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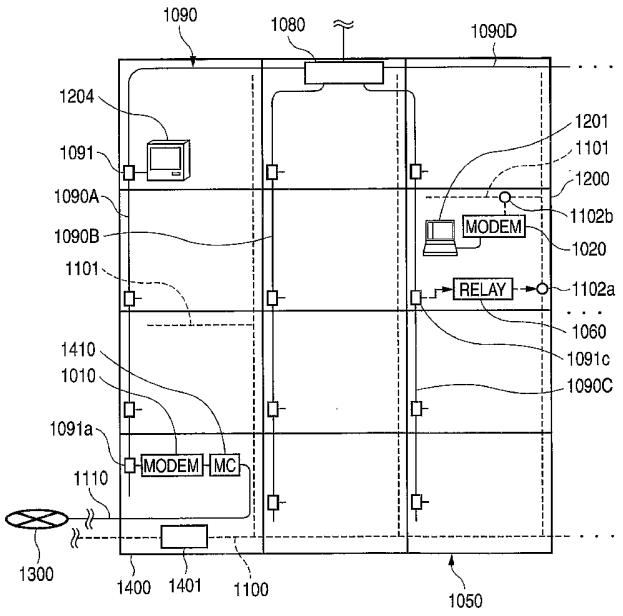
(54) Title: COMMUNICATION SYSTEM



(57) Abstract: A communication system utilizing a power line communication to be carried out in a building including a plurality of houses, in which a video and audio signal in a high frequency band such as TV or CATV signals are received in common, is provided in a manner such that the power line and the communication line are combined with each other to form a signal transmission path, by which reduces the attenuation of a communication signal, so as to ensure an excellent communication state without increasing the manufacturing cost of the system.

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DESCRIPTION

COMMUNICATION SYSTEM

<TECHNICAL FIELD>

The present invention relates to a power line communication system for carrying out a communication by utilizing a power line. In particular, the invention relates to a power line communication system capable of reducing the attenuation of a communication signal, thereby allowing each house to communicate in good condition with a communication signal provided in a building having a plurality of houses in it.

The invention relates to a communication system which is suitable for a building having a plurality of houses which receives a video and audio signals in a high frequency band such as a TV signal or a CATV signal in common. In particular, the invention relates to a communication system which reduces the attenuation of a transmission signal and is influenced by a mixing noise with difficulty.

The invention relates to a communication system which is suitable for a building having a plurality of houses which receive a video and audio signal in common. In particular, the invention relates to a communication system capable of reducing the attenuation of a communication signal.

<BACKGROUND ART>

(1) In recent years, there has been researched a communication utilizing a power line, for instance, a power line communication (PLC) for superimposing a communication signal on a low voltage distribution power line to carry out a high-speed communication.

Fig. 9 is an explanatory diagram typically showing the concept of a communication system using a PLC method, illustrating the case in which the PLC user houses are located in an apartment building. In the drawing, the same reference numerals denote the same portions. This method utilizes a power

line, which supplies a power with houses 1200A to 1200C of the PLC users, as a signal transmission path so as to communicate through a communication signal as shown in Fig. 9. In this example, an optical fiber cable 1110 is used for a communication from an external network 1300 to a power device chamber 1400 for accommodating a power device 1401 such as a transformer or a switch, and a low voltage distribution power line 1100 and indoor wirings 1101A to 1101C provided in the houses 1200A to 1200C respectively are used for a communication from the power device 1401 side to the houses 1200A to 1200C. The power device chamber 1400 includes a PLC modem (parent modem) 1500 which connects the optical fiber cable 1110 with the low voltage distribution power line 1100 to carry out a communication with the external network 1300 through a communication signal. Each of the houses 1200A to 1200C includes a PLC modem (a child modem) 1600 capable of carrying out a communication through a communication signal between a terminal device 1201 such as a personal computer provided in each of the houses 1200A to 1200C and the parent modem 1500. While the parent modem 1500 includes a media converter (MC) for carrying out a conversion to an optical signal/electric signal in the example shown in Fig. 9, it includes the MC separately in some cases. While the power device chamber 1400 is provided on the outside of the apartment building in this example, moreover, it is provided in the apartment building in some cases.

With such a structure, in the case in which the PLC user of the house 1200A is to transmit a communication signal to the external network 1300, for instance, the communication signal transmitted from the terminal device 1201 is extracted and modulated by the child modem 1600, which is injected to the indoor wiring 1101A through a receptacle (not shown) provided in the indoor wiring 1101A, and is delivered to the low voltage side (secondary side) of the power device 1401 through the indoor wiring 1101A → a cabinet panel 1202 → a watthour meter 1203 → the low voltage distribution power line 1100. Then, the communication signal is extracted and demodulated by the parent

modem 1500 connected to the low voltage side of the power device 1401, and is injected to the optical fiber cable 1110 and is transmitted to the external network 1300. In the case in which the PLC user is to receive the communication signal, the communication signal passes through a reverse course to the course in the transmission described above.

(2) In a building such as an apartment building having a plurality of houses or a commercial building, conventionally, a configuration referred to as a common receiving has been utilized as the receiving configuration of a video and audio signal such as a TV signal or a CATV signal. In this configuration, generally, a video and audio signal transmitted from a signal distribution side such as a TV station is distributed by a distributor and a plurality of houses receives the same signal. Fig. 11 is an explanatory diagram schematically showing the common receiving configuration of the CATV signal. In the drawing, the same reference numerals denote the same portions. The configuration shown in Fig. 11 is a wire type configuration for transmitting a video and audio signal from a station such as a TV station having an antenna for receiving the video and audio signal from a space satellite to each house through a communication line such as an optical fiber cable or a coaxial cable. In this configuration, in general, distribution apparatuses 2600 and 2601 such as a head end apparatus or a server, which can distribute a video and audio signal from a station 2500, are provided on the outside of buildings 2090 and 2091 such as apartment buildings including a plurality of houses and a detached house 2092. The head ends 2600 and 2601 are connected to the buildings 2090 and 2091 and the detached house 2092 through a communication line 2150 and transmit the video and audio signal from the station 2500 to the building 2090 through the communication line 2150. The building 2090 comprises an amplifier 2101 for amplifying a video and audio signal sent from the head end 2600, a distributor 2102 for distributing the video and audio signal to each house in the building 2090, and an indoor communication line 2110 for transmitting the video and audio

signal to each house. The indoor communication line 2110 is branched into a plurality of branch communication lines 2111 to 2114 through the distributor 2102, by which a plurality of houses shares one branch communication line. For instance, a house 2200 can receive a CATV signal by connecting a receiver 2300 such as a television to a terminal portion 2120 provided on the branch communication line 2111. In the example shown in Fig. 11, the video and audio signal is distributed from the rooftop portion of the building 2090. In some cases in which the communication line is buried in the ground, the video and audio signal is distributed from the underground portion or first floor of the building.

for instancefor instance (3) In a building such as an apartment building including a plurality of houses or a commercial building, conventionally, a configuration referred to as a common receiving has been utilized as the receiving configuration of a video and audio signal such as a TV signal or a CATV signal. In this configuration, generally, a video and audio signal transmitted from a signal distributing side such as a TV station is distributed by a distributor and a plurality of houses receives the same signal. Fig. 16 is an explanatory diagram schematically showing the common receiving configuration of the TV signal. In the drawing, the same reference numerals denote the same portions. In the configuration shown in Fig. 16, a building 3090 is provided with an antenna 3100 for receiving a TV signal from a station 3500 such as a TV station for distributing a video and audio signal by wireless, an amplifier 3101 for amplifying the TV signal, a distributor 3102 for distributing the TV signal to each house 3200, and a communication line 3110 for transmitting the TV signal to the house 3200. The communication line 3110 is branched into a plurality of branch communication lines 3111 to 3114 through the distributor 3102, and a plurality of houses shares one branch communication line. For instance, the house 3200 can receive the TV signal by connecting a receiver 3300 such as a television set to a terminal portion 3120 provided on the branch

communication line 3111. Fig. 16 shows the structure in which the antenna 3100 is provided in the building 3090 on a signal receiving side. The CATV signal is usually distributed from a head end provided on a signal distributing side to a building through a cable, and is distributed by a distributor and is transmitted from the cable to each house.

On the other hand, in recent years, there has been developed a communication utilizing a power line, for instance, a power line communication (PLC) for transmitting a communication signal to a low voltage distribution power line to carry out a high-speed communication for instance, see Kiyoshi Etoh, "Present Condition of Power Line Communication (PLC)", Interface (CQ Publishing Company; September 2000, pp. 70-81). In this communicating method, usually, there is provided a PLC modem for modulating/demodulating the frequency of a communication signal at 10 MHz or less, and the communication signal is properly modulated/demodulated by the PLC modem so that a high-speed communication using a power line as a signal transmission path can be carried out.

In the communicating method described in (1), however, in the case in which the attenuation of the communication signal is great in the power line provided in the apartment building, there is a problem in that some houses might not carry out a communication or might carry out the communication with difficulty. More specifically, in a house positioned apart from the signal injecting point of a parent modem in a power line, for instance, the length of the power line between the parent modem and a child modem is increased so that the amount of the attenuation of the communication signal is increased. For this reason, there is a possibility that it might be hard to extract a communication signal to be transmitted to a power line through the child modem or it might be impossible to extract the communication signal from the child modem by the parent modem.

In the conventional common receiving configuration described in (2), a plurality of houses are connected to one head end. When noises referred to as living noises are generated

in each of the houses, therefore, these noises are collected into the head end through a communication line and are further gathered into a station, that is, a so-called mixing noise might be generated. The head end or the distributing equipment of the station is influenced by the mixing noise so that a signal transmitting characteristic is deteriorated in some cases. The mixing noise is increased in a low frequency band, more specifically, a frequency band of less than 70 MHz. Referring to a TV signal and a CATV distribution signals, therefore, a frequency band of 70 MHz or more has conventionally been used to reduce the mixing noise, thereby lessening the influence of the mixing noise.

However, on the other hand, it is generally said that the attenuation of a signal such as a video and audio signal becomes lower in case of such a signal being transmitted in a lower usage frequency band. Accordingly, it is desirable that the usage frequency band should be more lowered to reduce the attenuation of a transmission signal. When the usage frequency band is lowered, however, there is a problem in that a deterioration in a transmission characteristic cannot be avoided due to the influence of the mixing noise. On top of this, when the usage frequency band is higher, the manufacture cost for a device becomes higher. In respect of these problems, it is desirable that the usage frequency band should be eventually selected at low.

For the conventional art described in (3), in recent years, a larger capacity and higher-speed communication has been demanded. In order to implement the communication at a lower cost, the utilization of an existing communication infrastructure is effective. The communication infrastructure includes an optical fiber cable, a pair cable and a coaxial cable, and so on. Although the optical fiber cable can carry out a larger capacity and higher-speed communication, it does not prevail sufficiently at present, rather, there are still places required for being introduced from now. To the contrary, in an apartment building, the percentage of the households having

the coaxial cable is very high. In this regard, if the coaxial cable is used as a signal transmission path, therefore, newly investment for additional facilities or equipments might be reduced or eliminated. Therefore, the inventors of this present invention have been developing a communication system with a coaxial cable set to be a signal transmission path and carrying out a high-speed communication by utilizing a PLC modem. In the communication system, however, there is a problem in that a communication signal modulated/demodulated by the PLC modem might be attenuated greatly by an amplifier or a distributor.

Therefore, it is a main object of the invention to provide a power line communication system capable of reducing the attenuation of a communication signal, particularly, the attenuation of a communication signal between a parent modem and a child modem, thereby carrying out an excellent communication in a building having a plurality of houses.

Moreover, it is an object of the invention to provide a communication system which reduces the attenuation of a transmission signal when the indoor communication line of a building is set to be a signal transmission path, and furthermore, is rarely influenced by a mixing noise.

Furthermore, it is an object of the invention to provide a communication system in which the attenuation of a communication signal modulated/demodulated by a communication device is small when a communication line provided in a building to carry out the communication receiving of a video and audio signal is set to be a signal transmission path.

<DISCLOSURE OF THE INVENTION>

The invention attains the objects by utilizing a communication line having the attenuation of a communication signal reduced in a signal transmission path in addition to a power line.

More specifically, the invention provides a power line communication system in a building having a plurality of houses, comprising a signal transmission path formed by a combination

of a communication line and a power line which are provided in the building, and a terminal device provided in at least one of the houses and serving to carry out a communication through the signal transmission path. The invention will be described below in detail.

The invention is intended for a building having a plurality of houses. The house is not always meant only a general residence but a plurality of small spaces obtained by partitioning the inside of a building. More specifically, examples of the house include an individual and independent residence requiring a communication, a company, an office and a room. Examples of the building include an apartment building and commercial buildings such as a multi-use building and an office building. For a suitable building, moreover, there are provided a communication line capable of transmitting a communication signal and a power line for supplying a power to each house. The invention utilizes, as a signal transmission path, the communication line and the power line which are to be provided in the building.

Examples of the communication line include a coaxial cable to be utilized for transmitting TV signal or CATV (Community Antenna TV) signal, LAN (Local Area Network) cable to be utilized for constructing Ethernet (registered trademark) for connecting computers to transmit a data signal, a telephone line, and furthermore, a communication line for an interphone which is utilized for transmitting an interphone signal between an interphone extension device provided on the entrance of a building and a master device provided in a house. In the case in which these communication lines are utilized, it is desirable that the signal and a power line communication signal should not be mutually influenced. As a countermeasure thereof, for instance, the frequency band of the communication signal to be utilized in the invention is determined to offset from the frequency band of the signal. For instance, there are often utilized a TV signal having a frequency band of approximately 100 MHz in a VHF band and approximately 500 MHz in a UHF band

and a CATV signal having a frequency band of 70 MHz or more with a down signal and approximately 40 MHz with an up signal. In the case in which the coaxial cable is utilized as the communication line, accordingly, it is preferable that the frequency band of the communication signal to be utilized in the invention should be different from the frequency band described above. Moreover, it is desirable to avoid an interference with an AM radio broadcast in which approximately 1 MHz is mainly used. In the invention, furthermore, a power line is utilized as a signal transmission path. Therefore, it is also desirable that a communication signal to be utilized in the invention should have a frequency band in which a transmission can be carried out with a power line. In consideration of these circumstances, it is suitable that the frequency band of the communication signal to be utilized in the invention should be 50 MHz or less, preferably 1.7 MHz to 50 MHz, and particularly 1.7 to 30 MHz, for instance.

In order to transmit the communication signal between the communication line and the power line, for instance, a relay device for relaying the communication signal between the communication line and the power line is provided. The relay device has a structure in which the communication signal to be transmitted to the power line can be extracted from and injected to the communication line, and the communication signal to be transmitted to the communication line can be extracted from and injected to the power line. A well-known repeater may be utilized. Moreover, an impedance matching device may be utilized. For instance, generally, the characteristic impedance of a coaxial cable for a CATV is 75Ω and the characteristic impedance of an indoor wiring is approximately 100Ω. In the case in which the characteristic impedance of the communication line is different from that of the power line, thus, the impedance matching device may be utilized as the relay device. For instance, the impedance matching device has such a structure as to include a high frequency transformer for transmitting and receiving a communication signal and a capacitor for correcting a frequency.

The high frequency transformer has such a structure as to include a ferromagnetic material such as a ferrite core which has a high permeability and a characteristic of a low loss also in a region having a high frequency, a first wiring which is provided on the ferromagnetic material and through which a communication signal is transmitted from/to a communication line, and a second wiring through which a communication signal is transmitted from/to a power line. It is possible to match the characteristic impedance by properly regulating the number of winds of each of the first winding and the second winding. It is also possible to produce an advantage that the installation space of a device is small and an increase in a delay time can be more suppressed as compared with a repeater in the use of a VoIP (Audio over Internet Protocol) in addition to the matching of the characteristic impedance in the case in which the impedance matching device is utilized as the relay device.

A house for carrying out a communication by utilizing the signal transmission path including the communication line and the power line comprises a terminal device for receiving the communication signal to be transmitted to the signal transmission path and transmitting the communication signal to the signal transmission path. Examples of the terminal device include a personal computer.

In the case in which the communication is to be carried out with the outside of the building through the communication signal, there is provided a first power line communication device (hereinafter referred to as a first PLC modem) capable of carrying out the communication with the outside of the building through the communication signal, for instance, an external network in the invention. The first PLC modem includes a device capable of injecting the communication signal from the outside of the building to the communication line or the power line and extracting the communication signal from the communication line or the power line, and properly modulating/demodulating the communication signal. For instance, there are provided a transmitting/receiving portion for transmitting/receiving a

communication signal, a power portion formed by a power circuit for obtaining a power to operate each component such as the transmitting/receiving portion, and an interface required for a communication with an outside. It is also possible to use a well-known PLC modem to be utilized as a so-called parent modem. Examples of a place in which the first PLC modem is to be provided include the inside of a house provided in a building, the inside of a power device chamber, and the rooftop portion of a building.

Moreover, at least one of houses provided in the building includes a second power line communication device (hereinafter referred to as a second PLC modem) capable of carrying out a communication with the first PLC modem through a communication signal. The second PLC modem includes a device capable of injecting the communication signal from the first PLC modem to the communication line or the power line / extracting the communication signal from the communication line or the power line and properly modulating/demodulating the communication signal. For instance, there are provided a transmitting/receiving portion for transmitting/receiving a communication signal and a power portion including a power circuit for obtaining a power to operate each component such as the transmitting/receiving portion. It is also possible to use a well-known PLC modem to be utilized as a so-called child modem. A plurality of houses including such a second PLC modem may be present in a building. In this case, it is preferable to use the first PLC modem having a structure in which a communication signal can be transmitted to a plurality of second PLC modems, more specifically, a structure in which the time sharing of each of the second PLC modems is controlled to transmit a communication signal to each of the second PLC modems, for instance. The terminal device is connected to the second PLC modem in such a manner that the terminal device can carry out a communication through a communication signal via a signal transmission path.

In the case in which the first PLC modem and the second PLC modem inject/extract the communication signal to/from the

communication line, the impedances of the modems are matched in order to adapt to the impedance of a communication line respectively.

As the first aspect in this invention, a first PLC modem is provided on a communication line and a second PLC modem is provided on a power line as explained below.

The first PLC modem injects the communication signal to one of the communication line and the power line / extracts the communication signal from one of them. First of all, consideration will be given to the case in which the first PLC modem injects/extracts the communication signal to/from the communication line. At this time, in the case in which the communication line is set to be a coaxial cable and the coaxial cable is constituted by a plurality of cores, for instance, the first PLC modem can employ such a configuration as to inject/extract the communication signal to/from one of the cores and such a configuration as to inject/extract the communication signal to/from each of the cores. In the former case, the first PLC modem is provided in one of houses provided in a building and injects/extracts a communication signal to/from the terminal portion of one core provided in the same house (this structure will be hereinafter referred to as a terminal pattern), for instance. In this configuration, the communication signal is transmitted to a core other than one core to/from which the communication signal is injected/extracted through the same core.

The coaxial cable provided in the building including a plurality of houses is constituted by a plurality of cores, each of which is collected in a rooftop portion in many cases. A TV signal and a CATV signal are injected at the rooftop portion and are distributed to each of the cores through a distributor, and are transmitted to each house in many cases. In the latter case, accordingly, the first PLC modem may be provided in the vicinity of the collecting place of the cores, for instance, the rooftop portion. More specifically, the first PLC modem

is provided in the rooftop portion in which the cores are gathered and injects/extracts the communication signal to/from each of the cores (this structure will be hereinafter referred to as a set pattern), for instance. In this configuration, the communication signal is transmitted to each of the cores.

In the case in which the communication signal to be utilized in the invention might be subjected to a great attenuation by the frequency characteristic of the distributor, it is preferable that the first PLC modem should be provided on the coaxial cable at the downstream side of the distributor and the communication signal should be injected/extracted at the same downstream side in the set pattern. In the terminal pattern, moreover, in the case in which a distributor for a TV signal or a CATV signal is provided between one core to which the communication signal to be utilized in the invention is injected and a core other than the one core and the same communication signal might be subjected to a great attenuation by the frequency characteristic, it is also possible to employ such a structure as to connect the one core to the other core through a wiring, thereby bypassing the distributor. By connecting the different cores through the wiring, there is a possibility that the transmission characteristic of the TV signal or the CATV signal might be deteriorated. In order to effectively prevent the deterioration in the transmission characteristic of the TV signal or the CATV signal, therefore, it is preferable that the wiring should be provided with a filter for cutting off a signal in the frequency band of the TV signal or the CATV signal. In the case in which the passage of the TV signal or the CATV signal is to be blocked, for instance, it is preferable that this filter should be a low-pass filter or a band-pass filter for cutting off a signal other than a signal in a specific frequency band.

