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**D E C I S I O N**  
**of 22 April 1998**

**Case Number:** T 0495/97 - 3.5.1

**Application Number:** 90117194.2

**Publication Number:** 0416622

**IPC:** H04B 10/18

**Language of the proceedings:** EN

**Title of invention:**

Predistorter for linearization of electronic and optical signals

**Applicant:**

Ortel Corporation

**Opponent:**

-

**Headword:**

-

**Relevant legal provisions:**

EPC Art. 52, 56

**Keyword:**

"Inventive step - main request (no), auxiliary request (yes)"

**Decisions cited:**

-

**Catchword:**

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Boards of Appeal

Chambres de recours

Case Number: T 0495/97 - 3.5.1

**D E C I S I O N**  
of the Technical Board of Appeal 3.5.1  
of 22 April 1998

**Appellant:**

Ortel Corporation  
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**Representative:**

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**Decision under appeal:**

Decision of the Examining Division of the  
European Patent Office posted 18 December 1996  
refusing European patent application  
No. 90 117 194.2 pursuant to Article 97(1) EPC.

**Composition of the Board:**

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

## Summary of Facts and Submissions

I. This appeal is against the decision of the Examining Division to refuse the application on the ground that the subject-matter of each of the claims lacked an inventive step in view of the disclosure of the following document:

D2: EP-A-078 884.

II. In the notice of appeal the appellant (applicant) requested that the decision under appeal be set aside and a patent granted on the basis of the claims on file. A conditional request for oral proceedings was also made.

III. In a communication the rapporteur, on behalf of the Board, expressed the preliminary view that the subject-matter of at least the independent apparatus and method claims did not involve an inventive step having regard to the disclosure of D2 when read in the light of the teaching of either of the following documents:

D1: US-A-4 068 186,

D5: The National Telesystems Conference,  
7-10 November 1982, pages E3.1.1 to E3.1.6,  
Chakraborty et al.: "Some aspects of wideband HPA  
linearizer testing".

IV. On 24 March 1998 the appellant filed a revised set of claims to replace those on file. At the oral proceedings, held on 22 April 1998, a further set of claims were filed; the appellant requested that the decision under appeal be set aside and a patent granted on the basis of the following documents of a main request and a single auxiliary request:

Main request:

**Claims:** 1 to 17 as received on 24 March 1998.

**Description:** pages 2, 5 to 11 and 13 as originally filed;  
pages 3 and 12 as received on 31 May 1995;  
pages 1 and 1a as received on 2 February 1996.  
page 4 as received on 24 March 1998.

**Figures:** 1 to 4 as originally filed.

Auxiliary request:

**Claims:** 1 to 16 as submitted at the oral proceedings.

**Description:** pages 1, 1a, 2 to 13 as submitted at the oral proceedings.

**Drawings:** Figures 1 to 4 as submitted at the oral proceedings.

V. Claim 1 of the main request reads as follows:

"A predistortion circuit comprising:

means (10) for splitting an input modulation signal for a non-linear device into a primary electrical path (13) and a secondary electrical path (14);

means (11) for additively recombining the primary and secondary paths (13,14) into a single path to form a signal for application to a non-linear device (40);

means (15) for generating at least second order intermodulation products in the secondary path (14) having a relative amplitude corresponding to the amplitude of distortion in the non-linear device (40) and for suppressing fundamental frequencies of the modulation signal;

means (17) in series with the means (15) for generating at least second order intermodulation products for adjusting the amplitude of the signal on the secondary electrical path (14); and

means (23) in the primary electrical path (13) and/or the secondary electrical path (14) for adjusting phase of primary path signal with respect to phase of secondary path signal;

**characterised by**

means (19) for providing frequency dependent amplitude adjustment of the at least second order intermodulation product in the secondary path."

Independent claim 15 is a method claim having substantially the same features as claim 1.

VI. Claim 1 of the auxiliary request reads as follows:

"A predistortion circuit comprising:

means (10) for splitting an input modulation signal for a non-linear device into a primary electrical path (13) and a secondary electrical path (14);

means (11) for additively recombining the primary and secondary paths (13,14) into a single path to form a signal for application to a non-linear device (40);

means (15) for generating intermodulation products in the secondary path (14) having a relative amplitude corresponding to the amplitude of distortion in the non-linear device (40) and for suppressing fundamental frequencies of the modulation signal;

means (17) in series with the means (15) for generating intermodulation products for adjusting the amplitude of the signal on the secondary electrical path (14); and

means (23) in the primary electrical path (13) and/or the secondary electrical path (14) for adjusting phase of primary path signal with respect to phase of secondary path signal;

**characterised by**

means (19) for providing frequency dependent amplitude adjustment of substantially only the second order and higher even order intermodulation products in the secondary path."

