

Sounding Reference signal measurement in LTE system

Eunjeong Shin*, Jeawook Shin**

*ETRI(Electronics and Telecommunications Research Institute), Korea

**ETRI(Electronics and Telecommunications Research Institute), Korea

eishin@etri.re.kr, jwshin@etri.re.kr

Abstract— The SRS are physical signals transmitted in uplink to enable the eNB to estimate the CSI over a range of frequencies in LTE system. The estimation of the CSI assists the eNB scheduler to properly allocated radio resource to the UE. The SRS transmission can be also be used to support downlink beamforming.

The sub-frame in which SRS is transmitted by any UE within the cell is signaled via cell specific broadcast signaling, there are 15 possible sets of subframe in which SRS may be transmitted within each radio frame. The SRS is based on the extended zadoff-chu sequence and transmitted in the last SC-FDMA symbol of an uplink subframe, the SRS transmitted by the UEs are multiplexed in the time and freq. domain through configuring SRS periodicity SRS, frequency comb pattern, and SRS bandwidth.

Different sets of UE-specific sounding signals are independently allocated for SRS transmission, including transmission bandwidth, frequency comb pattern, cyclic shift.

In this paper, transmission subframe, bandwidth, freq. comb pattern, for it suggests ways to reduce the measurement performance and HW complexity of the UE between the Sounding RS separated by a Cyclic shift value and Timing offset measurement method.

Keywords— LTE,SRS,Measurement

I. INTRODUCTION

The SRS are physical signals transmitted in the uplink to enable the eNB to estimate the channel state information over a range of frequencies. The estimation results in eNB assists the scheduler to properly allocated radio resource to UE. And to select different transmission parameters such as the in instantaneous data rate and uplink multi antenna transmission parameters for optimized uplink transmission. The SRS transmission can be used for uplink timing estimation as well as to estimate downlink channel conditions assuming downlink, uplink channel reciprocity. When up/Down channel reciprocity is assumed, SRS measurement can also be used to support downlink transmissions such as angle of arrival measurements on SRS to support downlink beamforming. SRS is not necessarily transmitted together with an uplink physical channel and when transmitted in conjunction with PUSCH, the SRS may cover a different and typically larger frequency region.

In this paper , by sending SRS transmission from multiple UEs to one SRS Transmission BW area , by utilizing the base sequence in the Transmission BW, and reducing the complexity of HW when distinguishing the UE in Cyclic shift it can.

II. SRS TRANSMISSION

The subframe in which SRS is transmitted by any UE within the cell is signalled via cell specific broadcast signalling. Cell specific parameter indicates 15 possible sets of subframes in which SRS may be transmitted within each radio frame.

Reference signal sequence $r_{u,v}^{(\alpha)}(n)$ is defined by a cyclic shift α of a base sequence $\bar{r}_{u,v}(n)$ according to

$$r_{u,v}^{(\alpha)}(n) = e^{j\alpha n} \bar{r}_{u,v}(n), \quad 0 \leq n < M_{sc}^{RS}$$

where $M_{sc}^{RS} = mN_{sc}^{RB}$ is the length of the reference signal sequence and $1 \leq m \leq N_{RB}^{max,UL}$. Multiple reference signal sequences are defined from a single base sequence through different values of α .

Base sequences $\bar{r}_{u,v}(n)$ are divided into groups, where $u \in \{0,1,\dots,29\}$ is the group number and v is the base sequence number within the group, such that each group contains one base sequence ($v=0$) of each length $M_{sc}^{RS} = mN_{sc}^{RB}$. The sequence group number u and the number v within the group may vary in time.

the base sequence $\bar{r}_{u,v}(0), \dots, \bar{r}_{u,v}(M_{sc}^{RS}-1)$ is given by

$$\bar{r}_{u,v}(n) = x_q(n \bmod N_{ZC}^{RS}), \quad 0 \leq n < M_{sc}^{RS}$$

where the q^{th} root Zadoff-Chu sequence is defined by

$$x_q(m) = e^{-j \frac{\pi q m(m+1)}{N_{ZC}^{RS}}}, \quad 0 \leq m \leq N_{ZC}^{RS}-1$$

with q given by

$$q = \lfloor \bar{q} + 1/2 \rfloor + v \cdot (-1)^{\lfloor 2\bar{q} \rfloor}$$

$$\bar{q} = N_{ZC}^{RS} \cdot (u+1)/31$$

The sequence-group number u in slot n_s is defined by a group hopping pattern $f_{gh}(n_s)$ and a sequence-shift pattern f_{ss} according to

$$u = (f_{gh}(n_s) + f_{ss}) \bmod 30$$

if group hopping enabled, The group-hopping pattern $f_{gh}(n_s)$ is

$$f_{gh}(n_s) = \left(\sum_{i=0}^q c(8n_s + i) \cdot 2^i \right) \bmod 30$$

where the pseudo-random sequence $c(i)$ The pseudo-random

sequence generator shall be initialized with $c_{init} = \left\lfloor \frac{n_{ID}^{RS}}{30} \right\rfloor$ at

the beginning of each radio frame where is $n_{ID}^{RS} = N_{ID}^{cell}$.

