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(54) Benævnelse: **Trådløst mikrofonsystem med fordelt modtagelse**

(56) Fremdragne publikationer:
US-A1- 2008 144 844
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None

DESCRIPTION

Field of the Invention

[0001] The field of the invention relates to public address and more particularly to wireless microphone systems.

Background of the Invention

[0002] Public address systems for public speaking events are well known. Typically, a person at a podium addresses a crowd through a microphone of a public address system. The voice of the person is detected by the microphone, amplified with an amplifier and the amplified sound is directed to the crowd through one or more speakers.

[0003] In more sophisticated systems, the microphone may be a wireless device. In this case, a wireless transmitter may be incorporated into the microphone. A corresponding wireless receiver may receive an audio signal from the transmitter and couple the audio signal to the speakers through the amplifier.

[0004] Wireless microphones have a distinct advantage over wired microphones because of the mobility provided. However, wireless microphones typically operate on unlicensed frequency bands that limit the available power and range of such devices.

[0005] Because of the flexibility, wireless microphones have become a necessary component in many public proceedings involving many different speakers. In such cases, each wireless microphone is provided with its own transmitter and receiver and each operating on its own frequency.

[0006] While wireless microphones work well, they have a number of features that make them difficult to use in many applications. For example, because of the limited output power, wireless microphones typically operate with a range of less than 100 feet. The limited range is reduced when a speaker places his own body between the wireless microphone transmitter and receiver. In addition, the limited number of frequencies requires that adjacent wireless microphones typically operate on the same or very close frequency ranges, often causing mutual interferences among wireless devices. Because of the importance of wireless microphones, a need exists for better ways of using more wireless microphones in close proximity. US2010166209 describes a plurality of transmit/receive units wherein each transmit/receive unit comprises a plurality of modules that are coordinated to transmit an audio packet into its corresponding slot and receive audio packets from other transmit/receive units within their corresponding slots. The reception and transmission of audio packets are controlled within each transmit/receive unit by a synchronization module.

Brief Description of the Drawings

[0007]

FIG. 1 is a plan view of a wires microphone system in accordance with an illustrated embodiment of the invention;

FIG. 2 is a plan view of a wireless microphone system in accordance with an alternate embodiment of the illustrated embodiment;

FIG. 3 is a timing diagram of synchronization pulse sequences that may be used by the system of FIG. 1;

FIGs. 4A-D is an alternate timing diagram of synchronization pulse sequences that may be used by the system of FIG. 1; and

FIG. 5 is a synchronization state diagram of a microphone transmitter unit that may be used with the system of FIG. 1.

Detailed Description of an Illustrated Embodiment

[0008] FIG. 1 depicts a distributed reception wireless microphone system 10 shown generally in accordance with an illustrated embodiment of the invention. The wireless microphone system 10 is used to detect audio information within an area 12 through one or more wireless microphone transmitter units (MTUs) 14, 16, to amplify the audio information within a public address (PA) system 18 and to deliver the amplified audio information back into the area 12 through a local set of loudspeakers.

[0009] Alternatively, the amplified audio information may be distributed to a number of remote listeners 21. For example, the system 10 may be used to monitor a public proceeding and to deliver the amplified audio over a public communication channel (e.g., radio, television, cable, etc.) 19. Accordingly, the system 10 may be more properly described in some embodiments as intended for entertainment, communication or announcement audio.

[0010] Included within the area 12 is a number of digital receiver modules (DRMs) 20, 22. The digital receiver modules 20, 22 may be coupled to the PA system 18 through a coordinator module 24 and one or more audio control interfaces (ACIs) 26, 28.

[0011] The microphone transmitter units 14, 16 and digital receiver modules 20, 22 of the system 10 exchange information over the wireless interface under a time division multiple access (TDMA) format. A repeating data frame under the TDMA format may be defined by a synchronization pulse followed by a number of slots (e.g., 14) in which the microphone transmitter units 14, 16 may transmit audio information.

[0012] In order to maintain synchronization within the system 10, the digital receiver modules 20, 22 each transmits synchronization pulses 23 at some appropriate time interval (e.g., once every one millisecond) for the benefit of the microphone transmitter units 14, 16. In response, each of the microphone transmitter units 14, 16 transmits audio information pulses 17 within a respective assigned slot.

[0013] The transceivers of the microphone transmitter units 14, 16 and digital receiver modules 20, 22 may operate under an ultrawideband (UWB) format. The synchronization pulses 23 and audio information pulses 17 may have a similar structure including an appropriate center frequency (e.g., 6.350 GHz), frequency range (e.g., 6.100 GHz to 6.600 GHz) and pulse duration (e.g., 3 nanoseconds).

[0014] The microphone transmitter units 14, 16 may each include a transmitter, a receiver, a microphone and a central processing unit (CPU) with non-volatile memory. The CPU may include one or more processors including a synchronization processor that monitors for and detects synchronization pulses from the digital receiver modules 20, 22.

