(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 April 2008 (03.04.2008)

PCT

(10) International Publication Number
WO 2008/037964 A1

(51) International Patent Classification:
H04R 3/04 (2006.01)

(21) International Application Number:
PCT/GB2007/003594

(22) International Filing Date:
21 September 2007 (21.09.2007)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
0619320.5 30 September 2006 (30.09.2006) GB

(71) Applicant *(for all designated States except US)*: **UNIVERSITY COLLEGE CARDIFF CONSULTANTS LIMITED** [GB/GB]; Cardiff University, 7th Floor, 30-36 Newport Road, Cardiff CF24 0DE (GB).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **CHAMBERS, Jonathan, Arthur** [GB/GB]; 4 Forge End, Alwalton, Peterborough PE7 3UT (GB). **BELCHER, Raymond, Allan** [GB/GB]; 8 Celyn Avenue, Lakeside, Cardiff CF23 6EH (GB).

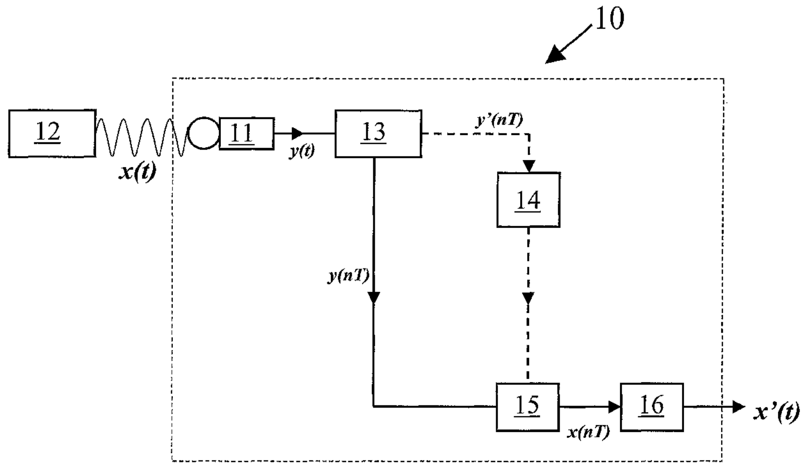
(74) Agent: **STRACHAN, Victoria, Jane**; Urquhart-Dykes & Lord LLP, Churchill House, Churchill Way, Cardiff CF10 2HH (GB).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*
— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

(54) Title: NONLINEAR SIGNAL PROCESSING



(57) Abstract: A method of determining a signal input to a transducer from the signal output from the transducer, the method comprising receiving as input at a processing means the signal output from the transducer, processing the signal output from the transducer in dependance upon a value for the linear gain coefficient of the transducer and a value for the quadratic nonlinear coefficient of the transducer, to determine the signal input to the transducer.

WO 2008/037964 A1

Nonlinear Signal Processing

The present invention relates to the processing of signals output from transducers to remove unwanted distortion, and particularly but not exclusively, to the processing of signals output from a transducer to reduce the effects of quadratic nonlinear distortion.

Nonlinear distortion is a term used in fields such as acoustics, electronics and telecommunications, to describe the distortion between the input and output signals of, for example, an electronic device such as a transducer, due to nonlinear effects. For small input signals, the signal output from most transducers can be considered to be linearly related to the input. However, for larger input signals, the variation of the output can be nonlinearly related to the input.

In audio systems for example, a sound wave is typically generated using a loudspeaker that is driven by a signal generator and is then detected using a microphone. The loudspeaker converts the electronic signals of the generator into a sound wave. The microphone then converts the detected sound wave back into an electrical signal for processing. In such a system, the loudspeaker and microphone are the principal sources of the nonlinearity.

Nonlinearity is generally unwanted in most situations as it can lead to the generation of additional frequencies within the desired signal, which can degrade the desired output signal through interference. Unfortunately, nonlinear signal distortion is inherent to many electronic devices since the origin of this distortion lies within their fundamental components, namely the active and passive components such as transistors and resistors. Consequently, nonlinear distortion is prevalent in many electronic systems.

