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Title	**The Incremental Redundancy H-ARQ for Convolutional Coding**
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Re:	For consideration in Working Group Recirculation Ballot #14, on P802.16e.
Abstract	The Incremental Redundancy H-ARQ for Convolutional Coding is proposed.
Purpose	Adoption
Notice	
Release	
Patent Policy and Procedures	

The Incremental Redundancy H-ARQ for Convolutional Coding

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1. Introduction

The basic idea of Incremental Redundancy (IR) based H-ARQ is taking the puncture pattern into account, and for each retransmission the coded block is not the same. Different puncture patterns are used to create the retransmission FEC block. The puncture patterns are predefined or can be easily deducted from the original pattern, and can be selected based on retransmission number. At the receiver, the received signals are depunctured according to its specific puncture pattern, which is decided by the current retransmission number, then the combination is performed at bit metrics level. The pros of this scheme are:

1. The combined version becomes a low rate code instead of a punctured code because of the puncture pattern change. The additional coding gain can be obtained. Our simulation results show nearly 1 dB addition gain over conventional Chase Combining (CC) in both AWGN and Rayleigh fading channel.
2. The retransmission block length can be flexible by choosing the puncture pattern with different puncture length.
3. The decoding complexity is almost the same as CC.
4. Compatible with conventional chase combining.
5. Only minor modification is needed.

2. Simulation results

This IR H-ARQ scheme is evaluated over both AWGN and uncorrelated Rayleigh fading channel. The modulation is QPSK. The channel coding scheme is _ punctured convolutional code, which is a puncture version from _ mother code is. In the simulation, 3 retransmissions are allowed. The puncture pattern for the n-th retransmission is generated by cyclically shifting n columns based on the original puncture pattern in the current standard.
For example, the original puncture pattern is [1,0,1;1,1,0] as Table 317 in 802.16 D5; the puncture patterns for the 1^{st}, 2^{nd}, and 3^{rd} retransmission are [1,1,0;0,1,1], [0,1,1;1,0,1] and [1,0,1;1,1,0], respectively. For the _ conventional code, we can regard the puncture pattern as [1 1 1;1 1 1], the IR scheme becomes conventional CC.
The simulation results are showed in Fig.1~4 for AWGN and uncorrelated Rayleigh channel, Block size 512 byte and 64 bytes. The IR HARQ has almost 1 dB gain compared to conventional CC H-ARQ over AWGN. In Rayleigh fading channel, the gain is even better.

