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Datasheet for the decision of 3 May 2007

Case Number: T 0949/05 - 3.5.02

Application Number: 99962532.0

Publication Number: 1147611

IPC: H03M 7/30

Language of the proceedings: EN

Title of invention:
Quantization method for iterative decoder in communication system

Applicant:
SAMSUNG ELECTRONICS CO., LTD.

Opponent:
-

Headword:
-

Relevant legal provisions:
EPC Art. 54, 56, 84, 87, 123(2)

Keyword:
"Subject-matter disclosed in the application as filed and in the priority application (yes) - clarity (yes) - novelty and inventive step (yes)"

Decisions cited:
-

Catchword:
-

Case Number: T 0949/05 - 3.5.02

D E C I S I O N
of the Technical Board of Appeal 3.5.02
of 3 May 2007

Appellant: (Applicant)	SAMSUNG ELECTRONICS CO., LTD. 416 Maetan-dong Paldal-gu Suwon City, Kyungki-do 442-370 (KR)
Representative:	Grünecker, Kinkeldey, Stockmair & Schwanhäusser Anwaltssozietät Maximilianstraße 58 D-80538 München (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted 15 February 2005 refusing European application No. 99962532.0 pursuant to Article 97(1) EPC.**

Composition of the Board:

Chairman: M. Rognoni
Members: M. Ruggiu
E. Lachacinski

Summary of Facts and Submissions

I. This is an appeal of the applicant against the decision of the examining division to refuse European patent application No 99 962 532.0.

II. The reasons given for the refusal were that claim 1 of a main request contravened Article 123(2) EPC and claim 1 of first to sixth auxiliary requests lacked clarity contrary to the requirement of Article 84 EPC. The decision under appeal indicated in particular that the lack of clarity could not be overcome because the application documents did not provide a clear definition of signal levels A and -A. It added that the subject-matter of the claims of the first auxiliary request as well as of the claims of the further requests - as far as they could be understood - did not involve an inventive step in view of the following prior art document:

D1: "Quantization Loss in Convolutional Decoding" by I. M. Onyszschuk, K.-M. Cheung and O. Collins, published in IEEE Transactions on Communications, vol. 41, No. 2, February 1993, pages 261 to 265.

III. In a communication annexed to summons to oral proceedings, the board observed that Figure 2 of the Korean application, from which priority was claimed, differed from Figure 2 of the present application as originally filed. Furthermore, the board questioned whether the priority application taught that the range between signal levels A and -A was the range between signal levels corresponding to probability density maxima. The board's communication further cited the following document:

D2: "Optimal Quantization for Soft-Decision Turbo Decoder" by G. Jeong and D. Hsia, a paper presented at the IEEE VTS 50th Vehicular Technology Conference of 19 to 22 September 1999 in Amsterdam, the Netherlands, and published in Gateway to 21st Century Communications Village, VTC 1999-Fall, vol. 3, pages 1620 to 1624 by IEEE, Piscataway, NJ, US.

IV. Oral proceedings before the board took place on 3 May 2007. The appellant requested that the decision under appeal be set aside and that a patent be granted in the following version:

Description
Pages 2, 5, 6 and 8 to 13 as originally filed,
Pages 3, 3b and 14 filed with the statement of grounds of appeal dated 23 June 2005,
Pages 1, 3a, 4 and 7 filed in the oral proceedings.

Claims
No. 1 to 9 as main request filed in the oral proceedings.

Drawings
Sheets 1/5 and 3/5 to 5/5 as originally filed,
Sheet 2/5 filed with the statement of grounds of appeal dated 23 June 2005.

V. Claim 1 reads as follows:

"A quantization method for an iterative decoder (320), comprising the steps of:

equally dividing received signal levels into predetermined intervals, said intervals occupying a range 2^{ℓ} times greater than the range between the signal levels (-A, A) received at probability density maxima, said levels (-A, A) being determined under the assumption that the transmission channel is an AWGN channel, ℓ being a positive integer, the range occupied by said intervals expanding below and above said signal levels (-A, A); and

quantizing the level of a received signal using the predetermined intervals."

Claims 2 to 9 are dependent on claim 1.

VI. The appellant essentially argued as follows:

Support for the feature that the signal levels +A and -A corresponded to maxima of the probability density function of the received signals could be found in the first paragraph on page 5 of the application as filed, together with Figure 2. It was apparent from lines 2 and 3 of page 5 that this was under the assumption that the transmission channel was an AWGN channel.

The features of claims 7, 8 and 9 were contained in table 2, page 10 of the application as filed.

