United States Patent	12388180
Kind Code	B2
Date of Patent	August 12, 2025
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Antenna structure and wireless communication device having same

Abstract

An antenna structure and a wireless communication device having the antenna structure are provided, the antenna structure includes a metal frame, a feeding portion, a first ground portion, and a second ground portion. The metal frame defines a first gap, a second gap, and a third gap, the metal frame between the first gap and the second gap forms a first radiating portion, the metal frame between the first gap and the third gap and the metal frame on a side of the third gap cooperatively form a second radiating portion, the metal frame on a side of the second gap forms a third radiating portion. The feeding portion is connected to the first radiating portion. The first ground portion is apart from the feeding portion and connected to the first radiating portion. The second ground portion closes to the second gap and is connected to the third radiating portion.

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Appl. No.: **17/868237**

Filed: **July 19, 2022**

Prior Publication Data

Document Identifier	Publication Date
US 20230070301 A1	Mar. 09, 2023

Foreign Application Priority Data

CN	202111045974.8	Sep. 07, 2021

Publication Classification

Int. Cl.: **H01Q5/335** (20150101); **H01Q1/24** (20060101)

U.S. Cl.:

CPC **H01Q5/335** (20150115); **H01Q1/243** (20130101);

Field of Classification Search

CPC: H01Q (5/335); H01Q (1/243); H01Q (5/328); H01Q (5/385); H01Q (3/22); H01Q (23/00); H01Q (3/44); H01Q (3/247)

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS
(1) This application claims priority to Chinese Patent Application No. 202111045974.8 filed on Sep. 7, 2021, in China National Intellectual Property Administration, the contents of which are incorporated by reference herein.
FIELD
(2) The subject matter herein generally relates to wireless communication, and more particularly to an antenna structure of a wireless communication device having the antenna structure.
BACKGROUND
(3) With the continuous development and evolution of wireless communication technology, the space for accommodating an antenna inside mobile terminal products, such as mobile phones, has reduced. Moreover, with the development of wireless communication technology, the demand for antenna bandwidth is also increasing. Therefore, obtaining an antenna with a wider bandwidth in a more limited space is challenging.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
(1) Implementations of the present disclosure will now be described, by way of embodiments, with reference to the attached figures.
(2) FIG. **1** is a schematic diagram of a wireless communication device having an antenna structure according to a first embodiment of the present application.
(3) FIG. **2** is a schematic diagram of the wireless communication device shown in FIG. **1** from another angle.
(4) FIG. **3** is a plane diagram of the wireless communication device shown in FIG. **1**.
(5) FIG. **4** is circuit diagrams of a first matching circuit, a second matching circuit, and a third matching circuit of the antenna structure according to the first embodiment of the present application.
(6) FIG. **5** is a graph of scattering parameters (S parameters) when a first side slot of the antenna structure has different lengths according to the first embodiment of the present application.
(7) FIG. **6** is a graph of S parameters when a second side slot of the antenna structure has different lengths according to the first embodiment of the present application.
(8) FIG. **7** is a schematic diagram of a wireless communication device having an antenna structure according to a second embodiment of the present application.
(9) FIG. **8** is a circuit diagram of a first switch circuit of the antenna structure according to the second embodiment of the present application.
(10) FIG. **9** is a graph of S parameters when the first switch circuit of the antenna structure has different inductances according to the second embodiment of the present application.
(11) FIG. **10** is a schematic diagram of a wireless communication device having an antenna structure according to a third embodiment of the present application.
(12) FIG. **11** is a circuit diagram of a second switch circuit of the antenna structure according to the third embodiment of the present application.
(13) FIG. **12** is a graph of S parameters when the second switch circuit of the antenna structure has

different inductances according to the third embodiment of the present application.
(14) FIG. **13** is a schematic diagram of a wireless communication device having an antenna structure according to a fourth embodiment of the present application.
(15) FIG. **14** is a graph of S parameters when the first switch circuit and the second switch circuit of the antenna structure are synchronously adjusted according to the fourth embodiment of the present application.

