UNITED STATES PATENT AND TRADEMARK OFFICE

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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 |

**CONFIRMATION NO. 9885**

51340
PELOQUIN, PLLC
PO Box 748
VASHON, WA 98070-0748

**POWER OF ATTORNEY NOTICE**

*OC000000061410730*

Date Mailed: 09/06/2023

## NOTICE REGARDING CHANGE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/28/2023.

- The Power of Attorney to you in this application has been revoked by the applicant. Future correspondence will be mailed to the new address of record(37 CFR 1.33).

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/elharris/



Luxottica et al. v. Solos
IPR2026-00412
Petitioners' Ex. 1002

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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 |

**CONFIRMATION NO. 9885**

145340
Caldwell Intellectual Property Law
200 Clarendon Street
59th Floor
Boston, MA 02116

**POA ACCEPTANCE LETTER**

*OC000000061410895*

Date Mailed: 09/06/2023

## NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 08/28/2023.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/elharris/

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
Approved for use through 01/31/2018. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

| | |
|---|---|
| Application Number | 16/851,044 |
| Filing Date | 04/16/2020 |
| First Named Inventor | Dashen FAN |
| Title | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| Art Unit | 2845 |
| Examiner Name | LAM T MAI |
| Attorney Docket Number | 1537-001USC3 |

**SIGNATURE of Applicant or Patent Practitioner**

| | | | |
|---|---|---|---|
| Signature | /Keegan Caldwell/ | Date (Optional) | |
| Name | Keegan Caldwell | Registration Number | 73731 |
| Title (if Applicant is a juristic entity) | | | |
| Applicant Name (if Applicant is a juristic entity) | | | |

**NOTE:** This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ *Total of _____ forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

Document Description: Power of Attorney

PTO/AIA/82B (07-13)
Approved for use through 03/31/2021. OMB 0651-0035
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# POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

| Application Number | Filing Date |
|---|---|
| | |

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 145340

**OR**

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

**Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:**

☑ The address associated with the above-mentioned Customer Number

**OR**

☐ The address associated with Customer Number:

**OR**

| | | | | | |
|---|---|---|---|---|---|
| ☐ Firm or Individual Name | | | | | |
| Address | | | | | |
| City | | State | | Zip | |
| Country | | | | | |
| Telephone | | Email | | | |

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

Solos Technology Limited

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

**SIGNATURE of Applicant for Patent**

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

| | | | |
|---|---|---|---|
| Signature | Kenneth Fan (User DocuSigned by: D409388C60ED4C5...) | Date (Optional) | |
| Name | Kenneth Fan | | |
| Title | Co-Founder | | |

**NOTE:** Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☐ Total of forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

DocuSign Envelope ID: 451E0DD7-F2B5-4173-9004-4ACAF141B6ED

PTO/AIA/82C (07-13)
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Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number

# POWER OF ATTORNEY BY APPLICANT

No more than ten (10) patent practitioners total may be appointed as set forth below by name and registration number. This page need not be submitted if appointing the Patent Practitioner(s) associated with a Customer Number (see form PTO/AIA/82B):

| Name | Registration Number |
|---|---|
| | |
| | |
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| | |
| | |
| | |
| | |
| | |

# Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 48500002 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Keegan M. Caldwell/Rachel Riley |
| **Filer Authorized By:** | Keegan M. Caldwell |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 28-AUG-2023 |
| **Filing Date:** | 16-APR-2020 |
| **Time Stamp:** | 14:17:21 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Power of Attorney | 1537-001USC3_POA.pdf | 268330<br>6644bcbc87bfbdad3d865690a33441ec1c0e8eab | no | 4 |

**Warnings:**

| Information: | |
|---|---|
| **Total Files Size (in bytes):** | 268330 |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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United States Patent and Trademark Office
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| APPLICATION NO. | ISSUE DATE | PATENT NO. | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 08/03/2021 | 11082055 | K41090.P8C3 | 9885 |

51340 7590 07/14/2021

PELOQUIN, PLLC
PO Box 748
VASHON, WA 98070-0748

# ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Dashen FAN, Bellevue, WA;
SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG
Joseph Yong KWON, San Jose, CA;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

IR103 (Rev. 10/09)

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16851044 |
| **Filing Date:** | 16-Apr-2020 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Filer:** | Mark S. Peloquin |
| **Attorney Docket Number:** | K41090.P8C3 |

Filed as Small Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |
| UTILITY APPL ISSUE FEE | 2501 | 1 | 600 | 600 |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **600** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 43127370 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Mark S. Peloquin |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 29-JUN-2021 |
| **Filing Date:** | 16-APR-2020 |
| **Time Stamp:** | 21:56:04 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | EFT |
| Payment was successfully received in RAM | $600 |
| RAM confirmation Number | E20216SL56290853 |
| Deposit Account | |
| Authorized User | |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Issue Fee Payment (PTO-85B) | 20210629K41090P8C3NOAwithfieldsi.pdf | 554752<br>76bf2c0e1e0157abad5603ffa8be507476bcd880 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Fee Worksheet (SB06) | fee-info.pdf | 30676<br>75a8e56650fe8cc8acbcd00a874ee2eb55143a1b | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 585428 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**
**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**
**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

UNITED STATES PATENT AND TRADEMARK OFFICE

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United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

# NOTICE OF ALLOWANCE AND FEE(S) DUE

51340 7590 04/05/2021

PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

| EXAMINER | |
|---|---|
| MAI, LAM T | |
| ART UNIT | PAPER NUMBER |
| 2845 | |

DATE MAILED: 04/05/2021

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 | 9885 |

TITLE OF INVENTION: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | SMALL | $600 | $0.00 | $0.00 | $600 | 07/06/2021 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.**

## PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

513480 7590 04/05/2021

PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

| | |
|---|---|
| MARK S PELOQUIN | (Typed or printed name) |
| /MARK S PELOQUIN/ | (Signature) |
| June 29, 2021 | (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.PSC3 | 9885 |

TITLE OF INVENTION: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | SMALL | $600 | $0.00 | $0.00 | $600 | 07/06/2021 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| MAI, LAM T | 2845 | 341-155000 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 PELOQUIN, PLLC
2 Mark S. Peloquin, Esq.
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: SOLOS TECHNOLOGY LIMITED

(B) RESIDENCE: (CITY and STATE OR COUNTRY): HONG KONG, CHINA

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☑ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☑ Issue Fee ☐ Publication Fee (if required) ☐ Advance Order - # of Copies .....

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

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5. **Change in Entity Status** (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /MARK S PELOQUIN/ Date June 29, 2021

Typed or printed name MARK S PELOQUIN Registration No. 50,787

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| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 | 9885 |

51340 7590 06/23/2021

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PO Box 748
VASHON, WA 98070-0748

| EXAMINER | |
|---|---|
| MAI, LAM T | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2845 | |

| MAIL DATE | DELIVERY MODE |
|---|---|
| 06/23/2021 | PAPER |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| Response to Rule 312 Communication | Application No. | Applicant(s) | |
|---|---|---|---|
| | 16/851,044 | FAN et al. | |
| | Examiner | Art Unit | AIA (FITF) Status |
| | LAM T MAI | 2845 | Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

1. ☑ The amendment filed on 16 June 2021 under 37 CFR 1.312 has been considered, and has been:

   a) ☑ entered.

   b) ☐ entered as directed to matters of form not affecting the scope of the invention.

   c) ☐ disapproved because the amendment was filed after the payment of the issue fee.
   Any amendment filed after the date the issue fee is paid must be accompanied by a petition under 37 CFR 1.313(c)(1) and the required fee to withdraw the application from issue.

   d) ☐ disapproved. See explanation below.

   e) ☐ entered in part. See explanation below.

| /LAM T MAI/<br>Primary Examiner, Art Unit 2845 | |
|---|---|

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | |
|---|---|---|
| Appl. No. | : | 16/851,044 |
| Attorney Docket No. | : | 101404.P8C3 |
| Applicant | : | SOLOS TECHNOLOGY LIMITED |
| Filed | : | April 16, 2020 |
| TC/A.U. | : | 2845 |
| Examiner | : | MAI, LAM T |
| Confirmation No. | : | 9885 |

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Alexandria, VA 22313-1450

**AMENDMENT UNDER 37 CFR 1.312**

Dear Examiner Mai:

Applicant makes the following amendment under 37 CFR 1.312 to correct informalities in the allowed claims. No new matter has been entered.

The listing of claims begins on page 2 of this paper.

**Remarks/Arguments** starts on page 19 of this paper.

OK TO ENTER: /L.T.M/

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# BIB DATA SHEET

**CONFIRMATION NO. 9885**

| SERIAL NUMBER | FILING or 371(c) DATE<br>RULE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | 341 | 2845 | K41090.P8C3 |

**APPLICANTS**

SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG

**INVENTORS**

Dashen FAN, Bellevue, WA;
Joseph Yong KWON, San Jose, CA;

**** CONTINUING DATA ***************************

This application is a CON of 16/399,867 04/30/2019 PAT 10651866
which is a CON of 15/947,845 04/08/2018 PAT 10298253
which is a CON of 15/225,745 08/01/2016 PAT 9941895

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
04/22/2020

| Foreign Priority claimed ☐ Yes ☑ No<br>35 USC 119(a-d) conditions met ☐ Yes ☑ No<br>Verified and Acknowledged /LAM T MAI/ Examiner's Signature | ☑ Met after Allowance<br>Im Initials | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|---|
| | | WA | 20 | 10 | 1 |

**ADDRESS**

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UNITED STATES

**TITLE**

BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

| FILING FEE RECEIVED | | |
|---|---|---|
| 3815 | FEES: Authority has been given in Paper<br>No._____ to charge/credit DEPOSIT ACCOUNT<br>No._____ for following: | ☐ All Fees<br>☐ 1.16 Fees (Filing)<br>☐ 1.17 Fees (Processing Ext. of time)<br>☐ 1.18 Fees (Issue)<br>☐ Other _____<br>☐ Credit |

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# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 43004114 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Mark S. Peloquin |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 16-JUN-2021 |
| **Filing Date:** | 16-APR-2020 |
| **Time Stamp:** | 14:37:32 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Amendment after Notice of Allowance (Rule 312) | 20210616K41090P8C3AMENDM1312USPTOv02i.pdf | 3869428<br>ce9d0adf35bf9cd2cce10eb07136023aca790f05 | no | 20 |
| **Warnings:** | | | | | |

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| **Total Files Size (in bytes):** | 3869428 |

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**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**
**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**
**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

| | | |
|---|---|---|
| Appl. No. | : | 16/851,044 |
| Attorney Docket No. | : | 101404.P8C3 |
| Applicant | : | SOLOS TECHNOLOGY LIMITED |
| Filed | : | April 16, 2020 |
| TC/A.U. | : | 2845 |
| Examiner | : | MAI, LAM T |
| Confirmation No. | : | 9885 |

Commissioner for Patents
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**AMENDMENT UNDER 37 CFR 1.312**

Dear Examiner Mai:

Applicant makes the following amendment under 37 CFR 1.312 to correct informalities in the allowed claims. No new matter has been entered.

The listing of claims begins on page 2 of this paper.

**Remarks/Arguments** starts on page 19 of this paper.

**Amendments to the Claims:**

The listing of claims will replace all prior versions, and listings, of claims in the application:

**Listing of Claims:**

Claim 1 (Currently amended). A non-transitory computer-readable storage medium storing program code for causing a data processing system to perform ~~the~~ steps comprising:

outputting a first oversampled digital signal output from an analog-to-digital converter (ADC), wherein the first oversampled digital signal is responsive to an analog field and the first oversampled digital signal is created at a sampling clock frequency;

delaying the first oversampled digital signal by a time delay wherein the time delay is equal to an integer number of sampling clock cycles to produce a time delayed first oversampled digital signal; and

combining the time delayed first oversampled digital signal with a second oversampled digital signal to obtain the beamformed digital signal, wherein the second oversampled digital signal is responsive to the analog field.

Claim 2 (Currently amended). The non-transitory computer-readable storage medium of claim 1, wherein the combining is performed in an oversampled signal domain.

Claim 3 (Currently amended). The non-transitory computer-readable storage medium of claim 1, wherein the combining is performed at an intermediate sampling rate.

Claim 4 (Currently amended). The non-transitory computer-readable storage medium of claim 1, wherein the combining is performed in a baseband signal domain.

Claim 5 (Currently amended). The non-transitory computer-readable storage medium of claim 1, wherein the first oversampled digital signal and the second oversampled digital signal are obtained from different sensors.

Claim 6 (Currently amended). The non-transitory computer-readable storage medium of claim 1, wherein the first oversampled digital signal and the second oversampled digital signal are obtained from the same sensor.

Claim 7 (Currently amended). The non-transitory computer-readable storage medium of claim 1, further comprising:

applying a low pass filter with decimation to the time delayed first oversampled digital signal to output a baseband digital signal that is delayed by the time delay.

Claim 8 (Currently amended). The non-transitory computer-readable storage medium of claim 7, wherein the time delay is equal to a fraction of a baseband sampling period.

Claim 9 (Currently amended). The non-transitory computer-readable storage medium of claim 7, wherein the time delay is greater than a baseband sampling period.

Claim 10 (Currently amended). The non-transitory computer-readable storage medium of claim 7, wherein the first oversampled digital signal is digitized to create samples which are more than one bit deep.

Claim 11 (Previously presented). A system to time delay digital signals, comprising:

a digital sensor responsive to an analog field quantity, the digital sensor is configured to output an oversampled digital output signal at a sampling clock frequency;

a first time delay element, the first time delay element is configured to receive as an input the oversampled digital output signal and to output a time delayed oversampled digital output signal, wherein the time delayed oversampled digital output signal is time delayed by a fractional delay, the fractional delay is equal to an integer number of sampling clock cycles times the sampling clock period;

a filter, the filter is configured to receive as an input the time delayed oversampled digital output signal, the filter to low pass filter and to decimate to a lower sample rate the time delayed oversampled digital output signal and to output a low pass filtered decimated delayed digital output signal, wherein the lower sample rate is less than the sampling clock frequency;

a second time delay element, the second time delay element is configured to receive, as an input, the low pass filtered decimated delayed digital output signal and to

impart an integer delay, the integer delay is an integer number of cycles at the lower sample rate times the lower sampling rate period, the integer delay is applied to the low pass filtered decimated time delayed digital output signal; and

a controller, the controller is configured to supply a control signal to set the fractional delay and the integer delay.

Claim 12 (Previously presented). The system of claim 11, wherein the digital sensor utilizes a sigma-delta modulator and the oversampled digital output signal is a pulse density modulated (PDM) signal.

Claim 13 (Previously presented). The system of claim 11, wherein the oversampled digital output signal is a pulse density modulated (PDM) signal.

Claim 14 (Previously presented). The system of claim 11, wherein the digital sensor is a digital microphone.

Claim 15 (Previously presented). The system of claim 14, wherein the digital microphone utilizes a micro-electromechanical systems (**MEMS**) sensor.

Claim 16 (Previously presented). The system of claim 11, wherein the analog field quantity is an acoustic pressure field.

Claim 17 (Previously presented). The system of claim 11, wherein the integer number of sampling clock cycles is selected from a range of one to the sampling clock frequency divided by a baseband sample rate.

Claim 18 (Previously presented). The system of claim of claim 13, wherein the filter is a PDM receiver.

Claim 19 (Previously presented). The system of claim 18, wherein the filter is a multistage filter further comprising:

a first stage, the first stage to low pass filter and to decimate to a first intermediate sampling rate the time delayed oversampled digital output signal; and

a second stage, wherein the second stage is configured to receive as an input an output from the first stage, the second stage to decimate the input to a baseband sample rate and to filter the input to a baseband signal bandwidth.

Claim 20 (Previously presented). The system of claim 18, wherein the filter is a multistage filter further comprising:

a first stage, the first stage to receive as a first stage input signal the time delayed oversampled digital output signal, the first stage to low pass filter and to decimate to a first intermediate sampling rate the first stage input signal to form a first stage output signal; and

a second stage, the second stage to receive as a second stage input signal the first stage output signal, the second stage to low pass filter and to decimate to a second

intermediate sampling rate the second stage input signal to form a second stage output signal; and

a third stage, the third stage to receive as a third stage input signal the second stage output signal the third stage to decimate the third stage input signal to a baseband sample rate and to filter the third stage input signal to a baseband signal bandwidth, wherein the first intermediate sampling rate is less than the sampling clock rate, the second intermediate sampling rate is less than the first intermediate sampling rate, and the baseband sampling rate is less that the second intermediate sampling rate.

Claim 21 (Currently amended). The system of claim 17, wherein the lower sample rate is a baseband sample rate and the low pass filtered decimated time delayed digital output signal is used in a beam forming process with a second signal, wherein the second signal is a digital measurement of the analog field quantity.

Claim 22 (Previously presented). A system to time delay signals, comprising:

a sensor element, the sensor element is responsive to an analog field quantity;

a sigma-delta modulator, the sensor element is electrically coupled to the sigma-delta modulator and is configured to produce a pulse density modulated (PDM) output signal at a sampling clock frequency responsive to the analog field quantity;

a first time delay element, the first time delay element is electrically configured to receive the PDM output signal, and to output a delayed PDM output signal, wherein the delayed PDM output signal is delayed by a fractional time delay equal to a number of cycles of the sampling clock frequency times a period of the sampling clock;

a decimation module, the decimation module is configured to receive as an input the delayed PDM output signal, the decimation module to low pass filter and to decimate to a lower sample rate the delayed PDM output signal and to output a low pass filtered decimated delayed PDM output signal, wherein the lower sample rate is less than the sampling clock frequency, the decimation module to convert to pulse code modulation (PCM) format;

a second time delay element, the second time delay element is configured to receive, as an input, the low pass filtered decimated delayed PDM output signal and to impart an integer delay, the integer delay is an integer number of cycles at the lower sample rate times a period at the lower sampling rate, the integer delay is applied to the low pass filtered decimated delayed PDM output signal; and

a controller, the controller is configured to supply a control signal to set the fractional delay and the integer delay.

Claim 23 (Previously presented). The system of claim 22, the decimation module further comprising:

a first stage, the first stage to receive as a first stage input signal the delayed PDM output signal, the first stage to low pass filter and to decimate to a first intermediate sample rate the first stage input signal to form a first stage output signal, wherein the first intermediate sample rating is less than the sample clock frequency; and

a second stage, the second stage to receive as a second stage input signal the first stage output signal, the second stage to low pass filter and to decimate to the lower sample rate the second stage input signal, wherein the lower sample rate is lower

than the first intermediate sampling rate, the decimation module to convert to pulse code modulation (PCM) format.

Claim 24 (Previously presented). The system of claim 22, the decimation module further comprising:

a first stage, the first stage to receive as a first stage input signal the delayed PDM output signal, the first stage to low pass filter and to decimate to a first intermediate sample rate the first stage input signal to form a first stage output signal, wherein the first intermediate sample rating is less than the sampling clock frequency;

a second stage, the second stage to receive as a second stage input signal the first stage output signal, the second stage to low pass filter and to decimate to a second intermediate sample rate the second stage input signal, wherein the second intermediate sample rate is lower than the first intermediate sample rate; and

a third stage, the third stage to receive as a third stage input signal the second stage output signal, the third stage to low pass filter and to decimate to the lower sample rate the third stage input signal, wherein the lower sample rate is lower than the second intermediate sample rate, the decimation module to convert to pulse code modulation (PCM) format.

Claim 25 (Previously presented). The system of claim 24, wherein the first stage employs a cascaded-integrator-comb (CIC) filter structure, the second stage is configured as two half-band filters, and the third stage is configured as a low pass filter.

Claim 26 (Previously presented). The system of claim 25, wherein a sampling clock operates at 2.048 MHz, the first stage provides 8:1 decimation, the second stage provides two 2:1 half band decimation stages, the third stage provides 4:1 decimation which results in a baseband sampling rate of 16 kHz, low pass filtering throughout the decimation module filters high frequency components from the sigma-delta modulation process.

Claim 27 (Previously presented). The system of claim 26, wherein the sampling clock frequency is selected from the group consisting of 1 MHz to 4 MHz and a user defined sampling rate.

Claim 28 (Currently amended). The system of claim 27, wherein the ~~digital~~ sensor element is a digital microphone and the analog field quantity is acoustic pressure.

Claim 29 (Previously presented). The system of claim 28, wherein the digital microphone utilizes a micro-electromechanical systems (**MEMS**) sensor.

Claim 30 (Previously presented). The system of claim 22, wherein the first time delay element is a buffer, wherein a minimum length of the buffer is equal to the sampling clock frequency divided by the lower sample rate and the time delay is equal to a value of the buffer.

Claim 31 (Previously presented). The system of claim 30, wherein the first time delay is programmable by specifying a value of the buffer with the control signal.

Claim 32 (Previously presented). The system of claim 22, wherein the first time delay element is implemented with a delay line.

Claim 33 (Previously presented). The system of claim 32, where the time delay provided by the delay line is programmable with the control signal.

Claim 34 (Previously presented). The system of claim 22, wherein the fractional time delay is equal to a fraction of a baseband sampling period.

Claim 35 (Previously presented). The system of claim 22, wherein the fractional time delay is greater than a baseband sampling period.

Claim 36 (Previously presented). A decimation module for use in time delaying digital signals, comprising:

a general number of N stages, the decimation module having as an input an oversampled digital output signal from a digital sensor;

an $i^{th}$ stage, the $i^{th}$ stage to low pass filter and to decimate to an $i^{th}$ intermediate sampling rate an $i^{th}$ stage input signal to form an $i^{th}$ stage output signal, wherein the $i^{th}$ intermediate sample rating is less than a sampling clock frequency used to create the oversampled digital output signal;

a first time delay element, the first time delay element to delay the $i^{th}$ stage output signal by a fractional time delay, wherein the fractional time delay is equal to an integer number of $i^{th}$ intermediate sampling rate cycles times the $i^{th}$ intermediate sampling rate period, the first time delay element to output a delayed $i^{th}$ stage output signal;

an i +1 stage, the i +1 stage to receive as an i +1 stage input signal the delayed $i^{th}$ stage output signal, the i+1 stage to low pass filter and to decimate to an i+1 intermediate sampling rate the i+1 stage input signal to form an i+1 stage output signal, wherein the i+1 intermediate sampling rate is lower than the $i^{th}$ intermediate sampling rate;

a second time delay element, the second time delay element is configured to receive, as an input, the i+1 stage output signal and to impart an integer delay, the integer delay is equal to an integer number of cycles at the i+1 intermediate sampling rate times the $i^{th}$ intermediate sampling rate period, the integer delay is applied to the i+1 stage output signal, the i+1 intermediate sampling rate is a baseband sampling rate, the i+1 stage output signal is an output signal from the decimation module that is time delayed by a combined time delay, the combined time delay is a sum of the fractional time delay and the integer time delay; and

a controller, the controller is configured to supply a control signal to set the fractional time delay and the integer time delay.

Claim 37 (Previously presented). The decimation module of claim 36, wherein the digital sensor is a digital microphone and the combined time delay is used during a beam forming operation with the output signal from the decimation module.

Claim 38 (Previously presented). A method to delay digital signals, comprising:

sensing an analog field;

outputting an oversampled digital signal responsive to the sensing, wherein the oversampled digital signal is created at a sampling clock rate;

delaying the oversampled digital signal by a fractional time delay wherein the fractional time delay is equal to an integer number of sampling clock cycles to produce a delayed oversampled digital signal;

applying a low pass filter with decimation to the delayed oversampled digital signal to output a baseband digital signal that is delayed by the fractional time delay; and

delaying the baseband digital signal by an integer time delay, wherein the integer time delay is equal to a number of cycles at a baseband sampling rate times the baseband sampling rate period.

Claim 39 (Previously presented). The method of claim 38, wherein the fractional time delay is equal to a fraction of a baseband sampling period.

Claim 40 (Previously presented). The method of claim 38, wherein the fractional time delay is greater than a baseband sampling period.

Claim 41 (Previously presented). The method of claim 38, wherein the oversampled digital signal is digitized to create samples which are more than one bit deep.

Claim 42 (Currently amended). A non-transitory computer-readable storage medium storing program code for causing a data processing system to perform ~~the~~ steps comprising:

receiving signals from a digital sensor, the signals are responsive to an analog field;

processing the signals to create an oversampled digital signal responsive to the receiving, wherein the oversampled digital signal is created at a sampling clock rate; and

delaying the oversampled digital signal by a fractional time delay wherein the fractional time delay is equal to an integer number of sampling clock cycles times the sampling clock period to produce a delayed oversampled digital signal;

applying a low pass filter with decimation to the delayed oversampled digital signal to output a baseband digital signal that is delayed by the fractional time delay; and

delaying the baseband digital signal by an integer time delay, wherein the integer time delay is equal to a number of sampling clock cycles times the sampling clock period at a baseband sampling rate.

Claim 43 (Currently amended). The non-transitory computer readable storage medium of claim 42, wherein the fractional time delay is equal to a fraction of a baseband sampling period.

Claim 44 (Currently amended). The non-transitory computer readable storage medium of claim 42, wherein the fractional time delay is greater than a baseband sampling period.

Claim 45 (Currently amended). The non-transitory computer readable storage medium of claim 42, wherein the oversampled digital signal is digitized to create samples which are more than one bit deep.

Claim 46 (Currently amended). A system to delay digital signals, comprising:

sensing means for measuring an analog field quantity;

over sampling means, the over sampling means to over sample a signal detected by the sensing means resulting in an oversampled digital signal;

fractional delaying means, the fractional delaying means to apply a fractional time delay to the oversampled digital signal, the fractional time delay is equal to an integer number of sampling clock cycles ~~times the sampling clock period~~, resulting in a delayed oversampled digital signal;

decimating means, the decimating means to receive the delayed oversampled digital signal and to low pass filter and to decimate to a lower sampling rate;

integer delaying means, the integer delaying means to apply an integer time delay to the delayed oversampled digital signal, the integer time delay is a number of lower sampling rate cycles; and

controlling means, the controlling means to adjust the fractional time delay and the integer time delay to establish a total time delay, wherein a resulting digital signal is delayed by a total time delay, wherein the total time delay is a sum of the fractional time delay and the integer time delay, and contains a digital representation of the analog field quantity without the noise introduced by the over sampling means.

Claim 47 (Previously presented). The system of claim 46, wherein the decimating means is accomplished in a multistage module.

Claim 48 (Previously presented). The system of claim 46, wherein the total time delay is equal to a fraction of a baseband sampling period.

Claim 49 (Previously presented). The system of claim 46, wherein the total time delay is greater than a baseband sampling period.

Claim 50 (Previously presented). The system of claim 46, wherein the oversampled digital signal is digitized to create samples which are more than one bit deep.

Claim 51 (Previously presented). A system to time delay digital signals, comprising:

a digital sensor responsive to an analog field quantity, the digital sensor is configured to output an oversampled digital output signal at a sampling clock frequency;

a replicator, the replicator to receive the oversampled digital output signal and to output a first replica of the oversampled digital output signal and a second replica of the oversampled digital output signal;

a first fractional time delay element, the first fractional time delay element is configured to receive as an input the first replica and to output a first time delayed oversampled digital output signal;

a first filter, the first filter is configured to receive as an input the first time delayed oversampled digital output signal, the first filter to low pass filter and to decimate to a lower sample rate the first time delayed oversampled digital output signal and to output a first low pass filtered decimated delayed digital output signal, wherein the lower sample rate is less than the sampling clock frequency;

a first integer time delay element, the first integer time delay element is configured to receive, as an input, the first low pass filtered decimated delayed digital output signal and to output a first time delayed digital output signal at the lower sample rate;

a second fractional time delay element, the second fractional time delay element is configured to receive as an input the second replica and to output a second time delayed oversampled digital output signal;

a second filter, the second filter is configured to receive as an input the second time delayed oversampled digital output signal, the second filter to low pass filter and to decimate to a lower sample rate the second time delayed oversampled digital output signal and to output a second low pass filtered decimated delayed digital output signal; and

a second integer time delay element, the second integer time delay element is configured to receive, as an input, the second low pass filtered decimated delayed digital output signal and to output a second time delayed digital output signal at the lower sample rate.

Claim 52 (Previously presented). The system of claim 51, wherein the replicator is a splitter.

Claim 53 (Previously presented). The system of claim 52, wherein the splitter is an **n**-way splitter.

Claim 54 (Previously presented). The system of claim 51, wherein the first time delayed digital output signal and the second time delayed digital output signal are used for beamforming.

Claim 55 (Previously presented). The system of claim 51, further comprising:

a sigma-delta modulator, the digital sensor is electrically coupled to the sigma-delta modulator and is configured to produce a pulse density modulated (PDM) output signal at the sampling clock frequency responsive to the analog field quantity.

**Non-transitory**

**Claims 1-10, and 42-45**

Applicant has amended claims 1 through 10, and 42-45 to add the term "Non-transitory" in response to the Examiner's discussion in the Corrected Notice of Allowability. No New matter has been entered.

**Antecedent Basis Informalities**

**Claims 1, 21, 28, 42, and 46**

Applicant has amended claims 1, 21, 28, 42, and 46 to cure antecedent basis informalities. No New matter has been entered.

## CONCLUSION

Applicant respectfully requests entry of this Amendment under 37 CFR 1.312.

Communication via cleartext email is authorized.

Respectfully submitted,
PELOQUIN, PLLC

June 16, 2021
Date

/Mark S. Peloquin/
Mark S. Peloquin, Esq.
USPTO Registration # 50,787

# PATENT ASSIGNMENT COVER SHEET

Electronic Version v1.1
Stylesheet Version v1.2

EPAS ID: PAT6765269

| | |
|---|---|
| **SUBMISSION TYPE:** | NEW ASSIGNMENT |
| **NATURE OF CONVEYANCE:** | ASSIGNMENT |

**CONVEYING PARTY DATA**

| Name | Execution Date |
|---|---|
| JOSEPH YONG KWON | 10/07/2016 |

**RECEIVING PARTY DATA**

| | |
|---|---|
| **Name:** | KOPIN CORPORATION |
| **Street Address:** | 125 NORTH DRIVE |
| **City:** | WESTBOROUGH |
| **State/Country:** | MASSACHUSETTS |
| **Postal Code:** | 01581 |

**PROPERTY NUMBERS Total: 1**

| Property Type | Number |
|---|---|
| **Application Number:** | 16851044 |

**CORRESPONDENCE DATA**

**Fax Number:** (206)770-6562

***Correspondence will be sent to the e-mail address first; if that is unsuccessful, it will be sent using a fax number, if provided; if that is unsuccessful, it will be sent via US Mail.***

**Phone:** 206-251-1699
**Email:** mark@peloquinlaw.com
**Correspondent Name:** PELOQUIN, PLLC
**Address Line 1:** PO BOX 748
**Address Line 4:** VASHON, WASHINGTON 98070-0748

| | |
|---|---|
| **ATTORNEY DOCKET NUMBER:** | K41090.P8C3 |
| **NAME OF SUBMITTER:** | MARK S PELOQUIN |
| **SIGNATURE:** | /MARK S PELOQUIN/ |
| **DATE SIGNED:** | 06/16/2021 |
| | This document serves as an Oath/Declaration (37 CFR 1.63). |

**Total Attachments: 4**
source=K41090.P008 Assignment Kwon Fan -ex#page1.tif
source=K41090.P008 Assignment Kwon Fan -ex#page2.tif
source=K41090.P008 Assignment Kwon Fan -ex#page3.tif
source=K41090.P008 Assignment Kwon Fan -ex#page4.tif

# ASSIGNMENT



Attorney's Docket No.: K41090.P008 ASSIGNMENT (For Execution After Filing Patent Application)

In consideration of good and valuable consideration, the receipt of which is hereby acknowledged, we the undersigned, Joseph Yong Kwon,

hereby sell, assign, and transfer to Kopin Corporation,
a Corporation of DE, having a principal place of business

125 North Drive, Westborough, MA 01581, ("Assignee"),
and its successors, assigns, and legal representatives, the entire right, title, and interest for the United States and all foreign countries, in and to any and all improvements that are disclosed in the application for the United States patent that was filed August 01, 2016 and assigned Application No. 15/225,745 and is entitled

**TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS**

and in and to said application and all divisional applications, continuation applications, continued prosecution applications, continuation-in-part applications, substitute applications, renewal applications, reissue applications, reexaminations, extensions, and all other patent applications that have been or shall be filed in the United States and all foreign countries on any of said improvements; and in and to all original patents, reissued patents, reexamination certificates, and extensions, that have been or shall be issued in the United States and all foreign countries on said improvements; and in and to all rights of priority resulting from the filing of said United States application;

agree that said Assignee may apply for and receive a patent or patents for said improvements in its own name; and that, when requested, without charge to, but at the expense of, said Assignee, its successors, assigns, and legal representatives, to carry out in good faith the intent and purpose of this Assignment, the undersigned will execute all divisional applications, continuation applications, continued prosecution applications, continuation-in-part applications, substitute applications, renewal applications, reissue applications, reexaminations, extensions and all other patent applications on any and all said improvements; execute all rightful oaths, assignments, powers of attorney, and other papers; communicate to said Assignee, its successors, assigns, and representatives all facts known to the undersigned relating to said improvements and the history thereof; and generally assist said Assignee, its successors, assigns, or representatives in securing and maintaining proper patent protection for said improvements and for vesting title to said improvements, and all applications for patents and all patents on said improvements, in said Assignee, its successors, assigns, and legal representatives; and

covenant with said Assignee, its successors, assigns, and legal representatives that no assignment, grant, mortgage, license, or other agreement affecting the rights and property herein conveyed has been made to others by the undersigned, and that full right to convey the same as herein expressed is possessed by the undersigned.

# ASSIGNMENT



**Each Inventor: Please Sign and Date Below:**

10-7, 2016
Date

Name: Joseph Yong Kwon

**Each Inventor: Please also list the date that you signed the accompanying DECLARATION AND POWER OF ATTORNEY:**

10-7, 2016
Date

State of: CALIFORNIA }
} SS.
County of: SANTA CLARA }

Assignment Document Return Address:
**PELOQUIN, PLLC**
**800 Fifth Avenue, Suite 4100**
**Seattle, WA 98104-3100**
**(206) 447.1336**

On this 7TH day of OCTOBER 2016, before me, PAUL J. KIEFER, the undersigned Notary Public, personally appeared JOSEPH YONG KWON [ ] personally known to me [X] proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) IS subscribed to the within instrument, and acknowledged that HE executed it.
WITNESS my hand and official seal.

Notary's Signature

PAUL J. KIEFER
COMM. # 2022369
NOTARY PUBLIC - CALIFORNIA
SANTA CLARA COUNTY
COMM. EXPIRES MAY 19, 2017

# ASSIGNMENT



Attorney's Docket No.: K41090.P008 ASSIGNMENT (For Execution After Filing Patent Application)

In consideration of good and valuable consideration, the receipt of which is hereby acknowledged, we the undersigned, Dashen Fan,

hereby sell, assign, and transfer to Kopin Corporation,
a Corporation of DE, having a principal place of business

125 North Drive, Westborough, MA 01581, ("Assignee"),
and its successors, assigns, and legal representatives, the entire right, title, and interest for the United States and all foreign countries, in and to any and all improvements that are disclosed in the application for the United States patent that was filed August 01, 2016 and assigned Application No. 15/225,745 and is entitled

**TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS**

and in and to said application and all divisional applications, continuation applications, continued prosecution applications, continuation-in-part applications, substitute applications, renewal applications, reissue applications, reexaminations, extensions, and all other patent applications that have been or shall be filed in the United States and all foreign countries on any of said improvements; and in and to all original patents, reissued patents, reexamination certificates, and extensions, that have been or shall be issued in the United States and all foreign countries on said improvements; and in and to all rights of priority resulting from the filing of said United States application;

agree that said Assignee may apply for and receive a patent or patents for said improvements in its own name; and that, when requested, without charge to, but at the expense of, said Assignee, its successors, assigns, and legal representatives, to carry out in good faith the intent and purpose of this Assignment, the undersigned will execute all divisional applications, continuation applications, continued prosecution applications, continuation-in-part applications, substitute applications, renewal applications, reissue applications, reexaminations, extensions and all other patent applications on any and all said improvements; execute all rightful oaths, assignments, powers of attorney, and other papers; communicate to said Assignee, its successors, assigns, and representatives all facts known to the undersigned relating to said improvements and the history thereof; and generally assist said Assignee, its successors, assigns, or representatives in securing and maintaining proper patent protection for said improvements and for vesting title to said improvements, and all applications for patents and all patents on said improvements, in said Assignee, its successors, assigns, and legal representatives; and

covenant with said Assignee, its successors, assigns, and legal representatives that no assignment, grant, mortgage, license, or other agreement affecting the rights and property herein conveyed has been made to others by the undersigned, and that full right to convey the same as herein expressed is possessed by the undersigned.

# ASSIGNMENT



| Each Inventor: Please Sign and Date Below: | Each Inventor: Please also list the date that you signed the accompanying DECLARATION AND POWER OF ATTORNEY: |
|---|---|
| 10-7, 2016 Date — Name: Dashen Fan | 10-7, 2016 Date |

State of: _____ }
} SS.
County of: _____ }

Assignment Document Return Address:
**PELOQUIN, PLLC**
**800 Fifth Avenue, Suite 4100**
**Seattle, WA 98104-3100**
**(206) 447.1336**

On this _____ day of _____ 20_____, before me, _____, the undersigned Notary Public, personally appeared _____ [___] personally known to me [___] proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) _____ subscribed to the within instrument, and acknowledged that _____ executed it.
WITNESS my hand and official seal.

_____
Notary's Signature

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 |

**CONFIRMATION NO. 9885**

51340
PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

**FORMALITIES LETTER**

*OC000000011846181*

Date Mailed: 04/23/2020

# NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

**FILED UNDER 37 CFR 1.53(b)**

***Filing Date Granted***

**Items Required To Avoid Abandonment:**

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing.

Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- Surcharge as set forth in 37 CFR 1.16(f) must be submitted.
  The surcharge is due for any one of:
  - late submission of the basic filing fee, search fee, or examination fee,
  - late submission of inventor's oath or declaration,
  - filing an application that does not contain at least one claim on filing, or
  - submission of an application filed by reference to a previously filed application.

**SUMMARY OF FEES DUE:**

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $ **80** surcharge.
- $( **0**) previous unapplied payment amount.
- $ **80** TOTAL FEE BALANCE DUE.

**Items Required To Avoid Processing Delays:**

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):

Dashen FAN
Joseph Yong KWON

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/mhaile/

PTO/AIA/01 (06-12)
Approved for use through 01/31/2013. OMB 0651-0032
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

| Title of Invention | TIME DELAY IN DIGITALLY OVER SAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
|---|---|

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number 15225745

filed on August 1, 2016.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

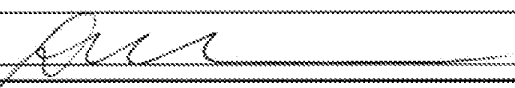
I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

## WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Dashen Fan Date (Optional): 10-7-2016

Signature: 

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

| Title of Invention | TIME DELAY IN DIGITALLY OVER SAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
|---|---|

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number 15225745

filed on August 1, 2016

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

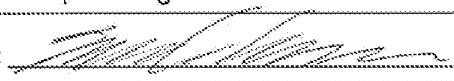
I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

## WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Joseph Yong Kwon Date (Optional): 10-7-2016

Signature: 

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 42982916 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Mark S. Peloquin |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 14-JUN-2021 |
| **Filing Date:** | 16-APR-2020 |
| **Time Stamp:** | 18:41:51 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Applicant Response to Pre-Exam Formalities Notice | NTFMPSN16851044i.pdf | 370006<br>2ae0b7b5e44724ef1a8fe71e0150cc3911e20e20 | no | 2 |
| **Warnings:** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Information:** | | | | | |
| 2 | Oath or Declaration filed | K41090P008DECFANi.pdf | 453491<br>523d7f8f157406668c8ece3a41a22e90e9f1ac4d | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Oath or Declaration filed | K41090P008DECKWONi.pdf | 421602<br>7aedef2be029e14c9689e4faf1acb206d4ef41c7 | no | 1 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 1245099 | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 | 9885 |

51340 7590 04/19/2021

PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

| EXAMINER | |
|---|---|
| MAI, LAM T | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2845 | |

| MAIL DATE | DELIVERY MODE |
|---|---|
| 04/19/2021 | PAPER |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| ***CORRECTIVE*** ***Notice of Allowability*** | **Application No.** 16/851,044 | **Applicant(s)** FAN et al. | |
|---|---|---|---|
| | **Examiner** LAM T MAI | **Art Unit** 2845 | **AIA (FITF) Status** Yes |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 2/25/2021.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-55 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   **Certified copies:**

   a) ☐ All  b) ☐ Some  *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

   **Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

**Attachment(s)**

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☑ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/LAM T MAI/
Primary Examiner, Art Unit 2845

## DETAILED ACTION

### *Notice of Pre-AIA or AIA Status*

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

## EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

The attorney of record Mark Pelqqin has been called 3 times with voice message at 216 447-1336 by the examiner on 3/24/2021, 3/25/2021 and 3/26/2021, but no response has been received.

The application has been amended as follows:

Claims 1, line 1, beginning of the claims **ADD** "Non-transistory" and **CHANGE** "A" to "a".

Claims 2-10, line 1, beginning of the claims **ADD** "Non-transistory" and **CHANGE** "The" to "the".

Claims 42, line 1, beginning of the claims **ADD** "Non-transistory" and **CHANGE** "A" to "a".

Claims 43-45, line 1, beginning of the claims **ADD** "Non-transistory" and **CHANGE** "The" to "the".

### *Conclusion*

Any inquiry concerning this communication or earlier communications from the examiner should be directed to LAM T MAI whose telephone number is **571 272-1807**. The examiner can normally be reached on Monday-Thursday 7am-530pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dameon Levi can be reached on 571-272-2105. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LAM T MAI/
Primary Examiner, Art Unit 2845

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

# BIB DATA SHEET

**CONFIRMATION NO. 9885**

| SERIAL NUMBER | FILING or 371(c) DATE<br>RULE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | 341 | 2845 | K41090.P8C3 |

**APPLICANTS**

SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG

**INVENTORS**

Dashen FAN, Bellevue, WA;
Joseph Yong KWON, San Jose, CA;

**** CONTINUING DATA ***************************

This application is a CON of 16/399,867 04/30/2019 PAT 10651866
which is a CON of 15/947,845 04/08/2018 PAT 10298253
which is a CON of 15/225,745 08/01/2016 PAT 9941895

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
04/22/2020

| Foreign Priority claimed ☐ Yes ☑ No<br>35 USC 119(a-d) conditions met ☐ Yes ☑ No<br>Verified and Acknowledged /LAM T MAI/ Examiner's Signature | ☑ Met after Allowance<br>Im Initials | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|---|
| | | WA | 20 | 10 | 1 |

**ADDRESS**

PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100
UNITED STATES

**TITLE**

BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

| FILING FEE RECEIVED | | |
|---|---|---|
| 3815 | FEES: Authority has been given in Paper<br>No._____ to charge/credit DEPOSIT ACCOUNT<br>No._____ for following: | ☐ All Fees<br>☐ 1.16 Fees (Filing)<br>☐ 1.17 Fees (Processing Ext. of time)<br>☐ 1.18 Fees (Issue)<br>☐ Other _____<br>☐ Credit |

BIB (Rev. 05/07).

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

# NOTICE OF ALLOWANCE AND FEE(S) DUE

51340 7590 04/05/2021

PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

| EXAMINER | |
|---|---|
| MAI, LAM T | |
| ART UNIT | PAPER NUMBER |
| 2845 | |

DATE MAILED: 04/05/2021

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 | 9885 |

TITLE OF INVENTION: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | SMALL | $600 | $0.00 | $0.00 | $600 | 07/06/2021 |

**THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.**

**THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.**

**HOW TO REPLY TO THIS NOTICE:**

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

**IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.**

## PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

51340 7590 04/05/2021
PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

**Certificate of Mailing or Transmission**

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

| (Typed or printed name) |
|---|
| (Signature) |
| (Date) |

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 | 9885 |

TITLE OF INVENTION: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

| APPLN. TYPE | ENTITY STATUS | ISSUE FEE DUE | PUBLICATION FEE DUE | PREV. PAID ISSUE FEE | TOTAL FEE(S) DUE | DATE DUE |
|---|---|---|---|---|---|---|
| nonprovisional | SMALL | $600 | $0.00 | $0.00 | $600 | 07/06/2021 |

| EXAMINER | ART UNIT | CLASS-SUBCLASS |
|---|---|---|
| MAI, LAM T | 2845 | 341-155000 |

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.

❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1_____
2_____
3_____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. Fees submitted: ❑Issue Fee ❑Publication Fee (if required) ❑Advance Order - # of Copies _____

4b. Method of Payment: *(Please first reapply any previously paid fee shown above)*

❑ Electronic Payment via EFS-Web ❑ Enclosed check ❑ Non-electronic payment by credit card (Attach form PTO-2038)

❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. **Change in Entity Status** (from status indicated above)

❑ Applicant certifying micro entity status. See 37 CFR 1.29

❑ Applicant asserting small entity status. See 37 CFR 1.27

❑ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 | 9885 |

51340 7590 04/05/2021

PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

| EXAMINER | |
|---|---|
| MAI, LAM T | |
| **ART UNIT** | **PAPER NUMBER** |
| 2845 | |

DATE MAILED: 04/05/2021

**Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)**
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

| *Notice Requiring Inventor's Oath or Declaration* | Application No.<br>16/851,044 | Applicant(s)<br>Dashen FAN | |
|---|---|---|---|
| | Examiner<br>MAI, LAM T | Art Unit<br>2845 | |

This notice is an attachment to the Notice of Allowability (PTOL-37), or the Notice of Allowability For A Design Application (PTOL-37D).

An inventor's oath or declaration in compliance with 37 CFR 1.63 or 1.64 executed by or with respect to each inventor has not yet been submitted.

An oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each inventor (for any inventor for which a compliant oath, declaration, or substitute statement has not yet been submitted) MUST be filed no later than the date on which the issue fee is paid. See 35 U.S.C. 115(f). Failure to timely comply will result in ABANDONMENT of this application.

A properly executed inventor's oath to declaration has not been received for the following inventor(s):

If applicant previously filed one or more oaths, declarations, or substitute statements, applicant may have received an informational notice regarding deficiencies therein.

The following deficiencies are noted:

INFORMAL ACTION PROBLEMS

- A properly executed inventor's oath or declaration has not been received for the following inventor(s): **Dashen FAN** and **Joseph Yong KWON**.
  Applicant may submit the inventor's oath or declaration at any time before the Notice of Allowance and Fee(s) Due, PTOL-85, is mailed.

Questions relating to this Notice should be directed to the Application Assistance Unit at 571-272-4200.

## OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

## Privacy Act Statement

**The Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

| *Notice of Allowability* | **Application No.** 16/851,044 | **Applicant(s)** FAN et al. | |
|---|---|---|---|
| | **Examiner** LAM T MAI | **Art Unit** 2845 | **AIA (FITF) Status** Yes |

***-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--***

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☑ This communication is responsive to 2/25/2021.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☑ The allowed claim(s) is/are 1-55 . As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see **http://www.uspto.gov/patents/init_events/pph/index.jsp** or send an inquiry to **PPHfeedback@uspto.gov.**

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   **Certified copies:**

   a) ☐ All  b) ☐ Some  *c) ☐ None of the:

   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____ .

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
**THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.**

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____ .

**Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**

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**Attachment(s)**

1. ☑ Notice of References Cited (PTO-892)
2. ☑ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date 2/25/2021.
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date. _____.
5. ☑ Examiner's Amendment/Comment
6. ☑ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/LAM T MAI/
Primary Examiner, Art Unit 2845

## DETAILED ACTION

### *Notice of Pre-AIA or AIA Status*

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

## EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

The attorney of record Mark Pelqqin has been called 3 times with voice message at 216 447-1336 by the examiner on 3/24/2021, 3/25/2021 and 3/26/2021, but no response has been received.

The application has been amended as follows:

Claims 1-10, line 1, beginning of the claims **ADD** "Non-transistory".

Claims 42-45, line 1, beginning of the claims **ADD** "Non-transistory".

### Response to TD/Amendments

Applicant's TD/amendments filed on 2/25/2021 has been carefully reconsidered.

### *Terminal Disclaimer*

The terminal disclaimer filed on 2/25/2021 disclaiming the terminal portion of any patent granted on this application which would extend beyond the expiration date of **USP 10,651,866** has been reviewed and is accepted. The terminal disclaimer has been recorded.

### *Allowable Subject Matter*

Claims 1-55 are allowable.

The following is an examiner's statement of reasons for allowance: Claim 1 is allowed over the prior art of record. The prior art of record, considered individually or in combination, fails to fairly teach or suggest claimed features, which is "*combining the time delayed first oversampled digital signal with a*

*second oversampled digital signal to obtain the beamformed digital signal, wherein the second oversampled digital signal is responsive to the analog field",* structurally and functionally interconnected with other limitations in the manner as cited in the claim and dependent claims.

Claim 11 is allowed over the prior art of record. The prior art of record, considered individually or in combination, fails to fairly teach or suggest claimed features, which is "the low pass filtered decimated delayed digital output signal and to impart an integer delay, the integer delay is an integer number of cycles at the lower sample rate times the lower sampling rate period, the integer delay is applied to the low pass filtered decimated time delayed digital output signal; and a controller, the controller is configured to supply a control signal to set the fractional delay and the integer delay", structurally and functionally interconnected with other limitations in the manner as cited in the claim and dependent claims.

Claim 22 is allowed over the prior art of record. The prior art of record, considered individually or in combination, fails to fairly teach or suggest claimed features, which is "the second time delay element is configured to receive, as an input, the low pass filtered decimated delayed PM output signal and to impart an integer delay, the integer delay is an integer number of cycles at the lower sample rate times a period at the lower sampling rate, the integer dela is applied to the low pass filtered decimated delayed PDM output signal; and a controller, the controller is configured to supply a control signal to set the fractional delay and the integer delay", structurally and functionally interconnected with other limitations in the manner as cited in the claim and dependent claims.

Claim 36 is allowed over the prior art of record. The prior art of record, considered individually or in combination, fails to fairly teach or suggest claimed features, which is "the intermediate sampling rate is a baseband sampling rate, the i+ 1 stage output signal is an output signal from the decimation module that is time delayed by a combined time delay, the combined time delay is a sum of the fractional time delay and the integer time delay; and a controller, the controller is configured to supply a

control signal to set the fractional time delay and the integer time delay", structurally and functionally interconnected with other limitations in the manner as cited in the claim and dependent claims.

