

# (12)Indian Patent Application

(21) Application Number: 201841008333

(22) Filing Date: 07/03/2018 (43) Publication Date: 13/12/2019

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(51) International Classifications: G06F 3/01

(54) Title: A SYSTEM AND METHOD FOR MEASURING SEMI - DYNAMIC CAPACITANCE IN WEARABLE DEVICES

(57) Abstract: A method and system for operating a wearable device is disclosed. The disclosed system and method measures a capacitance value of a capacitive sensor in a first capacitance measuring mode. The measured capacitance value is compared to a first reference threshold value to measure a change in capacitance value within a predefined time interval. A motion data of the wearable device is measured based on an output of a detector. A first activity is detected based on the change in the capacitance value or motion data. The disclosed system and method automatically switches from a first capacitance measuring mode to a second capacitance measuring mode on detection of the first activity. On switching to the second capacitance measuring mode, the disclosed system and method detects a second activity by comparing the measured capacitance value in the second capacitance measuring mode to a second threshold value. The disclosed system and method determines a worn status of the wearable device by comparing the measured change in capacitance value to a predefined value.

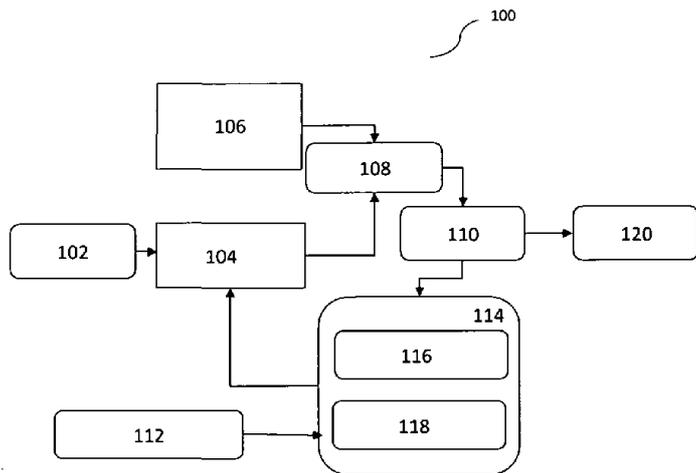


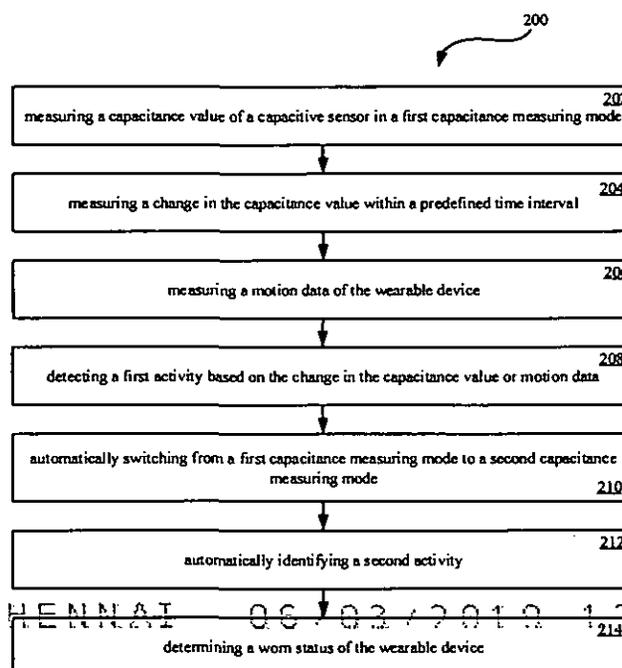
Figure 1



### ABSTRACT

#### A System and Method for Measuring Semi-Dynamic Capacitance in Wearable Devices

A method and system for operating a wearable device is disclosed. The disclosed system and method measures a capacitance value of a capacitive sensor in a first capacitance measuring mode. The measured capacitance value is compared to a first reference threshold value to measure a change in capacitance value within a predefined time interval. A motion data of the wearable device is measured based on an output of a detector. A first activity is detected based on the change in the capacitance value or motion data. The disclosed system and method automatically switches from a first capacitance measuring mode to a second capacitance measuring mode on detection of the first activity. On switching to the second capacitance measuring mode, the disclosed system and method detects a second activity by comparing the measured capacitance value in the second capacitance measuring mode to a second threshold value. The disclosed system and method determines a worn status of the wearable device by comparing the measured change in capacitance value to a predefined value.



