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DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) Title: SENSOR ASSEMBLY

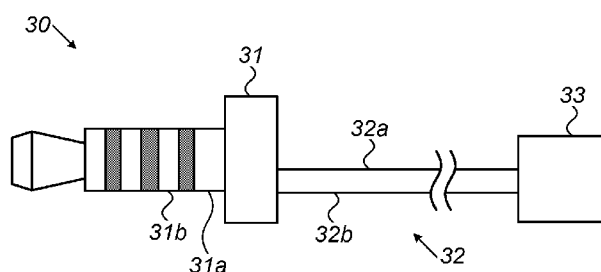


FIG. 2A

(57) Abstract: A sensor assembly for connection to a mobile consumer electronic device, the sensor assembly comprising a connector or for connection to the mobile consumer electronic device having first and second connector parts, a cable comprising at least two electrical conductors connected to the first and second connector parts, and a sensor assembly, the sensor being responsive to a detected parameter, the sensor being connected to the at least two electrical connectors to provide a signal in response to the detected parameter.

Title: Sensor Assembly

[0001] This invention relates to a sensor assembly, a program for a mobile consumer electronic device, a mobile consumer electronic device and a system comprising a sensor assembly and a mobile consumer electronic device, particularly but not exclusively where the mobile consumer electronic device comprises a mobile telephone.

Background to the Invention

[0002] A requirement for many modern utility or control systems is the ability to remotely monitor or measure a parameter of the system, and log or transmit the resulting data to a user or server for further use or processing. Examples may include logging electricity, water or gas use or temperature at one or more locations within a domestic, commercial or industrial building. The use may be as small as to provide a household with details of their power use, or as substantial as monitoring the functioning of a large factory or building to assess the efficiency of the factory or building and identify where energy use can be reduced.

[0003] It is known to use dedicated data loggers to carrying out this monitoring or measurement, but such devices tend to be expensive and inflexible.

Summary of the Invention

[0004] According to a first aspect of the invention there is provided a sensor assembly for connection to a mobile consumer electronic device, the sensor assembly comprising a connector for connection to the mobile consumer electronic device having first and second connector parts, a cable comprising at least two electrical conductors connected to the first and second connector parts, and a sensor assembly, the sensor being responsive to a detected parameter, the sensor being connected to the at least two electrical connectors to provide a signal in response to the detected parameter.

[0005] The connector may comprise an audio jack.

[0006] One of the at least two electrical conductors may comprise a sleeve connection of the cable connected to the first connector part.

[0007] One of the at least two electrical conductors may be connected to the second connector part, the second connector part corresponding to a microphone connection.

[0008] The cable may comprise at least a third electrical connector connected to a third connector part, the third connector part corresponding to an audio connection.

[0009] The sensor may be responsive to a signal transmitted on the third electrical connector.

[0010] The resistance of the sensor may vary in response to the detected parameter, such that a voltage across the first and second connector part varies.

[0011] The sensor may comprise one of an electrical current sensor, a light sensitive diode, a switch connection, a temperature sensor, a humidity sensor, a mechanical force sensor, or a movement sensor.

[0012] According to a second aspect of the invention there is provided a program to be run by a processor element of a mobile consumer electronic device, the program being operable to receive a signal from a connection port of the mobile connection device, store a plurality of data values corresponding to the received signal, and using a consumer electronic element of the mobile consumer electronic device, transmit the stored data values to a receiving system.

[0013] The connection port may comprise an audio port and the program may receive the signal from a microphone connection of the audio port.

[0014] The program may comprise an application for a mobile telephone.

[0015] According to a third aspect of the invention there is provided a mobile consumer electronic device having a connection port and a processor element, the processor element being operable to run a program to receive a signal from a connection port of the mobile

connection device, store a plurality of data values corresponding to the received signal, and using a consumer electronic element of the mobile consumer electronic device, transmit the stored data values to a receiving system.

[0016] The connection port may comprise an audio port and the program may receive the signal from a microphone connection of the audio port.

[0017] The mobile consumer electronic device may comprise a mobile telephone and the program may comprise an application for a mobile telephone.

[0018] According to a fourth aspect of the invention there is provided a system comprising a mobile consumer electronic device according to the third aspect of the invention and a sensor assembly according to the first aspect of the invention.

