

MULTI-CARRIER TRANSMISSION SYSTEM

This application is based upon and claims the benefit of priority from Japanese patent application No. 2006-270883, filed on October 2, 2006, the disclosure of which is incorporated herein in its entirety by reference.

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BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a transmission output control apparatus, a multi-carrier transmission system, a transmission output control method, and a transmission output control program which are applied to an xDSL (x Digital Subscriber Line) (x is a generic name of A, H, S, V, or the like) which performs data transmission at a high rate of several M bits/second through a metallic cable such as a telephone line.

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Description of Related Art

The xDSL uses a metallic cable such as a telephone line to make it possible to perform data transmission at a high rate of several M bits/second. An ADSL (Asymmetric Digital Subscriber Line), an SDSL (Symmetric Digital Subscriber Line), an HDSL (High bit-rate Digital Subscriber Line), a VDSL (Very high bit-rate Digital Subscriber Line), and the like are known as the xDSLs, and discriminated from each other by transmission rates, symmetry/asymmetry of rates, and the like. The DSLs are generically named as xDSLs.

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The xDSL is called a best-effort service. The transmission rate of the xDSL varies depending on environmental conditions such as a transmission distance of a communication line and noise. In general,

under the environmental condition that a transmission distance of a communication line is short and noise is low, the transmission rate increases. Under the environmental condition that the transmission distance of the communication line is long and noise is high, the
 5 transmission rate decreases.

The xDSL employs a DMT (Discrete Multi Tone) scheme as a modulation scheme. In this scheme, an initialization training is performed before a modem starts communication, a transmission distance of a communication line and an SNR (Single to Noise Ratio) of
 10 each carrier are measured, a bit rate arranged in each carrier is calculated on the basis of the SNR of the corresponding carrier, and a final transmission rate is determined on the basis of the calculated bit rate.

For example, an SNR of a carrier number: i (i is an arbitrary
 15 integer) is represented by SNR_i . Then a total sum of bit rates arranged in carriers: Totalrate, wherein the carrier numbers i of which are m th to n th, is calculated by the following (equation 1). A final transmission rate is determined on the basis of the calculated total sum of bit rates: Totalrate.

20 [Equation 1]

$$Totalrate = S \times \sum_{i=m}^n \log_2 \left(1 + \frac{SNR_i}{\Gamma} \right)$$

Reference symbol S denotes a symbol rate. In an ADSL conforming to G.992.1, the symbol rate is given as 4 kHz. Reference symbol Γ is an effective SNR gap. When an error rate is set at 10^{-7} , Γ
 25 = 9.75 dB.

The most dominated noise in the xDSL is a cross talk from another line. As shown in FIG. 1, cross talks includes a near end cross talk "NEXT" (a cross talk source and a cross talk receiver have

opposite directions) and a far end cross talk "FEXT" (s cross talk source and a cross talk receiver having the same direction). In general, the far end cross talk "FEXT" has an effect smaller than that of the near end cross talk "NEXT". The near end cross talk "NEXT" and the far end cross talk "FEXT" will be described below in detail with reference to FIG. 1.

When a communication line (1) shown in FIG. 1 is assumed to be an object to be measured, a cross talk generated by a communication line (2) as a "cross talk source" in which a signal flows in the same direction of the communication line (1) paid attention as an object to be measured is a far end cross talk "FEXT". Since a signal to be originally transmitted is attenuated according to a transmission distance, an amount of cross talk of the far end cross talk "FEXT" is also relatively attenuated depending on a transmission distance.

A cross talk generated by a communication line (3) as "cross talk source" in which a signal flows in a opposing direction of the communication line (1) paid attention as an object to be measured is a near end cross talk "NEXT". A signal to be originally transmitted is attenuated according to a transmission distance, whereas the near end cross talk "NEXT" has a large amount of cross talk at a destination of the signal to be originally transmitted. For this reason, an effect of the near end cross talk "NEXT" is more conspicuous than that of the far end cross talk "FEXT".

In a case of a conventional xDSL, as shown in FIG. 2, station-installed xTU-Cs (XDSL Termination Unit-Center side) (10 and 11) installed in a station side are present at the same position. However, at present, as shown in FIG. 3, the study of an xDSL installed in a remote terminal (RT) is advanced.

In a case of the xDSL installed in the remote terminal (RT), as

shown in FIG. 3, positions of the xTU-Cs (10 and 11) installed on the station side are different from each other. For this reason, a far end cross talk "FEXT" of the xTU-C (11) of the RT-installed xDSL is consequently generated on the way of a communication line (30) of the xTU-C (10) of an existing station-installed xDSL. As a result, the far end cross talk "FEXT" generated from the xTU-C (11) of the RT-installed xDSL considerably influences an xTU-R (XDSL Termination Unit-Remote side) (20) of existing station-installed xDSLs (10 and 20) adjacent to the RT-installed xDSLs (11 and 21).

10 This is because, when a signal of a high transmission output level is transmitted from the xTU-C (11) of the RT-installed xDSL under a condition wherein a signal transmitted from the xTU-C (10) of the station-installed xDSL is attenuated depending on a transmission distance of the communication line (30), a cross talk serving as a very large far end cross talk "FEXT" intercepts the xTU-R (20) of the existing station-installed xDSL.

