IN THE UNITED STATES PATENT AND TRADEMARK OFFICE BEFORE THE PATENT TRIAL AND APPEAL BOARD

In re U.S. Patent No. 7,936,245

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Inventors: Kai-Yi Huang, Yuh-Sheng Jean, Ta-Hsun Yeh

Assignee: Realtek Semiconductor Corp.

Title: Stacked Structure of a Spiral Inductor

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I, Paul R. Prucnal, make this declaration in connection with the petition for *inter partes* review submitted by Petitioner for U.S. Patent No. 7,936,245. All statements made herein of my own knowledge are true, and all statements made herein based on information and belief are believed to be true. Although I am being compensated for my time in preparing this declaration, the opinions expressed herein are my own, and I have no stake in the outcome of this proceeding or any related litigation or administrative proceedings.

TABLE OF CONTENTS

I. INTRODUCTION....3
II. QUALIFICATIONS AND COMPENSATION....5
III. RELEVANT LEGAL STANDARDS....12
A. Obviousness....12
B. Construing the Meaning of Claim Terms....15
IV. BACKGROUND OF THE TECHNOLOGY....16
A. Inductor Basics....16
B. How Inductance is Measured....19
C. General Uses for Inductors....21
D. Single-Ended versus Differential Inductors....23
E. The meaning of Q-factor....25
F. Inductors in Integrated Circuits....26
G. Single Layer vs. Multi-Layer inductors....27
H. Use of Vias to connect Metal Layers....34
I. Shape of Inductors and Symmetry....37
J. Serial (in series) versus Shunt (in parallel) windings....41
V. THE '245 PATENT....49
A. Background....49
B. Prosecution History....53
C. Overview of the Challenged Claims....53
VI. CLAIM CONSTRUCTION....56
A. "shunt winding"....56
VII. GROUND 1: OBVIOUSNESS BASED ON HO-HSIANG....61
VIII. GROUND 2: OBVIOUSNESS BASED ON CHRISTENSEN....111
IX. GROUND 3: OBVIOUSNESS BASED ON YANG....162
X. JURAT....214

I. INTRODUCTION

1. I am making this declaration at the request of Advanced Micro Devices, Inc. ("AMD") in the matter of the Inter Partes Review of U.S. Patent No. 7,936,245 ("the '245 Patent") to Huang et al, assigned to Realtek Semiconductor Corp. ("Patent Owner"). I understand that AMD has been sued by Patent Owner in Certain Integrated Circuits, Components thereof, and Products Containing the Same; ITC Inv. No. 337-TA-1350 (DN 3659) where it is has accused AMD of infringing the '245 Patent as well as U.S. Patent Nos. 8,006,218 ("the '218 Patent") and 9,590,582 ("the '582 Patent") (collectively, the "Asserted Patents").

2. In preparing my declaration, I have reviewed the following documents.

Exhibit No.	Description
1001	U.S. Patent No. 7,936,245
1002	File History of U.S. Patent No. 7,936,245
1003	Declaration of Dr. Paul R. Prucnal
1004	*Curriculum Vitae* of Dr. Paul R. Prucnal
1005	U.S. Patent No. 7,821,372 to Ho-Hsiang
1006	U.S. Patent No. 6,794,977 to Christensen
1007	U.S. Patent Application Publication No. 2009/0002114 A1 to Yang et al.
1008	Sadasiva Biswal, Basic Electronics Volume I, 45, (2001)
1009	A. Niknejad, Design, Simulation and Applications of Inductors and Transformers for Si RF ICs, Second Printing. (2002)
1010	A. Niknejad, Electromagnetics for High-Speed Analog and Digital Communication Circuits, (2008)
1011	J. Burghartz, *Spiral Inductors on Silicon – Status and Trends (Invited Article)*, International Journal of RF and

Exhibit No.	Description
	Microwave Computer-Aided Engineering, V. 8, No. 6, 422-432 (Nov. 1998)
1012	O.H. Murphy et al., *Design of Multiple-Metal Stacked Inductors Incorporating an Extended Physical Model*, IEEE Transactions on Microwave Theory and Techniques, Vol. 53, No. 6, 2063-2072 (June 2005)
1013	U.S. Patent No. 6,759,937 to Kyriazidou
1014	U.S. Patent No. 6,967,555 to Kao
1015	U.S. Patent No. 8,325,001 to Huang
1016	I. Bahl, Lumped Elements for RF and Microwave Cicuits, Artech House (2003)
1017	U.S. Patent No. 6,885,275 to Chang
1018	U.S. Patent Application Publication No. US 2008/0074229 A1 to Moinian
1019	Not Reviewed
1020	*Webster's New World College Dictionary,* Fourth Edition, 2009 (excerpt)
1021	*Encyclopedia of Electronics,* 2d (McGraw-Hill 1990) (excerpt)
1022	Realtek Exhibit 30 to Complaint, ITC Inv. No. 337-TA-1350
1023	7,936,245 Priority Application and Feb. 24, 2023 Transperfect Certified Translation
1024	D. Brooks, *Differential Signals Rules to Live By*, Printed Circuit Design, CMP Media Publication (Oct. 2001)
1025	M. Soyuer, Multilevel monolithic inductors in silicon technology, Electronics Letters Vol. 31 No. 5 (1995)
1026	Not Reviewed
1027	Not Reviewed
1028	Not Reviewed
1029	Burghartz, *On the Design of RF Spiral Inductors on Silicon (Invited Paper)*, IEEE Transactions on Electron Devices, V. 50, No. 3 (Mar. 2003)
1030	R. Lutz, M*odeling and Analysis of Multilevel Spiral Inductors for RFICS*, IEEE MTT-S Int'l Microwave Symposium Digest V. 1 (Jun. 1999)
1031	Not Reviewed
1032	Not Reviewed

3. In forming my opinions expressed below, I have considered the documents listed immediately above and my knowledge and experience based on my work and education in this area as described below.

4. The ’245 Patent issued from U.S. Patent Application Serial No. 12/773,024, filed May 4, 2010. The earliest application it claims priority to is a Taiwanese patent application filed on May 19, 2009. It is my opinion that, as of May 19, 2009, a person of ordinary skill in the art (“POSITA”) pertinent to the subject matter of the ’245 Patent would have had at least a bachelor’s degree in electrical engineering or an equivalent field, and at least 3-4 years of professional experience in the field of integrated circuit design. Further, it is my opinion that someone with additional education but less professional experience, and vice versa, may qualify as a POSITA. For instance, a POSITA would also include someone with a master’s degree in electrical engineering and 1-2 years of professional experience in the field of integrated circuit design or someone with a Ph.D. in electrical engineering. My analysis and opinions below are given from the perspective of a POSITA in this technological field in the relevant time frame, unless stated otherwise.

