

Title: Optimized channel coding for transmission of AMR WB low bit rate modes over 8-PSK Fullrate voice bearers

Source : Siemens

1. Introduction

Transmission of AMR WB speech over 8-PSK fullrate voice bearers enables very strong channel protection when using low bit rate modes. Code rates down to 1/10 require the repetition of many bits of the output of the convolutional encoder, if repetition codes are applied.

Analysis has shown, that for these low bit rate modes an alternative coding scheme can enhance the error protection capability of the channel codec.

2. Channel coding with constant bit insertion

2.1. Description of the algorithm

Constant bits are bits with a value known to both the sender and the receiver which are inserted into the bit stream at particular positions before convolutional encoding is performed. Using recursive systematic convolutional (RSC) codes the output bit stream of the convolutional encoder contains the original bit value for every input bit, known as systematic bit. Since the value of the systematic bits for the inserted constant bits is known at the receiving side, the transmission of these systematic bits is redundant. Consequently, these bits are removed from the convolutional encoded bit stream.

At the receiver the systematic bits are inserted again before convolutional decoding is performed at the positions where they have been formerly removed at the sender. The soft values for these systematic bits are set to the maximum amplitude and the sign corresponding to the value of the constant bits. After convolutional decoding the constant bits are removed from the bit stream.

Example:

Convolutional code: RSC, rate $\frac{1}{4}$

Constant bit value: 0

Correlated soft value to 0: # (e.g. # = 127 for 8 bit soft values)

Data bits: a,b,c,d,...

Received and decoded data bit soft values: A,B,C,D,...

Bit with value unknown or not of interest here: ?

Constant bit insertion pattern: 1,0,1,0,1,0,... (1 = data bit, 0 = constant bit)

Note: This corresponds to a code rate 1/7.

3. Channel coding for AMR WB 6.60 kbit/s and 8.85 kbit/s

3.1. Ordering according to subjective importance

The source encoded frames of speech data are reordered by using the reordering tables proposed in [1].

2.2. Protection classes

As proposed in [1] the bits of a speech frame are divided into two classes.

1a - Data protected with the CRC and the convolutional code.

1b - Data protected with the convolutional code.

No bits are transmitted unprotected.

2.3. Parity for speech frames

The class 1a bits are protected by a 6-bit CRC using the generator polynomial $g(D) = 1+D+D^2+D^3+D^5+D^6$ as proposed in [1].

2.4. Constant bit insertion

For the mode with 6.60 kbit/s 256 constant bits, for the mode with 8.85 kbit/s 196 constant bits are inserted into the bit stream.

2.4. Convolutional encoder

The class 1a bits, the 6 CRC bits and the class 1b bits and the constant bits then are encoded by a recursive systematic convolutional code using the polynomials as defined in [2] and proposed in [1].

$$G4 = 1+D^2+D^3+D^5+D^6$$

$$G5 = 1+D+D^4+D^6$$

$$G6 = 1+D+D^2+D^3+D^4+D^6$$

$$G7 = 1+D+D^2+D^3+D^6.$$

3.5. Puncturing

The output bits from the convolutional encoder are punctured properly to obtain 1344 channel bits per frame.

3.6. Inband data

24 bits are reserved for inband signalling.

3.7. Interleaving and mapping on bursts

The bits are interleaved and mapped on bursts as proposed in [1].

4. Results

In the following figures the performance of AMR WB speech transmission using the channel coding scheme described above and using the 3GPP SA4 example channel codec proposed in [1] are compared. Criteria for performance analysis are the frame

erasure rate (FER), the residual bit error rate (RBER) of the class 1b bits and subjective listening test (A-B test). For FER and RBER 1b 50,000 speech frames were transmitted. Informal listening tests were performed. 9 expert and non-expert listeners compared pairs of 8 seconds long samples of a male German speaker twice in alternating order. The error patterns for the simulations are generated with internal simulation chains for TU03 channel profiles with ideal frequency hopping at a carrier frequency of 900 MHz and have a length of 10,000 frames.

