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(54) METHOD AND SYSTEM FOR POWERING AN ELECTRONIC DEVICE

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H02J 7/00	(2006.01)

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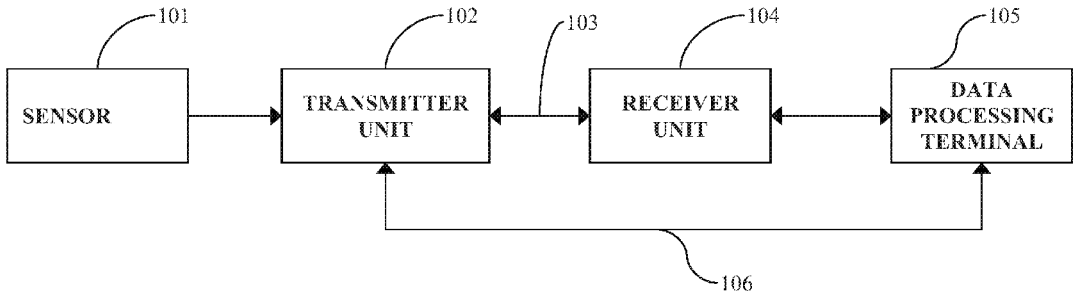
(57) **ABSTRACT**

Methods and apparatus for providing a power supply to a device, including an inductive rechargeable power supply for a data monitoring and management system in which a high frequency magnetic field is generated to provide power supply to a rechargeable power source such as a battery of a transmitter unit in the data monitoring and management system are provided.



