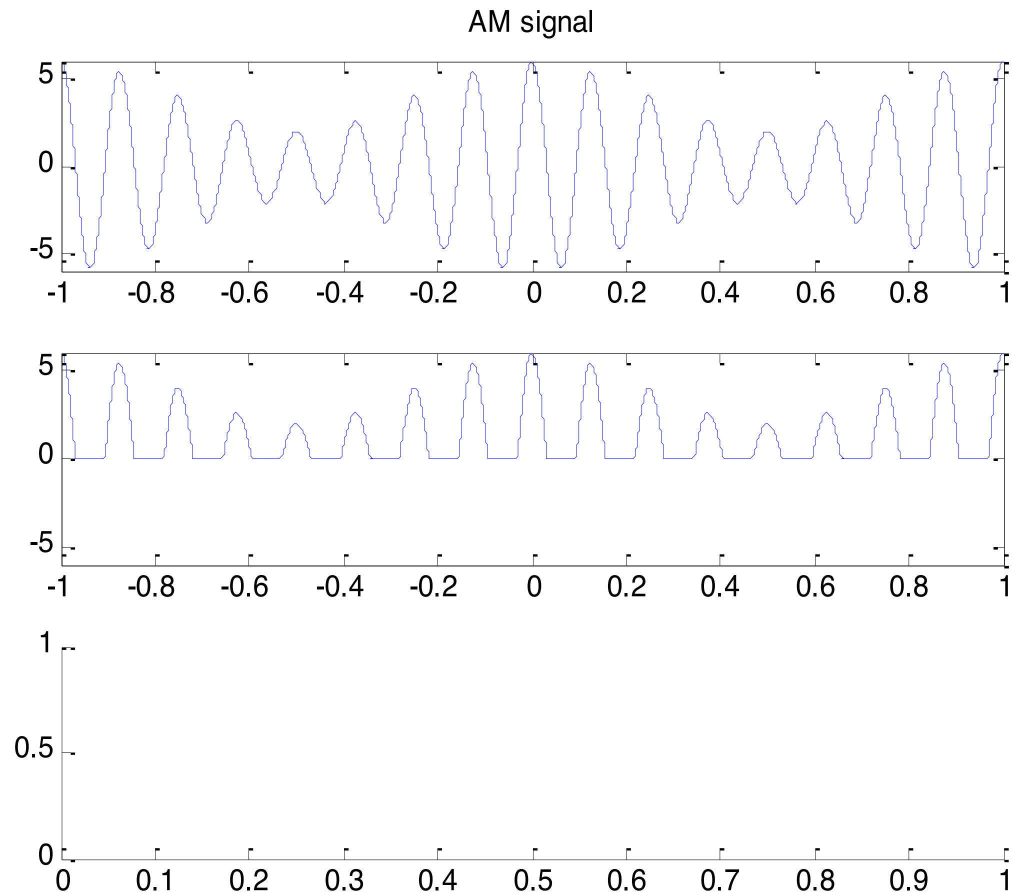
Envelope Detector

Q: What if the RC circuit has the wrong time constant?

AM Signal

After Diode

After RC circuit

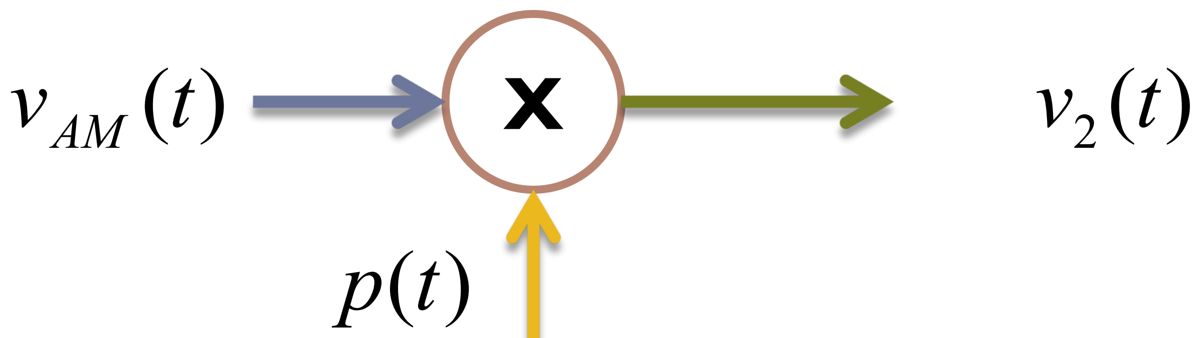


Envelope Detector

Q: What is an Envelope Detector?

We can write it as:

$$v_2(t) = v_{AM}(t)\,p(t) = \left[\left(V_c + v_m(t)\right)\cos(2\pi\ f_c t)\right]p(t)$$



where

$$p(t) = \begin{cases} 1 & nT_c/2 \geq |t| \geq (n+1)T_c/2 \\ 0 & (n+1)T_c/2 < |t| < (n+2)T_c/2 \end{cases}$$

Envelope Detector

Q: What is an Envelope Detector?

The Fourier series representation of p(t):

$$p(t) = \frac{1}{2} + \frac{2}{\pi}\cos(2\pi f_c t) - \frac{2}{3\pi}\cos(6\pi f_c t) + \frac{2}{5\pi}\cos(10\pi f_c t) - \ldots.$$

So the output of the diode is:

$$v_2(t) = [(V_c + v_m(t))\cos(2\pi\ f_c t)] \bullet \left[\frac{1}{2} + \frac{2}{\pi}\cos(2\pi f_c t) - \frac{2}{3\pi}\cos(6\pi f_c t) + \frac{2}{5\pi}\cos(10\pi f_c t) - \ldots\right]$$