For this reason, it is desirable to reduce an effect by the far end cross talk "FEXT" generated from the xTU-C (11) of the RT-installed xDSL, and to avoid a reduction in transmission rate of an adjacent station-installed xDSL.

As a method of reducing an effect by the far end cross talk "FEXT" of the RT-installed xDSL above described, a method of decreasing a transmission output level of a signal transmitted from the xTU-C (11) of the RT-installed xDSL may be used.

25 For example, in ITU-T recommended G.993.1 which is a recommendation of a VDSL, in order to reduce interference with an adjacent station-installed ADSL, a function which decreases a transmission output of 1.1 MHz or less of the station-installed VDSL is regulated.

30 It is proposed that transmission outputs in frequency bands

overlapping in an operation band of a station-installed VDSL and an operation band of a station-installed ADSL are suppressed to avoid a reduction of transmission rate of the station-installed ADSL.

However, even though the transmission outputs of the signals in the frequency bands overlapping in the operation band of the station-installed VDSL and the station-installed ADSL are suppressed, when a noise is generated in a high-frequency band higher than the operation band of the station-installed ADSL, a phenomenon in which a folding noise or the like is generated against the station-installed ADSL to deteriorate an SNR of an ADSL signal of the station-installed ADSL occurs. Consequently, it is found that a transmission rate of the station-installed ADSL is reduced.

For this reason, it is hoped to prevent a noise in a high-frequency band higher than the operation band of the station-installed ADSL and to desirably avoid a reduction of the transmission rate of the station-installed ADSL from at present.

As a technical document filed prior to the present invention, a document which discloses about a technique for performing data communication by using an optimum power spectrum depending on an operation state of an adjacent line is known (for example, see Japanese Patent Application Laid-Open (JP-A) No. 2006-14040).

A document which discloses about a technique for suppressing a transmission power in the same frequency band of an operation band used in an adjacent another communication scheme (for example, ADSL) to suppress interference with the other communication scheme is also known (for example, see JP-A No. 2006-115326).

However, in JP-A No. 2006-14040 and JP-A No. 2006-115326, it is not considered that a noise generated in a high-frequency band higher than an operation frequency band used by a communication apparatus is prevented to avoid a reduction in transmission rate of the

communication apparatus.

SUMMARY OF THE INVENTION

5 An exemplary object of the invention is to provide a transmission output control apparatus, a multi-carrier transmission system, a transmission output control method, and a transmission output control program which prevent a noise generated in a high-frequency band higher than an operation frequency used by a communication apparatus to avoid a reduction in transmission rate of
10 the communication apparatus.

A transmission output control apparatus according to an exemplary aspect of the invention controls a transmission output of a signal output to a communication line, including: a storing unit that stores at least one frequency band influencing a reduction in
15 transmission rate of a communication apparatus being present on an adjacent line adjacent to the communication line and including a range which is higher than an operation frequency band used by the communication apparatus; and a control unit that suppresses a transmission output of the signal in the frequency band to output a
20 signal to the communication line.

A multi-carrier transmission system according to an exemplary aspect of the invention is characterized in that a first communication apparatus and a second communication apparatus are connected to each other through a communication line, wherein the first
25 communication apparatus includes a storing unit that stores at least one frequency band influencing a reduction in transmission rate of a communication apparatus being present on an adjacent line adjacent to the communication line and including a range which is higher than an operation frequency band used by the communication apparatus;
30 and a control unit that suppresses a transmission output of the signal

in the frequency band to output a signal to the communication line.

A transmission output control method according to an exemplary aspect of the invention is performed by a transmission output control apparatus which controls a transmission output of a signal output to a communication line, wherein the transmission output control apparatus performs the storing step of storing at least one frequency band influencing a reduction in transmission rate of a communication apparatus being present on an adjacent line adjacent to the communication line and including a range which is higher than an operation frequency band used by the communication apparatus; and the control step of suppressing a transmission output of the signal in the frequency band to output a signal to the communication line.

A transmission output control program according to an exemplary aspect of the invention is executed in a transmission output control apparatus which controls a transmission output of a signal output to a communication line, the program causing a computer to perform: a storing process of storing at least one frequency band influencing a reduction in transmission rate of a communication apparatus being present on an adjacent line adjacent to the communication line and including a range which is higher than an operation frequency band used by the communication apparatus; and a control process of suppressing a transmission output of the signal in the frequency band to output a signal to the communication line.

BRIEF DESCRIPTION OF THE DRAWINGS

Features of the disclosed embodiments will be described by way of the following detailed description with reference to the accompanying drawings in which:

FIG. 1 is a diagram to explain a near end cross talk "NEXT" and a far end cross talk "FEXT";

FIG. 2 is a diagram showing a system configuration of a multi-carrier transmission system in which xTU-Cs (XDSL Termination Unit-Center side) (10 and 11) installed on a station side are present at the same position;

5 FIG. 3 is a diagram showing a system configuration of a remote-terminal (RT) installed multi-carrier transmission system in which xTU-Cs (XDSL Termination Unit-Center side) (10 and 11) installed on a station side are present at different positions to explain a far end cross talk "FEXT" of the xTU-C (11) of the RT-installed
10 xDSL;

FIG. 4 is a diagram showing a system configuration of a multi-carrier transmission system;

FIG. 5 is a diagram showing a table configuration which manages "station information", "terminal information", and "line
15 signal information" in association with "types of modems";

