Satellite Navigation
Lab 2: GPS Signal

Task 1

The C/A codes are generated by combining 2 bit streams generated by maximal period 10 stage: G1 and G2. Different codes are obtained by selectively delaying one of those bit streams.

G1 represents the output of the first LFSR *(Linear feedback shift registers)*, which is generated by the polynomial:

$$G1 = 1 + x^3 + x^{10}$$

and the initial state 1 1 1 1 1 1 1 1 1 1.

G2 represents the output of the second LFSR, whose generator polynomial is:

$$G2 = 1 + x^2 + x^3 + x^6 + x^8 + x^9 + x^{10}$$

And the initial state is 1 1 1 1 1 1 1 1 1 1.

Therefore, we can say:

$$CA\ Code = G1 \oplus G2$$

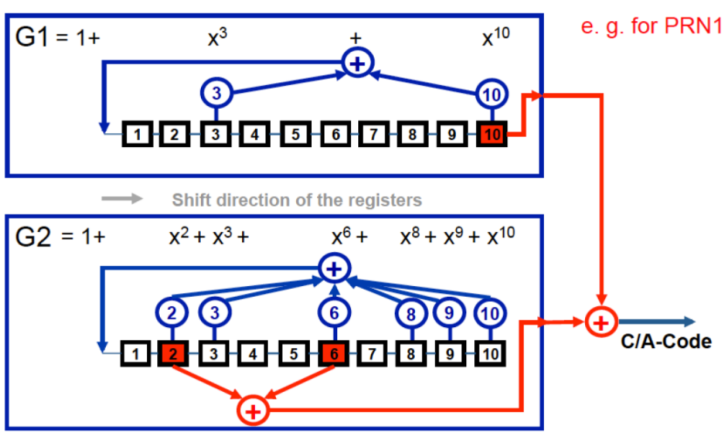

Fig. 1 – C/A Code construction

Using the function “cacode”, we were able to generate a C/A Code, structured in 32 rows, representing the PRN number, and 1023 columns, representing the number of chips, for every satellite (PRN).

For storing the data in a txt. file, we used the following command:

```
ca    = cacode(PRN);
dlmwrite('Data.txt',ca,'\t');
```

Task 2

The C/A code autocorrelation function is a series of correlation triangles with a period of 1023 chips.

The autocorrelation function is computed by the following algorithm and expresses the correlation with the code itself.

$$R(\tau) = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} X(t) \cdot X(t+\tau) dt$$

