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(54) **FRAME SYNCHRONIZATION METHOD, USER EQUIPMENT, AND BASE STATION**
RAHMENSYNCHRONISATIONSVERFAHREN, BENUTZERGERÄT UND BASISSTATION
PROCÉDÉ DE SYNCHRONISATION DE TRAME, ÉQUIPEMENT UTILISATEUR ET STATION DE
BASE

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(56) References cited:
WO-A1-2015/085550 WO-A1-2015/085550
CN-A- 104 519 576 US-A1- 2014 148 107
US-A1- 2015 030 029

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Description**TECHNICAL FIELD**

5 **[0001]** The present invention relates to the communications field, and in particular, to a frame synchronization method, user equipment, and a base station.

BACKGROUND

10 **[0002]** As a quantity of mobile terminals increases, users have higher requirements for a data volume, and a high frequency with rich bandwidth resources is introduced as a backhaul resource and an access frequency, to form a high-low frequency hybrid communications system, that is, both low-frequency communication and high-frequency communication can be performed between a base station and UE (user equipment). A beam of a high frequency needs to be relatively narrow, to ensure a particular transmission distance. However, a coverage area of a narrow beam system is limited. Therefore, to maximize an antenna gain, narrow-beam scanning alignment needs to be performed between a transmit end and a receive end. That is, when the transmit end scans a transmit beam, the receive end needs to scan a corresponding receive beam, so that synchronization of a high frequency frame is implemented. Only in this way, normal communication can be implemented between the base station and the UE.

15 **[0003]** In the current high-low frequency hybrid communications system, the base station has four transmit beams, and the UE has four receive beams (RX1 to RX4). If it is specified that a transmit beam and a receive beam that are aligned between the transmit end and the receive end are Z1 and RX1, respectively, the UE needs to receive, by using the receive beam RX1, all signals transmitted by using the transmit beam Z1. Only in this way, all data sent by the base station can be received.

20 **[0004]** In an actual case, the UE does not know when the base station scans a transmit beam, and therefore is uncertain about a synchronization point of a high frequency frame of the UE, that is, the UE is uncertain about a receive moment of the high frequency frame. Therefore, a case shown in FIG. 1 may occur. The UE scans a receive beam RX1 at a moment between a start moment and an end moment at which the base station scans a transmit beam Z1. In this case, the UE can never continuously receive a complete signal in the transmit beam Z1 and the receive beam RX1. It can be learned that, in the prior art, synchronization of the high-frequency frame cannot be implemented between the UE and the base station, and consequently, the UE cannot receive complete data transmitted by using a high frequency frame.

25 **[0005]** WO 2015/085550 discloses a synchronization scheme for a user equipment. When a user equipment accesses a millimetre-wave frequency band network, a first synchronization of a cellular frequency band via a cellular frequency band network covering the millimetre-wave frequency band network and a second synchronization of a millimetre-wave frequency band via the millimetre-wave frequency band network is carried out. The disclosure discusses avoiding the occurrence of a situation where a PSS is acquired by a user equipment in a PSS synchronization window which slides for a long time at a millimeter-wave frequency band.

SUMMARY

30 **[0006]** The present invention provides a frame synchronization method, user equipment, and a base station, to implement frame synchronization in a hybrid network of different frequencies as defined in the appended claims.

BRIEF DESCRIPTION OF DRAWINGS

35 **[0007]** To describe the technical solutions in the embodiments of the present invention or in the prior art more clearly, the following briefly introduces the accompanying drawings required for describing the embodiments or the prior art. Apparently, the accompanying drawings in the following description show merely some embodiments of the present invention, and a person of ordinary skill in the art may still derive other drawings from these accompanying drawings without creative efforts.

40 FIG. 1 is a schematic diagram of receiving a high frequency frame by user equipment in the prior art;
 FIG. 2 is a schematic flowchart of a frame synchronization method according to Embodiment 1 of the present invention;
 FIG. 3 is an architectural diagram of a high-low frequency hybrid communications system according to an embodiment of the present invention;
 FIG. 4 is another architectural diagram of a high-low frequency hybrid communications system according to an embodiment of the present invention;
 FIG. 5 is a schematic flowchart of a frame synchronization method according to Embodiment 2 of the present invention.

invention;

FIG. 6 is a schematic diagram of sending a high frequency frame and a low frequency frame according to Embodiment 2 of the present invention;

FIG. 6a is another schematic diagram of sending a high frequency frame and a low frequency frame according to Embodiment 2 of the present invention;

FIG. 7 is a schematic diagram of receiving a high frequency frame and a low frequency frame according to Embodiment 2 of the present invention;

FIG. 8 is a schematic diagram of obtaining a receive time difference by user equipment according to Embodiment 2 of the present invention;

FIG. 9 is a schematic flowchart of a frame synchronization method according to Embodiment 3 of the present invention;

FIG. 10 is a structural block diagram of user equipment according to Embodiment 4 of the present invention;

FIG. 10a is another structural block diagram of user equipment according to Embodiment 4 of the present invention;

FIG. 11 is a structural block diagram of a base station according to Embodiment 5 of the present invention;

FIG. 11a is another structural block diagram of a base station according to Embodiment 5 of the present invention;

FIG. 12 is a structural block diagram of user equipment according to Embodiment 6 of the present invention; and

FIG. 13 is a structural block diagram of a base station according to Embodiment 7 of the present invention.

DESCRIPTION OF EMBODIMENTS

[0008] The following clearly describes the technical solutions in the embodiments of the present invention with reference to the accompanying drawings in the embodiments of the present invention. Apparently, the described embodiments are merely some but not all of the embodiments of the present invention. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present invention without creative efforts shall fall within the protection scope of the present invention.

Embodiment 1

[0009] This embodiment of the present invention provides a frame synchronization method. As shown in FIG. 2, the method includes the following steps.

[0010] S101. User equipment completes synchronization of a first frequency frame, and determines a first moment of the synchronization of the first frequency frame.

[0011] It should be noted that the first frequency frame may be a low frequency frame. In the present invention, a frequency range of the low frequency frame has been described, and details are not described herein again. In addition, the user equipment supports first-frequency communication and second-frequency communication.

[0012] During specific implementation, the user equipment may receive a synchronization signal sent by a base station, and determine the first moment according to the synchronization signal.

[0013] S102. The user equipment obtains a receive time difference, where the receive time difference is a time difference between a moment at which the user equipment receives a second frequency frame and a moment at which the user equipment receives a first frequency frame.

[0014] The second frequency frame may be a high frequency frame.

[0015] S103. The user equipment completes synchronization of the second frequency frame according to the receive time difference and the first moment.

[0016] During specific implementation, a third moment may be determined according to the receive time difference and the first moment, and the second frequency frame is received at least before the third moment, so that the synchronization of the second frequency frame is completed.

[0017] According to the frame synchronization method in this embodiment of the present invention, the user equipment determines the first moment of the synchronization of the first frequency frame, obtains the receive time difference (that is, the time difference between the moment at which the user equipment receives the second frequency frame and the moment at which the user equipment receives the first frequency frame), and determines, according to the receive time difference and the first moment, the receive moment of the second frequency frame, to implement the synchronization of the second frequency frame. In the prior art, the user equipment is uncertain about a synchronization point of each type of frequency frame in a hybrid network of different frequencies (for example, cannot implement synchronization of a high frequency frame) and cannot implement time synchronization between the user equipment and the base station, and therefore the user equipment cannot receive complete data. According to the method provided in the present invention, the user equipment can determine the receive moment of the second frequency frame, and further implement frame synchronization in the hybrid network of different frequencies.

Embodiment 2

[0018] The frame synchronization method provided in the present invention may be applied to a high-low frequency hybrid communications system. User equipment may perform both high-frequency communication and low-frequency communication with a same base station (that is, high-low frequency intra-base-station communication). Alternatively, user equipment performs low-frequency communication with a macro base station, and performs high-frequency communication with a micro base station. The low-frequency communication is communication implemented by using a low frequency signal. Similarly, the high-frequency communication is communication implemented by using a high frequency frame.

[0019] The following describes in detail the frame synchronization method provided in the present invention, by assuming that a second frequency frame is a high frequency frame and a first frequency frame is a low frequency frame. A frequency corresponding to the first frequency frame is a first frequency, and a frequency corresponding to the second frequency frame is a second frequency. Signals include a low frequency (Low Frequency, LF) signal, a high frequency (High Frequency, HF) signal, and the like. A frequency of the low frequency signal is below 6 GHz, and a frequency of the high frequency signal is above 6 GHz. Certainly, the first frequency is not limited to being below 6 GHz, and the second frequency is not limited to being above 6 GHz. The first frequency and the second frequency are not limited in the present invention, provided that during specific implementation, the first frequency and the second frequency are different and the first frequency frame and the second frequency frame are different. The low frequency signal is transmitted in uplink and downlink by using a low frequency frame, and the high frequency signal is transmitted in uplink and downlink by using a high frequency frame. The high frequency frame has a similar frame structure to a low frequency frame in an LTE system. However, a difference lies in that the high frequency frame is sent and received by using a narrow beam, and strict narrow-beam scanning alignment needs to be ensured between a transmit end and a receive end. For example, it is assumed that a transmit beam and a receive beam that are aligned between a base station and user equipment are Z1 and R1, respectively. At a start moment at which the base station scans Z1, the user equipment needs to scan R1. Only in this way, time synchronization between the user equipment and the base station can be ensured, and a complete signal in the transmit beam Z1 and the receive beam R1 can be received.

[0020] In addition, it should be noted that, completing, by the user equipment, synchronization of a low frequency frame means receiving, by the user equipment, the low frequency frame. A synchronization point of the low frequency frame is a moment at which the user equipment receives the low frequency frame. Similarly, completing, by the user equipment, synchronization of a high frequency frame means receiving, by the user equipment, the high frequency frame. A synchronization point of the high frequency frame is a moment at which the user equipment receives the high frequency frame. Certainly, the synchronization of the low frequency frame may also be referred to as time synchronization of the low frequency frame, and the synchronization of the high frequency frame may also be referred to as time synchronization of the high frequency frame.

[0021] The high-low frequency hybrid communications system may be shown in FIG. 3 and FIG. 4. Referring to FIG. 3, user equipment performs low-frequency communication with a macro base station, and performs high-frequency communication with a micro base station. Referring to FIG. 4, user equipment may perform both high-frequency communication and low-frequency communication with a base station. A transmission path of a high frequency frame is first described. Referring to FIG. 4, transmission paths of the high frequency frame may be classified into a LOS (line of sight) and an NLOS (non line of sight). LOS transmission means that a transmission path of a high frequency frame between a base station and user equipment is approximately a path indicated by a line between the base station and the user equipment. NLOS transmission means that a transmission path of a signal (that is, a high frequency frame) changes due to a reflective surface, but a low frequency frame is still transmitted by using an LOS. As a result, in a high-low frequency intra-base-station communication scenario shown in FIG. 4, a transmission path of a high frequency frame and a transmission path of a low frequency frame are still different.

[0022] In a scenario shown in FIG. 3, even if both a low frequency frame sent by the macro base station and a high frequency frame sent by the micro base station are transmitted by using a LOS, a transmission path of the low frequency frame sent by the macro base station and a transmission path of the high frequency frame sent by the micro base station are different. If a low frequency frame is transmitted by using a LOS, and a high frequency frame is transmitted by using an NLOS, a transmission path of the low frequency frame sent by the macro base station and a transmission path of the high frequency frame sent by the micro base station are still different.

