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(54) Title of the Invention: **Electronics module for a wearable article**
Abstract Title: **Module for wearable article, including an antenna for wireless charging**

(57) An electronics module 100 for a wearable article (200, Fig. 1) preferably includes an interface 101 with an electronics arrangement (209, 211, Fig. 12) of the wearable article. The interface is suitable for receiving a sensing signal from the wearable article. The electronics module has a housing 119, 121 which encloses a controller (103, Fig. 12) for processing the sensing signal, a power source such as a battery 105, and a first antenna 107. The first antenna 107 is spaced apart from the power source and the controller along a longitudinal axis 123 of the housing. The first antenna receives power from an external device to charge the power source. The first antenna may also be used for near-field communications (NFC). The electronics module preferably has a second antenna (109, Fig. 2) for Bluetooth (RTM) communication. The sensing signal may contain medical telemetry such as electrocardiogram (ECG) data. The controller may be mounted on a PCB 113, along with a light source. The first antenna may be mounted on a different PCB.

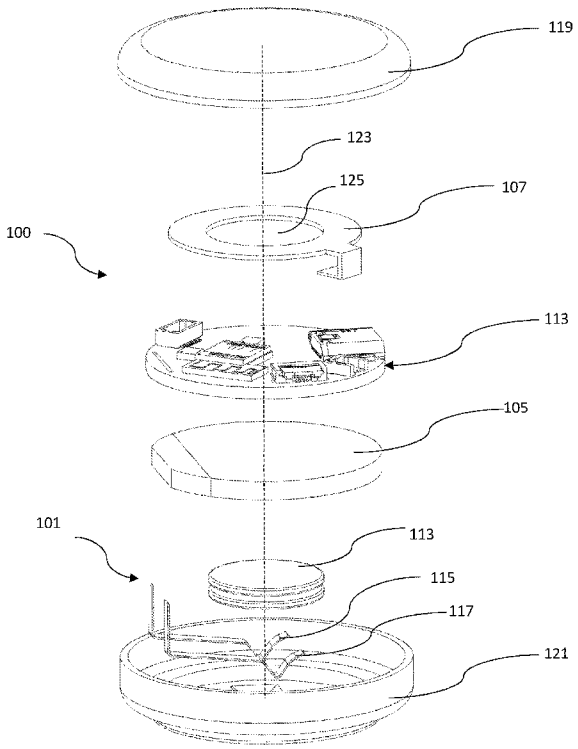


FIG. 7

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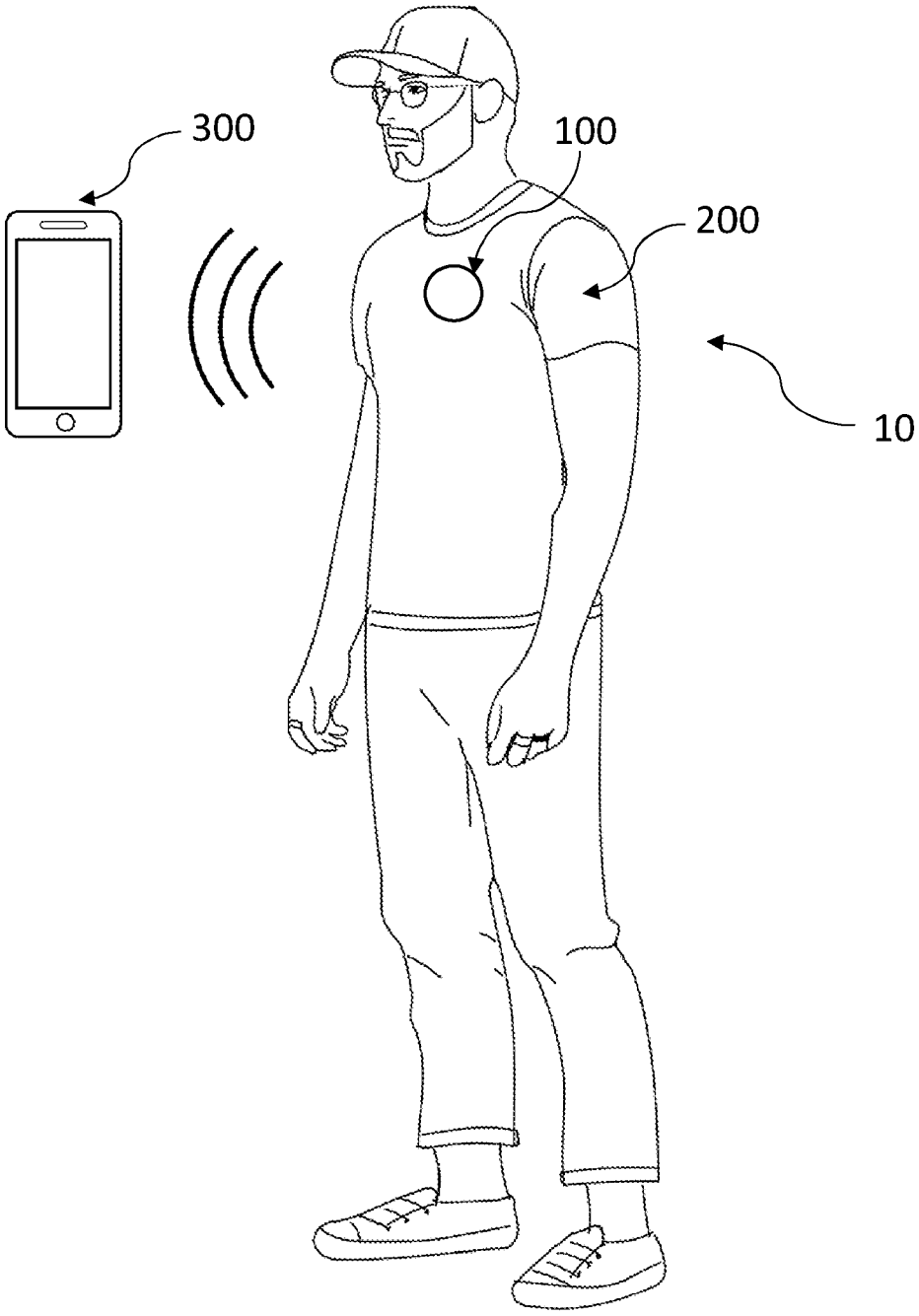


FIG. 1

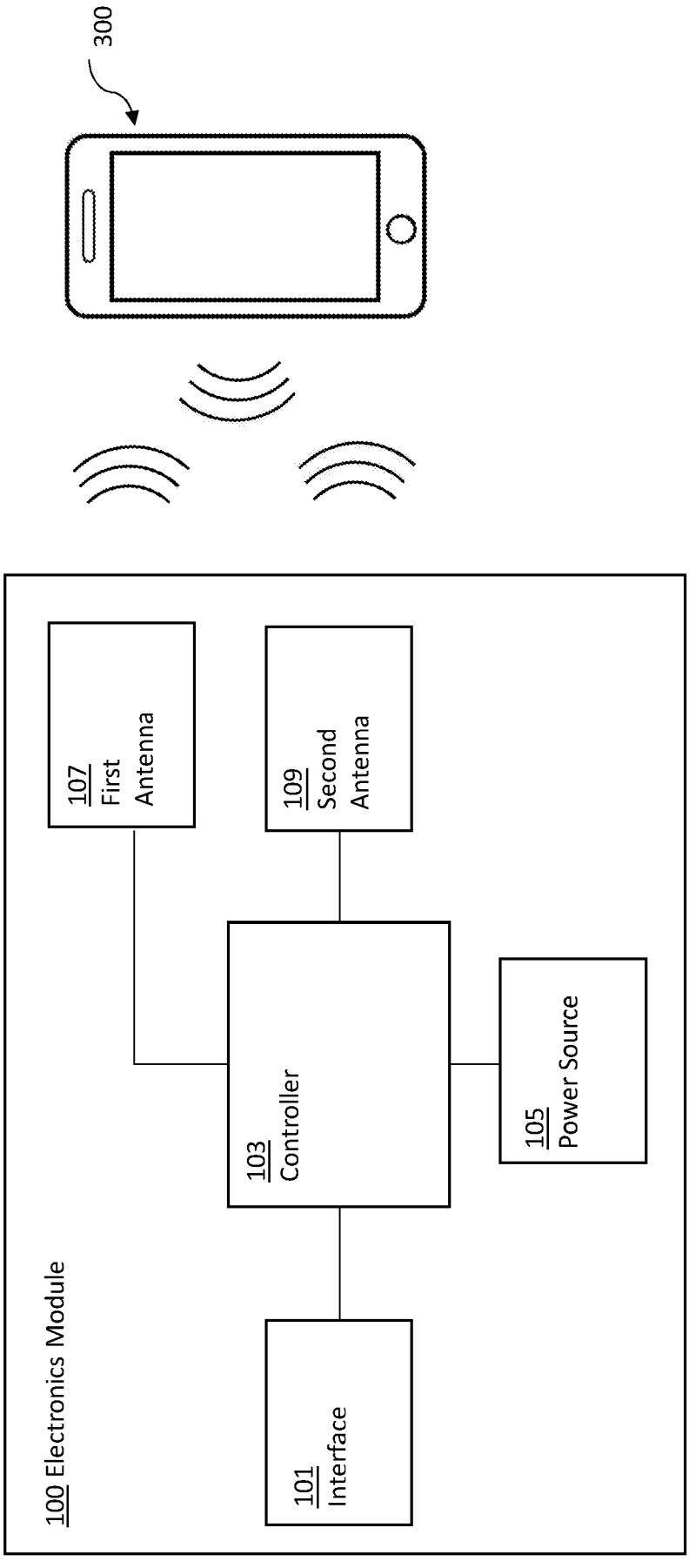

300
100 Electronics Module
107 First Antenna
109 Second Antenna
103 Controller
105 Power Source
101 Interface

