



US012095146B2

(12) **United States Patent**
Wu et al.

(10) **Patent No.:** **US 12,095,146 B2**
(45) **Date of Patent:** **Sep. 17, 2024**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)

(72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Hau Yuen Tan**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Cheng-Hsiung Wu**, Taipei (TW); **Chen-Kuang Wang**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Chia-Hung Chen**, Taipei (TW); **Sheng-Chin Hsu**, Taipei (TW); **Hao-Hsiang Yang**, Taipei (TW)

(73) Assignee: **PEGATRON CORPORATION**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 91 days.

(21) Appl. No.: **17/746,863**

(22) Filed: **May 17, 2022**

(65) **Prior Publication Data**
US 2023/0033219 A1 Feb. 2, 2023

(30) **Foreign Application Priority Data**
Jul. 29, 2021 (TW) 110127964

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

(52) **U.S. Cl.**
CPC **H01Q 1/2291** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/2291; H01Q 5/364; H01Q 9/0421; H01Q 1/24
See application file for complete search history.

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Primary Examiner — Hai V Tran

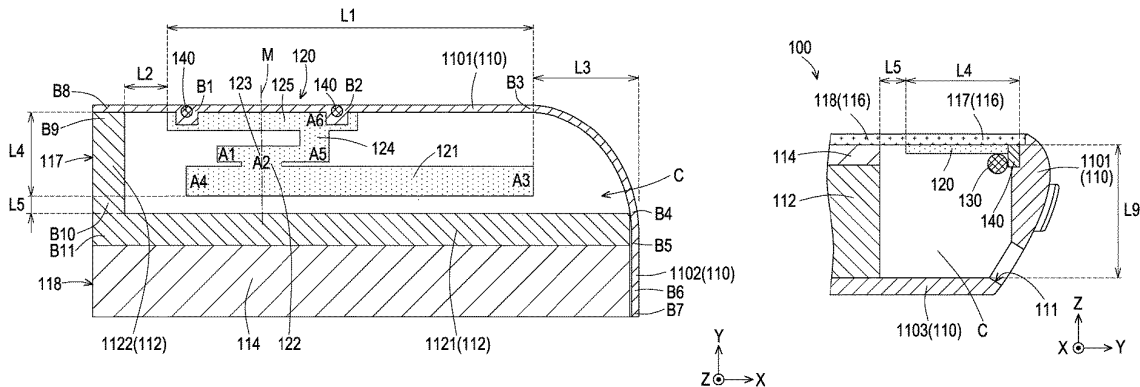
Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — J.C. PATENTS

(57) **ABSTRACT**

An electronic device, including a metal back cover, a front cover, a metal wall, and at least one antenna radiator, is provided. The front cover covers the metal back cover and includes a frame area. The metal wall is disposed between the metal back cover and the front cover, and forms a metal cavity corresponding to the frame area together with the metal back cover. Each of the at least one antenna radiator is disposed in the metal cavity, is connected to a first side wall of the metal back cover, and is spaced apart from the metal wall by a distance.

11 Claims, 5 Drawing Sheets





US012095159B2

(12) **United States Patent**
Shen et al.

(10) **Patent No.:** **US 12,095,159 B2**
(45) **Date of Patent:** **Sep. 17, 2024**

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

(71) Applicant: **Huawei Technologies Co., Ltd.**,
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(72) Inventors: **Laiwei Shen**, Shanghai (CN); **Liang Xue**, Shanghai (CN); **Jiaqing You**,
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(73) Assignee: **HUAWEI TECHNOLOGIES CO., LTD.**, Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 394 days.

(21) Appl. No.: **17/420,609**

(22) PCT Filed: **Jan. 4, 2019**

(86) PCT No.: **PCT/CN2019/070437**

§ 371 (c)(1),

(2) Date: **Jul. 2, 2021**

(87) PCT Pub. No.: **WO2020/140275**

PCT Pub. Date: **Jul. 9, 2020**

(65) **Prior Publication Data**

US 2022/0085513 A1 Mar. 17, 2022

(51) **Int. Cl.**
H01Q 13/10 (2006.01)
H01Q 1/24 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 13/103** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/44** (2013.01); **H01Q 5/378**
(2015.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/44; H01Q 1/243; H01Q 1/521;
H01Q 5/328; H01Q 5/378; H01Q 13/16;
H01Q 13/103; H01Q 9/42; H01Q 21/28
See application file for complete search history.

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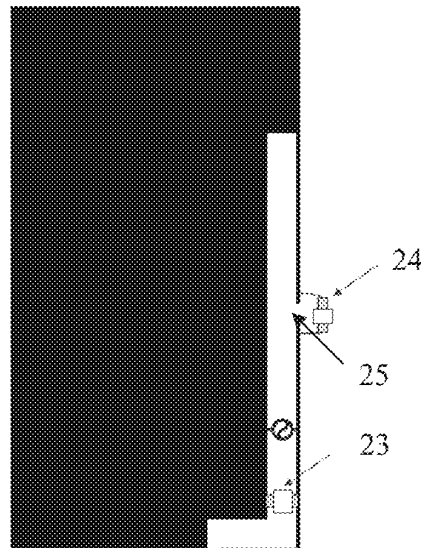
Primary Examiner — Tung X Le

(74) *Attorney, Agent, or Firm* — Conley Rose, P.C.

(57) **ABSTRACT**

An antenna system having a first antenna that includes a metal middle frame, a first metal frame, and a second metal frame. The middle frame is a ground of the first antenna. The first and second metal frames are side edges of the mobile terminal. A first gap is formed by the first, the second metal frames, and the middle frame. A first end of the first metal frame is connected to the middle frame by a first connection point, and a second end of the first metal frame is connected to a first end of the second metal frame. A first slit is located between a second end of the second metal frame and the middle frame. The first feed point on the first metal frame is connected to the middle frame. A length of the first metal frame is greater than a length of the second metal frame.

20 Claims, 9 Drawing Sheets





US012095175B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.:** **US 12,095,175 B2**
(45) **Date of Patent:** **Sep. 17, 2024**

(54) **ANTENNA STRUCTURE**

(56) **References Cited**

(71) Applicant: **Cheng Uei Precision Industry Co., LTD.**, New Taipei (TW)

U.S. PATENT DOCUMENTS

(72) Inventors: **Chih-Chung Wang**, New Taipei (TW);
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				343/702

(73) Assignee: **CHENG UEI PRECISION INDUSTRY CO., LTD.**, New Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 261 days.

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(21) Appl. No.: **17/942,142**

Primary Examiner — Hai V Tran

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

(74) Attorney, Agent, or Firm — Cheng-Ju Chiang

(65) **Prior Publication Data**

US 2023/0216195 A1 Jul. 6, 2023

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Jan. 4, 2022 (CN) 202220008152.6

An antenna structure includes a substrate, a radiator mounted at an upper portion of a front surface of the substrate, and a grounding element mounted at a lower portion of the front surface of the substrate. The radiator has a first radiating portion. A lower edge of the first radiating portion extends downward to form a second radiating portion. Two portions of a middle of the lower edge of the first radiating portion extend downward to form a third radiating portion and a feeding portion. A free end of the feeding portion is a feeding end. One side edge of the first radiating portion is recessed inward to form a recess. The grounding element has a first grounding portion and a second grounding portion. The first grounding portion and the second grounding portion are located to two sides of the feeding portion, respectively.

(51) **Int. Cl.**
H01Q 5/30 (2015.01)
H01Q 1/48 (2006.01)
H01Q 9/06 (2006.01)

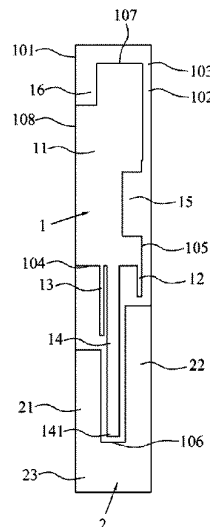
(52) **U.S. Cl.**
CPC **H01Q 5/30** (2015.01); **H01Q 1/48** (2013.01); **H01Q 9/06** (2013.01); **H01Q 9/065** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 1/48; H01Q 9/065; H01Q 9/06

See application file for complete search history.

18 Claims, 7 Drawing Sheets

100





US012095176B2

(12) **United States Patent**
Hong et al.

(10) **Patent No.:** **US 12,095,176 B2**
(45) **Date of Patent:** **Sep. 17, 2024**

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

(71) Applicant: **Samsung Electronics Co., Ltd.**,
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(72) Inventors: **Sanghue Hong**, Suwon-si (KR);
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Suwon-si (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 319 days.

(21) Appl. No.: **17/682,615**

(22) Filed: **Feb. 28, 2022**

(65) **Prior Publication Data**
US 2022/0302588 A1 Sep. 22, 2022

Related U.S. Application Data
(63) Continuation of application No.
PCT/KR2022/002819, filed on Feb. 25, 2022.

(30) **Foreign Application Priority Data**
Mar. 16, 2021 (KR) 10-2021-0033978

(51) **Int. Cl.**
H01Q 5/335 (2015.01)
H01Q 1/24 (2006.01)

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

(58) **Field of Classification Search**
CPC H01Q 1/243; H01Q 1/32; H01Q 1/3233;
H01Q 5/335
See application file for complete search history.