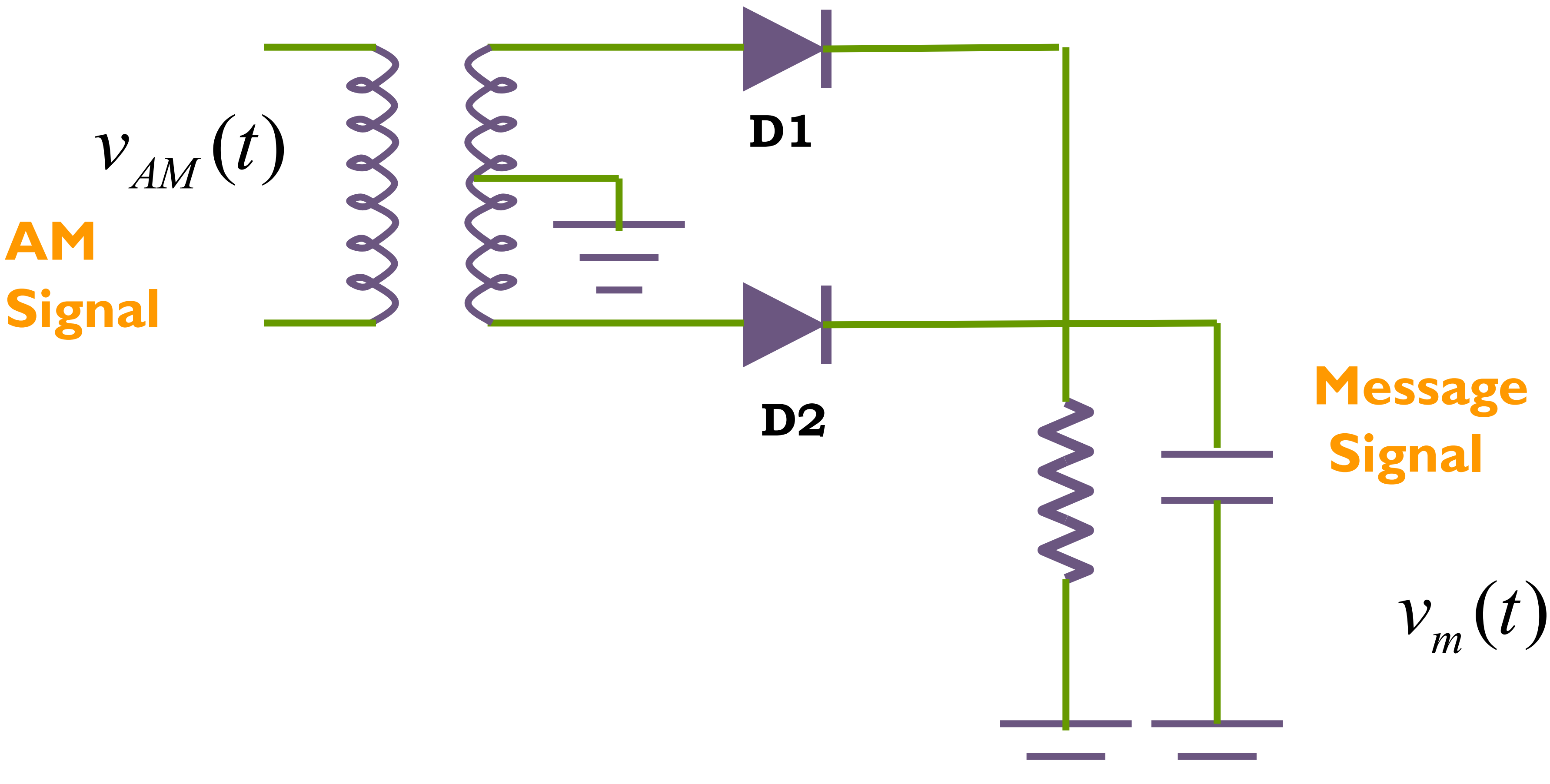
$$v_2(t) = [(V_c + v_m(t))\cos(2\pi\ f_c t)] \bullet \left[\frac{1}{2} + \frac{2}{\pi}\cos(2\pi f_c t) - \ldots\right]$$

$$v_2(t) = [V_c\cos(2\pi\ f_c t) + v_m(t)\cos(2\pi\ f_c t)] \bullet \left[\frac{1}{2} + \frac{2}{\pi}\cos(2\pi f_c t) - \ldots\right]$$

