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(12) **United States Patent**
Lee et al.

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(54) **MEMORY MODULE WITH
TIMING-CONTROLLED DATA PATHS IN
DISTRIBUTED DATA BUFFERS**

3/0659 (2013.01); *G06F 3/0683* (2013.01);
G06F 13/1642 (2013.01); *GI1C 8/18*
(2013.01)

(71) Applicant: **Netlist, Inc.**, Irvine, CA (US)

(58) **Field of Classification Search**
None

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See application file for complete search history.

(73) Assignee: **NETLIST, INC.**, Irvine, CA (US)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

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This patent is subject to a terminal dis-
claimer.

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Primary Examiner — Michael Sun

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(74) *Attorney, Agent, or Firm* — Maschoff Brennan

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 14/846,993, filed on
Sep. 7, 2015, now Pat. No. 9,563,587, which is a
(Continued)

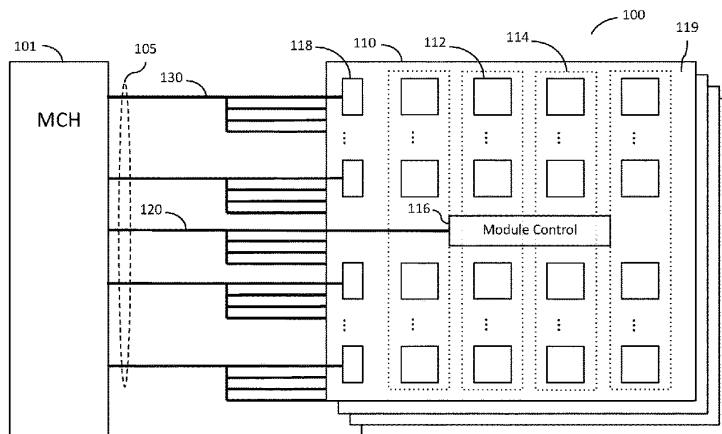
(57) **ABSTRACT**

A memory module is operatable in a memory system with a
memory controller. The memory module comprises a mod-
ule control device mounted on the module board to receive
command signals from the memory controller and to output
module command signals and module control signals, and
memory devices mounted on the module board to perform a
first memory operation in response to the module command
signals. The memory module further comprises a plurality of
buffer circuits distributed across a surface of the module
board. Each respective buffer circuit is associated with a
respective set of the memory devices and includes logic that
is configured to obtain timing information based on signals
received by the each respective buffer circuit during a
second memory operation prior to the first memory opera-
tion and to control timing of the data and strobe signals
through the each respective buffer circuit in accordance with
the timing information.

(51) **Int. Cl.**
G06F 3/00 (2006.01)
G06F 12/00 (2006.01)
G06F 13/00 (2006.01)
G06F 13/16 (2006.01)
G06F 3/06 (2006.01)
GI1C 8/18 (2006.01)

(52) **U.S. Cl.**
CPC *G06F 13/1673* (2013.01); *G06F 3/0613*
(2013.01); *G06F 3/0656* (2013.01); *G06F*

22 Claims, 26 Drawing Sheets



Related U.S. Application Data

continuation of application No. 13/952,599, filed on Jul. 27, 2013, now Pat. No. 9,128,632.

- (60) Provisional application No. 61/676,883, filed on Jul. 27, 2012.