II. QUALIFICATIONS AND COMPENSATION

5. I am currently a professor of Electrical and Computer Engineering at Princeton University in the School of Engineering and Applied Science.

6. I received my undergraduate education at Bowdoin College, where I graduated summa cum laude in 1974 with an A.B. in Mathematics and Physics. I then graduated from Columbia University in 1976 with an M.S. in Electrical Engineering. I went on to receive an M.Phil. from Columbia in 1978 in Electrical Engineering and a Ph.D. from Columbia in 1979 in Electrical Engineering.

7. Upon receiving my Ph.D. in 1979, I joined Columbia University as an Assistant Professor of Electrical Engineering and in 1984 I was promoted to Associate Professor.

8. In 1988, I joined the faculty of Princeton University as an Associate Professor of Electrical Engineering. My responsibilities there included teaching and research. During that time, I was also the founding director of the New Jersey Advanced Technology Center for Photonics and Optoelectronic Materials. My responsibilities there included leading a $10 million research program involving approximately thirty faculty members.

9. In 1990, I was promoted to the position of full Professor of Electrical Engineering at Princeton University. My teaching responsibilities have included courses in electronic circuits, signal processing, photonics, and communications. My broad research interests at Princeton have included wireless communications, fiber-optic communications networks, computer interconnects, and network

security. I also direct the Lightwave Communications Research Laboratory at Princeton University, through which much of my present research is conducted.

10. While at Princeton University, I received several awards and recognitions, including: (a) becoming a Fellow of the Institute for Electrical and Electronics Engineers (IEEE); (b) becoming a Fellow of the Optical Society of America (OSA); (c) receiving the Rudolf Kingslake Medal and Prize from the Society of Photo-Optical Instrumentation Engineers (SPIE) for the most noteworthy original paper in Optical Engineering; (d) receiving the Gold Medal Award from the Faculty of Mathematics, Physics, and Informatics at the Comenius University for leadership in the field of Optics; (e) receiving the Princeton University Graduate Mentoring Award; (f) receiving numerous Engineering Council Teaching Awards; (g) receiving the Walter Curtis Johnson Prize for Excellence in Teaching; (h) receiving the Princeton School of Engineering and Applied Science Distinguished Teacher Award; (i) receiving the 2015 President's Award for Distinguished Teaching at Princeton; (j) being elected to the National Academy of Inventors (2018). My election to the National Academy of Inventors cited my work on advanced wireless interference-cancellation technology.

11. I am the author of two books, "Optical Code Division Multiple Access: Fundamentals and Applications" (2005), and "Neuromorphic Photonics" (2018), and co-author or contributor to approximately 33 additional book chapters,

as well as over 300 peer-reviewed publications in peer-reviewed journals, and 365 conference proceedings.

12. In addition to the activities, education, and professional experience listed above, I have been involved in numerous research projects that contribute to my expertise relating to this report. My responsibilities in these projects have included, among other things, interference cancellation techniques for radio-frequency communications, simultaneous transmit-and-receive techniques for cellular radios, anti-jamming systems for radio communications and spread spectrum communications. Specifics on a few of these research projects are provided below.

13. In 1982, I worked for Optical Information Systems, Inc. on a project that involved transceiver design for fiber optic communications. My responsibilities included the design of transmitters and receivers for high-speed communication.

14. From 1983-1984, I worked for GTE Labs on a project that involved performance analysis of fiber optic communication systems. My responsibilities included the investigation of high-performance modulation formats for communications.

15. From 1985-1986, I worked for AT&T Bell Laboratories on a project that involved research on multiple access techniques. My responsibilities included investigating time-division multiplexing for fiber optic networks.

16. In 1987-1988, I worked for IBM on a project that involved research on multiple access techniques for local area networks.

17. From 1987-1989, I worked for Dove Electronics on a project that involved research on communication switching technology and architectures. My responsibilities included the design and analysis of packet switching architectures.

18. From 1992-1995, I worked for Siemens Corporate Research on a project that involved research on switching technology. My responsibilities included the investigation of technologies for high-speed multiplexing and switching networks.

19. From 1996 - present I have worked for the Institute for Defense Analyses on projects related to national security involving communications and computing.

20. From 1998-2000, I worked on a project for Ultrafast Optical Systems performing testing and measurement on optoelectronic transceivers.

21. From 1999-2000, I worked for SAIC on a project that involved research on communication network architectures. My responsibilities included

the investigation of novel switching and multiplexing techniques for high-speed communication networks.

22. From 1999-2002, I worked for Multi Link Technologies, Inc. on a project that involved communication transceiver design.

23. From 2000-2002, I worked for Ultra-Fast Optical Systems on a project that involved research and development on regenerators for communication systems.

24. From 2000 - present, I have been a member of the advisory board on network technology for Alphion, Inc.

25. From 2003-2006, I worked for Kailight Inc. on a project that involved research and development on switching technology. My responsibilities included the design and testing of digital repeater for communication networks.

26. From 2006-2008, I led a DARPA funded project developing an add drop multiplexer for self-healing ring networks.

27. From 2004-2011, I worked for NEC Laboratories on a project that involved research on physical layer security in communication networks. My responsibilities included the design and analysis of techniques for steganography and data encryption.

28. I am also a named inventor on at least 27 issued U.S. patents, and at least 5 additional U.S. patent applications.

29. I have extensive experience in the electrical engineering field throughout my career. In particular, during the past 10 years I have taught several undergraduate and graduate courses at Princeton on communications, such as "Photonics and Lightwave Communications," which covers optical and radio-frequency analog and digital communications systems; "Electronic Circuit Design," which covers circuits, including their design and implementation; and "An Introduction to Engineering," which covers general electrical engineering principles. I am also involved with independent research projects involving senior thesis work in a variety of electrical engineering disciplines.

30. My research has been supported by research contracts and grants from the National Science Foundation (NSF), the U.S. Army Communication Electronics Command, the Defense Advanced Research Projects Agency (DARPA), the U.S. Navy, the National Security Agency, and L3 Telemetry East.

31. I have extensive experience consulting for the communications industry, including AT&T Bell Laboratories, NEC Labs, the Institute for Defense Analyses, and Alphion, Inc.

