(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 949 652 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
02.01.2019 Bulletin 2019/01

(21) Application number: **06836928.9**

(22) Date of filing: **03.11.2006**

(51) Int Cl.:
H04L 29/08 $^{(2006.01)}$ ***A61B 5/00*** $^{(2006.01)}$

(86) International application number:
PCT/US2006/043075

(87) International publication number:
WO 2007/058798 (24.05.2007 Gazette 2007/21)

(54) **WIRELESS COMMUNICATION PROTOCOL FOR A MEDICAL SENSOR SYSTEM**

DRAHTLOSES KOMMUNIKATIONSPROTOKOLL FÜR EIN MEDIZINISCHES SENSORSYSTEM

PROTOCOLE DE COMMUNICATION SANS FIL POUR SYSTEME DE CAPTEUR MEDICAL

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(30) Priority: **14.11.2005 US 736408 P**
07.06.2006 US 449511

(43) Date of publication of application:
30.07.2008 Bulletin 2008/31

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WO-A-97/18639
WO-A-2004/072888
US-A1- 2002 013 518

Printed by Jouve, 75001 PARIS (FR)

Description

BACKGROUND OF THE INVENTION

[0001] One important aspect to delivering satisfactory care to patients within a hospital setting is monitoring different biological indicators used to diagnose medical conditions. For example, the careful monitoring of blood pressure, heartbeat rate, and EKG can help determine a patient's current health and future chances for recovery. Traditionally, this monitoring has been achieved by attaching sensors to a patient and then connecting these sensors to monitor units which display the sensor readings.

[0002] A sensor cable has been the simplest and most reliable means of connecting these sensors with a nearby patient monitor. However, these cables tangle easily, limit the distance of the patient from the monitor and can become damaged overtime.

[0003] More recently, wireless communication methods have been used between the sensor and the patient monitor, overcoming many of the disadvantages presented by traditional cable systems. Some typical examples of these wireless systems can be seen in U.S. Patent Nos. 5,748,103; 5,862,803; 6,441,747; 6,544,174; and 6,850,788.

[0004] Generally, wireless medical communications systems have included two popular types of system architectures: simple independent systems that transmit directly to a sensor monitor, such as U.S. Patent No. 5,862,803 and more complex hospital-wide telemetry systems having sensor networks throughout a hospital, such as U.S. Patent No. 6,544,174. Simple wireless sensor systems often include sensors that transmit medical data to specialized monitors near the patient. However, these systems are designed for use with only a few sensors and therefore tend to inefficiently use bandwidth. Further, using many of these units within a hospital can lead to interference between transmissions of nearby systems.

[0005] The more complex medical telemetry systems often include wireless receivers throughout the hospital connecting to a central server computer, allowing sensors to transmit data at nearly any location within the hospital. Additionally, these wireless transmitter systems are often designed to make more efficient use of the designated bandwidth and so are less likely to cause interference with nearby units. However, the size and complexity of these systems dramatically increases the expense for a hospital. Further, such complexity tends to reduce the reliability of the data transmissions, as well as the overall reliability of the system.

[0006] What is needed is a wireless communication system for medical sensors that combines the reliability of the simpler wireless sensor communication systems with the efficiency and reduced interference found in more complex telemetry systems.

OBJECTS AND SUMMARY OF THE INVENTION

[0007] It is an object of the present invention to overcome the limitations of the prior art.

[0008] It is another object of the present invention to provide a wireless communications system having a network-organizing master that is portable.

[0009] It is another object of the present invention to provide a wireless communications system that increases the stability of wireless networks.

[0010] It is another object of the present invention to provide a wireless communications system that does not require a master controller administering the wireless communications.

[0011] It is another object of the present invention to provide a wireless communications system that does not require a central server to administer.

[0012] The present invention attempts to achieve these objects, in one embodiment, by providing a wireless communication system for medical sensor data. This communications system includes a portable unit that connects to a wireless sensor and a monitor unit that connects to a sensor monitor. Once activated, the units will self organize into a wireless communication structure controlled by the portable unit. As other pairs of units activate, they can self-organize their transmissions by joining an existing network or by creating new networks.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]

Figure 1 illustrates a wireless communication system according to a preferred embodiment of the present invention;

Figure 2 illustrates a communications protocol structure according to a preferred embodiment of the present invention;

Figure 3 illustrates a wireless communication system according to a preferred embodiment of the present invention;

Figure 4 illustrates an ID tag according to a preferred embodiment of the present invention;

Figure 5 illustrates a message structure of a portable unit according to a preferred embodiment of the present invention;

Figure 6 illustrates a message structure of a stationary unit according to a preferred embodiment of the present invention;

Figure 7 illustrates a control message structure of a portable unit according to a preferred embodiment of the present invention; and

Figure 8 illustrates a control message structure of a stationary unit according to a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Wireless Communications Protocol Overview

[0014] Generally speaking, a preferred embodiment of the present invention is directed to a communication protocol or algorithm that facilitates data transfer between a portable sensor transmitter on a patient and a monitor for displaying the sensor data. This communication protocol not only organizes data transmissions between a single pair of a sensor transmitter and a monitor (also referred to generally as a "device pair") but allows "self-organization" of multiple device pairs within a close proximity to each other. By organizing communications between multiple device pairs, interference between multiple device pairs is reduced and the bandwidth of limited wireless frequencies is maximized, increasing data transmission reliability and the number of device pairs that can be used within close proximity.

[0015] The communication protocol combines some qualities of a TDMA communication protocol with that of an FDMA protocol to achieve organization around multiple frequency channels that each have a plurality of transmission timeslots. Typically, communications protocols that include some form of timeslots, such as TDMA, require a master communication organizer (generally referred to as a "master") that maintains a master time clock and tells other transmitter units (generally referred to as "slaves") in the networks which timeslot they can send data in. Traditionally, these masters are a single stationary unit since their constant transmissions typically require more power which is easier facilitated by the constant power of an AC outlet.

[0016] In the current communication protocol of the present preferred embodiment, the portable, battery-operated sensor transmitter acts as a master, organizing timeslots and designating them for use with specific device pairs. However, instead of only one master for a communication network, each frequency can have its own master that controls the timeslots for that frequency. Further, if a frequency lacks a master, a non-master sensor transmitter can "take charge" and become a master, ensuring that if a master is shut off, ceases communications, or otherwise becomes unavailable another sensor transmitter will take its place.

[0017] In this respect, instead of organizing around a single, unchanging, unmoving master, the communication protocol organizes around one master per frequency that may change from one sensor transmitter to another. The communication protocol network is therefore more dynamic than traditional network structures, allowing device pairs to switch frequencies, timeslots, and even their "status" as a master or slave.

[0018] To prevent every sensor transmitter from constantly fighting for control of a frequency as the master, a "line of succession" or hierarchy is created, constantly updated, and distributed to all of the sensor transmitters on a specific channel. Thus, all sensor transmitters on a frequency are always aware of which sensors transmitters are next in line to become masters. So, when the current master drops out, whichever sensor transmitter is "number two" in the line of succession becomes the master of that frequency.

[0019] To help each master with its organizational duties, such as assigning timeslots to device pairs for sending data, each frequency has a control timeslot, or a timeslot that is known to be reserved solely for organizational control communications between the current master and any other sensor transmitter nearby. In other words, when any commands or requests are transmitted to or from the master, the control timeslot is used for the transmissions, leaving the remaining timeslots available for transmission of sensor data.

[0020] In some situations, a slave sensor transmitter may have trouble communicating with its master due to, for example, a weak signal. If the slave sensor transmitter finds another frequency channel with a stronger master signal, it can jump over to that frequency by sending a timeslot request on the control channel of the new frequency. If the frequency has an open timeslot, its information will be transmitted back to the slave on the control timeslot, allowing the slave sensor transmitter and its sensor monitor (i.e. device pair) to join the new frequency and transmit on its new timeslot. If the new frequency does not have a new timeslot, the master instead sends a refusal signal on the control timeslot and the slave continues searching for a new frequency channel to join.

[0021] Occasionally, a slave sensor transmitter will not find a frequency channel with a suitable master. In this situation, the slave sensor transmitter can choose an empty frequency and become the master, allowing other slave sensor transmitters to join the frequency as needed.

[0022] When a sensor transmitter starts up, has decided to jump to a new frequency, or is otherwise looking for a new frequency channel to join, it will prefer to join a frequency that already includes another close device pair. Such a preference can minimize interference caused by the close proximity of these device pairs. More specifically, when two device pairs are close to each other, their transmissions can bleed into nearby frequencies, causing interference. However, if both nearby device pairs transmit on the same frequency, they transmit on different timeslots and therefore never transmit at the same time, preventing interference.

[0023] Before a device pair can join the communications network, and specifically a frequency channel, a sensor transmitter and a sensor monitor must be mated or paired together. By pairing a sensor transmitter and a sensor monitor together, each unit is aware of an ID number that distinguishes the other, thus telling each unit where to send communication data.

[0024] These units are not manufactured as device pairs. Instead, users can pair separate transmitters and monitors as desired. This pairing can be achieved by providing a user with an RFID token that can transmit a pairing ID to each unit, which in turn allows each unit to send and listen for the pairing ID and thus identify each other. The RFID token is positioned near a sensor transmitter and a sensor monitor which both read the pairing ID. The sensor transmitter first searches for an appropriate frequency channel, then requests a timeslot from the master of that frequency. Once a timeslot is obtained, the sensor transmits the RFID pairing ID so that it can be identified by the sensor monitor which is searching for the same pairing ID. Once the units "find" each other, they exchange permanent unit ID numbers which allows each unit to identify its paired unit.

[0025] In this respect, a user establishes communications between a sensor transmitter and a sensor monitor by pairing the two units by exchanging the same pairing ID, then allowing the sensor transmitter to join an existing frequency network as a slave or start a new frequency network as a master. In either case, a timeslot on a frequency is determined which allows the sensor transmitter to transmit sensor data to the sensor monitor.