Systems comprising the known art compensate for the nonlinearity introduced by a loudspeaker and microphone utilising the knowledge of the input signal and the measured output signal. However, in practical systems in which the input signal is an unknown combination of frequencies and waveforms, for example as in speech, and only the output signal can be measured, it has been found difficult to mitigate the quadratic nonlinearity introduced by the microphone and thus the input signal.

The quadratic nonlinearity refers to the component of the signal output of a transducer which varies as the square of the input signal. Known methods for processing an output signal of a transducer to compensate for quadratic distortion can only approximately correct for the quadratic distortion. In one such method, the measured output signal $y(t)$ is assumed as being approximately equal to the input signal $x(t)$, such that the compensated input signal can be determined according to the relationship $x(t)=y(t)-by^2(t)$, where b is the quadratic nonlinear coefficient of the microphone. As this method relies on the approximation $x(t)\approx y(t)$, there is always an error in the calculation of $x(t)$.

It is an aim of the present invention to improve upon such methods.

In accordance with this invention as seen from a first aspect there is provided a method of determining a signal input to a transducer from the signal output from the transducer, the method comprising receiving as input at a processing means the signal output from the transducer, processing the signal output from the transducer in dependance upon a value for the linear gain coefficient of the transducer and a value for the quadratic nonlinear coefficient of the transducer, to determine the signal input to the transducer.

In accordance with this invention as seen from a second aspect there is provided a processor for determining a signal input to a transducer from the signal output from the transducer, the processor comprising means for receiving as an input signal the signal output from a transducer, and processing means for processing the signal output from the transducer in dependance upon a value for the linear gain coefficient of the transducer and a value for the quadratic nonlinear coefficient of the transducer, to determine the signal input to the transducer.

Preferably, the processing is performed by solving a polynomial equation having as known terms values for the linear gain coefficient, the quadratic nonlinear coefficient and the signal output of the transducer.

Preferably, the processing is performed in accordance with the relationship:

$$x(t) = \pm[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

where a is a value of the linear gain coefficient of the transducer, b is a value of the quadratic nonlinear coefficient of the transducer, $y(t)$ is a value of the signal output from the transducer and $x(t)$ represents a value of the input signal to be determined, and wherein the value of $x(t)$ is selected as $+[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$, or as $-[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$.

Preferably, the value of $x(t)$ is selected according to the inequality

$$\text{if} \quad min[x(t)] \geq (-a/2b) \quad \text{then} \quad x(t) = [y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

$$min[x(t)] < (-a/2b) \quad \text{then} \quad x(t) = -[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

An embodiment of the present invention will now be described by way of example only and with reference to the accompanying drawings, in which

Figure 1 illustrates a schematic representation of a signal processing system embodying the present invention; and,

Figure 2 is a graphical comparison of the results of a prior art method and a method embodying the present invention for reducing the effects of quadratic nonlinear distortion.

Referring to figure 1, a system 10 comprises a microphone 11 having an output connected to the input of an analogue-to-digital converter (ADC) 13. The ADC 13 in turn has an output connected to a first processing unit 14. A sounding source 12, for example a high quality loud speaker without significant nonlinear distortion, generates a test sound signal $x(t)$ that is input to the microphone 11. The resultant electrical output $y(t)$ of the microphone 11 is digitised by the ADC 13 to generate digitised signal $y'(nT)$. The processing unit 14 processes the digitised signal $y'(nT)$ to determine values for the linear gain coefficient and the quadratic nonlinear coefficient of the microphone 11.

The system 10 further comprises a second processing unit 15 (subsequent to the first processing unit 14). The second processing unit 15 is arranged to receive a signal output from the ADC 13 and to process the signal to generate a digital signal $x(nT)$ that accurately approximates an analogue input signal of the microphone 11. The digitised signal $x(nT)$ is then converted to an analogue electronic signal $x'(t)$ by a digital-to-analogue converter (DAC) 16. Thus, the second processing unit 15 processes the signal input from the ADC 13 to substantially remove or reduce the quadratic nonlinear distortion introduced by the microphone 11.

