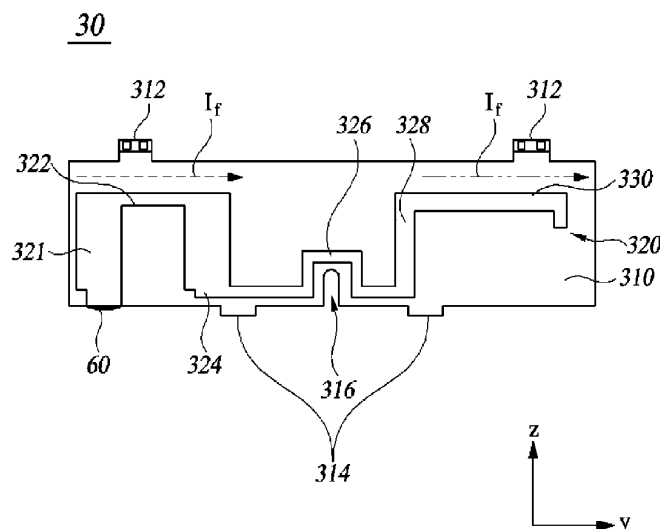
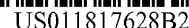






US011824283B2

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

(10) **Patent No.:** **US 11,824,283 B2**
(45) **Date of Patent:** **Nov. 21, 2023**

(54) **ANTENNA ELEMENT AND DISPLAY
DEVICE INCLUDING THE SAME**

(71) Applicant: **DONGWOO FINE-CHEM CO.,
LTD.**, Jeollabuk-do (KR)

(72) Inventors: **Byung Jin Choi**, Incheon (KR); **Young
Ju Kim**, Gyeonggi-do (KR); **Dong Pil
Park**, Incheon (KR)

(73) Assignee: **DONGWOO FINE-CHEM CO.,
LTD.**, Jeollabuk-Do (KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 140 days.

(21) Appl. No.: **17/524,924**

(22) Filed: **Nov. 12, 2021**

(65) **Prior Publication Data**
US 2022/0158350 A1 May 19, 2022

(30) **Foreign Application Priority Data**
Nov. 13, 2020 (KR) 10-2020-0152042

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0471** (2013.01); **H01Q 1/48**
(2013.01); **H01Q 9/0414** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/0414; H01Q 9/045; H01Q 1/38;
H01Q 9/0407

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0092080 A1 * 5/2006 Lee H01Q 9/0471
343/700 MS
2009/0174612 A1 * 7/2009 Ayala H01Q 9/42
343/702
2018/0253170 A1 * 9/2018 Noh H05K 3/046
2020/0403297 A1 * 12/2020 Park H01Q 1/243

FOREIGN PATENT DOCUMENTS

KR 10-2003-0095557 A 12/2003
KR 102031203 B1 * 10/2019 H01Q 9/045

* cited by examiner

Primary Examiner — Dimary S Lopez Cruz

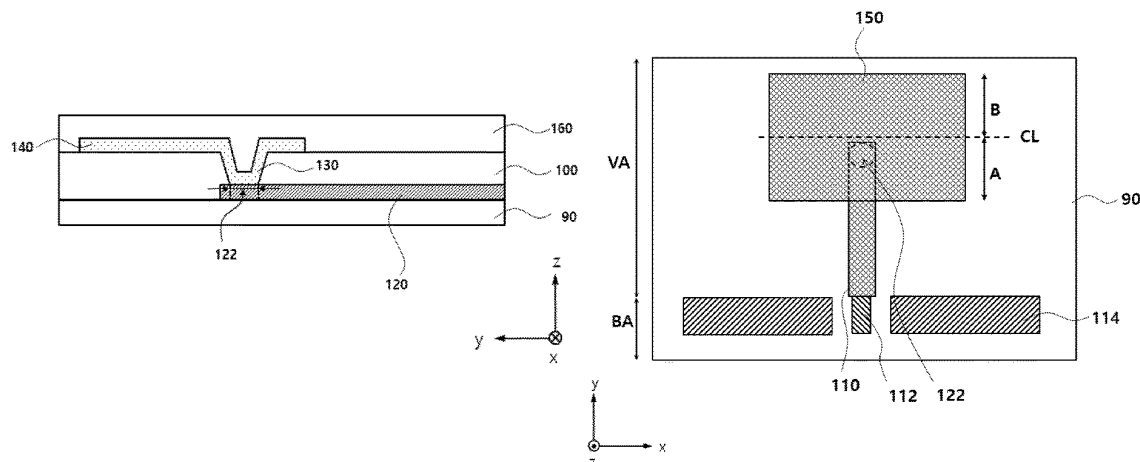
Assistant Examiner — Aladdin Abdulkaki

(74) *Attorney, Agent, or Firm* — The PL Law Group,
PLLC

(57) **ABSTRACT**

An antenna element according to an embodiment of the
present invention includes a radiation body including a
contact part which is concave toward the transmission line,
a transmission line disposed on a different layer from the
radiation body and connected to the radiation body through
the contact part, and a signal pad connected to an end of the
transmission line.

