

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

INTEL CORPORATION,
Petitioner

v.

Telefonaktiebolaget L M Ericsson
Patent Owner.

IPR2024-00728

U.S. Patent 7,151,430

**SUPPLEMENTAL DECLARATION OF MANOS TENTZERIS, PHD
IN SUPPORT OF INTER PARTES REVIEW OF U.S. PATENT 7,151,430**

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Patent Trial and Appeal Board
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I, Dr. Manos Tentzeris, declare as follows:

I. Introduction, Qualifications, and Materials Considered

1. I have been retained on behalf of Intel Corporation (“Petitioner”), to provide this Declaration concerning technical subject matter relevant to the petition for Inter Partes Review (“Petition”) of U.S. Patent 7,151,430 to Mattson (“the ’430 patent”). It is my understanding that the ’430 patent is currently assigned to Telefonaktiebolaget L M Ericsson (publ) (“Patent Owner”).

2. I previously prepared and submitted the Declaration of Manos Tentzeris, Ph.D. in Support of Inter Partes Review of U.S. Patent 7,151,430 (“First Declaration,” INTEL-1003), which I fully incorporate here by reference. I have been asked to prepare this Supplemental Declaration to provide my opinions regarding the opinions expressed by Patent Owner’s expert, Dr. Paul Prucnal, in the Expert Rebuttal Declaration of Paul R. Prucnal Regarding Validity of U.S. Patent No. 7,151,430 (“Rebuttal Declaration,” EX2002) and the Supplemental Expert Declaration of Paul R. Prucnal, Ph.D. (“Supplemental Declaration,” EX2009).

3. Since preparing my First Declaration, my qualifications and compensation have not changed. I am being reimbursed at my standard hourly consulting rate. My compensation is not affected by or dependent in any way on the outcome of this matter.

4. In forming my opinions expressed in this Declaration, I relied upon my education and experience, which I described in my First Declaration and in my *curriculum vitae* (INTEL-1003). In addition to the materials listed in my First Declaration and the materials listed in the Appendix to this document, I reviewed and considered the following:

- a. Paper 7, Patent Owner's Preliminary Response
- b. EX2002, Expert Rebuttal Declaration of Paul R. Prucnal Regarding Validity of U.S. Patent No. 7,151,430
- c. Paper 8, Petitioner's Reply to Patent Owner's Preliminary Response
- d. Paper 9, Patent Owner's Sur-Reply
- e. Paper 10, Institution Decision
- f. Paper 16, Patent Owner's Response
- g. EX2009, Supplemental Expert Declaration of Paul R. Prucnal, Ph.D.
- h. INTEL-1044, Deposition Transcript of Dr. Paul Prucnal.

5. I am over 18 years of age. I have personal knowledge of the facts stated in this Declaration and could testify competently to them if asked to do so.

II. EM Field Simulations

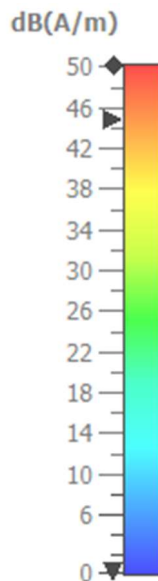
6. In the Institution Decision, the Board invited the parties to develop the record as to what a POSITA "would have understood regarding the characteristics of the EM fields emanating from Taniguchi's loop structures." (Paper 10, 19.) Dr.

Prucnal did not provide any additional details, explanation, simulations, or analysis to describe or visualize the EM fields produced by Taniguchi's inductors/antennas. At his deposition, Dr. Prucnal could not describe the field produced by an eight-shaped inductor. (INTEL-1044, 44:22-45:22.) Regardless, in order to assist the Board, I provide below a detailed discussion of the EM fields produced by current-carrying conducting loops, including the results of simulations I performed on loops of various shapes on both PCB and silicon substrates, from which semiconductor chips used in integrated circuits are formed.

7. In order to visualize the EM fields produced by various shapes of current-carrying conductors, I performed simulations using CST Microwave Studio. These simulations include the following: (1) a long current-carrying conductor; (2) a circular current-carrying conducting loop; (3) a rectangular current-carrying conducting loop; (4) an eight-shaped current-carrying conductor; (5) two closely-spaced terminals carrying equal and opposite current. All of the simulations were performed on a PCB substrate. For the rectangular and eight-shaped conductors and the closely-spaced terminals, I also performed simulations of the conductors on a silicon substrate. For simplicity of comparison, the PCB and IC simulated substrates are the same size. As I explain below, the fundamental physics of the EM field directions and relative strengths are the same regardless of whether the inductors are sized for placement on a PCB or an IC.

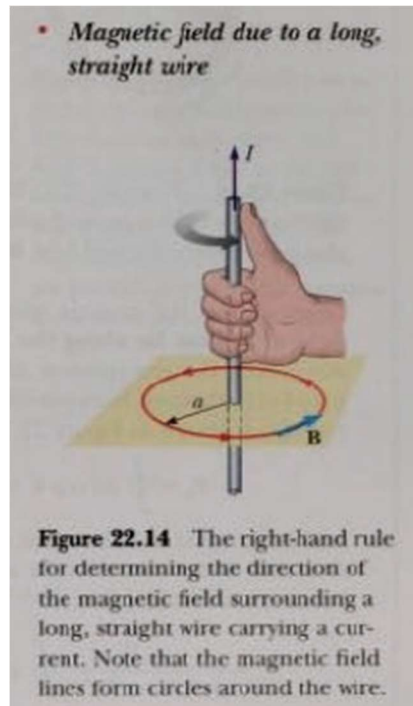
8. The simulation parameters are as follows:
 - a. Substrate: PCB (Rogers 3003 or FR-4) or Si, as noted; $Dk=3$,
 $Td=0.001$
 - b. Thickness = 0.127 mm
 - c. Line width = 100 μm
 - d. Conductor: PEC
 - e. Total simulation area: 60 mm $\times$ 40 mm
9. In each simulation, I used alternating current (“AC”) excitation, which is required for the production of EM waves. While direct current (“DC”) does create a magnetic field (and my explanations below for the basic physics of the magnitude and direction of magnetic field apply to both AC and DC current), DC current is static (i.e., does not oscillate) and therefore does not create EM waves. Because the simulations use an AC excitation signal, the magnetic field oscillates over time from a maximum positive value to a minimum negative value and back to a maximum positive value. In other words, the magnetic field changes direction as the current alternates direction in the conductor. In the simulation for each conductor, there are antinodes, or points where the magnitude of the magnetic field oscillates between a maximum and minimum value. These antinodes alternate between maximum and minimum along the conductor.

10. The simulation provides as output images representing the strength and direction of the magnetic field component of the EM field. In some images, magnetic field direction is indicated by arrows, with magnetic field strength indicated by size and color of the arrows. In other images, only magnetic field strength is indicated. The following scale is used in the images generated by this program to show field strength, where the darkest blue represents zero field and red represents where the field is largest. The color code expresses the amplitude of the magnetic field (also referred to as H-field) in decibels according to the following equation: $20 \times \log_{10} (H/H_{\text{ref}})$. In other words, an H-field of 20 db (light green) is $\sqrt{10}$ times greater than a field of 10 db (light blue), an H-field of 30 db (yellow-green) is 10 times greater than a field of 10 db and so forth.



Magnetic Field Strength

11. As I explained in my First Declaration, the direction of the magnetic field generated by a current-carrying conductor can be determined by using the right-hand rule. (INTEL-1003, ¶24.) In the case of a long, current-carrying conducting wire, the right-hand rule is applied by pointing your right thumb in the direction of the current; then the fingers of your right hand curl in the direction of the magnetic field, which makes circles around the conducting wire. This is shown in Figure 22.14 of Serway's Principles of Physics, 2nd Edition:

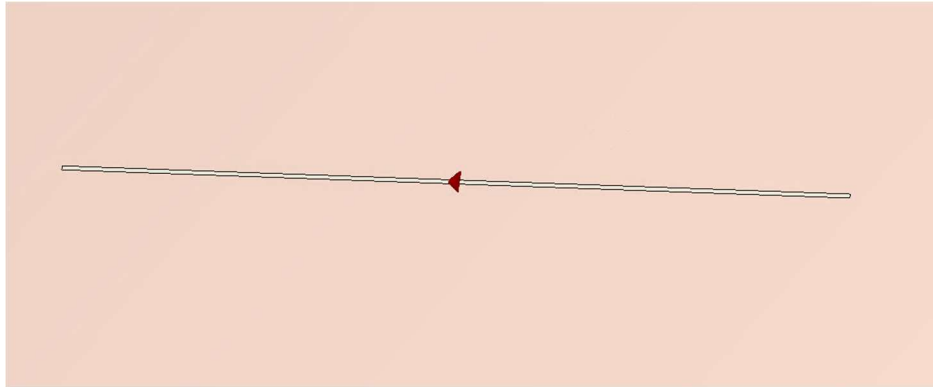


Serway, Figure 22.14 (INTEL-1013, 649)

12. In addition to magnetic field magnitude discussed above, the simulation also provides as output images representing magnetic field direction.

This is shown in the images generated by the program as colored arrows, where the color represents field strength according to the scale I discussed above.

