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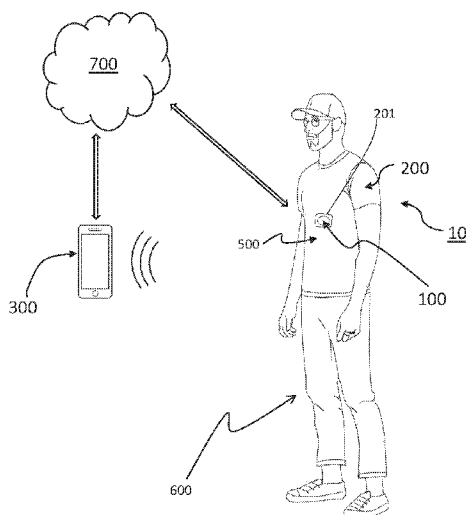


FIG. 1

(57) Abstract: An electronics module (100) receives biosignals such as biopotential and bioimpedance signals from sensors on a wearable article (200) and processes these signals to provide data and information to a user electronic device (300). The electronics module is operable to determine what level of activity of the wearer of the wearable article and to process the biosignals accordingly. In particular, the electronics module will process the bioimpedance signals at a lower rate, or not at all, when it is determined that the wearer is an inactive phase. In this way, battery life is optimised because data that requires higher power levels is only sent when required.

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## **ELECTRONICS MODULE, A CONTROLLER FOR AN ELECTRONICS MODULE AND A METHOD PERFORMED BY A CONTROLLER**

The present invention is directed towards an electronics module for a wearable article such as a garment. The wearable article comprises a biosignal measuring apparatus for sensing biosignals from a wearer of the wearable article, and which incorporates a sensor assembly and the electronics module. The electronics module is arranged to transmit biosignal data to the user electronics module or other remote device. The present invention is also directed towards a controller for an electronics module and a method performed by a controller for an electronics module for a wearable article.

### **10     Background**

Wearable articles, such as garments, incorporating sensors are wearable electronics used to measure and collect information from a wearer. Such wearable articles are commonly referred to as 'smart clothing'. It is advantageous to measure biosignals of the wearer during exercise, or other scenarios.

15     It is known to provide a garment, or other wearable article, to which an electronic device (i.e. an electronic module, and/or related components) is attached in a prominent position, such as on the chest or between the shoulder blades. Advantageously, the electronic device is a detachable device. The electronic device is configured to process the incoming signals, and the output from the processing is stored and/or displayed to a user in a suitable way.

20     A sensor senses a biosignal such as electrocardiogram (ECG) signals and the biosignals are coupled to the electronic device, via an interface.

The sensors may be coupled to the interface by means of conductors which are connected to terminals provided on the interface to enable coupling of the signals from the sensor to the interface.

25     Electronics modules for wearable articles such as garments are known to communicate with user electronic 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 user electronic device.

30     The electronics module includes drive and sensing electronics comprising components and associated circuitry, to provide the required functionality.

The drive and sensing electronics include a power source to power the electronics module and the associated components of the drive and sensing circuitry.

ECG sensing detects biopotential signals and used to provide a plethora of information about a person's heart. It is one of the simplest and oldest techniques used to perform cardiac investigations. In its most basic form, it provides an insight into the electrical activity generated within heart muscles that changes over time. By detecting and amplifying these differential biopotential signals, a lot of information can be gathered quickly, including the heart rate.

ECG measurements can be used to provide a measure of respiration.

In an alternative, respiration can be measured using bioimpedance measurement.

The processing and sending of raw and processed signal data utilises significant amounts of power. Whilst electronics modules can be provided that can operate continuously for a significant period of time, optimising battery life is an important consideration.

Measuring bioimpedance can consume significantly more power than ECG biopotential measurement, for example drawing 77 $\mu$ A for ECG measurement compared to 144 $\mu$ A for bioimpedance measurement.

An object of the present invention is to provide an improved electronic module for a wearable article with an improved utilisation of battery life.

### **Summary**

According to a first aspect of the present invention, there is provided an electronics module for a wearable article comprising a controller, an input arranged to receive biosignals from at least one biosensor provided on the wearable article, the biosignals comprising a first type of biosignal and a second type of biosignal of a wearer of the wearable article, and at least one activity sensor coupled to the controller and arranged to provide an indication of a level of activity of a wearer of the wearable article to the controller, wherein the controller is configured to process the second type of biosignal at a first rate when the level of activity of the wearer is determined to be in a first phase, and to process the second type of biosignal at a second rate when the level of activity of the wearer is determined to be in a second phase.

The first type of biosignal may be a biopotential signal.

The second type of biosignal may be a bioimpedance signal.

The biopotential signals may provide measurements including electrocardiograms, electrogastrograms, electroencephalograms, and electromyography. The bioimpedance signals may provide measurements including plethysmography (e.g., for respiration), body composition (e.g., hydration, fat, etc.), and electroimpedance tomography.

The first phase of the level of activity may be an active phase. The second phase of the level of activity may be an inactive phase. The first rate may be a standard rate and the second rate may be a reduced rate as compared to the standard rate.

The reduced rate may be zero.

The active phase may be a phase of sustained activity. The phase of sustained activity may be where the activity is for a predetermined period of time.

The first and second type of biosignals may be processed by respective channels of an analogue-to-digital convertor. The rate may be reduced by changing the duty cycle of the  
5 respective channel of the analogue-to-digital converter.

The activity sensor may be a motion detection device. The motion detection device may be an inertial measurement unit.

The activity sensor may be a location device.

According to a second aspect of the invention, there is provided a method performed by a  
10 controller for an electronics module for a wearable article, the electronics module comprising a controller, an interface, and at least one contextual data unit coupled to the controller, the method comprising the steps of:

receiving biosignal data of a first type and a second type from biosensors on the wearable article via the input;

15 receiving data relating to the determined activity level of a wearer of the wearable article from an activity sensor;

the controller is configured to process the second type of biosignal at a first rate when the level of activity of the wearer is determined to be in a first phase, and to process the second type of biosignal at a second rate when the level of activity of the wearer is  
20 determined to be in a second phase.

processing both the second type of biosignal at a first rate when the activity level of the wearer is determined to be in a first phase; and

processing the second type of biosignal when the level of activity of the wearer is determined to be in a second phase.

25 The first type of biosignal may be a biopotential signal.

The second type of biosignal may be a bioimpedance signal.

The biopotential signals may provide measurements including electrocardiograms, electrogastrograms, electroencephalograms, and electromyography. The bioimpedance signals may provide measurements including plethysmography (e.g., for respiration), body composition  
30 (e.g., hydration, fat, etc.), and electroimpedance tomography.

The first phase of the level of activity may be an active phase. The second phase of the level of activity may be an inactive phase. The first rate may be a standard rate. The second rate may be a reduced rate as compared to the standard rate. The active phase may be a phase of sustained activity. The phase of sustained activity may be where the activity is for a  
35 predetermined period of time.

The first and second type of biosignals may be processed by respective channels of an analogue-to-digital convertor. The rate may be reduced by changing the duty cycle of the respective channel of the analogue-to-digital converter.

- 5 The activity sensor may be a motion detection device. The motion detection device may be an inertial measurement unit.

The activity sensor may be a location device.

In a third aspect of the present invention, there is provided a wearable article comprising an electronics module according to any aspect of the first aspect of the invention.