100

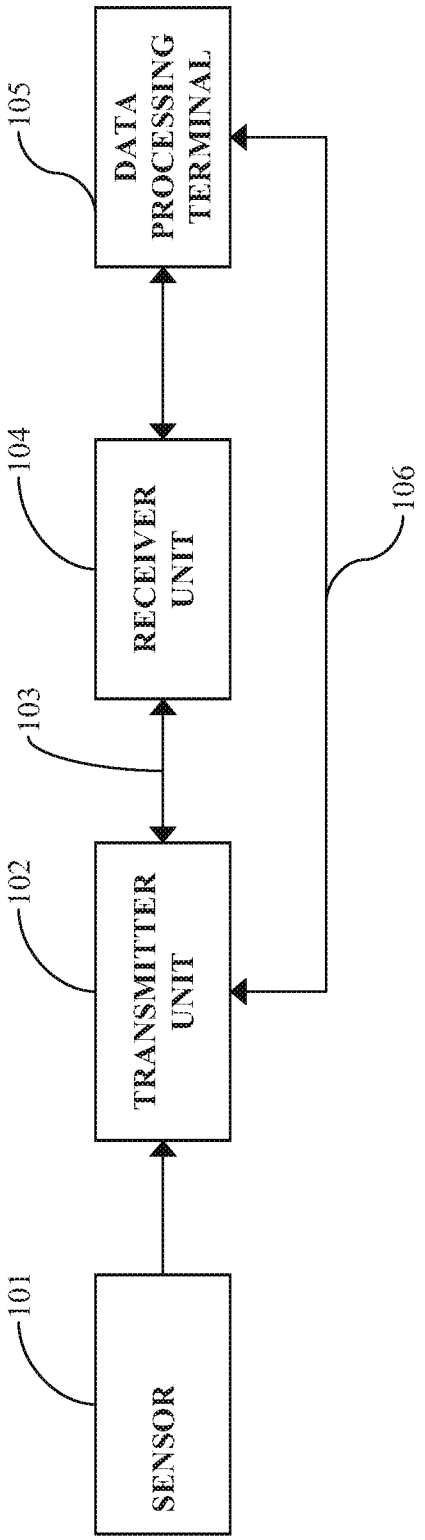

SENSOR
101
TRANSMITTER UNIT
102
103
RECEIVER UNIT
104
DATA PROCESSING TERMINAL
105
106
100

FIGURE 1

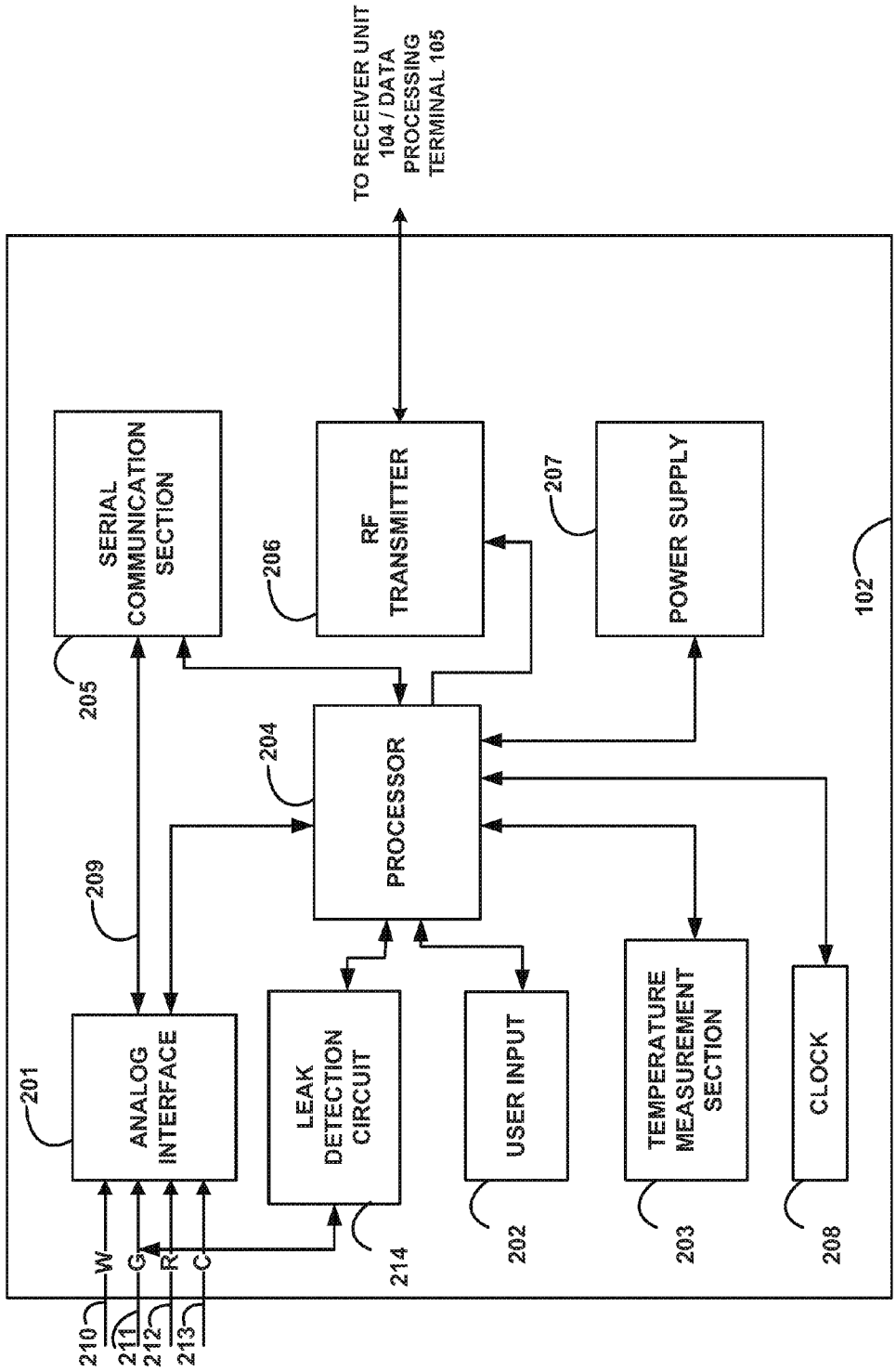

TO RECEIVER UNIT 104 / DATA PROCESSING TERMINAL 105
SERIAL COMMUNICATION SECTION
205
RF TRANSMITTER
206
POWER SUPPLY
207
102
PROCESSOR
204
209
ANALOG INTERFACE
201
LEAK DETECTION CIRCUIT
214
USER INPUT
202
TEMPERATURE MEASUREMENT SECTION
203
CLOCK
208
W
G
R
C
210
211
212
213

FIGURE 2

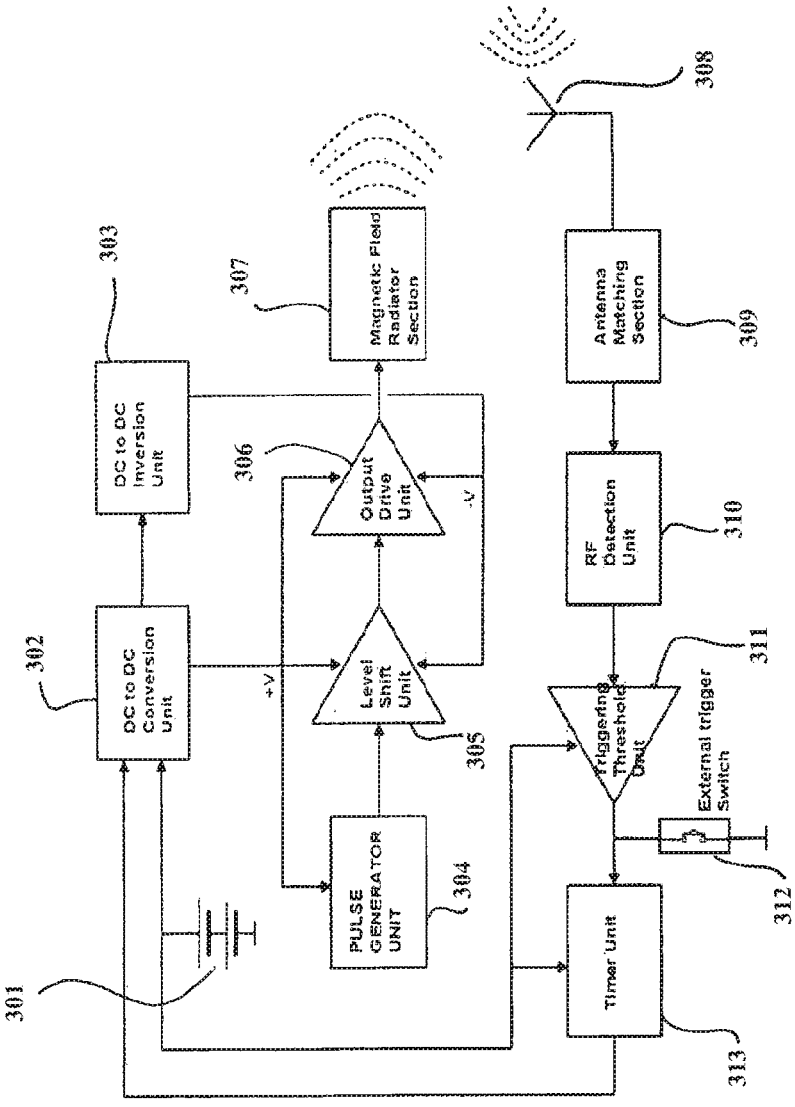

308
Magnetic Field Radiator Section
307
Antenna Matching Section
309
303
DC to DC Inversion Unit
306
Output Drive Unit
RF Detection Unit
310
302
DC to DC Conversion Unit
+V
-V
Level Shift Unit
305
311
Triggering Threshold Unit
External trigger Switch
312
PULSE GENERATOR UNIT
304
Timer Unit
313
301
300

