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

DECLARATION OF DANIEL VAN DER WEIDE, Ph.D.
IN SUPPORT OF PETITION FOR
POST-GRANT REVIEW OF U.S. PATENT NO. 12,095,149

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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

I, Daniel van der Weide, Ph.D., declare:

1. I have been retained by Wolf, Greenfield & Sacks, P.C., counsel for Geotab Inc. and Geotab USA, Inc. ("Petitioners" or "Geotab"), to assess claims 1-20 (the "Challenged Claims") of U.S. Patent No. 12,095,149 ("the '149 patent") (EX1005). I am being compensated for my time at my standard rate, plus actual expenses. My compensation is not dependent in any way upon the outcome of the post grant review of the '149 patent.

I. PERSONAL AND PROFESSIONAL BACKGROUND

2. My qualifications for forming the opinions set forth in this declaration are summarized below and explained in more detail in my current curriculum vitae, provided as EX1008. EX1008 also includes a list of my publications.

3. I am currently Grainger Institute for Engineering Professor of Electrical and Computer Engineering at the University of Wisconsin-Madison. I received my Bachelor of Science Degree in Electrical Engineering from the University of Iowa in 1987; my Master of Science Degree in Electrical Engineering from Stanford University in 1990; and my Ph.D. degree in Electrical Engineering from Stanford in 1993. I teach several courses in my area of expertise, which includes high-frequency electrical measurement and communications systems and advanced high-frequency circuit design and measurement.

4. I teach courses such as ECE 447 Applied Communications Systems, which focuses on the hardware aspects of wireless communications systems and uses the text "Microwave Transistor Amplifiers: Analysis and Design," 2nd Ed., Guillermo Gonzalez, Upper Saddle River NJ: Prentice-Hall (1997); ECE 420 Electromagnetic Wave Transmission, which focuses on electromagnetic theory applied to waveguides, transmission lines and antennas and uses the text "Engineering Electromagnetics and Waves" (custom text containing chapters from both Engineering Electromagnetics and Electromagnetic Waves) by U. S. Inan and A. S. Inan (Pearson Custom); ECE 547 Advanced Communications Circuit Design, which focuses on wireless communication systems circuits, antennas and protocols, and uses the text "Microwave and RF Design of Wireless Systems," David Pozar (Wiley, 2001).

5. I perform research on digital radio and communications systems ranging from RFID tags to lightwave transceivers, with emphasis on wireless circuits, antennas, and microwave communications. Some of my work on antennas (e.g. for medical imaging and RFID) has been supported by the National Science Foundation and commercialized. Furthermore, as a consultant, I have performed research on antennas for clients such as JDS-Uniphase (evaluating flexible substrates and metal deposition techniques for suitability as printed RFID antennas), Berntsen (designing and developing antennas for geolocation and buried

asset marking) and Terso (designing and developing RFID antennas for low-temperature reagent and medical sample storage). I have also sold ultrabroadband antennas to medical imaging researchers through my startup, Tera-X, LLC.

6. I have published results of my work in several peer-reviewed journals and presented my findings at recognized conferences. Some representative publications related to performance of planar antennas and means of fabrication in the timeframe relevant to the ’149 patent include: M. Martinez and D.W. van der Weide, “Compact single-layer depolarizing chipless RFID tag,” Microw. Opt. Technol. Lett., 58, 1897–1900 (2016); H. Y. Chen, A. S. Bhadkamkar, T. H. Chou, and D.W. van der Weide, “Vector backscattered signals improve piggyback modulation for sensing with passive UHF RFID tags,” IEEE Transactions on Microwave Theory and Techniques, vol. 59, pp. 3538-3545 (2011); Chih-Chuan Yen, A.E. Gutierrez, D. Veeramani, and D.W. van der Weide (2007). Radar cross-section analysis of backscattering RFID tags. IEEE Antennas and Wireless Propagation Letters, 6(1), 279-81 (2007); H. Y. Chen, Y. W. Mak, S. Bae, A. Bhadkamkar, and D.W. van der Weide, “Wireless impedance measurement of UHF RFID tag chips,” in IEEE MTT-S International Microwave Symposium Digest (MTT), 2012, pp. 1-3; H. Y. Chen, S. Bae, A. Bhadkamkar, Y. W. Mak, and D.W. van der Weide, “Coupling passive sensors to UHF RFID tags,” in IEEE Radio and Wireless Symposium (RWS), 2012, pp. 255-258; Chih-Chuan Yen,

Dharmaraj Veeramani, Alfonso E. Gutierrez, and D.W. van der Weide, "RFID Tag Reading Effects of Cylindrical Conductive Packages," Proceedings of the 36th European Microwave Conference, pp. 733-736, Sept. 2006.

7. I am an expert in the field of antenna design and analysis with over two decades of experience spanning both academic research and industrial applications. My work has encompassed a wide range of antenna technologies, including planar, conformal, broadband, phased array, and near-field measurement systems. I have designed and optimized antennas for use in wireless communications, radar, medical devices, and sensing systems, often operating across challenging frequency regimes including UHF, microwave, and millimeter-wave bands. My academic contributions include numerous peer-reviewed publications on antenna characterization, impedance matching, radiation pattern synthesis, and electromagnetic simulation techniques.

8. Throughout my career, I have applied experimental, theoretical and computational methods to solve design antenna problems. This includes the use of full-wave electromagnetic solvers, analytical modeling, and inverse design approaches for optimizing radiation performance under real-world constraints. I have also developed and implemented measurement systems for validating antenna performance in both near-field and far-field configurations. In particular, I have led efforts to enhance near-field scanning and NF-to-FF transformations, which are

essential for characterizing large or high-frequency antennas in compact environments. These efforts have resulted in measurable improvements in characterization accuracy and throughput.

9. In addition to my technical work, I have served as a consultant and expert in matters involving antenna system performance, electromagnetic interference, and regulatory compliance. I have evaluated antenna-related claims in the context of intellectual property, product validation, and system interoperability. My combination of hands-on design experience, rigorous analysis capabilities, and familiarity with industry standards enables me to provide technically sound, legally defensible opinions on antenna-related technologies. I am a co-founder of ANTENNEX, B.V. (Eindhoven, Netherlands), which develops new characterization technologies for (especially) integrated antennas used in wireless devices, such as those in the patent.

II. MATERIALS REVIEWED AND CONSIDERED

10. I have reviewed the '149 patent, its prosecution history, and the prior art and other documents and materials cited herein. For ease of reference, the full list of documents that I have considered is in Appendix A: Materials Considered. I have also considered the documents cited and referenced herein, even if not included in the exhibit list below. Each of these exhibits is a type of document that experts in my field would have reasonably relied upon when forming their

opinions and would have had access to either through the applicable patent office and/or well-known libraries, conferences, publications, organizations, and websites in the field as further discussed herein.

11. My opinions, as explained below, are based on my years of education, research, experience, and background in the field of design and fabrication of planar antennas and their application in compact-format packages as well as my investigation and study of relevant materials for this declaration. When developing the opinions set forth in this declaration, I assumed the perspective of a person having ordinary skill in the art, as set forth in Section VI below. In forming my opinions, I have studied and considered the materials identified in the table in Appendix A.

III. MY UNDERSTANDING OF PATENT LAW

12. In developing my opinions, I discussed various relevant legal principles with Petitioners' attorneys. I understood these principles when they were explained to me and have relied upon such legal principles, as explained to me, in the course of forming the opinions set forth in this declaration. My understanding in this respect is as follows:

13. I understand that "post-grant review" (PGR) is a proceeding before the United States Patent & Trademark Office for evaluating the patentability of an

issued patent's claims based on, *inter alia*, prior-art patents and printed publications.

14. I understand that, in this proceeding, Petitioner has the burden of proving that the challenged claims of the '149 patent are unpatentable by a preponderance of the evidence. I understand that "preponderance of the evidence" means that a fact or conclusion is more likely true than not true.

15. I understand that, in PGR proceedings, claim terms in a patent are given their ordinary and customary meaning as understood by a person of ordinary skill in the art ("POSA") in the context of the entire patent and its prosecution history. If the specification or prosecution history provides a special definition for a claim term that differs from the meaning the term would otherwise possess, that special definition applies. If a claim element is expressed as a "means" for performing a specified function, I understand that it covers the corresponding structure described in the specification and equivalents of the described structure. I have applied these standards in preparing the opinions in this declaration.

16. I understand that determining whether a particular patent or printed publication constitutes prior art to a challenged patent claim can require determining the effective filing date (also known as the priority date) to which the challenged claim is entitled. I understand that for a patent claim to be entitled to the benefit of the filing date of an earlier application to which the patent claims

priority, the earlier application must have described the claimed invention in sufficient detail to convey with reasonable clarity to the POSA that the inventor had possession of the claimed invention as of the earlier application's filing date. I understand that a disclosure that merely renders the claimed invention obvious is not sufficient written description for the claim to be entitled to the benefit of the filing date of the application containing that disclosure.

17. I understand that for an invention claimed in a patent to be patentable, it must be, among other things, new (novel—or in other words not anticipated) and not obvious from the prior art. My understanding of these two legal standards is set forth below.

A. Anticipation

18. I understand that, for a patent claim to be "anticipated" by the prior art (and therefore not novel), each and every limitation of the claim must be found, expressly or inherently, in a single prior-art reference. I understand that a claim limitation is disclosed for the purpose of anticipation if a POSA would have understood the reference to disclose the limitation based on inferences that a POSA would reasonably be expected to draw from the explicit teachings in the reference when read in light of the POSA's knowledge and experience.

19. I understand that a claim limitation is inherent in a prior art reference if that limitation is necessarily present when practicing the teachings of the

reference, regardless of whether a person of ordinary skill recognized the presence of that limitation in the prior art.

B. Obviousness

20. I understand that a patent claim may be unpatentable if it would have been obvious in view of a single prior-art reference or a combination of prior-art references.

21. I understand that a patent claim is obvious if the differences between the subject matter of the claim and the prior art are such that the subject matter as a whole would have been obvious to a person of ordinary skill in the relevant field at the time the invention was made. Specifically, I understand that the obviousness question involves a consideration of:

- the scope and content of the prior art;
- the differences between the prior art and the claims at issue;
- the knowledge of a person of ordinary skill in the pertinent art; and
- if present, objective factors indicative of non-obviousness, sometimes referred to as "secondary considerations." To my knowledge, the Patent Owner has not asserted any such secondary considerations with respect to the '149 patent.

22. I understand that in order for a claimed invention to be considered obvious, a POSA must have had a reason for combining teachings from multiple

prior-art references (or for altering a single prior-art reference, in the case of obviousness in view of a single reference) in the fashion proposed.

23. I further understand that in determining whether a prior-art reference would have been combined with other prior art or with other information within the knowledge of a POSA, the following are examples of approaches and rationales that may be considered:

- combining prior-art elements according to known methods to yield predictable results;
- simple substitution of one known element for another to obtain predictable results;
- use of a known technique to improve similar devices in the same way;
- applying a known technique to a known device ready for improvement to yield predictable results;
- applying a technique or approach that would have been "obvious to try," such as choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success.
- known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art;

- some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior-art reference or to combine prior-art reference teachings to arrive at the claimed invention. I understand that this teaching, suggestion or motivation may come from a prior-art reference or from the knowledge or common sense of one of ordinary skill in the art.

24. I understand that a universal motivation known in a particular field to improve technology can provide a motivation to combine prior art references even without any hint or suggestion in the references themselves. I also understand that obviousness is determined in light of all the facts and that a given course of action often has simultaneous advantages and disadvantages, and that this does not necessarily obviate motivation to combine teachings from multiple references.

25. I understand that for a single reference or a combination of references to render the claimed invention obvious, a POSA must have been able to arrive at the claimed invention by modifying, implementing, or combining the teachings of the applied references.

C. Claim Interpretation

26. I understand that determining whether a claimed invention is novel and non-obvious requires comparing the prior art to the claims. In this section, I discuss the interpretations I have applied to certain claim terms in my analysis.

27. I have been informed that patent claims are construed from the viewpoint of a person of ordinary skill in the art at the time of the alleged invention. I have been informed that patent claims generally should be interpreted consistent with their plain and ordinary meaning as understood by a person of ordinary skill in the art in the relevant time period (at the time of the purported invention, or the so called "effective filing date" of the patent application), after reviewing the patent claim language, the specification, and the prosecution history (the intrinsic record).

28. I have further been informed that a person of ordinary skill in the art must read the claim terms in the context of the claim itself, as well as in the context of the entire patent specification. I understand that in the specification and prosecution history, the patentee may specifically define a claim term in a way that differs from the plain and ordinary meaning. I understand that the prosecution history of the patent is a record of the proceedings before the U.S. Patent and Trademark Office and may contain explicit representations or definitions made during prosecution that affect the scope of the patent claims. I understand that an applicant may, during the course of prosecuting the patent application, limit the scope of the claims to overcome prior art or to overcome an examiner's rejection, by clearly and unambiguously arguing to overcome or distinguish a prior art reference, or to clearly and unambiguously disavow claim coverage.

29. In interpreting the meaning of the claim language, I understand that a person of ordinary skill in the art may also consider "extrinsic" evidence, including expert testimony, inventor testimony, dictionaries, technical treatises, other patents, and scholarly publications. I understand this evidence is considered to ensure that a claim is construed in a way that is consistent with the understanding of those of skill in the art at the time of the alleged invention. This can be useful for technical terms whose meaning may differ from its ordinary English meaning. I understand that extrinsic evidence may not be relied on if it contradicts or varies the meaning of claim language provided by the intrinsic evidence, particularly if the applicant has explicitly defined a term in the intrinsic record.

30. I understand that determining whether a claimed invention is novel and non-obvious requires comparing the prior art to the challenged claim. In this Declaration, I apply the above standards to the terms in the challenged claims. The meanings of specific terms are discussed below in connection with evaluating the disclosure in the priority documents.

IV. DESCRIPTION OF THE RELEVANT FIELD AND THE RELEVANT TIMEFRAME

31. I have reviewed the '149 patent (EX1005) and its prosecution history (EX1006). I have been instructed by Petitioners' counsel to assume that the relevant timeframe for my analysis of the prior art is **on or before June 19, 2006**.

32. Based on my review of this material, I believe that the relevant general field for the purposes of the ’149 patent is wireless communication devices with integrated antennas. The ’149 patent pertains to the field of wireless communication devices—specifically, to portable, handheld terminals (e.g., smartphones, multimedia devices) that incorporate multiple-body configurations (such as clamshells, sliders, or pivoting devices) and integrated multi-band antenna systems for operation across cellular and other wireless bands.

33. This field includes: Electromagnetic and antenna design for handheld, compact, multi-body devices; Physical form factor integration of RF components to support multi-frequency operation (e.g., GSM, LTE, Wi-Fi, GPS, Bluetooth).

V. UNPATENTABILITY GROUNDS

34. I have considered these unpatentability Grounds:

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

35. I have been instructed by Petitioners’ counsel to assume that Dou (EX1013), Ciais-Multiband (EX1010), Hilgers (EX1040), Ciais-Quadband

(EX1009), Nakano (EX1012), Jing (EX1011), and Ying (EX1049) are each prior art to the Challenged Claims addressed in each respective Ground.

VI. PERSON OF ORDINARY SKILL IN THE ART ("POSA")

36. I have been informed and understand that for purposes of assessing whether prior art references disclose every element of a patent claim (thus "anticipating" the claim) and/or would have rendered the claim obvious, the patent and the prior art references must be assessed from the perspective of a person having ordinary skill in the art ("POSA") to which the patent is related, based on the understanding of that person at the time of the patent claim's priority date.

37. I have been informed and understand that various factors may be considered in assessing the level of a POSA, including (1) educational level of the inventor; (2) type of problems encountered in the art; (3) prior art solutions to those problems; (4) rapidity with which innovations are made; (5) sophistication of the technology, and (6) educational level of workers active in the field. I have also been informed and understand that not all of these factors may be present in every case, and one or more of these or other factors may predominate in a particular case. I have further been informed and understand that these factors are not exhaustive but are merely a guide to determining the level of ordinary skill in the art. I have applied this standard throughout my declaration.

38. The '149 patent involves technology in the field of portable, handheld terminals (e.g., smartphones, multimedia devices) that incorporate multiple-body configurations (such as clamshells, sliders, or pivoting devices) and integrated multi-band antenna systems for operation across cellular and other wireless bands. *See* EX1005, *passim*. I have been asked to provide my opinions as to the state of the art in this field before June 19, 2006. I use this time frame because I have been informed by counsel that Patent Owner Fractus's earliest-alleged conception date is June 19, 2006.

39. Fractus has defined a POSA as follows:

> [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). I agree with this definition of a POSA and have applied the above definition of a POSA in this declaration.

40. The basis for my familiarity with the level of ordinary skill is my own technical experience and my interaction with students and professionals in the field of compact, broadband planar antennas (and the field of antenna design more broadly) who were at this level of skill as of June 2006. I am well-aware of the

knowledge that a POSA would have had at the time this patent was written as I have been actively consulting, teaching, and carrying out research with such students and collaborators in these fields for approximately 15 years prior to June 2006.

41. My opinion identifying the POSA's level of ordinary skill is consistent with the problems encountered in the art, the prior art solutions to those problems, the rapidity with which innovations are made, the sophistication of the technology, and the educational level and professional capabilities of workers in the field. This is shown, among other things, by the prior art references described in the Grounds below.

42. By June 2006, the field of wireless communication devices—particularly handheld multimedia terminals and smartphones—had matured significantly. Manufacturers routinely confronted the challenge of integrating multi-band antennas into compact, user-friendly enclosures. A key problem was maintaining acceptable radio-frequency (RF) performance despite increasingly complex and miniaturized form factors, such as clamshells, sliders, and swiveling devices. These configurations often altered the electromagnetic environment in which antennas operated, introducing detuning effects and radiation pattern variability.

43. To address these challenges, the prior art included several approaches for integrating internal antennas within multi-body devices, as I discuss in detail below. Designers employed planar inverted-F antennas (PIFAs), monopoles, fractal geometries, and multi-feed structures to achieve broadband and multiband operation. Techniques such as antenna diversity, adaptive impedance matching, and spatial separation were well known to mitigate interference and optimize performance. The prior-art references I assert (alone or in combination), as well as numerous publications and commercial devices, demonstrate that antenna geometry could be adjusted parametrically to control metrics such as bandwidth, return loss, and gain across varying device orientations and enclosures.

44. The field of mobile RF antenna integration progressed rapidly during the 2000s and 2010s, fueled by intense commercial competition and evolving wireless standards (e.g., GSM, UMTS, LTE, Wi-Fi, Bluetooth, GPS). Each new smartphone generation typically introduced novel mechanical designs and antenna layout strategies to accommodate additional frequency bands, more transceivers, and evolving SAR (specific absorption rate) requirements. Academic and industrial research routinely reported new methods for compact, multiband antennas using simulation-driven optimization, materials engineering, and hybrid mechanical-electromagnetic co-design.

45. Simulation tools such as CST Microwave Studio, HFSS, and ADS Momentum became standard in the design process, allowing engineers to evaluate full-wave 3D antenna performance under a variety of boundary conditions, including open and closed device states. The field demanded a high level of integration between industrial design, RF engineering, and mechanical packaging, and it attracted a globally competitive workforce pushing continuous incremental improvements.

46. By June 2006, I possessed at least the level of skill of a POSA to which the ’149 patent is directed.

47. I have worked with many people who fit the characteristics of the POSA, and I am familiar with their level of skill in and around June 2006. When developing the opinions set forth in this declaration, I assumed the perspective of a POSA as set forth above

48. Except as noted below, whenever I offer an opinion in this declaration about the knowledge of a POSA, the manner in which a POSA would have understood the claims of the ’149 patent or its description, the manner in which a POSA would have understood the prior art, or what a POSA would have been led to do based on the prior art, I am referencing the June 2006 timeframe, even if I do not say so specifically in each case.

VII. '149 PATENT[1]

49. The '149 patent concerns a "multifunction wireless device" with "smartphone functionality" that has an "antenna system." EX1005, Abstract. The wireless device comprises a "ground plane" and "first" and "second" antennas. The specification describes a wireless device having multiband antennas (antennas covering multiple frequency ranges associated with communication standards), and having antennas that cover different frequency ranges. EX1005, 9:59-10:39, 25:14-30, 25:61-26:5.

50. The '149 patent states that the wireless device is preferably capable of communicating (has "wireless connectivity") using several different communication standards that use frequency bands in several different frequency ranges. EX1005, 9:59-10:39, 25:14-30, 25:61-26:5. Thus, the '149 patent describes using antennas, including multiband antennas, that are designed to send and receive electromagnetic signals in frequency ranges used by the frequency bands for these communication standards. EX1005, 12:34-36 ("A structure of [the invention's] antenna system... is able to support different radiation modes."), 13:35-38 ("The resulting antenna structure… includes a plurality of portions that allow the operation of the antenna system in multiple frequency bands.").

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[1] Throughout this Declaration all emphasis is added unless otherwise indicated.

51. The ’149 patent asserts that the antenna system’s design “is intended to use efficiently as much of the volume” within a defined space “in order to obtain a 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 defines 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* §§IX.D.9; XI.B.8, XI.G.8.

52. 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.

53. 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, 19:27-31. The complexity factor F_{21} “is related to the number of paths that [an antenna system] structure… provides to electric currents… to excite

radiation modes…. In general, the more frequency bands and/or radiation modes that need to be supported by the antenna structure… the higher the value of F_{21} that needs to be attained." EX1005, 19:49-61.

54. The "[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 patent suggests that an "antenna contour" with "complexity factor F_{32} larger than a certain minimum value" will "achieve some degree of miniaturization" but may have "reduced capability to operate in multiple frequency bands and/or limited RF performance." EX1005, 20:62-21:7. The specification asserts that "effective antenna design" is achieved by specifying antenna complexity factors using any combination of F_{32} values between 1.10 and 1.90 in 0.05 increments, and F_{21} values between 1.05 and 1.80 in 0.05 increments. EX1005, 21:12-27.

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

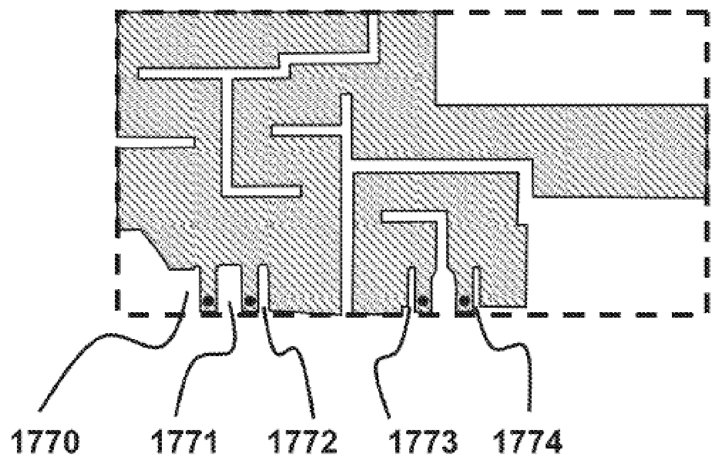


FIG. 17H

56. 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 and receive electrical signals that the antenna converts to RF radiation. EX1005, 2:9-11.

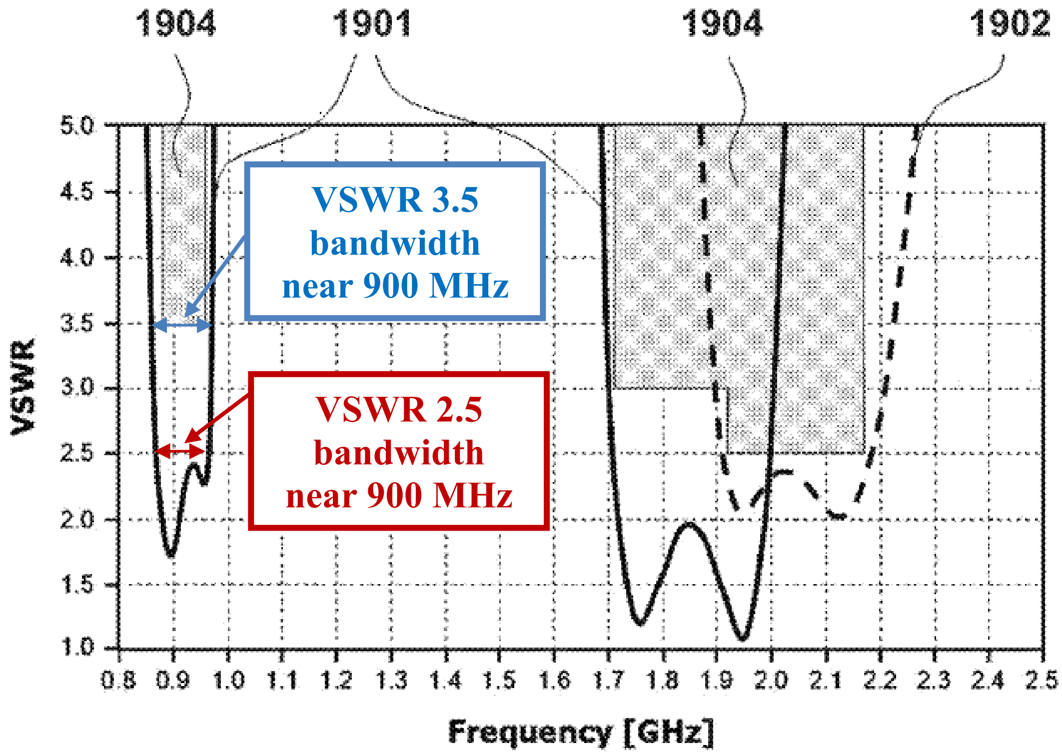


FIG. 19A

57. 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. 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. 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.

58. 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. Challenged Claims

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

60. 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]).

61. 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]).

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

VIII. CLAIM INTERPRETATION

63. I apply relevant claim constructions below in relation to the claim elements in which they appear. Where I do not discuss a particular claim construction, I apply the ordinary meaning that the claim term would have had to a POSA at the time of invention.

64. I understand that the '149 patent expressly defines several claim terms—e.g., "*antenna rectangle*," "*complexity factor*," and others—whose construction is discussed below.

65. I also understand that in litigation with ADT, Fractus argued constructions for (and the court construed) common claim terms from the '149 patent. EX1020, 1; EX1005, code (63).

66. In forming my opinions, I applied the claim constructions described below, as directed by Petitioners' counsel.

A. "*perimeter*" (all claims)

67. 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. In my opinion, a POSA would have agreed with the court's construction of "*perimeter*" in the ADT litigation.

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

68. 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.

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

69. "[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.

70. 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°.

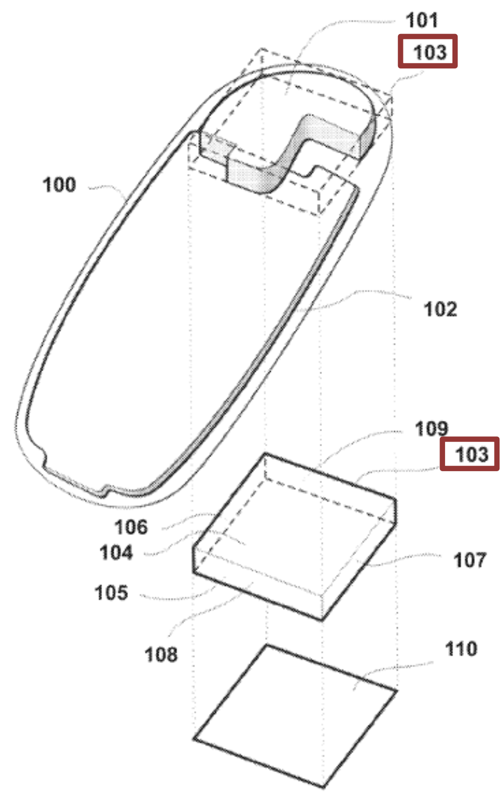


FIG. 1B

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

D. "*first contour*" (all claims)

71. 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].

72. 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)

73. 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.

74. 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.

IX. GROUND 1A: DOU+CIAIS-MULTIBAND RENDERS OBVIOUS CLAIMS 7-9, 11-14, 16-17, AND 19-20

A. Dou (EX1013)

75. Dou describes a wireless handheld device with an internal diversity antenna architecture for wireless devices having three or more antennas. Dou, Abstract, [0015], [0040]. Dou describes locating a first antenna substantially near the top—and a second antenna located substantially near the bottom—of a device housing and/or internal PCB. Dou, Figs. 2A-2B (below), [0017], [0032], [0040].

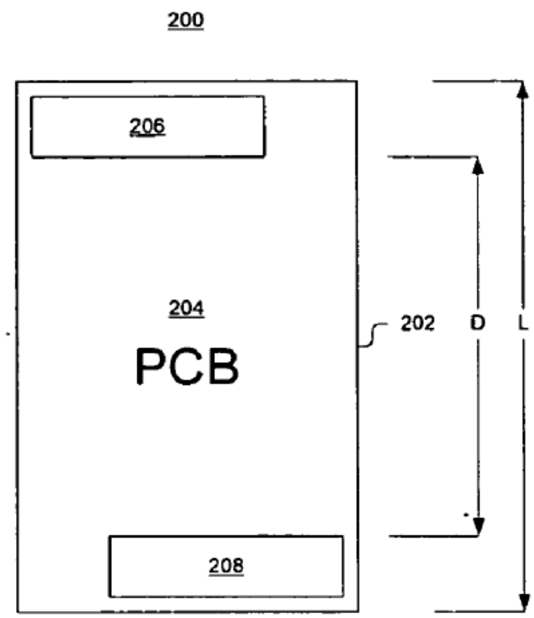


FIG. 2A

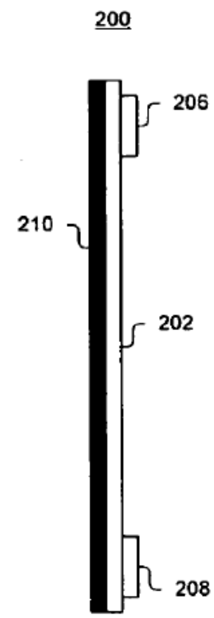


FIG. 2B

76. Antenna diversity refers to the use of multiple antennas within a communication system to improve signal reliability and quality. A diversity architecture such as that described in Dou can be implemented in various forms: spatial diversity (using physically separated antennas), pattern diversity (using antennas with different radiation patterns), and/or polarization diversity (using orthogonally polarized elements). These architectures can mitigate the effects of multipath fading, a phenomenon where signal reflections cause destructive interference at the receiver. By receiving multiple versions of the same signal through independent channels, a diversity architecture can select or combine the strongest signal, significantly improving reception quality, reducing bit error rate, and enhancing link robustness. Diversity is especially beneficial in mobile and

indoor environments where signal conditions can change rapidly due to movement, obstruction, or reflection. Indeed, I worked with diversity architectures in my first position at Motorola using automotive cellular radio.

77. Dou describes using antennas tuned for operating at multiple frequency ranges associated with several different services including, e.g., GSM, PCS, WCDMA/UMTS, GPS, NAMPS, “WiFi,” and Bluetooth. Dou, [0022]. The antennas “may be implemented using any type of suitable internal antenna” (Dou, [0028]) and can be of different types. Dou, [0034]. Dou’s wireless device can also include “an additional antenna” of “any suitable type… disposed within the housing[.]” Dou, [0040].

B. Ciais-Multiband (EX1010)

78. 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).

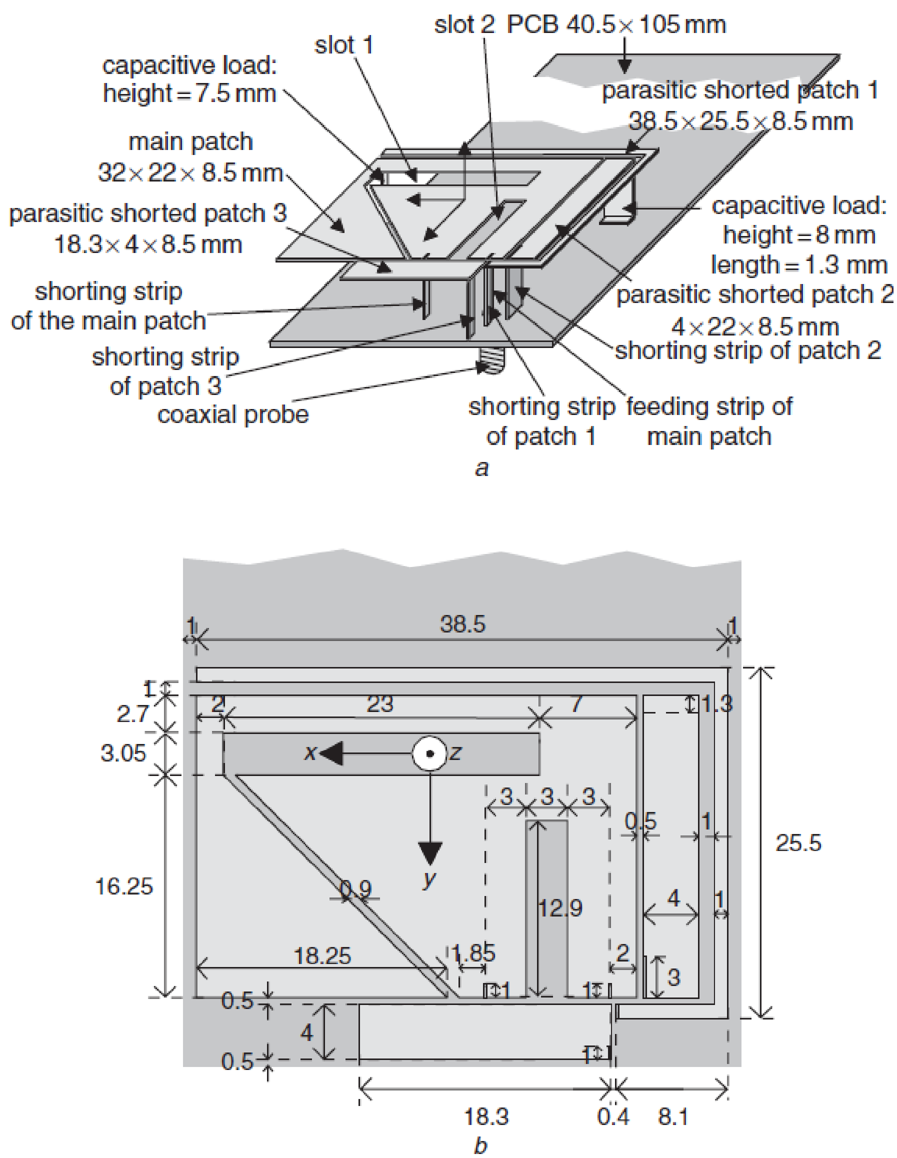


Fig. 1 *3D view of multiband antenna*
a 3D view *b* Top view (all dimensions in millimetres)

79. 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).

