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Starr et al.

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- (54) **INTEGRATED CIRCUITS WITH TEMPERATURE-CHANGE AND THRESHOLD-VOLTAGE DRIFT COMPENSATION**
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- (73) Assignee: **Altera Corporation**, San Jose, CA (US)
- (*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.
- (21) Appl. No.: **10/802,590**
- (22) Filed: **Mar. 17, 2004**
- (51) **Int. Cl.⁷** **H03M 1/10**
- (52) **U.S. Cl.** **341/120; 341/144**
- (58) **Field of Search** **341/120, 118, 119, 341/121, 122, 144, 155; 365/149, 189.07, 365/190, 205, 207, 208**

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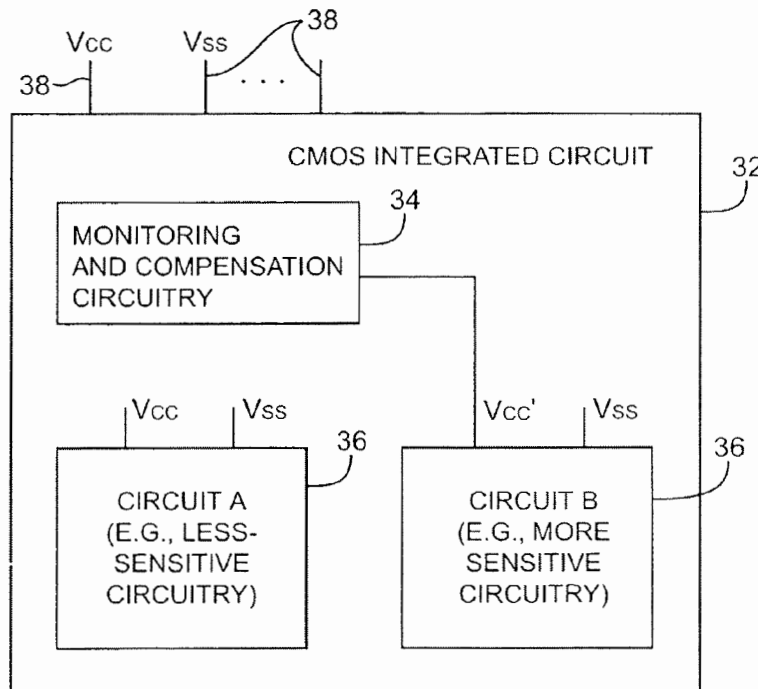
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(57) **ABSTRACT**

Integrated circuits are stabilized by monitoring changes that affect circuit operation and by compensating for those changes using power supply adjustments. Changes in operating temperature and threshold voltage changes may be measured. Differential measurements may be made in which threshold voltages measured in continuously-biased monitoring circuits are compared to threshold voltages measured in intermittently-biased monitoring circuits. Temperature changes may be monitored using a temperature monitoring circuit based on an adjustable current source and a diode. Monitoring and compensation circuitry on the integrated circuits may use analog-to-digital and digital-to-analog converters controlled by a control unit to make temperature and threshold voltage measurements and corresponding compensating changes in power supply voltages.