FIG. 2

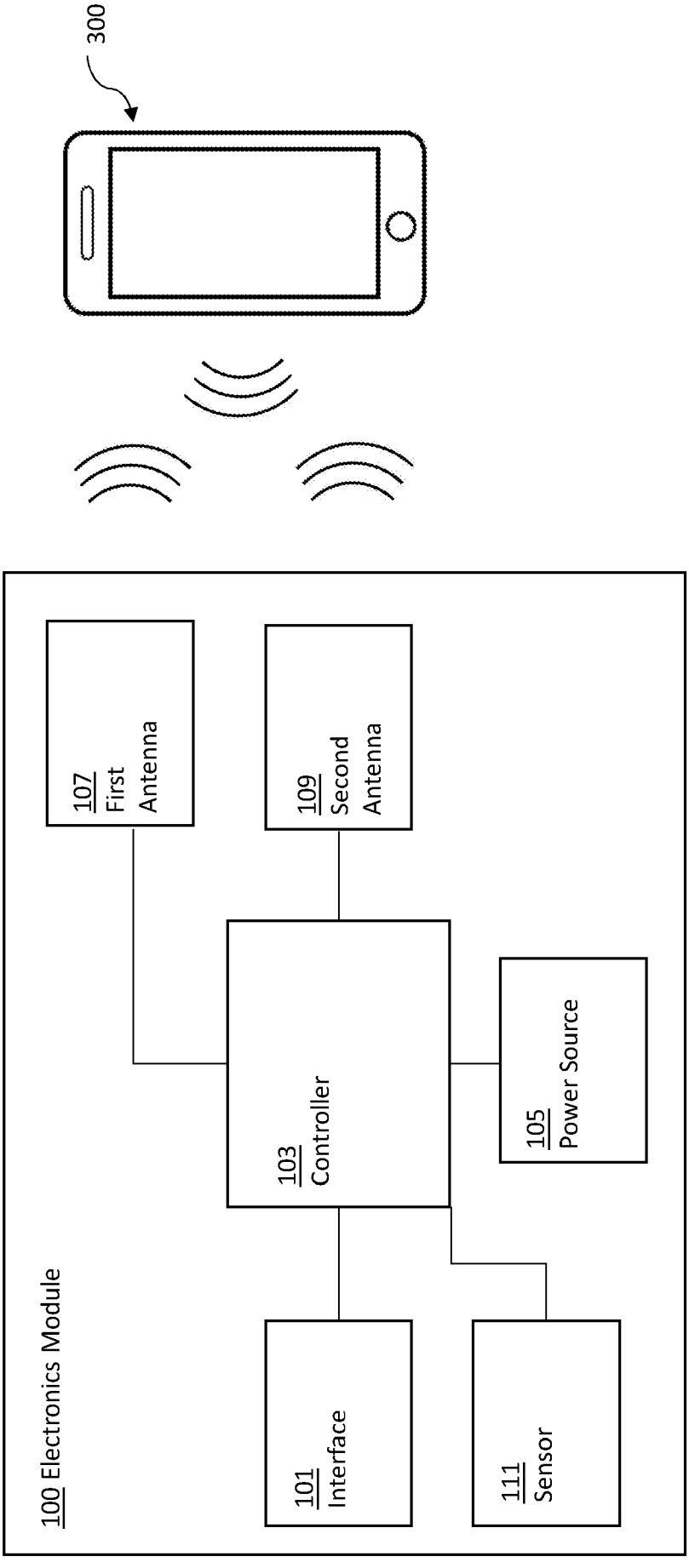

300
100 Electronics Module
107 First Antenna
109 Second Antenna
103 Controller
105 Power Source
101 Interface
111 Sensor

FIG. 3

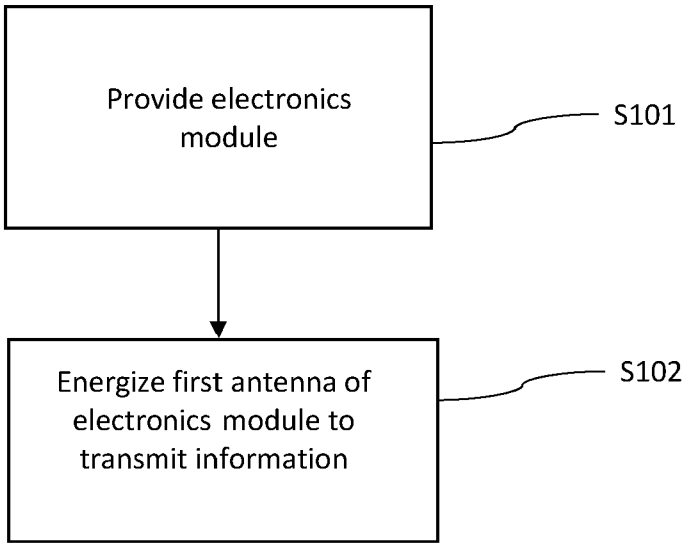

Provide electronics module
S101
Energize first antenna of electronics module to transmit information
S102

FIG. 4

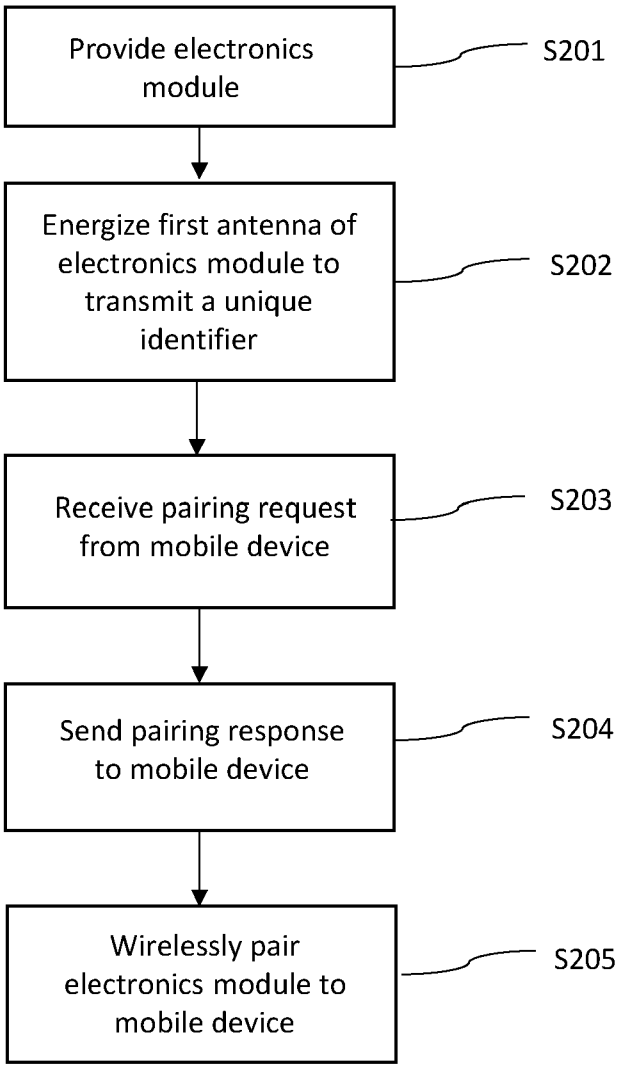

Provide electronics module
S201
Energize first antenna of electronics module to transmit a unique identifier
S202
Receive pairing request from mobile device
S203
Send pairing response to mobile device
S204
Wirelessly pair electronics module to mobile device
S205

FIG. 5

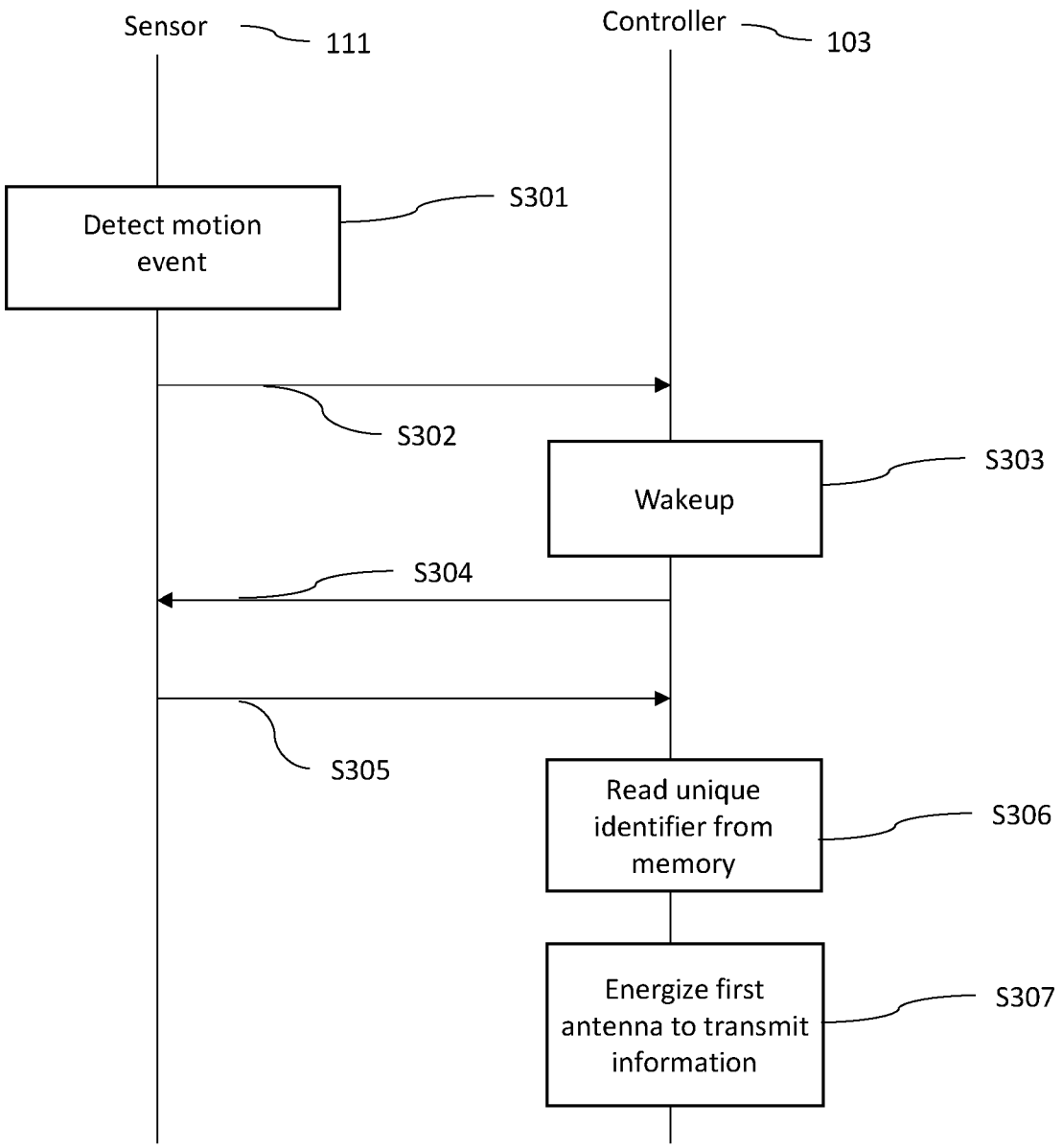

Sensor
111
Controller
103
Detect motion event
S301
S302
Wakeup
S303
S304
S305
Read unique identifier from memory
S306
Energize first antenna to transmit information
S307

