Computer Networks

Signal Encoding Techniques (Analog to Analog)

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DFT Properties

$$z_m = \sum_{n=0}^{N-1} x_n e^{\frac{-j2\pi.m.n}{N}}$$

$$X(f) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi ft}\,dt$$

Linearity property: $x_1(t) \leftrightarrow X_1(f)$, $x_2(t) \leftrightarrow X_2(f) \equiv a_1x_1(t) + a_2x_2(t) \leftrightarrow a_1X_1(f) + a_2X_2(f)$

$$a_1x_1(t) + a_2x_2(t) \leftrightarrow \int_{-\infty}^{\infty} \{a_1x_1(t) + a_2x_2(t)\}e^{-j2\pi ft}\,dt$$

$$= \int_{-\infty}^{\infty} a_1x_1(t)e^{-j2\pi ft}\,dt + \int_{-\infty}^{\infty} a_2x_2(t)e^{-j2\pi ft}\,dt = a_1X_1(f) + a_2X_2(f)$$

DFT Properties

$$z_m = \sum_{n=0}^{N-1} x_n e^{\frac{-j2\pi.m.n}{N}}$$

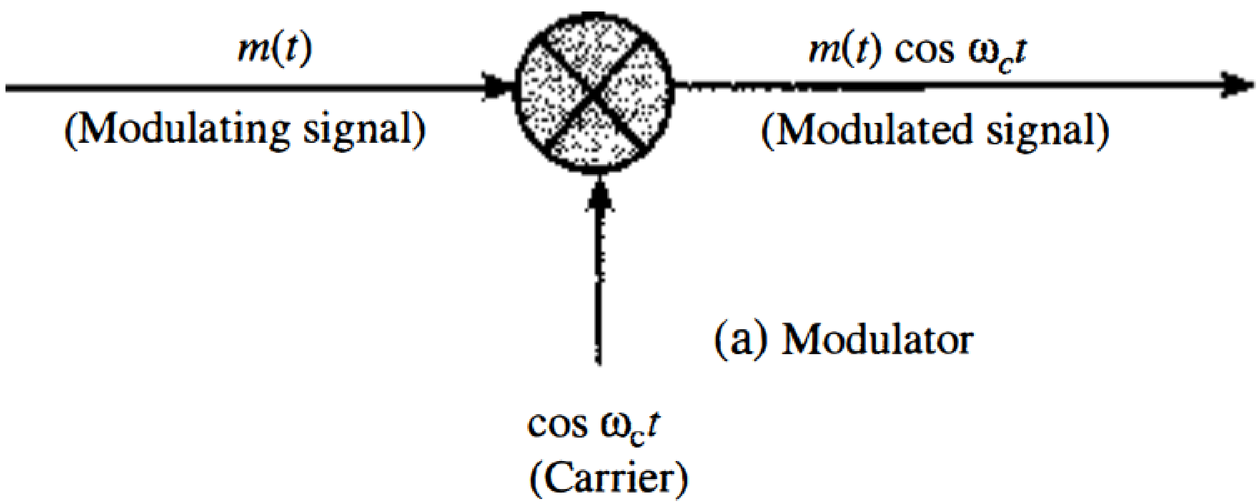
$$X(f) = \int_{-\infty}^{\infty} x(t) e^{-j2\pi f t}\, dt$$

Frequency shifting property: $x(t) \leftrightarrow X(f) \ \equiv e^{j2\pi f_c t} x(t) \leftrightarrow X(f - f_c)$

$$e^{j2\pi f_c t} x(t) \leftrightarrow \int_{-\infty}^{\infty} e^{j2\pi f_c t} x(t) e^{-j2\pi f t}\, dt = \int_{-\infty}^{\infty} x(t) e^{-j2\pi (f - f_c) t}\, dt = X(f - f_c)$$