(56) **References Cited**

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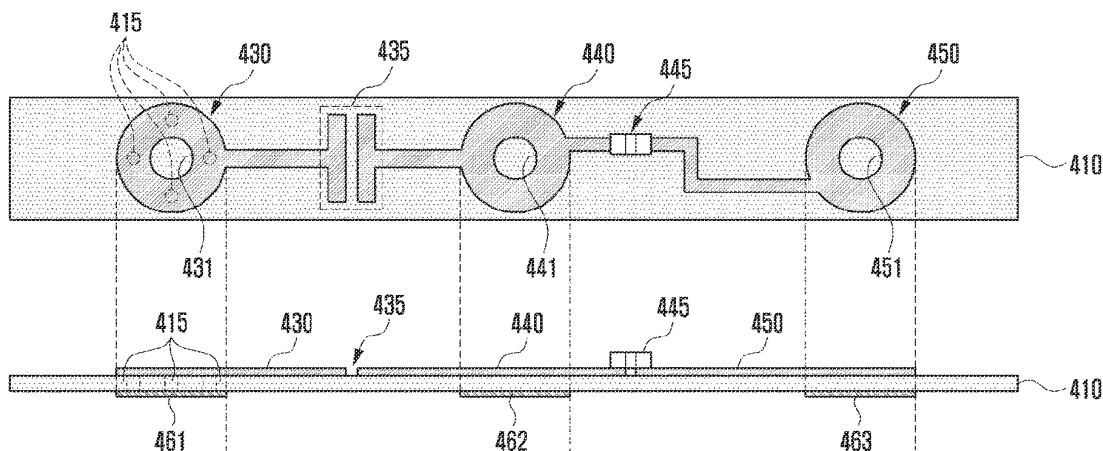
Primary Examiner — Daniel Munoz

(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes an antenna, a wireless communication module electrically connected to the antenna, a flexible printed circuit board (FPCB) including a first feeding element and a second feeding element which are electrically connected to the wireless communication module, a substrate disposed above the first feeding element and the second feeding element, a first conductive pattern including a first coupling hole and a second conductive pattern including a second coupling hole, which are formed on the upper surface of the substrate, a first coupling fastener configured to penetrate the first coupling hole and the first feeding element and electrically connect the first conductive pattern and the first feeding element, and a second coupling fastener configured to penetrate the second coupling hole and the second feeding element and electrically connect the second conductive pattern and the second feeding element.

18 Claims, 8 Drawing Sheets





US012095179B2

(12) **United States Patent**
Wu et al.

(10) **Patent No.:** **US 12,095,179 B2**
(45) **Date of Patent:** **Sep. 17, 2024**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)

(72) Inventors: **Chien-Yi Wu**, Taipei (TW); **Chao-Hsu Wu**, Taipei (TW); **Hau Yuen Tan**, Taipei (TW); **Cheng-Hsiung Wu**, Taipei (TW); **Chen-Kuang Wang**, Taipei (TW); **Tse-Hsuan Wang**, Taipei (TW); **Sheng-Chin Hsu**, Taipei (TW); **Shih-Keng Huang**, Taipei (TW); **Chia-Hung Chen**, Taipei (TW)

(73) Assignee: **PEGATRON CORPORATION**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 155 days.

(21) Appl. No.: **17/898,341**

(22) Filed: **Aug. 29, 2022**

(65) **Prior Publication Data**
US 2023/0107947 A1 Apr. 6, 2023

(30) **Foreign Application Priority Data**
Oct. 5, 2021 (TW) 110137082

(51) **Int. Cl.**
H01Q 5/50 (2015.01)
G06F 1/16 (2006.01)
H01Q 1/22 (2006.01)
H01Q 1/48 (2006.01)
H01Q 13/10 (2006.01)

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

CPC **H01Q 5/50** (2015.01); **G06F 1/1626** (2013.01); **H01Q 1/2291** (2013.01); **H01Q 1/48** (2013.01); **H01Q 13/106** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/371; H01Q 7/00; H01Q 1/38
See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Ricardo I Magallanes

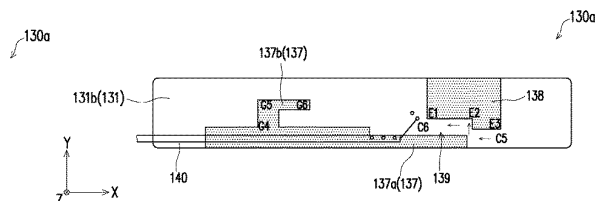
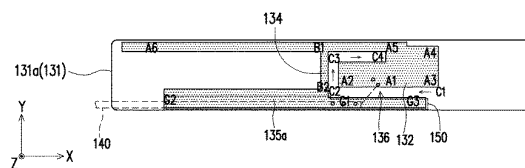
Assistant Examiner — Aladdin Abdulbaki

(74) *Attorney, Agent, or Firm* — J.C. PATENTS

(57) **ABSTRACT**

An electronic device includes a metal back cover and an antenna module. The metal back cover includes a slit. The antenna module is separated from the metal back cover and disposed far away from the slit. The antenna module includes an antenna radiator, a first ground radiator, and a connection radiator. The antenna radiator includes a first section, a second section, and a third section that are sequentially connected and form bends, and the first section has a feeding end. A first slot is formed between the first ground radiator, the first section, the second section, and a part of the third section. A width and length of the first slot are associated with a center frequency and impedance matching of a high frequency band.

10 Claims, 10 Drawing Sheets





US012095514B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 12,095,514 B2**
(45) **Date of Patent:** **Sep. 17, 2024**

(54) **ELECTRONIC APPARATUS INCLUDING ANTENNA AND AUDIO INTERFACE**

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

(72) Inventors: **Bonam Lee**, Suwon-si (KR); **Hosan Baek**, Suwon-si (KR); **Seongkyoo Byeon**, Suwon-si (KR); **Junyoung Yang**, Suwon-si (KR); **Cheungwon Ryu**, Suwon-si (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 232 days.

(21) Appl. No.: **17/584,934**

(22) Filed: **Jan. 26, 2022**

(65) **Prior Publication Data**
US 2022/0247500 A1 Aug. 4, 2022

Related U.S. Application Data
(63) Continuation of application No. PCT/KR2022/000597, filed on Jan. 13, 2022.

(30) **Foreign Application Priority Data**
Jan. 29, 2021 (KR) 10-2021-0013428

(51) **Int. Cl.**
H04B 15/02 (2006.01)
G06F 3/16 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H04B 15/02** (2013.01); **G06F 3/16** (2013.01); **H01Q 5/25** (2015.01); **H04L 12/66** (2013.01); **H04R 3/00** (2013.01)

(58) **Field of Classification Search**
CPC H04L 65/752; H04L 65/80; H04L 65/612; H04L 65/613; H04L 65/762; H04L 65/61;
(Continued)

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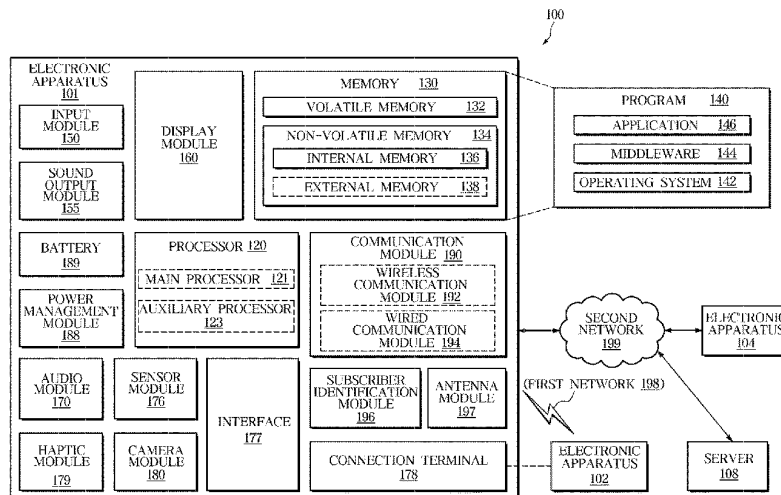
International Search Report dated May 9, 2022, issued in International Application No. PCT/KR2022/000597.

Primary Examiner — Lun-See Lao

(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**
An electronic apparatus is provided. The electronic apparatus includes a housing having a first surface, an antenna formed on the first surface, an interface that is connectable to an external terminal of an external apparatus via an audio connector formed on the first surface and configured to provide a detection signal indicating whether a connection with the external terminal is made, a processor configured to process an audio signal received from the external terminal of the external apparatus via the interface, a signal line extending from the interface, a noise filter connected to the processor, a matching element, and a switch configured to electrically connect one of the noise filter or the matching element to the signal line, based on the detection signal.

11 Claims, 15 Drawing Sheets





US012095531B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 12,095,531 B2**
(45) **Date of Patent:** **Sep. 17, 2024**

(54) **ELECTRONIC DEVICE COMPRISING ANTENNA**

(56) **References Cited**

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(71) Applicant: **Samsung Electronics Co., Ltd.**,
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(72) Inventors: **Jongwon Lee**, Gyeonggi-do (KR);
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Chonghwa Seo, Gyeonggi-do (KR)

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(73) Assignee: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 6 days.

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(21) Appl. No.: **18/125,867**

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

Primary Examiner — Leila Malek

(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(65) **Prior Publication Data**

US 2023/0239018 A1 Jul. 27, 2023

Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2022/010961, filed on Jul. 26, 2022.

(30) **Foreign Application Priority Data**

Aug. 12, 2021 (KR) 10-2021-0106836

(51) **Int. Cl.**
H04B 7/06 (2006.01)

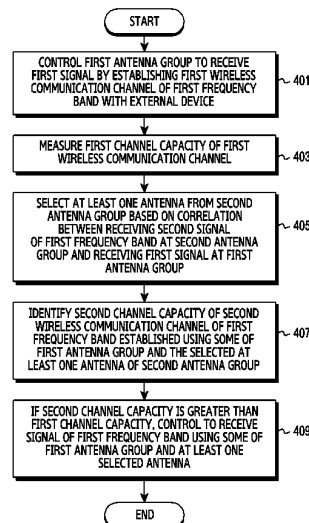
(52) **U.S. Cl.**
CPC **H04B 7/0608** (2013.01); **H04B 7/066**
(2013.01)

(58) **Field of Classification Search**
CPC H04B 7/0608; H04B 7/066
USPC 375/262
See application file for complete search history.

