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ANTENNA ASSEMBLY AND ELECTRONIC DEVICE

Abstract

Provided are an antenna assembly and an electronic device including the same. The antenna assembly includes a first radiation branch and a second radiation branch at an angle relative to each other, and a feeding excitation branch located between the first and second radiation branches. The feeding excitation branch includes a feeding point configured to receive a feeding signal. The feeding excitation branch is electrically coupled with the first radiation branch to couple the feeding signal to the first radiation branch and provide a first coupled feeding signal, and it is further magnetically coupled with the second radiation branch to couple the feeding signal to the second radiation branch and provide a second coupled feeding signal. The phase difference between the first and second coupled feeding signals is 90°, so that the first and second radiation branches have circular polarization or elliptical polarization radiation characteristics, for supporting satellite communication.

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Background/Summary

CROSS-REFERENCE OF RELATED APPLICATION [0001] This application is a continuation of International Application No. PCT/CN 2023/124180 filed Oct. 12, 2023, which claims priority to Chinese patent application No. 202211710706.8 filed Dec. 29, 2022. The entire contents of them are hereby incorporated by reference for all purposes.

TECHNICAL FIELD

[0002] The present disclosure relates to the field of communication technologies, and in particular to an antenna assembly and an electronic device having the antenna assembly.

BACKGROUND

[0003] At present, with the popularization of 5G communication technology, people's communication experience is getting better and better. In order to meet different communication needs, some electronic devices are equipped with satellite antennas which establish connections with satellites to achieve satellite communication. The structure of the existing satellite antenna is relatively complex. In addition, in order to improve the quality of satellite communication, the size of the existing satellite antenna is large, which leads to a large size of the electronic device equipped with such satellite antenna, resulting in inconvenience in carrying such electronic device.

SUMMARY

[0004] In a first aspect, an antenna assembly is provided. The antenna assembly includes a first radiation branch, a second radiation branch, and a feeding excitation branch. The first radiation branch and the second radiation branch are at an angle relative to each other. The feeding excitation branch is located between the first radiation branch and the second radiation branch. The feeding excitation branch includes a feeding point configured to receive a feeding signal. The feeding excitation branch is configured to be electrically coupled with the first radiation branch, to couple the feeding signal to the first radiation branch and provide a first coupled feeding signal fed into the first radiation branch. The feeding excitation branch is further configured to be magnetically coupled with the second radiation branch, to couple the feeding signal to the second radiation branch and provide a second coupled feeding signal fed into the second radiation branch. A phase difference between the first coupled feeding signal and the second coupled feeding signal is 90°, so that the first radiation branch and the second radiation branch have circular polarization radiation characteristics or elliptical polarization radiation characteristics, and the antenna assembly is enabled to support reception and/or transmission of a satellite communication signal.

[0005] In a second aspect, an electronic device is further provided. The electronic device includes an antenna assembly. The antenna assembly includes a first radiation branch, a second radiation branch, and a feeding excitation branch. The first radiation branch and the second radiation branch are at an angle relative to each other. The feeding excitation branch is located between the first radiation branch and the second radiation branch. The feeding excitation branch includes a feeding point configured to receive a feeding signal. The feeding excitation branch is configured to be electrically coupled with the first radiation branch, to couple the feeding signal to the first radiation branch and provide a first coupled feeding signal fed into the first radiation branch. The feeding excitation branch is further configured to be magnetically coupled with the second radiation branch, to couple the feeding signal to the second radiation branch and provide a second coupled feeding signal fed into the second radiation branch. A phase difference between the first coupled feeding signal and the second coupled feeding signal is 90°, so that the first radiation branch and the second radiation branch have circular polarization radiation characteristics or elliptical polarization radiation characteristics, and the antenna assembly is enabled to support reception and/or transmission of a satellite communication signal.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] In order to more clearly illustrate technical solutions in the embodiments of the present disclosure, the drawings required for use in the embodiments of the present disclosure will be described below.

[0007] FIG. **1** is a simple structural schematic diagram of an antenna assembly in some embodiments of the present disclosure.

[0008] FIG. **2** is another simple structural schematic diagram of the antenna assembly in some embodiments of the present disclosure.

[0009] FIG. **3** is a schematic diagram illustrating current distribution of the antenna assembly under electrical coupling and magnetic coupling in some embodiments of the present disclosure.

[0010] FIG. **4** is a further structural schematic diagram of the antenna assembly in some embodiments of the present disclosure.

[0011] FIG. **5** is yet a further structural schematic diagram of the antenna assembly in some embodiments of the present disclosure.

[0012] FIG. **6** is a schematic diagram illustrating an internal structure of a tuner in some embodiments of the present disclosure.

[0013] FIG. **7** is a structural block diagram of an electronic device in some embodiments of the present disclosure.

[0014] FIG. **8** is a schematic plan view of an electronic device in some embodiments of the present disclosure.

[0015] FIG. **9** is a partial structural schematic diagram of an electronic device including the aforementioned antenna assembly in some embodiments of the present disclosure.

[0016] FIG. **10** is a schematic diagram of a first three-dimensional axial ratio simulation of the electronic device in some embodiments of the present disclosure.

[0017] FIG. **11** is a schematic diagram of a second three-dimensional axial ratio simulation of the electronic device in some embodiments of the present disclosure.

[0018] FIG. **12** is another schematic plan view of the electronic device in some embodiments of the present disclosure.

[0019] FIG. **13** is a further structural block diagram of the electronic device in some embodiments of the present disclosure.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0020] The technical solutions in the embodiments of the present disclosure will be described clearly and comprehensively below in conjunction with the drawings in the embodiments of the present disclosure. Apparently, the described embodiments are only part of the embodiments of the present disclosure, rather than all the embodiments. All other embodiments, obtained by those of ordinary skill in the art based on the embodiments of the present disclosure without paying creative work, fall within the scope of protection of the present disclosure.

[0021] It is notable that, in the description of the embodiments of the present disclosure, the orientational or positional relationship indicated by terms such as “upper”, “lower”, “thickness”, and “width” is based on the orientational or positional relationship shown in the accompanying drawings, and is only for the convenience of describing the present disclosure and simplifying the description, rather than implying or indicating that the device or element referred to must have a specific orientation, or be constructed and operated in a specific orientation, and therefore they cannot be understood as a limitation on the present disclosure. The term “connect” in the disclosure mainly refers to a physical structural connection, unless otherwise specified; and if particularly specified, it may also include electrical connection, direct connection or indirect connection. In the description of the embodiments of the present disclosure, terms “first”, “second”, etc. are not specific but are used to distinguish objects with the same name. If particularly specified in the specification, the objects with the same name referred to by the terms “first”, “second”, etc. may be the same object.

[0022] Embodiments of the present disclosure provide an antenna assembly and an electronic device, by which the satellite communication function is enabled through a simple antenna structure without increasing the size of the electronic device. The provided antenna assembly and electronic device are described in detail below.

[0023] Referring to FIG. **1**, a simple structural schematic diagram of an antenna assembly **1** in some embodiments of the present disclosure is shown. As illustrated in FIG. **1**, the antenna assembly **1** includes a first radiation branch **11**, a second radiation branch **12** and a feeding excitation branch **13**. The first radiation branch **11** and the second radiation branch **12** are at an angle relative to each other. The feeding excitation branch **13** is located between the first radiation branch **11** and the second radiation branch **12**, and is spaced apart from each of the first radiation branch **11** and the second radiation branch **12**. The feeding excitation branch **13** includes a feeding point K **1** configured to receive a feeding signal. The feeding excitation branch **13** is electrically coupled with the first radiation branch **11**, to couple the feeding signal to the first radiation branch **11** and thus provide a first coupled feeding signal fed into the first radiation branch **11**. The feeding excitation branch **13** is further magnetically coupled with the second radiation branch **12**, to couple the feeding signal to the second radiation branch **12** and thus provide a second coupled feeding signal fed into the second radiation branch **12**. A phase difference between the first coupled feeding signal and the second coupled feeding signal is 90°, so that the first radiation branch **11** and the second radiation branch **12** have circular polarization radiation characteristics or elliptical polarization radiation characteristics, and the antenna assembly **1** is enabled to support reception and/or transmission of satellite communication signals.

[0024] That is, in the present disclosure, the feeding excitation branch **13** is electrically coupled with the first radiation branch **11** and also magnetically coupled with the second radiation branch **12**, so that the phase difference between the two coupled feeding signals obtained respectively through the electrical coupling and the magnetic coupling of the feeding signal received by the feeding excitation branch **13** is 90°. In addition, the first radiation branch **11** and the second radiation branch **12** is at an angle relative to each other. As such, the first radiation branch **11** and the second radiation branch **12** have circular polarization radiation characteristics or elliptical polarization radiation characteristics. Accordingly, the reception and/or transmission of satellite communication signals is enabled through a simple and compact structure.