FIG. 6

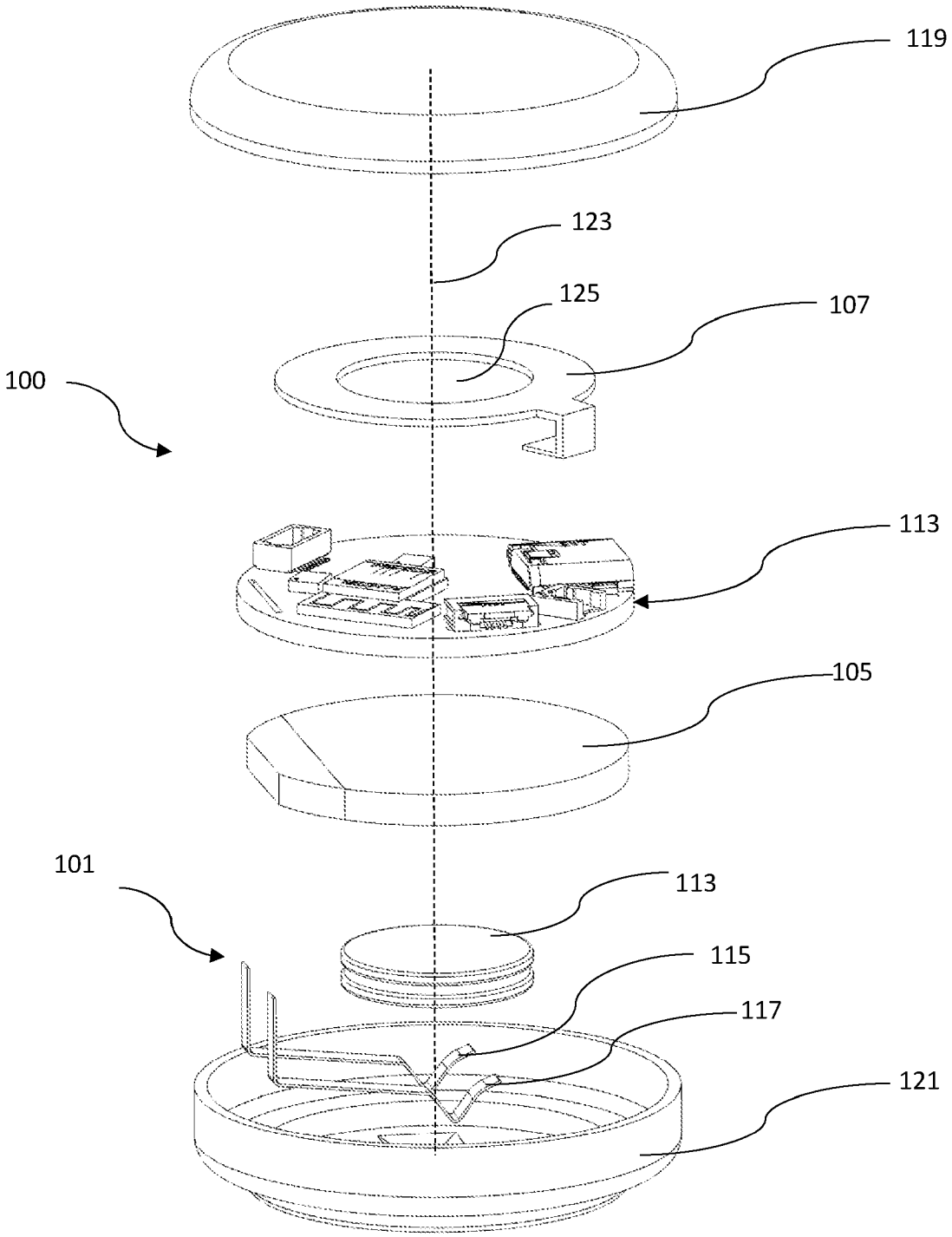


FIG. 7

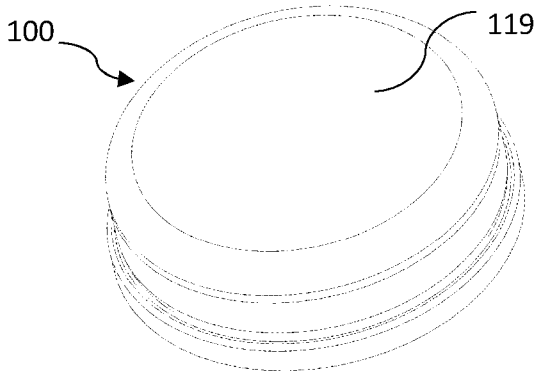


FIG. 8

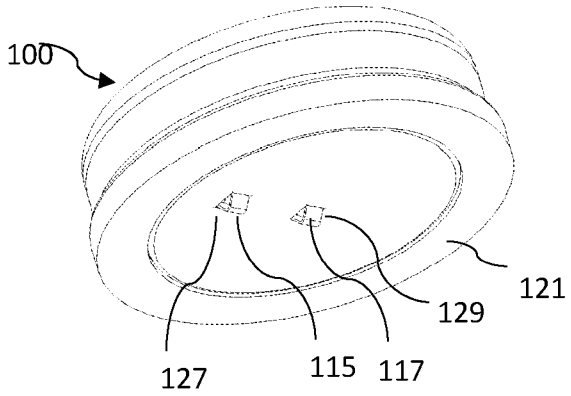


FIG. 9

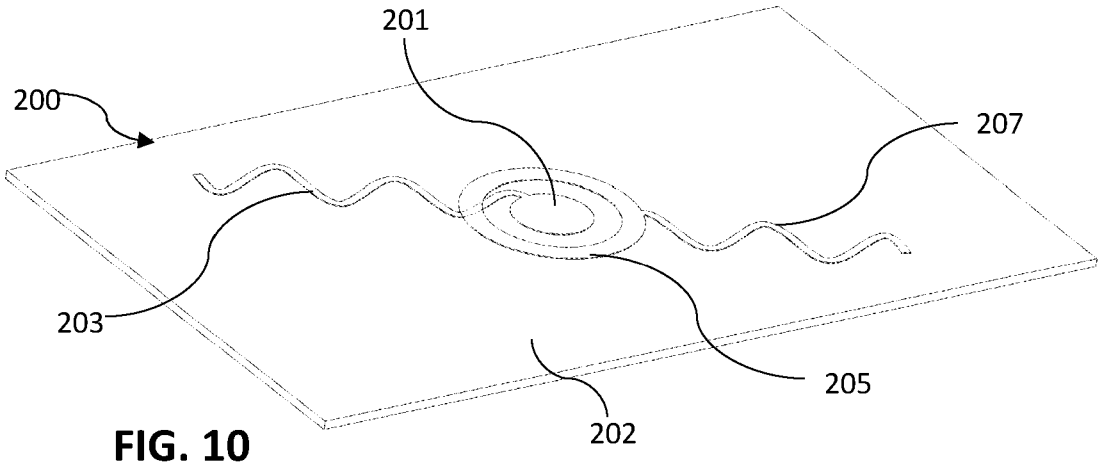


FIG. 10

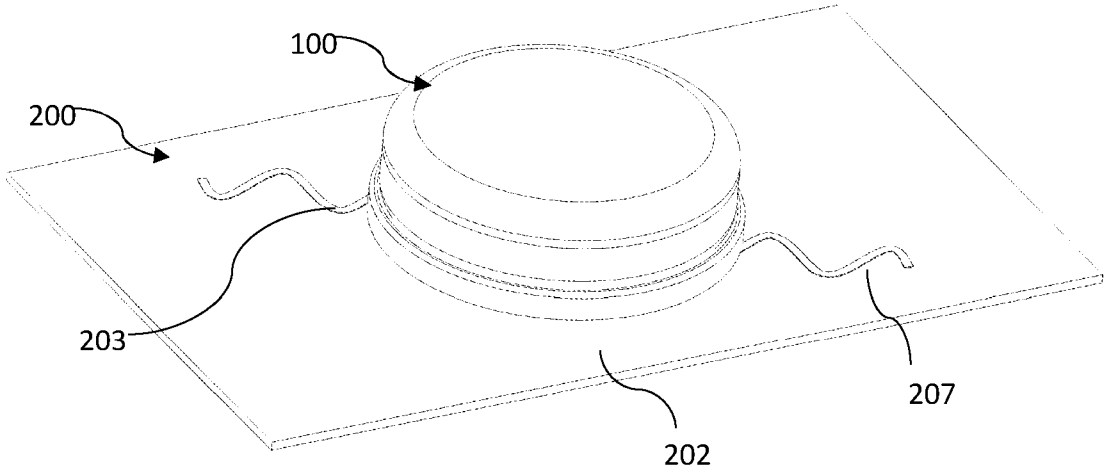


FIG. 11

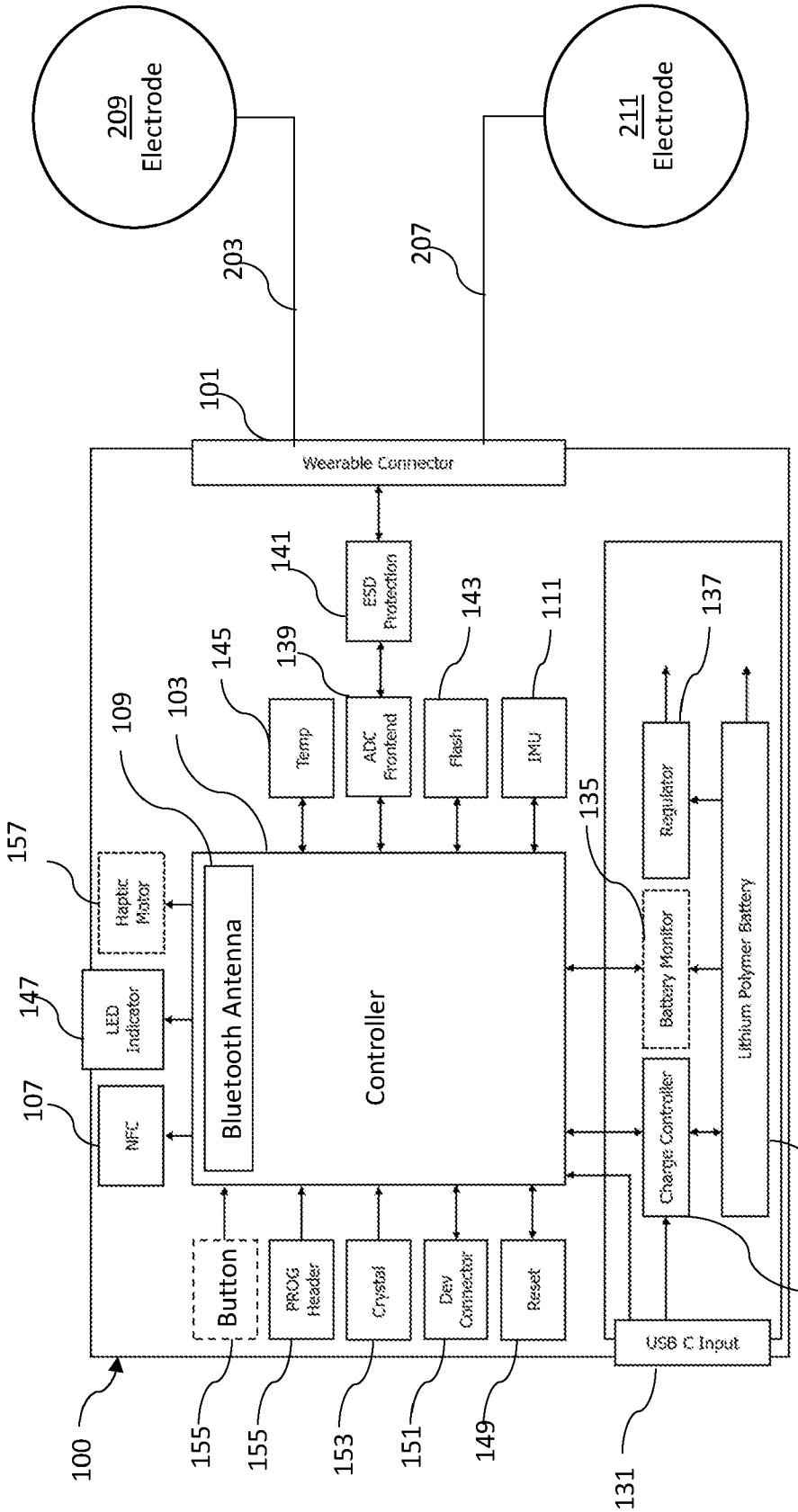

209 Electrode
211 Electrode
203
207
101
Wearable Connector
141
ESD Protection
139
ADC Frontend
145
Temp
143
Flash
111
IMU
109
103
157
Haptic Motor
147
LED Indicator
107
NFC
Bluetooth Antenna
Controller
135
Battery Monitor
Charge Controller
Regulator
137
Lithium Polymer Battery
105
133
Button
PROG Header
Crystal
Dev Connector
Reset
USB C Input
100
155
155
153
151
149
131

FIG. 12

ELECTRONICS MODULE FOR A WEARABLE ARTICLE

The present invention is directed towards an electronics module for a wearable article and, in particular, an electronics module arranged to transmit information to a mobile device such as for use in wireless pairing the electronics module to the mobile device.

