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(54) FREQUENCY-HOPPING RADIO SYSTEM WITH HYBRID DIRECT-SEQUENCE/FREQUENCY-HOPPING MODE DURING STARTUP

FREQUENZSPRUNGFUNKSYSTEM MIT HYBRIDER DIREKTSEQUENZ/FREQUENZSPRUNG-BETRIEBSART WÄHREND DER ANSCHALTPHASE

SYSTEME RADIO A SAUTS DE FREQUENCES CAPABLE DU MODE A SEQUENCE DIRECTE ET DU MODE A SAUTS DE FREQUENCES PENDANT LE LANCEMENT

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(73) Proprietor: **TELEFONAKTIEBOLAGET LM ERICSSON (publ)**
164 83 Stockholm (SE)

(72) Inventor: **HAARTSEN, Jacobus**
NL-7772 BG Hardenberg (NL)

(74) Representative: **O'Connell, David Christopher**
HASELTINE LAKE,
Redcliff Quay
120 Redcliff Street
Bristol BS1 6HU (GB)

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- **PATENT ABSTRACTS OF JAPAN vol. 098, no. 008, 30 June 1998 (1998-06-30) & JP 10 070490 A (BROTHER IND LTD), 10 March 1998 (1998-03-10)**
- **ATSUSHI HOSHIKUKI ET AL: "IMPLEMENTATION OF AN INDUSTRIAL R/C SYSTEM USING A HYBRID DS/FH SPREAD SPECTRUM TECHNIQUE" IEICE TRANSACTIONS ON COMMUNICATIONS, vol. E76-B, no. 8, 1 August 1993 (1993-08-01), pages 984-988, XP000396902 ISSN: 0916-8516**

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Description

BACKGROUND

[0001] The invention relates to radio systems that apply frequency hopping spread spectrum techniques, and more particularly to methods and apparatuses for speeding up the frequency-hop synchronization between units of frequency hopping systems at the time of connection setup.

[0002] In the last several decades, progress in radio and Very Large Scale Integrated circuit (VLSI) technology has fostered widespread use of radio communications in consumer applications. Portable devices, such as mobile radiotelephones, can now be produced having acceptable cost, size and power consumption.

[0003] Although wireless technology is today focused mainly on voice communications (e.g., with respect to handheld radios), this field will likely expand in the near future to provide greater information flow to and from other types of nomadic devices and fixed devices. More specifically, it is likely that further advances in technology will provide very inexpensive radio equipment which can be easily integrated into many devices. This will reduce the number of cables currently used for many applications. For example, radio communication can eliminate or reduce the number of cables used to connect master devices with their respective peripherals.

[0004] The aforementioned radio communications will require an unlicensed band with sufficient capacity to allow for high data rate transmissions. A suitable band is the so-called Industrial, Scientific and Medical (ISM) band at 2.4 GHz, which is globally available. The ISM band provides 83.5 MHZ of radio spectrum.

[0005] To allow different radio networks to share the same radio medium without coordination, signal spreading is usually applied. In fact, the Federal Communications Commission (FCC) in the United States currently requires radio equipment operating in the 2.4 GHz band to apply some form of spectrum spreading technique when the transmit power exceeds about 0dBm. Spread spectrum communication techniques, which have been around since the days of World War II, are of interest in today's commercial applications because they provide robustness against interference, which allows for multiple signals to occupy the same bandwidth at the same time.

[0006] Spreading can either be at the symbol level by applying direct-sequence (DS) spread spectrum techniques or at the channel level by applying frequency hopping (FH) spread spectrum techniques. In DS spread spectrum, the informational data stream to be transmitted is impressed upon a much higher rate data stream known as a signature sequence. Typically, the signature sequence data are binary, thereby providing a bit stream. One way to generate this signature sequence is with a pseudo-noise (PN) process that appears random, but can be replicated by an authorized receiver. The informational data stream and the high bit rate signature sequence stream are combined to generate a stream of so-called "chips" by multiplying the two bit streams together, assuming the binary values of the two bit streams are represented by + 1 or -1. This combination of the higher bit rate signal with the lower bit rate data stream is called spreading the informational data stream signal. Each informational data stream or channel is allocated a unique signature sequence. At the receiver, the same unique signature sequence is used to recover the underlying informational data stream signal.

[0007] In frequency hopping systems, the spreading is achieved by transmitting the informational data stream over ever-changing radio frequencies. For each communication, the particular frequencies used by both the transmitter and receiver are determined by a predefined frequency hop sequence.

[0008] The use of frequency hopping is attractive for the radio applications mentioned above because it more readily allows the use of cost effective radios. However, FH systems are less appropriate when a connection has to be established quickly. This is because, in order to communicate, a FH transmitter and receiver must be hop synchronized so that both use the same hop channel at the same time. Prior to synchronization, the transmitter may have no knowledge of which hop channel the recipient will listen in on and when. During the synchronization process, the uncertainty in both time and frequency must be resolved. This problem becomes more difficult when the number of hop frequencies used in the FH system increases because when the number of frequencies in the synchronization procedure increases, the uncertainty in frequency increases and the amount of time required to establish synchronization will increase as well, thus delaying the access time.

[0009] JP 10 070490 discloses a system in which the number of hop channels is decreased during start-up. "Implementation of an industrial R/C system using a hybrid DS/FH spread spectrum technique", by ATSUSHI HOSHIKUKI et al., IEICE transactions on communications, vol. E76-B, no. 8,1 1 August 1993, pages 984-988 discloses a system which uses hybrid DS/FH at all times.

[0010] There is therefore a need for techniques to reduce the access delay in FH systems such that the uncertainty in time and frequency can be resolved quickly.

SUMMARY

[0011] According to a first aspect of the invention, there is provided an apparatus comprising: means for employing a hybrid frequency hopping/direct sequence spread-spectrum mode of communication during a first mode of operation on a connection; and means for employing a pure frequency hopping spread-spectrum mode of communication during a second mode of operation of the connection, wherein a first hop sequence for use by the hybrid frequency hopping/direct sequence spread-spectrum mode of communication consists of fewer hop frequencies than are defined by a second hop sequence for use by the pure frequency hopping spread-spectrum mode of communication.

[0012] According to a second aspect of the invention, there is provided a method of operating a transceiver in a radio system, comprising the steps of: employing a hybrid frequency hopping/direct sequence spread-spectrum mode of communication during a first mode of operation on a connection; and employing a pure frequency hopping spread-spectrum mode of communication during a second mode of operation of the connection, wherein a first hop sequence for use by the hybrid frequency hopping/direct sequence spread-spectrum mode of communication consists of fewer hop frequencies than are defined by a second hop sequence for use by the pure frequency hopping spread-spectrum mode of communication.

[0013] Further features of the invention are described in the dependent claims.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0014] The objects and advantages of the invention will be understood by reading the following detailed description in conjunction with the drawings in which:

FIG. 1. is an example of traffic carrier allocation in 2.4 GHz ISM band;
FIG. 2. is a schematic diagram of a transmitter and receiver for a FH radio system;
FIG. 3. is an example of startup carrier allocation in the 2.4 GHz ISM band in accordance with one aspect of the invention;
FIG. 4. is a block diagram of a sliding correlator for despreading a page message in accordance with an aspect of the invention;
FIG. 5. is a schematic diagram of a transmitter and receiver for a DS/FH radio system used during startup in accordance with an aspect of the invention;
FIG. 6. is timing diagram showing the scan behavior of a DS/FH radio unit in standby mode in accordance with an aspect of the invention;
FIG. 7. is a timing diagram showing the transmit behavior of a DS/FH radio unit operating in page mode in accordance with an aspect of the invention; and
FIG. 8. is a timing diagram showing the information exchange that occurs during a page procedure in accordance with an aspect of the invention.

