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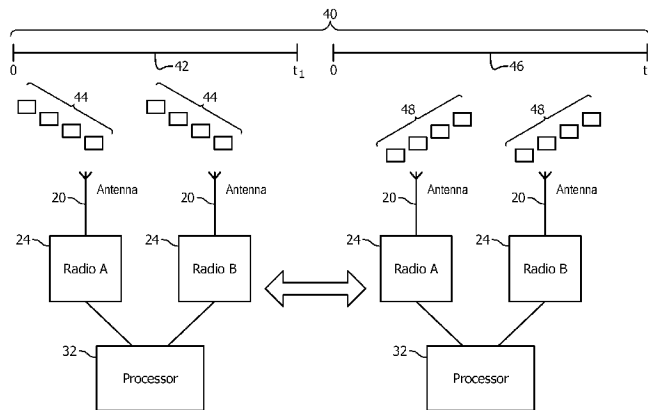


FIG. 2

(57) Abstract: A radio frequency (RF) receiving apparatus (10) includes a first and second omnidirectional RF antennas (20) at dif-  
ferent spatial locations or orientations, a first and second RF receivers (24), each connected to a corresponding one of the first and  
second omnidirectional RF antennas (20), and a controller (32) connected to the first and second RF receivers (24). The first and  
second RF receivers (24) receive and demodulate RF signals of at least first and second carrier frequencies to recover data packets  
from at least a first device which transmits data packets on the first carrier frequency RF signal and a second device which transmits  
data packets on the second carrier frequency RF signal. The controller (32) is configured to control the RF receivers to cycle  
between receiving and demodulating the first carrier frequency RF signals concurrently to recover redundant data packets from the  
first device, and receiving and demodulating the second carrier frequency RF signals concurrently to recover redundant data packets  
from the second device. The apparatus can be used to wirelessly transmit physiological patient monitoring data (e.g. an ECG signal)  
in the highly reflective environment of an MRI system.



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## PATIENT MONITORING INVOLVING RECEIVING MULTIPLE ASYNCHRONOUS DATA STREAMS WITH ANTENNA DIVERSITY

The following relates generally to receiving wireless data transmitted by multiple devices. It finds particular application in conjunction with medical monitoring data received by radio frequency (RF) in RF reflective environments such as a magnetic resonance imaging room, and will be described with particular reference thereto. However, it will be understood that it also finds application in other usage scenarios and is not necessarily limited to the aforementioned application.

Patient monitoring includes medical sensor devices which sense patient vital signs such as electrocardiograms (ECG), blood oxygen saturation ( $\text{SpO}_2$ ), respiration, and the like. The devices can transmit the sensed data wirelessly each device using an assigned or predetermined radio-frequency. The data transmitted is sent in data packets transmitted periodically. Each packet typically includes a current sample or patient measurement, and one or more previous measurements. For example, an ECG packet can include a current period waveform data point, and two prior waveform data points. The next ECG packet includes the next waveform data points and repeats the most recent two of the prior packet waveform data points. The data overlap between packets insures against data loss. Each packet, typically of a fixed size includes a checksum to ensure correct receipt of the data. The periodicity of the transmission varies by device.

Typically, a patient monitor uses multiple receivers or radios each receiving the transmitted packets using a separate antenna. Each antenna and receiver pair receives packets only from a single corresponding sensing device. Each sensing device transmits on a separate frequency and is received on a radio dedicated to receiving on the device frequency. As more devices are added, additional radios/antennas are added to the patient monitor. For example, a ECG sensing device transmits on a frequency  $F_{\text{ECG}}$ , and a  $\text{SpO}_2$  sensing device transmits on a frequency  $F_{\text{SpO}_2}$ . The monitor includes one radio receiver dedicated to receiving and demodulating packets transmitted at frequency  $F_{\text{ECG}}$ , and a second radio receiver dedicated to receiving and demodulating packets transmitted at frequency  $F_{\text{SpO}_2}$ . Adding a thirdsensing device adds a third antenna and receiver tuned to a third frequency. The monitor includes a processor which processes the received packets from each radio receiver and typically displays the processed data on a display device.

The performance of the dedicated receivers is diminished by the effects of multipath propagation. For outdoor transmissions, multipath propagation occurs in general when radio waves are reflected by buildings, mountains, the atmosphere, etc. and arrive in multiple paths at a particular radio and interfere with each other. The interference can include  
5 destructive interference, e.g. cancel out each other, cause ghosting, and the like. The problem can also exist indoors when RF reflective materials such as the shielding used in structures with strong magnetic fields like magnetic resonance imaging rooms causes reflections.

The following discloses a new and improved multiple asynchronous data  
10 streams with antenna diversity which addresses the above referenced issues, and others.

In accordance with one aspect, a radio frequency (RF) receiving apparatus includes a first and second omnidirectional RF antennas at different spatial locations or orientations, a first and second RF receivers, each connected to a corresponding one of the first and second omnidirectional RF antennas, and a processor connected to the first and  
15 second RF receivers. The first and second RF receivers receive and demodulate RF signals of at least first and second carrier frequencies to recover data packets from at least a first device which transmits data packets on the first carrier frequency RF signal and a second device which transmits data packets on the second carrier frequency RF signal. The processor is configured to control the RF receivers to cycle between receiving and demodulating the first  
20 carrier frequency RF signals concurrently to recover redundant data packets from the first device, and receiving and demodulating the second carrier frequency RF signals concurrently to recover redundant data packets from the second device.

