Lecture 23

Wednesday, April 08, 2015 10:27 AM

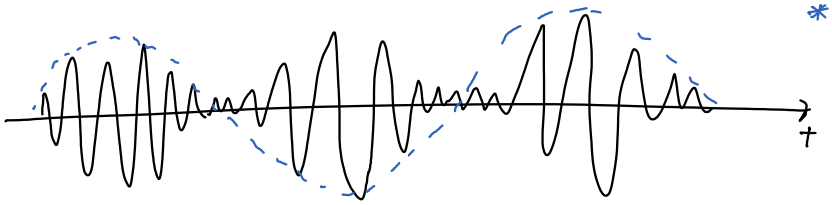
Modulation and Circular Convolution

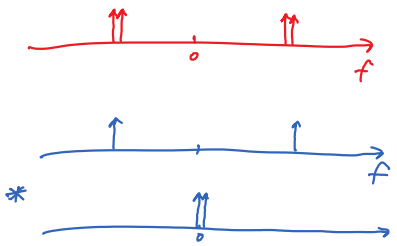
Modulation:

Multiplication Prop.: $x(t)\,y(t) \xrightarrow{\mathcal{F}} X(f) * Y(f)$

Example: $\cos(400\,2\pi t) + \cos(405\,2\pi t)$

$= 2\cos(402.5\,2\pi t)\cos(2.5\,2\pi t)$





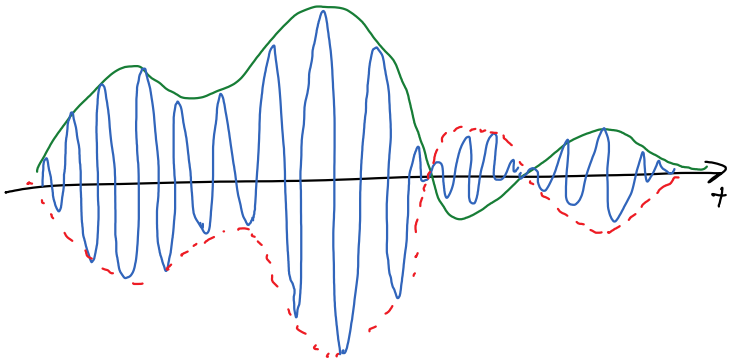
AM Radio: (Amplitude Modulation)

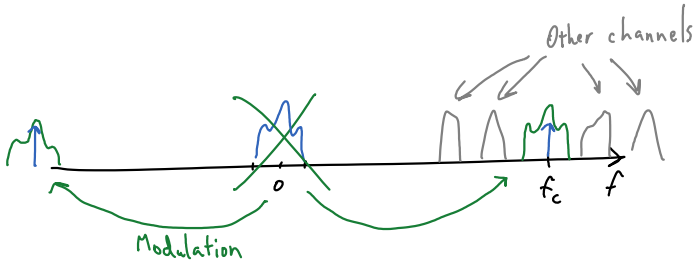
$x(t)$ is an audio signal (Band limited)

Let f_c be a carrier frequency (800 KHz)

Carrier wave: $y(t) = \cos(2\pi f_c t)$

Transmit: $r(t) = x(t) \cdot y(t)$



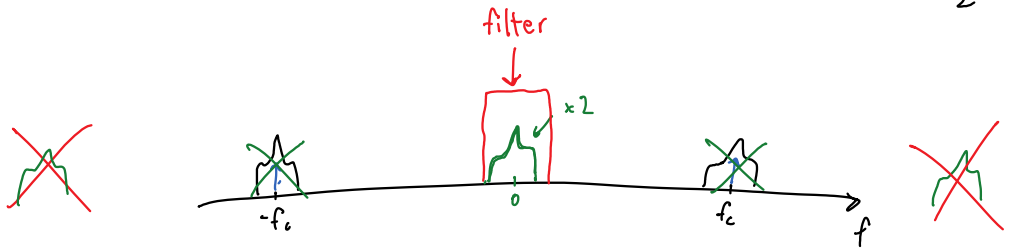


Demodulation:

$$r(t)\cdot\cos(2\pi f_c t) = x(t)\cdot\left(\cos(2\pi f_c t)\right)^2 = x(t)\cdot\left(\frac{1+\cos(2\pi\, 2f_c t)}{2}\right)$$

↑ Same as modulation

$$= \frac{x(t)}{2} + \frac{x(t)\cos(2\pi\, 2f_c t)}{2}$$



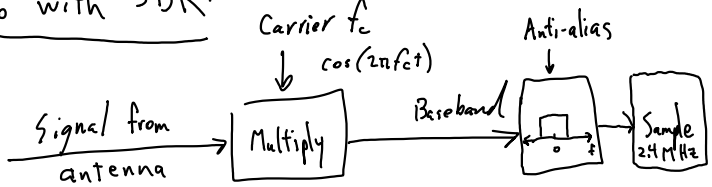
FM: (Frequency Modulation):

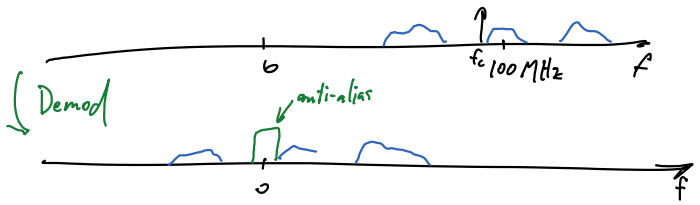
$$\cos\left(2\pi \int_0^t \left(f_c + x(\tau)\right) d\tau\right)$$

- Fourier analysis not so simple
- Demodulation not so simple

Bandwidth can be larger than that of $x(t)$. Contributes to SNR.

Demo with SDR:





Finally sample at 2.4 MHz

Actually demod with $e^{-i2\pi f_c t} = \cos(2\pi f_c t) - i\sin(2\pi f_c t)$

Device: Noo Elec SDR R820T

Sampling: 2.4 MHz

Carrier Range ≈ 24 MHz – 1.1 GHz

Many interesting signals in that range: FM stations 88–108 MHz

Amateur radio e.g. 144 MHz

Many interesting signals in that range:

- FM stations 88–108 MHz
- Amateur radio e.g. 144 MHz
- Air traffic control
- Car remote ≈ 315 MHz
- LTE

See similar demo here: https://www.youtube.com/watch?v=IaKEYEyrRgk