[0015] A synchronization clocking processor within the microphone transmitter units 14, 16 may be synchronized with synchronization pulses received at regular intervals. A separate counter may be used to count the number of missed synchronization pulses using a windowing function and to deactivate the transmitter after a predetermined number (sequence) of missing synchronization pulses.

[0016] Included within each microphone transmitter unit 14, 16 may be a transmission processor that synchronizes the transmission of audio information pulses with the received synchronization pulses. In this case, a predetermined slot identifier saved within the memory of the microphone transmitter units 14, 16 identifies a slot location for transmission of the audio information pulses.

[0017] An audio information processor within each of the microphone transmitter units 14, 16 receives audio information from a microphone, retrieve an identifier of the microphone transmitter unit 14, 16 from memory and incorporate the audio information and identifier into an audio information packet. A transmission processor receives the audio packet and transmits the packet as an audio information pulse aligned within the identified slot.

[0018] The synchronization pulses transmitted by each of the digital receiver modules 20, 22 are controlled by a processor within the coordinator module 24. A pulse control processor within the coordinator module 24 may send an instruction to a digital receiver module 20, 22 each time a pulse is to be transmitted or the pulses may be automatically generated by a pulse processor within each digital receiver module 20, 22 under control of the coordinator module 24. In either case, the pulse control processor of the coordination module 24 may retrieve predetermined pulse sequences from a set of pulse sequence files located within a non-volatile memory of the coordination module 24. The pulse sequence file and pulse sequence may be selected based upon the number of digital receiver modules 20 operating within the system 10.

[0019] The synchronization pulses transmitted by each of the digital receiver modules 20, 22 may be combined and incorporated into a multiframe sequence of synchronization pulses (i.e., a superframe) under control of the coordinator module 24 as shown in FIG. 3A. As shown in FIG. 3, no two digital receiver modules 20, 22 transmit synchronization pulses simultaneously.

[0020] Under one embodiment, as shown in FIG. 3A, the system 10 may operate under an 8 frame long superframe. As shown, a first digital receiver module 20 may transmit 4 synchronization pulses one ms apart for 4 ms followed by the second digital receiver module 22 transmitting another 4 synchronization pulses one ms apart for 4 ms, after which, the process repeats. Each synchronization pulse defines a portion (i.e., a frame) of the 8 frame superframe.

[0021] Following a synchronization pulse, the microphone transmitting units 14, 16 transmit audio information within the predefined slot of the frame that is defined by the synchronization pulse. For example, if the first microphone transmitting unit 14 were assigned to the first slot, then the first microphone transmitting unit 14 would always transmit in the first slot after each synchronization pulse. Similarly, if the second microphone transmitting unit 16 were assigned to the eighth slot, then the second microphone transmitting unit 16 would always transmit in the eighth slot.

[0022] It should be noted that after each synchronization pulse, a frame processor within each digital receiving module 20, 22 monitors for audio data within each of the respective slots. The information from each of the digital receiving modules 20, 22 is forwarded to the coordinating module 24 under a TDM format where the information is further processed. Processing in this case may mean that a content processor may retrieve the slot content received from each digital receiving module and compare the slot content with the corresponding slot content received from the other digital receiving module. The digital receiving module providing the greatest magnitude slot content is selected as the preferred audio signal source for that microphone transceiver unit 14, 16 for that frame. Alternatively, a magnitude of the respective slot contents from each digital receiving module 20, 22 may be combined (summed) to generate an audio output for each microphone transmitter unit 14, 16.

[0023] In this example, the content processor of the coordination module 24 would forward a single stream of audio data from the microphone transmitter units 14, 16 to the audio control interface 26, 28. A demultiplexing processor within the audio control interface 26, 28, in turn, recognizes and retrieves the contribution (i.e., the audio signal) from each microphone transmitter unit 14, 16. The audio control interface 26, 28, in turn, routes the audio signal from each microphone transmitting unit 14, 16 to a respective input of the PA system 18.

[0024] Data detected within the respective slots is packetized within the respective digital receiving modules 20, 22 and forwarded to the coordination module 24. Within the coordination module, an audio processor may compare audio information from each digital receiver module and it selects the packet having the greatest amplitude.

[0025] Alternatively, the coordination module 24 may sum the audio data received from the microphone transmitter units 14, 16 through the respective digital receiver modules 20, 22 and sum the values before forwarding to the PA system 18.