In accordance with another aspect, a method of receiving data packets includes cycling a first and second RF receivers, each connected to a corresponding one of a first and  
25 second omnidirectional RF antennas at different spatial locations or orientations, between receiving and demodulating a first carrier frequency RF signals concurrently to recover redundant data packets from at least a first device which transmits data packets on the first carrier frequency RF signal, and receiving and demodulating a second carrier frequency RF signals concurrently to recover redundant data packets from at least a second device which  
30 transmits data packets on the second carrier frequency RF signal. The step is performed by an electronic processor.

In accordance with another aspect, a radio frequency (RF) receiving apparatus includes a plurality of RF antennas (20) at different spatial orientations or locations, a plurality of RF receivers, each connected to corresponding one of the omnidirectional RF

antennas, and a processor connected to the RF receivers. The RF receivers receive and demodulate RF signals of at least first and second carrier frequencies to recover data packets from a first device which transmits data packets on the first carrier frequency RF signal and a second device which transmits data packets on the second carrier frequency RF signal. The processor is configured to control the RF receivers to cycle between receiving and demodulating the first carrier frequency RF signals concurrently to recover data packets from the first device for a first predetermined time, and receiving and demodulating the second carrier frequency RF signals concurrently to recover data packets from the second device for a second predetermined time.

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One advantage is reduction of multipath propagation effects.

Another advantage resides in adding additional transmitting devices without adding additional radios or antennas.

Another advantage resides in the use of existing sensing devices.

15

Still further advantages will be appreciated to those of ordinary skill in the art upon reading and understanding the following detailed description.

The invention may take form in various components and arrangements of components, and in various steps and arrangement of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

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FIGURE 1 schematically illustrates an embodiment of a receiver apparatus with multiple asynchronous data streams and antenna diversity in a highly reflective radio frequency (RF) structure.

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FIGURE 2 diagrammatically illustrates an exemplary duty cycle with two transmitting devices.

FIGURE 3 diagrammatically illustrates an exemplary acquisition phase.

FIGURE 4 diagrammatically illustrates an exemplary acquired phase.

FIGURE 5 flowcharts one method of using an embodiment of receiving multiple asynchronous data streams with antenna diversity.

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With reference to FIGURE 1, an embodiment of a receiver apparatus **10** with multiple asynchronous data streams with antenna diversity in a highly reflective radio frequency (RF) structure **12** is schematically illustrated. An MR scanner **14** is illustrated in

partial cross section with a subject **16** being wirelessly monitored. The MR scanner generates a strong magnetic field **18**. The structure **12**, such as a MR room, in isolating the external RF noise uses materials in the structure, e.g. a copper Faraday cage, which creates a highly reflective RF structure.

5           The receiver apparatus **10** includes at least two omnidirectional RF antennas **20** with different spatial orientations, e.g. on different sides of the apparatus. The RF antennas **20** receive data packets transmitted by devices **22** such as patient physiological sensors each at a predetermined frequency. Examples of transmitting patient sensors include a SpO<sub>2</sub> sensor, an ECG sensor, a respiratory sensor, and the like. The sensors sense patient  
10 vital signs, and store the measured vital signs redundantly in a data packet. For example, each packet can contain  $x$  prior measurements where  $x$  is a redundancy factor such as 3. Each device **22** transmits a data packet at a predetermined interval for that device and at a predetermined frequency. For example, a SpO<sub>2</sub> sensor transmits a data packet every 8 milliseconds (ms), while a ECG sensor can transmit a data packet every 1 ms. The data  
15 packets which can include measured vital signs are transmitted wirelessly.

A radio or RF receiver **24** is connected to each antenna **20**. The receivers **24** receive transmitted data packets. Each receiver receives on the same frequency at the same time. For example using two devices transmitting and two antenna/receiver pairs receiving, both pairs receive on a frequency  $F_1$  for a predetermined time  $t_1$ . Both antenna/receiver pairs  
20 switch to a second frequency  $F_2$  for a predetermined time  $t_2$ . A duty cycle includes the sum of the predetermined time periods  $\sum_1^n t_i$  where  $n$  is the number of predetermined periods each at a different frequency. The receivers cycle through each predetermined frequency for each predetermined time period. Data packets are received from each device at a different predetermined frequency. For example, device  $D_1$  transmits a packet every 8 ms on a  
25 frequency  $F_1$ , device  $D_2$  transmits a packet every one ms on a frequency  $F_2$ , both devices include a data redundancy factor of 3 in the packets, the antennas receive on the frequency  $F_1$  for a first predetermined period, e.g. 1 ms, and then receive on frequency  $F_2$  for a second predetermined period, e.g. 7 ms. One packet will be received from  $D_1$  in the first predetermined period and one packet from  $D_2$  will be missed. Seven packets will be received  
30 from  $D_2$  in the second predetermined period and none will be missed from  $D_1$ . The data redundancy factor of 3 in the packet allows data from the missed packet to be reconstructed from either of the next two received packets before data loss occurs. That is, each packet transmits the most recent data, the next most recent data, and the antepenultimate.

A transmitted packet can be reflected and cause destructive interference through multipath propagation to one antenna by arriving via a first path **26** and a second path **28**, but another antenna can correctly receive the data packet via a third path **30** because of the spatial separation. When signals arrive at an antenna  $180^{\circ}$  out of phase, such as by following paths that differ by a half wavelength of the carrier frequency, the signals cancel. Because the antennas are spaced, it is unlikely that destructive interference will occur at both antennas. A processor **32** or a non-software-based controller connected to the receivers **24** is configured to determine correct receipt of the packet by a data integrity checksum or cyclic redundancy check (CRC) included in each packet. Where the same packet is received by both antennas duplicates can be removed by ignoring one of the packets. The processor **32** can be configured to perform the disclosed frequency switching, packet determination, and display construction techniques using a non-transitory storage medium storing instructions (e.g., software) readable by an electronic data processing device such as the processor **32** and executable by the electronic data processing device to perform the disclosed techniques.