32. I have been a technical advisor to several startup companies in the telecommunications industry. Based on my patents, Kalight Photonics developed communication repeaters, before being acquired by a publicly traded company. Another company, in conjunction with L3 Telemetry East, developed an anti-

jamming system for the Army that helps defend against IEDs. This work is also based on my patents.

33. Unless otherwise noted, the statements made herein are based on my personal knowledge, experience, and education. If called to testify about this Declaration, I could and would do so competently and truthfully. I reserve the right to amend and/or supplement my opinions to the extent that new information becomes available.

34. I believe I am qualified to serve as a technical expert in this proceeding based upon my educational and work experience. A copy of my current *curriculum vitae* is provided as Exhibit 1004. A list of cases in which I have testified as an expert in deposition or trial is also included with Exhibit 1004.

35. I am being compensated at the rate of $750 per hour for the time I spend on this matter. I do not have any financial or other interest in this proceeding itself, or in any other proceeding involving the '245 patent or any related patents. My compensation is not dependent on the substance of my statements in this Declaration. I am over the age of 18 and am competent to write this Declaration.

III. RELEVANT LEGAL STANDARDS

A. Obviousness

36. I understand that obviousness is analyzed from the perspective of a POSITA at the time of the alleged invention. I also understand that a POSITA is

presumed to have been aware of all pertinent prior art at the time of the alleged invention.

37. I understand that an obviousness analysis involves comparing a claim to the prior art to determine whether the claimed invention would have been obvious to a POSITA in view of the prior art and in light of the general knowledge of the art at the time the invention was made. I also understand that the invention may be deemed obvious when a POSITA would have reached the claimed invention through routine experimentation.

38. I understand that obviousness can be established by combining or modifying the disclosures of the prior art to achieve the claimed invention. It is also my understanding that where there is a reason to modify or combine the prior art to achieve the claimed invention, there must also be a reasonable expectation of success in so doing to render the claimed invention obvious. I understand that the reason to combine prior art references can come from a variety of sources, not just the prior art itself or the specific problem the patentee was trying to solve. I also understand that the references themselves need not provide a specific hint or suggestion of the alteration needed to arrive at the claimed invention; the analysis may include recourse to logic, judgment, and common sense available to a POSITA.

39. I understand that when there is some recognized reason to solve a problem, and there are a finite number of identified, predictable solutions, a POSITA has good reason to pursue the known options within his or her technical grasp. If such an approach leads to the anticipated success, it is likely the product not of innovation but of ordinary skill and common sense. In such a circumstance, when a patent simply arranges old elements with each performing the same function it had been known to perform and yields no more than one would expect from such an arrangement, the combination is obvious.

40. I understand that when considering the obviousness of an invention, one should also consider whether there are any objective indicia that support the non-obviousness of the invention. I further understand that objective indicia of non-obviousness, also known as "secondary considerations," include failure of others, copying, unexpected results, information that "teaches away" from the claimed subject matter, perception in the industry, commercial success, and long felt but unmet need. I also understand that for objective indicia of non-obviousness to be applicable, the indicia must have some sort of nexus to the subject matter in the claim that was not known in the art. I understand that this nexus includes a factual connection between the patentable subject matter of the claim and the objective indicia alleged. I also understand that an independently made invention

that is made within a comparatively short period is evidence that the claimed invention was the product of ordinary skill.

41. Finally, I understand that patent examiners at the U.S. Patent and Trademark Office ("PTO") rely upon certain exemplary rationales in reviewing patent applications to understand whether the subject matter of the claims is obvious. I understand that the following is the list of exemplary rationales relied upon by patent examiners at the PTO: (i) combining prior art elements according to known methods to yield predictable results; (ii) simple substitution of one known element for another to obtain predictable results; (iii) use of a known technique to improve similar devices (methods, or products) in the same way; (iv) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results; (v) "obvious to try" – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and (vi) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art.

B. Construing the Meaning of Claim Terms

42. I understand that an IPR is a proceeding before the PTO for evaluating the validity of issued patent claims. I understand that, in an IPR, a claim term is interpreted in a manner consistent with the standard used in patent litigation, as set

forth in a case known as *Phillips v. AWH Corp*., 415 F.3d 1303 (Fed. Cir. 2005) (en banc). That standard generally construes the claims according to their "ordinary and customary" meaning in view of the claim language, specification, file history, and where applicable, relevant other evidence.

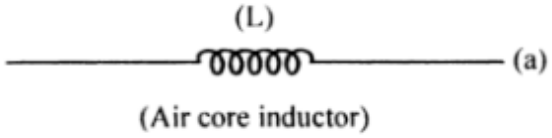
43. I understand that a patent's "specification" includes all the figures, written descriptions, and claims within the patent. I understand that the PTO will look to the specification and prosecution history to see if there is a definition for a given claim term, and, if not, will apply the ordinary and customary meaning from the perspective of a POSITA at the time in which the alleged invention was made.

44. As discussed above and detailed in my curriculum vitae, I have extensive experience in the electrical engineering field throughout my career, including related to semiconductors, inductors, and transformers. I believe that I would qualify as understanding the knowledge and skill of a POSITA as of May 19, 2009, and I have a sufficient level of knowledge, experience, and expertise to provide an expert opinion in the field of the '245 patent.

IV. BACKGROUND OF THE TECHNOLOGY

A. Inductor Basics

45. An inductor is a common electrical component that stores energy in the form of a magnetic field. EX-1008.004. Inductors are sometimes referred to as "coils" and the symbol for an inductor in an electrical circuit is the letter "L" or a drawn wound coil, as shown below. *Id*., .005.



Id.

46. A straight wire, when bent into a coil to form an inductor, possesses inductance which is known as the self-inductance of the coil. *Id*. This inductance plays the role of friction in mechanics, and it is sometimes called a "choking coil" because it chokes alternating current (AC). *Id.*, .010. In other words, inductors are used to resist the flow of AC current in a circuit. *Id.*, .004. AC current is the current which, when flowing through a conductor, changes continuously in magnitude and varies periodically in direction, as shown below. *Id.*, .009. In the graph below, "I" represents the magnitude of the AC current and "t" represents time.