Wireless Communications Protocol Embodiment

[0026] While the previous description generally described a preferred embodiment of the present invention, another description of the present invention is presented in greater detail below.

[0027] Figure 1 illustrates a preferred embodiment of a wireless communications system 100 that utilizes the wireless communication protocol of the present invention. In this preferred embodiment, a portable unit 104 is connected via a cable 118 to a pressure transducer 108 for obtaining the blood pressure of a patient. While a blood pressure transducer 108 will be discussed in the present preferred embodiment, other medical sensors may also be used, such as heart rate sensors and ECG electrodes.

[0028] The portable unit 104 obtains the sensor data from the pressure transducer 108, digitizes the data, and then incorporates the data and other relevant information into a transmission packet. The transmission packet is wirelessly transmitted, preferably by radio frequency, to a monitor unit 102 which extracts the sensor data from the transmission packet and communicates it via cable 120 to the monitor 106. A more thorough description of this operation is set forth in U.S. Non-Provisional Application Serial No. 11/292,872, filed December 2, 2005 entitled *Wireless Communication System For Pressure Monitoring* which is commonly owned with the present application, and which is incorporated herein by reference.

[0029] As will be described in greater detail below, the transmission packets are preferably coordinated by a TDMA/FDMA system having multiple time channels on each frequency channel used. Unlike prior art systems, the portable unit 104, not the monitor unit 102, acts as a timekeeper or master, controlling and coordinating the communications between multiple pairs of units 102 and 104. Additionally, when multiple pairs of units 102 and 104 are activated near each other, they self-organize their communications, as generally described in the overview above, to prevent collisions and maximize the use of designated frequency and time channels.

Frequency Channels and Timeslots

[0030] In a preferred embodiment, the wireless protocol used according to the present invention transmits data in a format that combines TDMA characteristics with those of FDMA protocols. More specifically, since the frequency range and therefore the number of frequencies for such wireless transmission is often limited (e.g. by FCC regulations or use by other wireless devices), the wireless protocol includes multiple timeslots 142A-142E within each frequency channel 140A-140D as seen in Figure 2. These timeslots 142A-142E occur once within every super frame 144 (i.e. a time period where every timeslot 142A-142E occurs once), providing a predictable time when data can be transmitted by a pair of units 102 and 104. In this respect, the communications protocol can accommodate more data transmissions than would otherwise be possible by only using different frequency channels 140A-140D alone.

Timing Master

[0031] The usage of timeslots 142A-142E of each super frame 144 seen in Figure 2 are controlled by a portable unit 104 that acts as a timing master (i.e. a unit maintaining a master clock by which the time of the timeslots are determined) coordinating the timeslot usage for all communications on a particular frequency channel. In the example of Figure 1, the portable unit 104 is the timing master, controlling, among other aspects, the timeslot usage on each frequency channel. However, when multiple portable units 104 are present, such as in Figure 3, one portable unit acts as the timing master for the portable units 104. For example, portable unit 104A controls the timeslot usage for a group of portable units 104B and 104C and thereby controls their transmission times to avoid interference or other communication complications. Generally, the timing master communicates a transmission schedule to other units on the network, informing them of when and how they can communicate on the network (e.g. assigning a timeslot for a particular pair of units).

[0032] As a timing master, the portable unit 104 not only transmits sensor data to its associated monitor unit 102A just like all other portable units, but also monitors a control timeslot (i.e. a timeslot reserved for control commands by the timing master), responds to commands and requests by other units 102 and 104 (e.g. a request by a portable unit 104 for a free timeslot), and determines a line of succession among nearby portable units 104 in the event the original timing master no longer qualifies as being the timing master.

[0033] The control timeslot is a timeslot, such as any one of timeslots 142A-142E in Figure 2 that is designated for conveying control data only, allowing and thereby governing the interaction of units 102 and 104 within one system. Preferably, this control timeslot is universally predetermined by the manufacturer for simplicity, such as the first timeslot 142A of every frequency channel. For example, referring to Figure 3, the portable unit 104C may wish to join a pre-existing frequency channel network controlled by timing master portable unit 104A. To do so, it sends a timeslot request on the control timeslot to the timing master 104A. The timing master then responds on the control timeslot with an appropriate response, such as by indicating an open slot for that frequency or that the frequency channel is full. Since the portable unit 104 is the "master" in the relationship with the monitor units 102, only these portable units 104 will send commands to each other.

[0034] Since the control timeslot can be used at any time by any of the portable units 104 to communicate with the timing master, the wireless protocol includes collision detection which prevents multiple control signals sent at the same time from colliding and therefore causing interference on the control timeslot. Generally, the collision detection directs each portable unit 104 to reference its own unique serial number before sending data on the control timeslot, allowing this number to guide its behavior in this regard.

[0035] The collision detection protocol is included with all portable units 104 (since all portable units 104 must communicate on the control timeslot to join a frequency channel). The collision detection protocol can generally be described as introducing asymmetrical or irregular transmission behaviors to reduce the likelihood that multiple units 104 will attempt to transmit data at the same time.

[0036] This asymmetrical transmission behavior of the collision detection protocol is achieved by irregularly switching the portable unit 104 between two main behaviors: a data transmission mode and a listening mode. In the data transmission mode, the portable unit 104 immediately sends its data message on the control timeslot. In the listening mode, the portable unit 104 listens for communications by other portable units 104 on the control timeslot.

[0037] To determine which mode a portable unit 104 irregularly switches into when it has data to transmit, the collision detection protocol looks to the value of the first digit of the unique serial (i.e. a number unique to each portable unit 104 and generated by the manufacturer). For example, if the serial number consists of only ones and zeros, a one may signal the data transmission mode while a zero may indicate that the portable unit 104 act according to the listening mode. In this respect, the portable unit 104 will either immediately transmit or listen for transmissions on the control slot.

[0038] If the portable unit sees a "listening mode digit", it switches to listening mode, ending the mode following a predetermined time after the control slot has been free of any transmissions. At this point, the collision detection protocol again looks to the next digit in the serial number, repeating this cycle until finding a "data transmission mode digit", at which point it transmits its data message. In this respect, irregular intervals of "waiting" can be introduced between portable units 104, reducing the likelihood that units will attempt to transmit at the same time.

[0039] After the portable unit 104 first transmits a message containing a desired command, it then waits for a valid response from the timing master. If the response is valid, the portable unit 104 acts accordingly. If the response is not valid, the collision detection protocol will again look to the next digit in its unique serial number and act accordingly, as previously described.

[0040] In the event the timing master ceases communications, a line of succession is followed by the units 104 so that another unit 104 takes its place, becoming the new timing master. This line of succession is determined by the current timing master who creates a ranked list that is frequently updated and distributed to the other units on that frequency channel network. If a portable unit 104 is activated and no timing master is present, that unit will automatically become the timing master for a specific frequency.

[0041] This line of succession is achieved, for example, by allowing each unit 102 and 104 of the group to monitor the radio strength signal indicator (RSSI) values, in other words the strength of the radio signal, for all timeslots. These units 102 and 104 transmit the RSSI data to the timing master in the control timeslot. The timing master then uses the RSSI values to calculate and rank each portable unit 104 according to their ability to communicate with all of the units 102 and 104 of the group. Thus, those portable units 104 receiving high RSSI values (i.e. strong radio signals) for other units will be positioned higher on the list. Similarly, other radio signal characteristics can be measured and factored into the preference list, such as the amount of interference in a signal.

[0042] Finally, the timing master transmits the succession order back to all of the units 102 and 104. As new pairs of units are added to a frequency channel, the process is repeated or at least repeated for the new pair, allowing the timing master to update the line of succession. Thus, if the current timing master is turned off or otherwise stops transmitting, the next portable unit 104 in the succession line begins to act as a timing master.

[0043] Further, the timing master may determine that a portable unit 104 is better positioned than itself to communicate with all of the units of a frequency channel. In this situation, the timing master places that portable unit 104 ahead of itself in the line of succession, causing it to become the new timing master for the frequency channel.

[0044] In this respect, a timing master is always present within a single pair of units 102 and 104 or multiple pairs of units 102 and 104, coordinating communications, reducing interference, and promoting efficient data transfer. Additionally, the high RSSI value preference ensures that the next unit to become the timing master is the best unit to receive signals from all units. Further, if a portable unit 104 is the first to start up, it automatically becomes the timing master until additional nearby units are activated and added to the list.

Jumping Frequency Channels

[0045] In some situations, the portable unit 104 may decide that it should jump from one frequency channel to another, such as jumping from frequency channel 140A to 140B in the example of Figure 2. The most common reasons for a frequency channel jump include situations where the portable unit 104 determines there is excessive interference with its transmissions, the portable unit 104 does not reliably receive data from the timing master, the portable unit 104 is directed to jump by the timing master, or the portable unit 104 becomes aware of a nearby unit jumping to a new frequency channel.

[0046] To make such a jump, the portable unit 104 transmits a jump message to the timing master on the control timeslot, which then acknowledges the jump message back on the control timeslot. The monitor unit 102 listens for the jump message on both the control timeslot and the allocated sensor data transmission timeslot and jumps with the portable unit 104 to the designated frequency channel. In the event that the monitor unit 102 loses contact with its associated portable unit 104, the monitor unit 102 scans all timeslots of all frequency channels to reestablish a connection.

[0047] After the pair jump, the timing master, which maintains a table of RSSI values measured by each unit, determines if there are other pairs of units 102 and 104 in close proximity to the jumping units (i.e. units that have high radio signals above a predetermined threshold as measured by the jumping pair of units 102 and 104). If other pairs are determined to be within a close proximity, the timing master will issue a jump command over the control timeslot, sending them to the same frequency channel as the pair of units 102 and 104 initially jumping. Thus, pairs of units 102 and 104 close to each other will tend to stay on the same frequency channel and therefore within the same group. As previously discussed, maintaining units on the same frequency can prevent bleeding-interference on nearby frequencies.