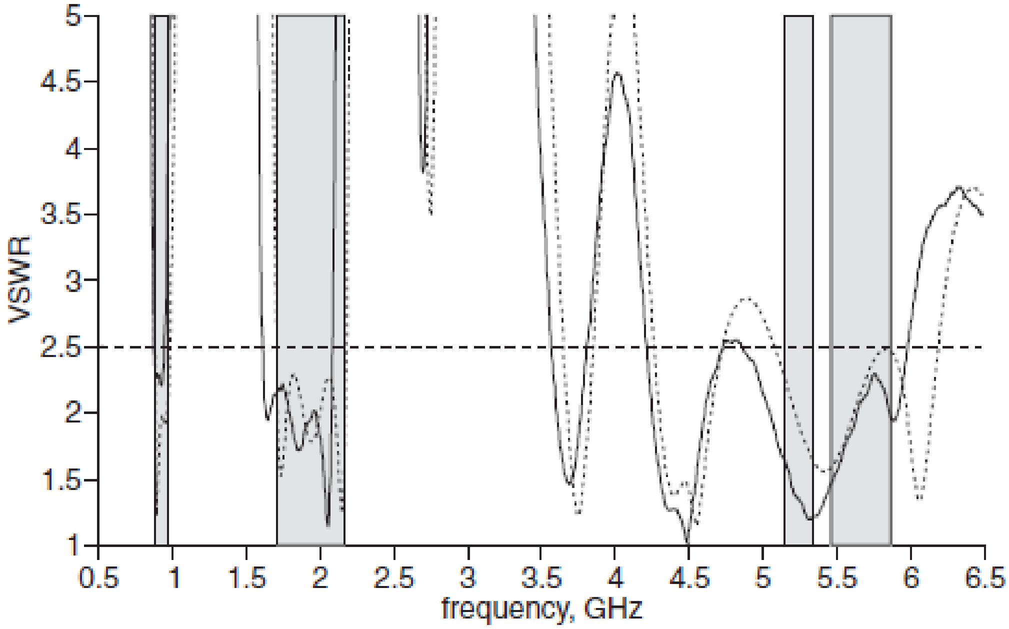


Fig. 2 *Measured and simulated VSWR of multiband antenna*
Standards bandwidth requirement in grey
—— measurement ------ simulation

80. Voltage Standing Wave Ratio or "VSWR" is defined as: VSWR = (1 + |Γ|) / (1 - |Γ|), where Γ is the reflection coefficient at the feed point and |Γ| ranges from 0 (perfect match) to 1 (total reflection). VSWR is used to evaluate how efficiently an antenna is impedance matched to the transmission line or system it is connected to—typically a coaxial cable and a radio transmitter or receiver. It is a dimensionless ratio that quantifies the amount of reflected power due to impedance mismatch between the antenna and the transmission line. When an RF signal is transmitted down a cable to an antenna, maximum power transfer occurs when the antenna's impedance matches the transmission line's characteristic impedance,

often 50 ohms. If there is an impedance mismatch, some of the signal is reflected back toward the source, creating a standing wave pattern along the line.

81. Acceptable VSWR values for an antenna range from 1.0:1 (perfect match (no reflection)) to > 3.5:1 (significant mismatch, poor efficiency). According to the ’149 patent’s Table 1, e.g., the “maximum VSWR allowed” for GSM900 is 3.5:1 while the maximum for UMTS is 2.5:1. EX1005, 37:41, 40:63-66, Fig. 19A. According to Ciais-Multiband, a VSWR of 2.5:1 offers “good efficiency” for various wireless communications standards. Ciais-Multiband, 921.

82. The VSWR graph in Ciais-Multiband’s Figure 2 (annotated detail below) “shows the measured and simulated VSWRs of [its] antenna” with the measured results using a solid line, the simulated results using a dashed line, and each “Standards bandwidth requirement in grey.” Ciais-Multiband, 920, Fig. 2. The blown-up portion of Figure 2 shows the GSM frequency band (880-960 MHz) in grey and the measured results (solid line) at VSWR of 3.5 spanning the range of at least 870 MHz to GSM900’s upper boundary of 960 MHz, thus satisfying the “maximum VSWR allowed” for the GSM900 frequency band of 3.5:1.

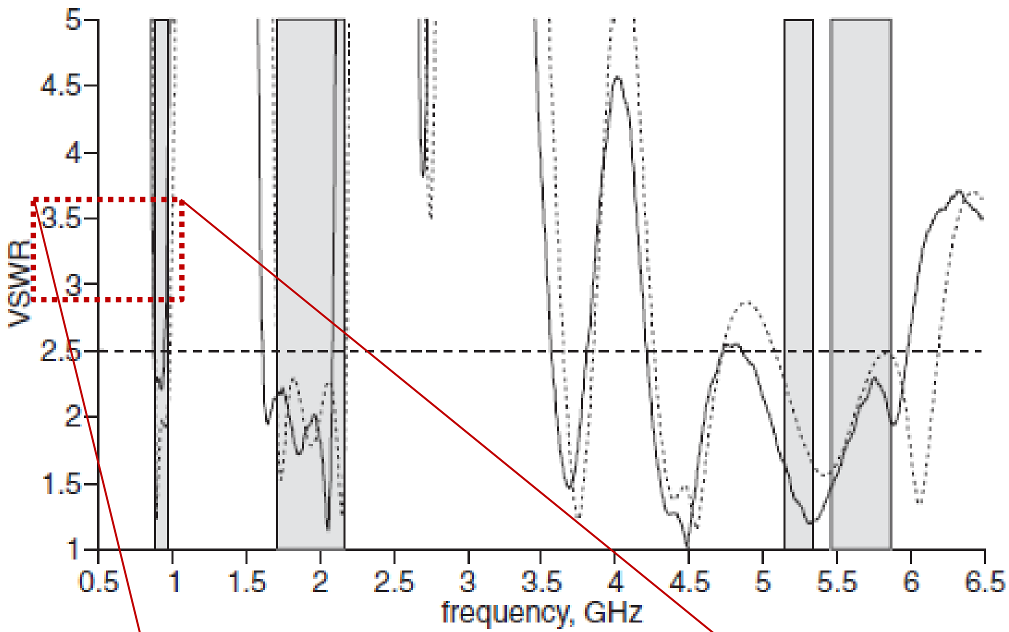
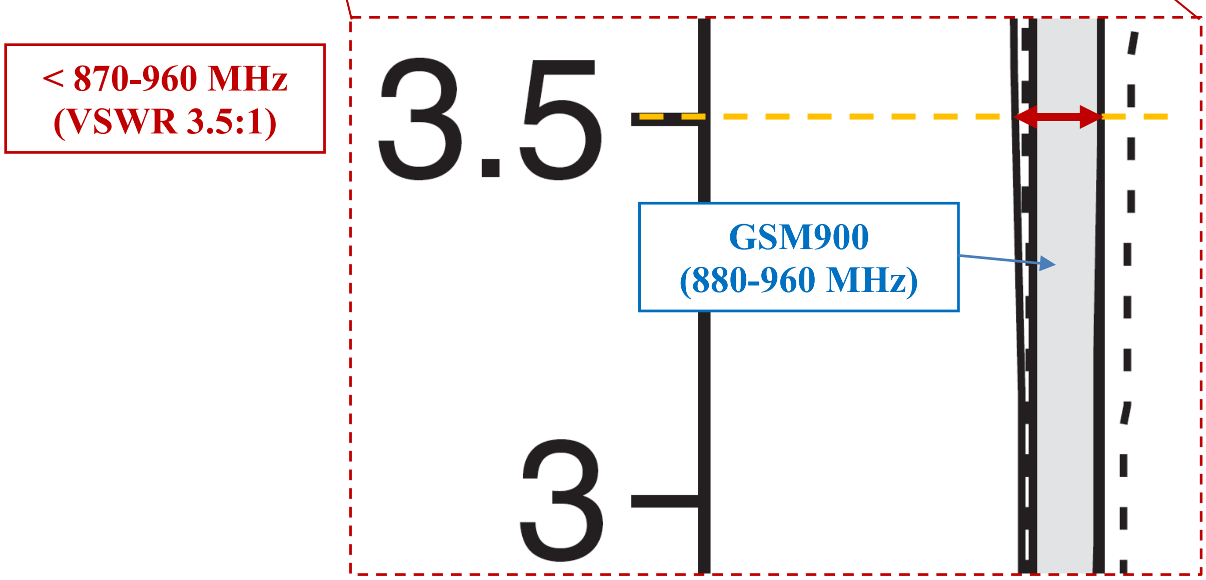


Fig. 2 *Measured and simulated VSWR of multiband antenna*

Standards bandwidth requirement in grey

—— measurement ------ simulation



83. Ciais's multiband antenna thus provides operation at 1710-1990 MHz (e.g., for DCS1800 (1710-1880 MHz) and PCS1900 (1850-1990 MHz)) and at

4863-5991 MHz (e.g., for wireless networking (WLAN) at 5 GHz ISM bands (5150-5350 MHz and 5470-5725 MHz) used by IEEE Std. 802.11a and HiperLAN/2) with VSWR 2.5:1. Ciais-Multiband, 920-921, Fig. 2; EX1030, 8-9. HiperLAN/2 is a European WLAN standard by ETSI that is similar to IEEE Std. 802.11a. Ciais's multiband antenna also covers 870 to 960 MHz (e.g., for extended (880-960 MHz) and standard (890-960 MHz) GSM900) with a VSWR of 3.5:1. Ciais-Multiband, 920-921, Fig. 2 (annotated detail above); EX1030, 8-9.

C. Dou+Ciais-Multiband

84. 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.

85. 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.

86. 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 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). EX1030, 8-9; *supra* §IX.B (Ciais-Multiband). 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).

87. 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 (*supra* §IX.B (Ciais-Multiband)), comporting with Dou's description of device antennas supporting wireless networking. Ciais-Multiband, 920-921, Fig. 2; Dou, [0022].

88. 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.

89. 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]). Dou describes antenna placement within the device according to "various performance and design constraints" known to a POSA. Dou, [0030]. 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]. 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].

90. 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 shown below.

D. Claim 7

1. Preamble [7.PRE]

[7.PRE]	A wireless device comprising:

91. 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* §IX.C (combination).

2. Limitation [7.a]

[7.a]	a ground plane;

92. 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).

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,

93. 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.

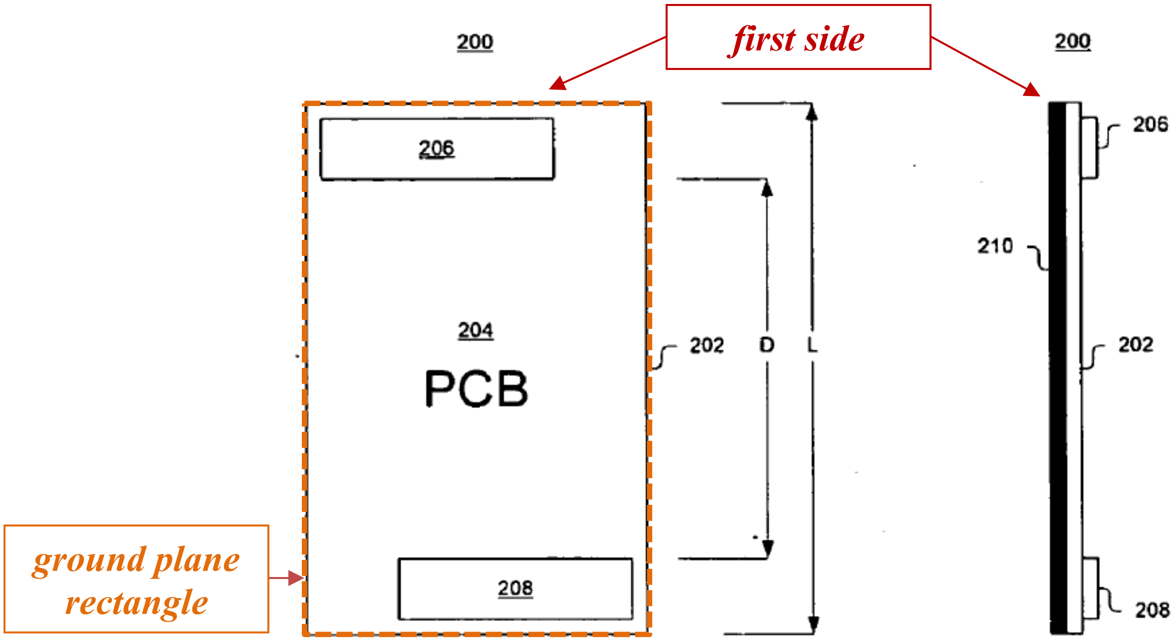
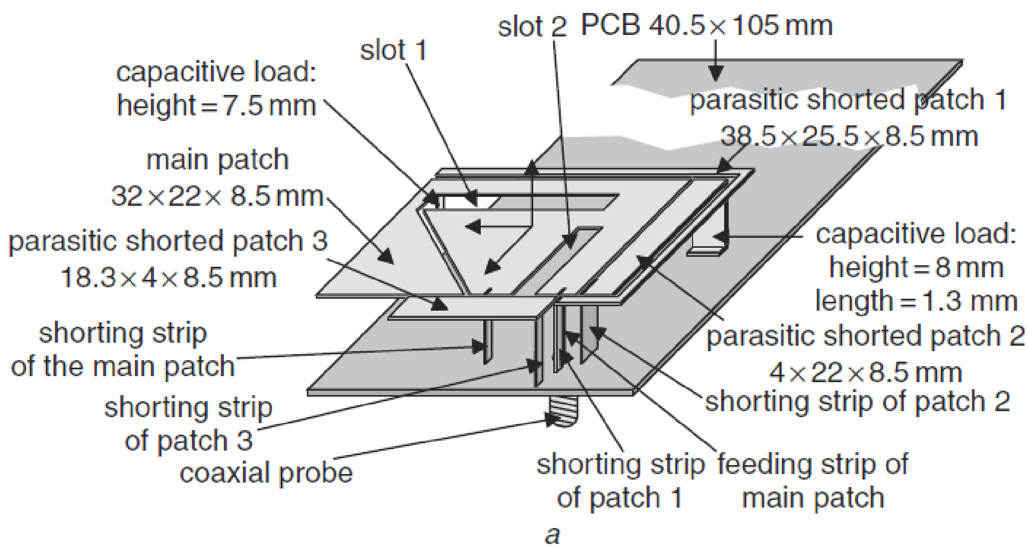


FIG. 2A FIG. 2B

94. 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]. 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.



95. 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].

4. Limitation [7.c]

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

96. 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* §§IX.B (Ciais-

Multiband), IX.C (combination). 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).

97. 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. Ciais's multiband antenna is "*configured to support*" at least **twenty-four** (**24**) "*frequency bands*" that are defined in the supported frequency ranges, as I discuss in detail below.

98. 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.

99. 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).

100. 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). U-NII refers to unlicensed national information infrastructure, a portion of the electromagnetic spectrum that the Federal Communication Commission (in the United States) allocates for wireless communication and is used by WLAN. The U-NII upper band is sometimes referred to as 5725-5825 MHz, and sometimes as 5725-5850 MHz. IEEE Std. 802.11a-1999 (EX1042) refers to it as 5725-5825 MHz, which is the range I specified in the table above.

a. UMTS background

101. As background, UMTS (Universal Mobile Telecommunications System) was a 3G mobile communication standard standardized by 3GPP as the successor to GSM. It introduced WCDMA (Wideband Code Division Multiple Access) as the radio access technology and featured both circuit-switched and packet-switched domains. HSDPA (High-Speed Downlink Packet Access) is an enhancement to UMTS introduced in 3GPP Release 5, often referred to as 3.5G (although the '149 regards it as 4G). It improves downlink speeds through advanced scheduling, adaptive modulation and coding, and Hybrid ARQ mechanisms. HSDPA is fully integrated into the UMTS framework and uses the same Node B (base station) and frequency bands.

102. Like LTE that followed it, UMTS typically operated in paired FDD bands, where uplink and downlink transmissions occur in separate frequency ranges. EX1033, 12-13 (Table 5.0 "UTRA FDD frequency bands"). These paired bands allow simultaneous two-way communication using separate frequencies. Some UMTS deployments also use TDD (Time Division Duplexing), where uplink

and downlink share the same frequency but are separated in time. EX1034, 11 (UTRA/TDD frequency bands).

b. LTE background

103. As background, 3GPP Release 8 ("LTE") replaced older circuit-switched architectures with a flat, packet-based core network called the Evolved Packet Core (EPC). The radio access component, known as Evolved-UTRA (E-UTRA), introduced a new air interface using OFDMA in the downlink and SC-FDMA in the uplink, offering improved spectral efficiency, higher throughput, and scalable bandwidths.

104. The LTE architecture includes E-UTRAN, composed of base stations (eNodeBs) that communicate directly with user equipment (UE). LTE does away with traditional circuit-switched voice, instead handling all services over IP. The 3GPP specifications define physical layer, RF requirements, and network interfaces across multiple documents (e.g., TS 36.101, 36.211). E-UTRA was designed as an evolution of UMTS, and even in 2006 it was widely understood by a POSA to be the basis for the upcoming 4G systems, despite the formal ITU definition of 4G arriving later. LTE typically uses Frequency Division Duplexing (FDD), which separates uplink and downlink transmissions into distinct frequency sub-bands. These bands are quoted with full frequency ranges for both uplink and downlink (e.g., Band 3: 1710–1785 MHz UL, 1805–1880 MHz DL) to ensure

device compatibility, regulatory compliance, and efficient spectrum planning. EX1025, 13, Table 5.5-1 ("E-UTRA operating bands" defining LTE bands); EX1026, 11 (listing LTE FDD and TDD bands); EX1039, 497-502 (LTE bands).

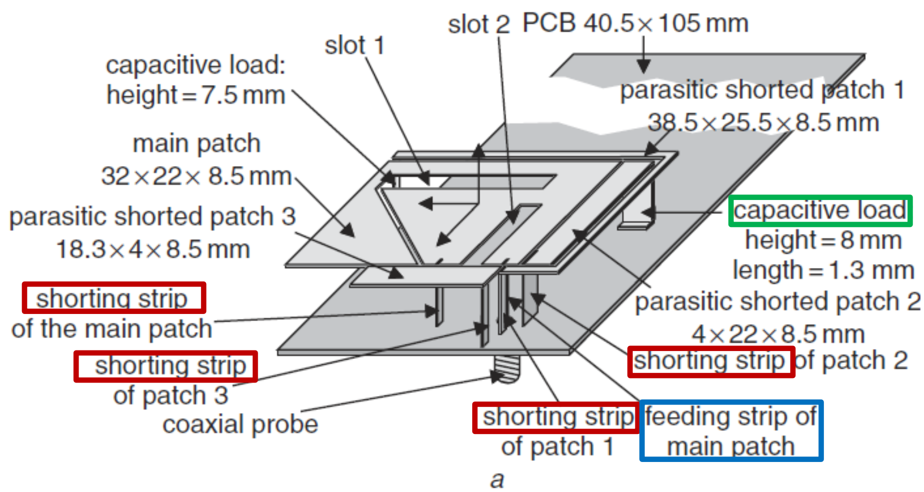
105. Devices must support both sub-bands in hardware, and the duplex spacing impacts filter design, duplexers, and interference management. Some LTE bands use Time Division Duplexing (TDD), sharing a single frequency band across time-separated uplink and downlink slots.

106. 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.

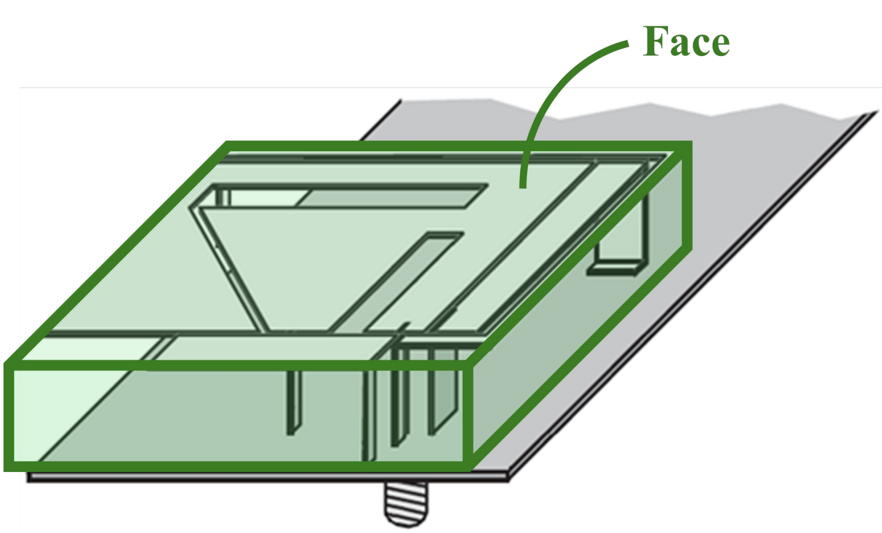
5. Limitation [7.d]

[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;

107. Ciais's multiband antenna is "*non-planar*" because it comprises antenna elements that are not contained within a single plane. 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."



108. 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" the Ciais multiband antenna ("*first non-planar antenna*") as shown below. Ciais-Multiband, Fig. 1(a) (annotated below); *supra* §VIII.C; EX1005, Fig. 1B, 11:35-49. The multiband antenna's "main patch" provides the parallelepiped with a "*face with a largest area*."



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;

109. 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].

110. 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* §IX.D.3 ([7.b]); Dou, Fig. 2A, [0016]-[0017].

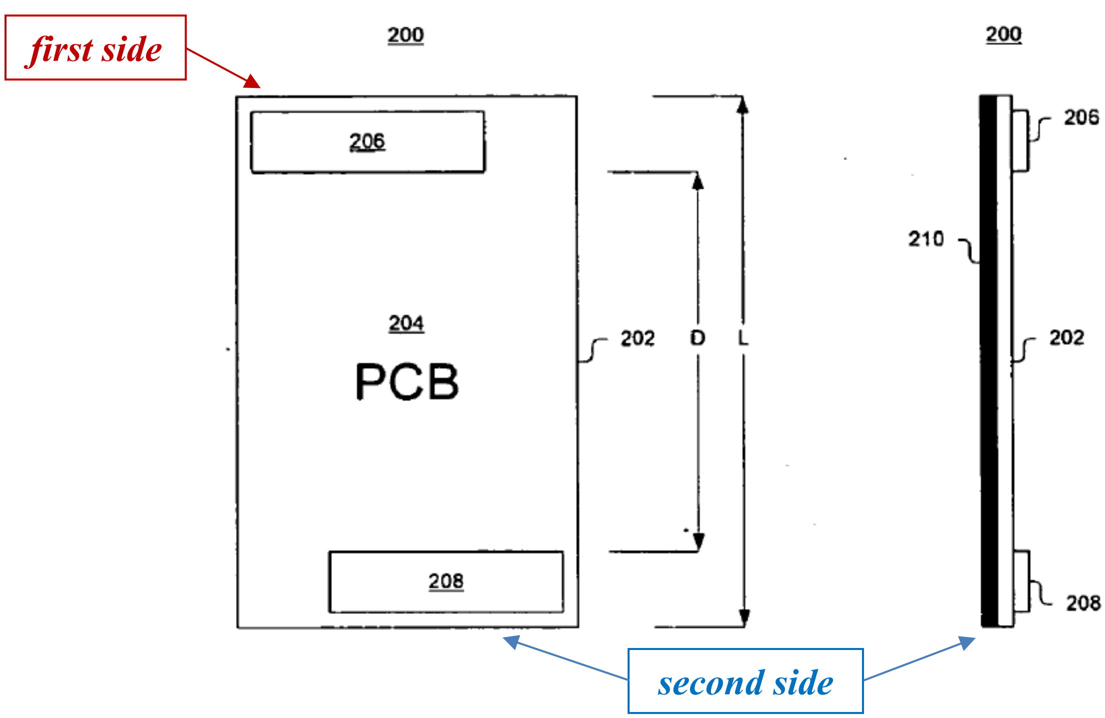


FIG. 2A FIG. 2B

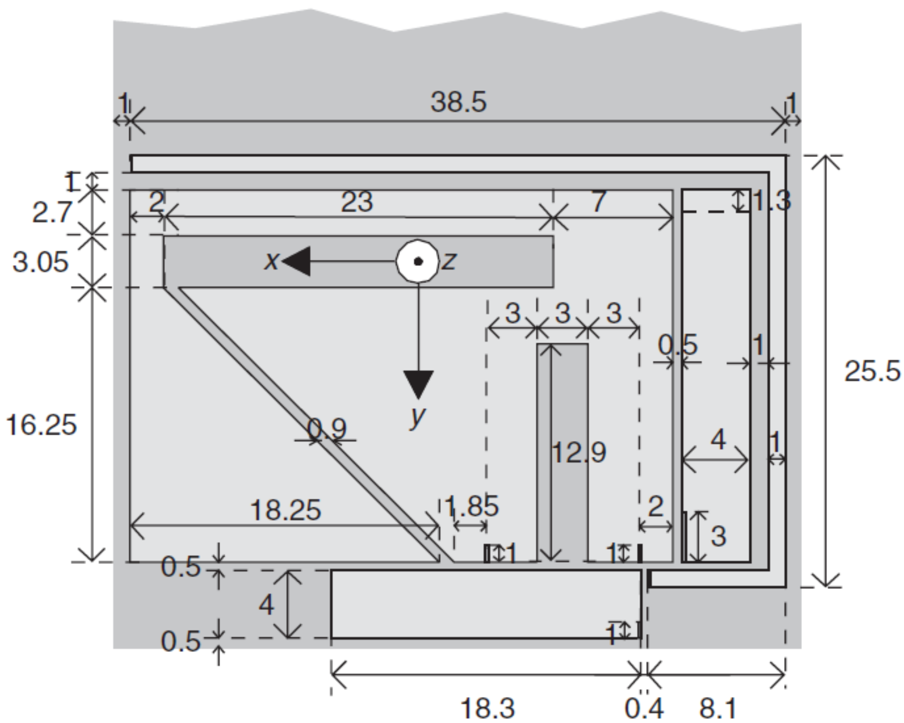
111. Dou+Ciais-Multiband meets the rest of [7.e] because the multiband antenna implementing Dou antenna 208 (*second antenna*) covers the same frequency bands as the multiband antenna implementing Dou antenna 206 (*first antenna*) *supra* §IX.D.4 ([7.c]).

7. Limitation [7.f]

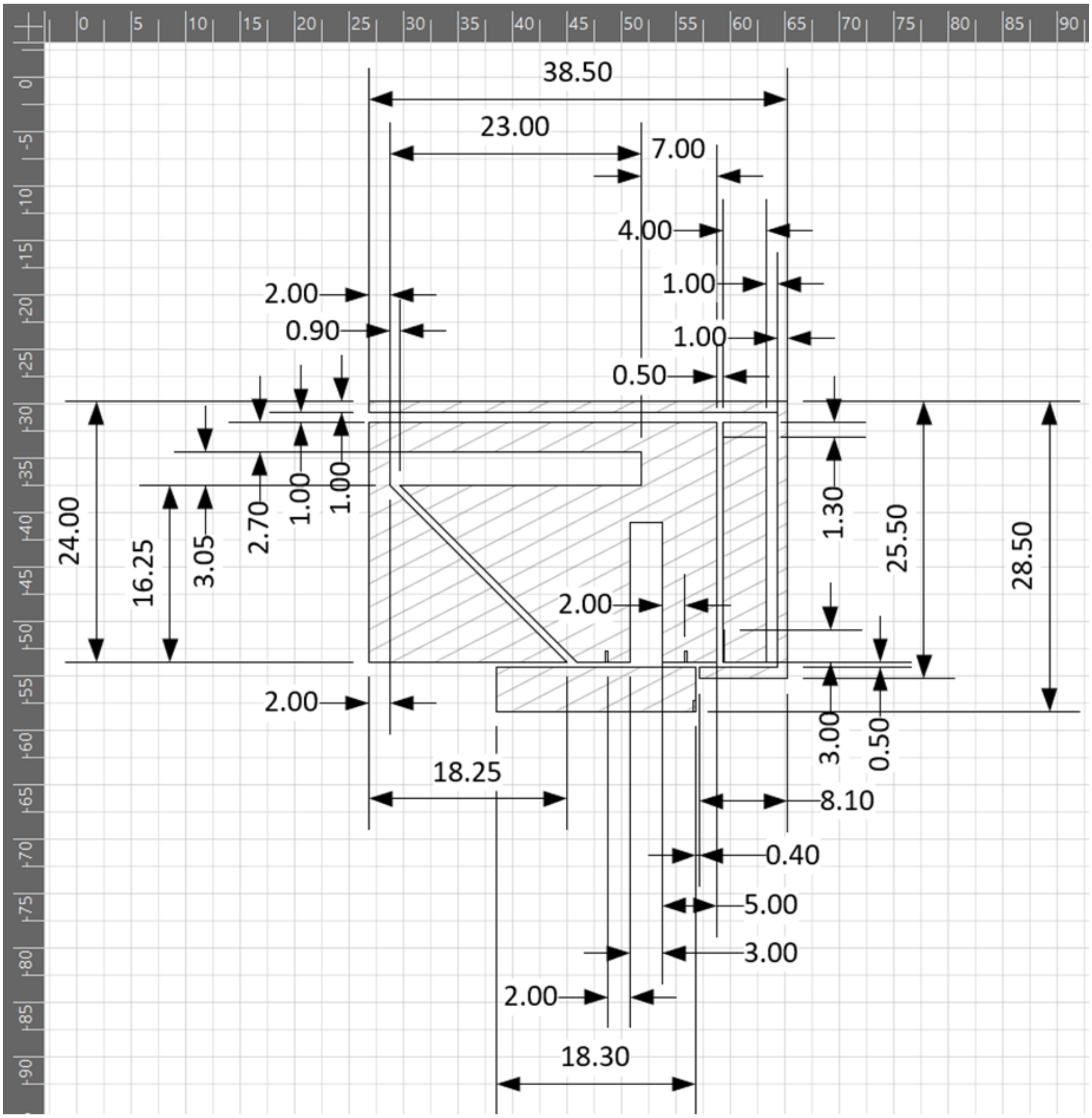
[7.f]	wherein the first non-planar antenna has a first contour defined as **[1]** a perimeter of any portions of the first non-planar antenna arranged in the face, **[2]** perimeters of any closed apertures of any portions of the first non-planar antenna arranged in the face, **[3]** a perimeter of an 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;

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

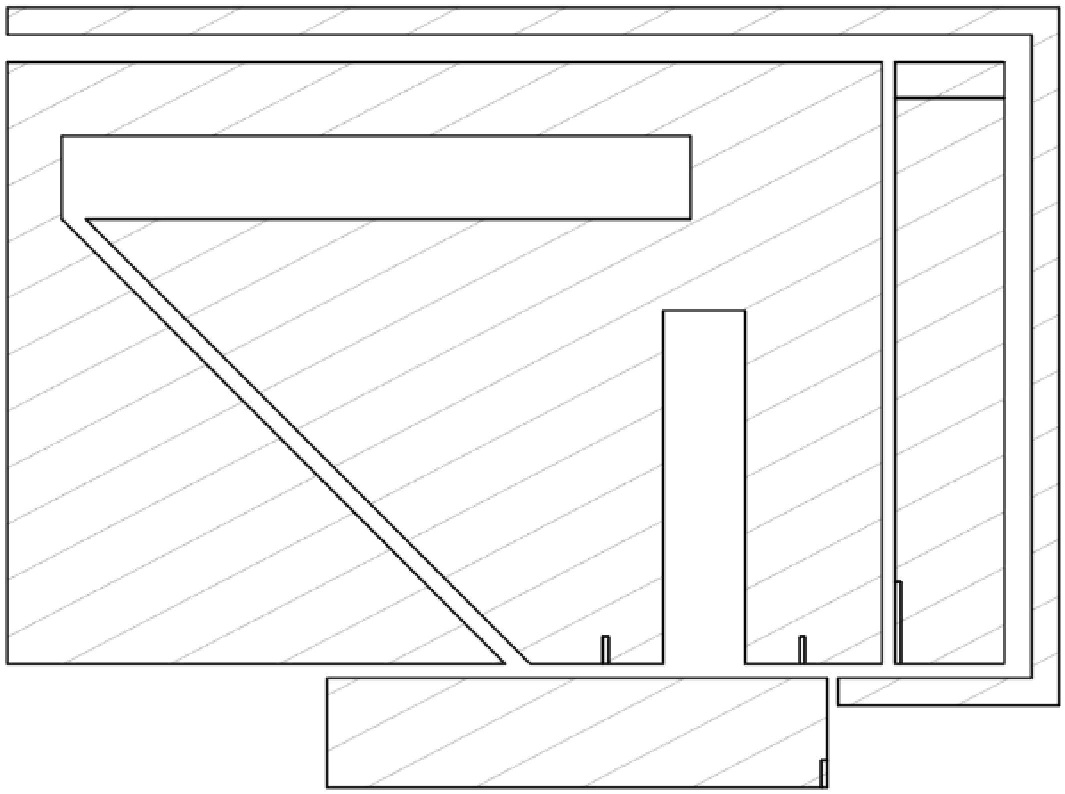
113. The Ciais multiband antenna implementing Dou's antenna 206 ("*first non-planar antenna*) has a "*first contour*" meeting [7.f] as shown below. Ciais's Figure 1(b) shows the antenna element dimensions including orthogonal projections of the out-of-plane antenna elements. Ciais-Multiband, Figs. 1(a)-1(b).



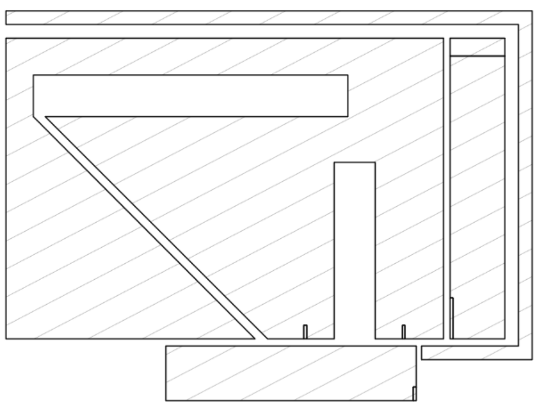
114. Using Ciais's description the antenna contour is produced to scale as follows, with dimensions in mm.