[0023] In the scenarios in FIG. 3 and FIG. 4, if a high frequency frame and a low frequency frame are sent in an alignment manner, that is, the high frequency frame and the low frequency frame are sent at a same moment, and it is assumed that a transmission path of the high frequency frame is the same as that of the low frequency frame, transmission duration of the high frequency frame is the same as that of the low frequency frame, and the user equipment receives the high frequency frame and the low frequency frame at a same moment. Actually, the transmission path of the high frequency frame is different from that of the low frequency frame, and therefore the transmission duration of the high frequency frame is different from that of the low frequency frame. Even if a base station sends the high frequency frame

and the low frequency frame simultaneously, the user equipment receives the high frequency frame and the low frequency frame at different moments, and a time difference exists.

[0024] Similarly, if a high frequency frame and a low frequency frame are not sent in an alignment manner, a time difference T exists between a moment at which the base station sends the high frequency frame and a moment at which the base station sends the low frequency frame. In addition, because of transmission paths, a time difference M exists between duration for transmitting the high frequency frame to the user equipment and duration for transmitting the low frequency frame to the user equipment. In this case, when determining a receive time difference, the user equipment needs to consider both the time difference T and the time difference M. It can be learned that the user equipment may use a receive moment of the low frequency frame as a reference for calculating a receive moment of the high frequency frame.

[0025] Based on this, a principle of the present invention is as follows: User equipment first implements synchronization of a low frequency frame according to a low-frequency synchronization signal, determines a receive moment of the low frequency frame, and obtains a receive time difference between the receive moment of the low frequency frame and a receive moment of a high frequency frame, and further can calculate the receive moment of the high frequency frame according to the receive moment of the low frequency frame and the receive time difference.

[0026] This embodiment of the present invention provides a frame synchronization method, applied to the high-low frequency hybrid communications system shown in FIG. 3 or FIG. 4. As shown in FIG. 5, the method includes the following steps.

[0027] 101. A base station sends a low-frequency synchronization signal to user equipment.

[0028] In this embodiment, for example, a first frequency frame is a low frequency frame and a second frequency frame is a high frequency frame. The low-frequency synchronization signal is used to determine a first moment at which the user equipment receives the low frequency frame. Usually, the base station may send the low-frequency synchronization signal to the user equipment, so that the user equipment determines when to receive the low frequency frame.

[0029] It should be noted that in the scenario shown in FIG. 3, the macro base station performs low-frequency communication with the user equipment, and therefore the macro base station sends the low-frequency synchronization signal to the user equipment. In addition, in the scenario shown in FIG. 3, the macro base station is mainly used, and the macro base station records a moment at which the micro base station sends a high frequency frame and a time difference between a moment at which the macro base station sends a low frequency frame and the moment at which the micro base station sends the high frequency frame. In the scenario shown in FIG. 4, high-low frequency intra-base-station communication is performed, that is, the base station in FIG. 4 sends the low-frequency synchronization signal to the user equipment.

[0030] 102. The user equipment receives the low-frequency synchronization signal sent by the base station, completes synchronization of a low frequency frame according to the low-frequency synchronization signal, and determines a first moment of the synchronization of the low frequency frame.

[0031] It should be noted that, completing, by the user equipment, synchronization of a low frequency frame means receiving, by the user equipment, the low frequency frame. A synchronization point of the low frequency frame is a moment at which the user equipment receives the low frequency frame.

[0032] A detailed solution for implementing synchronization of a low frequency frame (that is, determining a receive moment of the low frequency frame) according to a low-frequency synchronization signal sent by a base station is provided in an existing frame synchronization technology, and details are not described herein. For example, the low-frequency synchronization signal may be a 10- μ s bit sequence, a receive end sequentially receives the 10- μ s bit sequence, performs multiplication and addition operations, and determines a moment corresponding to a largest calculated value as a moment at which the receive end receives the low frequency frame, that is, the first moment.

[0033] It should be noted that only one implementation of completing, by the user equipment, the synchronization of the low frequency frame is provided in step 101 and step 102, and the user equipment may determine the receive moment of the low frequency frame in another manner, to complete the synchronization of the low frequency frame. This is not limited herein.

[0034] 103. The user equipment obtains a receive time difference.

[0035] The receive time difference is a time difference between a moment at which the user equipment receives the high frequency frame and the moment at which the user equipment receives the low frequency frame.

[0036] During specific implementation, the user equipment may obtain the receive time difference in the following five manners:

1. The user equipment receives time difference indication information sent by the base station, and calculates the receive time difference according to a transmit time difference carried in the time difference indication information.

[0037] The transmit time difference is a time difference between a transmit moment of the high frequency frame and a transmit moment of the low frequency frame. Herein, the base station does not send the high frequency frame and

the low frequency frame in an alignment manner, and therefore the transmit time difference needs to be considered when the receive time difference is calculated. Certainly, if the transmit time difference is 0, it indicates that the base station sends the high frequency frame and the low frequency frame in an alignment manner.

[0038] A frame structure of the high frequency frame and a frame structure of the low frequency frame are shown in FIG. 6. Each subframe of the high frequency frame and each subframe of the low frequency frame may be 1 ms long. Referring to FIG. 6, the base station may first send the high frequency frame and then send the low frequency frame, that is, the transmit time difference δ is less than 0. Alternatively, the base station may first send the low frequency frame and then send the high frequency frame. In this case, the transmit time difference δ is greater than 0. Certainly, in the scenario shown in FIG. 4, both the high frequency frame and the low frequency frame are sent by the base station in the figure, and therefore the time difference indication information is also sent by the base station shown in FIG. 4. In the scenario shown in FIG. 3, the high frequency frame is sent by the micro base station, and the low frequency frame is sent by the macro base station. The macro base station records the moment at which the macro base station sends the low frequency frame, and when sending the high frequency frame, the micro base station sends indication information to the macro base station, to notify the macro base station of the transmit moment of the high frequency frame. Therefore, the macro base station can determine the transmit time difference. Further, the time difference indication information is indicated by the macro base station to the user equipment.

[0039] In addition, as shown in FIG. 6a, each time before sending a high frequency frame, the base station needs to perform adaptive adjustment in a period of time (duration is a), where a represents a time difference between a transmit time point of a high-frequency synchronization signal and a transmit time point of the high frequency frame. The time difference a is fixed, and both the user equipment and the base station record the time difference. In a scenario shown in FIG. 6a, after obtaining the receive time difference Δ , the user equipment needs to adjust, according to $\Delta + a$, a start moment for scanning a receive beam corresponding to the high frequency frame. For example, if the first moment (that is, the synchronization point of the low-frequency frame) is determined as T , a third moment is determined as $T + \Delta + a$, and it is determined that the start moment for scanning the receive beam is at least before the third moment. It should be noted that when $a=0$, the foregoing scenario shown in FIG. 6 is applied.

[0040] Further, the calculating the receive time difference according to the transmit time difference specifically includes: determining the receive time difference Δ according to $\Delta = (d_2 - d_1)/c + \delta$, where d_2 is a value of a transmission path on which the high frequency frame arrives at the user equipment, d_1 is a value of a transmission path on which the low frequency frame arrives at the user equipment, c is a speed of light, and δ is the transmit time difference. The value of the transmission path is a distance value of the transmission path.

[0041] For example, referring to FIG. 6, when the base station sends a high frequency frame earlier than a low frequency frame, a time difference is δ (less than 0), and it is assumed that $(d_2 - d_1)/c$ is T , the second moment may be shown in FIG. 7. When a value of a transmission path on which the high frequency frame arrives at the user equipment is greater than a value of a transmission path on which the low frequency frame arrives at the user equipment, T is greater than 0, that is, transmission duration of the high frequency frame is greater than transmission duration of the low frequency frame. In this case, because δ is less than 0 and T is greater than 0, an absolute value of $(T + \delta)$ is less than an absolute value of δ , and further, a time difference between a moment at which the user equipment receives the low frequency frame and a moment at which the user equipment receives the high frequency frame in FIG. 7 is less than the time difference between a moment at which the base station sends the low frequency frame and a moment at which the base station sends the high frequency frame in FIG. 6. In addition, a synchronization point of a high frequency frame is a moment at which the high frequency frame is received provided that synchronization of the high frequency frame can be implemented. A synchronization point of a low frequency frame is a receive moment that is of the low frequency frame and that is determined according to a low-frequency synchronization signal.

[0042] During specific implementation, regardless of whether the user equipment performs high-low frequency intra-base-station communication, or the user equipment performs low-frequency communication with a macro base station and performs high-frequency communication with a micro base station, a transmission path of a high frequency frame and a transmission path of a low frequency frame may be different. Therefore, a difference between a path value of the high frequency frame and a path value of the low frequency frame is divided by the speed of the light, to obtain a difference between transmission duration of the high frequency frame and transmission duration of the low frequency frame, and then the transmission duration difference and a transmit time difference between a moment at which the base station sends the high frequency frame and a moment at which the base station sends the low frequency frame are added, to obtain a moment at which the user equipment receives the high frequency frame. For example, referring to FIG. 4, a value of a transmission path of the high frequency frame is $A+B$, and a value of a transmission path of the low frequency frame is C . $A+B$ is used as d_2 and C is used as d_1 in the formula $\Delta = (d_2 - d_1)/c + \delta$, and the receive time difference Δ can be calculated.

2. The user equipment obtains the receive time difference by receiving the receive time difference sent by user equipment in a same cell.

It should be noted that the user equipment in the same cell learns of the receive time difference in advance. The receive time difference may be determined after the user equipment in the same cell completes synchronization of a high frequency frame, or may be indicated by the base station to the user equipment in the same cell.

For example, as shown in FIG. 8, if UE 2 belonging to a same cell coverage area as the user equipment (UE 1) has completed synchronization of a high frequency frame and determined the receive time difference before the user equipment does, the UE 2 may notify the user equipment of the receive time difference. During specific implementation, the UE 2 may directly notify the user equipment of the receive time difference, or may notify the user equipment of a sequence number. The user equipment determines the receive time difference from a pre-stored receive time difference table according to the sequence number notified by the UE 2. For example, if the receive time difference table pre-stored by the UE 1 is $\{-20, -10, -5, 0, 4, 12, 20\}$, and the sequence number notified by the UE 2 is 3, the receive time difference is determined as -5 (provided that the receive time differences are numbered from 1). Certainly, the base station and the user equipment use a same rule for numbering receive time differences in a receive time difference table. For example, the base station starts numbering from 0, and the user equipment also starts numbering from 0.

3. The user equipment obtains the receive time difference by receiving the receive time difference sent by the base station.

During specific implementation, the base station records the value d_2 of the transmission path on which the high frequency frame arrives at the user equipment, the value d_1 of the transmission path on which the low frequency frame arrives at the user equipment, and the transmit time difference δ . Therefore, the base station can determine the receive time difference Δ according to $\Delta = (d_2 - d_1)/c + \delta$.

It should be noted that the macro base station in the scenario shown in FIG. 3 or the base station in the scenario shown in FIG. 4 sends the receive time difference to the user equipment herein.

4. That the user equipment obtains a receive time difference specifically includes:

receiving a time sequence number X sent by the base station, and determining an Xth receive time difference in a pre-stored receive time difference table as the receive time difference.

During specific implementation, the base station may determine a receive time difference Δ according to $\Delta = (d_2 - d_1)/c + \delta$, and then determine, as X, a sequence number of a largest receive time difference in time differences less than Δ in a receive time difference table. Certainly, the receive time difference table on a base station side is the same as the receive time difference table pre-stored by the user equipment.

5. The user equipment receives scenario indication information delivered by the base station, determines a scenario of the user equipment according to the scenario indication information, and determines a value of $(d_2 - d_1)$ according to the scenario of the user equipment.

