SINGLE-CABLE FOUR-STREAM COVERAGE SYSTEM BASED ON PASSIVE FREQUENCY CONVERSION, POWER CONSUMPTION CONTROL METHOD, AND MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims a priority to the Chinese patent application No. 202410235269.1 filed on March 1, 2024, disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of communications, in particular to a single-cable four-stream coverage system based on passive frequency conversion, a power consumption control method, and a medium.

BACKGROUND

[0003] Existing cross-floor coverage schemes include: 1. Chinese patent application No. 202210089069.0, which provides a 5th-Generation (5G) indoor distribution distributed antenna system (DAS) antenna monitoring device; 2. Chinese patent application No. 202211440707.5, which provides a device and a method for supporting 5G near-far end wireless frequency shift; and 3. Chinese patent application No. 202210056024.3, which provides a single-cable, dual-MIMO 5G frequency shift system.

[0004] In Scheme 1, only a 5G single-cable active frequency shift device is used to monitor the DAS antenna. The active frequency shift requires remote power supply, which makes the device more complicated and lacks implementation benefits. In addition, at the near end, a near-end unit needs to be added, further leading to an increase in the cost.

[0005] In Scheme 2, a frequency conversion signal is transmitted in a free space in a wireless manner, so more elements are required and the cost is higher.

[0006] In scheme 3, a so-called 2×2 Multiple Input Multiple Output (MIMO) essentially refers to two channels of 1.1 GHz signals and two channels of 1.3 GHz signals. Actually, the 1.1 GHz signal and the 1.3 GHz signal need to be mixed at a remote end. Finally, only two channels of signals are transmitted by a remote antenna, and a terminal can only receive two channels of signals.

[0007] Hence, the existing cross-floor coverage technology suffers from problems such as high cost and low reliability.

SUMMARY

[0008] Embodiments of the present disclosure provide a single-cable four-stream coverage system based on passive frequency conversion, a power consumption control method and a medium, so as to solve the problems in the existing cross-floor coverage technology, such as high cost and low reliability.

[0009] In a first aspect, the present disclosure provides in some embodiments a single-cable four-stream coverage system based on passive frequency conversion, including a power controller, a first Remote Radio Unit (RRU), a second RRU, a three-port multi-band combiner, a coupler, a two-port multi-band combiner and a passive frequency conversion antenna. The power controller is coupled to the first RRU, the first RRU is configured to output a signal carrying data information, and the power controller is configured to control signal output power of the first RRU; the first RRU is coupled to the three-port multi-band combiner via three channels, and the three-port multi-band combiner is configured to combine signals transmitted via the three channels; the three-port multi-band combiner is coupled to the two-port multi-band combiner via the coupler, the coupler is configured to equally divide a received signal to obtain equally-divided signals, and the two-port multi-band combiner is configured to combine the equally-divided signals sent by the coupler to obtain a combined signal; the two-port multi-band combiner is coupled to the passive frequency conversion antenna, and the passive frequency conversion antenna is configured to output the combined signal sent by the two-port multi-band combiner to the outside; the second RRU is coupled to the coupler via a single channel; and three channels of

signals generated by the first RRU and a channel of signals generated by the second RRU are sent to the passive frequency conversion antenna via the three channels, the single channel, the three-port multi-band combiner, the coupler and the two-port multi-band combiner.

[0010] In an embodiment of the present disclosure, the power controller includes a frequency-conversion RRU monitor, a frequency-conversion RRU channel power regulator, an RRU status reading unit, an initial condition input unit and a calculation unit; the frequency-conversion RRU channel power regulator is coupled to the first RRU and the calculation unit; the frequency-conversion RRU monitor is coupled to the RRU status reading unit and the calculation unit, and the frequency-conversion RRU monitor includes a frequency-conversion RRU traffic monitor, a frequency-conversion RRU power consumption monitor and a frequency-conversion RRU user number monitor; the RRU status reading unit is coupled to the first RRU; the initial condition input unit is coupled to the calculation unit; the RRU status reading unit is configured to read operating information of the first RRU; the frequency-conversion RRU monitor is configured to extract, from the operating information, a number of connected users, power consumption information and a sum of uplink and downlink traffic rates; the initial condition input unit is configured to obtain user historical status information; and the calculation unit is configured to control signal output power of the first RRU for each channel according to the number of connected users, the power consumption information, the sum of the uplink and downlink traffic rates, and the user historical status information.

[0011] In an embodiment of the present disclosure, the first RRU includes a high-speed interface module, a target signal transceiving unit, a power amplifier (PA), a low noise amplifier (LNA), a circulator, a radio frequency (RF) switch, a standing wave monitoring circuit, a high-power load, a first grounding unit, a second grounding unit, a non-frequency-shift filter, and a frequency-shift filter; the high-speed interface module is coupled to the three-port multi-band combiner via the target signal transceiving unit, and the target signal transceiving unit includes a non-frequency-shift signal transceiving unit and a frequency-shift signal transceiving unit; the target signal

transceiving unit is coupled to the three-port multi-band combiner sequentially via the PA, the circulator, and the non-frequency-shift filter or the frequency-shift filter; the target signal transceiving unit is coupled to the standing wave monitoring circuit sequentially via the LNA and the RF switch; the target signal transceiving unit is coupled to the first grounding unit sequentially via the LNA, the RF switch and the high-power load; and the frequency-shift signal transceiving unit is coupled to the second grounding unit sequentially via the PA, the circulator, the RF switch and the high-power load.

[0012] In an embodiment of the present disclosure, the three-port multi-band combiner includes a signal input receiver, a combining unit and a signal output unit; an end of the combining unit is coupled to the signal input receiver, and another end of the combining unit is coupled to the signal output unit; and the combining unit is configured to combine heterogeneous frequency signals transmitted by the signal input receiver, and send the combined heterogeneous frequency signals via the signal output unit.

[0013] In an embodiment of the present disclosure, the single-cable four-stream coverage system further includes a distribution system; an end of the distribution system is coupled to the two-port multi-band combiner, and another end of the distribution system is coupled to the passive frequency conversion antenna; and the distribution system is configured to send a signal sent by the two-port multi-band combiner to the passive frequency conversion antenna.

