GPS Lab Exercises

(4) Correlation and Signal Search

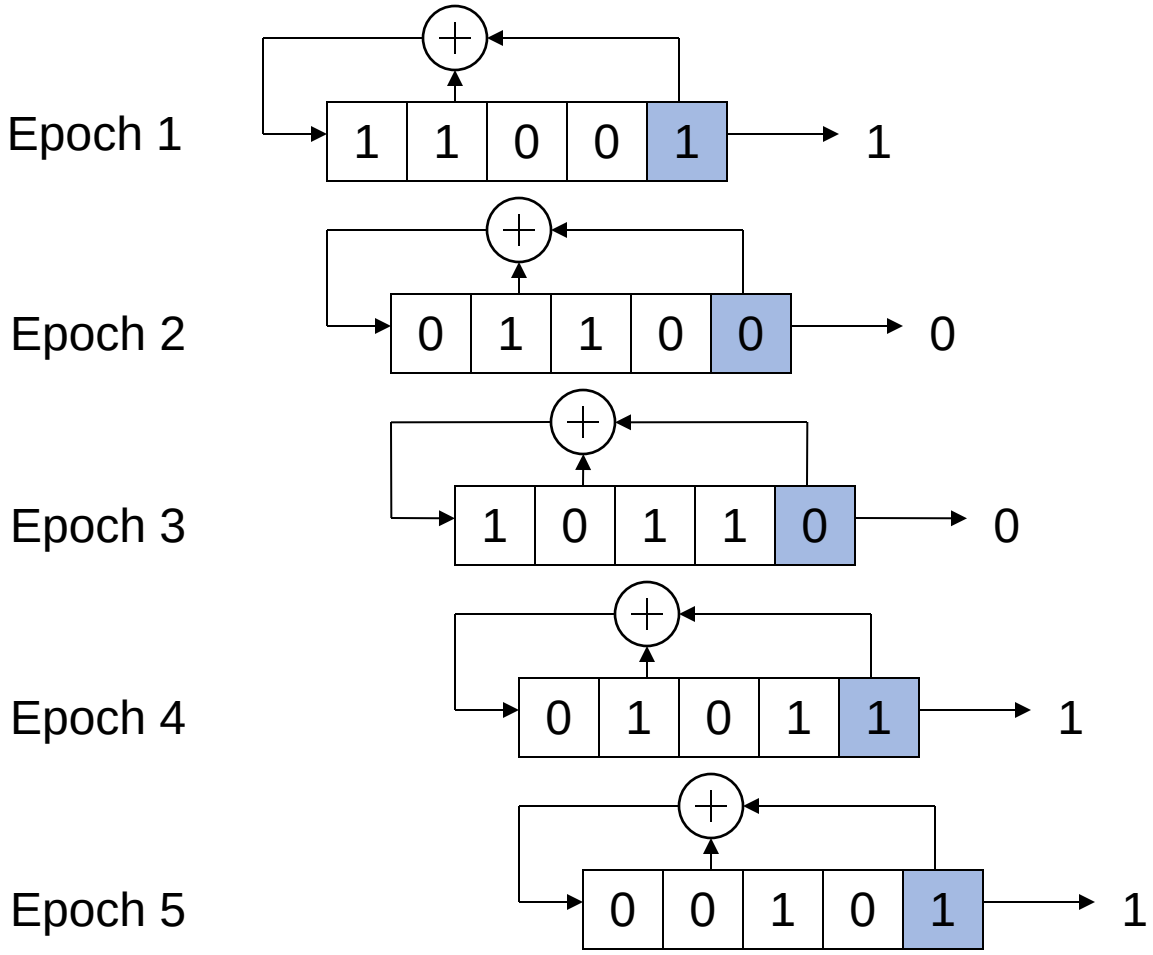
O. Montenbruck

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

Gold-Code Generation

- Shift register (length *n*) with feedback creates periodic bit sequence
- Feedback value computed from exclusive-or of individual registers
  - $0 \oplus 0 = 1 \oplus 1 = 0,\ \ 0 \oplus 1 = 1 \oplus 0 = 1$
  - Equivalent to multiplication of numbers +1 („0“) und –1(„1“)
- Favorable choice of feedback registers yields a sequence of maximum length 2^n-1 (*m-sequence*)
- Gold (1967): linear combinations of two (selected) m-sequences (with $n \neq 4,8,...$) can provide a family of 2^n+1 different *Gold codes* with optimimum correlation properties