Frequency Channel Preferences

[0048] When a pair of units 102 and 104 activate or decide to jump to a new frequency channel, the portable unit 104 will scan all frequency channels, rank these frequency channels based on various criteria, then attempt to join the most preferred frequency channel. Preferably, the frequency channel preference is primarily determined by the RSSI value (i.e. the strength of the radio signals) of any of the units using a frequency channel.

[0049] For example, the portable unit 104 may initially categorize each RSSI value into a predetermined low, medium, or high category. Then, the overall priority for each frequency channel is ranked by giving highest priority to the frequency channels with high RSSI values (i.e. strong radio signals), next those with medium RSSI values or lower, followed by open channels with no radio activity, then those with only low RSSI values (i.e. weak radio signals), followed last by frequency channels with an interfering or jamming frequency. Priority can be further distinguished by increasing the priority of frequency channels with a timing master having a higher RSSI value and by increasing priority for frequency channels including a greater numbers of high and/or medium RSSI values for each timeslot.

[0050] When pairs of units are close to each other, their radio transmissions can interfere with or bleed between transmissions between pairs of units on other frequencies. However, when these nearby units are included on the same frequency channel, they are assigned their own timeslot and therefore never transmit at the same time, preventing interference. Thus, grouping nearby pairs of units on the same frequency channel will reduce interference and therefore cause more efficient data transfer and overall network stability.

[0051] By following such a frequency channel preference protocol, the portable unit 104 will prefer to join frequency channels in which nearby units 102 and 104 are already communicating on, thus minimizing bleeding of transmissions into adjacent frequencies as previously discussed. Additionally, the portable unit 104 will generally avoid frequency channels with more distant units 102 and 104 or with disrupting interference. Instead, frequency channels with a greater number of strong radio signals are preferred, thus, enhancing the stability of network communications and maximizing signal clarity.

Startup Behavior

[0052] Generally, the startup behavior of the wireless communications system 100 includes associating a portable unit 104 and a monitor unit 102 together to facilitate sensor data transfer only between those two units, then locating an acceptable channel for communications.

[0053] The wireless communications system 100 allows for a portable unit 104 and a monitor unit 102 to be associated or "mated" with each other as a pair to prevent confusion with other pairs operating nearby and to facilitate transmission of sensor data to the desired monitor unit 102. This association is achieved, in a preferred embodiment, by providing an association code to both units 102 and 104 by way of an RFID system, as is known in the art, which allows the units 102 and 104 to initially "find" each other. Each unit 102 and 104 includes a RFID tag reader which can read any one of a series of external RFID tags 122, as seen in Figure 4. Each RFID tag 122 includes a small radiofrequency transponder which transmits a code when interrogated by the RFID tag readers of the units 102 and 104. In a preferred embodiment, each unit 102 and 104 generally includes two transceivers: a first transceiver for the RFID tag reader which is configured to communicate over a few centimeters and a second transceiver for transmitting sensor data over many meters (e.g. 10 meters). By using two transceivers, the units 102 and 104 communicate different types of information in an efficient manner.

[0054] More specifically, the first transceiver (for the RFID tag reader) communicates the RFID data for linking the units 102 and 104 together over a short range with low power frequencies while the second transceiver (for the sensor data) communicates the sensor data over a long range with high power frequencies. This is a more efficient configuration than one where, for example, both the RFID data and the sensor data are transmitted with one long range, high power frequency transceiver. Such a configuration would use more power than otherwise necessary to operate the invention.

[0055] Generally, RFID readers are composed of three components: control circuitry, a RFID transceiver, and an antenna. These three components can operate on a variety of frequencies, such as 125-134 kHz, 13.56 MHz, 902-928 MHz, and 2.4 GHz, depending on the desired characteristics of the system (e.g. transmission range, power consumption, creation of unwanted interference, etc.). With regard to the present invention, there are at least two different ways to configure these components into a suitable RFID reader. However, the main goal is always to maintain relatively low power requirements in order to maximize battery life in the portable unit 104. The first way is a customized approach and the second way is an off-the-shelf approach.

[0056] In the customized approach, the control component is provided by the microcontroller that already exists in each of the units 102 and 104. This avoids having two separate control chips in each of the units 102 and 104. An antenna and a transceiver are then selected based on the optimized frequency and power requirements and then mounted on a circuit board internal to the units 102 and 104. The customized approach leads to a RFID reader configuration that is precisely tailored to a desired frequency range and transmitting environment of the units 102 and 104 since both the transceiver and antenna can be individually selected. It also optimizes the power requirements of the units 102 and 104, especially to minimize power consumption of the battery within portable unit 104. The customized approach can also be less expensive than other approaches.

[0057] In a preferred embodiment under the customized approach, an acceptable RFID transceiver include the multi-protocol transceiver model S6700 or the TMS3705A, both from Texas Instruments. Additional technical information on these transceiver chips is available from Texas Instruments and is incorporated herein by reference.

[0058] As for a suitable antenna in the customized approach, such an antenna will typically vary in size and configuration based on the transmission frequency. For example a 125-134 kHz transmission frequency may operate with a 5 cm diameter air coil of copper wire having about 66 turns or a wire coil wound around a ferrite core, such as the low-Q P-7896 from Dynasys. In another example, higher transmission frequencies can be achieved with an antenna printed directly on the circuit board, such as those described in the technical specifications provided by Texas Instruments literature number 11-08-26-001, the contents of which are hereby incorporated by reference.

[0059] In the off-the-shelf approach, each of the RFID reader components (control, antenna, transceiver) are integrated in one reader chip or reader device which can be purchased ready-made or "off-the-shelf" and then added to each of the units 102 or 104. In a preferred embodiment, acceptable reader chips include the SkyeRead M1 from SkyeTek or the Series 2000 Micro Reader from Texas Instruments. Additional technical information on these chips are available through their respective manufacturers and is incorporated herein by reference. Such off-the-shelf reader chips communicate with the host microprocessor of the units 102 or 104 through a standard protocol such as RS-232, TTL, I^2C, or SPI, thereby integrating into the circuitry of each unit 102 and 104. While the off-the-shelf approach can lead to an easier integration of an RFID reader into the units 102 and 104 and while they also may provide more consistent performance, such off-the-shelf devices often lead to greater expense than what can be achieved with a customized approach..

[0060] Additional information regarding RFID can be found in U.S. Patents 6,972,662; 6,956,509; 6,951,596; 6,940,408; 6,903,656; 6,812,841; 6,809,952; and 6,097,622.

[0061] As seen in Figure 2, the user first moves the RFID tag 122 in close proximity to one of the units 102 and 104, allowing the RFID reader to read the association code transmitted by the RFID tag 122. Next, the same RFID tag 122 is moved in close proximity to the other unit 102 or 104, allowing that unit to also read that code. In this respect, the user causes both units 102 and 104 of the intended pair to receive the same association code unique to that RFID tag 122.

[0062] Since electromagnetic interference between closely spaced RFID reader modules of any type (i.e. regardless of whether they are readers based on a customized or an off-the-shelf approach) can cause interference with each other, the present invention preferably controls the RFID transmissions using timeslots. This reduces the possible interference between two RFID reader units. For example, timeslots may be randomly assigned to each unit 102 or 104 prior to use by the consumer, simply reducing the odds that two units will transmit on the same timeslot. Alternatively, a more ordered timeslot system can be used in which each unit 102 and 104 are assigned timeslots, similar to the sensor data timeslot system for transmission of sensor data described below. Other interference reducing techniques can be seen in U.S. Pat. No. 6,566,997, the contents of which are hereby incorporated by reference.

[0063] Preferably, the RFID reader is turned off after the two units 102 and 104 have been associated as a pair, and even more preferably immediately after obtaining information from the RFID tag 122. By minimizing the time the RFID reader is transmitting and receiving, power consumption is minimized and thus battery life on the portable unit is maximized. Additionally, any potential interference created by the RFID reader, or other readers of other nearby units 102 and 104 may be minimized, since any transmissions on RFID frequencies are minimized.

[0064] Alternatively, the RFID tag 122 can be another type of tag or device that can transmit an ID number or code, such as a magnetic code (e.g. a magnetic strip on a credit card) or an optical mechanism (e.g. bar code and reader). Additionally, each RFID tag 122 can be colored or numbered to help distinguish a group of different tags 122.

[0065] Once in possession of the association code from the RFID tag 122, the portable unit 104 scans all frequency channels for peak radio signal values, determines a preference for these frequency channels as previously discussed in this application, then attempts to join the most preferred frequency channel. If that frequency channel is completely free (i.e. there are no other units communicating on it), the portable unit 104 becomes the timing master and begins transmitting as such on that frequency channel. If the preferred frequency channel already includes a timing master, the portable unit 104 negotiates an open timeslot from the timing master, if available.

[0066] Once a timeslot has been determined, the portable unit 104 transmits a command to create a new partnership, which includes the association code from the RFID tag 122. The monitor unit 102 also scans all frequency channels for a command to create a new partnership. If that new partnership command includes the same association code obtained by the monitor unit 102 from the RFID tag 122, the monitor unit 102 responds back to that portable unit 104 with the monitor unit's unique identification serial number. Once received by the portable unit 104, it reciprocates by sending the monitor unit 102 its unique identification serial number.

[0067] As previously described, the unique identification serial number is a permanent identification number designated during the manufacturing process that is unique to all units and is included in any communications from that unit. After exchanging unique identification serial numbers, both units 102 and 104 can recognize signals sent from each other, since all data messages include this identification serial number. When the pairing is complete and the monitor unit 102 has jumped to the same frequency channel as the paired portable unit 104, the portable unit 102 begins transmitting sensor data.