Background

Electronics modules for wearable articles such as garments are known to communicate with mobile devices over wireless communication protocols such as Bluetooth ® and Bluetooth ® Low Energy. These electronics modules are typically removably attached to the wearable article, interface with internal electronics of the wearable article, and comprise a Bluetooth ® antenna for communicating with the mobile device. To pair the electronics module to the mobile device, the user of the mobile device must first select the appropriate electronics module from a potentially long list of devices on a user interface of the mobile device. This may be challenging for the user particularly if there are many Bluetooth ® devices in communication range with the mobile device.

Outside of the field of electronics modules for wearable articles, it is known to use near-field communication technologies to enhance the user experience of applications that use Bluetooth ® technology. In particular, the publication "Bluetooth ® Secure Simple Pairing Using NFC" which was published by the Bluetooth ® Special Interest Group of the NFC forum on 9th January 2014 describes that NFC can be used to enhance the selection of Bluetooth ® devices, the secure connection of Bluetooth ® devices and the initialisation of applications on Bluetooth ® devices. The disclosures of this document are hereby incorporated by reference.

It is an object of the present disclosure to provide an electronics module for a wearable article that facilitates a more seamless wireless user experience and which minimises the amount of interaction required by the user via an interface of a mobile device to facilitate communication between the mobile device and the electronics module.

It is another object of the present disclosure to provide an electronics module for a wearable article with a structure that facilitates the transfer of power and/or data between the electronics module and an external device.

Summary

According to the present disclosure there is provided an electronics module, wearable article, system, and method as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

According to a first aspect of the present disclosure, there is provided an electronics module for a wearable article. The electronics module comprises an interface arranged to communicatively couple with an electronics arrangement of the wearable article so as to receive a signal from the electronics arrangement. The module comprises a controller, communicatively coupled to the interface, and arranged to receive the signal from the interface. The module comprises a power source, coupled to the controller, and arranged to supply power to the controller. The module comprises a first antenna arranged to communicatively couple with a mobile device over a first wireless communication protocol. The module comprises a second antenna arranged to communicatively couple with the mobile device over a second wireless communication protocol. In response to the mobile device being brought into proximity with the electronics module, the electronics module is configured to: energize the first antenna to transmit information to the mobile device over the first wireless communication protocol.

The information may comprise a unique identifier for the electronics module. The unique identifier for the electronics module may comprise an address for the electronics module such as a MAC address or Bluetooth ® address or a component of such an address. Beneficially, transmitting a unique identifier for the electronics module removes the need for a discovery or inquiry procedure to establish a communication session under the second wireless communication protocol. That is, a user is no longer required to select the desired electronics module from a potentially long list of devices displayed on an interface of the mobile device.

The information may comprise authentication information used to facilitate the pairing between the electronics module and the mobile device over the second wireless communication protocol. This means that the transmitted information is used as part of an out of band (OOB) pairing process. OOB pairing involves exchange security information such as cryptographic keys and confirmation values over the first wireless communication protocol (e.g. near field communication, NFC) so as to facilitate the pairing over the second wireless communication protocol (e.g. Bluetooth ®). This approach allows for a larger cryptographic key to be used than other non-OOB techniques. Moreover, as the communication range of the first wireless communication protocol (e.g. NFC) is generally very limited it reduces the risk of another device eavesdropping on the communication and thus enhances security.

The information may comprise application information which may be used by the mobile device to start an application on the mobile device or configure an application running on the mobile device. The application may be started on the mobile device automatically (e.g. without user

input). Alternatively, the application information may cause the mobile device to prompt the user to start the application on the mobile device. These approaches provide an enhanced user experience as manual identification and operation of the application on the mobile device is not required. The information may comprise a uniform resource identifier such as a uniform resource location to be accessed by the mobile device, or text to be displayed on the mobile device for example. For example, the application information may cause an application associated with the wearable article to run on the mobile device. The application may be used to manage, process, and/or display data received from the wearable article. The application information may comprise information relating to the properties of the wearable such as the type of wearable article (e.g. a T-shirt) and the available sensors of the wearable article (e.g. ECG sensors). This information may be used to configure the application running on the mobile device such as by populating graphs on the mobile device to reflect the type of wearable article and available sensors. This allows the application to be configured while waiting for the paring between the electronics module and the mobile device to be completed.

The information may comprise a unique identifier for the electronics module. In response to receiving the unique identifier, the mobile device may transmit a pairing request message to the electronics module. This message may be transmitted over the second wireless communication protocol, but this is not required and the first wireless communication protocol may also be used, and may use the address for the electronics module as indicated by the received unique identifier. The second antenna of the electronics module may be arranged to receive the pairing request message over the second wireless communication protocol, but this is not required and the first antenna and first wireless communication protocol may also be used. The controller of the electronics module may be arranged to control the second antenna to transmit a pairing response message to the mobile device, but this is not required and the first antenna may also transmit the pairing response message. Once the pairing request and pairing response messages have been exchanged, the electronics module and mobile device may commence pairing. The pairing may be performed using any example pairing method such as Just Works ™, OOB pairing, or passkey pairing. Preferred implementations use OOB pairing. In this way, the first antenna of the electronics module is advantageously used to exchange the unique identifier and authentication information for use in pairing the electronics module to the mobile device. This simplifies the pairing process and improves the user experience as required user inputs to the mobile device are minimised.

In some examples, the electronics module may be configured to energize the first antenna to transmit information to the mobile device over the first wireless communication protocol in response to a current being induced in the first antenna. The current is induced in the first antenna as a result of the mobile device being brought into proximity with the electronics module. The mobile device may comprise an active antenna to induce the current in the first antenna. An

induced current in the first antenna may cause the controller of the electronics module to wake-up from a low power mode and energize the first antenna to transmit the information. In these examples, the first antenna functions as a sensor arranged to detect the mobile device being brought into proximity with the electronics module.

The electronics module may further comprise a sensor. The sensor may be arranged to detect the mobile device being brought into proximity with the electronics module. In response to the sensor detecting the mobile device being brought into proximity with the electronics module, the controller may be arranged to energize the first antenna to transmit the information (such as the unique identifier) to the mobile device over the first wireless communication protocol. The sensor may be a motion sensor arranged to detect a displacement of the electronics module caused by the mobile device being brought into proximity with the electronics module. That is, the sensor may be able to detect a "'tap" input caused by the mobile device being tapped against the electronics module or a pocket or other holder in which the electronics module is located. The sensor is not required to be a motion sensor. Other forms of sensor such as capacitive sensors, optical sensors, and ultrasound sensors may be used to detect a mobile device being brought into proximity with the electronics module. Preferred implementations use motion sensors particularly as motion sensors can utilised for additional tasks such as recognising and classifying motion activities (e.g. running, walking, swimming, cycling) performed by a user wearing the wearable article.

In response to the sensor detecting the mobile device being brought into proximity with the electronics module, the controller may be arranged to transition from a low power mode to a normal power mode. Beneficially, prior to the sensor detecting a mobile device being brought into proximity with the electronics module, components of the electronics module such as the controller, the first antenna and second antenna may be operating in a low power mode. This may mean that they are not supplied with power or only supplied with a minimal amount of power such as for refreshing an internal memory. This reduces unnecessary power consumption for the electronics module. Once the mobile device is brought into proximity with the electronics module, the sensor may cause the controller to wake-up and energize the first antenna. In an example implementation, when the sensor detects a mobile device being brought into proximity with the electronics module, the sensor sends an interrupt signal to the controller. This causes the controller to wake-up.

The electronics module may further comprise a housing. The housing may comprise a top enclosure and a bottom enclosure. The bottom enclosure may be closest to the wearable article/skin of the user wearing the article in use. The top enclosure may be furthest from the wearable article/skin of the user wearing the article in use. The power source, controller, first antenna and second antenna may be provided in the housing. The first antenna may be provided

proximate to the top enclosure. Beneficially, providing the first antenna proximate to the top enclosure minimises the communication distance between the mobile device and the first antenna. This is particularly beneficial when the first wireless communication protocol is a short-range communication protocol such as NFC. A longitudinal axis extends from the top enclosure to the bottom enclosure. The first antenna may be spaced apart from the power source, controller, and second antenna along the longitudinal axis of the housing.

The first antenna may comprise an aperture. The second antenna and the first antenna may be arranged such that the second antenna has line of sight through the aperture. The electronics module may further comprise a printed circuit board, wherein the controller and the second antenna may be provided on the printed circuit board.

The electronics module may further comprise a light source. The electronics module may further comprise a printed circuit board. The controller and the light source may be provided on the printed circuit board. The first antenna may comprise an aperture. The light source and the first antenna may be arranged such that the light source has line of sight through the aperture.

The electronics module may comprise a printed circuit board structure comprising a first printed circuit board. The first antenna may be provided on the first printed circuit board. The printed circuit board structure may further comprise a second printed circuit board. The controller and the second antenna may be provided on the second printed circuit board. A conductor may extend from the first printed circuit board to the second printed circuit board to conductively connect the first printed circuit board to the second printed circuit board. The printed circuit board structure may be a flex-rigid printed circuit board structure. The first and second printed circuit boards may be rigid components of the flex-rigid printed circuit board structure. The conductor may be a flexible component of the flex-rigid printed circuit board structure. The first and second printed circuit boards may form a single, integral, structure, or may be separate components. The conductor may be separate to the first and second printed circuit boards. The conductor may be integral with one or both of the printed circuit boards. The first printed circuit board may be a flexible printed circuit board. The second printed circuit board may be a rigid printed circuit board. The conductor portion connecting the first and second printed circuit boards may comprise a stiffener material.

The first printed circuit board may comprise a first region bounding an aperture extending through the first printed circuit board. The first antenna may be arranged in the first region of the first printed circuit board.

The first communication protocol may be a near-field communication protocol. The second communication protocol may be a Bluetooth ®, Bluetooth ® Low Energy , Bluetooth ® Mesh,

Bluetooth ® 5, Thread, Zigbee, IEEE 802.15.4, or Ant communication protocol. The present disclosure is not limited to these examples and other first and second communication protocols may be used. Generally, the second communication protocol will have a longer communication range and a faster data transfer rate than the first communication protocol.

The interface may not be required for all aspects of the present disclosure. That is, the wearable article may not be required to include an electronics arrangement and the electronics/sensing components may be self-contained within the electronics module.

