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Enhanced Cell Search with Signal Tracking in 3GPP LTE based FDD Receiver[1]

YoungkwonRyu

ERICSSON-LG R&D Center
Anyang, Kyunggi, KOREA
E-mail: youngkwon.ryu@ericsson.com

Bangwon Seo

Division of Electrical, Electronics and Control Engineering
Kongju National University, Cheonan, Chungnam, KOREA
E-mail: seobw@kongju.ac.kr

Jeong Gon Kim*

*: *Corresponding Author*
Dept. of Electronic Engineering, Korea Polytechnic University
Siheung, Kyunggi, KOREA.
E-mail: jgkim@kpu.ac.kr

Abstract

Long Term Evolution (LTE) system of the third generation partnership project (3GPP) has primary (P-SCH) and secondary synchronization channels (S-SCH) to help the terminal search cell.Cell search plays an important role to find a cell and handover to the neighboring cell smoothly. Cell search has usually two modes, which are initial cell search and tracking mode. This paper proposes interference cancelling (IC) technique in both initial cell search and tracking mode. Cancelling the pre-determined SCH from the received signal results in the improved search performance for the next target cell. Simulation results show that the proposed scheme can achieve the improved cell search performance over non-IC scheme in synchronous network environment.

Keywords: LTE, cell search, interference cancellation

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1 Introduction

The user equipment (UE) must perform the cell search process before it starts to communicate with network. During this cell search operation, UE acquires Cell ID and timing information

Timing synchronization across the cells is mandatory in TDD mode. But even in FDD mode, most cells need to be deployed with timing alignment for many beneficial reasons. Cell synchronization may cause the 'hidden cell' problem, which means that the cell to be detected may be hidden behind the serving or stronger cell [1].

Cell search algorithms have been proposed in many papers [2-7]. Most of them focus mainly on the complexity reduction. Cell search with IC generally increase search performance at the cost of increased latency and complexity. Searching for neighbour cell which is done regularly to help handover, has the delay tolerant property and it suggests that there is a room for adopting IC technique in cell search.

2 System with IC

2.1 Initial Cell Search

Overall initial cell searcher system using proposed IC is shown in Figure 1. For the first cell detection, there is no regenerated signal but for the second cell detection, the regenerated signal from the first cell that has been tracked is removed from the original received time domain signal before it is detected. Since interference from the pre-known cells is removed, detection performance for the next cell is improved.

Finite impulse response (FIR) filter is introduced to reduce noise by extracting SCH sequence mapped to the central 1.25MHz bandwidth as shown in [7].

SCH sequence and mapping is specified in [8]. Time domain correlation is used for P-SCH detection and the frequency domain correlation is used for S-SCH detection. And the coherent detection is adopted for S-SCH detection as it has much performance enhancement over non-coherent one as shown in [9]. S-SCH detection using IC in frequency domain is introduced in [10] while this paper proposes to use IC in time domain.

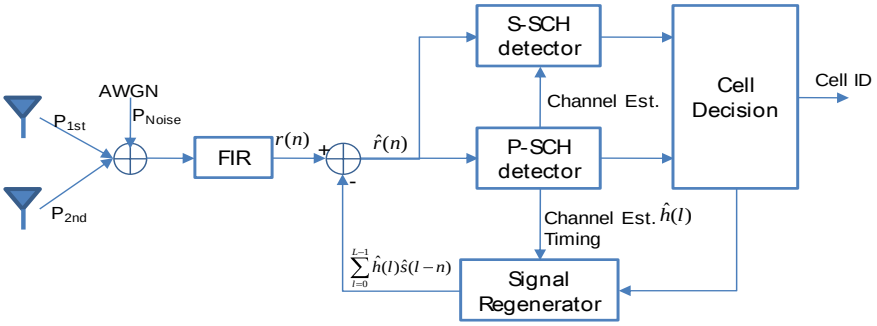

Fig. 1. Cell searcher system with IC

2.2Tracking Mode

Initial search usually requires heavy computational power, which results in limited capacity of transmission and reception. Hence, once the cell is found initially, tracking mode that consumes rather light processing power is generally introduced.

In this paper, the P-SCH tracking method by analyzing frequency domain signal is suggested. By utilizingtiming and cell ID information found in the initial cell search, we can expect that P-SCH signal would be found in some time bounded region although the difference of oscillator between base station and mobile station and movement of the mobile station make time offset from the expected region.

Block diagram for tracking mode operation is shown in Figure 2 in detail. Because the different timingof the cells are already known from the initial cell search, one symbol that is presumed to include P-SCH can be captured in time domain. This symbol long signal is fed to FFT to get frequency domain signal and P-SCH sub-carriers are extracted.