[0068] Once units 102 and 104 are paired and communicating, they retain this partnership until one unit is powered down or not responding to communications for a predetermined time. After such a termination of this partnership, the partnering can be reestablished as previously described.

[0069] Since the ID number of the RFID tag 122 is only used temporary, i.e. only for a short duration while the unique serial numbers of each unit 102 and 104 are exchanged, an RFID tag 122 can be reused to associate other units 102 and 104 as pairs. Thus, while RFID tags 122 using different ID's can be used to associate different units 102 and 104 (e.g. tag A can be used for pair 1 and tag B can be used for pair 2), a single RFID tag 122 can also be used to associate each pair as they are activated (e.g. tag A can be used for pair 1 and tag A can be used for pair 2 once pair 1 has finished pairing).

[0070] The RFID tag 122 can also include additional information used by each unit 102 and 104. For example, an RFID tag 122 may specify a specific frequency channel that both units may initially search on to locate each other during the previously described startup behavior. This may reduce the time needed for each unit to "find" each other, since only one frequency is searched, leading to quicker and more reliable startup behavior. Alternately, each RFID tag 122 may specify other relevant transmission control data, such as which frequency channels, timeslots, or RFID timeslots the units 102 and 104 can communicate on. In this respect, different units 102 and 104 can be restricted by the user to different frequency channels. Such frequency restrictions may be desired to reduce interference between the units 102 and 104 and other unrelated hospital equipment.

Power Down

[0071] To turn off the units 102 and 104, the user can press a power down button on either unit 102 and 104 causing that unit to send a message to the other unit indicating that it will power down. Once the receiving unit responds to the original unit, both units power down. In this respect, turning off one unit will also cause the other unit to turn off, saving battery power and reducing radio interference for other nearby pairs.

[0072] For example, a user presses a power down button on a portable unit 104, causing the portable unit 104 to send a power down message to its paired monitor unit 102. Once the monitor unit 102 receives this power down message, it sends a reply power down message back to the portable unit 104.

Message Definition

[0073] In a preferred embodiment, the transmitters within each portable unit 104 and monitor unit 102 can transmit at 153 kbps (6.5μs/bit) which allows about 8919 bits per superframe of 58.3ms (7 samples at a sample rate of 120 samples/sec). This allows 26 slots and a single control slot per frequency. With a 500kHz channel bandwidth, there could be up to 15 frequency channels which could allow 390 possible transmission positions. With an estimated maximum realistic loading of 33%, approximately 130 pairs of units could be reasonable in a typical ICU area.

[0074] More reliable performance could be achieved with transmission of redundant data. At the same latency, the transmission of redundant data would reduce the number of slots.

[0075] An increase in latency to 100 ms (15300 bits) would mean 12 samples per superframe. The message size of the portable unit 104 would increase by 40 bits for data and 1 bit for larger slot numbers, and the number of slots would increase to 41 slots and 1 control slot.

[0076] Figures 5-8 represent example message structures for some of the communications used by the wireless communication system 100. For example, Figure 5 illustrates the message structure of the portable unit, Figure 6 illustrates the message structure of the stationary unit, Figure 7 illustrates the control message structure of the portable unit, and Figure 8 illustrates the control message structure of the stationary unit.

Example Startup Operation

[0077] To better illustrate the present invention, the startup behavior of the previously described preferred embodiment will be further discussed below.

[0078] In operation, the portable unit 104 is activated by the user, activating the RFID reader within the portable unit 104. The user then selects an RFID tag 122 and moves it within proximity of the RFID reader, transmitting the association code contained within the RFID tag 122.

[0079] The portable unit 104 begins a scan of all frequency channels, measuring the peak RSSI value for each channel generally and for the timing master on each channel (if present). Also during this scan, the portable unit 104 stores the specific timeslot of each frequency channel.

[0080] If the portable unit 104 detects a frequency channel with a high RSSI value (i.e. a signal strength indicating another portable unit 104 is nearby) the portable unit 104 will listen for a predetermined amount of time to the timeslot of the unit 104 creating that signal in an attempt to "follow" that signal. By staying on the same frequency, frequency "bleeding" will be reduced since each nearby unit will be transmitting at different times.

[0081] For example, if the portable unit 104 hears that the nearby unit recently jumped to this frequency channel, the portable unit 104 will wait for sensor data to be transmitted before proceeding. If the nearby unit 104 initiates a jump command, the portable unit 104 begins to scan the frequency channels again.

[0082] Once the scan has been completed, the portable unit 104 follows predetermined frequency channel selection rules. Table 1 below provides some example rules that portable unit 104 may follow, in order of decreasing preference.

Table 1

Frequency Channel Measurement	Rule
A frequency channel includes a high signal strength on at least one timeslot.	Portable unit must join on an open timeslot. If no open timeslots, another frequency channel is chosen.
A frequency channel includes an intermediate signal strength on at least one timeslot.	Portable unit will join the frequency channel if it has the timing master with the strongest signal.
A frequency channel does not include transmissions on any slots.	Portable unit will select the frequency channel and become the timing master for that channel.
A frequency channel includes only weak signal strengths.	Portable unit will avoid joining this frequency channel.
A frequency channel includes jamming or interfering signals.	Portable unit will avoid joining this frequency channel.

[0083] If the frequency channel is empty, the portable unit establishes that it is the timing master and begins transmitting a "new link" message containing the association code of the RFID tag 122. If the frequency channel is not empty, the portable unit 104 transmits a timeslot request message on the control timeslot of that frequency channel. When the timing master responds with an allowable timeslot number, the portable unit 104 begins transmitting a "new link" message containing the association code of the RFID tag 122. If the monitor unit 102 does not respond within a predetermined period of time, the portable unit 104 will jump to the "next best" frequency channel.

[0084] The monitor unit 102 is preferably activated by the user shortly after the portable unit 104. The same RFID tag 122 is moved within proximity of the RFID reader within the monitor unit 102, transferring the association code within the RFID tag 122 to the memory of the monitor unit 102.

[0085] Next, the monitor unit 102 scans all of the frequency channels measuring peak RSSI values and RSSI values of the timing master of each channel. If one channel includes portable units with high signal strengths, the monitor unit 102 will listen on this frequency channel for the new link signal from the portable unit 104. If the portable unit 104 is not heard on this frequency channel, the monitor unit 102 will rotate through the remaining frequency channels, listening for the portable unit 104.

[0086] When the monitor unit 102 finds the new link message transmitted by the portable unit 104, each unit 102 and 104 respond with their unique serial numbers. These unique serial numbers allow each unit 102 and 104 to know which unit it is paired to, and therefore which unit to transmit to.

[0087] Once the portable unit 104 and the monitor unit 104 have connected to each other and exchanged unique serial numbers, the portable unit 104 can either jump to a more desirable frequency or begin transmitting sensor data to the monitor unit 102.

Alternative ID Linking Embodiments

[0088] In addition to the encoded RFID tag 122, other preferred devices and methods are possible for "linking" or "mating" a portable unit 104 with a monitor unit 102.

[0089] In one preferred embodiment, each unit 102 and 104 can be activated and directed to send linking radiofrequency signals. Each unlinked unit can display the units available for linking, by either presenting this data on an LCD screen, displaying a light that blinks in the same pattern as the newly activated unit, or by presenting a series of sounds (e.g. beeps) that sound in the same pattern as the newly activated unit. In this respect, the unlinked units 102 and 104 can communicate, either visually or aurally, a linking or mating ID, allowing the user to determine if a specific link is appropriate.

[0090] In another preferred embodiment, each unit 102 and 104 may allow a user to "make up" and type in a linking ID into two units 102 and 104 that are desired to be linked. The units 102 and 104 may allow multiple digits to be entered, a combination of colors linking to numbers, letters, or similar input methods.

[0091] In another preferred embodiment, the units 102 and 104 may include the ability to directly transmit a linking or mating ID code to each other when in close proximity. For example, each unit 102 and 104 can include a RFID tag within its structure, as well as an RFID reader. Thus, a portable unit 104 and a monitor unit 102 can simply be set to a "linking" mode and moved within close proximity of each other. In another example, such a direct communication of a linking ID may be achieved by providing infrared transmitters and receivers or a direct electrical connection (e.g. data cable).

[0092] In another preferred embodiment, the units 102 and 104 may transfer a linking ID by way of IC chips or "smart cards" (i.e. cards with memory chips or magnetic storage media) that plug into reader slots on each of the units 102 and

104. In this manner, a linking ID can either be preprogrammed on the smart card, or one unit 102 or 104 can initially write a linking ID onto a card, then that newly written linking ID can be read by another unit 102 or 104, causing them to link.

[0093] In yet another preferred embodiment, a patient unit can be included near the patient, such as on an IV pole or bed, which provides a common "platform" that supplies mounting positions, power connections, and communication connections for each portable unit 104 that is connected to a patient.

[0094] In another preferred embodiment, the previously described linking ID communications methods can also include a visual or auditory confirmation method. Since the units 102 and 104 may often be used in an area with many other pairs of units 102 and 104, a user may wish to confirm that the linking ID procedure created an appropriate link between the desired units 102 and 104. Additionally, a new user, such as a nurse who recently began their shift, may wish to examine or confirm pre-existing links. For example, the user may press a confirm button on one unit 102 and 104 which causes both of the linked units in the pair to flash a matching but randomly generated sequence of flashing lights or sounds. In this way, the user can easily determine if two units are linked.

[0095] Although the invention has been described in terms of particular embodiments and applications, one of ordinary skill in the art, in light of this teaching, can generate additional embodiments and modifications without departing from the spirit of or exceeding the scope of the claimed invention. Accordingly, it is to be understood that the drawings and descriptions herein are proffered by way of example to facilitate comprehension of the invention and should not be construed to limit the scope thereof.