A display device **34** is connected to the processor **32**. The processor **32** can process or read the data from the packets and display the data on the display device **34**. For example, data packets which include ECG waveform, SpO<sub>2</sub> values, respiration values and the like can be formatted into a display which superimposes the data in a waveform or other visual format to show each monitored vital sign as a function of time. Alternately or additionally, a display device can be located outside the MR room. As another option, the receivers can be located outside the MR room and be connected to antennas inside the MR room.

With reference to FIGURE 2, an exemplary duty cycle **40** with two transmitting devices is diagrammatically illustrated. During a first predetermined period **42** data packets **44** from the first transmitting device D<sub>1</sub> are received by both antennas **20**. Both receivers **24** are configured to receive and demodulate the carrier frequency F<sub>1</sub> of the first transmitting device. The processor **32** checks the received packets based on the checksum to determine that a complete and uncorrupted packet has been received. The processor checks the checksum or CRC of each received packets from each radio and selects the packet with the correct CRC, ignoring duplicate packets. Receiving the same packets on multiple antennas spatially separated provide antenna diversity and increases the likelihood that a packet will be correctly received by at least one antenna.

During a second predetermined period **46**, the receivers are reconfigured or switched to receive and demodulate data packets **48** carried by the carrier frequency of the

second transmitting device  $D_2$  at the second frequency  $F_2$ . The duty cycle **40** is the total time of all the predetermined periods and the minimal time to switch between frequencies. The duty cycle can be expressed as a time period with allocations to each frequency as a percentage or as the total of the predetermined time periods each expressed as time.

5 A third device can be added to the duty cycle **40** by allocating a predetermined time period where the receivers are configured to receive on a third frequency transmitted by the third device without an additional receiver or antenna. The multiplexing of the time between the devices takes advantage of the short duration of packet transmissions, e.g. about .5 ms, and the data redundancy within each packet transmission, e.g. repeated data  
10 samples, and the relative infrequency of transmission by at least some devices, e.g. transmitting once every duty cycle.

With reference to FIGURE 3, an exemplary acquisition phase is diagrammatically illustrated. During the acquisition or synchronization phase, the duty cycle **40** is set different from the maximum interval between transmission period of any device. For  
15 example, if one device transmits every 1 ms and another device transmits every 8 ms, then the duty cycle could be set greater than 8 ms such as 8.25 ms as shown, or less than 8 ms such as 7.75 ms. The duty cycle is illustrated with two predetermined periods. During the first predetermined period **42** the frequency matches the transmission of packets from a first device and during the second period **46** the frequency matches the transmission of packets  
20 from a second device. Initially a packet **50** transmitted does not line up temporally with the first predetermined period which means that a portion of the packet **50** is not received. However, because the duty cycle is slightly longer than the interval between packet transmissions of the first device, the time of packet transmission will eventually line up with the first predetermined period when the receivers are receiving on that particular frequency  
25 and an entire packet **52** will be received. Once the beginning points of the packets are located, the duty cycle of the receivers is synchronized to the transmission duty cycle.

With reference to FIGURE 4, an exemplary acquired phase is diagrammatically illustrated. Once packets are received as described in reference to FIGURE 3, the processor can synchronize the duty cycle with the transmission cycles of the devices by  
30 adjusting the predetermined time periods. The synchronization can include expected drift in the transmission cycles based on measured timing of received packets and/or other known information about the transmitting devices. For example, packets **60** are being received and the first predetermined period **62** is adjusted and/or duty cycle such that the first predetermined period **62** or period when the frequency of the first device is received

coincides with the transmission cycle **64** of the packets **60**. Each predetermined time period is based on a time interval between packet transmissions for the corresponding device and data redundancy in the data packet. Note that the listening windows are slightly larger than the data packet transmission times. In the above examples with  $D_1$  transmitting a 1 ms packet every 1 ms and  $D_2$  transmitting a 1 ms packet every 8 ms, the lengthened listening window may result in receiving every packet of  $D_2$  but only 6 or every 8 packets from  $D_1$ . However, with a redundancy factor of 3 all data from  $D_1$  is recovered.

FIGURE 5 flowcharts one embodied method of receiving data packets in multiple asynchronous data streams with antenna diversity. In a step **70**, a duty cycle is set. The duty cycle includes a predetermined period for each transmitting device. Each transmitting device transmits data packets with a different predetermined carrier frequency. The duty cycle is initially set according to the acquiring phase as described in reference to FIGURE 3. Each predetermined time period is based on a time period between data packet transmissions for the corresponding device and data redundancy in the data packet. The duty cycle can include a period of time greater than a maximum time period between data packet transmission of each of the devices. For example, if device  $D_1$  transmits periodically every  $X$  ms, and device  $D_2$  transmits periodically every  $Y$  ms, then the duty cycle period can be greater than the maximum of  $X$  and  $Y$ . During each duty cycle period the frequency cycles between each of the carrier frequency RF signals.

In a step **72**, the omnidirectional antennas **20** with different spatial orientations each connected to a corresponding one of receivers **24** are controlled by the processor to receive and demodulate data packets on a carrier frequency corresponding to a transmitting device for the predetermined period established with the duty cycle. The receiver/antenna pairs are concurrently set to the same carrier frequency which provides antenna diversity with each predetermined time period. The carrier frequencies  $F_1$  and  $F_2$  are selected sufficiently close that both antennas are able to pick up  $F_1$  and  $F_2$ .