Claim 38 is allowed over the prior art of record. The prior art of record, considered individually or in combination, fails to fairly teach or suggest claimed features, which is "applying a low pass filter with decimation to the delayed oversampled digital signal to output a baseband digital signal that is delayed by the fractional time delay; and delaying the baseband digital signal by an integer time delay, wherein the integer time delay is equal to a number of cycles at a baseband sampling rate times the baseband sampling rate period", structurally and functionally interconnected with other limitations in the manner as cited in the claim and dependent claims.

Claim 42 is allowed over the prior art of record. The prior art of record, considered individually or in combination, fails to fairly teach or suggest claimed features, which is "applying a low pass filter with decimation to the delayed oversampled digital signal to output a baseband digital signal that is delayed by the fractional time delay; and delaying the baseband digital signal by an integer time delay, wherein the integer time delay is equal to a number of sampling clock cycles times the sampling clock period at a baseband sampling rate", structurally and functionally interconnected with other limitations in the manner as cited in the claim and dependent claims.

Claim 46 is allowed over the prior art of record. The prior art of record, considered individually or in combination, fails to fairly teach or suggest claimed features, which is "adjust the fractional time delay and the integer time delay to establish a. total time delay, wherein ~~the~~ a resulting digital signal is delayed by a total time delay, wherein the total time delay is a sum of the fractional time delay and the integer time delay, and contains a digital representation of the analog field quantity without the noise introduced by the over sampling means", structurally and functionally interconnected with other limitations in the manner as cited in the claim and dependent claims.

Claim 51 is allowed over the prior art of record. The prior art of record, considered individually or in combination, fails to fairly teach or suggest claimed features, which is "the second filter is configured to receive as an input the second time delayed oversampled digital output signal, the second filter to low pass filter and to decimate to a lower sample rate the second time delayed oversampled digital output signal and to output a second low pass filtered decimated delayed digital output signal; and a second integer time delay element, the second integer time delay element is configured to receive, as an input, the second low pass filtered decimated delayed digital output signal and to output a second time delayed digital output signal at the lower sample rate", structurally and functionally interconnected with other limitations in the manner as cited in the claim and dependent claims.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

**Cited References**

The prior art made of record and not relied upon is considered pertinent to applicant's disclosure. Cited references are related to instant application subject matters.

***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to LAM T MAI whose telephone number is **571 272-1807**. The examiner can normally be reached on Monday-Thursday 7am-530pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dameon Levi can be reached on 571-272-2105. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/LAM T MAI/
Primary Examiner, Art Unit 2845

| Notice of References Cited | Application/Control No. 16/851,044 | Applicant(s)/Patent Under Reexamination FAN et al. | |
|---|---|---|---|
| | Examiner LAM T MAI | Art Unit 2845 | Page 1 of 1 |

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| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | CPC Classification | US Classification |
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| * | B | US-20140009564-A1 | 01-2014 | Cleve; Pascal | H04M3/568 | 348/14.08 |
| * | C | US-9941895-B2 | 04-2018 | Fan; Dashen | H03M1/1245 | 1/1 |
| * | D | US-10298253-B1 | 05-2019 | Fan; Dashen | H03M3/462 | 1/1 |
| * | E | US-10651866-B1 | 05-2020 | Fan; Dashen | H03M3/462 | 1/1 |
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**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | CPC Classification |
|---|---|---|---|---|---|---|
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
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*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
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| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/851,044 | FAN et al. |
| | Examiner | Art Unit |
| | LAM T MAI | 2845 |

| CPC - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
| H03M1/1245.cpc. | 03/27/2021 | lammai |
| H04B7/0617.cpc. | 03/27/2021 | lammai |
| H03M3//462.cpc. | 03/27/2021 | lammai |

| CPC Combination Sets - Searched* | | |
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| Symbol | Date | Examiner |
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| US Classification - Searched* | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 341 | 122-160 | 03/27/2021 | lammai |

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| Global Dossier/Google Scholar/NPL Search/IP.com/Plus/East Text Search | 03/27/2021 | lammai |
| Inventors and Assignee | 03/27/2021 | lammai |
| Reviewed Related Application 15/225,745 and 15/947,845 and 16/399867 | 03/27/2021 | lammai |

| /LAM T MAI/<br>Primary Examiner.Art Unit 2845 | |
|---|---|

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/851,044 | FAN et al. |
| | Examiner | Art Unit |
| | LAM T MAI | 2845 |

| Interference Search | | | |
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| **US Class/CPC Symbol** | **US Subclass/CPC Group** | **Date** | **Examiner** |
| H03M1 | 1245 | 03/27/2021 | lammai |
| H04B7 | 0617 | 03/27/2021 | lammai |
| H03M3 | 462 | 03/27/2021 | lammai |

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| /LAM T MAI/<br>Primary Examiner.Art Unit 2845 | |

| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/851,044 | FAN et al. |
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| | LAM T MAI | 2845 |

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| NONE | | Total Claims Allowed: | |
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| (Assistant Examiner) | (Date) | 55 | |
| /LAM T MAI/<br>Primary Examiner, Art Unit 2845 | 27 March 2021 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 9B |

U.S. Patent and Trademark Office — Part of Paper No.: 20210327

| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/851,044 | FAN et al. |
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| | LAM T MAI | 2845 |

| INTERNATIONAL CLASSIFICATION | | | | |
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| H03M1/12 | / | 1 | / | 12 |
| H04B7/06 | / | 7 | / | 06 |
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| US ORIGINAL CLASSIFICATION | |
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| CROSS REFERENCES(S) | | | | | | |
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| (Assistant Examiner) | (Date) | 55 | |
| /LAM T MAI/<br>Primary Examiner, Art Unit 2845 | 27 March 2021 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 9B |

U.S. Patent and Trademark Office — Part of Paper No.: 20210327

| Issue Classification | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/851,044 | FAN et al. |
| | **Examiner** | **Art Unit** |
| | LAM T MAI | 2845 |

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

**CLAIMS**

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| (Assistant Examiner) | (Date) | 55 | |
| /LAM T MAI/<br>Primary Examiner, Art Unit 2845 | 27 March 2021 | O.G. Print Claim(s) | O.G. Print Figure |
| (Primary Examiner) | (Date) | 1 | 9B |

U.S. Patent and Trademark Office — Part of Paper No.: 20210327

| Index of Claims | Application/Control No. | Applicant(s)/Patent Under Reexamination |
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| | 16/851,044 | FAN et al. |
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| | LAM T MAI | 2845 |

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**CLAIMS**

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| CLAIM | | DATE | | | | | | | | |
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| Final | Original | 08/29/2020 | 03/27/2021 | | | | | | | |
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| Index of Claims | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/851,044 | FAN et al. |
| | Examiner | Art Unit |
| | LAM T MAI | 2845 |

| CLAIM | | DATE | | | | | | | | |
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| Final | Original | 08/29/2020 | 03/27/2021 | | | | | | | |
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Attorney's Docket No. K41090.P8C3 PATENT

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /L.T.M/

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In Re Patent Application of: | |
| Dashen Fan | Examiner: MAI, LAM T |
| Application No.: 16/851,044 | Art Unit: 2845 |
| Filed: April 16, 2020 | |
| For: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

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Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

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Respectfully submitted,

PELOQUIN, PLLC

Dated: Feb 25, 2021 /Mark S. Peloquin/
Mark S. Peloquin, Esq.
Reg. No. 50,787

800 Fifth Avenue, Suite 4100
Seattle, WA 98104-3100
206-447-1336 telephone
206-770-6562 facsimile

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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

*(Use as many sheets as necessary)*

Sheet 1 of 2

| Complete if Known | |
|---|---|
| Application Number | 16/851,044 |
| Filing Date | April 16, 2020 |
| First Named Inventor | DASHEN FAN |
| Art Unit | 2845 |
| Examiner Name | MAI, LAM T |
| Attorney Docket Number | K41090.P8C3 |

**U. S. PATENT DOCUMENTS**

| Examiner Initials* | Cite No.[1] | Document Number<br>Number-Kind Code[2] (if known) | Publication Date MM-DD-YYYY | Name of Patentee or Applicant of Cited Document | Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear |
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| Examiner Initials* | Cite No.[1] | Foreign Patent Document<br>Country Code[3] Number[4] Kind Code[5] (if known) | Publication Date MM-DD-YYYY | Name of Patentee or Applicant of Cited Document | Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear | T[6] |
|---|---|---|---|---|---|---|
| | | JP2010122191 | 06-03-2010 | SANYO ELECTRIC CO | | ✓ |
| | | JP2000197180 | 07-14-2000 | VICTOR CO OF JAPAN LTD | | ✓ |
| | | JP2002300224 | 10-11-2002 | HITACHI INT ELECTRIC INC | | ✓ |
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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

*(Use as many sheets as necessary)*

Sheet 2 of 2

| Complete if Known | |
|---|---|
| Application Number | 16/851,044 |
| Filing Date | April 16, 2020 |
| First Named Inventor | DASHEN FAN |
| Art Unit | 2845 |
| Examiner Name | MAI, LAM T |
| Attorney Docket Number | K41090.P8C3 |

## NON PATENT LITERATURE DOCUMENTS

| Examiner Initials* | Cite No.[1] | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published. | T[2] |
|---|---|---|---|
| | | OFFICE ACTION ISSUED IN CORRESPONDING JP PATENT APPLICATION NO. 2019-526185. DECEMBER 04, 2020 | ✓ |
| | | OFFICE ACTION ISSUED IN CORRESPONDING JP PATENT APPLICATION NO. 2019-526185. JANUARY 23, 2020 | ✓ |
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| | | Written Opinion Of The International Searching Authority for Application PCT/US2017/015882, International Filing Date January 31, 2017 (12 pages) | ✓ |
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**EAST Search History**

**EAST Search History (Interference)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L1 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
| L2 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
| L3 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
| L4 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
| L5 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
| L6 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
| L7 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
| L8 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
| L9 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:51 |
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| L245 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L246 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L247 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L248 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L249 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L250 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L251 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L252 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L253 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L254 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L255 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L256 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L257 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L258 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L259 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L260 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L261 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L262 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |

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|---|---|---|---|---|---|---|
| L263 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L264 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L265 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L266 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L267 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L268 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L269 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L270 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L271 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L272 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L273 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L274 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L275 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L276 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L277 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L278 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L279 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L280 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L281 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:56 |
| L282 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |

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|---|---|---|---|---|---|---|
| L283 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L284 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L285 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L286 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L287 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L288 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L289 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L290 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L291 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L292 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L293 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L294 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L295 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L296 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L297 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L298 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L299 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L300 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L301 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L302 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |

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|---|---|---|---|---|---|---|
| L303 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L304 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L305 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L306 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L307 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L308 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L309 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L310 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L311 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L312 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L313 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L314 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L315 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L316 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L317 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:57 |
| L318 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:58 |
| L319 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:58 |
| L320 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:58 |
| L321 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:58 |
| L322 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/27 19:58 |

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**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L61 | 399 | "Kopin corporation".asn. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L62 | 46 | Fan.in. and dashen | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L63 | 6 | kwon.in. and "joseph Yong" | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L64 | 12,912 | digital adj sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L65 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L66 | 3,362 | (microphone (digital adj sensor)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L67 | 10 | (microphone (digital adj sensor)) with sampl$4 adj clock with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L68 | 28 | (microphone (digital adj sensor)) with (adc ad a/d (analog adj digital)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L69 | 43 | oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; | OR | ON | 2021/03/13 19:54 |

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|---|---|---|---|---|---|---|
| | | | JPO; DERWENT; IBM_TDB | | | |
| L70 | 6 | oversampl$4 adj digital adj output with time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L71 | 6 | oversampl$4 adj digital adj output same time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L72 | 10 | (microphone (digital adj sensor)) with oversampl$4 with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L73 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L74 | 6 | tim$4 near delay$4 near oversampl$4 near digital near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L75 | 7 | tim$4 near delay$4 near oversampl$4 near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L76 | 207 | (("3684829") or ("3755792") or ("3813485") or ("3914746") or ("4021616") or ("4290050") or ("4361729") or ("4414685") or ("4521099") or ("4577219") or ("4605921") or ("4628345") or ("5089820") or ("5089917") or ("5177711") or ("5333063") or ("5459718") or ("5483474") or ("5493581") or ("5594438") or ("5717618") or ("5742351") or ("5771012") or ("5801653") or ("5870051") or ("5910957") or ("5910995") or ("5969798") or ("5982132") or ("6034564") or ("6092130") or ("6188785") or ("6195394") or ("6201490") or | US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2021/03/13 19:54 |

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|---|---|---|---|---|---|---|
| | | ("6590616") or ("6643382") or ("6775684") or ("6947497") or ("6961151") or ("6972828") or ("7068841") or ("7187409") or ("7472206") or ("7583355") or ("7590675") or ("7626592") or ("7680807") or ("7706443") or ("7782439") or ("7817071")).PN. | | | | |
| L77 | 2 | L76 and time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L78 | 0 | L76 and digital near sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L79 | 399 | "Kopin corporation".asn. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L80 | 46 | Fan.in. and dashen | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L81 | 6 | kwon.in. and "joseph Yong" | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:54 |
| L82 | 12,912 | digital adj sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L83 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L84 | 3,362 | (microphone (digital adj sensor)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |

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|---|---|---|---|---|---|---|
| L85 | 10 | (microphone (digital adj sensor)) with sampl$4 adj clock with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L86 | 28 | (microphone (digital adj sensor)) with (adc ad a/d (analog adj digital)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L87 | 43 | oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L88 | 6 | oversampl$4 adj digital adj output with time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L89 | 6 | oversampl$4 adj digital adj output same time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L90 | 10 | (microphone (digital adj sensor)) with oversampl$4 with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L91 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L92 | 6 | tim$4 near delay$4 near oversampl$4 near digital near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L93 | 7 | tim$4 near delay$4 near oversampl$4 near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L94 | 207 | (("3684829") or ("3755792") or ("3813485") or ("3914746") or ("4021616") or ("4290050") or ("4361729") or ("4414685") or | US-PGPUB; USPAT; FPRS; EPO; JPO; | OR | OFF | 2021/03/13 19:55 |

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|---|---|---|---|---|---|---|
| | | ("4521099") or ("4577219") or ("4605921") or ("4628345") or ("5089820") or ("5089917") or ("5177711") or ("5333063") or ("5459718") or ("5483474") or ("5493581") or ("5594438") or ("5717618") or ("5742351") or ("5771012") or ("5801653") or ("5870051") or ("5910957") or ("5910995") or ("5969798") or ("5982132") or ("6034564") or ("6092130") or ("6188785") or ("6195394") or ("6201490") or ("6590616") or ("6643382") or ("6775684") or ("6947497") or ("6961151") or ("6972828") or ("7068841") or ("7187409") or ("7472206") or ("7583355") or ("7590675") or ("7626592") or ("7680807") or ("7706443") or ("7782439") or ("7817071")).PN. | DERWENT; IBM_TDB | | | |
| L95 | 2 | L94 and time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L96 | 0 | L94 and digital near sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L97 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L98 | 4 | digital adj sensor with time adj delay and oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L99 | 5 | digital adj sensor and time adj delay and oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |
| L100 | 7,715 | beamform$4 with delay | US-PGPUB; USPAT; EPO; JPO; | OR | ON | 2021/03/13 19:55 |

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|---|---|---|---|---|---|---|
| | | | DERWENT; IBM_TDB | | | |
| L101 | 305 | beamform$4 with delay with (adc ad a/d (analog adj digital)) | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/13 19:55 |

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Results: Patent Application Number 16851044
Family ID: 1000005030605
Allocations (3)

| No. | CPC Symbol | C* | Title | Allocated By | Date Modified (US) | IPC Concordant |
|---|---|---|---|---|---|---|
| 1 | H03M 1/1245 | Filled Star | {Details of sampling arrangements or methods} | US (F) | Aug 27, 2020 02:13 | H03M1/12 |
| 2 | H03M 3/462 | Filled Star | {Details relating to the decimation process (decimation filters in general H03H17/0416, H03H17/0621)} | US (I) | Aug 27, 2020 02:13 | H03M3/00 |
| 3 | H04B 7/0617 | Filled Star | {for beam forming} | US (I) | Aug 27, 2020 02:13 | H04B7/06 |

Combination Sets (0)

**EAST Search History**

**EAST Search History (Prior Art)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L61 | 399 | "Kopin corporation".asn. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L62 | 46 | Fan.in. and dashen | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L63 | 6 | kwon.in. and "joseph Yong" | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L64 | 12,957 | digital adj sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L65 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L66 | 3,372 | (microphone (digital adj sensor)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L67 | 10 | (microphone (digital adj sensor)) with sampl$4 adj clock with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L68 | 28 | (microphone (digital adj sensor)) with (adc ad a/d (analog adj digital)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L69 | 43 | oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; | OR | ON | 2021/03/27 19:52 |

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|---|---|---|---|---|---|---|
| | | | JPO; DERWENT; IBM_TDB | | | |
| L70 | 6 | oversampl$4 adj digital adj output with time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L71 | 6 | oversampl$4 adj digital adj output same time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L72 | 10 | (microphone (digital adj sensor)) with oversampl$4 with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L73 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L74 | 6 | tim$4 near delay$4 near oversampl$4 near digital near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L75 | 7 | tim$4 near delay$4 near oversampl$4 near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L76 | 207 | (("3684829") or ("3755792") or ("3813485") or ("3914746") or ("4021616") or ("4290050") or ("4361729") or ("4414685") or ("4521099") or ("4577219") or ("4605921") or ("4628345") or ("5089820") or ("5089917") or ("5177711") or ("5333063") or ("5459718") or ("5483474") or ("5493581") or ("5594438") or ("5717618") or ("5742351") or ("5771012") or ("5801653") or ("5870051") or ("5910957") or ("5910995") or ("5969798") or ("5982132") or ("6034564") or ("6092130") or ("6188785") or ("6195394") or ("6201490") or | US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2021/03/27 19:52 |

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|---|---|---|---|---|---|---|
| | | ("6590616") or ("6643382") or ("6775684") or ("6947497") or ("6961151") or ("6972828") or ("7068841") or ("7187409") or ("7472206") or ("7583355") or ("7590675") or ("7626592") or ("7680807") or ("7706443") or ("7782439") or ("7817071")).PN. | | | | |
| L77 | 2 | L76 and time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L78 | 0 | L76 and digital near sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L79 | 399 | "Kopin corporation".asn. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L80 | 46 | Fan.in. and dashen | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L81 | 6 | kwon.in. and "joseph Yong" | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L82 | 12,957 | digital adj sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L83 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L84 | 3,372 | (microphone (digital adj sensor)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |

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|---|---|---|---|---|---|---|
| L85 | 10 | (microphone (digital adj sensor)) with sampl$4 adj clock with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L86 | 28 | (microphone (digital adj sensor)) with (adc ad a/d (analog adj digital)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L87 | 43 | oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L88 | 6 | oversampl$4 adj digital adj output with time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L89 | 6 | oversampl$4 adj digital adj output same time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L90 | 10 | (microphone (digital adj sensor)) with oversampl$4 with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L91 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L92 | 6 | tim$4 near delay$4 near oversampl$4 near digital near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L93 | 7 | tim$4 near delay$4 near oversampl$4 near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L94 | 207 | (("3684829") or ("3755792") or ("3813485") or ("3914746") or ("4021616") or ("4290050") or ("4361729") or ("4414685") or | US-PGPUB; USPAT; FPRS; EPO; JPO; | OR | OFF | 2021/03/27 19:52 |

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|---|---|---|---|---|---|---|
| | | ("4521099") or ("4577219") or ("4605921") or ("4628345") or ("5089820") or ("5089917") or ("5177711") or ("5333063") or ("5459718") or ("5483474") or ("5493581") or ("5594438") or ("5717618") or ("5742351") or ("5771012") or ("5801653") or ("5870051") or ("5910957") or ("5910995") or ("5969798") or ("5982132") or ("6034564") or ("6092130") or ("6188785") or ("6195394") or ("6201490") or ("6590616") or ("6643382") or ("6775684") or ("6947497") or ("6961151") or ("6972828") or ("7068841") or ("7187409") or ("7472206") or ("7583355") or ("7590675") or ("7626592") or ("7680807") or ("7706443") or ("7782439") or ("7817071")).PN. | DERWENT; IBM_TDB | | | |
| L95 | 2 | L94 and time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L96 | 0 | L94 and digital near sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L97 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L98 | 4 | digital adj sensor with time adj delay and oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L99 | 5 | digital adj sensor and time adj delay and oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L100 | 7,747 | beamform$4 with delay | US-PGPUB; USPAT; EPO; JPO; | OR | ON | 2021/03/27 19:52 |

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|---|---|---|---|---|---|---|
| | | | DERWENT; IBM_TDB | | | |
| L101 | 308 | beamform$4 with delay with (adc ad a/d (analog adj digital)) | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:52 |
| L162 | 399 | "Kopin corporation".asn. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L163 | 46 | Fan.in. and dashen | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L164 | 6 | kwon.in. and "joseph Yong" | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L165 | 12,957 | digital adj sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L166 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L167 | 3,372 | (microphone (digital adj sensor)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L168 | 10 | (microphone (digital adj sensor)) with sampl$4 adj clock with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L169 | 28 | (microphone (digital adj sensor)) with (adc ad a/d (analog adj digital)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |

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|---|---|---|---|---|---|---|
| L170 | 43 | oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L171 | 6 | oversampl$4 adj digital adj output with time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L172 | 6 | oversampl$4 adj digital adj output same time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L173 | 10 | (microphone (digital adj sensor)) with oversampl$4 with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L174 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L175 | 6 | tim$4 near delay$4 near oversampl$4 near digital near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L176 | 7 | tim$4 near delay$4 near oversampl$4 near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L177 | 207 | (("3684829") or ("3755792") or ("3813485") or ("3914746") or ("4021616") or ("4290050") or ("4361729") or ("4414685") or ("4521099") or ("4577219") or ("4605921") or ("4628345") or ("5089820") or ("5089917") or ("5177711") or ("5333063") or ("5459718") or ("5483474") or ("5493581") or ("5594438") or ("5717618") or ("5742351") or ("5771012") or ("5801653") or ("5870051") or ("5910957") or ("5910995") or ("5969798") or ("5982132") or ("6034564") or | US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2021/03/27 19:54 |

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|---|---|---|---|---|---|---|
| | | ("6092130") or ("6188785") or ("6195394") or ("6201490") or ("6590616") or ("6643382") or ("6775684") or ("6947497") or ("6961151") or ("6972828") or ("7068841") or ("7187409") or ("7472206") or ("7583355") or ("7590675") or ("7626592") or ("7680807") or ("7706443") or ("7782439") or ("7817071")).PN. | | | | |
| L178 | 2 | L177 and time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L179 | 0 | L177 and digital near sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L180 | 399 | "Kopin corporation".asn. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L181 | 46 | Fan.in. and dashen | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L182 | 6 | kwon.in. and "joseph Yong" | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L183 | 12,957 | digital adj sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L184 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L185 | 3,372 | (microphone (digital adj sensor)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; | OR | ON | 2021/03/27 19:54 |

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|---|---|---|---|---|---|---|
| | | | DERWENT; IBM_TDB | | | |
| L186 | 10 | (microphone (digital adj sensor)) with sampl$4 adj clock with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L187 | 28 | (microphone (digital adj sensor)) with (adc ad a/d (analog adj digital)) with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L188 | 43 | oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L189 | 6 | oversampl$4 adj digital adj output with time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L190 | 6 | oversampl$4 adj digital adj output same time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L191 | 10 | (microphone (digital adj sensor)) with oversampl$4 with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L192 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L193 | 6 | tim$4 near delay$4 near oversampl$4 near digital near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L194 | 7 | tim$4 near delay$4 near oversampl$4 near output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |

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|---|---|---|---|---|---|---|
| L195 | 207 | (("3684829") or ("3755792") or ("3813485") or ("3914746") or ("4021616") or ("4290050") or ("4361729") or ("4414685") or ("4521099") or ("4577219") or ("4605921") or ("4628345") or ("5089820") or ("5089917") or ("5177711") or ("5333063") or ("5459718") or ("5483474") or ("5493581") or ("5594438") or ("5717618") or ("5742351") or ("5771012") or ("5801653") or ("5870051") or ("5910957") or ("5910995") or ("5969798") or ("5982132") or ("6034564") or ("6092130") or ("6188785") or ("6195394") or ("6201490") or ("6590616") or ("6643382") or ("6775684") or ("6947497") or ("6961151") or ("6972828") or ("7068841") or ("7187409") or ("7472206") or ("7583355") or ("7590675") or ("7626592") or ("7680807") or ("7706443") or ("7782439") or ("7817071")).PN. | US-PGPUB; USPAT; FPRS; EPO; JPO; DERWENT; IBM_TDB | OR | OFF | 2021/03/27 19:54 |
| L196 | 2 | L195 and time near delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L197 | 0 | L195 and digital near sensor | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L198 | 67 | digital adj sensor with time adj delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L199 | 4 | digital adj sensor with time adj delay and oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L200 | 5 | digital adj sensor and time adj delay and oversampl$4 adj digital adj output | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |

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| L201 | 7,747 | beamform$4 with delay | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |
| L202 | 308 | beamform$4 with delay with (adc ad a/d (analog adj digital)) | US-PGPUB; USPAT; EPO; JPO; DERWENT; IBM_TDB | OR | ON | 2021/03/27 19:54 |

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# BIB DATA SHEET

**CONFIRMATION NO. 9885**

| SERIAL NUMBER | FILING or 371(c) DATE<br>RULE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | 341 | 2845 | K41090.P8C3 |

**APPLICANTS**

SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG

**INVENTORS**

Dashen FAN, Bellevue, WA;
Joseph Yong KWON, San Jose, CA;

**** CONTINUING DATA ***************************

This application is a CON of 16/399,867 04/30/2019 PAT 10651866
which is a CON of 15/947,845 04/08/2018 PAT 10298253
which is a CON of 15/225,745 08/01/2016 PAT 9941895

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
04/22/2020

| Foreign Priority claimed ☐ Yes ☑ No<br>35 USC 119(a-d) conditions met ☐ Yes ☑ No<br>Verified and Acknowledged /LAM T MAI/ Examiner's Signature | ☑ Met after Allowance<br>Im Initials | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
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| | | WA | 20 | 10 | 1 |

**ADDRESS**

PELOQUIN, PLLC
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UNITED STATES

**TITLE**

BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

| FILING FEE RECEIVED | | |
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BIB (Rev. 05/07).

**EAST Search History**

**EAST Search History (Interference)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L1 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L2 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L3 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L4 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L5 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L6 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L7 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L8 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L9 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L10 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L11 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L12 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L13 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L14 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L15 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L16 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L17 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L18 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |

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| L19 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L20 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L21 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L22 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L23 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L24 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L25 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L26 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L27 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L28 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L29 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L30 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L31 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L32 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L33 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L34 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L35 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L36 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L37 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L38 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |

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|---|---|---|---|---|---|---|
| L39 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L40 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L41 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L42 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L43 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L44 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L45 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L46 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L47 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L48 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L49 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L50 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L51 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L52 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L53 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L54 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L55 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L56 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L57 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L58 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |

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|---|---|---|---|---|---|---|
| L59 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L60 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:54 |
| L102 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L103 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L104 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L105 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L106 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L107 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L108 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L109 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L110 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L111 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L112 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L113 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L114 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L115 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L116 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L117 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L118 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L119 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L120 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |

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|---|---|---|---|---|---|---|
| L121 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L122 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L123 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L124 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L125 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L126 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L127 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L128 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L129 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L130 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L131 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L132 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L133 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L134 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L135 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L136 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L137 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L138 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L139 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L140 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |

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|---|---|---|---|---|---|---|
| L141 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L142 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L143 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L144 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L145 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L146 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L147 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L148 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L149 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L150 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L151 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L152 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L153 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L154 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L155 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L156 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L157 | 143 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L158 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L159 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |
| L160 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:55 |

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|---|---|---|---|---|---|---|
| L161 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2021/03/13 19:56 |

3/13/2021 8:09:42 PM
C:\Users\lmai1\Documents\EAST\Workspaces\16851044.wsp

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www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 |

**CONFIRMATION NO. 9885**

51340
PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

**POA ACCEPTANCE LETTER**

*OC000000123726679*

Date Mailed: 03/01/2021

## NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 02/25/2021.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/hsarwari/

| *Application Number* * 16/851,044 * | Application/Control No. 16/851,044 | Applicant(s)/Patent under Reexamination FAN et al. | |
|---|---|---|---|
| | Examiner MAI, LAM T | Art Unit 2845 | |

| Document Code - DISQ | Internal Document - DO NOT MAIL |
|---|---|

| TERMINAL DISCLAIMER | ☑ APPROVED | ☐ DISAPPROVED |
|---|---|---|
| Date Filed: 25 February 2021 | This patent is subject to a Terminal Disclaimer | |

| Approved/Disapproved by: |
|---|
| /KIMBERLY R WHITE/<br><br>Technology Center: OPLC<br><br>Telephone: (571)272-6179<br><br>_____ |

# PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

To:
PELOQUIN, MARK S.

PELOQUIN, PLLC 800 FIFTH AVE, SUITE 4100 SEATTLE WA 98104 USA

# PCT

## NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT AND THE WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY, OR THE DECLARATION

**(PCT Rule 44.1)**

| | |
|---|---|
| Date of mailing *(day/month/year)* | 03 July 2017 (03.07.2017) |
| Applicant's or agent's file reference<br>K41090P08PCT | **FOR FURTHER ACTION** See paragraphs 1 and 4 below |
| International application No.<br>**PCT/US2017/015882** | International filing date *(day/month/year)*<br>**31 January 2017 (31.01.2017)** |
| Applicant<br>**KOPIN CORPORATION** | |

1. ☒ The applicant is hereby notified that the international search report and the written opinion of the International Searching Authority have been established and are transmitted herewith.

**Filing of amendments and statement under Article 19:**

The applicant is entitled, if he so wishes, to amend the claims of the international application (see Rule 46).

**When?** The time limit for filing such amendments is normally two months from the date of transmittal of the international search report.

**How?** Directly to the International Bureau of WIPO preferably through ePCT or on paper to, 34 chemin des Colombettes 1211 Geneva 20, Switzerland, Facsimile No.: +41 22 338 82 70

**For more detailed instructions,** see *PCT Applicant's Guide*, International Phase, paragraphs 9.004 . 9-011.

2. ☐ The applicant is hereby notified that no international search report will be established and that the declaration under Article 17(2)(a) to that effect and the written opinion of the International Searching Authority are transmitted herewith.

3. ☐ **With regard to any protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

☐ the protest together with the decision thereon has been transmitted to the International Bureau together with any request to forward the texts of both the protest and the decision thereon to the designated Offices.

☐ no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Reminders**

The applicant may submit comments on an informal basis on the written opinion of the International Searching Authority to the International Bureau. The International Bureau will send a copy of such comments to all designated Offices unless an international preliminary examination report has been or is to be established. Following the expiration of 30 months from the priority date, these comments will also be made available to the public.

Shortly after the expiration of **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau before the completion of the technical preparations for international publication (Rules 90*bis*.1 and 90*bis*.3).

Within **19 months** from the priority date, but only in respect of some designated Offices, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase **until 30 months** from the priority date (in some Offices even later); otherwise, the applicant must, **within 20 months** from the priority date, perform the prescribed acts for entry into the national phase before those designated Offices. In respect of other designated Offices, the time limit of **30 months** (or later) will apply even if no demand is filed within 19 months. For details about the applicable time limits, Office by Office, see www.wipo.int/pct/en/texts/time_limits.html and the *PCT Applicant's Guide*, National Chapters.

Within **19 months** from the priority date, the applicant may request that a supplementary international search be carried out by an International Searching Authority that offers this service (Rule 45*bis* 1). The procedure for requesting supplementary international search is described in the *PCT Applicant's Guide*, International Phase, paragraphs 8.006-8.032.

| | |
|---|---|
| Name and mailing address of the ISA/KR<br>International Application Division<br>Korean Intellectual Property Office<br>189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea | Authorized officer<br>COMMISSIONER |
| Facsimile No. 82-42-481-8578 | Telephone No. 82-42-481-8751 |

Form PCT/ISA/220 (July 2014)

* Attention

Copies of the documents cited in the international search report can be searched in the following Korean Intellectual Property Office English website for six months(expire date : **2018.01.03** ) from the date of mailing of the international search report.

http://www.kipo.go.kr/en/ => PCT Service => PCT Services

ID : PCT international application number
PW : **822LP59W**

Inquiries related to PCT International Search Report or Written Opinion prepared by KIPO as an International Searching Authority can be answered not only by KIPO but also through IPKC (Intellectual Property Korea Center), located in Vienna, VA, which functions as a PCT Help Desk for PCT applicants.

Homepage: http://www.ipkcenter.com

Email: ipkc@ipkcenter.com

Notes to Form PCT/ISA/220 (July 2014)

PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference K41090P08PCT | FOR FURTHER ACTION | see Form PCT/ISA/220 as well as, where applicable, item 5 below |
|---|---|---|
| International application No **PCT/US2017/015882** | International filing date *(day/month/year)* **31 January 2017 (31.01.2017)** | (Earliest) Priority Date *(day/month/year)* 01 August 2016 (01.08.2016) |
| Applicant **KOPIN CORPORATION** | | |

This International search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

☐ It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**
   a. With regard to the **language**, the international search was carried out on the basis of :
      ☒ the international application in the language in which it was filed
      ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))
   b. ☐ This international search report has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43.6*bis*(a))
   c. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, see Box No. I.
2. ☐ **Certain claims were found unsearchable** (See Box No. II)
3. ☒ **Unity of invention is lacking** (See Box No. III)
4. With regard to the **title,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established by this Authority to read as follows:
5. With regard to the **abstract,**
   ☒ the text is approved as submitted by the applicant.
   ☐ the text has been established, according to Rule 38.2, by this Authority as it appears in Box No. IV. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.
6. With regard to the drawings,
   a. the figure of the **drawings** to be published with the abstract is Figure No **2A**
      ☒ as suggested by the applicant.
      ☐ as selected by this Authority, because the applicant failed to suggest a figure.
      ☐ as selected by this Authority, because this figure better characterizes the invention.
   b. ☐ none of the figures is to be published with the abstract.

Form PCT/ISA/210 (first sheet) (January 2015)

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/US2017/015882**

**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.:
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:

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:

Group I: Claims 1-30 and 34-48, drawn to a system and a method for time delaying an oversampled signal within an ADC system.

Group II: Claims 31-33, drawn to a decimation module for use in an ADC system.

Group III: Claims 49-54, drawn to a system for applying multiple time delays to an output from a single sensor.

1. ☐ As all required addtional 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 any 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.:
1-30, 34-48

**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.

# INTERNATIONAL SEARCH REPORT

International application No.
**PCT/US2017/015882**

**A. CLASSIFICATION OF SUBJECT MATTER**

**H03M 1/50(2006.01)i, H03M 1/12(2006.01)i**

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)
H03M 1/50; H03F 99/00; H03M 3/02; H04R 3/00; H04B 1/06; G06K 7/08; H03F 1/32; H03M 1/12

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords:digital sensor, ADC, time delay, oversample, sampling clock frequency, pulse density modulated (PDM), sigma-delta modulator, decimating, multi-stage filter, low pass filter, beam forming

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 2005-0167496 A1 (ROBERT E. MORLEY JR. et al.) 04 August 2005<br>See paragraphs [0050]-[0056], [0082]-[0100]; claims 2, 3, 8, 12-14; and figures 1, 11A-11C, 13. | 1,2,34,35,37-40,42-44,47,48 |
| Y | | 3-19,25-30,36,41,45,46 |
| A | | 20-24 |
| Y | US 2015-0281836 A1 (KHIEM QUANG NGUYEN et al.) 01 October 2015<br>See paragraphs [0012], [0027]-[0037]; and figures 1, 3. | 3-19,25-30,45 |
| Y | US 2011-0013488 A1 (WEI MA et al.) 20 January 2011<br>See paragraphs [0028]-[0041]; and figures 3-6. | 12-15,19,25,26,36,41,46 |
| A | US 2013-0121504 A1 (ROBERT ADAMS et al.) 16 May 2013<br>See paragraphs [0023]-[0035]; and figure 1. | 1-30,34-48 |
| A | US 2009-0278721 A1 (KOICHI HAMASHITA et al.) 12 November 2009<br>See paragraphs [0030]-[0033]; and figure 1. | 1-30,34-48 |

☐ Further documents are listed in the continuation of Box C. ☒ 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 application or patent 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 June 2017 (21.06.2017) | **03 July 2017 (03.07.2017)** |

| Name and mailing address of the ISA/KR | Authorized officer |
|---|---|
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Form PCT/ISA/210 (second sheet) (January 2015)

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

International application No.
**PCT/US2017/015882**

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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# PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
PELOQUIN, MARK S.

PELOQUIN, PLLC 800 FIFTH AVE, SUITE 4100 SEATTLE WA 98104 USA

# PCT

**WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY**

**(PCT Rule 43bis.1)**

| | |
|---|---|
| Date of mailing *(day/month/year)* | **03 July 2017 (03.07.2017)** |
| Applicant's or agent's file reference<br>K41090P08PCT | **FOR FURTHER ACTION**<br>See paragraph 2 below |

| International application No. | International filing date *(day/month/year)* | Priority date *(day/month/year)* |
|---|---|---|
| **PCT/US2017/015882** | **31 January 2017 (31.01.2017)** | 01 August 2016 (01.08.2016) |

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

***H03M 1/50(2006.01)i, H03M 1/12(2006.01)i***

Applicant
**KOPIN CORPORATION**

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [x] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [x] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

| Name and mailing address of the ISA/KR | Date of completion of this opinion | Authorized officer |
|---|---|---|
| International Application Division<br>Korean Intellectual Property Office<br>189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea<br>Facsimile No. +82-42-481-8578 | 21 June 2017 (21.06.2017) | AHN, Jeong Hwan<br>Telephone No. +82-42-481-8633 |

Form PCT/ISA/237 (cover sheet) (January 2015)

# WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
**PCT/US2017/015882**

**Box No. I Basis of this opinion**

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:
      ☐ in the form of an Annex C/ST.25 text file.
      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:
      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

**WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY**

International application No.
**PCT/US2017/015882**

**Box No. IV Lack of unity of invention**

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees the applicant has, within the applicable time limit:
   - ☐ paid additional fees
   - ☐ paid additional fees under protest and, where applicable, the protest fee
   - ☐ paid additional fees under protest but the applicable protest fee was not paid
   - ☒ not paid additional fees
2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.
3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is
   - ☐ complied with
   - ☒ not complied with for the following reasons:

Group I: Claims 1-30 and 34-48, drawn to a system and a method for time delaying an oversampled signal within an ADC system.

Group II: Claims 31-33, drawn to a decimation module for use in an ADC system.

Group III: Claims 49-54, drawn to a system for applying multiple time delays to an output from a single sensor.

The inventions listed as Groups I, II and III do not relate to a single general inventive concept under PCT Rule 13.1 because under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reason: they are separate inventions with distinct fields of search.

4. Consequently, this opinion has been established in respect of the following parts of the international application :
   - ☐ all parts.
   - ☒ the parts relating to claims Nos. 1-30, 34-48

Form PCT/ISA/237 (Box No. IV) (January 2015)

**WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY**

International application No.
**PCT/US2017/015882**

**Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | | |
|---|---|---|---|
| Novelty (N) | Claims | 1-30,34-48 | YES |
| | Claims | NONE | NO |
| Inventive step (IS) | Claims | 20-24 | YES |
| | Claims | 1-19,25-30,34-48 | NO |
| Industrial applicability (IA) | Claims | 1-30,34-48 | YES |
| | Claims | NONE | NO |

2. Citations and explanations :

Reference is made to the following documents:

D1: US 2005-0167496 A1 (ROBERT E. MORLEY JR. et al.) 04 August 2005

D2: US 2015-0281836 A1 (KHIEM QUANG NGUYEN et al.) 01 October 2015

D3: US 2011-0013488 A1 (WEI MA et al.) 20 January 2011

D4: US 2013-0121504 A1 (ROBERT ADAMS et al.) 16 May 2013

D5: US 2009-0278721 A1 (KOICHI HAMASHITA et al.) 12 November 2009

1. Novelty and Inventive Step (PCT Article 33(2) and 33(3))

1.1 Independent Claim 1

D1, which is considered to be the closest prior art to the subject matter of claim 1, discloses a system comprising: a sensing unit to produce an analog signal indicative of a sensed magnetic field and over-sample the analog signal (see paragraph [0051]; claims 8, 12; figure 1). Claim 1 differs from D1 in a time delay element, wherein the time delay element is configured to receive as an input an oversampled digital output signal and to output a time delayed oversampled digital output signal. However, this feature is well known from D1 considering a plurality of delay lines between an over-sample modulator and at least one channel, wherein each of the delay lines is configured to provide a specific delay (see paragraph [0100]; claim 13; figures 11A, 13). Accordingly, it would be obvious to a person skilled in the art to arrive at claim 1 over D1. Therefore, claim 1 lacks an inventive step under PCT Article 33(3).

1.2 Dependent Claims 2-15

The additional feature of claim 2 can be easily derived from the feature of D1 considering a decimator to decimate the over-sampled signal; and a low pass filter to process the over-sampled signal (see paragraph [0086]; claim 8; figure 11A). Accordingly, claim 2 would

Continued on Supplemental Box

# WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
**PCT/US2017/015882**

**Box No. VIII Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:

Claim 10 is unclear in that the expression "claim of claim" seems to be a typo of 'claim' ( PCT Article 6).

Claim 12 is unclear in that the expression "less that" (line 16) seems to be a typo of 'less than' ( PCT Article 6).

Claim 13 is unclear because "the low pass filtered decimated time delayed digital output signal" has not been previously defined. Therefore, claim 13 does not meet the requirements of PCT Article 6.

Claim 14 is unclear because "the beam forming operation" has not been previously defined (PCT Article 6).
(Note: Referring to the description, it seems to be a typo of 'the beam forming process'.)

Claims 17-30 are unclear in that the expression "The ADC system" seems to be a typo of 'The system' (PCT Article 6).

Claim 23 is unclear because "the digital sensor" has not been previously defined. Therefore, claim 23 does not meet the requirements of PCT Article 6.

Claim 27 is unclear because "the delay element" has not been previously defined. Therefore, claim 27 does not meet the requirements of PCT Article 6. (Note: Referring to the description, it seems to be a typo of 'the time delay element'.)

Claim 44 is unclear in that the expression "{decimating means is multistage}" seems to be a typo (PCT Article 6).

Supplemental Box

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have been obvious over D1. Therefore, claim 2 lacks an inventive step under PCT Article 33(3).

The additional features of claims 3, 4 and 10 are not disclosed in D1. However, the additional features of claims 3, 4 and 10 can be easily derived from the feature of D2 considering that each of first and second sigma-delta modulators is an oversampled converter operating at an oversampled sampling rate or frequency, and a signal coder is configured to process and encode and format first and second digital microphone signals to generate a serial digital audio stream at a predetermined sample rate, wherein the serial digital audio stream may be unformatted, e.g. a double-edge modulated PDM stream (see paragraphs [0030], [0032]; figure 1). Accordingly, claims 3, 4 and 10 would have been obvious over D1 in view of D2. Therefore, claims 3, 4 and 10 lack an inventive step under PCT Article 33(3).

The additional features of claims 5-7 can be easily derived from the features of D2 considering that a MEMS microphone has a frequency response that extends from an audible frequency range (20 Hz-20 kHz) to ultrasonic frequencies (see paragraphs [0027]-[0030]; figure 1). Accordingly, claims 5-7 would have been obvious over D1 in view of D2. Therefore, claims 5-7 lack an inventive step under PCT Article 33(3).

The additional features of claims 8 and 9 can be easily derived from the feature of D1 considering applying a specific delay associated with a specific bandwidth and sampling rate, the specific bandwidth substantially matching a bandwidth of the analog signal (see claim 8). Accordingly, claims 8 and 9 would have been obvious over D1 in view of D2. Therefore, claims 8 and 9 lack an inventive step under PCT Article 33(3).

The additional feature of claim 11 can be easily derived from the feature of D2 considering a multi-stage decimator to reduce the sample rate of the first digital microphone signal with a predetermined factor, wherein the decimator comprises a lowpass filter (see paragraphs [0035], [0036]; figure 3). Accordingly, claim 11 would have been obvious over D1 in view of D2. Therefore, claim 11 lacks an inventive step under PCT Article 33(3).

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The additional feature of claim 12 is not disclosed in D1 and D2. However, the additional feature can be easily derived from the feature of D3 considering that a digitized receive signal is down sampled by a first decimation filter h1(z) in accordance with an over sampling clock signal, and the down sampled data are delayed by delay elements, wherein two delayed signals are down-sampled by a first reduced frequency clock signal for second decimation filters h2(z); further filtered data from two-phase outputs of the second decimation filters are delayed through second delay elements; second delayed data is down-sampled by a second reduced clock signal which drives third decimation filters h3(z); and outputs of the third decimation filters are further delayed through third delay elements to provide delayed data which corresponds to delayed data from a first N-phase poly-phase filter, wherein the decimation filters down sample an over sampled data stream to a lower sampling rate (see paragraphs [0037], [0041]; figure 6). Accordingly, claim 12 would have been obvious over a combination of D1-D3. Therefore, claim 12 lacks an inventive step under PCT Article 33(3).

The additional features of claims 13-15 can be easily derived from the feature of D3 considering that time delays needed for beam forming can be implemented by programmable time delays to generate sufficient delay resolution for dynamic beam focusing, and aligning multi-channel data streams and sub-beam former circuitry provides phase control by combining multiple signals into a single sub-beam signal with a fine delay resolution; and eight multi-phase signals are selected in accordance with a fine delay requirement and further delayed by a coarse delay unit by selected integer sample intervals (see paragraphs [0030], [0037], [0041]; figures 3, 6). Accordingly, claims 13-15 would have been obvious over a combination of D1-D3. Therefore, claims 13-15 lack an inventive step under PCT Article 33(3).

1.3 Independent Claim 16

D2, which is considered to be the closest prior art to the subject matter of claim 16, discloses a system comprising: a signal coder to process and encode and format first and second digital microphone signals to generate a serial digital audio stream at a predetermined sample rate, wherein the serial digital audio stream may be unformatted, e.g. a double-edge modulated PDM stream (see paragraphs [0030], [0032]; figure 1); and a sigma-delta modulator which is an oversampled converter operating at an oversampled sampling rate or frequency (see paragraphs

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[0030]-[0032]; figure 1). Claim 16 differs from D2 in a time delay element, wherein the time delay element is electrically coupled to a sigma-delta modulator and to receive a PDM signal and to output a delayed PDM output signal, wherein the delayed PDM output signal is delayed by a time delay equal to a number of cycles of a sampling clock frequency. However, it is well known from D1 considering a plurality of delay lines between an over-sample modulator and at least one channel (see paragraph [0100]; claim 13; figures 11A, 13). Accordingly, claim 16 would have been obvious over D2 in view of D1. Therefore, claim 16 lacks an inventive step under PCT Article 33(3).

1.4 Dependent Claims 17-30

The additional features of claims 17 and 18 can be easily derived from the features of D2 considering a multi-stage decimator to reduce the sample rate of the first digital microphone signal with a predetermined factor, wherein the decimator comprises a lowpass filter, wherein the first and second digital signals may be conveniently supplied as first and second PDM signals, and each of the first and second digital signals may be converted from a native PDM format to a multi-bit or PCM format (see paragraphs [0012], [0035], [0036]; figure 3). Accordingly, claims 17 and 18 would have been obvious over D2 in view of D1. Therefore, claims 17 and 18 lack an inventive step under PCT Article 33(3).

The additional feature of claim 19 can be easily derived from the feature of D3 considering that a digitized receive signal is down sampled by a first decimation filter h1(z) in accordance with an over sampling clock signal, and the down sampled data are delayed by delay elements, wherein two delayed signals are down-sampled by a first reduced frequency clock signal for second decimation filters h2(z); further filtered data from two-phase outputs of the second decimation filters are delayed through second delay elements; second delayed data is down-sampled by a second reduced clock signal which drives third decimation filters h3(z); and the outputs of the third decimation filters are further delayed through third delay elements to provide delayed data which corresponds to delayed data from a first N-phase poly-phase filter, wherein the decimation filters down sample an over sampled data stream to a lower sampling rate (see paragraphs [0037], [0041]; figure 6). Accordingly, claim 19 would have been obvious over a combination of D1-D3. Therefore, claim 19 lacks an inventive step under PCT Article

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33(3).

The additional feature of claim 20 is characterized in that a first state employs a cascaded-integrator-comb filter structure, a second state is configured as two half-band filters, and a third state is configured as a low pass filter. And it is not disclosed in any of the prior art documents, nor is it obvious by the documents, taken alone or in combination. Accordingly, claim 20 meets the requirements of PCT Article 33(2) and (3) with respect to novelty and inventive step.

Claims 21-24 are directly or indirectly dependent on claim 20 and therefore meet the requirements of PCT Article 33(2) and (3).

The additional features of claims 25 and 26 can be easily derived from the feature of D3 considering that eight multi-phase signals are selected in accordance with a fine delay requirement and further delayed by a coarse delay unit by selected integer sample intervals, and delay control data is stored in the coarse delay unit, wherein the stored data is accessed in accordance with coarse delay control data received as part of the delay control data (see paragraphs [0039], [0041]; figures 5, 6). Accordingly, claims 25 and 26 would have been obvious over a combination of D1-D3. Therefore, claims 25 and 26 lack an inventive step under PCT Article 33(3).

The additional features of claims 27 and 28 can be easily derived from the features of D1 considering a plurality of delay lines between the over-sampled modulator and the at least one channel, wherein each of the delay lines is configured to provide a specific delay (see claims 2, 3). Accordingly, claims 27 and 28 would have been obvious over D2 in view of D1. Therefore, claims 27 and 28 lack an inventive step under PCT Article 33(3).