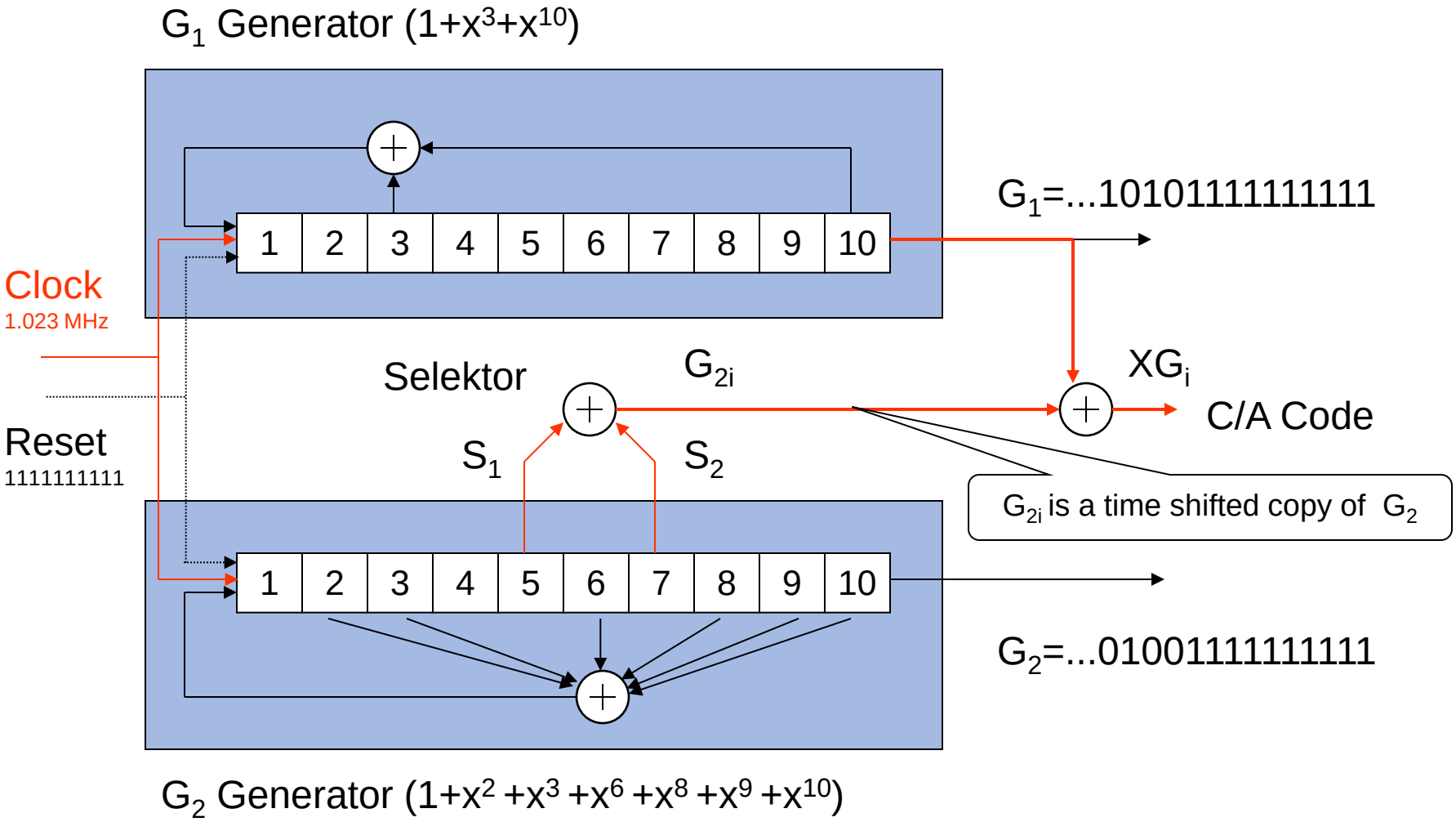
Feedback Shift Registers



exclusive-or

⊕	0	1
0	0	1
1	1	0