(57) **ABSTRACT**

An electronic device according to various embodiments may include a plurality of antennas including a first antenna group and a second antenna group and a wireless communication circuit, and the wireless communication circuit may control the first antenna group to receive a first signal by establishing a first wireless communication channel of the first frequency band with an external device, measure a first channel capacity, select at least one antenna from the second antenna group based on correlation, identify a second channel capacity of a second wireless communication channel of the first frequency band which is able to be established using some of the first antenna group and the selected at least one antenna of the second antenna group, and control to receive the signal of the first frequency band by using some of the first antenna group and the selected at least one antenna.

20 Claims, 15 Drawing Sheets





US012101901B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 12,101,901 B2**
(45) **Date of Patent:** **Sep. 24, 2024**

(54) **ELECTRONIC DEVICE INCLUDING
HOUSING AND METHOD FOR
MANUFACTURING THE HOUSING**

(58) **Field of Classification Search**
None
See application file for complete search history.

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

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Yoonhee Lee**, Suwon-si (KR); **Hangyu
Hwang**, Suwon-si (KR); **Junghyun Im**,
Suwon-si (KR)

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(73) Assignee: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 328 days.

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(21) Appl. No.: **17/590,039**

International Search Report and Written Opinion of the Interna-
tional Searching Authority dated May 2, 2022, in connection with
International Application No. PCT/KR2022/000726, 13 pages.

(22) Filed: **Feb. 1, 2022**

Primary Examiner — Anthony Q Edwards
Assistant Examiner — Rashen E Morrison

(65) **Prior Publication Data**

US 2022/0248551 A1 Aug. 4, 2022

Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2022/000726, filed on Jan. 14, 2022.

(30) **Foreign Application Priority Data**

Jan. 29, 2021 (KR) 10-2021-0012844

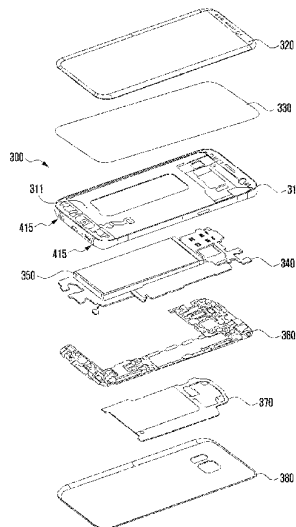
(51) **Int. Cl.**
H05K 5/00 (2006.01)
G06F 1/16 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H05K 5/0243** (2013.01); **G06F 1/1656**
(2013.01); **H01Q 1/243** (2013.01); **H04M**
1/0283 (2013.01)

(57) **ABSTRACT**

Various embodiments of the present disclosure relate to an electronic device including a housing and a method of manufacturing the housing. The electronic device includes a housing forming an exterior of the electronic device. The housing is constituted to include a non-conductive part including a non-conductive protrusion protruded from at least some area of the non-conductive part, a conductive deposition layer disposed on a top surface of the non-conductive part except on the non-conductive protrusion, and a decoration layer formed on the top of the conductive deposition layer. Accordingly, the housing is lightweight and can perform a function of an antenna radiator. Other various embodiments are possible.

19 Claims, 11 Drawing Sheets





US012107321B2

(12) **United States Patent**
Song et al.

(10) **Patent No.:** **US 12,107,321 B2**
(45) **Date of Patent:** **Oct. 1, 2024**

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

(71) Applicant: **Samsung Electronics Co., Ltd.**,
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(72) Inventors: **Keumsu Song**, Gyeonggi-do (KR);
Younghak Sin, Gyeonggi-do (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**,
Suwon-si (KR)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 210 days.

(21) Appl. No.: **17/568,002**

(22) Filed: **Jan. 4, 2022**

(65) **Prior Publication Data**

US 2022/0216594 A1 Jul. 7, 2022

Related U.S. Application Data

(63) Continuation of application No.
PCT/KR2021/018673, filed on Dec. 9, 2021.

(30) **Foreign Application Priority Data**

Dec. 31, 2020 (KR) 10-2020-0188778

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/38 (2006.01)

H01Q 15/24 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 15/24** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 1/24; H01Q 1/243; H01Q 1/1221;
H01Q 1/2283; H01Q 1/38; H01Q 1/405;

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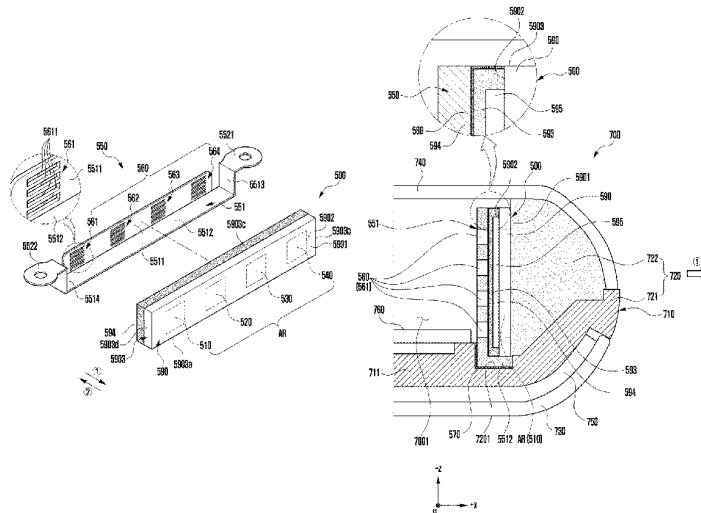
Primary Examiner — Thai Pham

(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(57) **ABSTRACT**

According to an embodiment of this disclosure, an electronic device comprises: a housing including a non-conductive portion; an antenna structure arranged in the housing, wherein the antenna structure includes: a substrate including a first substrate surface facing a first direction and a second substrate surface facing opposite the first substrate surface; and at least one antenna element arranged on the substrate to form a beam pattern in the first direction; a conductive member including a plurality of first slits arranged in an inner space of the housing to at least partially face the second substrate surface and formed at a position where the plurality of first slits at least partially overlap the at least one antenna element when the first substrate surface is viewed from above; and a wireless communication circuit configured to transmit or receive a wireless signal in a predetermined frequency band through the at least one antenna element.

15 Claims, 31 Drawing Sheets





US012107335B2

(12) **United States Patent**
Li et al.

(10) **Patent No.:** **US 12,107,335 B2**
(45) **Date of Patent:** **Oct. 1, 2024**

(54) **ELECTRONIC DEVICES WITH
DISTRIBUTED SLOT ANTENNA
STRUCTURES**

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

(72) Inventors: **Aobo Li**, Saratoga, CA (US); **Erdinc Irci**, Sunnyvale, CA (US); **Carlo Di Nallo**, Belmont, CA (US); **Enrique Ayala Vazquez**, Watsonville, CA (US); **Haozhan Tian**, San Jose, CA (US); **Hongfei Hu**, Cupertino, CA (US); **Liang Han**, Sunnyvale, CA (US); **Ming Chen**, Cupertino, CA (US); **Ming-Ju Tsai**, Sunnyvale, CA (US); **Salih Yarga**, Sunnyvale, CA (US); **Tiejun Yu**, Fremont, CA (US); **Victor C Lee**, Santa Clara, CA (US); **Xu Han**, Cupertino, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 282 days.

(21) Appl. No.: **17/728,737**

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

(65) **Prior Publication Data**

US 2023/0083466 A1 Mar. 16, 2023

Related U.S. Application Data

(60) Provisional application No. 63/243,547, filed on Sep. 13, 2021.

(51) **Int. Cl.**
H01Q 21/06 (2006.01)
H04B 1/00 (2006.01)
H04M 1/02 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/064** (2013.01); **H01Q 21/06** (2013.01); **H04B 1/00** (2013.01); **H04B 1/0064** (2013.01); **H04M 1/0266** (2013.01)

(58) **Field of Classification Search**
CPC ... H01Q 21/064; H01Q 21/06; H04M 1/0266; H04B 1/0064; H04B 1/00
(Continued)

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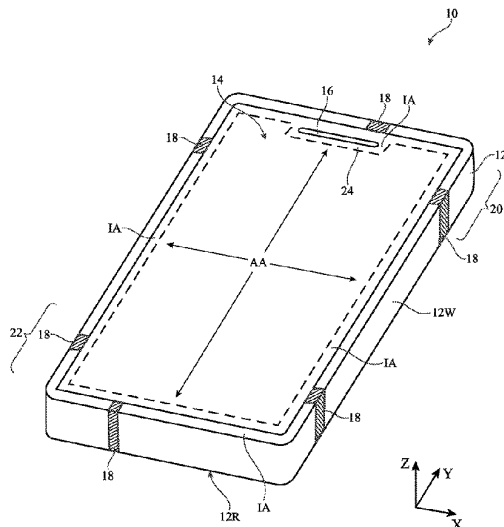
Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
Michael H. Lyons

(57) **ABSTRACT**

An electronic device may have peripheral conductive housing structures, a display frame, a support plate, a logic board, and an antenna. The antenna may have a resonating element that includes a first slot between the logic board and a segment of the peripheral conductive housing structures, a second slot between the display frame and the segment, and optionally a third slot between the support plate and the segment. The slots may be at least partially overlapping, may have respective lengths, may be located at respective distances from a cover layer for the display, and may collectively receive radio-frequency signals in a frequency band such as the L5 GPS band. Switching circuitry and filter circuitry may be coupled to the antenna feed and/or to the antenna feed (s) of one or more adjacent antennas in the electronic device to help to isolate the antennas from each other.

20 Claims, 14 Drawing Sheets





US012107350B2

(12) **United States Patent**
Lee et al.