[0026] FIG. 2 depicts the system 10 in an alternate embodiment. As shown in FIG. 2, the system 10 operates in two areas 50, 52. A first set of microphone transmitter units 54, 56, 58, 60, 62 are assigned to the first area 50 and a second set of microphone transmitter units 64, 66, 68, 70, 72 are assigned to the second area 52. Moreover, each of the microphone transmitting units 54, 56, 58, 60, 62, 64, 66, 68, 70, 72 is provided with a unique address that identifies the microphone transmitting unit according to its area 50, 52 of registration. Alternatively, each of the set of microphone transmitter units 54 may include a group identifier incorporated into the unique identifier of each microphone transmitter unit.

[0027] As shown in FIG. 2, the first area 50 includes a first and second digital receiving unit 74, 76. Similarly, the second area 52 includes a first and second digital receiving unit 78, 80.

[0028] In the embodiment of FIG. 2, the coordinating module 24 may also define a synchronization pulse sequence for each of the digital receiving modules 74, 76, 78, 80. One possible transmission sequence among the 4 digital receiving modules 74, 76, 78, 80 is shown in FIG. 3C. As shown in FIG. 3C, a first digital receiving module 74 may transmit a first pulse sequence of four synchronization pulses, a second digital receiving module 76 may transmit a second sequence of four synchronization pulses immediately after the first and the third and fourth digital receiving modules 78, 80 may subsequently transmit third and fourth sequences including a respective set of first four synchronization pulses after that.

[0029] After each synchronization pulse of FIG. 3C, each of the digital receiving modules 74, 76, 78, 80 may monitor for transmissions from each of the microphone transmitting units 54, 56, 58, 60, 62, 64, 66, 68, 70, 72. Any received audio packets from a microphone transmitting unit is packetized by the respective digital receiving module 74, 76, 78, 80 along with its unique identifier and forwarded to the coordinating module 24.

[0030] Within the coordinating module, the packets are compared (or combined) to achieve the greatest possible audio signal from each microphone transmitting unit. The coordinating module 24 may also forward the packets based upon the unique identifier assigned to each microphone transmitting unit 54, 56, 58, 60, 62, 64, 66, 68, 70, 72.

[0031] In this case, audio packets from microphone transmitting units assigned to the first area 50 are forwarded to a first PA system 84 and audio packets from microphone transmitting units assigned to the second area 52 are forwarded to a second PA system 86. In each case, the coordinating module 24 forwards the audio packets to the audio control interfaces 26, 28 where a source address of each packet is retrieved and compared with the list of microphone transmitting units assigned to each area 50, 52.

[0032] The system 10 offers significant advantages over convention audio systems. For example, the transmission of synchronization pulses from a number of different sources reduces or eliminates the possibility that a microphone transmitting unit could be in a location where the unit could not receive a synchronization pulse from any digital receiving module. For similar reasons, the receipt of audio signals by each of the digital receiving modules 74, 76, 78, 80 significantly increases the likelihood that at least one of the digital receiving modules will receive a strong audio signal.

[0033] The use of a unique identifier with each audio signal allows any digital receiving module to receive an audio signal from any microphone transmitting unit and route the audio signal to the proper PA system 84, 86. This allows an audio signal generated in an area 50, 52 to be amplified and the amplified audio signal delivered only to the area from which the audio signal originated.

[0034] It should be understood that the use of the word "only" is intended to mean delivery of the amplified audio signal to an intended area. For example, delivery of audio from a microphone transmitting unit 58 to listeners in area 52 would be a distraction to those listeners. However, delivery of an amplified audio signal from the microphone 58 to a radio listener that wishes to hear a public proceeding in area 50 would be an intended destination even though it would involve delivery of the audio signal to an area different from where the audio signal originated.

[0035] The failure of a microphone transmitting unit to detect one or more synchronization pulses does not significantly degrade the slot alignment of transmissions by the microphone transmitting units. In this case, an internal time base of each microphone transmitter unit 14, 16 maintains synchronization to a relatively good degree. However, after some extended period of missed pulses (e.g., 21 missed synchronization pulses in a row), the audio information transmitter portion of the microphone transmitting unit may be automatically deactivated. In this case, a receiver within the microphone transmitting unit may continue to search for and detect synchronization signals. In the event that the receiver detects a set of 4 synchronization pulses in a row, the microphone transmitting unit may again begin transmitting audio information.

[0036] In another illustrated embodiment, shown in FIG. 4, the number of synchronization pulses in a sequence from each digital receiver module are increased to improve the chances that a microphone transmitter unit will receive the minimum number of synchronization pulses that are required (e.g., 4 synchronization pulses in 4 ms) to ensure that the microphone transmitter unit is locked into or otherwise achieved synchronism.

[0037] FIG. 4B is an example of the use of two digital receiver modules. In this example, each digital receiver module transmits a sequence of 10 synchronization pulses and is then silent for the next 10 synchronization pulses.