9 Claims, 4 Drawing Sheets





(10) **Patent No.:** US 11,824,568 B2
(45) **Date of Patent:** Nov. 21, 2023

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,421,033 A * 5/1947 Mason H01P 1/2133
333/134

5,483,678 A * 1/1996 Abe H01Q 1/38
343/702

6,184,836 B1 * 2/2001 Ali H01Q 5/378
343/866

6,204,826 B1 * 3/2001 Rutkowski H01Q 5/371
343/895

6,765,539 B1 * 7/2004 Wang H01Q 21/30
343/700 MS

6,927,731 B2 * 8/2005 Leclerc H01Q 5/378
343/702

(Continued)

FOREIGN PATENT DOCUMENTS

CA	3086869	A1 *	1/2021	.....	H01Q 21/24
CN	102148420	A *	8/2011	.....	H01Q 1/38

(Continued)

Primary Examiner — Dimary S Lopez Cruz

Assistant Examiner — Jordan E. DeWitt

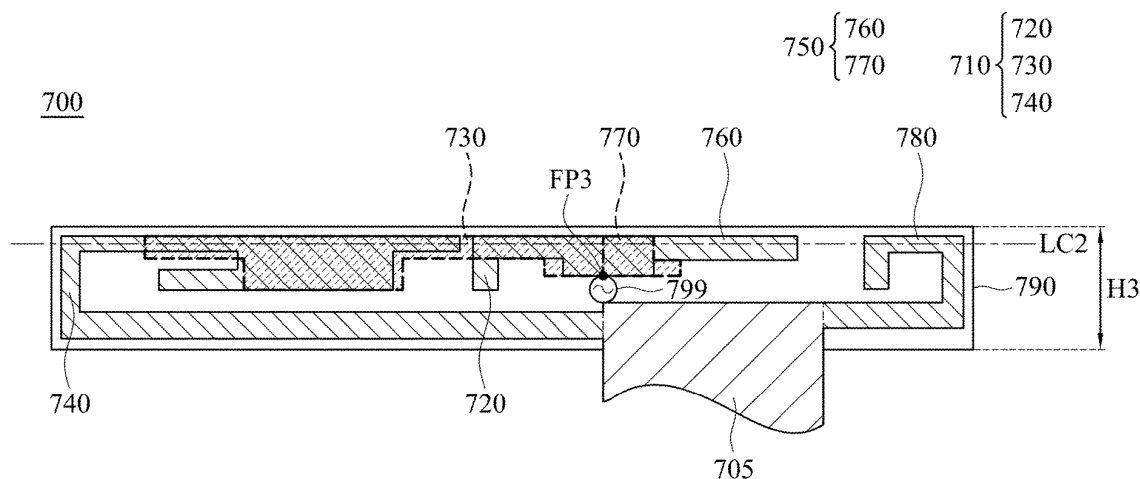
(74) *Attorney, Agent, or Firm* — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

An antenna structure includes a ground element, a first radiation element, a second radiation element, a third radiation element, and a dielectric substrate. The first radiation element has a feeding point. The first radiation element is coupled to a first grounding point on the ground element. The second radiation element is coupled to the feeding point. The third radiation element is coupled to a second grounding point on the ground element. The third radiation element is adjacent to the second radiation element. The ground element, the first radiation element, the second radiation element, and the third radiation element are all disposed on the dielectric substrate.

18 Claims, 15 Drawing Sheets

(58) **Field of Classification Search**
CPC H04B 1/0053; H01Q 1/38; H01Q 1/48;
H01Q 1/243; H01Q 5/392; H01Q 5/40
See application file for complete search history.





US011831076B2

(12) **United States Patent**
Yoshikawa

(10) **Patent No.:** **US 11,831,076 B2**
(45) **Date of Patent:** **Nov. 28, 2023**

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

(58) **Field of Classification Search**
CPC H01Q 21/0006; H01Q 13/08; H01Q 1/48;
H01Q 1/38; H01Q 1/521; H01Q 9/0442;
(Continued)

(71) Applicant: **KYOCERA Corporation**, Kyoto (JP)

(72) Inventor: **Hiromichi Yoshikawa**, Yokohama (JP)

(73) Assignee: **KYOCERA CORPORATION**, Kyoto
(JP)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 385 days.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,827,271 A 5/1989 Berneking et al.
4,924,236 A * 5/1990 Schuss H01Q 9/0442
343/859

(Continued)

FOREIGN PATENT DOCUMENTS

CN 105210232 A 12/2015
EP 2940795 A1 4/2015
JP 2017504274 A 2/2017

Primary Examiner — Seung H Lee

(74) Attorney, Agent, or Firm — HAUPTMAN HAM,
LLP

(21) Appl. No.: **17/288,914**

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

(86) PCT No.: **PCT/JP2019/042058**

§ 371 (c)(1),

(2) Date: **Apr. 27, 2021**

(87) PCT Pub. No.: **WO2020/090691**

PCT Pub. Date: **May 7, 2020**

(65) **Prior Publication Data**

US 2021/0399435 A1 Dec. 23, 2021

(30) **Foreign Application Priority Data**

Oct. 31, 2018 (JP) 2018-206002

(51) **Int. Cl.**

H01Q 21/00 (2006.01)

H01Q 13/08 (2006.01)

H01Q 1/48 (2006.01)