The additional features of claims 29 and 30 can be easily derived from the features of D1 considering applying the specific delay associated with a specific bandwidth and sampling rate, the specific bandwidth substantially matching a bandwidth of an analog signal (see claim 8). Accordingly, claims 29 and 30 would have been obvious over D2 in view of D1. Therefore,

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claims 29 and 30 lack an inventive step under PCT Article 33(3).

1.5 Independent Claim 34

D1, which is considered to be the closest prior art to the subject matter of claim 34, discloses a method comprising: producing an analog signal indicative of a sensed magnetic field and over-sampling the analog signal (see paragraph [0051]; claims 8, 12; figure 1). Claim 34 differs from D1 in delaying an oversampled digital signal by a time delay, wherein the time delay is equal to an integer number of sampling clock cycles to produce a delayed oversampled digital signal. However, this feature is well known from D1 in applying a specific delay associated with a specific bandwidth and sampling rate, the specific bandwidth substantially matching a bandwidth of the analog signal (see paragraph [0100]; claims 8, 13; figures 11A, 13). Accordingly, it would be obvious to a person skilled in the art to arrive at claim 34 over D1. Therefore, claim 34 lacks an inventive step under PCT Article 33(3).

1.6 Dependent Claims 35-38

The additional feature of claim 35 can be easily derived from the feature of D1 considering a decimator to decimate the over-sampled signal; and a low pass filter to process the over-sampled signal (see paragraph [0086]; claim 8; figure 11A). Accordingly, claim 35 would have been obvious over D1. Therefore, claim 35 lacks an inventive step under PCT Article 33(3).

The additional feature of claim 36 is not disclosed in D1. However, the additional feature of claim 36 can be easily derived from the feature of D3 considering that a total delay is a combination of fractional and integer sample delays (see paragraph [0041]). Accordingly, claim 36 would have been obvious over D1 in view of D3. Therefore, claim 36 lacks an inventive step under PCT Article 33(3).

The additional feature of claim 37 can be easily derived from the feature of D1 considering applying a specific delay associated with a specific bandwidth and sampling rate, the specific bandwidth substantially matching the bandwidth of the analog signal (see claim 8). Accordingly, claim 37 would have been obvious over D1. Therefore, claim 37 lacks an inventive step under

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PCT Article 33(3).

The additional feature of claim 38 is merely a matter of design option when general technical knowledge in the art is used. Accordingly, claim 38 would have been obvious over D1. Therefore, claim 38 lacks an inventive step under PCT Article 33(3).

1.7 Independent Claim 39 and Dependent Claims 40-43

Claims 39, 40, 42 and 43 relate to a computer-readable storage medium and have substantially the same technical features as claims 34, 35, 37 and 38, respectively, differing only in the category. Accordingly, it would be obvious to a person skilled in the art to arrive at claims 39, 40, 42 and 43 over D1. Therefore, claims 39, 40, 42 and 43 lack an inventive step under PCT Article 33(3) for the same reasoning as in claims 34, 35, 37 and 38.

The additional feature of claim 41 is substantially the same as that of claim 36, differing only in the category. Accordingly, it would be obvious to a person skilled in the art to arrive at claim 41 over D1 in view of D3. Therefore, claim 41 lacks an inventive step under PCT Article 33(3) for the same reasoning as in claim 36.

1.8 Independent Claim 44

D1, which is considered to be the closest prior art to the subject matter of claim 44, discloses a system comprising: a sensing unit to produce an analog signal indicative of a sensed magnetic field and over-sample the analog signal (see paragraph [0051]; claims 8, 12; figure 1); and a plurality of delay lines between an over-sample modulator and at least one channel, wherein each of the delay lines is configured to provide a specific delay (see paragraph [0100]; claim 13; figures 11A, 13). Claim 44 differs from D1 in decimating means to receive a delayed oversampled digital signal and to low pass filter and to decimate to a lower sampling rate, wherein the resulting digital signal contains a digital representation of an analog field quantity without noise introduced by over sampling means. However, this feature is well known from D1 considering a decimator to decimate the over-sampled signal; and a low pass filter to process the over-sampled signal (see paragraph [0086]; claim 8; figure 11A). Accordingly, it would be obvious to a person skilled in the art to arrive at claim 44 over D1. Therefore,

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claim 44 lacks an inventive step under PCT Article 33(3).

1.9 Dependent Claims 45-48

The additional feature of claim 45 is not disclosed in D1. However, the additional feature of claim 45 can be easily derived from the feature of D2 considering a multi-stage decimator that reduces a sample rate of a first digital microphone signal with a predetermined factor (see paragraph [0035]; figure 3). Accordingly, claim 45 would have been obvious over D1 in view of D2. Therefore, claim 45 lacks an inventive step under PCT Article 33(3).

The additional feature of claim 46 is not disclosed in D1. However, the additional feature of claim 46 can be easily derived from the feature of D3 considering that a total delay is a combination of fractional and integer sample delays (see paragraph [0041]). Accordingly, claim 46 would have been obvious over D1 in view of D3. Therefore, claim 46 lacks an inventive step under PCT Article 33(3).

The additional feature of claim 47 can be easily derived from the feature of D1 considering applying a specific delay associated with a specific bandwidth and sampling rate, the specific bandwidth substantially matching a bandwidth of the analog signal (see claim 8). Accordingly, claim 47 would have been obvious over D1. Therefore, claim 47 lacks an inventive step under PCT Article 33(3).

The additional feature of claim 48 is merely a matter of design option when general technical knowledge in the art is used. Accordingly, claim 48 would have been obvious over D1. Therefore, claim 48 lacks an inventive step under PCT Article 33(3).

2. Industrial Applicability (PCT Article 33(4))

Claims 1-30 and 34-48 are industrially applicable under PCT Article 33(4).

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 42027776 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Mark S. Peloquin |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 25-FEB-2021 |
| **Filing Date:** | 16-APR-2020 |
| **Time Stamp:** | 17:53:58 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Non Patent Literature | 20170703PCTUS2017015882SearchReporti3.pdf | 1441596<br>5206cdbf406d51c11908268d25d73d16099e141d | no | 6 |
| **Warnings:** | | | | | |

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|---|---|---|---|---|---|
| **Information:** | | | | | |
| 2 | Non Patent Literature | 20170703PCTUS2017015882WrittenOpinioni3.pdf | 3989971<br>a2ad60c4ce12d66daebf9576aa3c735e567d424f | no | 12 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Non Patent Literature | 20200123JP190052POAMachineTransi1STi3.pdf | 2349490<br>878dd2ab295624ca0c9428d92bcdd14de660930f | no | 9 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Non Patent Literature | 20201204JP190052POAMachineTrans2NDi3.pdf | 888478<br>57ff0d74262e2816eeb8ec37ab396693881d96f1 | no | 3 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
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# TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

| | |
|---|---|
| Application Number | 16/851,044 |
| Filing Date | APRIL 16, 2020 |
| First Named Inventor | DASHEN FAN |
| Title | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| Art Unit | 2845 |
| Examiner Name | MAI, LAM T |
| Attorney Docket Number | K41090.P8C3 |

**SIGNATURE of Applicant or Patent Practitioner**

| | | | |
|---|---|---|---|
| Signature | /MARK S. PELOQUIN/ | Date (Optional) | FEB 25, 2021 |
| Name | MARK S. PELOQUIN | Registration Number | 50,787 |
| Title (if Applicant is a juristic entity) | | | |
| Applicant Name (if Applicant is a juristic entity) | | | |

**NOTE:** This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82B (07-13)
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# POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

| Application Number | Filing Date |
|---|---|
| 16/851,044 | APRIL 16, 2020 |

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 51340

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

**Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:**

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

| | | | | | |
|---|---|---|---|---|---|
| ☐ Firm or Individual Name | PELOQUIN, PLLC | | | | |
| Address | 800 FIFTH AVE, SUITE 4100 | | | | |
| City | SEATTLE | State | WA | Zip | 98104 |
| Country | US | | | | |
| Telephone | (206) 447-1336 | Email | | | |

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

SOLOS TECHNOLOGY LIMITED

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

**SIGNATURE of Applicant for Patent**

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

| | | | |
|---|---|---|---|
| Signature | | Date (Optional) | |
| Name | WAI KUEN CHEUNG | | |
| Title | GENERAL MANAGER, SOLOS TECHNOLOGY LIMITED | | |

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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| Attorney Docket Number | K41090.P8C3 |
|---|---|

PTO/AIA/26 (04-14)
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| TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT | Docket Number (Optional) K41090.P8C3 |
|---|---|

In re Application of: DASHEN FAN

Application No.: 16/851,044

Filed: APRIL 16, 2020

For: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

The applicant, SOLOS TECHNOLOGY LIMITED, owner of 100 percent interest in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of **prior patent** No. US 10,651,866 as the term of said **prior patent** is presently shortened by any terminal disclaimer. The applicant hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the **prior patent** are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the applicant does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the **prior patent**, "as the term of said **prior patent** is presently shortened by any terminal disclaimer," in the event that said **prior patent** later:

expires for failure to pay a maintenance fee;
is held unenforceable;
is found invalid by a court of competent jurisdiction;
is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
has all claims canceled by a reexamination certificate;
is reissued; or
is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

Check either box 1 or 2 below, if appropriate.

1. ☐ The undersigned is the applicant. If the applicant is an assignee, the undersigned is authorized to act on behalf of the assignee.

I hereby acknowledge that any willful false statements made are punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

2. ☑ The undersigned is an attorney or agent of record. Reg. No. 50,787

/MARK S PELOQUIN/ — Signature
FEB 25, 2021 — Date

MARK S PELOQUIN — Typed or printed name

ATTORNEY OF RECORD — Title
(206) 447-1336 — Telephone Number

☑ Terminal disclaimer fee under 37 CFR 1.20(d) included.

**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

This collection of information is required by 37 CFR 1.321. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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# Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

# Electronic Acknowledgement Receipt

| | |
|---|---|
| **EFS ID:** | 42027626 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Mark S. Peloquin |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 25-FEB-2021 |
| **Filing Date:** | 16-APR-2020 |
| **Time Stamp:** | 17:43:15 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | no |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Power of Attorney | K41090P8C3POWEROFATTORNEY82A82BCOMPLETEi.pdf | 844882<br>13e9933f3c0cd756d66b72b7ea6b41a466559971 | no | 2 |
| **Warnings:** | | | | | |

| Information: | | | | | |
|---|---|---|---|---|---|
| 2 | Terminal Disclaimer Filed | 20210225K41090P8C3TDaia00261i.pdf | 794093<br>2558e5084da3ae0b807089fe1948c67474ffe72d | no | 2 |
| Warnings: | | | | | |
| Information: | | | | | |
| | | | Total Files Size (in bytes): | 1638975 | |

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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

Attorney's Docket No. K41090.P8C3 PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In Re Patent Application of: | |
| Dashen Fan | Examiner: MAI, LAM T |
| Application No.: 16/851,044 | Art Unit: 2845 |
| Filed: April 16, 2020 | |
| For: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Sir:

Enclosed is a copy of Information Disclosure Citation Form PTO/SB/08a and PTO/SB/08b. It is respectfully requested that the cited documents be considered and that the enclosed copy of Information Disclosure Citation Form PTO/SB/08b be initialed by the Examiner to indicate such consideration and a copy thereof returned to applicant(s).

Pursuant to 37 C.F.R. § 1.97, the submission of this Information Disclosure Statement is not to be construed as a representation that a search has been made and is not to be construed as an admission that the information cited in this statement is material to patentability.

Pursuant to 37 C.F.R. § 1.97, this Information Disclosure Statement is being submitted under one of the following (as indicated by an "X" to the left of the appropriate paragraph):

_____ 37 C.F.R. §1.97(b).

**X** 37 C.F.R. §1.97(c). If so, then enclosed with this Information Disclosure Statement is one of the following:

____ A statement pursuant to 37 C.F.R. §1.97(e) or

**X** A check for $130.00 for the fee under 37 C.F.R. § 1.17(p).

_____ 37 C.F.R. §1.97(d). If so, then enclosed with this Information Disclosure Statement are the following:

(1) A statement pursuant to 37 C.F.R. §1.97(e); and

(2) A check for $130.00 for the fee under 37 C.F.R. §1.17(p) for submission of the Information Disclosure Statement.

Respectfully submitted,

PELOQUIN, PLLC

Dated: Feb 25, 2021

/Mark S. Peloquin/
Mark S. Peloquin, Esq.
Reg. No. 50,787

800 Fifth Avenue, Suite 4100
Seattle, WA 98104-3100
206-447-1336 telephone
206-770-6562 facsimile

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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

*(Use as many sheets as necessary)*

Sheet 1 of 2

| Complete if Known | |
|---|---|
| Application Number | 16/851,044 |
| Filing Date | April 16, 2020 |
| First Named Inventor | DASHEN FAN |
| Art Unit | 2845 |
| Examiner Name | MAI, LAM T |
| Attorney Docket Number | K41090.P8C3 |

**U. S. PATENT DOCUMENTS**

| Examiner Initials* | Cite No.[1] | Document Number<br>Number-Kind Code[2] (if known) | Publication Date MM-DD-YYYY | Name of Patentee or Applicant of Cited Document | Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear |
|---|---|---|---|---|---|
| | | US- 5,883,822 | 03-16-1999 | LE TOURNEUR ET AL. | |
| | | US- 2015/0281836 A1 | 10-01-2015 | NGUYEN ET AL. | |
| | | US- 2016/0157828 A1 | 06-09-2016 | CHIKAYOSHI SUMI | |
| | | US- 2007/0189400 A1 | 08-16-2007 | NAKANO ET AL. | |
| | | US- 2011/0013488 A1 | 01-20-2011 | WEI MA | |
| | | US- 2010/0271957 A1 | 10-2010 | STAPLETON; SHAWN P. | |
| | | US- | | | |
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**FOREIGN PATENT DOCUMENTS**

| Examiner Initials* | Cite No.[1] | Foreign Patent Document<br>Country Code[3] Number[4] Kind Code[5] (if known) | Publication Date MM-DD-YYYY | Name of Patentee or Applicant of Cited Document | Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear | T[6] |
|---|---|---|---|---|---|---|
| | | JP2010122191 | 06-03-2010 | SANYO ELECTRIC CO | | ✓ |
| | | JP2000197180 | 07-14-2000 | VICTOR CO OF JAPAN LTD | | ✓ |
| | | JP2002300224 | 10-11-2002 | HITACHI INT ELECTRIC INC | | ✓ |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| Examiner Signature | | Date Considered | |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant. [1]Applicant's unique citation designation number (optional). [2]See Kinds Codes of USPTO Patent Documents at www.uspto.gov or MPEP 901.04. [3]Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). [4]For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. [5]Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST.16 if possible. [6]Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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# INFORMATION DISCLOSURE STATEMENT BY APPLICANT

*(Use as many sheets as necessary)*

Sheet 2 of 2

| *Complete if Known* | |
|---|---|
| Application Number | 16/851,044 |
| Filing Date | April 16, 2020 |
| First Named Inventor | DASHEN FAN |
| Art Unit | 2845 |
| Examiner Name | MAI, LAM T |
| Attorney Docket Number | K41090.P8C3 |

## NON PATENT LITERATURE DOCUMENTS

| Examiner Initials* | Cite No.[1] | Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published. | T[2] |
|---|---|---|---|
| | | OFFICE ACTION ISSUED IN CORRESPONDING JP PATENT APPLICATION NO. 2019-526185. DECEMBER 04, 2020 | ✓ |
| | | OFFICE ACTION ISSUED IN CORRESPONDING JP PATENT APPLICATION NO. 2019-526185. JANUARY 23, 2020 | ✓ |
| | | Notification Of Transmittal of The International Search Report and Written Opinion for Application PCT/US2017/015882, International Filing Date January 31, 2017 (6 pages) | ✓ |
| | | Written Opinion Of The International Searching Authority for Application PCT/US2017/015882, International Filing Date January 31, 2017 (12 pages) | ✓ |
| | | | |
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| | | | |
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| Examiner Signature | | Date Considered | |
|---|---|---|---|

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

1 Applicant's unique citation designation number (optional). 2 Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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Espacenet

# Bibliographic data: JP2010122191 (A) — 2010-06-03

## MAGNETIC MEASURING DEVICE AND AD CONVERSION APPARATUS

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**Classification:** **- international:** ***G01R33/09; H03H17/00; H03H17/02; H03M3/02***
**- cooperative:**

**Application number:** JP20080298623 20081121 Global Dossier

**Priority number(s):** JP20080298623 20081121

## Abstract of JP2010122191 (A)

PROBLEM TO BE SOLVED: To provide a magnetic measuring device having a plurality of magnetic sensors in which circuit size of its ΔΣ (delta-sigma) type ADC (Analog-to-Digital conversion apparatus) can be adjusted. ;SOLUTION: A ΔΣ modulator 22 in this device is delta-sigma modulated by input of sensor signal from one of the plurality of magnetic sensors 8 switched with prescribed input switching cycles to be selected. A digital filter 24 generates measurement data based on the data oversampled at cycle T by the ΔΣ modulator 22. The digital filter 24 has a counter 34. For the selected magnetic sensor 8, this counter 34 accumulates the data input every cycle T to generate and output measurement data, while resetting any counted value for this magnetic sensor 8 to newly start accumulation for the next magnetic sensor 8 to be selected then. ;COPYRIGHT: (C)2010,JPO&INPIT

(19)日本国特許庁(JP)　(12)公開特許公報(A)　(11)特許出願公開番号
特開2010-122191
(P2010-122191A)
(43)公開日　平成22年6月3日(2010.6.3)

| (51)Int.Cl. | | F I | | | テーマコード（参考） |
|---|---|---|---|---|---|
| G01R 33/09 | (2006.01) | G01R | 33/06 | R | 2G017 |
| H03M 3/02 | (2006.01) | H03M | 3/02 | | 5J064 |
| H03H 17/00 | (2006.01) | H03H | 17/00 | 621K | |
| H03H 17/02 | (2006.01) | H03H | 17/02 | 601Z | |
| | | H03H | 17/02 | 615E | |

審査請求 未請求　請求項の数 4　OL　（全 12 頁）

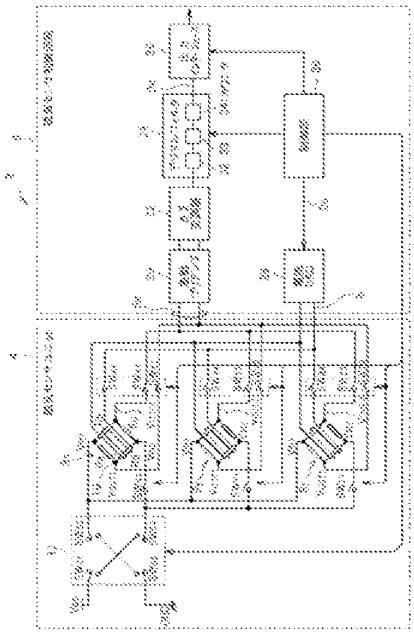
(21)出願番号　特願2008-298623 (P2008-298623)
(22)出願日　平成20年11月21日 (2008.11.21)

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(54)【発明の名称】磁気計測装置、及びＡＤ変換装置

(57)【要約】
【課題】複数の磁気センサを有した磁気計測装置におけるΔΣ型ＡＤＣの回路規模を抑制する。
【解決手段】ΔΣ変調器２２は、複数の磁気センサ８のうち所定の入力切換周期で切り換えて選択される１つからのセンサ信号を入力されΔΣ変調する。デジタルフィルタ２４は、ΔΣ変調器２２にて周期Ｔでオーバーサンプリングされたデータに基づいて計測データを生成する。デジタルフィルタ２４はカウンタ３４を有する。カウンタ３４は、選択された磁気センサ８について、周期Ｔ毎に入力されるデータを累積加算して計測データを生成して出力し、次に選択される磁気センサ８に対しては前回の磁気センサ８についての計数値をリセットして新たな累積加算を開始する。
【選択図】図１



【特許請求の範囲】
【請求項１】
複数の磁気センサと、
所定の切換周期で切り換えられ、前記複数の磁気センサのいずれか１つのセンサ信号を選択的に取り出す切換器と、
前記切換器から出力される前記センサ信号をΔΣ変調するΔΣ変調器、及び前記ΔΣ変調器にてオーバーサンプリングされたデータに基づいて計測データを生成するデジタルフィルタを備えたＡＤ変換回路と、
を有し、
前記デジタルフィルタは、前記切換周期に同期して、前記ΔΣ変調器でのサンプリング周期毎に入力されるデータを累積加算し前記計測データを出力するカウンタを有すること、
を特徴とする磁気計測装置。
【請求項２】
請求項１に記載の磁気計測装置において、
前記デジタルフィルタは、前記サンプリング周期毎に入力されるデータを直近の所定個数について加算し、加算結果のデータを後段へ出力する加算器を、前記カウンタの前段に１段又は複数段、直列に接続されること、
を特徴とする磁気計測装置。
【請求項３】
複数の磁気センサのうち所定の入力切換周期で切り換えて選択される１つからのセンサ信号を計測データに変換するＡＤ変換装置であって、
入力される前記センサ信号をΔΣ変調するΔΣ変調器と、
前記ΔΣ変調器にてオーバーサンプリングされたデータに基づいて前記計測データを生成するデジタルフィルタと、
を有し、
前記デジタルフィルタは、前記入力切換周期に同期して、前記ΔΣ変調器でのサンプリング周期毎に入力されるデータを累積加算し前記計測データを出力するカウンタを有すること、
を特徴とするＡＤ変換装置。
【請求項４】
請求項３に記載のＡＤ変換装置において、
前記デジタルフィルタは、前記サンプリング周期毎に入力されるデータを直近の所定個数について加算し、加算結果のデータを後段へ出力する加算器を、前記カウンタの前段に１段又は複数段、直列に接続されること、
を特徴とするＡＤ変換装置。
【発明の詳細な説明】
【技術分野】
【０００１】
本発明は、磁気計測装置、及び磁気センサにより得られるセンサ信号を計測データに変換するＡＤ変換装置に関する。
【背景技術】
【０００２】
ＡＤ変換器（Analog-to-Digital Convertor：ＡＤＣ）として、ΔΣ変調型のものが知られている。ΔΣ型ＡＤＣは、互いに直列に接続されたΔΣ変調器とデジタルフィルタとを有する。ΔΣ変調器は入力されたアナログ信号を目的のサンプリング周波数$f_s$より十分に高い周波数$f_{os}$でサンプリング（オーバーサンプリング）し、例えば、１ビットのデータ列を生成する。その際に生じる量子化誤差は、ΔΣ変調器のノイズシェーピング機能により高周波帯域へシフトされる。この高周波帯域への量子化雑音のシフトにより、入力アナログ信号の帯域が包含される低周波帯域では量子化雑音が少なくなる。

【０００３】
デジタルフィルタは、ローパスフィルタとしての機能を有し、高周波帯域を除去することで量子化雑音を低減する。例えば、このローパスフィルタの機能は移動平均処理によって行われる。また、デジタルフィルタは、データレートをオーバーサンプリング周波数$f_{os}$から目的のサンプリング周波数$f_s$まで落とす処理を行う。
【０００４】
例えば、入力アナログ信号がオーディオ信号である場合、ナイキスト周波数を可聴帯域の上限に応じて設定するため、周波数$f_s$は３２～４８ｋＨｚ程度となる。そのため、周波数$f_s$に対応する周期$\xi$が、ローパスフィルタリングに要するデータ変換期間より短くなり得る。図８は、この場合を説明する図であり、周期$\xi$毎に設定されるデータ変換期間の相互関係の一例を示す模式図である。この例では、データ変換期間１１０は周期$\xi$の１６倍である。例えば、時刻$t_0$に対応する出力データを得るためのデータ変換期間１１０-1は周期$\xi$毎の期間$P_1$～$P_{16}$に位置し、時刻$t_0+\xi$に対応する出力データを得るためのデータ変換期間１１０-2は期間$P_2$～$P_{17}$に位置し、両データ変換期間１１０は重複部分を有する。このように、時刻$t_0$～$t_0+15\xi$に対応する１６個のデータ変換期間１１０は重複する部分を有する。
【０００５】
この場合に、周期$\xi$ずつずれた１６個の各データ変換期間１１０についての移動平均値を求めるには、単純には、並列に動作する１６個の加算器等の移動平均手段を設ければよい。しかし、当該構成は回路規模が大きくなる。より回路規模が小さい構成は、長さ$\xi$の期間$P_n$（例えば、図８に示す期間$P_1$～$P_{16}$）内のデータレート$f_{os}$のデータを加算して１つのデータとするデシメーション（間引き）フィルタを用いるものであり、図８の例においては、１６個のデシメーションフィルタを設ければ、周期$\xi$ずつシフトする各データ変換期間１１０についての移動平均処理を実現することができる。具体的には、データ変換期間１１０-1に対しては、１６個の期間$P_1$～$P_{16}$それぞれでのデータ加算をデシメーションフィルタで行い、デシメーションフィルタの１６個の出力をさらに加算、平均することで、時刻$t_0$に対応する出力データが得られる。次のデータ変換期間１１０-2に対しては、期間$P_1$に用いたデシメーショフィルタをリセットし、これを用いて期間$P_{17}$のデータ加算を実行する。この新たに得られる期間$P_{17}$のデシメーションフィルタの出力値と、データ変換期間１１０-1での処理で既に得られている期間$P_2$～$P_{16}$に対応するデシメーションフィルタの出力値とを用いて、時刻$t_0+\xi$に対応する出力データを得ることができる。以下、同様の処理を繰り返すことで、データレート$f_s$でデータが得られる。
【特許文献１】特開２００５－３１８２０４号公報
【発明の開示】
【発明が解決しようとする課題】
【０００６】
上述のデシメーションフィルタはＤＳＰ（Digital Signal Processor：ＤＳＰ）やマイコンを用いて構成される。これらＤＳＰやマイコンで構成したデシメーションフィルタは構成が比較的複雑であり、１つの入力データ当たりの処理に複数クロックを要する。そのため、駆動クロックの周波数が高くなるという問題がある。また、ＤＳＰにおいて乗算器を用いて構成されるデジタルフィルタは、減衰量を大きくすると回路規模も大きくなるという問題点があった。ΔΣ型ＡＤＣは磁気センサの出力信号に対しても用いられる。磁気センサを備えた電子コンパス等の磁気計測装置は、例えば、携帯電話などにも搭載され、小型化が求められている。
【０００７】
本発明は上記問題点を解決するためになされたものであり、一層簡単な構成で、回路規模の縮小が図られるＡＤ変換装置を提供し、ひいてはより小型の磁気計測装置を提供することを目的とする。
【課題を解決するための手段】

【０００８】
本発明に係る磁気計測装置及びＡＤ変換装置は、複数の磁気センサのうち所定の入力切換周期で切り換えて選択される１つからのセンサ信号をΔΣ変調するΔΣ変調器と、前記ΔΣ変調器にてオーバーサンプリングされたデータに基づいて前記計測データを生成するデジタルフィルタと、を有し、前記デジタルフィルタは、前記入力切換周期に同期して、前記ΔΣ変調器でのサンプリング周期毎に入力されるデータを累積加算し前記計測データを出力するカウンタを有するものである。
【発明の効果】
【０００９】
本発明によれば、カウンタが有するローパスフィルタとしての機能に着目し、カウンタをΔΣ型ＡＤＣにおけるデジタルフィルタとして用いる。カウンタを用いたフィルタは、ＦＩＲフィルタなどの乗算器を用いたものに比べて構成が簡単であり、例えば、１つの入力データ当たりの処理に要するクロック数を１クロックにすることが可能である。また、例えば、同等の減衰率が得られるフィルタをより小さな回路規模で実現することができる。すなわち、ＡＤ変換装置及びそれを用いた磁気計測装置の構成をより簡単とし、回路規模の縮小を図ることができる。
【発明を実施するための最良の形態】
【００１０】
以下、本発明の実施の形態（以下実施形態という）について、図面に基づいて説明する。
【００１１】
図１は、実施形態に係る磁気計測装置２の概略の回路構成図である。磁気計測装置２は、磁気センサユニット４と磁気センサ制御回路６とからなる。
【００１２】
磁気センサユニット４は、直交座標系（ＸＹＺ座標系）の３軸に対応して、３つの磁気センサ８（磁気センサ８ｘ，８ｙ，８ｚ）を有する。磁気センサ８ｘ，８ｙ，８ｚはそれぞれ、外部磁界のＸ軸方向、Ｙ軸方向、Ｚ軸方向の成分を検出する。
【００１３】
各磁気センサ８は、抵抗素子Ｒａ，Ｒｂ，Ｒｃ，Ｒｄからなるブリッジ回路である。抵抗Ｒａ，Ｒｄは端子$V_{IN1}$，$V_{IN2}$の間に直列接続され、また、抵抗Ｒｂ，Ｒｃも端子$V_{IN1}$，$V_{IN2}$の間に直列接続される。そして、抵抗Ｒａ，Ｒｄの接続点が出力端子$V_{OUT1}$であり、抵抗Ｒｂ，Ｒｃの接続点が出力端子$V_{OUT2}$である。抵抗素子Ｒａ，Ｒｂ，Ｒｃ，Ｒｄのうち、磁気抵抗変化を示す素子はＲａ，Ｒｃである。一方、Ｒｂ，Ｒｄは固定抵抗である。このブリッジ回路の一対の入力端子$V_{IN1}$，$V_{IN2}$に電圧を印加すると、抵抗Ｒａ，Ｒｄで分圧された電圧が出力端子$V_{OUT1}$に得られ、抵抗Ｒｂ，Ｒｃで分圧された電圧が出力端子$V_{OUT2}$に得られる。抵抗Ｒａ，Ｒｃは外部磁界により抵抗が変化するので、外部磁界に応じた電圧信号が、出力端子$V_{OUT1}$，$V_{OUT2}$から差動形式で出力される。また、Ｒｂ，Ｒｄを磁気抵抗素子、Ｒａ，Ｒｃを固定抵抗素子としても、ブリッジ回路の差動出力であるため同様に動作する。
【００１４】
磁気抵抗素子としては、磁界に対して対称性のある変化を示すものを用いる。このような磁気抵抗素子としては、ＭＲ（Magneto Resistance）素子、ＧＩＧ（Granular In Gap）素子などが知られている。磁気計測装置２では例えば、ＭＲ素子の一種であるＧＭＲ（Giant Magneto Resistance）素子を抵抗Ｒａ，Ｒｃに用いる。
【００１５】
磁気センサ８には、コイル１０が併設される。コイル１０は供給される電流に応じた強度のバイアス磁界を抵抗Ｒａ，Ｒｃに及ぼし、それらの抵抗を変化させることができる。
【００１６】
スイッチ$SW_{X1}$，$SW_{Y1}$，$SW_{Z1}$は、３つの磁気センサ８のいずれか１つの端子$V_{IN1}$，$V_{IN2}$に電圧印加を行うために設けられている。

【００１７】
磁気センサ８の端子$V_{in1}$，$V_{in2}$の一方には正電圧$V_{cc}$が印加され、他方には接地電位ＧＮＤが印加される。この印加電圧の極性は、極性反転部１２のスイッチ$SW_{x1}$～$SW_{x4}$により切り換えることができる。

【００１８】
また、磁気センサ８ｘの出力端子$V_{out1}$，$V_{out2}$から磁気センサ制御回路６への信号線にはスイッチ$SW_{x2}$，$SW_{x3}$が設けられ、同様に、磁気センサ８ｙの出力端子$V_{out1}$，$V_{out2}$にはスイッチ$SW_{y2}$，$SW_{y3}$が設けられ、磁気センサ８ｚにはスイッチ$SW_{z2}$，$SW_{z3}$が設けられる。これら出力端子に設けられたスイッチを切り換えて、３つの磁気センサ８のいずれか１つの出力信号を磁気センサ制御回路６へ入力させることができる。

【００１９】
さらに、各磁気センサ８に併設されるコイル１０への電流供給を選択的に行うために、スイッチ$SW_{x1}$，$SW_{y1}$，$SW_{z1}$が設けられている。

【００２０】
磁気センサ制御回路６は、差動プリアンプ２０、ΔΣ変調器２２、デジタルフィルタ２４、出力インターフェース２６、電流ＤＡＣ２８及び制御部３０を有する。

【００２１】
差動プリアンプ２０は、磁気センサ８の出力端子$V_{out1}$，$V_{out2}$から出力される差動形式の磁界計測信号$S_M$を増幅する。

【００２２】
ΔΣ変調器２２とデジタルフィルタ２４とはΔΣ型ＡＤＣを構成し、アナログ信号である磁界計測信号$S_M$をデジタルデータに変換し磁界計測データ$D_M$を生成する。差動プリアンプ２０にて増幅された磁界計測信号$S_M$はΔΣ変調器２２に入力される。ΔΣ変調器２２は、１ビットのＡＤ変換機能を有し、磁界計測信号$S_M$を磁界計測データ$D_M$のサンプルレート（サンプリング周波数$f_s$）よりも十分に高い周波数$f_{os}$でオーバーサンプリングして、パルス密度変調（Pulse Density Modulation：ＰＤＭ）されたパルス列を生成する。このように、少ないビットで粗く量子化された出力には量子化ノイズが多く含まれる。この量子化ノイズは、ΔΣ変調器２２内部のノイズシェーピング回路で、高周波領域にシフトされる。

【００２３】
ΔΣ変調器２２の出力は、デジタルフィルタ２４に入力される。デジタルフィルタ２４は、プリフィルタ３２，３３とカウンタ３４とを備える。デジタルフィルタ２４はローパスフィルタ（Low-Pass Filter：ＬＰＦ）であり、ノイズシェーピング回路にて高周波領域に移された量子化ノイズを減衰させる一方、磁界計測データを表す信号成分が存在する低周波領域を通過させる。

【００２４】
カウンタ３４は入力されるデータを累積加算する。これは積分処理に相当し、カウンタ３４を周波数フィルタとしてみれば一次のＬＰＦの機能を有している。そこで、デジタルフィルタ２４は、上述の量子化ノイズを除去するためのメインフィルタとしてカウンタ３４を用いている。さらに、デジタルフィルタ２４は、カウンタ３４の前段にプリフィルタ３２，３３を備え、高周波領域の減衰率を高めている。

【００２５】
また、デジタルフィルタ２４の出力データのデータレートは、カウンタ３４からのカウント値の読み出しタイミングに応じて制御できる。すなわち、カウンタ３４は、データレートをオーバーサンプリング周波数$f_{os}$から目的のサンプリング周波数$f_s$に落とすことができる。

【００２６】
このように、デジタルフィルタ２４は、カウンタ３４を用いて、ΔΣ変調器２２からの高速の１ビットデータにフィルタリングとダウンサンプリングを施し、相対的に低速で多

ビットのデータとする。これが、磁界計測データ$D_M$として出力される。

【００２７】

デジタルフィルタ２４にて生成された磁界計測データ$D_M$は、半導体集積回路等で構成された磁気センサ制御回路６からバス等を介してマイコン等へ伝送される。出力インターフェース２６は時分割で順次得られるＸ，Ｙ，Ｚ各軸方向の磁界計測データ$D_M$をこのデータ伝送に適した形式に変換し、バス等へ送出する。

【００２８】

電流ＤＡＣ２８は、バイアス磁界発生手段であるコイル１０に供給する駆動電流$I_B$を生成する。電流ＤＡＣ２８は、制御部３０から目的バイアス磁界データ$D_B$を入力され、当該データを、アナログの駆動信号である駆動電流$I_B$に変換する。

【００２９】

制御部３０は，スイッチ$SW_{X1}$～$SW_{X3}$，$SW_{Y1}$～$SW_{Y3}$，$SW_{Z1}$～$SW_{Z3}$を切り換えて、磁気センサ８ｘ，８ｙ，８ｚのうち、電圧を印加し、その出力を差動プリアンプ２０へ取り出すものを順番に選択し、また、選択した磁気センサ８に対応して、スイッチ$SW_{X4}$，$SW_{Y4}$，$SW_{Z4}$を切り換えて、当該磁気センサ８に併設されたコイル１０へ電流ＤＡＣ２８から選択的に駆動電流$I_B$を供給させる。さらに、制御部３０は、選択した磁気センサ８での１回の磁界計測において、極性反転部１２を制御して印加電圧の極性を反転させる動作を行う。また、制御部３０は、磁気センサ８の切り換えや印加電圧の極性の切り換えに連動してデジタルフィルタ２４の動作を制御する。さらに、制御部３０は、磁気センサ８の切り換えなどに対応して出力インターフェース２６の動作を制御する。

【００３０】

図２は、プリフィルタ３２の構成を示す模式的なブロック図である。プリフィルタ３２は、それぞれα個の遅延器４０及び加算器４２からなる。各遅延器４０の遅延時間は、オーバーサンプリングの周期Ｔ（＝１／$f_{OS}$）である。遅延器４０-1～４０-αは直列接続され、ΔΣ変調器２２から初段の遅延器４０-1に入力されるデータは順次、後段の遅延器４０へ伝達される。初段の加算器４２-1は、プリフィルタ３２に入力されるデータと、遅延器４０-1から出力されるデータとを加算する。２段目以降の加算器４２-j（ｊは２≦ｊ≦αなる自然数）は、前段の加算器４２-(j-1)の出力と、遅延器４０-jから出力されるデータとを加算する。最終段の加算器４２-αの出力には、直近にプリフィルタ３２に入力された（α＋１）個のデータの合計値が得られる。例えば、α＝３１とした場合、加算器４２-αから出力されるデータは５ビットのバイナリデータで表される。

【００３１】

図３は、プリフィルタ３３の構成を示す模式的なブロック図である。プリフィルタ３３は、それぞれ４個の遅延器５０及び加算器５２からなる。各遅延器５０の遅延時間は、サンプリング周期Ｔである。遅延器５０-1はプリフィルタ３２から入力されるデータを遅延して、加算器５２-1に入力する。加算器５２-1はプリフィルタ３２から入力されるデータと、遅延器５０-1から出力されるデータとを加算する。２段目以降の遅延器５０-j及び加算器５２-j（ここではｊ＝２，３，４）は、加算器５２-(j-1)からデータを入力される。加算器５２-jは加算器５２-(j-1)から入力されるデータと、遅延器５０-jから出力されるデータとを加算する。例えば、プリフィルタ３２にてα＝３１とした場合、加算器５２-4から出力されるデータは９ビットのバイナリデータで表される。

【００３２】

図４は、カウンタ３４の構成を示す模式的なブロック図である。カウンタ３４は、全加算器６０及びＤフリップフロップ６２の対を、計数可能な桁数（カウンタ長）分接続した構造を有する。カウンタ３４は、下位ｍビットの全加算器６０のデータ入力端子“Ａ”に計数対象データのビット値ＳＯｊ（ここではｊは１≦ｊ≦ｍなる自然数）を入力される。残りの上位側のビットの全加算器６０のデータ入力端子”Ａ“には、信号ＲＥＶが入力される。一方、各全加算器６０のデータ入力端子“Ｂ”には対をなすＤフリップフロップ６２の出力端子”Ｑ“の値が入力される。データ信号ＲＥＶは最下位ビットの全加算器６０

のキャリー入力端子“ＣＩ“にも入力される。

【００３３】

全加算器６０は、端子”Ａ”，”Ｂ“，”ＣＩ”の値に基づいて加算出力端子“Ｓ”及びキャリー出力端子”ＣＯ”を設定する。加算出力端子“Ｓ”の値は、対をなすＤフリップフロップ６２の入力端子”Ｄ”に入力される。Ｄフリップフロップ６２はクロック信号ＣＬＫに同期して、入力データをラッチする。一方、キャリー出力端子“ＣＯ“の値はそれぞれ１つ上のビットの全加算器６０のキャリー入力端子”ＣＩ“に入力される。

【００３４】

制御部３０は、極性反転部１２から磁気センサ８への印加電圧が正極性の場合には信号ＲＥＶを”０“に設定して、カウンタ３４にて現在の計数値に、負極性の場合には”１”に設定する。これにより、正極性の場合には、カウンタ３４は、現在の計数値とｍビットの計数対象データが表す値とを加算した値を新たな計数値とする。一方、負極性の場合には、カウンタ３４は、現在の計数値から計数対象データが表す値を減算した値を新たな計数値とする。

【００３５】

カウンタ３４の計数値のビット値はＤフリップフロップ６２の出力端子”Ｑ”から読み出される。ここで、最上位ビットから所望のビット数だけ読み出せば、読み出さない下位ビット数分の除算をしたのと同様の結果を得ることができる。すなわち、除算器を用いずに平均処理を行うことができる。図４では、カウンタ３４は、上位ｎビットを計数結果のビット値ＡＤj（ここではｊは１≦ｊ≦ｎなる自然数）として出力する。

【００３６】

なお、カウンタ３４の計数値は、リセット信号ＲＳＴによりリセットすることができる。プリフィルタ３２，３３及びカウンタ３４は共通のクロック信号ＣＬＫで駆動される。クロック信号ＣＬＫの周波数は基本的に、プリフィルタ３２への入力データのデータレートｆ$_{ｏｓ}$に等しく設定される。

【００３７】

例えば、カウンタ３４はカウンタ長を２４ビットとすることができる。図４では、入力のＳＯ$_{ｍ}$の桁と出力のＡＤ1の桁とが同じであるが、これは必須ではなく、ＡＤ1の桁はより下位にも、上位にも設定することができる。

【００３８】

図５は、デジタルフィルタ２４での処理を説明するためのタイミング図である。センサセレクトとして示す波形は、Ｘ，Ｙ，Ｚ軸方向のいずれについて磁界計測が行われるかを示している。例えば、Ｘ軸の磁気センサ８ｘは、Ｘ軸のセンサセレクトがＨ(High)レベルの期間７０ｘに選択的に、電圧及びバイアス磁界を印加され、磁界計測信号Ｓ$_{ｍ}$が差動プリアンプ２０に入力される。Ｙ軸、Ｚ軸のセンサセレクトも同様のことを示している。Ｘ軸、Ｙ軸、Ｚ軸のセンサセレクトは基本的に同じ長さずつ順番に設定される。

【００３９】

センサ極性は、極性反転部１２の状態を示しており、例えば、Ｌ(Low）レベルの期間７２が、磁気センサ８への印加電圧が正極性であり、一方、Ｈレベルの期間７４が、印加電圧が正極性とは反転した負極性であるとする。各磁気センサ８の１回の磁界計測期間にて正極性の期間７２と負極性の期間７４とが同じ長さずつ設定される。図５に示す動作では、各軸のセンサセレクトの期間７０ｘ，７０ｙ，７０ｚがそれぞれ２等分され、前半が正極性、後半が負極性に設定される。

【００４０】

デジタルフィルタ２４は、ΔΣ変調器２２から出力されるパルスの数を例えば、プリフィルタ３２，３３での前処理の後、カウンタ３４で累積加算し、これにより、ΔΣ変調器２２の出力スペクトルの高周波領域に対する帯域制限を行う。カウンタ３４の累積加算は期間７０ｘ，７０ｙ，７０ｚのそれぞれにおいて行われ、カウンタ３４は各期間７０毎に１つの計数結果を出力する。

【００４１】

制御部３０は正極性の期間７２及び負極性の期間７４それぞれの期間内に、デジタルフィルタ２４を動作させる期間７６，７８を設定する。期間７６と期間７８とは同じ長さに設定される。また制御部３０は、上述のように信号ＲＥＶを切り換え、正極性の期間７２ではカウンタ３４での入力データに対する動作を加算動作とし、負極性の期間７４では減算動作とする。このデータ合成を行うことで、後述するように、電流ＤＡＣ２８の出力電流に含まれるフリッカノイズなどに起因して生じる磁界計測信号Ｓ$_N$のオフセットノイズを低減し、磁界計測データの高精度化を図ることができる。

【００４２】

期間７８が終了すると、デジタルフィルタ２４ではデータ合成処理が完了して１つの磁界計測データＤ$_N$が得られる。制御部３０は、得られた磁界計測データＤ$_N$を、次の磁界計測を開始する前の期間８０に、加算結果を保持するカウンタ３４から読み出し、出力インターフェース２６によるデータ転送動作を行う。また、磁界計測データＤ$_N$のデータ転送動作を行うと、続く期間８２にて制御部３０はカウンタ３４をリセットし、次の磁界計測の開始に備える。

【００４３】

次に、データ合成処理によるオフセットノイズの低減について説明する。或る外部磁界強度Ｂでの正極性電圧印加時の磁界計測信号Ｓ$_N$の値をｓ$_+$、負極性電圧印加時の磁界計測信号Ｓ$_N$の値をｓ$_-$とする。ｓ$_+$のうち外部磁界の強度に対応する成分をｓ$_0$とすると、オフセットノイズｓ$_N$が０でない状態でのｓ$_+$は次式で表される。

$$s_+ = s_0 + s_N \quad \cdots (1)$$

【００４４】

一方、同じ外部磁界強度Ｂにてｓ$_-$は次式で表される。

$$s_- = -s_0 + s_N \quad \cdots (2)$$

【００４５】

ｓ$_+$は、正極性の動作期間７６でのΔΣ変調器２２の出力の加算結果に相当し、一方、ｓ$_-$は、負極性の動作期間７８での加算結果に相当する。（１）式から（２）式を減じると、次式に示されるように、オフセットノイズｓ$_N$が相殺され、外部磁界強度ｓ$_0$を求めることができる。

$$s_+ - s_- = 2s_0 \quad \cdots (3)$$

【００４６】

カウンタ３４を期間７６では加算動作とし、期間７８では減算動作とするデジタルフィルタ２４の動作は、（１），（２）式から（３）式を得る演算に対応しており、この原理により、デジタルフィルタ２４にてオフセットノイズが低減される。

【００４７】

図６は、プリフィルタ３２，３３及びカウンタ３４それぞれのフィルタ特性の模式図であり、図７はそれらの合成特性の模式図である。図６，図７において横軸は対数スケールで表した周波数であり、縦軸はデシベル表示の減衰率である。これらの図は、ｆ$_{cs}$及びクロック信号ＣＬＫが６ＭＨｚである場合を示している。図６において特性曲線９０は、$\alpha = 31$とした場合のプリフィルタ３２のフィルタ特性の包絡線を表し、特性曲線９２は、プリフィルタ３３のフィルタ特性の包絡線を表し、また、特性曲線９４は、カウンタ３４での加算回数が$2^{10}$回である場合のカウンタ３４のフィルタ特性の包絡線を表している。特性曲線９０，９２，９４のいずれも低周波領域では減衰せず、高周波領域にｆ$_{cs}$へ向けて減衰率が増加する減衰域を有する。

【００４８】

図７の特性曲線１００がプリフィルタ３２，３３及びカウンタ３４の合成したフィルタ特性の包絡線である。カウンタ３４の前段にプリフィルタ３２，３３を設けることで、カウンタ３４単独の場合（特性曲線９４）よりも好適に高周波領域を減衰することができる。なお、プリフィルタの段数及び構成は、上述の実施形態に限定されない。

【００４９】

一方，カウンタ３４単独のフィルタ特性自体に関しても、加算回数を大きくすることに

より減衰率を向上させることができる。なお、加算回数の増加にはカウンタ長を大きくする必要が生じ得るが、カウンタ長は、上述の全加算器６０及びＤフリップフロップ６２の対の追加で容易に増加し、加算回数の上限はカウンタ長を１つ増やす毎に２倍ずつ指数的に増えるので、加算回数の増加が回路規模へ与える影響は少ない。

【図面の簡単な説明】

【００５０】

【図１】本発明の実施形態に係る磁気計測装置の概略の回路構成図である。

【図２】第１のプリフィルタの構成を示す模式的なブロック図である。

【図３】第２のプリフィルタの構成を示す模式的なブロック図である。

【図４】カウンタの構成を示す模式的なブロック図である。

【図５】磁気センサ制御回路のデジタルフィルタでの処理を説明するためのタイミング図である。

【図６】２つのプリフィルタ及びカウンタそれぞれのフィルタ特性の模式図である。

【図７】２つのプリフィルタ及びカウンタを合成したフィルタ特性の模式図である。

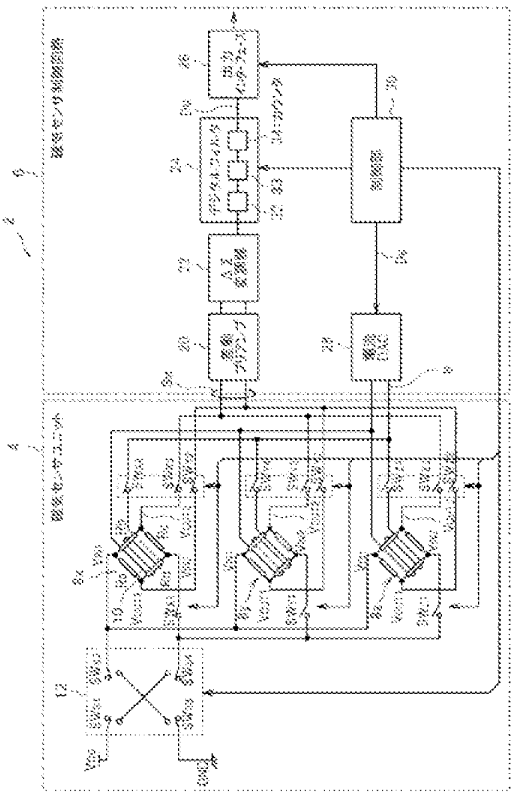
【図８】オーディオ信号をサンプリングする従来技術において、連続するサンプリングタイミングに対するデータ変換期間を示す模式図である。

【符号の説明】

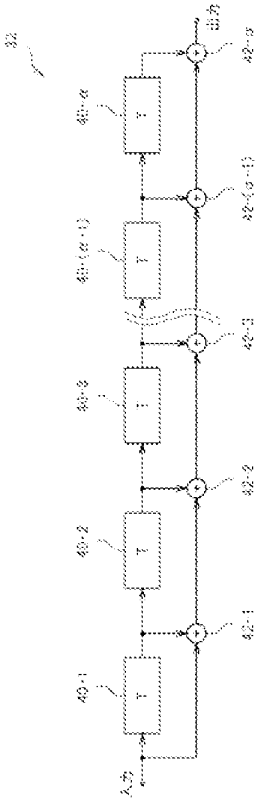
【００５１】

２　磁気計測装置、４　磁気センサユニット、６　磁気センサ制御回路、８　磁気センサ、１０　コイル、１２　極性反転部、２０　差動プリアンプ、２２　ΔΣ変調器、２４　デジタルフィルタ，２６　出力インターフェース、２８　電流ＤＡＣ、３０　制御部、３２，３３　プリフィルタ、３４　カウンタ、４０，５０　遅延器，４２，５２　加算器，６０　全加算器，６２　Ｄフリップフロップ。

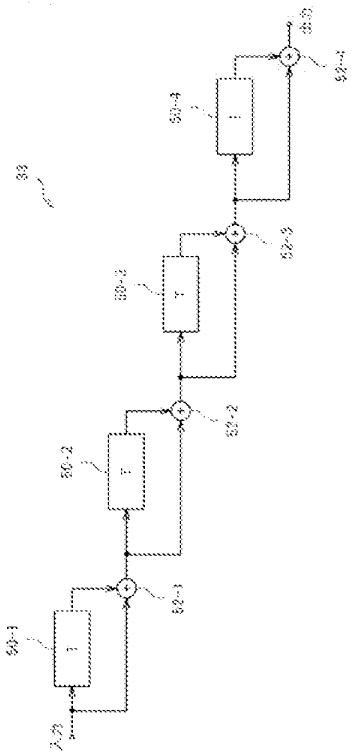
【図１】



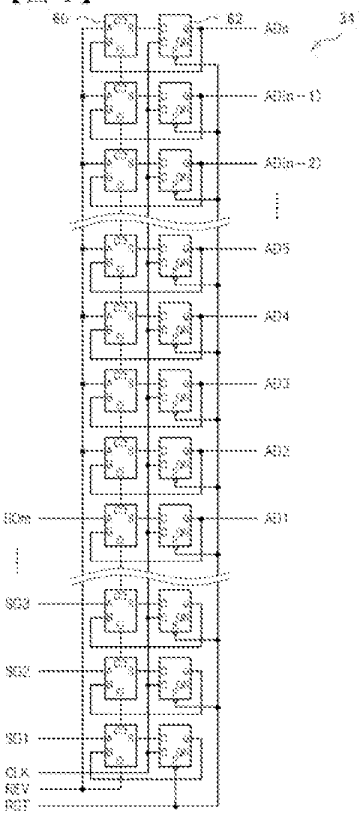
【図２】



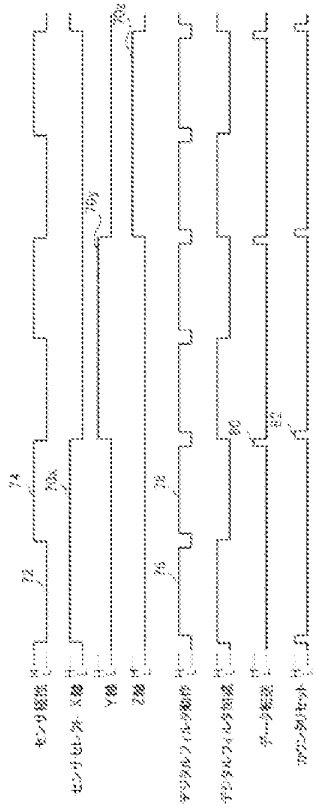
【図３】



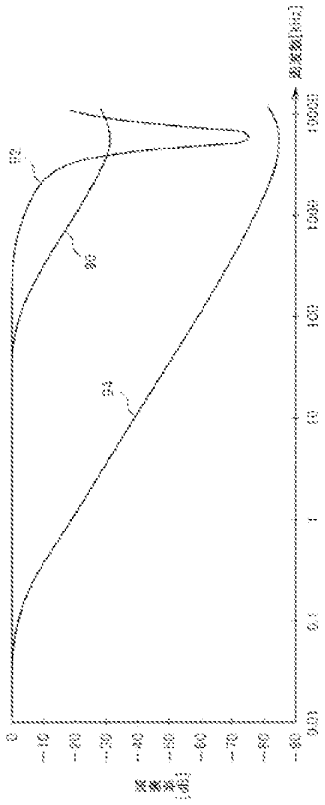
【図４】



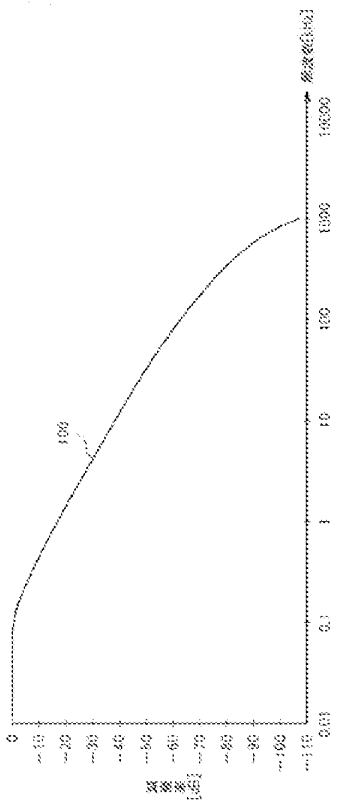
【図５】



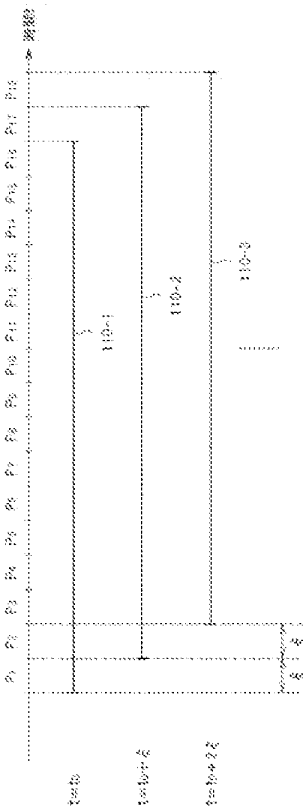
【図６】



【図７】



【図８】



フロントページの続き

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Ｆターム(参考) 2C017 AA01 AA10 AD55 BA09 BA15
5J064 AA04 BA03 BA06 BC05 BC06 BC08 BC12

Espacenet

# Bibliographic data: JP2000197180 (A) — 2000-07-14

## DIRECTIVITY CONTROLLER FOR MICROPHONE SYSTEM

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**Applicant(s):** VICTOR COMPANY OF JAPAN ± (VICTOR CO OF JAPAN LTD)

**Classification:** **- international:** ***H04R1/40; H04R3/00;*** (IPC1-7): H04R1/40; H04R3/00

**- cooperative:**

**Application number:** JP19980369543 19981225

**Priority number(s):** JP19980369543 19981225

### Abstract of JP2000197180 (A)

PROBLEM TO BE SOLVED: To enhance precision of delay of a delay device used especially for signal processing of the title controller. SOLUTION: The directivity controller obtains a synthesis directivity characteristic by subtracting a signal from one of microphones opposed to each other at a prescribed distance in between and a signal from the other that is delayed by a time in response to the prescribed distance. A means that conducts the time delay processing as above especially consists of an oversampling processing section 42d that samples an incoming digital signal with a sampling frequency at an integer multiple of the frequency of the incoming signal, an LPF 42e that limits a frequency band of the oversmapled signal, an oversampling delay section 42f that delays the signal whose frequency band is limited by a prescribed sampling time, and a down sampling processing section 42g that applies down sampling to the delayed signal to restore it to the original sampling signal or the like.

