



US 20230238687A1

(19) **United States**

(12) **Patent Application Publication**  
**GONZALEZ et al.**

(10) **Pub. No.: US 2023/0238687 A1**

(43) **Pub. Date: Jul. 27, 2023**

(54) **ANTENNA DEVICE WITH RADIATING LOOP**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(72) Inventors: **Ignacio GONZALEZ**, Munich (DE);  
**Bruno BISCONTINI**, Munich (DE);  
**Dmitrij SEMILOVSKY**, Munich (DE)

(21) Appl. No.: **18/192,842**

(22) Filed: **Mar. 30, 2023**

**Related U.S. Application Data**

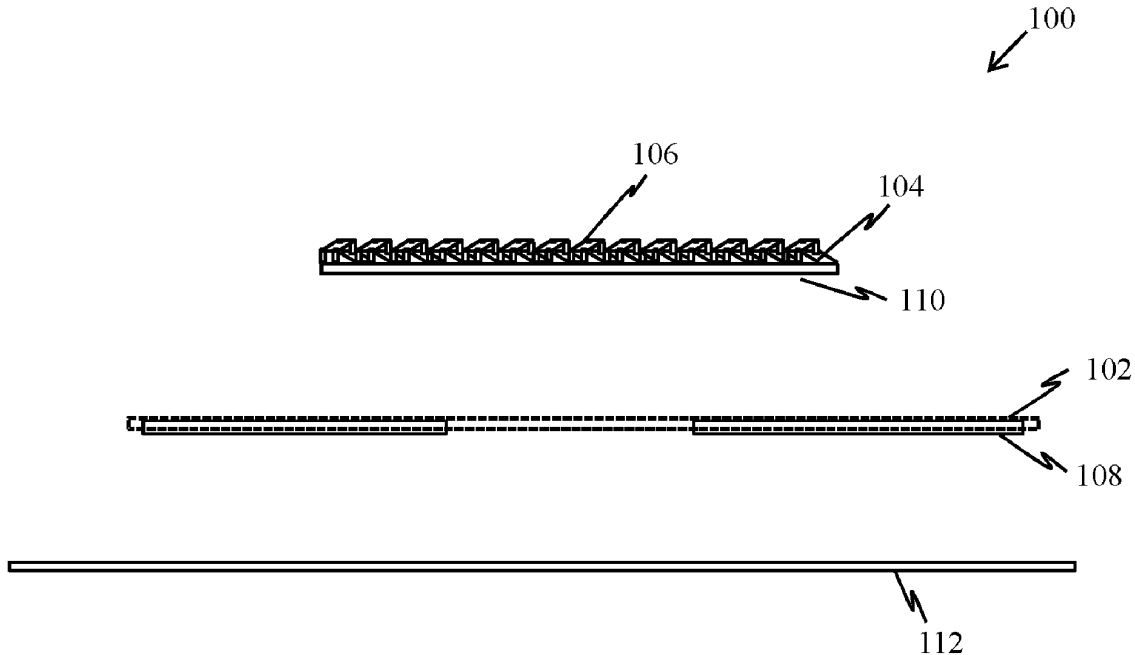
(63) Continuation of application No. PCT/EP2020/077793, filed on Oct. 5, 2020.

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 7/00** (2006.01)  
**H01Q 5/378** (2006.01)  
(52) **U.S. Cl.**  
CPC ..... **H01Q 1/246** (2013.01); **H01Q 7/00** (2013.01); **H01Q 5/378** (2015.01)

(57) **ABSTRACT**

An antenna device. The antenna device includes a first radiating structure that operates at a first frequency band. A second radiating structure operates at a second frequency band. The second radiating structure includes a radiating loop formed along a closed line, wherein the radiating loop is made as a coil extending along the closed line and is electrically invisible at the first frequency band. The second radiating structure operates at the second frequency band that does not affect the performance of the first radiating structure that operate at the first frequency band even when both radiating structures are placed in the vicinity of each other.





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(19) **United States**

(12) **Patent Application Publication**  
YU et al.

(10) **Pub. No.: US 2023/0238705 A1**

(43) **Pub. Date: Jul. 27, 2023**

(54) **ANTENNA AND PREPARATION METHOD THEREOF, MILLIMETER-WAVE SENSOR, AND TERMINAL**

(30) **Foreign Application Priority Data**

Sep. 30, 2020 (CN) ..... 202011066537.X

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

**Publication Classification**

(72) Inventors: **Tingting YU**, Shenzhen (CN); **Haowei LI**, Xi'an (CN); **Xiang GAO**, Xi'an (CN); **Yiting LIU**, Xi'an (CN); **Chen YAN**, Xi'an (CN)

(51) **Int. Cl.**  
*H01Q 9/04* (2006.01)  
*G01S 13/02* (2006.01)  
*H01Q 21/06* (2006.01)

(21) Appl. No.: **18/192,436**

(52) **U.S. Cl.**  
CPC ..... *H01Q 9/0457* (2013.01); *G01S 13/02* (2013.01); *H01Q 21/061* (2013.01)

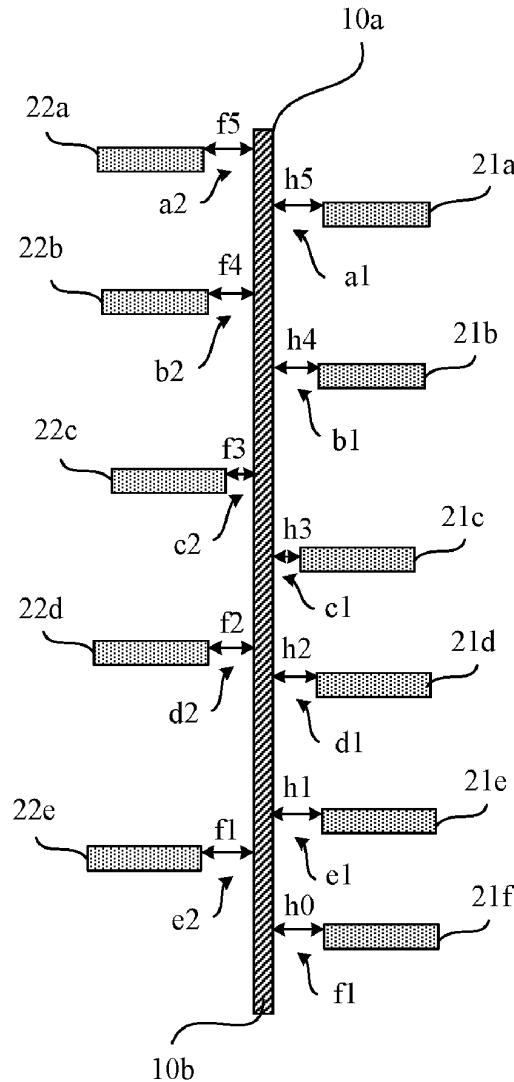
(22) Filed: **Mar. 29, 2023**

(57) **ABSTRACT**

**Related U.S. Application Data**

Embodiments of this application provide an antenna and a preparation method thereof, a millimeter-wave sensor, and a terminal. Gaps exist between a plurality of coupling stubs and a microstrip feeder.

(63) Continuation of application No. PCT/CN2021/114809, filed on Aug. 26, 2021.





US 20230238714A1

(19) **United States**

(12) **Patent Application Publication**  
**Makiyama et al.**

(10) **Pub. No.: US 2023/0238714 A1**

(43) **Pub. Date: Jul. 27, 2023**

(54) **DUAL POLARIZED FOLDED DIPOLE  
ELEMENT AND ANTENNA**

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/24** (2013.01); **H01Q 5/48**  
(2015.01); **H01Q 5/392** (2015.01)

(71) Applicant: **DKK Co., Ltd.**, Tokyo (JP)

(72) Inventors: **Sadayuki Makiyama**, Tokyo (JP);  
**Hiroataka Ogura**, Tokyo (JP)

(57) **ABSTRACT**

(21) Appl. No.: **18/153,444**

(22) Filed: **Jan. 12, 2023**

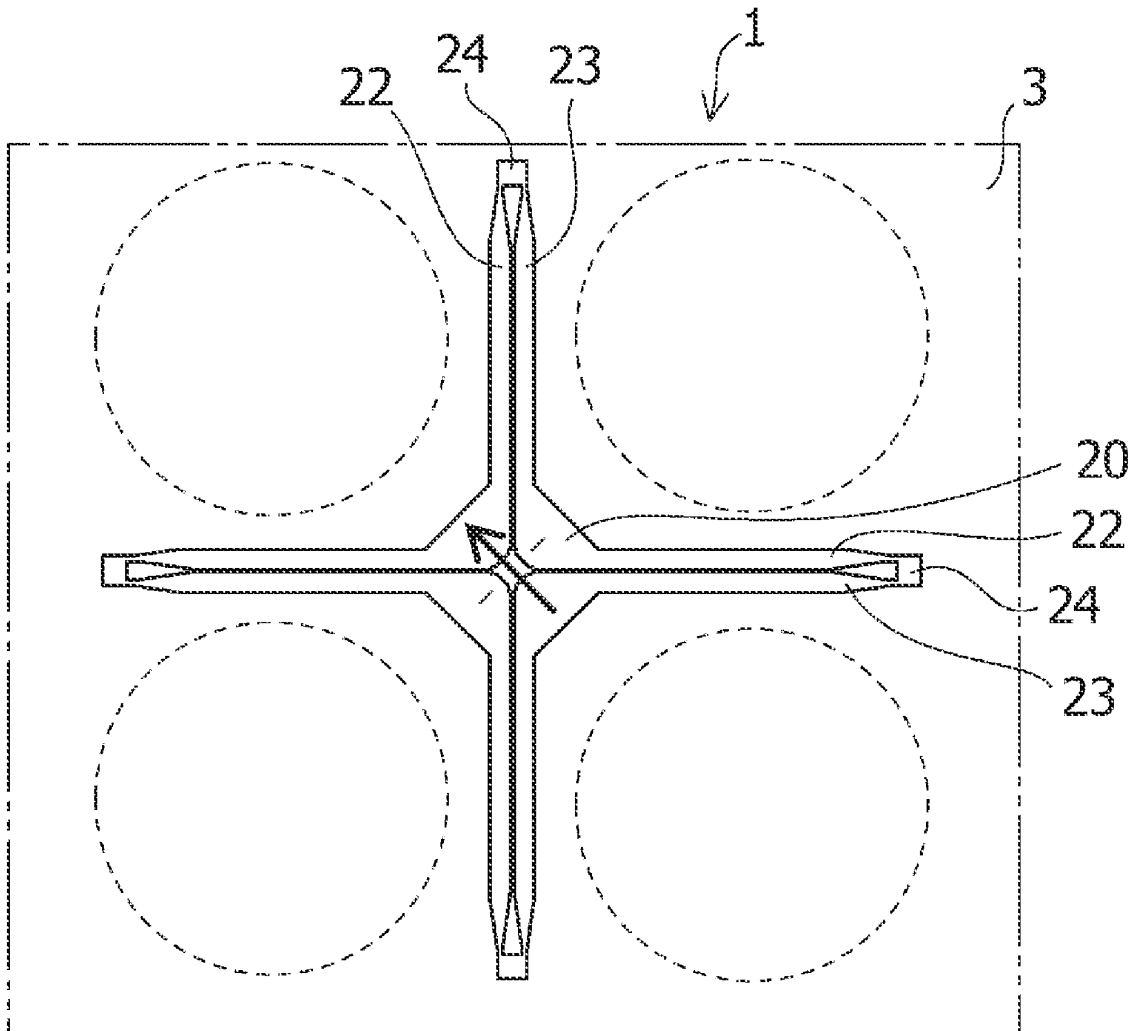
Provided is a dual polarized folded dipole element **1** including: four center portions **20** arranged adjacent to each other; and an element portion including two parallel wire portions **22, 23** extending in parallel to each other from different adjacent two of the center portions **20** and a short circuit portion **24** that short-circuits each two parallel wire portions **22, 23** at a distal end, in which: adjacent two of the center portions are physically connected to each other by the element portion; and the element portion extends in substantially the same plane in four directions from the center portions **20** with an angle of 90° therebetween. Also provided are antennae **10** and **10'** including the dual polarized folded dipole element **1**.