FIGURE 3

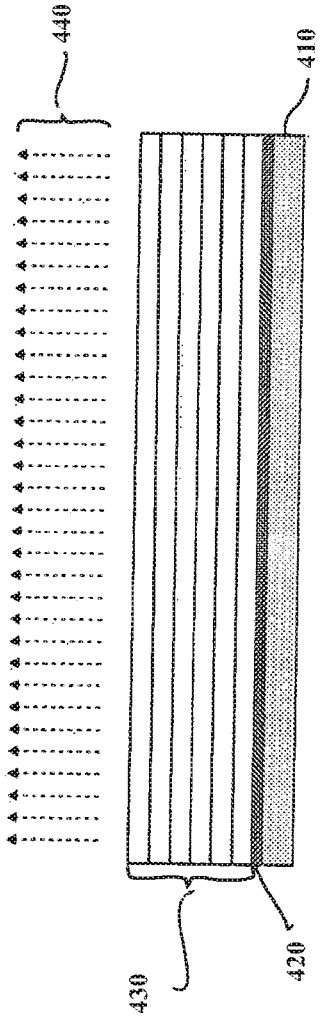


FIGURE 4

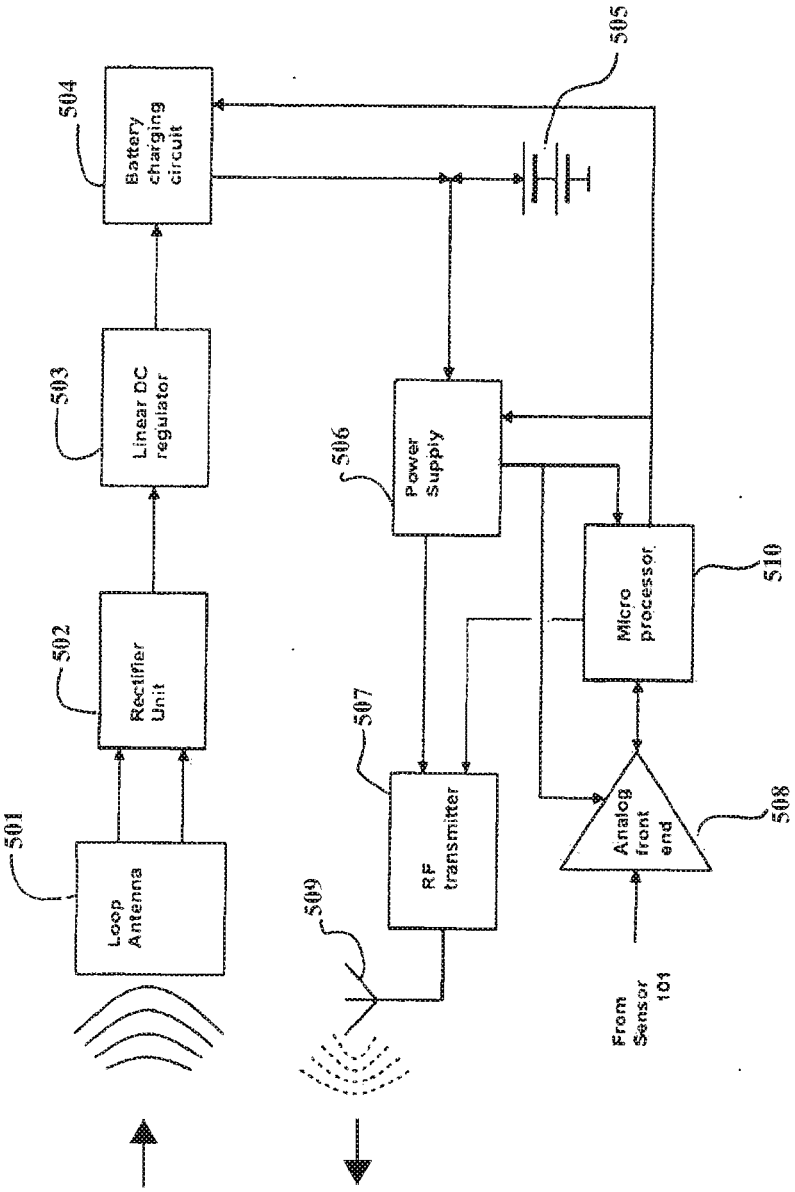

501
Loop Antenna
502
Rectifier Unit
503
Linear DC regulator
504
Battery charging circuit
505
506
Power Supply
507
RF transmitter
508
Analog front end
509
510
Micro processor
From Sensor 101

FIGURE 5

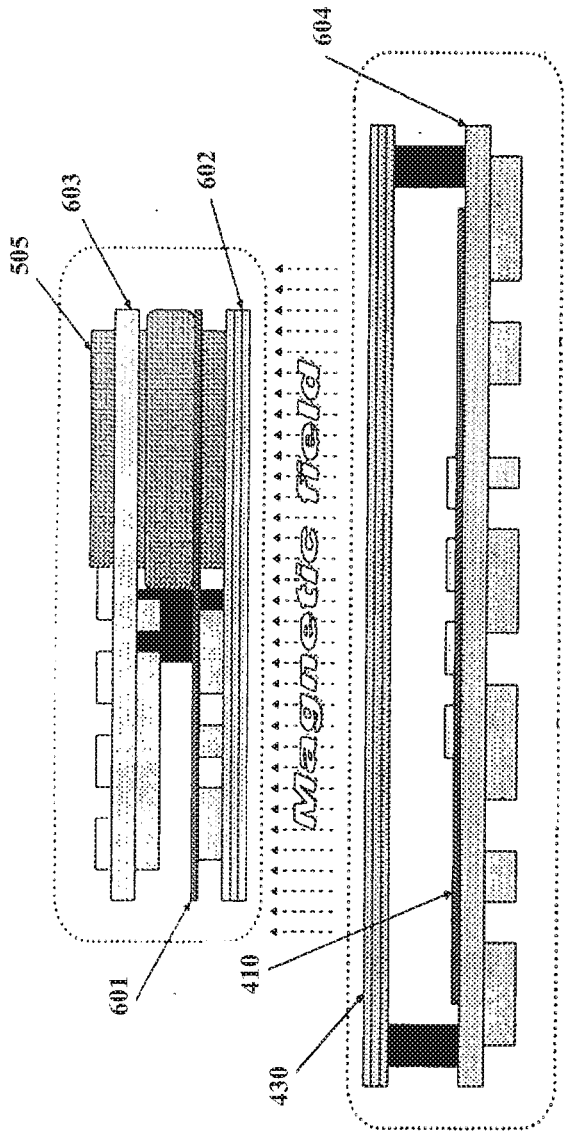


FIGURE 6

METHOD AND SYSTEM FOR POWERING AN ELECTRONIC DEVICE

RELATED APPLICATIONS

[0001] The present application is a continuation of U.S. patent application Ser. No. 15/169,750 filed Jun. 1, 2016, now U.S. Pat. No. 9,743,863, which is a continuation of U.S. patent application Ser. No. 14/562,630 filed Dec. 5, 2014, now U.S. Pat. No. 9,380,971, which is a continuation of U.S. patent application Ser. No. 14/089,348 filed Nov. 25, 2013, now U.S. Pat. No. 8,933,664, which is a continuation of U.S. patent application Ser. No. 12/611,734 filed Nov. 3, 2009, now U.S. Pat. No. 8,593,109, which is a continuation of U.S. patent application Ser. No. 11/396,135 filed Mar. 31, 2006, now U.S. Pat. No. 7,620,438, entitled "Method and System for Powering an Electronic Device", the disclosures of each of which are incorporated herein by reference for all purposes.

BACKGROUND

[0002] Analyte, e.g., glucose monitoring systems including continuous and discrete monitoring systems generally include a battery powered and microprocessor controlled system which is configured to detect signals proportional to the corresponding measured glucose levels using an electrometer, and RF signals to transmit the collected data. One aspect of certain glucose monitoring systems include a transcutaneous or subcutaneous analyte sensor configuration which is, for example, partially mounted on the skin of a subject whose glucose level is to be monitored. The sensor may use a two or three-electrode (work, reference and counter electrodes) configuration driven by a controlled potential (potentiostat) analog circuit connected through a contact system.