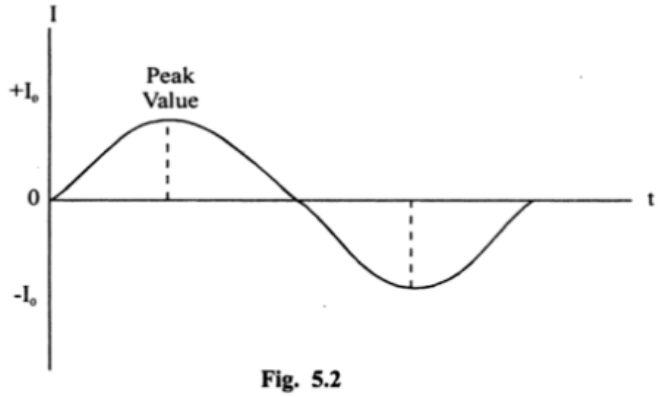


Fig. 5.2

Id., .009.

47. A fundamental principle of inductors is that while it resists the flow of AC current, a pure inductance offers no resistance to the flow of direct current

(DC) current through it. *Id.*, .005. Direct current is a current which, when flowing through a conductor, can change in magnitude but not in direction. *Id.*, .009. The role of inductance in an AC circuit is the same as the role of a resistor in a DC circuit, which opposes the flow of current in a conductor. *Id.*, .010.

48. Off-chip inductors are usually realized as a coil with a helical shape, as depicted below. EX-1009.023-.024. As current flows through the coil, a magnetic field is produced illustrated by the imaginary field lines that flow through the inner core of the winding and wrap around the outsides. *Id.*, .024. Each additional turn of the inductor adds to the magnetic field in phase with the previous turn. *Id.* The inductance is largely a function of the area of the loop and the number of turns in the winding. *Id.*

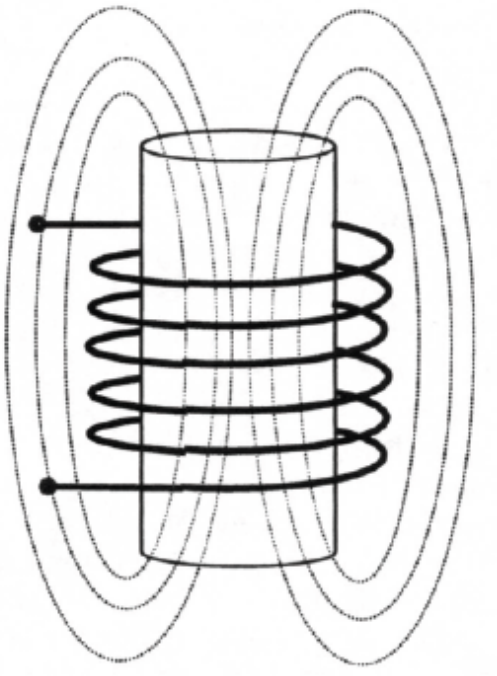


Figure 2.6. The typical coil inductor.

Id.

B. How Inductance is Measured

49. An inductor coil, which is the segment of an inductor that produces an induction effect as a result of current flowing through it, has a co-efficient of self-induction called the inductance "*L*." EX-1008.006. Self-inductance *L* of an inductor is generally defined as the "magnetic flux linked with it when a unit current flows through it," which is mathematically shown in the equation below. *Id.*

$$L = \frac{\Phi}{i}$$

Id.

50. In this equation, Φ represents the magnetic flux linked with the coil when the current is unity and "*i*" stands for current. *Id.* Two units used to represent inductance include the Henry and the Electromagnetic Unit (EMU). *Id.* These units, and their relationship to one another, are shown below.

$$1 \text{ Henry} = \frac{1 \text{ volt}}{1 \text{ amp./sec.}}$$

$$1 \text{ Emu of inductance} = \frac{1 \text{ emu of potential difference}}{1 \text{ emu of current / sec.}}$$

Relation between Henry and emu of inductance

$1 \text{ Henry} = 10^9 \text{ emu of inductance.}$

Id.

51. Further, another important property of an inductive coil is its Inductive Reactance (X_L). *Id.*, .007. As I previously stated, an inductor does not oppose the flow of DC current because it has negligible DC resistance. *Id.* But when AC current passes through an inductor, induced electromotive force (emf) is created, which opposes the AC current. *Id.* This opposition to DC current, which can be thought of loosely as an AC resistance of an inductor, is measured by inductive reactance (X_L). *Id.* Its equation is below.

$$X_L = \omega L = 2\ \pi f L$$

Id.

52. In this equation, "*L*" is the self-inductance of the coil measured in Henry and "*f*" is the frequency of applied AC measured in Hertz. *Id.*

C. General Uses for Inductors

53. Inductors have several applications including frequency filters, chokes, sensors, relays, switching power supplies, induction motors, transformers, among many other things. As is generally known, "Passive devices, such as inductors and transformers, play an integral part in the performance of circuit building blocks…." EX-1009.007.

54. One of these applications, the transformer, "find[s] wide and important applications in RF circuits." EX-1010.097. Historically, transformers have long been used in power systems for voltage step-up and step down. *Id.* Since power transmission is more efficient at high voltages, transformers are used to "transform" and boost signals to tens of thousands of volts for long-range transmission. *Id.* For safety reasons, transformers are then used to step down the voltage to a few hundred volts before delivery into homes and factories. *Id.* Transformers are also used to step these voltages down even further for use by electronic components. *Id.*

55. Essentially, a transformer is just two magnetically coupled inductors. *Id.*, .099. An ideal transformer is characterized by a turns ratio "*N*", which defines

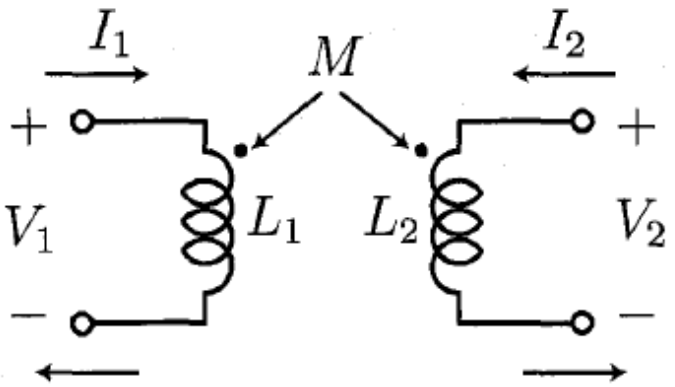
the voltage step up/down from one inductor's port to the other's. *Id.*, .097. This ideal equation is shown below.

$$V_2 = NV_1$$

Id.

