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(54) **DISTRIBUTED DIGITAL ANTENNA SYSTEM**

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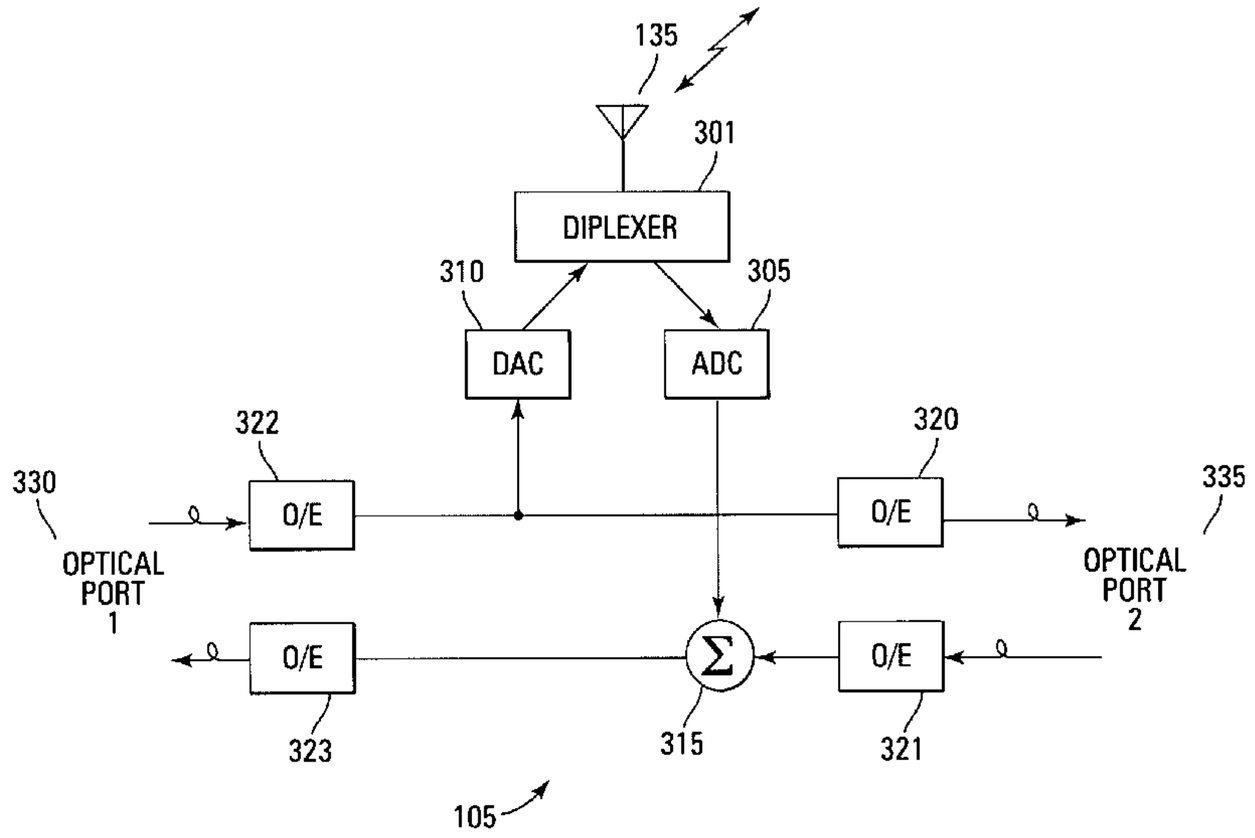
(57) **ABSTRACT**

An optical medium, such as fiber, is tapped to provide an antenna port wherever radio service coverage is desired. Each antenna port is a bi-directional remote unit that receives a digital optical signal from a host unit and transforms the signal to a radio frequency signal for transmission by the remote unit. The remote unit receives radio frequency signals that are converted to digital signals and summed with signals from other remote units and converted to an optical signal for transmission to the host unit.