The processor **32** controls the receivers **24** to concurrently receive and demodulate transmitted packets by the same corresponding device in a step **74**. Each receiver receives the transmitted packets which can be affected by multipath propagation, such as a MR suite's Faraday shield structure which reflects RF transmissions.

The processor **32** connected to the receivers **24** selects the received packets in a step **76**. The processor verifies transmitted packets from the received packets based on a checksum or CRC. The processor ignores received duplicative packets from the receivers. The step can include synchronizing the duty cycle or adjusting the predetermined time

periods based on a timing of the selected packets. The synchronizing during the acquired phase is described in reference to FIGURE 4.

In a step **78** the processor retrieves the data from the data packets. The data in the data packets can include electrocardiogram (ECG) waveforms, blood oxygen values (SpO<sub>2</sub>), respiration, and the like. Missing data is recovered from data packets in a step **80**. For example, if a packet is lost due to receiving on a different carrier frequency from the transmitting device, then data can be recovered from the next packet(s) based on the data repeated in the packets.

The retrieved data is displayed on the display device in a step **82**. For example, the processor can construct a visual display of the retrieved data values and/or waveform data sequenced in time. The visual display can include any recovered data. The processor can display the constructed visual display on the display device.

In a decision step **84** another carrier frequency and predetermined time period can be added to the duty cycle. For example, a third device D<sub>3</sub> transmits on a carrier frequency of F<sub>3</sub> for a third predetermined time period. If another frequency, e.g. F<sub>3</sub>, is added the method returns to the step **70** which sets the duty cycle to include cycling between the previous and added frequencies, e.g. F<sub>1</sub> for time period T<sub>1</sub>, F<sub>2</sub> for time period T<sub>2</sub>, and F<sub>3</sub> for time period T<sub>3</sub>.

In a decision step **86**, the continuation of the cycle is determined which returns to the step **72** that sets the next carrier frequency for the receivers, e.g. F<sub>1</sub> to F<sub>2</sub>, F<sub>2</sub> to F<sub>3</sub>, F<sub>3</sub> to F<sub>1</sub>, etc. Each duty cycle includes a repeat of the steps from setting the next carrier frequency for the next predetermined time period for each carrier frequency in the cycle. In one embodiment the constructing and displaying the retrieved data step is deferred according to the number of duty cycles or a predetermined time interval.

The steps are performed by one or more processors such as an electronic processing device. A non-transitory computer-readable storage medium carrying instructions (software) controls the one or more electronic data processing devices to perform the steps.

It is to be appreciated that in connection with the particular illustrative embodiments presented herein certain structural and/or function features are described as being incorporated in defined elements and/or components. However, it is contemplated that these features may, to the same or similar benefit, also likewise be incorporated in other elements and/or components where appropriate. It is also to be appreciated that different aspects of the exemplary embodiments may be selectively employed as appropriate to

achieve other alternate embodiments suited for desired applications, the other alternate embodiments thereby realizing the respective advantages of the aspects incorporated therein.

It is also to be appreciated that particular elements or components described herein may have their functionality suitably implemented via hardware, software, firmware or a combination thereof. Additionally, it is to be appreciated that certain elements described herein as incorporated together may under suitable circumstances be stand-alone elements or otherwise divided. Similarly, a plurality of particular functions described as being carried out by one particular element may be carried out by a plurality of distinct elements acting independently to carry out individual functions, or certain individual functions may be split-up and carried out by a plurality of distinct elements acting in concert. Alternately, some elements or components otherwise described and/or shown herein as distinct from one another may be physically or functionally combined where appropriate.

In short, the present specification has been set forth with reference to preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the present specification. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof. That is to say, it will be appreciated that various of the above-disclosed and other features and functions, or alternatives thereof, may be desirably combined into many other different systems or applications, and also that various presently unforeseen or unanticipated alternatives, modifications, variations or improvements therein may be subsequently made by those skilled in the art which are similarly intended to be encompassed by the following claims.

## CLAIMS:

What is claimed is:

1. A radio frequency (RF) receiving apparatus (**10**), comprising:

a first and second RF antennas (**20**) at different spatial locations or orientations;

a first and second RF receivers (**24**), each connected to a corresponding one of the first and second RF antennas (**20**), and the first and second RF receivers (**24**) receive and demodulate RF signals of at least a first and second carrier frequencies to recover data packets from at least a first device which transmits data packets on the first carrier frequency RF signal and a second device which transmits data packets on the second carrier frequency RF signal;

a processor or controller (**32**) connected to the first and second RF receivers (**24**) and configured to control the RF receivers to cycle between:

both receivers receiving and demodulating (**74**) the first carrier frequency RF signals concurrently to recover redundant data packets from the first device, and

both receivers receiving and demodulating (**74**) the second carrier frequency RF signals concurrently to recover redundant data packets from the second device.

2. The apparatus (**10**) according to claim 1, wherein the processor (**32**) is further configured to select between the received data packets concurrently recovered by the first and second receivers based on a checksum or CRC of the received packets.

3. The apparatus (**10**) according to either one of claims 1 and 2, wherein the first device transmits data packets with a first periodicity and the second device transmits data packets with a second periodicity and the processor controls the receivers (**24**) to cycle between receiving the first and the second carrier frequencies such that each carrier frequency is received for a predetermined time period (**42, 46**).