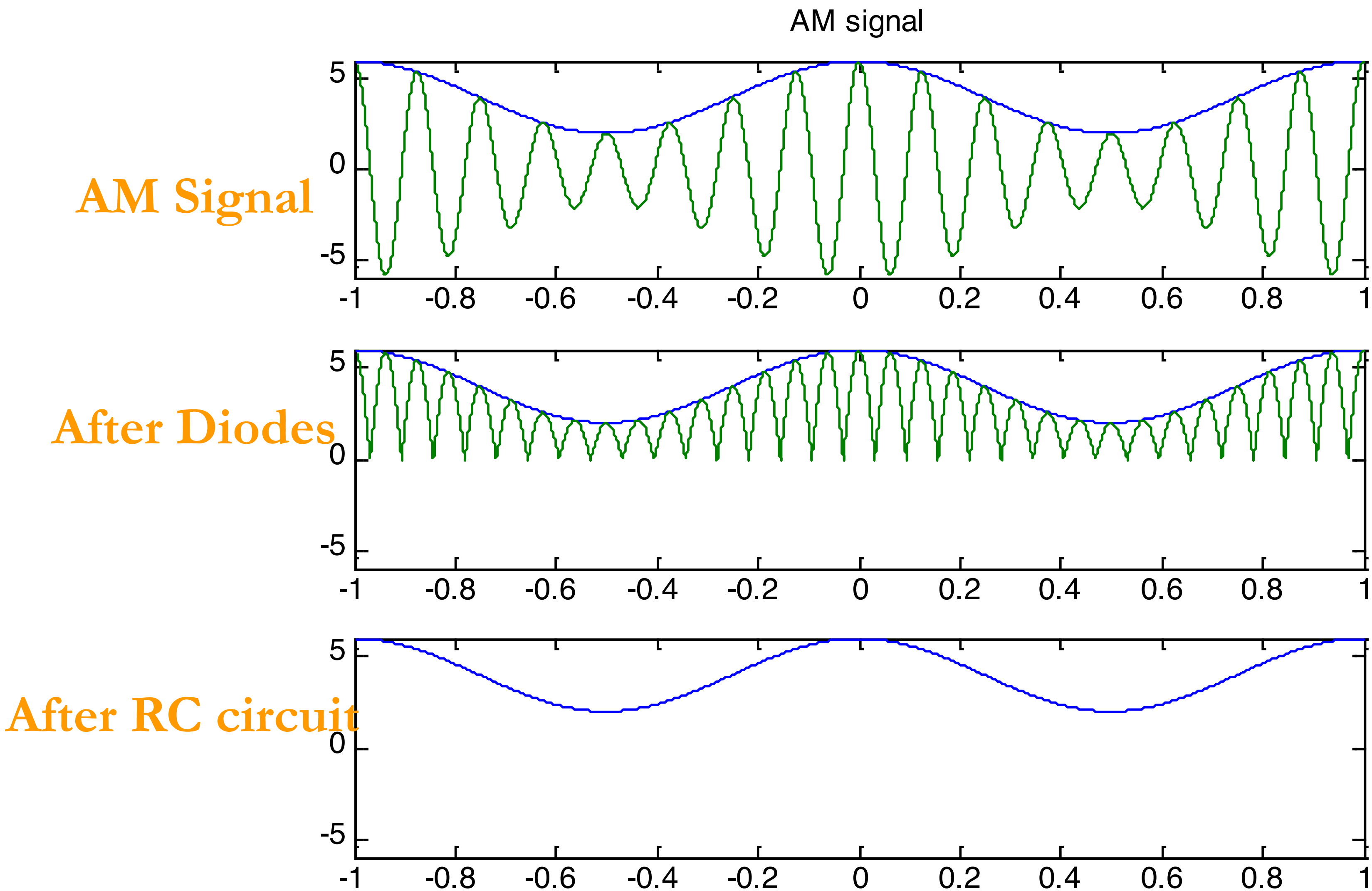
$$v_o(t) = v_{LPF}(t) =$$

Envelope Detector

Q: What is a Full wave envelope detector?



Envelope Detector



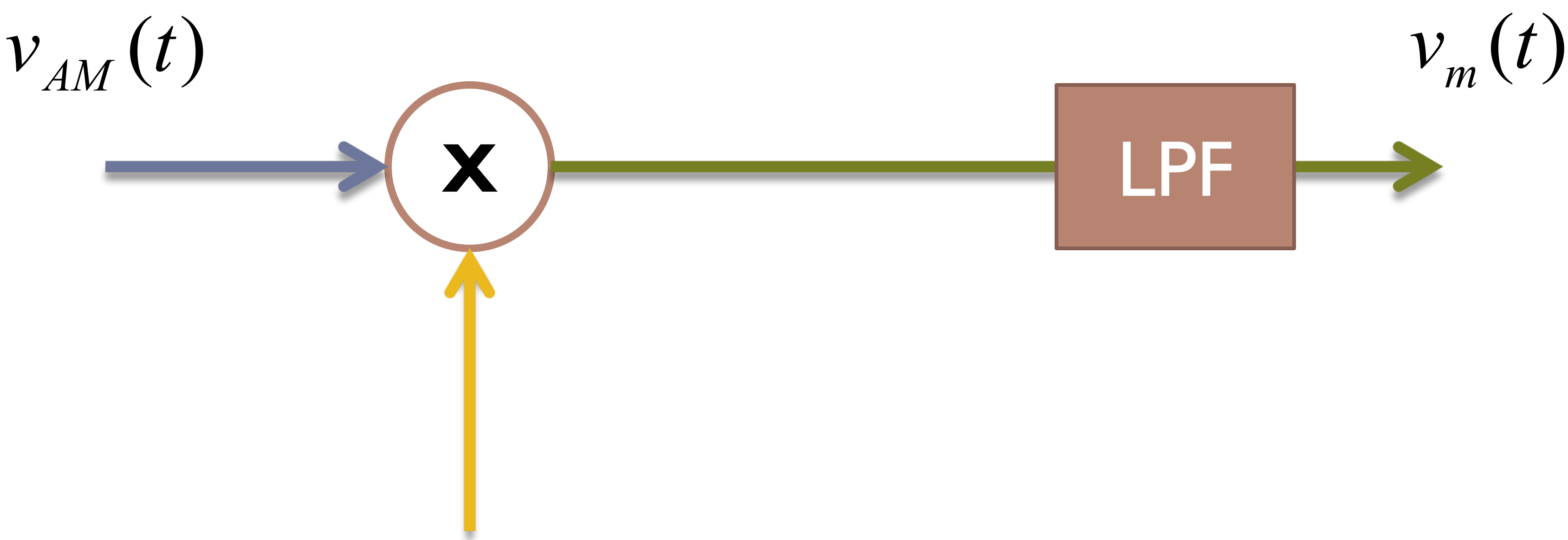
Envelope Detector

Exercise: Find an expression for the output of the full wave rectifier detector.