[0043] For example, both the base station and the user equipment pre-store value ranges of the receive time difference, and the value ranges of the receive time difference that are pre-stored by the base station and the user equipment are the same. For example, both the base station and the user equipment store $\delta \in [\delta_{\min}, \delta_{\max}]$. If the user equipment determines, according to the scenario indication information from the base station, that a current application scenario is the scenario shown in FIG. 3, the user equipment determines that a high-low frequency frame receive time difference exists when the user equipment is farthest from the macro base station (that is, in a cell edge of the macro base station) and is at a shortest distance (equal to 0) from the micro base station. It is assumed that the inter-site distance of the macro base stations, ISD=500 m, in consideration of an NLOS, a maximum transmission distance of the macro base station should not exceed 450 m. Assuming that $\delta = \delta_{\min} = 10\mu\text{s}$,

$$\Delta_{\min} = (d_{HF} - d_{LF}) / C + \delta = -1.5 - 10 = -11.5\mu\text{s}$$

[0044] That is, a synchronization point of a high frequency frame is a maximum of 11.5 μs earlier than a synchronization point of a low frequency frame.

[0045] If the user equipment determines, according to the scenario indication information from the base station, that a current application scenario is the scenario shown in FIG. 4, due to high-low frequency intra-base-station communication, a largest time difference is less than that in the scenario shown in FIG. 3. For example, due to NLOS transmission, a transmission distance of a low frequency signal is a maximum of 450 m longer than that of a high frequency signal transmitted by using a LOS, and $\delta = \delta_{\min} = -2\mu\text{s}$ (due to the high-low frequency intra-base-station communication), and therefore

$$\Delta_{\min} = (d_{HF} - d_{LF}) / C + \delta = -1.5 - 2 = -3.5\mu\text{s}$$

[0046] That is, a synchronization point of a high frequency frame is a maximum of 3.5 μ s earlier than a synchronization point of a low frequency frame.

[0047] In addition, if the user equipment cannot receive the scenario indication information from the base station, a value is determined from the pre-stored value range $\delta \in [\delta_{\min}, \delta_{\max}]$ of the receive time difference. For example, it is determined that $\delta = \delta_{\min}$.

[0048] 104. The user equipment completes synchronization of a high frequency frame according to the receive time difference and the first moment.

[0049] It should be noted that, the completing, by the user equipment, synchronization of a high frequency frame means receiving, by the user equipment, the high frequency frame. A synchronization point of the high frequency frame is a moment at which the user equipment receives the high frequency frame.

[0050] During specific implementation, the user equipment determines, according to the receive time difference and the first moment, a start moment for scanning a receive beam corresponding to the high frequency frame, scans the receive beam at the start moment, and receives data sent by using the high frequency frame, to complete the synchronization of the high frequency frame.

[0051] Further, that the user equipment determines, according to the receive time difference and the first moment, a start moment for scanning a receive beam corresponding to the high frequency frame is specifically: determining a third moment according to a sum of the receive time difference and the first moment, and determining that the start moment is at least before the third moment.

[0052] For example, if a difference between a moment at which the base station sends the high frequency frame and a moment at which the base station sends the low frequency frame is T, and a difference between transmission duration of the high frequency frame and transmission duration of the low frequency frame is M, the receive time difference is T+M. If T+M is greater than 0, a receive moment of the high frequency frame is later than a receive moment of the low frequency frame. If T+M is less than 0, a receive moment of the high frequency frame is before a receive moment of the low frequency frame. For example, if the first moment is a subframe #n, and T+M is greater than 0, the third moment may be a subframe #(n+T+M). Certainly, the third moment may alternatively be before the subframe #(n+T+M).

[0053] Further, the frame synchronization method provided in this embodiment may further include step 105.

[0054] 105. The user equipment determines a second moment of the synchronization of the high frequency frame, determines a time difference between the first moment and the second moment, and reports the time difference between the first moment and the second moment to the base station.

[0055] It should be noted that the receive time difference obtained by the user equipment is merely a predicted difference value, and further the determined start moment for scanning the receive beam should also be a predicted moment. Therefore, when really completing the synchronization of the high frequency frame, the user equipment should determine an accurate receive moment of the second high frequency frame, that is, the second moment.

[0056] Although the user equipment cannot learn of a moment at which the base station scans a transmit beam, and therefore cannot determine the receive moment of the high frequency frame, the user equipment can determine the receive moment of the low frequency frame, and further obtain the time difference between the receive moment of the high frequency frame and the receive moment of the low frequency frame, so that the user equipment can determine the start moment for scanning the corresponding receive beam, scan the receive beam at the start moment, and receive complete data, to implement the synchronization of the high frequency frame, and receive complete data. In addition, the user equipment can determine the accurate second moment at which the high frequency frame is received.

[0057] The time difference herein is an accurate receive time difference. After receiving the time difference, the base station delivers the time difference to another user equipment (user equipment belonging to a same cell coverage area as the user equipment), so that the another user equipment can also determine, according to this accurate receive time difference, an accurate moment for scanning a receive beam, and further complete synchronization of a high frequency frame.

[0058] According to the frame synchronization method in this embodiment of the present invention, the user equipment receives the low-frequency synchronization signal sent by the base station, determines, according to the low-frequency synchronization signal, the first moment at which the low frequency frame is received, obtains the receive time difference (that is, the time difference between the moment at which the user equipment receives the high frequency frame and the moment at which the user equipment receives the low frequency frame), determines, according to the receive time difference and the first moment, the start moment for scanning the corresponding receive beam, and receives the data transmitted by using the high frequency frame, to implement the synchronization of the high frequency frame;. In addition, the user equipment determines the second moment at which the high frequency frame is received, and reports the time difference between the first moment and the second moment to a base station. In the prior art, the user equipment does not know when the base station scans a transmit beam, and therefore is uncertain about a synchronization point of the high frequency frame (that is, a receive moment of the high frequency frame) and cannot implement time synchronization between the user equipment and the base station, and the user equipment cannot receive complete data that is transmitted by using the high frequency frame. According to the method provided in the present invention, the user equipment can

determine the receive moment of the high frequency frame, and further implement synchronization of the high frequency frame in the high-low frequency hybrid communications system, so that the user equipment can receive the complete data that is transmitted by using the high frequency frame.

Embodiment 3

[0059] This embodiment of the present invention provides a frame synchronization method. As shown in FIG. 9, the method includes the following steps.

[0060] 201. A base station determines a receive time difference.

[0061] The receive time difference is a time difference between a moment at which first user equipment receives a second frequency frame and a moment at which the first user equipment receives a first frequency frame. The first frequency frame may be a low frequency frame, and the second frequency frame is a high frequency frame.

[0062] During specific implementation, the base station may obtain the receive time difference in the following two manners.

1. The base station obtains a transmit time difference, where the transmit time difference is a time difference between a transmit moment of the second frequency frame and a transmit moment of the first frequency frame; and determines the receive time difference Δ according to $\Delta = (d_2 - d_1)/c + \delta$.

In the foregoing formula, d_2 is a value of a transmission path on which the second frequency frame arrives at the first user equipment, d_1 is a value of a transmission path on which the first frequency frame arrives at the first user equipment, c is a speed of light, and δ is the transmit time difference.

2. The base station receives a time difference, reported by second user equipment, between a first moment at which the second user equipment receives the first frequency frame and a second moment at which the second user equipment completes synchronization of the second frequency frame; and determines the time difference as the receive time difference.

[0063] The second user equipment and the first user equipment belong to a same cell.

[0064] It should be noted that the receive time difference determined in the first manner is a predicted value. The user equipment may determine a moment according to the receive time difference and the receive moment of the first frequency frame, scan a receive beam at least before the moment, and receive complete data, to implement the synchronization of the second frequency frame. The receive time difference determined in the second manner is an accurate value. The user equipment may determine a moment according to a sum of the receive time difference and the receive moment of the first frequency frame, and scan a receive beam at the moment, to implement the synchronization of the second frequency frame.

[0065] 202. The base station sends the receive time difference to the first user equipment, so that the first user equipment completes synchronization of a second frequency frame according to the receive time difference.

[0066] The base station in this embodiment of the present invention indicates the receive time difference to the user equipment, so that the user equipment determines, according to the receive time difference and the first moment, a start moment for scanning the corresponding receive beam, and receives the data transmitted by using the second frequency frame, to implement the synchronization of the second frequency frame. In addition, the user equipment determines the second moment at which the second frequency frame is received, to complete the synchronization of the second frequency frame. In the prior art, the user equipment does not know when the base station scans a transmit beam, and therefore is uncertain about a synchronization point of the second frequency frame and cannot implement time synchronization between the user equipment and the base station. According to the method provided in the present invention, the receive moment of the second frequency frame can be determined, so that synchronization (that is, time synchronization) of the second frequency frame is implemented in a high-low frequency hybrid communications system.

Embodiment 4

[0067] This embodiment of the present invention provides user equipment. As shown in FIG. 10, the user equipment includes a frame synchronization unit 301, a determining unit 302, and an obtaining unit 303. The frame synchronization unit 301 is configured to complete synchronization of a first frequency frame. The user equipment supports first-frequency communication and second-frequency communication.

[0068] The determining unit 302 is configured to determine a first moment of the synchronization of the first frequency frame.

[0069] During specific implementation, a low-frequency synchronization signal sent by a base station may be received by using a receiving unit, the synchronization of the first frequency frame is implemented according to the low-frequency synchronization signal, and the first moment is determined.

[0070] The obtaining unit 303 is configured to obtain a receive time difference. The receive time difference is a time difference between a moment at which the user equipment receives a second frequency frame and a moment at which the user equipment receives a first frequency frame.

[0071] The frame synchronization unit 301 is configured to complete synchronization of the second frequency frame according to the receive time difference obtained by the obtaining unit and the first moment determined by the determining unit.

[0072] As shown in FIG. 10a, the user equipment further includes a sending unit 304.

[0073] The determining unit 302 is further configured to: determine a second moment at which the synchronization of the second frequency frame is completed, and determine a time difference between the first moment and the second moment.

[0074] The sending unit 304 is configured to report the time difference between the first moment and the second moment to a base station.

[0075] The frame synchronization unit 301 is specifically configured to: determine, according to the receive time difference and the first moment, a start moment for scanning a receive beam corresponding to the second frequency frame, scan the receive beam at the start moment determined by the determining unit, and receive data sent by using the second frequency frame, to complete the synchronization of the second frequency frame.

[0076] The frame synchronization unit 301 is specifically configured to: determine a third moment according to a sum of the receive time difference and the first moment, and determine that the start moment is at least before the third moment.

[0077] The obtaining unit 303 is specifically configured to: receive time difference indication information sent by a base station, where the time difference indication information carries a transmit time difference, and the transmit time difference is a time difference between a transmit moment of the second frequency frame and a transmit moment of the first frequency frame; and calculate the receive time difference according to the transmit time difference.

[0078] The obtaining unit 303 is specifically configured to:

determine the receive time difference Δ according to $\Delta = (d_2 - d_1)/c + \delta$, where d_2 is a value of a transmission path on which the second frequency frame arrives at the user equipment, d_1 is a value of a transmission path on which the first frequency frame arrives at the user equipment, c is a speed of light, and δ is the transmit time difference.

[0079] The obtaining unit 303 is specifically configured to: receive scenario indication information delivered by the base station, determine a scenario of the user equipment according to the scenario indication information, and determine a value of $(d_2 - d_1)$ according to the scenario of the user equipment.

[0080] The obtaining unit 303 is specifically configured to receive the receive time difference sent by user equipment in a same cell.

[0081] The obtaining unit 303 is specifically configured to receive the receive time difference sent by a base station.

[0082] The obtaining unit 303 is specifically configured to receive a time sequence number X sent by a base station, and determine an X^{th} receive time difference in a pre-stored receive time difference table as the receive time difference.

[0083] The obtaining unit 303 is specifically configured to determine the receive time difference according to a pre-stored value range of the receive time difference.