As will be explained in more detail below, the second processing unit 15 processes the input signal using the values of the linear gain coefficient and the quadratic nonlinear coefficient, as determined by the first processing unit 14, to generate the data representing a signal input to the microphone.

It is envisaged that the linear gain coefficient and the quadratic nonlinear coefficient of the microphone will be determined under test conditions in the factory where the microphone 11 is manufactured. Subsequently, the second processing unit 15 can then be programmed so as to be able to process input signals $y(nT)$ in dependence upon the determined value of the quadratic nonlinear coefficient and a value for the linear gain of the microphone 11, to generate the undistorted microphone 11 output $x'(t)$.

The microphone 11, the ADC 13, the first and second processing units 14, 15, and the DAC 16, may then be sold for use as a single unit 10, which corrects for quadratic nonlinear distortion in signals output from the microphone 11.

The mathematics underpinning the processing performed by the first processing unit 14 and the second processing unit 15 are as follows:

The output $y(t)$ of a microphone , is generally a function of the input signal $x(t)$ and can be represented using the model,

$$y(t)=ax(t)+b(x(t))^2, \quad (1)$$

where a is the linear gain and b is the quadratic nonlinear coefficient of the microphone 11, which are collectively termed the model coefficients. The model coefficients are indicative of the relative contribution of the respective linear and nonlinear components to the output signal $y(t)$, as described above.

In practical systems it is possible to measure $y(t)$, however, it is often difficult to ascertain the exact input signal $x(t)$. The presence of the quadratic nonlinear term in equation 1, i.e. $b(x(t))^2$, degrades the output signal $y(t)$, which in an ideal system, would be a scalar multiple of the input $x(t)$. Accordingly, the ability to correct the output signal to correct for the undesired quadratic nonlinear component would allow for an accurate determination of the input signal $x(t)$.

For the purposes of describing the present invention, it is assumed that the input signal $x(t)$ is a simple sinusoidal waveform having a single frequency ω and amplitude A. However, the method of the present invention could be applied to any waveform having any number of frequency components.

Substituting the assumption $x(t)=A.\sin(\omega t)$ in equation 1, it is found that,

$$y(t)=a.A.\sin(\omega t) + b\,A^2.\sin^2(\omega t), \quad (2)$$

and using the trigonometric identity,

$$\cos(2\omega t)=1-2\sin^2(\omega t), \quad (3)$$

it is found that,

$$y(t)=b.A^2/2 + a.A\sin(\omega t)) - (b.A^2/2)\cos(2\,\omega t). \quad (4)$$

From equation 4, it is evident that the application of a single harmonic, i.e. single frequency (ω), to a quadratic nonlinear system, can lead to the generation of a higher harmonic (2ω), which can degrade the output signal. In addition, the microphone 11 is found to generate a component having zero frequency, namely $b.A^2/2$ - the *dc* component.

Applying a discrete Fourier transform, (which as is well known, relates the time domain of a signal to the frequency domain) to equation 4, the amplitude of the fundamental harmonic is found to be

$$(a.A) \quad (5)$$

and the amplitude of the second harmonic is found to be

$$(b.A^2/2). \quad (6)$$

In the factory context, the value of A would be known, as would the characteristics of the ADC 13. Therefore, using equation 5 and 6, the values of a and b can be determined.

Now, using equation 1 and the identity $(x(t) + a/2b)^2 = x(t)^2 + (a/b).x(t) + (a/2b)^2$, the output of a system having a quadratic nonlinearity can be represented as

$$y(t)= b((x(t) + a/2b)^2-(a/2b)^2), \qquad (7)$$

which can be rearranged to find the input $x(t)$ as

$$x(t) = \pm[y(t)/b + (a/2b)^2]^{1/2} - (a/2b). \qquad (8)$$

This gives two possible solutions for $x(t)$, namely

$$x(t)= [y(t)/b + (a/2b)^2]^{1/2} - (a/2b) \qquad (9)$$

$$x(t)= -[y(t)/b + (a/2b)^2]^{1/2} - (a/2b) \qquad (10)$$

In practice, there is ambiguity as to whether to use equation 9 or 10, as $x(t)$ is unmeasurable. However, since the linear gain coefficient and the quadratic nonlinear coefficient of the microphone 11 satisfy the conditions that $a>0$, $b>0$, and assuming $(a/2b)>>1$ and that $x(t)$ has a zero average during normal use, then provided that the minimum value of $x(t)$,

$$min[x(t)] \geq (-a/2b), \qquad (11)$$

the calculation of $x(t)$ proceeds via equation 9. Alternatively, if

$$min[x(t)]<(-a/2b), \qquad (12)$$

the calculation of $x(t)$ proceeds using equation 10.

