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Title	A method of designing the RS amble sequence
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Source(s)	Li Geng, Liu Qiaoyan li.geng@zte.com.cn Zhao Lu, Yu Qiuxing Tan Hanxi, Gong Yuanyuan liu.qiaoyanxa@zte.com.cn ZTE corporation R&D Center Xi An P.R China. 710065 zhao.lu@zte.com.cn
Abstract	This contribution provides a simple method of designing the RS amble sequence for the purpose of synchronization, channel estimation, carrier frequency estimation. The RS amble sequence should have properties very similar to the frame start preamble to minimize the impact on the existing standard and also enable reuse of existing technology defined for SS/MS receiver at the RS receiver.
Purpose	For discussion and approval of inclusion of the proposed text into the P802.16j baseline document.
Notice	
Release	
Patent Policy and Procedures	

A method of designing the RS amble sequence

1. Introduction

Based on the frame structure accepted by the baseline document, a RS amble is transmitted for the purposes as follows:

1) Downlink synchronization: RS amble can be used by a relay station (RS) to obtain the time synchronization, carrier frequency estimation and channel response estimation.

2) monitor: enable other RS(s) and BS(s) to monitor the RS(s) and BS(s) in their coverage areas.

RS amble sequence should have properties very similar to the frame start preamble to minimize the impact on the existing standard and also enable reuse of existing technology defined for SS/MS receiver at the RS receiver.

The proposed methods for designing RS amble sequence are listed as follows :.

1) RS amble is to use the same preamble sequence specified for IEEE 802.16e.The differentiation between the access zone amble and the relay zone amble should take place based on the FCH and MAPs following the preamble. However, this solution will cause problems since MSs could detect the same preamble twice in one frame, extending all the related network entry procedures.

2) RS amble is reusing the same PN sequence but allocating to the new relay amble sequence different (lower) amplitude. However, in the high mobility environment it could be expected that fast-fading could cause significant variation in path loss across the subframe that differentiation through amplitude will not be reliable.

3) Spliting the pool of 114 PN sequences into two smaller PN sub-pools: one allocated for BSs and another one re-allocated for RSs. This solution has the disadvantage of a relative small pool of RS sequences.

4) The relay amble series are obtained by reversing the corresponding preamble series in IEEE802.16e 8.4.6.1.1 for FFT size of 2048 and 1024. However, this solution will cause problems that one originality preamble can only produce one RS amble.

2. Detail

This contribution introduces a method for designing RS amble modulation series, avoiding the drawbacks related to the other solutions outlined above.

BS firstly uses the method proposed in this contribution and the threshold limit value (

$TLV1, TLV2$ and $TLV3$) of the cross-correlation for selecting new RS amble from sequences obtained by circle-shifting original preamble. Where the values of $TLV1, TLV2$ and $TLV3$ are determined by simulation in advance and the practical measurements.

The procedure includes the following steps:

1) The BS Circle-shifts the original preamble modulation series $PN_i, i \quad 0,1,\ldots,113$ (specified in 8.4.6.1.1 in IEEE 802.16-2005) j bit (j is between 0 and 567, 283, 143 , 35 respectively for FFT Size of 2048, 1024, 512 ,128) and obtains the new sequence of the $PN_i\ j\ , i \quad 0,1,\ldots,113$.

2) The BS computes the coefficient of cross-correlation between $PN_i\ j$ and PN_i. The BS selects the $PN_i\ k$ sequence based on (1).

$$|\mathrm{PN_i} \quad \mathrm{PN_i(k)}| \quad TLV1, k \quad j \ldots\ldots\ldots\ldots\ldots (1)$$

$TLV1$ is a threshold limit value (TLV) of the coefficient of cross-correlation. The value of $TLV1$ decides the new amble sequence's interference to original preamble sequence. In general, $TLV1$ is set to be zero.

3) The BS computes the coefficient of cross-correlation between $PN_i\ n$ and $PN_i(m)$. The BS selects the $PN_i\ n$ sequence based on (2).

$$|\mathrm{PN_i}\ n \quad \mathrm{PN_i(m)}| \quad TLV2, n \quad m, n, m \quad k \ldots\ldots\ldots\ldots\ldots (2)$$

$TLV2$ is a TLV of the coefficient of cross-correlation. The value of the $TLV2$ decides the interference level between one sequence and another sequence, both sequences are contained in $PN_i\ k$. In general, we should set the value of $TLV2$ lower than maximum cross-correlation of original Preambles.

4) The BS computes the coefficient of cross-correlation between $PN_i(d)$ and $PN_x(l)$. The BS selects the $PN_i^R(t)$ sequence based on (3).

$$\left|PN_i^R(t) \quad PN_x(l)\right| \quad TLV3, i \quad x, i, x \quad 0,1,\Lambda\, 113, t \quad n \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$TLV3$ is a TLV of the coefficient of cross-correlation. The value of the $TLV3$ decides the interference level between sequences obtained from PN_i and another sequences obtained from PN_x. All those sequences should satisfy equation (1) and (2). In general, we should set the value of $TLV3$ lower than maximum cross-correlation of original Preambles.