FIG. 6 is a diagram showing a table configuration which manages "frequency bands" and "signal powers" in association with "types of modems";

FIG. 7 is a diagram showing a "frequency band" which
20 influences a reduction in transmission rate of an xTU-C (500) of an adjacent line (400) and a "signal power" used in the "frequency band";

FIG. 8 is a flow chart showing a control operation performed by an xTU-C (100) according to a first embodiment;

FIG. 9 is a diagram showing a state in which the xTU-C (100)
25 transmits a signal at a predetermined default transmission output value without performing transmission output control;

FIG. 10 is a diagram showing a state in which the xTU-C (100) performs transmission output control, suppresses a transmission output of a signal in a frequency band influencing a reduction in
30 transmission rate of the xTU-C (500) to transmit a signal;

FIG. 11 is a flow chart showing a control operation performed by an xTU-C (100) according to a second embodiment;

FIG. 12 is a diagram for explaining the control operation performed by the xTU-C (100) according to the second embodiment;

5 FIG. 13 is a diagram showing a state in which the xTU-C (100) performs transmission output control and suppresses a transmission output of a signal in a frequency band influencing a reduction in transmission rate of the xTU-C (500) to transmit a signal;

FIG. 14 is a flow chart showing a method of determining
10 whether suppression control of a transmission output is performed; and

FIG. 15 is a diagram showing another system configuration constituting a multi-carrier transmission system according to the embodiment.

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DESCRIPTION OF EXEMPLARY EMBODIMENTS

(Characteristic Feature of Embodiment)

Characteristic features of a multi-carrier transmission system according to an embodiment will be described below.

20 The multi-carrier transmission system according to the embodiment is a multi-carrier transmission system in which, as shown in FIG. 4, a first communication apparatus (corresponding to an xTU-C: 100) and a second communication apparatus (corresponding to an x-TU-R: 200) are connected to each other through a communication
25 line (300).

A first communication apparatus (100) stores at least one frequency band influencing a reduction in transmission rate of a communication apparatus (500) being present on an adjacent line (400) adjacent to a communication line (300) in a storing means
30 (corresponding to a storing unit: (104)). A frequency band to be stored

in the first communication apparatus (100) includes a frequency band range which is higher than an operation frequency band used by the communication apparatus (500). The first communication apparatus (100) suppresses a transmission output of a signal in the frequency band stored in the storing means (104) to output the signal to the communication line (300).

In this manner, the first communication apparatus (100) suppresses a transmission output of a signal in a frequency band influencing a reduction in transmission rate of the communication apparatus (500) in at least one frequency band including a range which is higher than an operation frequency band used by the communication apparatus (500) being present on the adjacent line (400) to output the signal to the communication line (300). For this reason, the first communication apparatus (100) prevents a noise generated in the high-frequency band higher than the operation frequency band used by the communication apparatus (500) being present on the adjacent line (400) to make it possible to avoid a reduction in transmission rate of the communication apparatus (500). With reference to the accompanying drawings, the multi-carrier transmission system according to the embodiment will be described below in detail.

<System Configuration of Multi-Carrier Transmission System>

Referring to FIG. 4, a system configuration of a multi-carrier transmission system according to the embodiment will be described.

The multi-carrier transmission system according to the embodiment has a configuration in which an xTU-C (XDSL Termination Unit-Center side) (100) serving as a station-side apparatus and an xTU-R (XDSL Termination Unit-Remote side) (200) serving as a house-side apparatus are connected through the communication line (300).

The xTU-C (100) serving as the station-side apparatus is connected to a line information management server (50) which manages a type of modems and an interference information management server (60) which manages a frequency band influencing the modem.

The line information management server (50), for example, as shown in FIG. 5, includes a database which manages "station information", "terminal information", and "line signal information" in association with each "type of a modem".

The "station information" means information related to a position where a station-side communication apparatus being present on an adjacent line is installed. The "terminal information" means information related to a house-side communication apparatus being present on the adjacent line. The "line signal information" means information related to an operation frequency band and a transmission scheme used by the communication apparatus being present on the adjacent line.

The interference information management server (60), for example, as shown in FIG. 6, includes the database which manages a "frequency band" and a "signal power" in association with each "type of a modem".

The "frequency band" means a frequency band influencing a reduction in transmission rate, and the "signal power" means a signal power used in the frequency band influencing the reduction in transmission rate.

For example, when a "modem A" is used as a "type of a modem" in the xTU-C (500) of the adjacent line (400), as shown in FIG. 7, it is found that a reduction in transmission rate is influenced in "frequency bands": a_{11} to a_{1n} (n is an arbitrary integer), a_{21} to a_{2n} , a_{31} to a_{3n} ,.... For this reason, the interference information management server (60)

manages the "frequency bands": a11 to a1n, a21 to a2n, a31 to a3n,..., influencing a reduction in transmission rate and "signal powers": a1, a2, a3,... used in the frequency bands in association with the "modem A" in the database.

5 In this manner, the interference information management server (60) can manage the "frequency band" influencing a reduction in transmission rate and a "signal power" used in the frequency band for each "type of a modem".