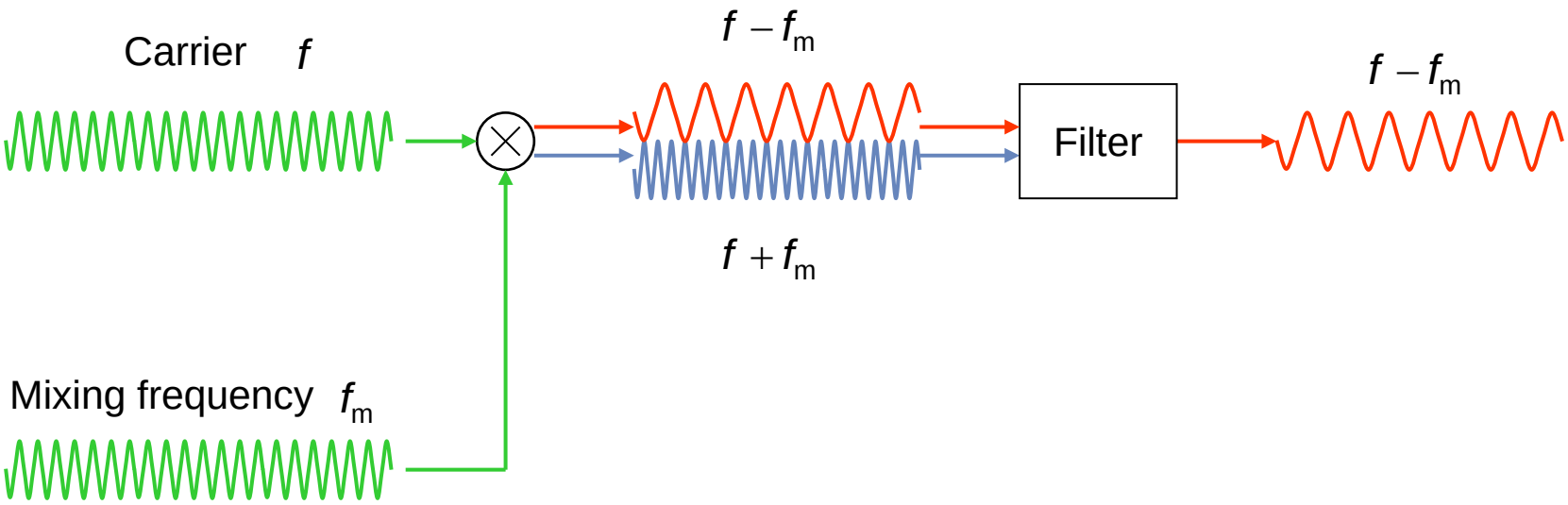
GPS C/A-Code Generation



PRN Association (ICD-GPS-200)