[0014] In an embodiment of the present disclosure, the coupler is configured to equally divide the received signal into two channels of signals having a same frequency and half the power.

[0015] In an embodiment of the present disclosure, the passive frequency conversion antenna includes a signal input port, a frequency shift module, a vertically polarized radiating unit and a horizontally polarized radiating unit, the signal input port is coupled to the two-port multi-band combiner and the frequency shift module, and the vertically polarized radiating unit and the horizontally polarized radiating unit are both coupled to the frequency shift module.

[0016] In an embodiment of the present disclosure, the signal input port is configured to classify the signals of the respective channels; the frequency shift module is configured to allow part of the signals of the respective channels to pass directly, and perform superposition and frequency shifting on another part of the signals of the respective channels; the vertically polarized radiating unit is configured to output the signals which are allowed to pass directly; and the horizontally polarized radiating unit is configured to output signals resulting from the superposition and frequency shifting.

[0017] In a second aspect, the present disclosure provides in some embodiments a power consumption control method, applied to the single-cable four-stream coverage system in the first aspect, including: determining a target power value according to the number of connected users, the power consumption information, the sum of the uplink and downlink traffic rates, and the user historical status information; and adjusting signal output power of the first RRU for each channel according to a comparison result between the target power value and a power threshold. The power threshold is determined according to the user historical status information.

[0018] In a third aspect, the present disclosure provides in some embodiments a non-transitory computer-readable storage medium storing therein a computer program. The computer program is executed by a processor to implement the single-cable four-stream coverage system in the first aspect.

[0019] The single-cable four-stream coverage system provided in the embodiments of the present disclosure includes the power controller, the first RRU, the second RRU, the three-port multi-band combiner, the coupler, the two-port multi-band combiner and the passive frequency conversion antenna. The first RRU is configured to output the signal carrying the data information, the power controller is configured to control the signal output power of the first RRU, the three-port multi-band combiner is configured to combine the signals transmitted via the three channels, the coupler is configured to equally divide the received signal, the two-port multi-band combiner is configured to combine the equally-divided signals sent by the coupler, and the passive frequency conversion antenna is configured to the combined signal sent by the two-port multi-band combiner to

the outside. Through the elements in the above-mentioned system, the three channels of signals generated by the first RRU and the single-channel signal generated by the second RRU are transmitted to the passive frequency conversion antenna, so as to achieve a four-stream coverage effect via a single-cable distribution system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] In order to describe the technical solutions in the present disclosure or the related art in a clearer manner, the drawings required for the description in the embodiments or the related art will be described hereinafter briefly. The following drawings relate to some embodiment of the present disclosure, and a person skilled in the art may further obtain the other drawings based on these drawings, without any creative effort.

[0021] Fig. 1 is a schematic structural view showing a single-cable four-stream coverage system based on passive frequency conversion according to an embodiment of the present disclosure.

[0022] Fig. 2 is a schematic view showing system architecture and signals of a single-cable four-stream coverage system according to an embodiment of the present disclosure.

[0023] Fig. 3 is a schematic structural view showing a power controller according to an embodiment of the present disclosure.

[0024] Fig. 4 is a schematic structural view showing a first RRU according to an embodiment of the present disclosure.

[0025] Fig. 5 is a schematic structural view showing a passive frequency conversion antenna according to an embodiment of the present disclosure.

[0026] Fig. 6 is a flow chart of a power consumption control method according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0027] In order to make the objects, the technical solutions and the advantages of the present disclosure more apparent, the present disclosure will be described hereinafter in a clear and thorough manner in conjunction with the drawings and embodiments. Obviously, the following embodiments merely relate to a part of, rather than all of, the embodiments of the present disclosure, and based on these embodiments, a person skilled in the art may, without any creative effort, obtain the other embodiments, which also fall within the scope of the present disclosure.

[0028] Referring to Fig. 1, Fig. 1 is a schematic structural view showing a single-cable four-stream coverage system based on passive frequency conversion according to an embodiment of the present disclosure. The single-cable four-stream coverage system includes a power controller, a first RRU, a second RRU, a three-port multi-band combiner, a coupler, a two-port multi-band combiner and a passive frequency conversion antenna. The power controller is coupled to the first RRU, the first RRU is configured to output a signal carrying data information, and the power controller is configured to control signal output power of the first RRU. The first RRU is coupled to the three-port multi-band combiner via three channels, and the three-port multi-band combiner is configured to combine signals transmitted via the three channels. The three-port multi-band combiner is coupled to the two-port multi-band combiner via the coupler, the coupler is configured to equally divide a received signal to obtain equally-divided signals, and the two-port multi-band combiner is configured to combine the equally-divided signals sent by the coupler to obtain a combined signal. The two-port multi-band combiner is coupled to the passive frequency conversion antenna, and the passive frequency conversion antenna is configured to output the combined signal sent by the two-port multi-band combiner to the outside. The second RRU is coupled to the coupler via a single channel. Three channels of signals generated by the first RRU and a channel of signals generated by the second RRU are sent to the passive frequency conversion antenna via the three channels, the single channel, the three-port multi-band combiner, the coupler and the two-port multi-band combiner.

[0029] To be specific, as shown in Fig. 1, the present disclosure provides in some embodiments a system instance for solving a problem in cross-floor coverage for a building having four floors. The system includes four remote passive frequency conversion antennae, one power controller, one 5G frequency-conversion RRU (i.e., the first RRU in the embodiments of the present disclosure), one 2nd-Generation (2G)/4th-Generation (4G) RRU (i.e., the second RRU in the embodiments of the present disclosure), two three-port multi-band combiners, four two-port multi-band combiners, four couplers, and four distribution systems. The 5G frequency-conversion RRU is coupled to the four passive frequency conversion antennae sequentially via the two three-port multi-band combiners, the four couplers, the four two-port multi-band combiners, and the four distribution systems.