[0038] FIG. 4C is an example of three digital receiver modules. In this case, the first digital receiver module transmits a sequence of 7 synchronization pulses. After the first digital receiver module transmits 7 synchronization pulses, the second digital receiver modules transmits a sequence of 7 synchronization pulses followed by the third digital receiver module transmitting a series of 7 synchronization pulses. After 21 synchronization pulses, the process repeats, again starting with the first digital receiver module.

[0039] FIG. 4D is an example of four digital receiver modules. In this case, the first digital receiver module transmits a sequence of 5 synchronization pulses. After the first digital receiver module transmits 5 synchronization pulses, the second digital receiver modules transmits a sequence of 5 synchronization pulses followed by the third and fourth digital receiver module transmitting a series of 5 synchronization pulses. After 20 synchronization pulses in this example, the process repeats, again starting with the first digital receiver module.

[0040] FIG. 5 is a sequence diagram of a microphone receiver module. As shown in FIG. 5, the microphone receiver module first assumes an initial acquisition, open aperture state where the microphone transmitter monitors for synchronization pulses. When the microphone transmitter unit detects a sequence of four synchronization pulses 1 ms apart, the microphone transmitter module enters an initial acquisition, closed aperture state. Finally, when the microphone transmitter unit detects a series of four synchronization pulses 1 ms apart three times in a row (i.e., over three multiframes), the microphone transmitter unit enters a locked, closed aperture state.

[0041] A specific embodiment of a wireless microphone system has been described for the purpose of illustrating the manner in which the invention is made and used.

REFERENCES CITED IN THE DESCRIPTION

Cited references

Patent documents cited in the description

- US2010166209A **[0006]**

Patentkrav

1. Trådløst mikrofonsystem (10) omfattende:
en flerhed af bærbare trådløse mikrofonsenderenheder (14, 16);
en flerhed af digitale modtagermoduler (20, 22), der er indrettet til vekslende transmission af
trådløse synkroniseringsimpulser og til at modtage audioinformationer fra flerheden af bærbare trådløse mikrofonsenderenheder (14, 16), der er synkroniseret med
synkroniseringsimpulserne; og
et koordinatormodul (24) i forbindelse med hvert af de digitale modtagermoduler (20, 22) og indrettet til at koordinere transmission af synkroniseringsimpulser blandt flerheden af digitale modtagermoduler (20, 22) i overensstemmelse med en på forhånd angivet transmissionssekvens; hvor
det trådløse mikrofonsystem (10) er indrettet til at modtage audioinformationen fra
i det mindste nogle af de bærbare trådløse mikrofonsenderenheder (14, 16) gennem de digitale modtagermoduler (20, 22)
og til at levere de forstærkede audioinformationer udelukkende til en på forhånd angivet destination, hvor hver fra flerheden af bærbare trådløse mikrofonsenderenheder (14, 16)
er indrettet til at arbejde under et fælles time division multiple access-format, TDMA-format,
inden for en gentagende ramme defineret af de vekslende trådløse synkroniseringsimpulser fra hver fra flerheden af digitale modtagermoduler (20,22), hvor hver fra flerheden af bærbare trådløse mikrofonsenderenheder (14,16) er tildelt til et respektivt slot af den gentagende ramme, hvor
en audioinformationsprocessor inden i hver af de bærbare trådløse mikrofonsenderenheder (14, 16) er indrettet til at modtage audioinformationerne fra en mikrofon, til at hente
identifikator af den bærbare trådløse mikrofonsenderenhed (14, 16) fra hukommelse og at inkorporere audioinformationerne og identifikatoren i en audioinformationspakke, og hvor
koordinatormodulet (24) endvidere er indrettet til at modtage audiopakker inden for det respektive

tildelte slot fra hver fra flerheden af bærbare trådløse mikrofonsenderenheder (14,16) gennem hvert fra flerheden af digitale modtagermoduler (20,22) og at udvælge det digitale modtagermodul (20,22), der tilvejebringer det slotindhold, der har den største størrelse, som den foretrukne audiosignalkilde for den bærbare trådløse mikrofonsenderenhed (14, 16) for den ramme.

2. Trådløst mikrofonsystem (10) ifølge krav 1, hvor flerheden af bærbare trådløse mikrofonsenderenheder (14, 16) og digitale modtagermoduler (20, 22) endvidere er indrettet til at arbejde under et ultrabredbåndsformat.

3. Trådløst mikrofonsystem (10) ifølge krav 1, hvor flerheden af digitale modtagermoduler (20, 22) endvidere er indrettet til vekslende at transmittere en sekvens af synkroniseringsimpulser (23).

4. Trådløst mikrofonsystem (10) ifølge krav 1, hvor synkroniseringsimpulserne (23) ligger ca. 1 millisekund fra hinanden.

5. Trådløst mikrofonsystem (10) ifølge krav 1, hvor synkroniseringsimpulserne (23) definerer time division multiple access-rammen, TDMA-rammen.