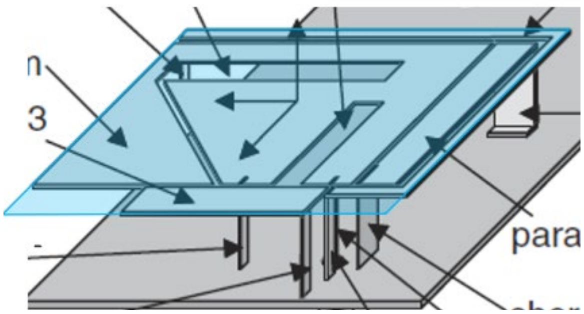
115. The multiband antenna's "*first contour*" is:



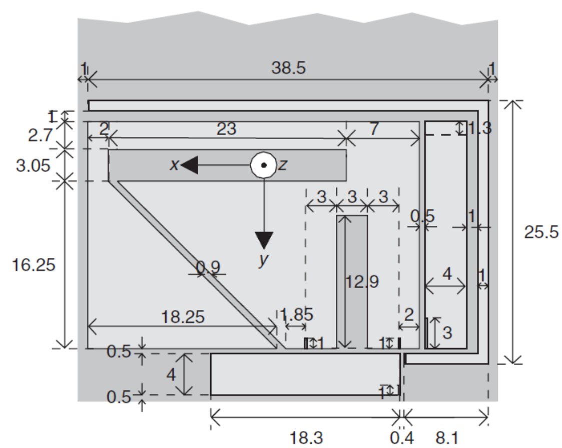
116. This *first contour* includes **[1]** the *perimeter* of all antenna elements (*portions*) in the plane of the multiband antenna's main patch (e.g., *arranged in the face*). Ciais-Multiband, Figs. 1(a) (annotated detail below top right), 1(b).



first contour

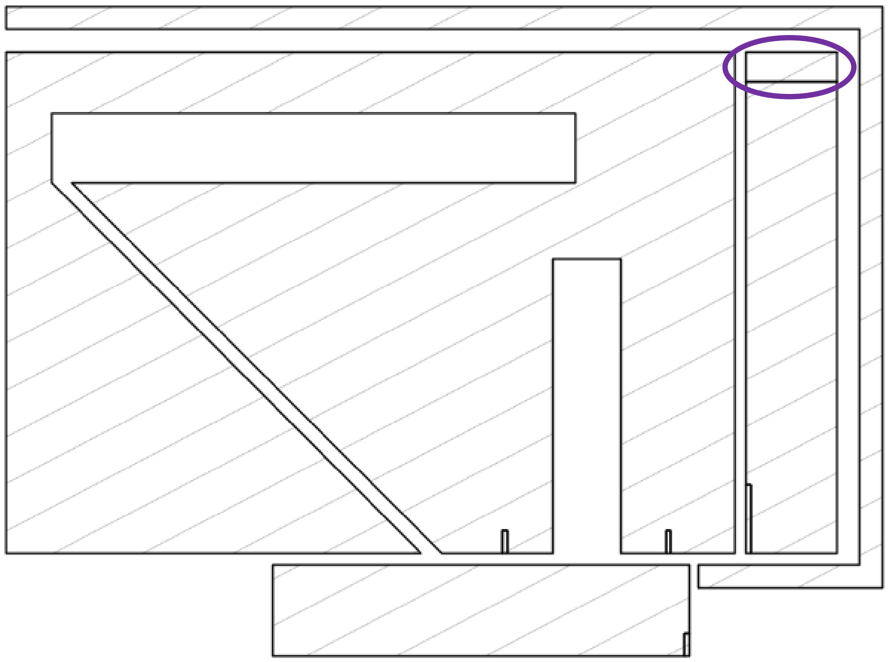


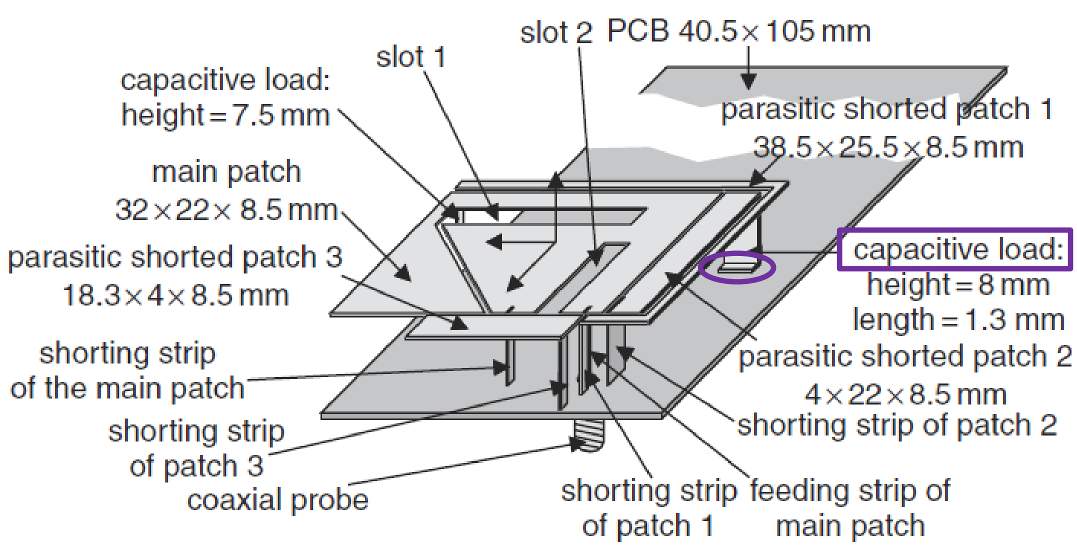
Ciais-Multiband Fig. 1(a)



Ciais-Multiband Fig. 1(b)

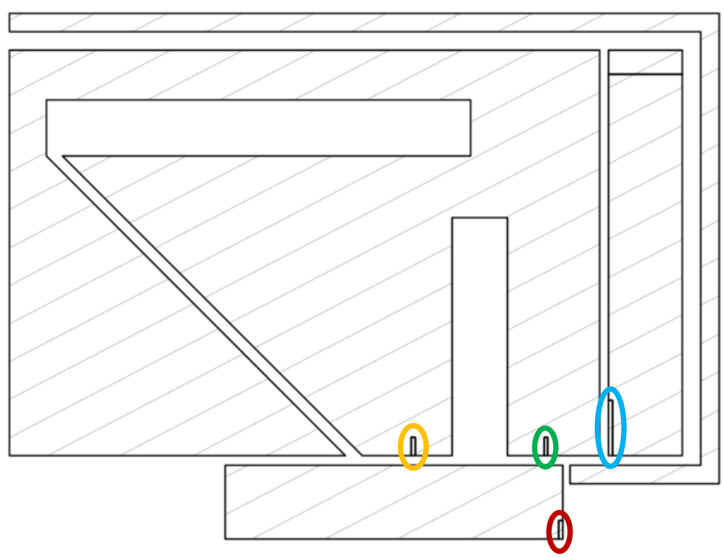
117. The *first contour* also includes **[3]** the *perimeter* of an *orthogonal projection* of the capacitive load (e.g., a *portion… not arranged in the face*), as highlighted below. Ciais-Multiband, 920, Figs. 1(a), 1(b).

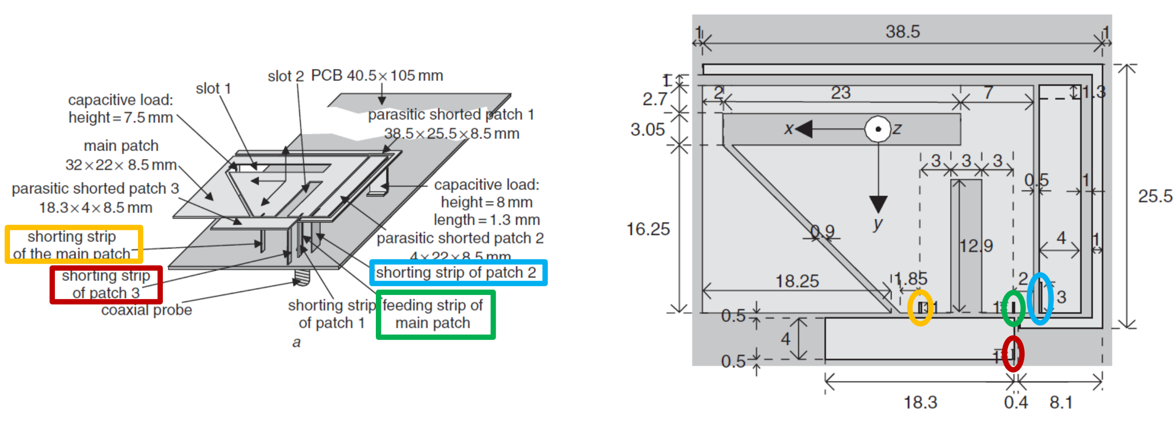




a

118. 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).





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

119. Dou+Ciais-Multiband meets [7.g] because the multiband antenna's contour ("*first contour*"), *supra* §IX.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.

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

120. 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]).

121. 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,

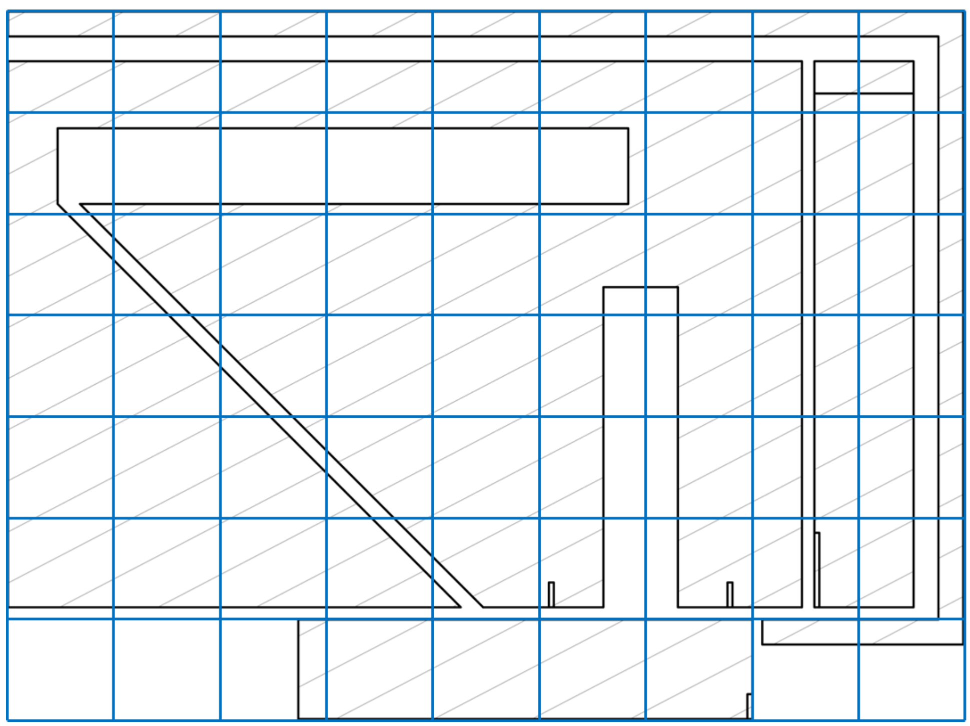
122. The antecedent for "*the face*" is "*the minimum-sized parallelepiped having a face with a largest area*" in [7.d]. However, [7.h.1] requires counting cells of a grid that include at least a point of an antenna *contour*, which according to [7.f] is formed by perimeters and orthogonal projections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

123. 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 $\left(\frac{38.5mm}{9}\right) = 4.28\,mm.$

124. 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).

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

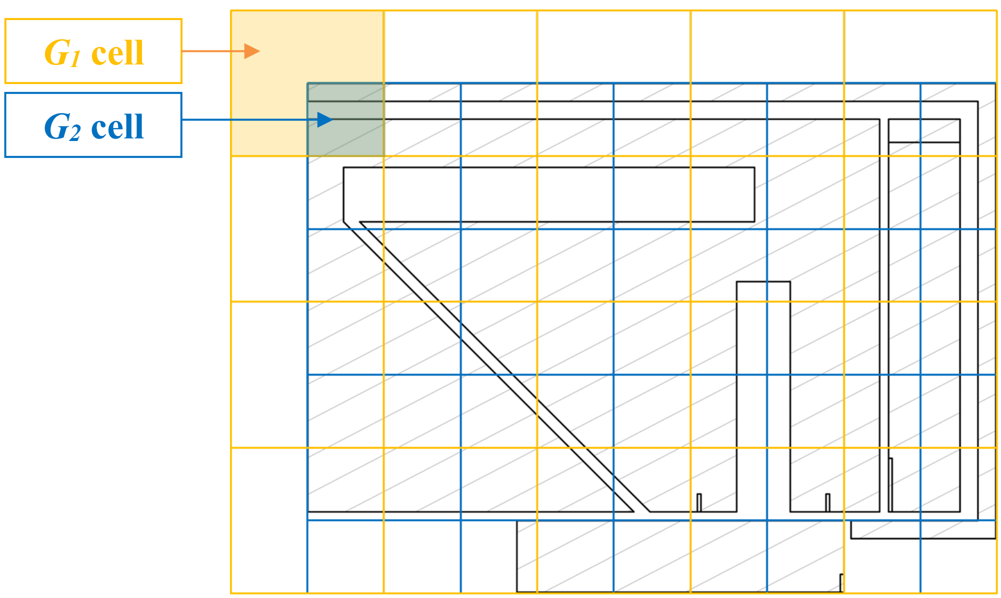


125. Thus, grid G_2 has 7 rows by 9 columns and "tessellates" the *first contour* as shown above (blue outline).

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

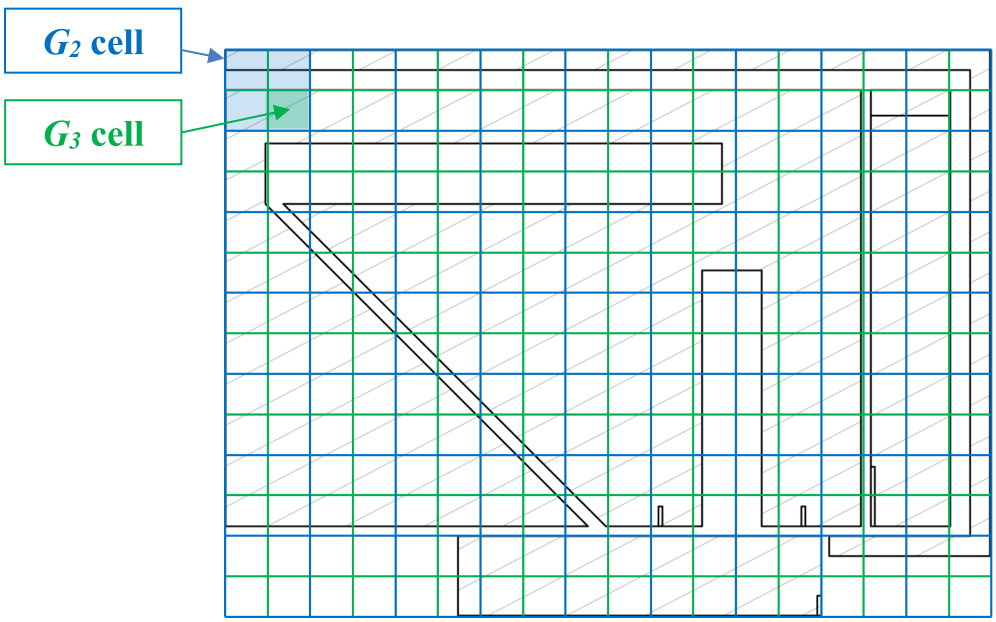
126. Grid G_1 (orange outline below) is "*aligned with a corner of the grid G_2*" and "*cover[s] the face*" (e.g., the first contour), wherein each G_1 cell has twice the width and height of a G_2 cell, e.g., "*widths and heights that respectively are double the widths and heights of the cells of the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



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

127. 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.*"



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

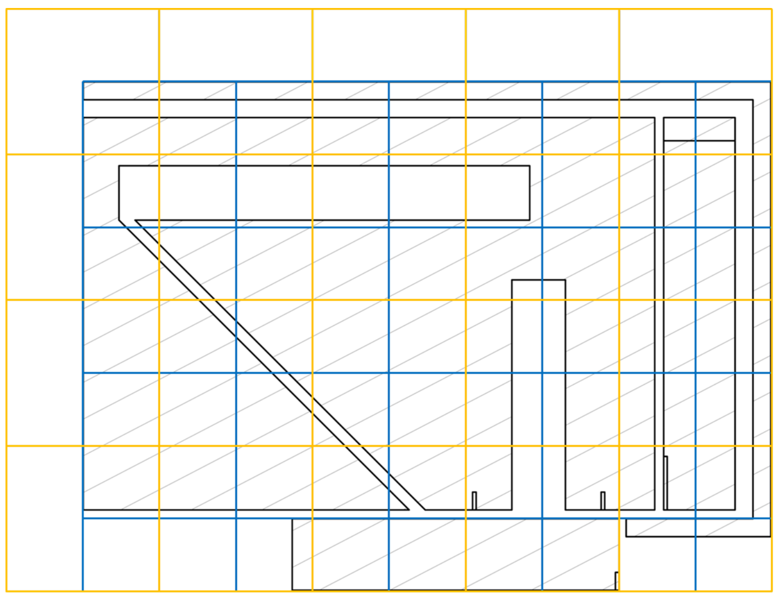
7.h.1	where N_1 is a number of cells of a grid G_1 that include at least a point of the first contour, N_2 is a number of cells of a grid G_2 that include at least a point of the first contour, and N_3 is a number of cells of a grid G_3 that include at least a point of the first contour,

128. 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. The count for each grid is shown below.

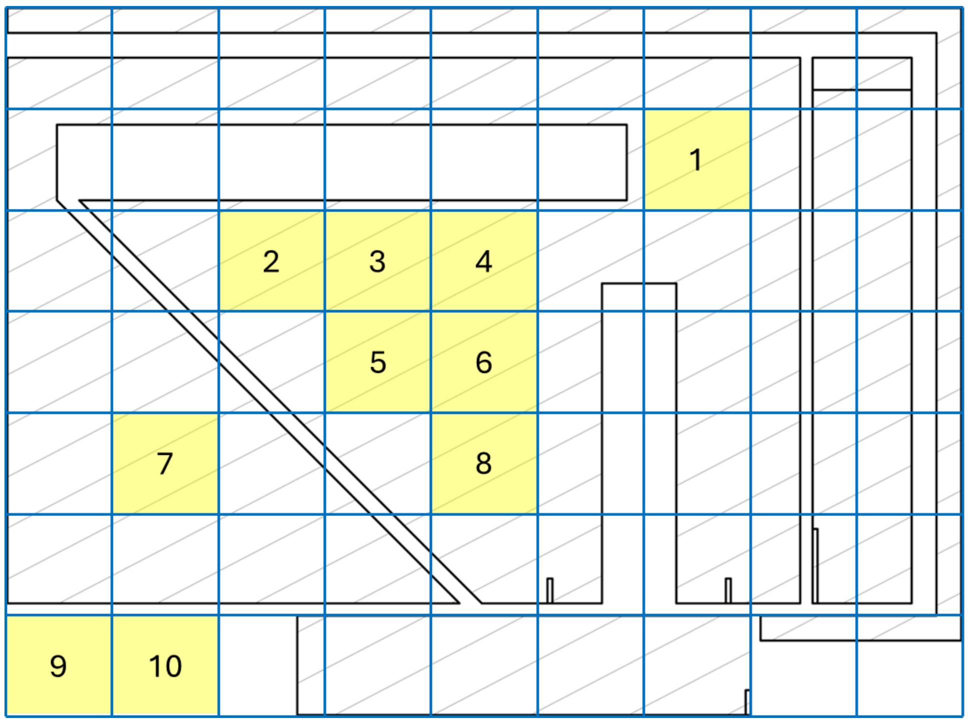
i. $N_1 = 20$

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



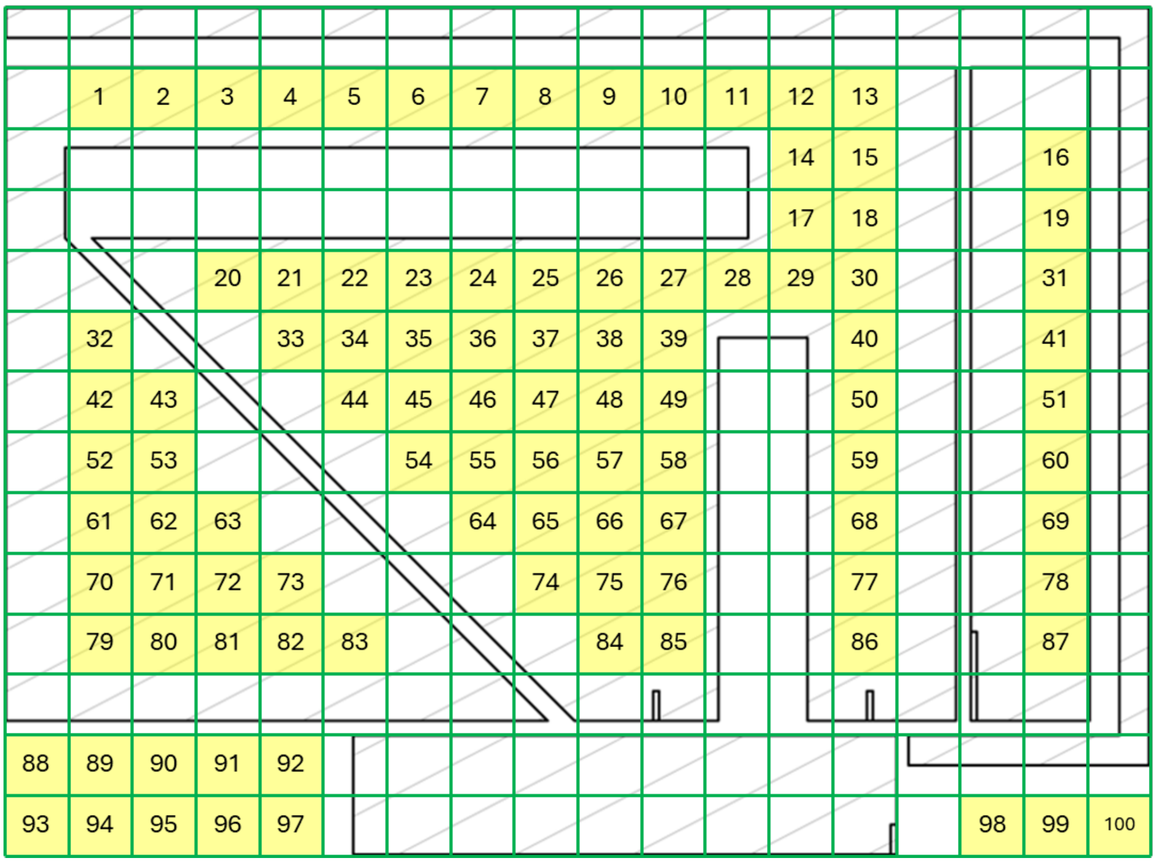
ii. $N_2 = 53$

130. 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, $N_2 = (63 - 10) = 53$.



iii. N_3 = 152

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

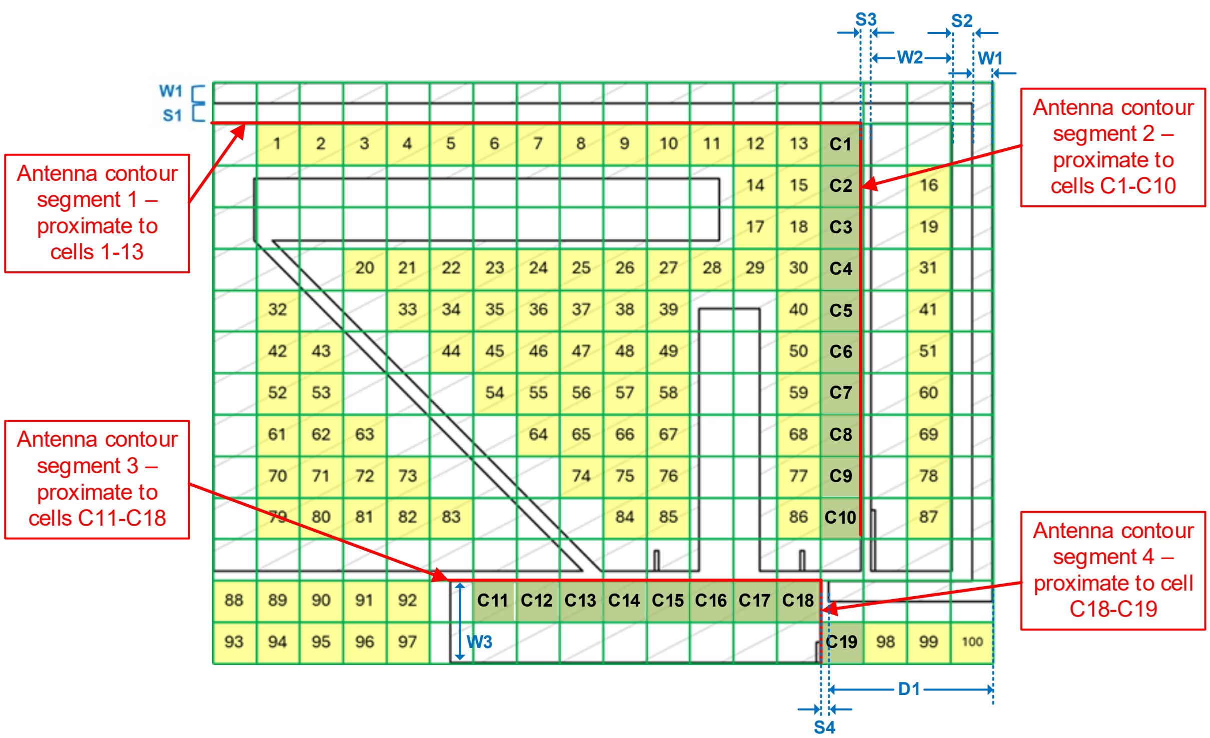


132. Among the cells that I shaded yellow above, cells 1-87 are completely within the multiband antenna contour, cells 88-100 are completely outside the antenna contour. Thus, cells 1-100 do not "include at least a point of the antenna contour." EX1005, 20:5-11.

133. In case it is not immediately obvious, I further explain whether certain G_3 cells "include at least a point of the antenna contour," alongside the below

annotated plots and a table summarizing relevant dimensions. *Supra* §IX.D.7 ([7.f]); Ciais-Multiband, Fig. 1(b), 920.

Symbol	Length (mm)	Explanation
W1	1	Width of parasitic patch no. 1
W2	4	Width of parasitic patch no. 2
W3	4	Width of parasitic patch no. 3
S1	1	Spacing between patch no. 1 and main patch
S2	1	Spacing between patch no. 1 and patch no. 2
S3	0.5	Spacing between patch no. 2 and main patch
S4	0.4	Spacing between patch no. 1 and patch no. 3
D1	8.1	Length of the bottom arm of patch no. 1



134. Each G_2 cell height is 4.07 mm, making each G_3 cell height half of that or 2.035 mm. *Supra* §§IX.D.9.a ([7.h.2]), IX.D.9.c ([7.h.4]). Likewise, each

G_2 cell width is 4.28 mm, making each G_3 cell width half of that or 2.14 mm. *Supra* §§IX.D.9.a ([7.h.2]), IX.D.9.c ([7.h.4]).

135. The top edge of cells numbered 1-13 (yellow shaded above) is 2.035 mm (a G_3 cell height) from the top of the *first contour*. The proximate *contour* edge ("segment 1" highlighted above in red) is W1+S1 = 1.0+1.0 = 2 mm from the top of the *first contour* and thus lies ***above*** the top edge of cells 1-13. Therefore, the cells numbered 1-13 do not "include at least a point of the antenna contour." Ciais-Multiband, Fig. 1(b), 920.

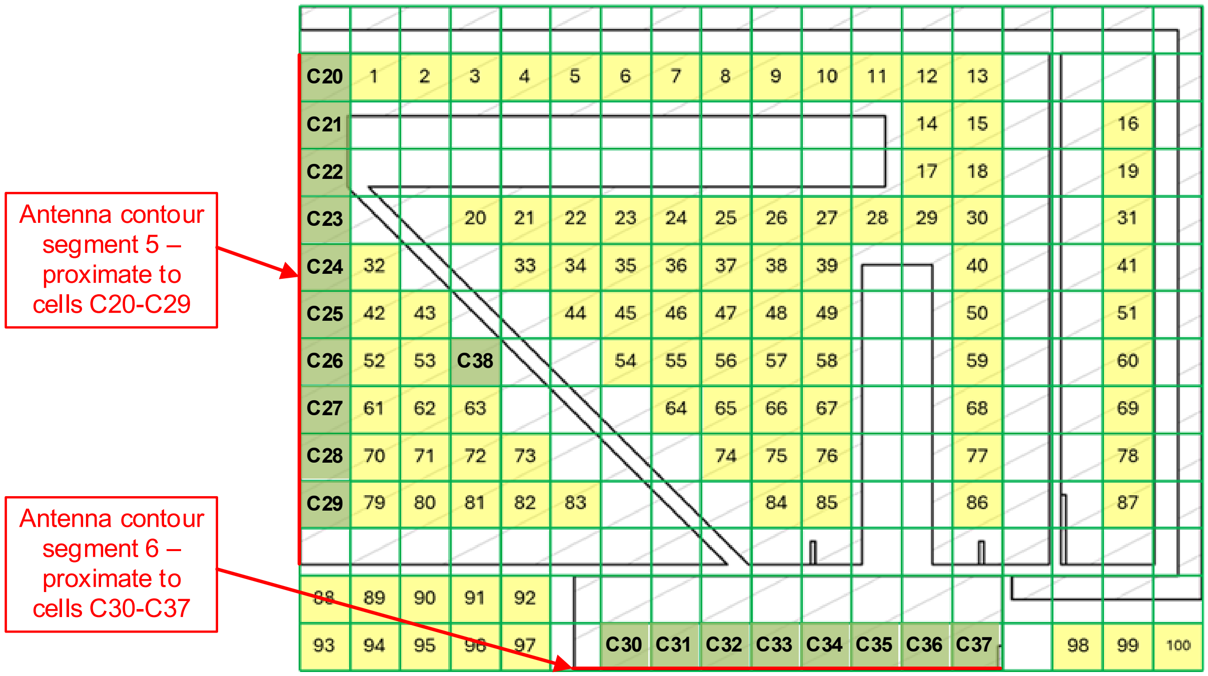
136. The right edges of cells numbered C1-C10 (green shaded above) are 2.14×3 = 6.42 mm (three times the G_3 cell width) from the right edge of the *first contour*. The proximate *contour* edge ("segment 2" highlighted above in red) is W1+S2+W2+S3 = 1+1+4+0.5 = 6.5 mm (highlighted in blue) from the right edge of the *first contour*, and thus lies inside cells C1-C10. *Supra* §IX.D.7 ([7.f]); Ciais-Multiband, Fig. 1(b), 920. Cells C1-C10 therefore "include at least a point of the antenna contour."

137. The top edges of cells numbered C11-C18 are 2.035×2 = 4.07 mm (two times the G_3 cell height) from the bottom of the antenna rectangle. The proximate *contour* edge ("segment 3" highlighted above in red) is 4 mm (i.e., width of parasitic patch no. 3) from the bottom of the antenna rectangle and thus ***within*** cells C11-C18. *Supra* §IX.D.7 ([7.f]); Ciais-Multiband, Fig. 1(b), 920.

Cells C11-C18 therefore include the *contour* passing through them and thus "include at least a point of the antenna contour."

138. The left edge of cell numbered C19 is 2.14×4 = 8.56 mm (four times the G_3 cell width, because C19 is at the fourth column from right) from the right edge of the *first contour*. The proximate *contour* edge ("segment 4" highlighted above in red) is D1+S4 = 8.1+0.4 = 8.5 mm from the right edge of the *first contour*. *Supra* §IX.D.7 ([7.f]); Ciais-Multiband, Fig. 1(b), 920. Thus, the proximate *contour* edge lies ***within*** cell C19, i.e., goes through cell C19. Cell 19 thus "include[s] at least a point of the antenna contour." Ciais-Multiband, Fig. 1(b), 920.

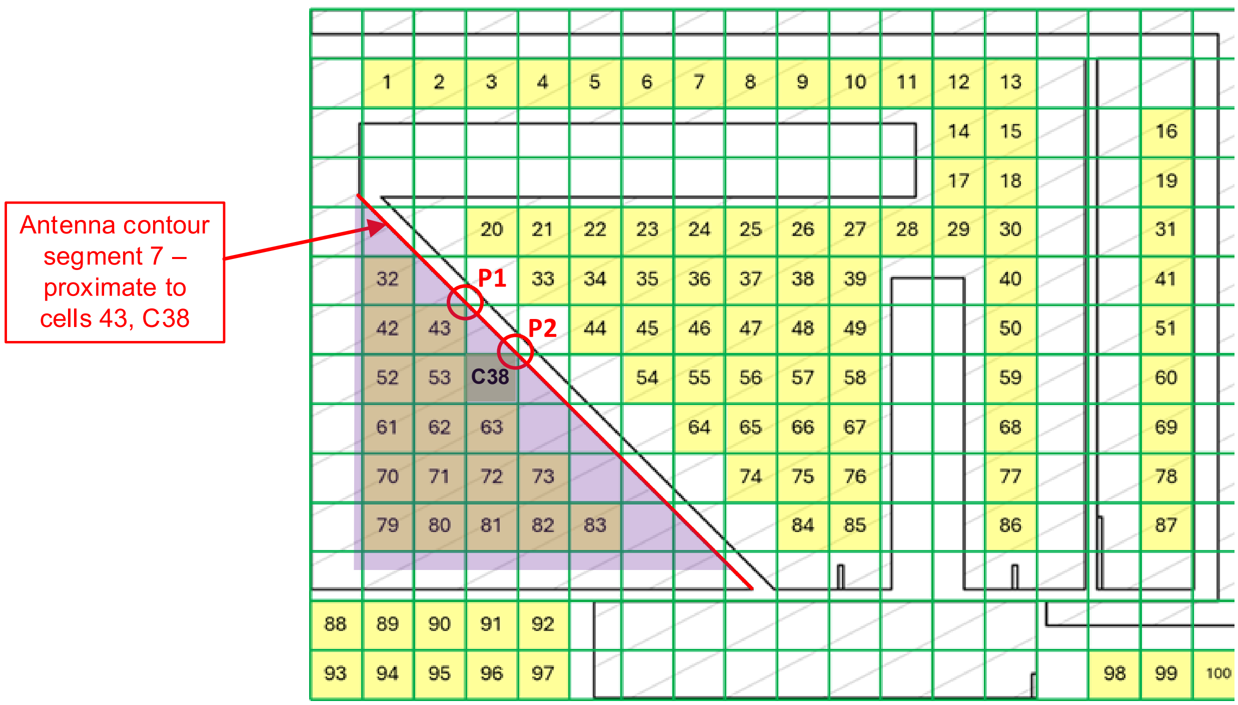
139. Additionally, the '149 patent states that "in the present invention the boundary of the cell is also part of the cell[.]" *Supra* §IX.D.9.d ([7.h.1]); EX1005, 19:15-17. Thus, even if a grid cell only includes points of the *first contour* on its cell boundary, *e.g.*, the *contour* matches the cell boundary and doesn't further extend into the cell, the cell "include[s] at least a point of the antenna contour." As shown below, the left edges of cells C20-C29 match the left edge of the main patch ("Antenna contour segment 5" in red below), and thus cells C20-C29 each "include at least a point of the antenna contour." Likewise, the bottom of cells C30-C37 matches the bottom of patch no. 3 ("Antenna contour segment 6" in red below), and thus "include at least a point of the antenna contour."

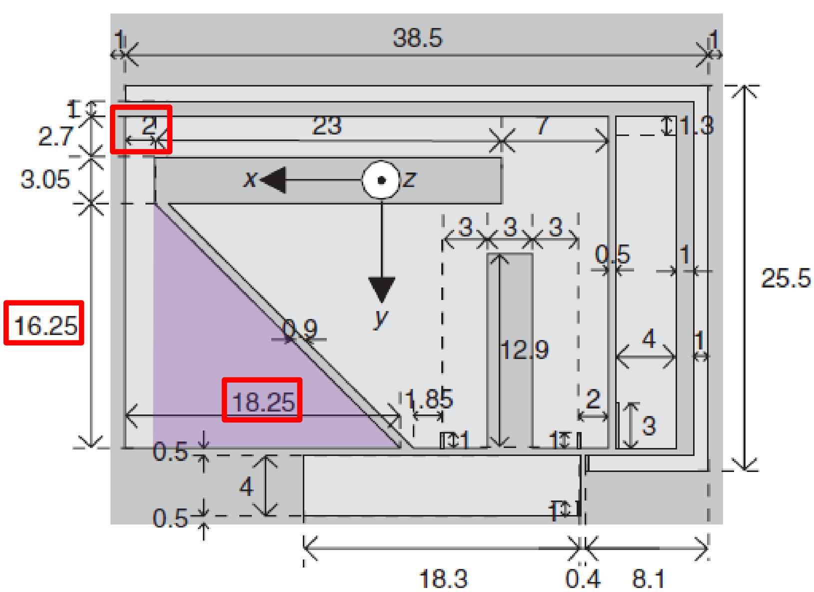


140. Whether cells 43 and C38 "include at least a point of the antenna contour" depends on whether their respective top-right corners are each within the main patch, i.e., if the top-right corner reaches or extends above the "Antenna contour segment 7" (red below) of the triangular portion (annotated in purple below) of the main patch, the cell "include[s] at least a point of the antenna contour."

141. As shown below the purple highlighted portion of the main patch is an isosceles right triangle. This can be confirmed by calculating its vertical and horizontal sides using relevant dimensions provided by Ciais-Multiband (reproduced in my plots below). *Supra* §IX.D.7 ([7.f]); Ciais-Multiband, Fig. 1(b), 920. The vertical side is taken as a line segment parallel to the left edge of the main patch, and its length is 16.25 (see dimensions below). The length of the

triangle's horizontal side (along the bottom of the main patch) is: 18.25-2.00 = 16.25 mm. Because the vertical and horizontal sides are of equal length and perpendicular to each other, the purple highlighted portion is an isosceles right triangle.