[0003] The analyte sensor may be configured so that at least a portion thereof is placed under the skin of the patient so as to detect the analyte levels of the patient, and another portion of segment of the analyte sensor that is in communication with the transmitter unit. The transmitter unit is configured to transmit the analyte levels detected by the sensor over a wireless communication link such as an RF (radio frequency) communication link. To transmit signals, the transmitter unit requires a power supply such as a battery. Generally, batteries have a limited life span and require periodic replacement. More specifically, depending on the power consumption of the transmitter unit, the power supply in the transmitter unit may require frequent replacement, or the transmitter unit may require replacement (e.g, disposable power supply such as disposable battery).

[0004] In view of the foregoing, it would be desirable to have an approach to provide a power supply for a transmitter unit in a data monitoring and management system.

SUMMARY

[0005] In view of the foregoing, in accordance with the various embodiments of the present invention, there is provided a method and apparatus for providing a power supply to an analyte monitoring system, where embodiments include an inductive rechargeable power supply for a data monitoring and management system in which a high frequency magnetic field is generated to provide power supply to a rechargeable power source such as a battery of a transmitter unit in the data monitoring and management system.

[0006] These and other objects, features and advantages of the present invention will become more fully apparent from the following detailed description of the embodiments, the appended claims and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** illustrates a block diagram of a data monitoring and management system for practicing one embodiment of the present invention;

[0008] FIG. **2** is a block diagram of the transmitter of the data monitoring and management system shown in FIG. **1** in accordance with one embodiment of the present invention;

[0009] FIG. **3** is a block diagram of a magnetic field generator unit of the receiver unit configured for providing inductive power recharge in the data monitoring and management system in accordance with one embodiment of the present invention;

[0010] FIG. **4** illustrates the magnetic field radiation unit of the serial resonant tank section of the receiver unit shown in FIG. **3** in accordance with one embodiment of the present invention;

[0011] FIG. **5** is a block diagram illustrating the transmitter unit with a rechargeable battery configured for inductive recharging in the data monitoring and management system in accordance with one embodiment of the present invention; and

[0012] FIG. **6** is a function illustration of the high frequency power transformer of the transmitter unit and the receiver unit including the magnetic field generator unit of the data monitoring and management system in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION

[0013] As described in accordance with the various embodiments of the present invention below, there are provided methods and system for inductively recharging a power source such as a rechargeable battery in an electronic device such as a data transmitter unit used in data monitoring and management systems such as, for example, in glucose monitoring and management systems.

[0014] FIG. **1** illustrates a data monitoring and management system such as, for example, an analyte (e.g., glucose) monitoring system **100** in accordance with embodiments of the present invention. The subject invention is further described primarily with respect to a glucose monitoring system for convenience and such description is in no way intended to limit the scope of the invention. It is to be understood that the analyte monitoring system may be configured to monitor a variety of analytes, e.g., lactate, ketones, and the like.

[0015] Indeed, analytes that may be monitored include, for example, acetyl choline, amylase, bilirubin, cholesterol, chorionic gonadotropin, creatine kinase (e.g., CK-MB), creatine, DNA, fructosamine, glucose, glutamine, growth hormones, hormones, ketones, lactate, peroxide, prostate-specific antigen, prothrombin, RNA, thyroid stimulating hormone, and troponin. The concentration of drugs, such as, for example, antibiotics (e.g., gentamicin, vancomycin, and the like), digitoxin, digoxin, drugs of abuse, theophylline, and warfarin, may also be monitored.

[0016] The embodiment of glucose monitoring system **100** includes a sensor **101**, a transmitter unit **102** coupled to the sensor **101**, and a receiver unit **104** which is configured to communicate with the transmitter unit **102** via a communication link **103**. The receiver unit **104** may be further configured to transmit data to a data processing terminal **105** for evaluating the data received by the receiver unit **104**. Moreover, the data processing terminal **105** in one embodiment may be configured to receive data directly from the transmitter unit **102** via a communication link **106** which may optionally be configured for bi-directional communication. In addition, within the scope of the present invention, the receiver unit **104** may be configured to include the functions of the data processing terminal **105** such that the receiver unit **104** may be configured to receive the transmitter data as well as to perform the desired and/or necessary data processing to analyze the received data, for example.

[0017] Only one sensor **101**, transmitter unit **102**, receiver unit **104**, and data processing terminal **105** are shown in the embodiment of the glucose monitoring system **100** illustrated in FIG. **1**. However, it will be appreciated by one of ordinary skill in the art that the glucose monitoring system **100** may include one or more sensor **101**, transmitter unit **102**, receiver unit **104**, and data processing terminal **105**, where each receiver unit **104** is uniquely synchronized with a respective transmitter unit **102**. Moreover, within the scope of the present invention, the glucose monitoring system **100** may be a continuous monitoring system, or semi-continuous, or a discrete monitoring system.

[0018] In one embodiment of the present invention, the sensor **101** is physically positioned in or on the body of a user whose glucose level is being monitored. The sensor **101** may be configured to continuously sample the glucose level of the user and convert the sampled glucose level into a corresponding data signal for transmission by the transmitter unit **102**. In one embodiment, the transmitter unit **102** is mounted on the sensor **101** so that both devices are positioned on the user's body. The transmitter unit **102** may perform data processing such as filtering and encoding of data signals, each of which corresponds to a sampled glucose level of the user, for transmission to the receiver unit **104** via the communication link **103**.

[0019] In one embodiment, the glucose monitoring system **100** is configured as a one-way RF communication path from the transmitter unit **102** to the receiver unit **104**. In such embodiment, the transmitter unit **102** transmits the sampled data signals received from the sensor **101** without acknowledgement from the receiver unit **104** that the transmitted sampled data signals have been received. For example, the transmitter unit **102** may be configured to transmit the encoded sampled data signals at a fixed rate (e.g., at one minute intervals) after the completion of the initial power on procedure. Likewise, the receiver unit **104** may be configured to detect such transmitted encoded sampled data signals at predetermined time intervals. Alternatively, the glucose monitoring system **100** may be configured with a bi-directional RF (or otherwise) communication between the transmitter unit **102** and the receiver unit **104**.

[0020] Additionally, in one aspect, the receiver unit **104** may include two sections. The first section is an analog interface section that is configured to communicate with the transmitter unit **102** via the communication link **103**. In one embodiment, the analog interface section may include an RF receiver and an antenna for receiving and amplifying the data signals from the transmitter unit **102**, which are thereafter, demodulated with a local oscillator and filtered through a band-pass filter. The second section of the receiver unit **104** is a data processing section which is configured to process the data signals received from the transmitter unit **102** such as by performing data decoding, error detection and correction, data clock generation, and data bit recovery.