6. Trådløst mikrofonsystem (10) ifølge krav 1, hvor i det mindste en første gruppe fra flerheden af bærbare mikrofonsenderenheder (14, 16) er tildelt til et første geografisk område fra en flerhed af geografiske områder, og en anden gruppe fra flerheden af bærbare trådløse mikrofonsenderenheder (14, 16) er tildelt til et anden geografisk område fra flerheden af geografiske områder.

7. System (10) ifølge krav 1, yderligere omfattende:
flerheden af bærbare trådløse mikrofonsenderenheder (14, 16), hver med en gruppeidentifikator;
hvor flerheden af digitale modtagermoduler (20, 22) er indrettet til at veksle transmissionen af trådløse synkroniseringsimpulser (23) og til at modtage audioinformationer fra flerheden af bærbare trådløse mikrofonsenderenheder (14, 16) synkroniseret med synkroniseringsimpulserne (23);
koordinatormodulet (24) i forbindelse med hvert af de digitale modtagermoduler (20, 22)

og indrettet til at koordinere transmission af synkroniseringsimpulser (23) blandt flerheden af digitale modtagermoduler (20, 22) i overensstemmelse med en på forhånd angivet transmissionssekvens; og

et offentligt adressesystem indrettet til at modtage audioinformationerne fra mindst nogle

af de bærbare trådløse mikrofonsenderenheder (14, 16) gennem de digitale modtagermoduler (20, 22)

for at forstærke audioinformationerne og levere de forstærkede audioinformationer udelukkende til en destination identificeret af kildens gruppeidentifikator.