Claim 14 is an independent method claim having substantially the same features as claim 1.

VII. The appellant argued as follows:

The gist of the invention was the provision, in a predistortion circuit, of a specific form of processing of second order distortion. Although higher order distortion products also required processing, the emphasis was on the second order products because, in the particular case of a semiconductor laser with a bandwidth of greater than one octave, second order products were in-band and caused output distortion. In accordance with the invention lower frequencies were treated differently to higher frequencies.

The prior art was exclusively concerned with third order distortion, all three prior art documents relating to comparatively narrow-band travelling-wave tube (TWT) technology, in which third-order distortion was important. It was not known from, or suggested by, the cited art to concentrate on second-order effects and to provide amplitude adjustment with frequency. In particular, in D2, which was the closest prior art document, there was no suggestion of frequency-dependent amplitude adjustment. The problems with which the application was concerned did not arise in D2 or indeed in D1 or D5. D5 in particular was explicitly concerned with third-order effects and although it provided frequency-dependent amplitude adjustment did so in the main signal path rather than the secondary path in which the predistortion signal was generated. The skilled person would have no reason to apply the teaching of D1 or D5 to the predistortion circuit known from D2, any such combination of documents being based on an ex post facto analysis.

The independent claims of the auxiliary request made explicit the importance of the second and higher even order effects. There was not the slightest suggestion in any of the cited documents that second-order effects were of importance.

## **Reasons for the Decision**

### **1. Amendments**

- 1.1 Claim 1 of the auxiliary request is limited to providing amplitude adjustment of "substantially only the second order and higher even order intermodulation products". The Board notes that this limitation is supported in the originally filed application at

page 10, lines 8 to 14 and page 10, line 35 to page 11, line 3.

1.2 The passages quoted at point 1.1 above also provide support for claim 7 of the auxiliary request.

1.3 The Board is satisfied that the claims of both requests meet the requirements of the EPC as regards clarity and support (Article 84 EPC), and added subject-matter (Article 123(2)).

## 2. *Background to the application*

2.1 A problem which arises in the field of high-frequency amplifiers is that non-linearity, usually in the form of limiting at higher power outputs, causes the production of harmonics and, when two independent signals are present at the input, intermodulation products. The simplest of these, the second order product, includes the sum and difference frequencies of the two input signals, whilst third order products comprise sum and difference frequencies of the second harmonic of one frequency and the fundamental of the other. In comparatively narrow band systems emphasis is placed on the third order products, in particular the difference products, since these are in-band. In a wide-band amplifier it can however happen that the second order products are also in-band.

2.2 It is known in the prior art to solve the problem of non-linearity by means of a predistortion circuit providing a non-linear characteristic which matches that of the amplifier but in the opposite sense, so as to cancel out the spurious signal products. The preamble of claim 1 of both requests is based on such a predistortion circuit, see document D2. In this known circuit the input signal to the non-linear device is

split into primary and secondary paths; in the secondary path the fundamental signals are cancelled out and by means of a non-linear device the required intermodulation products generated. After amplitude and phase correction the secondary signals are recombined with the primary signal and supplied to the non-linear device.

2.3 A problem which arises in wideband non-linear amplifiers is that the degree of non-linearity may vary across the frequency band. D2 does not discuss this problem; it is however known independently from each of documents D1 and D5. In each of these documents frequency-dependent predistortion of a non-linear amplifier is provided.

3. *Novelty and inventive step (main request)*

3.1 Claim 1 of the main request is correctly delimited with respect to acknowledged prior art document D2.

3.2 Turning to document D1, this discloses a predistortion circuit in which, referring to Figure 3a, a coupler 2 splits an input modulation signal into a primary path (1) and a secondary path (2), a subsequent coupler 5 recombining the two paths. Intermodulation products are generated in the secondary path by means of a low power TWT 4. It was not contested at the oral proceedings that the inherent non-linearity of such a device will cause at least second order intermodulation products to be generated. Amplitude adjustment means 13 are provided in the secondary path, together with means 10,12 which provide a frequency dependent amplitude adjustment of the intermodulation products. Phase adjustment means 3,9 are provided in the primary path.

The disclosure of D1 differs from what is claimed in

that in the secondary path the fundamental frequencies of the modulation signal are apparently not suppressed as required by claim 1. The subject-matter of claim 1 is accordingly novel having regard to the disclosure of D1.