DETAILED DESCRIPTION

[0015] The various features of the invention will now be described with respect to the figures, in which like parts are identified with the same reference characters.

[0016] Since the ISM bands at 900 MHZ and 2400 MHZ have been opened for commercial applications, many products have been introduced providing wireless communications in these bands. The usage of the band is restricted in the U.S. by the Part 15 rules of the FCC and in Europe by the ETS 300 328 of the ETSI. In other countries throughout the world, similar rules apply. In short, the rules require the systems to spread their power over the band not only in order to spread interference at the transmit side, but also to obtain interference immunity at the receive side. Spreading can be obtained either by frequency-hop (FH) spreading or by direct-sequence (DS) spreading, each of which is a well known spreading technique in communications theory. Both spreading methods have their merits and drawbacks. With the current state-of-the-art, FH spreading results in less-complex and cheaper radio transceivers than DS spreading.

[0017] FH systems operating in the U.S. in the 2.4 GHz band are required to use at least 75 hop frequencies. Recently, a standard has been developed by the IEEE (namely, IEEE 802.11) for use in Wireless Local Area Network (WLAN) applications. Both a FH version and a DS version have been defined. For the FH version, the ISM band at 2.4 GHz, which ranges from 2400 MHZ to 2483.5 MHZ, is divided into 79 hop channels spaced at 1 MHZ intervals, as illustrated in FIG. 1. Two or more radio units that communicate, hop from one channel to another channel according to a pseudo-random hop pattern which is used by all connected radio units. As long as the units are hop synchronized, they will simultaneously use the same channel, and thus stay in contact. A general schematic for a radio transceiver used for a FH system is shown in FIG. 2. The various components shown in the transmission (TX) section 201 and the Receive (RX) section 203 are well-known, and need not be described here in detail. Of pertinence to this discussion is the fact that a controller 205 causes a frequency synthesizer 207 to generate frequencies in accordance with a particular hop sequence for use in modulation/up-conversion and demodulation/down-conversion.

[0018] Typically, a FH radio unit operating in standby mode sleeps most of the time, but periodically "wakes up" to listen on a certain hop channel for a page message. To obtain resistance against jammers, this hop channel is chosen differently at each wake-up instant. A FH radio that wants to page another radio unit in order to set up a connection does not know when and on what channel the other radio unit will wake up, so it has to send its page message repeatedly on many hop channels. There are many ways to do this, several of which are described in U.S. Patent Application Serial No. 08/771,692, entitled "Access Technique of Channel Hopping Communications System," by J.C. Haartsen and P.W. Dent, filed December 23, 1996; and U.S. Patent Application Serial No. 09/168,604, entitled "Access Technique of Channel Hopping Communications System," by J.C. Haartsen, filed October 9, 1998 (Attorney Docket No. 040070-302). Other methods can, for example, be found in the IEEE 802.11 WLAN standard. The access delay (e.g., the amount of time its takes to get two units to operate in hop synchronization) and the effort to get two units hop synchronized depends on the number of hop channels. Decreasing the number of hop channels would improve the access delay, but the rules for operating in the band substantially prevent the usage of only a small amount of hop channels (75 is the minimum number of hop channels that must be utilized in the US according to FCC part 15).

[0019] However, reduction of the number of hop channels is allowed if the processing gain at the receive side can be obtained in some other way, for example by DS spreading. A combination of FH and DS spreading is allowed as long as the combined processing gain is at least 17 dB. Such a hybrid system spreads its power by first multiplying each bit with a high-rate chip spreading code, and then hopping from time to time to a new hop frequency. Since the number of hop channels is only an issue during startup (because after frequency hop synchronization has been established, the number of hop channels to spread over is immaterial), DS spreading is applied only during startup in order to permit a temporary reduction of the frequency hop spreading while still obtaining sufficient spreading gain to comply with the FCC rules. The reduced set of hop frequencies used during startup can be an arbitrary selection out of the 79 hops defmed in FIG. 1. FIG. 3 is an illustration of one such arbitrary selection. In this example, it is desirable to remain compatible with the hop allocation according to the IEEE 802.11 definition for FH systems. However, this need not be a limitation in all cases. In fact, a completely different set of hop channels can be defined in the 2.4 GHz band as long as the FCC part 15 rules are fulfilled. This selection can, for example, be based on an identity of a user or a network. Alternatively, selection of a reduced set of hop frequencies for use during paging can be based on intelligently avoiding jammers. For example, since microwave ovens operate in the region from about 2440 to 2480 MHZ, it may be advantageous to select the reduced set of FH channels from the lower end of the 2.4 GHz band.

[0020] During startup, signaling is used between the transmitter and the receiver in order to get them hop synchronized with respect to one another. By choosing an intelligent signaling scheme, the implementation of a complete DS spreader and despreader (including chip synchronization and tracking) can be avoided. Since the extra DS spreading is only required during startup, the DS operation should preferably be compatible with the FH radio transceiver implementation. This can be achieved by making the signaling rate during startup much lower than the data rate normally used in the FH transceiver. By considering the bits normally used by the FH radio as chips for the DS component, a processing gain is obtained by the difference between the chip rate and the signaling rate. This is accomplished as follows.

[0021] During the startup, the paging unit transmits a page message in the form of a pseudo-random bit stream sent at the bit rate normally used in the connection mode (i.e., after the transmitter and receiver have hop synchronized with respect to one another). This page message forms the code of the DS radio transmission. The page message may be a fixed bit sequence, used by all radio units. Alternatively, it can be derived from an address of the unit (or the network) being paged. For example, each unit can have its own page sequence, and can be designed to respond only to this particular page sequence. As mentioned, the page message is sent at the bit rate that the FH radio normally uses. In the FH radio receiver, a sliding correlator is included that is matched to the code of the page message. A sliding correlator 400 can be built as a tapped delay line, as illustrated in FIG. 4. The delay line comprises a number, N, of series-connected delay elements 401, each delay element 401 introducing a delay of one bit duration (i.e., one chip duration for the DS component). Oversampling can be applied to obtain a higher time resolution. The delay line is tapped, and each tap is multiplied (e.g., by a corresponding one of N multipliers 403) by a corresponding one of N chip values, designated c0, c1, ... , cN-1. Each chip value takes on a value of + 1 or -1. The tap outputs are accumulated in an adder 405. When the contents of the delay line match the chip values at the taps, the output 407 generated by the adder 405 reaches its maximum. This causes the correlator 400 to trigger (e.g., by comparison of the output 407 with a predetermined value), thereby indicating that a signal with the appropriate (matching) code has been found. The correlator 400 effectively despreads the page message.

[0022] A preferred implementation of a FH radio transceiver 500 having a DS component for startup synchronization is shown in FIG. 5. The transceiver 500 is capable of paging another transceiver, and is also capable of being paged by another transceiver.

[0023] During paging, a paging unit (not shown) provides a fixed bit (i.e., chip) sequence 501 to the transmitter 503. The sequence 501 may be a fixed page code that is useful for paging any unit, or it may alternatively be a specific code for paging only a single unit (or a group of units). The sequence 501 is transmitted over the reduced set of FH channels, as explained earlier. The combination of reduced frequency hopping and direct sequence spreading provides the necessary processing gain to satisfy the applicable broadcast standards.

[0024] When the transceiver 500 is in standby mode, it sleeps most of the time, and wakes up periodically to listen on a certain hop channel for a page message. As mentioned earlier, the particular wake-up hop frequency preferably changes with each wake-up period, and in accordance with the invention is selected from the reduced set of FH channels that are used during paging operations. The transceiver 500 in standby mode correlates the received input data at the bit (i.e., chip) rate in the sliding correlator. When the output of the correlator 400 exceeds a certain value, the resultant triggering indicates to the transceiver 500 that it has been paged. The transceiver 500 may then return an acknowledgment to the paging unit.