DRAWINGS

Fig. 1

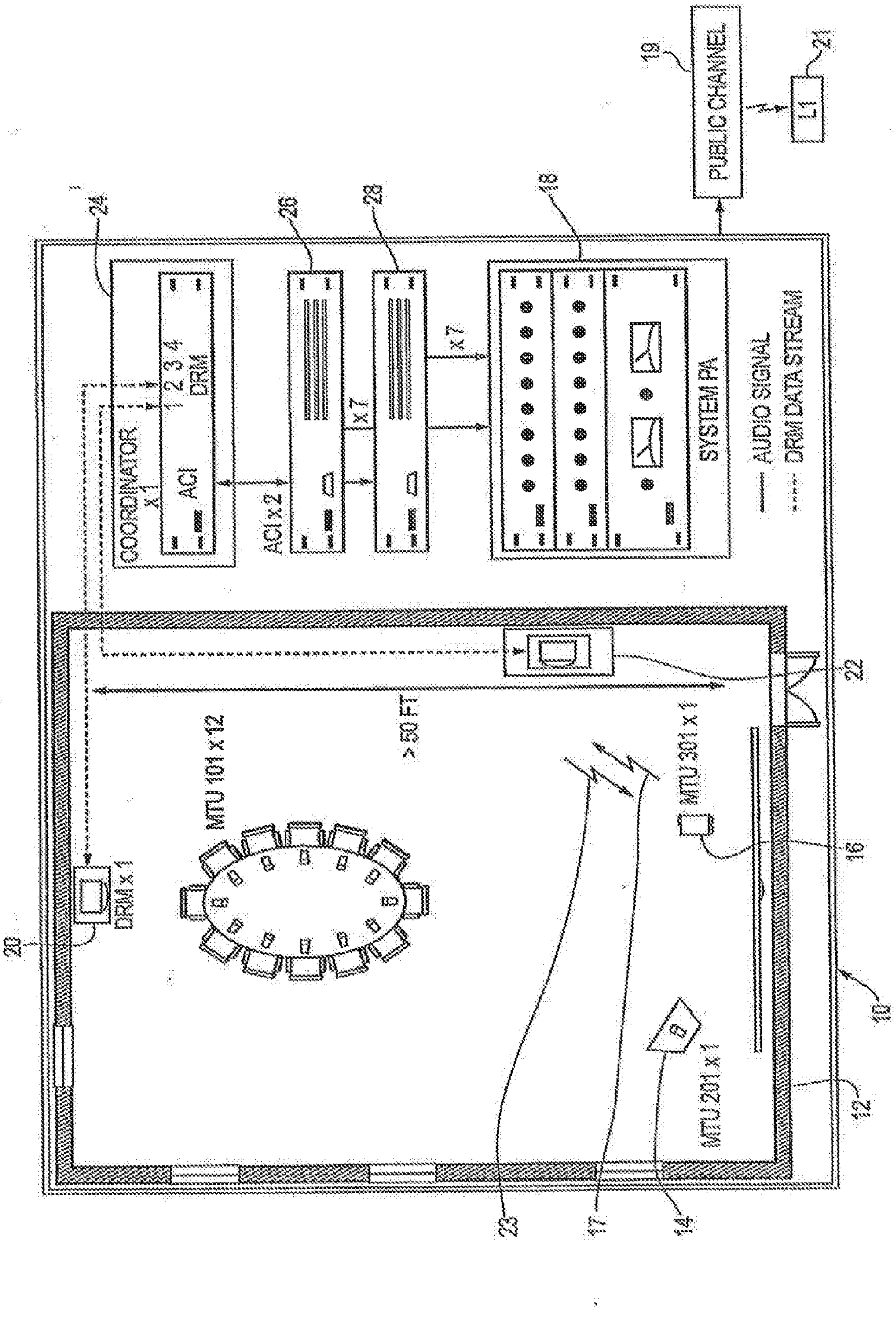


Fig. 2

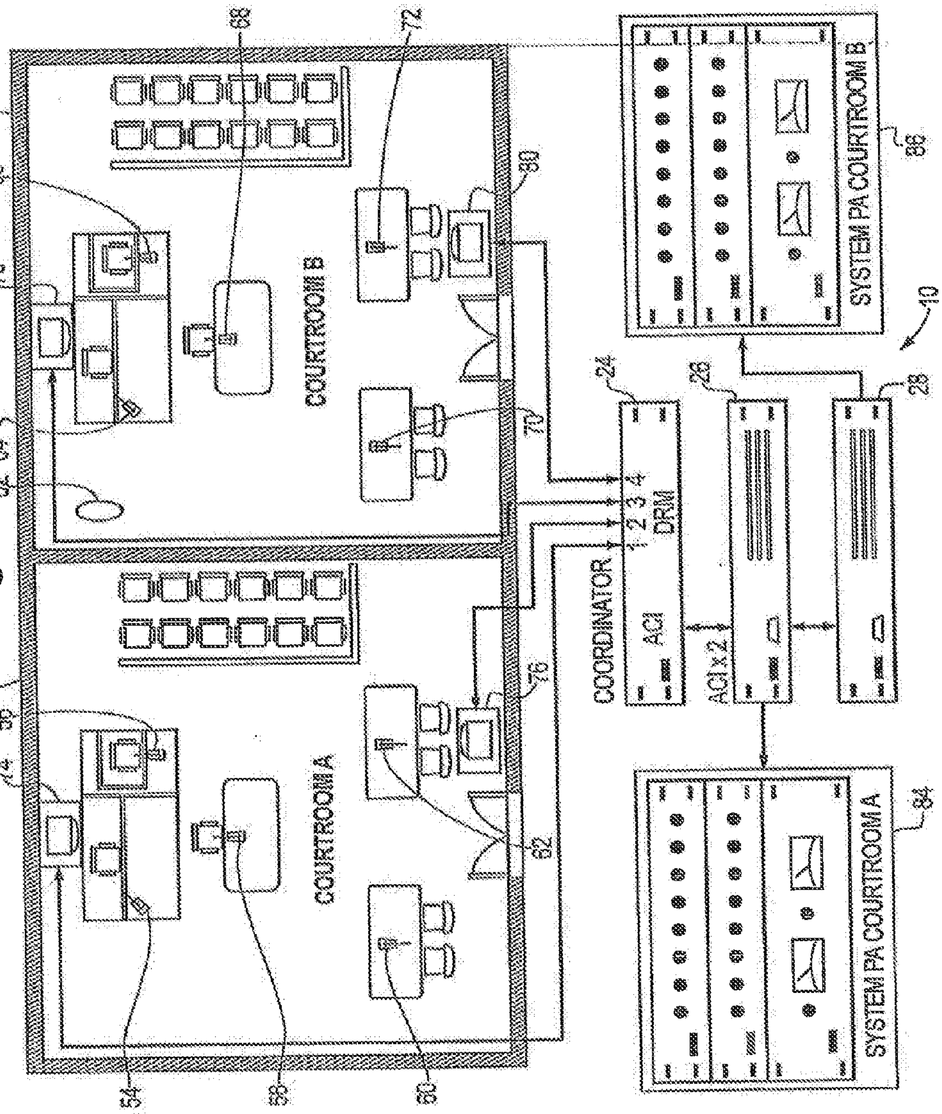

COURTROOM A
COURTROOM B
COORDINATOR
ACI
DRM
1 2 3 4
ACI x 2
SYSTEM PA COURTROOM A
SYSTEM PA COURTROOM B
10
24
26
28
50
52
54
56
58
60
62
64
66
68
70
72
74
76
78
80
82
84
86