25 Claims, 4 Drawing Sheets



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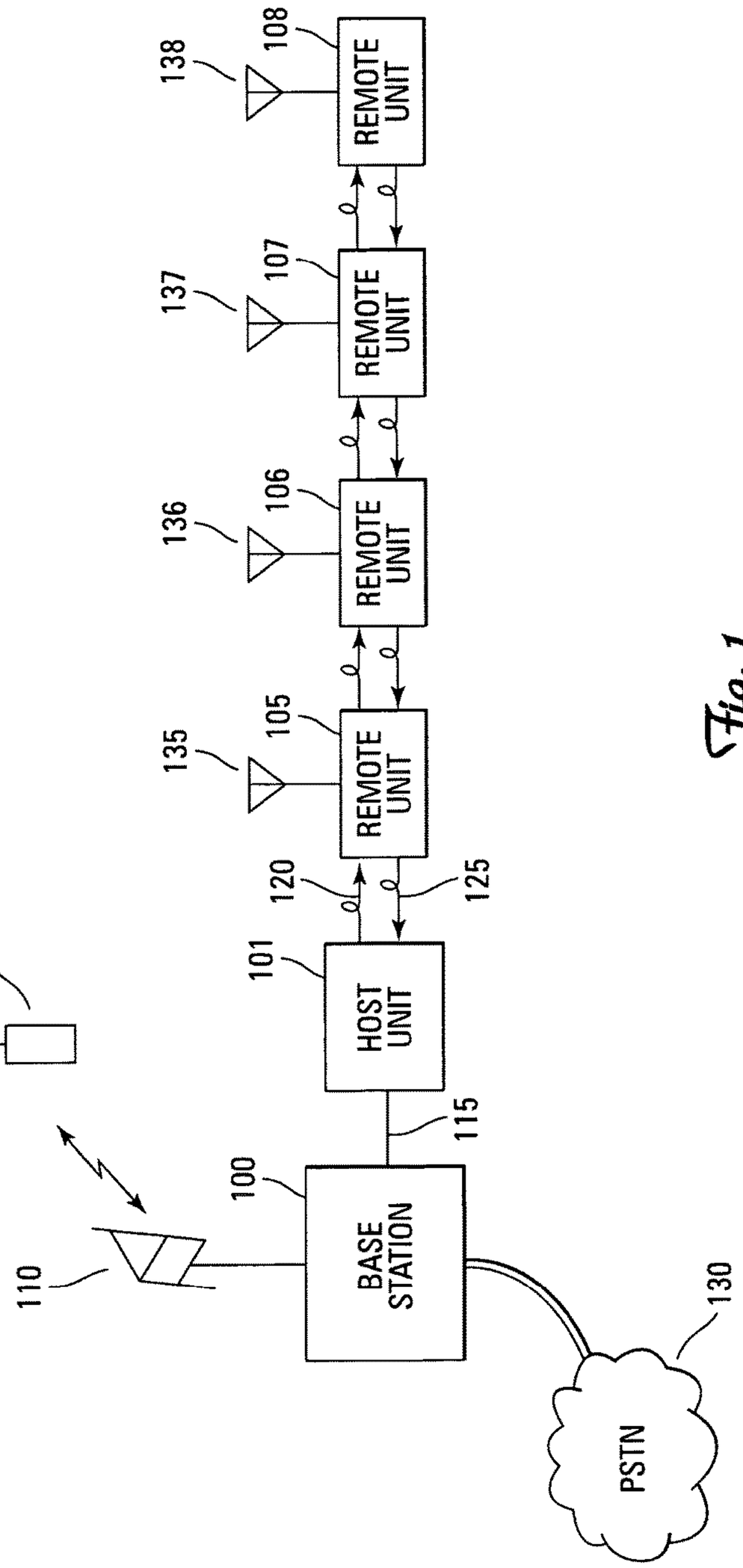
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PSTN
130
BASE STATION
100
110
115
HOST UNIT
101
120
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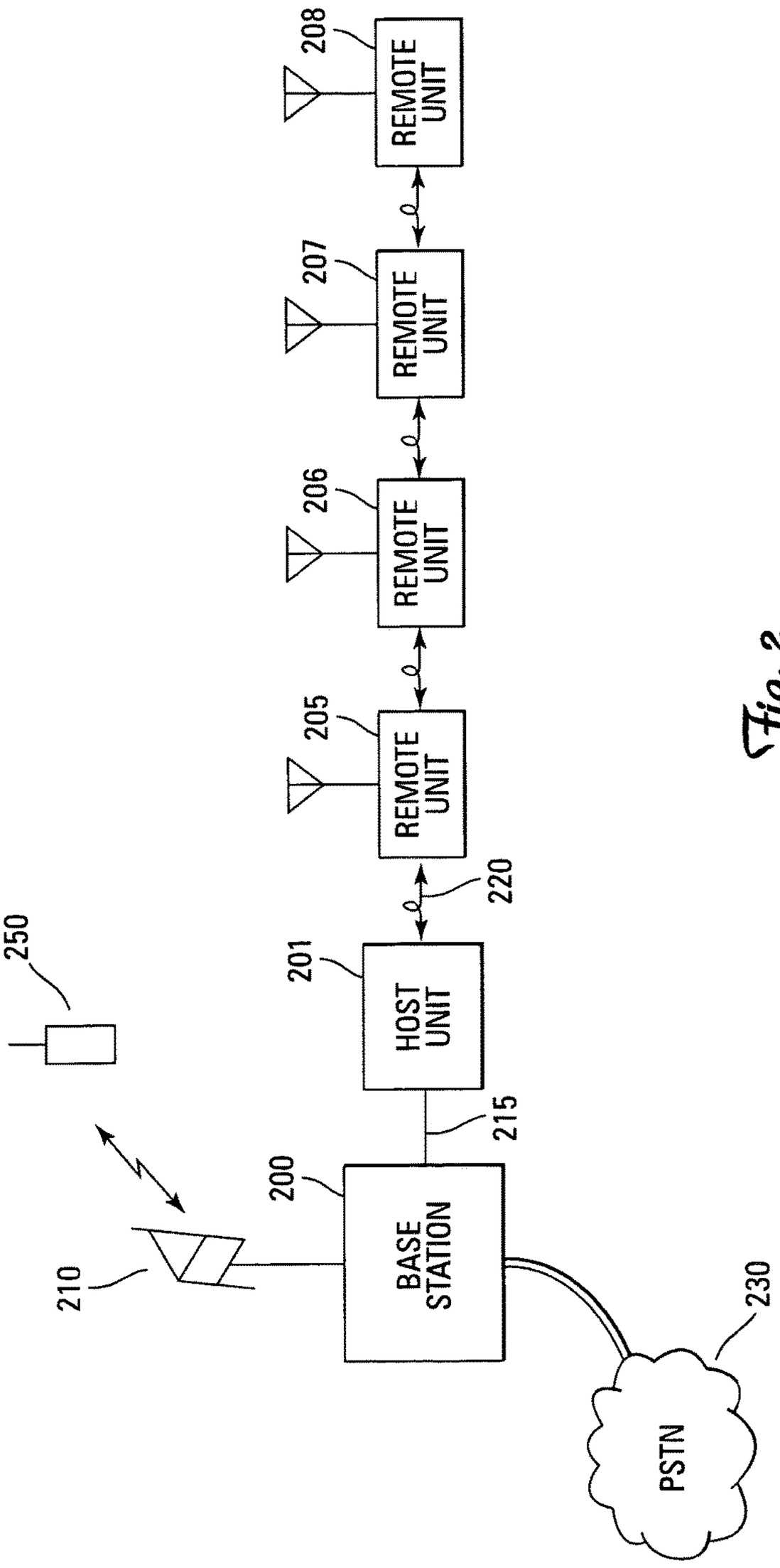
REMOTE UNIT
105
135
REMOTE UNIT
106
136
REMOTE UNIT
107
137
REMOTE UNIT
108
138

