Paper No. __

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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

GEOTAB INC. AND GEOTAB USA, INC.,
Petitioners,

v.

FRACTUS, S.A.
Patent Owner.

Case No. PGR2025-00056
Patent No. 12,095,149

PETITION FOR POST-GRANT REVIEW
UNDER 35 U.S.C. §§ 321-329 AND 37 C.F.R. § 42.1 et seq.

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1011	X. Jing, Z. Du, and K. Gong. "Compact Planar Monopole Antenna for Multi-band Mobile Phones," in *2005 Asia-Pacific Microwave Conference Proceedings*, vol. 4, pp. 2657-2660, IEEE, 2005 ("Jing")
1012	H. Nakano, Y. Sato, H. Mimaki and J. Yamauchi. "An Inverted FL Antenna for Dual-Frequency Operation," *IEEE Transactions on Antennas and Propagation*, vol. 53, no. 8, pp. 2417-2421, Aug. 2005 ("Nakano")
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1043	IEEE Std. 802.11b-1999, Supplement to the IEEE Standard for Information Technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements— Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Higher-Speed Physical Layer Extension in the 2.4 GHz Band (Jan. 20, 2000)
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1047	Pages from R. Graf, *Modern Dictionary of Electronics* (Newnes: 7th ed. 1999)
1048	Pages from S. Gilbilisco, ed., *The Illustrated Dictionary of Electronics* (McGraw-Hill: 8th ed. 2001)
1049	U.S. Patent No. 6,166,694 ("Ying")

ABBREVIATIONS

Abbreviation	Description
3GPP	3rd Generation Partnership Project
DCS	Digital Communication Service
DL	downlink
ETSI	European Telecommunication Standards Institute
E-UTRAN	Evolved Universal Terrestrial Radio Access Network
FDD	frequency division duplexing
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HiperLAN/2	High Performance Radio LAN version 2
HSDPA	High Speed Downlink Packet Access
HSPA	High Speed Packet Access
HSUPA	High Speed Uplink Packet Access
ISM	Industrial, Scientific, and Medical
ITU	International Telecommunication Union
LAN	local area network
LTE	Long Term Evolution
NAMPS	Narrowband Advanced Mobile Phone Service
PCB	printed circuit board
PCS	Personal Communication Service
PDA	personal digital assistant

Abbreviation	Description
PIFA	planar inverted-F antenna
TDD	time division duplexing
UL	uplink
UMTS	Universal Mobile Telecommunications System
U-NII	unlicensed national information infrastructure
UTRAN	UMTS Terrestrial Radio Access Network
UWB	ultra-wideband
VSWR	voltage standing wave ratio
WCDMA	Wideband Code Division Multiple Access
WiBro	Wireless Broadband
WiMax	Worldwide Interoperability for Microwave Access
WLAN	wideband local area network
WRC	World Radiocommunication Conference

MANDATORY NOTICES

A. Real Party-In-Interest

Petitioners Geotab USA Inc. and Geotab Inc. (collectively "Geotab") are real parties-in-interest under 37 C.F.R. §42.8(b)(1).

B. Related Matters

A decision in this proceeding could affect, or be affected by, the following:

1. United States Patent & Trademark Office

U.S. Patent No. 12,095,149 ("the '149 patent") issued from Application No. 18/339,523 filed June 22, 2023, which is a continuation of Application No. 17/704,942 filed March 25, 2022 (issued as U.S. Patent No. 11,735,810), which is a continuation of Application No. 17/246,192 filed April 30, 2021 (issued as U.S. Patent No. 11,349,200), which is a continuation of Application No. 16/832,820 filed March 27, 2020 (issued as U.S. Patent No. 11,031,677), which is a continuation of Application No. 15/856,626 filed December 28, 2017 (issued as U.S. Patent No. 10,644,380), which is a continuation of Application No. 14/738,090 filed June 12, 2015 (issued as U.S. Patent No. 9,899,727), which is a continuation of Application No. 14/246,491 filed April 7, 2014 (issued as U.S. Patent No. 9,099,773), which is a continuation of Application No. 11/614,429 filed December 21, 2006 (issued as U.S. Patent No. 8,738,103), which claims priority from Provisional Application No. 60/856,410 filed November 3, 2006 and Provisional Application No. 60/831,544 filed July 18, 2006.

U.S. Patent Application No. 18/782,669 was filed July 24, 2024 and is a continuation of Application No. 18/339,523.

2. United States Patent Trial and Appeal Board

a. ’149 patent

The ’149 patent has not been challenged in a post-grant proceeding before this petition.

b. Related patents

U.S. Patent Nos. 11,349,200 (“the ’200 patent”) and 11,031,677 (“the ’677 patent”), which issued from parent applications of the ’149 patent, are the subject of pending IPR2025-01027 (’200 patent) and IPR2025-01026 (’677 patent).

The ’200 patent and U.S. Patent No. 8,738,103, which issued from parent applications of the ’149 patent, were challenged in *Vivint, Inc. v. Fractus, S.A.*, IPR2024-00088 and *Vivint, Inc. v. Fractus, S.A.*, IPR2024-00087, respectively, which settled and were terminated before Fractus filed preliminary patent owner responses and before institution decisions. *Id.*, Paper 14 (Feb. 20, 2024).

3. U.S. District Court for the Eastern District of Texas

a. ’149 patent

The ’149 patent is currently asserted in (i) *Fractus, S.A. v. Geotab Inc.*, No. 2:24-cv-01008 (E.D. Tex.) (“the Geotab Litigation”), and (ii) *Fractus, S.A. v. Verizon Connect Inc. et al.*, No. 2:24-cv-01009 (E.D. Tex.) (“the Verizon Litigation”). The ’149 patent has not previously been asserted.

b. Related patents

The ’103 and ’200 patents (parents to the ’149 patent) were asserted in these actions:

(i) *Fractus, S.A. v. ADT LLC*, No. 2:22-cv-00412 (E.D. Tex.) (“ADT Litigation”), which was dismissed with prejudice on October 4, 2024 (D.I. 253).

(ii) *Fractus, S.A. v. Vivint, Inc.*, No. 2:22-cv-00413 (E.D. Tex.) (“Vivint Litigation”), which was dismissed with prejudice on February 20, 2024 (D.I. 22).

The ’200 patent is also asserted in the Geotab Litigation, while the ’677 patent is asserted in both the Geotab and Verizon Litigations.

C. Counsel and Service Information - §§42.8(b)(3) and (4)

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A power of attorney is submitted with the Petition. Counsel for Petitioner consents to service of all documents via electronic mail.

Geotab Inc. and Geotab USA, Inc. ("Geotab" or "Petitioners") request post-grant review ("PGR") and cancellation of claims 1-20 (the "Challenged Claims") of U.S. Patent No. 12,095,149 (EX1005, "the '149 patent").

I. INTRODUCTION

The '149 patent concerns antennas in wireless devices like mobile phones. The alleged "invention" purports to "provide antenna design parameters that tend to optimize the efficiency of" such antennas. EX1005, 5:25-28. The claims recite design parameters called "complexity factors"—a term coined by the inventors—that purport to characterize the "complexity" of an antenna's three-dimensional shape.[1] According to the specification, an antenna designer should ensure that a designed antenna has "complexity factors" within certain ranges because that will ensure that the antenna is "optimized."

Even if there were something inventive about this design methodology (which Petitioners do not concede), that is not what the '149 patent claims. Instead, every claim concerns a wireless device with an antenna that meets the claimed complexity factors, regardless of whether a designer used those factors during an "antenna system" design process. The '149 patent does not allege that

[1] The "complexity factors" are determined by mathematical calculation using a methodology described in the '149 patent and explained in detail below.

the inventors were the first to ever design an antenna having "complexity factor" values that fall within the claims. They indisputably were not, as demonstrated by the antennas disclosed in the Ciais-Multiband (Grounds 1A, 1B), Ciais-Quadband (Ground 2), Nakano (Ground 2), and Jing (Grounds 3A, 3B) references.

That the Examiner failed to appreciate that antennas were known that met the claimed complexity factors is unsurprising. Given that "complexity factor" was a term coined by the inventors, the Examiner could not have found in any reference describing an antenna an explanation of what the antenna's "complexity factor" values were. And as will become clear from the explanation below, applying the '149 patent's prescribed approach for calculating the complexity factor values—for even a single antenna—is a time consuming process.

Compounding the problem, the applicant overwhelmed the Examiner with volume. The '149 patent lists ***1909*** cited references (spanning 27 pages). The record does not reflect that the Examiner calculated the complexity factor values for even a single one of the antennas disclosed in the almost 2000 cited references. The claims issued without the Examiner rejecting a single claim over the prior art or discussing a single one of the cited references. The ***only*** rejections were for double-patenting over parent cases.

The claims are demonstrably unpatentable. Before the earliest possible priority date, Dou described a wireless device (e.g., a mobile phone) with multiple internal antennas and stated that any suitable antenna design could be used for those antennas. Ciais described just such a "suitable" antenna for a mobile device, and Ciais's multiband antenna meets the claimed complexity factors. **Ground 1A** shows that Dou implemented with Ciais's multiband antenna renders obvious independent claims 7 and 13, and several dependent claims. **Ground 1B** shows that Dou implemented with Hilgers's antenna, in addition to Ciais's multiband antenna, renders obvious dependent claims 10 and 18.

Nakano also describes a "suitable" antenna that provides support for wideband local area networks for a mobile device at 2.4 and 5.2 GHz, while Ciais's quadband antenna is a "suitable" antenna that provides support for cellular communications. **Ground 2** shows that Dou implemented with Ciais's quadband antenna supporting cellular communication, and Nakano's antenna supporting wideband local area networking, renders obvious all Challenged Claims.

Jing further describes a "suitable" antenna for a mobile device. Ground 3A shows that Dou implemented with Jing's antenna renders obvious independent claims 1 and 13, and several dependent claims. Ground 3B shows that Dou implemented with Ying's antenna, in addition to Jing's antenna, renders obvious dependent claims 6 and 18.

The Board should institute PGR and cancel claims 1-20.

II. STANDING CERTIFICATION

Petitioners certify that the ’149 patent, which issued September 17, 2024, is available for PGR. Petitioners are neither barred nor estopped from requesting PGR of the ’149 patent. 37 C.F.R. §42.204(a).

III. UNPATENTABILITY GROUNDS

The following claims are unpatentable as obvious over the following references.

Ground	References	Claims
1A	Dou, Ciais-Multiband	7-9, 11-14, 16-17, 19-20
1B	Dou, Ciais-Multiband, Hilgers	10, 18
2	Dou, Ciais-Quadband, Nakano	1-20
3A	Dou, Jing	1, 3-5, 13, 15, 17, 19-20
3B	Dou, Jing, Ying	6, 18

Each reference is prior art to the Challenged Claims as follows.

Reference	Priority Date	pre-AIA
Dou (EX1013)	2006-02-24	§102(e)
Ciais-Multiband (EX1010)	2004-08-06	§§102(a), (b)
Hilgers (EX1040)	2003-02-06	§102(b)
Ciais-Quadband (EX1009)	2004-04-04	§§102(a), (b)
Nakano (EX1012)	2005-08-08	§102(a)
Jing (EX1011)	2006-03-20	§102(a)
Ying (EX1049)	2000-12-26	§102(b)

In litigation, Patent Owner ("Fractus" or "PO") alleged that claims 1-5, 7-10, 12-15, and 17-20 were conceived June 19, 2006. EX1016, 1-4. Even if every Challenged Claim was conceived by June 19, 2006 and entitled to the earliest-alleged priority date (July 18, 2006) on the face of the '149 patent, each reference is prior art under the foregoing pre-AIA §102 sub-sections.

Ciais-Quadband was published in IEEE Microwave and Wireless Components Letters, volume 14, no. 4, dated April 2004, published May 4, 2004 on IEEE Explore. EX1009, 148; EX1027, ¶¶6-9, 12-13, p. 8; EX1014, ¶¶33-44. Ciais-Quadband is pre-AIA §102(b) prior art to every Challenged Claim because it published before July 18, 2005. EX1014, ¶¶57, 33-57, Attachment A-1.

Ciais-Multiband was included in *Electronics Letters*, volume 40, no. 15, dated July 2004. EX1010, 920-921; EX1014, ¶¶58-69. Ciais-Multiband is pre-AIA §102(b) prior art to every Challenged Claim because it was published before July 18, 2005. EX1014, ¶¶85, 70-85, Attachment B-1.

Nakano was published in *IEEE Transactions on Antennas and Propagation*, volume 53, no. 8, dated August 2005. EX1012, 2417; EX1014, ¶¶117-128. It published August 8, 2005 on IEEE Explore (EX1027, ¶¶6-8, 10, 12, 14, p.21), and Linda Hall Library stamped a hard copy received on August 16, 2005. EX1014, ¶¶121-123, Attachment D-1. Nakano was published no later than August 21, 2005 and is pre-AIA §102(a) prior art to every Challenged Claim. EX1014, ¶¶144, 117-144, Attachment D-1.

Jing was included in 2005 Asia-Pacific Microwave Conference Proceedings, volume 4, pp. 2657-2660, IEEE, 2005, published March 20, 2006 on IEEE Explore. EX1011, 2657-2660; EX1027, ¶¶6-8, 11-12, 15, p. 35; EX1014, ¶¶86-100. Jing is pre-AIA §102(a) prior art to every Challenged Claim because it was published before July 18, 2006 and before PO's alleged conception on June 19, 2006. EX1011, Spine, Front Cover, Inside Front Cover, Library Stamped Page, 2657-2660; EX1014, ¶¶101-116.

IV. '149 PATENT[2]

The '149 patent concerns a "wireless device" with "smartphone functionality" and an "antenna system" "within" the device comprising a "ground plane" and "first" and "second" antennas. The multiband antennas are described as designed to send and receive electromagnetic signals in frequency ranges used by the frequency bands associated with various communication standards. EX1005, 5:30-41, 9:59-10:39, 12:34-36; 13:35-38 ("The resulting antenna structure… allow[s] the operation of the antenna system in multiple frequency bands."), 25:14-30, 25:61-26:5.

[2] All emphasis added unless otherwise indicated.

The patent asserts that the antenna system's design "is intended to use efficiently as much of the volume of the space" within a defined space "in order to obtain superior RF performance… in at least one frequency band." EX1005, 14:1-6. The patent refers to the resulting antenna structure's "geometrical complexity" (EX1005, 14:10-20) and characterizes an antenna design's "level of complexity" in terms of "complexity factor"—which the specification and claims define as a mathematical calculation based on antenna dimensions using specific analytic steps, as explained for limitations [1.h]-[1.h.4] and [7.h]-[7.h.4] *infra* §§VI.D.9, VIII.B.8, VIII.G.8, IX.D.8.

The patent asserts,

> In accordance with embodiments of the invention, ***the level of complexity of an antenna contour can be advantageously parameterized by means of two complexity factors***, hereinafter referred to as F_{21} and F_{32}, which capture and characterize certain aspects of the geometrical details of the antenna contour (such as for instance its edge-richness, angle-richness and/or discontinuity-richness) when viewed at different levels of scale.

EX1005, 16:64-17:4. The "[c]omplexity factor F_{21} is predominantly characterized by capturing the complexity and degree of convolution of features of the antenna contour that appear when the contour is viewed at coarser levels of scale," (EX1005, 19:28-31), whereas "[c]omplexity factor F_{32} is predominantly characterized by capturing the complexity and degree of convolution of features of the antenna contour that appear when the contour is viewed at finer levels of scale" (EX1005, 20:19-22).

The specification shows a single example antenna, e.g., an "antenna contour" reflecting a physical antenna layout (Figs. 12A, 17H), with a known frequency response (Fig. 19A), evaluated for "*complexity factor*" (EX1005, 38:52-40:52).

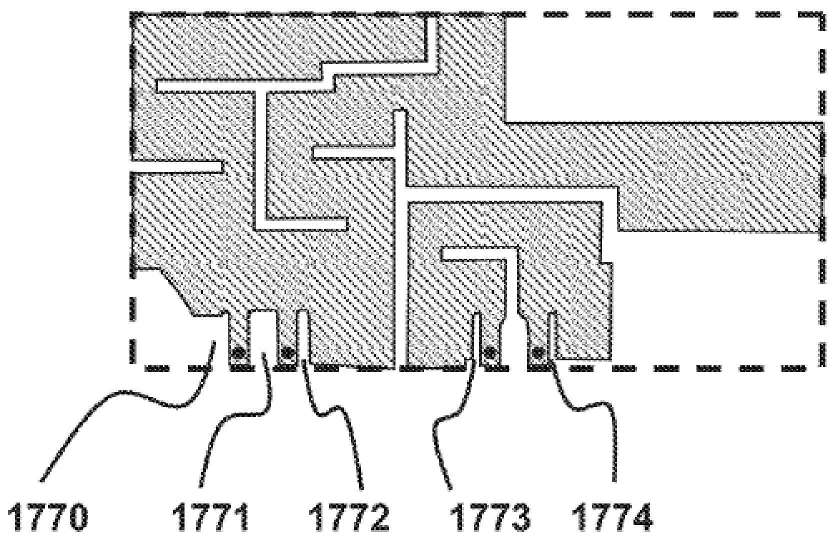


FIG. 17H

This antenna covers (meaning it can send and receive electromagnetic signals at) radio frequencies that are compatible with GSM and UMTS communication standards. EX1005, Fig. 19A, 38:52-39:32, 40:55-41:16. The operable frequency ranges are determined at a given voltage standing wave ratio

(VSWR), a design parameter that measures how well the antenna works with the device electronics (e.g., transceiver) that send/receive electrical signals converted to RF radiation. EX1005, 2:9-11; Weide, ¶56.

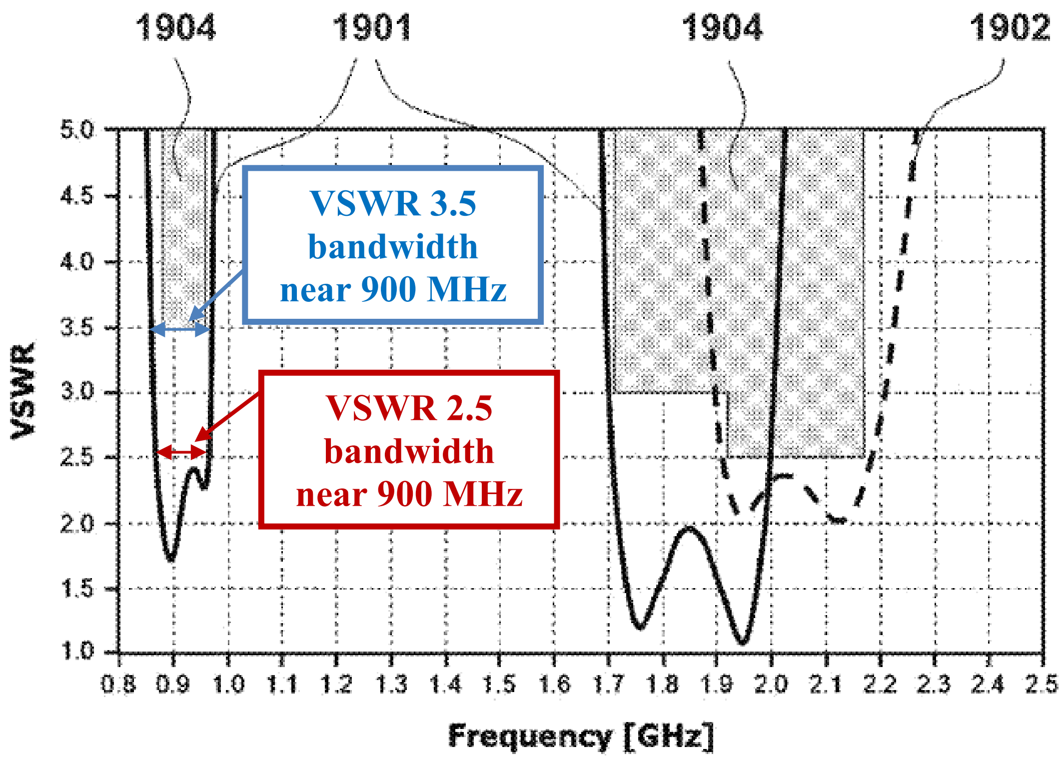


FIG. 19A

A ***lower*** VSWR means ***a better match*** between the antenna and the device electronics (e.g., transceiver), making the system more efficient at radiating energy: a perfect match has VSWR 1:1. Wiede, ¶57. Figure 19A shows that lower VSWR is associated with a smaller frequency range, illustrating a well-known tradeoff between impedance match (e.g., VSWR) and antenna bandwidth. Weide, ¶57. The specification describes "maximum" VSWR values for frequency ranges associated with GSM and UMTS communication standards (EX1005, 37:26-60, Table 1), and Figure 19A shades regions with VSWR above the specification's "maximum" levels at different frequency ranges used with different communication standards. EX1005, 40:63-41:2; Weide, ¶57.

While the specification describes "complexity factors" for each step of "progressive modification" of an antenna contour from Figures 17A-17H (EX1005, 38:64-40:54, Table 2), the patent never shows the antenna performance—e.g., frequency response—associated with each "progressive modification" of that antenna's "complexity factors."

A. POSA

Petitioners adopt Fractus's definition of a person having ordinary skill in the art ("POSA") from the ADT Litigation:

> [A] person with at least a bachelor's degree in electrical engineering, computer science, or a similar degree and at least four years of experience in applied electromagnetics with an emphasis on antennas. Alternatively, the person of ordinary skill in the art would have a master's degree in electrical engineering (or similar discipline) and at least two years of similar experience.

EX1018, 8-9, ¶32; Weide, ¶¶36-48.

B. Prosecution History

PO filed Application No. 18/339,523 ("the '523 application") with a single claim (EX1006, 206), which the Examiner rejected for ***non-statutory*** double patenting over five issued parent cases.[3] The Examiner rejected application-claim 1 for ***statutory*** (e.g., same invention) double patenting over U.S. Patent No. 9,099,733, claim 1 (EX1006, 822-824).

PO thereafter filed a terminal disclaimer over every issued patent in the priority chain. EX1006, 833-835. PO amended application-claim 1 (EX1006, 842-843) to "more explicitly state in the claims how the complexity factor values are calculated" (EX1006, 829), adding language corresponding to Limitations [1.h]-[1.h.4], and added application claims 2-20 (EX1006, 842-847, 855-860). PO's claim amendments removed several limitations ("digital camera," "microphone," etc.); required the application-claim 1's first antenna be "planar"; and added two new independent application claim 7 (in which the first antenna was

[3] U.S. Patent No. 8,738,103, claims 1 and 12 (EX1006, 811-813); U.S. Patent No. 9,899,727, claim 1 (EX1006, 813-815); U.S. Patent No. 10,644,380, claim 1 (EX1006, 815-817); U.S. Patent No. 11,031,677, claims 1 and 5-6 (EX1006, 817-819); and U.S. Patent No. 11,349,200, claims 1 and 3 (EX1006, 819-821).

"non-planar") and 13 (wherein the first antenna was not limited to being planar or non-planar). EX1006, 842-847, 855-860.

The Examiner thereafter allowed the claims without meaningful explanation. EX1006, 961, 956-963. The Examiner did not discuss a single one of 1,909 references cited on the face of the '149 patent.

C. Challenged Claims

The '149 patent has 20 claims, each concerning a "wireless device." Appendix A provides a claim list. Claims 1, 7, and 13 are independent.

Claim 13 is representative and recites a "*wireless device*" ([13.PRE]) comprising "*a ground plane*" ([13.a]), a "*first antenna*" ([13.b]), and a "*second antenna*" ([13.e]). The "*first antenna*" comprises a "*first contour*" ([13.f]), with "*complexity factor* F_{21}" being "*at least 1.20*" and "*complexity factor* F_{32}" being "*at least 1.35*" ([13.g]). The first antenna is "*configured to support at least three frequency bands*" ([13.c]). The second antenna is "*configured to receive signals from at least two [] of the at least three frequency bands*" ([13.e]).

Claims 1 and 7 recite similar limitations, except that claim 1 recites a "*first **planar** antenna*" ([1.b]), while claim 7 recites a "*first **non-planar** antenna*" ([7.b]). All claims recite limitations setting forth how to calculate the "*complexity factors*" (e.g., [13.h]-[13.h.4], [1.h]-[1.h.4], [7.h]-[7.h.4]).

Dependent claims add further limitations concerning the arrangement, frequency coverage, and "*complexity factor*" for the two antennas, and reciting a "*third antenna*."

V. CLAIM INTERPRETATION

Claim terms are construed using the standard for civil actions under 35 U.S.C. §282(b), in accordance with the ordinary and customary meaning as understood by POSAs and the patent's prosecution history. 37 C.F.R. §42.200(b). The Board need only construe claims to the extent needed to resolve disputes between parties. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). Various terms discussed below require construction. Remaining terms should be given their ordinary meaning to a POSA and are met by the prior art in each Ground under any reasonable construction.

A. "*perimeter*" (all claims)

In the ADT Litigation, Fractus argued constructions for (and the court construed) "*perimeter*" as it appeared in two parent cases—U.S. Patent No. 8,738,103 and U.S. Patent No. 11,349,200—having the same specification as the '149 patent. EX1020, 1; EX1005, code (63). The court rejected Fractus's construction and construed "*perimeter*" in two related patents as: "boundary of an object" ***excluding*** "any notion of 'following the shape of the radiating element and extending it as necessary to complete the boundary.'" EX1020, 14-17; EX1021.

The ADT Litigation was dismissed with prejudice. EX1023. That collaterally estops Fractus from arguing a different construction here. *Phil-Insul Corp. v. Airlite Plastics Co.*, 854 F.3d 1344, 1357-1358 (Fed. Cir. 2017). The ADT court's construction of "*perimeter*" comports with the ordinary meaning and the Board should apply it. Weide, ¶67.

B. "*wireless device*" (all claims)

In the ADT Litigation, Fractus argued (and the court agreed) that "[t]he ordinary meaning of 'wireless device'… refers to the nature of the communication," e.g., that the device communicates wirelessly. EX1020, 11. The Board should apply that construction here.

C. "*antenna rectangle*" (claims 11, 16)

"[A]n antenna rectangle is defined as being the orthogonal projection of the antenna box along the normal to the face with largest area of the antenna box." EX1005, 14:21-24; *Phillips v. AWH Corp.*, 415 F.3d 1303, 1316 (Fed. Cir. 2005) (en banc) ("specification may reveal a special definition given to a claim term" wherein "the inventor's lexicography governs").

The ’149 patent says that Fig. 1B’s element 103 shows an “antenna box,” stating:

> An antenna box… ***is herein defined*** as being the minimum-sized parallelepiped of square or rectangular faces that completely encloses the antenna volume of space and wherein each one of the faces of the minimum-sized parallelepiped is tangent to at least one point of the volume. Moreover, each possible pair of faces of the minimum-size parallelepiped shares an edge forming an inner angle of 90°.

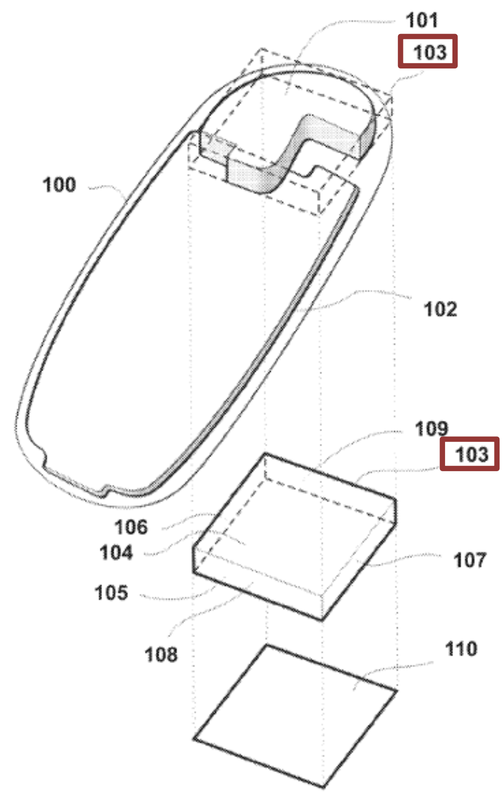


FIG. 1B

EX1005, Fig. 1B, 11:35-49.

D. “*first contour*” (all claims)

Claims 1, 7, and 13 recite a “*first contour*” at [1.d], [7.f], and [13.f]. Limitation [1.g] defines “*first contour*” for claims 1-6. Limitations [7.f] and [13.f] define the “*first contour*” for claims 7-20, but the definition at [7.f] and [13.f] is different from the definition at [1.g].

Regardless, the definitions relevant to each claim are applied and discussed in the claim mappings below.

E. "***complexity factors F_{21} and F_{32}***" (all claims)

Unlike the '103 patent and the '200 patent parent cases—which also recite "*complexity factor*" claim limitations that were subject to claim construction in the ADT Litigation (EX1017, 21-27)—the '149 patent claim limitations themselves define "*complexity factors F_{21} and F_{32}*." *See* Limitations [1.h]-[1.h.4], [7.h]-[7.h.4], [13.h]-[13.h.4]. The *complexity factor* analysis is discussed in claim mapping for each Ground below.

The remaining claim terms should be given their ordinary meaning to a POSA, as discussed below, and the prior art meets these terms under any reasonable construction. Weide, ¶74.

VI. <u>GROUND 1A</u>: DOU+CIAIS-MULTIBAND RENDERS OBVIOUS CLAIMS 7-9, 11-14, 16-17, AND 19-20

A. Dou (EX1013)

Dou describes wireless devices, e.g., handheld computers, mobile telephones, etc., with internal diversity antenna architectures having three or more antennas including a first antenna located substantially near the top, and a second antenna located substantially near the bottom, of a device housing and/or internal PCB. Dou, Abstract, Figs. 2A-2B (below), [0015], [0017], [0032], [0040]; Weide, ¶¶75-76.

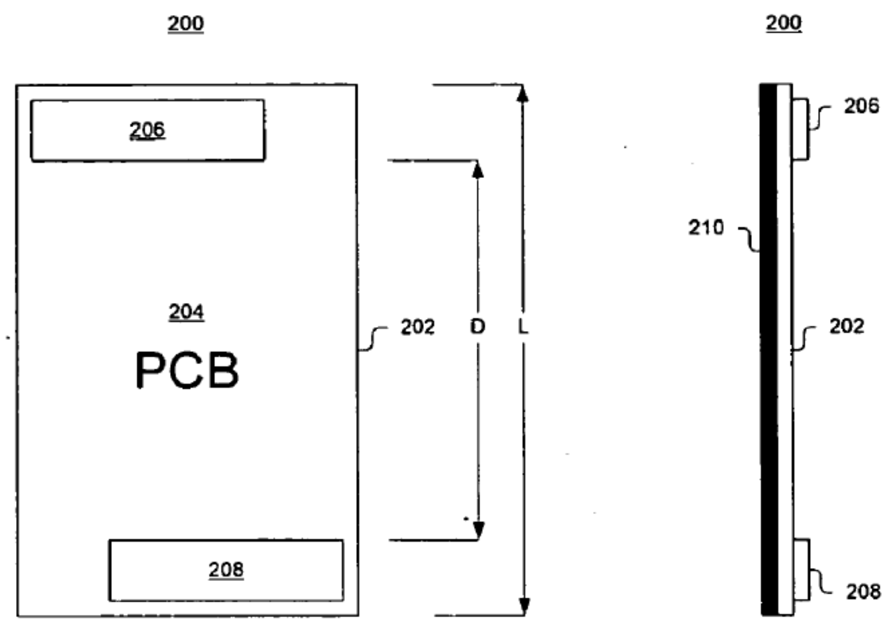


FIG. 2A FIG. 2B

Dou's antennas operate at multiple frequency ranges associated with different communication services, e.g., GSM, PCS, WCDMA/UMTS, GPS, NAMPS, "WiFi," and Bluetooth. Dou, [0022]. The antennas "may be… any type of suitable internal antenna" (Dou, [0028]) of different types. *E.g.*, Dou, [0034], [0040].

B. Ciais-Multiband (EX1010)

Ciais-Multiband describes a "[c]ompact internal multiband antenna for mobile phone and WLAN standards" in the form of an "internal planar inverted-F antenna (PIFA) suitable for handset terminals." Ciais-Multiband, 920, Figs. 1(a), 1(b) (below).

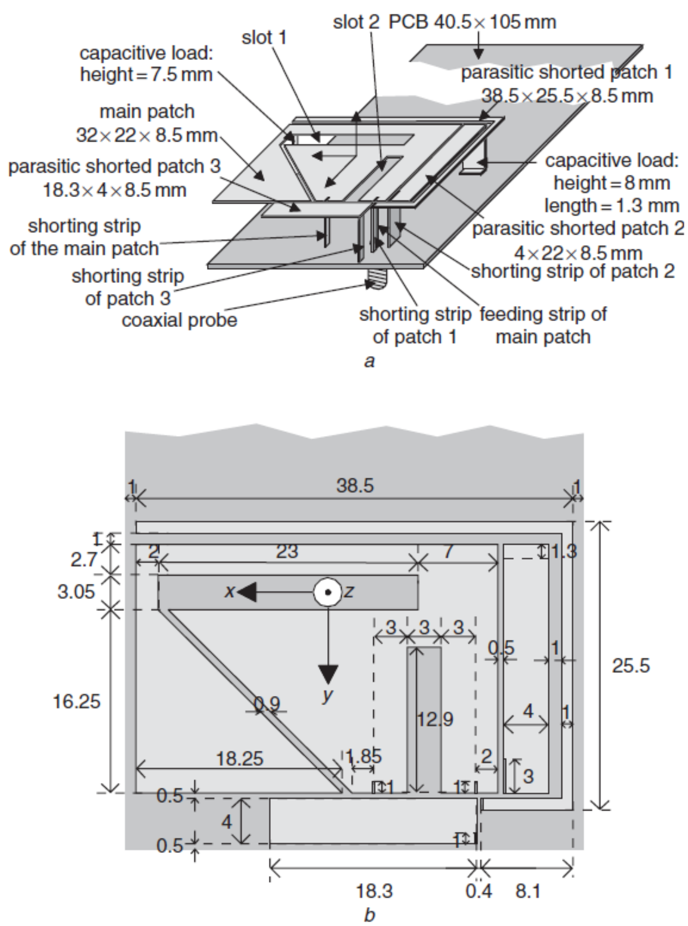


Fig. 1 *3D view of multiband antenna*
a 3D view *b* Top view (all dimensions in millimetres)

Ciais's multiband antenna covers radio frequency (RF) transmissions—meaning it is capable of transmitting and receiving signals—at 870-940 MHz, 1608-2084 MHz, and 4863-5991 MHz, with a VSWR of 2.5:1. Ciais-Multiband, 920-921, Fig. 2 (below); Weide, ¶¶79-80.

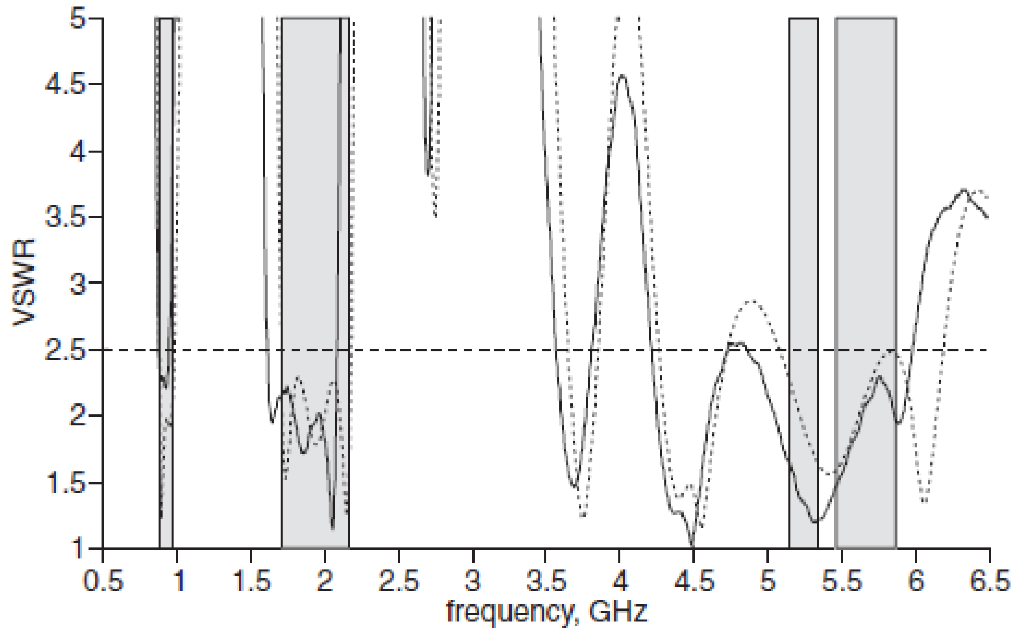


Fig. 2 *Measured and simulated VSWR of multiband antenna*
Standards bandwidth requirement in grey
—— measurement ------ simulation

C. Dou+Ciais-Multiband

While Dou describes a wireless handheld device having internally-mounted antennas, it does not describe particular antennas for implementing its wireless devices and Dou leaves the antenna selection to a POSA. Weide, ¶84.

A POSA had reasons to implement each of Dou's first antenna 206 and second antenna 208, as shown in Dou Figures 2A-2B, as a Ciais multiband antenna. Ciais's multiband antenna was designed for use in "handset terminals"/"handset devices" (e.g., mobile phones), making it suitable for use as Dou's "internal antenna" 206 and 208 "disposed within… housing 202 of the wireless device 200." Dou, [0018]; Ciais-Multiband, 920-921; Weide, ¶85.

Ciais's multiband antenna is a planar inverted-F antenna (PIFA) (Ciais-Multiband, 920), which Dou describes using for the first and second antennas. Dou, [0028]. Ciais's multiband antenna provides operation at 1710-1990 MHz with VSWR 2.5:1. Ciais-Multiband, 920-921, Fig. 2. Ciais's multiband antenna covered 870 to 940 MHz at VSWR 2.5:1 and Ciais's measurements showed that the antenna covered at least 880-960 MHz (e.g., for extended (880-960 MHz) and standard (890-960 MHz) GSM900) at VSWR 3.5:1. Ciais-Multiband, 920, Fig. 2 (annotated detail below); EX1005, 37:41 (Table 1 (showing maximum VSWR for GSM900 at 3.5:1), 40:63-66; EX1030, 8-9; Weide, ¶¶86, 81-83.

Ciais's multiband antenna thus provided coverage for well-known cellular services in extended GSM900 (880-960 MHz), standard GSM (890-960 MHz), DCS1800 (1710-1880 MHz), and PCS1900 (1850-1990 MHz). EX1005, 37:41 (Table 1), 40:63-66; EX1030, 8-9; Weide, ¶87. This coverage made Ciais's multiband antenna "suitable for mobile phone applications" like Dou's wireless device. Ciais-Multiband, 920-921; Dou, [0022] (describing exemplary coverage for GSM and PCS operations); Weide, ¶¶87, 81-83.