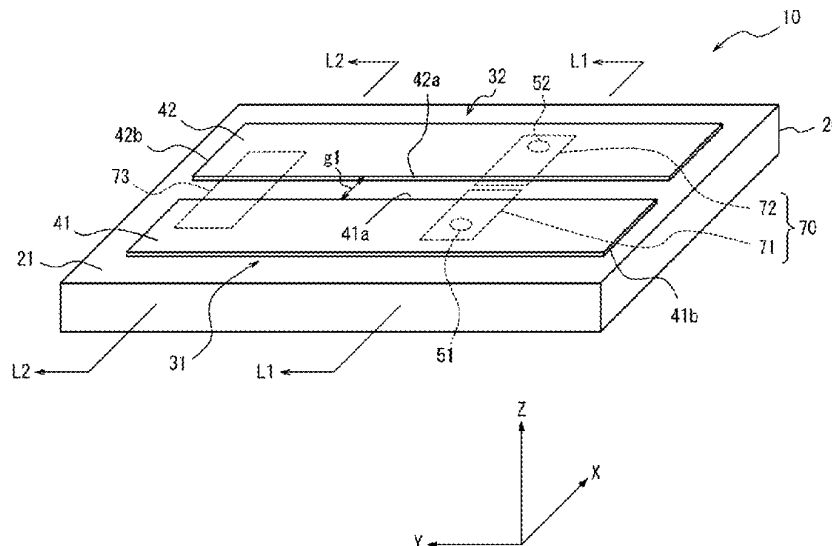
(52) **U.S. Cl.**

CPC **H01Q 21/0006** (2013.01); **H01Q 13/08**
(2013.01); **H01Q 1/48** (2013.01)

(57) **ABSTRACT**

An antenna includes first and second antenna elements and first and second couplers. The first antenna element includes a first radiation conductor and a first feeder line. The second antenna element includes a second radiation conductor and a second feeder line. The second feeder line is coupled to the first feeder line such that a first component, which is a capacitance component or an inductance component, is dominant. The first coupler couples the first and second feeder lines such that a second component is dominant. The first radiation conductor and the second radiation conductor are arranged at an interval of $\frac{1}{2}$ or less of a resonance wavelength. The second radiation conductor is coupled to the first radiation conductor with a first coupling method in which a capacitive coupling or a magnetic field coupling is dominant. The second coupler couples the first and second radiation conductors with a second coupling method.

20 Claims, 22 Drawing Sheets





US011831086B2

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

(10) **Patent No.:** **US 11,831,086 B2**
(45) **Date of Patent:** **Nov. 28, 2023**

(54) **ANTENNA STRUCTURE**

(56)

References Cited

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

U.S. PATENT DOCUMENTS

(72) Inventors: **Po-Yen Chen**, Hsinchu (TW);
Kuan-Hung Li, Hsinchu (TW)

9,929,473 B2	3/2018	Huang et al.	
10,644,407 B2 *	5/2020	Wu	H01Q 5/371
10,971,807 B2	4/2021	Tseng et al.	
2009/0058735 A1 *	3/2009	Hill	H01Q 5/371
			343/702
2017/0033467 A1 *	2/2017	Huang	H01Q 5/357
2017/0207542 A1 *	7/2017	Tseng	H01Q 1/48

(73) Assignee: **WISTRON NEWEB CORP.**, Hsinchu (TW)

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

(Continued)

FOREIGN PATENT DOCUMENTS

(21) Appl. No.: **17/370,181**

CN	111326858 A	6/2020
CN	111697317 A	9/2020

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

(Continued)

(65) **Prior Publication Data**

US 2022/0131267 A1 Apr. 28, 2022

Primary Examiner — Ricardo I Magallanes

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

(30) **Foreign Application Priority Data**

Oct. 27, 2020 (TW) 109137217

(57)

ABSTRACT

An antenna structure includes a metal mechanism element, a ground element, a feeding radiation element, and a dielectric substrate. The metal mechanism element has a slot. The slot has a first closed end and a second closed end. The ground element is coupled to the metal mechanism element. The feeding radiation element has a feeding point. The feeding radiation element is coupled to the ground element. The dielectric substrate has a first surface and a second surface which are opposite to each other. The feeding radiation element is disposed on the first surface of the dielectric substrate. The second surface of the dielectric substrate is adjacent to the metal mechanism element. The slot of the metal mechanism element is excited to generate a first frequency band and a second frequency band. The feeding radiation element is excited to generate a third frequency band.

(51) **Int. Cl.**

H01Q 5/10 (2015.01)

H01Q 1/48 (2006.01)

H01Q 13/10 (2006.01)

H01Q 9/42 (2006.01)

H01Q 5/364 (2015.01)

