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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

[Continued on next page]

(54) **Title**: METHOD, APPARATUS AND SYSTEM FOR OBTAINING AND MONITORING ENVIRONMENTAL DATA

(57) **Abstract**: In at least one aspect, a water-sports board is configured to collect environmental data. The water-sports board includes a waterproof sensor housing and, disposed within the housing, one or more sensor(s), processor(s), memory device(s), switch(es), batteries. The sensing device is configured, in a first state, not to store environmental data sensed by the at least one sensor in the at least one physical memory device. The sensing device is configured, in a second state, to store environmental data sensed by the at least one sensor in the at least one physical memory device.

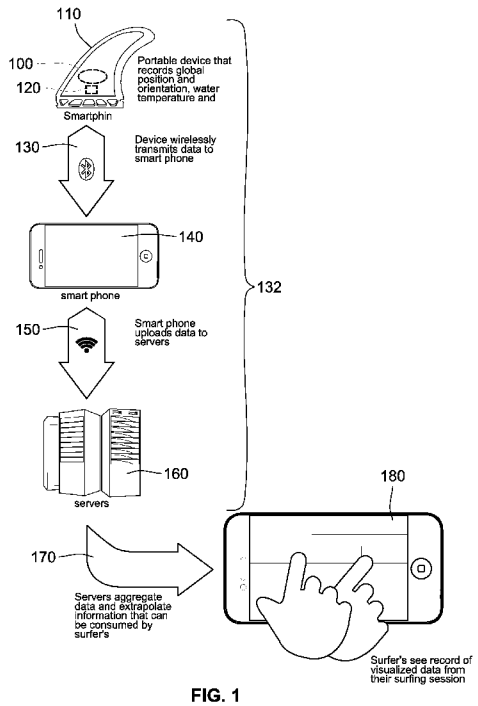


FIG. 1

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METHOD, APPARATUS AND SYSTEM FOR OBTAINING AND MONITORING ENVIRONMENTAL DATA

TECHNICAL FIELD

[001] The embodiments of the invention are related to systems and methods for obtaining environmental data and for monitoring of such environmental data.

BACKGROUND

[002] Buoys that collect oceanographic and atmospheric data ("weather buoys") are currently deployed, either moored or drifting, throughout the world's oceans and bodies of water. Weather buoys collect various data such as wind velocity (steady and gusting), wind direction, barometric pressure, water temperature, water currents, wave height, and wave direction.

[003] Deploying and maintaining buoys in the ocean is laborious and expensive. The ocean is also a hostile dynamic environment, with moored weather buoys going adrift and with moored and drifting weather buoys being damaged or broken. Because of these challenges, there are a limited number of weather buoys in the world. Furthermore, very few weather buoys or other monitoring systems are deployed in the nearshore environment (within 400 meters of the shore). Waves crest and break in the nearshore environment and, because of this water movement, the bathymetry is also changing. For these reasons, there are very few nearshore environmental monitoring systems maintained around the world.

SUMMARY OF THE INVENTION

[004] In one aspect of the present concepts, a water-sports board comprises a sensing device configured to collect environmental data, the sensing device comprising at least one waterproof sensor housing, at least one sensor disposed within the at least one sensor housing, at least one processor disposed within the at least one sensor housing, the at least one processor being communicatively connected to the at least one sensor, and at least one physical memory device disposed within the at least one sensor housing, the at least one memory physical device being communicatively connected with the at least one processor. The sensing device further comprises at least one switch adapted to change a state of the sensing device between at least a first state and a second state and at least one battery configured to power at least one of the at least sensor, the at least one processor, or the at least one memory device. The sensing device is configured, in the first state, not to store environmental data sensed by the at least one sensor in

the at least one physical memory device, and is configured, in the second state, to store environmental data sensed by the at least one sensor in the at least one physical memory device.

[005] In at least some other aspects, the present concepts include a waterproof device configured to collect environmental data, the device comprising at least one waterproof sensor housing integrated with a device borne by a person or attached to a device borne by a person. At least one sensor and at least one processor are disposed within the at least one sensor housing, the at least one processor being communicatively connected to the at least one sensor. Also disposed within the at least one sensor housing is at least one physical memory device, the at least one memory physical device being communicatively connected with the at least one processor and at least one switch adapted to change a state of the at least one sensor between at least a first state and a second state responsive to a manual manipulation of the at least one switch, automatically responsive to at least one triggering event, or either of a manual manipulation of the at least one switch through the at least one waterproof sensor or automatically responsive to at least one triggering event. The device further comprises at least one battery configured to power at least one of the at least one sensor, the at least one processor, or the at least one memory device. The first state is an off state and the second state is an on state. While in the second state, data sensed by the at least one sensor is stored in the at least one physical memory device.

[006] In still another aspect of the present concepts, a method for collecting environmental data, comprises the acts of integrating a waterproof environmental data sensing device comprising one or more sensors, at least one processor, at least one battery and at least one physical memory device into water-sports equipment adapted for use in a water-sports activity and activating the environmental data sensing device prior to or during initiation of the water-sports activity to enable collection of environmental data during the water-sports activity. The method further includes the acts of collecting environmental data using the one or more sensors during the water-sports activity and transmitting the environmental data to a central server via at least one communication device, wherein the environmental data comprises at least one of a water temperature, a water salinity, a water conductivity, a water pH, or any combination thereof.

[007] Additional aspects of the invention will be apparent to those of ordinary skill in the art in view of the detailed description of various embodiments, which is made with reference to the drawings, a brief description of which is provided below.

BRIEF DESCRIPTION OF THE DRAWINGS

[008] FIG. 1 is a schematic representation of a system for collecting environmental data according to at least some aspects of the present concepts.

[009] FIG. 2 is a schematic representation of a 4-conductor salinity circuit for collecting environmental salinity data according to at least some aspects of the present concepts.

[0010] FIG. 3 is a schematic representation of a pH measurement circuit using a connected ion sensitive field-effect transistor (ISFET) used for measuring ion concentrations in solution and reference electrode according to at least some aspects of the present concepts.

[0011] FIGS. 4(A)-4(K) show aspects of sensing device circuitry in accord with at least some aspects of the present concepts. 4(K) is an alternate to 4(D) using a Qi receiver module in lieu of a discrete Qi receiver.

[0012] FIGS. 5(A)-5(B) are a listing of components of the sensing device circuitry in FIGS. 4(A)-4(C), and 4(E)-4(K), which use a Qi receiver module. FIGS. 5(C)-5(D) are a listing of components of the sensing device circuitry in FIGS. 4(A)-4(J), which includes a discrete Qi receiver on-board.

[0013] While the invention is susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and will be described in detail herein. It should be understood, however, that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

[0014] While this invention is susceptible of embodiment in many different forms, there is shown in the drawings and will herein be described in detail preferred embodiments of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to the embodiments illustrated. For purposes of the present detailed description, the singular includes the plural and vice versa (unless specifically disclaimed); the words "and" and "or" shall be both conjunctive and disjunctive; the word "all" means "any and all"; the word "any" means "any and all"; and the word "including" means "including without limitation.

[0015] The inventors have developed a system and method to use the practitioners of various water-based activities (e.g., sports such as surfing, etc.) in nearshore environments to deploy sensors that collect data about the natural nearshore environments, and more particularly to

incorporate into such water-based activities suitable methods, apparatus and systems for obtaining and monitoring environmental data. In the aggregate, the environmental data can supplement data from conventional methods, apparatus and systems for obtaining and monitoring environmental data (e.g., weather buoys).

[0016] The inventors, recognizing the need to raise the public's awareness of the environment, and further recognizing the nexus between all biological systems on the planet and the oceans, developed the present concepts to not only facilitate tracking of oceanographic and atmospheric data, an important goal in its own right, but also to strengthen the public's connection with the oceans by empowering the public to participate in understanding of the nearshore environment, but also to help document and track changes in the nearshore environment over time.

[0017] As described herein, surfers, for example, can play an integral role in developing awareness of the nearshore environment and of changes to the nearshore environment over time. In accord with at least some aspects of the present concepts, a surfer's surfboard can be equipped with a sensing device comprising one or more sensors providing data for one or more variables (e.g., variables measured by a conventional weather buoy). In accord with at least some other aspects of the present concepts, a surfer's surfboard can be equipped with a plurality of sensing devices, each of the plurality of sensing devices comprising one or more sensors providing data for one or more variables (e.g., variables measured by a conventional weather buoy). Using such instrumented surfboards, when surfers go into the ocean, the surfboards can record data such as, but not limited to, wave energy, water temperature, water pH, and/or salinity. By various means, this data can then be aggregated and used to describe changes the nearshore environment. In this example, surfers become major stakeholders in the collection of data useful in characterizing the nearshore environment and useful in assessing changes in and any potential trends in such nearshore environment. In at least some aspects, it is desirable, but not necessary, for the device to also collect personal data about the movement of the surfer in the water to encourage utilization of the device, as surfers are more likely to bring the device in the ocean if it can be used to increase the enjoyment of their selected leisure and sport activity. Furthermore, the data about a surfer's movement can be related to the environmental data that the device is monitoring. A surfer will better understand how the environment directly affects his/her experience, which will enhance the surfer's connection with the ocean. Likewise, these same concepts are adaptable to other water-borne activities and other water-based activities can also advantageously utilize one or more sensing devices, each of the one or more sensing devices comprising one or more sensors providing data for one or more variables (e.g., variables measured by a conventional weather buoy). Without limitation, and by way of example, such

device(s) as are disclosed herein may be adapted for use by skin divers, scuba divers, wind surfers, ocean kayakers, or other operators of personal watercraft, and may be attached to ones' body and/or ones' equipment (e.g., directly or by a tethered attachment), so long as the device(s) and sensor(s) are positioned to obtain data that is not subjected to untoward measurement biases.

[0018] In at least some aspects of the present concepts, a water-sports board (e.g., a surfboard, paddle board, skimboard, body board, windsurfing board, etc.) comprises one or more sensing device(s) 100 configured to collect environmental data. As shown in FIG. 1, a sensing device 100 is disposed in, or integrated with, a fin 110, such as a fin (also referred to herein as a "Smartfin"or "Smartphin") that would be disposed on the ventral side of a surfboard (not shown). Alternatively, in other aspects, the sensing device 100 could be disposed in, or integrated with, the water-sports board itself, such as by being installed, or removably installed, within one or more openings, depressions, or cavities formed in a ventral surface of the water-sports board.

[0019] The sensing device 100 comprises one or more sensors disposed in one or more housings, which are advantageously, but not necessarily, waterproof, with the exception of pH and salinity sensors which must be partially exposed to the water to facilitate measurement. The sensor housings are only required to be waterproof where the sensor itself, and any appurtenant components (e.g., processor(s), wiring, memory, etc.) are not themselves waterproofed, and in a manner that does not interfere with components that must be exposed to ocean water. It is envisioned that, in various aspects of the present concepts, the sensing device housing(s) will be waterproof in an assembled, operational condition for use in the water-sports activity and, when not in an operational condition for use in the water-sports activity, the sensing device housing(s) may be opened (e.g., via rotation of a threaded connection cap, unlatching of a gasketed compartment, removal of one or more mechanical connectors to access a sealed interior compartment, etc.) to permit access to one or more components associated with the sensing device 100 such as, but not limited to a removal of a device therein, such as a removable memory device, or to an I/O port (e.g., USB, micro USB, serial, IEEE 1394, IEEE 1394b, HDMI Micro, IrDA, etc.)..

[0020] The sensing device housing(s) may comprise a single, centralized sensor housing having one or more sensors disposed therein, or may comprise a distributed sensing device comprising a plurality of sensors. By way of example, in a surfboard configuration, a first waterproof sensor housing could be disposed in a first ventral fin and a second waterproof sensor housing could be disposed in a second ventral fin, with each of the first and second waterproof sensor housing bearing the same sensors or different sensors. As another example, also relative to the surfboard

configuration, a first waterproof sensor housing could be disposed in a ventral fin at a tail of the surfboard a second waterproof sensor housing could be disposed in, or removably attached to, a ventral surface of the surfboard (e.g., toward a nose of the surfboard or in the vicinity of a midpoint of the surfboard lengthwise and widthwise, etc.). Of course, to the extent that an individual sensor is, itself, waterproofed, thus obviating at least some reasons for utilizing a distinct housing, such sensor may be deployed (e.g., on the surfboard) without a housing.

[0021] In various aspects, the sensing device(s) 100 may be integrated into an "after market" modification to existing water-sports equipment or water-borne vessels, where an existing component (e.g., tail fin) is replaced by a corresponding component (e.g., another tail fin) comprising the sensing device(s). In other aspects, the sensing device(s) 100 may be integrated into an OEM product. For example, the sensing device(s) 100 may be integrated into a Hobie paddleboard (e.g., in the paddleboard, in the fin, etc.), surfboard (e.g., in the surfboard, in the fin, etc.), or sailboat (e.g., in the hull, in the rudder, etc.).

[0022] In general, the waterproof sensor housing is desired to endure impacts common to the activity in a manner that provides longevity to the sensing device(s) 100 and components housed therein. In the embodiment depicted in FIG. 1, the waterproof housing comprises a fiberglass fin that can be mounted on a ventral surface of a surfboard or other water-sports board. Ideally, the housing material(s) should not markedly interfere with the reception of or transmission of signals (e.g., radio signals) or effect the accuracy of any measurements taken by the sensing device(s) 100.

[0023] The sensing device(s) 100 further comprise a CPU (i.e., one or more centralized or distributed processors or processing devices), such as, but not limited to, AVR or ARM processors, disposed within the sensing device housing(s). In other aspects, Qualcomm Snapdragon 200, 400, 600 and 800, Nvidia Tegra 4 and Tegra 4i, Intel Atom Z2580 Clover Trail+, Apple A7, Motorola X8, MediaTek MT6592, Intel Atom Z2420 Lexington, etc., or the like, could be used. The processor(s) are communicatively connected to the sensor(s) and to one or more physical, non-transient memory devices (e.g., non-volatile memory device, solid-state/ semiconductor-based flash memory, etc.). The sensing device(s) 100 are power by one or more batteries configured to power all components of the sensing device(s) requiring power to operate (e.g., sensor(s), processor(s), memory device(s), etc.). The battery or batteries are desirably, but not necessarily, rechargeable, either via a charging port or device integrated into the sensing device(s) 100, or following removal of the battery or batteries from the sensing device(s) 100. In at least some aspects, the battery or batteries are configured to be recharged inductively, such as via the Qi inductive power standard. In at least some aspects, the charging port or charging

system provides inputs (e.g., instructions, handshake signals, etc.) to the sensing device(s) processor(s) to register the connection of the rechargeable battery to a power charging source and, responsive thereto, the processor(s) are configured to automatically communicatively allow connection from an external communication device (e.g., external device 140 in FIG. 1) that would initiate data transfer from the memory device (e.g., wireless transmission of data 130 to smart phone 140 in FIG. 1). In other aspects of the present concepts, the download or transmission of data from the memory device(s) of the sensing device(s) 100 is initiated manually by a user.

[0024] In any event, it is generally desired that the battery or batteries are sized and selected to provide power to all powered elements for between about 2 hours to 8 hours (e.g., between about 2-3 hours or 6-8 hours), or optionally more, to permit sufficient utilization during a desired water-sports activity. In at least some aspects, the sensing device(s) 100 battery or batteries could be sized in correspondence with the water-sports activity and/or anticipated usage (e.g., a first sensing device 100 battery pack could provide a 2-3 hour charge, whereas a second sensing device battery pack could provide a 6-8 hour charge). In at least some aspects, it is desired for the battery or batteries to provide at least about 120maH (e.g., 3.7V LiPo 120mAh).

[0025] In at least some aspects of the present concepts, the sensing device(s) 100 further comprise one or more switches adapted to change a state of the sensing device(s) 100 between at least a first state and a second state. The sensing device(s) 100 is configured, in the first state, not to store environmental data sensed by the sensor(s) in the memory device(s) and is configured, in the second state, to store environmental data sensed by the sensor(s) in the device(s). Accordingly, when the water-sports board or object bearing the sensing device(s) 100 is not deployed in an intended water-sports activity (e.g., at home, strapped to a car, sitting on the beach, etc.), the sensing devices are inactive not only to minimize discharge of the battery or batteries, but also to prevent the collection of irrelevant or inappropriate data. In at least some aspects, these switches may be manual, user-actuated switches (e.g., one or more user-interfaces including, but not limited to, one or more actuatable buttons, a touch pad, or a connected electronic device such as a smart phone connected to the device via a wireless connection). In at least some other aspects, the switches comprise controller-based switches operating responsive to sensor data received by the controller from one or more sensors and instruction sets stored in the physical, non-transient memory device(s).

[0026] FIGS. 4(A)-4(K) show aspects of sensing device circuitry in accord with at least some aspects of the present concepts. FIG 4(D) applies when the Qi receiver is included as discrete components. FIG 4(K) applies when the Qi receiver is a separate module.

[0027] FIGS. 5(A)-5(D) are listings of components of the sensing device circuitry in FIGS. 4(A)-4(K). FIGS. 5(A) and 5(B) apply when the Qi receiver is a separate module. FIGS. 5(C) and 5(D) apply when the Qi receiver is included as discrete components.

[0028] By way of example, a "Storage" or inactive state can be entered whenever there is a lack of sufficient motion for a specified period of time, 5 minutes by default, and there is no detection of being "in the water" by a salinity detector or by other means. In this state, all of the measuring devices will either be in a low power state or de-energized, and the CPU will operate in 'power down standby' mode as shown in Table 1, below, which presents for illustration one non-limiting embodiment of the present concepts.

TABLE 1

On-board Device	**Storage State**
CPU	Power-down standby
IMU	Low power accelerometer-only with periodic wakeup
Temperature Sensors	OFF
Salinity/Conductivity Detector	OFF
pH Detector	OFF
GPS	OFF
Bluetooth	OFF
Qi Charge Receiver	inactive

[0029] In accord with at least some aspects of the present concepts, the Inertial Measurement Unit ("IMU") uses a built-in periodic "wakeup" mode to check for acceleration, which in at least one case is configured to only check the X and Y directions for motion to limit power consumption in this state. The gyros and magnetic circuits are also powered down. If the IMU detects acceleration above a preset threshold, it will issue an interrupt to the CPU. On interrupt, the CPU will then restart itself and check for the current conditions. If the interrupt was due to motion from the IMU, and a charger is not currently connected with the Qi receiver, it will enter the "Recording" state. The device will monitor and record all measured parameters until there is no sufficient motion for a pre-determined time, which is by default 5 minutes, at which point it will close and truncate any open log file, and re-enter the "Storage" state. As noted above, in accord with other aspects of the present concepts, a user may be enabled to selectively activate the IMU and/or other system components manually via a user-input device, such as, but not limited to, one or more buttons, a touch pad, or a connected electronic device (e.g., a smart phone connected to the device via a wireless connection).