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We Claim:



1. A method of operating a wearable device, the method comprising:
  - measuring a capacitance value of a capacitive sensor in a first capacitance measuring mode;
  - measuring a change in the capacitance value within a predefined time interval by comparing the measured capacitance value in the first capacitance measuring mode to a first reference threshold value;
  - measuring a motion data of the wearable device, based on an output of a detector;
  - detecting a first activity based on the change in the capacitance value or motion data;
  - on detection of the first activity, automatically switching from the first capacitance measuring mode to a second capacitance measuring mode;
  - on switching to the second capacitance measuring mode, detecting a second activity by comparing the measured capacitance value in the second capacitance measuring mode to a second reference threshold value; and
  - determining a worn status of the wearable device based on comparing the measured change in capacitance value to a predefined value.
2. The method as claimed in claim1, wherein the first capacitance measuring mode corresponds to a dynamic capacitance measuring mode and the second capacitance measuring mode corresponds to a static capacitance measuring mode.
3. The method as claimed in claim1, wherein determining worn status of the wearable device includes if the measured change in capacitance

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4. The method as claimed in claim1, wherein the capacitance sensor in the claim 1 includes a circuit that measures capacitance by charging and discharging times of capacitor.
5. The method as claimed in claim1, wherein the first activity and the second activity corresponds to a touch or proximity to the wearable device.
6. The method as claimed in claim1, wherein the detector is a MEMS sensor.
7. The method as claimed in claim1, further comprising automatically switching to the first capacitance mode if no activity is detected.
8. The method as claimed in claim1, wherein the change in the capacitance value is based on change in properties of dielectric constant or change in physical properties of conductors or change in environmental conditions.
9. The method as claimed in claim1 wherein detecting an activity is based on an external signal from a processor/controller.
10. The method as claimed in claim 1 further comprising monitoring the change in capacitance value by auto calibration and drift compensation.

Dated this 7<sup>th</sup> day of March 2018

  
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**FIELD OF INVENTION**

The invention relates to wearable devices and, more particularly, to capacitance measurement in wearable devices.

**BACKGROUND**

Capacitance touch switches are the most prominent types of switches compared with electro-mechanical switches. The capacitance touch switches have advantages over electro-mechanical switches in cost, user interface, life span, power consumption, form factor etc.

Static and dynamic capacitance measurements have their own drawbacks. The application of static capacitance measurement is limited to controlled and monitored environment. The application of dynamic capacitance measurement is timebound and not useful in applications where calibration at non-periodic intervals is required. For example, the dynamic capacitance measurements may not be useful in gaming applications where long key presses are required.

Hence, there is a need to design touch panels/keys to perform both static and dynamic capacitance measurement by inhibiting advantages of both static and dynamic capacitance measurement types.

The present invention is directed to overcoming one or more of the problems as set forth above.

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## SUMMARY OF THE INVENTION

Exemplary embodiments of the invention disclose a method and system for operating a wearable device. According to an exemplary embodiment, the disclosed system and method measures a capacitance value of a capacitive sensor in a first capacitance measuring mode. The disclosed system and method measures a change in the capacitance value within a predefined time interval by comparing the measured capacitance value to a first reference threshold value. A motion data of the wearable device is measured based on an output of a detector. A first activity is detected based on the change in the capacitance value or motion data. The disclosed system and method automatically switches from a first capacitance measuring mode to a second capacitance measuring mode. On switching to the second capacitance measuring mode, the disclosed system and method detects a second activity by comparing the measured capacitance value in the second capacitance measuring mode to a second threshold value. The disclosed system and method determines a worn status of the wearable device based on comparing the measured change in capacitance value to a predefined value.