- 10 The present invention provides an improved electronics module for a wearable article, and a method for operating such an electronics module with an improved utilisation of battery life.

#### **Brief Description of the Drawings**

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

- 15 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;

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

Figure 4 shows a schematic diagram for an example analogue-to-digital converter used in the example electronics module of Figures 4 and 5 according to aspects of the present disclosure;

Figure 5 shows a detailed schematic diagram of the electronics components of an example electronics module according to aspects of the present disclosure; and

- 25 Figure 6 shows a flow diagram for an example method according to aspects of the present disclosure.

#### **Detailed Description**

- 30 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 device interface which may be worn by a user such as a smart watch, necklace, garment, 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, garment brassiere, shorts, pants, arm or leg sleeve, vest, jacket/coat, glove, armband, underwear, headband, hat/cap, collar, wristband, stocking, sock, or shoe, athletic clothing, personal protective equipment, including hard hats, swimwear, wetsuit or dry suit.

The term “wearer” includes a user who is wearing, or otherwise holding, the wearable article.

The type of wearable garment may dictate the type of biosignals to be detected. For example, a hat or cap may be used to detect electroencephalogram or magnetoencephalogram signals.

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 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 garment has sensing units provided on an inside surface which are held in close proximity to a skin surface of a wearer wearing the garment. This enables the sensing units to measure biosignals for the wearer wearing the garment.

The sensing units may be arranged to measure one or more biosignals of a wearer wearing the garment.

“Biosignal” as referred to throughout the present disclosure may refer to signals from living beings that can be continually measured or monitored. Biosignals may be electrical or non-electrical signals. Signal variations can be time variant or spatially variant.

Sensing components may be used for measuring one or a combination of biopotential, bioimpedance, biochemical, biomechanical, bioacoustics, biooptical or biothermal signals of the wearer 600. The biopotential measurements include electrocardiograms (ECG), electrogastrograms (EGG), electroencephalograms (EEG), and electromyography (EMG). The bioimpedance measurements include plethysmography (e.g., for respiration), body composition (e.g., hydration, fat, etc.), and electroimpedance tomography (EIT). The biomagnetic measurements include magnetoneurograms (MNG), magnetoencephalography (MEG), magnetogastrogram (MGG), magnetocardiogram (MCG). The biochemical measurements include glucose/lactose measurements which may be performed using chemical analysis of the wearer 600's sweat. The biomechanical measurements include blood pressure. The bioacoustics measurements include phonocardiograms (PCG). The biooptical measurements include orthopantomogram (OPG). The biothermal measurements include skin temperature and core body temperature measurements.

Referring to Figures 1 to 5, there is shown an example system 10 according to aspects of the present disclosure. The system 10 comprises an electronics module 100, a wearable article in the form of a garment 200, and a user electronic device 300. The garment 200 is worn by a user who in this embodiment is the wearer 600 of the garment 200.

The electronics module 100 is arranged to integrate with sensing units 400 incorporated into the garment 200 to obtain signals from the sensing units 400.

The electronics module 100 and the wearable article 200 and including the sensing units 400 comprise a wearable assembly 500.

The sensing units 400 comprise one or more sensors 209, 211 with associated conductors 203, 207 and other components and circuitry. The electronics module 100 is further arranged to wirelessly communicate data to the user electronic device 300. Various protocols enable wireless communication between the electronics module 100 and the user electronic device 300. Example communication protocols include Bluetooth®, Bluetooth® Low Energy, and near-field communication (NFC).

The garment 200 has an electronics module holder in the form of a pocket 201. The pocket 201 is sized to receive the electronics module 100. When disposed in the pocket 201, the electronics module 100 is arranged to receive sensor data from the sensing units 400. The electronics module 100 is therefore removable from the garment 200.

The present disclosure is not limited to electronics module holders in the form pockets.

Alternatively, 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 the components required for data transmission and processing such that the garment 200 only comprises the sensing units 400 e.g. the sensors 209, 211 and communication pathways 203, 207. 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.

Referring to Figure 2, there is shown a schematic diagram of an example of the electronics module 100.

A more detailed block diagram of the electronics components of electronics module 100 and garment are shown in Figure 3.

The electronics module 100 comprises an interface 101, a controller 103, a power source 105, and one or more communication devices which, in the exemplar embodiment comprises a first antenna 107, a second antenna 109 and a wireless communicator 159. The electronics module 100 also includes an input unit such as a proximity sensor or a motion sensor 111, for example in the form of an inertial measurement unit (IMU).

The electronics module 100 also includes additional peripheral devices that are used to perform specific functions as will be described in further detail herein.

The interface 101 is arranged to communicatively couple with the sensing unit 400 of the garment 200. The sensing unit 400 comprises – in this example – the two sensors 209, 211 coupled to respective first and second electrically conductive pathways 203, 207, each with respective termination points 213, 215. The interface 101 receives signals from the sensors

209, 211. The controller 103 is communicatively coupled to the interface 101 and is arranged to receive the signals from the interface 101 for further processing.

The interface 101 of the embodiment described herein comprises first and second contacts 163, 165 which are arranged to be communicatively coupled to the termination points 213, 215 the  
5        respective first and second electrically conductive pathways 203, 207. The coupling between the termination points 213, 215 and the respective first and second contacts 163, 165 may be conductive or a wireless (e.g. inductive) communication coupling.

In this example the sensors 209, 211 are used to measure electropotential signals such as electrocardiogram (ECG) signals and bioimpedance signals, although the sensors 209, 211  
10        could be configured to measure other biosignal types as also discussed above.

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  
15        generate electric power signals in response to kinetic events such as kinetic events 10 performed by the wearer 600 of the garment 200. The kinetic event could include walking, running, exercising or respiration of the wearer 600. 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  
20        of the wearer 600 of the garment. The energy harvesting device may be a thermoelectric energy harvesting device. The power source 105 may be a super capacitor, or an energy cell.

The first antenna 107 is arranged to communicatively couple with the user electronic device 300 using a first communication protocol. In the example described herein, the first antenna 107 is a passive tag such as a passive Radio Frequency Identification (RFID) tag or Near Field  
25        Communication (NFC) tag. These tags comprise a communication module as well as a memory which stores the information, and a radio chip. The user electronic device 300 is powered to induce a magnetic field in an antenna of the user electronic device 300. When the user electronic device 300 is placed in the magnetic field of the communication module antenna 107, the user electronic device 300 induces current in the communication module antenna 107. This induced  
30        current is used to retrieve the information from the memory of the tag and transmit the same back to the user electronic device 300. The controller 103 is arranged to energize the first antenna 107 to transmit information.

In an example operation, the user electronic device 300 is brought into proximity with the electronics module 100. In response to this, the electronics module 100 is configured to energize  
35        the first antenna 107 to transmit information to the user electronic device 300 over the first wireless communication protocol. Beneficially, this means that the act of the user electronic

device 300 approaching the electronics module 100 energizes the first antenna 107 to transmit the information to the user electronic device 300.

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.

The information may comprise authentication information used to facilitate the pairing between the electronics module 100 and the user electronic 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 user electronic device 300 to start an application on the user electronic device 300 or configure an application running on the user electronic device 300. The application may be started on the user electronic device 300 automatically (e.g. without wearer 600 input). Alternatively, the application information may cause the user electronic device 300 to prompt the wearer 600 to start the application on the user electronic device. The information may comprise a uniform resource identifier such as a uniform resource location to be accessed by the user electronic device, or text to be displayed on the user electronic 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 user electronic device 300.