[0021] In operation, the receiver unit **104** is configured to detect the presence of the transmitter unit **102** within its range based on, for example, the strength of the detected data signals received from the transmitter unit **102** or a predetermined transmitter identification information. Upon successful synchronization with the corresponding transmitter unit **102**, the receiver unit **104** is configured to begin receiving from the transmitter unit **102** data signals corresponding to the user's detected glucose level. More specifically, the receiver unit **104** in one embodiment is configured to perform synchronized time hopping with the corresponding synchronized transmitter unit **102** via the communication link **103** to obtain the user's detected glucose level.

[0022] Referring again to FIG. **1**, the data processing terminal **105** may include a personal computer, a portable computer such as a laptop or a handheld device (e.g., personal digital assistants (PDAs)), and the like, each of which may be configured for data communication with the receiver via a wired or a wireless connection. Additionally, the data processing terminal **105** may further be connected to a data network (not shown) for storing, retrieving and updating data corresponding to the detected glucose level of the user.

[0023] Within the scope of the present invention, the data processing terminal **105** may include an infusion device such as an insulin infusion pump or the like, which may be configured to administer insulin to patients, and which may be configured to communicate with the receiver unit **104** for receiving, among others, the measured glucose level. Alternatively, the receiver unit **104** may be integrated with an infusion device so that the receiver unit **104** is configured to administer insulin therapy to patients, for example, for administering and modifying basal profiles, as well as for determining appropriate boluses for administration based on, among others, the detected glucose levels received from the transmitter unit **102**.

[0024] Additionally, the transmitter unit **102**, the receiver unit **104** and the data processing terminal **105** may each be configured for bi-directional wireless communication such that each of the transmitter unit **102**, the receiver unit **104** and the data processing terminal **105** may be configured to communicate (that is, transmit data to and receive data from) with each other via a wireless communication link. More specifically, the data processing terminal **105** may in one embodiment be configured to receive data directly from the transmitter unit **102** via the communication link **106**, where the communication link **106**, as described above, may be configured for bi-directional communication.

[0025] In this embodiment, the data processing terminal **105** which may include an insulin pump or the like, may be configured to receive the glucose signals from the transmitter unit **102**, and thus, incorporate the functions of the receiver unit **104** including data processing for managing the patient's insulin therapy and glucose monitoring. In one embodiment, the communication link **103** may include one or more of an RF communication protocol, an infrared communication protocol, a Bluetooth® enabled communi-

cation protocol, an 802.11x wireless communication protocol, or an equivalent wireless communication protocol which would allow secure, wireless communication of several units (for example, per HIPAA requirements) while avoiding potential data collision and interference.

[0026] FIG. **2** is a block diagram of the transmitter of the data monitoring and detection system shown in FIG. **1** in accordance with one embodiment of the present invention. Referring to the Figure, the transmitter unit **102** in one embodiment includes one or more of the following components. The transmitter may include an analog interface **201** configured to communicate with the sensor **101** (FIG. **1**), a user input **202**, and a temperature detection section **203**, each of which is operatively coupled to a transmitter processor **204** such as a central processing unit (CPU). As can be seen from FIG. **2**, there are provided four contacts, three of which are electrodes—work electrode (W) **210**, guard contact (G) **211**, reference electrode (R) **212**, and counter electrode (C) **213**, each operatively coupled to the analog interface **201** of the transmitter unit **102** for connection to the sensor **101** (FIG. **1**). In one embodiment, each of the work electrode (W) **210**, guard contact (G) **211**, reference electrode (R) **212**, and counter electrode (C) **213** may be made using a conductive material that is either printed or etched, for example, such as carbon which may be printed, or metal foil (e.g., gold) which may be etched.

[0027] Further shown in FIG. **2** are a transmitter serial communication section **205** and an RF transmitter **206**, each of which is also operatively coupled to the transmitter processor **204**. Moreover, a power supply **207** such as a battery is also provided in the transmitter unit **102** to provide the necessary power for the transmitter unit **102**. Additionally, as can be seen from the Figure, clock **208** is provided to, among others, supply real time information to the transmitter processor **204**.

[0028] In one embodiment, a unidirectional input path is established from the sensor **101** (FIG. **1**) and/or manufacturing and testing equipment to the analog interface **201** of the transmitter unit **102**, while a unidirectional output is established from the output of the RF transmitter **206** of the transmitter unit **102** for transmission to the receiver unit **104**. In this manner, a data path is shown in FIG. **2** between the aforementioned unidirectional input and output via a dedicated link **209** from the analog interface **201** to serial communication section **205**, thereafter to the processor **204**, and then to the RF transmitter **206**. As such, in one embodiment, via the data path described above, the transmitter unit **102** is configured to transmit to the receiver unit **104** (FIG. **1**), via the communication link **103** (FIG. **1**), processed and encoded data signals received from the sensor **101** (FIG. **1**). Additionally, the unidirectional communication data path between the analog interface **201** and the RF transmitter **206** discussed above allows for the configuration of the transmitter unit **102** for operation upon completion of the manufacturing process as well as for direct communication for diagnostic and testing purposes.

[0029] As discussed above, the transmitter processor **204** is configured to transmit control signals to the various sections of the transmitter unit **102** during the operation of the transmitter unit **102**. In one embodiment, the transmitter processor **204** also includes a memory (not shown) for storing data such as the identification information for the transmitter unit **102**, as well as the data signals received from the sensor **101**. The stored information may be retrieved and processed for transmission to the receiver unit **104** under the control of the transmitter processor **204**. Furthermore, the power supply **207** may include a commercially available battery.

[0030] The power supply section **207** provides power to the transmitter for a minimum amount of time, e.g., about three months of continuous operation after having been stored for a certain period of time, e.g., about eighteen months in a low-power (non-operating) mode. It is to be understood that the described three month power supply and eighteen month low-power mode are exemplary only and are in no way intended to limit the invention as the power supply may be less or more than three months and/or the low power mode may be less or more than eighteen months. In one embodiment, this may be achieved by the transmitter processor **204** operating in low power modes in the non-operating state, for example, drawing no more than approximately 1 μA of current. Indeed, in one embodiment, during the manufacturing process of the transmitter unit **102**, the transmitter unit **102** may be placed in the lower power, non-operating state (i.e., post-manufacture sleep mode). In this manner, the shelf life of the transmitter unit **102** may be significantly improved. Moreover, as shown in FIG. **2**, while the power supply unit **207** is shown as coupled to the processor **204**, and as such, the processor **204** is configured to provide control of the power supply unit **207**, it should be noted that within the scope of the present invention, the power supply unit **207** is configured to provide the necessary power to each of the components of the transmitter unit **102** shown in FIG. **2**.