Next, in the case in which the communication line is a telephone line, for instance, the first PLC modem injects/extracts a communication signal to/from the telephone line provided in a house including the second PLC modem. In the case in which there is a plurality of houses including the

second PLC modem, it is preferable that the first PLC modem should inject/extract the communication signal to/from the telephone line provided in each house. At this time, the telephone line to be provided in each house is gathered in one place in the building. In the case in which there is a plurality of houses including the second PLC modem, accordingly, the first PLC modem can easily inject/extract the communication signal if it is provided in a place in which the telephone lines are gathered and disposed, which is preferable.

In the case in which the first PLC modem injects/extracts the communication signal to/from the communication line as described above, the second PLC modem has such a structure as to inject/extract the communication signal to/from the power line. At this time, it is preferable to provide a relay device for relaying the communication signal between the communication line and the power line. The relay device includes a device capable of extracting the communication signal from the communication line to which the communication signal is transmitted from the first PLC modem and injecting the communication signal to the power line provided with the second PLC modem, and extracting the communication signal from the power line and injecting the communication signal to the communication line. An impedance matching device may be utilized as described above or a well-known repeater may be utilized. Such a relay device may be provided in a house including the second PLC modem and may have such a structure as to extract a communication signal from the terminal portion of a communication line which is provided in the house and to which the communication signal is transmitted from the first PLC modem and to inject the communication signal to the same terminal portion, and to inject the communication signal to a power line (for instance, an indoor wiring) provided in the house and serving to supply a power to the same house and to extract the communication signal from the power line.

With the structure, a communication line having the attenuation of the communication signal reduced is utilized for

a signal transmission path between the first PLC modem and the relay device, and a power line is utilized for a signal transmission path between the relay device and the second PLC modem. With this structure, the communication signal is attenuated with difficulty between the first PLC modem and the house including the second PLC modem. In the same house, it is possible to carry out a communication through a communication signal in a more excellent state by utilizing a terminal device connected to the second PLC modem.

In this configuration, moreover, the communication signal is transmitted to the power line in the house including the second PLC modem through the relay device. Therefore, the second PLC modem can inject/extract the communication signal to/from the terminal portion (receptacle) of an optional power line in the same house. Accordingly, the second PLC modem can be set to be an optional receptacle in the house including the second PLC modem.

As the second aspect in this invention, a first PLC modem is provided on a power line and a second PLC modem is provided on a communication line as explained below.

Namely, there will be considered the case in which the first PLC modem injects/extracts a communication signal to/from the power line. At this time, it is possible to employ a structure in which the first PLC modem is provided in a power device chamber for accommodating power devices such as a switch and a transformer in which power lines for supplying a power to each house are gathered, and injects/extracts a communication signal to/from a power line in the vicinity of the power devices, and the second PLC modem injects/extracts the communication signal to/from the communication line. It is preferable that a relay device should be provided between the communication line and the power line in the same manner as described above. The relay device can extract the communication signal from the power line to which the communication signal is transmitted from the first PLC modem and can inject the communication signal to the communication

line on which the second PLC modem is provided, and can extract the communication signal from the same communication line and can inject the communication signal to the same power line, and the impedance matching device may be utilized or a well-known repeater may be utilized.

With the structure, the power line is used for a signal transmission path between the first PLC modem and the relay device and the communication line is used for a signal transmission path between the relay device and the second PLC modem. In this case, if a section for using the power line as the signal transmission path is shortened as greatly as possible and a section for using the communication line as the signal transmission path is lengthened, the attenuation of the communication signal can be more lessened. Accordingly, it is preferable that the relay device should be provided in such a manner that the injecting/extracting points of the communication signal of the relay device and the injecting/extracting points of the communication signal of the first PLC modem in the power line approach each other as greatly as possible. Accordingly, it is preferable that the terminal portion of the communication line to/from which the relay device injects/extracts the communication signal should be close to the injecting/extracting points of the communication signal of the first PLC modem.

In this configuration, it is preferable that the second PLC modem should be provided in the terminal portion of the communication line provided in the house including the second PLC modem and the communication signal should be directly extracted/injected from/to the communication line. In this configuration, the second PLC modem is directly connected to the communication line. For this reason, the relay device is not required on the second PLC modem side as in a configuration which will be described below.

As the third aspect in this invention, both a first PLC modem and a second PLC modem are provided on a power line and a communication line is provided between a first power line on

which the first PLC modem is to be disposed and a second power line on which the second PLC modem is to be disposed as explained below.

While the configuration described above has the structure in which the second PLC modem directly injects/extracts the communication signal to/from the communication line, it is also possible to employ a structure in which the second PLC modem injects/extracts the communication signal to/from the communication line through the power line. More specifically, it is also possible to employ a structure in which both the first PLC modem and the second PLC modem inject/extract the communication signal to/from the power line and the communication line is present in a signal transmission path between the power lines on which both of the modems are provided. In this case, it is preferable that the first PLC modem should inject/extract the communication signal to/from a first power line (for instance, a low voltage distribution power line), the second PLC modem should inject/extract the communication signal to/from a second power line (for instance, the indoor wiring of a house including the second PLC modem), and a relay device should be provided between the first power line and the communication line and between the second power line and the communication line, respectively.

Examples of the relay device to be provided between the first power line and the communication line include a device capable of extracting the communication signal from the first power line and injecting the communication signal to the communication line, and extracting the communication signal from the communication line and injecting the communication signal to the first power line, and the impedance matching device may be utilized or a well-known repeater may be utilized. It is desirable that such a relay device should be provided in such a manner that the injecting/extracting points of the communication signal of the relay device and the injecting/extracting points of the communication signal of the first PLC modem in the first power line approach each other as

greatly as possible. Accordingly, it is preferable that the terminal portion of the communication line to/from which the relay device injects/extracts the communication signal should be close to the injecting/extracting points of the communication signal of the first PLC modem.

Examples of the relay device to be provided between the second power line and the communication line include a device capable of extracting the communication signal from the second power line and injecting the communication signal to the communication line, and extracting the communication signal from the communication line and injecting the communication signal to the second power line, and the impedance matching device may be utilized or a well-known repeater may be utilized. It is desirable that such a relay device should be provided in such a manner that the injecting/extracting points of the communication signal of the relay device and the injecting/extracting points of the communication signal of the second PLC modem in the second power line approach each other as greatly as possible. Accordingly, it is preferable that the relay device should be provided in a house including the second PLC modem. In this case, the communication signal is injected/extracted to/from the terminal portion of the communication line provided in the house including the second PLC modem in the relay device.

In this configuration, the communication signal is transmitted to the power line in the house including the second PLC modem through the relay device provided between the second power line and the communication line. Therefore, the second PLC modem can inject/extract the communication signal to/from the terminal portion (receptacle) of an optional power line in the same house. Accordingly, the second PLC modem can be set to be an optional receptacle in the house including the second PLC modem.

Moreover, the invention can attain the objects by lowering a usage frequency band and specifying a position in which a head end is to be provided.

More specifically, the invention provides a communication system comprising a common receiving terminal portion provided in a building having a plurality of houses and serving to receive a video and audio signal in a high frequency band in common, and a plurality of branch communication lines for transmitting the video and audio signal from the common receiving terminal portion to each of the houses. There are provided a first communication device for modulating a digital video and audio signal to a low frequency band having a lower frequency than a frequency in the high frequency band and injecting the same signal to the vicinity of the common receiving terminal portion, and a second communication device which is connected to a terminal portion of a branch communication line provided in each of the houses and can demodulate a signal modulated by the first communication device.

Conventionally, there has not been supposed that a video and audio signal is distributed in a frequency band of less than 70 MHz in respect of the problem of a mixing noise. However, the inventors investigated that the usage frequency band of the video and audio signal is to be more lowered. Therefore, they tried to utilize, as a head end, a PLC modem capable of modulating/demodulating a communication signal at a frequency of 10 MHz or less. However, the influence of the mixing noise cannot be reduced even if the conventional head end is simply replaced with the PLC modem. Therefore, the inventors provide a communication device capable of modulating the digital video and audio signal of the PLC modem to have a lower frequency than the frequency of the frequency band of a TV signal or a CATV signal in a building itself in place of a location other than the building. By such an arrangement, a house for receiving a signal transmitted from the communication device is limited so that a reduction in the influence of the mixing noise can be implemented at a downstream side seen from the distributing side of the TV signal.

The invention is intended for a building having a plurality of houses, for instance, an apartment building or a commercial

building such as an office building or a multi-use building, and a building in which the houses receive the video and audio signal of a high frequency band such as a TV signal or a CATV signal in common. More specifically, there is utilized a building including a common receiving terminal portion for receiving the video and audio signal of the high frequency band in common and a plurality of branch communication lines connected to the common receiving terminal portion and serving to transmit the same signal to each house.

The video and audio signal of the high frequency band includes a TV signal and a CATV (Community Antenna TV) signal. Examples of the common receiving terminal portion include an amplifier for amplifying the video and audio signal of the high frequency band and a distributor for distributing the same signal to each house. The distributor and the amplifier include an amplifier to be generally used in the amplification of the TV signal or the CATV signal and a distributor to be generally used in the distribution of the same signal. In the invention, moreover, each branch communication line is utilized as a signal transmission path. The branch communication line includes a coaxial cable to be generally used in the transmission of the TV signal or the CATV signal. The arrangement state of the branch communication line includes a state in which one end side of each branch communication line is connected to a common receiving terminal portion (usually, a distributor), that is, a tree-shaped arrangement configuration in which each branch communication line branches from the common receiving terminal portion. Moreover, there is generally used a configuration in which a plurality of houses shares one branch communication line. At this time, a plurality of terminal portions is provided on one branch communication line, and these terminal portions are provided in the houses, respectively. Consequently, it is possible to receive a video and audio signal such as the CATV signal.

In the building in which the common receiving configuration of the video and audio signal in the high frequency band is

constructed, the branch communication line is utilized as the signal transmission path. In the invention, a first communication device capable of carrying out a modulation into a low frequency band having a lower frequency than the frequency of the high frequency band is utilized for injecting a digital video and audio signal. The first communication device has a structure in which a modulated signal can be injected to the signal transmission path, for instance, includes a receiving portion for receiving the same signal, a power portion constituted by a power circuit for obtaining a power to operate each component such as the receiving portion, and an interface required for a communication with an outside.

In particular, it is assumed that the first communication device has such a structure that a digital video and audio signal can be modulated to have a lower frequency than the frequency of a high frequency band to be used for a video and audio signal. It is an object of the invention to reduce the attenuation of a transmission signal. In the invention, accordingly, the digital video and audio signal is defined to be modulated to a lower frequency band than a usage frequency band (a high frequency band) of the video and audio signal. More specifically, for instance, the frequency band of a TV signal has a VHF band of 90 MHz to 222 MHz and a UHF band of 470 MHz to 770 MHz, and the frequency band of a CATV signal has a distribution signal of 70 to 770 MHz. Accordingly, a frequency band in which the first communication device carries out the modulation is less than 70 MHz. In particular, a frequency band of 1.7 MHz to 50 MHz is preferable. A frequency band of 50 MHz or less is effective for reducing the attenuation of a signal, and a frequency band of 1.7 MHz or more can avoid an interference with an AM radio broadcast. In the CATV signal, moreover, the frequency band of a return signal is set to be 10 to 50 MHz, and a frequency band of approximately 40 MHz is often utilized. In the case in which the modulation is to be carried out with 10 to 50 MHz, accordingly, it is preferable that the first communication device should perform the modulation by masking the frequency band used

in a video and audio signal in such a manner that the frequency band of a digital video and audio signal is different from the frequency band used in the video and audio signal.

A modulating method includes a method of modulating the digital video and audio signal at a carrier frequency of 50 MHz or less and any of a single frequency, plural frequencies and a continuous frequency, for instance. More specifically, the modulating method includes an SS (Spread Spectrum ; frequency diffusing) method for distributing a sine wave having a single frequency into a large frequency and transmitting the sine wave and restoring the sine wave into the original sine wave having the single frequency upon receiving, an OFDM (Orthogonal Frequency Domain Multiplex ; orthogonal frequency multiplexing) method for dividing a signal into a large number of sine waves having orthogonal frequencies and densely superimposing wave data thus obtained by the division, and furthermore, an FSK (Frequency shift keying ; frequency modulating) method and a PSK (Phase Shift Keying ; phase modulating) method.

As the first communication device having the structure described above, it is possible to utilize a well-known PLC modem used as a so-called parent modem.

It is also an object of the invention to reduce the influence of a mixing noise. Therefore, the modulated signal is injected into the vicinity of the common receiving terminal portion in which a plurality of branch communication lines is gathered in the first communication device to limit a house capable of sufficiently receiving the injected signal. When the modulated signal is injected into the vicinity of the common receiving terminal portion, the injected signal is almost transmitted to the branch communication line connected to the common receiving terminal portion. More specifically, a house including a branch communication line positioned on the downstream side of the first communication device as seen from the distributing side of a video and audio signal in a high frequency band can receive the signal from the first communication device. In the invention, thus, a place in the first communication device in which the

signal is to be injected is defined to limit a range in which the signal can be received from the first communication device, thereby reducing the influence of the mixing noise. Depending on the capability of the first communication device or the number of the branch communication lines which are provided, the influence of the mixing noise is generated with difficulty if one well-known PLC modem is provided in a building having approximately 20 to 100 houses.

The vicinity of the common receiving terminal portion includes the upstream side of an amplifier seen from the signal distributing side of a video and audio signal in a high frequency band, a portion between the amplifier and a distributor (the downstream side of the amplifier and the upstream side of the distributor), and the downstream side of the distributor, for instance. In some cases in which the common receiving terminal portion of the amplifier or the distributor is a device for the video and audio signal in the high frequency band such as a TV signal or a CATV signal, the loss of a frequency band excluding the frequency band of the same signal is not considered. In such cases, it is preferable that the common receiving terminal portion should be bypassed to directly inject the modulated signal to the branch communication line. At this time, it is possible to prevent the signal from being attenuated by the common receiving terminal portion.

By the regulations of the portion of the first communication device in which the signal is to be injected, the first communication device is arranged in a building itself which has the common receiving terminal portion. A specific place of arrangement includes a place in which the common receiving terminal portion to be the signal injecting portion is provided, for instance, the vicinity of a rooftop portion or an underground portion.

In the invention, moreover, there is provided a second communication device which is connected to the terminal portion of the branch communication line included in each house and can demodulate a signal modulated by the first communication device.

More specifically, it is assumed that the second communication device can extract the modulated signal to be transmitted from the first communication device to the branch communication line. For instance, there are provided a receiving portion for receiving a modulated signal and a power portion constituted by a power circuit for obtaining a power to operate each component such as the receiving portion. As such a second communication device, it is possible to use a well-known PLC modem utilized as a so-called child modem. Moreover, the second communication device is connected to the terminal portion of the branch communication line provided in each house, for instance, a branching device for branching a video and audio signal such as a TV signal or a CATV signal, thereby extracting and demodulating the modulated signal.

A plurality of houses including the second communication device may be present in a building. In this case, it is preferable to utilize the first communication device having a structure in which a modulated signal can be transmitted to a plurality of second communication devices, more specifically, a structure in which the time sharing of each of the second communication devices is controlled to transmit the modulated signal to each of the second communication devices, for instance. In the invention, the house does not always imply only a general residence but a plurality of small spaces obtained by dividing the inside of a building. More specifically, examples of the house include an individual and independent house requiring a communication, a company, an office and a room.

The first communication device and the second communication device match impedances in order to adapt to the impedance of the branch communication line to be the signal transmission path, respectively.

Moreover, the invention can attain the objects by utilizing a communication device capable of modulating/demodulating a communication signal into a frequency band excluding the frequency band of a video and audio signal, and furthermore, injecting the communication signal to each of the branch

communication lines without carrying out branching after injecting the communication signal to the communication line.

More specifically, the invention provides a communication system in a building including a plurality of houses for receiving a video and audio signal in common, comprising a first distributor for distributing the video and audio signal to each house, and a plurality of branch communication lines connected to the first distributor and serving to transmit the video and audio signal to each house. Furthermore, there are provided a first communication device for modulating/demodulating a communication signal into a frequency band excluding the frequency band of the video and audio signal, and a second communication device which is connected to the terminal portion of a branch communication line provided in the house and can extract the communication signal to be transmitted to the branch communication line from / inject the communication signal to the branch communication line. The first communication device is characterized in that the communication signal is injected/extracted to/from each of the branch communication lines. The invention will be described below in detail.

The invention is intended for a building having a plurality of houses, for instance, an apartment building or a commercial building such as an office building or a multi-use building, and a building in which the houses receive a video and audio signal in common. More specifically, there is utilized a building including a first distributor for distributing the video and audio signal to each house, and a plurality of branch communication lines connected to the first distributor and serving to transmit the video and audio signal to each house. In the invention, the branch communication line to be provided in the building is utilized as a signal transmission path.

The video and audio signal includes a TV signal and a CATV (Community Antenna TV) signal. The first distributor includes a distributor to be generally used in the distribution of the TV signal or the CATV signal. Moreover, the branch communication line includes a coaxial cable to be generally used in the

transmission of the TV signal or the CATV signal. The arrangement state of the branch communication line includes a state in which one end side of each branch communication line is connected to the first distributor, that is, a so-called tree-shaped arrangement configuration in which each branch communication line branches from the first distributor. Moreover, there is generally used a configuration in which a plurality of houses shares one branch communication line. At this time, a plurality of terminal portions is provided on one branch communication line, and these terminal portions are provided in the houses, respectively. Consequently, it is possible to receive a video and audio signal such as the TV signal.

In the building in which the common receiving configuration of the video and audio signal is constructed, the invention utilizes the first communication device capable of modulating/demodulating a communication signal into a frequency band excluding the frequency band of the video and audio signal for injecting/extracting the communication signal. The first communication device has a structure in which the communication signal can be injected/extracted to/from the branch communication line, for instance, includes a transmitting/receiving portion for transmitting/receiving the communication signal, a power portion constituted by a power circuit for obtaining a power to operate each component such as the transmitting/receiving portion, and an interface required for a communication with an outside.

In particular, it is assumed that the first communication device has such a structure that a communication signal can be modulated/demodulated into a frequency band excluding the frequency band of a video and audio signal. The usage frequency band of the video and audio signal generally has a high frequency. Therefore, the frequency band for the modulation/demodulation of the first communication device includes a low frequency band which does not overlap with the high frequency band, for instance. More specifically, for instance, the frequency band of a TV signal has a VHF band of 90 MHz to 222 MHz and a UHF band of 470 MHz

to 770 MHz, and the frequency band of a CATV signal has a distribution signal of 70 to 770 MHz. Accordingly, a frequency band in which the first communication device carries out the modulation/demodulation has a band of less than 70 MHz. In particular, an interference with the video and audio signal is generated with difficulty if the frequency band is set to be 50 MHz or less, and an interference with an AM radio broadcast can be avoided if the frequency band is set to be 1.7 MHz to 50 MHz, which is preferable. In the CATV signal, moreover, the frequency band of a return signal is set to be 10 to 50 MHz, and a frequency band of approximately 40 MHz is often utilized. In the case in which the modulation/demodulation is to be carried out with 10 to 50 MHz, accordingly, it is preferable that the first communication device should perform the modulation/demodulation by masking the frequency band used in a video and audio signal in such a manner that the frequency band of the communication signal is different from the frequency band used in the video and audio signal.

A modulating/demodulating method includes a method of modulating/demodulating the communication signal at a carrier frequency of 50 MHz or less and any of a single frequency, plural frequencies and a continuous frequency, for instance. More specifically, the modulating/demodulating method includes an SS (Spread Spectrum ; frequency diffusing) method for distributing a sine wave having a single frequency into a large frequency and transmitting the sine wave and restoring the sine wave into the original sine wave having the single frequency upon receiving, an OFDM (Orthogonal Frequency Domain Multiplex ; orthogonal frequency multiplexing) method for dividing a communication signal into a large number of sine waves having orthogonal frequencies and densely superimposing wave data thus obtained by the division, and furthermore, an FSK (Frequency shift keying ; frequency modulating) method and a PSK (Phase Shift Keying ; phase modulating) method.

A well-known PLC modem to be utilized as a so-called parent modem may be used for the first communication device having the

injecting/extracting and modulating/demodulating functions of the communication signal. By using the PLC modem, it is possible to carry out a high-speed communication. A place in which such a first communication device is to be provided includes the vicinity of the first distributor in which a plurality of branch communication lines is gathered to easily inject/extract the communication signal.

In some cases, the distributor to be usually used in the distribution of a video and audio signal such as a TV signal or a CATV signal is not considered in respect of the loss of a frequency band excluding the frequency band of the same signal. On the other hand, in the invention, the communication signal is injected to each of the branch communication lines branched from the first distributor, and furthermore, the communication signal is extracted from each of the branch communication lines. Therefore, it is possible to prevent the communication signal from being attenuated by the first distributor.