56. A transformer's primary behavior derives from the phenomenon of mutual induction. *Id.*, .098-.100. Mutual induction of two circuits is the property by virtue of which a current changing in a first circuit results in a change of flux and induction of an emf in the second. EX-1008.008. For a transformer, this means that flux generated from the first inductor can induce emf in a second inductor, thereby generating current in the second circuit. *Id.*

57. A schematic diagram of a transformer is shown below, where L_1 represents the inductance of inductor 1, L_2 represents the inductance of inductor 2, and M represents the mutual inductance. *Id.*, .098.



(b)

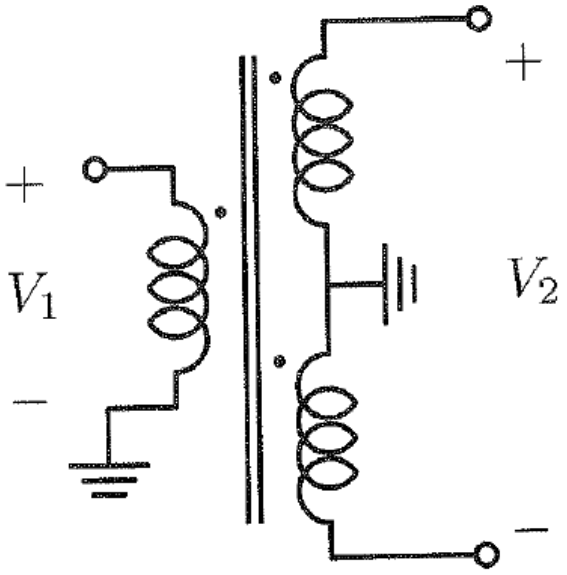
Id., .098, Fig. 10.1(b).

D. Single-Ended versus Differential Inductors

58. In electronics, signals can propagate through circuits in either single-ended or differential mode. EX-1024.001. The primary difference between the two is that for single-ended signal transmission, one wire or trace carries the signal, and it is referenced to a signal ground. *Id.* For differential signal transmission, two traces are used, and the signals along each trace are inverted and mirror each other. *Id.*

59. The principal advantage of single-ended signaling is that less board area is required, and the routing itself is easier. *Id.* Alternatively, differential signals take up more board space and require more complicated routing. *Id.* But differential signals have many advantages including immunity to common-mode noise. EX-1010.105. Other advantages include resistance to electromagnetic interference (EMI), ability to operate at lower voltages with a good signal to noise ratio (SNR), among other things. EX-1024.001.

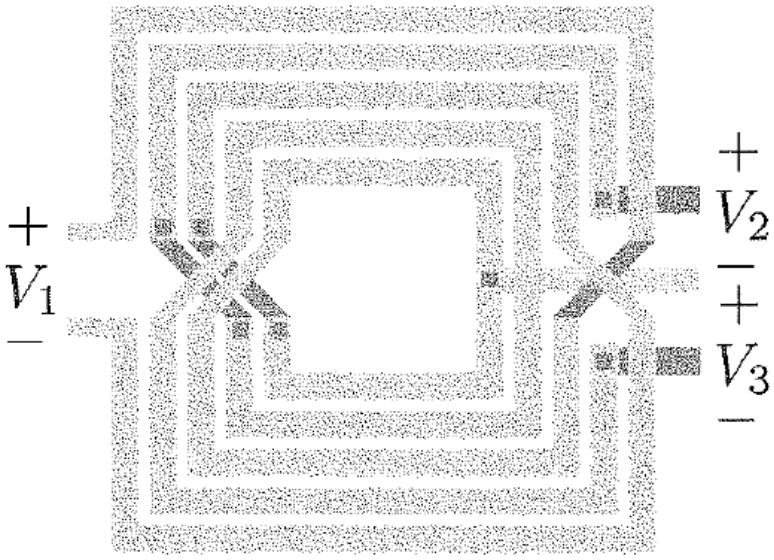
60. Transformers can be used to convert single-ended signals to differential, and vice versa. EX-1010.105-106. Transformers that have this functionality are called "baluns." *Id.* A balun is depicted below.



Id., .106, Fig. 10.11.

61. In the balun depicted, the primary inductor coil (on the left) is grounded and driven by a single-ended signal. *Id.* The secondary inductor coil (on the right) is grounded at the center tap to create a differential signal. *Id.* The voltage pickup on the top half of the secondary inductor coil is in phase with the primary inductor coil, and the bottom half of the secondary inductor coil is 180 degrees out of phase and thus inverted. *Id.*

62. A Common balun layout in an integrated circuit environment is depicted below. *Id.*, .107.



Id.

E. The meaning of Q-factor

63. At its core, the "Q-factor" or "Quality Factor" of a coil is the ratio of energy storage to energy loss in a practical inductor over a cycle of excitation, as shown below. *Id.*, .059.

$$Q \equiv \frac{\text{energy stored}}{\text{energy loss}}$$

Id.

64. From this fundamental equation, we can derive that the Q factor is also equal to the ratio of the reactance (X_L) of a coil at resonance to the resistance (R) of the coil. *Id.*; EX-1008.011. This equation is shown below.

$$Q = \frac{\omega L}{R}$$

EX-1010.059 (Q factor of inductor).

65. L is the inductance, R is the DC resistance, and the product ωL is the inductive reactance. The Q of an inductor at a given frequency is a ***measure of its efficiency***. *Id.*, .059-.060. The higher the Q factor of the inductor, the lower the energy loss of the device and the closer it approaches the behavior of an ideal inductor. EX-1009.016. High Q inductors are used with capacitors to make resonant circuits in radio transmitters and receivers, which are discussed in more detail below.

66. To improve an inductor and its Q factor, we must minimize the various loss mechanisms associated with the inductor. *Id.*, .060. These loss mechanisms include conductive losses, internally induced losses such as skin effect, externally induced losses such eddy current generated by nearby conductors, magnetization losses, displacement current losses, and radiative losses. *Id.*, .060-.062.

F. Inductors in Integrated Circuits

67. Inductors have many applications including frequency filters, chokes, sensors, relays, switching power supplies, induction motors, transformers, among many other things. As is generally known, "[p]assive devices such as inductors and transformers, play an integral part in the performance of circuit building blocks…." EX-1009.007.

