PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 :		
H04J 3/16, H04B 15/00	A1	(11) International Publication Number: WO 92/07434 (43) International Publication Date: 30 April 1992 (30.04.92)

(21) International Application Number: PCT/US91/07382

(22) International Filing Date: 3 October 1991 (03.10.91)

(30) Priority data:
600,772 23 October 1990 (23.10.90) US

(60) Parent Application or Grant
(63) Related by Continuation
US 600,772 (CON)
Filed on 23 October 1990 (23.10.90)

(71) Applicant *(for all designated States except US)*: OMNIPOINT DATA COMPANY, INC. [US/US]; 2120 Hollowbrook Drive, Colorado Springs, CO 80918 (US).

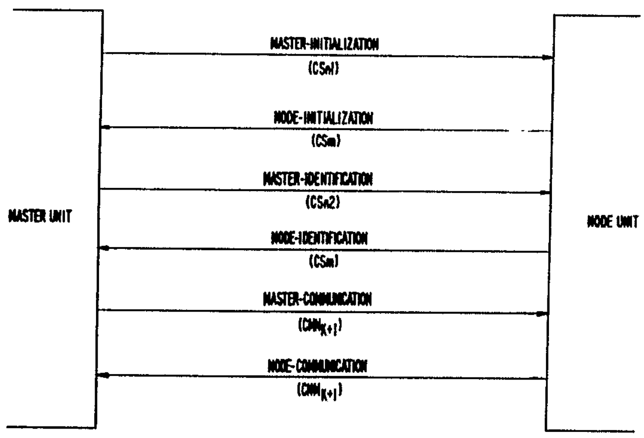
(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : DIXON, Robert, Clyde [US/US]; 14717 Perry Park Road, Palmer Lake, CO 80133 (US). VANDERPOOL, Jeffrey, Scott [US/US]; 2237 Moccassin Drive, Colorado Springs, CO 80915 (US).

(74) Agent: SWERNOFSKY, Steven, A.; 611 West Sixth Street, 34th Floor, Los Angeles, CA 90017 (US).

(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CI (OAPI patent), CM (OAPI patent), CS, DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MN, MR (OAPI patent), MW, NL, NL (European patent), NO, PL, RO, SD, SE, SE (European patent), SN (OAPI patent), SU+,TD (OAPI patent), TG (OAPI patent), US.

Published
With international search report.

(54) Title: METHOD AND APPARATUS FOR ESTABLISHING SPREAD SPECTRUM COMMUNICATIONS



(57) Abstract

A method for establishing communications between a master unit (50) and a plurality of node units (51-55). Of the plurality of node units, K node units are assumed to have established communications with a master unit. A first (K+1) node unit of the plurality of node units desires to establish communications with the master unit. The method includes transmitting from the master unit a base-station spread spectrum signal (CSn1) having a common-signalling chip code, transmitting from the first node unit a second spread spectrum signal (CSm) with a first identification code using the common-signalling chip code, transmitting from the master unit a third spread spectrum signal (CSn2) with a master unit identification code, using the common-signalling chip code. The method further includes generating at the first node unit using the master unit identification signal (CSn2) a master unit chip code for transmitting spread spectrum signals (CNM_{K+1}) to the master unit. Additionally, the method includes generating at the master unit using the first identification code, a first node unit chip code for transmitting spread spectrum signals (CMN_{K+1}) to the first node unit.

+ See back of page

+ DESIGNATIONS OF "SU"

Any designation of "SU" has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CS	Czechoslovakia
DE	Germany
DK	Denmark
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GN	Guinea
GR	Greece
HU	Hungary
IT	Italy
JP	Japan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
LI	Liechtenstein
LK	Sri Lanka
LU	Luxembourg
MC	Monaco
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
NL	Netherlands
NO	Norway
PL	Poland
RO	Romania
SD	Sudan
SE	Sweden
SN	Senegal
SU+	Soviet Union
TD	Chad
TG	Togo
US	United States of America

DESCRIPTION

Method and Apparatus for Establishing Spread Spectrum Communications

Background of the Invention

This invention relates to spread spectrum communications, and more particularly to a method for establishing spread spectrum communications between a base station and a handset.

Description of the Prior Art

A spread spectrum system is one in which the signal energy is distributed over a frequency spectrum that is much wider than the maximum bandwidth required to transmit the information being sent. Techniques for direct sequence spread spectrum modulation have been developed for several years to ensure, among other benefits, secure communications. Modulation is achieved by mixing the information to be sent with a periodic pseudo-noise (PN) code. The spectral density function for the resulting signal has a sin(X)/X shape with a very wide bandwidth, as compared to the information, and a lower spectral density function amplitude as compared to the information. This modification of the original spectral density function reduces the signal's sensitivity to in-band interference and jamming, as well as reducing interference to other equipment that is sensitive to radio frequencies. Among the other advantages inherent to a spread spectrum system are selective addressing capabilities, code division multiplexing for multiple access, and highly accurate ranging capabilities.

Due to the encoded nature of the signal, demodulation is a more involved process compared with demodulation schemes associated with traditional communications systems. In this case, demodulation involves a receiver reference code, identical to that transmitted, that synchronizes the receiver with the transmitter. The difficulty with this process is that there is no indication of the degree of non-synchronization between received and reference codes until a very high degree of synchronization is achieved. Additionally, mismatches between transmit and receive oscillators used to generate PN codes tend to cause drift in the synchronization between transmitter and receiver.

A prior art communications system using two pseudo-random waveforms and two correlators for designating a MARK and a SPACE, is disclosed in U.S. Patent No. 4,247,942, to Hauer, issued January 27, 1981, which is incorporated herein by reference. Hauer discloses in a communication system, a first delay line having multiple spaced taps for supplying successive input pulses to the delay line. In response to each input impulse, variously delayed pulses appear at the taps of the delay line, which are used to generate pulses representing a MARK or a SPACE. His disclosure includes synchronous detectors, and means for supplying the carrier-transmitted pulses to the detectors.

The prior art does not teach a method for establishing spread spectrum communications using a spread spectrum signal which allows the use of one or more common signalling spectrum spreading codes to manage handshaking from a master unit to a plurality of node units, without the use of a separate frequency channel for common signalling, and without requiring a separate time channel for common signalling.

Objects and Summary of the Invention

An object of the invention is to provide a method for establishing communications using spread spectrum signals to communicate between a master unit and a plurality of remote units.

Another object of the invention is to provide for a method for using spread spectrum signals to communicate between a master unit and a plurality of remote units requiring a minimum amount of digital signal processing.

A further object of the invention is to allow use of the same frequency for both common signalling as well as communications.

An additional object of the invention is to allow use of the same frequency and same time slot for both common signalling and communications.

Another object of the invention is to allow access and handshaking of a plurality of node units to a single master unit when no node unit has a-priori knowledge of spectrum spreading or identification codes, time slots, synchronization parameters, or frequencies utilized at the master unit to be accessed.

A still further object of the invention is to allow use of a collision avoidance protocol.

Another object of the invention is to allow the management of simultaneous users on a single master unit on a common signalling and communication time slot and frequency basis.

Another object of the invention is to allow the node units to have a minimal need for intelligence, processing power, or local synchronized clock sources.

Another object of the invention is to allow use of spectrum spreading codes as address codes.

Another object of the invention is to allow node response to a valid signal within a time slot through CDMA only, eliminating the need for a highly accurate clock and a level of node complexity and intelligence.

Another object of the invention is to allow half-duplex communication between master unit and node unit in the same TDMA time slot.

According to the present invention as embodied and broadly described herein, a method and apparatus for establishing and maintaining handshaking and communications between a master unit and a plurality of N node units, with multiple configurations, is provided. Of the plurality of N node units, K node units, where K < N, are assumed to have established 2K communications links with a master unit, using up to 2K different spectrum spreading codes to generate up to 2K different spread spectrum signals to transmit from the node units to the master unit. A time slot for each of the K linked node units is provided for transmitting and receiving in each of the first K time slots. A total of N time slots, constituting a time frame, are assumed available for communicating and/or initializing with the master unit by using time division multiple access. While system capacity allows N node units to establish and maintain simultaneous communications, with a single master unit, the number of node units which may access the master unit is not limited to N, but may be much greater.

In this invention, transmitting and/or receiving in a time slot may include transmitting and/or receiving in a plurality of time slots in a slot position within a frame and/or from frame to frame. Transmitting and/or receiving in a particular time slot also does not limit a time slot to a particular slot position within a frame.

A first (K+1) node unit of the plurality of the N node units, of the plurality of X node units able to access the master unit, is assumed to desire to establish communications with, or access, the master unit. The method constitutes handshaking between the (K+1)th node unit and the master unit in an access time slot.

A first embodiment of the present invention implements the (K+1)th time slot as the access slot and (K+1)th communication slot. The (K+1)th time slot may occupy, or float to, any open time slot within the time frame of the N-K open slots, and may change time slots as the number, K, of node units which have established communications links with the master unit, changes. This embodiment comprises several steps, the first of which is transmitting in a (K+1)th time slot from the master unit a master-initialization spread spectrum signal, CSn1, common to the plurality of X node units.

In response to receiving the master-initialization spread spectrum signal, CSn1, in the (K+1)th time slot, the (K+1)th node unit transmits in the (K+1)th time slot a first node-initialization spread spectrum signal, CSm1, which may be the same as, and thus a node retransmission of, the master-initialization spread spectrum signal, CSn1, or which may be a spread spectrum signal having a chip code distinct from the master-initialization spread spectrum signal, CSn1, and common to all master units that the (K+1)th node unit may access. The first node-initialization spread spectrum signal, CSm1, may contain the (K+1)th node unit's identification code as data information modulating the chip sequence for the (K+1)th node-initialization spread spectrum signal.

The master unit receives the first node-initialization spread spectrum signal, CSm1, from the (K+1)th node unit in the (K+1)th time slot, and, in reply, transmits in the (K+1)th time slot a master-identification spread spectrum signal, CSn2, which may be distinct from spread spectrum signal CSn1 but common to all X node units. The master-identification spread spectrum signal contains the master unit's (K+1)th slot identification code as data information modulating the chip sequence for the master-identification spread spectrum signal.