Claims

1. A wireless transmission system (130) for radio frequency communication between a plurality of pairs (102,104,A,B,C) of medical sensors (108) adapted for sensing medical parameters and monitors (106) adapted for displaying those sensed parameters, each pair comprising a first portable transceiver unit (104,A,B,C) being connected to one of the sensor and monitor and a second transceiver unit (102,A,B,C) connected to the other of the sensor and monitor,
characterised in that
each portable transceiver unit includes a processor and any one of the first portable transceiver units may be a master unit controlling the signalling between itself and its second, slave, transceiver unit, and between other pairs of transceiver units of the system, in which,
the master unit (102/104,A,B,C) is arranged to transmit a first wireless signal to a slave unit and a second signal transmitted by the slave unit (102/104,A,B,C) is controlled using the first signal, and coordinating wireless transmissions between said other pairs of transceiver units with the first signal of said master unit,
whereby interference between different pairs of the system can be minimised

2. A system as claimed in claim 1, in which said master unit controls said signalling by establishing a transmission schedule (144) for communications between pairs of the system.

3. A system as claimed in claim 2, in which said schedule includes a transmission frequency (140, A-D) and a timeslot (142, A-E) for communications between pairs of the system.

4. A system as claimed in claim 3, in which said schedule is transmitted on a predetermined timeslot.

5. A system as claimed in claim 3 or 4, in which a portable transceiver unit of a pair, when first introduced into the system, selects a transmission frequency at which it determines it is desirable to transmit and receive, and detects whether a master unit already controls that frequency and, if a master unit already exists for that frequency, requests a timeslot in which to transmit, and, if no master unit is presently established for that frequency, establishes itself as the master unit for that frequency.

6. A system as claimed in claim 5, in which said selection is based on a hierarchy of possible transmission frequencies, wherein the most desirable frequency is that which is most strongly detected by the portable transceiver unit; preferably followed by that which is less strongly detected; preferably followed by that which is not detected at all; and preferably avoiding transmission frequencies that are weakly detected and/or include jamming/interference signals.

7. A system as claimed in claim 5 or 6, in which there are a plurality of groups of pairs of sensors and monitors, each group having a master unit controlling a transmission frequency which is different from the transmission frequencies used by other groups in transmission range of that group.

8. A system as claimed in any preceding claim, in which portable units that are not a master unit are ranked in a line of succession by a presently subsisting master unit according to wireless signal strength detected by such master unit, the portable unit with the strongest signal being first in the line of succession as a master unit in the event of the presently subsisting master unit ceasing transmissions; preferably said line of succession being transmitted to said portable units by the master unit.

9. A system as claimed in any preceding claim, in which said pairs are established by each first and second transceiver including a respective first and second wireless ID tag reader, wherein an ID tag is moved near each of said first and second units which each read and transmit an association code contained within said ID tag, the units being paired when each receives the association code from the other as well as from the ID tag; said reading preferably being effected by short range radio transmission.

10. A system as claimed in claim 9, in which said pairing establishment further comprises:

transmission of a first portable transceiver unit serial number to said second transceiver unit and storing said portable transceiver unit serial number in a memory of said second transceiver unit; and
transmission of a second transceiver unit serial number to said first portable transceiver unit and storing said second transceiver unit serial number in a memory of said first portable transceiver unit; wherein
subsequent communications between said units include transmission of the respective serial number.

11. A system as claimed in claim 4, or any of claims 5 to 10 when dependent on claim 4, in which each unit has two modes, a first, listening mode, in which it does not transmit during said predetermined timeslot and instead it listens for communications from other portable units on that timeslot, and a data transmission mode, in which it transmits its data message during said timeslot.

12. A system as claimed in claim 11, in which each portable unit includes a unique number, the value of which determines at each predetermined timeslot whether the unit is in said listening mode or said data transmission mode.

13. A method of operating a wireless transmission system (130) for radio frequency communication between a plurality of pairs (102,104,A,B,C) of medical sensors (108) adapted for sensing medical parameters and monitors (106) adapted for displaying those sensed parameters, each pair comprising a first portable transceiver unit (104,A,B,C) connected to one of the sensor and monitor and a second transceiver unit (102,A,B,C) connected to the other of the sensor and monitor,
characterised in that
any one of the first portable transceiver units is a master unit and controls the signalling between itself and its second, slave, transceiver unit, and between other pairs of transceiver units of the system, in which,
the master unit (102/104,A,B,C) transmits a first wireless signal to a slave unit and a second signal, transmitted by the slave unit (102/104,A,B,C), is controlled using the first signal, and coordinates wireless transmissions between said other pairs of transceiver units with the first signal of said master unit,
whereby interference between different pairs of the system can be minimised.

Patentansprüche

1. Drahtloses Übertragungssystem (130) zur Funkfrequenzkommunikation zwischen einer Mehrzahl von Paaren (102,104,A,B,C) von medizinischen Sensoren (108), die zum Abfühlen von medizinischen Parametern angepasst sind, und Monitoren (106), die zum Anzeigen dieser abgefühlten Parameter angepasst sind, wobei jedes Paar eine erste tragbare Sender-Empfänger-Einheit (104,A,B,C) aufweist, die mit dem einem von Sensor und Monitor verbunden ist, und eine zweite Sender-Empfänger-Einheit (102,A,B,C), die mit dem anderen von Sensor und Monitor verbunden ist,
dadurch gekennzeichnet, dass
jede tragbare Sender-Empfänger-Einheit einen Prozessor enthält, und jede der ersten tragbaren Sender-Empfänger-Einheiten eine Master-Einheit sein kann, die die Signalisierung zwischen sich selbst und ihrer zweiten Sender-Empfänger-Slave-Einheit und zwischen anderen Paaren von Sender-Empfänger-Einheiten des Systems steuert, wobei
die Master-Einheit (102/104,A,B,C) angeordnet ist, um ein erstes drahtloses Signal zu einer Slave-Einheit zu übertragen, und ein zweites Signal, das durch die Slave-Einheit (102/104,A,B,C) übertragen wird, unter Verwendung des ersten Signals gesteuert wird, und wobei drahtlose Übertragungen zwischen den anderen Paaren von Sender-

Empfänger-Einheiten mit dem ersten Signal der Master-Einheit koordiniert werden, wodurch eine Interferenz zwischen verschiedenen Paaren des Systems minimiert werden kann.

2. System nach Anspruch 1, wobei die Master-Einheit die Signalisierung durch Erstellen eines Übertragungszeitplans (144) für Kommunikationen zwischen Paaren des Systems steuert.

3. System nach Anspruch 2, wobei der Zeitplan eine Übertragungsfrequenz (140, A-D) und ein Zeitfenster (142, A-E) für Kommunikationen zwischen Paaren des Systems enthält.

4. System nach Anspruch 3, wobei der Zeitplan in einem vorher festgelegten Zeitfenster übertragen wird.

5. System nach Anspruch 3 oder 4, wobei eine tragbare Sender-Empfänger-Einheit eines Paars beim erstmaligen Einführen in das System eine Übertragungsfrequenz auswählt, für die sie bestimmt, dass sie zum Senden und Empfangen wünschenswert ist, und erfasst, ob eine Master-Einheit diese Frequenz bereits steuert, und falls für diese Frequenz bereits eine Master-Einheit vorhanden ist, ein Zeitfenster zum Senden anfordert, und falls derzeit keine Master-Einheit für diese Frequenz eingerichtet ist, sie sich selbst als Master-Einheit für diese Frequenz erstellt.

6. System nach Anspruch 5, wobei die Auswahl auf einer Hierarchie von möglichen Übertragungsfrequenzen beruht, wobei die wünschenswerteste Frequenz diejenige ist, die von der tragbaren Sender-Empfänger-Einheit am stärksten erfasst wird; bevorzugt gefolgt von derjenigen, die weniger stark erfasst wird; bevorzugt gefolgt von derjenigen, die überhaupt nicht erfasst wird; und bevorzugt unter Vermeidung von Übertragungsfrequenzen, die schwach erfasst werden und/oder Störungs-/Interferenzsignale enthalten.

7. System nach Anspruch 5 oder 6, wobei eine Mehrzahl von Gruppen von Paaren von Sensoren und Monitoren vorhanden ist, wobei jede Gruppe eine Master-Einheit hat, die eine Übertragungsfrequenz steuert, die sich von den Übertragungsfrequenzen unterscheidet, die von anderen Gruppen im Übertragungsbereich dieser Gruppe verwendet werden.

8. System nach einem der vorhergehenden Ansprüche, wobei tragbare Einheiten, die keine Master-Einheit sind, durch eine aktuell vorhandene Master-Einheit in eine Reihenfolge gemäß der Stärke des drahtlosen Signals eingestuft werden, das von einer derartigen Master-Einheit erfasst wird, wobei die tragbare Einheit mit dem stärksten Signal die erste in der Reihenfolge als Master-Einheit ist für den Fall, dass die aktuell vorhandene Master-Einheit Übertragungen beendet; wobei die Reihenfolge bevorzugt von der Master-Einheit zu den tragbaren Einheiten übertragen wird.

9. System nach einem der vorhergehenden Ansprüche, wobei die Paare durch jeden ersten und zweiten Sender-Empfänger erstellt werden, einschließlich eines jeweiligen ersten und zweiten drahtlosen ID-Tag-Lesegeräts, wobei ein ID-Tag in die Nähe jeder der ersten und zweiten Einheiten verschoben wird, die einen Zuordnungscode lesen und übertragen, der in jedem ID-Tag enthalten ist, wobei die Einheiten gepaart werden, wenn jede den Zuordnungscode von der anderen sowie von dem ID-Tag empfängt; wobei das Lesen bevorzugt durch Funkübertragung mit kurzer Reichweite erfolgt.