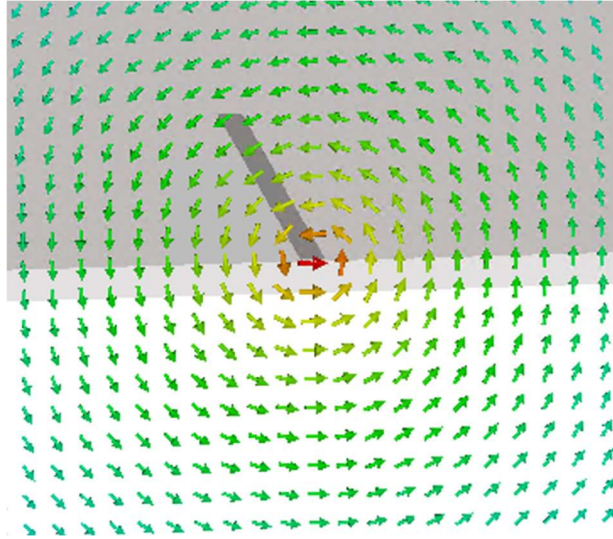
13. I performed a simulation of a long, current-carrying conducting wire on a PCB substrate to show the magnitude and direction of the magnetic field produced by the wire. The model for this is shown below. The red triangle in each of the figures shows the location where the excitation signal (AC current) is applied.



Simulated Long Current-Carrying Wire

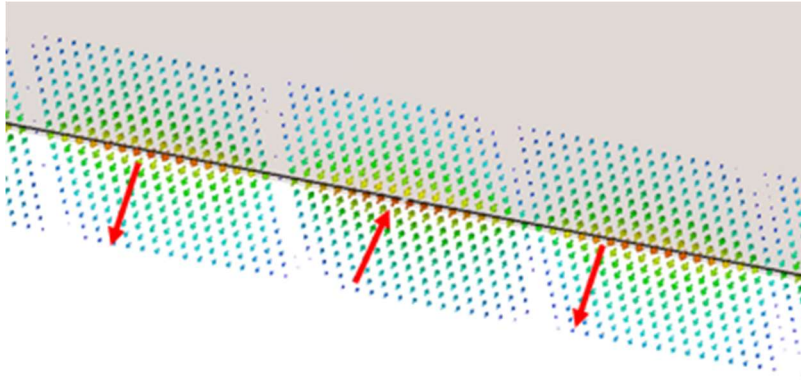
14. The magnitude and direction of the magnetic field produced by the wire is shown in the image below, which shows the magnetic field strength and direction in the plane perpendicular to a current-carrying conducting wire carrying a current directed out of the page. The arrows indicate the direction of the magnetic field follows the right-hand rule I explained above such that the magnetic field makes counterclockwise circles around the wire. The figure also shows that the

magnitude of the field is strongest (red arrows) closest to the wire and decreases with increasing distance from the conducting wire.



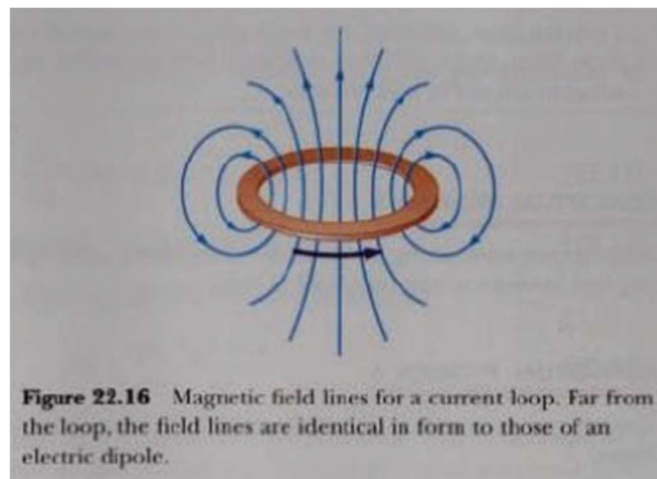
Magnetic Field Direction

15. As I explained above, the AC excitation signal produces a magnetic field that oscillates over time; in other words, the direction of the magnetic field at any given time alternates in direction along the wire. This means the magnetic field alternates between clockwise and counterclockwise around the wire. This is indicated in the image below, which shows the magnetic field below the wire alternates between out of the page and into the page as the direction of the current alternates.



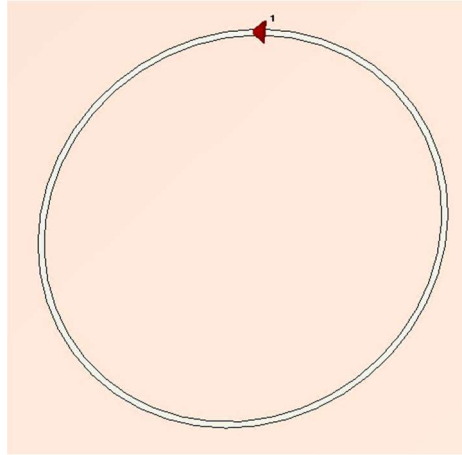
Magnetic Field Direction Near a Conducting Wire Carrying AC Current

16. The right-hand rule also allows us to determine the direction of the magnetic field produced by a circular current-carrying conducting loop. (INTEL-1003, ¶25.) Again, you would point your thumb in the direction of the current and curl your fingers around the wire. As with the long wire, the magnetic field forms loops around the circular wire, as shown in Serway's Figure 22.16:



Serway, Figure 22.16 (INTEL-1013, 650)

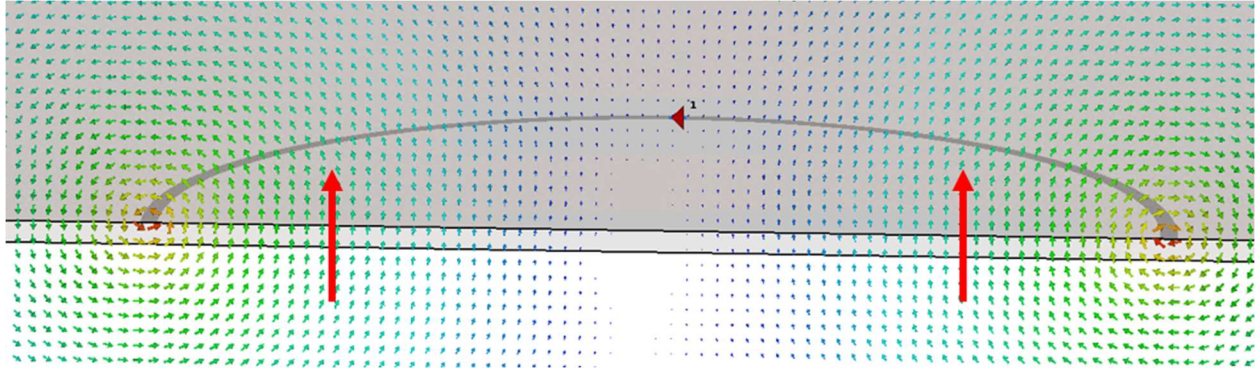
17. I performed a simulation of the magnetic field produced by a current-carrying conducting loop, like the one depicted in Serway's Figure 22.16, on a PCB substrate. The model for this is shown below.



Simulated Circular Current-Carrying Loop

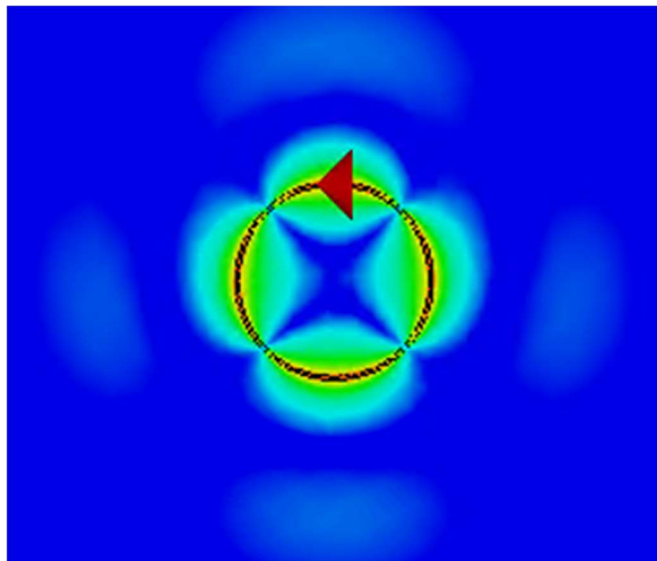
18. The magnitude and direction of the magnetic field in a plane perpendicular to and through the center of the loop is shown below. The magnetic field follows the right-hand rule as described above, so that current traveling in a direction into the page (on the right-hand side of the loop) produces a magnetic field that makes clockwise circles wire and current traveling out of the page (on the left-hand side of the loop) produces a magnetic field that makes counterclockwise circles around wire. Thus, the magnetic field points up in the region inside of the loop near the right and left hand edges of the loop (which I have indicated by large red arrows) and down in the regions outside of the loop. Again, because the excitation signal is AC, the magnetic field magnitude and direction oscillates over

time and alternates in direction along the wire. For this circular loop, the magnetic field points down in the region inside the loop near the front and back edges of the loop (outside of the plane shown in the image below).



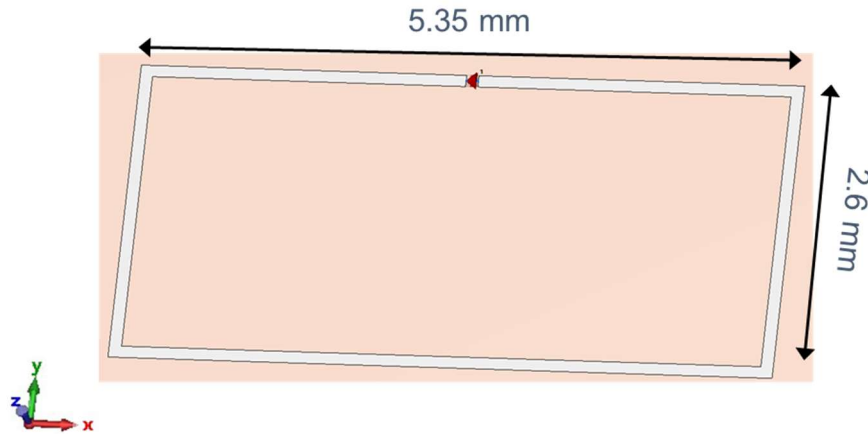
Magnetic Field Direction Near a Circular Current-Carrying Loop

19. The magnetic field strength near a circular conducting loop is shown below. Again, the magnetic field is strongest closest to the loop and decreases in magnitude with increasing distance.