The first communication device injects/extracts the communication signal to/from the branch communication lines, respectively. Consequently, the different branch communication lines are connected to each other through the first communication device. In many cases, an adjustment is carried out, for instance, the impedances of the branch communication lines are matched with each other in such a manner that the transmission characteristic of the video and audio signal is brought into an excellent state. For this reason, the different branch communication lines are connected to each other through the first communication device so that the transmission characteristic of the video and audio signal might be deteriorated. Therefore, it is preferable that a filter for cutting off a signal present in the frequency band of the video and audio signal should be provided between the first distributor and the first communication device in order to effectively prevent the deterioration in the transmission characteristic of the video and audio signal. In the case in which the video and audio signal is present in a high frequency band, for instance,

the filter includes a low-pass filter for cutting off the video and audio signal and a band-pass filter for cutting off a signal other than a signal in a specific frequency band (excluding the frequency band of the video and audio signal).

In the invention, moreover, there is provided a second communication device which is connected to the terminal portion of the branch communication line provided in each house and can carry out a communication with the first communication device through a communication signal. More specifically, it is assumed that the second communication device can extract the communication signal to be transmitted from the first communication device to the branch communication line / inject the communication signal to the branch communication line. For instance, there are provided a transmitting/receiving portion for transmitting/receiving the communication signal and a power portion constituted by a power circuit for obtaining a power to operate each component such as the transmitting/receiving portion. It is also possible to use a well-known PLC modem to be utilized as a so-called child modem. By using the PLC modem, it is possible to carry out a high-speed communication.

A plurality of houses including the second communication device may be present in a building. In this case, it is preferable to utilize the first communication device having a structure in which a communication signal can be transmitted to a plurality of second communication devices, more specifically, a structure in which the time sharing of each of the second communication devices is controlled to transmit the communication signal to each of the second communication devices, for instance. In the invention, the house does not always imply only a general residence but a plurality of small spaces obtained by dividing the inside of the building. More specifically, examples of the house include an individual and independent house requiring a communication, a company, an office and a room.

The second communication device is connected to the terminal portion of the branch communication line provided in each house, for instance, a branching device for branching a

video and audio signal such as a TV signal or a CATV signal. The branching device to be used for branching the TV signal or the CATV signal usually carries out an adjustment, for instance, matches an impedance with the usage frequency band of the same signal. Consequently, there is a possibility that the signal present in the frequency band other than the same signal might make a great loss. For this reason, it is preferable that the terminal portion of the branching device should be bypassed. More specifically, the branch communication line and the second communication device are connected to each other through a first bypass line. When the video and audio signal is transmitted to the first bypass line, however, there is a possibility that the impedance matching with the video and audio signal to be transmitted to the terminal portion might not be taken. Accordingly, it is preferable that the first bypass line should be provided with a filter capable of cutting off a signal in the frequency band of the video and audio signal. Examples of the filter include a low-pass filter for cutting off the video and audio signal and a band-pass filter for cutting off a signal other than a signal in a specific frequency band (excluding the frequency band of the video and audio signal) in the case in which the video and audio signal is present in a high frequency band.

The first communication device and the second communication device match impedances in order to adapt to the impedance of the branch communication line to be a signal transmission path, respectively.

In some cases, any of the branch communication lines connected to the first distributor (which will be hereinafter referred to as a main branch communication line) is further branched into a plurality of sub-branch communication lines. More specifically, there is provided a second distributor which is connected to any of the main branch communication lines and serves to further distribute the video and audio signal in addition to the first distributor. In some cases in which the second distributor is generally used for distributing the TV

signal or the CATV signal in the same manner as the first distributor, the loss of a signal present in a frequency band excluding the frequency band of the same signal is not considered. Therefore, it is preferable to bypass the second distributor in place of the transmission of a communication signal from the main branch communication line to the sub-branch communication line through the second distributor. More specifically, it is preferable to include a second bypass line for connecting the main branch communication line to the sub-branch communication line, thereby transmitting the communication signal through the second bypass line. In many cases, the sub-branch communication lines are subjected to the execution of an adjustment such as impedance matching respectively in the same manner as described above, and a plurality of different sub-branch communication lines is connected to each other through the second bypass line so that there is a possibility that the transmission characteristic of the video and audio signal might be deteriorated. In order to effectively prevent the deterioration, it is preferable to include a filter for cutting off a signal present in the frequency band of the video and audio signal. For instance, the filter includes a low-pass filter and a band-pass filter.

In such a common receiving configuration as to include a plurality of distributors such as the second distributors in a multi-stage in addition to the first distributor as described above, the signal injecting/extracting points of the communication signal of the first communication device are provided apart from the signal extracting/injecting points of the communication signal of the second communication device. At this time, the amount of the attenuation of the communication signal is increased. Consequently, there is a possibility that a communication cannot be carried out through the communication signal between the first communication device and the second communication device. Also in the case in which the signal injecting/extracting points in the first communication device are provided apart from the signal extracting/injecting points

in the second communication device, therefore, it is preferable to include a repeater in the second bypass line in such a manner that the communication can be carried out well. The repeater can extract the communication signal which is injected from the first communication device and is transmitted to the main branch communication line, can inject the communication signal to the second bypass line and can extract the communication signal to be transmitted to the second bypass line, and can inject the communication signal to the main branch communication line, and can reproduce a waveform distorted during the transmission into a normal state. A well-known repeater may be utilized.

<BRIEF DESCRIPTION OF THE DRAWINGS>

Fig. 1 is a diagram schematically showing a power line communication system according to a first embodiment of the invention, illustrating an embodiment in which a parent modem injects/extracts a communication signal to/from a coaxial cable and a child modem injects/extracts the communication signal to/from an indoor wiring and the case in which the house of a building includes the parent modem.

Fig. 2 is an explanatory diagram showing the bypass structure of a distributor in the power line communication system according to the first embodiment of the invention, schematically illustrating the vicinity of the distributor, (A) showing an embodiment in which branch communication lines are connected to each other through a wiring, (B) showing an embodiment in which the same wiring includes a filter, and (C) showing an embodiment in which a wiring connected to one branch communication line is branched to be connected to a plurality of branch communication lines.

Fig. 3 is a diagram schematically showing the power line communication system according to the second embodiment of the invention, illustrating an embodiment in which a parent modem injects/extracts a communication signal to/from a coaxial cable and a child modem injects/extracts the communication signal to/from an indoor wiring and the case in which the rooftop portion

of a building includes the parent modem.

Fig. 4 is a diagram schematically showing the power line communication system according to the third embodiment of the invention, illustrating an embodiment in which the parent modem injects/extracts the communication signal to/from a telephone line and the child modem injects/extracts the communication signal to/from the indoor wiring.

Fig. 5 is a diagram schematically showing the power line communication system according to the fourth embodiment of the invention, illustrating an embodiment in which the parent modem injects/extracts the communication signal to/from a low voltage distribution power line and the child modem injects/extracts the communication signal to/from the coaxial cable.

Fig. 6 is a diagram schematically showing the power line communication system according to the fifth embodiment of the invention, illustrating an embodiment in which both a first PLC modem and a second PLC modem are provided on a power line and a communication line is provided between a first power line on which the first PLC modem is to be disposed and a second power line on which the second PLC modem is to be disposed.

Fig. 7 is a diagram schematically showing the power line communication system according to the sixth embodiment of the invention, illustrating an embodiment of a first PLC modem is provided on a power line and a communication line and a second PLC modem is provided on a power line

Fig. 8 is a schematic diagram showing the structure of an impedance matching device to be utilized for the power line communication system according to the seventh embodiment of the invention.

Fig. 9 is an explanatory diagram typically showing a conventional art of a communication system using a PLC method, illustrating the case in which a PLC user house is an apartment building.

Fig. 10 is a diagram schematically showing a communication system according to an eighth embodiment of the invention.

Fig. 11 is an explanatory diagram schematically showing

another conventional art having the common receiving configuration of a CATV signal in a building including a plurality of houses.

Fig. 12 is a diagram schematically showing a communication system according to a ninth embodiment of the invention.

Fig. 13 is a diagram schematically showing the signal transmission path of the communication system according to the ninth embodiment of the invention, illustrating an embodiment in which a filter is provided between a parent modem and a distributor.

Fig. 14 is a diagram schematically showing the signal transmission path of the communication system according to the ninth embodiment of the invention, illustrating an embodiment in which a distributor is provided in a multi-stage.

Fig. 15 is a diagram showing an embodiment in which the communication system illustrated in Fig. 14 is further provided with a repeater.

Fig. 16 is an explanatory diagram schematically showing another conventional art having the common receiving configuration of a TV signal in a building including a plurality of houses.

Referring to designations in Figs. 1 to 9, 1010 to 1012 denote a parent modem, 1020 and 1021 denote a child modem, 1030 denotes an impedance matching device, 1031 denotes a ferromagnetic material, 1032 denotes a first winding, 1033 denotes a second winding, 1050 denotes a building, 1060 to 1062 denote a relay device, 1080 denotes a distributor, 1090 denotes a coaxial cables, 1090A to 1090D denote a core, 1091, 1091a, 1091c and 1091d denote a terminal portion, 1092 and 1093 denote a wiring, 1092a denotes a filter, 1095 and 1095a denote a telephone line, 1096 and 1096a denote a terminal portion, 97 denotes a communication line, 1097a denotes a conductor, 1097b denotes a shield layer, 1098 denotes a terminal portion, 1100 denotes a low voltage distribution power line, 1100a denotes a first power line, 1100b denotes a second power line, 1101 and 1101A to 1101C denote an indoor wiring, 1102a to 1102c denotes a

receptacle, 1110 denotes an optical fiber cable, 1200, 1200A to 1200C and 1210 denote a house, 1201 denotes a terminal device, 1202 denotes a cabinet panel, 1203 denotes a watthour meter, 1204 denotes a television, 1205 denotes a telephone, 1300 denotes an external network, 1400 denotes a power device chamber, 1401 denotes a power device, 1500 denotes a parent modem, and 1600 denotes a child modem.

Referring to designations in Figs. 10 and 11, moreover, 2010 denotes a parent modem, 2020 denotes a child modem, 2090 and 2091 denote a building, 2092 denotes a detached house, 2101 denotes an amplifier, 2102 denotes a distributor, 2110 denotes an indoor communication line, 2111 to 2114 denote a branch communication line, 2120 and 2121 denote a terminal portion, 2150 denotes a communication line, 2200 and 2210 denote a house, 2300 denotes an image receiver, 2400 denotes a terminal device, 2500 denotes a station, and 2600 and 2601 denote a head end.

Referring to designations in Figs. 12 to 16, furthermore, 3010 denotes a parent modem, 3020 denotes a child modem, 3030, 3040 and 3050 denote a filter, 3060 denotes a repeater, 3090 denotes a building, 3100 denotes an antenna, 3101 denotes an amplifier, 3102 to 3106 denote a distributor, 3110 denotes a communication line, 3111 to 3114 denote a branch communication line, 3111' to 3114' denote a wiring, 3111A, 3112A, 3113A, 3114A and 3111a to 3111d denote a sub-branch communication line, 3120 to 3122 denote a terminal portion, 3130 and 3160 to 3164 denote a bypass line, 3150 denotes an optical fiber cable, 3200 and 3210 denote a house, 3300 denotes an image receiver, 3400 denotes a terminal device, 3500 denotes a station, and 3600 denotes an upper network.

<BEST MODE FOR CARRYING OUT THE INVENTION>

<First Embodiment: A first PLC modem is provided on a communication line and a second PLC modem is provided on a power line>

Fig. 1 is a typical diagram schematically showing a power line communication system according to the invention,

illustrating an embodiment in which a parent modem injects/extracts a communication signal to/from a coaxial cable and a child modem injects/extracts the communication signal to/from an indoor wiring and the case in which a house (a power device chamber) in a building includes the parent modem. The system according to the invention serves to combine a power line (a low voltage distribution power line 1100 and an indoor wiring 1101) which is provided in a building 1050 having a plurality of houses and serves to supply a power to each of the houses and a communication line (a coaxial cable 1090 in an embodiment shown in Fig. 1) provided in the building 1050 with each other in the building 1050, thereby constructing the signal transmission path of a power line communication signal. This system comprises a parent modem (a first PLC modem) 1010 capable of carrying out a communication with an outside (an external network 1300) through a communication signal, and a child modem (a second PLC modem) 1020 which is provided in a house 1200 in the building 1050 and can carry out a communication with the parent modem 1010 through a communication signal. In this embodiment, the parent modem 1010 is provided on a communication line (a core 1090A of the coaxial cable 1090 in Fig. 1) and injects/extracts the communication signal to/from the communication line, and the child modem 1020 is provided on a power line (the indoor wiring 1101 of the house 1200 in Fig. 1) and injects/extracts the communication signal to/from the power line. More specifically, in this embodiment, the coaxial cable (the core 1090A) and the indoor wiring 1101 are combined with each other to construct the signal transmission path. Detailed description will be given below.

The building 1050 is provided with a power line for supplying a power to each house. More specifically, there are provided the low voltage distribution power line 1100 connected to a high-tension distribution power line (not shown) through a power device 1401 such as a transformer and the indoor wiring 1101 branched from the low voltage distribution power line 1100 and provided in each house. In the embodiment, the power device

1401 is disposed in a power device chamber 1400 provided in the building 150. Moreover, the building 1050 is provided with the coaxial cable 1090 for transmitting a TV signal to each house. The coaxial cable 1090 is constituted by a plurality of cores 1090A to 1090D, and the cores 1090A to 1090D are gathered in a rooftop portion. The cores 1090A to 1090D are provided in a plurality of houses respectively, and the houses share one core. A TV signal is received by an antenna (not shown) provided in the rooftop portion and is distributed to each of the cores 1090A to 1090D through a distributor 1080, and is received by connecting a television 1204 to a terminal portion (a branching device) 1091 of each of the cores 1090A to 1090D provided in each of the houses.

In the embodiment, the parent modem 1010 is provided in the power device chamber 1400 and is connected to a terminal portion 1091a of the core 1090A provided in the power device chamber 1400, and the parent modem 1010 injects/extracts a communication signal to/from the core 1090A through the terminal portion 1091a. The communication signal transmitted to the core 1090A is sent to the other cores 1090B to 1090D through the distributor 1080. Moreover, the communication signals transmitted to the cores 1090B to 1090D are sent to the core 1090A through the distributor 1080. In the embodiment, a parent modem having a well-known structure and taking matching with the impedance of the coaxial cable is utilized.

In the embodiment, moreover, the child modem 1020 is provided in the indoor wiring 1101 of the house 1200 and is connected to a receptacle 1102b provided on the indoor wiring 1101, and the child modem 1020 injects/extracts a communication signal to/from the indoor wiring 1101 through the receptacle 1102b. In the embodiment, a child modem having a well-known structure is utilized.

In the embodiment, there is provided a relay device 1060 for relaying a communication signal between the core 1090C provided in the house 1200 and the indoor wiring 1101 of the house 1200. The relay device 1060 is connected to a terminal

portion 1091c of the core 1090C provided in the house 1200 and a receptacle 1102a of the indoor wiring 1101 of the house 1200, and extracts the communication signal from the terminal portion 1091c and injects the communication signal to the receptacle 1102a / extracts the communication signal from the receptacle 1102a and injects the communication signal to the terminal portion 1091c. In the embodiment, there is utilized a relay device which is a well-known repeater and takes the matching of the characteristic impedance of the coaxial cable with that of the indoor wiring 1101.

By the structure, in the case in which the house 1200 receives a communication signal from the external network 1300, for instance, the communication signal is transmitted from the external network 1300 through an optical fiber cable 1110 and is converted to an optical signal / electric signal by an MC 1410, and is modulated by the parent modem 1010 and is then injected to the terminal portion 1091a of the core 1090A. The communication signal injected to the terminal portion 1091a is transmitted to the core 1090A and is transmitted to the cores 1090B to 1091D through the distributor 1080. The communication signal transmitted to the core 1090C is extracted by the relay device 1060 at the terminal portion 1091c of the core 1090C in the house 1200 and is injected to the receptacle 1102a provided in the indoor wiring 1101 of the house 1200, and is then transmitted to the indoor wiring 1101. The communication signal transmitted to the indoor wiring 1101 is extracted and demodulated by the child modem 1020 at the receptacle 1102b, and is then transmitted to a terminal device 1201 such as a personal computer. In the case in which the house 1200 transmits the communication signal to the external network 1300, a reverse course to the case of the receiving is followed.

In the system according to the invention, thus, it is possible to more lessen the attenuation of a communication signal as compared with the case in which a signal transmission path is constructed by only a power line by utilizing a communication line in at least a part of the signal transmission path in addition

to the power line. In the case in which the system according to the invention is constructed, accordingly, it is possible to extract the communication signal, thereby ensuring an excellent communication state also in a house present in a place positioned apart from the injecting point of the communication signal through the parent modem, for instance.

In the embodiment shown in Fig. 1, particularly, the communication line (the coaxial cable 1090) is utilized in the signal transmission path between the parent modem 1010 and the relay device 1060 and the power line (the indoor wiring 1101) is utilized in only the signal transmission path between the relay device 1060 and the child modem 1020. Consequently, it is possible to shorten a distance at which the communication signal is transmitted through the power line. Thus, it is possible to more lessen the attenuation of the communication signal. In the embodiment shown in Fig. 1, moreover, the communication signal is transmitted to the indoor wiring 1101 of the house 1200. Therefore, the child modem 1020 can inject/extract the communication signal to/from the optional receptacle of the indoor wiring 1101. In many cases in which the high-tension distribution power line or the optical fiber cable 1110 is buried in the ground as shown in Fig. 1, furthermore, the power device chamber 1400 is provided in the underground or first floor of the building 1050. By providing the parent modem 1010 in the power device chamber 1400, accordingly, it is possible to easily lead the optical fiber cable 1110 into the building 1050. Consequently, it is not necessary to provide an optical fiber cable separately.

The coaxial cable usually transmits a TV signal or a CATV signal. For this reason, the system according to the invention uses a communication signal in a frequency band which does not overlap with the frequency bands of the TV signal and the CATV signal, for instance, a communication signal in a frequency band of 1.7 to 30 MHz. While the parent modem and an MC are provided separately in the embodiment, moreover, it is also possible to utilize a parent modem having the MC built therein. In the case

in which the communication signal is greatly attenuated by the frequency characteristic of the distributor, furthermore, it is preferable to connect the cores 1090A to 1090D through a wiring 1092 respectively as shown in Fig. 2(A), thereby bypassing the distributor 1080. As shown in Fig. 2(B), moreover, it is preferable that the wiring 1092 should be provided with a filter 1092a for blocking the passage of a signal in a frequency band used by the TV signal or the CATV signal. Since the different cores 1090A to 1090D are connected to each other through the wiring 1092 as shown in Fig. 2(A), there is a possibility that the transmission characteristic of the TV signal or the CATV signal might be deteriorated. By providing the filter 1092a, however, it is possible to suppress the deterioration in the transmission characteristic. In the embodiment, a low-pass filter is used. While Fig. 2(B) shows an embodiment in which the core 1090A and the cores 1090B to 1090D are connected through the different wirings 1092 respectively, the wiring 1092 provided on the core 1090A may be branched and connected to each of the cores 1090B to 1090D as shown in Fig. 2(C). These matters (the frequency band of the communication signal, the arrangement of the MC and the bypass structure of the distributor) are the same as those in an embodiment (2) and embodiments 2 and 3 which will be described below. In addition, while one house carries out a power line communication in the embodiment, a plurality of houses may be provided. In this case, each of the houses has a child modem and a relay device. While the parent modem is provided in the power device chamber in the embodiment, moreover, it may be disposed in a house present in a building, for instance, a concierge room.

<Second Embodiment: A first PLC modem is provided on a communication line and a second PLC modem is provided on a power line>

While a parent modem is provided in a power device chamber present in a building in the embodiment described above, explanation will be given to an embodiment in which the parent

modem is disposed in the rooftop portion of the building. Fig. 3 shows an embodiment in which the parent modem injects/extracts a communication signal to/from a coaxial cable and a child modem injects/extracts a communication signal to/from an indoor wiring, illustrating the case in which the parent modem is provided in the rooftop portion of a building. The basic structure of a system according to the invention in this embodiment is the same as that in the first embodiment and is different from that in the first embodiment in that a parent modem 1010 is provided in the rooftop portion of a building 1050.

In the first embodiment, there has been employed the structure in which the parent modem 1010 injects/extracts the communication signal to/from only a core 1090A in a coaxial cable 1090 and the signal is transmitted from the core 1090A to other cores 1090B to 1090D through a distributor 1080. In the embodiment, there is employed a structure in which the parent modem 1010 injects/extracts the communication signal to/from each of a plurality of cores 1090A to 1090D constituting the coaxial cable 1090. The cores 1090A to 1090D of the coaxial cable 1090 are gathered in the rooftop portion of the building 1050 as described above. In this embodiment, therefore, the parent modem 1010 is provided in the rooftop portion in order to easily inject/extract the communication signal to/from each of the cores 1090A to 1090D. The parent modem 1010 and the cores 1090A to 1090D are connected to each other through a wiring 1093, thereby transmitting the communication signal.