DETAILED DESCRIPTION

(16) It will be appreciated that for simplicity and clarity of illustration, where appropriate, reference numerals have been repeated among the different figures to indicate corresponding or analogous elements. Additionally, numerous specific details are set forth in order to provide a thorough understanding of the embodiments described herein. However, it will be understood by those of ordinary skill in the art that the embodiments described herein can be practiced without these specific details. In other instances, methods, procedures and components have not been described in detail so as not to obscure the related relevant feature being described. The drawings are not necessarily to scale and the proportions of certain parts may be exaggerated to better illustrate details and features. The description is not to be considered as limiting the scope of the embodiments described herein.
(17) Several definitions that apply throughout this disclosure will now be presented.
(18) The term “coupled” is defined as connected, whether directly or indirectly through intervening components, and is not necessarily limited to physical connections. The connection can be such that the objects are permanently connected or releasably connected. The term “substantially” is defined to be essentially conforming to the particular dimension, shape, or another word that “substantially” modifies, such that the component need not be exact. For example, “substantially cylindrical” means that the object resembles a cylinder, but can have one or more deviations from a true cylinder. The term “comprising” means “including, but not necessarily limited to”; it specifically indicates open-ended inclusion or membership in a so-described combination, group, series, and the like.
(19) FIGS. **1-3** show at least one embodiment of an antenna structure **100** that can be applied to a wireless communication device **1**, such as a mobile phone or personal digital assistant, for transmitting and receiving radio waves for transmitting and exchanging wireless signals. The wireless communication device **1** includes the antenna structure **100**, a connector **300**, a speaker **400**, a battery **500**, and a circuit board **600**.
(20) The antenna structure **100** includes a metal frame **200**, a feeding portion **101**, a first ground portion **102**, a second ground portion **103**, a first radiating portion **104**, a second radiating portion **105**, a third radiating portion **106**, a first matching circuit **110**, a second matching circuit **120**, and a third matching circuit **130**.
(21) The frame portion **110** is arranged on a periphery of the middle frame portion **111**.
(22) The metal frame **200** is a substantially annular structure made of metal or other conductive material. The metal frame **200** at least includes a first side **201**, a second side **202**, and a third side **203**. The second side **202** and the third side **203** are connected to opposite ends of the first side **201**. In at least one embodiment, the first side **201** may be a bottom side of the metal frame **200**. The first side **201** defines a first gap **230** and a second gap **240** at intervals. The first gap **230** and the second gap **240** are arranged on positions close to opposite ends of the first side **201**. The second side **202** defines a third gap **250** on an end close to the first side **201**.
(23) The first side **201**, the second side **202**, and the third side **203** jointly divide the metal frame **200** into a first metal section **204**, a second metal section **205**, a third metal section **206**, and a fourth metal section **207** arranged at intervals. The first metal section **204** is a portion of the metal frame **200** between the first gap **230** and the second gap **240**. The second metal section **205** is a portion of the metal frame **200** between the first gap **230** and the third gap **250**. The third metal section **206** is a portion of the metal frame **200** that is on a side of the third gap **250** opposite to the