In response to receiving the master-identification spread spectrum signal, CSn2, the (K+1)th node unit may transmit in the (K+1)th time slot a second node-initialization spread spectrum signal, CSm2. The second node-initialization spread spectrum signal, CSm2, may contain (K+1)th node-identification code as data information modulating the chip sequence from the node-initialization spread spectrum signal. The node-identification spread spectrum signal may have a high degree of uniqueness to the plurality of the N-1 other node units.

The master unit receives the (K+1)th node unit's identification code, and transmits in the (K+1)th time slot a master unit (K+1)th slot communication spread spectrum signal, CMNk+1, generated from a spectrum spreading code derived from the (K+1)th node unit's identification code.

In response to receiving the (K+1)th master identification code in the (K+1)th time slot from the master unit the (K+1)th node unit transmits in the (K+1)th time slot a (K+1)th node unit communication spread spectrum signal, CNMk+1, generated from a spectrum spreading code derived from the (K+1)th master-identification code.

In a second embodiment of the present invention, a fixed, or Fth, time slot, such as the 1st or Nth slots of the plurality of N time slots in a time frame, serves as the access slot. The second embodiment comprises of the steps of transmitting in the Fth time slot from the master unit a master-initialization spread spectrum signal, CSn1, common to all node units. The Fth time slot may occupy a fixed time slot within the time frame of the N-K unused time slots, and does not change slots as the number, K, of node units which have established communications links with the master unit, changes.

In response to receiving the master-initialization spread spectrum signal, CSn1, in the Fth time slot, the (K+1)th node unit transmits in the Fth time slot a first and second code-initialization spread spectrum signal, CSm1, CSm2, having the characteristics and properties previously discussed.

The master unit receives the node-initialization spread spectrum signal, CSm, in the Fth time slot from the (K+1)th node unit, and transmits in the Fth time slot a master-identification spread spectrum signal, CSn2, which may be distinct from the master-initialization spread spectrum signal, CSn1, but common to all X node units, and containing the master unit's (K+1)th slot identification code. The master-identification spread spectrum signal, CSn2, may include information directing the (K+1)th node unit as to which time slot and spectrum spreading code to use for communication from the (K+1)th node unit to the master unit.

In response to receiving the master-identification spread spectrum signal, CSn2, the (K+1)th node unit transmits in the Fth time slot the second node-initialization spread spectrum signal, CSm2. The second node-initialization spread spectrum signal, CSm2, is common to all master units that (K+1)th node unit may access, and may contain its (K+1)th node-unit-identification code. The second node-initialization spread spectrum signal, CSm2, may have a high degree of uniqueness to the plurality of the N-1 other node units.

The master unit receives the (K+1)th node unit's identification code from the (K+1)th node unit in the Fth time slot, and transmits in the (K+1)th time slot a master unit (K+1)th slot communication spread spectrum signal, CMNk+1, generated from a spectrum spreading code derived from the (K+1)th node unit's identification code.

In response to receiving the (K+1)th master unit identification code from the master unit in the Fth time slot via the CSn2 spread spectrum signal, the (K+1)th node unit transmits in the (K+1)th time slot a (K+1)th node unit communication spread spectrum signal, CNMk+1, generated from a spectrum spreading code derived from the (K+1)th master unit identification code.

As an alternative architecture in this configuration, the (K+1)th node unit may transmit the (K+1)th node unit communication spread spectrum signal in the (K+1)th time slot in response to receiving the master unit (K+1)th slot communication signal in the (K+1)th time slot. In this case, the master unit (K+1)th slot identification signal transmitted in the Fth time slot would not necessarily contain information detailing which time slot of the N-K time slots to use for communication transmissions.

In a third embodiment of the invention, the master unit may function with the initialization, identification, and communication protocols detailed in first and second embodiments, but may be configured to transmit the master-initialization spread spectrum signal, CSn1, in a plurality of vacant (N-K) time slots. If the master unit does transmit in a plurality of vacant (N-K) time slots, then node units (K+1), (K+2), (K+3),..., (K+(N-K)) (or N) may access the master unit in the (K+1)th, (K+2)th, (K+3)th, ..., (K+(N-K))th (or Nth) time slots, respectively or randomly. Therefore, the (K+1)th node unit trying to access the master unit would access the first time slot immediately available after its initiation of the access attempt, instead of waiting for the (K+1)th or Fth time slot to occur in the next frame.

Thus, if K users are present, the master unit transmits in the 1st through Kth time slots the master unit communication spread spectrum signals, CMN1 through CMNk, pertaining to the 1st through Kth node units, and in the (K+1)th through Nth time slots a master-initialization spread spectrum signal, CSn1, which is common to the plurality, X, of node units that may access the master unit. The master-initialization spread spectrum signal may be distinct from all master or node unit communication and identification spread spectrum signals.

In all three embodiments, if a plurality of up to N-K node units tries to access the master unit sequentially in time, with the period between access attempts being greater than or equal to the slot period, upon reception of the master-initialization spread spectrum signal, CSn1, each node unit will access the open time slot available immediately following its initiation of the access attempt. When the first (K+1)th node unit has accessed the master unit (master unit slot and (K+1)th node unit identification signals are being transmitted in the (K+1)th time slot), the master unit may wait to transmit the (K+2)th through Nth master-identification signals until the (K+1)th slot is occupied with master unit-to-(K+1)th node unit and/or (K+1)th node unit-to-master unit communication signals.

If a plurality of up to N-K node units tries to access the master unit instantaneously (the time period between node unit access attempts being less than the slot period), upon reception of the master-initialization spread spectrum signal, CSn1, each node unit of this plurality of node units will transmit a node-initialization spread spectrum signal, CSm, within the same time slot, thus jamming at least one of the node-initialization spread spectrum signals, CSm, at the master unit. If the master unit does not receive a valid node-initialization spread spectrum signal, CSm, or identification code from a node unit during the time slot, it may cease to transmit any signal in that time slot for a predetermined period of time, or it may transmit a "jammed signal alarm" code through the master unit slot identification signal, CSn2. When a lack of response or a jammed signal alarm code from the master unit is encountered, the node units which tried to access the master unit instantaneously, of the plurality, N - K, of node units, may initiate a node unit internal "wait" state, whose period may be derived from each node nit's identification code. After the wait state period, the plurality of node units which failed to access the master unit may attempt to access it again. Since wait states may be highly unique to each node unit, it is unlikely that the same plurality of node units will jam each other again.

If all N time slots are being used for communication or initialization functions by N node units, then the master-initialization spread spectrum signal, CSn1, is not transmitted by the master unit, and no new node units of the plurality of X - N node units may access the master unit. The master unit may operate such that the Nth time slot may transmit a "busy" alarm to the plurality of N-K node units having not established communications with the master unit such that it informs them that no further access is available at that master unit, thereby allowing only N-1 node units to access the master unit.

Additional object of the inventions and advantages of the invention will be set forth in part in the description which follows, and in part will be obvious from the description or may be learned by practice of the invention. The objects and advantages of the invention also may be realized and attained by means of the instrumentalities and combinations particularly pointed out in the appended claims.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate preferred embodiments of the invention, and together with the description serve to explain the principles of the invention.

FIG. 1 illustrates a master unit with a plurality of remote units;

FIG. 2 illustrates time slots;

FIG. 3 illustrates the protocol of the method of the present invention;

FIG. 4 illustrates the multiple access system timing diagram of a preferred embodiment using binary signalling techniques; and

FIG. 5 illustrates the multiple access system timing diagram of a second preferred embodiment using M-ary signalling techniques.

Detailed Description of the Preferred Embodiments

Reference will now be made to the present preferred embodiments of the invention, examples of which are illustrated in the accompanying drawings.

The invention disclosed in this patent is related to the inventions disclosed in U.S. Patent Application entitled "Spread Spectrum Correlator," by Robert C. Dixon and Jeffrey S. Vanderpool and having Serial No. 07/390,315 and Filing Date of August 7, 1989; and in U.S. Patent Application entitled "Asymmetric Spread Spectrum Correlator," by Robert C. Dixon and Jeffrey S. Vanderpool and having Serial No. 07/389,914 and Filing Date of August 7, 1989, which are expressly incorporated herein by reference.

In the exemplary arrangement shown in FIG. 1, the present invention includes a method and apparatus for establishing communications between a master unit 50 and N node units. The master unit 50 may be a base station, PBX, file server or other central controlling device serving as the center of a star network, and the node units may be any type of computer, communications, telephone, video or other data device serving as a node point in the star network. While the system capacity allows N node units to establish simultaneous communications with a single master unit, the number, X, of node units that may access the master unit is not limited to N node units, but may be much larger than N.

As illustratively shown in FIG. 1, a master unit 50 is shown with a plurality of N node units 51, 52, 53, 54, 55, where N = 5, and a plurality of X node units 56, of which the plurality of N node units is a subset. Of the plurality of N node units 51, 52, 53, 54, 55, three node units (K = 3), are assumed to already have established communications channels with the master unit 50 using up to six different spectrum spreading chip codes to generate up to six different spread spectrum signals.

A particular node unit and master unit use two of the six spectrum spreading chip codes during communications. A first of the two spectrum spreading chip codes is used while communicating from the master unit to the particular node unit. A second of the two spectrum spreading chip codes is used while communicating from the particular node unit to the master unit. The spectrum spreading chip codes may be embodied as a pseudo-random sequence, and the spectrum spreading chip codes typically modulate information data which may be embodied as a data bit sequence, as is well known in the art.

A total of five time slots (N = 5), which constitute a time frame, are assumed available for communicating with the master unit by use of time division multiple access. Each of the three node units 51, 52, 53, communicates with the master unit 50 in a time slot, which may be the first three of five time slots. Alternatively, each of the three node units may communicate with the master unit 50 in three time slots which have any predetermined order. Additionally, a (K+1)th time slot, which by way of example is the fourth time slot (K + 1 = 4), may occupy, or "float" to, any open time slot within the time frame of the two unused time slots, and may change time slots as the number, K, of node units which have established communications links with the master unit, changes. A node unit, which of the five node units is the fourth node unit, desires to establish communications with, or access the master unit 50.

