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Source: Nokia

Further clarification of Nokia's RACH preamble proposal

Introduction

In the meeting No. 4 Nokia presented long random codes for PRACH preambles. This contribution further clarifies this proposal.

Receiver structure

Figure 1 shows the basic principle of the preamble detection. The MF, matched to the spreading code of the preamble filters the signal. The output is divided into 16 branches and each branch is multiplied with the appropriate signature waveform and integrated over 16 bits (delay line). This structure is similar to that in Ericsson's proposal (99)205.

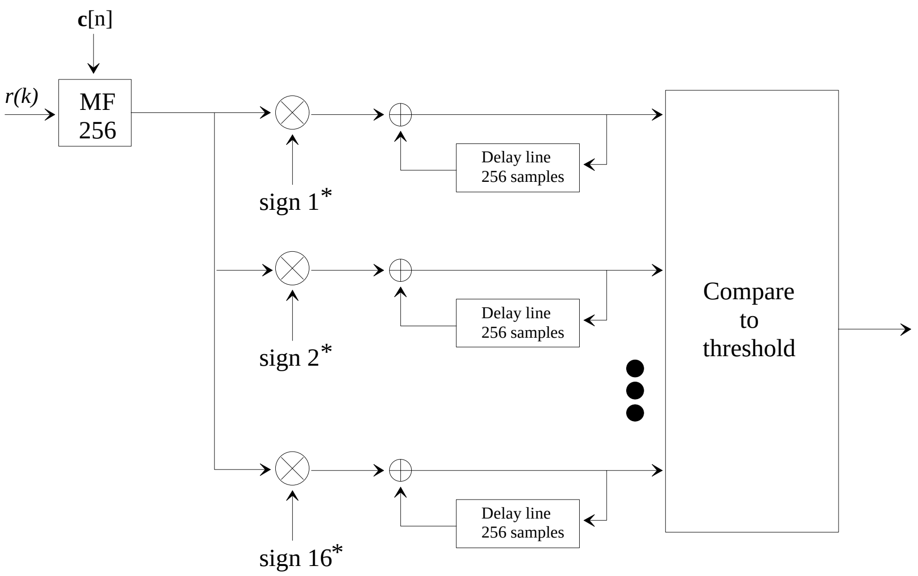

Figure 1. Block diagram of the preamble detector using long codes.

We can assume that the length of the preamble spreading code is 4096 chips and each base station has its own code, transmitted to UE through BCCH. The structure of the MF is shown below in figure 2, assuming 1 sample per chip and MF length of 256 chips. After receiving 256 samples the coefficients $\mathbf{c}[n]=\{\ c_0[n],\ c_1[n],\ \ldots\ ,\ c_{255}[n]\ \}$ of the filter are changed, n=0..15. Only one matched filter is required to receive all 16 signatures.

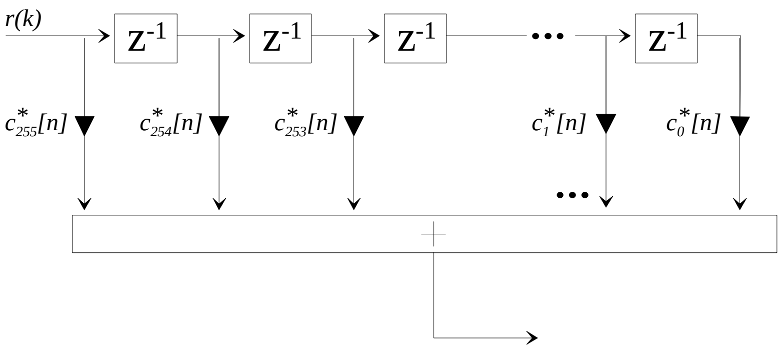

Figure 2. Matched filter.

Note that actual multipliers are not needed since real and imaginary components of c are both either +1 or –1 (simple compare and change sign –operation can be used), and the complexity of the MF is quite small compared to overall complexity of the receiver.

In figure 3 below Golay sequences and random codes as preamble spreading codes are compared. Simulation parameters are listed below:

- Channel: ITU Vehicular A, 120 km/h;
- Preamble/Message power = 0 dB
- Data/control power = 3 dB
- Preamble detection: ideal.
- Diversity: 2 antennas
- 4 fingers, 2 per antenna

If impulse response measurement is based only on preamble, the difference in performance is negligible. But if impulse response is estimated from both preamble and pilot symbols of 8 first timeslots of the message, the gain is about 2 decibels (due to time diversity and SNR improvement in the impulse response) . This is quite easy to implement if long code is used for both preamble and message parts, but if Golay sequences are used in preamble, additional hardware is required for impulse response measurement of the message.

Note also that only one scrambling code generator is needed since the same code is used for both dedicated channels and RACH.

Conclusions

This document clarifies some issues of the receiver structure proposed in [2]. It should be noted that with this proposal the existing HPSK method for reducing the envelope variations can be used in generating the gold code for RACH as well, thus no additional modifications are needed. The associated Tdoc 598/99 provided the text proposal for 25.211 and 25.213 specifications.

The benefits on the proposal can be summarised as follows:

- Allows to achieve the best possible performance

- Auto-correlation function is improved (as demonstrated in the earlier contribution)
- With respect to the new proposal in [1], the pros and cons are:
  - Pro: No extra code generators in UE or Node B side
  - Pro: No modifications needed for the modulation/demodulation side, HPSK can be used as currently.
  - Pro: The same hardware can be used for estimating the impulse response for the message part, no additional hardware needed for optimal performance
  - Con: As an individual component, the matched filter in node B will need more (binary) multiplication and additions.

References

[1] New RACH preambles with low auto-correlation sidelobes and reduced detector complexity / Ericsson

[2] Comments on the proposed RACH sequence structure / Nokia

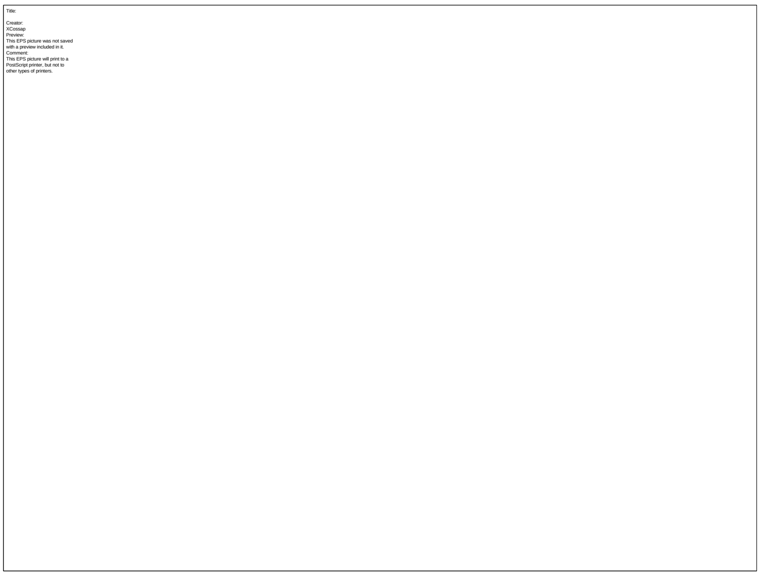

Figure 3. Performance of RACH receiver. Comparison of Golay sequences and random codes as preamble spreading code.

——— Golay sequence in preamble. Only preamble used in impulse response measurement.
– – – Long code in preamble. Only preamble used in impulse response measurement.
o—o– Long code in preamble. Preamble and first 8 timeslots used in impulse response measurement.