According to a second aspect of the disclosure, there is provided a wearable article comprising the electronics module of the first aspect of the disclosure. The wearable article may comprise a garment. The garment may comprise a holder for the electronics module. The holder may comprise a pocket. The electronics module may be arranged to be disposed within the pocket of the garment. The pocket may be an external pocket provided on an external surface of the garment. The pocket may be an internal pocket.

The wearable article may comprise one or more sensing components. The sensing components may be biosensing components. The sensing components may comprise one or more components of a temperature sensor, a humidity sensor, a motion sensor, an electropotential sensor, an electroimpedance sensor, an optical sensor, and/or an acoustic sensor. Here, “component” means that not all of the components of the sensor may be provided in the wearable article or are required to be provided in the wearable article. The processing logic, power and other functionality may be provided in the electronics module. The wearable article may only comprise the minimal functionality to perform the sensing such as by only including sensing electrodes. The temperature sensor may be arranged to measure an ambient temperature, a skin temperature of a human or animal body, or a core temperature of a human or animal body. The humidity sensor may be arranged to measure humidity or skin-surface moisture levels for a human or animal body. The motion sensor may comprise one or more of an accelerometer, a gyroscope, and a magnetometer sensor. The motion sensor may comprise an inertial measurement unit. The electropotential sensor may be arranged to perform one or more bioelectrical measurements. The electropotential sensor may comprise one or more of electrocardiography (ECG) sensor modules, electrogastrography (EGG) sensor modules, electroencephalography (EEG) sensor modules, and electromyography (EMG) sensor modules. The electroimpedance sensor may be arranged to perform one or more bioimpedance measurements. Bioimpedance sensors can include one or more of plethysmography sensor modules (e.g., for respiration), body composition sensor modules (e.g., hydration, fat, etc.), and electroimpedance tomography (EIT) sensors. An optical sensor may comprise a photoplethysmography (PPG) sensor module or an orthopantomogram (OPG) sensor module.

According to a third aspect of the disclosure, there is provided a system. The system comprises the electronics module of the first aspect of the disclosure and a mobile device. The mobile device is arranged to be brought into proximity with the electronics module and is arranged to receive the information from the electronics module over the first wireless communication protocol.

The mobile device may be a mobile phone, smart phone, tablet computer, personal computer, gaming system, MP3 player, head mounted display, or other form wearable device such as a smart watch. The mobile device may be any mobile device operable to communicate with the electronics module over first and second wireless communication protocols.

According to a fourth aspect of the disclosure, there is provided a method of communicating between an electronics module for a wearable article and a mobile device. The method comprises providing the electronics module of the first aspect of the disclosure. The method comprises energizing a first antenna of the electronics module to transmit information to the mobile device over a first wireless communication protocol in response to a mobile device being brought into proximity with the electronics module.

According to a fifth aspect of the disclosure, there is provided an electronics module for a wearable article. The electronics module comprises a controller configured to process signals received from a sensing component. The sensing component may be part of the electronics module and/or part of the wearable article. The electronics module comprises a power source, coupled to the controller, and arranged to supply power to the controller. The electronics module comprises a first antenna. The electronics module comprises a housing comprising a top enclosure and a bottom enclosure, and a longitudinal axis extending from the top enclosure to the bottom enclosure. The power source, controller, and antenna are provided in the housing. The first antenna is provided proximate to the top enclosure.

Beneficially, providing the first antenna proximate to the top enclosure minimises the communication distance between the mobile device and the first antenna. This is particularly beneficial when the first wireless communication protocol is a short-range communication protocol such as NFC. This is also useful when the first antenna is not used for communication, For example, the first antenna may be a power receiving antenna such as power receiving coil. Minimising the distance between the first antenna and the power transmitter (e.g. a mobile device) increases the effectiveness of the transfer of power to the electronics module. Therefore, the electronics module has a structure that facilitates the transfer of power and/or data between the electronics module and an external device.

The electronics module may comprise some or all of the features disclosed above in relation to the first aspect of the disclosure. The electronics module may be useable in the wearable article of the second aspect of the disclosure, the system of the third aspect of the disclosure, or the method of the fourth aspect of the disclosure.

According to a sixth aspect of the disclosure, there is provided a garment. The garment comprises an electronics module holder arranged to at least temporarily hold an electronics module. The garment comprises an electronics module comprising: a controller arranged to receive a signal from a sensing component of the garment; a power source, coupled to the controller, and arranged to supply power to the controller; a first antenna arranged to communicatively couple with a mobile device over a first wireless communication protocol; and a second antenna arranged to communicatively couple with the mobile device over a second wireless communication protocol, wherein, in response to the mobile device being brought into proximity with the electronics module, the electronics module is configured to: energize the first antenna to transmit information to the mobile device over the first wireless communication protocol.

The sensing component may be part of the electronics module and/or may be separate to the electronics module.

The electronics module may comprise some or all of the features disclosed above in relation to the first aspect of the disclosure. The garment may comprise some or all of the features disclosed above in relation to the wearable article of the second aspect of the disclosure, and may be useable in the system of the third aspect of the disclosure, or the method of the fourth aspect of the disclosure.

The present disclosure is not limited to wearable articles. The electronics modules disclosed herein may be incorporated into other forms of devices such as user electronic devices (e.g. mobile phones). In additions, they may be incorporated into any form of textile article. Textile articles may include upholstery, such as upholstery that may be positioned on pieces of furniture, vehicle seating, as wall or ceiling décor, among other examples.

Brief Description of the Drawings

Examples of the present disclosure will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a schematic diagram for an example system according to aspects of the present disclosure;

Figure 2 shows a schematic diagram for an example electronics module according to aspects of the present disclosure;

Figure 3 shows a schematic diagram for another example electronics module according to aspects of the present disclosure;

Figure 4 shows a flow diagram for an example method according to aspects of the present disclosure;

Figure 5 shows a flow diagram for another example method according to aspects of the present disclosure;

Figure 6 shows a swim lane diagram for another example method according to aspects of the present disclosure;

Figure 7 shows an exploded view of yet another example electronics module according to aspects of the present disclosure;

Figures 8 and 9 show perspective views of the electronics module of Figure 7;

Figure 10 shows a perspective view of a component of a garment according to aspects of the present disclosure;

Figure 11 shows a perspective view of the electronics module of Figures 8 and 9 mounted on the garment of Figure 10; and

Figure 12 shows a detailed schematic diagram of the electronics components of an example electronics module and garment according to aspects of the present disclosure.

Detailed Description

The following description with reference to the accompanying drawings is provided to assist in a comprehensive understanding of various embodiments of the disclosure as defined by the claims and their equivalents. 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 various embodiments described herein can be made without departing from the scope and spirit of the disclosure. In addition, descriptions of well-known functions and constructions may be omitted for clarity and conciseness.

The terms and words used in the following description and claims are not limited to the bibliographical meanings, but, are merely used by the inventor to enable a clear and consistent understanding of the disclosure. Accordingly, it should be apparent to those skilled in the art that the following description of various embodiments of the disclosure is provided for illustration purpose only and not for the purpose of limiting the disclosure as defined by the appended claims and their equivalents.

It is to be understood that the singular forms “a,” “an,” and “the” include plural referents unless the context clearly dictates otherwise.

“Wearable article” as referred to throughout the present disclosure may refer to any form of electronic device which may be worn by a user such as a smart watch, necklace, bracelet, or glasses. The wearable article may be a textile article. The wearable article may be a garment. The garment may refer to an item of clothing or apparel. The garment may be a top. The top may be a shirt, t-shirt, blouse, sweater, jacket/coat, or vest. The garment may be a dress, brassiere, shorts, pants, arm or leg sleeve, vest, jacket/coat, glove, armband, underwear, headband, hat/cap, collar, wristband, stocking, sock, or shoe, athletic clothing, swimwear, wetsuit or drysuit The wearable article/garment may be constructed from a woven or a non-woven material. The wearable article/garment may be constructed from natural fibres, synthetic fibres, or a natural fibre blended with one or more other materials which can be natural or synthetic. The yarn may be cotton. The cotton may be blended with polyester and/or viscose and/or polyamide according to the particular application. Silk may also be used as the natural fibre. Cellulose, wool, hemp and jute are also natural fibres that may be used in the wearable article/garment. Polyester, polycotton, nylon and viscose are synthetic fibres that may be used in the wearable article/garment. The garment may be a tight-fitting garment. Beneficially, a tight-fitting garment helps ensure that the sensor devices of the garment are held in contact with or in the proximity of a skin surface of the wearer. The garment may be a compression garment. The garment may be an athletic garment such as an elastomeric athletic garment.

The following description refers to particular examples of the present disclosure where the wearable article is a garment. It will be appreciated that the present disclosure is not limited to garments and other forms of wearable article are within the scope of the present disclosure as outlined above.

Referring to Figure 1, there is shown an example system 10 according to aspects of the present disclosure. The system 10 comprises an electronics module 100, a garment 200, and a mobile device 300. The garment 200 is worn by a user. The electronics module 100 is attached to the garment 200. The electronics module 100 is arranged to integrate with electronic components incorporated into the garment 200 so as to obtain signals from the electronic components. The electronics components may comprise components of sensors. The electronics components may comprise electrodes. The electronics module 100 is further arranged to wirelessly communicate data to the mobile device 300. Various protocols enable wireless communication between the electronics module 100 and the mobile device 300. Example communication protocols include Bluetooth ®, Bluetooth ® Low Energy, and near-field communication (NFC).

The electronics module 100 may be removable from the garment 200. The electronics module 100 may be configured to be releasably mechanically coupled to the garment 200. The mechanical coupling of the electronic module 100 to the garment 200 may be provided by a mechanical interface such as a clip, a plug and socket arrangement, etc. The mechanical coupling or mechanical interface may be configured to maintain the electronic module 100 in a particular orientation with respect to the garment 200 when the electronic module 100 is coupled to the garment 200. This may be beneficial in ensuring that the electronic module 100 is securely held in place with respect to the garment 200 and/or that any electronic coupling of the electronic module 100 and the garment 200 (or a component of the garment 200) can be optimized. The mechanical coupling may be maintained using friction or using a positively engaging mechanism, for example.

Beneficially, the removable electronic module 100 may contain all of the components required for data transmission and processing such that the garment 200 only comprises the sensor components and communication pathways. In this way, manufacture of the garment 200 may be simplified. In addition, it may be easier to clean a garment 200 which has fewer electronic components attached thereto or incorporated therein. Furthermore, the removable electronic module 100 may be easier to maintain and/or troubleshoot than embedded electronics. The electronic module 100 may comprise flexible electronics such as a flexible printed circuit (FPC). The electronic module 100 may be configured to be electrically coupled to the garment 200.

It may be desirable to avoid direct contact of the electronic module 100 with the wearer's skin while the garment 200 is being worn. It may be desirable to avoid the electronic module 100 coming into contact with sweat or moisture on the wearer's skin. The electronic module 100 may be provided with a waterproof coating or waterproof casing. For example, the electronic module 100 may be provided with a silicone casing. It may further be desirable to provide a pouch or pocket in the garment to contain the electronic module in order to prevent chafing or rubbing and thereby improve comfort for the wearer. The pouch or pocket may be provided with a waterproof lining in order to prevent the electronic module 100 from coming into contact with moisture.