[0025] In the present disclosure, the feeding excitation branch **13** serves as a feeding excitation structure, which is used to couple the received feeding signal to the first radiation branch **11** through electrical coupling and couple the received feeding signal to the second radiation branch **12** through magnetic coupling, and plays a role in transferring the feeding signal for excitation. The feeding excitation branch itself may not participate in radiation.

[0026] In some embodiments, the feeding excitation branch **13** further includes a first end D**1**, a second end D**2** and a first ground point G**1**. The first ground point G**1** is configured for grounding, and provided at the second end D**2**. The first end D**1** is an open-circuit end. The feeding point K**1** is provided at a position between the first ground point G**1** and the first end D**1**. The first radiation branch **11** includes a third end D**3**, a fourth end D**4** and a second ground point G**2**. The second ground point G**2** is configured for grounding, and provided at the fourth end D**4**. The third end D**3** is an open-circuit end. The second radiation branch **12** includes a fifth end D**5**, a sixth end D**6** and a third ground point G**3**. The third ground point G**3** is configured for grounding, and provided at the fifth end D**5**. The sixth end D**6** is an open-circuit end. The first end D**1** of the feeding excitation branch **13** is directly opposite to and spaced apart from the third end D**3** of the first radiation branch **11**. The second end D**2** of the feeding excitation branch **13** is directly opposite to and spaced apart from the fifth end D**5** of the second radiation branch **12**, or the second end D**2** of the feeding excitation branch **13** is connected to the fifth end D**5** of the second radiation branch **12** and the first ground point G**1** coincides with the third ground point G**3**.

[0027] In this case, the first end D**1** of the feeding excitation branch **13** is an open-circuit end, and the second end D**2** of the feeding excitation branch **13** is a grounding end grounded through the first ground point G**1**. The third end D**3** of the first radiation branch **11** is also an open-circuit end, and the fourth end D**4** of the first radiation branch **11** is a grounding end grounded through the second ground point G**2**. The fifth end D**5** of the second radiation branch **12** is a grounding end grounded through the third ground point G**3**, and the sixth end D**6** of the second radiation branch **12** is also an open-circuit end. The electric field at the first end D**1** of the feeding excitation branch **13** serving as the open-circuit end is the largest, and since the first end D**1** of the feeding excitation branch **13** serving as an open-circuit end is directly opposite to and spaced apart from the third end D**3** of the first radiation branch **11** serving as an open-circuit end, the strongest electric field coupling can be thereby generated, and the electrical coupling between the feeding excitation branch **13** and the first radiation branch **11** is provided. In addition, the current at the second end D**2** of the feeding excitation branch **13** serving as the grounding end is the largest, and the magnetic field intensity is proportional to the current. Therefore, the magnetic field intensity at the second end D**2** of the feeding excitation branch **13** serving as the grounding end is the largest. And since the second end D**2** of the feeding excitation branch **13** serving as the grounding end is directly opposite to and spaced apart from the fifth end D**5** of the second radiation branch **12** serving as the grounding end, or the second end D**2** of the feeding excitation branch **13** is connected to the fifth end D**5** of the second radiation branch **12** and the first ground point G**1** coincides with the third ground point G**3**, the strongest magnetic field coupling can be thereby generated, and the magnetic coupling between the feeding excitation branch **13** and the second radiation branch **12** is provided.

[0028] In the present disclosure, the electrical coupling refers to electric field coupling, and the magnetic coupling refers to magnetic field coupling. Due to the characteristics of electromagnetic wave signals, the electric field and the magnetic field are perpendicular to each other, so that the phase difference between the two coupled feeding signals obtained respectively through the electrical coupling and the magnetic coupling of the feeding signal received by the feeding excitation branch **13** is 90°.

[0029] As illustrated in FIG. **1**, the second end D**2** of the feeding excitation branch **13** serving as the grounding end is directly opposite to and spaced apart from the fifth end D**5** of the second radiation branch **12** serving as the grounding end.

[0030] Referring to FIG. **2**, another simple structural schematic diagram of the antenna assembly **1** in some embodiments of the present disclosure is shown. As illustrated in FIG. **2**, different from those shown in FIG. **1**, the second end D**2** of the feeding excitation branch **13** serving as the grounding end is directly connected to the fifth end D**5** of the second radiation branch **12** serving as the grounding end, and the first ground point G**1** coincides with the third ground point G**3**.

[0031] In the case illustrated in FIG. **2**, since the sixth end D**6** of the second radiation branch **12** is an open-circuit end, and the current at the second end D**2** of the feeding excitation branch **13** serving as the grounding end and the fifth end D**5** of the second radiation branch **12** serving as the grounding end is the largest, the magnetic coupling between the feeding excitation branch **13** and the second radiation branch **12** is also provided, and the second coupled feeding signal is generated in the second radiation branch **12** through excitation, thereby feeding the second coupled feeding signal into the second radiation branch **12**.

[0032] Therefore, in some embodiments, the second end D**2** of the feeding excitation branch **13** serving as the grounding end may be directly connected to the fifth end D**5** of the second radiation branch **12** serving as the grounding end, which can also achieve the magnetic coupling while reducing gaps, and the stability of the overall structure of the antenna assembly **1** is improved.

[0033] The second ground point G**2** being provided at the fourth end D**4** does not necessarily mean that the second ground point G**2** needs to be exactly provided at the fourth end D**4**, but may also include a situation where the second ground point G**2** is provided at a position close to the fourth end D**4**. In the case where the second end D**2** of the feeding excitation branch **13** serving as the grounding end is directly opposite to and spaced apart from the fifth end D**5** of the second radiation branch **12** serving as the grounding end, the first ground point G **1** provided at the second end D**2** does not need to be exactly provided at the second end D**2**, and it may also include a situation where the first ground point G**1** is provided at a position close to the second end D**2**; and the third ground point G**3** provided at the fifth end D**5** does not need to be exactly provided at the fifth end D**5**, and it may also include a situation where the third ground point G**3** is provided at a position close to the fifth end D**5**.

[0034] In some embodiments, the first radiation branch **11** and the second radiation branch **12** being at an angle relative to each other means that there is an angle between the first radiation branch **11** and the second radiation branch **12** greater than 0° and less than 180°.

[0035] In some embodiments, when the angle between the first radiation branch **11** and the second radiation branch **12** is 90°, the vertical polarization requirement of a circular polarization antenna is met. In this case, the first radiation branch **11** and the second radiation branch **12** can have relatively exact circular polarization radiation characteristics.

[0036] In some embodiments, when the first radiation branch **11** and the second radiation branch **12** are at an angle other than 90°, the first radiation branch **11** and the second radiation branch **12** are not completely vertically polarized, but have elliptical polarization radiation characteristics. In this case, the antenna radiation performance would be lower than the antenna radiation performance under the circular polarization radiation characteristics, but it can still meet the requirements for satellite communication.

[0037] In some embodiments, in order to obtain better circular polarization or elliptical polarization radiation performance of the first radiation branch **11** and the second radiation branch **12**, the angle between the first radiation branch **11** and the second radiation branch **12** may be greater than 10° and less than 170°.

[0038] In some embodiments, as illustrated in FIG. **1**, the angle between the first radiation branch **11** and the second radiation branch **12** is 90°, so that the first radiation branch **11** and the second radiation branch **12** are orthogonal to each other. And when the phase difference between the two coupled feeding signals respectively fed into the first radiation branch **11** and the second radiation branch **12** is 90°, vertical orthogonal polarization in a strict sense can be achieved. As mentioned above, the exact circular polarization radiation performance can be achieved, and the maximum radiation performance for satellite communication is enabled.

[0039] Evidently, when the angle between the first radiation branch **11** and the second radiation branch **12** is not 90°, that is, when the angle is other values greater than 0° and less than 180°, the circular polarization radiation performance would be decreased, and elliptical polarization radiation characteristics would be provided, but it can still meet the requirements for satellite communication and support the satellite communication.

[0040] Also referring to FIG. **3**, a schematic diagram illustrating current distribution of the antenna assembly **1** under the electrical coupling and magnetic coupling in an embodiment of the present disclosure is shown. FIG. **3** is a schematic diagram illustrating the simulated current distribution obtained when the angle between the first radiation branch **11** and the second radiation branch **12** is

90°, for example, it may be a schematic diagram illustrating the simulated current distribution obtained based on the structure shown in FIG. **1**.

