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(54) SYSTEM AND METHOD TO MONITOR BATTERY STATUS IN AN IMPLANTABLE MEDICAL DEVICE

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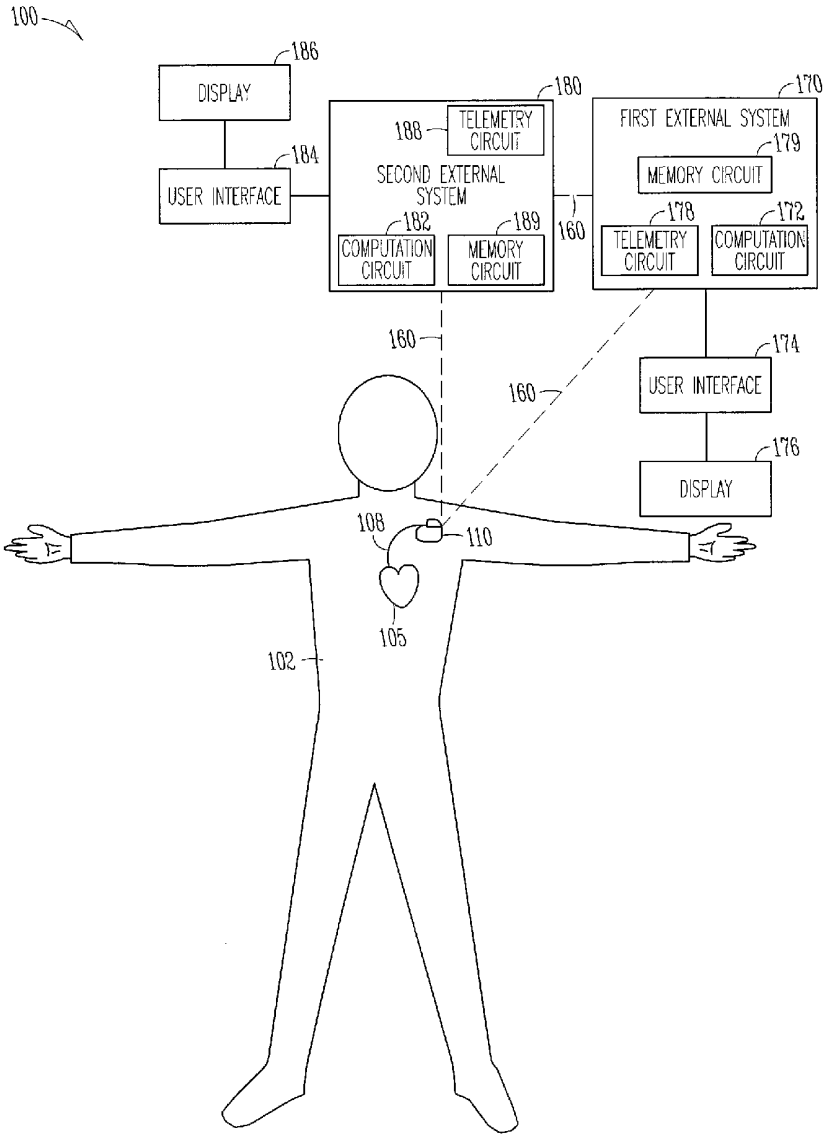
(52) **U.S. Cl.** ..... **600/300**

(57) **ABSTRACT**

An implantable medical device includes a control circuit. A rechargeable battery is coupled to the control circuit. A battery monitoring circuit is coupled to one or more of the rechargeable battery and the control circuit. A telemetry circuit, coupled to the control circuit, is configured to transmit a battery status of the rechargeable battery to a first external device at a first time and to a second external device, of a different type than the first external device, at a second time.



