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(54) METHOD AND DEVICE TO MEASURE DISRUPTIONS IN A CONTROLLED ELECTROMAGNETIC FIELD

(57) A method and device to measure disruptions in a controlled electromagnetic field comprising: a CEMF shield module; an electrode management module; a CEMF front-end module; a CEMF acquisition module; a memory module; a communications module; and a system manager module. This invention refers to a device comprising a controlled electromagnetic field (CEMF controlled electromagnetic field) sensor physically integrated in an ASIC (Application-Specific Integrated Circuit). Another object of this invention is a method to measure electromagnetic fields surrounding a conductor, as well as a plurality of uses for the sensor in different technical applications, such as the localisation of people, mixed reality, devices, IoT, domestic and industrial security applications, robotics, military applications, and security applications for transporting cargo and people, work-related and domestic prevention and security applications and applications for the logistics sector and fluid control and detection in bathrooms.

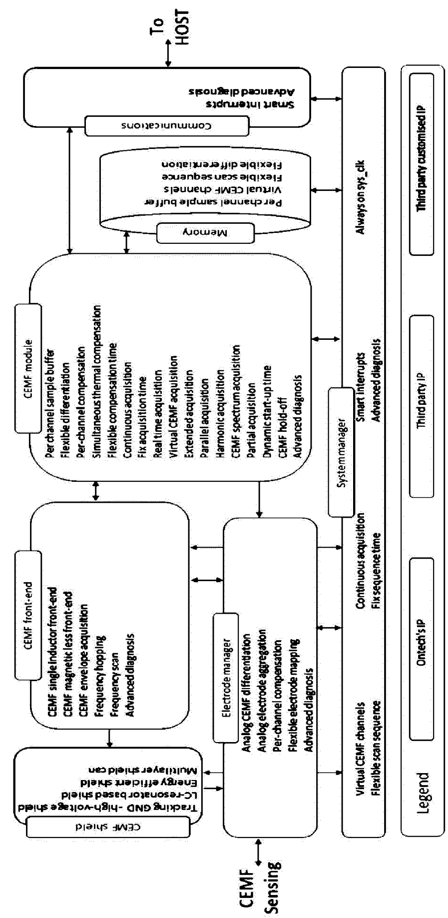

FIG.1

EP 4 213 121 A1

Description

Technical field

[0001] This invention refers to a device comprising a controlled electromagnetic field (CEMF controlled electromagnetic field) sensor physically integrated in an ASIC (Application-Specific Integrated Circuit). Another object of this invention is a method to measure electromagnetic fields surrounding a conductor, as well as a plurality of uses for the sensor in different technical applications, such as the localisation of people, mixed reality, devices, IoT, domestic and industrial security applications, robotics, military applications, and security applications for transporting cargo and people, work-related and domestic prevention and security applications and applications for the logistics sector.

Background of the invention

[0002] When an electric charge moves over a conductor it creates an EM field around it. The oscillation of the source charge generates a wave that radiates energy from said conductor, the EM field being the means that enables said energy to be transported remotely from its emitter.

[0003] An electromagnetic wave is an electric field and another magnetic one coupled together that oscillate at the same frequency as the electric source charge. At a short distance from the emitter, both fields are independent, but in the far-field zone both are coupled and, by knowing one, the value of the other can be determined.

[0004] In the known state of the art, capacitive sensors have been widely used in different applications, such as controlling the level of a fluid inside a container, controlling the fill-level and position of objects, or counting materials on conveyor belts. In another type of application related to the medical sector, these types of sensors have also been used to measure intraocular pressure, intracranial pressure, diagnosing pulmonary diseases or measuring the respiratory system.

[0005] Within capacitive sensors, capacitive systems based on an oscillator are known wherein the oscillation frequency is used as a parameter to determine the value of the capacity to be measured. Of the different types of oscillators that exist, however, the oscillator used in applications like the one described in this invention must resolve two technical problems:

- Frequency sensitivity must be high regarding small variations in the capacity to be measured. This question is very important because when an object approaches the sensor, a disruption of the EM field generated by the sensor will occur and this small variation generated in the field is of vital importance in determining how far away the object is.
- That the oscillator generates a stable frequency when faced with phenomena such as vibrations, temperature changes and, ultimately, any possible interference regarding the sensor.

[0006] The basic principles of the detection and use of disruptions in electromagnetic fields for the detection of people are described, for example, in document GB1404838. According to this invention, an alarm system comprising at least one ultra-high frequency (UHF) oscillator circuit, at least one electromagnetic wave radiation element connected to the oscillator circuit in order to irradiate ultra-high frequency electromagnetic radiation are provided wherein each one of said electromagnetic wave radiation elements is arranged so that movement in the vicinity of the element produces a very low frequency variation in the impedance of the ultra-high frequency of the element and, therefore, a very low frequency variation in the oscillation frequency of the oscillator circuit.

[0007] On the other hand, the sensor should be operative within a wireless sensor network. To this effect, it is necessary that the wireless technology used should be suitable for lowconsumption and low-data-transfer rate at the same time as achieving a high level of reliability and security in the communications that enable its integration with other types of sensors, such as optical sensors, CCD sensors or any other type of sensors.

[0008] Document WO9741458 describes a quasi-electrostatic detection system that surrounds an electrically conductive mass with an electric field the magnitude of which is detected in one or more locations to analyse a property of interest with respect to the mass. The object intercepts a part of the electric field that extends between the "emitter" electrode coupled to a CA and the other "receiver" electrodes, the amount of the field intercepted according to the size and orientation of the mass detected, regardless of whether the mass provides an earth connection pathway, and the geometry of the electrodes distributed. Due to the response of the field to an object being a complex non-linear function, the addition of electrodes can always be distinguished among other cases. In other words, each electrode represents an independent weighting of the mass within the field; adding an electrode provides information with respect to that mass which is not redundant for the information provided by the other electrodes.

[0009] Document WO03022641 describes a device for detecting the size and location of an occupant of a vehicle which includes a conductor that is electrically coupled to a voltage signal generator and fitted inside the vehicle seat. The conductor generates a periodic electric field. A plurality of electrostatic sensor antennae is fitted adjacent to the roof and can detect at least one part of the electric field. A detection circuit determines the size and location of a vehicle occupant based on an incidental quantity of electric field in each electrostatic antenna of the sensor.

[0010] Document US2004090234 describes well-logging devices and methods for determining the resistivity of the formation to multiple (>3) research depths. At least one transmitter antenna and at least two receiver antennae which are mounted in a logging tool casing, in a substantially common axis. The antennae are untuned wire coils. The electromagnetic energy is emitted at multiple frequencies from the transmitter to the formation. The receiver's antennae, which are separated from each other and from the transmitter, detect the electromagnetic energy reflected.

[0011] Finally, document EP256805 describes a sensor comprising an analysis and control circuit and a reference electrode coupled to the analysis and control circuit. The electrode sensor of a capacitive sensor is coupled to said analysis and control circuit. The capacitive sensor is adapted to detect the proximity of an object. The analysis and control circuit of the sensor is designed so that the capacitance data detected between the sensor electrode and the reference electrode are variable to the potential of an objective electrode by means of an analysis and control circuit of the sensor.

[0012] The above documents display the particularity of being configured by means of an emitter-receiver structure, in other words, that there is an electrode that emits and an electrode that receives a signal, and so the disruptions between said emitter and said receiver are measured. Meanwhile, this presents a certain complexity in the circuitry. Furthermore, it does not permit the emission of the magnetic field to be controlled since the dispersion in the emitter is not defined in a determined direction so that it does not restrict its use and application to very specific cases wherein it is possible to implement or use both emitters and receivers.

[0013] Document EP2980609 discloses a sensor capable of measuring electrostatic fields and their variations to determine human presence in an area close to and surrounding said probe and differentiate it from any other animal or object. The electrostatic fields sensor, whose signals are uncoupled from each other by means of an uncoupling circuit, and wherein said circuits for measuring electrostatic fields are connected to an antenna consisting of a coaxial cable by means of a phase measurement circuit. This invention shares the same technical objective and resolves the same technical problems as this document, albeit with an alternative and different solution. Other documents from the same applicant as patent EP2980609 reflect solutions based on the same technology and physical properties such as documents EP3190569, EP3076206, WO2017077165 and WO2017070166.

[0014] The present invention, just like document EP280609 and/or WO2019197677, is based on the measurement of the variation of a controlled magnetic field surrounding a conductor that acts like a probe or antenna when said body is affected by the influence of a charged body such as the human body. In other words, that the human body, just like any other existent body, presents intrinsic electrical characteristics, dependent on the materials, density, volume, temperature, and conductivity. Potential differences between the different objects give rise to electrostatic discharges from one object to another when they come into contact or are infinitesimally close. This effect is exploited by the sensor that is the object of this invention, managing to measure continuously the fluctuations that said field cause in a circuit connected to the conductor that acts like an antenna. Notwithstanding, this invention describes a series of improvements to the technology described in the state of the art as will be described in detail in this document.