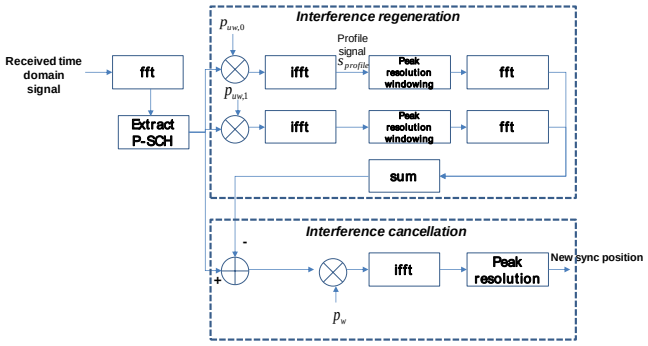

Fig. 2. Block Diagram for Tracking Mode Operation

In order to regenerate interfering signal, the extracted P-SCH is correlated with *j*th unwanted P-SCH sequence, $p_{uw,i}$. After applying IFFT, we get profile signal. By analyzing the power profile of the profile signal with peak resolution windowing, we can easily decide whether interfering P-SCH is included or not in this symbol.

3Simulation Results

The detection performances of both P-SCH and S-SCH detectors using IC technique compared with non-IC are shown in Figure 3.

The P-SCH detector with IC can adopt lower threshold than the other while meeting false alarm rate because it finds peak from interference removed signal, which results in performance gain. The reason of slight poor P-SCH detection performance with IC at low SNR for the second cell detection in 3dB power offset case is that the regenerated signal is not so accurate enough to remove the first cell correctly. But IC gets good cancellation advantage in rather high SNR.

S-SCH detection performances for the first cell are similar for both IC and non-IC detectors as both detectors select physical-layer cell identity group that has the largest correlation value in the same way. But detection performance for the second cell is improved greatly with IC. Since Cell ID is determined by the detection results from both P-SCH and S-SCH, S-SCH that has higher dynamic range than P-SCH would dominate the overall cell search performance.

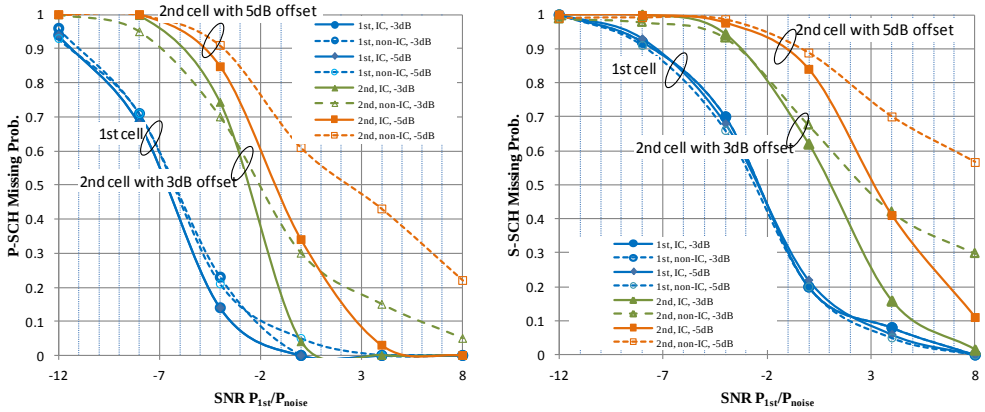

Fig. 3. Performance of cell searcher for P-SCH and S-SCH

Figure 4 shows the missing performance of P-SCH in tracking mode. As shown in the figure, timing detection performance is improved by removing interfering signal.

Main purpose of the initial cell search is to find cells around the mobile terminal. But after the mobile station is turned on, to keep tracking the timing of the serving,the neighbouring cells becomes important in order to do seamless handover to better cell. The performance enhancement for the 1stcell is marginal.The received power gap between the serving and neighbouring cell becomes smallin the cell edge. The curves marked as 0dB in the figure show performance gain of interference cancellation when received powers from the two cells are the same. This shows the tracking performance for the second cell is improved more in the cell edge than in the centre of the cell.

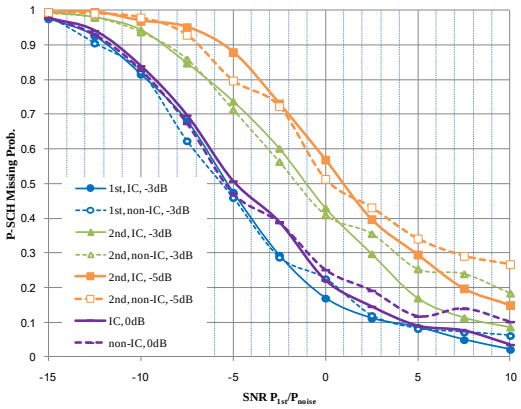

Fig. 4. Performance of P-SCH in tracking mode

4 Conclusion

In this paper, cell search algorithm using IC technique is introduced. Cell search is composed of initial cell search and tracking mode and this paper proposes IC technique for both modes. It is shown from the simulation that IC can improve cell search performance especially for the

second cell which is usually hidden in synchronous network. Synchronous network is mandatory in TDD mode and is very likely even for the FDD system for many beneficial reasons. So the proposed technique can be used widely to improve cell search performance in both systems. Small cells that are expected to be used more and more will make SCH pollution. Proposed technique is advantageous in this environment.

The proposed IC method for initial cell search is done in time domain allowing that the IC scheme can be expanded to other symbols. This suggests that cancelling of SCH can be beneficial for reception of any time domain signal. We can remove cell specific signal which is usually already known before the communication starts. So it is also suggested that removing not only SCH but also cell specific sequence such as reference signal (RS) from other cells would give performance gain further.

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