DSB-SC Modulation

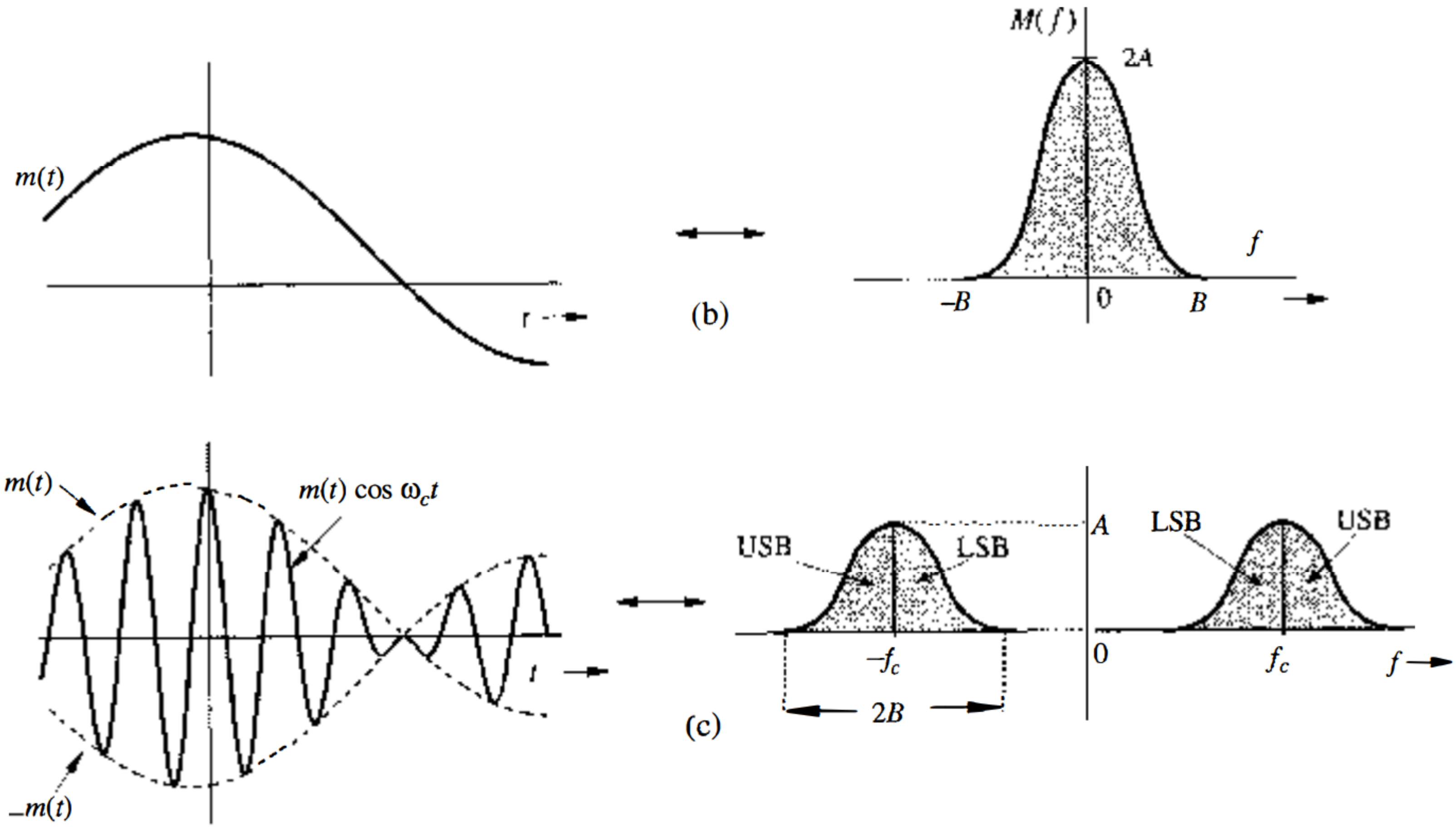
Transmitted signal: $m(t)\cos(2\pi f_c t)$



$$F[m(t)\cos(2\pi f_c t)] = F\left\{\left(\frac{e^{j2\pi f_c t} + e^{-j2\pi f_c t}}{2}\right) m(t)\right\}$$

