TSG-RAN Working Group1 meeting #7 **TSGR1#7(99)d48**
Hannover, Germany, Aug. 30-Sept. 3, 1999

Agenda Item:
Source: SAMSUNG Electronics Co.
Title: Parameters (a,b) selection for rate matching algorithm
Document for: Discussion

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1. Introduction

This document supplements Tdoc [1] and [2] proposed by Samsung and LGIC with some analysis and some additional simulation results over AWGN channel. In the Ad Hoc 5 report, it has been mentioned that *(a,b)* parameter is to be studied for optimization. In this document, we show that *(a,b)* parameter is only related to the initial offset of puncturing pattern. In order to make arbitrary offset for a given puncturing pattern, it is sufficient to control *(a,b)* parameter. We also show that a specific *(a,b)* parameter set determines a regular puncturing pattern.

2. Initial offset and period of rate matched symbol stream

Assume that N_{cs} is the number of bits before rate matching for each rate matching block and N_{is} is number of bits after rate matching for each rate matching block. For given rate matching parameters, the number punctured bits y is determined as $y= N_{cs} - N_{is}$ and puncturing is performed by the following rate matching algorithm.

```
e=(a*s(k)*y+bNcs) mod aNcs;
if e=0 then e=aNcs;
m=1
do while m<=Ncs
  e=e-a*y;
  if e <=0 then
  punctured
    puncture bit m from set S0
    e=e+a*Ncs
  end if
  m=m+1;
end do
```

For simplicity, let's define the initial offset ***Offset_m*** of rate matching block to be the number of symbols from the first symbol to the first punctured symbol. Also, let's define period ***P*** to be the puncturing period. In figure 1, definition of ***Offset_m*** and period ***P*** are given. If N_{cs}/y is an integer, then initial offset and period ***P*** of the rate matching block can be easily obtained from the above algorithm and they are given by

$$\textbf{Offset\_m} = \lceil (b/a)*(N_{cs}/y) \rceil = \lceil (b/a)*\textbf{P} \rceil \quad (1)$$

$$\textbf{P} = N_{cs}/y \quad (2)$$

$$\text{where } 1 \le a \le b*(N_{cs}/y) \text{ and } 1 \le b \le a.$$

The current rate matching algorithm uses *(a,b)=(2,1)*. This means that the initial offset ***Offset_m*** of the current algorithm is just 1/2 of the period ***P***$(=N_{cs}/y)$. For a given parameter ***b***, the initial offset decreases as the parameter ***a*** increases. If $a \ge N_{cs}/y$, the initial offset always becomes 1. Therefore, the first bit should be punctured.

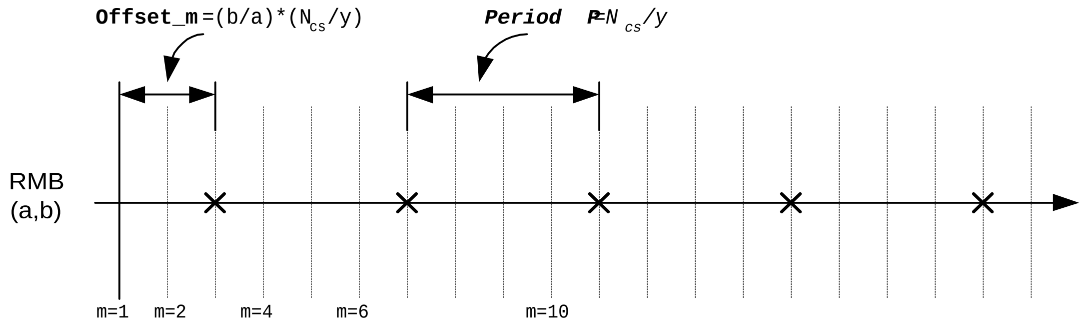

Figure 1. Definitions of initial offset ***Offset_m*** and period ***P*** in the rate matching block.