Summary of the invention

[0015] The object of this invention is a method and a device comprising a controlled electromagnetic field sensor with which it is possible to detect the presence of any nearby object by means of the detection of the disruption in an electromagnetic field around a sole conductor which is configured as an antenna that emits a controlled electromagnetic field and, at the same time, detects the variation or disruption to said field. All this according to the device described in the claims. In the dependant claims, specific embodiments of the device of the invention are described. Other aspects of the invention are described in independent embodiments.

[0016] One of the virtues of this invention is that it can emit the electromagnetic field in a controlled way by means of an active screening by means of a high impedance circuit so that, by means of the only conductive element comprising the emitter-receiver antenna, it is possible to direct the electromagnetic field towards a determined zone of influence and configurable for each specific application as will be described subsequently in this document.

[0017] The present invention relates to improvements in the device disclosed in WO2019197677. Thanks to this structure, the device is capable of distinguishing, as a function of the magnitude of the change -i.e., the disruption generated- if there is a person, an animal or any other object, since the invention is based on the device's capacity to measure the variations of the electromagnetic field existent around each one of the antennae the device is connected to, since the device can be connected to various antennae, with the particularity that each one of the antennae acts independently with respect to the others, in other words, each antenna has the same capabilities and functionalities in the detection of the disruption - it emits a controlled electromagnetic field and, at the same time, detects disruptions to this field-.

[0018] The device essentially comprises an RLC-circuit that generates a wave and whose output is connected to at least one antenna like those indicated. Meanwhile, the circuit has the particularity of being a closed loop since the signal from the antenna is, at the same time, configured as the input signal from the RLC-circuit. This configuration enables the antenna signal to be followed, in other words, when there is a disruption and the magnitude of the field changes, this change will immediately affect the input of the RLC-circuit, thereby significantly increasing the sensitivity of the device and, furthermore, makes the traditional emitter-receiver configuration described in the state of the art unnecessary. Another important benefit is that said configuration is not affected by external noise since the closed-loop configuration logically cancels out any noise that may exist in the signal. This closed-loop configuration, already described in document WO2019197677 from the same applicant, is significantly improved in its sensitivity and response with the circuit and configuration described in this invention.

[0019] Thus, this invention, just like document WO2019197677 starts from the fact that, the human body, just like any other existent object, displays its own electrical characteristics, dependent on the materials, density, volume, temperature, and conductivity. The differences of potential between different objects give rise to a plurality of electromagnetic interactions from one object to another when they enter in contact or are nearby. This effect generates fluctuations in the electromagnetic field surrounding the antenna, which are continuously measured by the device. To be precise, the measurement of this signal from the antenna due to a disruption -i.e., the measurement of the change in the antenna's impedance due to a disruption- in turn shapes the controlled electromagnetic field surrounding the antenna and enables it to be determined, according to the change caused, which object has caused said disruption -person, animal, or thing-.

[0020] More specifically, the improvements to the device disclosed in WO2019197677 cover several functionalities of the CEMF technology. Some of the technical improvements address the same functionality, they extend the original functionality or describe different ways of implementing it. By joining the required functionalities into an ASIC, a complete CEMF solution can be integrated.

[0021] The applications of the device that is the object of the invention are all those requiring the detection of an object prior to it resulting in the violation of the restricted space. Amongst these applications we can highlight the following: the localisation of people, mixed reality, IoT, devices, domestic and industrial security applications, robotics, military applications, and security applications for transporting cargo and people, work-related and domestic prevention and security applications and applications for the logistics sector.

[0022] The device applied to security systems in industrial installations involves notifying a specific user or operator that he/she is approaching a determined restricted or unauthorised zone. This enables -for example, in the operational zone of a robot arm, for it to be paralysed when an operator is within its operating range, regardless of whether the operator him/herself is subsequently called upon to explain if he/she were not authorised to be there, for which purpose the system can also identify the operator.

[0023] Also, an object of the invention is an access control in restricted areas comprising at least one of the following: a virtual fence, a crossings detector in sensitive, restricted, or dangerous zones such as railway platforms or loading docks for land or maritime transport, as well as safety in the use of domestic appliances; or a combination of the above.

[0024] The virtual fence or crossings detector comprises, at least, a device according to this invention, with the particularity of having a plurality of antennae configured to delimit a determined work or transit area, so that any object, person, or animal that affects, at least, one generated field in, at least, one of the antennae, generates an alarm, a notification or similar. It is also intended that said signal might activate physical closure element -for example, the automatic closing of a door or physical barrier-.

[0025] Similarly, the device of this invention can be used in the surveillance and control of railway platforms, loading docks for land or maritime transport, access to safes, monitoring exhibitions of valuable objects, such as works of art, and safety control in the use of domestic appliances.

[0026] In all the above cases, the antenna or antennae delimit a determined control area or restricted use zone, so that any object, person, or animal that generates a disruption in at least one antenna connected to at least one device will generate an alarm, a notification, or similar. It is also intended that said signal might activate physical closure element -for example, the automatic closing of a door or physical barrier-.

[0027] Also, an object of this invention is a detector of objects adhered to a vehicle by means of the detection of the approach of the person and/or the characterisation of the foreign element. In a second aspect of this use, it is configured as a security element inside vehicles, for example, in the detection of the correct position of security anchors or the detection of people in bathrooms, cellars or restricted areas of the vehicles themselves, such as the driver's cab. Finally, the security system is capable of precisely detecting the position of the vehicle in a car park or parking area.

[0028] Another object of the invention is its use as a weapons and explosives detector and a method for the detection of weapons and explosives. More specifically, this invention refers to the detection of IEDs (Improvised Explosive Devices) in the passage of vehicles, the detection of limpet bombs, the detection of land mines or the detection of weapons, by means of the detection of the approach of the person or characterisation of a foreign element that may be deemed a threat.

[0029] Another object of the invention is its use as a fluid detector and controller. More specifically, the present invention makes it possible to detect the passage of fluids and the control of fluid consumption, for example, in bathrooms, both in public and private use.

[0030] Also, an object of the invention is its use in mixed reality. Mixed reality (MR) is the merging of real and virtual worlds to produce new environments and visualizations, where physical and digital objects co-exist and interact in real time. Mixed reality does not exclusively take place in either the physical world or virtual world but is a hybrid of reality and virtual reality. Augmented reality, a related term, takes place in the physical world, with information or objects added virtually. There are many practical applications of mixed reality, including design, entertainment, military training, and remote working. For example, the present invention is able to detect the movements of a user in a mixed reality environment.

[0031] IoT is also object of this invention. IoT covers a wide range of applications, a sample is a device that can be fitted or connected to a computer in such a way that senses the presence of a user. Such device communicates to a server when the employee is on his/her workplace to allow companies operate remotely with certain guaranties of success.

[0032] Lastly, a final use in domestic security applications, conferring the capacity of preventive detection of intruders to doors, windows, walls or, in general, any other architectonic enclosure, in other words, the device of the invention is used for the detection of the intrusion before it takes place, precisely thanks to its capacity to measure the disruptions at distance.

[0033] The scope of this invention is defined by the claims, which are incorporated in this section for reference. Throughout the description and the claims, the word "comprises", and its variants, does not intend to exclude other technical characteristics, components, or steps. For those skilled in the art, other objects, benefits, and characteristics of the invention will emanate partly from the description and partly from using the invention. The following examples of use and associated figures are provided for illustrative purposes and are non-limiting. Furthermore, this invention covers all the possible combinations of the preferred embodiments indicated here.

Brief description of the drawings

[0034] Below follows a brief description of a series of drawings and diagrams which help to understand the invention better and which expressly relate to an embodiment of said invention which is presented as a non-limiting example of it.

Figure 1 - CEMF ASIC - Block diagram
Figure 2 - Flexible electrode mapping
Figure 3 - Analog electrode aggregation
Figure 4 - CEMF RLC output front-end
Figure 5 - Accurate Acquisition Time
Figure 6 - Acquisition with CEMF Hold-Off
Figure 7 - Flexible scan sequence
Figure 8 - Smart Interrupts

Detailed description of preferred embodiments of the invention

[0035] The different aspects of the invention comprise a controlled electromagnetic field (hereinafter CEMF) sensor capable of detecting a disruption in the electromagnetic field surrounding a sole conductor or antenna that has the particularity of emitting a controlled electromagnetic field and, at the same time, detecting any disruption in said field so that, by means of the characterisation of said disruption, it is possible to detect and discern the object that generated said disruption. In Figure 1 it is displayed where the different modules and sub-modules covered in this document are located. As it can be seen some sub-modules are in more than one module. This means that the sub-module is implemented across several modules (e.g., advanced diagnosis). Also, some of the sub-modules are complementary. This means that must be instantiated simultaneously in the module for it to be able to work. Other sub-modules are redundant and can or cannot be instantiated simultaneously as the ASIC designer chooses to do.