[0031] Referring back to FIG. **2**, the power supply section **207** of the transmitter unit **102** in one embodiment may include a rechargeable battery unit that may be recharged by a separate power supply recharging unit (for example, provided in the receiver unit **104** or in a mount to which the transmitter may be coupled, e.g., for on-body securement) so that the transmitter unit **102** may be powered for a longer period of usage time. Moreover, in one embodiment, the transmitter unit **102** may be configured without a battery in the power supply section **207**, in which case the transmitter unit **102** may be configured to receive power from an external power supply source (for example, a battery) as discussed in further detail below.

[0032] Referring yet again to FIG. **2**, the temperature detection section **203** of the transmitter unit **102** is configured to monitor the temperature of the skin near the sensor insertion site. The temperature reading may be used to adjust the glucose readings obtained from the analog interface **201**. The RF transmitter **206** of the transmitter unit **102** may be configured for operation in the frequency band of about 315 MHz to about 470 MHz, for example, in the United States. Further, in one embodiment, the RF transmitter **206** is configured to modulate the carrier frequency by performing Frequency Shift Keying and Manchester encoding. In one embodiment, the data transmission rate is 19,200 symbols per second, with a minimum transmission range for communication with the receiver unit **104**.

[0033] Referring yet again to FIG. **2**, also shown is a leak detection circuit **214** coupled to the guard contact (G) **211** and the processor **204** in the transmitter unit **102** of the data monitoring and management system **100**. The leak detection circuit **214** in accordance with one embodiment of the present invention may be configured to detect leakage

current in the sensor **101** to determine whether the measured sensor data are corrupt or whether the measured data from the sensor **101** is accurate.

[0034] Additional detailed description of the continuous glucose monitoring system, its various components including the functional descriptions of the transmitter are provided in U.S. Pat. No. 6,175,752 issued Jan. 16, 2001 entitled "Analyte Monitoring Device and Methods of Use", and in U.S. patent application Ser. No. 10/745,878 filed Dec. 26, 2003, now U.S. Pat. No. 7,811,231, entitled "Continuous Glucose Monitoring System and Methods of Use", and elsewhere.

[0035] FIG. **3** is a block diagram of a magnetic field generator unit of the receiver unit (or other component) configured for providing inductive power recharge in the data monitoring and management system in accordance with one embodiment of the present invention. Referring to FIG. **3**, the magnetic field generator unit **300** includes a power source such as a battery **301** configured to provide DC power to the magnetic field generator unit **300**. Also shown in FIG. **3** is a DC to DC conversion unit **302** operatively coupled to the power source **301** and a DC to DC inversion unit **303**. The magnetic field generator unit **300** in one embodiment also includes a pulse generator unit **304** operatively coupled to a level shift unit **305** which is in turn, operatively coupled to an output driver unit **306**.

[0036] Referring again to FIG. **3**, the output driver unit **306** is operatively coupled to a magnetic field radiation section **307** which, as described in further detail below, may be configured to generate and radiate a magnetic field. Also shown in FIG. **3** is an RF receiver antenna **308** which is configured to receive data from the transmitter unit **102** (FIG. **1**) over the communication link **103** (FIG. **1**). Additionally, referring still to FIG. **3**, the RF receiver antenna **308** is operatively coupled to an antenna matching section **309** which in turn, is operatively coupled to an RF detection unit **310** which may be configured to rectify the received RF signal from the transmitter unit **102** as discussed in further detail below. In addition, the RF detection unit **310** as shown in FIG. **3** is operatively coupled to a triggering threshold unit **311**. The triggering threshold unit **311** is also operatively coupled to an external trigger switch **312** and a timer unit **313**. In one embodiment, the timer unit **313** is operatively coupled to the power source **301** and the DC to DC conversion unit **302**, and may be configured to control power supply in the magnetic field generator unit **300** to preserve power consumption and effectively conserve the life of the power source **301**.

[0037] In one embodiment, the power source **301** is configured to provide direct current (DC) power supply for the magnetic field generator unit **300** that is provided in the receiver unit **104** (FIG. **1**) of the data monitoring and management system **100**. Alternatively, the magnetic field generator unit **300** may be incorporated into a separate unit or component and used to charge the power supply of the transmitter unit **102**.

[0038] Referring back to FIG. **3**, the DC to DC conversion unit **302** in one embodiment includes a step up DC to DC converter which is configured to boost the voltage level of the power source **301** to a higher positive DC voltage for the pulse generator unit **304**, the level shift unit **305**, and the output driver unit **306**. The DC to DC inversion unit **303** in one embodiment may include a step up DC to DC inverter configured to boost the positive DC voltage received from the DC to DC conversion unit **303** to a negative DC voltage to increase signal swing dynamic range between the positive and negative power supply rails for the level shift unit **305** and the output drive unit **306**.

[0039] Referring still to FIG. **3**, the pulse generator unit **304** in one embodiment includes a square wave generator and configured to generate square wave signals from, for example, approximately 100 KHz to approximately 1 MHz and to provide the generated square wave signals to the level shift unit **305**. The frequency range specified above may vary depending upon the specific component used and other design considerations. With the received square wave signals, the level shift unit **305** in one embodiment is configured to convert the positive square wave signals into corresponding positive and negative swing square wave signals with doubled voltage amplitude, which is provided to the output drive unit **306**. The output drive unit **306**, in turn, is configured to drive the magnetic field radiation section **307** by applying the full swing square wave signals from the level shift unit **305**. In one embodiment, as discussed in further detail below in conjunction with FIG. **4**, the magnetic field radiation section **307** includes a serial inductor-capacitor (LC) resonance circuit that may include tuning capacitors and multilayered printed circuit board (PCB) core coil inductor.

[0040] Referring yet again to FIG. **3**, the RF receiver antenna **308** in one embodiment is configured to receive the RF signals from the transmitter unit **102** (which may be associated with monitored or detected analyte levels received from the sensor **101** (FIG. **1**)). In one embodiment, the resonance frequency of the RF receiver antenna **308** may be tuned at the same frequency of the RF carry signal from the transmitter unit **102**. The antenna matching circuit **309** is configured to receive the RF signals from the RF receiver antenna **308**, and to deliver the received energy from the RF receiver antenna **308** to the RF detection unit **310**. In one aspect, the RF detection unit **310** may be configured to use a zero bias or biased RF Schottkey barrier diode to rectify the amplitude envelope of the received RF signals from the RF receiver antenna **308**.

[0041] Referring yet still to FIG. **3**, the rectified signal from the RF detection unit **310** is provided to the triggering threshold unit **311** which, in one embodiment includes a voltage comparator that compares the signal amplitude level of the rectified signal from the RF detection unit **310** and a reference voltage. Thereafter, the triggering threshold unit **311** in one embodiment is configured to switch the output of the triggering threshold unit **311** to low logical level when the signal level from the RF detection unit **310** exceeds the reference voltage. Similarly, an external trigger switch **312** may be provided which is configured to pull down the output voltage of the triggering threshold unit **311** to a low logical level when the external trigger switch **312** is activated. In one embodiment, the external trigger switch **312** is provided to allow the user to manually turn on the magnetic field generator unit **300**.