The second antenna 109 is arranged to communicatively couple with the user electronic device 300 over a second wireless communication protocol. The second wireless communication protocol may be a Bluetooth® protocol, Bluetooth® 5 or a Bluetooth® Low Energy protocol but is not limited to any particular communication protocol. In the present embodiment, the second antenna 109 is integrated into controller 103. The second antenna 109 enables communication between the user electronic device 300 and the controller 100 for configuration and set up of the controller 103 and the peripheral devices as may be required. Configuration of the controller 103 and peripheral devices utilises the Bluetooth® protocol.

Other wireless communication protocols can also be used, such as used for communication over: a wireless wide area network (WWAN), a wireless metro area network (WMAN), a wireless local area network (WLAN), a wireless personal area network (WPAN), Bluetooth® Low Energy, Bluetooth® Mesh, Thread, Zigbee, IEEE 802.15.4, Ant, a Global Navigation Satellite System (GNSS), a cellular communication network, or any other electromagnetic RF communication protocol. 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 electronics module 100 includes configured a clock unit in the form of a real time clock (RTC) 153 coupled to the controller 103 and, for example, to be used for data logging, clock building, time stamping, timers, and alarms. As an example, the RTC 153 is driven by a low frequency clock source or crystal operated at 32.768 Hz.

- 5 The electronics module 100 also includes a location device 161 such as a GNSS (Global Navigation Satellite System) device which is arranged to provide location and position data for applications as required. In particular, the location device 161 provides geographical location data at least to a nation state level. Any device suitable for providing location, navigation or for tracking the position could be utilised. The GNSS device may include Global Positioning System  
10 (GPS), BeiDou Navigation Satellite System (BDS) and the Galileo system devices.

- 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 or far field wireless charging are within the scope of the present disclosure.  
15 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 30 dedicated power management integrated circuit (PMIC).

The USB C input 131 is also coupled to the controller 103 to enable direct communication between the controller 103 and an external device if required.

- 20 The controller 103 is communicatively connected to a battery monitor 135 so that that the controller 103 may obtain information about the state of charge of the battery 105.

- The controller 103 has an internal memory 167 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  
25 module 100 and a user electronic device 300. The memory 143 may have a storage capacity of at least 1GB and preferably at least 2 GB.

- The electronics module 100 also 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  
30 151, the real time clock 153 and a PROG header 155.

Additionally, the electronics module 100 may comprise a haptic feedback unit 157 for providing a haptic (vibrational) feedback to the wearer 600.

- The wireless communicator 159 may provide wireless communication capabilities for the garment 200 and enables the garment to communicate via one or more wireless communication  
35 protocols to a remote server 700. Wireless communications may include : a wireless wide area network (WWAN), a wireless metro area network (WMAN), a wireless local area network

(WLAN), a wireless personal area network (WPAN), Bluetooth® Low Energy, Bluetooth® Mesh, Bluetooth® 5, Thread, Zigbee, IEEE 802.15.4, Ant, a near field communication (NFC), a Global Navigation Satellite System (GNSS), a cellular communication network, or any other electromagnetic RF communication protocol. The cellular communication network may be a  
5 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 wireless communicator 159 may be an alternative, or in addition to, the first and second antennas 107, 109.

10 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  
15 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  
20 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.

The controller 103 is connected to the interface 101 via an analog-to-digital converter (ADC)  
25 front end 139 and an electrostatic discharge (ESD) protection circuit 141.

Figure 4 is a schematic illustration of the component circuitry for the ADC front end 139.

In the example described herein, the ADC front end 139 is an integrated circuit (IC) chip which converts the raw analogue biosignal received from the sensors 209, 211 into a digital signal for further processing by the controller 103. ADC IC chips are known, and any suitable one can be  
30 utilised to provide this functionality. ADC IC chips for biosignal applications include, for example, the MAX30001 chip produced by Maxim Integrated Products Inc.

The ADC front end 139 includes an input 169 and an output 171.

Raw biosignals from the electrodes 209, 211 are input to the ADC front end 139, where received signals are processed in a biopotential channel 175 and subject to appropriate filtering through  
35 high pass and low pass filters for static discharge and interference reduction as well as for reducing bandwidth prior to conversion to digital signals. The reduction in bandwidth is important

to remove or reduce motion artefacts that give rise to noise in the signal due to movement of the sensors 209, 211.

The raw biosignals are also processed in a bioimpedance channel 179 and also subject to appropriate filtering through high pass and low pass filters, an amplifier and mixer.

- 5 The output digital signals may be decimated to reduce the sampling rate prior to being passed to a serial programmable interface (SPI) 173 of the ADC front end 139.

ADC front end IC chips suitable for biopotential and bioimpedance applications may be configured to determine information from the input biosignals such as respiration rate, heart rate and the QRS complex and including the R-R interval of the QRS complex. Support circuitry  
10 177 provides base voltages for the biopotential channel 175 and bioimpedance channel 179.

The determining of the QRS complex can be implemented for example using the known Pan Tomkins algorithm as described in Pan, Jiapu; Tompkins, Willis J. (March 1985). "A Real-Time QRS Detection Algorithm". IEEE Transactions on Biomedical Engineering. BME-32 (3): 230–236.

- 15 Signals are output to the controller 103 via the SPI 173.

The controller 103 can also be configured to apply digital signal processing (DSP) to the digital signal from the ADC front end 139.

The DSP may include noise filtering additional to that carried out in the ADC front end 139 and may also include additional processing to determine further information about the signal from  
20 the ADC front end 139.

The controller 103 is configured to send the biosignals to the user electronic device 300 using either of the first antenna 107, second antenna 109, or wireless communicator 159.

In some examples, the input unit – such as a proximity sensor or motion sensor - is arranged to detect a displacement of the electronics module 100. These displacements of the electronics  
25 module 100 may be caused by the object being tapped against the electronics module 100 or by the wearer 600 of the electronics module 100 being in motion, for example walking or running, or simply getting up from a recumbent position. As such, the input unit provides activity level detection as will be further described below.

In the exemplar embodiment described herein, motion detection is provided by the IMU 111  
30 which 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.

The input unit could be an AI system, machine or engine.

The IMU 111 can therefore be used to detect can detect orientation and gestures with event-detection interrupts enabling motion tracking and contextual awareness. It has recognition of free-fall events, tap and double-tap sensing, activity or inactivity, stationary/motion detection, and wakeup events in addition to 6D orientation. A single tap, for example, can be used enable  
5 toggling through various modes or waking the electronics module 100 from a low power mode.

Known examples of IMUs that can be used for this application include the ST LSM6DSOX manufactured by STMicroelectronics. This IMU a system-in-package IMU featuring a 3D digital accelerometer and a 3D digital gyroscope.

Another example of a known IMU suitable for this application is the LSM6DSO also be  
10 STMicroelectronics.

The IMU 111 can include machine learning functionality, for example as provided in the ST LSM6DSOX. The machine learning functionality is implemented in a machine learning core (MLC). The machine learning processing capability uses decision-tree logic. The MLC is an embedded feature of the IMU 111 and comprises a set of configurable parameters and decision  
15 trees. As is understood in the art, decision tree is a mathematical tool composed of a series of configurable nodes. Each node is characterized by an "if-then-else" condition, where an input signal (represented by statistical parameters calculated from the sensor data) is evaluated against a threshold.

