[03LPXBG, 02LPXQW] – Satellite Navigation Systems

Lab Session 6: Tracking

Laboratory on correlations and discriminators

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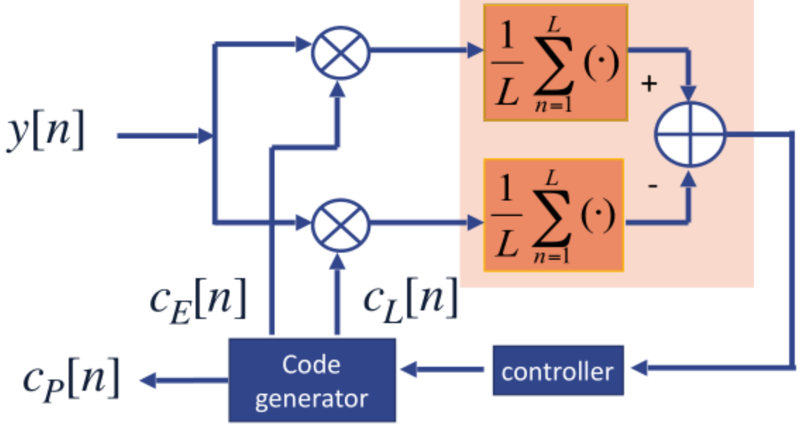
DLL tracking architecture

Consider the DLL tracking stage of a GNSS receiver.

Coherent DLL : Early-Late Codes



The output of the correlators depends on the value of the cross correlation function of the early and late version

$$\epsilon_\tau = \tau - \hat{\tau}$$

$$\boxed{S_E = \frac{\sqrt{P_R}}{L}\sum_{n=1}^{L} c(nT_S - \tau)c(nT_S - \hat{\tau} + d_S T_c/2)} \qquad S_E = \sqrt{P_R} R_C(\epsilon_\tau + d_S T_c/2)$$

$$\boxed{S_L = \frac{\sqrt{P_R}}{L}\sum_{n=1}^{L} c(nT_S - \tau)c(nT_S - \hat{\tau} - d_S T_c/2)} \qquad S_L = \sqrt{P_R} R_C(\epsilon_\tau - d_S T_c/2)$$

CORRELATIONS

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Step 1: correlators

TASK 1

Using the codes generated in **Lab 3**, simulate the received signal.
Draw the correlation functions of the prompt (circular correlation of 1 code period) and the output of the Early and Late correlators, in absence of noise.

The front-end has a sampling frequency equal to 16.368 MHz.

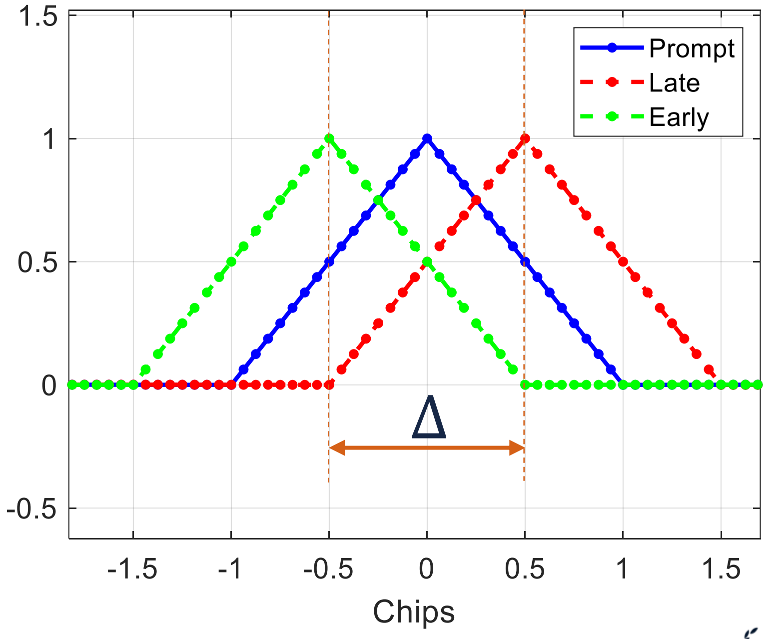
Consider the following signals:

- GPS L1 C/A, BPSK
- Galileo E1, BOC(1,1)

And the following discriminator spacings, Δ:

- Δ= 1 chip
- Δ= 0.5 chips
- Δ= 0.25 chips

Tip: zoom your correlation plot in the range $\pm 2T_{chip}$



Step 2: discriminator

TASK 2

Draw the open-loop discrimination function of the Early and Late correlators (S-curves).
Consider the following discrimination functions:

- Early minus Late $s = S_E - S_L$ Coherent
- Early minus Late normalized $s = \frac{1}{2}\frac{S_E - S_L}{S_E + S_L}$
- Early minus Late power normalized $s = \frac{1}{2}\frac{{S_E}^2 - {S_L}^2}{{S_E}^2 + {S_L}^2}$

$\left.\begin{array}{l} \text{Early minus Late normalized} \\ \text{Early minus Late power normalized} \end{array}\right\}$ Non-coherent

TASK 3

Evaluate the slope of each discrimination function in the tracking point.

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Step 2: discriminator

TASK
4

Repeat the analysis by introducing a simple model of the front-end filter, to be applied on the received code (i.e., a Butterworth filter):

```
wn = 1/2;
order = 4;
Bf, Af] = butter(order, wn, 'low');
Code = filter(Bf, Af, Code);
```


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Step 3: multipath

In presence of multipath, the correlation function and the S-curve are distorted.

TASK

5

Add a reflected ray, with the following characteristics:

- **delay**: 0.25 chips
- **amplitude**: 0.4 of the chip amplitude

Repeat the analysis for the 3 discriminators considered at step 2 and evaluate the bias introduced by the presence of multipath with and without the front-end filter.

Comment the results obtained.

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