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File Number: T 772/90 - 3.5.1

Application No.: 84 106 621.0

Publication No.: 0 129 175

Title of invention: Equalizer modifying a phase of a gain control signal to  
carry out equalization

Classification: H04L 27/00

D E C I S I O N  
of 13 June 1991

Applicant: NEC Corporation

Headword: "Inventive step" (no)

EPC Article 56

Keyword:

Headnote



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Boards of Appeal

Chambres de recours

Case Number : T 772/90 - 3.5.1

**D E C I S I O N**  
of the Technical Board of Appeal 3.5.1  
of 13 June 1991

**Appellant :** NEC Corporation  
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**Decision under appeal :** Decision of Examining Division of the European Patent Office dated 14 May 1990 refusing European patent application No. 84 106 621.0 pursuant to Article 97(1) EPC.

**Composition of the Board :**

**Chairman :** P.K.J. van den Berg  
**Members :** A.S. Clelland  
E.M.C. Holtz

## Summary of facts and submissions

- I. European patent application 84106621.0, filed on 8 June 1984 claiming a priority of 10 June 1983 and published under No. 0 129 175, was refused by a decision of the Examining Division dated 14 May 1990.
- II. The reason given for the refusal was that the subject matter of independent claim 1 filed on 7 May 1990 and that of dependent claims 2 to 14 filed on 12 February 1990 lacked an inventive step having regard to the following prior art document:  
  
D1 = EP-A-0 055 922
- III. On 13 July 1990 the Applicant lodged an appeal against this decision and paid the prescribed appeal fee. He requested cancellation of the decision and the grant of a patent. On 12 September 1990 a statement setting out the grounds of appeal was filed.
- IV. In a communication dated 8 March 1991 the Rapporteur expressed the preliminary view that having regard to the disclosure of D1 the subject-matter of claim 1 indeed lacked an inventive step.
- V. Oral Proceedings were held on 13 June 1991. The Appellant requested the grant of a patent on the basis of the following claims:

### Main request:

- Claim 1 filed on 7 May 1990
- Claims 2 to 14, filed on 12 February 1990

First auxiliary request:

- As main request, with the addition to the end of claim 1 of the words "if that specific phase is adjacent to  $+\pi/2$  or  $-\pi/2$ "

Second auxiliary request:

- Claim 1 as formed by a combination of claim 1 filed on 7 May 1990 and claims 2 and 3 filed on 12 February 1990
- Claims 4 to 14, filed on 12 February 1990

Third auxiliary request:

- As second auxiliary request, with the addition to claim 1 of the wording according to the first auxiliary request.

VI. Claim 1 according to the main request reads:

"An equalizer responsive to an input signal subjected to modulation at a modulation rate for producing an output signal, said input signal being accompanied by a carrier wave of a carrier frequency, said equalizer including delay means responsive to said input signal for successively delaying said input signal in relation to said modulation rate to produce a central tap signal and additional tap signals, control signal generating means for generating a central control signal and complex control signals which are in one-to-one correspondence to said central and said additional tap signals, respectively, and output signal producing means responsive to said central and said additional tap signals and to said central control signal for producing said output signal, said complex control signals having different phases relative to said central control signal, comprising phase modifying means for modifying a specific phase of one of said complex control signals into a modified phase

by shifting said specific phase, said modified phase being placed in a predetermined range which is greater than  $-\pi/2$ (rad) and smaller than  $+\pi/2$  (rad), characterised in that the specific phase is shifted by a step equal to  $\pi/2$  (rad)."

VII. The Appellant's arguments in support of the patentability of claim 1 can be summarised as follows:

D1 discloses an equalizer corresponding to the first part of claim 1. D1 aims at solving the same problem as the one underlying the invention, namely to bring the phase of the signals at additional taps of a transversal filter within  $\pm 90^\circ$  from the phase of the signal at the mid tap (page 12, lines 8 to 11). It is recognized in D1 that the closer the phase difference is to  $0^\circ$ , the greater is the insensitivity of the equalizer to variations of the carrier (page 13, lines 3 to 5). In D1, three methods of achieving this goal are proposed. The first method consists in reversing the signal polarity of one of the circuits taking part in the control loop, the second involves adjusting the delay times of the delay circuits between the signal taps, and the third is a combination of the first and second methods. The first method results in a shift of  $180^\circ$  and would not be useful if the initial phase difference is in the vicinity of  $\pm 90^\circ$ . In such cases D1 implies that the second or third methods must be used, rendering modifications of the delay times necessary. D1 thus points away from the invention by devising a separate, comparatively cumbersome method for shifts of approximately  $90^\circ$ .