## BRIEF DESCRIPTION OF DRAWINGS

Other objects, features, and advantages of the invention will be apparent from the following description when read with reference to the accompanying drawings. In the drawings, wherein like reference numerals denote corresponding parts throughout the several views:

Figure 1 illustrates a system for operating a wearable device, according to an exemplary embodiment of the invention; and

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Figure 2 illustrates a method for operating a wearable device, according to an exemplary embodiment of the invention.

## DETAILED DESCRIPTION OF DRAWINGS

The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of exemplary embodiments of the invention. It includes various specific details to assist in that understanding but these are to be regarded as merely exemplary. Accordingly, those of ordinary skill in the art will recognize that various changes and modifications of the embodiments described herein can be made without departing from the scope and spirit of the invention. In addition, descriptions of well-known functions and constructions are omitted for clarity and conciseness.

According to embodiments of the invention, a system and method for operating a wearable device is disclosed.

Figure 1 illustrates an exemplary system 100 for operating a wearable device, according to an embodiment of the invention. According to an embodiment, the wearable device may be a smart device.

The disclosed system 100 may include one or more processors configured to provide an input component 102, a waveform generator component 104, a reference waveform generator component 106, a comparator component 108, a counter component 110, an activity detection component 112 and a control component 114. According to an embodiment, the control component may comprise a calibration component 116 and a drift compensation component

118. According to an embodiment, the one or more processors may correspond to a microcontroller.

The input component 102 may be configured to receive user input. According to an embodiment, the input component 102 may be a touch pad/panel. The input component 102 may use capacitance change as a sensing element to detect touch/proximity to the wearable device. The input component 102 may be used to measure the change in capacitance. According to an embodiment, the change in capacitance may be based on change in physical properties of conductive or dielectric material. According to an exemplary embodiment, the physical parameters may be such as, but not limited to, length, breadth, thickness, distance between plates and dielectric constants. According to an exemplary embodiment, the change in physical properties may occur through application of external stimuli or environmental factors.

The waveform generator component 104 may be configured to convert the measured change in capacitance in 102 to voltage readings by either charging or discharging the capacitor connected with a resistor network. According to an embodiment, the voltage readings may be measured by both charging and discharging the capacitor connected with the resistor network.

The reference waveform generator component 106 may be configured to generate reference waveforms. The waveforms generated by the waveform generator component 104 may be based on changes in external capacitance and may be compared with the reference waveform generated by the reference waveform generator component 106. According to an embodiment, the change in external capacitance may correspond to change in capacitance generated by the

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generator component 104 may be synchronously charged or discharged to generate waveforms with a fixed sampling frequency.

The comparator component 108 may be configured to compare voltages generated by the waveform generator component 104 and the reference waveform generator component 106. The comparator may monitor the rate at which voltages are raising. If the internal circuit voltage reaches the reference voltage at charging cycle the COUNT\_UP is held high else COUNT\_DOWN is held high and vice-versa for discharging cycle. The internal circuitry includes the components of system 100 except input component 102.

The counter component 110 counts a value based on a number of times the COUNT\_UP/COUNT\_DOWN is high in N consecutive cycles. According to an embodiment, N may be 64.

The activity detection component 112 detects an activity based on the inputs collected from sensors. According to an embodiment, the activity may correspond to a touch or proximity to the wearable device. According to an embodiment, the activity detection component 112 may be a MEMS sensor. According to an exemplary embodiment, the activity detection component 112 may be an external device with a processor or a controller. According to an embodiment, the processor or controller may run a software algorithm to identify human activity. According to another exemplary embodiment, the activity detection component 112 may be an external device without a processor or a controller.

The control component 114 may comprise a calibration component 116 and a drift compensation component 118. Initially, the calibration component may be enabled to calibrate

capacitors in the system 100 to environment conditions. On detection of the activity, the drift compensation may be enabled to compensate for drift in capacitance measurements in the system 100. According to an embodiment, switching between calibration and drift compensation may be based on output from activity detection block. The calibration component and drift compensation component are parallel blocks and may be switched interchangeably either by hardware or software control. The feedback from the control component 114 may be fed to the waveform generator component 104.