Fig. 1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201
HOST UNIT
220
205
REMOTE UNIT
206
REMOTE UNIT
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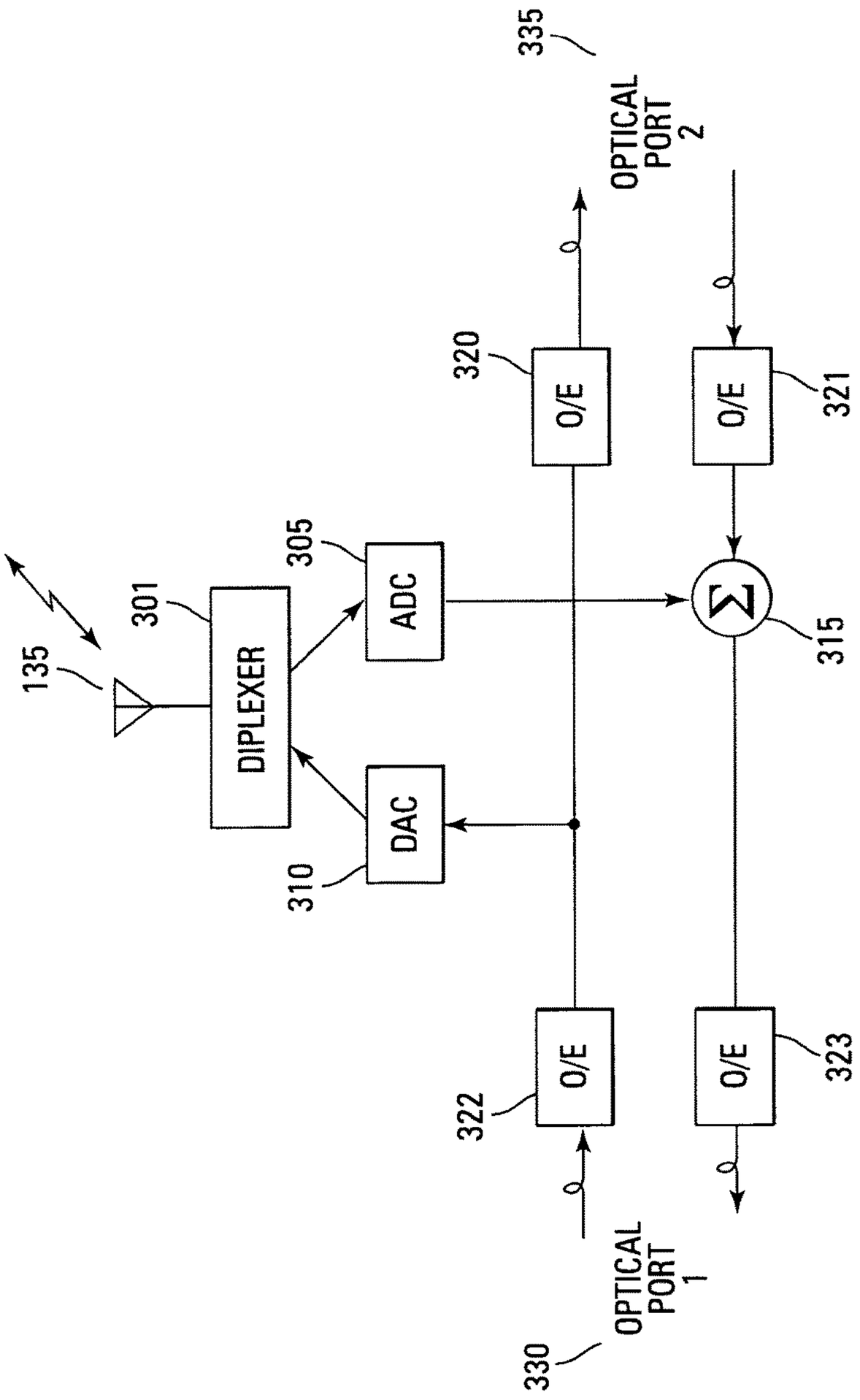
REMOTE UNIT
215
200
BASE STATION
210
230
PSTN