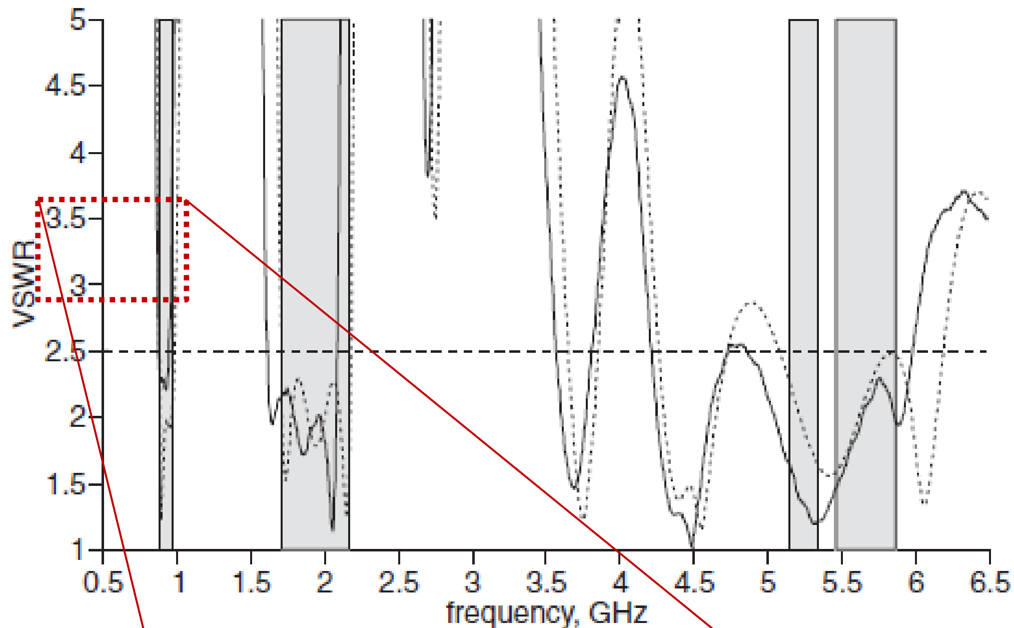
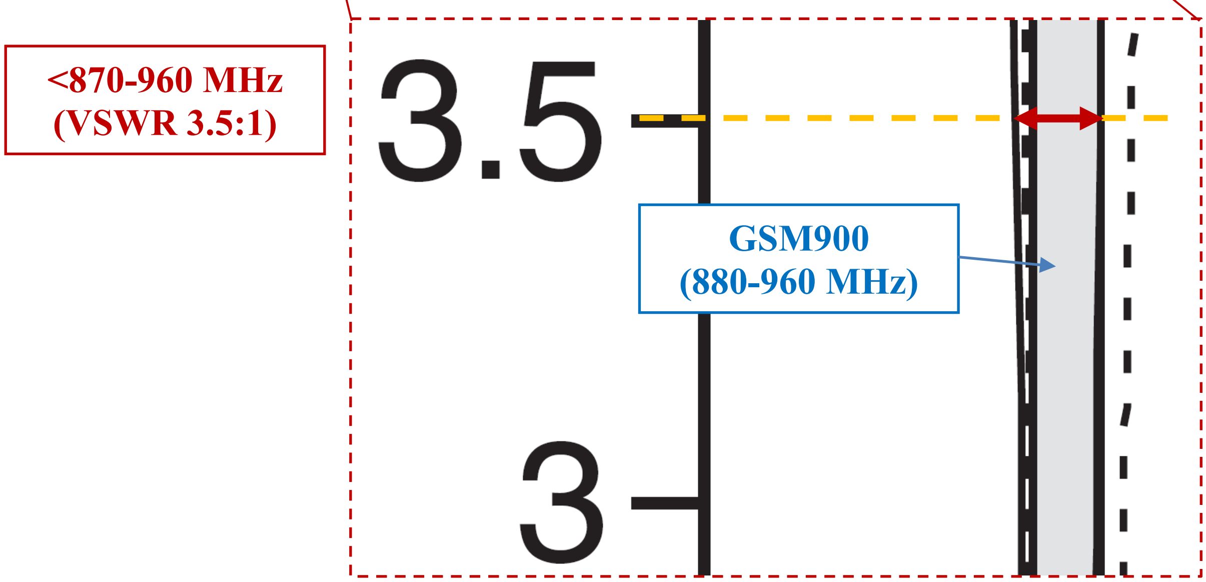


Fig. 2 *Measured and simulated VSWR of multiband antenna*

Standards bandwidth requirement in grey

—— measurement ------ simulation



The Ciais multiband antenna also provides coverage at 4863-5991 MHz, supporting wireless networking (WLAN) at 5 GHz ISM bands (5150-5350 MHz and 5470-5725 MHz) used by IEEE Std. 802.11a and HiperLAN/2, comporting with Dou's description of device antennas supporting wireless networking. Ciais-Multiband, 920-921, Fig. 2; Dou, [0022]; Weide, ¶¶87, 83.

Implementing Dou's wireless device with Dou's first antenna 206 and second antenna 208 each provided by a separate Ciais multiband antenna would have been nothing more than combining familiar elements according to known methods with predictable results, and been no more than the "predictable use of prior art elements according to their established functions." *KSR Int'l v. Teleflex*, 550 U.S. 398, 416-417 (2007); Weide, ¶88.

A POSA would have had a reasonable expectation of success in using Ciais's multiband antenna in Dou's wireless device because Ciais designed the multiband antenna for internal use in cellular telephones (Ciais-Multiband, 920), and Dou expressly contemplates using a multiband PIFA antenna—like the Ciais multiband antenna—as its first and second internal antennas (e.g., Dou, [0028]-[0029]). Weide, ¶89. Dou describes antenna placement within the device according to "various performance and design constraints" known to a POSA. Dou, [0030]; Weide, ¶89. Ciais describes placing the multiband antenna at the end of a PCB "on the corner of a ground plane" where Dou places its antennas 206 and

208. Ciais-Multiband, Fig. 1(a), 920 (antenna is placed "on the corner of a ground plane having a size approximately equal to that of the [PCB] of a typical mobile phone, i.e. 40.5 × 105 mm."); Dou, Figs. 2A-2B, [0029]; Weide, ¶89. It was well within the POSA's ordinary skill to implement Dou's wireless device with Ciais's multiband antenna, and the resulting antenna operation was predictable. Dou, [0012], [0063]; Weide, ¶89.

This combination of Dou in view of Ciais-Multiband (hereinafter "Dou+Ciais-Multiband") has **two** antennas: antennas 206 and 208 (each a Ciais multiband antenna), and meets the Challenged Claims as follows. Weide, ¶90.

D. Claim 7

1. Preamble [7.PRE]

[7.PRE]	A wireless device comprising:

Dou+Ciais-Multiband meets [7.PRE] because Dou's modified device is a wireless device like a handheld computer, mobile telephone, or PDA. Dou, [0015]-[0016], claim 1; *supra* §VI.C (combination); Weide, ¶91.

2. Limitation [7.a]

[7.a]	a ground plane;

Dou+Ciais-Multiband meets [7.a] because it uses Dou's ground plane 210 to implement Ciais's ground plane teaching. Dou, Fig. 2B, [0029]; Ciais-Multiband, 920, Fig. 1(a); Weide, ¶92.

3. Limitation [7.b]

[7.b]	a first non-planar antenna proximate to a first side of a ground plane rectangle enclosing the ground plane,

Dou+Ciais-Multiband meets [7.b] because it implements Dou using Ciais's teaching to dispose antenna 206 (*first antenna*) at the top of PCB 204 "on the corner of a ground plane." Dou, Fig. 2A, [0016]-[0017]; Ciais-Multiband, Fig. 1(a), 920; Weide, ¶93.

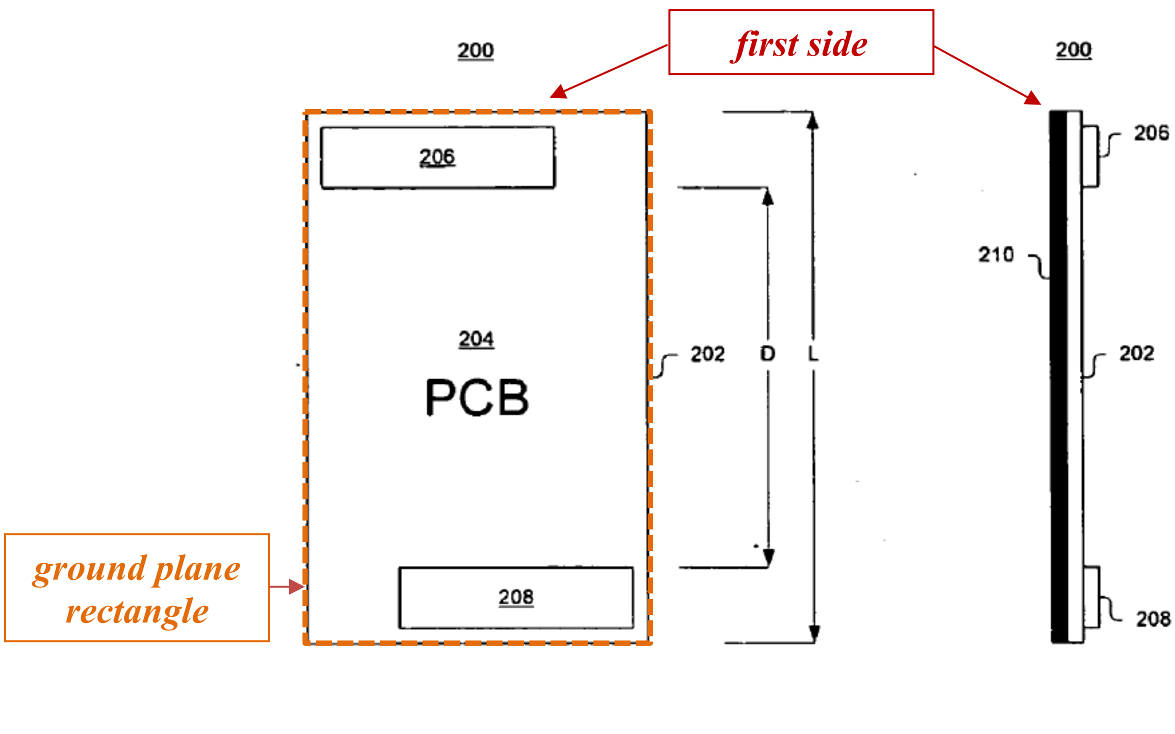
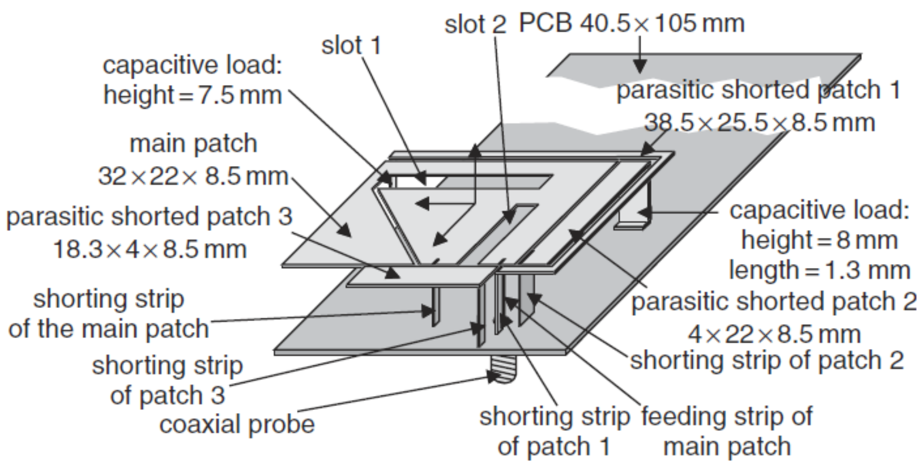


FIG. 2A FIG. 2B

PCB 204's rectangular area defines a rectangle ("*ground plane rectangle*") that "*enclos[es]*" the ground plane 210 disposed on the side of the PCB opposite from antenna 206. Dou, Figs. 2A-2B, [0016]-[0017], [0029]; Weide, ¶94. PCB

204 implements Ciais's teaching of a rectangular (40.5 mm × 105 mm) PCB, also backed by a ground plane, that Ciais explains is representative of PCBs for typical mobile phones. Ciais-Multiband, Fig. 1(a) (below), 920; Weide, ¶94.



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The top (40.5 mm) edge of the "*ground plane rectangle*" defined by PCB 204 is a "*first side*." Disposing antenna 206 at the top of the PCB as taught by Dou, over "the corner of a ground plane" as taught by Ciais-Multiband, places it "*proximate to a first side of a ground plane rectangle*" defined by the PCB area. Dou, Figs. 2A-2B (annotated above), [0016]-[0017], [0029]; Weide, ¶95.

4. Limitation [7.c]

[7.c]	the first non-planar antenna being configured to support at least three frequency bands of the electromagnetic spectrum,

Dou+Ciais-Multiband meets [7.c] because Ciais's multiband antenna ("*first antenna*") covers—i.e., is capable of sending and receiving electromagnetic radiation ("*configured to support*")—in regions of the "*electromagnetic spectrum*" at 870-960 MHz with VSWR 3.0:1 and at 1608-2084 MHz and 4863-5991 MHz with VSWR 2.5:1. Ciais-Multiband, 920-921, Fig. 2; *supra* §VI.C (combination); Weide, ¶96. Ciais's multiband antenna exceeds the '149 patent's VSWR performance "requirements" for these frequency ranges. EX1005, 37:26-59 (specifying "maximum" VSWR of 3.5:1 for "GSM900" between 800 and 960 MHz, and "maximum" VSWR of 3.0:1 for "GSM1800" (e.g., DCS1800 at 1710-1880 MHz) and "GSM1900" (e.g., PCS1900 at 1850-1990 MHz); Weide, ¶96.

A POSA understood that in the context of cellular communications a "*frequency band*" is a frequency range specified by a regulatory or standards body for a particular use, such as a type of wireless communication. Weide, ¶97. Ciais's multiband antenna is "*configured to support*" at least **twenty-four** (**24**) "*frequency bands*" that are defined in the supported frequency ranges. Weide, ¶97.

The **870-960 MHz** range contains at least ***four*** (**4**) "*frequency bands*" shown in Table 1.

Table 1: Frequency bands within 870-960 MHz.

Band	Range (MHz)
standard GSM900	890-960
extended GSM900	880-960
ISM	902-928
LTE Band 8	880-960

EX1030, 8-9 ("Standard or primary" and "Extended" "GSM 900 band"); EX1005, 10:24-34 (discussing ISM 902-928 MHz); EX1025, 13, Table 5.5-1 ("E-UTRA operating bands"); EX1026, 11 (listing LTE FDD and TDD bands); EX1039, 497-501; Weide, ¶¶98, 103-105.

The **1608-2084 MHz** range ("*second frequency range*") contains at least **fifteen** (**15**) "*frequency bands*" shown in Table 2.

Table 2: Frequency bands within 1608-2084 MHz.

Band	Range (MHz)
DCS1800	1710-1880
PCS1900	1850-1990
UMTS Band II	1880-1990
UMTS Band III	1710-1880
UMTS Band b	1850-1910, 1930-1990
UMTS Band c	1910-1930
LTE Band 2	1850-1990
LTE Band 3	1710-1880
LTE Band 9	1749.9-1879.9
LTE Band 33	1900-1920
LTE Band 34	2010-2025
LTE Band 35	1850-1910
LTE Band 36	1930-1990
LTE Band 37	1910-1930
LTE Band 39	1880-1920

EX1030, 8-9 (DCS1800, PCS1900); EX1039, 139 (reference [100] identifies HSDPA specifications), 497-501, 599 (reference [100] is 3GPP TS 25.308 (EX1032)); EX1032 (UMTS HSDPA description); EX1035, 11-12 (UMTS standard comprises TS 25.101 (EX1033), TS 25.102 (EX1034), TS 25.308 (EX1032)); EX1033, 12-13 (Table 5.0 "UTRA FDD frequency bands"); EX1034, 11 (UTRA/TDD frequency bands); EX1025, 13, Table 5.5-1 ("E-UTRA operating bands” defining LTE bands); EX1026, 11 (listing LTE FDD and TDD bands); Weide, ¶¶99, 101-105.

The **4863-5991 MHz** range contains at least **five** (**5**) “*frequency bands*” shown in Table 3.

Table 3: Frequency bands within 4863-5991 MHz.

Band	Range (MHz)
U-NII lower	5150-5250
U-NII middle	5250-5350
U-NII	5470-5725
U-NII upper	5725-5825
U-NII	5850-5895

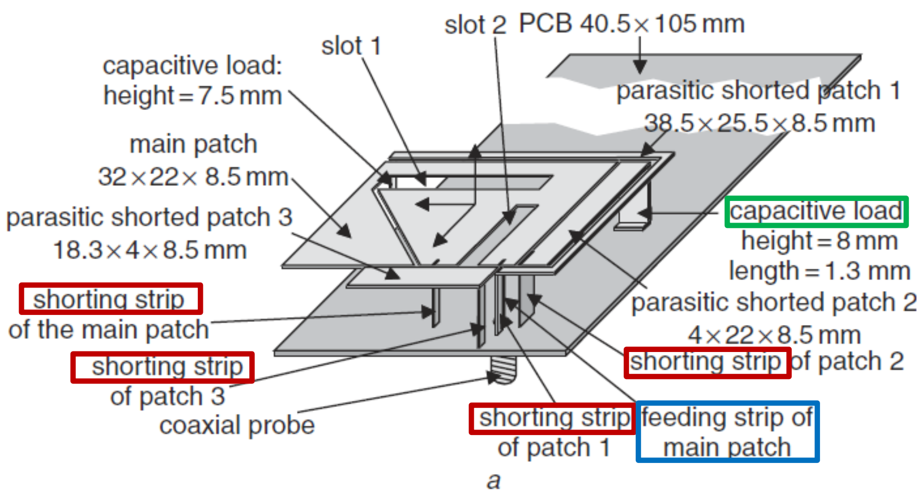
EX1042, 26 (IEEE Std. 802.11a defining WLAN channels in 5 GHz U-NII bands); 47 C.F.R. §§15.401, 15.403 (U-NII devices in 5.15-5.35 GHz and 5.47-5.895 GHz frequency bands); 47 C.F.R. §§15.407(a)(1) (discussing 5150-5250 MHz U-NII band), 15.407(a)(2) (discussing 5250-5350 MHz and 5470-5725 MHz U-NII bands), 15.407(a)(3)(i) (discussing 5725-5850 MHz U-NII band), 15.407(a)(3)(ii)-(v) (discussing 5850-5895 MHz U-NII band); 69 Fed. Reg. 54027, 54036-54037 (Sep. 7, 2004) (codified at 47 C.F.R. §15.407); Weide, ¶100.

Thus, Ciais’s multiband antenna is “*configured to support at least three frequency bands of the electromagnetic spectrum*” because it covers (i.e., is operable to send and receive radiation in) at least twenty-four frequency bands. Weide, ¶106.

5. Limitation [7.d]

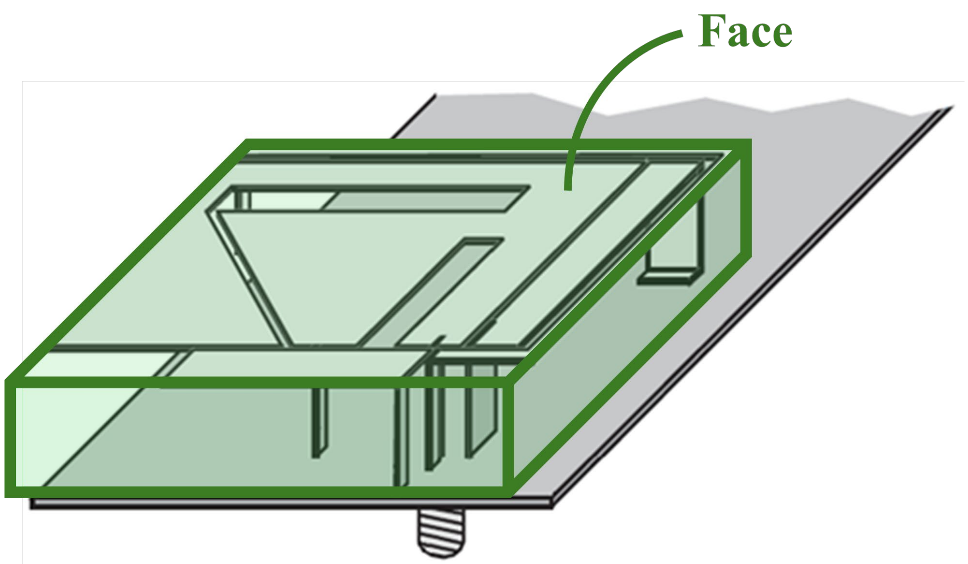
[7.d]	a minimum-sized parallelepiped completely enclosing a volume of the first non-planar antenna, the minimum-sized parallelepiped having a face with a largest area;

Ciais's multiband antenna is "*non-planar*" because it comprises antenna elements that are not contained within a single plane. Weide, ¶107. For example, each "shorting strip," "feeding strip," and "capacitive load" in the "3D view of multiband antenna" in Ciais's Figure 1(a) (annotated below) are "non-planar" antenna elements because they extend out of the plane containing the "main patch." Weide, ¶107.



Dou+Ciais-Multiband meets [7.d] because Ciais's multiband antenna has an "antenna box" defined by "a minimum-sized parallelepiped of… rectangular faces that completely encloses a volume of" Ciais's multiband antenna ("*first non-planar antenna*") as shown below. Ciais-Multiband, Fig. 1(a) (annotated below); *supra*

§V.C; EX1005, Fig. 1B, 11:35-49; Weide, ¶108. The multiband antenna's "main patch" provides the parallelepiped with a "*face with a largest area*." Weide, ¶108.



6. Limitation [7.e]

[7.e]	a second antenna proximate to a second side of the ground plane rectangle, and wherein the second antenna is configured to receive signals from at least two frequency bands of the at least three frequency bands;

Dou+Ciais-Multiband meets [7.e] because it implements Dou's teaching to dispose antenna 208 (*second antenna*) at the bottom of PCB 204. Dou, Fig. 2A, [0016]-[0017]; Weide, ¶109.

Dou+Ciais-Multiband's antenna 208 ("*second antenna*") is positioned along (*proximate to*) "*a second side*" of PCB 204 that is opposite to the first side, which is also the "*second side of the ground plane rectangle*." *Supra* §VI.D.3 ([7.b]); Dou, Fig. 2A, [0016]-[0017]; Weide, ¶110.

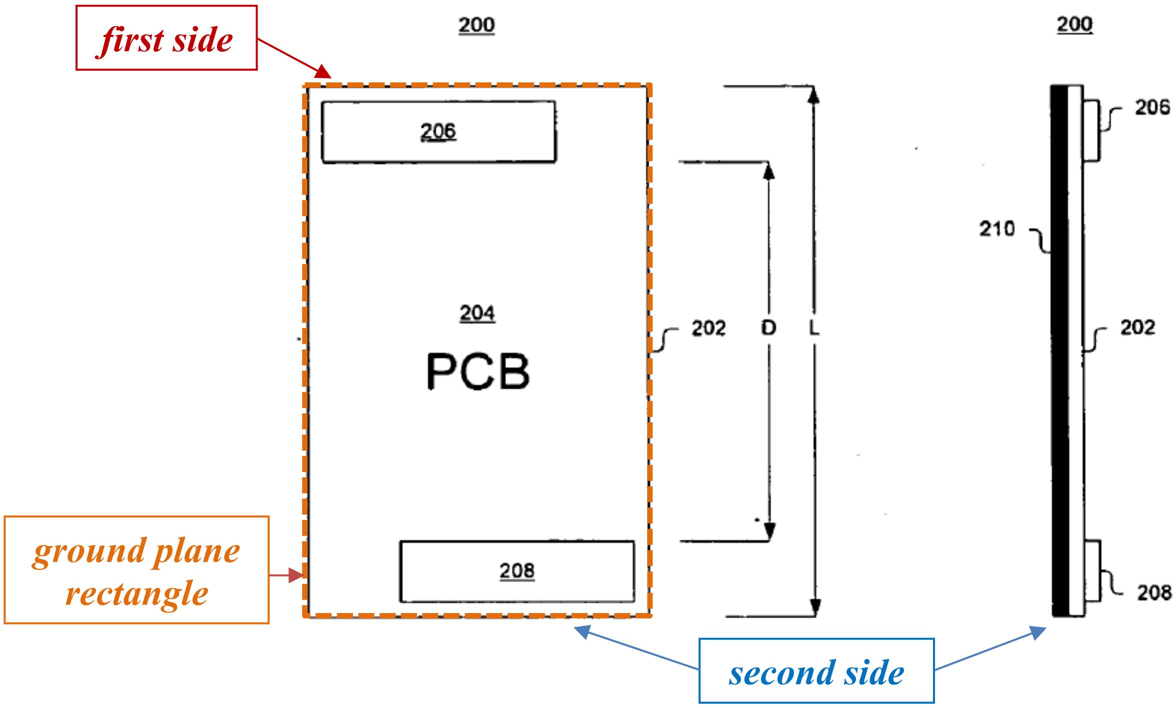


FIG. 2A FIG. 2B

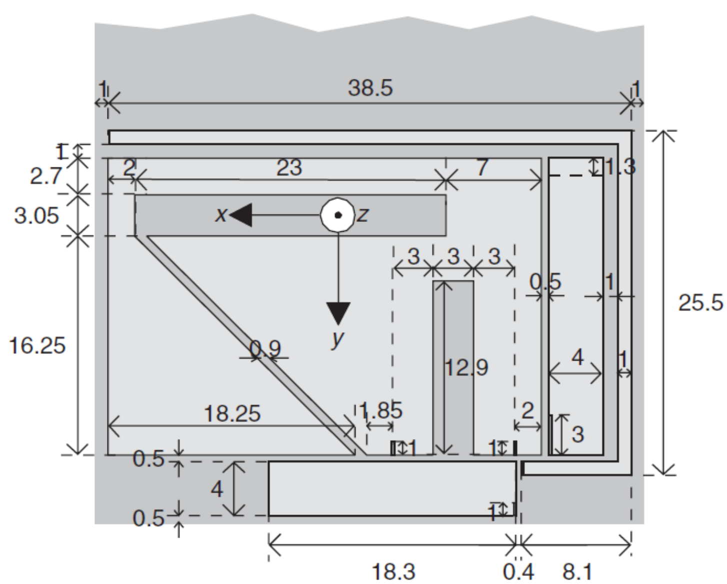
Dou+Ciais-Multiband meets the rest of [7.e] because the multiband antenna implementing Dou antenna 208 (*second antenna*) covers the same frequency bands as the multiband antenna implementing Dou antenna 206 (*first antenna*) *supra* §VI.D.4 ([7.c]). Weide, ¶111.

7. Limitation [7.f]

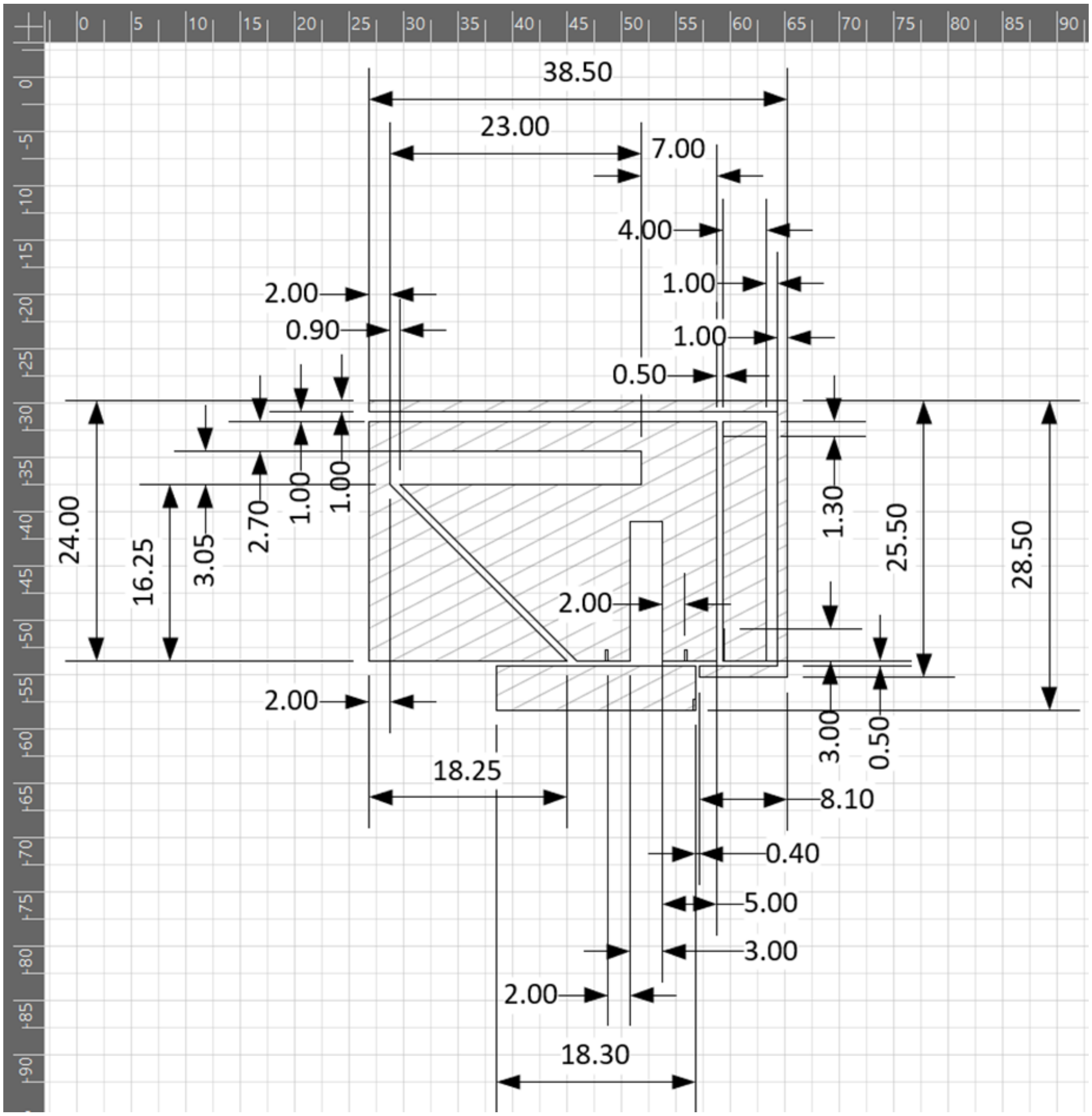
[7.f]	wherein the first non-planar antenna has a first contour defined as **[1]** a perimeter of any portions of the first non-planar antenna arranged in the face, **[2]** perimeters of any closed apertures of any portions of the first non-planar antenna arranged in the face, **[3]** a perimeter of an orthogonal projection onto the face of any portions of the first non-planar antenna that are not arranged in the face, and **[4]** perimeters of any closed apertures of the orthogonal projection;

The antecedent for "*the face*" is the *parallelepiped* in [7.d] *supra* §VI.D.5, corresponding to *parallelepiped* surface containing the "main patch" of the multiband antenna. Ciais-Multiband, Figs. 1(a), 1(b); Weide, ¶112.

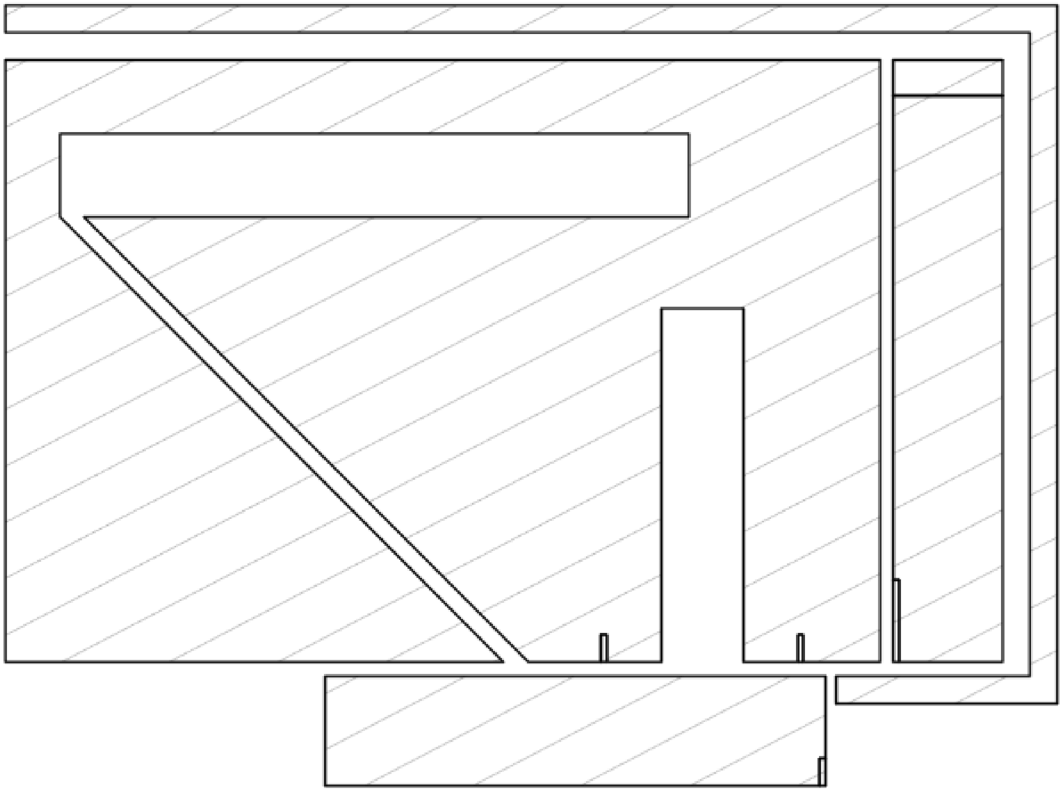
The Ciais multiband antenna implementing Dou's antenna 206 ("*first non-planar antenna*) has a "*first contour*" meeting [7.f] as shown below. Ciais's Figure 1(b) shows the antenna element dimensions including orthogonal projections of the out-of-plane antenna elements. Ciais-Multiband, Figs. 1(a)-1(b); Weide, ¶113.



Using Ciais's description the antenna contour is produced to scale as follows, with dimensions in mm. Weide, ¶114.

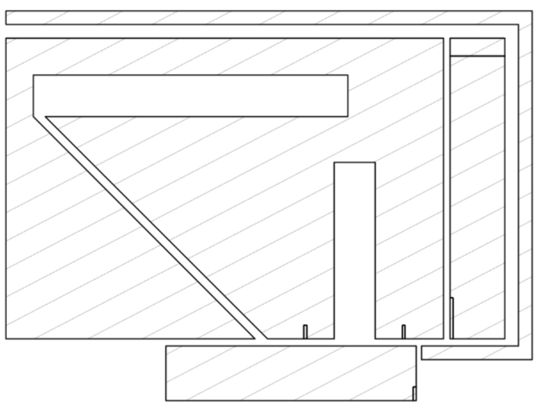


The multiband antenna's "*first contour*" is:

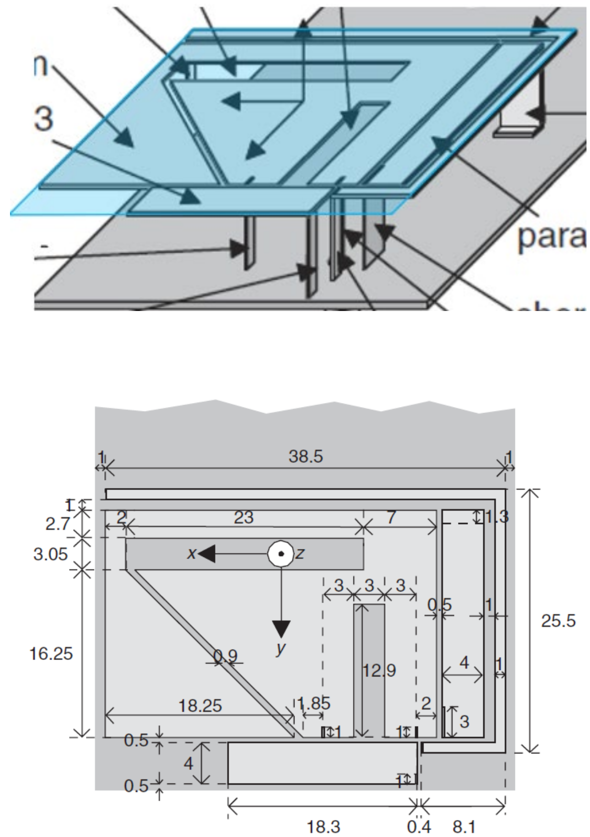


Weide, ¶115.

This *first contour* includes **[1]** the *perimeter* of all antenna elements (*portions*) in the plane of the multiband antenna's main patch (e.g., *arranged in the face*). Weide, ¶116; Ciais-Multiband, Figs. 1(a) (annotated detail below top right), 1(b).

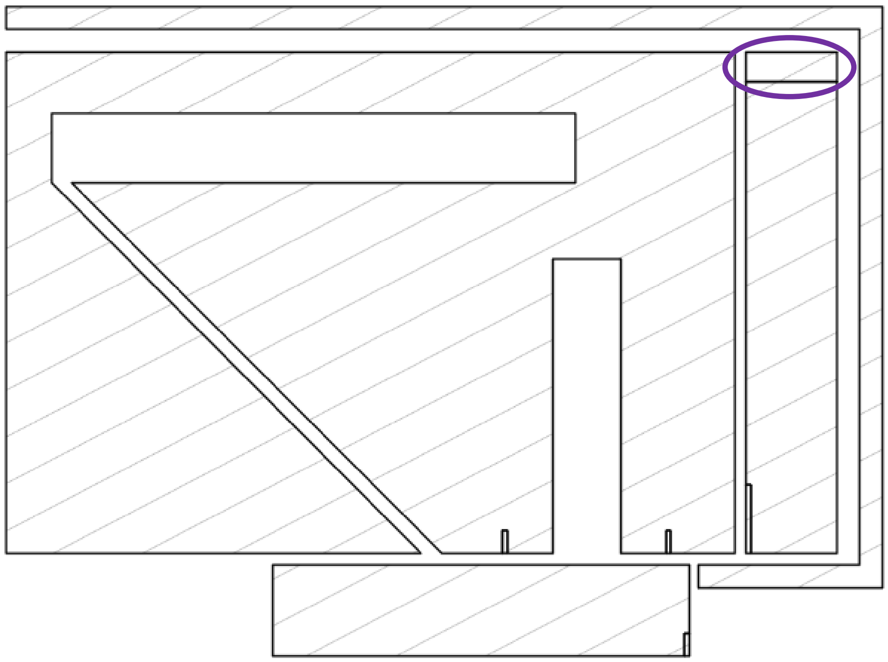


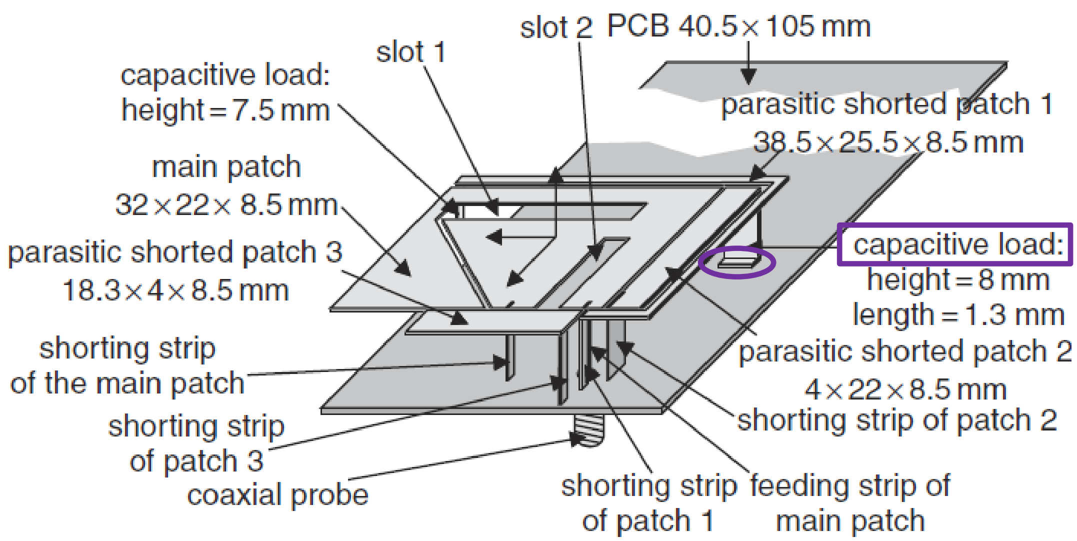
first contour



Ciais-Multiband Figs. 1(a), 1(b)

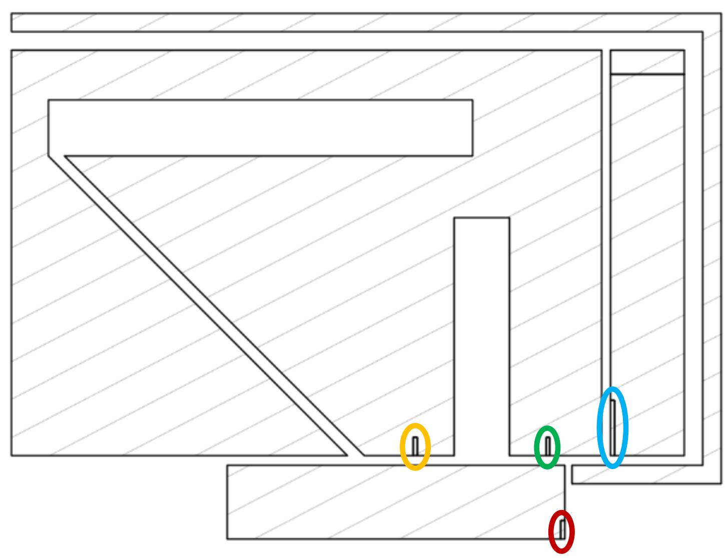
The *first contour* also includes **[3]** the *perimeter* of an *orthogonal projection* of the capacitive load (e.g., a *portion… not arranged in the face*), as highlighted below. Ciais-Multiband, 920, Figs. 1(a), 1(b); Weide, ¶117.

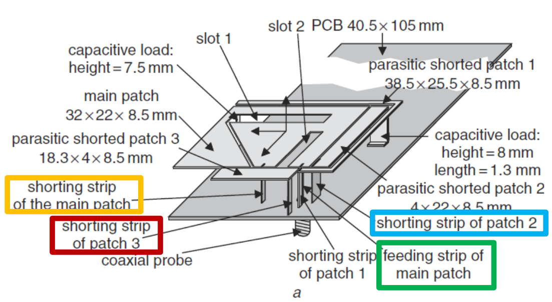


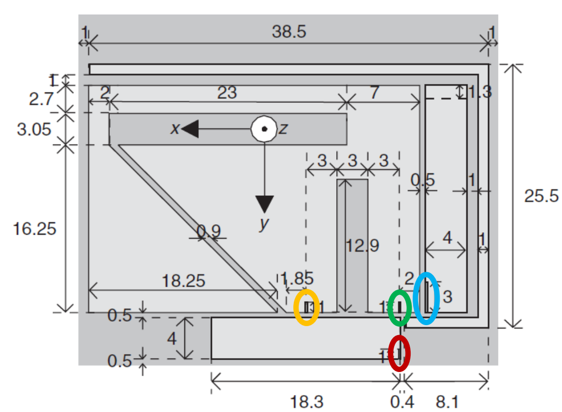


a

Regardless of whether the multiband antenna elements in *the face* comprise slots defining **[2]** *perimeters of… closed apertures* that receive vertical shorting and feeding strips, or *orthogonal projection* of each vertical strip defines **[3]** *a perimeter* on *the face* or **[4]** *a closed aperture* having a *perimeter*, the *first contour* includes segments defining these *perimeters* as shown below. Ciais-Multiband, 920, Figs. 1(a), 1(b) (annotated below); Weide, ¶118.