[0041] As mentioned above, the first end D**1** of the feeding excitation branch **13** serving as the open-circuit end is directly opposite to and spaced apart from the third end D**3** of the first radiation branch **11** serving as the open-circuit end, and the strongest electric field coupling is thereby generated. As illustrated in FIG. **3**, under the effect of the electric field coupling, a current i**1** is generated in the first radiation branch **11** and flows along the length direction of the first radiation branch **11**. Since the feeding signal itself is a high-frequency current signal, the current i**1** is generated in the first radiation branch **11** may be actually regarded as the first coupled feeding signal fed into the first radiation branch **11**.

[0042] As mentioned above, when the second end D**2** of the feeding excitation branch **13** serving as the grounding end is directly opposite to and spaced apart from the fifth end D**5** of the second radiation branch **12** serving as the grounding end, or when the second end D**2** of the feeding excitation branch **13** is connected to the fifth end D**5** of the second radiation branch **12** and the first ground point G**1** coincides with the third ground point G**3**, the strongest magnetic field coupling can be thereby generated. As illustrated in FIG. **3**, under the effect of the magnetic field coupling, a current i**2** is generated in the second radiation branch **12** and flows along the length direction of the second radiation branch **12**. Since the feeding signal itself is a high-frequency current signal, the current i**2** generated in the second radiation branch **12** may be actually regarded as the second coupled feeding signal fed into the second radiation branch **12**.

[0043] As can be seen from FIG. **3**, the direction of the current i**1** in the first radiation branch **11** is perpendicular to the direction of the current i**2** in the second radiation branch **12**. As mentioned above, when the phase difference between the two coupled feeding signals, i.e., the currents, fed through the electrical coupling and magnetic coupling respectively into the first radiation branch **11** and the second radiation branch **12** is 90°, vertical orthogonal polarization can be achieved, and the circular polarization radiation characteristics in a strict sense can be achieved, thereby obtaining the optimum radiation performance.

[0044] In some embodiments, the feeding signal received at the feeding point K**1** may be a feeding signal provided by a feed source or a received satellite communication signal. Specifically, when the antenna assembly **1** is used to transmit a satellite communication signal, the feeding signal received at the feeding point K**1** may be a feeding signal provided by a feed source; and when the antenna assembly **1** is used to receive a satellite communication signal, the feeding signal fed into the feeding point K **1** may be a received satellite communication signal.

[0045] Also referring to FIG. **4**, a further structural schematic diagram of the antenna assembly **1** in some embodiments of the present disclosure is shown. As illustrated in FIG. **4**, the antenna assembly **1** further includes a feed source S**1** configured to generate the feeding signal. The feeding signal generated by the feed source S**1** is coupled to the first radiation branch **11** through the feeding excitation branch **13**, to provide the first coupled feeding signal fed into the first radiation branch **11**. The feeding signal generated by the feed source S**1** is also coupled to the second radiation branch **12** through the feeding excitation branch **13**, to provide the second coupled feeding signal fed into the second radiation branch **12**. The phase difference between the first coupled feeding signal and the second coupled feeding signal is 90°, so that a satellite communication signal can be transmitted by the first radiation branch **11** under excitation of the first coupled feeding signal and the second radiation branch **12** under excitation of the second coupled feeding signal.

[0046] That is, in some embodiments, the antenna assembly **1** supports the transmission of a satellite communication signal(s). After the feeding signal is received from the feed source S**1**, the feeding signal is coupled to the first radiation branch **11** through the feeding excitation branch **13** to provide the first coupled feeding signal fed into the first radiation branch **11**, and the feeding signal generated by the feed source S**1** is also coupled to the second radiation branch **12** through the feeding excitation branch **13** to provide the second coupled feeding signal fed into the second radiation branch **12**, with the phase difference between the first coupled feeding signal and the second coupled feeding signal being 90°. As such, the first radiation branch **11** and the second radiation branch **12** can transmit the satellite communication signal(s), under excitation of the first coupled feeding signal and the second coupled feeding signal respectively.

[0047] In some embodiments, the electrical length of each of the first radiation branch **11** and the second radiation branch **12** is λ.sub.1/4, where λ.sub.1 is a wavelength corresponding to a transmit frequency of the satellite communication signal. λ.sub.1/4 refers to one quarter of λ.sub.1.

[0048] When the electrical length of each of the first radiation branch **11** and the second radiation branch **12** is λ.sub.1/4, the first radiation branch **11** and the second radiation branch **12** each resonate at the transmit frequency of the satellite communication signal, to achieve better or optimal radiation performance.

[0049] In some embodiments, the electrical length of the feeding excitation branch **13** is also λ.sub.1/4. In a case where the electrical length of the feeding excitation branch **13** is λ.sub.1/4, when the feeding excitation branch **13** receives the feeding signal provided by the feed source S**1**, the intensity of electric field coupling between the first end D**1** serving as the open-circuit end and the third end D**3** of the first radiation branch **11** serving as the open-circuit end, which are directly opposite to and spaced apart from each other, can reach its achievable maximum value, and the intensity of magnetic field coupling generated by the second end D**2** of the feeding excitation branch **13** serving as the grounding end can also reach its achievable maximum value. For the feeding excitation branch **13** of any electrical length, the intensity of electric field coupling is the strongest at the first end D**1** serving as the open-circuit end, and the intensity of magnetic field coupling is the strongest at the second end D**2** serving as a short-circuit end. However, when the electrical length of the feeding excitation branch **13** is λ.sub.1/4, λ.sub.1 is the wavelength corresponding to the transmit frequency of the satellite communication signal, at the time of transmitting the satellite communication signal, the intensity of electric field coupling at the first end D**1** serving as the open-circuit end would be stronger than the intensity of electric field coupling at this end of the feeding excitation branch **13** with other electrical lengths, and the intensity of magnetic field coupling at the second end D**2** serving as the short-circuit end would also be stronger than the intensity of magnetic field coupling at this end of the feeding excitation branch **13** with other electrical lengths; thus, the intensity of electric field coupling and the intensity of magnetic field coupling can all reach the achievable maximum values.

[0050] That is, in some embodiments, the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11**, and the second radiation branch **12** are mainly designed based on the transmission of the satellite communication signal(s).

[0051] In some embodiments, the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** are all strip-shaped, and the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** may be approximately equal to the lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** respectively. The first end D**1** and the second end D**2** of the feeding excitation branch **13** are respectively two ends of the feeding excitation branch **13** in the extension direction thereof, and the length of the feeding excitation branch **13** is approximately a length from the first end D**1** to the second end D**2** along the extension direction of the feeding excitation branch **13**. The third end D**3** and the fourth end D**4** of the first radiation branch **11** are respectively two ends of the first radiation branch **11** in the extension direction thereof, and the length of the first radiation branch **11** is approximately a length from the third end D**3** to the fourth end D**4** along the extension direction of the first radiation branch **11**. Similarly, the fifth end D**5** and the sixth end D**6** of the second radiation branch **12** are respectively two ends of the second radiation branch **12** in the extension direction thereof, and the length of the second radiation branch **12** is approximately a length from the fifth end D**5** to the sixth end D**6** along the extension direction of the second radiation branch **12**.

[0052] The extension direction of each of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** refers to an extension direction of a long side of each of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12**.

[0053] As illustrated in FIG. **1** to FIG. **4**, the feeding excitation branch **13** is an arc-shaped strip, and the first radiation branch **11** and the second radiation branch **12** may be a straight strip.

[0054] Also referring to FIG. **5**, a further structural schematic diagram of the antenna assembly **1** in some embodiments of the present disclosure is shown. The antenna assembly **1** further includes a first tuner **14**, a second tuner **15** and a third tuner **16**. The first tuner **14** is connected between the first ground point G**1** and the ground, the second tuner **15** is connected between the second ground point G**2** and the ground, and the third tuner **16** is connected between the third ground point G**3** and the ground. That is, in some embodiments, the first ground point G**1** is grounded through the first tuner **14**, the second ground point G**2** is grounded through the second tuner **15**, and the third ground point G**3** is grounded through the third tuner **16**. The first tuner **14**, the second tuner **15** and the third tuner **16** are enabled at the time of receiving a satellite communication signal, so as to adjust the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** to λ.sub.2/4 for reception of the satellite communication signal, where λ.sub.2 is a wavelength corresponding to the receive frequency of the satellite communication signal. λ.sub.2/4 refers to one quarter of λ.sub.2.

[0055] That is, in some embodiments, in certain satellite communication systems, the receive frequency and the transmit frequency of the satellite communication signal are different. By configuring the first tuner **14**, the second tuner **15** and the third tuner **16** to adjust the electrical lengths, the antenna assembly **1** is further enabled to receive the satellite communication signal.