Homodyne Demodulator

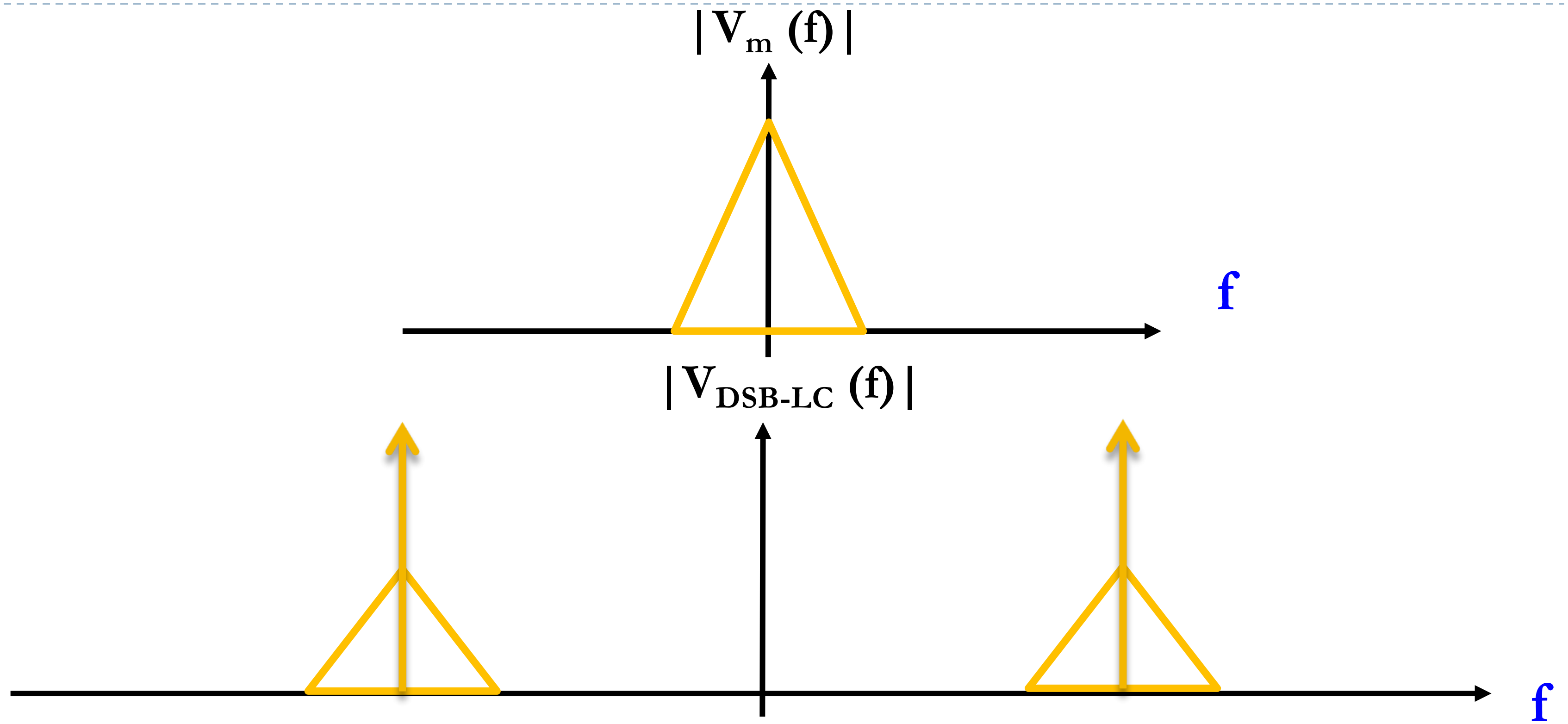
Q: What is a Homodyne Demodulator?

Also known as Synchronous or Coherent Demodulator :



$$v_c(t) = \cos(2\pi f_c t)$$

DSB-LC



Homodyne Demodulator

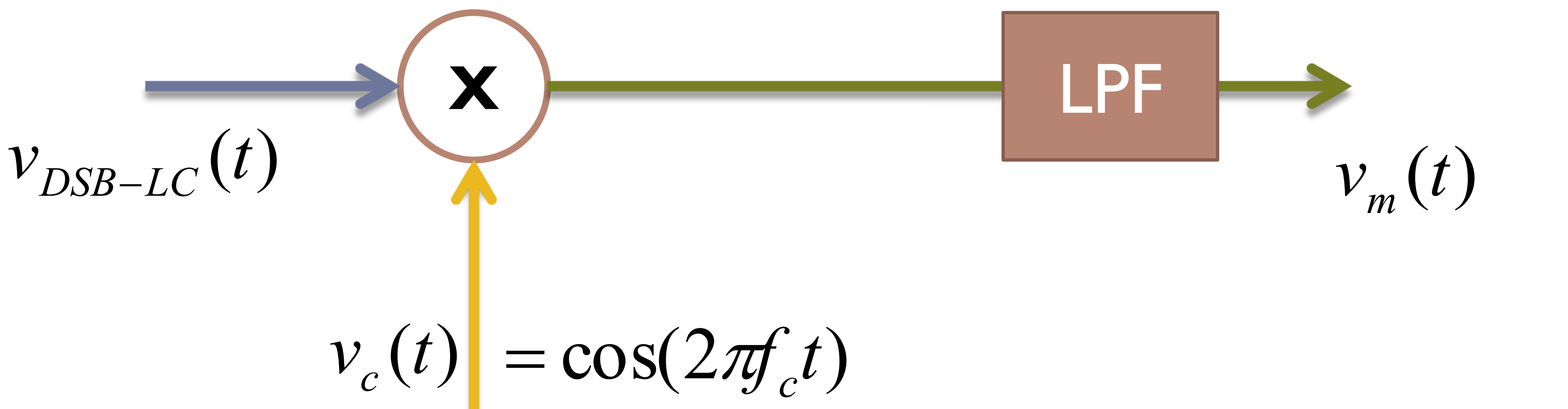
Q: What if the input is DSC-LC?

Also known as Synchronous or Coherent Demodulator :