4. The apparatus **(10)** according to claim 3, wherein during an initial acquisition, a total of the cycled predetermined time periods is different from a maximum time interval between data packet transmissions for each of the devices **(22)**.
5. The apparatus **(10)** according to claim 4, wherein each predetermined time period **(42, 46)** is based on a time interval between data packet transmissions for the corresponding device and data redundancy in the data packets.
6. The apparatus **(10)** according to any one of claims 3-5, wherein the processor **(32)** is further configured to adjust the predetermined time periods **(62)** based on a timing of the selected data packets.
7. The apparatus **(10)** according to any one of claims 1-6, wherein the processor **(32)** is further configured to process the data in the data packets; and further including:
  - a display **(34)** connected to the processor which displays the processed data.
8. The apparatus **(10)** according to any one of claims 1-7, wherein data in the data packets includes at least one of:
  - electrocardiogram (ECG) waveforms;
  - blood oxygen values (SpO<sub>2</sub>); or
  - respiration waveforms.
9. The apparatus **(10)** according to either one of claims 7 and 8, wherein the data packet includes an overlap in the data with at least two prior data packets.
10. The apparatus **(10)** according to any one of claims 1-9, further including:
  - a shielded structure **(12)** which reflects RF transmissions and in which the apparatus is disposed.
11. A method of receiving data packets, comprising:
  - cycling **(86)** a first and second RF receivers **(24)**, each connected to a corresponding one of a first and second RF antennas **(20)** at different spatial locations or orientations, between receiving and demodulating a first carrier frequency RF signals concurrently to recover redundant data packets from at least a first device which transmits

data packets on the first carrier frequency RF signal, and receiving and demodulating a second carrier frequency RF signals concurrently to recover redundant data packets from at least a second device which transmits data packets on the second carrier frequency RF signal.

12. The method according to claim 11, further including:

selecting **(76)** between the redundant data packets based on a checksum or CRC associated with the concurrently received RF signal.

13. The method according to either one of claims 11 and 12, wherein cycling **(86)** further includes:

controlling **(74)** both of the RF receivers to receive concurrently on the first carrier frequency for a first predetermined time period and to receive concurrently on the second carrier frequency for a second predetermined time period.

14. The method according to claim 13, wherein cycling **(86)** includes:

a duty cycle which is different from a maximum time period between data packet transmissions of each of the devices.

15. The method according to either one of claims 13 and 14, wherein each predetermined time period is based on a time period between data packet transmissions for the corresponding device and data redundancy in the data packet.

16. The method according to any one of claims 13-15, further including:

adjusting **(76)** the predetermined time periods based on at least one of a timing of the selected data packets and phases of the RF signals.

17. A non-transitory computer-readable storage medium carrying software which controls one or more electronic data processing devices **(32)** to perform the method according to any one of claims 11-16.

18. An electronic data processing device **(32)** configured to perform the method according to any one of claims 11-16.

19. A radio frequency (RF) receiving apparatus **(10)**, comprising:

a plurality of RF antennas (20) at different spatial orientations or locations;  
a plurality of RF receivers (24), each connected to corresponding one of the RF antennas (20), and the RF receivers (24) receive and demodulate RF signals of at least a first and second carrier frequencies to recover data packets from a first device which transmits data packets on the first carrier frequency RF signal and a second device which transmits data packets on the second carrier frequency RF signal;

wherein the RF receivers (24) are configured to cycle together between:

receiving and demodulating the first carrier frequency RF signals concurrently to recover data packets from the first device for a first predetermined time, and

receiving and demodulating the second carrier frequency RF signals concurrently to recover data packets from the second device for a second predetermined time.

20. The apparatus according to claim 19, wherein the RF receivers further receive and demodulate RF signals of a third carrier frequency to recover data packets from a third device which transmits data packets on the third carrier frequency RF signal, the RF receivers further being configured to cycle between:

receiving and demodulating the first carrier frequency RF signals concurrently to recover data packets from the first device for a first predetermined time, and

receiving and demodulating the second carrier frequency RF signals concurrently to recover data packets from the second device for a second predetermined time; and

receiving and demodulating the third carrier frequency RF signals concurrently to recover data packets from the third device for a third predetermined time.