[0056] Therefore, in some embodiments, the antenna assembly **1** can not only receive a satellite communication signal(s), but also transmit a satellite communication signal(s). That is, the antenna assembly **1** can support both the transmission and the reception of the satellite communication signals in a time-sharing manner.

[0057] Evidently, in some embodiments, when the receive frequency and the transmit frequency of the satellite communication signal are the same, the first tuner **14**, the second tuner **15** and the third tuner **16** may be omitted, and the first ground point G**1**, the second ground point G**2** and the third ground point G**3** are directly grounded.

[0058] Referring to FIG. **6**, a schematic diagram illustrating the internal structure of the tuner in some embodiments of the present disclosure is shown. Each of the first tuner **14**, the second tuner **15** and the third tuner **16** includes a tuning element X**1** and a tuning switch W**1** connected in parallel between a corresponding ground point and the ground. At the time of receiving a satellite communication signal(s), the tuning switch W**1** of each of the first tuner **14**, the second tuner **15** and the third tuner **16** is turned off, which enables its corresponding tuning element X**1**, that is, the branch where the corresponding tuning element X**1** is located would not be short-circuited by the tuning switch W**1** and may be connected between the corresponding ground point and the ground. This enables the first tuner **14**, the second tuner **15** and the third tuner **16** at the time of receiving the satellite communication signal(s).

[0059] That is, in some embodiments, the enabling of the first tuner **14**, the second tuner **15**, and the third tuner **16** means that the tuning elements in the first tuner **14**, the second tuner **15**, and the third tuner **16** are enabled.

[0060] In some embodiments, each tuning switch W**1** is turned on at the time of transmitting a satellite communication signal(s), and the branch where the corresponding tuning element X**1** is located is accordingly short-circuited, so that the branch where the corresponding tuning element X**1** is located is disabled. As such, the first ground point G**1**, the second ground point G**2** and the third ground point G**3** are directly grounded through the turned-on tuning switches W**1**. Thus, the first tuner **14**, the second tuner **15** and the third tuner **16** are disabled at the time of transmitting the satellite communication signal(s).

[0061] In FIG. **6**, it is illustrated by taking the first tuner **14** as an example. As illustrated in FIG. **6**, the first tuner **14** includes a tuning element X**1** and a tuning switch W**1** connected in parallel between the first ground point G**1** and the ground. Apparently, the second tuner **15** similarly includes a tuning element X**1** and a tuning switch W**1** connected in parallel between the second ground point G**2** and the ground, and the third tuner **16** also includes a tuning element X**1** and a tuning switch W**1** connected in parallel between the third ground point G**3** and the ground.

[0062] Each tuning element X**1** may include a capacitor and/or an inductor, and when both a capacitor and an inductor are included, the capacitor and the inductor may be connected in parallel or in series. The capacitor and/or inductor of the tuning element X**1** included in the first tuner **14** may be equivalent to an electrical length, and the sum of the equivalent electrical length of the tuning element X**1** included in the first tuner **14** and the original electrical length of the feeding excitation branch **13** is λ.sub.2/4. Similarly, the capacitor and/or inductor of the tuning element X**1** included in the second tuner **15** may be equivalent to an electrical length, and the sum of the equivalent electrical length of the tuning element X**1** included in the second tuner **15** and the original electrical length of the first radiation branch **11** is λ.sub.2/4. The capacitor and/or inductor of the tuning element X**1** included in the third tuner **16** may be equivalent to an electrical length, and the sum of the equivalent electrical length of the tuning element X**1** included in the third tuner **16** and the original electrical length of the second radiation branch **12** is λ.sub.2/4.

[0063] Thus, the inductance and/or capacitance of the tuning element X**1** included in the first tuner **14** may be preset in such a manner that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the feeding excitation branch **13** is λ.sub.2/4. The inductance and/or capacitance of the tuning element X**1** included in the second tuner **15** may be preset in such a manner that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the first radiation branch **11** is λ.sub.2/4. The inductance and/or capacitance of the tuning element X**1** included in the third tuner **16** may be preset in such a manner that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the second radiation branch **12** is λ.sub.2/4.

[0064] In the case where the electrical length of the feeding excitation branch **13** is adjusted to λ.sub.2/4, when the feeding excitation branch **13** receives a satellite communication signal, the intensity of electric field coupling between the first end D**1** serving as the open-circuit end and the third end D**3** of the first radiation branch **11** serving as the open-circuit end, which are directly opposite to and spaced apart from each other, reaches its achievable maximum value, and the intensity of magnetic field coupling generated by the second end D**2** of the feeding excitation branch **13** serving as the grounding end can also reach its achievable maximum value.

[0065] When the electrical lengths of the first radiation branch **11** and the second radiation branch **12** are adjusted to λ.sub.2/4, the first radiation branch **11** and the second radiation branch **12** resonate at the receive frequency of the satellite communication signal, to achieve better or optimal radiation performance.

[0066] The first tuner **14** after being enabled is connected to the feeding excitation branch **13**, and it may be regarded as a part of the feeding excitation branch **13**. The adjusting the electrical length of the feeding excitation branch **13** to λ.sub.2/4 means that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the feeding excitation branch **13** is adjusted to λ.sub.2/4; the adjusting the electrical length of the first radiation branch **11** to λ.sub.2/4 means that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the first radiation branch **11** is adjusted to λ.sub.2/4; and the adjusting the electrical length of the second radiation branch **12** to λ.sub.2/4 means that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the second radiation branch **12** is adjusted to λ.sub.2/4.

[0067] In some other embodiments, in the structure shown in FIG. **1**, the feeding signal received at the feeding point K**1** is a received satellite communication signal, the feeding signal is coupled to the first radiation branch to provide the first coupled feeding signal fed into the first radiation branch, and the feeding signal is also coupled to the second radiation branch to provide the second coupled feeding signal fed into the second radiation branch, with the phase difference between the first coupled feeding signal and the second coupled feeding signal being 90°. As such, the first radiation branch **11** and the second radiation branch **12** can receive the satellite communication signal, under excitation of the first coupled feeding signal and the second coupled feeding signal respectively.
[0068] That is, in the some other embodiments, the structure shown in FIG. **1** may also be a structure supporting the reception of satellite communication signals.
[0069] In the some other embodiments, the electrical length of each of the first radiation branch **11** and the second radiation branch **12** is λ.sub.2/4, where λ.sub.2 is the wavelength corresponding to the receive frequency of the satellite communication signal. In some other embodiments, the electrical length of the feeding excitation branch **13** is also λ.sub.2/4.
[0070] That is, in the some other embodiments, the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** are mainly designed based on the reception of the satellite communication signals. For relevant description, reference may be made to the aforementioned related contents that the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** are mainly designed based on the transmission of the satellite communication signals.
[0071] In the some other embodiments, in the structure shown in FIG. **5**, the antenna assembly **1** further includes a first tuner **14**, a second tuner **15** and a third tuner **16**. The first tuner **14** is connected between the first ground point G**1** and the ground, the second tuner **15** is connected between the second ground point G**2** and the ground, and the third tuner **16** is connected between the third ground point G**3** and the ground. That is, in some embodiments, the first ground point G**1** is grounded through the first tuner **14**, the second ground point G**2** is grounded through the second tuner **15**, and the third ground point G**3** is grounded through the third tuner **16**. The first tuner **14**, the second tuner **15** and the third tuner **16** are enabled at the time of transmitting a satellite communication signal, so that the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** are adjusted to λ.sub.2/4 to transmit the satellite communication signal, where A**1** is the wavelength corresponding to the transmit frequency of the satellite communication signal.
[0072] That is, in the some other embodiments, the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** are mainly designed based on the reception of the satellite communication signals. By configuring the first tuner **14**, the second tuner **15** and the third tuner **16** to be enabled at the time of transmitting a satellite communication signal, the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** may be adjusted to λ.sub.2/4 at the time of transmitting the satellite communication signal, so as to realize the transmission of the satellite communication signal.
[0073] Similarly, as illustrated in the aforementioned FIG. **6**, each of the first tuner **14**, the second tuner **15** and the third tuner **16** includes a tuning element X**1** and a tuning switch W**1** connected in parallel between a corresponding ground point and the ground. At the time of transmitting a satellite communication signal(s), the tuning switch W**1** of each of the first tuner **14**, the second tuner **15** and the third tuner **16** is turned off, which enables its corresponding tuning element X**1**, that is, the branch where the corresponding tuning element X**1** is located would not be short-circuited by the tuning switch W**1** and may be connected between the corresponding ground point and the ground. This enables the first tuner **14**, the second tuner **15** and the third tuner **16** at the time of transmitting the satellite communication signal(s).