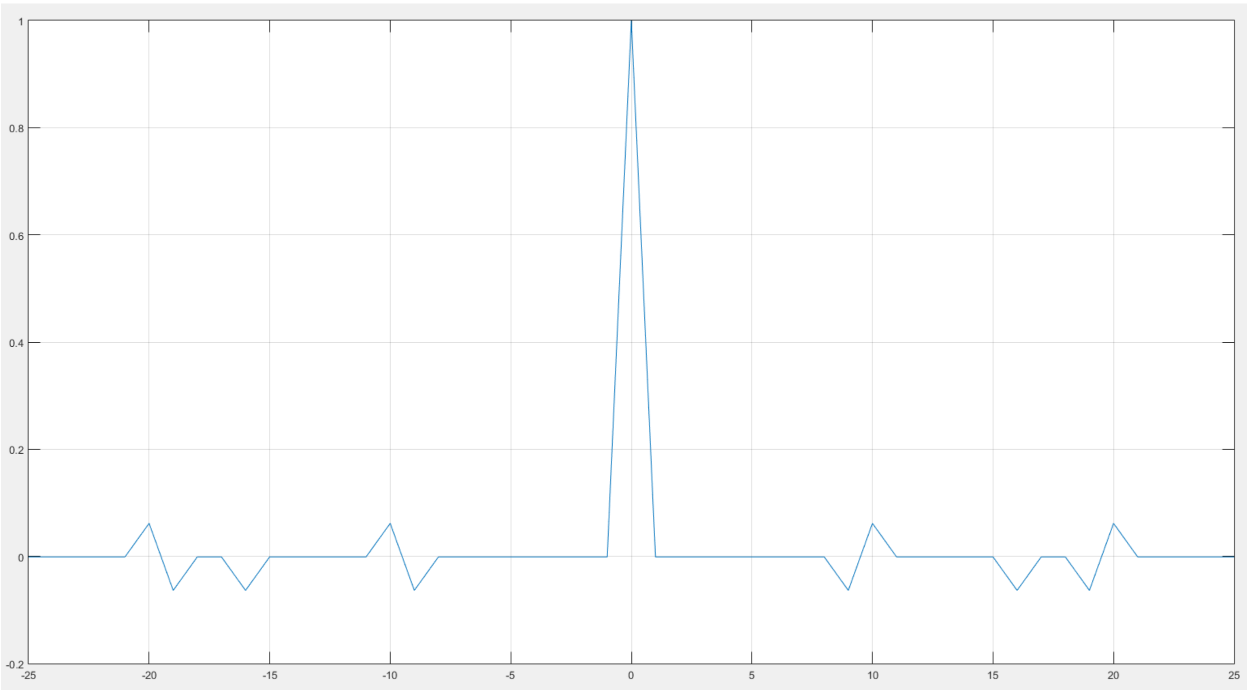

Fig. 2 - Autocorrelation function

The inverse correlation function is computed by the following algorithm and expresses the correlation with the same inverse code.

$$R(\tau) = \lim_{T \to \infty} \frac{1}{T} \int_{-T/2}^{T/2} X(t) \cdot Y(t+\tau) dt$$