Brief Description of the Drawings

[0019] The invention will now be described by way of example only with reference to the accompanying drawings, wherein;

[0020] Figure 1 is a diagrammatic view of a sensor system embodying the present invention,

[0021] Figure 2a is a diagrammatic view of a sensor assembly for use in the system of figure 1,

[0022] Figure 2b is a diagrammatic view of a further sensor assembly for use in the system of figure 1,

[0023] Figure 2c is a diagrammatic view of an alternative sensor assembly for use in the system of figure 1,

[0024] Figure 3a is a circuit diagram for a sensor assembly for use in the system of figure 1,

[0025] Figure 3b is an alternative circuit diagram for a sensor assembly for use in the system of figure 1 and

[0026] Figure 4 is a flow diagram illustrating operation of the system of figure 1.

Detailed Description of the Preferred Embodiments

[0027] With specific reference now to the drawings in detail, it is stressed that the particulars shown are by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention only, and are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention, the description taken with the drawings making apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

[0028] Before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is applicable to other embodiments or of being practiced or carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein is for the purpose of description and should not be regarded as limiting.

[0029] Referring now to figure 1, a sensing system is generally shown at 10. The system 10 comprises a mobile communications device 20 and a sensor assembly 30. The mobile communications device 20 is operable to communicate via a communication network 40 to a remote server generally shown at 50. The communication network 40 may be a mobile telephone network, a local wireless ('wifi') network, a connection via the internet, or indeed a combination of different networks as needed to provide a communication link between the mobile communications device 20 and the remote server 50. Users or client systems may communicate directly with the server 50 as shown at 51, or through the communication network 40 as shown at 52, to access data received from the sensing system 10.

[0030] The mobile communication device 20 comprises a processing element 21, a communication element 22 and a memory 23. The mobile communication device also has a connection port 24. The processing element 21 runs the necessary software or firmware for the device 20 to operate, and communicates with the communication element 22, memory 23 and connection port 24 as illustrated by arrows 22a, 23a, 24a. In addition the manufacturer-provided software or firmware, the processing element 21 is also operable to run user-provided programs, shown here at 25 stored in the memory 23. In addition to the memory 23, the device 20 comprises an auxiliary memory 23b, to which data may be written in addition to, or separately from, the memory 23. The auxiliary memory 23a may comprise a removable element, such as an SD card.

[0031] It will be apparent that the mobile device 20 may advantageously comprise a conventional mobile telephone. The various elements described above are inherently present in a mobile telephone, and the manufacturer-provided firmware or software conventionally provides APIs or 'hooks' which expose parts of the device's capabilities to a third-party programs or 'apps' to allow the programs to access and operate parts of the device's hardware. Because of the nature of the current consumer market for mobile telephones, quite sophisticated devices are available cheaply or indeed are simply disposed of by consumers following an upgrade to a new device. Consequently, the present invention takes advantage of the availability of these devices to provide flexible low-cost monitoring devices and provides an alternative to wasteful disposal of otherwise unwanted mobile telephones.

[0032] It is also noted that, depending on the nature of communication network 40, other consumer electronic devices may be used, not merely mobile telephones. For example, where the communication network 40 is a wifi network, a device such as a music player, with the ability to run programs and communicate over the network, will be suitable for use in this way.

[0033] A first embodiment of a sensor assembly 30 is illustrated in figure 2a. A connector is shown at 31, in this example comprising a conventional 3.5mm audio jack. A cable 32 is connected to the connector 31, and to a sensor 33. The cable 32 in this example has two conductors 32a, 32b, connected respectively to first and second contact parts 31a, 31b of

the connector 31. Where the connector 31 comprises a conventional audio jack, it will be apparent that first and second contact parts 31a, 31b correspond to the sleeve and microphone connections respectively. The contact parts 31a, 31b engage corresponding contact parts (not shown) in the connection port 24.

[0034] Where the connector 31 comprises a conventional audio jack, it will further be apparent that the cable connected thereto will have two further conductors, corresponding to two audio channels. As shown in figure 2b, cable 32' comprises first and second conductors 32'a, 32'b as in the embodiment of figure 3a, but also comprises second and third conductors 32'c, 32'd, connected to second and third contact parts 31c, 31d of the connector 31. One or both of these conductors can be used to control or send instructions to the sensor 33 or provide power to a sensor 33, as shown at 35 in figure 2b. In addition, or alternatively, as shown in figure 2c, the sensor assembly 30 may comprise an actuator 36 in addition to sensor 33. For example, the actuator 36 may comprise a relay operable to connect or disconnect an electrical supply in response to data captured by the sensor 33, but it may be any suitable actuator as required.