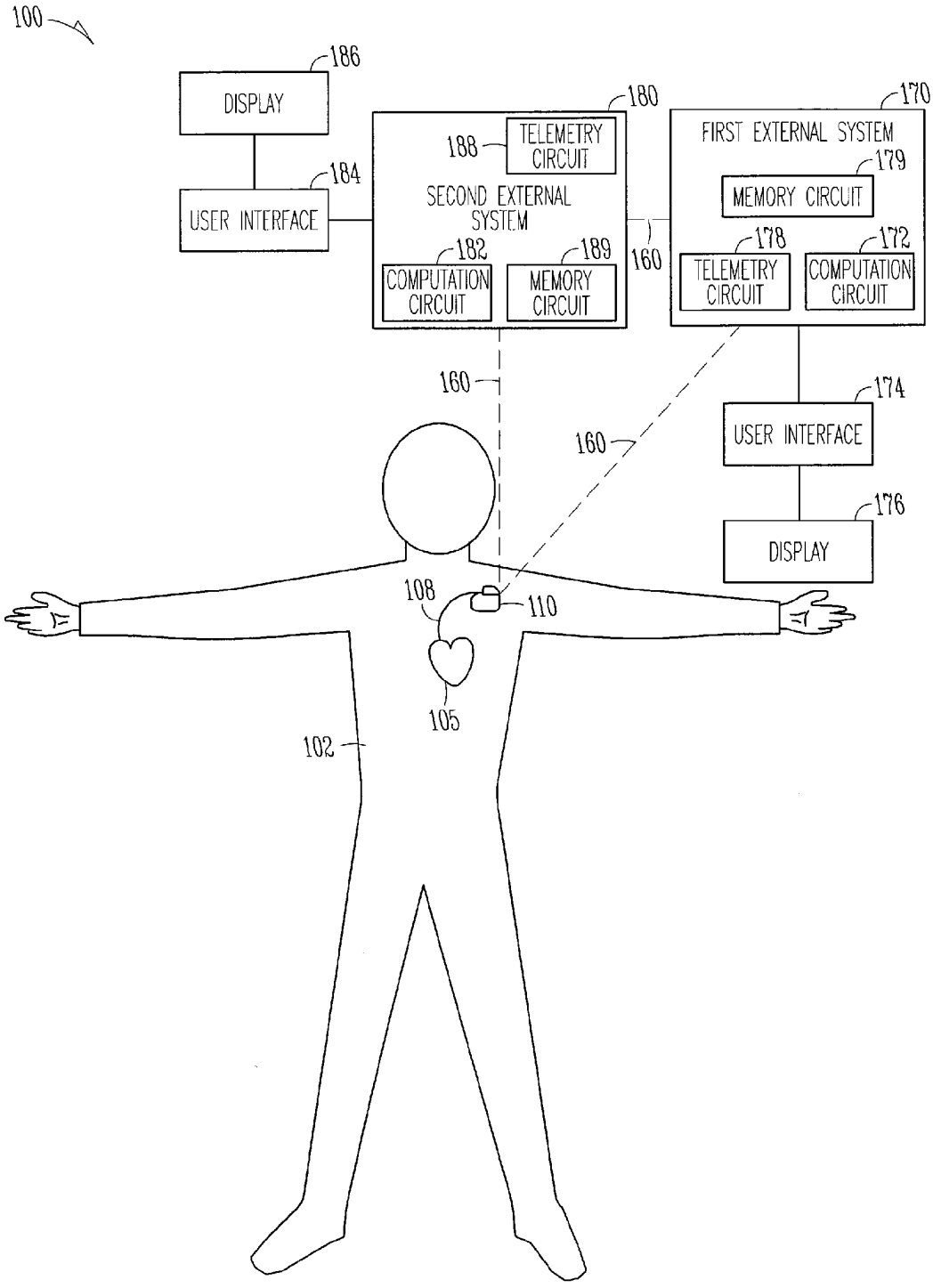

100
186
DISPLAY
184
USER INTERFACE
180
188
TELEMETRY CIRCUIT
SECOND EXTERNAL SYSTEM
182
COMPUTATION CIRCUIT
189
MEMORY CIRCUIT
160
170
FIRST EXTERNAL SYSTEM
179
MEMORY CIRCUIT
178
TELEMETRY CIRCUIT
172
COMPUTATION CIRCUIT
160
160
174
USER INTERFACE
176
DISPLAY
108
110
105
102

*FIG. 1*

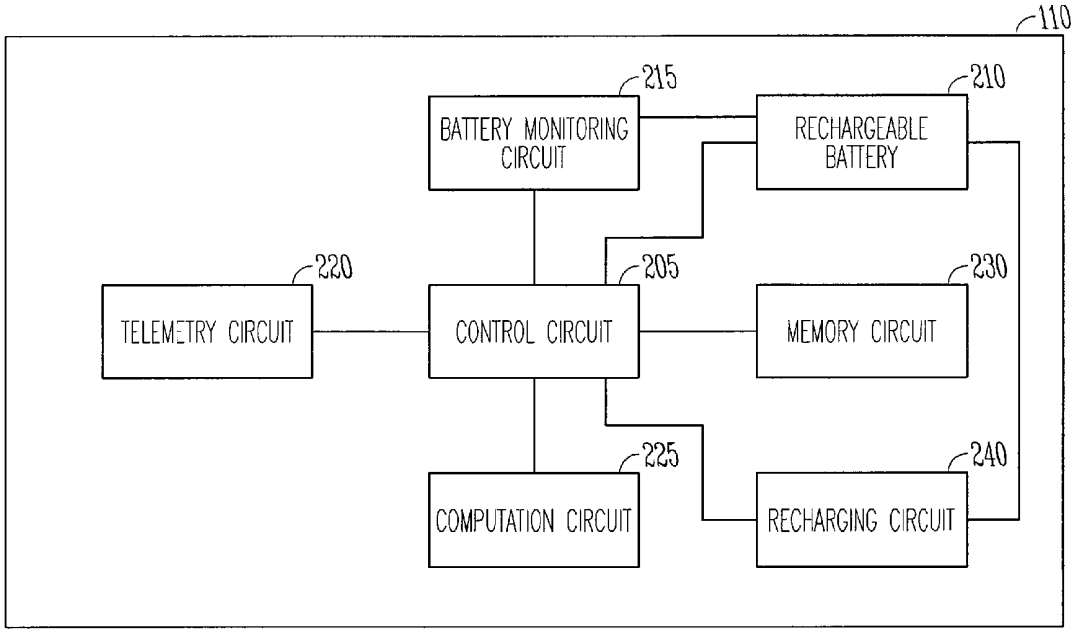

110
215
BATTERY MONITORING CIRCUIT
210
RECHARGEABLE BATTERY
220
TELEMETRY CIRCUIT
205
CONTROL CIRCUIT
230
MEMORY CIRCUIT
225
COMPUTATION CIRCUIT
240
RECHARGING CIRCUIT