Magnetic Field Strength Near a Circular Current-Carrying Loop

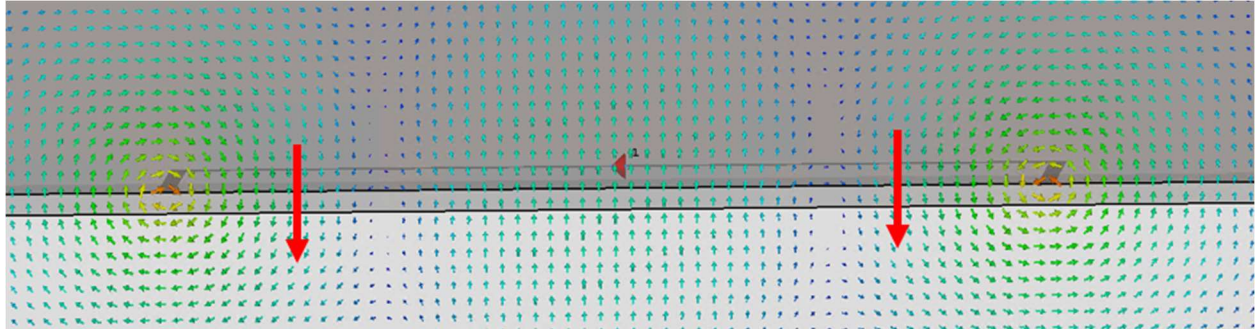
20. I performed a similar simulation on a rectangular-shaped current carrying conducting loop on a PCB substrate. The model for this is shown below:



Simulated Rectangular Current-Carrying Loop

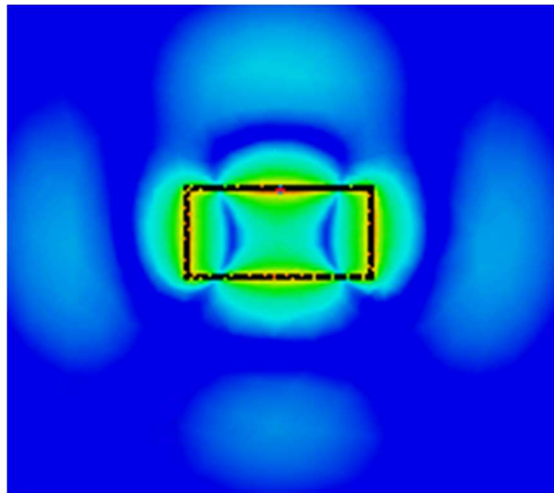
21. The image below shows the magnetic field direction produced by current flow in the rectangular loop. The view is from a plane perpendicular to the loop through the center of the short ends of the loop. Similar to the circular loop, the right-hand rule shows that for current flow into the page on the left-hand edge of the rectangular loop and out of the page on the right-hand edge of the loop, the magnetic field direction points down in the region inside the loop near the right-hand edge (which I have indicated with large red arrows) and up in the region outside of the loop. Again, because the excitation signal is AC, the magnetic field magnitude and direction oscillates over time and alternates in direction along the wire. For this rectangular loop, the magnetic field points down in the region inside

the loop near the front and back edges of the loop (outside of the plane shown in the image below).



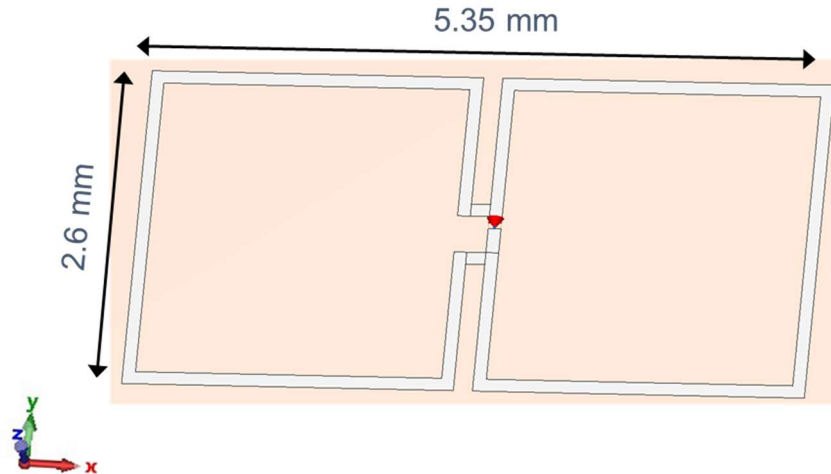
Magnetic Field Direction Near a Rectangular Current-Carrying Loop

22. The magnetic field strength near the rectangular conducting loop is shown below. Again, the magnetic field is strongest closest to the loop and decreases in magnitude with increasing distance.



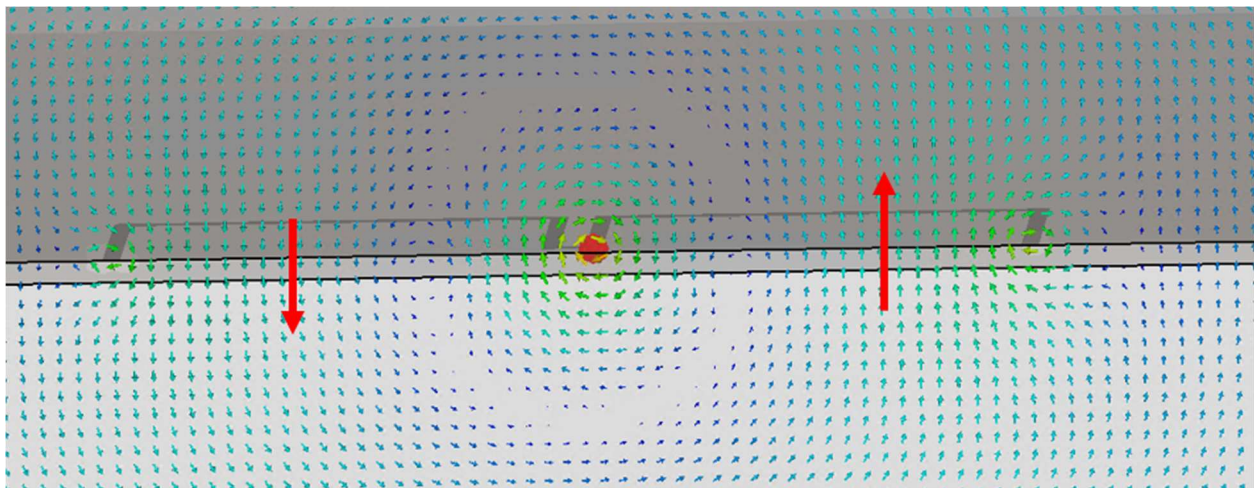
Magnetic Field Strength Near a Rectangular Current-Carrying Loop

23. Finally, I performed simulations for an eight-shaped current-carrying conductor on a PCB substrate. The model for this is shown below:



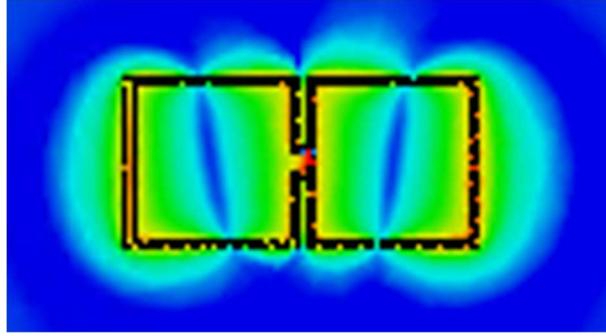
Simulated Eight-Shaped Current-Carrying Loop

24. Here, the right-hand rule can still be used to determine the direction of the magnetic field produced by each of the two loops in the figure-eight, but then the fields produced by each loop must be added together to determine the total magnetic field in each region. Again, the view in the image below is of a plane perpendicular to the figure-eight through the center of the short edges of each loop. In this simulation, current flows into the page in both the right-hand edge of the right-hand loop of the figure-eight and in the left-hand edge of the left-hand loop of the figure-eight. This results in the loops producing magnetic fields that are opposite in direction, up in the region inside the right-hand loop and down in the region inside the left-hand loop, as indicated by the large red arrows below. Again, because the excitation signal is AC, the magnetic field magnitude and direction oscillates over time and alternates in direction along the wire.



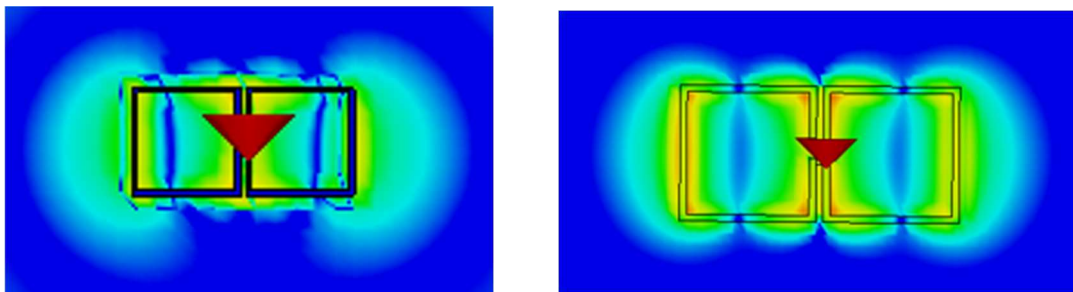
Magnetic Field Direction Near an Eight-Shaped Current-Carrying Loop

25. The simulation shows that the total magnetic field produced by the figure-eight shaped loop is of the greatest magnitude on either side of the central portion of the “eight” and in the vicinity of the right-most and left-most edges of the “eight.” The simulation further shows cancellation of the magnetic field in the regions shown in dark blue (zero field) due to the fact that the magnetic field produced by the upper loop is opposite the direction of the magnetic field produced by the lower loop in those regions. The net magnetic field due to both loops will be approximately zero at locations where the magnetic field produced by the upper loop is equal in magnitude and opposite in direction to that produced by the bottom loop.

