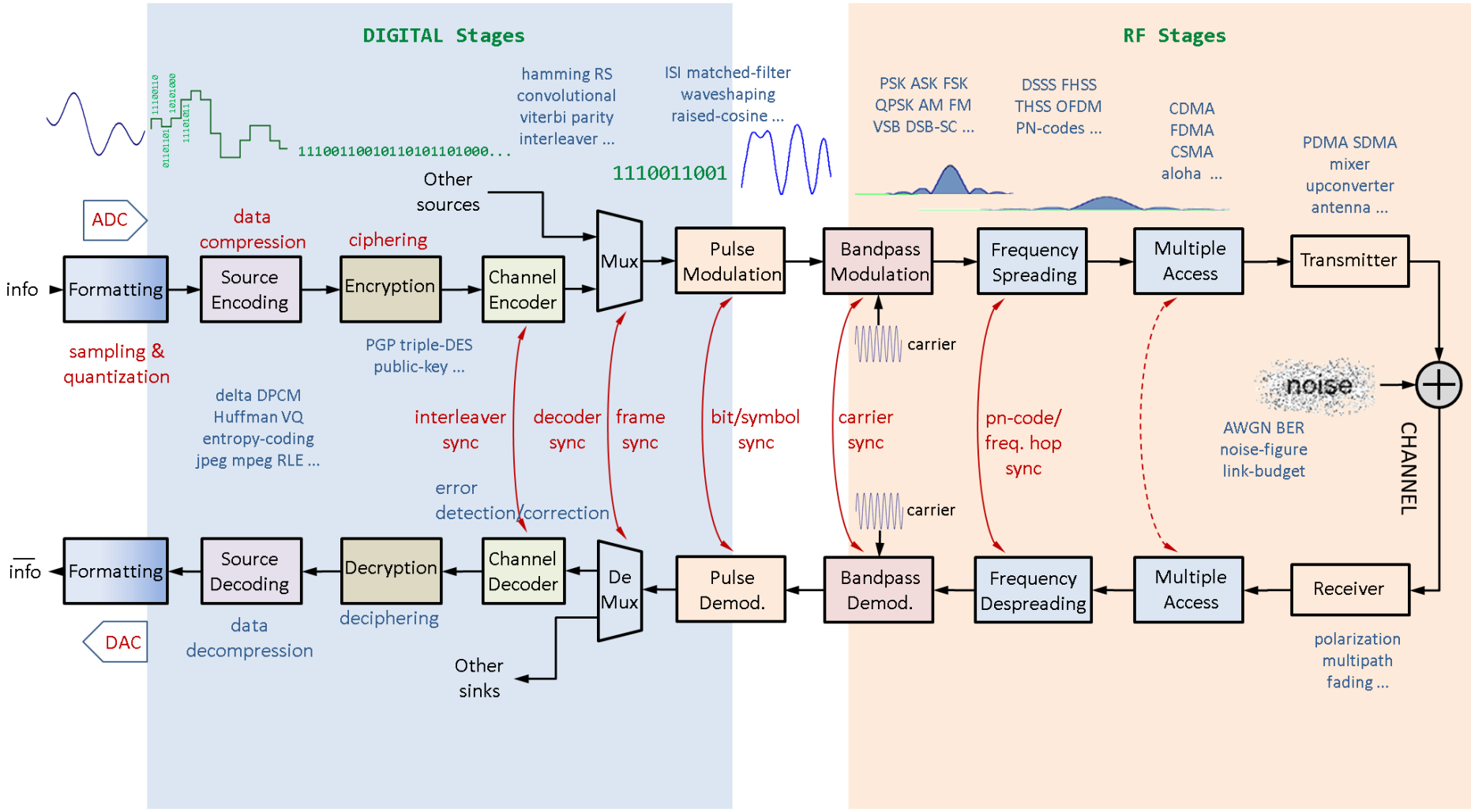
Synchronization

by Erol Seke

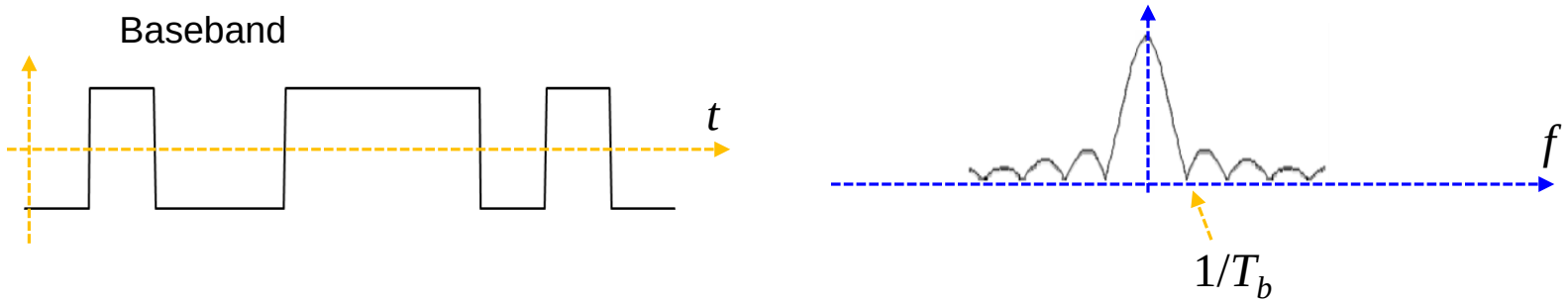
For the course “**Communication**”

ESKİŞEHİR OSMANGAZİ UNIVERSITY

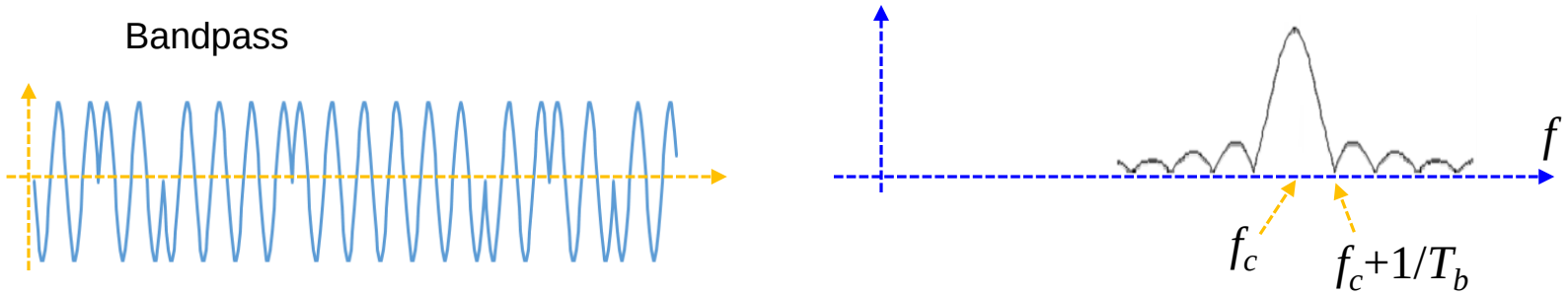
General Communication System



What To Do



What to do : symbol synchronization, detection, decision



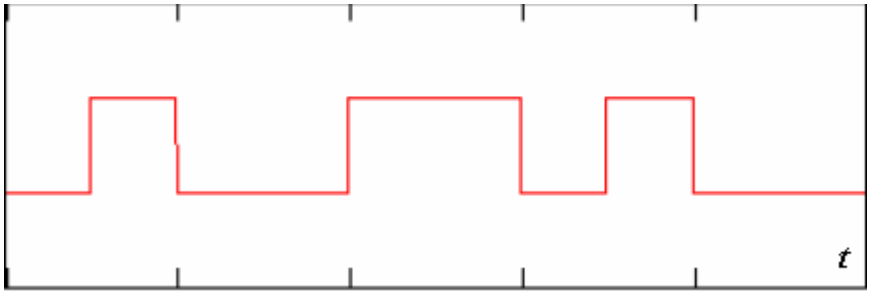
What to do : carrier synchronization, demodulation, symbol synchronization, detection, decision