*FIG. 2*

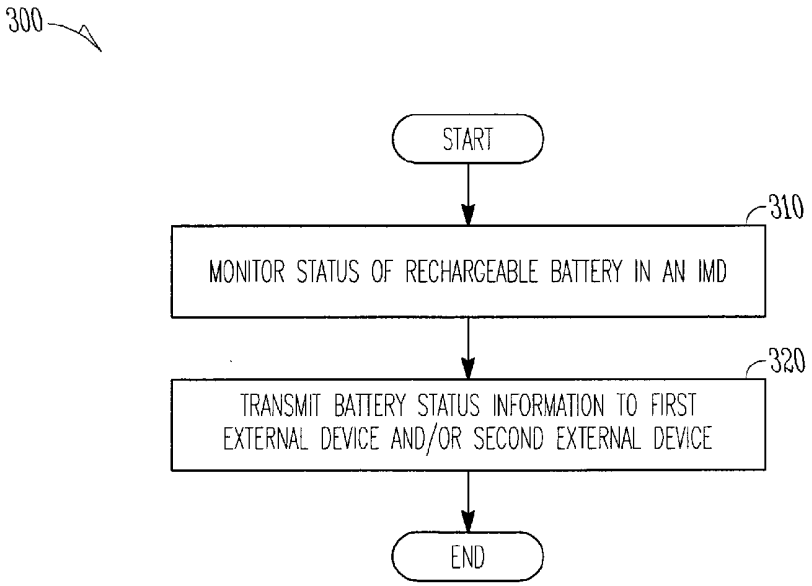

300
START
310
MONITOR STATUS OF RECHARGEABLE BATTERY IN AN IMD
320
TRANSMIT BATTERY STATUS INFORMATION TO FIRST EXTERNAL DEVICE AND/OR SECOND EXTERNAL DEVICE
END

