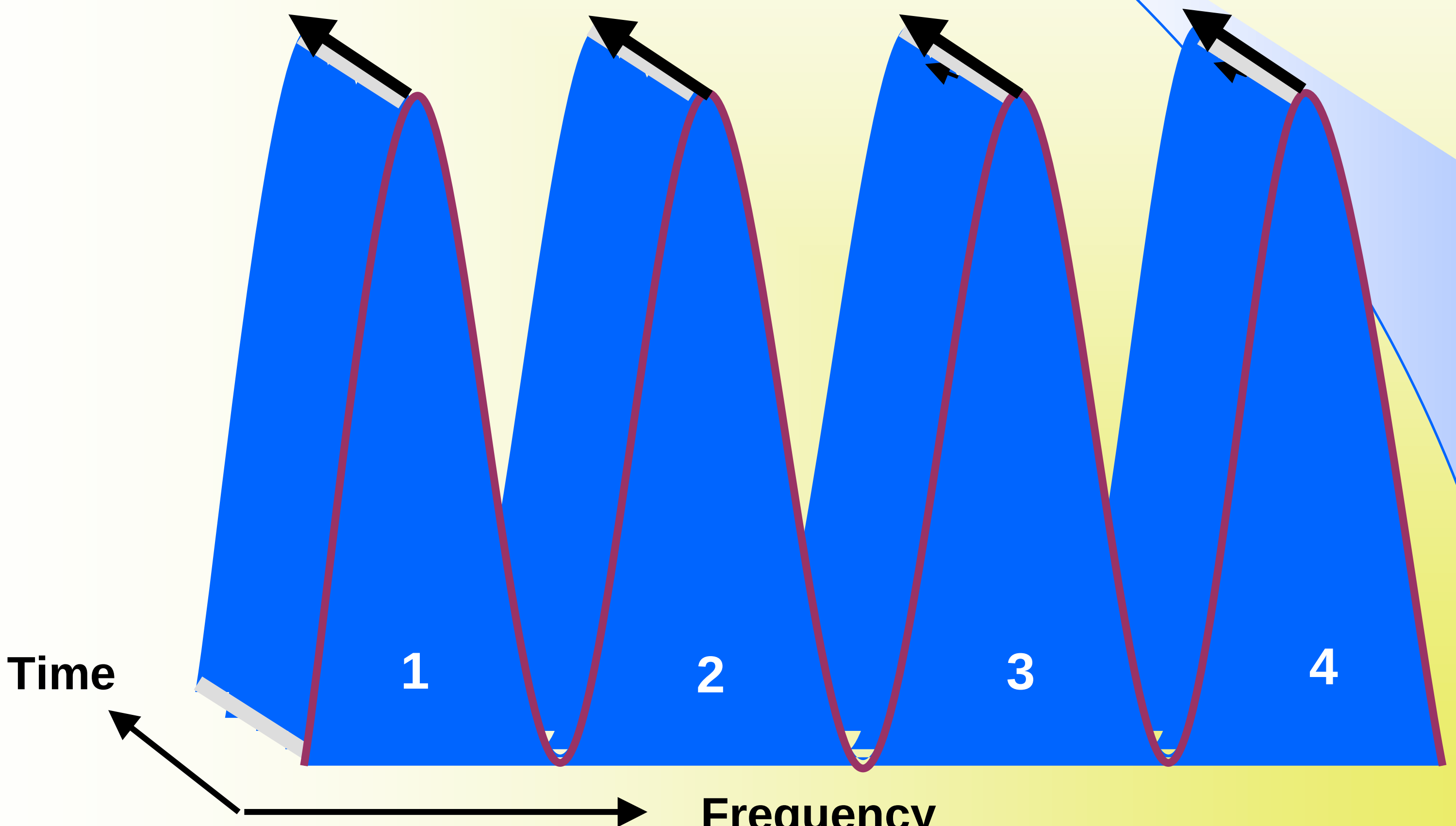
Multiple Access Techniques

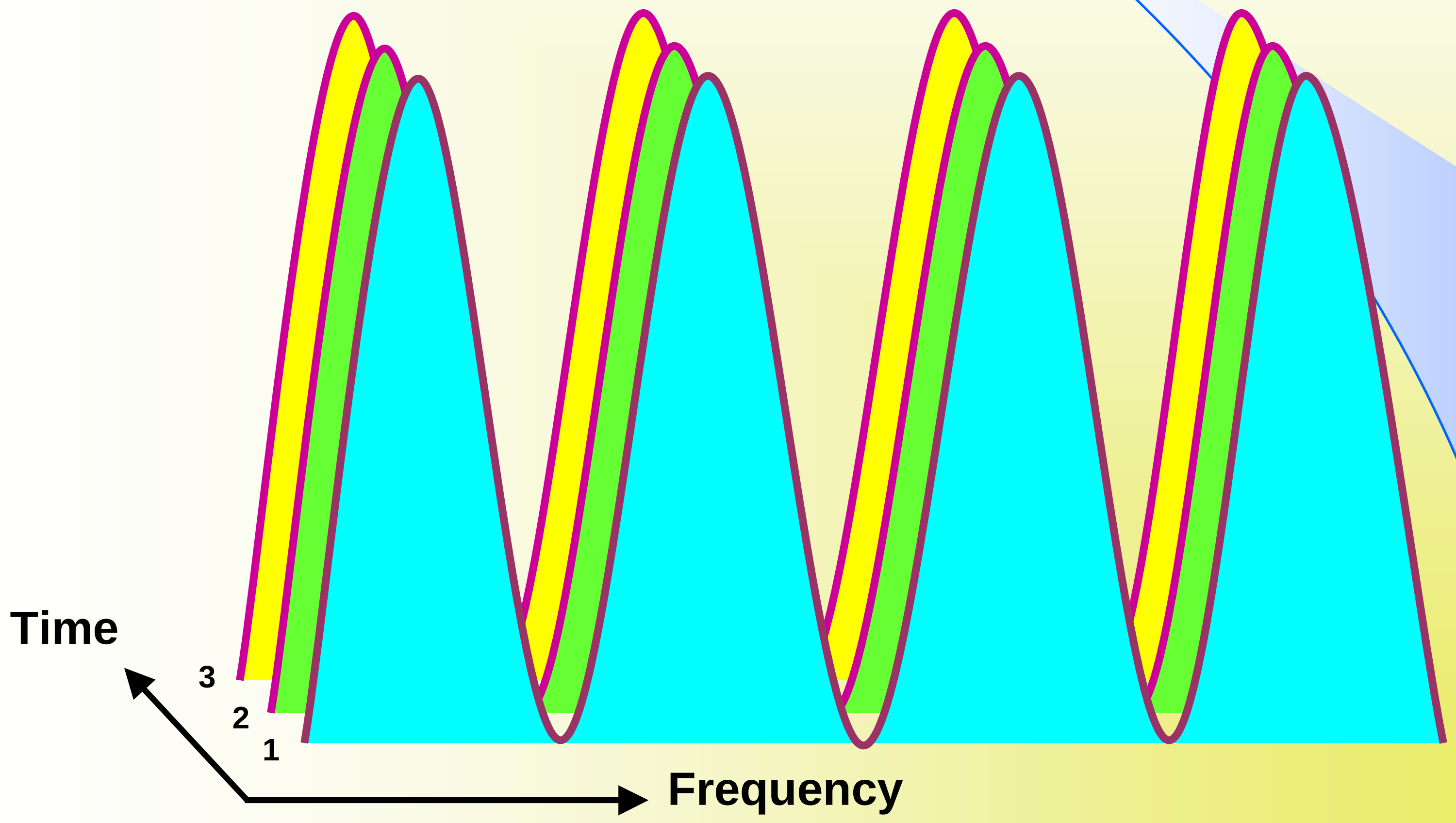
FDMA: Frequency Division Multiple Access