(10) **Patent No.:** **US 12,107,350 B2**
(45) **Date of Patent:** **Oct. 1, 2024**

(54) **ELECTRONIC DEVICE HAVING 5G ANTENNA**

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

(72) Inventors: **Songyi Lee**, Seoul (KR); **Moonsoo Song**, Seoul (KR); **Chisang You**, Seoul (KR); **Kyoungsun Hwang**, Seoul (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 210 days.

(21) Appl. No.: **17/773,020**

(22) PCT Filed: **Oct. 30, 2019**

(86) PCT No.: **PCT/KR2019/014410**

§ 371 (c)(1),

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

(87) PCT Pub. No.: **WO2021/085665**

PCT Pub. Date: **May 6, 2021**

(65) **Prior Publication Data**

US 2023/0039020 A1 Feb. 9, 2023

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

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/26** (2013.01); **H01Q 1/243** (2013.01); **H01Q 9/0457** (2013.01); **H01Q 21/08** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/26; H01Q 1/243; H01Q 9/0457; H01Q 21/08; H01Q 1/38; H01Q 1/523;
(Continued)

(56) **References Cited**

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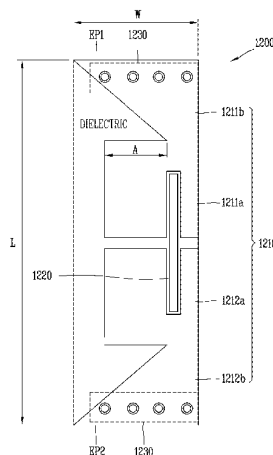
Primary Examiner — David E Lotter

(74) *Attorney, Agent, or Firm* — LEE, HONG, DEGERMAN, KANG & WAIMEY

(57) **ABSTRACT**

An electronic device having a 5G antenna, according to the present invention, is provided. The electronic device comprises an antenna, which includes: a first metal pattern formed so that metal having a predetermined length and width is printed and arranged on the top of a substrate; a second metal pattern formed so that metal, which is spaced a predetermined distance from the first metal pattern and has a predetermined length and width, is printed and arranged; and a power feeding pattern formed so that a signal is coupling-fed to the first metal pattern and the second metal pattern.

13 Claims, 19 Drawing Sheets





US012107980B2

(12) **United States Patent**
Chen et al.

(10) **Patent No.:** **US 12,107,980 B2**
(45) **Date of Patent:** **Oct. 1, 2024**

(54) **MOBILE TERMINAL**

(71) Applicant: **HuiZhou TCL Mobile Communication Co., Ltd.**, Guangdong (CN)

(72) Inventors: **Wei Chen**, Guangdong (CN); **Yi Huang**, Guangdong (CN); **Zhiwei Chen**, Guangdong (CN)

(73) Assignee: **HuiZhou TCL Mobile Communication Co., Ltd.**, HuiZhou (CN)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 291 days.

(21) Appl. No.: **17/616,680**

(22) PCT Filed: **Dec. 19, 2019**

(86) PCT No.: **PCT/CN2019/126544**

§ 371 (c)(1),

(2) Date: **Dec. 6, 2021**

(87) PCT Pub. No.: **WO2021/114348**

PCT Pub. Date: **Jun. 17, 2021**

(65) **Prior Publication Data**

US 2022/0311850 A1 Sep. 29, 2022

(30) **Foreign Application Priority Data**

Dec. 12, 2019 (CN) 201911271148.8

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

(Continued)

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

CPC **H04M 1/0277** (2013.01); **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/50** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

(56) **References Cited**

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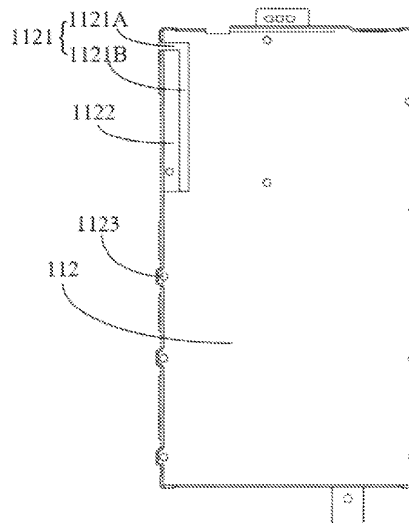
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Primary Examiner — Tuan A Tran

(57) **ABSTRACT**

A mobile terminal is provided, including a front housing, wherein the front housing includes a main body and a conductive ground plate mounted on the main body, a side of the conductive ground plate is provided with a cut, and the cut is configured to divide a conductive strip as an antenna from the conductive ground plate.

18 Claims, 3 Drawing Sheets





US012113275B2

(12) **United States Patent**
Wu et al.

(10) **Patent No.:** **US 12,113,275 B2**
(45) **Date of Patent:** **Oct. 8, 2024**

(54) **PRINTED ANTENNA**

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

(72) Inventors: **Dongwei Wu**, Wuhan (CN); **Jinjin Shao**, Wuhan (CN); **Cao Shi**, Dongguan (CN)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 220 days.

(21) Appl. No.: **17/846,215**

(22) Filed: **Jun. 22, 2022**

(65) **Prior Publication Data**

US 2022/0320723 A1 Oct. 6, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/CN2020/116438, filed on Sep. 21, 2020.

(30) **Foreign Application Priority Data**

Dec. 23, 2019 (CN) 201911345171.7

(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 7/00 (2006.01)
H01Q 19/10 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/38** (2013.01); **H01Q 7/00** (2013.01); **H01Q 19/10** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/38; H01Q 7/00; H01Q 19/10; H01Q 7/005; H01Q 15/14; H01Q 3/247; H01Q 1/50; H01Q 1/36
See application file for complete search history.

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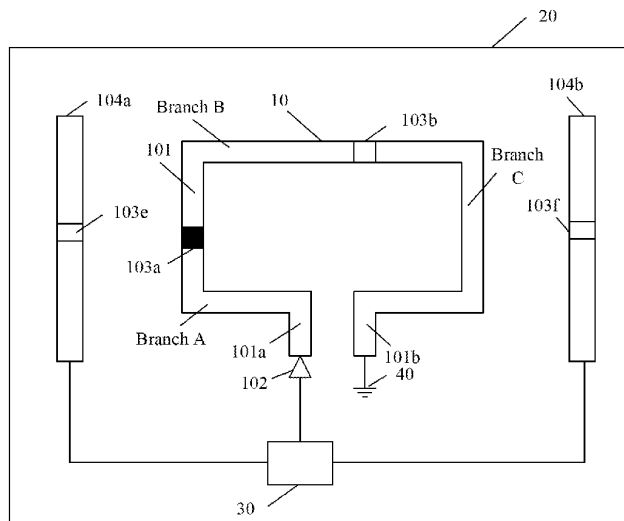
Primary Examiner — Hai V Tran

Assistant Examiner — Michael M Bouizza

(57) **ABSTRACT**

A printed antenna may include a loop antenna body, a feed port, and a switch component. The loop antenna body includes a first end and a second end, there is a spacing between the first end and the second end, a connection line between the first end and the second end forms a closed loop with the loop antenna body. The feed module is configured to output a feed signal to the loop antenna body by using the feed port. The loop antenna body includes a plurality of loop antenna branches, the switch component is disposed between every two adjacent loop antenna branches, and the switch component is configured to connect or disconnect the two adjacent loop antenna branches.

14 Claims, 12 Drawing Sheets





US012113286B2

(12) **United States Patent**
Hu

(10) **Patent No.:** **US 12,113,286 B2**
(45) **Date of Patent:** **Oct. 8, 2024**

(54) **HIGH-GAIN LOW-PROFILE CIRCULARLY
POLARIZED ANTENNA**

(56) **References Cited**

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Primary Examiner — David E Lotter

(74) *Attorney, Agent, or Firm* — THE SUN IP LAW

(57) **ABSTRACT**

The present disclosure relates to a technical field of antennas
for communication. Disclosed is a high-gain low-profile
circularly polarized antenna. The antenna includes a circu-
larly polarized patch, a composite dielectric high-impedance
surface array, and a metal backplate. The circularly polarized
patch includes a patch dielectric layer, wherein a first
fan-shaped patch, a second fan-shaped patch, a third fan-
shaped patch, and a fourth fan-shaped patch are formed on
an upper surface of the patch dielectric layer; four coaxial
feeding lines are arranged at positions that are close to a
center of the patch dielectric layer; and an upper end of each
of the coaxial feeding lines is electrically connected to one
corresponding fan-shaped patch, and the other end of the
each of the coaxial feeding lines penetrates the patch dielec-
tric layer to extend to an outside of a lower surface of the
patch dielectric layer.

10 Claims, 14 Drawing Sheets

(71) Applicant: **Nan Hu**, Irvine, CA (US)

(72) Inventor: **Nan Hu**, Irvine, CA (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/589,375**

(22) Filed: **Feb. 27, 2024**

(65) **Prior Publication Data**

US 2024/0250450 A1 Jul. 25, 2024

Related U.S. Application Data

(63) Continuation of application No.
PCT/CN2022/095731, filed on May 27, 2022.

(30) **Foreign Application Priority Data**

Aug. 27, 2021 (CN) 202110998101.2

(51) **Int. Cl.**

H01Q 21/26 (2006.01)

H01Q 9/04 (2006.01)

H01Q 21/06 (2006.01)

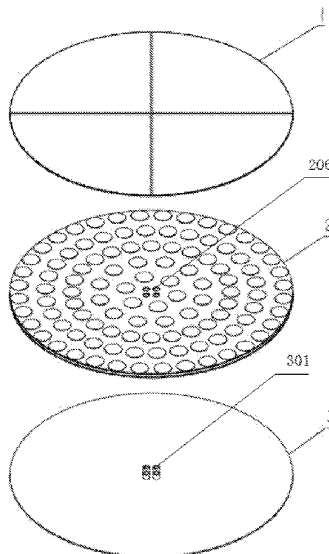
H01Q 21/24 (2006.01)

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

CPC **H01Q 21/065** (2013.01); **H01Q 9/0428**
(2013.01); **H01Q 21/24** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 21/065; H01Q 9/0428
See application file for complete search history.