[0030] If the CPU interrupt was caused by a "charging" detect (Qi charger active), the Smartphin will immediately enter the "'Charging" state.

[0031] Periodically the CPU is capable of "waking up"' to check the battery voltage. It also checks battery voltage while in the "Recording" state. If at any time (other than in the "Charging" state) the battery voltage is detected as being below the "low voltage" threshold, the CPU will de-energize ALL on-board devices (including the IMU) and place itself into a "Power-Down Standby" state to minimize additional current draw from the battery. This is similar to the "Storage" state except that it will not be awakened by motion detection. During the "Recording" state, measured battery voltage is recorded along with the other data.

[0032] The charging state, represented by way of example, for one embodiment, in Table 2 below, is initiated whenever the Qi charger is activated, regardless of the current battery state. If the batteries have been completely drained, this will also cause a re-boot of the CPU as it powers up. To prevent rapid reboot or other undesirable conditions, the regulator circuit has been designed to prevent the CPU from energizing whenever battery voltage drops below a "low voltage threshold". When leaving the "Recording" state, the open data log file is first closed, then truncated, to ensure data reliability. The GPS, environmental measurement, and temperature devices are de-energized. When entering the "Charging" state, the Bluetooth device is energized and set to "factory default", then immediately re-configured to run at a significantly higher baud rate.

TABLE 2

On-board Device	**Charging State**
CPU	active
IMU	OFF
Temperature Sensors	OFF
Salinity/Conductivity Detector	OFF
pH Detector	OFF
GPS	OFF
Bluetooth	ON
Qi Charge Receiver	Initially Active; inactive for 5 minutes to end Charging State.

[0033] Communications with the Bluetooth device may be initiated once the red "power" LED begins to blink at a 1/2Hz rate. Communications may be re-initiated at any time, so long as the Qi charger remains active, or the time without communication is less than 5 minutes.

[0034] When there has been a lack of Qi charger activation and Bluetooth activity for 5 minutes, the device will reset itself and go into the "Storage" state.

[0035] In accord with the present example, a CPU reset, which by example may be initiated using a physical, magnetic, or other type of switch, will simply re-initialize all of the various components and enter the "Recording" state. However, if the Qi charger is active, the boot loader will perform a factory reset on the bluetooth device and enable "Flash Mode". Once the boot loader has enabled "Flash Mode" 60 seconds are provided for a communication device to connect to the Bluetooth and initiate a firmware update. "Flash Mode" is indicated by a series of LED blinks, first with the "Power" LED on solid, and then off, for a time period of around 6 seconds. When the Power LED is off AND you get 3 rapid blinks on the device LED, the Bluetooth device is ready to accept a connection. At this point the 60 second delay starts. If the firmware update program does not instruct the boot loader to begin updating the firmware at the end of the 60 second delay, a normal reboot will occur, and the device will enter Charging mode or Transport mode, depending on the state of the Qi Charge Receiver.

[0036] The "Recording" state, represented by way of example, for one embodiment, in Table 3 below, is initiated following the "Storage" state by detected motion via the IMU. There are two operating modes in the "Recording" state, consisting of 'minimal' and 'high speed' data recording modes. Whenever detected motion remains below a second 'low speed recording' threshold for a period of time, which by default is 15 seconds, only a minimal amount of data is recorded. The default time period for IMU data during the 'minimal' mode is 5 times per second. IMU data continues to be measured at the normal rate (which by default is about 90 times per second), but not recorded. Other data, such as battery voltage, GPS coordinates, temperature, salinity, or pH, are still recorded at their normal rate.

TABLE 3

On-board Device	**Recording State (minimal mode)**
CPU	Active
IMU	5 times per second (by default)
Temperature Sensors	ON
Salinity/Conductivity Detector	ON
pH Detector	ON
GPS	ON
Bluetooth	OFF
Qi Charge Receiver	inactive

[0037] The device is also capable of entering a "Periodic" recording mode, which is independent of motion, in which environmental data is recorded at periodic intervals. In this state, IMU data recording is optional, and the device 'wakes up' at specified time intervals, and records for specified periods of time, then goes back into a 'Power-Down Standby' state until the next recording period causes it to 'wake up' and record data again. This mode facilitates capturing data over longer periods, for example if the Smartphin was deployed on a boat crossing the Pacific Ocean. The Periodic recording would enable the battery life to be extended. In at least some aspects of the present concepts, the interval is programmable or user-selectable and may further optionally comprise a plurality of selected intervals with each interval being triggered by an event such as a time-based event or a location-based event (e.g., position).

[0038] If a salinity detector is utilized in combination with the other aspects of the present concepts, it has the capability of measuring a value that indicates that the device is "in the water". So long as readings from a salinity or other kind of detector determines that the device is "in the water", and not charging, it will not leave the "Recording" state. This helps to prevent the need to re-start the system, should motion while in the water fall low enough to cause the device to enter the "Storage" state, since a short period of time is needed to reset all of the connected devices and begin recording again, and thereby cause important motion data to be missed.

[0039] When there is a lack of sufficient acceleration for more than a pre-determined time, which is by default 5 minutes but could be set to any other desired pre-determined time, the Smartphin will go into the "Storage" state. This is to save as much battery life as possible whenever the Smartphin is "at rest". Additionally, the Smartphin will check its battery voltage to see if it is below the "low voltage" threshold. If the battery voltage is detected as being below the "low voltage" threshold, the CPU will first stop all data recording (closing the file and truncating it to the current record), de-energize ALL on-board devices (including the IMU) and place itself into a "Power-Down Standby" state to minimize additional current draw from the battery. This is similar to the "Storage" state except that it will not be awakened by motion detection.

[0040] When the Smartphin has detected sufficient motion above a threshold that is adjustable (e.g., a delta or differential of IMU data from one measurement to the next corresponding to a predetermine change in acceleration, velocity, orientation, etc.), represented by way of example, for one embodiment, in Table 4 below, it switches to the "Recording" state 'normal' mode, recording with high sample rate IMU data, as well as environmental data and GPS location data. Below the 'low speed recording' threshold, only a fraction of the IMU data is recorded. But

whenever motion exceeds the 'low speed recording' threshold, all of the IMU data is recorded, at a default rate of about 90 times per second. Subsequently, if motion remains below the 'low speed recording' threshold for a period of time that is by default 15 seconds, the device will re-enter 'low speed' mode and record data accordingly.

TABLE 4

On-board Device	**Recording State (normal mode)**
CPU	Active
IMU	90 times per sec (by default)
Temperature Sensors	ON
Salinity/Conductivity Detector	ON
pH Detector	ON
GPS	ON
Bluetooth	OFF
Qi Charge Receiver	inactive

[0041] When a sufficient salinity level is present, the salinity detector is capable of re-charging its capacitor through the salinity probes themselves. This enables faster charging, and more frequent measurements of salinity. Additionally, reversing the polarity of the probes may decrease ionic migration and therefore salt deposition on a probe. Experimentation has shown that frequent salinity measurements are actually more accurate and, more likely, to stabilize within a short period of time following the immersion of the salinity probes. Typically it may take up to 5 minutes for the readings to stabilize. Dry probes may have accumulated material on them, and 5 minutes worth of salinity measurements while immersed in water seems to be sufficient to "clean them off" enough to get good readings. As to the sufficiency of the salinity level in a particular embodiment, the salinity threshold is derived from an inverse conductivity measured value and when this measured value exceeds a threshold, the conductivity is deemed too low for a normal "ocean water" salinity value (e.g., about 3.5% or 35 g/L), and a "not in the water" state is assigned. The threshold value is adjustable.

[0042] Whenever a salinity detector is included in the device, salinity records will be captured at a lower rate if the salinity value shows that the device is not 'in the water', which is by default every 30 seconds. Once the salinity indicates that it is, in fact, 'in the water', the salinity capture is more frequent, by default every 2 seconds. A typical 4 conductor salinity probe is tolerant of drying out, but requires a short period of time to stabilize when first entering the water. This must be considered when analyzing the data.

[0043] Additionally, when a surfer is heading out to where the waves are, he or she is typically going to remain in-place for a significant amount of time, waiting for a decent wave. The amount of time paddling the board out to a good location, plus the waiting time for a wave, is likely to be long enough to capture at least one good salinity reading. Once the surfboard is on a wave, however, the Smartphin may actually ride out of the water for short periods of time. The salinity detector and device firmware can indicate when the Smartphin is in the water, and when it is not, and coordinate this with temperature readings and additional salinity readings. For this reason, there is a 5 minute timeout on the salinity readings NOT indicating "in the water" before the Smartphin will change to the "Transport" state.

[0044] As with the "Transport" state, the Smartphin will monitor battery voltage. If the battery voltage is detected as being below the "low voltage" threshold, the CPU will first stop all data recording (closing the file and truncating it to the current record), de-energize ALL on-board devices (including the IMU) and place itself into a "Power-Down Standby" state to minimize additional current draw from the battery. Again, this is similar to the "Storage" state except that it will not be awakened by motion detection.

[0045] A typical surf session will put the Smartphin through all of its states, in a predictable manner. Beginning with the "Storage" state, the surfboard (with the Smartphin attached) will enter the "Recording" state as soon as it is moved, most likely when being loaded onto a vehicle. If present, the salinity detector will detect that it is not submerged in sea water, but data will still be recorded.

[0046] While being transported, the charger can be placed over the Smartphin in order to make sure the battery is properly charged during the trip, placing it into the "Charging" state, and stopping all data recording. This may also happen beforehand, with a final short-duration charge done from within the vehicle during transport, or just prior to moving the board to the water. In any case, the Smartphin will enter the "Charging" state, and enable bluetooth communication. If the user chooses, he or she may transfer whatever data is on the Smartphin at that time to the online repository, or store it on his or her smart phone or other bluetooth capable computing device for later transfer.

[0047] After arriving at the beach, the surfboard (with Smartphin attached) is removed from the vehicle and transported to the ocean. IMU data will be logged, as well as temperature and other environmental data, and GPS information. Even though initial recordings of environmental data may not be valid, these results will be post-processed by scientist once the data is moved to a public server.

[0048] While surfing, the Smartphin occasionally leaves the water. If a salinity detector is present, the Smartphin requires that salinity indicate "out of the water" for the 'no motion' time period, by default 5 minutes, before it will allow transition back into the "Storage" state.

[0049] On several occasions a surfer may rest on the beach for a while, leaving his or her board out of the water. During these times, the Smartphin will transition from the "Recording" state to the "Storage" state. And if the user wants to, he or she may choose to transfer data right away by using a charger in his or her vehicle and performing a data transfer with his or her smart phone, while the Smartphin is in the "Charging" state.

[0050] At some point the surf session is over, and the user may transfer his or her surfboard (with the Smartphin attached) back to his or her vehicle. Ideally he or she will place the charger on the Smartphin and perform a data transfer while the Smartphin is in the "Charging" state. Alternately this may be done once the surfer returns back home.

[0051] Finally the surfboard is stowed away, and the Smartphin transitions to the "Storage" state, using minimal current to detect if there is any motion.

[0052] In case the battery might drain to a point where voltage is too low, the Smartphin will occasionally wake up and test for this condition. If the battery voltage is too low, it will power off the IMU and go back into "Power-Down Standby", with an absolute minimal current draw. In this state motion will not wake up the Smartphin. It will be necessary to charge the battery first.

[0053] In at least some aspects, the sensor device 100 optionally comprises at least one switch comprising a manually actuatable switch. The manually actuatable switch could comprise a conventional push-button switch utilizing a short-stroke displaceable actuator (e.g., responsive to pressure) or, alternatively, could comprise a small touch screen button (e.g., responsive to a capacitive input, a resistive input, etc. from a user's finger). The sensor device 100, or the manually actuatable switch, may optionally comprise one or more LED lights (e.g., a green LED) to provide a visual indicate of one or more variables (e.g., on/off, battery charge, transmitter operability, etc.).

[0054] In at least some other aspects, the water-sports board switch is automatically actuated from the first state (e.g., off) to the second state (e.g., on) responsive to immersion in water, and vice versa upon removal from water, based on a sensed characteristic and/or completion of an external circuit by the water. For example, a switch is operatively associated with a conductivity sensor, and the switch is automatically actuated from the first state to the second state responsive to a conductivity change (i.e., immersion in salt water, which is a very efficient electrical conductor), greater than a predetermined threshold, sensed by the at least one sensor. For

example, seawater has a resistivity (ρ) of 2×10^{-1} Ω•m at 20 °C and a conductivity (σ) of 4.8 S/m at 20 °C, whereas air has a resistivity (ρ) of 1.3×10^{16} to 3.3×10^{16} Ω•m at 20 °C and a conductivity (σ) of 3×10^{-15} to 8×10^{-15} S/m at 20 °C. These differences can be used by the sensor device 100 to differentiate as to whether the device is in the air (and should advantageously be in a quiescent state) or in the ocean, where it should activate to obtain environmental data (and optionally water-sports movement data).

[0055] In other aspects, the sensor device 100 optionally comprises a salinity sensor and the salinity sensor is used to automatically actuate a switch to change a state of the sensor device from a first state (e.g., off, asleep, low-power operation, etc.) to a second state (e.g., on) responsive to change in salinity, greater than a predetermined threshold (e.g., from substantially zero to between about 3.1-3.9%), sensed by the at least one sensor. Likewise, upon removal from the water, the sensed salinity decreases from a steady state between about 3.1-3.9% back to a lower value, thus causing the switch to actuate to change a state of the sensor device from the second state back to the first state responsive to the change in (e.g., decrease in) sensed salinity.

[0056] The sensing device(s) 100 sensor(s) may comprise, for example, one or more temperature sensors, one or more water salinity sensors, one or more conductivity sensors, one or more pH sensors, or a combination thereof.

[0057] One aspect of a salinity measurement sensor circuit in accord with the present concepts is shown in FIG. 2. The depicted salinity measurement circuit is configured to measure conductivity using a 4 conductor conductivity probe, in which an AC signal is coupled from one set of probes to another according to the amplitude of the coupled signal being roughly proportional to the inverse of the water conductivity.

[0058] The salinity of seawater, for practical purposes, is considered directly proportional to its conductivity, when the water temperature, probe surface area, and the distance between them is constant. However, because of the many variables in the relationship between conductivity and salinity, it is necessary to calibrate the salinity measurement against known concentrations of salt in water, and also compensate for temperature. Additionally, the salinity probes must consist of a material that is not very susceptible to corrosion or oxidation/reduction reactions when placed in salt water and with an electric current applied.

[0059] To minimize the effect of electroplating and salt deposition, the salinity circuit uses an AC signal and DC blocking capacitors, as well as a non-reactive probe material such as graphite or blackened platinum.

[0060] As shown in the example of FIG. 2, the salinity sensor circuit comprises a constant current (Q6, R1) 'H' bridge (Q1 through Q4) to drive the AC signal through one set of probes,

and a differential AC amplifier (U1a,d) and pair of 'peak' detectors (U1b,c) to measure the induced signal on the other set of probes, for a 4 conductor conductivity probe. By using a constant current AC signal, the actual induced voltage should be more linearly representative of the effective resistance (i.e. inverse conductivity) of the water, thus improving accuracy. The two 'peak' values are then measured via a differential A/D converter, and their voltage difference becomes the measured signal.

[0061] FIG 2 also shows that a small 'bypass' signal is coupled via C12, C13, R21, and R22 from the H bridge to the differential amplifier in order to ensure that a large signal appears when the probe is dry or removed from the water. Higher conductivity results in a lower measured value, and low conductivity in a high measured value. As such, when not in the water, the conductivity should be zero, resulting in a very large measured value. However, in actual practice, a dry probe has an indeterminate signal, which does not suit the ability to accurately measure salinity and 'out of the water' conditions, and may be high, low, or anywhere in between. Therefore, to correct for this, the bypass signal is applied through a high impedance series circuit. A dry probe exhibits a high impedance state across the measurement electrodes, allowing a comparably high impedance RC circuit to be used to essentially 'leak' a signal as if the probe were in water with very low conductivity. But whenever the conductivity probe is in salt water, the effect of these capacitors and resistors is negligible, thereby providing a reliable 'in the water' indication without impacting the conductivity measurement.

[0062] Whenever the processor(s) make(s) a salinity measurement, it first puts an AC signal of at least 8khz on pin 2 of the daughter board connector (labeled 'DBINT') to energize the H bridge. This couples the AC frequency through the water to the differential AC amplifier U1a and U1d. DC blocking capacitors C15 and C16 ensure that no induced DC will pass through, improving accuracy and preventing certain kinds of drift.

[0063] The peak detectors U1b and U1c operate as 'ideal diodes' in a sample and hold configuration, essentially measuring the high and low peak of the resulting AC waveform from the differential amplifier. The capacitors C5 and C6 maintain their charge for a sufficiently long enough period of time as to remain accurate and eliminate a large quantity of noise. This value is measured by the CPU's differential A/D converter from pins 3 and 4 on the daughter board connector (labeled 'DBIO1' and 'DBIO2').

[0064] The CPU allows the AC signal to stabilize for 1 second, then averages as many readings as it can for an additional 1 second, to minimize the effects of noise and improve overall accuracy. Once the measurement is complete, the AC signal on pin 2 (labeled 'DBINT') is

stopped. This effectively turns the salinity circuit off, though power is still supplied on the 'GPS' power circuit.

[0065] When there is no salt water exposed to the probes, a 'maximum' value results due to the high impedence 'bypass' circuit, indicating that the device is 'out of the water'. A threshold for 'out of the water' can be configured, and is by default 50% of the maximum possible reading. Values above this threshold are considered to be 'out of the water' and invalid.

[0066] When the device is immersed in salt water, the signal level is well below the 'out of the water' threshold for the normal range of ocean water salinity. The selection of R1, which determines the H bridge current level, is such that the normal range of values from ocean water will fall well below the 'out of the water' threshold, and at a value high enough to ensure proper precision and accuracy. A typical raw value might be in the neighborhood of '700' for normal ocean water at 65 degrees Fahrenheit.

