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. IPR2025-00929
Patent No. 8,810,458

EXPERT DECLARATION OF HOSSEIN HASHEMI, Ph.D.

I, Hossein Hashemi, Ph.D., do hereby declare as follows:

I. Introduction

1. I am currently Professor of Electrical Engineering at the University of Southern California. I am, however, currently on a leave of absence and temporarily working as a full-time employee at Astera Labs, Inc.

2. I have been retained by Edell, Shapiro and Finnan, LLC (hereinafter "the Edell Firm"), to provide various opinions regarding U.S. Patent No. 8,810,458 ("the '458 Patent"). I understand that my declaration is being submitted in connection with a Patent Owner Preliminary Response in an *inter partes* review of the '458 Patent. Unless otherwise noted, the statements made herein are based on my personal knowledge and, if called to testify with regards to this declaration, I could and would do so competently and truthfully.

3. I have been retained in this matter by the Edell Firm as a technical expert in the field of electrical engineering, particularly within the context of antenna design and operation in multifunction wireless devices. I am being compensated for my work in this matter at my usual and customary rate of $760.00 per hour. I have no personal or financial stake or interest in the outcome of the *inter partes* review or any related action. My compensation in no way depends upon my testimony or the outcome of the *inter partes* review.

4. I have been advised that the Edell Firm represents Fractus, S.A. (hereinafter "Patent Owner") in this matter and that Geotab Inc. and Geotab USA, Inc. (hereinafter "Petitioners") have petitioned for *inter partes* review of the '458 Patent. I have no personal or financial stake or interest in Patent Owner, Petitioners, or the '458 Patent.

5. I reserve the right to supplement and/or amend my opinions in this declaration based on future positions taken by Petitioners or their experts, additional documents, testimony or other information provided by Petitioners or their witnesses, any actions from the Board, or as otherwise necessary.

II. Qualifications

6. My qualifications for forming the opinions set forth in this expert report are summarized here and explained in more detail in my *curriculum vitae* which is attached as Exhibit A to this Declaration. Exhibit A includes a full list of my publications and other professional contributions and achievements, and a list of the cases in which I have testified at deposition, hearing or trial.

7. I am currently the Ming Hsieh Electro-Physics Professor of Electrical and Computer Engineering, and a Co-Director of the Ming Hsieh Institute at the University of Southern California ("USC"). I received my Bachelor of Science degree in Electronics Engineering from Sharif University of Technology in 1997. I received my Master's degree in Electronics Engineering from Sharif University of

Technology in 1999. I received my Master's degree and Ph.D. in Electrical Engineering from the California Institute of Technology in 2001 and 2003 respectively.

8. From 1997 to 1999 I was a radiofrequency integrated circuit design engineer at Keresem Communications Research. I became an Assistant Professor of Electrical Engineering at the USC in October 2003 and remained in that position until May of 2009. From November 2007 to May 2009, I also occupied the Gordon S. Marshall Early Career Chair at USC. In May 2009 I became a tenured Associate Professor of Electrical Engineering at USC and remained in that position until my promotion to Professor in December 2014, a title I have held since then.

9. I have over 25 years of industry and academic experience. In particular, I have experience with antennas and electromagnetic technologies including designing, simulating, taping out, and measuring complex electromagnetic structures spanning frequency ranges of 100 MHz – 170 GHz, as well as infrared frequencies (1550nm wavelength), and demonstrating numerous phased arrays (multi-antenna systems) spanning radiofrequency to infrared frequencies.

10. I have been privileged to receive a number of awards and honors throughout my career. These include:

- Fellow, Optica 2023
- Fellow, Institute of Electrical and Electronics Engineers (IEEE) - 2019

- Winner, Nokia Bell Labs Prize - 2016
- Outstanding Young Engineer Award of the IEEE Microwave Theory and Techniques Society (MTT-S) - 2015
- Distinguished Lecturer, IEEE Solid State Circuits Society 2013 – 2014
- Distinguished Scholar for "Outstanding Achievement in Advancement of Engineering", Association of Professors and Scholars of Iranian Heritage -2011
- Inaugural Winner, Maseeh Entrepreneurship Prize Competition, USC - 2011
- NSF CAREER Award - 2009
- USC Viterbi School of Engineering Junior Faculty Research Award - 2008
- DARPA Young Faculty Award - 2008
- Lewis Winner Award for Outstanding Paper, IEEE International Solid-State Circuits Symposium (ISSCC) - 2007
- Best Paper Award, IEEE Journal of Solid-State Circuits - 2004
- Charles Lee Powell Foundation Research Award - 2004
- Young Scholar Award, Association of Professors and Scholars of Iranian Heritage - 2003
- Graduate Fellowship Award, Intel Foundation - 2002
- Outstanding Student Designer Award, Analog Devices - 2001
- Outstanding Accomplishment Award, von Brimer foundation - 2000
- Engineering and Applied Science Division Fellowship, California Institute of Technology - 1999
- Ranked first in Ph.D. EE qualifying exam, California Institute of Technology - 2000

- Ninth place out of 300,000 in national qualifying exam for undergraduate studies – 1993

11. I have co-authored two books and over 125 peer-reviewed journal and conference papers. I have also spoken at numerous invited workshops, talks and short courses. Many of these relate directly or indirectly to antennas, antenna arrays and various modes of wireless communication and electronics design.

12. I am the named inventor on 15 United States Patents, including patents related to antenna technology, including U.S. Patent Nos. 10,615,949 (Hybrid-based cancellation in presence of antenna mismatch) and 8,203,484 (Path-sharing transceiver architecture for antenna arrays).

III. Legal Standards

13. While I am not an attorney, I have been informed by counsel of certain legal principles I should apply in reaching my opinions in this matter. Also, as an inventor, expert witness and otherwise in the course of my work, I have experience studying and analyzing patents and patent claims from the perspective of a person of ordinary skill in the art (POSITA or "skilled artisan").

A. Claim Construction

14. I understand that claim terms are to be interpreted from the point of view of a person of ordinary skill in the art (also referred to herein as the "skilled artisan") at the time the application leading to the patent was filed. I further

understand that claim terms are generally to be given their ordinary meaning, considered in light of the claim language, patent specification, and prosecution history. I further understand that a patentee may act as its own lexicographer and depart from the ordinary and customary meaning by defining a term with reasonable clarity, deliberateness, and precision, but that there is a presumption that a claim term carries its ordinary and customary meaning.

B. Person of Ordinary Skill in the Art

15. I understand that a person of ordinary skill in the art is a hypothetical person who is presumed to have known the relevant art at the time of the invention. He or she is a person of ordinary creativity who understands the scientific and engineering principles applicable to the pertinent art. I am familiar with the knowledge and capabilities of one of ordinary skill in the art in the field of the '458 Patent at the time of invention.

16. I understand that whether a patent claim would have been obvious is determined through the point of view of a person of ordinary skill in the art at the time of the invention. I have applied this standard in my analysis.

C. Validity

17. I understand that to invalidate a claim, the Petitioner must show that there is a reasonable likelihood of success as to any of the claims challenged. I understand that the Petitioner bears the burden of proving any instituted grounds of

invalidity by a preponderance of the evidence. I understand that a "preponderance" means "more likely than not." I understand that general and conclusory assertions, without underlying factual evidence, may not support a conclusion that something is "more likely than not." Rather, the preponderance of the evidence standard requires that a reasonable finder of fact be convinced that the existence of a specific material fact is more probable than the non-existence of that fact. The preponderance of the evidence standard does not support speculation regarding specific facts and is instead focused on whether the evidence more likely than not demonstrates the existence or non-existence of specific material facts. Here, I understand that Petitioners have argued that the claims at issue are obvious over different grounds, each applying a combination of two or more references.

18. I also understand that, in performing a proper unpatentability analysis, an expert must do more than simply provide quotes from the evidentiary record along with conclusory allegations of unpatentability. To the contrary, an expert's conclusions regarding unpatentability must be supported by actual analysis and reasoning set forth in the expert declaration, such that the theoretical and factual foundation for the expert's conclusions can be properly evaluated.

19. I understand that a patent claim may be found unpatentable as obvious under 35 U.S.C. §103 only if the Office establishes by a preponderance of the evidence that, as of the priority date, the subject matter of the claim, considered as a

whole, would have been obvious to a person having ordinary skill in the field of the technology (the "art") to which the claimed subject matter belongs.

20. I understand that the analysis of whether a claim is obvious depends on a number of necessary factual inquiries, for example, (1) the scope and content of the prior art; (2) the differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) objective evidence of nonobviousness.

21. I understand that the claimed invention must be considered as a whole in analyzing obviousness or nonobviousness. In determining the differences between the prior art and the claims, the question under the obviousness inquiry is not whether the differences themselves would have been obvious, but whether the claimed invention as a whole would have been obvious. Relatedly, I understand that it may be appropriate to consider whether there is evidence of a "teaching, suggestion, or motivation" to combine the prior art teachings in the prior art, the nature of the problem or the knowledge of a person having ordinary skill in the art. I further understand arguments in support of obviousness cannot be sustained by mere conclusory statements; instead, there must be some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness.

22. I have also been informed that some examples of rationales that may support a conclusion of obviousness include:

a) Combining prior art elements according to known methods to yield predictable results;

b) Simply substituting one known element for another to obtain predictable results;

c) Using known techniques to improve similar devices (or product) in the same way (*e.g.*, obvious design choices);

d) Applying a known technique to a known device (or product) ready for improvement to yield predictable results;

e) Choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success—in other words, whether something is "obvious to try";

f) Using work in one field of endeavor to prompt variations of that work for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art; and

g) Arriving at a claimed invention as a result of 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.

23. I have also been informed that other rationales to support a conclusion of obviousness may be relied upon, for instance, that common sense (where

substantiated) may be a reason to combine or modify prior art to achieve the claimed invention.

24. I understand that one indicator of nonobviousness is when prior art "teaches away" from combining certain known elements. For example, a prior art reference teaches away from the patent's particular combination if it leads in a different direction or discourages that combination, recommends steps that would not likely lead to the patent's result, or otherwise indicates that a seemingly inoperative device would be produced.

25. I understand that an obviousness determination also requires that a person of ordinary skill in the art would have had a reasonable expectation of success in making any modifications to the cited references.