142. Referring back to cell 43 and its top-right corner P1. P1 is 2.14 × 3 = 6.42 mm (three times a G_3 cell width) from the left edge of the *first contour*, and 2.035 × 6 = 12.21 mm from top of the *first contour*. Relative to the purple triangle's x-y coordinates below, P1's x-position is 6.42–2 = 4.42 mm, and y-position is 12.21-1-1-2.7-3.05 = 4.46 mm. On the "segment 7" (hypotenuse), any point's horizontal (x) and vertical (y) offsets are equal, and thus when x-position is 4.42 mm, the y-position is also 4.42 mm. This is less than P1's y-position. Thus, at the same x-position as P1, the "segment 7" is closer to the top of the *contour*, i.e., above P1. That is, P1 lies below "segment 7" and is within the main patch, and thus cell 43 is completely within the main patch and does ***not*** "include at least a point of the first contour.

143. Referring now to cell C38 and its top right corner P2. P2 is 2.14 × 4 = 8.56 mm (four times a G_3 cell width) from the left edge of the *first contour*, and 2.035 × 7 = 14.245 mm from top of the *first contour*. Relative to the purple triangle's x-y coordinates below, P1's x-position is 8.56–2 = 6.56 mm, and y-position is 14.245-1-1-2.7-3.05 = 6.495 mm. On the "segment 7" (hypotenuse), any point's horizontal (x) and vertical (y) offsets are equal, and thus when x-position is 6.56 mm, the y-position is also 6.56 mm. This is more than P2's y-position. Thus, at the same x-position as P2, the "segment 7" is farther from the top of the *contour*, i.e., below P2. That is, P2 extends beyond "segment 7" and is

outside the main patch, and thus cell C38 "include[s] at least a point of the antenna contour."

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 $F_{21} = 1.41$

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

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

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

ii. Calculation $F_{32} = 1.52$

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

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

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

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.

146. 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. This changed the "higher-order modes" and antenna resonances. Ciais-Multiband, 920. Ciais thereby "configured" the *first contour*'s "*level of complexity*" to provide the frequency operation discussed *supra* §IX.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]. EX1005, 16:64-17:4, 19:26-29, 20:19-22.

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

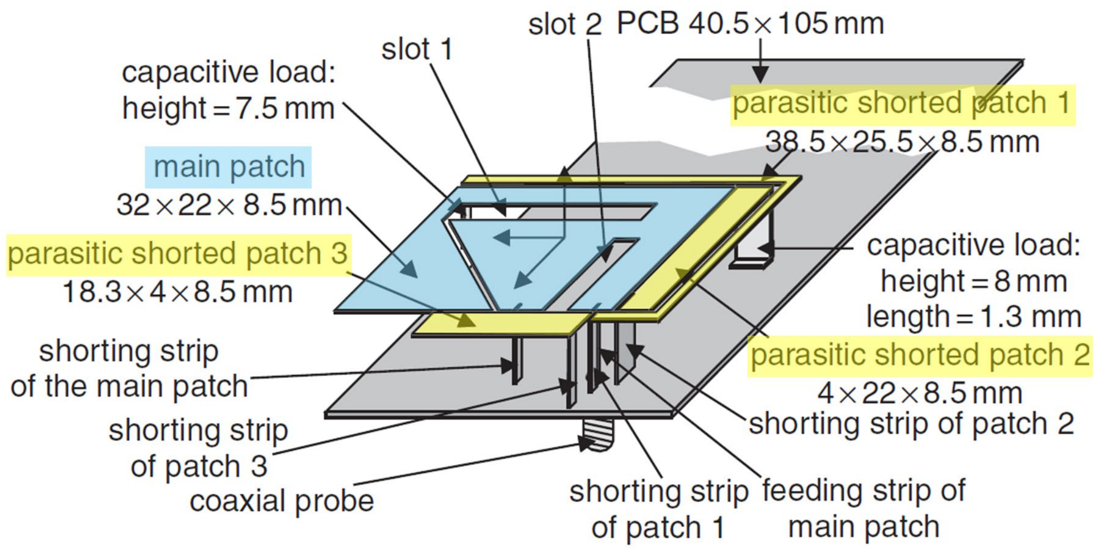
[redacted]

E. Claim 8

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

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

149. 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).



150. 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. Thus, the main patch and each of parasitic shorted patches 1 to 3 are "*at least two antenna elements*" that are "*electromagnetically coupled*."

F. Claim 9

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

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

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.

152. 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* §VIII.C. There also is no antecedent basis for "antenna box" in claim 7.

153. 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* §IX.D.3 ([7.b]). 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).

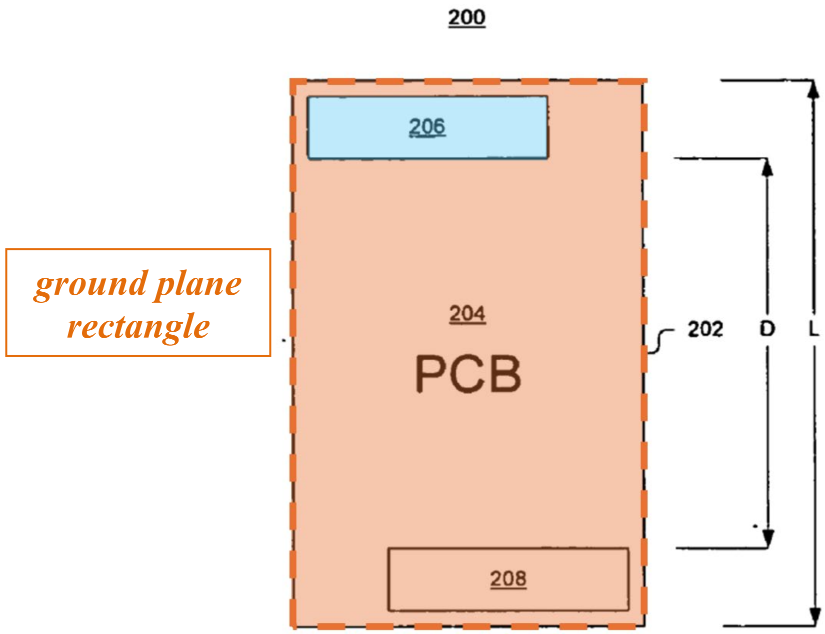

200
ground plane rectangle
206
204
PCB
208
202
D
L

FIG. 2A

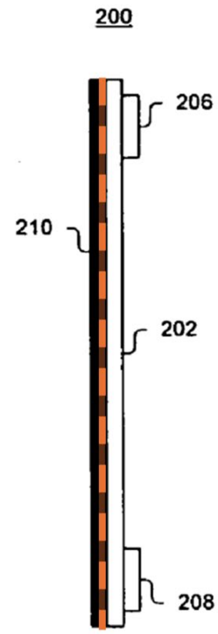
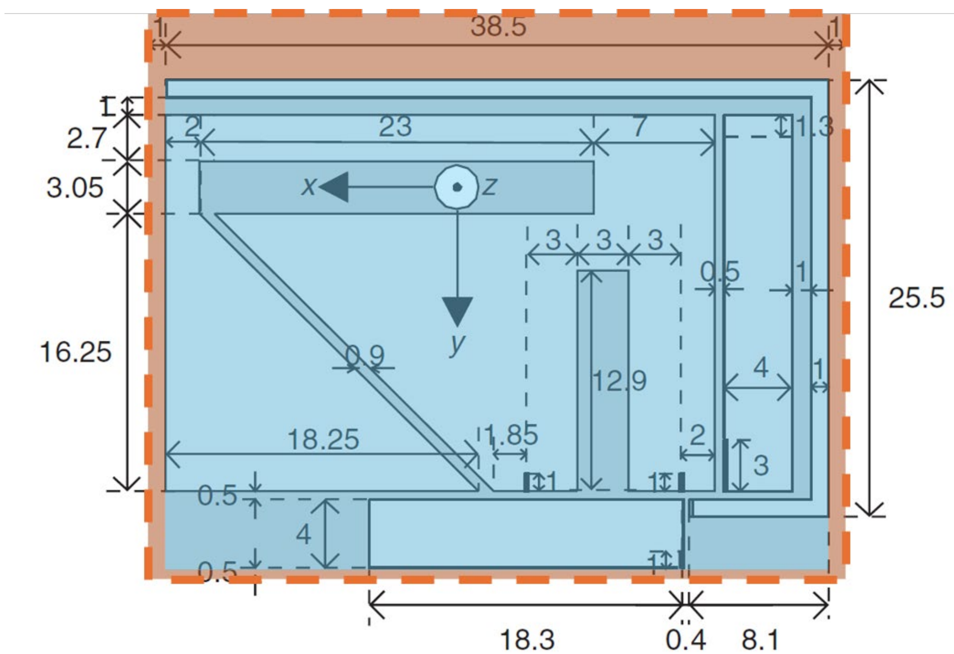

200
206
210
202
208

FIG. 2B


38.5
1
1
1
2.7
3.05
16.25
2
23
7
1.3
x
z
y
3
3
3
0.5
1
0.9
12.9
4
1
25.5
18.25
1.85
1
1
2
3
0.5
4
0.5
1
18.3
0.4
8.1

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.

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

I. Claim 13

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

155. 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.

Limitation	**Corresponding limitation**	**Discussion *supra***
13.PRE	7.PRE	§IX.D.1
13.a	7.a	§IX.D.2
13.b	7.b	§IX.D.3
13.c	7.c	§IX.D.4
13.d	7.d	§IX.D.5
13.e	7.e	§IX.D.6
13.f	7.f	§IX.D.7
13.g	7.g	§IX.D.8
13.h	7.h	§IX.D.9.e132
13.h.1	7.h.1	§IX.D.9.d
13.h.3	7.h.3	§IX.D.9.b

Limitation	Corresponding limitation	Discussion *supra*
13.h.4	7.h.4	§IX.D.9.c
13.i	7.i	§IX.D.10

2. Limitation [13.h.2]

156. 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* §IX.D.9.a.

J. Claims 14, 16-17, and 19

157. 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. Dou+Ciais-Multiband meets the additional limitations in claims 14, 16-17, and 19 for the same reasons it meets the corresponding limitations below.

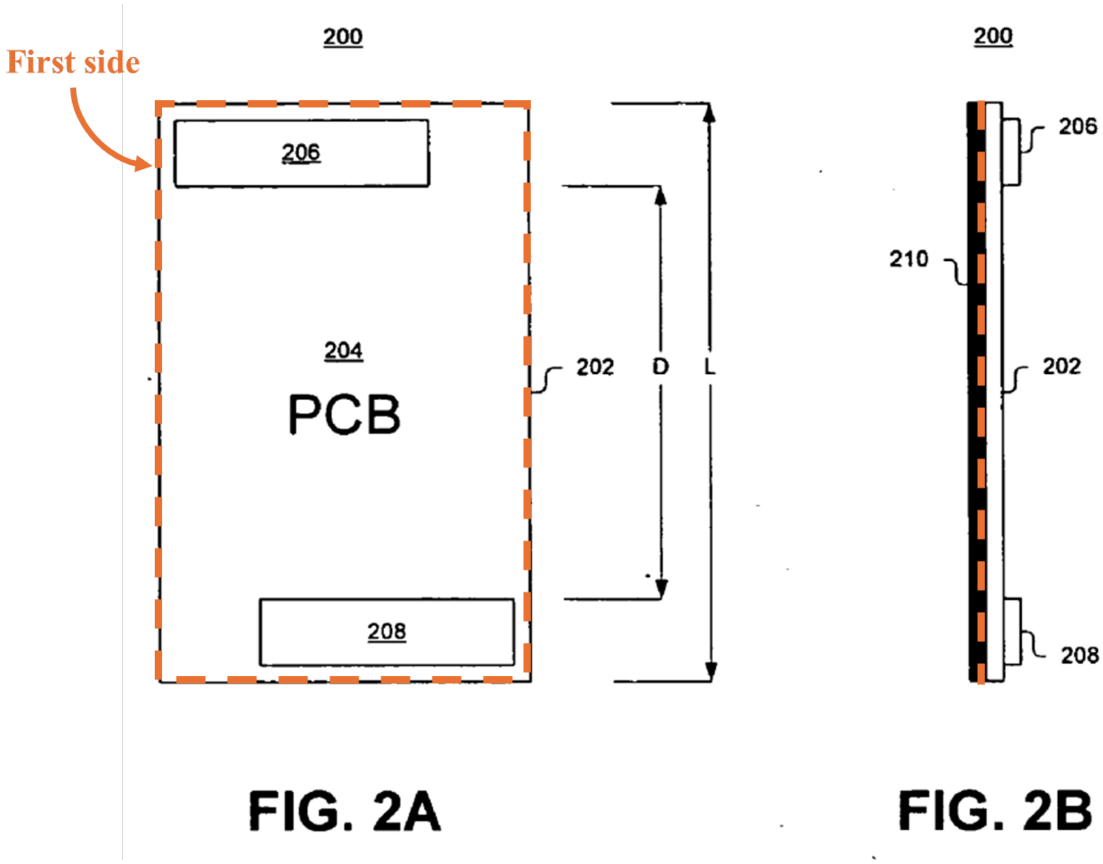
Limitation	Corresponding limitation	Discussion *supra*
14	8	§IX.E
16	11	§IX.G
17	9	§IX.F
19	12	§IX.H

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.

158. 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."). 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* §§IX.D.3 ([7.b]), IX.I.1 [13.b].

159. 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* §§IX.D.3 ([7.b]), IX.I.1 ([13.b]).



160. 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* §IX.C (combination); Ciais-Multiband, 920, Figs. 1(a)-1(b). 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). 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* §§IX.D.3 ([7.b]), IX.I.1 ([13.b]).

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

A. Hilgers (EX1040)

161. 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

162. 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].

163. 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. 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. 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**).

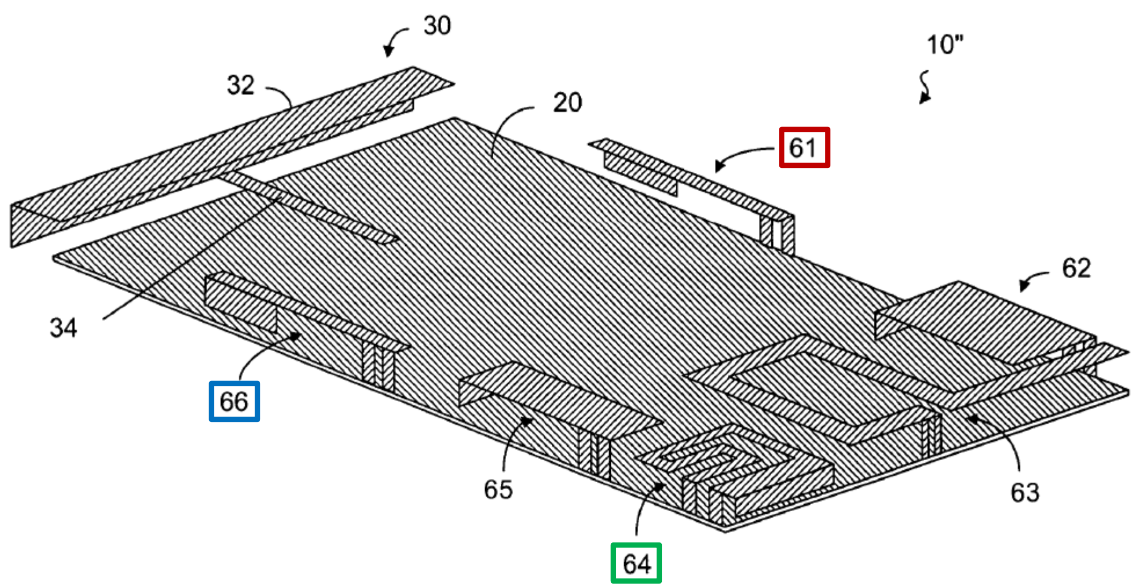


FIG. 9

164. 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].

165. 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. This combination would have provided the multiband coverage that Dou describes.

166. 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]).

167. 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.

C. Claims 10 and 18

168. 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.

169. 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* §IX.D.4 ([7.c]); Hilgers, [0001], [0025], Fig. 4. Hilgers's dual-band antenna is "*arranged within*" the Dou+Ciais-Multiband+Hilgers device. *Supra* §X.B (combination).

XI. GROUND 2: DOU+CIAIS-QUADBAND+NAKANO RENDERS OBVIOUS CLAIMS 1-6, 13-15, AND 17-20

A. References

1. Ciais-Quadband (EX1009)

170. 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 "less than" 2.0:1. Ciais-Quadband, Fig. 3, 148-150.

2. Nakano (EX1012)

171. 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 5-6 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, 2419-2420, Figs 1(b), 4.

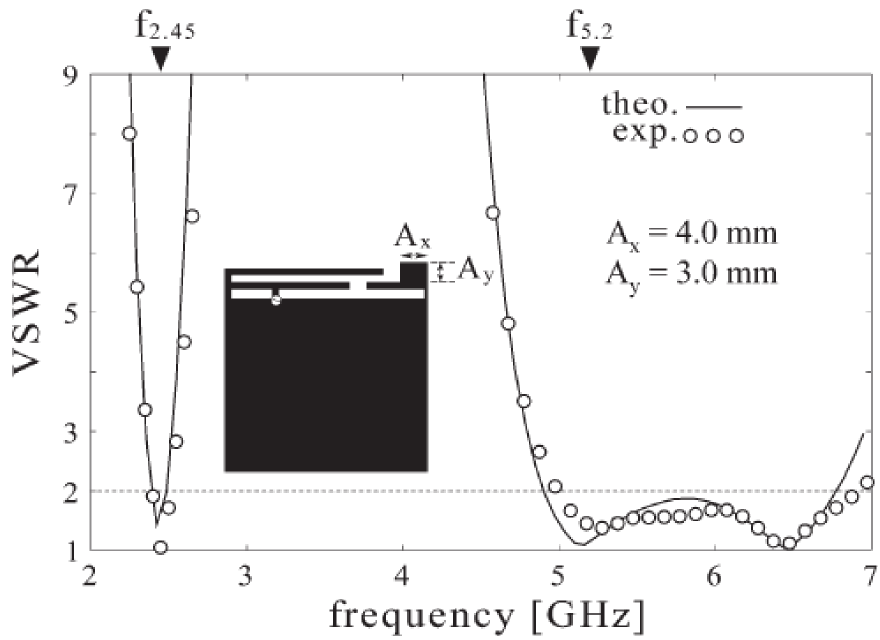


Fig. 4. VSWR for an inverted FL antenna. The structural parameters are $(H_L, L_L) = (4.5 \text{ mm}, 24.5 \text{ mm})$, $(H_F, L_F) = (2.5 \text{ mm}, 10.5 \text{ mm})$, $L_{FD} = 7.5 \text{ mm}$, $(H_P, L_P) = (2.5 \text{ mm}, 9.0 \text{ mm})$, $(A_x, A_y) = (4.0 \text{ mm}, 3.0 \text{ mm})$, and $(L_x \times L_y) = (30 \text{ mm} \times 25.5 \text{ mm})$.

Nakano, Figure 4

3. Dou+Ciais-Quadband+Nakano

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

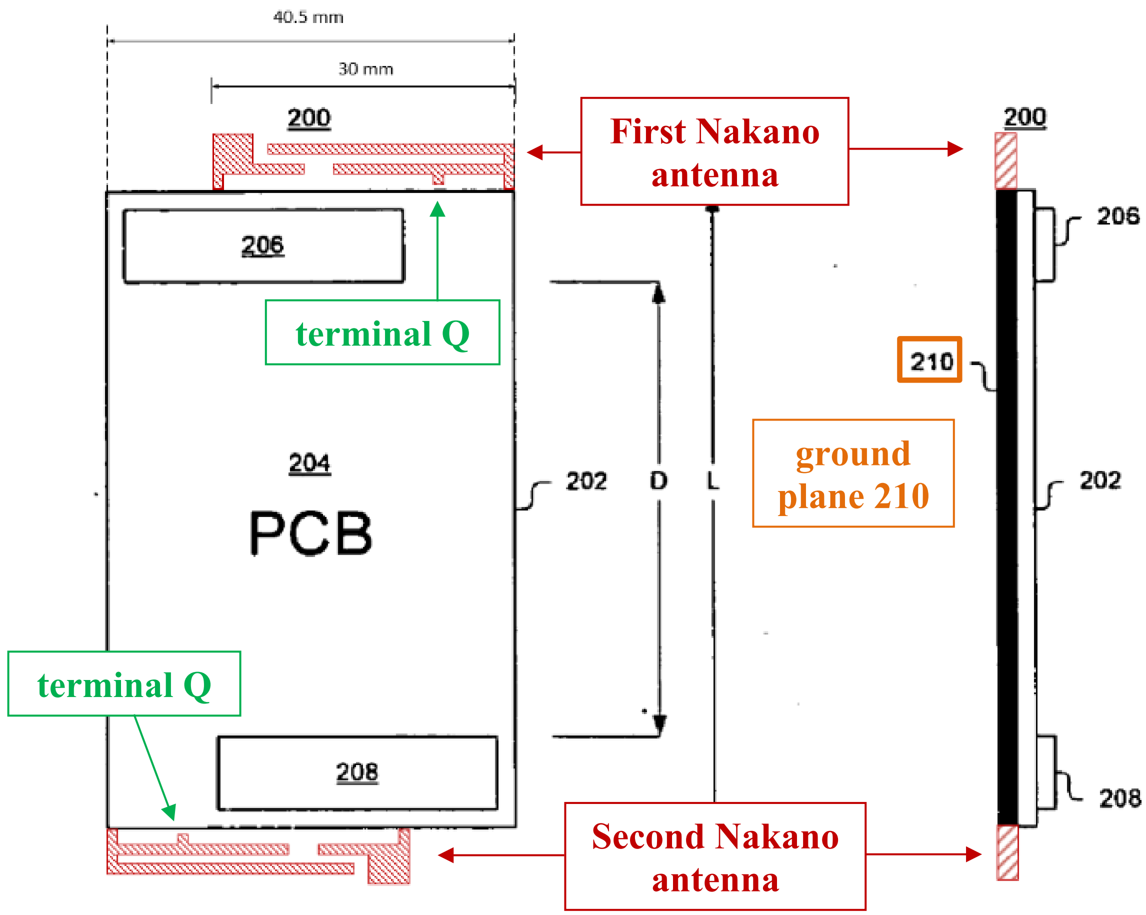
given implementation" (Dou, [0039]). *Supra* §§IX.A (Dou), IX.C (Ground 1A, combination).

173. 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.

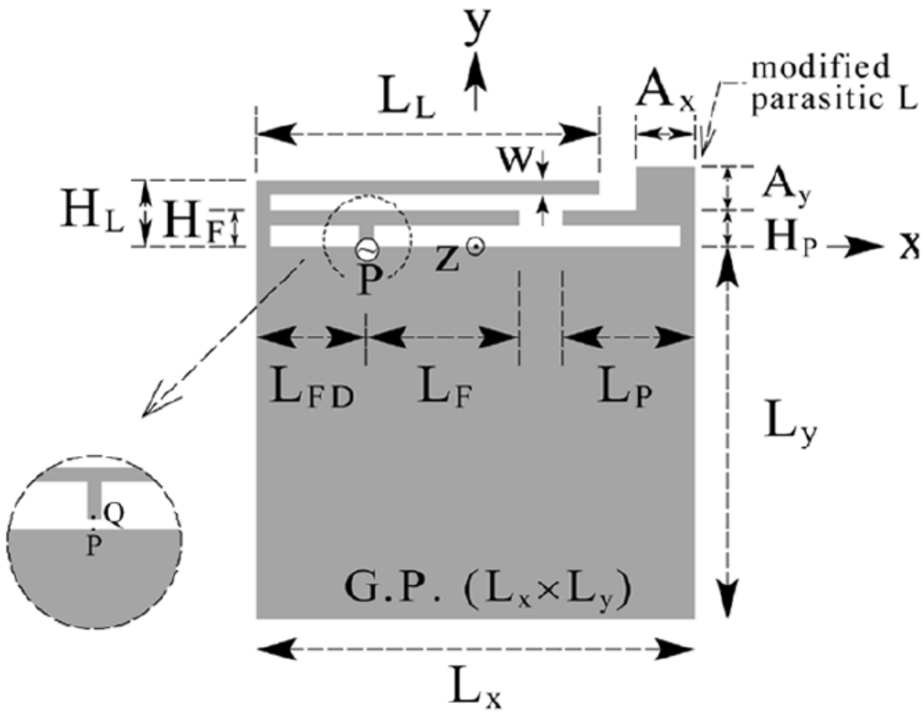
a. Modifying Dou with Nakano's teachings.

174. 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 [U-NII] 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."). 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.

175. 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]. 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. 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].


40.5 mm
30 mm
200
First Nakano antenna
200
206
206
terminal Q
210
204
PCB
202
D
L
ground plane 210
202
terminal Q
208
208
Second Nakano antenna

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



(b)

177. 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).

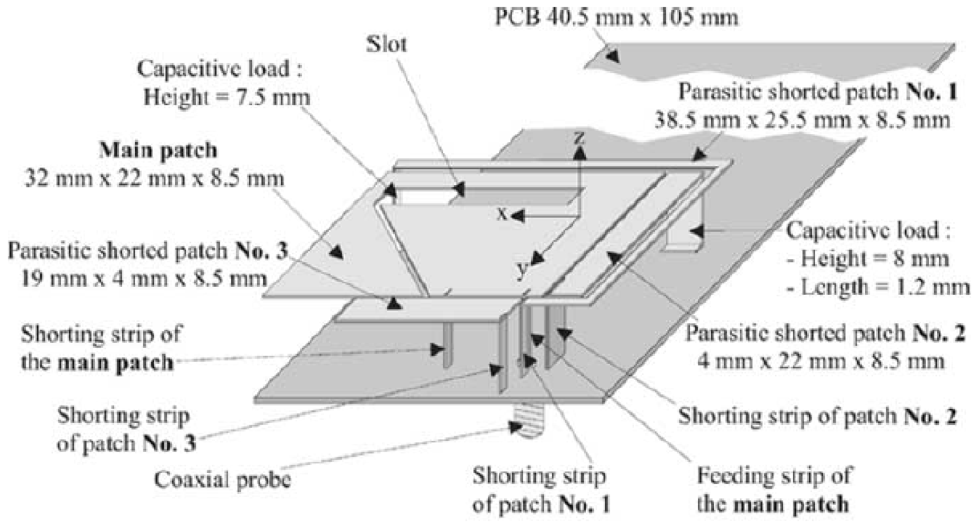
178. Implementing Dou's wireless device with two Nakano InvFL antennas as described above would have been nothing more than combining familiar elements according to known methods with predictable results, and been no more than the predictable use of prior art elements according to their established functions.

b. Modifying Dou with Ciais-Quadband's teachings

179. 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.

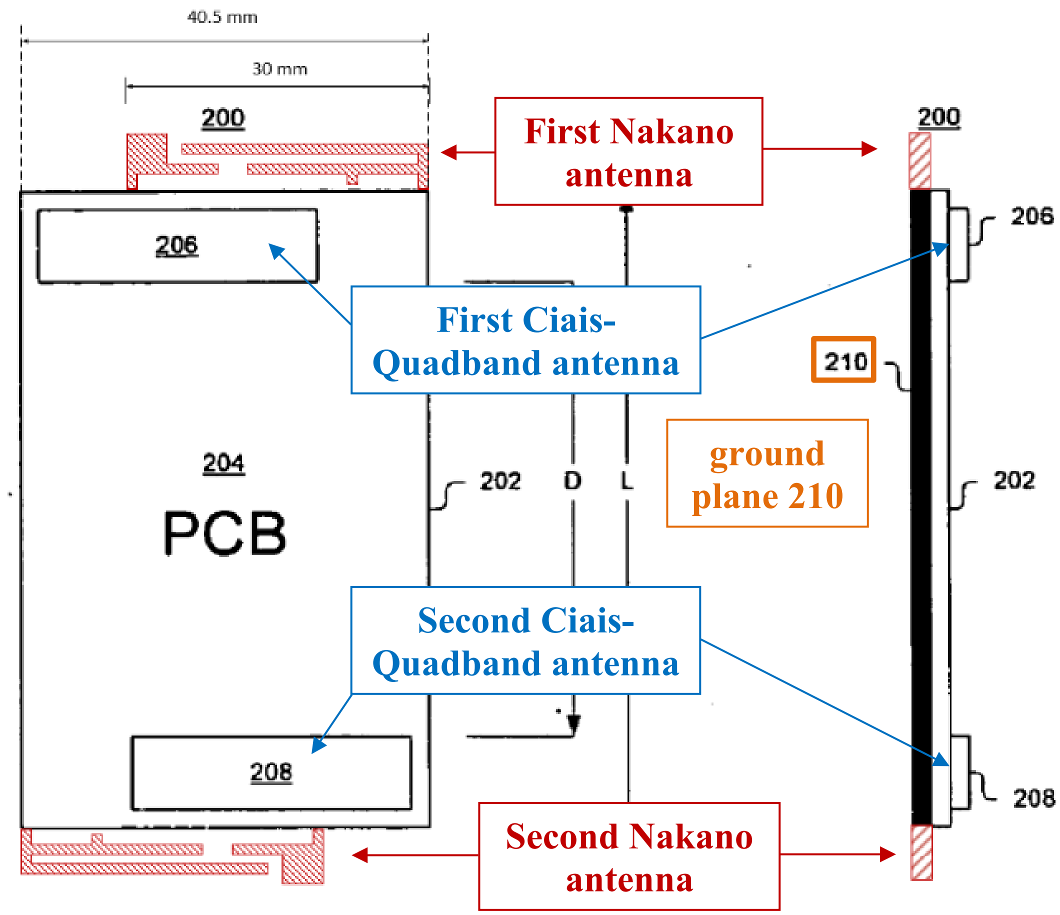
180. Ciais's quadband antenna is a planar inverted-F antenna (PIFA) (Ciais-Quadband, Abstract), which Dou describes using for the first and second antennas. Dou, [0028]. Ciais's quadband antenna provided operation at 870-960 MHz and 1710-2170 MHz, used in well-known communication standards (GSM, DCS, 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).

181. 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)

182. 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.



183. 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.

184. 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.

c. Reasonable expectation of success

185. 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* §IX.C (Ground 1A, combination). Dou confirms that combining multiple antennas within a single mobile wireless device was conventional and within the POSA's ordinary skill. Dou, [0022], [0040]. 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].

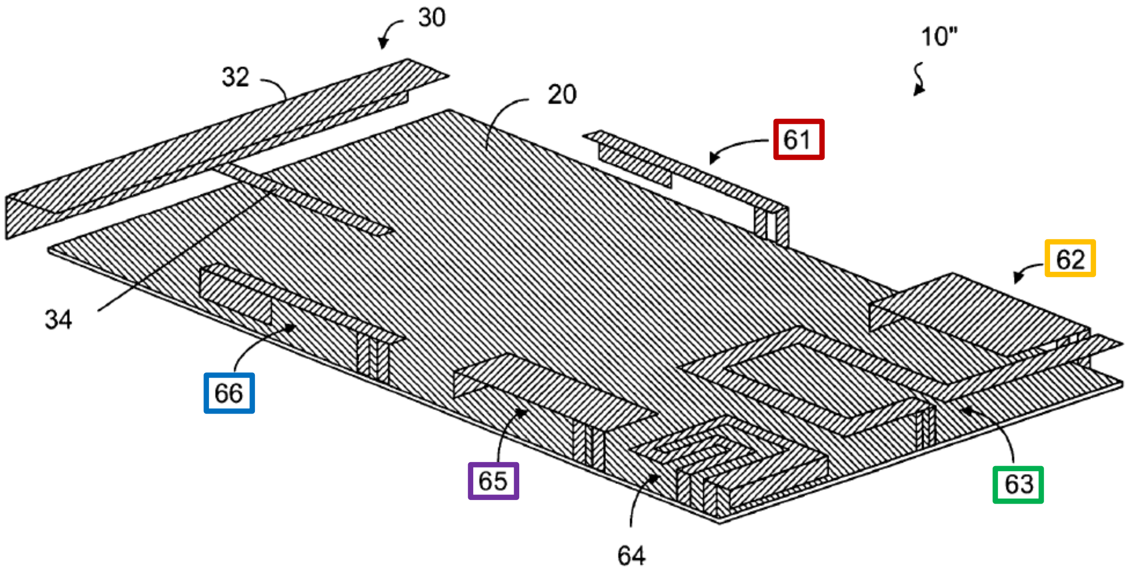


FIG. 9

186. 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. 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].

187. 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]. 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].

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

B. Claim 1

1. Preamble [1.PRE]

[1.PRE]	A wireless device comprising:

189. 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.

2. Limitation [1.a]

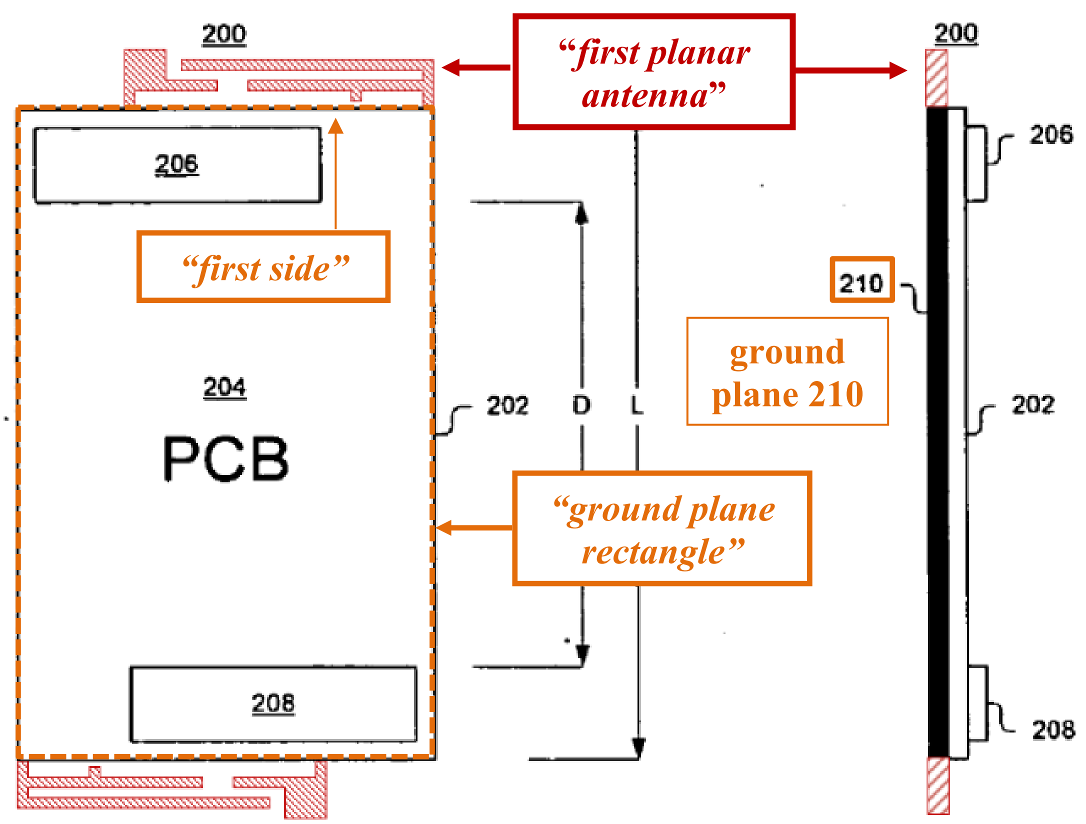
[1.a]	a ground plane;

190. 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).

3. Limitation [1.b]

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

191. 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* §XI.A.3 (combination); Nakano, 2417, Fig. 1; Dou, Figs. 2A-2B (annotated below to show Dou+Ciais-Quadband+Nakano). 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.