(30) **Foreign Application Priority Data**

Jan. 21, 2022 (JP) ..... 2022-007806

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 21/24** (2006.01)  
**H01Q 5/48** (2006.01)  
**H01Q 5/392** (2006.01)





US 20230238717A1

(19) **United States**

(12) **Patent Application Publication**  
**WANG et al.**

(10) **Pub. No.: US 2023/0238717 A1**

(43) **Pub. Date: Jul. 27, 2023**

(54) **TERMINAL ANTENNA AND TERMINAL ELECTRONIC DEVICE**

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/30** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/0407** (2013.01)

(71) Applicant: **HONOR DEVICE CO., LTD.**, Futian District, SHENZHEN (CN)

(72) Inventors: **Yi WANG**, Shenzhen (CN); **Chongfeng ZHAO**, Shenzhen (CN); **Kunpeng WEI**, Shenzhen (CN)

(57) **ABSTRACT**

(21) Appl. No.: **18/008,907**

(22) PCT Filed: **May 12, 2022**

(86) PCT No.: **PCT/CN2022/092521**

§ 371 (c)(1),  
(2) Date: **Dec. 7, 2022**

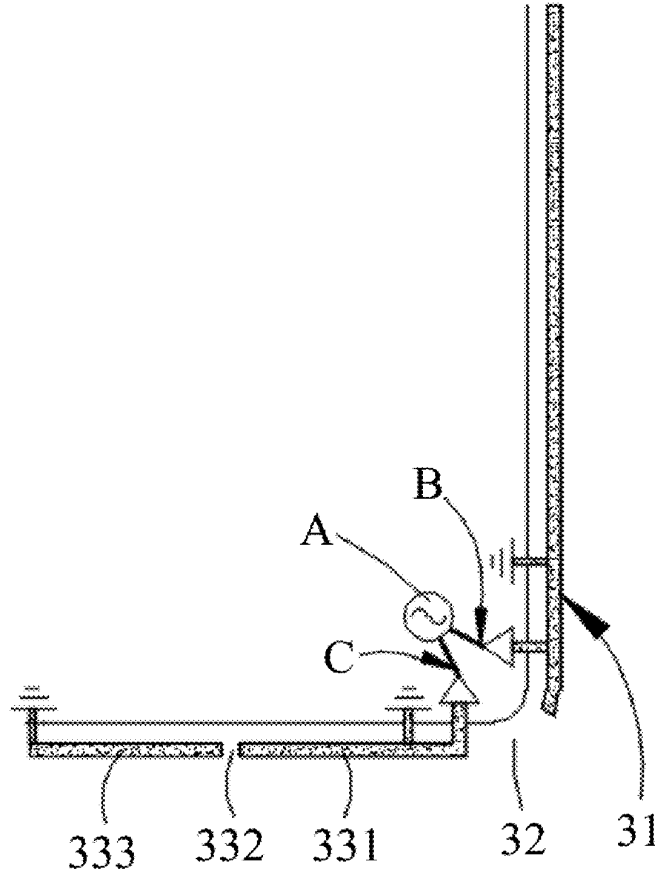
(30) **Foreign Application Priority Data**

May 28, 2021 (CN) ..... 202110594251.7

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 21/30** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 9/04** (2006.01)

This application provides a terminal antenna, including a first radiator, a second radiator, a third radiator, a first regulating circuit, and a second regulating circuit. The third radiator includes a low frequency radiator and a medium-high frequency radiator. The first regulating circuit is configured to adjust a frequency of a resonance of a  $\frac{3}{4}\lambda$ , mode of a medium-high frequency produced by the low frequency radiator to be less than a frequency of a resonance of a left-handed antenna pattern. The second regulating circuit is configured to adjust the frequency of the resonance of the left-handed antenna pattern to be greater than the frequency of the resonance of the  $\frac{3}{4}\lambda$ , mode of the medium-high frequency produced by resonating by the low frequency radiator. Values of both the first distance and the second distance are less than  $\frac{1}{16}\lambda$ , of a frequency band in which the third radiator produces a low frequency.





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(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2023/0239385 A1**

**LEE et al.**

(43) **Pub. Date: Jul. 27, 2023**

(54) **ANTENNA AND ELECTRONIC APPARATUS INCLUDING SAME**

(52) **U.S. Cl.**  
CPC ..... **H04M 1/0277** (2013.01); **H01Q 1/243** (2013.01)

(71) Applicant: **Samsung Electronics Co., Ltd.**,  
Suwon-si (KR)

(72) Inventors: **Hyungjoo LEE**, Suwon-si (KR);  
**Gyusub KIM**, Suwon-si (KR);  
**Hosaeng KIM**, Suwon-si (KR)

(57) **ABSTRACT**

(21) Appl. No.: **18/189,772**

An electronic apparatus is provided. The electronic device includes a lateral member including a first conductive part disposed between a first non-conductive part formed on a first lateral surface and a second non-conductive part formed on a second lateral surface, a second conductive part disposed between the first non-conductive part and a third non-conductive part formed on a third lateral surface, and a third conductive part disposed on the second lateral surface and facing the first conductive part, a wireless communication circuit electrically connected to a first point of the first conductive part, a first switching circuit for electrically connecting the wireless communication circuit to a second point of the second conductive part, a second switching circuit for connecting the first conductive part to the third conductive part, and at least one processor for controlling the first switching circuit and the second switching circuit.

(22) Filed: **Mar. 24, 2023**

**Related U.S. Application Data**

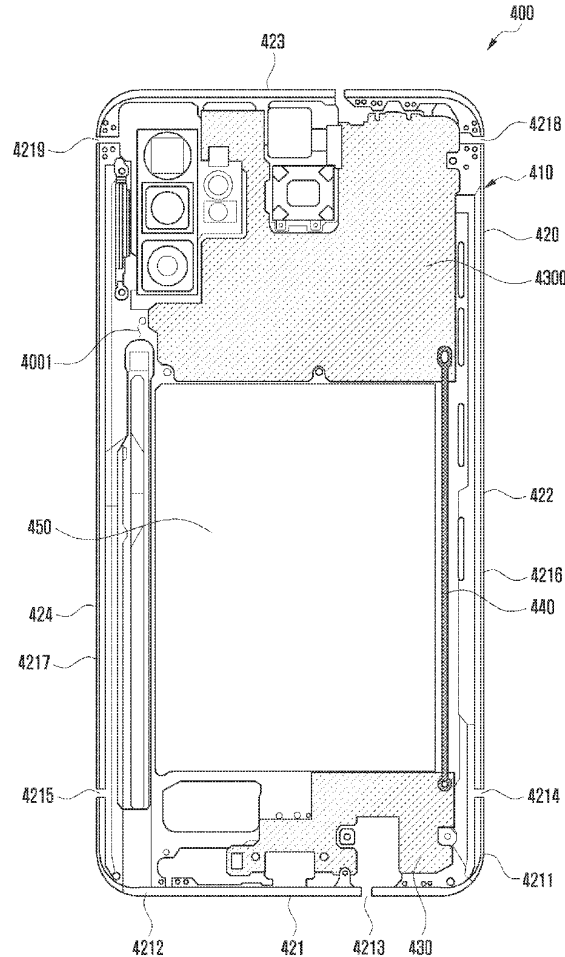
(63) Continuation of application No. PCT/KR2021/013001, filed on Sep. 24, 2021.

(30) **Foreign Application Priority Data**

Oct. 7, 2020 (KR) ..... 10-2020-0129571

**Publication Classification**

(51) **Int. Cl.**  
**H04M 1/02** (2006.01)  
**H01Q 1/24** (2006.01)





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(19) **United States**

(12) **Patent Application Publication**  
**WOO et al.**

(10) **Pub. No.: US 2023/0246326 A1**

(43) **Pub. Date: Aug. 3, 2023**

(54) **ELECTRONIC DEVICE EQUIPPED WITH ANTENNA MODULE**

*H01Q 9/04* (2006.01)

*H01Q 3/36* (2006.01)

*H01Q 9/28* (2006.01)

(71) Applicant: **LG ELECTRONICS INC.**, Seoul (KR)

(52) **U.S. Cl.**

CPC ..... *H01Q 1/243* (2013.01); *H01Q 1/48* (2013.01); *H01Q 9/0407* (2013.01); *H01Q 3/36* (2013.01); *H01Q 9/28* (2013.01)

(72) Inventors: **Seungmin WOO**, Seoul (KR); **Yusuhk SUH**, Seoul (KR); **Dongik LEE**, Seoul (KR)

(73) Assignee: **LG ELECTRONICS INC.**, Seoul (KR)

(57) **ABSTRACT**

(21) Appl. No.: **18/002,957**

(22) PCT Filed: **Jul. 22, 2020**

(86) PCT No.: **PCT/KR2020/009638**

§ 371 (c)(1),

(2) Date: **Dec. 22, 2022**

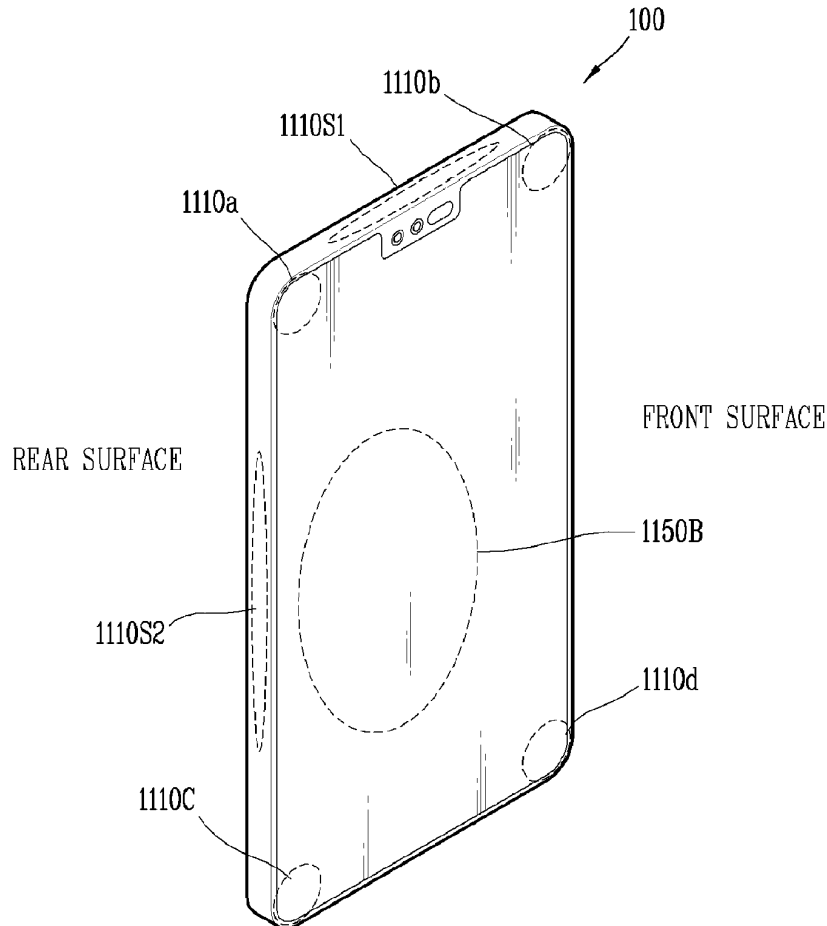
**Publication Classification**

(51) **Int. Cl.**

*H01Q 1/24* (2006.01)

*H01Q 1/48* (2006.01)

Provided is an electronic device having a multilayer substrate according to an embodiment. The electronic device may include a multilayer substrate on which an antenna is disposed and which includes a front layer, a back layer, a plurality of middle layers, and a plurality of ground layers. The antenna may include a lower patch that is disposed on a layer different from an upper ground among the plurality of ground layers and is electrically connected to the upper ground at a plurality of offset points; and an upper patch disposed spaced apart from the lower patch by a predetermined distance.





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(19) **United States**

(12) **Patent Application Publication**  
TSAI et al.

