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Datasheet for the decision of 16 September 2009

Case Number: T 0067/07 - 3.5.05

Application Number: 97850081.7

Publication Number: 0814587

IPC: H04L 27/26

Language of the proceedings: EN

Title of invention:
Pulse shaping for multicarrier systems

Applicant:
TELIASONERA AB

Opponent:
-

Headword:
OFDM pulse shaping/TELIASONERA

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

Relevant legal provisions (EPC 1973):
-

Keyword:
"Inventive step - no"

Decisions cited:
-

Catchword:
-

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Case Number: T 0067/07 - 3.5.05

D E C I S I O N
of the Technical Board of Appeal 3.5.05
of 16 September 2009

Appellant: TELIASONERA AB
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Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 16 June 2006 refusing European patent application No. 97850081.7 pursuant to Article 97(1) EPC 1973.**

Composition of the Board:

Chairman: D. H. Rees
Members: P. Cretaine
F. Blumer

Summary of Facts and Submissions

I. This appeal is against the decision of the examining division dispatched 16 June 2006, refusing European patent application No. 97 850 081.7. The decision was based on the ground that the subject-matter of the independent claims of each of the requests did not involve an inventive step having regard to the disclosure of

D2: GUDMUNDSON M. and ANDERSON P.O.: "ADJACENT CHANNEL INTERFERENCE IN AN OFDM SYSTEM", IEEE 46TH VEHICULAR TECHNOLOGY CONFERENCE, 1996, MOBILE TECHNOLOGY FOR THE HUMAN RACE, vol. 2, 28 April 1996 - 1 May 1996, pages 918-922, XP002153112, IEEE, ZJUNEW YORK, US.

II. Notice of appeal dated 14 August 2006 was received on 18 August 2006 and the appeal fee was paid on the same day. The statement setting out the grounds of appeal was submitted on 19 October 2006.

III. The appellant (applicant) requested that the decision under appeal be set aside and a patent be granted on the basis of claims 1 to 31 filed with the statement setting out the grounds of appeal. As a first auxiliary request the appellant requested that the application be referred back to the examining division for a new communication pursuant to Art. 96(2) EPC 1973, based on the claims filed with the statement setting out the grounds of appeal. As a second auxiliary request, the appellant requested oral proceedings.

IV. The board issued an invitation to oral proceedings scheduled to take place on 16 September 2009. The board

gave a preliminary opinion that the independent claims 1, 13 and 20 did not meet the requirement of Article 84 EPC, that the independent claims 1 and 13 did not meet the requirement of Article 123(2) EPC and that the subject-matter of independent claims 1, 13 and 20 did not involve an inventive step, having regard to the disclosure of D2 alone or taken in combination with

D3: AHN J. and LEE H. S.: "FREQUENCY DOMAIN EQUALISATION OF OFDM SIGNALS OVER FREQUENCY NONSELECTIVE RAYLEIGH FADING CHANNELS", ELECTRONICS LETTERS, vol. 29, no. 16, 5 August 1993, pages 1476-1477, UK.

The board further gave its reasons why the appellant's arguments were not convincing.

V. In a letter submitted on 7 September 2009, the appellant announced that it would not attend the oral proceedings. The letter contained neither arguments nor amendments to the requests.

VI. Oral proceedings were held on 16 September 2009 in the absence of the appellant.

After deliberation on the basis of the submissions and requests as filed with the statement setting out the grounds of appeal, the board announced its decision.

VII. The appellant requests that the decision under appeal be set aside and that a patent be granted based on claims 1 to 31 as filed with the statement setting out the grounds of appeal.

The further text on which this decision is based is:

description	pages 1, 3-12	as originally filed,
	pages 2, 2a	as filed with letter of 21 December 2005;
drawings sheets 1/3-3/3		as originally filed.

VIII. Claim 1 of the sole request reads as follows:

"An OFDM system comprising a transmitter configured to transmit an orthogonal frequency division multiplexing (OFDM) signal in which side lobes are suppressed by a pulse shaping operation performed by a pulse shaping mechanism on said signal, said pulse shaping operation comprising a cyclic convolution operation, said pulse shaping operation causing a loss of carrier orthogonality; and a receiver configured to receive said signal, said system being characterised in that said receiver comprises a frequency equaliser configured to compensate for said loss of carrier orthogonality caused by said pulse shaping operation and in that said receiver also comprises a decoder for detecting said received OFDM-signal, said decoder having built-in appropriate data, relating to the said cyclic convolution operation."