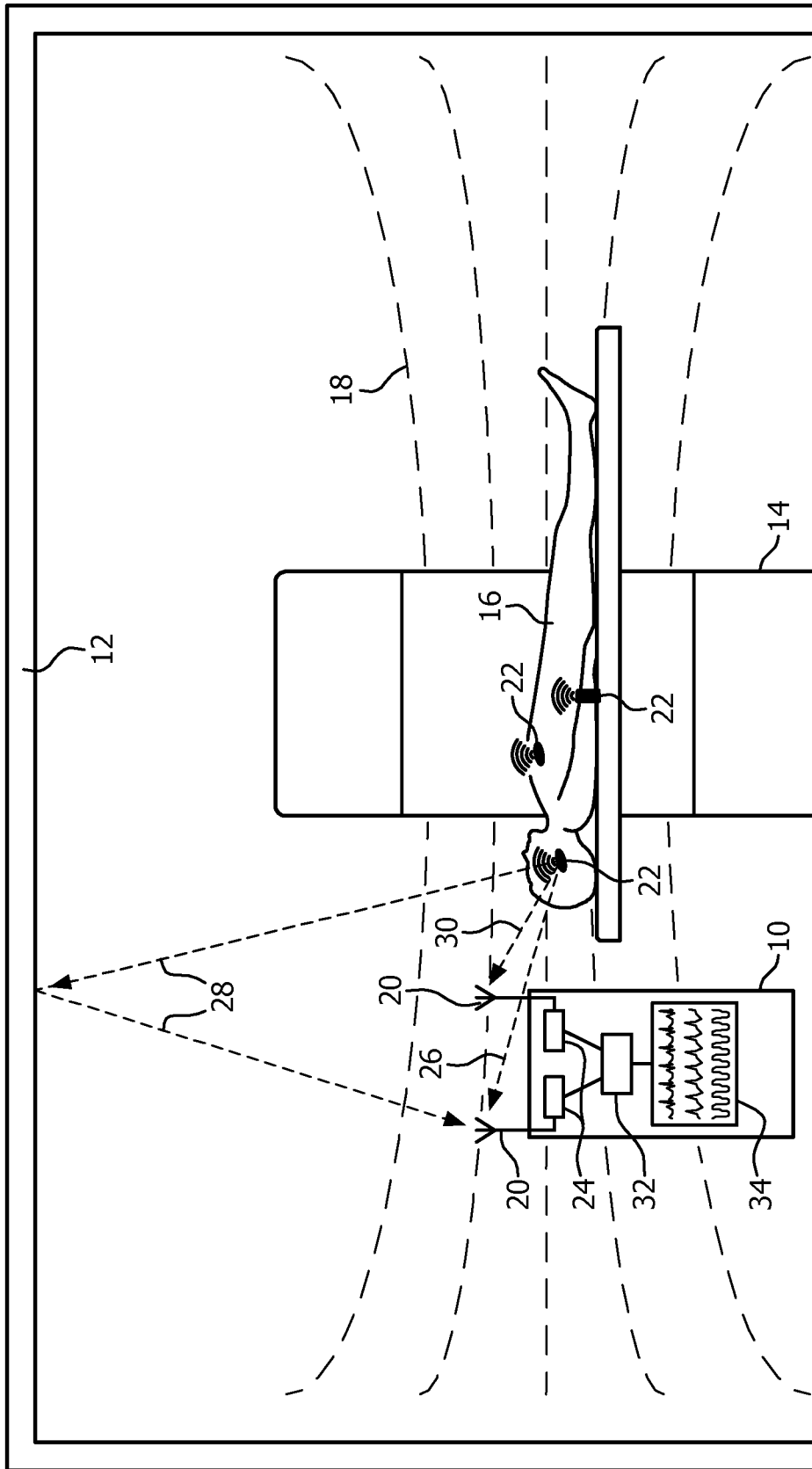


FIG. 1

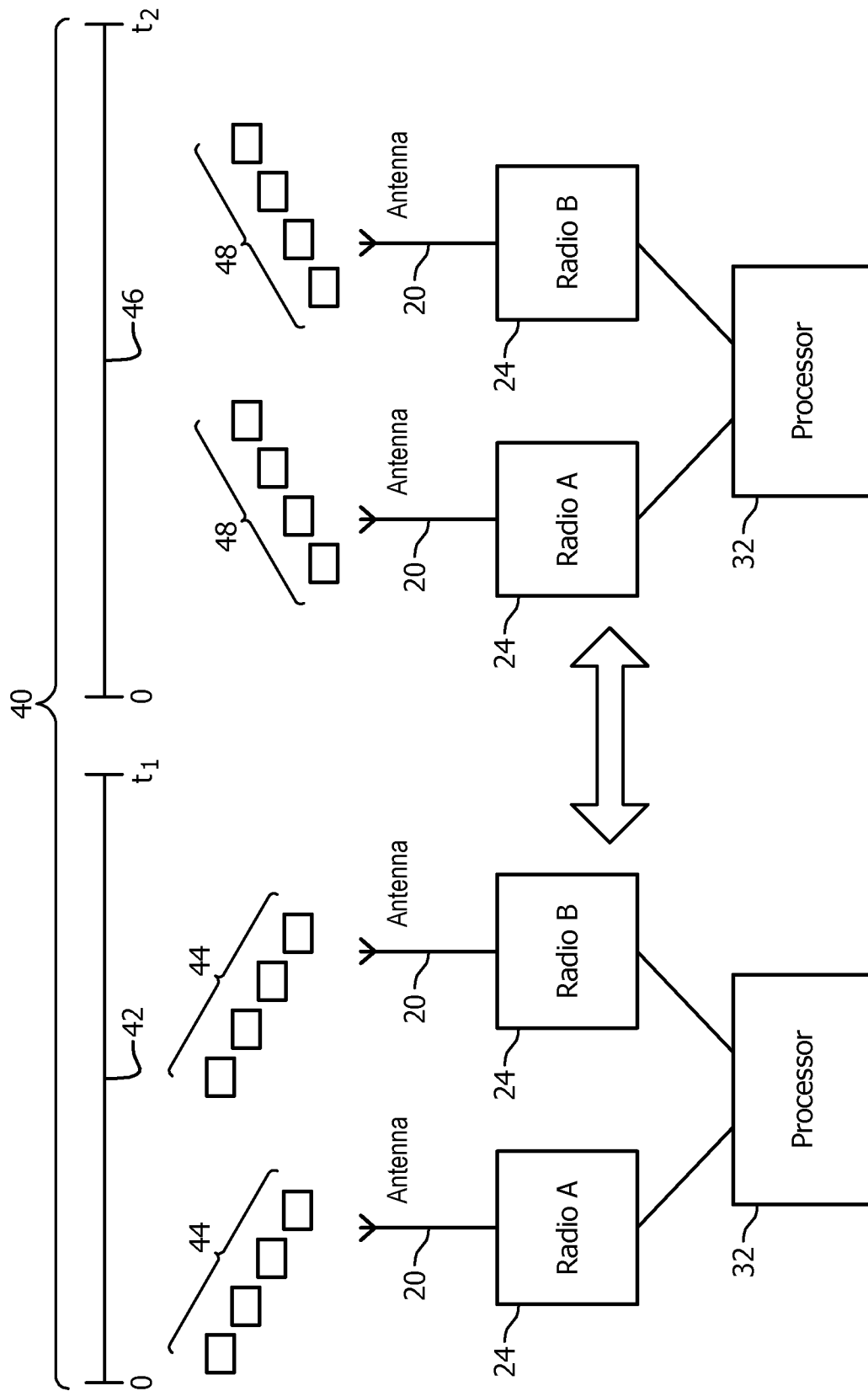