The sequence shift pattern f_{ss}^{SRS} given by $f_{ss}^{SRS} = n_{ID}^{RS} \bmod 30$ sequence shift pattern

If group hopping is disabled and sequence hopping is enabled, the base sequence number v within the base sequence group in slot n_s is defined by

$$v = c(n_s)$$

The pseudo-random sequence generator shall be initialized with

$$c_{init} = \left\lfloor \frac{n_{ID}^{RS}}{30} \right\rfloor \cdot 2^5 + (n_{ID}^{RS} + \Delta_{ss}) \bmod 30, \quad n_{ID}^{RS} = N_{ID}^{cell}$$

$$\Delta_{ss} \in \{0, 1, \dots, 29\}, \text{ configured by higher layers}$$

Reference signal sequence $r_{u,v}^{(\alpha)}(n)$ can be defined as sounding reference signal sequence.

$$r_{SRS}^{(\tilde{p})}(n) = r_{u,v}^{(\alpha_{\tilde{p}})}(n)$$

The Cyclic shift $\alpha_{\tilde{p}}$ of the sounding reference signal is given as

$$\alpha_{\tilde{p}} = 2\pi \frac{n_{SRS}^{cs, \tilde{p}}}{8}$$

$$n_{SRS}^{cs, \tilde{p}} = \left(n_{SRS}^{cs} + \frac{8\tilde{p}}{N_{ap}} \right) \bmod 8,$$

$$\tilde{p} \in \{0, 1, \dots, N_{ap} - 1\}$$

Where $n_{SRS}^{cs} = \{0, 1, 2, 3, 4, 5, 6, 7\}$ is configured separately for periodic and each configuration of aperiodic sounding by the higher-layer parameters cyclicShift. N_{ap} is the number of antenna ports used for sounding reference signal transmission

III. SRS MEASUREMENT

SRS Demodulation block operates in subframe units, definition of SRS transmission subframe is cell specific parameters.

eNB request an individual SRS transmission from a UE, or configure a UE to transmit SRS periodically until it is no longer necessary. The periodicity of SRS is 2,5,10,20,40,80,160,320ms. The SRS periodicity and SRS subframe offset within the period in which the UE should transmit its SRS are configured via a UE specific dedicated signaling parameters. The SRS transmitted by the UEs are multiplexed in the time and frequency domain through configuring SRS periodicity. Up to eight orthogonal SRS transmissions can be cod-division multiplexed over a frequency region using different cyclic shifts of the root Zadoff-Chu sequence. SRS transmission was not sufficiently flexible to support sounding from an increased number of UE antennas and an increased number of UEs due to use of semi-static RRC signalling for UE configuration. So aperiodic SRS transmission was introduced to complement periodic SRS transmission, where the eNB dynamically schedules a UE for SRS transmission on demand. It allows efficient management if a fixed set of time/frequency/code SRS resources for a larger number of UEs.

SRS transmission share a common set of cell specific SRS resources. It is subframe configuration period, subframe offset, SRS Bandwidth.

Different sets of UE-Specific sounding parameters are independently allocated for periodic and aperiodic SRS transmission including transmission bandwidth, periodicity, frequency comb pattern, and cyclic shift.

The figure below shows a top structure of the SRS measurement block.

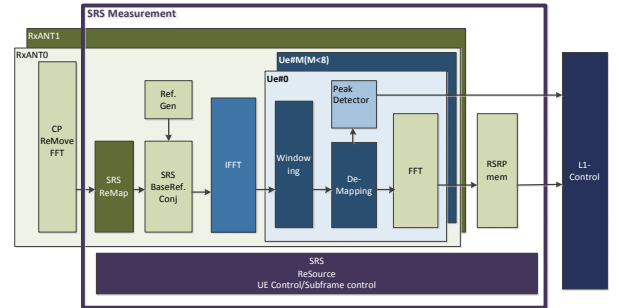


Figure 1. Top structure of SRS measurement block

The SRS measurement block is enabled by L1 Control.

L1 Control Block makes the enable signal by subframe configuration period, subframe offset, SRS bandwidth.

In the Received signal processing, CP removed, and changed to frequency domain signal by FFT block, the SRS measurement block generate the SRS reference signal.