[0067] Conductivity through a salt solution is directly proportional to the surface area of the salinity probes, and inversely proportional to the distance between them. Even when an AC current is rapidly pulsed through the salt solution (as it is being done here), some non-linearity can be introduced simply because of the behavior of various ions in the solution. Additionally, since seawater has more than just sodium and chloride ions, these other ions can interfere with the measurements to some extent. So some inaccuracy is inherent in the measurement itself, which can only be accurately performed using chemical means (such as a titration or precipitation measurement). However, when the range of concentration is relatively small, and the non-linearities are properly compensated for, the measurement accuracy can be retained. Further, the 4-conductor probe design with AC signal coupling is well known to be one of the most accurate non-chemical means of determining conductivity and salinity.

[0068] In the pH circuit of FIG. 3, an ISFET is used as the detector, with a standard KCl+Ag reference electrode. The voltage difference between the Gate of the ISFET (which is behind an ionic barrier), and the reference electrode, is generally proportional to the pH of the measured solution, very similar to a glass bulb probe. The operational amplifier U1 regulates the voltage across the Drain and Source of the ISFET, as well as the amount of current flowing through it, maintaining both of them constant, such that the voltage on the Drain accurately tracks the Gate voltage, and therefore the pH.

[0069] In FIG. 3, Q1 and Q2 clamp a PWM signal supplied by the CPU on 'DBINT', which is pin 2 of the daughter board connector. This signal adjusts a reference voltage, which is further filtered and buffered as 'DBIO1' on pin 3 of the daughter board connector. During initial calibration, a 'zero' is performed in which the PWM signal is adjusted to generate a 'zero' result

for a specific pH solution, usually a value below 7.0. This calibration is not critical, but doing it properly improves precision. Measurements on the ISFET Source are buffered via U1b and applied to 'DBIO2' on pin 4 of the daughter board connector. The CPU will then compare DBIO1 to DBIO2, and the resulting differential A/D comparison will become the raw value for pH.

[0070] The calibration process determines how to map the raw pH values as measured from the circuit in FIG. 3. Measurements of known pH and temperature are made, and an appropriate calibration curve is generated on the server that translates the raw pH and temperature values into accurate pH values. Therefore, raw data values are always captured for pH data, and then calibration is applied by the server before displaying the data.

[0071] To improve A/D accuracy, a method is applied by the firmware on the A/D value to change its amplification factor as needed, so that very small values can be measured accurately, while still retaining the ability to measure large values. In one example, the gain can be adjusted from a value of ½ to a value of 64, based on the CPU's capabilities. This extends the 12-bit A/D's capabilities significantly, being able to measure the very small voltages that you would typically have for a pH measurement.

[0072] To improve accuracy, the processor will average pH data sensed over a predetermined period of time (e.g., 0.5 seconds, 1 second, 2 seconds, etc.) before recording the result. This helps to eliminate the effect of external noise on a very high impedence circuit. Noise sources exist on the circuit board itself, as well as external to the device. Assuming that the noise exists and then eliminating its effect helps to ensure proper accuracy.

[0073] Although the present concepts may advantageously utilize a variety of conventional materials for the salinity probe(s), the presently preferred materials for the salinity probe(s) comprise 'blackened' (aka 'platinized') Platinum or Graphite, which have the least potential for chemical reaction in a galvanic cell. Graphite works well with a 4-conductor AC probe, and is the lower cost solution. Many commercial 4-conductor cells use graphite conductors, often in a concentric configuration, where the outer 2 probes couple the AC signal to the inner 2 probes. The appearance is similar to a 'bullseye' on a target, with the outer graphite probe encircling the inner graphite probe on each of two opposing surfaces, and with the ocean water flowing in between the 2 sets of probes. This concentric configuration appears to work best for conductivity measurements, with the graphite probes.

[0074] In each of the above examples of a switch or switches being used to cause a change in state of the sensor device 100, the sensor device may further comprise a timer configured to automatically change the sensor device from the second state to the first state, or from the first

state to the second state, following satisfaction of a respective triggering condition (e.g., motion, change in resistivity, change in conductivity, change in salinity, etc.) or input (e.g., depression of a manually actuated button, magnetic field applied to a hall sensor, etc.), and further following a lapse in a predetermined period of time. Thus, a delay of 5 seconds, 15 seconds, 30 seconds, 1 minute, 2 minutes, 3 minutes, 4 minutes, 5 minutes, or longer periods, or periods intermediate thereto, could be used to ensure that a temporary condition (e.g., a surfboard going airborne or flipping over) doesn't deactivate the device to thereby require reactivation. During such period, the environmental data sensed by the sensor(s) of the sensor device 100 may advantageously be flagged, omitted from storage, or otherwise characterized as suspect.

[0075] To facilitate utilization of the sensor device(s) 100 in a water-sports board (or other water-sports gear, attire, or equipment) to collect environmental data, the sensor device(s) 100 may advantageously comprise at least one water-sports sensor configured to sense movement-based data relating to the water-sports activity. For example, in at least some aspects of the present concepts, the sensor device(s) 100 comprises one or more of a three-axis accelerometer, a three-axis magnetometer, a three-axis gyroscope, or combinations thereof, such water-sports sensor(s) being configured to determine an orientation of the water-sports sensor(s) relative to one another or relative to a mounted position and/or motion of and/or orientation of the water-sports sensor(s) relative to one another or relative to one or more reference points.

[0076] To facilitate the integrity of data collection, the sensor device(s) 100 may comprises a GPS unit configured to enable determination of a location of the sensor(s) devices, wherein the processor(s) of the sensor device(s) are configured, while the at least one switch is in the second state (e.g., on), to determine whether a location of the sensor device(s) corresponds to a nearshore environment and to cause storage of data sensed by the sensor(s) in the memory device only when the location corresponds to a nearshore environment. Such determination could be performed either within the device itself, or in the post-processing of transferred data by the servers. Thus, if a paddle board or a windsurfing board utilizing the sensor device(s) 100 is used both in an inland water body (e.g., a lake) and in a nearshore environment, the collection or display of data from the sensor device(s) would be enabled when the device or servers can verify, using the GPS unit, that the sensor device(s) are disposed in a nearshore environment where such data collection is appropriate. Moreover, such location-based differentiation enables the servers 160 that aggregate data from a plurality of such sensor device(s) 100 (e.g., thousands, tens of thousands, hundreds of thousands) over a plurality of uses of each of such sensor device(s), to parse the environmental data by characteristics such as, but not limited to, distance from the shoreline, latitude, longitude, disposition relative to known man-made or geological

features, depth (where the sensor device(s) comprise a depth gauge, etc.) to appropriately characterize the received data.

[0077] The sensing device(s) 100 optionally, but advantageously, comprises a transmitter 120 disposed within the sensor housing By way of example, one suitable transmitter is the RN42-I/RM Bluetooth/802.15.1 Modules Class 2.1 Bluetooth module w/ antenna, manufactured by Roving Networks of Microchip Technology Inc., Chandler, Arizona, US. The transmitter 120 is configured to transmit sensor data (represented as 130 in FIG. 1) to an external device 140, disposed either locally (e.g., a user's smart phone, a device connected to the transmitter by a personal area network, etc.) or remotely (e.g., directly to a computer or server 160 disposed in a location far from the transmitter as represented by reference numeral 132 in FIG. 1, etc.), in real-time (e.g., on the fly, directly to a user's borne personal electronic device or to a remote device, etc.) and/or at a later time (e.g., post water-sport activity, transmitting sensor data stored in the memory device), depending on selection of transmitter functionality for the sensing device(s).

[0078] In the embodiment depicted in FIG. 1, the transmitter 120 is configured to transmit the sensor data to an external local device, a smart phone 130 as shown, via a Bluetooth connection. Alternatively, the transmitter 120 is configured to transmit the sensor data to an external local device 130, via one or more other types of local wireless (or hardwired) via another communication protocol, such as, but not limited to, spread spectrum frequency-hopping, wifi, xbee, ZigBee, ISA100.11a, WirelessHART, MiWi, or IEEE 802. Of course, in other aspects, the sensor device(s) 100 may simply transmit the sensor data to an external local device 130 (e.g., smart phone, laptop, desk top computer, tablet computer, etc.) via a cord or cable appropriate to a convention I/O port on each of the sensor device 100, or common to a plurality of sensor devices 100, and a respective external local device 130.

[0079] Desirably, the sensing device(s) 100 may implement, in lieu of or in additional to sensor-based modalities that control activation of the sensing device(s) based on sensed physical characteristics of the immediate environment (e.g., salinity, pH, etc.), the processor(s) may be configured to execute instructions stored on the memory devices that cause the processor(s) to determine a status of use by the motion of the sensing device(s) characteristic to such use.

[0080] FIG. 1 is a schematic representing at least some manners of communication and transfer of data from the sensing device(s) 100 transmitter 120 either directly to a remote device (e.g., servers 160) or to an intermediate external device 140 and then to the remote device. The present concepts also include an "Application," hosted by a web server, configured to communicate with user's transmitter 120 or external device 140 (e.g., smart phone, laptop, tablet, watch, other computing device, etc.) and receive the data transmitted from such device,

performing conventional acts such as authenticating the user and ensuring that the data sets are complete, not broken. The application is programmed using any high-level database and/or website application language capable of providing conventional web app service functionality such as, but not limited to, Django, Rails, PHP, and SQL.

[0081] The application is then configured to generate a human-readable file for each data transmission (e.g., a surf session) by converting the uploaded data from a binary format to human-readable format, which is then loaded into a single file to facilitate manipulation by the user. Such file is also advantageously aggregated for the user in a database or library of the user's past data uploads.

[0082] Although the collection of viable or useful environmental data is a primary focus of the present concepts, the present concepts also recognize the desirability for collection of motion-based data and presentation of such motion-based data in a format that provides the user with sports-based performance feedback. By way of example, the sensing device(s) 100 accelerometers, magnetometers, and/or gyroscopes, can graphically represent a surfer's relative motion and orientation at every moment (e.g., depending on the sampling frequency and memory storage limitations and settings) into a global orientation, thereby providing snapshot virtual images of global position and orientation of the surfboard and/or a rendering of the recorded motion of the surfboard in a motion picture format. The application, using such data, could then optionally extrapolate body movements of a surfer from the motion of the surfboard (e.g., using as inputs the length and width of surfboard used, manufacturer of surfboard, model of surfboard, user height, user weight, etc.) and render the body movement of the surfer in a motion picture format. For example, based on a position of and orientation of the surfboard, and velocity of the surfboard, it can be determined if a surfer is riding a wave versus, laying or sitting on the surfboard. The application could also, optionally, extrapolate the changing shape of the wave that was ridden by the surfer from the motion of the surfboard and render the changing shape of the wave in a motion picture format. Thus, the surfer can store, and view, each surf session, reliving each wave of the day (and providing data to show the user's friends just how big or fast that wave really was).

[0083] As to the environmental data, the application is configured, at a minimum, to flag or remove fallacious data. Desirably, but optionally, the application uploads valid data to other websites (e.g., NOAA) for analysis. The application itself, or other applications, is advantageously adapted to analyze the uploaded environmental data, such as, by way of example, but not limitation, to geographically interpolate and extrapolate of oceanographic conditions based on the received data from the sensing device(s) 100, provide near-time-forecast

oceanographic conditions based on recent environmental data uploads, and/or forecast geographic location and time of optimal water sports experience for a participant based on historical environmental data of the individual user or based on historical environmental data of the other users in the general vicinity of the user (or in another selected area of interest to the user).

[0084] In some aspects, the sensing device(s) may be swappable from a first carrier (e.g., surfboard) to a second carrier (e.g., paddle board) or to a third carrier (e.g., sky diving equipment rig) so that a user can obtain sports movement data and environmental data in a plurality of activities.

[0085] Accordingly, the web app available to each user of the sensing device(s) provides a user interface for the users water-sport(s) and provides an archive of "videos", virtual renderings of the user's historical water sports sessions, as well as statistics of historical water sports sessions, summaries of uploads of oceanographic data from other users ("Surf Reports"), near-time-forecasts of oceanographic conditions (e.g., as a supplement to conventional surf reports and NOAA forecasts), and may further provide interfaces and links to amateur and professional organizations associated with various water-sports, as well as to private or governmental science or environmental organizations.

[0086] Each of these embodiments and obvious variations thereof is contemplated as falling within the spirit and scope of the claimed invention, which is set forth in the following claims. Moreover, the present concepts expressly include any and all combinations and sub-combinations of the preceding elements and aspects. Further, it is contemplated that the present concepts may have applicability to other sporting activities and non-sporting activities other than those noted above, such as atmospheric sports (e.g., skydiving), that do not manipulate the natural environment so as to introduce biases into the measured data (e.g., a nearby vehicle or craft could introduce localized heating). In this regard, the present concepts are applicable to installation on boats, such as, but not limited to sailboats, kayaks, and rowboats.

CLAIMS

1. A water-sports board comprising a sensing device configured to collect environmental data, the sensing device comprising:

at least one waterproof sensor housing;

at least one sensor disposed within the at least one sensor housing;

at least one processor disposed within the at least one sensor housing, the at least one processor being communicatively connected to the at least one sensor;

at least one physical memory device disposed within the at least one sensor housing, the at least one memory physical device being communicatively connected with the at least one processor;

at least one switch adapted to change a state of the sensing device between at least a first state and a second state; and

at least one battery configured to power at least one of the at least sensor, the at least one processor, or the at least one memory device,

wherein the sensing device is configured, in the first state, not to store environmental data sensed by the at least one sensor in the at least one physical memory device, and

wherein the sensing device is configured, in the second state, to store environmental data sensed by the at least one sensor in the at least one physical memory device.

2. The water-sports board configured to collect environmental data, in accord with claim 1, further comprising:

a transmitter disposed within the at least one housing,

wherein the at least one battery is further configured to power the transmitter.

3. The water-sports board configured to collect environmental data, in accord with claim 1,

wherein the at least one physical memory device comprises a removable memory device, a non-removable memory device, or both a removable memory device and a non-removable memory device.

4. The water-sports board configured to collect environmental data, in accord with claim 1, further comprising:

an external I/O port.

5. The water-sports board configured to collect environmental data, in accord with claim 1, wherein the water-sports board comprises one of a surfboard, paddle board, skimboard, body board or windsurfing board.

6. The water-sports board configured to collect environmental data, in accord with claim 1, wherein the at least one switch comprises a manually actuatable pressure switch.

7. The water-sports board configured to collect environmental data, in accord with claim 1, wherein the at least one switch is automatically actuated from the first state to the second state responsive to immersion in water.

8. The water-sports board configured to collect environmental data, in accord with claim 7, further comprising:

at least one conductivity or salinity sensor,

wherein the at least one switch is operatively associated with a conductivity or salinity sensor, and is automatically actuated from the first state to the second state responsive to a conductivity change, greater than a predetermined threshold, sensed by the at least one sensor.

9. The water-sports board configured to collect environmental data, in accord with claim 7, further comprising:

at least one motion sensor,

wherein the at least one switch is operatively associated with the motion sensor, and is automatically actuated from the first state to the second state responsive to change in motion, greater than a predetermined threshold, sensed by the at least one sensor.

10. The water-sports board configured to collect environmental data, in accord with claim 1, wherein the at least one switch is automatically actuated from the second state to the first state responsive to removal from water.

11. The water-sports board configured to collect environmental data, in accord with claim 8 or claim 9, further comprising a timer,

wherein the at least one switch is automatically actuated from the second state to the first state responsive to removal from water or lack of motion for a predetermined period of time.

12. The water-sports board configured to collect environmental data, in accord with claim 1, wherein the at least one waterproof sensor housing is disposed within a ventral fin.

13. The water-sports board configured to collect environmental data, in accord with claim 1, wherein the at least one sensor comprises at least one water-sports sensor configured to sense movement-based data relating to the water-sports activity,

wherein the at least one water-sports sensor comprises one or more of a three-axis accelerometer, a three-axis magnetometer, of a three-axis gyroscope, or combinations thereof, the at least one water-sports sensor being configured to determine orientation of the water-sports board, motion of the water-sports board, or both orientation and motion of the water-sports board.

14. The water-sports board configured to collect environmental data, in accord with claim 1, wherein the at least one sensor comprises at least one of one or more temperature sensors, one or more water salinity sensors, one or more conductivity sensors, one or more pH sensors, or any combination thereof.

15. The water-sports board configured to collect environmental data, in accord with claim 2, wherein the transmitter is configured to transmit sensor data from the at least sensor, data from the at least sensor stored in the at least one physical memory device, or both, to an external local device, an external remote device, or both.

16. The water-sports board configured to collect environmental data, in accord with claim 15, wherein the transmitter is configured to transmit the sensor data to an external local device via a Bluetooth, spread spectrum frequency-hopping, wifi, xbee, ZigBee, ISA100.11a, WirelessHART, MiWi, or IEEE 802.15 communication protocol.

17. The water-sports board configured to collect environmental data, in accord with claim 16, wherein the external local device comprises a smartphone or other bluetooth capable computing device

18. The water-sports board configured to collect environmental data, in accord with any one of claims 1-17,

wherein the transmitter is configured to transmit the sensor environmental data, the movement-based data relating to the water-sports activity, or both, to an external remote device comprising a communication device operatively associated with at least one of computer, a server, or a router.

19. The water-sports board configured to collect environmental data, in accord with any one of claims 1-18,

wherein the at least one battery comprises at least one rechargeable battery.

20. The water-sports board configured to collect environmental data, in accord with claim 19,

wherein the at least one rechargeable battery is configured to be recharged inductively.

21. The water-sports board configured to collect environmental data, in accord with any one of claims 2-20,

wherein the at least one sensor comprises a GPS unit, and

wherein the at least one processor is further configured, while the at least one switch is in the second state, to determine whether a location determined by the GPS unit corresponds to a nearshore environment and to cause storage of data sensed by the at least one sensor in the at least one physical memory device only when the location determined by the GPS unit corresponds to a nearshore environment.

22. The water-sports board configured to collect environmental data, in accord with any one of claims 15-19,

wherein the at least one processor is configured to register connection of the at least one rechargeable battery to a power source and, responsive thereto, is further configured to automatically communicatively provide a means by which an external communication device can connect and initiate data transfer from the at least one physical memory device.

23. The water-sports board configured to collect environmental data, in accord with any one of claims 1-20,

wherein the at least one battery comprises a plurality of batteries configured to provide power to all powered elements for between about 2 hours to 8 hours.

24. The water-sports board configured to collect environmental data, in accord with claim 23,

wherein the at least one battery comprises a plurality of batteries configured to provide power to all powered elements for between about 3 hours to 4 hours.