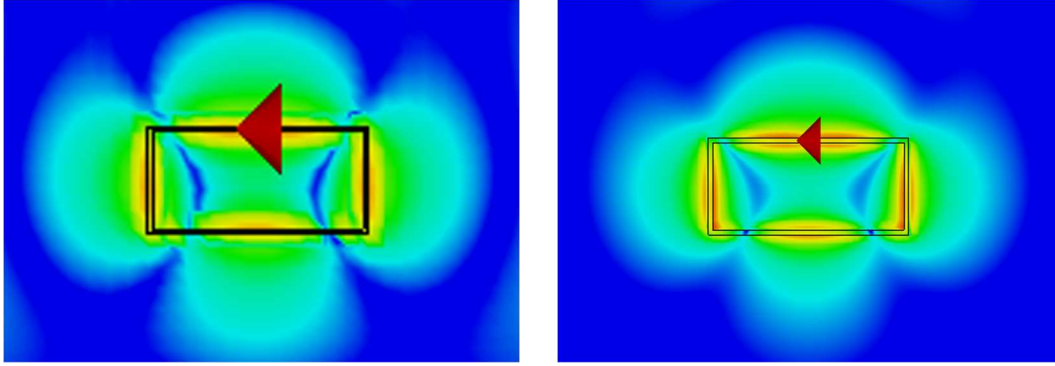


Magnetic Field Strength Near an Eight-Shaped Current-Carrying Loop

26. For the rectangular and eight-shaped inductor/antenna shapes, I performed simulations on both a PCB and silicon substrate. The results for relative strength and direction of the magnetic field produced for each shape were the same in both the PCB substrate and silicon substrate simulations, as shown below. This supports my conclusion that because the fundamental physics is the same, a POSITA would understand that the EM field direction and relative strength produced by antennas/inductors would be the same whether integrated on a PCB or IC. (*See infra* §III.B.)

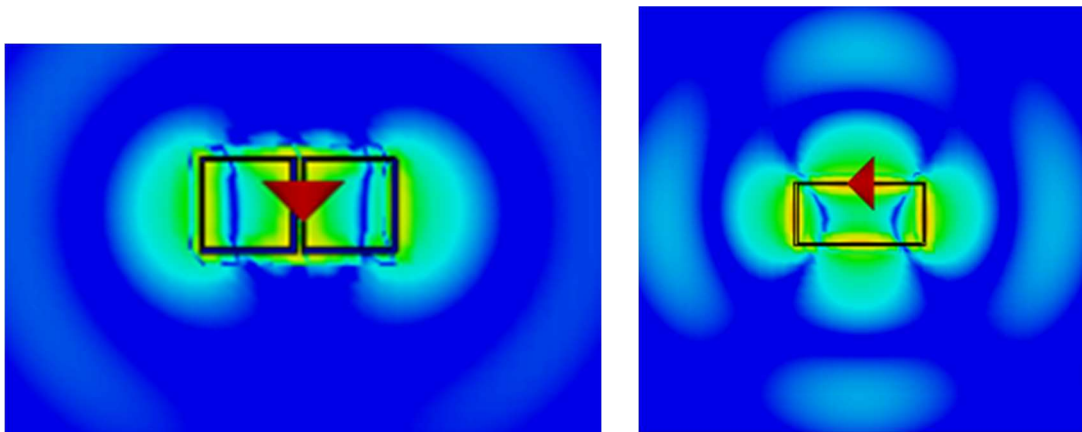


**Magnetic Field Produced by Eight-Shaped Conducting Loop
on PCB (left) and Silicon (right)**

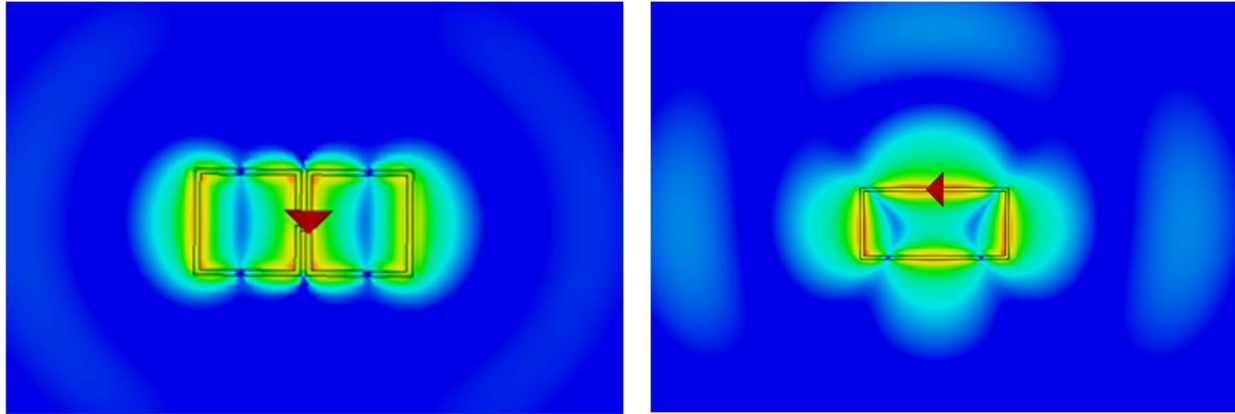


**Magnetic Field Produced by Rectangular Conducting Loop
on PCB (left) and Silicon (right)**

27. The simulations also show that the eight-shaped conducting loop has a substantially reduced field at locations outside of the conducting loop as compared to the rectangular conducting loop.

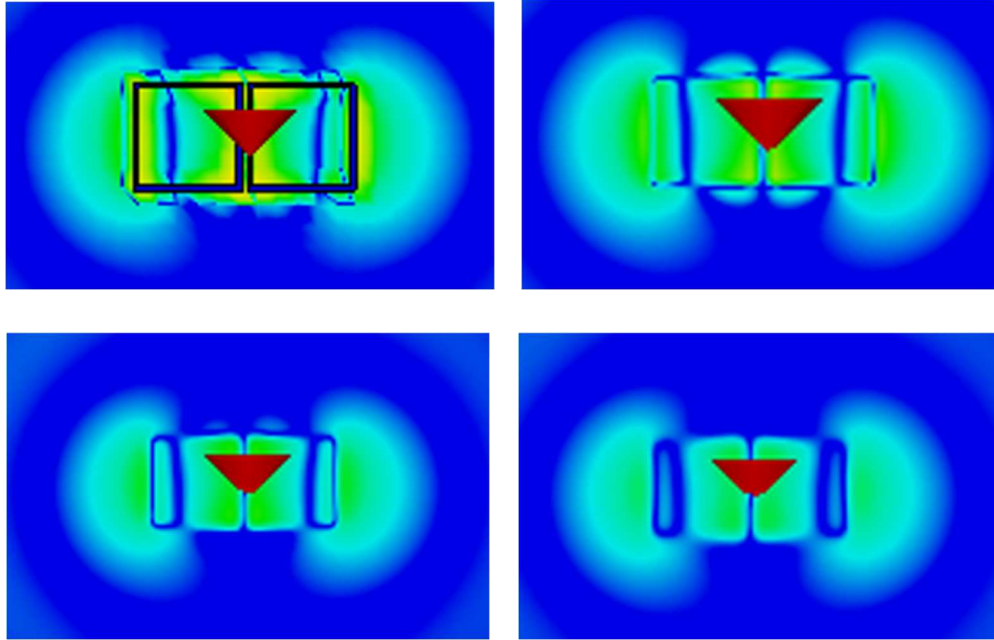


**Magnetic Field Produced by Conducting Loop on PCB
Eight-Shaped (left) vs. Rectangular (right)**



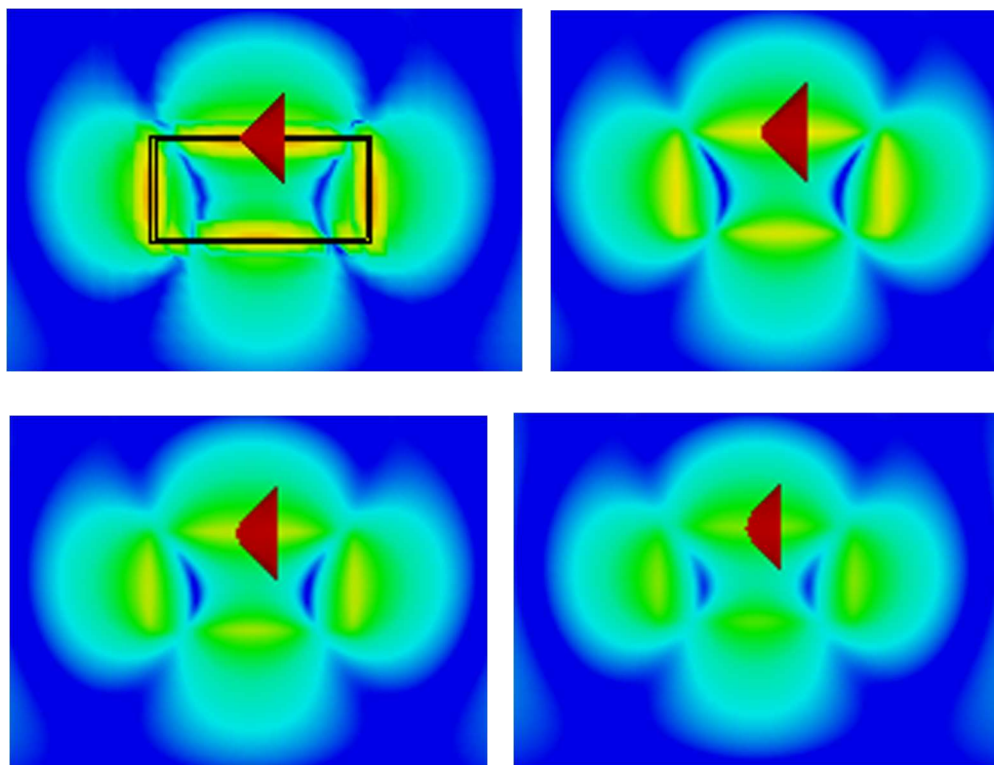
**Magnetic Field Produced by Conducting Loop on Silicon
Eight-Shaped (left) vs. Rectangular (right)**