[0084] It should be noted that a receiving function of the obtaining unit 303 may be implemented by using a receiver of the user equipment, and the sending unit 304 may be a transmitter of the user equipment, or the transmitter and the receiver are integrated as a transceiver. The determining unit 302, the obtaining unit 303, and the frame synchronization unit 301 may be integrated into a processor of the user equipment for implementation, or may be stored in a memory of the user equipment in a form of program code. The processor of the user equipment invokes the code stored in the memory of the user equipment, to execute the foregoing functions of the determining unit 302, the obtaining unit 303, and the frame synchronization unit 301.

[0085] The user equipment in this embodiment of the present invention receives the low-frequency synchronization signal sent by the base station, determines, according to the low-frequency synchronization signal, the first moment at which the first frequency frame is received, obtains the receive time difference (that is, the time difference between the moment at which the user equipment receives the second frequency frame and the moment at which the user equipment receives the first frequency frame), determines, according to the receive time difference and the first moment, the start moment for scanning the corresponding receive beam, and receives data transmitted by using the second frequency frame, to implement the synchronization of the second frequency frame. In addition, the user equipment determines the second moment at which the second frequency frame is received, to complete the synchronization of the second frequency frame. In the prior art, the user equipment does not know when the base station scans a transmit beam, and therefore is uncertain about a synchronization point of the second frequency frame and cannot implement time synchronization between the user equipment and the base station. According to the method provided in the present invention, the receive moment of the second frequency frame can be determined, so that time synchronization of the second frequency frame is implemented in a high-low frequency hybrid communications system.

Embodiment 5

[0086] This embodiment of the present invention provides a base station, including a determining unit 401 and a sending unit 402, as shown in FIG. 11.

[0087] The determining unit 401 is configured to determine a receive time difference, where the receive time difference is a time difference between a moment at which first user equipment receives a second frequency frame and a moment at which the first user equipment receives a first frequency frame.

[0088] The sending unit 402 is configured to send the receive time difference to the first user equipment, so that the first user equipment completes synchronization of the second frequency frame according to the receive time difference.

[0089] The determining unit 401 is specifically configured to: obtain a transmit time difference, where the transmit time difference is a time difference between a transmit moment of the second frequency frame and a transmit moment of the first frequency frame; and

determine the receive time difference Δ according to $\Delta = (d_2 - d_1)/c + \delta$, where d_2 is a value of a transmission path on which the second frequency frame arrives at the first user equipment, d_1 is a value of a transmission path on which the first frequency frame arrives at the first user equipment, c is a speed of light, and δ is the transmit time difference.

[0090] As shown in FIG. 11a, the base station further includes a receiving unit 403.

[0091] The receiving unit is configured to receive a difference, reported by the user equipment, between the first moment and the second moment.

[0092] It should be noted that the receiving unit 403 may be a receiver of the base station, and the sending unit 402 may be a transmitter of the base station, or the transmitter and the receiver are integrated as a transceiver. The determining unit 401 may be integrated into a processor of the base station for implementation, or may be stored in a memory of the base station in a form of program code. The processor invokes the code stored in the memory, to execute the foregoing functions of the determining unit 401.

[0093] The base station in this embodiment of the present invention indicates the receive time difference to the user equipment, so that the user equipment determines, according to the receive time difference and the first moment, a start moment for scanning a corresponding receive beam, and receives data transmitted by using the second frequency frame, to implement the synchronization of the second frequency frame, and determines the second moment at which the second frequency frame is received, to complete the synchronization of the second frequency frame. In the prior art, the user equipment does not know when the base station scans a transmit beam, and therefore is uncertain about a synchronization point of the second frequency frame and cannot implement time synchronization between the user equipment and the base station. According to the method provided in the present invention, the receive moment of the second frequency frame can be determined, so that time synchronization of the second frequency frame is implemented in a high-low frequency hybrid communications system.

Embodiment 6

[0094] This embodiment of the present invention provides user equipment. As shown in FIG. 12, the user equipment includes a processor 501, a system bus 502, a memory 503, a receiver 504, and a transmitter 505.

[0095] The processor 501 may be a central processing unit (English: central processing unit, CPU for short).

[0096] The memory 503 is configured to store program code and transmit the program code to the processor 501. The processor 501 executes instructions according to the program code. The memory 503 may include a volatile memory (English: volatile memory), for example, a random access memory (English: random access memory, RAM for short). The memory 503 may include a nonvolatile memory (English: nonvolatile memory), for example, a read-only memory (English: read-only memory, ROM for short), a flash memory (English: flash memory), a hard disk drive (English: hard disk drive, HDD for short), or a solid-state drive (English: solid-state drive, SSD for short). The memory 503 may alternatively include a combination of the foregoing types of memories. The processor 501 and the memory 503 are connected and communicate with each other by using the system bus 502.

[0097] The receiver 504 may be implemented by using an optical receiver, an electrical receiver, a radio receiver, or any combination thereof. For example, the optical receiver may be a small form-factor pluggable (English: small form-factor pluggable, SFP for short) receiver (English: transceiver), an enhanced small form-factor pluggable (English: enhanced small form-factor pluggable, SFP+ for short) receiver, or a 10 gigabit small form-factor pluggable (English: 10 Gigabit small form-factor pluggable, XFP for short) receiver. The electrical receiver may be an Ethernet (English: Ethernet) network interface controller (English: network interface controller, NIC for short). The radio receiver may be a wireless network interface controller (English: wireless network interface controller, WNIC for short).

[0098] The transmitter 505 may be implemented by using an optical transmitter, an electrical transmitter, a radio transmitter, or any combination thereof. For example, the optical transmitter may be a small form-factor pluggable transmitter, an enhanced small form-factor pluggable transmitter, or a 10 gigabit small form-factor pluggable transmitter. The electrical transmitter may be an Ethernet network interface controller. The radio transmitter may be a wireless

network interface controller.

[0099] The processor 501 is configured to: complete synchronization of a first frequency frame; determine a first moment of the synchronization of the first frequency frame; obtain a receive time difference, where the receive time difference is a time difference between a moment at which the user equipment receives a second frequency frame and a moment at which the user equipment receives the first frequency frame; and complete synchronization of the second frequency frame according to the receive time difference and the first moment.

[0100] The processor 501 is further configured to: determine a second moment at which the synchronization of the second frequency frame is completed, and determine a time difference between the first moment and the second moment.

[0101] The transmitter 505 is configured to report the time difference between the first moment and the second moment to a base station.

[0102] The processor 501 is specifically configured to: determine, according to the receive time difference and the first moment, a start moment for scanning a receive beam corresponding to the second frequency frame, scan the receive beam at the start moment determined by the processor 501, and receive data sent by using the second frequency frame, to complete the synchronization of the second frequency frame.

[0103] The processor 501 is specifically configured to: determine a third moment according to a sum of the receive time difference and the first moment, and determine that the start moment is at least before the third moment.

[0104] The receiver 504 is specifically configured to: receive time difference indication information sent by a base station, where the time difference indication information carries a transmit time difference, and the transmit time difference is a time difference between a transmit moment of the second frequency frame and a transmit moment of the first frequency frame; and calculate the receive time difference according to the transmit time difference.

[0105] The processor 501 is specifically configured to:
determine the receive time difference Δ according to $\Delta = (d_2 - d_1)/c + \delta$, where d_2 is a value of a transmission path on which the second frequency frame arrives at the user equipment, d_1 is a value of a transmission path on which the first frequency frame arrives at the user equipment, c is a speed of light, and δ is the transmit time difference.

[0106] The receiver 504 is specifically configured to receive the receive time difference sent by user equipment in a same cell.

[0107] The receiver 504 is specifically configured to receive the receive time difference sent by a base station.

[0108] The receiver 504 is specifically configured to receive a time sequence number X sent by a base station, and determine an X^{th} receive time difference in a pre-stored receive time difference table as the receive time difference.

[0109] The user equipment in this embodiment of the present invention receives a low-frequency synchronization signal sent by the base station, determines, according to the low-frequency synchronization signal, the first moment at which the first frequency frame is received, obtains the receive time difference (that is, the time difference between the moment at which the user equipment receives the second frequency frame and the moment at which the user equipment receives the first frequency frame), determines, according to the receive time difference and the first moment, the start moment for scanning the corresponding receive beam, receives data transmitted by using the second frequency frame, to implement the synchronization of the second frequency frame. In addition, the user equipment determines the second moment at which the second frequency frame is received, to complete the synchronization of the second frequency frame. In the prior art, the user equipment does not know when the base station scans a transmit beam, and therefore is uncertain about a synchronization point of the second frequency frame and cannot implement time synchronization between the user equipment and the base station. According to the method provided in the present invention, the receive moment of the second frequency frame can be determined, so that time synchronization of the second frequency frame is implemented in a high-low frequency hybrid communications system.

Embodiment 7

[0110] This embodiment of the present invention provides a base station. As shown in FIG. 13, the base station includes a processor 601, a system bus 602, a memory 603, a receiver 604, and a transmitter 605.

[0111] The processor 601 may be a central processing unit.

[0112] The memory 603 is configured to store program code and transmit the program code to the processor 601. The processor 601 executes instructions according to the program code. The memory 603 may include a volatile memory, for example, a random access memory. The memory 603 may include a nonvolatile memory, for example, a read-only memory, a flash memory, a hard disk, or a solid-state drive. The memory 603 may alternatively include a combination of the foregoing types of memories. The processor 601 and the memory 603 are connected and communicate with each other by using the system bus 602.

[0113] The receiver 604 may be implemented by using an optical receiver, an electrical receiver, a radio receiver, or any combination thereof. For example, the optical receiver may be a small form-factor pluggable receiver, an enhanced small form-factor pluggable receiver, or a 10 gigabit small form-factor pluggable receiver. The electrical receiver may be an Ethernet network interface controller. The radio receiver may be a wireless network interface controller.

[0114] The transmitter 605 may be implemented by using an optical transmitter, an electrical transmitter, a radio transmitter, or any combination thereof. For example, the optical transmitter may be a small form-factor pluggable transmitter, an enhanced small form-factor pluggable transmitter, or a 10 gigabit small form-factor pluggable transmitter. The electrical transmitter may be an Ethernet network interface controller. The radio transmitter may be a wireless network interface controller.

[0115] The processor 601 is configured to determine a receive time difference, where the receive time difference is a time difference between a moment at which first user equipment receives a second frequency frame and a moment at which the first user equipment receives a first frequency frame.

[0116] The transmitter 605 is configured to send the receive time difference to the first user equipment, so that the first user equipment completes synchronization of the second frequency frame according to the receive time difference.

[0117] The processor 601 is specifically configured to: obtain a transmit time difference, where the transmit time difference is a time difference between a transmit moment of the second frequency frame and a transmit moment of the first frequency frame; and

determine the receive time difference Δ according to $\Delta = (d_2 - d_1)/c + \delta$, where d_2 is a value of a transmission path on which the second frequency frame arrives at the first user equipment, d_1 is a value of a transmission path on which the first frequency frame arrives at the first user equipment, c is a speed of light, and δ is the transmit time difference.

[0118] The receiver 604 is configured to receive a time difference, reported by second user equipment, between a first moment at which the second user equipment receives the first frequency frame and a second moment at which the second user equipment completes synchronization of the second frequency frame, where the second user equipment and the first user equipment belong to a same cell.

[0119] The processor 601 is specifically configured to determine the time difference as the receive time difference.