## Reasons for the Decision

1. The appeal is admissible.
2. Admissibility of the requests.
  - 2.1 According to the first auxiliary request, claim 1 includes the feature that the specific phase is shifted by  $90^\circ$  "if that specific phase is adjacent to  $+\pi/2$  or  $-\pi/2$ ". At the Oral Proceedings the Appellant's representative stated that the amendment was based on the description at page 15, lines 6 to 9. He argued that the claimed equalizer was one of several possible configurations using the same basic apparatus, which is reconfigured in dependence on the phase shift; in the event that the phase shift is  $\pi$  the configuration of Fig. 1 of D1 is desirable whereas for a phase shift of  $\pi/2$  the configuration of Fig. 2 of the application or one of the related embodiments should be used. The actual embodiment would depend on whether the phase was leading or lagging. By changing the configuration the phase shift could be made as small as possible.
  - 2.2 The cited passage at page 15 does not however provide support for the proposed wording. This passage refers to the prior art equalizer of Fig. 1 and indicates that for use of the zero forcing algorithm the phase displacement must fall within the so-called first or fourth quadrants, i.e. within a limit of  $\pm\pi/2$  radians. Close to the limit, when the phase is "adjacent to  $\pm\pi/2$ " (page 15, line 7) stability is disturbed. From lines 11 to 18 of page 15 it can be seen that in order to maintain stability it is necessary to introduce further delays to bring the phase displacement further into the first or fourth quadrants. The size of these delays is not specified.

- 2.3 Nowhere in the originally filed application can the Board find any explicit indication that different configurations of equalizer are used to bring the phase as close to zero as possible. It is self-evident that when the phases are "adjacent to  $\pm \pi/2$ " a specific phase shift of  $\pi/2$  will bring the overall phase shift down to zero, but there is no indication that this particular case is the subject of the application. The application consistently indicates the desirability merely of a phase shift to within the first or fourth quadrant, see page 2 lines 17 to 19, page 14 line 24 to page 15 line 6, and page 16 line 23 to page 17 line 8. The vector diagram of Fig. 3 shows signal vectors in the second quadrant which are each shifted by  $-\pi/2$ ; in the case of vector 91 the phase is arguably "adjacent to  $\pm\pi/2$ " but this is not so for vector 92, so that no teaching is derivable from this diagram that specifically in the case of a phase "adjacent to  $\pm\pi/2$ " a phase shift of  $\pi/2$  should be used. Although it seems evident that the closer the phase shift is to zero the higher the stability, the application merely teaches a specific phase shift, not the use of a specific phase shift in a specific situation. The proposed amendment therefore goes further than the originally filed disclosure and fails to meet the requirement of Article 123(2) EPC.
- 2.4 The first auxiliary request is accordingly inadmissible.
- 2.5 The second auxiliary request, based on a combination of claims 1 to 3 of the main request, was made for the first time at the conclusion of the oral proceedings. No specific text of a claim was presented to the Board and no consequential amendments to the remaining claims and the description were proposed.

- 2.6 The third auxiliary request combines the subject-matter of the first and second auxiliary requests. Since the first auxiliary request is inadmissible, the third auxiliary request is accordingly also inadmissible.
- 2.7 No objection under Article 123(2) EPC arises to either the main request or the second auxiliary request.
- 2.8 Since all the other requests have been found inadmissible, only the main request and the second auxiliary request remain to be considered below.