By this structure, a communication line is used in at least a part of a signal transmission path in addition to a power line in the same manner as that in the embodiment (1). Consequently, it is possible to reduce the attenuation of the communication signal. In this embodiment, particularly, the parent modem injects/extracts the communication signal to/from each of the cores. As compared with the first embodiment in which the communication signal is transmitted through a plurality of cores in some cases, therefore, it is possible to more shorten a distance at which the communication signal is transmitted to the

communication line, thereby reducing the attenuation of the communication signal in the communication line portion. Accordingly, it is possible to ensure a more excellent communication state.

While the injecting/extracting points of the communication signal of the parent modem 1010 are provided on the downstream side of the distributor 1080 in the embodiment shown in Fig. 3, the same injecting/extracting points may be provided on the upstream side of the distributor 1080 in the case in which the communication signal can pass through the distributor 1080. In the embodiment, moreover, the parent modem 1010 is disposed in the rooftop portion of the building 1050. Therefore, the optical fiber cable 1110 is provided up to the rooftop portion.

<Third Embodiment: A first PLC modem is provided on a communication line and a second PLC modem is provided on a power line>

While the coaxial cable is utilized as the communication line in the two first and second embodiments, description will be given to an embodiment in which a telephone line is utilized as the communication line. Fig. 4 is a typical diagram schematically showing the power line communication system according to the invention, illustrating an embodiment in which a parent modem injects/extracts a communication signal to/from the telephone line and a child modem injects/extracts a communication signal to/from an indoor wiring. The basic structure of the system according to the invention in this embodiment is the same as that in the embodiment shown in Fig. 1 and is different from that in the embodiment shown in Fig. 1 in that a parent modem (a first PLC modem) 1011 injects/extracts a communication signal to/from a telephone line 1095.

The telephone lines 1095 are individually provided in the houses of a building 1050, respectively. The telephone lines 1095 are gathered in a power device chamber 1400 and are led to the outside of the building 1050, for instance. A telephone

signal is transmitted to each of the telephone lines 1095 and is received by connecting a telephone 1205 to a terminal portion (a jack portion) 1096 of the telephone line 1095 provided in each house.

The telephone lines 1095 are individually provided in the houses respectively as described above. In the case in which the telephone line 1095 is utilized as the signal transmission path of a power line communication signal, therefore, the parent modem 1011 is connected to each of the telephone lines 1095 provided in the house for carrying out a power line communication and injects/extracts a communication signal to the telephone line 1095. The telephone lines 1095 in the embodiment are gathered in the power device chamber 1400 of the building 1050 as described above. In the embodiment, therefore, the parent modem 1011 is provided in the power device chamber 1400 in order to easily inject/extract the communication signal to/from the telephone line 1095. A house 1200 carrying out the power line communication connects a relay device 1061 to a terminal portion 1096a of a telephone line 1095a provided in the house 1200 and injects/extracts the communication signal to/from the terminal portion 1096a.

By this structure, a communication line is used in at least a part of a signal transmission path in addition to a power line in the same manner as that in the first and second embodiments. Consequently, it is possible to reduce the attenuation of the communication signal. In this embodiment, particularly, the parent modem injects/extracts the communication signal to/from each of the telephone lines. As compared with the first embodiment in which the communication signal is transmitted through a plurality of coaxial cables in some cases, therefore, it is possible to more reduce the attenuation of the communication signal in the communication line portion. Accordingly, it is possible to ensure a more excellent communication state.

While the parent modem 1011 is provided in the power device chamber 1400 in the embodiment shown in Fig. 4, it is sufficient that the parent modem 1011 is provided in a place in which the

telephone lines 1095 are gathered. Moreover, there is utilized the parent modem 1011 which is a well-known parent modem and takes matching with the impedance of the telephone line. There is utilized the relay device 1061 which is a well-known repeater and takes the matching of the characteristic impedance of the telephone line with that of a power line (low voltage distribution power line) 1100.

<Fourth Embodiment: A first PLC modem is provided on a power line and a second PLC modem is provided on a communication line>

Fig. 5 is a diagram schematically showing the power line communication system according to the invention, illustrating an embodiment in which a parent modem injects/extracts a communication signal to/from a low voltage distribution power line and a child modem injects/extracts a communication signal to/from a coaxial cable. In this embodiment, a coaxial cable 1090 is utilized as a communication line in the same manner as in the embodiment shown in Fig. 1 and a basic structure is similar. The embodiment is characterized in that a parent modem 1012 is provided on a power line (a low voltage distribution power line 1100 in Fig. 5) to inject/extract a communication signal to the power line, and a child modem 1020 is provided on a coaxial cable 1090 (a core 1090C in Fig. 5) to inject/extract the communication signal to/from the coaxial cable 1090. More specifically, in this embodiment, the low voltage distribution power line 1100 and the coaxial cable (cores 1090A and 1090C) are combined with each other to construct a signal transmission path.

In the embodiment, the parent modem 1012 is provided in a power device chamber 1400 and is connected to the low voltage distribution power line 1100 provided in the power device chamber 1400 so that the parent modem 1012 injects/extracts the communication signal to/from the low voltage distribution power line 1100. In the embodiment, the parent modem 1012 having a well-known structure is utilized.

On the other hand, in a house 1210, the child modem 21 is provided on the core 1090C of the coaxial cable 1090 provided

in the house 1210 and is connected to a terminal portion 1091d of the core 1090C so that the child modem 1021 injects/extracts a communication signal to/from the core 1090C through the terminal portion 1091d. In the embodiment, the child modem 1021 having a well-known structure and taking matching with the impedance of the coaxial cable is utilized.

There is provided a relay device 1062 for relaying a communication signal between the coaxial cable (the core 1090C) provided in the house 1210 and the low voltage distribution power line 1100. In the embodiment, the relay device 1062 is connected to a terminal portion 1091a of the core 1090A disposed in a house 1220 provided in a building 1050 and a receptacle 1102c of an indoor wiring 1101 provided in the house 1220, and the relay device 1062 extracts a communication signal from the receptacle 1102c and injects the communication signal to the terminal portion 1091a / extracts the communication signal from the terminal portion 1091a and injects the communication signal to the receptacle 1102c. In the embodiment, there is utilized the relay device 1062 which is a well-known repeater and takes the matching of the characteristic impedance of the coaxial cable with that of the power line (the low voltage distribution power line) 1100.

By the structure, in the case in which the house 1210 receives the communication signal from an external network 1300, for instance, the same communication signal passes through an optical fiber cable 1110 from the external network 1300 and is converted to an optical signal / electric signal at an MC 1410, and is modulated by the parent modem 1012 and is injected to the low voltage distribution power line 1100. The communication signal injected to the low voltage distribution power line 1100 is extracted by the relay device 1062 at the receptacle 1102c provided on the indoor wiring 1101 of the house 1220 which is the branch of the low voltage distribution power line 1100, and is injected to the terminal portion 1091a of the core 1090A provided in the house 1220 and is thus transmitted to the core 1090A. The communication signal transmitted to the core 1090A

is sent to cores 1090B to 1090D through a distributor 1080 and is extracted and demodulated by a child modem 1021 at the terminal portion 1091d of the core 1090C provided in the house 1210, and is transmitted to a terminal device 1201 such as a personal computer. In the case in which the house 1210 transmits the communication signal to the external network 1300, a reverse course to the case of the receiving is followed.

By the structure, the communication line is used for at least a part of the signal transmission path in addition to the power line in the same manner as that in the embodiment 1. Therefore, it is possible to reduce the attenuation of the communication signal. In this embodiment, particularly, the parent modem injects/extracts the communication signal to/from the power line. Also in a place in which the communication line is not provided, therefore, it is possible to inject the communication signal from the external network. This respect is the same as in an third embodiment which will be described below.

While there has been described the case in which one house carries out a power line communication in the embodiment, a plurality of houses may be provided. In that case, each of the houses has the child modem. While the parent modem is provided in the power device chamber and the relay device is provided in another house in the embodiment, moreover, both the parent modem and the relay device may be provided in the same house, for instance, a concierge room. This respect is the same as in the third embodiment which will be described below.

<Fifth Embodiment: A first PLC modem and a second PLC modem are provided on a power line and a communication line is provided between a first power line on which the first PLC modem is to be disposed and a second power line on which the second PLC modem is to be disposed>

Fig. 6 is a diagram schematically showing the power line communication system according to the invention, illustrating an embodiment in which both a parent modem and a child modem

inject/extract a communication signal to/from a power line. In this embodiment, a coaxial cable 1090 is utilized as a communication line in the same manner as that in the fourth embodiment and a basic structure is the same as that in the fourth embodiment. This embodiment is characterized in that a child modem 1020 is also provided on a power line (an indoor wiring 1101 of a house 1200 in Fig. 6) in addition to a parent modem 1012 and a communication signal is injected/extracted to/from the power line, and the communication signal is not directly transmitted between a low voltage distribution power line 1100 and the indoor wiring 1101 but the coaxial cable 1090 is provided therebetween. More specifically, in this embodiment, the low voltage distribution power line 1100, the coaxial cable (cores 1090A and 1090C) and the indoor wiring 1101 are combined with each other to construct a signal transmission path.

In the embodiment, the parent modem 1012 is provided in a power device chamber 1400 and is connected to the low voltage distribution power line 1100 provided in the power device chamber 1400 so that the parent modem 1012 injects/extracts the communication signal to the low voltage distribution power line 1100 in the same manner as in the fourth embodiment. In the same manner as in the fourth embodiment, moreover, there is provided a relay device 1062 for relaying a communication signal between the coaxial cable (the core 1090C) provided in the house 1200 and the low voltage distribution power line 1100 and the relay device 1062 is connected to a terminal portion 1091a of the core 1090A and a receptacle 1102c and extracts a communication signal from the receptacle 1102c and injects the communication signal to the terminal portion 1091a / extracts the communication signal from the terminal portion 1091a and injects the communication signal to the receptacle 1102c.

On the other hand, the house 1200 has the child modem 1020 provided on the indoor wiring 1101 thereof, and the child modem 1020 is connected to a receptacle 1102b and injects/extracts a communication signal to/from the indoor wiring 1101 through the receptacle 1102b in the same manner as in the third embodiment.

Moreover, the house 1200 is provided with a relay device 1060 for relaying the communication signal between the core 1090C and the indoor wiring 1101 of the house 1200, and the relay device 1060 is connected to a terminal portion 1091c of the core 1090C and a receptacle 1102a and extracts the communication signal from the terminal portion 1091c and injects the communication signal to the receptacle 1102a / extracts the communication signal from the receptacle 1102a and injects the communication signal to the terminal portion 1091c.

By the structure, in the case in which the house 1200 receives the communication signal from an external network 1300, for instance, the same communication signal passes through an optical fiber cable 1110 from the external network 1300 and is converted to an optical signal / electric signal at an MC 1410, and is modulated by the parent modem 1012 and is injected to the low voltage distribution power line 1100. The communication signal injected to the low voltage distribution power line 1100 is extracted by the relay device 1062 at the receptacle 1102c provided on the indoor wiring 1101 of a house 1220 which is the branch of the low voltage distribution power line 1100, and is injected to the terminal portion 1091a of the core 1090A provided in the house 1220 and is thus transmitted to the core 1090A. The communication signal transmitted to the core 1090A is sent to cores 1090B to 1090D through a distributor 1080 and is extracted by the relay device 1060 at the terminal portion 1091c of the core 1090C provided in the house 1200, and is injected to the receptacle 1102a provided on the indoor wiring 1101 of the house 1200 and is thus transmitted to the same indoor wiring 1101. The communication signal transmitted to the indoor wiring 1101 of the house 1200 is extracted and demodulated by the child modem 1020 through the receptacle 1102b, and is transmitted to a terminal device 1201 such as a personal computer. In the case in which the house 1200 transmits the communication signal to the external network 1300, a reverse course to the case of the receiving is followed.

By the structure, the communication line is used for at

least a part of the signal transmission path in addition to the power line in the same manner as that in the first and second embodiments. Therefore, it is possible to reduce the attenuation of the communication signal. In this embodiment, particularly, the communication signal is transmitted to the indoor wiring of the house. Consequently, it is possible to inject/extract the communication signal to/from the optional receptacle of the indoor wiring. While there has been described the case in which one house carries out a power line communication in the embodiment, a plurality of houses may be provided. In that case, each of the houses has the child modem and the relay device.

<Sixth Embodiment: A first PLC modem is provided on a power line and a communication line and a second PLC modem is provided on a power line>

Fig. 7 is a typical diagram schematically showing a power line communication system according to the invention, illustrating an embodiment in which a parent modem injects/extracts a communication signal to/from both a power line and a communication line and a child modem injects/extracts a communication signal to the power line. In this embodiment, a basic structure is the same as that in the third embodiment except that the parent modem injects/extracts the communication signal to both the power line and the communication line.

A parent modem 1012 is connected to a low voltage distribution power line 1100, and furthermore, is connected to a core 1090A of a coaxial cable. For instance, in the case in which a house 1200 is to receive a communication signal, it is changed to an optical signal / electric signal at an MC 1410 from an external network 1300 through an optical fiber cable 1110 and is then modulated by the parent modem 1012, and is injected to a terminal portion 1091d of the core 1090A. The communication signal thus injected is extracted at a terminal portion 1091c of a core 1090C by a relay device 1060, and is then injected to a receptacle 1102a and is extracted at a receptacle 1102b

by a child modem 1020, and is thereafter demodulated and transmitted to a terminal device 1201 such as a personal computer. In the case in which the house 1200 is to transmit the communication signal to the external network 1300, a reverse course to the case of the receiving is followed.

For instance, in the case in which a house 1230 is to receive a communication signal, moreover, the communication signal passing through the external network 1300, the optical fiber cable 1110 and the MC 1410 and modulated by the parent modem 1012 is injected to the low voltage distribution power line 1100. The communication signal thus injected is injected to a receptacle 1102d provided in an indoor wiring 1101 of the house 1230 which is the branch of the low voltage distribution power line 1100 and is extracted and demodulated by the child modem 1020, and is then transmitted to the terminal device 1201 such as a personal computer. In the case in which the house 1230 is to transmit the communication signal to the external network 1300, a reverse course to the case of the receiving is followed.

In the embodiment, the parent modem is connected to the power line and the communication line. For instance, therefore, the communication signal can be transmitted through the transmission line to the house placed apart from the injecting point of the communication signal by the parent modem, and furthermore, can be transmitted through the power line to the house placed close to the injecting point. The communication signal is transmitted through the communication line to the house placed apart from the injecting point. Therefore, it is possible to suppress the attenuation of the communication signal, thereby transmitting the communication signal. In the house placed close to the injecting point, moreover, the communication signal is transmitted through the power line having a short distance. Consequently, it is possible to ensure an excellent communication state without causing a great attenuation.

In the embodiment, moreover, in the case in which it is impossible or hard to carry out a communication due to a fluctuation in a communication state, for instance, an increase

in the attenuation of the communication signal in the house in which the communication signal is injected/extracted from the parent modem to the power line and is received/transmitted by a terminal device through a receptacle, the communication signal can be injected/extracted from the parent modem to the communication line and can be thus received/transmitted by the terminal device through the communication line.

While the description has been given to the embodiment in which the external network and the parent modem communicate with each other through the optical fiber cable in the first to fourth embodiments, it is also possible to carry out the communication by using a power line therebetween in place of the optical fiber cable.

In the communication system according to the invention, moreover, an image signal and a audio signal can be applied to be the communication signal. Furthermore, the invention can also be applied to a packet communication to be used in an IP (internet Protocol) telephone employing VoIP (Voice over Internet Protocol).

<Seventh Embodiment>

While the repeater is utilized as the relay device in all the embodiments described above, an impedance matching device may be utilized. Fig. 8 is a schematic diagram showing the structure of the impedance matching device. An impedance matching device 1030 shown in Fig. 8 comprises a high frequency transformer including a first winding 1032 which is connected to a communication line 1097 and through which a communication signal to be sent from/to the communication line 1097 is transmitted, a second winding 1033 which is connected to a power line (low voltage distribution power line) 1100 and through which a communication signal sent from/to the power line 1100 is transmitted, and a ferromagnetic material 1031 upon which these windings 1032 and 1033 are wound, and capacitors C_1 and C_2 for correcting a frequency. In the seventh embodiment, a ferrite core is used as the ferromagnetic material 1031. The impedance

matching device 1030 can match the characteristic impedance of the communication line with that of the power line by changing the numbers of winds of the windings 1032 and 1033. More specifically, a characteristic impedance Z_1 of the communication line 1097 can be expressed in the following equation, wherein the characteristic impedance of the communication line 1097 is represented by Z_1, the characteristic impedance of the power line 1100 is represented by Z_2, the number of winds of the first winding 1032 is represented by N_1 and the number of winds of the second winding 1033 is represented by N_2.

$$Z_1 = \frac{1}{\left(\frac{N_2}{N_1}\right)^2} \bullet Z_2$$

From the above equation, $N_2^2 Z_1 = N_1^2 Z_2$ can be obtained. By selecting N_1 and N_2 to satisfy $N_2^2 Z_1 = N_1^2 Z_2$, accordingly, it is possible to take matching with the characteristic impedance.

The communication line 1097 shown in Fig. 8 has such a structure that a shield layer 1097b is provided on the outer periphery of a conductor 1097a. Accordingly, the first winding 1032 and the communication line 1097 are connected to each other by connecting terminals provided on both ends of the first winding 1032 to the conductor 1097a of the communication line 1097 through a terminal portion 1098 and to the shield layer 1097b respectively as shown in Fig. 8. Moreover, the power line 1100 shown in Fig. 8 has such a structure as to include a first power line 1100a and a second power line 1100b. Accordingly, the second winding 1033 and the power line 1100 are connected to each other by connecting terminals provided on both ends of the second winding 1033 to the first power line 1100a and the second power line 1100b respectively as shown in Fig. 8.

In the case in which the impedance matching device is utilized as the relay device as described above, it is also possible to obtain an effect that the installation space of a device can be decreased and a delay time can be reduced in the utilization of VoIP in addition to an advantage that the

characteristic impedances can be matched between the communication line and the power line.

Next, description will be given to another embodiment of the communication systems according to the invention.

<Eighth Embodiment>

Fig. 10 is a diagram schematically showing the communication system according to the eighth invention. The system according to the invention utilizes, as a head end, a communication device (a parent modem 2010) capable of modulating a digital video and audio signal into a low frequency band having a lower frequency than the frequency of a high frequency band in a building 2090 including a plurality of houses (2200 and 2210) for receiving a video and audio signal in the high frequency band in common, and furthermore, serves to set, as a signal transmission path, an indoor communication line 2110 to be used for transmitting the video and audio signal in the high frequency band. In the invention, particularly, a modulated signal is injected to the vicinity of a common receiving terminal portion (an amplifier 2101 and a distributor 2102) provided in the building 2090 by a parent modem 2010. Detailed description will be given below.

The building 2090 includes a plurality of houses 2200 and 2210 for receiving a TV signal or a CATV signal in common, and comprises the amplifier 2101 for receiving and amplifying the TV signal or the CATV signal transmitted from a signal distributing side, the distributor 2102 for distributing the TV signal or the CATV signal to each of the houses, and the indoor communication line 2110 for transmitting the TV signal or the CATV signal to each of the houses. The indoor communication line 2110 is branched into a plurality of branch communication lines 2111 to 2114 through the distributor 2102, and a plurality of houses shares one branch communication line. Each of the branch communication lines 2111 to 2114 includes a plurality of terminal portions 2120, and each of the terminal portions 2120 is provided in each of the houses. Accordingly, the house

2200 can receive the TV signal or the CATV signal by connecting an image receiver 2300 such as a television to the terminal portion 2120 provided on the branch communication line 2111. In the embodiment, the distributor 2102 is a well-known device capable of distributing the TV signal or the CATV signal. Moreover, the branch communication lines 2111 to 2114 are well-known coaxial cables to be used in the transmission of the TV signal or the CATV signal.

In the building 2090 for receiving a video and audio signal in a high frequency band such as the TV signal or the CATV signal in common, the system according to the invention comprises the parent modem 2010 capable of modulating a digital video and audio signal and injecting a modulated signal to the vicinity of a common receiving terminal portion. Moreover, the house 2210 includes a child modem 2020 capable of extracting and demodulating the modulated signal which is modulated by the parent modem 2010 and is to be transmitted to the branch communication line 2114.

In the invention, particularly, the parent modem 2010 modulates a digital video and audio signal into a low frequency band having a lower frequency than the frequencies of the frequency bands of the TV signal and the CATV distribution signal in order to reduce the attenuation of the transmission signal (the digital video and audio signal). In the embodiment, for the parent modem 2010, there is used a PLC modem capable of modulating the digital video and audio signal to have a lower frequency than frequencies in the usage frequency bands of the TV signal and the CATV signal and injecting a modulated signal to a signal transmission path. In the embodiment, moreover, it is assumed that the modulating method of the parent modem 2010 is set to be an OFDM method and carries out a modulation at a carrier frequency of 50 MHz or less.