26. I further understand that certain objective indicia can be important evidence regarding whether a patent is obvious or nonobvious, including the existence of a long-felt but unsolved need, unexpected results, commercial success, copying, and industry acceptance or praise. Evidence of such objective indicia must be considered when present. It is generally an error to reach a conclusion on obviousness before considering the evidence of secondary considerations, and then evaluating the latter solely in terms of whether it may fill any gaps in the initial conclusion on obviousness. On the other hand, such evidence is not a requirement

for patentability, and the absence of such evidence is a neutral factor in the analysis of obviousness or nonobviousness.

27. I also understand that a prior art reference must be enabled to anticipate a patent. That is, I understand that the prior art reference's description must be such that a person of ordinary skill in the field of the invention can practice the subject matter based on the reference without undue experimentation.

28. Finally, I understand that the obviousness analysis cannot be based on "hindsight. The skilled artisan must view prior art at the time the invention was made and without using the disclosure of the subject patent as a guide.

IV. Material Reviewed

29. In forming the opinions offered in this Declaration I reviewed and considered as appropriate the following materials, the '458 Patent and its prosecution history, the Petition, the Expert Declaration of David M. Pozar, Ph.D. (Ex. 1003), and the remaining exhibits to the Petition and any additional materials cited herein.

V. Background

A. Person of Ordinary Skill in the Art

30. I understand that Petitioners have relied upon the following definition of a POSITA:

> [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.

Petition at 7, *citing* Ex. 1003, at ¶¶ 38-48.

31. For the purpose of forming my opinions as set forth in this Declaration I have applied this definition of a POSITA.

B. Overview of the '458 Patent

32. The '458 Patent is entitled "Handheld Device with Two Antennas, and Method of Enhancing the Isolation Between the Antennas," issued on August 19, 2014. Petition, Ex. 1001. I understand the '458 Patent issued from United States Patent Application No. 13/718,348, filed on December 18, 2012, which is a continuation of United States Patent Application No. 13/341,051, filed on December 30, 2011 (now U.S. Patent No. 8,362,960), which is a continuation of United States Patent Application No. 11/988,888, filed as Application No. PCT/EP007050, filed July 18, 2006 (now U.S. Patent No. 8,115, 686), which claims priority to Provisional Application No. 60/702,205, filed on July 25, 2005.

33. The '458 Patent generally "relates to a handheld device comprising a first antenna …. arranged to operate in at least on frequency band, and a second antenna…. arranged to operate in at least a second frequency band, wherein said second frequency band is differ from said first frequency band." Petition, Ex. 1001

at Abstract. In addition, "the second antenna comprises a slot antenna comprising at least one slot and at least one conductive layer." *Id.*

C. Claim Construction

34. I understand that the claims of the '458 Patent are being given their ordinary meaning as understood by the POSITA in light of the Specification for the pre-institution phase of this proceeding. I reserve the right to provide different and additional opinions on claim construction if an IPR is instituted.

D. Background Regarding Antenna Isolation/Coupling

35. When multiple antennas are implemented in the same device, especially when they share a common ground plane, electromagnetic coupling between the antennas may degrade system performance. Coupling occurs because antennas are inherently sensitive to both the desired signals they are intended to receive or transmit, and to unintended signals from nearby radiators. The shared ground plane, while necessary for some types of antennas *(e.g.*, slot antennas), also acts as a medium for surface currents that facilitate energy transfer between antennas. These currents can cause mutual coupling, leading to interference, radiation pattern distortion, and reduced efficiency. In certain applications, even modest levels of coupling can reduce antenna performance . The necessity for isolation between such antennas, *i.e.*, the flip side of coupling, is driven by the fact that each antenna is typically optimized for a specific frequency band, polarization, and radiation pattern.

Insufficient isolation can make it impossible for the receiver to discern the desired signal from the overwhelming local interference, leading to dropped connections or corrupted data.

36. Shared ground planes compound these challenges because they support surface currents that are not confined to the immediate feed point of the antennas. When a transmitter excites an antenna, part of the energy can travel across the ground plane surface, being consumed at unintended points. A neighboring antenna connected to the same ground structure can inadvertently pick up this energy, not through free-space propagation alone but also via ground plane surface current. Coupling through the ground plane may be stronger than coupling through the air, making physical separation alone insufficient to achieve adequate isolation.

37. At shorter wavelengths (higher frequencies), surface current tends to be more localized around the feed region. At longer wavelengths (lower frequencies), surface currents can occupy a greater fraction of the ground plane area.

38. If two antennas are configured to operate at the same or nearby frequencies, the coupling between the antennas will likely increase. Specifically, the transmitting antenna launches strong surface currents on the ground plane at its resonant frequency, and the receiving antenna is most sensitive to currents and fields at that same frequency or nearby frequencies. As a result, even small amounts of

ground-plane-mediated energy transfer can cause significant coupling and interference.

39. Further, the electromagnetic behavior of the ground plane changes with frequency, geometry, and loading from connected antennas in a complex manner that cannot be easily or fully understood without substantial work to simulate the antenna system. At certain frequencies, resonances in the ground structure can occur, enhancing coupling between antennas in complicated ways. These resonances can shift or intensify depending on environmental conditions, mounting structures, or nearby conductive elements, making isolation performance unpredictable without deliberate design measures.

40. Ultimately, while a shared ground plane can offer performance benefits, it inherently increases the likelihood of antenna-to-antenna coupling unless isolation measures are deliberately engineered. The challenge lies in balancing the structural and integration benefits of a common ground plane with the electromagnetic necessity of keeping antenna systems functionally independent.

E. Background Regarding Antenna Diversity

41. Antenna spatial diversity and polarization diversity are two different but complementary techniques for improving wireless system performance by reducing the effects of fading, interference, and multipath. Spatial diversity involves using two or more antennas that operate at the same frequencies placed at different

physical locations so that the signals they receive (or transmit) experience different propagation paths. Polarization diversity uses antennas with different polarization orientations to reduce signal degradation caused by polarization mismatch or rotation during propagation.

F. Background Regarding the Effect of Different Materials on Electromagnetic Radiation Wavelength

42. The wavelength λ of electromagnetic radiation propagating in a material is inversely proportional to the square root of the permittivity of the material:

$$\lambda = \frac{\lambda_0}{\sqrt{\tau_r}} = \frac{c}{f\sqrt{\tau_r}};$$

where λ_0 is the free-space operating wavelength, τ_r refers to the permittivity of the dielectric material (sometimes referred to as ε_r), c is the speed of light and *f* is the frequency of the radiation. *See* EX2009 at 169. When radiation passes through both air and a dielectric, or multiple dielectric materials, an effective permittivity – a permittivity value which is bound on the low end by the lowest permittivity of materials (often 1 if the radiation passes through air or a vacuum) and bound on the high end by the highest permittivity for the materials through which the radiation transmits (such as 4.4. for the FR-4 dielectric material used in the construction of circuit boards) – may be used to determine an effective wavelength for the radiation. EX2009 at 169.

43. For radiation that passes through the air and a dielectric material, the effective permittivity can, in some instances, be roughly estimated as follows, as the permittivity of air is essentially 1:

$$\tau_{eff} = \frac{\tau_r + 1}{2}.$$

Id.

G. Background Regarding Decibel Scales

44. Many of the graphs and values discussed in this declaration, the cited art and the Patent Owner Preliminary Response make use of values given using a decibel (dB) scale. The decibel scale is a logarithmic, as opposed to linear, way of expressing ratios, most commonly used for comparing power, voltage, or current levels. The values discussed herein compare power values. When applied to power, the decibel value is calculated using the formula dB = 10 × log10(P2/P1), where P2 is the output power and P1 is the reference input power. This means that if the powers are equal, the ratio is one and the result is 0 dB, while a tenfold increase in power corresponds to +10 dB. A doubling of power results in approximately +3 dB. These linear values can be calculated using $P_{linear} = 10^{(PdB/10)}$.

45. When the decibel scale is applied to voltage or current, the formulas change because power is proportional to the square of voltage or current across a constant resistance, so the logarithmic factor doubles. Accordingly, the decibel value is calculated using the formula dB = 20 × log10(V2/V1), where V2 is the output

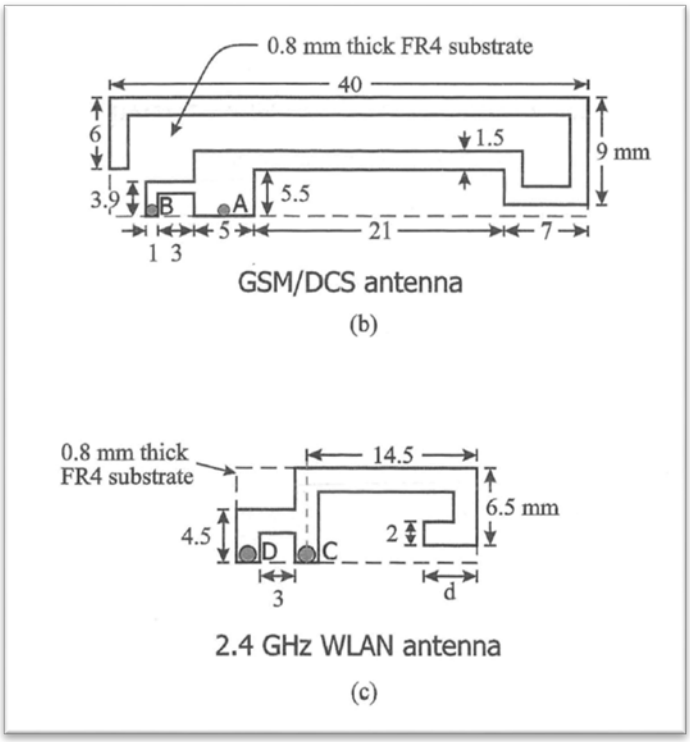
voltage and V1 is the reference voltage. Linear values can be calculated using $V_{linear} = 10^{(VdB/20)}$.

46. The decibel scale is particularly useful for describing changes in electrical signals, since it compresses very large or small ratios into manageable numbers.