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号
特開2000－197180
（P2000－197180A）
(43)公開日　平成12年７月14日(2000.7.14)

| (51)Int.Cl.[7] | | 識別記号 | FI | | | ﾃｰﾏｺｰﾄﾞ(参考) |
|---|---|---|---|---|---|---|
| H04R | 3/00 | 320 | H04R | 3/00 | 320 | 5D020 |
| | 1/40 | 320 | | 1/40 | 320Z | |

審査請求　未請求　請求項の数２　ＯＬ　（全 ９ 頁）

(21)出願番号　特願平10－369543

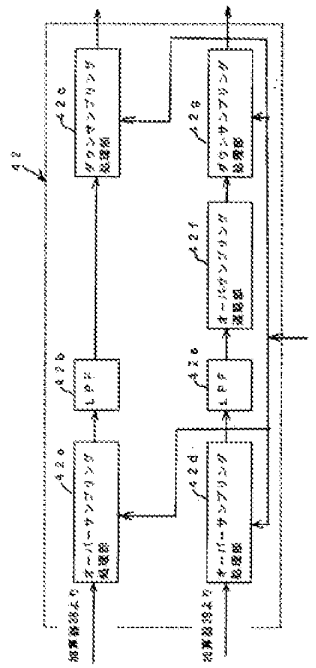
(22)出願日　平成10年12月25日(1998.12.25)

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Ｆターム(参考)　5D020 BB04

(54)【発明の名称】　マイクロホン装置における指向性制御装置

(57)【要約】
【課題】　マイクロホン装置の指向性制御装置に関し、特にその信号処理に使用する遅延器の遅延精度を向上させることにある。
【解決手段】　所定距離を介して対向配置したマイクロホンの一方側に基づく信号と、他方側に基づく信号を前記所定距離に応じた時間遅延させた信号とを減算して合成指向特性を得るための指向性制御装置であり、特に、前記の時間遅延処理を行わせる手段を、入来デジタル信号の整数倍のサンプリング周波数でサンプリングするオーバーサンプリング処理部４２ｄ、このオーバーサンプリングした信号の帯域を制限するＬＰＦ４２ｅ、この帯域制限された信号を所定サンプル分遅延させるためのオーバーサンプリング遅延部４２ｆ、この遅延した信号をもとのサンプリング信号となるようにダウンサンプリングするダウンサンプリング処理部４２ｇ等で構成したものである。



【特許請求の範囲】
【請求項１】ディジタル信号に変換された、所定距離を介して対向配置される一対のマイク手段に基づく信号又はこれらマイク手段に基づく信号と実質的に等価な信号を、一方のマイク手段に基づく信号又はこの一方のマイク手段に基づく信号と実質的に等価な信号と、他方のマイク手段に基づく信号又はこの他方のマイク手段に基づく信号と実質的に等価な信号に前記所定距離に応じた時間遅延を加えた信号と、を演算処理して合成指向特性を得るようにしたマイクロホン装置における指向性制御装置において、
前記所定距離に応じた時間遅延を行う遅延手段を、変換されたデジタル信号のサンプリング周波数の整数倍のサンプリング周波数でオーバーサンプリングする手段と、このオーバーサンプリングされた信号を所定の帯域成分に制限するための帯域フィルタ手段と、この帯域制限された信号を前記時間遅延に対応したサンプル数分だけ遅延するためのオーバーサンプリング信号遅延手段と、この遅延した信号を前記オーバーサンプリングされる前のデジタル信号と同期した同一のサンプリング周波数の信号となるようにダウンサンプリングするための手段とで構成する共に、
前記一方のマイク手段に基づく信号又はこの一方のマイク手段に基づく信号と実質的に等価な信号に、前記オーバーサンプリングする手段、前記帯域フィルタ手段、及び前記ダウンサンプリングするための手段によって生じる遅延時間分に相当する遅延量を調整するための遅延量調整手段を設けたことを特徴とするマイクロホン装置における指向性制御装置。
【請求項２】請求項１の指向性制御装置を、マイク手段に基づく信号を記録するための記録手段の後段側に設けるようにしたことを特徴するマイクロホン装置における指向性制御装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、複数のマイクロホンを使用して、その出力信号を電気的に演算することにより、マイクロホンの指向特性や指向性軸の方向を可変するマイクロホン装置の指向性制御装置に関する。
【０００２】
【従来の技術及び発明が解決しようとする課題】複数のマイクロホンの出力信号を電気的に演算することでマイクロホンの指向特性を制御する装置としては、ビデオカメラの集音マイクロホン等で可変指向性やズーム特性を得る装置として数々の提案がある。その主な演算処理内容は、加算、減算、遅延処理であり、アナログ処理で行われるものが殆どである。
【０００３】ここで、電気的演算処理を行う例として、図８に示す２個の無指向性マイクに遅延処理を加えて単一指向特性を得る場合を考察してみる。同図において、無指向性マイクロホンＭ１０の出力と、距離ｄ離れた無指向性マイクロホンＭ１１の出力を、距離ｄの音波伝達時間に相当する遅延ｒを遅延器１２で遅延した信号とで減算すると、図９に示す略ハート形の単一指向特性が得られる。
【０００４】この場合、遅延ｒは全周波数帯域にわたって一定であることが理想であるが、アナログ遅延処理では位相シフトにより遅延を実現することになるので、全周波数帯域にわたって任意の遅延量で遅延特性を一定に保つことは困難である。
【０００５】また、当該出願人は、先に図１０に示すように、指向性の中心Ｏを合わせて、指向性軸Ｘ，Ｙが互いに直交するように２個の一次双指向性マイクロホンＭ１２，Ｍ１３を配置し、その出力に、それぞれＣＯＳθとＳＩＮθとを乗算することにより、図１１に示すようにマイクロホンＭ１２の指向特性１７とマイクロホンＭ１３の指向特性１８との間である角度θの位置に合成特性１９を得る方法を提案した。
【０００６】この場合、ＣＯＳθとＳＩＮθの乗算を行うことになるが、アナログ回路で正確に実現するためには、相当複雑な回路構成を必要とすることになり、デジタル処理にて行う方が容易であり、正確である。
【０００７】ところで、前述したように、マイクロホンの指向特性制御をデジタル演算処理にて行うことは大きな利点であるが、遅延処理に必要な遅延量は扱う周波数範囲にもよるが、可聴帯域では大凡２５μｓから１００μｓであり、また、マイクロホン間の距離により任意可変する必要がある。
【０００８】一方、デジタル化された信号データは、そのサンプル時間単位によってしか遅延量を可変できない。例えば、サンプリング周波数が４８ｋＨｚならば、約２０．８μｓ単位で、又、３２ｋＨｚならば、３１．２５μｓ単位でしか遅延量を可変できず、マイクロホン間の距離に応じた可変ができないという問題点があった。
【０００９】そこで、本発明は、所定距離間にあるマイクロホンの出力に所定の演算処理をし、一方の信号に所定の距離間に基づいた遅延量を加算し、互いの出力を減算して合成特性を得るための指向性制御装置において、その遅延量を加算するにあたり、マイクロホン間の距離がどのような距離であっても、その距離に応じた正確な遅延量を生成して、正確な指向特性の制御が可能となる指向性制御装置を提供することにある。
【００１０】
【課題を解決するための手段】本願発明は、上記課題を解決するために、以下の１）及び２）の手段より成るものである。即ち、
【００１１】１）ディジタル信号に変換された、所定距離を介して対向配置される一対のマイク手段に基づく信号又はこれらマイク手段に基づく信号と実質的に等価な

信号を、一方のマイク手段に基づく信号又はこの一方のマイク手段に基づく信号と実質的に等価な信号と、他方のマイク手段に基づく信号又はこの他方のマイク手段に基づく信号と実質的に等価な信号に前記所定距離に応じた時間遅延を加えた信号と、を演算処理して合成指向特性を得るようにしたマイクロホン装置における指向性制御装置において、前記所定距離に応じた時間遅延を行う遅延手段を、変換されたデジタル信号のサンプリング周波数の整数倍のサンプリング周波数でオーバーサンプリングする手段と、このオーバーサンプリングされた信号を所定の帯域成分に制限するための帯域フィルタ手段と、この帯域制限された信号を前記時間遅延に対応したサンプル数分だけ遅延するためのオーバーサンプリング信号遅延手段と、この遅延した信号を前記オーバーサンプリングされる前のデジタル信号と同期した同一のサンプリング周波数の信号となるようにダウンサンプリングするための手段とで構成する共に、前記一方のマイク手段に基づく信号又はこの一方のマイク手段に基づく信号と実質的に等価な信号に、前記オーバーサンプリングする手段、前記帯域フィルタ手段、及び前記ダウンサンプリングするための手段によって生じる遅延時間分に相当する遅延量を調整するための遅延量調整手段を設けたことを特徴とするマイクロホン装置における指向性制御装置。

【００１２】２）請求項１の指向性制御装置を、マイク手段に基づく信号を記録するための記録手段の後段側に設けるようにしたことを特徴するマイクロホン装置における指向性制御装置。

【００１３】

【発明の実施の形態】以下、本発明の実施の形態につき、好ましい実施例により説明する。図１は、本願発明に係るマイクロホン装置における指向性制御装置を採用するために前提となるマイクロホン装置の一例で、各マイクロホンの配置を示した図であり、前述の図１０及び図１１で説明したと同様の考え方に基づくものである。まず、このマイクロホン装置の原理及びその構成につき詳細に説明する。

【００１４】同図において、Ｍ１，Ｍ２，Ｍ３，Ｍ４は、双指向性のマイクロホンで、これらのマイクロホンは、それぞれの指向性軸Ｘ，Ｙが同一平面上で直交すると共に、その直交点Ｏから各マイクロホンＭ１，Ｍ２，Ｍ３，Ｍ４に至る距離が等しいように配置された構成となっている。例えば、各マイクロホンＭ１及びマイクロホンＭ２の指向特性は、それぞれ同一平面上の直交する指向性軸Ｘ及び指向性軸Ｙ上に形成され、図３における符号２０，２１として示されように二つの円形を連ねたような特性となっている。

【００１５】また、マイクロホンＭ３及びマイクロホンＭ４は、それぞれ同一平面上の直交する指向性軸Ｘ及び指向性軸Ｙ上に形成され、図３における符号２０′，２１′として示されるような特性となっている。なお、この図３では、それぞれの特性原点が全て一致した状態で示されているが、特性方向と特性範囲の形状とを概略的に図示したいがために示したもので、実際には各々の特性原点は離れている。これ以降の特性図においても、同一趣旨による図示としてある。

【００１６】ここで、例えば、図２におけるマイクロホンＭ１の指向性軸Ｘからの角度を$\phi$とすると、マイクロホンＭ１の指向特性はＣＯＳ$\phi$で表され、マイクロホンＭ２の指向特性はＳＩＮ$\phi$で表される。

【００１７】そして、ここで、指向性軸Ｘに対して、目標とする双指向特性への角度を$\theta$とし、$0 \leqq \theta \leqq \pi/2$の角度範囲の指向性について考察してみる。マイクＭ１の出力にＣＯＳ$\theta$を、マイクＭ２の出力にＳＩＮ$\theta$をそれぞれ乗算して加算すると、その合成特性は、

$$\mathrm{COS}\theta \times \mathrm{COS}\phi + \mathrm{SIN}\theta \times \mathrm{SIN}\phi$$

で表される。

【００１８】図２におけるマイクロホンＭ１とマイクロホンＭ２とを結ぶ直線と、目標とする角度$\theta$の指向性軸Ｐとの交点Ａを指向原点する双指向性が得られる。その双指向性は、例えば、図３における指向性軸Ｐ上の２つの円として示される合成一次双指向性２４である。

【００１９】また、次に、マイクロホンＭ３及びマイクロホンＭ４の合成特性については、マイクロホンＭ３の出力にＣＯＳ（$\pi+\theta$）を、マイクロホンＭ４の出力にＳＩＮ（$\pi+\theta$）をそれぞれ乗算し、それらを加算すると、そのときの合成特性は、

$$\mathrm{COS}(\pi+\theta) \times \mathrm{COS}\phi + \mathrm{SIN}(\pi+\theta) \times \mathrm{SIN}\phi$$

で表される。このときの合成特性は、マイクロホンＭ３とマイクロホンＭ４とを結ぶ直線と、目標とする角度$\theta$の指向性軸Ｐとの交点Ｂを特性原点する双指向性が得られる。また、その双指向性特性の形状は、図３における符号２４′として示され、特性２４と同一形状である。また、この場合においても、前記と同様に、実際には、特性２４，２４′の特性原点Ａ，Ｂは同一となっておらず、図示を簡略化するために便宜上同一点としてある。

【００２０】次に、前記のようにして得られたマイクロホンＭ３，Ｍ４の合成出力に、それぞれの合成特性の特性原点Ａ，Ｂ間の距離の音波伝搬時間に相当する遅延を加え、その後に互いの合成出力を減算すると、目標指向性方向と反対側からの音は互いに位相がほぼ同一になり、前記マイクロホンＭ１，Ｍ２及びマイクロホンＭ３，Ｍ４合成出力が相殺され、目標指向性方向からの音は、前記の音波伝搬時間の２倍に相当する位相差に基づく出力が得られて、図４における符号２５として示される単一狭指向特性２５が得られる。

【００２１】また、次に、$\pi/2 < \theta \leqq \pi$の角度範囲において、図５における指向軸Ｑ上にあるような単一狭指向特性２６を得たい場合には、今度はマイクロホンＭ２

とマイクロホンＭ３とを一組としてこれらの合成出力を得ると共に、これらに１８０度対向位置にあるマイクロホンＭ４とマイクロホンＭ１とを一組とした合成出力を得て、その一方に両者の特性原点間の距離による音波伝搬時間に相当する遅延を加え、互いに減算することにより単一狭指向特性２６が得られる。

【００２２】また、$\pi<\theta\leqq 3\pi/2$と$3\pi/2<\theta<2\pi$との角度範囲における単一狭指向特性を得るためには、マイクロホンＭ３とマイクロホンＭ４及びマイクロホンＭ１とマイクロホンＭ２、又マイクロホンＭ４とマイクロホンＭ１及びマイクロホンＭ２とマイクロホンＭ３の組み合わせで前記と同様な処理を行うことで求めることができる。

【００２３】そして、上記のように構成する各マイクロホンは、例えば、周知の取り付け法により、ビデオカメラの本体部に取り付けたり、或いは、各ユニットを一つの筐体内に納めて別体にして使用たりすることが可能である。

【００２４】次に、上記のようにな構成をしたマイクロホン装置から、前記の理論に基づいて構成された本願発明の実施例に係る指向性制御装置につき説明する。図６は、その実施例に係る指向性制御装置の概略ブロック図である。同図において、指向性制御装置は、各マイクロホンから出力される出力信号を入力するため入力端子３０，３１，３２，３３と、それぞれが各マイクロホンに接続され、図示しない制御手段により入力を切り換えられる４回路の入出力マトリックスＳＷ回路（ＳＷ内の接続線は図示が複雑になるため省略してある）と、図示しない記憶手段のテーブルに予め用意されている$\mathrm{COS}\theta$や$\mathrm{SIN}\theta$等の係数を乗算するための乗算器３４，３５，３６，３７と、これら乗算器の出力信号を加算するための加算器３８，３９と、詳細に後述する本発明の要部となる回路で、入力信号を入力信号間で、各特性原点間の距離による音波伝搬時間に相当する時間（$\tau$）等を相対的に遅延させるため遅延器４２と、互いの合成出力を減算するための減算器４３と、減算された信号をアナログ信号に変換するためのＤ／Ａ変換器４４と、このアナログ信号を出力するための出力端子４５とから概略構成されている。

【００２５】次に、上記のような構成による動作につき説明する。まず、目標とする指向性の角度が図４に示すような$\theta$の角度方向であるような場合には、例えば、図示しない操作手段により予め角度$\theta$方向を選んでおく、この情報が図示しない制御手段に供給され、ここで、制御手段内の図示しない記憶テーブルから$\mathrm{COS}\theta$，$\mathrm{SIN}\theta$，$\mathrm{COS}(\pi+\theta)$，$\mathrm{SIN}(\pi+\theta)$の各係数がそれぞれ選ばれる。

【００２６】これと同時に、制御手段からマトリックスＳＷ回路に切換信号が供給され、マイクロホンＭ１と乗算器３４とが、マイクロホンＭ２と乗算器３５とが、マイクロホンＭ３と乗算器Ｍ３とか、マイクロホンＭ４と乗算器３７とが、それぞれ接続されるように切り換えられる。

【００２７】そして、双指向性特性のマイクロホンＭ１，Ｍ２，Ｍ３，Ｍ４から出力されたアナログ信号は、Ａ／Ｄ変換器２９においてそれぞれデジタル信号に変換されて、マトリックスＳＷ回路を通じて乗算器３４，３５，３６，３７にそれぞれ供給される。これら乗算器では、このデジタル信号に前記の予め選択された$\mathrm{COS}\theta$，$\mathrm{SIN}\theta$，$\mathrm{COS}(\pi+\theta)$，$\mathrm{SIN}(\pi+\theta)$の各係数が供給されてそれぞれ乗算処理される。

【００２８】次に、これら乗算器３４，３５と乗算器３６，３７とで処理された信号は、次段の加算器３８，３９でそれぞれ加算され、一方の加算器３８からの合成信号は本発明の要部である遅延手段４２内に供給され、ここで、他方の加算器３９から供給される合成信号の後述する処理を行う際に生じる遅延量との調整処理がされて減算器４３の一方に供給される。また、他方の加算器３９から出力される合成信号も遅延器４２に供給され、ここで、詳細に後述する特性原点Ａ，Ｂ間の距離による音波伝搬時間$\tau$に相当する正確な両信号間の相対的な時間遅延等の処理がなされるようになっている。

【００２９】そして、この遅延された信号と前記の一方より入来した合成信号とが減算器４３において互いに減算され、その減算信号がＤ／Ａ変換器４４で再びアナログ信号に変換されて出力端子４５から目標角度$\theta$方向への単一狭指向特性が得られた信号が取り出されることになる。即ち、図４で示す指向特性２５が得られる。

【００３０】また、図５における指向特性２６で示すような方向での単一狭指向特性を得たい場合には、前記と同様にして操作手段により予めその所望方向を選んでおく。これに基づき制御手段では、今度は、マトリックスＳＷ回路をマイクロホンＭ２，Ｍ３を一組とし、マイクロホンＭ４，Ｍ１を一組とするようにそれぞれ切り換え制御を行う。

【００３１】即ち、マイクロホンＭ２が乗算器３４と、マイクロホンＭ３が乗算器３５と、マイクロホンＭ４が乗算器３６と、マイクロホンＭ１が乗算器３７と、それぞれ接続されるように切り換えられ、記憶テーブルから前記の所定の係数が選ばれる。そして、各マイクロホンにおいて集音された信号は、制御装置内で前述と同様の処理が施されて、出力端子４５からは図５に示すような単一狭指向特性２６が得られることになる。

【００３２】次に、今度は、図４に示す指向特性２５と１８０度逆方向の単一狭指向特性を得たいような場合には、前記と同様にして操作手段により予めその所望方向を選んでおく。制御手段では、マトリックスＳＷ回路をマイクロホンＭ３，Ｍ４を一組とし、マイクロホンＭ１，Ｍ２を一組とするようにそれぞれ切り換えられる。即ち、マイクロホンＭ３が乗算器３４と、マイクロホン

Ｍ４が乗算器３５と、マイクロホンＭ１が乗算器３６と、マイクロホンＭ２が乗算器３７と、それぞれ接続されるように切り換えられ、前述の所定係数が選ばれる。

【００３３】これにより、乗算器３８，３９から出力される合成出力が減算器４３で互いに減算処理され、出力端子４４からは、１８０～２７０度の位置に指向特性２５で示すような単一狭指向特性が得られることになる。

【００３４】更にまた、図５の特性２６と１８０度逆方向の単一狭指向特性を得たい場合には、操作手段によりその希望する角度方向を選ぶ。これにより、マトリックスＳＷ回路をマイクロホンＭ４，Ｍ１を一組とし，マイクロホンＭ２、Ｍ３を一組とし、マイクロホンＭ４が乗算器３４と、マイクロホンＭ１が乗算器３５と、マイクロホンＭ２が乗算器３６と、マイクロホンＭ３が乗算器３７と、それぞれ接続されるように切り換えられる。、また、前述の所定係数が選ばれる。

【００３５】この結果、前述と同じような信号処理が施されて、出力端子４５からは図５の特性２６と１８０度逆方向の単一狭指向特性が得られることになる。このように、操作手段等により所望方向の角度方向を選ぶことにより、水平方向３６０度任意の方向に同一レベルの単一狭指向特性が得られることになる。本願実施例の指向性制御装置は、概略以上のように動作する。

【００３６】次に、本願発明の要旨である遅延器４２の構成及び動作につき詳細に説明する。図７は、その遅延器４２の詳細ブロック図であり、遅延器４２は加算器３８の合成信号の入来側にオーバーサンプリング部４２ａと、帯域制限フィルタ（ＬＰＦ）４２ｂと，ダウンサンプリング処理部４２ｃとが設けられ、加算器３９の合成信号の入来側にオーバーサンプリング部４２ｄと、帯域制限フィルタ（ＬＰＦ）４２ｅと、オーバーサンプリング遅延部４２ｆと、ダウンサンプリング処理部４２ｇとが設けられ、各サンプリング処理部４２ａ，４２ｃ，４２ｄ，４２ｇには図示しない基準信号生成部より同期信号が入来する構成となっている。

【００３７】この遅延器４２では、他方側である加算器３９から入来する合成特性信号は、オーバーサンプリング部４２ｄに供給され，ここで、もとのサンプリング周波数の整数倍のサンプリング周波数のデジタル信号に変換され、次段のＬＰＦ４２ｅに供給される。ＬＰＦ４２ｅではオーバーサンプリング時に発生する折り返し歪み成分等の余分な帯域成分の除去が行われる。

【００３８】そして、帯域制限された信号は、次段のオーバーサンプリング遅延部４２ｆに供給され、ここで、必要とする遅延量のオーバーサンプリング信号データ数分だけ遅延される。即ち、この処理部４２ｆで、特性原点Ａ、Ｂ間の距離による音波伝搬時間τに相当する正確な時間の遅延がなされることになる。

【００３９】例えば、この遅延処理では、元のサンプリング周波数を４８ｋＨｚとし、８倍のオーバーサンプリング周波数のデジタル信号を得るとすれば、オーバーサンプリング信号１データ遅延当たり、１／（８×４８ｋＨｚ）＝約２．６０４μｓの遅延処理が可能となる。そして、前記のように遅延された信号は、更に次段のダウンサンプリング処理部４２ｇに供給され、ここで、他方からから入来する同期信号に同期して、元のサンプリング周波数の信号に同期するようにダウンサンプリングされる。

【００４０】また、一方側である加算器３８から入来する合成特性信号は、オーバーサンプリング部４２ａに供給されて、オーバーサンプリング４２ｄと同じ元のサンプリング周波数の整数倍のサンプリング周波数のデジタル信号に変換され、次段のＬＰＦ４２ｂにおいてＬＰＦ４２ｃと同じ折り返し歪み成分等の余分な帯域成分の除去が行われ、ダウンサンプリング処理部４２ｃにおいて再びダウンサンプリング処理部４２ｆと同様に元のサンプリング周波数の信号に同期した信号にダウンサンプリングされる。この一方側の各処理部４２ａ，４２ｂ，４２ｃは、他方側に設けられるオーバーサンプリング部４２ｄ、ＢＰＦ４２ｅ、及びダウンサンプリング処理部４２ｇに対応して設けられたもので、各部で処理を行う際に生じる遅延時間を合わせるために設けたいわゆる遅延量調整手段であり、これにより正確な相対遅延時間を得ることができる。

【００４１】そして、前記のようにして精度良く遅延された信号は、図６に示す減算器４３に供給され、ここで、他方から入来する合成信号と減算処理されるようになっているものである。

【００４２】以上のように、遅延器４２では，オーバーサンプリングにより，そのオーバサンプリング比に応じた遅延量を設定できるため、極めて短い遅延を行う場合にも簡単な構成で、かつ，正確な遅延が行えるものとなる。

【００４３】このような遅延器を採用した本実施例の指向性制御装置によれば、所定距離間にあるマイクロホンの出力を合成して、所定の合成特性を得るに際し、その信号処理過程で、正確な遅延量の生成が必要な場合にも、その遅延量に対応した正確な遅延量を生成できるので，水平方向３６０度の任意の角度方向に亘って同一レベルの理想的な単一狭指向特性が得られる。

【００４４】なお、上記実施例においては、遅延器４２を加算器３９の後段部に設ける構成としたが、これに限ることなく、乗算器３６，３７の前段側に用意しても良い。

【００４５】また、上記実施例の指向性制御装置は、テープ等が装着される記録手段の前段側に用意することもできるし、ビデオカメラ等の撮像時に、リアルタイムの指向性制御が難しいような場合には、図６におけるＡ／Ｄ変換器２９までの上流側を記録手段の前段側に用意し、入力端子以降の指向性制御装置を記録手段の後段側

に用意しても良い。このような構成の場合には、それぞれの角度方向の音声をチャンネル毎に一旦記録媒体に記録し、その後の編集時等において、再生画像を見ながら、ゆっくりと所望方向の音声を取り出すことができる。

【００４６】更に、上記実施例の指向性制御装置は、マイクロホン装置と一体に設けても良く、別体装置としても良い。

【００４７】また、更に、上記実施例では、Ａ／Ｄ変換器２９を、マイクロホン装置側に用意したが、指向性制御装置内に用意しても良い。

【００４８】更に、また、前記本発明の要旨である遅延器は、前述したような構成の指向性制御装置に限らず、ディジタル信号の遅延量の可変を必要とする信号処理ならどのような構成の装置でも良く、特に、１サンプリングデータより短い遅延を行わせる場合には好適な回路である。

【００４９】また、上記実施例では、一方側と他方側の信号を一対の双指向性マイクロホンから得るようにしているが、これに限らず４個以上の無指向性のマイクロホンを所定の位置に配置し、これらから本実施例の一対の双指向性のマイクロホンから得ると実質的に等価な信号を合成し、これらの信号に基づいて、本実施例で行うような指向性制御を行うようにしても良い。

【００５０】

【発明の効果】請求項１記載の指向性制御装置によれば、簡単な構成で正確な遅延処理が行え、理想的な指向特性が得られる。また、特に、請求項２記載の指向特性制御装置によれば、前述の効果に加えて、信号記録後の編集時等において、再生画像を見ながら、ゆっくりと所望方向の音声を取り出すことができる等の効果を奏する。

【図面の簡単な説明】

【図１】本発明に適用されるマイクロホン装置の一実施例に係る各マイクロホンの配置構成図である。

【図２】一実施例に係るマイクロホン装置における各マイクロホンと目標角度方向への指向性を得るための説明＊図である。

【図３】０～９０度方向への合成特性を得るための説明図である。

【図４】０～９０度方向への単一狭指向性を得るための説明図である。

【図５】９０～１８０度方向への単一狭指向性を得るための説明図である。

【図６】本発明の一実施例に係る指向性制御の概略構成図である。

【図７】遅延器４２の詳細ブロック図である。

【図８】従来のマイクロホン装置の説明図である。

【図９】合成指向特性を示した図である。

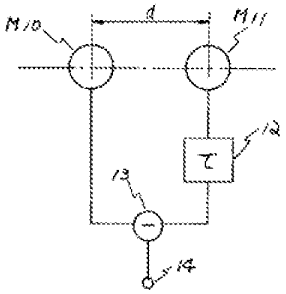
【図１０】本願出願人が先に提案したマイクロホン装置の説明図である。

【図１１】図１０のマイクロホン装置における合成特性を示す図である。

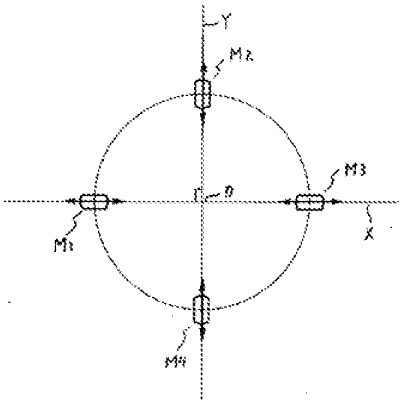
【符号の説明】

１０，１１，１２，１３　　双指向特性
１４　　単一指向特性
１５　　無指向特性
２０，２０′，２１，２１′，２４，２４′　　指向特性
２５，２６　　単一狭指向特性
２９　　Ａ／Ｄ変換器
３４，３５，３６，３７　　乗算器
３８，３９　　加算器
４２　　遅延器
４２ａ，４２ｄ　　オーバサンプリング処理部
４２ｂ，４２ｅ　　ＢＰＦ
４２ｃ，４２ｇ、　　ダウンサンプリング処理部
４２ｆ　　オーバサンプリング遅延部
４３　　減算器
４４　　Ｄ／Ａ変換器
Ａ，Ｂ　　指向原点
Ｍ１，Ｍ２，Ｍ３，Ｍ４　　マイクロホン
Ｐ，Ｑ　指向性軸

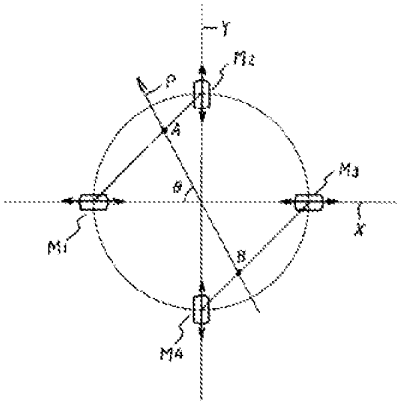
【図８】



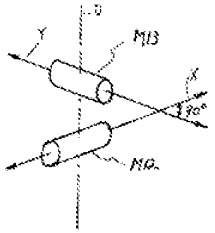
【図１】



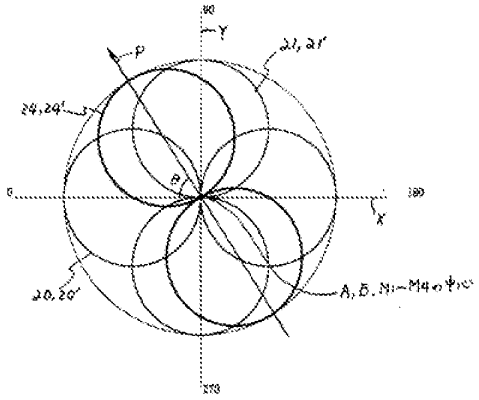

【図２】



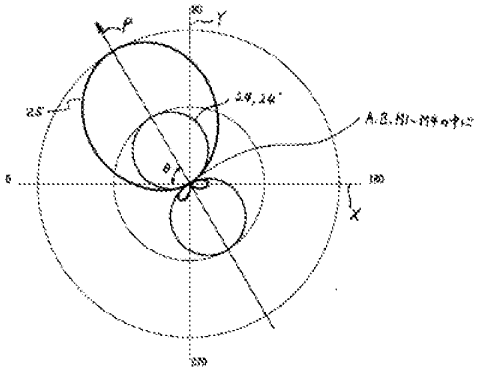

【図１０】



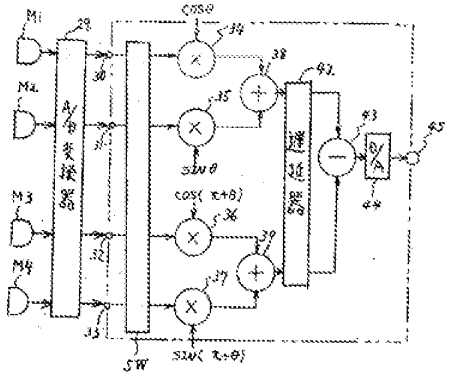

【図３】



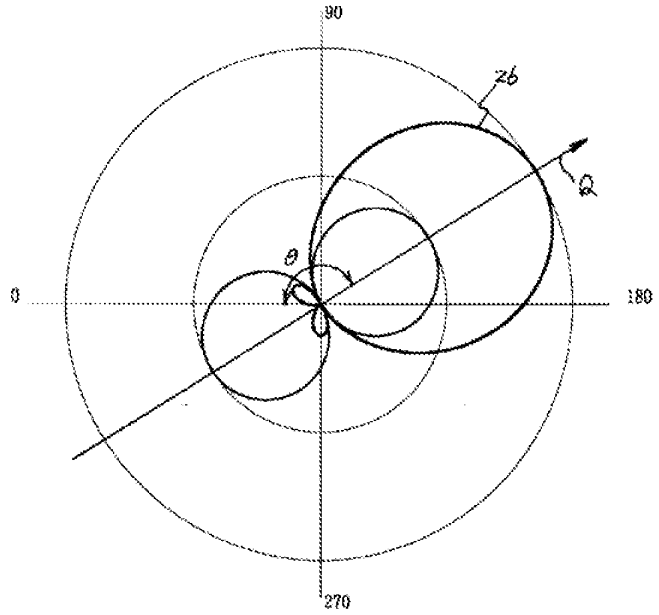

【図４】



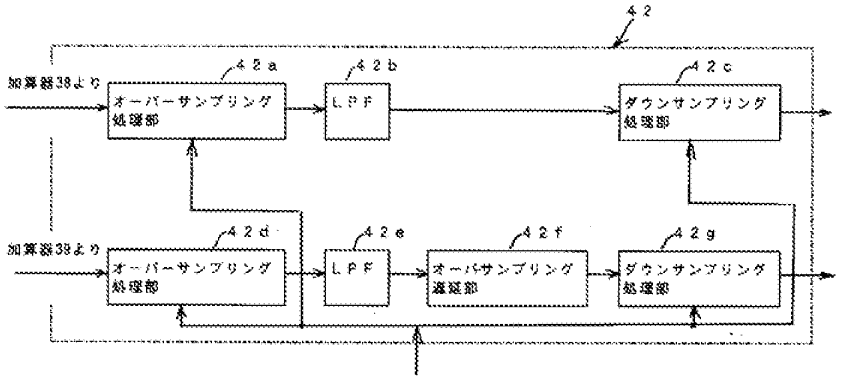

【図６】



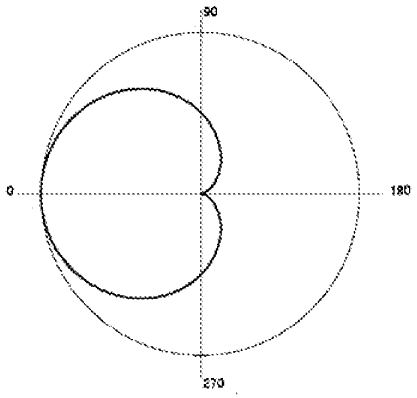
【図５】


90
26
Q
θ
0
180
270

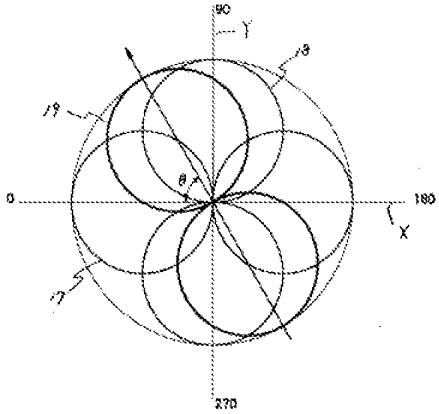
【図７】


42
42a
42b
42c
オーバーサンプリング処理部
LPF
ダウンサンプリング処理部
42d
42e
42f
42g
オーバーサンプリング処理部
LPF
オーバーサンプリング遅延部
ダウンサンプリング処理部

【図９】




【図１１】



Espacenet

# Bibliographic data: JP2002300224 (A) — 2002-10-11

## RECEIVER

**Inventor(s):** IDE TERUJI ± (IDE TERUJI)

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**Classification:** **- international:** ***H04B1/26; H04B14/04; H04L27/38;*** (IPC1-7): H04B1/26; H04B14/04; H04L27/38

**- cooperative:**

**Application number:** JP20010097977 20010330

**Priority number(s):** JP20010097977 20010330

## Abstract of JP2002300224 (A)

PROBLEM TO BE SOLVED: To select a sampling rate of a signal in a demodulation processing regardless of the sampling rate of A/D conversion of an input side in a receiver of an orthogonal demodulation system. SOLUTION: A receiver is provided with a clock oscillator 105 that can select the output frequency of A/D conversion independently of the sampling rate of the A/D conversion, interpolation filters 101 and 102 perform rate conversion of the common mode and orthogonal components of a band-limited baseband by using resample processing by this output clock to be the signal of a desired sampling rate, and demodulation processing is subsequently carried out.