Independent claim 13 reads as follows:

"An OFDM receiver adapted to receive an OFDM signal in which side lobes are suppressed by pulse shaping involving cyclic convolution using a windowing function at a transmitter, said receiver characterised in that it comprises a receiver mechanism configured to receive

said OFDM signal transmitted from the transmitter; and, an equaliser adapted to compensate for a loss of carrier orthogonality induced by said pulse shaping, and in that said receiver also comprises a decoder for decoding said received OFDM-signal, said decoder having built-in appropriate data, relating to the cyclic convolution."

Independent claim 20 reads as follows:

"In an OFDM system in which side lobes are suppressed by pulse shaping at a transmitter, said system also including a receiver, a method for communicating an OFDM signal, the method comprising the steps of:
- forming at the transmitter said OFDM signal,
- at the transmitter, pulse shaping said signal so as to reduce side lobes of said signal, thereby causing a loss of carrier orthogonality in said OFDM signal,
- transmitting said signal,
- receiving said signal at a receiver, and,
- applying at said receiver said signal to an equaliser compensating for said loss of carrier orthogonality by equalising."

Reasons for the Decision

1. *Admissibility*

The appeal complies with the provisions of Article 106 to 108 EPC 1973. Therefore it is admissible (see Facts and Submissions, points II and III).

2. *Non-attendance of oral proceedings*

In its letter of 7 September 2009 the appellant announced that it would not be represented at the oral proceedings. The board considered it to be expedient to maintain the set date for oral proceedings. Nobody attended the hearing on behalf of the appellant.

Article 15(3) RPBA stipulates that the board shall not be obliged to delay any step in the proceedings, including its decision, by reason only of the absence at the oral proceedings of any party duly summoned who may then be treated as relying only on its written case.

Thus, the board was in a position to take a decision at the end of the hearing.

3. *Inventive step*

3.1 *Effect of added subject-matter*

In the summons to the oral proceedings, to which the appellant has not made any substantive response, the board pointed out that the feature of claims 1 and 13 that the pulse shaping comprises or involves cyclic convolution did not appear to be disclosed in the application as filed. The board sees no reason to depart from its preliminary opinion on this point, which would be sufficient reason in itself to dismiss the appeal. However, it is an objection which could easily be overcome and is not central to the issue of inventive step, which seems to the board to be more decisive in the present case. In fact the application as filed describes the pulse shaping operation as being

performed by multiplying the time-domain signal by a window function and the claimed subject-matter will be treated in the following as if this were the specified feature. The board notes in passing that the skilled person in the field would be aware that multiplying a time-domain signal by a function is equivalent to convolving the signal by a corresponding function once it has been transformed to the frequency domain.

3.2 *Prior art*

D2 describes analytical expressions of the interference in an OFDM system, i.e. how one OFDM symbol transmitted on a given subcarrier in a given time interval interferes with a given received OFDM symbol (see figure 1 which describes the time/subcarrier position of the two symbols considered, ($x_{k,l}(t)$ and ($y_{m,n}(t)$).

In the view of the Board these analytical expressions in the time domain define what is denominated in the OFDM field as the inter-carrier interference ICI (when the data detected on one subcarrier is affected by the signals transmitted on other subcarriers) and the inter-symbol interference ISI (when the data detected on one subcarrier is affected by the signals transmitted on that subcarrier in the previous and subsequent symbol periods).

These analytical expressions of the interference also take into account the transmission window or transmitted pulse shape $w_T(t)$ (see equation 2.10), in particular a rectangular transmission window and a Hanning transmission window. In the view of the Board, the use of a transmission window represents a pulse

shaping operation on the OFDM signal. The use of a transmission window implies either multiplication of the time-domain signal by a window function or an equivalent cyclic convolution of the signal in the frequency domain, known by the skilled person to be alternatives, as mentioned above. D2 equations 2.10 and 2.13 show both options.

In particular, D2 considers the case where the transmission window is a Hanning window (paragraph II.B) and draws the conclusion (paragraphs V.B and VI) that the use of such a window produces less interference at the price of having a subcarrier packing half as dense compared to an OFDM system using a rectangular window, implying a 50% reduction of the bit rate. The Board interprets this limitation of the subcarrier packing as an indication that loss of carrier orthogonality has occurred due to the Hanning window use.

The Board also notes that the Appellant has acknowledged in page 2 of the description, on lines 7-11 and in page 3, lines 31-36, that pulse shaping for OFDM (in particular using a Hanning window) was known at the priority date of the application, was used to suppress side lobes, and has the drawback of breaking orthogonality on every other subcarrier.