[0030] As shown in Fig. 1, in the single-cable four-stream coverage system based on passive frequency conversion provided in the embodiments of the present disclosure, an overall signal transmission path is as follows. A signal transmission port 1 (channel 1 in Fig. 1), a signal transmission port 2 (channel 2 in Fig. 1) and a signal transmission port 3 (channel 3 in Fig. 1) are coupled to input ends of the three-port multi-band combiner 1, respectively, and an output end of the three-port multi-band combiner 1 is coupled to a coupler 1. The coupler 1 outputs two same signals to a two-port multi-band combiner 1 at a fourth floor and a two-port multi-band combiner 3 at a second floor, respectively. The two-port multi-band combiner 1 receives the signal from the coupler 1 and a signal from a coupler 3, combines the two signals, and transmits a combined signal to a distribution system 1 at the fourth floor. The distribution system 1 transmits the combined signal to a remote passive frequency conversion antenna 1. At this time, the passive frequency conversion antenna 1 totally receives four signals transmitted via the channel 1, the channel 2, the channel 3 and a channel A respectively. The channel A is a channel via which an A-channel 2G/4G signal is sent by the 2G/4G RRU. The two-port multi-band combiner 3 receives the signal from the coupler 1 and a signal from a coupler 4, combines the two signals, and transmits a combined signal to a distribution system 3 at the second floor. The distribution system 3 transmits the combined signal to a remote passive frequency conversion antenna 3. At this time, the

passive frequency conversion antenna 3 totally receives four signals transmitted via the channel 1, the channel 2, the channel 3 and the channel A respectively.

[0031] A signal transmission port 4 (channel 4 in Fig. 1), a signal transmission port 5 (channel 5 in Fig. 1) and a signal transmission port 6 (channel 6 in Fig. 1) are coupled to input ends of a three-port multi-band combiner 2, respectively, and an output end of the three-port multi-band combiner 2 is coupled to a coupler 2. The coupler 2 outputs two same signals to a two-port multi-band combiner 2 at a third floor and a two-port multi-band combiner 4 at a first floor, respectively. The two-port multi-band combiner 2 receives a signal from the coupler 2 and a signal from the coupler 4, combines the two signals, and transmits a combined signal to a distribution system 2 at the third floor. The distribution system 2 transmits the combined signal to a remote passive frequency conversion antenna 2. At this time, the passive frequency conversion antenna 2 totally receives four signals transmitted via the channel 4, the channel 5, the channel 6 and a channel B respectively. The channel B is a channel via which a B-channel 2G/4G signal is sent by the 2G/4G RRU. The two-port multi-band combiner 4 receives the signal from the coupler 2 and the signal from the coupler 4, combines the two signals, and transmits a combined signal to a distribution system 4 at the first floor. The distribution system 4 transmits the combined signal to a remote passive frequency conversion antenna 4. At this time, the passive frequency conversion antenna 4 totally receives four signals transmitted via the channel 4, the channel 5, the channel 6 and the channel B respectively.

[0032] As shown in Fig. 2, the present disclosure further provides in some embodiments a signal reception procedure for implementing the single-cable four-stream scheme.

[0033] In a case that the power controller is in a full-load state, the 5G frequency-conversion RRU outputs at full power, and at this time, the channels 1 to 6 are all fully loaded. For example, a signal S1 having a frequency of 2.6 GHz, a bandwidth of 100 M and carrying data information is transmitted via the channel 1, a signal SA2 having a frequency of 1.4 GHz, a bandwidth of 100 M and carrying data information is transmitted via the channel 2, and a signal SB2 having a frequency of 1.2 GHz, a

bandwidth of 100 M and carrying data information is transmitted via the channel 3. The signals S1, SA2 and SB2 are inputted to the three-port multi-band combiner 1, and the three-port multi-band combiner 1 combines the three signals, and sends a combined signal S1+SA2+SB2 to the coupler 1. The coupler 1 divides the combined signal S1+SA2+SB2 into two signals having half the power and a same frequency. Because the frequency of the two signals and the information carried thereby remain unchanged, and the power merely influences an remote coverage range rather than the frequency and information, so the two signals may be continuously considered as S1+SA2+SB2. Further, the coupler 1 outputs the two signals S1+SA2+SB2 to a second port of the two-port multi-band combiner 1 and a first port of the two-port multi-band combiner 3, respectively.

[0034] A signal S3 having a frequency of 2.6 GHz and a bandwidth of 100 M is transmitted via the channel 4, a signal SA4 having a frequency of 1.4 GHz and a bandwidth of 100 M is transmitted via the channel 5, and a signal SB4 having a frequency of 1.2 GHz and a bandwidth of 100 M is transmitted via the channel 6. The signals S3, SA4 and SB4 are inputted to the three-port multi-band combiner 2, and the three-port multi-band combiner 2 combines the three signals, and sends a combined signal S3+SA4+SB4 to the coupler 2. The coupler 2 transmits two signals S3+SA4+SB4 to a first port of the two-port multi-band combiner 2 and a first port of the two-port multi-band combiner 4, respectively.

[0035] A signal A having a frequency other than 2.6 GHz, 1.4 GHz and 1.2 GHz is transmitted via the channel A of the 2G/4G RRU of existing distribution system to the coupler 3. The coupler 3 divides the signal A into two signals having half the power and a same frequency after coupling, and transmits the two signals A to a first port of the two-port multi-band combiner 1 and a second port of the two-port multi-band combiner 3, respectively.

[0036] A signal B having a frequency other than 2.6 GHz, 1.4 GHz and 1.2 GHz is transmitted via the channel B of the 2G/4G RRU to the coupler 4. The coupler 4 divides the signal B into two signals having half the power and a same frequency after

coupling, and transmits the two signals B to a second port of the two-port multi-band combiner 2 and a second port of the two-port multi-band combiner 4, respectively.