(19)日本国特許庁（ＪＰ）　(12) **公開特許公報（Ａ）**　(11)特許出願公開番号
特開2002－300224
（P2002－300224A）
(43)公開日　平成14年10月11日(2002.10.11)

| (51)Int.Cl.[7] | 識別記号 | ＦＩ | | テーマコード(参考) |
|---|---|---|---|---|
| Ｈ０４Ｌ　27/38 | | Ｈ０４Ｂ　1/26 | | Ｈ　５Ｋ００４ |
| Ｈ０４Ｂ　1/26 | | | 14/04 | Ｂ　５Ｋ０２０ |
| 14/04 | | Ｈ０４Ｌ　27/00 | | Ｇ　５Ｋ０４１ |

審査請求　未請求　請求項の数１　ＯＬ　（全　４　頁）

(21)出願番号　特願2001－97977(P2001－97977)

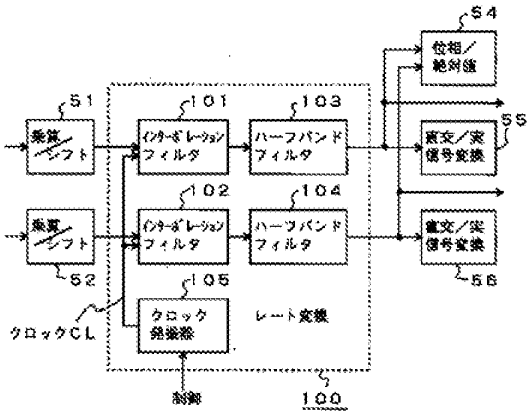
(22)出願日　平成13年３月30日(2001.3.30)

(71)出願人　000001122
株式会社日立国際電気
東京都中野区東中野三丁目14番20号
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最終頁に続く

(54)【発明の名称】　受信装置

(57)【要約】
【課題】　直交復調方式の受信装置において、入力側のＡ／Ｄ変換のサンプリングレートに関係なく復調処理のときの信号のサンプリングレートを選べるようにする。
【解決手段】　Ａ／Ｄ変換のサンプリングレートとは独立にその出力周波数を選定できるクロック発振器１０５を設け、この出力クロックによるリサンプル処理を用いて、帯域制限されたベースバンドの同相及び直交成分をインターポレーションフィルタ１０１、１０２でレート変換し、所望のサンプリングレートの信号としたのち復調処理を行う。



【特許請求の範囲】
【請求項１】　入力中間周波信号をディジタル化するＡ／Ｄ変換手段と、
この手段から出力された中間周波信号を同相、直交成分に分けてそれぞれをベースバンド信号へ変換し、その各ベースバンド信号のサンプリングレートをデシメーションフィルタを用いて低減したのち周波数帯域制限を行う直交復調処理手段と、
前記Ａ／Ｄ変換手段のサンプリングレートとは独立にその出力周波数を設定可能なクロック発振器からのクロックを用いて前記直交復調処理手段からの同相及び直交ベースバンド信号をリサンプルしてサンプリングレートの変換を行うレート変換手段と、
この手段によりサンプリングレートが変換されたベースバンド信号の復調処理を行う処理手段と、
を備えたことを特徴とする受信装置。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、受信した変調波をマルチレート信号処理によって復調するようにした受信装置に係り、とくに変調方式や変調信号の帯域が異なる種々の変調波を受信・復調可能な受信装置に関する。
【０００２】
【従来の技術】変調信号の帯域あるいはディジタル変調信号の場合のパルスレートが異なったり、変調方式が異なる通信システムが混在する環境下で、これら異なる通信システムの信号を選択して受信可能な受信装置では、受信した変調信号に応じたフィルタリングや復調処理を行う必要がある。また、このような受信装置をＤＳＰ等のディジタル処理で実現する場合には、ディジタル処理装置の処理負荷を軽減するために、扱うディジタル信号のサンプリングレートを変換して処理を実行するマルチレート信号処理が用いられる。
【０００３】図４は、上記のような受信装置の構成例を示すブロック図で、入力された中間周波数のデジタル変調波信号がＡ／Ｄ変換器１でＡＤ変換され、直交復調処理部２へ入力される。直交復調処理部２では、所定のキャリア周波数の互いに直交した信号がキャリア発生器２１から出力され、乗算器２２、２３にて入力信号とそれぞれ乗算される。乗算器２２、２３の出力ベースバンド信号は、それぞれデシメーションフィルタ２４、２５により サンプリングレートが降下され、所定のサンプリングレートとなる。この信号は、入力信号の変調方式、帯域等に適合した帯域制限フィルタ２６、２７によりそれぞれ帯域制限処理される。この帯域制限フィルタ２６、２７としてはナイキストフィルタが一般に用いられる。帯域制限フィルタ２６、２７の出力は復調処理２８へ入力され、入力信号の変調方式に適合した復調処理が行われ、復調データとして出力される。ここでデシメーションフィルタは、一般にＣＩＣフィルタ（Ｃａｓｃａｄｅｄ　Ｉｎｔｅｇｒａｔｏｒ－Ｃｏｍｂ　Ｆｉｌｔｅｒ）やハーフバンドフィルタ等により構成され、例えば入力信号が１２００　ｂａｕｄ／ｓのとき、４倍オーバサンプリングのレートとするときはデシメーションフィルタ出力のレートは４８００Ｈｚとなる。
【０００４】図５は復調処理２８の構成例で、図４の帯域制限フィルタ２６、２７からの信号は、ＡＧＣのための乗算／シフト回路５１、５２へ夫々入力され、この出力はレート変換回路５３で再びレート変換され、アナログ信号のときは直交／実信号変換器５５、５６によって直交信号から実信号への変換が行われる。位相／絶対値回路５４は、ディジタル信号のときの位相角を求めて復調に使えるようにし、また振幅を求めてＡＧＣループフィルタ５７へ出力する。選択／フォーマット変換回路５８は、ディジタル信号のときの多値数に応じた変換処理を行う。レート変換回路５３は、２つの入力信号の各々に対して、アップサンプラ５３１、５３２、ＬＰＦ（ローパスフィルタ）５３３、５３４、ダウンサンプラ５３５、５３６を用いてサンプリングレートの変換を行う。なお図４では省略したが、Ａ／Ｄ変換器１と直交復調処理部２との間にも、上記と同様の選択／フォーマット変換回路が設けられ、入力信号の同相・直交成分への分離が行われる。
【０００５】
【発明が解決しようとする課題】上記のように、最初のＡ／Ｄ変換器１では、入力信号の種々の変調方式、帯域に対しても十分なサンプリングレートとなるようなディジタル化が行われ、その後の帯域制限や復調処理では入力信号の変調方式や帯域に適したサンプリングレートでの処理が行われる。そしてこのためにデシメーションフィルタによるサンプリングレートの低減とレート変換回路によるレート変換が行われる。デシメーションフィルタは、ＣＩＣフィルタ（Ｃａｓｃａｄｅｄ　Ｉｎｔｅｇｒａｔｏｒ－Ｃｏｍｂ　Ｆｉｌｔｅｒ）やハーフバンドフィルタ等を用いて構成されるが、デシメーションフィルタ及びレート変換回路の出力側サンプリングレートとＡ／Ｄ変換器１のサンプリングレートとの比は整数比であり、入力信号に適した所望のサンプリングレートを実現できないことがある。
【０００６】本発明の目的は、種々の変調方式や帯域巾の信号を直交復調方式により復調する際の復調処理を、その変調方式や帯域巾に応じて自由に設定できるようにした受信装置を提供することにある。
【０００７】
【課題を解決するための手段】上記の目的を達成するために、本発明は、入力中間周波信号をディジタル化するＡ／Ｄ変換手段と、この手段から出力された中間周波信号を同相、直交成分に分けてそれぞれをベースバンド信号へ変換し、その各ベースバンド信号のサンプリングレートをデシメーションフィルタを用いて低減したのち周

波数帯域制限を行う直交復調処理手段と、前記Ａ／Ｄ変換手段のサンプリングレートとは独立にその出力周波数を設定可能なクロック発振器からのクロックを用いて前記直交復調処理手段からの同相及び直交ベースバンド信号をリサンプルしてサンプリングレートの変換を行うレート変換手段と、この手段によりサンプリングレートが変換されたベースバンド信号の復調処理を行う処理手段と、を備えたことを特徴とする受信装置を提供する。

【０００８】

【発明の実施の形態】以下、本発明の実施の形態を説明する。図１は、本発明の特徴とするレート変換回路の構成例で、図５のレート変換回路５３に代わって本発明の受信装置で用いられる。受信装置の他の部分の構成は図４、図５と同じである。図１に於いて、レート変換回路１００は、インターポレーションフィルタ１０１、１０２とハーフバンドフィルタ１０３、１０４及びクロック発振器１０５から構成され、インターポレーションフィルタ１０１、１０２への入力は、それぞれ図５の乗算／シフト回路５１、５２の出力であり、またハーフバンドフィルタ１０３、１０４の出力は、やはり図５と同様に直交／実信号変換器５５、５６と位相／絶対値回路５４の入力となる。クロック発振器１０５のクロック周波数は、復調処理に適した値をもち、これは入力される信号のサンプリングレートとは独立で、非同期である。

【０００９】図２は、インターポレーションフィルタ１０１の構成を示す図で、インターポレーションフィルタ１０２も同じ構成である。ゼロ値挿入回路１１１、ローパスフィルタ１１２，補間フィルタ１１３から成り、補間フィルタ１１３は図３に示す構成をもつ。即ちクロック発振器１０５からのクロックＣＬでサンプリングを行うリサンプラ１２１、減算器１２２、乗算器１２３、遅延回路１２４、加算器１２５から成っている。

＊【００１０】以上のような構成で、クロック発振器１０５の出力クロックＣＬの周波数を、レート変換回路１００への入力信号のサンプリングレートとは独立に、復調処理に適したサンプリングレートに選んでおき、このクロックＣＬで入力信号をリサンプルすることで、いつでも希望のサンプリングレートによる復調処理が可能になる。

【００１１】なお、図１等の各処理は、ＤＳＰ（Ｄｉｇｉｔａｌ　Ｓｉｇｎａｌ　Ｐｒｏｃｅｓｓｉｏｇ）に限らず、例えばＦＰＧＡ（Ｆｉｅｌｄ　Ｐｒｏｇｒａｍｍａｂｌｅ　Ｇａｔｅ　Ａｒｒａｙ）やゲートアレイ、汎用ロジック等で実現できることはいうまでもない。

【００１２】

【発明の効果】本発明によれば、信号の変調方式や変調速度／帯域巾に適したサンプリングレートを入力側Ａ／Ｄ変換器のサンプリングレートとは独立に選定できるという効果がある。

【図面の簡単な説明】

【図１】本発明の特徴とするレート変換回路の構成例を示すブロック図である。

【図２】図１のインターポレーションフィルタの構成図である。

【図３】図２の補間フィルタの構成図である。

【図４】種々の変調方式や帯域巾をもつ信号の受信装置の構成を示す図である。

【図５】図４の復調処理の構成を示す図である。

【符号の説明】

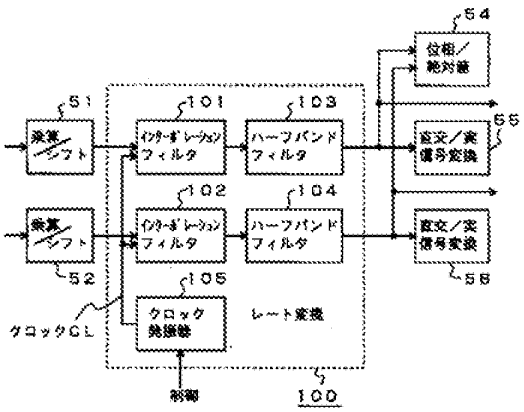
１００　レート変換回路

１０１、１０２　インターポレーションフィルタ

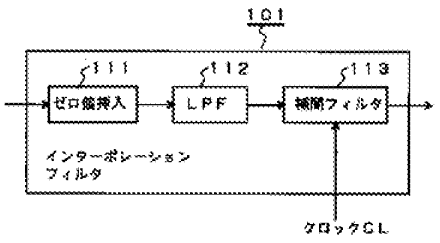
１０３、１０４　ハーフバンドフィルタ

１０５　クロック発振器

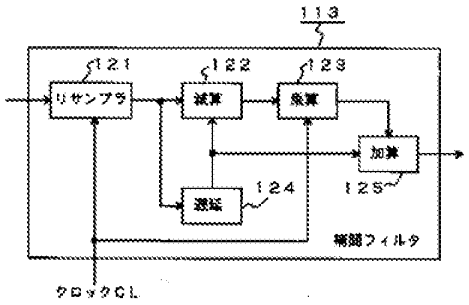
【図１】



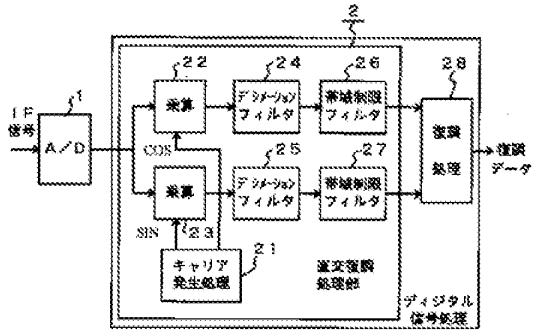

【図２】



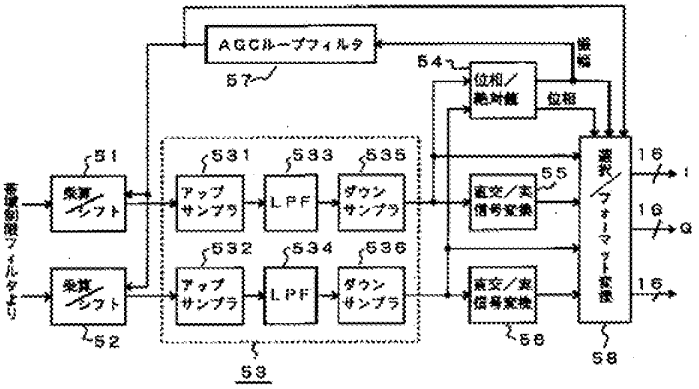
【図３】




【図４】




【図５】




フロントページの続き

Ｆターム(参考) 5K004 AA05 AA08 FC02 JG01
5K020 EE04 EE05 HH13 LL00
5K041 AA08 EE02 HH11 HH40 JJ14
JJ38

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16851044 |
| **Filing Date:** | 16-Apr-2020 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Filer:** | Mark S. Peloquin |
| **Attorney Docket Number:** | K41090.P8C3 |

Filed as Small Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| CLAIMS IN EXCESS OF 20 | 2202 | 35 | 50 | 1750 |
| INDEPENDENT CLAIMS IN EXCESS OF 3 | 2201 | 5 | 240 | 1200 |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
| Extension - 3 months with $0 paid | 2253 | 1 | 740 | 740 |
| **Miscellaneous:** | | | | |
| SUBMISSION- INFORMATION DISCLOSURE STMT | 2806 | 1 | 130 | 130 |
| STATUTORY OR TERMINAL DISCLAIMER | 2814 | 1 | 170 | 170 |
| | | **Total in USD ($)** | | **3990** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 42026887 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Mark S. Peloquin |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 25-FEB-2021 |
| **Filing Date:** | 16-APR-2020 |
| **Time Stamp:** | 17:03:04 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | EFT |
| Payment was successfully received in RAM | $3990 |
| RAM confirmation Number | E20212OH04384277 |
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| Authorized User | |
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| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
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| 1 | Extension of Time | 20210225K41090P8C3EXTTIME aia0022i.pdf | 772417<br>11d0d9193ba9864693460f97b755bfcccae05f9b | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Applicant Arguments/Remarks Made in an Amendment | 20210225K41090P8C3Respons etoOfficeActionv04USPTOREN UMBEREDCLAIMSasfiledi.pdf | 4042242<br>63d7888ad3e5c1f1c6c42be9bc0739c4f7922796 | no | 22 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Information Disclosure Statement (IDS) Form (SB08) | 20210225K41090P8C3IDSwSBA SBBCOMPLETEi.pdf | 1100656<br>3a7e74747cd6dc78b4127f494e9ab692e1940b10 | no | 4 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| This is not an USPTO supplied IDS fillable form | | | | | |
| 4 | Foreign Reference | 2JPA2010122191EngBiblioi.pdf | 5146390<br>d6f0f2a98c1b1940fc42c1279bb72ca281395e38 | no | 13 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 5 | Foreign Reference | 3JPA2000197180EngBiblioi.pdf | 4679197<br>aa1b1dc872ddc7a0ae2a238095e9aefacb269277 | no | 10 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 6 | Foreign Reference | 7JPA2002300224EngBiblioi.pdf | 1861661<br>377519e02473a802d02004058b0ea49500e37cad | no | 5 |
| **Warnings:** | | | | | |

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| 7 | Fee Worksheet (SB06) | fee-info.pdf | 37172<br>e124b300b66ad14cb84056feb10ce73e57c4d03b | no | 2 |
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**New Applications Under 35 U.S.C. 111**

**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

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# PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): K41090.P8C3

Application Number: 16/851,044

Filed: 04/16/2020

For: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

Art Unit: 2845

Examiner: MAI, LAM T

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

| | | Fee | Small Entity Fee | Micro Entity Fee | |
|---|---|---|---|---|---|
| ☐ | One month (37 CFR 1.17(a)(1)) | $220 | $110 | $55 | $ |
| ☐ | Two months (37 CFR 1.17(a)(2)) | $640 | $320 | $160 | $ |
| ☑ | Three months (37 CFR 1.17(a)(3)) | $1,480 | $740 | $370 | $ 740.00 |
| ☐ | Four months (37 CFR 1.17(a)(4)) | $2,320 | $1,160 | $580 | $ |
| ☐ | Five months (37 CFR 1.17(a)(5)) | $3,160 | $1,580 | $790 | $ |

☑ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☐ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number _____.

☑ Payment made via EFS-Web.

**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 50,787.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/MARK S PELOQUIN/ — Signature

FEBRUARY 25, 2021 — Date

MARK S PELOQUIN — Typed or printed name

(206) 447-1336 — Telephone Number

**NOTE:** This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

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6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

# IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | | |
|---|---|---|
| Appl. No. | : | 16/851,044 |
| Attorney Docket No. | : | 101404.P8C3 |
| Applicant | : | SOLOS TECHNOLOGY LIMITED |
| Filed | : | April 16, 2020 |
| TC/A.U. | : | 2845 |
| Examiner | : | MAI, LAM T |
| Confirmation No. | : | 9885 |

Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

## RESPONSE TO OFFICE ACTION

Sir:

In response to the Office Action mailed on 09/01/2020, Applicant makes the following amendment and asks the Office to consider the following remarks:

**Listing of Claims** starts on page 2 of this paper.

**Amendments to Specification** starts on page 19 of this paper.

**Remarks/Arguments** starts on page 20 of this paper.

**Amendments to the Claims:**

The listing of claims will replace all prior versions, and listings, of claims in the application:

**Listing of Claims:**

Claim 1 (original). A computer-readable storage medium storing program code for causing a data processing system to perform the steps comprising:

outputting a first oversampled digital signal output from an analog-to-digital converter (ADC), wherein the first oversampled digital signal is responsive to an analog field and the first oversampled digital signal is created at a sampling clock frequency;

delaying the first oversampled digital signal by a time delay wherein the time delay is equal to an integer number of sampling clock cycles to produce a time delayed first oversampled digital signal; and

combining the time delayed first oversampled digital signal with a second oversampled digital signal to obtain the beamformed digital signal, wherein the second oversampled digital signal is responsive to the analog field.

Claim 2 (original). The computer-readable storage medium of claim 1, wherein the combining is performed in an oversampled signal domain.

Claim 3 (original). The computer-readable storage medium of claim 1, wherein the combining is performed at an intermediate sampling rate.

Claim 4 (original). The computer-readable storage medium of claim 1, wherein the combining is performed in a baseband signal domain.

Claim 5 (original). The computer-readable storage medium of claim 1, wherein the first oversampled digital signal and the second oversampled digital signal are obtained from different sensors.

Claim 6 (original). The computer-readable storage medium of claim 1, wherein the first oversampled digital signal and the second oversampled digital signal are obtained from the same sensor.

Claim 7 (original). The computer-readable storage medium of claim 1, further comprising:

applying a low pass filter with decimation to the time delayed first oversampled digital signal to output a baseband digital signal that is delayed by the time delay.

Claim 8 (original). The computer-readable storage medium of claim 7, wherein the time delay is equal to a fraction of a baseband sampling period.

Claim 9 (original). The computer-readable storage medium of claim 7, wherein the time delay is greater than a baseband sampling period.

Claim 10 (original). The computer-readable storage medium of claim 7, wherein the first oversampled digital signal is digitized to create samples which are more than one bit deep.

Claim 11 (New). A system to time delay digital signals, comprising:

a digital sensor responsive to an analog field quantity, the digital sensor is configured to output an oversampled digital output signal at a sampling clock frequency;

a first time delay element, the first time delay element is configured to receive as an input the oversampled digital output signal and to output a time delayed oversampled digital output signal, wherein the time delayed oversampled digital output signal is time delayed by a fractional delay, the fractional delay is equal to an integer number of sampling clock cycles times the sampling clock period;

a filter, the filter is configured to receive as an input the time delayed oversampled digital output signal, the filter to low pass filter and to decimate to a lower sample rate the time delayed oversampled digital output signal and to output a low pass filtered decimated delayed digital output signal, wherein the lower sample rate is less than the sampling clock frequency;

a second time delay element, the second time delay element is configured to receive, as an input, the low pass filtered decimated delayed digital output signal and to impart an integer delay, the integer delay is an integer number of cycles at the lower sample rate times the lower sampling rate period, the integer delay is applied to the low pass filtered decimated time delayed digital output signal; and

a controller, the controller is configured to supply a control signal to set the fractional delay and the integer delay.

Claim 12 (New). The system of claim 11, wherein the digital sensor utilizes a sigma-delta modulator and the oversampled digital output signal is a pulse density modulated (PDM) signal.

Claim 13 (New). The system of claim 11, wherein the oversampled digital output signal is a pulse density modulated (PDM) signal.

Claim 14 (New). The system of claim 11, wherein the digital sensor is a digital microphone.

Claim 15 (New). The system of claim 14, wherein the digital microphone utilizes a micro-electromechanical systems (**MEMS**) sensor.

Claim 16 (New). The system of claim 11, wherein the analog field quantity is an acoustic pressure field.

Claim 17 (New). The system of claim 11, wherein the integer number of sampling clock cycles is selected from a range of one to the sampling clock frequency divided by a baseband sample rate.

Claim 18 (New). The system of claim of claim 13, wherein the filter is a PDM receiver.

Claim 19 (New). The system of claim 18, wherein the filter is a multistage filter further comprising:

a first stage, the first stage to low pass filter and to decimate to a first intermediate sampling rate the time delayed oversampled digital output signal; and

a second stage, wherein the second stage is configured to receive as an input an output from the first stage, the second stage to decimate the input to a baseband sample rate and to filter the input to a baseband signal bandwidth.

Claim 20 (New). The system of claim 18, wherein the filter is a multistage filter further comprising:

a first stage, the first stage to receive as a first stage input signal the time delayed oversampled digital output signal, the first stage to low pass filter and to decimate to a first intermediate sampling rate the first stage input signal to form a first stage output signal; and

a second stage, the second stage to receive as a second stage input signal the first stage output signal, the second stage to low pass filter and to decimate to a second intermediate sampling rate the second stage input signal to form a second stage output signal; and

a third stage, the third stage to receive as a third stage input signal the second stage output signal the third stage to decimate the third stage input signal to a baseband

sample rate and to filter the third stage input signal to a baseband signal bandwidth, wherein the first intermediate sampling rate is less than the sampling clock rate, the second intermediate sampling rate is less than the first intermediate sampling rate, and the baseband sampling rate is less that the second intermediate sampling rate.

Claim 21 (New). The system of claim 17, wherein the lower sample rate is a baseband sample rate and the low pass filtered decimated time delayed digital output signal is used in a beam forming process with a second signal, wherein the second signal is a digital measurement of the field quantity.

Claim 22 (New). A system to time delay signals, comprising:

a sensor element, the sensor element is responsive to an analog field quantity;

a sigma-delta modulator, the sensor element is electrically coupled to the sigma-delta modulator and is configured to produce a pulse density modulated (PDM) output signal at a sampling clock frequency responsive to the analog field quantity;

a first time delay element, the first time delay element is electrically configured to receive the PDM output signal, and to output a delayed PDM output signal, wherein the delayed PDM output signal is delayed by a fractional time delay equal to a number of cycles of the sampling clock frequency times a period of the sampling clock;

a decimation module, the decimation module is configured to receive as an input the delayed PDM output signal, the decimation module to low pass filter and to decimate to a lower sample rate the delayed PDM output signal and to output a low pass filtered decimated delayed PDM output signal, wherein the lower sample rate is less than the

sampling clock frequency, the decimation module to convert to pulse code modulation (PCM) format;

a second time delay element, the second time delay element is configured to receive, as an input, the low pass filtered decimated delayed PDM output signal and to impart an integer delay, the integer delay is an integer number of cycles at the lower sample rate times a period at the lower sampling rate, the integer delay is applied to the low pass filtered decimated delayed PDM output signal; and

a controller, the controller is configured to supply a control signal to set the fractional delay and the integer delay.

Claim 23 (New). The system of claim 22, the decimation module further comprising:

a first stage, the first stage to receive as a first stage input signal the delayed PDM output signal, the first stage to low pass filter and to decimate to a first intermediate sample rate the first stage input signal to form a first stage output signal, wherein the first intermediate sample rating is less than the sample clock frequency; and

a second stage, the second stage to receive as a second stage input signal the first stage output signal, the second stage to low pass filter and to decimate to the lower sample rate the second stage input signal, wherein the lower sample rate is lower than the first intermediate sampling rate, the decimation module to convert to pulse code modulation (PCM) format.

Claim 24 (New). The system of claim 22, the decimation module further comprising:

a first stage, the first stage to receive as a first stage input signal the delayed PDM output signal, the first stage to low pass filter and to decimate to a first intermediate sample rate the first stage input signal to form a first stage output signal, wherein the first intermediate sample rating is less than the sampling clock frequency;

a second stage, the second stage to receive as a second stage input signal the first stage output signal, the second stage to low pass filter and to decimate to a second intermediate sample rate the second stage input signal, wherein the second intermediate sample rate is lower than the first intermediate sample rate; and

a third stage, the third stage to receive as a third stage input signal the second stage output signal, the third stage to low pass filter and to decimate to the lower sample rate the third stage input signal, wherein the lower sample rate is lower than the second intermediate sample rate, the decimation module to convert to pulse code modulation (PCM) format.

Claim 25 (New). The system of claim 24, wherein the first stage employs a cascaded-integrator-comb (CIC) filter structure, the second stage is configured as two half-band filters, and the third stage is configured as a low pass filter.

Claim 26 (New). The system of claim 25, wherein a sampling clock operates at 2.048 MHz, the first stage provides 8:1 decimation, the second stage provides two 2:1 half band decimation stages, the third stage provides 4:1 decimation which results in a

baseband sampling rate of 16 kHz, low pass filtering throughout the decimation module filters high frequency components from the sigma-delta modulation process.

Claim 27 (New). The system of claim 26, wherein the sampling clock frequency is selected from the group consisting of 1 MHz to 4 MHz and a user defined sampling rate.

Claim 28 (New). The system of claim 27, wherein the digital sensor is a digital microphone and the field quantity is acoustic pressure.

Claim 29 (New). The system of claim 28, wherein the digital microphone utilizes a micro-electromechanical systems (**MEMS**) sensor.

Claim 30 (New). The system of claim 22, wherein the first time delay element is a buffer, wherein a minimum length of the buffer is equal to the sampling clock frequency divided by the lower sample rate and the time delay is equal to a value of the buffer.

Claim 31 (New). The system of claim 30, wherein the first time delay is programmable by specifying a value of the buffer with the control signal.

Claim 32 (New). The system of claim 22, wherein the first time delay element is implemented with a delay line.

Claim 33 (New). The system of claim 32, where the time delay provided by the delay line is programmable with the control signal.

Claim 34 (New). The system of claim 22, wherein the fractional time delay is equal to a fraction of a baseband sampling period.

Claim 35 (New). The system of claim 22, wherein the fractional time delay is greater than a baseband sampling period.

Claim 36 (New). A decimation module for use in time delaying digital signals, comprising:

a general number of N stages, the decimation module having as an input an oversampled digital output signal from a digital sensor;

an $i^{th}$ stage, the $i^{th}$ stage to low pass filter and to decimate to an $i^{th}$ intermediate sampling rate an $i^{th}$ stage input signal to form an $i^{th}$ stage output signal, wherein the $i^{th}$ intermediate sample rating is less than a sampling clock frequency used to create the oversampled digital output signal;

a first time delay element, the first time delay element to delay the $i^{th}$ stage output signal by a fractional time delay, wherein the fractional time delay is equal to an integer number of $i^{th}$ intermediate sampling rate cycles times the $i^{th}$ intermediate sampling rate period, the first time delay element to output a delayed $i^{th}$ stage output signal;

an i +1 stage, the i +1 stage to receive as an i +1 stage input signal the delayed $i^{th}$ stage output signal, the i+1 stage to low pass filter and to decimate to an i+1 intermediate

sampling rate the i+1 stage input signal to form an i+1 stage output signal, wherein the i+1 intermediate sampling rate is lower than the $i^{th}$ intermediate sampling rate;

a second time delay element, the second time delay element is configured to receive, as an input, the i+1 stage output signal and to impart an integer delay, the integer delay is equal to an integer number of cycles at the i+1 intermediate sampling rate times the $i^{th}$ intermediate sampling rate period, the integer delay is applied to the i+1 stage output signal, the i+1 intermediate sampling rate is a baseband sampling rate, the i+1 stage output signal is an output signal from the decimation module that is time delayed by a combined time delay, the combined time delay is a sum of the fractional time delay and the integer time delay; and

a controller, the controller is configured to supply a control signal to set the fractional time delay and the integer time delay.

Claim 37 (New). The decimation module of claim 36, wherein the digital sensor is a digital microphone and the combined time delay is used during a beam forming operation with the output signal from the decimation module.

Claim 38 (New). A method to delay digital signals, comprising:

sensing an analog field;

outputting an oversampled digital signal responsive to the sensing, wherein the oversampled digital signal is created at a sampling clock rate;

delaying the oversampled digital signal by a fractional time delay wherein the fractional time delay is equal to an integer number of sampling clock cycles to produce a delayed oversampled digital signal;

applying a low pass filter with decimation to the delayed oversampled digital signal to output a baseband digital signal that is delayed by the fractional time delay; and

delaying the baseband digital signal by an integer time delay, wherein the integer time delay is equal to a number of cycles at a baseband sampling rate times the baseband sampling rate period.

Claim 39 (New). The method of claim 38, wherein the fractional time delay is equal to a fraction of a baseband sampling period.

Claim 40 (New). The method of claim 38, wherein the fractional time delay is greater than a baseband sampling period.

Claim 41 (New). The method of claim 38, wherein the oversampled digital signal is digitized to create samples which are more than one bit deep.

Claim 42 (New). A computer-readable storage medium storing program code for causing a data processing system to perform the steps comprising:

receiving signals from a digital sensor, the signals are responsive to an analog field;

processing the signals to create an oversampled digital signal responsive to the receiving, wherein the oversampled digital signal is created at a sampling clock rate; and

delaying the oversampled digital signal by a fractional time delay wherein the fractional time delay is equal to an integer number of sampling clock cycles times the sampling clock period to produce a delayed oversampled digital signal;

applying a low pass filter with decimation to the delayed oversampled digital signal to output a baseband digital signal that is delayed by the fractional time delay; and

delaying the baseband digital signal by an integer time delay, wherein the integer time delay is equal to a number of sampling clock cycles times the sampling clock period at a baseband sampling rate.

Claim 43 (New). The computer readable storage medium of claim 42, wherein the fractional time delay is equal to a fraction of a baseband sampling period.

Claim 44 (New). The computer readable storage medium of claim 42, wherein the fractional time delay is greater than a baseband sampling period.

Claim 45 (New). The computer readable storage medium of claim 42, wherein the oversampled digital signal is digitized to create samples which are more than one bit deep.

Claim 46 (New). A system to delay digital signals, comprising:

sensing means for measuring an analog field quantity;

over sampling means, the over sampling means to over sample a signal detected by the sensing means resulting in an oversampled digital signal;

fractional delaying means, the fractional delaying means to apply a fractional time delay to the oversampled digital signal, the fractional time delay is equal to an integer number of sampling clock cycles times the sampling clock period, resulting in a delayed oversampled digital signal;

decimating means, the decimating means to receive the delayed oversampled digital signal and to low pass filter and to decimate to a lower sampling rate.;

integer delaying means, the integer delaying means to apply an integer time delay to the delayed oversampled digital signal, the integer time delay is a number of lower sampling rate cycles; and

controlling means, the controlling means to adjust the fractional time delay and the integer time delay to establish a total time delay, wherein ~~the~~ a resulting digital signal is delayed by a total time delay, wherein the total time delay is a sum of the fractional time delay and the integer time delay, and contains a digital representation of the analog field quantity without the noise introduced by the over sampling means.

Claim 47 (New). The system of claim 46, wherein the decimating means is accomplished in a multistage module.

Claim 48 (New). The system of claim 46, wherein the total time delay is equal to a fraction of a baseband sampling period.

Claim 49 (New). The system of claim 46, wherein the total time delay is greater than a baseband sampling period.

Claim 50 (New). The system of claim 46, wherein the oversampled digital signal is digitized to create samples which are more than one bit deep.

Claim 51 (New). A system to time delay digital signals, comprising:

a digital sensor responsive to an analog field quantity, the digital sensor is configured to output an oversampled digital output signal at a sampling clock frequency;

a replicator, the replicator to receive the oversampled digital output signal and to output a first replica of the oversampled digital output signal and a second replica of the oversampled digital output signal;

a first fractional time delay element, the first fractional time delay element is configured to receive as an input the first replica and to output a first time delayed oversampled digital output signal;

a first filter, the first filter is configured to receive as an input the first time delayed oversampled digital output signal, the first filter to low pass filter and to decimate to a lower sample rate the first time delayed oversampled digital output signal and to output a first low pass filtered decimated delayed digital output signal, wherein the lower sample rate is less than the sampling clock frequency;

a first integer time delay element, the first integer time delay element is configured to receive, as an input, the first low pass filtered decimated delayed digital

output signal and to output a first time delayed digital output signal at the lower sample rate;

a second fractional time delay element, the second fractional time delay element is configured to receive as an input the second replica and to output a second time delayed oversampled digital output signal;

a second filter, the second filter is configured to receive as an input the second time delayed oversampled digital output signal, the second filter to low pass filter and to decimate to a lower sample rate the second time delayed oversampled digital output signal and to output a second low pass filtered decimated delayed digital output signal; and

a second integer time delay element, the second integer time delay element is configured to receive, as an input, the second low pass filtered decimated delayed digital output signal and to output a second time delayed digital output signal at the lower sample rate.

Claim 52 (New). The system of claim 51, wherein the replicator is a splitter.

Claim 53 (New). The system of claim 52, wherein the splitter is an **n**-way splitter.

Claim 54 (New). The system of claim 51, wherein the first time delayed digital output signal and the second time delayed digital output signal are used for beamforming.

Claim 55 (New). The system of claim 51, further comprising:

a sigma-delta modulator, the digital sensor is electrically coupled to the sigma-delta modulator and is configured to produce a pulse density modulated (PDM) output signal at the sampling clock frequency responsive to the analog field quantity.

**AMENDMENTS TO SPECIFICATION**

Kindly amend Specification paragraph [0063] as shown below. No new matter has been entered.

[0063] In operation, a time delay $\Delta t_1$ is associated with the digital signal output at 912 for the digital microphone 920. Similarly, a time delay $\Delta t_2$ is associated with the digital signal output at 914 for the digital microphone ~~930~~940. And a time delay $\Delta t_n$ is associated with the digital signal output at 916 for the digital microphone 960. A controller 904 is used to supply one or more control signals to each signal path 906, 908, up to 910. As described above in the preceding figures, a control signal 922 supplied to a time delay element 924 is used to specify a time delay applied by the time delay element 924 to the oversampled digital signal received from the microphone 920. Optionally, the controller 904 can supply a control signal 928 to a time delay element ~~940~~930 (if present in a given system configuration). Similarly, a control signal 942 supplied to a time delay element 944 is used to specify a time delay applied by the time delay element 944 to the oversampled digital signal received from the microphone 940. Optionally, the controller 904 can supply a control signal 948 to a time delay element 950 (if present in a given system configuration). Control signals are supplied as need to successive microphone signal paths, and finally within microphone signal path 910 a control signal 962 supplied to a time delay element 964 which is used to specify a time delay applied by the time delay element 964 to the oversampled digital signal received from the microphone 960. Optionally, the controller 904 can supply a control signal 968 to a time delay element 970 (if present in a given system configuration).

**NONSTATUTORY DOUBLE PATENTING REJECTION**

In the Office Action, mail date September 09, 2020 the Office issued a nonstatutory double patenting rejected of all pending claims 1-10 over the issued claims in US Patents: U.S. Patent No. 10,651,866.

Applicant files herewith an eTerminal Disclaimer to remove the statutory double patenting rejections.

**NEW CLAIMS**

New claims 11 through 55 are presented for examination herein. Applicant requests entry of new claims 11 through 55.

**CONCLUSION**

All pending claims are in condition for allowance. Applicant requests a timely notice of allowance.

Respectfully submitted,
PELOQUIN, PLLC

February 25, 2021
Date

/Mark S. Peloquin/
Mark S. Peloquin, Esq.
USPTO Registration # 50,787

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

| **PATENT APPLICATION FEE DETERMINATION RECORD**<br>Substitute for Form PTO-875 | Application or Docket Number<br>16/851,044 | Filing Date<br>04/16/2020 | ☐ To be Mailed |
|---|---|---|---|

**ENTITY:** ☑ LARGE ☐ SMALL ☐ MICRO

## APPLICATION AS FILED - PART I

| FOR | (Column 1)<br>NUMBER FILED | (Column 2)<br>NUMBER EXTRA | | RATE ($) | FEE ($) |
|---|---|---|---|---|---|
| ☐ BASIC FEE<br>(37 CFR 1.16(a), (b), or (c)) | N/A | N/A | | N/A | |
| ☐ SEARCH FEE<br>(37 CFR 1.16(k), (i), or (m)) | N/A | N/A | | N/A | |
| ☐ EXAMINATION FEE<br>(37 CFR 1.16(o), (p), or (q)) | N/A | N/A | | N/A | |
| TOTAL CLAIMS<br>(37 CFR 1.16(i)) | minus 20 = | * | | x $100 = | |
| INDEPENDENT CLAIMS<br>(37 CFR 1.16(h)) | minus 3 = | * | | x $460 = | |
| ☐ APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | | |
| ☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | | TOTAL | |

## APPLICATION AS AMENDED - PART II

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | 02/25/2021 | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total (37 CFR 1.16(i)) | * 55 | Minus | ** 20 | = 35 | | x $100 = | 3500 |
| | Independent (37 CFR 1.16(h)) | * 8 | Minus | *** 3 | = 5 | | x $480 = | 2400 |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | 5900 |

| | | (Column 1) | | (Column 2) | (Column 3) | | | |
|---|---|---|---|---|---|---|---|---|
| AMENDMENT | | CLAIMS REMAINING AFTER AMENDMENT | | HIGHEST NUMBER PREVIOUSLY PAID FOR | PRESENT EXTRA | | RATE ($) | ADDITIONAL FEE ($) |
| | Total (37 CFR 1.16(i)) | * | Minus | ** | = | | x $0 = | |
| | Independent (37 CFR 1.16(h)) | * | Minus | *** | = | | x $0 = | |
| | ☐ Application Size Fee (37 CFR 1.16(s)) | | | | | | | |
| | ☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | |
| | | | | | | | TOTAL ADD'L FEE | |

| | |
|---|---|
| * If the entry in column 1 is less than the entry in column 2, write "0" in column 3. | LIE |
| ** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20". | /SHEILA D CHAPMAN/ |
| *** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3". | |
| The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1. | |

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.*

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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www.uspto.gov

| APPLICATION NO. | FILING DATE | FIRST NAMED INVENTOR | ATTORNEY DOCKET NO. | CONFIRMATION NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 | 9885 |

51340 7590 09/01/2020

PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

| EXAMINER | |
|---|---|
| MAI, LAM T | |

| ART UNIT | PAPER NUMBER |
|---|---|
| 2845 | |

| MAIL DATE | DELIVERY MODE |
|---|---|
| 09/01/2020 | PAPER |

**Please find below and/or attached an Office communication concerning this application or proceeding.**

The time period for reply, if any, is set in the attached communication.

| *Office Action Summary* | Application No. 16/851,044 | Applicant(s) FAN et al. | |
|---|---|---|---|
| | Examiner LAM T MAI | Art Unit 2845 | AIA (FITF) Status Yes |

*-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --*

**Period for Reply**

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

**Status**

1)☑ Responsive to communication(s) filed on 4/16/2020.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL.** 2b) ☑ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

**Disposition of Claims***

5) ☑ Claim(s) 1-10 is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6) ☐ Claim(s) _____ is/are allowed.

7) ☑ Claim(s) 1-10 is/are rejected.

8) ☐ Claim(s) _____ is/are objected to.

9) ☐ Claim(s) _____ are subject to restriction and/or election requirement

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to **PPHfeedback@uspto.gov.**

**Application Papers**

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

**Priority under 35 U.S.C. § 119**

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

**Certified copies:**

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

**Attachment(s)**

1) ☑ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date _____.

4) ☐ Other: _____.

**DETAILED ACTION**

***Notice of Pre-AIA or AIA Status***

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

***Claim Rejections - 35 USC § 112***

The following is a quotation of 35 U.S.C. 112(b):
(b) CONCLUSION.—The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the inventor or a joint inventor regards as the invention.

The following is a quotation of 35 U.S.C. 112 (pre-AIA), second paragraph:
The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claim 1 recites the limitation "the beamformed digital signal" in the claim on line 10. There is insufficient antecedent basis for this limitation in the claim.

Claims 2-10 are rejected under 112(b) as well as being depended on based rejected claim 1.

***Double Patenting***

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the “right to exclude” granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP § 2146 *et seq.* for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

Claim 1 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 1 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: outputting a first oversampled digital signal output from an analog-to-digital converter (ADC), wherein the first oversampled digital signal is responsive to an analog field and the first oversampled digital signal is created at a sampling clock frequency; delaying the first oversampled digital signal by a time delay wherein the time delay is equal to an integer number of sampling clock cycles to produce a time delayed

first oversampled digital signal: and combining the time delayed first oversampled digital signal with a second oversampled digital signal to obtain the beamformed digital signal. wherein the second oversampled digital signal is responsive to the analog field.

Claim 2 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 2 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: wherein, the combining is performed in a oversampled signal domain.

Claim 3 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 3 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: wherein the combining is performed at an intermediate sampling rate.

Claim 4 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 4 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: wherein the combining is performed in a baseband signal domain.

Claim 5 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 5 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and

functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: wherein the first oversampled digital siiznal and the second oversampled digital signal are obtained from different sensors.

Claim 6 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 6 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: wherein the first oversampled digital signal and the second oversampled digital signal are obtained from the same sensor.

Claim 7 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 7 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: applying a low pass filter with decimation to the time delayed first oversampled digital signal to output a baseband digital signal that is delayed by the time delay.

Claim 8 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 8 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: wherein the time delay is equal to a fraction of a baseband sampling period.

Claim 9 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 9 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: wherein the time delay is greater than a baseband sampling period.

Claim 10 is rejected on the ground of nonstatutory double patenting as being unpatentable over claim 10 of U.S. Patent No. USP 10,651,866. Although the claims at issue are not identical, they are not patentably distinct from each other because the USP 10,651,866 disclosed similar limitations and functions as claimed in instant application. Although, the instant application claim computer program while the USP 10,651,866 disclosed a method of creating beamformed digital signal, such as: wherein the first oversampled digital signal is digitized to create samples which are more than one bit deep.

***Conclusion***

Any inquiry concerning this communication or earlier communications from the examiner should be directed to LAM T MAI whose telephone number is **571 272-1807**. The examiner can normally be reached on Monday-Thursday 7am-530pm.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at http://www.uspto.gov/interviewpractice.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Dameon Levi can be reached on 571-272-2105. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained

from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see https://ppair-my.uspto.gov/pair/PrivatePair. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

***/LAM T MAI/***
***Primary Examiner, Art Unit 2845***

| Notice of References Cited | Application/Control No. 16/851,044 | Applicant(s)/Patent Under Reexamination FAN et al. | |
|---|---|---|---|
| | Examiner LAM T MAI | Art Unit 2845 | Page 1 of 1 |

**U.S. PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Name | CPC Classification | US Classification |
|---|---|---|---|---|---|---|
| * | A | US-20110271957-A1 | 11-2011 | Matis; Robert J. | A61K31/57 | 128/203.12 |
| * | B | US-20140009564-A1 | 01-2014 | Cleve; Pascal | H04M3/568 | 348/14.08 |
| * | C | US-9941895-B2 | 04-2018 | Fan; Dashen | H03M1/1245 | 1/1 |
| * | D | US-10298253-B1 | 05-2019 | Fan; Dashen | H03M3/462 | 1/1 |
| * | E | US-10651866-B1 | 05-2020 | Fan; Dashen | H03M3/462 | 1/1 |
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**FOREIGN PATENT DOCUMENTS**

| * | | Document Number Country Code-Number-Kind Code | Date MM-YYYY | Country | Name | CPC Classification |
|---|---|---|---|---|---|---|
| | N | | | | | |
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**NON-PATENT DOCUMENTS**

| * | | Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages) |
|---|---|---|
| | U | |
| | V | |
| | W | |
| | X | |

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/851,044 | FAN et al. |
| | Examiner | Art Unit |
| | LAM T MAI | 2845 |

| CPC - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
| H03M1/1245.cpc. | 08/29/2020 | lammai |
| H04B7/0617.cpc. | 08/29/2020 | lammai |
| H03M3//462.cpc. | 08/29/2020 | lammai |

| CPC Combination Sets - Searched* | | |
|---|---|---|
| Symbol | Date | Examiner |
| | | |

| US Classification - Searched* | | | |
|---|---|---|---|
| Class | Subclass | Date | Examiner |
| 341 | 122-160 | 08/29/2020 | lammai |

* See search history printout included with this form or the SEARCH NOTES box below to determine the scope of the search.

| Search Notes | | |
|---|---|---|
| Search Notes | Date | Examiner |
| Global Dossier/Google Scholar/NPL Search/IP.com/Plus/East Text Search | 08/29/2020 | lammai |
| Inventors and Assignee | 08/29/2020 | lammai |
| Reviewed Related Application 15/225,745 and 15/947,845 and 16/399867 | 08/29/2020 | lammai |

| /LAM T MAI/<br>Primary Examiner.Art Unit 2845 | |
|---|---|

| Search Notes | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/851,044 | FAN et al. |
| | Examiner | Art Unit |
| | LAM T MAI | 2845 |

| Interference Search | | | |
|---|---|---|---|
| US Class/CPC Symbol | US Subclass/CPC Group | Date | Examiner |
| H03M1 | 1245 | 08/29/2020 | lammai |
| H04B7 | 0617 | 08/29/2020 | lammai |
| H03M3 | 462 | 08/29/2020 | lammai |

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|---|---|
| /LAM T MAI/<br>Primary Examiner.Art Unit 2845 | |

| Index of Claims | Application/Control No. | Applicant(s)/Patent Under Reexamination |
|---|---|---|
| | 16/851,044 | FAN et al. |
| | Examiner | Art Unit |
| | LAM T MAI | 2845 |

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|---|---|---|---|---|---|---|---|
| ✓ | Rejected | - | Cancelled | N | Non-Elected | A | Appeal |
| = | Allowed | ÷ | Restricted | I | Interference | O | Objected |

**CLAIMS**

☑ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

| CLAIM | | DATE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Final | Original | 08/29/2020 | | | | | | | | |
| | 1 | ✓ | | | | | | | | |
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| | 3 | ✓ | | | | | | | | |
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| | 7 | ✓ | | | | | | | | |
| | 8 | ✓ | | | | | | | | |
| | 9 | ✓ | | | | | | | | |
| | 10 | ✓ | | | | | | | | |

**EAST Search History**

**EAST Search History (Interference)**

| Ref # | Hits | Search Query | DBs | Default Operator | Plurals | Time Stamp |
|---|---|---|---|---|---|---|
| L16 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L17 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L18 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L43 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L44 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L45 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L46 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L47 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L48 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L49 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L50 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L51 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L52 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L53 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L54 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:17 |
| L55 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L56 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L57 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |

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| L58 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L59 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L60 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L61 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L62 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L63 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L64 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L65 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L66 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L67 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L68 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L69 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L70 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L71 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L72 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L73 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L74 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L75 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L76 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L77 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |

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| L78 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L79 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L80 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L81 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L82 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L83 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L84 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L85 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L86 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L87 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L88 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L89 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L90 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L91 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L92 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L93 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L94 | 12 | (digital adj sensor and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L95 | 140 | (sigma near delta and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L96 | 15 | (sigma near delta and oversampl$4 and time adj delay).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L97 | 3 | (digital adj sensor and time adj delay and oversampl$4 adj digital adj output).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |

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|---|---|---|---|---|---|---|
| L98 | 3 | (beamform$4 adj digital adj signal and delay$4 near tim$4).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |
| L99 | 7 | (beamform$4 and time near delay$4 and oversampl$4).clm. | US-PGPUB; USPAT | OR | ON | 2020/08/30 09:18 |

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Main Concept Text

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outputting a first oversampled digital signal output from an analog-to-digital converter (ADC), wherein the first oversampled digital signal is responsive to an analog field and the first oversampled digital signal is created at a sampling clock frequency; delaying the first oversampled digital signal by a time delay wherein the time delay is equal to an integer number of sampling clock cycles to produce a time delayed first oversampled digital signal: and combining the time delayed first oversampled digital signal with a second oversampled digital signal to obtain the beamformed digital signal. wherein the second oversampled digital signal is responsive to the analog field.

(No Concept Modifiers)

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(No Filters)

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Options

IQQueryQuickExport-202008292111

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De-dup: None

Cut-off: None

Sort: Relevance

Content: Patent Publications (164)

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US Patents

US Designs

US Applications

EPO Patents

EPO Applications

China Patents

China Applications

Japan Patents

Japan Applications

Korea Patents

Korea Applications

WIPO Applications

Argentina Patents

Argentina Applications

Brazil Patents

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Canada Applications

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Morocco Applications
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EAPO Applications
Georgia Patents
Georgia Applications
Kazakhstan Patents
Kazakhstan Applications
Russia Patents
Russia Applications
Turkey Patents
Turkey Applications

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Main Concept Text

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ADC includes a digital sensor responsive to an analog field quantity. The digital sensor is configured to output an oversampled digital output signal at a sampling clock frequency. A time delay element is configured to receive as an input, the oversampled digital output signal and to output a time delayed oversampled digital output signal. A filter is configured to receive as an input the delayed oversampled digital output signal. The filter low pass filters and decimates to a lower sample rate the delayed oversampled digital output signal. An output includes a low pass filtered decimated delayed digital output signal, where the lower sample rate is less than the sampling clock frequency

(No Concept Modifiers)

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(No Filters)

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Options

IQQueryQuickExport-202008292110

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De-dup: None

Cut-off: None

Sort: Relevance

Content: Patent Publications (164)

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US Patents

US Designs

US Applications

EPO Patents

EPO Applications

China Patents

China Applications

Japan Patents

Japan Applications

Korea Patents

Korea Applications

WIPO Applications

Argentina Patents

Argentina Applications

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Brazil Applications

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Canada Applications

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# BIB DATA SHEET

**CONFIRMATION NO. 9885**

| SERIAL NUMBER | FILING or 371(c) DATE | CLASS | GROUP ART UNIT | ATTORNEY DOCKET NO. |
|---|---|---|---|---|
| 16/851,044 | 04/16/2020<br>**RULE** | 341 | 2845 | K41090.P8C3 |

**APPLICANTS**
SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG

**INVENTORS**
Dashen FAN, Bellevue, WA;
Joseph Yong KWON, San Jose, CA;

** **CONTINUING DATA** *************************
This application is a CON of 16/399,867 04/30/2019 PAT 10651866
which is a CON of 15/947,845 04/08/2018 PAT 10298253
which is a CON of 15/225,745 08/01/2016 PAT 9941895

** **FOREIGN APPLICATIONS** *************************

** **IF REQUIRED, FOREIGN FILING LICENSE GRANTED** ** ** SMALL ENTITY **
04/22/2020

| Foreign Priority claimed ❑ Yes ☑ No<br>35 USC 119(a-d) conditions met ❑ Yes ☑ No<br>Verified and Acknowledged /LAM T MAI/ Examiner's Signature | ☑ Met after Allowance<br>lm Initials | STATE OR COUNTRY | SHEETS DRAWINGS | TOTAL CLAIMS | INDEPENDENT CLAIMS |
|---|---|---|---|---|---|
| | | WA | 20 | 10 | 1 |

**ADDRESS**

PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100
UNITED STATES

**TITLE**

BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

| FILING FEE RECEIVED | FEES: Authority has been given in Paper | |
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| 865 | No.____________ to charge/credit DEPOSIT ACCOUNT<br>No.____________ for following: | ❑ All Fees<br>❑ 1.16 Fees (Filing)<br>❑ 1.17 Fees (Processing Ext. of time)<br>❑ 1.18 Fees (Issue)<br>❑ Other ________________<br>❑ Credit |

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PLUS Search Results for S/N 16851044, Searched Mon Aug 31 11:34:53 EDT 2020

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5561425 99
5790072 98
5222101 97
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| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 |

**CONFIRMATION NO. 9885**

51340
PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

**INFORMAL NOTICE**

*OC000000119498894*

Date Mailed: 08/26/2020

## INFORMATIONAL NOTICE TO APPLICANT

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

The item(s) indicated below are also required and should be submitted with any reply to this notice to avoid further processing delays.

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):
  Dashen FAN
  Joseph Yong KWON

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/tlulu/

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| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | 2845 | 865 | K41090.P8C3 | 10 | 1 |

**CONFIRMATION NO. 9885**

**UPDATED FILING RECEIPT**

51340
PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

OC000000119498533

Date Mailed: 08/26/2020

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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**Inventor(s)**

Dashen FAN, Bellevue, WA;
Joseph Yong KWON, San Jose, CA;

**Applicant(s)**

SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG

**Assignment For Published Patent Application**

SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG

**Power of Attorney:** None

**Domestic Priority data as claimed by applicant**

This application is a CON of 16/399,867 04/30/2019 PAT 10651866
which is a CON of 15/947,845 04/08/2018 PAT 10298253
which is a CON of 15/225,745 08/01/2016 PAT 9941895

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 04/22/2020
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/851,044**
**Projected Publication Date:** Request for Non-Publication Acknowledged
**Non-Publication Request:** Yes
**Early Publication Request:** No
**** SMALL ENTITY ****
**Title**

BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

**Preliminary Class**

341

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

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Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

## LICENSE FOR FOREIGN FILING UNDER

## Title 35, United States Code, Section 184

## Title 37, Code of Federal Regulations, 5.11 & 5.15

**GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

**NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

---

## *SelectUSA*

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

## PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/851,044

### APPLICATION AS FILED - PART I

| FOR | (Column 1) NUMBER FILED | (Column 2) NUMBER EXTRA | SMALL ENTITY RATE($) | SMALL ENTITY FEE($) | OR | OTHER THAN SMALL ENTITY RATE($) | OTHER THAN SMALL ENTITY FEE($) |
|---|---|---|---|---|---|---|---|
| BASIC FEE (37 CFR 1.16(a), (b), or (c)) | N/A | N/A | N/A | 75 | | N/A | |
| SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | 330 | | N/A | |
| EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | 380 | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | 10 minus 20 = | * | x 50 = | 0.00 | OR | | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | 1 minus 3 = | * | x 230 = | 0.00 | | | |
| APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | 0.00 | | | |
| MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | 0.00 | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | 785 | | TOTAL | |

### APPLICATION AS AMENDED - PART II

AMENDMENT A

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE($) | SMALL ENTITY ADDITIONAL FEE($) | OR | OTHER THAN SMALL ENTITY RATE($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | x = | | OR | x = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | x = | | OR | x = | |
| Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

AMENDMENT B

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | RATE($) | ADDITIONAL FEE($) | | RATE($) | ADDITIONAL FEE($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | x = | | OR | x = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | x = | | OR | x = | |
| Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 |

**CONFIRMATION NO. 9885**

51340
PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

**FORMALITIES LETTER**

OC000000116465151

Date Mailed: 04/23/2020

# NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

**FILED UNDER 37 CFR 1.53(b)**

***Filing Date Granted***

**Items Required To Avoid Abandonment:**

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing.

Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- Surcharge as set forth in 37 CFR 1.16(f) must be submitted.
  The surcharge is due for any one of:
  - late submission of the basic filing fee, search fee, or examination fee,
  - late submission of inventor's oath or declaration,
  - filing an application that does not contain at least one claim on filing, or
  - submission of an application filed by reference to a previously filed application.

