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Datasheet for the decision
of 17 October 2012

Case Number: T 0276/09 - 3.5.05

Application Number: 00307409.3

Publication Number: 1081908

IPC: H04L27/38

Language of the proceedings: EN

Title of invention:
Signal processing without multiplication in receivers for
digital signals

Applicant:
LUCENT TECHNOLOGIES INC.

Headword:
Multiplication-free signal processing/LUCENT

Relevant legal provisions:
EPC 1973 Art. 56, 84
EPC Art. 123(2)

Keyword:
Added subject-matter - (no, after amendment)
Claims - support by description (yes, after amendment)
Inventive step (yes, after amendment)

Decisions cited:

Catchword:

Case Number: T 0276/09 - 3.5.05

D E C I S I O N
of the Technical Board of Appeal 3.5.05
of 17 October 2012

Appellant: (Applicant)	LUCENT TECHNOLOGIES INC. 600 Mountain Avenue Murray Hill, NJ 07974-0636 (US)
Representative:	Williams, David John Page White & Farrer Bedford House John Street London WC1N 2BF (GB)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted 2 July 2008 refusing European patent application No. 00307409.3 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chair:	A. Ritzka
Members:	K. Bengi-Akyuerek
	G. Weiss

Summary of Facts and Submissions

I.   The appeal is against the decision of the examining
        division, posted on 2 July 2008, refusing European
        patent application No. 00307409.3 on the grounds of
        added subject-matter (Article 123(2) EPC) and lack of
        support of the claims by the description (Article 84
        EPC 1973) regarding a main request, while a late-filed
        auxiliary request was not admitted into the examination
        proceedings under Rule 116(1) EPC 1973.

        The following documents were cited in the examination
        proceedings:

        D1:   S. Ariyavisitakul and L.J. Greenstein: "Redu-
                ced-Complexity Equalization Techniques for
                Broadband Wireless Channels", IEEE Journal On
                Selected Areas in Communications, pages 5-15,
                January 1997;
        D2:   G.M. Durant and S. Ariyavisitakul: "Implemen-
                tation of a Broadband Equalizer for High-Speed
                Wireless Data Applications", Proceedings of IEEE
                International Conference on Universal Personal
                Communications, pages 1015-1020, October 1998;
        D3:   US-A-4 381 546.

II.   Notice of appeal was received on 28 August 2008. The
        appeal fee was paid on the same day. The statement
        setting out the grounds of appeal was received on
        12 November 2008. The appellant requested that the
        decision of the examining division be set aside in its
        entirety and that a patent be granted on the basis of a
        new set of claims (claims 1 to 18) according to a main
        request or to an auxiliary request, both filed with the
        statement setting out the grounds of appeal. In
        addition, oral proceedings were requested as an

auxiliary measure.

III.   A summons to oral proceedings scheduled for 26 October
        2012 was issued on 29 May 2012. In an annex to this
        summons pursuant to Article 15(1) RPBA, the board
        expressed its preliminary opinion on the appeal. In
        particular, objections were raised under
        Articles 123(2) EPC, 84 EPC 1973 and Article 52(1) EPC
        in conjunction with Articles 54 and 56 EPC 1973 with
        respect to the main request. The appellant was also
        informed that the claims of the auxiliary request were
        considered to fulfil the requirements of the EPC.

IV.   With a letter of reply dated 26 September 2012, the
        appellant filed another set of claims (claims 1 to 18)
        according to a new main request replacing the claims of
        the former main request. Moreover, it was requested
        that the procedure be continued in writing.

V.   With a communication dated 17 October 2012, the
        appellant was informed that the oral proceedings
        appointed for 26 October 2012 were cancelled.