Decision trees are stored and generate results in the dedicated output registers. The results of  
20 the decision tree can be read from the application processor at any time. Furthermore, there is the possibility to generate an interrupt for every change in the result in the decision tree, which is beneficial in maintaining low-power consumption.

Decision trees can be generated using a known machine learning tool such as Waikato Environment for Knowledge Analysis software (Weka) developed by the University of Waikato  
25 or using MATLAB® or Python™.

In an example operation, the wearer 600 has positioned the electronics module 100 within the pocket 201 (Figure 1) of the garment 200 and is wearing the garment 200. The wearer 600 taps their hand or mobile phone 300 against the pocket 201 and this tap event is detected by the input unit, which in this exemplar embodiment is the IMU 111. The IMU 111 sends a signal to  
30 the controller 103 to wake-up the controller 103 from the low power mode.

A processor of the IMU 111 may perform processing tasks to classify different types of detected motion. The processor of the IMU 111 may use the machine-learning functions so as to perform this classification. Performing the processing operations on the IMU 111 rather than the controller 103 is beneficial as it reduces power consumption and leaves the controller 103 free  
35 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 IMU 111 may be configured to detect when the electronic device 100 has been stationary but then begins to move, for example when left on a surface but then attached to the garment 200. The IMU 111 may be configured to detect that the wearer 600 of the garment 200, with the electronic device attached, is resting, or is moving, for example during exercise. The IMU 111  
5 may be configured to establish the level of activity, for example, whether the wearer 600 is walking or running. The IMU 111 acts as an activity sensor which can determine the activity level of a wearer of the wearable article 200. A wearer can be determined to be in one or more phases, such as an active phase, an inactive, or any other intermediate phase of activity.

Activity level could be determined by location using the location device 161. For example, if a  
10 wearer 600 is determined to be in a gym, then the activity level could be determined as an active phase.

The IMU 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  
15 present disclosure. The IMU 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, for example, or vice versa. The interrupt signals may be transmitted via one or more dedicated interrupt pins.

The user electronic device 300 in the example of Figure 5 is in the form of a mobile phone or  
20 tablet and comprises a controller 305, a memory 304, a wireless communicator 307, a display 301, a user input unit 306, a capturing device in the form of a camera 303 and an inertial measurement unit (IMU) 309. The controller 305 provides overall control to the user electronic device 300.

The user input unit 306 receives inputs from the user such as a user credential.

25 The memory 304 stores information for the user electronic device 300.

The display 301 is arranged to display a user interface 302 for applications operable on the user electronic device 300.

The IMU 309 provides motion and/or orientation detection and may comprise an accelerometer and optionally one or both of a gyroscope and a magnetometer.

30 The user electronic device 300 may also include a biometric sensor. The biometric sensor may be used to identify a user or users of device based on unique physiological features. The biometric sensor may be: a fingerprint sensor used to capture an image of a user's fingerprint; an iris scanner or a retina scanner configured to capture an image of a user's iris or retina; an ECG module used to measure the user's ECG; or the camera of the user electronic arranged to  
35 capture the face of the user. The biometric sensor may be an internal module of the user

electronic device. The biometric module may be an external (stand-alone) device which may be coupled to the user electronic device by a wired or wireless link.

The controller 305 is configured to launch an application which is configured to display insights derived from the biosignal data processed by the ADC front end 139 of the electronics module 100, input to electronics module controller 103, and then transmitted from the electronics module 100. The transmitted data is received by the wireless communicator 307 of the user electronic device 300 and input to the controller 305.

Insights include, but are not limited to, heart rate, respiration rate, core temperature but can also include identification data for the wearer 600 using the wearable assembly 500.

The display 301 is also configured to display an ECG signal trace part of the user interface 302. To display a signal trace may require raw ECG data from the electronic module 100.

The display 301 may be a presence-sensitive display and therefore may comprise the user input unit 306. The presence-sensitive display may include a display component and a presence-sensitive input component. The presence sensitive display may be a touch-screen display arranged as part of the user interface 302.

User electronic devices in accordance with the present invention are not limited to mobile phones or tablets and may take the form of any electronic device which may be used by a user to perform the methods according to aspects of the present invention. The user electronic device 300 may be a electronics module such as a smartphone, tablet personal computer (PC), mobile phone, smart phone, video telephone, laptop PC, netbook computer, personal digital assistant (PDA), mobile medical device, camera or wearable device. The user electronic device 300 may include a head-mounted device such as an Augmented Reality, Virtual Reality or Mixed Reality head-mounted device. The user electronic device 300 may be desktop PC, workstations, television apparatus or a projector, e.g. arranged to project a display onto a surface.

In use, the electronics module 100 is configured to receive raw biosignal data from the sensors 209, 211 and which are coupled to the controller 103 via the interface 101 and the ADC front end 139 for further processing and transmission to the user electronic device 300 as described above. The data transmitted to the user electronics device 300 includes raw or processed biosignal data such as ECG data, heart rate, respiration data, core temperature, IMU data and other insights as determined, and as required.

The controller 305 of the user electronics device 300 is also operable to launch an application which is configured to receive, process and display data, such as raw or processed biosignal data, from the electronics module 100. A user, such as the wearer 600, is able to configure the application, using user inputs, to receive, process and display the received data in accordance with these user inputs.

The user electronic device 300 is arranged to receive the transmitted data from the electronics module 100 via the communicator 307 and which are coupled to the controller 305, and then to process and display the data in accordance with the user configuration.

5 The controller 305 of the user electronics device 300 is operable to display information to a user on the display 301 as part of the user interface 302. Information displayed can be an ECG trace as well using raw data points transmitted from the electronic module 100. Other insights and data can be displayed on the display 301 as part of the user interface 302 and as required. Examples might be a heart rate in beats per minute, core temperature data and respiration rate.

10 The amount of power used by the electronics module 100 will depend to a significant extent on the data and signal processing being carried out by the electronics module 100.

For example, a current draw of 1.6mA may be expected when the electronics module 100 is connected to the user electronics device 300 and streaming raw data such as ECG data and IMU data along with other information such as heart rate, the so-called R-to-R interval, core temperature, activity level or type, step count and battery charge level etc. The MLC of the IMU 15 111 is active.

A current draw of 1.3mA may be expected when the electronics module 100 is connected to the user electronics device 300 but only transmitting calculated values such as heart rate, R-to-R value, core temperature, activity level or type, step count and battery charge level, but is not transmitting raw biosignal and raw IMU data. The MLC of the IMU 111 is active.

20 A current draw of 1mA may be expected when the electronics module 100 is connected to the user electronics device 300 but is only transmitting low energy data. The MLC of the IMU 111 is active.

As mentioned above, current draw is significantly greater when processing data through the bioimpedance channel 179, compared to the biopotential channel 175. Measuring 25 bioimpedance can consume significantly more power than ECG biopotential measurement, for example drawing 77 $\mu$ A for ECG measurement compared to 144 $\mu$ A for bioimpedance measurement.

Bioimpedance measurements are also prone to noise, particularly when operating in circumstances when the wearer 600 is active, for example, when running. Bioimpedance 30 measurements, such as respiration rate, are less reliable therefore when the wearer 600 is active.

The controller 103 of the electronics module 100 is configured to determine whether the wearer is in active phase or an inactive phase, such as resting or sleeping, in response to signals from the IMU 111 or other sensor such as the location device 161.

