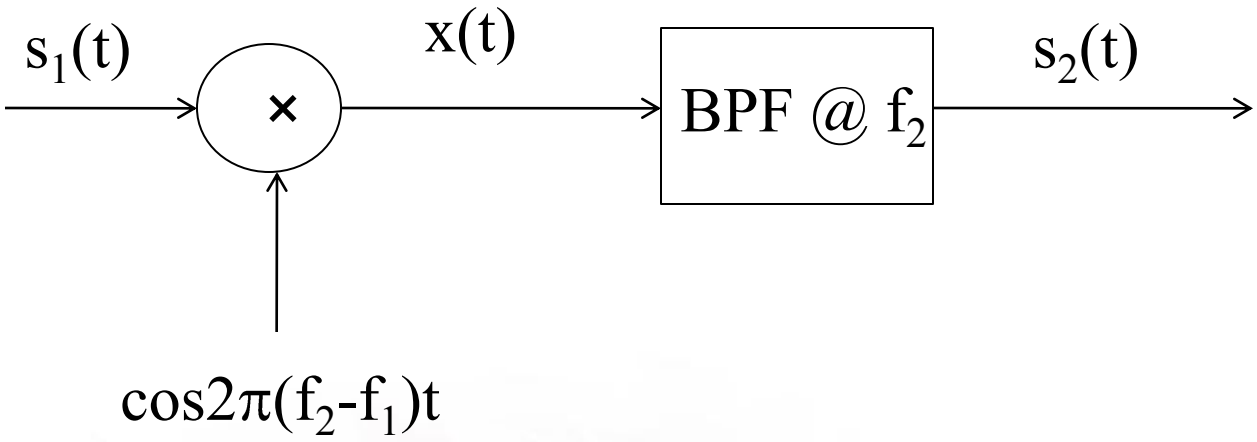
ELG3175 Introduction to Communication Systems

Frequency Translation, Frequency Division Multiplexing and Superheterodyne Receivers

Frequency Translation

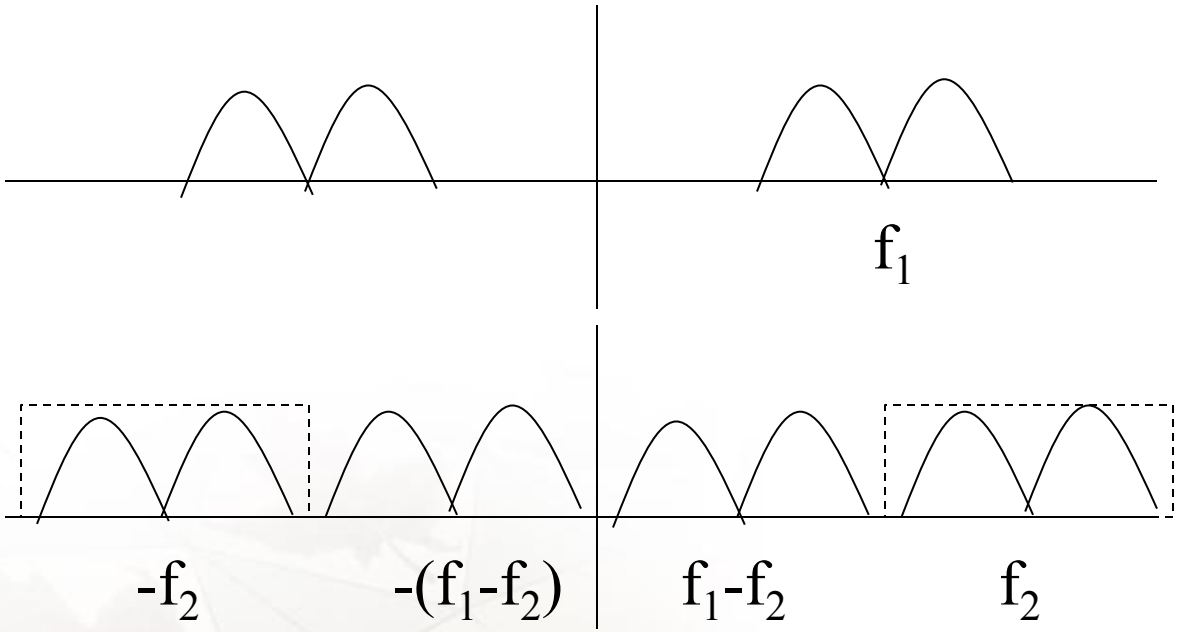
- Suppose we have a modulated wave $s_1(t)$ whose spectrum is centered around frequency f_1 and we wish to move it upward in frequency, so that its spectrum is centered around f_2.
- This can be accomplished by multiplying $s_1(t)$ by $\cos 2\pi(f_2-f_1)t$ and passing it through a BPF.