The output component 120 provides touch output and may be based on a value of COUNT\_UP and COUNT\_DOWN of counter component 110.

Figure 2 illustrates a block diagram of a process 200 for operating a wearable device, according to an embodiment of the invention.

At step 202, a capacitance value of a capacitive sensor may be measured in a first capacitance measuring mode. According to an embodiment, the first capacitance measuring mode may be a dynamic capacitance measuring mode. According to another embodiment, the capacitance sensor may include a circuit to measure capacitance by charging and discharging times of capacitor.

At step 204, a change in the capacitance value may be measured within a predefined time interval by comparing the measured capacitance value in step 202 to a first reference threshold value. According to an embodiment, the change in the capacitance value may be based on a change in properties of dielectric constant or change in physical properties of conductors or

change in environmental conditions. According to another embodiment, the first reference

threshold value may indicate the reference threshold value in the first capacitance measuring mode. According to yet another embodiment, the first reference threshold value may be defined by a user.

At step 206, a motion data of the wearable device may be measured based on an output of a detector. According to an embodiment, the detector may be a MEMS sensor. According to an exemplary embodiment, the MEMS sensor may be a software signal generated by a processor, controller or integrated circuit. According to another exemplary embodiment, the MEMS sensor may be a control signal from a controller. According to yet another exemplary embodiment, the MEMS sensor may or may not be controlled by a processor.

At step 208, a first activity may be detected based on the change in capacitance value or motion data. According to an embodiment, the detection of the first activity may be based on an external signal from a processor or controller. According to an exemplary embodiment, the first activity may correspond to a touch or proximity identified for the first time with respect to the wearable device when it is not in motion. According to another exemplary embodiment, the first activity may correspond to a defined customized touch or motion pattern.

At step 210, on detection of the first activity, the wearable device automatically switches from the first capacitance measuring mode to a second capacitance measuring mode. According to an embodiment, the second capacitance measuring mode may be a static capacitance measuring mode.

At step 212, on switching to the second capacitance measuring mode, the wearable device automatically identifies a second activity by comparing the measured change in capacitance

value to a second reference threshold value. According to an embodiment, the second reference threshold value may indicate the reference threshold value in the second capacitance measuring mode. According to another embodiment, the second reference threshold value may be defined by a user. According to yet another embodiment, the second activity may correspond to a touch or proximity detected when the wearable device is in the second capacitance measuring mode. According to a further embodiment, the wearable device may switch to the first capacitance measuring mode if no activity is detected for a predetermined amount of time.

At step 214, a worn status of the wearable device may be determined by comparing the measured change in capacitance value in the second capacitance measuring mode to a predefined value.

In the drawings and specification there has been set forth preferred embodiments of the invention, and although specific terms are employed, these are used in a generic and descriptive sense only and not for purposes of limitation. Changes in the form and the proportion of parts, as well as in the substitution of equivalents, are contemplated as circumstances may suggest or render expedient without departing from the spirit or scope of the invention.

Throughout the various contexts described in this disclosure, the embodiments of the invention further encompass computer apparatus, computing systems and machine-readable media configured to carry out the foregoing systems and methods. In addition to an embodiment consisting of specifically designed integrated circuits or other electronics, the present invention may be conveniently implemented using a conventional general purpose or a specialized digital computer or microprocessor programmed according to the teachings of the present disclosure,

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The embodiments of the present invention may be provided as a computer program product that may include a machine-readable medium, having stored thereon instructions which may be used to program a computer (or other electronic devices) to perform a process according to the present invention. The machine-readable medium may include, but is not limited to, floppy diskettes, optical disks, compact disc read-only memories (CD-ROMs), and magneto-optical disks, ROMs, random access memories (RAMs), erasable programmable read-only memories (EPROMs), electrically erasable programmable read-only memories (EEPROMs), magnetic or optical cards, flash memory, or other type of media/machine-readable medium suitable for storing electronic instructions. In addition to an embodiment consisting of specifically designed integrated circuits or other electronics, the present invention may be conveniently implemented using a conventional general purpose or a specialized digital computer or microprocessor programmed according to the teachings of the present disclosure, as will be apparent to those skilled in the computer art.