[0035] The sensor 33 may comprise any suitable sensor to measure a desired parameter. In one example, described in more detail below, the sensor may comprise a current clamp, where the sensor has an output voltage depending on the current flowing within the clamp. Alternatively, the sensor 33 may comprise a light sensitive diode, a voltmeter, or any other sensor as desired.

[0036] Examples of particular uses will now be described.

Current sensor

[0037] In this example, the mobile communications device comprises a mobile telephone running the Android (RTM) operating system. The sensor 33 is illustrated in figure 3a, and comprises a current clamp 37 connected to the cable 32 via a resistor network 38. The sensor 33 is connected to the mobile telephone via a 4 pole 3.5mm jack cable with the sensor 33 connected across microphone input and earth, i.e. to conductors 32a and 32b. Either conductor 32a, 32b may serve as the earth or microphone input, as it is the voltage difference between the two conductors which is detected. When the current clamp 37 is

clamped around any current-carrying wire, the voltage across the current clamp is a function of the current through the wire (which is itself a function of the power in the current-carrying wire). The resistor network 38 comprises an 18 Ω resistor 38a connected across the output connections 37a, 37b of the current clamp to allow the induced voltage to drive a current in the current clamp (to prevent coil saturation). Two 10 k Ω resistors 38b, 38c in series are connected in parallel with the 18 Ω resistor 38a. The voltage across one of these resistors is measured at the mobile telephone. The resistor network steps down the voltage by a factor of 2, but these resistors can have values depending on the current to be measured and the exact specification of the current clamp 37. Conventionally, the mobile telephone microphone connections must be attached across a minimum resistance to ensure that the mobile telephone recognises that an external device is connected rather than defaulting to an internal microphone, and the 10 k Ω resistors are used to ensure that this occurs and also for stability. The connection port 24, the microphone socket, in this example is capacitively coupled and will not react to frequencies below about 20Hz, but will respond to faster changes in voltage, such as pulses or spikes, or waveforms with a frequency greater than 20Hz. In this case, the voltage will be varying at mains frequency, ~50 Hz, and therefore is detectable by the mobile telephone.

[0038] The program 25 in this example comprises an Android app which makes use of APIs in the Android OS to access the resources provided by the mobile telephone, and is illustrated at 60 in Figure 4.

[0039] In this example, at step 61, the AudioRecord API is called. The AudioRecord API measures the voltage at the microphone port, specified as a 16-bit value, which is written to a buffer at 44.1 kHz.

[0040] At step 62, the program 25 copies 100 readings at a time from the buffer, and at step 63 averages the readings to give a value for the voltage at a sample frequency 441 Hz. This is advantageous as the sample frequency is far above what is necessary to read the mains voltage of 50Hz.

[0041] As shown at 64 the program 25 checks if a suitable time has elapsed, in this example 5 seconds. If the required time has elapsed, the root mean square (RMS) of the voltage

readings is calculated over the elapsed time as shown at step 65. As shown at step 66, the RMS value is uploaded to server 50 (for example via wifi if connected or over a mobile telephone network if there is no wifi and a SIM card is present in the mobile telephone). Where the server 50 is contactable using TCP/IP, the data is sent via an http GET request to the server and the response from the server is interrogated. As shown at 67, the program checks for a successful data transfer, and if the data is transferred a counter is incremented and stored and/or displayed on the phone as shown at 68. If data is not successfully transferred, an error counter is incremented and this is stored and/or displayed on the phone as shown at 69. It might be envisaged that unsent data may be stored in a file, and the entire file subsequently sent when a network connection is established or re-established. Alternatively, all the data may be stored on a removable medium or written to a suitable file and subsequently downloaded after the mobile telephone is retrieved.

[0042] As illustrated at step 70, the program 25 checks whether it is necessary to restart the AudioRecord session. In some versions of Android, an AudioRecord session has to be closed and reopened every few hours, otherwise the session will crash after 27 hours due to an internal 32 bit counter overflowing. This check may be a comparison of the current time with a stored starting time, or may be implemented by providing an internal timer, or otherwise. If a restart is not required, steps 62 onwards are repeated.

[0043] The actual power in the wire can be calculated from the RMS voltage by the program 25 or at the server 50, or at both. If it is calculated by the program 25, the power can be displayed on the mobile telephone every 5 seconds. The transfer function relating the calculated RMS voltage and the power through the monitored wire in the present example has been calculated by plotting the RMS against known currents. The relationship is proportional over the range of currents investigated. At higher currents it may not be linear, but there will still be a single transfer functions between RMS and power which can be applied.