8. Limitation [7.g]

[7.g]	wherein the first contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value of at least 1.35; and

Dou+Ciais-Multiband meets [7.g] because the multiband antenna's contour ("*first contour*"), *supra* §VI.D.7 ([7.f]), has $F_{21} = 1.41 \geq 1.20$, and $F_{32} = 1.52 \geq 1.35$, as shown for [7.h]-[7.h.4] below. Weide, ¶119.

9. Complexity factor limitations ([7.h]-[7.h.4])

Limitation [7.h] defines "*complexity factors F_{21} and F_{32}*" in terms of cell counts N_1, N_2, and N_3 ([7.h.1]), which are ascertained by overlaying grids G_2, G_1, and G_3 ([7.h.2]-[7.h.4], respectively) on the "*first contour*" ([7.f]).

Numerically calculating the *complexity factors* depends on:

- ***first*** forming the grids (starting with grid G_2)
- ***second*** overlaying the grids on the *contour*
- ***third*** counting cells (for each grid) meeting certain criteria, then
- ***fourth*** computing the values for the complexity factor equations in [7.h].

Claim 7, however, is written in a convoluted fashion reciting calculations before the predicate steps needed to evaluate them. The analysis below addresses the steps in order, with the consequence of presenting the claim limitations out of the sequence in which the patent recites them.

a. Limitation [7.h.2]: Grid G_2

7.h.2	the grid G_2 divides the face into nine columns of equal width arranged along a long side of the face and an odd number of rows of equal height arranged along a short side of the face, wherein the number of rows results in the cells of grid G_2 being as square as possible,

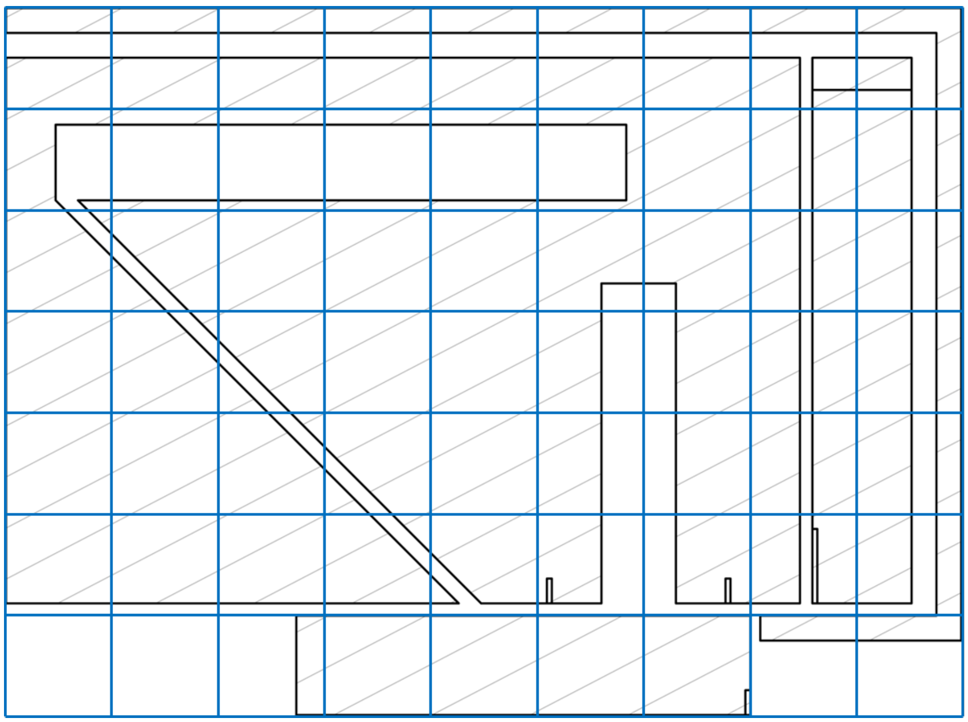
The antecedent for "*the face*" is "*the minimum-sized parallelepiped having a face with a largest area*" in [7.d]. However, [7.h.1] requires counting cells of a grid that include at least a point of an antenna *contour*, which [7.f] recites is formed by perimeters and orthogonal projections of antenna elements "*onto the face*." Thus, a POSA would have understood that "*the face*" referred to a minimum-sized rectangle enclosing the *first contour*. Weide, ¶122.

The multiband antenna contour (*first contour*) is 38.5 mm wide (*long side of the face*) and 28.5 mm in height (*short side of the face*). Ciais-Multiband, 920, Fig. 1(b). Grid G_2 with nine (9) columns yields cell width (*columns of equal width*) of $\left(\frac{38.5mm}{9}\right) = 4.28\ mm$. Weide, ¶123.

With 9 columns, seven (7) rows provides an "*odd number of rows of equal height arranged along a short side of the face*" with "*the cells… being as square as possible*" because seven rows provides a cell with an aspect ratio closer to 1 (e.g., where width = height) than any other *odd number of rows*. EX1005, 14:34-36 (defining "aspect ratio" as the ratio of width to height); Weide, ¶124.

Rows	Cell Height (mm)	Cell Aspect Ratio $\left(\frac{width}{height}\right)$
5	$\left(\frac{28.5}{5}\right) = 5.70$	$\left(\frac{4.28}{5.70}\right) = 0.75$
7	$\left(\frac{28.5}{7}\right) = 4.07$	$\left(\frac{4.28}{4.07}\right) = 1.05$
9	$\left(\frac{28.5}{9}\right) = 3.17$	$\left(\frac{4.28}{3.17}\right) = 1.35$

Grid G_2

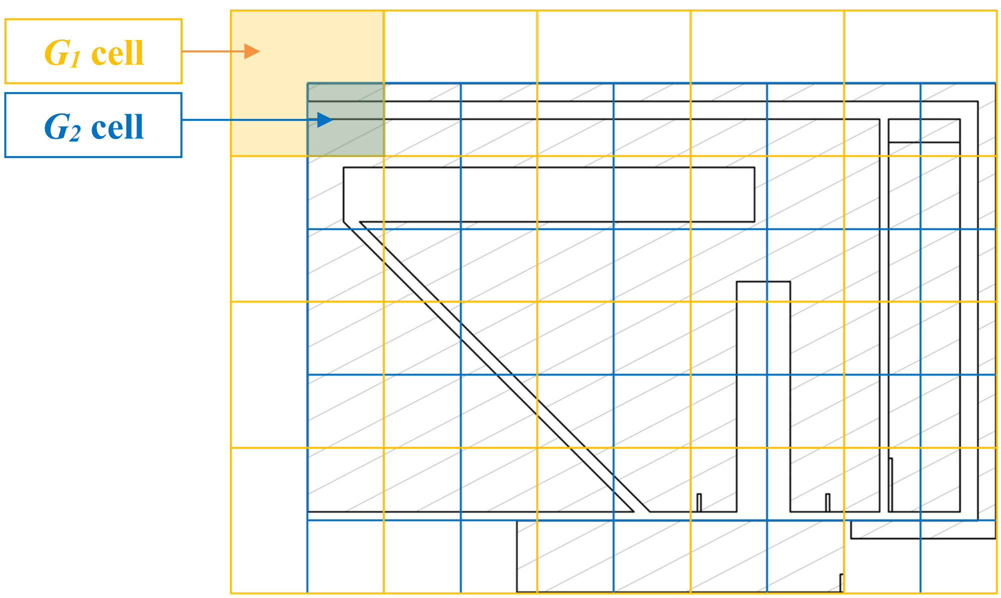


Thus, grid G_2 has 7 rows by 9 columns and "tessellates" the *first contour* as shown above (blue outline). Weide, ¶125.

b. Limitation [7.h.3]: Grid *G_1*

7.h.3	the grid G_1 being aligned with a corner of the grid G_2 to cover the face, the cells of grid G_1 having widths and heights that respectively are double the widths and heights of the cells of the grid G_2, and

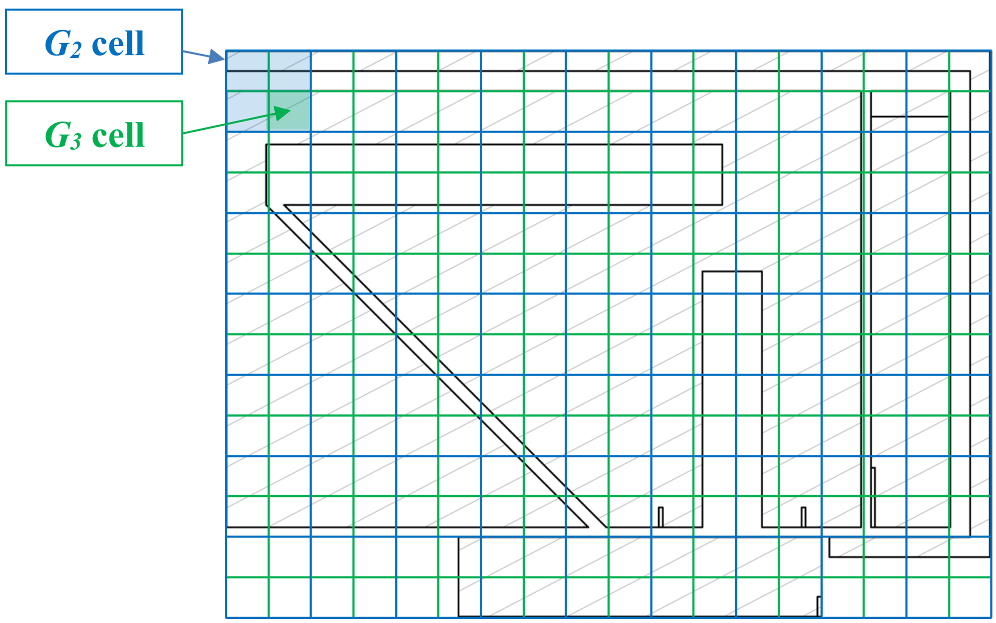
Grid *G_1* (orange outline below) is "*aligned with a corner of the grid G_2*" and "*cover[s] the face*" (e.g., the *first contour*), wherein each *G_1* cell has twice the width and height of a *G_2* cell, e.g., "*widths and heights that respectively are double the widths and heights of the cells of the grid G_2*." Weide, ¶126.



c. Limitation [7.h.4]: Grid G_3

7.h.4	the grid G_3 being aligned with the grid G_2, the cells of the grid G_3 having widths and heights that respectively are half the widths and heights of the cells of the grid G_2, and

Grid G_3 (green outline below) is "*aligned with the grid G_2*" and each G_2 cell (green) comprises ***four*** G_3 cells—meaning that G_3 cells have "*widths and heights that respectively are half the widths and heights of the cells of the grid G_2.*" Weide, ¶127.



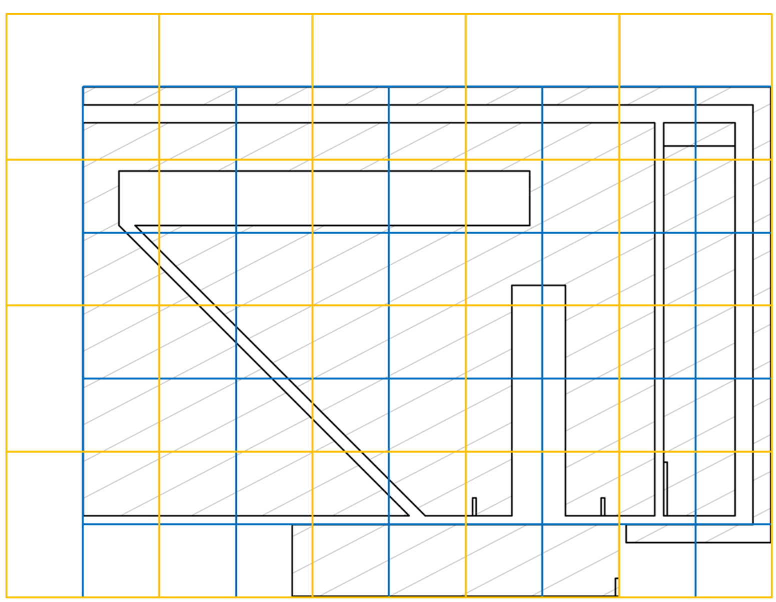
d. Limitation [7.h.1]: Cell counts

7.h.1	where N_1 is a number of cells of a grid G_1 that include at least a point of the first contour, N_2 is a number of cells of a grid G_2 that include at least a point of the first contour, and N_3 is a number of cells of a grid G_3 that include at least a point of the first contour,

When evaluating [7.h.1] a cell whose boundary coincides with a point on the "*first contour*" will "*include at least a point of the first contour*"—and is counted for N_1, N_2, and N_3—because the '149 patent specification states that "in the present invention ***the boundary of the cell is also part of the cell***." EX1005, 19:15-17; Weide, ¶128. The count for each grid is shown below.

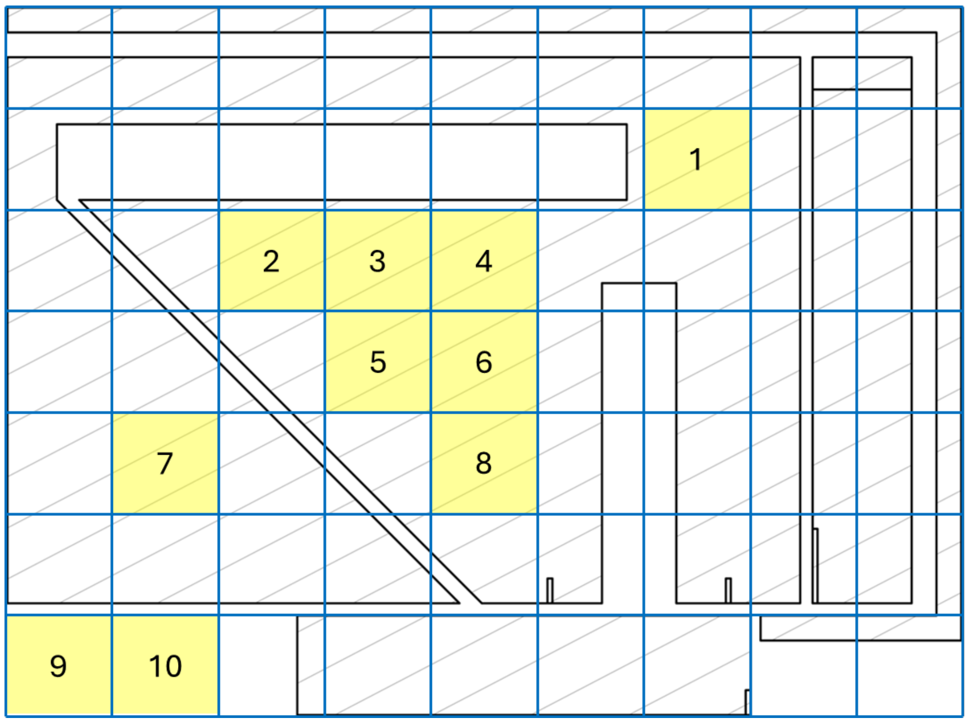
i. $N_1 = 20$

All cells in 4 × 5 grid G_1 "*include... a point*" of the *first contour* (black outline) so each cell is counted and $N_1 = 20$. Weide, ¶129.



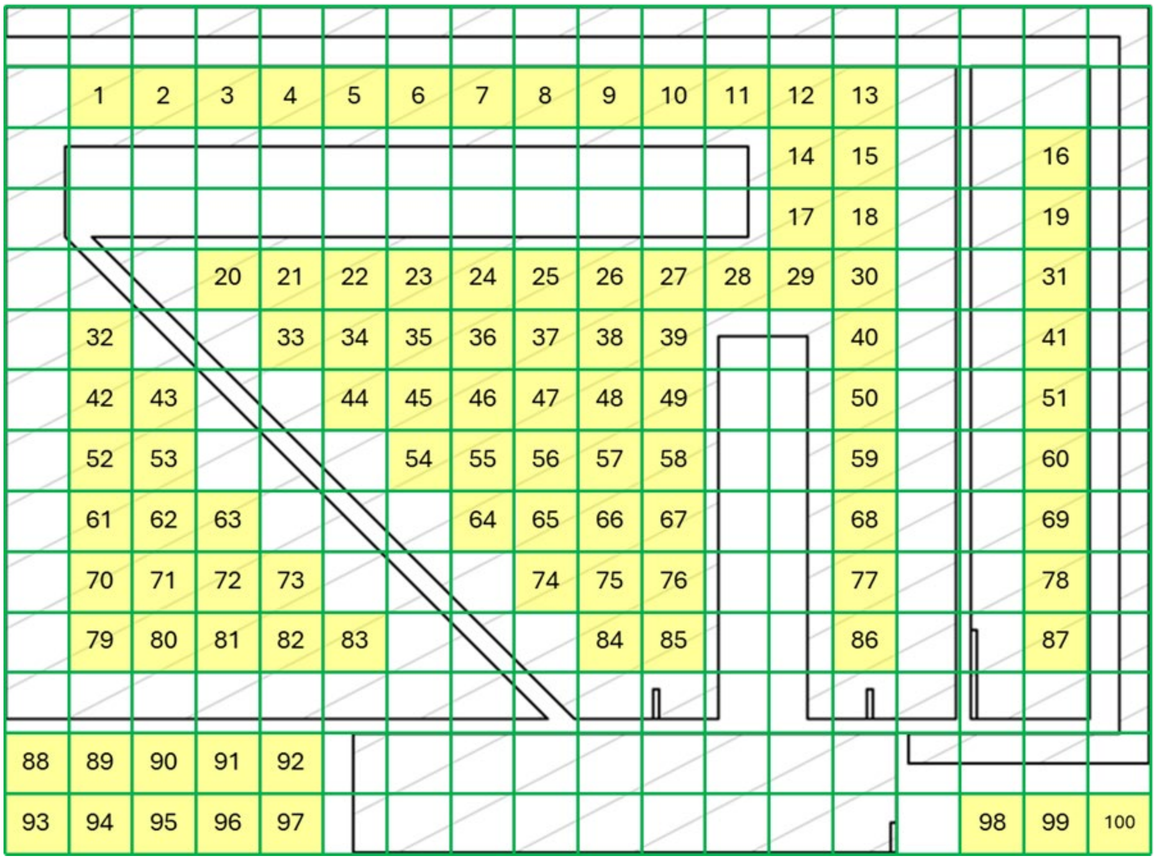
ii. $N_2 = 53$

As shown below, in 7×9 grid G_2 the cells numbered 1-10 (marked below) do ***not*** "*include… a point*" of the *first contour* and are excluded from the count. Thus, $N_2 = (63 - 10) = 53$. Weide, ¶130.



iii. N_3 = 152

In the 14×18 grid G_3 the cells numbered 1-100 (marked below) do ***not*** "*include… a point*" on the *first contour*. Thus $N_3 = (252 - 100) = 152$. Weide, ¶¶131-143.



e. **Limitation [7.h]**

7.h	wherein the complexity factors F_{21} and F_{32} are given by: $$F_{21} = -\frac{log(N_2) - log(N_1)}{log(1/2)}$$ $$F_{32} = -\frac{log(N_3) - log(N_2)}{log(1/2)}$$

i. Calculation F_{21} = 1.41

The *complexity factor F_{21}* for the multiband *first contour* is:

$$\boldsymbol{F_{21}} = -\left(\frac{\log(N_2) - \log(N_1)}{\log(1/2)}\right) = -\left(\frac{\log(53) - \log(20)}{(-1)\log(2)}\right)$$

$$= \left(\frac{\log\left(53/20\right)}{\log(2)}\right) = \left(\frac{0.423}{0.301}\right) = \mathbf{1.41}.$$

Weide, ¶144.

ii. Calculation F_{32} = 1.52

The *complexity factor F_{32}* for the multiband *first contour* is:

$$\boldsymbol{F_{32}} = -\left(\frac{\log(N_3) - \log(N_2)}{\log(1/2)}\right) = -\left(\frac{\log(152) - \log(53)}{(-1)\log(2)}\right)$$

$$= \left(\frac{\log\left(152/53\right)}{\log(2)}\right) = \left(\frac{0.458}{0.301}\right) = \mathbf{1.52}.$$

Weide, ¶145.

10. Limitation [7.i]

7.i	wherein the level of complexity of the first contour is configured to provide operation of the wireless device in the at least three frequency bands.

Dou+Ciais-Multiband uses Ciais's multiband antenna, which Ciais optimized with a "meticulous parametric study" and "independently changing" the "physical parameters" of antenna elements, including the "main shorted resonator," adding "parasitic shorted patches and capacitive loads," and adding "slots" to the main patch. Ciais-Multiband, 920; Weide, ¶146. This changed the "higher-order modes" and antenna resonances. Ciais-Multiband, 920; Weide, ¶146. Ciais thereby "configured" the *first contour*'s "*level of complexity*" to provide the frequency operation discussed *supra* §VI.D.4 ([7.c]) because the "*complexity*" measures the antenna's physical features as captured by orthogonal projection in the antenna "*contour*" as explained in [7.f]. Weide, ¶146; EX1005, 16:64-17:4, 19:26-29, 20:19-22.

In its litigation arguments, Fractus alleges that this limitation is met because [redacted]; Weide, ¶147. Under Fractus's construction, Ciais's multiband antenna meets [7.i] because it supports the frequency bands meeting [7.c]. Weide, ¶147.

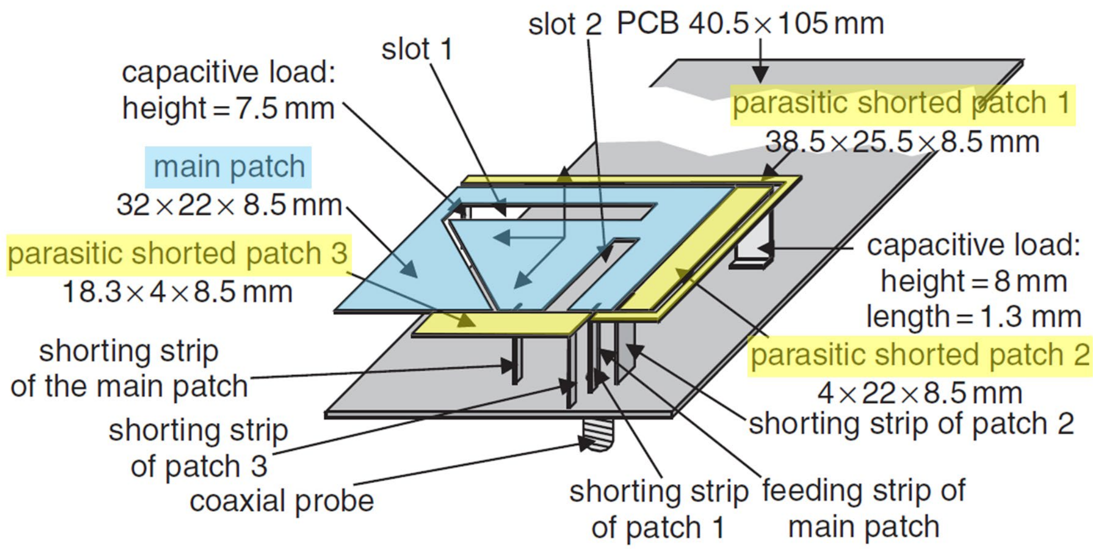
[redacted]

E. Claim 8

[8]	[Claim 7's device], wherein the first non-planar antenna includes at least two antenna elements that are electromagnetically coupled.

The plain meaning of "*electromagnetically coupled*" is an interaction between circuit components through electromagnetic fields. EX1047, 242; EX1048, 240, 362; Weide, ¶148.

Dou+Ciais-Multiband uses Ciais's multiband antenna (*first non-planar antenna*), comprising "[t]hree quarter-wavelength type, parasitic shorted patches" separated by air from a main patch that "widen" the "bandwidths" of the main patch. Ciais-Multiband, 920, Fig. 1(a) (annotated below); Weide, ¶149.



Each parasitic shorted patch is physically separated from the main patch by an air gap but "located near the main patch ***in order to be efficiently electromagnetically coupled***." Ciais-Multiband, 920; Wiede, ¶150. Thus, the main patch and each of parasitic shorted patches 1 to 3 are "*at least two antenna elements*" that are "*electromagnetically coupled*." Weide, ¶150.

F. Claim 9

[9]	[Claim 7's device], wherein the complexity factor F_{32} for the first contour is smaller than 1.75.

Dou+Ciais-Multiband meets claim 9 because the *first contour*'s $F_{32} = 1.53 < 1.75$. *Supra* §§VI.D.8-VI.D.9.e.ii ([7.g])-([7.h.4]). Weide, ¶151.

G. Claim 11

[11]	[Claim 7's device], wherein a projection of the antenna rectangle on the ground plane rectangle partially overlaps the ground plane rectangle.

There is no antecedent basis for "*antenna rectangle*" in claim 7. "[A]n antenna rectangle is defined as being the orthogonal projection of the antenna box along the normal to the face with largest area of the antenna box." EX1005, 14:21-24; *supra* §V.C; Weide, ¶152. There also is no antecedent basis for "antenna box" in claim 7. Weide, ¶152.

If "*antenna rectangle*" is assumed to mean a rectangle enclosing the first multiband antenna's *first contour*, then Dou+Ciais-Multiband meets claim 11 because Ciais's multiband antenna (*first non-planar antenna*) is disposed in a corner of the "*ground plane rectangle*" as taught in Ciais-Multiband and explained *supra* §VI.D.3 ([7.b]). Weide, ¶153. An *antenna rectangle* enclosing the antenna's *first contour* in this location is within and overlaps (e.g., at least *partially overlaps*) the *ground plane rectangle*. Dou, Figs. 2A, 2B (annotated below); Ciais-Multiband, 920, Fig. 1(b) (annotated detail below); Weide, ¶153.

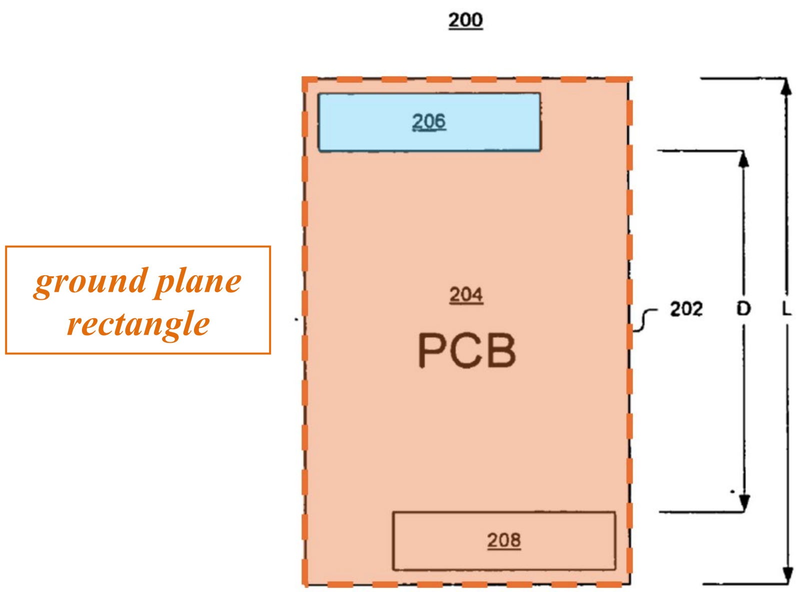

200
ground plane rectangle
206
204
PCB
208
202
D
L

FIG. 2A

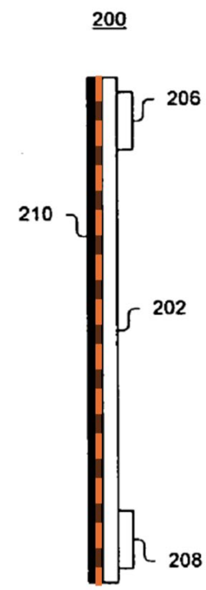
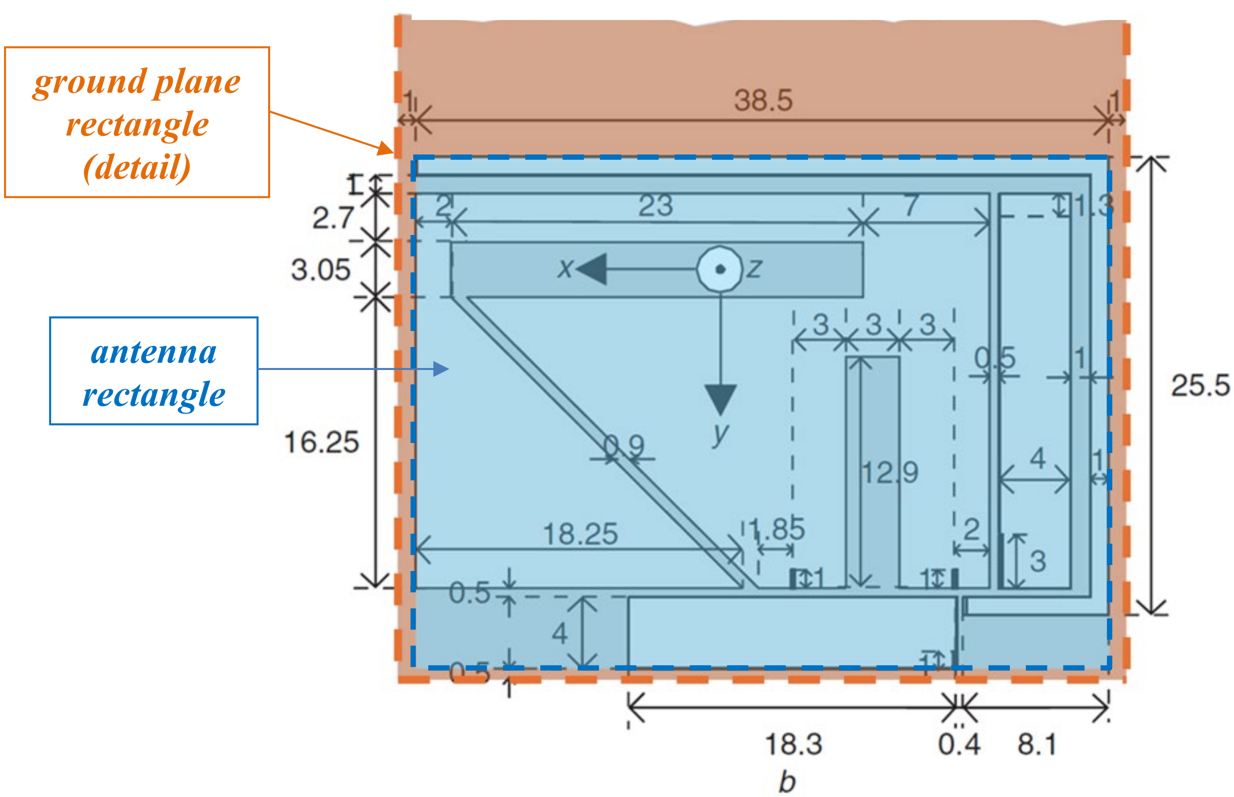

200
206
210
202
208

FIG. 2B


ground plane rectangle (detail)
antenna rectangle
38.5
1
1
2.7
3.05
16.25
2
23
7
1.3
x
z
y
3
3
3
0.5
1
25.5
0.9
12.9
4
1
18.25
1.85
2
3
1
1
0.5
4
0.5
18.3
0.4
8.1
b

H. Claim 12

[12]	[Claim 7's device], wherein the first side of the ground plane rectangle is a short side of the ground plane rectangle.

Dou+Ciais-Multiband meets claim 12 because the *ground plane rectangle*'s "*first side*" is a "*short side*" as explained *supra* §VI.D.3 ([7.b]). Ciais-Multiband, 920, Fig. 1(a); Dou, Figs. 2A-2B; Weide, ¶154.

I. Claim 13

1. Limitations [13.PRE]-[13.h.1], [13.h.3]-[13.i]

Claim 13 recites limitations similar to those in claim 7 and Dou+Ciais-Multiband meets [13.PRE]-[13.h.1] and [13.h.3]-[13.i] for the same reasons it meets the corresponding limitations below. EX1028, 1-4; Weide, ¶155.

Limitation	Corresponding limitation	Discussion *supra*
13.PRE	7.PRE	§VI.D.1
13.a	7.a	§VI.D.2
13.b	7.b	§VI.D.3
13.c	7.c	§VI.D.4
13.d	7.d	§VI.D.5
13.e	7.e	§VI.D.6
13.f	7.f	§VI.D.7
13.g	7.g	§VI.D.8
13.h	7.h	§VI.D.9.e
13.h.1	7.h.1	§VI.D.9.d
13.h.3	7.h.3	§VI.D.9.b
13.h.4	7.h.4	§VI.D.9.c
13.i	7.i	§VI.D.10

2. Limitation [13.h.2]

Limitation [13.h.2] recites a sentence fragment "*an odd number of rows of equal height arranged along a short side of the*." Limitation [7.h.2] recites the same language ending with "*of the face*." Assuming the "*short side*" in [13.h.2] means "*a short side of the face*" as recited in [7.h.2], then Dou+Ciais-Multiband meets [13.h.2] for the same reasons it meets [7.h.2] *supra* §VI.D.9.a. Weide, ¶156.

J. Claims 14, 16-17, and 19

Claims 14, 16-17, and 19 depend from claim 13 and recite the same additional limitations as claims 8, 11, 9, and 12, respectively. EX1028, 5; Weide, ¶157. Dou+Ciais-Multiband meets the additional limitations in claims 14, 16-17, and 19 for the same reasons it meets the corresponding limitations below. Weide, ¶157.

Limitation	Corresponding limitation	Discussion *supra*
14	8	§VI.E
16	11	§VI.G
17	9	§VI.F
19	12	§VI.H

K. Claim 20

[20]	[Claim 13's device], wherein the first side of the ground plane rectangle is a long side of the ground plane rectangle.

Dou+Ciais-Multiband meets claim 20 because Dou's modified device implements antenna 206 as a Ciais multiband antenna, and implements Ciais's teaching that the multiband antenna is placed "on the corner of a ground plane."

Ciais-Multiband, Fig. 1(a), 920 (antenna is placed "on the corner of a ground plane having a size approximately equal to that of the [PCB] of a typical mobile phone, i.e. 40.5 × 105 mm."); Weide, ¶158. Thus, in Dou+Ciais-Multiband, the multiband antenna (*first antenna*) is proximate to both a short side and a *long side* of the *ground plane rectangle*. *Supra* §§VI.D.3 ([7.b]), VI.I.1 [13.b]; Weide, ¶158.

While in claims 12 and 19 the "*first side*" is mapped to a "*short side*," for claim 20, the "*first side*" is mapped to a "*long side*" as shown below, without any change to the claim 13 analysis, because the Ciais multiband antenna implementing Dou antenna 206 ("*first antenna*") is "*proximate*" to the "*long side*" of the *"ground plane rectangle*" for [13.b] as shown below. Dou, Figs. 2A, 2B (annotated below); *supra* §§VI.D.3 ([7.b]), VI.I.1 ([13.b]); Weide, ¶159.

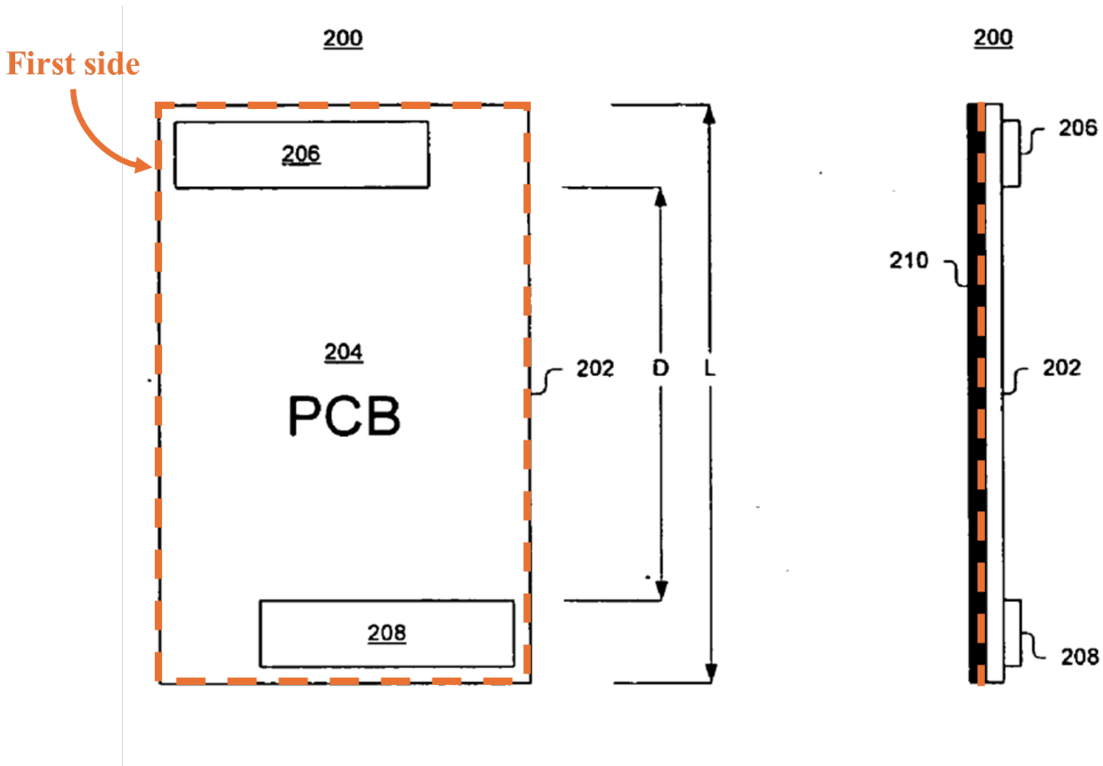


FIG. 2A FIG. 2B

Ciais's multiband antenna has a length of 38.5 mm while Dou's PCB 204 is implemented with a width of 40.5mm as taught in Ciais-Multiband. *Supra* §VI.C (combination); Ciais-Multiband, 920, Figs. 1(a)-1(b); Weide, ¶160. Thus, even if the Ciais multiband antenna were centered on the short side (rather than placed "on the corner of a ground plane"), the Ciais multiband antenna ("*first antenna*") would be at most 1 mm from a long edge of the PCB and ground plane (e.g., when centered on the 40.5 mm edge). Weide, ¶160. This is "*proximate*" to a long edge (*second side*) of the *ground plane rectangle* and still meets [13.b] when the *first side* is mapped to the long side of PCB 204 and *ground plane rectangle*. *Supra* §§VI.D.3 ([7.b]), VI.I.1 ([13.b]); Weide, ¶160. This meets claim 20.

VII. GROUND 1B: DOU+CIAIS-MULTIBAND+HILGERS RENDERS OBVIOUS CLAIMS 10 AND 18

A. Hilgers (EX1040)

Hilgers discloses a dual-band antenna for receiving GPS signals (at 1575.42 MHz) and transmitting/receiving Bluetooth at 2400-2483.5 MHz in the 2.4 GHz ISM band. Hilgers, [0001], [0003] (GPS), [0023] (GPS module), [0024] (Bluetooth), [0035] (dual-band antenna for GPS and Bluetooth); EX1044, 27 (Bluetooth uses 2.4 GHz ISM band). Hilgers' antenna is a surface mount component that solders to a PCB. Hilgers, [0041]. It is designed for use in wireless devices like a mobile phone. Hilgers, [0005], [0027], [0054].

B. Dou+Ciais-Multiband+Hilgers

Dou describes its wireless device having "three or more antennas" "disposed within the housing of a wireless device," which "may comprise any suitable type of internal antenna" (Dou, [0040]), and describes the wireless device having an antenna covering frequencies for GPS (1575 MHz) as well as covering Bluetooth at the 2.4 GHz ISM band. Dou, [0022]; Weide, ¶162.

While Ciais's multiband antenna provided coverage in the 5 GHz ISM bands used by IEEE Std. 802.11a and HiperLAN/2, it did not provide coverage at 1575 MHz for GPS or in the 2.4 GHz ISM band used by Bluetooth. Ciais-Multiband, 920-921, Fig. 2; Weide, ¶163. A POSA would have had reasons to include Hilgers's dual band antenna in order to support GPS and Bluetooth, to provide the services that Dou describes, in frequency ranges Ciais's multiband antenna did not cover. Weide, ¶163. Providing GPS and Bluetooth antenna within a mobile device—as Dou describes—was conventional. E.g., EX1029, Fig. 9 (below), [0044] (GPS antenna **64**, WLAN antenna **61**, Bluetooth antenna **66**); Weide, ¶163.