<Internal Configuration of xTU-C: 100>

10 An internal configuration of the xTU-C (100) serving as a station-side apparatus will be described below.

The xTU-C (100) according to the embodiment includes a transmission unit (101), a receiving unit (102), a transmission output control unit (103), a storing unit (104), and a modem identifying unit
15 (105).

The transmission unit (101) is to transmit a signal to the xTU-R (200). The receiving unit (102) is to receive a signal transmitted from the xTU-R (200).

20 The transmission output control unit (103) is to control a transmission output of a signal transmitted from the xTU-C (100) to the communication line (300).

The storing unit (104) is to store information required for control in communication with the xTU-C (100).

25 The modem identifying unit (105) is to specify the type of the modem used by another xDSL being present on the adjacent line (400).

Particularly, the modem identifying unit (105) acquires the "station information", "terminal information", and "line signal information" from the outside of the xTU-C (100) and acquires a "type of a modem" corresponding to the acquired "station information",
30 "terminal information", and "line signal information" from the line

information management server (50) so as to specify the "type of the modem" used by an xDSL being present on the adjacent line (400).

For example, in the case in FIG. 5, the line information management server (50) manages "station information A", "terminal information A", and "line signal information A" in association with each other for the "modem A" in the database. When the modem identifying unit (105) acquires the "station information A", the "terminal information A", and the "line signal information A", the modem identifying unit (105) is to acquire the "modem A" from a database of the line information management server (50) corresponding to the acquired "station information A", the "terminal information A", and the "line signal information A". In this manner, the modem identifying unit (105) can specify the "modem A" used by the xDSL being present on the adjacent line (400).

A table configuration shown in FIG. 5 which is managed by the line information management server (50) in the database is an example. When the modem identifying unit (105) can specify a type of a modem on the basis of information acquired from the outside of the xTU-C (100), every of information can be managed in association with the "type of the modem" in the database of the line information management server (50). When the number of every "information" which is managed in association with the type of the modem is large, a type of a modem can be specified at high accuracy.

In the case shown in FIG. 5, the line information management server (50) manages "station information", "terminal information", and "line signal information" in association with a "type of a modem" in the database. However, the line information management server (50) may manage at least one of the "station information", the "terminal information", and "line signal information" in association with the "type of the modem" in the database, so that the modem identifying

unit (105) can acquire at least one piece of information of the "station information", the "terminal information", and the "line signal information" from the outside of the xTU-C (100) to specify a "type of a modem" from the database of the line information management server
 5 (50) on the basis of at least one of the acquired "station information", "terminal information", and the "line signal information".

<Internal Configuration of xTU-R:200>

An internal configuration of the xTU-R (200) serving as a house-side apparatus will be described below.

10 The xTU-R (200) according to the embodiment includes a transmission unit (201), a receiving unit (202), a transmission output control unit (203), a storing unit (204), and a modem identifying unit (205).

The transmission unit (201) is to transmit a signal to the xTU-C
 15 (100). The receiving unit (202) is to receive a signal transmitted from the xTU-C (100).

The transmission output control unit (203) is to control a transmission output of a signal transmitted from the xTU-R (200) to the communication line (300).

20 The storing unit (204) is to store information required for control in communication with the xTU-R (200).

The modem identifying unit (205) is to specify a type of a modem used by another xDSL being present on the adjacent line (400).

<Processing Operation>

25 A control operation performed by the xTU-C (100) will be described below with reference to FIG. 8. FIG. 8 is a flow chart showing a control operation to avoid a reduction in transmission rate of the xTU-C (500) being present on the adjacent line (400).

The modem identifying unit (105) specifies a type of a modem of
 30 the xTU-C (500) being present on the adjacent line (400)(Step S1).

For example, the modem identifying unit (105) acquires "station information", "terminal information", and "line signal information" from the outside of the xTU-C (100). The modem identifying unit (105) accesses the line information management server (50), acquires a
5 "type of a modem" corresponding to the "station information", the "terminal information", and the "line signal information" acquired from the outside of the xTU-C (100) from the line information management server (50) with reference to the table managed in the database of the line information management server (50) which is
10 shown in FIG. 5, and specifies a type of a modem of the xTU-C (500) being present on the adjacent line (400).

The transmission output control unit (103) accesses the interference information management server (60), acquires a
15 "frequency band" corresponding to the "type of the modem" specified by the modem identifying unit (105) in step S1 and a "signal power" used in the frequency band from the interference information management server (60) with reference to the table managed in the database of the interference information management server (60) which is shown in
FIG. 6 (step S2), and stores the acquired "frequency band" and the
20 "signal power" in the storing unit (104).

In this manner, the xTU-C (100) can store and manage the "frequency band" influencing a reduction in transmission rate of the communication apparatus (500) being present on the adjacent line (400) and a "signal power" used in the frequency band in the storing
25 unit (104).

The transmission output control unit (103) generates a bit gain table in which the signal power in the frequency band influencing the reduction in transmission rate of the xTU-C (500) being present on the adjacent line (400) on the basis of the "frequency band" and the "signal
30 power" stored in the storing unit (104) (step S3). The transmission

output control unit (103) outputs a signal to the communication line (300) on the basis of the generated bit gain table (step S4).