[0025] The operation of the paging procedure is further illustrated in FIGS. 6-8. The reader is also referred to the several applications, each entitled "Access Technique of Channel Hopping Communications System," mentioned above. A unit in standby mode wakes up after every time interval T_sleep and listens on a single hop frequency for a time duration designated T_scan. During each wake-up event, another hop frequency is selected from the reduced set of wake-up frequencies, as shown for example in FIG. 3. When the unit listens, all input signals are routed to the correlator 400 where the unit tries to match the input bit stream to the expected page message. If the correlator does not trigger during the scan period, the radio unit returns to sleep.

[0026] In order to increase the likelihood of synchronizing with the standby unit, the paging unit transmits the page message (which, in order to keep the complexity of the correlator low, can be quite short, for example, 64 bits or chips) sequentially at each of the various wake-up hop frequencies, as illustrated in FIG. 7 for the case of M hop frequencies used during paging. For this paging activity, the hop rate of the transmitter is increased such that many hop frequencies are visited during the T_scan period. Because the standby unit listens in on only one hop frequency during any one T_scan period, the paging unit's use of many hop frequencies during this same interval increases the probability that the paging unit will be heard by the standby unit. In order to ease implementation, the paging hop rate is preferably a multiple of the hop rate used during the connection mode when only FH is applied.

[0027] The paging is continued until either the recipient responds or a timeout is exceeded. In order to know whether the recipient has received the page message, the paging unit must repeatedly listen as well. In a preferred embodiment, DS spreading is used in the response message as well. This is accomplished by using a spreading code for both paging and responding. As shown in FIG. 8, when the recipient has received the page message (step 801), it returns a response message (step 803) which is correlated in the paging unit preferably by means of the same techniques as are used by the recipient to correlate a received signal with the paging message. Although this need not be the case in all embodiments, the contents of the response message can even be identical to the contents of the page message. After the transmission of each page message the paging unit listens at a corresponding frequency for a response message. For example, as shown in FIG. 8, after transmitting a page message on the frequency corresponding to hop k, the paging unit listens for a response on a corresponding frequency specified by hop m. When no response is detected, the paging unit next transmits a page message on the frequency corresponding to hop $k+1$, and then listens for a response on a corresponding frequency specified by hop $m+1$. During each listening interval, the paging unit routes any received signal to the correlator which is initialized with the response code. When the correlator 400 in the paging unit triggers, the paging unit knows that the intended recipient has received the page message and from that point both units are effectively in hop synchrony. From then on, communication between the units is no longer restricted to the reduced set of hop frequencies used for paging; instead, all the hop channels can be used. Furthermore, DS spreading need no longer be employed, since the use of the full set of hop frequencies will be adequate to provide the processing gain set by the applicable standard.

[0028] In the previous discussion, the hybrid FH/DS mode was used during the startup procedure. However, in accordance with the invention, the hybrid mode is also used in other procedures where only a low or moderate signaling rate is required while there is a preference for the reduction of the number of channels to hop over.

[0029] To summarize, then, the access delay in a FH system during start up can be decreased by reducing the number of frequencies used. However, this will also reduce the processing gain. In certain frequency bands, such as the ISM band at 2.4 GHz, decreasing the number of hop frequencies below a certain minimum is not permitted. In order to decrease the number of frequencies but retain the required processing gain, direct-sequence spreading is added to the system, thus resulting in a hybrid FH/DS system. However, in some embodiments, the DS spreading is used only during startup for the purpose of temporarily reducing the number of hop frequencies. After startup, the synchronization has been established and a large amount of hop channels can be used. Therefore, after startup, the DS spreading can be removed since all processing gain can be obtained from the FH spreading. Since the data rate during startup can be rather low (only signaling is required), no high speed circuitry is needed for the DS processing. Preferably, the chip rate of the DS spreading at startup is equal to the bit rate used during the connection. Since the signaling rate during startup is much smaller than the chip rate, a processing gain is obtained.

Claims

1. An apparatus comprising:

   means for employing a hybrid frequency hopping/direct sequence spread-spectrum mode of communication during a first mode of operation on a connection; and

   means for employing a pure frequency hopping spread-spectrum mode of communication during a second mode of operation of the connection,

   wherein a first hop sequence for use by the hybrid frequency hopping/direct sequence spread-spectrum mode of communication consists of fewer hop frequencies than are defined by a second hop sequence for use by the pure frequency hopping spread-spectrum mode of communication.

2. The apparatus of claim 1, wherein the means for employing the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication during the first mode of operation of the connection utilizes a chip rate that is identical to a bit transmission rate used by the pure frequency hopping spread-spectrum transmission during the second mode of operation of the connection.

3. The apparatus of claims 1 or 2, wherein the means for employing the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication during the first mode of operation of the connection includes means for transmitting a page message that comprises a fixed chip sequence that is unique to a radio unit being paged.

4. The apparatus of claim 3, wherein a chip rate of the page message is identical to a bit rate used during the pure frequency hopping spread-spectrum transmission during the second mode of operation of the connection.

5. The apparatus of claim 1, wherein the means for employing the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication during the first mode of operation of the connection includes means for transmitting a page message that comprises a fixed chip sequence that is common to all radio units in the radio system.

6. The apparatus according claim 5, wherein a chip rate of the page message is identical to a bit rate used during the pure frequency hopping spread-spectrum transmission during the second mode of operation of the connection.

7. The apparatus as claimed in any preceding claim, further comprising a sliding correlator for despreading a page message that is transmitted during the first mode of operation of the connection.

8. The apparatus of claim 7, wherein the sliding correlator is implemented as a tapped delay line.

9. The apparatus as claimed in any preceding claim, wherein a processing gain of the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication equals or exceeds 17 dB.

10. The apparatus as claimed in any preceding claim, wherein a hop rate utilized by a paging unit operating in the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication is a multiple of a hop rate utilized by the pure frequency hopping spread-spectrum transmission mode of communication.

11. The apparatus as claimed in any preceding claim, wherein a hop sequence for use by the pure frequency hopping spread-spectrum transmission mode of communication comprises at least 75 hop frequencies.

12. An apparatus as claimed in any preceding claim, wherein the first mode of communication is during startup of a connection, and wherein the second mode of communication is during a connected mode of the connection.

13. A method of operating a transceiver in a radio system, comprising the steps of:

employing a hybrid frequency hopping/direct sequence spread-spectrum mode of communication during a first mode of operation on a connection; and

employing a pure frequency hopping spread-spectrum mode of communication during a second mode of operation of the connection,

wherein a first hop sequence for use by the hybrid frequency hopping/direct sequence spread-spectrum mode of communication consists of fewer hop frequencies than are defined by a second hop sequence for use by the pure frequency hopping spread-spectrum mode of communication.

14. The method of claim 13, wherein the step of employing the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication during the first mode of operation of the connection comprises utilizing a chip rate that is identical to a bit transmission rate used by the pure frequency hopping spread-spectrum transmission during the second mode of operation of the connection.

15. The method of claim 13, wherein the step of employing the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication during the first mode of operation of the connection includes transmitting a page message that comprises a fixed chip sequence that is unique to a radio unit being paged.

16. The method of claim 15, wherein a chip rate of the page message is identical to a bit rate used during the pure frequency hopping spread-spectrum transmission during the second mode of operation of the connection.

17. The method of claim 13, wherein the step of employing the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication during the first mode of operation of the connection includes transmitting a page message that comprises a fixed chip sequence that is common to all radio units in the radio system.