US012113292B2

(12) **United States Patent**
Kanasaki et al.

(10) **Patent No.:** **US 12,113,292 B2**
(45) **Date of Patent:** **Oct. 8, 2024**

(54) **ANTENNA DEVICE**

(71) Applicant: **Panasonic Intellectual Property Management Co., Ltd.**, Osaka (JP)

(72) Inventors: **Yoshihiro Kanasaki**, Ishikawa (JP); **Takahiro Ochi**, Miyagi (JP); **Kazuya Tani**, Osaka (JP)

(73) Assignee: **PANASONIC INTELLECTUAL PROPERTY MANAGEMENT CO., LTD.**, Osaka (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 169 days.

(21) Appl. No.: **17/877,894**

(22) Filed: **Jul. 30, 2022**

(65) **Prior Publication Data**
US 2022/0368035 A1 Nov. 17, 2022

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2021/003185, filed on Jan. 29, 2021.

(30) **Foreign Application Priority Data**

Feb. 13, 2020 (JP) 2020-022355

(51) **Int. Cl.**
H01Q 21/28 (2006.01)
H01Q 9/04 (2006.01)
H01Q 9/30 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/28** (2013.01); **H01Q 9/0421** (2013.01); **H01Q 9/30** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/28; H01Q 9/0421; H01Q 9/30; H01Q 1/2266; H01Q 1/521; H01Q 5/35; H01Q 5/378; H01Q 9/42

See application file for complete search history.

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Primary Examiner — Hai V Tran

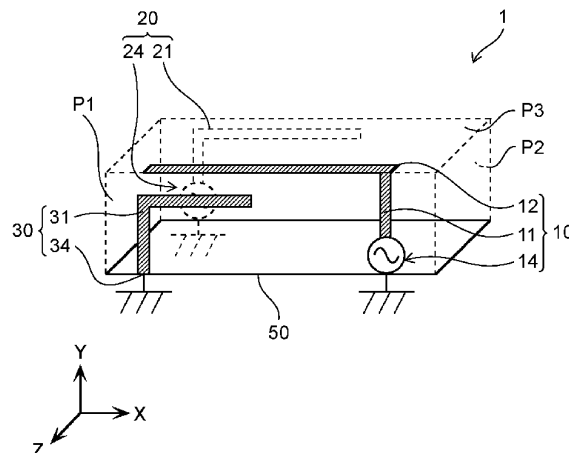
Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — Renner, Otto, Boisselle & Sklar, LLP

(57) **ABSTRACT**

An antenna device is disposed on a first, a second, and a third surfaces, and includes a first antenna disposed on the first and the third surfaces, a second antenna disposed on the second surface, and a ground line disposed on the first surface. The first antenna includes a first feedpoint disposed on the first surface, a first element disposed on the first surface, and extending from the first feedpoint to the third surface, and a second element disposed on the third surface, and extending in a direction along the first surface from an end of the first element. The second antenna includes a second feedpoint disposed in a manner separated from the first feedpoint in a direction parallel with the first and the second surfaces, and an antenna element extending from the second feedpoint. The ground line includes a ground line element capacitively coupled to the first antenna.

7 Claims, 11 Drawing Sheets





US012119541B2

(12) **United States Patent**
Li et al.

(10) **Patent No.:** **US 12,119,541 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

(54) **PACKAGE STRUCTURE AND ANTENNA
DEVICE USING THE SAME**

(71) Applicant: **InnoLux Corporation**, Miao-Li County
(TW)

(72) Inventors: **I-Yin Li**, Miao-Li County (TW);
Tang-Chin Hung, Miao-Li County
(TW)

(73) Assignee: **INNOLUX CORPORATION**, Miao-Li
County (TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 92 days.

(21) Appl. No.: **17/848,508**

(22) Filed: **Jun. 24, 2022**

(65) **Prior Publication Data**

US 2022/0320713 A1 Oct. 6, 2022

Related U.S. Application Data

(63) Continuation of application No. 16/246,663, filed on
Jan. 14, 2019, now abandoned.
(Continued)

(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01L 23/498 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H01Q 1/2283** (2013.01); **H01L 23/49838**
(2013.01); **H01L 23/552** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC H01Q 1/2283; H01Q 1/38; H01Q 1/50;
H01L 23/49838; H01L 23/552;
(Continued)

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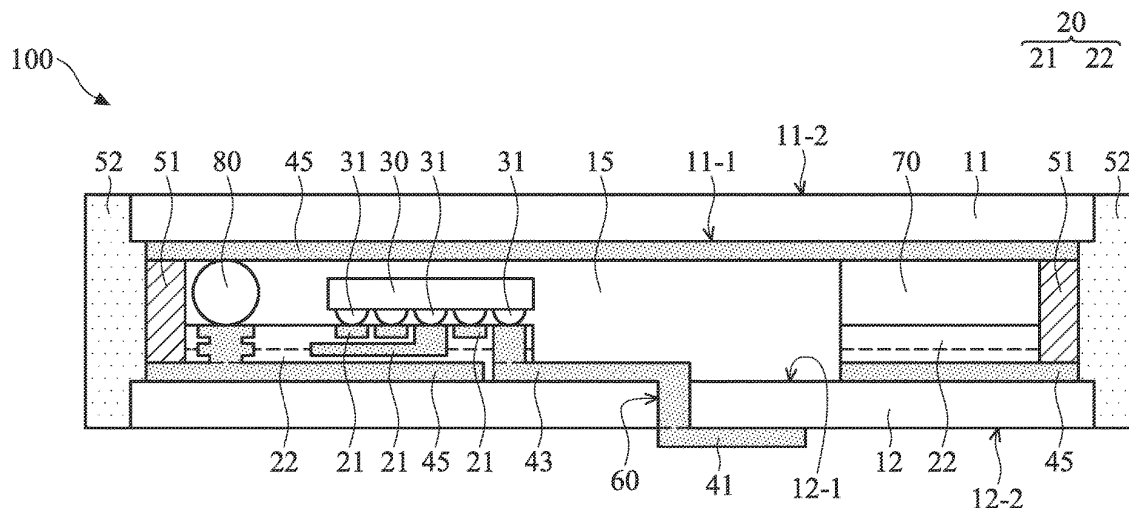
Primary Examiner — Seung H Lee

(74) *Attorney, Agent, or Firm* — McClure, Qualey &
Rodack, LLP

(57) **ABSTRACT**

An antenna device is provided. The antenna device includes a first substrate and a second substrate facing the first substrate. The first substrate includes an inner surface and an outer surface opposite the inner surface of the first substrate. The second substrate includes an inner surface and an outer surface opposite the inner surface of the second substrate. The antenna device also includes a die disposed between the first substrate and the second substrate, a redistribution layer disposed between the die and the inner surface of the second substrate, and an antenna unit electrically connected to the die via the redistribution layer. The antenna unit is arranged on at least one of the inner surface of the first substrate, the outer surface of the first substrate, the inner surface of the second substrate, and the outer surface of the second substrate.

13 Claims, 4 Drawing Sheets





US012119542B2

(12) **United States Patent**
Kim et al.

(10) **Patent No.:** **US 12,119,542 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

(54) **MOBILE DEVICE WITH ANTENNA ARRAY**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Jihoon Kim**, Gyeonggi-do (KR);
Hyoseok Na, Gyeonggi-do (KR);
Jongin Lee, Gyeonggi-do (KR)

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(73) Assignee: **Samsung Electronics Co., Ltd.** (KR)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 431 days.

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(21) Appl. No.: **17/297,868**

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(22) PCT Filed: **Dec. 5, 2019**

Korean Office Action dated Dec. 20, 2022 issued in counterpart
application No. 10-2018-0155141, 14 pages.

(86) PCT No.: **PCT/KR2019/017120**

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§ 371 (c)(1),

(2) Date: **May 27, 2021**

(87) PCT Pub. No.: **WO2020/116968**

PCT Pub. Date: **Jun. 11, 2020**

Primary Examiner — Raymond R Chai

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm,
P.C.

(65) **Prior Publication Data**

US 2022/0037763 A1 Feb. 3, 2022

(30) **Foreign Application Priority Data**

Dec. 5, 2018 (KR) 10-2018-0155141

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 1/38 (2006.01)

H01Q 21/06 (2006.01)

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

CPC **H01Q 1/243** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 21/06** (2013.01)

(58) **Field of Classification Search**

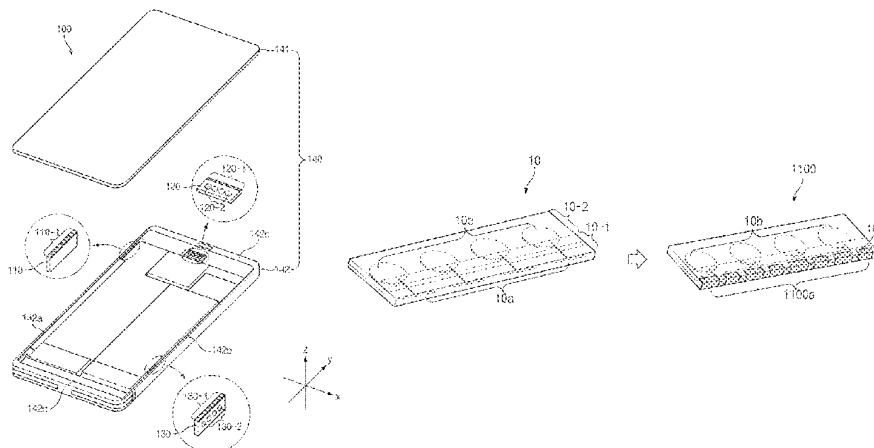
CPC H01Q 1/243; H01Q 1/38; H01Q 3/267;
H01Q 9/26; H01Q 21/0087; H01Q 21/06;

(Continued)

(57) **ABSTRACT**

An electronic device according to an embodiment disclosed herein includes a housing and a plurality of antenna modules disposed adjacent to an edge of the housing, wherein the plurality of antenna modules may include: a first antenna array including a printed circuit board, which includes a first face, a second face facing away from the first face, and a side face disposed between the first face and the second face, and a plurality of first antenna elements extending from a point on the first face to a point on the second face through the side face; and a second antenna array including a plurality of second antenna elements disposed on the first face. In addition, various embodiments conceived through the specification are possible.