28. I also simulated the magnetic field as a function of vertical distance above the eight-shaped conducting loops on a PCB substrate. Shown below is the field as measured in the plane of the eight-shaped conducting loop (left image) as compared with the field as measured a vertical distance equal to the thickness of a typical PCB substrate above the eight-shaped conducting loop as well as at distances of twice and three times the substrate thickness. As shown below, the EM field produced by the eight-shaped conducting loop drops off rapidly with increasing vertical distance.



**Magnetic Field Measured in Plane of 8-Shaped Loop (top left)
and Above Loop: 1X (top right), 2X (bottom left) and
3X (bottom right) Substrate Thickness**

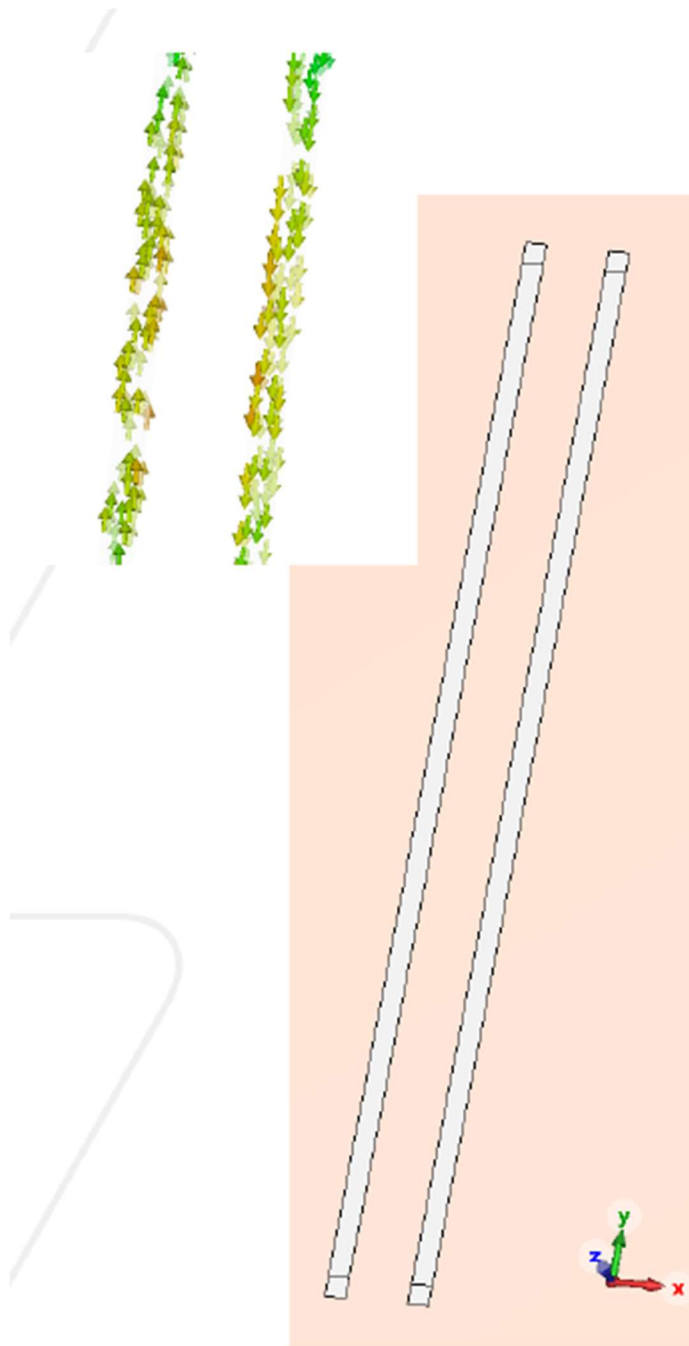
29. In contrast, the EM field produced by the rectangular conducting loop simulated on a PCB substrate does not show this rapid decrease in magnitude with increasing vertical distance.



Magnetic Field Measured in the Plane of the Rectangular Conducting Loop (left) and Above the Conducting Loop: 1X (top right), 2X (bottom left) and 3X (bottom right) Substrate Thickness

30. These simulations demonstrate that the eight-shaped antenna/inductor of Taniguchi and the '430 patent provides much better magnetic field containment than a rectangular shaped inductor, resulting in substantially reduced field at locations outside of the conducting loop, both laterally and vertically displaced from the conducting loop.

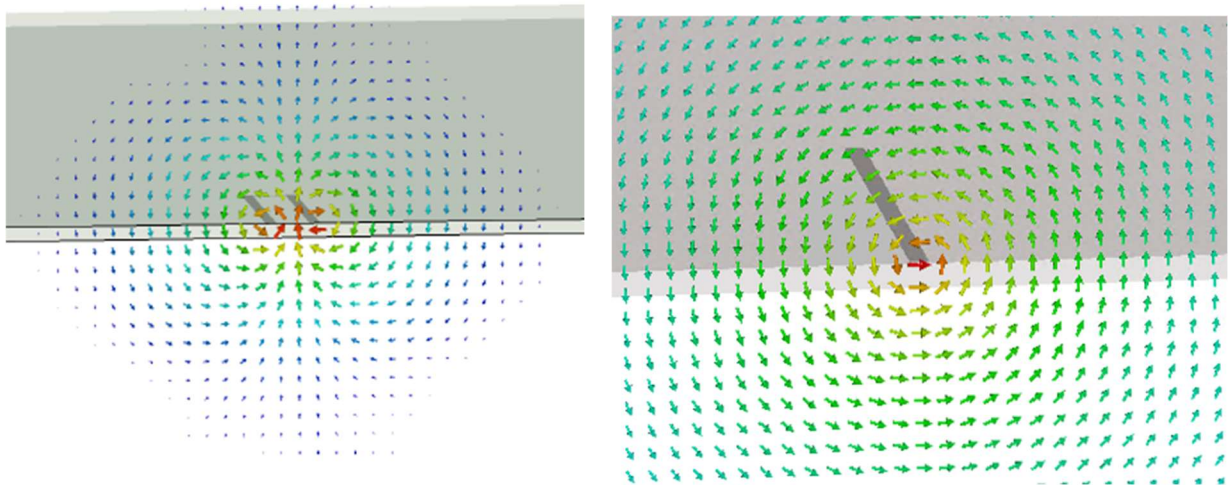
31. I also simulated the magnetic field produced by two closely spaced conducting wires carrying current in opposite directions on a PCB substrate. The model for this is shown below, where current is flowing up in the left-hand wire and down in the right-hand wire:



Simulated Pair of Closely-Spaced Current-Carrying Wires

32. As I explained above, the right-hand rule indicates that the magnetic field produced by a current-carrying wire makes circles around the wire. Here, the right-hand wire (current flowing down) makes counterclockwise circles around the

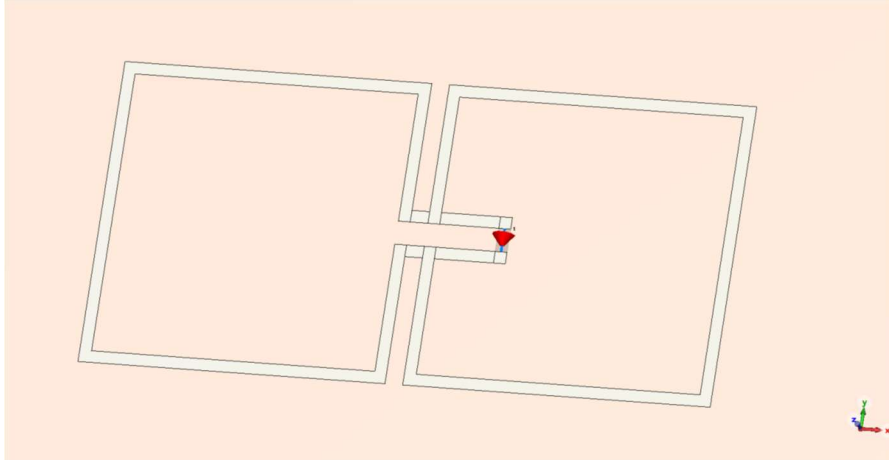
wire and the magnetic field produced by the left-hand wire (current flowing up) makes clockwise circles around the wire. Because the magnetic fields produced by the wires is opposite in direction, the net field produced by both closely-spaced wires cancels at locations away from the wires. This is shown in the image on the left below. The magnetic field produced by a single current-carrying conducting wire is reproduced on the right below for comparison.