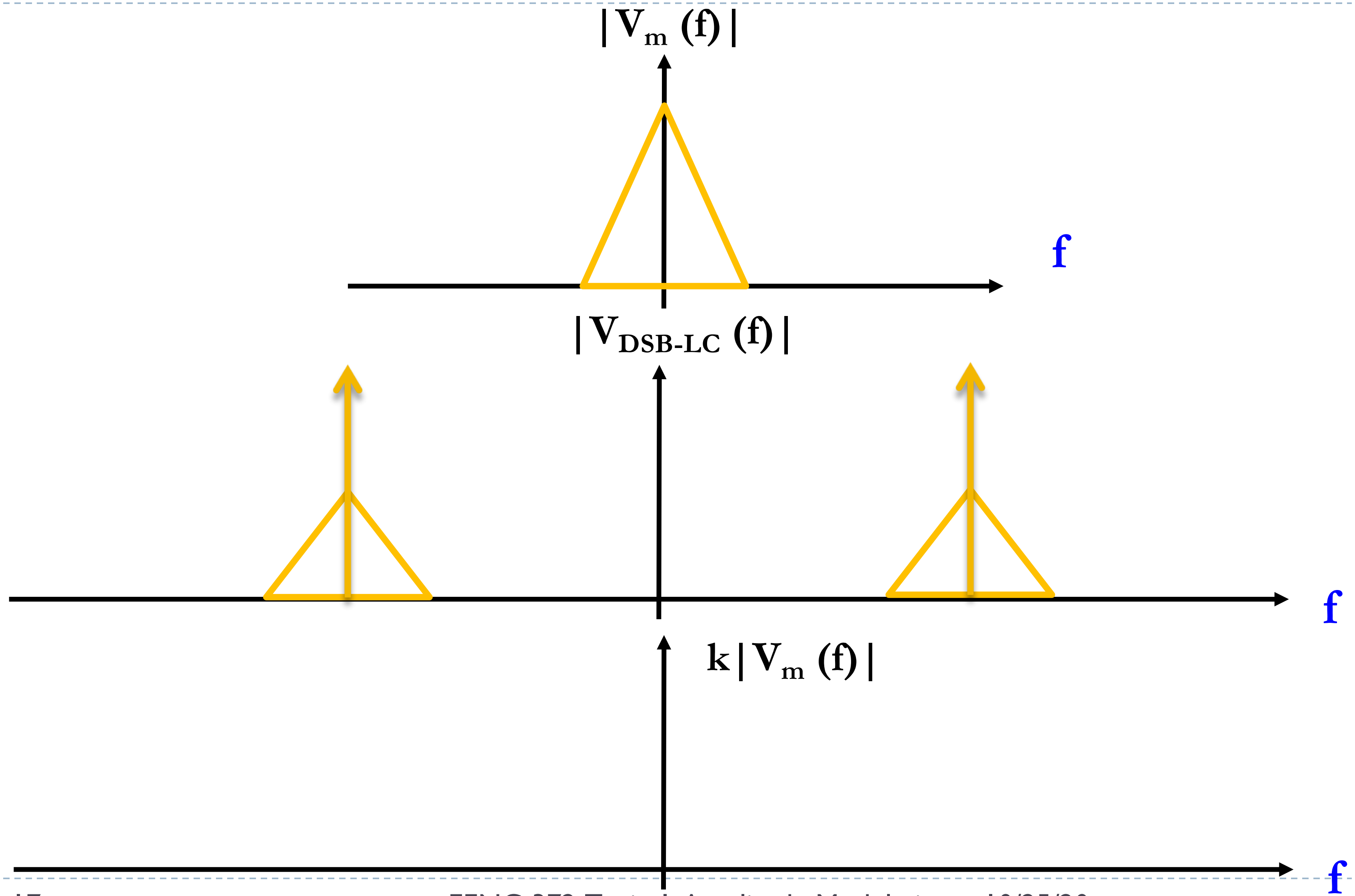
$$v_{DSB-TC}(t) = V_c \cos(2\pi\, f_c\, t) + V_m \cos(2\pi\, f_m\, t)\cos(2\pi\, f_c\, t)$$

$$V_{DSB-LC}(f) = \frac{V_c}{2}[\delta(f - f_c) + \delta(f + f_c)]$$

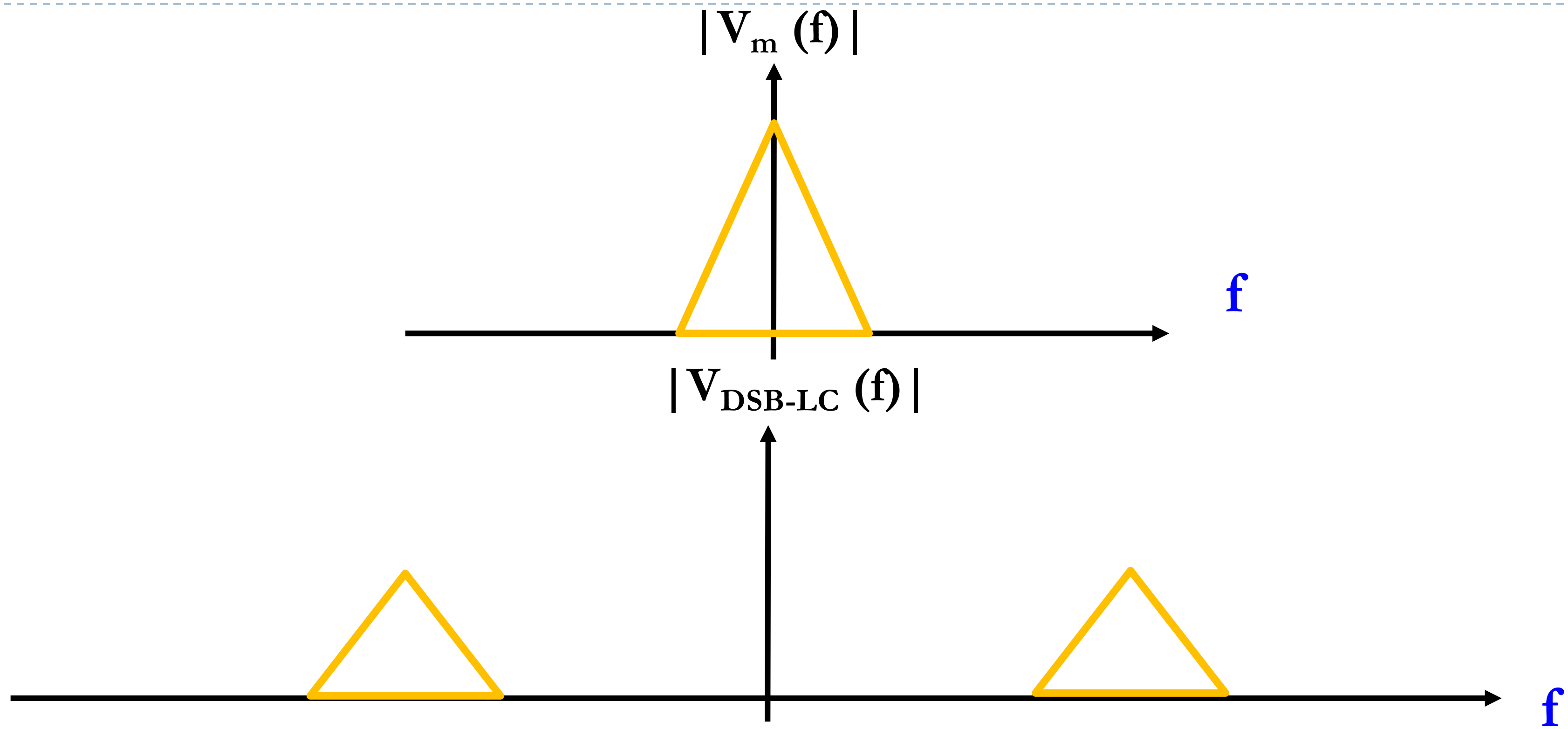
$$+\frac{1}{4}[V_m(f - f_{USB}) + V_m(f + f_{USB})] + \frac{1}{4}[V_m(f - f_{LSB}) + V_m(f + f_{LSB})]$$