9 Claims, 15 Drawing Sheets





US012119549B2

(12) **United States Patent**
Barrera et al.

(10) **Patent No.:** **US 12,119,549 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

(54) **ELECTRONIC DEVICE ANTENNAS IN ACOUSTIC CAVITIES**

(56) **References Cited**

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(71) Applicant: **Apple Inc.**, Cupertino, CA (US)
(72) Inventors: **Joel D Barrera**, Cedar Park, TX (US);
Nikolaos Chiotellis, San Jose, CA (US); **Michael J Williams**, Saratoga, CA (US); **Jerzy S Guterman**, Sunnyvale, CA (US); **Trevor J Edmonds**, San Francisco, CA (US); **Joshua P Song**, Cupertino, CA (US); **Richard D Kosoglow**, San Jose, CA (US)

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(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 197 days.

U.S. Appl. No. 17/573,524, filed Jan. 11, 2022.

Primary Examiner — Hasan Islam

Assistant Examiner — Jordan E. DeWitt

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
Michael H. Lyons; Jinie M. Guihan

(21) Appl. No.: **17/832,465**

(22) Filed: **Jun. 3, 2022**

(57) **ABSTRACT**

(65) **Prior Publication Data**

US 2023/0395984 A1 Dec. 7, 2023

An electronic device may have an upper housing and a lower housing separated by a slot. An antenna module may be mounted in the lower housing and may include a cavity. An antenna element may be disposed within the cavity. Grounded traces may be patterned onto walls of the module and may be coupled to conductive walls of the lower housing by conductive gaskets. The antenna element may have a high band arm displaced farther into the cavity than a low band arm by a shim. The antenna module may have an acoustic port aligned with a speaker port. The acoustic port may allow sound waves from a speaker to pass into the cavity from the speaker port. The cavity may be configured to optimize an audio response of the speaker while concurrently optimizing radio-frequency performance of the antenna element.

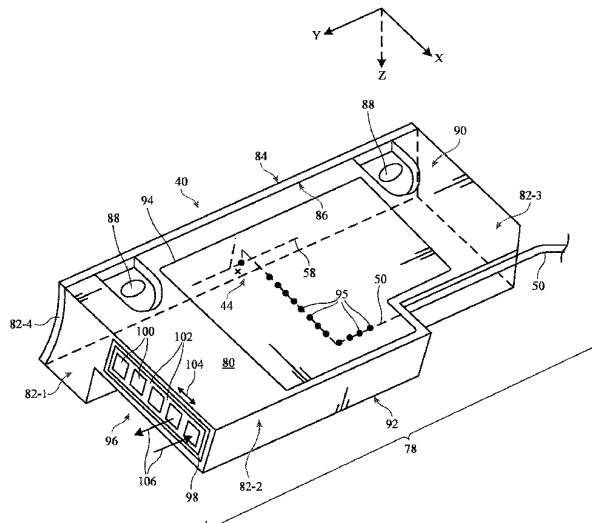
(51) **Int. Cl.**
H01Q 1/22 (2006.01)
H01Q 13/18 (2006.01)
H04R 1/02 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 13/18** (2013.01); **H01Q 1/22** (2013.01); **H04R 1/02** (2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 13/18; H01Q 1/22; H01Q 1/241–243; H04R 1/02

See application file for complete search history.

20 Claims, 7 Drawing Sheets





US012119553B2

(12) **United States Patent**
Koga et al.

(10) **Patent No.:** **US 12,119,553 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

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

(71) Applicant: **FCNT LIMITED**, Yamato (JP)

(72) Inventors: **Yohei Koga**, Yamato (JP); **Yasumitsu Ban**, Yamato (JP); **Manabu Yoshikawa**, Yamato (JP)

(73) Assignee: **FCNT LLC**, Yamato (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 136 days.

(21) Appl. No.: **18/075,571**

(22) Filed: **Dec. 6, 2022**

(65) **Prior Publication Data**

US 2023/0098428 A1 Mar. 30, 2023

Related U.S. Application Data

(63) Continuation of application No. PCT/JP2020/022732, filed on Jun. 9, 2020.

(51) **Int. Cl.**
H01Q 21/00 (2006.01)
H01Q 13/08 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/0075** (2013.01); **H01Q 13/085** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/2291; H01Q 1/243; H01Q 5/307; H01Q 5/35; H01Q 9/30; H01Q 9/42; H01Q 13/10; H01Q 13/085; H01Q 21/0075

See application file for complete search history.

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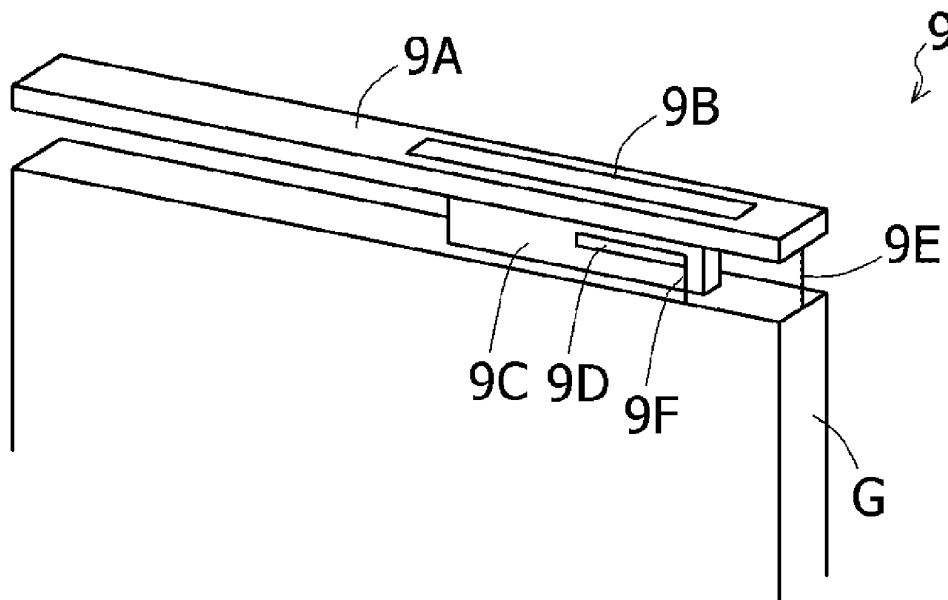
Primary Examiner — Hoang V Nguyen

(74) *Attorney, Agent, or Firm* — WHDA, LLP

(57) **ABSTRACT**

An antenna device includes a first antenna having a length corresponding to a first frequency, and arranged along a ground, a second antenna formed by a slot penetrating metal constituting the first antenna, and having a slot length corresponding to a second frequency higher than the first frequency, a first feeder wire for the first frequency, connected from the ground to the first antenna, a metal element for electromagnetic field coupling, arranged in a non-contact state relative to the second antenna, between the slot and the ground; and a second feeder wire for the second frequency, connected from the ground to the metal element.

13 Claims, 14 Drawing Sheets





US012119555B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.:** **US 12,119,555 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

(54) **ANGLE-OF-ARRIVAL ANTENNA SYSTEM**

(56)

References Cited

(71) Applicant: **Maxim Integrated Products, Inc.**, San Jose, CA (US)

U.S. PATENT DOCUMENTS

(72) Inventors: **Jianwei Wang**, Beaverton, OR (US);
Michael Alan Fredd, Tigard, OR (US);
Junqiang Wu, Beaverton, OR (US);
Dipak Kumar Desai, Frisco, TX (US)

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(73) Assignee: **Maxim Integrated Products, Inc.**, San Jose, CA (US)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 400 days.

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(21) Appl. No.: **17/535,214**

Primary Examiner — Timothy X Pham

(22) Filed: **Nov. 24, 2021**

(74) *Attorney, Agent, or Firm* — Cozen O'Connor

(65) **Prior Publication Data**

US 2023/0125795 A1 Apr. 27, 2023

Related U.S. Application Data

(60) Provisional application No. 63/118,348, filed on Nov. 25, 2020.

(51) **Int. Cl.**
H01Q 21/24 (2006.01)
G01S 3/04 (2006.01)
H01Q 1/48 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/24** (2013.01); **G01S 3/043** (2013.01); **H01Q 1/48** (2013.01); **H01Q 9/0421** (2013.01)

(58) **Field of Classification Search**
CPC .. G01S 3/043; G01S 3/46; H01Q 1/48; H01Q 21/08; H01Q 21/24; H01Q 25/001; H01Q 9/0421

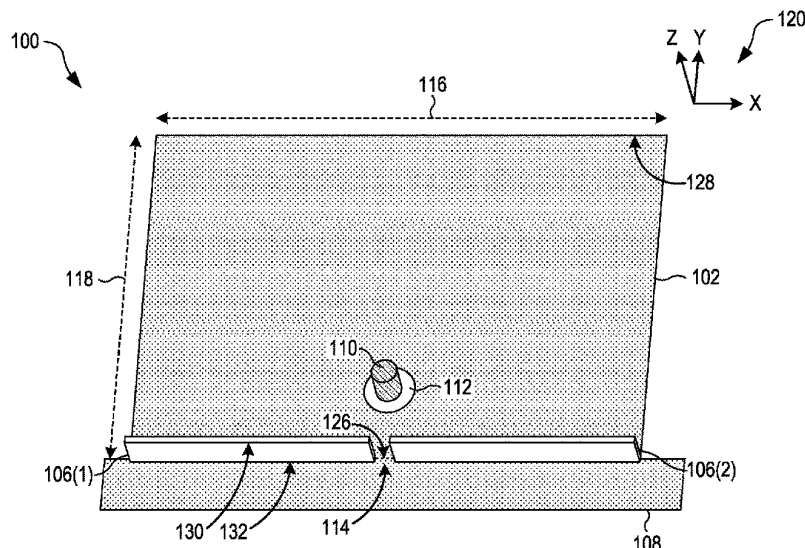
See application file for complete search history.