20 Claims, 13 Drawing Sheets



INTEL 1002

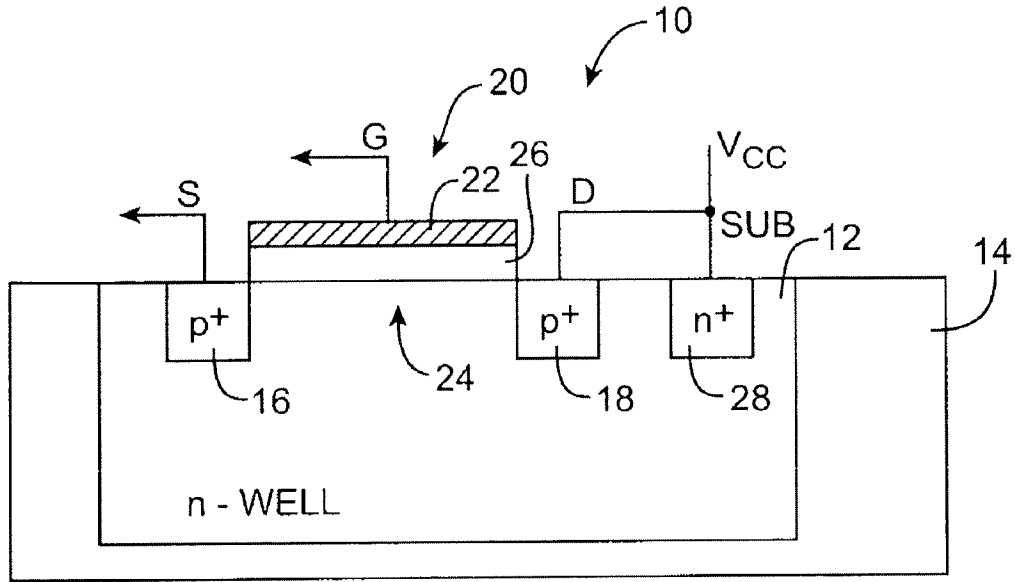


FIG. 1

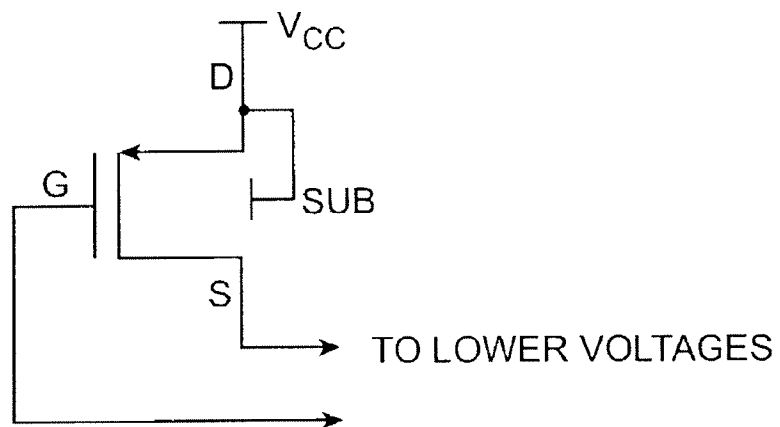


FIG. 2

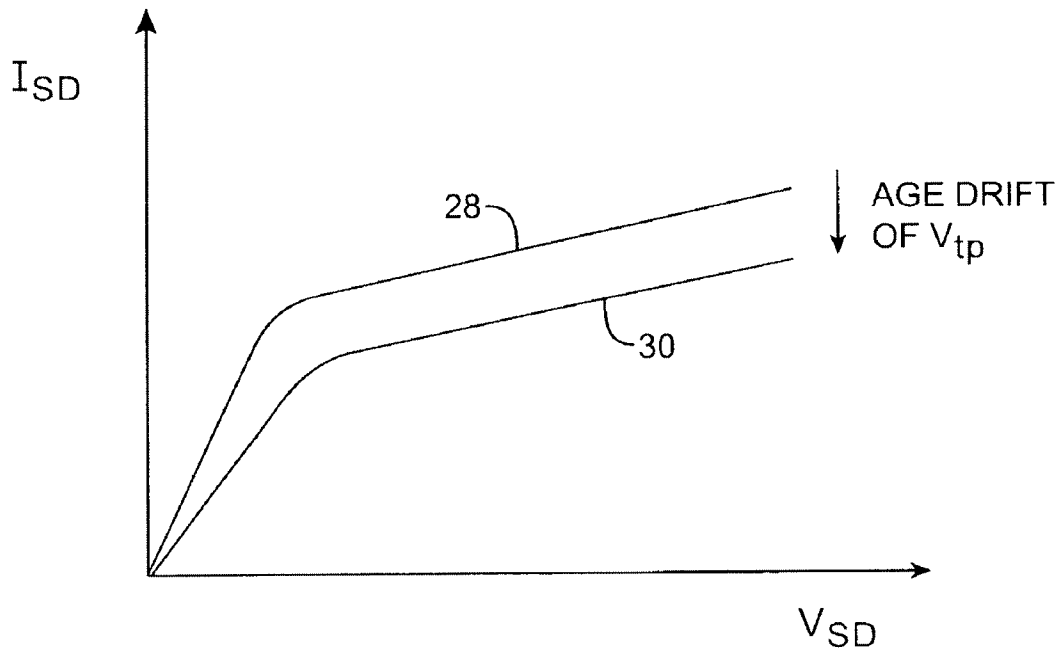