(one carrier for each user for all connection time)



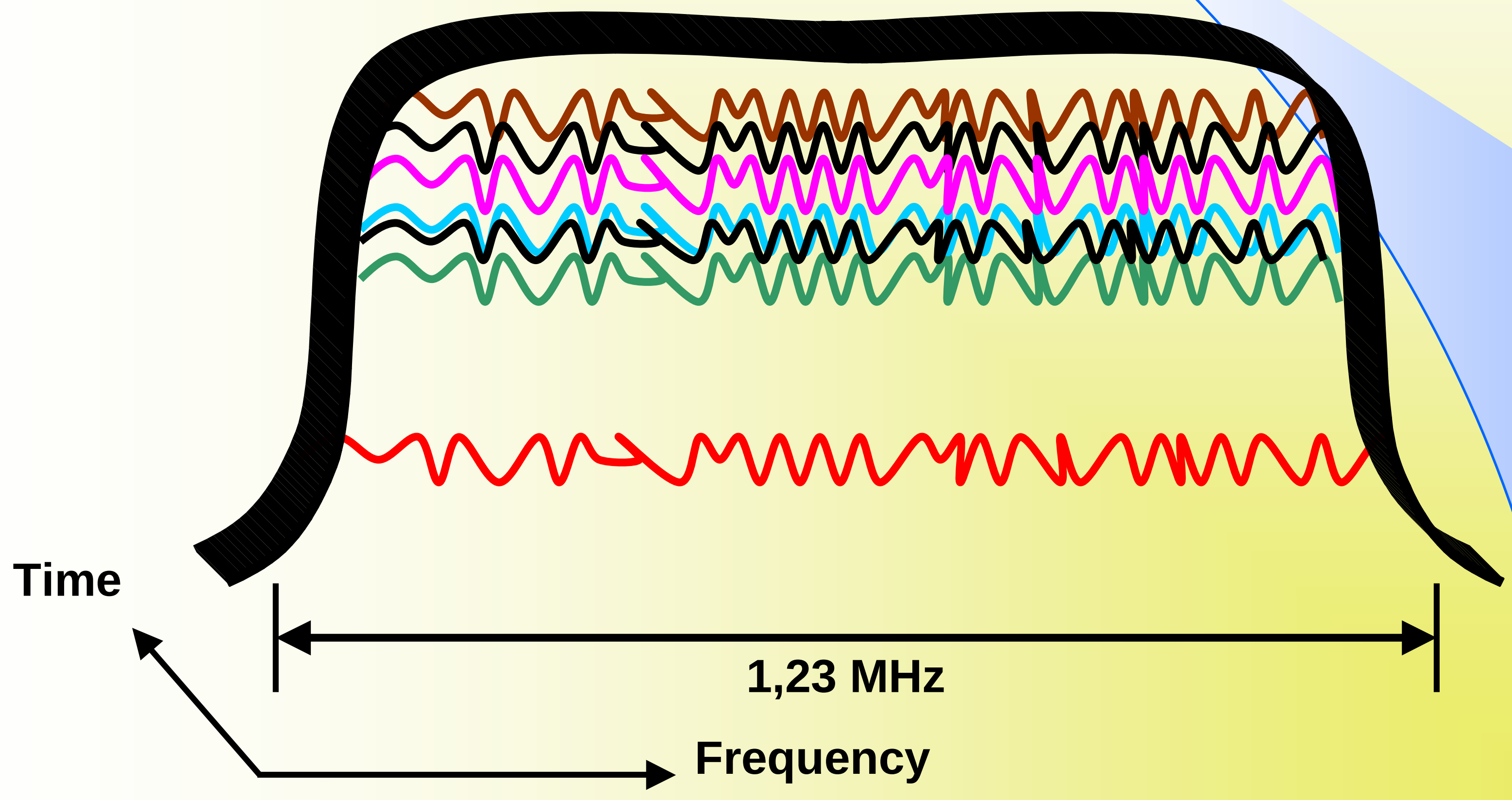
TDMA: Time Division Multiple Access

(one carrier for a group of users in a time division principle)