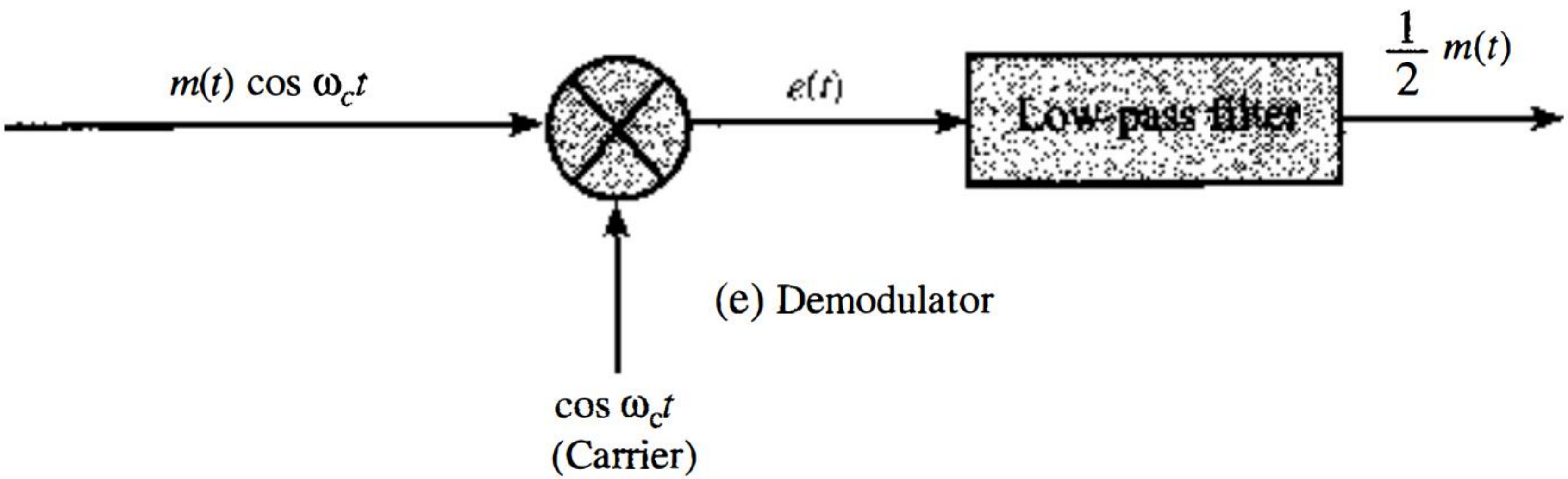
$$= \frac{1}{2}\left[F\{e^{j2\pi f_c t} m(t)\} + F\{e^{-j2\pi f_c t} m(t)\}\right] = \frac{1}{2}[M(f - f_c) + M(f + f_c)]$$