The Korean priority application stated (page 3, lines 6, 7 of the translation filed at the EPO) that +A and -A were the levels of a signal received from a transmitter and Figure 1 of the priority application showed that +A and -A corresponded to maxima of the probability density functions. In connection with Figure 2, the priority application stated that +A and -A defined the transmission level range (page 5, lines 2 to 24 of the translation) and that, if L=1, the quantization range was between the levels +A and -A as shown in Figure 1 (page 9, lines 18 to 22 of the translation). It was therefore apparent from the priority application that the positions of +A and -A had to be the same in Figure 1 and Figure 2. Thus, claim 1 enjoyed the priority of 31 December 1998 from the Korean application.

It was clear that the range occupied by the intervals defined in claim 1 related to received signal levels and not transmitted signal levels. How to determine that range was also clear to a skilled person: namely by modelling a received signal level distribution under the assumption that the transmission channel was an AWGN channel, and then by finding the probability density maxima.

Document D1 referred to convolutionaly-encoded bits sent over an AWGN channel, but not to iterative decoding. Figure 1 of D1 showed quantization intervals with reference to a probability density function. The maximum of the probability density function occurred in interval +3 and only one further quantization interval +4 was located above that maximum. Thus, in D1 the quantization range was slightly expanded above the probability density maximum, but certainly not as much as specified in claim 1.

Figure 2 of D1 graphically showed the step size that would minimize the BER. The quantization range could be obtained from Figure 2 of D1 by multiplying the step size that minimized the BER and the corresponding number of quantization intervals. The quantization range obtained thereby was comparable with the one shown in Figure 1 and substantially smaller than the one claimed. According to D1, it was safer to make the quantizer step size larger than the value that minimized the BER. This did not mean that arbitrarily large step sizes could be chosen. Rather, it meant that, if the step size that exactly minimized BER could not be used, then it was safer to use the next larger step size rather than use the next smaller step size. Thus, D1 did not suggest expanding the quantization range substantially beyond what was shown in Figure 1.

Reasons for the Decision

1. The appeal is admissible.

2. *Amendments*

2.1 The application as filed indicates at page 2, lines 32 to 34, that the quantization range should be expanded beyond the level range between +A and -A. Figure 2 of the application as filed is a graph illustrating a quantization method for an iterative decoder according to the preferred embodiment of the invention. The first paragraph of page 5 of the application as filed explains that Figure 2 shows amplitude levels of a received signal, that it is assumed that the transmission channel for the received signal is an AWGN channel and that the quantization range is expanded above the highest level and below the lowest level of the quantization level range from +A to -A shown in Figure 1. Both Figure 1 and Figure 2 of the application as filed show probability density functions having maxima at signal levels A and -A respectively.

Further taking into account that claim 1 as originally filed specifies intervals occupying a range 2^{ℓ} (ℓ is a positive integer) times greater than a transmission signal level range, the board considers that the subject-matter of present claim 1 does not extend beyond the content of the application as filed.

2.2 Present claims 2 to 6 are based on claims 2 to 6 as originally filed. The particular combinations of quantization step sizes and numbers of quantization bits specified in present claims 7 to 9 are contained in table 2 (page 10) of the application as filed, which illustrates combinations of parameters for a turbo decoder.

2.3 The description of the application has been amended to be consistent with the claims and acknowledge the background art disclosed in document D1.

2.4 Thus, the amendments to the application do not contravene Article 123(2) EPC.

3. *Priority*

In Figure 2 of the Korean application from which priority is claimed, the level -A is shown as being lower than the maxima of the probability density functions and the level A as being higher than those maxima. However, Figure 2 also specifies that $-A = -\sqrt{Es}$ and $A = \sqrt{Es}$, whereby Es is the code symbol energy. The priority application further states that it is assumed for the graph of Figure 2 that the transmission channel is an AWGN channel (see page 5, lines 18 to 20 of the translation filed at the EPO). Since it is known that in the case of an AWGN channel the demodulator output is a conditionally Gaussian random variable with means, and thus maxima, at levels $\sqrt{Es}$ and $-\sqrt{Es}$ (see for example document D1, the four sentences following "II. Branch Metrics" in pages 261 and 262), it is apparent that the maxima of the probability density functions in Figure 2 should have been shown at the levels -A and A, respectively. This is further confirmed by the passages of the translation filed at the EPO that have been cited by the appellant. Thus, a skilled person would immediately realise that the levels -A and A should have been represented in Figure 2 of the priority application in correspondence with the maxima of the probability density functions. Therefore, the board is of the opinion that claim 1 enjoys the priority of 31 December 1998 from the Korean application in accordance with Article 87 EPC and, consequently, that document D2 is not comprised in the state of the art due to Article 89 EPC.