18. The method of claim 17, wherein a chip rate of the page message is identical to a bit rate used during the frequency hopping spread-spectrum transmission during the second mode of operation of the connection.

19. The method as claimed in any one of claims 13 to 18, further comprising the step of using a sliding correlator to despread a page message that is transmitted during the first mode of operation of the connection.

20. The method of claim 19, wherein the sliding correlator is implemented as a tapped delay line.

21. The method as claimed in any one of claims 13 to 20, wherein a processing gain of the hybrid frequency hopping/direct sequence spread-spectrum transmission during the first mode of operation of the connection equals or exceeds 17 dB.

22. The method as claimed in any one of claims 13 to 21, wherein:

the step of employing the hybrid frequency hopping/direct sequence spread-spectrum transmission mode of communication during the first mode of operation of the connection utilizes a first hop rate;
the step of employing the pure frequency hopping spread-spectrum transmission mode of communication during the second mode of operation of the connection uses a second hop rate; and
the first hop rate is a multiple of the second hop rate.

23. The method as claimed in any one of claims 13 to 22, wherein the step of employing the pure frequency hopping spread-spectrum transmission mode of communication during the second mode of operation of the connection uses a hop sequence that comprises at least 75 hop frequencies.

24. A method as claimed in any one of claims 13 to 23, wherein the first mode of operation of the connection is a startup mode and wherein the second mode of operation of the connection is a connected mode of the connection.

Patentansprüche

1. Vorrichtung, die Folgendes umfasst:

ein Mittel zum Anwenden einer hybriden Frequenzsprung- Direktsequenz- Spreizbandkommunikationsbetriebsart während einer ersten Betriebsart einer Verbindung; und
ein Mittel zum Anwenden einer reinen Frequenzsprung- Spreizbandkommunikationsbetriebsart während einer zweiten Betriebsart der Verbindung;

wobei eine erste Sprungsequenz zur Verwendung durch die hybride Frequenzsprung-Direktsequenz-Spreizbandkommunikationsbetriebsart aus weniger Sprungfrequenzen besteht, als durch eine zweite Sprungsequenz zur Verwendung durch die reine Frequenzsprung- Spreizbandkommunikationsbetriebsart definiert sind.

2. Vorrichtung nach Anspruch 1, wobei das Mittel zum Anwenden der hybriden Frequenzsprung-Direktsequenz-Spreizbandkommunikationsbetriebsart während der ersten Betriebsart der Verbindung mit einer Chiprate arbeitet, die mit einer Bitübertragungsrate identisch ist, die durch die reine Frequenzsprung-Spreizbandübertragung während der zweiten Betriebsart der Verbindung benutzt wird.

3. Vorrichtung nach den Ansprüchen 1 oder 2, wobei das Mittel zum Anwenden der hybriden Frequenzsprung- Direktsequenz- Spreizbandübertragungskommunikationsbetriebsart während der ersten Betriebsart der Verbindung ein Mittel zum Übertragen einer Seitennachricht enthält, die eine feste Chipsequenz umfasst, die für eine gepagte Funkeinheit eindeutig ist.

4. Vorrichtung nach Anspruch 3, wobei eine Chiprate der Seitennachricht mit einer Bitrate identisch ist, die während der reinen Frequenzsprung-Spreizbandübertragung während der zweiten Betriebsart der Verbindung benutzt wird.

5. Vorrichtung nach Anspruch 1, wobei das Mittel zum Anwenden der hybriden Frequenzsprung-Direktsequenz- Spreizbandübertragungskommunikationsbetriebsart während der ersten Betriebsart der Verbindung ein Mittel zum Übertragen einer Seitennachricht enthält, die eine feste Chipsequenz umfasst, die für alle Funkeinheiten in dem Funksystem gemein ist.

6. Vorrichtung nach Anspruch 5, wobei eine Chiprate der Seitennachricht mit einer Bitrate identisch ist, die während der reinen Frequenzsprung-Spreizbandübertragung während der zweiten Betriebsart der Verbindung benutzt wird.

7. Vorrichtung nach einem der vorangehenden Ansprüche, die des Weiteren einen Schiebekorrelator zum Entspreizen einer Seitennachricht umfasst, die während der ersten Betriebsart der Verbindung übertragen wird.

8. Vorrichtung nach Anspruch 7, wobei der Schiebekorrelator als eine abgegriffene Verzögerungsleitung implementiert ist.

9. Vorrichtung nach einem der vorangehenden Ansprüche, wobei eine Verarbeitungsverstärkung der hybriden Frequenzsprung-Direktsequenz-Spreizbandübertragungskommunikationsbetriebsart mindestens 17 dB beträgt.

10. Vorrichtung nach einem der vorangehenden Ansprüche, wobei eine Sprungrate, die von einer Paging-Einheit benutzt wird, die in der hybriden Frequenzsprung- Direktsequenz- Spreizbandübertragungskommunikationsbetriebsart arbeitet, ein Vielfaches einer Sprungrate ist, die von der reinen Frequenzsprung-Spreizbandübertragungskommunikationsbetriebsart benutzt wird.

11. Vorrichtung nach einem der vorangehenden Ansprüche, wobei eine Sprungsequenz zur Verwendung durch die reine Frequenzsprung-Spreizbandübertragungskommunikationsbetriebsart wenigstens 75 Sprungfrequenzen umfasst.

12. Vorrichtung nach einem der vorangehenden Ansprüche, wobei die erste Kommunikationsbetriebsart während der Anschaltphase einer Verbindung stattfindet und wobei die zweite Kommunikationsbetriebsart während einer verbundenen Betriebsart stattfindet.

13. Verfahren zum Betreiben eines Sender-Empfängers in einem Funksystem, das folgende Schritte umfasst:

Anwenden einer hybriden Frequenzsprung-Direktsequenz- Spreizbandkommunikationsbetriebsart während einer ersten Betriebsart einer Verbindung; und
Anwenden einer reinen Frequenzsprung-Spreizbandkommunikationsbetriebsart während einer zweiten Betriebsart der Verbindung;

wobei eine erste Sprungsequenz zur Verwendung durch die hybride Frequenzsprung-Direktsequenz-Spreizbandkommunikationsbetriebsart aus weniger Sprungfrequenzen besteht, als durch eine zweite Sprungsequenz zur Verwendung durch die reine Frequenzsprung- Spreizbandkommunikationsbetriebsart definiert sind.

14. Verfahren nach Anspruch 13, wobei der Schritt des Anwendens der hybriden Frequenzsprung-Direktsequenz- Spreizbandübertragungskommunikationsbetriebsart während der ersten Betriebsart der Verbindung das Benutzen einer Chiprate umfasst, die mit einer Bitüberträgungsrate identisch ist, die durch die reine Frequenzsprung-Spreizbandübertragung während der zweiten Betriebsart der Verbindung benutzt wird.

15. Verfahren nach Anspruch 13, wobei der Schritt des Anwendens der hybriden Frequenzsprung-Direktsequenz- Spreizbandübertragungskommunikationsbetriebsart während der ersten Betriebsart der Verbindung das Übertragen einer Seitennachricht enthält, die eine feste Chipsequenz umfasst, die für eine gepagte Funkeinheit eindeutig ist.

16. Verfahren nach Anspruch 15, wobei eine Chiprate der Seitennachricht mit einer Bitrate identisch ist, die während der reinen Frequenzsprung-Spreizbandübertragung während der zweiten Betriebsart der Verbindung benutzt wird.