4.1. AMR WB, mode with 6.60 kbit/s

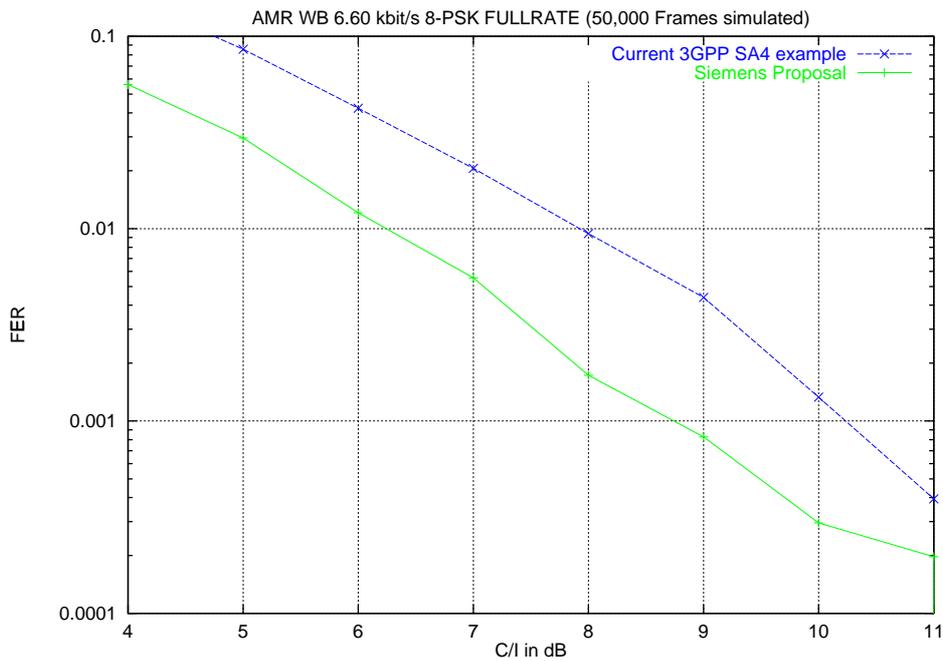


Fig 1a: FER: AMR WB Mode 6.60 kbit/s over 8-PSK FR Channel

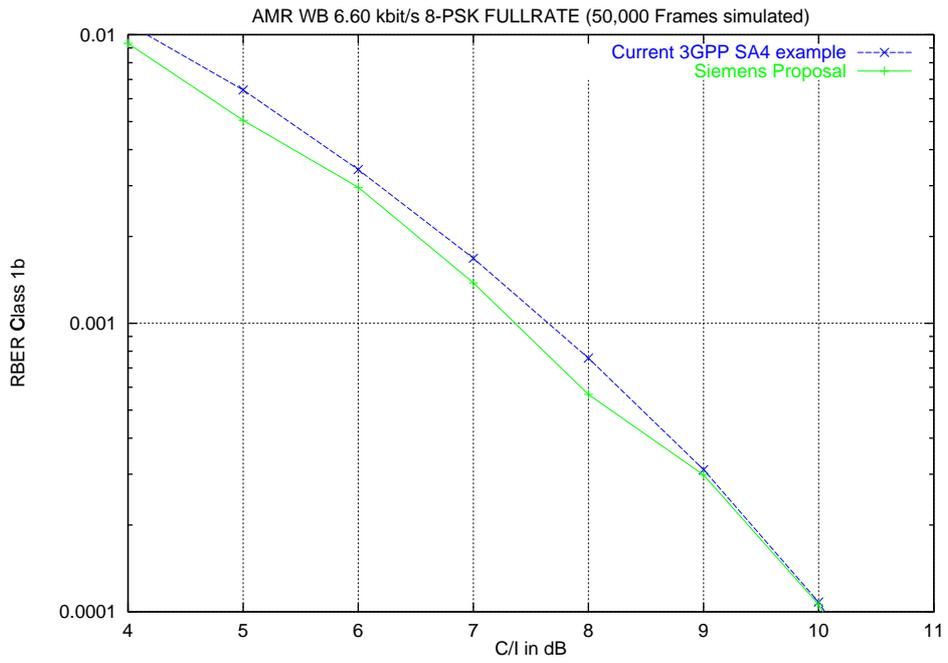


Fig 1b: RBER 1b: AMR WB Mode 6.60 kbit/s over 8-PSK FR Channel

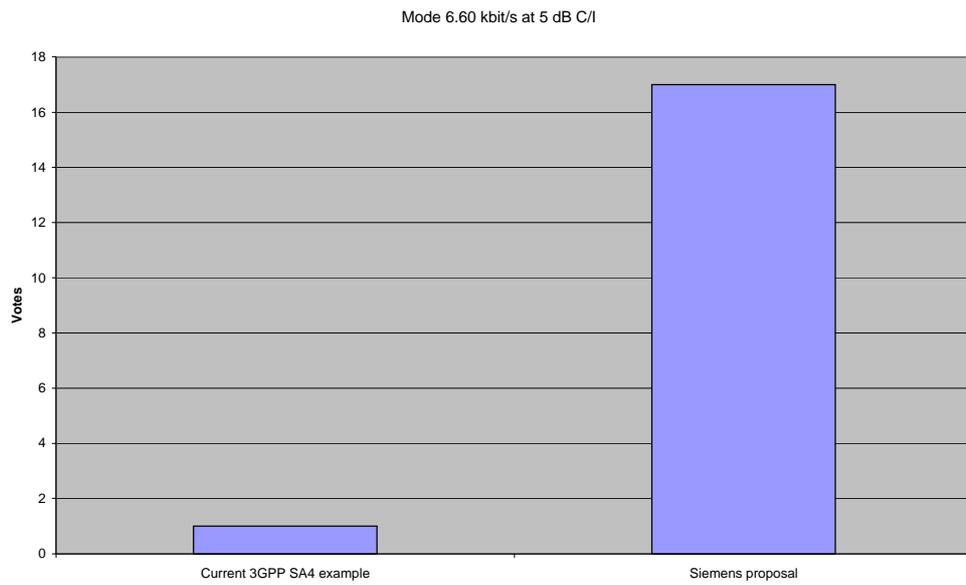


Fig 1c: Listening test (A-B): AMR WB Mode 6.60 kbit/s over 8-PSK FR Channel

4.2. AMR WB, mode with 8.85 kbit/s

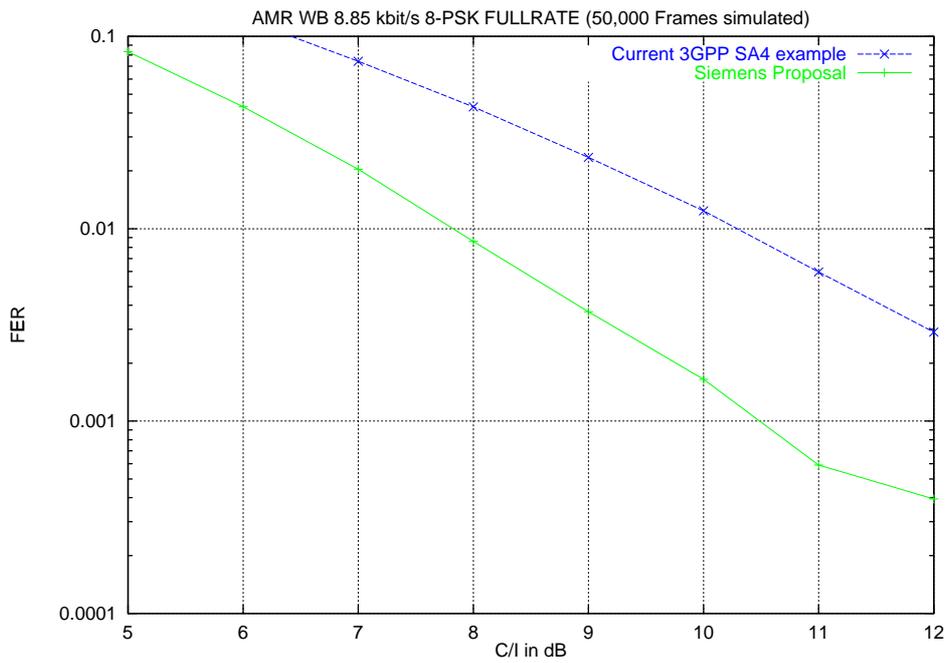


Fig 2a : FER: AMR WB Mode 8.85 kbit/s over 8-PSK FR Channel

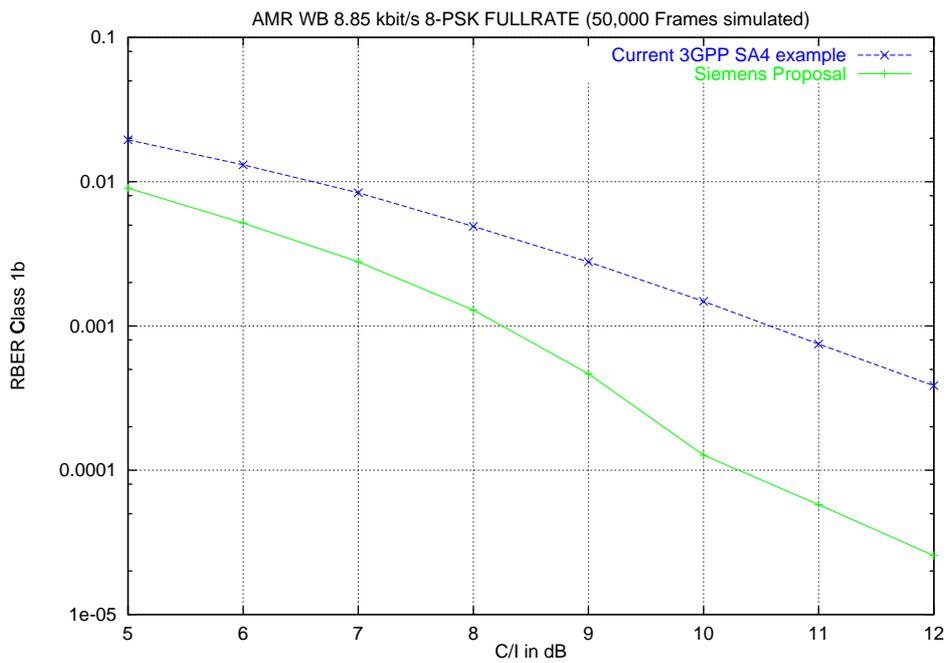


