(54) Title: PREDISTORTION OF PULSE MODULATOR FOR CORRECTION OF SLEWING DISTORTION

![Fig. 3](image-url)

(57) Abstract: The present invention relates to a circuit arrangement and method of applying predistortion to a baseband signal used for modulating a pulse-shaped signal, wherein an envelope information of the baseband signal is detected and slewing distortions of the pulse-shaped signal are reduced by applying at least one of a phase modulation and a duty cycle modulation to the baseband signal as additional predistortion in response to the detected envelope information. Thereby, slewing distortions in the pulse-shaped signal are removed or at least reduced.
Declaration under Rule 4.17:
— as to applicant’s entitlement to apply for and be granted a patent (Rule 4.17(ii))
— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

Published:
— with international search report

(88) Date of publication of the international search report: 28 August 2008
A. CLASSIFICATION OF SUBJECT MATTER

INV. HO3F/32 HO3K7/10 HO3C3/04

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
HO3K HO3C HO3F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
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<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>SHAWN KUO: &quot;Linearization of a Pulse Width Modulated Power Amplifier&quot;</td>
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<td>June 2004 (2004-06), MASSACHUSETTS</td>
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<td></td>
<td>INSTITUTE OF TECHNOLOGY, XP002486022 pages 48-49; figures &quot;4-3&quot;, &quot;4-5&quot;.</td>
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<tr>
<td>X</td>
<td>EP 1 271 870 A (NOKIA CORP [FI])</td>
<td>1-3, 8, 9</td>
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<td></td>
<td>2 January 2003 (2003-01-02) paragraphs [0025] - [0027]</td>
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<td>paragraphs [0030], [0033]. - [0037]</td>
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<td>X</td>
<td>US 5 617 058 A (ADRIAN ANDREW A [US] ET AL) 1 April 1997 (1997-04-01)</td>
<td>1, 4-6, 8-10</td>
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<td>abstract; figures 3a-3c, 6a, 8a-9a</td>
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Further documents are listed in the continuation of Box C.

See patent family annex.

* "A" document defining the general state of the art which is not considered to be of particular relevance

* "E" earlier document but published on or after the international filing date

* "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another document or other special reason (as specified)

* "O" document referring to an oral disclosure, use, exhibition or other means

* "P" document published prior to the international filing date but later than the priority date claimed

* "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

* "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

* "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

* "S" document member of the same patent family

Date of the actual completion of the international search

27 June 2008

Date of mailing of the international search report

15/07/2008

Name and mailing address of the ISA/European Patent Office, P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epc nl,
Fax; (+31-70) 340-3016

Authorized officer

Robinson, Victoria
<table>
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<td>X</td>
<td>US 4 509 017 A (ANDREN CARL F [US] ET AL)</td>
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Continuation of Box II.2

Claims Nos.: 1-10

1. Independent claims 1 and 9 do not meet the requirements of Article 6 PCT for the following reasons:

1.1 In claims 1 and 9 there is confusion as to whether the pulse-shaped signal is at the input of the modulator (i.e. the carrier signal) or at the output. According to the wording "used for modulating a pulse-shaped signal" the pulse shaped signal should be the input carrier signal, but "for reducing slewing distortions of said pulse shaped signal" and the features of claim 8 suggest it is the output (modulated) signal and not the input (modulating) signal. It has been assumed for the purposes of search and for this opinion that the wording of claim 8 is correct since this is more in agreement with the description.

1.2 The wording "for detecting an envelope information" is also not clear. This can mean many things, but based on the fact that the baseband signal is an IQ signal (e.g. fig 3 and equation (1)), the envelope AENV as described (equ. (2)) is not merely the amplitude of those signals and cannot therefore be detected per se. The description suggests instead that the envelope of equation 2 the magnitude component of a polar representation as calculated from the Cartesian components. This is the only variant supported by the description. The vague and misleading formulation of the claim therefore lacks clarity.