17. Verfahren nach Anspruch 13, wobei der Schritt des Anwendens der hybriden Frequenzsprung-Direktsequenz- Spreizbandübertragungskommunikationsbetriebsart während der ersten Betriebsart der Verbindung das Übertragen einer Seitennachricht enthält, die eine feste Chipsequenz umfasst, die für alle Funkeinheiten in dem Funksystem gemein ist.

18. Verfahren nach Anspruch 17, wobei eine Chiprate der Seitennachricht mit einer Bitrate identisch ist, die während der Frequenzsprung-Spreizbandübertragung während der zweiten Betriebsart der Verbindung benutzt wird.

19. Verfahren nach einem der Ansprüche 13 bis 18, das des Weiteren den Schritt des Verwendens eines Schiebekorrelators zum Entspreizen einer Seitennachricht umfasst, die während der ersten Betriebsart der Verbindung übertragen wird.

20. Verfahren nach Anspruch 19, wobei der Schiebekorrelator als eine abgegriffene Verzögerungsleitung implementiert ist.

21. Verfahren nach einem der Ansprüche 13 bis 20, wobei eine Verarbeitungsverstärkung der hybriden Frequenzsprung- Direktsequenz- Spreizbandübertragung während der ersten Betriebsart der Verbindung mindestens 17 dB beträgt.

22. Verfahren nach einem der Ansprüche 13 bis 21, wobei:

der Schritt des Anwendens der hybriden Frequenzsprung- Direktsequenz- Spreizbandübertragungskommunikationsbetriebsart während

der ersten Betriebsart der Verbindung eine erste Sprungrate benutzt;
der Schritt des Anwendens der reinen Frequenzsprung- Spreizbandübertragungskommunikationsbetriebsart während der zweiten Betriebsart der Verbindung eine zweite Sprungrate benutzt; und
die erste Sprungrate ein Vielfaches der zweiten Sprungrate ist.

23. Verfahren nach einem der Ansprüche 13 bis 22, wobei der Schritt des Anwendens der reinen Frequenzsprung- Spreizbandübertragungskommunikationsbetriebsart während der zweiten Betriebsart der Verbindung eine Sprungsequenz benutzt, die wenigstens 75 Sprungfrequenzen umfasst.

24. Verfahren nach einem der Ansprüche 13 bis 23, wobei die erste Betriebsart der Verbindung eine Anschaltbetriebsart ist und wobei die zweite Betriebsart der Verbindung eine verbundene Betriebsart der Verbindung ist.

Revendications

1. Appareil comprenant:

un moyen pour utiliser un mode de communication hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant un premier mode de fonctionnement sur une connexion ; et
un moyen pour utiliser un mode de communication pur à saut de fréquence et à étalement de spectre pendant un second mode de fonctionnement de la connexion,

dans lequel une première séquence de sauts pouvant être utilisée par le mode de communication hybride à étalement de spectre à saut de fréquence/à séquence directe consiste en un plus petit nombre de fréquences de saut que celles qui sont définies par une seconde séquence de sauts pour utilisation par le mode de communication pur à étalement de spectre à saut de fréquence.

2. Appareil selon la revendication 1, dans lequel le moyen pour utiliser le mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant le premier mode de fonctionnement de la connexion utilise un débit de bribes qui est identique à un débit de transmission binaire utilisé par la transmission pure à étalement de spectre à saut de fréquence pendant le second mode de fonctionnement de la connexion.

3. Appareil selon la revendication 1 ou 2, dans lequel le moyen pour utiliser le mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant le premier mode de fonctionnement de la connexion, comporte un moyen pour transmettre un message de recherche qui comprend une séquence fixe de bribes qui est propre à une unité radio recherchée.

4. Appareil selon la revendication 3, dans lequel un débit de bribes du message de recherche est identique à un débit binaire utilisé pendant la transmission pure à étalement de spectre à saut de fréquence pendant le second mode de fonctionnement de la connexion.

5. Appareil selon la revendication 1, dans lequel le moyen pour utiliser le mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant le premier mode de fonctionnement de la connexion, inclut un moyen pour transmettre un message de recherche qui comprend une séquence de bribes fixe qui est commune à toutes les unités radio du système radio.

6. Appareil selon la revendication 5, dans lequel un débit de bribes du message de recherche est identique à un débit de bribes utilisé pendant la transmission pure à étalement de spectre à saut de fréquence pendant le second mode de fonctionnement de la connexion.

7. Appareil selon l'une quelconque des revendications précédentes, comprenant en outre un corrélateur à glissement pour désétaler un message de recherche qui est transmis pendant le premier mode de fonctionnement de la connexion.

8. Appareil selon la revendication 7, dans lequel le corrélateur à glissement est mis en oeuvre sous la forme d'une ligne à retard à prises.

9. Appareil selon l'une quelconque des revendications précédentes, dans lequel un gain de traitement du mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste est égal ou supérieur à 17 dB.

10. Appareil selon l'une quelconque des revendications précédentes, dans lequel une vitesse de saut utilisée par une unité de recherche fonctionnant dans le mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste est un multiple d'une vitesse de saut utilisée par le mode de communication de transmission pur à étalement de spectre à saut de fréquence.

11. Appareil selon l'une quelconque des revendications précédentes, dans lequel une séquence de sauts pouvant être utilisée par le mode de communication de transmission pur étalement de spectre à saut de fréquence comprend au moins 75 fréquences de saut.

12. Appareil selon l'une quelconque des revendications précédentes, dans lequel le premier mode de communication a lieu pendant le démarrage d'une connexion et dans lequel le second mode de communication a lieu pendant un mode connecté de la connexion.

13. Procédé de mise en fonctionnement d'un émetteur/récepteur dans un système radio, comprenant les étapes consistant à :

utiliser un mode de communication hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant un premier mode de fonctionnement sur une connexion ; et
utiliser un mode de communication pur à étalement de spectre à saut de fréquence pendant un second mode de fonctionnement de la connexion,

dans lequel une première séquence de sauts pour utilisation par le mode de communication hybride à étalement de spectre à saut de fréquence/à séquence directe consiste en un plus petit nombre de fréquences de saut qui sont définies par une seconde séquence de sauts pouvant être utilisée par le mode de communication pur à étalement de spectre à saut de fréquence.

14. Procédé selon la revendication 13, dans lequel l'étape d'utilisation du mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant le premier mode de fonctionnement de la connexion comprend l'utilisation d'un débit de bribes qui est identique à un débit de transmission binaire utilisé par la transmission pure à étalement de spectre à saut de fréquence pendant le second mode de fonctionnement de la connexion.

15. Procédé selon la revendication 13, dans lequel l'étape d'utilisation du mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant le premier mode de fonctionnement de la connexion, comprend la transmission d'un message de recherche comprenant une séquence fixe de bribes qui est propre à une unité radio recherchée.

16. Procédé selon la revendication 15, dans lequel un débit de bribes du message de recherche est identique à un débit binaire utilisé pendant la transmission pure à étalement de spectre à saut de fréquence pendant le second mode de fonctionnement de la connexion.

17. Procédé selon la revendication 13, dans lequel l'étape d'utilisation du mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant le premier mode de fonctionnement de la connexion comprend la transmission d'un message de recherche qui comprend une séquence fixe de bribes qui est commune à toutes les unités radio du système radio.

18. Procédé selon la revendication 17, dans lequel un débit de bribes du message de recherche est identique à un débit de bribes utilisé pendant la transmission à étalement de spectre à saut de fréquence pendant le second mode de fonctionnement de la connexion.

19. Procédé selon l'une quelconque des revendications 13 à 18, comprenant en outre l'étape consistant à utiliser un corrélateur à glissement pour désétaler un message de recherche qui est transmis pendant le premier mode de fonctionnement de la connexion.