Fig. 2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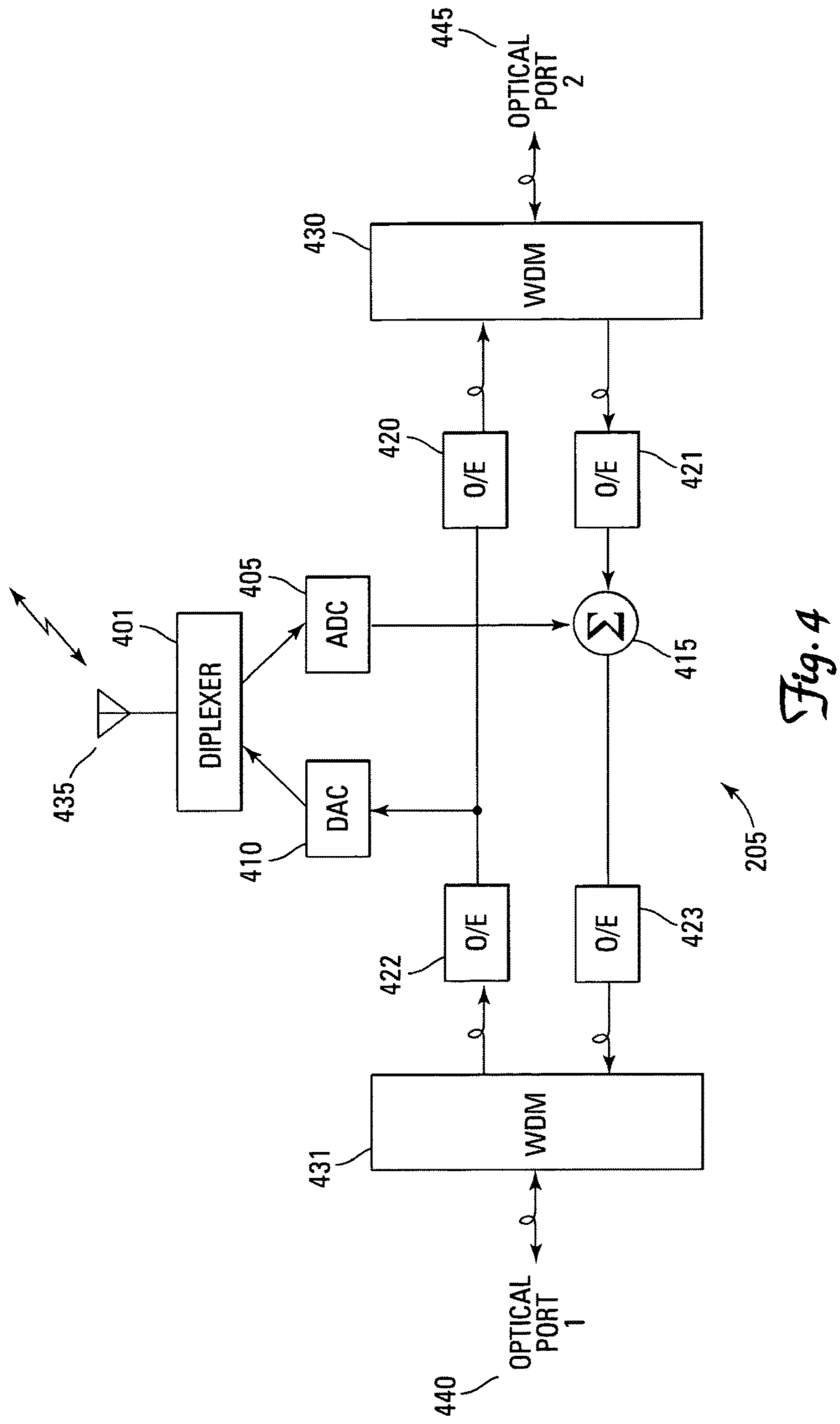
320
O/E
321
O/E
305
ADC
301
DIPLEXER
135
315
310
DAC
105
322
O/E
323
O/E
330
OPTICAL PORT 1

Fig. 3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OPTICAL PORT 2
430
WDM
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O/E
421
O/E
405
ADC
401
DIPLEXER
435
DAC
410
415
205
422
O/E
423
O/E
431
WDM
OPTICAL PORT 1
440

Fig. 4

DISTRIBUTED DIGITAL ANTENNA SYSTEM

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

RELATED APPLICATION

This Reissue Application is a reissue of application Ser. No. 10/395,743, filed Mar. 24, 2003, which issued as U.S. Pat. No. 8,958,789. This application claims priority to U.S. Provisional Patent Application Ser. No. 60/430,434 filed Dec. 3, 2002, and titled "Distributed Digital Antenna System," which is commonly assigned and incorporated by reference herein.

TECHNICAL FIELD

The present invention relates generally to communications and particularly to communications through a distributed antenna system.

BACKGROUND

Various types of wireless communication systems have become prevalent around the world. For example, cellular communication systems cover most major metropolitan areas as well as major highways through remote areas. Cellular systems permit individuals with cellular handsets to communicate with base stations that are connected to the public switched telephone network (PSTN) or some other communication network.

As with any communication system, cellular systems can leave coverage "holes" where the signal from the base stations cannot reach. The holes can be in tunnels, valleys, city streets between tall buildings, or any other location where a radio frequency (RF) signal is blocked.

Placing additional base stations where these coverage holes are located is not always an option. Base stations tend to be very expensive due not only to the cost of the equipment but also because of land acquisition costs. Additionally, large base station antennas may not fit within an area either physically or aesthetically.

One solution to hole coverage is to use smaller remote antennas where coverage is needed but a base station is not warranted or desired. One problem with remote antennas, however, is that coaxial cable cannot be run long distances due to attenuation. Remote antennas are difficult to install along a highway or through a tunnel due to this attenuation problem. Using repeaters may not be an option since this only adds to the expense and complexity of the system. There is a resulting need in the art for a distributed antenna system that does not suffer from attenuation problems.

SUMMARY OF THE INVENTION

The embodiments of the present invention encompass a distributed digital antenna system that has a host unit for converting radio frequency signals to digital optical signals and digital optical signals to radio frequency signals. The digital optical signals are transmitted over an optical medium to a plurality of remote units that are daisy-chained along the optical medium. Each remote unit transmits an analog representation of the digital optical signals from the host unit and receives radio frequency signals that are converted by the remote unit to digital optical signals for use by the host unit.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a block diagram of one embodiment of a distributed digital antenna system of the present invention.