10. System nach Anspruch 9, wobei die Paarerstellung ferner aufweist:

Übertragung einer Seriennummer einer ersten tragbaren Sender-Empfänger-Einheit an die zweite Sender-Empfänger-Einheit und Speichern der Seriennummer der tragbaren Sender-Empfänger-Einheit in einem Arbeitsspeicher der zweiten Sender-Empfänger-Einheit; und
Übertragung einer Seriennummer einer zweiten Sender-Empfänger-Einheit an die erste Sender-Empfänger-Einheit und Speichern der Seriennummer der zweiten Sender-Empfänger-Einheit in einem Arbeitsspeicher der ersten tragbaren Sender-Empfänger-Einheit; wobei
anschließende Kommunikationen zwischen Einheiten eine Übertragung der jeweiligen Seriennummer enthalten.

11. System nach Anspruch 4 oder einem der Ansprüche 5 bis 10 bei Abhängigkeit von Anspruch 4, wobei jede Einheit zwei Modi hat, einen ersten Hörmodus, in dem sie während des vorab festgelegten Zeitfensters nicht überträgt und stattdessen Kommunikationen von anderen tragbaren Einheiten in diesem Zeitfenster abhört, und einen Datenübertragungsmodus, in dem sie ihre Datennachricht während des Zeitfensters überträgt.

12. System nach Anspruch 11, wobei jede tragbare Einheit eine eindeutige Zahl enthält, deren Wert in jedem vorab festgelegten Zeitfenster bestimmt, ob sich die Einheit in dem Hörmodus oder dem Datenübertragungsmodus befindet.

13. Verfahren zum Betreiben eines drahtlosen Übertragungssystems (130) zur Funkfrequenzkommunikation zwischen einer Mehrzahl von Paaren (102,104,A,B,C) von medizinischen Sensoren (108), die zum Abfühlen von medizinischen Parametern angepasst sind, und Monitoren (106), die zum Anzeigen dieser abgefühlten Parameter angepasst sind, wobei jedes Paar eine erste tragbare Sender-Empfänger-Einheit (104,A,B,C) aufweist, die mit dem einem von Sensor und Monitor verbunden ist, und eine zweite Sender-Empfänger-Einheit (102,A,B,C), die mit dem anderen von Sensor und Monitor verbunden ist,
dadurch gekennzeichnet, dass
jede der ersten tragbaren Sender-Empfänger-Einheiten eine Master-Einheit ist, die die Signalisierung zwischen sich selbst und ihrer zweiten Sender-Empfänger-Slave-Einheit und zwischen anderen Paaren von Sender-Empfänger-Einheiten des Systems steuert, wobei
die Master-Einheit (102/104,A,B,C) ein erstes drahtloses Signal zu einer Slave-Einheit überträgt, und ein zweites Signal, das durch die Slave-Einheit (102/104,A,B,C) übertragen wird, unter Verwendung des ersten Signals gesteuert wird und drahtlose Übertragungen zwischen den anderen Paaren von Sender-Empfänger-Einheiten mit dem ersten Signal der Master-Einheit koordiniert,
wodurch eine Interferenz zwischen verschiedenen Paaren des Systems minimiert werden kann.

Revendications

1. Système de transmission sans fil (130) pour la communication radiofréquence entre une pluralité de paires (102, 104,A,B,C) de capteurs médicaux (108) conçus pour détecter des paramètres médicaux et des écrans de surveillance (106) conçus pour afficher ces paramètres détectés, chaque paire comprenant une première unité d'émetteur-récepteur transportable (104,A,B,C) étant connectée à l'un du capteur et de l'écran de surveillance et une seconde unité d'émetteur-récepteur (102,A,B,C) connectée à l'autre du capteur et de l'écran de surveillance,
caractérisé en ce que chaque unité d'émetteur-récepteur transportable comprend un processeur et l'une quelconque des premières unités d'émetteur-récepteur transportables peut être une unité maître commandant la signalisation entre elle-même et sa seconde unité d'émetteur-récepteur esclave et entre d'autres paires d'unités d'émetteur-récepteur du système, ladite unité maître (102/104,A,B,C) étant agencée pour transmettre un premier signal sans fil à une unité esclave et un second signal transmis par l'unité esclave (102/104,A,B,C) étant commandé à l'aide du premier signal, et coordonnant les transmissions sans fil entre lesdites autres paires d'unités d'émetteur-récepteur avec le premier signal de ladite unité maître, ce qui permet de pouvoir minimiser des interférences entre différentes paires du système.

2. Système selon la revendication 1, ladite unité maître commandant ladite signalisation en établissant un programme de transmission (144) pour des communications entre des paires du système.

3. Système selon la revendication 2, ledit programme comprenant une fréquence de transmission (140,A-D) et une plage horaire (142,A-E) pour des communications entre des paires du système.

4. Système selon la revendication 3, ledit programme étant transmis sur une plage horaire prédéfinie.

5. Système selon la revendication 3 ou 4, une unité d'émetteur-récepteur transportable d'une paire, lorsque elle est introduite pour la première fois dans le système, sélectionnant une fréquence de transmission à laquelle elle détermine qu'il est souhaitable d'émettre et de recevoir et détectant si une unité maître commande déjà cette fréquence et, si une unité maître existe déjà pour cette fréquence, demandant une plage horaire dans laquelle émettre et, si aucune unité maître n'est actuellement établie pour cette fréquence, s'établissant en tant qu'unité maître pour cette fréquence.

6. Système selon la revendication 5, ladite sélection étant basée sur une hiérarchie de fréquences de transmission possibles, ladite fréquence la plus souhaitable étant celle dont la détection par l'unité d'émetteur-récepteur transportable s'avère la plus forte ; de préférence suivie par celle dont la détection s'avère moins forte ; de préférence suivie, par celle qui n'est pas du tout détectée ; de préférence évitant les fréquences de transmission qui n'est pas détectée du tout ; et de préférence en évitant les fréquences de transmission qui sont faiblement détectées et/ou comprennent des signaux de brouillage / d'interférence.

7. Système selon la revendication 5 ou 6, une pluralité de groupes de paires de capteurs et d'écrans de surveillance existent, chaque groupe possédant une unité maître commandant une fréquence de transmission qui est différente des fréquences de transmission utilisées par d'autres groupes dans la plage de transmission de ce groupe.

8. Système selon l'une quelconque des revendications précédentes, lesdites unités transportables qui ne sont pas une unité maître sont classées dans une ligne de succession par une unité maître actuellement subsistante selon la force du signal sans fil détecté par cette unité maître, ladite unité transportable avec le signal le plus fort étant la première dans la ligne de succession en tant qu'unité maître au cas où l'unité maître actuellement subsistante interromprait des transmissions ; de préférence ladite ligne de succession étant transmise auxdites unités transportables par l'unité maître.

9. Système selon l'une quelconque des revendications précédentes, lesdites paires étant établies par chaque premier et second émetteur-récepteur comprenant un premier et un second lecteur d'étiquette d'identification respectif, une étiquette d'identification étant déplacée près de chacune desdites première et seconde unités qui lisent et transmettent chacune un code d'association contenu dans ladite étiquette d'identification, lesdites unités étant appariées lorsque chacune reçoit le code d'association provenant de l'autre ainsi que de l'étiquette d'identification ; ladite lecture étant de préférence effectuée par transmission radio de courte portée.

10. Système selon la revendication 9, ledit établissement de l'appariement comprenant en outre :

la transmission d'un numéro de série de première unité d'émetteur-récepteur transportable à une seconde unité d'émetteur-récepteur et le stockage dudit numéro de série d'unité d'émetteur-récepteur transportable dans une mémoire de ladite seconde unité d'émetteur-récepteur ; et
la transmission d'un numéro de série de seconde unité d'émetteur-récepteur à ladite première unité d'émetteur-récepteur transportable et le stockage dudit numéro de série de seconde unité d'émetteur-récepteur dans une mémoire de ladite première unité d'émetteur-récepteur transportable ; lesdites communications ultérieures entre lesdites unités comprenant une transmission du numéro de série respectif.

11. Système selon la revendication 4, ou selon l'une quelconque des revendications 5 à 10 lorsqu'elles dépendent de la revendication 4, chaque unité possédant deux modes, un premier mode d'écoute, dans lequel il ne transmet pas durant ledit intervalle de temps prédéfini et au écoutant lieu de cela d'autres communications provenant des autres unité transportables sur cet intervalle de temps et un mode de transmission de données, dans lequel il transmet son message de données durant ledit intervalle de temps.

12. Système selon la revendication 11, chaque unité transportable comprenant un numéro unique, dont la valeur détermine à chaque intervalle de temps prédéfini si l'unité est dans ledit mode d'écoute ou dans ledit mode de transmission de données.

13. Procédé de fonctionnement d'un système de transmission sans fil (130) pour une communication radiofréquence entre une pluralité de paires (102, 104,A,B,C) de capteurs médicaux (108) conçus pour détecter des paramètres médicaux et des écrans de surveillance (106) conçus pour l'affichage de ces paramètres détectés, chaque paire comprenant une première unité d'émetteur-récepteur transportable (104,A,B,C) connectée à l'un du capteur et de l'écran de surveillance et d'une seconde unité d'émetteur-récepteur (102,A,B C) connectée à l'autre du capteur et de l'écran de surveillance, **caractérisé en ce que** l'une quelconque des premières unités d'émetteur-récepteur transportable est une unité maître et commande la signalisation entre elle-même et sa seconde unité d'émetteur-récepteur esclave et entre d'autres paires d'unités d'émetteur-récepteur du système, ladite unité maître (102/104,A,B,C) transmettant un premier signal sans fil à une unité esclave et un second signal, transmis par l'unité esclave (102/104,A,B,C), étant commandé à l'aide du premier signal, et coordonne des transmissions sans fil entre lesdits autres paires d'unités d'émetteur-récepteur à l'aide du premier signal de ladite unité maître, ce qui permet de pouvoir minimiser les interférences entre les différentes paires du système.