20. Procédé selon la revendication 19, dans lequel le corrélateur à glissement est mis en oeuvre sous la forme d'une ligne à retard à prises.

21. Procédé selon l'une quelconque des revendications 13 à 20, dans lequel un gain de traitement de la transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste pendant le premier mode de fonctionnement de la connexion est égal ou supérieur à 17 dB.

22. Procédé selon l'une quelconque des revendications 13 à 21, dans lequel:

l'étape consistant à utiliser le mode de communication de transmission hybride à étalement de spectre à saut de fréquence/à séquence directe consiste directe pendant le premier mode de fonctionnement de la connexion utilise une première vitesse de saut ;
l'étape consistant à utiliser le mode de communication de transmission pur à saut de fréquence à étalement de spectre pendant le second mode de fonctionnement de la connexion utilise une seconde vitesse de saut ; et
la première vitesse de saut est un multiple de la seconde vitesse de saut.

23. Procédé selon l'une quelconque des revendications 13 à 22, dans lequel l'étape consistant à utiliser le mode de communication de transmission pur à saut de fréquence à étalement de spectre pendant le second mode de fonctionnement de la connexion utilise une séquence de sauts qui comprend au moins 75 fréquences de saut.

24. Procédé selon l'une quelconque des revendications 13 à 23, dans lequel le premier mode de fonctionnement de la connexion est un mode de démarrage, et dans lequel le second mode de fonctionnement de la connexion est un mode connecté de la connexion.

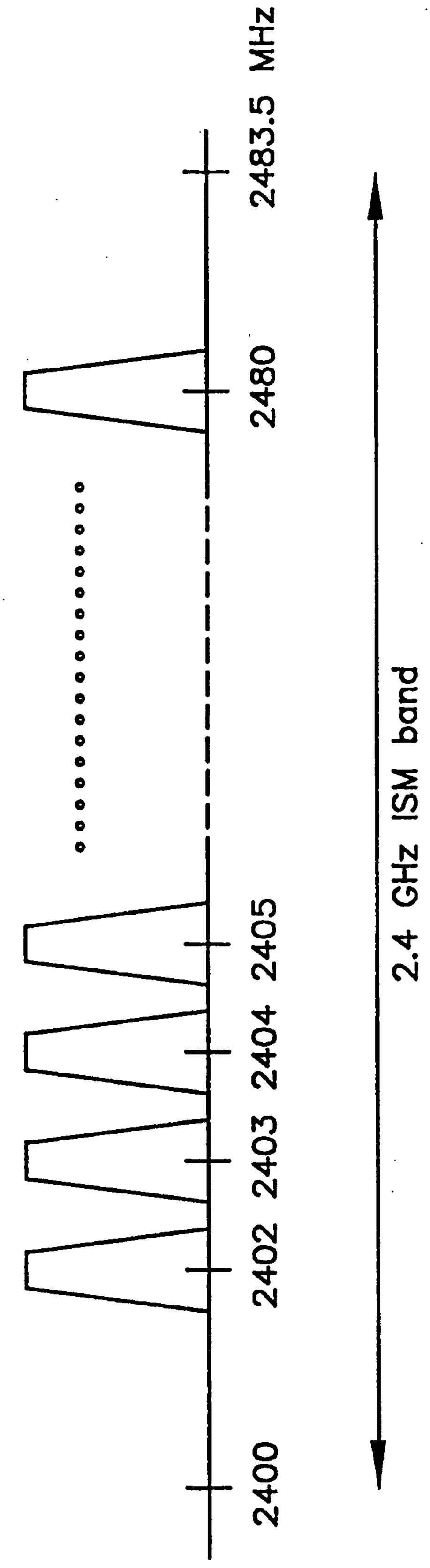
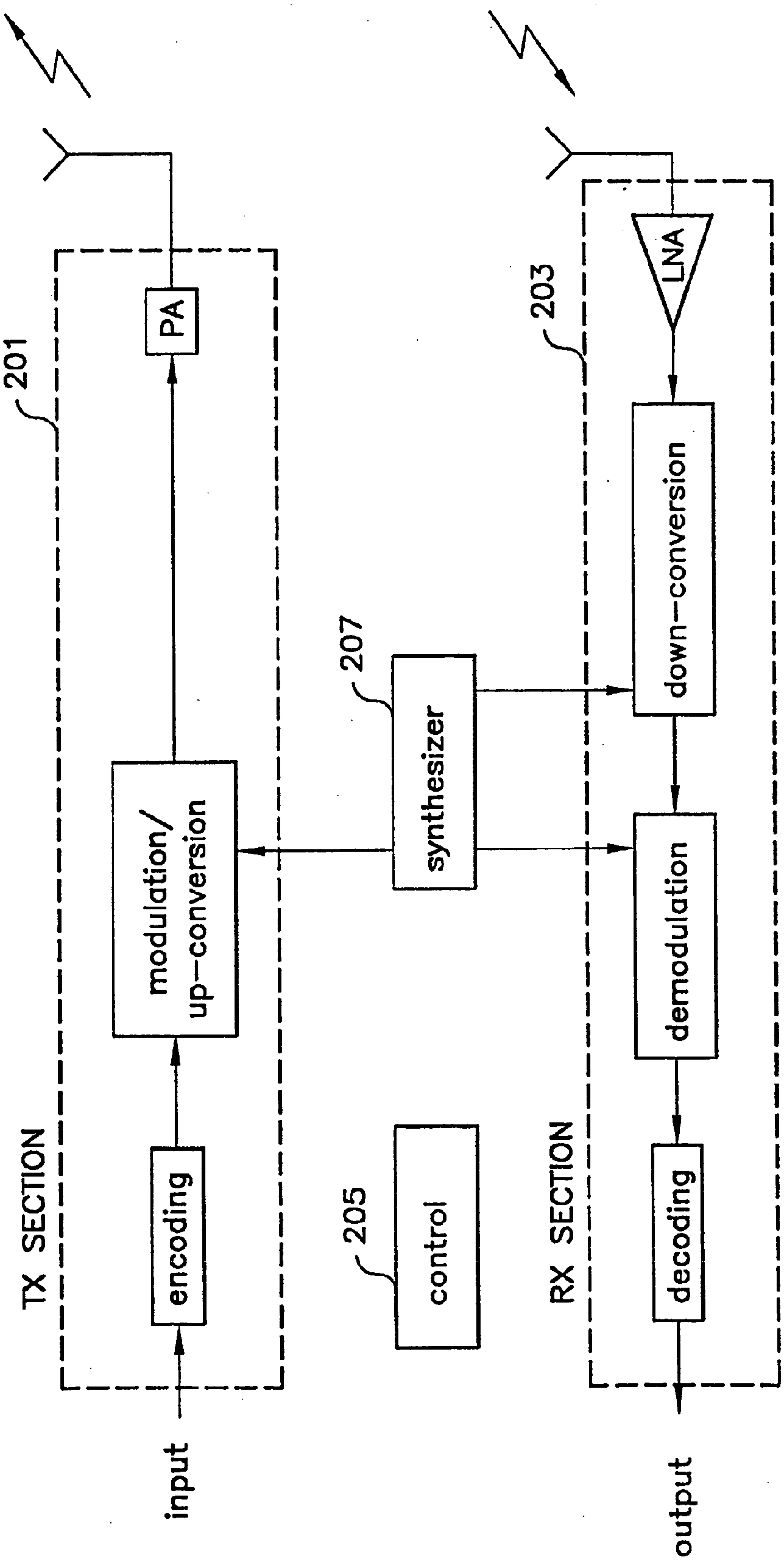