[0037] Further, the two-port multi-band combiner 1 combines the signal A and the signal S1+SA2+SB2 to obtain a signal A+S1+SA2+SB2, and transmits the signal A+S1+SA2+SB2 to the distribution system 1. Upon the receipt of the signal, the distribution system 1 transmits the signal to the passive frequency conversion antenna 1. The passive frequency conversion antenna 1 performs signal identification on the signal A+S1+SA2+SB2, filters out the signal SA2 having a frequency of 1.4 GHz and the signal SB2 having a frequency of 1.2 GHz via a filter in the antenna, mixes the two signals via a mixer to generate a signal S2, and transmits the signal S2 to a vertical array element of the passive frequency conversion antenna, so that the vertical array element sends the signal S2 to a free space. The filter in the antenna may further identify the signal S1 having a frequency of 2.6 GHz and the 2G/4G signal A, and transmit the signal S1 and the signal A to the vertical array element of the passive frequency conversion antenna, so that the vertical array element sends the signal S1 and the signal A to the free space. Hence, the passive frequency conversion antenna 1 finally sends the 2.6 GHz signal S1, the 2.6 GHz signal S2 and the 2G/4G signal A, i.e., S1+S2+A.

[0038] Further, the two-port multi-band combiner 2 combines the signal B and the signal S3+SA4+SB4 to obtain a signal B+S3+SA4+SB4, and transmits the signal B+S3+SA4+SB4 to the distribution system 2. Upon the receipt of the signal, the distribution system 2 transmits the signal to the passive frequency conversion antenna 2. The passive frequency conversion antenna 2 performs signal identification on the signal B+S3+SA4+SB4, filters out the signal SA4 having a frequency of 1.4 GHz and the signal SB4 having a frequency of 1.2 GHz via a filter in the antenna, mixes the two signals via a mixer to generate a signal S4, and transmits the signal S4 to a vertical array element of the passive frequency conversion antenna, so that the vertical array element sends the signal S4 to a free space. The filter in the antenna may further identify the signal S3 having a frequency of 2.6 GHz and the 2G/4G signal B, and transmit the signal S3 and the signal B to the vertical array element of the passive frequency

conversion antenna. Hence, the passive frequency conversion antenna 2 finally sends the 2.6 GHz signal S3, the 2.6 GHz signal S4 and the 2G/4G signal B, i.e., S3+S4+B.

[0039] Further, the two-port multi-band combiner 3 combines the signal A and the signal S1+SA2+SB2 to obtain a signal A+S1+SA2+SB2, and transmits the signal A+S1+SA2+SB2 to the distribution system 3. Upon the receipt of the signal, the distribution system 3 transmits the signal to the passive frequency conversion antenna 3. The passive frequency conversion antenna 3 performs signal identification on the signal A+S1+SA2+SB2, filters out the signal SA2 having a frequency of 1.4 GHz and the signal SB2 having a frequency of 1.2 GHz via a filter in the antenna, mixes the two signals via a mixer to generate a signal S2, and transmits the signal S2 to a vertical array element of the passive frequency conversion antenna, so that the vertical array element sends the signal S2 to a free space. The filter in the antenna may further identify the signal S1 having a frequency of 2.6 GHz and the 2G/4G signal A, and transmit the signal S1 and the signal A to the vertical array element of the passive frequency conversion antenna, so that the vertical array element sends the signal S1 and the signal A to the free space. Hence, the passive frequency conversion antenna 3 finally sends the 2.6 GHz signal S1, the 2.6 GHz signal S2 and the 2G/4G signal A, i.e., S1+S2+A.

[0040] Further, the two-port multi-band combiner 4 combines the signal B and the signal S3+SA4+SB4 to obtain a signal B+S3+SA4+SB4, and transmits the signal B+S3+SA4+SB4 to the distribution system 4. Upon the receipt of the signal, the distribution system 4 transmits the signal to the passive frequency conversion antenna 4. The passive frequency conversion antenna 4 performs signal identification on the signal B+S3+SA4+SB4, filters out the signal SA4 having a frequency of 1.4 GHz and the signal SB4 having a frequency of 1.2 GHz via a filter in the antenna, mixes the two signals via a mixer to generate a signal S4, and transmits the signal S4 to a vertical array element of the passive frequency conversion antenna, so that the vertical array element sends the signal S4 to a free space. The filter in the antenna may further identify the signal S3 having a frequency of 2.6 GHz and the 2G/4G signal B, and transmit the signal S3 and the signal B to the vertical array element of the passive frequency

conversion antenna. Hence, the passive frequency conversion antenna 4 finally sends the 2.6 GHz signal S3, the 2.6 GHz signal S4 and the 2G/4G signal B, i.e., S3+S4+B.

[0041] The signal sent by the passive frequency conversion antenna 1 may be transmitted from the fourth floor to the third floor through a floor slab, the signal sent by the passive frequency conversion antenna 2 may be transmitted from the third floor to the second floor through a floor slab, and the signal sent by the passive frequency conversion antenna 3 may be transmitted from the second floor to the first floor through a floor slab. Hence, a terminal at the fourth floor may receive not only the signals S1, S2 and A sent by the passive frequency conversion antenna 1, but also the signals S3, S4 and B sent by the passive frequency conversion antenna 2, and terminals at the first floor, the second floor and the third floor (which are not the top floor, i.e., the fourth floor) may receive four 5G signals S1, S2, S3 and S4. As a result, the single-cable distribution system in the embodiments of the present disclosure may be used to achieve the four-stream coverage effect.

[0042] In the embodiments of the present disclosure, through the single-cable distribution system, it is able to achieve the four-stream coverage effect.

[0043] In an embodiment of the present disclosure, the power controller includes a frequency-conversion RRU monitor, a frequency-conversion RRU channel power regulator, an RRU status reading unit, an initial condition input unit and a calculation unit. The frequency-conversion RRU channel power regulator is coupled to the first RRU and the calculation unit. The frequency-conversion RRU monitor is coupled to the RRU status reading unit and the calculation unit, and the frequency-conversion RRU monitor includes a frequency-conversion RRU traffic monitor, a frequency-conversion RRU power consumption monitor and a frequency-conversion RRU user number monitor. The RRU status reading unit is coupled to the first RRU. The initial condition input unit is coupled to the calculation unit. The RRU status reading unit is configured to read operating information of the first RRU. The frequency-conversion RRU monitor is configured to extract, from the operating information, a number of connected users, power consumption information and a sum of uplink and downlink traffic rates. The initial condition input unit is configured to obtain user historical status

information. The calculation unit is configured to control signal output power of the first RRU for each channel according to the number of connected users, the power consumption information, the sum of the uplink and downlink traffic rates, and the user historical status information.