*FIG. 3*

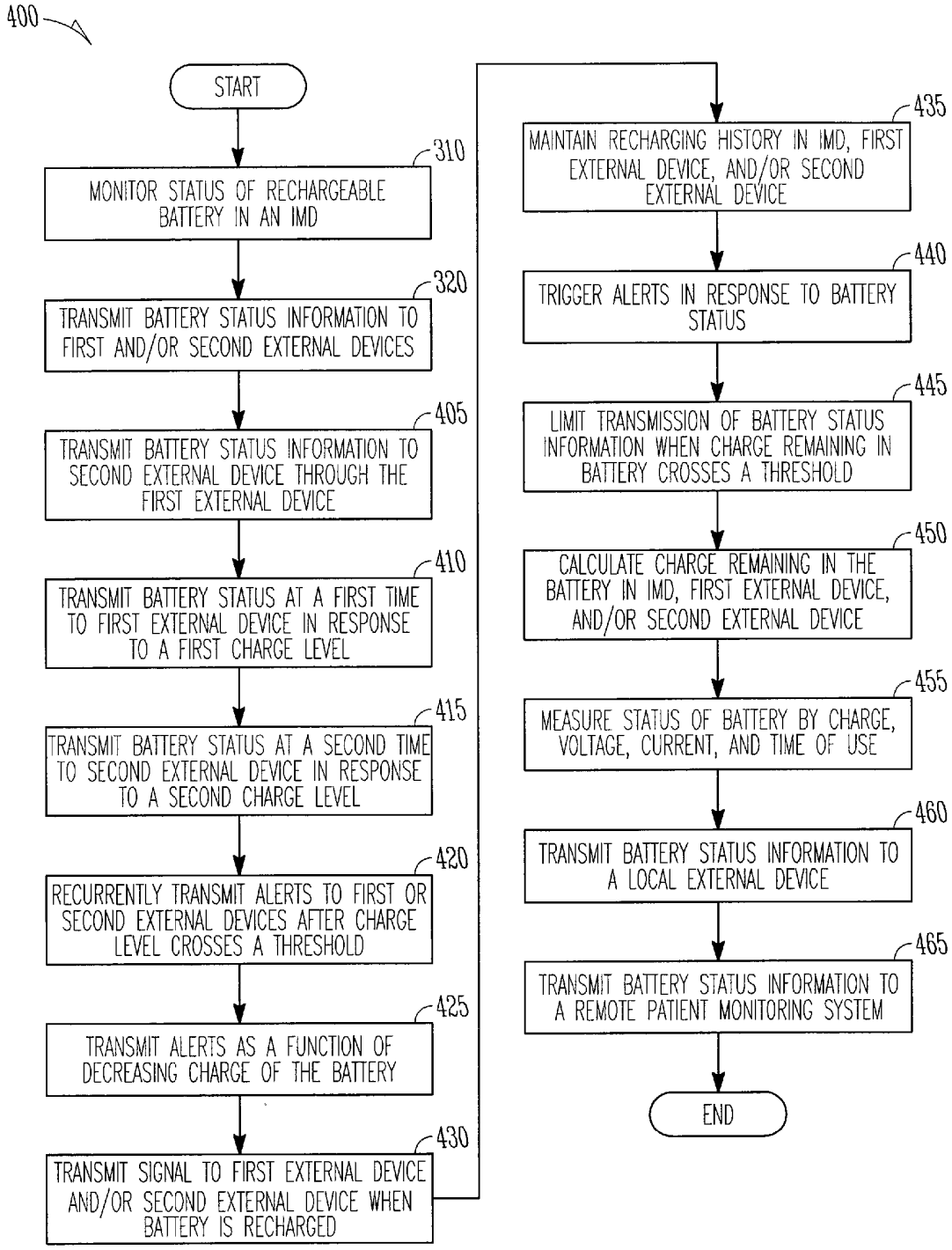

400
START
310
MONITOR STATUS OF RECHARGEABLE BATTERY IN AN IMD
320
TRANSMIT BATTERY STATUS INFORMATION TO FIRST AND/OR SECOND EXTERNAL DEVICES
405
TRANSMIT BATTERY STATUS INFORMATION TO SECOND EXTERNAL DEVICE THROUGH THE FIRST EXTERNAL DEVICE
410
TRANSMIT BATTERY STATUS AT A FIRST TIME TO FIRST EXTERNAL DEVICE IN RESPONSE TO A FIRST CHARGE LEVEL
415
TRANSMIT BATTERY STATUS AT A SECOND TIME TO SECOND EXTERNAL DEVICE IN RESPONSE TO A SECOND CHARGE LEVEL
420
RECURRENTLY TRANSMIT ALERTS TO FIRST OR SECOND EXTERNAL DEVICES AFTER CHARGE LEVEL CROSSES A THRESHOLD
425
TRANSMIT ALERTS AS A FUNCTION OF DECREASING CHARGE OF THE BATTERY
430
TRANSMIT SIGNAL TO FIRST EXTERNAL DEVICE AND/OR SECOND EXTERNAL DEVICE WHEN BATTERY IS RECHARGED
435
MAINTAIN RECHARGING HISTORY IN IMD, FIRST EXTERNAL DEVICE, AND/OR SECOND EXTERNAL DEVICE
440
TRIGGER ALERTS IN RESPONSE TO BATTERY STATUS
445
LIMIT TRANSMISSION OF BATTERY STATUS INFORMATION WHEN CHARGE REMAINING IN BATTERY CROSSES A THRESHOLD
450
CALCULATE CHARGE REMAINING IN THE BATTERY IN IMD, FIRST EXTERNAL DEVICE, AND/OR SECOND EXTERNAL DEVICE
455
MEASURE STATUS OF BATTERY BY CHARGE, VOLTAGE, CURRENT, AND TIME OF USE
460
TRANSMIT BATTERY STATUS INFORMATION TO A LOCAL EXTERNAL DEVICE
465
TRANSMIT BATTERY STATUS INFORMATION TO A REMOTE PATIENT MONITORING SYSTEM
END

*FIG. 4*

# SYSTEM AND METHOD TO MONITOR BATTERY STATUS IN AN IMPLANTABLE MEDICAL DEVICE

## TECHNICAL FIELD

**[0001]** Various examples relate to the field of implantable medical devices, and in an example, but not by way of limitation, to a system and method to monitor a battery in an implantable medical device.

## BACKGROUND

**[0002]** Implantable medical devices include a built in power supply such as a battery. Such a battery has a limited life, and must be replaced or recharged at some point in time. If it is to be replaced, explant of the implantable device is required. If a battery is rechargeable, the recharging can be performed without an explant of the device via transcutaneous power transfer.

## OVERVIEW

**[0003]** An implantable medical device can include a control circuit, a rechargeable battery that is connected to the control circuit, a battery monitoring circuit that is connected to the rechargeable battery and/or the control circuit, and a telemetry circuit that is connected to the control circuit. The telemetry circuit can be configured to transmit a battery status of the rechargeable battery to a first external device at a first time and to a second external device at a second time. The second external device is of a different type than the first external device. In an example, the first external device can be a local external device to which a patient or a patient's local caregiver has access, and the second external device can be a remote patient monitoring system that is accessible by one or more of a physician and a plurality of implantable medical devices.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0004]** In the drawings, which are not necessarily drawn to scale, like numerals describe similar components throughout the several views. The drawings illustrate generally, by way of example, but not by way of limitation, various examples discussed in the present document.

**[0005]** FIG. **1** illustrates an example of an implanted medical device coupled to a first adjunct external device and a second adjunct external device.

**[0006]** FIG. **2** illustrates an example block diagram of an implantable medical device.

**[0007]** FIG. **3** illustrates a flowchart of an example process to monitor the status of a battery in an implantable medical device.

**[0008]** FIG. **4** illustrates a flowchart of another example process to monitor the status of a battery in an implantable medical device.

## DETAILED DESCRIPTION

**[0009]** The following detailed description refers to the accompanying drawings which form a part hereof, and in which is shown by way of illustration specific examples in which the disclosure may be practiced. These examples, which are sometimes referred to as examples, are discussed in sufficient detail to enable those skilled in the art to practice the teachings of the disclosure, and such examples may be combined, or other examples may be utilized, and structural, logical and electrical changes may be made without departing from the scope of the present disclosure. The following detailed description provides examples, and the scope of the present disclosure is defined by the appended claims and their equivalents.

**[0010]** It should be noted that references to "an", "one", or "various" examples in this disclosure are not necessarily to the same example, and such references contemplate more than one example. It should further be noted that references to "or" are meant to include "and", "or", and "and/or".