Fig 2b: RBER 1b: AMR WB Mode 8.85 kbit/s over 8-PSK FR Channel

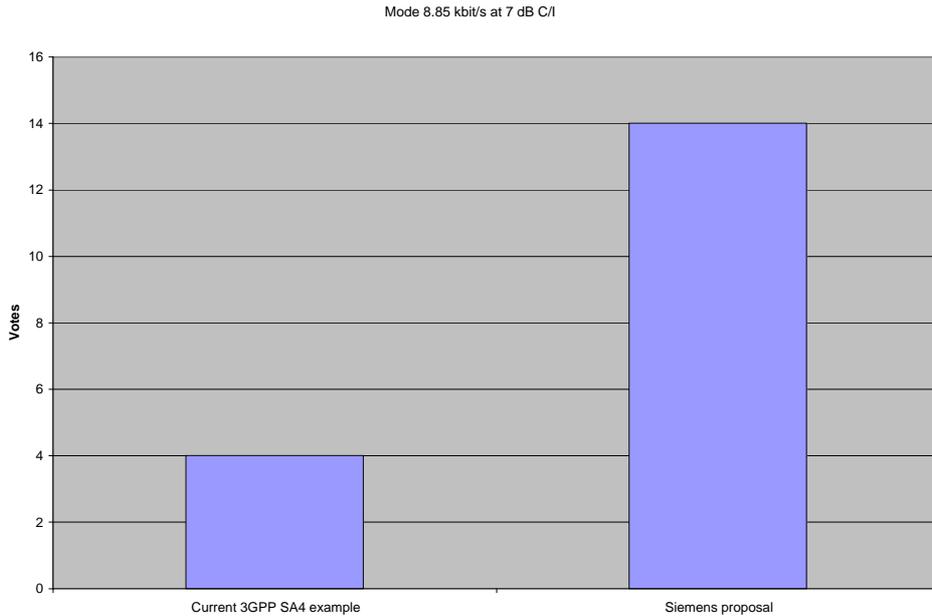


Fig 2c: Listening test: AMR WB Mode 8.85 kbit/s over 8-PSK FR Channel

5. AMR NB over 8-PSK halfrate voice bearers

Constant bit insertion can also increase channel protection for AMR NB, when low bit rates are transmitted over 8-PSK halfrate bearers. We are preparing a detailed channel codec proposal and results will follow in future contributions.

6. Conclusion

Applying constant bit insertion improves the performance of the channel codec for modes with low bit rates transmitted over 8-PSK FR voice bearers. Gains of more than 2 dB C/I can be obtained with respect to objective criteria like FER and RBER class 1b. Furthermore, the improved channel protection results in increased subjective listening quality.

7. References

[1] 3GPP TSG GERAN Adhoc #3, Tdoc GAHW-000229, "Change Request GSM 05.03", Nokia, 12.12.-14.12.2000, Orlando, USA

[2] Digital Cellular Telecommunications System (Phase 2+), Channel Coding, GSM 05.03 version 8.5.0. Release 1999, June 2000