Binary PAM

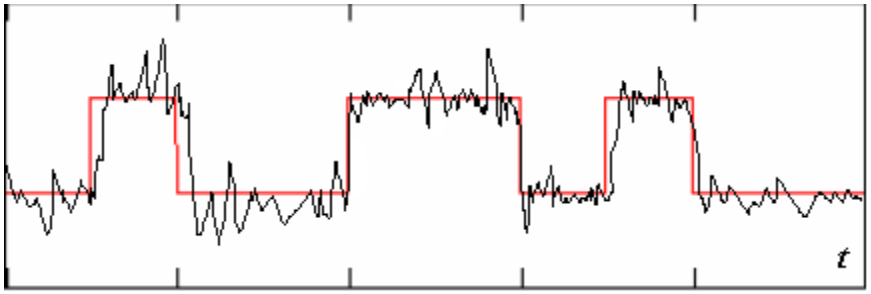
Example Data : 0100110100...

Transmitted signal is a sum of the corresponding waveforms at appropriate positions

Transmitted signal



Received signal
(black)



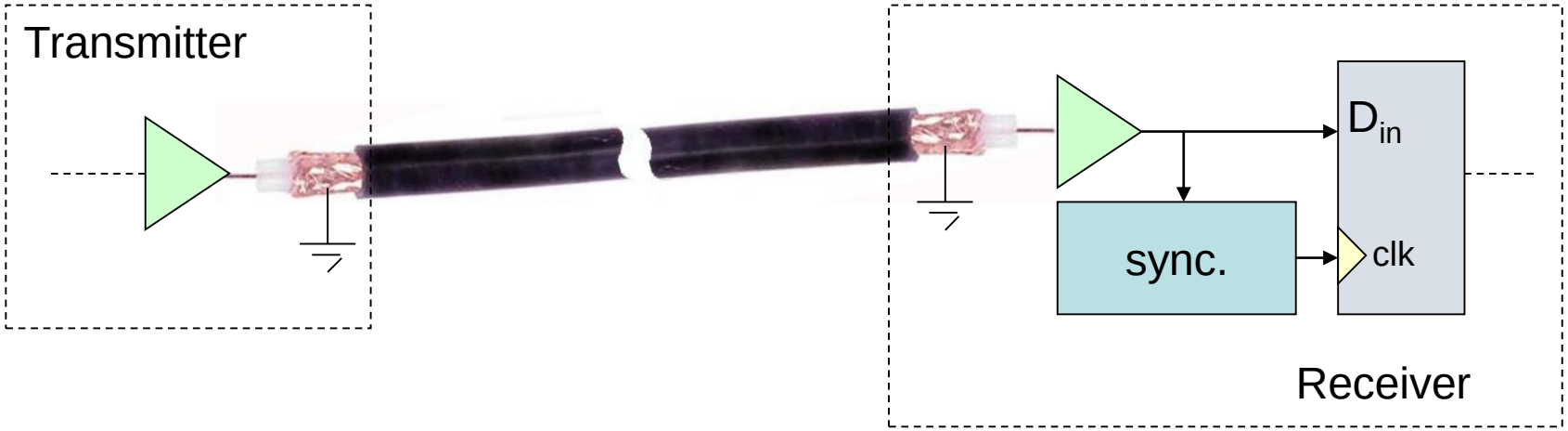
Problem of the receiver :

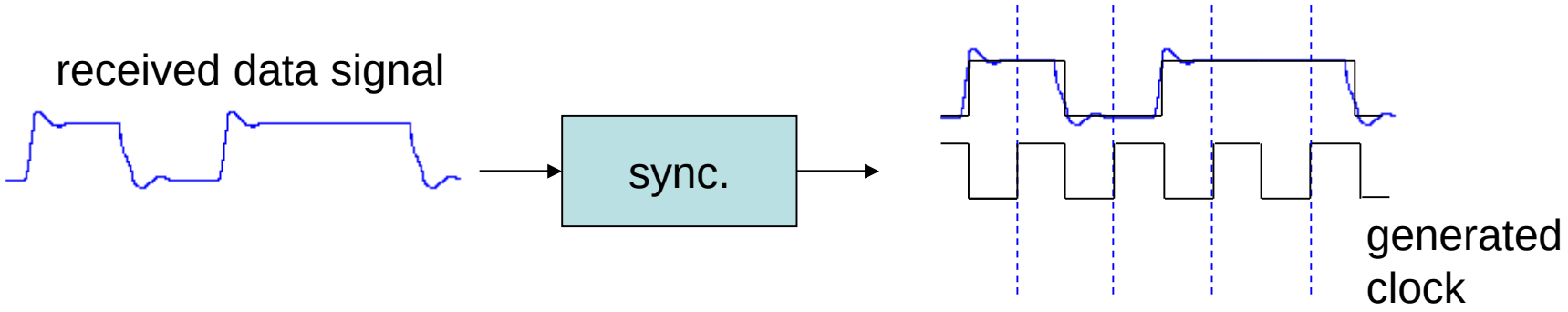
Measure the signal at correct instants and

Determine the 1-0 data sequence from the noisy signal

Generation of Clock at Receiver

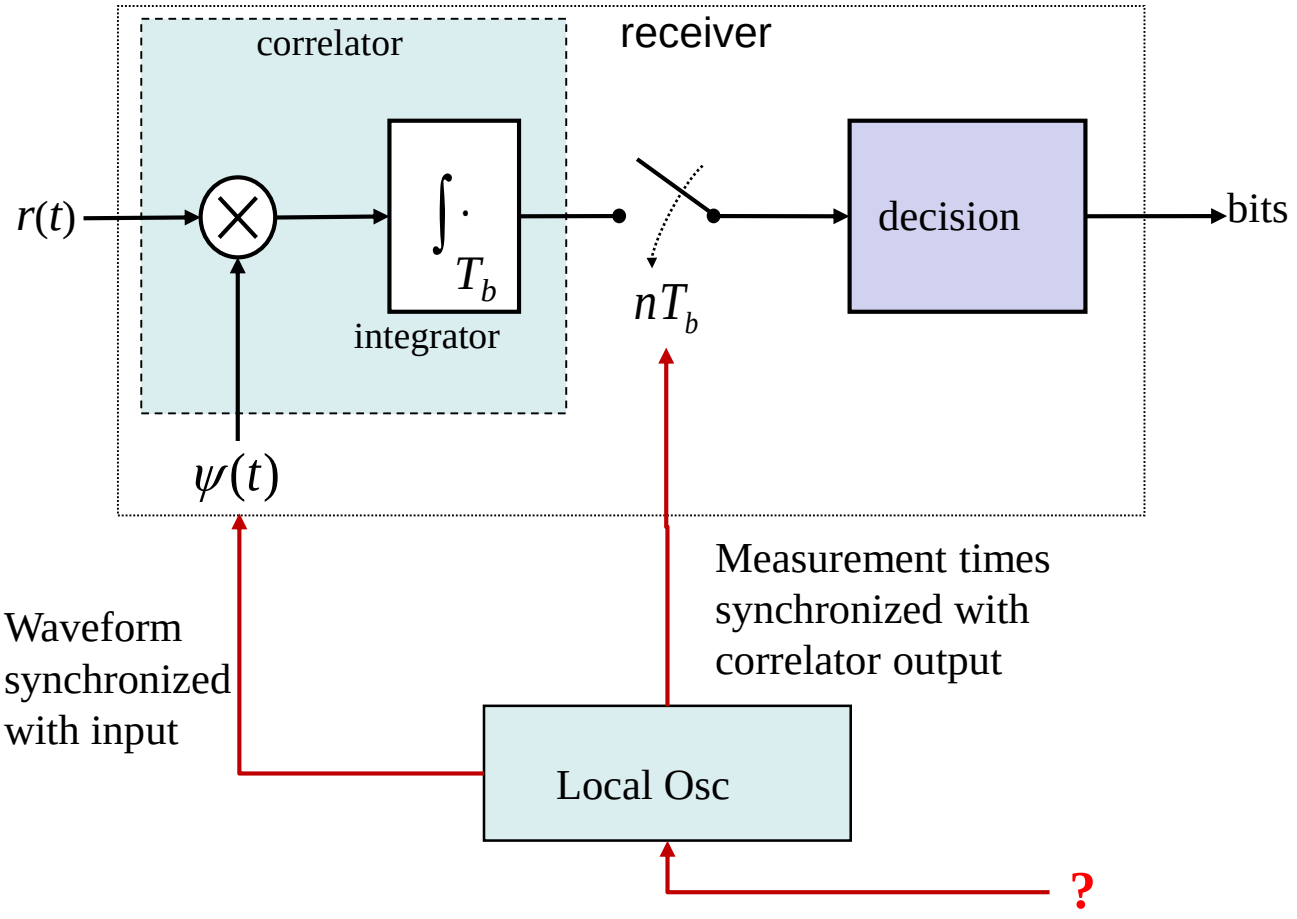
The data signal should necessarily be designed to perform such an operation