The following two examples show the role of *(a,b)* parameter for the initial offset control for each rate matching block. In the following cases, we assume that ***b*** is 1 according to the current rate matching scheme. In the following figures, ‘X” means the punctured bit.

Example 1. (a,b)=(2,1) for RMB2 and (a,b)=(1,1) for RMB3. Period=4 (=éNcs/yù).

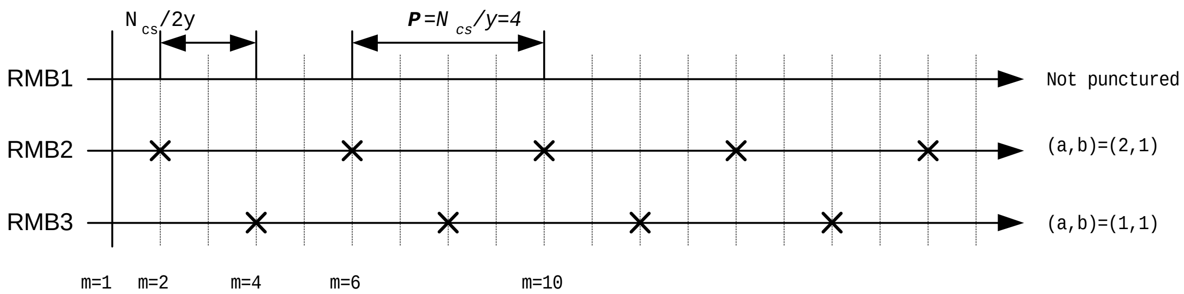

Figure 2. **Offset_m**=2 for RMB2, **Offset_m**=4 for RMB3. **P**=4.

Example 2. (a,b)=(2,1) for RMB2 and (a,b)=(2,1) for RMB3. Period=4 (=éNcs/yù).

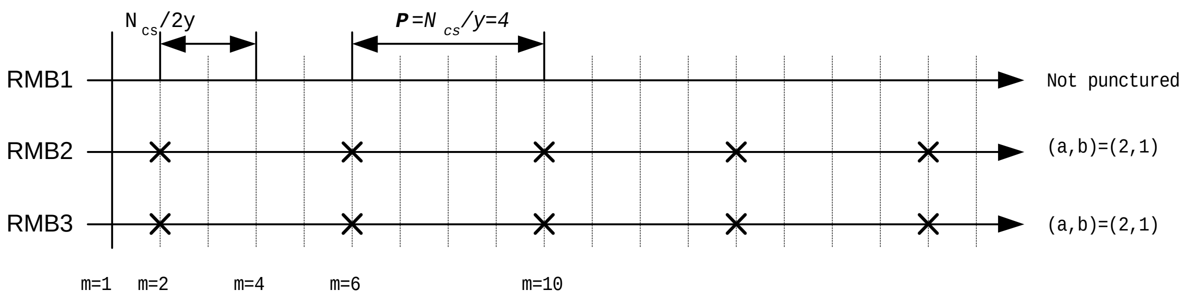

Figure 3. **Offset_m**=2 for RMB2, **Offset_m**=2 for RMB3. **P**=4.

Example 3. Ncs=480, Nis=384, y= 96: a=2, b=1,2.

(a,b)=(2,1)

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- *Note that '-' and '|' mean the unpunctured bit and the punctured bits, respectively.*

(a,b)=(2,2)

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Example 4. Ncs=480, Nis=384, y= 96: a=3, b=1,2,3.

(a,b)=(3,1)

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(a,b)=(3,2)

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(a,b)=(3,3)

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3. Simulation conditions

For turbo codes, the simulation conditions are as follows;

- Block sizes: 320, 640
- Puncturing rates: p=20, 15, 10%
- Decoding algorithm: Log MAP decoder
- Turbo interleaver: PIL
- Number of iterations: 12
- Number of frame errors: greater than 100
- Channel model: AWGN
- Algorithms: SEC & LGIC puncturing

In the following figures, _20, _15, and _10 mean puncturing with p=20, 15, and 10, respectively [1],[2]. Notation of (a,b,a,b) means the following parameters for each rate matching block (RMB).