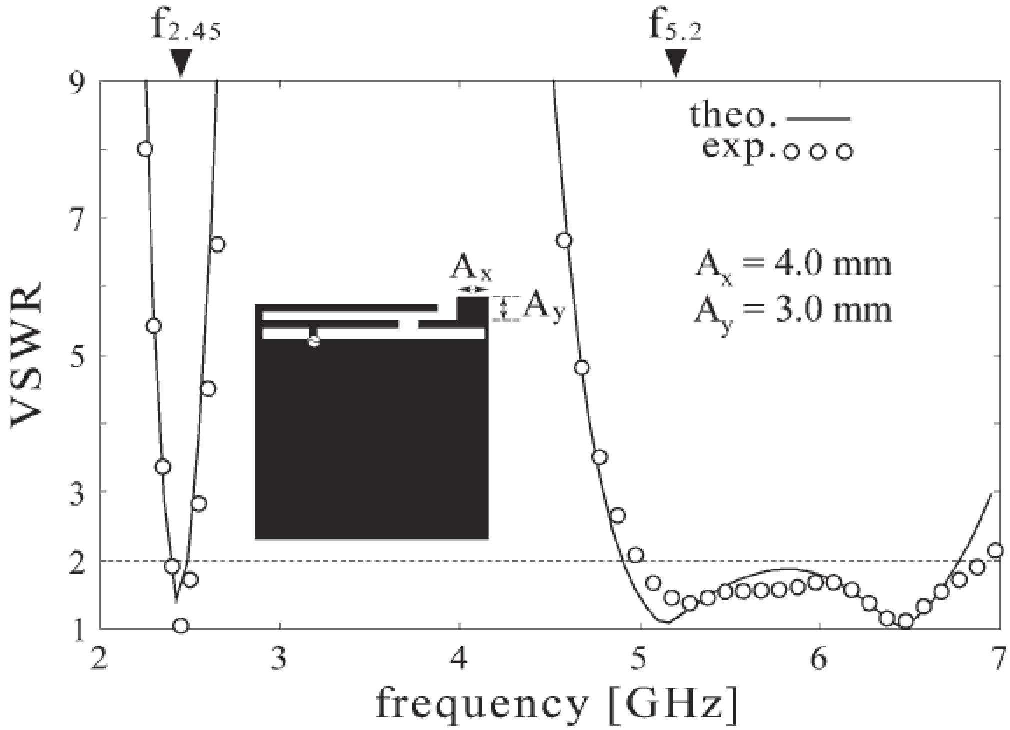
192. Ground plane 210 covers the back surface of PCB 204 consistent with the ground plane teaching in Ciais-Quadband and Nakano. *Supra* §XI.A.3 (combination). PCB 204's rectangular area defines a rectangle ("*ground plane rectangle*") that "*enclos[es]*" the ground plane 210 disposed on the side of the PCB opposite from antenna 206. *Supra* §IX.D.3 (Ground 1A, [7.b]); Dou, Figs. 2A-2B, [0016]-[0017], [0029]. The top (e.g., 40.5 mm) edge of the "*ground plane rectangle*" is a "*first side*." *Supra* §XI.A.3.b; Ciais-Quadband, 148 (describing that "the [PCB] of a typical mobile phone" has a rectangular dimension of "40.5 mm × 105 mm (Fig. 1)"), Fig. 1(a) (similar).

193. 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].

4. Limitation [1.c]

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

194. 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).



195. 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 ("The Bluetooth system operates in the 2.4 GHz ISM band.").

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

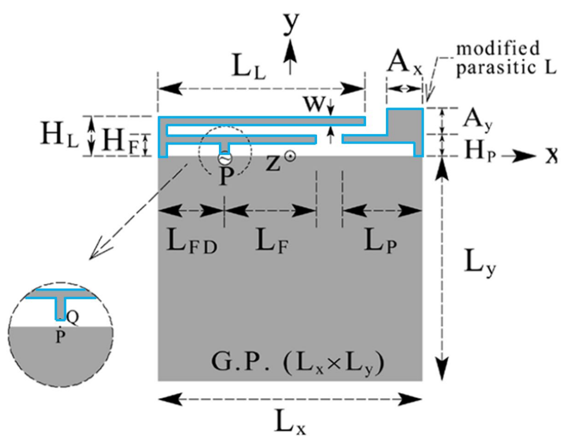
EX1042, 26 (IEEE Std. 802.11a defining WLAN channels in 5 GHz U-NII bands); 47 C.F.R. §§15.401, 15.403 (U-NII devices in 5.15-5.35 GHz and 5.47-5.895 GHz frequency bands); 47 C.F.R. §§15.407(a)(1) (discussing 5150-5250 MHz U-NII band), 15.407(a)(2) (discussing 5250-5350 MHz and 5470-5725 MHz U-NII bands), 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)).

197. 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].

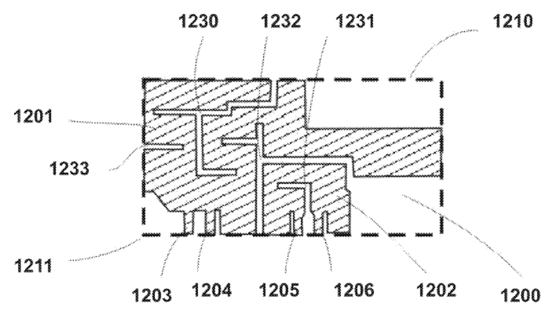
5. Limitations [1.d], [1.g]

[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;

198. 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.

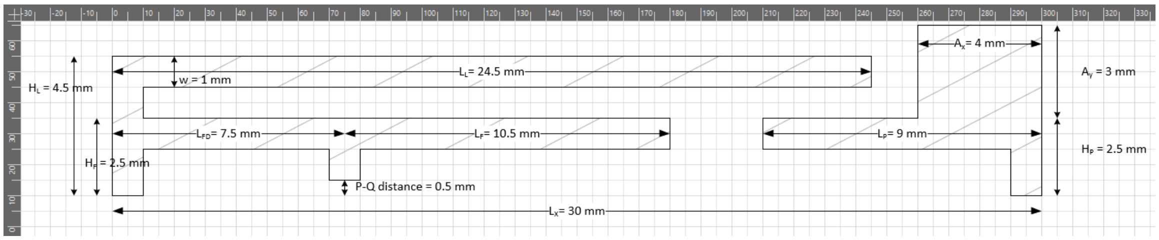


Nakano, Fig. 1(b) (annotated)



'149 patent

199. 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.



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

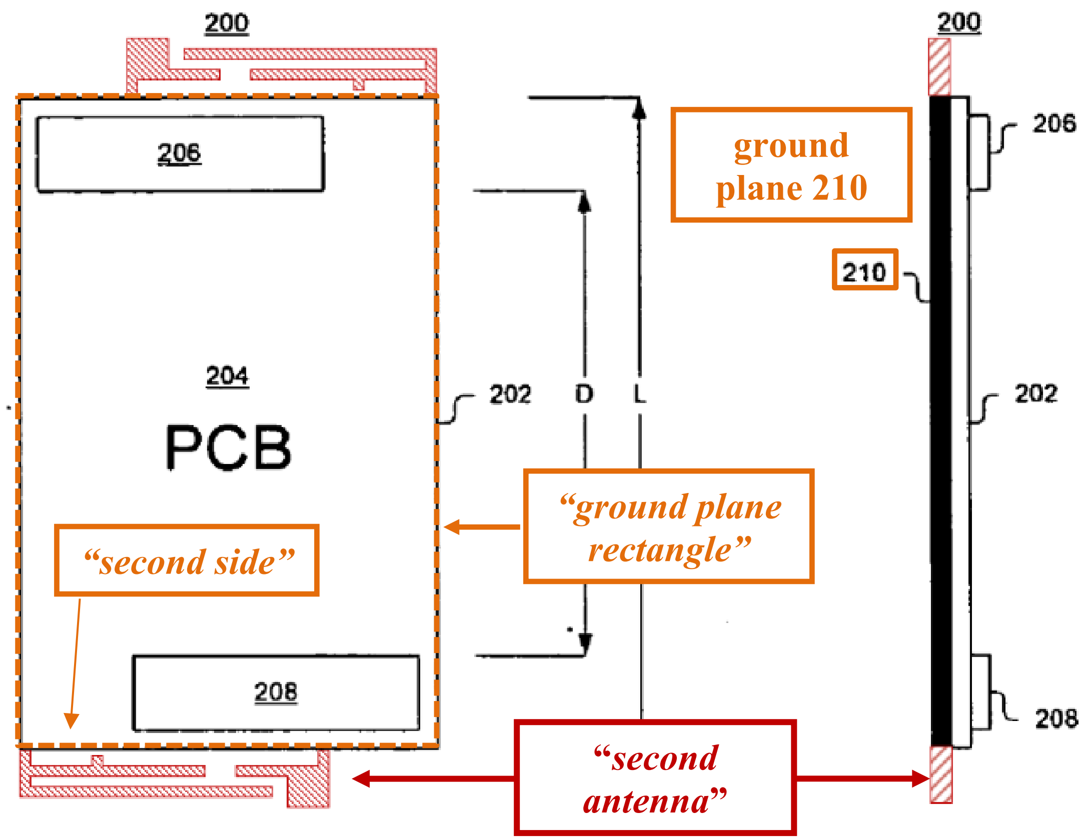
200. Dou+Ciais-Quadband+Nakano meets [1.e] because the *first contour* for Nakano's antenna has $F_{21} = 1.43 \geq 1.20$, and $F_{32} = 1.43 \geq 1.35$, as shown for [1.h]-[1.h.4] below.

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;

201. 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* §XI.A.3 (combination).



202. 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* §XI.B.4 ([1.c]).

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

203. 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* §IX.D.9 (Ground 1A, [7.h]-[7.h.4])132. 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

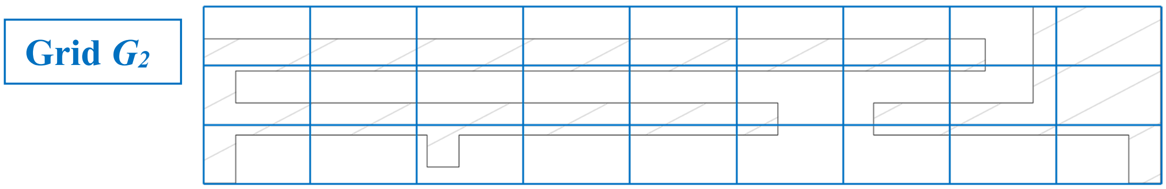
204. Nakano's antenna contour (*first contour*) is 30 mm wide (*long side of the face*) and 5.5 mm in height (*short side of the face*). Nakano, 2417, 2419, Figs. 1(b), 4. Grid G_2 with nine (9) columns across a "*minimum-sized rectangle enclosing the first planar antenna*" yields cell width for *columns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

205. Setting an odd number of "2n+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):

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	$\left(\frac{5.5}{5}\right) = 1.1$	$\left(\frac{3.33}{1.1}\right) = 3.03$

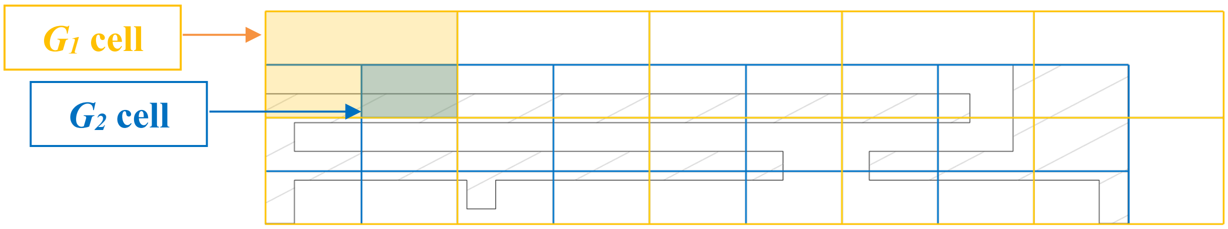
206. Three (3) rows provides an "*odd number of rows of equal height arranged along a short side of the minimum-sized rectangle*" with "*the cells… being as square as possible*" because three rows provides a cell with an aspect ratio closer to 1 (e.g., where width = height) than any other *odd number* ("*2n+1*")

of rows with integer n such that $0 < n < 5$. Thus, grid G_2 has 3 rows by 9 columns as shown below (blue outline).



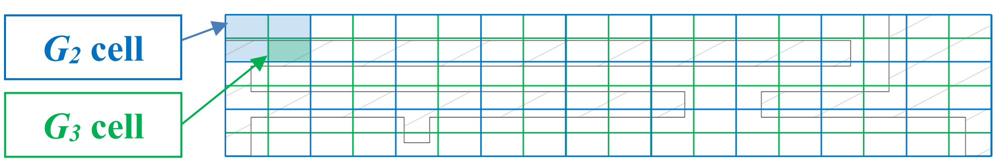
b. Limitation [1.h.3]: Grid G_1

207. 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.*"



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

208. 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.*"

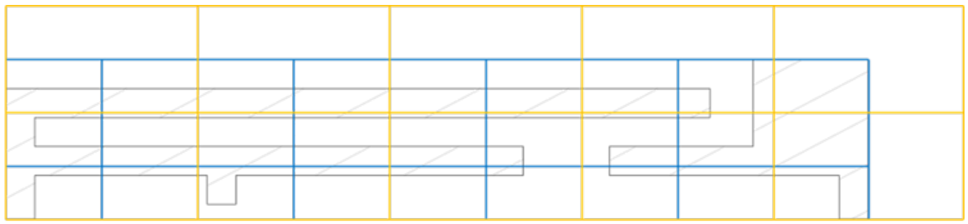


d. Limitation [1.h.1]: Cell counts

209. The count for each grid is shown below.

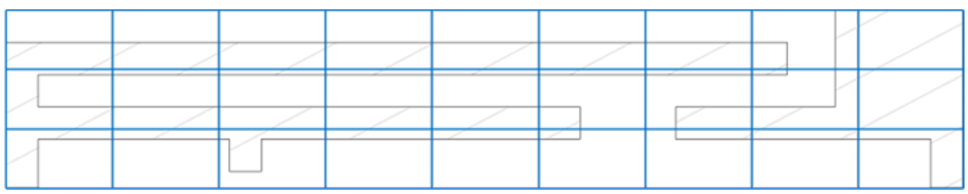
i. $N_1 = 10$

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



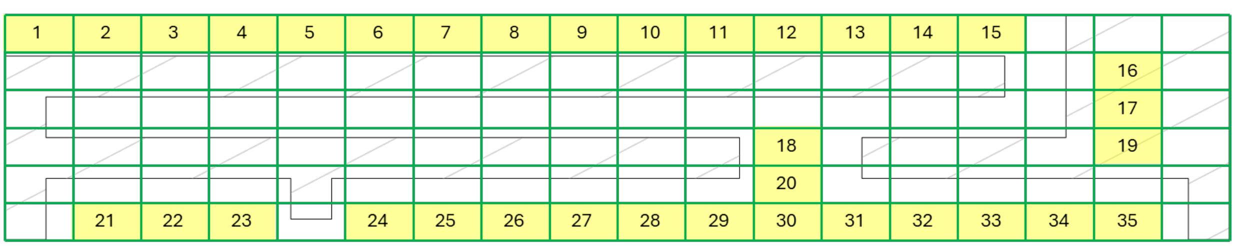
ii. $N_2 = 27$

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



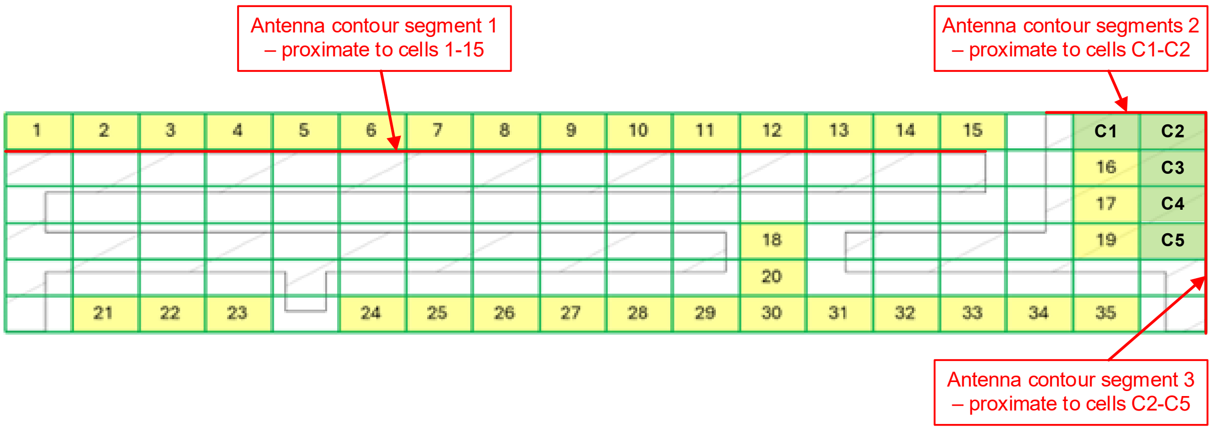
iii. $N_3 = 73$

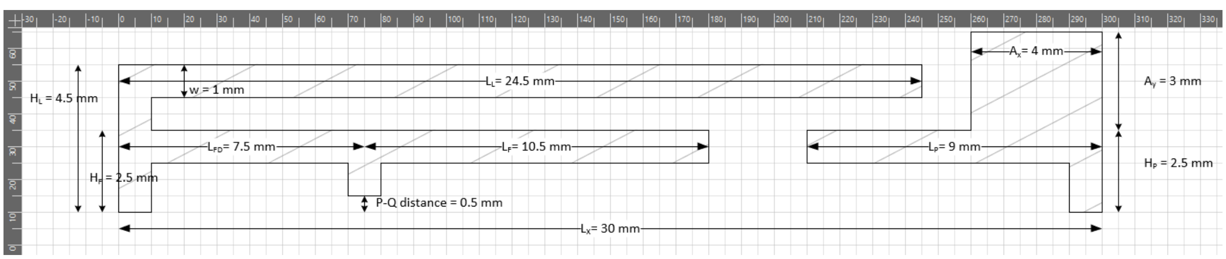
212. In the 6×18 grid G_3 the cells numbered 1-35 (marked below) do ***not*** "*include… a point*" on the *first contour*. Thus, $N_3 = (108 - 35) = 73$.



213. Each G_2 cell height is 1.83 mm, making each G_3 cell height half of that or 0.915 mm. *Supra* §§XI.B.8.a ([1.h.2]), XI.B.8.c ([1.h.4]). Likewise, each

G_2 cell width is 3.33 mm, making each G_3 cell width half of that or 1.665 mm. *Supra* §§XI.B.8.a ([1.h.2]), XI.B.8.c ([1.h.4]).





214. Cells 1-15 do ***not*** "include… a point" on the *first contour* because antenna contour segment 1 (in red above) is 1.0 mm from the top of the rectangle defining the *first contour*, which place segment 1 outside cells 1-15 that have a cell height of 0.915 mm.

215. Additionally, the '149 patent states that "in the present invention the boundary of the cell is also part of the cell[.]" *Supra* §IX.D.9.d ([7.h.1]); EX1005, 19:15-17. Thus, even if a grid cell only includes points of the *first contour* on its cell boundary, *e.g.*, the *contour* matches the cell boundary and doesn't further extend into the cell, the cell "include[s] at least a point of the antenna contour."

EX1005, 20:5-11. As shown above, the top edges of cells C1-C2 and right edges of cells C2-C5 match the top and/or right edges of the *first contour* (Antenna contour segments 2 and 3 in red above), and thus cells C1-C5 each "include at least a point of the antenna contour."

e. Limitation [1.h]

i. Calculation $F_{21} = 1.43$

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

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

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

ii. Calculation $F_{32} = 1.43$

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

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

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

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.

218. 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. Nakano thereby "*configured*" the antenna's *first contour*'s "*level of complexity*" to provide the frequency operation discussed *supra* §XI.B.4 ([1.c]) because the "*complexity*" measures the antenna's physical features as captured by the antenna "*contour*." EX1005, 16:64-17:4, 19:27-30, 20:19-22.

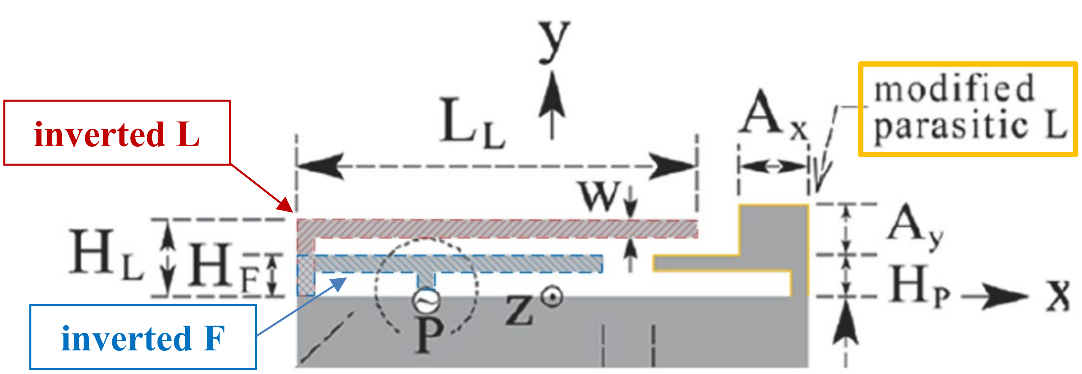
219. In its litigation arguments, Fractus alleges that this limitation is met because [redacted]. Under Fractus's construction, Nakano's InvFL antenna meets [1.i] because it supports the frequency bands meeting [1.c].

[redacted]

C. Claim 2

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

220. 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).



221. 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. 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. As explained *supra* §IX.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.

D. Claims 3-4

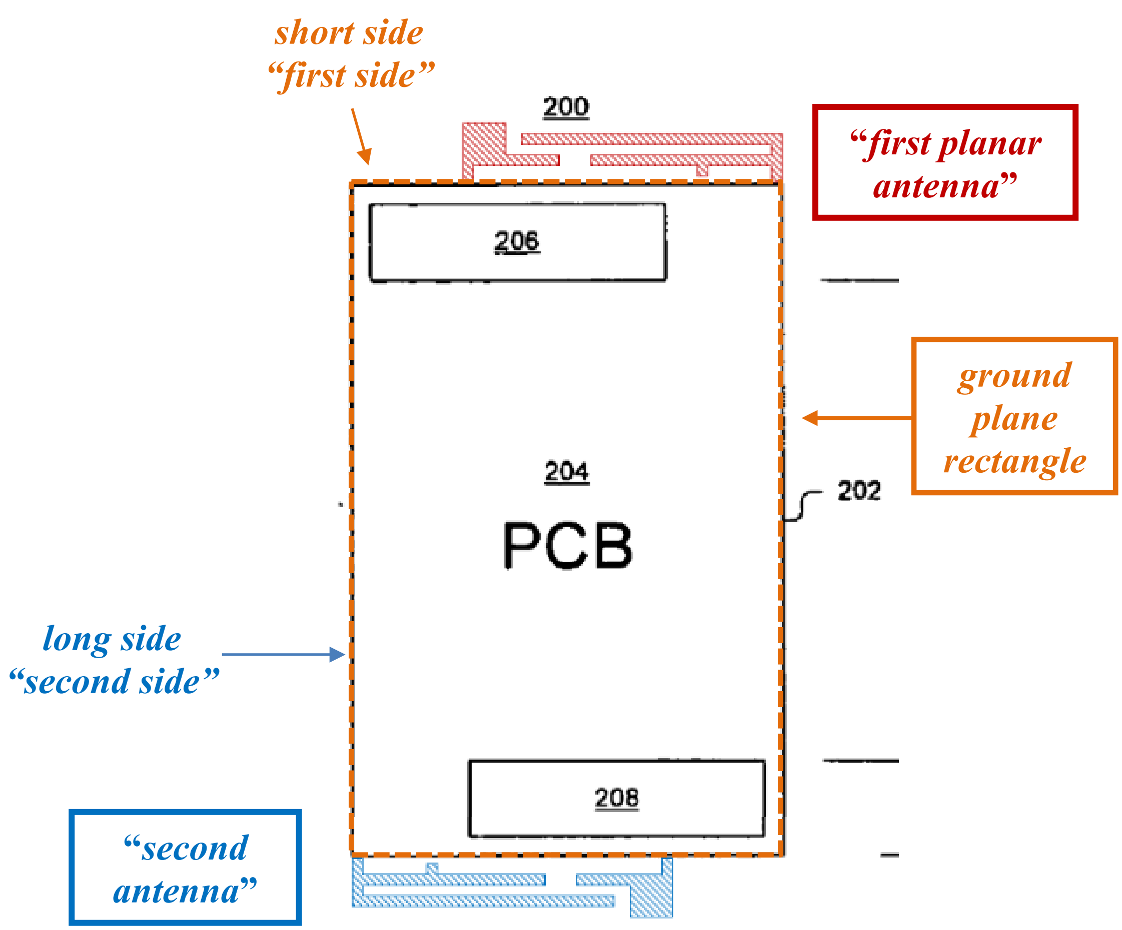
[3]	[Claim 1's device], wherein the first side of the ground plane rectangle is a short side of the ground plane rectangle.
[4]	[Claim 1's device], wherein the second side of the ground plane rectangle is a long side of the ground plane rectangle.

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

223. 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* §§XI.A.3 (combination), XI.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* §XI.A.3.a (combination).

224. 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* §XI.B.7. Dou, Fig. 2A (annotated below).



225. 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*.

E. Claim 5

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

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

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.

227. 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 "less than" 2.0:1. Ciais-Quadband, Fig. 3, 148-150. Nakano does not support frequency bands in these frequency ranges. Nakano, 2417, 2419, Fig. 4;

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

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

G. Claim 7

230. 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.

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

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

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,

232. 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* §XI.A.3 (combination); Dou, Fig. 2A, [0016]-[0017].

233. 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]. 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.

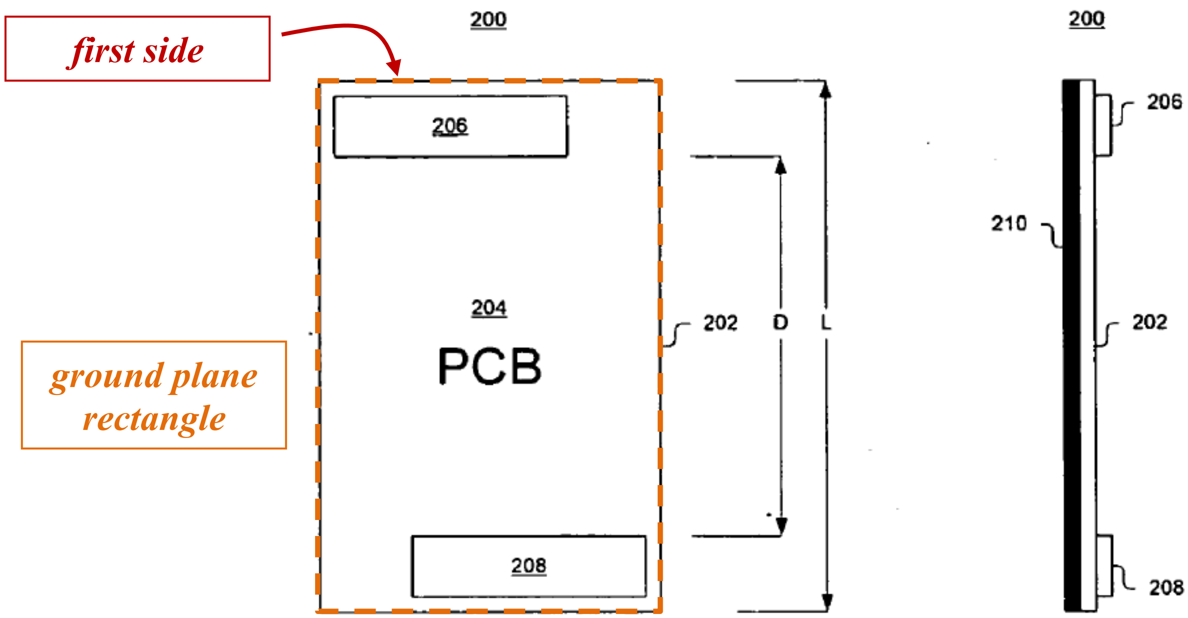


FIG. 2A FIG. 2B

234. 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].

3. Limitation [7.c]

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

235. 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* §XI.A.1XI.A.1 (discussing Ciais-Quadband).

236. 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*").

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

238. 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

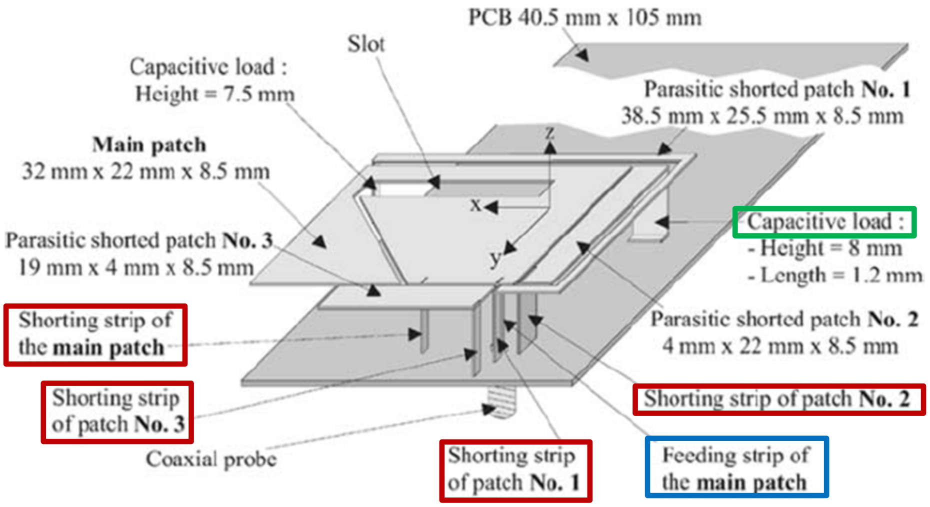
Ciais-Quadband, 148 (DCS, PCS, UMTS); EX1030, 8-9 (DCS1800, PCS1900); EX1039, 139 (reference [100] identifies HSDPA specifications), 497-501, 599 (reference [100] is 3GPP TS 25.308 (EX1032)); EX1032 (UMTS HSDPA description); EX1035, 11-12 (UMTS standard comprises TS 25.101 (EX1033), TS 25.102 (EX1034),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

239. 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.

4. Limitation [7.d]

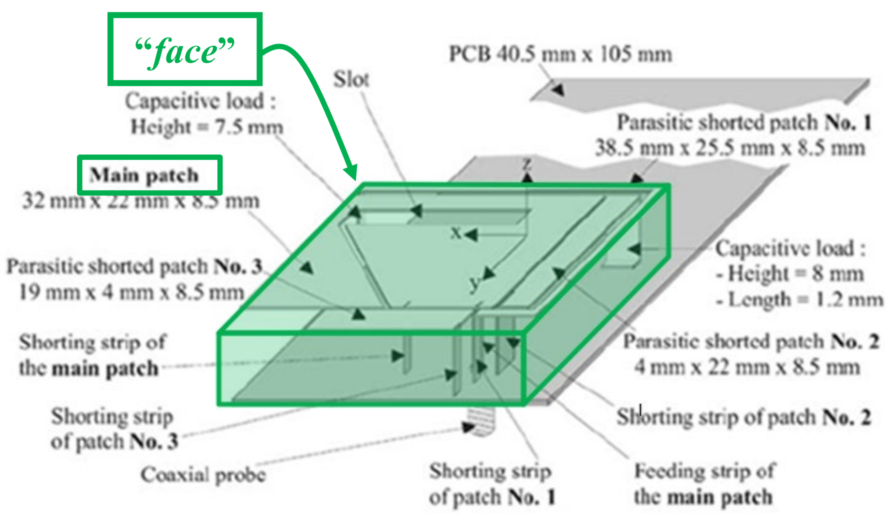
[7.d]	a minimum-sized parallelepiped completely enclosing a volume of the first non-planar antenna, the minimum-sized parallelepiped having a face with a largest area;

240. 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* §IX.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).



(a)

241. 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). The quadband antenna's "main patch" provides the parallelepiped with a "*face with a largest area*."



(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;

242. 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].

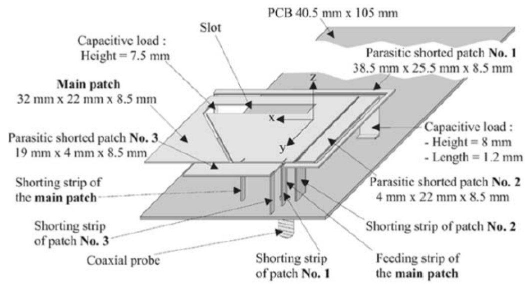
243. Dou+Ciais-Quadband+Nakano's antenna 208 ("*second antenna*") is positioned along (*proximate to*) "*a second side*" of PCB 204 that is opposite to the first side, which is also the "*second side of the ground plane rectangle*." *Supra* §XI.G.2 ([7.b]); Dou, Fig. 2A, [0016]-[0017].

244. 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*.

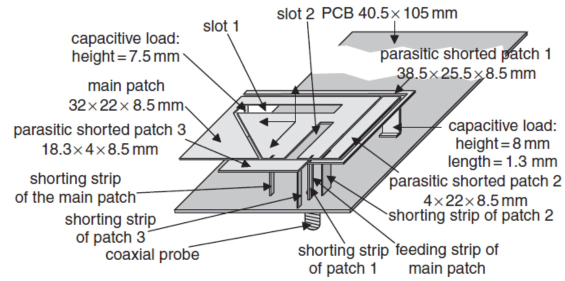
6. Limitation [7.f]

[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;

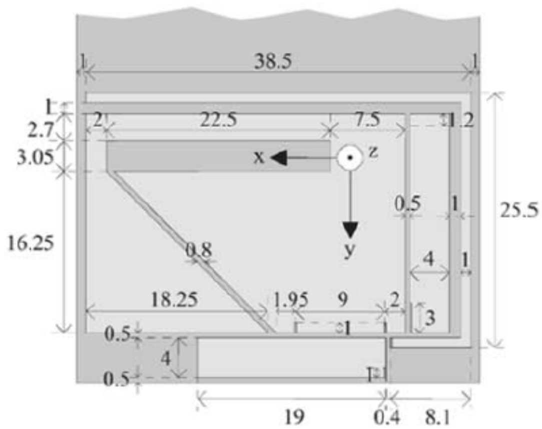
245. The Ciais quadband antenna implementing Dou's antenna 206 ("*first non-planar antenna*) has a "*first contour*" meeting [7.f] as shown below. Ciais's Figure 1(b) shows the antenna element dimensions including orthogonal projections of the out-of-plane antenna elements. Ciais-Quadband, Fig. 1(a). 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).