Fig. 3A

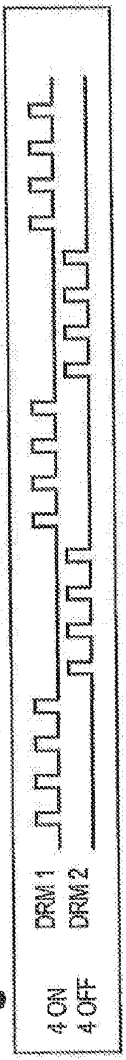


Fig. 3B

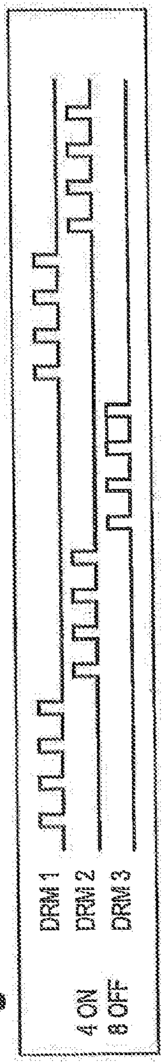
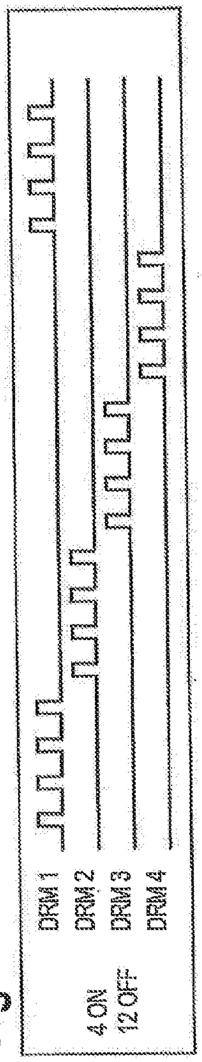