(a,b,a,b)	RMB1	RMB2	RMB3
(2,1,2,1)	Not used	(a,b)=(2,1)	(a,b)=(2,1)
(2,1,1,1)	Not used	(a,b)=(2,1)	(a,b)=(1,1)
(2,1,3,1)	Not used	(a,b)=(2,1)	(a,b)=(3,1)

4. Results and conclusion

Figure 1 to 3 show the performances with interleaver size of 320, and Figure 4 to 6 show the performances of interleaver size of 640, both with different set of (a,b,a,b) parameter. According to the simulation results in Figure 1 to 6, the performances with (2,1,1,1) are slightly better consistently than those with others. Therefore, we propose to use (a,b,a,b) parameter set as (2,1,1,1) for RMB2 and RMB3.

5. References

[1] "Unified rate matching scheme for Turbo/convolutional codes and up/down links", Samsung Electronics Co., TSGR1#6(99)919

[2] "Unified rate matching scheme for turbo codes in both uplink and downlink", Samsung Electronics Co. and LGIC, TSGR1#6(99)a30

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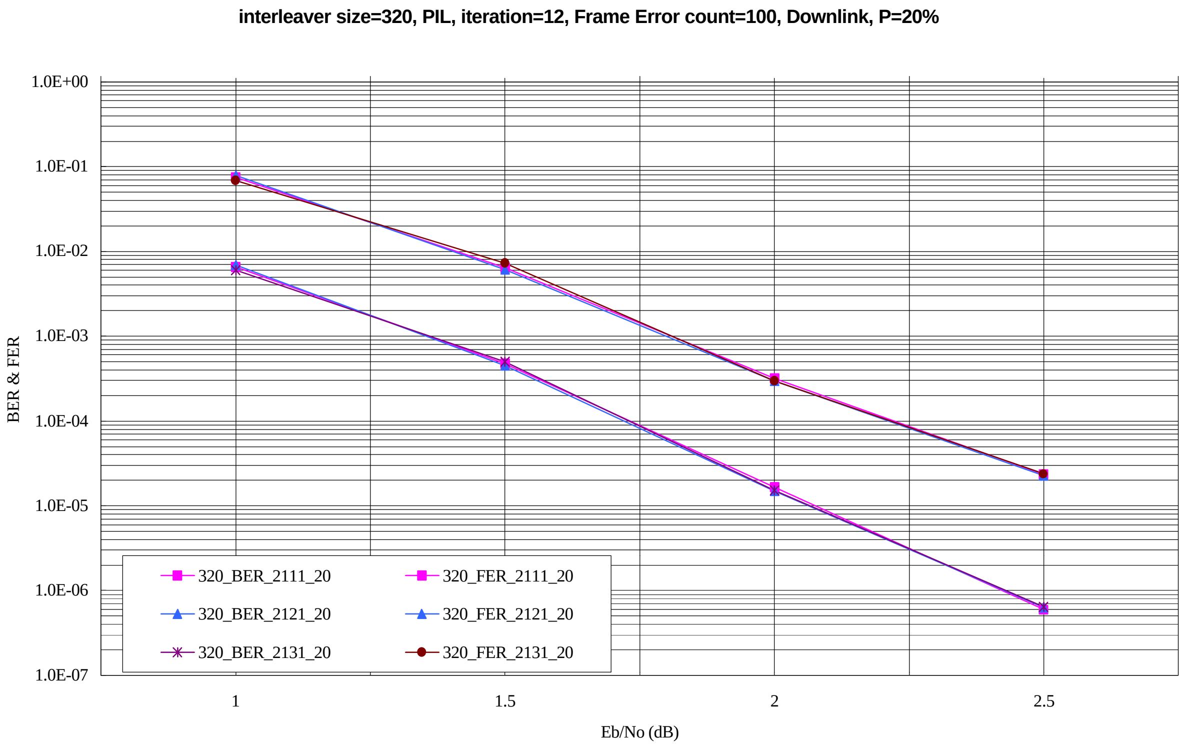

Figure 1. BER and FER of rate matching algorithm with various (a,b). N=320, p=20%.