VI.   Independent claim 1 of the new main request reads as
        follows:

        "A method of processing information in a receiver
        (100; 120) of a digital communication system, the
        method comprising the step of:
        applying a signal processing operation to a
        sequence of transmitted symbols, wherein the
        transmitted symbols correspond to points in a first
        modulation constellation, the first modulation
        constellation corresponds to a rotated version of a
        second modulation constellation, and each of the
        transmitted symbols represents a particular number of

information bits including a first information bit b_0 and a second information bit b_1;

the signal processing operation utilizing at least one selector (30) to compute a product of an element of a channel estimate and a given one of the transmitted symbols;

CHARACTERIZED IN THAT the selector comprises first and second controllable inverters (10-1, 10-2) and first and second switches (12-1, 12-2), the first and second controllable inverters being adapted to receive respective real and imaginary parts of the element of the channel estimate, said first controllable inverter either inverting or not inverting the real part based on a first control signal, the first control signal being determined by b_1, said second controllable inverter either inverting or not inverting the imaginary part based on a second control signal, the second control signal being determined by both b_0 and b_1, wherein each of the first and second switches has one input adapted to receive the inverted or non-inverted real part from the first controllable inverter and another input adapted to receive the inverted or non-inverted imaginary part from the second controllable inverter, each of the first and second switches being operative to select as its output one of its two inputs responsive to a third control signal, the third control signal being determined by b_0, wherein the outputs of the first and second switches provide respective real and imaginary parts of a product of the element of the channel estimate and the given symbol."

The further independent claims 10 and 18 of the new main request are directed towards a corresponding

apparatus and system, respectively.

Reasons for the Decision

1.   Admissibility of the appeal

        The appeal complies with the provisions of Articles 106
        to 108 EPC (cf. point II above) and is therefore
        admissible.

2.   New Main Request (Sole Request)

        This request was filed in response to the objections
        raised in the board's communication under Article 15(1)
        RPBA and is therefore admitted into the proceedings
        under Article 13(1) RPBA.

        The claims of this request are identical to those of
        the auxiliary request filed with the statement setting
        out the grounds of appeal and differ from the claims of
        the main request underlying the appealed decision in
        that independent claims 1, 10, and 18 as amended
        further specify that
        (a) the selector includes controllable inverters which
            invert the respective real and imaginary parts of
            the channel estimates based on first and second
            control signals, while the corresponding switches
            generate the resulting product based on the
            inverters' outputs and a third control signal;
        (b) the transmitted symbols include a first information
            bit b_0 and a second information bit b_1;
        (c) the first control signal is determined by b_1;
        (d) the second control signal is determined by both
            b_0 and b_1;

(e) the third control signal is determined by b_0.

2.1   Article 123(2) EPC

2.1.1   The added feature (a) is supported by the disclosure of
        page 8, lines 5-10 in conjunction with Fig. 3 of the
        application as filed.

        The added feature (b) is based on the disclosure of
        page 8, lines 4-5 in combination with Fig. 2, while
        added features (c) to (e) are supported, for example,
        by Fig. 3 of the application as filed.

2.1.2   As a result of the above amendments made in response to
        the objections under Article 123(2) EPC raised by the
        examining division (cf. appealed decision, sections 3.1
        and 3.2) and by the board (cf. board's communication
        under Article 15(1) RPBA, section 3.1), the board is
        satisfied that those objections no longer apply.

        Therefore, the board concludes that the application
        complies with the provision of Article 123(2) EPC.

2.2   Article 84 EPC 1973: Support by the description

        Likewise, the board judges that the claims are now
        supported by the description as required by Article 84
        EPC 1973 due to the amendments made to the claims.

2.3   Article 52(1) EPC: Novelty and inventive step

        In the board's judgment, the present claims meet the
        requirements of Article 52(1) EPC for the following
        reasons:

2.3.1   The board concurs with the examining division in
        considering D2 as the closest prior art.

2.3.2   Document D2 is related to a decision-feedback equaliser
        (DFE) technique for QPSK-based wireless broadband
        communications with reduced complexity and discloses,
        with regard to the wording of claim 1, a method of
        processing information in a receiver of a digital
        communication system (see e.g. Fig. 1) utilising a
        selector (*viz.* "feedback filter FBF") to compute a
        product of channel estimates (*viz.* "h_k") and
        transmitted symbols (*viz.* "x_n"). Moreover, using
        symbols of value ±1±j in D2 (see page 1016, left-hand
        column, lines 8-13) implies that π/4-QPSK is adopted,
        i.e. that the symbols are rotated by 45° with respect
        to conventional QPSK modulation and thus correspond to
        a rotated modulation constellation as claimed.