FIG. 1



TX SECTION
201
encoding
modulation/
up–conversion
PA
input
205
control
207
synthesizer
RX SECTION
203
LNA
down–conversion
demodulation
decoding
output

FIG. 2

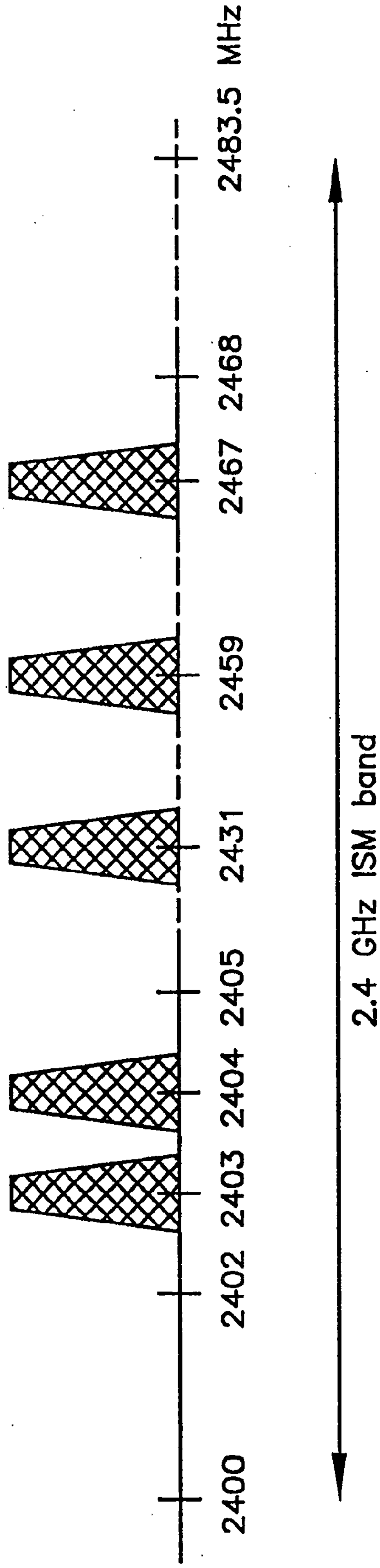

2400
2402
2403
2404
2405
2431
2459
2467
2468
2483.5 MHz
2.4 GHz ISM band

FIG. 3

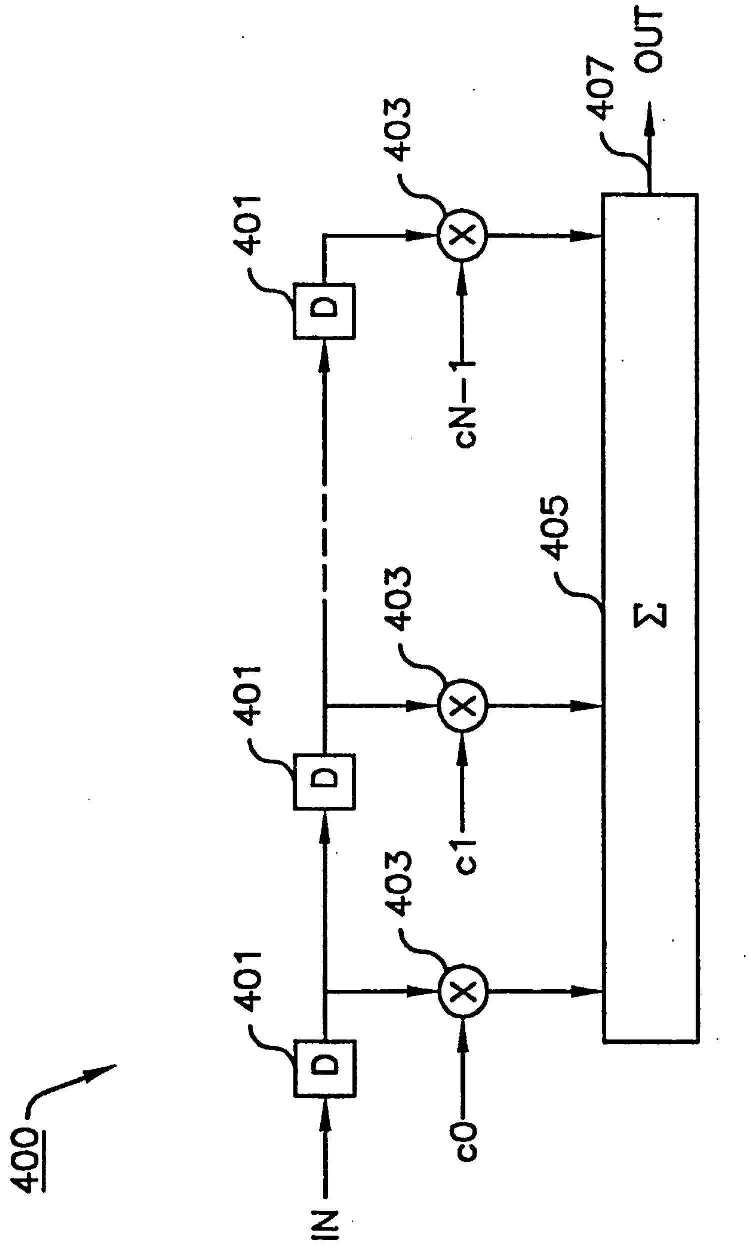


FIG. 4

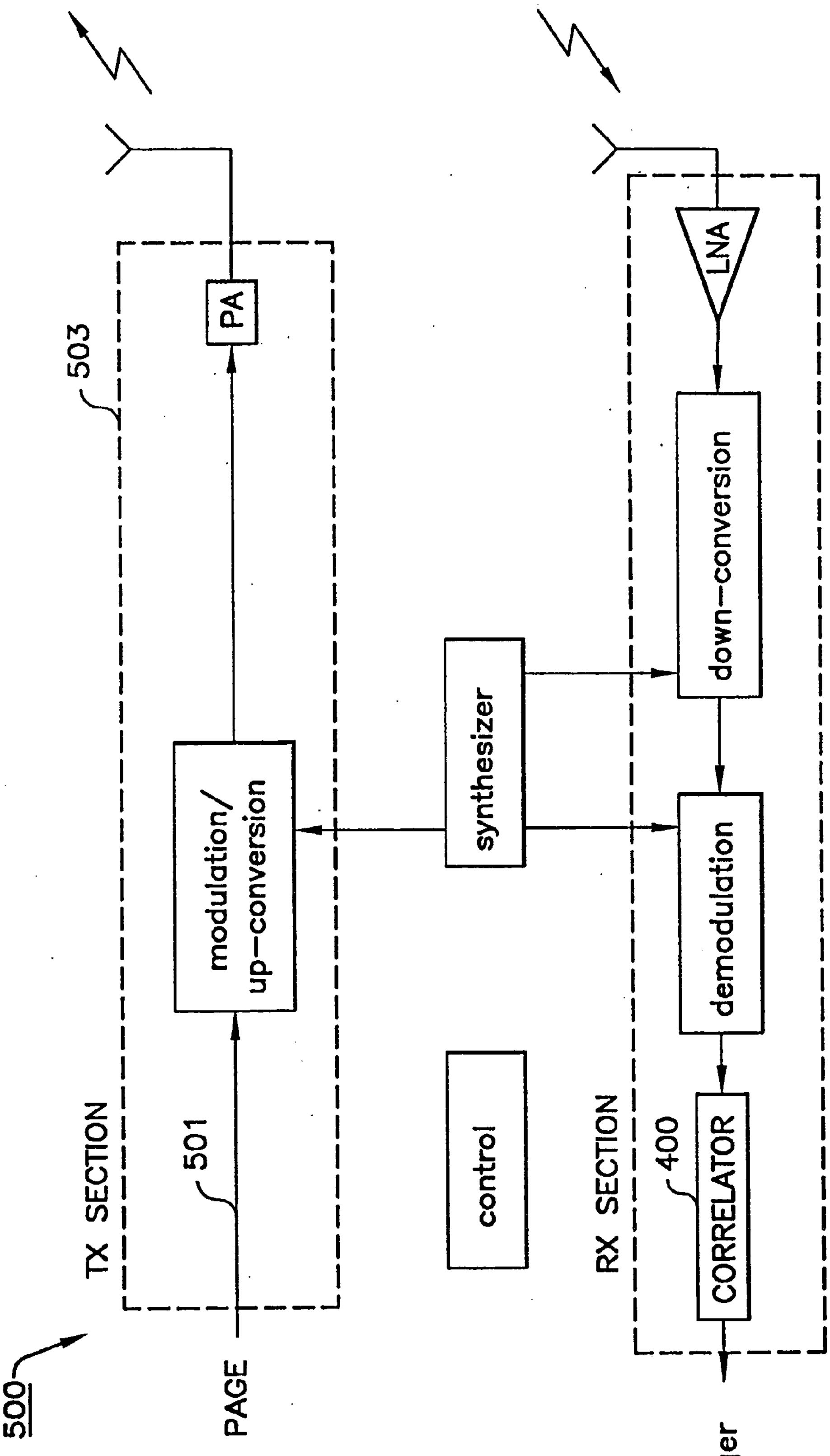

500
FIXED PAGE CODE
501
TX SECTION
modulation/ up-conversion
PA