[0044] To be specific, as shown in Fig. 3, the power controller includes the frequency-conversion RRU channel power regulator, the frequency-conversion RRU user number monitor, the frequency-conversion RRU traffic monitor, the frequency-conversion RRU power consumption monitor, the calculation unit and the initial condition input unit. The RRU status reading unit is externally coupled to a 5G frequency-conversion RRU, and the RRU status reading unit is internally coupled to the frequency-conversion RRU user number monitor, the frequency-conversion RRU traffic monitor and the frequency-conversion RRU power consumption monitor. The frequency-conversion RRU user number monitor, the frequency-conversion RRU traffic monitor and the frequency-conversion RRU power consumption monitor are coupled to the calculation unit, and the calculation unit is further coupled to the initial condition input unit. The calculation unit is externally coupled to the 5G frequency-conversion RRU.

[0045] The RRU status reading unit is configured to read a current operating information log of the 5G frequency-conversion RRU, the frequency-conversion RRU user number monitor is configured to read a real-time number N of connected users of the 5G frequency-conversion RRU from the current operating information log, the frequency-conversion RRU power consumption monitor is configured to read real-time power consumption information W of the 5G frequency-conversion RRU from the current operating information log, the frequency-conversion RRU traffic monitor is configured to read a real-time sum G of uplink and downlink traffic rates of the 5G frequency-conversion RRU from the current operating information log, and the initial condition input unit is configured to obtain initial status information inputted by a user and status information of each day within a previous time period. The calculation unit calculates a parameter according to the obtained information, and the parameter is used to determine how to control signal output power of the first RRU for each channel.

[0046] In the embodiments of the present disclosure, the signal output power of the first RRU for each channel is adjusted through the power controller, so as to reduce the power consumption.

[0047] In an embodiment of the present disclosure, the first RRU includes a high-speed interface module, a target signal transceiving unit, a PA, an LNA, a circulator, an RF switch, a standing wave monitoring circuit, a high-power load, a first grounding unit, a second grounding unit, a non-frequency-shift filter, and a frequency-shift filter. The high-speed interface module is coupled to the three-port multi-band combiner via the target signal transceiving unit, and the target signal transceiving unit includes a non-frequency-shift signal transceiving unit and a frequency-shift signal transceiving unit. The target signal transceiving unit is coupled to the three-port multi-band combiner via the PA, the circulator, and the non-frequency-shift filter (or the frequency-shift filter) sequentially. The target signal transceiving unit is coupled to the standing wave monitoring circuit via the LNA and the RF switch sequentially. The target signal transceiving unit is coupled to the first grounding unit via the LNA, the RF switch and the high-power load sequentially. The frequency-shift signal transceiving unit is coupled to the second grounding unit via the PA, the circulator, the RF switch and the high-power load sequentially.

[0048] To be specific, as shown in Fig. 4, the 5G frequency-conversion RRU includes the high-speed interface module, the non-frequency-shift signal transceiving unit, the frequency-shift signal transceiving unit, the PA, the LNA, the circulator, the RF switch, the standing wave monitoring circuit, the high-power load, the grounding unit, the non-frequency-shift filter, the frequency-shift filter, a power supply module and an extended interface. The 5G frequency-conversion RRU in the embodiments of the present disclosure differs from an existing 5G frequency-conversion RRU in that, the 5G frequency-conversion RRU in the embodiments of the present disclosure is a 6-channel RRU, so the high-speed interface module is coupled to 2 non-frequency-shift signal transceiving unit and 2 frequency-shift signal transceiving units.

[0049] To be specific, a non-frequency-shift signal transceiving unit 1 is coupled to a PA1, the PA1 is coupled to a circulator 1, the circulator 1 is coupled to a non-

frequency-shift filter 1, and the non-frequency-shift filter 1 is externally coupled to the three-port multi-band combiner 1. To be specific, the non-frequency-shift signal transceiving unit 1 is further coupled to an LNA1, the LNA1 is coupled an RF switch 1, the RF switch 1 is coupled to the circulator 1, a standing wave monitoring circuit 1 and a high-power load 1, and the high-power load 1 is coupled to a grounding unit 1.

[0050] To be specific, the frequency-shift signal transceiving unit 1 is coupled to a PA2, a PA3 and an LNA2, the PA2 is coupled to a circulator 2, the circulator 2 is coupled to an RF switch 2, the RF switch 2 is coupled to a high-power load 2, the high-power load 2 is coupled to a grounding unit 2, the circulator 2 is further coupled to a frequency-shift filter 1, and the frequency-shift filter 1 is externally coupled to the three-port multi-band combiner 1. The PA3 is coupled to a circulator 3, the circulator 3 is coupled to an RF switch 3, the circulator 3 is further coupled to a frequency-shift filter 2, and the frequency-shift filter 2 is externally coupled to the three-port multi-band combiner 1. The LNA2 is coupled to an RF switch 3, the RF switch 3 is further coupled to a standing wave monitoring circuit 2 and a high-power load 3, and the high-power load 3 is coupled to a grounding unit 3.

[0051] To be specific, a non-frequency-shift signal transceiving unit 2 is coupled to a PA4, the PA4 is coupled to a circulator 4, the circulator 4 is coupled to a non-frequency-shift filter 2, the non-frequency-shift filter 2 is externally coupled to the three-port multi-band combiner 2. To be specific, the non-frequency-shift signal transceiving unit 2 is further coupled to an LNA3, the LNA3 is coupled an RF switch 4, the RF switch 4 is further coupled to the circulator 4, a standing wave monitoring circuit 3 and a high-power load 4, and the high-power load 4 is coupled to a grounding unit 5.