[0120] The base station in this embodiment of the present invention indicates the receive time difference to the user equipment, so that the user equipment determines, according to the receive time difference and a first moment, a start moment for scanning a corresponding receive beam, and receives data transmitted by using the second frequency frame, to implement the synchronization of the second frequency frame. In addition, the user equipment determines a second moment at which the second frequency frame is received, to complete the synchronization of the second frequency frame. In the prior art, the user equipment does not know when the base station scans a transmit beam, and therefore is uncertain about a synchronization point of the second frequency frame and cannot implement time synchronization between the user equipment and the base station. According to the method provided in the present invention, the receive moment of the second frequency frame can be determined, so that time synchronization of the second frequency frame is implemented in a high-low frequency hybrid communications system.

[0121] The foregoing descriptions about implementations allow a person skilled in the art to clearly understand that, for the purpose of convenient and brief description, merely division of the foregoing function modules is used as an example for illustration. During actual application, the foregoing functions can be allocated to different modules for implementation according to a requirement, that is, an inner structure of an apparatus is divided into different function modules to implement all or some of the functions described above. For a detailed working process of the foregoing apparatus, refer to a corresponding process in the foregoing method embodiments, and details are not described herein again.

[0122] The units described as separate parts may or may not be physically separate, and parts displayed as units may be one or more physical units, that is, may be located in one place, or may be distributed on different places. Some or all of the units may be selected according to an actual requirement to achieve the objectives of the solutions in the embodiments. In addition, function units in the embodiments of the present invention may be integrated into one processing unit, or each of the units may exist alone physically, or two or more units are integrated into one unit. The integrated unit may be implemented in a form of hardware, or may be implemented in a form of a software function unit.

[0123] When the integrated unit is implemented in the form of a software function unit and sold or used as an independent product, the integrated unit may be stored in a readable storage medium. Based on such an understanding, the technical solutions in the present invention essentially, or the part contributing to the prior art, or all or some of the technical solutions may be implemented in the form of a software product. The software product is stored in a storage medium and includes several instructions for instructing a device (which may be a single-chip microcomputer, a chip, or the like) or a processor (processor) to perform all or some of the steps of the methods described in the embodiments of the present invention. The foregoing storage medium includes: any medium that can store program code, such as a USB flash drive, a removable hard disk, a read-only memory (ROM, Read-Only Memory), a random access memory (RAM, Random Access Memory), a magnetic disk, or an optical disc.

[0124] The foregoing descriptions are merely specific implementations of the present invention, but are not intended to limit the protection scope of the present invention. Any variation or replacement readily figured out by a person skilled in the art within the technical scope disclosed in the present invention shall fall within the protection scope of the present invention. Therefore, the protection scope of the present invention shall be subject to the protection scope of the claims.

Claims**1.** A frame synchronization method, comprising:

5 Completing (S101), by user equipment, synchronization of a first frame transmitted on a first frequency, and determining a first moment of the synchronization of the first frame, wherein the user equipment supports first-frequency communication and second-frequency communication;

Obtaining (S102), by the user equipment, a receive time difference, wherein the receive time difference is a time difference between a moment at which the user equipment receives a second frame transmitted on a
10 second frequency and a moment at which the user equipment receives the first frame; and

Completing (S103), by the user equipment, synchronization of the second frame according to the receive time difference and the first moment, wherein after the completing, by the user equipment, synchronization of the second frame according to the receive time difference and the first moment, the method further comprises:

15 determining, by the user equipment, a second moment of the synchronization of the second frame and a time difference between the first moment and the second moment, and reporting the time difference between the first moment and the second moment to a base station.

2. A frame synchronization method, comprising:

determining, by a base station, a receive time difference, wherein the receive time difference is a time difference between a moment at which first user equipment receives a second frame transmitted on a second frequency and a moment at which the first user equipment receives a first frame transmitted on a first frequency; and
25 sending, by the base station, the receive time difference to the first user equipment, so that the first user equipment completes synchronization of the second frame according to the receive time difference and a moment at which the first user equipment completes synchronization of the first frame,

wherein the determining, by a base station, a receive time difference specifically comprises: receiving a time difference, reported (105) by second user equipment, between a first moment at which the second user equipment completes synchronization of the first frame and a second moment at which the second user equipment completes synchronization of the second frame, wherein the second user equipment and the first user equipment belong to a same cell; determining said time difference as the receive time difference.

3. User equipment, wherein the user equipment supports first-frequency communication and second-frequency communication, and comprises:

35 a frame synchronization unit (301), configured to complete synchronization of a first frame transmitted on a first frequency;

a determining unit (302), configured to determine a first moment at which the user equipment completes the synchronization of the first frame; and

40 an obtaining unit (303), configured to obtain a receive time difference, wherein the receive time difference is a time difference between a moment at which the user equipment receives a second frame and a moment at which the user equipment receives a first frame, wherein

the frame synchronization unit is configured to complete synchronization of the second frame transmitted on a second frequency according to the receive time difference obtained by the obtaining unit and the first moment determined by the determining unit, wherein

45 the determining unit (302) is further configured to determine a second moment at which the synchronization of the second frame is completed;

the determining unit (302) is further configured to determine a time difference between the first moment and the second moment; and

50 a sending unit (304) is configured to report the time difference between the first moment and the second moment to a base station.

4. A base station, **characterized in:**

55 a determining unit (401), configured to determine a receive time difference, wherein the receive time difference is a time difference between a moment at which first user equipment receives a second frame transmitted on a second frequency and a moment at which the first user equipment receives a first frame transmitted on a first

frequency; and

a sending unit (402), configured to send the receive time difference to the first user equipment, so that the first user equipment completes synchronization of the second frame according to the receive time difference and a moment at which the first user equipment completes synchronization of the first frame,

further comprising a receiving unit (403), wherein

the receiving unit (403) is configured to receive a time difference, reported by second user equipment, between a first moment at which the second user equipment receives the first frame and a second moment at which the second user equipment completes synchronization of the second frame, wherein the second user equipment and the first user equipment belong to a same cell; and

the determining unit (401) is specifically configured to determine the time difference as the receive time difference.

Patentansprüche

1. Rahmensynchronisationsverfahren, umfassend:

Abschließen (S101) der Synchronisation eines ersten auf einer ersten Frequenz gesendeten Rahmens durch Benutzer-Equipment und Festlegen eines ersten Zeitpunkts der Synchronisation des ersten Rahmens, wobei das Benutzer-Equipment Kommunikation erster Frequenz und Kommunikation zweiter Frequenz unterstützt; Erhalten (S102) einer Empfangszeitdifferenz durch das Benutzer-Equipment, wobei die Empfangszeitdifferenz eine Zeitdifferenz ist zwischen einem Zeitpunkt, zu dem das Benutzer-Equipment einen auf einer zweiten Frequenz übertragenen zweiten Rahmen empfängt, und einem Zeitpunkt, zu dem das Benutzer-Equipment den ersten Rahmen empfängt; und

Abschließen (S103) der Synchronisation des zweiten Rahmens durch das Benutzer-Equipment entsprechend der Empfangszeitdifferenz und dem ersten Zeitpunkt, wobei das Verfahren nach dem Abschließen der Synchronisation des zweiten Rahmens durch das Benutzer-Equipment entsprechend der Empfangszeitdifferenz und dem ersten Zeitpunkt ferner umfasst:

Festlegen eines zweiten Zeitpunkts der Synchronisation des zweiten Rahmens durch das Benutzer-Equipment und einer Zeitdifferenz zwischen dem ersten Zeitpunkt und dem zweiten Zeitpunkt und Berichten der Zeitdifferenz zwischen dem ersten Zeitpunkt und dem zweiten Zeitpunkt an eine Basisstation.

2. Rahmensynchronisationsverfahren, umfassend:

Ermitteln einer Empfangszeitdifferenz durch eine Basisstation, wobei die Empfangszeitdifferenz eine Zeitdifferenz ist zwischen einem Zeitpunkt, zu dem erstes Benutzer-Equipment einen auf einer zweiten Frequenz gesendeten zweiten Rahmen empfängt, und einem Zeitpunkt, zu dem das erste Benutzer-Equipment einen auf einer ersten Frequenz gesendeten Rahmen empfängt; und

Senden der Empfangszeitdifferenz durch die Basisstation zu dem ersten Benutzer-Equipment, sodass das erste Benutzer-Equipment die Synchronisation des zweiten Rahmens abschließt entsprechend der Empfangszeitdifferenz und einem Zeitpunkt, zu dem das erste Benutzer-Equipment die Synchronisation des ersten Rahmens abschließt,

wobei das Ermitteln einer Empfangszeitdifferenz durch eine Basisstation im Einzelnen umfasst:

Empfangen einer Zeitdifferenz, berichtet (105) durch zweites Benutzer-Equipment, zwischen einem ersten Zeitpunkt, zu dem das zweite Benutzer-Equipment die Synchronisation des ersten Rahmens abschließt, und einem zweiten Zeitpunkt, zu dem das zweite Benutzer-Equipment die Synchronisation des zweiten Rahmens abschließt, wobei das zweite Benutzer-Equipment und das erste Benutzer-Equipment zu einer gleichen Zelle gehören; Festlegen der Zeitdifferenz als die Empfangszeitdifferenz.

3. Benutzer-Equipment, wobei das Benutzer-Equipment Kommunikation erster Frequenz und Kommunikation zweiter Frequenz unterstützt und umfasst:

eine Rahmensynchronisationseinheit (301), ausgelegt zum Abschließen der Synchronisation eines ersten, auf einer ersten Frequenz gesendeten Rahmens;

eine Bestimmungseinheit (302), ausgelegt zum Ermitteln eines ersten Zeitpunkts, zu dem das Benutzer-Equipment die Synchronisation des ersten Rahmens abschließt; und eine Erhalteinheit (303), ausgelegt zum Erhalten einer Empfangszeitdifferenz, wobei die Empfangszeitdifferenz eine Zeitdifferenz ist zwischen einem Zeitpunkt, zu dem das Benutzer-Equipment einen zweiten Rahmen empfängt, und einem Zeitpunkt, zu dem das Benutzer-Equipment einen ersten Rahmen empfängt, wobei

die Rahmensynchronisationseinheit dafür ausgelegt ist, die Synchronisation des zweiten, auf einer zweiten Frequenz gesendeten Rahmens entsprechend der durch die Erhalteinheit erhaltenen Empfangszeitdifferenz und dem durch die Bestimmungseinheit festgelegten ersten Zeitpunkt abzuschließen, wobei
 5 die Bestimmungseinheit (302) ferner dafür ausgelegt ist, einen zweiten Zeitpunkt zu ermitteln, zu dem die Synchronisation des zweiten Rahmens abgeschlossen ist;
 die Bestimmungseinheit (302) ferner dafür ausgelegt ist, eine Zeitdifferenz zwischen dem ersten Zeitpunkt und dem zweiten Zeitpunkt zu ermitteln; und
 eine Sendeeinheit (304) dafür ausgelegt ist, die Zeitdifferenz zwischen dem ersten Zeitpunkt und dem zweiten Zeitpunkt an eine Basisstation zu berichten.

4. Basisstation, **gekennzeichnet durch**

eine Bestimmungseinheit (401), ausgelegt zum Ermitteln einer Empfangszeitdifferenz, wobei die Empfangszeitdifferenz eine Zeitdifferenz ist zwischen einem Zeitpunkt, zu dem erstes Benutzer-Equipment einen zweiten, auf einer zweiten Frequenz gesendeten Rahmen empfängt, und einem Zeitpunkt, zu dem das erste Benutzer-Equipment
 15 einen auf einer ersten Frequenz gesendeten ersten Rahmen empfängt; und
 eine Sendeeinheit (402), ausgelegt zum Senden der Empfangszeitdifferenz zu dem ersten Benutzer-Equipment, sodass das erste Benutzer-Equipment die Synchronisation des zweiten Rahmens abschließt entsprechend der Empfangszeitdifferenz und einem Zeitpunkt, zu dem das erste Benutzer-Equipment die Synchronisation des ersten Rahmens abschließt,
 20 ferner umfassend eine Empfangseinheit (403), wobei
 die Empfangseinheit (403) ausgelegt ist zum Empfangen einer Zeitdifferenz, berichtet durch zweites Benutzer-Equipment, zwischen einem ersten Zeitpunkt, zu dem das zweite Benutzer-Equipment den ersten Rahmen empfängt, und einem zweiten Zeitpunkt, zu dem das zweite Benutzer-Equipment die Synchronisation des zweiten Rahmens abschließt, wobei das zweite Benutzer-Equipment und das erste Benutzer-Equipment zu einer gleichen Zelle ge-
 25 hören; und
 die Bestimmungseinheit (401) im Einzelnen ausgelegt ist zum Ermitteln der Zeitdifferenz als der Empfangszeitdifferenz.