Magnetic Field Produced by Pair of Wires (left) and Single Wire (right)

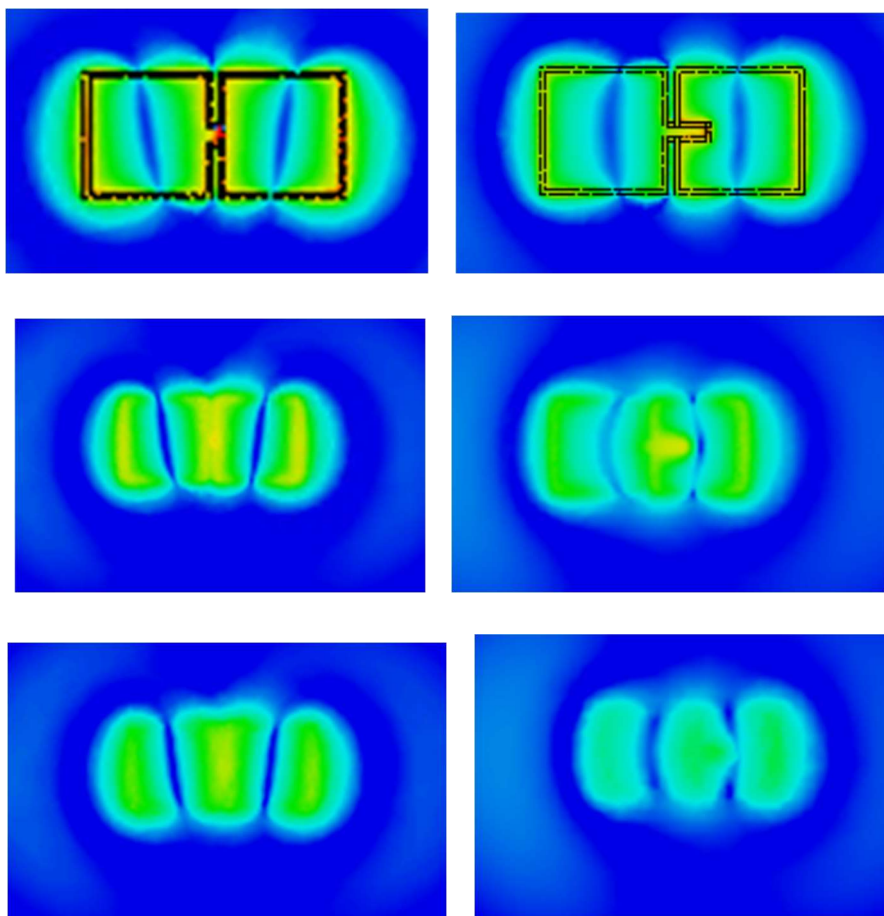
33. These figures show that the magnetic field strength away from the pair of closely-spaced wires is significantly smaller in magnitude as compared with that produced by the single wire due to this cancellation.

34. I also performed simulations for an eight-shaped current-carrying conductor with two closely spaced terminals. The model for this is shown below:



Simulated Eight-Shaped Current-Carrying Loop With Terminals

35. The magnetic field magnitude produced by the eight-shaped conducting loop with closely spaced terminals on a PCB substrate is shown in the images on the right below. The magnetic field of an eight-shaped conducting loop without terminals on a PCB substrate is reproduced in the images on the left for comparison. I simulated the magnetic field in the plane of the loop and at a distance of one and three times the thickness of a typical substrate above the plane of the loop.



Magnetic Field Measured in Plane of 8-Shaped Loop (top left) and Above Loop: 1X (middle left), and 3X (bottom left) Substrate Thickness (PCB)

36. These figures show that at locations away from the terminals, the magnetic fields produced by the two terminals cancel each other such that there is no meaningful contribution to the net magnetic field from the closely-spaced terminals.

III. Patent Owner’s Arguments

37. Patent Owner (“PO”) and its expert, Dr. Paul Prucnal, make a number of statements that are inconsistent with the understanding of a person of ordinary

skill in the art (“POSITA”) and with the teachings of the prior art. I address these statements below.

A. PO’s Argument that Antennas are not Inductors

38. As I explained in my First Declaration, loop antennas are inductors. (INTEL-1003, ¶¶85, 88-93.) In fact, as I explained at my deposition, current-carrying conductors produce magnetic fields and generate magnetic flux, and this is true whether the current-carrying conductor is labeled an “antenna” or an “inductor.” (EX2010, 9:12-15, 12:17-21; *see also* 12:22-13:1 (“magnetic flux is, in a sense, the fundamental feature of both the loop antennas and inductors”).)

39. References commonly relied on by persons skilled in the art confirm that there is no meaningful difference between an inductor and a loop antenna in terms of the underlying physical principles.

40. In my First Declaration, I provided several examples of loop antennas used in inductive coupling identification applications that are referred to or understood to be inductors. (INTEL-1003, ¶93.) One such example is U.S. Patent 5,345,231 to Koo, which uses an inductor as an antenna in a contactless data transmission that operates through the use of inductive coupling. (INTEL-1022, Fig. 1, 2:42-45, 2:54-59, 2:63-68, 5:47-6:2, 6:31-39, 7:7-9, claim 9.) Another example is U.S. Patent 6,533,178 to Gaul, which is also a contactless data

transmission system that uses a loop antenna as an inductor. (INTEL-1021, 1:14-26, 6:51-58, 7:39-40, Figs. 1, 2a.)

41. As a further example, the textbook “Antenna Theory,” by Constantine Balanis (second edition, 1997) is one of the most widely used references on antenna design. (INTEL-1045.) Balanis describes a loop antenna as a “very versatile antenna type” which can “take many different forms such as a rectangle, square, triangle, ellipse, circle, and many other configurations.” (INTEL-1045, 203.) Balanis explains that a small circular or square loop is the equivalent of a magnetic dipole and, therefore, “the fields radiated by an electrically small circular or square loop are of the same mathematical form as those radiated by an infinitesimal magnetic dipole.” (INTEL-1045, 203.) Electrically small simply means that the overall length of the antenna is less than about one-tenth of the operating wavelength. (INTEL-1045, 203.) Balanis further explains that “[a] small loop is primary inductive.” (INTEL-1045, 214.) A POSITA would understand from these disclosures that a loop antenna and an inductor of the same size and shape, and carrying the same current, are essentially the same and would produce identical EM fields.

42. Based on his deposition, Dr. Prucnal’s only substantive objections to the applicability of Taniguchi’s antenna teachings to the inductor layout of the ’430 patent appears to be (1) the relative size of the antennas/inductors; that is,

according to Dr. Prucnal, Taniguchi's disclosures are not applicable to the '430 patent's inductor layouts because Taniguchi's antennas are orders of magnitude larger (INTEL-1044, 110:7-18); and (2) rather than EM field cancellation, Taniguchi teaches production of a field at the location of the tags that is strong enough to couple with the tags (INTEL-1044, 110:19-111:1). I disagree on both points.

43. First, Dr. Prucnal agrees that antennas and inductors "have the same physics." (INTEL-1044, 110:15.) In fact, during his deposition, Dr. Prucnal at times referred to Taniguchi's antennas as "inductors" (INTEL-1044, 65:7-13) and the '430 patent's inductors as "antennas" (INTEL-1044, 108:12-15).

44. Second, Dr. Prucnal focuses on the size of Taniguchi's antennas/inductors relative to the size of an integrated circuit. (INTEL-1044, 110:13-14; EX2002, ¶¶22, 27.) But this is irrelevant—a POSITA had ample skill to scale Taniguchi's antennas/inductors for use in smaller form factor applications.

45. As of 2004, a POSITA would have been well aware of techniques for miniaturization of electronic components, including magnetic elements such as inductors. In fact, the demand for miniaturization of inductors was recognized at least as early as the late 1980s or early 1990s. (INTEL-1034, 6:21-24 (describing the present invention as providing LC-circuit sections that "contribute[] to the miniaturization of the electronic devices."); INTEL-1046, 4:3-25 (describing

invention as “a miniaturized electronic part including at least one inductor” and methods of making the electronic parts).)

46. Further, as I explained at my deposition, a POSITA would have known that antennas span frequency ranges all the way to MHz and GHz frequencies and, as discussed above, since the physical principles are the same regardless of frequency, all that is required to scale an antenna for use at different frequencies is to scale the dimensions of the antenna. (EX2010, 10:23-11:17.)

47. In other words, a POSITA would have had ample skill to scale Taniguchi’s antennas/inductors for use in smaller form factor applications, and would have known that the fundamental physics of the EM fields produced by those antennas/inductors would be the same.

48. Third, as Dr. Prucnal admitted during his deposition, the strong EM field at the location of the tags is produced not by antenna/inductor 1 alone, but by the combination of antenna/inductor 1 and antenna/inductor 2. (INTEL-1044, 85:20-86:2.)

B. PO’s Argument that a POSITA Would Not Look to Teachings from Inductors on PCBs in Designing Inductor Layouts on ICs

49. Dr. Prucnal states that Taniguchi does not expressly say that its teachings apply to semiconductors and that the ’430 patent does not expressly say that its teachings apply to PCBs. (EX2009, ¶38.) Dr. Prucnal makes similar statements about Rostoker (antennas on chips, EX2009, ¶24), Midya (inductors on

PCBs, EX2009, ¶27), Raghavan (inductors on ICs, EX2009, ¶33), and Brooks (circuit components on PCBs, EX2009, ¶36). To the extent Dr. Prucnal, in making these statements, is arguing that a POSITA would not have looked to the teachings of PCB art in designing inductor layouts for ICs (or vice versa), or that a POSITA would not have been motivated to combine PCB art (Taniguchi, Midya, or Brooks) with IC art (Rostoker or Raghavan), I disagree.