For example, in a state in which the xTU-C (500) being present on the adjacent line (400) does not perform communication, a signal power in the frequency band need not be suppressed, so that a signal is sent to the communication line (300) as a signal power as shown in FIG. 9. FIG. 9 shows a "frequency band" used when the xTU-C (500) being present on the adjacent line (400) performs "ADSL communication" and the xTU-C (100) performs "VDSL communication", and a "signal power" used in the frequency band. As shown in FIG. 9, it is found that the "ADSL" uses a frequency band lower than that of the "VDSL".

When the xTU-C (100) determines that the xTU-C (500) being present on the adjacent line (400) performs communication, the xTU-C (100) generates a bit gain table in which the signal power in the frequency band influencing the reduction in transmission rate of the xTU-C (500) being present on the adjacent line (400) on the basis of the "frequency band" and the "signal power" stored in the storing unit (104), and outputs a signal to the communication line (300) on the basis of the generated bit gain table.

In this manner, for example, when the type of the modem of the xTU-C (500) being present on the adjacent line (400) is the modem A, the modem A is influenced in the frequency bands: a_{11} to a_{1n} , a_{21} to a_{2n} , a_{31} to a_{3n} ,... shown in FIG. 7. For this reason, as shown in FIG. 10, the xTU-C (100) suppresses a transmission output of a signal in a frequency band influencing the reduction in transmission rate of the xTU-C (500) on the basis of the "frequency band" and the "signal power" shown in FIG. 7 to output a signal to the communication line (300).

In this manner, the xTU-C (100) can prevent noise generated in

a high-frequency band higher than an operation frequency band used by the xTU-C (500) being present on the adjacent line (400), and avoid a reduction in transmission rate of the xTU-C (500).

As described above, the xTU-C (100) according to the
5 embodiment specifies the "type of the modem" of the xTU-C (500) being present on the adjacent line (400) and stores a "frequency band" and a "signal power" corresponding to the specified "type of the modem" in the storing unit (104). The xTU-C (100) suppresses a transmission output of a signal in the frequency band influencing the reduction in
10 transmission rate of the xTU-C (500) on the basis of the "frequency band" and the "signal power" stored in the storing unit (104) to output a signal to the communication line (300).

In this manner, the xTU-C (100) suppresses a transmission output of a signal in a frequency band influencing a reduction in
15 transmission rate of the xTU-C (500) in a frequency band including at least one high-frequency band including a range which is higher than an operation frequency band used by the xTU-C (500) being present on the adjacent line (400) to output a signal to the communication line (300). For this reason, the xTU-C (100) can prevent a noise generated
20 in the high-frequency band higher than the operation frequency band used by the xTU-C (500) being present on the adjacent line (400) to make it possible to avoid the reduction in transmission rate of the xTU-C (500).

(Second Embodiment)

25 A second embodiment will be described below.

In the multi-carrier transmission system according to the first embodiment, it is assumed that one modem is present on the adjacent line (400) and that the modem identifying unit (105) specifies a type of one modem. However, it can also be assumed that a plurality of
30 modems is present on the adjacent line (400).

For this reason, in the multi-carrier transmission system according to the second embodiment, when a plurality of modems are present on the adjacent line (400), the modem identifying unit (105) specifies types of a plurality of modems and stores "frequency bands" and "signal powers" corresponding to the specified types of the plurality of modems in the storing unit (104). Then the modem identifying unit (105) suppresses a transmission output of a signal in a frequency band influencing a reduction in transmission rate of the xTU-C (500) on the basis of the plurality of "frequency bands" and the plurality of "signal powers" stored in the storing unit (104) to output a signal to the communication line (300). In this manner, even though the plurality of modems is present on the adjacent line (400), transmission outputs of signals in frequency band suitable for the plurality of modems can be suppressed. The multi-carrier transmission system according to the second embodiment will be described below with reference to FIGS. 11 to 13. A system configuration of the multi-carrier transmission system according to the second embodiment is the same configuration as in the first embodiment.

A control operation performed by the xTU-C (100) will be described below with reference to FIG. 11. FIG. 11 is a flow chart showing a control operation to avoid a reduction in transmission rate of the xTU-C (500) being present on the adjacent line (400).

The modem identifying unit (105) specifies types of a plurality of modems of the xTU-C (500) being present on the adjacent line (400) (step S11).

For example, the modem identifying unit (105) acquires "station information", "terminal information", and "line signal information" from the outside of the xTU-C (100). The modem identifying unit (105) accesses the line information management server (50) and

acquires "types of a plurality of modems" corresponding to the "station information", the "terminal information" and the "line signal information" from the line information management server (50) with reference to the table managed in the database of the line information management server (50) which is shown in FIG. 5, and specifies the types of the plurality of modems of the xTU-C (500) being present on the adjacent line (400).

Then the transmission output control unit (103) accesses the interference information management server (60), acquires "frequency bands" corresponding to "types of a plurality of modems" specified by the modem identifying unit (105) in step S11 and "signal powers" used in the frequency bands from the interference information management server (60) with reference to the table managed in the database of the interference information management server (60) which is shown in FIG.6 (Step S12), and stores the acquired "frequency bands" and the "signal powers" in the storing unit (104).

In this manner, the xTU-C (100) can store and manage a plurality of "frequency bands" influencing a reduction in transmission rate of the communication apparatus (500) being present on the adjacent line (400) and "signal powers" used in the frequency bands in the storing unit (104).