Appropriate software coding can readily be prepared by skilled programmers based on the teachings of the present disclosure, as will be apparent to those skilled in the software art. The invention may also be implemented by the preparation of application specific integrated circuits or by interconnecting an appropriate network of conventional component circuits, as will be readily apparent to those skilled in the art.

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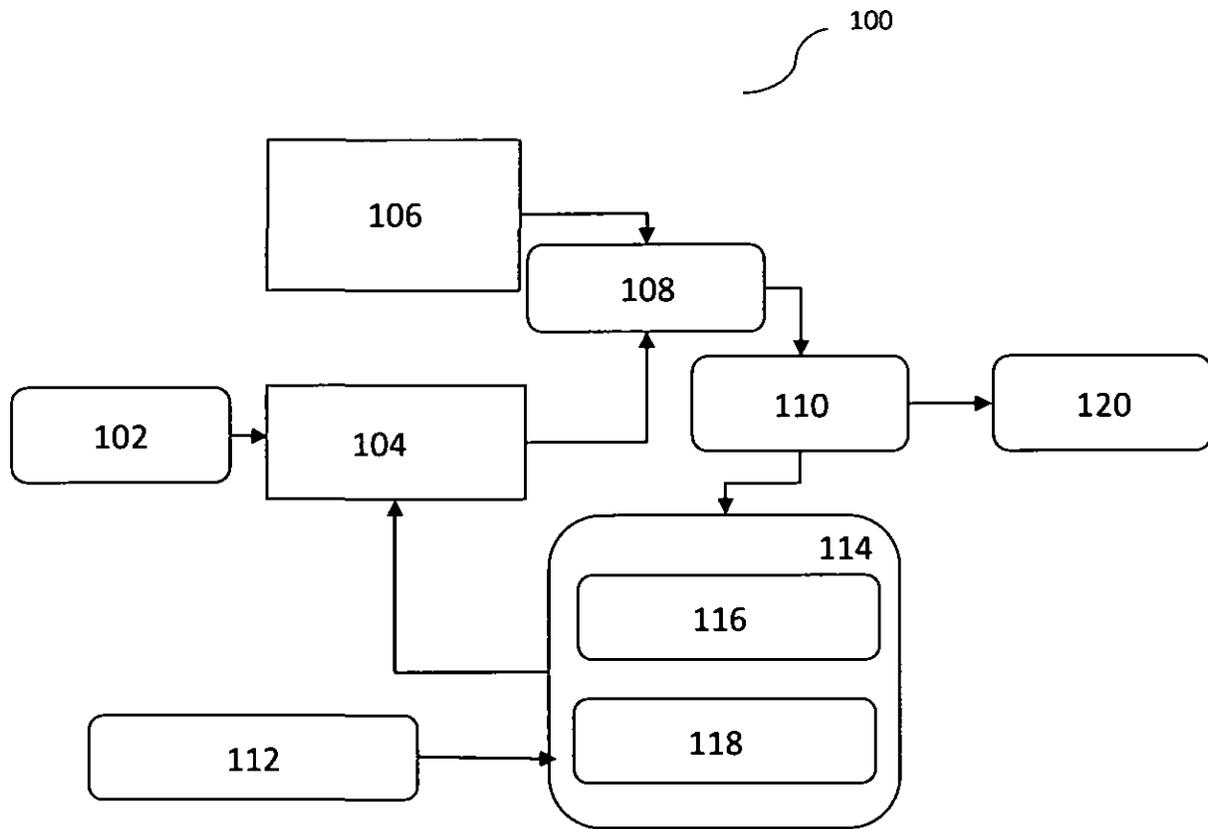