25. The water-sports board configured to collect environmental data, in accord with claim 23,

wherein the at least one battery comprises a plurality of batteries configured to provide a collective rating of at least about 120maH.

26. A waterproof device configured to collect environmental data comprising:

at least one waterproof sensor housing;

at least one sensor disposed within the at least one sensor housing;

at least one processor disposed within the at least one sensor housing, the at least one processor being communicatively connected to the at least one sensor;

at least one physical memory device disposed within the at least one sensor housing, the at least one memory physical device being communicatively connected with the at least one processor;

at least one switch adapted to change a state of the at least sensor between at least a first state and a second state responsive to a manual manipulation of the at least one switch, automatically responsive to at least one triggering event, or either of a manual manipulation of the at least one switch through the at least one waterproof sensor or automatically responsive to at least one triggering event; and

at least one battery configured to power at least one of the at least sensor, the at least one processor, or the at least one memory device,

wherein the first state is an off state and the second state is an on state,

wherein, while in the second state, data sensed by the at least one sensor is stored in the at least one physical memory device, and

wherein the at least one waterproof sensor housing is integrated with a device borne by a person or attached to a device borne by a person.

27. The waterproof device configured to collect environmental data, in accord with claim 26, further comprising:

a transmitter disposed within the at least one housing,

wherein the at least one battery is further configured to power the transmitter.

28. The waterproof device configured to collect environmental data, in accord with claim 26,

wherein the at least one physical memory device comprises a removable memory device, a non-removable memory device, or both a removable memory device and a non-removable memory device.

29. The waterproof device configured to collect environmental data, in accord with claim 26, further comprising:

an external I/O port.

30. The waterproof device configured to collect environmental data, in accord with claim 26, wherein the device borne by a person to which the at least one waterproof sensor housing is integrated comprises an insulated wetsuit, scuba equipment, skin diving equipment, a personal electronic device, or a camera.

31. The waterproof device configured to collect environmental data, in accord with claim 26,

wherein the at least one triggering event comprises a first triggering event of immersion in water and a second triggering event of removal from the water, or

wherein the at least one triggering event comprises a first triggering event of motion above a threshold, and the second triggering event a lack of sufficient motion.

32. The waterproof device configured to collect environmental data, in accord with claim 27,

wherein the at least one sensor comprises a GPS unit, and

wherein the at least one processor is further configured, while the at least one switch is in the second state, to determine whether a location determined by the GPS unit corresponds to a nearshore environment and to cause storage of data sensed by the at least one sensor in the at least one physical memory device only when the location determined by the GPS unit corresponds to a nearshore environment.

33. The waterproof device configured to collect environmental data, in accord with claim 32,

wherein the at least one switch is operatively associated with a conductivity sensor, and

wherein the at least one triggering event comprises a conductivity change greater than a predetermined threshold.

34. The waterproof device configured to collect environmental data, in accord with claim 32,

wherein the at least one switch is operatively associated with a salinity sensor, and

wherein the at least one triggering event comprises a change in salinity greater than a predetermined threshold.

35. The waterproof device configured to collect environmental data, in accord with claim 33 or claim 34, further comprising:

a timer,

wherein the at least one triggering event comprises both a first triggering event of removal from water and a second triggering event of a lapse of a timer initiated responsive to the removal from water.

36. The waterproof device configured to collect environmental data, in accord with any of claims 27-35, further comprising:

a GPS unit to determine a location of the waterproof device.

37. The waterproof device configured to collect environmental data, in accord with claim 26,

wherein the at least one waterproof sensor housing is attached to an insulated wetsuit, scuba equipment, personal electronic device, or camera by a tether.

38. The waterproof device configured to collect environmental data, in accord with claim 26,

wherein the at least one sensor comprises at least one water-sports sensor configured to sense movement-based data relating to the water-sports activity,

wherein the at least one water-sports sensor comprises one or more of a three-axis accelerometer, a three-axis magnetometer, of a three-axis gyroscope, or combinations thereof.

39. The waterproof device configured to collect environmental data, in accord with claim 26,

wherein the at least one sensor comprises at least one of one or more temperature sensors, one or more water salinity sensors, one or more conductivity sensors, or one or more pH sensors, one or more depth sensors, or any combination thereof.

40. The waterproof device configured to collect environmental data, in accord with claim 27,

wherein the transmitter is configured to transmit sensor data from the at least sensor, data from the at least sensor stored in the at least one physical memory device, or both, to an external local device, an external remote device, or both.

41. The waterproof device configured to collect environmental data, in accord with claim 40, wherein the transmitter is configured to transmit the sensor data to an external local device via a Bluetooth, spread spectrum frequency-hopping, wifi, xbee, ZigBee, ISA100.11a, WirelessHART, MiWi, or IEEE 802.15 communication protocol.

42. The waterproof device configured to collect environmental data, in accord with claim 41, wherein the external local device comprises a smartphone or other computing device.

43. The waterproof device configured to collect environmental data, in accord with claim 40, wherein the transmitter is configured to transmit the sensor data to an external remote device comprising a communication device operatively associated with at least one of computer, a server, or a router.

44. The waterproof device configured to collect environmental data, in accord with claim 26, wherein the at least one battery comprises at least one rechargeable battery.

45. The waterproof device configured to collect environmental data, in accord with claim 44, wherein the at least one rechargeable battery is configured to be recharged inductively.

46. The waterproof device configured to collect environmental data, in accord with claim 44, wherein the at least one rechargeable battery is configured to be recharged inductively in accord with the Qi interface standard.

47. The waterproof device configured to collect environmental data, in accord with any one of claims 40-44,

wherein the at least one processor is configured to register connection of the at least one rechargeable battery to a power source and, responsive thereto, is further configured to automatically communicatively provide a means by which an external communication device can connect and initiate data transfer from the at least one physical memory device.

48. The waterproof device configured to collect environmental data, in accord with any one of claims 26-46,

wherein the at least one battery comprises a plurality of batteries configured to provide power to all powered elements for between about 2 hours to 8 hours.

49. The waterproof device configured to collect environmental data, in accord with claim 48,

wherein the at least one battery comprises a plurality of batteries configured to provide power to all powered elements for between about 3 hours to 4 hours.

50. The waterproof device configured to collect environmental data, in accord with any one of claims 26-49,

wherein the at least one battery is configured to output at least about 120maH.

51. A method for collecting environmental data, comprising the acts of:

integrating a waterproof environmental data sensing device comprising one or more sensors, at least one processor, at least one battery and at least one physical memory device into water-sports equipment adapted for use in a water-sports activity;

activating the environmental data sensing device prior to or during initiation of the water-sports activity to enable collection of environmental data during the water-sports activity;

collecting environmental data using the one or more sensors during the water-sports activity; and

transmitting the environmental data to a central server via at least one communication device,

wherein the environmental data comprises at least one of a water temperature, a water salinity, a water conductivity, a water pH, or any combination thereof.

52. The method for collecting environmental data according to claim 51,

wherein the environmental data sensing device further comprises at least one switch adapted to cause the activating of the environmental data sensing device by changing a state of the environmental data sensing device between a first state and a second state,

wherein, in the first state, the at least one processor does not store environmental data sensed by the at least one sensor in the at least one physical memory device, and

wherein, in the second state, the at least one processor is configured at least to store environmental data sensed by the at least one sensor in the at least one physical memory device.

53. The method for collecting environmental data according to claim 51,

wherein the at least one communication device comprises a transmitter,

wherein the environmental data sensing device further comprises at least one switch adapted to cause the activating of the environmental data sensing device by changing a state of the environmental data sensing device between a first state and a second state,

wherein, in the first state, the transmitter is disabled, and

wherein, in the second state, the transmitter is activated and the at least one processor is configured to use the transmitter to transmit the environmental data to an external device.

54. The method for collecting environmental data according to one of claims 52 or 53,

wherein the at least one physical memory device comprises a removable memory device, a non-removable memory device, or both a removable memory device and a non-removable memory device.

55. The method for collecting environmental data according to claim 54, wherein the water-sports activity comprises surfing, paddle boarding, skimboarding, body boarding or windsurfing.

56. The method for collecting environmental data according to claim 55,

wherein the act of activating the environmental data sensing device prior to or during the water-sports activity comprises an act of manually activating the at least one switch.

57. The method for collecting environmental data according to claim 55,

wherein the act of activating the environmental data sensing device comprises automatically activating the environmental data sensing device responsive to an initiation of the water-sports activity.

58. The method for collecting environmental data according to claim 57, further comprising:

automatically deactivating the environmental data sensing device, to stop collection of environmental data, responsive to a termination of the water-sports activity.

59. The method for collecting environmental data according to claim 58,

wherein the act of automatically activating the environmental data sensing device is triggered responsive to a first triggering condition relating to a first change in a conductivity change or a salinity change sensed by the one or more sensors, or by motion above a specified threshold as sensed by the one or more sensors, and

wherein the act of automatically deactivating the environmental data sensing device is triggered responsive to a second triggering condition relating to a second change in a conductivity change or a salinity change sensed by the one or more sensors, or a lack of sufficient motion for a specified period of time as sensed by the one or more sensors.

60. The method for collecting environmental data according to claim 59,

wherein the environmental data sensing device comprises at least one timing device, and

wherein the at least one timing device automatically delays the act of automatically deactivating the environmental data sensing device, the act of automatically activating the environmental data sensing device, or both, for a predetermined period of time following an occurrence of the first or second triggering condition.

61. The method for collecting environmental data according to claim 51,

wherein the at least one waterproof sensor housing is disposed within a ventral fin of a surfboard, paddle board, or windsurfing board.

62. The method for collecting environmental data according to claim 61,

wherein the at least one sensor comprises at least one water-sports sensor configured to sense movement-based data relating to the water-sports activity,

wherein the at least one water-sports sensor comprises one or more of a three-axis accelerometer, a three-axis magnetometer, of a three-axis gyroscope, or combinations thereof, the at least one water-sports sensor being configured to determine orientation of at least the ventral fin within space.

63. The method for collecting environmental data according to claim 61,

wherein the at least one sensor comprises at least one water-sports sensor configured to sense movement-based data relating to the water-sports activity,

wherein the at least one water-sports sensor comprises one or more of a three-axis accelerometer, a three-axis magnetometer, of a three-axis gyroscope, or combinations thereof, the at least one water-sports sensor being configured to determine orientation of the environmental data sensing device, and appurtenant surfaces, in space.

64. The method for collecting environmental data according to any one of claims 51-63,

wherein the at least one sensor comprises at least one of one or more temperature sensors, one or more water salinity sensors, one or more conductivity sensors, one or more pH sensors, or any combination thereof.

65. The method for collecting environmental data according to any one of claims 53-64,

wherein the transmitter is configured to transmit sensor data comprising environmental data, movement-based data, or both, from the at least one physical memory device, to an external local device, an external remote device, or both.

66. The method for collecting environmental data according to claim 65,

wherein the transmitter is configured to transmit the sensor data to an external local device via a Bluetooth, spread spectrum frequency-hopping, wifi, xbee, ZigBee, ISA100.11a, WirelessHART, MiWi, or IEEE 802.15 communication protocol.

67. The method for collecting environmental data according to claim 65,

wherein the external local device comprises a smartphone or other computing device.

68. The method for collecting environmental data according to claim 65,

wherein the transmitter is configured to transmit the sensor data to an external remote device comprising a communication device operatively associated with at least one of computer, a server, or a router.

69. The method for collecting environmental data according to any one of claims 51-68,

wherein the at least one battery comprises at least one rechargeable battery.

70. The method for collecting environmental data according to claim 69,

wherein the at least one rechargeable battery is configured to be recharged inductively.

71. The method for collecting environmental data according to claim 52,

wherein the at least one sensor comprises a GPS unit, and

wherein the at least one processor is further configured, while the environmental data sensing device is in the second state, to determine whether a location determined by the GPS unit corresponds to a nearshore environment and to cause storage of data sensed by the at least

one sensor in the at least one physical memory device only when the location determined by the GPS unit corresponds to a nearshore environment.

72. The method for collecting environmental data in accord with any one of claims 53-71, further comprising the acts of:

docking the environmental data sensing device in a charging port;

communicatively connecting the at least one physical memory device of the environmental data sensing device to an external communication device responsive to the docking of the environmental data sensing device in the charging port, and

transferring sensor data comprising environmental data, movement-based data, or both, stored in the at least one physical memory device from the environmental data sensing device to the external communication device.

73. The method for collecting environmental data in accord with any one of claims 53-70,

wherein the at least one battery comprises a plurality of batteries configured to provide power to all powered elements for between about 2 hours to 8 hours.

74. The method for collecting environmental data in accord with any one of claims 53-70,

wherein the at least one battery comprises a plurality of batteries configured to provide power to all powered elements for between about 3 hours to 4 hours.

75. The method for collecting environmental data in accord with any one of claims 53-70,

wherein the at least one battery is configured to output at least about 120maH.

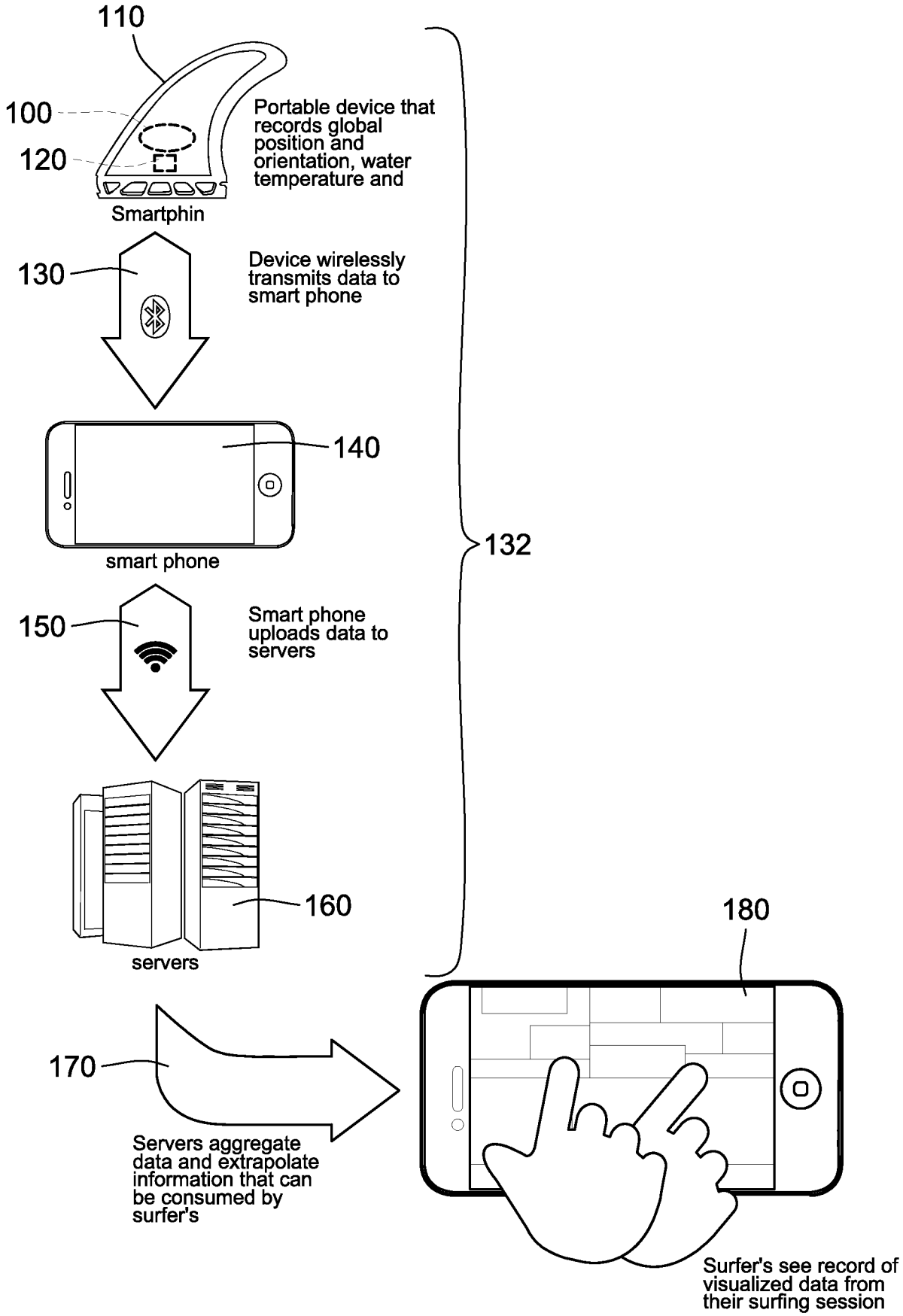

110
100
120
Portable device that records global position and orientation, water temperature and
Smartphin
130
Device wirelessly transmits data to smart phone
140
smart phone
132
150
Smart phone uploads data to servers
160
servers
180
170
Servers aggregate data and extrapolate information that can be consumed by surfer's
Surfer's see record of visualized data from their surfing session