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

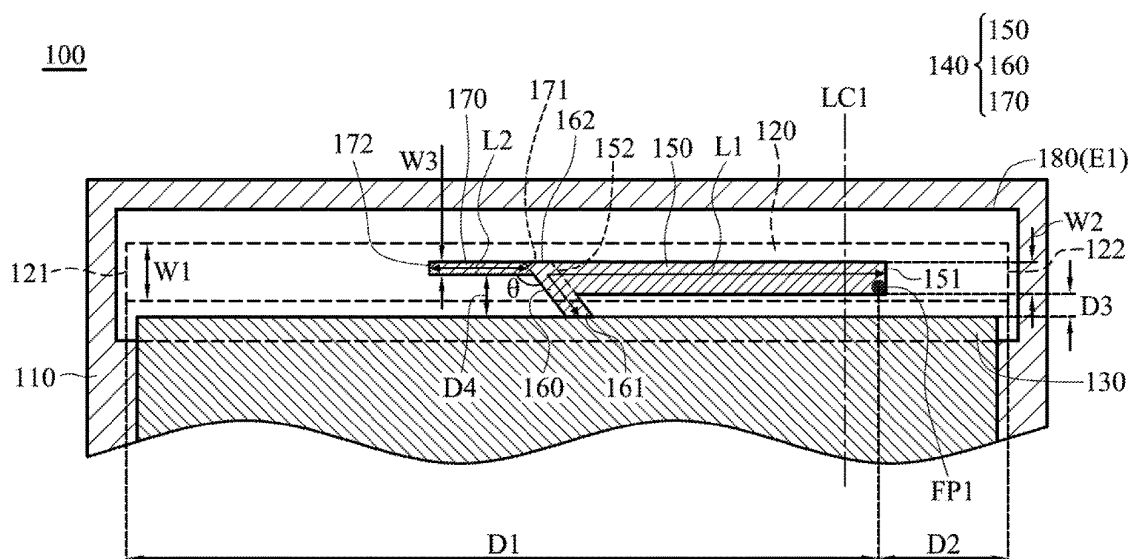
CPC **H01Q 5/10** (2015.01); **H01Q 1/48** (2013.01); **H01Q 5/364** (2015.01); **H01Q 9/42** (2013.01); **H01Q 13/10** (2013.01)

(58) **Field of Classification Search**

CPC H01Q 13/10; H01Q 5/357; H01Q 13/106; H01Q 5/10; H01Q 1/48; H01Q 5/364; H01Q 9/42

See application file for complete search history.

9 Claims, 6 Drawing Sheets





US011831089B2

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

(10) **Patent No.:** **US 11,831,089 B2**
(45) **Date of Patent:** **Nov. 28, 2023**

(54) **ANTENNA SUBSTRATE AND ANTENNA
MODULE COMPRISING THE SAME**

H01Q 23/00; H01Q 19/005; H01Q 15/10;
H01Q 15/08; H01Q 1/38; H01Q 9/065;
H01Q 21/08; H01Q 25/00; H01Q 9/0414

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

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Moon Hee Yi**, Suwon-si (KR); **Tae
Seong Kim**, Suwon-si (KR)

9,331,030 B1 * 5/2016 Tsai H01L 21/76877
9,935,065 B1 * 4/2018 Baheti H01L 23/66
10,157,834 B1 * 12/2018 Tang H01L 24/19
2005/0088260 A1 * 4/2005 Ajioka H01L 23/66
333/247

(73) Assignee: **SAMSUNG**
ELECTRO-MECHANICS CO., LTD.,
Suwon-si (KR)

(Continued)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 358 days.

FOREIGN PATENT DOCUMENTS

KR 10-2014-0115808 A 10/2014
KR 10-2019-0052486 A 5/2019

Primary Examiner — Hai V Tran

Assistant Examiner — Bamidele A Jegede

(21) Appl. No.: **16/789,039**

(22) Filed: **Feb. 12, 2020**

(74) Attorney, Agent, or Firm — Morgan, Lewis &
Bockius LLP

(65) **Prior Publication Data**

US 2021/0175627 A1 Jun. 10, 2021

(57) **ABSTRACT**

(30) **Foreign Application Priority Data**

Dec. 10, 2019 (KR) 10-2019-0163278

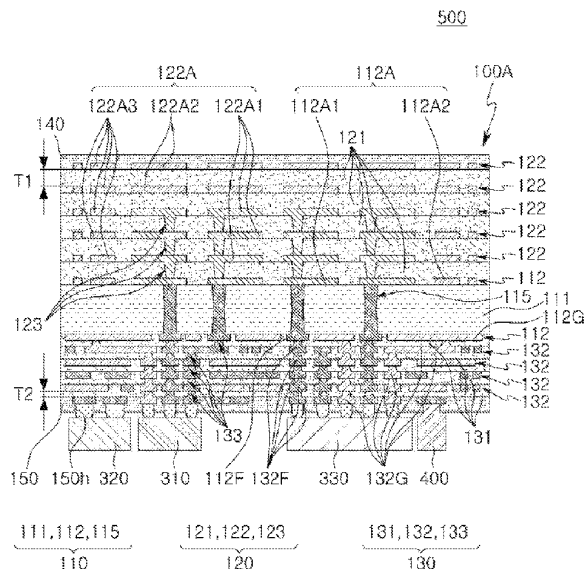
(51) **Int. Cl.**
H01Q 1/38 (2006.01)
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 1/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/045** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 1/422** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/045; H01Q 1/243; H01Q 1/422;

An antenna substrate and an antenna module including the same are provided. The antenna substrate includes an antenna unit including first and second pattern layers adjacent to each other and disposed on different levels and a first insulating layer providing a first insulating region between the first and second pattern layers, and a feed unit including third and fourth pattern layers adjacent to each other and disposed on different levels and a second insulating layer providing a second insulating region between the third and fourth pattern layers. Each of the first and second pattern layers includes an antenna pattern, and each of the third and fourth pattern layers includes a feed pattern. The antenna unit is disposed on the feed unit. The first insulating region is thicker than the second insulating region.