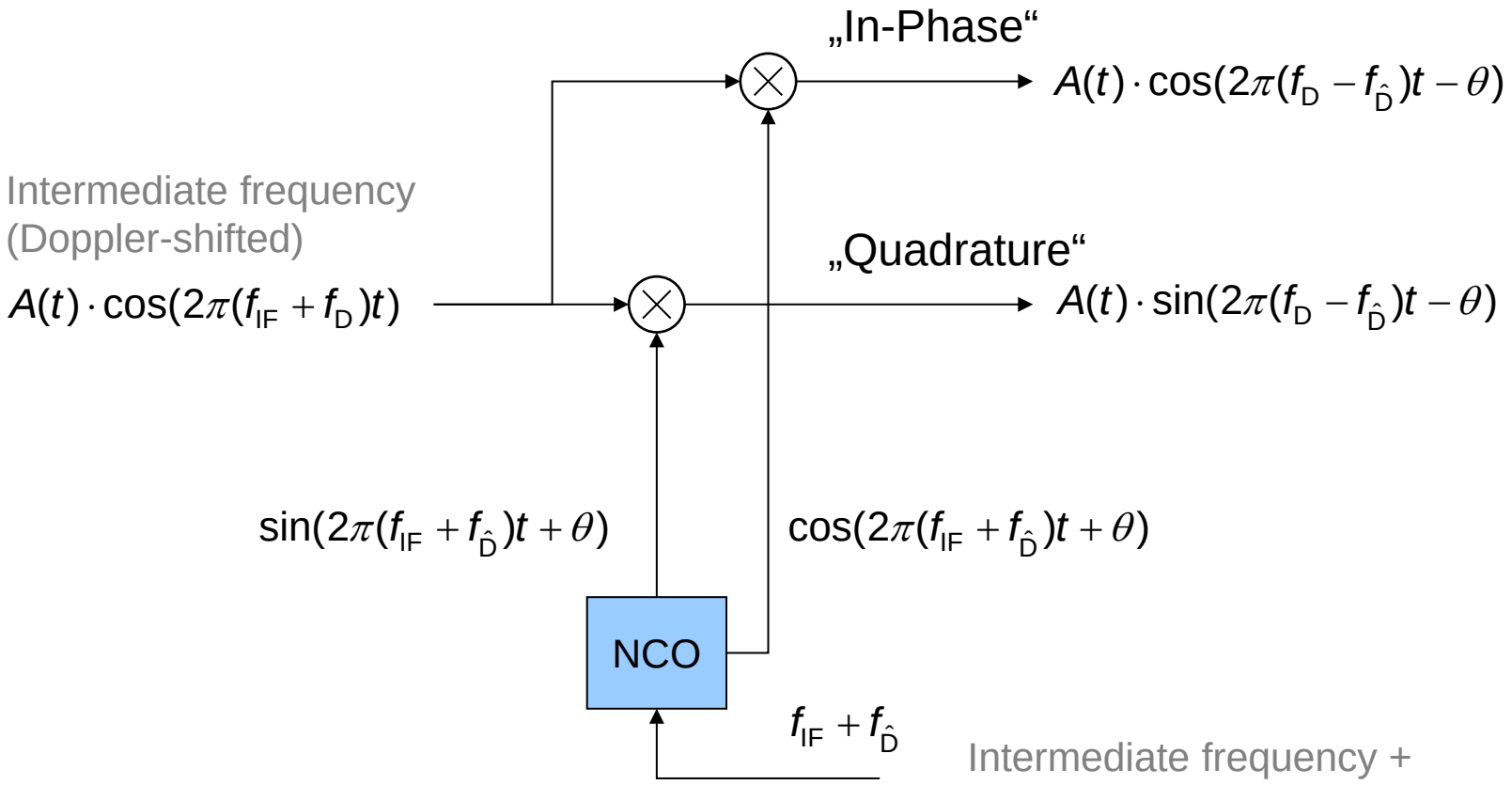
PRN	Selector	Offset	PRN	Selector	Offset
1	2 ⊕ 6	5	17	1 ⊕ 4	469
2	3 ⊕ 7	6	18	2 ⊕ 5	470
3	4 ⊕ 8	7	19	3 ⊕ 6	471
4	5 ⊕ 9	8	20	4 ⊕ 7	472
5	1 ⊕ 9	17	21	5 ⊕ 8	473
6	2 ⊕ 10	18	22	6 ⊕ 9	474
7	1 ⊕ 8	139	23	1 ⊕ 3	509
8	2 ⊕ 9	140	24	4 ⊕ 6	512
9	3 ⊕ 10	141	25	5 ⊕ 7	513
10	2 ⊕ 3	251	26	6 ⊕ 8	514
11	3 ⊕ 4	252	27	7 ⊕ 9	515
12	5 ⊕ 6	254	28	8 ⊕ 10	516
13	6 ⊕ 7	255	29	1 ⊕ 6	859
14	7 ⊕ 8	256	30	2 ⊕ 7	860
15	8 ⊕ 9	257	31	3 ⊕ 8	861
16	9 ⊕ 10	258	32	4 ⊕ 9	862