[0042] The triggering threshold unit **311** may be coupled to the timer unit **313** which in one embodiment includes a mono-stable timer, and may be configured to be triggered by the triggering threshold unit **311** to turn on or turn off the magnetic field generator **300** automatically and conserve the battery life of the power source **301**. More specifically, in one embodiment, the timer unit **313** may be programmed to a time period that is longer than one time interval between

two received RF signals from the transmitter unit **102**, but which is shorter than two time intervals, such that the magnetic field generator unit **300** is configured to be turned on continuously when the RF signals are received by the RF receiver antenna **308**.

[0043] In this manner, in one embodiment of the present invention, the magnetic field generator unit **300** may be configured to inductively charge the rechargeable power source of the transmitter unit **102** (FIG. **1**). More specifically, when the transmitter unit **102** is positioned in close proximity to the magnetic field generator unit **300** (for example, incorporated into the receiver unit **104**), the magnetic field generator unit **300** may be configured to activate automatically or manually depending upon the transmitter unit **102** transmission status.

[0044] That is, in one embodiment, when the transmitter unit **102** is transmitting RF signals, these signals received by the receiver unit **104** including the magnetic field generator unit **300** will activate the magnetic field generator unit **300** as described above by the RF receiver antenna **308** providing the received RF signals to the RF detection unit **310** via the antenna matching section **309**. The rectified amplitude envelope signals from the RF detection unit **310** is then configured to pull down the output voltage of the triggering threshold unit **311** to a low logical level. The low logical level starts the mono stable timer unit **313**, which turns on the DC to DC conversion unit **302** for the pulse generator unit **304**, the level shift unit **305**, and the output drive unit **306** to generate the magnetic field which is then used to inductively recharge the power source in the transmitter unit **102**.

[0045] In this manner, the RF signal transmission from the transmitter unit **102** in one embodiment is configured to maintain the magnetic field generator unit **300** to continuously generate the magnetic field, or alternatively, the trigger switch **312** may be activated to manually trigger the magnetic field generator unit **300** to continuously generate the magnetic field to inductively recharge the power supply of the transmitter unit **102**.

[0046] FIG. **4** illustrates the magnetic field radiation section **307** shown in FIG. **3** in accordance with one embodiment of the present invention. Referring to FIG. **4**, the magnetic field radiation section **307** of FIG. **3** in one embodiment includes a flexible ferrite layer **410** having disposed thereon an adhesive layer **420** on which, there is provided multilayered PCB core coil inductor **430**. In this manner, when the magnetic field generator unit **300** (FIG. **3**) is activated, the magnetic field **440** is generated as shown by the directional arrows in FIG. **4**. The flexible ferrite layer **410** increases the permeability of the PCB core coil inductor **430** by confining the bottom magnetic field in close proximity to the magnetic field radiation section **307**. For a given coil inductor, the inductance is proportional to the permeability of the core material. Furthermore, since Q factor of the inductor is proportional to inductance of the inductor, in one embodiment, the Q factor and inductance of the multilayered PCB core coil inductor **430** are increased by the presence of the flexible ferrite layer **410**. Moreover, the resonance voltage and current developed on the multilayered PCB core coil inductor **430** is proportional to the Q factor. The magnetic field is, therefore, enhanced.

[0047] FIG. **5** is a block diagram illustrating the transmitter unit with a rechargeable battery configured for inductive recharging in the data monitoring and management system in accordance with one embodiment of the present invention. Referring to FIG. **5**, the transmitter unit **102** with inductive power recharge capability includes an antenna **501** which in one embodiment includes a parallel resonant loop antenna configured to resonate at the same frequency as the magnetic field generated by the magnetic field generator unit **300** (FIG. **3**). The generated magnetic field **440** (FIG. **4**) induces a current flow in the antenna **501** of the transmitter unit **102** when the transmitter unit **102** is positioned in close proximity to the magnetic field generator unit **300** (for example, when the transmitter unit **102** is placed on top of the magnetic field generator unit **300**). The induced current flow then builds up AC voltage across the two ends of the loop antenna **501**.

[0048] Referring back to FIG. **5**, also shown is a rectifier unit **502** which, in one embodiment includes a full bridge rectifier, and is configured to rectify the AC voltage built up in the loop antenna **501** into a corresponding DC voltage. In turn, a linear DC regulator unit **503** is provided to convert the varying DC voltage from the rectifier unit **502** into a constant voltage which is provided to a battery charging circuit **504**. The battery charging circuit **504** in one embodiment is configured to provide a constant charging current to charge a rechargeable battery **505** provided in the transmitter unit **102**. Accordingly, in one embodiment, the rechargeable battery **505** may be configured to store the energy from the battery charging circuit **504** to provide the necessary power to drive the circuitry and components of the transmitter unit **102**.

[0049] As shown in FIG. **5**, an RF antenna **509** is coupled to an RF transmitter **507** which, under the control of a microprocessor **510** is configured to transmit RF signals that are associated with analyte levels monitored by a sensor **101** and processed by an analog front end section **508** which is configured to interface with the electrodes of the sensor **101** (FIG. **1**). A power supply **506** is optionally provided to provide additional power to the transmitter unit **102**.

[0050] FIG. **6** is a function illustration of the high frequency power transformer of the transmitter unit and the receiver unit including the magnetic field generator unit of the data monitoring and management system in accordance with another embodiment of the present invention. Referring to FIG. **6**, as can be seen, a high frequency power transformer is formed by the magnetic field radiation section **307** including the flexible ferrite layer **410** with the multilayered PCB core coil inductor **430** (for example, as similarly shown in FIG. **4**), and a similar flexible ferrite layer **601** with a corresponding multilayered PCB core coil inductor **602** provided in the transmitter unit **102**. The multilayered PCB core coil inductor **602** in one embodiment includes the loop antenna **501**, the rectifier unit **502**, and the linear DC regulator unit **503**. As shown, when the transmitter unit **102** is positioned in close proximity to the magnetic field generator unit **300** of the receiver unit **104**, for example, the high frequency power transformer is generated so as to inductively charge the rechargeable battery **505** of the transmitter unit **102**.