Referring again to figure 1, to determine a and b, the output signal $y(t)$ from the microphone 11 is passed to the ADC 13 which produces a discrete sample of the analogue signal $y(t)$ at periodic time intervals T and generates the digital signal $y(nT)$, where n is an integer. In the factory context, where likely ranges on a and b are available, the microphone input signal would be designed so that $y(nT)$ lies within the full scale range of the ADC 13. This digital signal is then passed to the first processing unit 14 which applies a discrete

Fourier transform to the signal to generate values for $a.A$ and $b.A^2/2$. Using a known or measured value for A, the first processing unit 14 calculates a value for a and a value for b.

Once the values for a and b have been calculated, the second processing unit 15 is arranged so that it can subsequently process signals output from the ADC according to equation 9 or 10, to calculate the corresponding undistorted signal input to the microphone 11. The second processing unit 15 is arranged to apply the inequalities 11 and 12 to select which of equations 9 and 10 is to be used to calculate the undistorted signal.

It is envisaged that processor 10, namely the ADC 13, the first and second processing units 14, 15 and the DAC 16 are realised on a digital signal processing chip or card and housed within the microphone 11. The values for a and b will be determined at manufacture and the second processing unit 15 then arranged to perform the operation of equation 9 and 10. Post sale, such a processing chip could then be utilised to minimise the quadratic nonlinear distortion in a signal output from the microphone 11, during any subsequent use of the microphone 11.

It is further envisaged that the calibration of the processor 10 to correct for quadratic nonlinear distortion of the microphone 11, could be selectively performed by a user following manufacture, to re-calibrate the processor 10 to accommodate for any degradation of the device 11.

Embodiments of the present invention remove the quadratic distortion by solving an exact equation for $x(t)$. The advantage this provides is confirmed with reference to figure 2, which shows a plot of the total harmonic distortion (THD) against the assumed value of the quadratic nonlinear coefficient, b, on a decibel (dB) scale, for both a prior art compensation method 20 described in the introduction and a method embodying the present invention 21. The THD is defined as the ratio of total power created by the nonlinear component to the total power of the fundamental component. Accordingly, on a logarithmic scale, a perfect correction for the nonlinear quadratic component would reveal a value of THD which tends to $-\infty$, since the perfect correction is one whereby the total power of the nonlinear quadratic component is zero.

From figure 2 it is evident that the embodiment of the method of the present invention is always better than the approximation technique described in the introduction. Assuming the exact value of b can be determined for a particular microphone (around -20dB for the example in figure 2), then a perfect correction for quadratic nonlinear distortion can be achieved. Even if non exact values for b are used, figure 2 demonstrates that embodiments of the present invention still provide improved results over the prior art. Typical sounding sources used to produce the test signal for the determination of b will also typically produce some quadratic nonlinear distortion and so the calculation of b will also be influenced by the sounding source, resulting in incorrect values of b. Nevertheless, the use of high quality sounding sources can minimise the contribution to b from the sounding source and thereby optimise the correction for the quadratic distortion produced by the microphone.

While the specific embodiment described here refers to a microphone transducer, it is appreciated that the invention could be used with other types of transducer.

Claims

1. A method of determining a signal input to a transducer from the signal output from the transducer, the method comprising receiving as input at a processing means the signal output from the transducer, processing the signal output from the transducer in dependance upon a value for the linear gain coefficient of the transducer and a value for the quadratic nonlinear coefficient of the transducer, to determine the signal input to the transducer.