503
control
synthesizer
trigger
RX SECTION
400
CORRELATOR
demodulation
down-conversion
LNA

FIG. 5

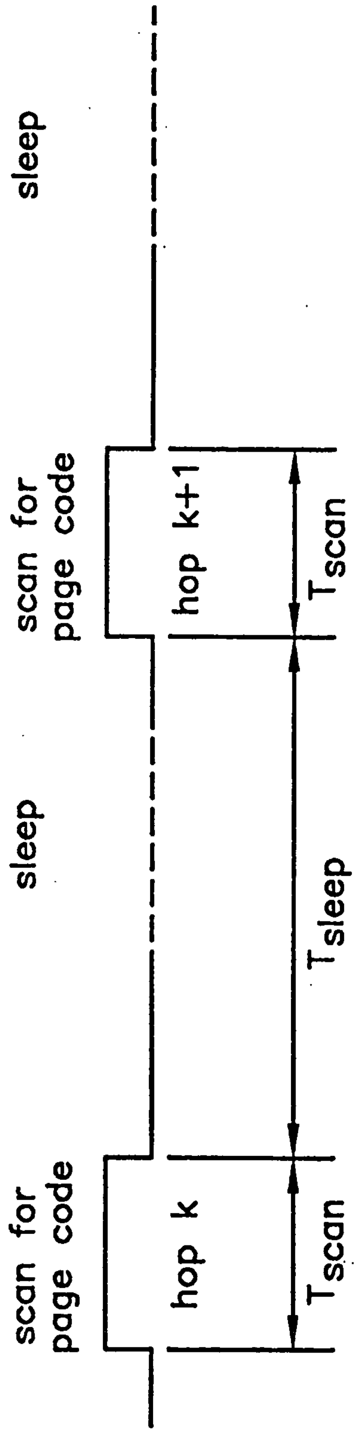

scan for
page code
hop k
T_{scan}
sleep
T_{sleep}
scan for
page code
hop k+1
T_{scan}
sleep

FIG. 6

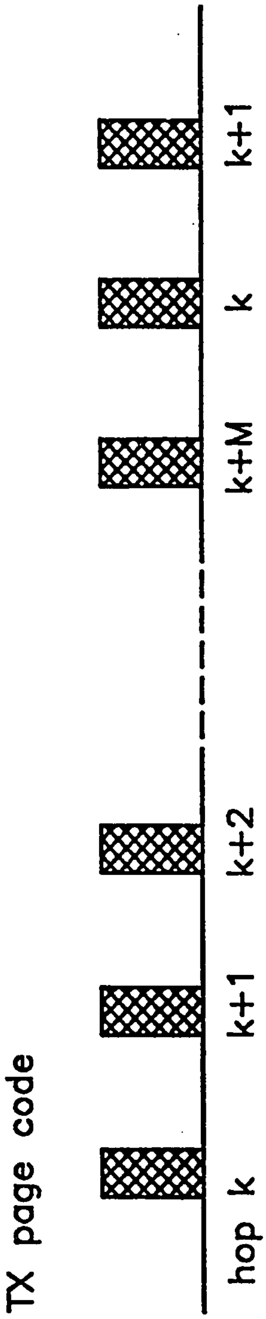


FIG. 7

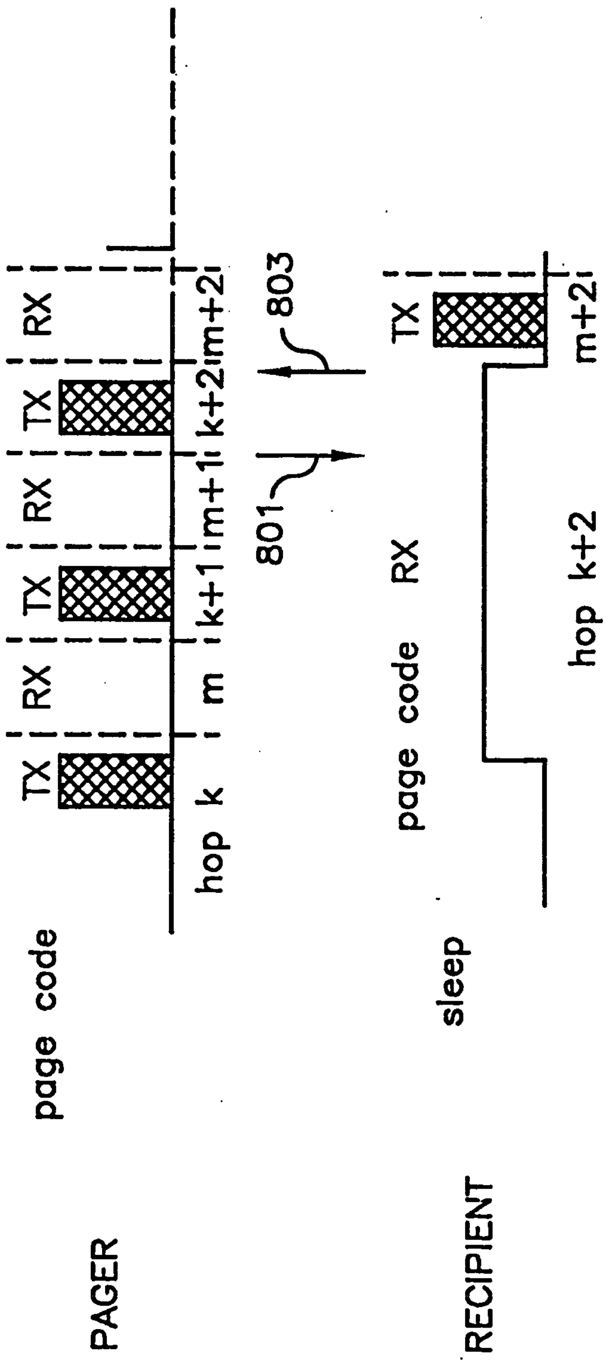

PAGER
page code
TX
RX
TX
RX
TX
RX
hop k
m
k+1
m+1
k+2
m+2
801
803
RECIPIENT
sleep
page code RX
TX
hop k+2
m+2

FIG. 8