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

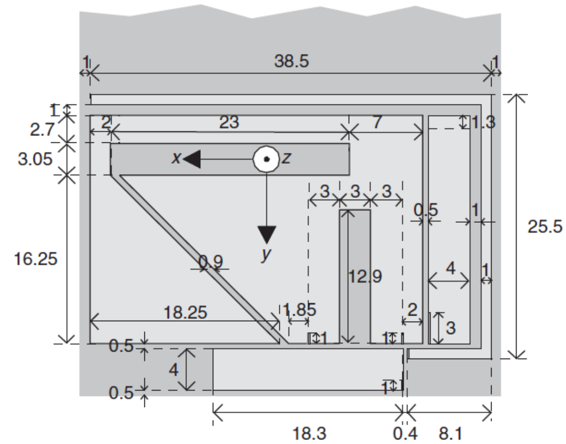
(a)


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

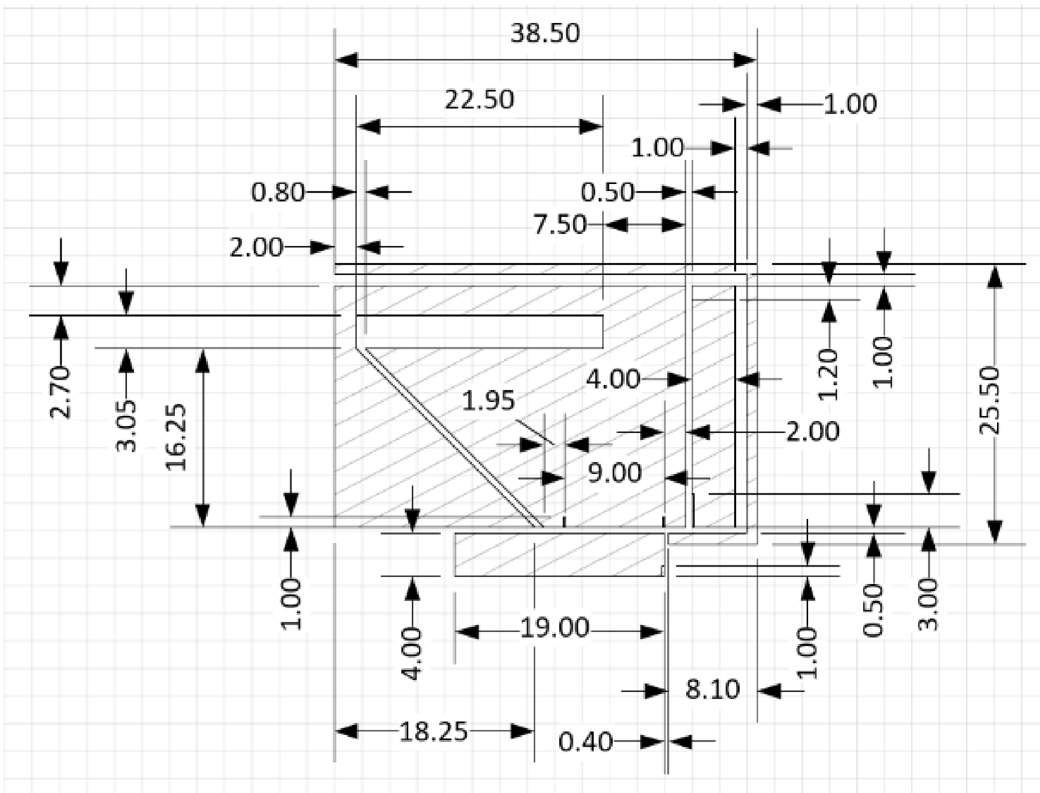

38.5
22.5
7.5
1.2
2.7
3.05
16.25
25.5
0.8
0.5
18.25
1.95
9
4
19
0.4
8.1

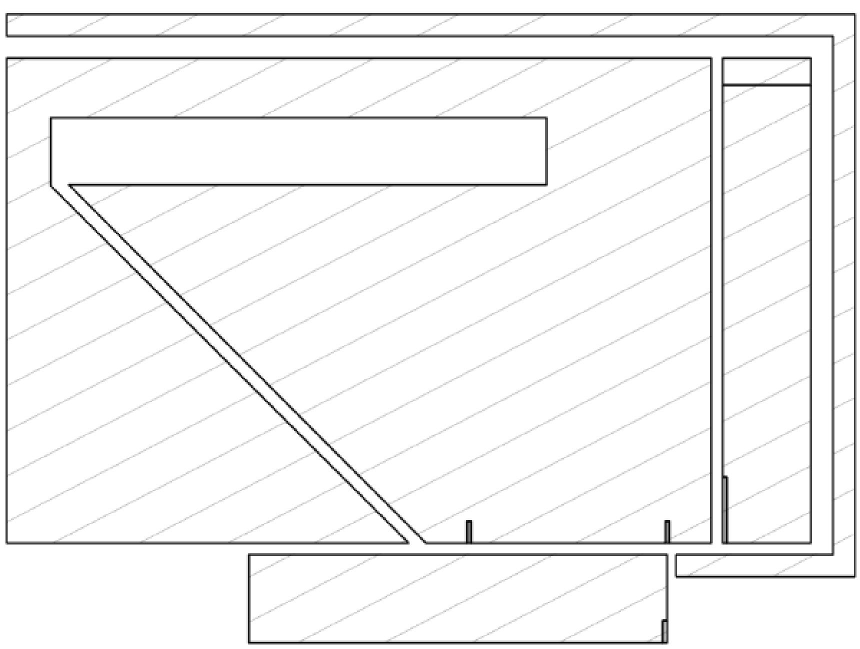
(b)


38.5
23
7
1.3
2.7
3.05
16.25
25.5
0.9
12.9
18.25
1.85
0.5
4
18.3
0.4
8.1

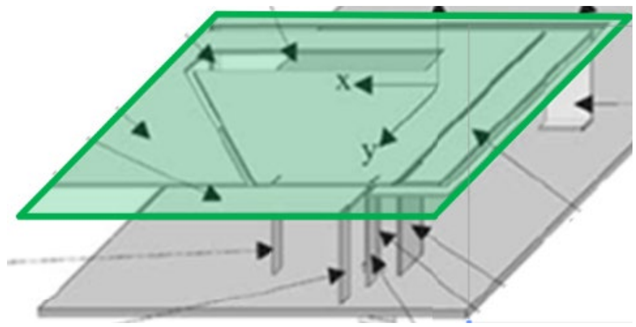
b

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

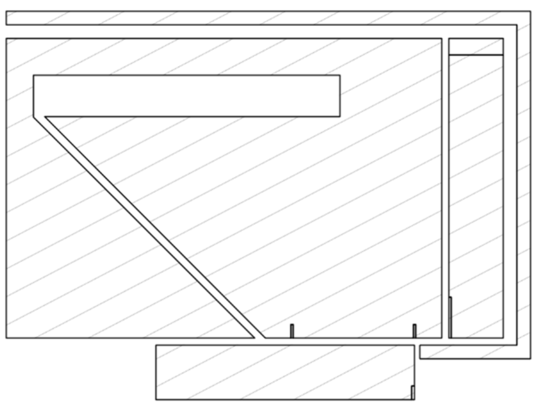




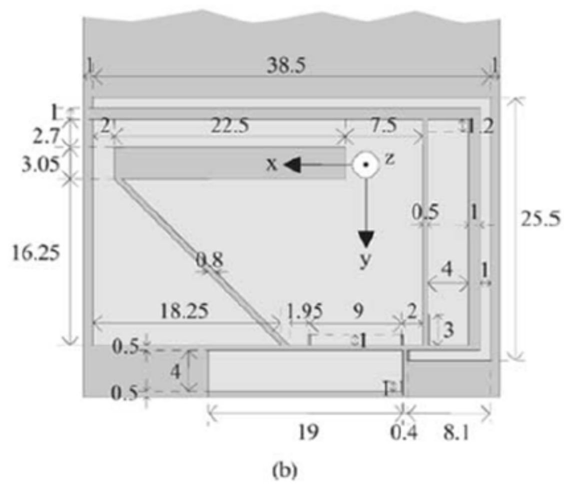
247. This *first contour* includes **[1]** the *perimeter* of all antenna elements (*portions*) in the plane of the quadband antenna's main patch (e.g., *arranged in the face*). Ciais-Quadband, Figs. 1(a) (annotated detail below top right), 1(b).



Ciais-Quadband Fig. 1(a)

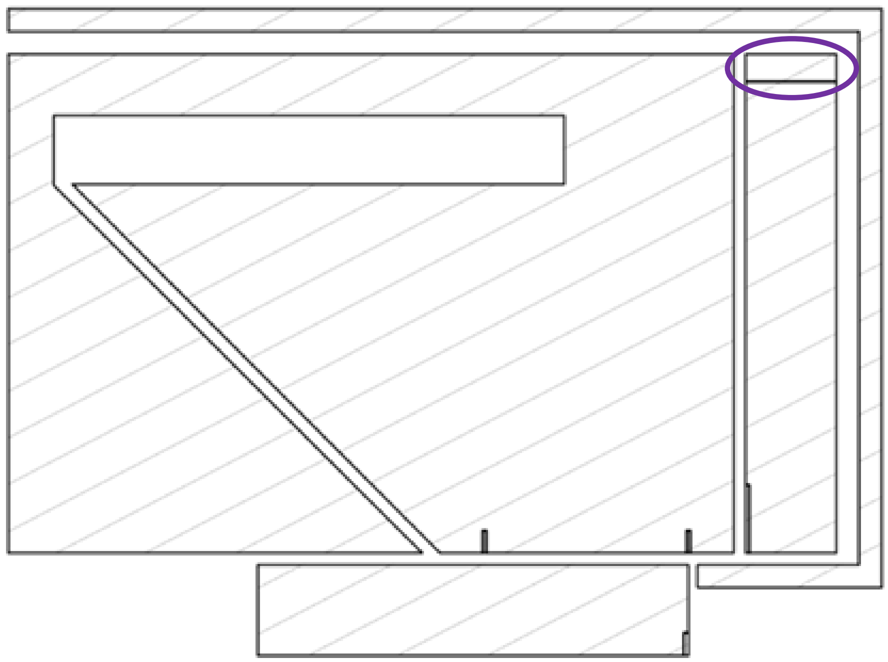


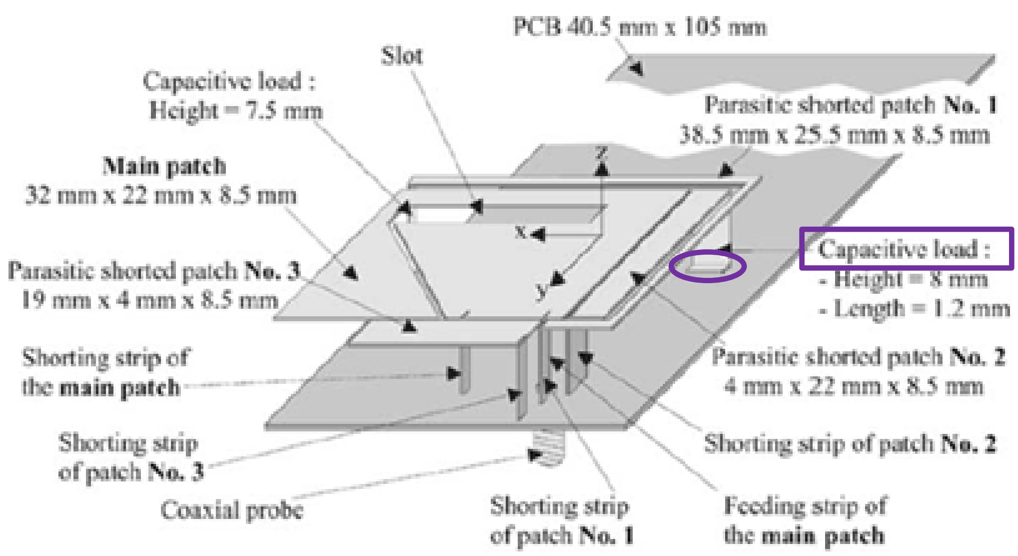
first contour



Ciais-Quadband Fig. 1(b)

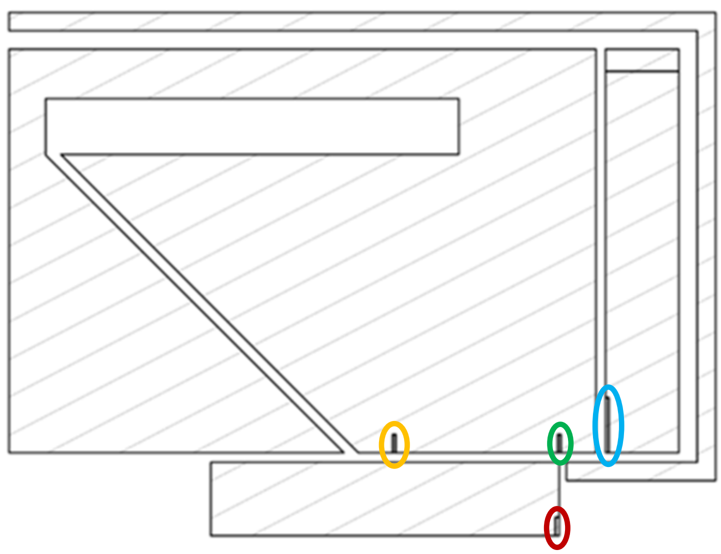
248. The *first contour* also includes **[3]** the *perimeter* of an *orthogonal projection* of the capacitive load (e.g., a *portion… not arranged in the face*), as highlighted below. Ciais-Quadband, 148-149, Figs. 1(a), 1(b).

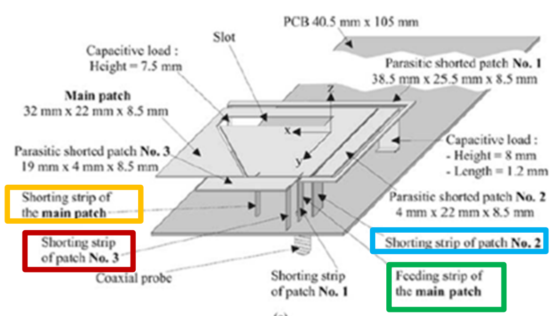




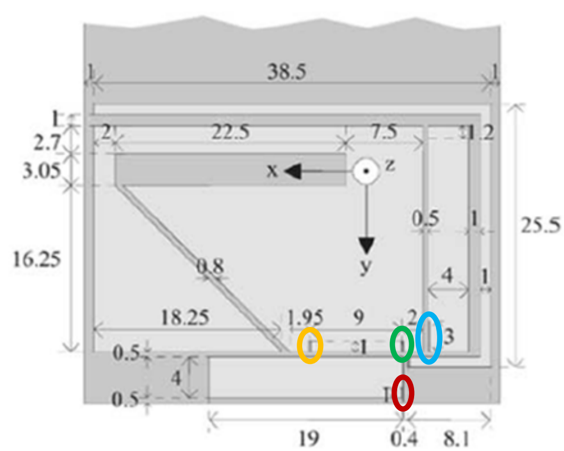
(a)

249. 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).





(a)



(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

250. Dou+Ciais-Quadband+Nakano meets [7.g] because the quadband antenna's contour ("*first contour*"), *supra* §XI.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.

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

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,

251. As explained *supra* §IX.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*.

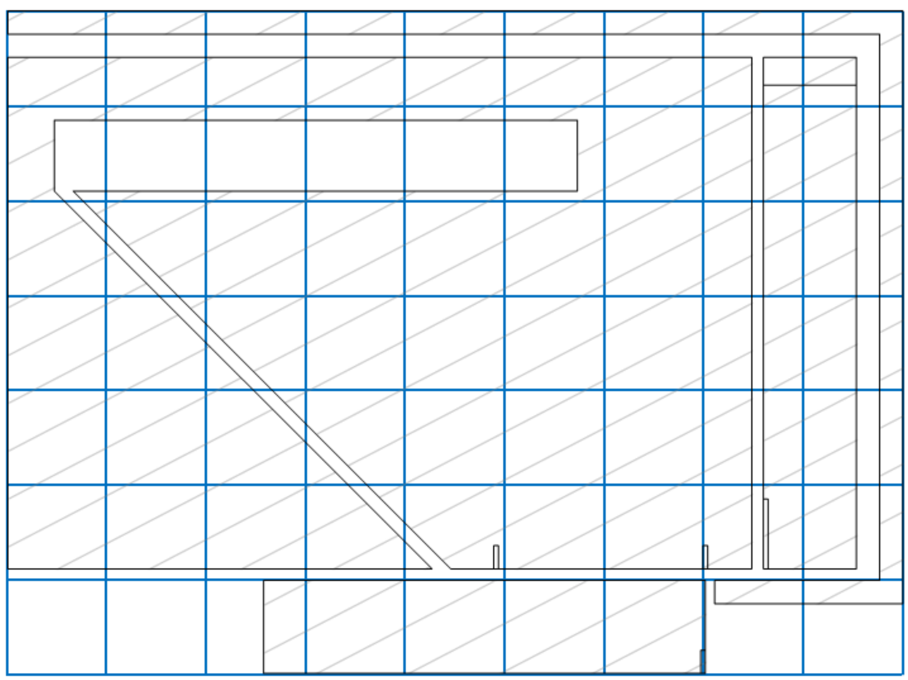
252. The quadband antenna contour (*first contour*) is 38.5 mm wide (*long side of the face*) and 28.5 mm in height (*short side of the face*). Ciais-Quadband, 148, Fig. 1(b). Grid G_2 with nine (9) columns yields cell width (*columns of equal width*) of $\left(\frac{38.5mm}{9}\right) = 4.28\ mm$.

253. 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).

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

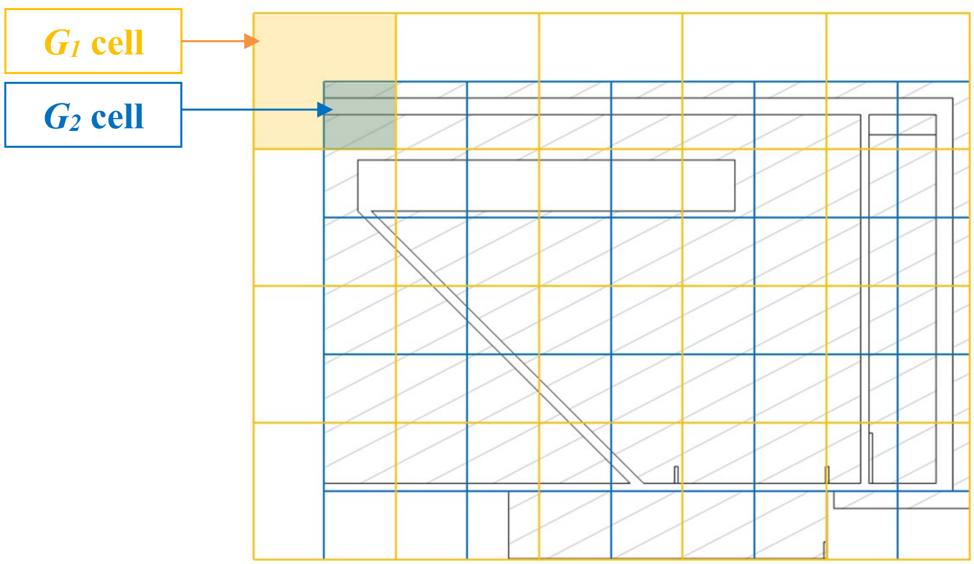


254. Thus, grid G_2 has 7 rows by 9 columns and "tessellates" the *first contour* as shown above (blue outline).

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

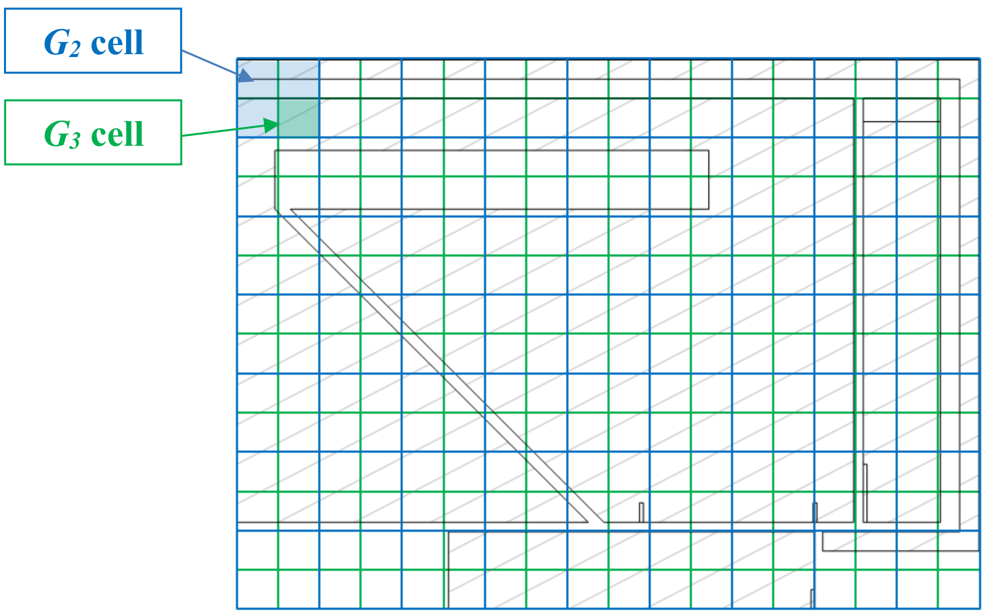
255. Grid G_1 (orange outline below) is "*aligned with a corner of the grid* G_2" and "*cover[s] the face*" (e.g., the *first contour*), wherein each G_1 cell has twice the width and height of a G_2 cell, e.g., "*widths and heights that respectively are double the widths and heights of the cells of the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



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

256. 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.*"



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

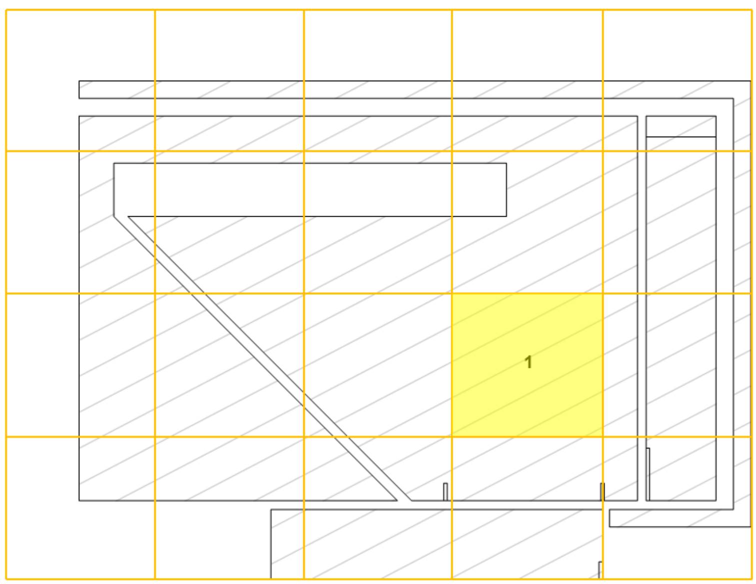
7.h.1	where N_1 is a number of cells of a grid G_1 that include at least a point of the first contour, N_2 is a number of cells of a grid G_2 that include at least a point of the first contour, and N_3 is a number of cells of a grid G_3 that include at least a point of the first contour,

257. 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. The count for each grid is shown below.

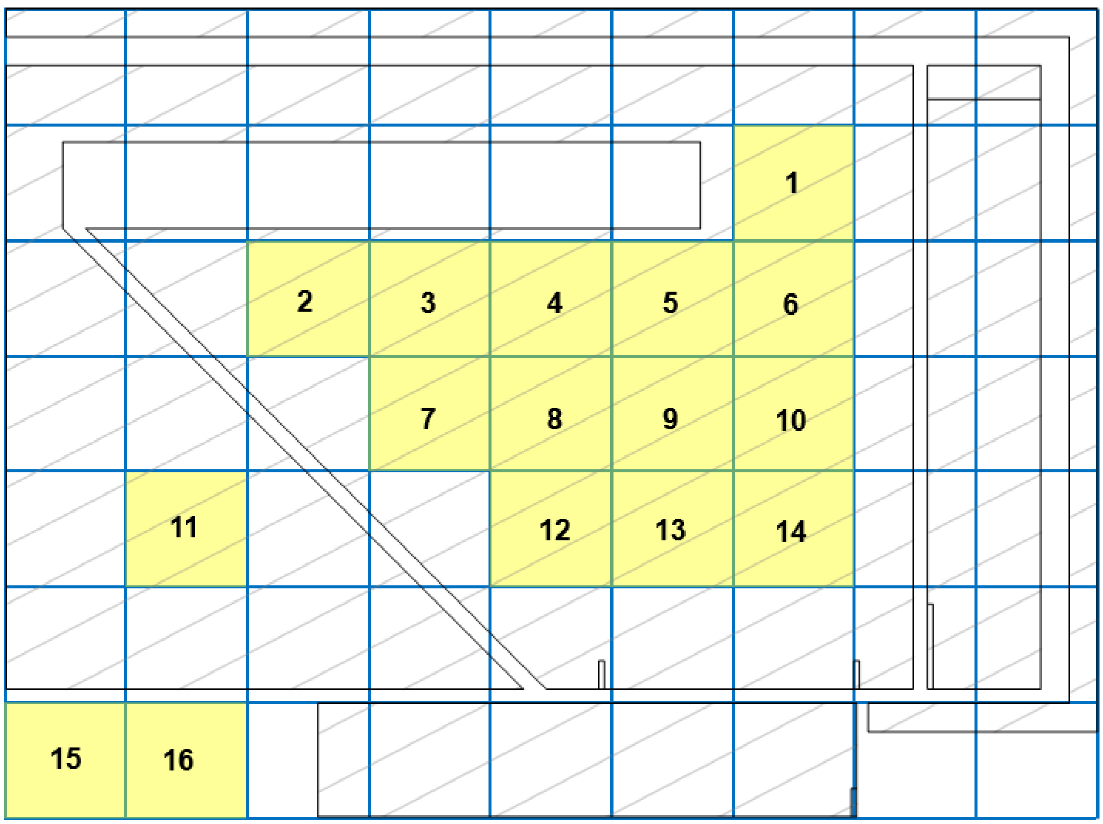
i. $N_1 = 19$

258. 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 $\boldsymbol{N_1} = (20 - 1) = 19$.



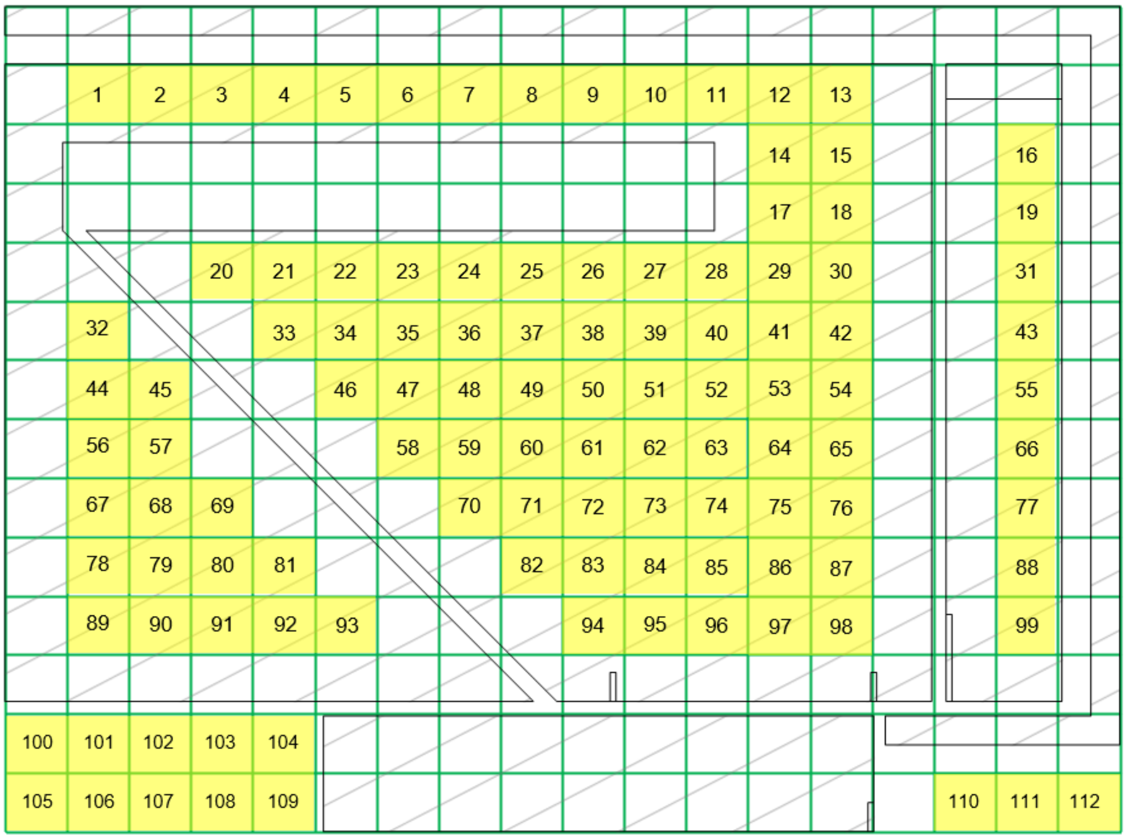
ii. $N_2 = 47$

259. The 7 × 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. Thus, the G_2 cell count $\boldsymbol{N_2} = (63 - 16) = 47$.



iii. $N_3 = 140$

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

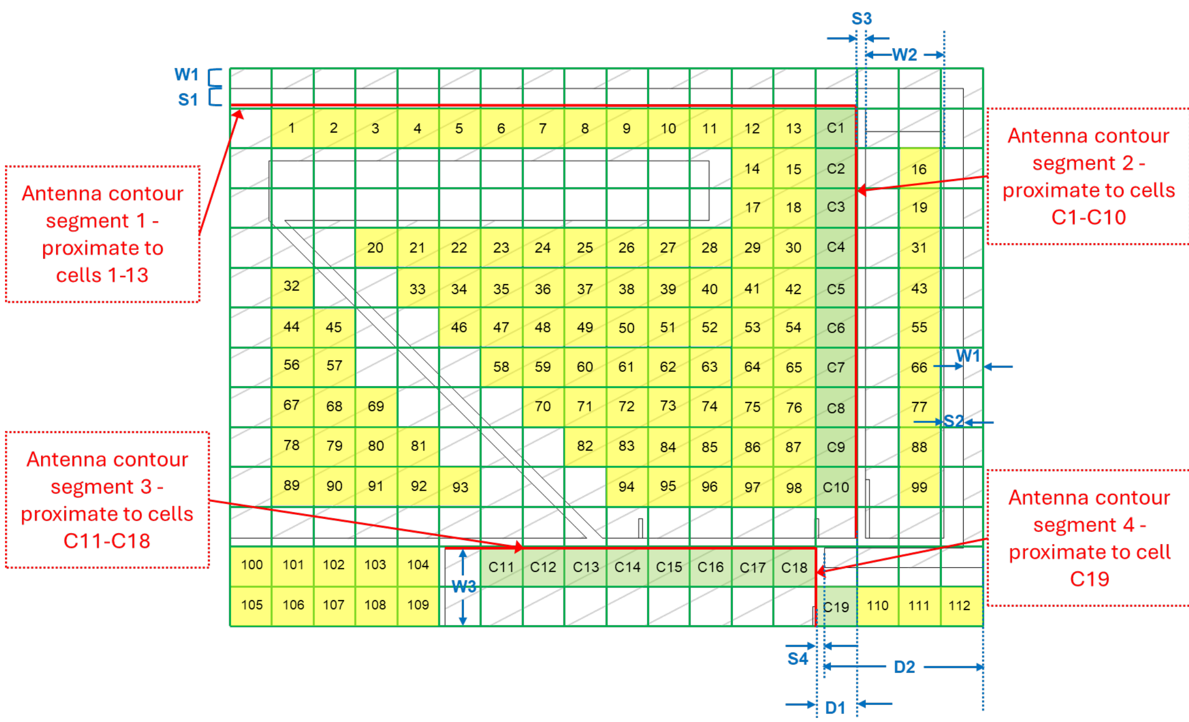


261. Among the cells that I shaded yellow above, cells 1-99 are completely within the quadband antenna contour, cells 100-112 are completely outside the antenna contour. Thus, cells 1-112 do not "include at least a point of the antenna contour." EX1005, 20:5-11.

262. In case it is not immediately obvious, I further explain whether certain G_3 cells "include at least a point of the antenna contour," alongside the below

annotated plots and a table summarizing relevant dimensions. *Supra* §XI.G.6 ([7.f]); Ciais-Quadband, Fig. 1(b), 148.

Symbol	Length (mm)	Explanation
W1	1	Width of parasitic patch no. 1
W2	4	Width of parasitic patch no. 2
W3	4	Width of parasitic patch no. 3
S1	1	Spacing between patch no. 1 and main patch
S2	1	Spacing between patch no. 1 and patch no. 2
S3	0.5	Spacing between patch no. 2 and main patch
S4	0.4	Spacing between patch no. 1 and patch no. 3
D1	2	Distance between right edge of main patch and center line of projection of feeding strip
D2	8.1	Length of the bottom arm of patch no. 1



263. The top edge of cells numbered 1-13 (yellow shaded above) is 2.036 mm (a G_3 cell height) from the top of the *antenna rectangle*. The proximate *contour* edge ("segment 1" highlighted above in red) is W1+S1 = 1.0+1.0 = 2 mm

from the top of the *first contour* and thus lies ***above*** the top edge of cells 1-13. Therefore, the cells numbered 1-13 do not "include at least a point of the antenna contour." Ciais-Quadband, Fig. 1(b), 148.

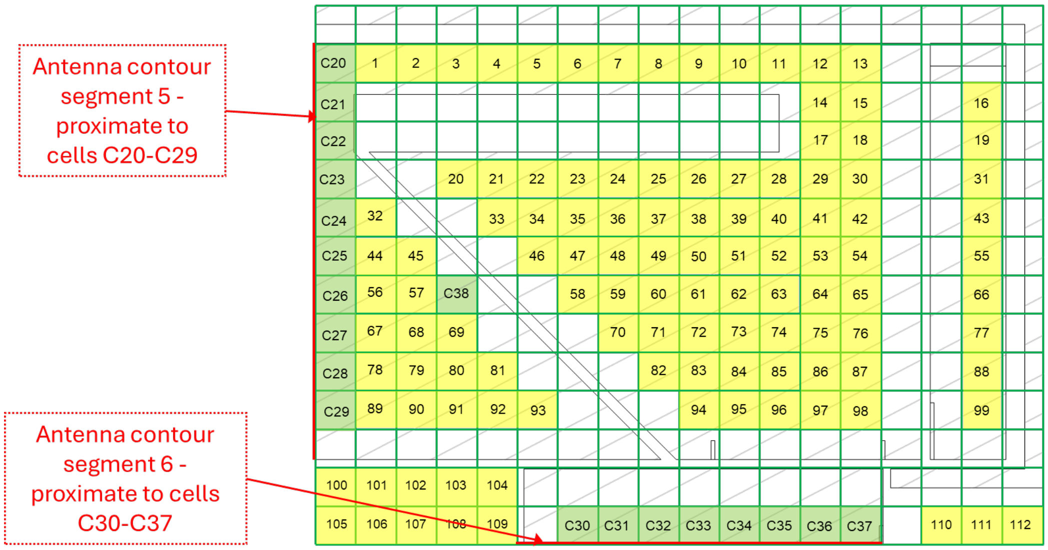
264. The right edges of cells numbered C1-C10 (green shaded above) are 2.139 × 3 = 6.417 mm (three times the G_3 cell width) from the right edge of the *first contour*. The proximate *contour* edge ("segment 2" highlighted above in red) is W1+S2+W2+S3 = 1+1+4+0.5 = 6.5 mm (highlighted in blue) from the right edge of the *first contour*, and thus lies inside cells C1-C10. *Supra* §XI.G.6 ([7.f]); Ciais-Quadband, Fig. 1(b), 148. Cells C1-C10 therefore "include at least a point of the antenna contour."

265. The top edges of cells numbered C11-C18 are 2.036 × 2 = 4.072 mm (two times the G3 cell height) from the bottom of the antenna rectangle. The proximate *contour* edge ("segment 3" highlighted above in red) is 4 mm (i.e., width of parasitic patch no. 3) from the bottom of the antenna rectangle and thus ***within*** cells C11-C18. *Supra* §XI.G.6 ([7.f]); Ciais-Quadband, Fig. 1(b), 148. Cells C11-C18 therefore include the *contour* passing through them and thus "include at least a point of the antenna contour."

266. The left edge of cell numbered C19 is 2.139 × 4 = 8.556 mm (four times the G_3 cell width, because C19 is at the fourth column from right) from the right edge of the *first contour*. The proximate *contour* edge ("segment 4"

highlighted above in red) is W1+S2+W2+S3 +D1 = 1+1+4+0.5+2 = 8.5 mm from the right edge of the *first contour*. *Supra* §XI.G.6 ([7.f]); Ciais-Quadband, Fig. 1(b), 148. This distance is confirmed by calculating it in another way: D2+S4 = 8.1+0.4 = 8.5 mm. Thus, the proximate *contour* edge lies ***within*** cell C19, i.e., goes through cell C19. Cell 19 thus "include[s] at least a point of the antenna contour." Ciais-Quadband, Fig. 1(b), 148.