50. First, as of 2004, a POSITA had the skill and knowledge to integrate both antennas and inductors on both PCBs and ICs. Such applications are disclosed in a great many references, including the art cited in Intel's Petition and prior art cited by the applicant and examiner during prosecution of the '430 patent. *See* INTEL-1005 (antennas on PCBs); INTEL-1006 (antennas on ICs); INTEL-1007 (inductors on PCBs); INTEL-1008 (inductors on ICs); INTEL-1009 (inductors on ICs); EX2004 (inductors on ICs); EX2005 (inductors on ICs); EX2006 (inductors on ICs); EX2007 (inductors on PCBs); EX2008 (inductors on ICs); INTEL-1052 (inductors on PCBs).

51. As of 2004, a POSITA would have recognized the applicability of PCB design principles to IC design. This is at least in part because a POSITA would have known that the fundamental physics governing the EM fields produced by inductors and antennas is the same whether those antennas/inductors are integrated onto a PCB or an IC. This understanding is confirmed by the

simulations I described above that show that the magnetic field direction and relative strength produced by current-carrying conducting loops on PCBs and silicon substrates are the same. (*See supra* ¶26.)

52. Further, at least as early as the 1990s, researchers in the field of IC design recognized the relevance of PCB design to their work. For example, several papers by Rennselaer Polytechnic Institute Professor and IEEE Fellow Ronald J. Gutmann describe trends in IC design, predicting that Virtual Design Environment (VDE) software developed for PCB design would find application in designing ICs and systems-on-a-chip (SOCs) and that VDE would be a “key component” in a software tool set for IC design. (INTEL-1047, 667, 670.) Gutmann explained that the “anticipated IC design environment is similar to the PCB design environment, where selection of IP cores is analogous to selection of packaged IC’s and where chip design becomes analogous to PCB design.” (INTEL-1047, 670.) In a separate paper, Gutmann noted the current trends (in 1999) “establish[] a parallel between leading-edge PCB design and IC design.” (INTEL-1048, 164.)

53. Other references identified parallels between IC/SOC design and PCB design. One reference identified several core design techniques, including interfacing with on-chip buses. (INTEL-1049, 28.) The method of using standard on-chip buses was “[s]uccessfully used in the world of printed circuit board design,” and the “method is extendable to SOC designs.” (INTEL-1049, 28.) The

author describes similarities between PCB and SOC design, and identified model toolkits used in PCB design that “are equally important to the SOC designer.” (INTEL-1049, 28-29.)

54. These references, coupled with a POSITA’s understanding of miniaturization of circuit components, confirm that a POSITA in 2004 would have recognized the applicability of PCB design rules to ICs.

C. PO’s Argument Regarding Level of Ordinary Skill in the Art

55. I provided my opinion regarding the level of ordinary skill in the art in my First Declaration. (INTEL-1003, ¶58.) My opinion has not changed.

56. In his Supplemental Declaration, Dr. Prucnal provides a “refined” description of the level of ordinary skill in the art that he claims is consistent with my own opinion. I disagree. In my opinion, Dr. Prucnal’s description improperly limits the level of skill to require as an alternative to a master’s degree, “two years of experience designing integrated radiofrequency circuits and inductors for semiconductors.” (EX2009, ¶7.) This is not consistent with my description, which calls for “four years of experience in designing integrated circuits *or inductors*.” (INTEL-1003, ¶58 (emphasis added).)

57. Regardless of which definition the Board adopts, my opinions and analysis in my First Declaration and this Supplemental Declaration remain the same.

D. PO's Taniguchi Arguments

58. Dr. Prucnal argues that Taniguchi's antennas/inductors are not "positioned at a predetermined distance" from each other because they are spaced apart vertically rather than laterally spaced in the same plane. (EX2002, ¶¶51-52; EX2009, ¶20-21.) I disagree.

59. It is my opinion that a POSITA reading the '430 patent specification would not understand the claims to be so limited. I have reviewed the specification of the '430 patent, including the portions cited by Dr. Prucnal as support for his understanding of the meaning of "predetermined distance." (EX2002, ¶51.) First, the phrase "predetermined distance" does not appear anywhere in the specification. Second, a POSITA reading the portions of the specification Dr. Prucnal relies on would understand configurations to be a non-limiting set of exemplary configurations used for representative simulations. (EX2002, ¶51; *citing* INTEL-1001, Figs. 6, 8, 12, 6:60-61, 7:20-21, 9:3-5.) There is nothing in the specification that would indicate to a POSITA that the claimed invention is limited to inductors that are laterally spaced from one another in the same plane.

60. Dr. Prucnal also argues that a "POSITA would not have looked to Taniguchi's concentrically arranged antennas when positioning inductors on a semiconductor die." (EX2009, ¶50.) According to Dr. Prucnal, "[i]t would have been difficult, if not impossible, to make two inductors from different circuits at

different locations on the semiconductor chip concentric with one another.” (EX2009, ¶50.) I disagree. As of 2004, a POSITA would have been aware of planar concentric inductors for used on semiconductor chips. For example, U.S. Patent No. 7,671,714 to Tiemeijer describes a “planar inductive component” comprised of at least two “concentric inductor[s].” (INTEL-1050, Abstract, 2:62-64.)

61. In his Declarations, Dr. Prucnal made no attempt to describe or illustrate the magnetic field produced by an eight-shaped inductor and did not provide any analysis at all of the magnetic field in the vicinity of the eight-shaped inductors/antennas of Taniguchi and the ’430 patent. Nor did Dr. Prucnal do any simulations to assist in visualizing the fields. (INTEL-1044, 48:10-15.) At his deposition, he was unable to describe the magnetic field. (INTEL-1044, 44:22-45:22.) In my opinion, Dr. Prucnal’s conclusions about the fields produced by these eight-shaped inductors/antennas are incorrect.

62. For example, Dr. Prucnal argues that Taniguchi does not disclose a “reduced far field.” He states that “Taniguchi’s antenna’s magnetic field is not cancelled ... by having two identical but opposite fields superimposed in the far field.” (EX2009, ¶48.) Dr. Prucnal also states that “Taniguchi has no cancellation of the magnetic field whatsoever.” (EX2002, ¶60; EX2009, ¶48.) I disagree. As I explained in my First Declaration, eight-shaped antennas/inductors, such as those

in Taniguchi and the '430 patent, have a reduced far field because the two loops generate electromagnetic fields that are opposite in direction and equal in magnitude. (INTEL-1003, ¶¶95-97, 99.) Specifically, the magnetic field generated by Taniguchi's eight-shaped antenna/inductor cancels at locations away from the antenna/inductor (both laterally and vertically) because the current in the upper and lower loops flows in opposite directions and, therefore, produces magnetic fields that are opposite in direction. This is consistent with the simulations that I performed, as detailed above. (*Supra* ¶¶23-30.)

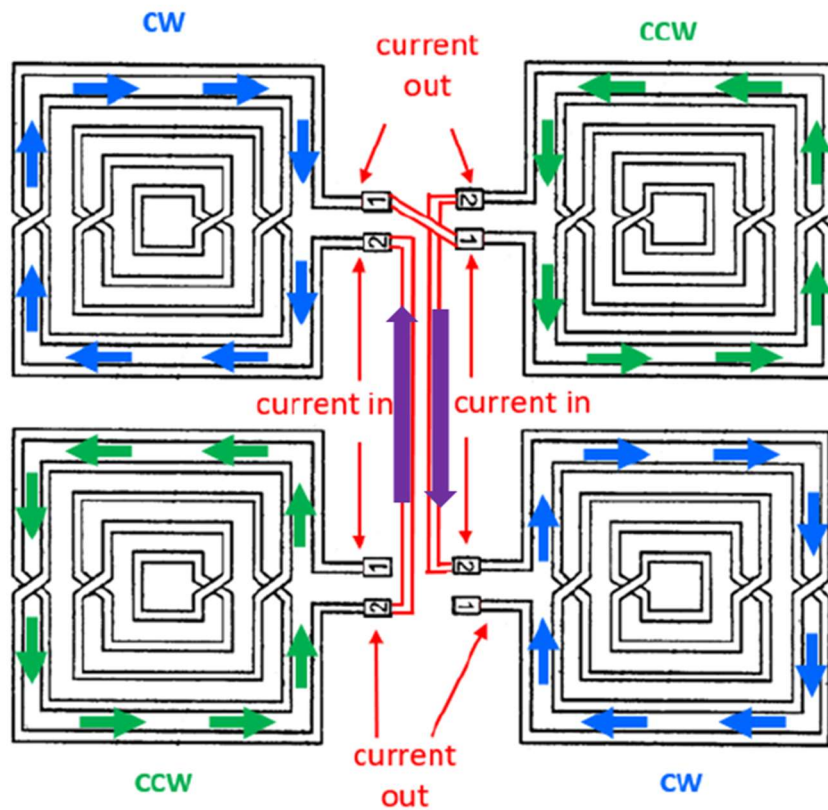
63. I have reviewed a declaration Dr. Prucnal submitted in previous litigation involving this patent in ITC Investigation 337-TA-1300. (INTEL-1051.) In my opinion, Dr. Prucnal's sworn testimony in the 1300 Investigation regarding the magnetic field cancellation produced by two conductors carrying equal and opposite current is consistent with my simulations and conclusions. For example, Dr. Prucnal explained that "if current is flowing in opposite directions in two different conductors, the magnetic fields from the conductors will also be in opposite directions and tend to cancel each other out at locations away from those two conductors." (INTEL-1051, ¶64.)

E. PO's Midya-Raghavan Arguments

64. Dr. Prucnal argues that the Midya-Raghavan combination does not teach the "closely spaced terminals" limitations because there is an "additional

loop” created by the interconnections between the inductors that generates an EM field that is not reduced or cancelled. (EX2002, ¶¶94; EX2009, ¶¶57.) I disagree.