[0044] The uploaded data may be appended by the server 50 to a file which is unique to the sending phone, for example identified by a MAC address associated with the mobile telephone. In this way, the server 50 can receive data from multiple mobile telephones, to measure power use throughout a building or otherwise

Meter monitor

[0045] To provide a cost-effective way to monitor a meter, such as an electricity, gas, oil or water meter, the system of figure 1 may be used with a suitable sensor.

[0046] For example, where the meter is a fluid flow meter, such as a gas, oil or water meter, conventionally such meters have an internal switch which connects and disconnects each time a given volume of fluid has passed through the meter. Accessible connections to the internal switch are provided at the meter. The sensor apparatus as shown in figure 3b may be used, equivalent to the apparatus of figure 3a with the current clamp 37 and 18 Ω resistor 38a omitted and a sensor element comprising the switch connections illustrated at 39 connected across the resistors 38b, 38c. Each operation of the internal switch will result in a voltage spike. The program 25 can be adapted to simply count the number of spikes in the session buffer, and upload this value to the server 50 at suitable intervals. It is possible to calculate the quantity of fluid used by multiplying the number of spikes by the given volume.

[0047] In some electricity meters, an externally-visible LED is provided which flashes every time a given quantity of electrical energy (e.g. 1 Wh or 800 mWh) has been consumed. The sensor element 39 of figure 3b may then simply comprise a light-sensitive diode. Each time the externally-visible LED flashes, the resistance of the light-sensitive diode will change, and this will be detected as a voltage spike by the program 25. The program 25 can simply count the number of spikes, to provide a value for consumed power, and transmit this count or the calculated value to the server 50.

Other applications

[0048] It will be apparent that other environmental or other parameters may be measured by providing a suitable sensor 33. This may include temperature, humidity, mechanical forces, movement, vibrations or any other parameter of interest.

[0049] As shown in figure 2b, conventional microphone cables include two conductors corresponding to respective audio channels. These may be used to transmit control signals, as discussed above, or may be used to transmit power to a sensor or a microcontroller.

Where the mobile device has other connection ports, it will be apparent these may be used as well as, or in place of, the microphone port.

[0050] In the above description, an embodiment is an example or implementation of the invention. The various appearances of “one embodiment”, “an embodiment” or “some embodiments” do not necessarily all refer to the same embodiments.

[0051] Although various features of the invention may be described in the context of a single embodiment, the features may also be provided separately or in any suitable combination. Conversely, although the invention may be described herein in the context of separate embodiments for clarity, the invention may also be implemented in a single embodiment.

[0052] Furthermore, it is to be understood that the invention can be carried out or practiced in various ways and that the invention can be implemented in embodiments other than the ones outlined in the description above.

[0053] Meanings of technical and scientific terms used herein are to be commonly understood as by one of ordinary skill in the art to which the invention belongs, unless otherwise defined.

CLAIMS

1. A sensor assembly for connection to a mobile consumer electronic device, the sensor assembly comprising;
 - a connector for connection to the mobile consumer electronic device having first and second contact parts,
 - a cable comprising at least two electrical conductors connected to the first and second contact parts, and
 - a sensor assembly, the sensor being responsive to a detected parameter, the sensor being connected to the at least two electrical connectors to provide a signal in response to the detected parameter.
2. A sensor assembly according to claim 1 wherein the connector comprises an audio jack.
3. A sensor assembly according to claim 2 wherein one of the at least two electrical conductors comprises a sleeve connection of the cable connected to the first connector part.
4. A sensor assembly according to claim 2 or claim 3 wherein one of the at least two electrical conductors is connected to the second connector part, the second connector part corresponding to a microphone connection.
5. A sensor assembly according to any one of the preceding claims wherein the cable comprises at least a third electrical connector connected to a third connector part, the third connector part corresponding to an audio connection.
6. A sensor assembly according to claim 5 wherein the sensor is responsive to a signal transmitted on the third electrical connector.

7. A sensor assembly according to any one of the preceding claims wherein the resistance of the sensor varies in response to the detected parameter, such that a voltage across the first and second connector part varies.
8. A sensor assembly according to any one of the preceding claims wherein the sensor comprises one of an electrical current sensor, a light sensitive diode, a switch connection, a temperature sensor, a humidity sensor, a mechanical force sensor, or a movement sensor.
9. A program to be run by a processor element of a mobile consumer electronic device, the program being operable to;
 - receive a signal from a connection port of the mobile connection device,
 - store a plurality of data values corresponding to the received signal, and
 - using a consumer electronic element of the mobile consumer electronic device, transmit the stored data values to a receiving system.
10. A program according to claim 9 where the connection port comprises an audio port and the program receives the signal from a microphone connection of the audio port.
11. A program according to claim 9 or claim 10 comprising an application for a mobile telephone.
12. A mobile consumer electronic device having a connection port and a processor element, the processor element being operable to run a program to;
 - receive a signal from a connection port of the mobile connection device,
 - store a plurality of data values corresponding to the received signal, and
 - using a consumer electronic element of the mobile consumer electronic device, transmit the stored data values to a receiving system.
13. A mobile consumer electronic device according to claim 12 where the connection port comprises an audio port and the program receives the signal from a microphone connection of the audio port.

