

(51) International Patent Classification:
G11C 11/00 (2006.01)(21) International Application Number:
PCT/US2013/035613(22) International Filing Date:
8 April 2013 (08.04.2013)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
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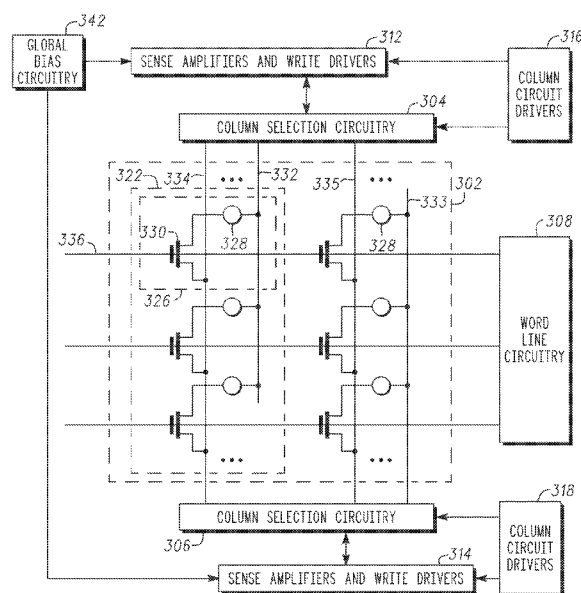
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(US).(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, 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).

Published:

— with international search report (Art. 21(3))

[Continued on next page]

(54) Title: SELF-REFERENCED SENSE AMPLIFIER FOR SPIN TORQUE MRAM



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FIG. 3

(57) Abstract: Circuitry and a method provide a plurality of
timed control and bias voltages to sense amplifiers and write
drivers of a spin-torque magnetoresistive random access
memory array for improved power supply noise rejection, in-
creased sensing speed with immunity for bank-to-bank noise
coupling, and reduced leakage from off word line select
devices in an active column.



— *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:**
5 December 2013

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US13/35613

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G11C 11/00 (2013.01)

USPC - 365/158

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) Classification(s): G11C 11/00, 11/14 (2013.01)

USPC Classification(s): 365/158, 148, 171

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 (US-G, US-A, EP-A, EP-B, WO, JP-bib, DE-C,B, DE-A, DE-T, DE-U, GB-A, FR-A); DialogPRO; IEEE/IEEExplore; Google/Google Scholar; IP.com; Search Terms Used: magnetoresistive, spin torque, array, mram, stmram, sttmem, offset, adjust, compensate, delay, optimize, calibrate, current, bit, source, line

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2009/0323402 A1 (LI, H. et al.) December 31, 2009; entire document	1-10, 22-24
A	US 2010/0321985 A1 (YANG, H.) December 23, 2010; entire document	1-10, 22-24
A	US 2011/0194337 A1 (WANG, X. et al.) August 11, 2011; entire document	1-10, 22-24

☐ 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

05 August 2013 (05.08.2013)

Date of mailing of the international search report

04 OCT 2013

Name and mailing address of the ISA/US

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P.O. Box 1450, Alexandria, Virginia 22313-1450
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US13/35613

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 1-10 and 22-24; Group II: Claims 11-21

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fee must be paid.

Group I: Claims 1-10 and 22-24 are directed toward reading data from each of a plurality of memory cells in a spin torque magnetoresistive memory array, the spin torque magnetoresistive memory array comprising: column selection circuitry to select a specific bit line; global bias circuitry configured to provide a plurality of timed bias voltages; sense amplifiers and write drivers circuitry configured to: receive the timed bias voltages; apply a read voltage across the source line and bit line coupled to a memory cell on the selected bit line; apply a write current in a first direction through the memory cell to write a first state; and reapply the read voltage across the source line and the bit line.

---Continued Within the Extra Page---

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.:
Group I: Claims 1-10 and 22-24

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/US13/35613

-Continued from Box No. III: Observations where unity of invention is lacking-

Group II: Claims 11-21 are directed toward a method of reading data from each of a plurality of memory cells in a spin torque magnetoresistive memory array, the method comprising: applying read voltage across a magnetic tunnel junction (MTJ) within a memory cell; converting a current through the MTJ into a sample voltage; storing the sample voltage in a capacitor; applying a write current through the MTJ to reset the memory cell to a first state; reapplying the read voltage across the MTJ; creating a current reference; converting the difference between the reference current and the current through the MTJ to generate an evaluation voltage; and comparing the sample voltage and the evaluation voltage.

The common technical feature shared by Groups I and II is a method of reading data from each of a plurality of memory cells in a spin torque magnetoresistive memory array, the method comprising: applying a read voltage within a memory cell; applying a write current through the memory cell to a first state; and reapplying the read voltage. However, this common feature is previously disclosed by US 2011/0194337 A1 (Wang). Wang discloses a method of reading data from each of a plurality of memory cells in a spin torque magnetoresistive memory array (writing data to spin-torque transfer random access memory, or STRAM, memory cell and resistive state is verified (read); Abstract), the method comprising: applying a read voltage within a memory cell (read power source applies a selected read voltage to the memory cell; paragraph [0021]); applying a write current through the memory cell to a first state (state is changed by subsequent write operations; paragraph [0020]); and reapplying the read voltage (subsequent read operations (reapply) are performed; paragraph [0044]).

Since the common technical feature is previously disclosed by the Wang reference, this common feature is not special and so Groups I and II lack unity.