[0052] To be specific, the frequency-shift signal transceiving unit 2 is coupled to a PA5, a PA6 and an LNA4, the PA5 is coupled to a circulator 5, the circulator 5 is coupled to an RF switch 5, the RF switch 5 is coupled to a high-power load 5, the high-power load 5 is coupled to a grounding unit 5, the circulator 5 is further coupled to a frequency-shift filter 3, and the frequency-shift filter 3 is externally coupled to the three-port multi-band combiner 2. The PA6 is coupled to a circulator 6, the circulator 6

is coupled to an RF switch 6, the circulator 6 is further coupled to a frequency-shift filter 4, and the frequency-shift filter 4 is externally coupled to the three-port multi-band combiner 2. The LNA4 is coupled to an RF switch 6, the RF switch 6 is further coupled to a standing wave monitoring circuit 4 and a high-power load 6, and the high-power load 6 is coupled to a grounding unit 6.

[0053] In the embodiments of the present disclosure, through the 6-channel RRU which is different from the existing 5G frequency-conversion RRU, it is able to achieve the four-stream coverage effect.

[0054] In an embodiment of the present disclosure, the three-port multi-band combiner includes a signal input receiver, a combining unit and a signal output unit. An end of the combining unit is coupled to the signal input receiver, and another end of the combining unit is coupled to the signal output unit. The combining unit is configured to combine heterogeneous frequency signals transmitted by the signal input receiver, and send the combined heterogeneous frequency signals via the signal output unit.

[0055] To be specific, the three-port multi-band combiner includes a signal input receiver 1, a signal input receiver 2, a signal input receiver 3, a combining unit and a signal output unit. The signal input receiver 1, the signal input receiver 2 and the signal input receiver 3 are coupled to inputs of the combining unit respectively, and send three signals having different frequencies to the combining unit. Another end of the combining unit is coupled to the signal output unit. The combining unit functions to combine the three signals, and input a combined signal to the signal output unit, so that the signal output unit sends the combined signal to the outside. The signal input receiver 1 may receive a signal having a frequency within a range of 2515 Hz to 2675 Hz, the signal input receiver 2 may receive a signal having a frequency within a range of 1370 Hz to 1470 Hz, the signal input receiver 3 may receive a signal having a frequency within a range of 1145 Hz to 1245 Hz, and the signal output unit may output a signal having a frequency within a range of 800 Hz to 2700 Hz.

[0056] Similar to the three-port multi-band combiner, the two-port multi-band combiner includes a signal input receiver A, a signal input receiver B, a combining unit and a signal output unit. The signal input receiver A and the signal input receiver B are

coupled to inputs of the combining unit respectively, and send a plurality of signals having different frequencies to the combining unit. Another end of the combining unit is coupled to the signal output unit, so that the signal output unit sends a combined signal to the outside. The signal input receiver A and the signal input receiver B both may receive a signal having a frequency within a range of 800 Hz to 2700 Hz, and the signal output unit may output a signal having a frequency within a range of 800 Hz to 2700 Hz.

[0057] In the embodiments of the present disclosure, through the three-port multi-band combiner and the two-port multi-band combiner, it is able to combine multiple signals.

[0058] In an embodiment of the present disclosure, the single-cable four-stream coverage system further includes a distribution system. An end of the distribution system is coupled to the two-port multi-band combiner, and another end of the distribution system is coupled to the passive frequency conversion antenna. The distribution system is configured to send a signal sent by the two-port multi-band combiner to the passive frequency conversion antenna.

[0059] To be specific, as shown in Fig. 1, an end of the distribution system 1 is coupled to the two-port multi-band combiner 1, and another end of the distribution system 1 is coupled to the passive frequency conversion antenna 1. The distribution system 1 sends a signal sent by the two-port multi-band combiner 1 to the passive frequency conversion antenna 1. An end of the distribution system 2 is coupled to the two-port multi-band combiner 2, and another end of the distribution system 2 is coupled to the passive frequency conversion antenna 2. The distribution system 2 sends a signal sent by the two-port multi-band combiner 2 to the passive frequency conversion antenna 2. An end of the distribution system 3 is coupled to the two-port multi-band combiner 3, and another end of the distribution system 3 is coupled to the passive frequency conversion antenna 3. The distribution system 3 sends a signal sent by the two-port multi-band combiner 3 to the passive frequency conversion antenna 3. An end of the distribution system 4 is coupled to the two-port multi-band combiner 4, and another end of the distribution system 4 is coupled to the passive frequency conversion

antenna 4. The distribution system 4 sends a signal sent by the two-port multi-band combiner 4 to the passive frequency conversion antenna 4.

[0060] In the embodiments of the present disclosure, through the distribution system, it is able to send the signal sent by the two-port multi-band combiner to the passive frequency conversion antenna.

[0061] In an embodiment of the present disclosure, the coupler is configured to equally divide the received signal into two signals having a same frequency and half the power.

[0062] To be specific, as mentioned hereinabove, the coupler equally divides the received signal into two signals having a same frequency and half the power. Although the above-mentioned embodiments merely provide the cross-floor coverage for four floors, more couplers may be added on the basis of the single-cable four-stream coverage system based on passive frequency conversion in Fig. 1, so as to achieve the cross-floor coverage for more floors.

[0063] In the embodiments of the present disclosure, through the coupler, it is able to achieve the cross-floor coverage for more floors.

[0064] In an embodiment of the present disclosure, the passive frequency conversion antenna includes a signal input port, a frequency shift module, a vertically polarized radiating unit and a horizontally polarized radiating unit. The signal input port is coupled to the two-port multi-band combiner and the frequency shift module. The vertically polarized radiating unit and the horizontally polarized radiating unit are both coupled to the frequency shift module.

[0065] The signal input port is configured to classify the signals of the respective channels; the frequency shift module is configured to allow part of the signals of the respective channels to pass directly, and perform superposition and frequency shifting on another part of the signals of the respective channels. The vertically polarized radiating unit is configured to output the signals which are allowed to pass directly, and the horizontally polarized radiating unit is configured to output signals resulting from the superposition and frequency shifting.