[0074] In the some other embodiments, each tuning switch W**1** is turned on at the time of receiving a satellite communication signal(s), and the branch where the corresponding tuning element X**1** is located is short-circuited, so that the branch where the corresponding tuning element X**1** is located is disabled. As such, the first ground point G**1**, the second ground point G**2** and the third ground point G**3** are directly grounded through the turned-on tuning switches W**1**. Thus, the first tuner **14**, the second tuner **15** and the third tuner **16** are disabled at the time of receiving the satellite communication signal(s).
[0075] Each tuning element X**1** may include a capacitor and/or an inductor, and when both a capacitor and an inductor are included, the capacitor and the inductor may be connected in parallel or in series. The capacitor and/or inductor of the tuning element X**1** included in the first tuner **14** may be equivalent to an electrical length, and the sum of the equivalent electrical length of the tuning element X**1** included in the first tuner **14** and the original electrical length of the feeding excitation branch **13** is λ.sub.2/4. Similarly, the capacitor and/or inductor of the tuning element X**1** included in the second tuner **15** may be equivalent to an electrical length, and the sum of the equivalent electrical length of the tuning element X**1** included in the second tuner **15** and the original electrical length of the first radiation branch **11** is λ.sub.2/4. The capacitor and/or inductor of the tuning element X**1** included in the third tuner **16** may be equivalent to an electrical length, and the sum of the equivalent electrical length of the tuning element X**1** included in the third tuner **16** and the original electrical length of the second radiation branch **12** is λ.sub.2/4.
[0076] Thus, in the some other embodiments, the inductance and/or capacitance of the tuning element X**1** included in the first tuner **14** may be preset in such a manner that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the feeding excitation branch **13** is λ.sub.2/4. The inductance and/or capacitance of the tuning element X**1** included in the second tuner **15** may be preset in such a manner that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the first radiation branch **11** is λ.sub.2/4. The inductance and/or capacitance of the tuning element X**1** included in the third tuner **16** may be preset in such a manner that the sum of the equivalent electrical length of the tuning element X**1** and the original electrical length of the second radiation branch **12** is λ.sub.2/4. Thus, in the some other embodiments, the first tuner **14**, the second tuner **15** and the third tuner **16** are enabled at the time of transmitting a satellite communication signal(s), so that the antenna assembly **1** can resonate at the transmit frequency of the satellite communication signal(s).
[0077] Thus, in the some other embodiments, when the first tuner **14**, the second tuner **15** and the third tuner **16** are not enabled, i.e., disabled, the antenna assembly **1** can support the reception of satellite communication signals; and when there is a need to transmit a satellite communication signal, the first tuner **14**, the second tuner **15** and the third tuner **16** may be enabled, so that the antenna assembly **1** can support the transmission of the satellite communication signal. Thus, similarly, through the time-sharing manner, both the transmission of satellite communication signals and the reception of satellite communication signals are supported.
[0078] As mentioned above, at the time of transmitting the satellite communication signal(s), the feeding signal is provided by the feed source S**1**.
[0079] Referring to FIG. **7**, a structural block diagram of an electronic device **100** in some embodiments of the present disclosure is shown. As illustrated in FIG. **7**, the electronic device **100** may include the antenna assembly **1** in any of the aforementioned embodiments.
[0080] Thus, the electronic device **100** can transmit and/or receive satellite communication signals by being equipped with the antenna assembly **1** having a simple and compact structure as described above, so that the electronic device **100** has a small overall volume of small and is easy to carry.
[0081] Referring to FIG. **8**, a schematic plan view of the electronic device **100** in some embodiments of the present disclosure is shown. As illustrated in FIG. **8**, the electronic device **100** further includes a frame **10**. The first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** are metal segments provided on the frame **10** of the electronic device

100.

[0082] As illustrated in FIG. **8**, in some embodiments, the frame **10** of the electronic device **100** is a metal frame, and the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** are metal frame segments **101** formed by providing gaps F**1** in the metal frame of the electronic device **100**. The first radiation branch **11** is formed by a part of the metal frame on a first side B**1** of the electronic device **100**, and the second radiation branch **12** is formed by a part of the metal frame on a second side B**2** of the electronic device **100**, the first side B**1** and the second side B**2** being adjacent to each other. The feeding excitation branch **13** is a metal frame segment at a top corner between the first side B**1** and the second side B**2**.

[0083] In the case where the first end D**1** of the feeding excitation branch **13** is directly opposite to and spaced apart from the third end D**3** of the first radiation branch **11**, and the second end D**2** of the feeding excitation branch **13** is directly opposite to and spaced apart from the fifth end D**5** of the second radiation branch **12**, the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** are three independent metal frame segments **101** formed by providing gaps F**1** in the metal frame of the electronic device **100**. In the case where the first end D**1** of the feeding excitation branch **13** is directly opposite to and spaced apart from the third end D**3** of the first radiation branch **11**, the second end D**2** of the feeding excitation branch **13** is connected to the fifth end D**5** of the second radiation branch **12** and the first ground point G**1** coincides with the third ground point G**3**, the second radiation branch **12** and the feeding excitation branch **13** are an integral metal frame segment **101**, and the first radiation branch **11** is an independent metal frame segment **101** which is spaced, by a gap F**1**, from the metal frame segment **101** forming the second radiation branch **12** and the feeding excitation branch **13**.

[0084] In the case where the first end D**1** of the feeding excitation branch **13** is directly opposite to and spaced apart from the third end D**3** of the first radiation branch **11**, the second end D**2** of the feeding excitation branch **13** is connected to the fifth end D**5** of the second radiation branch **12** and the first ground point G**1** coincides with the third ground point G**3**, the electrical coupling and magnetic coupling can also be achieved, the provided gaps can be reduced, and the stability of the overall structure of the antenna assembly **1** is improved. For the electronic device **100**, it can also improve the overall strength of the frame and reduce the complexity of process.

[0085] In some embodiments, the frame **10** of the electronic device **100** may also be a non-metal frame, and the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** are metal segments provided at the frame **10** of the electronic device **100**.

[0086] That is, in some embodiments, the frame **10** of the electronic device **100** may also be a non-metal frame with low conductivity, such as a resin, plastic, or ceramic frame. The first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** are metal segments provided at the frame **10** of the electronic device **100**.

[0087] The first radiation branch **11** is a metal segment provided at a part of the frame **10** on the first side B**1** of the electronic device **100**, and the second radiation branch **12** is a metal segment provided at a part of the frame **10** on the second side B**2** of the electronic device **100**, the first side B**1** and the second side B**2** being adjacent sidestep each other. The feeding excitation branch **13** is a metal segment provided at a part of the frame **10** at the top corner between the first side B**1** and the second side B**2** of the electronic device **100**.

[0088] Similarly, in the case where the first end D**1** of the feeding excitation branch **13** is directly opposite to and spaced apart from the third end D**3** of the first radiation branch **11**, and the second end D**2** of the feeding excitation branch **13** is directly opposite to and spaced apart from the fifth end D**5** of the second radiation branch **12**, the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** are three independent metal segments provided at the frame **10** of the electronic device **100**. In the case where the first end D**1** of the feeding excitation branch **13** is directly opposite to and spaced apart from the third end D**3** of the first radiation branch **11**, the second end D**2** of the feeding excitation branch **13** is connected to the fifth end D**5** of the second radiation branch **12** and the first ground point G**1** coincides with the third ground point G**3**, the second radiation branch **12** and the feeding excitation branch **13** are an integral metal segment provided at the frame **10** of the electronic device **100**, and the first radiation branch **11** is another independent metal segment provided at the frame **10** of the electronic device **100** which is spaced, by a gap, from the metal segment forming the second radiation branch **12** and the feeding excitation branch **13**.

[0089] When the frame **10** of the electronic device **100** may also be a non-metal frame, the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** may be embedded in the frame **10** of the electronic device **100**, or provided on the inner side of the frame **10** of the electronic device **100**.

[0090] In some embodiments, as illustrated in FIG. **8**, the first side B**1** is a short side of the electronic device **100**, and the second side B**2** is a long side of the electronic device **100**. Thus, since the adjacent first side B**1** and second side B**2** are perpendicular to each other, the first radiation branch **11** and the second radiation branch **12** are also perpendicular to each other, that is, they are in vertical orthogonality, thereby achieving better vertical orthogonal polarization.

[0091] Evidently, in some other embodiments, the first side B**1** may be a long side of the electronic device **100**, and the second side B**2** may be a short side of the electronic device **100**.