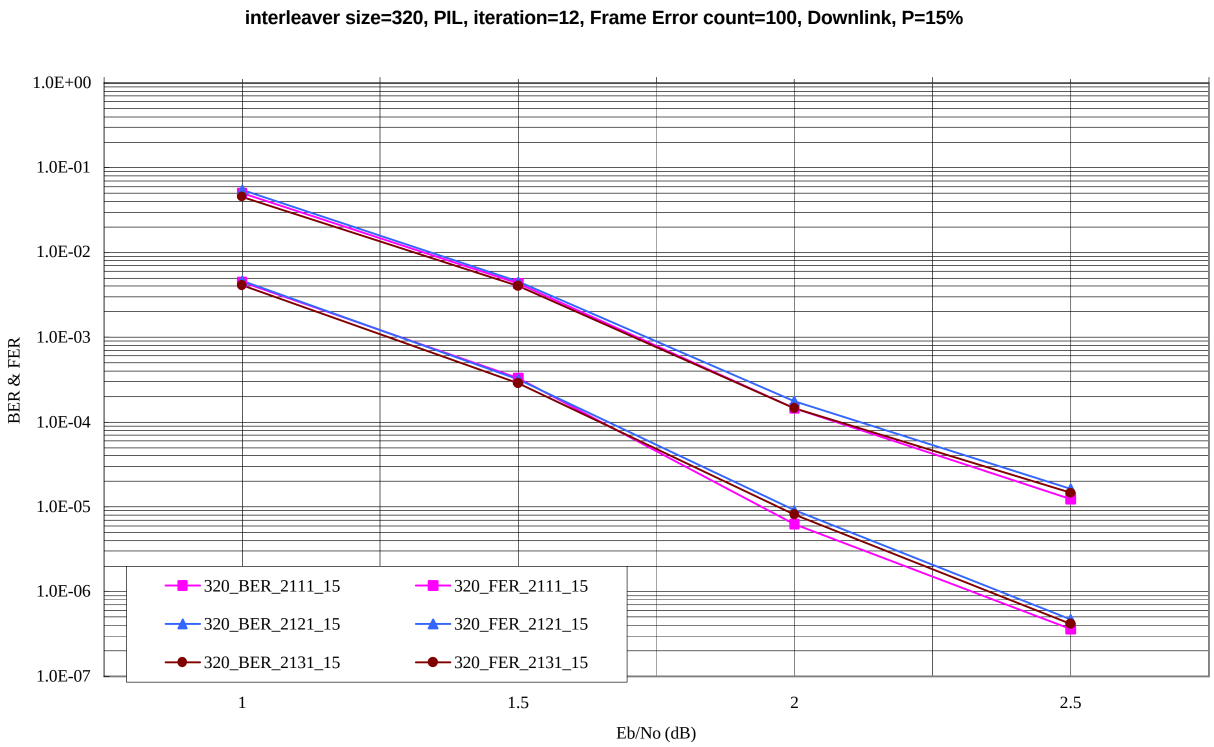

Figure 2. BER and FER of rate matching algorithm with various (a,b). N=320, p=15%.