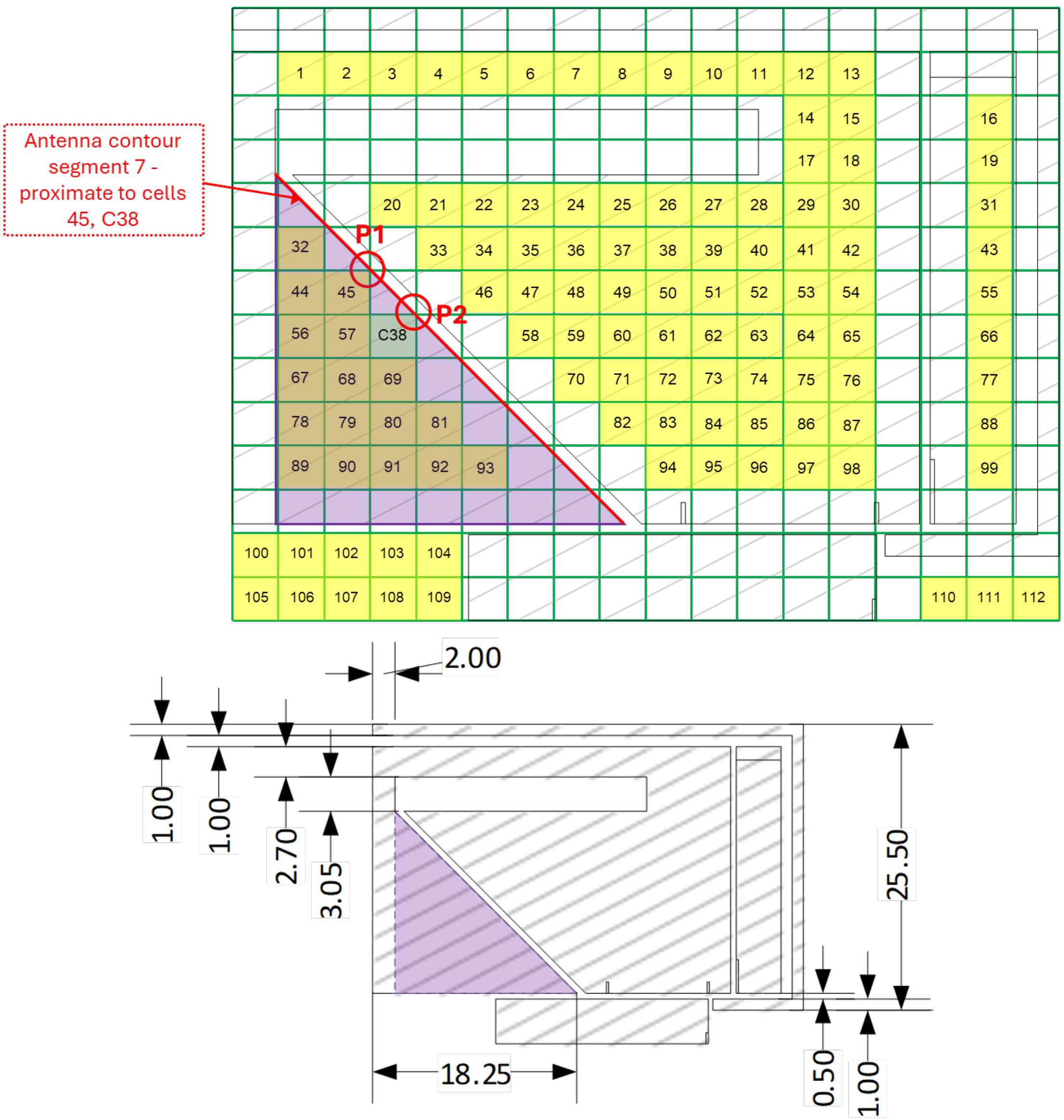
267. Additionally, the '149 patent states that "in the present invention the boundary of the cell is also part of the cell[.]" *Supra* §XI.G.8.d ([7.h.1]); EX1005, 19:15-17. Thus, even if a grid cell only includes points of the *first contour* on its cell boundary, *e.g.*, the *contour* matches the cell boundary and doesn't further extend into the cell, the cell "include[s] at least a point of the antenna contour." As shown below, the left edges of cells C20-C29 match the left edge of the main patch ("Antenna contour segment 5" in red below), and thus cells C20-C29 each "include at least a point of the antenna contour." Likewise, the bottom of cells C30-C37 matches the bottom of patch no. 3 ("Antenna contour segment 6" in red below), and thus "include at least a point of the antenna contour."



268. Whether cells 45 and C38 "include at least a point of the antenna contour" depends on whether their respective top-right corners are each within the main patch, i.e., if the top-right corner reaches or extends above the "Antenna contour segment 7" (red below) of the triangular portion (annotated in purple below) of the main patch, the cell "include[s] at least a point of the antenna contour."

269. As shown below the purple highlighted portion of the main patch is an isosceles right triangle. This can be confirmed by calculating its vertical and horizontal sides using relevant dimensions provided by Ciais-Quadband (reproduced in my plots below). *Supra* §XI.G.6 ([7.f]); Ciais-Quadband, Fig. 1(b), 148. The vertical side is taken as a line segment parallel to the left edge of the main patch, and its length is: 25.50-1.00-1.00-2.70-3.05-0.50-1.00 = 16.25 (see dimensions below). The length of the triangle's horizontal side (along the bottom

of the main patch) is: 18.25-2.00 = 16.25 mm. Because the vertical and horizontal sides are of equal length and perpendicular to each other, the purple highlighted portion is an isosceles right triangle.



270. Referring back to cell 45 and its top-right corner P1. P1 is 2.139 × 3 = 6.417 mm (three times a G_3 cell width) from the left edge of the *first contour*,

and 2.036 × 6 = 12.216 mm from top of the *first contour*. Relative to the purple triangle's x-y coordinates below, P1's x-position is 6.417 – 2 = 4.417 mm, and y-position is 12.216 -1-1-2.7-3.05 = 4.466 mm. On the "segment 7" (hypotenuse), any point's horizontal (x) and vertical (y) offsets are equal, and thus when x-position is 4.417 mm, the y-position is also 4.417 mm. This is less than P1's y-position. Thus, at the same x-position as P1, the "segment 7" is closer to the top of the *contour*, i.e., above P1. That is, P1 lies below "segment 7" and is within the main patch, and thus cell 45 is completely within the main patch and does ***not*** "include at least a point of the antenna contour.

271. Referring now to cell C38 and its top right corner P2. P2 is 2.139 × 4 = 8.556 mm (four times a G_3 cell width) from the left edge of the *first contour*, and 2.036 × 7 = 14.252 mm from top of the *first contour*. Relative to the purple triangle's x-y coordinates below, P1's x-position is 8.556 – 2 = 6.556 mm, and y-position is 14.252-1-1-2.7-3.05 = 6.502 mm. On the "segment 7" (hypotenuse), any point's horizontal (x) and vertical (y) offsets are equal, and thus when x-position is 6.556 mm, the y-position is also 6.556 mm. This is more than P2's y-position. Thus, at the same x-position as P2, the "segment 7" is farther from the top of the *contour*, i.e., below P2. That is, P2 extends beyond "segment 7" and is outside the main patch, and thus cell C38 "include[s] at least a point of the antenna contour."

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 $F_{21} = 1.31$

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

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

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

ii. Calculation $F_{32} = 1.57$

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

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

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

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.

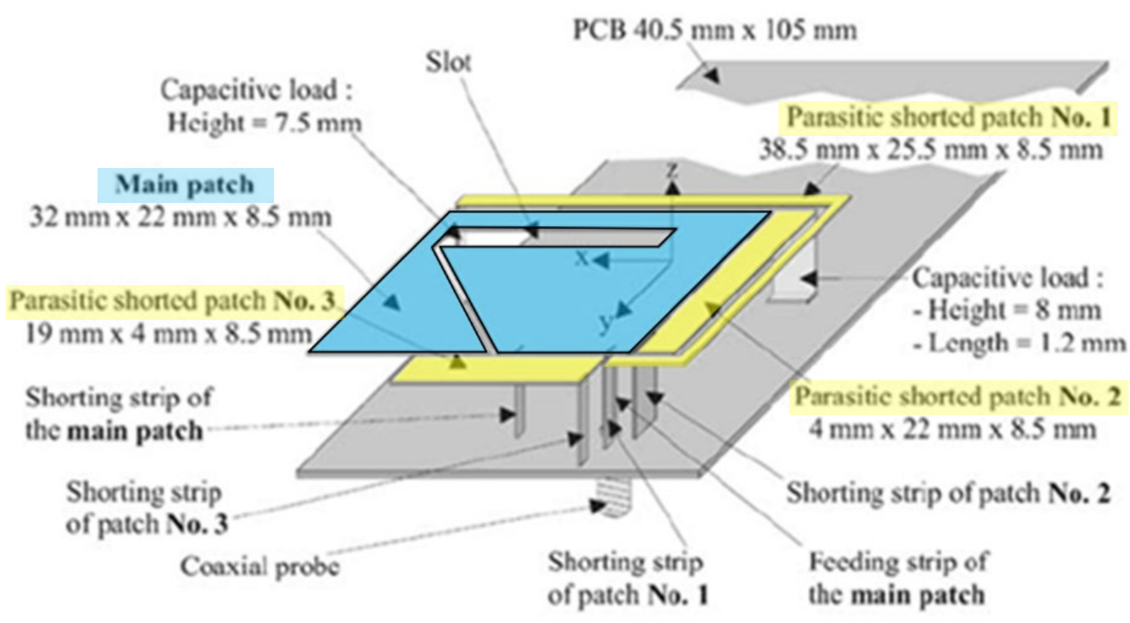
274. Dou+Ciais-Quadband+Nakano uses Ciais's quadband antenna, which Ciais optimized by adding a slot to "allow[] a frequency decrease of its fundamental resonance while the use of an end positioned capacitive load allows its higher order modes to be decreased in frequency," while "the addition of three 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. Ciais thereby "configured" the *first contour*'s "*level of complexity*" to provide the frequency operation discussed *supra* §XI.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* §XI.G.6 ([7.f]). EX1005, 16:64-17:4, 19:26-29, 20:19-22.

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

H. Claim 8

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

276. 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. The parasitic patches are separated by air from a main patch. Ciais-Quadband, 148, Fig. 1(a) (annotated below).



(a)

277. 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* §IX.E (Ground 1A, claim 8). EX1047, 242; EX1048, 240, 362.

I. Claim 9

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

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

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.

279. 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* §XI.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* §XI.A.3 (combination); Dou, [0040]. 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. 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*").

K. Claim 11

280. Dou+Ciais-Quadband+Nakano meets claim 11 for the same reasons that Dou+Ciais-Multiband meets claim 11 *supra* §IX.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. In each case, the projection "*partially overlaps the ground plane rectangle*" for the reasons explained *supra* §IX.G (Ground 1A, claim 11).

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.

281. 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* §IX.H (Ground 1A, claim 12) for Dou+Ciais-Multiband.

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

282. 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]

283. 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.

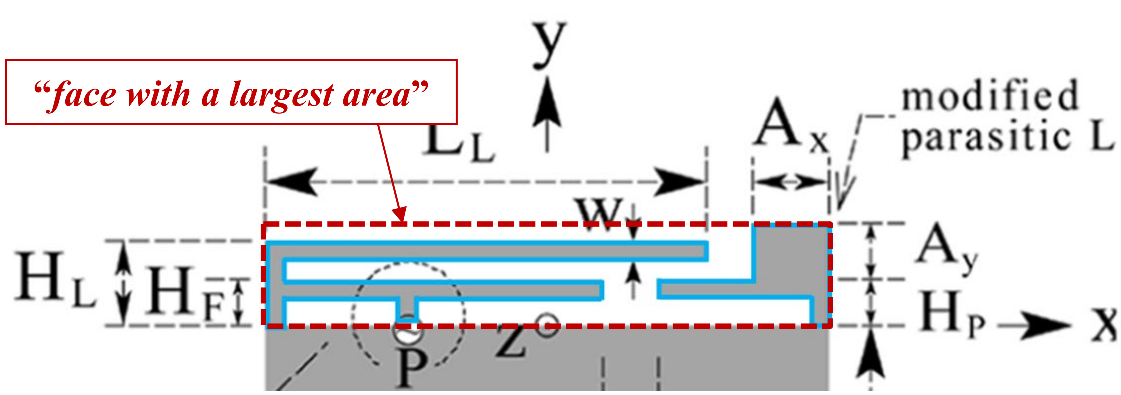
Limitation	Corresponding limitation	Discussion *supra*
13.PRE	1.PRE	§XI.B.1
13.a	1.a	§XI.B.2
13.b	1.b	§XI.B.3
13.c	1.c	§XI.B.4
13.e	1.f	§XI.B.7
13.g	1.e	§XI.B.6
13.h	1.h	§XI.B.8.e
13.h.1	1.h.1	§XI.B.8.d
13.h.3	1.h.3	§XI.B.8.b
13.h.4	1.h.4	§XI.B.8.c
13.i	1.i	§XI.B.9

284. 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;

285. 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. 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. The top 30 × 5.5 mm^2 surface of the *parallelepiped* enclosing Nakano's antenna is *a face with a largest area* of *the minimum-sized parallelepiped*.

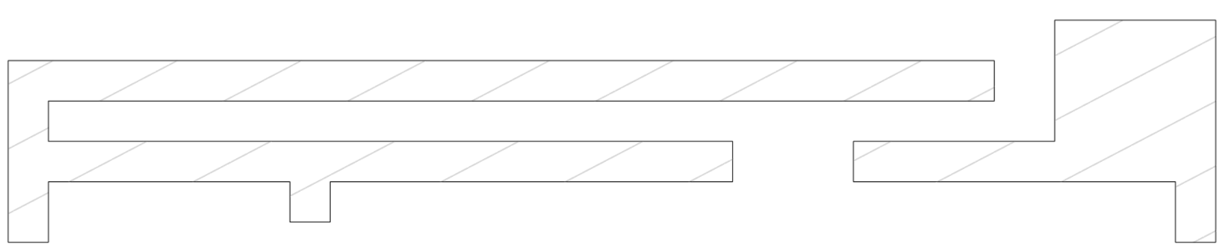


c. Limitation [13.f]

286. 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* §XI.B.5 ([1.g]) and shown below, because Nakano only contains antenna portions within "*the face*" of the *parallelepiped* as defined *supra* §XI.M.1.bXI.M.1.bXI.M.1.b ([13.d]).



d. Limitation [13.h.2]

287. As explained *supra* §IX.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* §XI.B.8.a.

2. Claims 14, 17, 19

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

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

3. Claim 15

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

4. Claim 18

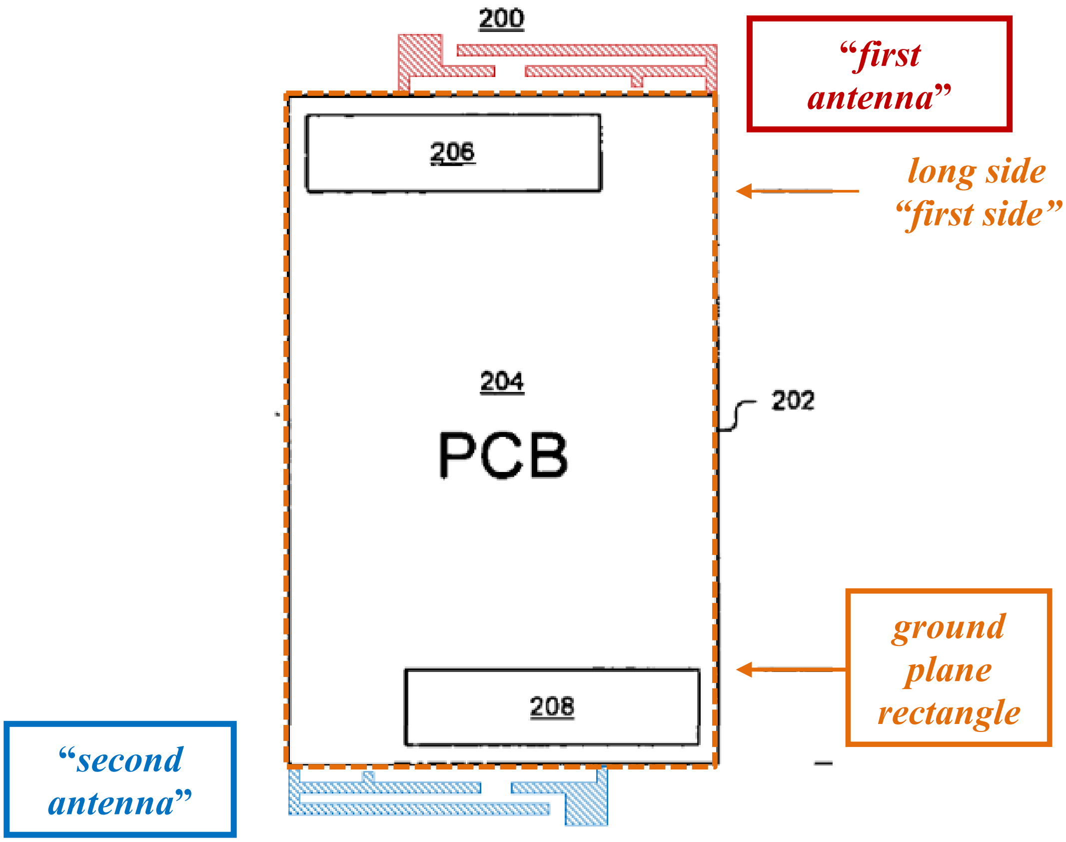
[18]	[Claim 13's device], wherein a third antenna is configured to operate in at least two frequency bands being different from the at least three frequency bands and the third antenna is arranged within the wireless device.

290. Dou+Ciais-Quadband+Nakano meets the additional limitations in claim 18 for the reasons it meets claim 6 *supra* §XI.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* §XI.A.3 (combination); Ciais-Quadband, Title ("Design of an Internal Quad-Band Antenna for Mobile Phones"), 148.

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.

291. 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* §§XI.A.3 (combination), XI.B.3 ([1.b]), XI.D (claims 3-4), XI.M.1.a ([13.b]); Dou, Fig. 2A (annotated below to show combination).



292. Thus, the *first antenna* is "*proximate*" to a "*first side of the ground plane rectangle*" (*supra* §§XI.G.1 ([7.b]), XI.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.

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

293. 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.

1. Claim 13

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

294. 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.

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

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

b. Limitation [13.h.2]

296. As explained *supra* §IX.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* §XI.G.8.a.

2. Claims 14, 16-19

297. 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. Dou+Ciais-Quadband+Nakano meets the additional limitations in claims 14, 16-19 for the same reasons it meets the corresponding limitations below.

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

298. 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* §§XI.A.3XI.A.2 (combination), XI.G.2 ([7.b]), XI.N.1.a ([13.b]); Dou, Fig. 2A. 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* §XI.A.3XI.A.2 (combination); Ciais-Quadband, 148, Fig. 1(a).

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

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

A. Dou (EX1013)

300. 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* §IX.A (Ground 1A, Dou). 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).

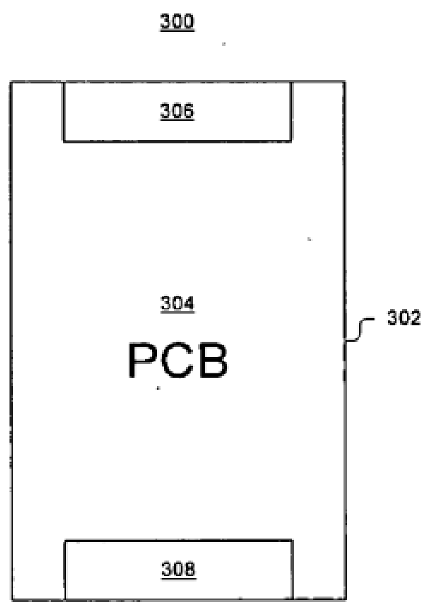


FIG. 3A

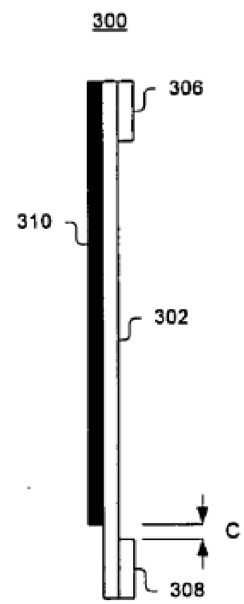
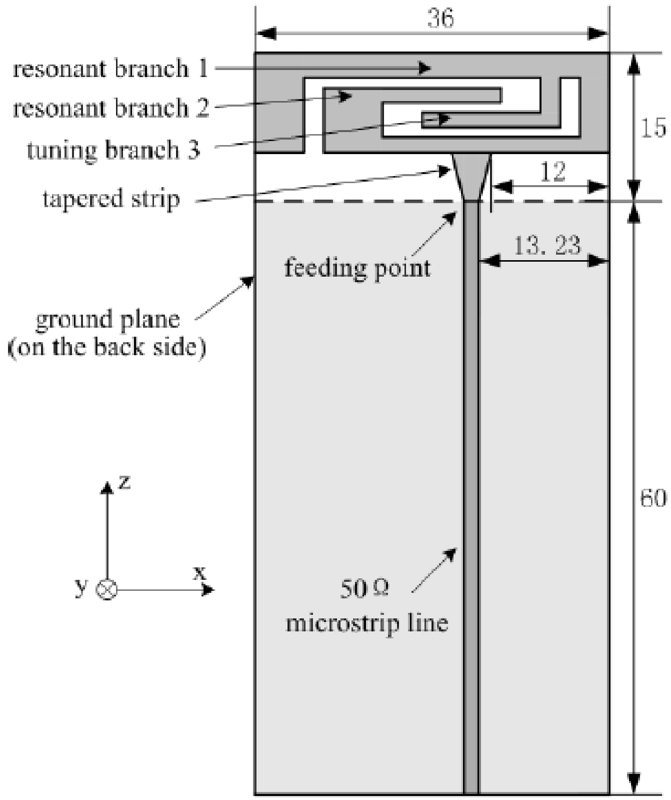


FIG. 3B

B. Jing (EX1011)

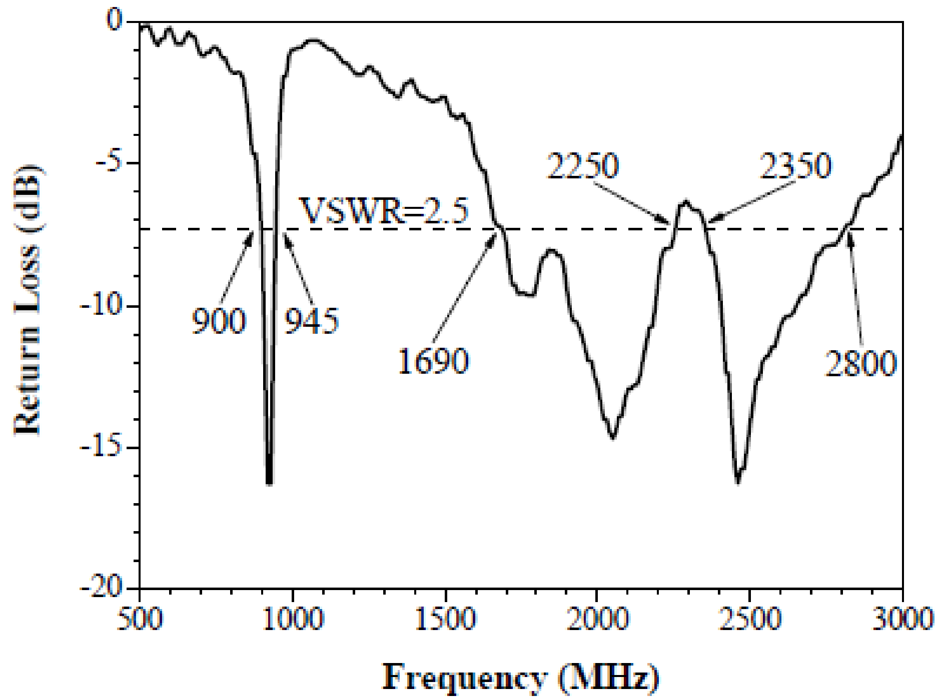
301. Jing teaches a compact multiband "planar monopole antenna with a 2-dimensional structure" for mobile handsets that operates with GSM, DCS, PCS, UMTS, and WLAN services. Jing, 2657, 2660, Fig. 1(a) (below).[2]

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



(a)

302. 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.



C. Dou+Jing

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

304. 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).

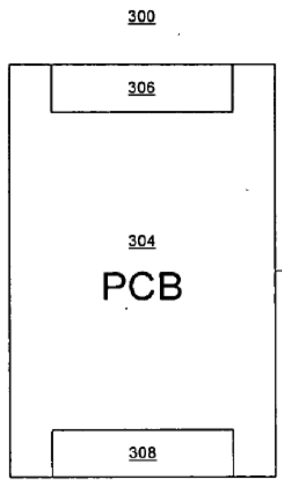


FIG. 3A

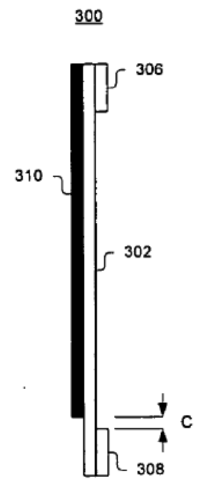
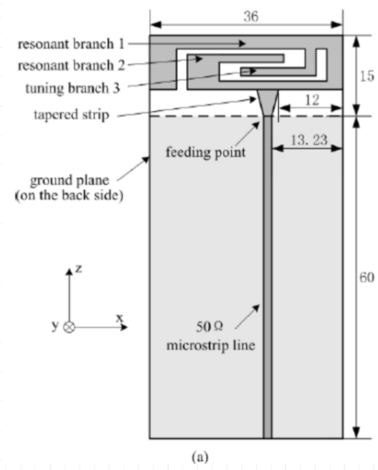


FIG. 3B



Dou Jing

305. 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* §XII.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").

306. POSAs would have used Jing as Dou's antennas 306 and 308. 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. POSAs would have recognized that whether the ground plane extends under Dou's antennas depends on the specifications required by the implemented

antennas. 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. 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). 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.

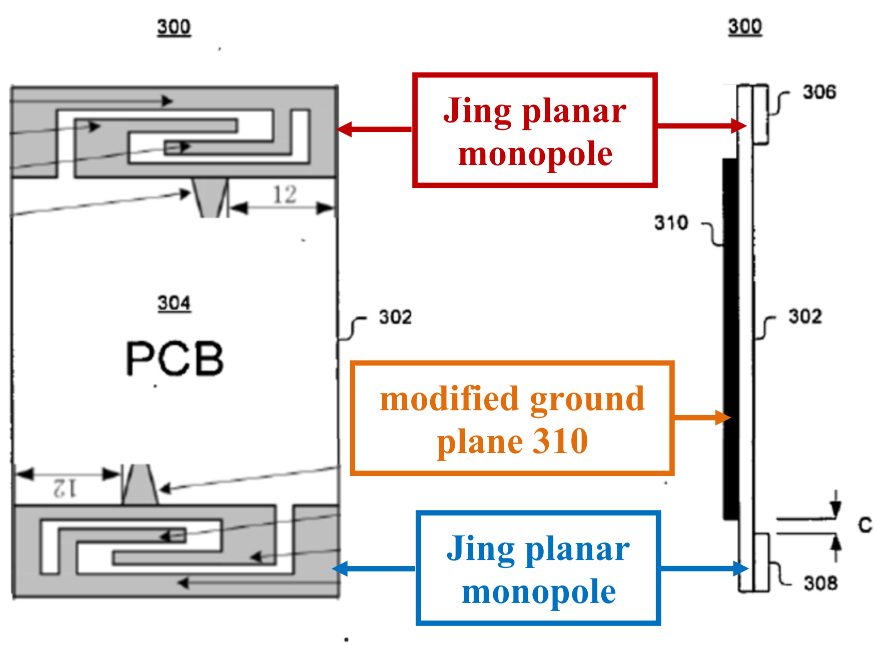


FIG. 3A FIG. 3B

307. Implementing Dou's antennas 306 and 308 using separate Jing antennas would have combined 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.

308. 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]). Dou describes antenna placement within the device according to "various performance and design constraints" known to POSAs. Dou, [0030]. 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]. 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].

309. 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.

D. Claim 1

1. Preamble [1.PRE]

[1.PRE]	A wireless device comprising:

310. 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.

2. Limitation [1.a]

[1.a]	a ground plane;

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

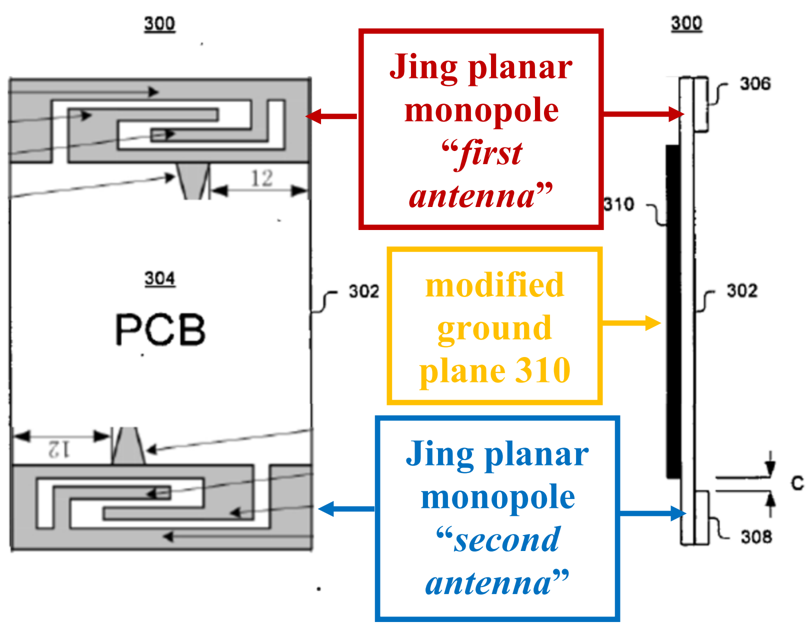


FIG. 3A FIG. 3B

3. Limitation [1.b]

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

312. 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.

313. 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). 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* §XII.C (combination).

314. 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. 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* §XII.C (combination).

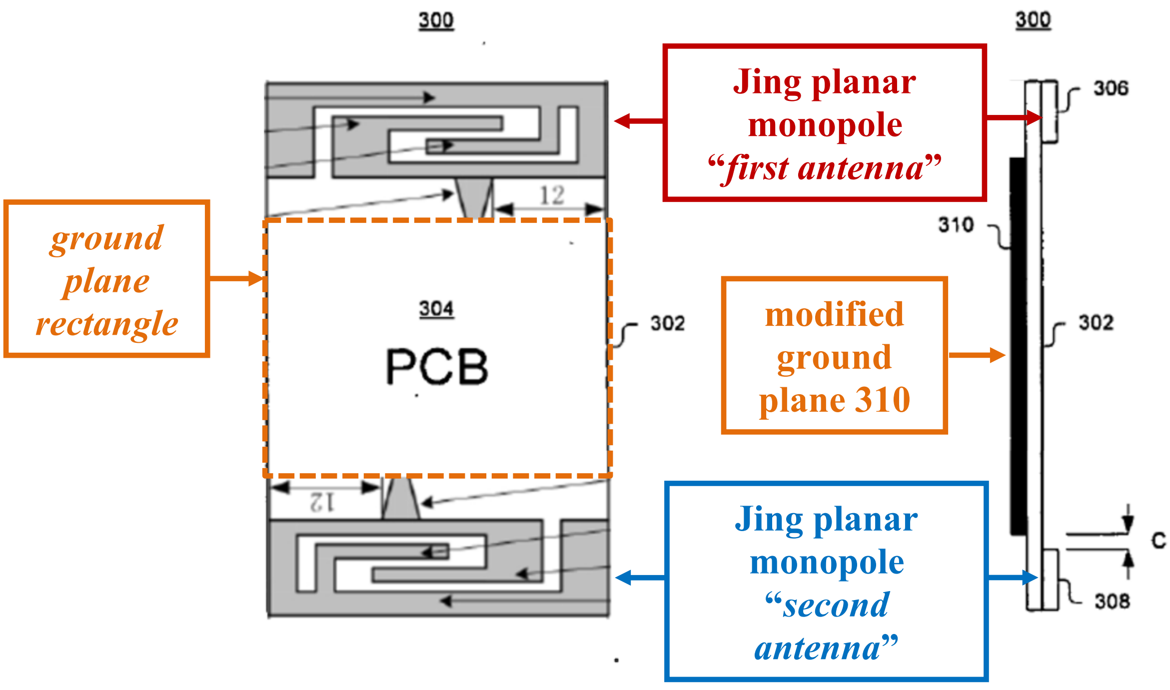


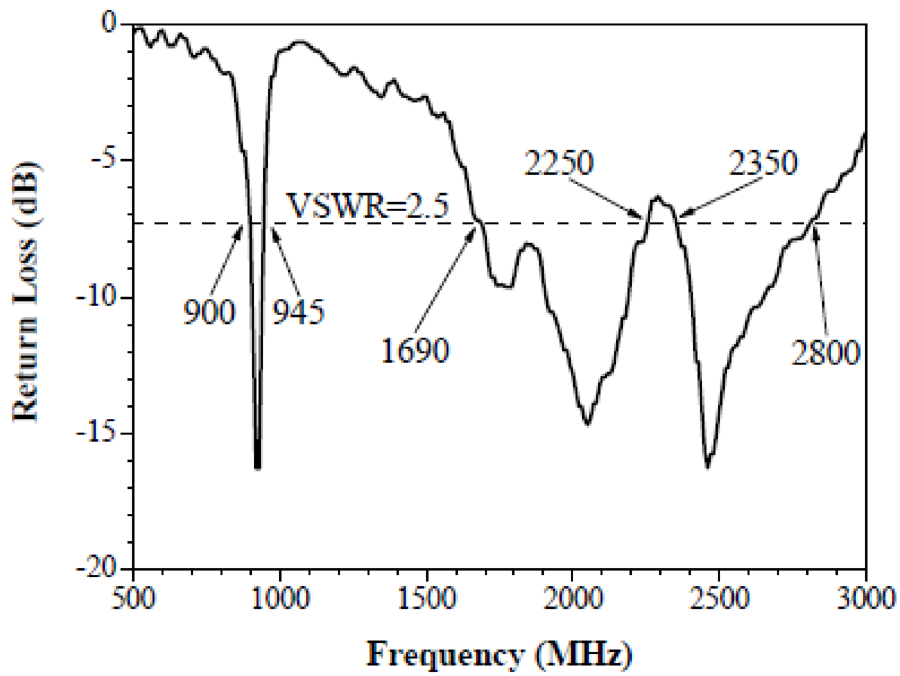
FIG. 3A FIG. 3B

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,

315. 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).



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

317. 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* §XI.G.3 (Ground 2, [7.c]). Jing, 2658 (DCS, PCS, UMTS).

318. 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

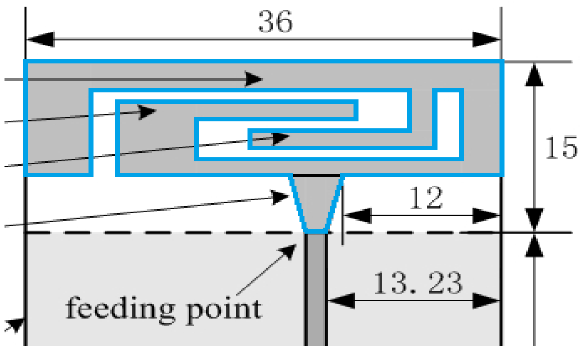
Jing, 2658 (WLAN); EX1024, 27 (Fractus citing LTE bands); EX1025, 13, Table 5.5-1 ("E-UTRA operating bands" defining LTE bands); EX1026, 11 (listing LTE FDD and TDD bands); EX1031, 70 (listing ZigBee bands); EX1039, 497-501; EX1043, 1 (defining the 802.11 band); EX1044, 29 (defining Bluetooth band).