In the invention, furthermore, the modulated signal in the low frequency band is transmitted as described above. Therefore, the receiving range of the modulated signal is limited in order to reduce the influence of a mixing noise. More

specifically, the parent modem 2010 injects the modulated signal to the vicinity of a common receiving terminal portion provided in the building 2090. Thus, the signal is injected to the vicinity of the common receiving portion so that the modulated signal is almost transmitted to the branch communication lines 2111 to 2114 connected to the common receiving portion. More specifically, the branch communication lines 2111 to 2114 provided on the downstream side of the parent modem 10 as seen from the distributing side of the CATV signal are set within the main transmitting range of the modulated signal and the house present on the downstream side seen from the distributing side of the CATV signal is more limited as compared with a conventional head end for the CATV signal. Consequently, the influence of the mixing noise can be reduced. In the embodiment, the parent modem 2010 is provided on the upstream side of the amplifier 2101 as seen from the distributing side of the CATV signal, thereby injecting the modulated signal.

For the child modem 2020, there is used a PLC modem capable of extracting the modulated signal to be transmitted to the branch communication lines 2111 to 2114 and demodulating the modulated signal to have a lower frequency than the frequencies of the usage frequency bands of the TV signal and the CATV signal. In the embodiment, it is assumed that the demodulating method of the child modem 2020 is set to be an OFDM method and a modulation is carried out at a carrier frequency of 50 MHz or less.

The child modem 2020 is connected to a terminal portion 2121 of the branch communication line 2114 provided in the house 2210 and serves to extract the modulated signal from the terminal portion 2121. In the embodiment, the terminal portion 2121 is a well-known branching device capable of branching the TV signal and the CATV signal. Both the parent modem 2010 and the child modem 2020 match impedances to adapt to the impedance of the branch communication line.

By the structure, when a digital video and audio signal is distributed from an upper network NT, the digital video and audio signal is transmitted to the parent modem 2010 through

an optical fiber cable 2150 connected to the upper network NT and is modulated to have a lower frequency than the frequencies of the frequency bands of the TV signal and the CATV signal. In the embodiment, the modulation is carried out by the OFDM method at the carrier frequency of 50 MHz or less. The modulated signal is transmitted to each of the branch communication lines 2111 to 2114 and is extracted and demodulated by the child modem 20 through the terminal portion 2121 provided in the house 2210, and is extracted and received by a terminal device 400 such as a personal computer. In the embodiment, the demodulation is carried out by the OFDM method at the carrier frequency of 50 MHz or less. While the parent modem 2010 includes a media converter (MC) capable of carrying out a conversion to an optical signal / electric signal in the embodiment, the MC may be provided separately.

In the invention, thus, the distribution is carried out by a communication device capable of performing a modulation to a low frequency band having a lower frequency than the frequency of a video and audio signal in a high frequency band, for instance, a TV signal or a CATV signal. Consequently, it is possible to reduce the attenuation of a distribution signal. In the invention, particularly, the communication device is provided in the building itself, thereby limiting the transmitting range of the modulated signal from the communication device. Consequently, it is also possible to reduce the influence of a mixing noise. In the invention, therefore, a video and audio signal having a low frequency can be distributed in a more excellent state.

While the description has been given to an embodiment in which one house for receiving a digital video and audio signal is provided in the building as shown in Fig. 10, a plurality of houses may be provided. In this case, it is preferable that each house should include a child modem to be connected to the terminal portion of a branch communication line provided in each house and a parent modem to be used should have a structure in which the time sharing of each child modem can be controlled.

While the OFDM method has been employed as the modulating method and the demodulating method in the embodiment, moreover, it is possible to properly utilize an SS method, an FSK method and a PSK method. In the case in which there is a portion in which the frequency band of a digital video and audio signal overlaps with the usage frequency band of a video and audio signal in a high frequency band, furthermore, it is preferable that the same frequency band should be modulated to be different from the usage frequency band through the execution of masking.

In addition, while the description has been given to the case in which the modulated signal is injected to the upstream side of the amplifier 2101 in the embodiment, it may be injected to the downstream side of the distributor 2102 between the amplifier 2101 and the distributor 2102. In the case in which an attenuation might be caused when the modulated signal is transmitted through the amplifier 2101 and the distributor 2102, particularly, the common receiving terminal portion of the amplifier 2101 or the distributor 2102 may be bypassed to inject a modulated signal to each of the branch communication lines. Moreover, the description has been given to the case in which a video and audio signal is delivered from the rooftop portion of the building 2090 provided with the common receiving terminal portion in the embodiment. In some cases in which the communication line such as an optical fiber cable is buried in the ground, the common receiving terminal portion is provided in the underground portion or first floor portion of the building 2090. In such cases, it is preferable that the parent modem 2010 should be disposed in the underground portion or first floor portion of the building 2090 in which the common receiving terminal portion is provided.

Finally, description will be given to a third embodiment of the invention.

<Ninth Embodiment>

Fig. 12 is a diagram schematically showing the communication system according to the invention. The system

according to the invention has such a structure that a communication line 3110 to be used in the transmission of a video and audio signal is set to be a signal transmission path for a communication signal and a communication is carried out through the communication signal by utilizing a modem (a parent modem 3010) capable of modulating/demodulating the communication signal to a frequency band excluding the frequency band of the video and audio signal in a building 3090 including a plurality of houses (3200, 3210) for receiving the video and audio signal in common. In the invention, particularly, the communication signal is injected/extracted through the parent modem 3010 to/from branch communication lines 3111 to 3114 branched and provided in each of the houses. Detailed description will be given below.

The building 3090 includes a plurality of houses 3200 and 3210 for receiving a video and audio signal in common, and comprises an amplifier 3101 for receiving and amplifying the video and audio signal transmitted from a signal distributing side, a distributor (a first distributor) 3102 for distributing the video and audio signal to each of the houses 3200 and 3210, and the communication line 3110 for transmitting the video and audio signal to each of the houses 3200 and 3210. The communication line 3110 has such an arrangement as to be branched into a plurality of branch communication lines 3111 to 3114 through the distributor 3102 and to cause a plurality of houses to share one branch communication line. Each of the branch communication lines 3111 to 3114 includes a plurality of terminal portions 3120, and each of the terminal portions 3120 is provided in each of the houses. Accordingly, the house 3200 can receive the video and audio signal by connecting an image receiver 3300 such as a television to the terminal portion 3120 provided on the branch communication line 3111. In the embodiment, the distributor 3102 is a well-known device capable of distributing a TV signal or a CATV signal. Moreover, the branch communication lines 3111 to 3114 are well-known coaxial cables to be used in the transmission of the TV signal and the CATV signal.

In the building 3090 for receiving the video and audio signal in common, there is provided the parent modem 3010 for injecting a communication signal to each of the branch communication lines 3111 to 3114 / extracting the communication signal from each of the branch communication lines 3111 to 3114 in order to utilize the branch communication lines 3111 to 3114 as a signal transmission path for the communication signal. Moreover, the house 3210 for carrying out a communication through the communication signal includes a child modem 3020 capable of extracting a communication signal to be transmitted from the parent modem 3010 to the branch communication line 3114 / injecting the communication signal to the branch communication line 3114.

In the embodiment, a coaxial cable through which a TV signal and a CATV signal are transmitted is utilized as the signal transmission path for the communication signal. Accordingly, the TV signal and the CATV signal are usually transmitted to the branch communication lines 3111 to 3114. For the parent modem 3010 in the embodiment, therefore, there is used a PLC modem capable of modulating the communication signal injected from the parent modem 3010 to each of the branch communication lines 3111 to 3114 into a frequency band other than the usage frequency bands of the TV signal and the CATV signal, and furthermore, demodulating the communication signal to be transmitted to the branch communication lines 3111 to 3114 into a frequency band other than the usage frequency bands of the TV signal and the CATV signal. In the embodiment, moreover, the modulating/demodulating method of the parent modem 3010 is set to be an OFDM method.

The parent modem 3010 is connected to the branch communication lines 3111, 3112, 3113 and 3114 through wirings 3111', 3112', 3113' and 3114' respectively, and injects/extracts a communication signal to the branch communication lines 3111 to 3114 through the wirings 3111' to 3114'. More specifically, the parent modem 3010 injects/extracts the communication signal at the downstream side of the amplifier 3101 and the distributor

3102 as seen from the distributing side of the TV signal or the CATV signal. In the invention, thus, the distributor 3102 is bypassed to inject/extract the communication signal to/from each of the branch communication lines 3111 to 3114. Also in the case in which the amplifier 3101 and the distributor 3102 are not considered in respect of a signal present in a frequency band other than the frequency bands of the TV signal and the CATV signal, therefore, it is possible to prevent the communication signal from being attenuated by the amplifier 3101 and the distributor 3102. In the embodiment, the parent modem 3010 is provided in the vicinity of the distributor 3102 in which the branch communication lines 3111 to 3114 are gathered in order to easily inject/extract the communication signal.

On the other hand, for the child modem 3020, there is used a PLC modem capable of demodulating the communication signal to be transmitted to the branch communication lines 3111 to 3114 into a frequency band other than the usage frequency bands of the TV signal and the CATV signal / modulating the communication signal to be injected to the branch communication lines 3111 to 3114 into the frequency band other than the usage frequency bands of the TV signal and the CATV signal in the same manner as the parent modem. In the invention, moreover, the modulating/demodulating method of the child modem 3020 is set to be the OFDM method.

The child modem 3020 is connected to a terminal portion 3121 of the branch communication line 3114 provided in the house 3210 and injects/extracts the communication signal to/from the branch communication line 3114. In the embodiment, the terminal portion 3121 is a well-known distributor capable of branching the TV signal and the CATV signal. Both the parent modem 3010 and the child modem 3020 match impedances to adapt to the impedance of the branch communication line.

By the structure, in the case in which the communication user of the house 3210 is to receive the communication signal from an upper network 3600, the communication signal is transmitted to the parent modem 3010 through an optical fiber

cable 3150 connected to the upper network 3600 and is modulated to have a frequency other than the frequencies of the frequency bands of the TV signal and the CATV signal. In the embodiment, a modulation is carried out by the OFDM method at a carrier frequency of 50 MHz or less. The communication signal thus modulated is transmitted to the branch communication lines 3111 to 3114 through the wirings 3111' to 3114', respectively. The communication signal transmitted to the branch communication line 3114 is extracted and demodulated by the child modem 3020 through the terminal portion 3121 included in the house 3210 and is extracted and received by a terminal device 3400 such as a personal computer. In the embodiment, a demodulation is carried out by the OFDM method at a carrier frequency of 50 MHz or less.

On the other hand, in the case in which the communication user of the house 3210 is to transmit the communication signal to the upper network 3600, the communication signal sent from the terminal device 400 such as a personal computer is modulated to have a frequency other than the frequencies of the frequency bands of the TV signal and the CATV signal by the child modem 3020 and is injected to the terminal portion 3121. In the embodiment, the modulation is carried out by the OFDM method at the carrier frequency of 50 MHz or less. The communication signal injected to the terminal portion 121 is transmitted to the branch communication line 3114 and is extracted and demodulated by the parent modem 3010 through the wiring 3114', and is transmitted to the upper network 3600 through the optical fiber cable 3150. In the embodiment, the demodulation is carried out by the OFDM method at the carrier frequency of 50 MHz or less. While the parent modem 3010 includes a media converter (MC) capable of carrying out a conversion to an optical signal/electric signal, moreover, the MC may be provided separately.

In the invention having the structure described above, a communication line provided in a building for receiving a video and audio signal in common is set to be a signal transmission

path, and furthermore, a communication signal is injected/extracted by utilizing a communication device capable of modulating/demodulating the communication signal to a frequency band other than the frequency band of the same signal, for instance, a PLC modem. Consequently, it is possible to implement a high-speed communication at a low cost. In the invention, particularly, the communication signal is not injected/extracted with a distributor for distributing a video and audio signal or an amplifier for amplifying the same signal provided. Therefore, it is possible to provide an excellent communication state without attenuating the communication signal through the distributor or the amplifier. In the invention, moreover, the frequency band of the communication signal to be transmitted is set to be other than the usage frequency band of the video and audio signal. Therefore, a drawback such as the interference of the video and audio signal with the communication signal is caused with difficulty and an excellent communication state can be set to both of the signals.

While the description has been given to the embodiment in which one house for carrying out a communication through the communication signal is provided in a building in Fig. 12, a plurality of houses may be provided. At this time, it is preferable that each house should be provided with a child modem to be connected to the terminal portion of the branch communication line disposed in each house and the parent modem to be used should have a structure in which the time sharing of each child modem can be controlled. While the OFDM method has been employed as the modulating/demodulating method in the embodiment, moreover, it is possible to properly utilize an SS method, an FSK method and a PSK method. In the case in which there is a portion in which the frequency band of the communication signal overlaps with the usage frequency band of the video and audio signal, furthermore, it is preferable that the frequency band should be modulated/demodulated to be different from the frequency band of the video and audio signal by the execution of masking.

(Embodiment in which a filter is provided)

In the embodiment described above, the different branch communication lines 3111 to 3114 are connected to each other through the parent modem 3010 (the wirings 3111′ to 3114′). For this reason, there is a possibility that the transmission characteristics of the TV signal and the CATV signal might be deteriorated in each of the branch communication lines 3111 to 3114. In order to effectively prevent the deterioration in the transmission characteristics, it is preferable that a filter 3030 capable of cutting off the TV signal or the CATV signal should be provided in the wirings 3111′ to 3114′ as shown in Fig. 13. It is preferable that the filter 3030 should be a low-pass filter capable of cutting off a high frequency signal such as the TV signal or the CATV signal or a band-pass filter through which a signal present in a specific frequency band excluding the usage frequency band of the TV signal or the CATV signal can pass. It is sufficient that the filter 3030 is provided on the wiring (the wiring 3114′) connected to the branch communication line (the branch communication line 3114 in the embodiment) to be used as at least the signal transmission path for the communication signal and may be provided on all the wirings 3111′ to 3114′.

On the other hand, while there has been employed the structure in which the child modem 3020 is connected to the branching device 3121 to inject/extract the communication signal in the embodiment described above, there is a possibility that the loss of the communication signal might be increased depending on the branching device 3121. In case of the branching device 3121, it is preferable that a bypass line (a first bypass line) 3130 for bypassing the branching device 3121 should be provided to connect the child modem 3020 to the branch communication line 3114. At this time, there is a possibility that a drawback might be caused, for instance, the impedances of the TV signal and the CATV signal transmitted to the bypass line 3130 might not be matched with those of the TV signal and the CATV signal to

be transmitted to the branching device 3121. Therefore, it is preferable that the bypass line 3130 should be provided with a filter 3040 capable of cutting off the TV signal and the CATV signal. It is preferable that the filter 3040 should be a low-pass filter or a band-pass filter in the same manner as the filter 3030.

While the description has been given to the embodiment in which one distributor is provided in the building in the ninth embodiment, a large building includes a plurality of distributors in a multi-stage in some cases. In this example, description will be given to the case in which a plurality of distributors is provided. Fig. 14 is an explanatory diagram schematically showing a signal transmission path in the communication system according to the invention, illustrating an embodiment in which there is provided another distributor connected to a branch communication line and serving to further branch a video and audio signal. The basic structure of the common receiving configuration of a building in the example is the same as that in the first embodiment and is different from that in the first embodiment in that there are provided distributors (second distributors) 3103 to 3106 connected to branch communication lines 3111 to 3114 connected to a distributor 3102 respectively and serving to further distribute a TV signal and a CATV signal and sub-branch communication lines 3111A to 3114A are connected to the distributors 3103 to 3106 respectively. The distributors 3103 to 3106 are well-known distributors capable of distributing the TV signal and the CATV signal in the same manner as the distributor 3102.

In the case in which the distributor is provided in a multi-stage, thus, there is a possibility that the distributors 3103 to 3106 might not be considered in respect of a signal present in the frequency band other than the frequency bands of the TV signal and the CATV signal in the same manner as the distributor 3102. In the example, therefore, there is employed a structure in which the distributors 3103 to 3106 are also bypassed in addition to the distributor 3102. In the example shown in Fig.

14, there is provided a bypass line 3160 for bypassing the distributor 3103 to connect the branch communication line 3111 to the sub-branch communication line 3111A. In the example, bypass lines 3161 to 164 to be connected to the branch communication line 3111 are provided for sub-branch communication lines 3111a to 3111d connected to the distributor 3103 and branched, respectively.

By this structure, the communication signal to be transmitted to the branch communication line 3111 is transmitted to the sub-branch communication lines 3111a to 3111d through the bypass lines 3161 to 3164. Therefore, it is possible to prevent an attenuation from being caused by the distributor 3103, thereby bringing an excellent communication state. Moreover, the communication signal to be transmitted to the sub-branch communication lines 3111a to 3111d is transmitted to the branch communication line 3111 through the bypass lines 3161 to 3164. Similarly, the attenuation can be prevented from being caused by the distributor 3103.

In the case in which the injecting/extracting points of the communication signal of a child modem 3020 are provided apart from those of the communication signal of a parent modem 3010 as shown in Fig. 15, furthermore, the attenuation of the communication signal is increased so that it is impossible or hard to carry out a communication through the communication signal between the parent modem 3010 and the child modem 3020. In order to eliminate such a drawback, it is preferable that the bypass line 3160 should be provided with a repeater 3060. The repeater 3060 to be used is a well-known repeater capable of reproducing a waveform distorted during a transmission into a normal state.

By providing the repeater 3060, it is possible to carry out the communication through the communication signal well between the child modem 3020 connected to a terminal portion 3122 of the sub-branch communication line 3111c and the parent modem 3010.

In the case in which a power line communication is to be carried out in a building such as an apartment building, conventionally, only a power line is set to be a signal transmission path. For this reason, there is a possibility that a house which is hard to carry out the communication might be generated if the attenuation of the communication signal is increased. On the other hand, in the invention, it is possible to effectively reduce the attenuation of the communication signal by utilizing a communication line having the attenuation of the communication signal reduced in at least a part of a signal transmission path in addition to the power line. By constructing the system according to the invention in a building including a plurality of houses, accordingly, the houses can carry out the communication through the communication signal well.

In the invention, it is possible to reduce the attenuation of the signal by utilizing, as distribution equipment, a communication device capable of modulating a digital video and audio signal to a band having a low frequency (a low frequency band), for instance, a PLC modem. In the invention, particularly, the communication device is provided in a building itself. Consequently, it is possible to produce an excellent advantage that the influence of a mixing noise can be reduced even if a transmission signal is set into a low frequency band.

In the invention, a communication line such as a coaxial cable is set to be a signal transmission path, and furthermore, a communication device such as a PLC modem is utilized. Consequently, it is possible to produce an excellent advantage that a high-speed communication can be carried out at a low cost. In the invention, particularly, there is employed a structure in which a communication signal is injected/extracted to/from each of branch communication lines. Therefore, it is possible to provide an excellent communication state without attenuating the communication signal through a distributor to which the branch communication line is connected.

A communication system according to the invention is

suitable for a utilization in the case in which a power line communication is to be carried out. In particular, the communication system is suitable for the case in which the power line communication is to be carried out in a building such as an apartment building including a plurality of houses. By constructing the system according to the invention in which a power line and a communication line are combined with each other to form a signal transmission path, it is possible to more reduce the attenuation of a communication signal, thereby ensuring an excellent communication state as compared with the case in which only the power line is set to be the signal transmission path.

The communication system according to the invention is optimum when a digital video and audio signal is to be received in a building including a plurality of houses for receiving a video and audio signal in a high frequency band such as a TV signal or a CATV signal in common.

The communication system according to the invention is optimum when a high-speed communication is to be carried out in a building including a plurality of houses for performing a common receiving. In the invention, particularly, it is possible to reduce the construction cost of the system by utilizing a communication line provided in the building as a signal transmission path.

CLAIMS

1. A power line communication system in a building having a plurality of houses, comprising:

a signal transmission path formed by a combination of a communication line and a power line which are provided in the building; and

a terminal device provided in at least one of the houses and serving to carry out a communication through the signal transmission path.

2. The communication system according to claim 1, further comprising a relay device for relaying a communication signal between the communication line and the power line.

3. The communication system according to claim 2, wherein the relay device is an impedance matching device.

4. The communication system according to claim 3, wherein the impedance matching device includes a high frequency transformer and a capacitor.

5. The communication system according to any of claims 1 to 4, further comprising a first power line communication device capable of carrying out a communication with an outside of a building through a communication signal; and

a second power line communication device which is connected to a terminal device and can carry out a communication with the first power line communication device through a communication signal,

a transmission of the communication signal between the first power line communication device and the second power line communication device being carried out through a signal transmission path formed by a combination of a communication line and a power line.

6. The communication system according to claim 5, wherein the first power line communication device injects a communication signal to the communication line, and extracts the communication signal from the communication line,

the second power line communication device injects a

communication signal to the power line / extracts the communication signal from the power line, and

a relay device is provided between the communication line and the power line.