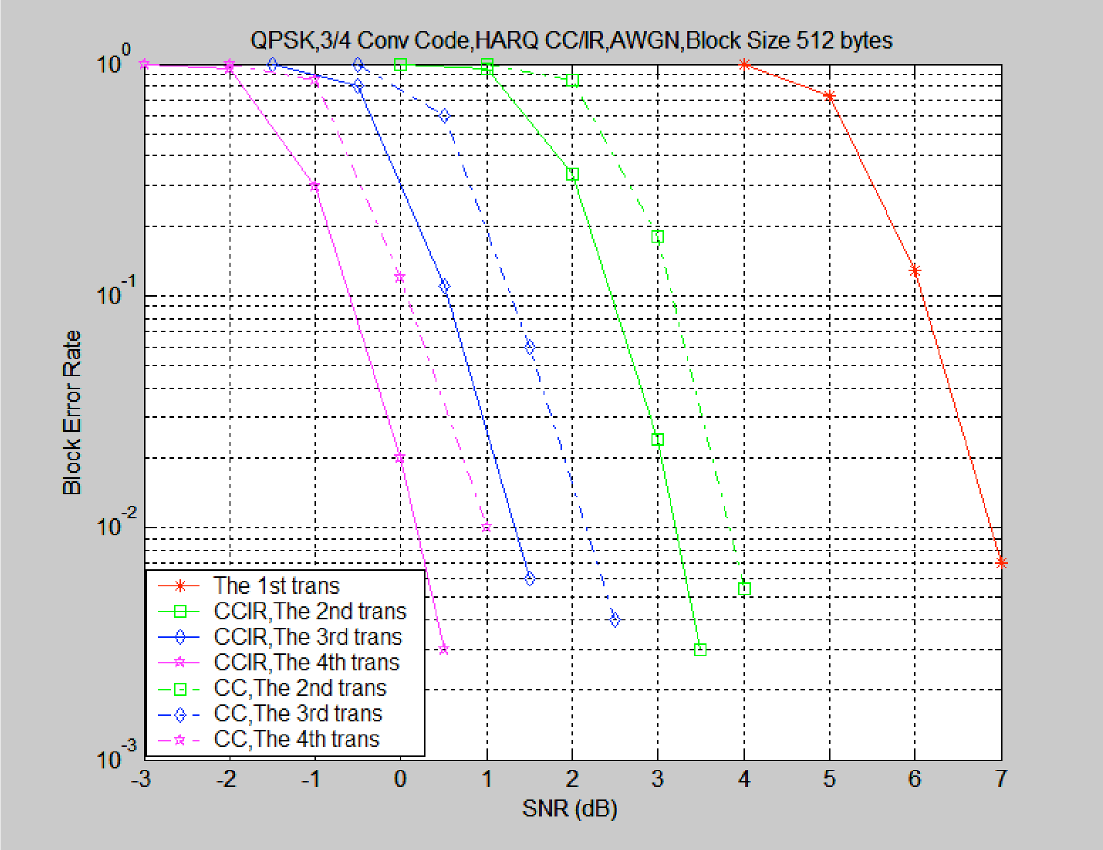

Fig.1 The block error rate of IR and CC H-ARQ scheme over AWGN, block 512 bytes

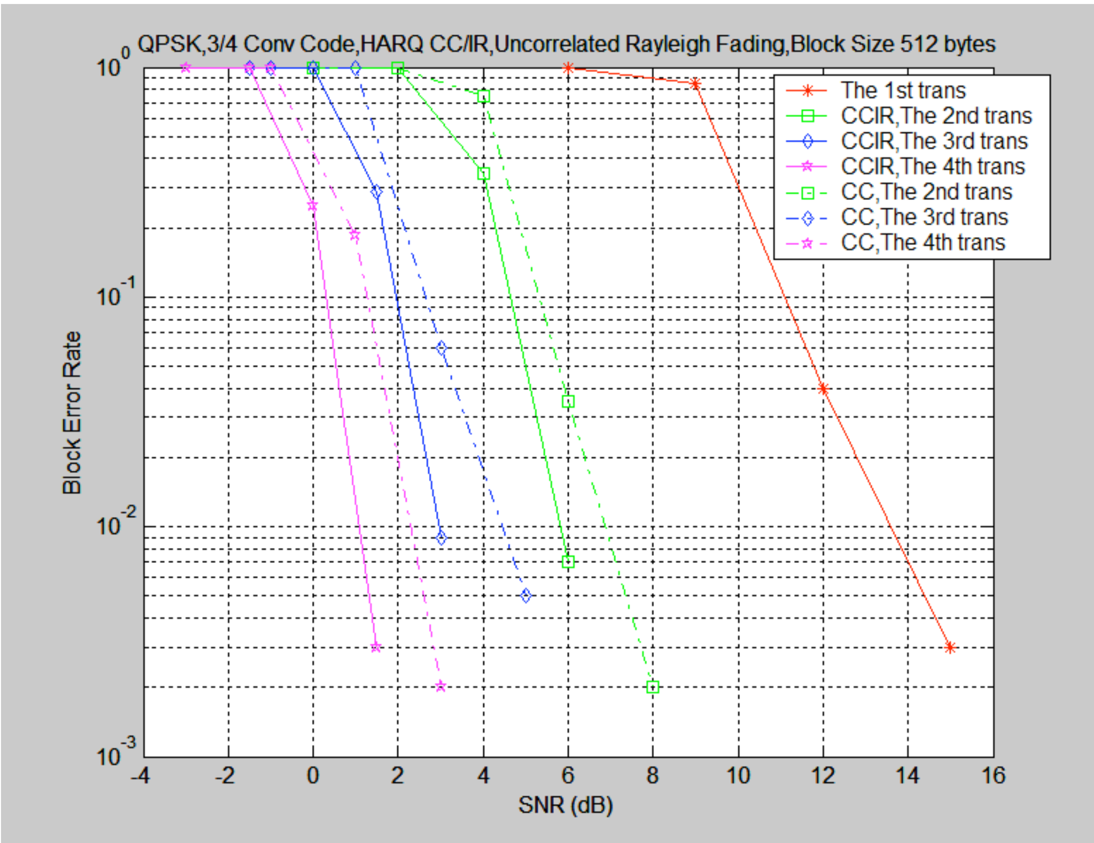

Fig.2 The block error rate of IR and CC H-ARQ scheme over uncorrelated Rayleigh fading, block 512 bytes