68. Until the early 2000s, passive devices such as inductors played a relatively minor role in silicon integrated circuits in comparison with active devices. EX-1009.006. The main reason for this was the size difference. *Id.* Active devices were continually shrinking and occupying less and less chip area whereas passive devices remained large. *Id.* While it was possible to fabricate a small value of capacitance on-chip, inductors were more difficult to integrate due to the large physical area required to obtain sufficient inductance at a given frequency. *Id.* This was compounded by the losses in the substrate which made it very difficult to fabricate high quality devices. *Id.*

69. When passive devices like inductors were needed, they usually were connected externally on the circuit broad rather than on-chip. *Id.* This led to the push for and development of integrating passive devices on semiconductor devices. *Id.*, .007.

G. Single Layer vs. Multi-Layer inductors

70. As described earlier, inductor coils can be either single coil or multiple coils. When formed in integrated circuits, it was well known prior to the priority date of the ’245 patent that the coils of an inductor could be formed on a single metal layer (planar) or multiple metal layers. EX-1011.002-.012, e.g., .006 (“In addition to the planar coil structure … multilevel interconnects offer the

possibility to fabricate inductor structures with several stacked spiral coils."); EX-1012.005-.013.

71. Another publication discusses "Metal Layer Shunting" and how "shunting several metal layers in a multilevel interconnect technology together [is] a simple technique to provide an effectively thicker conductor without changing the process technology." EX-1029.011. Different metal layer thicknesses can be utilized for various purposes, e.g., metal thicknesses of 2 μm, 3 μm, or 4 μm. *Id.*, .012-.013. Varying thicknesses are also shown below.

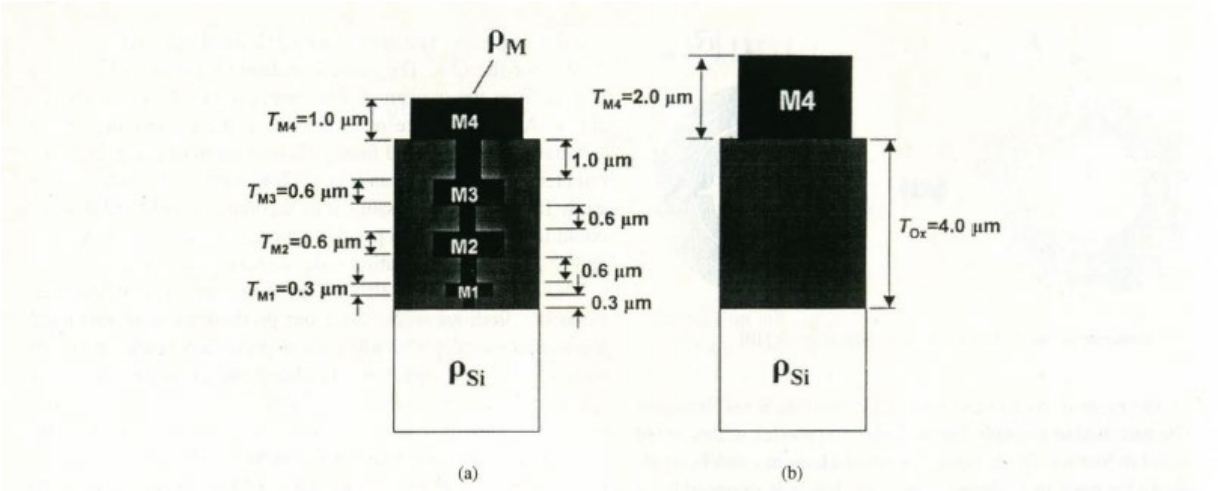
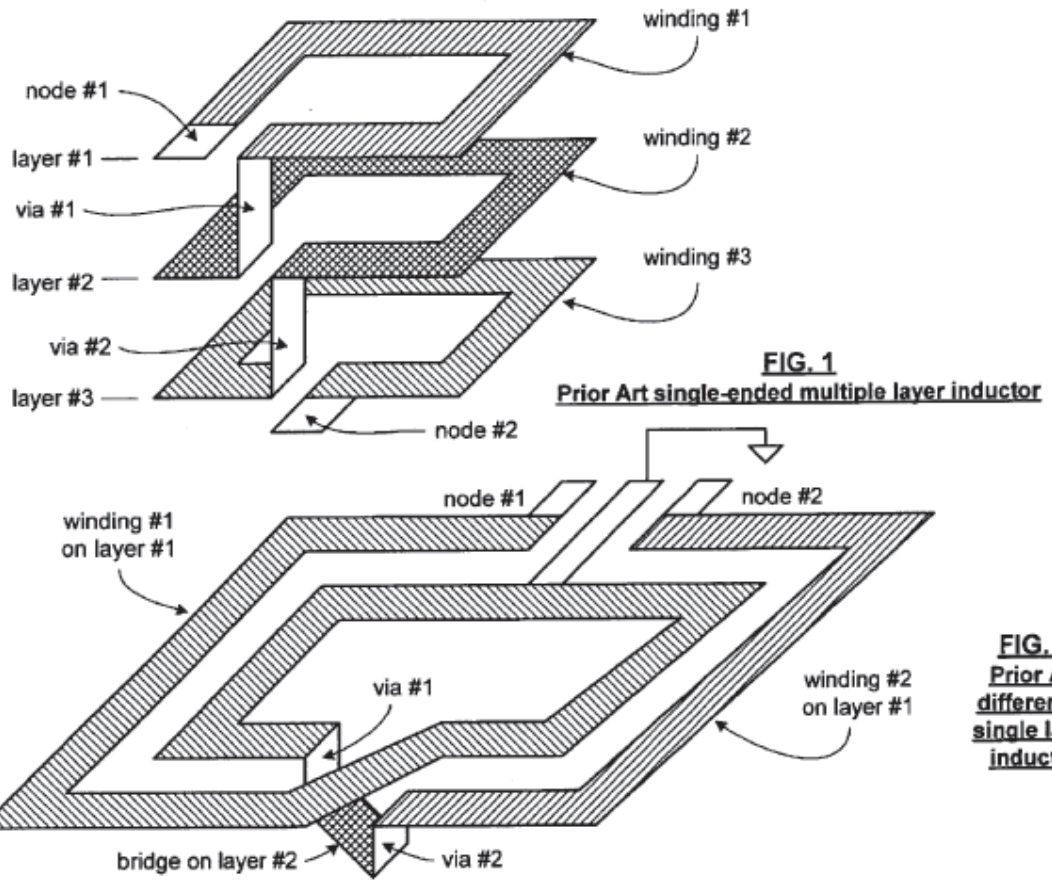


Fig. 2. Cross sections of a four-level metal interconnect stack with (a) all metal layers shown and (b) only a thicker top metal layer; the thickness of the metal layers and insulating oxide layers are indicated.