7. The communication system according to claim 5, wherein the first power line communication device injects a communication signal to the power line and the communication line, and extracts the communication signal from the power line and the communication line,

the second power line communication device injects a communication signal to the power line, and extracts the communication signal from the power line, and

a relay device is provided between the communication line and the power line.

8. The communication system according to claim 6 or 7, wherein the communication line is constituted by a plurality of cores which is collected in a rooftop portion of a building, and

the first power line communication device injects a communication signal to each of the cores, and extracts the communication signal from each of the cores in the rooftop portion.

9. The communication system according to claim 6, wherein the communication line is constituted by a plurality of cores which is collected in a rooftop portion of a building, and

the first power line communication device injects a communication signal to each of the cores, and extracts the communication signal from each of the cores in the rooftop portion.

10. The communication system according to claim 5, wherein the first power line communication device injects a communication signal to the power line, and extracts the communication signal from the power line,

the second power line communication device injects a communication signal to the communication line / extracts the communication signal from the communication line, and

a relay device is provided between the communication line

and the power line.

11. The communication system according to claim 5, wherein the first power line communication device injects a communication signal to a first power line, and extracts the communication signal from the first power line,

the second power line communication device injects a communication signal to a second power line, and extracts the communication signal from the second power line, and

a relay device is provided between the first power line and the communication line and between the second power line and the communication line, respectively.

12. The communication system according to any of claims 1 to 11, wherein the communication line is any of a coaxial cable, a LAN cable, a telephone line and a communication line for an interphone.

13. A communication system comprising:

a common receiving terminal portion provided in a building having a plurality of houses and serving to receive a video and audio signal in a high frequency band in common;

a plurality of branch communication lines for transmitting the video and audio signal from the common receiving terminal portion to each of the houses;

a first communication device for modulating a digital video and audio signal to a low frequency band having a lower frequency than a frequency in the high frequency band and injecting the same signal to the vicinity of the common receiving terminal portion; and

a second communication device which is connected to a terminal portion of a branch communication line provided in each of the houses and can demodulate a signal modulated by the first communication device.

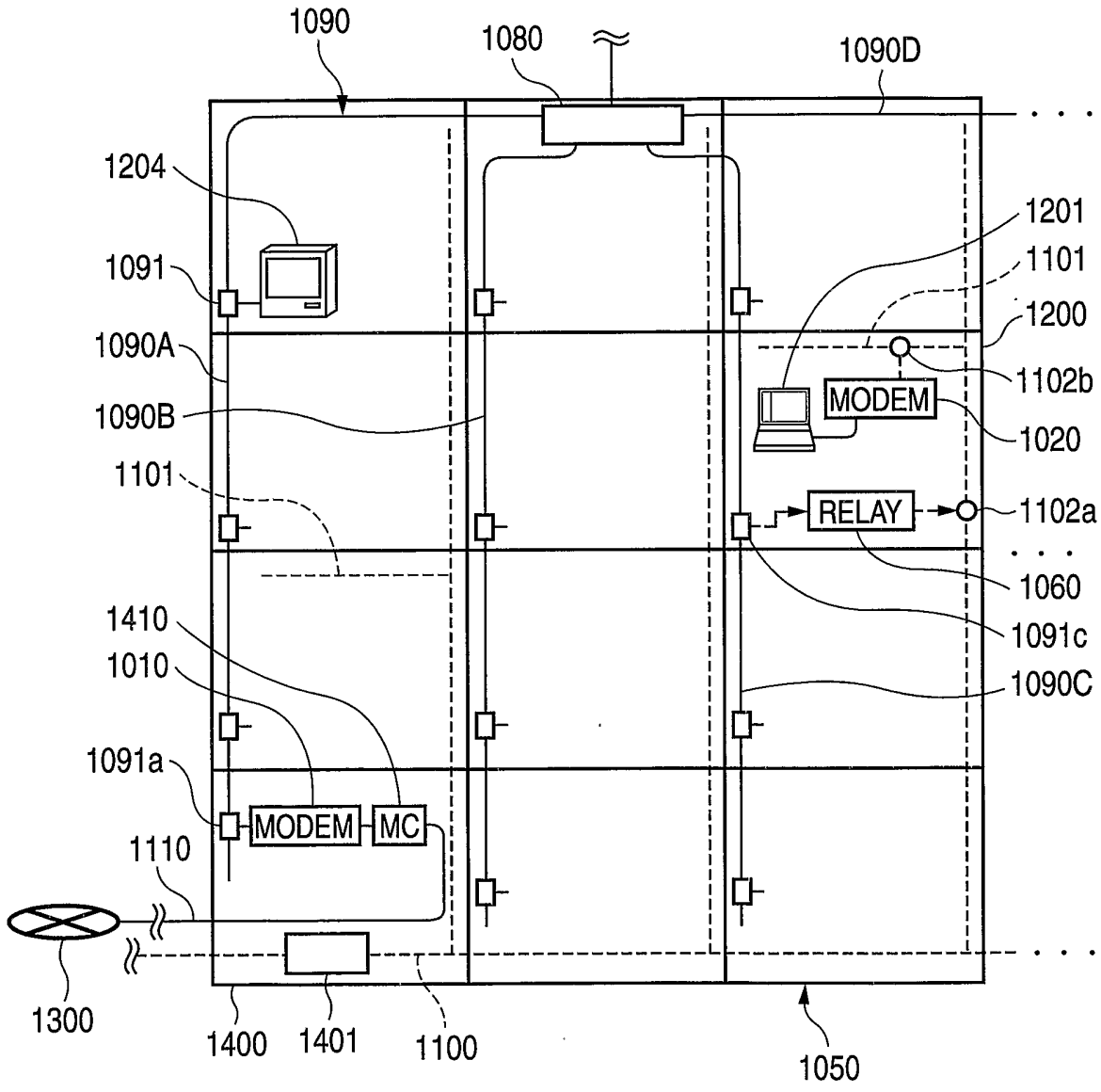
14. The communication system according to claim 13, wherein the low frequency band has a frequency of less than 70 MHz.

15. The communication system according to claim 13, wherein the low frequency band has a frequency of 1.7 MHz to 50 MHz.

16. The communication system according to claim 13, wherein

the first communication device modulates a digital video and audio signal to have any of a first frequency, plural frequencies and a continuous frequency at a carrier frequency of 50 MHz or less.

FIG. 1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MODEM
MC

FIG. 2A

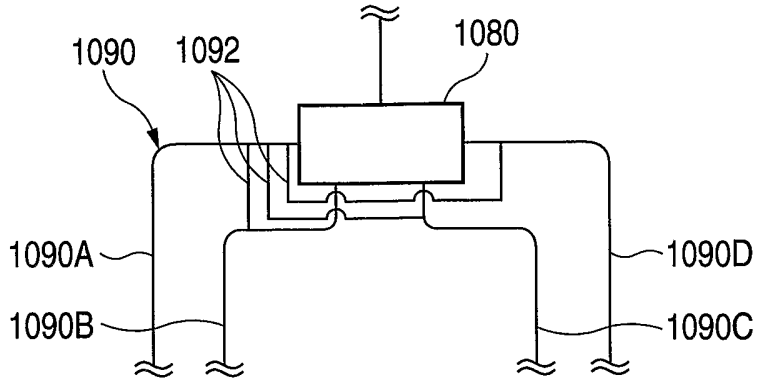

FIG. 2B

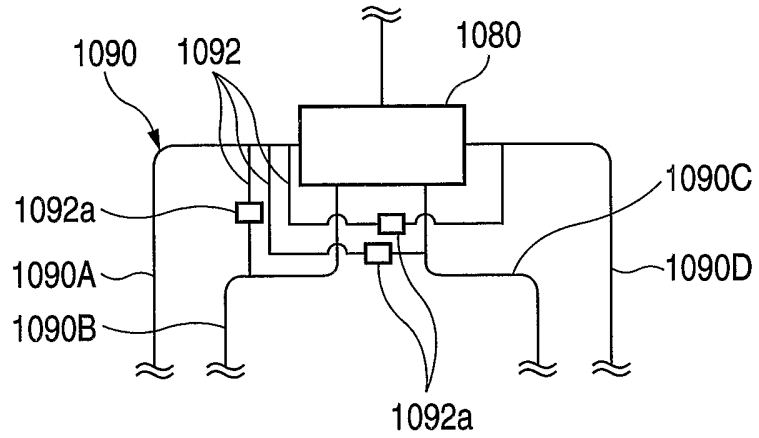

FIG. 2C

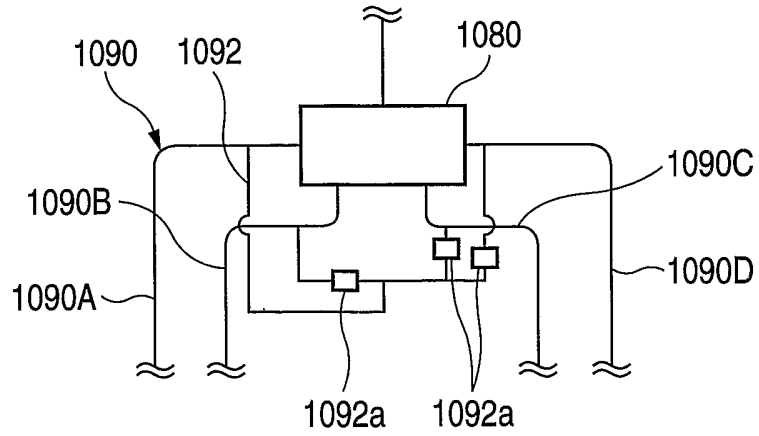

FIG. 3

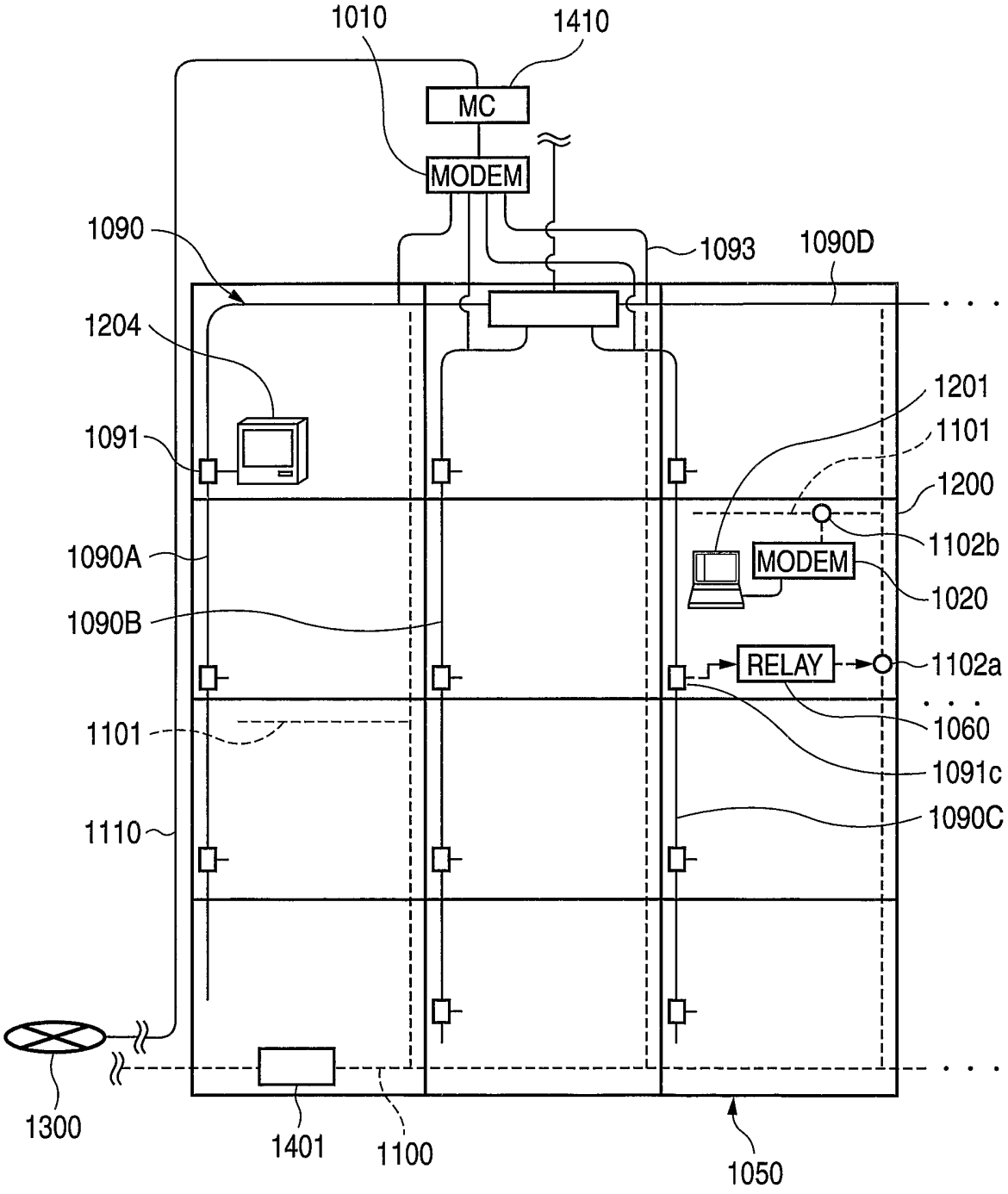
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FIG. 4

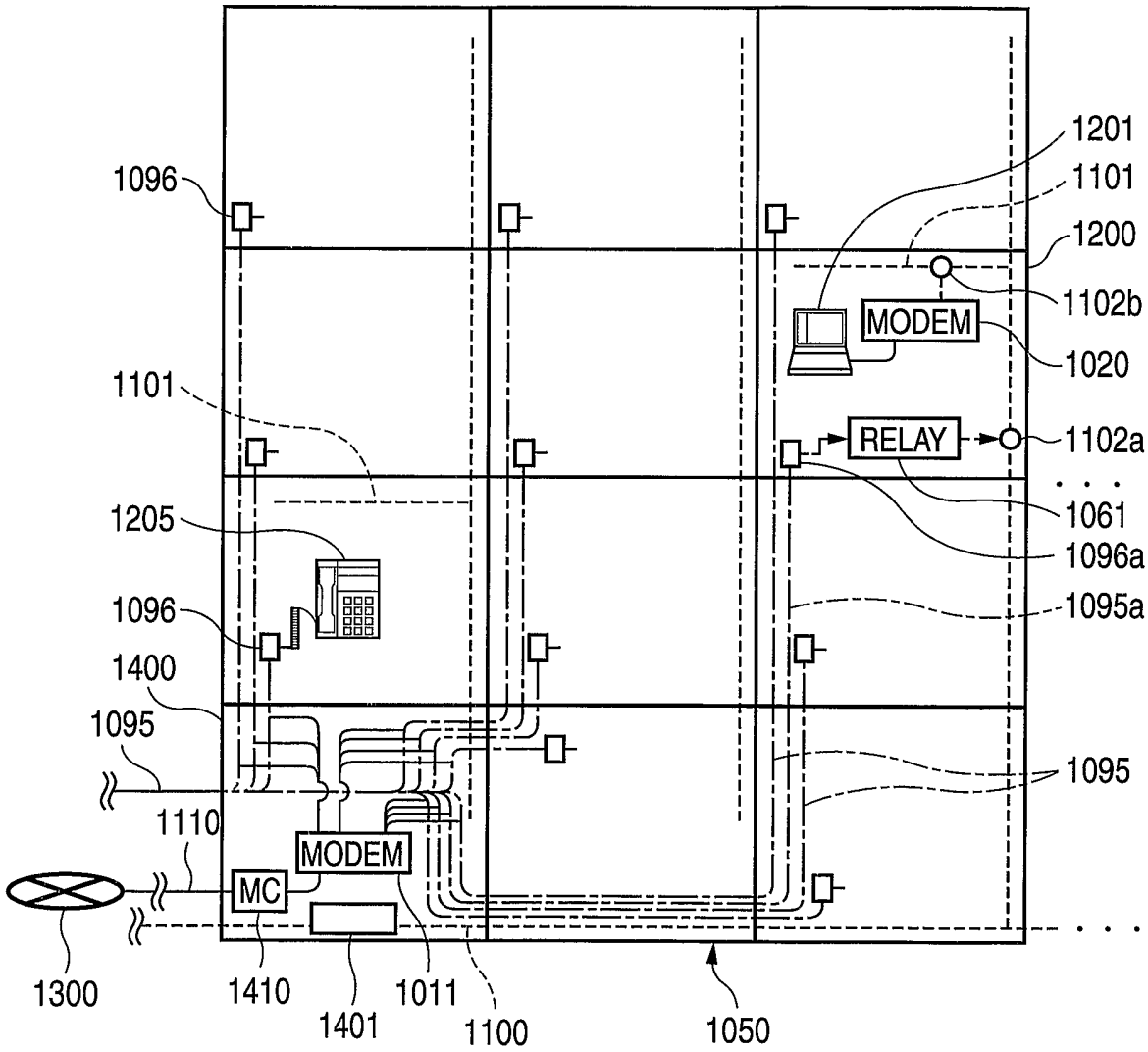
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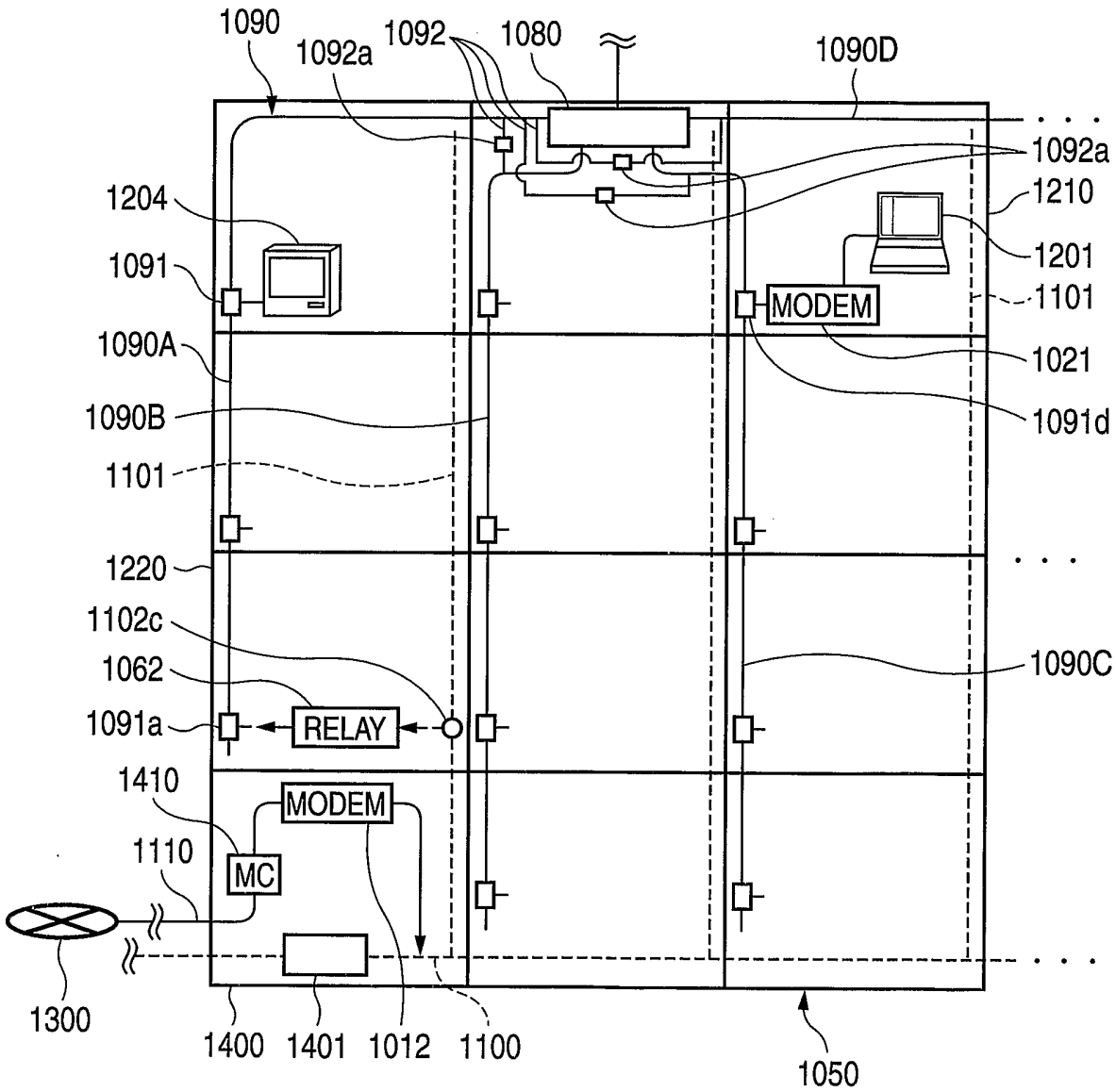
FIG. 5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RELAY
1091a
1410
MODEM
1110
MC
1300
1400
1401
1012
1100
1050