[0036] Therefore, with respect to figure 1, the device according with the invention comprises:

- an electrode management module further comprising at least one an analog electrode aggregation sub-module; and/or a flexible electrode mapping sub-module;
- a CEMF front-end module further comprising at least a RLF output CEMF front-end sub-module;
- a CEMF acquisition module further comprising at least one of the following sub-modules: a fix acquisition time sub-module; and/or a CEMF hold-off sub-module; and
- a system manager module further comprising at least one of the following sub-modules: a flexible scan sequence sub-module; and/or a smart interrupts sub-module.

[0037] In another aspect of the invention, the device implements the following method:

- an electrode management process further comprising at least one of the following steps: an analogic electrode aggregation step; and/or a flexible electrode mapping step;
- a CEMF front-end process further comprising at least a CEMF RLC output front-end step;
- a CEMF acquisition process further comprising at least one of the following steps: a fix acquisition time step; and/or a CEMF hold-off step; and
- a system manager process further comprising at least one of the following steps: a flexible scan sequence step; and/or a smart interrupts step.

[0038] In general terms, the control-electromagnetic field is generated by electrical signals populated by the

ASIC as "CEMF sensing" this are input-output signals, and simultaneously generate and sense the field. These signals are connected to the ASIC connections through an Electrode Manager module, in charge of providing great flexibility on what and how the CEMF wants to be generated. The Electrode manager sources its signals from CEMF shield and CEMF front-end. The CEMF shield block generated a signal used to control the field into some areas as well as to protect the CEMF signal and boost the CEMF sensitivity. The CEMF front-end generates the CEMF signal creating and sampling the field simultaneously, and it is also connected to the CEMF module. The CEMF module takes the CEMF signal and acquires it according to the configuration of the ASIC. It also processes the patterns and stores the data into the memory. Finally, the communications block provides a path for the host of the system to read and write to the memory and registers of the ASIC. All blocks are also connected to the system manager that monitors the overall execution of process.

[0039] Throughout the present description a "Wardiam Module" should be interpreted as a controlled electromagnetic field sensor module implemented in the silicon area of an ASIC. Essentially, the CEMF sensor module comprises an RLC-circuit connected to at least one electrode; a digital module configured to process the signals received from the RLC-circuit; and a processor connected to the digital module. A detailed description of the internal structure of the controlled electromagnetic sensor module can be found in WO2019197677.

[0040] In this description, the terms «circuit» and «circuitry» refer to the electronic physical components -i.e., hardware components- and any software and/or firmware -machine codethat can configure or be susceptible to configuring the hardware and/or be associated in any way with the hardware. In certain parts of the description, hardware and software may be abbreviated to HW and SW, respectively.

Detailed description of the electrode management module

[0041] As it is previously disclosed, the electrode management module comprises, at least, one of the following sub-modules: an analog electrode aggregation sub-module; and/or a flexible electrode mapping sub-module. In the electrode management module, an advanced diagnosis sub-module is also implemented (as well as in other modules).

Flexible electrode mapping sub-module

[0042] In WO2019197677, each Wardiam module will use its own electrode. Therefore, Wardiam module #1 would use electrode #1, Wardiam module #2 uses electrode #2, and so on and so forth. The new implementation allows for each CEMF channel to be configured to use any of the available electrodes. In fig.2(a) can be shown the fix electrode mapping (i.e., as it is implemented in WO2019197677) in front of the flexible electrode mapping implemented in the invention (fig.2(b)).

Analog electrode aggregation sub-module

[0043] The flexible electrode mapping disclosed above in view of fig.2 can be extended, so that any context can not only work with any electrode, but with any combination of electrodes at the same time. This feature allows for electrode aggregation in the analog domain. Compared to the previous approach (digital aggregation, fig.3(a)) this means a larger electrode area and, therefore, a larger electromagnetic field and thus an improved sensitivity and range. Plus, the advantages of a much shorter acquisition time as all electrodes are simultaneously acquired in a single cycle (fig.3(b)).

Detailed description of the CEMF front-end module

[0044] As it is previously depicted in fig.1, the CEMF front-end module comprises, at least, a CEMF RLC output front-end sub-module.

CEMF RLC output *front-end*

[0045] The prior art CEMF front-end uses a transformer to generate a high voltage output, but a new topology based on an RLC-circuit has been tested with good results (fig.4). The basic principle is to amplify the output voltage of an active circuit by using an RLC-circuit. Additionally, an amplitude control circuit can be optionally inserted between the active circuit and the RLC-circuit to ensure constant amplitude across load changes. A feedback network provides the input signal required by active circuit to operate.

Detailed description of the CEMF acquisition module

[0046] The CEMF module as it is depicted in fig.1 comprises, at least, the following sub-modules: a fix acquisition time sub-module; and/or a CEMF hold-off sub-module.

Fix acquisition time sub-module

[0047] The diagram of fig.5 illustrates the performance of this sub-module. The current acquisition mechanism has proved to be very accurate and effective, but it has the disadvantage of not having a deterministic acquisition time. The fix acquisition time is a feature designed to reuse all learned from the current method, while ensuring a configurable and deterministic acquisition time. The idea is to start-up and finish the acquisition process using an independent counter. Each time a new CEMF edge is detected, the acquisition counter is captured on a buffer together with the number of CEMF edges. Once the configured acquisition time is reached, the last stored tuple of CEMF cycles and Acquisition cycles is taken, and the output of the acquisition algorithm is calculated.

CEMF hold-off sub-module

[0048] Prior art acquisition mechanism is always exposed. Therefore, if noise interferences occur, they are somehow feed into the acquisition generating large errors. Because the nature of the CEMF signal is periodic, the CEMF hold-off mechanism predicts where the next interesting feature should happen and disconnects the acquisition from all possible spurious signals in between. In fig.6 it can be shown that the traditional acquisition incorrectly includes noise into the acquisition process, while the process with CEMF hold-off feature rejects noise as it happens outside the acceptance windows.

Detailed description of the memory module

[0049] In the fig.1 it is depicted the memory module that comprises, at least, a flexible scan sequence sub-module.

Flexible scan sequence sub-module

[0050] With the fix sequence implementation (fig.7), if a channel is used as compensation, as this channel is only sampled once per iteration, the channel acquired immediately after the compensation will enjoy of a more accurate compensation because acquisitions has been done closer in time, and the channel acquired just before the compensation, will have the worst compensation because the more time has passed since the signal used for compensation was acquired longest time ago, and therefore the environment is likely to have changed the more.

[0051] However, with the flexible scan sequence (fig.7), it is possible to scan the compensation channel just right before each non-compensation channels, therefore all channels will enjoy of an equally recent compensation signal; and/or there is an electrode that needs to be sampled twice the sample rate of the rest because is sensing something more sensitive to change, and/or a combination of both. Therefore, the flexible scan sequence mechanism allows for any combination required.

Detailed description of the communications module

[0052] In the communication module it is implemented a smart interrupts sub-module. The device in WO2019197677 handles many types of events (Errors, Start of Conversion, End of Conversion, CEMF noise, CEMF event, etc). If a dedicated interrupt per event type is desired, the number of required pins/balls in the padring and the ASIC package becomes very large. This fact increases the silicon size, the ASIC size, the cost as well as impacts in the yield. Therefore, it has been decided to have a couple of programable interrupt pins/balls that can be associated to any event type or to a set of types. If more than one event type is mapped to an interrupt, a OR/AND combination need to be chosen as aggregation method (fig.8).

Detailed description of the system manager module

[0053] The system manager module comprises at least one a fix sequence time sub-module; and/or a smart interrupts sub-module (previously disclosed, fig.8).

Fix sequence time sub-module

[0054] Due to the nature of the start-up and acquisition process, the CEMF sequence does not have a deterministic period. Therefore, it is not possible to align the acquisitions with a periodic phenomenon like the AC power (50Hz-60Hz) or a motor turning (hundreds of rpm). In some applications this may be a significant disadvantage as the result is a large noise mapped into the signal due to acquisitions happening in different conditions. However, the fix sequence time ensures each sequence step starts precisely at the same distance of the one before and the one next, enabling CEMF to be synchronised with cyclic physical phenomena.

[0055] Various means of embodiment provided by this description may be implemented using hardware, software, or combinations of hardware and software. As also may be the case, the different components of hardware and/or software established in this document may be combined in composite materials comprising software, hardware and/or both, without deviating from the object of this invention defined by its claims. The different components of hardware and/or software established in this document can be separated in the sub-components comprising software, hardware, or both, without deviating from the object of this invention defined by its claims. As also may be the case, it is considered that the software components can be used as hardware components and vice versa. The software according to this description, such as non-transitory instructions, programme and/or data, code, can be stored in one or more legible means of the non-transitory machine. It is also considered that the software identified in this document can be implemented using one or more general-purpose, or specific-purpose, computers and/or computer systems, in a network and/or of another type. The order of the different steps described in this document can be changed and/or divided into substages to deliver the characteristics described in this document. The means of embodiment described above illustrate, but do not limit, the invention. It should also be understood that numerous modifications and variations are possible according to the object of this invention. Consequently, the scope of the invention is only defined by the following claims.