[0092] As illustrated in FIG. **8**, the frame **10** is arc-shaped at the top corner between the first side B**1** and the second side B**2**, and the feeding excitation branch **13** is an arc-shaped segment.

[0093] As illustrated in FIG. **8**, in some embodiments, the first side B**1** is a short side at the top of the electronic device **100**, and the second side B**2** is a long side at the left side of the electronic device **100**.

[0094] The directional terms such as "top" and "bottom" used in the embodiments of the present disclosure to describe the electronic device **100** are mainly explained based on the orientation when the user holds the electronic device **100** in hand. The position at the top side of the electronic device **100** is referred to as the "top", and the position at the bottom side of the electronic device **100** is referred to as the "bottom". It does not indicate or imply that the device or element referred to must have a specific orientation, or be constructed and operated in a specific orientation. Therefore, they cannot be understood as a limitation on the orientation of the electronic device **100** in actual application scenarios. In some embodiments, the bottom end of the electronic device **100** is an end where a headphone jack and an USB port are provided, and the top end of the electronic device **100** is another end opposite to the end where the headphone jack and the USB port are provided, and may also refer to an end where a camera, a receiver, etc. are provided.

[0095] As shown in FIG. **8**, the electronic device **100** further includes a display screen **2**, and the schematic diagram shown in FIG. **9** is a schematic diagram viewed from one side of the display screen **2**. The "left" and "right" are those viewed from the perspective of FIG. **9**.

[0096] Evidently, in some embodiments, the first side B**1** is also a short side at the top of the electronic device **100**, and the second side B**2** is a long side on the right side of the electronic device **100**, and so on.

[0097] Referring to FIG. **9**, a partial structural schematic diagram of the electronic device **100** including the aforementioned antenna assembly **1** in some embodiments of the present disclosure is shown. As illustrated in FIG. **9**, the electronic device **100** further includes a circuit board **3**, and the feed source S**1** may be provided on the circuit board **3**. The feeding point K**1** is connected with the feed source S**1**. As illustrated in FIG. **9**, the first ground point G**1**, the second ground point G**2** and the third ground point G**3** are connected to the ground on the circuit board **3**. Specifically, FIG. **9** illustrates an example in which the electronic device **100** includes the antenna assembly **1** shown in FIG. **4**.

[0098] The circuit board **3** may be a main board. The ground on the circuit board **3** may be ground of the main board, such as a ground region or a ground layer on the circuit board **3**. In some embodiments, the middle frame of the electronic device **100** is the ground of the entire device, and the ground of the main board may be connected to the middle frame of the electronic device **100** (not shown in the figure), so that the first ground point G**1**, the second ground point G**2** and the third ground point G**3** are connected to the middle frame of the electronic device **100**, so as to be connected to the ground of the entire device. The aforementioned ground may be the ground on the circuit board **3** or the ground of the middle frame.

[0099] The specific structure of the antenna assembly **1** shown in FIG. **9** does not include the first tuner **14**, the second tuner **15** and the third tuner **16**. Evidently, when the antenna assembly **1** includes the first tuner **14**, the second tuner **15** and the third tuner **16**, the first ground point G**1** is connected to the ground on the circuit board **3** through the first tuner **14**, the second ground point G**2** is connected to the ground on the circuit board **3** through the second tuner **15**, and the third ground point G**3** is connected to the ground on the circuit board **3** through the third tuner **16**.

[0100] In some embodiments, the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** may also be metal segments provided on the circuit board **3**. For example, the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** are flexible printed circuit (FPC) metal segments fixedly provided on an antenna bracket(s) or laser-direct-structuring (LDS) metal segments formed on an antenna bracket(s) by laser technology, and then they are arranged on the circuit board **3** through the antenna bracket(s).

[0101] Referring to FIG. **10**, a schematic diagram of a first three-dimensional axial ratio simulation of the electronic device **100** in some embodiments of the present disclosure is shown. The first three-dimensional axial ratio simulation diagram of the electronic device **100** shown in FIG. **11** is a three-dimensional axial ratio simulation diagram of side radiation obtained by simulation based on the electronic device **100** including the structure of the antenna assembly **1** shown in any of the aforementioned embodiments.

[0102] As can be seen from FIG. **10**, when viewed from the side of the electronic device **100**, the intensities of radiation radiated by the antenna assembly **1** sideward substantially are approximately equal within a circle centered on the top, so that the ratio of the maximum radiation intensity to the minimum radiation intensity is approximately **1**, which achieves a low axial ratio in the lateral direction of the electronic device **100**.

[0103] The lower the axial ratio, the better the circular polarization characteristics. The lowest axial ratio is generally **1**.

[0104] FIG. **10** is specifically a schematic diagram of three-dimensional axial ratio simulation viewed from the long side where the second radiation branch **12** is provided.

[0105] Referring to FIG. **11**, a schematic diagram of a second three-dimensional axial ratio simulation of the electronic device **100** in some embodiments of the present disclosure is shown. The second three-dimensional axial ratio simulation schematic diagram of the electronic device **100** shown in FIG. **11** is a three-dimensional axial ratio simulation schematic diagram of planar radiation obtained by simulation based on the electronic device **100** including the antenna assembly **1** shown in any of the aforementioned embodiments.

[0106] As can be seen from FIG. **11**, when viewed from a plane where the display screen **2** of the electronic device **100** is located, the intensities of radiation radiated by the antenna assembly **1** in most directions within the plane of the display screen **2** are substantially equal, which appears to be circular. Thus, the ratio of the maximum radiation intensity to the minimum radiation intensity is approximately **1**, and a low axial ratio is also achieved in the plane where the display screen **2** of the electronic device **100** is located. Therefore, the electronic device **100** achieves good vertical orthogonal polarization.

[0107] The electronic device **100** includes at least one antenna assembly **1**. That is, the electronic device **100** may include one or more antenna assemblies **1**.

[0108] Referring to FIG. **12**, another schematic plan view of the electronic device **100** in some embodiments of the present disclosure is shown. As shown in FIG. **12**, the electronic device **100** may include two antenna assemblies **1**, and each antenna assembly **1** includes the aforementioned structure.

[0109] As illustrated in FIG. **12**, one antenna assembly **1** is provided at the upper left corner of the electronic device **100**, and the other antenna assembly **1** is provided at the lower right corner of the electronic device **100**. The “upper left” and “lower right” are all directions from the viewing angle shown in FIG. **12**.

[0110] As illustrated in FIG. **12**, the first radiation branch **11** of the antenna assembly **1** located at the upper left corner of the electronic device **100** is a metal segment provided at a part of the frame **10** on the first side B**1** of the electronic device **100**, and the second radiation branch **12** of this antenna assembly is a metal segment provided at a part of the frame **10** on the second side B**2** of the electronic device **100**, the first side B**1** and the second side B**2** being adjacent to each other. The feeding excitation branch **13** of this antenna assembly is a metal segment provided on a part of the frame **10** at the top corner between the first side B**1** and the second side B**2** of the electronic device **100**.

[0111] The first radiation branch **11** of the antenna assembly **1** located at the lower right corner of the electronic device **100** is a metal segment provided at a part of the frame **10** on the third side B**3** of the electronic device **100**, and the second radiation branch **12** of this antenna assembly is a metal segment provided at a part of the frame **10** on the fourth side B**4** of the electronic device **100**, the third side B**3** and the fourth side B**4** being adjacent to each other. The feeding excitation branch **13** of this antenna assembly is a metal segment provided on a part of the frame **10** at the top corner between the third side B**3** and the fourth side B**4** of the electronic device **100**.

[0112] As illustrated in FIG. **12**, in some embodiments, the first side B**1** is a short side located at the top of the electronic device **100**, the third side B**3** is a short side at the bottom of the electronic device **100**, the second side B**2** is a long side on the left side of the electronic device **100**, and the fourth side B**4** is a long side on the right side of the electronic device **100**.

[0113] In some embodiments, one of the two antenna assemblies **1** may support transmission of satellite communication signals and the other one may support reception of the same satellite communication signals. For example, the electrical length of each the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** of one antenna assembly is λ.sub.2/4, where **21** is the transmit frequency of the satellite communication signal; and the electrical length of each of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** of another antenna assembly is λ.sub.2/4, where **22** is the receive frequency of the satellite communication signal. In this way, the two antenna assemblies may resonate at the transmit frequency and the receive frequency of the satellite communication signals respectively, and support the transmission and reception of the satellite communication signals respectively. In some embodiments, satellite communication signals supported by the two antenna assemblies **1** are the same, for example, both are Beidou satellite communication signals, in which one of the antenna assemblies may support the transmission of the satellite communication signal, and the other of the antenna assemblies may support the reception of the same satellite communication signal. Thus, in some embodiments, when the electronic device **100** includes two antenna assemblies **1** at the same time, one of the antenna assemblies may be used as a transmitting antenna and the other of the antenna assemblies may be used as a receiving antenna, so that dual-frequency circular polarization or dual-frequency elliptical polarization can be realized under the same satellite communication system, thereby realizing the transmission and reception of satellite communication signals at the same time.