Next, the transmission output control unit (103) determines a "frequency band" including a type of each modem and a "signal power" used in the "frequency band" on the basis of the plurality of "frequency bands" and the "signal powers" stored in the storing unit (104) (Step S13).

For example, when the transmission output control unit (103) acquires "frequency bands" and "signal powers" corresponding to a modem A and a modem B in step S12, as shown in FIGS. 12A and 12B, the transmission output control unit (103) can specify a frequency

band influencing the modem A and a frequency band influencing the modem B. FIG. 12A shows the frequency band influencing the modem A, and FIG. 12B shows a frequency band influencing the modem B.

The transmission output control unit (103) determines, as shown in FIG. 12C, a "frequency band" including the "frequency band" of the modem A and the "frequency band" of the modem B. In this manner, even though types of a plurality of modems are present on the adjacent line (400), a "frequency band including the types of the plurality of modems can be determined.

As the "signal power", a minimum signal power is preferably determined by the modem A and the modem B. For example, in FIG. 12C, a "signal power" in a frequency band "a21 to b2n" including the modem A and the modem B is given by " $b2 > a2$ ", so that "a2" is selected.

Depending on a ratio of the "frequency band" of the modem A to the "frequency band" of the modem B obtained when the "frequency band" including the modem A and the modem B is determined, a signal power used in the "frequency band" including the modem A and the modem B can also be determined.

For example, when the ratio of the "frequency band" of the modem A to the "frequency band" of the modem B is given by modem A : modem B = 7 : 3, a signal power: x used in the "frequency band" including the modem A and the modem B is a signal power calculated by $x = (7a + 3b) \div 10$.

The transmission output control unit (103) generates a bit gain table, in which a signal power in a frequency band influencing a reduction in transmission rate of the xTU-C (500) being present on the adjacent line (400) is suppressed, on the basis of the "frequency band" including the types of the plurality of modems shown in FIG. 12C and the "signal powers" used in the frequency bands (step S14). Then, the

transmission output control unit (103) outputs a signal to the communication line (300) by using the generated bit gain table (step S15).

5 In this manner, the xTU-C (100), as shown in FIG. 13, suppresses a transmission output of a signal in the frequency band influencing the reduction in transmission rate of the xTU-C (500) on the basis of the frequency band and the signal power shown in FIG. 12C to output a signal to the communication line (300).

10 In this manner, in the multi-carrier transmission system according to the second embodiment, when a plurality of modems are present on the adjacent line (400), the modem identifying unit (105) specifies types of a plurality of modems and stores frequency bands and signal powers corresponding to the specified types of the plurality of modems in the storing unit (104). The modem identifying unit
15 (105) suppresses a transmission output of a signal in the frequency band influencing the reduction in transmission rate of the xTU-C (500) on the basis of the plurality of frequency bands and the plurality of signal powers stored in the storing unit (104) to output a signal to the communication line (300). In this manner, even though the plurality
20 of modems is present on the adjacent line (400), a transmission output of a signal in a frequency band suitable for the plurality of modems can be suppressed.

In the second embodiment described above, as shown in FIG. 12C, the "frequency band" including the "frequency band" of the
25 modem A and the "frequency band" of the modem B is determined. However, when the number of types of modems being present on the adjacent line (400) is large, a "frequency band" including the types of the modems at a predetermined ratio can be determined.

For example, as the types of the modems being present on the
30 adjacent line (400), a modem A, a modem B, a modem C, and a modem

D are assumed. When the frequency bands influencing the modems are given by modem A: 2 to 5 MHz,..., modem B: 3 to 4 MHz,..., modem C: 2 to 6 MHz,..., and modem D: 3 to 8 MHz..., a frequency band including the modems A to D ranges from 2 to 8 MHz. However, a
5 frequency band of 2 to 5 MHz shared by the modems A to D at a ratio of 50% or more may be determined. The predetermined ratio can be arbitrarily set.

The above embodiments are preferred embodiments of the present invention. The spirit and scope of the invention are not
10 limited by only the above embodiments. Various changes and modifications of the invention can be effected without departing from the gist of the invention.

For example, a method of determining whether suppression control of a transmission output in the embodiment is performed can
15 be executed when it is determined that a noise having a value equal to or higher than a predetermined threshold value is generated in the adjacent line (400).

For example, as shown in FIG. 14, the xTU-C (100) measures a crosstalk noise of the adjacent line (400) by using a spectrum analyzer
20 or the like (step S21).

The xTU-C (100) determines whether a noise having a value equal to or higher than a predetermined threshold value is generated in the adjacent line (400) (step S22).

When it is not determined that the noise having the value equal
25 to or higher than the predetermined threshold value is generated in the adjacent line (400) (step S22/No), the xTU-C (100) determines that transmission output control is unnecessary, and a signal is transmitted at a default predetermined transmission output value shown in FIG. 9 (step S23). As the predetermined transmission
30 output value, a maximum transmission output value disclosed in

ITU-T recommendation G.993.2, ITU-T recommendation G.993.3, and the like is applicable.

When it is determined that the noise having the value equal to or higher than the predetermined threshold value is generated in the adjacent line (400) (step S23/Yes), the xTU-C (100) performs suppression control of a transmission output and transmission output control of a signal transmitted to the communication line (300).