first metal section **204**. The fourth metal section **207** is a portion of the metal frame **200** that is on a side of the second gap **240** opposite to the first metal section **204**.
(24) The first metal section **204** forms the first radiating portion **104**. The second metal section **205** and a portion of the third metal section **206** close to the second metal section **205** cooperatively form the second radiating portion **105**. The fourth metal section **207** forms the third radiating portion **106**.
(25) The feeding portion **101** is electrically connected to a feed source of the first circuit board **600** through the first matching circuit **110**, for feeding current. The first ground portion **102** is grounded through the second matching circuit **120** for grounding the antenna structure **100**. The second ground portion **103** is grounded through the third matching circuit **130** for grounding the antenna structure **100**.
(26) Referring to FIG. **4**, the first matching circuit **110** includes a first inductor L**1**, a second inductor L**2**, and a capacitor C. One end of the first inductor L**1** is electrically connected to the feed source of the first circuit board **600**, and the other end of the first inductor L**1** is electrically coupled to the feeding portion **101**. One end of the second inductor L**2** is electrically coupled between the feeding portion **101** and the first inductor L**1**, and the other end of the second inductor L**2** is grounded. One end of the capacitor C is grounded, and the other end of the capacitor C is electrically coupled between the feeding portion **101** and the first inductor L**1**, that is, the capacitor C is in parallel with the second inductor L**2**.
(27) The second matching circuit **120** includes a third inductor L**3**. One end of the third inductor L**3** is electrically coupled to the first ground portion **102**, and the other end of the third inductor L**3** is grounded. The third matching circuit **130** includes a fourth inductor L**4**. One end of the fourth inductor L**4** is electrically coupled to the second ground portion **103**, and the other end of the fourth inductor L**4** is grounded.
(28) The battery **500** is spaced away from the second side **202** and the third side **203**. A first groove **210** is formed between the battery **500** and the second side **202**. The first circuit board **600** is spaced apart from the first side **201** and the third side **203**. A second groove **220** is formed between the first circuit board **600** and the third side **203**. The first gap **230**, the second gap **240**, and the third gap **250** communicate with the first groove **210** and the second groove **220**. In one embodiment, the first gap **230**, the second gap **240**, and the third gap **250** are infilled with an insulating material (such as plastic, rubber, glass, wood, ceramic, or the like).
(29) The connector **300** is between the first radiating portion **104** and the first circuit board **600**. The first radiating portion **104** defines an opening at a position corresponding to the connector **300**, the connector **300** may connect to an external device through the opening. The speaker **400** is between the first circuit board **600** and the second side **202**.
(30) As the feeding portion **101** feeds current, the current flows through the first radiating portion **104**, flows to the second gap **240** and is coupled to the third radiating portion **106**, and is grounded through the second ground portion **103**, thereby exciting a first mode to generate a radiation signal in a first radiation frequency band. At least one embodiment, the first mode may include a middle frequency mode, the first radiation frequency band may include 1710-2170 MHz frequencies.
(31) As the feeding portion **101** feeds current, the current flows through the first radiating portion **104**, flows to the first gap **230** and the third gap **250**, is coupled to the second radiating portion **105**, and is grounded through the first ground portion **102**, thereby exciting a second mode to generate a radiation signal in a second radiation frequency band. At least one embodiment, the second mode may include a high frequency mode, the second radiation frequency band may include 2496-2690 MHz frequencies.
(32) Referring to FIG. **4**, in at least one embodiment, an inductance of each of the first matching circuit **110**, the second matching circuit **120**, and the third matching circuit **130** may be a fixed value. By adjusting a length of the first groove **210**, the high frequency (2496-2690 MHz) mode offset can be adjusted.