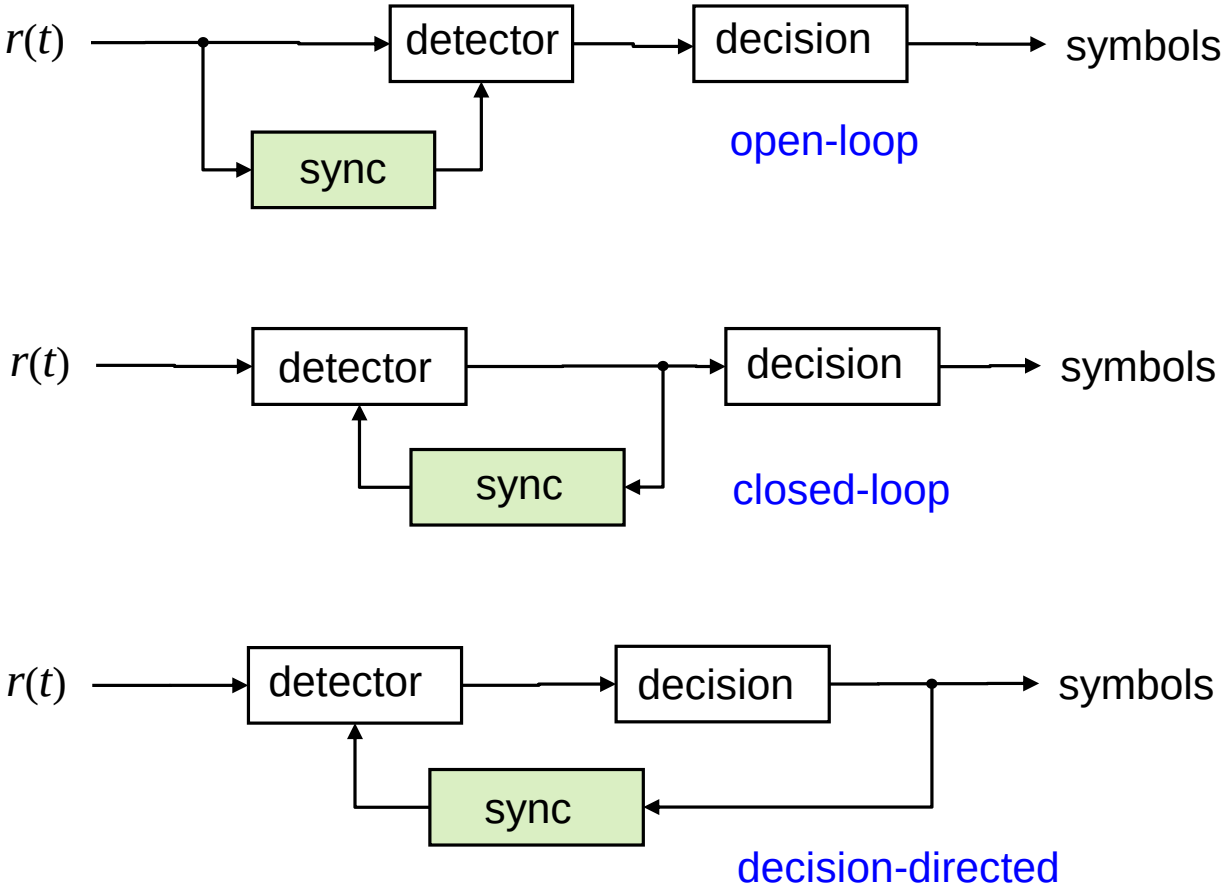


A Phase Locked Loop (PLL) can be used if there are enough transitions in the signal