FIG. **2** shows a block diagram of another embodiment of a distributed digital antenna system of the present invention.

FIG. **3** shows a block diagram of one embodiment of a remote unit in accordance with the system of FIG. **1**.

FIG. **4** shows a block diagram of one embodiment of a remote unit in accordance with the system of FIG. **2**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The embodiments of the present invention provide a digital distributed antenna system that enables a communication system to fill coverage holes without the expense of additional base stations. This is accomplished by distributing a fiber optic cable through the area in which coverage is desired and tapping into the fiber at desired antenna locations.

The embodiments of the present invention refer to fiber optics as a means of communication between remote units and the host unit. However, any optical medium, such as a laser through the air, can be substituted for the optical fiber.

FIG. **1** illustrates a block diagram of one embodiment of a distributed digital antenna system of the present invention. The system has a base station (**100**) that communicates over an RF link using an antenna (**110**). The base station communicates over the RF link using any appropriate air interface standard. For example, the air interface standard comprises one of Advanced Mobile Phone System (AMPS), code division multiple access (CDMA), time division multiple access (TDMA), or Global System for Mobile communications (GSM) or any other appropriate air interface standard.

The RF link is made up of a forward link over which the base station (**100**) transmits to a subscriber unit wireless terminal (**150**). The subscriber unit (**150**) transmits back to the base station (**100**) over a reverse link. The subscriber unit (**150**) is either a mobile station or a fixed station such as in a wireless local loop system.

The base station (**100**) has the transmitters and receivers that enable the subscriber unit (**150**) to communicate with the public switched telephone network (PSTN) (**130**). In one embodiment, the base station also links the subscriber unit (**150**) to other subscriber units that are communicating with other base stations. In one embodiment, the base station (**100**) is connected to the PSTN through a mobile switching center that handles the switching of calls with multiple base stations.

A host unit (**101**) is connected to the base station (**100**) through an RF link (**115**). In one embodiment, this link (**115**) is a coaxial cable. Other embodiments use other types of connections such as an air interface or an optical fiber carrying digital RF signals. U.S. patent application Ser. No. 09/619,431, assigned to ADC Telecommunications, Inc. and incorporated herein by reference, discusses digital RF signals.

The host unit (**101**) is responsible for converting the RF signal from the base station (**100**) to an optical signal for transmission over an optical medium. The host unit (**101**)

also converts a received optical signal to an RF signal for transmission to the base station (**100**). In other embodiments, the host unit (**101**) performs additional functions.

One or more remote units (**105-108**) are connected to the host unit (**101**) through an optical medium, such as fiber optic lines (**120** and **125**), in a daisy-chain arrangement. The remote units (**105-108**) are placed in locations that require additional signal coverage due to a lack of coverage by the base station (**100**). The remote units (**105-108**) communicate with subscriber units in a particular remote unit's coverage area over an RF link provided by the remote unit antennas (**135-138**).

For purposes of illustration, four remote units (**105-108**) are shown. However, alternate embodiments use other quantities of remote units. If only a small geographic area requires coverage, as few as one remote unit (**105**) is used. If a highway in a remote area requires additional coverage, more than four remote units are typically used.

The embodiment of FIG. **1** uses a separate fiber optic line for each direction of communication. Each fiber carries a different wavelength. For example, the fiber optic line (**120**) from the host unit (**101**) to the remote units (**105-108**) carries a wavelength of λ_1. The fiber optic line (**125**) from the remote units (**105-108**) to the host unit (**101**) carries a wavelength of λ_2. In alternate embodiments, each fiber carries the same wavelength.

The fiber optic line (**120**) from the host unit (**101**) to the remote units (**105-108**) carries the digital optical signal for transmission by the (**105-108**). The fiber optic line (**125**) from the remote units (**105-108**) carries a digital optical signal comprising the sum of the received signals from each of the remote units (**105-108**). The generation of this summation signal from the remote units is discussed subsequently.

FIG. **2** illustrates a block diagram of another embodiment of a distributed digital antenna system of the present invention. This system is similar to the embodiment of FIG. **1** except that the remote units (**205-208**) are connected to the host unit (**201**) over a single optical medium (**220**).

The system of FIG. **2** has a base station (**200**) that communicates over an RF link using an antenna (**210**). The base station can communicate over the RF link using any air interface standard. For example, the air interface standard may be code division multiple access (CDMA), time division multiple access (TDMA), or Global System for Mobile communications (GSM).

The RF link is made up of a forward link over which the base station (**200**) transmits to a subscriber unit (**250**). The subscriber unit (**250**) transmits back to the base station (**200**) over a reverse link. The subscriber unit (**250**) may be a mobile station or a fixed station such as in a wireless local loop system.

The base station (**200**) has the transmitters and receivers that enable the subscriber unit (**250**) to communicate with the public switched telephone network (PSTN) (**230**). The base station may also link the subscriber unit (**250**) to other subscriber units that are communicating with other base stations. In one embodiment, the base station (**200**) is connected to the PSTN through a mobile switching center that handles the switching of calls with multiple base stations.

A host unit (**201**) is connected to the base station (**200**) through an RF link (**215**). In one embodiment, this link (**215**) is a coaxial cable. Other embodiments use other types of connections such as an air interface or an optical fiber carrying digital RF signals.

The host unit (**201**) is responsible for converting the RF signal from the base station (**200**) to a digital optical signal for transmission over an optical medium. The host unit (**201**) also converts a received optical signal to an RF signal for transmission to the base station (**200**). In other embodiments, the host unit (**201**) performs additional functions.