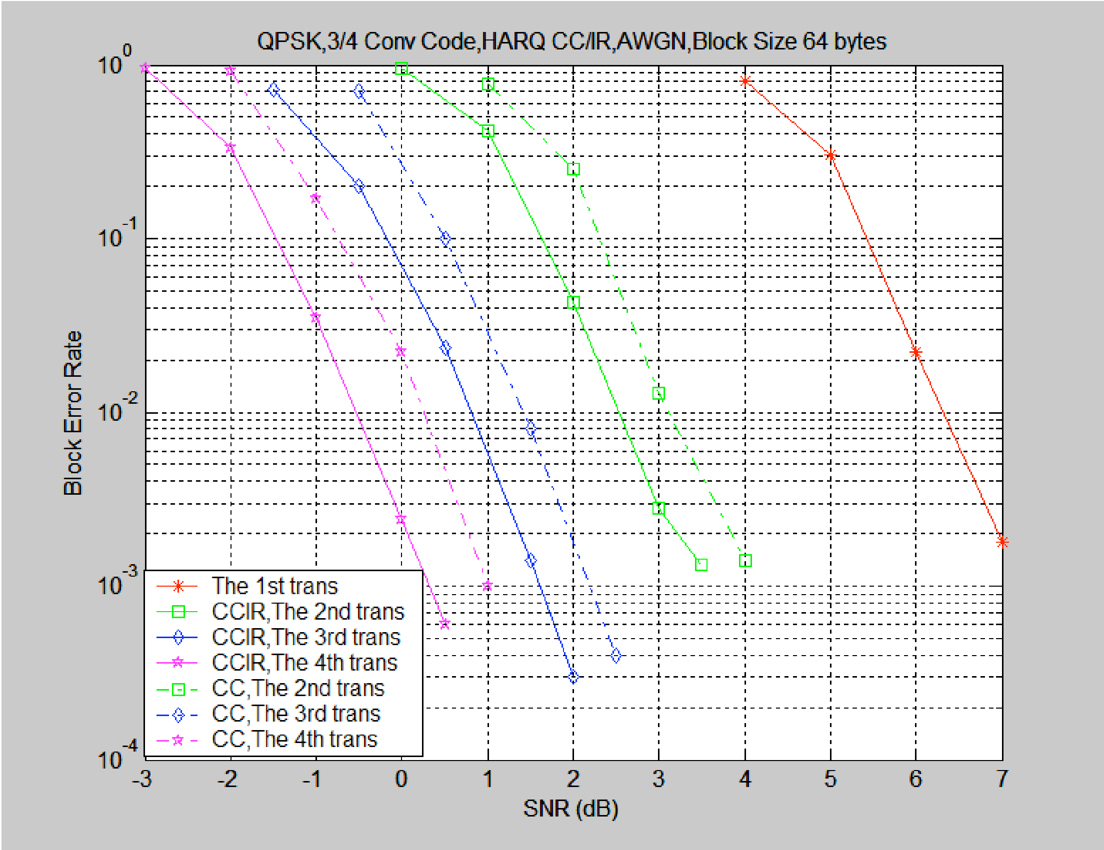

Fig.3 The block error rate of IR and CC H-ARQ scheme over AWGN, block 64 bytes

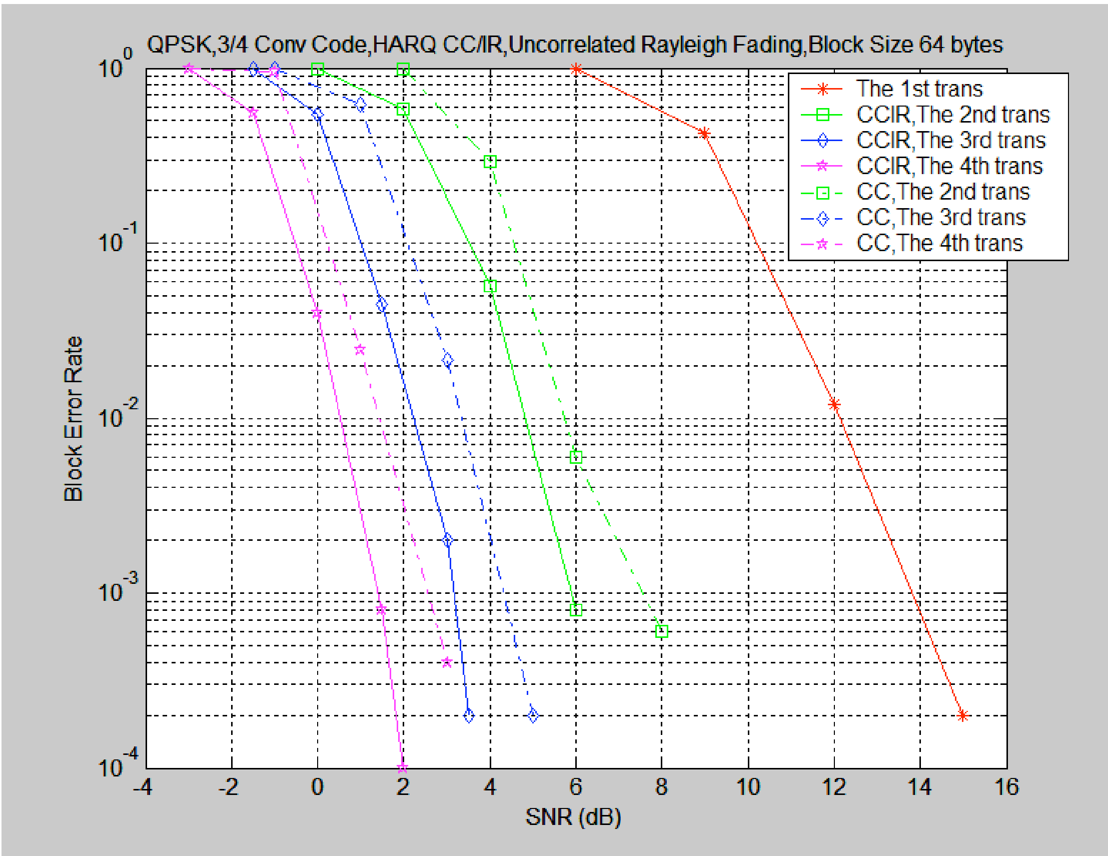

Fig.4 The block error rate of IR and CC H-ARQ scheme over uncorrelated Rayleigh fading, block 64 bytes

3. New Text

Editor Note: First accept all changes in 136r2, and then add the additional changes within this document.

Editor Note: Replace the changes for section 8.4.9.5 from 136r2 with the following

8.4.9.5 ~~Chase Combining~~Multiple HARQ (optional)

~~Chase Combining~~Multiple HARQ modes may be enabled for any of the existing FEC modes. A change in the H-ARQ mode is signaled using the "H-ARQ Compact_DL-MAP IE format for Switch H-ARQ Mode" (see section 6.3.2.3.43.6.7). The definitions of the H-ARQ modes are defined in Table AAA.