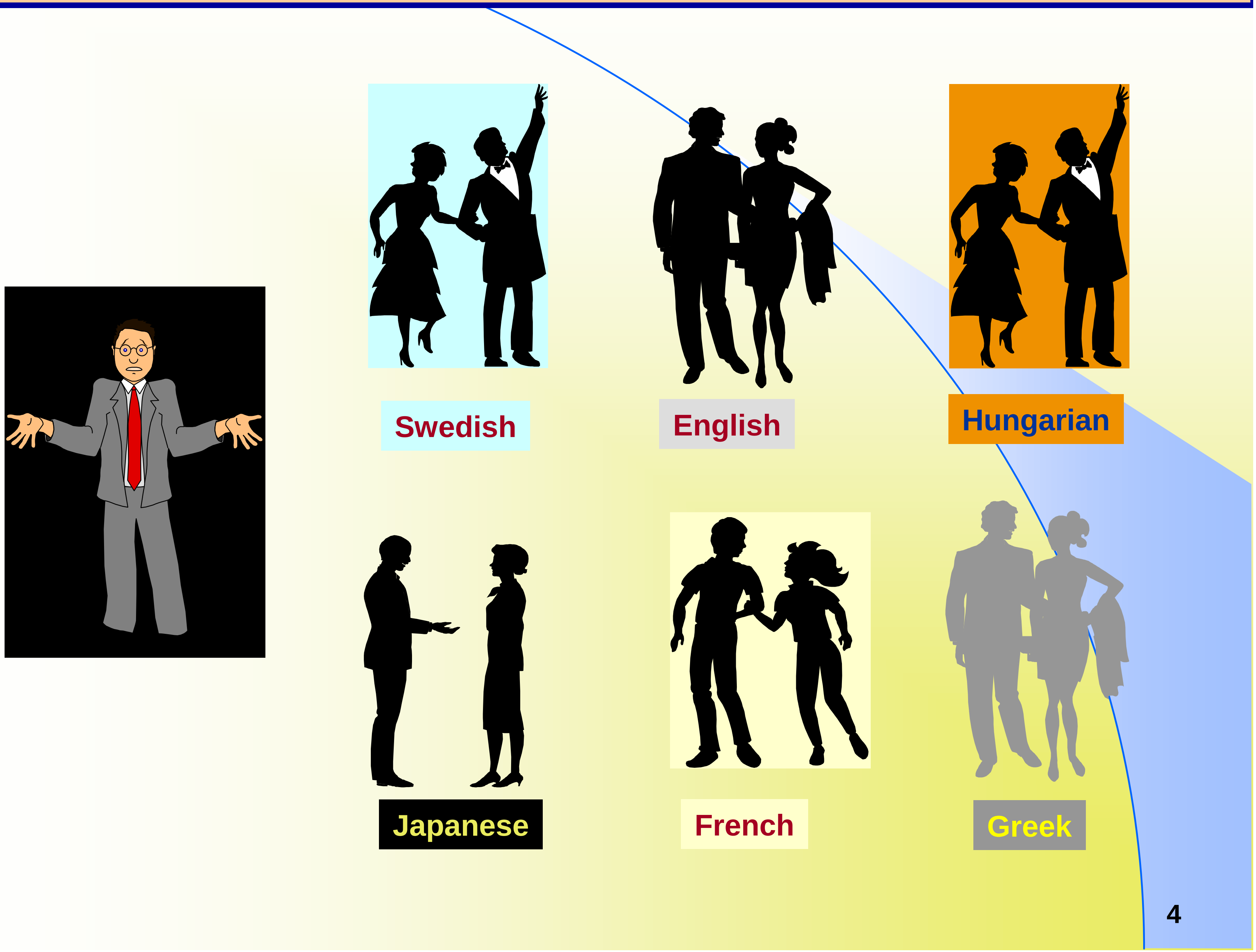


CDMA: Code Division Multiple Access

(one carrier for all users for all time in a code division principle)