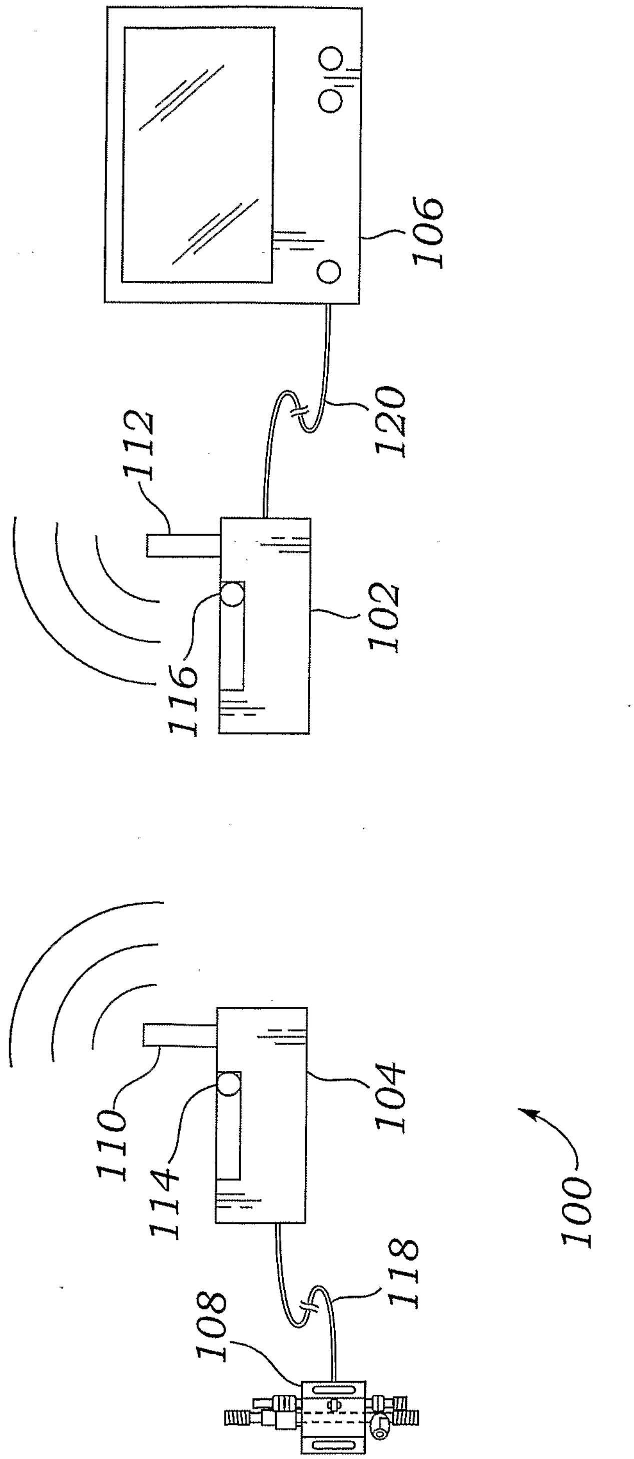

Fig. 1

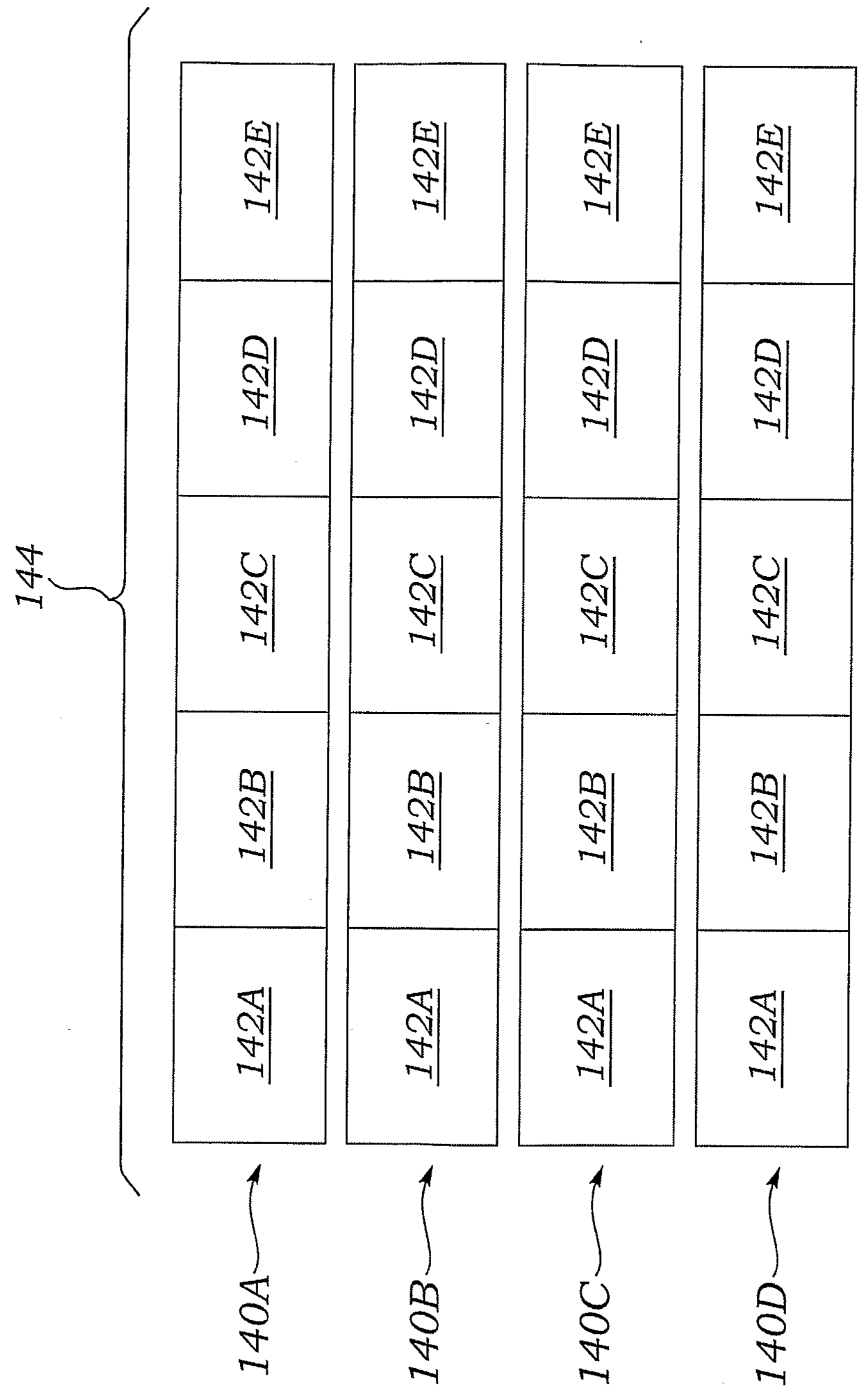

Fig. 2

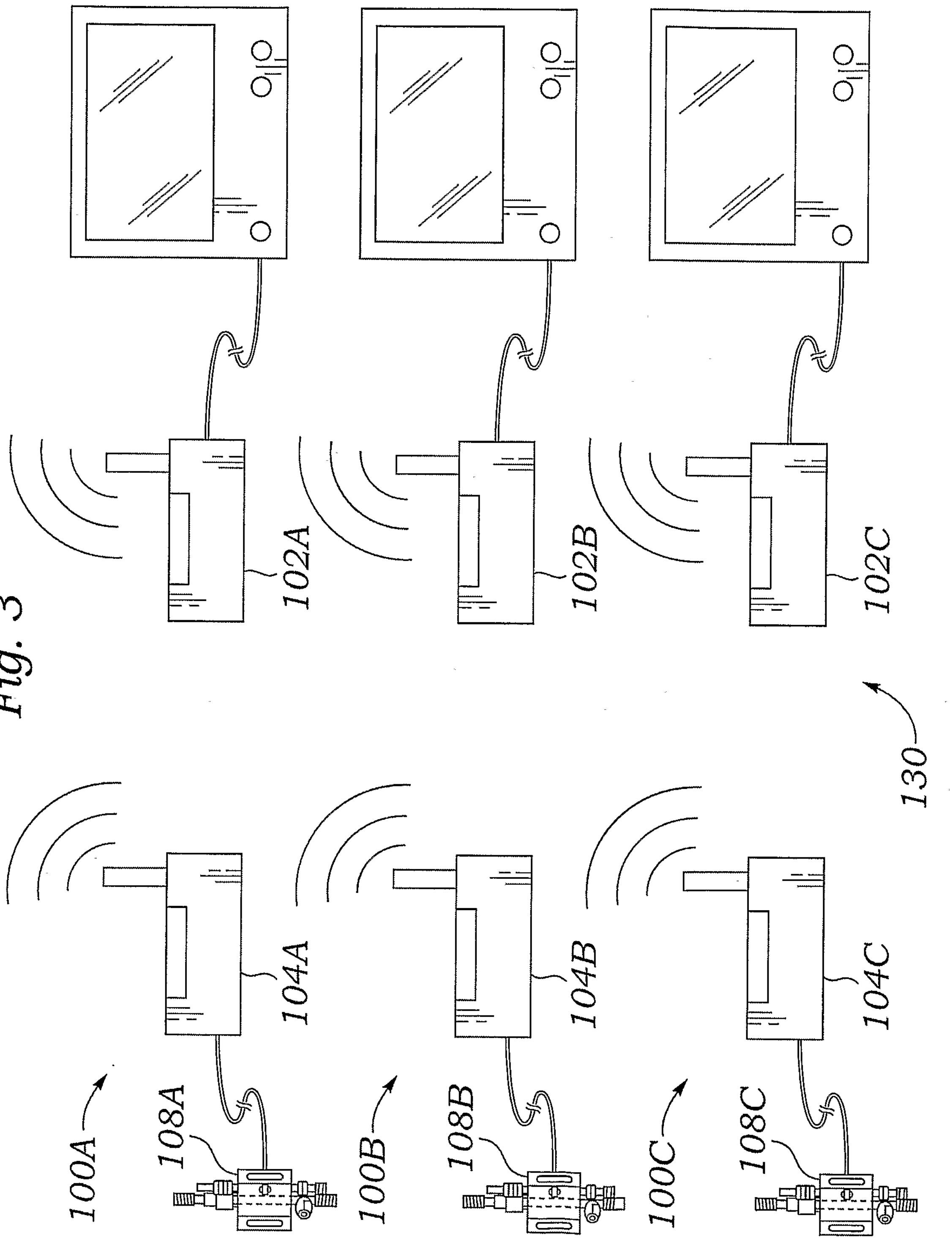
100A
108A
104A
102A
100B
108B
104B
102B
100C
108C
104C
102C
130