4. *Clarity*

It is true that a purely AWGN channel constitutes a theoretical model. However, the AWGN channel is widely used for modelling real, physical communication channels (see for example D1) and it is apparent that the skilled person is able to determine parameters defining an AWGN channel suitable for use as a model for a real, physical communication channel. For example, the skilled person could derive the levels -A and A from the maxima of the probability density function of the received signal levels, or from the code symbol energies. Thus, the board considers that claim 1 is clear in the sense of Article 84 EPC.

5. *Novelty and inventive step*

5.1 Document D1 relates to quantization schemes for convolutional decoding and soft-decision decoding of block codes. It assumes that convolutionaly-encoded bits are sent over an AWGN channel. Figure 1 of D1 shows a probability density function of the signal at the demodulator output, which is a Gaussian random variable. D1 only considers uniform quantization schemes characterised by two parameters: the number q of bits used to represent the quantized intervals, and the step size ρ. Figure 1 of D1 illustrates the situation where q = 3 and there are seven quantization intervals or zones identified as -3, -2, -1, 0, +1, +2 and +3. The maximum of the probability density function shown in the Figure falls in interval +3. According to D1, to "improve the quantizer performance, zones +4 and -4 are appended as shown in Fig. 1". The intervals +4 and -4 thus cover levels above and below the levels at which the maxima of the probability density function occur. Even assuming that the intervals +4 and -4 are bounded and have step size ρ, the quantization range of Figure 1 is smaller than twice the range between the signal levels at probability density maxima. D1 teaches to select the quantization scheme to minimise the bit error rate (BER) and Figure 2 of D1 shows curves for different numbers of quantization levels, each curve giving the BER as a function of the quantizer step size plotted as a fraction of the variance σ. However, it appears that this information is not sufficient to establish a relationship between the quantization range (i.e. the range that would be equally divided by the quantization intervals) and the range between the maxima of the probability density functions. D1 further states that it "appears from Fig. 2 that it is safer to make the quantizer step size larger than the value which minimizes BER". This appears to be related to the fact that the curves of Figure 2 of D1 show a steeper increase of the BER on the left of the minimum (i.e. for smaller step sizes than the value which minimises the BER) than on the right side of the minimum (i.e. for larger step sizes than the value which minimises the BER). Thus, this passage of D1 means that if one cannot select the exact step size that minimises the BER, it is preferable to choose a slightly greater step size rather than a slightly lower step size. Therefore, this passage does not disclose to select a step size substantially greater than the one that minimises the BER in Figure 2.

5.2 Thus, the subject-matter of present claim 1 differs from the prior art disclosed in D1 in that the quantization method is for an iterative decoder. A further difference is that said intervals into which received signal levels are equally divided occupy a range 2^{ℓ} times greater than the range between the signal levels received at probability density maxima, ℓ being a positive integer. This provides a quantization method that is particularly effective for an iterative decoder, in particular a turbo decoder (see page 3, lines 13 to 19, and page 11, the first sentence following table 3 of the application as filed).

5.3 The board has no reason to doubt that, in the case of an iterative decoder, making the range occupied by the equal quantization intervals 2^{ℓ} times greater than the range between the signal levels received at probability density maxima, ℓ being a positive integer, should result in improved BER and FER (see in particular table 3 of the application as filed). Neither D1, nor the other documents cited in the search report suggest making the quantization range as large as specified in claim 1 of the application. The board therefore concludes that, having regard to the cited state of the art, the subject-matter of claim 1 is not obvious to a skilled person.

5.4 The subject-matter of claim 1 is therefore considered as being new and involving an inventive step in the sense of Article 54(1) and Article 56 EPC. The subject-matter of claims 2 to 9, which are dependent on claim 1, is thereby also to be considered as being new and involving an inventive step.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the first instance with the order to grant a patent in the following version:

   Description
   Pages 2, 5, 6 and 8 to 13 as originally filed,
   Pages 3, 3b and 14 filed with the statement of grounds of appeal dated 23 June 2005,
   Pages 1, 3a, 4 and 7 filed in the oral proceedings of 3 May 2007.

   Claims
   No. 1 to 9 as main request filed in the oral proceedings of 3 May 2007.

   Drawings
   Sheets 1/5 and 3/5 to 5/5 as originally filed,
   Sheet 2/5 filed with the statement of grounds of appeal dated 23 June 2005.

The Registrar: The Chairman:

U. Bultmann M. Rognoni