Id., .007, Fig. 2.

72. The two different techniques are shown in Figs. 1 and 2 of U.S. Patent No. 6,759,937 filed on Jun. 3, 2002, titled "On-Chip Differential Multi-Layer Inductor" to Chryssoula Kyriazidou ("Kyriazidou"), as shown below.



EX-1013, [Figs. 1, 2].

73. According to Kyriazidou, Fig. 1 "illustrates a schematic block diagram of a prior art single ended ***multiple layer*** inductor" while Fig. 2 "illustrates a diagram of a prior art differential ***single layer*** inductor." *Id.*, [2:52-55] (emphasis added).

74. The single layer inductor of Fig. 2 depicts two windings (#1 and #2) on layer 1, coupled together via a bridge on layer 2 as well as interconnecting vias #1 and #2. *Id.*, [1:55-60].

75. In contrast, the multilayer inductor of Fig. 1, includes three windings (#1, #2, #3) on three layers (layers #1, #2, #3), with the windings being connected by two vias (via #1 connecting layers #1 and #2, and via #2 connecting layers #2 and #3). *Id.*, [1:42-45]. Kyriazideou explains that such an inductor provides a relatively small footprint (i.e., space on the chip) and can have higher inductance values than single layer inductors of a similar footprint. *Id.*, [1:45-48]. However, it typically has a relatively significant capacitance value that limits the resonant frequency, which in turn limits the operating frequency of the inductor. *Id.*, [1:48-50].

76. Similarly, many other U.S. patents disclose multi-layer inductors. For example, U.S. Patent No. 6,967,555 filed on Jun. 18, 2003 titled "Multi-Level Symmetrical Inductor" to Felix Kao ("Kao") (EX-1014) discloses a multilayer inductor as shown below.

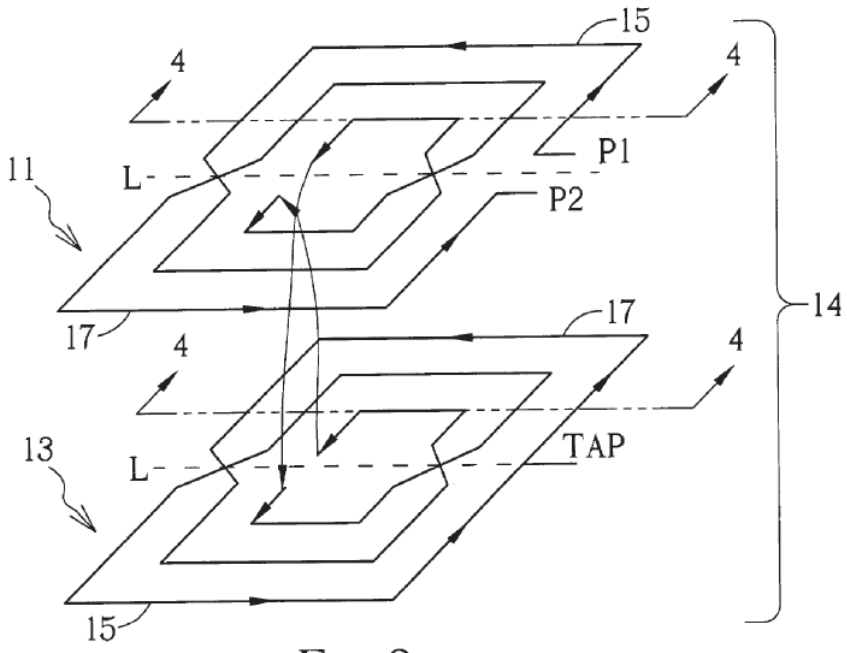


Fig. 3

EX-1014, [Fig. 3].

77. Kao explains that "[a] major drawback of the one-layer spiral inductor 10 according to the prior [art] is that the inductor consumes a large chip area, increasing the cost and reducing the possibility of integrating it into a chip. In addition, the quality factor of the inductor 10 and the resistance of the coil are inversely proportional, that is, the longer coil, the larger resistance. Thus, increased energy dissipation of the inductor 10 reduces the quality factor, and it becomes difficult to apply such an inductor in wireless integrated circuit design." *Id.*, [1:28-36]. The multi-layer inductor disclosed sought to solve these above-mentioned problems. *Id.*, [2:17-20].

78. U.S. Patent No. 8,325,001 claiming priority to Aug. 4, 2005, titled "Interleaved Three-Dimensional On-Chip Differential Inductors and Transformers" to Daquan Huang ("Huang") (EX-1015) also discloses a multi-layer inductor as shown in Figure 1 below.

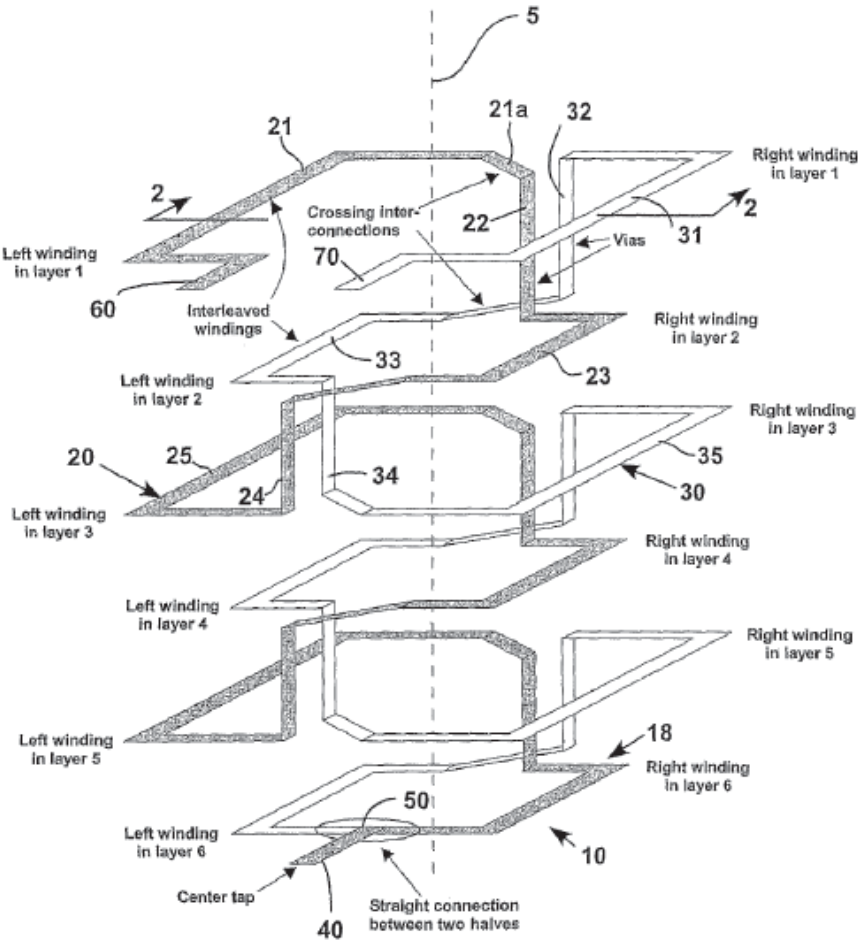


FIG. 1

EX-1015, [Fig. 1].