Symbol Sync. Case

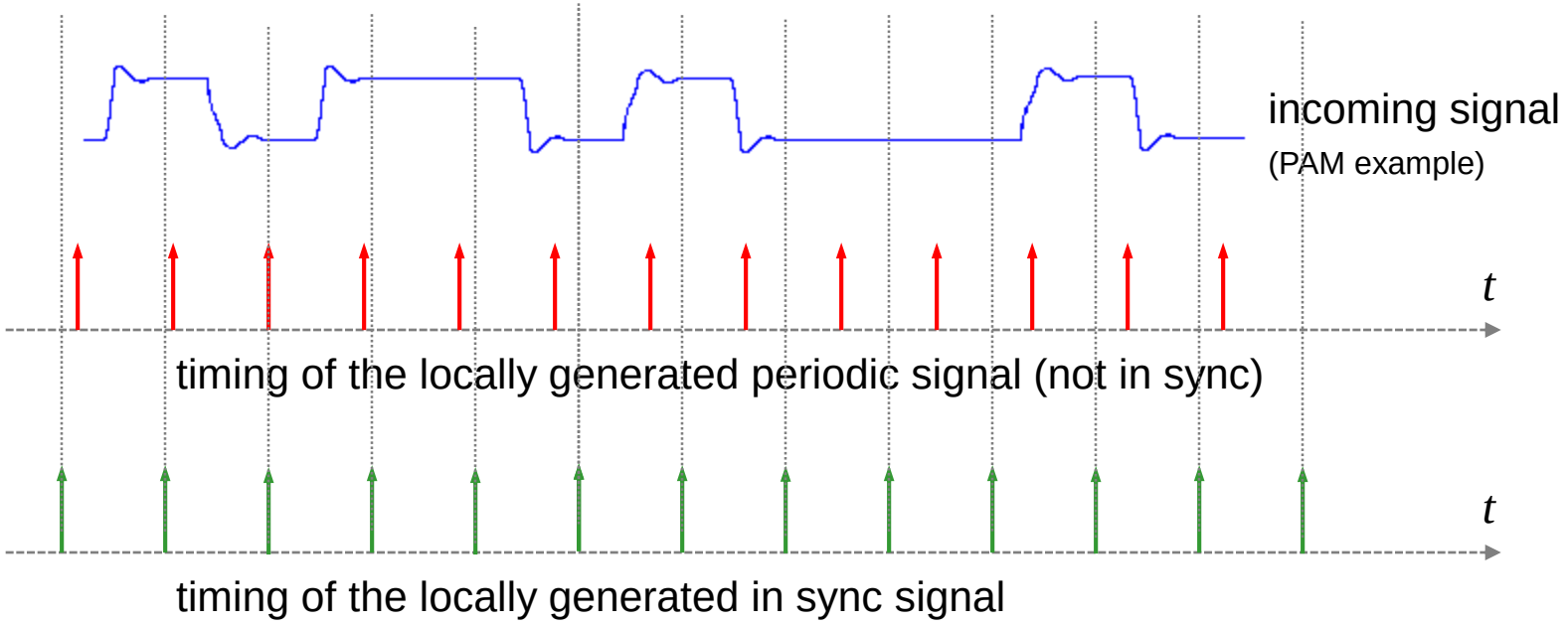


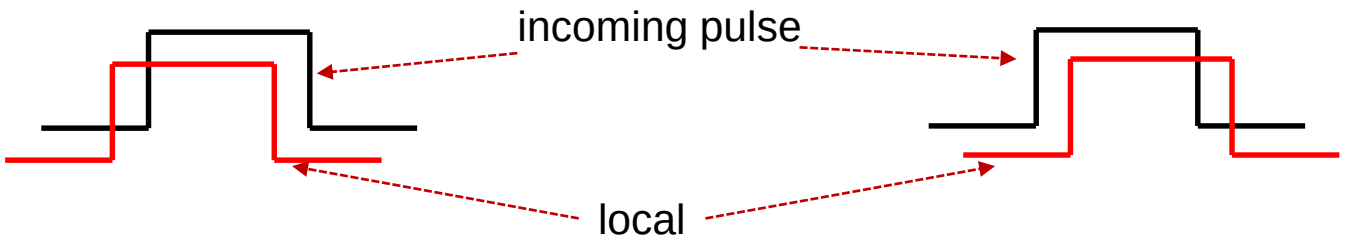
Three Synchronization Approaches



Symbol Synchronization

The aim is to locally generate a signal that is synchronous to the incoming symbol signal





we are early (not in sync)

we are late (not in sync)