Fig. 3C



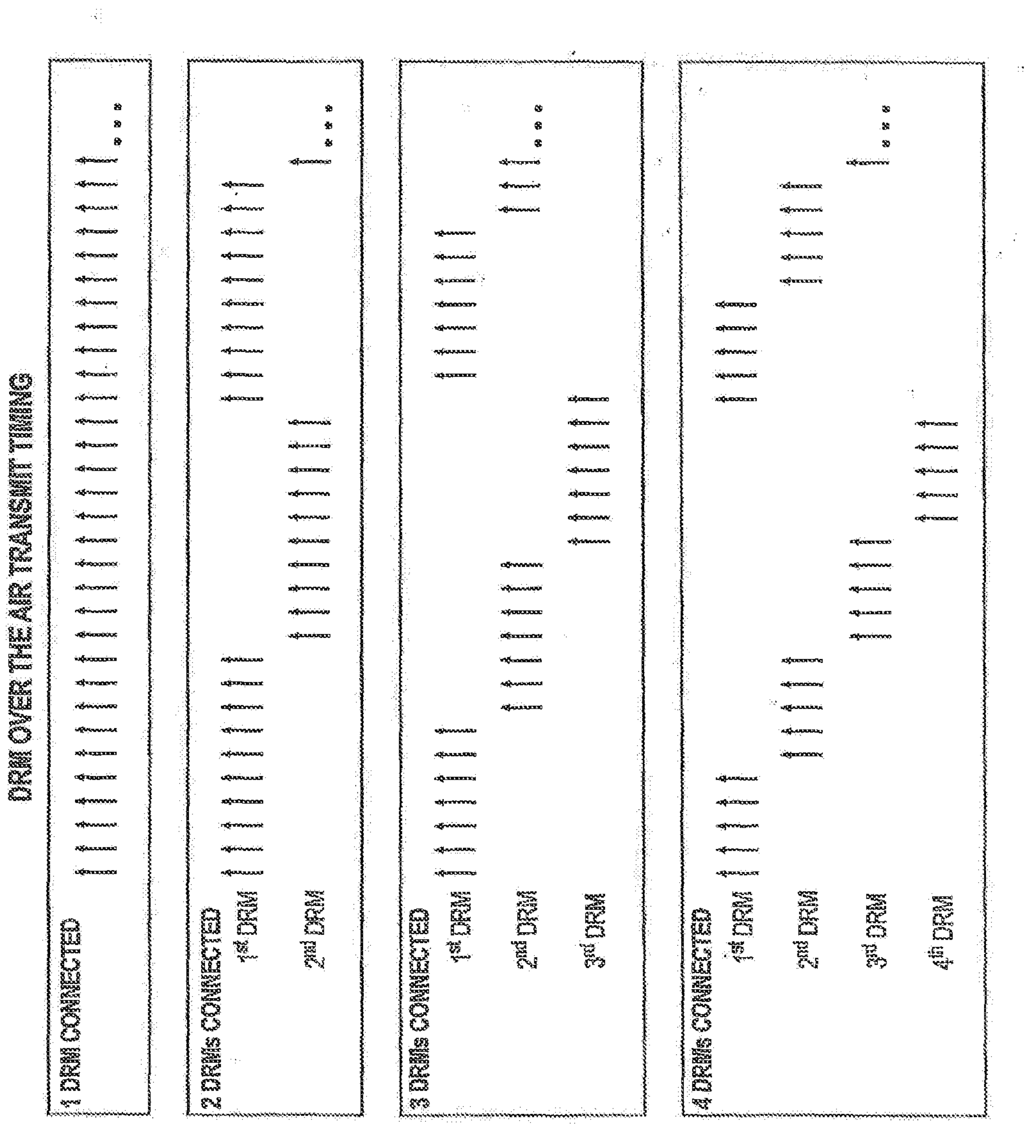
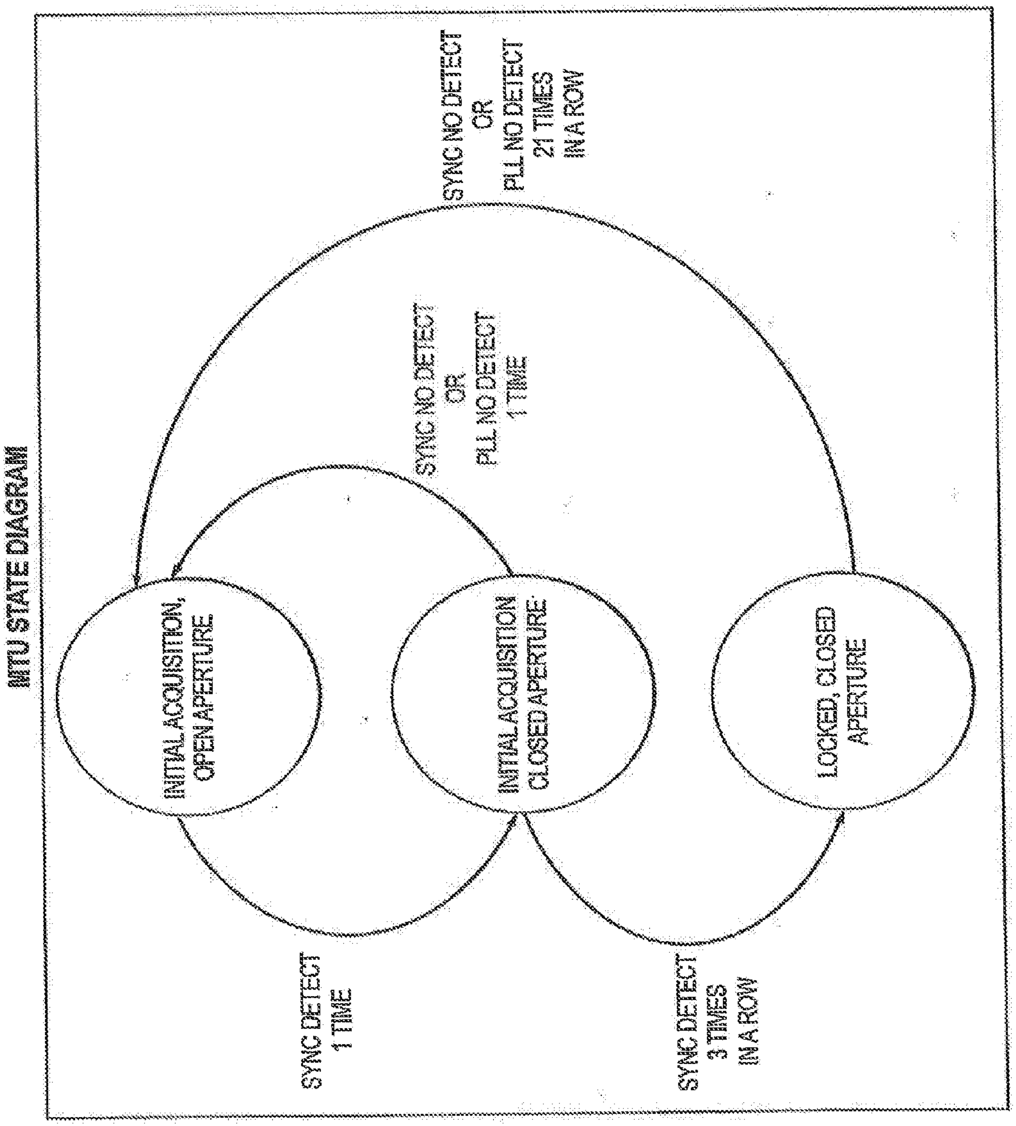


Fig. 4A
Fig. 4B
Fig. 4C
Fig. 4D

Fig. 5


MTU STATE DIAGRAM
INITIAL ACQUISITION, OPEN APERTURE
INITIAL ACQUISITION CLOSED APERTURE
LOCKED, CLOSED APERTURE
SYNC DETECT 1 TIME
SYNC DETECT 3 TIMES IN A ROW
SYNC NO DETECT OR PLL NO DETECT 1 TIME
SYNC NO DETECT OR PLL NO DETECT 21 TIMES IN A ROW