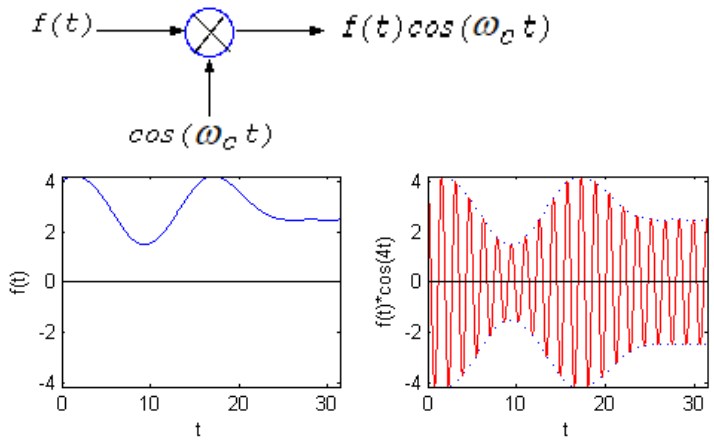
Lecture 35, Tuesday, March 29, 2022

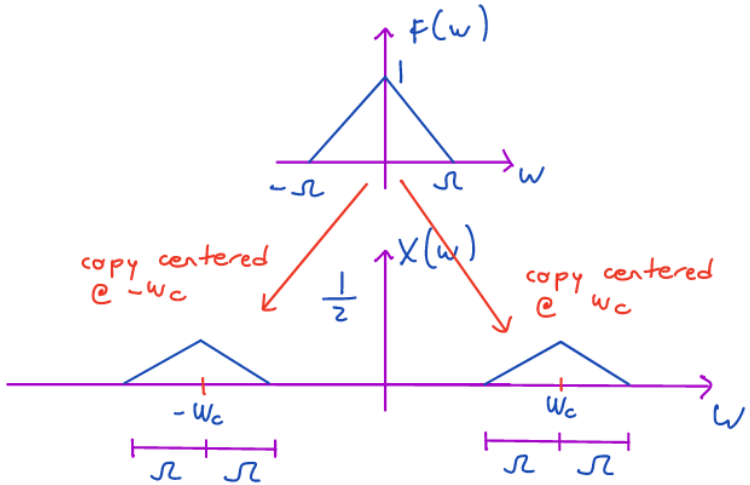
- Frequency shift

$$f(t) \leftrightarrow F(\omega) \quad \Rightarrow \quad f(t)e^{j\omega_c t} \leftrightarrow F(\omega - \omega_c)$$

- Modulation

$$f(t) \leftrightarrow F(\omega) \quad \Rightarrow \quad x(t) = f(t)\cos(\omega_c t) \leftrightarrow X(\omega) = \frac{1}{2}F(\omega - \omega_c) + \frac{1}{2}F(\omega + \omega_c)$$





- Why modulate?
  - Antennas are like high-pass filters.
    - Antenna length for efficient transmission: $L > \frac{c}{4f_c}$
      - Audio bandwidth: $\approx$ 15KHz $\Rightarrow$ $L >$ 5Km
      - Satellite: 10GHz $\Rightarrow$ $L >$ 7.5mm

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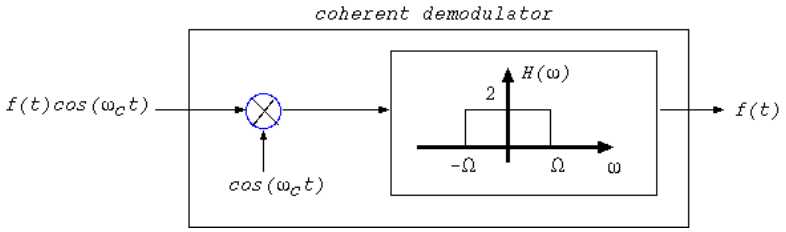
- Available bandwidth
  - Can't all transmit at baseband
  - Transmitters are assigned frequency bands

- How to demodulate?



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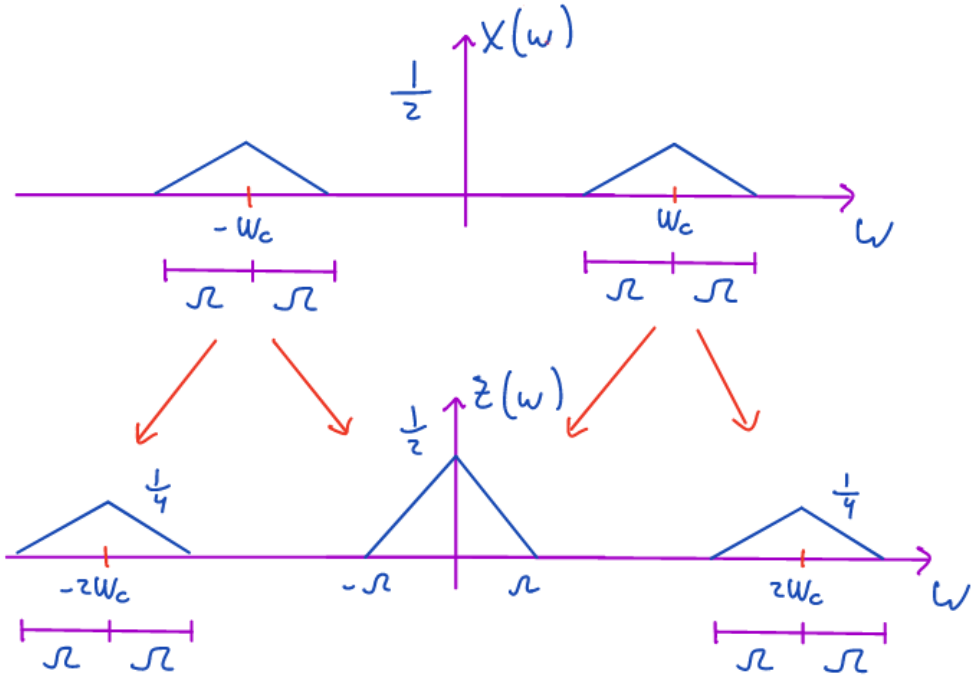
$$x(t) = f(t)\cos(\omega_c t)$$

$$z(t) = x(t)\cos(\omega_c t) = f(t)\cos^2(\omega_c t)$$



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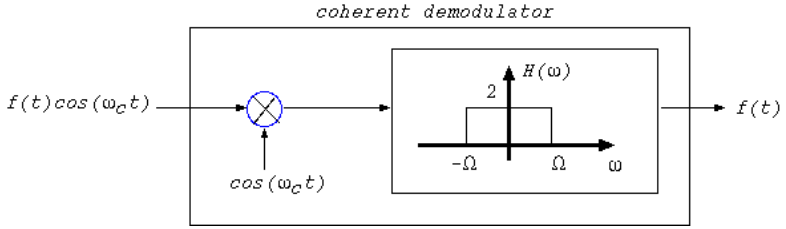
- Coherent demodulation



  - If there is a phase difference, $\theta = \omega_c t_0$, between cosines in modulation/demodulation

$$\text{output of coherent demodulator} \quad = \quad \cos(\omega_c t_0) f(t)$$

    which is zero if $\cos(\omega_c t_0) = 0$

    It could be bad if $\cos(\omega_c t_0) \approx 0$ and there is noise