**SUMMARY OF FEES DUE:**

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $ **80** surcharge.
- $( **0**) previous unapplied payment amount.
- $ **80** TOTAL FEE BALANCE DUE.

**Items Required To Avoid Processing Delays:**

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):

Dashen FAN
Joseph Yong KWON

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/mhaile/

PTO/AIA/22 (03-13)
Approved for use through 11/30/2020. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

# PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): K41090.P8C3

Application Number: 16/851,044

Filed: 04/16/2020

For: BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

Art Unit: 2845

Examiner: Not yet assigned

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

| | | Fee | Small Entity Fee | Micro Entity Fee | |
|---|---|---|---|---|---|
| ☐ | One month (37 CFR 1.17(a)(1)) | $200 | $100 | $50 | $ |
| ☑ | Two months (37 CFR 1.17(a)(2)) | $600 | $300 | $150 | $ 300.00 |
| ☐ | Three months (37 CFR 1.17(a)(3)) | $1,400 | $700 | $350 | $ |
| ☐ | Four months (37 CFR 1.17(a)(4)) | $2,200 | $1,100 | $550 | $ |
| ☐ | Five months (37 CFR 1.17(a)(5)) | $3,000 | $1,500 | $750 | $ |

☑ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☐ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number _____.

☑ Payment made via EFS-Web.

**WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.**

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 50,787.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

/MARK S. PELOQUIN/ — Signature

AUGUST 24, 2020 — Date

MARK S PELOQUIN — Typed or printed name

(206) 447-1336 — Telephone Number

**NOTE:** This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

# Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (*i.e.*, GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | 16851044 |
| **Filing Date:** | 16-Apr-2020 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Filer:** | Mark S. Peloquin |
| **Attorney Docket Number:** | K41090.P8C3 |

Filed as Small Entity

**Filing Fees for Utility under 35 USC 111(a)**

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Basic Filing:** | | | | |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| LATE FILING FEE FOR OATH OR DECLARATION | 2051 | 1 | 80 | 80 |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |
| **Post-Allowance-and-Post-Issuance:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Extension-of-Time:** | | | | |
| Extension - 2 months with $0 paid | 2252 | 1 | 300 | 300 |
| **Miscellaneous:** | | | | |
| | | | **Total in USD ($)** | **380** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 40368779 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | Dashen FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Mark S. Peloquin |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 24-AUG-2020 |
| **Filing Date:** | 16-APR-2020 |
| **Time Stamp:** | 18:46:44 |
| **Application Type:** | Utility under 35 USC 111(a) |

## Payment information:

| | |
|---|---|
| Submitted with Payment | yes |
| Payment Type | EFT |
| Payment was successfully received in RAM | $380 |
| RAM confirmation Number | E20208NI47036042 |
| Deposit Account | |
| Authorized User | |
| The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: | |

## File Listing:

| Document Number | Document Description | File Name | File Size(Bytes)/ Message Digest | Multi Part /.zip | Pages (if appl.) |
|---|---|---|---|---|---|
| 1 | Applicant Response to Pre-Exam Formalities Notice | 20200423K41090P8C3NFTCAPi.pdf | 292909<br>5c60334fd16e6adbb56853199152a27db4c50340 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Extension of Time | 20200824K41090P8C3EXTTIMEaia0022i.pdf | 464270<br>f1d5ca1c3038cb13e8ca48f1461d6a739e0bff1e | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 3 | Fee Worksheet (SB06) | fee-info.pdf | 32626<br>2a0dcfeb0fed243dba506cc4af4d69d873da52fb | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | **Total Files Size (in bytes):** | 789805 | | |

**This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.**

**New Applications Under 35 U.S.C. 111**
**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**
**National Stage of an International Application under 35 U.S.C. 371**
**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**
**New International Application Filed with the USPTO as a Receiving Office**
**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING OR 371(C) DATE | FIRST NAMED APPLICANT | ATTY. DOCKET NO./TITLE |
|---|---|---|---|
| 16/851,044 | 04/16/2020 | Dashen FAN | K41090.P8C3 |

**CONFIRMATION NO. 9885**

51340
PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

**FORMALITIES LETTER**

*OC000000116465181*

Date Mailed: 04/23/2020

# NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

**FILED UNDER 37 CFR 1.53(b)**

***Filing Date Granted***

**Items Required To Avoid Abandonment:**

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing.

Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- Surcharge as set forth in 37 CFR 1.16(f) must be submitted.
  The surcharge is due for any one of:
  - late submission of the basic filing fee, search fee, or examination fee,
  - late submission of inventor's oath or declaration,
  - filing an application that does not contain at least one claim on filing, or
  - submission of an application filed by reference to a previously filed application.

**SUMMARY OF FEES DUE:**

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $ **80** surcharge.
- $( **0**) previous unapplied payment amount.
- $ **80** TOTAL FEE BALANCE DUE.

**Items Required To Avoid Processing Delays:**

Applicant is notified that the above-identified application contains the deficiencies noted below. No period for reply is set forth in this notice for correction of these deficiencies. However, if a deficiency relates to the inventor's oath or declaration, the applicant must file an oath or declaration in compliance with 37 CFR 1.63, or a substitute statement in compliance with 37 CFR 1.64, executed by or with respect to each actual inventor no later than the expiration of the time period set in the "Notice of Allowability" to avoid abandonment. See 37 CFR 1.53(f).

- A properly executed inventor's oath or declaration has not been received for the following inventor(s):

Dashen FAN
Joseph Yong KWON

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at 1-866-217-9197 or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/mhaile/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

| APPLICATION NUMBER | FILING or 371(c) DATE | GRP ART UNIT | FIL FEE REC'D | ATTY.DOCKET.NO | TOT CLAIMS | IND CLAIMS |
|---|---|---|---|---|---|---|
| 16/851,044 | 04/16/2020 | 2845 | 785 | K41090.P8C3 | 10 | 1 |

**CONFIRMATION NO. 9885**

**FILING RECEIPT**

51340
PELOQUIN, PLLC
800 FIFTH AVENUE
SUITE 4100
SEATTLE, WA 98104-3100

OC000000118485180

Date Mailed: 04/23/2020

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

**Please verify the accuracy of the data presented on this receipt.** If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

**Inventor(s)**

Dashen FAN, Bellevue, WA;
Joseph Yong KWON, San Jose, CA;

**Applicant(s)**

SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG

**Assignment For Published Patent Application**

SOLOS TECHNOLOGY LIMITED, Hong Kong, HONG KONG

**Power of Attorney:** None

**Domestic Priority data as claimed by applicant**

This application is a CON of 16/399,867 04/30/2019 PAT 10651866
which is a CON of 15/947,845 04/08/2018 PAT 10298253
which is a CON of 15/225,745 08/01/2016 PAT 9941895

**Foreign Applications** for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
*Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.*

**Permission to Access Application via Priority Document Exchange:** Yes

**Permission to Access Search Results:** Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

**If Required, Foreign Filing License Granted:** 04/22/2020
The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 16/851,044**
**Projected Publication Date:** Request for Non-Publication Acknowledged
**Non-Publication Request:** Yes
**Early Publication Request:** No
**** SMALL ENTITY ****
**Title**

BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

**Preliminary Class**

341

**Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications:** No

## PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

## LICENSE FOR FOREIGN FILING UNDER

## Title 35, United States Code, Section 184

## Title 37, Code of Federal Regulations, 5.11 & 5.15

**GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

**NOT GRANTED**

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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## *SelectUSA*

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit http://www.SelectUSA.gov or call +1-202-482-6800.

## PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 16/851,044

### APPLICATION AS FILED - PART I

| FOR | (Column 1) NUMBER FILED | (Column 2) NUMBER EXTRA | SMALL ENTITY RATE($) | SMALL ENTITY FEE($) | OR | OTHER THAN SMALL ENTITY RATE($) | OTHER THAN SMALL ENTITY FEE($) |
|---|---|---|---|---|---|---|---|
| BASIC FEE (37 CFR 1.16(a), (b), or (c)) | N/A | N/A | N/A | 75 | | N/A | |
| SEARCH FEE (37 CFR 1.16(k), (i), or (m)) | N/A | N/A | N/A | 330 | | N/A | |
| EXAMINATION FEE (37 CFR 1.16(o), (p), or (q)) | N/A | N/A | N/A | 380 | | N/A | |
| TOTAL CLAIMS (37 CFR 1.16(i)) | 10 minus 20 = | * | x 50 = | 0.00 | OR | | |
| INDEPENDENT CLAIMS (37 CFR 1.16(h)) | 1 minus 3 = | * | x 230 = | 0.00 | | | |
| APPLICATION SIZE FEE (37 CFR 1.16(s)) | If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s). | | | 0.00 | | | |
| MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j)) | | | | 0.00 | | | |
| * If the difference in column 1 is less than zero, enter "0" in column 2. | | | TOTAL | 785 | | TOTAL | |

### APPLICATION AS AMENDED - PART II

AMENDMENT A

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE($) | SMALL ENTITY ADDITIONAL FEE($) | OR | OTHER THAN SMALL ENTITY RATE($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | x = | | OR | x = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | x = | | OR | x = | |
| Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

AMENDMENT B

| | (Column 1) CLAIMS REMAINING AFTER AMENDMENT | | (Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR | (Column 3) PRESENT EXTRA | SMALL ENTITY RATE($) | SMALL ENTITY ADDITIONAL FEE($) | OR | OTHER THAN SMALL ENTITY RATE($) | OTHER THAN SMALL ENTITY ADDITIONAL FEE($) |
|---|---|---|---|---|---|---|---|---|---|
| Total (37 CFR 1.16(i)) | * | Minus | ** | = | x = | | OR | x = | |
| Independent (37 CFR 1.16(h)) | * | Minus | *** | = | x = | | OR | x = | |
| Application Size Fee (37 CFR 1.16(s)) | | | | | | | | | |
| FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j)) | | | | | | | OR | | |
| | | | | | TOTAL ADD'L FEE | | OR | TOTAL ADD'L FEE | |

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

PTO/SB/35 (07-09)
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# NONPUBLICATION REQUEST UNDER 35 U.S.C. 122(b)(2)(B)(i)

| | |
|---|---|
| First Named Inventor | Dashen Fan |
| Title | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIG |
| Attorney Docket Number | K41090.P8C3 |

I hereby certify that the invention disclosed in the attached application **has not and will not be** the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

I hereby request that the attached application not be published under 35 U.S.C. 122(b).

/MARK S PELOQUIN/ — Signature

April 16, 2020 — Date

MARK S PELOQUIN — Typed or printed name

50787 — Registration Number, if applicable

(206) 447-1336 — Telephone Number

This request must be signed in compliance with 37 CFR 1.33(b) and submitted with the application **upon filing.**

Applicant may rescind this nonpublication request at any time. If applicant rescinds a request that an application not be published under 35 U.S.C. 122(b), the application will be scheduled for publication at eighteen months from the earliest claimed filing date for which a benefit is claimed.

If applicant subsequently files an application directed to the invention disclosed in the attached application in another country, or under a multilateral international agreement, that requires publication of applications eighteen months after filing, the applicant **must** notify the United States Patent and Trademark Office of such filing within forty-five (45) days after the date of the filing of such foreign or international application. **Failure to do so will result in abandonment of this application (35 U.S.C. 122(b)(2)(B)(iii)).**

This collection of information is required by 37 CFR 1.213(a). The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

*If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786-9199) and select option 2.*

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | K41090.P8C3 |
|---|---|---|
| | Application Number | |
| Title of Invention | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

## Secrecy Order 37 CFR 5.2:

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

## Inventor Information:

**Inventor 1** Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | DASHEN | | FAN | |

**Residence Information (Select One)** ◉ US Residency ○ Non US Residency ○ Active US Military Service

| City | BELLEVUE | State/Province | WA | Country of Residence | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| Address 1 | 14714 SE 49th ST | | |
|---|---|---|---|
| Address 2 | | | |
| City | BELLEVUE | State/Province | WA |
| Postal Code | 98006 | Country | US |

**Inventor 2** Remove

**Legal Name**

| Prefix | Given Name | Middle Name | Family Name | Suffix |
|---|---|---|---|---|
| | JOSEPH | YONG | KWON | |

**Residence Information (Select One)** ◉ US Residency ○ Non US Residency ○ Active US Military Service

| City | SAN JOSE | State/Province | CA | Country of Residence | US |
|---|---|---|---|---|---|

**Mailing Address of Inventor:**

| Address 1 | 2789 LAVENDER TERRACE | | |
|---|---|---|---|
| Address 2 | | | |
| City | SAN JOSE | State/Province | CA |
| Postal Code | 95111 | Country | US |

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

## Correspondence Information:

**Enter either Customer Number or complete the Correspondence Information section below.**
**For further information see 37 CFR 1.33(a).**

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | K41090.P8C3 |
|---|---|---|
| | Application Number | |
| Title of Invention | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

| ☐ An Address is being provided for the correspondence Information of this application. | | | |
|---|---|---|---|
| **Customer Number** | 51340 | | |
| **Email Address** | | Add Email | Remove Email |

## Application Information:

| **Title of the Invention** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | | |
|---|---|---|---|
| **Attorney Docket Number** | K41090.P8C3 | **Small Entity Status Claimed** | ☒ |
| **Application Type** | Nonprovisional | | |
| **Subject Matter** | Utility | | |
| **Total Number of Drawing Sheets (if any)** | 20 | **Suggested Figure for Publication (if any)** | 13 |

## Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

| Application number of the previously filed application | Filing date (YYYY-MM-DD) | Intellectual Property Authority or Country |
|---|---|---|
| | | |

## Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☒ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

## Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

| Please Select One: | ◉ Customer Number | ○ US Patent Practitioner | ○ Limited Recognition (37 CFR 11.9) |
|---|---|---|---|
| Customer Number | 51340 | | |

| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | K41090.P8C3 |
|---|---|---|
| | Application Number | |
| Title of Invention | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

## Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.
When referring to the current application, please leave the "Application Number" field blank.

| Prior Application Status | Pending | | Remove |
|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing or 371(c) Date (YYYY-MM-DD) |
| | Continuation of | 16399867 | 2019-04-30 |

| Prior Application Status | Patented | | | | Remove |
|---|---|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing Date (YYYY-MM-DD) | Patent Number | Issue Date (YYYY-MM-DD) |
| 16399867 | Continuation of | 15947845 | 2018-04-06 | 10298253 | 2019-05-21 |

| Prior Application Status | Patented | | | | Remove |
|---|---|---|---|---|---|
| Application Number | Continuity Type | Prior Application Number | Filing Date (YYYY-MM-DD) | Patent Number | Issue Date (YYYY-MM-DD) |
| 15947845 | Continuation of | 15225745 | 2016-08-01 | 9941895 | 2018-04-10 |

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button.

## Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)[i] the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

Remove

| Application Number | Country[i] | Filing Date (YYYY-MM-DD) | Access Code[i] (if applicable) |
|---|---|---|---|
| | | | |

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button.

## Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

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| **Application Data Sheet 37 CFR 1.76** | Attorney Docket Number | K41090.P8C3 |
|---|---|---|
| | Application Number | |
| Title of Invention | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | K41090.P8C3 |
|---|---|---|
| | Application Number | |
| Title of Invention | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

## Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

**NOTE**: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

**1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)**

**A. Priority Document Exchange (PDX)** - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

**B. Search Results from U.S. Application to EPO** - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

**2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)**

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

**NOTE:** Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | K41090.P8C3 |
|---|---|---|
| | Application Number | |
| Title of Invention | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

## Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

**Applicant 1**

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

| ○ Assignee | ○ Legal Representative under 35 U.S.C. 117 | ○ Joint Inventor |
|---|---|---|
| ◉ Person to whom the inventor is obligated to assign. | ○ Person who shows sufficient proprietary interest | |

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

| Name of the Deceased or Legally Incapacitated Inventor: | |
|---|---|
| If the Applicant is an Organization check here. | ☒ |
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| Application Data Sheet 37 CFR 1.76 | Attorney Docket Number | K41090.P8C3 |
|---|---|---|
| | Application Number | |
| Title of Invention | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS | |

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UNITED STATES PATENT APPLICATION

FOR

# BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS

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## RELATED APPLICATIONS

**[0001]** This patent application is a continuation of United States Patent Application Serial Number 15/947,845, titled "TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS," filed on April 08, 2018, which is a continuation of United States Patent Application Serial Number 15/225,745, titled "TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS," filed on August 01, 2016, now U.S. Patent 9,941,895. United States Patent Application Serial Number 15/225,745 and United States Patent Application Number 15/947,845 are hereby incorporated by reference.

## BACKGROUND OF THE INVENTION

### 1. FIELD OF INVENTION

**[0002]** The invention relates generally to sampled systems more specifically to time delay in digitally oversampled sensor systems, apparatuses, and methods.

### 2. ART BACKGROUND

**[0003]** Field quantities which exist in the natural world are generally analog signals which have continuously varying amplitude as a function of time. Examples of these field quantities are sound pressure, vibration, light, etc. Measurement of a field quantity is accomplished with an analog sensor or a digital sensor. Digital electronics

work with digital signals. Interfacing analog signals with digital electronics presents a technical problem for which a technical solution using a technical means is needed.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0004]** The invention may best be understood by referring to the following description and accompanying drawings that are used to illustrate embodiments of the invention. The invention is illustrated by way of example in the embodiments and is not limited in the figures of the accompanying drawings, in which like references indicate similar elements.

**[0005]** **Figure 1** illustrates a digital sensor system.

**[0006]** **Figure 2A** illustrates time delaying an oversampled signal within an analog-to-digital converter (ADC) system, according to embodiments of the invention.

**[0007]** **Figure 2B** illustrates two signals from **Figure 2A**, according to embodiments of the invention.

**[0008]** **Figure 2C** illustrates an oversampling system utilizing sigma-delta modulation and pulse density modulation (PDM), according to embodiments of the invention.

**[0009]** **Figure 3** illustrates applications of the system from **Figure 2C**, according to embodiments of the invention.

**[0010]** **Figure 4** illustrates a pulse density modulation (PDM) receiver architecture, according to embodiments of the invention.

**[0011]** **Figure 5** illustrates placing a time delay between stages of a pulse density modulation (PDM) receiver, according to embodiments of the invention.

**[0012]** **Figure 6** illustrates placing a time delay between different stages of a pulse density modulation (PDM) receiver, according to embodiments of the invention.

**[0013]** **Figure 7** illustrates placing a time delay in yet another location within a pulse density modulation (PDM) receiver, according to embodiments of the invention.

**[0014]** **Figure 8** illustrates programmable time delay in an analog-to-digital converter (ADC) system, according to embodiments of the invention.

**[0015]** **Figure 9A** illustrates time delays for multiple sensors, according to embodiments of the invention.

**[0016]** **Figure 9B** illustrates multiple time delays applied to an output from a single sensor, according to embodiments of the invention.

**[0017]** **Figure 10** illustrates beamforming, according to embodiments of the invention.

**[0018]** **Figure 11A** and **11B** illustrate increased resolution provided by a fractional delay, according to embodiments of the invention.

**[0019]** **Figure 12** illustrates a process to impart a time delay to an oversampled system, according to embodiments of the invention.

**[0020]** **Figure 13** illustrates a process to use a time delay imparted to an oversampled system in a beamforming process, according to embodiments of the invention.

**[0021]** **Figure 14** illustrates a data processing system in which embodiments of the invention may be used.

**[0022]** **Figure 15A-15B** illustrates integrated circuit dies in which embodiments of the invention may be implemented.

## DETAILED DESCRIPTION

**[0023]** In the following detailed description of embodiments of the invention, reference is made to the accompanying drawings in which like references indicate similar elements, and in which is shown by way of illustration, specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those of skill in the art to practice the invention. In other instances, well-known circuits, structures, and techniques have not been shown in detail in order not to obscure the understanding of this description. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the invention is defined only by the appended claims.

**[0024]** Systems and methods are described for applying a time delay to an oversampled digital signal. In various embodiments the time delay is applied in various locations within the oversampled domain of the digital signal during signal processing in an analog-to-digital converter (ADC).

**[0025]** **Figure 1** illustrates, generally at 100, a digital sensor system. With reference to **Figure 1**, an analog field quantity 102 is sensed by a digital sensor system 104. As represented in **Figure 1** at 104, the digital sensor system includes a digital sensor which is typically configured to oversample the analog signal 102. Within the digital sensor system 104 the oversampled signal is input to a receiver which decimates and low pass filters the oversampled signal in order to output a signal at a baseband sampling rate at 106 which is the digital representation of the analog field quantity 102. A time delay can be imparted to the digital baseband signal at 108. The time delay 108

can be of various lengths and is sometimes expressed in two parts, i.e., an integer part and a fractional part. A first part 114 can be referred to as an integer delay where "integer" refers to an integer number of baseband sampling rate cycles. A second part 110 can be referred to as a fractional delay where "fraction" refers to a fraction of the baseband sampling rate period. A time delayed digital version of the digital signal 106 is output at 116. The time delayed digital signal 116 can be used in various subsequent processes such as beamforming, etc.

**[0026]** **Figure 2A** illustrates, generally at 200, time delaying an oversampled signal within an analog-to-digital converter (ADC) system, according to embodiments of the invention. With reference to **Figure 2A**, a time delay is inserted in the oversampled domain of the ADC. In various embodiments, the time delay is inserted between a digitally oversampled sensor output signal and a receiver used to process the oversampled digital output signal. In operation, an analog field quantity 202 is incident upon a digital sensor 212. The digital sensor 212 converts the incident analog field to an oversampled digital output signal at 214 which preserves phase information of the signal within the bit stream of the signal 214. In various embodiments, the oversampled signal 214 is provided as a pulse density modulated (PDM) signal. In other embodiments, other digitizing methodologies can be employed to digitize the oversampled signal. The oversampling which occurs in the oversampled sensor 212 occurs at a sampling clock frequency. The sampling clock signal is often provided externally by the data processing system or a dedicated digital signal processing system (DSP) clock which is divided down to the desired sampling clock frequency used to sample the digital sensor 212. In

other embodiments, the sampling clock can be provided locally even on the same integrated circuit with a digital sensor.

**[0027]** The oversampled digital signal 214 is input into a delay element 216 and is output at 218 after a time delay "Δt" is imparted to the oversampled digital signal. The time delay Δt imparted to the oversampled digital signal 214 at delay element 216 is represented by an integer number of sampling clock cycles. When it is desirable to impart a "fractional delay" at delay element 216, then the maximum number of sampling clock cycles that would be imparted at 216 is equal to the ratio of sampling clock frequency divided by the baseband sampling rate, indicated herein by the variable "**R**." **R** is discussed more completely below in conjunction with the figures that follow. Note that in other embodiments, systems are configured without the constraint **R** of equation (3). In such cases, the delay imposed by the delay element 216 exceeds the upper limit **R** of equation (3).

**[0028]** In various embodiments, the delay element 216 is implemented as a buffer, which can be programmable. In other embodiments, the delay element is implemented with a delay line; the delay line can be a programmable delay line. In yet other embodiments, the delay element is implemented with a circuit constructed to provide a delay and the delay can be programmable. A programmable delay element 216 will allow the magnitude of the delay Δt to be adjusted as desired. In the context of beamforming, a programmable delay(s) will allow a beam formed with two or more sensors to be steered to different directions. Beamforming will be discussed more completely below in conjunction with the figures that follow.

**[0029]** The output signal from the delay element 216 is a delayed oversampled digital signal 218 which is input into a receiver module 220. The receiver module 220 performs the functions of low pass filtering and decimation. Low pass filtering removes the high frequency noise resulting from the oversampling process and decimation reduces the sampling frequency to a baseband sampling rate. A baseband digital signal is output at 222 from the receiver module 220. The baseband signal 222 is a digital signal having a bandwidth as prescribed by an application of interest and, depending on the digitization methodology, an increased dynamic range relative to the oversampled digital signal 214 output from the digital sensor 212.

**[0030]** As an illustration of a sinusoidal representation of an analog field quantity 204 is illustrated as a function of time 206 and amplitude 208. A marker 210 indicates a peak $t_1$ in the field quantity 204. After the time delay "Δt" is imparted to the oversampled digital signal and the post processing described above in the receiver 220 is performed, for illustration herein, when the signal at 222 is converted back to an analog signal it would appear as illustrated at 224 where the time delayed amplitude 224 is time delayed by Δt resulting in the peak amplitude of the signal 224 delayed to $t_1 + \Delta t$ as illustrated at 219. Thus, a time delay is imparted to the oversampled digital signal in the system described above in **Figure 2A**. Imparting the time delay is accomplished by insertion of the delay element 216 which can be accomplished, in various embodiments, by inserting, in one embodiment, a buffer as shown between the oversampled digital sensor output 214 and the input to the receiver module 220. In alternative embodiments, described in the figures that follow, a time delay element will be inserted between stages

of a receiver module. Thus, embodiments of the invention are not limited to introduction of the time delay element on the input to the receiver module 220.

**[0031]** In various embodiments, the oversampling performed in the digital sensor 212 is accomplished with a sigma-delta modulator in an analog-to-digital conversion (ADC) process which outputs at 214 a one-bit deep pulse density modulated (PDM) oversampled digital signal representing the digitization of the analog signal 256 (**Figure 2B**). Note that for illustration purposes only, without limiting embodiments of the invention, the illustration of the oversampled digital signal 214 is presented at 252 as a pulse density modulated (PDM) signal in the time domain and again in **Figure 2B** in enlarged view. At 252 the oversampled digital signal is illustrated with marker 254 indicating a peak of the analog signal 256.

**[0032]** Following application of the time delay $\Delta t$, imparted by delay element 216, the time delayed oversampled digital signal 218 is illustrated at 262 with the oversampled digital signal illustrated with marker 254 indicating the peak of the analog signal 256 which has been delayed in time by $\Delta t$, the peak is now indicated at 264.

**[0033]** The illustrative example presented with 252, 262, **Figure 2A,** and **Figure 2B** illustrates oversampling where one wavelength of an analog signal has been sampled one hundred (100) times. No limitation is implied thereby and this example is provided merely for illustration. **Figure 2B** illustrates, generally at 250, two signals from **Figure 2A**, according to embodiments of the invention.

**[0034]** Referring back to **Figure 2A**, as described above the sampling clock frequency is represented by a variable $f_{SF}$; the baseband sampling frequency is given by the variable $f_{bb}$. Equation (1) is the requirement for the oversampling condition where

$f_{SF} > f_{bb}$. The ratio of the sampling clock frequency to the baseband sampling frequency is given by equation (2) as $\mathbf{R} = f_{SF} / f_{bb}$. In analog-to-digital conversion methodologies that are one-bit deep, **R** will represent the number of subintervals that a baseband sampling period can be divided into for the purpose of applying a "fractional" time delay to the oversampled digital signal 214. Pulse density modulation (PDM) is such a digital conversion methodology that is one-bit deep where the sign is carried by the bit value where a "1" corresponds to a pulse of plus polarity (+A) and a "0" corresponds with a pulse of negative polarity (-A). Equation (3) indicates that a fractional delay can be selected based on a number of sampling clock cycles **N** from the range $\mathbf{1 \leq N \leq R}$, and the time delay which is applied by delay element 216 is given by equation (4) as: $\Delta t = N * \tau_{SF}$. Where $\tau_{SF}$ is the period of the sampling clock. Where as described above, "fractional delay" refers to a fraction of a baseband sampling rate cycle.

**[0035]** Note that when other analog-to-digital digitization methodologies are used in the digital sensor 212 the resulting digital bit stream can be other than one-bit deep. In such cases, the oversampled digital signal at 212 can still be delayed with delay element 216, where the delay will be a multiple of a "sample" regardless of how many bits are used to encode the "sample" at the digital sensor 212. The minimum time delay increment will depend on the bit depth of the analog-to-digital digitization methodology used in the digital sensor 212. Thus, equation (4) is modified to equation (5) as follows: $\Delta t = N *(M* \tau_{SF})$. Where $\tau_{SF}$ is the period of the sampling clock, M is the bit depth of the digitization methodology and the product N*M, given by equation (6), which is: $\mathbf{1 \leq N*M \leq R}$ with N being an integer subject to the constraint of equation (6) for a fractional

delay. Note that in other embodiments, systems are configured without the constraint **R** of equation (6). In such cases, the delay imposed by the delay element 216 exceeds the upper limit **R** in equation (6). Thus, a time delay imposed by the system on the oversampled digital signal can be a fraction of a baseband sampling period or greater than the baseband sampling period.

**[0036]** For example, in one non-limiting embodiment, given merely for illustration, a 2-bit amplitude modulated digitization methodology utilizes 2 bits to establish 4 amplitude states for a digital representation of an analog signal. In this example, M =2, which means that a magnitude of the time delay which can be applied to the oversampled digital signal will be an integer number (a multiple) of two successive sampling clock cycles, e.g., 2, 4, 6, 8, etc., thus the oversampled digital signal is delayed 2 bits at a time in this example of M=2. Introducing a delay of one sampling clock cycle or three sampling clock cycles at 216 when the analog-to-digital encoding methodology is 2 bits deep would introduce noise into the system because 2 successive bits are required to represent the expected value of the analog signal, i.e., a sample.

**[0037]** A variety of different digital sensors can be used at 212. For example, some non-limiting examples of sensors used to detect field quantities are sensors used to detect pressure fluctuations such as acoustic pressure fluctuations in air or water. Frequency ranges can range from the low end of the audio spectrum to the ultrasonic range. Sensors can also be used to detect field quantities such as vibration or electromagnetic energy. The following description and the associated figures are set in the context of a digital microphone however; the description is applicable to sensors other than digital microphones and is generally applicable to oversampled sensors used during

analog-to-digital conversion (ADC) where a time delay is introduced in the oversampled digital domain.

**[0038]** **Figure 2C** illustrates, generally at 270, an oversampling system utilizing sigma-delta modulation and pulse density modulation (PDM), according to embodiments of the invention. With reference to **Figure 2C**, a digital microphone is indicated at 272. Digital microphone 272 responds to an acoustic field 273. The digital microphone 272 can take the form of an electret capsule microphone or it can be made using microelectromechanical systems (MEMS) technology as a component on an integrated circuit. In some embodiments, MEMS digital microphones are made as a structure on an integrated circuit which uses a membrane that forms a capacitor with a base plate. Sound waves cause a vibration of the membrane which causes variations in capacitance which are sensed, amplified, and processed in the integrated circuit.

**[0039]** The MEMS digital microphones can be configured with a sigma-delta modulator which produces an oversampled digital output of the analog signal sensed by the microphone. A digital MEMS microphone configured with a sigma-delta modulator is supplied with power and a sampling clock signal. In various embodiments, the digital microphone outputs a pulse density modulated (PDM) oversampled signal. A clock signal can be provided as an external clock signal from a digital data processing system or the sampling clock signal can be provided locally as part of the integrated circuit package that houses the digital microphone. Digital microphones using MEMS technology and sigma-delta modulators for analog-to-digital conversion can be designed to operate at a variety of sampling clock frequencies. Common sampling clock

frequencies are in the range of 1 MHz to 5MHz. The sampling clock frequencies listed here are given merely for illustration and do not limit embodiments of the invention.

**[0040]** Some baseband audio signal applications have established frequency ranges and these ranges together with a desired dynamic range for the audio signal place requirements on the sampling clock frequency used to with the digital microphone 272. For example, telephony, compact disk (CD) format, etc. all have requirements for the baseband audio signal that can be accommodated through embodiments of the invention as described herein. Some non-limiting examples are, for example, pulse code modulated (PCM) audio which can be provided at various dynamic ranges and sample rates, which could be provided at 16 bits per sample at 48 kHz in one or more embodiments. Another non-limiting example is 16 bit CD quality stereo PCM at 44.1 kHz. Telephony can be accommodated at different specifications. A non-limiting example is PCM audio at 12 bits per sample at 8 kHz. The foregoing examples of baseband audio formats are provided merely for example and do not limit embodiments of the invention.

**[0041]** The oversampled digital output 274 is input to a delay element 276 as described previously. The delay element 276 applies a time delay to the oversampled digital signal and outputs a time delayed oversampled digital signal at 278.

**[0042]** The oversampled digital signal 278 is input into a PDM receiver module 280. In various embodiments, the PDM receiver module 280 converts an input signal to pulse code modulation (PCM) format and can be alternatively referred to as a PDM to PCM conversion module 280 without limitation to embodiments of the invention. The PDM receiver module 280 decimates and low pass filters the time delayed oversampled digital signal 278 and outputs a time delayed PCM baseband digital signal at 282. Those

of ordinary skill in the art will recognize that PCM format is a digital data format in use with digital signals such as digital audio signals. PDM receiver modules such as 280, as well as other receiver modules described in the other figures in this description of embodiments, can be implemented with conversion to a format other than PCM format and the description given herein with conversion to PCM format does not impose any limitation on embodiments of the invention.

**[0043]** As described above, the time delay element 276 can apply a fractional time delay to the oversampled digital signal 274. In some embodiments, the system design is such that a total time delay applied to the baseband signal 286 is made up from the fractional delay contribution at 276 and an integer delay contribution at 284. In other embodiments, the entire delay is applied by the delay element 276.

**[0044]** Accomplishing a fractional delay at the baseband stage in a digital microphone system is computationally intensive and has been eliminated by embodiments of the invention described herein by introducing the fractional delay in the oversampled signal domain. Equations (1), (2), and (3) from **Figure 2A** apply to the digital microphone system of **Figure 2C**. Here the digital microphone 272 is driven by a sampling clock frequency $f_{SF}$ the baseband sampling frequency is given by $f_{bb}$, therefore from equation (1) $f_{SF} > f_{bb}$. The ratio of the sampling clock frequency to the baseband sampling frequency is given by equation (2) as $\mathbf{R} = f_{SF} / f_{bb}$. Equation (3) indicates that a fractional delay can be selected based on a number of sampling clock cycles **N** from the range $\mathbf{1} \leq \mathbf{N} \leq \mathbf{R}$, and the time delay which is applied by delay element 276 is given by equation (4) as: $\Delta t = \mathbf{N} * \tau_{SF}$. Where $\tau_{SF}$ is the period of the sampling clock. In various

embodiments, the PDM receiver module 280 is constructed with a sequence of stages as explained below in conjunction with the figures that follow.

**[0045]** **Figure 3** illustrates, generally at 300, applications of the system from **Figure 2C**, according to embodiments of the invention. With reference to **Figure 3**, a non-limiting example of a digital microphone system is provided with a four stage PDM receiver module. An analog field quantity e.g., an acoustic field 302 is sensed by a digital microphone 304. The digital microphone 304 employs a one-bit sigma-delta modulation to perform analog-to-digital conversion (ADC). In one non-limiting embodiment, the digital microphone 304 is driven with a 2.048 MHz sampling clock frequency to output an oversampled digital output signal at 306. In the example of **Figure 3**, the baseband sampling frequency is chosen to be 16 kHz. From equation 2 (**Figure 2A**), **R** = 2,048,000/16,000 = **128**. Thus, the period of the baseband sampling frequency can be divided by 128 by selecting a time delay $\Delta t$ which is related to a number of sampling clock cycles **N** from the range $\mathbf{1 \leq N \leq 128}$. In this example, the time delay which is applied by delay element 308 is given by equation (4) from **Figure 2B** as: $\Delta t = N * \tau_{SF}$ where $\tau_{SF}$ is the period of the 2.048 MHz sampling clock frequency, which equals $4.8828 \times 10^{-7}$ seconds. Equation (4) from **Figure 2B** then provides as a fractional delay: $\Delta t = N * 4.8828 \times 10^{-7}$.

**[0046]** In one or more embodiments, the time delay element 308 is implemented with a buffer one-bit deep and 128 bits wide. At 8 bits per byte the buffer needed for time delay element 308 in the present example is of size 16 bytes. 16 bytes is a very small buffer which makes the system and process needed to impart a fractional time delay to an oversampled digital signal much less resource intensive than that of existing

systems which impart a fractional time delay to the baseband signal through application of filtering and or post processing in the baseband domain. The time delay element 308 can be configured to be controllable, such that the time delay imparted to the oversampled digital signal can be set using a control line 310. A controller can be configured with one or more digital microphones according to embodiments of the invention to provide a steerable array of microphones for beamforming applications. Utilizing a controller with multiple microphones is described more fully below in conjunction with the figures that follow.

**[0047]** Illustrated in **Figure 3**, is a PDM receiver module 314 which has, in one embodiment, an architecture based on four main stages, also shown in **Figure 3** in enlarged view at 332. The time delay element 308 applies a delay to the oversampled digital signal outputting a time delayed oversampled digital signal at 312. The oversampled digital signal 312 is input in the PDM receiver module 314 and enters a first stage 316. For the purpose of this example, the first stage of the PDM receiver module 314 is a cascaded-integrator-comb (CIC) filter structure. The integrator keeps a running sum of values adding each new sample, the comb filter subtracts off the oldest sample. The CIC filter is a cascade of integrator comb stages. The final component is a decimator which reduces the sampling rate by a multiple of 2. In the example of **Figure 3,** the CIC filter provides 8:1 decimation which reduces the sampling clock frequency of 2.048MHz to 256 kHz at 318 following the CIC 316 stage. The CIC stage 316 low pass filters the input digital signal 312 thereby providing an increase to the dynamic range of the output digital signal at 318.

**[0048]** In the example of **Figure 3**, the second stage of PDM receiver module 314 is a half-band filter 320. Half-band filter 320 decimates by a factor of 2:1 thereby reducing the sampling rate of the input signal 318 from 256 kHz to 128 kHz at the output 322. Half-band filter 320 provides further low pass filtering and a further increase in dynamic range of the signal at 322.

**[0049]** Similarly, in the example of **Figure 3**, the third stage of PDM receiver module 314 is a half-band filter 324. Half-band filter 324 decimates by a factor of 2:1 thereby reducing the sampling rate of the input signal 322 from 128 kHz to 64 kHz at the output 326. Half-band filter 324 provides further low pass filtering and a further increase in dynamic range of the signal at 326

**[0050]** In the example of **Figure 3**, the fourth stage of PDM receiver module 314 is a low pass filter 328 which decimates by a factor of 4:1 thereby reducing the input digital signal at 326 from a sample rate of 64 kHz to a baseband sample rate of 16 kHz at 330. A finite impulse response (FIR) filter structure or an infinite impulse response (IIR) filter structure can be used in the stages of the PDM receiver module 314 described above, such as, for example in low pass filter 328, etc. Thus, the PDM receiver module receives as an input a time delayed oversampled digital signal at 312 with sampling rate of 2.048 MHz and outputs a baseband signal, which in some embodiments is an acoustic signal, at a baseband sampling rate of 16 kHz at 330. Note that in order to eliminate aliasing, the useful frequency range of the baseband signal will be reduced by a factor of 1/2 from the baseband sampling rate in order to satisfy the Nyquist sampling criteria which requires the maximum useful frequency $\mathbf{F_{NYQUIST}} \leq f_{bb} / 2$, where $f_{bb}$ is the baseband sample rate.

**[0051]** **Figure 4** illustrates, generally at 400, a pulse density modulation (PDM) receiver architecture, according to embodiments of the invention. With respect to **Figure 4**, alternative locations for the time delay element 308 from **Figure 3** are illustrated. An initial position for the time delay element 416 corresponds with the position of the time delay element 308 in **Figure 3**. In this initial position, as described above the time delay element 416 delays the oversampled digital signal and outputs a time delayed digital signal at 312.

**[0052]** The time delay element can be located throughout the oversampled domain of the PDM module 314. In **Figure 4**, a first alternative location of the delay element is indicated at 418 between the first stage 402 and the second stage 406 at location 418. In this alternative location, in one embodiment, the time delay element 416 is removed and 312 represents the digital oversampled signal, the time delay is applied internal to 314. When the delay element is located at 418 the number of fractional delay elements is obtained by dividing the sampling rate which exists at 404, which is the output of 402 and the input to time delay element at 418, by the baseband sampling rate at 330. For the non-limiting example of **Figure 3, R** = 256 kHz/16 kHz = 16. Thus, the fractional delay which can be imparted by the time delay element when located at position 418 is calculated by equation (4) from **Figure 2B** as: $\Delta t = N * \tau_{SP}$ where is the period of the 256 kHz sampling rate period equals $3.90625 \times 10^{-6}$ seconds. Equation (4) from **Figure 2B** then provides: $\Delta t = N * 3.90625 \times 10^{-6}$ seconds.

**[0053]** In **Figure 4**, a second alternative location of the delay element is indicated at 420 between the second stage 406 and the third stage 410 at location 420. In this alternative location, in one embodiment, the time delay element 416 is removed and 312

represents the digital oversampled signal, the time delay is applied internal to 314. When the time delay element is located at 420 the number of fractional delay elements is obtained by dividing the sampling rate which exists at 408, which is the output of 406 and the input to time delay element at 420, by the baseband sampling rate at 330. For the non-limiting example of **Figure 3, R** = 128 kHz/16 kHz = 8. Thus, the fractional delay which can be imparted by the time delay element when located at position 420 is calculated by equation (4) from **Figure 2B** as: $\Delta t = N * \tau_{SF}$ where $\tau_{SF}$ is the period of the 128 kHz sampling rate period which equals $7.8125 \times 10^{-6}$ seconds. Equation (4) from **Figure 2B** then provides: $\Delta t = N * 7.8125 \times 10^{-6}$ seconds.

**[0054]** In **Figure 4**, a third alternative location of the delay element is indicated at 422 between the third stage 410 and the fourth stage 414 at location 422. In this alternative location, in one embodiment, the time delay element 416 is removed and 312 represents the digital oversampled signal, the time delay is applied internal to 314. When the delay element is located at 422 the number of fractional delay elements is obtained by dividing the sampling rate which exists at 412, which is the output of 410 and the input to time delay element at 422, by the baseband sampling rate at 330. For the example of **Figure 3,** R = 64 kHz/16 kHz = 4. Thus, the fractional delay which can be imparted by the time delay element when located at position 422 is calculated by equation (4) from **Figure 2B** as: $\Delta t = N * \tau_{SF}$ where $\tau_{SF}$ is the period of the 64 kHz sampling rate period which equals $1.5625 \times 10^{-5}$ seconds. Equation (4) from **Figure 2B** then provides: $\Delta t = N * 1.5625 \times 10^{-5}$ seconds. In other embodiments, a time delay element can be located in a plurality of locations, i.e., one or more of 416, 418, 420, and 422.

**[0055]** **Figure 5** illustrates, generally at 500, placing a time delay between stages of a pulse density modulation (PDM) receiver, according to embodiments of the invention. With respect to **Figure 5**, a PDM receiver module 580 is illustrated with an oversampled digital input signal at 578. The oversampled digital input signal 578 originates in various embodiments, for example, from a digital microphone such as 272 in **Figure 2C**. The PDM receiver module 280 is configured with a 1st stage 502, a second stage 510, a third stage 514, and up to an $i^{th}$ stage 518. Each stage can provide one or both of decimation and low pass filtering. A time delay element 506 is located between the first stage 502 the second stage 510. In operation, an oversampled digital signal 578 originates from example a digital microphone or another type of digital sensor as described above.

**[0056]** The oversampled digital signal 578 is input into a first stage 502 of the PDM receiver module 580 where the signal is decimated and low pass filtered. An output of the first stage 502 is then input at 504 into the time delay element 506. An output of the time delay element 506 is input at 508 into the second stage 510. The second stage 510 performs further decimation and low pass filtering with an output 512 providing an input into the third stage 514. The third stage 514 performs further decimation and low pass filtering with an output 516 providing an input into the $i^{th}$ stage 518. The $i^{th}$ stage 518 provides the output 582 from the PDM receiver module 580 which can be configured to be at the baseband sampling rate. In various other embodiments, the time delay element 506 can be placed between other stages of the PDM receiver module 580.

**[0057]** **Figure 6** illustrates, generally at 600, placing a time delay between different stages of a pulse density modulation (PDM) receiver, according to embodiments of the invention. With respect to **Figure 6**, the PDM receiver module 580 from **Figure 5** illustrated with stages 502, 510, 514, up to 518. Here in **Figure 6**, a time delay element is inserted between the second stage 510 and the third stage 514. An output 604 from the second stage 510 is input to a time delay element 602. An output 606 from the time delay element 602 is a time delayed digital signal at an intermediate sampling rate.

**[0058]** **Figure 7** illustrates, generally at 700, placing a time delay in yet another location within a pulse density modulation (PDM) receiver, according to embodiments of the invention. With respect to **Figure 7**, the PDM receiver module 580 from **Figure 5** illustrated with stages 502, 510, 514, up to 518. In **Figure 7**, a time delay element is inserted between the i-1 stage 514 and the $i^{th}$ stage 518. An output 704 from the i-1 stage 514 is time delayed at time delay element 702. An output 706 from the time delay element 702 is a time delayed digital signal at an intermediate sampling rate which is input into the $i^{th}$ stage 518 for further processing before being output at 582 from the PDM receiver module 580. The output 582 is at a sampling frequency which is a reduced sample rate, which in some embodiments can be the baseband sample rate of the desired output signal from the system.

**[0059]** **Figure 8** illustrates, generally at 800, programmable time delay in an analog-to-digital converter (ADC) system, according to embodiments of the invention. With respect to **Figure 8**, an analog field quantity is represented by 802 incident on a digital sensor 804, which in various embodiments, is a digital microphone, vibration sensor, electromagnetic energy sensor, etc. For the discussion herein, digital sensor 804

is referred to as a digital microphone without limitation implied thereby. In response to the incident field 802 the digital microphone 804 outputs an oversampled digital signal at 806. The oversampled digital signal output 806 is input to a time delay element 808 which outputs a time delayed oversampled digital output at 810. The time delayed oversampled digital output 810 is input into a PDM receiver module 812. The PDM receiver module 812 can be a configured with a single stage or a multi-stage architecture as described above. At 814 an output from PDM receiver module 812 can optionally be time delayed at 816 before being output at 822. In some embodiments, a controller 818 provides a control signal 820 to the time delay element 808. In some embodiments, when the time delay element 816 is configured with the system, the controller 818 or a separate controller provides a control signal at 822 to the time delay element 816.

**[0060]** In various embodiments, the time delay element such as 808 can be configured as a buffer or to include a buffer which has a number of values, where each value corresponds to a different number of clock cycles of the sampling clock used within the digital sensor 804. In various embodiments, the time delay element 808 can be configured to provide a fixed time delay to the input digital signal 806 or the time delay element 808 can be programmable. In operation, the controller 818 provides a control signal 820 which is used to specify a number of sampling clock cycles which will be used by the time delay element 808 to provide the time delay to the input signal 806.

**[0061]** Similarly, when present in the system, the time delay element such as 816 can be configured as a buffer or to include a buffer which has a number of values, where each value corresponds to a different number of cycles at the lower sample rate corresponding to the output of the PDM receiver module 812. In various embodiments,

the time delay element 816 can be configured to provide a fixed time delay to the input digital signal 814 or the time delay element 816 can be programmable. In operation, the controller 818 provides a control signal 822 which is used to specify a number of cycles at the lower sample rate which will be used by the time delay element 816 to provide the time delay to the input signal 814. Thus, the total time delay imparted by the system at the output 822 relative to the input 806 is the sum of the time delay imparted by the time delay element 808 and the time delay element 816.

**[0062]** **Figure 9A** illustrates, generally at 900, time delays for multiple sensors, according to embodiments of the invention. With respect to **Figure 9A**, an analog field quantity is represented by 902, which is incident on digital sensors 920, 940, up to a general number of **n** sensors indicated by 960, which in various embodiments is a digital microphone, vibration sensor, electromagnetic energy sensor, etc. For the discussion herein, digital sensors 920, 940, and 960 are referred to as digital microphones without limitation implied thereby. Each digital microphone has a signal transmission path indicated by 906, 908 and 910. A controller 904 is used to adjust time delay(s), which are used to delay each of the microphone signal paths.

**[0063]** In operation, a time delay $\Delta t_1$ is associated with the digital signal output at 912 for the digital microphone 920. Similarly, a time delay $\Delta t_2$ is associated with the digital signal output at 914 for the digital microphone 930. And a time delay $\Delta t_n$ is associated with the digital signal output at 916 for the digital microphone 960. A controller 904 is used to supply one or more control signals to each signal path 906, 908, up to 910. As described above in the preceding figures, a control signal 922 supplied to a time delay element 924 is used to specify a time delay applied by the time delay element

924 to the oversampled digital signal received from the microphone 920. Optionally, the controller 904 can supply a control signal 928 to a time delay element 940 (if present in a given system configuration). Similarly, a control signal 942 supplied to a time delay element 944 is used to specify a time delay applied by the time delay element 944 to the oversampled digital signal received from the microphone 940. Optionally, the controller 904 can supply a control signal 948 to a time delay element 950 (if present in a given system configuration). Control signals are supplied as need to successive microphone signal paths, and finally within microphone signal path 910 a control signal 962 supplied to a time delay element 964 which is used to specify a time delay applied by the time delay element 964 to the oversampled digital signal received from the microphone 960. Optionally, the controller 904 can supply a control signal 968 to a time delay element 970 (if present in a given system configuration).

**[0064]** Note that the time delay element 924 can be located within the PDM receiver module 926, e.g., between stages of the PDM receiver module 926 as described in the figures above. Similarly, and without limitations, the time delay element 944 can be located within the PDM receiver module 946, e.g., between stages of the PDM receiver module 946 and the time delay element 964 can be located within the PDM receiver module 966, e.g., between stages of the PDM receiver module 966 as described in the figures above. The microphone signal paths 906, 908, up through 910 need not be configured in the same way. For example, one or more microphone signal paths can be configured with a time delay element inserted between a digital microphone and a PDM receiver module while another microphone signal path can be configured with a time delay element inserted internally to the PDM receiver module.

**[0065]** In various embodiments, the controller 904 is used to steer the array of microphones 920, 940, through 960 as needed in order to perform beamforming with the time delayed microphone signals 912, 914, through 916. As described in **Figure 9A**, a general number of **n** microphones has been described; however, beamforming can be performed with as few as two microphones as described below in conjunction with **Figure 10**.