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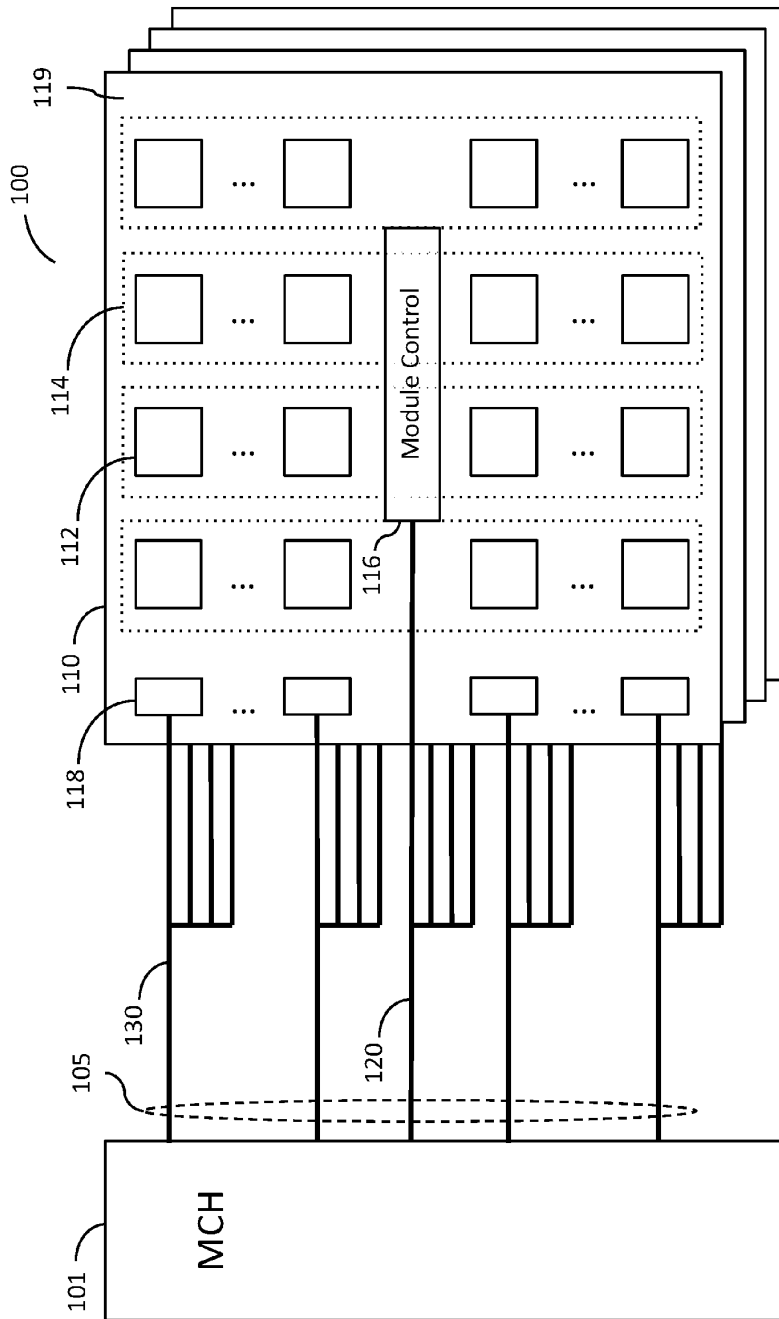


FIG. 1

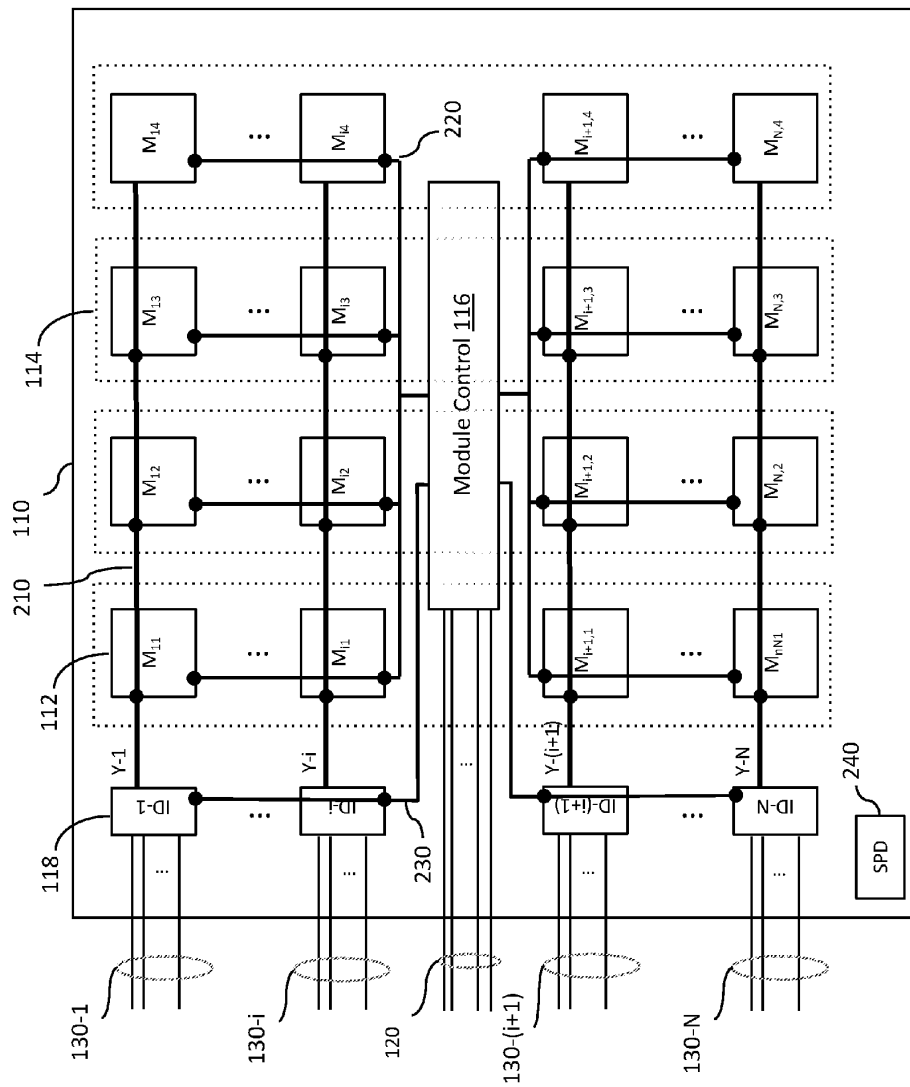


FIG. 2A

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