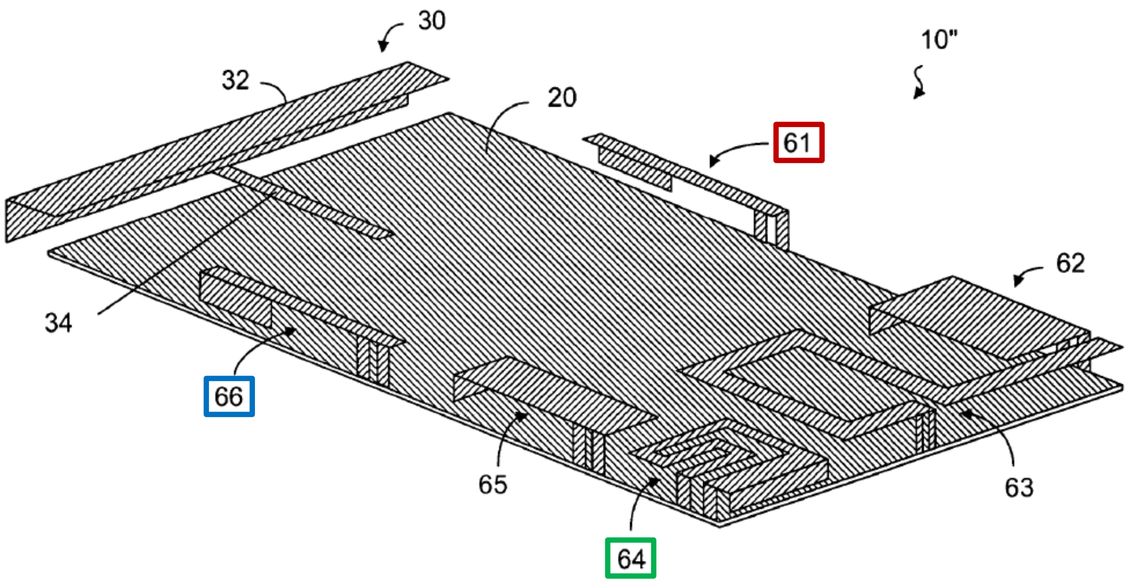


FIG. 9

A POSA would have mounted Hilgers's dual-band antenna within Dou's device housing because Hilgers teaches that its dual-band antenna is "mounted or soldered on to a printed circuit board," which is "within" the housing of Dou's wireless device. Hilgers, [0054]; Dou, Abstract ("housing enclosing a [PCB]"), [0016]-[0017]; Wiede, ¶164.

Implementing Dou-Ciais-Multiband's wireless device further including Hilgers's dual-band GPS/Bluetooth antenna would have been nothing more than combining familiar elements according to known methods with predictable results, and been no more than the "predictable use of prior art elements according to their established functions." *KSR*, 550 U.S. at 416-417; Weide, ¶165. This combination would have provided the multiband coverage that Dou describes. Weide, ¶165.

A POSA also would have had a reasonable expectation of success including Hilgers's GPS/Bluetooth antenna in Dou's wireless device—as Dou describes—because it was conventional (EX1029, [0044]), Dou explains that "the antenna architecture may comprise three or more antennas" (Dou, [0040]), and Dou specifically describes the wireless device having coverage including for GPS and Bluetooth (Dou, [0022]). Weide, ¶166.

This combination of Dou in view of Ciais-Multiband, and further in view of Hilgers (hereinafter "Dou+Ciais-Multiband+Hilgers") has **three** antennas: antennas 206 and 208 (each a Ciais multiband antenna), and Hilgers's dual-band GPS/Bluetooth antenna, and meets the Challenged Claims as shown below. Weide, ¶167.

C. Claims 10 and 18

Claim 10 depends from claim 7, while claim 18 depends from claim 13. Claims 10 and 18 recite the same additional limitation, "*wherein a third antenna is configured to operate in at least two frequency bands being different from the at least three frequency bands and the third antenna is arranged within the wireless device.*" EX1028, 6; Weide, ¶168.

Dou+Ciais-Multiband+Hilgers meets claims 10 and 18 because Hilgers's dual-band antenna (*third antenna*) covers (*is configured to operate in*) 1575 MHz (for GPS) and the 2.4 GHz ISM band (for Bluetooth) (*at least two frequency bands being different*), which Ciais's multiband antenna does not cover. *Supra* §VI.D.4 ([7.c]); Hilgers, [0001], [0025], Fig. 4; Weide, ¶169. Hilgers's dual-band antenna is "*arranged within*" the Dou+Ciais-Multiband+Hilgers device. *Supra* §VII.B (combination); Weide, ¶169.

VIII. GROUND 2: DOU+CIAIS-QUADBAND+NAKANO RENDERS OBVIOUS CLAIMS 1-20

A. References

1. Ciais-Quadband (EX1009)

Ciais-Quadband discloses a "miniature multiband internal antenna" for "modern mobile handsets" that can send and receive signals at 870-960 MHz with a VSWR "better than" (i.e., less than) 2.5:1, and at 1710-2170 MHz with a VSWR under 2.0:1. Ciais-Quadband, Fig. 3, 148-150; Weide, ¶170.

2. Nakano (EX1012)

Nakano describes an antenna for use "inside mobile phone handsets." Nakano, 2417. The antenna extends from a ground plate that "backs a radiation element (patch element)," and supports operation between 2400-2500 MHz and 5 and 6 GHz—e.g., WLAN bands at "2.45 GHz" (e.g., 2400-2500 MHz) and 5.2 GHz—at a VSWR of 2.0:1. Nakano, 2417, 2419, Figs. 1(b), 4; Weide, ¶171.

3. Dou+Ciais-Quadband+Nakano

While Dou describes a wireless handheld device having "three or more" internally-mounted antennas (Dou, [0040]), it leaves the antenna selection to a POSA. Weide, ¶172. Dou describes using antennas that are "compatible with multiple wireless data, multimedia and cellular telephone systems," including "WiFi and Bluetooth" (Dou, [0022]). Weide, ¶172. Dou also discusses the benefits of "spatial diversity techniques to improve communication of wireless signals across one or more frequency bands." Dou, [0022]; Weide, ¶172. Dou teaches that the antennas may be of "any suitable type" (Dou, [0040]) and may be arranged in "any suitable topology… for a given implementation" (Dou, [0039]). *Supra* §VI.C (Ground 1A, combination); Weide, ¶172.

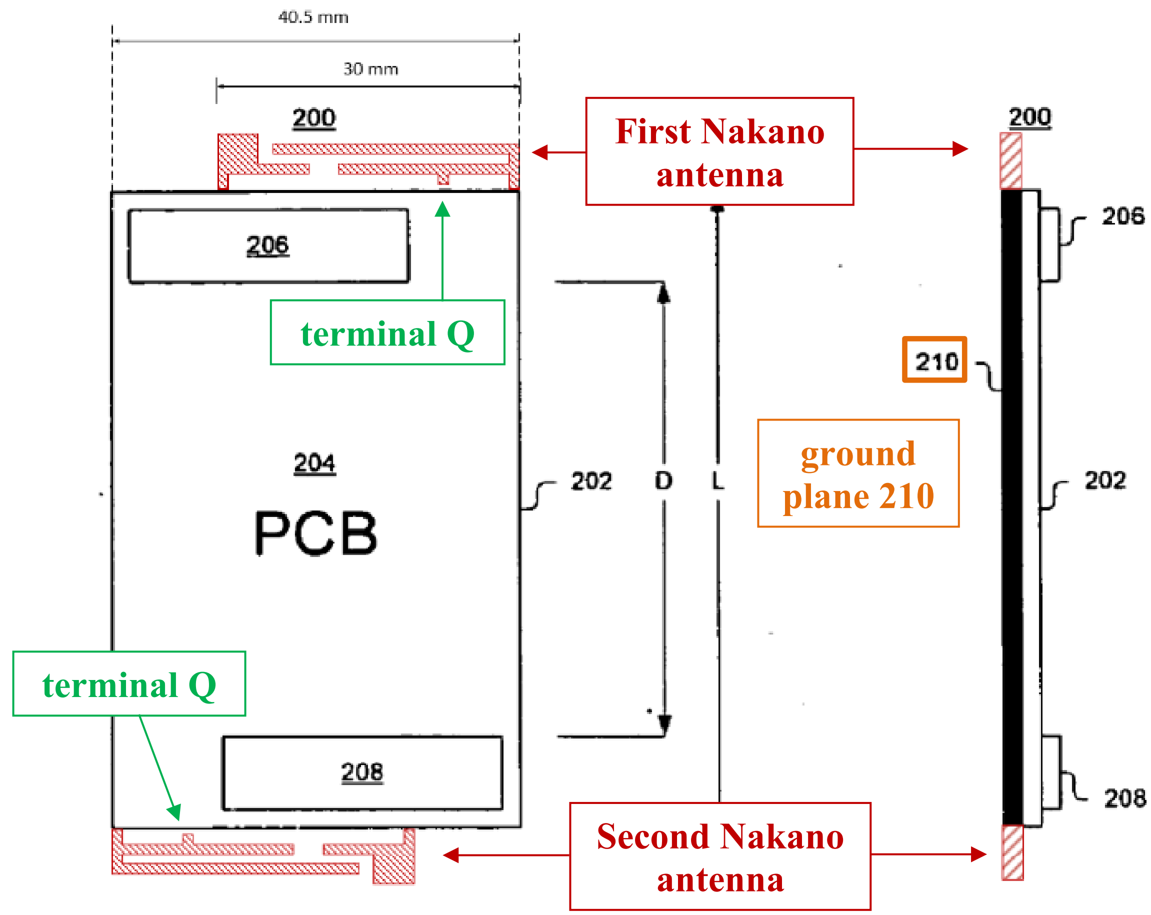
As explained below, a POSA would have had reasons to implement Dou's wireless device in a diversity architecture with Nakano's InvFL antenna providing coverage at frequencies used by WLAN, and Ciais's quadband antenna providing coverage at frequencies used for cellular communications. Weide, ¶173.

a. Modifying Dou with Nakano's teachings

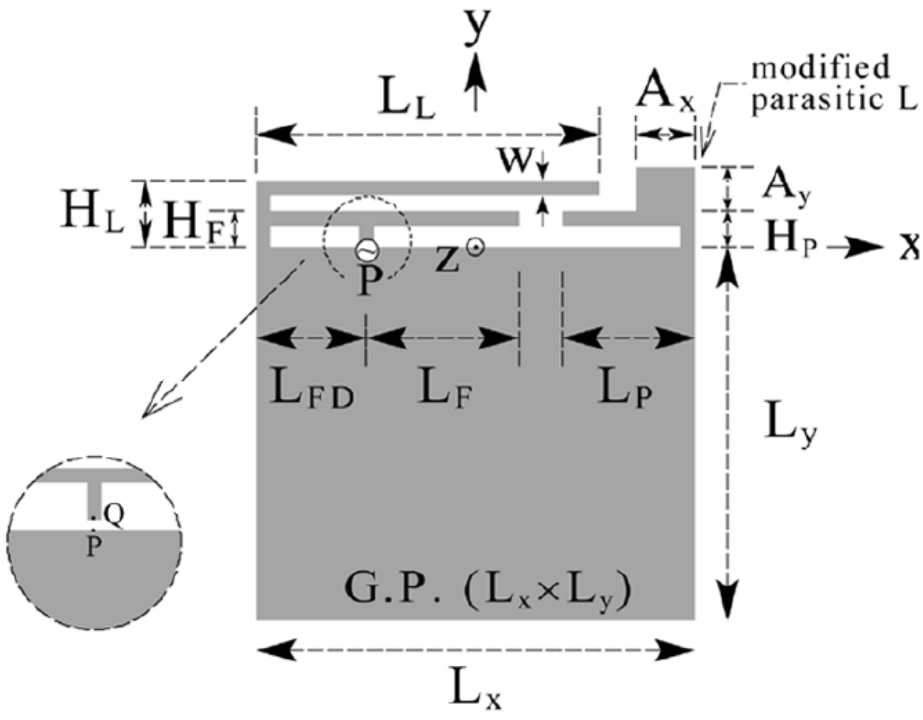
A POSA would have had reasons to use Nakano's InvFL antenna to implement the WLAN functionality that Dou describes its wireless device having because Nakano's antenna was designed for internal use in "mobile phone handsets" like Dou's wireless device and covered the 5.2 GHz band used by IEEE

Std. 802.11a, in addition to the "2.45 GHz" (2400-2500 MHz) ISM band used by IEEE Std. 802.11b and Bluetooth. Nakano, 2417, 2419, Fig. 4; Dou, [0022]; EX1042, 3 (802.11a uses "5.15–5.25, 5.25–5.35 and 5.725–5.825 GHz… bands"), 26 (Table 88 showing channels in 5 GHz bands); EX1043, 49-50 (802.11b defines channels between 2400 and 2484 MHz); EX1044, 27 ("Bluetooth devices operate in the unlicensed 2.4 GHz ISM [] band."); Weide, ¶174. Nakano's dual-frequency WLAN antenna met an "increasing demand for wireless communications" (Nakano, 2417). The market demand gave POSAs additional reasons to include Nakano's antenna in Dou's wireless device. Weide, ¶174.

A POSA would have had reasons to place one of Nakano's InvFL antenna at the "top" and "bottom" of Dou's PCB 204—as shown below—to provide spatial diversity in a "diversity antenna architecture" that Dou explains improves "receiving sensitivity" and device performance. Dou, Abstract, [0001], [0014]-[0017], [0022], [0030]; Weide, ¶175. Nakano's InvFL antenna extends from a "co-planar ground plate" on the short side of a rectangular "card-type structure." Nakano, 2517, Fig. 1; Weide, ¶175. A POSA would have modified Dou's wireless device to use Nakano's teaching by placing an InvFL antenna co-planar with ground plane 210 (Dou, Fig. 2B) and extending it from the ground plane both "above" and "below" PCB 204 as shown below. Dou, Figs. 2A-2B (modified below), [0016]-[0017]; Weide, ¶175.



Nakano's antenna is excited at terminal Q. Nakano, Fig. 1(b), 2418; Weide, ¶176.



(b)

A POSA would have positioned each Nakano antenna along an edge of the PCB, as shown, to simplify offsetting the feed lines to terminal Q from Dou antennas 206 and 208, respectively. Nakano, 2417-2418, Figs. 1(a)-1(b); Weide, ¶177.

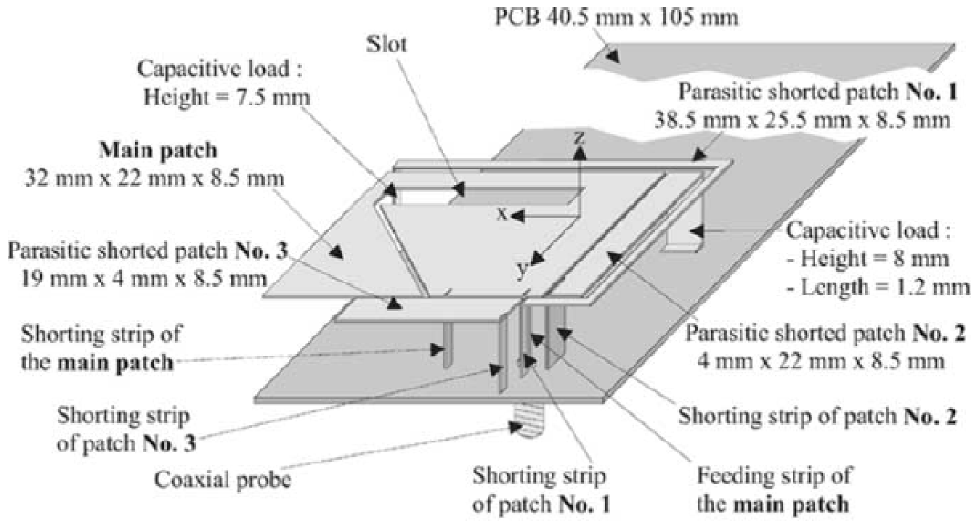
Implementing Dou's wireless device with two Nakano InvFL antennas as described above would have been nothing more than combining familiar elements according to known methods with predictable results, and been no more than the "predictable use of prior art elements according to their established functions." *KSR*, 550 U.S. at 416-417; Weide, ¶178.

b. Modifying Dou with Ciais-Quadband's teachings

A POSA would have had reasons to implement each of Dou's first antenna 206 and second antenna 208 as a Ciais quadband antenna. Ciais's quadband antenna was designed for internal use in mobile phones, making it suitable for use as Dou's "internal antenna" 206 and 208 "disposed within… housing 202 of the wireless device 200." Dou, [0018]; Ciais-Quadband, 148, 150; Weide, ¶179.

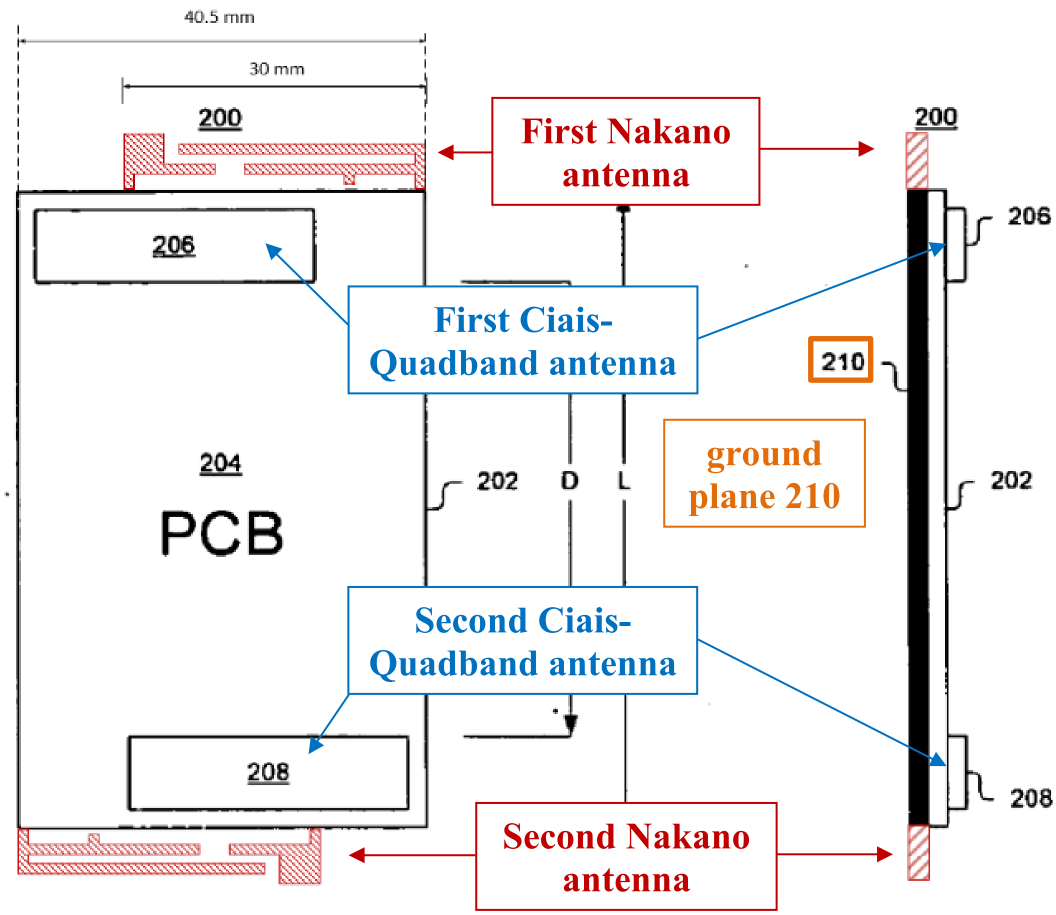
Ciais's quadband antenna is a planar inverted-F antenna (PIFA) (Ciais-Quadband, Abstract), which Dou describes using for the first and second antennas. Dou, [0028]. Ciais's quadband antenna provided operation at 870-960 MHz and 1710-2170 MHz, used in well-known communication standards (GSM, DCS, PCS, UMTS), making the antenna "suitable for mobile phone applications" like Dou's wireless device. Ciais-Quadband, 148, 150; Dou, [0022] (describing exemplary coverage for GSM, PCS, and "WCDMA/UMTS" operations); Weide, ¶180.

Ciais teaches placing the quadband antenna "on the corner of a ground plane" with dimensions (40.5×105 mm) that are "representative" of a "typical mobile phone" PCB. Ciais-Quadband, 148, Fig. 1(a) (below).



(a)

A POSA would have used Ciais's teaching to modify Dou by covering the back surface of PCB 204 with ground plane 210, and placing a Ciais quadband antenna over "the corner of" ground plane 210 to provide Dou antennas 206 and 208. Weide, ¶182.



Implementing Dou's wireless device with Dou's first antenna 206 and second antenna 208 each provided by a separate Ciais quadband antenna would have been nothing more than combining familiar elements according to known methods with predictable results, and been no more than the "predictable use of prior art elements according to their established functions." *KSR*, 550 U.S. at 416-417; Weide, ¶183.

The resulting combination (hereinafter "Dou+Ciais-Quadband+Nakano") has four antennas: antennas 206 and 208 implemented as Ciais-Quadband antennas with spatial diversity supporting frequencies for cellular communications, and two "additional antenna[s]" (Dou, [0040]) implemented as Nakano antennas with spatial diversity supporting frequencies for WLAN/Bluetooth. Weide, ¶184.

c. Reasonable expectation of success

A POSA would have had a reasonable expectation of success in combining Ciais's and Nakano's teachings with Dou for the reasons explained *supra* §VI.C (Ground 1A, combination). Weide, ¶185. Dou confirms that combining multiple antennas within a single mobile wireless device was conventional and within the POSA's ordinary skill. Dou, [0022], [0040]; Weide, ¶185. For example, EX1029 describes "an integrated antenna system" having a WLAN antenna **61**, UMTS antenna **62**, "GSM 850/900 antenna **63**," "GSM1800/1900 UMTS diversity antenna **65**," and Bluetooth antenna **66** in a single a "hand-held electronic device" such as a mobile phone or PDA. EX1029, Fig. 9, [0006], [0044]; Weide, ¶185.

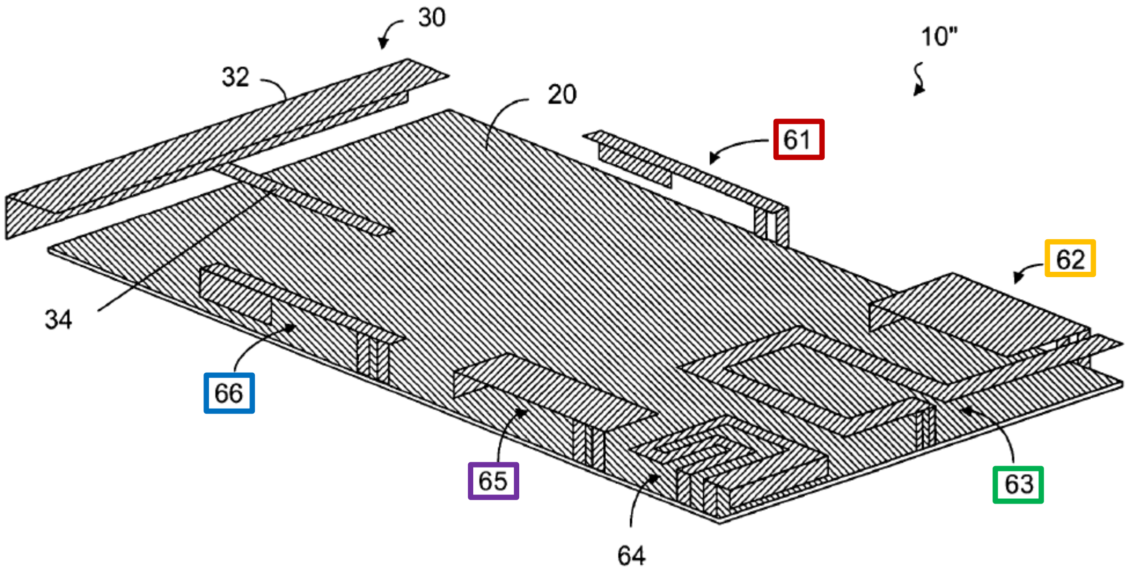


FIG. 9

Both Nakano's InvFL antenna and Ciais's quadband antenna were designed for internal use in "mobile phone handsets" like Dou's wireless device. Nakano, 2417; Ciais-Quadband, Fig. 3, 148, 150; Weide, ¶186. Dou expressly describes embodiments using planar inverted-L and planar inverted-F antennas (which Nakano combines in an inverted FL antenna) as well as a multiband PIFA antenna—like the Ciais quadband antenna. E.g., Dou, [0028]-[0029]; Weide, ¶186.

Dou describes antenna placement within the device according to "various performance and design constraints" known to a POSA, allowing for "any suitable topology… as desired for a given implementation. Dou, [0030], [0039]; Weide, ¶187. Nakano describes an inverted FL antenna extending from a co-planar ground plate while Ciais describes placing the quadband antenna at the end of a

PCB "on the corner of a ground plane" where Dou places its antennas 206 and 208. Ciais-Quadband, Fig. 1, 148; Dou, Figs. 2A-2B, [0029]. It was well within the POSA's ordinary skill to implement Dou's wireless device with Nakano's inverted FL antenna, and Ciais's quadband antenna, and the resulting antenna operation for each was predictable. Dou, [0012], [0063]; Weide, ¶187.

Dou+Ciais-Quadband+Nakano meets the Challenged Claims as shown below.

B. Claim 1

1. Preamble [1.PRE]

[1.PRE]	A wireless device comprising:

Dou+Ciais-Quadband+Nakano meets [1.PRE] because the modified Dou wireless device is, e.g., a handheld computer, mobile telephone, or PDA. Dou, [0015]-[0016], [0031], claim 1; Weide, ¶189.

2. Limitation [1.a]

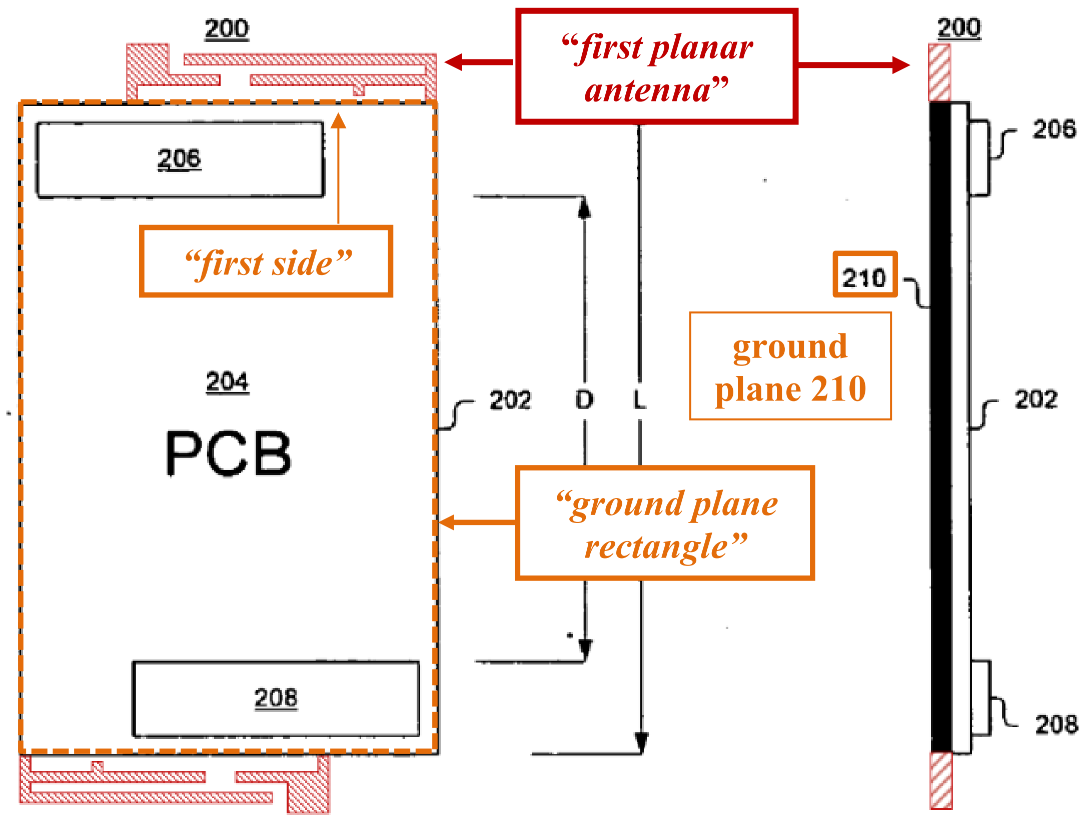
[1.a]	a ground plane;

Dou+Ciais-Quadband+Nakano because it uses Dou's ground plane 210 to implement Nakano's and Ciais's ground plane teachings. Dou, Fig. 2B, [0029]; Nakano, 2417-18, Fig. 1(b); Ciais-Quadband, 148, 150, Fig. 1(a); Weide, ¶190.

3. Limitation [1.b]

[1.b]	a first planar antenna proximate to a first side of a ground plane rectangle enclosing the ground plane,

Dou+Ciais-Quadband+Nakano meets [1.b] because Dou's modified wireless device has a first Nakano antenna ("*first planar antenna*") extending from ground plane 210 providing a "co-planar ground plate" as described in Nakano. *Supra* §VIII.A.3 (combination); Nakano, 2417, Fig. 1; Dou, Figs. 2A-2B (annotated below to show Dou+Ciais-Quadband+Nakano); Weide, ¶191. Nakano's antenna is "*planar*" because its elements "lie in the same plane" and form "a flat structure". Nakano, Abstract, 2417, Fig. 1(b); Dou, [0017], Fig. 2B; Weide, ¶191.



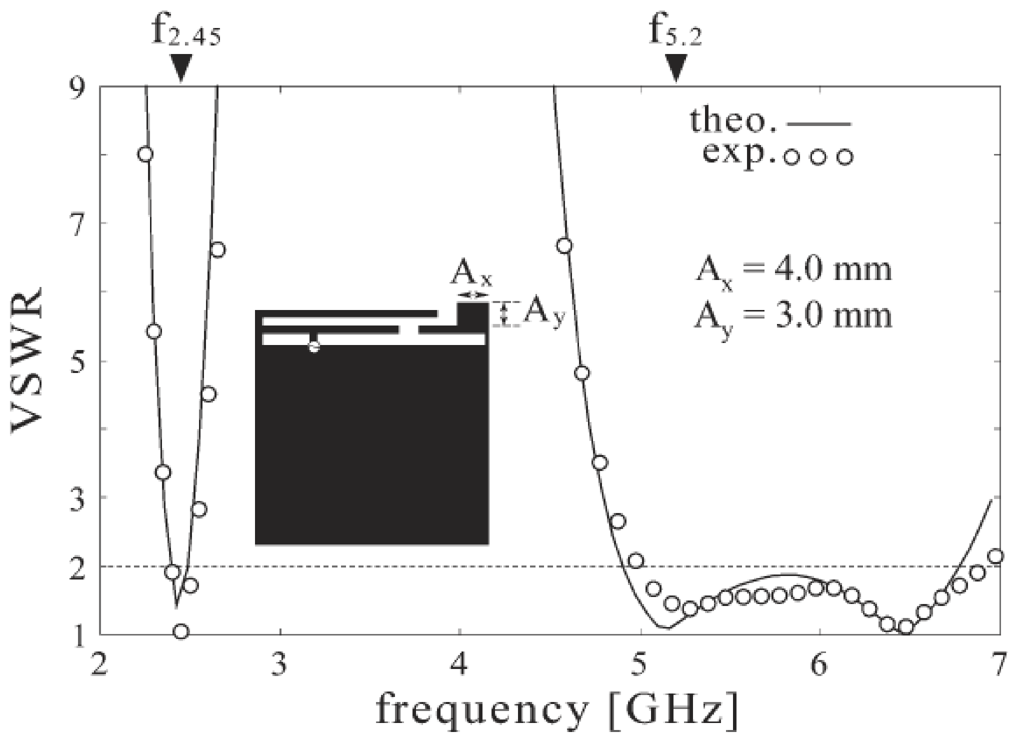
Ground plane 210 covers the back surface of PCB 204 consistent with the ground plane teaching in Ciais-Quadband and Nakano. *Supra* §VIII.A.3 (combination). PCB 204's rectangular area defines a rectangle ("*ground plane rectangle*") that "*enclos[es]*" the ground plane 210 disposed on the side of the PCB opposite from antenna 206. *Supra* §VI.D.3 (Ground 1A, [7.b]); Dou, Figs. 2A-2B, [0016]-[0017], [0029]; Weide, ¶192. The top (e.g., 40.5 mm) edge of the "*ground plane rectangle*" is a "*first side*." *Supra* §VIII.A.3.b; Ciais-Quadband, 148, Fig. 1(a); Weide, ¶192.

The first Nakano antenna ("*first planar antenna*") is "*proximate to a first side of a ground plane rectangle*" because it extends from it. Dou, Figs. 2A-2B (annotated above), [0016]-[0017], [0029]; Weide, ¶193.

4. Limitation [1.c]

[1.c]	the first planar antenna being configured to support at least three frequency bands of the electromagnetic spectrum,

Dou+Ciais-Quadband+Nakano meets [1.c] because Nakano's antenna (*first planar antenna*) covers 2400-2500 MHz ("has a 4.1% bandwidth around 2.45 GHz") and at least 5150-5900 MHz ("a 31.8% bandwidth around 5.2 GHz") at VSWR 2.0:1. Nakano, 2417 (Abstract), 2419-20, Fig. 4 (below); Weide, ¶194.



The 2400 MHz to 2500 MHz frequency range is the 2.4 GHz ISM band that

IEEE Std. 802.11b and Bluetooth each use. EX1005, 25:20-22; EX1043, 1, 11 (IEEE Std. 802.11b uses 2.4 GHz ISM band); EX1044, 29 (Bluetooth uses 2.4 GHz ISM band); Weide, ¶195.

The Nakano InvFL antenna's 5150-5900 MHz coverage includes at least five frequency bands as shown in Table 4.

Table 4: Frequency bands at 5 GHz

Band	Range (MHz)
U-NII lower	5150-5250
U-NII middle	5250-5350
U-NII	5470-5725
U-NII upper	5725-5825
U-NII	5850-5895

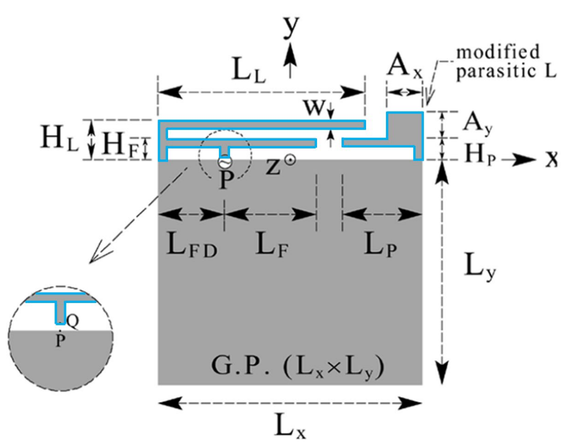
EX1042, 26 (IEEE Std. 802.11a defining WLAN channels in 5 GHz U-NII bands); 47 C.F.R. §§15.401, 15.403 (U-NII devices in 5.15-5.35 GHz and 5.47-5.895 GHz frequency bands); 47 C.F.R. §§15.407(a)(1) (discussing 5150-5250 MHz U-NII band), 15.407(a)(2) (discussing 5250-5350 MHz and 5470-5725 MHz U-NII bands), 15.407(a)(3)(i) (discussing 5725-5850 MHz U-NII band), 15.407(a)(3)(ii)-(v) (discussing 5850-5895 MHz U-NII band); 69 Fed. Reg. 54027, 54035 (describing 5725-5850 MHz band) (Sep. 7, 2004) (codified at 47 C.F.R. §15.247), 54036-54037 (describing "band 5.725-5.825 GHz") (codified at 47 C.F.R. §15.407(a)(3)); Weide, ¶196.

Therefore Nakano's InvFL antenna is operable in ("*configured to support*") frequency ranges used by "*at least three frequency bands of the electromagnetic spectrum*," meeting [1.c]. Weide, ¶197.

5. Limitations [1.d], [1.g]

[1.d]	the first planar antenna defining a first contour,
[1.g]	wherein the first contour is defined as a perimeter of the first planar antenna and perimeters of any closed apertures defined within the first planar antenna;

Nakano's antenna defines a "*first contour*" just like the perimeter of antenna contour 350 in the '149 patent's embodiments in Figure 3 or antenna system 1200 in Figure 12A (below right), meeting [1.d] and [1.g]. EX1005, 7:62-64, 33:65-34:7; Nakano, 2417, 2419, Figs. 1(b), 4; Weide, ¶198.



Nakano, Fig. 1(b) (annotated)

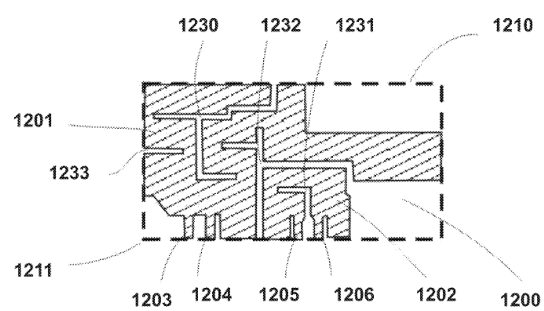
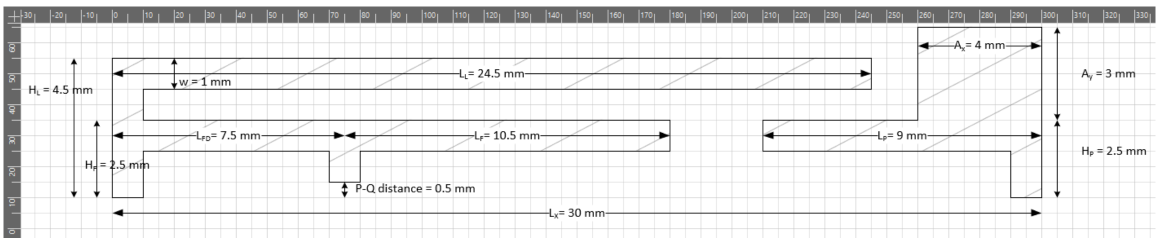


FIG. 12A

'149 patent

Nakano provides antenna dimensions for "*a perimeter*" of the InvFL antenna defining "*a first contour*" meeting [1.d] and [1.g] as shown below. Nakano, 2417, 2419 Figs. 1(b), 4; Weide, ¶199.



6. Limitation [1.e]

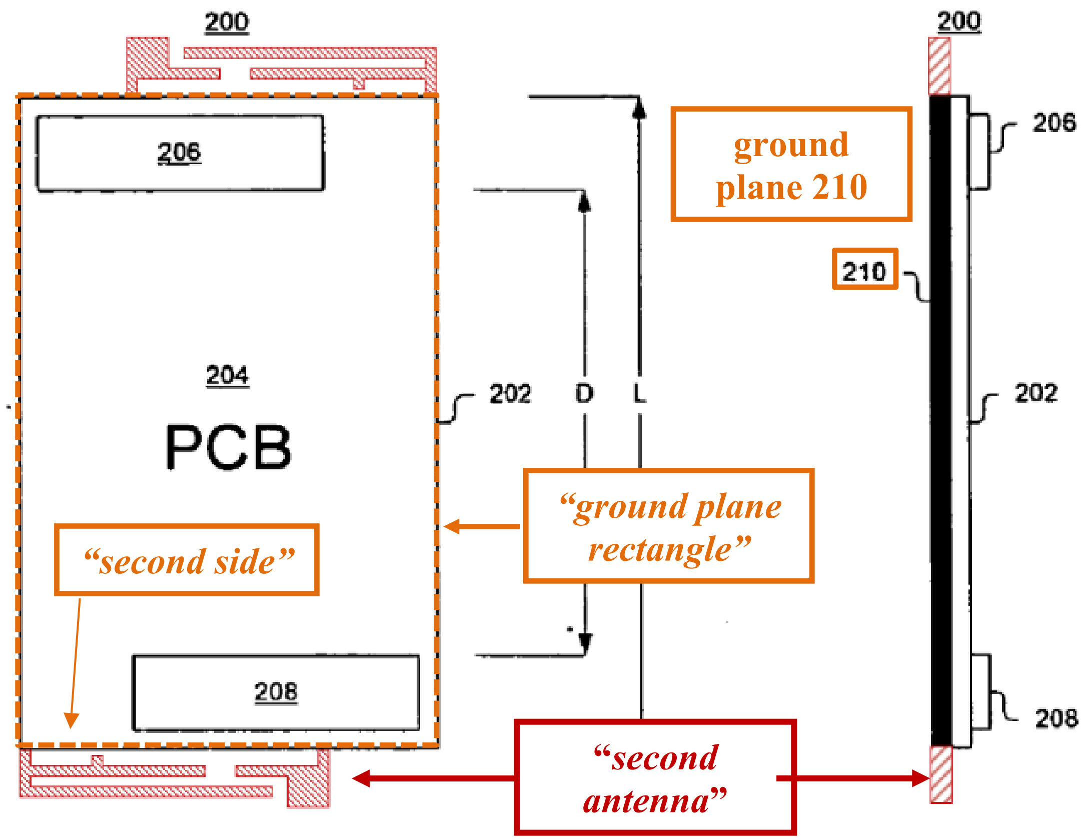
[1.e]	wherein the first contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value of at least 1.35; and

Dou+Ciais-Quadband+Nakano meets [1.e] because the *first contour* for Nakano's antenna has $F_{21} = 1.43 \geq 1.20$, and $F_{32} = 1.43 \geq 1.35$, as shown for [1.h]-[1.h.4] below. Weide, ¶200.

