International Journal of Scientific & Engineering Research, Volume 7, Issue 9, September-2016 779
ISSN 2229-5518

# PSS Generation and Detection In LTE

[1]Sanket Singhania,[2]Smita Lonkar

**Abstract**—A User Equipment (UE) wishing to access an LTE cell must first undertake a cell search procedure. The cell search procedure in LTE begins with a synchronization procedure which makes use of two specially designed physical signals that are broadcast in each cell the Primary Synchronization Signal (PSS) and the Secondary Synchronization Signal (SSS).This paper focuses on the aspects of the physical layer that are designed to facilitate cell search and have simulated the schemes for PSS generation & detection using Cross Correlation.

**Index Terms**—LTE, cell search, PSS, Cross Correlation

## 1 Introduction

The Long Term Evolution of UMTS is one of the latest teps in an advancing series of mobile telecommunications systems. The LTE specification provides downlink peak rates of at least 100 Mbps, and uplink of at least 50 Mbps. LTE supports scalable carrier bandwidths, from 1.4 MHz to 20 MHz and supports both frequency division duplexing (FDD) and time division duplexing (TDD).

3GPP LTE systems are designed to provide higher data rate with superior QoS than its predecessor 3G systems. This requires reliable high data rate systems over limited spectrum over time-dispersive channels. To overcome difficulties such as inter-symbol interference (ISI) introduces by multi-path propogation, Orthogonal Frequency Division Multiple access (OFDMA) gives multiple advantages such as rodurstness against multiple path fading, higher spectrum efficiency and simpler reciver design.

In the LTE system, cell search supports a scalable transmission bandwidth from 1.08 to 19.8 MHz.The cell search is assumed to be based on two signals transmitted in the downlink, primary synchronization signal (PSS) and secondary synchronization signal(SSS).The primary purpose of the synchronization signals is to enable the acquisition of the received symbol timing and frequency of the downlink signal. The cell idenity information is also carried on the synchronization signals.

The synchronization signals PSS and SSS transmitted using the minimum bandwidthof 1.08MHz in the central part of the overall transmission band of the cell. This is because,regardless of the total transmission bandwidth capability of an eNB, a UE should be able todetermine the cell ID using only the central portion of the bandwidth in order to achieve a fast cell search[1].

LTE systems consist of 504 unique physical layer cell identities. To accommodate and manage this large amount, the cell identities are divided into 168 unique cell layer identity groups. Each group further consists of three physical layer identities.

This is usually represented as:

$N^{(1)}_{ID}=0\ldots.167$ and $N^{(2)}_{ID}=0,1,2$.

And Cell Identity: $N^{cell}_{ID} = 3\,N^{(1)}_{ID} + N^{(2)}_{ID}$

This hierarchical cell search procedure is performed in two steps using two signals:

a. Primary Synchronization Signal

b. Secondary Synchronization Signal

The PSS uses Zadoff–Chu(ZC) sequences. These are non-binary unit-amplitude sequences , which exibits a Constant Amplitude Zero Autocorrelation (CAZAC) property.A Zadoff-Chu sequence is a complex-valued mathematical sequence which exhibits the useful property that cyclically shifted versions of it are orthogonal to each other. The SSS sequences are based on maximum length sequences, known as M-sequences, which can be created by cycling through every possible state of a shift register of length n. This results in a sequence of length 2n − 1.[2]

The paper [3] based on partial correlation and mirror symmetrical of PSS, a novel time estimation algorithm is proposed which can combat the effect of frequency offset. Using the correlation between the received PSS and local PSS, frequency offset estimation algorithm is proposed.In the traditional cell search scheme, the receiver performs cross correlation between local PSS and received PSS. This scheme shows good detection performance for low noise level and small frequency offset at the cost of intensive complexity. However, its performance is much limited when the received data is deteriorated seriously either due to low SNR or large frequency offsets. It aslo proposes a novel time and frequency offset estimation algorithm for LTE cell search. Exploiting the character of mirror symmetrical of PSS and the method of partial correlation, the author has proposed to improve the PSS detection probability and obtain more accurate symbol timing estimation. The accuracy of the frequency offset estimation is also improved by the proposed algorithm.

In the paper [4], relying on the PSS time center-symmetric property, PSS autocorrelation method is performed twice in the time domain to obtain and compensate fractional carrier frequency offset. Next, relying on the PSS frequency center-symmetric property, energy difference computations is used to estimate the integral carrier frequency offset, which is equal to the distance between the calculated minimum and the cen-

- P. G. Student, ARMIET ,Asangaon. ,Thane, India singhania12@gmail.com
- H.O.D.,Electronics and Telecommunication Dept ,S.S.Jondhale College of Engineering,Thane, India, smitalonkar@gmail.com

ISSN 2229-5518

tral frequency in frequency domain.The PSS time domain cross-correlation algorithm mainly takes advantage of the good correlation of time-domain PSS.

