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(12) **United States Patent**
Lamego

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(45) **Date of Patent:** **Mar. 5, 2019**

(54) **MODULATION AND DEMODULATION TECHNIQUES FOR A HEALTH MONITORING SYSTEM**

(58) **Field of Classification Search**
CPC A61B 5/0059; A61B 5/0084
See application file for complete search history.

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(56) **References Cited**

(72) Inventor: **Marcelo M. Lamego**, Cupertino, CA (US)

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(73) Assignee: **Apple Inc.**, Cupertino, 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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(21) Appl. No.: **14/621,268**

Primary Examiner — Hien Nguyen

(22) Filed: **Feb. 12, 2015**

(74) *Attorney, Agent, or Firm* — Brownstein Hyatt Farber Schreck, LLP

Related U.S. Application Data

(57) **ABSTRACT**

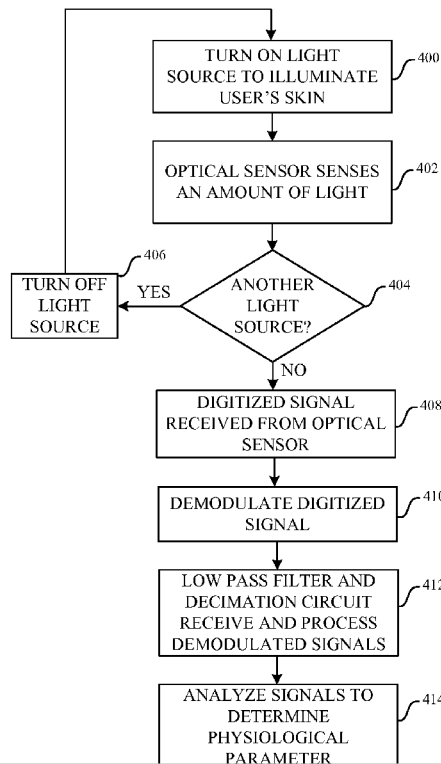
(60) Provisional application No. 62/047,818, filed on Sep. 9, 2014.

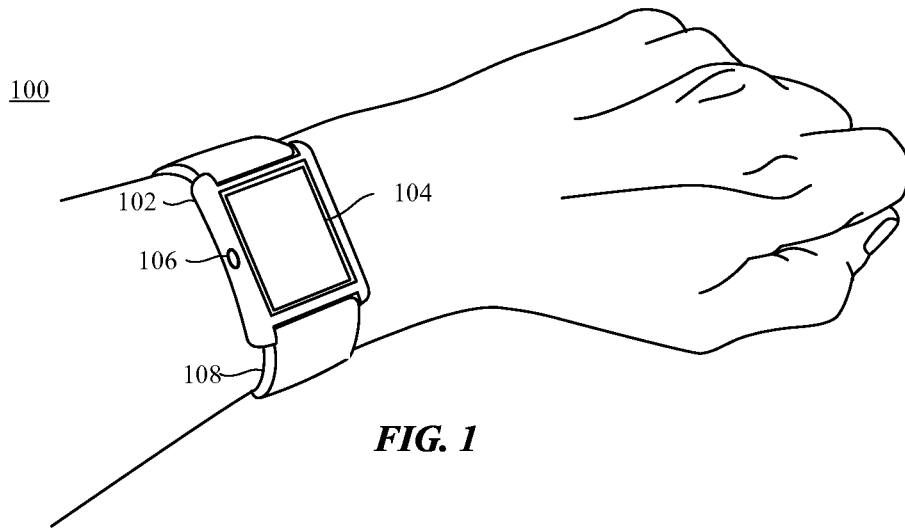
An electronic device includes one or more light sources for emitting light toward a body part of a user and one or more optical sensors for capturing light samples while each light source is turned on and for capturing dark samples while the light source(s) are turned off. A signal produced by the one or more optical sensors is demodulated produce multiple demodulated signals. Each demodulated signal is received by one or more decimation stages to produce a signal associated with each light source. Each signal associated with the light source(s) is analyzed to estimate or determine a physiological parameter of the user.