(57)

ABSTRACT

An angle-of-arrival antenna system uses two orthogonal arrays of patch antenna elements to measure the angle of arrival of a wireless signal irrespective of its polarization. Each antenna element has an antenna patch located over a corresponding ground patch. A shorting wall directly electrically connects one edge of the antenna patch to a corresponding edge of the underlying ground patch. The edge of the ground patch is also directly connected to a system ground plane. No other edges of the ground patch are connected to the system ground plane. The shorting wall acts as an impedance that isolates the ground patch from the system ground plane, and therefore improves isolation between the antenna elements. The antenna system may be constructed using conventional circuit-board fabrication techniques by implementing each shorting wall as an array of plated through-holes or slots.

19 Claims, 13 Drawing Sheets





US012119561B2

(12) **United States Patent**
Wang et al.

(10) **Patent No.:** **US 12,119,561 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

(54) **DUAL PORT ANTENNA STRUCTURE**

(56) **References Cited**

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Hanyang Wang**, Reading (GB); **Hai Zhou**, Reading (GB)

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(73) Assignee: **Huawei Technologies Co., Ltd.**, Shenzhen (CN)

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 285 days.

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(22) PCT Filed: **Feb. 25, 2019**

(86) PCT No.: **PCT/EP2019/054579**

§ 371 (c)(1),

(2) Date: **Aug. 25, 2021**

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(87) PCT Pub. No.: **WO2020/173540**

PCT Pub. Date: **Sep. 3, 2020**

Primary Examiner — Awat M Salih

(74) Attorney, Agent, or Firm — Leydig, Voit & Mayer, Ltd.

(65) **Prior Publication Data**

US 2022/0149525 A1 May 12, 2022

(51) **Int. Cl.**

H01Q 1/24 (2006.01)

H01Q 5/328 (2015.01)

(Continued)

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

CPC **H01Q 5/35** (2015.01); **H01Q 1/243** (2013.01); **H01Q 5/328** (2015.01); **H01Q 5/335** (2015.01)

(58) **Field of Classification Search**

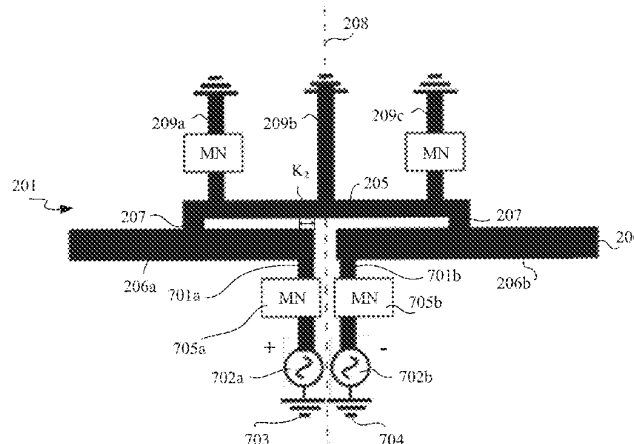
CPC H01Q 5/35; H01Q 5/328; H01Q 5/335; H01Q 1/243; H01Q 1/328

See application file for complete search history.

(57) **ABSTRACT**

An antenna structure comprising: a first port; a second port; and a single radiator connected to both the first and second ports, the single radiator being operable to simultaneously transeive in: a symmetrical excited mode in which current flows symmetrically through the single radiator to or from the first port, thereby causing the single radiator to resonate at a first resonant frequency; and an asymmetrical excited mode in which current flows asymmetrically through the single radiator to or from the second port, thereby causing the single radiator to resonate at a second resonant frequency. The single radiator comprises: a first element, a second element, and arm connectors connecting the first element to the second element. The first element being elongate and linear. The second element being elongate, linear, and parallel to the first element.

20 Claims, 13 Drawing Sheets





US012119564B2

(12) **United States Patent**
Woo et al.

(10) **Patent No.:** **US 12,119,564 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

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

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

(72) Inventors: **Seungmin Woo**, Seoul (KR); **Yusuhk Suh**, Seoul (KR); **Dongik Lee**, Seoul (KR)

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

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/293,173**

(22) PCT Filed: **Jul. 29, 2021**

(86) PCT No.: **PCT/KR2021/009935**

§ 371 (c)(1),

(2) Date: **Jan. 29, 2024**

(87) PCT Pub. No.: **WO2023/008618**

PCT Pub. Date: **Feb. 2, 2023**

(65) **Prior Publication Data**

US 2024/0266738 A1 Aug. 8, 2024

(51) **Int. Cl.**

H01Q 5/50 (2015.01)

H01Q 9/04 (2006.01)

H05K 1/02 (2006.01)

H05K 1/11 (2006.01)

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

CPC **H01Q 5/50** (2015.01); **H01Q 9/0414** (2013.01); **H05K 1/0243** (2013.01); **H05K 1/115** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 5/50; H01Q 9/04; H01Q 9/0414; H01Q 1/46; H05K 1/0243; H05K 1/115

See application file for complete search history.

(56) **References Cited**

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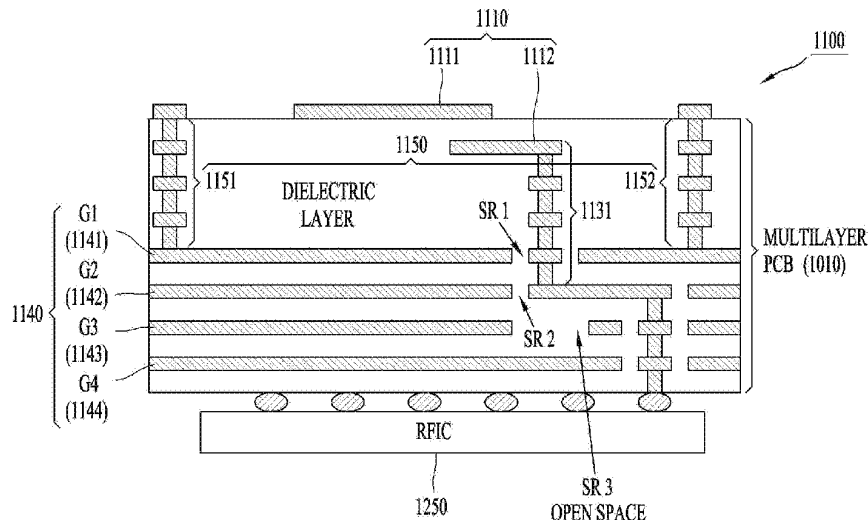
Primary Examiner — Hoang V Nguyen

(74) Attorney, Agent, or Firm — LEE, HONG, DEGERMAN, KANG & WAIMEY

(57) **ABSTRACT**

Provided is an antenna module produced into a multi-layer substrate. The antenna module comprises: a first radiator disposed on an inner area or an upper area of the multi-layer substrate and formed into a first conductive layer to radiate a radio signal; a second radiator disposed in a lower area of the first radiator to be offset from the center of the first radiator, and formed into a second conductive layer to radiate a radio signal; and a feed line connected to the second radiator by means of a signal via, wherein the first radiator and the second radiator overlap on one axis, and the length of the first radiator on one axis and the length of the second radiator on one axis may differ from each other.

14 Claims, 24 Drawing Sheets





US012119567B1

(12) **United States Patent**
Komandla et al.

(10) **Patent No.:** **US 12,119,567 B1**
(45) **Date of Patent:** **Oct. 15, 2024**

(54) **NOISE-IMMUNE MINIATURIZED ANTENNA**

(71) Applicant: **Amazon Technologies, Inc.**, Seattle, WA (US)

(72) Inventors: **Mohana Vamshi Komandla**, Sunnyvale, CA (US); **Syed Abdullah Nauroze**, Mississauga (CA); **Peruvemba Ranganath Sai Ananthanarayanan**, Fremont, CA (US); **Hariharan Muthukrishnan**, Milpitas, CA (US)

(73) Assignee: **Amazon Technologies, Inc.**, Seattle, WA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 127 days.

(21) Appl. No.: **18/081,566**

(22) Filed: **Dec. 14, 2022**

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 5/335 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0421** (2013.01); **H01Q 5/335** (2015.01)

(58) **Field of Classification Search**
CPC H01Q 1/44; H01Q 9/42; H01Q 1/273; H01Q 7/005; H01Q 1/002; H01Q 1/02;

H01Q 1/2291; H01Q 1/24; H01Q 1/243;
H01Q 13/10; H01Q 13/106; H01Q 21/28;
H01Q 5/10; H01Q 5/30; H01Q 5/378;
H01Q 7/00; H01Q 9/0421; H01Q 5/335;
G08B 13/19656

See application file for complete search history.