Table AAA HARQ Companded Sub Channel Definitions

H-ARQ Mode	Description
0	CTC Incremental Redundancy
1	Generic Chase
2	CC Incremental Redundancy
~~2~~3 …15	Reserved

8.4.9.5.1 Generic Chase HARQ

When Chase Combining HARQ is enabled for a particular SS, the HARQ_MAP will be used to signal the allocation and the HARQ Control IE will use the "Generic Chase" allocation format. The encoding of the companded sub channel field is defined in Table BBB below. Concatenation rules for each respective coding mode are applied as defined for non-HARQ transmissions.

Table BBB HARQ Companded Sub Channel Definitions

Companded Sub Channels	Assigned Sub Channels	Companded Sub Channels	Assigned Sub Channels
0	1	16	40
1	2	17	48
2	3	18	56
3	4	19	64
4	5	20	80
5	6	21	96
6	7	22	1

			12
7	8	23	128
8	10	24	160
9	12	25	192
10	14	26	224
11	16	27	256
12	20	28	320
13	24	29	384
14	28	30	448
15	32	31	512

8.4.9.5.2 CC Incremental Redundancy HARQ

When Convolutional Coding (CC) Incremental Redundancy (IR) is enabled for a particular SS, the HARQ_MAP will be used to signal the allocation and the HARQ Control IE will use the “CC IR” allocation format. The encoding of the companded sub channel field is identical to Generic Chase HARQ and is defined in Table BBB. Concatenation rules for each respective coding mode are applied as defined for non-HARQ transmissions.

Editor Note: Add the following subsection

c. Add the section 8.4.9.2.1.1

8.4.9.2.1.2 HARQ support (optional)

H-ARQ implementation is optional. An Incremental Redundancy (IR) based H-ARQ is taking the puncture pattern into account, and for each retransmission the coded block is not the same. Different puncture patterns are used to create the retransmission FEC block. The puncture patterns are predefined or can be easily deducted from the original pattern, and can be selected based on retransmission number. At the receiver, the received signals are depunctured according to its specific puncture pattern, which is decided by the current retransmission number, then the combination is performed at bit metrics level.

The puncture pattern for the first transmission is the same as the mandatory one in table 317. The puncture pattern for the second transmission is the right cyclic shift of the one for the first transmission, as shown in Table CCC. Following the same rule, the puncture pattern for the third and fourth transmission is available. This rule shall apply to the more than four transmissions.

Table CCC Puncture Pattern Definition for HARQ

		Code Rate			
		1/2	2/3	_	5/6
The 1st transmission	X	1	10	101	10101
	Y	1	11	110	11010
The 2nd transmission	X	1	01	011	01011
	Y	1	11	101	10101
The 3rd transmission	X	1	10	110	10110
	Y	1	11	011	01011
The 4th transmission	X	1	01	101	01101
	Y	1	11	110	10110

Editor Note: Replace changes for section 6.3.2.3.43.6.1, 6.3.2.3.43.6.2, and 6.3.2.3.43.6.3 in 136r2 with the following changes:

c. Section 6.3.2.43 "H-ARQ MAP message" requires the Nep and Nsch table entries to be replaced depending on the type of H-ARQ mode.
In sections 6.3.2.3.43.6.1, 6.3.2.3.43.6.2, and 6.3.2.3.43.6.3, replace the table entries for Nep and Nsch:

***NEP* code**	4 bits	Code of encoder packet bits (see 8.4.9.2.3.5)
***NSCH* code**	4 bits	Code of allocated subchannels (see 8.4.9.2.3.5)

With:

if (H-ARQ mode = "CTC IR") {		
***NEP* code**	4 bits	Code of encoder packet bits (see 8.4.9.2.3.5)
***NSCH* code**	4 bits	Code of allocated subchannels (see 8.4.9.2.3.5)
} elsif (H-ARQ mode = "Generic Chase" or H-ARQ mode = "CC IR") {		
Shortened DIUC	3 bits	Shortened DIUC
Companded SC	5 bits	Code of allocated subchannels (see 8.4.9.5.1)
}		

Also, replace the text describing Nep and Nsch as:

NEP code, NSCH code

The combination of *NEP* code and *NSCH* code indicates the number of allocated subchannels and scheme of coding and modulation for the DL burst.