DSB-SC Modulation



$$F[m(t)\cos(2\pi f_c t)] = \frac{1}{2}[M(f - f_c) + M(f + f_c)]$$

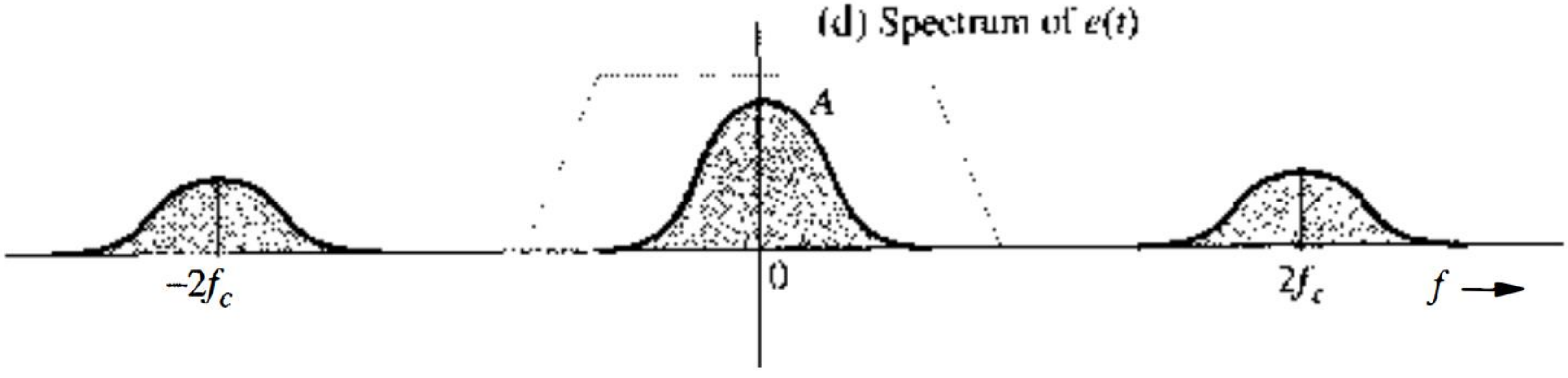
DSB-SC Demodulation



$$F[m(t)\cos^2(2\pi f_c t)] = F\left\{\left(\frac{1+\cos(2\pi 2 f_c t)}{2}\right)m(t)\right\} =$$

$$= \frac{1}{2}M(f) + \frac{1}{4}[M(f-2f_c) + M(f+2f_c)]$$

DSB-SC Modulation



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$$= \frac{1}{2}M(f) + \frac{1}{4}[M(f-2f_c) + M(f+2f_c)]$$

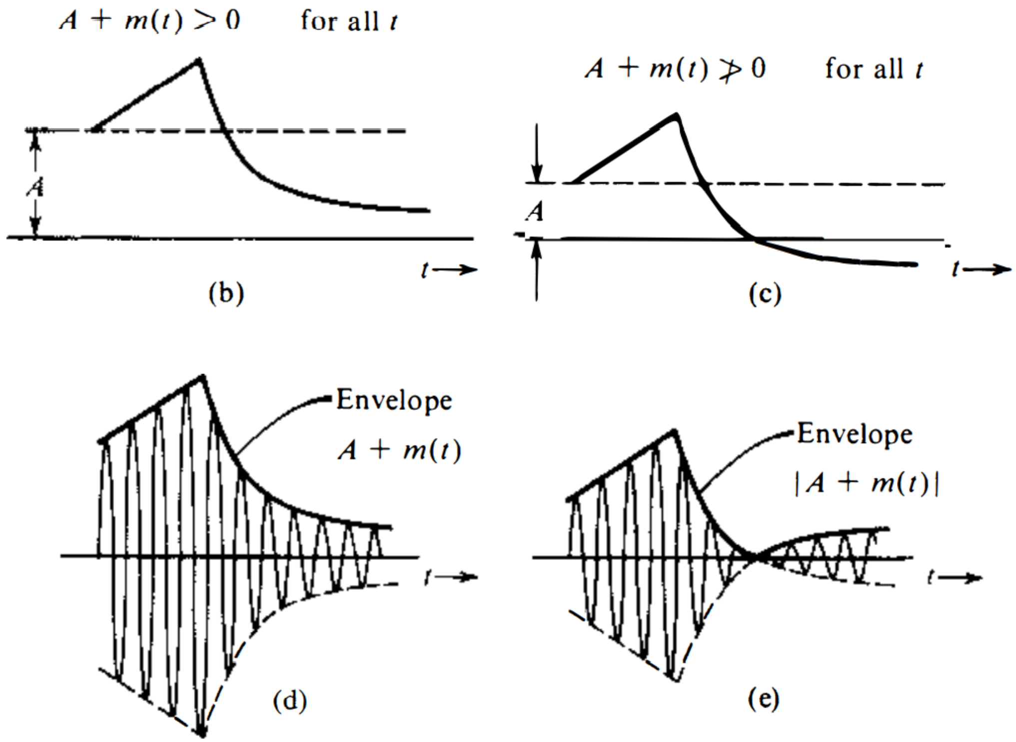
DSB-TC Modulation

- The carrier is sent along with the message

Transmitted signal: $A\cos(2\pi f_c t) + \ m(t)\cos(2\pi f_c t)$

$$F[A\cos(2\pi f_c t) + \ m(t)\cos(2\pi f_c t)] = F[A\cos(2\pi f_c t)] + \ m(t)\,[\cos(2\pi f_c t)]$$
$$= \frac{A}{2}[\delta(f - f_c) + \delta(f + f_c)] + \frac{1}{2}[M(f - f_c) + M(f + f_c)]$$