(56) **References Cited**

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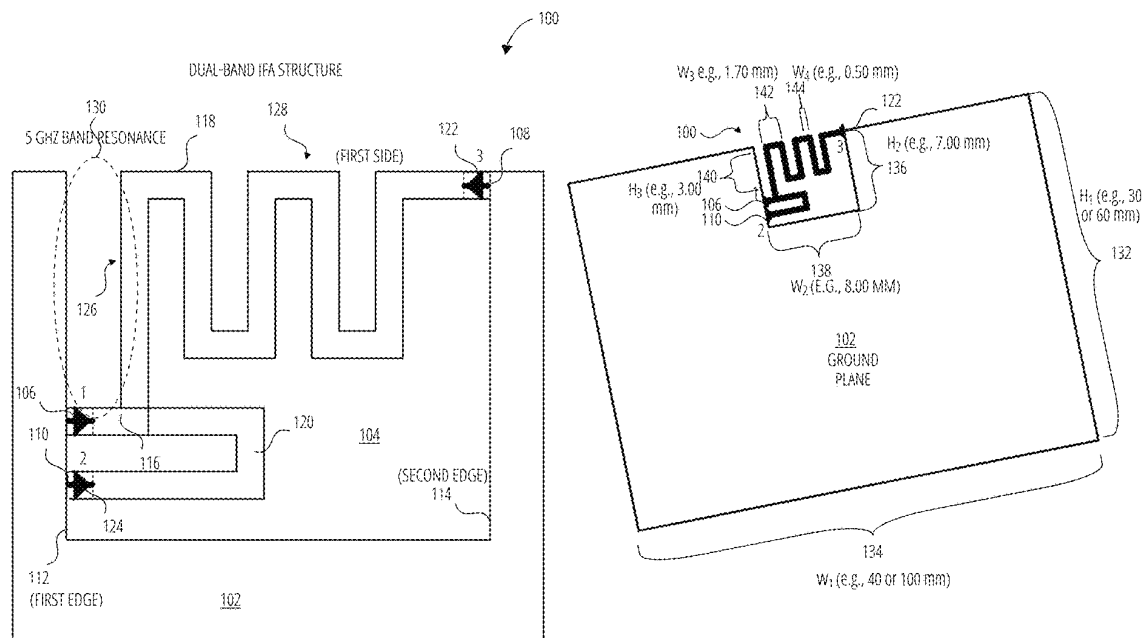
Primary Examiner — Monica C King

(74) *Attorney, Agent, or Firm* — Lowenstein Sandler LLP

(57) **ABSTRACT**

Technologies directed to a noise-immune miniaturized antenna (NIMA) structure in a main logic board (MLB) and diverting surface currents from the MLB to a metal structure to reduce noise coupling from a chipset on the MLB to the NIMA structure are described. The NIMA structure is located at a side of the MLB and includes a first tuning component coupled to a distal end of a radiating arm of the NIMA structure and a second tuning component coupled to a distal end of a shorting arm of the NIMA structure. The NIMA structure radiates in a first frequency range and a second frequency range. A conductive fastener couples the MLB to a metal structure to divert surface currents from the MLB to the metal structure.

24 Claims, 29 Drawing Sheets





US012119570B2

(12) **United States Patent**
Shao et al.

(10) **Patent No.:** **US 12,119,570 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

(54) **ANTENNA, ANTENNA MODULE, AND WIRELESS NETWORK DEVICE**

(56) **References Cited**

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(71) Applicant: **Huawei Technologies Co., Ltd.**,
Shenzhen (CN)

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(72) Inventors: **Jinjin Shao**, Wuhan (CN); **Cao Shi**,
Dongguan (CN)

(73) Assignee: **Huawei Technologies Co., Ltd.**,
Shenzhen (CN)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 257 days.

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(21) Appl. No.: **17/951,649**

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(22) Filed: **Sep. 23, 2022**

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(65) **Prior Publication Data**

US 2023/0020807 A1 Jan. 19, 2023

Primary Examiner — Graham P Smith

(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

Related U.S. Application Data

(63) Continuation of application No.
PCT/CN2021/081771, filed on Mar. 19, 2021.

(30) **Foreign Application Priority Data**

Mar. 24, 2020 (CN) 202010215335.0

(51) **Int. Cl.**

H01Q 9/26 (2006.01)

H01Q 21/24 (2006.01)

H01Q 21/29 (2006.01)

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

CPC **H01Q 9/265** (2013.01); **H01Q 21/24**
(2013.01); **H01Q 21/29** (2013.01)

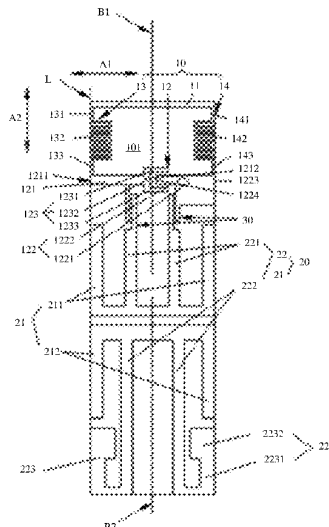
(58) **Field of Classification Search**

CPC H01Q 9/265; H01Q 21/24; H01Q 21/29
See application file for complete search history.

(57) **ABSTRACT**

This application provides an antenna, including a folded antenna, a dipole antenna, and a coupling structure. An extension direction of a primary radiator of the folded antenna is a first direction, an extension direction of a primary radiator of the dipole antenna is a second direction, and the first direction is orthogonal to the second direction. In the second direction, the folded antenna is disposed at one end of the dipole antenna, an operating frequency of the folded antenna is a first frequency band, an operating frequency of the dipole antenna includes a second frequency band, and the first frequency band is higher than the second frequency band. The coupling structure is connected between the folded antenna and the dipole antenna.

20 Claims, 16 Drawing Sheets





US012119571B2

(12) **United States Patent**
Tsuchiya

(10) **Patent No.:** **US 12,119,571 B2**
(45) **Date of Patent:** **Oct. 15, 2024**

(54) **ANTENNA DEVICE**

(71) Applicant: **NEC Platforms, Ltd.**, Kawasaki (JP)

(72) Inventor: **Masato Tsuchiya**, Kanagawa (JP)

(73) Assignee: **NEC Platforms, Ltd.**, Kanagawa (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 126 days.

(21) Appl. No.: **17/908,319**

(22) PCT Filed: **Mar. 22, 2021**

(86) PCT No.: **PCT/JP2021/011658**

§ 371 (c)(1),

(2) Date: **Aug. 31, 2022**

(87) PCT Pub. No.: **WO2021/193506**

PCT Pub. Date: **Sep. 30, 2021**

(65) **Prior Publication Data**

US 2023/0101103 A1 Mar. 30, 2023

(30) **Foreign Application Priority Data**

Mar. 27, 2020 (JP) 2020-057192

(51) **Int. Cl.**
H01Q 9/16 (2006.01)
H01Q 9/26 (2006.01)

(Continued)

(52) **U.S. Cl.**
CPC **H01Q 9/28** (2013.01); **H01Q 19/06** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 19/06; H01Q 5/37; H01Q 5/378;
H01Q 9/16; H01Q 9/26; H01Q 9/28;
H01Q 9/285

See application file for complete search history.

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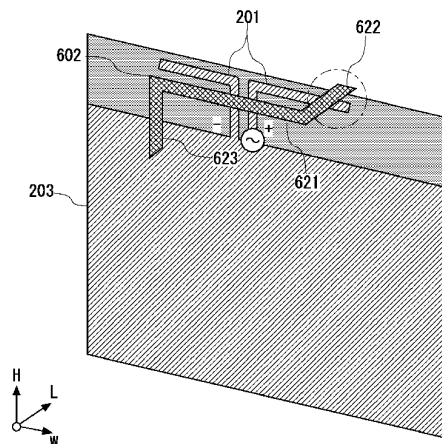
Primary Examiner — Tho G Phan

(57) **ABSTRACT**

An antenna device includes: a mounting board including a circuit configured to process a radio signal; a dipole antenna element configured to receive the radio signal, the dipole antenna element being disposed in the mounting board; and a parasitic element including a first conductor wire parallel to the dipole antenna element, a second conductor wire connected to the first conductor wire at a first end of the first conductor wire at an angle larger than 0 degrees and smaller than 180 degrees, and a third conductor wire connected to the first conductor wire at a second end of the first conductor wire at an angle larger than 0 degrees and smaller than 180 degrees, in which at least an end of the second conductor wire is located near the dipole antenna element.

3 Claims, 10 Drawing Sheets

600





US012120911B2

(12) **United States Patent**
Kim et al.

(10) **Patent No.:** **US 12,120,911 B2**
(45) **Date of Patent:** ***Oct. 15, 2024**

(54) **DISPLAY APPARATUS AND ELECTRIC APPARATUS INCLUDING THE SAME**

(58) **Field of Classification Search**

CPC H10K 59/00; H01Q 1/243; H01Q 9/0407;
H04M 1/0268

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

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This patent is subject to a terminal dis-
claimer.

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(21) Appl. No.: **18/298,565**

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(22) Filed: **Apr. 11, 2023**

(Continued)

(65) **Prior Publication Data**

US 2023/0255054 A1 Aug. 10, 2023

Related U.S. Application Data

(63) Continuation of application No. 16/983,184, filed on
Aug. 3, 2020, now Pat. No. 11,626,455.

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(30) **Foreign Application Priority Data**

Oct. 4, 2019 (KR) 10-2019-0123288

(57) **ABSTRACT**

A display apparatus includes a flexible display panel includ-
ing a display area with a first folding area, the display area
including an upper surface and a lower surface and display-
ing an image via the upper surface, a cover window disposed
on the upper surface of the display area of the flexible
display panel and an antenna layer including a first antenna
disposed on an upper surface of the first folding area. The
upper surface of the display area includes the upper surface
of the first folding area. The first antenna is disposed
between the upper surface of the first folding area and the
cover window.

(51) **Int. Cl.**
H10K 59/00 (2023.01)
H01Q 1/24 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC **H10K 59/00** (2023.02); **H01Q 1/243**
(2013.01); **H01Q 9/0407** (2013.01);
(Continued)

20 Claims, 15 Drawing Sheets