DSB-LC



DSB-SC



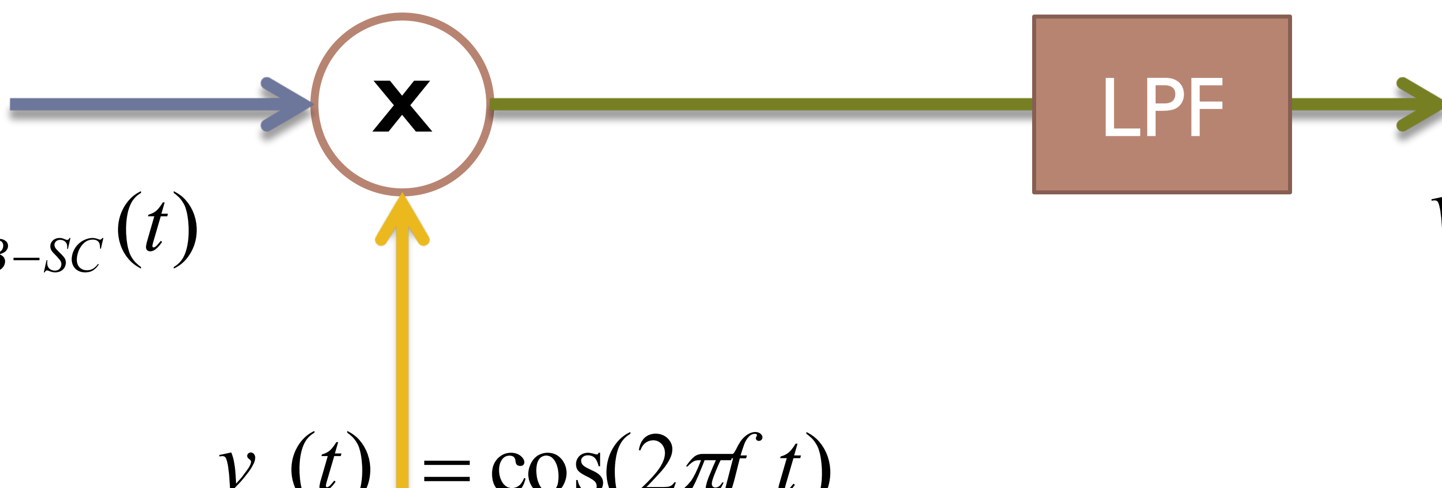
Homodyne Demodulator

Q: What if the input is DSC-SC?

Also known as Synchronous or Coherent Demodulator :

$$v_{DSB-SC}(t) = v_m(t)\cos(2\pi f_c t)$$

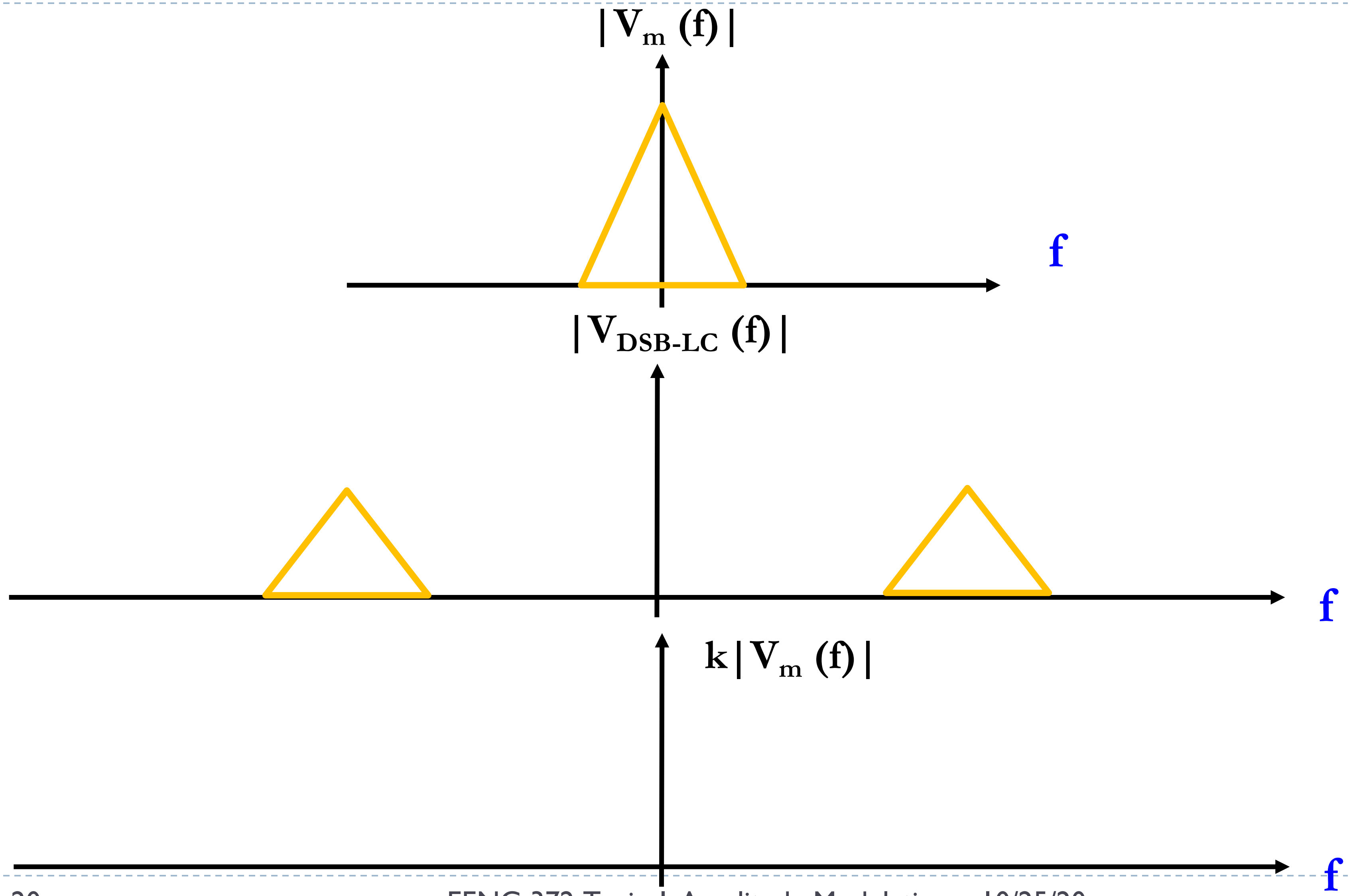
$$V_{DSB-SC}(f) = \frac{1}{2}\left[V_m(f - f_c) + V_m(f - f_c)\right]$$