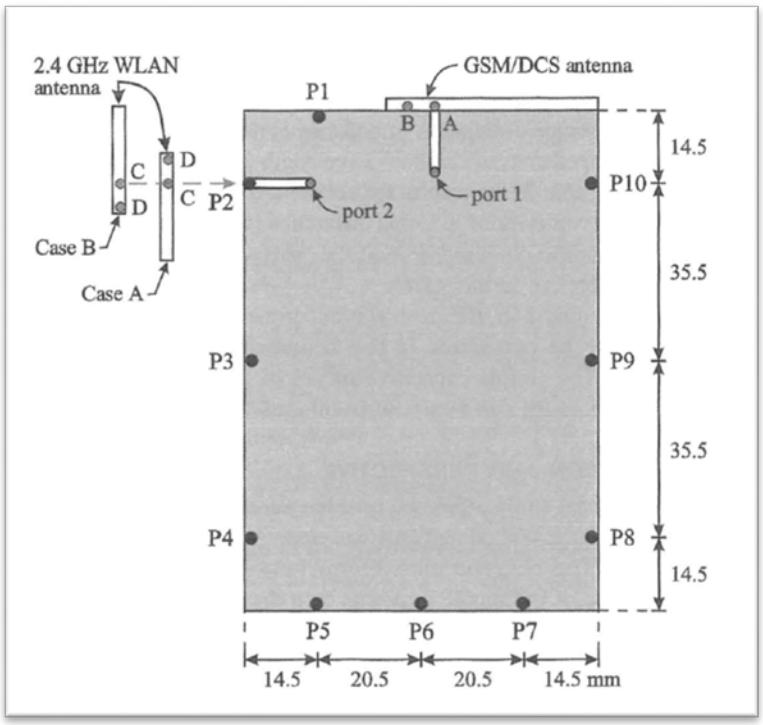
H. Overview of the Cited Art

i. Wong

47. Wong (EX1005) describes "a study on two promising internal antennas" for use in a personal digital assistant (PDA) phone for cellular and wireless local area network (WLAN) operation. EX1005 at 347. The specific antennas studied in Wong are illustrated in FIGs. 1(b) and 1(c) of the reference.



48. For purposes of the study, the GSM/DCS antenna of FIG. 1(b) is positioned at the top of a ground plane, while the WLAN antenna of FIG. 1(c) is measured at 10 different positions around the ground plane, positions P1 through P10, illustrated in FIG. 2. The WLAN antenna was also tested at different orientations relative to its feed point (point C) and its short or ground point (point D). The study showed that not all of locations P1-P10 were acceptable (EX1005 at 349), that the location of the WLAN antenna affected its operating frequency (EX1005 at 349), and that the isolation between the two antennas is strongly related to the excited surface current distributions in the system ground plane (EX1005 at 351).



49. As illustrated in Table 1 from Wong, location P10 generally exhibited the worst isolation between the two antennas, with location P4 being the optimized location. EX1004 at 349. The results of the measurements here are, however, not predictable. For example, location P7 generally exhibited worse isolation than locations P2 and P3 even though location P7 is substantially further from the GSM/PCS antenna. Depending on its orientation, location P5 can exhibit better or worse isolation than location P2, even though P5 is essential the same distance from the GSM/DCS antenna as location P4, the "optimized" location. This all illustrates the complicated nature of antenna coupling.

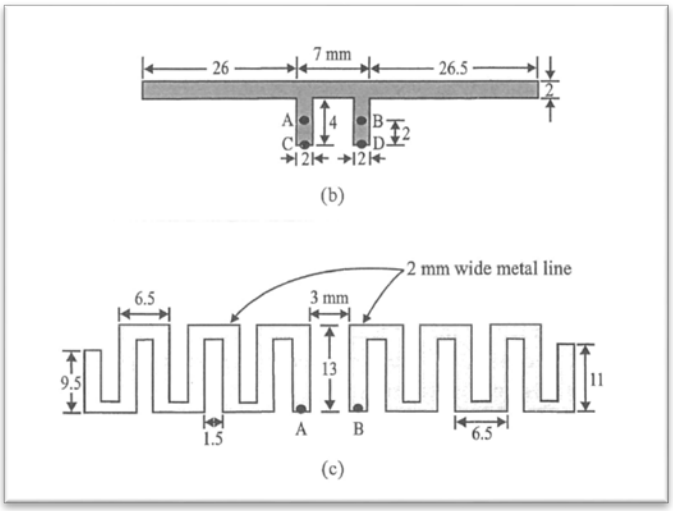
50. The observed isolation was also difficult to foresee with regard to the orientation of the antennas. For example, when the WLAN antenna was arranged at location P8, orthogonal to the GSM/DCS antenna, it exhibited worse isolation than when arranged art location P7 with a parallel orientation. In other words, an orthogonal orientation does not necessarily result in improved isolation between two antennas.

51. Wong further discloses that the isolation/coupling between the antennas is strongly influenced by the surface currents resulting in the ground plane from antennas.

52. To the extent that any conclusions may be drawn from Wong, it is that *for these specific antenna,* position P10 is "not acceptable for practical applications" while position P4 is the optimal position. EX1005 at 349.

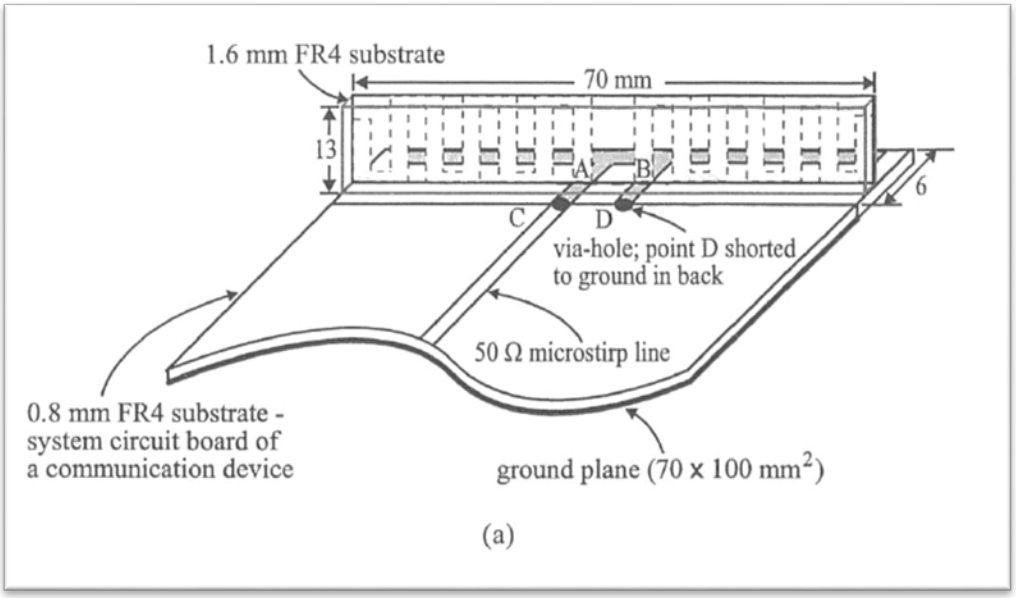
ii. Lee

53. Lee (EX1011), which shares an author in common with Wong, discloses what is described as a "quadband antenna," but which is actually two independent, orthogonally arranged, monopole antennas. EX1011 at 359. These two independent antennas are illustrated in FIGs. 1(b) and 1(c) of Lee.



54. The combination of the two independent monopole antennas provide operation in the APMS (824-894 MHz), GSM (890-960 MHz), DCS (1710-1880 MHz), and PCS (1850-1990 MHz) frequency bands. EX1011 at 359. The GSM and DCS bands correspond to the Wong bands, but the APMS and PCS bands are new and will introduce new coupling challenges. While the Lee antenna has a ground

plane which is similar in size to that of Wong, the antenna is substantially larger than the Wong antenna, extending across the entire top of the ground plane, as illustrated in FIG. 1(a) in the reference. The increased size of the antenna will also introduce additional isolation challenges.



55. As noted above, the Lee antenna operates at two of the same frequencies as the Wong DCS/GSM antenna, and adds the APMS band and the PCS band. The APMS band, which has a lower frequency of 824-894 MHz, will result in longer surface currents, being associated with a longer wavelength due to the inverse relationship between frequency and wavelength of electromagnetic radiation. The PCS band, with a higher frequency of 1850-1990 MHz, comes substantially closer to the frequencies at which Wong's WLAN antenna operates, 2400-2482 MHz, than

the GSM (890-960 MHz) and DCS (1710-1880 MHz) frequencies of the Wong antenna.

56. Further, Lee illustrates that its antenna includes a resonant frequency very close to 2500 MHz, which is indicated by the highlighting added to FIG. 2 from the reference, and identified by the substantial return loss around 2500 MHz. This resonant frequency of around 2500 MHz is substantially the same frequency as the resonant frequency of Wong's WLAN antenna. EX1005 at 347.

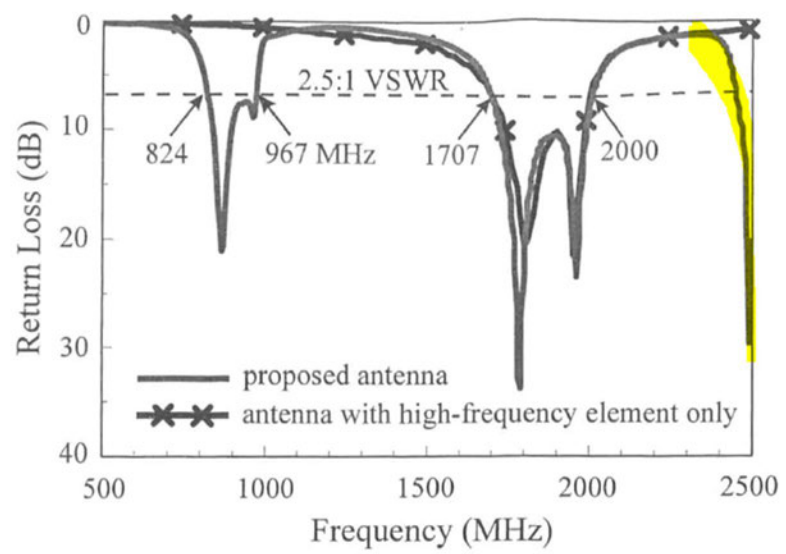


Figure 2 Measured return loss for the proposed antenna and the antenna with the high-frequency element only

iii. Gaucher

57. Gaucher (EX1012) is directed to a quad-band antenna for use in portable devices. EX1012 at Abstract. The antenna is constructed from a plurality of radiating elements as shown in FIGs. 5A and 5B.