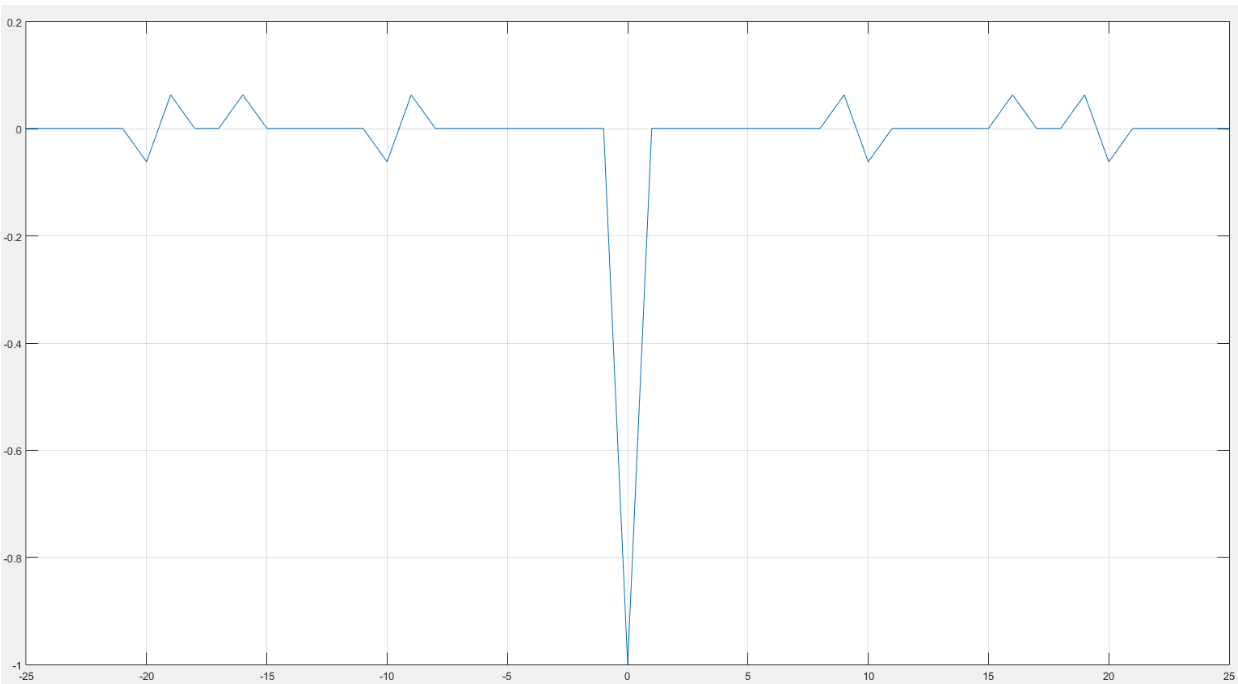

Fig. 3 – Inverse autocorrelation function

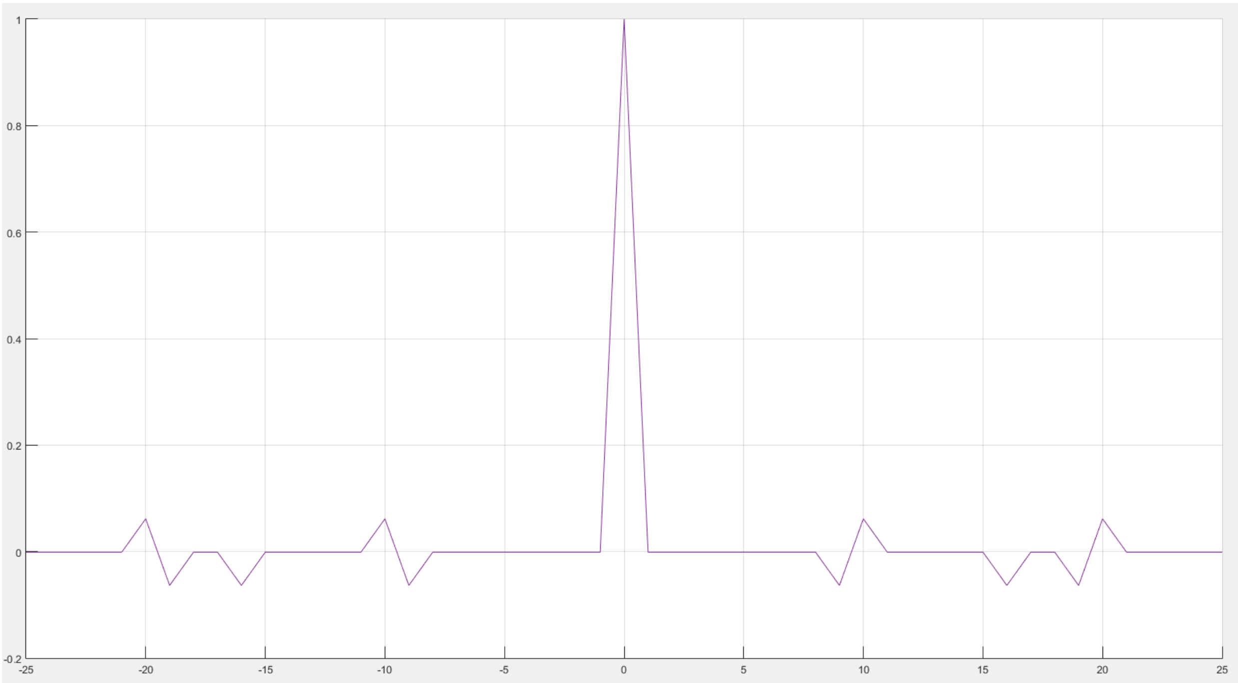

Fig. 4 – Correlation of C/A Code 12 with another C/A Code

Task 3

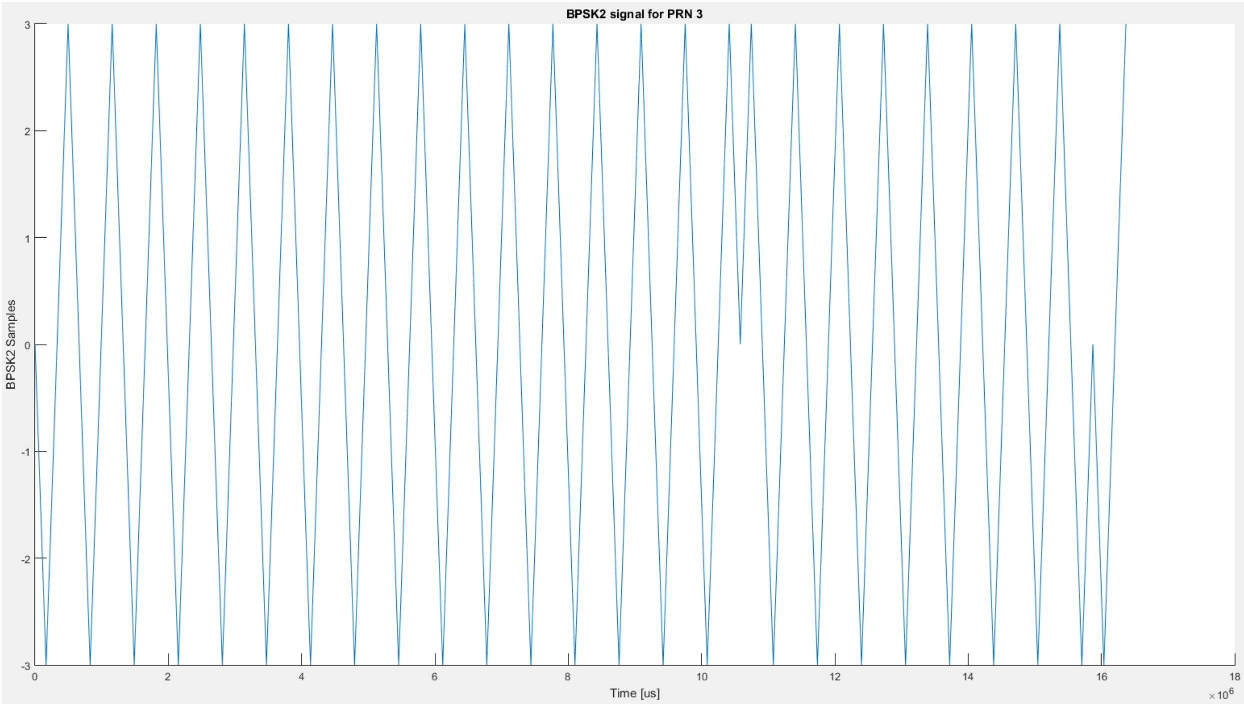

Fig. 4 – BPSK Signal for PRN 3

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
1	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
2	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
3	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
4	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
5	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	1.8377e-14	3	-2.8668e-14	-3	
6	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
7	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	1.8377e-14	3	-2.8668e-14	-3	
8	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
9	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
10	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
11	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
12	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
13	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
14	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
15	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
16	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
17	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	1.8377e-14	3	-2.8668e-14	-3	
18	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
19	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
20	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