Frequency Translation



$$X(f) = 0.5S_1(f-f_2+f_1)+0.5S_1(f+f_2-f_1)$$

Frequency Translation



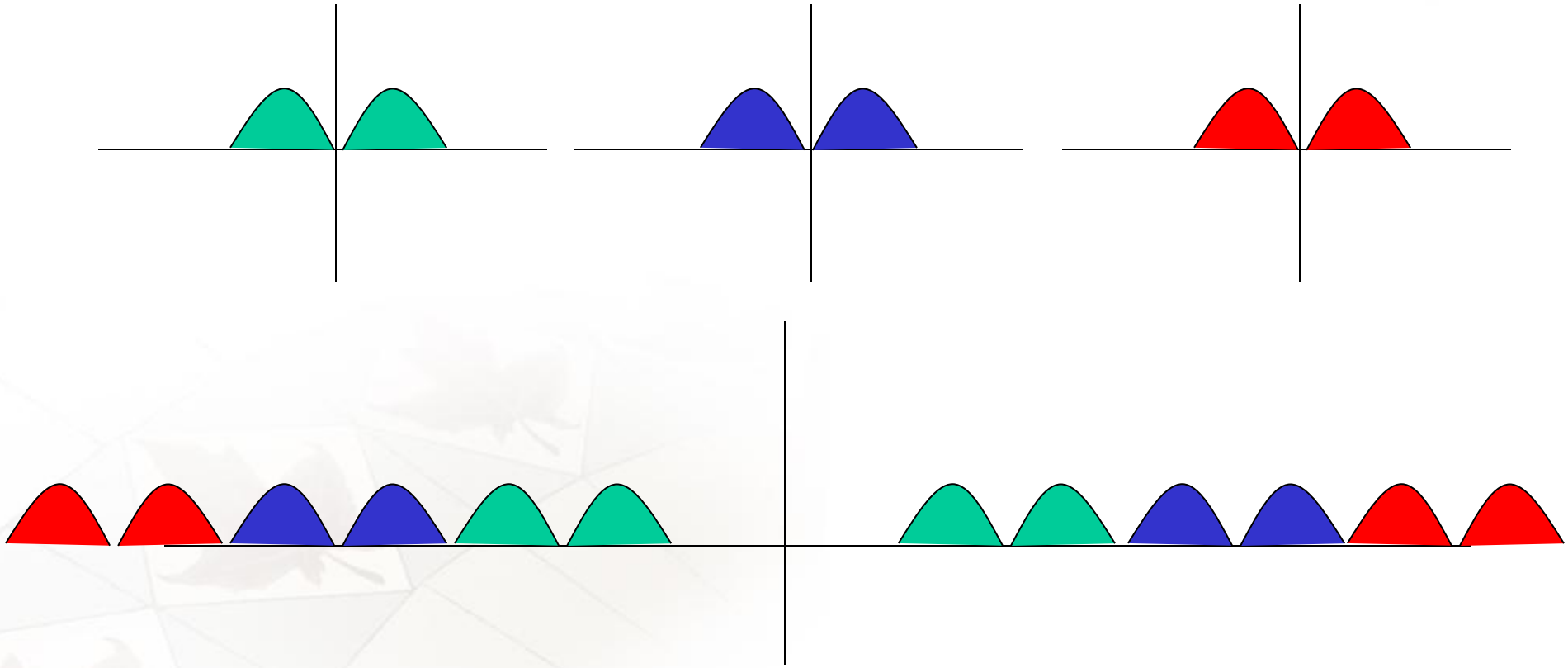
Downward Frequency Translation (Downconversion)

- We can also decrease the frequency of a modulated signal by multiplying by $\cos 2\pi(f_1-f_2)t$

Frequency Division Multiplexing

- When multiple signals are to be transmitted they can be multiplexed in frequency by assigning different carrier frequencies that are sufficiently spaced.
- For example, in a DSB-SC system the messages $m_1(t)$, $m_2(t)$ and $m_3(t)$ can be multiplexed by assigning carriers $A_{c1}\cos 2\pi f_1 t$, $A_{c2}\cos 2\pi f_2 t$ and $A_{c3}\cos 2\pi f_3 t$.
- The signal that is transmitted on the common channel is
- $s(t) = A_{c1}m_1(t)\cos 2\pi f_1 t + A_{c2}m_2(t)\cos 2\pi f_2 t + A_{c3}m_3(t)\cos 2\pi f_3 t$.
- The spectrum of the signals are:

Frequency Division Multiplexing



Signal Separation

- In the previous example, we can demodulate $m_1(t)$, for example, by multiplying by cos2pf1t and using an LPF.
- But in conventional AM or FM demodulation, the detector requires 1 AM or 1 FM signal at its input.
- Filtering is required.
  - Multiple RF filters?
  - Tunable RF filters?
  - Downconversion?

Superheterodyne Receiver

- Combines tunable RF filters with downconversion to produce a unique AM or FM signal at the input to the detector
- RF filter must be able to remove the image frequencies.