2. A method according to claim 1, wherein the processing is performed by solving a polynomial equation having as known terms values for the linear gain coefficient, the quadratic nonlinear coefficient and the signal output of the transducer.

3. A method according to claim 2, wherein said polynomial equation is a quadratic equation.

4. A method according to any preceding claim, wherein the processing is performed in accordance with the relationship:

$$x(t) = \pm[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

where a is a value of the linear gain coefficient of the transducer, b is a value of the quadratic nonlinear coefficient of the transducer, $y(t)$ is a value of the signal output from the transducer and $x(t)$ represents a value of the input signal to be determined, and wherein the value of $x(t)$ is selected as $+[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$, or as $-[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$.

5. A method according to claim 4, wherein the value of $x(t)$ is selected in dependance upon a comparison between a minimum obtained value of $x(t)$ with a quantity that depends upon a ratio of the linear gain coefficient and the quadratic nonlinear coefficient.

6. A method according to claim 4 or 5, wherein the value of $x(t)$ is selected according to the inequality

$$\text{if} \quad min[x(t)] \geq (-a/2b) \quad \text{then} \quad x(t) = [y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

$$min[x(t)] < (-a/2b) \quad \text{then} \quad x(t) = -[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

7. A method according to any preceding claim, wherein the signal output from the transducer is converted from an analogue signal to a digital signal using an analogue-to-digital converter.

8. A method according to any preceding claim, wherein the transducer comprises a microphone.

9. A method according to any preceding claim, wherein the linear gain coefficient and the quadratic nonlinear gain coefficient are determined using Fourier analysis.

10. A processor for determining a signal input to a transducer from the signal output from the transducer, the processor comprising means for receiving as an input signal the signal output from a transducer, and processing means for processing the signal output from the transducer in dependance upon a value for the linear gain coefficient of the transducer and a value for the quadratic nonlinear coefficient of the transducer, to determine the signal input to the transducer.

11. A processor according to claim 10, wherein the processing is performed by solving a polynomial equation having as known terms values for the linear gain coefficient, the quadratic nonlinear coefficient and the signal output of the transducer.

12. A processor according to claim 11, wherein said polynomial equation is a quadratic equation.

13. A processor according to any of claims 10-12, wherein the processing is performed in accordance with the relationship:

$$x(t) = \pm[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

where a is a value of the linear gain coefficient of the transducer, b is a value of the quadratic nonlinear coefficient of the transducer, $y(t)$ is a value of the signal output from the transducer and $x(t)$ represents a value of the input signal to be determined, and wherein the value of $x(t)$ is selected as $+[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$, or as $-[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$.

14. A processor according to claim 13, comprising means for selecting the value of $x(t)$ in dependance upon a comparison between a minimum obtained value of $x(t)$ with a quantity that depends upon a ratio of the linear gain coefficient and the quadratic nonlinear coefficient.

15. A processor according to claim 13 or 14, wherein the value of $x(t)$ is selected according to the inequality

$$\text{if} \quad \min[x(t)] \geq (-a/2b) \quad \text{then} \quad x(t) = [y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

$$\min[x(t)] < (-a/2b) \quad \text{then} \quad x(t) = -[y(t)/b + (a/2b)^2]^{1/2} - (a/2b)$$

16. A processor according to any of claims 10-15, comprising an analogue-to-digital converter for converting an analogue signal output from the transducer into a digital signal.

17. A processor according to any of claims 10-16, further comprising means for determining the linear gain coefficient and the quadratic nonlinear gain coefficient using Fourier analysis.