Mixing

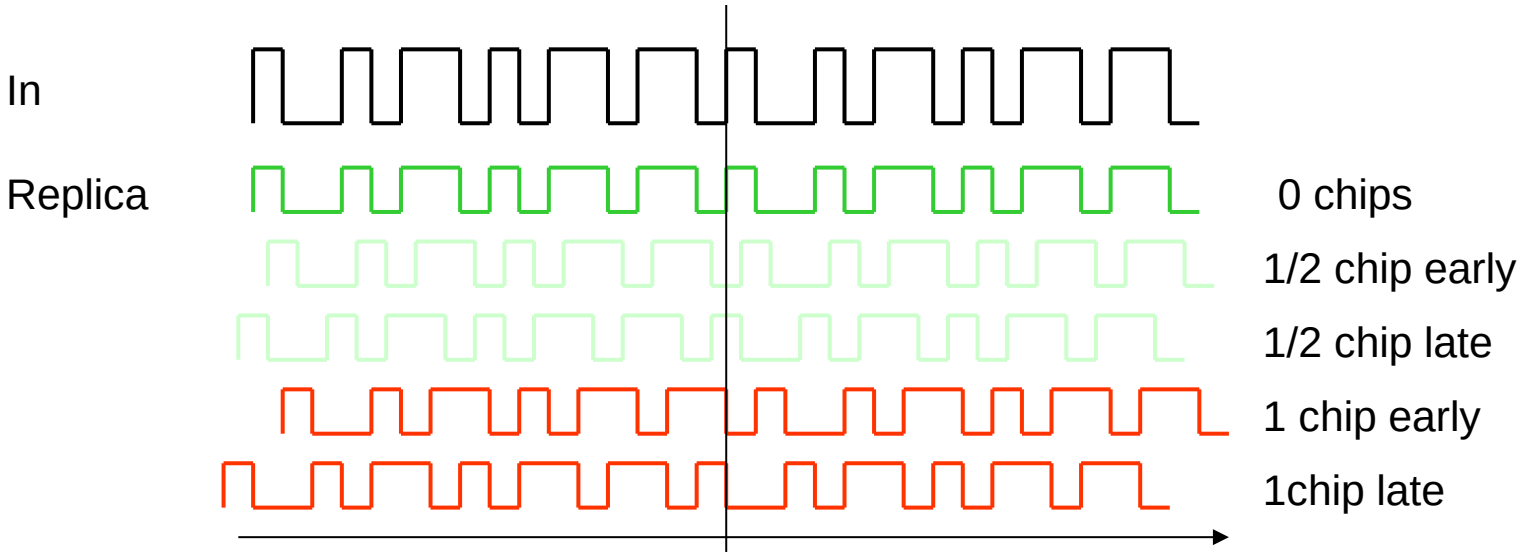


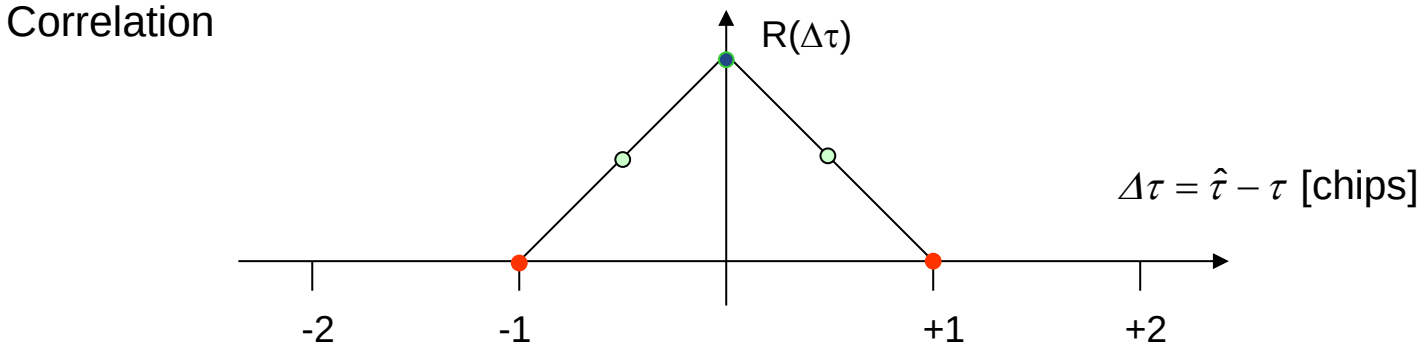
$$\cos(2\pi f t)\cdot\cos(2\pi f_m t) = \frac{1}{2}\cos(2\pi(f - f_m)t) + \frac{1}{2}\cos(2\pi(f + f_m)t)$$