Referring to Figure 2, there is shown a schematic diagram of an example of the electronics module 100 of Figure 1. The electronics module 100 is shown in wireless communication with mobile device 300. The electronics module 100 comprises an interface 101, a controller 103, a power source 105, a first antenna 107, and a second antenna 109.

The interface 101 is arranged to communicatively couple with an electronics arrangement of the wearable article 200 (Figure 1) so as to receive a signal from the electronics arrangement. The controller 103 is communicatively coupled to the interface 101 and is arranged to receive the

signals from the interface 101.The interface 101 may form a conductive coupling or a wireless (e.g. inductive) communication coupling with the electronics components of the wearable article.

The power source 105 is coupled to the controller 103 and is arranged to supply power to the controller 103. The power source 105 may comprise a plurality of power sources. The power source 105 may be a battery. The battery may be a rechargeable battery. The battery may be a rechargeable battery adapted to be charged wirelessly such as by inductive charging. The power source 105 may comprise an energy harvesting device. The energy harvesting device may be configured to generate electric power signals in response to kinetic events such as kinetic events performed by a wearer of the garment. The kinetic event could include walking, running, exercising or respiration of the wearer. The energy harvesting material may comprise a piezoelectric material which generates electricity in response to mechanical deformation of the converter. The energy harvesting device may harvest energy from body heat of a wearer of the garment. The energy harvesting device may be a thermoelectric energy harvesting device. The power source may be a super capacitor, or an energy cell.

The first antenna 107 is arranged to communicatively couple with the mobile device 300 over a first wireless communication protocol. The first wireless communication protocol may be a near field communication (NFC) protocol but is not limited to any particular communication protocol. The second antenna 109 is arranged to communicatively couple with the mobile device 300 over a second wireless communication protocol. The second wireless communication protocol may be a Bluetooth ® protocol or a Bluetooth ® Low Energy protocol but is not limited to any particular communication protocol.

In an example operation, the mobile device 300 is brought into proximity with the electronics module 100. In response to this, the electronics module 100 is configured to energize the first antenna 107 to transmit information to the mobile device 300 over the first wireless communication protocol. Beneficially, this means that the act of the mobile device 300 approaching the electronics module 100 energizes the first antenna 107 to transmit the information to the mobile device 300. This provides a simple and intuitive mechanism for transmitting information to the mobile device 300 which does not require the user manually input the information via a user interface of the mobile device 300 for example.

The information may comprise a unique identifier for the electronics module 100. The unique identifier for the electronics module 100 may be an address for the electronics module 100 such as a MAC address or Bluetooth ® address. Beneficially, transmitting a unique identifier for the electronics module 100 removes the need for a discovery or inquiry procedure to establish a communication session under the second wireless communication protocol.

The information may comprise authentication information used to facilitate the pairing between the electronics module 100 and the mobile device 300 over the second wireless communication protocol. This means that the transmitted information is used as part of an out of band (OOB) pairing process.

The information may comprise application information which may be used by the mobile device to start an application on the mobile device or configure an application running on the mobile device. The application may be started on the mobile device automatically (e.g. without user input). Alternatively, the application information may cause the mobile device to prompt the user to start the application on the mobile device. The information may comprise a uniform resource identifier such as a uniform resource location to be accessed by the mobile device, or text to be displayed on the mobile device for example.

It will be appreciated that the same electronics module 100 can transmit any of the above example information either alone or in combination. The electronics module 100 may transmit different types of information depending on the current operational state of the electronics module 100 and based on information it receives from other devices such as the mobile device 300.

In some examples, the first antenna 107 is a component of a passive tag such as a passive Radio Frequency Identification (RFID) tag or Near Field Communication (NFC) tag. These tags comprise the first antenna 107 as well as a memory which stores the information, and a radio chip. The mobile device 300 is powered to induce a magnetic field in an antenna of the mobile device 300. When the mobile device 300 is placed in the magnetic field of the first antenna 107, the mobile device 300 induces current in the first antenna 107. This induced current is used to retrieve the information from the memory of the tag and transmit the same back to the mobile device 300.

In other examples, the first antenna 107 is not a component of a tag. In these examples, the electronics module 100 may detect a mobile device 300 being brought into proximity with electronics module 100 based on factors such as through a sensor of the electronics module 100 or a current being induced in the first antenna 107. Once the electronics module 100 determines that the mobile device 300 is in proximity with the electronics module 100, the controller 103 reads the information from the memory of the controller 103 or an external memory and energizes the first antenna 107 to transmit the information Beneficially, this approach provides greater customisability and allows for different information and dynamically changing information to be transmitted by the first antenna 107. That is, the information transmitted by the first antenna 107 can be dynamically changed. This is because the controller 103 is able to update the content stored in the memory which is not possible in a passive NFC or RFID tag.

This is particularly beneficial for authentication information and as it may be desirable to change this information over time for security reasons and application information.

The unique identifier transmitted to the mobile device 300 by the first antenna 107 using the first wireless communication protocol can be used to wireless pair the electronics module 100 to the mobile device 300 for communication using the second wireless communication protocol. The first wireless communication protocol may be NFC and the second wireless communication protocol may be Bluetooth ®.

In an example operation, the mobile device 300 receives the unique identifier from the electronics module 100 over the first wireless communication protocol. In response, the mobile device 300 transmits a pairing request message to the electronics module 100. The second antenna 109 of the electronics module 100 receives the paring request message from the mobile device 300. It will be appreciated that the second antenna 109 may receive the pairing request message when the mobile device 300 is no longer in proximity with the electronics module 100. This is because the second wireless communication protocol has a longer communication range than the first wireless communication protocol. The controller 103 of the electronics module 100 then processes the pairing request message and transmits a pairing response message in reply via the second antenna using the second wireless communication protocol. Pairing is then performed between the electronics module 100 and the mobile device 300. For OOB pairing, the mobile device 300 will still need to be in communication range with the electronics module 100 under the first wireless communication protocol.

Beneficially, the present disclosure provides a mechanism by which an electronics module 100 can be wirelessly paired to a mobile device 300 which minimizes or entirely removes the need for the user to manually input commands for pairing via an interface of the mobile device 300. Instead, the act of bringing the mobile device 300 into vicinity with the electronics module 100 commences the pairing operation by energizing the first antenna 107 to transmit the unique identifier over the first wireless communication protocol.

Referring to Figure 3, there is shown a schematic diagram of another example electronics module 100 according to aspects of the present disclosure. The electronics module 100 is shown in wireless communication with mobile device 300. The electronics module 100 comprises an interface 101, a controller 103, a power source 105, a first antenna 107, a second antenna 109 and sensor 111. The interface 101, controller 103, power source 105, first antenna 107 and second antenna 109 are the same as described in reference to Figure 2. The sensor 111 is arranged to detect the mobile device 300 being brought into proximity with the electronics module 100. In particular, the sensor 111 is a motion sensor that is arranged to detect a displacement of the electronics module 100 caused by the mobile device being brought into

proximity with the electronics module 100. These displacements of the electronics module 100 may be caused by the mobile device 300 being tapped against the electronics module 100. Physical contact between the mobile device 300 and the electronics module 100 is not required as the electronics module 100 may be in a holder such as a pocket of a wearable article. This means that there may be a fabric (or other material) barrier between the electronics module 100 and the mobile device 300. In any event, the electronics module 100 being brought into contact with the fabric of the pocket will cause an impulse to be applied to the electronics module 100 which will be sensed by the sensor 111.

The sensor 111 may comprise an inertial measurement unit. The inertial measurement unit may comprise an accelerometer and optionally one or both of a gyroscope and a magnetometer. A gyroscope/magnetometer is not required in all examples, and instead only an accelerometer may be provided or a gyroscope/magnetometer may be present but put into a low power state. A processor of the sensor 111 may perform processing tasks to classify different types of detected motion. The processor of the sensor 111 may, in particular, perform machine-learning functions so as to perform this classification. Performing the processing operations on the sensor 111 rather than the controller 103 is beneficial as it reduces power consumption, and leaves the controller 103 free to perform other tasks. In addition, it allows for motion events to be detected even when the controller 103 is operating in a low power mode. The sensor 111 communicates with the controller 103 over a serial protocol such as the Serial Peripheral Interface (SPI), Inter-Integrated Circuit (I2C), Controller Area Network (CAN), and Recommended Standard 232 (RS-232). Other serial protocols are within the scope of the present disclosure. The sensor 111 is also able to send interrupt signals to the controller 103 when required so as to transition the controller 103 from a low power model to a normal power mode when a motion event is detected. The interrupt signals may be transmitted via one or more dedicated interrupt pins.

In an example operation, the electronics module 100 is operating in a low power mode. In this low power mode, the majority of the components of the electronics module 100 are not operating so as to save power. For example, the first antenna 107 and second antenna 109 are not energized to transmit data and the controller 103 is not activated to process signal data received via the interface 101. The sensor 111 is supplied with power during the low power mode and is arranged to sense motion data. The sensor 111 may not have full functionality in the low power mode and may only have the necessary processing power to classify motion events into simple categories such as whether a tap has occurred. More computationally expensive processing operations may be disabled during the low power mode. In response to the sensor 111 detecting a tap event, the sensor 111 sends an interrupt to the controller 103. As a result, the controller 103 wakes up from the low power mode and polls the sensor 111 to determine the reason for the interrupt being sent. The sensor 111 responds with a signal indicating that a tap has been detected. The controller 103 then begins the process for controlling the first antenna 107 to

transmit the unique identifier. In particular, the controller 103 reads the unique identifier from a memory of the electronics module 100 and energizes the first antenna 107 to transmit the information such as the unique identifier.

In addition to being used for triggering the first antenna 107 to transmit information, the tap detection by the sensor 111 can be used to control operations of the electronics module 100. In this way, the detected taps may replicate the basic function of a user button on existing electronics module 100. A physical button is therefore not required for the present example. A single tap may be used to wake up the electronics module or cycle through different modes of operation.

Referring to Figure 4, there is shown a process flow diagram for an example method according to aspects of the present disclosure. Step S101 of the method comprises providing an electronics module. The electronics module may be the electronics module of Figure 2 or 3. Step S102 of the method comprises energizing a first antenna of the electronics module to transmit information to a mobile device over a first wireless communication protocol in response to a mobile device being brought into proximity with the electronics module.

Referring to Figure 5, there is shown a process flow diagram for an example method according to aspects of the present disclosure. This method is for wirelessly pairing an electronics module to a mobile device over a second wireless communication protocol. Step S201 of the method comprises providing an electronics module. The electronics module may be the electronics module of Figure 2 or 3. Step S202 of the method comprises energizing a first antenna of the electronics module to transmit a unique identifier to a mobile device over a first wireless communication protocol in response to a mobile device being brought into proximity with the electronics module. Step S203 of the method comprises receiving, via the second antenna of the electronics module, a pairing request message from the mobile device over the second wireless communication protocol. Step S204 of the method comprise transmitting a pairing response message to the mobile device via the second antenna over the second wireless communication protocol. Step S205 of the method comprises wirelessly pairing the electronics module to the mobile device over the second wireless communication protocol. Step S205 may use an out of band pairing approach which involves sharing authentication information between the electronics module and the mobile device via the first wireless communication protocol.