Back to Correlation

is a measure of similarity of two signals $\psi(t)$ and $r(t)$

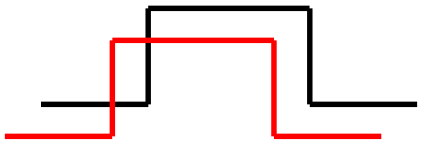
received signal

local signal

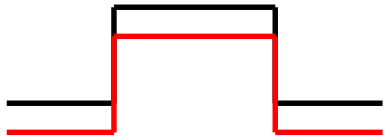
$$R_{\psi} = \int r(t)\psi(t)dt$$

is also named as inner product

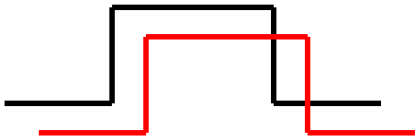
$$< r(t), \psi(t) >$$



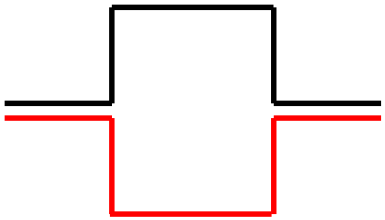
low correlation



high correlation



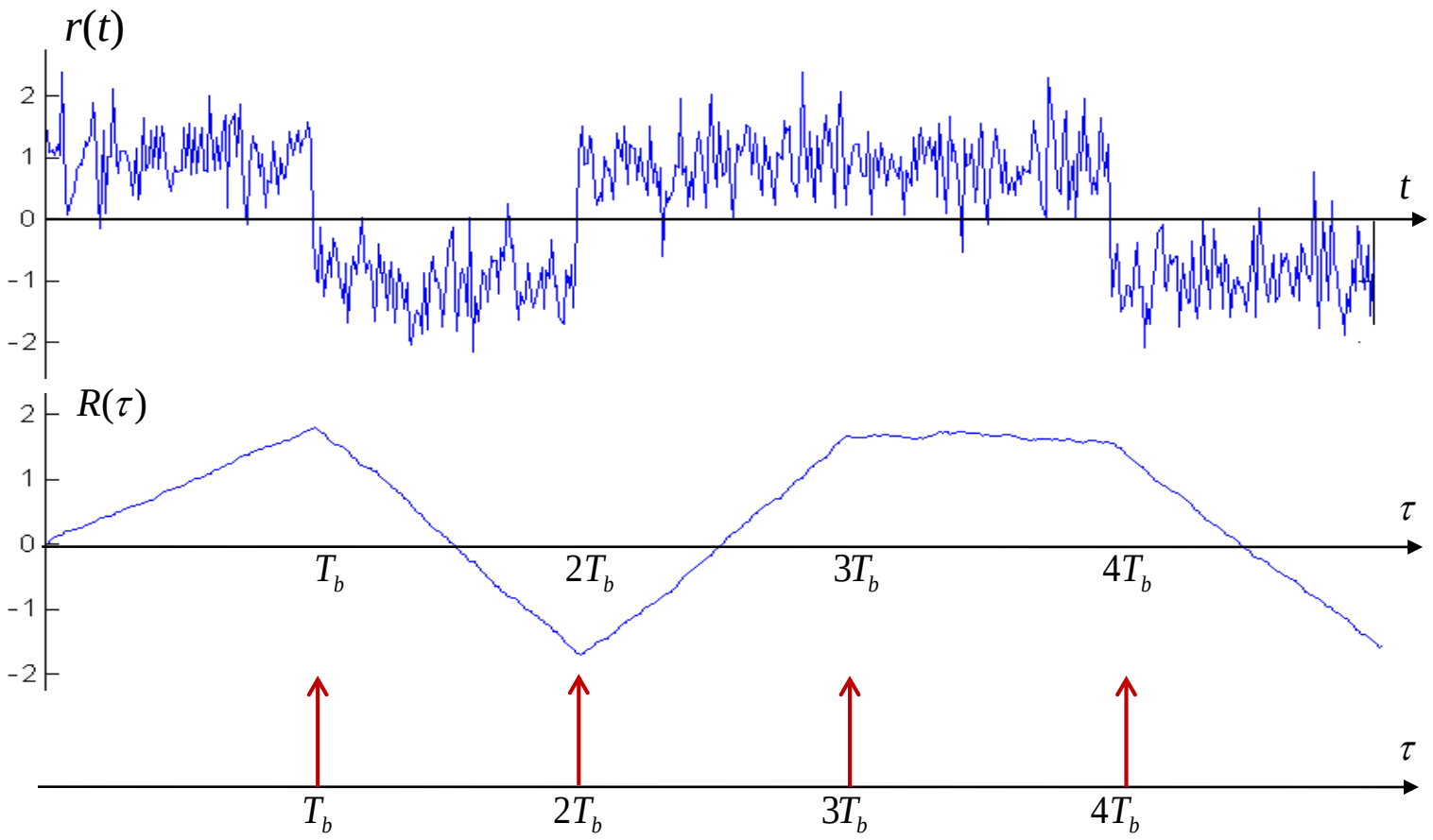
low correlation



negative high correlation

correlation values can be used to adjust the local oscillator

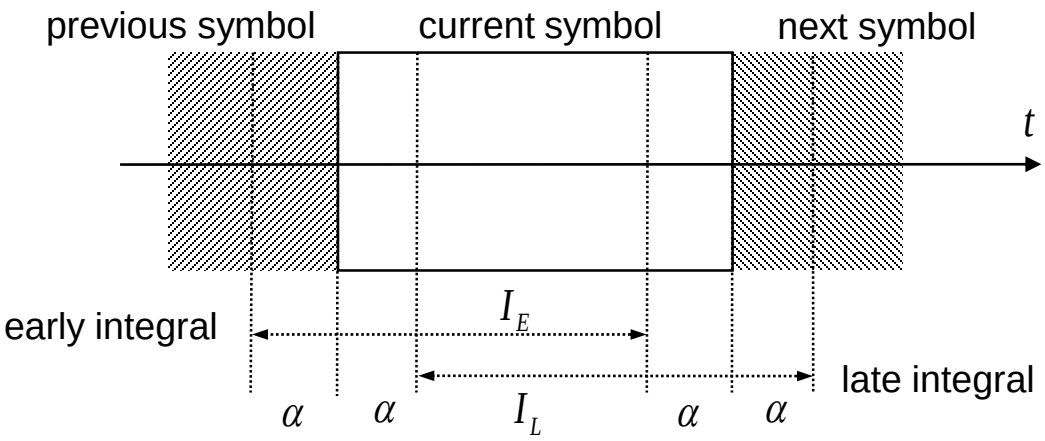
Remember the Correlator output for Binary Rect. Pulses

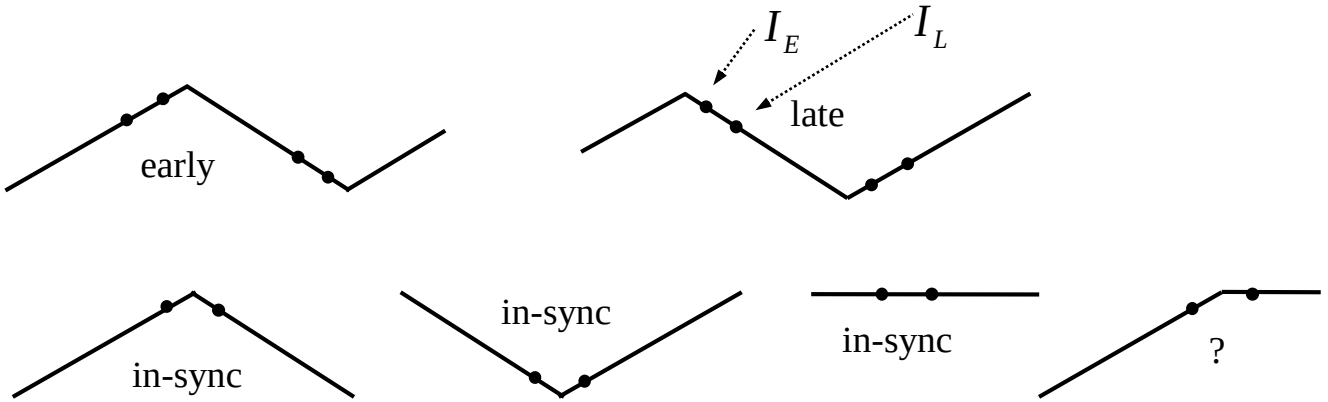


measurement and decision instants : nT_b

Having synchronization is equivalent to correct detection of symbols

Early-Late Gating



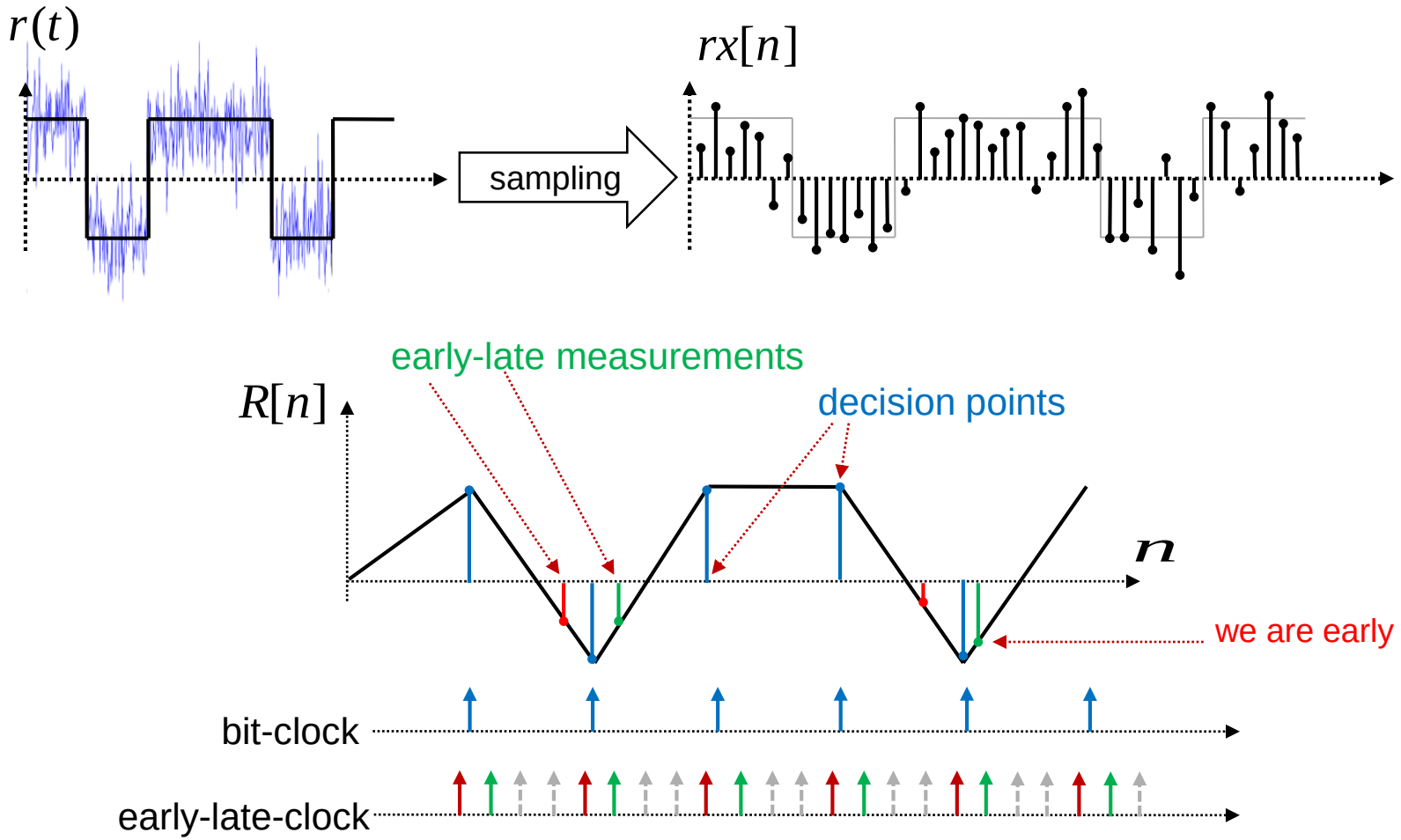


$|I_L| > |I_E|$: we are early

$|I_L| < |I_E|$: we are late

$d = |I_E| - |I_L|$ can be used to adjust local clock (oscillator)