**[0011]** FIG. **1** illustrates an example of a medical device system **100**, and portions of an environment in which it is used. The environment includes a body **102** with a heart **105**. System **100** includes an implantable medical device **110**, a lead system **108**, a first adjunct device or system **170**, a second adjunct device or system **180**, and wireless telemetry links **160**. The link between the first adjunct device and the second adjunct device may also be a wired connection. While FIG. **1** illustrates an implantable medical device in connection with a heart **105**, the present disclosure is not so limited, and the present disclosure applies to any type of implantable medical device including, but not limited to, implantable pharmaceutical infusion pumps, implantable neural-stimulation devices, implantable hearing aids, inserted hearing aids, etc.

**[0012]** Data from the implantable device **110** may be transferred from the device **110** to the first external system **170** and the second external system **180** via the telemetry links **160**. The data can be transferred directly to either of the external devices **170** or **180**, or the data can be transferred from the implantable medical device **110** to the first external system **170**, and the first external system **170** can then transfer that data to the second external system **180**. The telemetered data loaded into the first external device **170** or the second external device **180** can then be used for analysis and interpretation either immediately or at a later time. In an example, the first external device **170** includes a local external programmer device, which allows a patient or a patient's aide to receive telemetered data from the implantable device **110** and also allows the patient or patient's aide to telemeter data or instructions from the local external programmer to the implantable device. In another example, the second external device **180** includes a remote external patient management device configured to manage implantable medical devices associated with different patients. A physician or other caregiver may use such a remote external patient management device to remotely monitor a patient with an implantable device. In another example, one or more local external repeaters couple the first external system **170** and the second external system **180**.

**[0013]** FIG. **1** further illustrates that the first external device **170** can include a computation circuit **172** and the second external device **180** can include a computation circuit **182**. The computation circuits **172** and **182** can compute information related to the status of the battery including one or more of a charge associated with the rechargeable battery, a voltage output of the rechargeable battery, a current flow through the rechargeable battery, and an amount of time that the rechargeable battery has been in use since implant or the last recharging of the battery. In an example, the computation circuit **182** in the second external device **180** can transmit information to a plurality of first external devices with which the second external device can communicate. As a result, the functionality of many first external devices can be altered simply by

changing the configuration of the second external device. The first external device **170** can further include a user interface **174** that is connected to an external display **176**, and the second external device **182** can further include a user interface **184** that is connected to an external display **186**. In an example, the external displays **176** and **186** can be configured to display information relating to the status of a battery that supplies power to the implantable device **110**. This status information can be displayed as a graphic. An example graphic is simple gauge, similar to a gas gauge in an automobile, and the gauge can include markings such as an Elective Replacement Indicator (ERI) or an End of Life (EOL) indicator. Additionally, the first external device **170** can include a telemetry circuit **178** and the second external device can include a telemetry circuit **188**. The first external device **170** further can include a memory circuit **179** and the second external device can include a memory circuit **189**.

**[0014]** FIG. **2** illustrates an example of the implantable medical device **110** of FIG. **1**. The implantable medical device includes a control circuit **205**. Connected to the control circuit **205** are a rechargeable battery **210**, a battery monitoring circuit **215**, and a telemetry circuit **220**. The battery monitoring circuit **215** can also be coupled to the rechargeable battery **210**. FIG. **2** also illustrates that the implantable medical device **110** can have a computation circuit **225** coupled to the control circuit **205**. Like the computation circuits **172** and **182** of the first and second external devices respectively, the computation circuit **225** can be configured to carry out computations relating to the status of the battery **210**. Further, like the computation circuits **172** and **182**, the computation circuit **225** can determine one or more of a remaining or delivered charge associated with the rechargeable battery, a voltage output of the rechargeable battery, a current flow through the rechargeable battery, and an amount of time that the rechargeable battery has been in use since implant or since the last recharging of the battery. The implantable medical device **110** may further include a memory circuit **230** coupled to the control circuit **205**. The implantable medical device **110** can further include a recharging circuit **240** that is coupled to the control circuit **205** and the rechargeable battery **210**.

**[0015]** The telemetry circuit **220** can be configured to transmit a battery status of the rechargeable battery **210** to the first external device **170** at a first time and to the second external device **180** at a second time. In an example, the first external device **170** is a different type of device than the second external device **180**. In this manner, initial warnings about a waning charge of the rechargeable battery **210** can first be transmitted to a device that is accessible to and monitored by a patient with the implantable medical device. Then, if the battery monitoring circuit **215** determines that the remaining charge of the battery **210** has further decreased because the patient has failed to recharge the battery, another alert can be transmitted to the second external device **180**. The second external device **180** may be monitored by the patient's physician or other health care professional, and upon receiving the warning, the physician can act to remedy the failure of the patient to recharge the battery and the resultant diminishing charge of the battery.

**[0016]** As referred to in the previous paragraph, information relating to the battery status may be transmitted first to the first external device **170**, and then at a later time to the second external device **180**. In a particular example, the battery status relates to the charge remaining in the rechargeable battery. The telemetry circuit **220** can be configured to transmit information relating to the remaining charge in the battery at the first time to the first external device in response to a first charge level. For example, if the battery has 25% of its charge remaining (i.e., 25% of a fully charged state), that can serve as a threshold to trigger the transmission of battery status information to the first external device **170**. Other levels of remaining charge can be chosen depending on numerous factors including the type or device, the individual patient, the functions performed by the device, the type of battery in the device, etc. Then, if the battery **210** is not recharged before it reaches a second remaining charge level, for example if the charge level of the battery falls to 10%, a signal can be transmitted to the second external device **180**. The second external device **180**, which may be monitored by the patient's physician, can then take action in response to the failure of the patient to take steps to recharge the battery in the implantable device.