FIG. 3

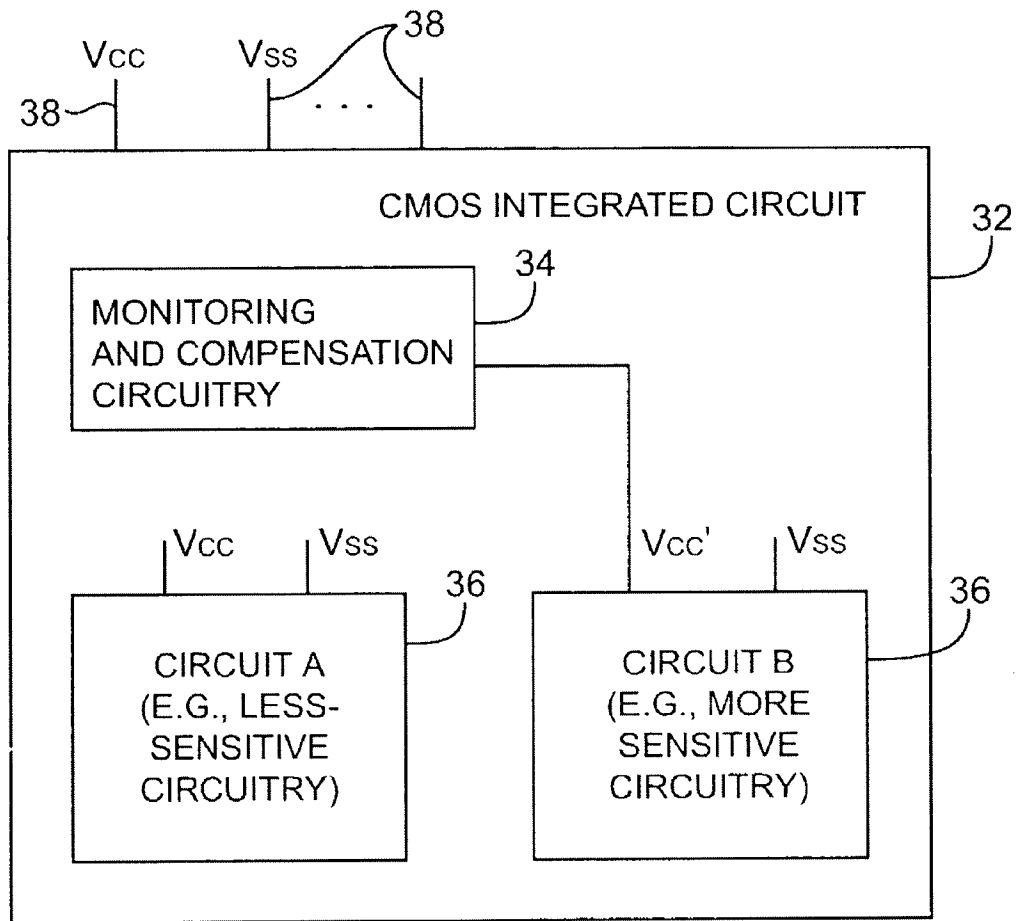


FIG. 4

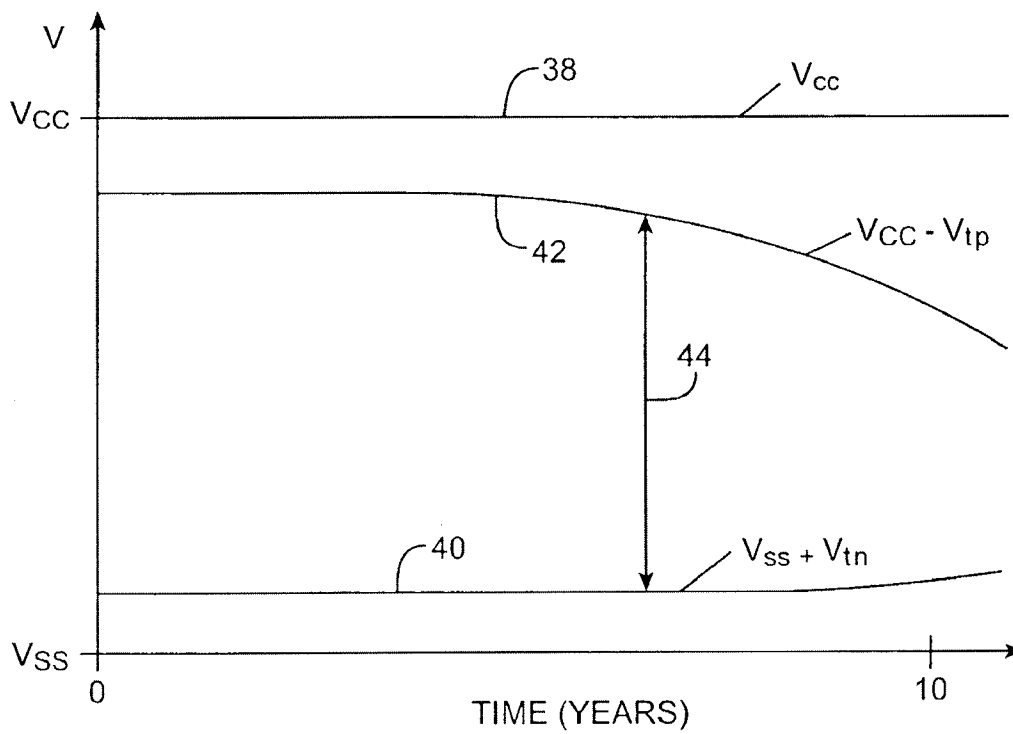


FIG. 5
(PRIOR ART)

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