Claims

1. A device to measure disruptions in a controlled electromagnetic field comprising:

   an electrode management module further comprising at least one an analog electrode aggregation sub-module; and/or a flexible electrode mapping sub-module;
   a CEMF front-end module further comprising at least a RLC output CEMF front-end sub-module;
   a CEMF acquisition module further comprising at least one of the following sub-modules: a fix acquisition time sub-module; and/or a CEMF hold-off sub-module; and
   a system manager module further comprising at least one of the following sub-modules: a flexible scan sequence sub-module; and/or a smart interrupts sub-module.

2. The device according to claim1 wherein: the analog electrode aggregation sub-module is arranged to use any combination of electrodes at the same time; and/or the flexible electrode mapping sub-module is arranged to use any available electrode for each implemented virtual CEMF channel; and/or the CEMF RLC output front-end sub-module comprising an RLC-circuit configured to amplify the output voltage of the CEMF signal.

3. The device according to any of claims 1 to 2 wherein the fix acquisition time sub-module is arranged to start-up and finish the acquisition process using an independent counter. Each time a new CEMF edge is detected, the acquisition counter is captured on a buffer together with the number of CEMF edges. Once the configured acquisition time is reached, the last stored tuple of CEMF cycles and Acquisition cycles is taken, and the output of the acquisition algorithm is calculated.

4. The device according to any of claims 1 to 3 wherein the CEMF hold-off sub-module is arranged to predict where the next cycle should happen and rejects all spurious detections happening in between through the rejection of the noise that happens outside an acceptance window.

5. The device according to claims 1 to 4 wherein the flexible scan sequence sub-module is arranged to scan the compensation channel just right before each non-compensation channels, therefore all channels will enjoy of an equally recent compensation signal; and/or there is an electrode that needs to be sampled twice the sample rate of the rest because is sensing something more sensitive to change, and/or a combination of both.

6. The device according to claims 1 to 5 wherein the smart interrupts sub-module comprises at least one programable interrupt pin that can be associated to any event type or to a set of types; and wherein if more than one event type is mapped to an interrupt, a OR/AND combination need to be chosen as aggregation method.

7. A method to measure disruptions in a controlled electromagnetic field comprising:

   an electrode management process further comprising at least one of the following steps: an analogic electrode aggregation step; and/or a flexible electrode mapping step;
   a CEMF front-end process further comprising at least a CEMF RLC output front-end step;
   a CEMF acquisition process further comprising at least one of the following steps: a fix acquisition time step; and/or a CEMF hold-off step; and
   a system manager process further comprising at least one of the following steps: a flexible scan sequence step; and/or a smart interrupts step.

8. The method according to claim 7 wherein the electrode aggregation step comprises the use of any combination of electrodes at the same time.

9. The method according to any of claims 7 to 8 wherein the flexible electrode mapping step comprises the use of any available electrode for each implemented virtual CEMF channel.

10. The method according to any of claims 7 to 9 wherein the CEMF RLC output front-end step comprises the use of an RLC-circuit configured to amplify the output voltage of the CEMF signal.

11. The method according to any of claims 7 to 10 wherein the fix acquisition time step comprises to start-up and finish the acquisition process using an independent counter. Each time a new CEMF edge is detected, the acquisition counter is captured on a buffer together with the number of CEMF edges. Once the configured acquisition time is reached, the last stored tuple of CEMF cycles and Acquisition cycles is taken, and the output of the acquisition algorithm is calculated.

12. The method according to any of claims 7 to 11 wherein the CEMF hold-off step comprises to predict where the next cycle should happen and rejects all spurious detections happening in between through the rejection of the noise that happens outside an acceptance window.

13. The method according to any of claims 7 to 12 wherein the flexible scan sequence step comprises to scan

the compensation channel just right before each non-compensation channels, therefore all channels will enjoy of an equally recent compensation signal; and/or there is an electrode that needs to be sampled twice the sample rate of the rest because is sensing something more sensitive to change, and/or a combination of both.

14. The method according to any of claims 7 to 13 wherein the smart interrupts sub-module comprises at least one programable interrupt pin that can be associated to any event type or to a set of types; and wherein if more than one event type is mapped to an interrupt, a OR/AND combination need to be chosen as aggregation method.

15. Use of the device according to any of claims 1-6 to measure electromagnetic fields surrounding a conductor for the localisation of people, mixed reality, devices, IoT, domestic and industrial security applications, robotics, military applications, and security applications for transporting cargo and people, work-related and domestic prevention and security applications and applications for the logistics sector and fluid control and detection in bathrooms.

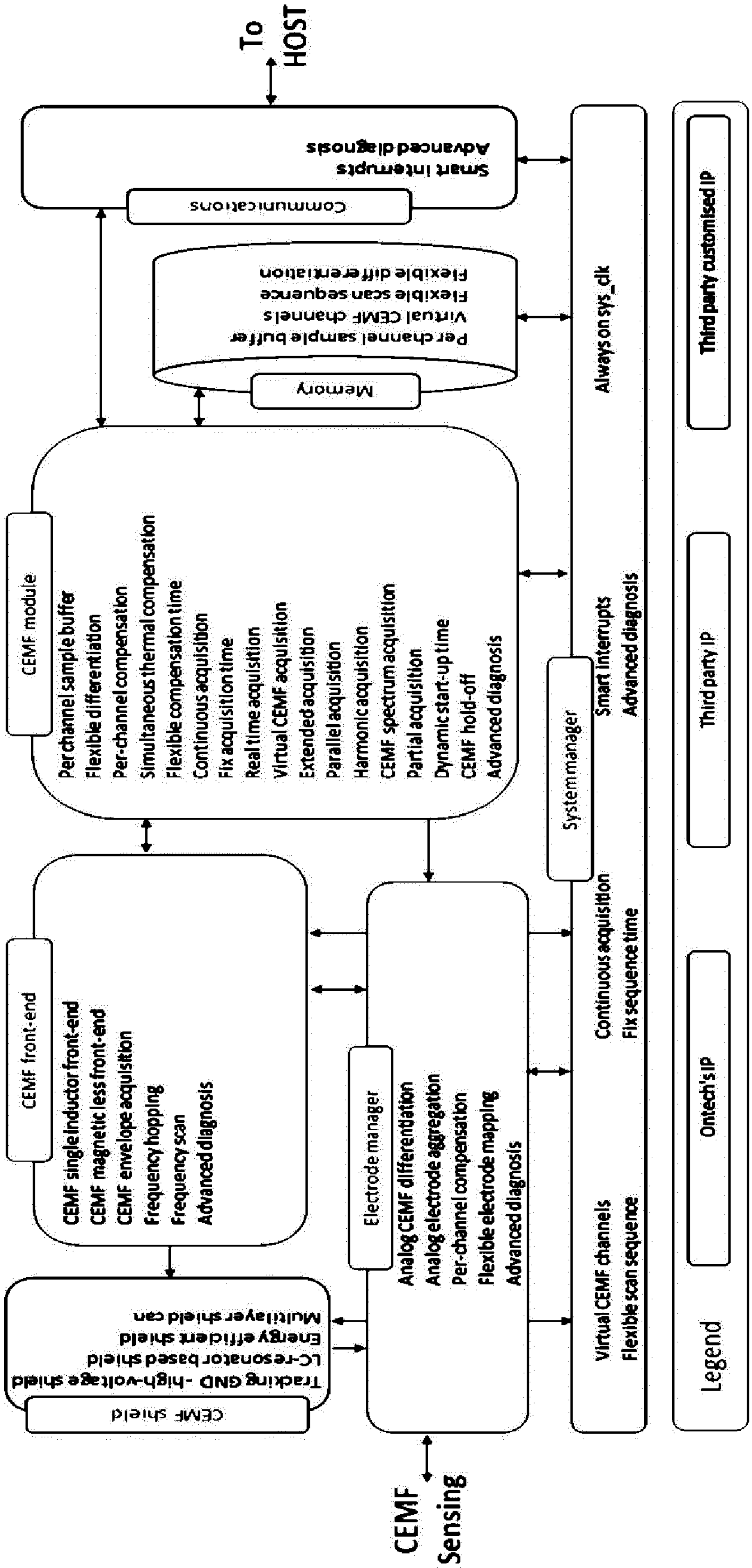
To HOST
Communications
Smart interrupts
Advanced diagnosis
Memory
Per channel sample buffer
Virtual CEMF channels
Flexible scan sequence
Flexible differentiation
CEMF module
Per channel sample buffer
Flexible differentiation
Per-channel compensation
Simultaneous thermal compensation
Flexible compensation time
Continuous acquisition
Fix acquisition time
Real time acquisition
Virtual CEMF acquisition
Extended acquisition
Parallel acquisition
Harmonic acquisition
CEMF spectrum acquisition
Partial acquisition
Dynamic start-up time
CEMF hold-off
Advanced diagnosis
CEMF front-end
CEMF single inductor front-end
CEMF magnetic less front-end
CEMF envelope acquisition
Frequency hopping
Frequency scan
Advanced diagnosis
CEMF shield
Tracking GND -high-voltage shield
LC-resonator based shield
Energy efficient shield
Multilayer shield can
Electrode manager
Analog CEMF differentiation
Analog electrode aggregation
Per-channel compensation
Flexible electrode mapping
Advanced diagnosis
CEMF Sensing
Always on sys_clk
System manager
Smart interrupts
Advanced diagnosis
Continuous acquisition
Fix sequence time
Virtual CEMF channels
Flexible scan sequence
Legend
Ontech's IP
Third party IP
Third party customised IP