7. Limitation [1.f]

[1.f]	a second antenna proximate to a second side of the ground plane rectangle, wherein the second antenna is configured to receive signals from at least two frequency bands of the at least three frequency bands;

Dou+Ciais-Quadband+Nakano meets [1.f] because as shown below Dou's modified device includes a second Nakano antenna ("*second antenna*") extending from "*a second side of the ground plane rectangle*" opposite the "*first side*" with the first Nakano antenna. *Supra* §VIII.A.2 (combination); Weide, ¶201.



Nakano's antenna (*second antenna*) meets the remaining limitations in [1.f] because it covers the same frequency bands as the *first planar antenna* as explained *supra* §VIII.B.4 ([1.c]). Weide, ¶202.

8. Complexity factor limitations ([1.h]-[1.h.4])

Limitations [1.h]-[1.h.4] define "*complexity factors F_{21} and F_{32}*" using the same language and convoluted sequence as limitations [7.h]-[7.h.4] *supra* §VI.D.9 (Ground 1A, [7.h]-[7.h.4]). As with Ground 1A, the analysis below addresses the steps in order, with the consequence of presenting the claim limitations out of the sequence in which the patent recites them.

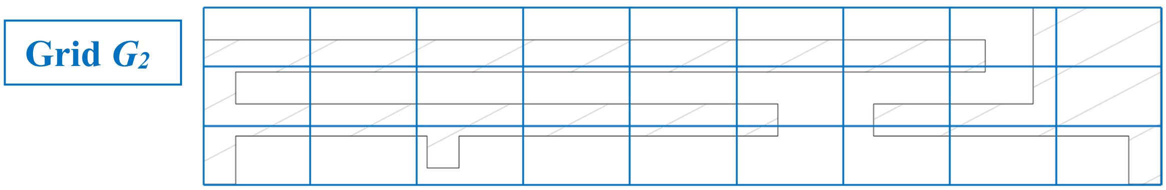
a. Limitation [1.h.2]: Grid G_2

Nakano's antenna contour (*first contour*) is 30 mm wide (*long side of the face*) and 5.5 mm in height (*short side of the face*). Nakano, 2417, 2419, Figs. 1(b), 4. Grid G_2 with nine (9) columns across a "*minimum-sized rectangle enclosing the first planar antenna*" yields cell width for *columns of equal width* of $\left(\frac{30mm}{9}\right) = 3.33\ mm$. Weide, ¶204.

Setting an odd number of "2*n*+1" rows with integer *n* such that $0 < n < 5$ yields these cells for "*rows of equal height*," where the aspect ratio is the ratio of cell width to cell height. EX1005, 18:8-10; Weide, ¶205.

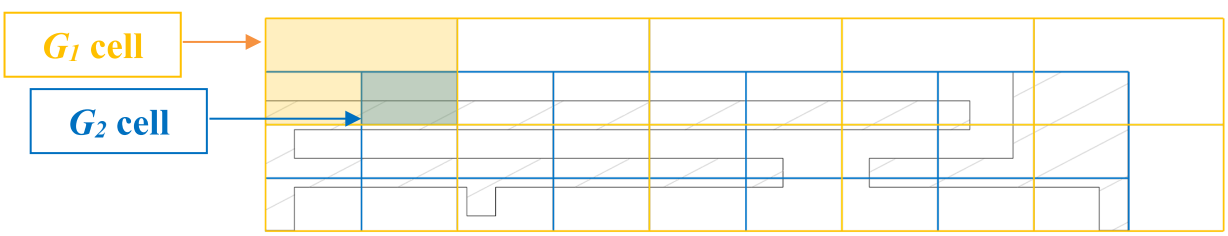
Rows	Cell Height (mm)	Cell Aspect Ratio $\left(\frac{width}{height}\right)$
3	$\left(\frac{5.5}{3}\right) = 1.83$	$\left(\frac{3.33}{1.83}\right) = 1.82$
5	$\left(\frac{5.5}{5}\right) = 1.1$	$\left(\frac{3.33}{1.1}\right) = 3.03$

Three (3) rows provides an "*odd number of rows of equal height arranged along a short side of the minimum-sized rectangle*" with "*the cells… being as square as possible*" because three rows provides a cell with an aspect ratio closer to 1 (e.g., where width = height) than any other *odd number* ("2*n*+1") *of rows* with integer *n* such that $0 < n < 5$. Weide, ¶206. Thus, grid G_2 has 3 rows by 9 columns as shown below (blue outline). Weide, ¶206.



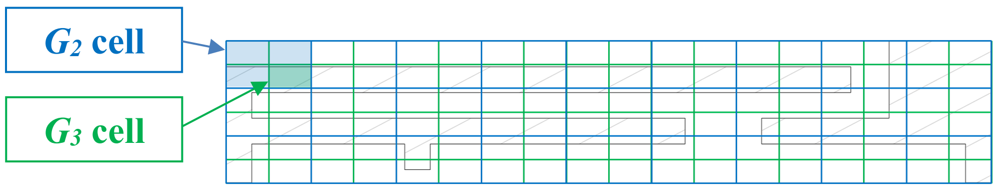
b. Limitation [1.h.3]: Grid G_1

Grid G_1 (orange outline below) is "*aligned with a corner of the grid G_2*" and "*cover[s] the face*" (e.g., the *first contour*), wherein each G_1 cell has twice the width and height of a G_2 cell, e.g., "*widths and heights that respectively are double the widths and heights of the cells of the grid G_2*." Weide, ¶207.



c. Limitation [1.h.4]: Grid G_3

Grid G_3 (green outline below) is "*aligned with the grid G_2*" and each G_2 cell (green) comprises ***four*** G_3 cells—meaning that G_3 cells have "*widths and heights that respectively are half the widths and heights of the cells of the grid G_2.*" Weide, ¶208.

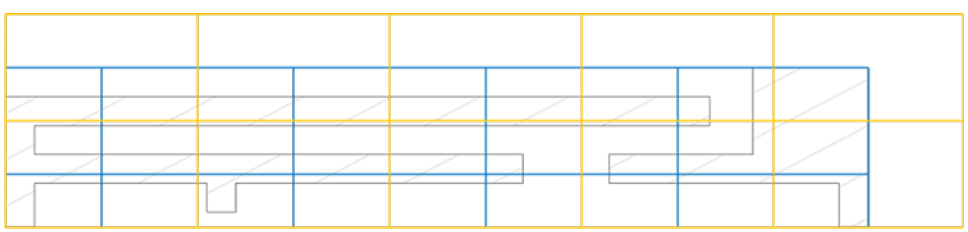


d. Limitation [1.h.1]: Cell counts

The count for each grid is shown below.

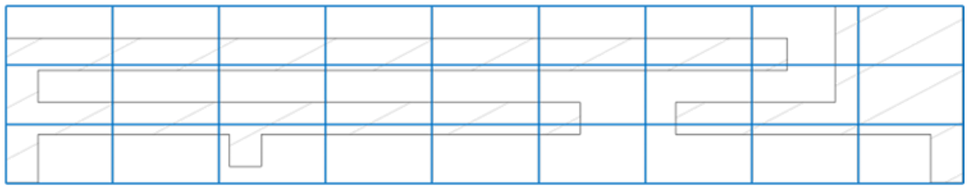
i. N_1 = 10

All cells in 2 × 5 grid G_1 "*include... a point*" of the *first contour* (black outline) so each cell is counted and N_1 = 10. Weide, ¶210.



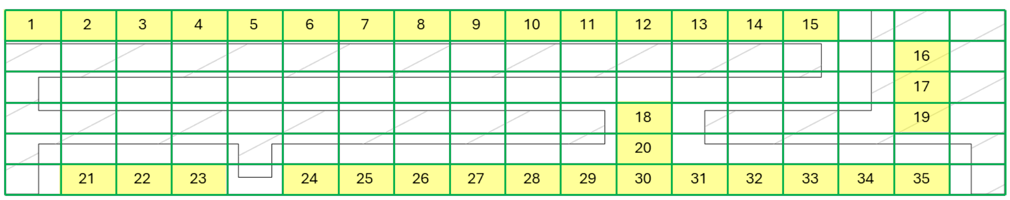
ii. $N_2 = 27$

As shown below, in 3 × 9 grid G_2 all 27 cells "*include… a point*" of the *first contour* and are counted. Thus, $N_2 = 27$. Weide, ¶211.



iii. $N_3 = 73$

In the 6×18 grid G_3 the cells numbered 1-35 (marked below) do ***not*** "*include… a point*" on the *first contour*. Thus, $N_3 = (108 - 35) = 73$. Weide, ¶¶212-215.



e. Limitation [1.h]

i. Calculation $F_{21} = 1.43$

The *complexity factor* F_{21} for the *first contour* is:

$$\boldsymbol{F_{21}} = -\left(\frac{\log(N_2) - \log(N_1)}{\log(1/2)}\right) = -\left(\frac{\log(27) - \log(10)}{(-1)\log(2)}\right)$$

$$= \left(\frac{\log(27/10)}{\log(2)}\right) = \left(\frac{0.431}{0.301}\right) = \mathbf{1.43.}$$

Weide, ¶216.

ii. Calculation $F_{32} = 1.43$

The *complexity factor* F_{32} for the *first contour* is:

$$\boldsymbol{F_{32}} = -\left(\frac{\log(N_3) - \log(N_2)}{\log(1/2)}\right) = -\left(\frac{\log(73) - \log(27)}{(-1)\log(2)}\right)$$

$$= \left(\frac{\log(73/27)}{\log(2)}\right) = \left(\frac{0.432}{0.301}\right) = \mathbf{1.43}.$$

Weide, ¶217.

9. Limitation [1.i]

[1.i]	wherein the level of complexity of the first contour is configured to provide operation of the wireless device in the at least three frequency bands.

Dou+Ciais-Quadband+Nakano meets [1.i] because Nakano tuned the antenna using "five steps" described therein, "where the first three steps are rough adjustments and the fourth and fifth steps are devoted to a fine-tuning of the design" to obtain "an appropriate VSWR frequency response". Nakano, 2418; Weide, ¶218. Nakano thereby "*configured*" the antenna's *first contour*'s "*level of complexity*" to provide the frequency operation discussed *supra* §VIII.B.4 ([1.c]) because the "*complexity*" measures the antenna's physical features as captured by the antenna "*contour*". Weide, ¶218; EX1005, 16:64-17:4, 19:27-30, 20:19-22.

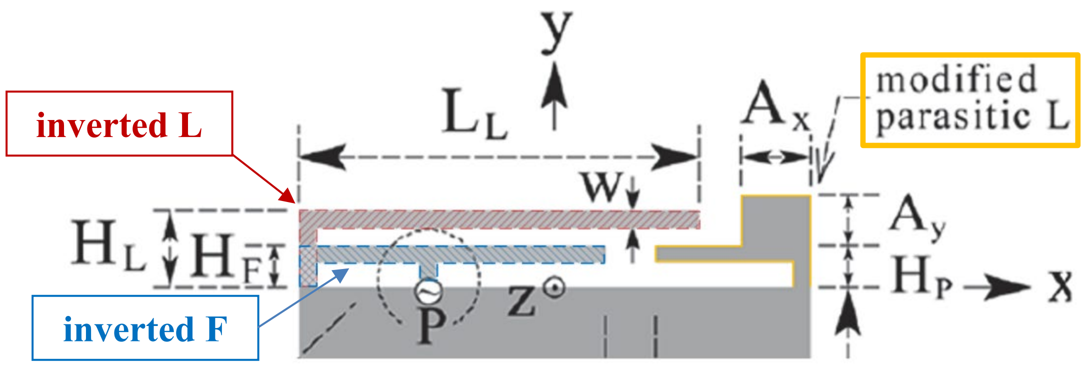
In its litigation arguments, Fractus alleges that this limitation is met because [redacted]; Weide, ¶219. Under Fractus's construction, Nakano's InvFL antenna meets [1.i] because it supports the frequency bands meeting [1.c]. Weide, ¶219.

[redacted]

C. Claim 2

[2]	[Claim 1's device], wherein the first planar antenna includes at least two antenna elements that are electromagnetically coupled.

Dou+Ciais-Quadband+Nakano meets claim 2 because Nakano's antenna ("*first planar antenna*") has "inverted L and F elements" (e.g., "compounded LF") and a "parasitic L" element that have no electrical connection except through the ground plane. Nakano, 2417-2418, Fig. 1(b) (detail below). Weide, ¶220.



Nakano adds the parasitic L element to mitigate the effect on VSWR of mutual coupling between the inverted L and F elements. Nakano, 2418-2419; Weide, ¶221. The parasitic L element is "*electromagnetically coupled*" to the "compounded LF" elements (e.g., the "inverted L and F elements") because they interact through electromagnetic fields. EX1047, 242; EX1048, 240, 362; Wiede, ¶221. As explained *supra* §VI.E (Ground 1A, claim 8), parasitic antenna elements were known to modify antenna properties by electromagnetic coupling to radiating elements. *See also* EX1041 (Poilasne), [0062]-[0063] ("Power is supplied to parasitic component 156 through magnetic coupling"), Figs. 4C-4D; Weide, ¶221.

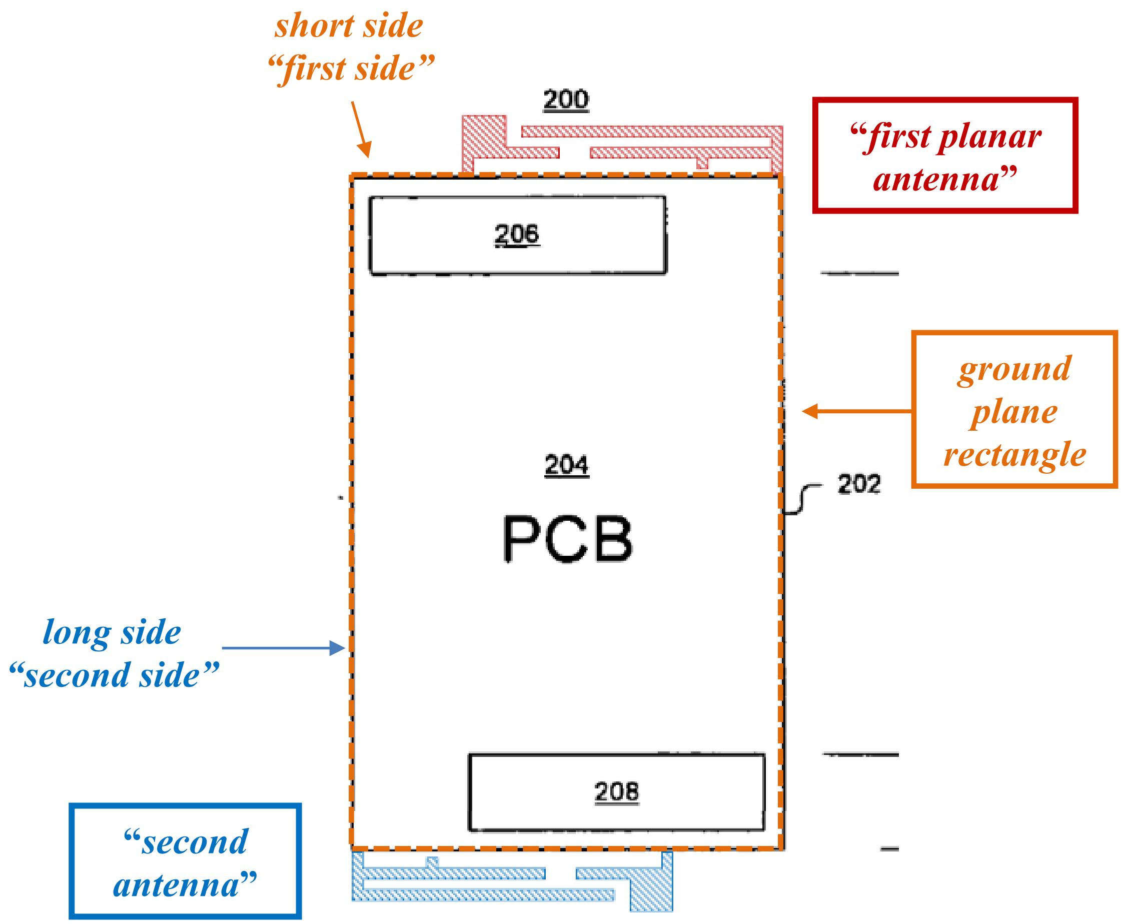
D. Claims 3-4

[3]	[Claim 1's device], wherein the first side of the ground plane rectangle is a short side of the ground plane rectangle.
[4]	[Claim 1's device], wherein the second side of the ground plane rectangle is a long side of the ground plane rectangle.

Dou+Ciais-Quadband+Nakano meets claim 3 because the *first side* is *a short side of the ground plane rectangle* as explained *supra* §VIII.B.3 ([1.b]). Weide, ¶222.

Dou+Ciais-Quadband+Nakano meets claim 4 because Dou's modified ground plane 210 is 40.5×105 mm^2 as taught by Ciais-Quadband, so the *ground plane rectangle* has a "*long side*" of 105 mm. *Supra* §§VIII.A.3 (combination), VIII.B.2 ([1.a]); Ciais-Quadband, 148. In the modified Dou device, each Nakano antenna is placed with one edge (the edge of the combined FL element) along the ground plane long edge. *Supra* §VIII.A.3.a (combination); Weide, ¶223.

Mapping the *second side* to "*a long side of the ground plane rectangle*" for claim 4 thus places the **second Nakano antenna** ("*second antenna*") "*proximate to a second side of the ground plane rectangle*" meeting [1.f] *supra* §VIII.B.7. Dou, Fig. 2A (annotated below); Weide, ¶224. This meets claim 4.



Moreover, the second Nakano antenna would be "*proximate*" to a "*second side*" and meet claim 4 regardless of where it is placed along the *short side* because even if the antenna were centered on the short length of the ground plane side the antenna could at most only be 5.25 mm from a long edge of the PCB and thus the "*second side*" of the *ground plane rectangle*. Wiede, ¶225.

E. Claim 5

[5]	[Claim 1's device], wherein the complexity factor F_{32} for the first contour is smaller than 1.75.

Dou+Ciais-Quadband+Nakano meets claim 5 because the *first contour* $F_{32} = 1.43 < 1.75$, as explained *supra* §§VIII.B.6 ([1.e]), VIII.B.8.e.ii ([1.h]). Weide, ¶226.

F. Claim 6

[6]	[Claim 5's device], comprising a third antenna configured to operate in at least two frequency bands that are different from the at least three frequency bands.

Dou+Ciais-Quadband+Nakano meets claim 6 because the Ciais-Quadband antenna (*third antenna*) covers (*is configured to operate in*) 870-960 MHz with a VSWR "better than" (i.e., less than) 2.5:1 and at 1710-2170 MHz with a VSWR under 2.0:1. Ciais-Quadband, Fig. 3, 148-150; Weide, ¶227. Nakano does not support frequency bands in these frequency ranges. Nakano, 2417, 2419, Fig. 4;

The **870-960 MHz** range contains at least **four** (**4**) "*frequency bands*" as shown in Table 1 *infra* §VIII.G.3 ([7.c]), none of which are supported by Nakano's antenna. Weide, ¶228.

The **1710-2170 MHz** range ("*second frequency range*") contains at least **fifteen** (**15**) "*frequency bands*" as shown in Table 5 *infra* §VIII.G.3 ([7.c]), none of which are supported by Nakano's antenna. Weide, ¶229.

G. Claim 7

Dou+Ciais-Quadband+Nakano renders obvious claim 7 wherein "*a first non-planar antenna*" [7.b] is mapped to a Ciais quadband antenna as explained below. Weide, ¶230

1. Preamble [7.PRE] and Limitation [7.a]

Dou+Ciais-Quadband+Nakano meets [7.PRE] and [7.a] for the same reasons it meets [1.PRE] and [1.a], respectively. *Supra* §§VIII.B.1-VIII.B.2; Weide, ¶231.

2. Limitation [7.b]

[7.b]	a first non-planar antenna proximate to a first side of a ground plane rectangle enclosing the ground plane,

Dou+Ciais-Quadband+Nakano meets [7.b] because it implements Dou's teaching to dispose antenna 206, which is a Ciais quadband antenna (*first non-planar antenna*), at the top of PCB 204. *Supra* §VIII.A.3 (combination); Dou, Fig. 2A, [0016]-[0017]; Weide, ¶232.

PCB 204's rectangular area defines a rectangle ("*ground plane rectangle*") that "*enclos[es]*" the ground plane 210 disposed on the side of the PCB opposite from antenna 206. Dou, Figs. 2A-2B, [0016]-[0017], [0029]; Weide, ¶233. Ciais teaches a rectangular (40.5 mm × 105 mm) PCB, also backed by a ground plane, that Ciais explains is representative of PCBs for typical mobile phones. Ciais-Quadband, Fig. 1(a), 148; Weide, ¶233.

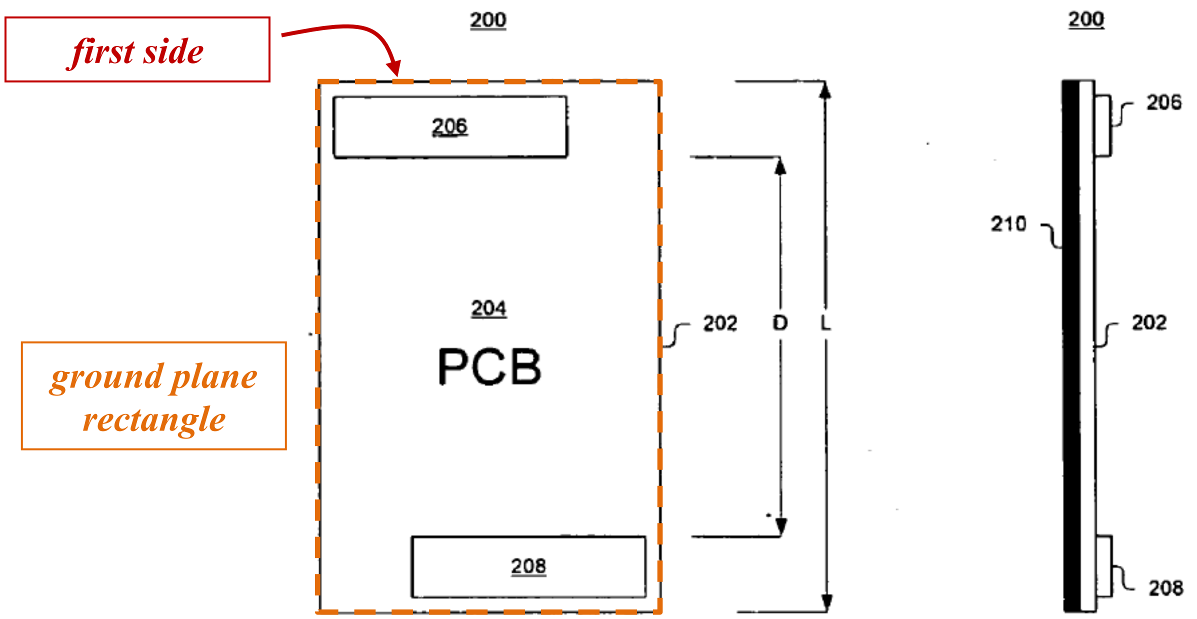


FIG. 2A FIG. 2B

The top/shorter edge of PCB 204 is a "first side." Disposing antenna 206 at the top of the PCB as taught by Dou places it "*proximate to a first side of a ground plane rectangle*" defined by (and "*enclosing*") the PCB area. Dou, Figs. 2A-2B (annotated above), [0016]-[0017], [0029]; Weide, ¶234.

3. Limitation [7.c]

[7.c]	the first non-planar antenna being configured to support at least three frequency bands of the electromagnetic spectrum,

Dou+Ciais-Quadband+Nakano meets [7.c] because it uses Ciais's quadband antenna, which is capable of sending and receiving electromagnetic radiation ("*configured to support*") at **870-960 MHz** and **1710-2170 MHz**. Ciais-Quadband, Fig. 3, 148-150; *supra* §VIII.A.1 (discussing Ciais-Quadband); Weide, ¶235.

Ciais's quadband antenna supports at least twenty-five (25) "*frequency bands*" that are contained within the antenna's supported frequency ranges ("*frequency bands of the electromagnetic spectrum*"). Weide, ¶236.

The **870-960 MHz** range contains at least **four** "*frequency bands*" shown in Table 1, reproduced below. *Supra* §VI.D.4 (Ground 1A, [7.c]); Weide, ¶237.

Table 1: Frequency bands within 870-960 MHz.

Band	Range (MHz)
standard GSM900	890-960
extended GSM900	880-960
ISM	902-928
LTE Band 8	880-960

The **1710-2170 MHz** range contains at least **twenty-one** "*frequency bands*" shown in Table 5.

Table 5: Frequency bands within 1710-2170 MHz.

Band	Range (MHz)
DCS1800	1710-1880
PCS1900	1850-1990
UMTS Band I	1920-2170
UMTS Band II	1880-1990
UMTS Band III	1710-1880
UMTS Band IV	1710-2155
UMTS Band a	1900-1920, 2010-2025
UMTS Band b	1850-1910, 1930-1990
UMTS Band c	1910-1930
LTE Band 1	1920-2170
LTE Band 2	1850-1990
LTE Band 3	1710-1880
LTE Band 4	1710-2155
LTE Band 9	1749.9-1879.9
LTE Band 10	1710-2170
LTE Band 33	1900-1920
LTE Band 34	2010-2025
LTE Band 35	1850-1910
LTE Band 36	1930-1990
LTE Band 37	1910-1930
LTE Band 39	1880-1920

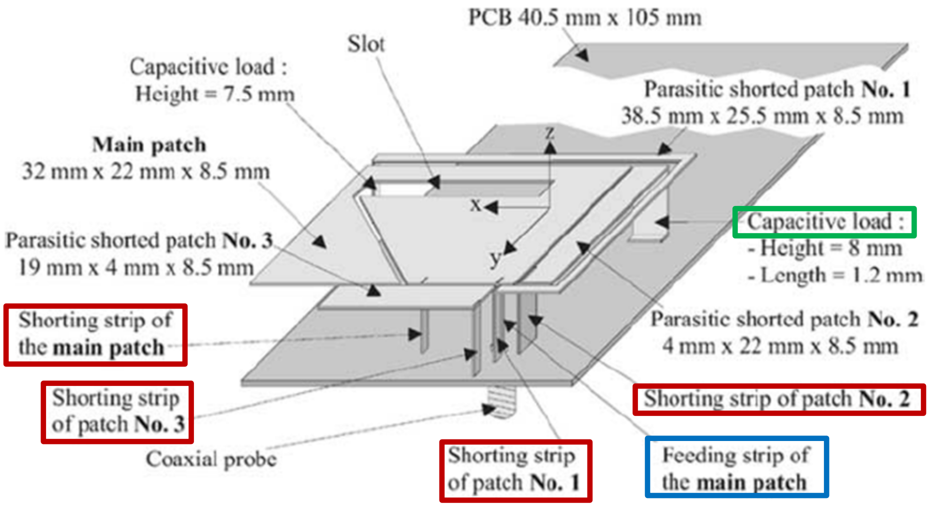
Ciais-Quadband, 148 (DCS, PCS, UMTS); EX1030, 8-9 (DCS1800, PCS1900); EX1039, 139 (reference [100] identifies HSDPA specifications), 497-501, 599 (reference [100] is 3GPP TS 25.308 (EX1032)); EX1032 (UMTS HSDPA description); EX1035, 11-12 (UMTS standard comprises TS 25.101 (EX1033), TS 25.102 (EX1034), TS 25.308 (EX1032)); EX1033, 12-13 (Table 5.0 “UTRA FDD frequency bands"); EX1034, 11 (UTRA/TDD frequency bands);[4] EX1025, 13, Table 5.5-1 ("E-UTRA operating bands" defining LTE bands); EX1026, 11 (listing LTE FDD and TDD bands); Weide, ¶238.

4. Limitation [7.d]

[7.d]	a minimum-sized parallelepiped completely enclosing a volume of the first non-planar antenna, the minimum-sized parallelepiped having a face with a largest area;

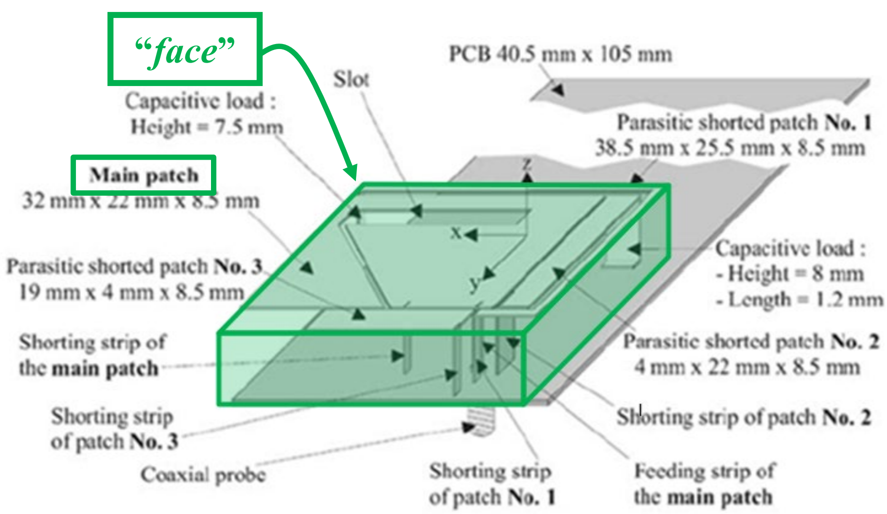
Dou+Ciais-Quadband+Nakano meets [7.d] because it uses Ciais's quadband antenna ("*first non-planar antenna*"), which is "*non-planar*" because it comprises the same antenna elements that are not contained within a single plane as the Ciais multiband *supra* §VI.D.5 (Ground 1A, [7.d]). Ciais-Quadband, Fig. 1(a) (annotated below); Ciais-Multiband, 920 (multiband antenna is based on Ciais's quadband structure); Weide, ¶240.

[4] While Dou refers to "WCDMA/UMTS" in 1710-2170 MHz (Dou, [0022]), as shown in Table 5 the standard defines at least twenty-one distinct "bands" within the 1710-2170 MHz frequency range. Weide, ¶239.



(a)

Ciais's quadband antenna has an "antenna box" defined by "a minimum-sized parallelepiped of rectangular faces that completely encloses a volume of the" Ciais quadband antenna ("*first non-planar antenna*") as shown below. Ciais-Quadband, Fig. 1(a) (annotated below). Weide, ¶241. The quadband antenna's "main patch" provides the parallelepiped with a "*face with a largest area*." Weide, ¶241.



(a)

5. Limitation [7.e]

[7.e]	a second antenna proximate to a second side of the ground plane rectangle, and wherein the second antenna is configured to receive signals from at least two frequency bands of the at least three frequency bands;

Dou+Ciais-Quadband+Nakano meets [7.e] because it implements Dou's teaching to dispose antenna 208 (*second antenna*) at the bottom of PCB 204. Dou, Fig. 2A, [0016]-[0017]; Weide, ¶242.

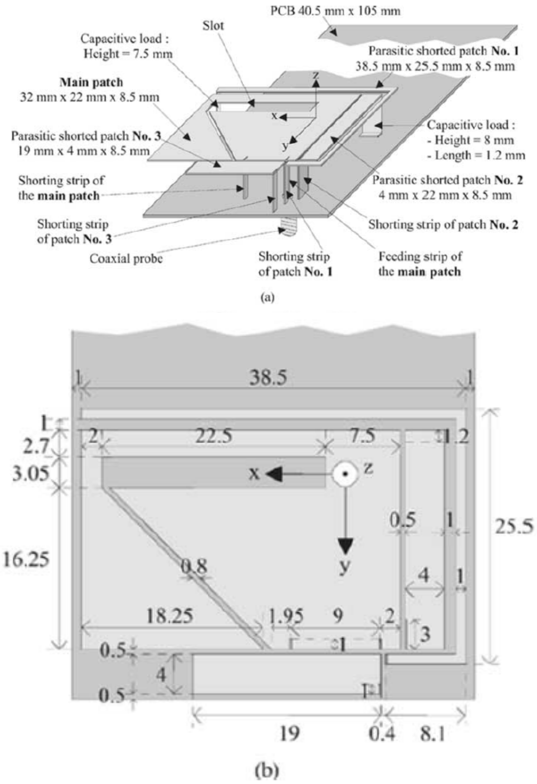
Dou+Ciais-Quadband+Nakano's antenna 208 ("*second antenna*") is positioned along (*proximate to*) "*a second side*" of PCB 204 that is opposite to the first side, which is also the "*second side of the ground plane rectangle*." *Supra* §VIII.G.2 ([7.b]); Dou, Fig. 2A, [0016]-[0017]; Weide, ¶243.

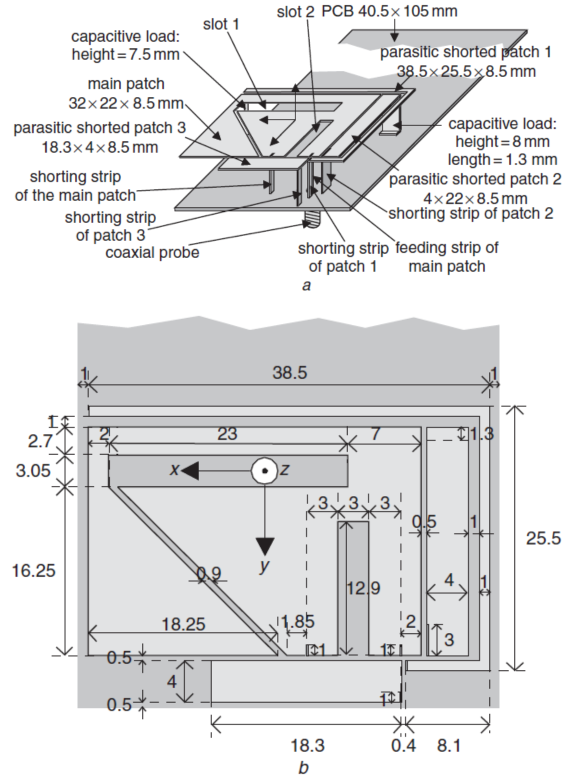
Dou+Ciais-Quadband+Nakano meets the rest of [7.e] because the *second antenna* is mapped to a Ciais quadband antenna that supports the same frequency ranges (and frequency bands therein) as the Ciais quadband antenna that is the *first non-planar antenna*. Weide, ¶244.

6. Limitation [7.f]

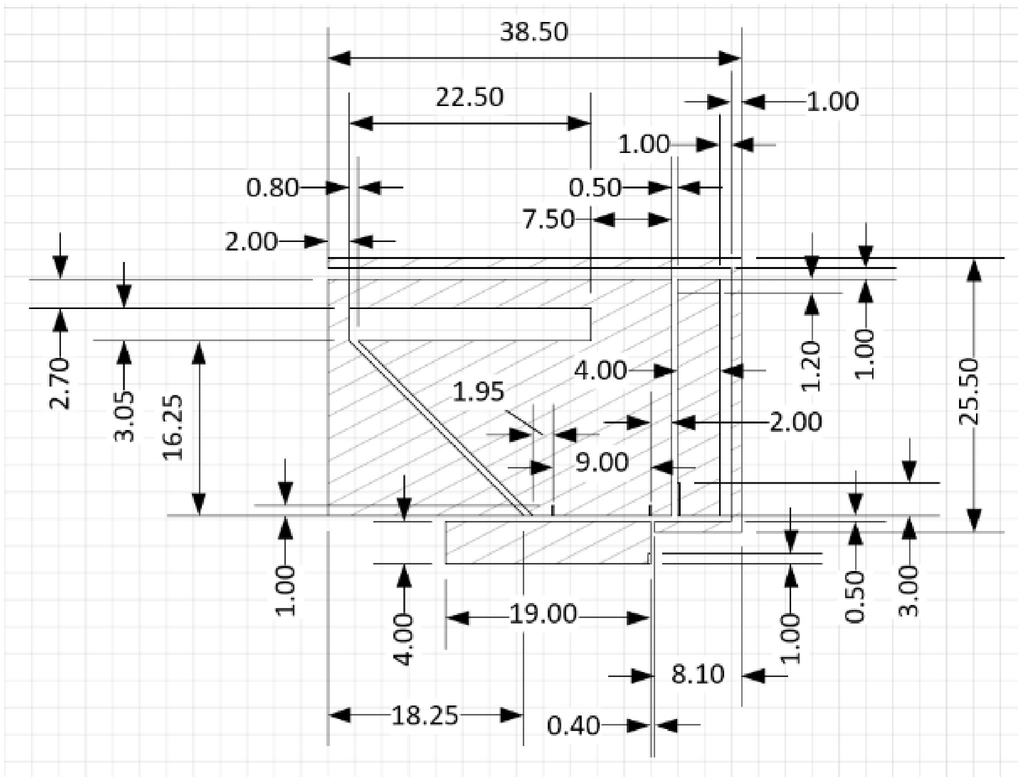
[7.f]	wherein the first non-planar antenna has a first contour defined as **[1]** a perimeter of any portions of the first non-planar antenna arranged in the face, **[2]** perimeters of any closed apertures of any portions of the first non-planar antenna arranged in the face, **[3]** a perimeter of an orthogonal projection onto the face of any portions of the first non-planar antenna that are not arranged in the face, and **[4]** perimeters of any closed apertures of the orthogonal projection;

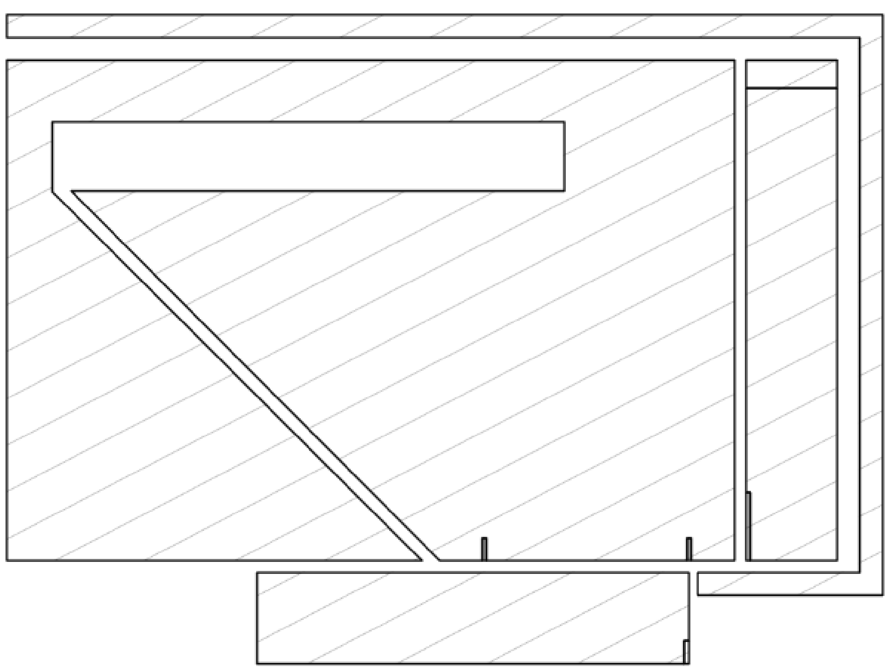
The Ciais quadband antenna implementing Dou's antenna 206 ("*first non-planar antenna*) has a "*first contour*" meeting [7.f] as shown below. Ciais's Figure 1(b) shows the antenna element dimensions including orthogonal projections of the out-of-plane antenna elements. Ciais-Quadband, Fig. 1(a); Weide, ¶245. The "first contour" for the quadband antenna resembles the "first contour" for the multiband antenna in Ground 1A: the quadband antenna lacks the multiband antenna's "slot 2" and has somewhat different layout dimensions. *Compare* Ciais-Quadband, Figs. 1(a)-1(b) (left below) *with* Ciais-Multiband, Figs. 1(a)-1(b) (right below); Weide, ¶245.


PCB 40.5 mm x 105 mm
Slot
Capacitive load :
Height = 7.5 mm
Parasitic shorted patch No. 1
38.5 mm x 25.5 mm x 8.5 mm
Main patch
32 mm x 22 mm x 8.5 mm
Capacitive load :
- Height = 8 mm
- Length = 1.2 mm
Parasitic shorted patch No. 3
19 mm x 4 mm x 8.5 mm
Shorting strip of
the main patch
Parasitic shorted patch No. 2
4 mm x 22 mm x 8.5 mm
Shorting strip
of patch No. 3
Shorting strip of patch No. 2
Coaxial probe
Shorting strip
of patch No. 1
Feeding strip of
the main patch
(a)
38.5
22.5
7.5
1.2
2.7
3.05
16.25
25.5
0.8
0.5
18.25
1.95
9
19
0.4
8.1
(b)

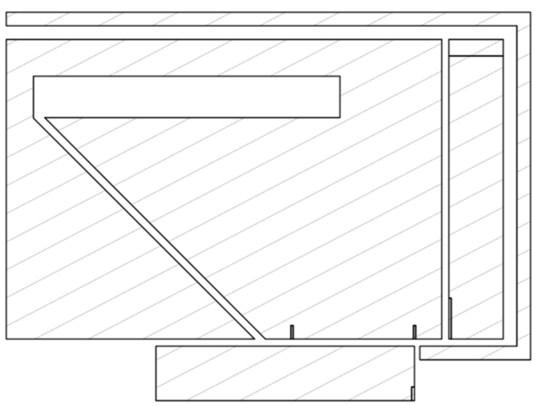

slot 1
slot 2
PCB 40.5 × 105 mm
capacitive load:
height = 7.5 mm
parasitic shorted patch 1
38.5 × 25.5 × 8.5 mm
main patch
32 × 22 × 8.5 mm
parasitic shorted patch 3
18.3 × 4 × 8.5 mm
capacitive load:
height = 8 mm
length = 1.3 mm
shorting strip
of the main patch
parasitic shorted patch 2
4 × 22 × 8.5 mm
shorting strip
of patch 3
shorting strip of patch 2
coaxial probe
shorting strip
of patch 1
feeding strip of
main patch
a
38.5
23
7
1.3
2.7
3.05
16.25
25.5
0.9
12.9
18.25
1.85
18.3
0.4
8.1
b

Using Ciais's description the quadband antenna *first contour* is produced to scale as follows, with dimensions in mm. Weide, ¶246.