In the present invention, transmitting and/or receiving in a time slot may include transmitting and/or receiving in a plurality of time slots in a slot position within a frame and/or from frame to frame. Transmitting and/or receiving in a particular time slot also does not limit a time slot to a particular slot position within a frame.

In a first embodiment of the invention, the apparatus and method comprises the steps of transmitting in a (K+1)th time slot from the master unit 50, a master-initialization spread spectrum signal, CSn1. The master-initialization spread spectrum signal uses a master-common-signalling chip code which is known and stored in all the node units able to access the master unit. All of the node units have means responsive to the master-initialization spread spectrum signal, for correlating with the master-common-signalling chip code of the master unit 50. The correlating means may be embodied as a surface acoustic wave device (SAW), digital device, or any other device which can perform the required function. The master-common-signalling chip code may, but is not required, to modulate information data embodied as a data bit sequence or data symbol sequence. The information data may include indexing or other data pertinent to the (K+1)th time slot. The entire chip sequence of the master-common-signalling chip code is transmitted per data bit or data symbol during the (K+1)th time slot from the master unit.

In response to receiving the master-initialization spread spectrum signal, CSn1, at the (K+1)th node unit, the method and apparatus include transmitting from the (K+1)th node unit in the (K+1)th time slot a first node-initialization spread spectrum signal, CSm1. The first node-initialization spread spectrum signal may, but is not required,retransmit the master-common-signalling chip code which was transmitted from the master unit during the (K+1)th time slot. Alternatively, the first node-initialization spread spectrum signal, CSm1, may use a node-common-signalling chip code which can be received by all master units that the (K+1)th node unit may access. The first node-initialization spread spectrum, CSm1, signal additionally may be modulated by information data, such as the (K+1)th node unit's identification code. The entire chip sequence of the master-common-signalling chip code or node-common-signalling chip code modulates each bit, or symbol, of the information data, i.e., the node unit's identification code, using spread spectrum modulation.

The master unit 50 receives the first node-initialization spread spectrum signal, CSm1, from the (K+1)th node unit in the (K+1)th time slot, and transmits in the (K+1)th time slot a master-identification spread spectrum signal, CSn2. The master-identification spread spectrum signal uses a master-identification code which is common to all X node units. The master-identification code is modulated by the master-common-signalling chip code or node common-signalling chip code to produce the master-identification spread spectrum signal.

The master-identification code may be unique to the (K+1)th master unit slot, and may be unique to a minimum of N master-identification codes available at the master unit 50. The master-identification code, which may be distinct from all other master-identification codes and node-identification codes, is used by the node unit for generating a chip code for a spread spectrum signal used to communicate with the master unit 50. The chip code is generated from an algorithm processing the master-identification code, which may include, for example, a one-to-one relationship for setting taps on a set of shift registers.

In response to receiving the master-identification spread spectrum signal, CSn2, from the master unit 50 in the (K+1)th time slot, the (K+1)th node unit transmits in the (K+1)th time slot its node-identification code to the master unit using a second node-initialization spread spectrum signal, CSm2. As described previously for the first node-initialization spread spectrum signal, the second node-initialization spread spectrum signal, CSm2, uses a master-common-signalling chip code, or a node-common-signalling chip code which is common to all master units to which the (K+1) node unit may access for modulating the node-identification code. The (K+1) node-identification code has a high degree of uniqueness compared with node unit identification codes by which the plurality of other node units may access the master unit.

The master unit 50 receives the (K+1)th node-identification code, and establishes the master-unit-to-(K+1)th-node-unit communication channel by transmitting in the (K+1)th time slot a master-unit-(K+1)th-slot communication spread spectrum signal, CMNK+1. The spectrum spreading chip code for the master-unit-(K+1)th-slot-communication spread spectrum signal is generated from the (K+1)th node unit identification code.

In response to receiving the (K+1)th master-identification code, the (K+1)th node unit establishes the (K+1)th node-unit-to-master unit communication channel by transmitting in the (K+1)th time slot a (K+1)th node-unit-communication spread spectrum signal, CNMK+1. The spectrum spreading chip code for the (K+1)th node unit communication spread spectrum signal is generated from the (K+1)th master-identification code.

In the explanatory embodiment discussed herein, the master unit may operate such that it does not transmit in a time slot except to send a plurality of K master unit slot communication spread spectrum signals, CMN1 to CMNK, in K time slots, to K node units which have established communications links with the master unit, plus a master-initialization spread spectrum signal, CSn1, in the case of a search for a new node unit trying to access the master unit, or a master unit slot identification signal, CSn2, in the case of a node unit being in the process of accessing a master unit, leaving N-K-1 time slots unused. If the master unit is transmitting a master-identification spread spectrum signal, CSn2, in the (K+1)th time slot (the (K+1)th node unit is in the process of accessing the master unit), it then may transmit a master-initialization spread spectrum signal, CSn1, in the (K+2)th time slot, in order to allow the (K+2)th node unit to access the master unit through the same method.

If a plurality of up to N-K node units tries to access the master unit sequentially in time, with the period between access attempts being greater than or equal to the time frame period, upon reception of the master-initialization spread spectrum signal, CSn1, each node unit of the plurality of N - K node units will access the time slot immediately available following its initiation of the access attempt. When the first (K+1)th node unit has accessed the master unit (master unit (K+1)th slot and

(K+1)th node unit identification signals are being transmitted in the (K+1)th time slot), the master unit may wait to transmit the (K+2)th master unit slot identification signal until the (K+1)th slot is occupied with master unit-to-(K+1)th node unit and/or (K+1)th node unit-to-master unit communication signals.

If a plurality of up to N-K node units tries to access the master unit instantaneously (the time period between node unit access attempts being less than the frame period), upon reception of the master-initialization spread spectrum signal, CSn1, each node unit of this plurality of node units will transmit a first node initialization spread spectrum signal, CSm1, within the same time slot, thus jamming at least one of the node unit initialization signals, CSm, at the master unit. If the master unit does not receive a valid node-initialization spread spectrum signal, CSm, or identification code from a node unit during the time slot, it may cease to transmit any signal in that time slot for a predetermined period of time, or it may transmit a "jammed signal alarm" code through the master-identification spread spectrum signal, CSn2. When a lack of response or a jammed signal alarm code from the master unit is encountered, the node units which tried to access the master unit instantaneously, of the plurality, N - K, of node units, may then initiate a node unit internal "wait" state, whose period may be derived from each node unit's identification code. After the wait state period, the plurality of node units which failed to access the master unit may attempt to access it again. Since wait states may be highly unique to each node unit, it is unlikely that the same plurality of node units will jam each other again.

If all N time slots are being used for communication or initialization functions by N node units, then the master-initialization spread spectrum signal, CSn1, is not transmitted by the master unit, and no new node units of the plurality of X - N node units may access the master unit until a time slot opens up through one or more of the N node units abandoning communications with the master unit.

As an alternative architecture to the present embodiment, the master unit may operate such that the Nth time slot may be held in reserve to transmit a "busy" alarm to the plurality of N-K node units having not established communications with the master unit such that it informs them that no further access is available at that master unit, thereby allowing only N-1 node units to access the master unit.

The time division multiple access frame and time slots of the present invention are illustratively shown in FIG. 2. There are N time slots, with N = 5, available for N node units to communicate with the master unit, with K = 3 time slots already being used by the first K node units which are communicating with the master unit. During any one or all of the available N-K = 2 time slots, the master unit transmits a master-initialization spread spectrum signal, CSn1, common to the set of X node units that may access the master unit, of which the N = 5 node units is a subset. Since all node units which may access the master unit recognize the first master-initialization spread spectrum signal, CSn1, the 4th node unit trying to access the master unit will know that this time slot is available for communicating. In response to receiving the master-initialization spread spectrum signal, CSn1, in the 4th time slot, the 4th node unit may transmit in the 4th time slot to the master unit its identification code or a simple acknowledgment ("ACK") through a first node-initialization spread spectrum signal, CSm1, common to all master units it may access, but distinct from the master-initialization spread spectrum signal, CSn1.

In response to receiving the first node-initialization spread spectrum signal, CSm1, in the 4th time slot from the 4th node unit, the master unit transmits its 4th master-identification code, which may be distinct from all other master and node unit identification codes, with a master-identification spread spectrum signal, CSn2, common to the plurality of node units that may access the master unit and distinct from the master-initialization spread spectrum signal, CSn1, and the first node-initialization spread spectrum signal, CSm1. In response to receiving the 4th master-identification spread spectrum signal, CSn2, the 4th node unit may transmit in the 4th time slot its identification code through the second node-initialization spread spectrum signal, CSm2. In response to receiving the 4th node-identification code, the master unit derives a master unit spectrum spreading communication code for the 4th slot from the 4th node-identification code, and uses it to generate a master unit 4th slot communication spread spectrum signal, CMN4. The 4th master unit slot communication signal, CMN4, is then used for all transmissions from the master unit to the 4th node unit.

In response to receiving the master-identification code for the 4th time slot, the 4th node unit derives a 4th node unit spectrum spreading communication code from the master-identification code, and uses it to generate a 4th node unit communication spread spectrum signal, CNM4. The 4th node unit communication signal, CNM4, is then used for all transmissions from the 4th node unit to the master unit.

In a particular embodiment, there may be 4K samples per second, divided into K frames of four time slots of one milliseconds each, allowing N = 4 users to use one time slot 1000 times per second. The master unit transmits eighteen bits (two addressing, sixteen data) in each time slot it uses, yielding 16 kbps throughput from the master unit to each node unit per slot. In initialization or identification modes, the eighteen bits may be used differently. Node units, which may be embodied as handsets as illustrated in FIG. 1, transmit eighteen bits per time slot only in response to receiving a spread spectrum initialization, identification, or communication signal from the master unit. The master unit transmission frame comprises four time slots, and is configured such that it does not transmit in a time slot except to send a spread spectrum communication signal to K users who are on line, plus an initialization (in the case of a search for a new node unit trying to access the master unit) or identification (in the case of a new node unit in the process of accessing a master unit) signal, leaving N-K-1 time slots open. If the master unit is transmitting a master-identification spread spectrum signal in the (K+1)th time slot (i.e. the (K+1)th node unit is accessing the system), it then may transmit a master-initialization spread spectrum signal in the (K+2)th time slot, in order to allow the (K+2)th node unit to access the master unit. Thus, if two node units are present, then the master unit transmits in the 1st through second time slots the communication spread spectrum signals pertaining to the 1st through second nodes, and in the third time slot an initialization spread spectrum signal common to all node units that may access the master unit, which may be distinct from all communication and identification spread spectrum signals.