[0066] To be specific, as shown in Fig. 5, the internal and external functions and structures of the passive frequency conversion antennae 1 to 4 are completely the same, and each passive frequency conversion antenna includes the signal input port, the frequency shift module, the vertically polarized radiating unit and the horizontally polarized radiating unit. The signal input port is configured to receive signals sent by the distribution system, and classify the received signal. The frequency shift module is configured to allow the signals from the signal input port to pass directly or perform frequency shifting on the signals. The signal having a frequency of 2.6 GHz from the 5G RRU channel 1 or 2 and the signal from the 2G/4G RRU channel A or B remain unchanged and are outputted to the outside via the vertically polarized radiating unit. The signals from the 5G RRU channels 2 and 3 or from the 5G RRU channels 5 and 6 are subjected to superposition and frequency shifting, and after the frequency is shifted to 2.6 GHz, the signals are outputted via the horizontally polarized radiating unit.

[0067] In the embodiments of the present disclosure, the received signals are sent via the passive frequency conversion antenna to the outside, so that the terminal can receive the signals.

[0068] Referring to Fig. 6 which is a flow chart of a power consumption control method according to an embodiment of the present disclosure, the power consumption control method includes the following steps.

[0069] Step 100: determining a target power value according to the number of connected users, the power consumption information, the sum of the uplink and downlink traffic rates, and the user historical status information.

[0070] Step 200: adjusting signal output power of the first RRU for each channel according to a comparison result between the target power value and a power threshold. The power threshold is determined according to the user historical status information.

[0071] To be specific, the initial status information inputted by the user and the status information of each day within a previous time period, which are obtained by the initial condition input unit, include a peak time period T1, a normal time period T2, a valley time period T3, a maximum number of users N-max, a proportional coefficient K, a proportional coefficient L-low, time-period-based average number of users, time-

period-based average power consumption data, average traffic per hour within the previous period, etc. A user Quality of Service (QoS) function G/N×K is defined, and initial setting is performed according to actual conditions of the communication operator. The QoS is set to be not less than a service value lower limit L-low (i.e., the above-mentioned proportional coefficient L-low).

[0072] An artificial intelligence optimization algorithm based on historical data learning is used to dynamically adjust the power of the 5G frequency-conversion RRU according to historical data features and a corresponding QoS ratio. When the algorithm is started for the first time, training samples for the algorithm are data traversing all status parameters. After running for one week, the algorithm shall be retrained through obtaining part of the historical data from the previous week as training samples. Specifically, a random forest model is adopted, and its algorithm mainly includes the following steps.

[0073] 1. Randomly selecting n samples from a sample set with replacement.

[0074] 2. Randomly selecting k features from all feature values, and establishing a decision tree using these features for the selected samples (the decision tree is typically generated using a Classification and Regression Trees (CART) method, and each tree is not pruned).

[0075] 3. Repeating the above two steps for m times to generate m decision trees, thereby to form a random forest.

[0076] 4. For new data, decisions are made by using all trees, and finally classification is performed through voting.

[0077] When a real-time number of connected users N=0, the channels 1 and 4 of the 5G frequency-conversion RRU output at half power, and the channels 2, 3, 5 and 6 are turned off to save energy. When N>0, the channels 1 and 4 of the 5G frequency-conversion RRU output at full power to ensure the QoS experience for users, while the output powers of the channels 2, 3, 5 and 6 are adjusted according to real-time dynamic thresholds Y1, Y2 and Y3 obtained using the artificial intelligence optimization algorithm based on historical data learning. The artificial intelligence optimization algorithm based on historical data learning may be expressed as Y=F(N, W, G, N-max,

K, L-low), and this function is influenced by historical data such as time-period-based average user number, time-period-based average energy consumption, and average traffic per hour in the previous time period. When Y2>Y≥Y1, the channels 2 and 3 are turned off, and the channels 1, 4, 5 and 6 are turned on and output at full power. When Y3>Y≥Y2, the channels 1 to 6 are turned on, the channels 1 and 2 are maintained at full output power, while the output powers of the channels 2, 3, 5 and 6 are max[50%, (Y-Y2)/(Y3-Y2)]. When Y≥Y3, the channels 1 to 6 are turned on and maintained at full load.

[0078] In the embodiments of the present disclosure, through the artificial intelligence optimization algorithm based on historical data learning, it is able to reduce the power consumption of the single-cable four-stream coverage system.

[0079] The present disclosure further provides in some embodiments a non-transitory computer-readable storage medium storing therein a computer program. The computer program is executed by a processor, so that a computer implements the steps of the above-mentioned power consumption control method.

[0080] The embodiments of the present disclosure may be combined randomly to form a new embodiment in a case of no conflict, which will not be particularly defined herein.

[0081] The above-mentioned device embodiments are for illustrative purposes only. The units as separate components may be, or may not be, separated from each other physically, and the components may be, or may not be, physical units, i.e., they may be located at an identical position, or distributed over a plurality of network elements. All or parts of the modules may be selected according to the practical need so as to achieve the object of the present disclosure. A person skilled in the art may understand and implement these units without any creative effort.

[0082] Through the above-mentioned description, it may be apparent for a person skilled in the art that the present disclosure may be implemented by software as well as a necessary common hardware platform, or by hardware, and the former may be better in most cases. Based on this, the technical solutions of the present disclosure, partial or full, or parts of the technical solutions of the present disclosure contributing

to the related art, may appear in the form of software products, which may be stored in a storage medium, e.g., Read-Only Memory (ROM)/Random Access Memory (RAM), magnetic disk or optical disk, and which may include several instructions so as to enable a computer device (personal computer, server, or network device) to implement the single-cable four-stream coverage system described in the embodiments of the present disclosure or described in some parts of the embodiments of the present disclosure.