(10) **Pub. No.: US 2023/0246328 A1**

(43) **Pub. Date: Aug. 3, 2023**

(54) **MOBILE DEVICE**

*H01Q 9/04* (2006.01)

(71) Applicant: **HTC Corporation**, Taoyuan City (TW)

*H04M 1/02* (2006.01)

(72) Inventors: **Tiao-Hsing TSAI**, Taoyuan City (TW);  
**Chien-Pin CHIU**, Taoyuan City (TW);  
**Hsiao-Wei WU**, Taoyuan City (TW);  
**Li-Yuan FANG**, Taoyuan City (TW);  
**Shen-Fu TZENG**, Taoyuan City (TW);  
**Yi-Hsiang KUNG**, Taoyuan City (TW)

*H01Q 21/28* (2006.01)

*H01Q 9/42* (2006.01)

(52) **U.S. Cl.**

CPC ..... *H01Q 1/243* (2013.01); *H01Q 5/335*  
(2015.01); *H01Q 9/04* (2013.01); *H04M 1/026*  
(2013.01); *H01Q 21/28* (2013.01); *H01Q 9/42*  
(2013.01)

(73) Assignee: **HTC Corporation**, Taoyuan City (TW)

(21) Appl. No.: **18/297,325**

(57) **ABSTRACT**

(22) Filed: **Apr. 7, 2023**

**Related U.S. Application Data**

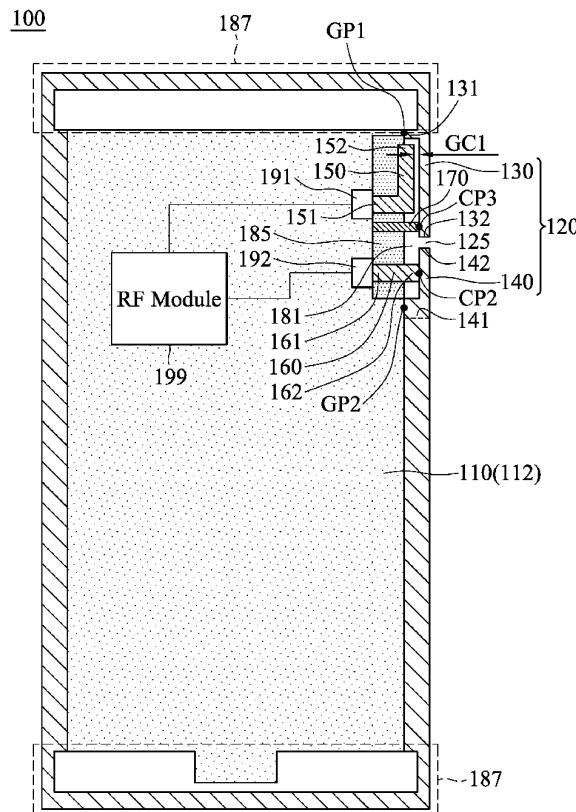
(63) Continuation of application No. 17/038,963, filed on Sep. 30, 2020, now Pat. No. 11,664,583, which is a continuation of application No. 15/722,355, filed on Oct. 2, 2017, now Pat. No. 10,879,588.

(60) Provisional application No. 62/439,356, filed on Dec. 27, 2016.

**Publication Classification**

(51) **Int. Cl.**  
*H01Q 1/24* (2006.01)  
*H01Q 5/335* (2006.01)

A mobile device includes a system circuit board, a metal frame, one or more other antenna elements, a display device, a first feeding element, and an RF (Radio Frequency) module. The system circuit board includes a system ground plane. The metal frame at least includes a first portion and a second portion. The metal frame at least has a first cut point positioned between the first portion and the second portion. The metal frame further has a second cut point for separating the other antenna elements from the first portion. The first cut point is arranged to be close to a middle region of the display device. The first feeding element is directly or indirectly electrically connected to the first portion. A first antenna structure is formed by the first feeding element and the first portion.





US 20230246333A1

(19) **United States**

(12) **Patent Application Publication**  
**Gaier et al.**

(10) **Pub. No.: US 2023/0246333 A1**

(43) **Pub. Date: Aug. 3, 2023**

(54) **MULTIBAND LOOP ANTENNA**

*H01Q 5/378* (2006.01)

*H01Q 5/357* (2006.01)

(71) Applicant: **BSH Hausgeräte GmbH**, München (DE)

(52) **U.S. Cl.**

CPC ..... *H01Q 5/321* (2015.01); *H01Q 7/00* (2013.01); *H01Q 1/22* (2013.01); *H01Q 5/378* (2015.01); *H01Q 5/357* (2015.01)

(72) Inventors: **Stefan Gaier**, Stuttgart (DE); **Matthias Lungwitz**, Mössingen (DE)

(21) Appl. No.: **18/011,933**

(57) **ABSTRACT**

(22) PCT Filed: **Jul. 8, 2021**

A multiband loop antenna includes a first, electrically conductive, L-shaped partial structure on a first layer of a printed circuit board. The first partial structure has a first resonant frequency and a feed point of the antenna. The multiband loop antenna includes a second, electrically conductive, L-shaped partial structure on the first layer of the circuit board. The second partial structure is configured for a second resonant frequency. The first partial structure and the second partial structure are capacitively coupled to one another in a coupling region. The multiband loop antenna includes an electrically conductive first reference region. The first partial structure and the second partial structure are disposed on the first layer of the circuit board in such a way that they form a loop together with the first reference region. A household appliance including a communication unit having the multiband loop antenna is also provided.

(86) PCT No.: **PCT/EP2021/068996**

§ 371 (c)(1),

(2) Date: **Dec. 21, 2022**

(30) **Foreign Application Priority Data**

Jul. 29, 2020 (DE) ..... 10 2020 209 545.0

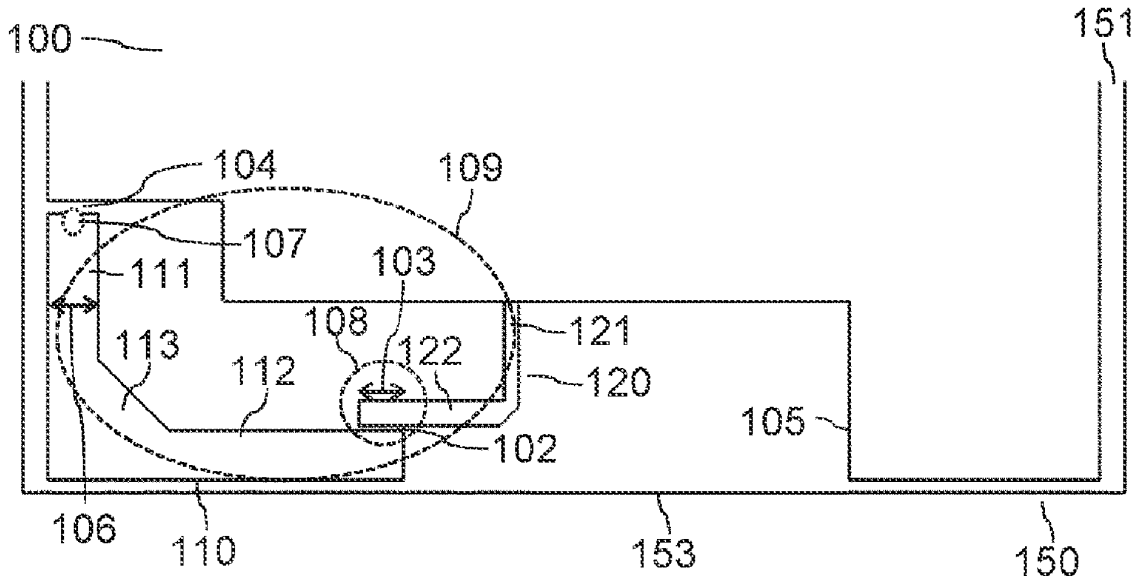
**Publication Classification**

(51) **Int. Cl.**

*H01Q 5/321* (2006.01)

*H01Q 7/00* (2006.01)

*H01Q 1/22* (2006.01)







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(19) **United States**

(12) **Patent Application Publication**  
**Wu et al.**

(10) **Pub. No.: US 2023/0246335 A1**

(43) **Pub. Date: Aug. 3, 2023**

(54) **ANTENNA APPARATUS AND ELECTRONIC DEVICE**

(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen, Guangdong (CN)

(72) Inventors: **Pengfei Wu**, Shanghai (CN); **Hanyang Wang**, Reading (CN); **Dong Yu**, Shanghai (CN); **CHIEN-MING LEE**, Shenzhen (CN); **Liang Xue**, Shanghai (CN)

(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen, Guangdong (CN)

(21) Appl. No.: **18/009,810**

(22) PCT Filed: **Jun. 15, 2021**

(86) PCT No.: **PCT/CN2021/100089**

§ 371 (c)(1),

(2) Date: **Dec. 12, 2022**

(30) **Foreign Application Priority Data**

Jun. 15, 2020 (CN) ..... 202010544996.8

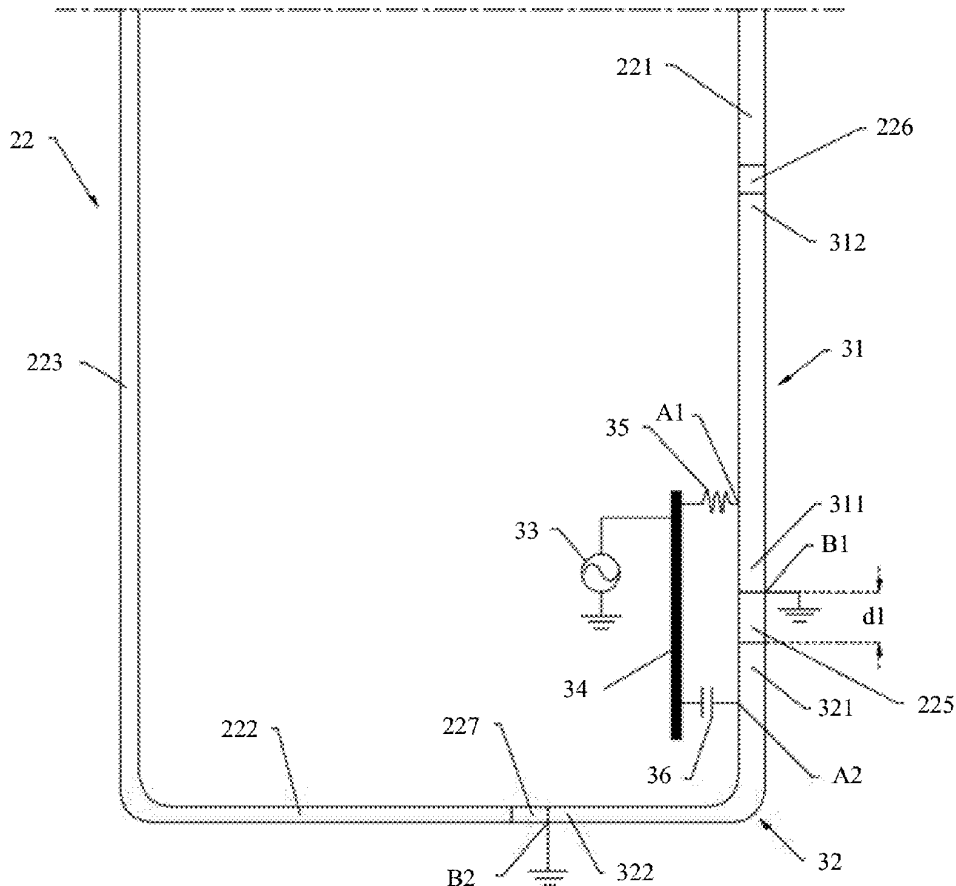
**Publication Classification**

(51) **Int. Cl.**  
*H01Q 5/50* (2006.01)  
*H01Q 1/52* (2006.01)  
*H01Q 5/335* (2006.01)  
*H01Q 1/24* (2006.01)

(52) **U.S. Cl.**  
 CPC ..... *H01Q 5/50* (2015.01); *H01Q 1/521* (2013.01); *H01Q 5/335* (2015.01); *H01Q 1/243* (2013.01)

(57) **ABSTRACT**

An antenna apparatus and an electronic device. The antenna apparatus includes a feed source, a transmission line, a first radiator including a first feed point, and a second radiator including a second feed point. The transmission line is electrically connected to the feed source. A second end part of the second radiator is disposed away from the first radiator compared to the first end part of the second radiator, a first gap is formed between the first end part of the first radiator and the first end part of the second radiator, the first end part of the first radiator is a ground end, and the first end part of the second radiator is an open end. The two feed points are electrically connected to the transmission line, and the transmission line input a radio frequency signal in a same frequency band to the two feed points.





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(19) **United States**  
 (12) **Patent Application Publication** (10) **Pub. No.: US 2023/0246339 A1**  
**HONG et al.** (43) **Pub. Date: Aug. 3, 2023**

(54) **ANTENNA STRUCTURE INCLUDING PATCH ANTENNA AND ELECTRONIC DEVICE INCLUDING SAME**

(52) **U.S. Cl.**  
 CPC ..... *H01Q 9/0414* (2013.01);  
*H01Q 1/422* (2013.01)

(71) Applicant: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(57) **ABSTRACT**

(72) Inventors: **Yonguei HONG**, Suwon-si (KR);  
**Yonghyun YOON**, Suwon-si (KR);  
**Youngjun CHO**, Suwon-si (KR)

An electronic device according to an embodiment may include: a housing forming at least a part of an exterior of the electronic device; a printed circuit board (PCB) disposed in the housing; a dielectric layer disposed between the PCB and the housing and comprising a first surface facing a surface of the housing and a second surface facing the PCB; a patch antenna disposed on the first surface of the dielectric layer and electrically connected to a first point of the PCB; a conductive plate disposed adjacent to the second surface of the dielectric layer, connected to a ground on the PCB through a second point spaced apart from the first point, and overlapping with the patch antenna; and a wireless communication circuit electrically connected to the PCB, wherein the wireless communication circuit is configured to feed power to the patch antenna through the first point of the PCB to transmit or receive a first signal of a first frequency band, and to transmit and/or receive a second signal of a second frequency band different from the first frequency band through a first electric path including the patch antenna, the conductive plate, and the ground.