Early-Late Gating

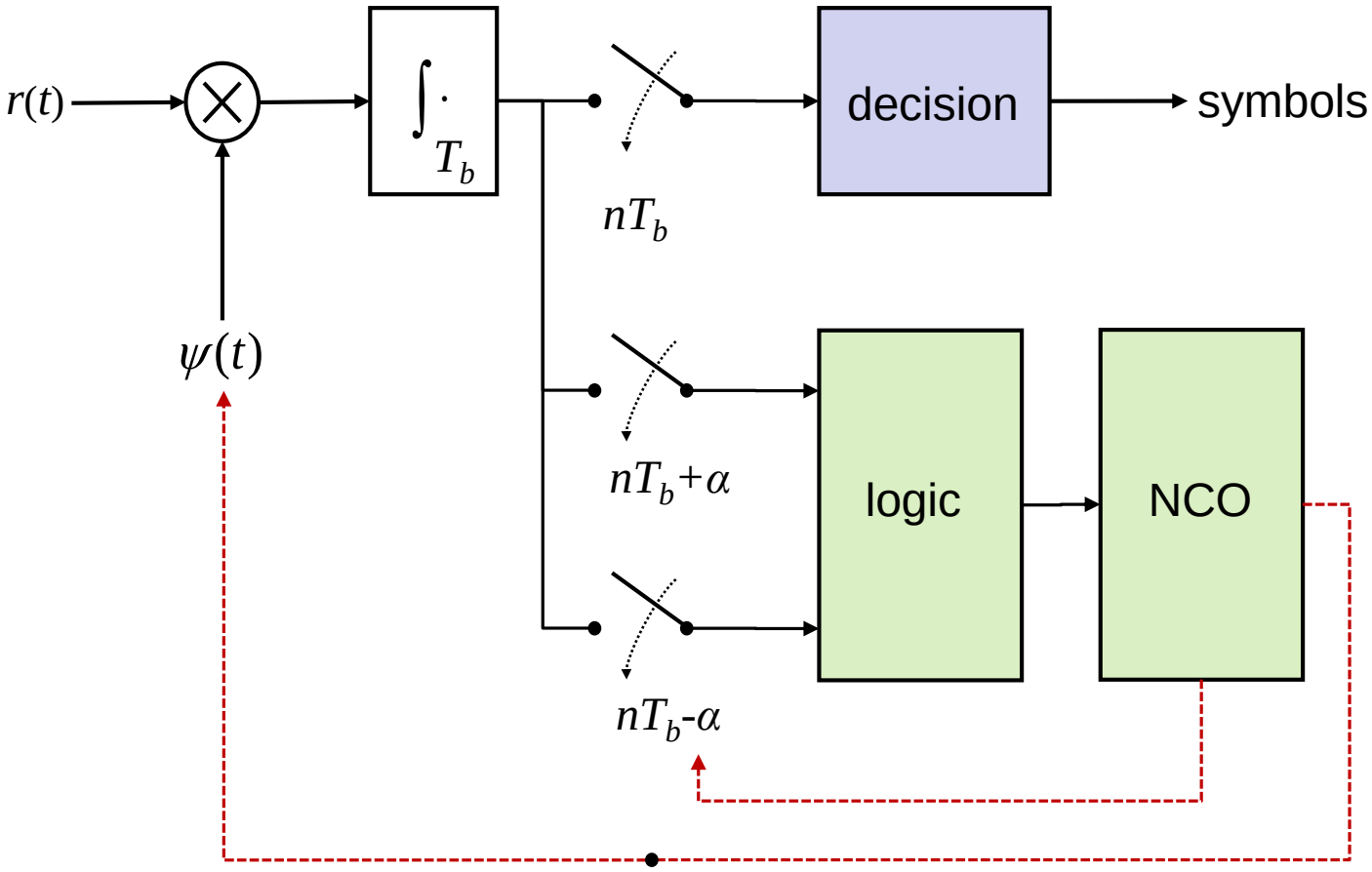


We expect that consecutive early-late-measurements should be close.
Average differences of absolutes (avg($|R_{early}|$-$|R_{late}|$)) should be zero.

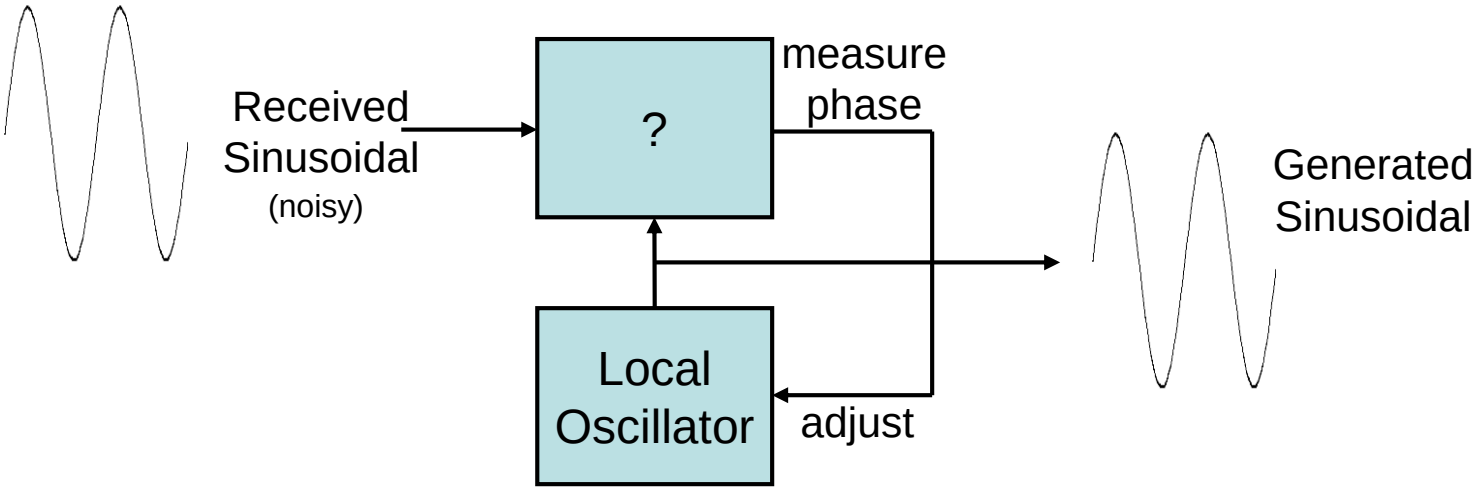
positive average difference = we are late (increase clock rate)

negative average difference = we are early (decrease clock rate)

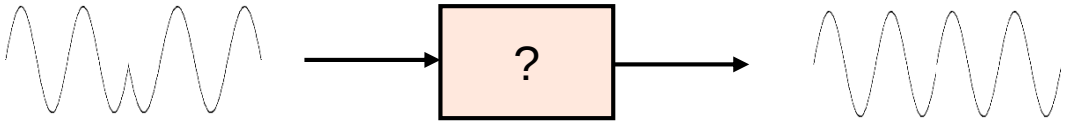
Early & Late Measurements of Corr. Output