20 Claims, 10 Drawing Sheets





US011831090B2

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

(10) **Patent No.:** **US 11,831,090 B2**
(45) **Date of Patent:** **Nov. 28, 2023**

(54) **ELECTRONIC DEVICES WITH
DISPLAY-OVERLAPPING ANTENNAS**

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

(72) Inventors: **Forhad Hasnat**, Cupertino, CA (US);
David Garrido Lopez, Campbell, CA
(US); **Harish Rajagopalan**, San Jose,
CA (US); **Mikal Askarian Amiri**,
Tempe, AZ (US); **Rodney A. Gomez**
Angulo, Santa Clara, CA (US); **Lu**
Zhang, Shanghai (CN)

(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 351 days.

(21) Appl. No.: **16/903,198**

(22) Filed: **Jun. 16, 2020**

(65) **Prior Publication Data**

US 2021/0391651 A1 Dec. 16, 2021

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 9/40 (2006.01)
H01Q 7/00 (2006.01)
H01Q 13/22 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/40** (2013.01); **H01Q 1/243**
(2013.01); **H01Q 7/00** (2013.01); **H01Q 13/22**
(2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/40; H01Q 1/243; H01Q 7/00;
H01Q 13/22; H01Q 13/18; H01Q 9/42
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,814,776	A *	3/1989	Caci	H01Q 7/00 343/702
5,933,330	A	8/1999	Beutler et al.	
8,805,272	B2	8/2014	Kawamura	
9,153,856	B2 *	10/2015	Rappoport	H01Q 1/48
9,354,673	B2	5/2016	Sakakibara et al.	
10,158,384	B1 *	12/2018	Yarga	H04B 1/0458
10,193,597	B1 *	1/2019	Garrido Lopez	H04B 1/38
10,200,105	B2	2/2019	Hu et al.	
10,218,052	B2	2/2019	Pascolini et al.	
10,320,069	B2	6/2019	Zhou et al.	
10,355,344	B1	7/2019	Ruaro et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

WO WO-2014203967 A1 * 12/2014 H01Q 1/243

Primary Examiner — Hai V Tran

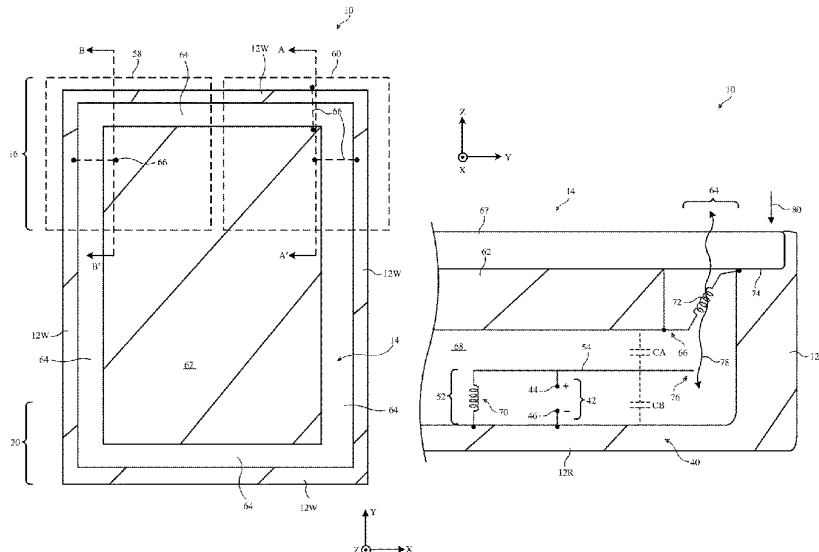
Assistant Examiner — Bamidele A Jegede

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

(57) **ABSTRACT**

An electronic device may include a conductive housing with a rear wall and a sidewall. A display may be mounted to the sidewall and may include a conductive display structure separated from the sidewall by a slot. An antenna arm may be interposed between the conductive display structure and the rear wall. A first inductor may couple the conductive display structure to the housing and may compensate for a distributed capacitance between the antenna arm and the conductive display structure. A second inductor may couple the antenna arm to the rear wall and may compensate for a distributed capacitance between the antenna arm and the rear wall. A speaker may be co-located with the antenna. A third inductor may couple the antenna arm to the rear wall to allow antenna currents to bypass the speaker.

20 Claims, 9 Drawing Sheets





US01183777B2

(12) **United States Patent**
Zeng

(10) **Patent No.:** **US 11,837,777 B2**
(45) **Date of Patent:** **Dec. 5, 2023**

(54) **ANTENNA ASSEMBLY AND TERMINAL**

2013/0027167 A1* 1/2013 Sano H05K 1/182

(71) Applicant: **BEIJING XIAOMI MOBILE
SOFTWARE CO., LTD.**, Beijing (CN)

2013/0308282 A1* 11/2013 Shin H05K 1/0277

(72) Inventor: **Lun Zeng**, Beijing (CN)

336/192

2015/0061941 A1 3/2015 Hill et al.

2020/0365972 A1 11/2020 Jeon et al.

(73) Assignee: **BEIJING XIAOMI MOBILE
SOFTWARE CO., LTD.**, Beijing (CN)

FOREIGN PATENT DOCUMENTS

CN 109378584 A 2/2019

CN 208923342 U 5/2019

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 335 days.

OTHER PUBLICATIONS

(21) Appl. No.: **17/446,294**

Extended European Search Report in Application No. 21194530.8, dated Feb. 14, 2022.