Revendications

1. Procédé de synchronisation de trames, comprenant :

la réalisation (S101), par un équipement utilisateur, de la synchronisation d'une première trame transmise sur
 35 une première fréquence, et la détermination d'un premier point temporel de la synchronisation de la première trame, l'équipement utilisateur prenant en charge la communication sur une première fréquence et sur une seconde fréquence ;
 l'obtention (S102), par l'équipement utilisateur, d'une différence temporelle de réception, la différence temporelle de réception étant une différence temporelle entre un point temporel auquel l'équipement utilisateur reçoit une
 40 seconde trame transmise sur une seconde fréquence et un point temporel auquel l'équipement utilisateur reçoit la première trame ; et
 la réalisation (S103), par l'équipement utilisateur, de la synchronisation de la seconde trame en fonction de la différence temporelle de réception et du premier point temporel,
 après la réalisation, par l'équipement utilisateur, de la synchronisation de la seconde trame en fonction de la
 45 différence temporelle de réception et du premier point temporel, le procédé comprenant en outre :
 la détermination, par l'équipement utilisateur, d'un second point temporel de la synchronisation de la seconde trame et d'une différence temporelle entre le premier point temporel et le second point temporel, et le signalement de la différence temporelle entre le premier point temporel et le second point temporel à une station de base.

2. Procédé de synchronisation de trames, comprenant :

la détermination, par une station de base, d'une différence temporelle de réception, la différence temporelle de réception étant une différence temporelle entre un point temporel auquel un premier équipement utilisateur
 55 reçoit une seconde trame transmise sur une seconde fréquence et un point temporel auquel le premier équipement utilisateur reçoit une première trame transmise sur une première fréquence ; et
 l'envoi, par la station de base, de la différence temporelle de réception au premier équipement utilisateur, de sorte que le premier équipement utilisateur réalise la synchronisation de la seconde trame en fonction de la différence temporelle de réception et d'un point temporel auquel le premier équipement utilisateur réalise la

synchronisation de la première trame,
 la détermination, par une station de base, d'une différence temporelle de réception comprenant spécifiquement :
 la réception d'une différence temporelle, signalée (105) par un second équipement utilisateur, entre un premier
 point temporel auquel le second équipement utilisateur réalise la synchronisation de la première trame et un
 second point temporel auquel le second équipement utilisateur réalise la synchronisation de la seconde trame,
 le second équipement utilisateur et le premier équipement utilisateur appartenant à une même cellule ; la
 détermination de ladite différence temporelle comme la différence temporelle de réception.

3. Équipement utilisateur, l'équipement utilisateur prenant en charge la communication sur une première fréquence
 et la communication sur une seconde fréquence, et comprenant :

une unité de synchronisation de trame (301), configurée pour réaliser la synchronisation d'une première trame
 transmise sur une première fréquence ;
 une unité de détermination (302), configurée pour déterminer un premier point temporel auquel l'équipement
 utilisateur réalise la synchronisation de la première trame ; et
 une unité d'obtention (303), configurée pour obtenir une différence temporelle de réception, la différence tem-
 porelle de réception étant une différence temporelle entre un point temporel auquel l'équipement utilisateur
 reçoit une seconde trame et un point temporel auquel l'équipement utilisateur reçoit une première trame,
 l'unité de synchronisation de trame étant configurée pour réaliser la synchronisation de la seconde trame
 transmise sur une seconde fréquence en fonction de la différence temporelle de réception obtenue par l'unité
 d'obtention et du premier point temporel déterminé par l'unité de détermination,
 l'unité de détermination (302) étant en outre configurée pour déterminer un second point temporel auquel la
 synchronisation de la seconde trame est réalisée ;
 l'unité de détermination (302) étant en outre configurée pour déterminer une différence temporelle entre le
 premier point temporel et le second point temporel ; et
 une unité d'envoi (304) étant configurée pour signaler la différence temporelle entre le premier point temporel
 et le second point temporel à une station de base.

4. Station de base, caractérisée par :

une unité de détermination (401), configurée pour déterminer une différence temporelle de réception, la diffé-
 rence temporelle de réception étant une différence temporelle entre un point temporel auquel un premier équi-
 pement utilisateur reçoit une seconde trame transmise sur une seconde fréquence et un point temporel auquel
 le premier équipement utilisateur reçoit une première trame transmise sur une première fréquence ; et
 une unité d'envoi (402), configurée pour envoyer la différence temporelle de réception au premier équipement
 utilisateur, de sorte que le premier équipement utilisateur réalise la synchronisation de la seconde trame en
 fonction de la différence temporelle de réception et d'un point temporel auquel le premier équipement utilisateur
 réalise la synchronisation de la première trame,
 comprenant en outre une unité de réception (403),
 l'unité de réception (403) étant configurée pour recevoir une différence temporelle, signalée par un second
 équipement utilisateur, entre un premier point temporel auquel le second équipement utilisateur reçoit la première
 trame et un second point temporel auquel le second équipement utilisateur réalise la synchronisation de la
 seconde trame, le second équipement utilisateur et le premier équipement utilisateur appartenant à une même
 cellule ; et
 l'unité de détermination (401) étant configurée spécifiquement pour déterminer la différence temporelle comme
 différence temporelle de réception.