(33) FIG. **5** is a graph of scattering parameters (S parameters) of the antenna structure **100** when the first groove **210** has different lengths. Wherein, a curve S**501** is a graph of S parameters of the antenna structure **100** when the first groove **210** is 27.3 millimeters long; a curve S**502** is a graph of S parameters of the antenna structure **100** when the first groove **210** is 28.3 millimeters long. Comparing the curve S**501** with the curve S**502**, the high frequency (2496-2690 MHz) mode is shifted towards the 2690 MHz frequency. A curve S**503** is a graph of S parameters of the antenna structure **100** when the first groove **210** is 29.3 millimeters long. Comparing the curve S**503** with the curve S**502**, the high frequency (2496-2690 MHz) mode is shifted towards the 2496 MHz.
(34) Obviously, when the length of the first groove **210** is reduced, the high frequency (2496-2690 MHz) mode is shifted towards a higher frequency within the frequency range; when the length of the first groove **210** is increased, the high frequency (2496-2690 MHz) mode is shifted towards a lower frequency within the frequency range.
(35) Referring to FIG. **4**, in at least one embodiment, an inductance of each of the first matching circuit **110**, the second matching circuit **120**, and the third matching circuit **130** may be a fixed value. By adjusting a length of the second groove **220**, the middle frequency (1710-2170 MHz) mode offset can be adjusted.
(36) FIG. **6** is a graph of scattering parameters (S parameters) of the antenna structure **100** when the second groove **220** has different lengths. Wherein, a curve S**601** is a graph of S parameters of the antenna structure **100** when the second groove **220** is 19.2 millimeters long; a curve S**602** is a graph of S parameters of the antenna structure **100** when the second groove **220** is 21.2 millimeters long. Comparing the curve S**601** with the curve S**602**, the middle frequency (1710-2170 MHz) mode is shifted towards the range of 1920-2170 MHz. A curve S**603** is a graph of S parameters of the antenna structure **100** when the second groove **220** is 23.2 millimeters long. Comparing the curve S**603** with the curve S**602**, the middle frequency (1710-2170 MHz) mode is shifted towards the range of 1710-1880 MHz.
(37) Obviously, when the length of the second groove **220** is reduced, the middle frequency (1710-2170 MHz) mode is shifted towards a higher frequency within the frequency range; when the length of the second groove **220** is increased, the middle frequency (1710-2170 MHz) mode is shifted towards a lower frequency within the frequency range.
(38) FIG. **7** is a schematic diagram of a wireless communication device having an antenna structure according to a second embodiment of the present application. Comparing the wireless communication device of the second embodiment with the wireless communication device of the first embodiment, the wireless communication device **1** further includes a second circuit board **700**, the antenna structure **100** further includes a first switch **107**. The second circuit board **700** is spaced apart from the second side **202** and the speaker **400**. The first switch **107** is spaced apart from the second side **202** and the second circuit board **700**. An end of the first switch **107** is electrically connected to the second radiating portion **105**, the other end of the first switch **107** is grounded. The first switch **107** is configured to adjust the high frequency band of the second radiating portion **105**.
(39) Referring to FIG. **8**, the first switching circuit **140** includes the first switch **107** and a fifth inductor L**5**. One end of the fifth inductor L**5** is electrically connected to the first switch **107**, the other end of the fifth inductor L**5** is grounded.
(40) Referring to FIG. **7**, an inductance of each of the first matching circuit **110**, the second matching circuit **120**, and the third matching circuit **130** may be a fixed value, and the length of the first groove **210** may be fixed. By adjusting an inductance of the first switching circuit **140**, the high frequency (2496-2690 MHz) mode offset can be adjusted, for receiving and transmitting wireless signals in the high frequency (2496-2690 MHz).
(41) FIG. **9** is a graph of scattering parameters (S parameters) of the antenna structure **100** of the second embodiment when the first switching circuit **140** has different inductances. Wherein, a curve S**901** is a graph of S parameters of the antenna structure **100** of the second embodiment when

the first switching circuit **140** has an inductance of 0 nanohenry (nH); a curve S**902** is a graph of S parameters of the antenna structure **100** of the second embodiment when the first switching circuit **140** has an inductance of 9.5 nH. Comparing the curve S**901** with the curve S**902**, the high frequency (2496-2690 MHz) mode is shifted towards the 2690 MHz. A curve S**903** is a graph of S parameters of the antenna structure **100** of the second embodiment when the first switching circuit **140** has an inductance of 39 nH. Comparing the curve S**903** with the curve S**902**, the high frequency (2496-2690 MHz) mode is shifted towards the 2496 MHz.

(42) Obviously, decreasing the inductance of the first switching circuit **140** shifts the high frequency (2496-2690 MHz) mode towards a higher frequency within the frequency range; increasing the inductance of the first switching circuit **140** shifts the high frequency (2496-2690 MHz) mode towards a lower frequency within the frequency range.

(43) FIG. **10** is a schematic diagram of a wireless communication device having an antenna structure according to a third embodiment of the present application. Comparing the wireless communication device of the third embodiment with the wireless communication device of the first embodiment, the antenna structure **100** further includes a second switch **108**. The second switch **108** is spaced apart from the first circuit board **600** and the third side **203**. One end of the second switch **108** is electrically connected to the third radiating portion **106**, the other end of the second switch **108** is grounded. The second switch **108** is configured to adjust the middle frequency band of the third radiating portion **106**.

