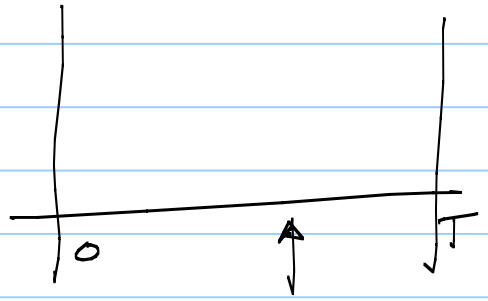
Lecture 38

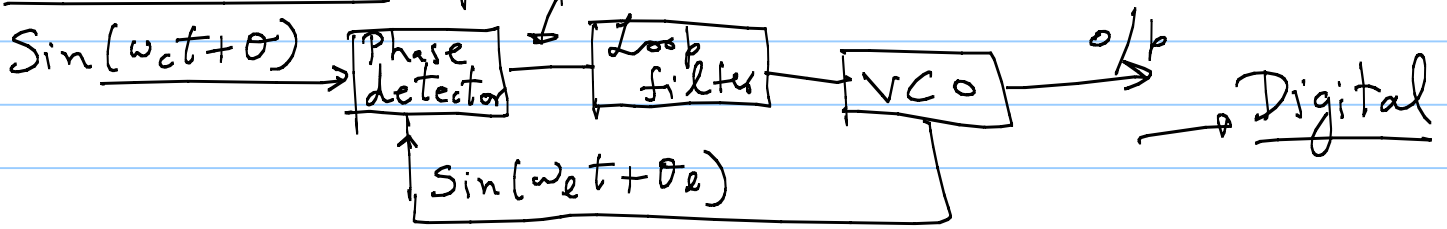
Note Title 10/23/2008

Carrier and Timing Synchronization



Easiest Solution: Use control/pilot channels for transmitter carrier + timing.

Phase Locked Loop: $(\omega_c t+\theta)-(\omega_\ell t+\theta_\ell)$



Timing recovery by spectral line methods

Baseband PAM signal

$$r(t) = \sum_{m=-\infty}^{\infty} A_m \, p(t - mT)$$

$$r(t) = E[A] \sum_{m=-\infty}^{\infty} p(t - mT) \qquad (E[A] \neq 0)$$

$$+ \sum_{m=-\infty}^{\infty} (A_m - E[A]) \, p(t - mT)$$

deterministic periodic T → Can be extracted with a narrow band BPF.

$(A_m - E[A])$ → random "wriggle"

$$|r(t)|^2 = \sum_{m=-\infty}^{\infty} |A_m|^2 |p(t-mT)|^2$$

$$+ \sum_{m,n} A_m A_n^* p(t-mT) p(t-nT)$$

$A_m A_n^* \to 0$

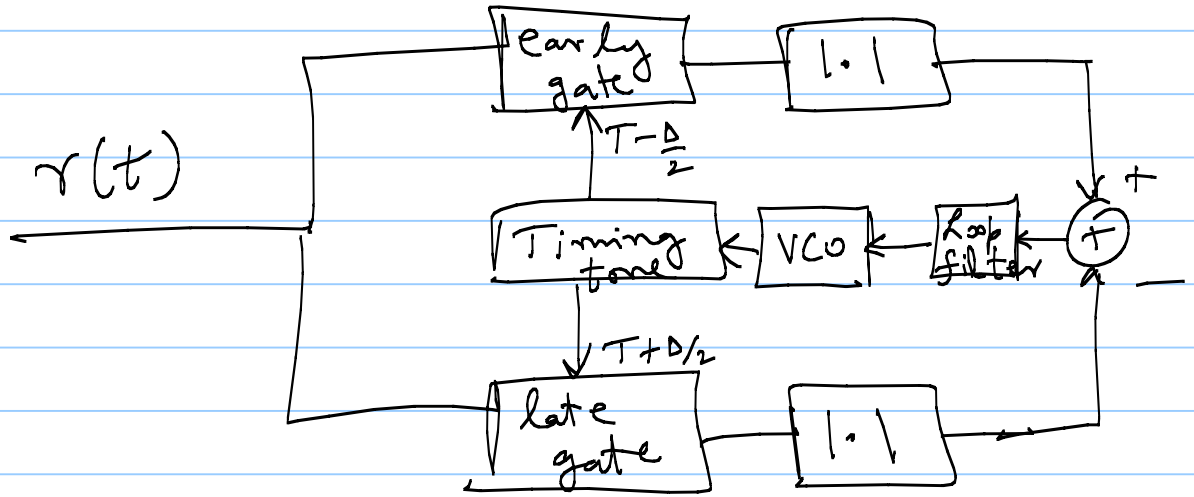
$$= \sum_{m=-\infty}^{\infty} E[|A_\cdot|^2] |p(t-mT)|^2 + \text{random "wiggle"}$$

$E[|A_\cdot|^2]$ nonzero

deterministic, periodic T

narrow band BPF

Early-Late gate timing recovery



Power of N carrier recovery:

$$x[k] = e^{j(2\pi f_c kT + \theta_k)} \sum_{m=-\infty}^{\infty} A[m]\, p[k-m]$$

overall pulse shape

$$p[k] \approx \delta[k].$$

$$x[k] \approx e^{j(2\pi f_c kT + \theta_k)} A[k]$$

Find N s.t. $E[(A[k])^N] \neq 0$.

$$(x[k])^N = e^{jN(2\pi f_c kT + \theta_k)} \cdot E[(A[k])^N]$$

+ random "wriggle".

BPF at $\sim N f_c$

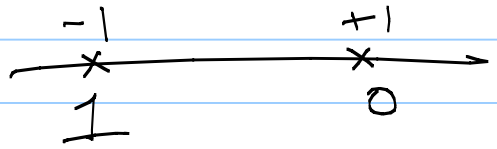
PLL

Differential Encoding

→ QAM constellations : symmetric to rotations by $\pi/2$.

Differential BPSK

BPSK



b_k : 0 1 0 0 1 1 0

ϕ_k : 0 π 0 0 π π 0

$\hat{b}_k$: 0 1 0 0 1 1 0

DBPSK.

$\phi_k = \phi_{k-1} + \Delta_k$ $\quad (\phi_{-1} = 0)$

bit	Δ_k
0	0
1	π

ϕ_k : +1 -1 -1 -1 +1 +1 -1

π π π 0 π π

1st step: 0 0 1 1 1 0 1 1

2nd step: 0 1 0 0 1 1 0