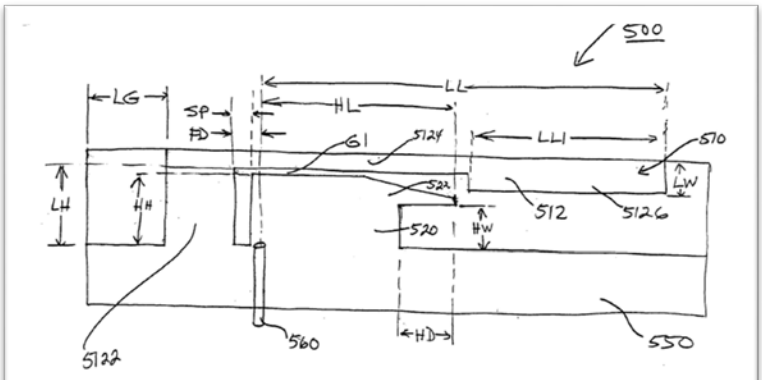


FIG. 5A

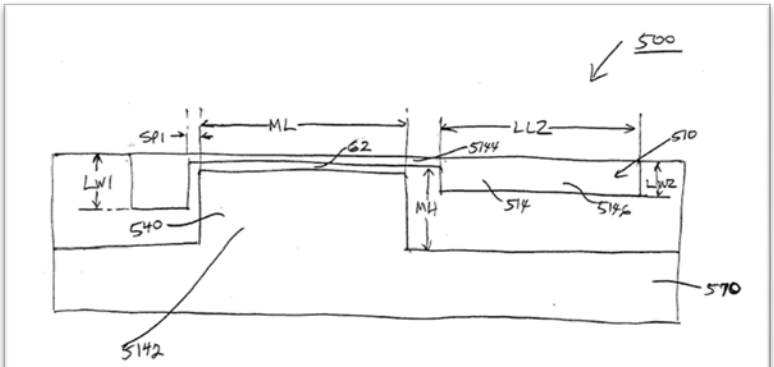
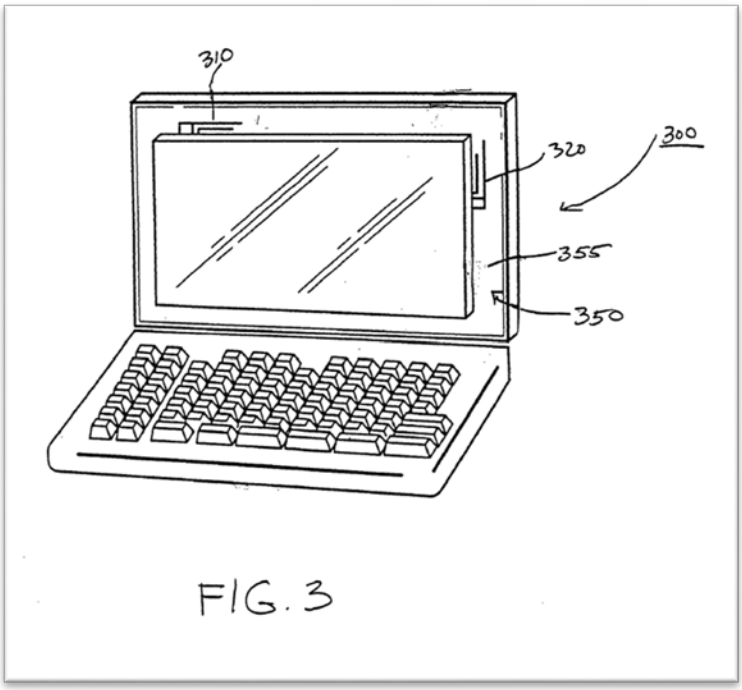


FIG. 5B

58. As further explained in the reference, multiple copies of the antenna may be incorporated into a portable device, such as a laptop, which are illustrated as antennas 310 and 320 in FIG. 3 of the reference.



59. The POSITA would understand from the background of Gaucher that the purpose of providing two copies of the same antenna in the same portable device is to provide multiple copies of the antenna arranged at different locations to reduce the blockage caused by the laptop display in some directions, or to provide spatial diversity to the portable device. EX1012 at ¶ [0004]. The multiple antennas may also be provided with orthogonal orientations to provide polarization diversity. EX1012 at ¶ [0004].

60. The POSITA looking to the references incorporated into Gaucher would have this understanding confirmed. Gaucher848 (EX1013) and Asano (EX1024), both incorporated by reference in Gaucher, confirm that the purpose of the multiple antennas in Gaucher is to provide spatial and/or polarization diversity.

EX1013 at ¶ [0004]; EX1024 at ¶¶ [0008]; [0100], [0126], [0130]. Gaucher848 further explains that if one of the antennas is moved to a different location, the other antenna should also be moved to maintain the desired diversity:

> FIG. 6(a) illustrates two tri-band antennas (61, 62) mounted to a metallic support frame (63) of the laptop display unit having a plastic cover (66), wherein the plane of each tri-band antenna (61, 62) is substantially parallel to the plane of the display frame (63). FIG. 6(b) illustrates two tri-band antennas (64, 65) mounted to the display frame (63) wherein the plane of each tri-band antenna (64, 65) is substantially perpendicular to the plane of the display frame (63). **In FIGS. 6(a) and 6(b), the tri-band antennas (62) and (65) can be positioned on the left side of the display frame (63)(as opposed to the right side of the frame as shown) and the tri-band antennas (61) and (64) can be located on the right side of the upper portion of the frame (63) (as opposed to the left side of the upper portion of the frame as shown).**

Gaucher848 at ¶ [0049] (emphasis added).

61. None of these references provide another explanation for why multiple copies of the same antennas are used in Gaucher, Gaucher848 and Asano.

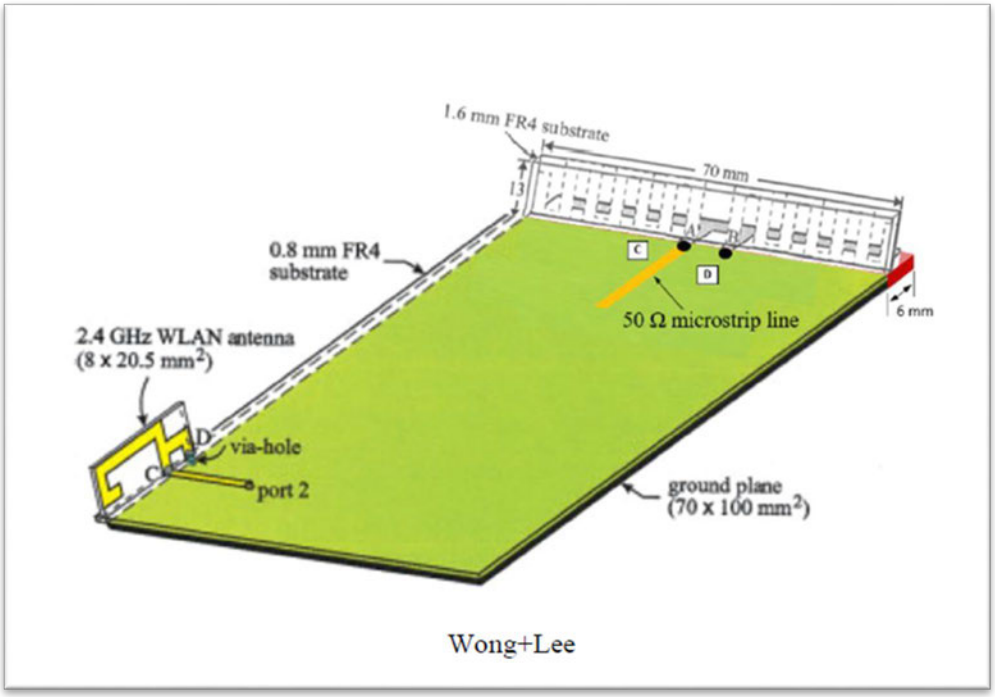
iv. Zhao

62. Zhao (EX1008) is a patent that discloses wireless ultra-wideband ("UWB") communication systems comprising a quarter-wavelength slot UWB antenna integrated on a PCB and used for mobile terminals. EX1008 at ¶ [0006]. Relevant to the current proceedings is an embodiment in Zhao in which a "dual-band PIFA antenna 40" along with the "quarter-wavelength slot UWB antenna 50" are arranged on the PCB of the handset. EX1008 at ¶ [0035]. Zhao includes a return loss

plot for this antenna in FIG. 7B, which allows the POSITA to evaluate the operating characteristics of the PIFA antenna 40 and the UWB antenna 50 in this embodiment.

VI. Ground 1A -- A POSITA Would Not Combine Wong and Lee to Obtain the Invention Claimed in Claims 1-9, 12 and 13

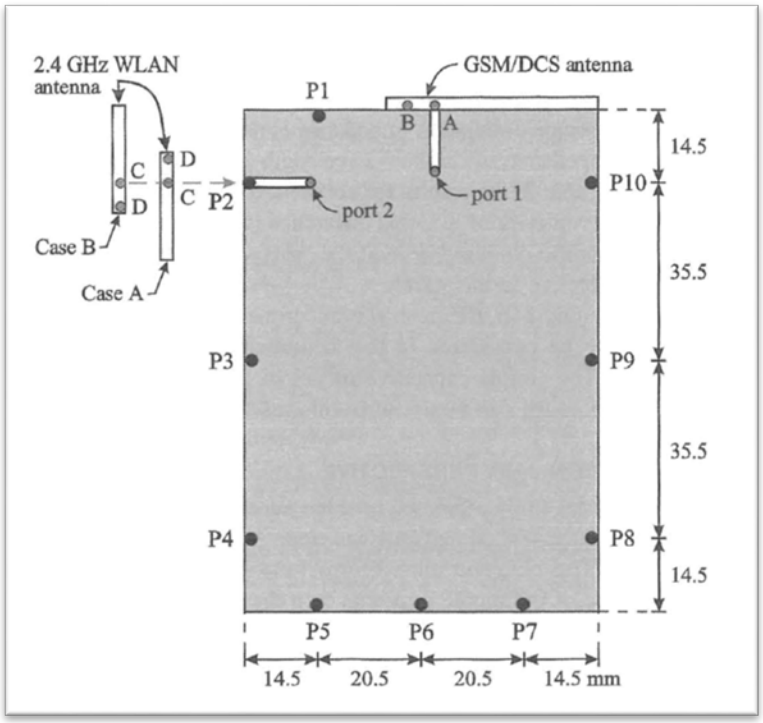
63. The Petition alleges that claims 1-9, 12 and 13 would have been obvious to the POSITA at the time of invention based on the combined teachings of Wong and Lee. More specifically, the Petition asserts that it would have been obvious to the POSITA to combine the teachings of Wong and Lee such that Wong's GSM/DCS antenna is replaced with Lee's quadband antenna (*i.e.*, its orthogonally arranged dual band antennas), as illustrated in the figure below reproduced from the Petition. Petition at 12.