319. 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.

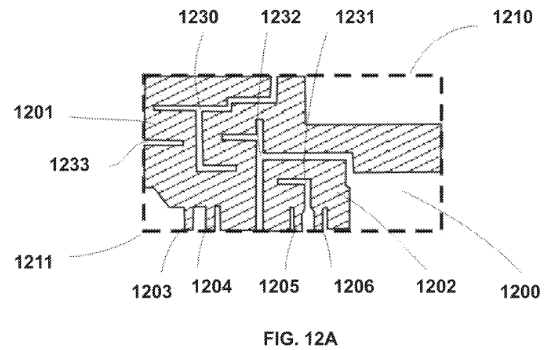
5. Limitations [1.d], [1.g]

[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;

320. 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.").

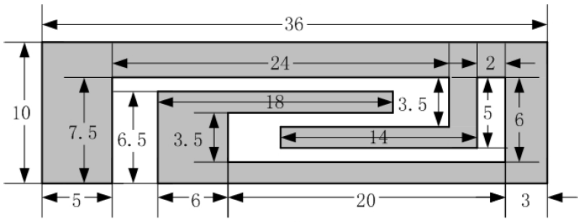


Jing, Fig. 1(a) (annotated detail)

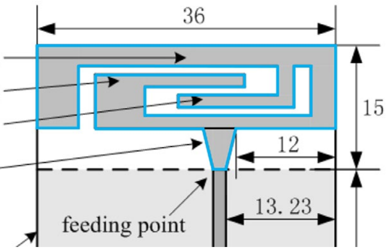


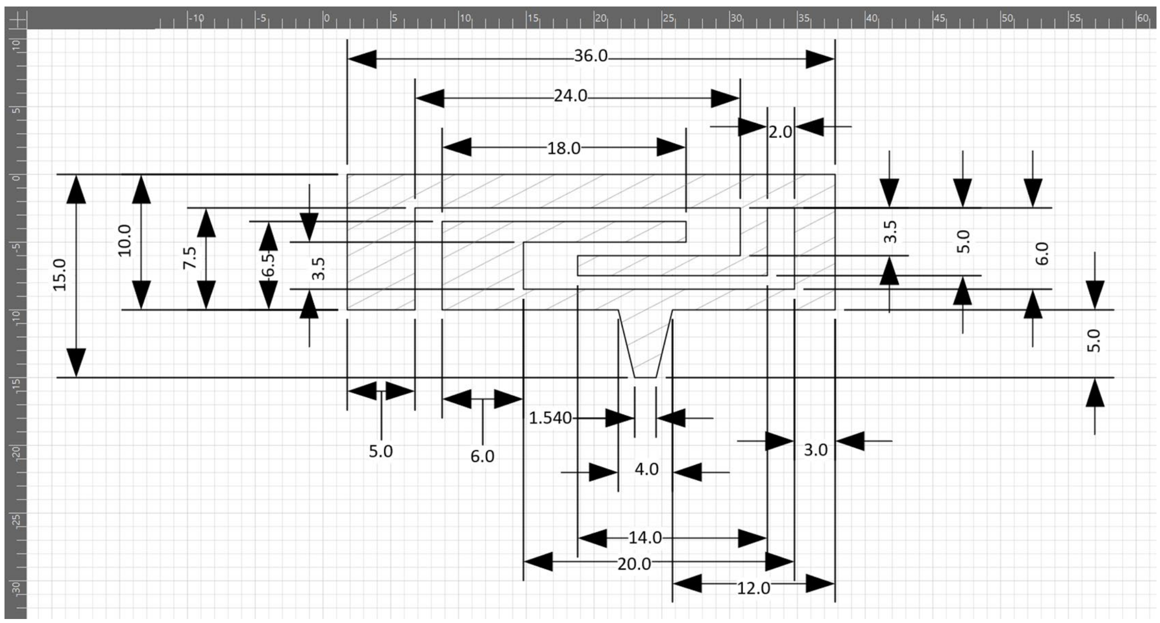
’200 patent

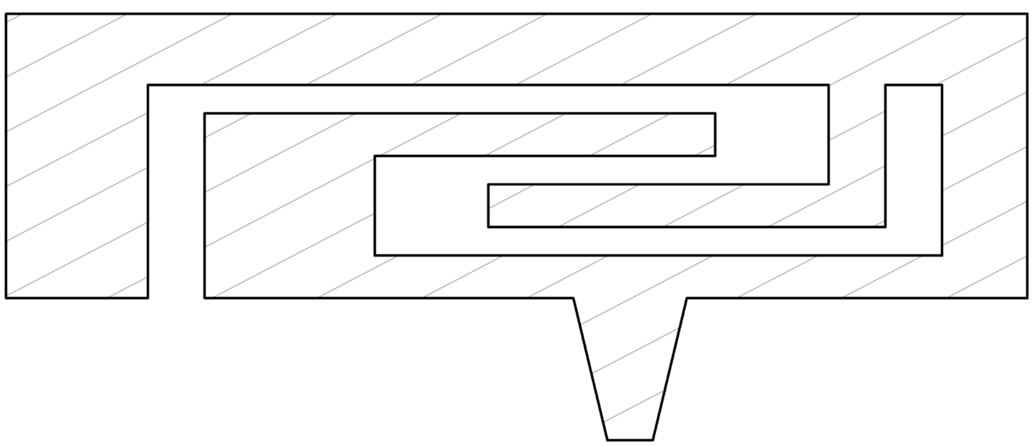
321. A scaled rendering of Jing’s “*first contour*” is generated from the dimensions in Jing. Jing, 2657-2658, Figs. 1(a)-1(b) (annotated detail below).


36
24
2
18
3.5
14
10
7.5
6.5
3.5
5
6
5
6
20
3

(b)


36
resonant branch 1
resonant branch 2
tuning branch 3
tapered strip
feeding point
15
12
13.23


36.0
24.0
18.0
2.0
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

322. Dou+Jing meets [1.e] because the *first contour* for Jing's antenna implementing Dou antenna 306, *supra* §XII.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.

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;

323. Dou+Jing meets [1.f] because it implements Dou antenna 308 as a Jing antenna (*second antenna*). *Supra* §XII.C (combination). 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* §§XII.C (combination), XII.D.2 ([1.a]).

324. 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* §XII.C (combination).

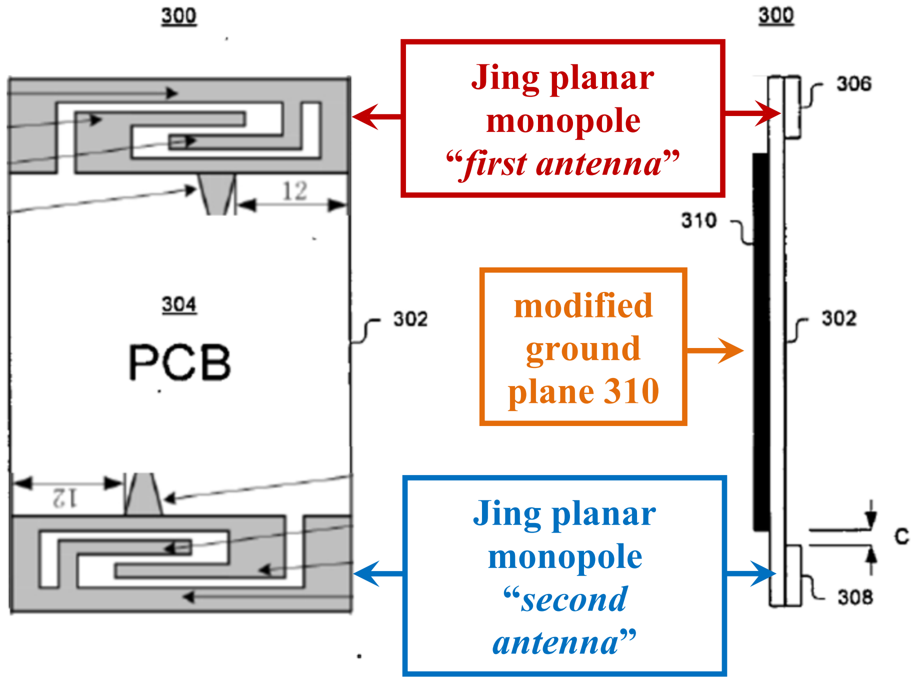


FIG. 3A FIG. 3B

325. 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* §XII.D.4 ([1.c]).

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

326. 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* §IX.D.9. 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.

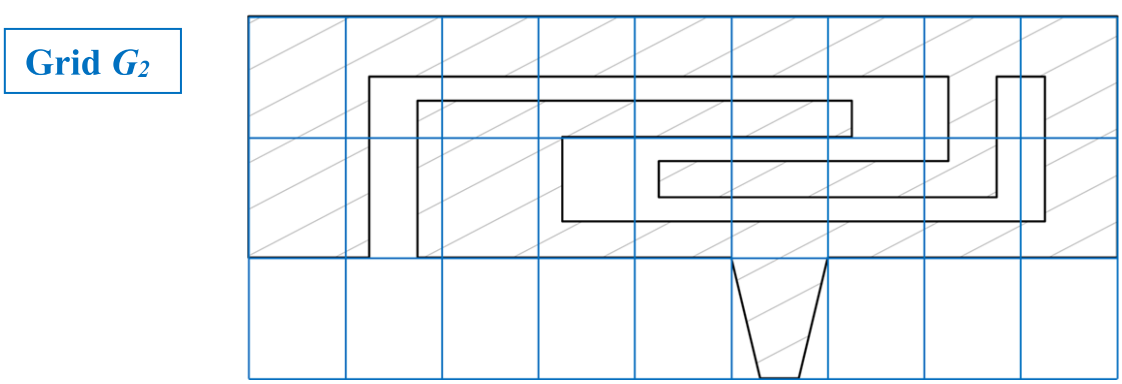
a. Limitation [1.h.2]: Grid G_2

327. 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 $\left(\frac{36mm}{9}\right) = 4.0\ mm$.

328. 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*, $(0 < n < 5)$.

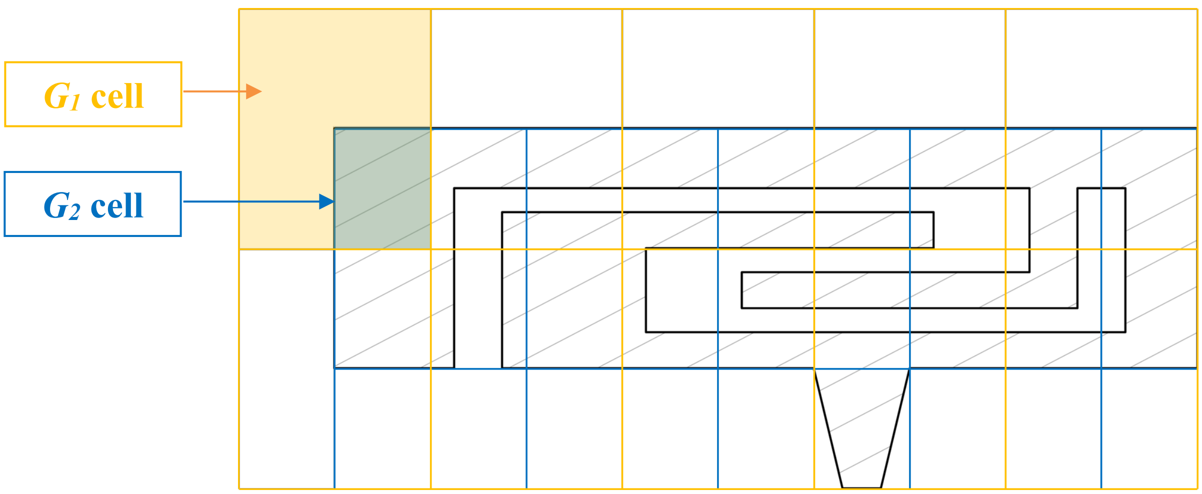
Rows	**Cell Height (mm)**	**Cell Aspect Ratio** $\left(\frac{width}{height}\right)$
3	$\left(\frac{15}{3}\right) = 5.0$	$\left(\frac{4.0}{5.0}\right) = 0.80$
5	$\left(\frac{15}{5}\right) = 3.0$	$\left(\frac{4.0}{3.0}\right) = 1.33$

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



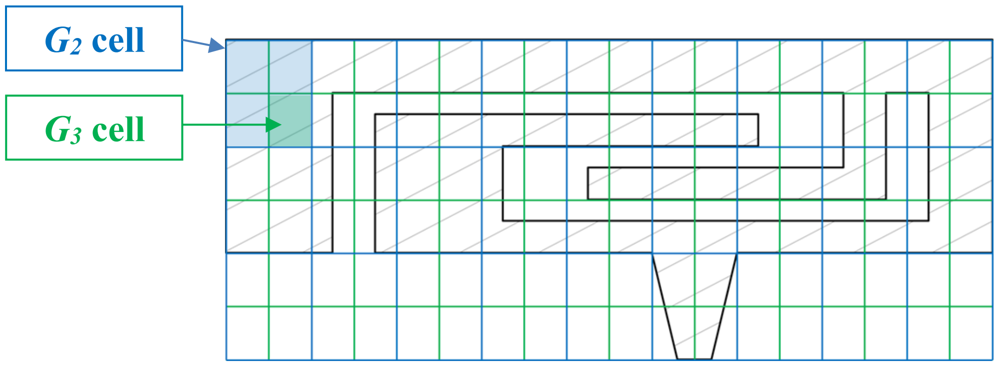
b. Limitation [1.h.3]: Grid G_1

329. 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*".



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

330. 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.*"

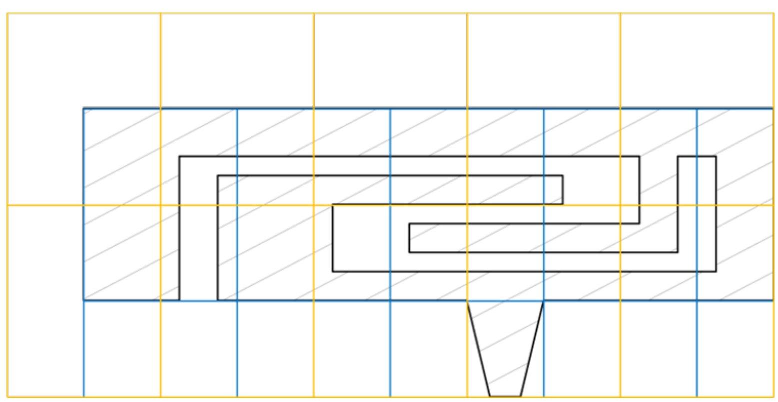


d. Limitation [1.h.1]: Cell counts

331. The count for each grid is shown below.

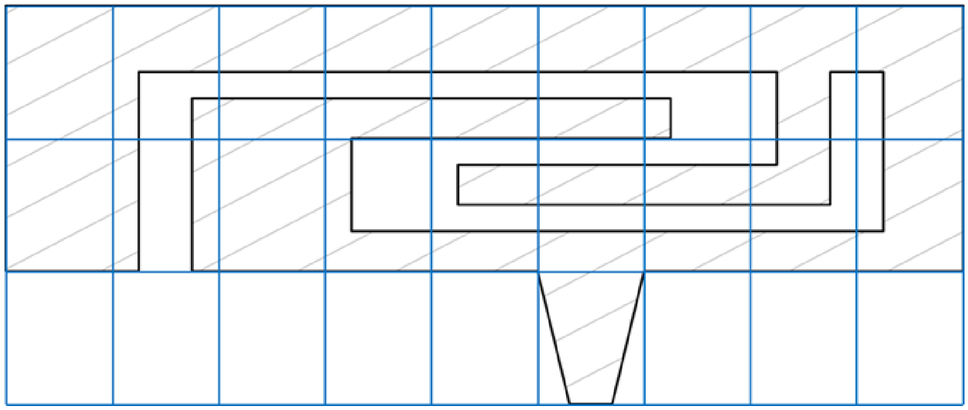
i. N_1 = 10.

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



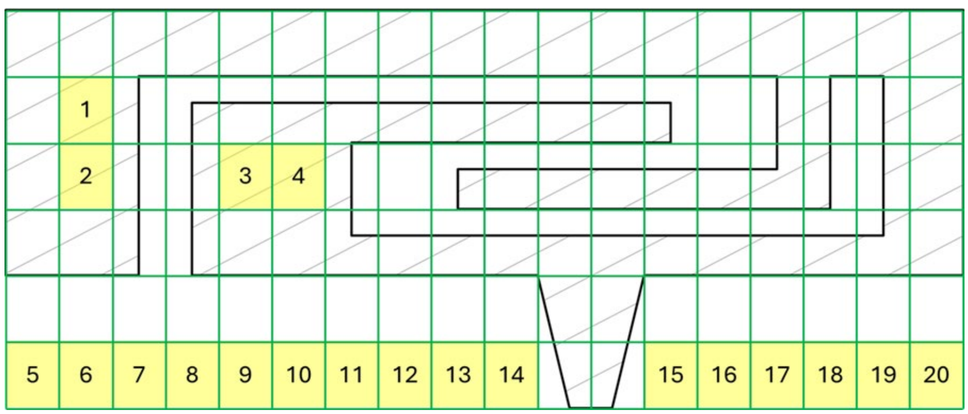
ii. N_2 = 27.

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



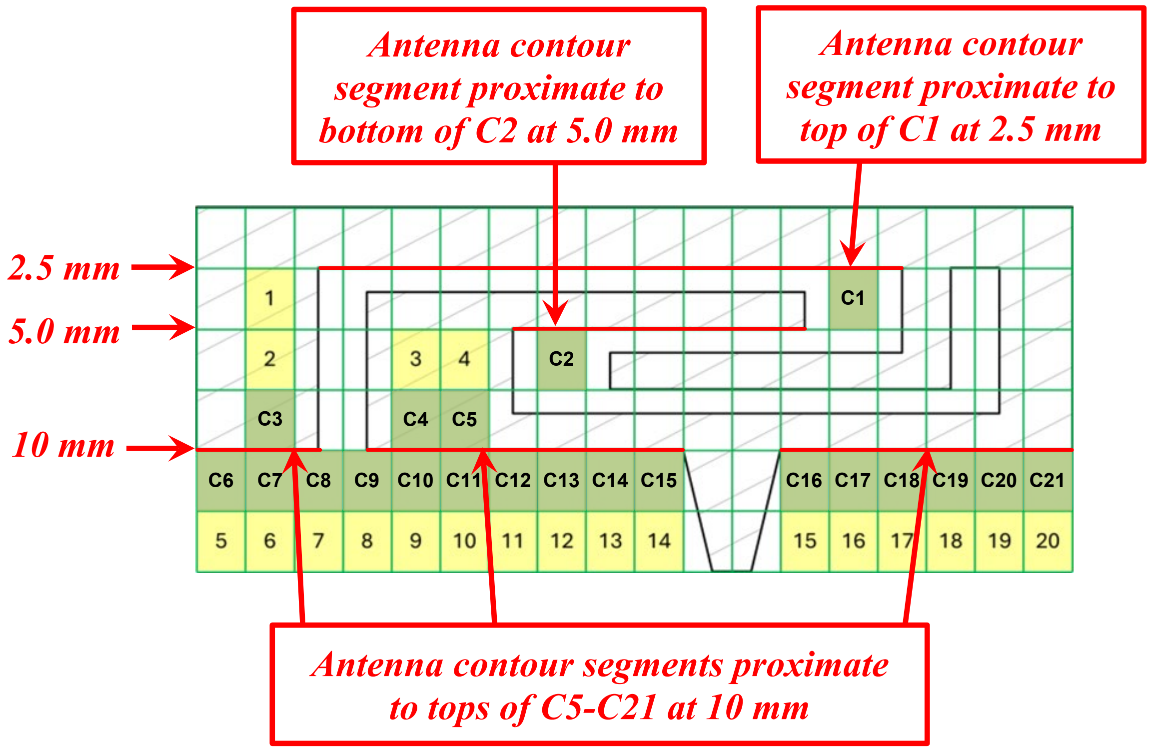
iii. $N_3 = 88$**.**

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



335. Among the cells that I shaded yellow above, cells 1-4 are completely within Jing's antenna contour, cells 5-20 are completely outside the antenna contour. Thus, cells 1-20 do not "include at least a point of the antenna contour." EX1005, 20:5-11.

336. In case it is not immediately obvious, I further explain why certain cells "include at least a point of the antenna contour," based on the below annotated figure. EX1005, 20:5-11.



Each G_2 cell height is 5.0 mm (*supra* §XII.D.8.a), making each G_3 cell height 2.5 mm. The bottom edge of Jing's antenna segment marked in red above C1 is at 2.5 mm. Jing, 2657, Figs. 1(a), 1(b). The top edge of Jing's antenna segment marked in red above C2 is at 5.0 mm (2.5 mm × 2). Jing, 2657, Figs. 1(a), 1(b). The bottom edge of Jing's antenna segments above C6-C21 marked in red are at 10 mm (2.5 mm × 4). Jing, 2657, Figs. 1(a), 1(b). Thus, an edge of C1-C21 align with an edge of an antenna segment, and thus "include at least a point of the antenna contour." EX1005, 20:5-11.

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

i. Calculation F_{21} = 1.43.

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

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

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

ii. Calculation F_{32} = 1.70.

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

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

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

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.

339. 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. Jing thereby "configured" the antenna's *first contour*'s "*level of complexity*" to provide the frequency operation discussed *supra* §XII.D.4 ([1.c]) because the

"*complexity*" measures the antenna's physical features as captured by orthogonal projection in the antenna "*contour*". EX1005, 16:64-17:4, 19:27-30, 20:19-22.

340. 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* §§XII.D.4 ([1.c]), IX.D.4 (Ground 1A, [7.c]). *Supra* IX.D.10 (Ground 1A, [7.i]).

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.

341. Dou+Jing meets claim 3 because the "*first side of the ground plane rectangle*" (*supra* §XII.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* §XII.C (combination).

342. 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* §§XII.C (combination), XII.D.7 ([1.f]).

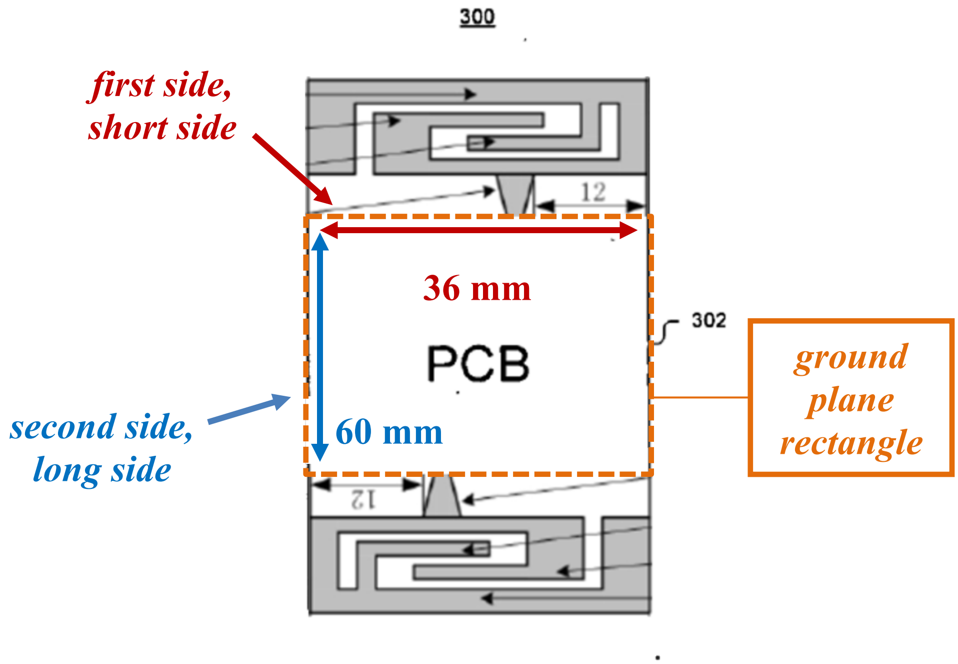


FIG. 3A

F. Claim 5

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

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

G. Claim 13

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

344. 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.

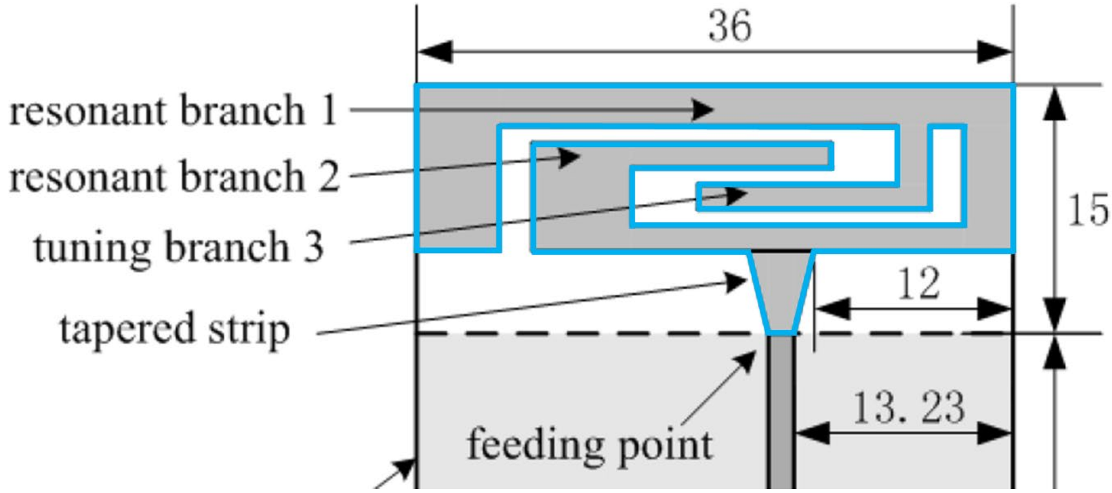
Limitation	Corresponding limitation	Discussion *supra*
13.PRE	1.PRE	§XII.D.1
13.a	1.a	§XII.D.2
13.b	1.b	§XII.D.3
13.c	1.c	§XII.D.4
13.e	1.f	§XII.D.7
13.g	1.e	§XII.D.6
13.h	1.h	§XII.D.8.e
13.h.1	1.h.1	§XII.D.8.d
13.h.3	1.h.3	§XII.D.8.b
13.h.4	1.h.4	§XII.D.8.c
13.i	1.i	§XII.D.9

345. 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;

346. 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* §XII.D.3 ([1.b]). 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. The "*face with a largest area*" is the top 36×15 mm^2 surface of the *parallelepiped* enclosing Jing's antenna trace.

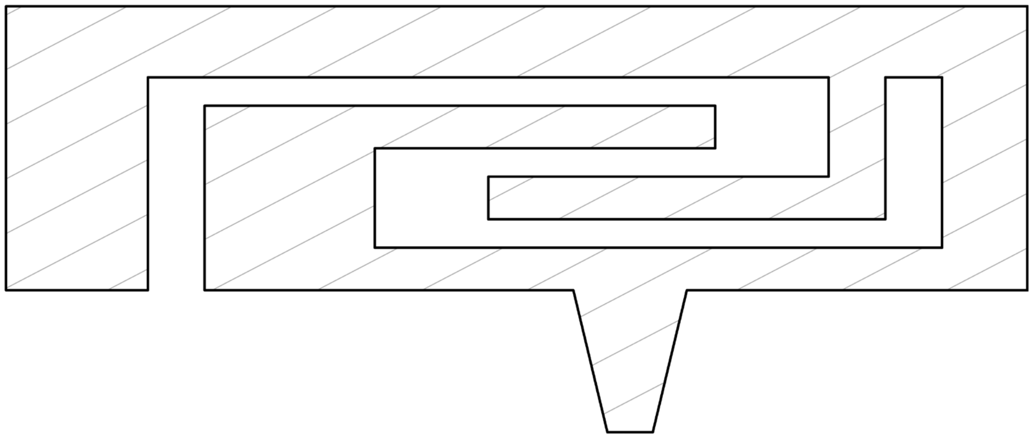


3. Limitation [13.f]

347. 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 Jing's antenna ("first antenna") the two definitions yield the same result as explained *supra* §XII.D.5 ([1.g]) and shown below, because Jing only contains antenna portions within "*the face*" of the *parallelepiped* as defined *supra* §XII.G.2 ([13.d]).



4. Limitation [13.h.2]

348. As explained *supra* §IX.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* §XII.D.8.a.

H. Claim 15

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

I. Claims 17, 19

350. Claims 17 and 19 depend from claim 13 and recite the same additional limitations as claims 5 and 3, respectively. EX1028, 12. Dou+Jing meets the

additional limitations in claims 17 and 19 for the same reasons it meets the corresponding limitations below.

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

351. 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* §§XII.C (combination), XII.D.3 ([1.b]), XII.G.1 ([13.b]).

352. 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* §§XII.D.3 ([1.b]), XII.G.1 ([13.b]). Dou, Figs. 3A, 3B.

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

A. Ying

353. 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

354. 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. 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. This would have provided a wireless device with coverage for the GPS and GSM services that Dou describes its wireless device having. Dou, [0022].

355. As explained *supra* §X.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]. 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").

356. 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. This combination would have provided the multiband coverage that Dou describes.

357. 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]).

358. 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.

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.

359. 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* §§XII.D.4 ([1.c]), XIII.B (combination); Ying, 5:13-28; Jing, 2658 (measured bandwidth is "insufficient to cover the GSM (890-960 MHz) band."). Thus, Ying's antenna covers "*at least two frequency bands that are different*" from those Jing covers, meeting claim 6.

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.

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

XIV. CONCLUSION

361. I declare that all statements made herein of my own knowledge are true, that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

362. I declare under penalty of perjury that the foregoing is true and correct.

Dated: June 16, 2025 By: ______________________

Daniel van der Weide, Ph.D.

APPENDIX A: MATERIALS CONSIDERED

Exhibit	Description
1001	U.S. Patent No. 11,031,677
1002	Prosecution History of U.S. Patent No. 11,031,677
1003	U.S. Patent No. 11,349,200
1004	Prosecution History of U.S. Patent No. 11,349,200
1005	U.S. Patent No. 12,095,149
1006	Prosecution History of U.S. Patent No. 12,095,149
1007	*intentionally left blank*
1008	Curriculum Vitae of Daniel van der Weide, Ph.D.
1009	P. Ciais, R. Staraj, G. Kossiavas, and C. Luxey. "Design of an Internal Quad-Band Antenna for Mobile Phones," *IEEE Microwave and Wireless Components Letters*, vol. 14, no. 4, pp. 148-150, April 2004 ("Ciais-Quadband").
1010	P. Ciais, R. Staraj, G. Kossiavas, and C. Luxey. "Compact Internal Multiband Antenna for Mobile Phone and WLAN Standards," *Electronics Letters*, vol. 40, no. 15, pp. 920-921, July 2004 ("Ciais-Multiband")
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")
1013	U.S. Patent App. Pub. No. 2007/0200773 ("Dou")
1014	Declaration of James L. Mullins, Ph.D.

Exhibit	Description
1015	Curriculum Vitae of James L. Mullins, Ph.D.
1016	Plaintiff's Disclosure of Asserted Claims and Infringement Contentions Against Geotab Pursuant to Local Patent Rules 3-1 and 3-2, *Fractus, S.A., v. Geotab Inc.*, No. 2:24-cv-01008 (E.D. Tex.), served March 12, 2025
1017	D.I. 75, Fractus's Opening Claim Construction Brief, *Fractus, S.A. v. ADT LLC*, No. 2:22-cv-00412 (E.D. Tex. Nov. 16, 2023)
1018	D.I. 75-1, Exhibit 1 to D.I. 75, Fractus's Opening Claim Construction Brief, *Fractus, S.A. v. ADT LLC*, No. 2:22-cv-00412 (E.D. Tex. Nov. 16, 2023)
1019	D.I. 92, Joint Claim Construction Chart, *Fractus, S.A. v. ADT LLC*, No. 2:22-cv-00412 (E.D. Tex. Jan. 4, 2024)
1020	D.I. 115, Claim Construction Order, *Fractus, S.A. v. ADT LLC*, No. 2:22-cv-00412 (E.D. Tex. Feb. 25, 2024) (Payne, M.J.)
1021	D.I. 127, Order, *Fractus, S.A. v. ADT LLC*, No. 2:22-cv-00412 (E.D. Tex. Mar. 15, 2024) (Gilstrap, D.J.)
1022	D.I. 82, Defendants ADT LLC and Vivint, Inc.'s Responsive Claim Construction Brief, *Fractus, S.A. v. ADT LLC*, No. 2:22-cv-00412 (E.D. Tex. Dec. 14, 2023)
1023	D.I. 253, Order, Fractus, S.A. v. ADT LLC, No. 2:22-cv-00412 (E.D. Tex. Oct. 4, 2024) (Gilstrap, D.J.)
1024	D.I. 1, Complaint, *Fractus, S.A., v. Geotab Inc.*, No. 2:24-cv-01008 (E.D. Tex. Dec. 6, 2024)
1025	3GPP TS 36.101 v8.4.0 (2008-12) Technical Specification: 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 8), 2008

Exhibit	Description
1026	Ericsson white paper, “LTE—an introduction,” no. 284 23-3124 Uen Rev B (June 2009)
1027	Declaration of Gordon MacPherson
1028	’149 patent Claim Limitation Comparison Chart
1029	U.S. Patent Publication No. 2006/0214857 (“Ollikainen”)
1030	ETSI TS 145 005 V4.3.0 (2001-14) Technical Specification: Digital cellular telecommunications system (Phase 2+); Radio transmission and reception (3GPP TS 45.005 version 4.3.0 Release 4)
1031	ZigBee Specification (Jun. 27, 2005)
1032	ETSI TS 125 308 V6.2.0 (2004-09) Technical Specification: Universal Mobile Telecommunications System (UMTS); UTRA High Speed Downlink Packet Access (HSDPA); Overall description; Stage 2 (3GPP TS 25.308 version 6.2.0 Release 6)
1033	ETSI TS 125 101 V6.5.0 (2004-09) Technical Specification: Universal Mobile Telecommunications System (UMTS); User Equipment (UE) radio transmission and reception (FDD) (3GPP TS 25.101 version 6.5.0 Release 6)
1034	ETSI TS 125 102 V6.0.0 (2003-12) Technical Specification: Universal Mobile Telecommunications System (UMTS); User Equipment (UE) radio transmission and reception (TDD) (3GPP TS 25.102 version 6.0.0 Release 6)
1035	ETSI TS 121 101 V6.0.0 (2004-12) Technical Specification: Universal Mobile Telecommunications System (UMTS); Technical Specifications and Technical Reports for a UTRAN-based 3GPP system (3GPP TS 21.101 version 6.0.0 Release 6)
1036	3GPP TR 23.882 V1.2.3 (2006-06) Technical Report: 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution: Report on Technical Options and Conclusions (Release 7)

Exhibit	Description
1037	3GPP TR 23.882 V1.6.1 (2006-11) Technical Report: 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution: Report on Technical Options and Conclusions (Release 7)
1038	3GPP TR 23.882 V1.8.0 (2007-02) Technical Report: 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; 3GPP System Architecture Evolution: Report on Technical Options and Conclusions (Release 7)
1039	Pages from E. Dahlman et al., *3G Evolution: HSPA and LTE for Mobile Broadband* (Academic Press 2d ed. 2008)
1040	U.S. Patent Publication No. 2003/0025635 ("Hilgers")
1041	U.S. Patent Publication No. 2003/0201942 ("Poilasne")
1042	IEEE Std. 802.11a-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: High-speed Physical Layer in the 5 GHz Band (Dec. 30, 1999)
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)
1044	Specification of the Bluetooth System version 2.0, volume 2 (issued Nov. 4, 2004)
1045	Chart 63 to EX1016 [confidential]
1046	Chart 65 to EX1016 [confidential]

Exhibit	Description
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”)

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

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.