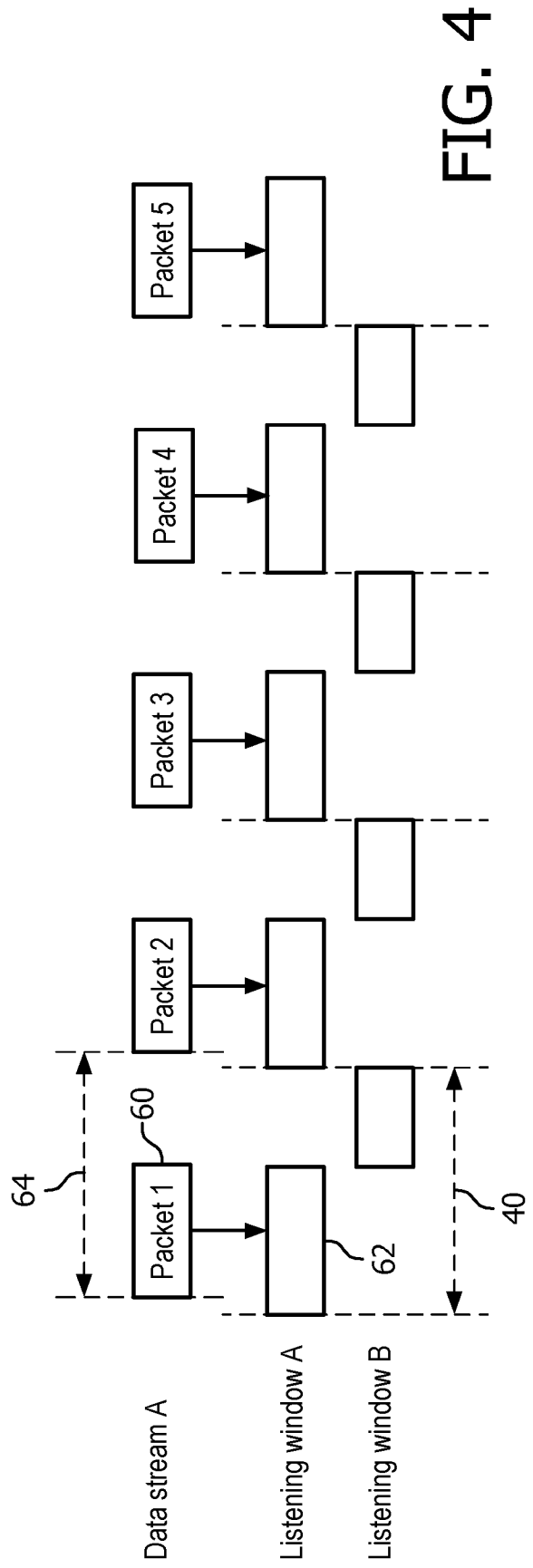
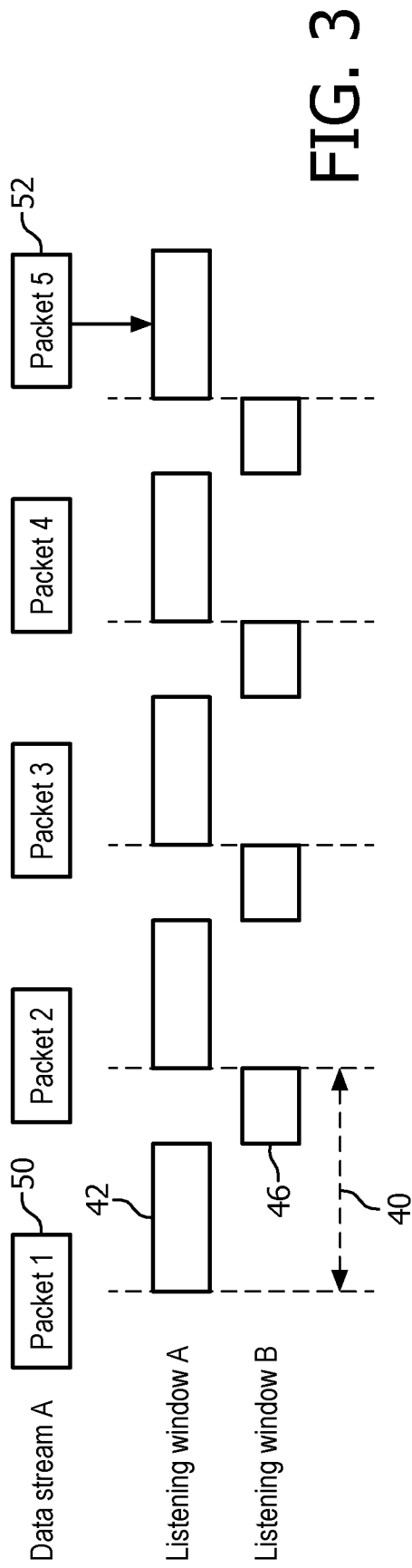