(22) Filed: **Aug. 28, 2021**

* cited by examiner

(65) **Prior Publication Data**

US 2022/0209408 A1 Jun. 30, 2022

Primary Examiner — Krystal Robinson

(74) *Attorney, Agent, or Firm* — SYNCODA LLC; Feng Ma

(30) **Foreign Application Priority Data**

Dec. 28, 2020 (CN) 202011580679.8

(57) **ABSTRACT**

(51) **Int. Cl.**
H05K 1/18 (2006.01)

H01Q 1/24 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H05K 1/181** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/243; H05K 1/181
See application file for complete search history.

A antenna assembly includes: a first antenna disposed on the first support provided with a first through hole, wherein the first antenna includes a first part disposed on an upper surface of the first support, a second part disposed inside the first through hole, and a third part disposed on a lower surface of the first support; a first connecting plate, an upper surface of which abuts against the third part, and lower surface is attached to an upper surface of the circuit board; a second connecting plate, an upper surface of which is attached to a lower surface of the circuit board; and a second antenna disposed on a middle frame of the terminal and connected to a lower surface of the second connecting plate, the first antenna being connected to a feed point of the second antenna through the first connecting plate and the second connecting plate.

(56) **References Cited**

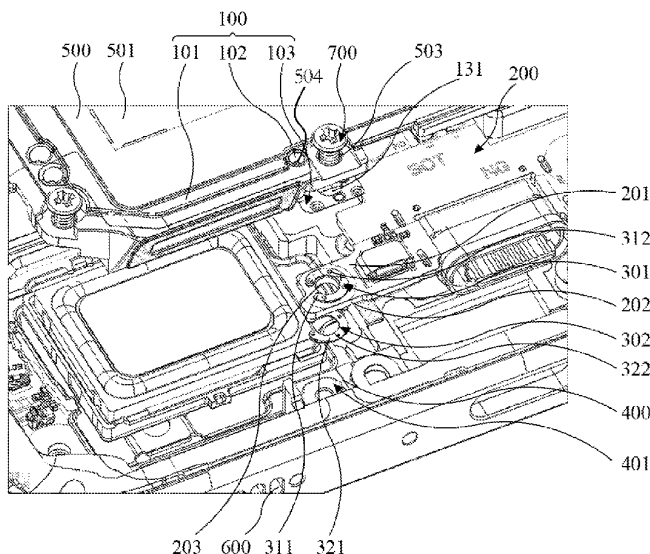
U.S. PATENT DOCUMENTS

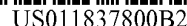
2011/0267783 A1* 11/2011 Mutnury H05K 1/115

174/266

2012/0313825 A1 12/2012 Kuramoto et al.

17 Claims, 5 Drawing Sheets





(10) **Patent No.:** US 11,837,800 B2
(45) **Date of Patent:** Dec. 5, 2023

- (56)
- References Cited**

- 11,646,495 B2 * 5/2023 Ishizuka H01Q 21/30
343/700 MS

- 2008/0231526 A1* 9/2008 Sato H01Q 7/00
343/722

- (Continued)

- | | | | |
|----|-------------|----|---------|
| JP | 2012-109875 | A | 6/2012 |
| WO | 2012/153690 | A1 | 11/2012 |
| WO | 2018/101284 | A1 | 6/2018 |

- ## OTHER PUBLICATIONS

- Official Communication issued in International Patent Application
No. PCT/JP2020/030063, dated Oct. 20, 2020.

- Primary Examiner* — Jany Richardson

- (74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

- (57) **ABSTRACT**

- An antenna unit includes a coupling element including first and second coils, a feeding radiating element, and a parasitic radiating element. A series circuit including the first coil and a feeder circuit is connected to the feeding radiating element, and the parasitic radiating element is connected to the second coil. A distance between open ends of the parasitic radiating element and a short portion of the feeding radiating element is shorter than a distance between open ends of the parasitic radiating element and a long portion of the feeding radiating element. The antenna unit is an antenna for a first frequency band with fundamental wave resonance of the long portion and fundamental wave resonance of the parasitic radiating element, and a second frequency band with higher-order resonance of the parasitic radiating element and resonance of the short portion, the second frequency band being higher than the first frequency band.

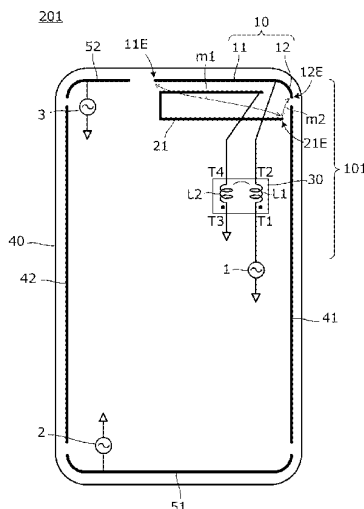
- An antenna unit includes a coupling element including first and second coils, a feeding radiating element, and a parasitic radiating element. A series circuit including the first coil and a feeder circuit is connected to the feeding radiating element, and the parasitic radiating element is connected to the second coil. A distance between open ends of the parasitic radiating element and a short portion of the feeding radiating element is shorter than a distance between open ends of the parasitic radiating element and a long portion of the feeding radiating element. The antenna unit is an antenna for a first frequency band with fundamental wave resonance of the long portion and fundamental wave resonance of the parasitic radiating element, and a second frequency band with higher-order resonance of the parasitic radiating element and resonance of the short portion, the second frequency band being higher than the first frequency band.