(21) Appl. No.: **18/299,916**

(22) Filed: **Apr. 13, 2023**

**Related U.S. Application Data**

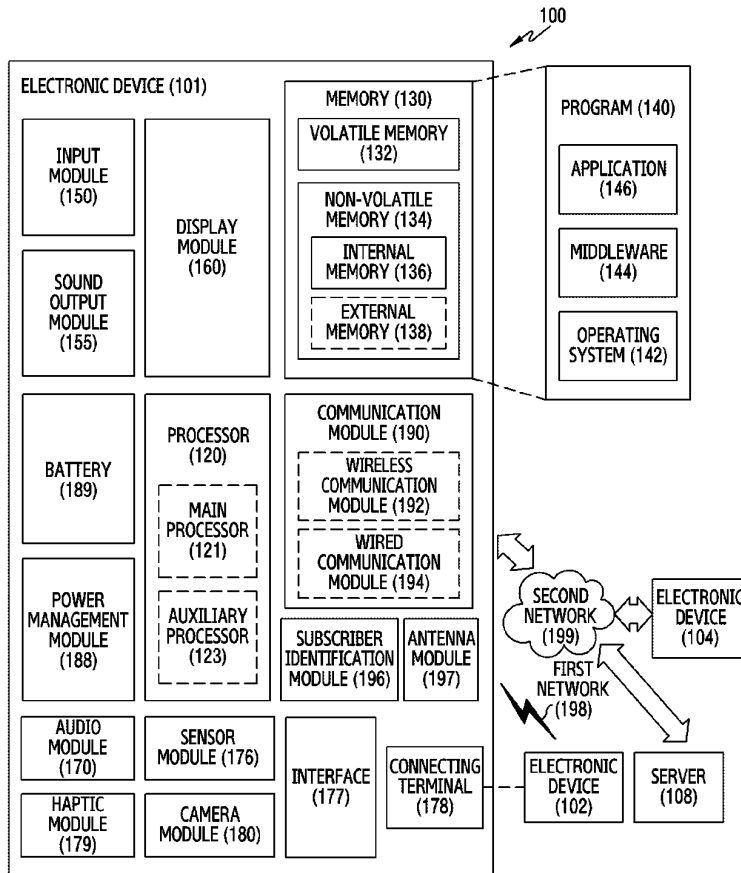
(63) Continuation of application No. PCT/KR2022/011512, filed on Aug. 4, 2022.

**Foreign Application Priority Data**

(30) Sep. 27, 2021 (KR) ..... 10-2021-0127326

**Publication Classification**

(51) **Int. Cl.**  
*H01Q 9/04* (2006.01)  
*H01Q 1/42* (2006.01)





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(19) **United States**

(12) **Patent Application Publication**  
**YUN et al.**

(10) **Pub. No.: US 2023/0247121 A1**

(43) **Pub. Date: Aug. 3, 2023**

(54) **ELECTRONIC DEVICE COMPRISING AN ANTENNA**

*H01Q 1/24* (2006.01)

*H04B 1/00* (2006.01)

*H04M 1/22* (2006.01)

(71) Applicant: **Samsung Electronics Co., Ltd.**,  
Suwon-si (KR)

(52) **U.S. Cl.**

CPC ..... *H04M 1/0266* (2013.01); *H01Q 1/38*

(2013.01); *H01Q 1/243* (2013.01); *H04B*

*1/0053* (2013.01); *H04M 1/22* (2013.01)

(72) Inventors: **Sumin YUN**, Suwon-si (KR); **Hosaeng KIM**, Suwon-si (KR); **Kookjoo LEE**, Suwon-si (KR); **Jaehoon JO**, Suwon-si (KR); **Jaebong CHUN**, Suwon-si (KR); **Jinwoo JUNG**, Suwon-si (KR); **Hochul HWANG**, Suwon-si (KR)

(57)

**ABSTRACT**

(21) Appl. No.: **18/131,784**

An electronic device includes a display having a plurality of layers; a conductive mesh pattern disposed on a first layer among the plurality of layers and formed adjacent to a first edge of the display; a feeding line connecting from the first edge to the conductive mesh pattern; and a wireless communication circuit electrically connected to the feeding line and feeding electricity to the conductive mesh pattern through the feeding line, wherein the first layer includes the conductive mesh pattern and a dummy pattern in a first area in an area surrounding the conductive mesh pattern, the first area corresponding to an area between the conductive mesh pattern and the first edge, the dummy pattern being spaced apart from the feeding line, and the first layer does not include a conductive pattern in a second area remaining after excluding the first area from the area surrounding the conductive mesh pattern.

(22) Filed: **Apr. 6, 2023**

**Related U.S. Application Data**

(63) Continuation of application No. PCT/KR2021/013025, filed on Sep. 24, 2021.

(30) **Foreign Application Priority Data**

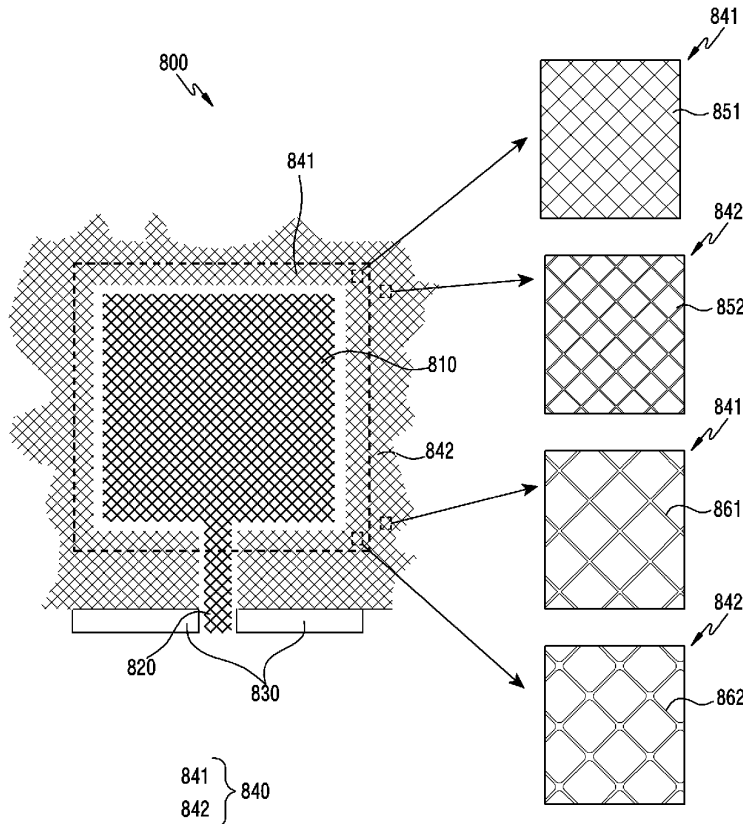
Oct. 7, 2020 (KR) ..... 10-2020-0129608

**Publication Classification**

(51) **Int. Cl.**

*H04M 1/02* (2006.01)

*H01Q 1/38* (2006.01)





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(19) **United States**  
(12) **Patent Application Publication** (10) **Pub. No.: US 2023/0253706 A1**  
**YANG et al.** (43) **Pub. Date: Aug. 10, 2023**

(54) **ANTENNA STRUCTURE AND MOBILE DEVICE**

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/307** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/50** (2015.01)

(71) Applicant: **Wistron Corp.**, New Taipei City (TW)

(57) **ABSTRACT**

(72) Inventors: **Cheng-Chieh YANG**, New Taipei City (TW); **Chih-Ming CHEN**, New Taipei City (TW); **Po-Yu CHEN**, New Taipei City (TW)

An antenna structure includes a feeding radiation element, a first radiation element, a second radiation element, a third radiation element, a fourth radiation element, a fifth radiation element, and a switch circuit. The feeding radiation element has a feeding point. The second radiation element is coupled through the first radiation element to the feeding radiation element. The third radiation element is coupled to the second radiation element. The fourth radiation element is coupled to the second radiation element. The fourth radiation element and the third radiation element extend in different directions. The fifth radiation element has a tuning point, and is coupled to the feeding radiation element. The feeding radiation element is disposed between the first radiation element and the fifth radiation element. The switch circuit selectively couples the tuning point to a ground voltage.

(21) Appl. No.: **17/700,136**

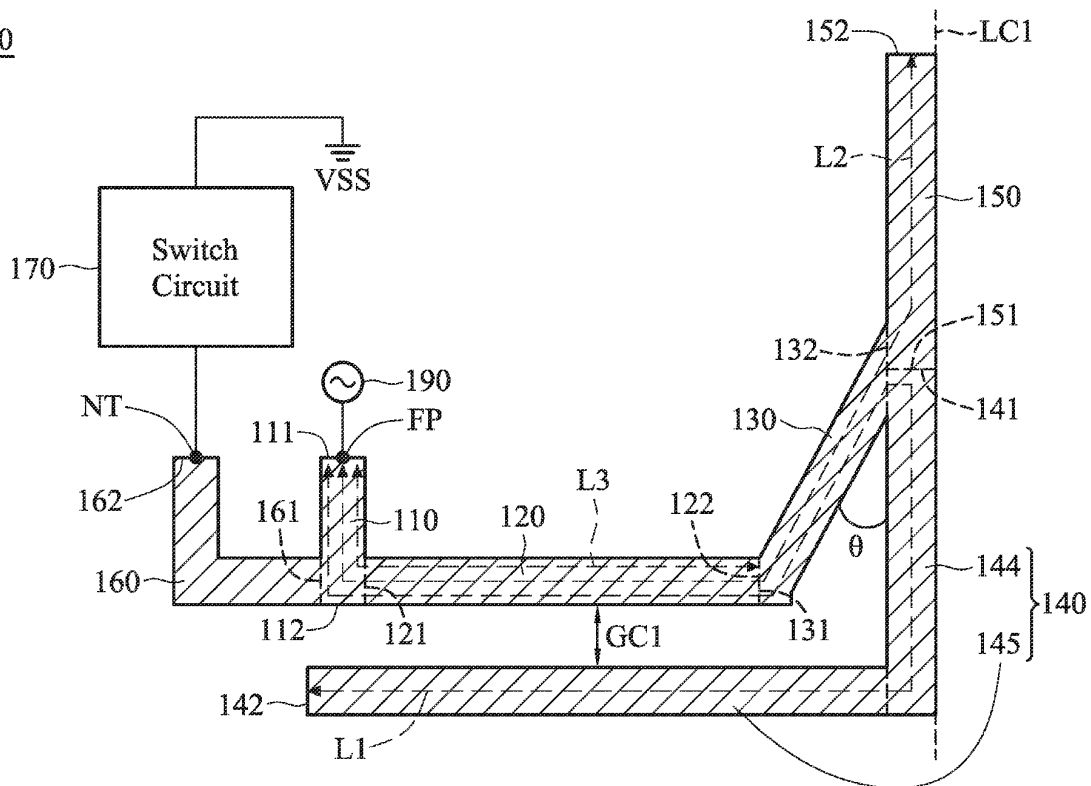
(22) Filed: **Mar. 21, 2022**

(30) **Foreign Application Priority Data**  
Feb. 9, 2022 (TW) ..... 111104696

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 5/307** (2006.01)  
**H01Q 5/50** (2006.01)  
**H01Q 1/24** (2006.01)

100





(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2023/0253992 A1**  
**YU et al.** (43) **Pub. Date: Aug. 10, 2023**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA**

(52) **U.S. Cl.**  
CPC ..... *H04B 1/0064* (2013.01); *H01Q 1/48* (2013.01); *H01Q 1/243* (2013.01); *H01Q 9/045* (2013.01); *H01Q 21/30* (2013.01); *H04M 1/0277* (2013.01)

(71) Applicant: **SAMSUNG ELECTRONICS CO., LTD.**, Suwon-si (KR)

(72) Inventors: **Changha YU**, Suwon-si (KR); **Yunsik KIM**, Suwon-si (KR); **Woosuk KANG**, Suwon-si (KR); **Mincheol SEO**, Suwon-si (KR); **Gyubok PARK**, Suwon-si (KR); **Donghun SHIN**, Suwon-si (KR); **Minkyung LEE**, Suwon-si (KR)

(57) **ABSTRACT**

An electronic device may include a housing including a first side surface and a second side surface; a support member disposed inside the housing and connected to a part of the first and second side surfaces; a first opening formed between the first side surface and the support member, and a second opening formed among a part of the first side surface, the second side surface, and the support member; a printed circuit board disposed on the support member and having a ground; a first conductive portion disposed between a first segmenting portion formed in the first side surface and a second segmenting portion formed in the second side surface, and including a first ground portion, a first feeding point, a first point, and/or a second point; a second conductive portion disposed between the first segmenting portion and a third segmenting portion formed in the first side surface, and including a second feeding point, a second ground portion, a third feeding point, and/or a third ground portion; a wireless communication circuit electrically connected to the first feeding point, the second feeding point, and/or the third feeding point; a processor electrically connected to the wireless communication circuit; and a first matching circuit electrically connected to the ground and the first point and/or a second matching circuit electrically connected to the ground and the second point, wherein the first conductive portion and at least a part of the second conductive portion may be configured to operate as at least one antenna, depending on an operation of the first matching circuit or the second matching circuit corresponding to control of the processor. Other various embodiments are possible.