FIG. 1

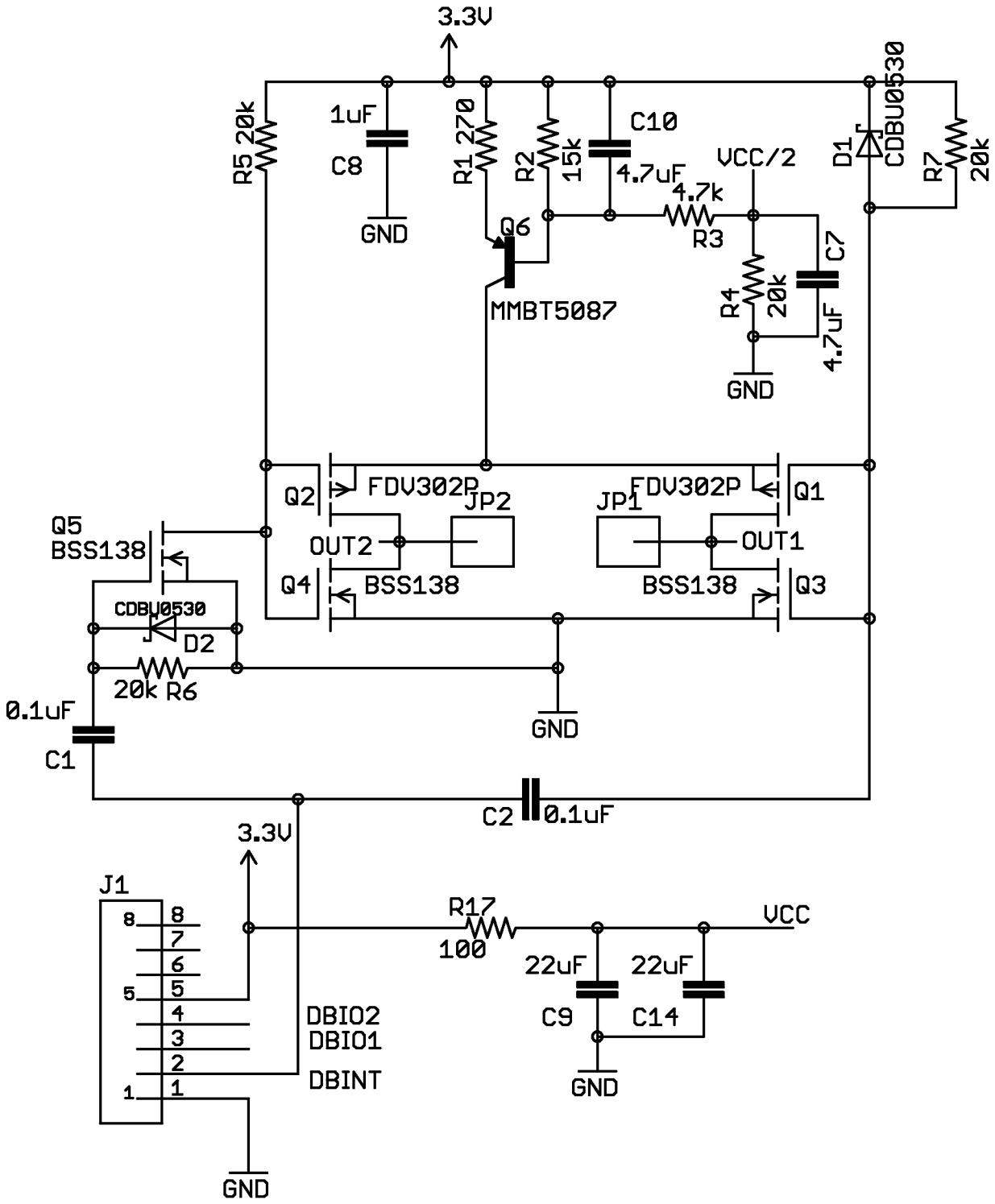

3.3V
R5 20k
1uF
C8
GND
R1 270
R2 15k
C10
4.7uF
Q6
MMBT5087
VCC/2
4.7k
R3
R4 20k
C7
4.7uF
GND
D1 CDBU0530
R7 20k
Q2 FDV302P
JP2
OUT2
Q4 BSS138
JP1 FDV302P Q1
OUT1
BSS138 Q3
Q5 BSS138
CDBU0530
D2
20k R6
0.1uF
C1
GND
C2 0.1uF
3.3V
J1
DBIO2
DBIO1
DBINT
GND
R17
100
VCC
22uF
C9
22uF
C14
GND

FIG. 2A

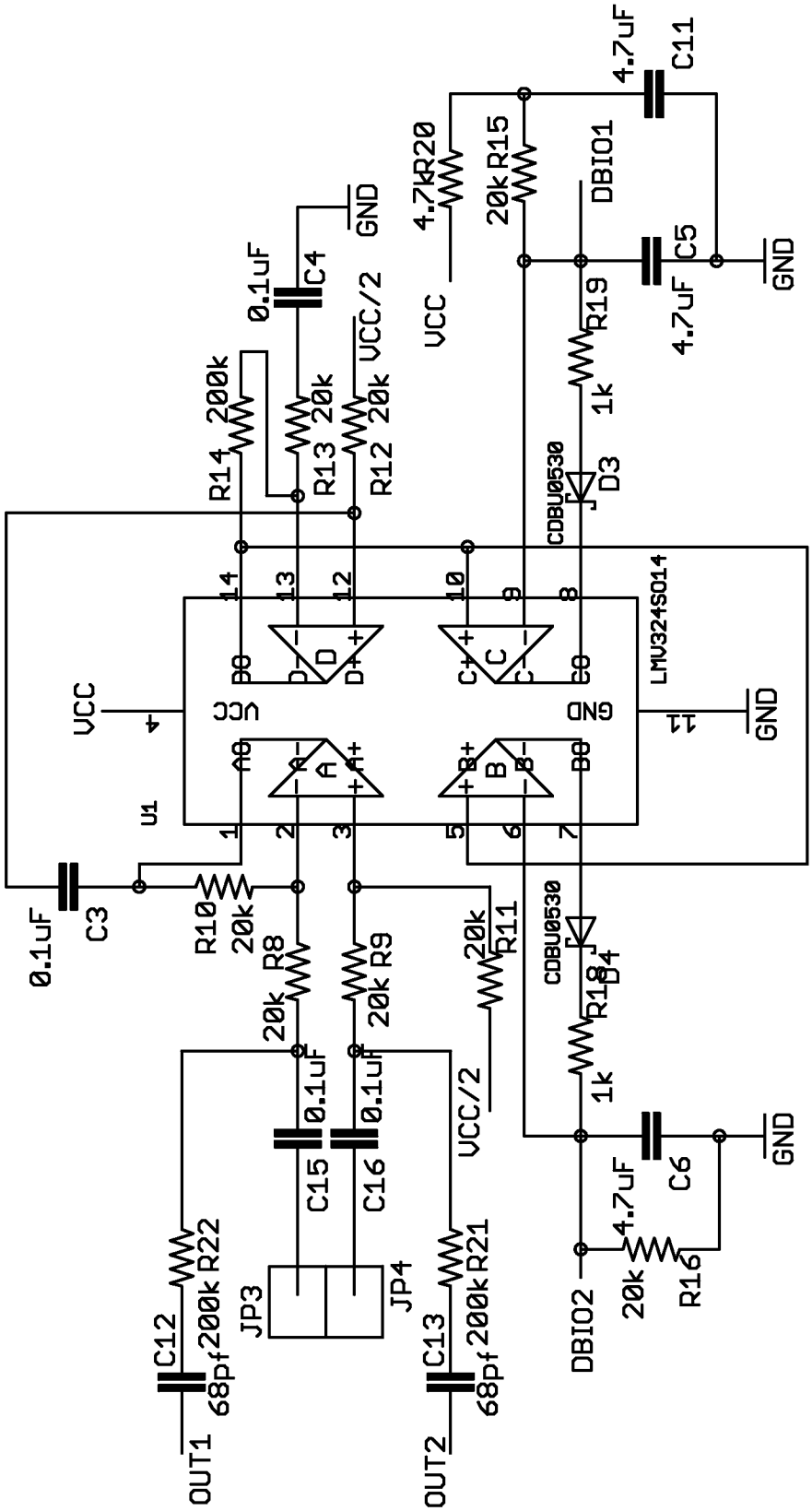

U1
LMV324SO14
VCC
GND
VCC/2
0.1uF
C3
C4
4.7uF
C11
C5
C6
R10 20k
R8 20k
R9 20k
R11 20k
R12 20k
R13 20k
R14 200k
R15 20k
R16 20k
R18 1k
R19 1k
R20 4.7k
R21 200k
R22 200k
C12 68pf
C13 68pf
C15 0.1uF
C16 0.1uF
JP3
JP4
D3 CDBU0530
D4 CDBU0530
DBIO1
DBIO2
OUT1
OUT2

FIG. 2B

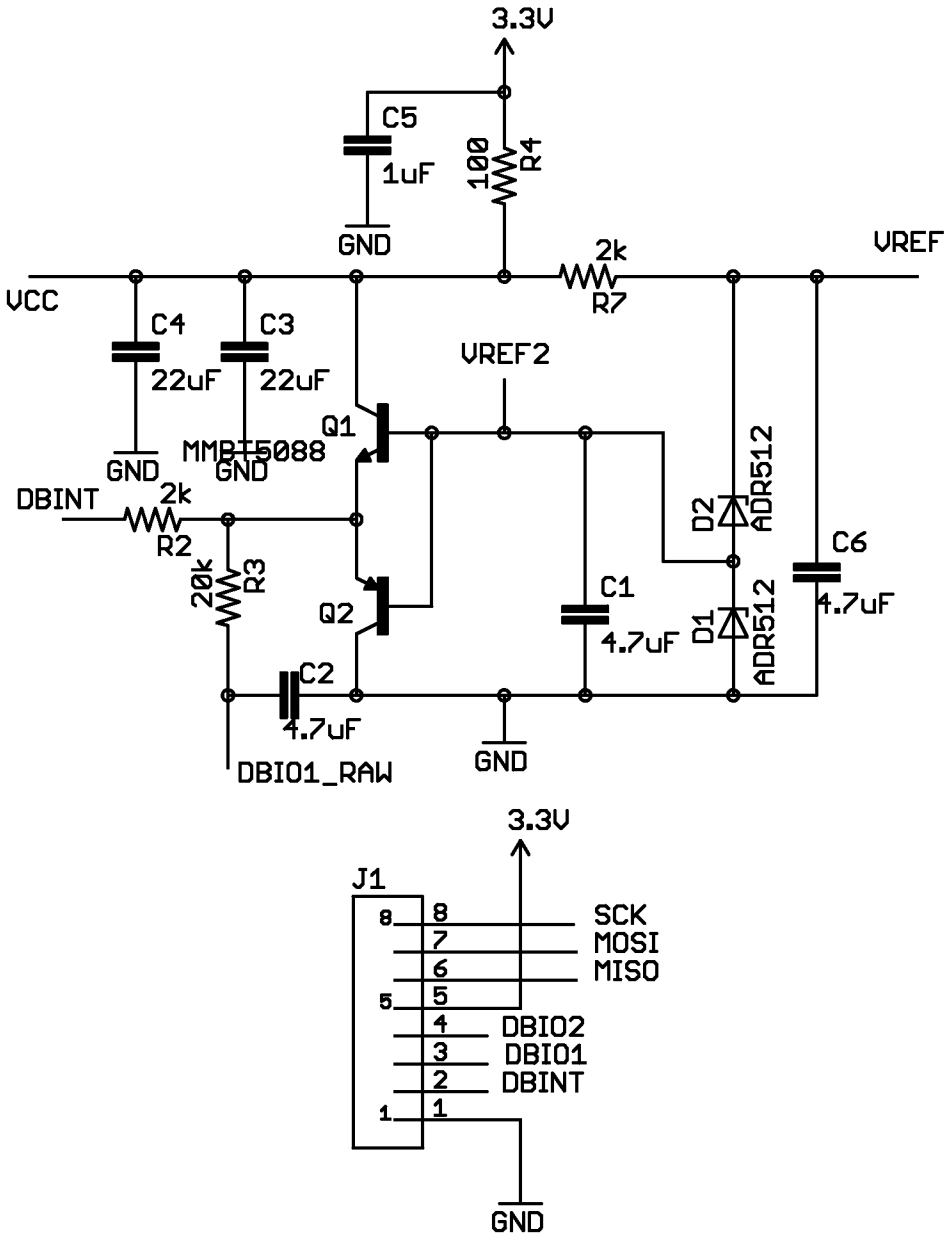

3.3V
C5
1uF
100
R4
GND
2k
R7
VREF
VCC
C4
22uF
C3
22uF
VREF2
Q1
MMBT5088
GND
GND
DBINT
2k
R2
20k
R3
Q2
C1
4.7uF
D2
ADR512
D1
ADR512
C6
4.7uF
C2
4.7uF
GND
DBIO1_RAW
3.3V
J1
8
7
6
5
4
3
2
1
SCK
MOSI
MISO
DBIO2
DBIO1
DBINT
GND

FIG. 3A

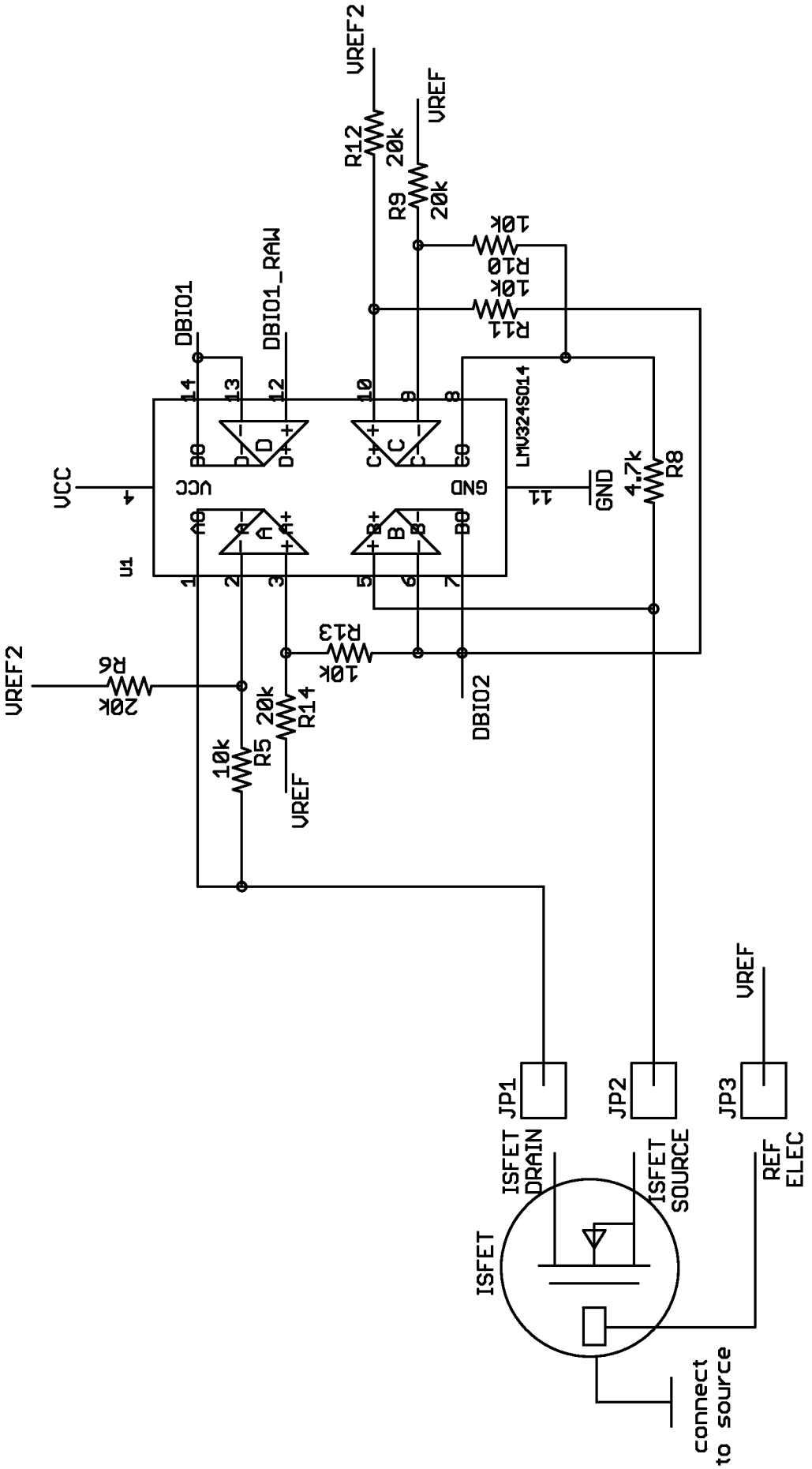

VREF2
R12
20k
VREF
R9
20k
10K
R10
10K
R11
DBIO1
DBIO1_RAW
LMV324SO14
VCC
GND
4.7k
R8
U1
R13
10K
VREF2
R6
20K
20k
R14
10k
R5
VREF
DBIO2
JP1
JP2
JP3
VREF
ISFET DRAIN
ISFET SOURCE
REF ELEC
ISFET
connect to source

FIG. 3B

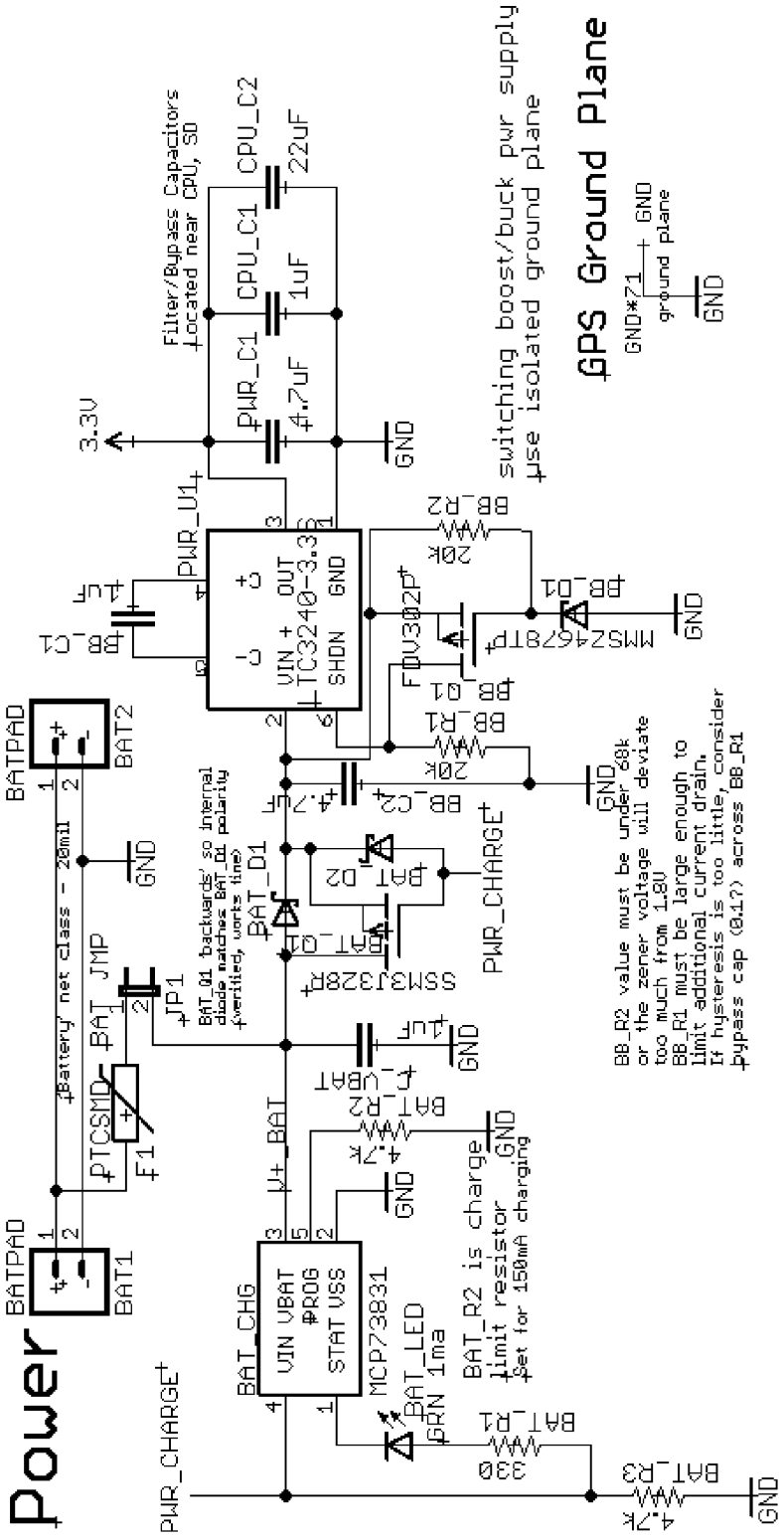

Power
GPS Ground Plane
switching boost/buck pwr supply
use isolated ground plane
Filter/Bypass Capacitors
located near CPU, SD
3.3V
PWR_C1
4.7uF
CPU_C1
1uF
CPU_C2
22uF
GND
PWR_U1
TC3240-3.3
VIN + OUT
SHDN GND
BB_C1
BB_R2
20K
BB_D1
MMSZ4678T1
FDV302P
BB_Q1
BB_R1
20K
BB_C2
4.7
BATPAD
BAT2
BAT1
'Battery' net class - 20mil
BAT_JMP
JP1
PTCSMD
F1
BAT_D1
BAT_Q1
SSM3J328R
BAT_D2
PWR_CHARGE
BAT_C1
1uF
BAT_R2
4.7K
BAT_R2 is charge
limit resistor
set for 150mA charging
V+_BAT
BAT_CHG
VIN VBAT
PROG
STAT VSS
MCP73831
BAT_LED
GRN 1ma
BAT_R1
330
BAT_R3
4.7K
BB_R2 value must be under 68k
or the zener voltage will deviate
too much from 1.8V
BB_R1 must be large enough to
limit additional current drain.
If hysteresis is too little, consider
bypass cap (B17) across BB_R1
GND*71
ground plane