In this manner, depending on whether the noise having the value equal to or higher than the predetermined threshold value is generated in the adjacent line (400), it can be determined whether transmission output control of a signal transmitted to the communication line (300) is performed. The method of measuring the crosstalk noise in the adjacent line (400) is not limited to a spectrum analyzer or the like. The crosstalk noise in the adjacent line (400) can be measured by applying every method. The noise may also be measured by using a modem.

In the embodiments described above, a specifying method used when a type of a modem being present on the adjacent line (400) is specified is not limited to a specific method. For example, information is acquired from modem management software in a telephone exchange station, so that a type of a modem is specified on the basis of the acquired information. Alternatively, a type of a modem can be specified by directly using information installed in a house, or a type of a modem can be specified on the basis of a signal of a line, crosstalk noise, or the like.

In the embodiments described above, as shown in FIGS. 5 and 6, pieces of information are managed in units of "types of modems". However, the technical idea of the present invention is not limited to a type of a modem. When a frequency band influencing a reduction in transmission rate of a communication apparatus can be specified,

everything can be applied.

In the above embodiments, a suppression value which suppresses a transmission output of a signal in a frequency band influencing a reduction in transmission rate of the xTU-C (500) can be arbitrarily adjusted. For example, the suppression value of the transmission output can also be arbitrarily adjusted depending on a type of a modem, or a transmission output of a signal in the frequency band influencing a reduction in transmission rate of the xTU-C (500) can be completely made zero. The suppression value suppressing a transmission output can also be adjusted depending on noise generated in the adjacent line (400).

In the embodiments described above, the line information management server (50), for example, as shown in FIG. 5, manages "station information", "terminal information", and "line signal information" in association with each "type of a modem", and the interference information management server (60), for example, as shown in FIG. 6, manages a "frequency band" and a "signal power" in association with each "type of a modem". However, the pieces of information managed by the line information management server (50) and the frequency band management server (60) can also be managed by the xTU-C (100).

The multi-carrier transmission system according to the embodiment described above can also be applied to a system as shown in FIG. 15. In the system configuration shown in FIG. 15, an ADSL in-station apparatus (500) and an ADSL in-house apparatus (600) are connected to each other through a communication line (400). And an OLT (Optical Line Terminal) (700) and a remote composite apparatus (100) are connected to each other through a communication line (800), and the remote composite apparatus (100) and a VDSL in-house apparatus (200) are connected to each other through a communication

line (300). The remote composite apparatus (100) includes an ONU (Optical Network Unit) and a VDSL station-side apparatus.

A control operation for the xTU-C (100) and the xTU-R (200) constituting the multi-carrier transmission system according to the above embodiments in the communication apparatus can be executed by not only a hardware configuration but also software such as a computer program. The program is recorded on a recording medium such as an optical recording medium, a magnetic recording medium, a magneto-optical recording medium, or a semiconductor or the like, and the program is loaded from the recording medium onto a communication apparatus to make it possible to execute the control operation in the communication apparatus. The program is loaded from an external equipment connected through a predetermined network onto the communication apparatus to also make it possible to execute the control operation in the communication apparatus.

A transmission output control apparatus, a multi-carrier transmission system, a transmission output control method, and a transmission output control program according to the present invention can be applied to an xDSL (x Digital Subscriber Line) (x is a generic name of A, H, S, V, or the like) which performs data transmission at a high rate of several M bits/second through a metallic cable such as a telephone line.

A third exemplary embodiment of the invention is a transmission output control apparatus including: an interference management unit that manages the frequency band for each type of the communication apparatus; a specifying unit that specifies the type of the communication apparatus being present on the adjacent line; and an acquiring unit that acquires a frequency band depending on the type of the communication apparatus from the interference

management means, wherein the storing unit stores the frequency band depending on the type of the communication apparatus.

A fourth exemplary embodiment of the invention is that the acquiring unit acquires, when communication apparatuses of a plurality of types are specified by the specifying unit, a plurality of frequency bands depending on the types of the communication apparatuses by the interference management unit, the storing unit stores the plurality of frequency bands depending on the types of the communication apparatuses, and the control unit determines a frequency band which suppresses a transmission output on the basis of the plurality of frequency bands and suppresses a transmission output of a signal in the determined frequency band.

A fifth exemplary embodiment of the invention is that the control unit determines a frequency band including the plurality of frequency bands as the frequency band which suppresses the transmission output.

A sixth exemplary embodiment of the invention is that the control unit determines a frequency band including the plurality of frequency bands at a predetermined ratio as the frequency band which suppresses the transmission output.

A seventh exemplary embodiment of the invention is that the transmission output control apparatus includes a setting unit that sets the predetermined ratio.

A eighth exemplary embodiment of the invention is that a transmission output control apparatus includes: a line management unit that manages states of the adjacent lines and types of the communication apparatuses in association with each other; and a state acquiring unit that specifies a state of the adjacent line, wherein the specifying unit specifies a type of the communication apparatus corresponding to the state of the adjacent line specified by the state

acquiring unit from the line management unit.

A ninth exemplary embodiment of the invention is that the state of the adjacent line is at least one of information related to a position where a station-side communication apparatus being present on the adjacent line is installed, information related to a house-side communication apparatus being present on the adjacent line, and information related to an operation frequency band and a transmission scheme which are used by the communication apparatuses being present on the adjacent line.

10 A tenth exemplary embodiment of the invention is that the interference management unit is arranged separately from and independently of the transmission output control apparatus.