3.3 Thus, the differences between the subject-matter of claim 1 and the disclosure of D2 are that, in claim 1, the system comprises at the receiver:
- a frequency equalizer configured to compensate for the loss of carrier orthogonality caused by the pulse shaping operation, and

- a decoder for detecting the received OFDM signal having built-in appropriate data relating to said cyclic convolution operation.

The technical problem may therefore be defined as how to remove, at the OFDM receiver, the distortion introduced by the pulse shaping operation.

3.4 The Board shares the view expressed by the Examining Division that an obvious way to reduce distortion is to use equalizers.

Starting from the prior art disclosed in D2, in particular the expression in equation 2.23, and faced with the problem of reducing the distortion, the skilled person would, as a normal design option, configure an equalizer for compensating the identified distortion terms in the received signal. The features that the equalizer is a frequency equalizer and that the decoder has data relating to the cyclic convolution would derive from the frequency domain transformation applied to the terms of equation 2.23, whereby a multiplicative operation in the time domain, like the pulse shaping operation, corresponds to a cyclic convolution in the frequency domain.

The appellant has not attempted to rebut these arguments, which were made in the communication accompanying the summons to oral proceedings, and the board sees no reason to deviate from its preliminary opinion. The subject-matter of claim 1 therefore does not involve an inventive step.

The observations made above in respect to claim 1 (transmitter-receiver system) apply to the corresponding independent claims 13 (receiver) and 20 (method).

3.5 In the statement setting out the grounds of appeal, the appellant first argued that D2 did not disclose a pulse shaping operation on an OFDM signal but rather an interference model valid for any kind of model transmission window.

This argument does not convince the board. In this respect, D2 presents expressions for interference calculations in an OFDM system, which are valid for any kind of transmission window, guard time and symbol time. Symbol time, guard time, and also transmission window are parameters chosen by the person designing the OFDM system. Guard time and transmission window are explicitly given as design parameters on page 921, right-hand column, last paragraph. Symbol time is always a design parameter in digital modulation systems of which OFDM is an example. Further, although D2 does not explicitly use the wording "pulse shaping", it does disclose at page 918, right-hand column, line 6, that a "transmitted pulse shape" is used. The Board therefore judges that this transmitted pulse shape has been chosen by the designer of the system for a pulse shaping operation.

In this respect, the Board also notes that the appellant has acknowledged in the description (see page 2, lines 6-11 and page 3, lines 31-36) and in his response in examination dated 12 April 2006 (see first

paragraph) that pulse shaping in OFDM was known at the priority date of the present application.

The appellant further argued that the skilled person, in order to cope with loss of carrier orthogonality, would choose as a first choice to transmit data on every second sub-carrier.

The Board however considers that, starting from D2 as the closest prior art, the objective technical problem based on the technical differences identified between the subject-matter of claim 1 and the disclosure of D2 (see section 3.3 above) is **to compensate at the receiver the contribution to the interference which is due to the loss of orthogonality between adjacent carriers introduced by pulse shaping** and not **to eliminate at the transmitter the loss of orthogonality.**

In the Board's judgment, the paragraph B on page 921 of D2, stating that the use of a Hanning window implies a subcarrier packing half as dense compared to an OFDM system using a rectangular window, may well define a solution at the transmitter to the problem of loss of carrier orthogonality but does not prevent the skilled person from looking for a solution at the receiver.

3.6 Furthermore, the Board considers that, even if the skilled person having knowledge of D2 would not immediately think of using an equalizer, he would, by looking into the prior art dealing with solutions to distortion in OFDM systems, come across D3.

D3 uses the fact that multiplicative distortion in the time domain (e.g. fading) in OFDM systems acts as

intersymbol interference in the frequency domain (page 1476, left-hand column, "Introduction") and compensates the distortion by using an equalizer in the frequency domain (page 1476, right-hand column, lines 12-27). Since the pulse shaping operation in D2 is also a multiplicative operation in the time domain, the skilled person would be inclined to apply the teaching of D3 in respect of equalization in frequency domain of OFDM signals to the pulse shaped OFDM signal of D2 and thus would arrive at a system according to claim 1.

3.7 The above arguments having been put to the appellant in the board's communication accompanying the summons to oral proceedings and no rebuttal having been received, the board sees no reason to deviate from its preliminary opinion. The subject-matter of claim 1 thus lacks an inventive step and a patent cannot be granted on the basis of the only text put forward by the appellant.

4. No new issues have needed to be considered by the board in coming to the above conclusion and there is therefore no reason to accede to the appellant's request to refer the application back to the examining division.

Order

For these reasons, it is decided that:

The appeal is dismissed.

The Registrar The Chairman

K. Götz D. H. Rees