FIG.1

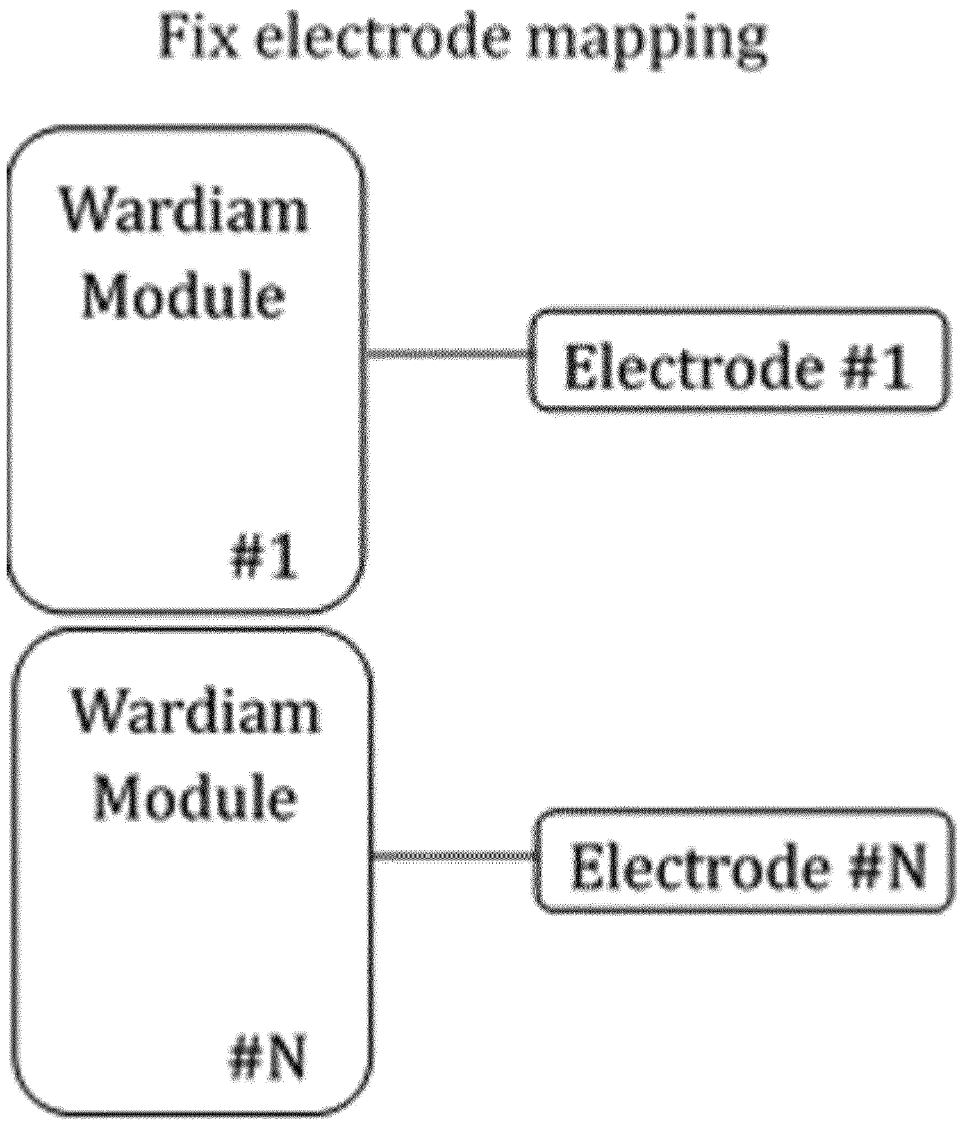
Fix electrode mapping
Wardiam
Module
#1
Electrode #1
Wardiam
Module
#N
Electrode #N

Fig.2(a)

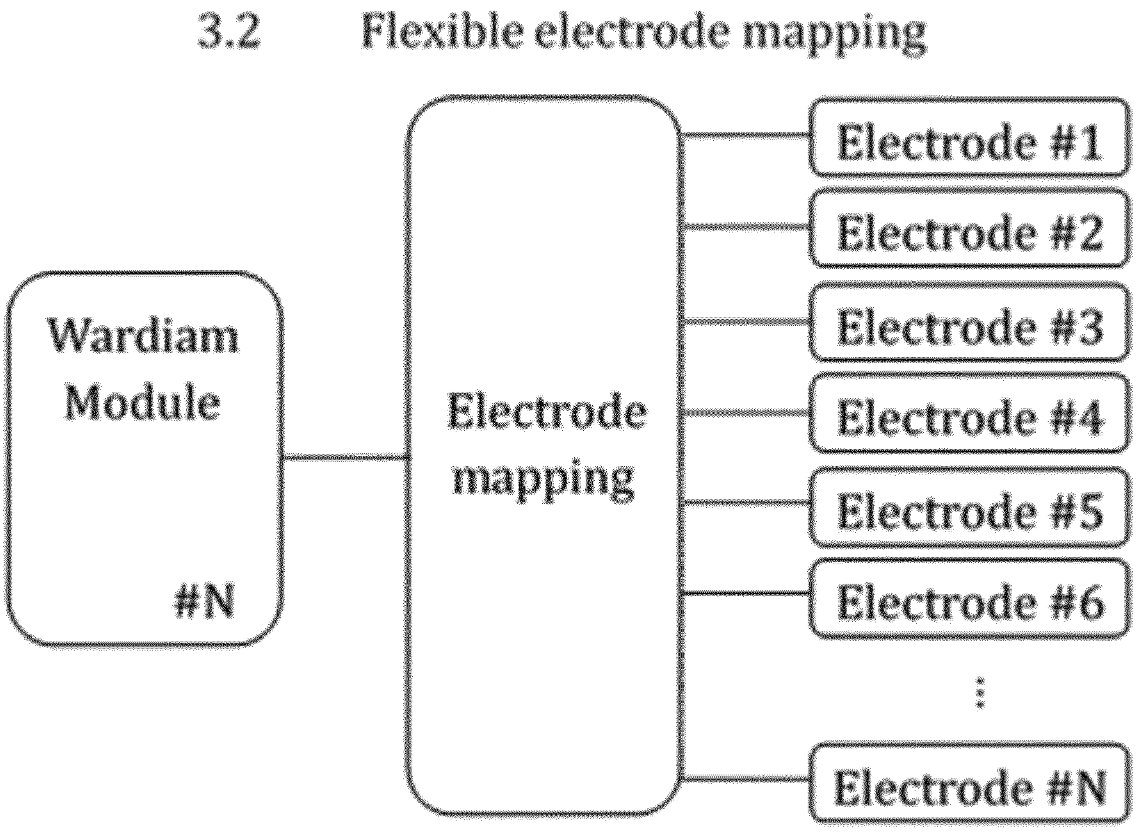
3.2 Flexible electrode mapping
Wardiam Module
#N
Electrode mapping
Electrode #1
Electrode #2
Electrode #3
Electrode #4
Electrode #5
Electrode #6
Electrode #N

Fig.2(b)