**[0017]** In a similar example, the warnings transmitted to the first external device **170** or the second external device **180** can be based on a combination of the remaining charge of the battery and the rate of discharge of the rechargeable battery. Therefore, if the control circuit **205** and the battery monitoring circuit **215** sense a high rate of discharge in the battery **210**, a warning can be transmitted when the battery has a comparatively higher level of charge remaining than in circumstances when the rate of discharge of the battery is not as great. For example, if the level of charge remaining in the battery reaches a 50% level, and the rate of discharge is at a rather high rate, then the transmission of the signal to the first external device **170** can occur at this 50% level. The rate of discharge can be measured by the computation circuit **225**. Similarly, if the remaining charge of the battery then decreases to a second level, for example down to a 25% remaining charge, and the rate of discharge is at a certain level, then an alert can be sent to the second external device when the battery reaches this 25% level. When determining the remaining charge of the battery, one or more of the computation circuits **172**, **182**, and **225** can be configured to compute this remaining charge.

**[0018]** In another example, the telemetry circuit **220** can be configured to recurrently transmit alerts after the remaining charge level in the battery **210** has crossed a certain threshold. For example, the telemetry circuit can transmit a first alert when the remaining charge level in the battery falls to a 25% level. Then, for example, if the charge level thereafter decreases to 15%, the telemetry circuit can be configured to transmit the alert recurrently. These recurrent transmissions can be based on certain charge level decrements, such as transmitting for each 2% decrease in the charge level (or an absolute decrease in the charge level), or the recurrent transmissions can be based on time, such as recurrently transmitting the alerts every hour until the battery is recharged.

**[0019]** In another example, the system **100** can be configured to maintain a recharging history of the rechargeable battery **210**. This history can be maintained in the memory circuit **230** of the implantable device **110**, the memory circuit **179** of the first external device **170**, or the memory circuit **189** of the second external device **180**. When the recharging history is stored in the memory circuit **230** of the device **110**, the control circuit **205** monitors the battery recharging circuit **240** and the rechargeable battery **210**. When the control circuit initiates recharging of the battery through the recharging circuit **240**, the control circuit thereafter monitors the recharging process, and if the rechargeable battery crosses a threshold,

for example it becomes 90% recharged, then the control circuit treats this as a successful recharge and writes a record to the recharging history in the memory circuit **230**. When the recharging history is maintained in the first or second external device, the control circuit **205** monitors the recharging process, and when the charge level in the battery crosses the threshold, the control circuit causes the telemetry circuit **220** to transmit an indication of the recharging to the first or second external device for storage in the recharging history maintained in those devices. A recharging history in the second external device can be used by a physician or other caregiver to monitor a patient's compliance with the recharging of the battery in the implanted device.

**[0020]** The transmission of information relating to the status of the battery **210**, or any other data or information, can be transmitted from the implantable device **110** to the first or second external devices via a radio frequency (RF) signal. In an example, an implantable medical device can be configured to transmit one or more of an Industrial, Scientific and Medical (ISM) signal, a Medical Implant Communication Service (MICS) signal, a BLUETOOTH® signal, and a Short Range Device (SRD) signal.

**[0021]** In an example, the battery monitoring circuit **215** monitors the charge level of the battery **210**, and triggers an alert when the charge level of the battery falls below a threshold. Such an alert can be transmitted by the telemetry circuit **220** to the first external device **170** or the second external device **180**. When transmitted to the first or second external device, the alert can be an audible alert, a vibration alert, or a visual alert (displayed on the display units **176** or **186**). A vibration alert can also be programmed into the implantable device itself.

**[0022]** In an example, the implantable medical device **110** is configured such that the telemetry circuit **220** is limited in the transmission of information relating to the battery status (or other data or information) when the level of charge remaining in the battery crosses a threshold. Other functionalities of the implantable medical device may also be disabled under a low charge condition (such as rate-responsiveness for example). This feature prevents the implantable device **110** from unduly wasting the remaining charge on the battery with transmissions of information to the external devices, thereby conserving the diminishing charge in the battery for the vital functions of the implantable device.

**[0023]** FIGS. **3** and **4** illustrate example processes **300** and **400** respectively for monitoring the battery status of an implantable medical device, and in an example, the level of charge remaining in that battery. In FIG. **3**, at **310**, a battery status of a rechargeable battery in an implantable medical device is monitored. At **320**, information relating to the battery status of the rechargeable battery is transmitted to a first external device at a first time and to a second external device at a second time. In this process **300**, the second external device is of a different type than the first external device.