### 3. Novelty

- 3.1 Figure 1 of D1 discloses an equalizer responsive to an input signal subjected to modulation at a modulation rate for producing an output signal, the input signal being accompanied by a carrier wave of a carrier frequency. This known equalizer includes the following features:

delay means (10, 11) responsive to said input signal for successively delaying said input signal in relation to said modulation rate to produce a central tap signal and additional tap signals,

control signal generating means for generating a central control signal ( $r_0$ ) and complex control signals ( $r_{-1}$ ,  $d_{-1}$ ,  $r_1$ ,  $d_1$ ) which are in one-to-one correspondence to said central and said additional tap signals, respectively,

output signal producing means (33, 34, 40) responsive to said central and said additional tap signals and to said central control signal for producing said output signal, said complex control signals having different phases relative to said central control signal,

phase modifying means (51 to 92; see page 12, lines 18 to 22 of the description as regards the "first method") for modifying a specific phase of one of said complex control signals into a modified phase by shifting said specific phase, said modified phase being placed in a predetermined range which is greater than  $-\pi/2$  and smaller than  $+\pi/2$ .

- 3.2 The characterising part of claim 1 of the main request specifies shifting the phase by a step equal to  $\pi/2$  (rad). How this result is achieved is not specified and it appears that the claim does not exclude the use of delay lines. Although D1 does not explicitly specify any particular shift of phase angle, the embodiment discussed in connection with the so-called "first method" at page 12, lines 18 to 22 implies a shift of  $\pi$  radians. The "second method" has an indeterminate step which appears from page 13, lines 5 to 7 to be smaller than  $\pi$ . The "third method", which combines the two, apparently has a shift greater than  $\pi$  radians. Thus, D1 does not specifically disclose the provision of a phase shift equal to  $\pi/2$ ; the subject matter of the claim is accordingly new.

#### 4. Inventive step

- 4.1 The problem underlying the present invention is also addressed in D1. The problem is that control loop instability can arise in equalizers working according to the zero forcing algorithm if the carrier frequency is not an integral multiple of the modulation rate. D1 proposes as a solution to this problem a shift of the phase of the signals at additional taps of the transversal filter into a range of  $\pm\pi/2$  radians from the phase of the signal at the central tap. According to the "first method", the phase of a control signal in the equalizer control loop is

reversed, thereby apparently achieving a phase shift of  $\pi$  radians. The "second method" makes use of delay lines to shift the signals into the first and fourth quadrants. As noted at paragraph 3.2 above, it is implicit in the discussion of the delay lines that the phase shift they provide is comparatively small with respect to that provided by the "first method", since the shifts caused by the delays are said not to affect the equalizing capacity of the equalizer if they are small enough. The "third method", which combines the two previous methods, again suggests that the delays effected by the delay lines are comparatively small.

4.2 Although at first blush both the "first method" and "second method" of D1 appear to be highly relevant to the invention as claimed, the representative contested this. He argued that it was incorrect to consider D1 exclusively by reference to the individual "methods" and the correct approach was to consider the combined arrangement known from the "third method" in which either a phase reversal or a delay circuit brought the phase displacement to within the desired range. Such an arrangement was shown in Figure 1 of the application and represented the correct starting point.

4.3 In support of this argument the representative drew attention to the passage at page 12, line 18 to page 13, line 12 of D1, in which the so-called "first", "second" and "third" methods of D1 are disclosed. He pointed out that these three methods are not alternative ways of arriving at the same phase shift but are separate methods giving differing phase shifts, the method used being chosen in dependence on the phase displacement of the signals.

- 4.4 However, the Board takes the view that the skilled man is led by D1 to practice not merely a phase shift of  $\pi$  or greater but also - as in the "second method" -intermediate phase shifts. D1 indicates at page 13, lines 3-5, that the closer the phases of the shifted signals to that of the reference signal the more stable the control loop, so that the skilled man could be expected to ensure that the shifted signals are as close to being in-phase as possible. If a phase shift of  $\pi/2$  radians was necessary he would seek to provide this, either by modification of the control loop as in the "first method" or provision of delay lines as in the "second method". Neither alternative involves the exercise of invention.
- 4.5 Accordingly, the subject-matter of Claim 1 of the main request does not involve an inventive step. Therefore the main request is to be refused.
- 4.6 Dependent claims 2 to 14, insofar as they can be understood, do not add any inventive feature to claim 1.
- 4.7 Since claim 1 of the second auxiliary request combines the subject-matter of claims 1 to 3 of the main request it does not involve an inventive step either.

Order

For these reasons, it is decided that:

The appeal is dismissed.

The Registrar:

The Chairman:

M. Beer

P.K.J. van den Berg