If, with N = 4 and K = 2 node units, a plurality of up to 2 node units try to access the master unit sequentially in time, with the period between access attempts being greater than or equal to the frame period, or one millisecond, upon reception of the master-initialization spread spectrum signal, CSn1, the third and fourth node units will access the third and fourth time slots, respectively, immediately available in the first time frame following their respective initiations of the access attempt. When the third node unit has accessed the system (master unit slot and third node unit identification signals are being transmitted in the third time slot), the master unit may wait to transmit the fourth master unit slot identification signal until the third slot is occupied with master unit-to-3rd node unit and/or 3rd node unit-to-master unit communication signals. If, with N = 4 and K = 2 node units, a plurality of up to 2 node units tries to access the master unit instantaneously (the time period between node unit access attempts being less than the frame period, or one millisecond), upon reception of the master-initialization spread spectrum signal, CSn1, in the third time slot, the third and fourth node units will transmit a first node-initialization spread spectrum signal, CSm1, within the third time slot, thus jamming at least one of the first node-initialization signals, CSm1, at the master unit. If the master unit does not receive a valid initialization signal, CSm, or identification code from a node unit during the third slot, it may cease to transmit any signal in the third time slot for a predetermined period of time, or it may transmit a "jammed signal alarm" code through the master-identification spread spectrum signal, CSn2. When a lack of response or a jammed signal alarm code from the master unit is encountered, the third and fourth node units may then initiate a node unit internal "wait" state, whose period may be derived from each node unit's identification code. After the wait state period, the third and fourth node units may attempt to access it again. Since wait states may be highly unique to each node unit, it is unlikely that the third and fourth node will units jam each other again. If all four time slots are being used for communication or initialization functions by four node units, then the initialization spread spectrum signal, CSn1, is not transmitted by the master unit, and no new node units of the plurality of X - 4 node units may access the master unit.

With N = 4 and K = 2, the master unit may function with the initialization, identification, and communication procedures detailed above, but may be configured to transmit the master-initialization spread spectrum signal, CSn1, in the vacant the third and fourth time slots. If the master unit does transmit the third and fourth vacant time slots, node units three and four may access the master unit in the third and fourth time slots, respectively or randomly. Therefore, the third node unit trying to access the master unit would access the first time slot immediately available after its initiation of the access attempt, instead of waiting for the third time slot to occur in the next frame.

Thus, if two users are present, the master unit transmits in the 1st through second time slots the master unit communication spread spectrum signals, CMN1 through CMN2, pertaining to the first through second node units, and in the third through fourth time slots a master initialization spread spectrum signal, CSn1, common to the plurality, X, of node units that may access the master unit, which may be distinct from all master or node unit communication and identification spread spectrum signals. If 2 node units try to access the master unit sequentially in time, with the period between access attempts being greater than or equal to the slot period of 250 microseconds, upon reception of the master-initialization spread spectrum signal, CSn1, each node unit will access the open time slot available immediately following its initiation of the access attempt. When the third node unit has accessed the master unit (master unit slot and third node unit identification signals are being transmitted in the third time slot), the master unit may wait to transmit the fourth master unit slot identification signal until the third slot is occupied with master unit-to-4th node unit and/or third node unit-to-master unit communication signals.

If a plurality of up to 2 node units tries to access the master unit instantaneously (the time period between node unit access attempts being less than the slot period, or 250 microseconds), upon reception of the master-initialization spread spectrum signal, CSn1, the third and fourth node units will transmit a first node-initialization spread spectrum signal, CSM1, or second node-initialization spread spectrum signal, CSm2, within the same time slot, thus jamming at least one of the node-initialization spread spectrum signal or node-identification spread spectrum signal, CSm, at the master unit. If the master unit does not receive a valid node-initialization spread spectrum signal or node-identification spread spectrum signal, CSm1, or identification code from a node unit during the time slot, it may cease to transmit any signal in that time slot for a predetermined period of time, or it may transmit a "jammed signal alarm" code through the master-identification spread spectrum signal, CSn2. When a lack of response or a jammed signal alarm code from the master unit is encountered, the third and fourth node units may initiate a node unit internal "wait" state, whose period may be derived from each node unit's identification code. After the wait state period, the third and fourth node units may attempt to access it again. Since wait states may be highly unique to each node unit, it is unlikely that the third and fourth node units will jam each other again.

FIG. 3 illustratively shows the foregoing protocol of the present invention.

In a second embodiment of the present invention, a fixed, or Fth, time slot, such as the 1st or Nth slots of the plurality of N time slots in a time frame, serves as the access slot. The second method and apparatus comprises the steps of transmitting in the Fth time slot from the master unit the master-initialization spread spectrum signal, CSn1, common to all node units. The Fth time slot may occupy a fixed time slot within the time frame of the N-K unused time slots, and does not change slots as the number, K, of node units which have established communications links with the master unit, changes. In response to receiving the master-initialization spread spectrum signal, CSn1, in the Fth time slot, the (K+1)th node unit transmits in the Fth time slot a (K+1)th node-initialization spread spectrum signal, CSm, which may be the same as CSn1, common to all master units that the (K+1)th node unit may access, which may contain the (K+1)th node unit's identification code.

The master unit receives the node-initialization spread spectrum signal, CSm, in the Fth time slot from the (K+1)th node unit, and transmits in the Fth time slot a master-identification spread spectrum signal, CSn2, which may be distinct from spread spectrum signal CSn1 but common to all X node units, containing the master unit's (K+1)th slot identification code, which may include information directing the (K+1)th node unit as to which time slot and spectrum spreading code to use for communication from the (K+1)th node unit to the master unit.

In response to receiving the master-identification spread spectrum signal, CSn2, the (K+1)th node unit may transmit in the Fth time slot the (K+1)th node-initialization spread spectrum signal, CSm, common to all master units that it may access, which may contain its (K+1)th node unit identification code, which may have a high degree of uniqueness to the plurality of the N-1 other node units.

The master unit receives the (K+1)th node unit's identification code from the (K+1)th node unit in the Fth time slot via the node-initialization spread spectrum signal, CSm, common to all master units accessible by the (K+1)th node unit, and transmits in the (K+1)th time slot a master unit (K+1)th slot communication spread spectrum signal, CMNk+1, generated from a spectrum spreading code derived from the (K+1)th node unit's identification code.

In response to receiving the (K+1)th master unit identification code from the master unit in the Fth time slot via the master-identification spread spectrum signal, CSn2, common to all X node units, the (K+1)th node unit transmits in the (K+1)th time slot a (K+1)th node unit communication spread spectrum signal, CNMk+1, generated from a spectrum spreading code derived from the (K+1)th master-identification code.

As an alternative architecture of the second embodiment, the (K+1)th node unit may transmit the (K+1)th node communication spread spectrum signal in the (K+1)th time in slot in response to receiving the master unit (K+1)th slot communication signal in the (K+1)th time slot. In this case, the master-identification spread spectrum signal transmitted in the Fth time slot would not necessarily contain information detailing which time slot of the N-K time slots to use for communication transmissions.

In the second embodiment, the master unit may operate such that it does not transmit in a time slot except to send a plurality of K master unit slot communication spread spectrum signals, CMN1 to CMNK, to K node units which have established communications links with the master unit, plus a master-initialization spread spectrum signal, CSn1, in the case of a search for a new node unit trying to access the master unit, or a master-identification spread spectrum signal, CSn2, in the case of a node unit being in the process of accessing a master unit, in the Fth time slot, leaving N-K-1 time slots unused. If the master unit is transmitting a master-identification spread spectrum signal, CSn2, in the Fth time slot (assuming the (K+1)th node unit is in the process of accessing the system), it then may transmit a master initialization spread spectrum signal, CSn1, in one of the N-K-1 unused time slots, in order to allow the (K+2)th node unit to access the master unit.

If a plurality of up to N-K node units tries to access the master unit sequentially in time, with the period between access attempts being greater than or equal to the frame period, upon reception of the master-initialization spread spectrum signal, CSn1, each node unit of the plurality of N - K node units will access the (K+1)th time slot through the Fth time slot immediately available following its initiation of the access attempt. When the first (K+1)th node unit has accessed the system (assuming the master-identification and (K+1)th node-identification spread spectrum signals are being transmitted in the Fth time slot), the master unit may wait to transmit the (K+2)th master-identification spread spectrum signal until the (K+1)th slot is occupied with master unit-to-(K+1)th node unit and/or (K+1)th node unit-to-master unit communication signals.

If a plurality of up to N-K node units tries to access the master unit instantaneously (the time period between node unit access attempts being less than the frame period), upon reception of the master-initialization spread spectrum signal, CSn1, in the Fth time slot, each node unit of this plurality of node units will transmit a node-initialization spread spectrum signal, CSm, within the same time slot, thus jamming at least one of the node-initialization spread spectrum signals, CSm, at the master unit. If the master unit does not receive a valid initialization signal, CSm, or identification code from a node unit during the time slot, it may cease to transmit any signal in the Fth time slot for a predetermined period of time, or it may transmit a "jammed signal alarm" code through the master-identification spread spectrum signal, CSn2. When a lack of response or a jammed signal alarm code from the master unit is encountered, the node units which tried to access the master unit instantaneously, of the plurality, N - K, of node units, may then initiate a node unit internal "wait" state, whose period may be derived from each node unit's identification code. After the wait state period, the plurality of node units which failed to access the master unit may attempt to access it again. Since wait states may be highly unique to each node unit, it is unlikely that the same plurality of node units will jam each other again.