(44) Referring to FIG. **11**, the second switching circuit **150** includes the second switch **108** and a sixth inductor L**6**. One end of the sixth inductor L**6** is electrically connected to the second switch **108**, the other end of the sixth inductor L**6** is grounded.

(45) Referring to FIG. **10**, an inductance of each of the second matching circuit **120** and the third matching circuit **130** may be a fixed value, and the length of the second groove **220** may be fixed. By adjusting an inductance of the second switching circuit **150**, the middle frequency (1710-2170 MHz) mode offset can be adjusted, for receiving and transmitting wireless signals in the middle frequency (1710-2170 MHz).

(46) FIG. **12** is a graph of scattering parameters (S parameters) of the antenna structure **100** of the third embodiment when the second switching circuit **150** has different inductances. Wherein, a curve S**201** is a graph of S parameters of the antenna structure **100** of the third embodiment when the second switching circuit **150** has an inductance of 0 nH; a curve S**202** is a graph of S parameters of the antenna structure **100** of the third embodiment when the second switching circuit **150** has an inductance of 3.6 nH. Comparing the curve S**201** with the curve S**202**, the middle frequency (1710-2170 MHz) mode is shifted towards the 2170 MHz. A curve S**203** is a graph of S parameters of the antenna structure **100** of the third embodiment when the second switching circuit **150** has an inductance of 8 nH. Comparing the curve S**203** with the curve S**202**, the middle frequency (1710-2170 MHz) mode is shifted towards the 1710 MHz frequency.

(47) Obviously, decreasing the inductance of the second switching circuit **150** shifts the middle frequency (1710-2170 MHz) mode towards a higher frequency within the frequency range; increasing the inductance of the second switching circuit **150** shifts the middle frequency (1710-2170 MHz) mode towards a lower frequency within the frequency range.

(48) FIG. **13** is a schematic diagram of a wireless communication device having an antenna structure according to a fourth embodiment of the present application. Comparing the wireless communication device of the fourth embodiment with the wireless communication device of the first embodiment, the wireless communication device **1** further includes a second circuit board **700**, the antenna structure **100** further includes the first switch **107** and the second switch **108**. The second circuit board **700** is spaced apart from the second side **202** and the speaker **400**. The first switch **107** is spaced apart from the second side **202** and the second circuit board **700**. One end of the first switch **107** is electrically connected to the second radiating portion **105**, the other end of the first switch **107** is grounded. The first switch **107** is configured to adjust the high frequency

band of the second radiating portion **105**. The second switch **108** is spaced apart from the first circuit board **600** and the third side **203**. One end of the second switch **108** is electrically connected to the third radiating portion **106**, the other end of the second switch **108** is grounded. The second switch **108** is configured to adjust the middle frequency band of the third radiating portion **106**.
(49) Referring to FIG. **13**, an inductance of each of the second matching circuit **120** and the third matching circuit **130** may be a fixed value, and the length of the first groove **210** and of the second groove **220** may be fixed. By synchronously adjusting an inductance of each of the first switching circuit **140** and the second switching circuit **150**, the middle frequency (1710-2170 MHz) mode and the high frequency (2496-2690 MHz) offset can be adjusted, for receiving and transmitting wireless signals in the middle frequency (1710-2170 MHz) and the high frequency (2496-2690 MHz).
(50) FIG. **14** is a graph of scattering parameters (S parameters) of the antenna structure **100** of the fourth embodiment when the first switching circuit **140** and the second switching circuit **150** are synchronously changed. Wherein, a curve S**401** is a graph of S parameters of the antenna structure **100** of the fourth embodiment when each of the first switching circuit **140** and the second switching circuit **150** has an inductance of 0 nH; a curve S**402** is a graph of S parameters of the antenna structure **100** of the fourth embodiment when each of the first switching circuit **140** and the second switching circuit **150** has an inductance of 3 nH; a curve S**403** is a graph of S parameters of the antenna structure **100** of the fourth embodiment when each of the first switching circuit **140** and the second switching circuit **150** has an inductance of 6 nH; a curve S**404** is a graph of S parameters of the antenna structure **100** of the fourth embodiment when each of the first switching circuit **140** and the second switching circuit **150** has an inductance of 9 nH; a curve S**405** is a graph of S parameters of the antenna structure **100** of the fourth embodiment when each of the first switching circuit **140** and the second switching circuit **150** has an inductance of 12 nH. Comparing the curves S**901**, S**902**, S**903**, S**904**, and S**905**, synchronous adjustment of the inductances of each of the first switching circuit **140** and the second switching circuit **150**, provides a shift of the middle frequency (1710-2170 MHz) mode and the high frequency (2496-2690 MHz) mode towards a higher frequency when the value of inductance is decreased; when the inductance is increased, the middle frequency (1710-2170 MHz) mode and the high frequency (2496-2690 MHz) mode are shifted towards the middle frequency.
(51) The antenna structure and the wireless communication device of the present disclosure may transmit and receive wireless signals in the middle frequency (1710-2170 MHz) and the high frequency (2496-2690 MHz) ranges covering 4G LTE, and additional frequencies are obtainable by adding adjusting structures and adding an antenna circuit switching platform, such additions allowing adjustment of the middle frequency and the high frequency ranges.
(52) The embodiments shown and described above are only examples. Even though numerous characteristics and advantages of the present technology have been set forth in the foregoing description, together with details of the structure and function of the present disclosure, the disclosure is illustrative only, and changes may be made in the detail, including in matters of shape, size and arrangement of the parts within the principles of the present disclosure, up to and including the full extent established by the broad general meaning of the terms used in the claims.