Fig. 3

Fig. 4

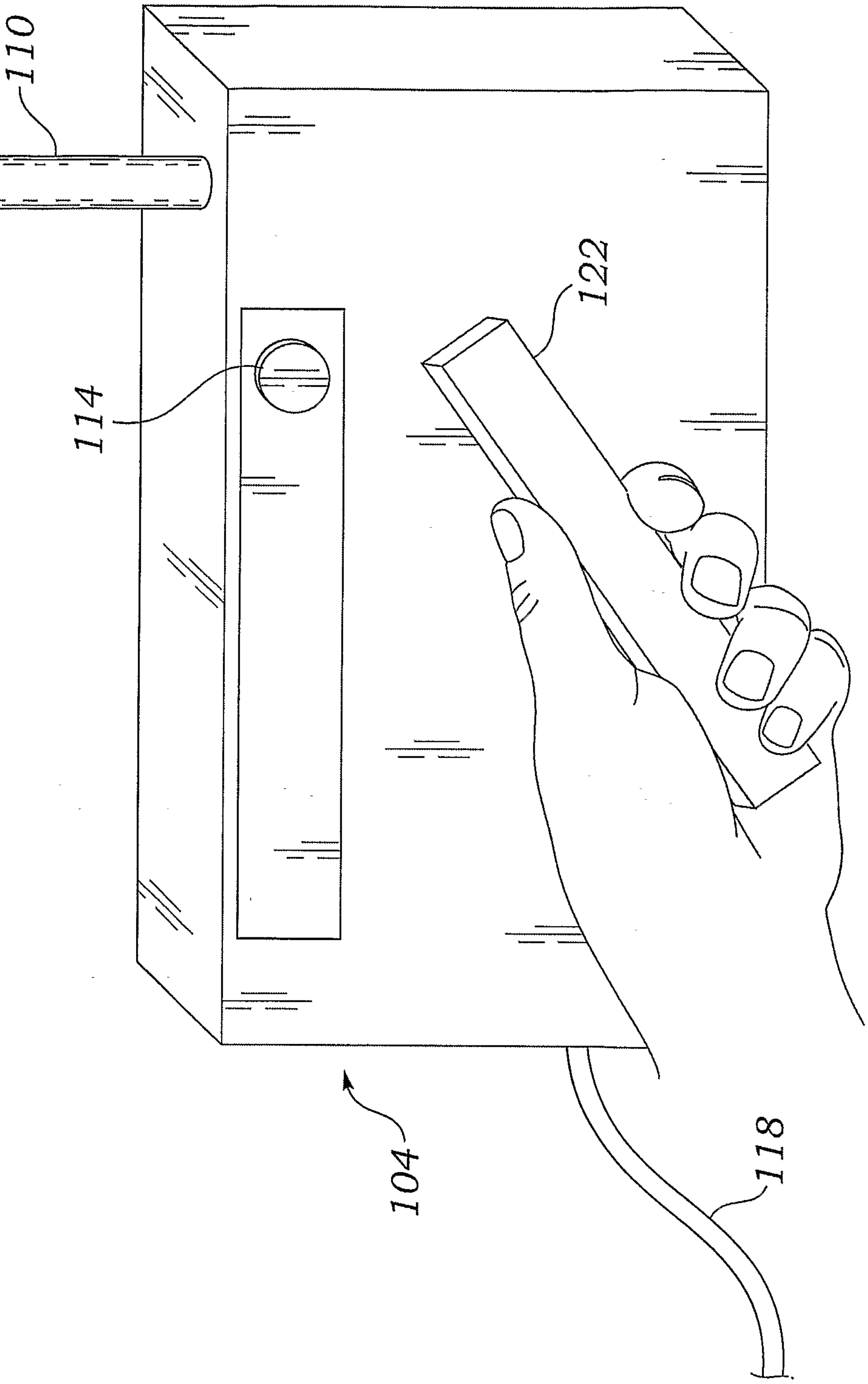

Figure 5

Message Section Name	Bits	Description
Preamble	32	
Synch	32	Unique synch word for each frequency channel to facilitate synching the message
Unique ID	23	Provides a unique identification number designating the message origin
Unit Type	1	Designates the unit type, such as a portable unit or a monitor unit
Fill	1	Rounds message out to even number of bytes
Timeslot Number	5	Number for 26 timeslots plus control timeslot may be possible
Timing Master	1	If set, other portable units should be adjusting their time base to stay in step with this unit.
Synced/Availability	1	This communication shows if the portable unit is synching with a timing master If portable unit is timing master, it communicates the number of open timeslots
Sensor Connected	1	Indicates whether a sensor is connected
Command	3	Communicates commands to the monitor unit such as: DATA – indicates sensor data is present in the message POWER_DOWN – indicates portable unit will power down NEW_LINK – establishes initial contact with M mate and gives it a new ID JUMP – tells the monitor unit to jump to a different frequency channel RSSI – contains the RSSI values for other units OPEN_SLOTS – sends the number of slots available on frequency channel (transmitted by timing master whenever another command is not being sent)
Data	60	Contains the sensor data. This data can be "whitened" by inverting every other sample to reduce any biases that may change the sensor readings.
Command Data	8	Provides data needed for some commands sent to the monitor unit. For example, the jump frequency channel number, RSSI values, and open timeslot numbers (for timing master only)
CRC	16	Error correction data within the message allowing the receiving unit to determine if any errors are present within the message.
Guard	8	Non coding bits
Total Bits	192	

Figure 6

Message Section Name	Bits	Description
Preamble	32	
Synch	32	Unique synch word for each frequency channel to facilitate synching the message
Unique ID	23	Provides a unique identification number designating the message origin
Unit Type	1	Designates the unit type, such as a portable unit or a monitor unit
Timeslot Number	5	Number for 26 timeslots plus control timeslot may be possible
Synced	1	This communication shows if the portable unit is synching with a timing master
Fill	6	Rounds message out to even number of bytes
Reply	4	Provides reply commands to the portable unit such as: NEW_LINK_INTIMATE confirms initial contact with portable unit and lets portable unit know that it is paired with another portable unit NEW_LINK_UNRESTRICTED to confirm initial contact with X mate and let X know that it is not intimate with another unit JUMP_REPLY indicates the new channel the monitor unit is jumping to DATA_GOOD indicates that the data message was successfully received POWERING_DOWN indicates that the monitor unit is powering down
Reply Data	8	Provides data needed for some reply commands sent back to the portable unit, such as RSSI values
CRC	16	Error correction data within the message allowing the receiving unit to determine if any errors are present within the message.
Guard	10	Non coding bits
Total Bits	138	

Figure 7

Message Section Name	**Bits**	**Description**
Preamble	32	
Synch	32	Unique synch word for each frequency channel to facilitate synching the message
Unique ID	23	Provides a unique identification number designating the message origin
Unit Type	1	Designates the unit type, such as a portable unit or a monitor unit
Timeslot Number	6	Number for 63 timeslots plus control timeslot may be possible
Command	2	Communicates commands to the timing master such as: SLOT_REQUEST to ask the timing master for a timeslot that it can use JUMP to tell monitor units (and nearby portable units) to jump to new channel
Command Data	4	Provides data needed for some commands sent to the monitor unit. For example, the jump frequency channel number
CRC	16	Error correction data within the message allowing the receiving unit to determine if any errors are present within the message.
Guard	15	Non coding bits
Total Bits	131	

Figure 8

Message Section Name	Bits	Description
Preamble	32	
Synch	32	Unique synch word for each frequency channel to facilitate synching the message
Unique ID	23	Provides a unique identification number designating the message destination
Timeslot Number	6	Number for 26 timeslots plus control timeslot may be possible
Unit Type	1	Designates the unit type, such as a portable unit or a monitor unit
Reply	9	Provides reply commands to the portable unit such as: OPEN_SLOT indicating the number and location of open timeslots CHANNEL_FULL indicates that a frequency channel is full RSSI_REQUEST indicates a request for RSSI data JUMP indicates a frequency channel that will be jumped to
CRC	16	Error correction data within the message allowing the receiving unit to determine if any errors are present within the message.
Guard	15	Non coding bits
Total Bits	134	

REFERENCES CITED IN THE DESCRIPTION

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patsnap

专利名称(译)	用于医疗传感器系统的无线通信协议		
公开(公告)号	EP1949652A2	公开(公告)日	2008-07-30
申请号	EP2006836928	申请日	2006-11-03
[标]申请(专利权)人(译)	爱德华兹生命科学公司		
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IPC分类号	H04L29/08 H04L12/56 A61B5/00		
CPC分类号	H04L67/125 A61B5/0002		
优先权	60/736408 2005-11-14 US 11/449511 2006-06-07 US		
其他公开文献	EP1949652B1		
外部链接	Espacenet		

摘要(译)

在一个实施例中，本发明提供一种用于医疗传感器数据的无线通信系统。该通信系统包括连接到无线传感器的便携式单元和连接到传感器监视器的监视器单元。一旦被激活，这些单元将自组织成由便携式单元控制的无线通信结构。当其他单元对激活时，它们可以通过加入现有网络或创建新网络来自行组织其传输。