[0083] It should be appreciated that, the above embodiments are only used to describe the technical solutions of the present disclosure, but shall not be construed as limiting the present disclosure. Although detailed description has been given with reference to the above-mentioned embodiments, a person skilled in the art may still make modifications or equivalent substitutions, and these modification and substitutions also fall within the spirit and scope of the present disclosure.

What is claimed is:

1. A single-cable four-stream coverage system based on passive frequency conversion, comprising a power controller, a first Remote Radio Unit (RRU), a second RRU, a three-port multi-band combiner, a coupler, a two-port multi-band combiner and a passive frequency conversion antenna, wherein

the power controller is coupled to the first RRU, the first RRU is configured to output a signal carrying data information, and the power controller is configured to control signal output power of the first RRU;

the first RRU is coupled to the three-port multi-band combiner via three channels, and the three-port multi-band combiner is configured to combine signals transmitted via the three channels;

the three-port multi-band combiner is coupled to the two-port multi-band combiner via the coupler, the coupler is configured to equally divide a received signal to obtain equally-divided signals, and the two-port multi-band combiner is configured to combine the equally-divided signals sent by the coupler to obtain a combined signal;

the two-port multi-band combiner is coupled to the passive frequency conversion antenna, and the passive frequency conversion antenna is configured to output the combined signal sent by the two-port multi-band combiner to outside;

the second RRU is coupled to the coupler via a single channel; and

three channels of signals generated by the first RRU and a channel of signals generated by the second RRU are sent to the passive frequency conversion antenna via the three channels, the single channel, the three-port multi-band combiner, the coupler and the two-port multi-band combiner.

2. The single-cable four-stream coverage system according to claim 1, wherein the power controller comprises a frequency-conversion RRU monitor, a frequency-conversion RRU channel power regulator, an RRU status reading unit, an initial condition input unit and a calculation unit; the frequency-conversion RRU channel power regulator is coupled to the first RRU and the calculation unit; the frequency-conversion RRU monitor is coupled to the RRU status reading unit and the calculation

unit, wherein the frequency-conversion RRU monitor comprises a frequency-conversion RRU traffic monitor, a frequency-conversion RRU power consumption monitor and a frequency-conversion RRU user number monitor; the RRU status reading unit is coupled to the first RRU; the initial condition input unit is coupled to the calculation unit; wherein

the RRU status reading unit is configured to read operating information of the first RRU;

the frequency-conversion RRU monitor is configured to extract, from the operating information, a number of connected users, power consumption information and a sum of uplink and downlink traffic rates;

the initial condition input unit is configured to obtain user historical status information; and

the calculation unit is configured to control signal output power of the first RRU for each channel according to the number of connected users, the power consumption information, the sum of the uplink and downlink traffic rates, and the user historical status information.

3. The single-cable four-stream coverage system according to claim 1, wherein the first RRU comprises a high-speed interface module, a target signal transceiving unit, a power amplifier (PA), a low noise amplifier (LNA), a circulator, a radio frequency (RF) switch, a standing wave monitoring circuit, a high-power load, a first grounding unit, a second grounding unit, a non-frequency-shift filter, and a frequency-shift filter, wherein

the high-speed interface module is coupled to the three-port multi-band combiner via the target signal transceiving unit, and the target signal transceiving unit comprises a non-frequency-shift signal transceiving unit and a frequency-shift signal transceiving unit;

the target signal transceiving unit is coupled to the three-port multi-band combiner sequentially via the PA, the circulator, and the non-frequency-shift filter or the frequency-shift filter;

the target signal transceiving unit is coupled to the standing wave monitoring circuit sequentially via the LNA and the RF switch;

the target signal transceiving unit is coupled to the first grounding unit sequentially via the LNA, the RF switch and the high-power load; and

the frequency-shift signal transceiving unit is coupled to the second grounding unit sequentially via the PA, the circulator, the RF switch and the high-power load.

4. The single-cable four-stream coverage system according to claim 1, wherein the three-port multi-band combiner comprises a signal input receiver, a combining unit and a signal output unit, wherein

an end of the combining unit is coupled to the signal input receiver, and another end of the combining unit is coupled to the signal output unit; and

the combining unit is configured to combine heterogeneous frequency signals transmitted by the signal input receiver, and send the combined heterogeneous frequency signals via the signal output unit.

5. The single-cable four-stream coverage system according to claim 1, further comprising a distribution system, wherein

an end of the distribution system is coupled to the two-port multi-band combiner, and another end of the distribution system is coupled to the passive frequency conversion antenna; and

the distribution system is configured to send a signal sent by the two-port multi-band combiner to the passive frequency conversion antenna.

6. The single-cable four-stream coverage system according to claim 1, wherein the coupler is configured to equally divide the received signal into two channels of signals having a same frequency and half the power.

7. The single-cable four-stream coverage system according to claim 1, wherein the passive frequency conversion antenna comprises a signal input port, a frequency shift module, a vertically polarized radiating unit and a horizontally polarized radiating unit, wherein

the signal input port is coupled to the two-port multi-band combiner and the frequency shift module; and

the vertically polarized radiating unit and the horizontally polarized radiating unit are both coupled to the frequency shift module.

8. The single-cable four-stream coverage system according to claim 7, wherein the signal input port is configured to classify the signals of the respective channels;

the frequency shift module is configured to allow part of the signals of the respective channels to pass directly, and perform superposition and frequency shifting on another part of the signals of the respective channels;

the vertically polarized radiating unit is configured to output the signals which are allowed to pass directly; and

the horizontally polarized radiating unit is configured to output signals resulting from the superposition and frequency shifting.

9. A power consumption control method, applied to the single-cable four-stream coverage system based on passive frequency conversion according to any one of claims 1 to 8, comprising:

determining a target power value according to the number of connected users, the power consumption information, the sum of the uplink and downlink traffic rates, and the user historical status information; and

adjusting signal output power of the first RRU for each channel according to a comparison result between the target power value and a power threshold, wherein the power threshold is determined according to the user historical status information.

10. A non-transitory computer-readable storage medium storing therein a computer program, wherein the computer program, when being executed by a processor, implements the power consumption control method according to claim 9.