[0114] In some embodiments, each of the two antenna assemblies **1** may further include the aforementioned first tuner **14**, second tuner **15** and third tuner **16**. Each of the two antenna assemblies can support the transmission and reception of satellite communication signals, and each of the two antenna assemblies can support the transmission and reception of different satellite communication signals. For example, one antenna assembly **1** may support the transmission and reception of a first satellite communication signal, and the other antenna assembly **1** may support the transmission and reception of a second satellite communication signal. Thus, one antenna assembly **1** independently supports the transmission and reception of the first satellite communication signal, and the other antenna assembly **1** independently supports the transmission and reception of the second satellite communication signal, which enables dual-frequency circular polarization or dual-frequency elliptical polarization under different satellite communication systems. Therefore, at a same time, the antenna assemblies **1** can simultaneously transmit or receive the first satellite communication signal and transmit or receive the second satellite communication signal, thereby effectively improving the performance and reliability of satellite communication. The first satellite communication signal may be a Beidou satellite communication signal, and the second satellite communication signal may be a satellite communication signal of other satellite communication systems.

[0115] Evidently, in some other embodiments, the electronic device **100** may further include three antenna assemblies **1**, or even four antenna assemblies **1**. For example, at each of the upper left corner, the upper right corner, the lower left corner, and the lower right corner of the electronic device **100**, one antenna assembly **1** may be provided.

[0116] When the frame **10** of the electronic device **100** is a metal frame, the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** of each antenna assembly **1** are metal frame segments formed by providing gaps F**1** in the metal frame of the electronic device **100**.

[0117] When the frame **10** of the electronic device **100** is a non-metal frame, the first radiation branch **11**, the second radiation branch **12** and the feeding excitation branch **13** of each antenna assembly **1** are metal segments provided at the frame **10** of the electronic device **100**, for example, they are metal segments embedded in the frame **10** of the electronic device **100** or metal segments provided on the inner side of the frame **10** of the electronic device **100**.

[0118] Referring to FIG. **13**, a further structural block diagram of the electronic device **100** in some embodiments of the present disclosure is shown. As illustrated in FIG. **13**, the electronic device **100** includes the antenna assembly **1** and a processor **4**. When the antenna assembly **1** further includes the first tuner **14**, the second tuner **15** and the third tuner **16**, the processor **4** is connected to the first tuner **14**, the second tuner **15** and the third tuner **16**, and is also used to control the first tuner **14**, the second tuner **15** and the third tuner **16** to be enabled or disabled.

[0119] For example, in some embodiments, the original electrical length of each of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** is λ.sub.2/4, where A**1** is the wavelength corresponding to the transmit frequency of a satellite communication signal. That is, in some embodiments, the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11**, and the second radiation branch **12** are mainly designed based on the transmission of the satellite communication signal. Therefore, at the time of transmitting the satellite communication signal, the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** have met the requirements. In this case, the processor **4** controls the first tuner **14**, the second tuner **15** and the third tuner **16** to be disabled. At the time of receiving a satellite communication signal, the processor **4** controls the first tuner **14**, the second tuner **15** and the third tuner **16** to be enabled, so that the electrical length of each of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** is adjusted to λ.sub.2/4, where **22** is the wavelength corresponding to the receive frequency of the satellite communication signal, thereby supporting the reception of the satellite communication signal.

[0120] As mentioned above, each of the first tuner **14**, the second tuner **15** and the third tuner **16** includes a tuning element X**1** and a tuning switch W**1** connected in parallel between the corresponding ground point and the ground. In some embodiments, the processor **4** is specifically configured to, at the time of transmitting a satellite communication signal, control the tuning switch W **1** in each of the first tuner **14**, the second tuner **15** and the third tuner **16** to be turned on, so as to make the branch where the corresponding tuning element X**1** is located be short-circuited. Thus, the first tuner **14**, the second tuner **15** and the third tuner **16** are disabled at the time of transmitting the satellite communication signal. The processor **4** is further configured to, at the time of receiving a satellite communication signal, control the tuning switch W**1** in each of the first tuner **14**, the second tuner **15** and the third tuner **16** to be turned off, so as to make the branch where the corresponding tuning element X**1** is located be switched in. Thus, the first tuner **14**, the second tuner **15** and the third tuner **16** are enabled at the time of receiving the satellite communication signal.

[0121] In some other embodiments, the original electrical lengths of each of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** is λ.sub.2/4, where **12** is the wavelength corresponding to the receive frequency of a satellite communication signal. That is, in some other embodiments, the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** are mainly designed based on the reception of the satellite communication signal. Therefore, at the time of receiving the satellite communication signal, the electrical lengths of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** have met the requirements. In this case, the processor **4** controls the first tuner **14**, the second tuner **15** and the third tuner **16** to be disabled. At the time of transmitting a satellite communication signal, the processor **4** controls the first tuner **14**, the second tuner **15** and the third tuner **16** to be enabled, so that the electrical length of each of the feeding excitation branch **13**, the first radiation branch **11** and the second radiation branch **12** is adjusted λ.sub.2/4, where A**1** is the wavelength corresponding to the transmit frequency of the satellite communication signal, thereby supporting the transmission of the satellite communication signal.

[0122] Similarly, each of the first tuner **14**, the second tuner **15** and the third tuner **16** includes a tuning element X**1** and a tuning switch W**1** connected in parallel between the corresponding ground point and the ground. In some embodiments, the processor **4** is specifically configured to, at the time of receiving a satellite communication signal, control the tuning switch W**1** in each of the first tuner **14**, the second tuner **15** and the third tuner **16** to be turned on, so as to make the branch where the corresponding tuning element X**1** is located be short circuited. Thus, the first tuner **14**, the second tuner **15** and the third tuner **16** are disabled at the time of receiving the satellite communication signal. The processor **4** is further configured to, at the time of transmitting a satellite communication signal, control the tuning switch W**1** in each of the first tuner **14**, the second tuner **15** and the third tuner **16** to be turned off, so as to make the branch where the corresponding tuning element X**1** is located be switched in. Thus, the first tuner **14**, the second tuner **15** and the third tuner **16** are enabled at the time of transmitting the satellite communication signal.

[0123] The tuning switch W**1** may be a transistor such as a MOS tube or a triode. The processor **4** controls the tuning switch W**1** to be turned on or off by outputting a corresponding level signal. For example, when the tuning switch W**1** is a MOS tube, the processor **4** is connected to the gates of all NM OS tubes of the first tuner **14**, the second tuner **15** and the third tuner **16**, and outputs a corresponding high-level or low-level signal as needed to control the tuning switches W**1** to be turned on or off, or turned off or on.

[0124] The processor **4** may be a central processing unit, a microcontroller, a single chip microcomputer, a digital signal processor, etc.

[0125] The electronic device **100** of the present disclosure may be any electronic device with an antenna, such as a mobile phone or a tablet computer. The electronic device **100** may further include other elements, which are irrelevant to the improvement of the present disclosure and will not be described in detail here.

[0126] In the antenna assembly **1** and the electronic device **100** of the present disclosure, the feeding excitation branch **13** of the antenna assembly **1** is electrically coupled with the first radiation branch **11** and magnetically coupled with the second radiation branch **12**, so that the phase

difference between two coupled feeding signals obtained respectively through the electrical coupling and magnetic coupling of the feeding signal received by the feeding excitation branch **13** is 90°. In addition, the first radiation branch **11** and the second radiation branch **12** are at an angle relative to each other. As such, the first radiation branch **11** and the second radiation branch **12** have circular polarization radiation characteristics or elliptical polarization radiation characteristics. Accordingly, the reception and/or transmission of satellite communication signals is enabled through a simple and compact structure. The electronic device **100** may be equipped with such simple and compact antenna assembly to transmit and/or receive satellite communication signals, which enables the electronic device to have a small overall size and be easy to carry.
[0127] The foregoing only describes specific implementations of the present disclosure, but the scope of protection of the present disclosure is not limited thereto. Any technician familiar with the technical field can easily think of changes or substitutions within the technical scope disclosed in the present disclosure, and such changes and substitutions should fall within the scope of protection of the present disclosure. The embodiments of the present disclosure and the features in the embodiments can be combined with each other without conflict. Therefore, the scope of protection of the present disclosure shall be subjected to those of the claims.