FIG. 6

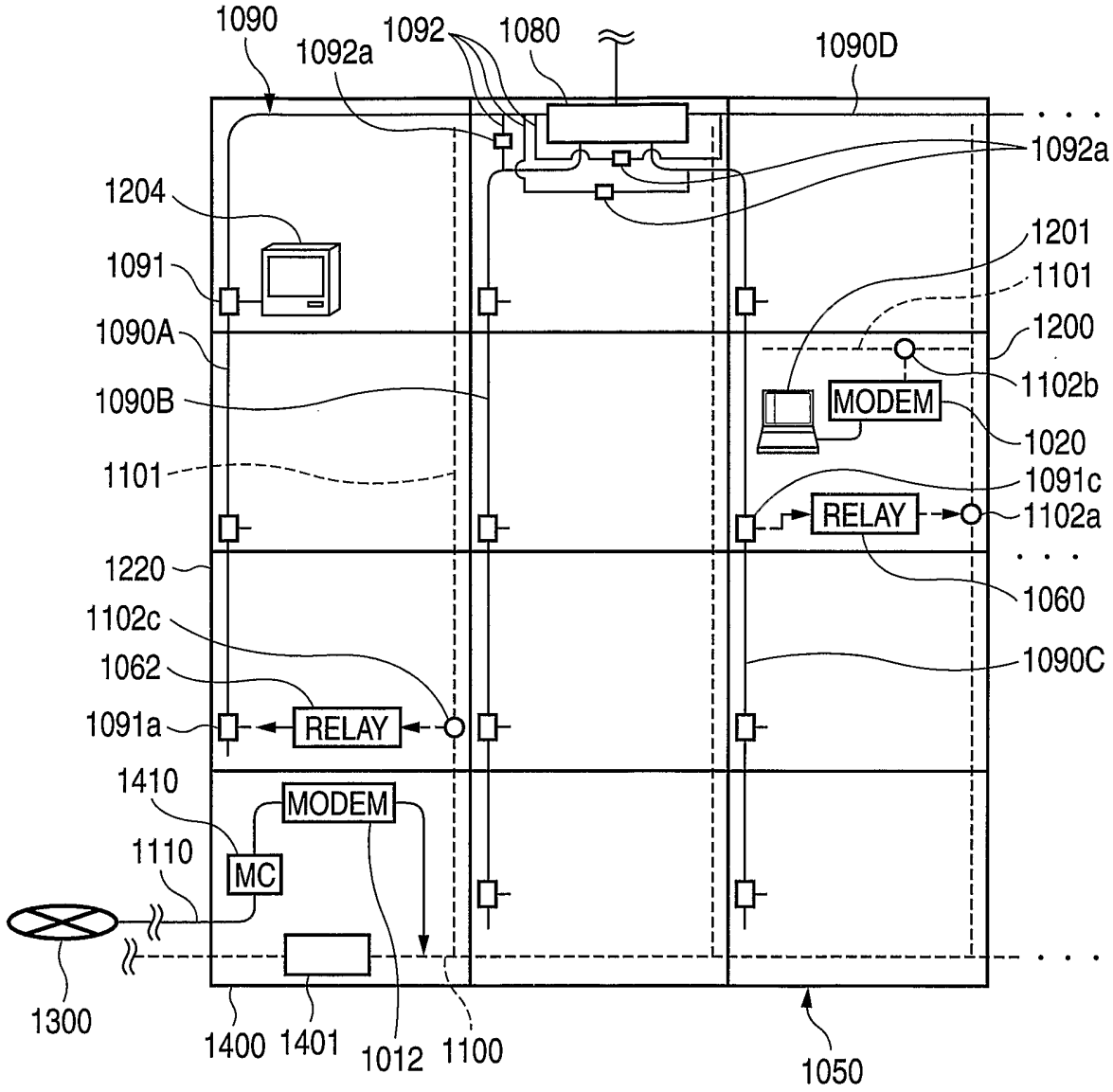

1090
1092a
1092
1080
1090D
1092a
1204
1201
1091
1101
1090A
1200
1090B
1102b
MODEM
1020
1101
1091c
RELAY
1102a
1220
1060
1102c
1090C
1062
1091a
RELAY
1410
MODEM
1110
MC
1300
1400
1401
1012
1100
1050

FIG. 7

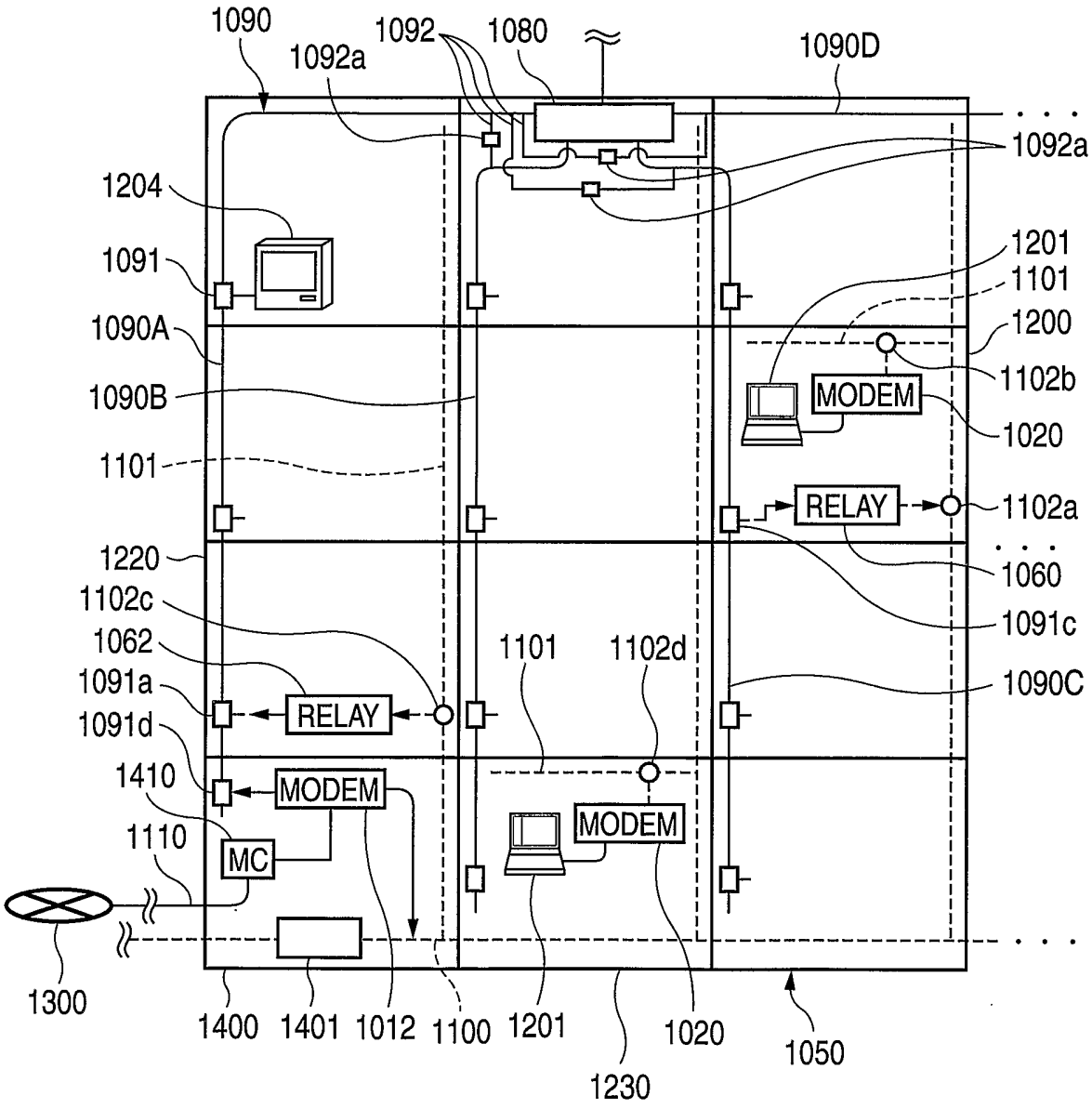

1090
1092
1080
1092a
1090D
1092a
1204
1091
1201
1101
1090A
1200
1090B
1102b
MODEM
1020
1101
RELAY
1102a
1220
1060
1102c
1091c
1062
1101
1102d
1091a
RELAY
1090C
1091d
1410
MODEM
MODEM
1110
MC
1300
1400
1401
1012
1100
1201
1020
1050
1230

FIG. 8

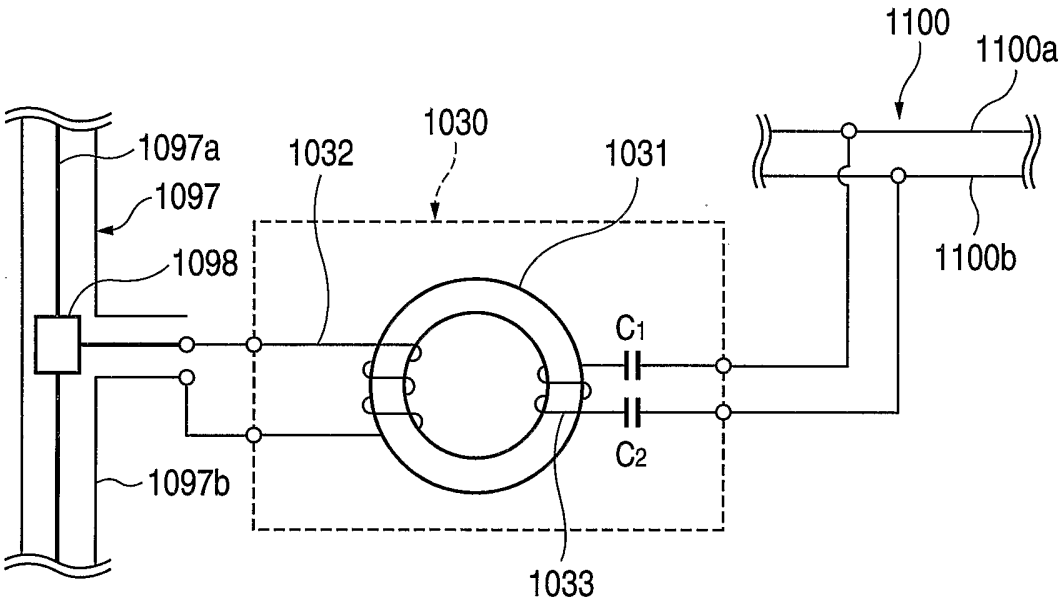

1100
1100a
1030
1097a
1032
1031
1097
1098
1100b
C1
C2
1097b
1033

FIG. 9

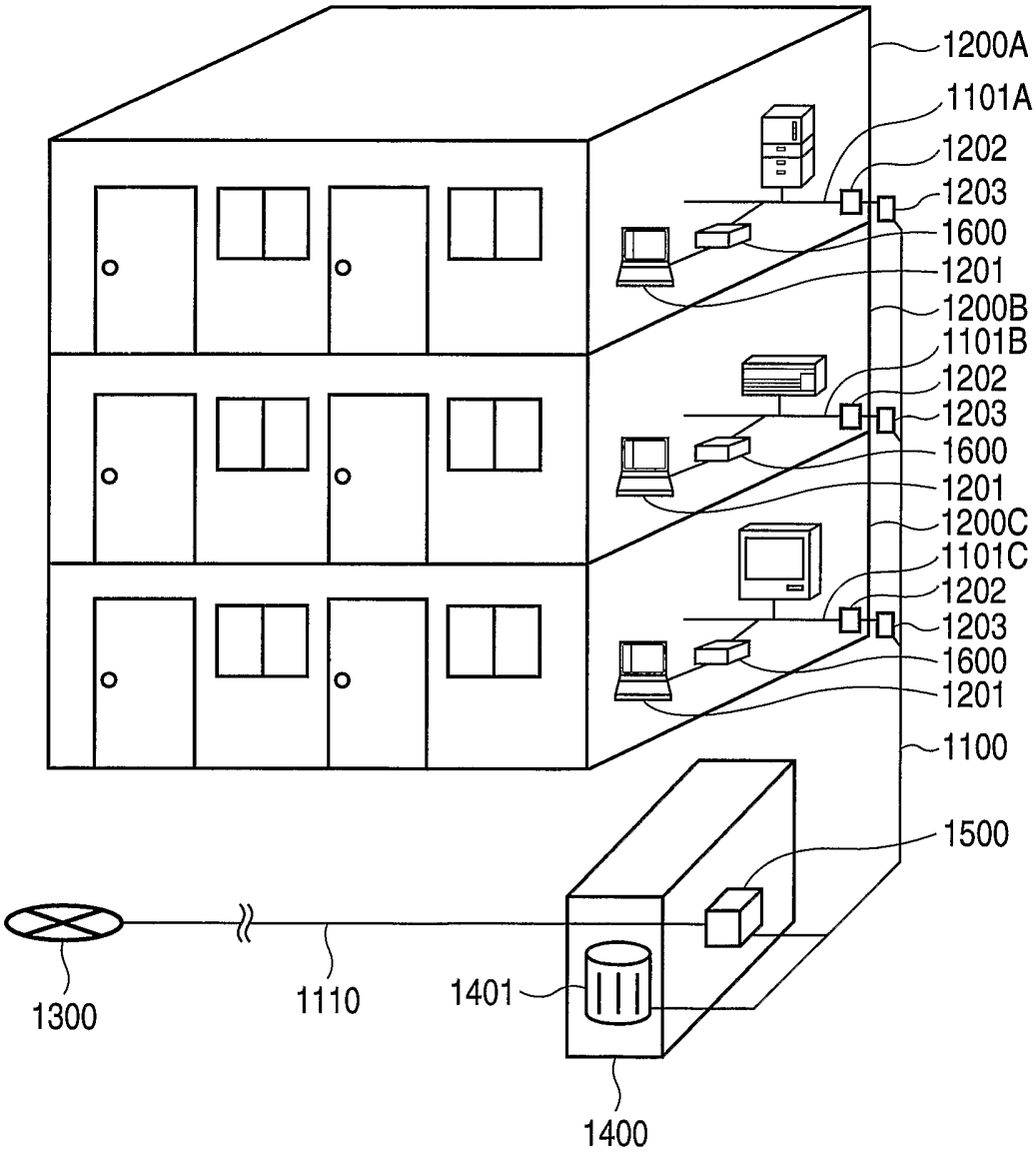

1200A
1101A
1202
1203
1600
1201
1200B
1101B
1202
1203
1600
1201
1200C
1101C
1202
1203
1600
1201
1100
1500
1300
1110
1401
1400

FIG. 10

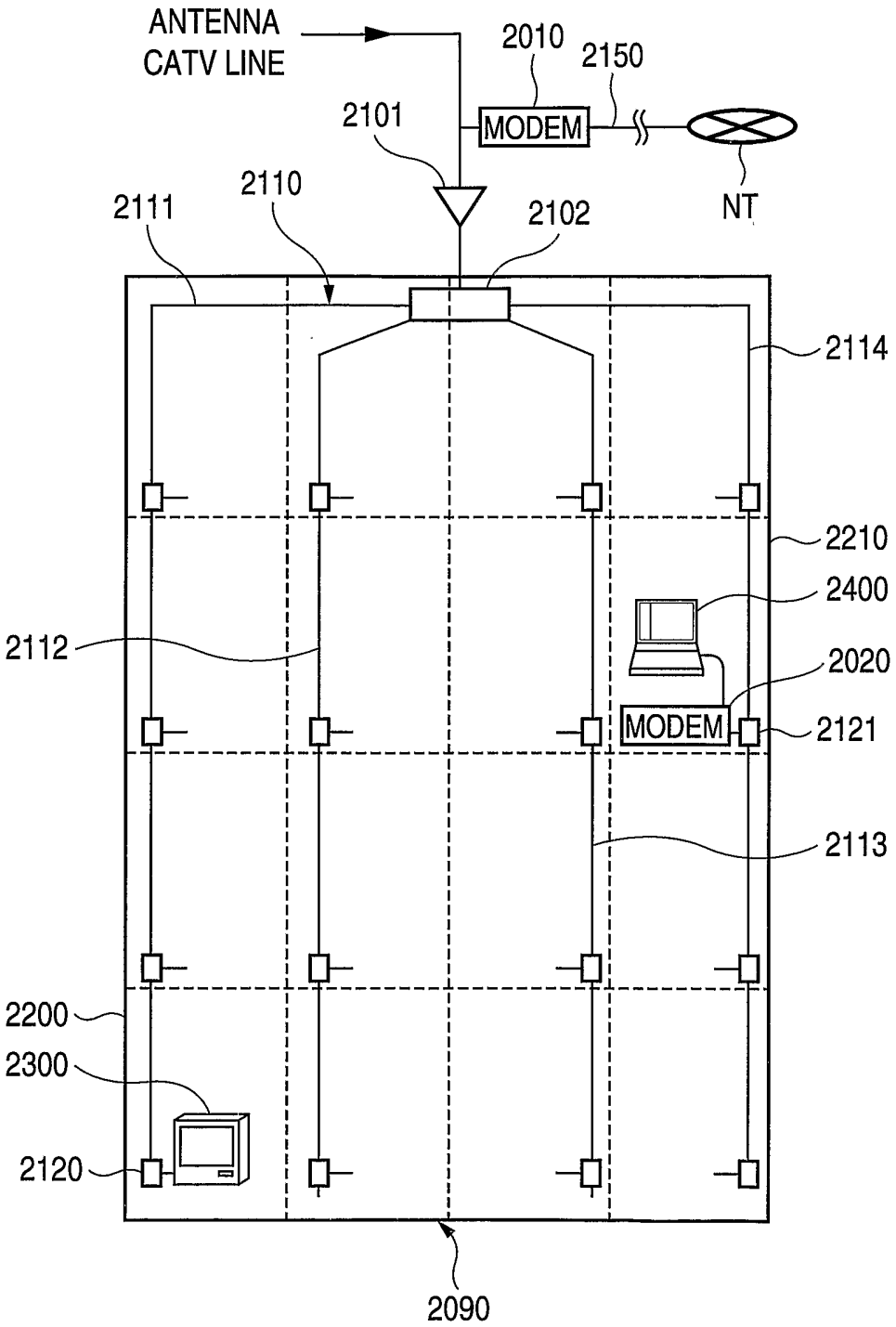

ANTENNA
CATV LINE
2010
2150
2101
MODEM
NT
2110
2111
2102
2114
2210
2400
2112
2020
MODEM
2121
2113
2200
2300
2120
2090

FIG. 11

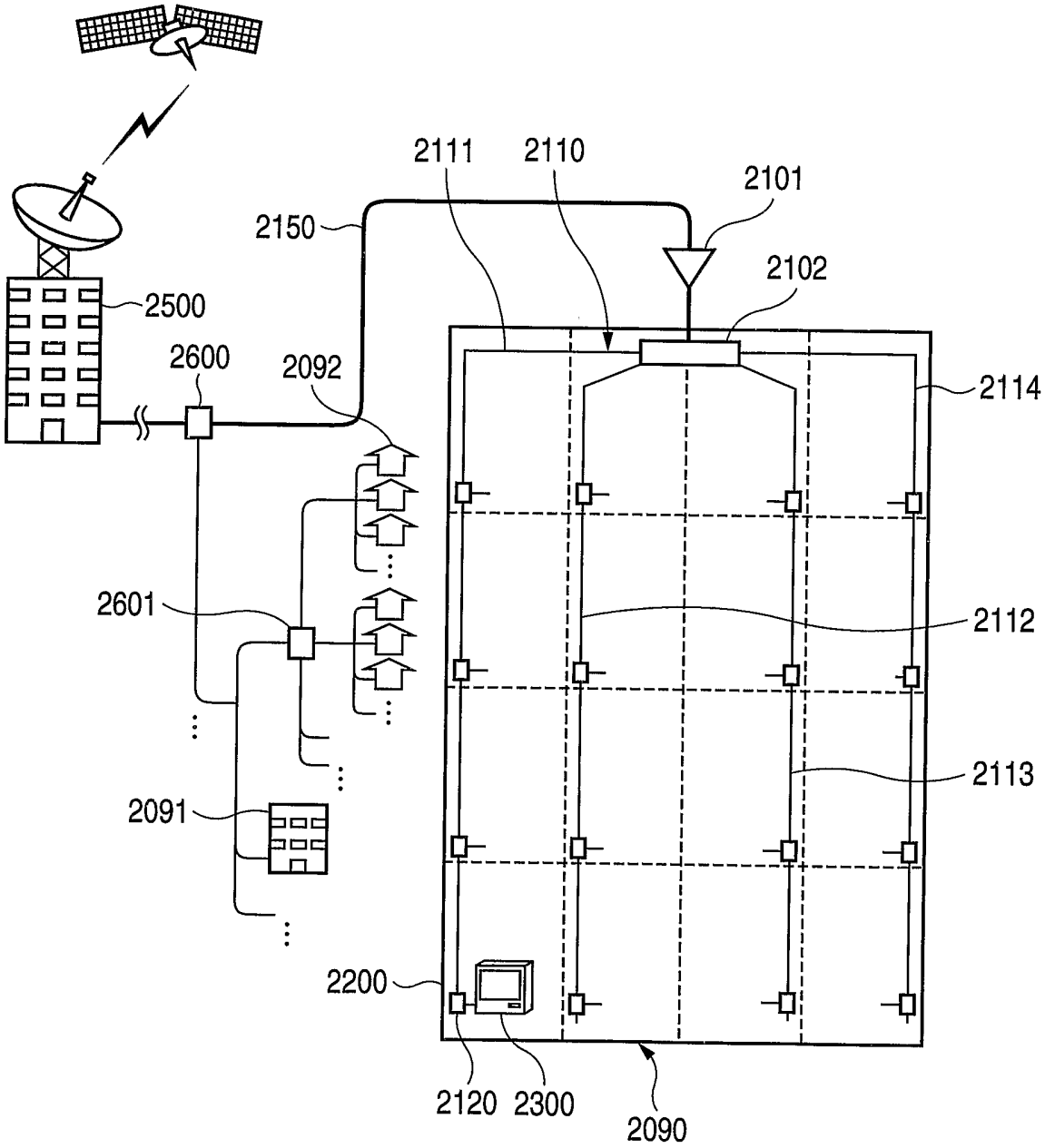

2111
2110
2101
2150
2102
2500
2600
2092
2114
2601
2112
2113
2091
2200
2120
2300
2090