Claims

1. An antenna structure applied in a wireless communication device, the antenna structure comprising: a metal frame, the metal frame defining a first gap, a second gap, a third gap, a first radiating portion, a second radiating portion, and a third radiating portion, wherein a portion of the metal frame between the first gap and the second gap forming the first radiating portion, a portion of the metal frame between the first gap and the third gap and a portion of the metal frame on a side of the third gap away from the first radiating portion cooperatively forming the second radiating portion, a portion of the metal frame on a side of the second gap opposite to the first radiation

portion forming the third radiating portion; a feeding portion electrically connected to the first radiating portion; a first ground portion spaced apart from the feeding portion and electrically connected to the first radiating portion; and a second ground portion near the second gap and electrically connected to the third radiating portion, wherein when the feeding portion feeding current, the first radiating portion conducting the current to the second gap, the third radiating portion coupling the current and conducting the current to ground through the second ground portion, thereby exciting a first mode to generate a radiation signal in a first radiation frequency band; and when the feeding portion feeding current, the first radiating portion conducting the current to the first gap and the third gap, the second radiating portion coupling the current and conducting the current to ground through the first ground portion, thereby exciting a second mode to generate a radiation signal in a second radiation frequency band; wherein the antenna structure further comprises a first matching circuit, a second matching circuit, and a third matching circuit; the wireless communication device further comprises a first circuit board and a battery; wherein the feeding portion is electrically connected to a feed source of the first circuit board through the first matching circuit to feed current; the first ground portion is grounded through the second matching circuit to ground the antenna structure; the second ground portion is grounded through the third matching circuit to ground the antenna structure; wherein the antenna structure further comprises a second switch and a second switching circuit; the second switch is spaced apart from the first circuit board and the third radiating portion; one end of the second switch is electrically connected to the third radiating portion, the other end of the second switch is grounded, the second switch is configured to adjust the first radiation frequency band of the third radiating portion; the second switching circuit comprises the second switch; the third radiating portion is spaced apart from the first circuit board to form a second groove; an inductance of each of the first matching circuit and the second matching circuit is a fixed value, a length of the second groove is fixed, the first radiation frequency band is adjustable by adjusting an inductance of the second switching circuit, for receiving and transmitting wireless signals in a middle frequency band.

2. The antenna structure of claim 1, wherein the second radiating portion is spaced apart from the battery to form a first groove; an inductance of each of the feeding portion, the first matching circuit, and the second matching circuit is a fixed value, the second radiation frequency band is adjustable by adjusting a length of the first groove.