FIG. 2



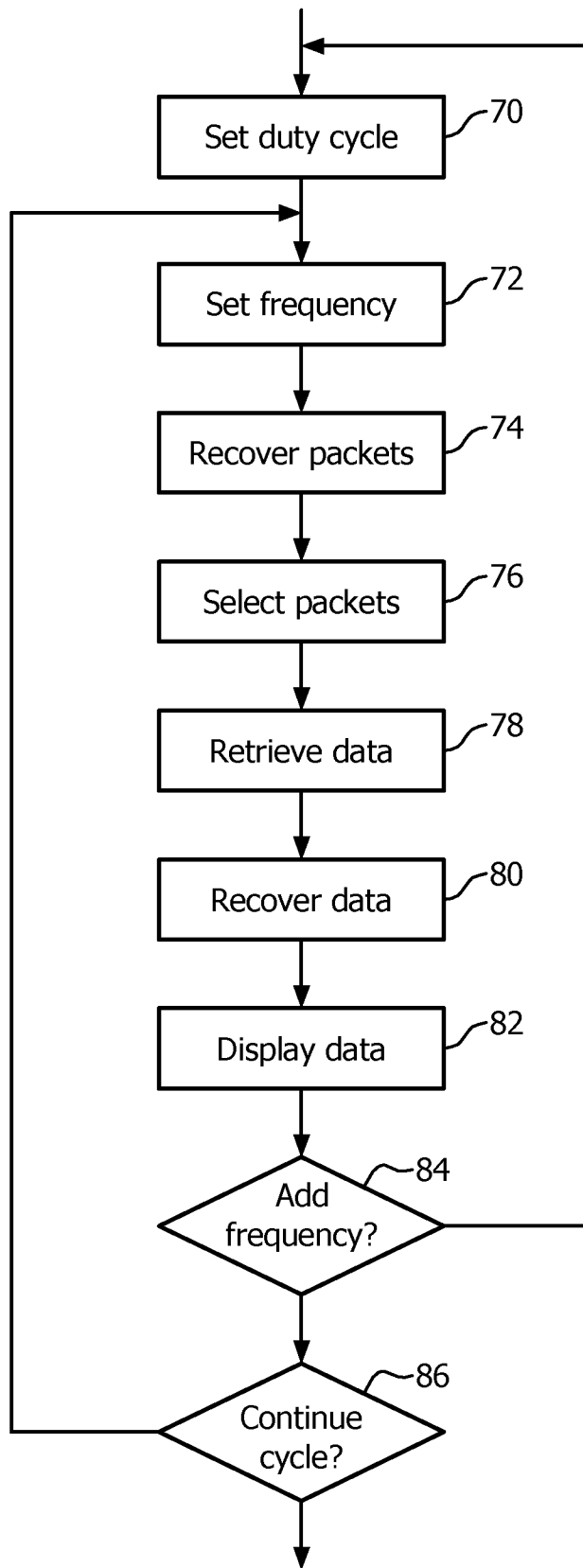


FIG. 5

**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/IB2014/063469

**A. CLASSIFICATION OF SUBJECT MATTER**

INV. G01R33/36  
ADD. A61B5/00                      A61B5/055                      G01R33/28                      H04B7/02

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
G01R A61B H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
EPO-Internal, BIOSIS, COMPENDEX, EMBASE, INSPEC, IBM-TDB, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/206024 A1 (WEEKS ARTHUR R JR [US] ET AL) 14 September 2006 (2006-09-14) paragraph [0043] - paragraph [0065] figures 1-4	1-20
X	US 2004/087282 A1 (ISHIKAWA KIMIHIKO [JP]) 6 May 2004 (2004-05-06) paragraph [0015] - paragraph [0036] figures 1-6	1-7,9,11-20
A	WO 2011/058458 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; HARRIS OTIS ROBERT III [US]; HARW) 19 May 2011 (2011-05-19) the whole document	1-20
A	WO 2012/095753 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; HARRIS III OTIS ROBERT [US]) 19 July 2012 (2012-07-19) the whole document	1-20

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- |   |   |
|---|---|
| <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> | <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p> |
|---|---|

Date of the actual completion of the international search

9 December 2014

Date of mailing of the international search report

18/12/2014

Name and mailing address of the ISA/

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2014/063469

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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专利名称(译)	患者监测涉及接收具有天线分集多个异步数据流		
公开(公告)号	<a href="#">EP3033629A1</a>	公开(公告)日	2016-06-22
申请号	EP2014776903	申请日	2014-07-28
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
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当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	HAWKES CALVERT TAZEWELL HARWELL ROBERT ANDREW		
发明人	HAWKES, CALVERT TAZEWELL HARWELL, ROBERT ANDREW		
IPC分类号	G01R33/36 A61B5/00 A61B5/055 G01R33/28 H04B7/02		
优先权	61/866181 2013-08-15 US		
外部链接	<a href="#">Espacenet</a>		

#### 摘要(译)

射频 ( RF ) 接收设备 ( 10 ) 包括处于不同空间位置或取向的第一和第二全向RF天线 ( 20 ) , 第一和第二RF接收器 ( 24 ) , 每个连接到第一和第二相应的一个全向RF天线 ( 20 ) 和连接到第一和第二RF接收器 ( 24 ) 的控制器 ( 32 ) 。第一和第二RF接收器 ( 24 ) 接收和解调至少第一和第二载波频率的RF信号 , 以从至少第一设备恢复数据分组 , 第一设备在第一载波频率RF信号上发送数据分组 , 以及第二设备发送数据第二载波频率RF信号上的分组。控制器 ( 32 ) 被配置为控制RF接收器在同时接收和解调第一载波频率RF信号之间循环以从第一设备恢复冗余数据分组 , 以及同时接收和解调第二载波频率RF信号以恢复冗余数据来自第二个设备的数据包。该装置可用于在MRI系统的高反射环境中无线传输生理患者监测数据 ( 例如ECG信号 ) 。