The generated reference signal is base reference signal which cyclic shift value is 0.

Then, conjugated base reference signal are lease squared by received signal.

$$G_u^{(p)}(k) = \tilde{r}_u^{(p)}(k) \times (r_u(k))^*, \quad k = 0, 1, \dots, M_{sc}^{RS} - 1$$

P is antenna index.

Then, least squared signal mapped in IFFT resource.

$$\hat{G}_u^{(p)} = \left[G_u^{(p)}(0), G_u^{(p)}(1), \dots, G_u^{(p)}(M_{sc}^{RS} - 1), \underbrace{0, \dots, 0}_{1024 - M_{sc}^{RS}} \right]$$

Then 1024 point IFFT,

$$g_u^{(p)}(m) = \frac{1}{\sqrt{1024}} \sum_{k=0}^{1024-1} \hat{G}_u^{(p)}(k) \cdot e^{j2\pi mk/1024} \quad m = 0, 1, \dots, 1023$$

IFFT size can be changed by system bandwidth. The IFFT size is associated with a timing accuracy. The timing accuracy varies from system bandwidth.

The out of IFFT, makes the impulse, then Find the greatest impulse in the UE-specific time-axis measures the timing offset.

The figure below shows the results of the IFFT output signal impulse when 8 UE transmits the SRS.

m01, m02 area is a windowing area corresponding to the base sequence. m51, m52 area is a windowing area corresponding to the cyclic shift 5 from the base sequence.

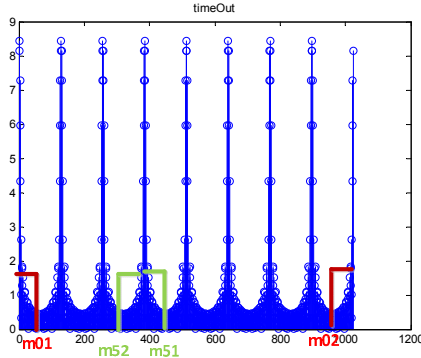


Figure 2. Windowing of IFFT output

Peak detector is a function block to find the greatest signal of the impulse. Peak detector also determines whether the SRS transmission. As shown in the following formula.

$$\eta_u = \frac{y_u^{(p)}(n_{\max})}{\frac{1}{1024/8-1} \left(\sum_{\substack{n=0 \\ n \neq n_{\max}}}^{1024/8-1} y_u^{(p)}(n) \right)}$$

$$y_u^{(p)}(n) = \sum_{p=0}^3 |\tilde{g}_u^{(p)}(m)|^2$$

$$n_{\max} = \arg \max_n y_u^{(p)}(n)$$

Estimated for each UEs channel signal by the windowing is changed to the frequency domain.

$$\tilde{G}^{(p)}(k) = \frac{1}{\sqrt{1024}} \sum_{m=0}^{1024-1} \tilde{g}_u^{(p)}(m) \cdot e^{-j2\pi mk/1024}$$

$$\hat{H}^{(p)}(k) = \tilde{G}_u^{(p)}(k)$$

It estimates the CQI as follows, average power per Resource block.

$$CQI_u^{SRS}(m) = \frac{1}{6P} \sum_{p=0}^{P-1} \sum_{k=6m}^{6m+5} |\hat{H}_u^{(p)}(k)|^2 \quad m = 0, 1, \dots, \lfloor M_{sc}^{RS} / 6 \rfloor - 1$$

The simulation results are as follows.