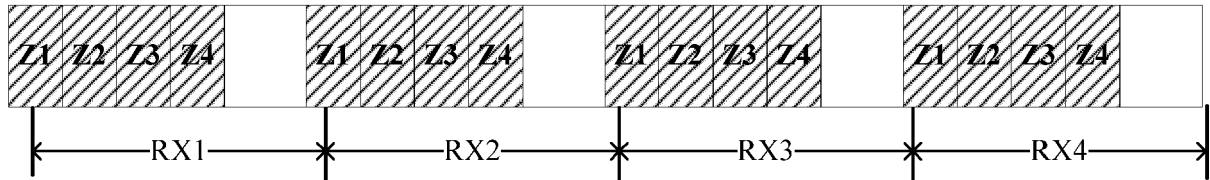


FIG. 1

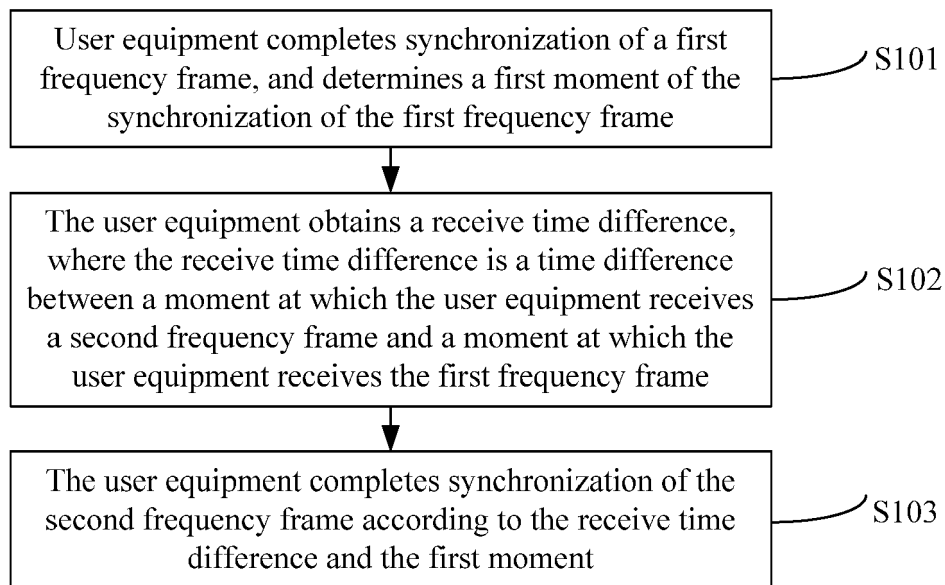


FIG. 2

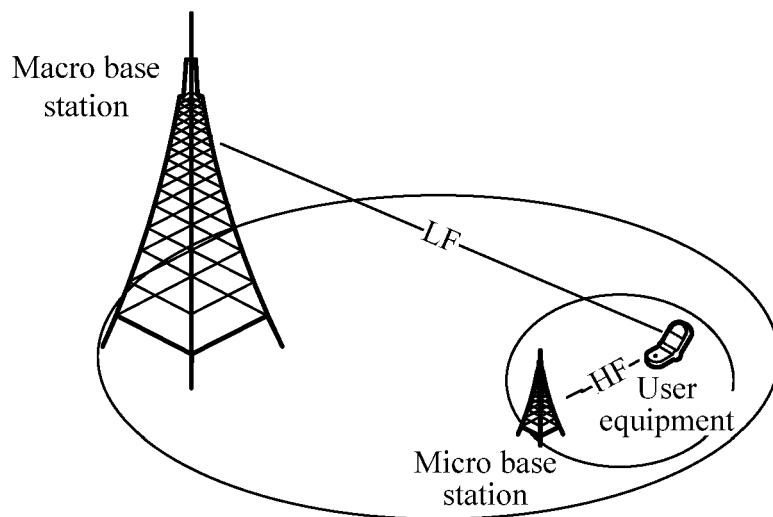


FIG. 3

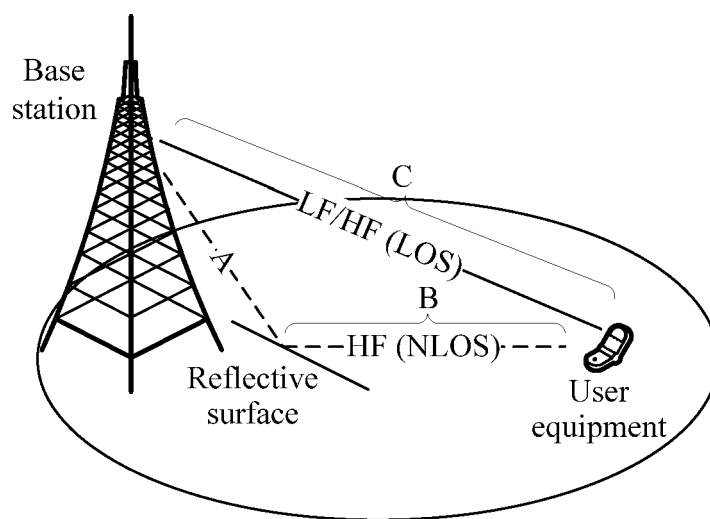


FIG. 4

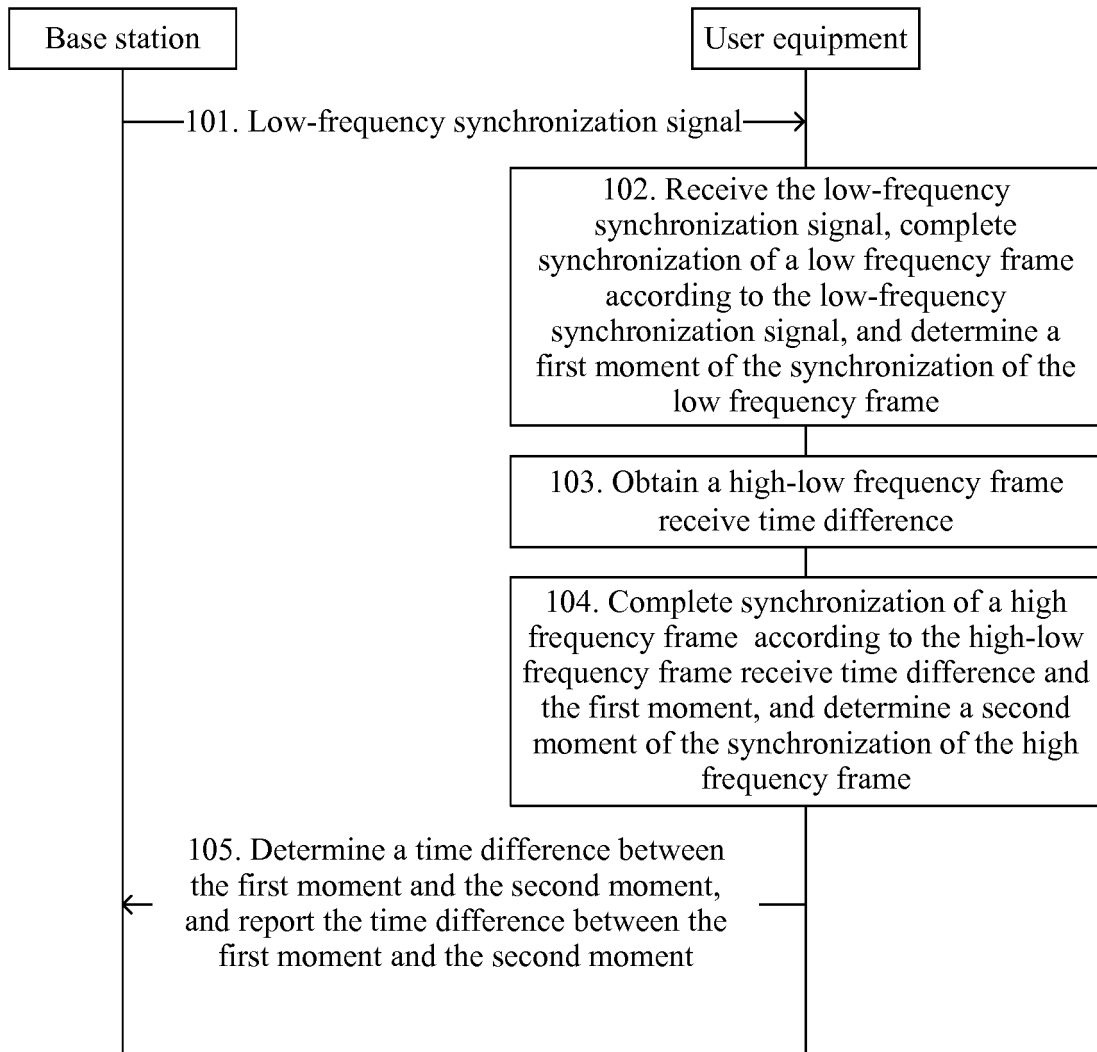


FIG. 5

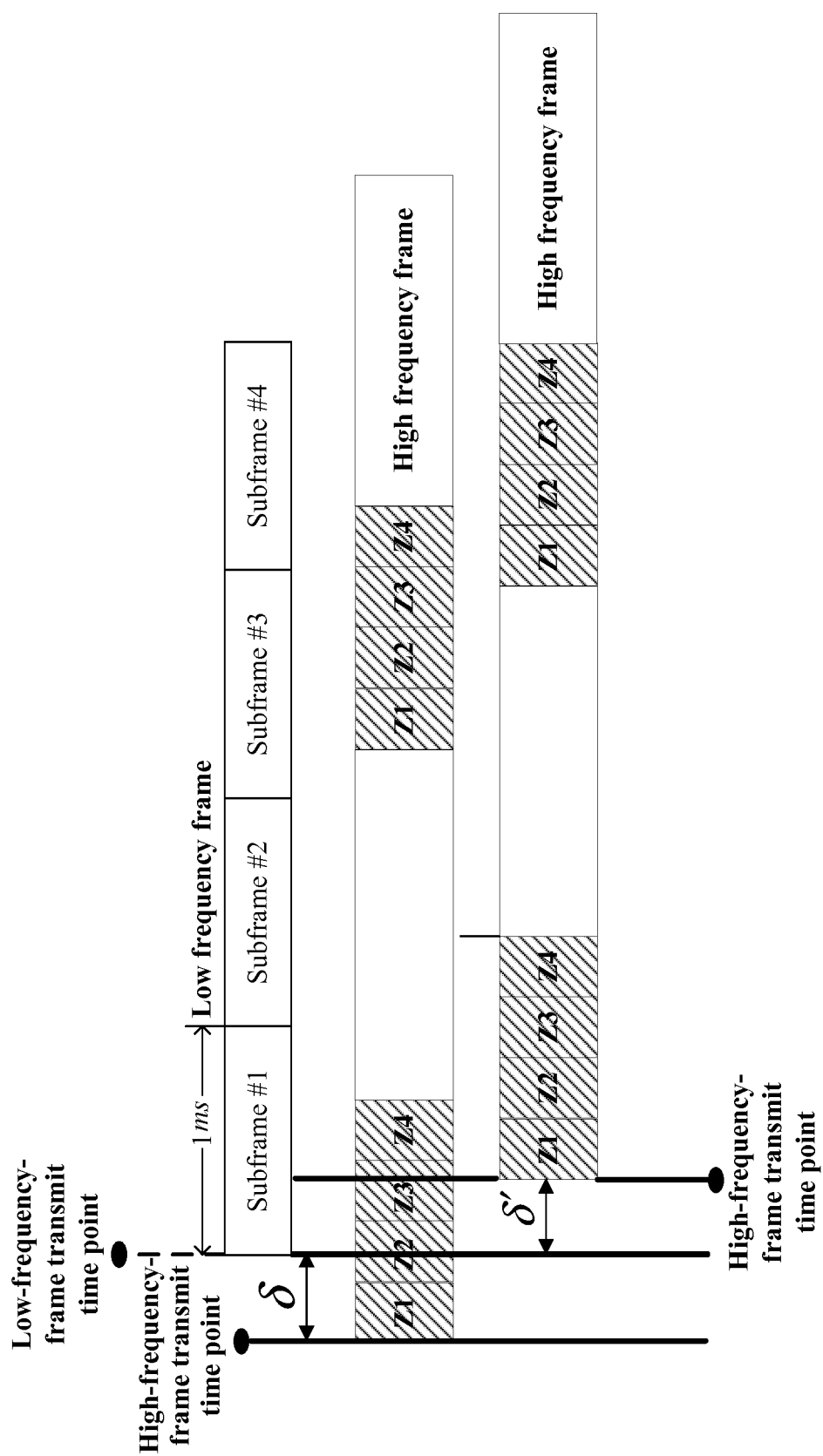


FIG. 6

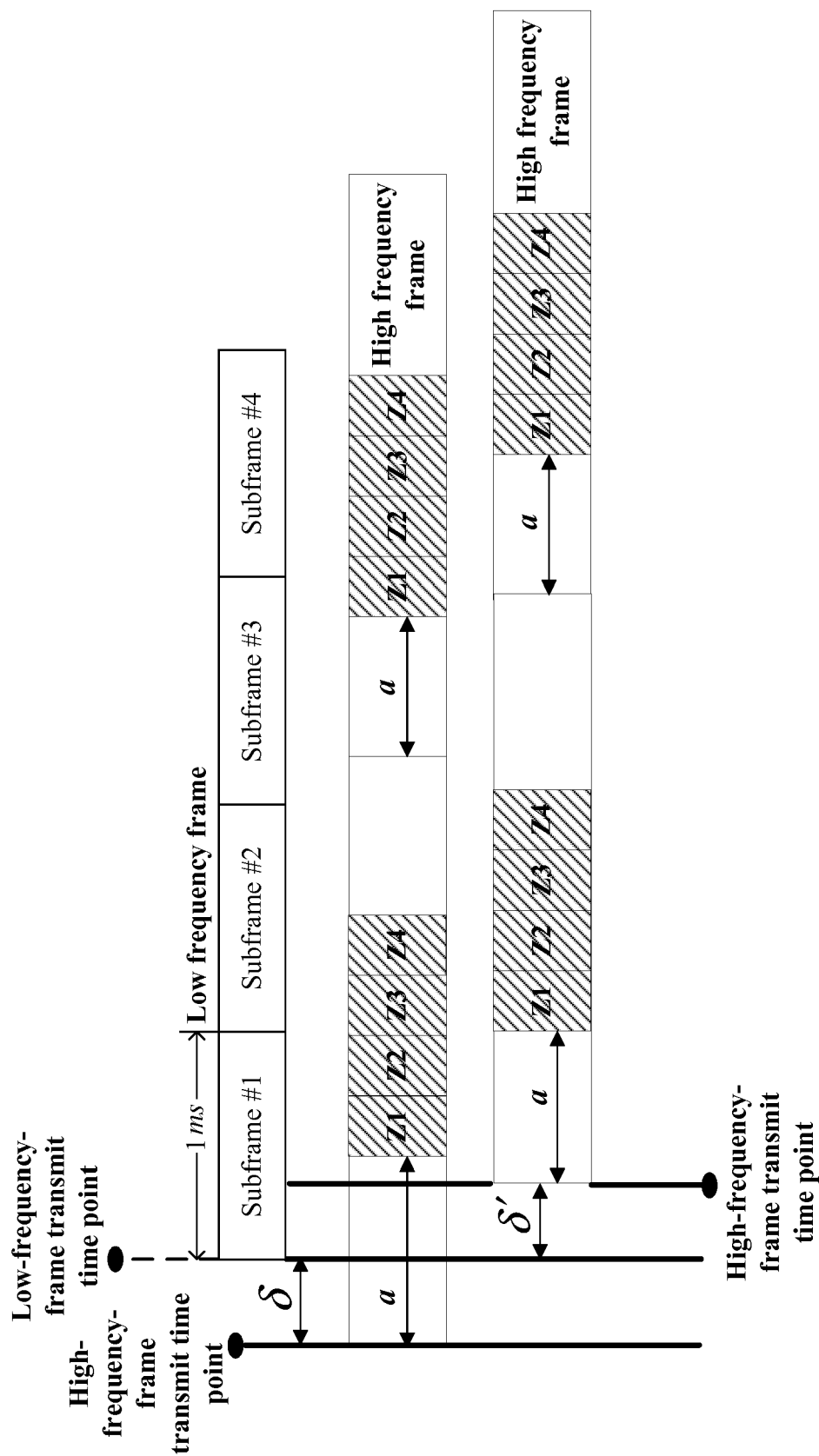


FIG. 6a

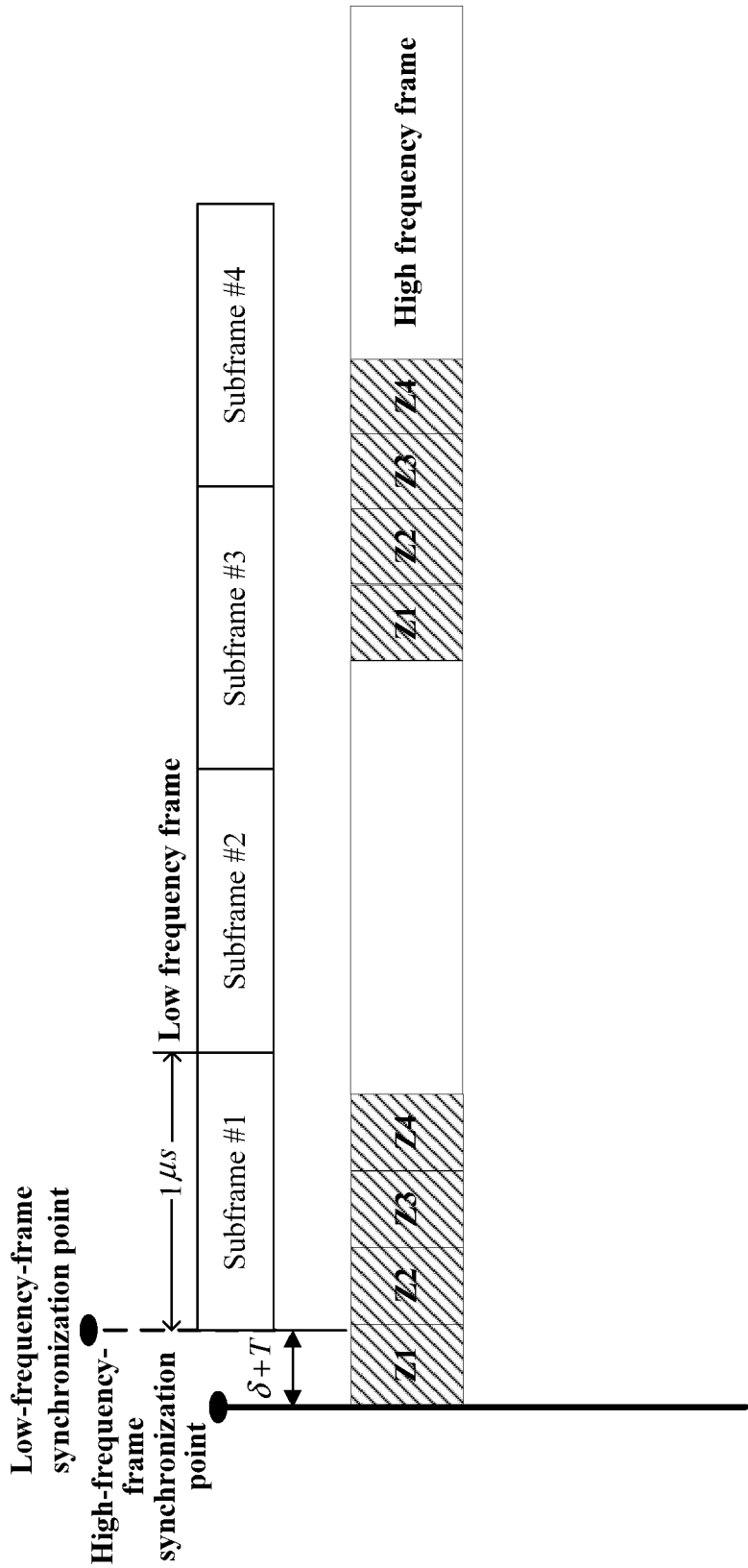


FIG. 7

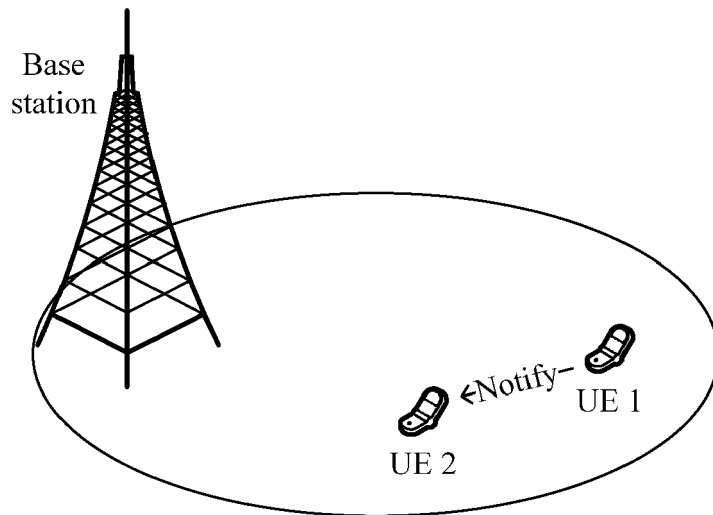