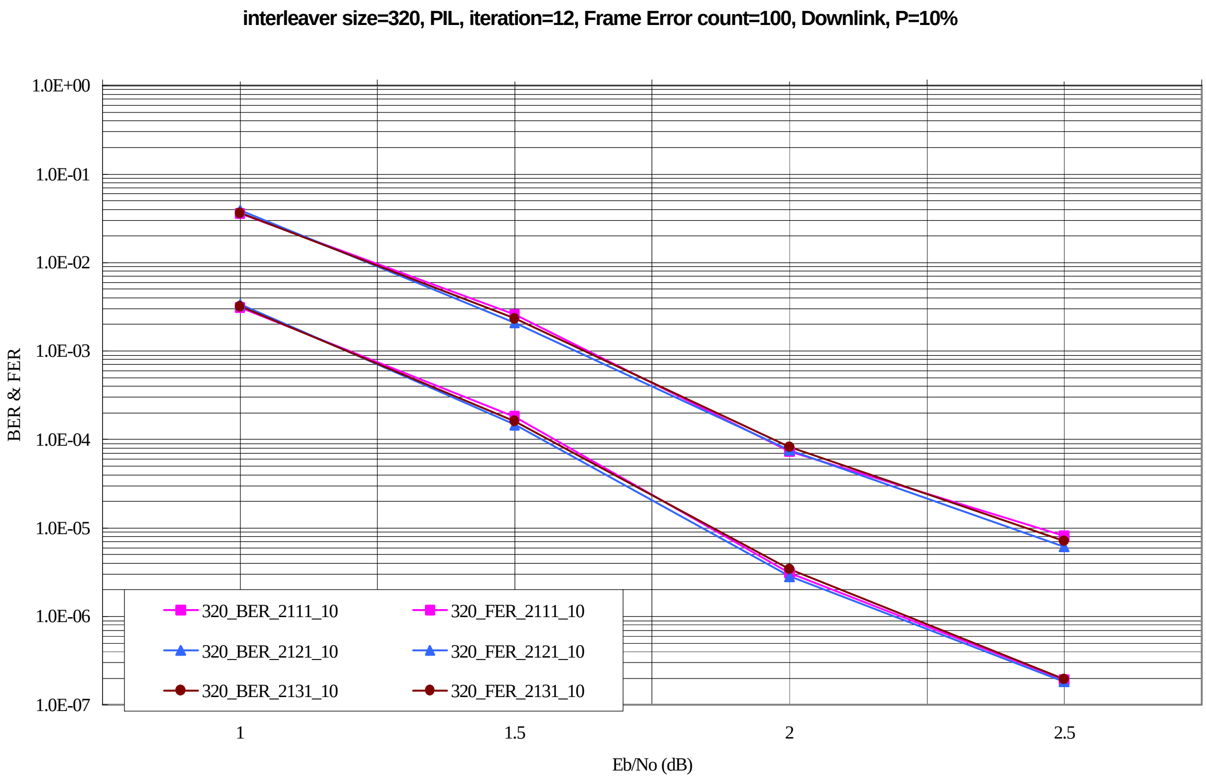

Figure 3. BER and FER of rate matching algorithm with various (a,b). N=320, p=20%.