(51) **Int. Cl.**
A61B 5/00 (2006.01)

(52) **U.S. Cl.**
CPC **A61B 5/7228** (2013.01); **A61B 5/0059** (2013.01); **A61B 5/681** (2013.01); **A61B 5/7203** (2013.01); **A61B 5/725** (2013.01); **A61B 5/7225** (2013.01); **A61B 5/7278** (2013.01)

6 Claims, 9 Drawing Sheets





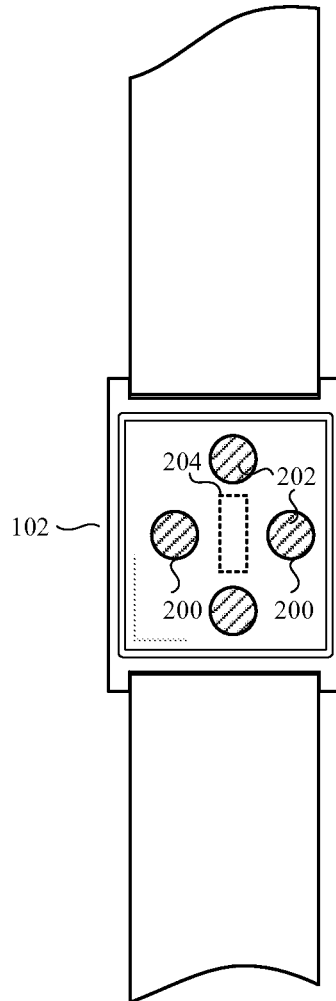


FIG. 2

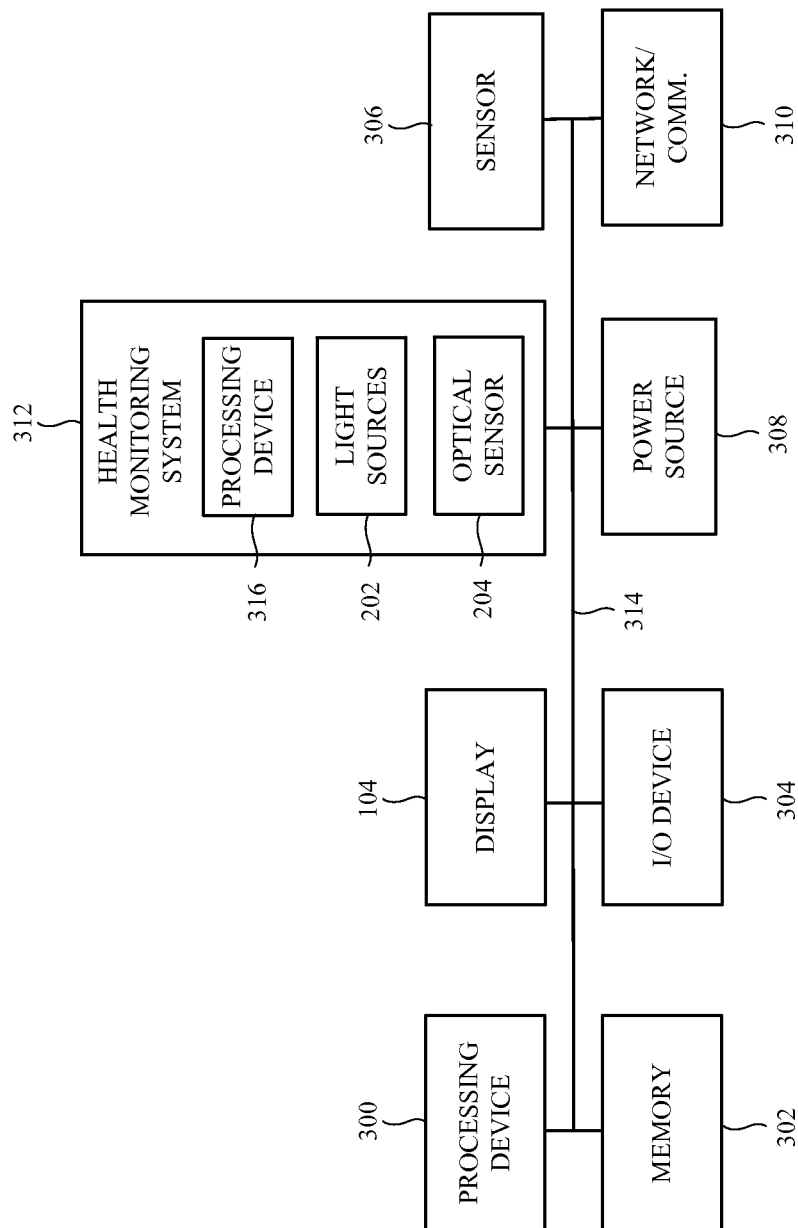


FIG. 3

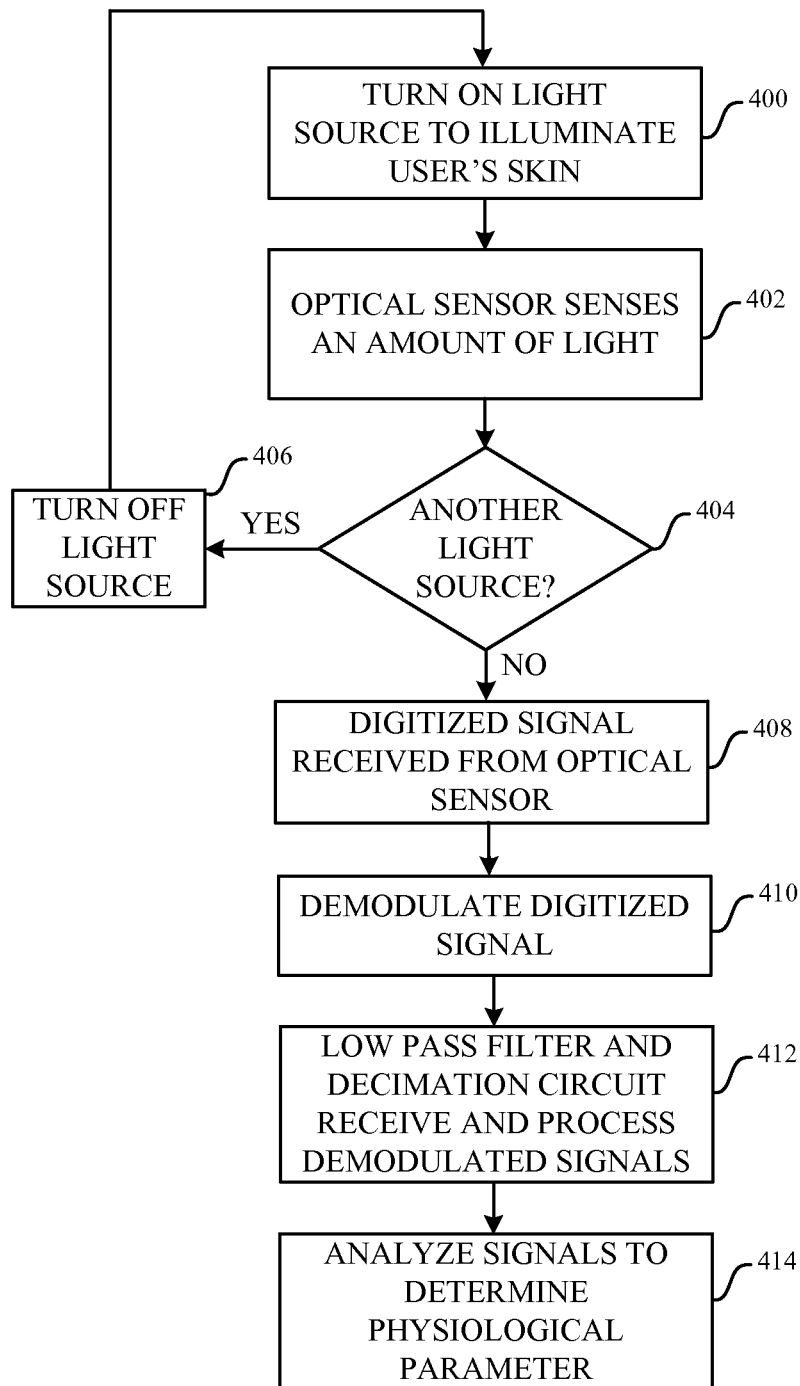


FIG. 4

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