18. A transducer comprising a processor according to any of claims 10-17.

19. A method substantially as herein described with reference to the accompanying drawings.

20. A processor substantially as herein described with reference to the accompanying drawings.

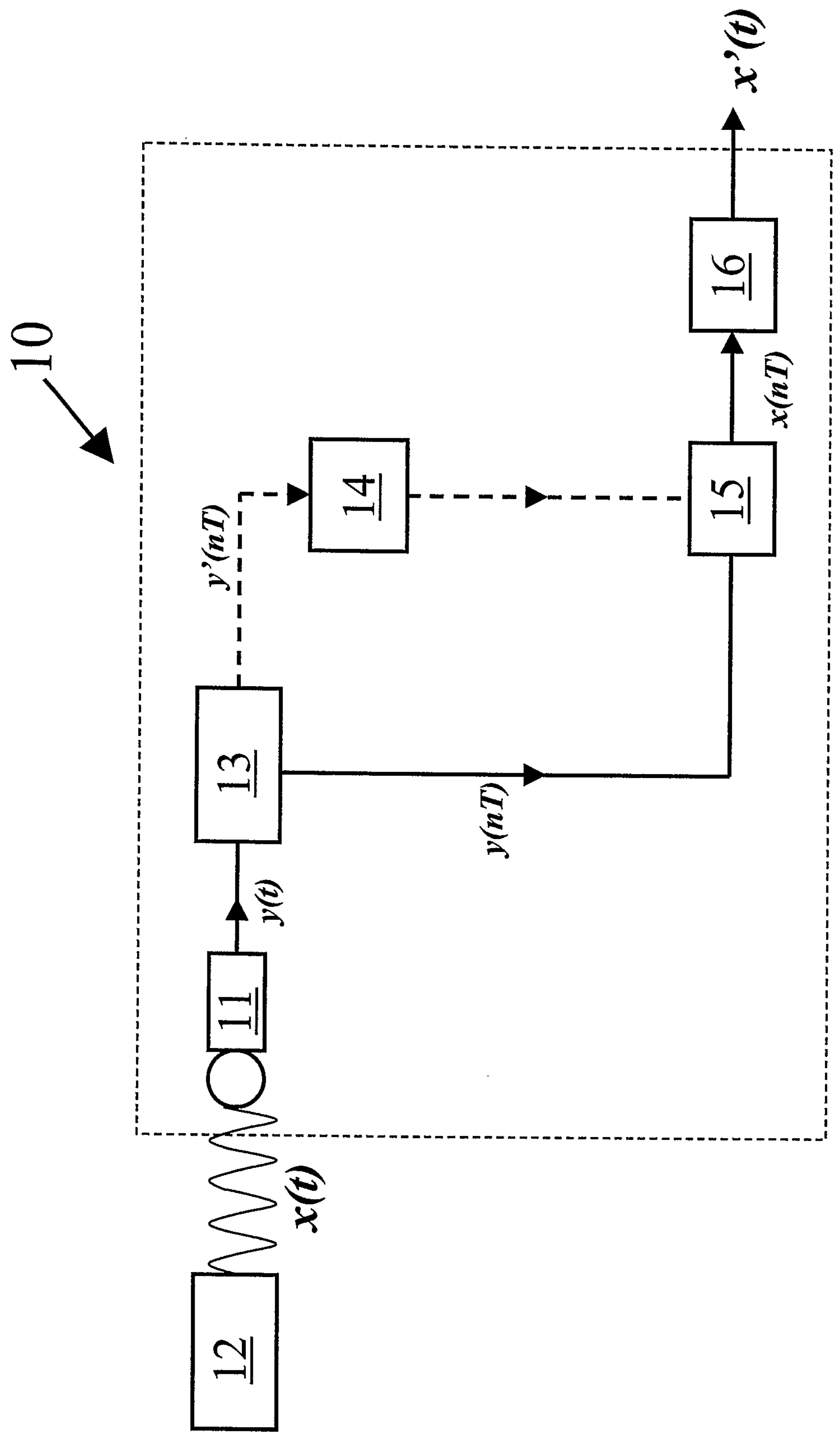


Figure 1

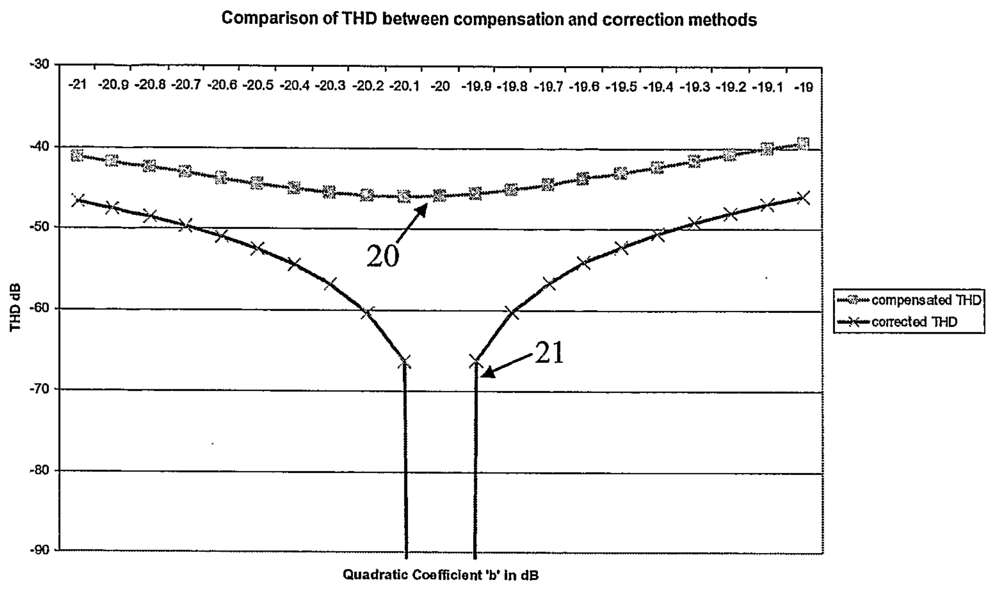

Comparison of THD between compensation and correction methods
-30
-40
-50
-60
-70
-80
-90
THD dB
-21 -20.9 -20.8 -20.7 -20.6 -20.5 -20.4 -20.3 -20.2 -20.1 -20 -19.9 -19.8 -19.7 -19.6 -19.5 -19.4 -19.3 -19.2 -19.1 -19
20
21
compensated THD
corrected THD
Quadratic Coefficient 'b' in dB

Figure 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2007/003594

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04R3/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04S H04R G01H H03M

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, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 5 594 612 A (HENRION W S [US]) 14 January 1997 (1997-01-14) column 5, line 41 - column 8, line 67; figure 2	1-4, 9-13,17 7,8,16, 18 5,6,14, 15
Y	US 4 631 749 A (RAPAICH MARK [US]) 23 December 1986 (1986-12-23) the whole document	7,8,16, 18
A	US 2002/121993 A1 (VELAZQUEZ SCOTT R [US]) 5 September 2002 (2002-09-05) the whole document	1-18

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"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 citation 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.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 January 2008	31/01/2008

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

4

INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2007/003594