**[0024]** FIG. **4** illustrates another example process **400** for monitoring the charge state of a battery of an implantable medical device. Not all the steps of process **400** need be executed in any particular example, and the steps of a particular example need not be executed in the order outlined in FIG. **4**. The process **400** includes the steps **310** and **320** of process **300**. At **405**, the information relating to the battery status of the rechargeable battery is transmitted to the second external device through the first external device. At **410**, the information relating to the battery status is transmitted at a first time to the first external device in response to a level of remaining charge in the rechargeable battery, and at **415** the information relating to the remaining charge in the battery or other battery status is transmitted at a second time to the second external device in response to a second level of remaining charge in the rechargeable battery. In steps **410** and **415**, the remaining charge levels at the first and second times are different.

**[0025]** At **420**, alerts are recurrently transmitted to the first or second devices after the remaining charge in the rechargeable battery has crossed a threshold. The threshold normally signals a level of charge that is approaching a point at which operation of the device can be imperiled, and the recurrent transmissions notify the patient or doctor of that potentially dangerous charge level. Similarly, at **425**, alerts are transmitted as a function of a decreasing charge of the rechargeable battery. At **430**, a signal is transmitted to one or more of the first external device and the second external device when the rechargeable battery is recharged, and at **435**, a record is maintained in one or more of the implantable device, the first external device, and the second external device regarding a recharging history of the rechargeable battery.

**[0026]** At **440**, one or more of an audible alert, a visual alert, or a vibration alert is triggered in response to the information relating to the battery status. At **445**, the transmission of the information relating to the battery status is limited when the remaining charge in the rechargeable battery crosses a threshold. This conserves the dwindling battery energy for vital device functions when the charge remaining in the battery becomes too low. At **450**, the remaining charge in the rechargeable battery is calculated in one or more of the implantable medical device, the first external device, and the second external device. At **455**, the battery status is monitored by measuring one or more of a charge associated with the rechargeable battery, a voltage output of the rechargeable battery, a current flow through the rechargeable battery, and a time that the battery has been used since an initial charging or recharging of the rechargeable battery. At **460**, the information relating to the battery status of the rechargeable battery is transmitted to a first external device at a first time that includes a local external device to which a patient or a patient's local caregiver has access. At **465**, the information relating to the battery status of the rechargeable battery is transmitted to a second external device at a second time that includes a remote patient monitoring system that is accessible by one or more of a physician and a plurality of implantable medical devices.

**[0027]** In the foregoing detailed description, various features are grouped together in one or more examples or examples for the purpose of streamlining the disclosure. This method of disclosure is not to be interpreted as reflecting an intention that the claimed examples of the invention require more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive subject matter lies in less than all features of a single disclosed example. Thus the following claims are hereby incorporated into the detailed description of examples of the invention, with each claim standing on its own as a separate example. It is understood that the above description is intended to be illustrative, and not restrictive. It is intended to cover all alternatives, modifications and equivalents as may be included within the scope of the invention as defined in the appended claims. Many other examples will be apparent to those of skill in the art upon reviewing the above description. The scope of the invention should, therefore, be determined with reference to the

appended claims, along with the full scope of equivalents to which such claims are entitled. In the appended claims, the terms "including" and "in which" are used as the plain-English equivalents of the respective terms "comprising" and "wherein," respectively. Moreover, the terms "first," "second," and "third," etc., are used merely as labels, and are not intended to impose numerical requirements on their objects.

**[0028]** As used in this disclosure, the term "circuit" is broadly meant to refer to hardware, software, or a combination of hardware and software. That is, a particular function may be implemented in specialized circuits, in software executing on general processor circuits, and/or a combination of specialized circuits, generalized circuits, and software.

**[0029]** The abstract is provided to comply with 37 C.F.R. 1.72(b) to allow a reader to quickly ascertain the nature and gist of the technical disclosure. The Abstract is submitted with the understanding that it will not be used to interpret or limit the scope or meaning of the claims.

**1**. An apparatus comprising:

an implantable medical device comprising:

a control circuit;

a rechargeable battery, the rechargeable battery coupled to the control circuit;

a battery monitoring circuit, the battery monitoring circuit coupled to one or more of the rechargeable battery and the control circuit; and

a telemetry circuit, coupled to the control circuit, wherein the telemetry circuit is configured to transmit a battery status of the rechargeable battery to a first external device at a first time and to a second external device, of a different type than the first external device, at a second time.

**2**. The apparatus of claim **1**, wherein the telemetry circuit is configured to transmit a battery status of the rechargeable battery to the first external device at a first time, and to the second external device via the first external device at a second time.

**3**. The apparatus of claim **1**, further comprising the first and second external devices.

**4**. The apparatus of claim **3**, wherein the first external device includes a local external programmer device, and wherein the second external device includes a remote external patient management device configured to manage implantable medical devices associated with different patients.

**5**. The apparatus of claim **3**, wherein one or more of the implantable medical device, the first external device, and the second external device comprise a computation circuit configured to perform a computation relating to the battery status that is carried out in one or more of the implantable medical device, the first external device, and the second external device.

**6**. The apparatus of claim **5**, comprising an external display configured to display the battery status as a graphic, wherein the external display is associated with a user interface of one or more of the first or second external devices.

**7**. The apparatus of claim **5**, wherein the computation circuit is configured to perform a computation of a remaining charge of the rechargeable battery.

**8**. The apparatus of claim **1**, wherein the battery status relates to a remaining charge of the rechargeable battery, and wherein the telemetry circuit is configured to transmit information relating to the remaining charge at the first time to the first external device in response to a first level of remaining charge, and further wherein the telemetry circuit transmits the information relating to the remaining charge at the second time to the second external device in response to a second level of remaining charge that is different from the first level of remaining charge.