With the following text:

NEP code, NSCH code

The combination of *NEP* code and *NSCH* code indicates the number of allocated subchannels and scheme of coding and modulation for the DL burst.

Shortened DIUC

A shortened version of the DIUC. The shortened DIUC takes on values 0..7 of the DIUC as defined in the DCD. See section 8.4.5.3.1.

Companded SC

The compand SC indicates the number of allocated subchannels.

Editor Note: Replace changes for section 6.3.2.3.43.6.1 and 6.3.2.3.43.6.3 in 136r2 with the following changes:

d. In sections 6.3.2.3.43.6.1 and 6.3.2.3.43.6.3, replace the table entries for Nep and Nsch:

NEP **code for UL**	4 bits	Code of encoder packet bits (see 8.4.9.2.3.5)
NSCH **code for UL**	4 bits	Code of allocated subchannels (see 8.4.9.2.3.5)

With:

if (H-ARQ mode = "CTC IR") {		
NEP **code for UL**	4 bits	Code of encoder packet bits (see 8.4.9.2.3.5)
NSCH **code for UL**	4 bits	Code of allocated subchannels (see 8.4.9.2.3.5)
} elsif (H-ARQ mode = "Generic Chase" or H-ARQ mode = "CC IR") {		
Shortened UIUC	3 bits	Shortened UIUC
Companded SC	5 bits	Code of allocated subchannels (see 8.4.9.5.1)
}		

Also, replace the text describing Nep and Nsch as:

NEP code for UL, NSCH code for UL

The combination of *NEP* code and *NSCH* code indicates the number of allocated subchannels and scheme of coding and modulation for the UL burst.

With the following text:

NEP code for UL, NSCH code for UL

The combination of *NEP* code and *NSCH* code indicates the number of allocated subchannels and scheme of coding and modulation for the UL burst.

Shortened DIUC

A shortened version of the UIUC. The shortened UIUC takes on values 1..8 of the UIUCas defined in the UCD. See section 8.4.5.4.1.

Companded SC

The compand SC indicates the number of allocated subchannels.

Editor Note: Replace changes for section 6.3.2.3.43.7.1, 6.3.2.3.43.7.2, and 6.3.2.3.43.7.3 in 136r2 with the following changes:

e. In sections 6.3.2.3.43.7.1, 6.3.2.3.43.7.2, and 6.3.2.3.43.7.3, replace the table entries for Nep and Nsch:

***NEP* code**	4 bits	Code of encoder packet bits (see 8.4.9.2.3.5)
***NSCH* code**	4 bits	Code of allocated subchannels (see 8.4.9.2.3.5)

With:

if (H-ARQ mode = “CTC IR”) {		
***NEP* code**	4 bits	Code of encoder packet bits (see 8.4.9.2.3.5)
***NSCH* code**	4 bits	Code of allocated subchannels (see 8.4.9.2.3.5)
} elsif (H-ARQ mode = “Generic Chase” or H-ARQ mode = “CC IR”) {		
Shortened DIUC	3 bits	Shortened DIUC
Companded SC	5 bits	Code of allocated subchannels (see 8.4.9.5.1)
}		

Also, replace the text describing Nep and Nsch as:

NEP code, NSCH code

The combination of *NEP* code and *NSCH* code indicates the number of allocated subchannels and scheme of coding and modulation for the DL burst.

With the following text:

NEP code, NSCH code

The combination of *NEP* code and *NSCH* code indicates the number of allocated subchannels and scheme of coding and modulation for the DL burst.

Shortened DIUC

A shortened version of the DIUC. The shortened DIUC takes on values 0..7 of the DIUC as defined in the DCD. See section 8.4.5.3.1.

Companded SC

The compand SC indicates the number of allocated subchannels.