As mentioned above, this can be determined, for example, through detection of movement and/or orientation of the wearer 600, or through location e.g. at the gym, using the location device 161.

5 As also mentioned above, the IMU 111 of the electronics module 100 can be configured to use decision tree logic to determine the activity level of the wearer of the electronics module 100 and to provide an output to the controller 103.

The location of the wearer 600 can be established using the location device 161 which, as described above, is operable to provide location data to the controller 103.

10 When the controller 103 determines that the wearer 600 is in an inactive phase, then the controller 103 of the electronics module 100 is operable to use data from both the bioimpedance channel 179 and the biopotential channel 175. However, the bioimpedance channel 179 is configured to operate at a reduced duty cycle during this phase.

In an alternative embodiment, the bioimpedance channel 179 can be powered down during an inactive phase.

15 However, if the controller 103 determines – from data from the IMU 111 and other sensors and devices – that the wearer 600 is in a sustained active phase, then the controller 103 of the electronics module 100 is operable to increase the duty cycle of the bioimpedance channel 179.

A sustained active phase can be determined as being active over a predetermined period of time.

20 Although the controller 103 will not be able to determine respiration rate from the bioimpedance data, the information from the bioimpedance data in this context is less useful. If required, the data from the biopotential channel 175 could still be used to provide a measure of respiration but with reduced power consumption and sufficient to provide insights into respiration.

25 Referring to Figure 6, there is shown a flow diagram for an example method according to aspects of the present disclosure.

Step S201 of the method comprises providing an electronics module 100 and a user electronics device. The electronics module is communicatively coupled to sensors on a wearable article worn by a wearer.

30 In step S202, a user launches an application on the user electronic device. The user can be the wearer or some other person, for example, a sports coach.

In step S203 the user electronic device is paired to the electronics module.

In step S204, the electronics module continuously reads motion and orientation data from the IMU, whilst at step S205 the electronics module continuously reads location data from the location device.

35 At step S206, it is determined as to whether the wearer is in an active or inactive phase.

If it is determined that the wearer is in an active phase, then at step S207, then the bioimpedance channel is powered up and configured to operate at a regular, standard duty cycle.

If it is determined that the wearer is in an inactive phase, then at step S208, the bioimpedance channel is configured to operate at a reduced duty cycle, or powered down completely.

- 5 Whilst the steps example embodiments described above are implemented on specific components of the system 10, it will be understood that other combinations are possible. For example, steps implemented on the wearable assembly 500, user electronic device 300 or server 700 could equally be carried out on another of the wearable assembly 500, user electronic device or server.
- 10 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,
- 15 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
- 20 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
- 25 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.

- 30 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
- 35 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 comprising a controller, an input arranged to receive biosignals from at least one biosensor provided on the wearable article, the biosignals comprising a first type of biosignal and a second type of biosignal of a wearer of the wearable article, and at least one activity sensor coupled to the controller and arranged to provide an indication of a level of activity of a wearer of the wearable article to the controller, wherein the controller is configured to process the second type of biosignal at a first rate when the level of activity of the wearer is determined to be in a first phase, and to process the second type of biosignal at a second rate when the level of activity of the wearer is determined to be in a second phase.
2. An electronics module according to claim 1, wherein the first type of biosignal is a biopotential signal.
3. An electronics module according to claim 1 or claim 2, wherein the second type of biosignal is a bioimpedance signal.
4. An electronics module according to any preceding claim, wherein the first phase of the level of activity is an active phase and the second phase of the level of activity is an inactive phase and wherein the first rate is a standard rate and the second rate is a reduced rate as compared to the standard rate.
5. An electronics module according to claim 4, wherein the active phase is a phase of sustained activity.
6. An electronics module according to claim 5, wherein the phase of sustained activity is for a predetermined period of time.
7. An electronics module according to any one of claims 4 to 6, wherein the reduced rate is zero.
8. An electronics module according to any preceding claim, wherein the activity sensor is a motion detection device.
9. An electronics module according to claim 8, wherein the motion detection device is an inertial measurement unit.
10. A method performed by a controller for an electronics module for a wearable article, the electronics module comprising a controller, an interface, and at least one contextual data unit coupled to the controller, the method comprising the steps of:
  - receiving biosignal data of a first type and a second type from biosensors on the wearable article via the input;
  - receiving data relating to the determined activity level of a wearer of the wearable article from an activity sensor;

the controller is configured to process the second type of biosignal at a first rate when the level of activity of the wearer is determined to be in a first phase, and to process the second type of biosignal at a second rate when the level of activity of the wearer is determined to be in a second phase.

5           processing both the second type of biosignal at a first rate when the activity level of the wearer is determined to be in a first phase; and

          processing the second type of biosignal when the level of activity of the wearer is determined to be in a second phase.

10           11. A method according to claim 10, wherein the first type of biosignal is a biopotential signal.

          12. A method according to claim 10 or claim 11, wherein the second type of biosignal is a bioimpedance signal.

          13. A method according to any of claims 10 to 12, wherein the first phase of the level of activity is an active phase and the second phase of the level of activity is an inactive phase and wherein the first rate is a standard rate and the second rate is a reduced rate as compared to the standard rate.

          14. A method according to claim 13, wherein the active phase is a phase of sustained activity.

20           15. A method according to claim 14, wherein the phase of sustained activity is for a predetermined period of time.