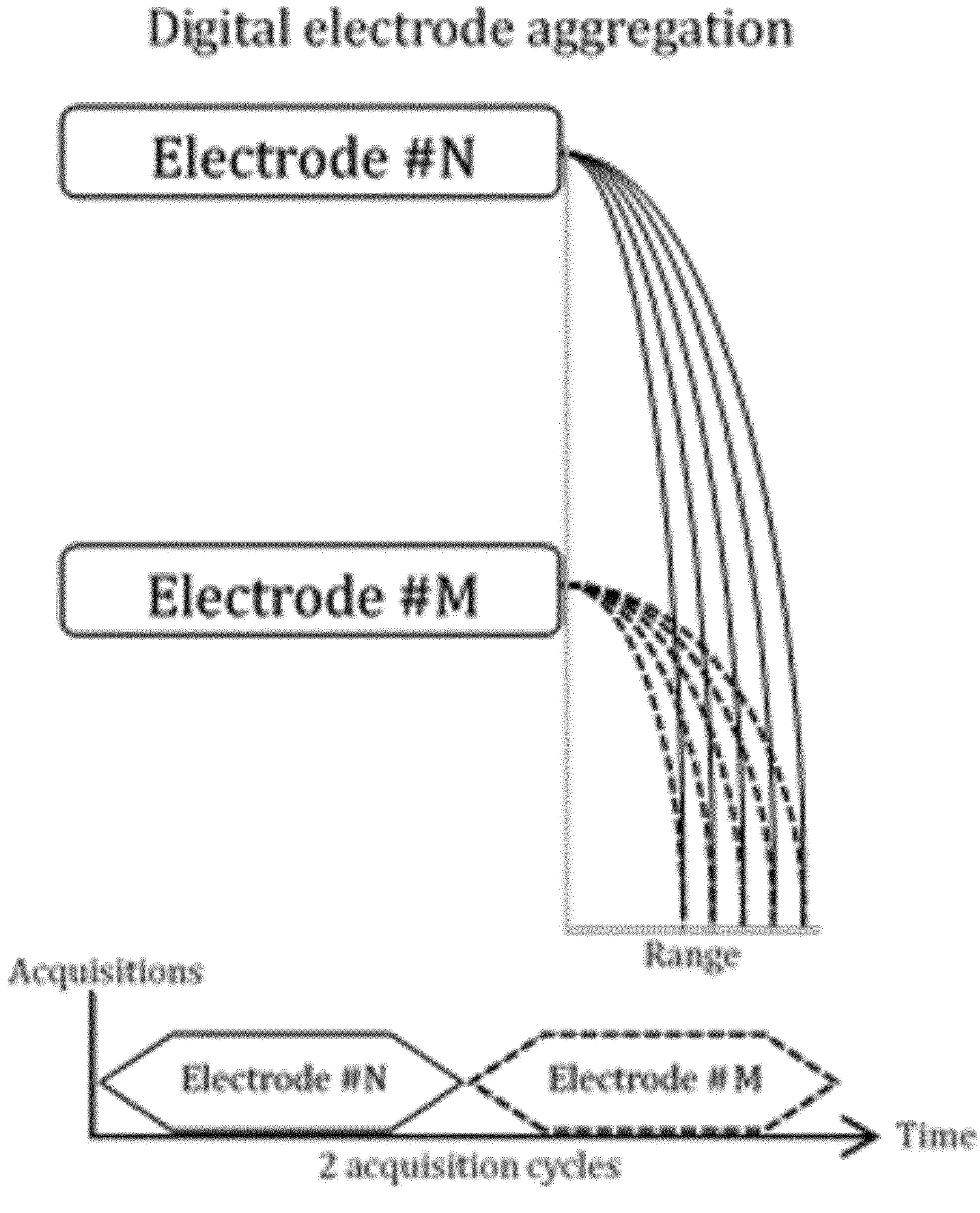
Digital electrode aggregation
Electrode #N
Electrode #M
Range
Acquisitions
Electrode #N
Electrode # M
Time
2 acquisition cycles

Fig.3(a)

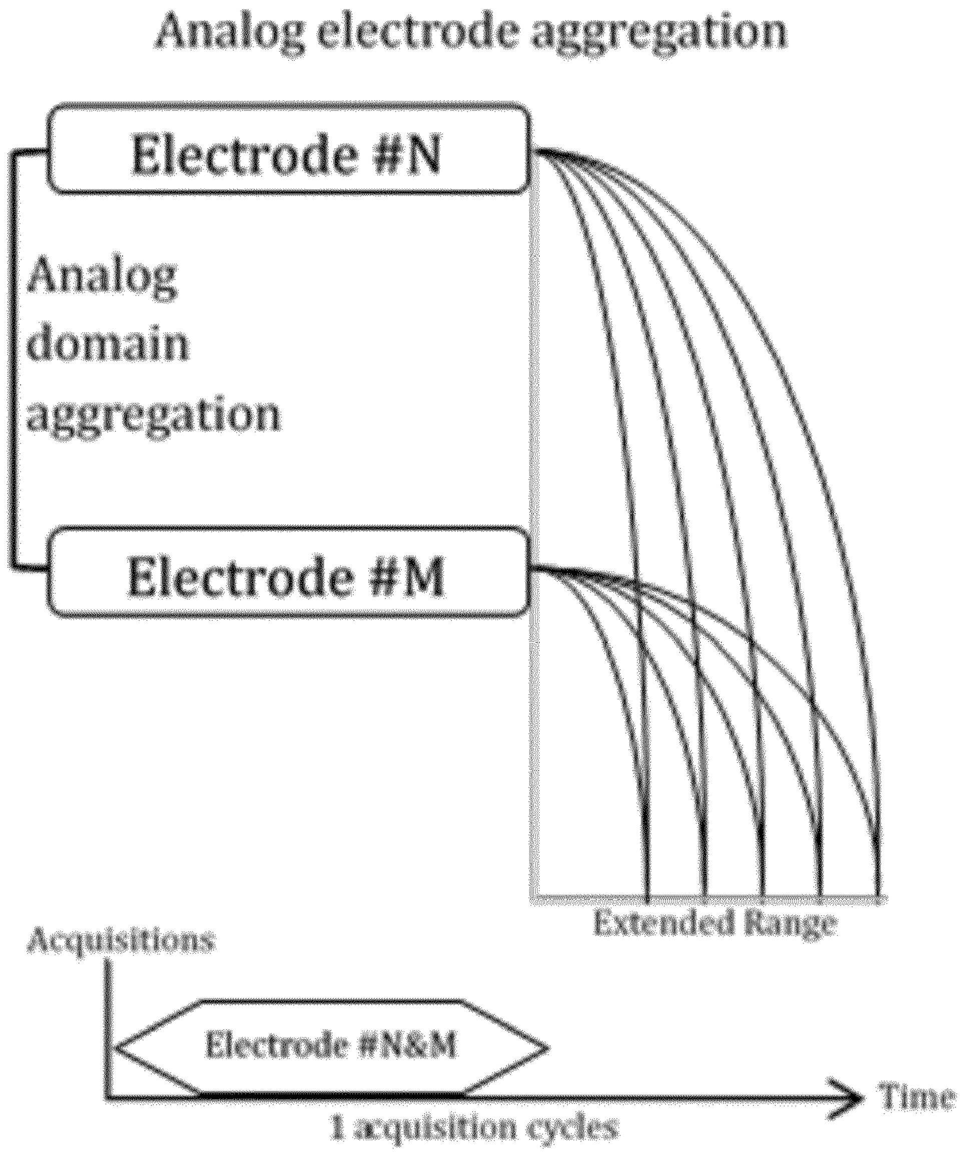
Analog electrode aggregation
Electrode #N
Analog
domain
aggregation
Electrode #M
Extended Range
Acquisitions
Electrode #N&M
Time
1 acquisition cycles

Fig.3(b)

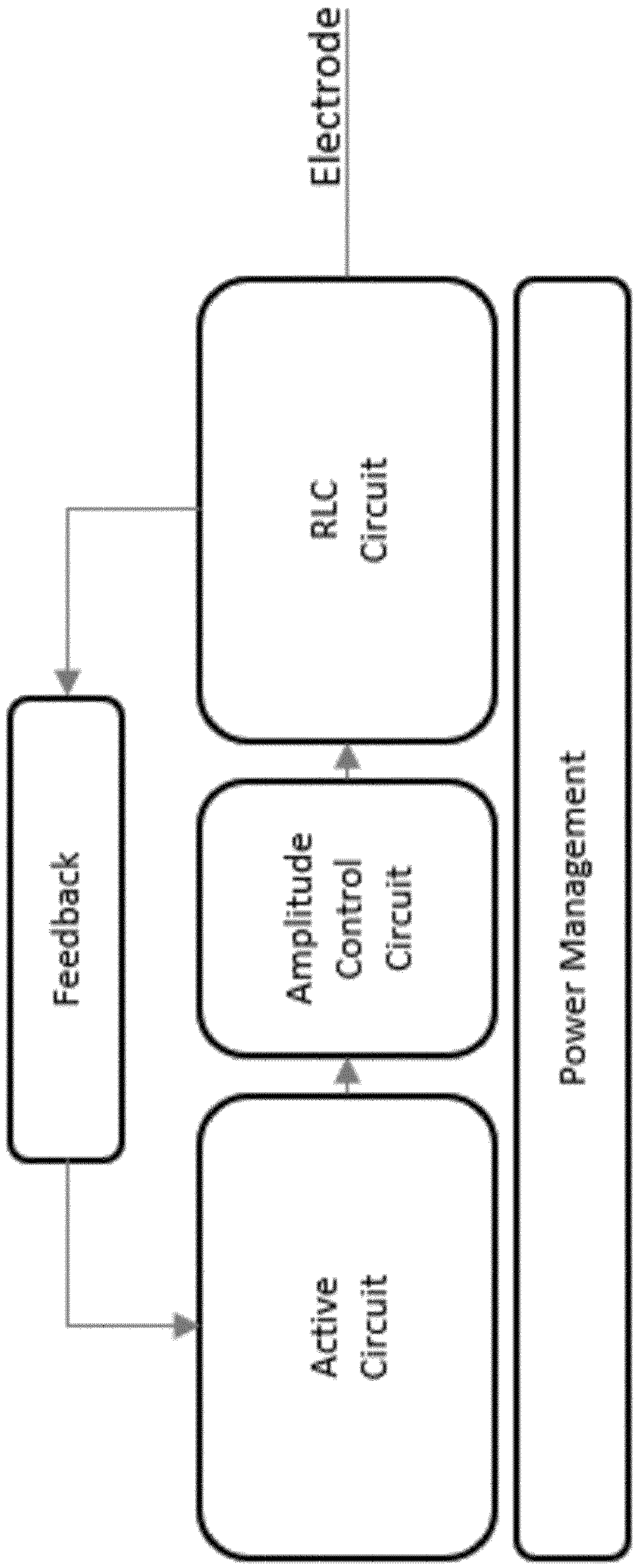
Electrode
RLC Circuit
Feedback
Amplitude Control Circuit
Active Circuit
Power Management