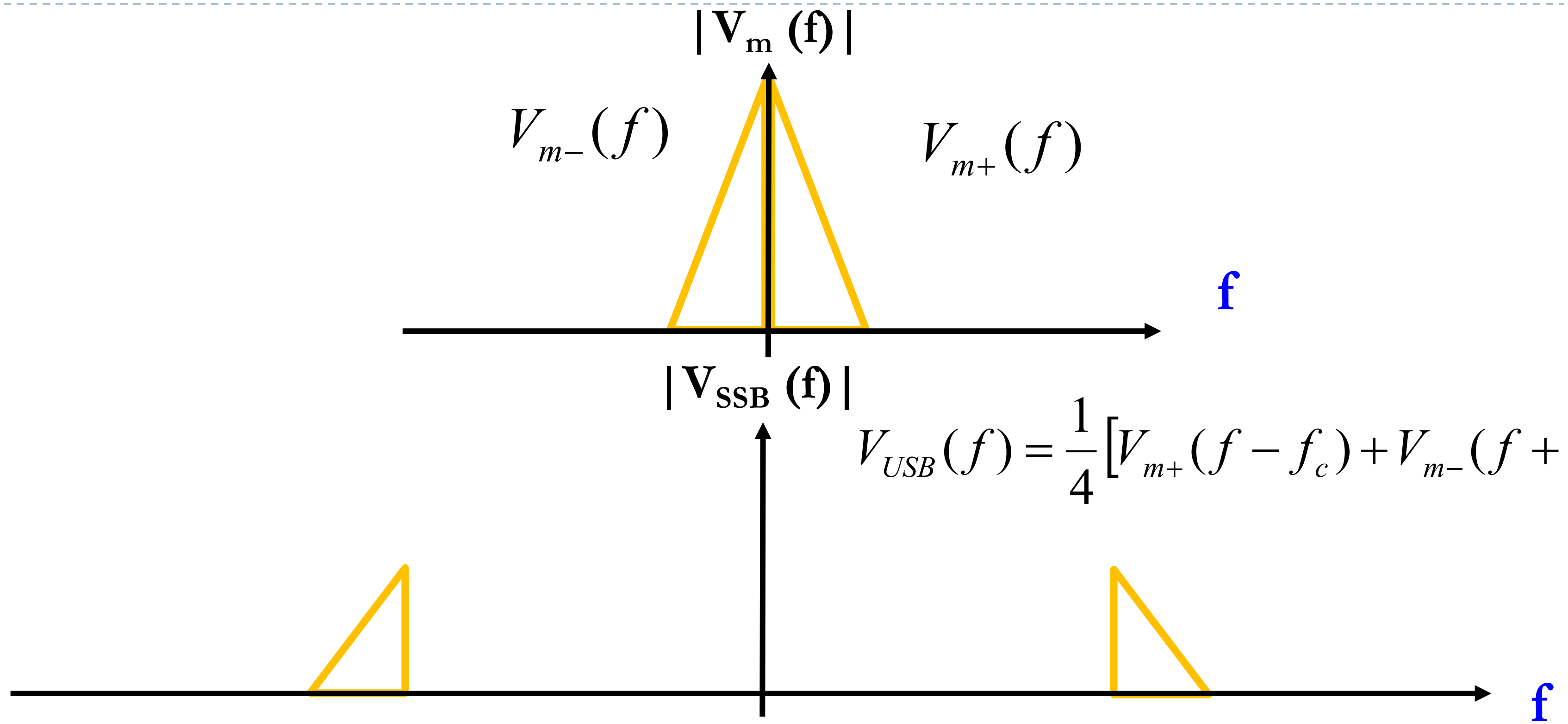
$v_{DSB-SC}(t)$ $\quad$ $v_m(t)$

$$v_c(t) = \cos(2\pi f_c t)$$

DSB-SC



Single Side band (SSB)