3. The antenna structure of claim 1, further comprising a first switch, wherein the wireless communication device comprises a second circuit board, the second circuit board is spaced apart from the second radiating portion; the first switch is spaced apart from the second radiating portion and the second circuit board; one end of the first switch is electrically connected to the second radiating portion, the other end of the first switch is grounded, the first switch is configured to adjust the second radiating frequency band of the second radiating portion.

4. The antenna structure of claim 3, wherein the antenna structure further comprises a first switching circuit; the first switching circuit comprises the first switch; an inductance of each of the second matching circuit and the third matching circuit is a fixed value, a length of each of a first groove and the second groove is fixed, the first radiating frequency band and the second radiating frequency band are adjustable by synchronously adjusting an inductance of each of the first switching circuit and the second switching circuit, for transmitting and receiving wireless signals in a middle frequency band and a high frequency band.

5. A wireless communication device comprising an antenna structure, the antenna structure comprising: a metal frame, the metal frame defining a first gap, a second gap, a third gap, a first radiating portion, a second radiating portion, and a third radiating portion, wherein a portion of the metal frame between the first gap and the second gap forming the first radiating portion, a portion of the metal frame between the first gap and the third gap and a portion of the metal frame on a side of the third gap away from the first radiating portion cooperatively forming the second radiating portion, a portion of the metal frame on a side of the second gap opposite to the first radiation

portion forming the third radiating portion; a feeding portion electrically connected to the first radiating portion; a first ground portion spaced apart from the feeding portion and electrically connected to the first radiating portion; and a second ground portion near the second gap and electrically connected to the third radiating portion, wherein when the feeding portion feeding current, the first radiating portion conducting the current to the second gap, the third radiating portion coupling the current and conducting the current to ground through the second ground portion, thereby exciting a first mode to generate a radiation signal in a first radiation frequency band; and when the feeding portion feeding current, the first radiating portion conducting the current to the first gap and the third gap, the second radiating portion coupling the current and conducting the current to ground through the first ground portion, thereby exciting a second mode to generate a radiation signal in a second radiation frequency band; wherein the antenna structure further comprises a first matching circuit, a second matching circuit, and a third matching circuit; the wireless communication device further comprises a first circuit board and a battery; wherein the feeding portion is electrically connected to a feed source of the first circuit board through the first matching circuit to feed current; the first ground portion is grounded through the second matching circuit to ground the antenna structure; the second ground portion is grounded through the third matching circuit to ground the antenna structure; wherein the antenna structure further comprises a second switch and a second switching circuit; the second switch is spaced apart from the first circuit board and the third radiating portion; one end of the second switch is electrically connected to the third radiating portion, the other end of the second switch is grounded, the second switch is configured to adjust the first radiation frequency band of the third radiating portion; the second switching circuit comprises the second switch; the third radiating portion is spaced apart from the first circuit board to form a second groove; an inductance of each of the first matching circuit and the second matching circuit is a fixed value, a length of the second groove is fixed, the first radiation frequency band is adjustable by adjusting an inductance of the second switching circuit, for receiving and transmitting wireless signals in a middle frequency band.

6. The wireless communication device of claim 5, wherein the second radiating portion is spaced apart from the battery to form a first groove; an inductance of each of the feeding portion, the first matching circuit, and the second matching circuit is a fixed value, the second radiation frequency band is adjustable by adjusting a length of the first groove.

7. The wireless communication device of claim 5, wherein the antenna structure further comprises a first switch, the second circuit board is spaced apart from the second radiating portion; the first switch is spaced apart from the second radiating portion and the second circuit board; one end of the first switch is electrically connected to the second radiating portion, the other end of the first switch is grounded, the first switch is configured to adjust the second radiating frequency band of the second radiating portion.

8. The wireless communication device of claim 7, wherein the antenna structure further comprises a first switching circuit; the first switching circuit comprises the first switch; an inductance of each of the second matching circuit and the third matching circuit is a fixed value, a length of each of the first groove and the second groove is fixed, the first radiation frequency band and the second radiating frequency band are adjustable by synchronously adjusting an inductance of each of the first switching circuit and the second switching circuit, for transmitting and receiving wireless signals in a middle frequency band and a high frequency band.