**9**. The apparatus of claim **1**, wherein the battery status relates to a remaining charge of the rechargeable battery and a rate of discharge of the rechargeable battery, and wherein the telemetry circuit is configured to transmit information relating to the remaining charge and the rate of discharge at the first time to the first external device in response to a first level of remaining charge and a first rate of discharge, and further wherein the telemetry circuit transmits the information relating to the remaining charge and the rate of discharge at the second time to the second external device in response to a second level of remaining charge and a second rate of discharge that are different from the first level of remaining charge and the first rate of discharge.

**10**. The apparatus of claim **1**, wherein the telemetry circuit is configured to recurrently transmit alerts after a level of remaining charge has crossed a certain threshold.

**11**. The apparatus of claim **1**, wherein the telemetry circuit is configured to transmit alerts as a function of decreasing charge levels of the rechargeable battery.

**12**. The apparatus of claim **1**, wherein at least one of the implantable medical device, the first external device, and the second external device is configured to maintain a history of recharging of the rechargeable battery.

**13**. The apparatus of claim **1**, wherein the telemetry circuit is configured to transmit the battery status to one or more of the first external device and the second external device using an RF signal such as an Industrial, Scientific and Medical (ISM) signal, a Medical Implant Communication Service (MICS) signal, a BLUETOOTH® signal, and a Short Range Device (SRD) signal.

**14**. The apparatus of claim **1**, wherein the battery status triggers an alert by one or more of the first external device and the second external device, the alert including one or more of an audible alert, a visual alert, and a vibration alert.

**15**. The apparatus of claim **1**, wherein the implantable medical device is configured such that the telemetry circuit is limited in the transmission of the battery status when a level of remaining charge of the rechargeable battery crosses a threshold.

**16**. The apparatus of claim **1**, wherein information relating to the battery status comprises one or more of a measurement of a charge associated with the rechargeable battery, a voltage output of the rechargeable battery, a current flow through the rechargeable battery, and a time of use of the rechargeable battery since initial charging or a recharging.

**17**. A process comprising:

monitoring a battery status of a rechargeable battery in an implantable medical device; and

transmitting information relating to the battery status of the rechargeable battery to a first external device at a first time and to a second external device at a second time, wherein the second external device is of a different type than the first external device.

**18**. The process of claim **17**, wherein the transmitting information relating to the battery status of the rechargeable battery to the second external device passes through the first external device.

**19**. The process of claim **17**, comprising:

transmitting the information relating to the battery status at the first time to the first external device in response to a first level of remaining charge of the rechargeable battery; and

transmitting the information relating to the battery status at the second time to the second external device in response to a second level of remaining charge of the rechargeable battery that is different than the first level of remaining charge.

**20**. The process of claim **17**, comprising recurrently transmitting alerts after a level of remaining charge of the rechargeable battery has crossed a threshold.

**21**. The process of claim **17**, comprising transmitting alerts as a function of a decreasing charge of the rechargeable battery.

**22**. The process of claim **17**, comprising:

transmitting a signal to one or more of the first external device and the second external device when the rechargeable battery is recharged; and

maintaining a record in one or more of the implantable device, the first external device, and the second external device regarding a recharging history of the rechargeable battery.

**23**. The process of claim **17**, comprising:

monitoring the battery status by measuring one or more of a charge associated with the rechargeable battery, a voltage output of the rechargeable battery, a current flow through the rechargeable battery, and a time that the battery has been used since an initial charging or recharging of the rechargeable battery; and

triggering, in response to the information relating to the battery status, one or more of an audible alert, a visual alert, and a vibration alert.

**24**. The process of claim **17**, comprising:

calculating a level of remaining charge of the rechargeable battery in one or more of the implantable medical device, the first external device, and the second external device; and

limiting the transmission of the information relating to the battery status when a level of remaining charge of the rechargeable battery crosses a threshold.

**25**. The process of claim **17**, wherein transmitting information relating to the battery status of the rechargeable battery to a first external device at a first time includes transmitting the information to a local external device to which a patient or a patient's local caregiver has access, and wherein transmitting information relating to the battery status of the rechargeable battery to a second external device at a second time includes transmitting the information to a remote patient monitoring system that is accessible by one or more of a physician and a plurality of implantable medical devices.

**26**. An apparatus comprising:

an implantable medical device comprising:

a control circuit;

a rechargeable battery, the rechargeable battery coupled to the control circuit;

a battery monitoring circuit, the battery monitoring circuit coupled to one or more of the rechargeable battery and the control circuit; and

a telemetry circuit, coupled to the control circuit, wherein the telemetry circuit is configured to transmit a battery status of the rechargeable battery to one or more of a first external device and a second external device, the second external device of a different type than the first external device;

wherein one or more of the first external device and the second external device are configured to trigger an alert at a first time and at a later second time based on the transmitted battery status.

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摘要(译)

可植入医疗设备包括控制电路。可充电电池耦合到控制电路。电池监控电路耦合到可充电电池和控制电路中的一个或多个。耦合到控制电路的遥测电路被配置为在第一时间将可再充电电池的电池状态传输到第一外部设备并且传输到与第一外部设备不同类型的第二外部设备，在第二时间。时间。