This paper proposes a novel method for local generation of PSS and using cross correlation between the received signal and the locally generated PSS signal we determine the $N^{ID}_{(2)}$ of the received signal.

## 2 LTE DOWNLINK FRAME STRUCTURE

The downlink transmissions in the LTE system are scheduledon a subframe basis. A subframe of duration 1ms consists of two slots each of duration 0.5 ms. A group of 20 slots (10 subframes) forms a radio frame of duration 10 ms. A slot further consists of seven or six OFDM symbols for the normal cyclic prefix or extended cyclic prefix cases respectively.The PSS and SSS are carried in the frequency domain over the middle six resource blocks using 62 subcarriers out of a total of 72 subcarriers (1.08 MHz). Note that the DC subcarrier is not used for any transmission.

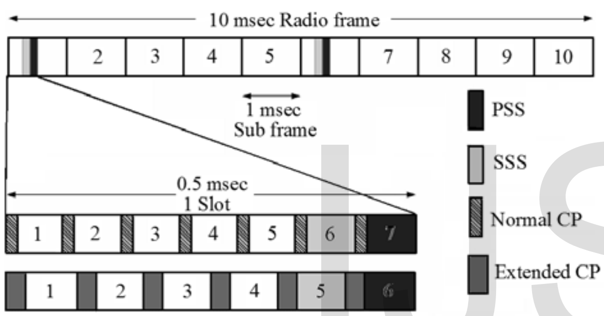



Figure 1 LTE Frame structure

A large number of physical layer cell identities (IDs) simplify the task of network planning. This is because neighboring cells are generally required to use different cell IDs. A total of 504 unique physical layer cell identities are provided. A cell identity is derived from a physical layer cell identity group, $N^{(1)}_{ID}$ in the range of 0–167 and another physical layer identity (within the cell-identity group) $N^{(2)}_{ID}$ in the range 0–2.

## 3PRIMARY SYNCHRONIZATION SIGNAL

PSS provides information about physical layer identity, which can have 3 different values (0-2) depending [5] upon the root index of the Zadoff-Chu sequence (see Table 1)

Table 1. Zadoff-Chu Root Index

| $N^2_{ID}$ | Root Index($u$) |
|---|---|
| 0 | 25 |
| 1 | 29 |
| 2 | 34 |

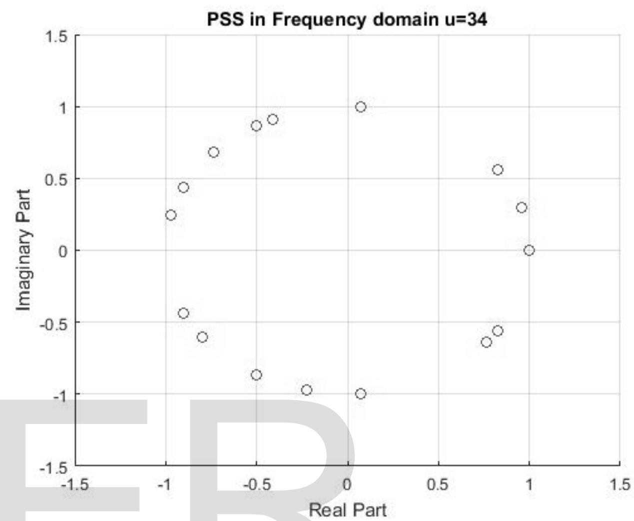
### 3.1 PSS generation

PSS is generated using Equations

$$d_n(n) = \begin{cases} e^{-j\frac{\pi u n(n+1)}{63}}, n=0,1,\ldots,30 \\ e^{-j\frac{\pi u(n+1)(n+2)}{63}}, n=31,32\ldots,61 \end{cases} \quad (1)$$

Primary Synchronization Signal in LTE downlink frame appears twice, first in slot 0 and the then in slot 10. Both the slots carry the same sequence.The Zadoff-Chu sequence of

Figure 2 Generated PSS with Root Index (*u=34*)




length 62 is centered around the d.c. zero frequencyindex subcarrier to avoid d.c. injection.The roots used to generation the PSS with physicallayer identity $N^2_{ID}$ = 0, 1, 2 are u = 25, 29, and 34 respectively. These sets of roots areselected due to good autocorrelation and cross correlation properties, resulting in betterfrequency and time offset sensitivity.The UEuses non-coherent detection, as it detects PSS without prior knowledge of channel.

In the figure 2 we can see that the generated PSS (u=34) is a complex valued unit circle representing a constant amplitude.