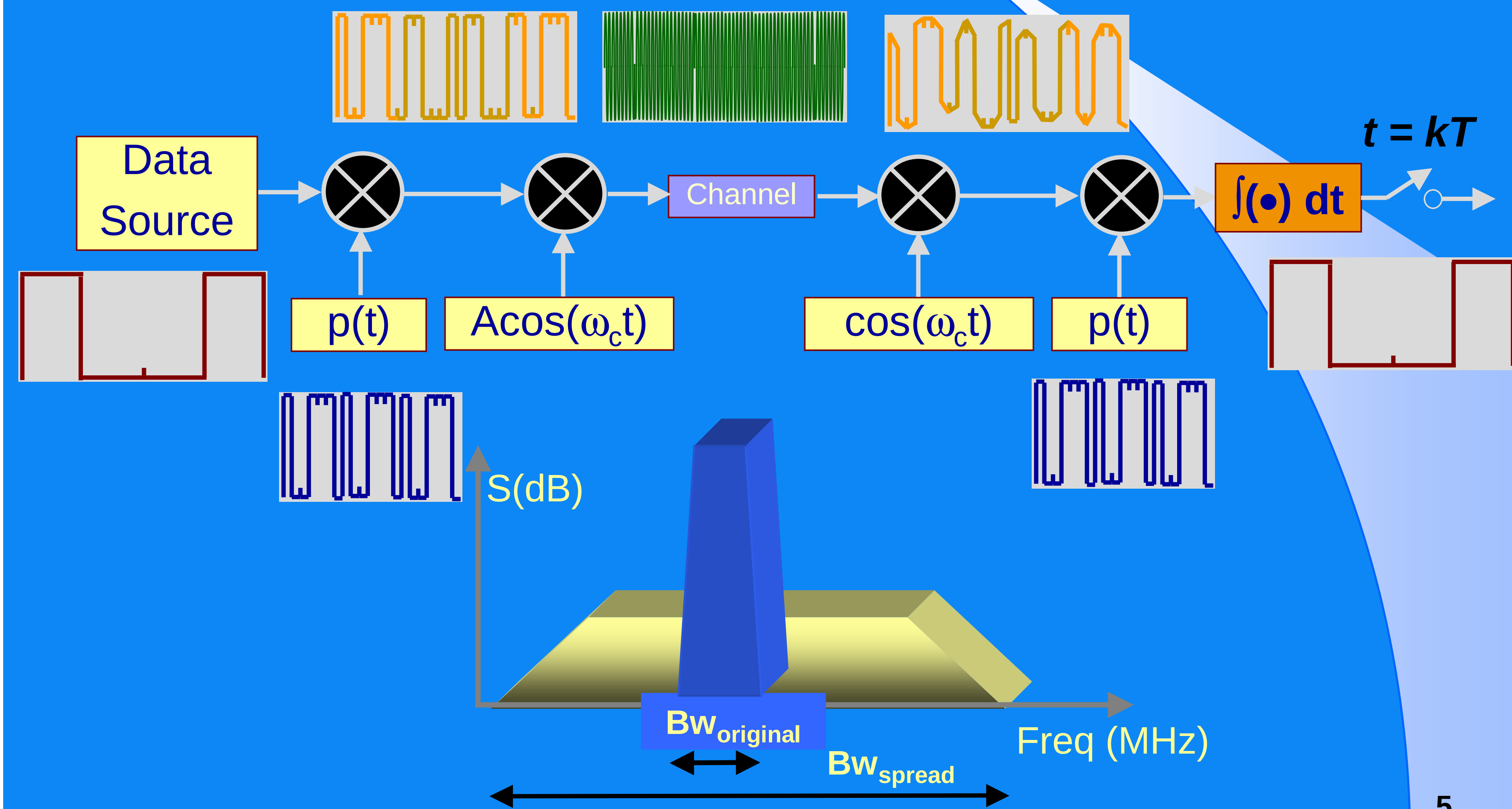


CDMA Philosophy

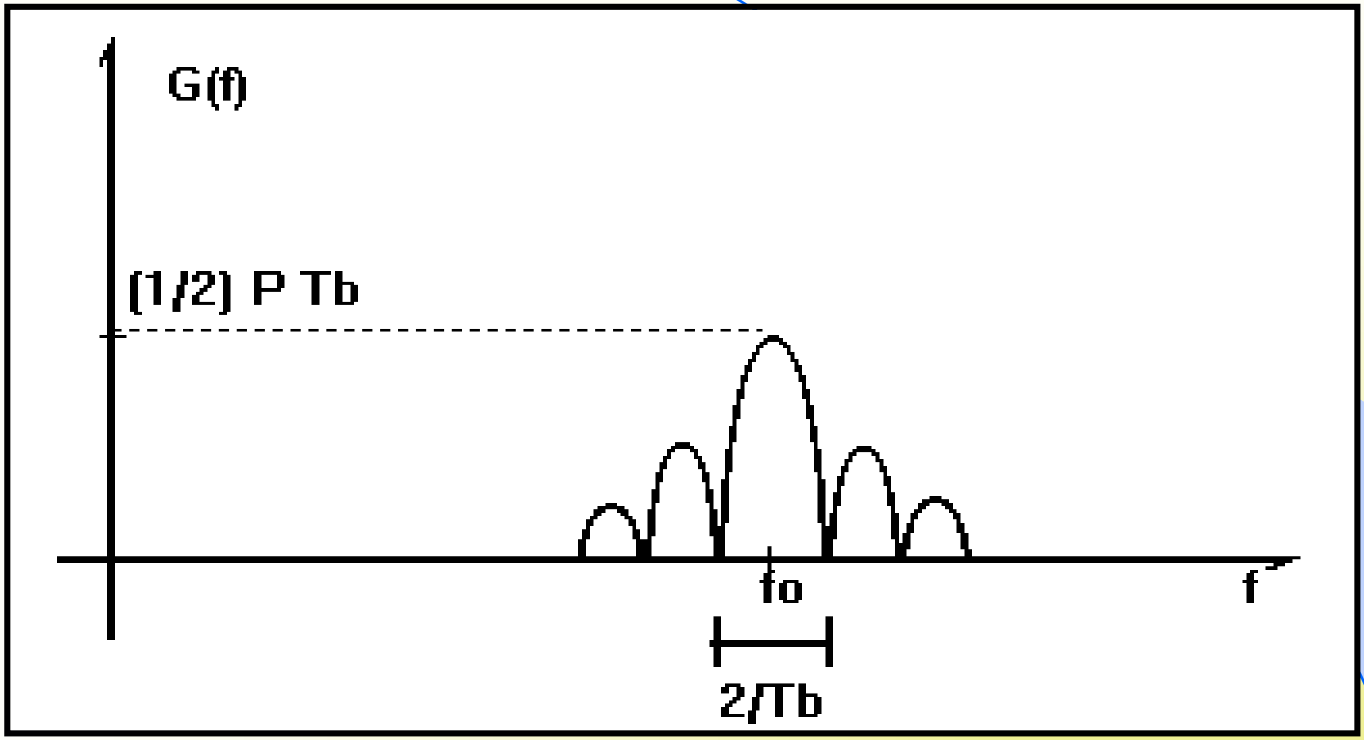


Some General Characteristics

DS/SS Block Diagram

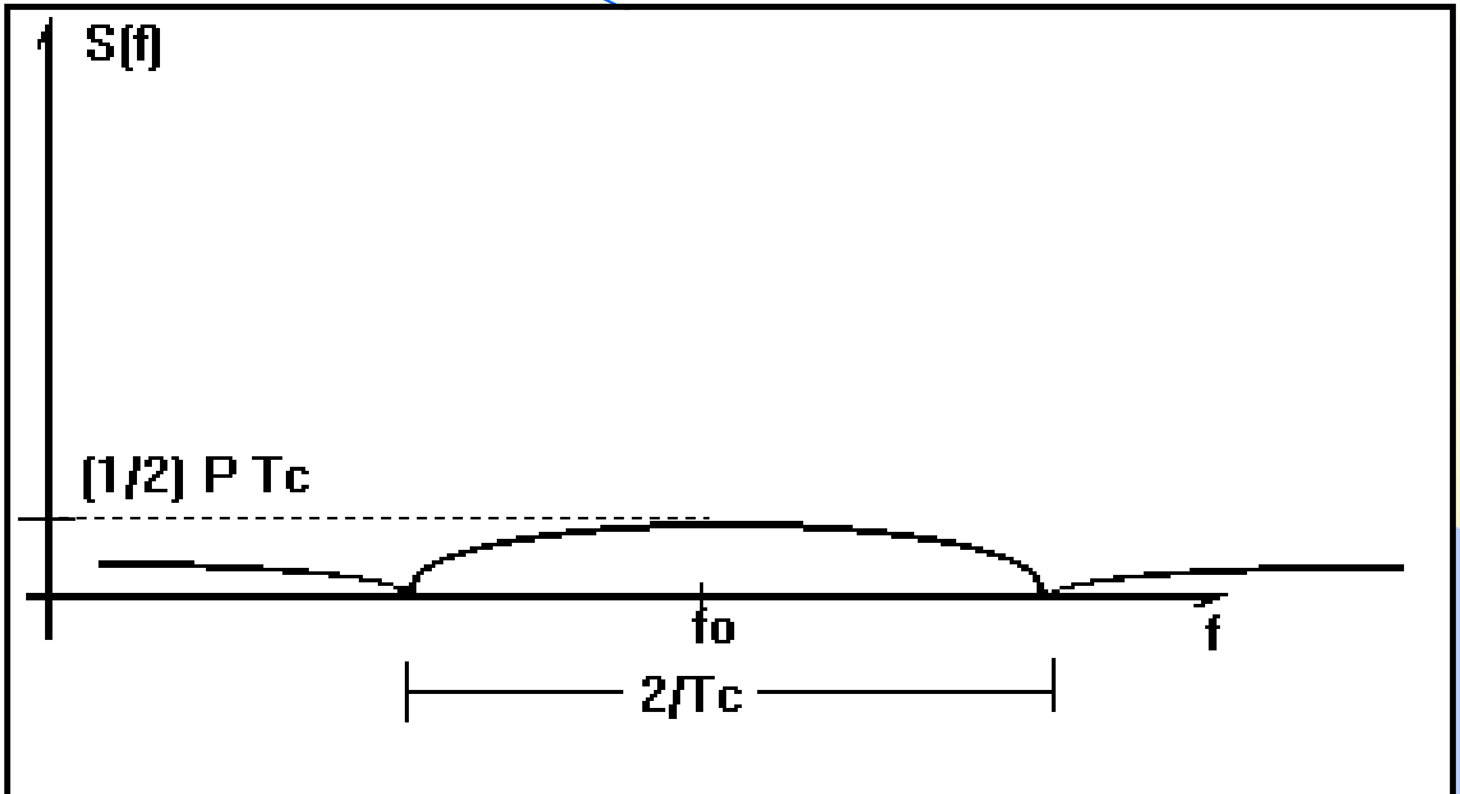


Power Spectral Densities (PSD) of DS/SS Signals



BPSK signal with power P, carrier frequency f_o and a data rate $R_b=1/T_b$

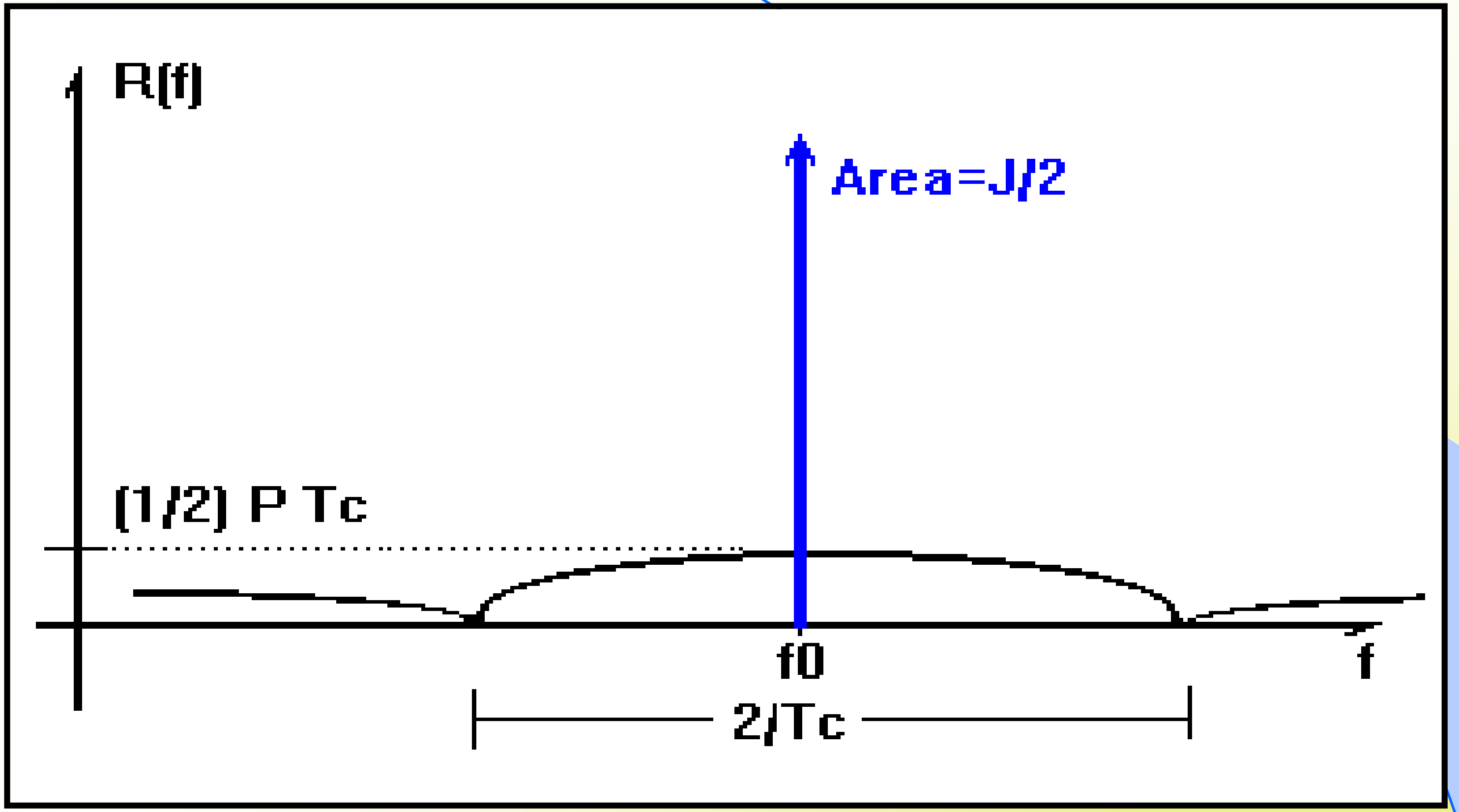
$$G(f) = \frac{PT_b}{2}[\text{sinc}^2(f - f_0)T_b + \text{sinc}^2(f + f_0)T_b]$$



Previous BPSK signal spread by a code with a chip rate $R_c=1/T_c$

- Note that spreading maintains unchanged the total power P;

- The ratio $G = R_c/R_b = T_b/T_c$ is known as processing gain and determines the interference rejection capability.



Previous signal and a centred tonal jammer with power J at receiver’s input

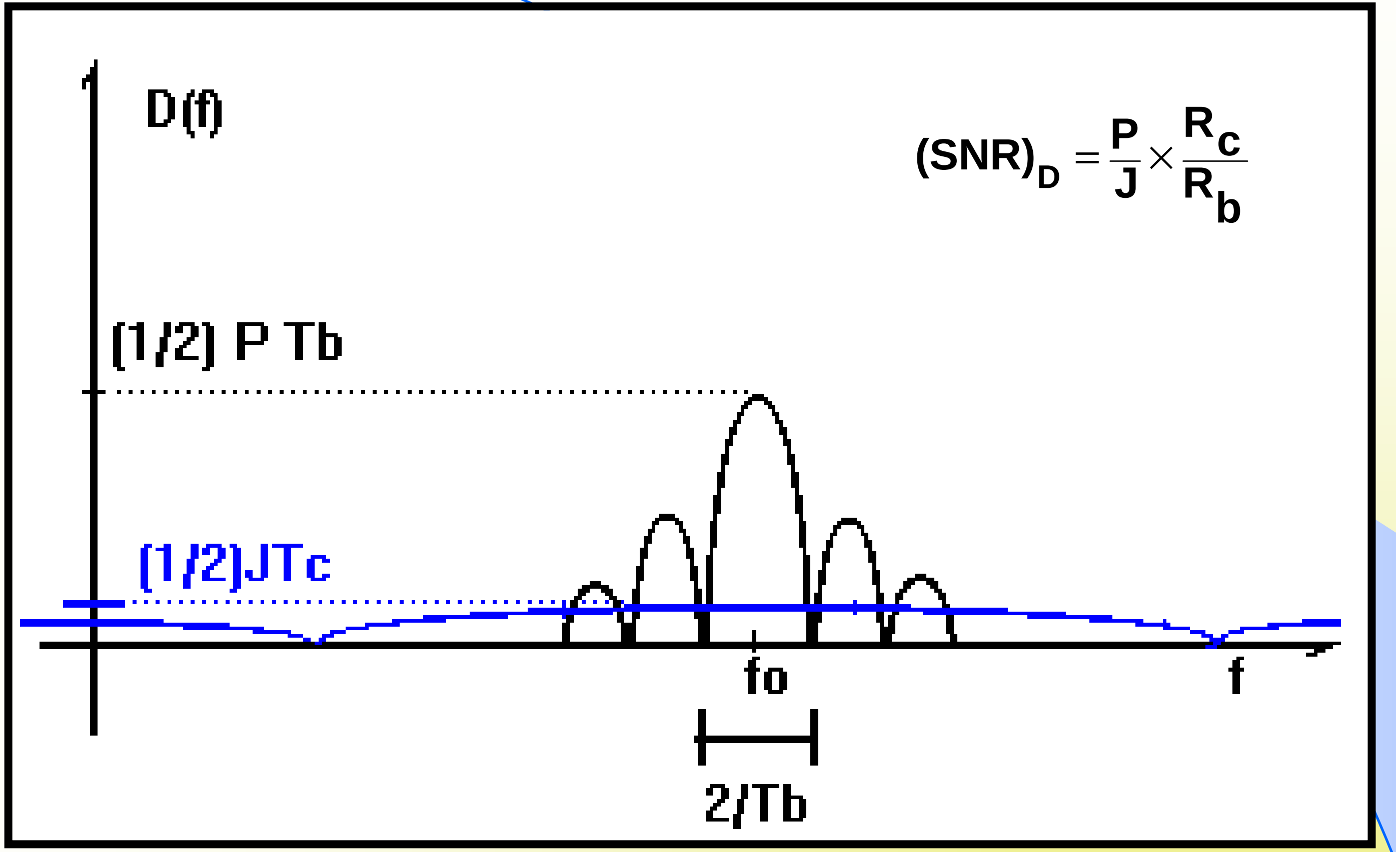
The composed signal at detector's input, r(t), can be written as

$$r(t) = s(t) + j(t)$$
$$s(t) = \sqrt{2P}d(t)p(t)co(\omega_0 t + \varphi)$$
$$j(t) = \sqrt{2J}\cos\omega_0 t$$

Admitting a perfect code synchronism (i. e., p(t) has exactly recovered in the synchronism stage $\Rightarrow$ $p^2(t) = 1$) after de-spreading we have

$$r'(t) = r(t)p(t) = s'(t) + j'(t)$$
$$s'(t) = \sqrt{2P}d(t)co(\omega_0 t + \varphi)$$
$$j'(t) = \sqrt{2J}p(t)\cos\omega_0 t$$

Therefore the de-spread effect is to return the desirable signal to its original form and to spread the interference (next slide).



$$(SNR)_D = \frac{P}{J} \times \frac{R_c}{R_b}$$

Previous signals now at detector's output

This set of PSD figures shows the interference rejection capability and also the low probability of interception (LPI) for DS-SS signals.