          16. A method according to any of claims 13 to 15, wherein the reduced rate is zero.

          17. A wearable article comprising an electronics module according to any of claims 1 to 9.

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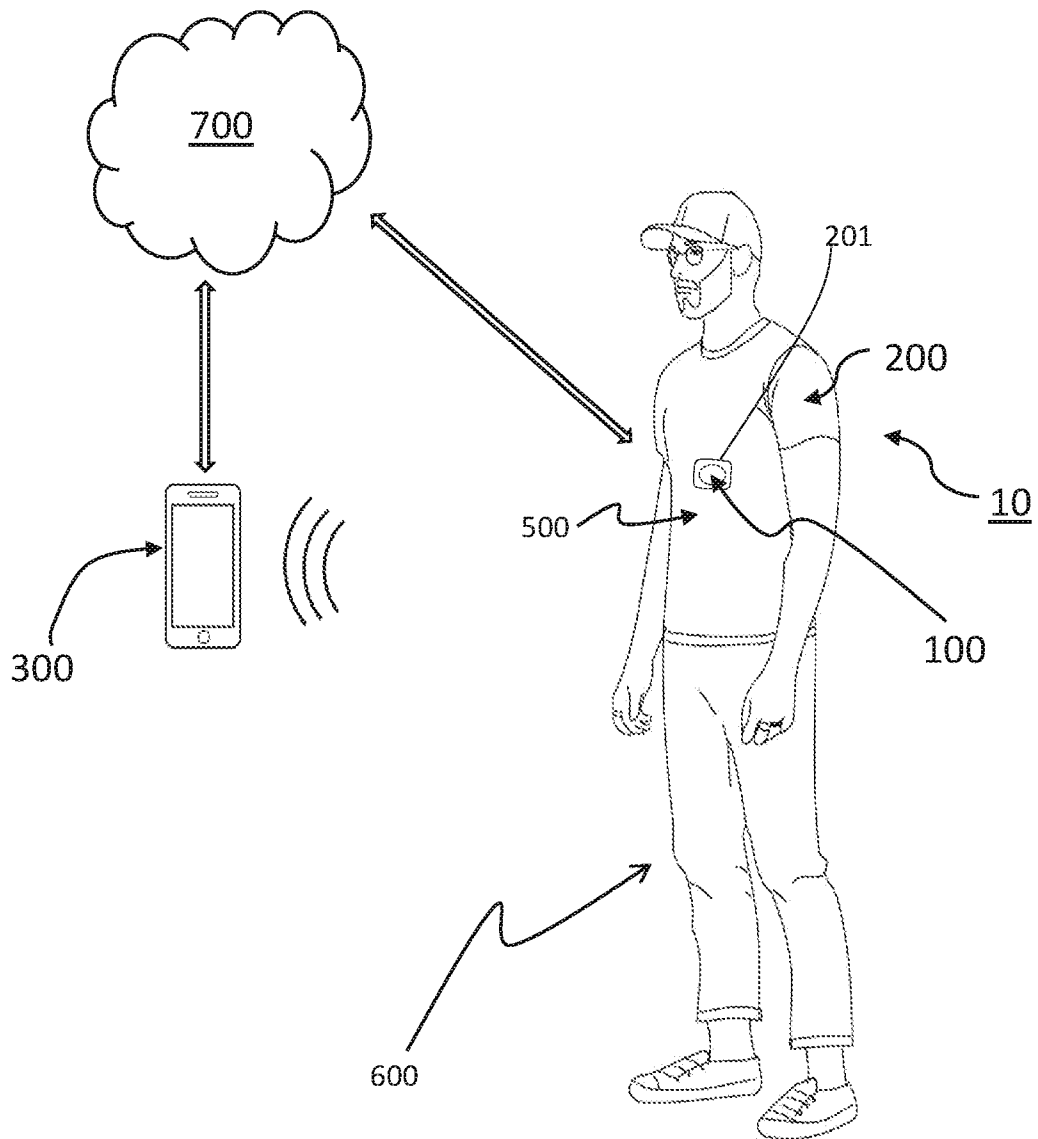


