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Title	A method of designing the RS amble sequence
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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	
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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) In 80216j-06_026r3 document, ~~The~~ 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.; for FFT size of 512 and 128, the relay amble series shall be obtained by circle-shifting the corresponding preamble series 2 and 1 bit respectively. However, this solution will cause problems that one originality preamble can only produce one RS amble. In some scenes, the number of relay amble may not enough, for example in one sector/cell has two relay stations in first hop, if two relay stations use the same relay amble, they may bring interference to each other.

5) In 80216j-06_026r3 document, the cross-correlation between the relay amble and the same index preamble in access zone is same as the original preamble series. It is not good for avoiding the possibility of false amble series detection at the MSs or RSs caused by interference.

6) In 80216j-06_026r3 document, it is need to provide complicated avoiding conflict mechanism, because all RSs in same sector of a cell use the same relay amble. It may cause false amble series detection and strong interference if there are not avoiding conflict mechanism.

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 ~~(~~$TLV2$ (A and $TLV3$ ~~)~~ B) of the cross-correlation for selecting new RS amble from sequences obtained by circle-shifting original preamble. Where the values of $TLV2$ A and $TLV3$ B are determined by simulation in advance and the practical measurements. The values of A and B should lower than the maximum cross-correlation of original preambles.

The procedure includes the following steps:

1) The BS Circle-shifts the own~~original~~ preamble modulation series $PN_i, i = 0,1,\ldots,113$ (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 $PN_i(j), i = 0,1,\ldots,113$.

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).

$$|PN_i \; PN_i(k)| \quad 0, k \quad j \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$TLV1$ ~~is a threshold limit value (TLV) of the coefficient of cross-correlation.~~ The equation (1) ~~value of~~ $TLV1$ decides the ~~new~~ amble sequence $PN_i(k)$ ~~'s~~ having no interference to ~~original~~ the same index preamble sequence. ~~In general,~~ $TLV1$ ~~is set to be zero.~~

3) The BS computes the ~~coefficient of~~ cross-correlation between $PN_i(n)$ and $PN_i(m)$ which are contained in $PN_i(k)$ .The BS selects the $PN_i(n)$ sequence based on (2).

$$|PN_i(n) \cdot PN_i(m)| \le A, n \ne m, n,m \in k \ldots\ldots\ldots\ldots\ldots(2)$$

The threshold limit value A $TLV2$ is a TLV of the coefficient of cross-correlation. The value of the $TLV2$ A decides the interference level between different relay amble in same sector of a cell~~one sequence and another sequence, both sequences are contained in~~ $PN_i(k)$. In general, we should set the value of $TLV2$ Alower than maximum cross-correlation of original ~~Preambles~~preambles.

4) The BS computes the ~~coefficient of~~ cross-correlation between $PN_i(d)$ and $PN_x(l)$. $PN_x(l)$ are the relay amble series used in neighboring cell or sector. The BS selects the $PN_i^R(t)$ sequence based on (3).

$$|PN_i^R(t) \cdot PN_x(l)| \le B, i \ne x, i,x \in \{0,1,\ldots,113\}, t \in n \ldots\ldots\ldots\ldots\ldots(3)$$

the threshold limit value B $TLV3$ is a TLV of the coefficient of cross-correlation. The value of the $TLV3$ B decides the interference level between relay amble series in different sector/ cell. The $PN_x(l)$ should satisfy equation (1) and (2).~~sequences obtained from~~ PN~~and another sequences obtained from~~ PN~~.All those sequences should satisfy equation (1) and (2).~~ In general, we should set the value of $TLV3$ B should lower than maximum cross-correlation of original ~~Preambles~~preambles.

The BS saves all PN_i^R sequences as ~~RS~~ relay amble pool. The i is the same index to the preamble in access zone.~~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 threshold limit value A and B ~~the value of~~ $TLV2$ ~~and~~ $TLV3$ and creates new ambles to the ~~RS~~relay 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 relay amble sequences in same sector of a cell~~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 relay amble sequences in different sector/cell~~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)

Table 1 provides the statistical number of relay amble series which satisfy all equations above ,and the value of $TLV2$ TLV Aand $TLV3$ TLVBare set to the aximum cross-correlation of preambles.

Table 1 The statistical number of relay amble series

FFT Size		2048		1024		512		128	
~~TLV2~~ TLVA	~~TLV3~~ TLVB	0.166	0.166	0.162	0.162	0.236	0.236	0.444	0.444
Max number		81		63		49		28	
Mean number		58		41		33		19	
Min number		43		23		21		11	

3. Specific text changes

8.4.6.1.1.3 Relay amble

The BS obtains the relay amble series $PN_i^R, i \;\; 0,1,\ldots,113$ from $PN_i \; j, i \;\; 0,1,\ldots,113$ 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 equation(1), equation(2) and equation(3). $TLV1, TLV2$ ~~and~~ $TLV3$ ~~.~~ The values of $TLV2$ A and $TLV3$ B are determined by simulation in advance and the practical measurements. The threshold limit value A and B should lower than the maximum cross-correlation of original preambles.

The procedure includes the following steps:

1) The BS selects $PN(k)$ from $PN(j)$ based on equation (1_xxx).

$$|PN \;\; PN(k)| \;\; 0, k \;\; l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1\_xxx)}$$

Where $PN(j)$ is obtained by circle-shifting the same index preamble. Where j is between 0 and 567, 283, 143 , 35 for FFT Size of 2048, 1024, 512 ,128 respectively.

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

2) The BS selects $PN_i(n)$ from $PN_i(k)$ based on equation (2_xxx).

$|PN_i\ n \quad PN_i(m)| \quad A, n \quad m, n, m \quad k$ ....(2_xxx)

Where the threshold limit value A $TLV2$ is set in advance. Generally, the threshold limit value A $TLV2$ ~~is~~ should lower than maximum cross-correlation of ~~original Preambles~~preambles. $PN_i\ n$ and $PN_i(m)$ are contained in $PN_i(k)$.

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

$|PN_i^R\ t \quad PN_x(l)| \quad B, i \quad x, i, x \quad 0,1,\Lambda\ 113, t \quad n$........... (3_xxx) .

Where the threshold limit value B $TLV3$ is set in advance. Generally, the threshold limit value B $TLV3$ is lower than maximum cross-correlation of ~~original Preambles~~preambles. $PN_x(l)$ are the relay amble series in neighboring cell or neighboring sector and should satisfy equation (1_xxx) and (2_xxx). The threshold limit value of A and B should be set by BS 's vendor.

The BS saves all the PN_i^R sequences obtained through above procedures as ~~RS~~ the relay amble pool, where i is ~~related to the index of BS's IDcell and Segment~~the same index as the preamble. 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 threshold limit value A and B~~the values of~~ $TLV2$ ~~and~~ $TLV3$, and creates new RS amble sequences to RS amble pool.

Both the threshold limit value A and B ~~the value of~~ $TLV2$ ~~and~~ $TLV3$ should be lower than the maximum cross-correlation of ~~origina~~l ~~Preambles~~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