The BS saves all PN_i^R sequences as RS amble pool. The i is related to the indexes of BS's Cell and BS's Segment.

After the RS completes the procedure of initial network entry, the BS to which the RS attached selects a RS amble sequence which has not assigned to the other RSs from RS amble pool and assigns it to currently RS using a message. If there is no usable RS amble in pool, the BS can change the value of $TLV1$, $TLV2$ and $TLV3$ and creates new ambles to the RS amble pool.

The RS amble modulation series in pool have the following properties:

1) The new RS amble modulation series have the same PAPR performance and amplitude as the original preamble sequences.

2) The cross-correlation between new RS amble series and the original preamble is zero; the cross-correlation between different RS amble sequences obtained by circle-shifting the same preamble series is lower than maximum cross-correlation of original preambles; the cross-correlation between RS amble sequences obtained by circle-shifting different preamble series is lower than maximum

cross-correlation of original preambles.

3) The relay amble series has a simple relationship with the corresponding preamble series and is easy to be implemented

4) The number of new RS amble can be changed by changing the Threshold Limit Value (TLV)

3. Specific text changes

8.4.6.1.1.3 Relay amble

The BS obtains the relay amble series $PN_i^R, i \quad 0, 1, \ldots, 113$ from $PN_i \; j, i \quad 0, 1, \ldots, 113$ which is obtained by circle-shifting the corresponding preamble series (specified in 8.4.6.1.1 in IEEE802.16-2005) j bit (j is between 0 and 567, 283, 143, 35 respectively for FFT Size of 2048, 1024, 512, 128) through selecting by using $YLV1, TLV2$ and $TLV3$. The values of $TLV1, TLV2$ and $TLV3$ are determined by simulation in advance and the practical measurements.

The procedure includes the following steps:

1) The BS selects $\mathrm{PN}_i(\mathrm{k})$ from $\mathrm{PN}_i(\mathrm{j})$ based on equation (1_xxx).

$$|\mathrm{PN}_i \quad \mathrm{PN}_i(\mathrm{k})| \quad TLV1, k \quad l \text{ .... (1\_xxx)}$$

Where $TLV1$ is set in advance. Generally, $TLV1$ is set to be zero.

2) The BS selects $\mathrm{PN}_i(\mathrm{n})$ from $\mathrm{PN}_i(\mathrm{k})$ based on equation (2_xxx).

$$|\mathrm{PN}_i \; n \quad \mathrm{PN}_i(\mathrm{m})| \quad TLV2, n \quad m, n, m \quad k \text{ ....(2\_xxx)}$$

Where $TLV2$ is set in advance. Generally, $TLV2$ is lower than maximum cross-correlation of original Preambles.

3) The BS selects $PN_i^R(t)$ from $PN_i(n)$ based on equation (3_xxx).

$$|PN_i^R\ t \quad PN_x(l)| \quad TLV3, i \quad x, i, x \quad 0,1,\wedge 113, t \quad n \text{ ....} \quad (3\_xxx)\ .$$

Where $TLV3$ is set in advance. Generally, $TLV3$ is lower than maximum cross-correlation of original Preambles.

The BS saves all the PN_i^R sequences obtained through above procedures as RS amble pool, where i is related to the index of BS's IDcell and Segment. After the RS completion the initial network entry procedure, the BS to which the RS is attached selects a RS amble sequence which has not assigned to the other RS from RS amble pool and assigns this amble to the RS through the message in Table 1_xxx.

Table1_ xxx RNG-RSP message format

Name	Type (bit)	Length	Notes
Cyc_Num_bit	14	9	Index of circle-shift numbers The range is from 0 to511

The BS only informs the RS the bits of circle-shift instead of the RS amble sequences. RS receives the bits of circle-shift and correspondingly circle-shifts the preamble obtained during initial network entry. After these procedures the RS obtains its amble sequence.

When there is no RS amble in pool, the BS can changes the values of $YLV1, TLV2$ and $TLV3$, and creates new RS amble sequences to RS amble pool.

Both the value of $TLV2$ and $TLV3$ should be lower than the maximum cross-correlation of original Preambles. The maximum cross-correlation of original preambles is listed in table 2_xxx.

Table 2_XXX. Maximum cross-correlation between preamble series

FFT Size	2048	1024	512	128
Maximum cross-correlation of Preambles	0.166	0.162	0.236	0.444

References

1. IEEE 802.16-2004 “IEEE Standard for Local and Metropolitan Area Networks – Part 16”

2. IEEE 802.16e-2005