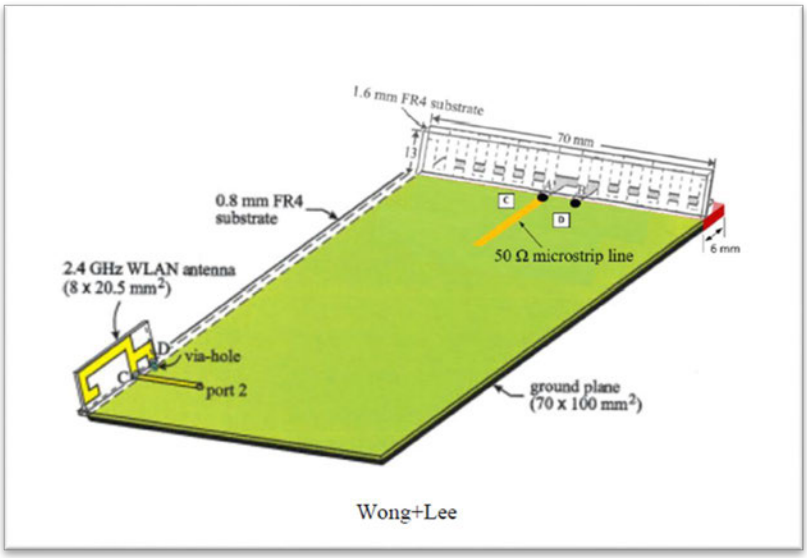
64. Further, the Petition alleges that the POSITA would have expected to be successful in making this modification to Wong's structure. Petition at 15. It is my opinion that this conclusion is incorrect and ignores both the knowledge of the POSITA at the time of invention and the explicit teachings of both Wong and Lee. It is further my opinion that the POSITA would have expected that the proposed modification to Wong set forth in the Petition would likely present isolation challenges considered insurmountable at the time.

65. First, it is my opinion that the POSITA would not have made the proposed modification to Wong, and would not have expected to have been successful in doing so, because it ignores the conclusion Wong reaches regarding the optimal location for the WLAN antenna.

66. Wong concludes that "that the isolation obtained at location P4 for case A orientation is optimal among all the locations and orientations of the WLAN a nte1rnas studied here." EX1005 at 350. As illustrated in FIG. 2 from Wong, location P4 is diagonally opposite or "catty corner" from the GSM/DCS antenna.



67. Petitioners' proposed combination of Wong and Lee eliminates the possibility of arranging the WLAN antenna diagonally opposite the Lee quadband antenna. As illustrated in the figure I provide below, the Lee antenna extends across the entire top of the ground plane so that there can no longer be a location for the WLAN antenna that is diagonally opposite the quadband antenna. Essentially, the modification to Wong proposed in the Petition turns location P4 into another P8 – a location on the opposite end but on a same side as a lateral edge of the other quadband antenna.



68. This modification converts the optimal location P4 into a mirror of location P8. Location P8, however, exhibits substantially degraded antenna isolation performance. As illustrated in Table 1 from Wong (which I have annotated below), location P8 exhibits some of the worst antenna isolation out of all the locations studied in Wong, substantially worse isolation performance than the "optimal" location P4. In fact, the modification converts the optimal location P4 into location P8, a location with some of the worst isolation measured in Wong. It is my opinion that this is not a modification that the POSITA would have been motivated to make.

TABLE 1 Measured Maximum Isolation (S_{21}) Within the GSM, DCS, and WLAN Bands, Respectively, at Different Locations (P1 to P10) of the WLAN Antenna Shown in Fig. 2

Location	Case	Max. S_{21} [dB] in GSM band	Max. S_{21} [dB] in DCS band	Max. S_{21} [dB] in WLAN band
P1	A	−27.4	−18.8	−27.3
	B	−24.3	−14.2	−22.2
P2	A	−28.6	−20.9	−26.1
	B	−27.6	−24.9	−27.0
P3	A	−29.5	−21.9	−31.8
	B	−28.0	−23.2	−33.4
P4	A	−33.6	−27.9	−33.0
	B	−26.5	−26.8	−35.6
P5	A	−34.2	−21.6	−32.8
	B	−26.8	−29.7	−34.6
P6	A	−29.6	−21.8	−32.1
	B	−28.1	−25.6	−34.1
P7	A	−26.9	−19.7	−22.5
	B	−28.8	−19.0	−24.9
P8	A	−28.3	−14.8	−22.4
	B	−35.6	−19.8	−25.5
P9	A	−26.3	−15.8	−21.6
	B	−30.0	−13.9	−20.0
P10	A	−14.9	−5.9	−4.6
	B	−23.7	−4.2	−16.1

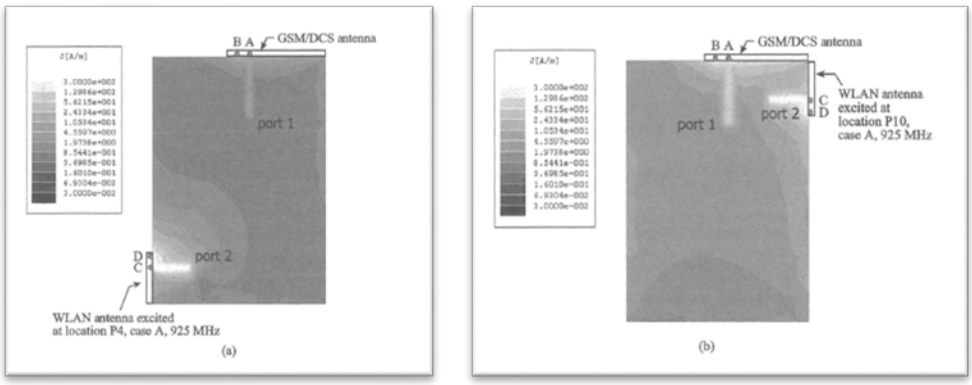
69. It is further my opinion that the POSITA would not have made the modification to Wong as proposed in the Petition because it would have been expected to introduce substantial additional isolation problems from larger surface currents.

70. As I discuss in the background above, Lee's quadband antenna (or two dual band antennas) operates at two additional frequency bands, the APMS band which has a lower frequency, 824-894 MHz, than those supported by Wong's GSM/DCS antenna, and the PCS band which has a higher frequency, 1850-1990 MHz, than those supported by Wong's GSM/DCS antenna. While the Petition argues that these additional frequencies would motivate the POSITA to make the proposed modification (Petition at 13), it is my opinion that these additional bands would have *discouraged* the POSITA from making the modification.

71. As Wong explains, "the isolation between the two antennas is strongly related to the excited surface current distributions in the system ground plane." EX1005 at 351. As illustrated in FIG. 8 from Wong, antennas in closer in closer proximity have correspondingly closer surface currents, which results in decreased isolation/increased coupling between the antennas:

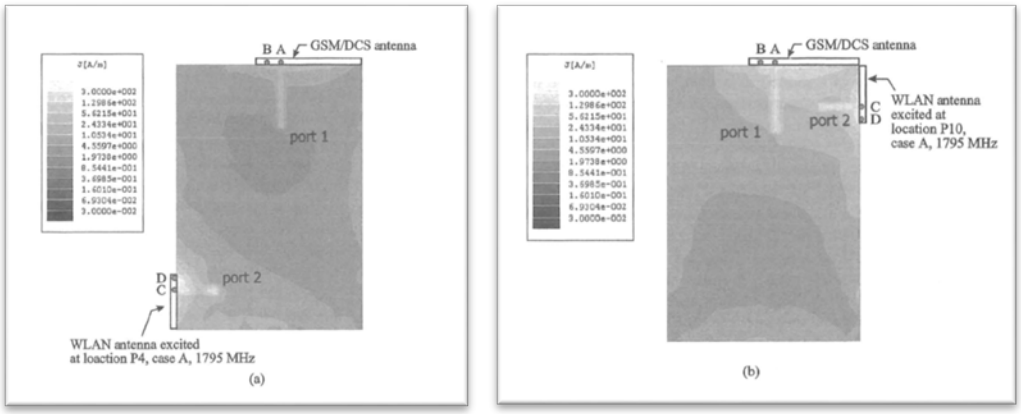
> [I]t is clearly seen that **the excited surface currents near the GSM/DCS antenna are much stronger in Figure 6(b) than in Figure 6(a). This behavior may explain the reason for the poor isolation obtained in the GSM band for location P10 with case A shown in Figure 4.** …

EX1005 at 351 (emphasis added).



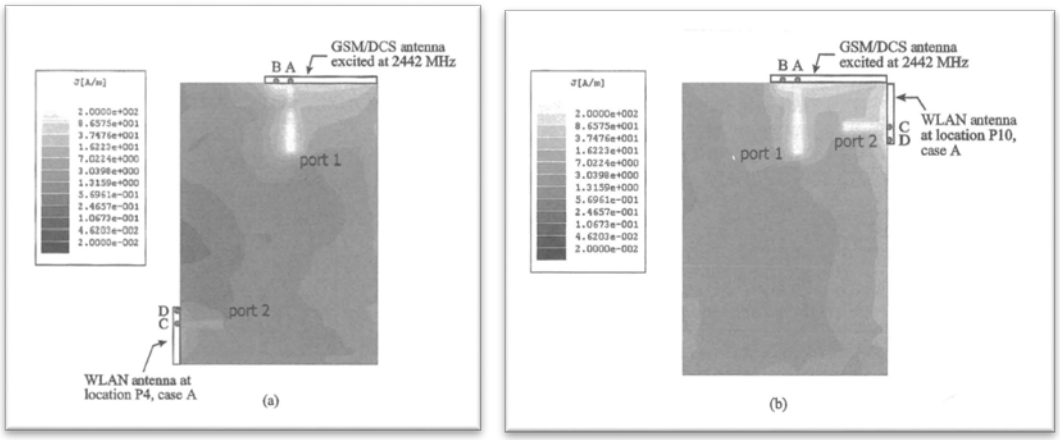
> Similarly, by comparing Figure 7(a) (location P4 with case A , the same as the study in Fig. 3) to Figure 7(b) (location PIO for case A, the same as the study in Fig. 4), **much stronger excited surface currents near the GSM/DCS antennas in Figure 7(b) are seen. This behavior may also explain the reason for the poor isolation obtained in the DCS band for location P10 with case A shown in Figure 4.**

EX1005 at 351 (emphasis added).