One or more remote units (**205-208**) are connected to the host unit (**201**) through an optical medium, such as a fiber optic line (**220**), that is connected in a daisy-chain arrangement. The remote units (**205-208**) are placed in locations that require additional signal coverage due to a lack of coverage by the base station (**200**).

For purposes of illustration, four remote units (**205-208**) are shown. However, alternate embodiments use other quantities of remote units.

The embodiment of FIG. **2** uses a single fiber optic line (**220**) for communication both to and from the remote units (**205-208**). This is accomplished by the single fiber (**220**) carrying multiple wavelengths. For example, the fiber optic line (**220**) uses a wavelength of λ_1 for the digital signal from the host unit to the remote units (**205-208**). The fiber optic line (**220**) also carries a digital summation signal with a wavelength of λ_2. This digital summation signal is the sum of the received signals from the remote units (**205-208**). The generation of this summation signal from the remote units is discussed subsequently.

FIG. **3** illustrates a block diagram of one embodiment of a remote unit (**105**) of FIG. **1**. Each of the remote units (**105-108**) of the embodiment of FIG. **1** are substantially identical in functional composition.

The remote unit (**105**) transmits and receives RF signals over the antenna (**135**). Both the receive and transmit circuitry is connected to the antenna (**135**) through a diplexer (**301**).

Alternate embodiments use other quantities of antennas. For example, one embodiment uses three antennas to cover three different sectors of an area.

An analog signal that is received on the antenna (**135**) is split off by the diplexer (**301**) to an analog-to-digital converter (**305**). The analog-to-digital converter (**305**) digitizes the received analog signal by periodically sampling the signal. The sampling generates a digital representation of the received analog signal.

The digitized received signal is input to a summer (**315**) to be added to the digitized signals from the preceding remote units in the daisy-chain. The input of the summer (**315**), therefore, is coupled to an output of a previous remote unit. The output of the summer (**315**) is a summation signal that is coupled to either the input of a subsequent remote unit or to the host unit. The host unit thus receives a summation signal that represents the sum of all the signals received by the remote units (**105-108**) of the system.

A digital signal from the host unit is coupled to a digital-to-analog converter (**310**). The digital-to-analog converter (**310**) takes the digital representation of an analog signal and converts it to the analog signal for transmission by the antenna (**135**).

Optical-to-Electrical converters (**320-323**) are located at the optical ports (**330** and **335**) of the remote unit (**105**). Each optical port (**330** and **335**) has an input and an output that are each coupled to an Optical-to-Electrical converter (**320-323**).

Since the remote unit (**105**) operates with electrical signals that are represented by the optical signals coming in through the optical ports (**330** and **335**), the Optical-to-Electrical converters (**320-323**) are responsible for converting the optical signals to electrical signals for processing by

the remote unit (**105**). The Optical-to-Electrical converters (**320-323**) are also responsible for converting received electrical signals from electrical to an optical representation for transmission over the optical fiber.

FIG. **4** illustrates a block diagram of one embodiment of a remote unit (**205**) of FIG. **2**. Each of the remote units (**205-208**) of the embodiment of FIG. **1** is substantially identical in functional composition.

The remote unit (**205**) transmits and receives RF signals over the antenna (**435**). Both the receive and transmit circuitry are connected to the antenna (**435**) through a diplexer (**401**).

Alternate embodiments use other quantities of antennas. For example, one embodiment uses three antennas to cover three sectors of an area.

An analog signal that is received on the antenna (**435**) is split off by the diplexer (**401**) to an analog-to-digital converter (**405**). The analog-to-digital converter (**405**) digitizes the received analog signal by periodically sampling the signal. The sampling generates a digital representation of the received analog signal.

The digitized received signal is input to a summer (**415**) to be added to the digitized signals from the preceding remote units in the daisy-chain. The host unit thus receives a summation signal that represents the sum of all the signals received by the remote units (**205-208**) of the system.

A digital signal from the host unit is coupled to a digital-to-analog converter (**410**). The digital-to-analog converter (**410**) takes the digital representation of an analog signal and converts it to the analog signal for transmission by the antenna (**435**).

Optical-to-Electrical converters (**420-423**) are located at the optical ports (**440** and **445**) of the remote unit (**205**). Each optical port (**440** and **445**) has an input and an output that are each coupled to an Optical-to-Electrical converter (**420-423**).

Since the remote unit (**205**) operates with electrical signals that are represented by the optical signals coming in through the optical ports (**440** and **445**), the Optical-to-Electrical converters (**420-423**) are responsible for converting the optical signals to electrical signals for processing by the remote unit (**205**). The Optical-to-Electrical converters (**420-423**) are also responsible for converting received electrical signals from electrical to an optical representation for transmission over the optical fiber.

A wavelength division multiplexer (WDM) (**430** and **431**) is located at each optical port (**440** and **445**). The WDMs (**430** and **431**) perform the optical processing necessary to combine several optical signals having several wavelengths. The WDMs (**430** and **431**) also perform the optical demultiplexing necessary to split the multiple wavelengths of a single fiber to their own signal paths.

In summary, the distributed digital antenna system provides multiple daisy-chained antennas on a single medium such as optical fiber. The fiber can be tapped anywhere along its length multiple times to provide economical radio coverage in areas where a base station would be cost prohibitive.

Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

What is claimed is:

1. A distributed digital antenna system comprising:

a host unit **[**that converts a**]** *configured to receive a first signal from a base station communicatively coupled to the host unit and to transmit a second signal to the base station, the host unit further configured to convert the* first signal to a transmitted digital optical signal and **[**that converts**]** *to convert* a received digital optical signal to **[**a**]** *the* second signal**[**;**]**, *wherein the host unit is configured to transmit and receive signals over* an optical medium coupled to the host unit**[**to carry the transmitted and received digital optical signals**]**; and

a plurality of remote units daisy-chained along the optical medium such that each *particular* remote unit *of the plurality of remote units* transmits an analog representation of the transmitted digital optical signal and receives radio frequency signals that are converted by the *particular* remote unit to a digitized received spectrum, each *particular remote unit* of the *plurality of* remote units including a summer that sums the digitized received spectrum with a corresponding digitized received spectrum from any preceding remote unit of the *plurality of remote units* daisy-chained **[**remote units**]** *along the optical medium* to generate the received digital optical signal for transmission to the host unit.

2. The *distributed digital antenna* system of claim **1**, wherein the first *signal* and *the* second **[**signals**]** *signal* are transported over an optical, electrical or wireless medium.

3. The *distributed digital antenna* system of claim **1**, wherein the optical medium is an optical fiber.

4. The *distributed digital antenna* system of claim **1[**and further including a**]**, *wherein the* base station**[**, coupled to the host unit, that communicates**]** *is configured for communicating* with subscriber units over a radio frequency air interface.

5. The *distributed digital antenna* system of claim **[4]** *1*, wherein the base station transmits the first signal and receives the second signal.

6. The *distributed digital antenna* system of claim **[4]** *1*, wherein the base station communicates signals from the host unit to a public switched telephone network.

7. A distributed digital antenna system that communicates signals with a base station that is coupled to a data network, the *distributed digital antenna* system comprising:

a host unit **[**that converts**]** *configured to receive forward link radio frequency signals from the base station and the transmit reverse link radio frequency signals to the base station, the host unit further configured to convert the forward link* radio frequency signals *received* from the base station to *forward link* digital optical signals and **[**that converts**]** *to convert reverse link* digital optical signals from the *distributed* digital antenna system to *reverse link* radio frequency signals for use by the base station**[**;**]**, *wherein the host unit is configured to communicate the forward link digital optical signals across* an optical medium coupled to the host unit**[**that carries the digital optical signals**]**; and

a plurality of remote units daisy-chained along the optical medium such that each *particular* remote unit *of the plurality of remote units* transmits *first* radio frequency signals over an air interface as an analog representation of the digital optical signals from the base station and receives *second* radio frequency signals over the air interface that are converted by **[**a receiving**]** *the particular* remote unit to a digitized received spectrum, each *particular remote unit* of the *plurality of* remote units **[**and the receiving remote unit**]** including a summer that sums the digitized received spectrum with a corresponding digitized received spectrum from any preceding remote unit of the *plurality of remote units*

daisy-chained [remote units] *along the optical medium* to generate the [received] *reverse link* digital optical signals for use by the host unit.

8. The *distributed digital antenna* system of claim **7**, wherein the *forward link* radio frequency signals *and the reverse link radio frequency signals communicated* between the base station and the host unit are carried over an optical link.

9. The *distributed digital antenna* system of claim **7**, wherein the optical medium is an optical fiber that carries multiple wavelengths.

10. The *distributed digital antenna* system of claim **7**, wherein the optical medium is a first optical fiber that carries a first wavelength from the host unit to the plurality of remote units and a second optical fiber that carries a second wavelength from the plurality of remote units to the host unit.

11. The *distributed digital antenna* system of claim **10**, wherein the second wavelength carries a digital signal that represents a summation of signals received by each of the plurality of remote units.

12. The *distributed digital antenna* system of claim **7**, wherein *each remote unit of* the plurality of remote units [each comprise] *comprises*:

an antenna that communicates the *forward link* radio frequency signals *and the reverse link radio frequency signals* over the air interface;

a plurality of optical-to-electrical converters that convert forward link digital optical signals input to the remote unit to forward link digital electrical signals and that convert reverse link electrical signals in the digitized received spectrum to reverse link digital optical signals for output to the host unit;

a digital to analog converter that converts the forward link digital electrical signals to the analog representation;

an analog-to-digital converter that converts the [received] *reverse link* radio frequency signals to the reverse link electrical signals in the digitized received spectrum; and

wherein the summer sums the reverse link electrical signals in the digitized received spectrum with corresponding reverse link electrical signals in the *corresponding* digitized received spectrum from the *any* preceding remote [units] *unit* of the *plurality of remote units daisy-chained along the* optical medium [daisy-chain] to generate the [received] *reverse link* digital optical signals.

13. A remote unit in a distributed digital antenna system that communicates signals with a base station, the remote unit comprising:

an antenna that communicates radio frequency signals using an air interface standard;

a plurality of optical-to-electrical converters that convert input digital optical signals, from a host unit coupled to the base station and a daisy-chain of previous remote units, to forward link digital electrical signals;

a digital to analog converter that converts the forward link digital electrical signals to analog signals for transmission by the antenna as *forward link* radio frequency signals;

an analog-to-digital converter that converts *reverse link* radio frequency signals from the antenna to a digitized spectrum of reverse link electrical signals; and

a summer that sums the reverse link electrical signals in the digitized spectrum from the analog-to-digital converter [to] *with* corresponding reverse link electrical signals from the daisy-chain of previous remote units to generate an output digital optical signal.

14. The remote unit of claim **13**[and], further [including] *comprising*:

a first optical port that is coupled to either the host unit or a subsequent remote unit of the daisy-chain of remote units; and

a second optical port that is coupled to the daisy-chain of previous remote units.