14. A mobile consumer electronic device according to claim 12 or claim 13 wherein the mobile consumer electronic device comprises mobile telephone and the program comprises an application for a mobile telephone.
15. A system comprising a mobile consumer electronic device according to any one of claims 12 to 14 and a sensor assembly according to any one of claims 1 to 8.

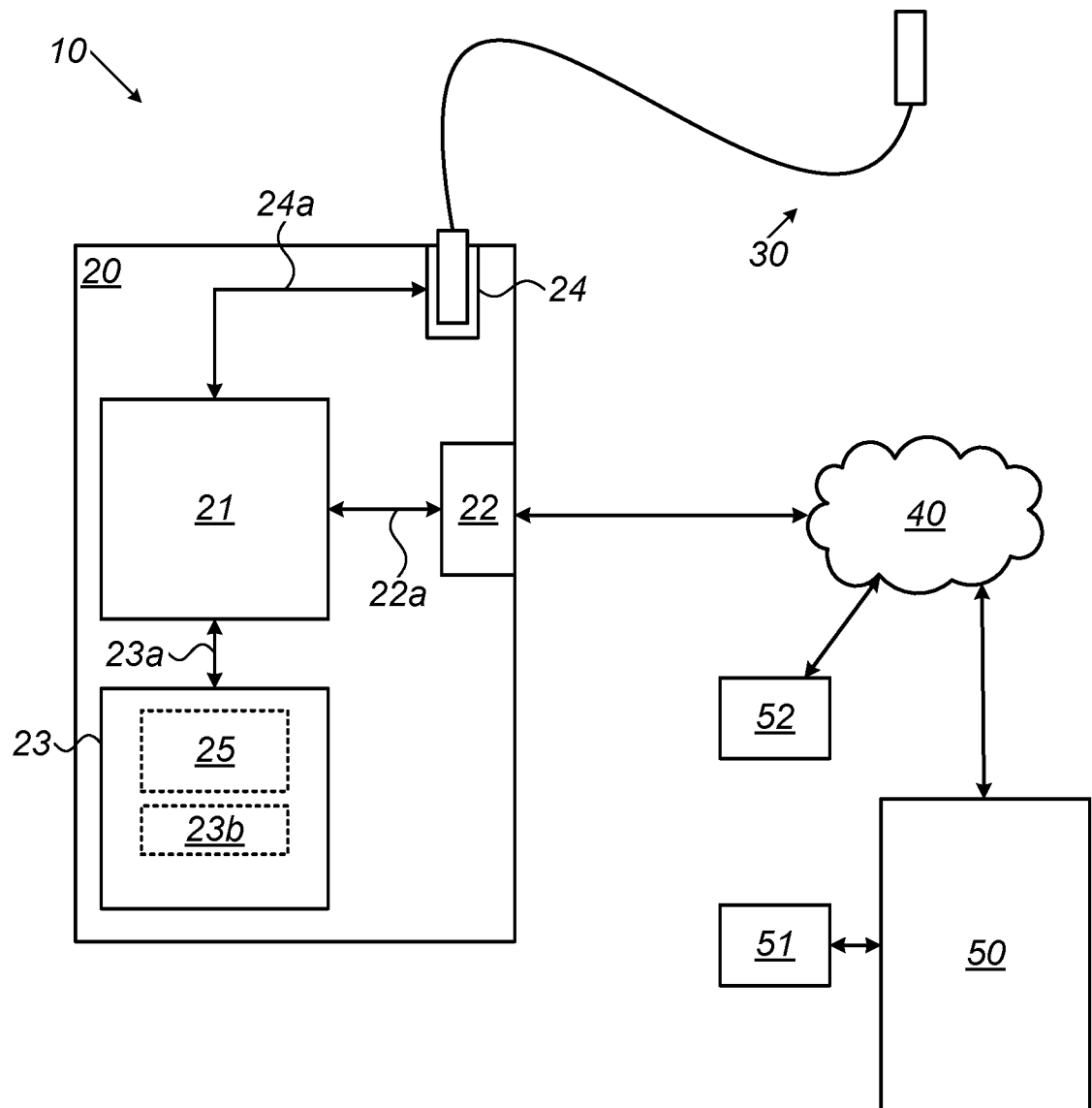


FIG. 1

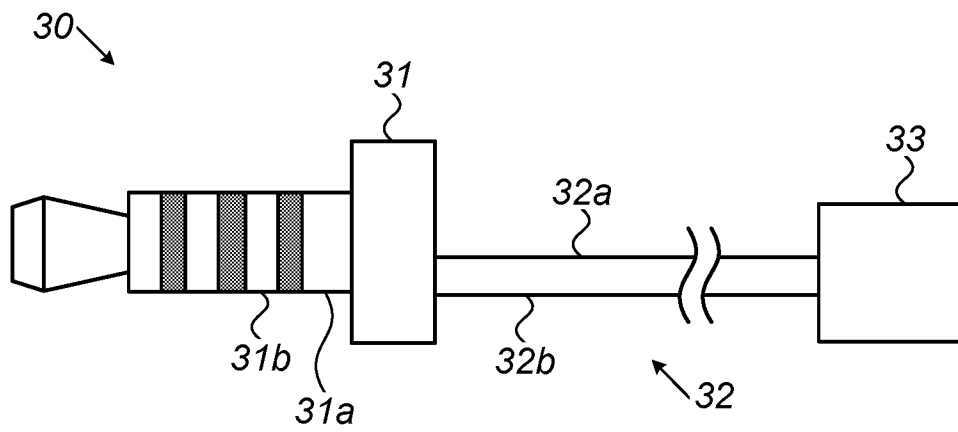


FIG. 2A

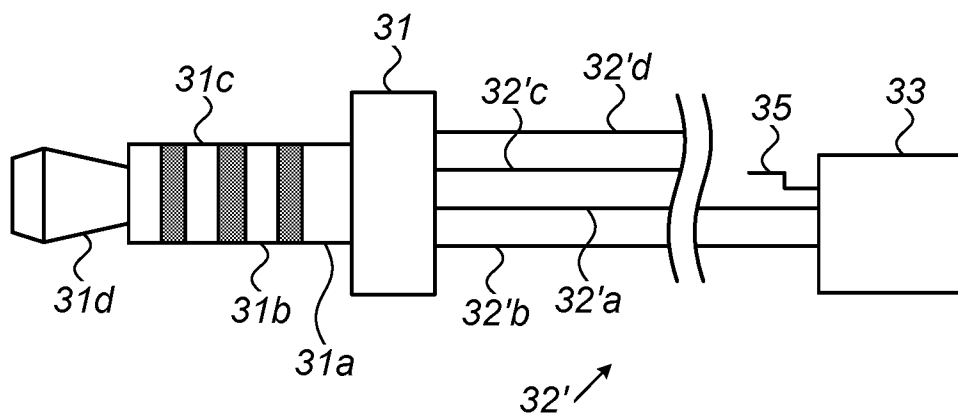


FIG. 2B

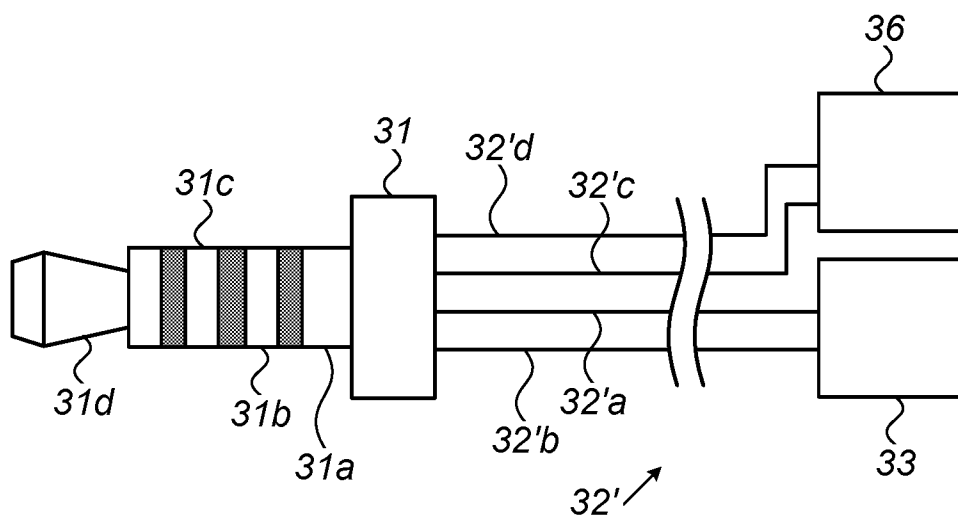


FIG. 2C

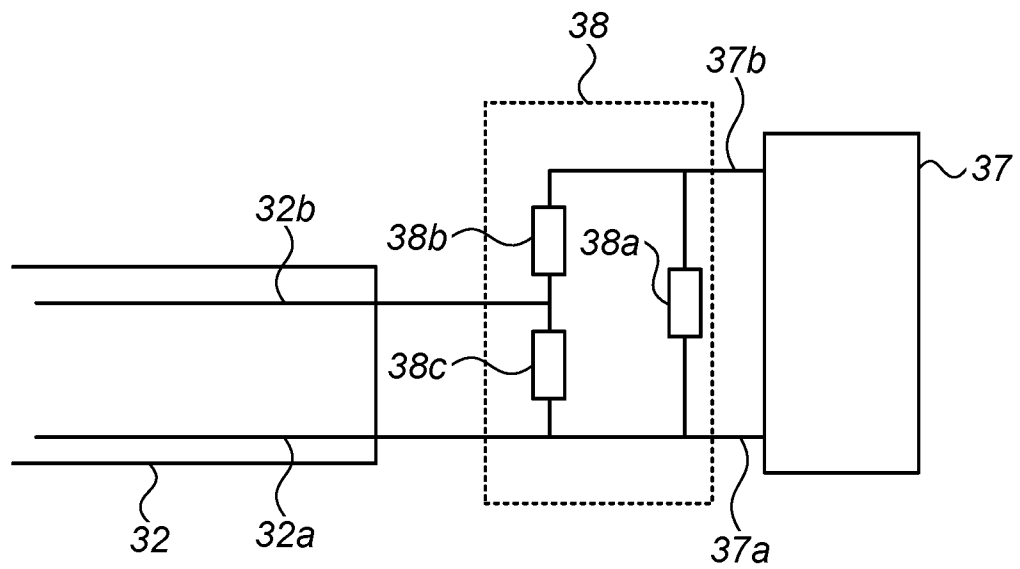


FIG. 3A