An eleventh exemplary embodiment of the invention is that the line management unit is arranged separately from and independently of the transmission output control apparatus.

15 An twelfth exemplary embodiment of the invention is that a transmission output control apparatus includes an adjustment unit which adjusts a suppression value which suppresses a transmission output of a signal in a frequency band.

20 An exemplary advantage according to the present invention is that in a frequency band including a range which is higher than an operation frequency band used by a communication apparatus, it is possible to suppress a transmission output of a signal in a frequency band influencing a reduction in transmission rate of the communication apparatus and to output a signal to a communication line. For this reason, a generation of a noise in a high-frequency band higher than the operation frequency band used by a communication apparatus being present on an adjacent line can be prevented, and a reduction of the transmission rate of the communication apparatus can be avoided.

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While the invention has been particularly shown and described with reference to exemplary embodiments thereof, the invention is not limited to these embodiments. It will be understood by those of ordinary skill in the art that various changes in form and details may
5 be made therein without departing from the spirit and scope of the present invention as defined by the claims.

WHAT IS CLAIMED IS:

1. A transmission output control apparatus that controls a transmission output of a signal output to a communication line, comprising:

5 storing means for storing at least one frequency band that influences a reduction in transmission rate of a communication apparatus being present on an adjacent line adjacent to the communication line and includes a range that is higher than an operation frequency band used by the communication apparatus; and

10 control means for suppressing a transmission output of the signal in the frequency band to output a signal to the communication line.

2. The transmission output control apparatus according to claim 1, comprising:

interference management means for managing the frequency band for each type of the communication apparatus;

5 specifying means for specifying the type of the communication apparatus being present on the adjacent line; and

acquiring means for acquiring the frequency band depending on the type of the communication apparatus from the interference management means, wherein

10 the storing means stores the frequency band depending on the type of the communication apparatus.

3. The transmission output control apparatus according to claim 2, wherein

the acquiring means acquires, when communication apparatuses of a plurality of types are specified by the specifying means, a plurality of frequency bands depending on the types of the

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communication apparatuses by the interference management means,
the storing means stores the plurality of frequency bands
depending on the types of the communication apparatuses, and
the control means determines a frequency band that suppresses
10 a transmission output on the basis of the plurality of frequency bands
and suppresses a transmission output of a signal in the determined
frequency band.

4. The transmission output control apparatus according to
claim 3, wherein

the control means determines a frequency band including the
plurality of frequency bands as the frequency band that suppresses the
5 transmission output.

5. The transmission output control apparatus according to
claim 3, wherein

the control means determines a frequency band including the
plurality of frequency bands at a predetermined ratio as the frequency
5 band that suppresses the transmission output.

6. The transmission output control apparatus according to
claim 5, comprising

setting means for setting the predetermined ratio.

7. The transmission output control apparatus according to
claim 2, comprising:

line management means for managing states of the adjacent
lines and types of the communication apparatuses in association with
5 each other; and

state acquiring means for specifying a state of the adjacent line,

wherein

the specifying means specifies a type of the communication apparatus corresponding to the state of the adjacent line specified by
10 the state acquiring means from the line management means.

8. The transmission output control apparatus according to claim 7, wherein

the state of the adjacent line is at least one of information related to a position where a station-side communication apparatus
5 being present on the adjacent line is installed, information related to a house-side communication apparatus being present on the adjacent line, and information related to an operation frequency band and a transmission scheme that are used by the communication apparatuses being present on the adjacent line.

9. The transmission output control apparatus according to claim 2, wherein

the interference management means is arranged separately from and independently of the transmission output control apparatus.

10. The transmission output control apparatus according to claim 7, wherein

the line management means is arranged separately from and independently of the transmission output control apparatus.

11. The transmission output control apparatus according to claim 1, comprising

adjustment means for adjusting a suppression value that suppresses a transmission output of a signal in the frequency band.

12. A multi-carrier transmission system in which a first communication apparatus and a second communication apparatus are connected to each other through a communication line wherein

the first communication apparatus includes:

5 storing means for storing at least one frequency band influencing a reduction in transmission rate of a communication apparatus being present on an adjacent line adjacent to the communication line and including a range that is higher than an operation frequency band used by the communication apparatus; and

10 control means for suppressing a transmission output of the signal in the frequency band to output a signal to the communication line.

13. A transmission output control method that is performed in a transmission output control apparatus that controls a transmission output of a signal output to a communication line, wherein

5 the transmission output control apparatus performs:

the storing step of storing at least one frequency band influencing a reduction in transmission rate of a communication apparatus being present on an adjacent line adjacent to the communication line and including a range that is higher than an
10 operation frequency band used by the communication apparatus; and

the control step of suppressing a transmission output of the signal in the frequency band to output a signal to the communication line.

14. A transmission output control program that is executed in a transmission output control apparatus that controls a transmission output of a signal output to a communication line,

wherein

- 5 the transmission output control apparatus is caused to execute:
 a storing process of storing at least one frequency band
influencing a reduction in transmission rate of a communication
apparatus being present on an adjacent line adjacent to the
communication line and including a range that is higher than an
10 operation frequency band used by the communication apparatus; and
 a control process of suppressing a transmission output of the
signal in the frequency band to output a signal to the communication
line.