(21) Appl. No.: **18/098,332**

(22) Filed: **Jan. 18, 2023**

**Related U.S. Application Data**

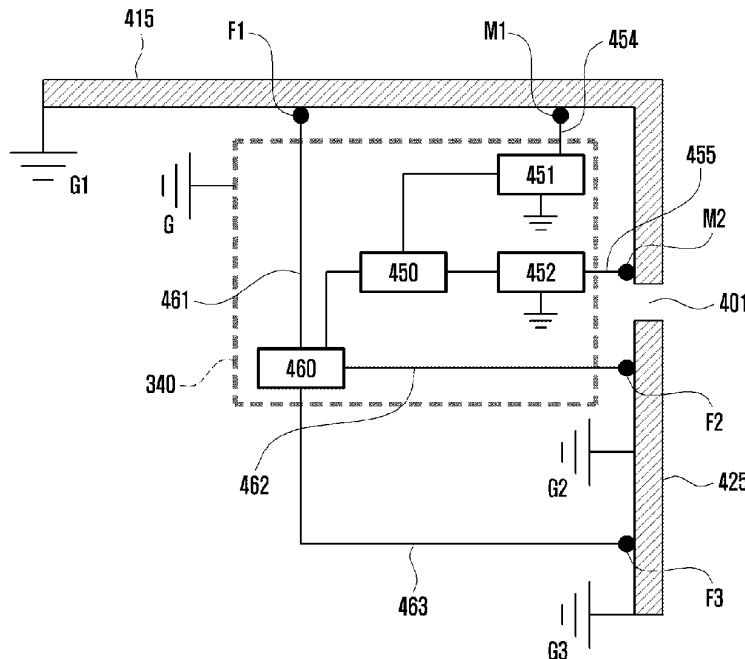
(63) Continuation of application No. PCT/KR2022/020297, filed on Dec. 14, 2022.

**Foreign Application Priority Data**

Feb. 8, 2022 (KR) ..... 10-2022-0016196

**Publication Classification**

(51) **Int. Cl.**  
*H04B 1/00* (2006.01)  
*H01Q 1/48* (2006.01)  
*H01Q 1/24* (2006.01)  
*H01Q 9/04* (2006.01)  
*H01Q 21/30* (2006.01)  
*H04M 1/02* (2006.01)





US 20230259179A1

(19) **United States**

(12) **Patent Application Publication**  
**CHANG et al.**

(10) **Pub. No.: US 2023/0259179 A1**

(43) **Pub. Date: Aug. 17, 2023**

(54) **HOUSINGS FOR ELECTRONIC DEVICES**

**Publication Classification**

(71) Applicant: **Hewlett-Packard Development Company, L.P.**, Spring, TX (US)

(51) **Int. Cl.**  
*G06F 1/16* (2006.01)  
*H01Q 1/22* (2006.01)  
*H01Q 1/40* (2006.01)

(72) Inventors: **CHI HAO CHANG**, TAIPEI CITY (TW); **HENDRY HUANG**, TAIPEI CITY (TW); **KUAN-TING WU**, TAIPEI CITY (TW)

(52) **U.S. Cl.**  
CPC ..... *G06F 1/1698* (2013.01); *G06F 1/1656* (2013.01); *H01Q 1/22* (2013.01); *H01Q 1/40* (2013.01)

(73) Assignee: **Hewlett-Packard Development Company, L.P.**, Spring, TX (US)

(57) **ABSTRACT**

(21) Appl. No.: **18/011,493**

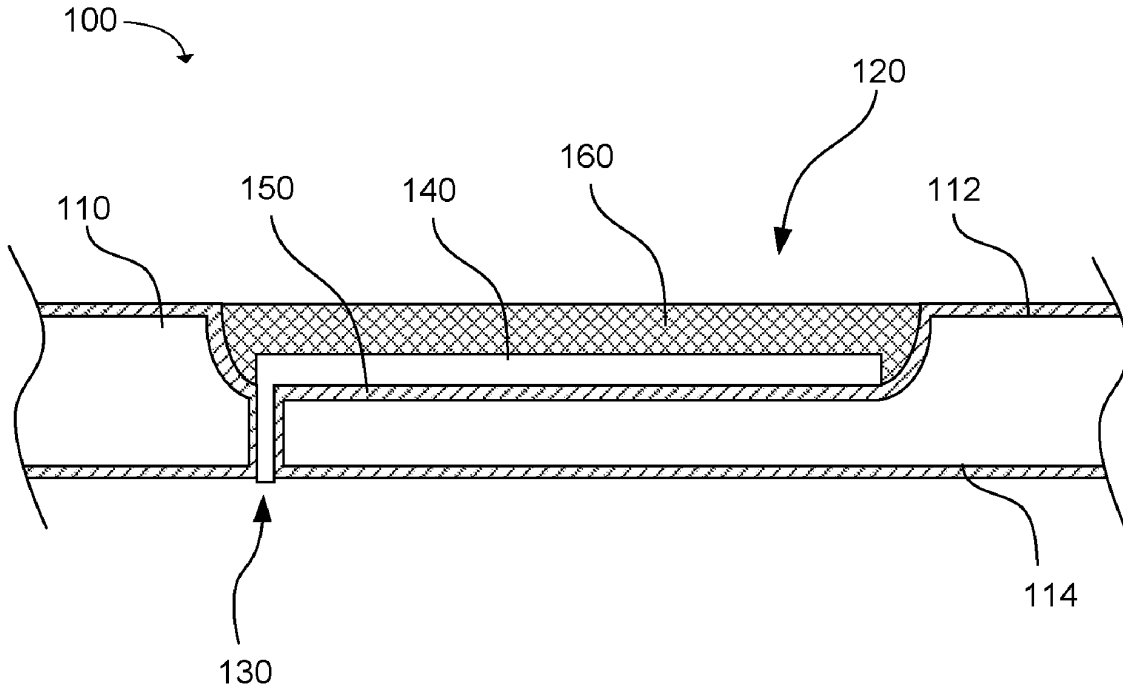
(22) PCT Filed: **Jul. 27, 2020**

(86) PCT No.: **PCT/US2020/043667**

§ 371 (c)(1),

(2) Date: **Dec. 19, 2022**

The present disclosure is drawn to housings for electronic devices. In one example, a housing for an electronic device can include a rigid substrate having an exterior surface including a recessed region positioned at an opening extending through the rigid substrate connecting the recessed region to an interior surface of the rigid substrate. A conductive metal antenna is conformally carried by the recessed region and positioned at the opening.





US 20230261362A1

(19) **United States**

(12) **Patent Application Publication**  
**Compton et al.**

(10) **Pub. No.: US 2023/0261362 A1**

(43) **Pub. Date: Aug. 17, 2023**

(54) **ELECTRONIC DEVICES WITH DIELECTRIC RESONATOR ANTENNAS HAVING CONDUCTIVE WALLS**

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/0485** (2013.01); **H01Q 13/02** (2013.01)

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(57) **ABSTRACT**

(72) Inventors: **Lucas R. Compton**, San Francisco, CA (US); **Harish Rajagopalan**, San Jose, CA (US)

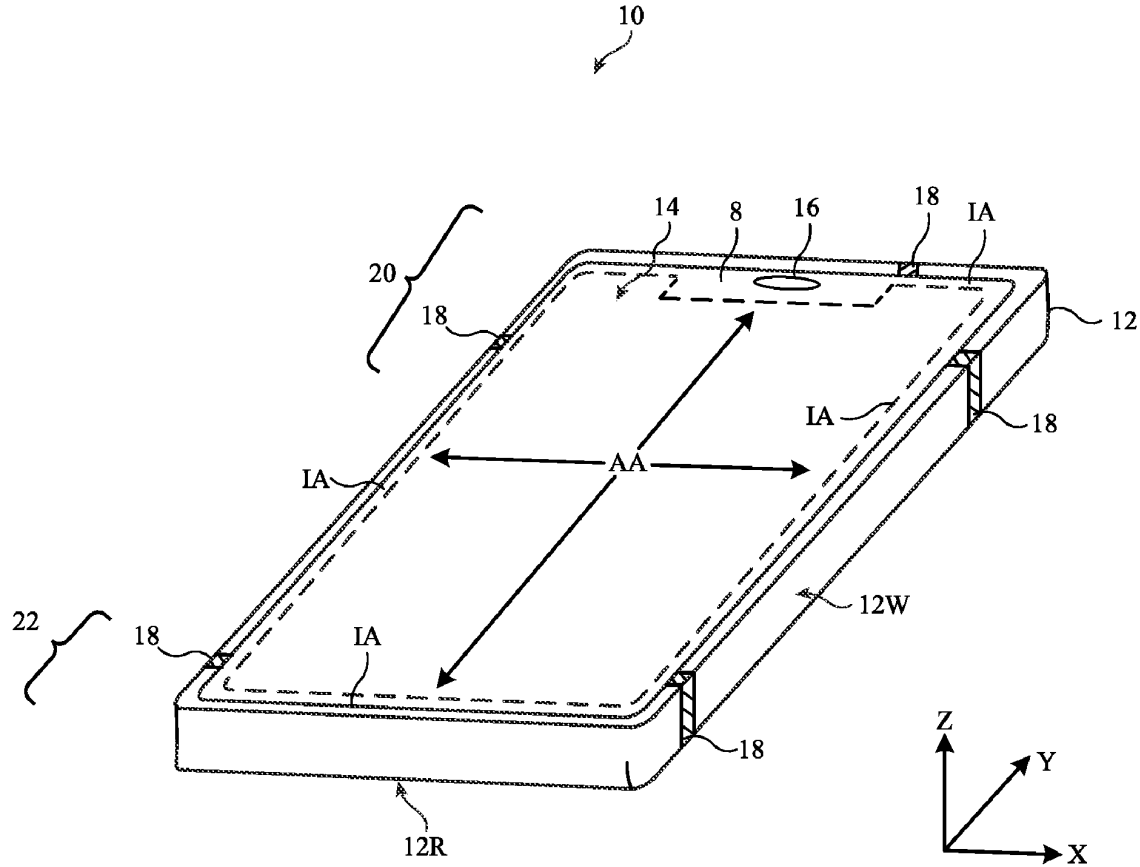
An electronic device may be provided with a phased antenna array that includes a dielectric resonator antenna having a dielectric column mounted to a circuit board. The dielectric column may be embedded in a dielectric substrate such as a plastic overmold. Conductive walls may be disposed on the dielectric substrate and may laterally surround the dielectric substrate and one or more dielectric resonating elements in the phased antenna array. The conductive walls may be grounded. The conductive walls may have a tapered shape. The conductive walls may help to isolate the antenna from electromagnetic influences from nearby conductive components in the electronic device. The conductive walls may form a conductive horn that helps to maximize the gain of the antenna in conveying radio-frequency signals greater than 10 GHz through a display cover layer, housing window, camera sapphire, or rear housing wall.