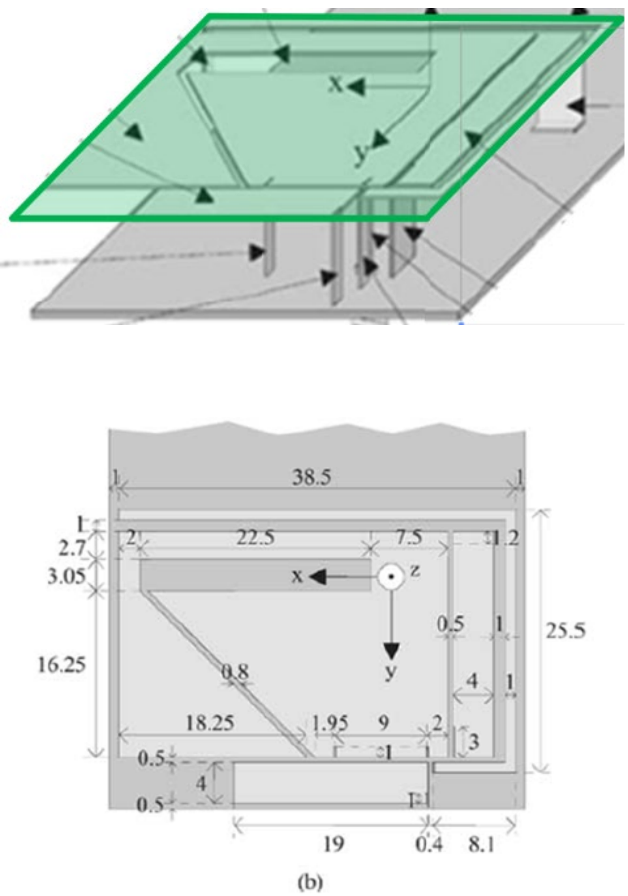




This *first contour* includes **[1]** the *perimeter* of all antenna elements (*portions*) in the plane of the quadband antenna's main patch (e.g., *arranged in the face*). Weide, ¶247; Ciais-Quadband, Figs. 1(a) (annotated detail below top right), 1(b).

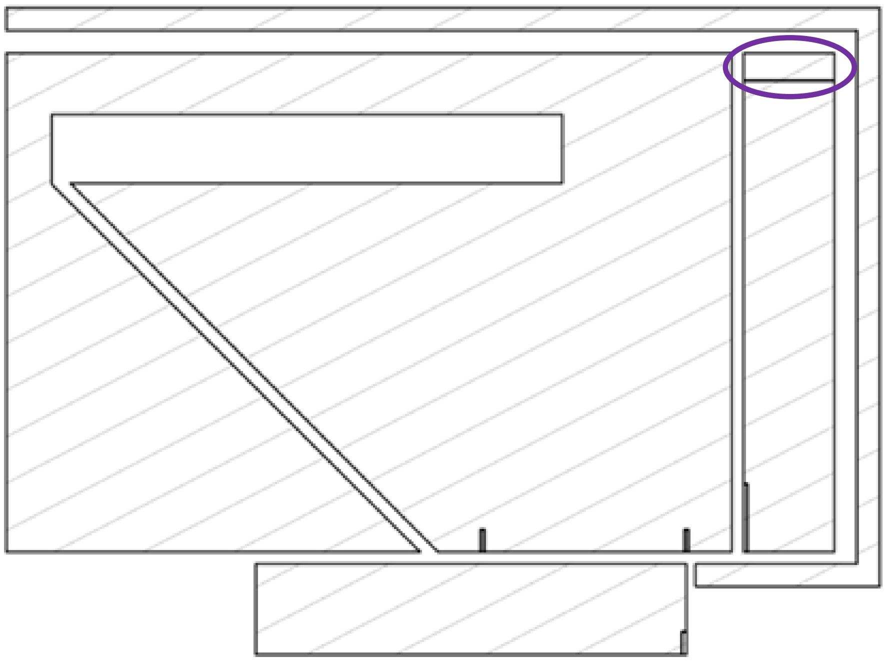


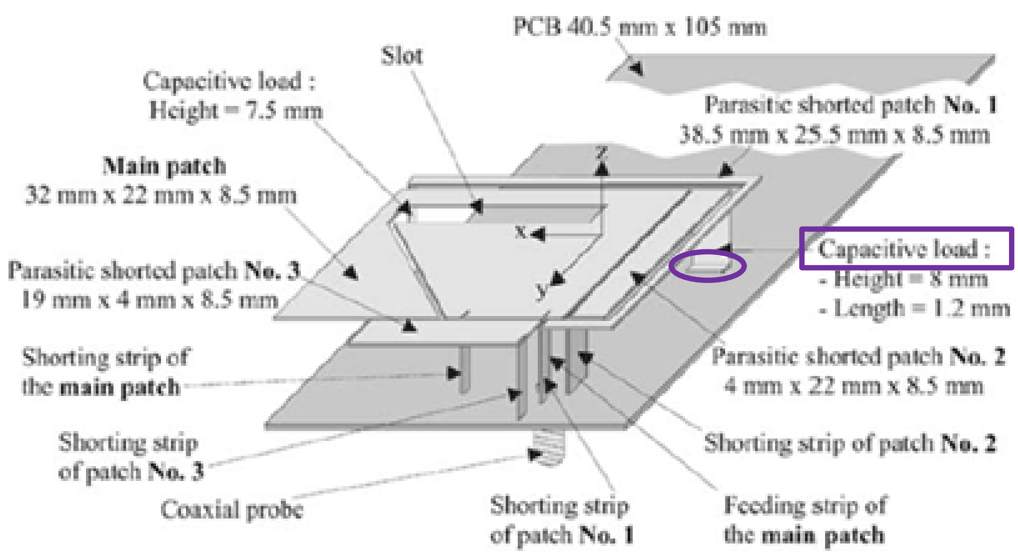
first contour



Ciais-Quadband Figs. 1(a), 1(b)

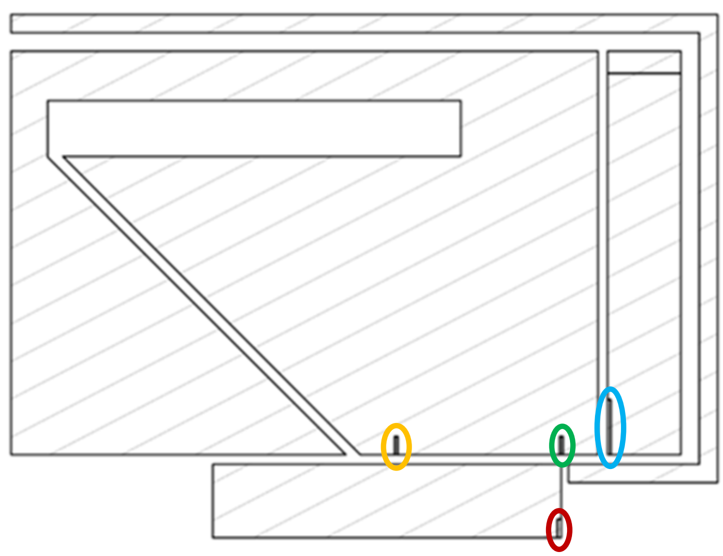
The *first contour* also includes **[3]** the *perimeter* of an *orthogonal projection* of the capacitive load (e.g., a *portion… not arranged in the face*), as highlighted below. Ciais-Quadband, 148-149, Figs. 1(a), 1(b); Weide, ¶248.

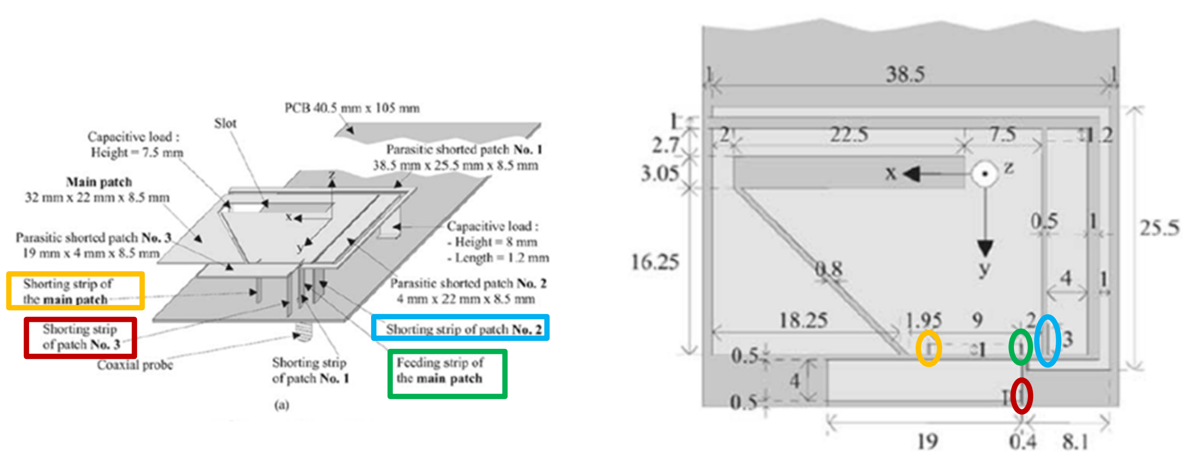




(a)

Regardless of whether the quadband antenna elements in *the face* comprise slots defining **[2]** *perimeters of… closed apertures* that receive vertical shorting and feeding strips, or *orthogonal projection* of each vertical strip defines **[3]** *a perimeter* on *the face* or **[4]** *a closed aperture* having a *perimeter*, the *first contour* includes segments defining these *perimeters* as shown below. Ciais-Quadband, 148-149, Figs. 1(a), 1(b) (annotated below); Weide, ¶249.





(b)

7. Limitation [7.g]

[7.g]	wherein the first contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value of at least 1.35; and

Dou+Ciais-Quadband+Nakano meets [7.g] because the quadband antenna's contour ("*first contour*"), *supra* §VIII.G.6 ([7.f]), has $F_{21} = 1.31 \geq 1.20$, and $F_{32} = 1.57 \geq 1.35$, as shown for [7.h]-[7.h.4] below. Weide, ¶250.

8. Complexity factor limitations ([7.h]-[7.h.4])

a. Limitation [7.h.2]: Grid *G₂*

7.h.2	the grid G_2 divides the face into nine columns of equal width arranged along a long side of the face and an odd number of rows of equal height arranged along a short side of the face, wherein the number of rows results in the cells of grid G_2 being as square as possible,

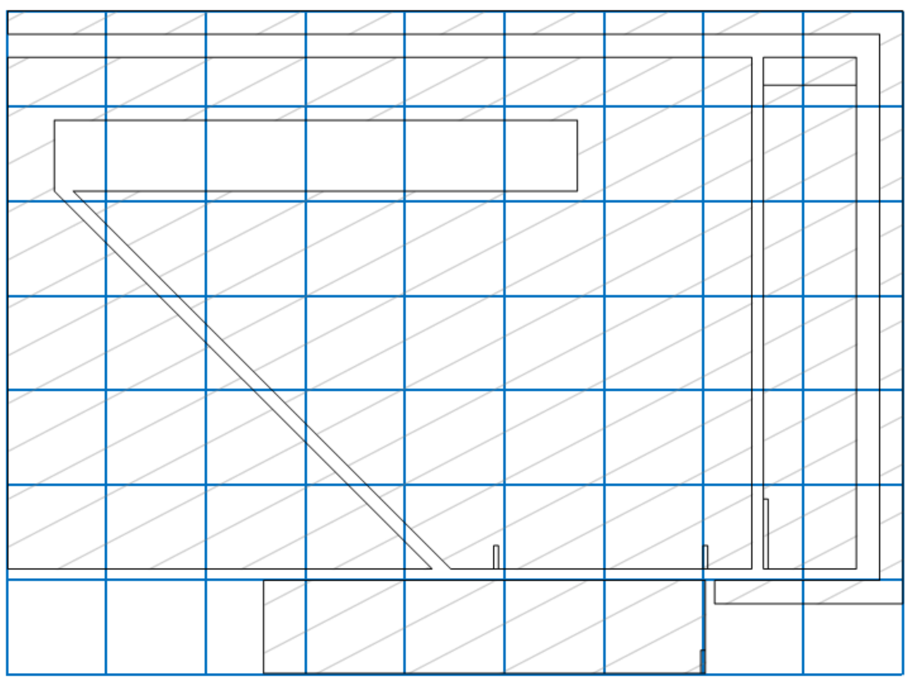
As explained *supra* §VI.D.9.a (Ground 1A, [7.h.2]), a POSA would have understood that "*the face*" referred to a minimum-sized rectangle enclosing the *first contour*. Weide, ¶251.

The quadband antenna contour (*first contour*) is 38.5 mm wide (*long side of the face*) and 28.5 mm in height (*short side of the face*). Ciais-Quadband, 148, Fig. 1(b). Grid G_2 with nine (9) columns yields cell width (*columns of equal width*) of $\left(\frac{38.5mm}{9}\right) = 4.28\,mm$. Weide, ¶252.

With 9 columns, seven (7) rows provides an "*odd number of rows of equal height arranged along a short side of the face*" with "*the cells… being as square as *possible*" because seven rows provides a cell with an aspect ratio closer to 1 (e.g., where width = height) than any other *odd number of rows*. EX1005, 14:34-36 (defining "aspect ratio" as the ratio of width to height); Weide, ¶253.

Rows	Cell Height (mm)	Cell Aspect Ratio $\left(\frac{width}{height}\right)$
5	$\left(\frac{28.5}{5}\right) = 5.70$	$\left(\frac{4.28}{5.70}\right) = 0.75$
7	$\left(\frac{28.5}{7}\right) = 4.07$	$\left(\frac{4.28}{4.07}\right) = 1.05$
9	$\left(\frac{28.5}{9}\right) = 3.17$	$\left(\frac{4.28}{3.17}\right) = 1.35$

Grid G_2

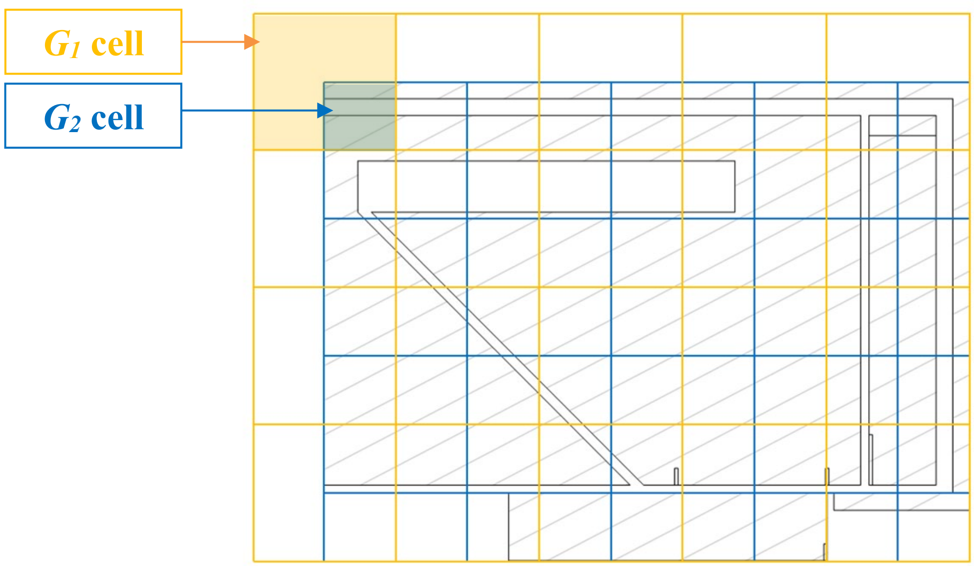


Thus, grid G_2 has 7 rows by 9 columns and "tessellates" the *first contour* as shown above (blue outline). Weide, ¶254.

b. Limitation [7.h.3]: Grid G_1

7.h.3	the grid G_1 being aligned with a corner of the grid G_2 to cover the face, the cells of grid G_1 having widths and heights that respectively are double the widths and heights of the cells of the grid G_2, and

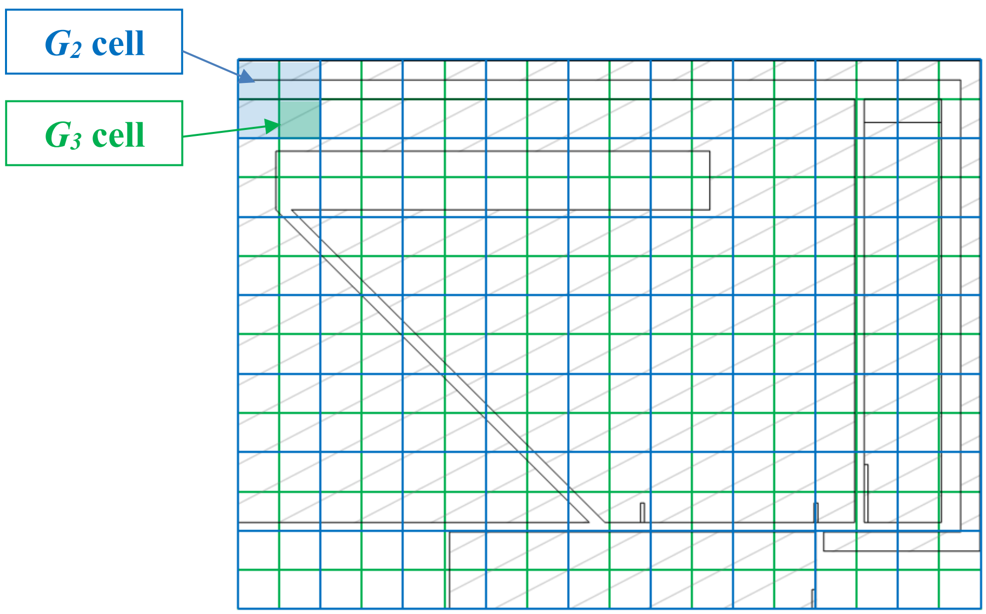
Grid G_1 (orange outline below) is "*aligned with a corner of the grid G_2*" and "*cover[s] the face*" (e.g., the *first contour*), wherein each G_1 cell has twice the width and height of a G_2 cell, e.g., "*widths and heights that respectively are double the widths and heights of the cells of the grid G_2.*" Weide, ¶255.



c. Limitation [7.h.4]: Grid G_3

7.h.4	the grid G_3 being aligned with the grid G_2, the cells of the grid G_3 having widths and heights that respectively are half the widths and heights of the cells of the grid G_2, and

Grid G_3 (green outline below) is "*aligned with the grid G_2*" and each G_2 cell (green) comprises ***four*** G_3 cells—meaning that G_3 cells have "*widths and heights that respectively are half the widths and heights of the cells of the grid G_2.*" Weide, ¶256.



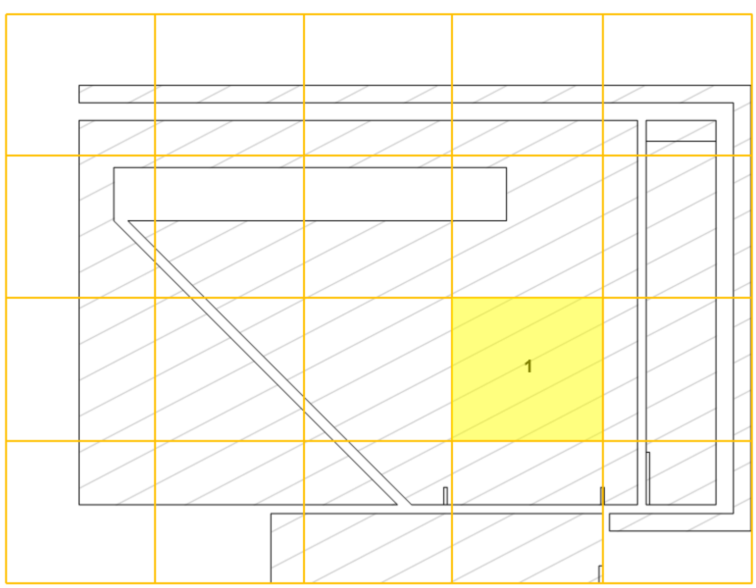
d. Limitation [7.h.1]: Cell counts

7.h.1	where N_1 is a number of cells of a grid G_1 that include at least a point of the first contour, N_2 is a number of cells of a grid G_2 that include at least a point of the first contour, and N_3 is a number of cells of a grid G_3 that include at least a point of the first contour,

When evaluating [7.h.1] a cell whose boundary coincides with a point on the "*first contour*" will "*include at least a point of the first contour*"—and is counted for N_1, N_2, and N_3—because the '149 patent specification states that "in the present invention ***the boundary of the cell is also part of the cell***." EX1005, 19:15-17; Weide, ¶257. The count for each grid is shown below.

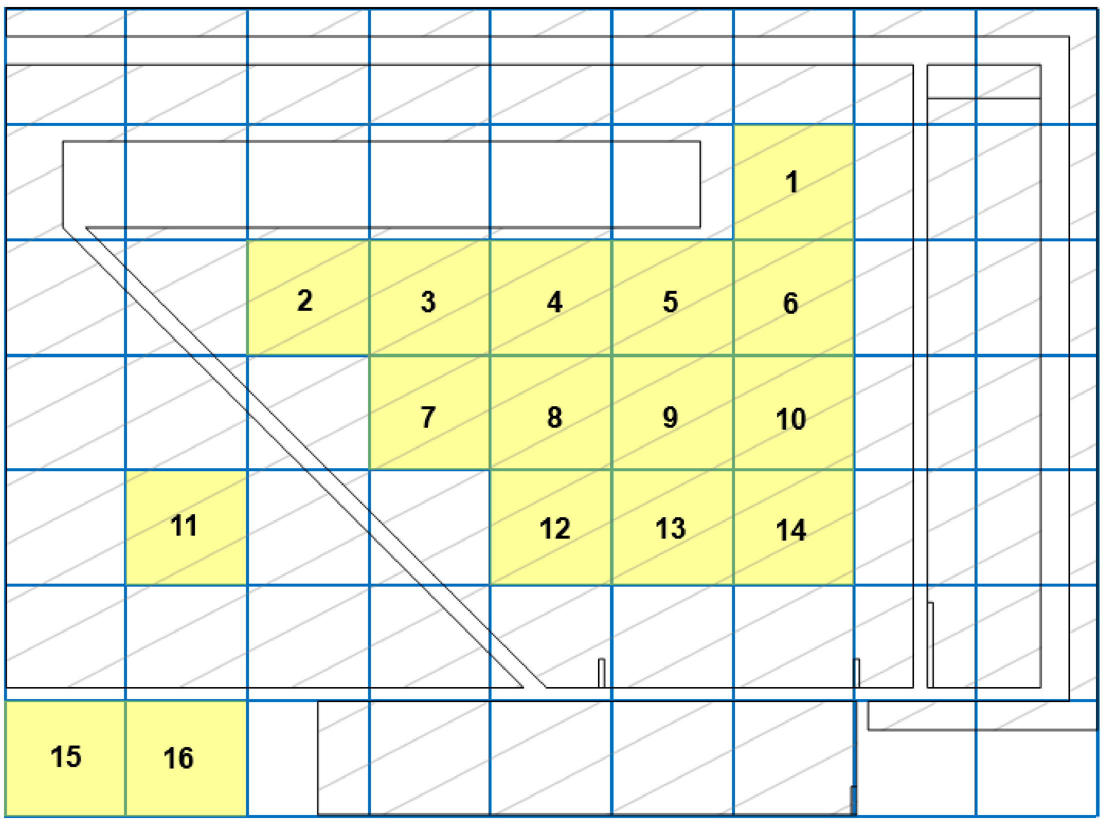
i. $N_1 = 19$

A single cell within G_1 (yellow below) does ***not*** "*include at least a point of the first contour*." EX1005, 19:13-20. Thus, the G_1 cell count $\boldsymbol{N_1} = (20 - 1) = 19$. Weide, ¶258.



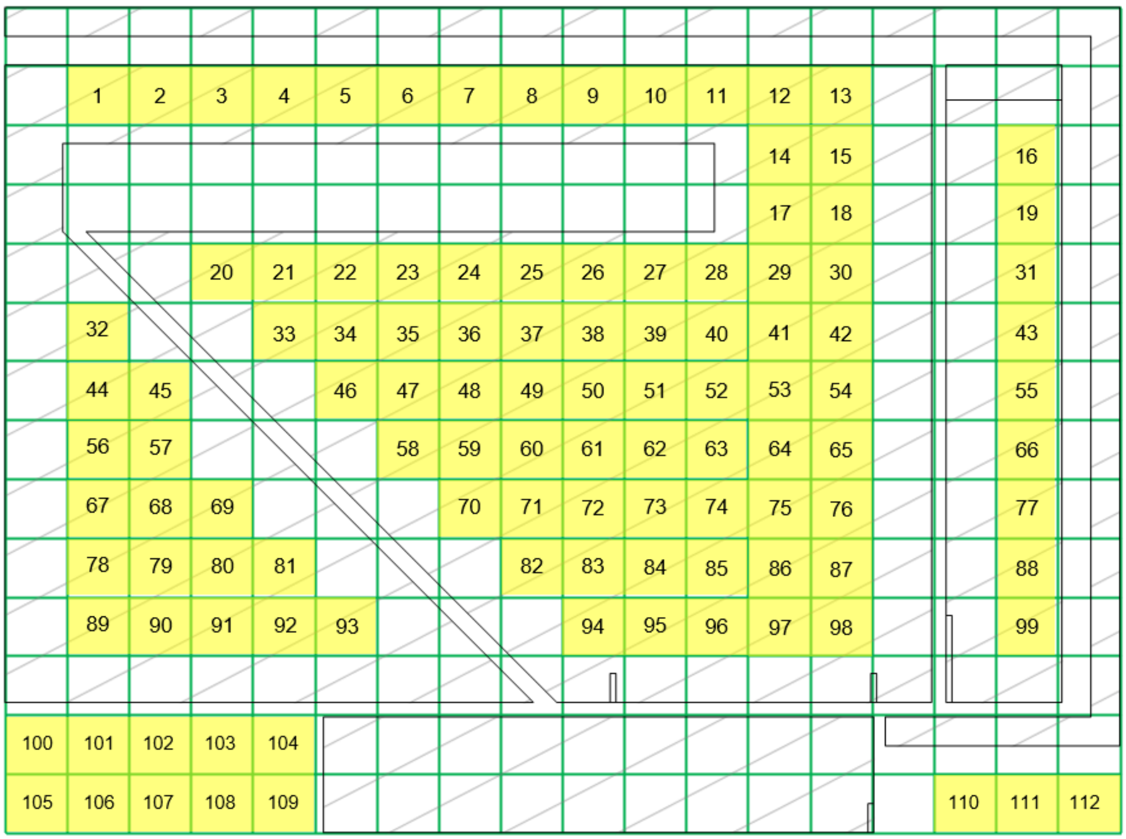
ii. $N_2 = 47$

The 7 x 9 grid G_2 (blue outline) is superimposed over the quadband *antenna contour* below. For visual clarity, the sixteen (16) cells that do ***not*** "*include at least a point of the first contour*" are shaded yellow. Weide, ¶259. Thus, the G_2 cell count $\boldsymbol{N_2} = (63 - 16) = 47$. Weide, ¶259.



iii. $N_3 = 140$

In the 14×18 grid G_3 the cells numbered 1-112 (marked below) do ***not*** "*include… a point*" on the *first contour*. Weide, ¶¶259-271. Thus, the G_3 cell count $\boldsymbol{N_3} = (252 - 112) = 140$. Weide, ¶259.



e. Limitation [7.h]

7.h	wherein the complexity factors F_{21} and F_{32} are given by: $$F_{21} = -\frac{log(N_2) - log(N_1)}{log(1/2)}$$ $$F_{32} = -\frac{log(N_3) - log(N_2)}{log(1/2)}$$

i. Calculation F_{21} = 1.31

The *complexity factor* F_{21} for the quadband *first contour* is:

$$\boldsymbol{F_{21}} = -\left(\frac{\log(N_2) - \log(N_1)}{\log(1/2)}\right) = -\left(\frac{\log(47) - \log(19)}{(-1)\log(2)}\right)$$

$$= \left(\frac{\log(47/19)}{\log(2)}\right) = \left(\frac{0.393}{0.301}\right) = \mathbf{1.31}.$$

Weide, ¶272.

ii. Calculation F_{32} = 1.57

The *complexity factor* F_{32} for the quadband *first contour* is:

$$\boldsymbol{F_{32}} = -\left(\frac{\log(N_3) - \log(N_2)}{\log(1/2)}\right) = -\left(\frac{\log(140) - \log(47)}{(-1)\log(2)}\right)$$

$$= \left(\frac{\log(140/47)}{\log(2)}\right) = \left(\frac{0.474}{0.301}\right) = \mathbf{1.57}.$$

Weide, ¶273.

9. Limitation [7.i]

7.i	wherein the level of complexity of the first contour is configured to provide operation of the wireless device in the at least three frequency bands.

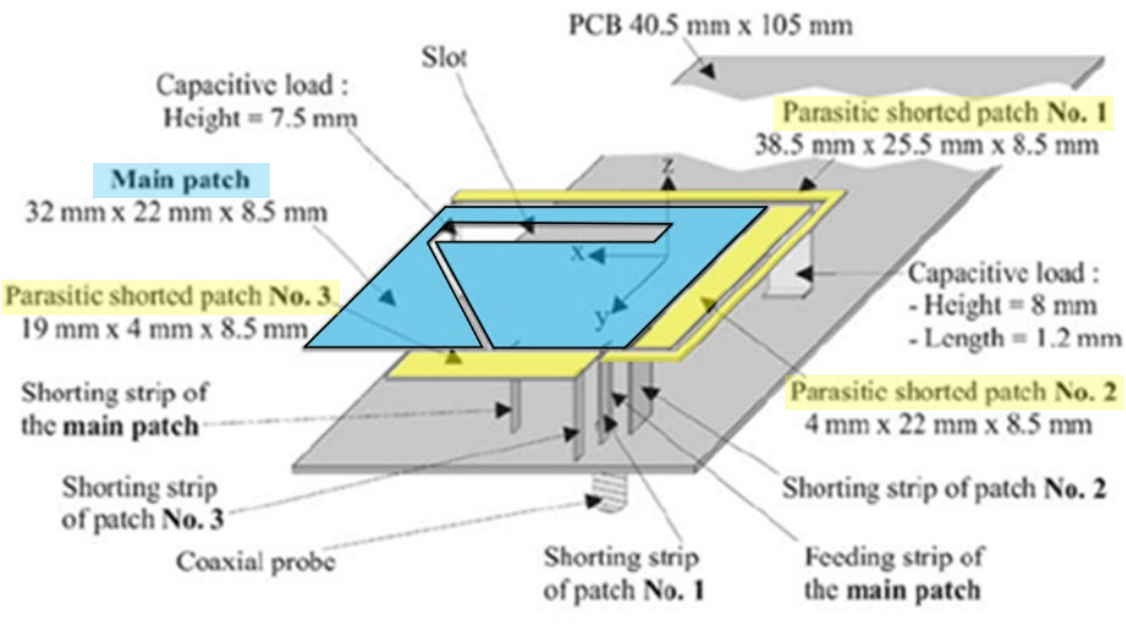
Dou+Ciais-Quadband+Nakano uses Ciais's quadband antenna, which Ciais optimized by adding a slot to "allow[] a frequency decrease of its fundamental resonance while the use of an end positioned capacitive load allows its higher order modes to be decreased in frequency," while "the addition of three quarter-wavelength parasitic elements is used here to create new resonances. These new resonances are tuned thanks to a lengthening by capacitive loads." Ciais-Quadband, 148; Weide, ¶274. Ciais thereby "configured" the *first contour*'s "*level of complexity*" to provide the frequency operation discussed *supra* §VIII.G.3 ([7.c]) because the "*complexity*" measures the antenna's physical features as captured by orthogonal projection in the antenna "*contour*" as explained *supra* §VIII.G.6 ([7.f]). EX1005, 16:64-17:4, 19:26-29, 20:19-22; Weide, ¶274.

In its litigation arguments, Fractus alleges that this limitation is met because [redacted]; Weide, ¶275. Under Fractus's construction, Ciais's quadband antenna meets [7.i] because it supports the frequency bands meeting [7.c]. Weide, ¶275.

H. Claim 8

[8]	[Claim 7's device], wherein the first non-planar antenna includes at least two antenna elements that are electromagnetically coupled.

Dou+Ciais-Quadband+Nakano uses Ciais's quadband antenna (*first non-planar antenna*), which uses three quarter-wavelength parasitic elements "to create new resonances. These new resonances are tuned thanks to a lengthening by capacitive loads." Ciais-Quadband, 148-149; Weide, ¶276. The parasitic patches are separated by air from a main patch. Ciais-Quadband, 148, Fig. 1(a) (annotated below); Weide, ¶276.



(a)

The "parasitic shorted patch" are each "*electromagnetically coupled*" to the "main patch" because they interact with, and alter resonance of, the main patch through electromagnetic fields, just like the parasitic patches in the Ciais multiband antenna are *electromagnetically coupled* to the main patch in the multiband antenna as explained *supra* §VI.E (Ground 1A, claim 8). EX1047, 242; EX1048, 240, 362; Weide, ¶277.

I. Claim 9

[9]	[Claim 7's device], wherein the complexity factor F_{32} for the first contour is smaller than 1.75.

Dou+Ciais-Quadband+Nakano meets claim 9 because the *first contour*'s $F_{32} = 1.57 < 1.75$. *Supra* §§VIII.G.7-VIII.G.8 ([7.g])-([7.h.4]). Weide, ¶278.

J. Claim 10

10	[Claim 7's device], wherein a third antenna is configured to operate in at least two frequency bands being different from the at least three frequency bands and the third antenna is arranged within the wireless device.

Dou+Ciais-Quadband+Nakano meets claim 10 because it uses Nakano's InvFL antenna, which operates in at least five "*frequency bands*" between 5150 and 5900 MHz as explained *supra* §VIII.B.4 ([1.c]). Each of the two Nakano InvFL antennas are "*arranged within the wireless device*" because they are "internally mounted" as Dou described, e.g., enclosed by the modified Dou wireless device housing. *Supra* §VIII.A.3 (combination); Dou, [0040]; Weide, ¶279. Ciais's quadband antenna does not support operation at 5150-5900 MHz, which Ciais described as the focus of "[f]urther work." Ciais-Quadband, 150; Weide, ¶279. Thus, each Nakano antenna in the combination meets the additional limitations in claim 10 because each "*is configured to operate in at least two frequency bands being different from the at least three frequency bands*" supported by the Ciais-quadband antenna ("*first antenna*"). Weide, ¶279.

K. Claim 11

Dou+Ciais-Quadband+Nakano meets claim 11 for the same reasons that Dou+Ciais-Multiband meets claim 11 *supra* §VI.G (Ground 1A, claim 11), because the Ciais quadband antenna and Ciais multiband antenna have the same "*antenna rectangle*" and a "*projection of the antenna rectangle on the ground plain rectangle*" for the Ciais quadband antenna is the same as for the Ciais multiband antenna. Weide, ¶280. In each case, the projection "*partially overlaps the ground plane rectangle*" for the reasons explained *supra* §VI.G (Ground 1A, claim 11). Weide, ¶280.

L. Claim 12

[12]	[Claim 7's device], wherein the first side of the ground plane rectangle is a short side of the ground plane rectangle.

The "*ground plane rectangle*" in Dou+Ciais-Quadband+Nakano has the same placement and dimensions in Dou's modified device as it does in Dou+Ciais-Multiband, and Dou+Ciais-Quadband+Nakano meets claim 12 for the reasons explained *supra* §VI.H (Ground 1A, claim 12) for Dou+Ciais-Multiband. Weide, ¶281.

M. Claims 13-15 and 17-20 wherein a Nakano InvFL antenna is mapped to a "*first antenna*"

Dou+Ciais-Quadband+Nakano renders claims 13-15 and 17-20 obvious wherein a Nakano InvFL antenna is mapped to a "*first antenna*" ([13.b]), as shown below.

1. Claim 13

a. Limitations [13.PRE]-[13.c], [13.e], [13.g]-[13.h.1], [13.h.3]-[13.i]

Dou+Ciais-Quadband+Nakano meets [13.PRE]-[13.c], [13.e], [13.g]-[13.h.1], and [13.h.3]-[13.i] with the Nakano InvFL antenna mapped to the "*first antenna*" for the same reasons it meets the corresponding limitations below. EX1028, 7-10; Weide, ¶283.

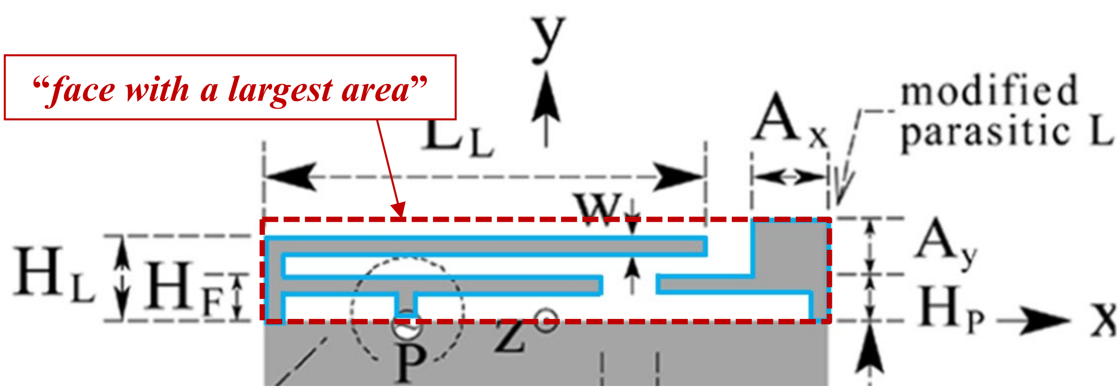
Limitation	Corresponding limitation	Discussion *supra*
13.PRE	1.PRE	§VIII.B.1
13.a	1.a	§VIII.B.2
13.b	1.b	§VIII.B.3
13.c	1.c	§VIII.B.4
13.e	1.f	§VIII.B.7
13.g	1.e	§VIII.B.6
13.h	1.h	§VIII.B.8.e
13.h.1	1.h.1	§VIII.B.8.d
13.h.3	1.h.3	§VIII.B.8.b
13.h.4	1.h.4	§VIII.B.8.c
13.i	1.i	§VIII.B.9

Dou+Ciais-Quadband+Nakano meets the remaining limitations in claim 13 as follows.

b. Limitation [13.d]

[13.d]	a minimum-sized parallelepiped completely enclosing a volume of the first antenna, the minimum-sized parallelepiped having a face with a largest area;

Dou+Ciais-Quadband+Nakano meets [13.d] because it uses Nakano's antenna as the *first antenna*. Nakano's antenna "is made of a thin conducting film." Nakano, 2417; Weide, ¶285. The "volume" of "*a minimum-sized parallelepiped completely enclosing a volume of*" Nakano's antenna is a planar 30×5.5 mm^2 area enclosing the antenna by the thickness of the thin film. Nakano, 2417, 2419, Figs. 1(b), 4; Weide, ¶285. The "*face with a largest area*" is the top 30×5.5 mm^2 surface of the *parallelepiped* enclosing Nakano's antenna. Weide, ¶285.