FIG.4

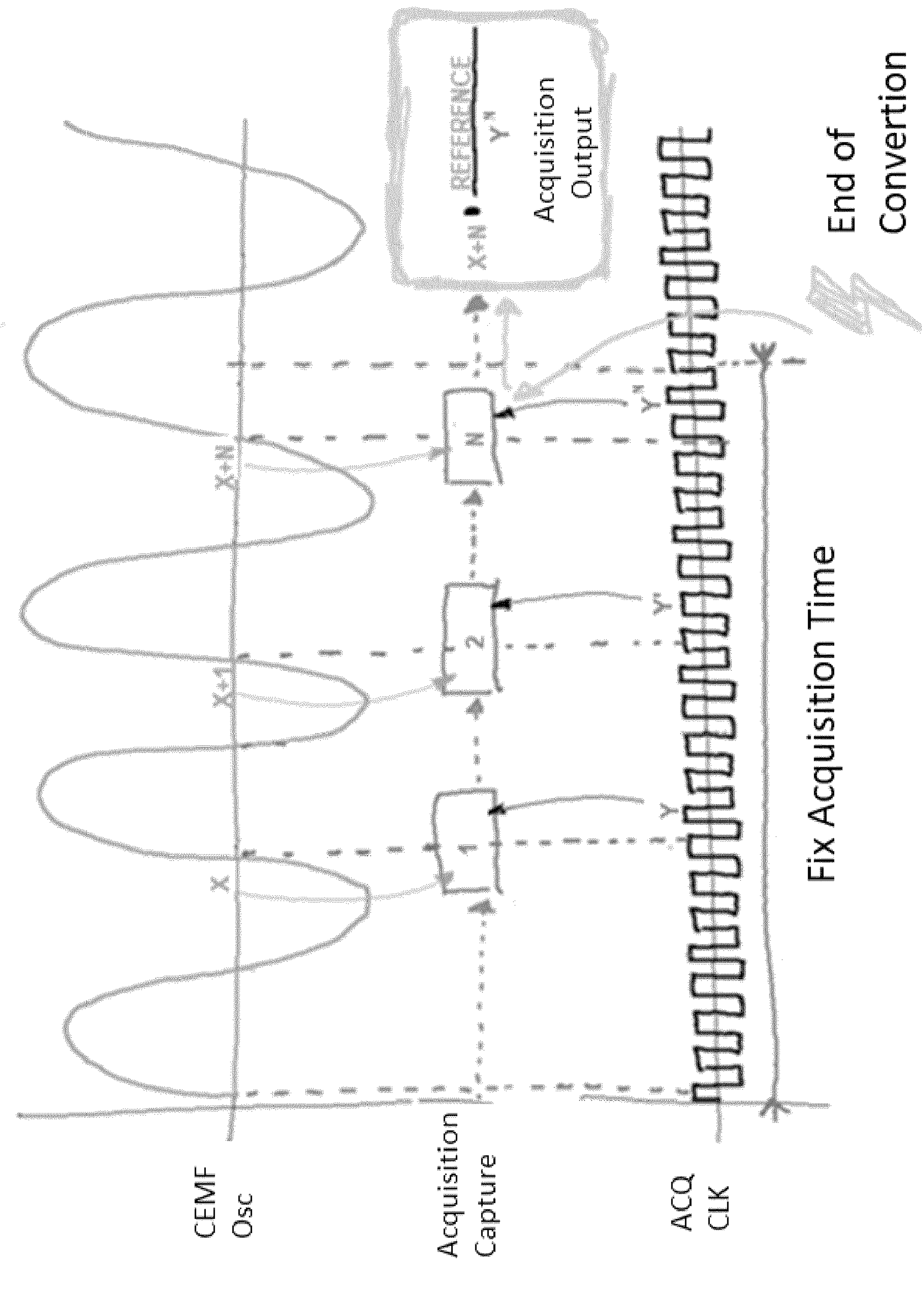
CEMF
Osc
Acquisition
Capture
ACQ
CLK
X
X+1
X+N
1
2
N
Y
Y'
Y^N
REFERENCE
Acquisition
Output
Fix Acquisition Time
End of
Convertion

FIG.5

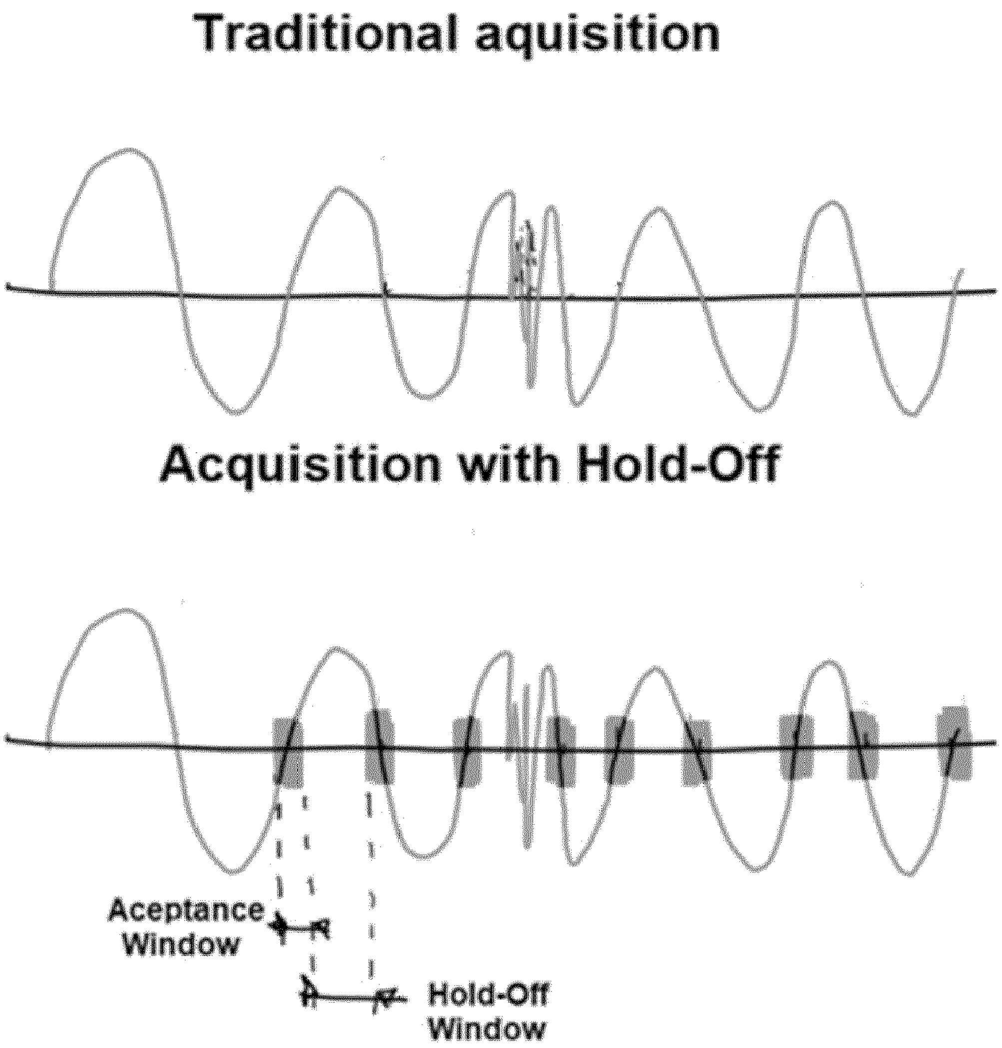
Traditional aquisition
Acquisition with Hold-Off
Aceptance
Window
Hold-Off
Window