(21) Appl. No.: **17/669,983**

(22) Filed: **Feb. 11, 2022**

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 1/38** (2006.01)  
**H01Q 9/04** (2006.01)





US 20230261363A1

(19) **United States**

(12) **Patent Application Publication**  
**Compton et al.**

(10) **Pub. No.: US 2023/0261363 A1**

(43) **Pub. Date: Aug. 17, 2023**

(54) **ELECTRONIC DEVICES WITH BENT DIELECTRIC RESONATOR ANTENNAS**

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/24** (2013.01); **H05K 5/0017** (2013.01); **H01Q 15/14** (2013.01)

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(57) **ABSTRACT**

(72) Inventors: **Lucas R. Compton**, San Francisco, CA (US); **Harish Rajagopalan**, San Jose, CA (US); **James T. Handy**, San Francisco, CA (US)

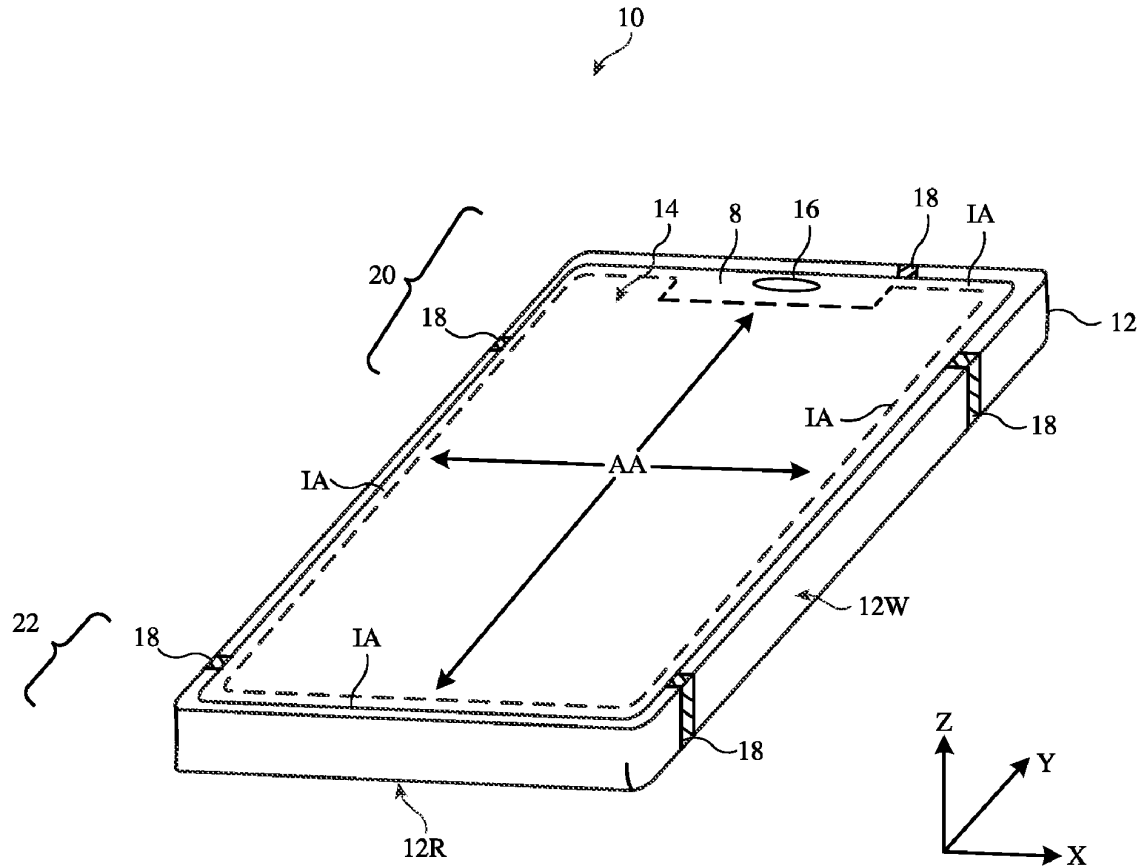
An electronic device may be provided with a phased antenna array having a bent dielectric resonating element. The bent dielectric resonating element may have a first segment, a second segment nonparallel to the first segment, and an angled surface that couples the first segment to the second segment. One or more feed probes may be coupled to the first segment to excite the dielectric resonating element. A reflector may be provided on the angled surface to direct electromagnetic energy from the first segment to the second segment and vice versa. The bent dielectric resonating element may exhibit less overall height than dielectric resonators having straight columns of dielectric material, thereby allowing for a reduction in the thickness of the electronic device. The angled surface and the reflector may optimize the radio-frequency performance of the antenna despite the reduction in overall height.

(21) Appl. No.: **17/670,020**

(22) Filed: **Feb. 11, 2022**

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H05K 5/00** (2006.01)  
**H01Q 15/14** (2006.01)







US 20230261364A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2023/0261364 A1**

**LIM et al.**

(43) **Pub. Date: Aug. 17, 2023**

(54) **ANTENNA AND ELECTRONIC DEVICE  
COMPRISING SAME**

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 5/335**  
(2015.01); **H04M 1/0216** (2013.01); **H04M**  
**1/0268** (2013.01); **H01Q 5/342** (2015.01);  
**H01Q 5/385** (2015.01)

(71) Applicant: **Samsung Electronics Co., Ltd.**,  
Gyeonggi-do (KR)

(72) Inventors: **Jae-Ho LIM**, Gyeonggi-do (KR);  
**Kyung-Jong LEE**, Gyeonggi-do (KR);  
**Hosaeng KIM**, Gyeonggi-do (KR);  
**Seunghwan KIM**, Gyeonggi-do (KR)

(57) **ABSTRACT**

Provided is an electronic device that includes a first housing including a first side facing a first direction, a second side facing a second direction opposite to the first direction, and a first lateral side surrounding at least part of a space between the first side and the second side, wherein the first lateral side includes a first conductive portion and a first non-conductive portion; a second housing including a third side facing a third direction, a fourth side facing a fourth direction opposite to the third direction, a second lateral side surrounding at least part of a space between the third side and the fourth side and a ground member, wherein the second lateral side includes a second conductive portion and a second non-conductive portion; a flexible display disposed in the first housing and the second housing; a connecting member which connects the first housing and the second housing such that the first housing and the second housing are folded to face each other, wherein when the first housing and the second housing are folded, the first non-conductive portion and the second non-conductive portion abut against each other; at least one wireless communication circuit electrically connected to the first conductive portion; and at least one switching circuit disposed in the second housing, wherein the at least one switching circuit is electrically connected between the second conductive portion and the ground member such that the second conductive portion can be selectively connected to the ground member, and wherein the first lateral side forms at least a part of an exterior of the electronic device.

(21) Appl. No.: **18/137,125**

(22) Filed: **Apr. 20, 2023**

**Related U.S. Application Data**

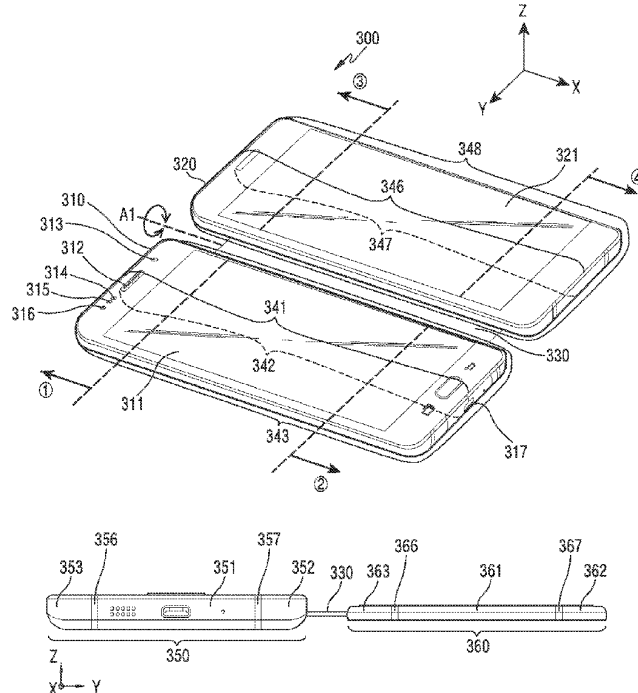
(63) Continuation of application No. 17/113,577, filed on Dec. 7, 2020, now Pat. No. 11,658,394, which is a continuation of application No. 16/095,618, filed on Oct. 22, 2018, now Pat. No. 10,879,589, filed as application No. PCT/KR2017/000984 on Jan. 26, 2017.

(30) **Foreign Application Priority Data**

Apr. 22, 2016 (KR) ..... 10-2016-0049632

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 5/335** (2006.01)  
**H04M 1/02** (2006.01)  
**H01Q 5/342** (2006.01)





US 20230261365A1

(19) **United States**

(12) **Patent Application Publication**  
**YOON et al.**

(10) **Pub. No.: US 2023/0261365 A1**

(43) **Pub. Date: Aug. 17, 2023**

(54) **ELECTRONIC DEVICE INCLUDING ANTENNA DEVICE**

*H01Q 1/48* (2006.01)

*H01Q 13/16* (2006.01)

*H04M 1/02* (2006.01)

*G06F 1/16* (2006.01)

(71) Applicant: **Samsung Electronics Co., Ltd.**,  
Suwon-si (KR)

(52) **U.S. Cl.**

CPC ..... *H01Q 1/243* (2013.01); *H01Q 1/42*  
(2013.01); *H01Q 1/48* (2013.01); *H01Q 13/16*  
(2013.01); *H04M 1/0216* (2013.01); *G06F*  
*1/1681* (2013.01)

(72) Inventors: **Shinho YOON**, Suwon-si (KR);  
**Dongjun OH**, Suwon-si (KR);  
**Jonghyuck LEE**, Suwon-si (KR);  
**Soonho HWANG**, Suwon-si (KR)

(21) Appl. No.: **18/305,764**

(57)

**ABSTRACT**

(22) Filed: **Apr. 24, 2023**

**Related U.S. Application Data**

(63) Continuation of application No. 17/957,631, filed on Sep. 30, 2022, now Pat. No. 11,637,363, which is a continuation of application No. 17/459,165, filed on Aug. 27, 2021, now Pat. No. 11,462,818, which is a continuation of application No. 16/794,859, filed on Feb. 19, 2020, now Pat. No. 11,139,554.

An electronic device is provided. The electronic device includes a first housing structure including a first side surface member, a second housing structure including a second side surface member, a hinge structure configured to rotatably connect the first housing structure and the second housing structure and configured to provide a folding axis on which the first housing structure and the second housing structure rotate, and at least one printed circuit board, wherein the first side surface member or the second side surface member includes a first side surface portion, a second side surface portion, a third side surface portion, a fourth side surface portion, a fifth side surface portion, a first slit, a second slit, a third slit, and a fourth slit, and wherein at least part of at least one of the second side surface portion, the third side surface portion, and the fourth side surface portion is formed of a radiation conductor and is electrically connected to the at least one printed circuit board.

(30) **Foreign Application Priority Data**

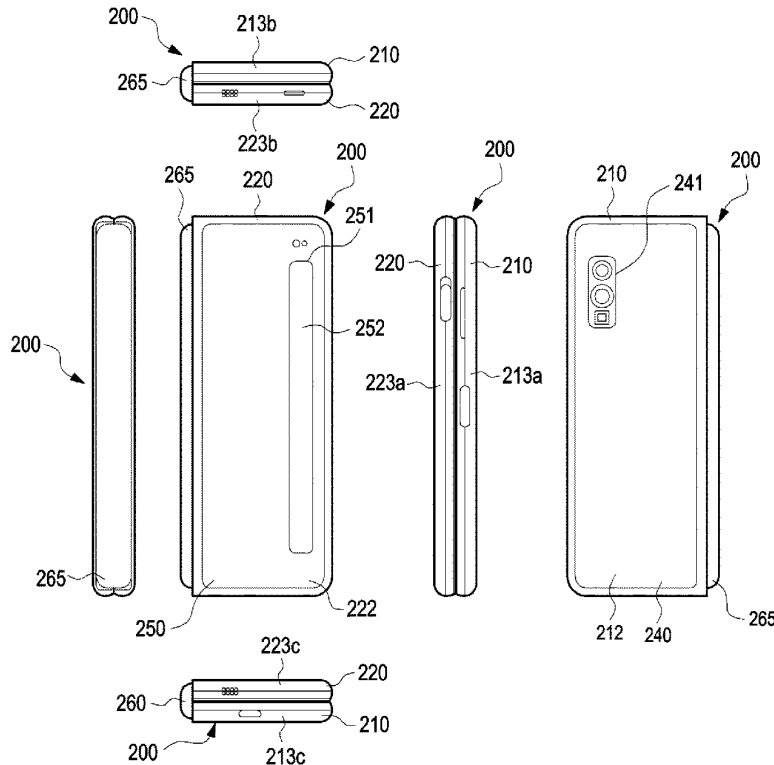
Feb. 19, 2019 (KR) ..... 10-2019-0019551  
Jul. 1, 2019 (KR) ..... 10-2019-0078718

**Publication Classification**

(51) **Int. Cl.**

*H01Q 1/24* (2006.01)

*H01Q 1/42* (2006.01)





US 20230261370A1

(19) **United States**

(12) **Patent Application Publication**  
**HU et al.**

(10) **Pub. No.: US 2023/0261370 A1**

(43) **Pub. Date: Aug. 17, 2023**

(54) **ANTENNA DECOUPLING STRUCTURE,  
MIMO ANTENNA, AND TERMINAL**

*H01Q 1/22* (2006.01)

*H01Q 21/00* (2006.01)

(71) Applicant: **HONOR DEVICE CO., LTD.**, Futian District, SHENZHEN (CN)

(52) **U.S. Cl.**  
CPC ..... *H01Q 1/521* (2013.01); *H01Q 1/48* (2013.01); *H01Q 9/0421* (2013.01); *H01Q 9/0457* (2013.01); *H01Q 1/2291* (2013.01); *H01Q 21/00* (2013.01)

(72) Inventors: **Yiwu HU**, Shenzhen (CN); **Kunpeng WEI**, Shenzhen (CN)

(21) Appl. No.: **18/013,338**

(57) **ABSTRACT**

(22) PCT Filed: **Apr. 25, 2022**

(86) PCT No.: **PCT/CN2022/089005**

§ 371 (c)(1),

(2) Date: **Dec. 28, 2022**

This application provides an antenna decoupling structure, a MIMO antenna, and a terminal. The antenna decoupling structure includes a grounding stub and a capacitor structure, where a first end of the grounding stub is connected to an antenna floor, to form an equivalent inductor; and a first end of the capacitor structure is connected to the antenna floor, and a second end of the capacitor structure is connected to a second end of the grounding stub, so that the equivalent inductor and the capacitor structure form an LC resonant structure, where a parameter corresponding to the LC resonant structure meets a decoupling requirement for at least one target decoupling frequency band. Because the resonant frequency depends on the inductance and the capacitance that correspond to the LC resonant structure, antenna miniaturization can be realized by reducing a size of each portion of the decoupling structure.