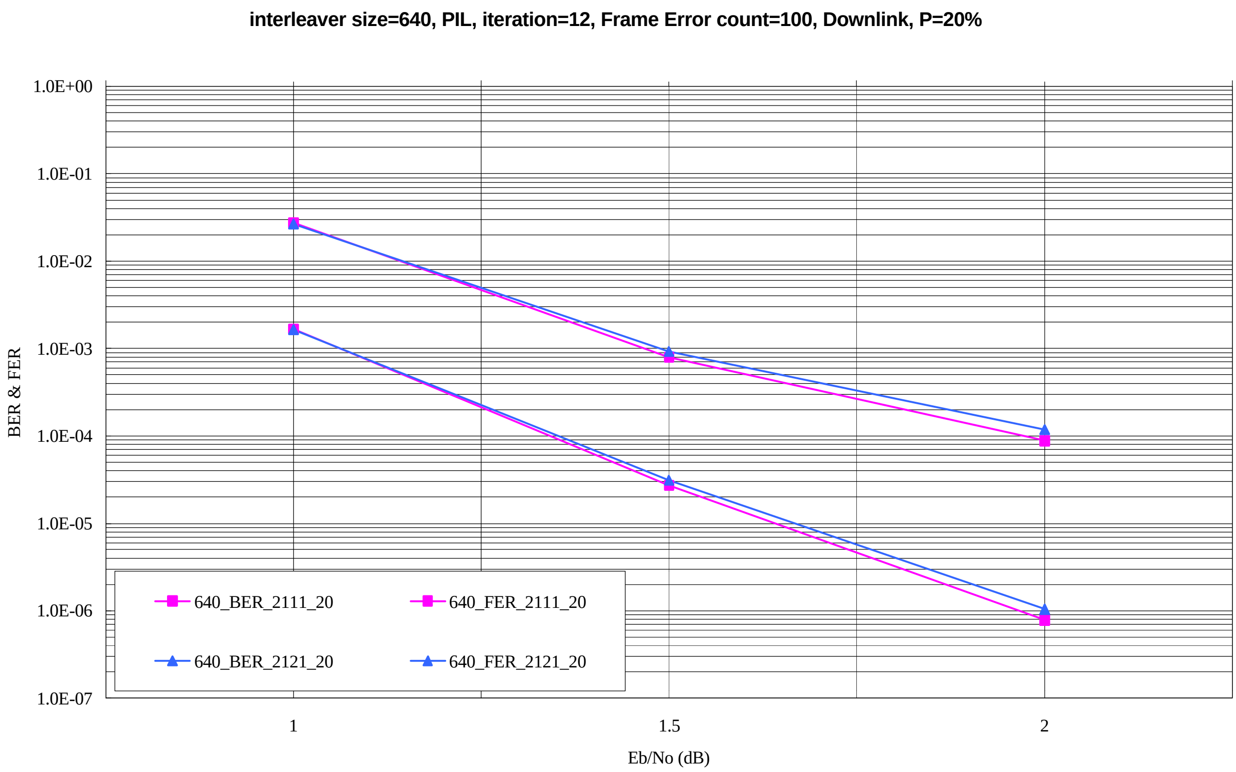

Figure 4. BER and FER of rate matching algorithm with various (a,b). N=640, p=20%.