3.3 D5 discloses in connection with Figure 1 a predistortion circuit in which the features of the preamble of claim 1 can be identified. A coupler DC(1) splits the signal into primary and secondary electrical paths, the latter including a FET amplifier FET(2) which operates in a non-linear region; the resultant distorted signal is combined in a coupler DC(3) with a signal from a linear FET amplifier FET(1) in inverse phase, apparently so that fundamental frequencies are suppressed. Amplitude and phase adjustment means PC(2) and AC(2) are provided in the secondary electrical path. This circuit also includes a "slope equalizer" which according to the associated text at page E3.1.2, left hand column, serves to "compensate for the intrinsic amplitude and phase slopes of the device to be linearized", the implication being that slope with frequency is meant. The frequency dependent amplitude adjustment is however in the recombined signal path rather than the secondary path as required by claim 1, so that the claim is novel with respect to the disclosure of D5.

3.4 Although it was argued at the oral proceedings that none of the prior art related specifically to second order intermodulation products, the Board notes that the claim is not in fact limited to such products; it merely requires that at least second order intermodulation products be generated. The prior art non-linear devices - such as the TWT 4 of D1, the Schottky barrier diodes of D2 and the non-linear FET of D5 - will provide such products. The skilled person can accordingly be expected to appreciate that the prior

art devices also generate second order intermodulation products.

3.5 The Board considers that the skilled person starting out from the D2 circuit and faced with the problem that the non-linearity varies with frequency, would find the solution to this problem in D1. In this document, as stated above, means are provided in the secondary path which permit a frequency dependent amplitude adjustment of the intermodulation products. Although it was argued that the combining of D1 with D2 was based on a purely ex post facto analysis, the Board does not agree. The problem of variation of non-linearity with frequency is the problem to be solved, a problem explicitly mentioned in D1: column 2, lines 37 to 39 states that "it is difficult to compensate for the characteristics in a high-frequency amplifier whose non-linear characteristics varies with frequency". Lines 53 and 54 of the same column state that an object of the invention is to permit compensation "for such nonlinear characteristics even if they vary with frequency". The skilled person, faced with the problem of such variation in the system of D2 will therefore, without the exercise of invention, derive the solution from D1. The subject-matter of claim 1 accordingly lacks an inventive step.

3.6 The above argument applies mutatis mutandis to independent method claim 15.

4. *Novelty and inventive step (auxiliary request)*

4.1 The preamble of claim 1 of the auxiliary request differs from that of the main request only in that the words "at least second order" have been removed; as noted above, the deleted expression has no practical

limitative effect and the comments above as regards novelty apply also to claim 1 of the auxiliary request.

- 4.2 Turning now to inventive step, claim 1 of this request is characterised by frequency dependent amplitude adjustment of "substantially only the second order and higher even order intermodulation products". The additional limitation to second and higher even order products deals with the problem which arises in a wide-band amplifier of second order products occurring in-band.
- 4.3 In the Board's view the skilled person, starting out from the disclosure of D2 and providing frequency dependent amplitude adjustment in accordance with the disclosure of D1, would not limit this adjustment to second order and higher even order intermodulation products. D1, like D5, is primarily concerned with non-linearity in a travelling wave tube; hence the compensation is carried out by a second TWT, device 4 in Figure 3a. D1 is somewhat vague as to the actual processing of the signals in the secondary path, but there is no indication that particular components such as the even order intermodulation products are processed any differently from other components. The skilled person would not therefore be lead by the teaching of D1 to provide frequency dependent amplitude adjustment only of the second order and higher even order intermodulation products.
- 4.4 Document D5 can be seen from page E3.1.2, equations 1 to 8, to be exclusively concerned with third and higher order odd modulation products. The Board accepts the appellant's contention that in the context of a TWT amplifier the expression "broad band" has a comparatively narrow meaning - see Table 2 at page E3.1.3 of D5, in which the frequency range is given as 5925 to 6425 MHz - so that the term of

interest to the skilled person is primarily the third order. The skilled person, seeking to carry the teaching of D5 into effect, would therefore concentrate on compensating for odd order products.

- 4.5 Although it might be argued that the skilled person, faced with the problem of second and higher even order products occurring in-band in the case of a broad band system, i.e. a system having a range of greater than one octave, would also seek to compensate for these components, there is no suggestion in any of the cited art that only these components be selected. The Board accordingly concludes that the skilled person would not arrive at the claimed arrangement without the exercise of an inventive step.

## Order

### For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The main request is refused.
3. The case is remitted to the first instance with the order to grant a patent on the basis of the auxiliary request.

The Registrar:

The Chairman:

M. Kiehl

P. K. J. van den Berg