15. The remote unit of claim **13**, wherein a first optical-to-electrical converter of the plurality of optical-to-electrical converters converts an optical summation signal from the daisy-chain of previous remote units to the output digital optical signal and a second optical-to-electrical converter converts an optical transmit signal from the host unit to [the] *a* forward link digital electrical signal for conversion to an analog signal by the digital to analog converter.

16. A remote unit in a distributed digital antenna system that communicates signals with a base station, the remote unit comprising:

an antenna that communicates radio frequency signals using an air interface standard;

a plurality of optical-to-electrical converters that convert *forward link* digital optical signals, from a host unit coupled to the base station and a daisy-chain of previous remote units, to forward link digital electrical signals, the plurality of optical-to-electrical converters further convert reverse link digital electrical signals to *reverse link* digital optical signals, each *forward link* digital optical signal *of the forward link digital optical signals and each reverse link digital optical signal of the reverse link digital optical signals* comprising a wavelength;

a digital to analog converter that converts the forward link digital electrical signals to analog signals for transmission by the antenna as *forward link* radio frequency signals;

an analog-to-digital converter that converts *reverse link* radio frequency signals from the antenna to a digitized spectrum of reverse link electrical signals;

a summer that sums the reverse link electrical signals in the digitized spectrum from the analog-to-digital converter to an output digital optical signal from the daisy-chain of previous remote units; and

a wavelength division multiplexer that demultiplexes an input digital optical signal, comprising a plurality of wavelengths, to the digital optical signals each having a *particular* wavelength in the plurality of wavelengths, the wavelength division multiplexer further multiplexes *the* digital optical signals to the output digital optical signal comprising the plurality of wavelengths.

17. A method for communicating over a distributed digital antenna system, the method comprising:

converting a first radio frequency signal from a base station to a *forward link* digital optical signal;

transmitting the *forward link* digital optical signal over an optical medium to a plurality of remote units in a daisy-chain configuration along the optical medium;

converting the *forward link* digital optical signal to a forward link digital electrical signal at each remote unit;

converting the forward link digital electrical signal to an analog signal for transmission by at least one of the *plurality of* remote units as a second radio frequency signal;

receiving a third radio frequency signal over an air interface of *the* at least one of the *plurality of* remote units;

converting the third radio frequency signal to a **[**received**]** *reverse link* electrical signal within a digitized spectrum; and

summing the digitized spectrum of the **[**received**]** *reverse link* electrical signal with a corresponding digitized spectrum of **[**received**]** *reverse link* electrical signals from previous remote units in the daisy-chain configuration.

18. The method of claim **17[**and**]**, further **[**including**]** *comprising*:

converting a result of the summing of the digitized spectrum of the **[**received**]** *reverse link electrical signal with the corresponding digitized spectrum of the reverse link* electrical signals *from the previous remote units in the daisy-chain configuration* to a *reverse link* digital optical signal;

transmitting the *reverse link* digital optical signal over the optical medium; and

converting the *reverse link* digital optical signal to a fourth radio frequency signal for use by the base station.

19. The method of claim **17[**and**]**, further **[**including**]** *comprising:*

demultiplexing the *forward link* digital optical signal into a plurality of optical signals each having one wavelength.

20. The method of claim **18[**and**]**, further **[**including the base station**]** *comprising:*

transmitting information in the fourth radio frequency signal *from the base station* to a public switched telephone network.

21. The method of claim **18[**and**]**, further **[**including**]** *comprising:*

multiplexing single wavelength optical signals from **[**the**]** *a particular* remote unit into a single optical signal comprising a plurality of wavelengths.

22. A method for a remote terminal to communicate with a wireless terminal in a geographic area, the method comprising:

converting an optical signal to a forward link electrical signal;

converting the forward link electrical signal to a forward link analog signal;

transmitting the forward link analog signal to the wireless terminal;

receiving a reverse link analog signal from the wireless terminal;

converting the reverse link analog signal to a reverse link electrical signal;

summing a digitized spectrum of the reverse link electrical signal with a corresponding digitized spectrum of other reverse link electrical signals from other remote terminals that are daisy-chained together over an optical link *to create a summed digitized spectrum of reverse link electrical signals*; and

converting the summed digitized spectrum of reverse link electrical signals to a reverse link summed optical signal for transmission to a host unit *communicatively coupled to a base station*.

23. The **[**system**]** *method* of claim **[1]***22*, **[**wherein**]** *further comprising:*

receiving, at the host unit**[**receives**]**, a total digitized received spectrum representing **[**the**]** *a* sum of all digitized received spectrum from **[**the**]** *a* plurality of remote **[**units**]** *terminals including the remote terminal and the other remote terminals*.

24. The method of claim **[22]***23*, wherein the summed digitized spectrum of reverse link electrical signals represents a sum of the digitized spectrum of the reverse link electrical signals of **[**all**]** the *plurality of* remote terminals**[**that are daisy-chained together over the optical link**]**.

25. A distributed digital antenna system comprising:

a host unit configured to receive a first signal from a base station communicatively coupled to the host unit and to transmit a second signal to the base station, the host unit further configured to convert the first signal to a transmitted digital signal and to convert a received digital signal to the second signal, wherein the host unit is configured to transmit and receive signals over a medium coupled to the host unit; and

a plurality of remote units daisy-chained along the medium such that each particular remote unit of the plurality of remote units transmits an analog representation of the transmitted digital signal and receives radio frequency signals that are converted by the particular remote unit to a digitized received spectrum, each particular remote unit of the plurality of remote units including a summer that sums the digitized received spectrum with a corresponding digitized received spectrum from any preceding remote unit of the plurality of remote units daisy-chained along the optical medium to generate the received digital signal for transmission to the host unit.

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