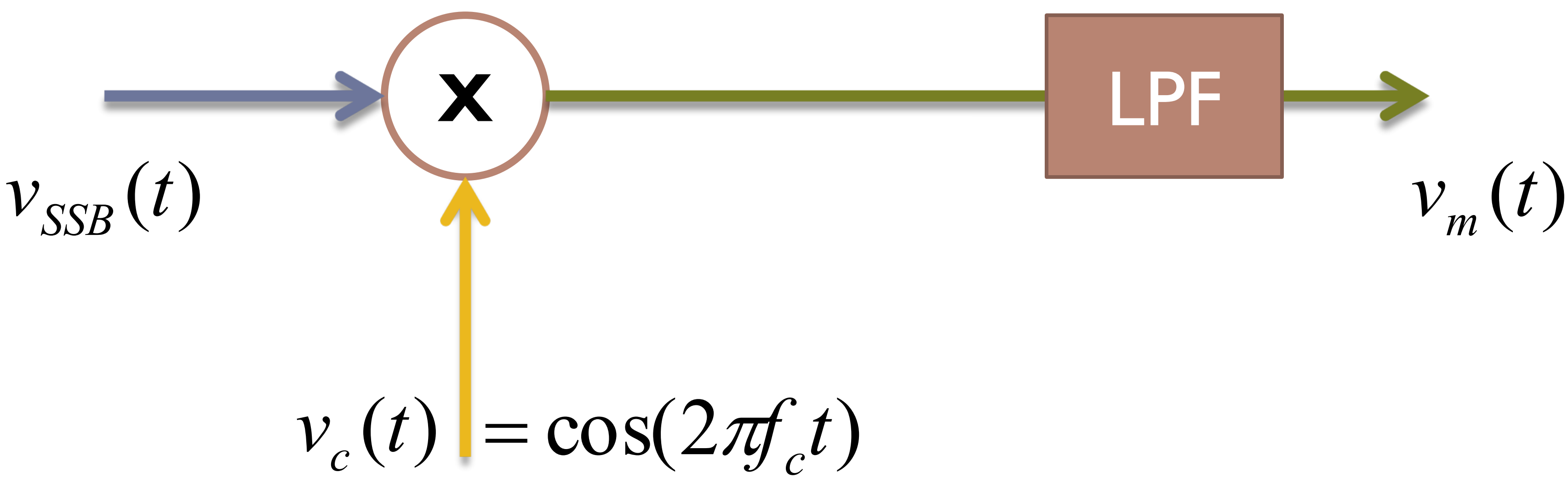
$$V_{USB}(f) = \frac{1}{4}\left[V_{m+}(f - f_c) + V_{m-}(f + f_c)\right]$$

Homodyne Demodulator

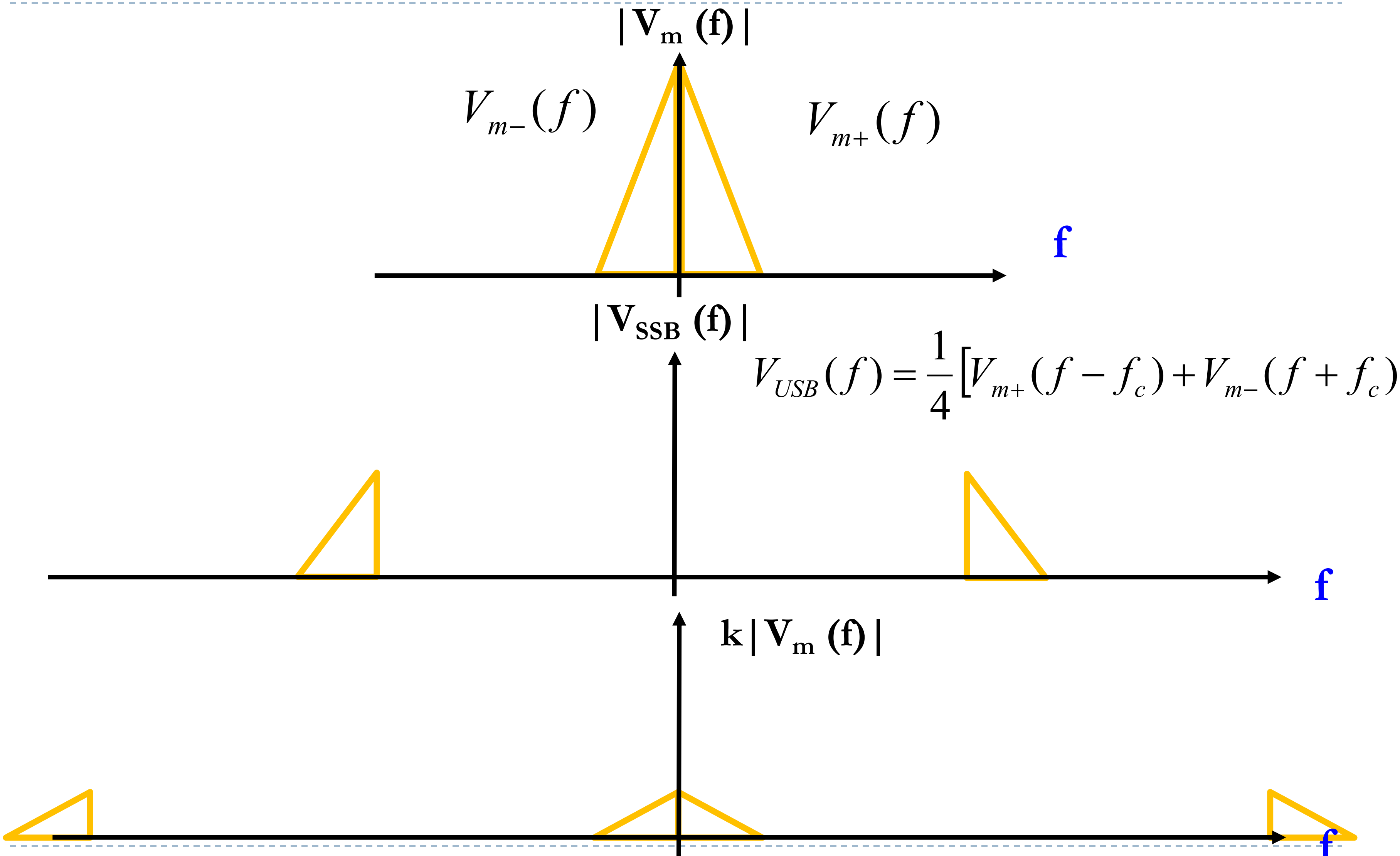
Q: What if the input is SSB?

Also known as Synchronous or Coherent Demodulator :

$$V_{USB}(f) = \frac{1}{4}\left[V_{m+}(f - f_c) + V_{m-}(f + f_c)\right]$$



Single Side band (SSB)



Frequency Division Multiplexing (FDM)