If all N-1 time slots are being used for communication or initialization functions by N-1 node units, then the master-initialization spread spectrum signal, CSn1, is not transmitted. The master unit may operate such that the Fth time slot may a "busy" alarm to the plurality of N-K node units having not established communications with the master unit such that it informs them that no further access is available at that master unit, thereby allowing only N-1 node units to access the master unit.

In a third embodiment of the present invention, the master unit may function with the initialization, identification, and communication protocols as set forth in the first and second embodiments, but may be configured to transmit the master-initialization spread spectrum signal, CSn1, in a plurality of vacant (N-K) time slots, simultaneously. If the master unit does transmit in a plurality of vacant (N-K) time slots, node units (K+1), (K+2), (K+3),..., (K+(N-K)) (or N) may access the master unit in the (K+1)th, (K+2)th, (K+3)th,..., (K+(N-K))th (or Nth) time slots, respectively or randomly. Therefore, the (K+1)th node unit trying to access the master unit would access the first time slot immediately available after its initiation of the access attempt, instead of waiting for the (K+1)th or Fth time slot to occur in the next frame.

Thus, if K users are present, the master unit transmits in the 1st through Kth time slots the master unit communication spread spectrum signals, CMN1 through CMNk, pertaining to the 1st through Kth node units, and in the (K+1)th through Nth time slots a master initialization spread spectrum signal, CSn1, common to the plurality,X, of node units that may access the master unit, which may be distinct from all master or node unit communication and identification spread spectrum signals.

If a plurality of up to N-K node units tries to access the master unit sequentially in time, with the period between access attempts being greater than or equal to the slot period, upon reception of the master-initialization spread spectrum signal, CSn1, each node unit will access the open time slot available immediately following its initiation of the access attempt. When the first (K+1)th node unit has accessed the master unit (master unit slot and (K+1)th node unit identification signals are being transmitted in the (K+1)th time slot), the master unit may wait to transmit the (K+2)th through Nth master unit slot identification signals until the (K+1)th slot is occupied with master unit-to-(K+1)th node unit and/or (K+1)th node unit-to-master unit communication signals.

If a plurality of up to N-K node units tries to access the master unit instantaneously (the time period between node unit access attempts being less than the slot period), upon reception of the master-initialization spread spectrum signal, CSn1, each node unit of this plurality of node units will transmit a node-initialization spread spectrum signal, CSm, within the same time slot, thus jamming at least one of the node-initialization spread spectrum signals, CSm, at the master unit. If the master unit does not receive a valid node-initialization spread spectrum signal, CSm, or identification code from a node unit during the time slot, it may cease to transmit any signal in that time slot for a predetermined period of time, or it may transmit a "jammed signal alarm" code through the master unit slot identification signal, CSn2. When a lack of response or a jammed signal alarm code from the master unit is encountered, the node units which tried to access the master unit instantaneously, of the plurality, N - K, of node units, may initiate a node unit internal "wait" state, whose period may be derived from each node unit's identification code. After the wait state period, the plurality of node units which failed to access the master unit may attempt to access it again. Since wait states may be highly unique to each node unit, it is unlikely that the same plurality of node units will jam each other again.

If all N time slots are being used for communication or initialization functions by N node units, then the initialization spread spectrum signal, CSn1, is not transmitted by the master unit, and no new node units of the plurality of X - N node units may access the master unit. The master unit may operate such that the Nth time slot may transmit a "busy" alarm to the plurality of N-K node units having not established communications with the master unit such that it informs them that no further access is available at that master unit, thereby allowing only N-1 node units to access the master unit.

It will be apparent to those skilled in the art that various modifications can be made to the method for establishing spread spectrum communications between a master unit and a plurality of node units of the present invention, without departing from the scope or spirit of the invention, and it is intended that the present invention cover modifications and variations of the method for establishing spread spectrum communications as described herein, provided they come within the scope of the appended claims and their equivalents.

Claims

1. A method for establishing communications between a master unit and a plurality of N node units wherein K node units of said plurality of node units have established communications channels with said master unit using K spread spectrum codes, respectively, with a time slot for each the the K node units in the first K time slots, respectively, and a first node unit of the N-K node units of said plurality of said node units, desires to establish communications with said master unit, comprising the steps of:

transmitting, in a (K+1)th time slot from said master unit, a master-initialization spread spectrum signal modulated by a master-common-signalling chip code;

transmitting, in the (K+1)th time slot from said first node unit, responsive to receiving the master-initialization spread spectrum signal at said first node unit, a first node-initialization spread spectrum signal;

transmitting, in the (K+1)th time slot from said master unit, responsive to receiving the first node-initialization spread spectrum signal at said master unit, a master-identification spread spectrum signal with a master-unit-slot-identification code, modulated by the master-common-signalling chip code having a master-identification code;

transmitting, in the (K+1)th time slot from said first node unit, responsive to receiving the master-identification spread spectrum signal at said first node unit, a second node-initialization spread spectrum signal modulated by a first identification code and the master-common-signalling chip code of the master-initialization spread spectrum signal;

generating, at said first node unit using the master identification spread spectrum signal, a master unit chip code for transmitting spread spectrum signals to said master unit;

generating, at said master unit using the first identification code, a first node unit chip code for transmitting spread spectrum signals to said first node unit; and

communicating from said master unit using the node unit chip code, and from said first node unit using the master unit chip code, in the (K+1)th time slot.

2. A method for establishing communications between a master unit and a first node unit comprising the steps of:

transmitting, a master-initialization spread spectrum signal modulated by a master-common-signalling chip code;

transmitting, responsive to receiving the master-initialization spread spectrum signal at said first node unit, a first node-initialization spread spectrum signal;

transmitting, responsive to receiving the first node-initialization spread spectrum signal at said master unit, a master-identification spread spectrum signal having a master-unit-slot-identification code modulated by the master-common-signalling chip code having a master-identification code;

transmitting, responsive to receiving the master-identification spread spectrum signal at said first node unit, a second node-initialization spread spectrum signal modulated by a first identification code and the master-common-signalling chip code of the master-initialization spread spectrum signal;

generating, at said first node unit using the master identification spread spectrum signal, a master unit chip code for transmitting spread spectrum signals to said master unit;

generating, at said master unit using the first identification code, a first node unit chip code for transmitting spread spectrum signals to said first node unit; and communicating from said master unit using the node unit chip code, and from said first node unit using the master unit chip code.

3. The method as set forth in claim 2 further comprising the steps, using a second node unit, of:

transmitting, responsive to receiving the slot-initialization spread spectrum signal at said second node unit, a node-unit-initialization spread spectrum signal with a second identification code, using the common-signalling chip code;

transmitting, responsive to receiving the node-unit-initialization spread spectrum signal at said master unit, the second slot-initialization spread spectrum signal with the base-station identification code, using the common-signalling chip code;

generating, at said second node unit using the master-unit-slot-identification code, a second master unit chip code for transmitting spread spectrum signals to said master unit; and

generating, at said master unit using the second identification code, a node unit chip code for transmitting spread spectrum signals to said second node unit.

4. A system for establishing communications between a master unit and a plurality of N node units wherein K node units of said plurality of node units have established communications channels with said master unit using K spread spectrum codes, respectively, with a time slot for each the the K node units in the first K time slots, respectively, and a first node unit of the N-K node units of said plurality of said node units, desires to establish communications with said master unit, comprising:

means, located at said master unit, for transmitting, in a (K+1)th time slot from said master unit, a master-initialization spread spectrum signal modulated by a master-common-signalling chip code;

means, located at said first node unit and responsive to receiving the master-identification spread spectrum signal at said first node unit, for transmitting,in the (K+1)th time slot from said first node unit, a second node-initialization spread spectrum signal modulated by a first identification code and the master-common-signalling chip code of the master-initialization spread spectrum signal;

means, located at said master unit and responsive to receiving the first node-initialization spread spectrum signal at said master unit, for transmitting in the (K+1)th time slot from said master unit, a master-identification spread spectrum signal with a master-unit-slot-identification code, modulated by the master-common-signalling chip code having a master-identification code;

means located at said first node unit and responsive to receiving the master-identification spread spectrum signal at said first node unit, for transmitting, in the (K+1)th time slot from said first node unit, a second node-initialization spread spectrum signal modulated by a first identification code and the master-common-signalling chip code of the master-initialization spread spectrum signal;

means, located at said first node unit and using the master identification spread spectrum signal, for generating, a master unit chip code for transmitting spread spectrum signals to said master unit;

mean, located at said master unit and using the first identification code, for generating a first node unit chip code for transmitting spread spectrum signals to said first node unit;

means located at said master unit for communicating from said master unit using the node unit chip code, in the (K+1)th time slot; and

means located at said first node unit for communicating from said first node unit using the master unit chip code, in the (K+1)th time slot.

5. A system for establishing communications between a master unit and a first node unit, comprising:

means, located at said master unit, for transmitting, a master-initialization spread spectrum signal modulated by a master-common-signalling chip code;

means, located at said first node unit and responsive to receiving the master-identification spread spectrum signal, for transmitting, a second node-initialization spread spectrum signal modulated by a first identification code and the master-common-signalling chip code of the master-initialization spread spectrum signal;

means, located at said master unit and responsive to receiving the first node-initialization spread spectrum signal at said master unit, for transmitting a master-identification spread spectrum signal with a master-unit-slot-identification code, modulated by the master-common-signalling chip code having a master-identification code;

means located at said first node unit and responsive to receiving the master-identification spread spectrum signal at said first node unit, for transmitting, a second node-initialization spread spectrum signal modulated by a first identification code and the master-common-signalling chip code of the master-initialization spread spectrum signal;

means, located at said first node unit and using the master identification spread spectrum signal, for generating, a master unit chip code for transmitting spread spectrum signals to said master unit;

mean, located at said master unit and using the first identification code, for generating a first node unit chip code for transmitting spread spectrum signals to said first node unit;

means located at said master unit for communicating from said master unit using the node unit chip code, in the (K+1)th time slot; and means located at said first node unit for communicating from said first node unit using the master unit chip code, in the (K+1)th time slot.