- An antenna unit includes a coupling element including first and second coils, a feeding radiating element, and a parasitic radiating element. A series circuit including the first coil and a feeder circuit is connected to the feeding radiating element, and the parasitic radiating element is connected to the second coil. A distance between open ends of the parasitic radiating element and a short portion of the feeding radiating element is shorter than a distance between open ends of the parasitic radiating element and a long portion of the feeding radiating element. The antenna unit is an antenna for a first frequency band with fundamental wave resonance of the long portion and fundamental wave resonance of the parasitic radiating element, and a second frequency band with higher-order resonance of the parasitic radiating element and resonance of the short portion, the second frequency band being higher than the first frequency band.

- An antenna unit includes a coupling element including first and second coils, a feeding radiating element, and a parasitic radiating element. A series circuit including the first coil and a feeder circuit is connected to the feeding radiating element, and the parasitic radiating element is connected to the second coil. A distance between open ends of the parasitic radiating element and a short portion of the feeding radiating element is shorter than a distance between open ends of the parasitic radiating element and a long portion of the feeding radiating element. The antenna unit is an antenna for a first frequency band with fundamental wave resonance of the long portion and fundamental wave resonance of the parasitic radiating element, and a second frequency band with higher-order resonance of the parasitic radiating element and resonance of the short portion, the second frequency band being higher than the first frequency band.

- An antenna unit includes a coupling element including first and second coils, a feeding radiating element, and a parasitic radiating element. A series circuit including the first coil and a feeder circuit is connected to the feeding radiating element, and the parasitic radiating element is connected to the second coil. A distance between open ends of the parasitic radiating element and a short portion of the feeding radiating element is shorter than a distance between open ends of the parasitic radiating element and a long portion of the feeding radiating element. The antenna unit is an antenna for a first frequency band with fundamental wave resonance of the long portion and fundamental wave resonance of the parasitic radiating element, and a second frequency band with higher-order resonance of the parasitic radiating element and resonance of the short portion, the second frequency band being higher than the first frequency band.

- An antenna unit includes a coupling element including first and second coils, a feeding radiating element, and a parasitic radiating element. A series circuit including the first coil and a feeder circuit is connected to the feeding radiating element, and the parasitic radiating element is connected to the second coil. A distance between open ends of the parasitic radiating element and a short portion of the feeding radiating element is shorter than a distance between open ends of the parasitic radiating element and a long portion of the feeding radiating element. The antenna unit is an antenna for a first frequency band with fundamental wave resonance of the long portion and fundamental wave resonance of the parasitic radiating element, and a second frequency band with higher-order resonance of the parasitic radiating element and resonance of the short portion, the second frequency band being higher than the first frequency band.





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

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(45) **Date of Patent:** **Dec. 12, 2023**

(54) **MULTI-BAND ANTENNA STRUCTURE**

(56) **References Cited**

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U.S. PATENT DOCUMENTS

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6,831,615 B2 12/2004 Gottl
2015/0036601 A1 2/2015 Kiim et al.
(Continued)

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CN 1404639 A 3/2003
CN 103259087 A 8/2013
(Continued)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 358 days.

FOREIGN PATENT DOCUMENTS

OTHER PUBLICATIONS

(21) Appl. No.: **17/358,417**

“Remaining Issues on UL Data Transmission Procedure,” Agenda Item: 7.1.3.3.4, Source: LG Electronics, Document for: Discussion and decision, 3GPP TSG RAN WG1 Meeting #92, R1-1802215, Athens, Greece, Feb. 26-Mar. 2, 2018, 13 pages.
(Continued)

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Primary Examiner — Graham P Smith

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(Continued)

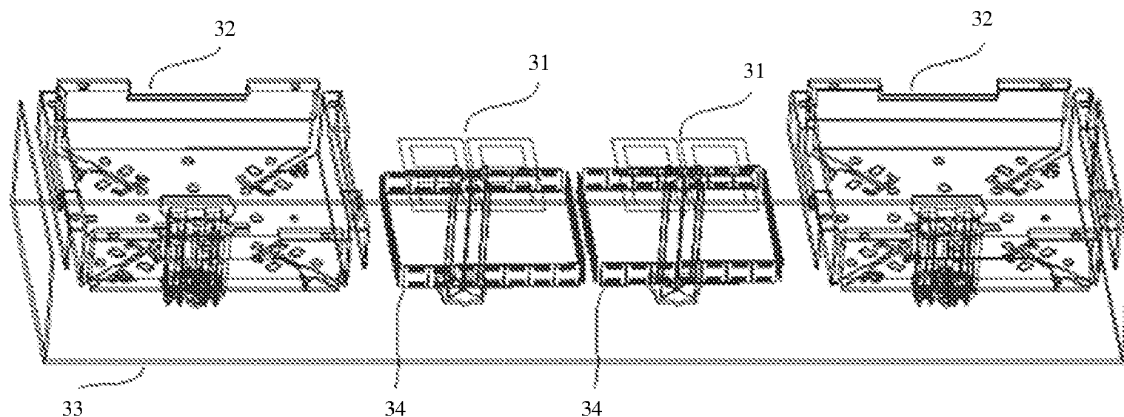
(52) **U.S. Cl.**
CPC **H01Q 5/30** (2015.01); **H01Q 1/36**
(2013.01); **H01Q 15/00** (2013.01); **H01Q 19/10** (2013.01); **H01Q 21/30** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 5/30; H01Q 1/36; H01Q 15/00;
H01Q 19/10; H01Q 21/30
See application file for complete search history.