21	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
22	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
23	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	1.8377e-14	3	-2.8668e-14	-3	
24	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
25	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
26	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
27	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
28	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
29	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	1.8377e-14	3	-2.8668e-14	-3	
30	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
31	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-
32	0	-3	-3.6739e-16	3	7.3479e-16	-3	-1.1022e-15	3	1.4696e-15	-3	-1.8370e-15	3	2.2044e-15	-3	8.0864e-15	3	-1.8377e-14	-3	2.8668e-14	3	-

Fig.5 – BPSK Signal structure

Task 4

In the Task 4, we used "sort of" correlation function, in order to compute which satellite provides the signal from the "signal.txt" file. Plotting the figure, we observe that the biggest correlation factor is for PRN 11. The used algorithm and the figure are presented in the following rows.

```
%% TASK 4

signal = importdata('signal.txt');
R = 1/16368*BPSK2*signal;
maxR = max(R(:))
Sat_Number = find(R == maxR)

figure
hold on
plot(R,'*');
for x = 1:32;
    text(x, R(x), num2str(x))
end
title('Satellite identification');
ylabel('Correlation');
xlabel('PRN');
```

Fig. 6 - Computation

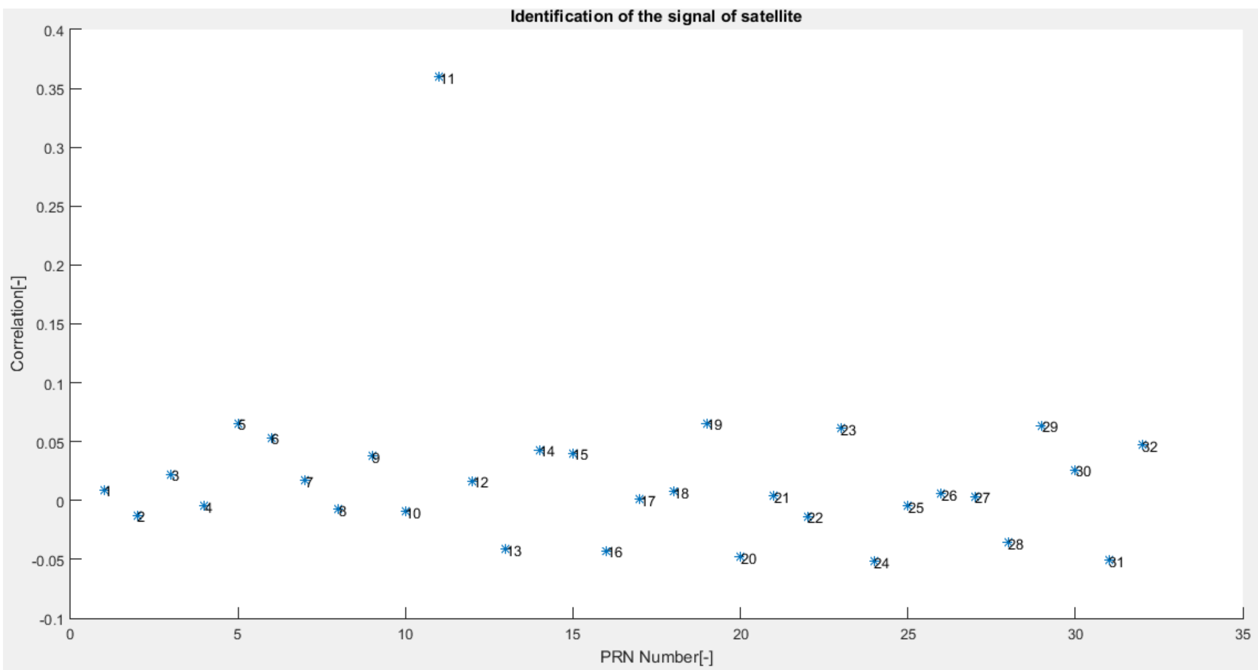

Fig.6 – Identification of the signal of satellite