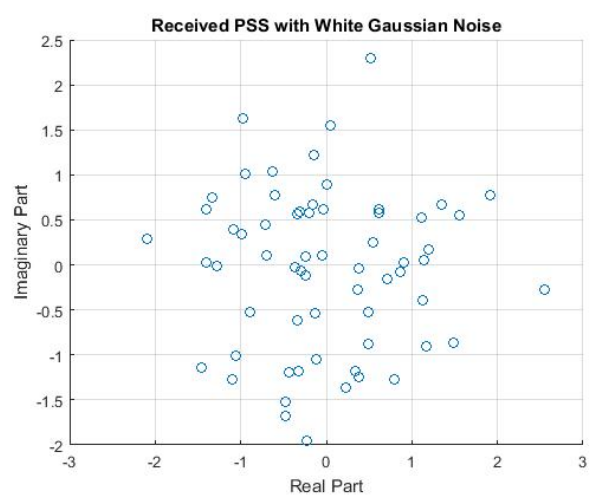



Figure 3 Received PSS signal

3.2 Transmission through Channel

To induce channel effects Additive White Gassuian Noise (AWGN) is mixed with the generated signal. Figure 3 shows the effect of channel noise on the transmitted signal.

3.3 PSS detection

All three images of the possible transmitted PSS are generated at the user equipments. These images are then used to perform cross correlation with the received signal.

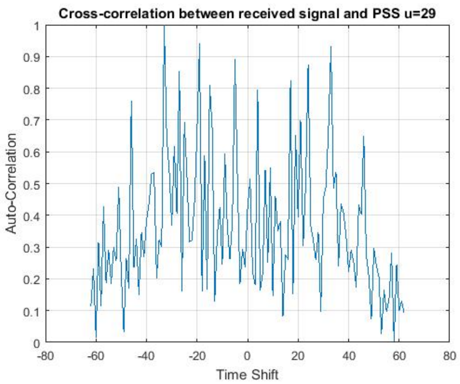



Figure 4(a) Cross-correlation of received signal (u=34) with PSS (u=29)

Figure 4(a) shows the cross correlation results of the locally generated PSS with root 29signal with the received PSS of root 34signal.As expected the plot do not have correlation peaks at zero lag colcluding that this generated signal is differented from the received signal.

Figure 4(b) shows the cross (auto)correlation results betweenreceived signal with root 34 and the locally generated PSS signal of root 34. And it can be clearly seen that the plot has a peak at zero lag implying that both signals are equal.

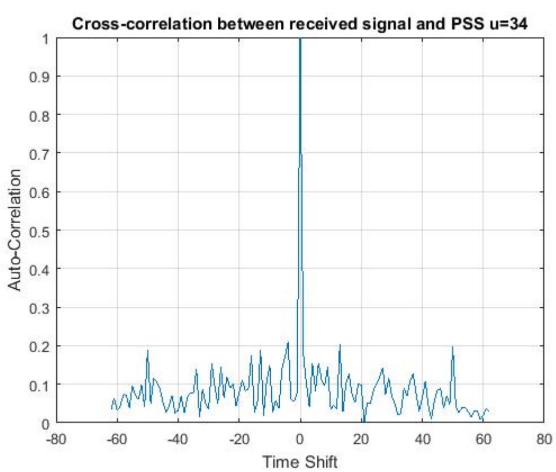



Figure 4(b) Cross-correlation of received signal (u=34) with PSS (u=29)

From this knowledge of the PSS signal the user equipment has information about the $N^{ID}_{(2)}$ of the eNode B in the nearest vicinity.

## 4CONCLUSION

This paper hase identified a novel method for generation and detection of PSSin LTE. The proposed method uses cross correlation technique to detect the received signal with images of all possible expectations of the sequences. The relation gives us peak at zero lag for the matched sequences making the detection simple and effective with least possibilities of false detection.

## REFERENCES

[1] F. Khan, LTE for 4G Mobile Broadband, Air Interface Technologies and Performance, Cambridge University Press, 2009.

[2] B. M. Popovic, 'Generalized Chirp-Like Polyphase Sequences with Optimum Correlation Properties'. IEEE Trans. on Information Theory, Vol. 38, pp. 1406–1409, July 1992.

[3] A Novel Time and Frequency Synchronization for 3GPP LTE Cell Search Yongzhi Yu ,Harbin, Qidan Zhu, IEEE 2012 8th International Conference Wireless CommunicationsNetworking and Mobile Computting

[4] Low-Complexity Carrier Frequency Offset Estimation Algorithm in TD-LTE Dan Wang, Weiping Shi, and Xiaowen Li School of Communication and Information Engineering, Chongqing University of Posts and Telecommunications Chongqing China © 2013 ACADEMY PUBLISHER

[5] Y. Tsai, G. Zhang, D. Grieco, and F. Ozluturk, "Cell search in 3GPP long term evolution systems," IEEE Veh. Technol., vol. 2, no. 2, pp. 23-29, Jun. 2007.