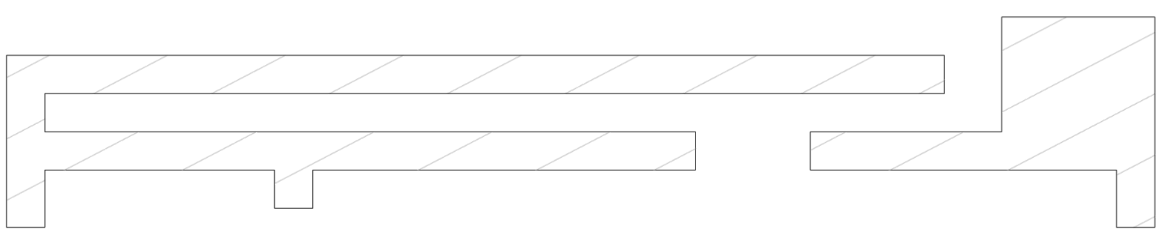


c. Limitation [13.f]

While [13.f] and [1.g] use different language to define a "*first contour*,"

[13.f]	wherein the first antenna has a first contour defined as a perimeter of any portions of the first antenna arranged in the face, perimeters of any closed apertures of any portions of the first antenna arranged in the face, a perimeter of an orthogonal projection onto the face of any portions of the first antenna that are not arranged in the face, and perimeters of any closed apertures of the orthogonal projection;	[1.g]	wherein the first contour is defined as a perimeter of the first planar antenna and perimeters of any closed apertures defined within the first planar antenna;

as applied to Nakano's antenna ("*first antenna*") the two definitions yield the same result as explained *supra* §VIII.B.5 ([1.g]) and shown below, because Nakano only contains antenna portions within "*the face*" of the *parallelepiped* as defined *supra* §VIII.M.1.b ([13.d]). Weide, ¶286.



d. Limitation [13.h.2]

As explained *supra* §VI.I.2 (Ground 1A, [13.h.2]), limitation [13.h.2] recites a sentence fragment "*an odd number of rows of equal height arranged along a short side of the*." Assuming the "*short side*" in [13.h.2] means "*a short side of the minimum-sized rectangle*" in [1.h.2], then Dou+Ciais-Quadband+Nakano meets [13.h.2] for the same reasons it meets [1.h.2] *supra* §VIII.B.8.a. Weide, ¶287.

2. Claims 14, 17, 19

Claims 14, 17, and 19 depend from claim 13 and recite the same additional limitations as claims 2, 5, and 3, respectively. EX1028, 11; Weide, ¶288. Dou+Ciais-Quadband+Nakano meets the additional limitations in claims 14, 17, and 19 for the same reasons it meets the corresponding limitations below. Weide, ¶288.

Limitation	Corresponding limitation	Discussion *supra*
14	2	§VIII.C
17	5	§VIII.EVIII.EVIII.E
19	3	§VIII.D

3. Claim 15

Dou+Ciais-Quadband+Nakano meets claim 15 because Nakano's antenna (*first antenna*) is planar as explained *supra* §VIII.B.3 ([1.b]). Nakano, Abstract, 2417, Fig. 1(b); Weide, ¶289.

4. Claim 18

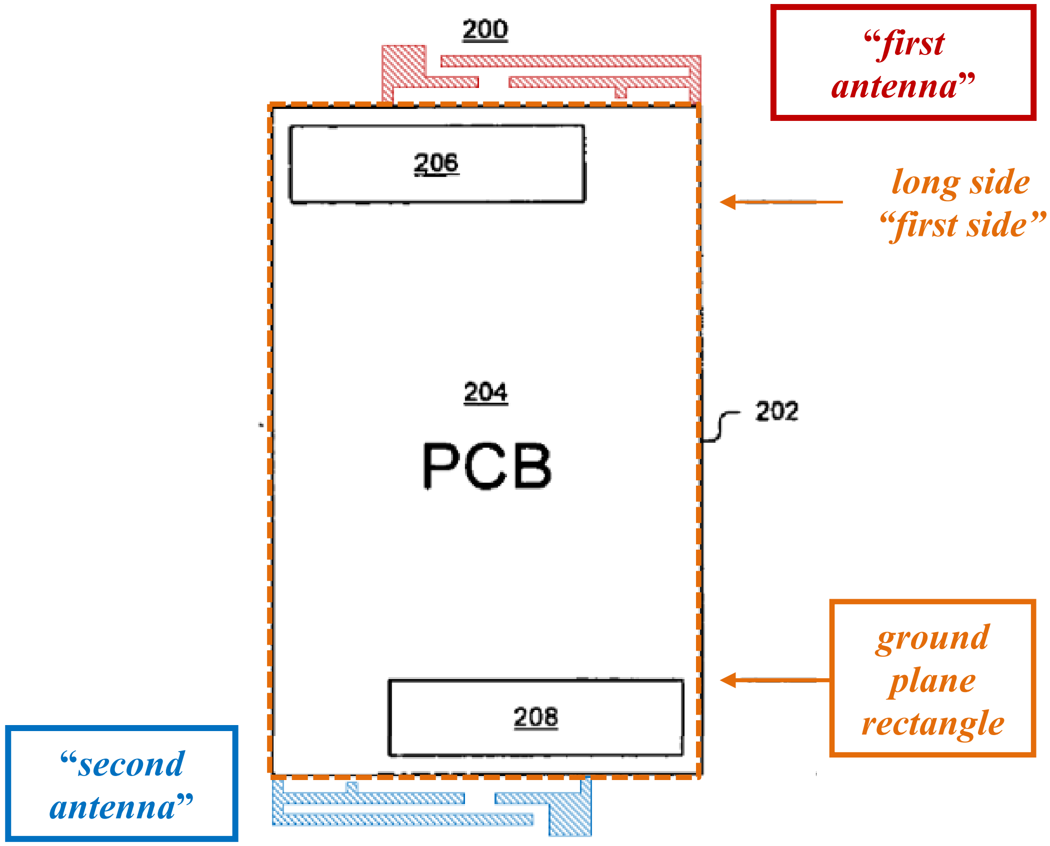
[18]	[Claim 13's device], wherein a third antenna is configured to operate in at least two frequency bands being different from the at least three frequency bands and the third antenna is arranged within the wireless device.

Dou+Ciais-Quadband+Nakano meets the additional limitations in claim 18 for the reasons it meets claim 6 *supra* §VIII.F. It meets the remaining limitations in claim 18 because the Dou+Ciais-Quadband+Nakano device arranges Ciais-Quadband's antenna "*within the wireless device*." *Supra* §VIII.A.3 (combination); Ciais-Quadband, Title ("Design of an Internal Quad-Band Antenna for Mobile Phones"), 148; Weide, ¶290.

5. Claim 20

[20]	[Claim 13's device], wherein the first side of the ground plane rectangle is a long side of the ground plane rectangle.

Dou+Ciais-Quadband+Nakano's "*first antenna*" implemented as Nakano's antenna is adjacent to a long edge of PCB 204, ground plane 210, and the *ground plane rectangle* that the ground plane defines. *Supra* §§VIII.A.3 (combination), VIII.B.3 ([1.b]), VIII.D (claims 3-4), VIII.M.1.a ([13.b]); Dou, Fig. 2A (annotated below to show combination); Weide, ¶291.



Thus, the *first antenna* is "*proximate*" to a "*first side of the ground plane rectangle*" (*supra* §§VIII.M.1.a ([7.b]), VIII.M.1.a ([13.b])) and continues to meet [13.b] wherein the "*first side*" is mapped to a "*long side*" of the "*ground plane rectangle*," meeting claim 20. Weide, ¶292.

N. Claims 13-14 and 16-20 wherein a Ciais quadband antenna is mapped to a "*first antenna*"

Dou+Ciais-Quadband+Nakano renders claims 13-14 and 16-20 obvious wherein a Ciais quadband antenna is mapped to a "*first antenna*" ([13.b]), as shown below. Weide, ¶293.

1. Claim 13

a. Limitations [13.PRE]- [13.h.1], [13.h.3]-[13.i]

Dou+Ciais-Quadband+Nakano meets [13.PRE]-[13.h.1], and [13.h.3]-[13.i] with Dou antenna 206 implemented as a Ciais quadband antenna mapped to the "*first antenna*," for the same reasons it meets the corresponding limitations below. EX1028, 1-4; Weide, ¶294.

Limitation	Corresponding limitation	Discussion *supra*
13.PRE	7.PRE	§VIII.G.1
13.a	7.a	§VIII.G.1
13.b	7.b	§VIII.G.2
13.c	7.c	§VIII.G.3
13.d	7.d	§VIII.G.4
13.e	7.e	§VIII.G.5
13.f	7.f	§VIII.G.6
13.g	7.g	§VIII.G.7
13.h	7.h	§VIII.G.8.e
13.h.1	7.h.1	§VIII.G.8.d
13.h.3	7.h.3	§VIII.G.8.b
13.h.4	7.h.4	§VIII.G.8.c
13.i	7.i	§VIII.G.9

Dou+Ciais-Quadband+Nakano meets the remaining limitations in claim 13 as follows.

b. Limitation [13.h.2]

As explained *supra* §VI.I.2 (Ground 1A, [13.h.2]), limitation [13.h.2] recites a sentence fragment "*an odd number of rows of equal height arranged along a short side of the*." Assuming the "*short side*" in [13.h.2] means "*a short side of the* *minimum-sized rectangle*" in [7.h.2], then Dou+Ciais-Quadband+Nakano meets [13.h.2] for the same reasons it meets [7.h.2] *supra* §VIII.G.8.a. Weide, ¶296.

2. Claims 14, 16-19

Claims 14 and 16-19 depend from claim 13 and recite the same additional limitations as claims 8, 11, 9, 10, and 12, respectively. EX1028, 12; Weide, ¶297. Dou+Ciais-Quadband+Nakano meets the additional limitations in claims 14, 16-19 for the same reasons it meets the corresponding limitations below. Weide, ¶297.

Limitation	Corresponding limitation	Discussion *supra*
14	8	§VIII.H
16	11	§VIII.K
17	9	§VIII.I
18	10	§VIII.J
19	12	§VIII.L

3. Claim 20

[20]	[Claim 13's device], wherein the first side of the ground plane rectangle is a long side of the ground plane rectangle.

Dou+Ciais-Quadband+Nakano's "*first antenna*" implemented as Ciais's quadband antenna is adjacent to a long edge of PCB 204, ground plane 210, and the *ground plane rectangle* that the ground plane defines. *Supra* §§VIII.A.2 (combination), VIII.G.2 ([7.b]), VIII.N.1.a ([13.b]); Dou, Fig. 2A; Weide, ¶298. Ciais's quadband antenna is 38.5 mm long, while PCB 204 and ground plane 210 implements Ciais's description of a "typical mobile phone" PCB with a width of

40.5 mm on the short side. *Supra* §VIII.A.2 (combination); Ciais-Quadband, 148, Fig. 1(a); Weide, ¶298.

Thus, the *first antenna* is "*proximate*" to a "*first side of the ground plane rectangle*" and continues to meet [13.b] *supra* §VIII.M.1.a wherein the "*first side*" is mapped to a "*long side*" of the "*ground plane rectangle*," meeting claim 20. Weide, ¶299.

IX. GROUND 3A: DOU+JING RENDERS OBVIOUS CLAIMS 1, 3-5, 13, 15, 17, AND 19-20

A. Dou (EX1013)

Dou discloses a second embodiment comprising wireless device 300 (in Figs. 3A-3B) that is similar in structure and operation to device 200 (in Figs. 2A-2B). Dou, [0031]; *supra* §VI.A; Weide, ¶300. In this embodiment, device 300's second antenna 308 is "separated from the ground plane," such that "the ground plane 310 does not extend underneath the second antenna 308." Dou, [0034]; Figs. 3A, 3B (below).

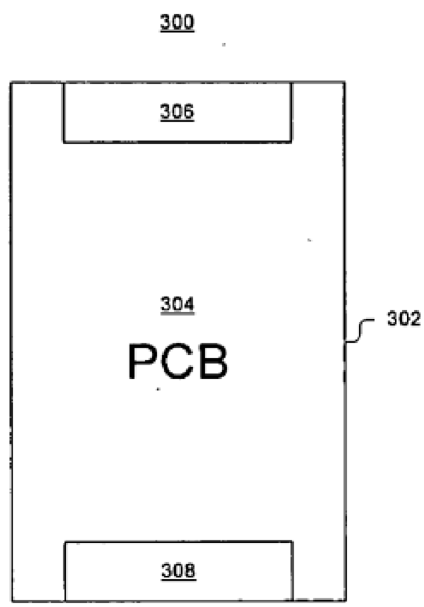


FIG. 3A

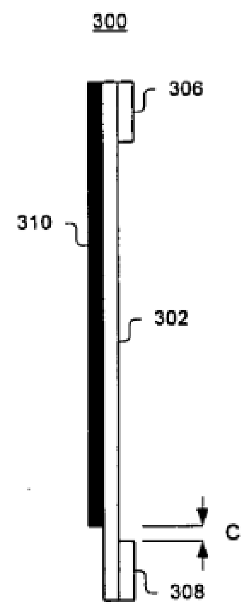


FIG. 3B

B. Jing (EX1011)

Jing teaches a compact multiband "planar monopole antenna with a 2-dimensional structure" for mobile handsets that operates with GSM, DCS, PCS, UMTS, and WLAN services. Jing, 2657, 2660, Fig. 1(a) (below).[5]

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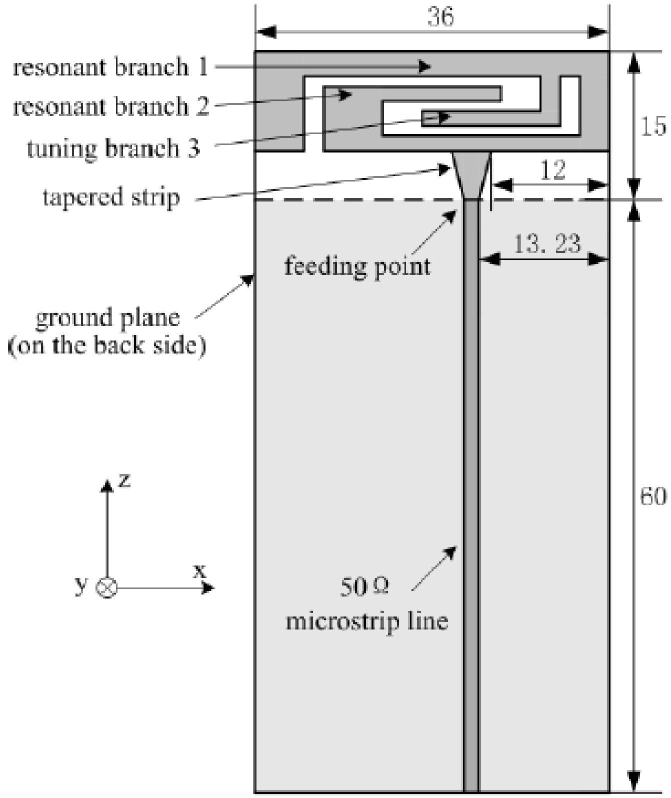
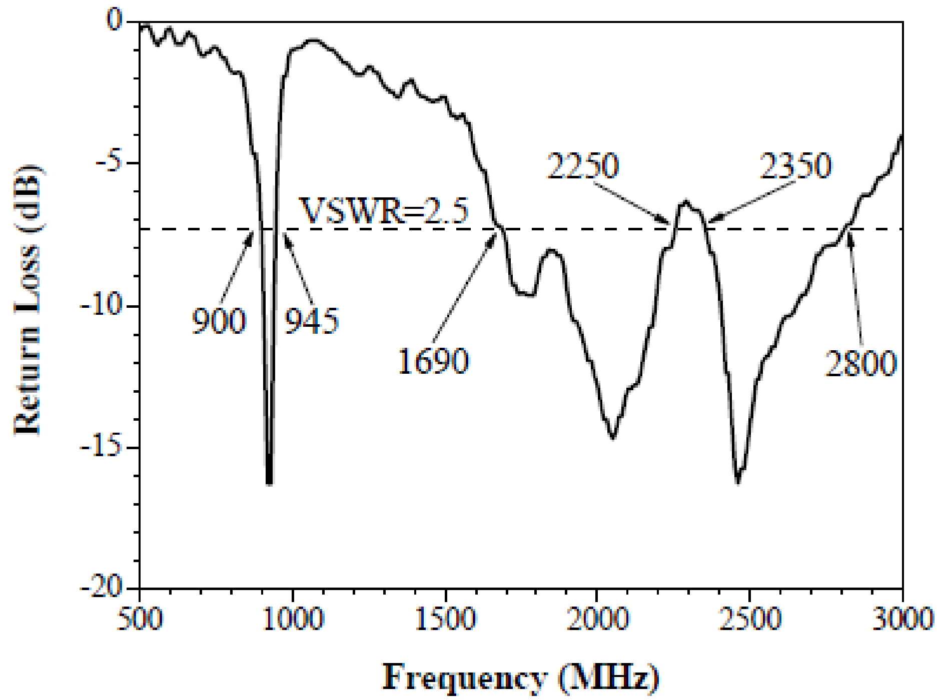
[5] The Petition uses figures from Jing's more legible online version (EX1014, Att. C-1), which is materially identical to EX1011.



(a)

When matched to suitable electronics (e.g., a transceiver) at VSWR (voltage standing wave ratio) of 2.5:1, Jing's antenna operates at 900-945 MHz, 1690-2250 MHz, and 2350-2800 MHz. Jing, Fig. 3 (measured return loss below), 2657-2658; Weide, ¶¶301-302.



C. Dou+Jing

While Dou describes a wireless device having internally-mounted antennas, it does not describe particular antennas for achieving its wireless devices. Weide, ¶303. Instead, Dou leaves antenna selection to a POSA. Weide, ¶303.

A POSA would have had reasons to use a Jing antenna for each of Dou's first and second antenna. Jing's antenna was designed for internal use in mobile handsets, making it suitable for use as Dou's "internal antenna[s]" 306 and 308 "integrated with the wireless device." Dou, [0033], Figs. 3A-3B (below); Jing, 2657, Fig. 1(a) (below); Weide, ¶304.

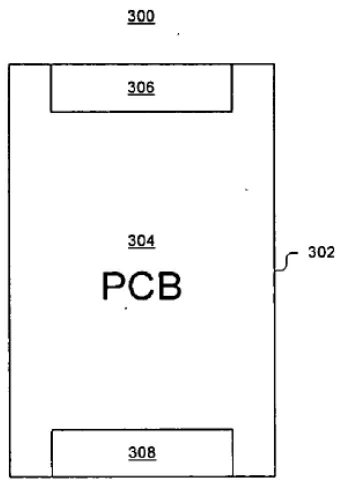


FIG. 3A

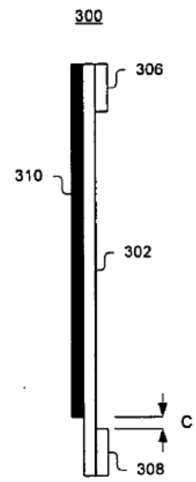
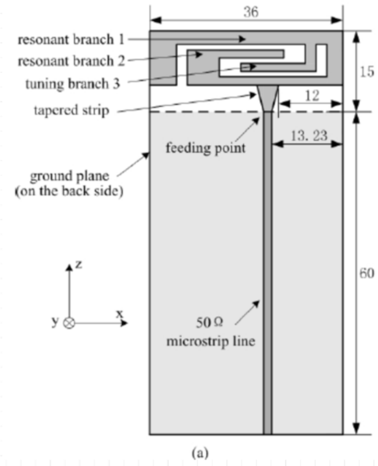


FIG. 3B



Dou Jing

Jing's antenna is a "planar monopole antenna" (Jing, 2657 (Abstract)), which Dou describes using for the first/second antennas. Dou, [0034]. Jing's antenna provided operation at frequencies used by well-known communication standards (DCS, PCS, UMTS, Zigbee, WiFi/Bluetooth) making it "suitable for mobile phone applications" like Dou's device. *Supra* §IX.B (Jing); Jing, 2658, Fig. 3; Dou, [0022] (describing exemplary coverage for PCS, "WCDMA/UMTS," and "ISM band in 2.4 GHz range for WiFi and Bluetooth"); Weide, ¶305.

POSAs would have used Jing as Dou's antennas 306 and 308. Weide, ¶306. Dou's PCB 302 has ground plane 310 on the back, just like Jing has a "system ground plane" on the back surface of an FR4 substrate. Dou, Fig. 3B, [0034]; Jing, Fig. 1(a), 2658; Weide, ¶306. POSAs would have recognized that whether the ground plane extends under Dou's antennas depends on the specifications required by the implemented antennas. Weide, ¶306. Dou places antenna 308 at "no less than 5 mm" offset from ground plane 310 just like Jing places its antenna with a 5 mm taper offsetting it from its ground plane. Dou, Fig. 3B, [0034]; Jing, Fig. 1(a), 2657-2658; Weide, ¶306. POSAs would have implemented Dou's antenna 306 and 308 using a Jing antenna for each and Jing's 36 × 60 mm ground plane as a modified ground plane 310, to achieve Dou's diversity architecture. Dou, [0034] (explaining embodiments not limited to depiction in Fig. 3); Weide, ¶306. As shown in modified Dou Figs. 3A-3B (below), consistent with Jing's teachings, POSAs would have limited the extent of Dou's ground plane 310 to not extend behind Jing's antenna at 306, just like Dou does not extend it behind antenna 308. Weide, ¶306.

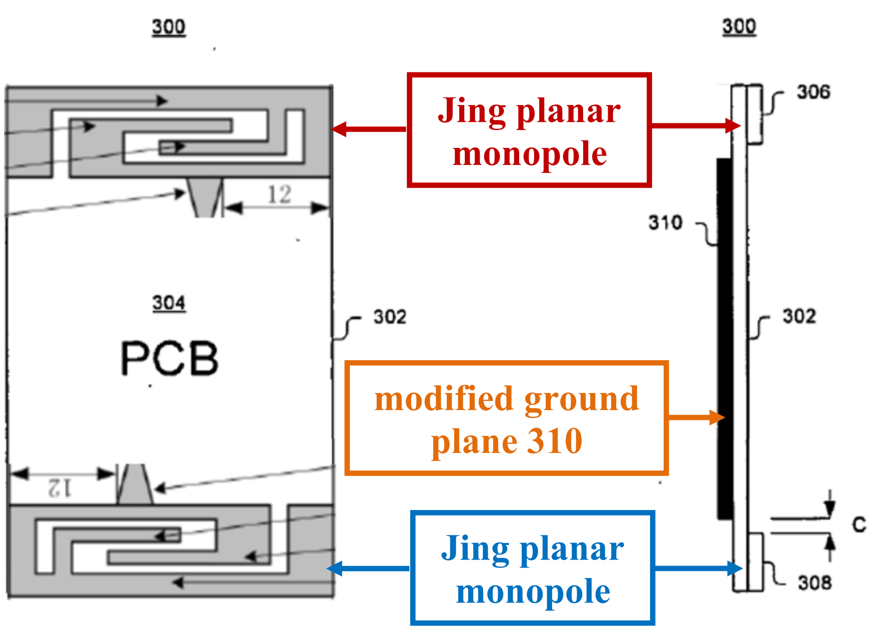


FIG. 3A FIG. 3B

Implementing Dou's antennas 306 and 308 using separate Jing antennas would have combined familiar elements according to known methods with predictable results, *KSR*, 550 U.S. at 416, and been no more than the "predictable use of prior art elements according to their established functions." *Id.*, 417; Weide, ¶307.

POSAs would have reasonably expected success using Jing's antenna in Dou's device because Jing designed its antenna for internal use in mobile handsets (Jing, 2657), and Dou expressly contemplates using multiband PIFA antennas—like Jing's—as its first/second internal antenna (e.g., Dou, [0028]-[0029], [0034]). Weide, ¶308. Dou describes antenna placement within the device according to "various performance and design constraints" known to POSAs. Dou, [0030]; Weide, ¶308. Jing describes placing its antenna at the end of a PCB, just like Dou. Jing, Fig. 1(a), 2657; Dou, Figs. 3A-3B, [0031]-[0032]; Weide, ¶308. It was well-within the POSA's ordinary skill to implement Dou's device with Jing's antenna, and the resulting antenna operation was predictable. Dou, [0012], [0063]; Weide, ¶308.

The combination ("Dou+Jing") thus had at least ***two*** antennas: Dou antennas 306 and 308 each implement by a separate Jing antenna, and renders obvious the Challenged Claims as shown below. Weide, ¶309.

D. Claim 1

1. Preamble [1.PRE]

[1.PRE]	A wireless device comprising:

Dou+Jing meets [1.PRE] because Dou describes a wireless device comprising, e.g., a handheld computer, mobile telephone, or PDA. Dou, [0015]-[0016], [0031], claim 1. Weide, ¶310.

2. Limitation [1.a]

[1.a]	a ground plane;

Dou+Jing modifies Dou's ground plane 310, which serves "to improve antenna performance in talk position and reduce SAR." *Supra* §IX.C (combination), Dou, Figs. 3A-3B (modified below), [0034]; Weide, ¶311.

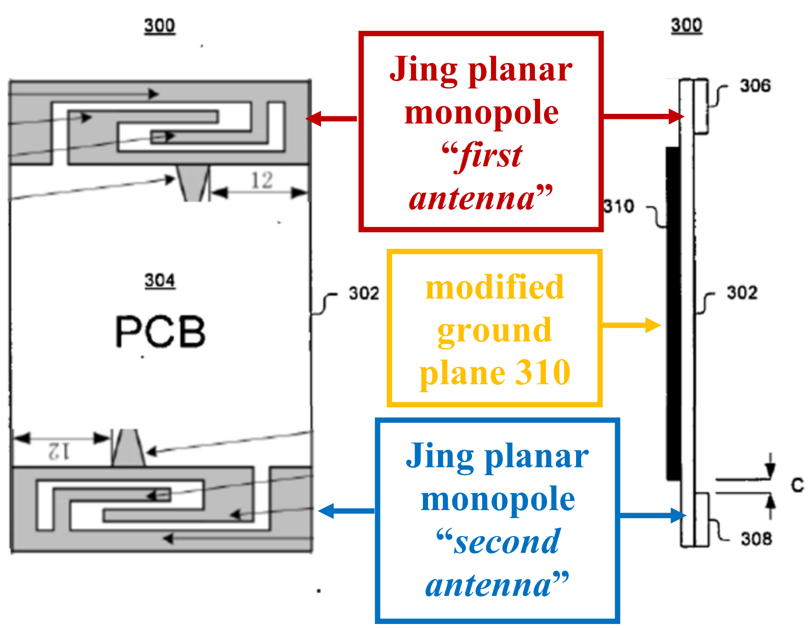


FIG. 3A FIG. 3B

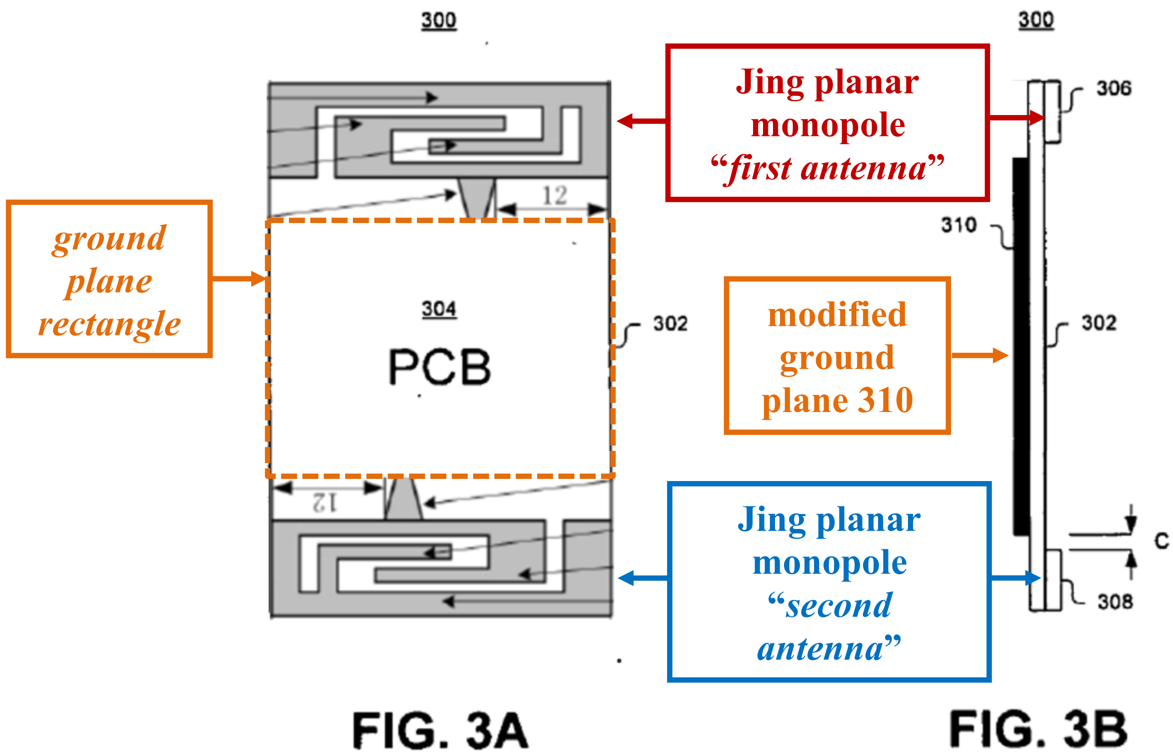
3. Limitation [1.b]

[1.b]	a first planar antenna proximate to a first side of a ground plane rectangle enclosing the ground plane,

Dou+Jing meets [1.b] because Dou's antenna 306 (*first planar antenna*) is "located substantially at the top of… the PCB 304[.]" Dou, [0032]-[0033]. Jing's antenna is "*planar*" because it is "printed on" a planar PCB surface. Jing, Abstract, 2657-2658, Fig. 1(a); Dou, [0034], Fig. 3B; Weide, ¶312.

Dou describes ground plane 310 disposed on the back of PCB 304. Dou, Fig. 3B, [0032], [0034]. In Dou+Jing, ground plane 310 conforms to the dimensions of the ground plane in Jing, which is coterminous with the FR4 substrate (e.g., with dimensions 36 mm × 60 mm) but not extending beneath Jing's antenna. Jing, 2657-2658, Fig. 1(a); Weide, ¶313. Jing places its antenna on the substrate's top surface "*proximate*" to a 36 mm wide edge (*first short side*) of a rectangle enclosing the ground plane on the substrate's opposite side. Jing, 2658, Fig. 1(a) (below). *Supra* §IX.C (combination); Weide, ¶313.

In Dou+Jing, modified ground plane 310 is bounded (e.g., *enclos[ed]*) by a 36 mm × 60 mm rectangle (*ground plane rectangle*) as Jing describes. Weide, ¶314. Jing's antenna implementing Dou's antenna 306 is "*proximate to a first side*" of that *ground plane rectangle* because it extends from the 36 mm *first short side* of the rectangle enclosing the ground plane. Jing, 2657-2658, Fig. 1(a); Dou, Figs. 3A-3B (as modified below), [0032]-[0034] (antenna is "located substantially at the top of… the PCB 304," but "the ground plane 310 does not extend underneath" it); *supra* §IX.C (combination); Weide, ¶314.

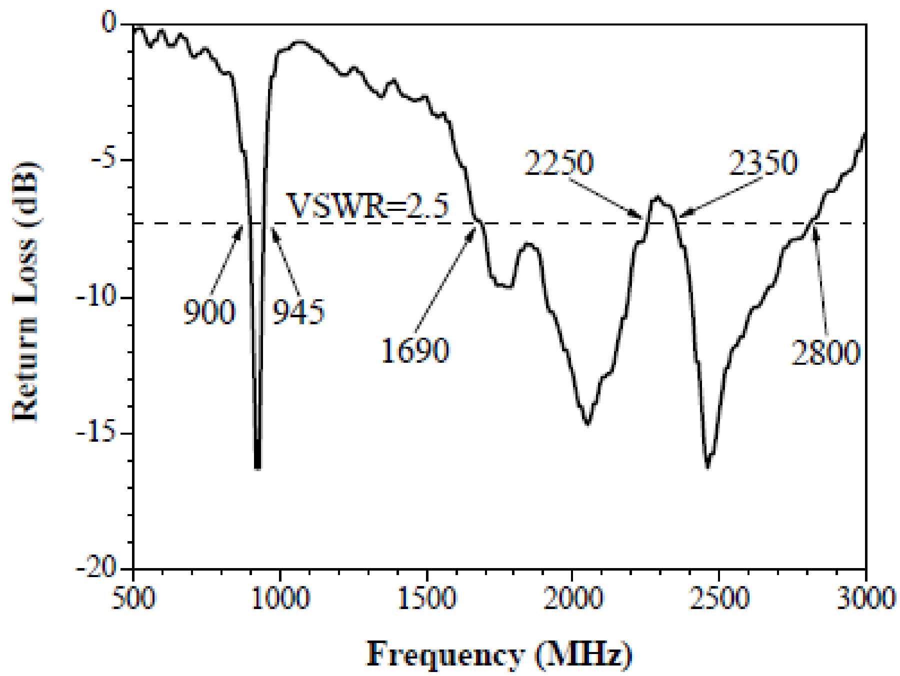


Dou+Jing

4. Limitation [1.c]

[1.c]	the first planar antenna being configured to support at least three frequency bands of the electromagnetic spectrum,

Dou+Jing meets [1.c] because Jing's antenna (*first planar antenna*) operates—within the "*electromagnetic spectrum*"—at 900-945 MHz, 1690-2250 MHz and 2350-2800 MHz with VSWR 2.5:1. Jing, 2658, Fig. 3 (below); Weide, ¶315.



The 900-945 MHz range contains the ISM band at 902-928 MHz, which is used by Zigbee. EX1031, 70; Weide, ¶316.

The **1690-2250 MHz** range contains at least the same **twenty-one** "*frequency bands*" within the frequency range 1710-2170 MHz as shown in Table 5 above and explained *supra* §VIII.G.3 (Ground 2, [7.c]). Jing, 2658 (DCS, PCS, UMTS); Weide, ¶317.

The **2350-2800 MHz** range contains at least **three** "*frequency bands*" shown in Table 6.

Table 6: Frequency bands within 2350-2800 MHz.

Band	Range (MHz)
ISM 2.4 GHz	2400-2500
LTE Band 7	2500-2690
LTE Band 38	2570-2620

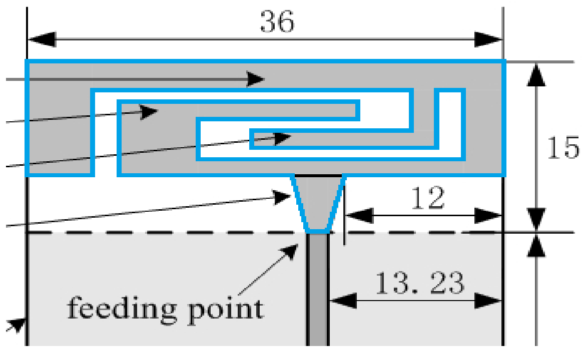
Jing, 2658 (WLAN); EX1024, 27 (Fractus citing LTE bands); EX1025, 13, Table 5.5-1 ("E-UTRA operating bands" defining LTE bands); EX1026, 11 (listing LTE FDD and TDD bands); EX1031, 70 (listing ZigBee bands); EX1039, 497-501; EX1043, 1 (defining the 802.11 band); EX1044, 29 (defining Bluetooth band); Weide, ¶318.

Thus, Jing's antenna meets [1.c] because it operates in (e.g., is operable to send and receive radiation in) at least twenty-five (25) bands. Weide, ¶319.

5. Limitations [1.d], [1.g]

[1.d]	the first planar antenna defining a first contour,
[1.g]	wherein the first contour is defined as a perimeter of the first planar antenna and perimeters of any closed apertures defined within the first planar antenna;

Jing's antenna defines a "*first contour*" just like the perimeter of antenna contour 350 in the '149 patent's embodiments in Figure 3 or antenna system 1200 in Figure 12A (below right), meeting [1.d] and [1.g]. EX1005, 7:62-64, 33:65-34:7; Jing, 2658 ("The planar monopole occupies an area of 36×15 mm^2."); Weide, ¶320.



Jing, Fig. 1(a) (annotated detail)

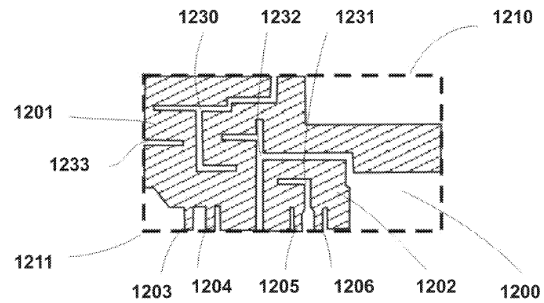
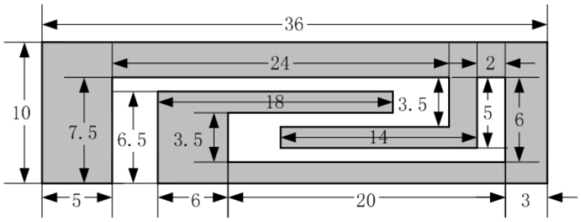


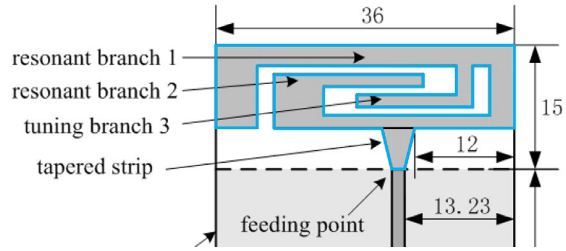
FIG. 12A

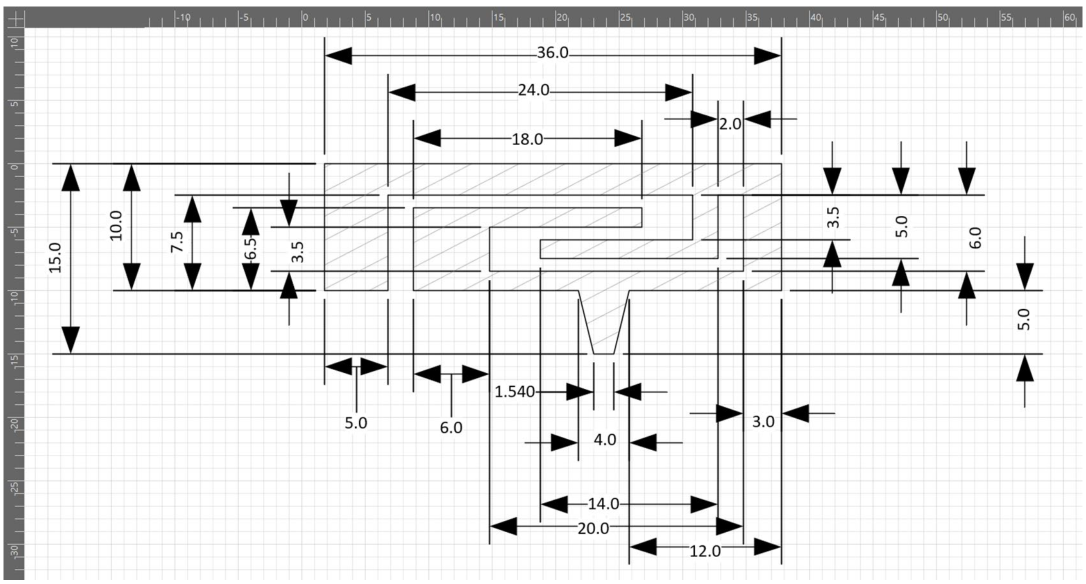
’200 patent

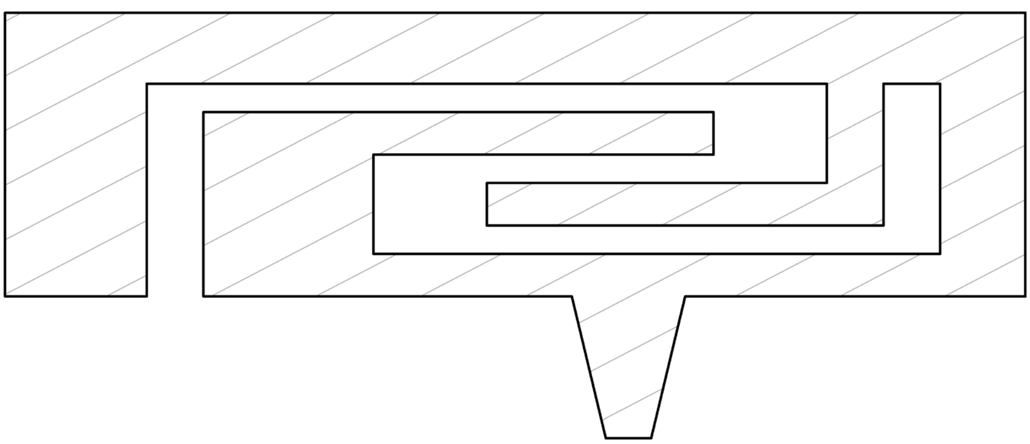
A scaled rendering of Jing’s “*first contour*” is generated from the dimensions in Jing. Jing, 2657-2658, Figs. 1(a)-1(b) (annotated detail below); Weide, ¶321.


36
24
2
18
3. 5
10
7. 5
6. 5
3. 5
5
6
14
5
6
20
3

(b)


36
resonant branch 1
resonant branch 2
tuning branch 3
tapered strip
15
12
feeding point
13. 23


36.0
24.0
2.0
18.0
15.0
10.0
7.5
6.5
3.5
3.5
5.0
6.0
5.0
5.0
6.0
1.540
4.0
3.0
14.0
20.0
12.0



6. Limitation [1.e]

[1.e]	wherein the first contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value of at least 1.35; and

Dou+Jing meets [1.e] because the *first contour* for Jing's antenna implementing Dou antenna 306, *supra* §IX.D.5 ([1.d]), [1.g]), has $F_{21} = 1.43 \geq 1.20$, and $F_{32} = 1.70 \geq 1.35$, as shown for [1.h]-[1.h.4] below. Weide, ¶322.