FIG. 12

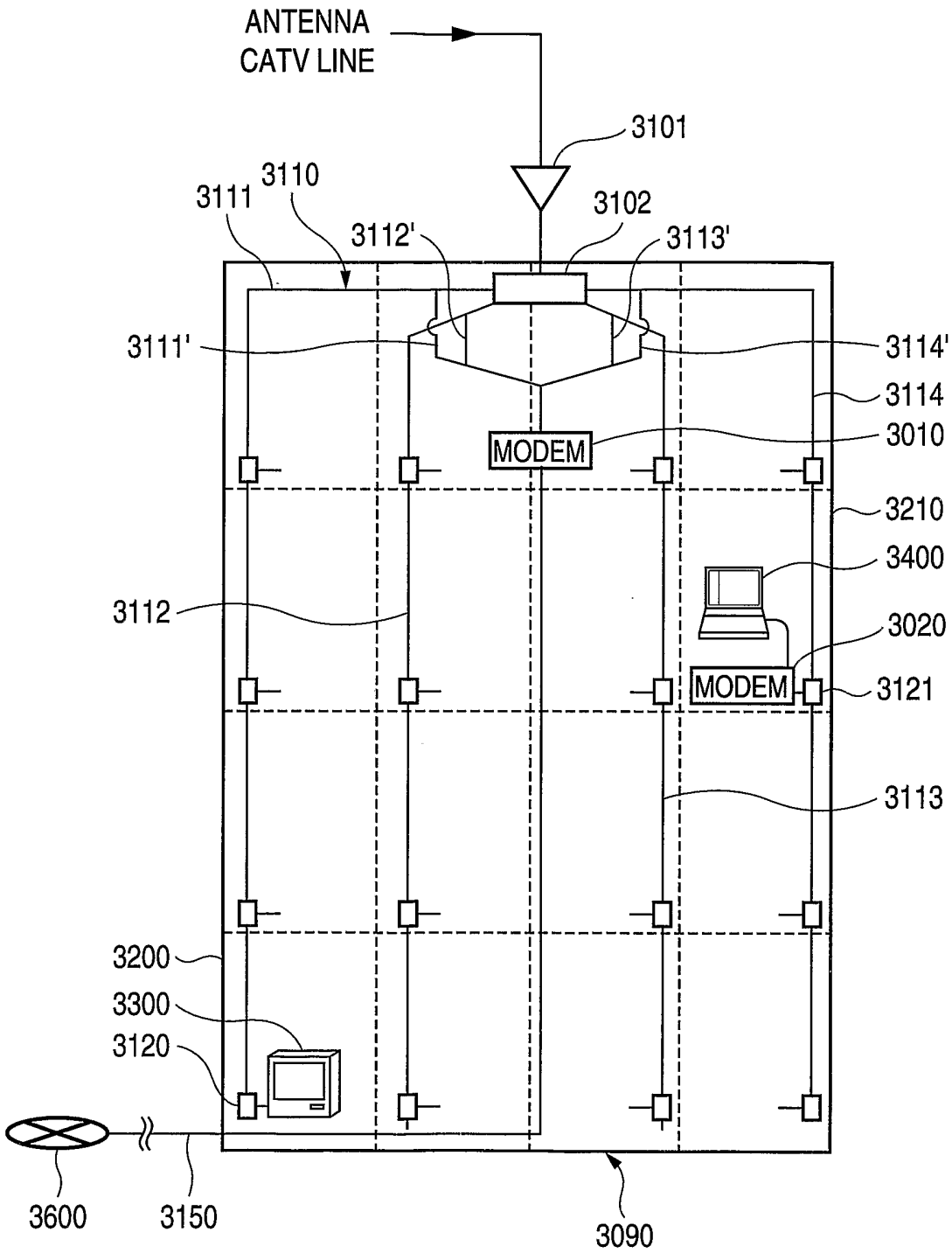

ANTENNA
CATV LINE
3101
3110
3111
3102
3112'
3113'
3111'
3114'
3114
MODEM
3010
3210
3400
3112
3020
MODEM
3121
3113
3200
3300
3120
3600
3150
3090

FIG. 13

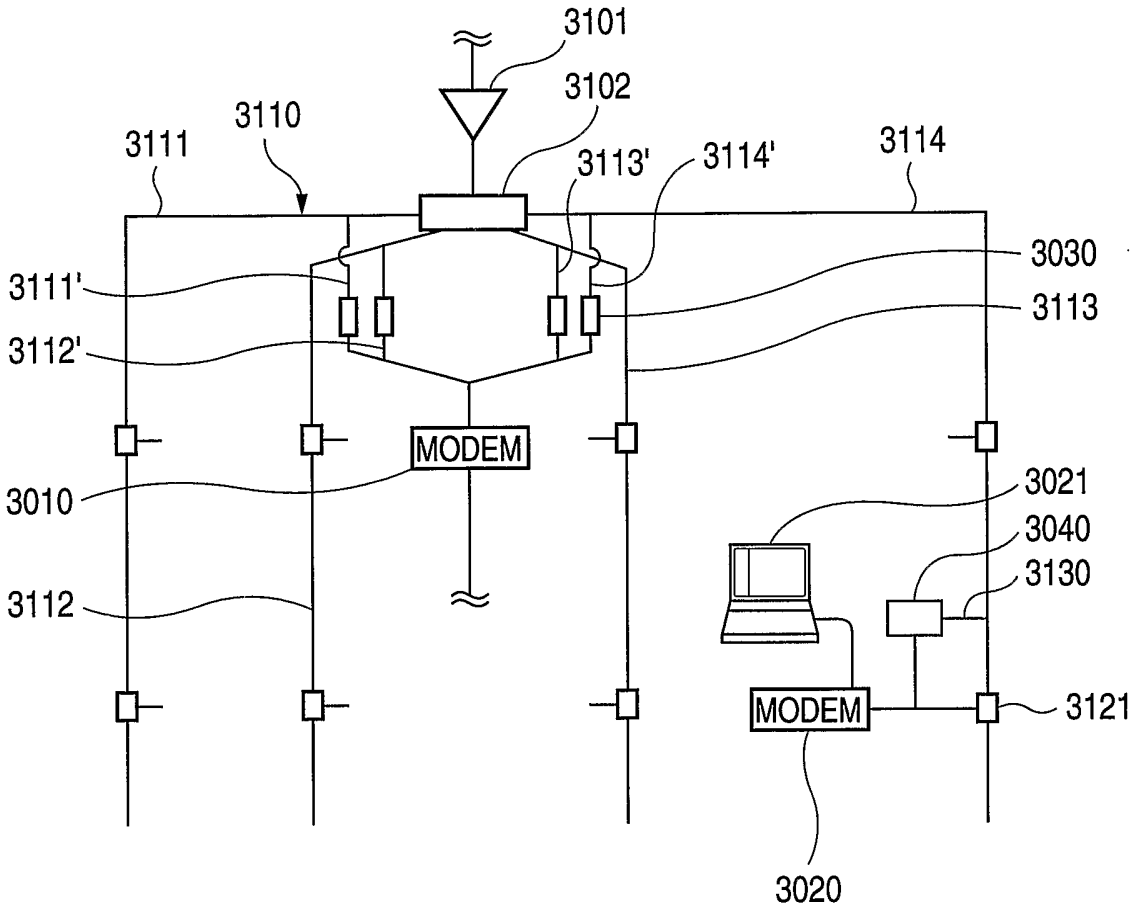

3101
3102
3110
3111
3113'
3114'
3114
3030
3111'
3113
3112'
MODEM
3010
3021
3040
3130
3112
MODEM
3121
3020

FIG. 14

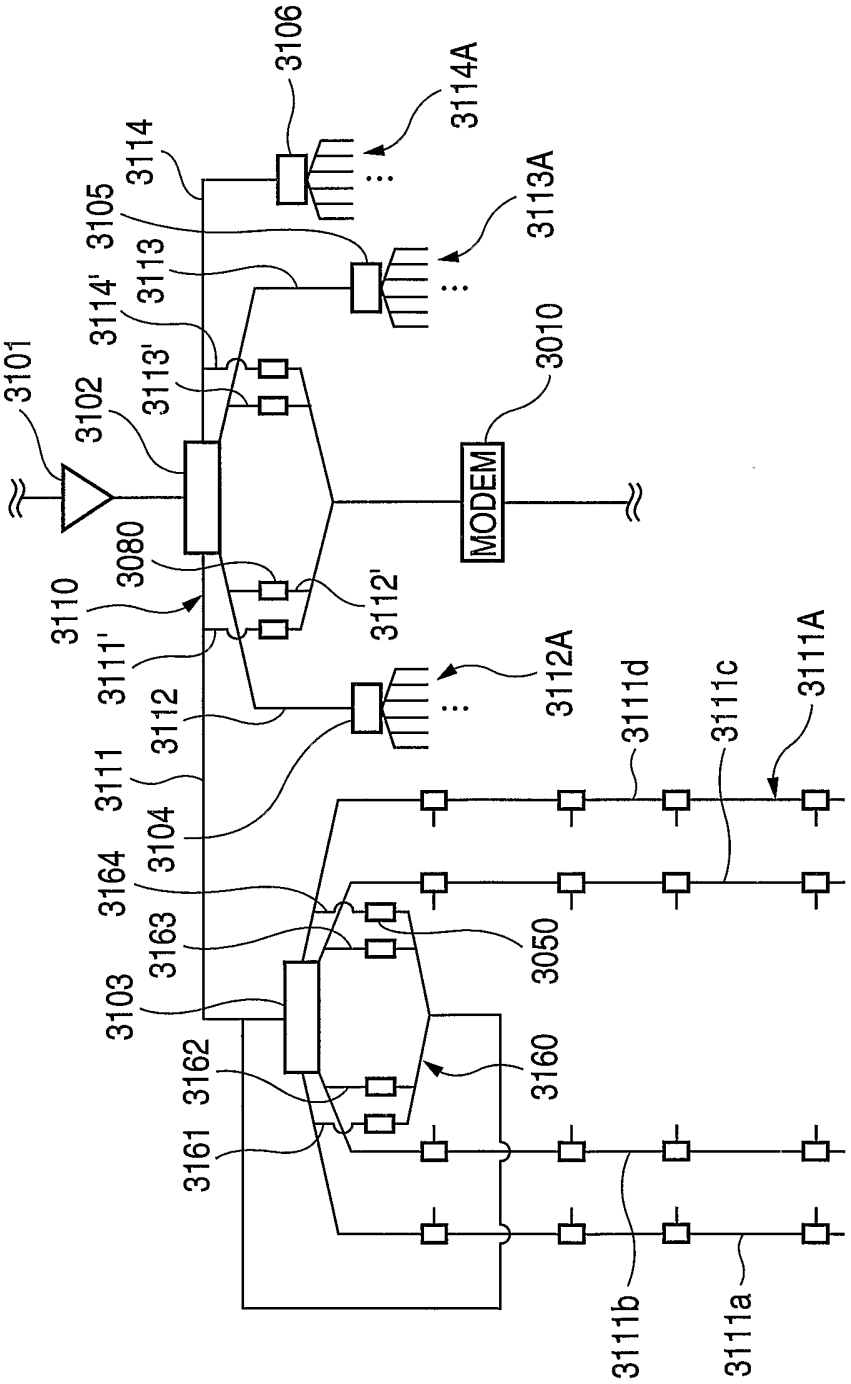

3106
3114A
3114
3105
3113A
3114'
3113
3010
3101
3102
3113'
MODEM
3080
3110
3112'
3111'
3112A
3111d
3111c
3111A
3111
3112
3104
3164
3163
3050
3103
3162
3160
3161
3111b
3111a

FIG. 15

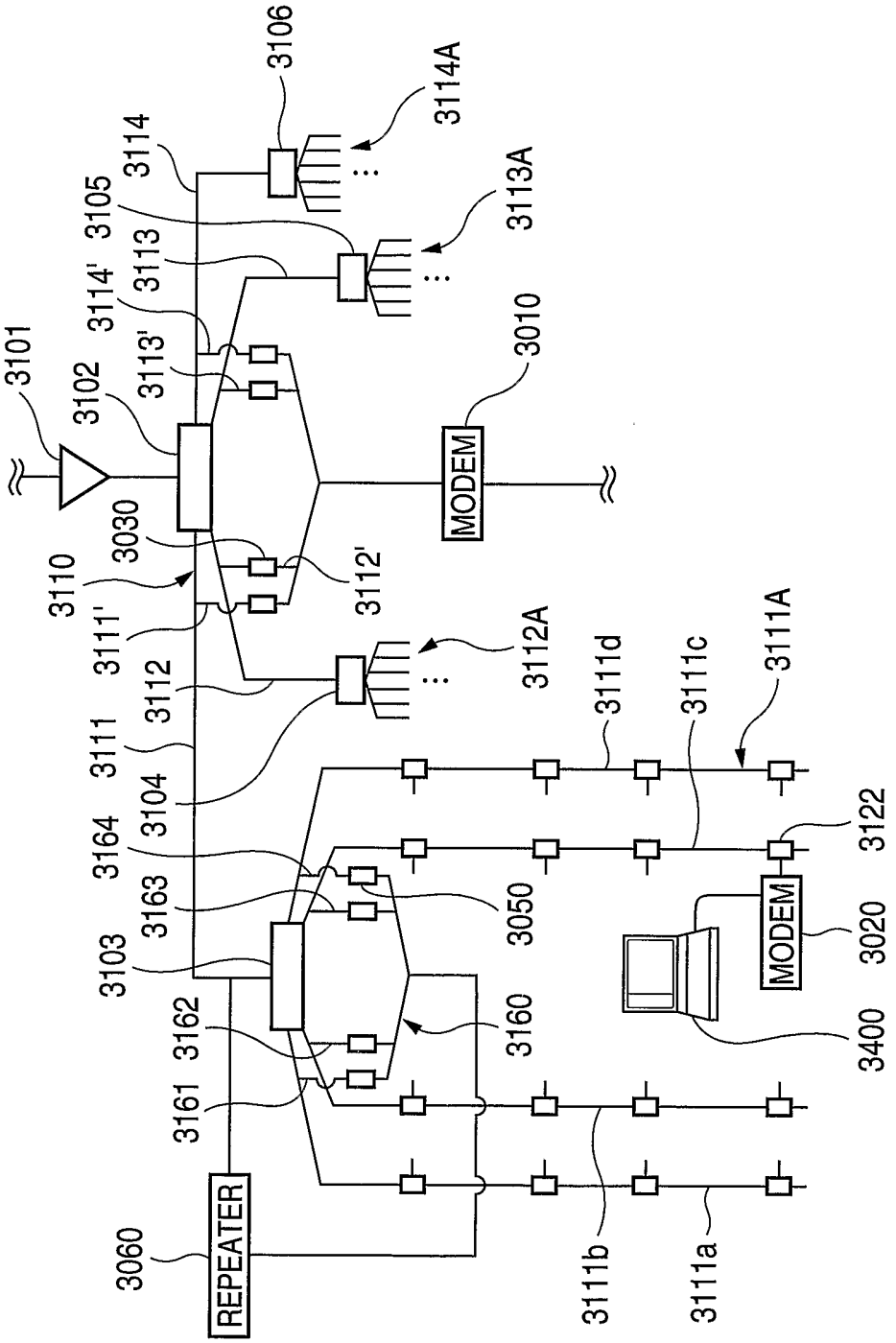
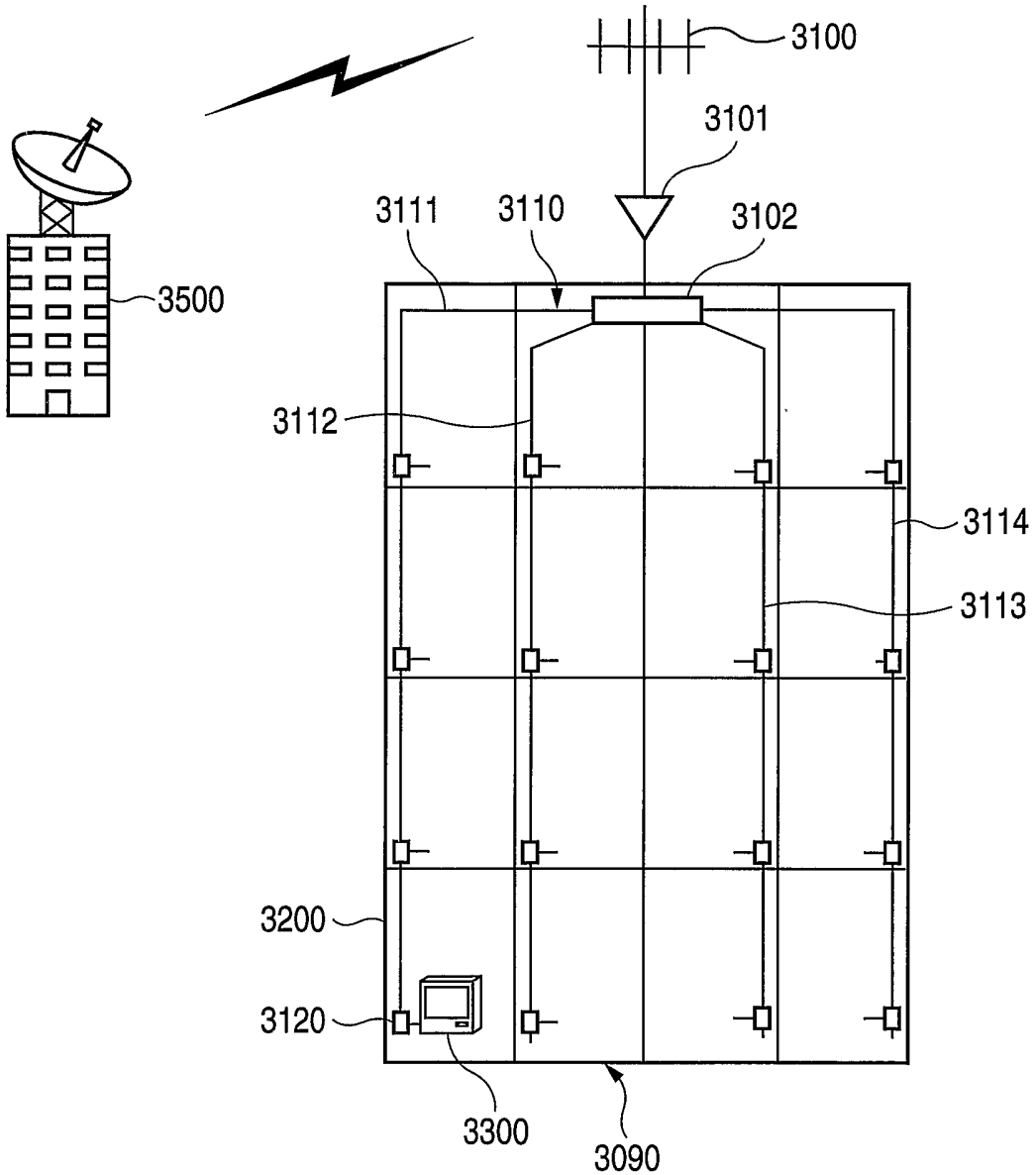

3106
3114A
3114
3105
3113A
3113
3114'
3113'
3101
3102
3010
MODEM
3030
3110
3111'
3112'
3112A
3111
3112
3111d
3111c
3111A
3104
3164
3122
3163
3050
3103
MODEM
3020
3162
3160
3400
3161
3060
REPEATER
3111b
3111a

FIG. 16


3100
3101
3111
3110
3102
3500
3112
3114
3113
3200
3120
3300
3090