Doppler Compensation, In-Phase and Quadrature Channel

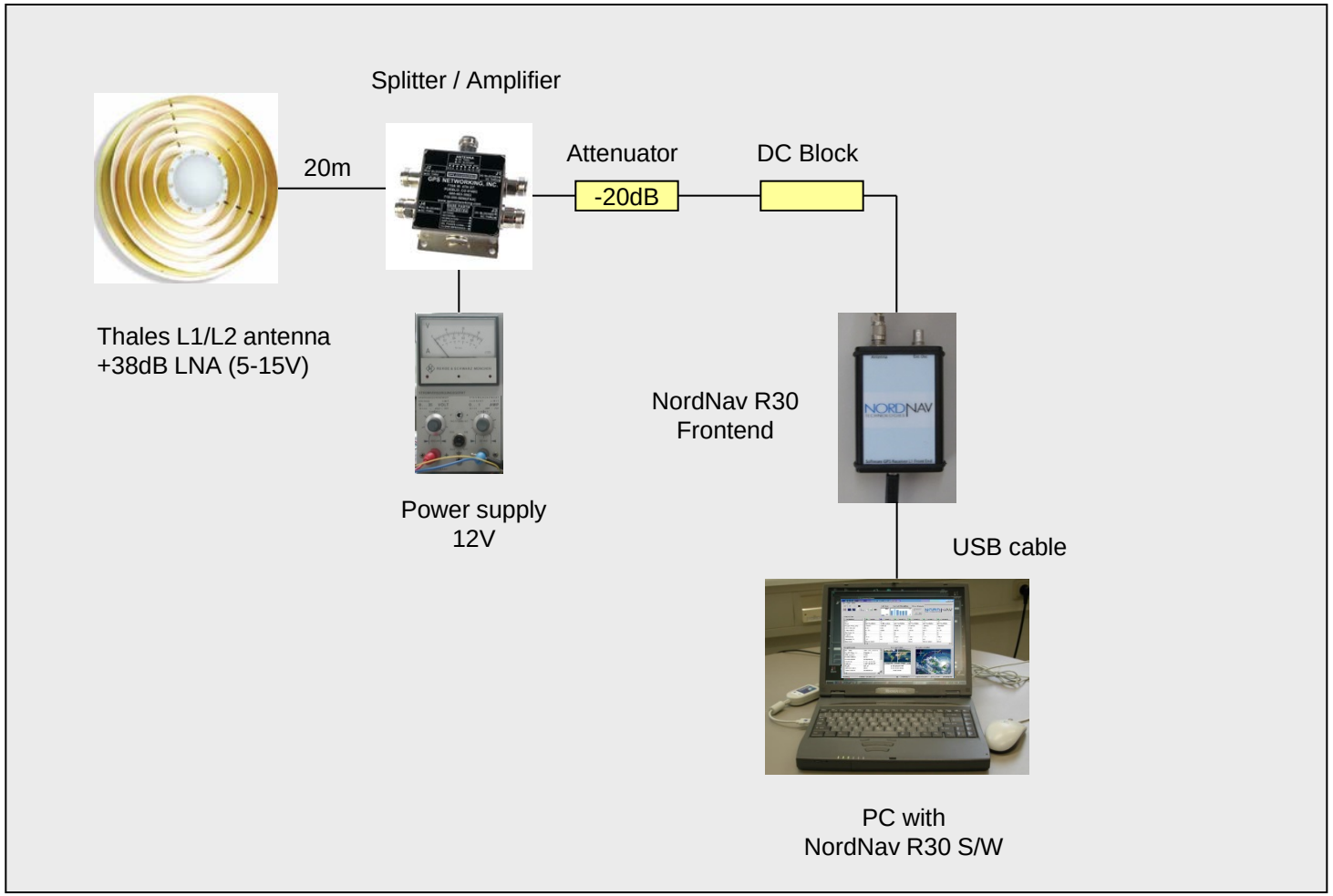


Code Correlation

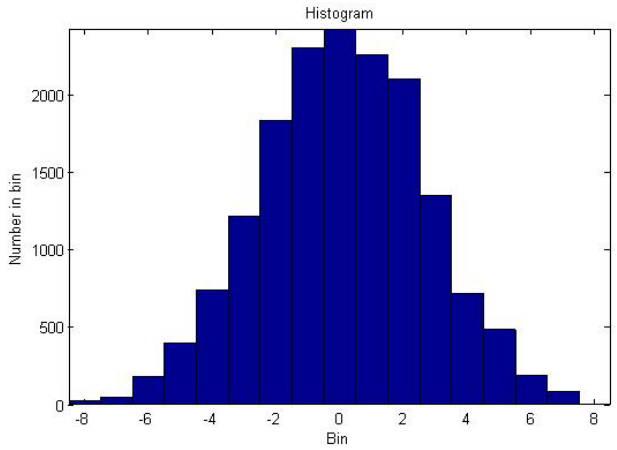


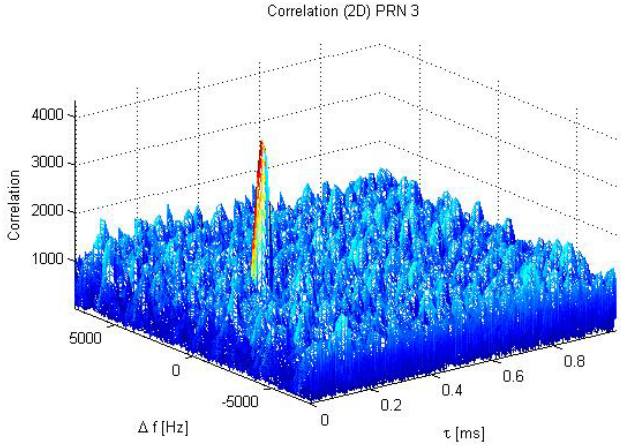


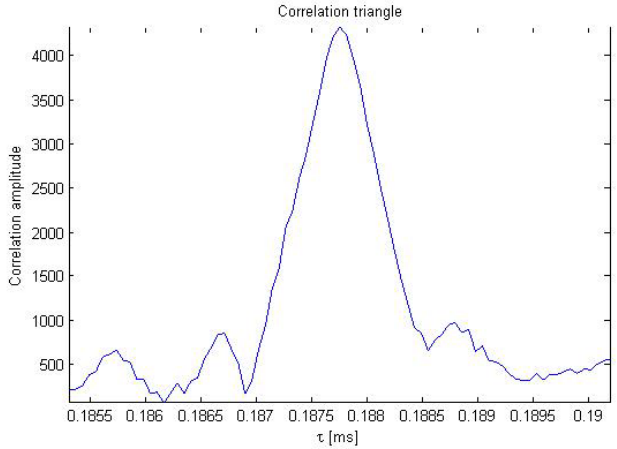
Measurement Setup

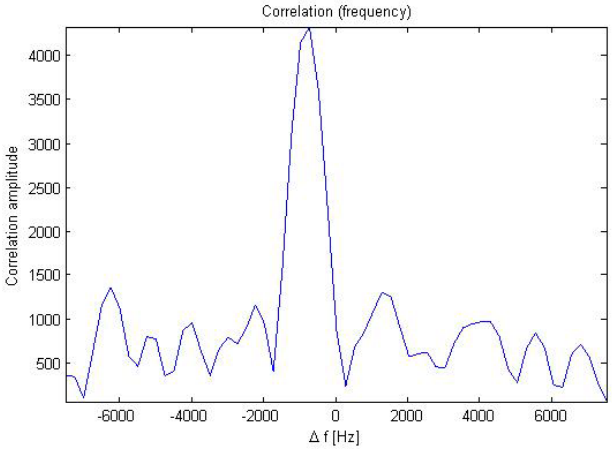


Example


Histogram
Number in bin
Bin
2000
1500
1000
500
0
-8
-6
-4
-2
0
2
4
6
8


Correlation (2D) PRN 3
Correlation
4000
3000
2000
1000
5000
0
-5000
Δ f [Hz]
0
0.2
0.4
0.6
0.8
τ [ms]


Correlation triangle
Correlation amplitude
4000
3500
3000
2500
2000
1500
1000
500
0.1855
0.186
0.1865
0.187
0.1875
0.188
0.1885
0.189
0.1895
0.19
τ [ms]


Correlation (frequency)
Correlation amplitude
4000
3500
3000
2500
2000
1500
1000
500
-6000
-4000
-2000
0
2000
4000
6000
Δ f [Hz]