Referring to Figure 6, there is shown a swim-lane diagram showing an example interaction between the sensor 111 (Figure 3) of the electronics module 100 and the controller 103 (Figure 3) of the electronics module 100 prior to energizing the first antenna 107 (Figure 3) to transmit the unique identifier (or other information). These steps may be performed in the example methods shown in Figures 4 and 5.

In step S301 the sensor 111 detects a motion event caused by a mobile device being brought into proximity with the electronics module 100. In step S302, the sensor 111 transmits an interrupt signal to the controller 103 over a dedicated interrupt pin. In step S303, the sensor 111 wakes-up from a low power mode in response to receiving the interrupt signal. In step S304 the controller 103 sends a status request to the sensor 111 over a serial communication interface. In step S305, the sensor 111 transmits a status response back to the controller 103 over the serial communication interface. From the status response, the controller 103 determines that a mobile device has been brought into proximity with the electronics module 100. As a result, the controller in step S306 reads the unique identifier (or other information) from a memory of the controller 103 and, in step S307 energizes the first antenna of the electronics module to transmit the unique identifier to the mobile device over the first wireless communication protocol.

The processes described above may be performed when the electronics module 100 is mounted on the garment, but this is not required in all examples of the present disclosure. That is, communication between the electronics module 100 and the garment may be performed when the electronics module is removed from the garment.

Referring to Figure 7, there is shown an exploded view of an example electronics module 100 according to aspects of the present disclosure. The electronics module 100 comprises a first antenna 107, printed circuit board 113, power source 105, and interface 111. The interface comprises a magnet 113, and two conductive prongs 115, 117. The electronics module 100 may be the electronics module 100 of Figure 2 or 3, but this is not required. For example, the first antenna 107 may not be a communication antenna but may instead be a power receiving antenna such as a power receiving coil. In these examples, the first antenna 107 would be used to receive power from an external device for charging the power source 105.

The components of the electronics module 100 are provided within a housing formed of a top enclosure 119 and a bottom enclosure 121. A longitudinal axis 123 extends from the top enclosure 119 to the bottom enclosure 121. The first antenna 107 is provided proximate to the top enclosure 119. The bottom enclosure 121 is closest to the body of the wearer in use and the top enclosure 119 is furthest away from the body of the wearer in use. Beneficially, providing the first antenna 107 proximate to the top enclosure 119 minimises the communication distance between the first antenna 107 and the mobile device. This is particularly beneficial when the first antenna 107 is a short-range communication antenna 107 such as an NFC antenna 107.

The electronics module 100 may be the electronics module 100 of Figure 2 or 3. The printed circuit board 113 may comprise the controller 103 and second antenna 109 of Figure 2 or the controller 103, second antenna 109, and sensor 111 of Figure 3. The first antenna 107 is spaced

apart from the printed circuit board 113 and the power source 105 along the longitudinal axis 123 of the housing and is therefore spaced apart from the power source 105, controller 103, second antenna 109, and sensor 111. This further helps reduces the communication distance between the first antenna 107 and the mobile device 300.

The first antenna 107 comprises an aperture 125. That is, the first antenna 107 has an annular shape with a central aperture 125. The second antenna 109 (Figures 2 and 3) and the first antenna 107 are arranged such that the second antenna 109 has line of sight through the aperture 125. This means that the second antenna 109 is positioned on the printed circuit board 113 at a central position which is aligned with the aperture 125 of the first antenna 107. The printed circuit board 113 may additionally comprise a light source (not shown). The light source may be positioned on the printed circuit board 113 such that it has line of sight through the aperture 125.

The housing 119, 121 has a circular cross-sectional shape in the example of Figure 7 but this is not required. The housing may have any cross-sectional shape such as oval, square or rectangular.

In the example of Figure 7, the first antenna 107 and the printed circuit board 113 are shown as two separate structures. This is not required in all implementations of the present disclosure. Instead, the first antenna 107 and the printed circuit board 113 may be formed from the same printed circuit board structure. This printed circuit board structure comprises a first printed circuit board on which the first antenna is provided and a second printed circuit board on which the controller and the second antenna are provided. A conductor extends from the first printed circuit board to the second printed circuit board to conductively connect the first printed circuit board to the second printed circuit board. This printed circuit board structure may be a flex-rigid printed circuit board structure. The first and second printed circuit boards are rigid components of the flex-rigid printed circuit board structure. The conductor is a flexible component of the flex-rigid printed circuit board structure. The first printed circuit board may comprise a first region bounding an aperture extending through the first printed circuit board. The first antenna may be arranged in the first region of the first printed circuit board.

Referring to Figures 8 and 9, there is shown an electronics module 100 according to aspects of the present disclosure. The electronics module 100 may be the same as any of the electronics modules 100 as described above in relation to Figures 1 to 3 and 7. The electronics module 100 comprises a housing which contains the components of the electronics module 100. The housing comprises a top enclosure 119 and a bottom enclosure 121. The bottom enclosure 121 is closest to the body of the wearer in use and the top enclosure 119 is furthest away from the body of the wearer in use. First and second conductive prongs 115, 117 extend from openings 127, 129 in

the bottom enclosure 121. The first and second conductive prongs 115, 117 are able to electrically conductively connect with conductive elements provided on a textile so as to electrically conductively connect the electronics module 100 to the conductive elements of the textile. The use of conductive prongs 115, 117 to electrically conductively connect the electronics module 100 to the textile are not required in all aspects of the present disclosure. Other forms of conductive connection may be provided such as via conductive studs or pins. In addition, a conductive connection may not be required as a wireless communication connection may be formed between the electronics module 100 and electronics components of the textile to allow for data exchange between the electronics module 100 and the electronics components of the textile. In one example, the electronics module 100 comprises an NFC antenna such as an NFC coil proximate to the bottom enclosure 121 and the textile material comprises a corresponding NFC coil These NFC coils form a communicative coupling when the electronics module 100 is brought into proximity with the textile to allow for data exchange.

Referring to Figure 10, there is shown an example textile layer of a garment 200 according to aspects of the present disclosure. The garment 200 comprises a textile material 202 and conductive elements 201, 203, 205, 207 provided on the textile material 202. The conductive elements 201, 203, 205, 207 comprise a first terminal 201 and a first electrically conductive pathway 203 that extends from the first terminal 201 to a first electrode (not shown). The first electrically conductive pathway 203 therefore electrically connects the first terminal 201 to the first electrode. The conductive elements 201, 203, 205, 207 further comprise a second terminal 205 and a second electrically conductive pathway 207 that extends from the second terminal 205 to a second electrode (not shown). The second electrically conductive pathway 207 therefore electrically connects the second terminal 205 to the second electrode. The first and second terminals 201, 205 are arranged as concentric circles. A portion of the first electrically conductive pathway 203 extends under the second terminal 205. An insulating layer (not shown) insulates the first electrically conductive pathway 203 from the second terminal 205. This is just one example arranged of electrically conductive pathways on a textile. Other arrangements such as different positioning of electrically conductive pathways, and the use of different materials are within the scope of the present disclosure. For example, the electrically conductive pathways may be formed from a conductive thread or wire. The electrically conductive pathway may be incorporated into the textile. The electrically conductive pathway may be an electrically conductive track or film. The electrically conductive pathway may be a conductive transfer. The conductive material may be formed from a fibre or yarn of the textile. This may mean that an electrically conductive materials are incorporated into the fibre/yarn. In some examples, the conductive pathways may be provided on the underside surface of the textile. In some examples, an aperture may be provided in the textile so as to allow the electronics module to conductively connect to the conductive pathways.

Referring to Figure 11, there is shown the electronics module 100 of Figures 8 and 9 attached to the garment 200 of Figure 10. The first conductive prong 115 is brought into conductive electrical contact with the first terminal 201 and the second conductive prong 117 is brought into conductive electrical contact with the second terminal 205. A magnet (Figure 7, element 113) may be provided in the electronics module 100 and on the underside of the garment 200 so as to maintain the electronics module 100 in releasable attachment with the garment 200.

Referring to Figure 12, there is shown a detailed schematic diagram of an electronics module 100 according to example aspects of the present disclosure. The electronics module 100 comprises an interface 101, a controller 103, power source 105, first antenna 107, a second antenna 109, and a sensor 111. These components may be the same as the electronics module 100 described in any of Figures 1 to 3 and 7 to 9. The electronics module 100 is mounted on a garment and conductively connected to a first electrode 209 and a second electrode 211 of the garment via the first and second electrically conductive pathways 203, 207. In a particular example, the electrodes 209, 211 are used to measure electropotential signals such as electrocardiogram (ECG) signals.

The controller 103 is a microcontroller with an integral second antenna 109 for communication over the second wireless communication protocol. The second antenna 109 in this example is a Bluetooth ® antenna 109. The controller 103 is communicatively connected to the first antenna 107 which in this example is an NFC antenna 107. The controller 103 is arranged to energize the first antenna 107 to transmit information.

The power source 105 in this example is a lithium polymer battery 105. The battery 105 is rechargeable and charged via a USB C input 131 of the electronics module 100. Of course, the present disclosure is not limited to recharging via USB and instead other forms of charging such as inductive of far field wireless charging are within the scope of the present disclosure. Additional battery management functionality is provided in terms of a charge controller 133, battery monitor 135 and regulator 147. These components may be provided through use of a dedicated power management integrated circuit (PMIC). The controller 103 is communicatively connected to the battery monitor 135 such that the controller 103 may obtain information about the state of charge of the battery 105.

The controller 103 is connected to the interface 101 via an analog-to-digital converter (ADC) fronted end 139 and an electrostatic discharge (ESD) protection circuit 141. The ADC fronted end 131 converts the raw analog signal received from the electrodes 209, 211 into a digital signal. The ADC frontend 131 may also perform filtering operations on the received signals.

The controller 103 has an internal memory and is also communicatively connected to an external memory 143 which in this example is a NAND Flash memory. The memory 143 is used to for the storage of data when no wireless connection is available between the electronics module 100 a mobile device 300 (Figure 1). The memory 143 may have a storage capacity of at least 1GB and preferably at least 2 GB. The electronics module 100 comprises a temperature sensor 145 and a light emitting diode 147 for conveying status information. The electronic module 100 also comprises conventional electronics components including a power-on-reset generator 149, a development connector 151, a crystal 153, and a PROG header 155. Additionally, the electronics module 100 may comprise a button 155 for allowing the user to control the electronics module 100 although this is not required due to the functionality of the motion sensor 111 as described previously. Additionally, the electronics module 100 may comprise a haptic feedback unit 157 for providing a haptic (vibrational) feedback to the user.

In some examples, the electronics module 100 may additionally comprise a mobile/cellular communicator operable to communicate the data wirelessly via one or more base stations. The communicator may provide wireless communication capabilities for the garment and enables the garment to communicate via over a cellular communication network. The cellular communication network may be a fourth generation (4G) LTE, LTE Advanced (LTE-A), LTE Cat-M1, LTE Cat-M2, NB-IoT, fifth generation (5G), sixth generation (6G), and/or any other present or future developed cellular wireless network. The first antenna 107 provided with an aperture 125 as described above in relation to Figure 7 may be beneficial in allowing for a line-of-sight to be provided for the cellular communication of the electronics module 100.