1.3 The function of the predistortion unit is also unclear. Assuming the baseband signal to relate to the I and Q signals, it is noted that these are not really predistorted, since there is no mention anywhere in the description of the generation or calculation of altered I and Q signals. Instead, the signals of equation 27 are generated (figure 1) the incorporate the extra factors defined in equations 23 (see equ 26 and fig 3). This can certainly not be called phase modulation or duty cycle modulation of the baseband (IQ) signal. It is somewhat understood although not expressly described that this extra factor must lead to an extra component of phase modulation in the following modulator. Furthermore, the functional definition of the predistortion unit "for reducing slewing distortions of said pulse-shaped signal" is not clear. The examiner is not aware of any specific technical meaning of "slewing distortion" and can therefore only assume that it covers any kind of distortion (in amplitude, phase, frequency) somehow caused by slewing somewhere. It is further assumed that the distortions are probably generated in the modulator or power amplifier of figure 2. However, these units do not appear to be claimed at all. The function of the predistorter is therefore defined by reference to the output signal of unspecified and unclaimed units, even the types of which are not known and with the aim of reducing distortions, the cause, type or effects of which are not known.

Particularly in view of the fact that this unit is apparently central to the invention, these represent a major lack of clarity. Even upon consideration of the dependent claims, none of these were suitable to
provide clarity in combination with the independent claims.

2. In view of the fact that serious clarity issues affect the claims and in particular because they throw extreme doubt on to all features of the invention, the claims themselves could not be searched at this point in time.

2.1 In particular, the lack of clarity as to what distortions, caused by which components are to be precompensated and how, and the fact that despite being central to the invention, there are no clear characteristics of the predistortion unit claimed, means no meaningful search of the claims is possible.

2.2 However, in view of the description, a search of the invention as disclosed therein could be carried out. The search has therefore been limited to the invention as far as it could be understood while staying as close as possible to the original claim 1. The subject-matter of the search was therefore:
- Circuit arrangements for applying predistortion to a baseband signal [claim 1]
- Applied as a modulating signal to a pulse modulation circuit which generates a pulse-shaped signal [claim 8]
- And comprising:
  - A detection unit for calculating the envelope component of said baseband signal. [claim 1, page 11, line 16-20 and page 3, line 27-page 4 line 6]; and
  - A predistortion unit arranged to calculate and supply signals in accordance with equations (27) and (22)-(26) to the pulse modulator [page 11, lines 9-12].

the signals applied to the phase modulator therefore containing a component calculated to add phase or duty cycle modulation to the pulse-shaped signal to reduce slewing distortions therein.

Additionally, the added features of the dependent claims were considered for the search.

Concerning the citations in the search report, indications to claims 1 and 9 should be understood as referring to the subject-matter of the search as indicated above and the corresponding method respectively, while indications to claims 2-8 and 10 should be understood as referring to those claims, but dependent on the matter defined above instead of the corresponding independent claim.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2)PCT declaration be
overcome.
INTERNATIONAL SEARCH REPORT

Box No. II  Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.☐ Claims Nos.:
   because they relate to subject matter not required to be searched by this Authority, namely:

2.☒ Claims Nos. 1-10
   because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
   see FURTHER INFORMATION sheet PCT/ISA/210

3.☐ Claims Nos.:
   because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III  Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1.☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2.☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3.☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4.☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☒ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.
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<td>US 2003058956 A1</td>
<td>27-03-2003</td>
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<tr>
<td>US 5617058 A</td>
<td>01-04-1997</td>
<td>AU 7605196 A</td>
<td>05-06-1997</td>
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<td></td>
<td>CA 2237633 A1</td>
<td>22-05-1997</td>
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<td>DE 69634781 D1</td>
<td>30-06-2005</td>
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<td>DE 69634781 T2</td>
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<td>EP 0861520 A1</td>
<td>02-09-1998</td>
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<td>JP 2000500625 T</td>
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<td>WO 9718626 A1</td>
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