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- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD,

ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

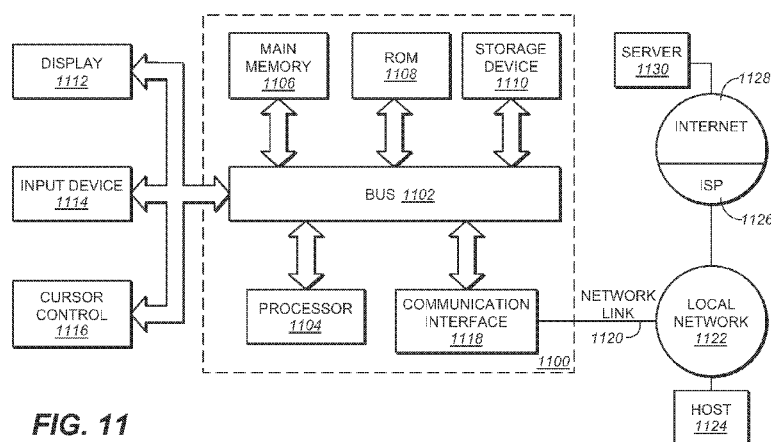
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

- with international search report (Art. 21(3))
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(88) Date of publication of the international search report:

22 May 2014

(54) Title: LOW LATENCY AND LOW COMPLEXITY PHASE SHIFT NETWORK**FIG. 11**

(57) **Abstract:** A high performance, low complexity phase shift network may be created with one or more non-first-order all-pass recursive filters that are built on top of a plurality of first-order and/or second-order all-pass recursive filters and/or delay lines. A target time delay, whether large or small, may be specified as a constraint for a non-first-order all-pass recursive filter. A target phase response may be determined for the non-first-order all-pass recursive filter. Phase errors between the target phase response and a calculated phase response with filter coefficients of the non-first-order all-pass recursive filter may be minimized to yield a set of optimized values for the filter coefficients of the non-first-order all-pass recursive filter.

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2013/040948

A. CLASSIFICATION OF SUBJECT MATTER
 INV. H03H17/04 H03H17/08
 ADD.

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)
 H03H

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, INSPEC, COMPENDEX, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2009/304213 A1 (COOK BRYAN AUSTIN [US] ET AL) 10 December 2009 (2009-12-10) paragraphs [0084] - [0108]	1,14, 21-29 2-13, 15-20
A	----- US 6 526 429 B1 (LAI YHEAN-SEN [US] ET AL) 25 February 2003 (2003-02-25) figure 1	1-29
A	----- REDDY G R ET AL: "Digital all-pass filter design through discrete Hilbert transform", 1990 IEEE INTERNATIONAL SYMPOSIUM ON CIRCUITS AND SYSTEMS (CAT. NO.90CH2868-8) IEEE NEW YORK, NY, USA, 1990, page 646, XP002715953, the whole document ----- -/-	1-29



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

7 November 2013

Date of mailing of the international search report

09/04/2014

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

PCT/US2013/040948

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	TAPIA J J ET AL: "Frequency-delay domain design of stable all-pass digital filters", PROCEEDINGS OF THE 43RD IEEE MIDWEST SYMPOSIUM ON CIRCUITS AND SYSTEMS (CAT.NO.CH37144) IEEE PISCATAWAY, NJ, USA, vol. 1, 2000, pages 74-78 vol.1, XP002716036, ISBN: 0-7803-6475-9 the whole document -----	1-29

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2013/040948

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009304213	A1	10-12-2009	AT 475273 T 15-08-2010
			EP 1994795 A1 26-11-2008
			JP 2009530915 A 27-08-2009
			KR 20080096591 A 30-10-2008
			TW 200810582 A 16-02-2008
			US 2009304213 A1 10-12-2009
			WO 2007106551 A1 20-09-2007

US 6526429	B1	25-02-2003	NONE

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2013/040948

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:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-29

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-29

Method for determining a phase shift network comprising an all-pass recursive filter of order N

2. claims: 30-48

Phase-shift network comprising one or more non-first-order all-pass recursive filter.