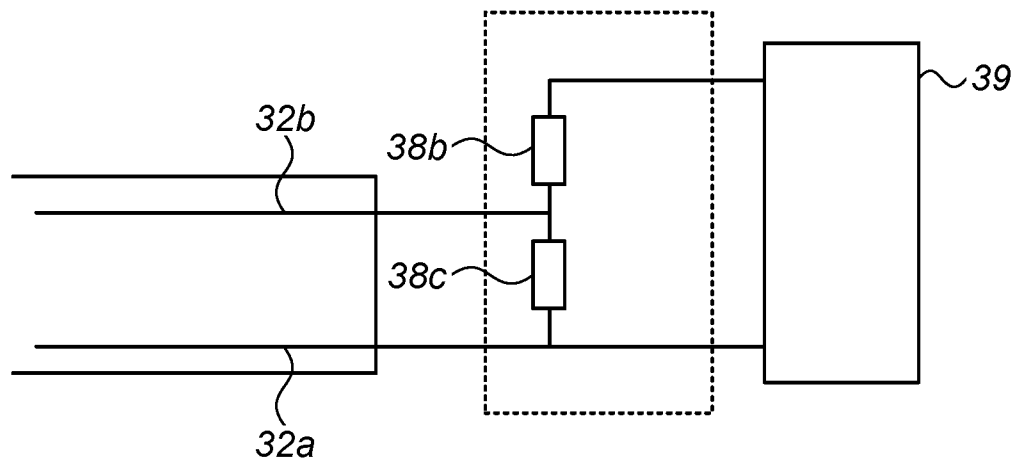


FIG. 3B

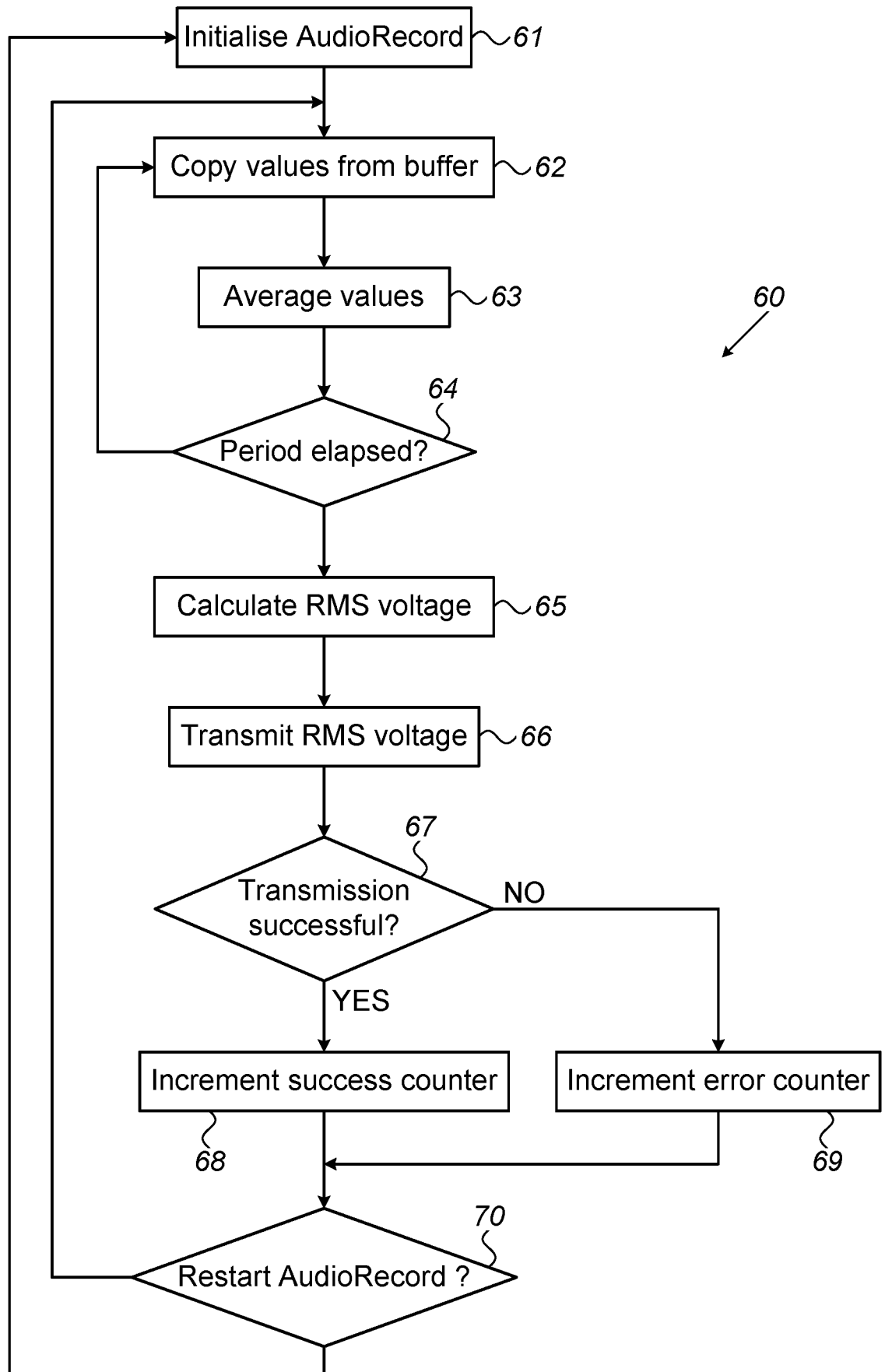


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2015/055082

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01D4/00 H04M1/725
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01D H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EP0-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	YE-SHENG KUO ET AL: "Hijacking power and bandwidth from the mobile phone's audio interface", PROCEEDINGS OF THE FIRST ACM SYMPOSIUM ON COMPUTING FOR DEVELOPMENT, 17 December 2010 (2010-12-17), pages 1-10, XP055116865, DOI: 10.1145/1926180.1926210 ISBN: 978-1-45-030473-3 the whole document -----	1-8

☐

Further documents are listed in the continuation of Box C.

☐

See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search

4 September 2015

Date of mailing of the international search report

17/11/2015

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
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Authorized officer

Stenger, Michael

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2015/055082

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of Item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-8

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-8

Problem to be solved:

Measure a parameter of a system and log the resulting data (par. 2).

Solution:

Provide a sensor assembly with a sensor being responsive to a detected parameter according to claim 1.

2. claims: 9-15

Problem to be solved:

Transmit data to a user or server for further use of processing (par. 2).

Solution:

Provide a mobile consumer electronic device with a connection port for receiving a signal, a processor to store data values corresponding to the received signal and a consumer electronic element to transmit the stored data values to a receiving system according to independent claims 9 and 12.