DS/SS Signals Synchronism

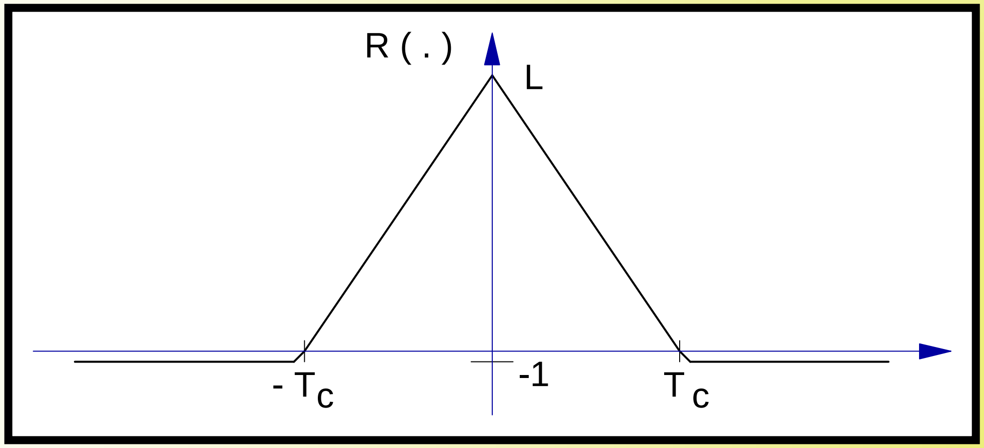
Synchronism is a two step task: acquisition and tracking.

The two more usual acquisition methods are:
Serial Search and Matched Filter.

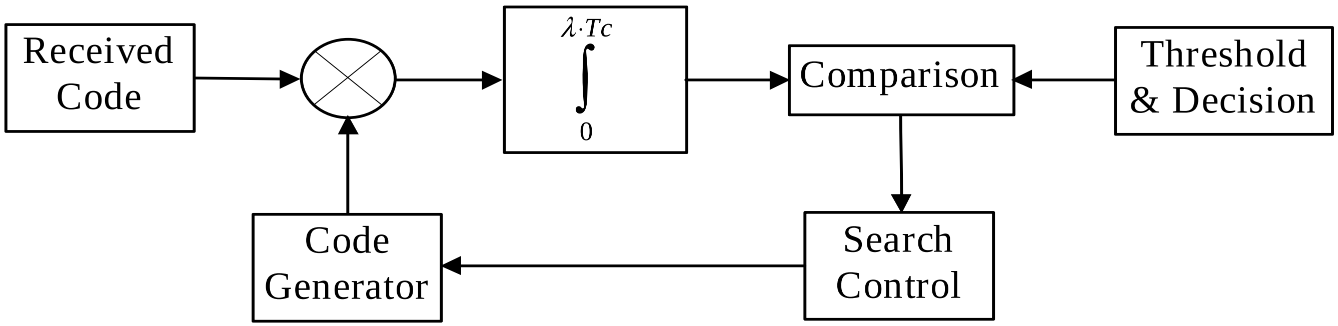
After the acquisition stage (which guarantees a $T_c/2$ uncertainty for the delay between received and local codes) the tracking loop is started.

The two more usual tracking loops are:
DLL-Delay Lock Loop and Tau-Dither.

Acquisition and tracking are based on the well known code sequences auto-correlation function (maximal length in the figure)



Acquisition by Serial Search (Sliding Window)



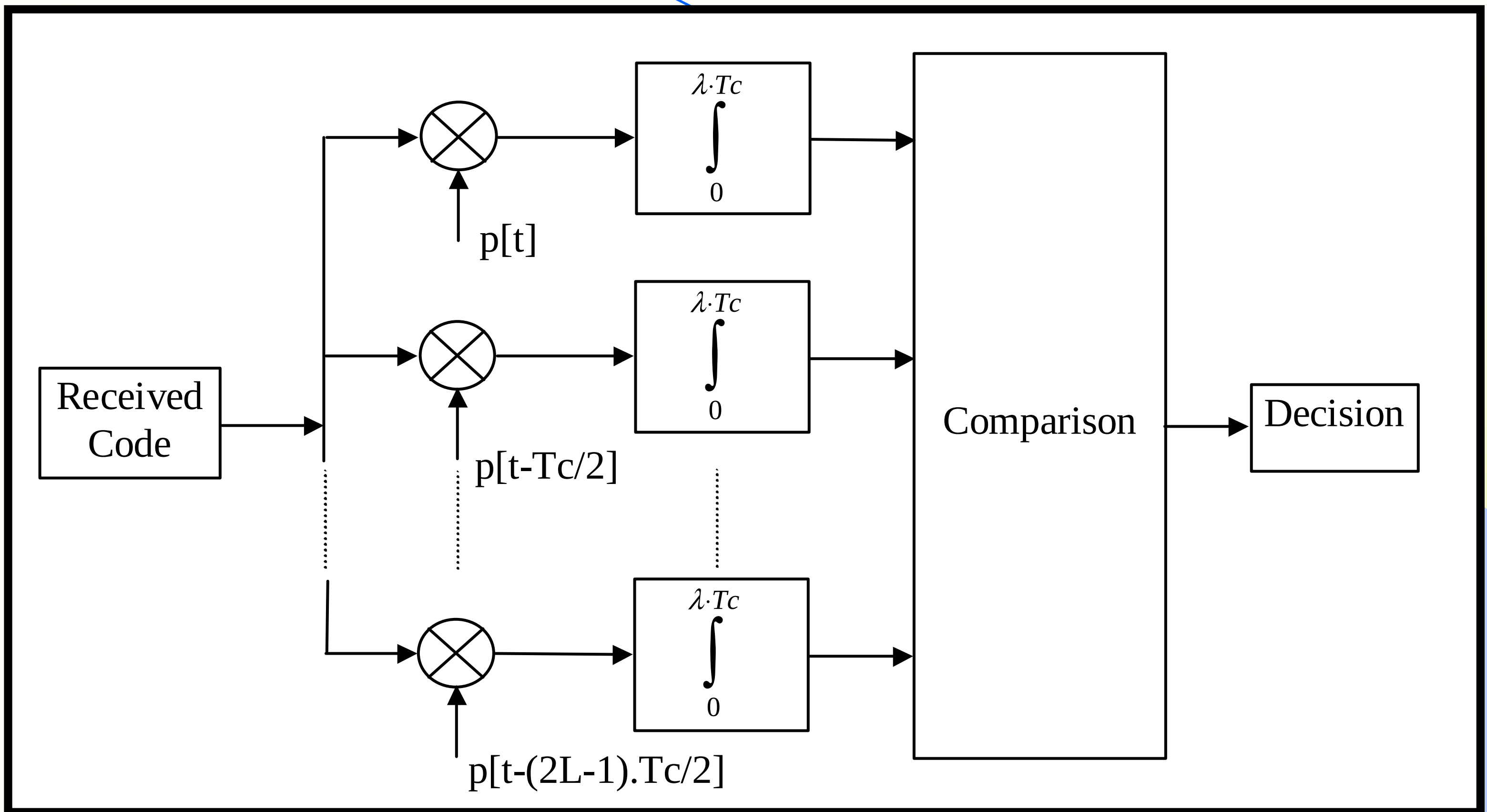
- Each successive search is carried out at $T_c/2$ intervals (i. e., 2L possible intervals where L is the code length);