(30) **Foreign Application Priority Data**

May 6, 2021 (CN) ..... 202110490769.6

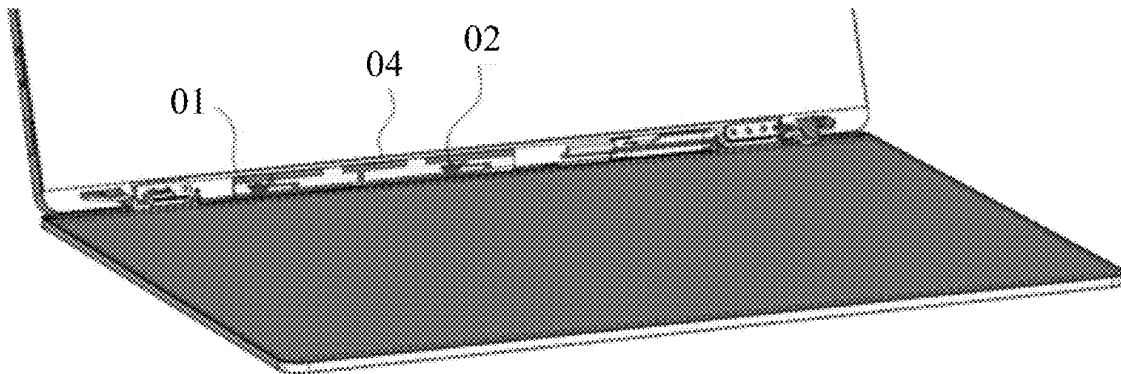
**Publication Classification**

(51) **Int. Cl.**

*H01Q 1/52* (2006.01)

*H01Q 1/48* (2006.01)

*H01Q 9/04* (2006.01)





US 20230261372A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2023/0261372 A1**  
**ZHAO et al.** (43) **Pub. Date: Aug. 17, 2023**

(54) **IMPROVEMENT ON ISOLATION BETWEEN ANTENNAS**

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/523** (2013.01); **H01Q 9/045** (2013.01); **H01Q 21/065** (2013.01)

(71) Applicant: **NOKIA TECHNOLOGIES OY**, Espoo (FI)

(72) Inventors: **Huaicheng ZHAO**, Hangzhou, Zhejiang (CN); **Yuanhao WANG**, Hangzhou, Zhejiang (CN); **Hao WANG**, Hangzhou, Zhejiang (CN)

(57) **ABSTRACT**

(21) Appl. No.: **18/011,657**

(22) PCT Filed: **Jun. 24, 2020**

(86) PCT No.: **PCT/CN2020/098219**

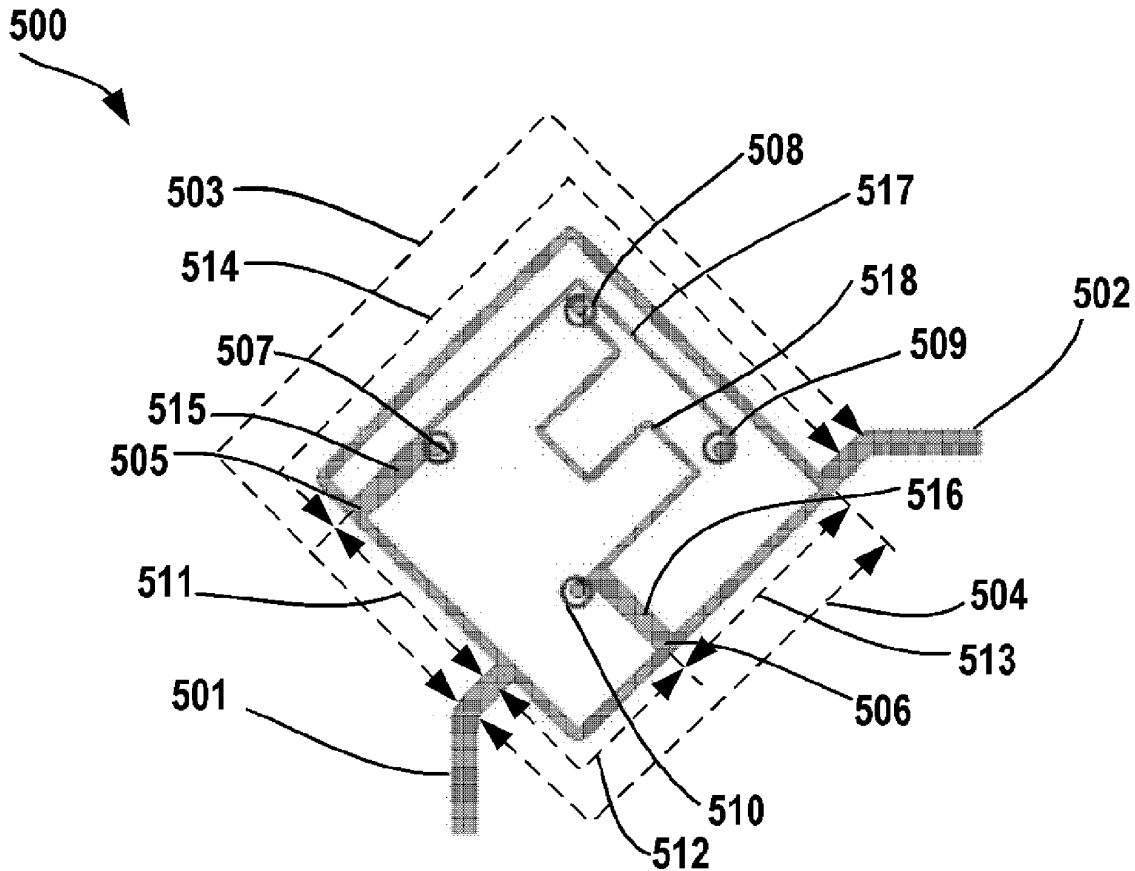
§ 371 (c)(1),

(2) Date: **Dec. 20, 2022**

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 1/52** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 21/06** (2006.01)

Embodiments of the present disclosure relate to improvement on isolation between antennas and provide an antenna, an antenna array comprising the antenna and a communication device comprising the antenna array. The antenna comprises an improved feeding network. The feeding network comprises: first and second ports each configured to transmit and/or receive a signal; first and second feed lines coupled in parallel between the first and second ports and formed into a continuous conductive loop; and first and second feeders each arranged to couple to a first node on the first feed line and to a radiating element of the antenna, and third and fourth feeders each arranged to couple to a second node on the second feed line and to the radiating element.





US 20230261388A1

(19) **United States**

(12) **Patent Application Publication**  
**HUANG**

(10) **Pub. No.: US 2023/0261388 A1**

(43) **Pub. Date: Aug. 17, 2023**

(54) **ANTENNA SYSTEM**

(52) **U.S. Cl.**

(71) Applicant: **Wistron NeWeb Corp.**, Hsinchu (TW)

CPC ..... **H01Q 19/108** (2013.01); **H01Q 19/106** (2013.01)

(72) Inventor: **Chun-Lin HUANG**, Hsinchu (TW)

(57) **ABSTRACT**

(21) Appl. No.: **18/155,338**

(22) Filed: **Jan. 17, 2023**

An antenna system includes a first antenna element, a second antenna element, a dielectric substrate, a first reflective plate, and a second reflective plate. The first antenna element and the second antenna element are disposed on the dielectric substrate. The first reflective plate is adjacent to the dielectric substrate. The second reflective plate is coupled to the first reflective plate. A first angle is formed between the first reflective plate and the second reflective plate. The antenna system provides a relative large HPBW (Half-Power Beamwidth).

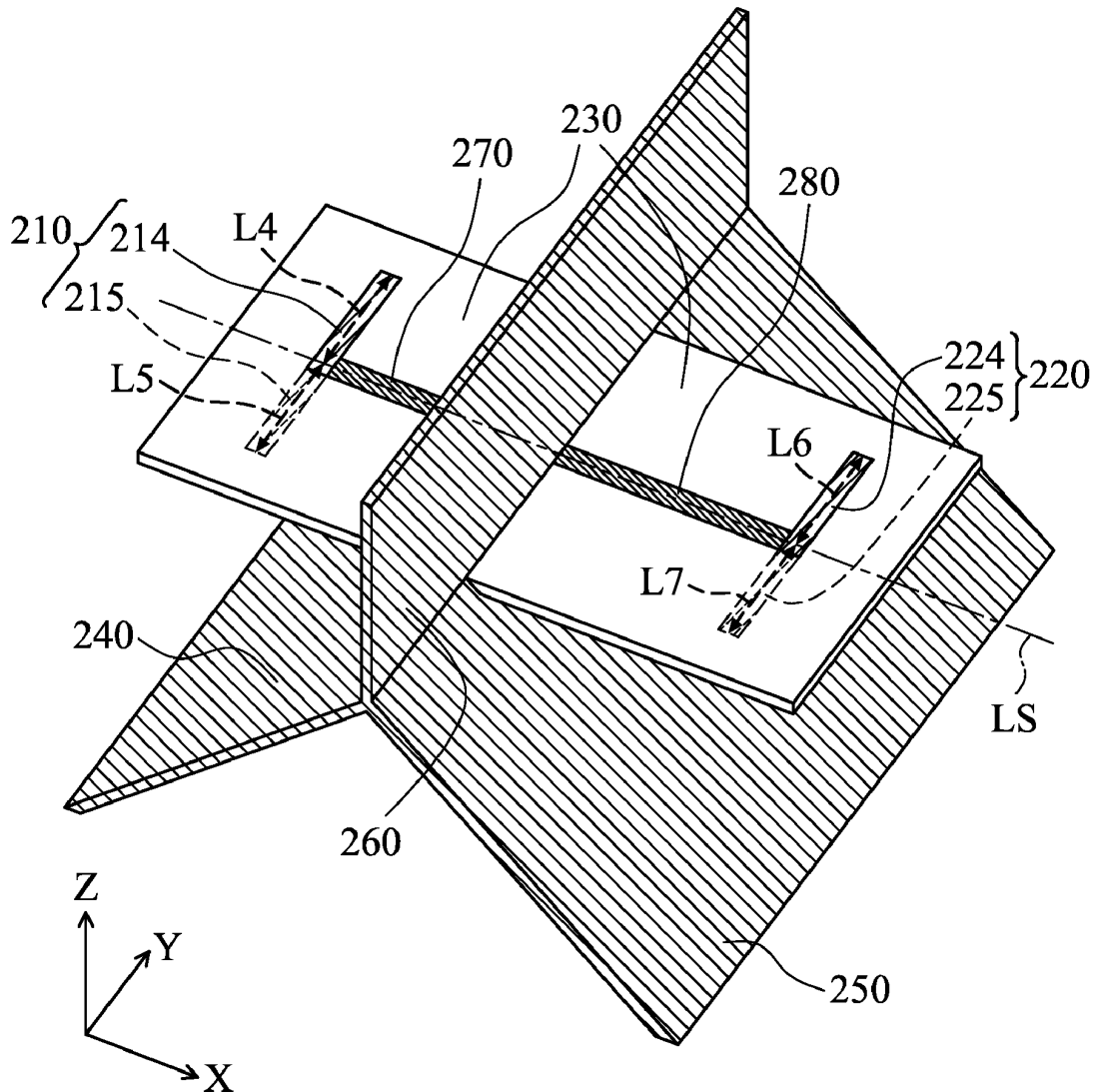
(30) **Foreign Application Priority Data**

Feb. 11, 2022 (TW) ..... 111105006

**Publication Classification**

(51) **Int. Cl.**  
**H01Q 19/10** (2006.01)

**200**





US 20230261391A1

(19) **United States**

(12) **Patent Application Publication**  
**Bao et al.**

(10) **Pub. No.: US 2023/0261391 A1**

(43) **Pub. Date: Aug. 17, 2023**

(54) **RADIATING ELEMENT, ANTENNA ARRAY,  
AND NETWORK DEVICE**

**Publication Classification**

(71) Applicant: **HUAWEI TECHNOLOGIES CO.,  
LTD.**, Shenzhen (CN)