> [T]he obtained results shown in Figure 8 also indicate that **<u>much stronger surface currents are excited near the WLAN antenna in Figure 8(b) than in Figure 8(a). This may also lead to the poor isolation obtained in the 2.4-GHz WLAN band</u>** for location P10 with case A shown in Figure 4.

EX1005 at 351 (emphasis added).



72. It is my opinion that the POSITA would understand from Wong's explicit teachings that strong surface currents resulting from one antenna which are excited near the other antenna result in poor isolation/increased coupling between the two antennas. The Petition, however, proposes a modification that would

increase the proximity between the WLAN antenna and the surface currents induced by the other antenna.

73. As I discussed in the background section above, Lee's antenna, which extends across the entire top of the ground plane, will decrease the distance between the WLAN antenna and the surface currents induced by the other antenna. Further, the Lee antenna adds an additional low frequency band – the APMS band which operates at 824-894 MHz. The POSITA would understand that surface currents associated with this lower frequency band will be larger than the surface currents associated with the GSM and DCS frequency bands used by the Wong antenna.

74. As understood by the POSITA, the size of length of the surface currents is related to the wavelength associated with the frequency at which the antenna is operating. The lower frequencies of the APMS frequency band will result in larger/longer surface currents in the ground plane, resulting in decreased isolation/increased coupling between the antennas.

75. Given the POSITA would understand that the size of the Lee antenna and the low frequency APMS band at which it operates would substantially decrease isolation/increase coupling, it is my opinion that the POSITA would not have had an expectation of successfully implementing the combination of the teachings of Wong and Lee as proposed in the Petition.

76. As discussed, the lower frequency APMS band would have discouraged the POSITA from making the modification proposed in the Petition. The same is also true for the higher frequency PCS band. The POSITA would have understood that this higher frequency band would have introduced additional isolation problems if implemented as proposed in the Petition.

77. As understood by the POSITA, if two antennas are configured to operate at the same or nearby frequencies, the coupling between the antennas will likely increase. Specifically, the transmitting antenna launches strong surface currents on the ground plane at its resonant frequency, and the receiving antenna is most sensitive to currents and fields at that same or nearby frequencies. As a result, even small amounts of ground-plane-mediated energy transfer can cause significant coupling and interference.

78. The upper bound of the PCS frequency at which the Lee antenna operates is substantially closer to the operating frequency of the WLAN antenna than the upper bound of the Wong antenna's DCS frequency band. It is my opinion that the proximity of Lee's high frequency PCS range to that of the Wong's WLAN antenna would be understood by the POSITA as decreasing isolation/increasing coupling between the two antennas. Therefore, it is further my opinion that the resulting decreased isolation/increased coupling from the Lee antenna PCS

operating frequency range would indicate to the POSITA that there was no likelihood of success of modifying the Wong antenna as proposed by the Petition.

79. Finally, it is also my opinion that the additional resonant frequency present in Lee's antenna further illustrate why the POSITA would not have modified Wong as proposed in the Petition and would not have expected that such a modification would have been successful.

80. As discussed above, if two antennas are configured to operate at the same or nearby frequencies, the coupling between the antennas will likely increase. The Lee antenna has a resonant frequency that corresponds almost exactly to the operating frequency of the Wong WLAN antenna. Accordingly, the POSITA would expect the modification proposed in the Petition would exhibit substantially decreased isolation/increased coupling between the antennas.

81. Reproduced below is the return loss plot for the Lee quadband antenna. As illustrated, there is substantially low return loss at the frequencies associated with the APMS (824-894 MHz), GSM (890-960 MHz), DCS (1710-1880 MHz), and PCS (1850-1990 MHz) frequency bands. The POSITA would understand from this that the Lee antenna radiates within these frequency bands – the return loss is a result of the antenna radiating this energy away instead of it being reflected back. As indicated in the highlighting I have provided in the figure below, the Lee antenna

also exhibits substantial return loss at 2500 MHz. The POSITA would understand from this low return loss that the Lee antenna resonates at 2500 MHz. .

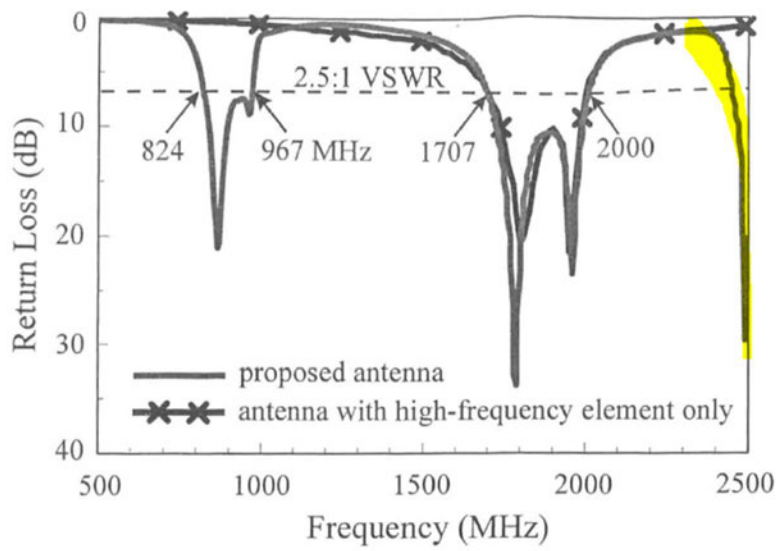


Figure 2 Measured return loss for the proposed antenna and the antenna with the high-frequency element only

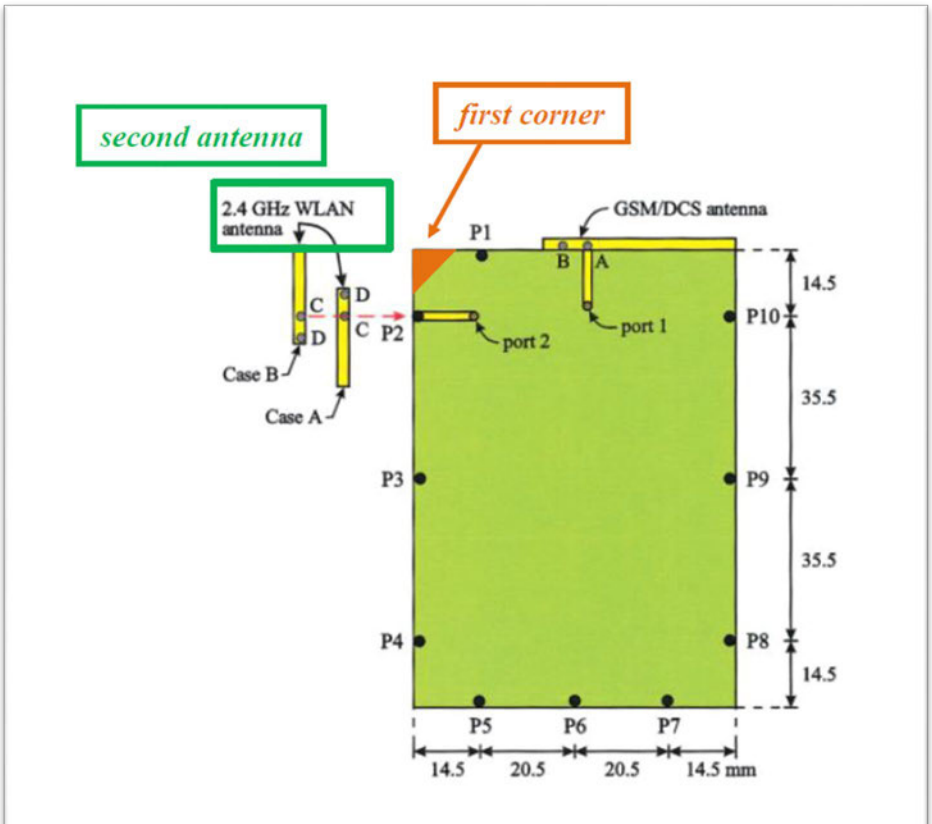
82. The POSITA would further understand that this resonant frequency corresponds almost exactly to the operating frequency of the WLAN antenna would result in decreased isolation/increased coupling between the Lee antenna and the Wong WLAN antenna.

83. The resulting decreased isolation/increased coupling from the additional Lee antenna resonant frequencies would indicate to the POSITA that there was no likelihood of success of modifying the Wong antenna as proposed by the Petition.

84. Based on all the reasons set forth above, it is my opinion that the POSITA simply would not have modified the Wong device to use the quadband (*i.e.*, orthogonal dual band) antenna from Lee. It is my opinion that the POSITA would understand that the modification to Wong proposed in the Petition would decrease isolation/increase coupling between the antennas due to the four different mechanisms that I outline above. Accordingly, it is my opinion that the proposed modification would have been non-obvious at the time of invention, and would have been understood as being unlikely to succeed by the POSITA.