DSB-TC Modulation



$$A + m(t) \geq 0 \quad \therefore A \geq -m(t) \geq -m_p$$

$$k_a = \frac{m_p}{A} \quad \therefore 0 \leq k_a \leq 1$$

Angle Modulation (Frequency Modulation)

$$s(t) = A\ \cos\theta(t)$$

Instantaneous angular frequency is $\mathrm{w_i}(t) = \frac{d\theta}{dt}$ $\therefore\ \theta(t) = \int_0^t w_i(\alpha)d\alpha$

- Angle modulation:
  - Frequency modulation
  - Phase modulation

$$w_i(t) = 2\pi f_c t + k_f m(t) \qquad \therefore\ s_{FM}(t) = \cos((2\pi f_c + k_f m(t))t)$$

Angle Modulation (Phase Modulation)

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$\theta(t) = 2\pi f_c t + k_p m(t)$ $\quad \therefore s_{PM}(t) = \cos(2\pi f_c t + k_p m(t))$

Angle Modulation

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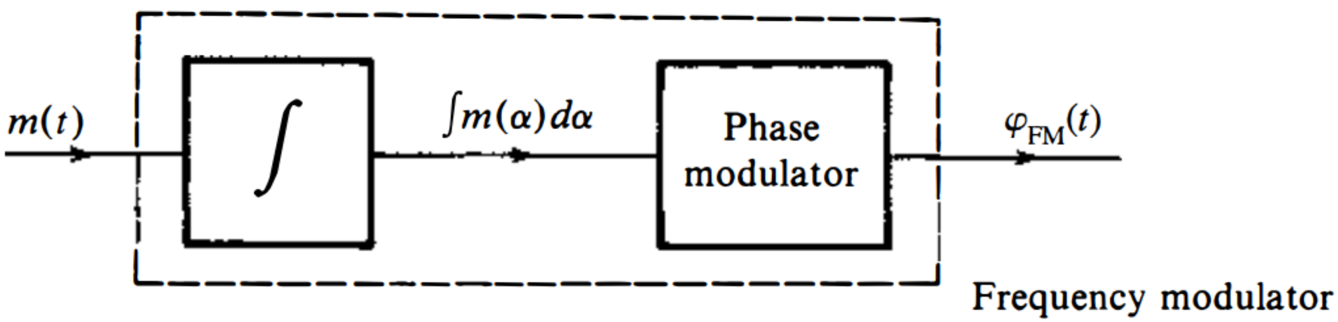
$$\therefore\ \theta(t) = \int_0^t w_i(\alpha)d\alpha = 2\pi f_c \int_0^t d\alpha + k_f \int_0^t m(\alpha)d\alpha = 2\pi f_c t + k_f \int_0^t m(\alpha)d\alpha$$



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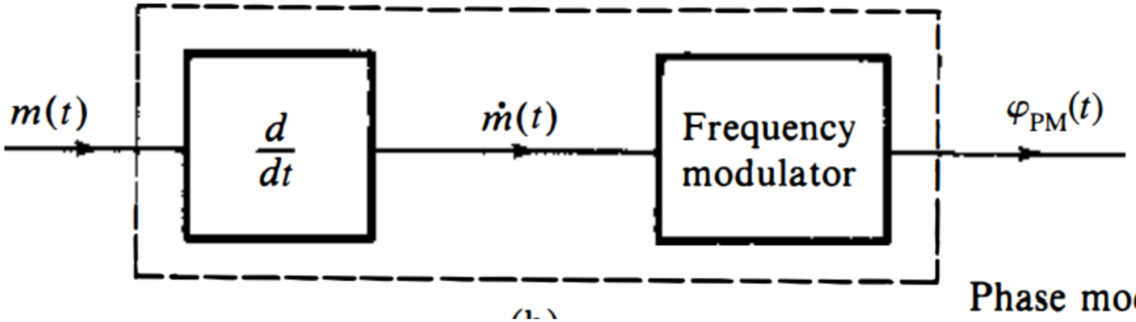
Instantaneous angular frequency is $w_i(t) = \frac{d\theta}{dt} = 2\pi f_c + k_p \dot{m}(t)$



Phase modulator

AM vs FM/PM

Why Modulation?

THANK YOU

QUESTIONS???