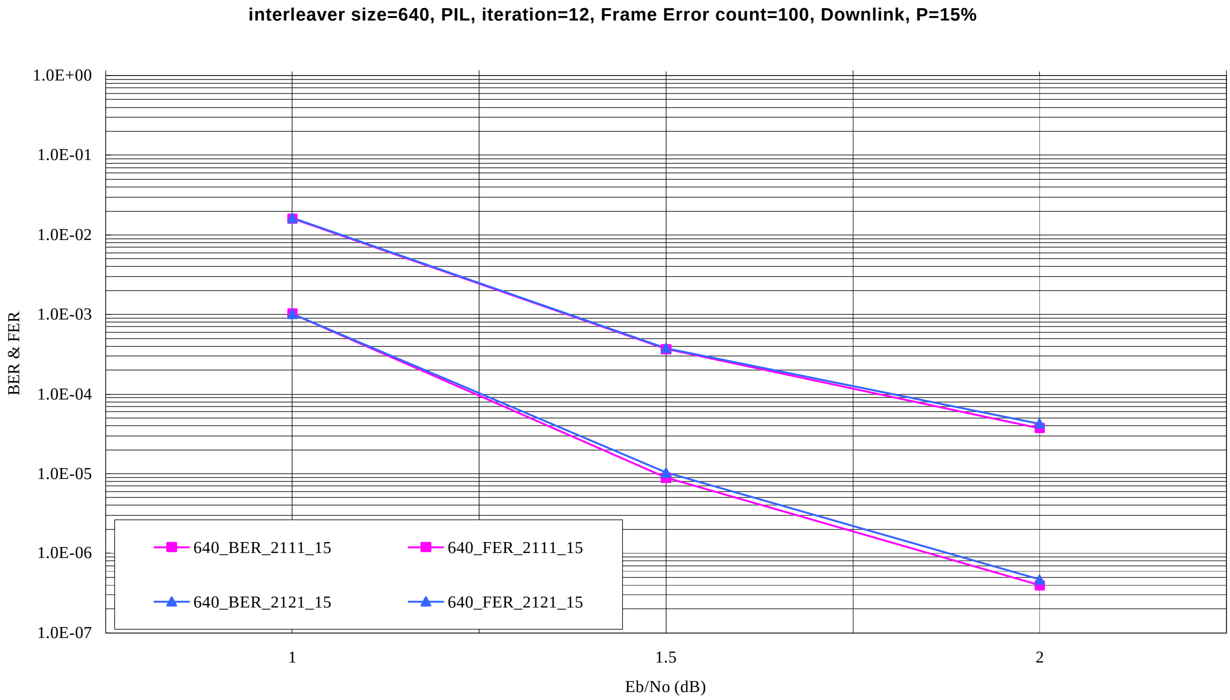

Figure 5. BER and FER of rate matching algorithm with various (a,b). N=640, p=15%.

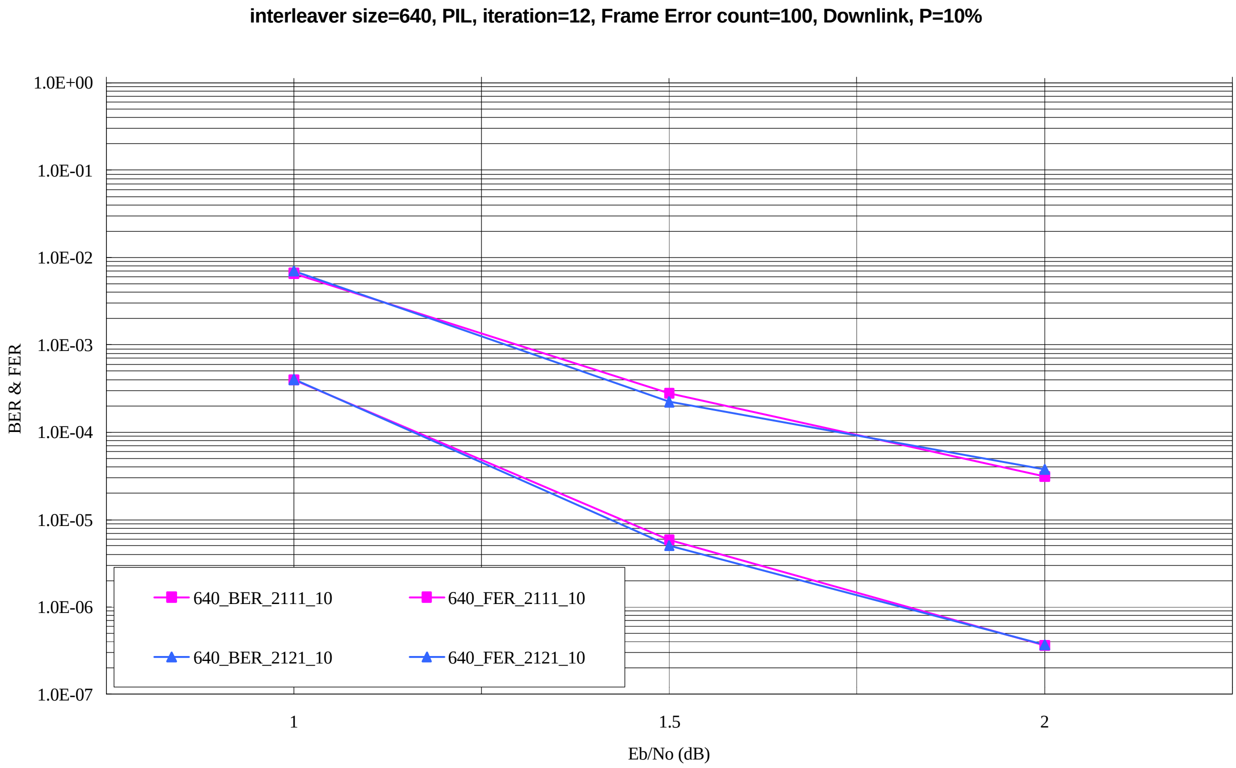

Figure 6. BER and FER of rate matching algorithm with various (a,b). N=640, p=10%.