- The mean acquisition time is given by $\overline{T}_{acq} = L\lambda T_c$

where λ is a fraction of full sequence period, i. e., $0 < \lambda \leq L$ and its value is a compromise between T_{acq} and false alarm probability;

- Less complexity $\times$ Greater acquisition time.

Acquisition by Matched Filters



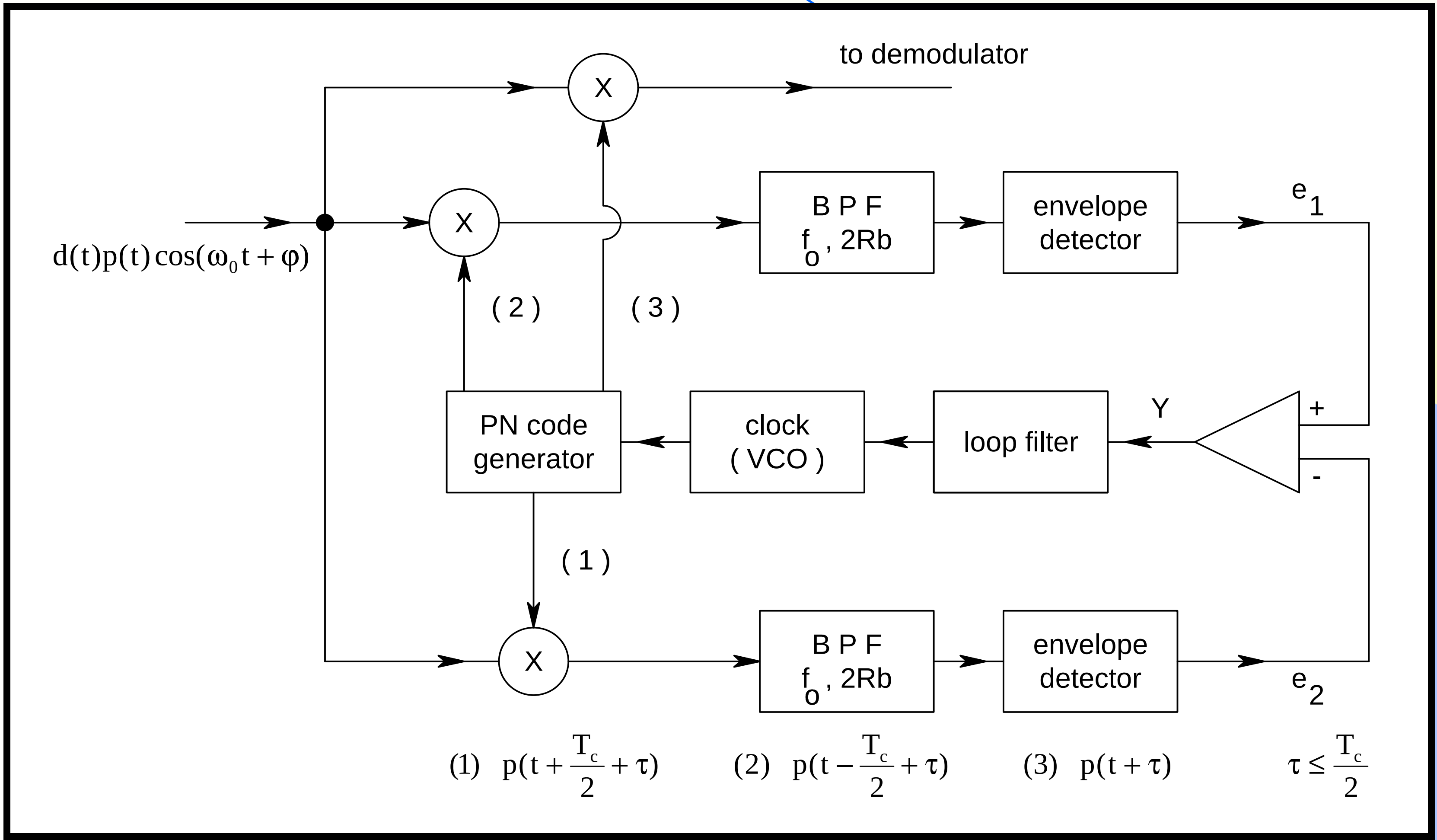
- All 2L possible search positions are checked in a parallel way;