FIG. 1

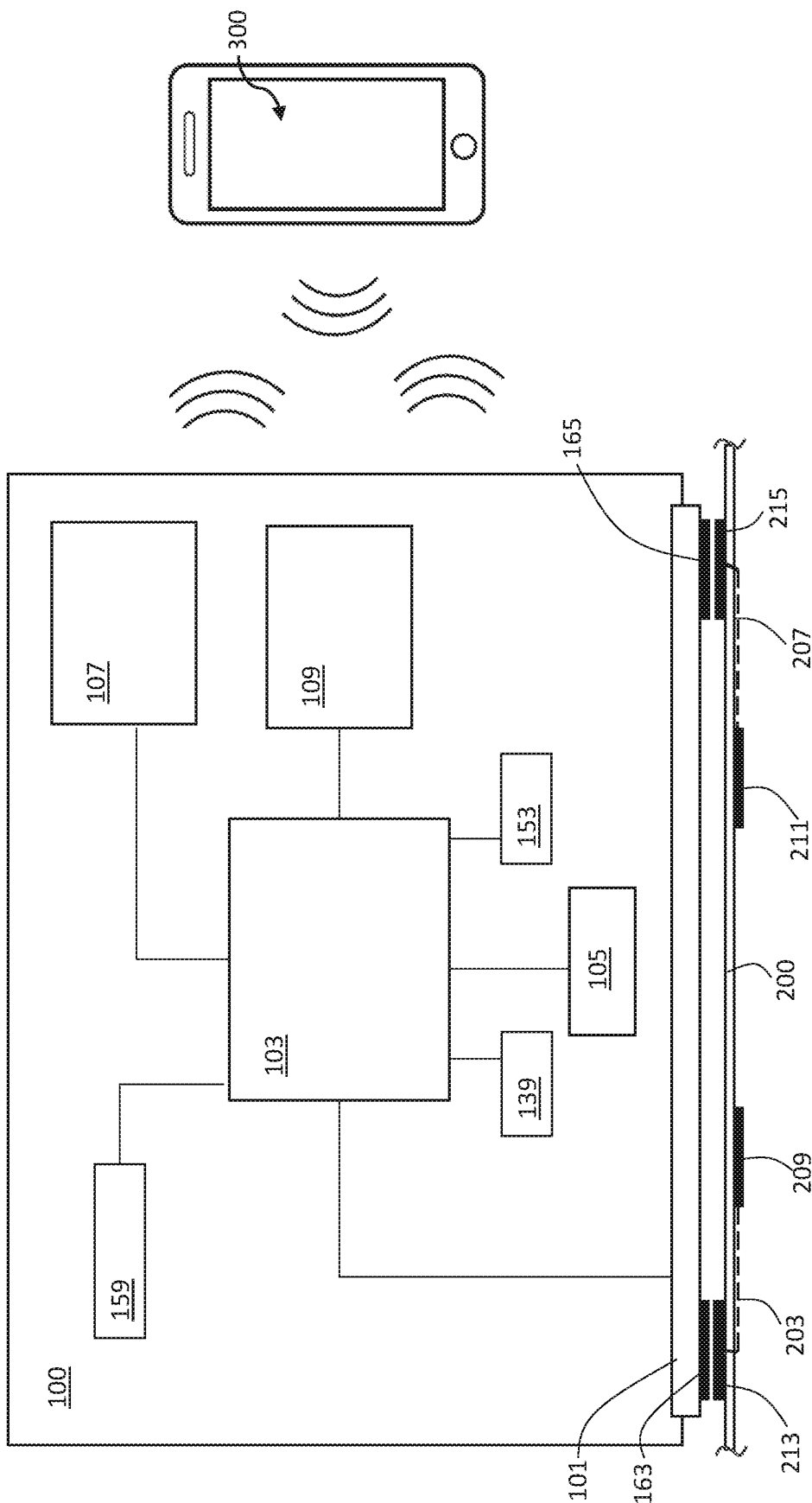


FIG. 2

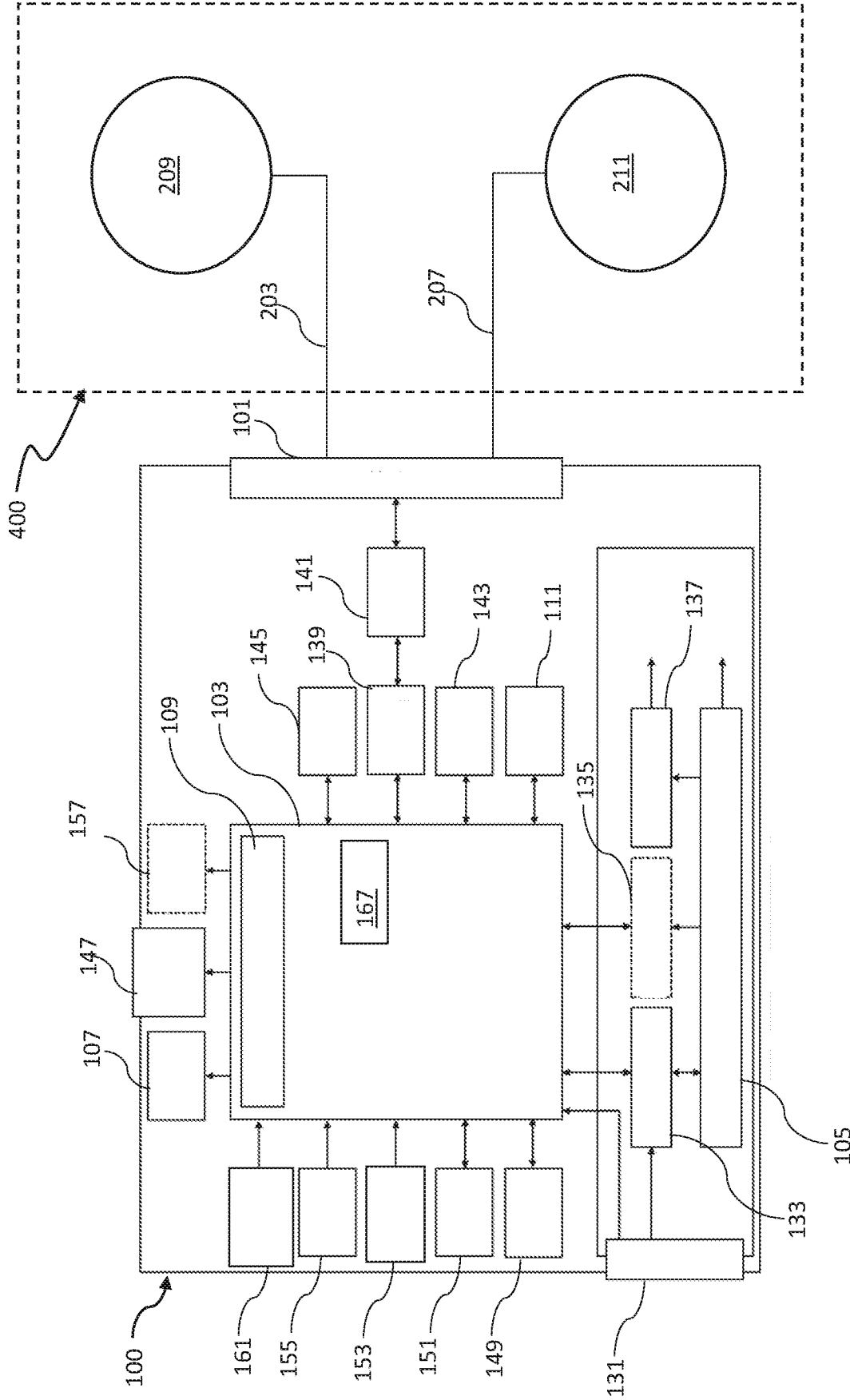


FIG.3

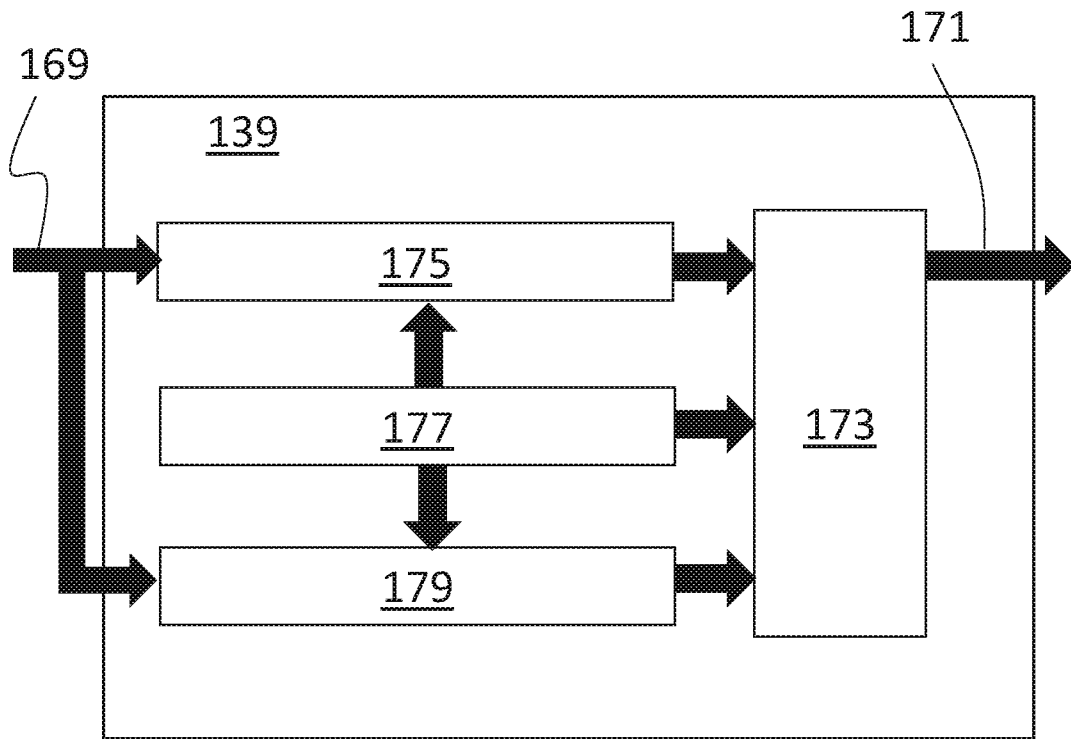
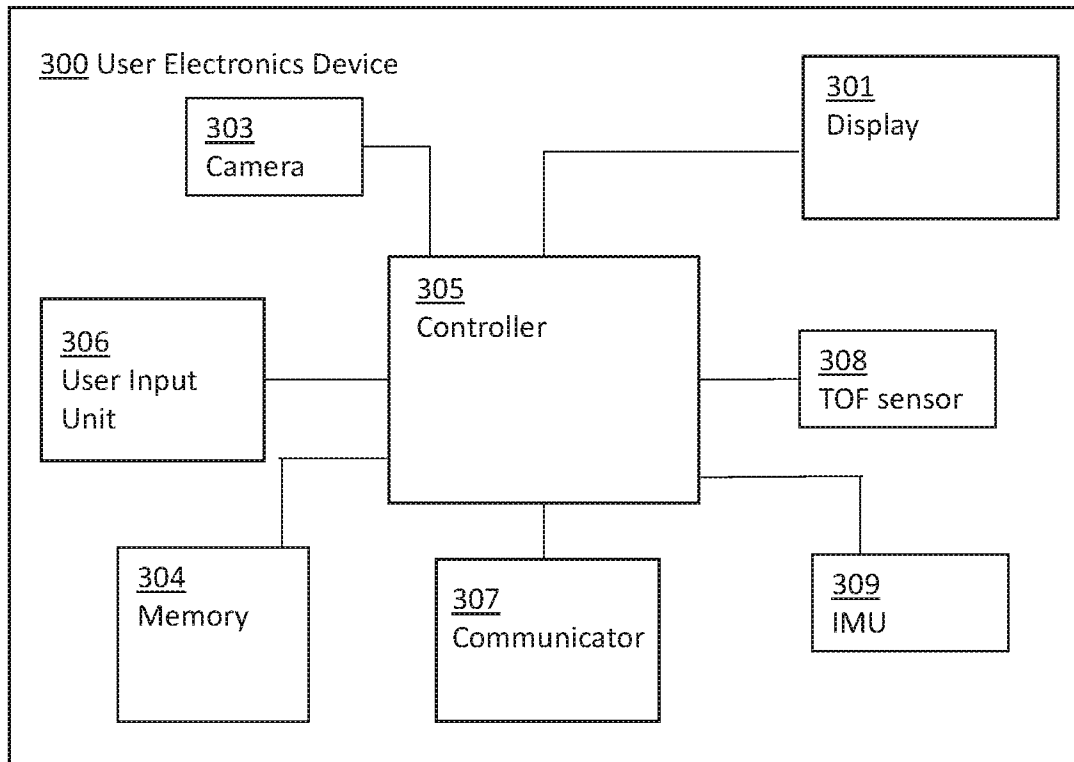