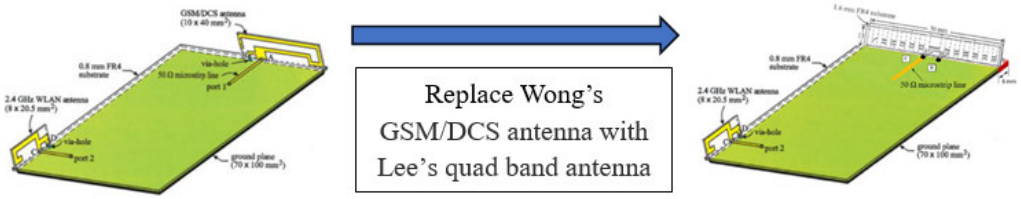
VII. Ground 1A – The Necessary Modifications to Wong Needed to Address Claim 8 are Non-Obvious for Additional Reasons

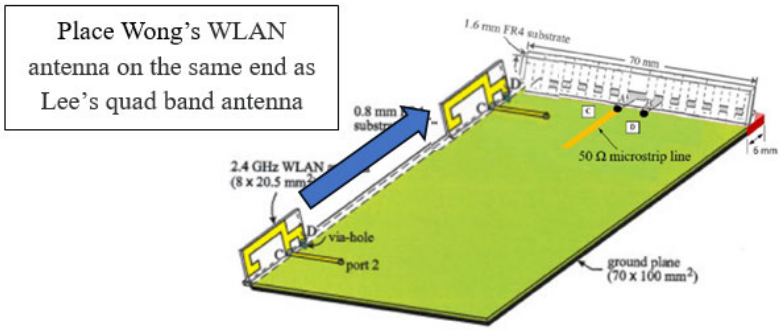
85. It is my opinion that claim 8 and its dependents further distinguish over Ground 1A from the Petition. Claim 8 recites that the "second antenna," which Ground 1A alleges corresponds to Wong's WLAN antenna, "is arranged substantially close to a first corner of the portable device." The recited "first corner" is a corner of the portable device that Petitioners assert corresponds to a top corner of the Wong ground plane, as illustrated in Petitioners' annotated figure from page 50 of the Petition, reproduced below.



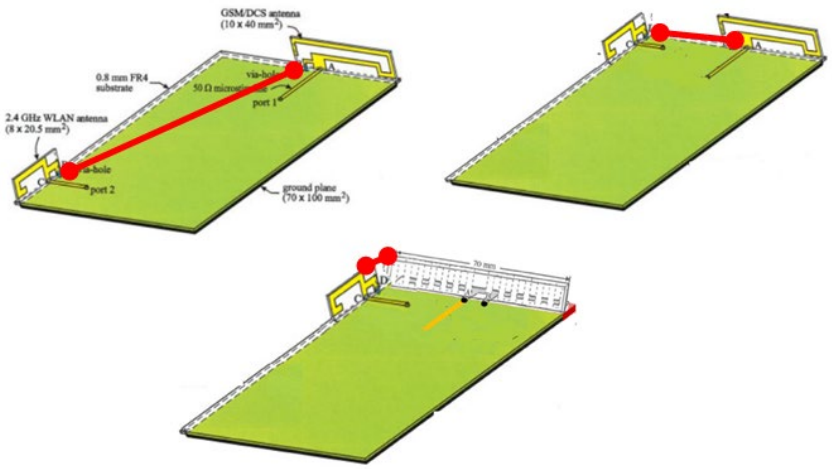
Wong, Figure 2 (annotated)

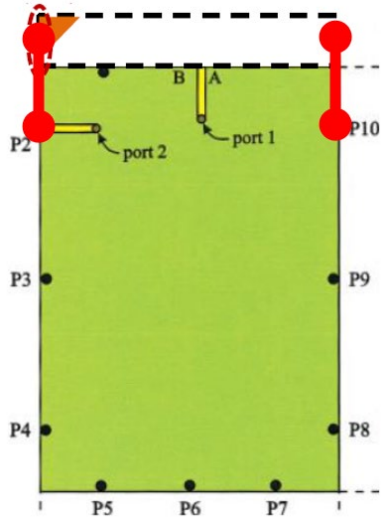
86. The Petition proposes first replacing Wong's GSM/DCS antenna with Lee's quadband antenna, and then positioning the WLAN antenna at location P2.





87. As I discuss above, by replacing Wong's GSM/DCS antenna with Lee's quadband antenna, the Petition's modification to Wong makes position P2 equivalent to position P10 – because Lee's quadband antenna extends across the entire top of the ground plane, the relative distance between the WLAN antenna and the quadband antenna at location P2 is the same as the relative position between the WLAN antenna and the quadband antenna at location P10.





88. Wong is, however, explicit about location P10 – the level of antenna isolation at location P10 is "**<u>not acceptable for practical applications</u>**." EX1005 at 349 (emphasis added).

89. It is my opinion that the POSITA would simply not make this modification to Wong. The modification proposed in the Petitioners make position P2 equivalent to position 10, but Wong explicitly teaches that position P10 is not acceptable for practical applications. The modification in the Petition asks the POSITA to essentially break the antenna, making it unacceptable for practical applications. It is my opinion that this is not something the POSITA would do, and it is not something the POSITA would not have expected to be able to implement with any expectation of success.

VIII. Ground 1B – The POSITA Would Not Have Consider Claims 14-15 and 17-19 over Obvious over Wong

90. It is my opinion that claim 14 and its dependents would not have been obvious to the POSITA based on the work undertaken in Wong. Specifically, claim 14 essentially recites that the two claimed antennas are arranged such that they extend parallel to each other, but on opposite ends of the recited ground plane. The Petition alleges that alleges that Wong's GSM/DCS antenna corresponds to the recited "first antenna" and that Wong's WLAN antenna arranged at location P5 corresponds to the recited "second antenna." Petition at 59.

91. Wong, however, teaches away from this position and location. Wong teaches placing the WLAN antenna at location P4, stating that this is the optimal position for the antenna.EX1005 at 350 ("By comparing the obtained results, it can be concluded that the isolation obtained at location P4 for case A orientation is optimal among all the locations and orientations of the WLAN antennas studied here."). The Petition claims that the POSITA would deviate from this explicit teachings of Wong, and would reposition the WLAN antenna, moving it from position P4 to position P5. In my opinion this is not a modification that the POSITA would make.

IX. Ground 2 -- A POSITA Would Not Consider claims 1-10, 12 and 13 Obvious from the Disclosures of Gaucher

92. The Petition alleges that claims 1-10, 12 and 13 would have been obvious from the teachings of Gaucher combined with references incorporated into

it, such as Gaucher848. Specifically, the Petition proposes replacing one of Gaucher's multiband antennas with a tri-band antenna from Gaucher848. Petition at 69-70. It is my opinion that such a modification to Gaucher is contrary to the intended purposes of providing multiple copies of the Gaucher multiband antenna. Therefore, the modification proposed in Ground 2 would not have been obvious to the POSITA.

93. As I discuss in the background provide above, Gaucher is directed to a specific quadband antenna constructed from "f-shaped" and "l-shaped" pieces. EX1012 at Abstract. These quadband antennas (antennas 310 and 320 in FIG. 3 from Gaucher, reproduced below) may be arranged on the long and short sides of the display of a portable device.

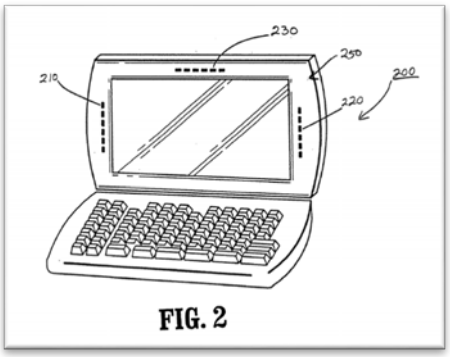


FIG. 2

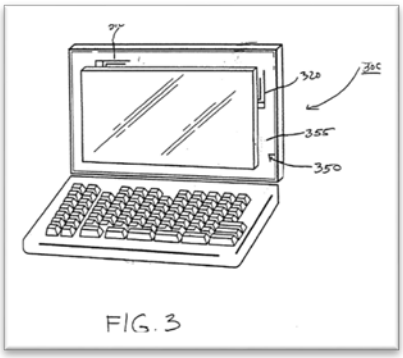


FIG. 3

94. The POSITA would understand from the background of Gaucher, as well as Gaucher848 and Asano (both incorporated by reference in Gaucher), the purpose of providing these multiple antennas that operate at the same frequencies is to provide spatial diversity, polarization diversity, or both:

> In one exemplary embodiment, two embedded antennas 210, 220 may be placed on the left and right edges of the laptop display 250, respectively, whereby **the use of the two antennas 210 and 220 may reduce the blockage caused by the laptop display 250 in some directions that occurs in one antenna designs, and provide space diversity to the wireless communication system. Alternatively, one of the antennas 210 or 220 may be disposed on one side of the laptop display 250 while a second antenna 230 is disposed in an upper portion of the laptop display 250, whereby providing antenna polarization diversity, depending on the antenna design used**.

EX1012 at ¶ [0004] (emphasis added); *see also* EX1013 at ¶ [0004]; EX1024 at ¶¶ [0008]; [0100], [0126], [0130].

95. As I explain in the background section above, the spatial and polarization diversity techniques of Gaucher (as well as Gaucher848 and Asano), are dependent on both antennas 310 and 320 (in FIG. 3) or antennas 210, 220 and 230 (in FIG. 2) operating over the same frequency ranges.

96. Ground 2 in the Petition, however, proposes replacing one of the antennas 310, 320 from Gaucher with a different antenna from Gaucher848. Petition at 79 ("Gaucher's antenna 310 implemented as Gaucher848's tri-band wireless antenna is '*a second antenna*' included in Gaucher's laptop 300"). This modification to Gaucher runs directly contrary to the teaching in Gaucher that the purpose of antennas 310 and 320 is to provide spatial or polarization diversity. By replacing antenna 310 with a different antenna, the two antennas would no longer provide spatial or polarization diversity.

97. Specifically, Gaucher's quadband antenna operates at the 824-894 MHz frequency band, the 880-960 MHz frequency band, the 1710-1880 MHz frequency band, and the 1850-1990 MHz frequency band. EX1012 at ¶ [0030]. The triband antenna from Gaucher848 operates at the 2.4-2.5 GHz frequency band, the 5.15-5.35 GHz frequency band, and the 5.47-5.825 GHz frequency band. EX1013 at ¶ [0041]. With zero overlap between the frequency bands supported by the quadband antenna in Gaucher and the triband antenna in Gaucher848, the combination of antennas proposed in the Petition is incapable of providing spatial or polarization diversity – two multiband antennas that operate at completely different bands from each other provide no spatial or polarization diversity at all.

98. Therefore, it is my opinion that the proposed modification would not have been obvious to the POSITA at the time of invention. Specifically, Gaucher, Gaucher848 and Asano all teach the purpose of multiple antennas is to provide spatial or polarization diversity. It simply would not have been obvious to the POSITA to change one of the antennas so that it no longer provided such diversity.