7. Limitation [1.f]

[1.f]	a second antenna proximate to a second side of the ground plane rectangle, wherein the second antenna is configured to receive signals from at least two frequency bands of the at least three frequency bands;

Dou+Jing meets [1.f] because it implements Dou antenna 308 as a Jing antenna (*second antenna*). *Supra* §IX.C (combination); Weide, ¶323. Jing's antenna is 36 mm wide and extends at each end to the two long edges of PCB 302, as shown below (modified Dou Figs. 3A-3B). Each long edge of PCB 302 coincides with a "*long side of the ground plane rectangle*" that encloses modified ground plane 310 shown below. *Supra* §§IX.C (combination), IX.D.2 ([1.a]); Weide, ¶323.

Since Jing's antenna and ground plane are both 36 mm wide, and positioned next to the ground plane rectangle, using two Jing antennas in Dou's device locates both antennas "*proximate to*" a short side (36 mm edge) and a "*long side*" (60 mm edge) of "*the ground plane rectangle*" (orange outline). *Supra* §IX.C (combination); Weide, ¶324.

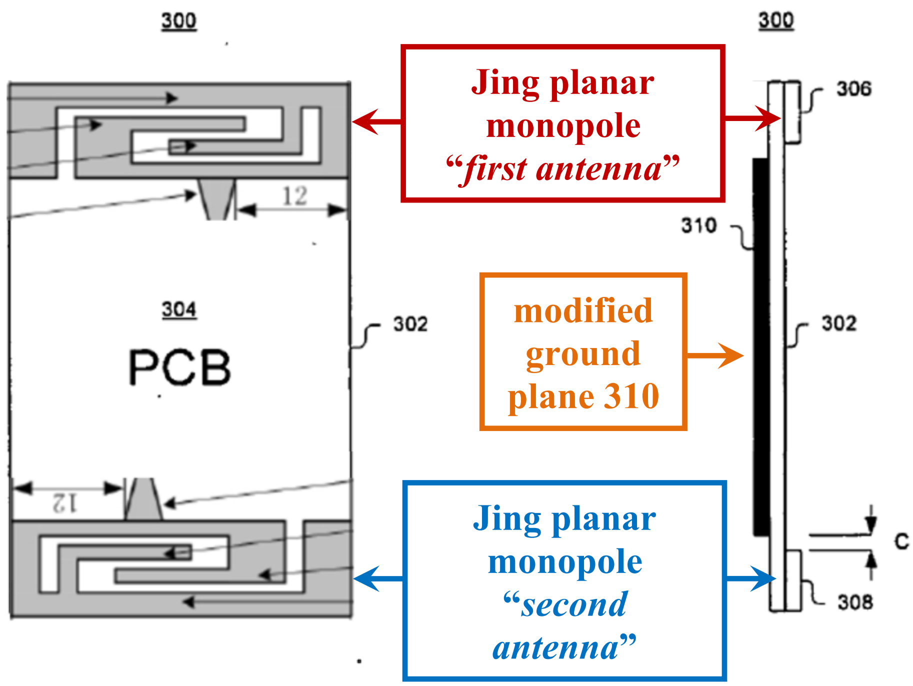


FIG. 3A FIG. 3B

Jing's antenna (*second antenna*) meets the remaining limitations in [1.f] because it covers the same frequency bands as the *first antenna* as explained *supra* §IX.D.4 ([1.c]). Weide, ¶325.

8. Complexity factor limitations ([1.h]-[1.h.4])

Limitations [1.h]-[1.h.4] define "*complexity factors* F_{21} *and* F_{32}" using the same language and convoluted sequence as limitations [7.h]-[7.h.4] *supra* §§VI.D.9-VI.D.9.e. As with Ground 1A, the analysis below addresses the steps in order, with the consequence of presenting the claim limitations out of the sequence in which the patent recites them.

a. Limitation [1.h.2]: Grid G_2

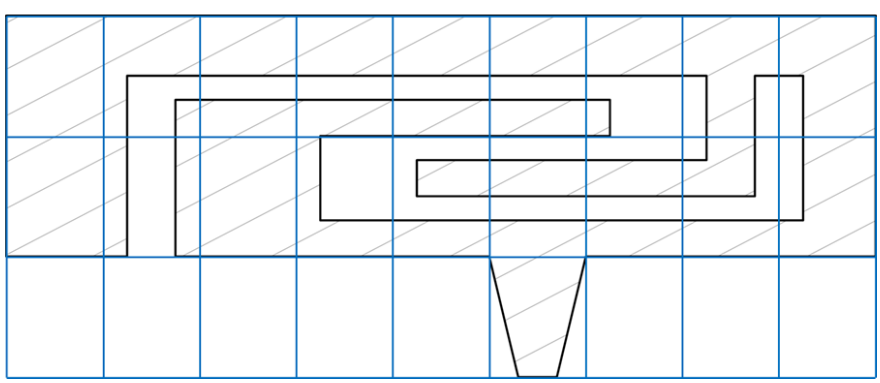
Jing's antenna contour (*first contour*) is 36 mm wide (*long side of the face*) and 15 mm in height (*short side of the face*). Jing, 920, Fig. 1(b). Grid G_2 with nine (9) columns yields cell width (*columns of equal width*) of $\left(\frac{36mm}{9}\right) = 4.0\ mm$. Weide, ¶327.

Three (3) rows provides an "*odd number of rows*" with "*the cells… being as square as possible*" because it provides a cell with an aspect ratio closer to 1 (e.g., where width = height) than any other (2*n*+1) rows with integer *n*, $(0 < n < 5)$. Weide, ¶328.

Rows	Cell Height (mm)	Cell Aspect Ratio $\left(\frac{width}{height}\right)$
3	$\left(\frac{15}{3}\right) = 5.0$	$\left(\frac{4.0}{5.0}\right) = 0.80$
5	$\left(\frac{15}{5}\right) = 3.0$	$\left(\frac{4.0}{3.0}\right) = 1.33$

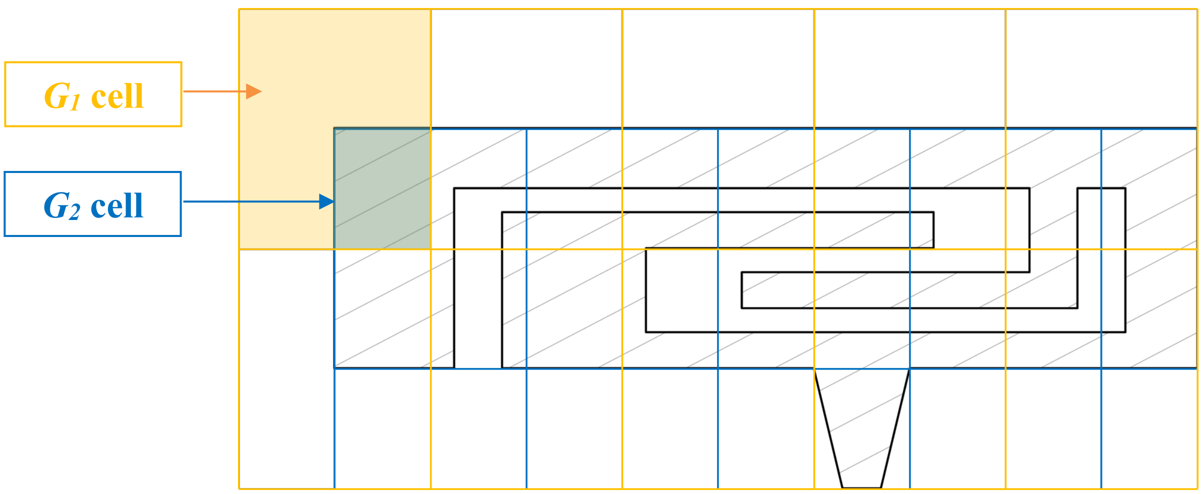
Thus, grid G_2 has 3 rows by 9 columns as shown below (blue outline). Weide, ¶328.

Grid G_2



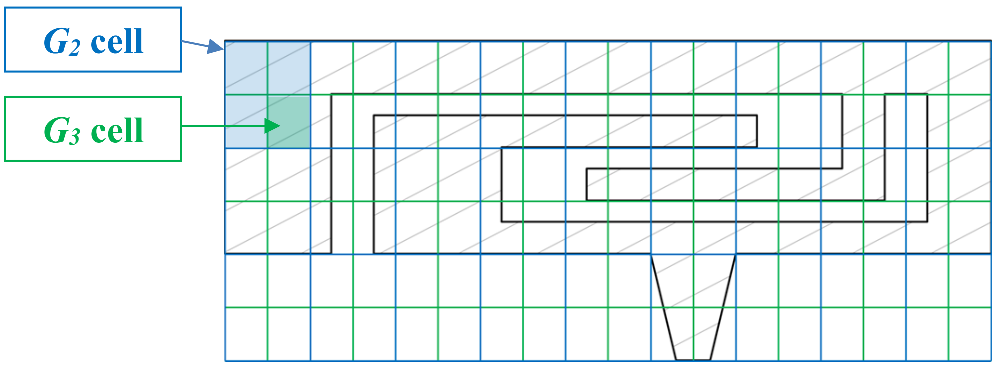
b. Limitation [1.h.3]: Grid G_1

Grid G_1 (orange outline below) is "*aligned with a corner of the grid G_2*" and "*cover[s] the face*" (e.g., the *first contour*), wherein each G_1 cell has twice the width and height of a G_2 cell, e.g., "*widths and heights that respectively are double the widths and heights of the cells of the grid G_2*". Weide, ¶329.



c. Limitation [1.h.4]: Grid G_3

Grid G_3 (green outline below) is "*aligned with the grid G_2*" and each G_2 cell (green) comprises ***four*** G_3 cells—meaning that G_3 cells have "*widths and heights that respectively are half the widths and heights of the cells of the grid G_2.*" Weide, ¶330.

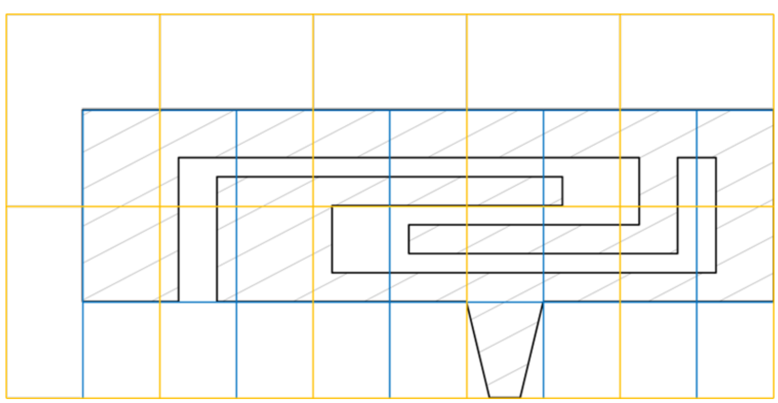


d. Limitation [1.h.1]: Cell counts

The count for each grid is shown below.

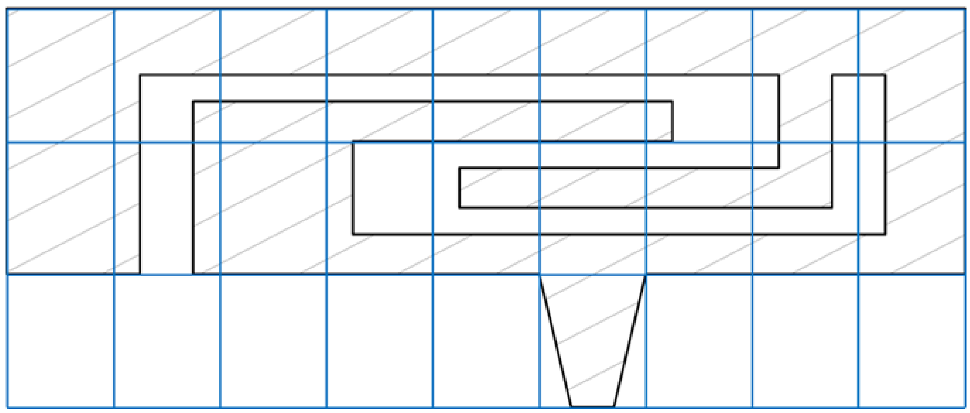
i. N_1 = 10.

All cells in 2 × 5 grid G_1 "*include... a point*" of the *first contour* (black outline) so each cell is counted and N_1 = 10. Weide, ¶332.



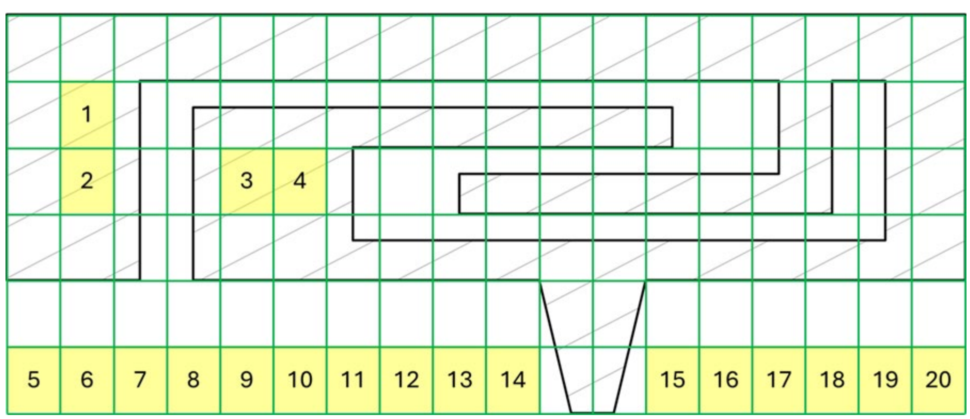
ii. N_2 = 27.

As shown below, in 3×9 grid G_2 all 27 cells "*include… a point*" of the *first contour* and are counted. Thus, $N_3 = 27$. Weide, ¶333.



iii. N_3 = 88.

In the 6×18 grid G_3 the cells numbered 1-20 (marked below) do ***not*** "*include… a point*" on the *first contour*. Thus, $N_3 = (108 - 20) = 88$. Weide, ¶¶334-336.



e. **Limitation [1.h]**

i. **Calculation F_{21} = 1.43.**

The *complexity factor* F_{21} for the *first contour* is:

$$\boldsymbol{F_{21}} = -\left(\frac{\log(N_2) - \log(N_1)}{\log(1/2)}\right) = -\left(\frac{\log(27) - \log(10)}{(-1)\log(2)}\right)$$

$$= \left(\frac{\log(27/10)}{\log(2)}\right) = \left(\frac{0.431}{0.301}\right) = 1.43.$$

Weide, ¶337.

ii. **Calculation F_{32} = 1.70.**

The *complexity factor* F_{32} for the *first contour* is:

$$\boldsymbol{F_{32}} = -\left(\frac{\log(N_3) - \log(N_2)}{\log(1/2)}\right) = -\left(\frac{\log(88) - \log(27)}{(-1)\log(2)}\right)$$

$$= \left(\frac{\log(88/27)}{\log(2)}\right) = \left(\frac{0.513}{0.301}\right) = 1.70.$$

Weide, ¶338.

9. **Limitation [1.i]**

[1.i]	wherein the level of complexity of the first contour is configured to provide operation of the wireless device in the at least three frequency bands.

Dou+Jing meets [1.i] because Jing tuned the antenna "by carefully adjusting the dimensions of branch 3," based on which "the fundamental and higher modes of branch 1 can be tuned to appropriate frequencies." Jing, 2657-2658; Wiede, ¶339. Jing thereby "configured" the antenna's *first contour*'s "*level of complexity*" to provide the frequency operation discussed *supra* §IX.D.4 ([1.c]) because the "*complexity*" measures the antenna's physical features as captured by orthogonal projection in the antenna "*contour*". Weide, ¶339; EX1005, 16:64-17:4, 19:27-30, 20:19-22.

Jing's antenna's "*first contour*" also meets [1.i] under Fractus's litigation arguments because Jing's antenna is optimized to support operation in the frequency bands discussed *supra* §§IX.D.4 ([1.c]) VI.D.4 (Ground 1A, [7.c]). *Supra* VI.D.10 (Ground 1A, [7.i]); Weide, ¶340.

E. Claims 3-4

[3]	[Claim 1's device], wherein the first side of the ground plane rectangle is a short side of the ground plane rectangle.
[4]	[Claim 1's device], wherein the second side of the ground plane rectangle is a long side of the ground plane rectangle.

Dou+Jing meets claim 3 because the "*first side of the ground plane rectangle*" (*supra* §IX.D.3 [1.b]) is 36 mm long which is shorter than the 60 mm long axis of the *rectangle* and is thus *a short side*. *Supra* §IX.C (combination); Weide, ¶341.

Dou+Jing meets claim 4 because Jing's antenna implementing Dou antenna 308 ("*second antenna*") spans the *ground plane rectangle*, making it adjacent to "*a long side of the ground plane rectangle*." Dou, Figs. 3A, 3B; *supra* §§IX.C (combination), IX.D.7 ([1.f]); Weide, ¶342.

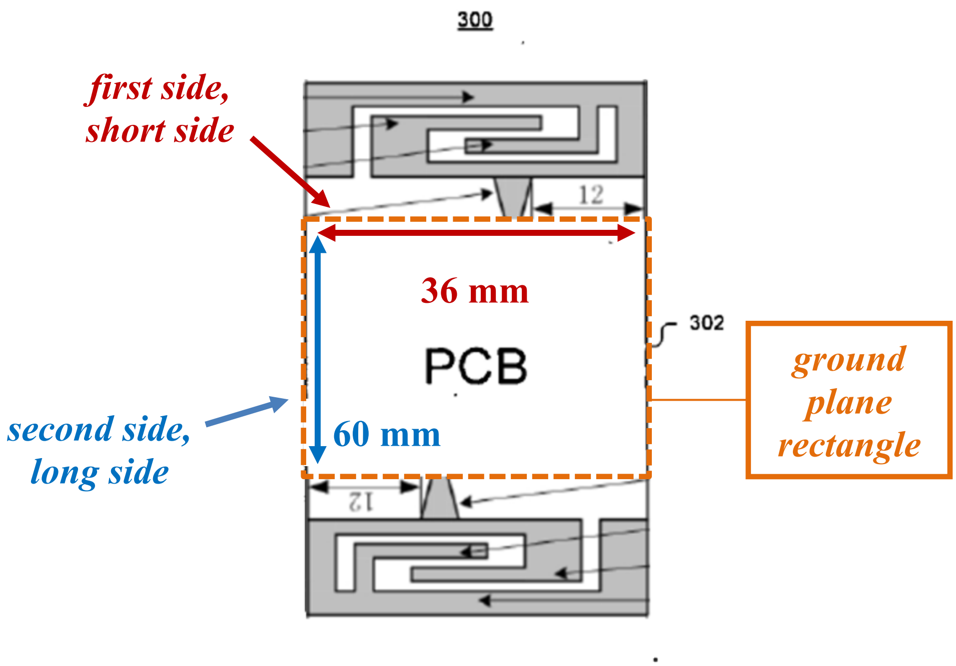


FIG. 3A

F. Claim 5

[5]	[Claim 1's device], wherein the complexity factor F_{32} for the first contour is smaller than 1.75.

Dou+Jing meets claim 5 because the *first contour* $F_{32} = 1.70 < 1.75$, as explained *supra* §IX.D.6 ([1.e]). Weide, ¶343.

G. Claim 13

1. Limitations [13.PRE]-[13.c], [13.e], [13.g]-[13.h.1], [13.h.3]-[13.i]

Dou+Jing meets [13.PRE]-[13.c], [13.e], [13.g]-[13.h.1], and [13.h.3]-[13.i] for the same reasons it meets the corresponding limitations below. EX1028, 7-10; Weide, ¶344.

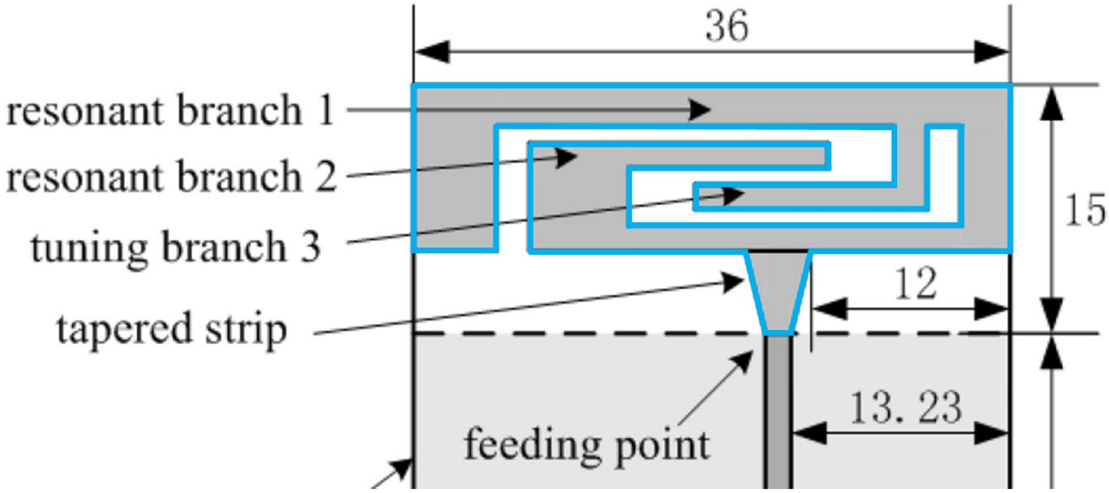
Limitation	Corresponding limitation	Discussion *supra*
13.PRE	1.PRE	§IX.D.1
13.a	1.a	§IX.D.2
13.b	1.b	§IX.D.3
13.c	1.c	§IX.D.4
13.e	1.f	§IX.D.7
13.g	1.e	§IX.D.6
13.h	1.h	§IX.D.8.e
13.h.1	1.h.1	§IX.D.8.d
13.h.3	1.h.3	§IX.D.8.b
13.h.4	1.h.4	§IX.D.8.c
13.i	1.i	§IX.D.9

Dou+Jing meets the remaining limitations in claim 13 as follows.

2. Limitation [13.d]

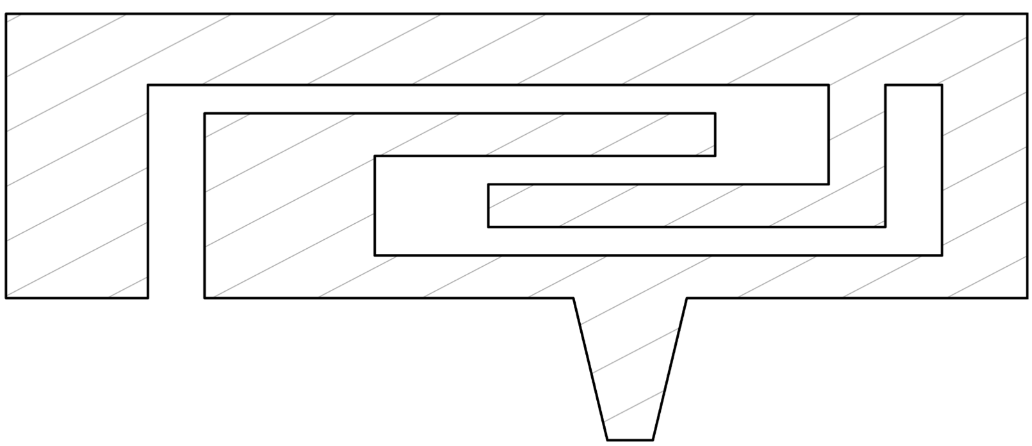
[13.d]	a minimum-sized parallelepiped completely enclosing a volume of the first antenna, the minimum-sized parallelepiped having a face with a largest area;

Dou+Jing meets [13.d] because it uses Jing's antenna for Dou antenna 306 (*first antenna*). Jing's antenna is printed on a PCB. *Supra* §IX.D.3 ([1.b]); Weide, ¶346. The "volume" of "*a minimum-sized parallelepiped completely enclosing a volume of*" Jing's antenna is planar 36×15 mm^2 area enclosing the antenna by the 0.8 mm thickness of the printed trace and the substrate supporting it. Jing, 2658, Fig. 1; Weide, ¶346. The "*face with a largest area*" is the top 36×15 mm^2 surface of the *parallelepiped* enclosing Jing's antenna trace. Weide, ¶346.



3. Limitation [13.f]

While [13.f] and [1.g] use different language to define a "*first contour*," *supra* §VIII.M.1.c (Ground 2, [13.f]), as applied to Jing's antenna ("first antenna") the two definitions yield the same result as explained *supra* §IX.D.5 ([1.g]) and shown below, because Jing only contains antenna portions within "*the face*" of the *parallelepiped* as defined *supra* §IX.G.2 ([13.d]). Weide, ¶347.



4. Limitation [13.h.2]

As explained *supra* §VI.I.2, limitation [13.h.2] recites a sentence fragment "*an odd number of rows of equal height arranged along a short side of the*."

Assuming the "*short side*" in [13.h.2] means "*a short side of the minimum-sized rectangle*" in [1.h.2], then Dou+Jing meets [13.h.2] for the same reasons it meets [1.h.2] *supra* §IX.D.8.a. Weide, ¶348.

H. Claim 15

Dou+Jing meets claim 15 because Jing's antenna implementing Dou's antenna 306 (*first antenna*) is planar as explained *supra* §IX.D.3 ([1.b]). Jing, Abstract, 2657-2658, Fig. 1(a); Weide, ¶349.

I. Claims 17, 19

Claims 17 and 19 depend from claim 13 and recite the same additional limitations as claims 5 and 3, respectively. EX1028, 12; Weide, ¶350. Dou+Jing meets the additional limitations in claims 17 and 19 for the same reasons it meets the corresponding limitations below. Weide, ¶350.

Limitation	Corresponding limitation	Discussion *supra*
17	5	§IX.F
19	3	§IX.E

J. Claim 20

[20]	[Claim 13's device], wherein the first side of the ground plane rectangle is a long side of the ground plane rectangle.

Dou+Jing's antenna 306 as Jing's antenna spans PCB 304, so that it is placed *proximate* both a short side and a *long side* of the *ground plane rectangle*. *Supra* §§IX.C (combination), IX.D.3 ([1.b]), IX.G.1 ([13.b]); Weide, ¶351.

While in claims 12 and 19 the "*first side*" is mapped to a "*short side*," for claim 20, the "*first side*" is mapped to a "*long side*" as shown below, without any change to the claim 13 analysis because Jing's antenna implementing Dou antenna 306 ("*first antenna*") is "*proximate*" to the "*long side*" of the *"ground plane rectangle*" shown *supra* §§IX.D.3 ([1.b]), IX.G.1 ([13.b]). Dou, Figs. 3A, 3B; Weide, ¶352.

X. GROUND 3B: DOU+JING+YING RENDERS OBVIOUS CLAIMS 6 AND 18

A. Ying

Ying discloses "a miniature, built-in dual band antenna which is suitable for use in [] compact mobile terminals." Ying, Abstract, 3:43-46. Ying's antenna is designed for use in "phones which need multiple antennas for cellular, wireless local area network, GPS and diversity." Ying, 3:39-40. Ying identifies several "low and high bands" that can be implemented for the antenna's dual band coverage, including "GSM+GPS." Ying, 5:14-28.

B. Dou+Jing+Ying

Dou+Jing does not provide coverage for GPS (at 1575 MHz), and Jing's antenna provided "insufficient bandwidth to cover the GSM (890-960 MHz) band." Jing, 2658, Fig. 3; Weide, ¶354. A POSA would have had reasons to use Ying's antenna, covering GPS and GSM900, with Dou+Jing, in order to provide Dou+Jing's wireless device with GPS and GSM900 coverage. Weide, ¶354. This would have provided a wireless device with coverage for the GPS and GSM services that Dou describes its wireless device having. Dou, [0022]. Weide, ¶354.

As explained *supra* §VII.B (Dou+Ciais-Multiband+Hilgers), it was conventional for mobile devices to comprise multiple internal antennas, and Dou describes its device having "three or more" antennas. Dou, [0040]; Weide, ¶355. Ying's antenna was designed for use within a multi-antenna device such as Dou's. Ying, 5:26 ("GSM+GPS"), 3:43-46 ("phones which need multiple antennas"); Weide, ¶355.

Implementing Dou+Jing's wireless device further including Ying's dual-band GPS/GSM900 antenna would have been nothing more than combining familiar elements according to known methods with predictable results, and been no more than the "predictable use of prior art elements according to their established functions." *KSR*, 550 U.S. at 416-417; Weide, ¶356. This combination would have provided the multiband coverage that Dou describes. Weide, ¶356.

A POSA also would have had a reasonable expectation of success including Ying's GPS/GSM900 antenna in Dou's wireless device—as Dou describes—because it was conventional (EX1029, [0044]), Dou explains that "the antenna architecture may comprise three or more antennas" (Dou, [0040]), and Dou specifically describes the wireless device having coverage including for GPS and GSM (Dou, [0022]). Weide, ¶357.

This combination of Dou in view of Jing, and further in view of Ying (hereinafter "Dou+Jing+Ying") has **three** antennas: antennas 306 and 308 (each a Jing antenna), and Ying's dual-band GPS/GSM900 antenna, and meets claims 6 and 18 as shown below. Weide, ¶358.

C. Claim 6

[6]	[Claim 5's device], comprising a third antenna configured to operate in at least two frequency bands that are different from the at least three frequency bands.

Dou+Jing+Ying meets claim 6 because Ying's dual-band antenna (*third antenna*) covers (*is configured to operate in*) 880-960 MHz (for GSM900) and 1575 MHz (for GPS) (*at least two frequency bands being different*). Jing's antenna does not cover 1575 MHz, and Jing's antenna does not cover the full 890-960 MHz band for standard GSM900. *Supra* §§IX.D.4 ([1.c]), X.B (combination); Ying, 5:13-28; Jing, 2658 (measured bandwidth is "insufficient to cover the GSM (890-960 MHz) band."); Weide, ¶359. Thus, Ying's antenna covers "*at least two frequency bands that are different*" from those Jing covers, meeting claim 6. Weide, ¶359.

D. Claim 18

[18]	[Claim 13's device], wherein a third antenna is configured to operate in at least two frequency bands being different from the at least three frequency bands and the third antenna is arranged within the wireless device.

Dou+Jing+Ying meets the additional limitations in claim 18 for the reasons is meets claim 6 *supra* §X.C. Weide, ¶360. It meets the remaining limitations in claim 18 because the Dou+Jing+Ying device arranges Ying's antenna "*within the wireless device*." *Supra* §X.B (combination); Ying, 1:12-15 (Ying provides "built-in antennas which can be incorporated into portable terminals."); Weide, ¶360.

XI. ***SOTERA***

Petitioners stipulate that if PGR is instituted on this Petition they will not pursue, in the Geotab Litigation, any ground raised or that reasonably could have been raised in this PGR. *Sotera Wireless v. Masimo*, IPR2020-01019, Paper 12, 18-19 (Dec. 1, 2020) (precedential as to §II.A).

XII. DISCRETIONARY DENIAL IS UNWARRANTED

There is no basis for discretionary denial. Petitioners rely on the Director's March 26, 2025 Memorandum concerning Interim Processes for PTAB Workload Management[6] and the Board's guidance concerning "the new interim processes

[6] Available at https://www.uspto.gov/sites/default/files/documents /InterimProcesses-PTABWorkloadMgmt-20250326.pdf (visited April 30, 2025).

relating to institution in AIA proceedings"[7] wherein "the Director… will determine whether discretionary denial of institution is appropriate" in separate briefing filed after a Notice of Filing Date Accorded.

Petitioners reserve the right to respond to any Patent Owner discretionary denial arguments in opposition briefing under the March 26, 2025 Interim Process.

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[7] FAQ, available at https://www.uspto.gov/patents/ptab/faqs/interim-processes-workload-management (visited April 30, 2025); USPTO Boardside Chat (Apr. 17, 2025), available at https://www.uspto.gov/about-us/events/learn-about-new-interim-processes-relating-institution-aia-proceedings (visited April 30, 2025).

XIII. CONCLUSION

The Board should institute review and cancel claims 1-20.

Respectfully submitted,
Geotab Inc. and Geotab USA, Inc.

Dated: June 17, 2025 By: /Adam R. Wichman/
Adam R. Wichman, Reg. No. 43,988
WOLF, GREENFIELD & SACKS, P.C.

APPENDIX A: CLAIM LIST U.S. PATENT NO. 12,095,149

Ref	Limitation
1.PRE	A wireless device comprising:
1.a	a ground plane;
1.b	a first planar antenna proximate to a first side of a ground plane rectangle enclosing the ground plane,
1.c	the first planar antenna being configured to support at least three frequency bands of the electromagnetic spectrum,
1.d	the first planar antenna defining a first contour,
1.e	wherein the first contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value of at least 1.35; and
1.f	a second antenna proximate to a second side of the ground plane rectangle, wherein the second antenna is configured to receive signals from at least two frequency bands of the at least three frequency bands;
1.g	wherein the first contour is defined as a perimeter of the first planar antenna and perimeters of any closed apertures defined within the first planar antenna;
1.h	wherein the complexity factors F_{21} and F_{32} are given by: $$F_{21} = -\frac{log(N_2) - log(N_1)}{log(1/2)}$$ $$F_{32} = -\frac{log(N_3) - log(N_2)}{log(1/2)}$$

Ref	Limitation
1.h.1	where N_1 is a number of cells of a grid G_1 that include at least a point of the first contour, N_2 is a number of cells of a grid G_2 that include at least a point of the first contour, and N_3 is a number of cells of a grid G_3 that include at least a point of the first contour,
1.h.2	the grid G_2 divides a minimum-sized rectangle enclosing the first planar antenna into nine columns of equal width arranged along a long side of the minimum-sized rectangle and into an odd number of rows of equal height arranged along a short side of the minimum-sized rectangle, wherein the number of rows results in the cells of grid G_2 being as square as possible,
1.h.3	the grid G_1 being aligned with a corner of the grid G_2 to cover the minimum-sized rectangle, the cells of the grid G_1 having widths and heights that respectively are double the widths and heights of the cells of the grid G_2, and
1.h.4	the grid G_3 being aligned with the grid G_2, the cells of the grid G_3 having widths and heights that respectively are half the widths and heights of the cells of the grid G_2, and
1.i	wherein the level of complexity of the first contour is configured to provide operation of the wireless device in the at least three frequency bands.
2	The wireless device of claim 1, wherein the first planar antenna includes at least two antenna elements that are electromagnetically coupled.
3	The wireless device of claim 1, wherein the first side of the ground plane rectangle is a short side of the ground plane rectangle.
4	The wireless device of claim 1, wherein the second side of the ground plane rectangle is a long side of the ground plane rectangle.
5	The wireless device of claim 1, wherein the complexity factor F_{32} for the first contour is smaller than 1.75.

Ref	Limitation
6	The wireless device of claim 5, comprising a third antenna configured to operate in at least two frequency bands that are different from the at least three frequency bands.
7.PRE	A wireless device comprising:
7.a	a ground plane;
7.b	a first non-planar antenna proximate to a first side of a ground plane rectangle enclosing the ground plane,
7.c	the first non-planar antenna being configured to support at least three frequency bands of the electromagnetic spectrum,
7.d	a minimum-sized parallelepiped completely enclosing a volume of the first non-planar antenna, the minimum-sized parallelepiped having a face with a largest area;
7.e	a second antenna proximate to a second side of the ground plane rectangle, and wherein the second antenna is configured to receive signals from at least two frequency bands of the at least three frequency bands;
7.f	wherein the first non-planar antenna has a first contour defined as a perimeter of any portions of the first non-planar antenna arranged in the face, perimeters of any closed apertures of any portions of the first non-planar antenna arranged in the face, a perimeter of an orthogonal projection onto the face of any portions of the first non-planar antenna that are not arranged in the face, and perimeters of any closed apertures of the orthogonal projection;
7.g	wherein the first contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value of at least 1.35; and

Ref	Limitation
7.h	wherein the complexity factors F_{21} and F_{32} are given by: $$F_{21} = -\frac{log(N_2) - log(N_1)}{log(1/2)}$$ $$F_{32} = -\frac{log(N_3) - log(N_2)}{log(1/2)}$$
7.h.1	where N_1 is a number of cells of a grid G_1 that include at least a point of the first contour, N_2 is a number of cells of a grid G_2 that include at least a point of the first contour, and N_3 is a number of cells of a grid G_3 that include at least a point of the first contour,
7.h.2	the grid G_2 divides the face into nine columns of equal width arranged along a long side of the face and an odd number of rows of equal height arranged along a short side of the face, wherein the number of rows results in the cells of grid G_2 being as square as possible,
7.h.3	the grid G_1 being aligned with a corner of the grid G_2 to cover the face, the cells of grid G_1 having widths and heights that respectively are double the widths and heights of the cells of the grid G_2, and
7.h.4	the grid G_3 being aligned with the grid G_2, the cells of the grid G_3 having widths and heights that respectively are half the widths and heights of the cells of the grid G_2, and
7.i	wherein the level of complexity of the first contour is configured to provide operation of the wireless device in the at least three frequency bands.
8	The wireless device of claim 7, wherein the first non-planar antenna includes at least two antenna elements that are electromagnetically coupled.
9	The wireless device of claim 7, wherein the complexity factor F_{32} for the first contour is smaller than 1.75.

Ref	Limitation
10	The wireless device of claim 7, wherein a third antenna is configured to operate in at least two frequency bands being different from the at least three frequency bands and the third antenna is arranged within the wireless device.
11	The wireless device of claim 7, wherein a projection of the antenna rectangle on the ground plane rectangle partially overlaps the ground plane rectangle.
12	The wireless device of claim 7, wherein the first side of the ground plane rectangle is a short side of the ground plane rectangle.
13.PRE	A wireless device comprising:
13.a	a ground plane;
13.b	a first antenna proximate to a first side of a ground plane rectangle enclosing the ground plane,
13.c	the first antenna being configured to support at least three frequency bands of the electromagnetic spectrum,
13.d	a minimum-sized parallelepiped completely enclosing a volume of the first antenna, the minimum-sized parallelepiped having a face with a largest area;
13.e	a second antenna proximate to a second side of the ground plane rectangle configured to receive signals from at least two frequency bands of the at least three frequency bands,
13.f	wherein the first antenna has a first contour defined as a perimeter of any portions of the first antenna arranged in the face, perimeters of any closed apertures of any portions of the first antenna arranged in the face, a perimeter of an orthogonal projection onto the face of any portions of the first antenna that are not arranged in the face, and perimeters of any closed apertures of the orthogonal projection;

Ref	Limitation
13.g	wherein the first contour has a level of complexity defined by complexity factor F_{21} having a value of at least 1.20 and complexity factor F_{32} having a value of at least 1.35; and
13.h	wherein the complexity factors F_{21} and F_{32} are given by: $$F_{21} = -\frac{log(N_2) - log(N_1)}{log(1/2)}$$ $$F_{32} = -\frac{log(N_3) - log(N_2)}{log(1/2)}$$
13.h.1	where N_1 is a number of cells of a grid G_1 that include at least a point of the first contour, N_2 is a number of cells of a grid G_2 that include at least a point of the first contour, and N_3 is a number of cells of a grid G_3 that include at least a point of the first contour,
13.h.2	the grid G_2 divides the face into nine columns of equal width arranged along a long side of the face and an odd number of rows of equal height arranged along a short side of the, wherein the number of rows results in the cells of grid G_2 being as square as possible,
13.h.3	the grid G_1 being aligned with a corner of the grid G_2 to cover the face, the cells of grid G_1 having widths and heights that respectively are double the widths and heights of the cells of the grid G_2, and
13.h.4	the grid G_3 being aligned with the grid G_2, the cells of the grid G_3 having widths and heights that respectively are half the widths and heights of the cells of the grid G_2, and
13.i	wherein the level of complexity of the first contour is configured to provide operation of the wireless device in the at least three frequency bands.
14	The wireless device of claim 13, wherein the first antenna includes at least two antenna elements that are electromagnetically coupled.

Ref	Limitation
15	The wireless device of claim 13, wherein the first antenna is planar.
16	The wireless device of claim 13, wherein a projection of the antenna rectangle on the ground plane rectangle partially overlaps the ground plane rectangle.
17	The wireless device of claim 13, wherein the complexity factor F_{32} for the first contour is smaller than 1.75.
18	The wireless device of claim 13, wherein a third antenna is configured to operate in at least two frequency bands being different from the at least three frequency bands and the third antenna is arranged within the wireless device.
19	The wireless device of claim 13, wherein the first side of the ground plane rectangle is a short side of the ground plane rectangle.
20	The wireless device of claim 13, wherein the first side of the ground plane rectangle is a long side of the ground plane rectangle.

CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. § 42.24, the undersigned certifies that the foregoing Petition for Post-Grant Review contains 18,698 words excluding a table of contents, a table of authorities, Mandatory Notices under § 42.8, a certificate of service or word count, or appendix of exhibits or claim listing. Petitioner has relied on the word count feature of the word processing system used to create this paper in making this certification.

Date: June 17, 2025

/Dara Del Rosario/
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Paralegal
WOLF, GREENFIELD & SACKS, P.C.

<u>CERTIFICATE OF SERVICE UNDER 37 C.F.R. §§ 42.6(E)(4), 42.55(A)</u>

I certify that on June 17, 2025, a copy of the foregoing document, including any public redacted exhibits or appendices filed therewith, is being served via *Overnight FedEx* at the following correspondence address of record for the patent:

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