FIG. 4

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**Fig. 5**

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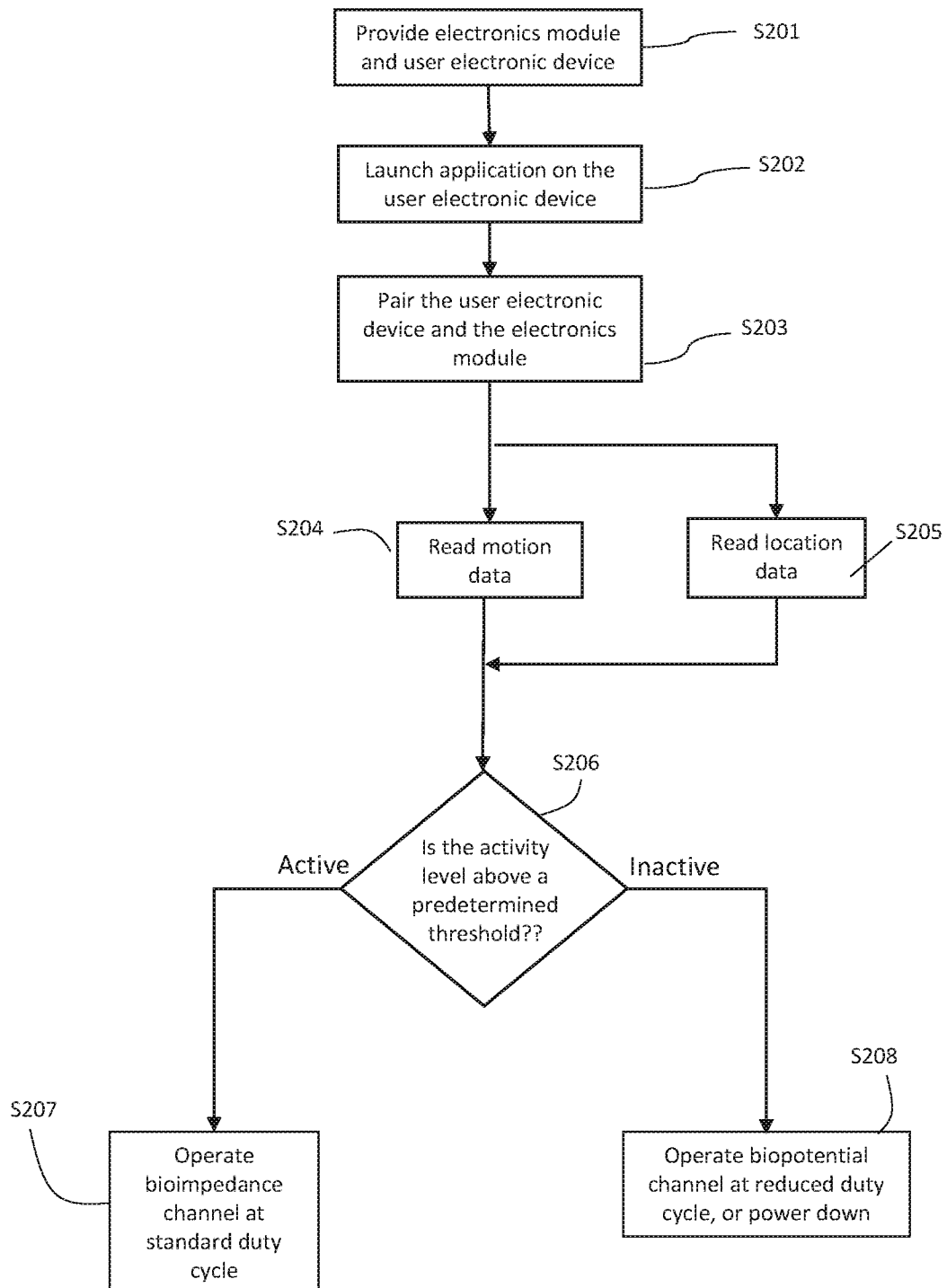


FIG. 6

# INTERNATIONAL SEARCH REPORT

International application No  
**PCT/GB2022/053088**

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                   |                                                                                                                    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| <b>A. CLASSIFICATION OF SUBJECT MATTER</b><br><b>INV.</b> <b>A61B5/00</b> <b>A61B5/318</b> <b>A61B5/369</b> <b>A61B5/389</b> <b>A61B5/0535</b><br><b>A61B5/0536</b> <b>A61B5/0537</b> <b>A61B5/053</b><br><b>ADD.</b><br>According to International Patent Classification (IPC) or to both national classification and IPC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                   |                                                                                                                    |
| <b>B. FIELDS SEARCHED</b><br>Minimum documentation searched (classification system followed by classification symbols)<br><b>A61B</b><br><br>Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched<br><br>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)<br><b>EPO-Internal, WPI Data</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                   |                                                                                                                    |
| <b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                   |                                                                                                                    |
| Category*                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Citation of document, with indication, where appropriate, of the relevant passages                                                                                                                                | Relevant to claim No.                                                                                              |
| <b>X</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>US 2019/046086 A1 (JAYALATH DHANANJA [US] ET AL) 14 February 2019 (2019-02-14) paragraphs [0020] - [0022], [0039], [0045], [0076] figure 1</b><br><div style="text-align: center;">-----</div>                 | <b>1-17</b>                                                                                                        |
| <b>X</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>US 2014/194761 A1 (LEE TAK HYUNG [KR] ET AL) 10 July 2014 (2014-07-10) paragraphs [0013], [0021], [0022], [0030], [0061], [0074] - [0076] figures 1, 3B, 8</b><br><div style="text-align: center;">-----</div> | <b>1-17</b>                                                                                                        |
| <b>X</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <b>EP 2 298 164 A2 (IMEC [BE]; STICHTING IMEC NEDERLAND [NL]) 23 March 2011 (2011-03-23) paragraphs [0001], [0016], [0032], [0036], [0082], [0115] figure 1</b><br><div style="text-align: center;">-----</div>   | <b>1-6, 8, 10-15, 17</b>                                                                                           |
| <div style="display: flex; justify-content: space-between;"> <div> <input type="checkbox"/> Further documents are listed in the continuation of Box C. </div> <div> <input checked="" type="checkbox"/> See patent family annex. </div> </div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                   |                                                                                                                    |
| <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p>* Special categories of cited documents :</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 50%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p> </div> </div> |                                                                                                                                                                                                                   |                                                                                                                    |
| Date of the actual completion of the international search<br><br><div style="text-align: center;"><b>3 March 2023</b></div>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                   | Date of mailing of the international search report<br><br><div style="text-align: center;"><b>14/03/2023</b></div> |
| Name and mailing address of the ISA/<br>European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                   | Authorized officer<br><br><div style="text-align: center;"><b>Worms, Georg</b></div>                               |

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB2022/053088

| Patent document<br>cited in search report | Publication<br>date | Patent family<br>member(s) | Publication<br>date |
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