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FRANK W ET AL: "Loudspeaker nonlinearities-analysis and compensation" SIGNALS, SYSTEMS AND COMPUTERS, 1992. 1992 CONFERENCE RECORD OF THE TWENTY-SIXTH ASILOMAR CONFERENCE ON PACIFIC GROVE, CA, USA 26-28 OCT. 1992, LOS ALAMITOS, CA, USA,IEEE COMPUT. SOC, US, 26 October 1992 (1992-10-26), pages 756-760, XP010031029 ISBN: 0-8186-3160-0 the whole document -----	1-18
A	US 6 911 925 B1 (SLAVIN KEITH R [US]) 28 June 2005 (2005-06-28) the whole document -----	1-18

4

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

International application No.
PCT/GB2007/003594

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. [X] Claims Nos.: 19, 20
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 allsearchable 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 reportcovers 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.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: 19, 20

The subject-matter of claims 19 and 20 is solely defined by references to the drawings. According to Rule 6.2(a) PCT, claims should not contain such references except where absolutely necessary, which is not the case here.

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

Information on patent family members

International application No
PCT/GB2007/003594

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5594612	A	14-01-1997	FR	2725328 A1	05-04-1996
			JP	8204559 A	09-08-1996
US 4631749	A	23-12-1986	NONE		
US 2002121993	A1	05-09-2002	NONE		
US 6911925	B1	28-06-2005	CN	1677870 A	05-10-2005
			EP	1583243 A2	05-10-2005
			JP	2005295542 A	20-10-2005