The electronics module 100 may additionally comprise a Universal Integrated Circuit Card (UICC) that enables the garment to access services provided by a mobile network operator (MNO) or virtual mobile network operator (VMNO). The UICC may include at least a read-only memory (ROM) configured to store an MNO or VMNO profile that the garment can utilize to register and interact with an MNO or VMNO. The UICC may be in the form of a Subscriber Identity Module (SIM) card. The electronics module 100 may have a receiving section arranged to receive the SIM card. In other examples, the UICC is embedded directly into a controller of the electronics module 100. That is, the UICC may be an electronic/embedded UICC (eUICC). A eUICC is beneficial as it removes the need to store a number of MNO profiles, i.e. electronic Subscriber Identity Modules (eSIMs). Moreover, eSIMs can be remotely provisioned to garments. The electronics module 100 may comprise a secure element that represents an embedded Universal Integrated Circuit Card (eUICC).

In the present disclosure, the electronics module may also be referred to as an electronics device or unit. These terms may be used interchangeably.

Examples

Example 1: An electronics module for a wearable article, the electronics module comprising:
a controller configured to process signals received from a sensing component;
a power source, coupled to the controller, and arranged to supply power to the controller;
a first antenna;
a housing comprising a top enclosure and a bottom enclosure, and a longitudinal axis extending from the top enclosure to the bottom enclosure,
wherein the power source, controller, and first antenna are provided in the housing, and
wherein the first antenna is provided proximate to the top enclosure.

Example 2: An electronics module according to Example 1, wherein the first antenna is spaced apart from the power source and the controller along the longitudinal axis of the housing.

Example 3: An electronics module according to Example 1 or 2, further comprising a second antenna.

Example 4: An electronics module according to Example 1, 2 or 3, wherein the first antenna comprises an aperture.

Example 5: An electronics module according to Example 4, further comprising a second antenna, wherein the second antenna is arranged in the housing such that the second antenna has a line of sight through the aperture.

Example 6: An electronics module according to Example 5, further comprising a printed circuit board, wherein the controller and the second antenna are provided on the printed circuit board.

Example 7: An electronics module according to any of Examples 4 to 6, further comprising a light source, wherein the light source is arranged in the housing such that the light source has a line of sight through the aperture.

Example 8: An electronics module according to Example 7, further comprising a printed circuit board, wherein the controller and the light source are provided on the printed circuit board.

Example 9: An electronics module according to any of Examples 1 to 8, wherein the electronics module comprises a printed circuit board structure comprising: a first printed circuit board, wherein the first antenna is provided on the first printed circuit board.

Example 10: An electronics module according to Example 9, wherein the printed circuit board structure further comprises a second printed circuit board, wherein the controller is provided on the second printed circuit board.

Example 11: An electronics module according to Example 10, wherein a conductor extends from the first printed circuit board to the second printed circuit board to conductively connect the first printed circuit board to the second printed circuit board.

Example 12: An electronics module according to Example 11, wherein the printed circuit board structure is a flex-rigid printed circuit board structure, and wherein the first and second printed circuit boards are rigid components of the flex-rigid printed circuit board structure, and wherein the conductor is a flexible component of the flex-rigid printed circuit board structure.

Example 13: An electronics module according to any of Examples 9 to 12, wherein the first printed circuit board comprises a first region bounding an aperture extending through the first printed circuit board, and wherein the first antenna is arranged in the first region of the first printed circuit board.

Example 14: An electronics module according to any preceding Example, wherein the first antenna comprises a power receiving antenna.

Example 15: An electronics module according to any preceding Example, wherein the first antenna comprises a communication antenna.

Example 16: An electronics module according to Example 15, wherein the first antenna comprises a short-range communication antenna.

Example 17: An electronics module according to Example 16, wherein the second antenna comprises a near-field communication antenna.

Example 18: An electronics module according to any preceding Example, further comprising an interface arranged to communicatively couple with an electronics arrangement of the wearable article so as to form a signal pathway between the electronics module and the electronics arrangement.

Example 19: An electronics module according to any preceding Example, wherein, in response to the mobile device being brought into proximity with the electronics module, the electronics module is configured to: energize the first antenna to transmit information to the mobile device over a first wireless communication protocol.

Example 20: An electronics module according to Example 19, wherein the information comprises a unique identifier for the electronics module.

Example 21: An electronics module according to Example 19 or 20, wherein the information comprises authentication information useable to facilitate pairing between the electronics module and the mobile device over a second wireless communication protocol.

Example 22: An electronics module according to any of Examples 19 to 21, wherein the information comprises application information useable by the mobile device to start an application on the mobile device or configure an application running on the mobile device.

Example 23: An electronics module according to any of Examples 19 to 22, further comprising a sensor, the sensor is arranged to detect the mobile device being brought into proximity with the electronics module.

Example 24: A wearable article comprising the electronics module according to any preceding Example.

Example 25: A wearable article according to Example 24, wherein the wearable article is a garment.

At least some of the example embodiments described herein may be constructed, partially or wholly, using dedicated special-purpose hardware. Terms such as 'component', 'module' or 'unit' used herein may include, but are not limited to, a hardware device, such as circuitry in the form of discrete or integrated components, a Field Programmable Gate Array (FPGA) or Application Specific Integrated Circuit (ASIC), which performs certain tasks or provides the associated functionality. In some embodiments, the described elements may be configured to reside on a tangible, persistent, addressable storage medium and may be configured to execute on one or more processors. These functional elements may in some embodiments include, by way of example, components, such as software components, object-oriented software components, class components and task components, processes, functions, attributes, procedures, subroutines, segments of program code, drivers, firmware, microcode, circuitry, data, databases, data structures, tables, arrays, and variables. Although the example embodiments have been described with reference to the components, modules and units discussed herein, such functional elements may be combined into fewer elements or separated into additional elements. Various combinations of optional features have been described herein, and it will be appreciated that described features may be combined in any suitable combination. In particular, the features of any one example embodiment may be combined with features of any other

embodiment, as appropriate, except where such combinations are mutually exclusive. Throughout this specification, the term “comprising” or “comprises” means including the component(s) specified but not to the exclusion of the presence of others.

All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

CLAIMS

1. An electronics module for a wearable article, the electronics module comprising:
a controller configured to process signals received from a sensing component;
a power source, coupled to the controller, and arranged to supply power to the controller;
a first antenna;
a housing,
wherein the power source, controller, and first antenna are provided in the housing, and
wherein the first antenna is spaced apart from the power source and the controller along a longitudinal axis of the housing,
wherein the first antenna comprises a power receiving antenna arranged to receive power from an external device for charging the power source.

2. An electronics module as claimed in claim 1, wherein the housing comprises a top enclosure and a bottom closure, and wherein the first antenna is provided proximate to the top enclosure.

3. An electronics module as claimed in claim 1 or 2, further comprising a sensor.

4. An electronics module as claimed in claim 3, wherein the sensor is a motion sensor.

5. An electronics module as claimed in any preceding claim, further comprising a light source.

6. An electronics module as claimed in claim 5, wherein the electronics module further comprises a printed circuit board, and wherein the controller and light source are provided on the printed circuit board.

7. An electronics module as claimed in any preceding claim, further comprising a printed circuit board structure comprising a first printed circuit board, wherein the first antenna is provided on the first printed circuit board.

8. An electronics module as claimed in claim 7, wherein the printed circuit board structure further comprises a second printed circuit board, wherein the controller is provided on the second printed circuit board, and wherein a conductor extends from the first printed circuit board to the second printed circuit board to conductively connect the first printed circuit board to the second printed circuit board.

9. An electronics module as claimed in claim 8, wherein the conductor comprises a stiffener material.

10. An electronics module as claimed in any preceding claim, wherein the first antenna comprises an aperture.

11. An electronics module as claimed in any preceding claim, further comprising a second antenna.

12. An electronics module as claimed in any preceding claim, further comprising an interface arranged to communicatively couple with an electronics arrangement of the wearable article so as to form a signal pathway between the electronics module and the electronics arrangement.

13. An electronics module as claimed in any preceding claim, wherein the electronics module is arranged to be removably coupled to the wearable article.

14. A wearable article comprising the electronics module as claimed in any preceding claim.

15. A wearable article as claimed in claim 14, wherein the wearable article is a garment.

Amendments to the claims have been filed as follows

CLAIMS

1. An electronics module for a wearable article, the electronics module comprising:
a controller configured to process signals received from a sensing component;
a power source, coupled to the controller, and arranged to supply power to the controller;
a first antenna;
a printed circuit board structure comprising a first printed circuit board on which the first antenna is provided and a second printed circuit board on which the controller is provided, and a conductor which extends from the first printed circuit board to the second printed circuit board to conductively connect the first printed circuit board to the second printed circuit board; and
a housing comprising a top enclosure and a bottom enclosure, wherein the bottom enclosure is arranged to be closer to the skin of a user than the top enclosure in use,
wherein the power source, controller, and first antenna are provided in the housing, and wherein the first antenna is provided proximate to the top enclosure and positioned above the power source and the controller,
wherein the first antenna comprises a power receiving antenna arranged to receive power from an external device for charging the power source.

2. An electronics module as claimed in claim 1, further comprising a sensor.

3. An electronics module as claimed in claim 2, wherein the sensor is a motion sensor.

4. An electronics module as claimed in any preceding claim, further comprising a light source.

5. An electronics module as claimed in claim 4, wherein the light source is provided on the second printed circuit board.

6. An electronics module as claimed in any preceding claim, wherein the conductor comprises a stiffener material.

7. An electronics module as claimed in any preceding claim, wherein the first antenna comprises an aperture.

8. An electronics module as claimed in any preceding claim, further comprising a second antenna.

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9. An electronics module as claimed in any preceding claim, further comprising an interface arranged to communicatively couple with an electronics arrangement of the wearable article so as to form a signal pathway between the electronics module and the electronics arrangement.

10. An electronics module as claimed in any preceding claim, wherein the electronics module is arranged to be removably coupled to the wearable article.

11. A wearable article comprising the electronics module as claimed in any preceding claim.

12. A wearable article as claimed in claim 11, wherein the wearable article is a garment.

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Intellectual Property Office

Application No:	GB2109912.2	**Examiner:**	Dr John Cullen
Claims searched:	1-15	**Date of search:**	8 November 2021

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-6 and 10-14	US2018/259914 A1 (CHAE) See Abstract, Figs 1-3 and 5 and paras 45, 49, 56, 57, 63 and 83-85.
X,E	1-3, 10, 11, 14	WO2020/033242 A1 (VERILY) See Abstract, Figs 2A, 2B, 4A, 4B and paras 30, 31, 56-58 and 61.
X	1-5, 7-14	US2015/364938 A1 (LAPETINA) See Figs 5B, 6A and 8 and paras 48-60, 63, 64, 69, 71, 75, 76, 91 and 92.
X	1-5 and 10-14	US2015/102879 A1 (JACOBS) See Figs 18 and 29 and pras 2, 59, 69-71 and 75-77.
X	1, 3, 5 and 10-14	US2019/393730 A1 (WITTENBERG) See Abstract, Figs 1, 9 and 11 and paras 73-76, 109-112, 118 and 123.
X	1-5 and 7-15	CN106911193 A (NINGBO) See whole document, but mainly Fig. 4 and EPODOC abstract.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

Intellectual Property Office

International Classification:

Subclass	Subgroup	Valid From
H02J	0050/10	01/01/2016
A61B	0005/00	01/01/2006