6. The system as set forth in claim 5 further comprising:

means located at said second node unit and responsive to receiving the slot-initialization spread spectrum signal at said second node unit, for transmitting a node-unit-initialization spread spectrum signal with a second identification code, using the common-signalling chip code;

means located at said master unit and responsive to receiving the node-unit-initialization spread spectrum signal at said master unit, for transmitting the second slot-initialization spread spectrum signal with the base-station identification code, using the common-signalling chip code;

means located at said second node unit using the master-unit-slot-identification code, for generating a second master unit chip code for transmitting spread spectrum signals to said master unit; and

means located at said master unit using the second identification code, for generating a node unit chip code for transmitting spread spectrum signals to said second node unit.

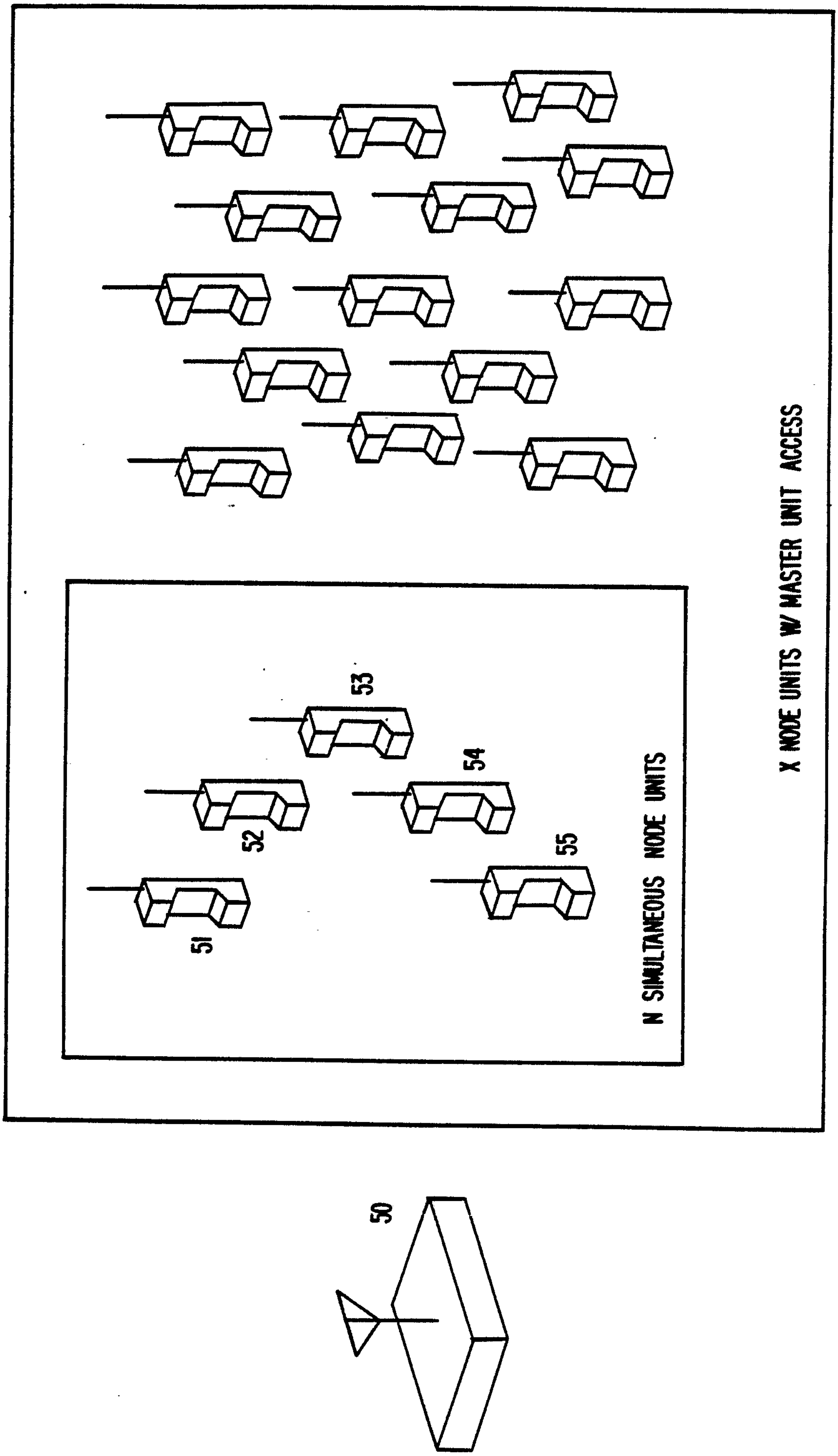

X NODE UNITS W/ MASTER UNIT ACCESS
N SIMULTANEOUS NODE UNITS
51
52
53
54
55
50

FIG. 1.

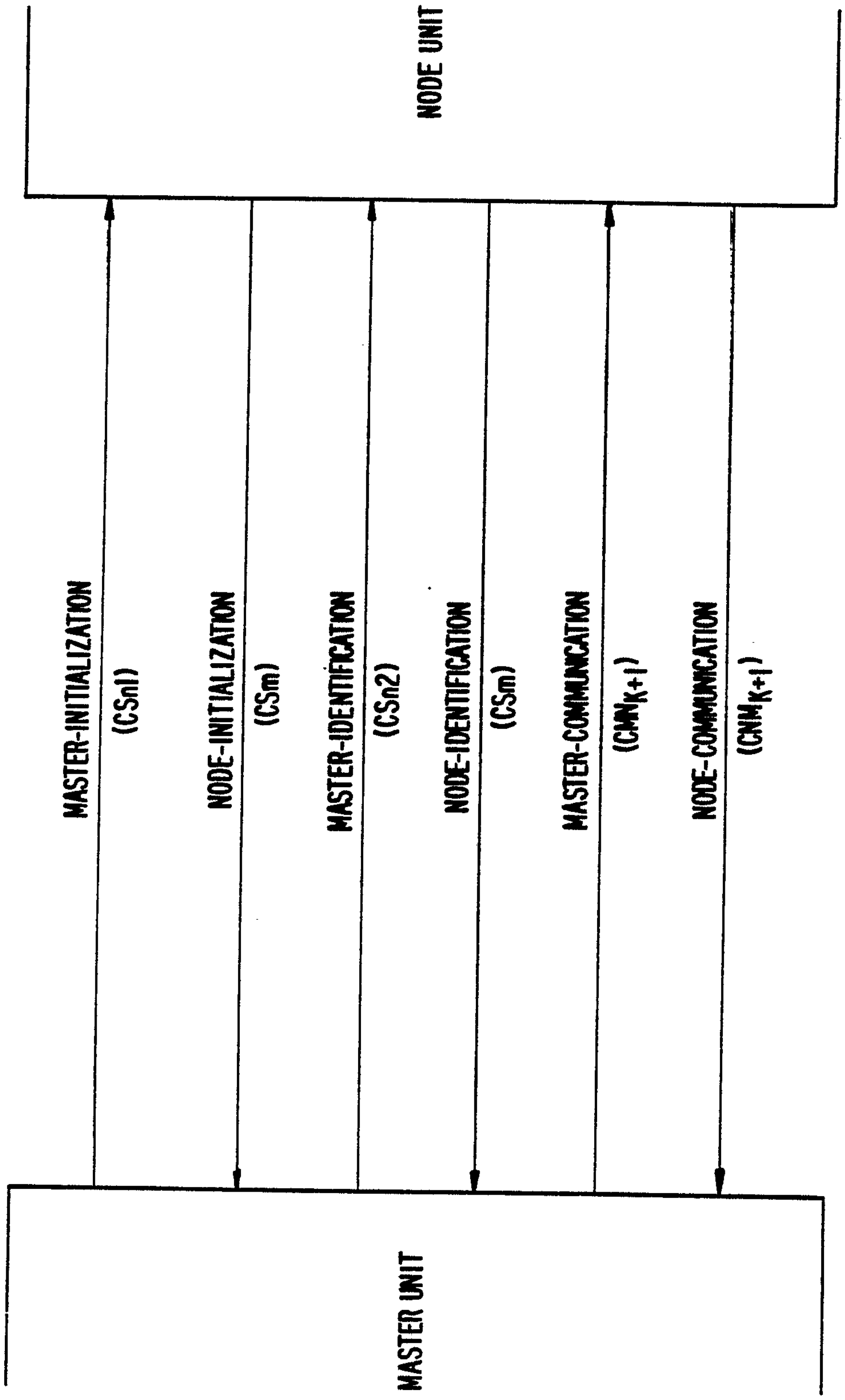

NODE UNIT
MASTER-INITIALIZATION
(CSnl)
NODE-INITIALIZATION
(CSm)
MASTER-IDENTIFICATION
(CSn2)
NODE-IDENTIFICATION
(CSm)
MASTER-COMMUNICATION
(CNM$_{K+1}$)
NODE-COMMUNICATION
(CNM$_{K+1}$)
MASTER UNIT

FIG. 2a.