(57) **ABSTRACT**

A multi-band antenna structure, including a first antenna element, a second antenna element, a reflection panel, and a first parasitic structure of the first antenna element. A distance between the reflection panel and an antenna element with a higher operating frequency band is less than a distance between the reflection panel and an antenna element with a lower operating frequency band. A distance between the first antenna element and the second antenna element is less than 0.5 times a vacuum wavelength corresponding to a lower frequency bands. A distance between the first antenna element and the first parasitic structure is less than 0.5 times a vacuum wavelength corresponding to an operating frequency band of the first antenna element. A distance between the second antenna element and the first parasitic structure is less than 0.5 times a vacuum wavelength corresponding to an operating frequency band of the second antenna element.

20 Claims, 15 Drawing Sheets





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

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(54) **DISTRIBUTED, TUNABLE RADIATING
ELEMENT**

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- (*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
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H01Q 9/04 (2006.01)
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(2013.01); **H01Q 9/0414** (2013.01)
- (58) **Field of Classification Search**
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H01Q 5/314; H01Q 5/378; H01Q 5/50;
H01Q 9/42

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2009/0040115	A1 *	2/2009	Zhang	.....	H01Q 1/36 343/702
2012/0214412	A1 *	8/2012	Schlub	.....	H01Q 1/243 455/41.1
2014/0015720	A1 *	1/2014	Handro	.....	H01Q 9/42 343/745
2014/0375515	A1 *	12/2014	Qiu	.....	H01Q 5/378 343/745
2016/0043467	A1 *	2/2016	Desclos	.....	H01Q 5/378 343/745
2016/0286169	A1 *	9/2016	Sannala	.....	H01Q 21/28
2017/0207829	A1 *	7/2017	Morris	.....	H01Q 5/50
2017/0212554	A1 *	7/2017	Guterman	.....	H01Q 1/2291
2018/0226719	A1 *	8/2018	Wong	.....	H01Q 9/0442
2022/0069437	A1 *	3/2022	Yoo	.....	H01Q 1/42

* cited by examiner

Primary Examiner — Hai V Tran

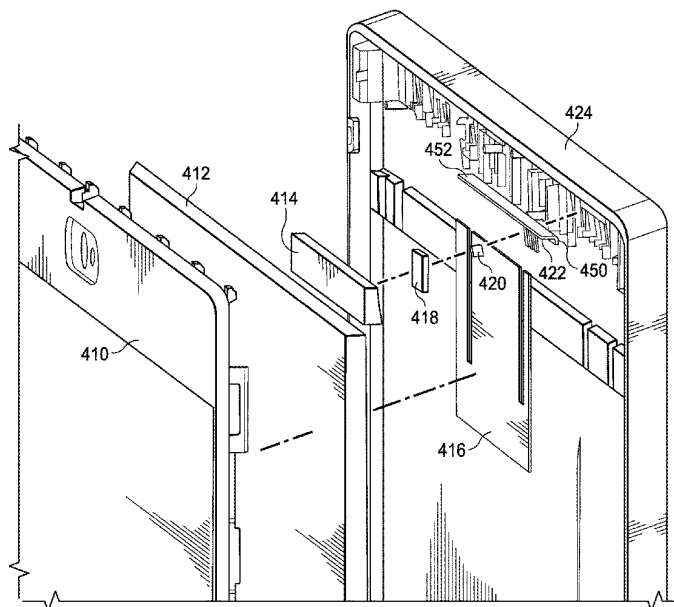
Assistant Examiner — Michael M Bouizza

(74) *Attorney, Agent, or Firm* — Terrile, Cannatti &
Chambers; Stephen A. Terrile

(57) **ABSTRACT**

An information handling system (IHS) includes an antenna system. The antenna system includes an antenna; a radiating element, the radiating element being capacitively coupled with the antenna; and, a tuner module electrically coupled to the antenna and the radiating element, the tuner module tuning the antenna and the radiating element.

12 Claims, 9 Drawing Sheets





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

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

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(58) **Field of Classification Search**

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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2005/0083234 A1 * 4/2005 Poilasne H03F 1/56 343/700 MS
2008/0266202 A1 10/2008 Lin et al.

FOREIGN PATENT DOCUMENTS

CN 111641028 9/2020

* cited by examiner

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(57) **ABSTRACT**

An antenna module includes first, second, third antenna radiators, and first, second, third ground radiators. The first antenna radiator includes a first feeding terminal. The second antenna radiator extends from the first antenna radiator. The third antenna radiator extends from the first feeding terminal. The first ground radiator is disposed beside the first and second antenna radiators. A first coupling gap exists between the first ground radiator and the first and second antenna radiators. The second ground radiator is disposed beside the second antenna radiator. A second coupling gap exists between the second ground radiator and the second antenna radiator. The third ground radiator is disposed beside the first and second antenna radiators. A third coupling gap exists between the third ground radiator and the first antenna radiator. A fourth coupling gap exists between the third ground radiator and the second antenna radiator.

10 Claims, 9 Drawing Sheets