Figure 1

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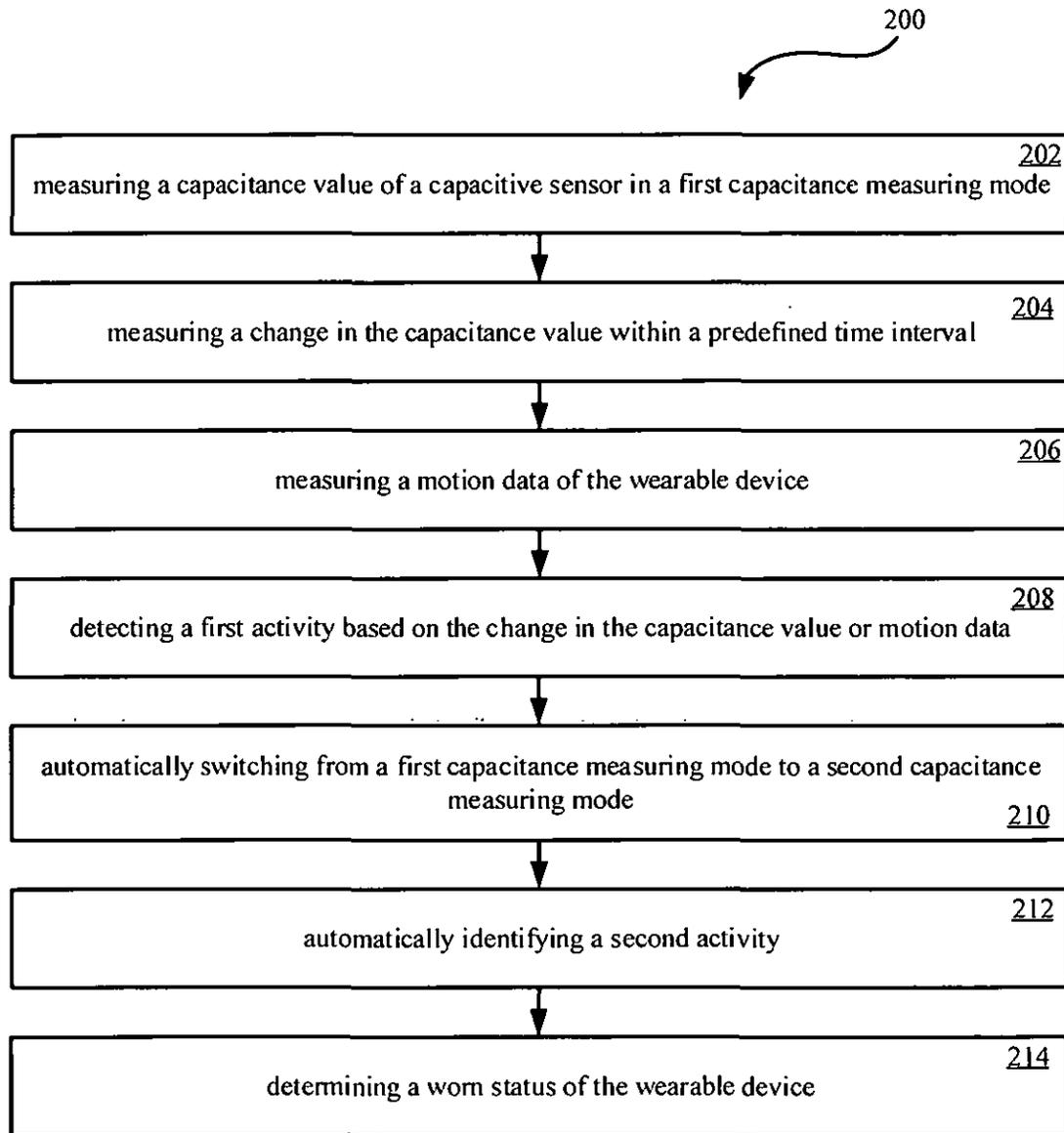
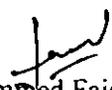


Figure 2

  
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