FIG. 4A

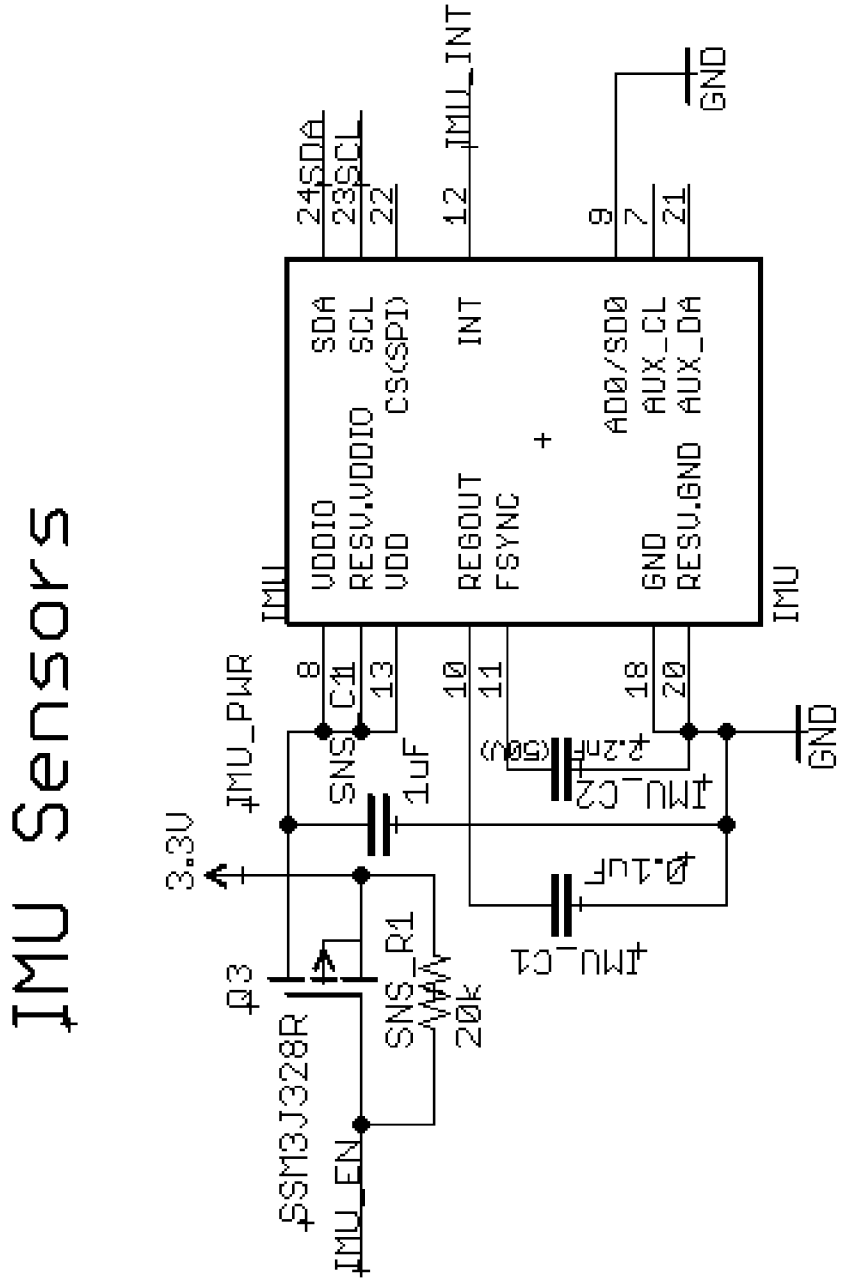

IMU Sensors
IMU
VDDIO
RESV.VDDIO
VDD
SDA
SCL
CS(SPI)
INT
REGOUT
FSYNC
GND
RESV.GND
AD0/SD0
AUX_CL
AUX_DA
24SDA
23SCL
22
12 IMU_INT
9
7
21
GND
IMU_PWR
8
SNS_C1
13
1uF
10
11
18
20
GND
3.3V
Q3
SSM3J328R
IMU_EN
SNS_R1
20k
IMU_C1
0.1uF
IMU_C2
2.2nF

FIG. 4B

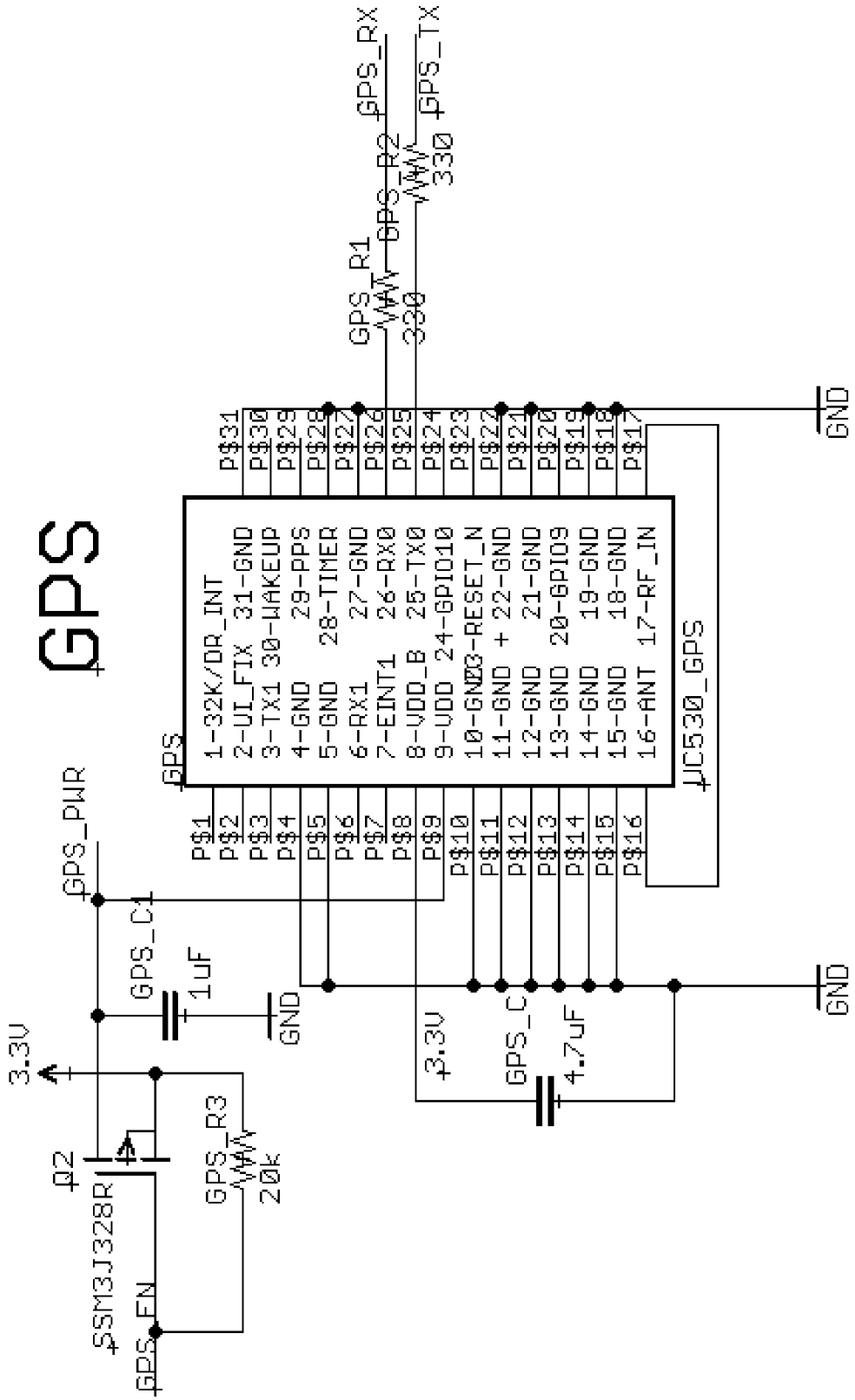

GPS
GPS_PWR
GPS_C1
1uF
GND
3.3V
Q2
SSM3J328R
GPS_EN
GPS_R3
20k
GPS_R1
330
GPS_R2
330
GPS_RX
GPS_TX
GPS
1-32K/DR_INT
2-UI_FIX
3-TX1
4-GND
5-GND
6-RX1
7-EINT1
8-VDD_B
9-VDD
10-GND
11-GND
12-GND
13-GND
14-GND
15-GND
16-ANT
31-GND
30-WAKEUP
29-PPS
28-TIMER
27-GND
26-RX0
25-TX0
24-GPIO10
23-RESET_N
22-GND
21-GND
20-GPIO9
19-GND
18-GND
17-RF_IN
UC530_GPS
GPS_C
4.7uF

FIG. 4C

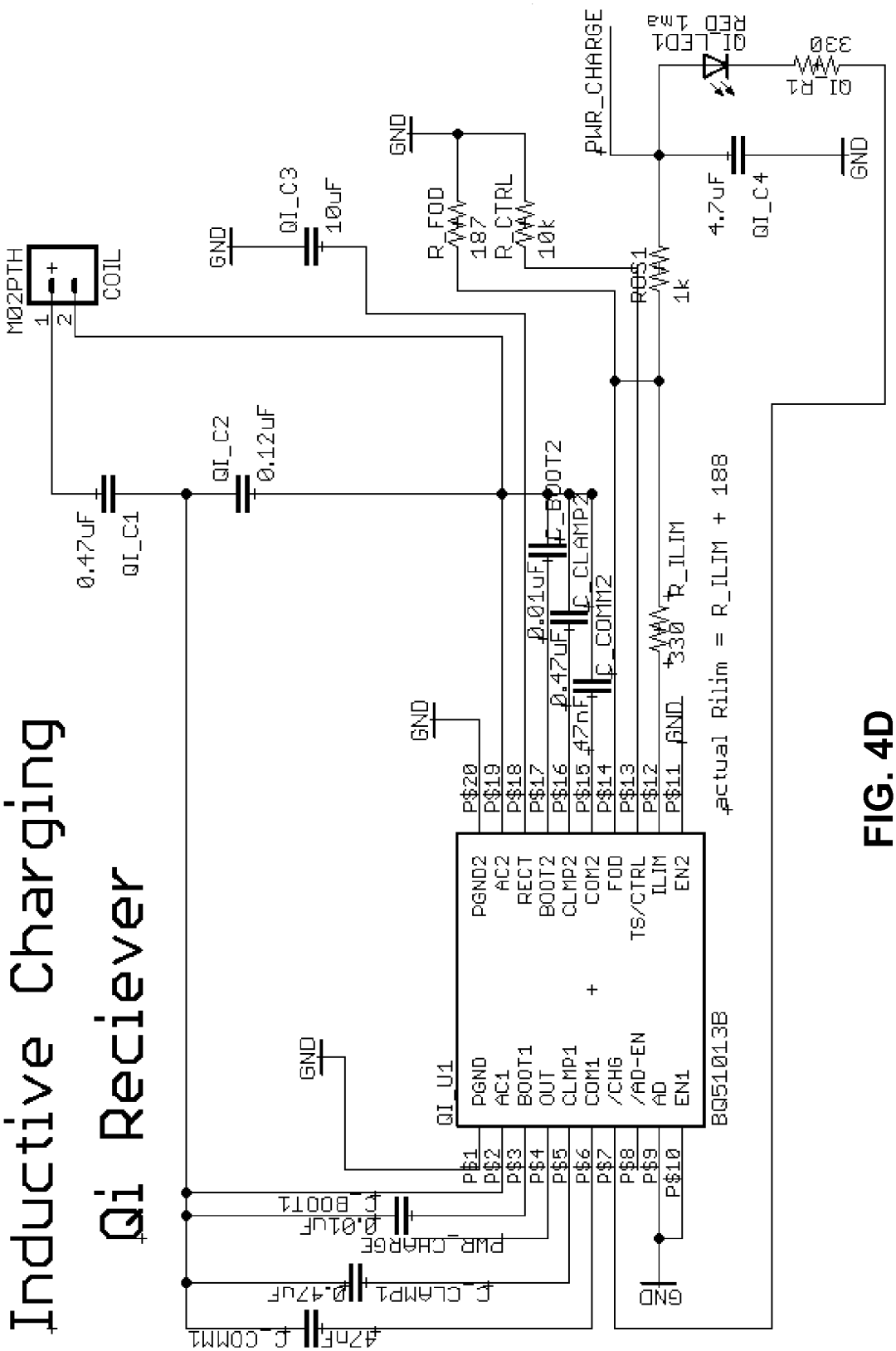

Inductive Charging
Qi Reciever
M02PTH
COIL
QI_C1
0.47uF
QI_C2
0.12uF
QI_C3
10uF
R_FOD
187
R_CTRL
10k
R_ILIM
330
R051
1k
QI_C4
4.7uF
PWR_CHARGE
QI_LED1
QI_R1
330
GND
QI_U1
BQ51013B
PGND
AC1
BOOT1
OUT
CLMP1
COM1
/CHG
/AD-EN
AD
EN1
PGND2
AC2
RECT
BOOT2
CLMP2
COM2
FOD
TS/CTRL
ILIM
EN2
C_BOOT2
0.01uF
C_CLAMP2
0.47uF
C_COMM2
47nF
actual Rilim = R_ILIM + 188
C_BOOT1
0.01uF
PWR_CHARGE
C_CLAMP1
0.47uF
C_COMM1
47nF