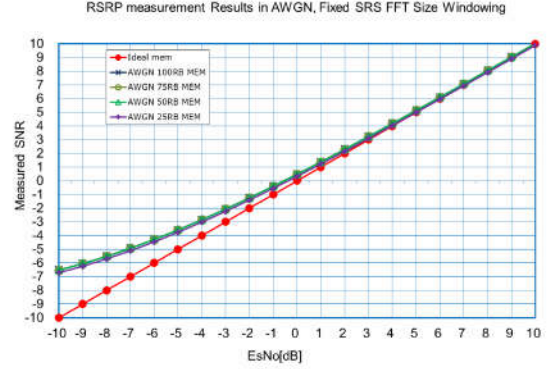


Figure 3. RSRP Results per system BW

The figure below shows the simulation results for a set threshold

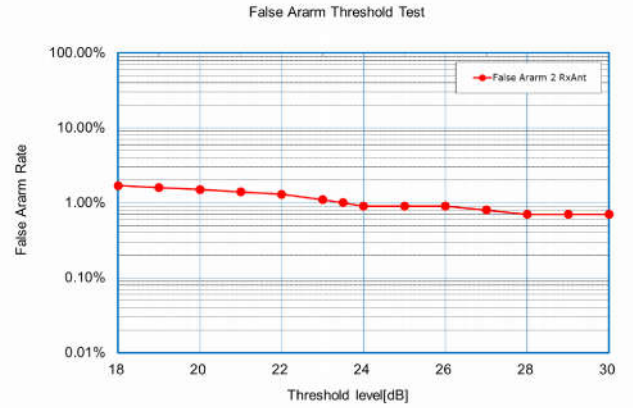


Figure 4. Threshold decision Test

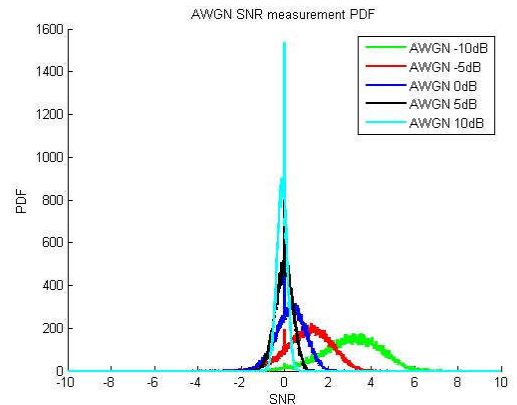


Figure 5. SRS measurement PDF, 25RB, 1024 IFFT

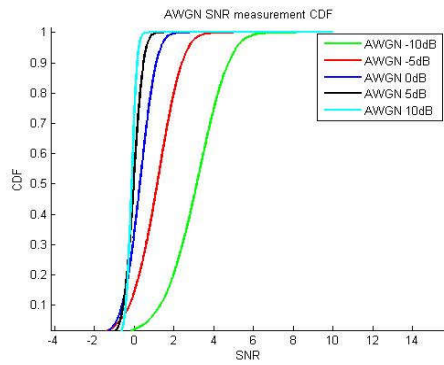


Figure 6. SRS measurement CDF,25RB, 1024FFT

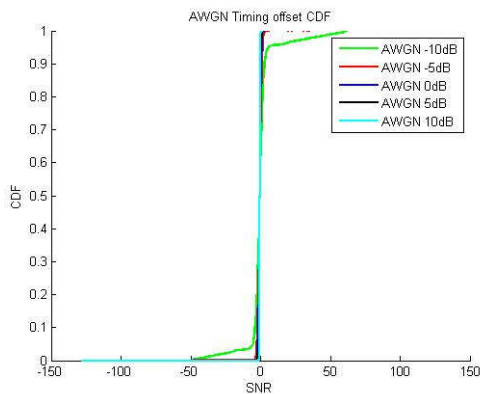


Figure 7. Timing offset CDF, 25RB, 1024 IFFT

The timing resolution of 512 FFT is lower, CDF converge more quickly.

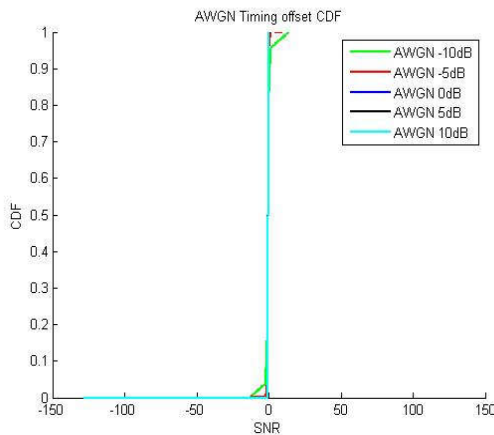


Figure 8. Timing offset CDF, 25RB, 512 IFFT

IV. CONCLUSIONS

In this paper, by using the base sequence proposes a method that can be applied to measurement of the number of UE.

This method reduces the HW complexity. Maximum complexity of SRS measurement, 8 IFFT, 8 FFT operations are needed. But this way, It needs 1 IFFT, 8 FFT operations.

This method is more effective when the multiple SRS measurement BW.

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Eunjeong SHIN received the M.S. degree in telecommunication Engineering from Chungbuk University, South Korea in 2001. She has been working for Electronics and Telecommunications Research Institute (ETRI) as a researcher since 2001. She is currently a director of radio transmission technology section in ETRI. Her current research interests include 5G mobile telecommunication, D2D and M2M



Jaewook SHIN received the M.S. degree from the Kyungpook National University, South Korea in 1994 and Ph.D. degree in computer science from the Chungnam National University, South Korea in 2005. He has been working for Electronics and Telecommunications Research Institute (ETRI) as a researcher since 1994. He was a visiting researcher at the University of California, Irvine in 2012. He is currently a director of radio transmission technology section in ETRI. His current research interests include 5G mobile telecommunication, D2D and M2M..