65. In my opinion, the conducting structures required to connect the inductors in the Midya-Raghavan combination, shown in red in the annotated figure below, do not materially impact the reduced far field achieved using the four-loop inductor layout of the Midya-Raghavan combination. These interconnects carry equal current flowing in opposite directions. Therefore, EM fields produced by those interconnects will cancel each other, as discussed above and consistent with the disclosures of Brooks. (*Supra* ¶¶31-32; INTEL-1010, 157; *see also* INTEL-1044, 132:7-12.) This is shown in purple in the annotated figure below (current flows up in the left-hand interconnect and down in the right-hand interconnect):



Midya-Raghavan Combination

F. PO's Gardner Arguments

66. Dr. Prucnal argues that Gardner teaches away because Gardner's terminals are "spaced far apart." (EX2002, ¶¶106-107.) Dr. Prucnal further argues that the EM fields produced by Gardner's terminals do not cancel because those terminals are perpendicular to one another. (EX2009, ¶58.) In my opinion, Dr. Prucnal's arguments are irrelevant to the Midya-Raghavan-Gardner combination presented in Intel's Petition.

67. Specifically, Gardner is used in the combination only for the teaching to fabricate inductors on a semiconductor die (i.e., "fabricated on-chip"). (INTEL-

1003, ¶322; INTEL-1009, ¶¶5, 30, 108.) That is, Gardner’s inductor is not itself used in the combination. In my opinion, a POSITA would have understood Gardner’s disclosures related to fabricating inductors on-chip to be generally applicable to inductor design on semiconductor dies (or ICs) and not limited solely to the specific inductor disclosed in Gardner. (INTEL-1009, ¶[0003] (“The present invention relates generally to the field of electrical inductors. More particularly, the present invention relates to the field of electrical inductors for integrated circuits (ICs) and IC packages.”))

G. PO’s Brooks Arguments

68. Dr. Prucnal argues that a POSITA would not have been motivated to combine Brooks with Taniguchi or Midya-Raghavan-Gardner because at high frequencies, using RF transceivers on a semiconductor die results in “problems with noise, capacitance, and complexity of the conductive traces, such as capacitive crosstalk between the interconnect lines.” (EX2002, ¶¶82, 111.) I disagree.

69. First, Dr. Prucnal does not provide any specifics about these alleged “problems.” Nor does he explain why the potential for noise or capacitive crosstalk would dissuade a POSITA from combining these references. (EX2002, ¶82.)

70. Second, the portion of Brooks Dr. Prucnal points to is not relevant to the terminals in the antennas/inductors of the combinations presented in the

Petition. This disclosure from Brooks relates to conductive traces that are not connected. (INTEL-1010, 222.) Thus, these conductive traces carry different signals. This is not the case with Taniguchi's and Midya-Raghavan's terminals, which are connected as part of the same wire or conductive trace and therefore carry the same signal in opposite directions.

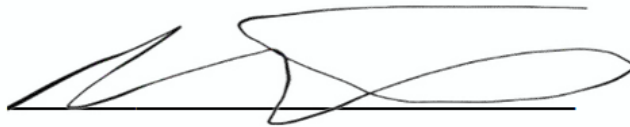
IV. Conclusion

71. In signing this declaration, I recognize that the declaration will be filed as evidence in a contested case before the Patent Trial and Appeal Board of the United States Patent and Trademark Office. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

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

Executed this 15th day of April in Atlanta, Georgia

Respectfully submitted,

A handwritten signature in black ink, consisting of a series of loops and a long horizontal stroke, positioned above a solid horizontal line.

Manos M. Tentzeris, Ph.D.

EXHIBIT LIST

Petitioner's Exhibits

Exhibit	Reference
1001	U.S. Patent 7,151,430 to Mattsson
1002	File History for U.S. Patent 7,151,430
1003	Declaration of Dr. Manos Tentzeris in Support of Petition
1004	CV of Dr. Manos Tentzeris
1005	U.S. Patent Publication 2003/0063034 to Taniguchi, et al (“Taniguchi”)
1006	U.S. Patent 6,373,447 to Rostoker, et al (“Rostoker”)
1007	PCT Publication WO 98/05048 to Midya, et al (“Midya”)
1008	U.S. Patent Publication 2005/0077992 to Raghavan, et al (“Raghavan”)
1009	U.S. Patent Publication 2001/0030591 to Gardner (“Gardner”)
1010	“Signal Integrity Issues and Printed Circuit Board Design,” to Brooks (“Brooks”)
1011	Declaration of June Ann Munford
1012	“RFID Handbook: Fundamentals and Applications in Contactless Smart Cards and Identification” to Finkenzeller (Wiley, Second Edition)
1013	“Principles of Physics,” to Serway, 2nd Edition (“Serway”)
1014	“Fundamentals of Applied Electromagnetics” to Ulaby (“Ulaby”)
1015	Certified Translation of Excerpts from prosecution of JP2007526642
1016	Excerpts from the EP prosecution of EP3567614

Exhibit	Reference
1017	PCT Publication WO 2004/012213 to Einzinger (“Einzinger-US”)
1018	U.S. Patent 6,708,880 to Acher, et al (“US-Acher”)
1019	ITC-337-TA-1376 Claim Construction Order
1020	ITC-337-TA-1300 Claim Construction Order
1021	U.S. Patent 6,533,189 to Gaul (“Gaul”)
1022	U.S. Patent 5,345,231 to Koo (“Koo”)
1023	U.S. Patent 6,137,447 to Saitoh, et al (“Saitoh”)
1024	U.S. Patent 6,320,491 to Gevorgian, et al (“Gevorgian”)
1025	U.S. Patent 7,088,964 to O (“O”)
1026	U.S. Patent Publication 2002/0044058 to Heinrich, et al (“Heinrich”)
1027	U.S. Patent 6,970,088 to Kovach (“Kovach”)
1028	U.S. Patent 4,724,427 to Carroll (“Carroll”)
1029	U.S. Patent 7,057,514 to Mickle (“Mickle”)
1030	“A Comprehensive Explanation On the High Quality Characteristics of Symmetrical Octagonal Spiral Inductor” to Ooi, et al (“Ooi”)
1031	“Design and Analysis of Symmetric Dual-Layer Spiral Inductors for RF Integrated Circuits” to Lee, et al (“Lee”)
1032	“A Q-Factor Enhancement Technique for MMIC Inductors” to Danesh, et al (“Danesh”)
1033	PCT Publication WO 99/49513 to Zhou, et al. (“Zhou”)
1034	U.S. Patent 5,583,474 to Mizoguchi (“Mizoguchi”)

Exhibit	Reference
1035	Reserved
1036	“A Single-Chip 900-MHz Spread-Spectrum Wireless Transceiver in 1-up CMOS – Part 1: Architecture and Transmitter Design” by Ahmadsreza Rofougaran et al. , IEEE Journal of Solid-State Circuits, Vol. 33, No. 4 (April 1998)
1037	“A Single-Chip CMOS Transceiver for DCS-1800 Wireless Communication” by Michiel Steyaert, et al. ISSCC98, Session 3, Transceiver and Power Amplifiers (1998)
1038	“A 1.8-GHz Low-Phase-Noise CMOS VCO Using Optimized Hollow Spiral Inductors” by Craninckx, et al. (“Craninckx”)
1039	“Low-Phase-Noise LC Quadrature VCO Using Coupled Tank Resonators in a Ring Structure” by ElSayed, et al. (“ElSayed”)
1040	“A CMOS Frequency Synthesizer with an Injection-Locked Frequency Divider for a 5-GHz Wireless LAN Receiver” to Rategh, et al. (“Rategh”)
1041	“Illustrated Dictionary of Electronics” to Gibilisco, Eighth Edition
1042	“Class Definition for Class 343 Communications: Radio Wave Antennas,” U.S. Patent & Trademark Office (2001), https://web.archive.org/web/20011123183942/http://www.uspto.gov/web/patents/classification/uspc343/defs343.htm
1043	Supplemental Declaration of Dr. Manos Tentzeris
1044	Deposition Transcript of Dr. Paul Prucnal
1045	“Antenna Theory” by Constantine Balanis (2 nd Ed. 1997)
1046	U.S. Patent 5,070,317 to Bhagat (“Bhagat”)
1047	“Advanced Silicon IC Interconnect Technology and Design: Present Trends and RF Wireless Implications” by Ronald J. Gutmann, IEEE Transactions on Microwave Theory and Techniques, Vol. 47, No. 6 (June 1999)

Exhibit	Reference
1048	“Interconnect Technology and Design Implications for Future ASIC and System-on-a-Chip (SOC) Implementations” by Ronald J. Gutmann et al., 10 th Annual IEEE/SEMI Advanced Semiconductor Manufacturing Conference, ASMC 99 Proceedings (Cat. No.99CH36295) (1999)
1049	“Core Design and System-on-a-Chip Integration” by Ann Marie Rincon, et al., IEEE Design and Test of Computers (October-December 1997)
1050	WO 03/015110 to Tiemeijer (“Tiemeijer”)
1051	Prucnal Ex. 1, ITC-337-TA-1300, CXM-0035, Declaration of Paul R. Prucnal, Ph.D. in Support of Complainant’s Claim Construction Brief
1052	U.S. Patent Publication 2003/0186674 to Keeney (“Keeney”)

Patent Owner's Exhibits

Exhibit	Reference
2001	Statutory Disclaimer of claims 20 & 21 of U.S. Patent 7,151,430
2002	Declaration of Dr. Paul Prucnal In Support of Patent Owner Preliminary Response
2003	US 6,512,422 Dufour
2004	US 6,664,606 Estes
2005	US 6,891,444 Jacobson
2006	US 6,894,598 Heima
2007	WO 2003/084295 Bhailis
2008	US 6,194,987 Zhou
2009	Supplemental Declaration of Dr. Paul Prucnal, Ph.D.
2010	Dr. Tentzeris Deposition Transcript