**[0066]** **Figure 9B** illustrates, generally at 980, multiple time delays applied to an output from a single sensor, according to embodiments of the invention. With respect to **Figure 9B**, an analog field quantity is represented by 902, which is incident on a digital sensor 920, which in various embodiments is a digital microphone, vibration sensor, electromagnetic energy sensor, etc. For the discussion herein, the digital sensor 920 is referred to as digital microphone without limitation implied thereby. The digital microphone 920 outputs a signal 912 which is replicated (split) at 982 into **n** replicas, indicated by 984 through 986. Each replica of the microphone 920 signal 912 has a signal transmission path indicated by 906 through 910. A controller 904 is used to adjust time delay(s), which are used to delay each of the replicas 984 through 986 of the microphone signal paths.

**[0067]** In operation, the signal 912 is input into 982 in order to produce the **n** replicas 984 through 986. In various embodiments, 982 is an **n**-way splitter. In other embodiments, replication at 982 is accomplished by other means. In some embodiments, replication is performed in software. A time delay $\Delta t_1$ is associated with the digital signal output at 984 for the digital microphone 920 at 924. Similarly, a time delay $\Delta t_n$ is

associated with the digital signal output at 986 for the digital microphone 920 at 964. A controller 904 is used to supply one or more control signals to each signal path 906 up to 910. As described above in the preceding figures, a control signal 922 supplied to the time delay element 924 is used to specify a time delay applied by the time delay element 924 to the oversampled digital signal received from the microphone 920. Optionally, the controller 904 can supply a control signal 928 to a time delay element 930 (if present in a given system configuration). Control signals are supplied as need to successive microphone signal paths, and finally within microphone signal path 910 a control signal 962 supplied to the time delay element 964 which is used to specify a time delay applied by the time delay element 964 to the oversampled digital signal received from the microphone 920 at 986. Optionally, the controller 904 can supply a control signal 968 to a time delay element 970 (if present in a given system configuration).

**[0068]** Note that the time delay element 924 can be located within the PDM receiver module 926, e.g., between stages of the PDM receiver module 926 as described in the figures above. Similarly, and without limitations, the time delay element 964 can be located within the PDM receiver module 966, e.g., between stages of the PDM receiver module 966 as described in the figures above. The microphone signal paths 906 up through 910 need not be configured in the same way. For example, one or more microphone signal paths can be configured with a time delay element inserted between a digital microphone and a PDM receiver module while another microphone signal path can be configured with a time delay element inserted internally to the PDM receiver module.

**[0069]** In various embodiments, the controller 904 is used to steer the array of signals obtained from the single microphone 920 as needed in order to perform beamforming with the time delayed microphone signals 912 through 916. As described in **Figure 9B**, a general number of **n** time delayed signals from a single microphone has been described. However, beamforming, as described below in conjunction with **Figure 10**, can be performed with as few as two time delayed signals (**n** =2) from a single microphone. Thus, in some embodiments, the **n**-way splitter is a splitter providing two outputs (**n** =2) from a single input.

**[0070]** **Figure 10** illustrates, generally at 1000, beamforming, according to embodiments of the invention. With respect to **Figure 10**, an analog field quantity is represented by 1002, which is incident on digital sensors 1004 and 1006. In one or more embodiments, the digital sensors 1004 and 1006 are digital microphones; however no limitation is implied thereby. The digital microphone 1004 outputs an oversampled digital signal which is time delayed at a time delay element 1008. Optionally a gain is adjusted at 1010 which either increases or decreases an amplitude of the signal output at 1016. The second microphone 1006 outputs an oversampled digital signal which is time delayed at a time delay element 1012. Optionally a gain is adjusted at 1014 which either increases or decreases an amplitude of the signal output at 1018.

**[0071]** The signals 1016 and 1018 are input into an arithmetic block at 1020 and the beamformed output is provided at 1022. Depending on a given implementation of a system and the processing of the signals therein, the arithmetic block 1020 can perform a summation or a subtraction of the inputs 1016 and 1018 as needed for the given

beamforming operation. In **Figure 10**, beamforming is illustrated with two microphones however beamforming can be performed with a general number of microphones. The example of **Figure 10** is provided merely for illustration and does not limit embodiments of the invention.

**[0072]** **Figure 11A** and **11B** illustrate increased resolution provided by a fractional delay, according to embodiments of the invention. Referring to **Figure 11A** and **Figure 11B** together, as described above, a "fractional delay" is used in this description of embodiments to refer to a fraction of a baseband sampling rate cycle. In the context of beamforming, increased resolution in time corresponds to increased resolution in space, which is advantageous to the beamforming process.

**[0073]** Equation (7) provides the relationship between a signal with frequency f and period $\tau$. As described above, a time delay can be introduced into an output of an analog-to-digital converter (ADC) process which has an integer time delay based on the baseband sampling rate of the system given by equation (8). Similarly, when the time delay is introduced at the sampling clock frequency in the oversampled domain, the time delay is given by equation (9).

**[0074]** Equations (8) and (9) are substituted into equation (2) **Figure 2A** to yield equation (10). Solving equation (10) for $\Delta t_{\text{fractional delay}}$ yields for equation (11):

$$\Delta t_{\text{fractional delay}} = \Delta t_{\text{integer delay}}/R.$$

**[0075]** The Nyquist sampling theorem states that the highest unaliased frequency "$f_{NYQUIST}$" which can be measured with sampling frequency $f_s$ is defined to be: $f_{NYQUIST}$

$=f_s/2$, in this context the sampling frequency $f_s$ which is relevant is the baseband sampling rate $f_{bb}$. Thus $f_{NYQUIST}=f_{bb}/2$.

**[0076]** The periods for three waveforms are illustrated in **Figure 11B**. 1102 is an illustration of a period corresponding with a sampling clock frequency which would be used to oversample a digital sensor according to embodiments of the invention. 1104 is an illustration of a period of a baseband sampling rate which corresponds to the sampling rate after decimation of the oversampled signal. The relationship between periods 1102 and 1104 is given by equation (10). 1104 also represents an integer time delay which can be applied to a baseband signal. 1106 represents a period of the waveform that corresponds with the Nyquist frequency for the system. The Nyquist wavelength 1106 is the shortest wavelength (and highest frequency) of the field quantity that can be processed without aliasing.

**[0077]** Fractional time delay qualitatively represented by 1102 can be applied to baseband signal 1106 and represents an improvement in spatial resolution over the spatial resolution which could be achieved from integer time delay represented by 1104.

**[0078]** Field quantities such as those indicated in the figures above represent wave propagation in a medium. In the case of acoustic wave propagation, the relevant medium is either air or water and the speed of sound in air is nominally 340 meters per second. The speed of sound will vary as the physical properties of a medium change, for example in the case of air and water the speed of sound will vary with temperature, pressure, and salinity (water). In the non-limiting examples presented herein a nominal value of 340 meters per second is used for illustration purposes and no limitation is implied thereby.

**[0079]** Fractional time delay permits the spatial resolution of a system used for beamforming to be increased with respect to the spatial resolution achievable with integer time delay. The spatial resolution is given by $\Delta X$ in terms of C and $\Delta t_{\text{fractional delay}}$, where $\Delta X = C * \Delta t_{\text{fractional delay}}$.

**[0080]** In other embodiments as described above, a time delay element can be inserted within a receiver module for a digital oversampled sensor such as for example a PDM receiver module. In such cases a period 1102 represents an intermediate sampling rate. The number of sampling clock cycles or intermediate sampling rate cycles that are used to produce a time delay in the oversampled domain that is incorporated into the decimated and low pass filtered signal can vary as described above.

**[0081]** In the oversampled systems described above, in various non-limiting embodiments, the variable **R** has been used to represent the ratio of the sampling clock frequency (at the digital microphone) to the sampling rate at baseband. In the non-limiting example of **Figure 3**, with $f_{SF}$ equal to 2.048 MHz and $f_{bb}$ equal to 16 kHz, then from equation 2 in **Figure 2A**, $\mathbf{R} = f_{SF}/f_{bb} = 128$. From equation (10) in **Figure 11A** in this non-limiting example a minimum fraction that R represents with respect to the integer sampling rate is 1/128. Other fractional time delay values are achieved by the techniques described herein, such as by time delaying for additional clock cycles at $f_{SF}$ or additional intermediate sampling rate cycles or by changing the sampling clock frequency that is used to drive the ADC in the digital sensor.

**[0082]** **Figure 12** illustrates, generally at 1200, a process to impart a time delay to an oversampled system, according to embodiments of the invention. With reference to

**Figure 12**, a process begins at a bock 1202. At a block 1204 a relationship is established between sampling clock cycles and the digital representation of the analog signal produced by the digitization methodology employed in an analog-to-digital converter (ADC) process. In some instances, this is a one-bit deep process such as with Pulse Density Modulation (PDM) described above. In other embodiments, the process is other than one-bit deep but is then multiple bits deep. At a block 1206 a number of clock cycles needed for a given time delay is computed taking into consideration the bit depth of the encoding methodology used in the ADC. At a block 1208 the oversampled digital signal is delayed by a number of clock cycles that represents the time delay calculated in the block 1206. The process stops at the block 1210.

**[0083]** **Figure 13** illustrates, generally at 1300, a process to use a time delay imparted to an oversampled system in a beamforming process, according to embodiments of the invention. With reference to **Figure 13**, a process starts with a block 1302. At a block 1304 a time delay is selected for a beamforming process. At a block 1306 the time delay from the block 1304 is applied to a digitally oversampled signal in the oversampled domain for the signal. The oversampled domain for the signal can be, as described in the figures above, between the digital sensor and a receiver module for the digital sensor or in other embodiments the time delay is inserted at a location within the receiver module. In yet other embodiments, the time delay is inserted at more than one location within the oversampled domain. At a block 1308 a beamforming process is performed with the time delayed digital signal that represents the field quantity of interest. The time delay applied in the beamforming process at the block 1308 can be a fractional time delay with respect to a baseband sampling rate or it can be a sum of the fractional time delay and an

integer time delay. In some embodiments, a magnitude of the time delay applied in the oversampled domain can exceed the duration of a sampling interval (or clock cycle) in the baseband domain. Thus, use of the terms "fractional delay" does not limit embodiments of the invention, but is used herein to describe the relative magnitude of the delays in some embodiments. Where the integer time delay is a number of baseband sampling rate cycles. The process ends at a block 1310.

**[0084]** **Figure 14** illustrates, generally at 1400, a data processing system in which embodiments of the invention may be used. The block diagram is a high-level conceptual representation and may be implemented in a variety of ways and by various architectures. With reference to **Figure 14**, bus system 1402 interconnects a Central Processing Unit (CPU) 1404, Read Only Memory (ROM) 1406, Random Access Memory (RAM) 1408, storage 1410, display 1420, audio 1422, keyboard 1424, pointer 1426, data acquisition unit (DAU) 1428, and communications 1430. The bus system 1402 may be for example, one or more of such buses as a system bus, Peripheral Component Interconnect (PCI), Advanced Graphics Port (AGP), Small Computer System Interface (SCSI), Institute of Electrical and Electronics Engineers (IEEE) standard number 1394 (FireWire), Universal Serial Bus (USB), or a dedicated bus designed for a custom application, etc. The CPU 1404 may be a single, multiple, or even a distributed computing resource or a digital signal processing (DSP) chip. Storage 1410 may be Compact Disc (CD), Digital Versatile Disk (DVD), hard disks (HD), optical disks, tape, flash, memory sticks, video recorders, etc. The signal processing system 1400 can be an acoustic signal processing system used to receive acoustic signals that are input from a single microphone or a plurality of microphones (e.g., a first microphone, a second

microphone, etc.). Note that depending upon the actual implementation of the acoustic signal processing system, the acoustic signal processing system may include some, all, more, or a rearrangement of components in the block diagram. In some embodiments, aspects of the system 1400 are performed in software. While in some embodiments, aspects of the system 1400 are performed in dedicated hardware such as a digital signal processing (DSP) chip 1440, or a system on a chip (SOC) which can also be represented at 1440, etc. as well as combinations of dedicated hardware and software as is known and appreciated by those of ordinary skill in the art.

**[0085]** Thus, in various embodiments, acoustic signal data is received at 1429 for processing by the acoustic signal processing system 1400. Such data can be transmitted at 1432 via communications interface 1430 for further processing in a remote location. Connection with a network, such as an intranet or the Internet is obtained via 1432, as is recognized by those of skill in the art, which enables the acoustic signal processing system 1400 to communicate with other data processing devices or systems in remote locations.

**[0086]** For example, embodiments of the invention can be implemented on a computer system 1400 configured as a desktop computer or work station, on for example a WINDOWS® compatible computer running operating systems such as WINDOWS® XP Home or WINDOWS® XP Professional, WINDOWS® 10 Home or WINDOWS® 10 Professional, Linux, Unix, etc. as well as computers from APPLE COMPUTER, Inc. running operating systems such as OS X, etc. Alternatively, or in conjunction with such an implementation, embodiments of the invention can be configured with devices such as speakers, earphones, video monitors, etc. configured for use with a Bluetooth

communication channel. In yet other implementations, embodiments of the invention are configured to be implemented by mobile devices such as a smart phone, a tablet computer, a wearable device, such as eye glasses, a near-to-eye (NTE) headset, or the like.

**[0087]** In various embodiments, the components of systems as well as the systems described in the previous figures are implemented in an integrated circuit device, which may include an integrated circuit package containing the integrated circuit. In some embodiments, the components of systems as well as the systems are implemented in a single integrated circuit die. In other embodiments, the components of systems as well as the systems are implemented in more than one integrated circuit die of an integrated circuit device which may include a multi-chip package containing the integrated circuit. For example, in one non-limiting embodiment using **Figure 8**, as illustrated by the example of **Figure 8** and **Figure 15A**, the components of the system are implemented in more than one integrated circuit die. With reference to 1500, a first integrated circuit die 1502 includes the digital sensor 804 and time delay element 808; a second integrated circuit die 1504 includes one or more of the PDM receiver module 812, time delay controller 818, and time delay element 816. In some embodiments the second integrated circuit die 1504 does not include time delay controller 818 and time delay element 816. PDM receiver module 812 together with one or more of time delay controller 818 and time delay element 816 can also be referred to as an Application Processor. In another non-limiting embodiment, as illustrated by the example of **Figure 8** and **Figure 15B**, the components of the system are implemented in more than one integrated circuit die. With reference to 1550 a first integrated circuit die 1502 includes the digital sensor 804; a

second integrated circuit die 1504 includes the PDM receiver module 812, the time delay element 808, and one or more of the time delay controller 818, and time delay element 816. In some embodiments the second integrated circuit die 1504 does not include time delay controller 818 and time delay element 816. PDM receiver module 812 and time delay element 808 together with one or more of time delay controller 818 and time delay element 816 can also be referred to as an Application Processor. Distribution of any of the systems illustrated in the figures above (e.g., any one or more of **Figure 1** through **Figure 14**) can be distributed between one or more integrated circuits dies. The examples of **Figure 15A** and **Figure 15B** are provided merely for illustration and do not limit embodiments of the invention. In some embodiments, the components of systems illustrated in the first integrated circuit die 1502 and the second integrated circuit die 1504 are implemented in a single integrated circuit die. In some embodiments, the entire system is implemented in a single integrated circuit die.

**[0088]** For purposes of discussing and understanding the embodiments of the invention, it is to be understood that various terms are used by those knowledgeable in the art to describe techniques and approaches. Furthermore, in the description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be evident, however, to one of ordinary skill in the art that the present invention may be practiced without these specific details. In some instances, well-known structures and devices are shown in block diagram form, rather than in detail, in order to avoid obscuring the present invention. These embodiments are described in sufficient detail to enable those of ordinary skill in the art to practice the invention, and it is to be understood that other embodiments may be

utilized and that logical, mechanical, electrical, and other changes may be made without departing from the scope of the present invention.

**[0089]** Some portions of the description may be presented in terms of algorithms and symbolic representations of operations on, for example, data bits within a computer memory. These algorithmic descriptions and representations are the means used by those of ordinary skill in the data processing arts to most effectively convey the substance of their work to others of ordinary skill in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of acts leading to a desired result. The acts are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, waveforms, data, time series or the like.

**[0090]** It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, can refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other

data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission, or display devices.

**[0091]** An apparatus for performing the operations herein can implement the present invention. This apparatus may be specially constructed for the required purposes, or it may comprise a general-purpose computer, selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable storage medium, such as, but not limited to, any type of disk including floppy disks, hard disks, optical disks, compact disk read-only memories (CD-ROMs), and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), electrically programmable read-only memories (EPROM)s, electrically erasable programmable read-only memories (EEPROMs), FLASH memories, magnetic or optical cards, etc., or any type of media suitable for storing electronic instructions either local to the computer or remote to the computer.

**[0092]** The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the required method. For example, any of the methods according to the present invention can be implemented in hard-wired circuitry, by programming a general-purpose processor, or by any combination of hardware and software. One of ordinary skill in the art will immediately appreciate that the invention can be practiced with computer system configurations other than those described, including hand-held devices, multiprocessor systems, microprocessor-based or programmable consumer electronics, digital signal processing (DSP) devices, network

PCs, minicomputers, mainframe computers, and the like. The invention can also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In other examples, embodiments of the invention as described in the figures above can be implemented using a system on a chip (SOC), a Bluetooth chip, a digital signal processing (DSP) chip, a codec with integrated circuits (ICs) or in other implementations of hardware and software.

**[0093]** The methods of the invention may be implemented using computer software. If written in a programming language conforming to a recognized standard, sequences of instructions designed to implement the methods can be compiled for execution on a variety of hardware platforms and for interface to a variety of operating systems. In addition, the present invention is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the invention as described herein. Furthermore, it is common in the art to speak of software, in one form or another (e.g., program, procedure, application, driver,...), as taking an action or causing a result. Such expressions are merely a shorthand way of saying that execution of the software by a computer causes the processor of the computer to perform an action or produce a result.

**[0094]** It is to be understood that various terms and techniques are used by those knowledgeable in the art to describe communications, protocols, applications, implementations, mechanisms, etc. One such technique is the description of an implementation of a technique in terms of an algorithm or mathematical expression. That is, while the technique may be, for example, implemented as executing code on a

computer, the expression of that technique may be more aptly and succinctly conveyed and communicated as a formula, algorithm, mathematical expression, flow diagram or flow chart. Thus, one of ordinary skill in the art would recognize a block denoting A+B=C as an additive function whose implementation in hardware and/or software would take two inputs (A and B) and produce a summation output (C). Thus, the use of formula, algorithm, or mathematical expression as descriptions is to be understood as having a physical embodiment in at least hardware and/or software (such as a computer system in which the techniques of the present invention may be practiced as well as implemented as an embodiment).

**[0095]** Non-transitory machine-readable media is understood to include any mechanism for storing information in a form readable by a machine (e.g., a computer). For example, a machine-readable medium, synonymously referred to as a computer-readable medium, includes read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; flash memory devices; except electrical, optical, acoustical or other forms of transmitting information via propagated signals (e.g., carrier waves, infrared signals, digital signals, etc.); etc.

**[0096]** As used in this description, "one embodiment" or "an embodiment" or similar phrases means that the feature(s) being described are included in at least one embodiment of the invention. References to "one embodiment" in this description do not necessarily refer to the same embodiment; however, neither are such embodiments mutually exclusive. Nor does "one embodiment" imply that there is but a single embodiment of the invention. For example, a feature, structure, act, etc. described in "one embodiment" may also be included in other embodiments. Thus, the invention may

include a variety of combinations and/or integrations of the embodiments described herein.

**[0097]** Thus, embodiments of the invention can be used in various acoustic systems. Some non-limiting examples of such systems are, but are not limited to, use in short boom headsets, such as an audio headset for telephony suitable for enterprise call centers, industrial and general mobile usage, an in-line "ear buds" headset with an input line (wire, cable, or other connector), mounted on or within the frame of eyeglasses, a near-to-eye (NTE) headset display or headset computing device, a long boom headset for very noisy environments such as industrial, military, and aviation applications as well as a gooseneck desktop-style microphone which can be used to provide theater or symphony-hall type quality acoustics without the structural costs.

**[0098]** While the invention has been described in terms of several embodiments, those of skill in the art will recognize that the invention is not limited to the embodiments described, but can be practiced with modification and alteration within the spirit and scope of the appended claims. The description is thus to be regarded as illustrative instead of limiting.

What is claimed is:

1. A computer-readable storage medium storing program code for causing a data processing system to perform the steps comprising:

outputting a first oversampled digital signal output from an analog-to-digital converter (ADC), wherein the first oversampled digital signal is responsive to an analog field and the first oversampled digital signal is created at a sampling clock frequency;

delaying the first oversampled digital signal by a time delay wherein the time delay is equal to an integer number of sampling clock cycles to produce a time delayed first oversampled digital signal; and

combining the time delayed first oversampled digital signal with a second oversampled digital signal to obtain the beamformed digital signal, wherein the second oversampled digital signal is responsive to the analog field.

2. The computer-readable storage medium of claim 1, wherein the combining is performed in an oversampled signal domain.

3. The computer-readable storage medium of claim 1, wherein the combining is performed at an intermediate sampling rate.

4. The computer-readable storage medium of claim 1, wherein the combining is performed in a baseband signal domain.

5. The computer-readable storage medium of claim 1, wherein the first oversampled digital signal and the second oversampled digital signal are obtained from different sensors.

6. The computer-readable storage medium of claim 1, wherein the first oversampled digital signal and the second oversampled digital signal are obtained from the same sensor.

7. The computer-readable storage medium of claim 1, further comprising:

applying a low pass filter with decimation to the time delayed first oversampled digital signal to output a baseband digital signal that is delayed by the time delay.

8. The computer-readable storage medium of claim 7, wherein the time delay is equal to a fraction of a baseband sampling period.

9. The computer-readable storage medium of claim 7, wherein the time delay is greater than a baseband sampling period.

10. The computer-readable storage medium of claim 7, wherein the first oversampled digital signal is digitized to create samples which are more than one bit deep.

**ABSTRACT**

Systems and methods are described to time delay a signal output from an analog-to-digital converter (ADC). The ADC includes a digital sensor responsive to an analog field quantity. The digital sensor is configured to output an oversampled digital output signal at a sampling clock frequency. A time delay element is configured to receive as an input, the oversampled digital output signal and to output a time delayed oversampled digital output signal. A filter is configured to receive as an input the delayed oversampled digital output signal. The filter low pass filters and decimates to a lower sample rate the delayed oversampled digital output signal. An output includes a low pass filtered decimated delayed digital output signal, where the lower sample rate is less than the sampling clock frequency.

FIGURE 1



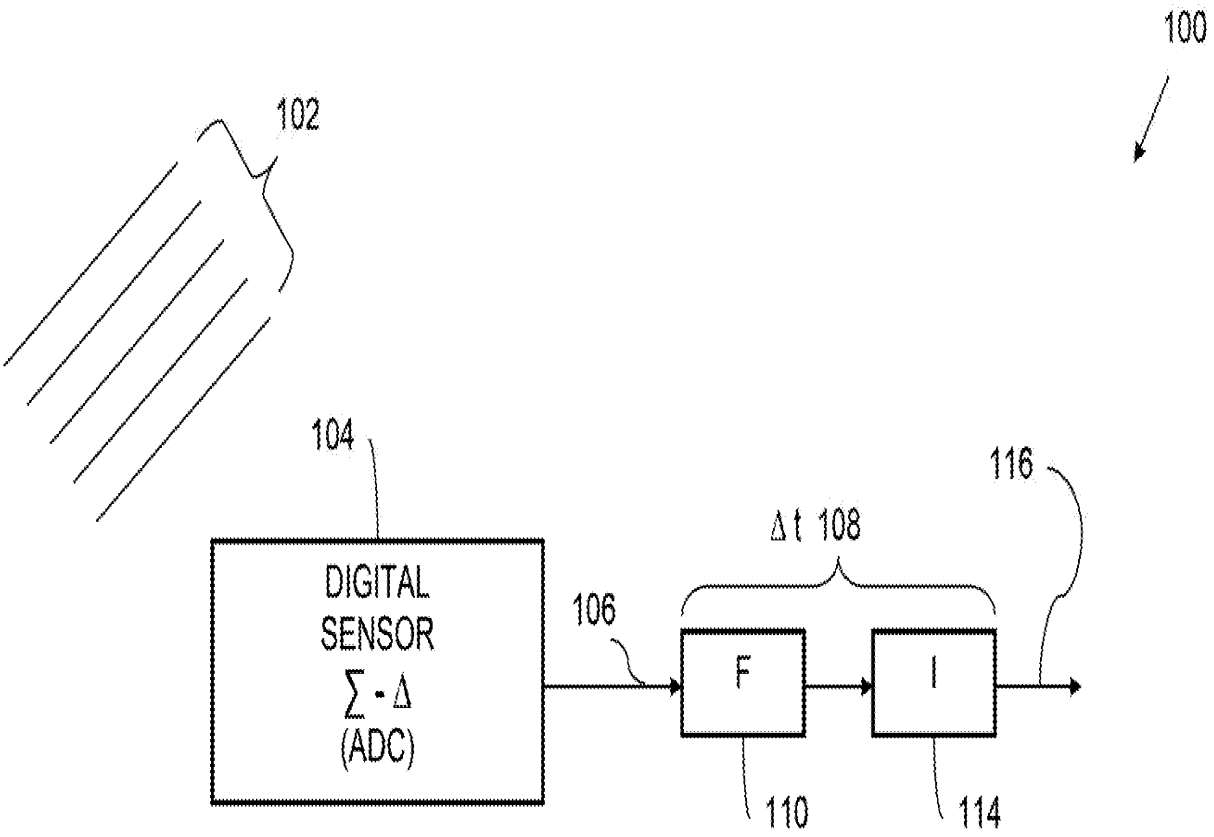


FIGURE 2A



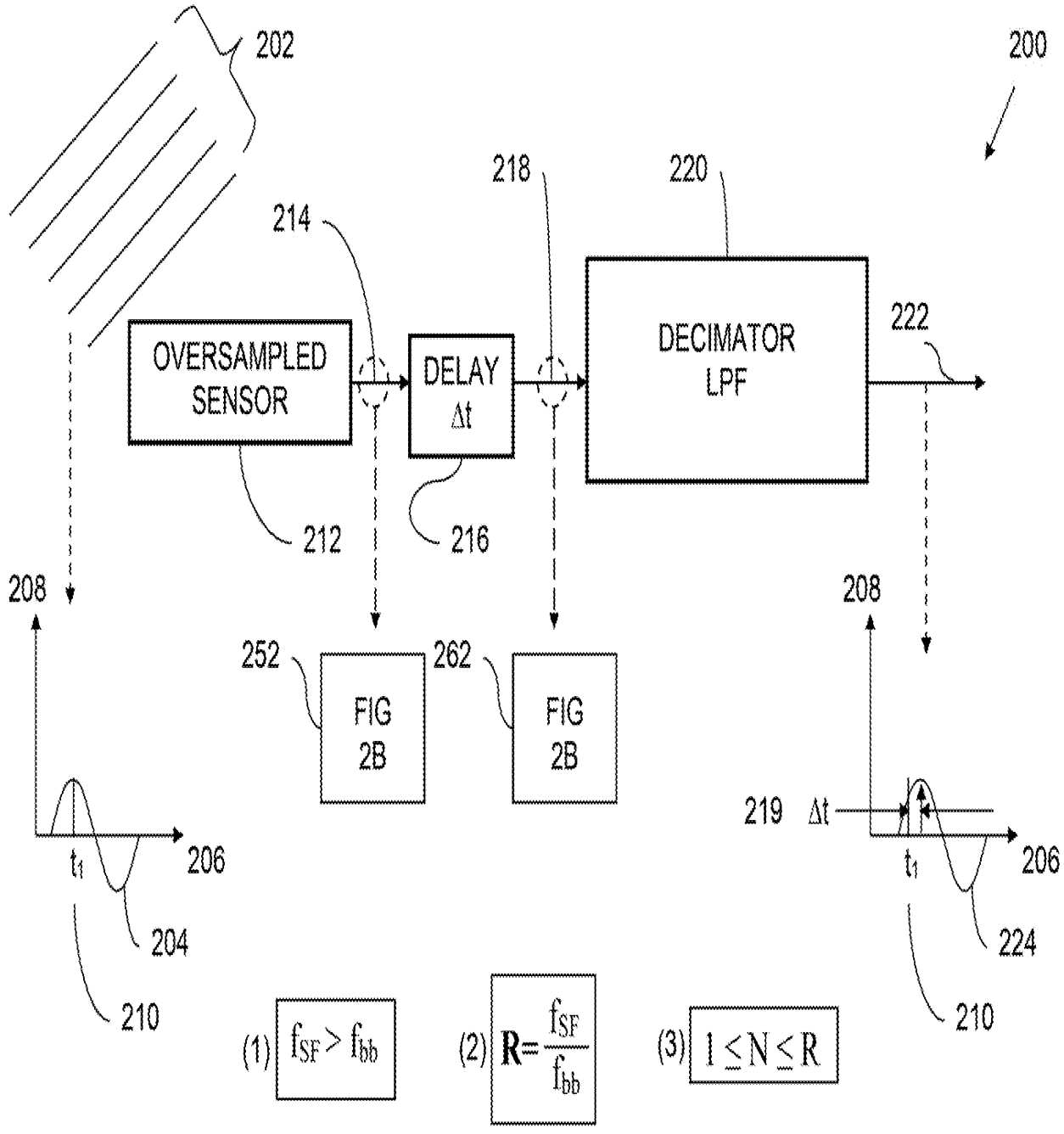
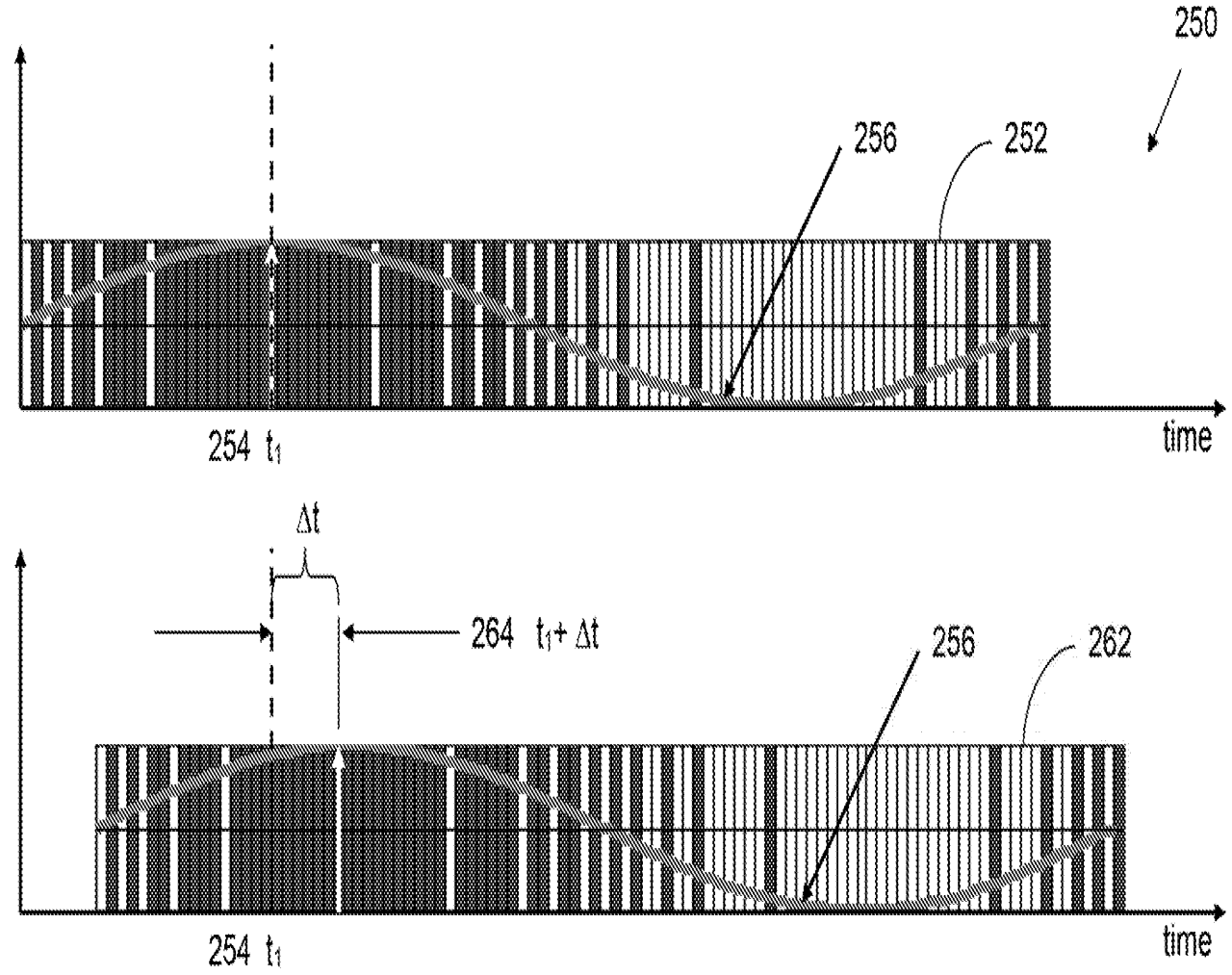

202
200
218
220
214
OVERSAMPLED SENSOR
DELAY Δt
DECIMATOR LPF
222
212
216
208
252
262
FIG 2B
FIG 2B
208
219 Δt
t1
206
204
210
t1
206
224
210
(1) $f_{SF} > f_{bb}$
(2) $R = \frac{f_{SF}}{f_{bb}}$
(3) $1 \leq N \leq R$

FIGURE 2B






(4) $\Delta t = N^* \tau_{SF}$

(5) $\Delta t = N^*(M^* \tau_{SF})$

(6) $1 \leq N^*M \leq R$

FIGURE 2C



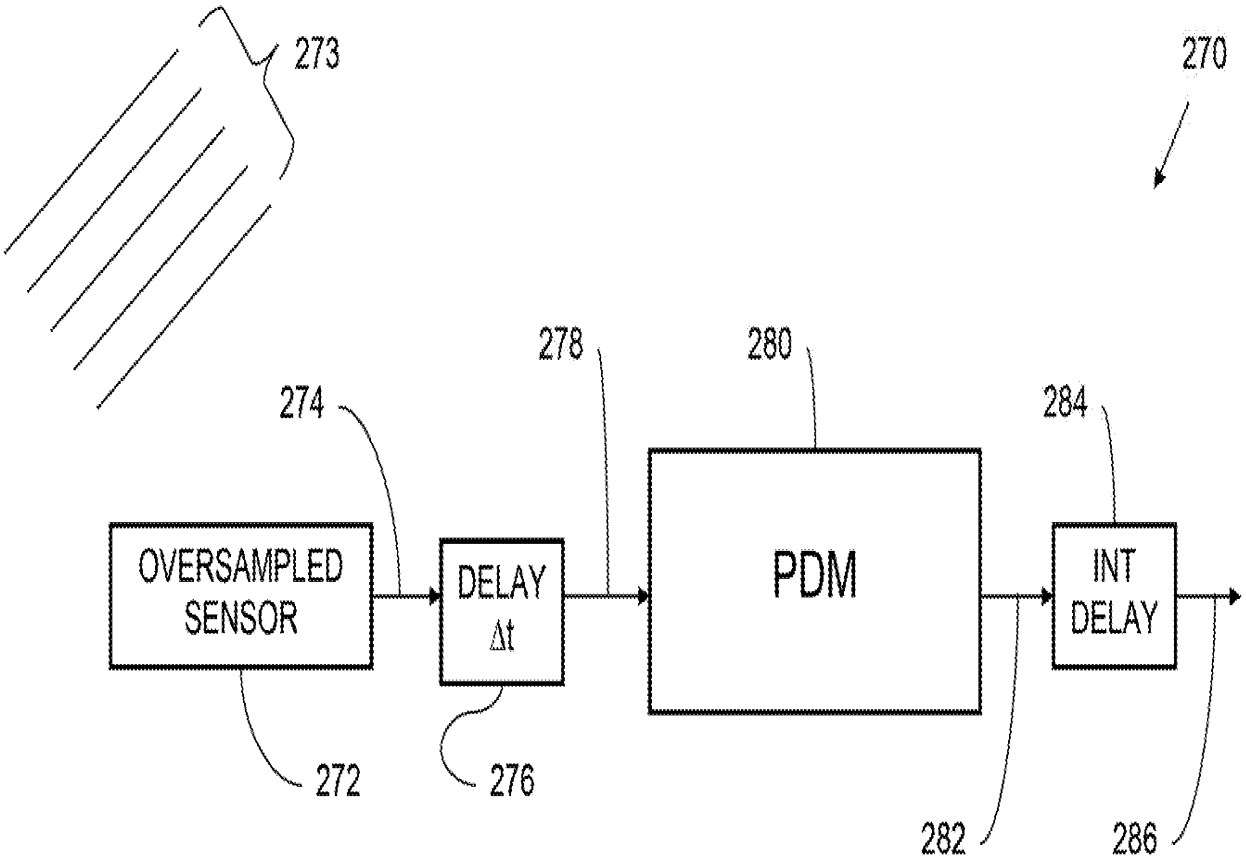

273
270
278
280
274
284
OVERSAMPLED SENSOR
DELAY Δt
PDM
INT DELAY
272
276
282
286

FIGURE 3



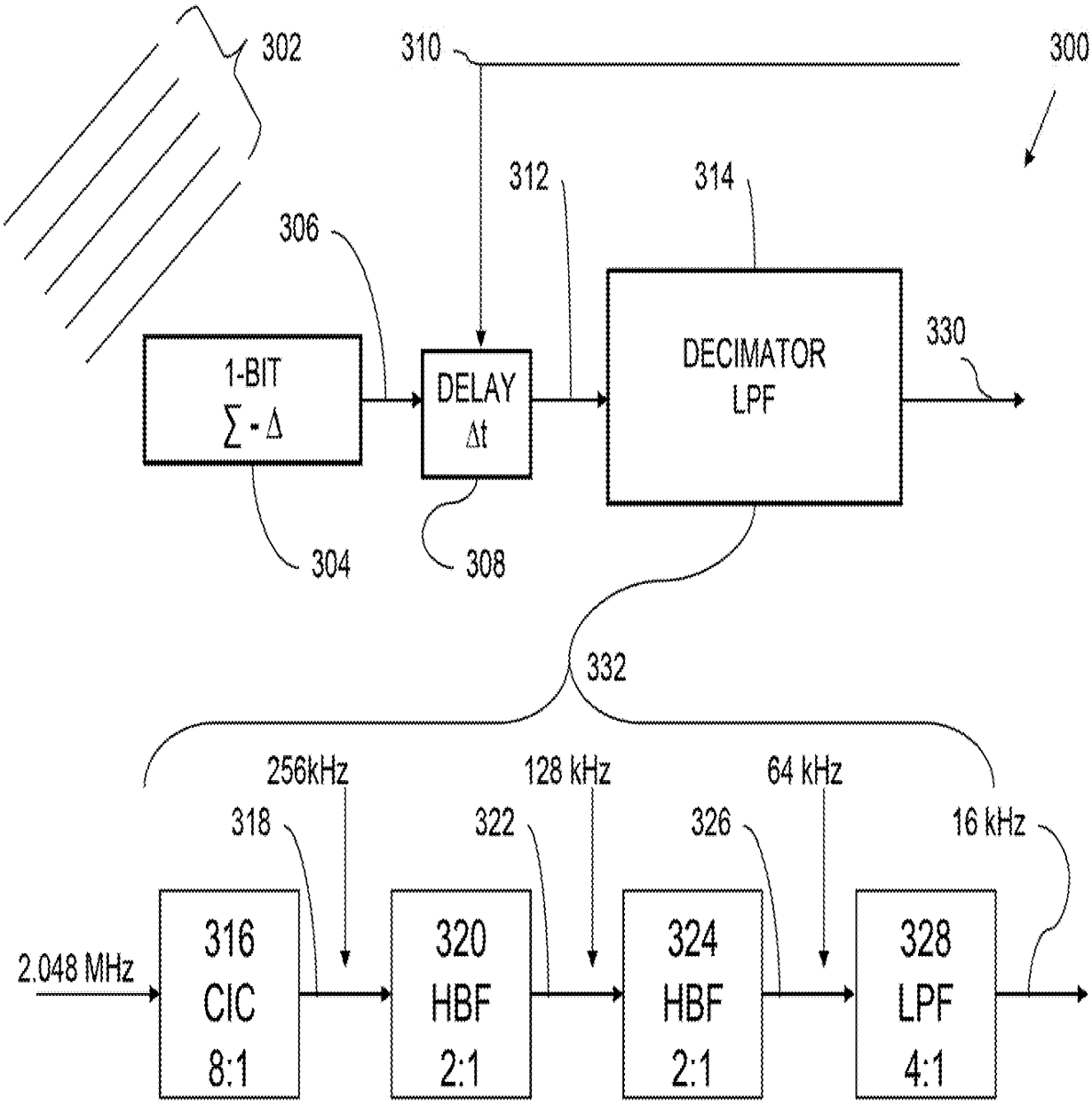

302
310
300
312
314
306
1-BIT
∑ - Δ
DELAY
Δt
DECIMATOR
LPF
330
304
308
332
256kHz
128 kHz
64 kHz
318
322
326
16 kHz
2.048 MHz
316
CIC
8:1
320
HBF
2:1
324
HBF
2:1
328
LPF
4:1