[0051] Moreover, referring to FIG. **6**, the circuit board **603** is configured in one embodiment to include the electronic components associated with the transmitter unit **102**, for example, as discussed above in conjunction with FIGS. **2** and **5**, while circuit board **604** is configured in one embodiment to include the electronic components associated with the receiver unit **104** including the magnetic field generator

unit **300**. For example, in one embodiment, the circuit board **603** includes the power supply **506**, the RF transmitter **507**, the analog front end section **508**, the RF antenna **509**, and the microprocessor **510** as described above in conjunction with FIG. **5**.

[0052] In the manner described above, in accordance with the various embodiments of the present invention, there are provided method and system for inductively recharging the power supply such as a rechargeable battery of a transmitter unit **102** in the data monitoring and management system **100** using a high frequency magnetic transformer that is provided on the primary and secondary printed circuit boards **603**, **604** respectively. Accordingly, a significant reduction in size may be achieved in the transmitter unit **102** design and configuration which may be worn on the patient's body for an extended period of time. Moreover, since the transmitter unit power supply can be recharged without exposing the internal circuitry for example, using a battery cover to periodically replace the battery therein, the transmitter unit housing may be formed as a sealed enclosure, providing water tight seal.

[0053] In addition, within the scope of the present invention, the magnetic field generator may be integrated into a flexible arm cuff type device such that the power supply of the transmitter unit **102** may be recharged without being removed from its operating position on the skin of the patient or user, such that the contact between the electrodes of the sensor **101** and the transmitter unit **102** analog front end section may be continuously maintained during the active life cycle of the sensor **101**.

[0054] Accordingly, an apparatus for providing rechargeable power for use in a data communication system in accordance with one embodiment of the present invention includes a power source section including a magnetic field generator unit configured to generate a magnetic field, and a rechargeable power section including a rechargeable power supply unit, wherein the rechargeable power supply unit is configured to be recharged when the rechargeable power section is provided in a predetermined proximity to the generated magnetic field of the power source section.

[0055] In one aspect, the power source section and the rechargeable power section may comprise a power transformer unit, which may include a high frequency power transformer.

[0056] The magnetic field generator unit may include a first coil inductor, and further, where the rechargeable power supply unit may include a second coil inductor, where also, each of the first and second coil inductors may include a plurality of PCB layers.

[0057] The rechargeable power section in one embodiment may include a data transmission unit, and further, wherein the power source section includes a data receiver unit, where the data transmission unit may be configured to transmit one or more signals to the data receiver unit in the rechargeable power section over a wireless communication link including an RF communication link.

[0058] In one embodiment, the magnetic field generator unit may be configured to be controlled by one or more of the transmitted signals from the data transmission unit.

[0059] An apparatus for providing rechargeable power for use in a data communication system in accordance with another embodiment of the present invention includes a power source section including a magnetic field generator unit configured to generate a magnetic field, a power section that is rechargeable provided in a predetermined proximity to the generated magnetic field of the power source section.

[0060] The power section may include a rechargeable power supply unit configured to be inductively recharged by the power source section.

[0061] In another aspect, a data transmitter unit may be configured to transmit one or more signals associated with an analyte level, the data transmitter unit including the power section.

[0062] In yet another aspect, a data receiver unit may be configured to receive one or more signals associated with an analyte level, the receiver unit including the power source section.

[0063] In still another aspect, a glucose monitoring system may be provided including a data transmitter unit configured to transmit one or more signals associated with an analyte level, and a data receiver unit configured to receive the one or more signals from the transmitter unit, wherein the transmitter unit includes the power section, and further, where the receiver unit including the power source section.

[0064] An analyte monitoring system with rechargeable power supply in accordance with another embodiment of the present invention includes an analyte sensor at least a portion of which is configured for subcutaneous placement under a skin layer, the sensor configured to detect an analyte level, a data transmission unit operatively coupled to the analyte sensor, the data transmission unit configured to transmit a plurality of signals including a signal associated with the detected analyte level, the data transmission unit further including a rechargeable power supply unit, and a data monitoring unit configured to receive the signal from the data transmission unit, the data monitoring unit further including a magnetic field generator unit, where the rechargeable power supply unit is configured to be recharged by the magnetic field generator unit.

[0065] In one aspect, the magnetic field generator unit may be configured to inductively charge the rechargeable power supply unit.

[0066] Further, the magnetic field generator unit may include a first multilayered coil inductor, and the rechargeable power supply unit may include a second multilayered coil inductor, where a first ferrite layer may be disposed on the first multilayered coil inductor, and a second ferrite layer may be disposed on the second multilayered coil inductor.

[0067] Moreover, the magnetic field generator unit may be configured to be controlled by one or more of the transmitted signals from the data transmission unit.

[0068] In another aspect, the magnetic field generator unit may be configured to generate a magnetic field, and where the rechargeable power supply unit may be configured to be recharged by the magnetic field generator unit when the data transmission unit is positioned in a predetermined proximity to the magnetic field.

[0069] Also, the magnetic field generator unit may be configured to generate a power transformer between the data transmission unit and the data monitoring unit.

[0070] A method of providing rechargeable power supply in accordance with yet another embodiment of the present invention includes generating a magnetic field, positioning a rechargeable power source within a predetermined distance from the generated magnetic field, and inductively charging the rechargeable power source. In certain embodiments, the method is a method of providing power to a transmitter of a transmitter of an analyte monitoring system.

[0071] In one aspect, generating the magnetic field may be triggered by the RF data transmission detection.

[0072] Also, the method may further include manually controlling the step of generating the magnetic field.

[0073] Moreover, in a further aspect, the method may also include detecting one or more analyte levels of a patient, and transmitting one or more signals associated with the detected one or more analyte levels.

[0074] In addition, the method may also include receiving the transmitted one or more signals, and/or monitoring an analyte level of a patient, where the analyte level includes a glucose level.

[0075] Various other modifications and alterations in the structure and method of operation of this invention will be apparent to those skilled in the art without departing from the scope and spirit of the invention. Although the invention has been described in connection with specific preferred embodiments, it should be understood that the invention as claimed should not be unduly limited to such specific embodiments. It is intended that the following claims define the scope of the present invention and that structures and methods within the scope of these claims and their equivalents be covered thereby.

What is claimed is:

1. A method, comprising:

generating a magnetic field at a receiver unit during a time period associated with data communication between sensor electronics and the receiver unit, wherein generating the magnetic field is programmed to turn on or turn off only during the time period, and wherein the sensor electronics is operatively coupled to an analyte sensor in fluid contact with interstitial fluid, wherein one or more signals are generated by the analyte sensor and associated with a monitored analyte level;

inductively coupling a rechargeable power source of the sensor electronics when the sensor electronics is placed within a predetermined distance from the generated magnetic field during the time period associated with the data communication; and

communicating data associated with the monitored analyte level from the sensor electronics to the receiver unit during the time period.

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