- The acquisition time is given by $\overline{T}_{acq} = \lambda T_c$

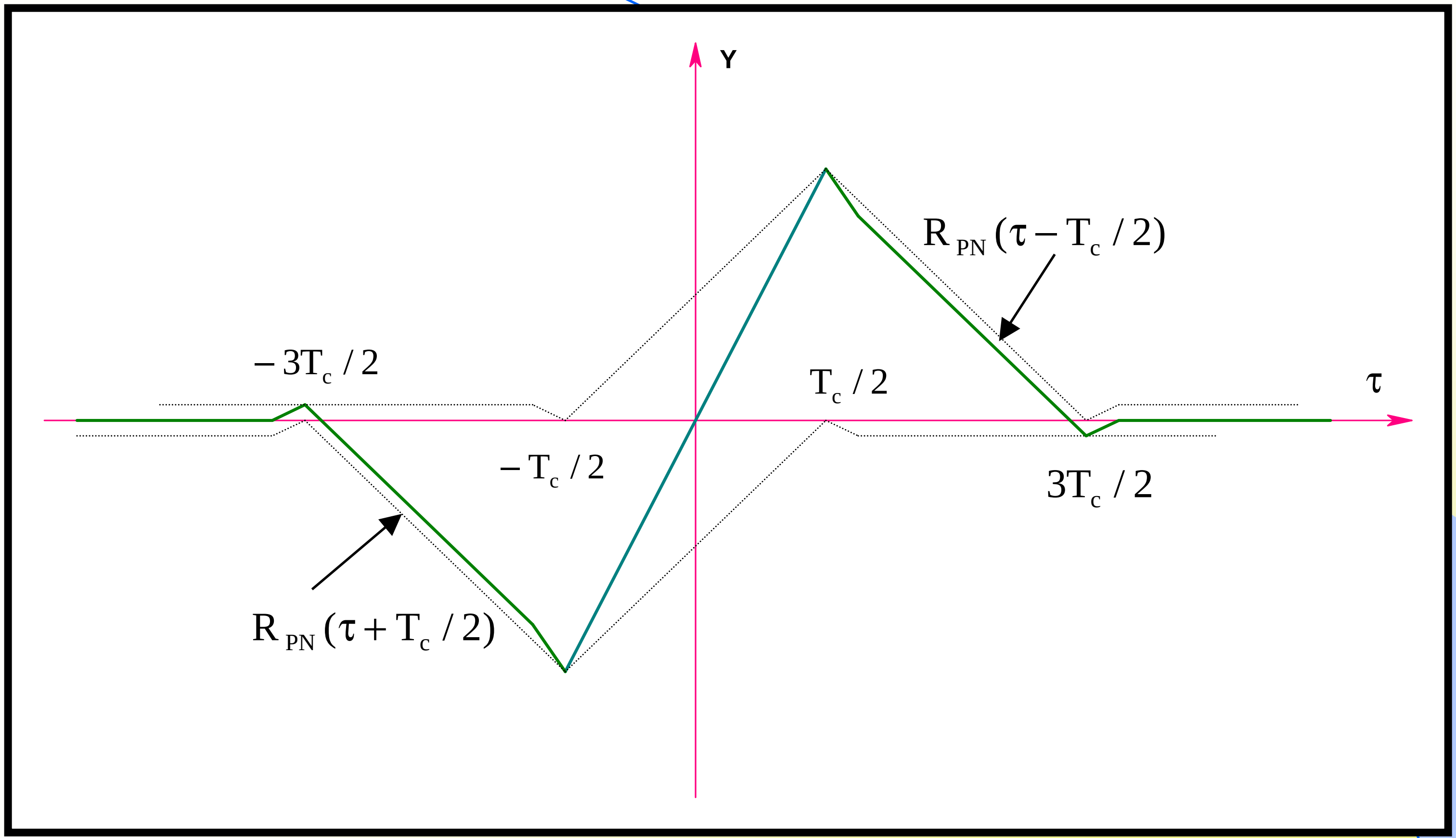
- More complexity × Smaller acquisition time.

DLL-Delay Lock Tracking Loop

The DLL starts after the acquisition stage which means that $| \tau | < T_c / 2$.



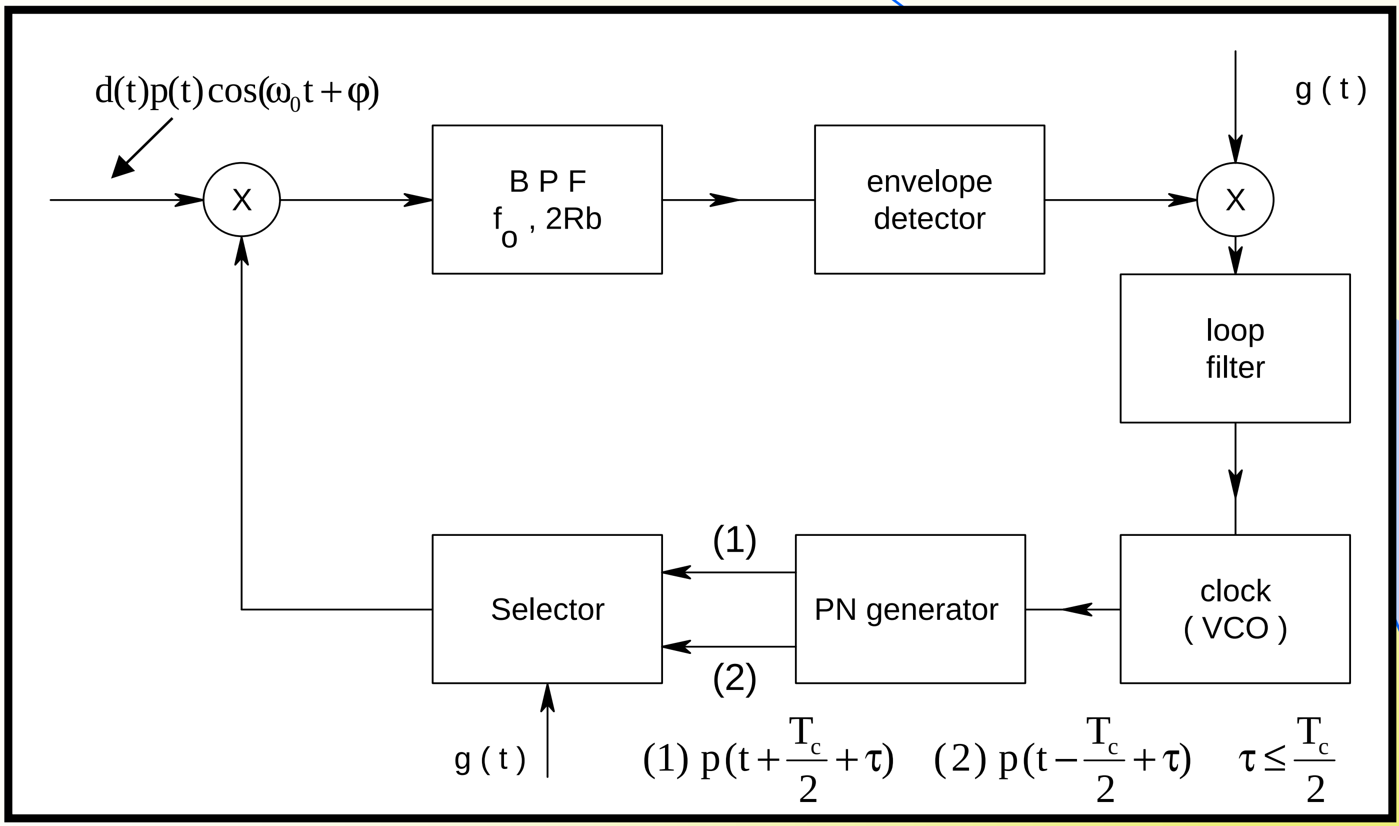
The tracking performance is based on the Y signal which acts as the VCO control signal (next figure).



In the range $\pm T_c/2$ the Y signal is a linear function of the delay and therefore this signal can be used to drive the VCO whose equilibrium point is Y=0.

Tau-Dither Tracking Loop

The Tau-Dither tracking loop is a time sharing version of DLL with only one correlator circuit avoiding therefore any mismatch between correlators.



The dither function g(t) (unitary bipolar square wave signal) selects the local code early or late version and also, in correspondence, the signal of the envelope detector output. See reference [22] for additional details.