FIGURE 4



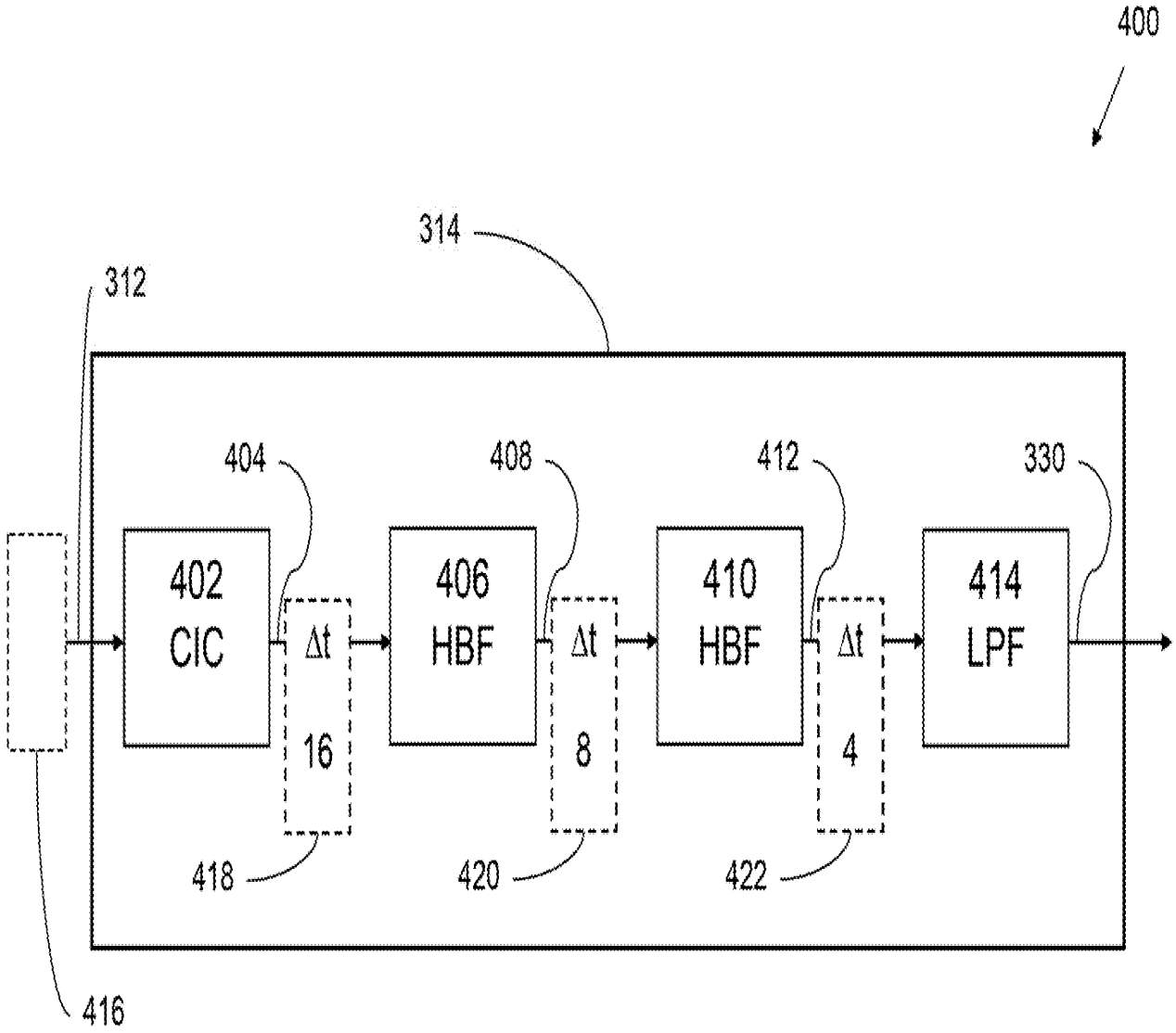

400
314
312
404
408
412
330
402
CIC
Δt
16
406
HBF
Δt
8
410
HBF
Δt
4
414
LPF
418
420
422
416

FIGURE 5 7/20

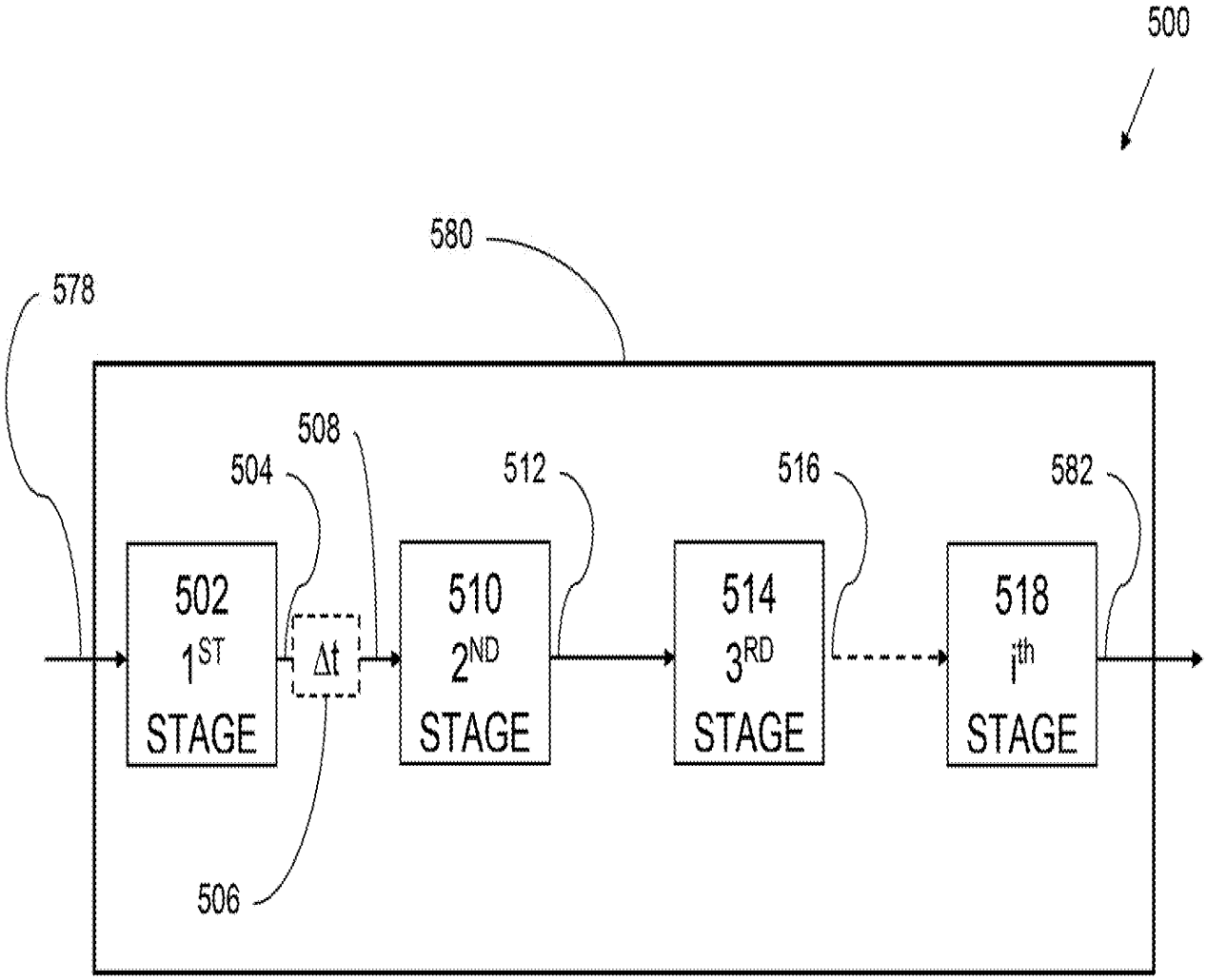

500
580
578
508
504
512
516
582
502
1ST
STAGE
Δt
510
2ND
STAGE
514
3RD
STAGE
518
i th
STAGE
506

FIGURE 6



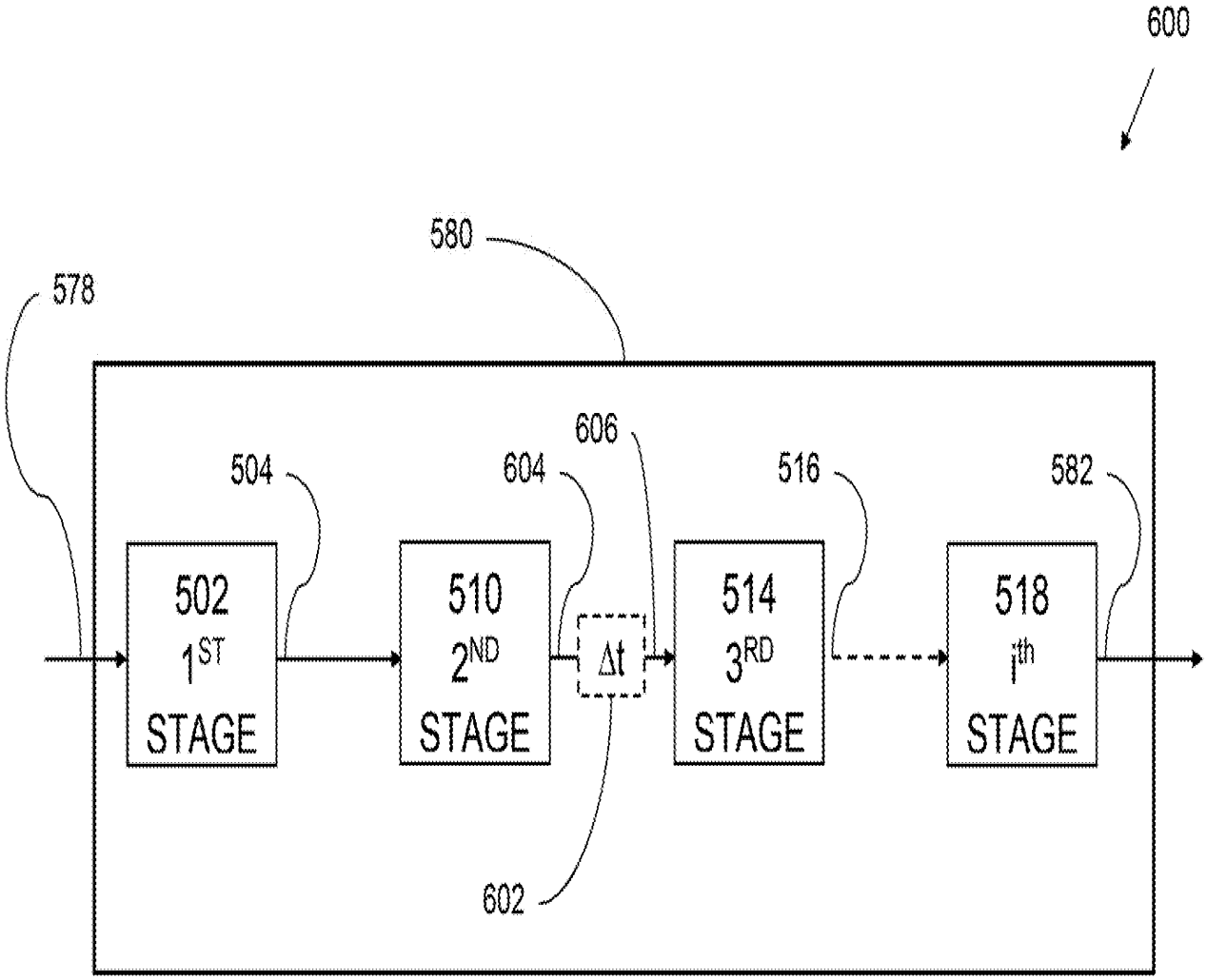

600
580
578
606
504
604
516
582
502
1ST
STAGE
510
2ND
STAGE
Δt
514
3RD
STAGE
518
ith
STAGE
602

FIGURE 7



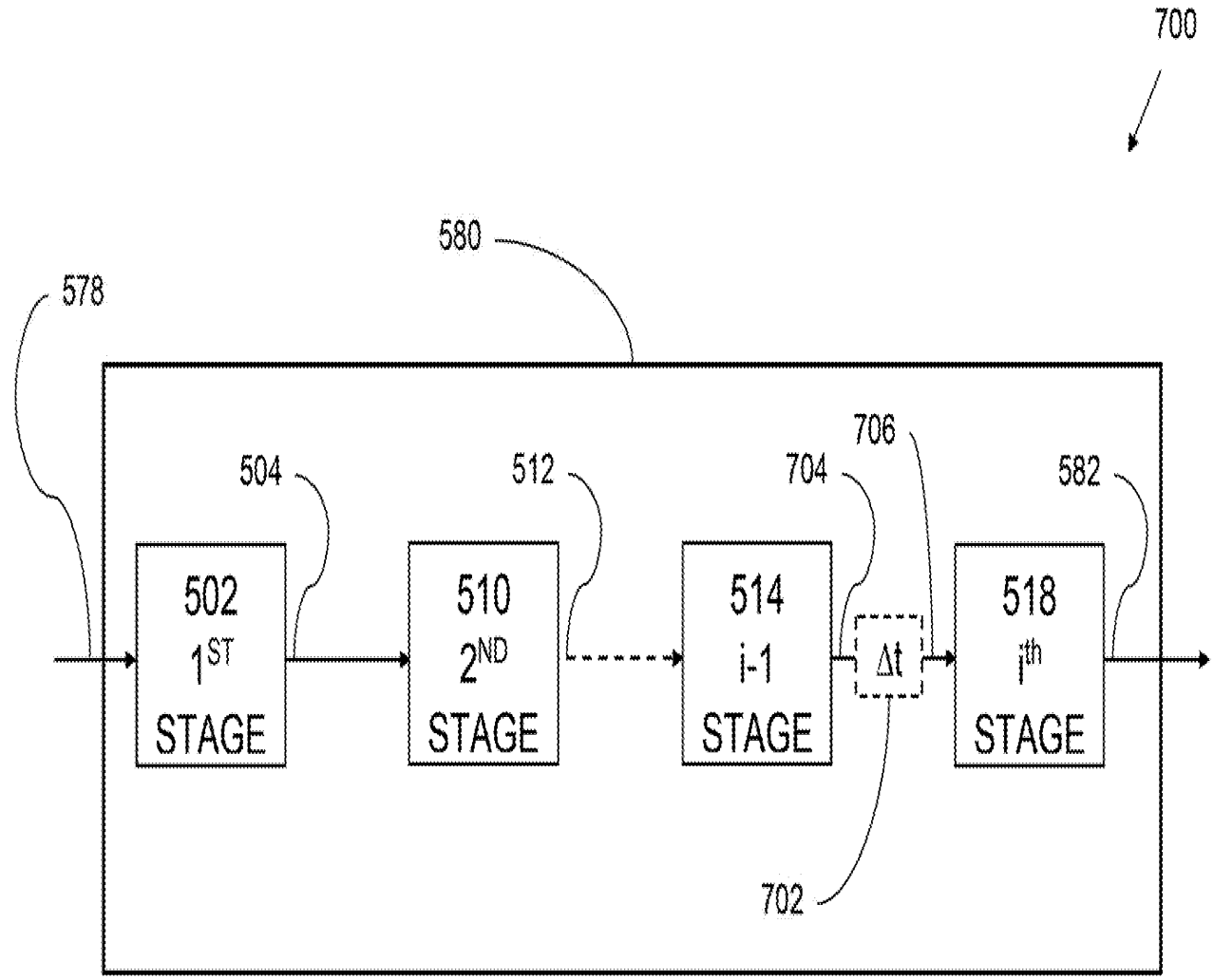

700
580
578
504
512
704
706
582
502
1ST
STAGE
510
2ND
STAGE
514
i-1
STAGE
Δt
518
ith
STAGE
702

FIGURE 8



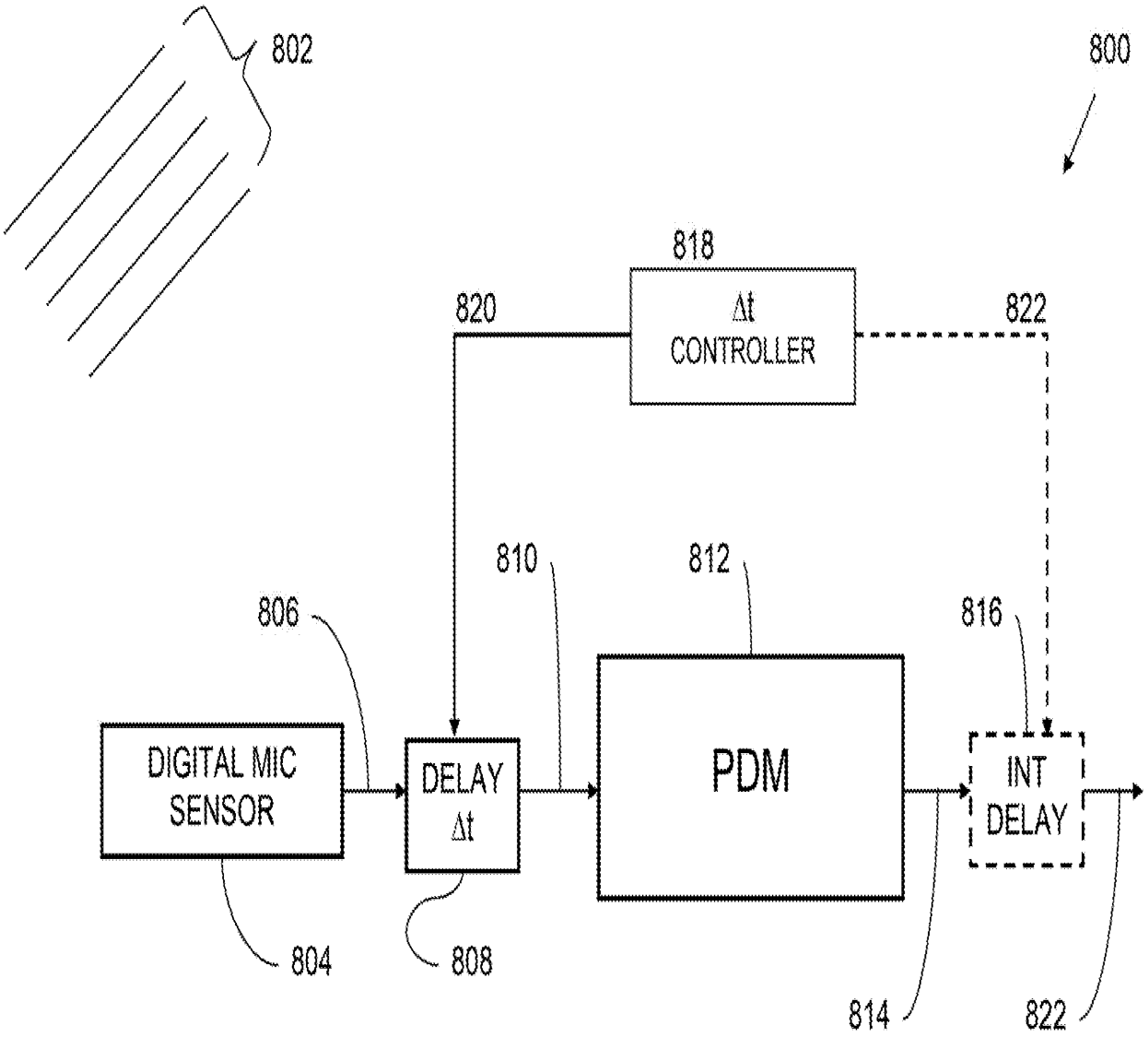

802
800
818
820
Δt
CONTROLLER
822
810
812
806
816
DIGITAL MIC
SENSOR
DELAY
Δt
PDM
INT
DELAY
804
808
814
822

FIGURE 9A



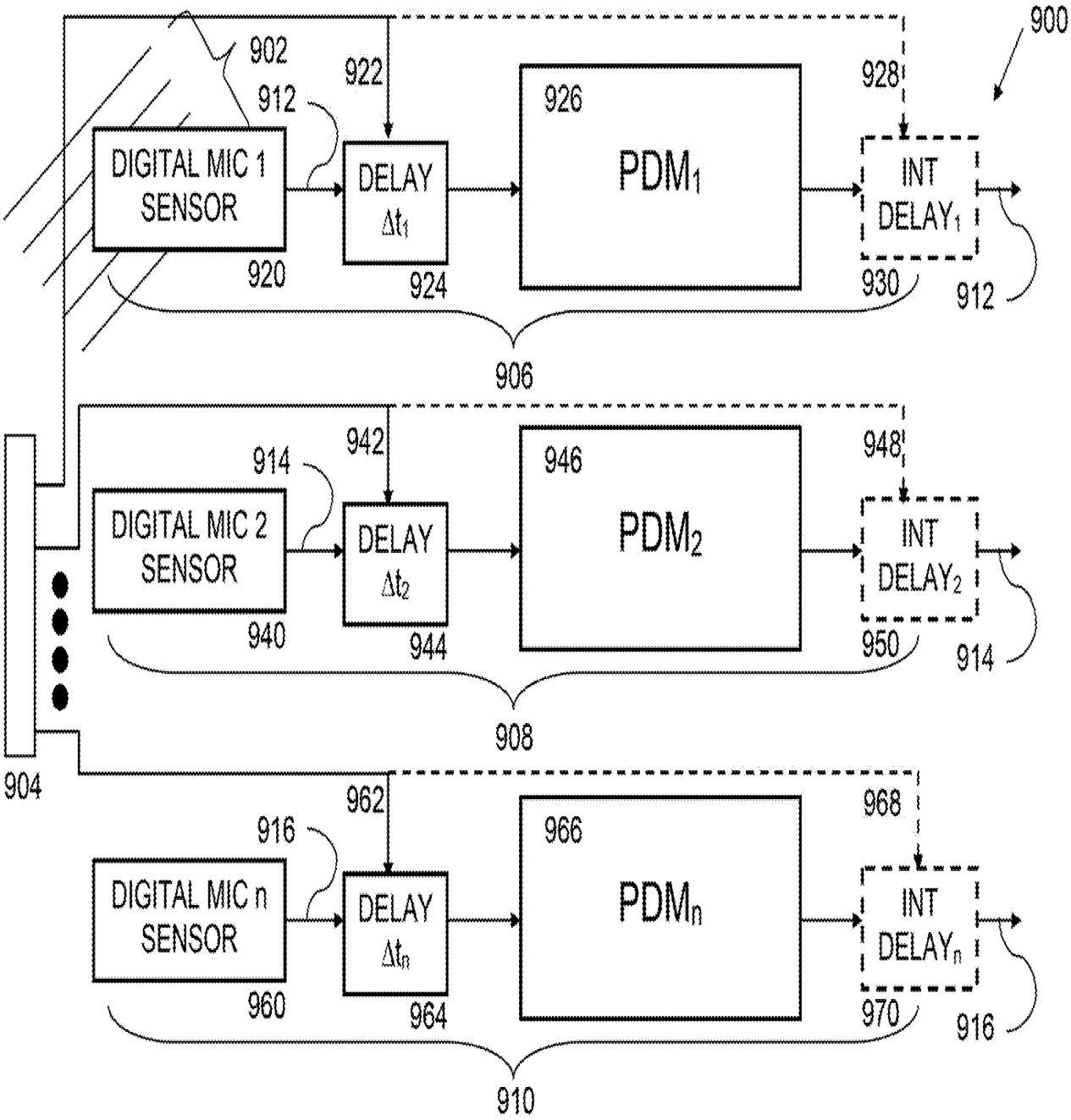

900
902
912
922
926
928
DIGITAL MIC 1 SENSOR
DELAY $\Delta t_1$
$PDM_1$
INT DELAY$_1$
920
924
930
912
906
914
942
946
948
DIGITAL MIC 2 SENSOR
DELAY $\Delta t_2$
$PDM_2$
INT DELAY$_2$
940
944
950
914
908
904
916
962
966
968
DIGITAL MIC n SENSOR
DELAY $\Delta t_n$
$PDM_n$
INT DELAY$_n$
960
964
970
916
910

FIGURE 9B



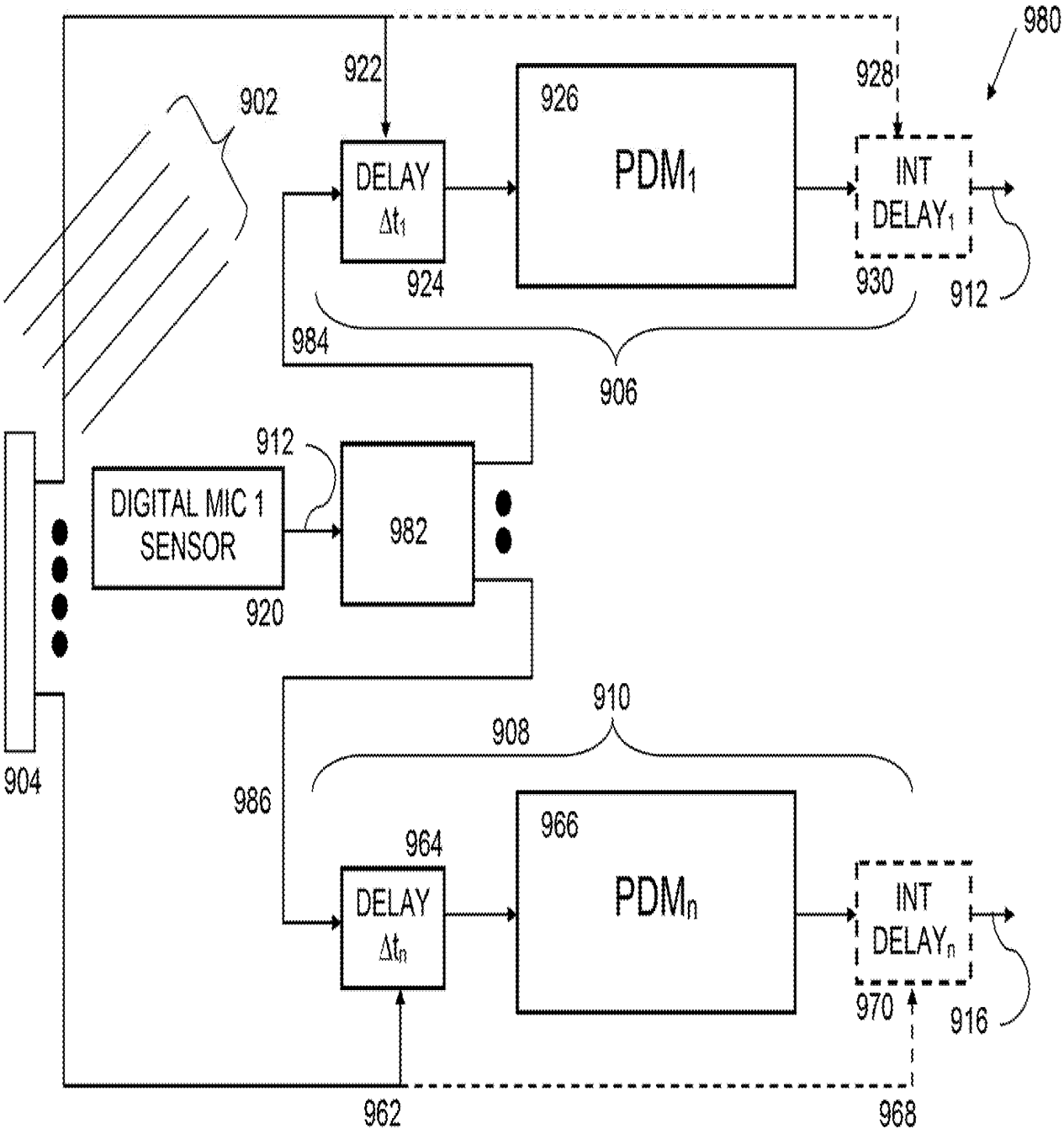

980
922
928
902
926
DELAY
$\Delta t_1$
$PDM_1$
INT
$DELAY_1$
924
930
912
984
906
912
DIGITAL MIC 1
SENSOR
982
920
910
908
904
986
966
964
DELAY
$\Delta t_n$
$PDM_n$
INT
$DELAY_n$
970
916
962
968

FIGURE 10



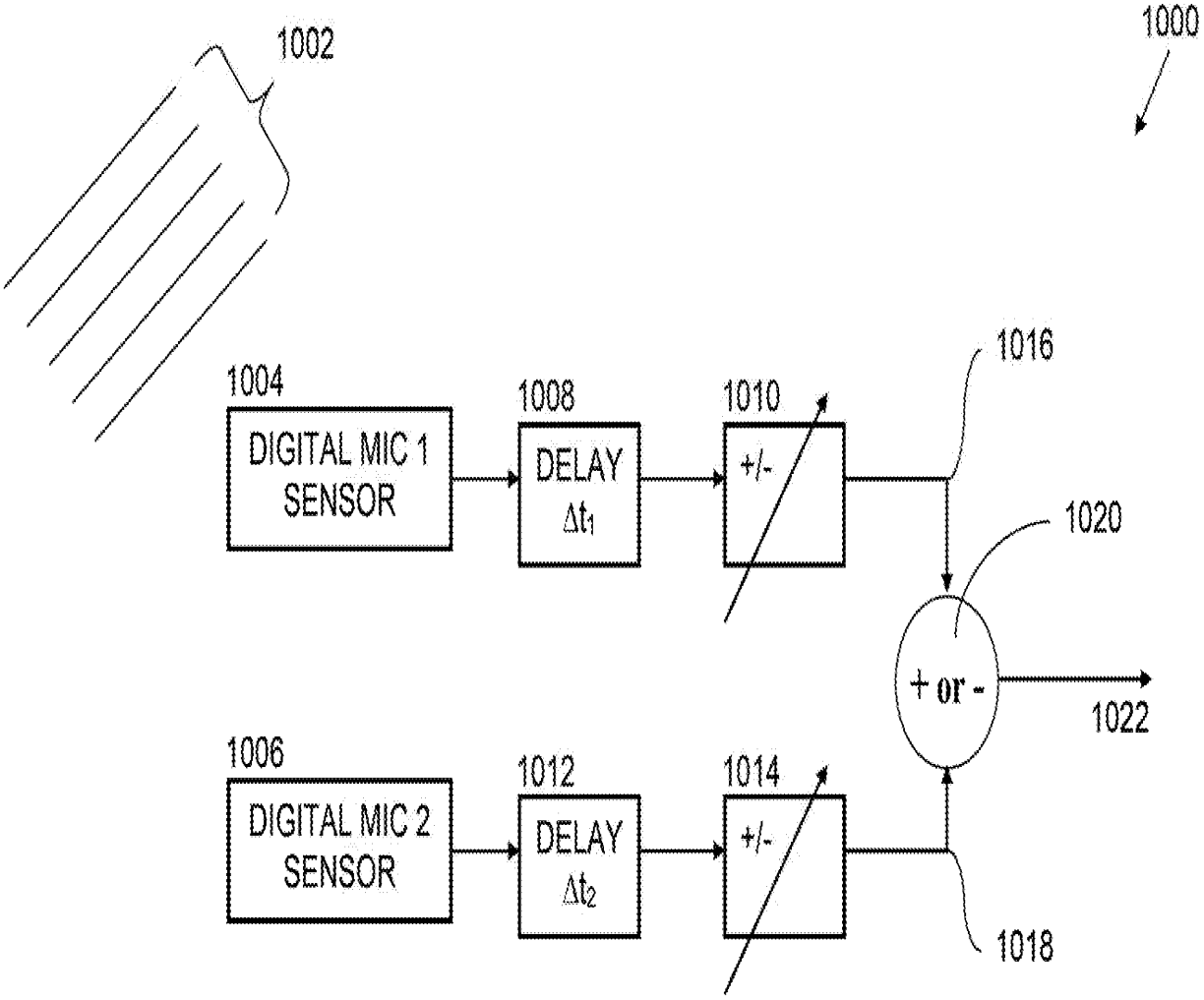

1000
1002
1004
DIGITAL MIC 1 SENSOR
1008
DELAY Δt1
1010
+/-
1016
1020
+ or -
1022
1006
DIGITAL MIC 2 SENSOR
1012
DELAY Δt2
1014
+/-
1018

FIGURE 11A



$$(7)\quad \Delta t = \tau = 1/f$$

$$(8)\quad \Delta t_{\text{integer delay}} = 1/f_{bb}$$

$$(9)\quad \Delta t_{\text{fractional delay}} = 1/f_{SF}$$

$$(10)\quad \frac{1}{R} = \frac{\Delta t_{\text{fractional delay}}}{\Delta t_{\text{integer delay}}}$$

$$(11)\quad \Delta t_{\text{fractional delay}} = \frac{\Delta t_{\text{integer delay}}}{R}$$

FIGURE 11B



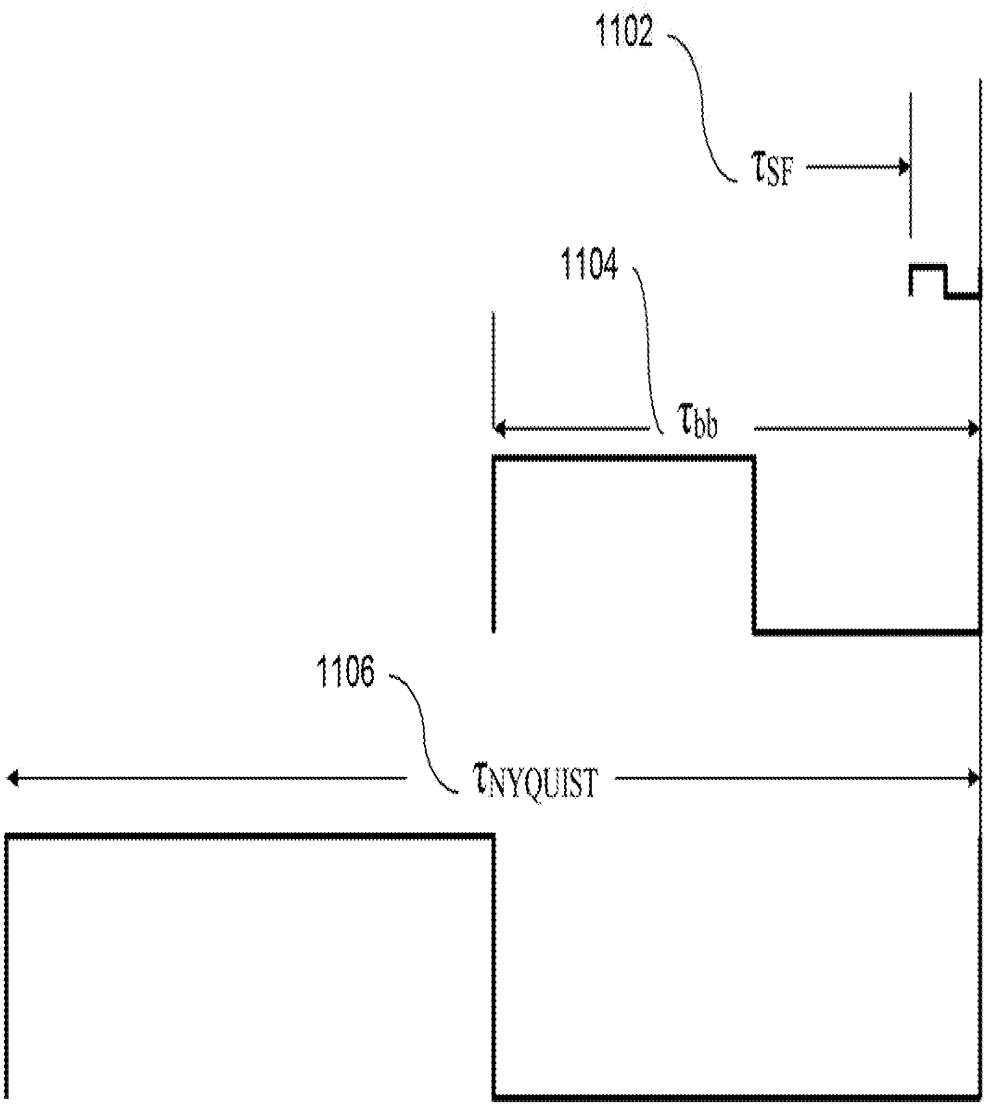


FIGURE 12



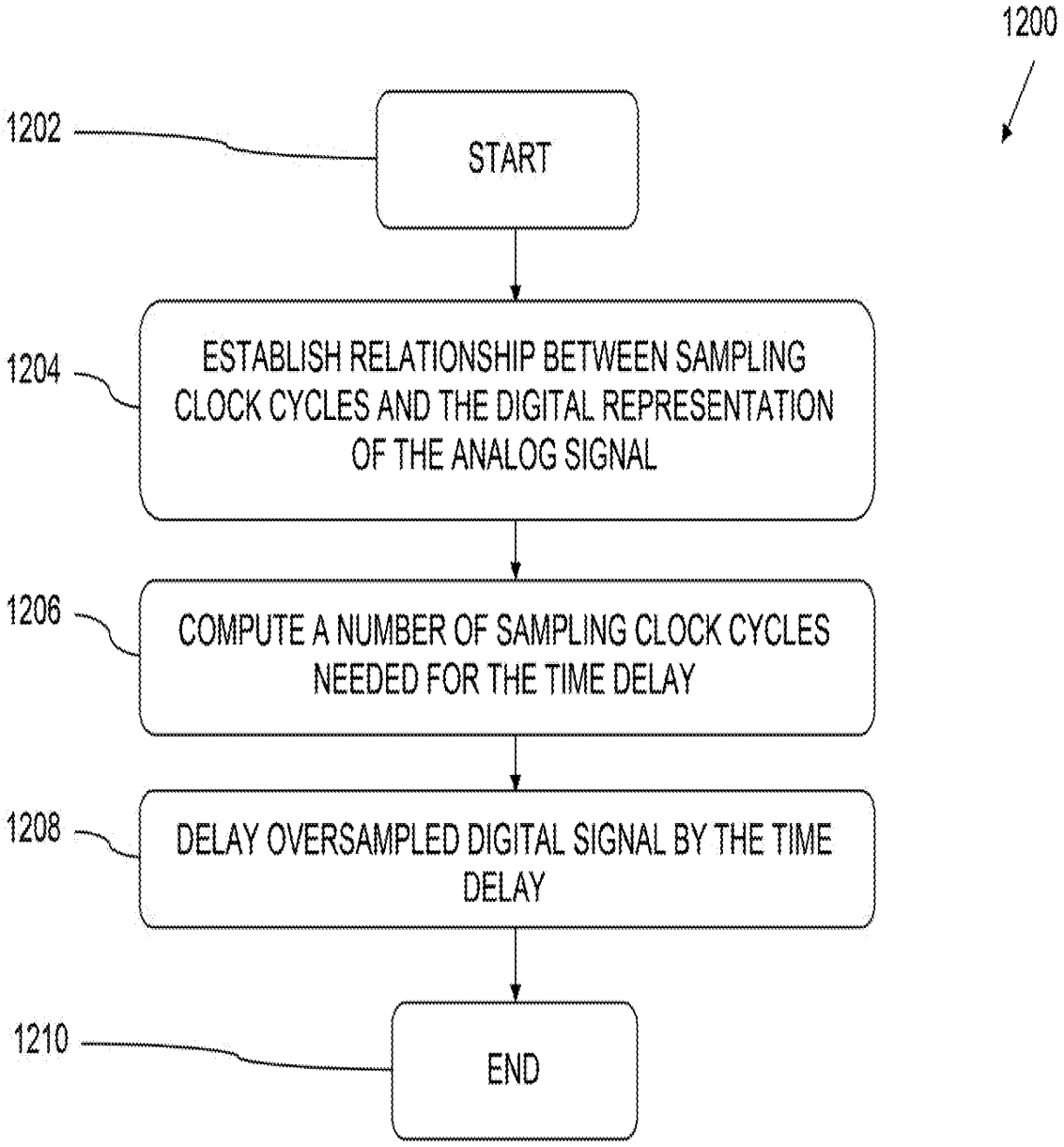

1200
1202
START
1204
ESTABLISH RELATIONSHIP BETWEEN SAMPLING CLOCK CYCLES AND THE DIGITAL REPRESENTATION OF THE ANALOG SIGNAL
1206
COMPUTE A NUMBER OF SAMPLING CLOCK CYCLES NEEDED FOR THE TIME DELAY
1208
DELAY OVERSAMPLED DIGITAL SIGNAL BY THE TIME DELAY
1210
END

FIGURE 13



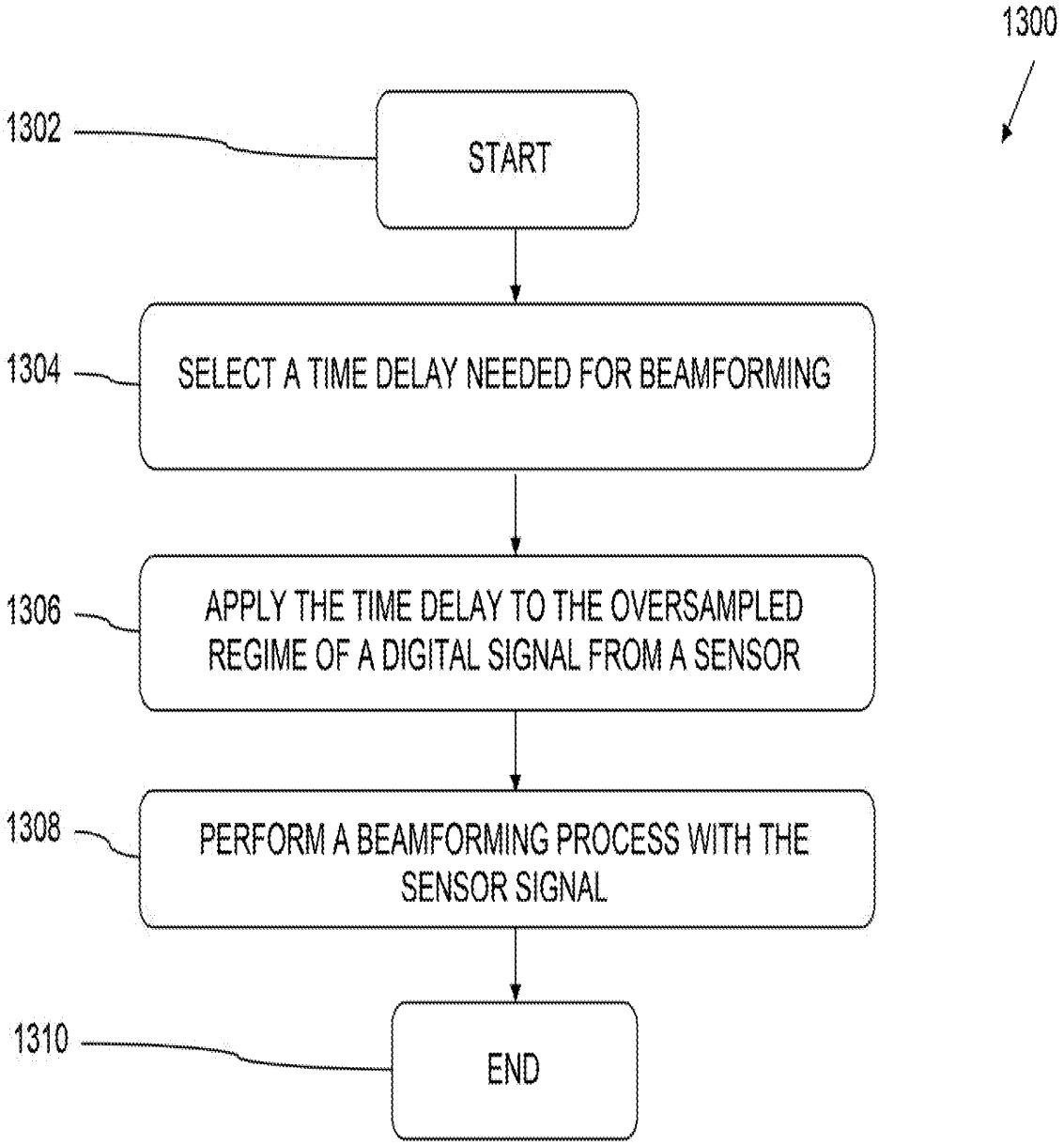

1300
1302
START
1304
SELECT A TIME DELAY NEEDED FOR BEAMFORMING
1306
APPLY THE TIME DELAY TO THE OVERSAMPLED REGIME OF A DIGITAL SIGNAL FROM A SENSOR
1308
PERFORM A BEAMFORMING PROCESS WITH THE SENSOR SIGNAL
1310
END

FIGURE 14



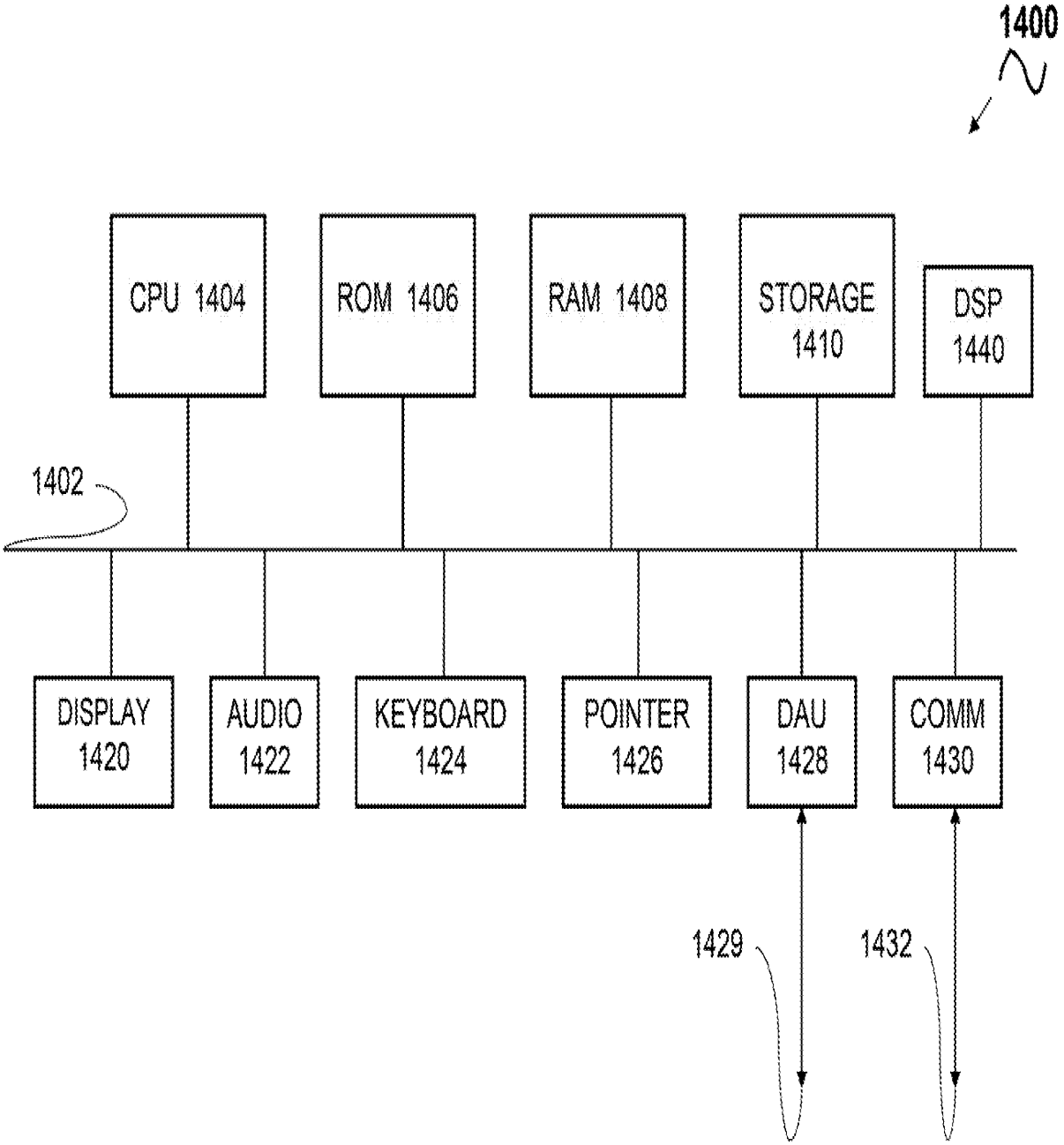

1400
CPU 1404
ROM 1406
RAM 1408
STORAGE 1410
DSP 1440
1402
DISPLAY 1420
AUDIO 1422
KEYBOARD 1424
POINTER 1426
DAU 1428
COMM 1430
1429
1432

FIGURE 15A



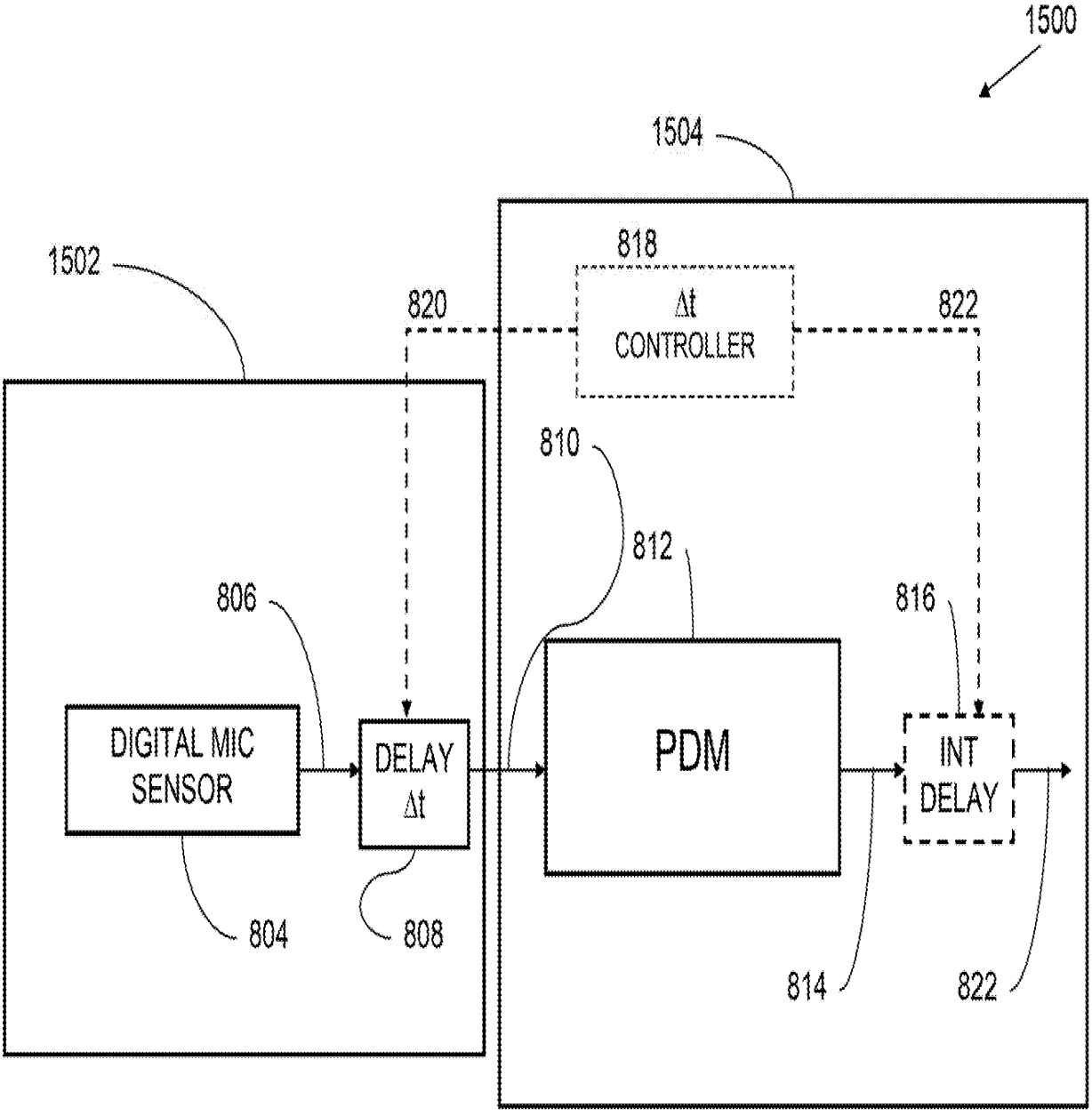
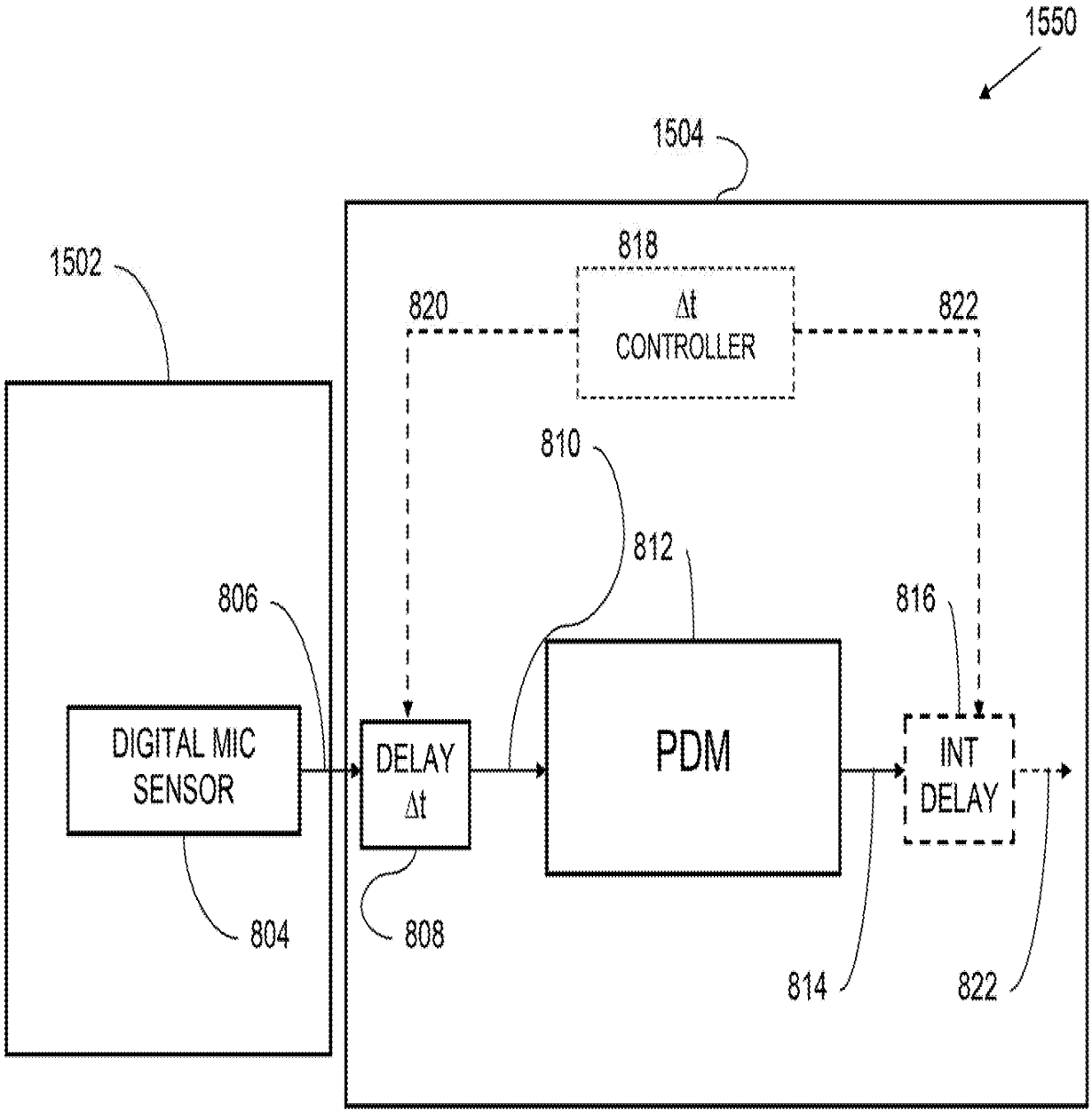

1500
1504
1502
818
Δt
CONTROLLER
820
822
810
812
806
816
DIGITAL MIC
SENSOR
DELAY
Δt
PDM
INT
DELAY
804
808
814
822

FIGURE 15B




1550
1504
1502
818
820
Δt
CONTROLLER
822
810
812
806
816
DIGITAL MIC
SENSOR
DELAY
Δt
PDM
INT
DELAY
804
808
814
822

# Electronic Patent Application Fee Transmittal

| | |
|---|---|
| **Application Number:** | |
| **Filing Date:** | |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | DASHEN FAN |
| **Filer:** | Mark S. Peloquin |
| **Attorney Docket Number:** | K41090.P8C3 |

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**Filing Fees for Utility under 35 USC 111(a)**

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| UTILITY FILING FEE (ELECTRONIC FILING) | 4011 | 1 | 75 | 75 |
| UTILITY SEARCH FEE | 2111 | 1 | 330 | 330 |
| UTILITY EXAMINATION FEE | 2311 | 1 | 380 | 380 |
| **Pages:** | | | | |
| **Claims:** | | | | |
| **Miscellaneous-Filing:** | | | | |
| **Petition:** | | | | |
| **Patent-Appeals-and-Interference:** | | | | |

| Description | Fee Code | Quantity | Amount | Sub-Total in USD($) |
|---|---|---|---|---|
| **Post-Allowance-and-Post-Issuance:** | | | | |
| **Extension-of-Time:** | | | | |
| **Miscellaneous:** | | | | |
| | | **Total in USD ($)** | | **785** |

| Electronic Acknowledgement Receipt | |
|---|---|
| **EFS ID:** | 39184974 |
| **Application Number:** | 16851044 |
| **International Application Number:** | |
| **Confirmation Number:** | 9885 |
| **Title of Invention:** | BEAMFORMING USING FRACTIONAL TIME DELAY IN DIGITALLY OVERSAMPLED SENSOR SYSTEMS, APPARATUSES, AND METHODS |
| **First Named Inventor/Applicant Name:** | DASHEN FAN |
| **Customer Number:** | 51340 |
| **Filer:** | Mark S. Peloquin |
| **Filer Authorized By:** | |
| **Attorney Docket Number:** | K41090.P8C3 |
| **Receipt Date:** | 16-APR-2020 |
| **Filing Date:** | |
| **Time Stamp:** | 21:32:30 |
| **Application Type:** | Utility under 35 USC 111(a) |

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| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 2 | Application Data Sheet | 20200416K41090P8C3ADSaia0014i.pdf | 1619934<br>a4a30b7b8f4ecbee942419cdbcac124a12f7d7d7 | no | 9 |
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| Specification | 1 | 41 |
| Claims | 42 | 43 |
| Abstract | 44 | 44 |

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| **Warnings:** | | | | | |
| **Information:** | | | | | |
| 4 | Drawings-only black and white line drawings | 20200416K41090P8C3FIGURES117v08FINAL2i.pdf | 2205605<br>4375ed45c018d14f05527f820608aa48dbc150af | no | 20 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 5 | Fee Worksheet (SB06) | fee-info.pdf | 35150<br>5f1124775faf89a8508e06c528adcf1ff794cf23 | no | 2 |
| **Warnings:** | | | | | |
| **Information:** | | | | | |
| | | | **Total Files Size (in bytes):** | 16233289 | |

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**If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.**

**National Stage of an International Application under 35 U.S.C. 371**

**If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.**

**New International Application Filed with the USPTO as a Receiving Office**

**If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.**

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