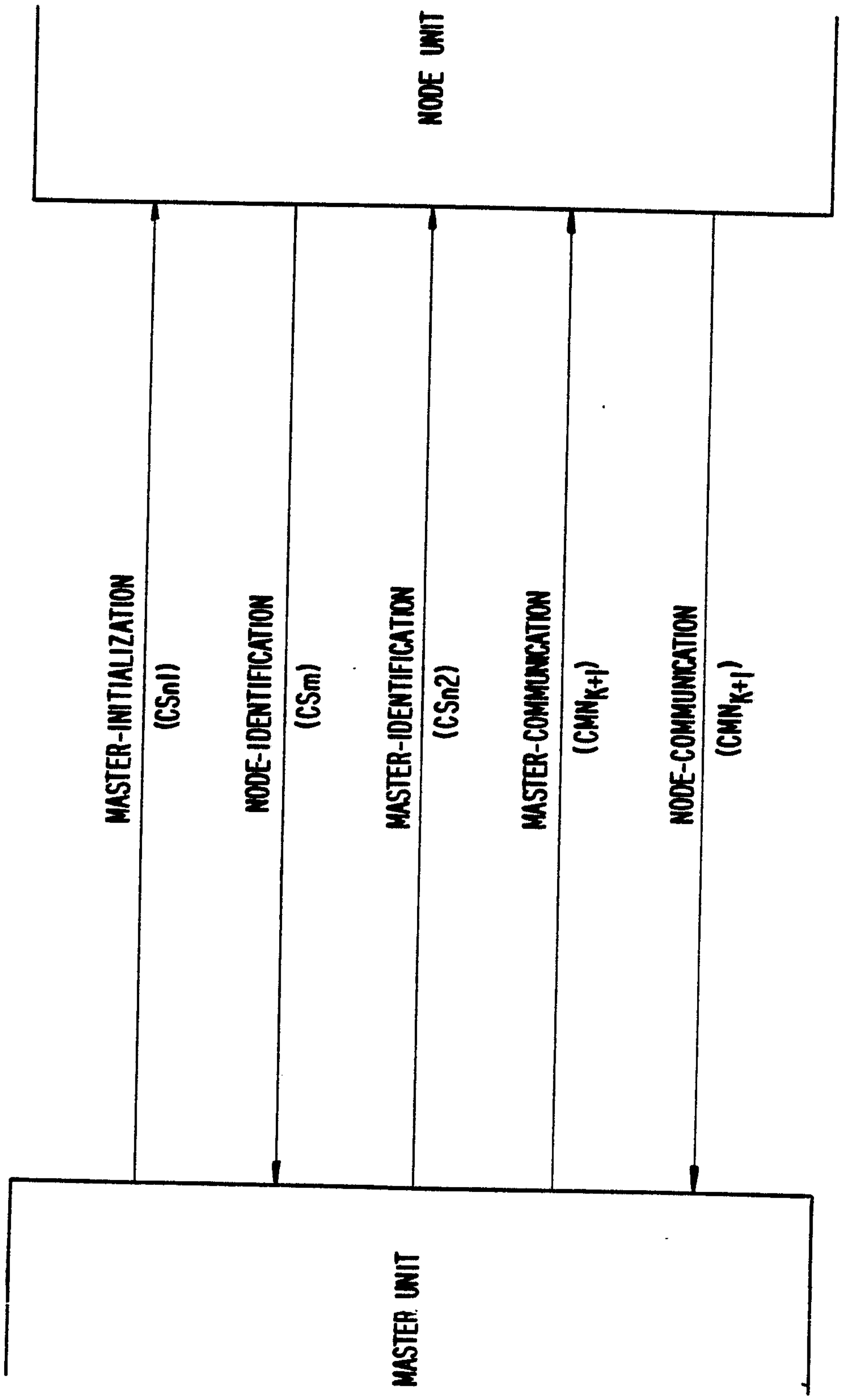
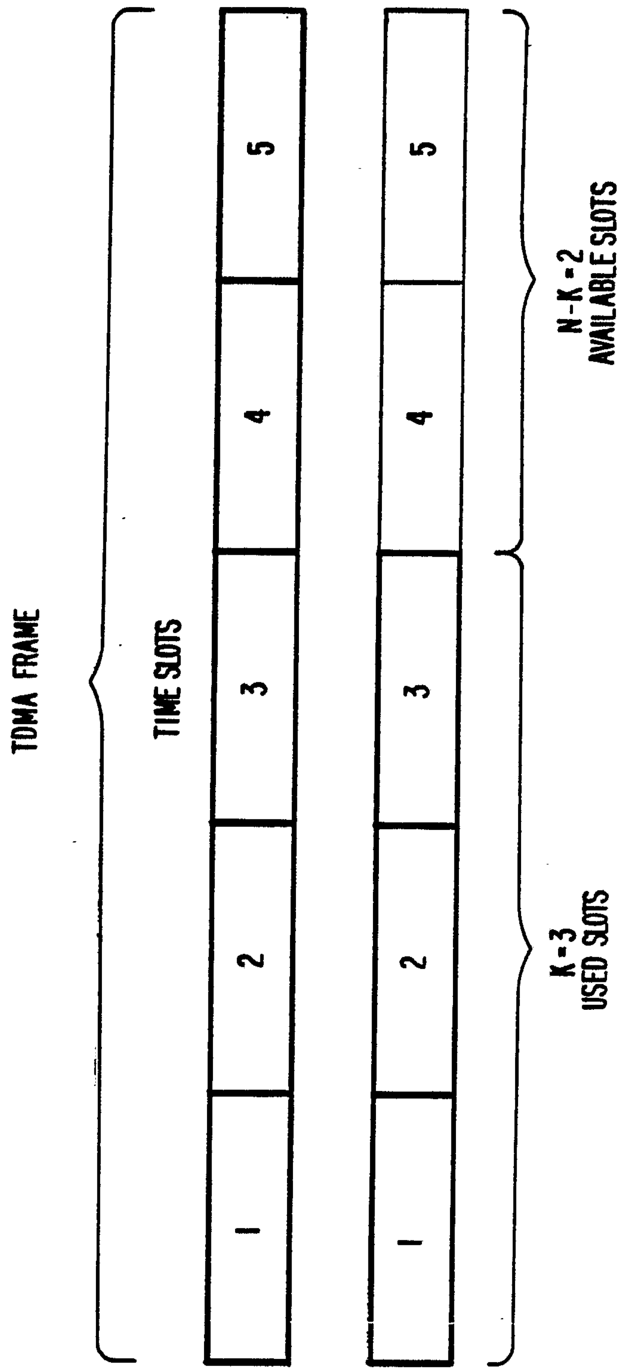

NODE UNIT
MASTER-INITIALIZATION (CSn1)
NODE-IDENTIFICATION (CSm)
MASTER-IDENTIFICATION (CSn2)
MASTER-COMMUNICATION (CMN_{K+1})
NODE-COMMUNICATION (CMN_{K+1})
MASTER UNIT

FIG. 2b.

FIG. 3


TDMA FRAME
TIME SLOTS
1
2
3
4
5
1
2
3
4
5
K=3
USED SLOTS
N-K=2
AVAILABLE SLOTS

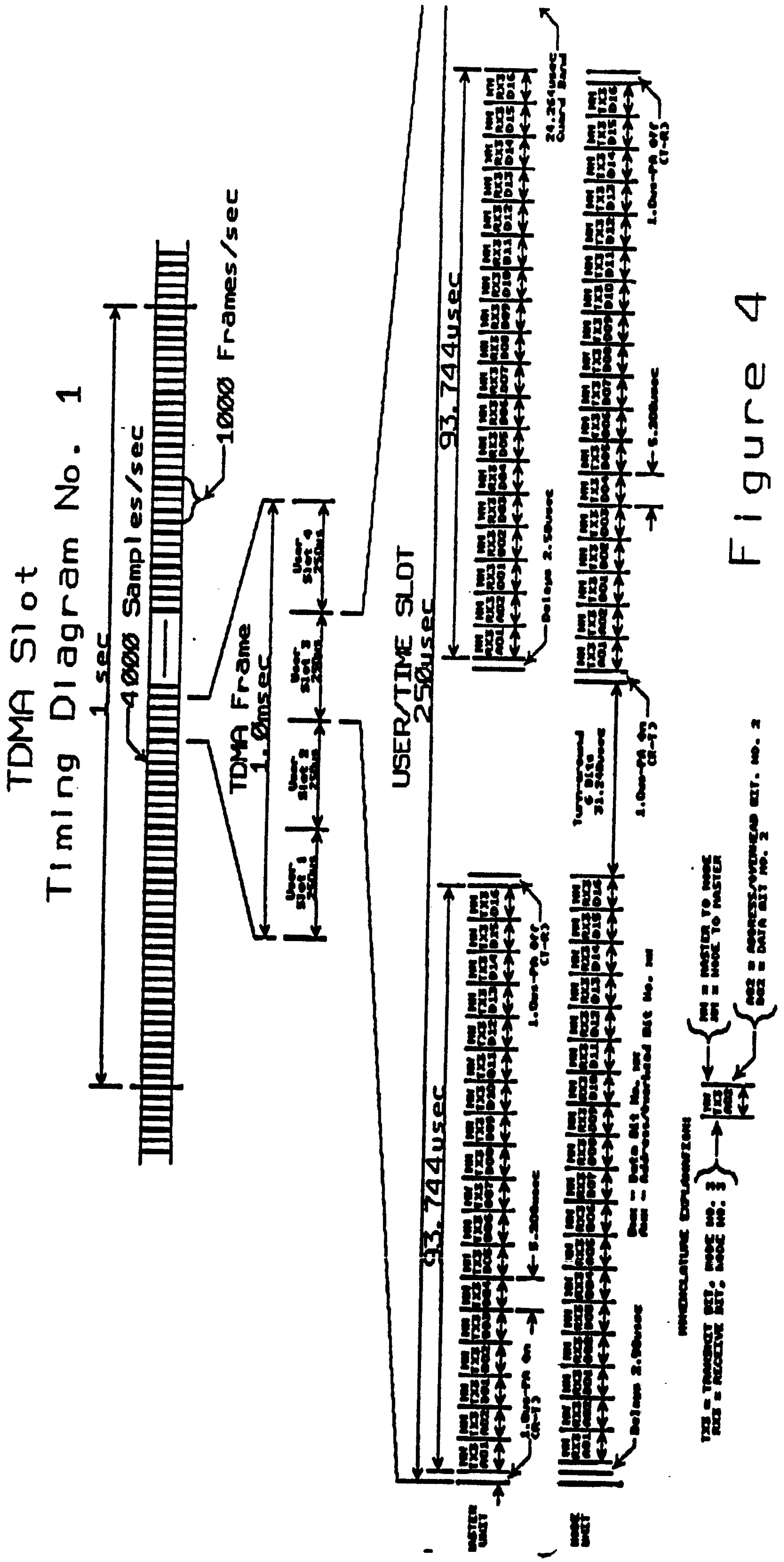

TDMA Slot
Timing Diagram No. 1
1 sec
4000 Samples/sec
1000 Frames/sec
TDMA Frame
1.0msec
USER/TIME SLOT
250usec
93.744usec
93.744usec