FIG. 4D

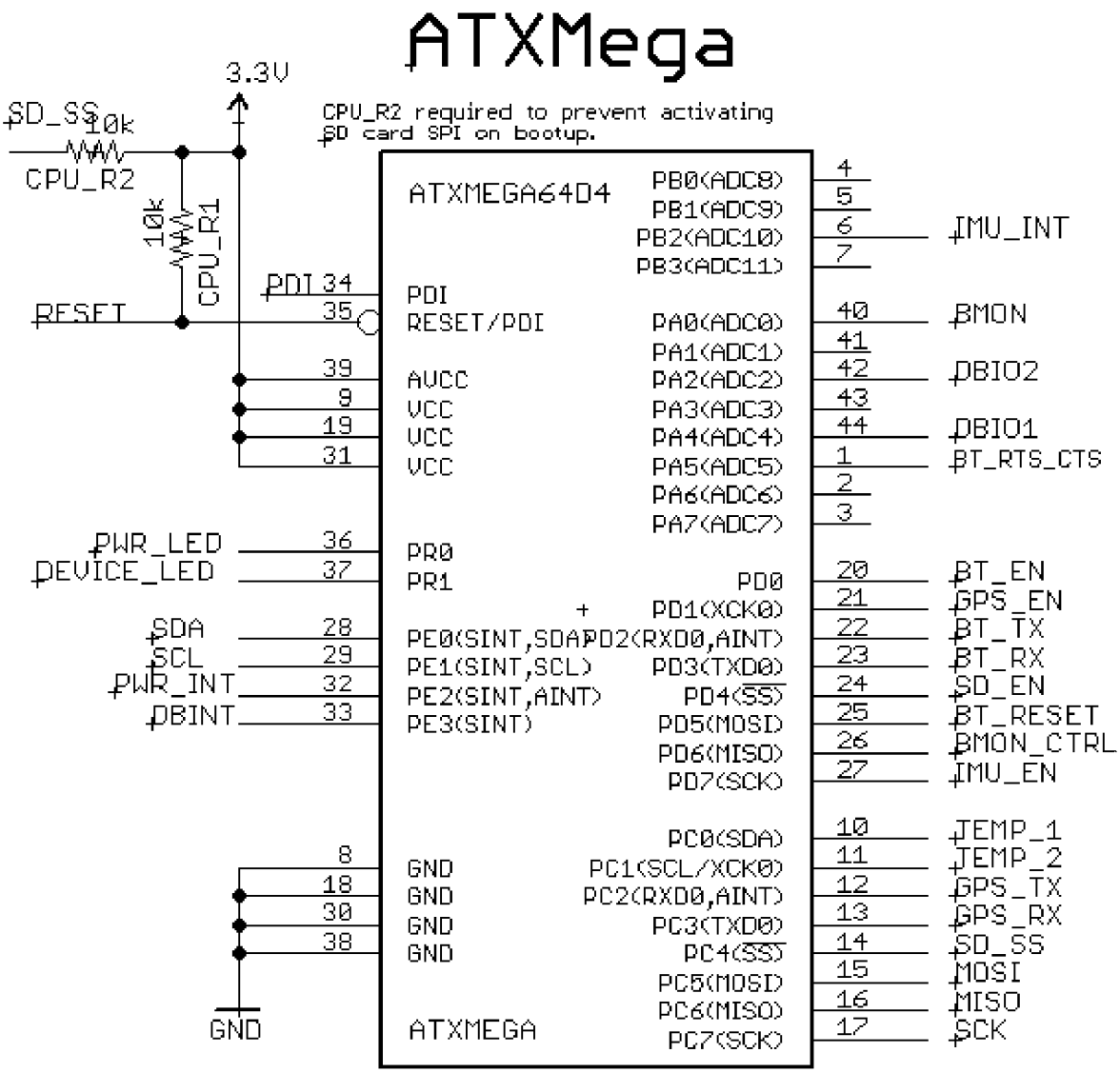

ATXMega
3.3V
SD_SS
10k
CPU_R2
10k
CPU_R1
RESET
PDI
CPU_R2 required to prevent activating SD card SPI on bootup.
ATXMEGA64D4
PDI 34
35
39
9
19
31
PWR_LED 36
DEVICE_LED 37
SDA 28
SCL 29
PWR_INT 32
DBINT 33
8
18
30
38
GND
PB0(ADC8)
PB1(ADC9)
PB2(ADC10)
PB3(ADC11)
PDI
RESET/PDI
AVCC
VCC
VCC
VCC
PR0
PR1
PE0(SINT,SDA)
PE1(SINT,SCL)
PE2(SINT,AINT)
PE3(SINT)
PA0(ADC0)
PA1(ADC1)
PA2(ADC2)
PA3(ADC3)
PA4(ADC4)
PA5(ADC5)
PA6(ADC6)
PA7(ADC7)
PD0
PD1(XCK0)
PD2(RXD0,AINT)
PD3(TXD0)
PD4(SS)
PD5(MOSI)
PD6(MISO)
PD7(SCK)
PC0(SDA)
PC1(SCL/XCK0)
PC2(RXD0,AINT)
PC3(TXD0)
PC4(SS)
PC5(MOSI)
PC6(MISO)
PC7(SCK)
ATXMEGA
4
5
6
7
40
41
42
43
44
1
2
3
20
21
22
23
24
25
26
27
10
11
12
13
14
15
16
17
IMU_INT
BMON
DBIO2
DBIO1
BT_RTS_CTS
BT_EN
GPS_EN
BT_TX
BT_RX
SD_EN
BT_RESET
BMON_CTRL
IMU_EN
TEMP_1
TEMP_2
GPS_TX
GPS_RX
SD_SS
MOSI
MISO
SCK

FIG. 4E

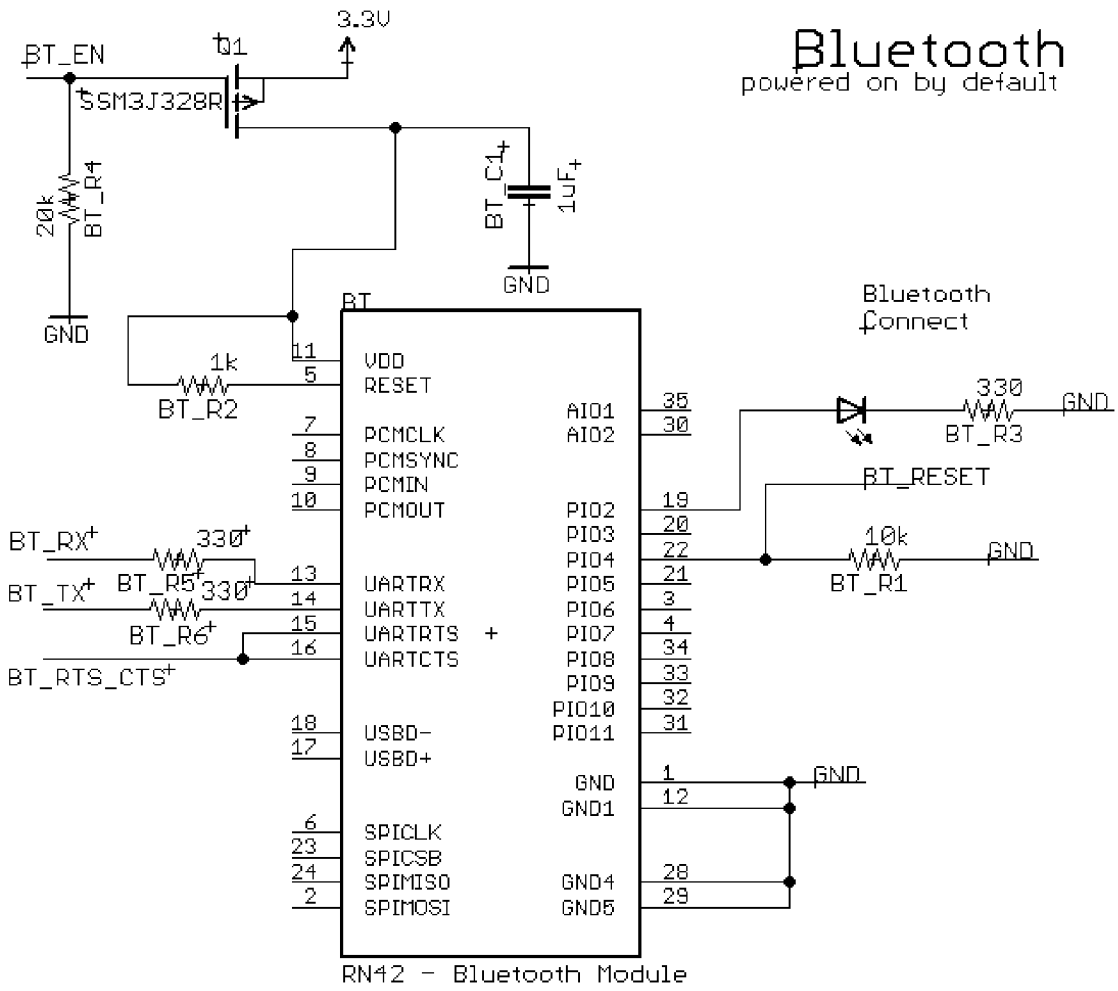

Bluetooth
powered on by default
3.3V
BT_EN
Q1
SSM3J328R
20k
BT_R4
BT_C4
1uF
GND
BT
1k
BT_R2
VDD
RESET
PCMCLK
PCMSYNC
PCMIN
PCMOUT
UARTRX
UARTTX
UARTRTS
UARTCTS
USBD-
USBD+
SPICLK
SPICSB
SPIMISO
SPIMOSI
AIO1
AIO2
PIO2
PIO3
PIO4
PIO5
PIO6
PIO7
PIO8
PIO9
PIO10
PIO11
GND
GND1
GND4
GND5
Bluetooth
Connect
330
BT_R3
BT_RESET
10k
BT_R1
BT_RX
BT_R5
BT_TX
BT_R6
BT_RTS_CTS
RN42 - Bluetooth Module

FIG. 4F

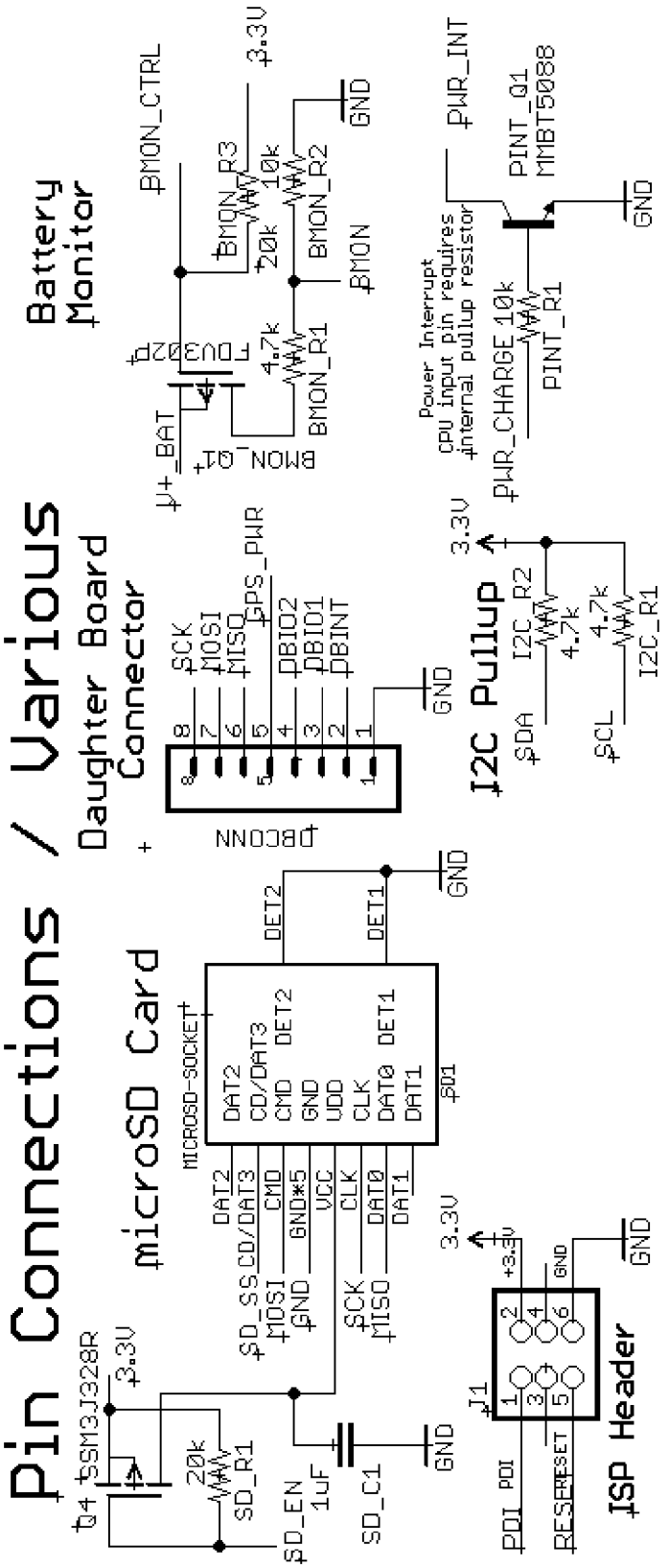

Pin Connections / Various
Battery Monitor
Daughter Board Connector
microSD Card
I2C Pullup
ISP Header
BMON_CTRL
BMON_R3
BMON_R2
BMON_R1
BMON
BMON_Q1
3.3V
GND
PWR_INT
PINT_Q1
MMBT5088
PINT_R1
PWR_CHARGE 10k
Power Interrupt
CPU input pin requires
internal pullup resistor
SCK
MOSI
MISO
GPS_PWR
GBIO2
GBID1
GBINT
DBCONN
SDA
SCL
I2C_R2
I2C_R1
MICROSD-SOCKET
DAT2
CD/DAT3
CMD
GND
VDD
CLK
DAT0
DAT1
DET2
DET1
SD_SS
VCC
GND*5
SD_EN
SD_C1
SD_R1
SSM3J328R
PDI
RESET
J1

FIG. 4G

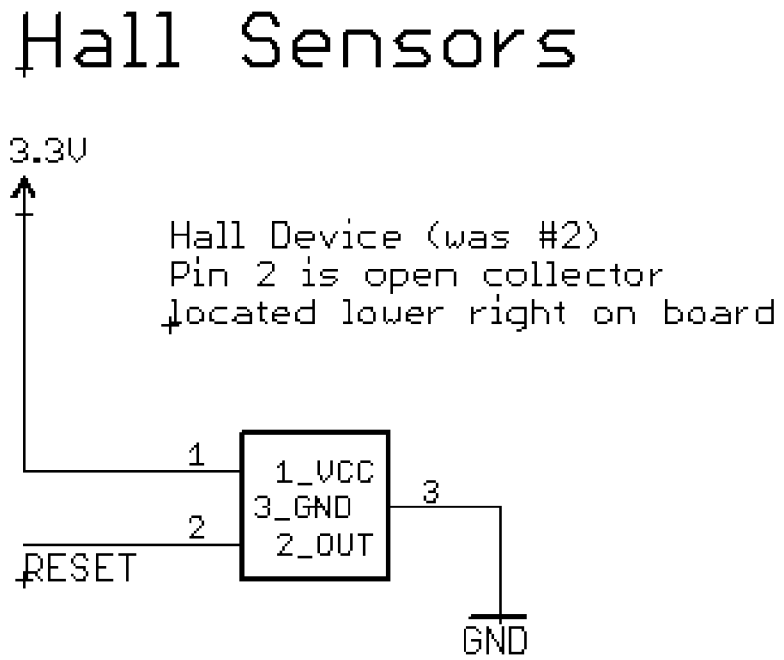

Hall Sensors
3.3V
Hall Device (was #2)
Pin 2 is open collector
located lower right on board
1
2
1_VCC
3_GND
2_OUT
3
RESET
GND

FIG. 4H

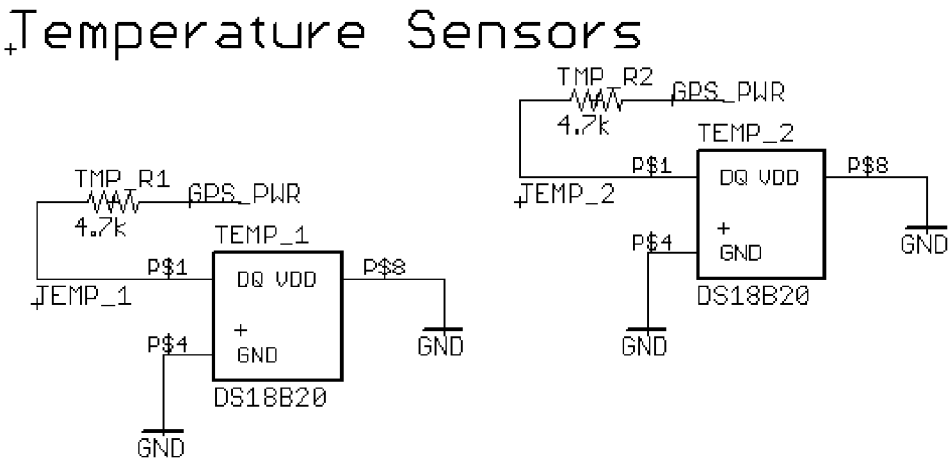

Temperature Sensors
TMP_R1
4.7k
GPS_PWR
TEMP_1
P$1
DQ VDD
P$8
TEMP_1
+
GND
P$4
GND
DS18B20
GND
TMP_R2
4.7k
GPS_PWR
TEMP_2
P$1
DQ VDD
P$8
TEMP_2
+
GND
P$4
GND
DS18B20
GND

FIG. 4I

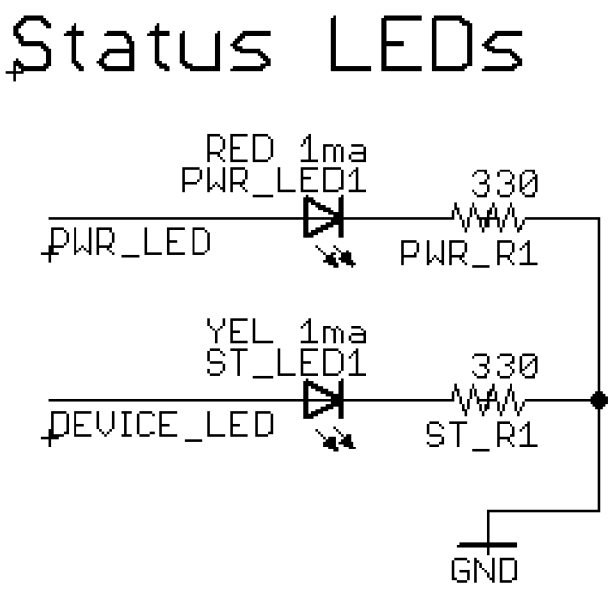

Status LEDs
RED 1ma
PWR_LED1
330
PWR_LED
PWR_R1
YEL 1ma
ST_LED1
330
DEVICE_LED
ST_R1
GND

FIG. 4J

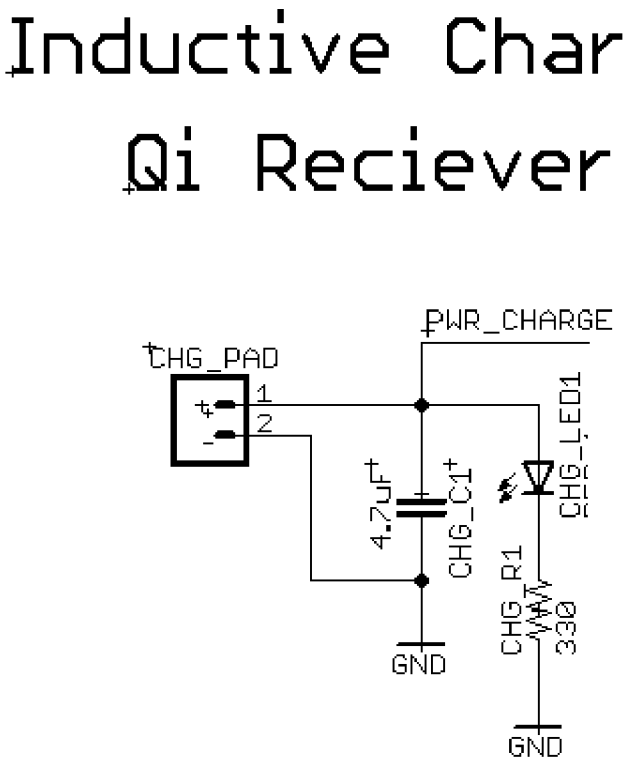

Inductive Charging
Qi Reciever
PWR_CHARGE
CHG_PAD
1
2
4.7uF
CHG_C1
CHG_LED1
CHG_R1
330
GND
GND