FIG.6

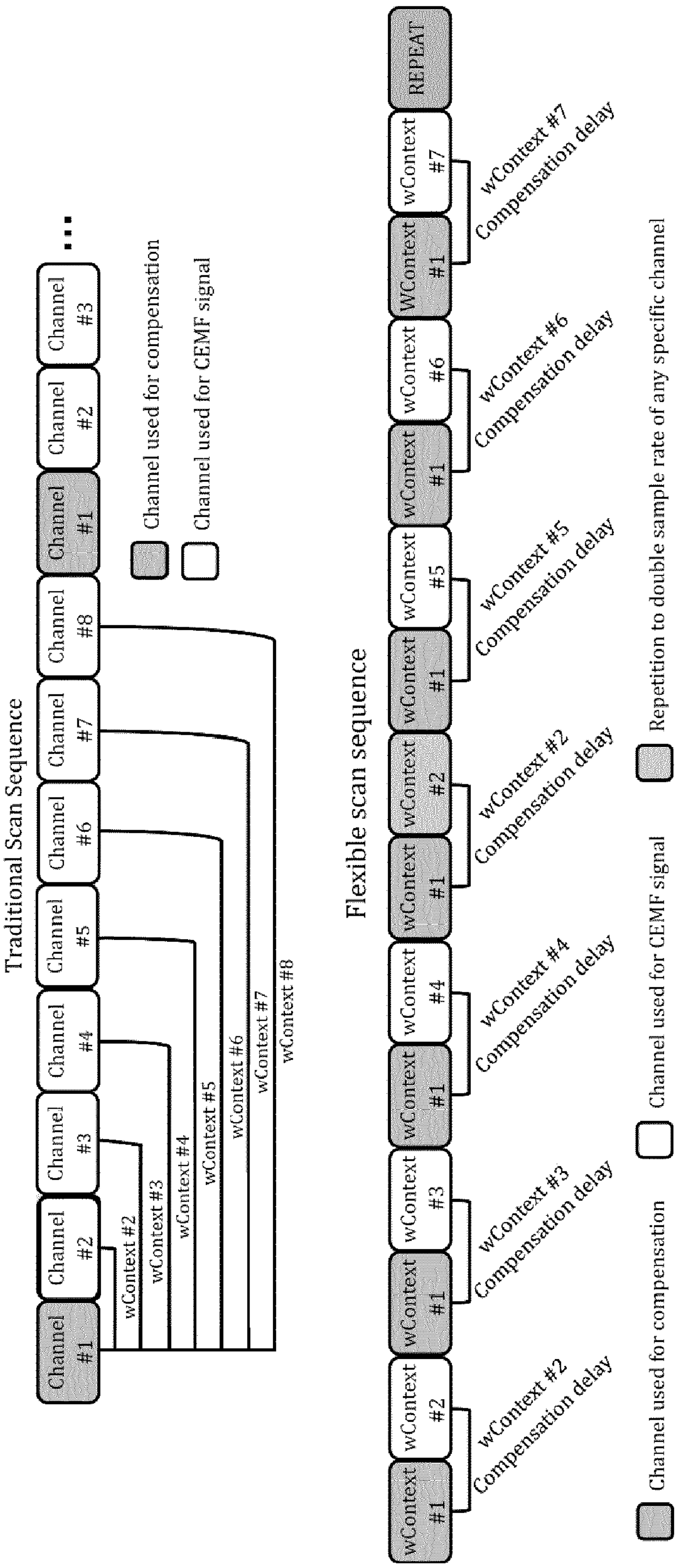
Traditional Scan Sequence
Channel #1
Channel #2
Channel #3
Channel #4
Channel #5
Channel #6
Channel #7
Channel #8
Channel #1
Channel #2
Channel #3
...
wContext #2
wContext #3
wContext #4
wContext #5
wContext #6
wContext #7
wContext #8
Channel used for compensation
Channel used for CEMF signal
Flexible scan sequence
wContext #1
wContext #2
wContext #1
wContext #3
wContext #1
wContext #4
wContext #1
wContext #2
wContext #1
wContext #5
wContext #1
wContext #6
WContext #1
wContext #7
REPEAT
wContext #2 Compensation delay
wContext #3 Compensation delay
wContext #4 Compensation delay
wContext #2 Compensation delay
wContext #5 Compensation delay
wContext #6 Compensation delay
wContext #7 Compensation delay
Channel used for compensation
Channel used for CEMF signal
Repetition to double sample rate of any specific channel

FIG.7

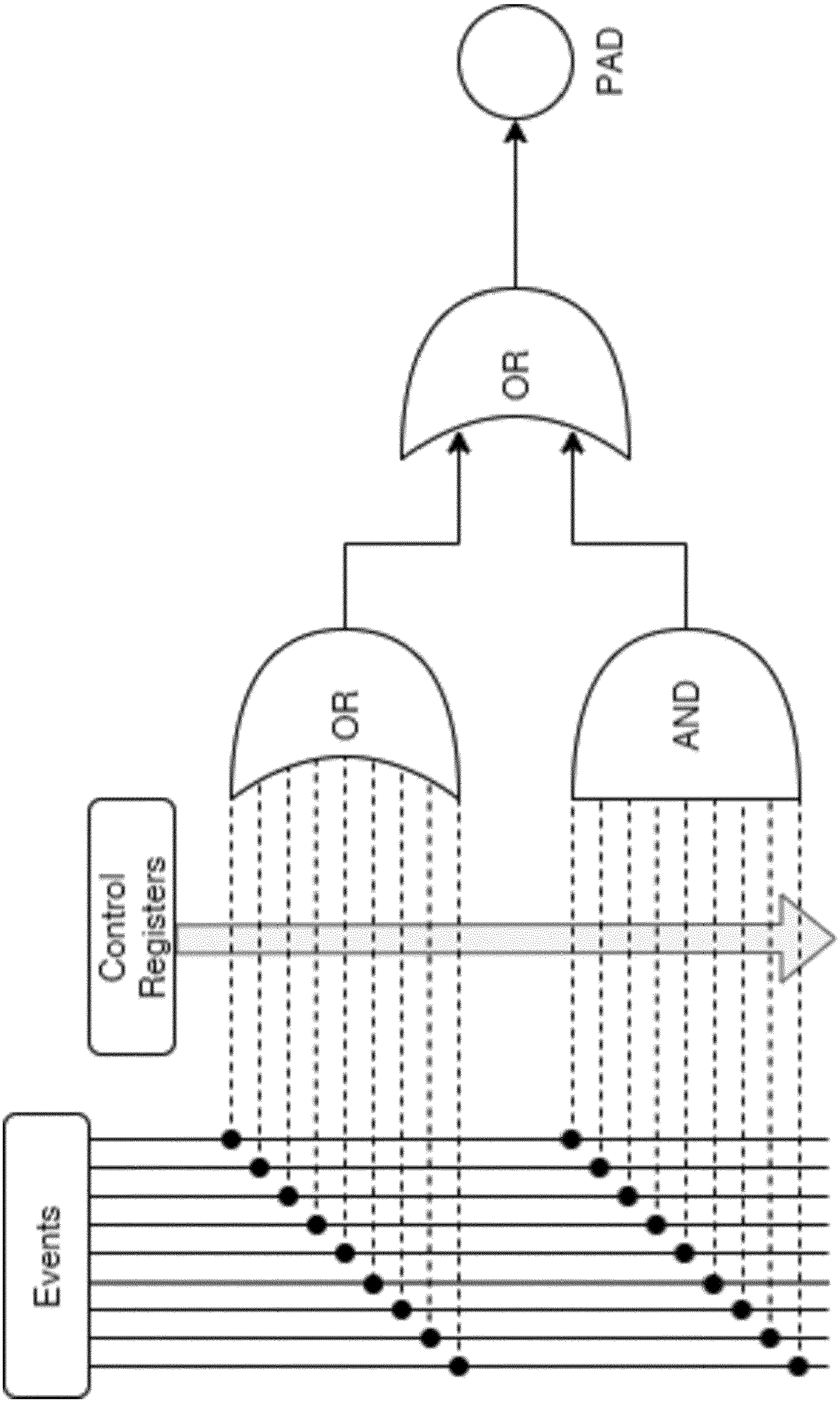

FIG.8

Europäisches Patentamt
European Patent Office
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DECLARATION

which under Rule 63 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

Application Number
EP 22 38 2020

The Search Division considers that the present application, does not comply with the provisions of the EPC to such an extent that it is not possible to carry out a meaningful search into the state of the art on the basis of all claims

Reason:

It has been determined that no meaningful search is possible.
A detailed reasoning is provided on the EPO Form 1703 of the ESOP.

The applicant's attention is drawn to the fact that a search may be carried out during examination following a declaration of no search under Rule 63 EPC, should the problems which led to the declaration being issued be overcome (see EPC Guideline C-IV, 7.2).

CLASSIFICATION OF THE APPLICATION (IPC)

INV.
G08B13/24

1

Place of search	Date	Examiner
Munich	10 February 2023	Kurzbauer, Werner

EPO FORM 1504 (P04F37)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 1404838 A **[0006]**
- WO 9741458 A **[0008]**
- WO 03022641 A **[0009]**
- US 2004090234 A **[0010]**
- EP 256805 A **[0011]**
- EP 2980609 A **[0013]**
- EP 3190569 A **[0013]**
- EP 3076206 A **[0013]**
- WO 2017077165 A **[0013]**
- WO 2017070166 A **[0013]**
- EP 280609 A **[0014]**
- WO 2019197677 A **[0014] [0017] [0018] [0019] [0020] [0039] [0042] [0052]**