Figure 4

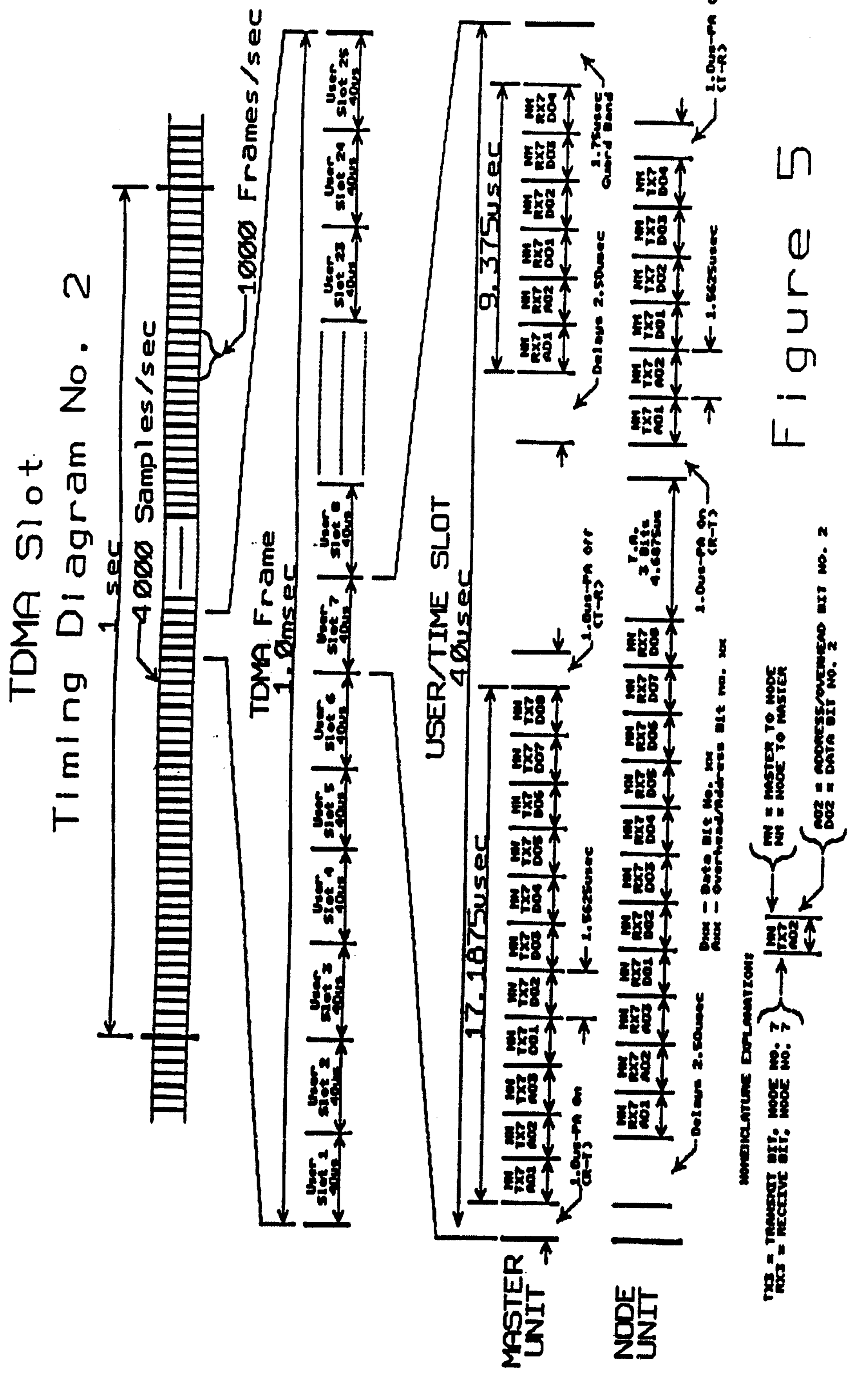

TDMA Slot
Timing Diagram No. 2
1 sec
4000 Samples/sec
1000 Frames/sec
TDMA Frame
1.0msec
User Slot 1 40us
User Slot 2 40us
User Slot 3 40us
User Slot 4 40us
User Slot 5 40us
User Slot 6 40us
User Slot 7 40us
User Slot 8 40us
User Slot 23 40us
User Slot 24 40us
User Slot 25 40us
USER/TIME SLOT
40usec
17.1875usec
9.375usec
MASTER UNIT
NODE UNIT
1.0us-PA On (R-T)
1.5625usec
Delays 2.50usec
1.0us-PA Off (T-R)
T.O. 3 Bits 4.6875us
1.75usec Guard Band
DXX - Data Bit No. XX
AXX - Overhead/Address Bit No. XX
NOMENCLATURE EXPLANATIONS:
TXX = TRANSMIT BIT, NODE NO. 7
RXX = RECEIVE BIT, NODE NO. 7
NN = MASTER TO NODE
NN = NODE TO MASTER
AO2 = ADDRESS/OVERHEAD BIT NO. 2
DO2 = DATA BIT NO. 2

Figure 5

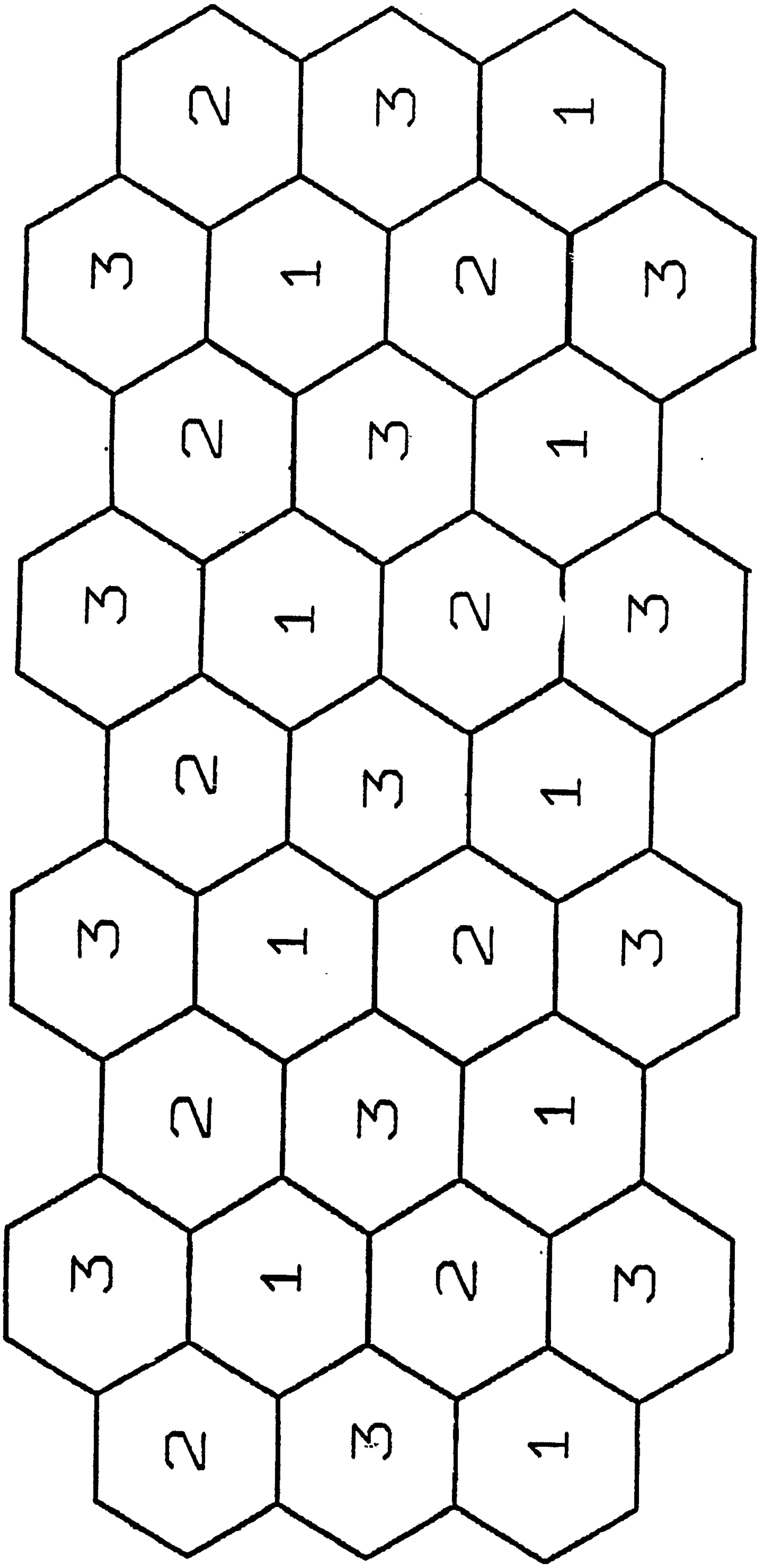


Figure 6

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US91/07382

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC(5): H04J 3/16; H04B 15/00
U.S. CL.: 370/95.3; 375/1

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
US CL.	375/1; 370/85.7, 85.8, 95.1, 95.2, 95.3, 18 455/33; 379/58, 59, 60, 61, 62, 63

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category *	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
A	US, A, 4,418,425 (FENNEL, JR. ET AL.) 29 November 1983, See Column 1, Lines 56-63.	2,5
A	US, A, 4,866,732 (CAREY ET AL.) 12 September 1989, See Column 2, Lines 52-68, Column 3, Lines 1-2.	2,5
A	US, A, 4,672,658 (KAVEHRAD ET AL.) 09 June 1987, See Fig. 1; Column 2, Lines 24-41.	1-6
A,P	US, A, 4,995,083 (BAKER ET AL.) 19 February 1991, See Fig. 3; Column 1, lines 24-40 and 48.	2,5

* Special categories of cited documents: [10]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"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)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"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

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"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.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
13 JANUARY 1992	29 JAN 1992
International Searching Authority	**Signature of Authorized Officer**
ISA/US	HASSAN KIZOU