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61/314,870 17 March 2010 (17.03.2010) US(71) Applicant (for all designated States except US): **UNIVERSITY OF VIRGINIA PATENT FOUNDATION** [US/US]; 250 West Main Street, Suite 300, Charlottesville, Virginia 22902 (US).

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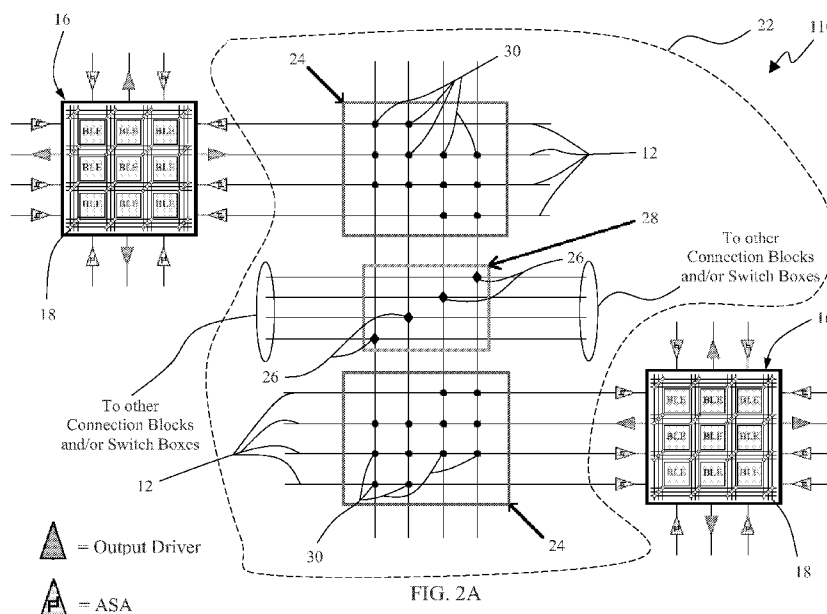
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**Published:**

- 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))

[Continued on next page]

(54) Title: A SUB-THRESHOLD FPGA AND RELATED CIRCUITS AND METHODS THEREOF



(57) Abstract: A sub- $V_T$  FPGA uses a low swing, dual- $V_{DD}$  interconnect scheme to reduce FPGA area per LUT, delay at a constant energy, and energy at a constant delay relative to a conventional design at low voltage. These improvements are made possible by a custom asynchronous sense amp, a separated voltage for memory cells, and an improved passgate interconnect to optimize routing delay with low energy overhead. This sub-threshold FPGA design enables energy efficient and cost effective configurable logic for a wide variety of ULP applications.



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26 January 2012

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/028805

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - H03K 19/00 (2011.01)

USPC - 326/37

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)

IPC(8) - H03K 19/00, 19/01, 19/017, 19/018; G11C 7/00, 7/06 (2011.01)

USPC - 326/37, 35, 36, 38, 39, 41, 49, 50; 365/189.05, 189.05, 189.011

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)

MicroPatent, Google Scholar

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ---	US 5,808,942 A (SHARPE-GEISLER) 15 September 1998 (15.09.1998) entire document	1, 42/1, 43/1
Y		2-38, 42/2, 43/2, 46, 49-53, 55-57
X ---	US 6,683,818 B1 (CORNELL et al) 27 January 2004 (27.01.2004) entire document	39, 40, 58/39, 58/40
Y		20, 21, 41, 58/41
Y	US 2007/0164785 A1 (HE) 19 July 2007 (19.07.2007) entire document	2-38, 41, 42/2, 43/2, 46, 49-53, 55-57, 58/41
Y	US 2009/0261902 A1 (MIDYA et al) 22 October 2009 (22.10.2009) entire document	17-21, 38
Y	US 5,850,359 A (LIU) 15 December 1998 (15.12.1998) entire document	18, 19
A	US 7,378,867 B1 (YU et al) 27 May 2008 (27.05.2008) entire document	1-53, 55-58
A	US 2005/0040851 A1 (NEW) 24 February 2005 (24.02.2005) entire document	1-53, 55-58

☐ Further documents are listed in the continuation of Box C. ☐

\* 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

15 November 2011

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# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2011/028805

## 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.: 54  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

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

### Remark on Protest

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