Another Simple Problem



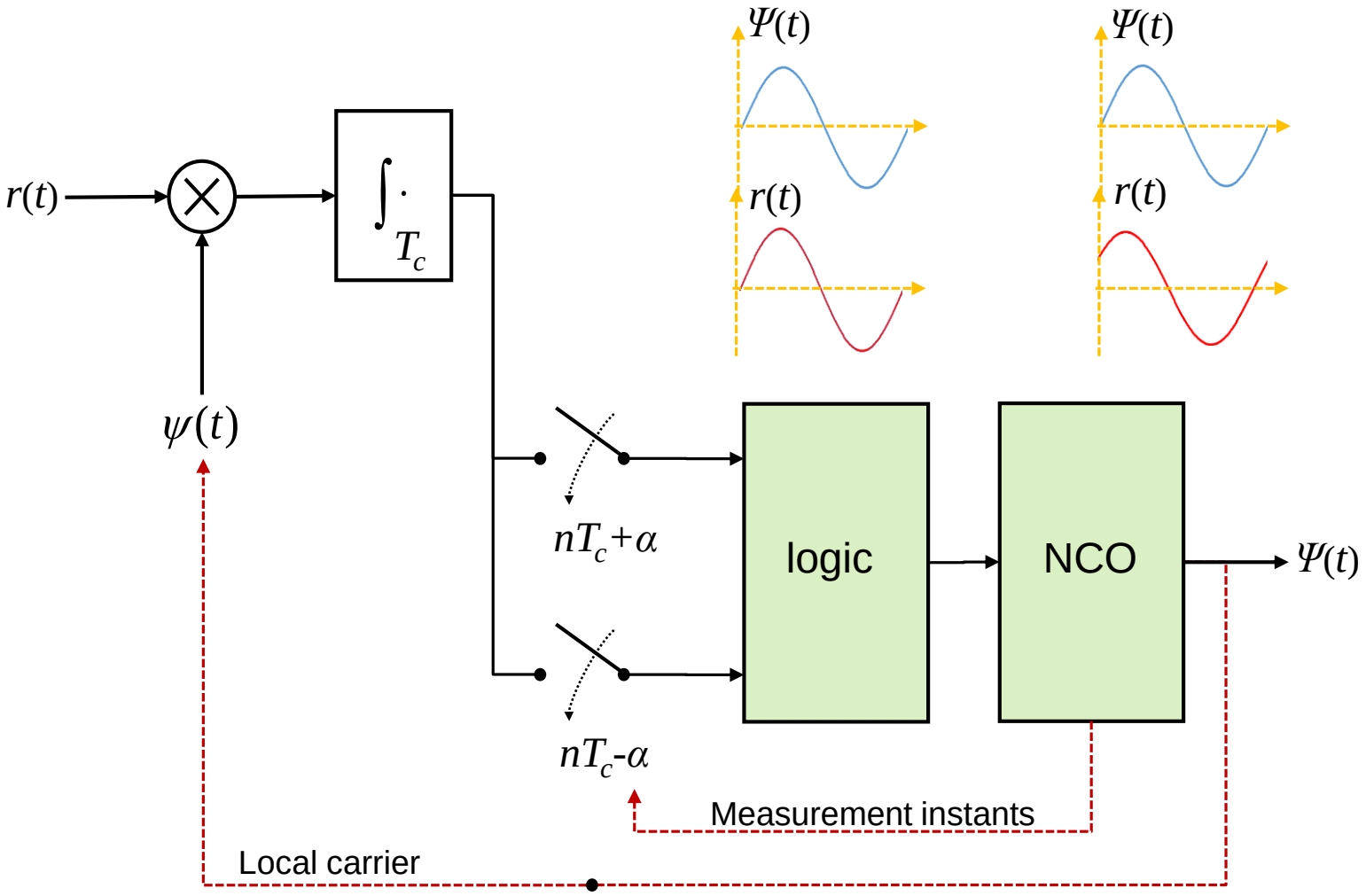
better yet



We need to generate required waveforms locally

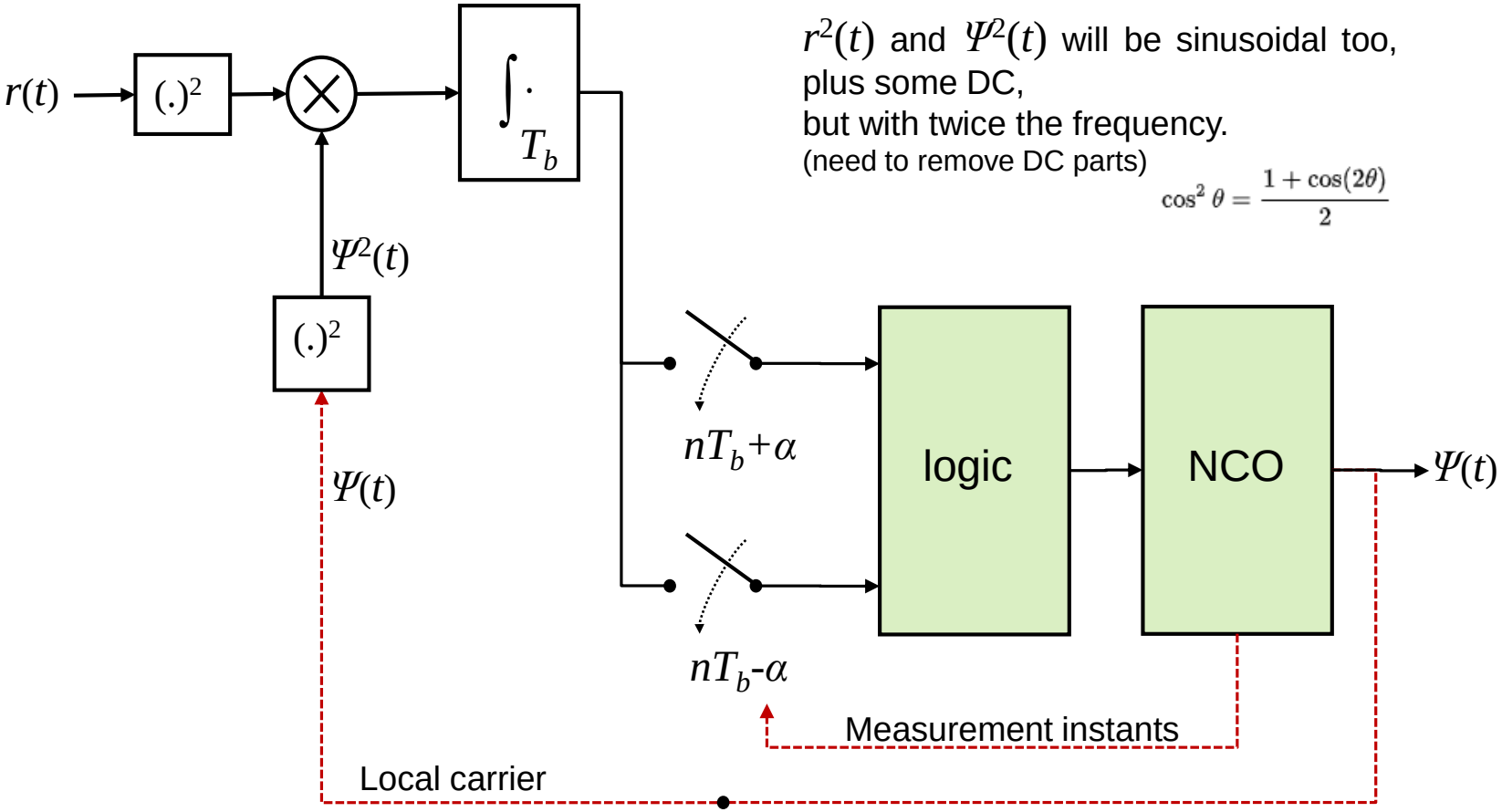
Basic Closed-Loop Phase Control Works for Carrier Sync

(if $r(t)$ is just a carrier)



note : there is no meaning in transmitting/receiving just a carrier. (conceptual)

What if $r(t)$ is a BPSK Signal?