2.3.3   The difference between the subject-matter of claim 1
        and the disclosure of D2 is seen as being that
        (i)   the selector comprises first and second
              controllable inverters and first and second
              switches;
        (ii) the first and second controllable inverters are
              adapted to receive respective real and imaginary
              parts of the element of the channel estimate,
              said first controllable inverter either inverting
              or not inverting the real part based on a first
              control signal being determined by b_1, said
              second controllable inverter either inverting or
              not inverting the imaginary part based on a
              second control signal being determined by both b_0
              and b_1;
        (iii) each of the switches has one input adapted to
              receive the inverted or non-inverted real part
              from the first controllable inverter and another

input adapted to receive the respective inverted or non-inverted imaginary part from the second controllable inverter, each of the switches being operative to select as its output one of its two inputs responsive to a third control signal being determined by b_0, wherein the outputs of the first and second switches provide respective real and imaginary parts of a product of the element of the channel estimate and the given symbol.

2.3.4   As a consequence, the subject-matter of claim 1 is new over the cited prior art (Article 54 EPC 1973).

2.3.5   The objective problem associated with claim 1 is therefore regarded as being how to implement the calculation of real and imaginary parts of an inner vector product made up of channel estimation weights and transmitted symbols at a QPSK-based digital data receiver without performing complex-number multiplications.

2.3.6   D2, albeit touching on the issue of multiplication-free implementation of feedback filters for QPSK-based communications, does not provide a hint towards the separate calculation of real and imaginary parts without resorting to complex-number multiplications. Rather, D2 merely teaches replacing multiplications for correlating complex values in a QPSK-based receiver implementation by using additions (see e.g. page 1016, left-hand column, lines 8-13; page 1018, left-hand column, second paragraph) while being silent as to calculations of the real and imaginary parts of a symbol/channel estimate product via inverters and switches based on control signals depending on the respective information bits of incoming symbols.

Likewise, D1 solely discloses the replacement of
multiplications by additions for the purpose of
correlating complex values in a QPSK-based receiver
implementation, thus clearly leading away from
calculating real and imaginary parts of an inner vector
product using inverters and switches based on control
signals depending on the incoming symbols. Therefore,
even if the teachings of D2 and D1 were combined, the
skilled person would not arrive at the claimed
solution.

Finally, D3 deals with a 45°-rotation of QAM-based
transmissions at the receiver for channel impairment
measurements, but it is silent as to building products
of channel estimate coefficients and incoming symbols.

2.3.7   Therefore, the subject-matter of claim 1 is also found
to be inventive in the light of the cited prior art
(Article 56 EPC 1973).

Since the subject-matter of the further independent
claims 10 and 18 corresponds to that of claim 1, the
above reasoning also applies to those claims.

2.3.8   In conclusion, the subject-matter of the present claims
is new and involves an inventive step within the
meaning of Articles 54 and 56 EPC 1973.

2.4   Since all the other requirements of the EPC are also
found to be fulfilled, the board decides to grant a
patent on the basis of claims 1 to 18 according to the
new main request.

Order

For these reasons it is decided that:

1.   The decision under appeal is set aside.

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

        Description (pages):

        - 1, 4 to 20 as originally filed;
        - 2, 3 filed with the letter of 30 June 2004;
        - 2a filed with the letter of 14 June 2007;

        Claims (nos.):

        - 1 to 18 filed with the letter of 26 September 2012;

        Drawings (sheets):

        - 1/8 to 8/8 as originally filed.

The Registrar: The Chair:

K. Götz   A. Ritzka

Decision electronically authenticated