FIG. 8

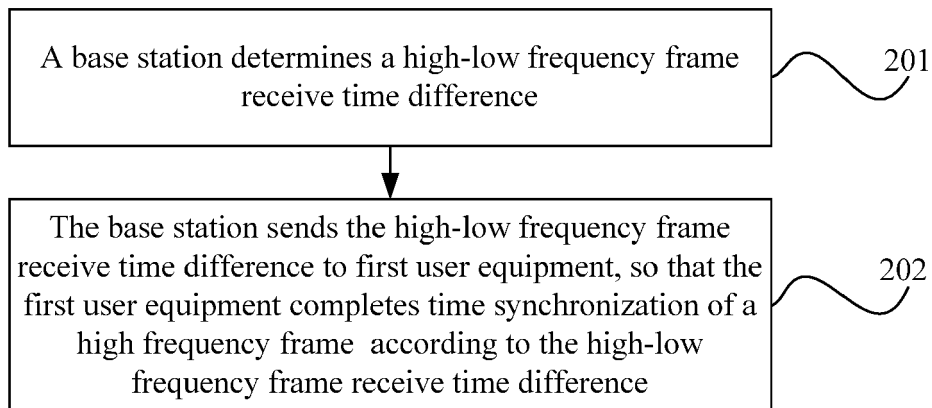


FIG. 9

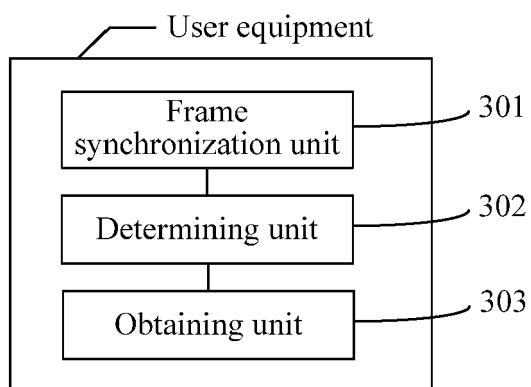


FIG. 10

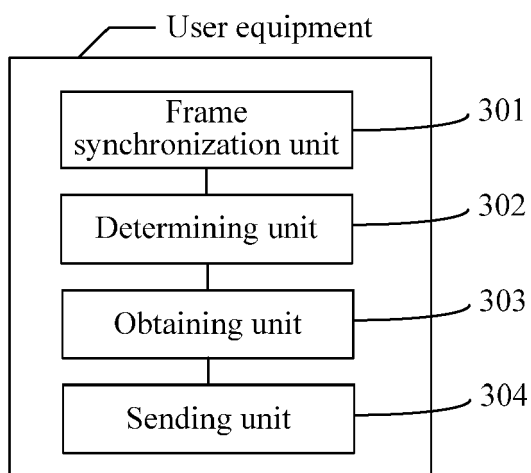


FIG. 10a

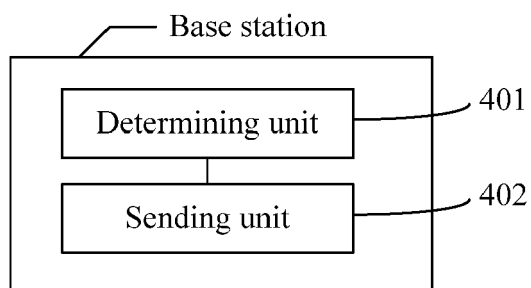


FIG. 11

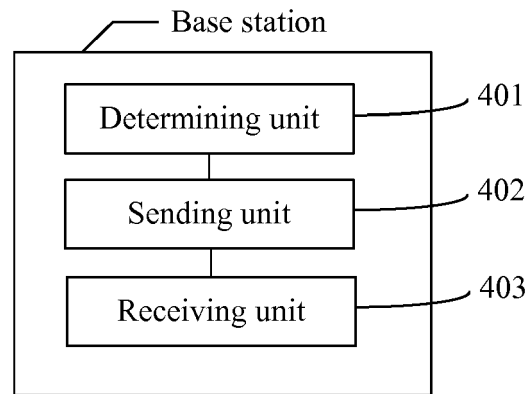


FIG. 11a

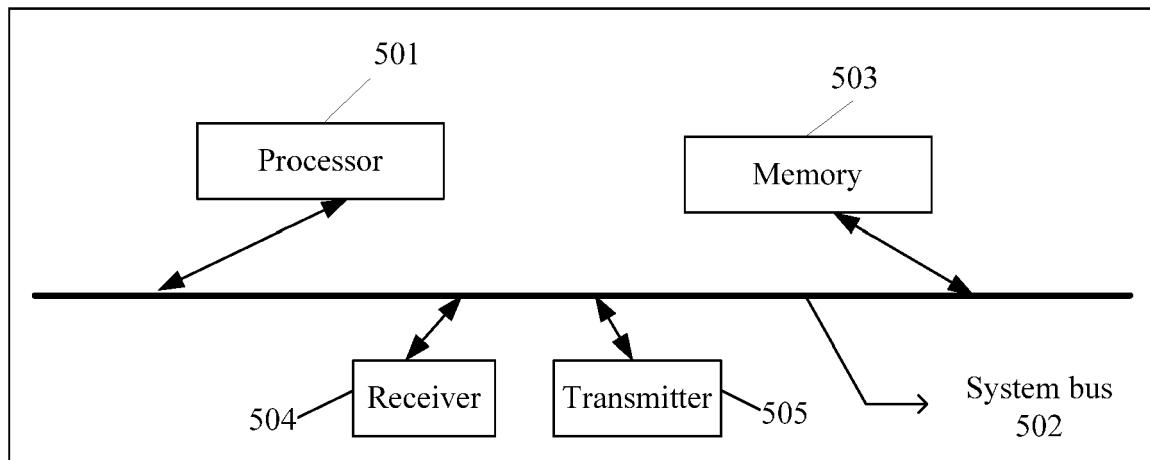


FIG. 12

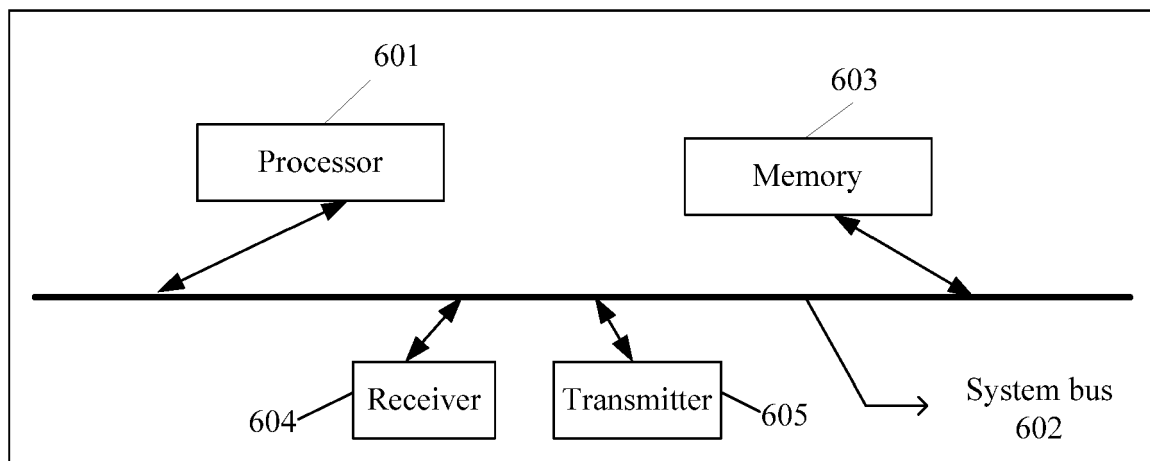


FIG. 13

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2015085550 A [0005]