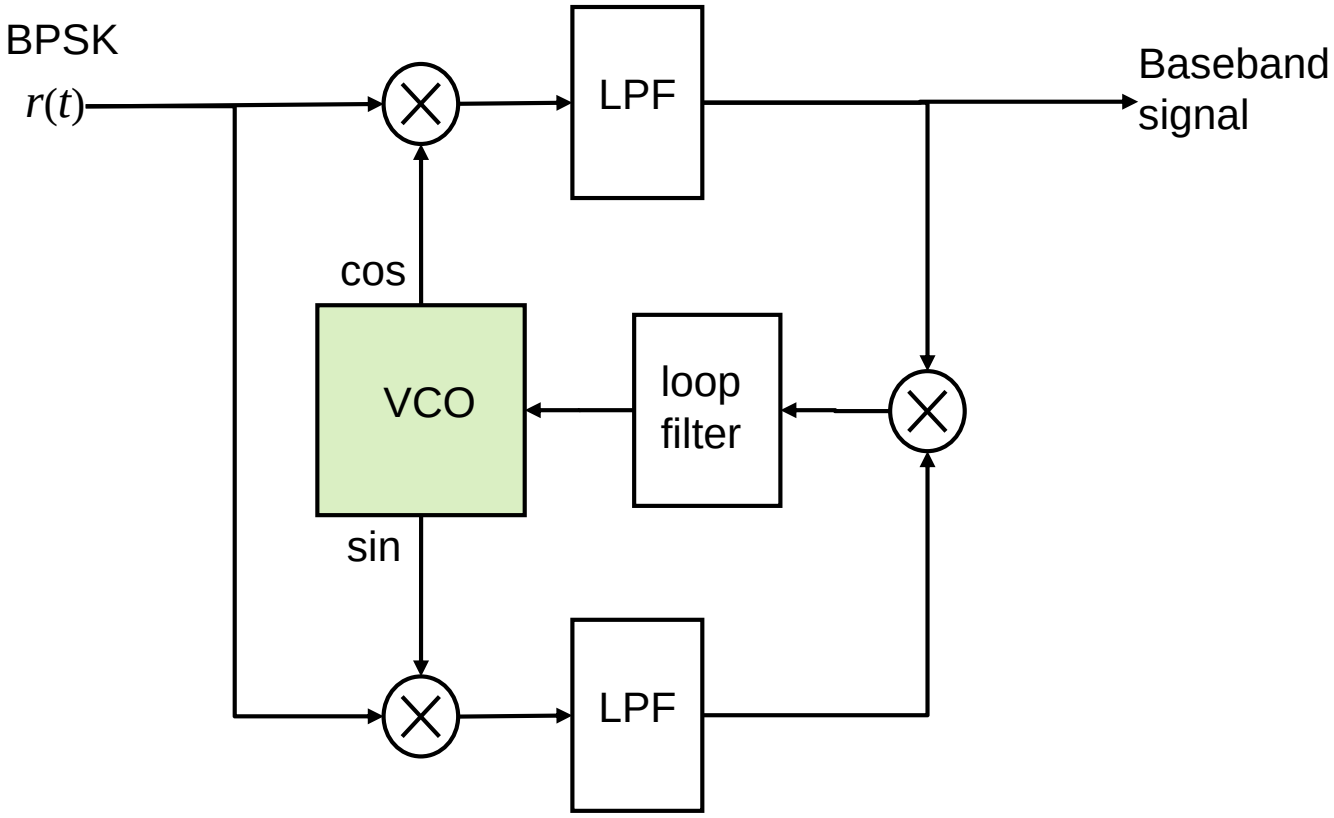


$r^2(t)$ and $\Psi^2(t)$ will be sinusoidal too, plus some DC,
but with twice the frequency.
(need to remove DC parts)

$$\cos^2\theta = \frac{1+\cos(2\theta)}{2}$$

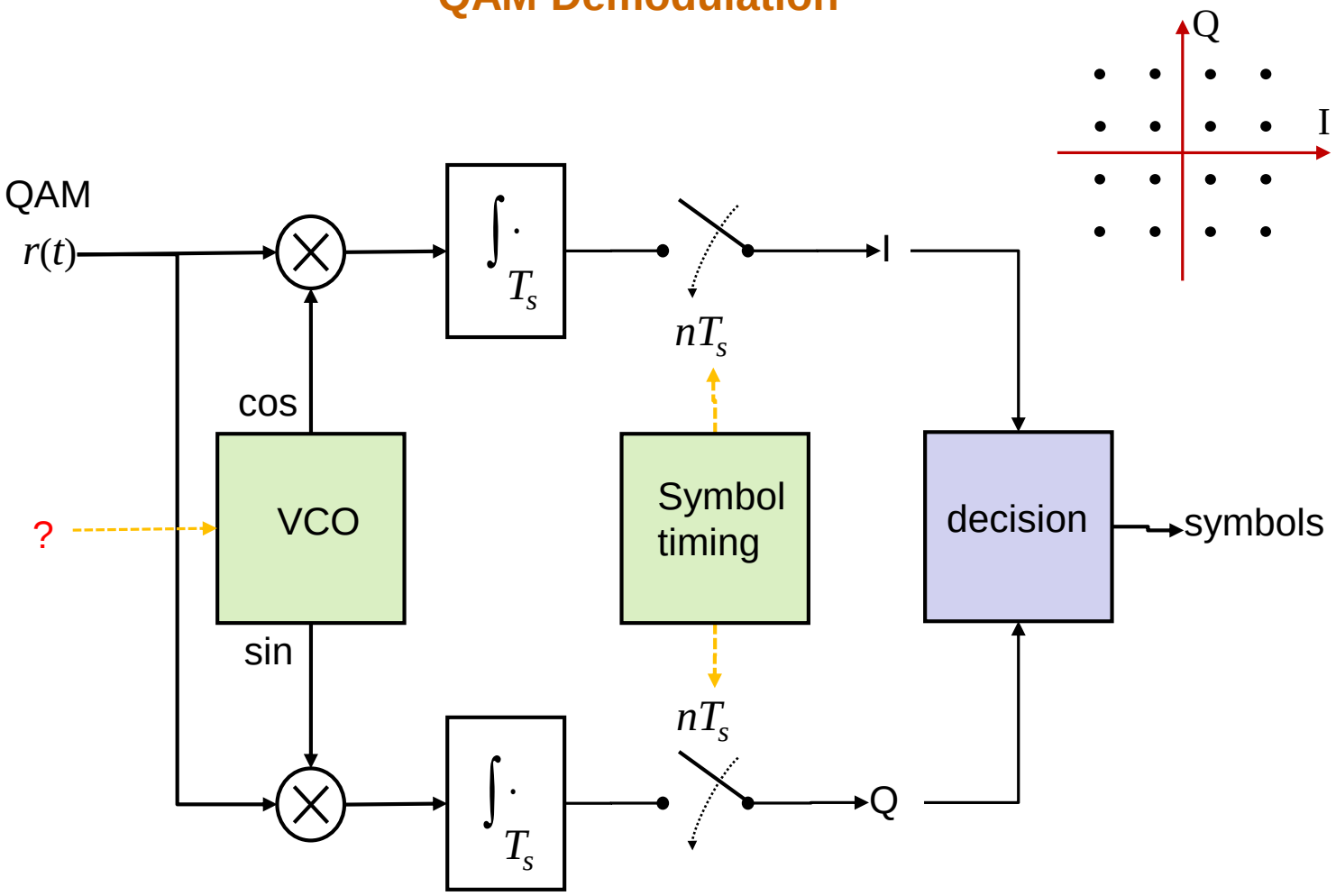
Hmw : What if $r(t)$ is a QPSK Signal?

Costas Loop



This is for carrier sync and demodulation.
Baseband signal is then synchronized with and detected afterwards

QAM Demodulation



Q : where do we get I & Q carriers?

END