X. Ground 2 – The Necessary Modifications to Gaucher Needed to Address Claim 8 are Non-Obvious for Additional Reasons

99. It is my opinion that claim 8 and its dependents further distinguish over Ground 2 from the Petition. Claim 8 recites that the "second antenna," is "arranged substantially close to a first corner of the portable device." It is my opinion that the

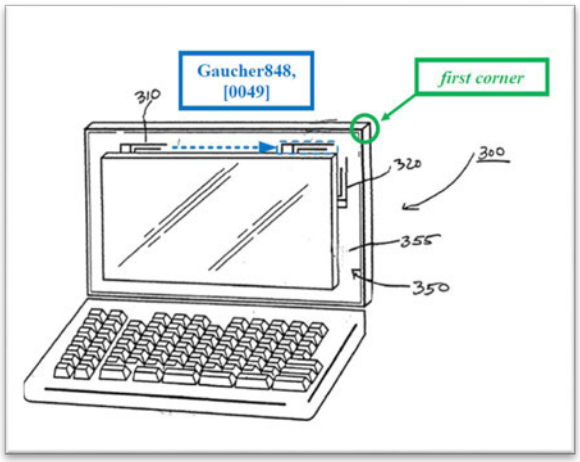
Petition mischaracterizes the teachings of Gaucher848 in an attempt to invalidate claim 8.

100. Specifically, the Petition alleges that it would have been obvious to the POSITA to:

> rearrang[e] antenna 310 (second antenna) in Gaucher's Figure 3 from the upper-left portion to the upper-right portion of support frame 355, **as Gaucher848 specifically teaches as an option for its tri-band antenna**.

Petition at 93 (emphasis added).

101. The Petition illustrates this "rearranging" in the annotated FIG. 3 from Gaucher provided on page 94 of the Petition and reproduced below.



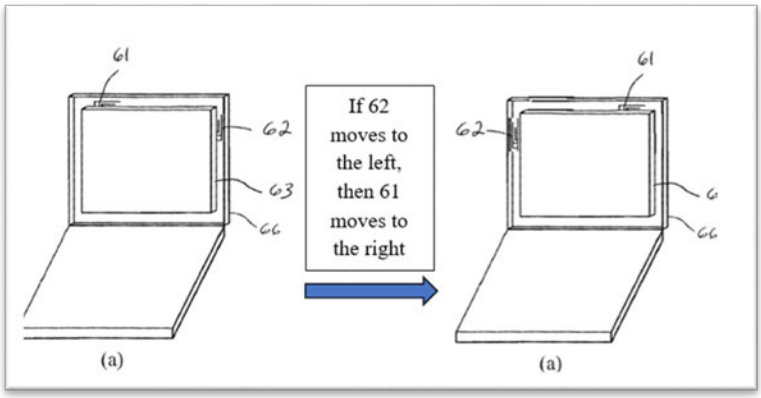
102. The Petition cites paragraph [0049] of Gaucher848 as describing the above-illustrated rearranging. Petition at 93. It is my opinion, however, that this passage from Gaucher848, does not propose rearranging only one of the antennas.

Instead, Gaucher848 teaches that if antenna 310 were moved to the right as proposed above, then antenna 320 would move to the left hand side of the display:

> FIG. 6(a) illustrates two tri-band antennas (61, 62) mounted to a metallic support frame (63) of the laptop display unit having a plastic cover (66), wherein the plane of each tri-band antenna (61, 62) is substantially parallel to the plane of the display frame (63). FIG. 6(b) illustrates two tri-band antennas (64, 65) mounted to the display frame (63) wherein the plane of each tri-band antenna (64, 65) is substantially perpendicular to the plane of the display frame (63). **In FIGS. 6(a) and 6(b), the tri-band antennas (62) and (65) can be positioned on the left side of the display frame (63)(as opposed to the right side of the frame as shown) and the tri-band antennas (61) and (64) can be located on the right side of the upper portion of the frame (63) (as opposed to the left side of the upper portion of the frame as shown).**

Gaucher848 at ¶ [0049] (emphasis added).

103. It is, therefore, my opinion that the POSITA would understand from a complete reading of Gaucher848 that if antenna 62 is repositioned on the left side of the display frame, then antenna 61 is repositioned to the right side of the upper frame 63, as illustrated in the annotated figure below.



104. Accordingly, it is my opinion that moving only one of the antennas as proposed in the Petition would ***not*** have been obvious to the POSITA. When considered with its full context, the POSITA would understand that Gaucher848 teaches that if one antenna is moved, then the other antenna should also be relocated to preserve the spatial diversity techniques of Gaucher, Gaucher848 and Asano. Therefore, it is my opinion that it would not have been obvious to the POSITA to move only one of Gaucher's antennas as proposed in the Petition.

XI. Ground 3 -- A POSITA Would Not Consider claims 14-18 Obvious from the Disclosures of Zhao

105. Claim 14 recites a "second rectangular area" whose length and width sum to a value smaller than a quarter of the operating wavelength of the second antenna. It is my opinion that the Petition has not shown that Zhao includes a "second rectangular area" whose length and width sum to a value smaller than a quarter of the operating wavelength of the second antenna. It is also my opinion that the POSITA would not have found this recitation obvious at the time of invention from the teachings of Zhao.

106. Zhao teaches that "The length of second side 10 of slot 8 [of its half wavelength antennas] is about one half-wavelength of the lower resonant frequency" and that its "quarter-wavelength slot UWB antennas can be designed by using half of the slot [of its half wavelength antennas]." EX1008 at ¶¶ [0040], [0042]. The half

wavelength antenna slot is 28 mm, which would make the quarter wavelength slot 14 mm. Accordingly, absent other effects, ¼ Zhao's resonant frequency wavelength is about 14 mm. Antenna 50 is one such quarter wavelength slot antenna, and therefore, ¼ the operating wavelength of this antenna is "about" 14 mm. I note that Zhao discloses that the lengths of its ¼ wavelength slot antennas is between 11.8 mm and 12.75 mm, which is smaller than the 14 mm value discussed above. EX1008 at ¶ [0042]. Zhao explains this discrepancy, discussing how "strong capacitive effects" result in size reduction of the ¼ wavelength slot antenna 50. EX1008 at ¶ [0043]. Regardless, this value is substantially closer to the value for ¼ the operating wavelength than the value calculated in the Petition

107. Zhao also discloses the permittivity for its FR-4 dielectric material: "The dielectric material used for the PCB is FR4 with τ_r=4.4 …" EX1008 at ¶ [0038]. This disclosure would indicate to the POSITA to take this value into consideration when determining the wavelength associated with the resonant frequencies of the Zhao antenna 50. First, the POSITA would estimate the effective permittivity for Zhao antenna 50 using the permittivity of the air and the dielectric, which can be estimated as follows, as the permittivity of air is essentially 1:

$$\tau_{eff} = \frac{\tau_r + 1}{2}.$$

EX20009 at 169.

108. Next, the POSITA would calculate the wavelength of the resonant frequency for the antenna 50 using the following formula:

$$\lambda = \frac{\lambda_0}{\sqrt{\tau_r}} = \frac{c}{f\sqrt{\tau_{eff}}};$$

where λ_0 is the free-space operating wavelength, τ_r refers to the permittivity of the dielectric material (sometimes referred to as ε_r), c is the speed of light and *f* is the frequency of the radiation. *See Id*.

109. Using 3.0 x 10^{11} as the speed of light in millimeters, the operating wavelength in millimeters for the Zhao antenna as a function of frequency may be calculated as follows:

$$\lambda = \frac{\lambda_0}{\sqrt{\frac{\tau_r + 1}{2}}}$$

$$= \frac{\mathrm{c}}{f\sqrt{\frac{\tau_r + 1}{2}}}$$

$$= \frac{3.0 \times 10^{11}}{f\sqrt{\frac{4.4 + 1}{2}}}$$

$$= \frac{3.0 \times 10^{11}}{f\sqrt{\frac{4.4 + 1}{2}}}$$

$$\lambda = \frac{3.0 \times 10^{11}}{f \times 1.64}$$

110. Using the frequency values from Zhao of 3.1 GHz and 4.9 GHz (EX1008 at [0025]) results in the following values for the resonant wavelengths in Zhao:

$$\lambda_{3.1} = \frac{3.0\times10^{11}}{3.1\times10^{9}\times1.64} = 59.1 \text{ mm}$$

$$\lambda_{4.9} = \frac{3.0\times10^{11}}{4.9\times10^{9}\times1.64} = 37.2 \text{ mm}$$

111. Claim 14, however, refers to ¼ the operating wavelength, which for Zhao would result in the following values:

$$\frac{\lambda_{3.1}}{4} = \frac{59.1}{4} = 14.8\ mm$$

$$\frac{\lambda_{4.9}}{4} = \frac{37.2}{4} = 9.3\ mm$$

112. As indicated above, ¼ the wavelength associated with the lower 3.1 GHz resonant frequency is 14.8 mm, which is "about" 14 mm. Accordingly, the ¼ wavelength value calculated using the permittivity of Zhao's FR-4 dielectric is consistent with the value associated with the lengths of the slots used for Zhao's UWB antennas 50.

113. The Petition ignored the permittivity of the FR-4 material in Zhao, and purported to calculate an operating wavelength of the antenna 50 using the simplified formula of $\lambda = \frac{c}{f}$. Petition at 112. As a result, the Petition incorrectly determines that ¼ the wavelength associated with the 3.1 GHz frequency is 24.25 mm. *Id.* This 24.25

mm value, unlike the value of 14.8 mm calculated using the permittivity of Zhao's substrate, is nowhere close to either the 14 mm or 11.8 mm to 12.75 mm values taught in Zhao. *See* EX1008 at ¶¶ [0040], [0042], [00430], [0052]. It is my opinion that this mismatch of the ¼ operating wavelength calculated in the Petition and the ¼ wavelength disclosed in Zhao confirms that the Petition's approach was not correct.

114. As a result, it is my opinion that the Petition is incorrect that Zhao provides "a sum of a length and a width of the second rectangular area is smaller than a quarter of an operating wavelength of the second antenna," and therefore, the Petition has not shown that it is likely to succeed in showing the invalidity of claim 14 and its dependents over Zhao.

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 of under Section 1001 of Title 18 of the United States Code.

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

Date: 08/28/2025 By: _____

Hossein Hashemi, Ph.D.