Claims

1. An antenna assembly, comprising: a first radiation branch; a second radiation branch, wherein the first radiation branch and the second radiation branch are at an angle relative to each other; and a feeding excitation branch, wherein the feeding excitation branch is located between the first radiation branch and the second radiation branch, and the feeding excitation branch comprises a feeding point configured to receive a feeding signal; the feeding excitation branch is configured to be electrically coupled with the first radiation branch, to couple the feeding signal to the first radiation branch and provide a first coupled feeding signal fed into the first radiation branch, the feeding excitation branch is further configured to be magnetically coupled with the second radiation branch, to couple the feeding signal to the second radiation branch and provide a second coupled feeding signal fed into the second radiation branch, a phase difference between the first coupled feeding signal and the second coupled feeding signal being 90°, so that the first radiation branch and the second radiation branch have circular polarization radiation characteristics or elliptical polarization radiation characteristics, and the antenna assembly is enabled to support reception and/or transmission of a satellite communication signal.
2. The antenna assembly as claimed in claim 1, wherein the feeding excitation branch further comprises a first end, a second end and a first ground point, the first ground point is configured for grounding and provided at the second end, the first end is an open-circuit end, and the feeding point is provided between the first ground point and the first end; the first radiation branch comprises a third end, a fourth end and a second ground point, the second ground point is configured for grounding and provided at the fourth end, and the third end is an open-circuit end; the second radiation branch comprises a fifth end, a sixth end and a third ground point, the third ground point is configured for grounding and provided at the fifth end, and the sixth end is an open-circuit end; the first end of the feeding excitation branch is directly opposite to and spaced apart from the third end of the first radiation branch; and the second end of the feeding excitation branch is directly opposite to and spaced apart from the fifth end of the second radiation branch, or the second end of the feeding excitation branch is connected to the fifth end of the second radiation branch and the first ground point coincides with the third ground point.
3. The antenna assembly as claimed in claim 2, wherein the antenna assembly further comprises a feed source, the feed source is configured to generate the feeding signal, the feeding excitation branch is configured to couple, through the electrical coupling, the feeding signal generated by the feed source to the first radiation branch to provide the first coupled feeding signal fed into the first

radiation branch, and the feeding excitation branch is further configured to couple, through the magnetic coupling, the feeding signal generated by the feed source to the second radiation branch to provide the second coupled feeding signal fed into the second radiation branch, and the first radiation branch and the second radiation branch are configured to transmit the satellite communication signal under excitation of the first coupled feeding signal and the second coupled feeding signal respectively.

4. The antenna assembly as claimed in claim 3, wherein an electrical length of each of the feeding excitation branch, the first radiation branch, and the second radiation branch is λ.sub.2/4, where λ.sub.1 is a wavelength corresponding to a transmit frequency of the satellite communication signal.

5. The antenna assembly as claimed in claim 3, wherein the antenna assembly further comprises a first tuner, a second tuner and a third tuner, the first tuner is connected between the first ground point and ground, the second tuner is connected between the second ground point and the ground, and the third tuner is connected between the third ground point and the ground; and at a time of receiving the satellite communication signal, each of the first tuner, the second tuner and the third tuner is configured to be enabled to adjust an electrical length of each of the feeding excitation branch, the first radiation branch and the second radiation branch to λ.sub.2/4 for the reception of the satellite communication signal, where **22** is a wavelength corresponding to a receive frequency of the satellite communication signal.

6. The antenna assembly as claimed in claim 5, wherein each of the first tuner, the second tuner and the third tuner comprises a tuning element and a tuning switch connected in parallel between a corresponding ground point and the ground, and the tuning switch of each of the first tuner, the second tuner and the third tuner is configured to be turned off at the time of receiving the satellite communication signal to enable a corresponding tuning element, so that the first tuner, the second tuner and the third tuner are configured to be enabled at the time of receiving the satellite communication signal.

7. The antenna assembly as claimed in claim 2, wherein the feeding signal is a received satellite communication signal, the feeding excitation branch is configured to couple, through the electrical coupling, the received satellite communication signal to the first radiation branch to provide the first coupled feeding signal fed into the first radiation branch, and the feeding excitation branch is further configured to couple, through the magnetic coupling, the received satellite communication signal to the second radiation branch to provide the second coupled feeding signal fed into the second radiation branch, and the first radiation branch and the second radiation branch are configured to receive the satellite communication signal under excitation of the first coupled feeding signal and the second coupled feeding signal respectively.

8. The antenna assembly as claimed in claim 7, wherein an electrical length of each of the feeding excitation branch, the first radiation branch, and the second radiation branch is λ.sub.2/4, where λ.sub.2 is a wavelength corresponding to a receive frequency of the satellite communication signal.

9. The antenna assembly as claimed in claim 7, wherein the antenna assembly further comprises a first tuner, a second tuner and a third tuner, the first tuner is connected between the first ground point and ground, the second tuner is connected between the second ground point and the ground, and the third tuner is connected between the third ground point and the ground; and at a time of transmitting the satellite communication signal, each of the first tuner, the second tuner and the third tuner is configured to be enabled to adjust an electrical length of each of the feeding excitation branch, the first radiation branch and the second radiation branch to λ.sub.2/4 for the transmission of the satellite communication signal, where λ.sub.1 is a wavelength corresponding to a transmit frequency of the satellite communication signal.

10. The antenna assembly as claimed in claim 9, wherein each of the first tuner, the second tuner and the third tuner comprises a tuning element and a tuning switch connected in parallel between a corresponding ground point and the ground, and the tuning switch of each of the first tuner, the second tuner and the third tuner is configured to be turned off at the time of transmitting the satellite communication signal to enable a respective tuning element, so that the first tuner, the second tuner and the third tuner are configured to be enabled at the time of transmitting the satellite communication signal.

11. The antenna assembly as claimed in claim 1, wherein the angle between the first radiation branch and the second radiation branch is greater than 0° and less than 180°.

12. The antenna assembly as claimed in claim 11, wherein the angle between the first radiation branch and the second radiation branch is 90°.

13. The antenna assembly as claimed in claim 2, wherein a receive frequency and a transmit frequency of the satellite communication signal are the same, and the first ground point, the second ground point and the third ground point are directly grounded.

14. An electronic device, comprising an antenna assembly comprising: a first radiation branch; a second radiation branch at an angle relative to the first radiation branch; and a feeding excitation branch, wherein the feeding excitation branch is located between the first radiation branch and the second radiation branch, and the feeding excitation branch comprises a feeding point configured to receive a feeding signal; the feeding excitation branch is configured to be electrically coupled with the first radiation branch, to couple the feeding signal to the first radiation branch and provide a first coupled feeding signal fed into the first radiation branch, the feeding excitation branch is further configured to be magnetically coupled with the second radiation branch, to couple the feeding signal to the second radiation branch and provide a second coupled feeding signal fed into the second radiation branch, a phase difference between the first coupled feeding signal and the second coupled feeding signal being 90°, so that the first radiation branch and the second radiation branch have circular polarization radiation characteristics or elliptical polarization radiation characteristics, and the antenna assembly is enabled to support reception and/or transmission of a satellite communication signal.

15. The electronic device as claimed in claim 14, wherein a frame of the electronic device is a metal frame, and the first radiation branch, the second radiation branch, and the feeding excitation branch are metal frame segments formed by providing gaps in the metal frame of the electronic device.

16. The electronic device as claimed in claim 15, wherein the first radiation branch is formed by a part of the metal frame on a first side of the electronic device, and the second radiation branch is formed by a part of the metal frame on a second side of the electronic device, the first side and the second side being adjacent to each other; and the feeding excitation branch is a metal frame segment at a top corner between the first side and the second side.

17. The electronic device as claimed in claim 14, wherein a frame of the electronic device is a non-metal frame, and the first radiation branch, the second radiation branch and the feeding excitation branch are metal segments provided at the frame of the electronic device.

18. The electronic device as claimed in claim 17, wherein the first radiation branch is a metal segment provided at a part of the frame on a first side of the electronic device, and the second radiation branch is a metal segment provided at a part of the frame on a second side of the electronic device, the first side and the second side being adjacent to each other; and the feeding excitation branch is a metal segment provided at a top corner between the first side and the second side of the electronic device.

19. The electronic device as claimed in claim 14, wherein the electronic device further comprises a circuit board, and each of the first radiation branch, the second radiation branch and the feeding excitation branch is provided on the circuit board through an antenna bracket.

20. The electronic device as claimed in claim 14, wherein at least one antenna assembly is comprised in the electronic device.