(51) **Int. Cl.**  
*H01Q 21/06* (2006.01)  
*H01Q 21/26* (2006.01)

(72) Inventors: **Han Bao**, Dongguan (CN); **Fangjun  
Qin**, Shenzhen (CN); **Di Xue**,  
Dongguan (CN); **Yong Shao**, Dongguan  
(CN)

(52) **U.S. Cl.**  
CPC ..... *H01Q 21/062* (2013.01); *H01Q 21/26*  
(2013.01)

(73) Assignee: **HUAWEI TECHNOLOGIES CO.,  
LTD.**, Shenzhen (CN)

(57) **ABSTRACT**

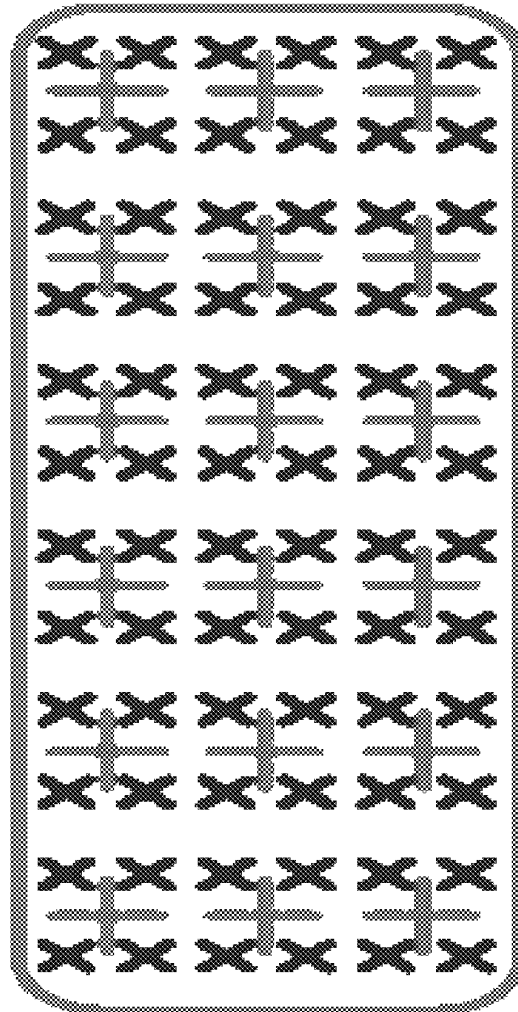
(21) Appl. No.: **18/302,009**

This disclosure provides a radiating element, an antenna array, and a network device, to improve polarization self-isolation inside a dipole in an antenna, and improve radiation performance of the antenna. The radiating element includes at least one dipole and a reflection plate, where the at least one dipole is disposed on a surface of the reflection plate; and each of the at least one dipole includes a radiation surface, the radiation surface includes a plurality of metal sheets forming a ring shape, at least two of the metal sheets of the at least one dipole are covered with a metal protrusion structure, and a length of the metal protrusion structure is less than lengths of the covered metal sheets.

(22) Filed: **Apr. 18, 2023**

**Related U.S. Application Data**

(63) Continuation of application No. PCT/CN2020/  
125231, filed on Oct. 30, 2020.





US 20230261393A1

(19) **United States**

(12) **Patent Application Publication**  
**YANG et al.**

(10) **Pub. No.: US 2023/0261393 A1**

(43) **Pub. Date: Aug. 17, 2023**

(54) **PATCH ANTENNA ARRAY**

*H01Q 5/364* (2006.01)

(71) Applicant: **QUALCOMM Incorporated**, San Diego, CA (US)

*H01Q 5/385* (2006.01)

(52) **U.S. Cl.**

(72) Inventors: **Taesik YANG**, San Diego, CA (US);  
**Jorge FABREGA SANCHEZ**, San Diego, CA (US); **Mohammad Ali TASSOUDJIL**, San Diego, CA (US);  
**Kevin Hsi-Huai WANG**, San Diego, CA (US); **Jeongil Jay KIM**, San Diego, CA (US)

CPC ..... *H01Q 21/065* (2013.01); *H01Q 1/2283* (2013.01); *H01Q 5/364* (2015.01); *H01Q 5/385* (2015.01)

(57)

**ABSTRACT**

(21) Appl. No.: **18/138,542**

Methods, systems, and devices for wireless communication are described. According to one or more aspects, the described apparatus includes one or more stacks of patch radiators (such as patch antennas) comprising at least a first patch radiator and a second patch radiator. The first patch radiator is associated with a low-band frequency; the second patch radiator is associated with a high-band frequency. The first patch radiator and the second patch radiator may overlap a ground plane, which may be asymmetric. Some or all patch radiators in a stack may be rotated relative to the ground plane, such that some or all edge of a patch radiator may be nonparallel with one or more edges of the ground plane. Further, each patch radiator stack may include separate feeds for each of at least two frequencies and two polarizations, and thus at least four feeds (one for each frequency/polarization combination) in total.

(22) Filed: **Apr. 24, 2023**

**Related U.S. Application Data**

(63) Continuation of application No. 16/379,553, filed on Apr. 9, 2019, now Pat. No. 11,652,301.

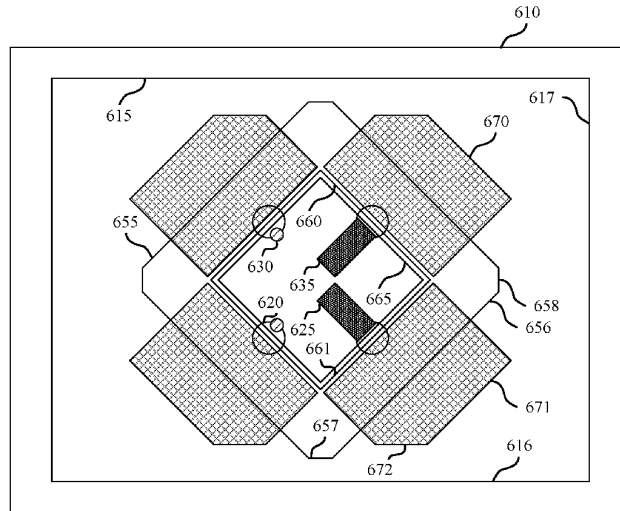
(60) Provisional application No. 62/785,636, filed on Dec. 27, 2018, provisional application No. 62/656,181, filed on Apr. 11, 2018.

**Publication Classification**

(51) **Int. Cl.**

*H01Q 21/06* (2006.01)

*H01Q 1/22* (2006.01)



600



US 20230261680A1

(19) **United States**  
 (12) **Patent Application Publication** (10) **Pub. No.: US 2023/0261680 A1**  
**LEE et al.** (43) **Pub. Date: Aug. 17, 2023**

(54) **ANTENNA AND FOLDABLE ELECTRONIC DEVICE INCLUDING THE SAME**

*H05K 5/02* (2006.01)  
*H05K 1/11* (2006.01)  
*H05K 1/02* (2006.01)  
*H05K 7/14* (2006.01)

(71) Applicant: **Samsung Electronics Co., Ltd.**,  
Gyeonggi-do (KR)

(72) Inventors: **Taeyun LEE**, Gyeonggi-do (KR);  
**Yongyoun KIM**, Gyeonggi-do (KR);  
**Haeyeon KIM**, Gyeonggi-do (KR);  
**Taekyung LEE**, Gyeonggi-do (KR);  
**Dongil YANG**, Gyeonggi-do (KR);  
**Hyoseok NA**, Gyeonggi-do (KR);  
**Soyoung LEE**, Gyeonggi-do (KR)

(52) **U.S. Cl.**  
 CPC ..... *H04B 1/16* (2013.01); *H05K 1/111*  
 (2013.01); *H05K 1/0237* (2013.01); *H05K*  
*1/0277* (2013.01); *H05K 5/0017* (2013.01);  
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**Foreign Application Priority Data**

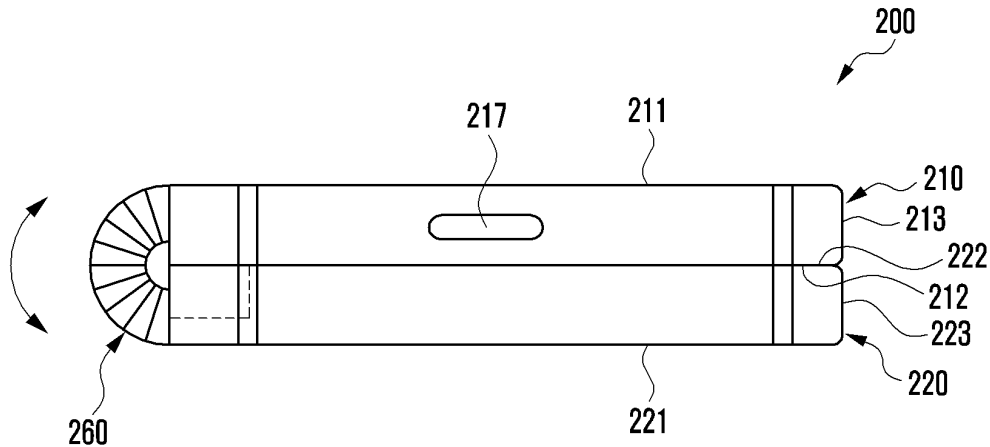
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(57) **ABSTRACT**

In an embodiment, an electronic device may include a housing including a hinge module, a first housing, and second housing. The first and second housings are rotatably coupled to each other via the hinge module to be in a folded state or an unfolded state. The electronic device may further include a flexible display, at least one conductive pattern disposed in the first housing, at least one conductor disposed at a position in the second housing corresponding to the at least one conductive pattern such that the at least one conductor is capacitively coupled to the conductive pattern when the electronic device is in the folded state, and a wireless communication circuit electrically connected to the at least one conductive pattern in the first housing. Other embodiments are also possible.







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(54) **DIELECTRIC RESONATOR ANTENNA MODULES**

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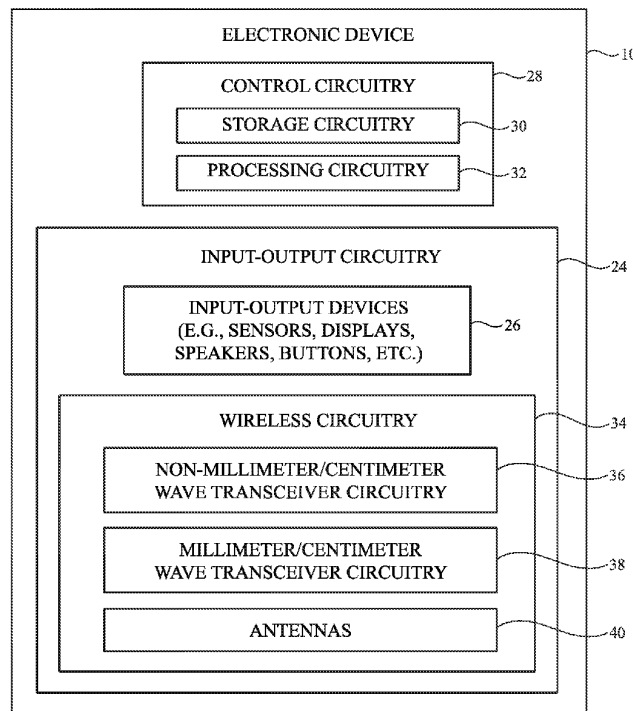
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(57) **ABSTRACT**

An electronic device may be provided with an antenna module having a substrate. A phased antenna array of dielectric resonator antennas and a radio-frequency integrated circuit for the array may be mounted to one or more surfaces of the substrate. The dielectric resonator antennas may include dielectric columns excited by feed probes. The feed probes may be printed onto sidewalls of the dielectric columns or may be pressed against the sidewalls by biasing structures. A plastic substrate may be molded over each dielectric column and each of the feed probes in the array. The feed probes may cover multiple polarizations. The array may include elements for covering multiple frequency bands. The dielectric columns may be aligned a longitudinal axis and may be rotated at a non-zero and non-perpendicular angle with respect to the longitudinal axis.





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(54) **FOLDABLE ELECTRONIC DEVICE  
COMPRISING ANTENNA**

**Publication Classification**

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(57) **ABSTRACT**

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An electronic device is provided. The electronic device includes a housing, a first antenna including a first portion of a first part, a second antenna including a second portion of a second part, a power distribution circuit electrically connected to the first antenna through a first path and electrically connected to the second antenna through a second path longer than the first path, a wireless communication circuit. The housing comprises the first part, the second part, and a connecting part disposed between the first part and the second part, wherein the first part is coupled to the connecting part so as to be rotatable with respect to the second part, and in a state where the housing is folded, a first point of the first antenna may correspond to a second point of the second antenna.

**Related U.S. Application Data**

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