FIG. 4K

Qty	Value	Device	Package	Parts	Description
1	2.2nF (50V)	CAP0603-CAP	0603-CAP	IMU_C2	Capacitor
1	0.1uF	CAP0603-CAP	0603-CAP	IMU_C1	Capacitor
7	1uF	CAP0603-CAP	0603-CAP	BB_C1, BT_C1, CPU_C1, C_VBAT, GPS_C1, SD_C1, SNS_C1	Capacitor
4	4.7uF	CAP0603-CAP	0603-CAP	BB_C2, CHG_C1, GPS_C2, PWR_C1	Capacitor
1	22uF	CAP0603-CAP	0603-CAP	CPU_C2	Capacitor
9	330 ohm	RESISTOR0603-RES	0603-RES	BAT_R1, BT_R3, BT_R5, BT_R6, CHG_R1, GPS_R1, GPS_R2, PWR_R1, ST_R1	Resistor
1	1k	RESISTOR0603-RES	0603-RES	BT_R2	Resistor
7	4.7k	RESISTOR0603-RES	0603-RES	BAT_R2, BAT_R3, BMON_R1, I2C_R1, I2C_R2, TMP_R1, TMP_R2	Resistor
5	10k	RESISTOR0603-RES	0603-RES	BMON_R2, BT_R1, CPU_R1, CPU_R2, PINT_R1	Resistor
7	20k	RESISTOR0603-RES	0603-RES	BB_R1, BB_R2, BMON_R3, BT_R4, GPS_R3, SD_R1, SNS_R1	Resistor
1	LTC3240-3.3S	LTC3240-3.3S	6-DFN	PWR_U1	Boost/Buck 3.3v regulator
2	DS18B20	DS18B20	8-USOP	TEMP_1, TEMP_2	Temperature sensor
2	RED 1ma	LED0603	LED-0603	CHG_LED1, PWR_LED1	Red LED
2	GRN 1ma	LED0603	LED-0603	BAT_LED, BT_LED1	Green LED
1	YEL 1ma	LED0603	LED-0603	ST_LED1	Yellow LED
1	PTCSMD	PTCSMD	PTC-1206	F1	Resettable Fuse PTC
1	IMU	MPU-9250	MPU-9250	IMU	IMU 9-axis sensor
1	RN42 - Bluetooth Module	RN42	RN42	BT	Bluetooth module
1	MMBT5088	TRANSISTOR_NPNSOT23-3	SOT23-3	PINT_Q1	Generic NPN BJT SOT-23 case
1	AH183-WG	AH183-WG	SOT23	HALL_1	Hall Device
2	FDV302P	FDV302P	SOT23-3	BB_Q1, BMON_Q1	P-Channel Enhancement MOSFET -200V; -0,15A; 11Ohm
1	MCP73831	MCP73831	SOT23-5	BAT_CHG	Microchip's MCP73831
1	ATXMEGA64D4	ATXMEGAXX-44PIN	TQFP44	ATXMEGA	CPU ATXMega64D4
5	SSM3J328R	SSM3J328R	SOT23-3	BAT_Q1, Q1, Q2, Q3, Q4	P-Channel Enh MOSFET SSM3J328R 20V 6A 1.5VGSth
2	CDBU0530	CDBU0530	0603-DIODE	BAT_D1, BAT_D2	0.5A 20V SCHOTTKY BARRIER RECTIFIER
1	MMSZ4678TP	MMSZ4678TP	SOD123FL	BB_D1	Reference DIODE
1	UC530_GPS	UC530_GPS	FASTRAX_UC530C4322	GPS	Fastrax UC530 GPS Module
1	MICROSD-SOCKET	MICROSD-SOCKET	MOLEX-104031-0811	SD1	MicroSD card socket with card detect

FIG. 5A

SUBSTITUTE SHEET (RULE 26)

Item #	Qty	RefDes	Part No.	Description	Package	Type
1	1	IMU_C2	399-1085-1-ND	CAP 2.2nF (50V)	0603-CAP	smt
2	1	IMU_C1	445-5666-1-ND	CAP 0.1uF	0603-CAP	smt
3	7	BB_C1, BT_C1, CPU_C1, C_VBAT, GPS_C1, SD_C1, SNS_C1	445-13234-1-ND	CAP 1uF	0603-CAP	smt
4	4	BB_C2, CHG_C1, GPS_C2, PWR_C1	445-11253-1-ND	CAP 4.7uF	0603-CAP	smt
5	1	CPU_C2	445-8028-1-ND	CAP 22uF	0603-CAP	smt
6	9	BAT_R1, BT_R3, BT_R5, BT_R6, CHG_R1, GPS_R1, GPS_R2, PWR_R1, ST_R1	541-330GCT-ND	RES 330 ohm	0603-RES	smt
7	1	BT_R2	A106049CT-ND	RES 1k	0603-RES	smt
8	7	BAT_R2, BAT_R3, BMON_R1, I2C_R1, I2C_R2, TMP_R1, TMP_R2	541-4.7KGCT-ND	RES 4.7k	0603-RES	smt
9	5	BMON_R2, BT_R1, CPU_R1, CPU_R2, PINT_R1	541-10KGCT-ND	RES 10k	0603-RES	smt
10	7	BB_R1, BB_R2, BMON_R3, BT_R4, GPS_R3, SD_R1, SNS_R1	A102237CT-ND	RES 20k	0603-RES	smt
11	1	PWR_U1	LTC3240EDC-3.3#TRMPBFCT-ND	LTC3240-3.3S	6-DFN	Fine-pitch
12	2	TEMP_1, TEMP_2	DS18B20U+T&RCT-ND	DS18B20	8-USOP	smt
13	2	CHG_LED1, PWR_LED1	754-1122-1-ND	LED RED 1ma	LED-0603	smt
14	2	BAT_LED, BT_LED1	754-1121-1-ND	LED GRN 1ma	LED-0603	smt
15	1	ST_LED1	754-1124-1-ND	LED YEL 1ma	LED-0603	smt
16	1	F1	F3370CT-ND	PTCSMD	PTC-1206	smt
17	1	IMU	1428-1019-1-ND	MPU-9250 IMU	MPU-9250	Fine-pitch
18	1	BT	740-1038-ND	RN42 - Bluetooth Module	RN42	smt
19	1	PINT_Q1	MMBT5088CT-ND	MMBT5088	SOT23-3	smt
20	1	HALL_1	AH183-WG-7DICT-ND	AH183-WG	SOT23	smt
21	2	BB_Q1, BMON_Q1	FDV302PCT-ND	FDV302P	SOT23-3	smt
22	1	BAT_CHG	MCP73831T-2ACI/OTCT-ND	MCP73831	SOT23-5	smt
23	1	ATXMEGA	ATXMEGA64D4-AU-ND	ATXMEGA64D4	TQFP44	smt
24	5	BAT_Q1, Q1, Q2, Q3, Q4	SSM3J328RLF(TCT-ND	SSM3J328R	SOT23-3	smt
25	2	BAT_D1, BAT_D2	641-1285-1-ND	CDBU0530	0603-DIODE	smt
26	1	BB_D1	MMSZ4678-TPMSCT-ND	MMSZ4678TP	SOD123FL	smt
27	1	GPS	MOUSER: 916-UC530	UC530_GPS	FASTRAX_UC530C4322	smt
28	1	SD1	MOUSER: 538-104031-0811	MICROSD-SOCKET	MOLEX-104031-0811	smt

FIG. 5B

SUBSTITUTE SHEET (RULE 26)

Qty	Value	Device	Package	Parts	Description
1	2.2nF (50V)	CAP0603-CAP	0603-CAP	IMU_C2	Capacitor
2	0.01uF	CAP0603-CAP	0603-CAP	C_BOOT1, C_BOOT2	Capacitor
2	47nF	CAP0603-CAP	0603-CAP	C_COMM1, C_COMM2	Capacitor
1	0.1uF	CAP0603-CAP	0603-CAP	IMU_C1	Capacitor
1	0.12uF	CAP0603-CAP	0603-CAP	QI_C2	Capacitor
3	0.47uF	CAP0603-CAP	0603-CAP	C_CLAMP1, C_CLAMP2, QI_C1	Capacitor
7	1uF	CAP0603-CAP	0603-CAP	BB_C1, BT_C1, CPU_C1, C_VBAT, GPS_C1, SD_C1, SNS_C1	Capacitor
4	4.7uF	CAP0603-CAP	0603-CAP	BB_C2, GPS_C2, PWR_C1, QI_C4	Capacitor
1	10uF	CAP0603-CAP	0603-CAP	QI_C3	Capacitor
1	22uF	CAP0603-CAP	0603-CAP	CPU_C2	Capacitor
1	187 ohm	RESISTOR0603-RES	0603-RES	R_FOD	Resistor
10	330 ohm	RESISTOR0603-RES	0603-RES	BAT_R1, BT_R3, BT_R5, BT_R6, GPS_R1, GPS_R2, PWR_R1, QI_R1, R_ILIM, ST_R1	Resistor
2	1k	RESISTOR0603-RES	0603-RES	BT_R2, ROS1	Resistor
7	4.7k	RESISTOR0603-RES	0603-RES	BAT_R2, BAT_R3, BMON_R1, I2C_R1, I2C_R2, TMP_R1, TMP_R2	Resistor
6	10k	RESISTOR0603-RES	0603-RES	BMON_R2, BT_R1, CPU_R1, CPU_R2, PINT_R1, R_CTRL	Resistor
7	20k	RESISTOR0603-RES	0603-RES	BB_R1, BB_R2, BMON_R3, BT_R4, GPS_R3, SD_R1, SNS_R1	Resistor
1	LTC3240-3.3S	LTC3240-3.3S	6-DFN	PWR_U1	Boost/Buck 3.3v regulator
2	DS18B20	DS18B20	8-USOP	TEMP_1, TEMP_2	Temperature Sensor
2	RED 1ma	LED0603	LED-0603	PWR_LED1, QI_LED1	Red LED
2	GRN 1ma	LED0603	LED-0603	BAT_LED, BT_LED1	Green LED
1	YEL 1ma	LED0603	LED-0603	ST_LED1	Yellow LED
1	PTCSMD	PTCSMD	PTC-1206	F1	Resettable Fuse PTC
1	IMU	MPU-9250	MPU-9250	IMU	IMU 9-axis sensor
1	BQ51013B	BQ51013B	R-PVQFN-N20	QI_U1	Qi Receiver
1	RN42 - Bluetooth Module	RN42	RN42	BT	Bluetooth Module
1	MMBT5088	TRANSISTOR_NPNSOT23-3	SOT23-3	PINT_Q1	Generic NPN BJT SOT-23 case
1	SS351AT	SS351AT	SOT23	HALL_1	Hall Device
2	FDV302P	FDV302P	SOT23-3	BB_Q1, BMON_Q1	P-Channel Enhancement MOSFET -200V; -0.15A; 11Ohm
1	MCP73831	MCP73831	SOT23-5	BAT_CHG	Microchip's MCP73831
1	ATXMEGA64D4	ATXMEGAXX-44PIN	TQFP44	ATXMEGA	CPU ATXMega64D4
5	SSM3J328R	SSM3J328R	SOT23-3	BAT_Q1, Q1, Q2, Q3, Q4	P-Channel Enh MOSFET SSM3J328R 20V 6A 1.5VGSth
2	CDBU0530	CDBU0530	0603-DIODE	BAT_D1, BAT_D2	0.5A 20V SCHOTTKY BARRIER RECTIFIER
1	MMSZ4678TP	MMSZ4678TP	SOD123FL	BB_D1	Reference DIODE
1	UC530_GPS	UC530_GPS	FASTRAX_UC530C43:GPS		Fastrax UC530 GPS Module
1	MICROSD-SOCKET	MICROSD-SOCKET	MOLEX-104031-0811	SD1	MicroSD card socket with card detect

FIG. 5C

Item #	Qty	RefDes	Part No.	Description	Package	Type
1	1	IMU_C2	399-1085-1-ND	CAP 2.2nF (50V)	0603-CAP	smt
2	2	C_BOOT1, C_BOOT2	445-5100-1-ND	CAP 0.01uF	0603-CAP	smt
3	2	C_COMM1, C_COMM2	445-8127-1-ND	CAP 47nF	0603-CAP	smt
4	1	IMU_C1	445-5666-1-ND	CAP 0.1uF	0603-CAP	smt
5	1	QI_C2	490-6430-1-ND	CAP 0.12uF	0603-CAP	smt
6	3	C_CLAMP1, C_CLAMP2, QI_C1	445-5144-1-ND	CAP 0.47uF	0603-CAP	smt
7	7	BB_C1, BT_C1, CPU_C1, C_VBAT, GPS_C1, SD_C1, SNS_C1	445-13234-1-ND	CAP 1uF	0603-CAP	smt
8	4	BB_C2, GPS_C2, PWR_C1, QI_C4	445-11253-1-ND	CAP 4.7uF	0603-CAP	smt
9	1	QI_C3	1276-1869-1-ND	CAP 10uF	0603-CAP	smt
10	1	CPU_C2	445-8028-1-ND	CAP 22uF	0603-CAP	smt
11	1	R_FOD	541-187HCT-ND	RES 187 ohm	0603-RES	smt
12	10	BAT_R1, BT_R3, BT_R5, BT_R6, GPS_R1, GPS_R2, PWR_R1, QI_R1, R_ILIM, ST_R1	541-330GCT-ND	RES 330 ohm	0603-RES	smt
13	2	BT_R2, ROS1	A106049CT-ND	RES 1k	0603-RES	smt
14	7	BAT_R2, BAT_R3, BMON_R1, I2C_R1, I2C_R2, TMP_R1, TMP_R2	541-4.7KGCT-ND	RES 4.7k	0603-RES	smt
15	6	BMON_R2, BT_R1, CPU_R1, CPU_R2, PINT_R1, R_CTRL	541-10KGCT-ND	RES 10k	0603-RES	smt
16	7	BB_R1, BB_R2, BMON_R3, BT_R4, GPS_R3, SD_R1, SNS_R1	A102237CT-ND	RES 20k	0603-RES	smt
17	1	PWR_U1	LTC3240EDC-3.3#TRMPBFCT-ND	LTC3240-3.3S	6-DFN	Fine-pitch
18	2	TEMP_1, TEMP_2	DS18B20U+T&RCT-ND	DS18B20	8-USOP	smt
19	2	PWR_LED1, QI_LED1	754-1122-1-ND	RED 1ma	LED-0603	smt
20	2	BAT_LED, BT_LED1	754-1121-1-ND	GRN 1ma	LED-0603	smt
21	1	ST_LED1	754-1124-1-ND	YEL 1ma	LED-0603	smt
22	1	F1	F3370CT-ND	PTCSMD	PTC-1206	smt
23	1	IMU	1428-1019-1-ND	IMU	MPU-9250	Fine-pitch
24	1	QI_U1	296-35638-1-ND	BQ51013B	R-PVQFN-N20	Fine-pitch
25	1	BT	740-1038-ND	RN42 - Bluetooth Module	RN42	smt
26	1	PINT_Q1	MMBT5088CT-ND	MMBT5088	SOT23-3	smt
27	1	HALL_1	480-3610-1-ND	SS351AT	SOT23	smt
28	2	BB_Q1, BMON_Q1	FDV302PCT-ND	FDV302P	SOT23-3	smt
29	1	BAT_CHG	MCP73831T-2ACI/OTCT-ND	MCP73831	SOT23-5	smt
30	1	ATXMEGA	ATXMEGA64D4-AU-ND	ATXMEGA64D4	TQFP44	smt
31	5	BAT_Q1, Q1, Q2, Q3, Q4	SSM3J328RLF(TCT-ND	SSM3J328R	SOT23-3	smt
32	2	BAT_D1, BAT_D2	641-1285-1-ND	CDBU0530	0603-DIODE	smt
33	1	BB_D1	MMSZ4678-TPMSCT-ND	MMSZ4678TP	SOD123FL	smt
34	1	GPS	MOUSER: 916-UC530	UC530_GPS	FASTRAX_UC530C4322	smt
35	1	SD1	MOUSER: 538-104031-0811	MICROSD-SOCKET	MOLEX-104031-0811	smt

FIG. 5D

SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/014454

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - B63B 35/79 (2015.01)
CPC - B63B 35/79 (2015.04)
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)
IPC(8) - A42B 3/046; A63C 5/00,5/075,9/00; B63B 35/73,35/79,35/85; G01D 21/02 (2015.01)
CPC - A42B 3/046; A63C 5/00,5/075,9/00; B63B 35/73,35/79,35/85; G01D 21/02 (2015.04)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC - 114/55.56; 280/14.21,600,601,809; 381/386; 434/247; 440/13; 441/74; 702/141(keyword delimited)

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

PatBase, Google Patents, Google Scholar, Google, YouTube.
Search terms used: water, sport, board, sensor, surfboard, paddle, skimboard, body, windsurf, computer, controller, processor

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/0015287 A1 (VOCK et al) 19 January 2006 (19.01.2006) entire document	1,3,5,26,28
Y		2,4,6,7,9-17,27,29-31, 37-47,51-58,61
Y	US 2008/0080734 A1 (FORTH et al) 03 April 2008 (03.04.2008) entire document	2,4,14-17,27,29,39-47, 51-58,61
Y	US 5,590,908 A (CARR) 07 January 1997 (07.01.1997) entire document	6
Y	US 7,302,905 B1 (WYNNE) 04 December 2007 (04.12.2007) entire document	7,9-11,57,58
Y	US 2013/0314044 A1 (BAHADIK et al) 28 November 2013 (28.11.2013) entire document	9,11,31
Y	US 2011/0201238 A1 (ROTT et al) 18 August 2011 (18.08.2011) entire document	12,61
Y	US 2011/0056423 A1 (RAILEY) 10 March 2011 (10.03.2011) entire document	13,38
Y	US 2013/0323989 A1 (DERRAH) 05 December 2013 (05.12.2013) entire document	30,37
Y	US 2014/0002239 A1 (TREEFROG DEVELOPMENTS, INC.) 02 January 2014 (02.01.2014) entire document	46
A	WO 03/056529 A1 (TIRLONI et al) 10 July 2003 (10.07.2003) entire document	1-17,26-35,37-47,51-63, 71

☒ Further documents are listed in the continuation of Box C. ☐

* 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	Date of mailing of the international search report
08 April 2015	11 MAY 2015
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/014454

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	A surfboard gets an onboard computer. UC San Diego Jacobs School of Engineering. 11 August 2010 [retrieved on 08 April 2015]. Retrieved from the internet: <URL: http://www.jacobsschool.ucsd.edu/news/news_releases/release.sfe?id=973> entire document	1-17,26-35,37-47,51-63, 71

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2015/014454

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.: 18-25, 36, 48-50, 64-70, 72-75
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:

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 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.:

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.