79. Many other examples are disclosed in the prior art, a few of which are shown below.

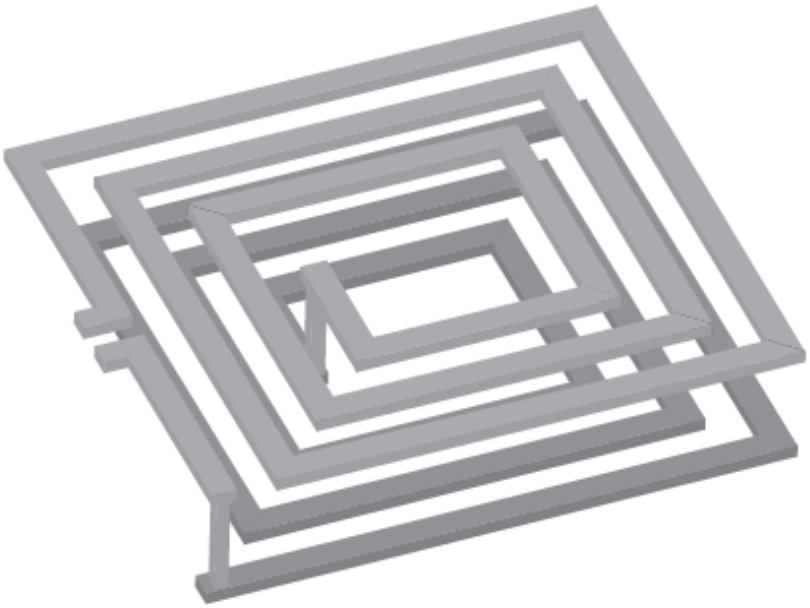


Figure 6.16 A three-dimensional view of the multi-layer series connected spiral shown in Fig. 6.15. The via thickness is exaggerated for illustration.

EX-1010, .077, Fig. 6.16.

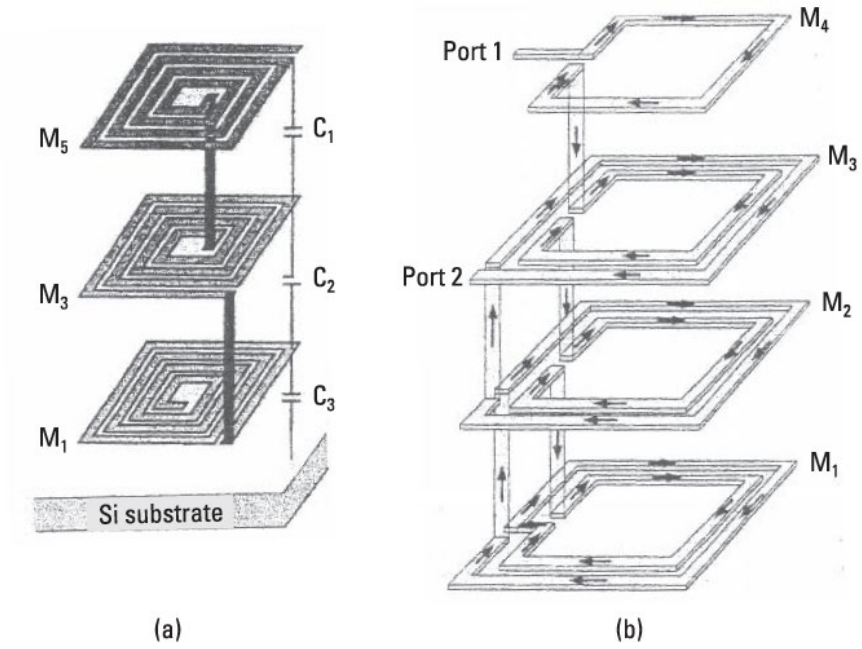


Figure 3.19 (a) Conventional three-level inductor using metals 5, 3, and 1 on a Si substrate. (b) Improved SRF four-level stacked inductor with current flow path. (*From:* [48]. © 2002 IEEE. Reprinted with permission.)

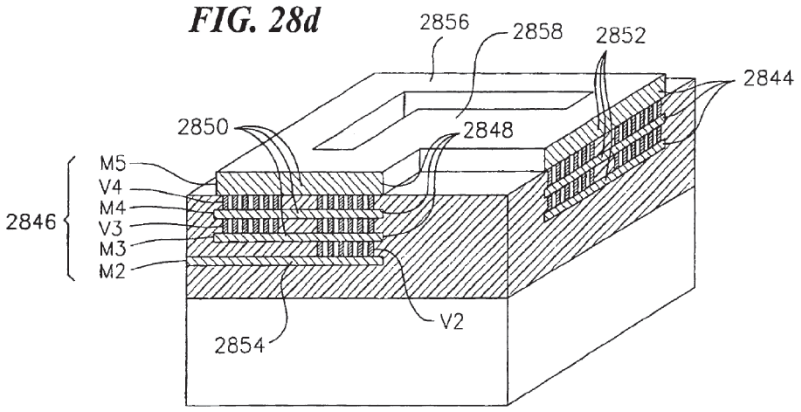
EX-1016.012, Fig. 3.19.

H. Use of Vias to connect Metal Layers

80. At its core, a via is an electrical connection between metal layers. *Id*., .013. Vias are typically formed by punching holes through two or more adjacent layers, which are then filled with a metallic paste making the interconnection from layer to layer. *Id*.

81. This is illustrated in Figure 28d in U.S. Patent No. 6,885,275 filed on Jan. 28, 2000, titled "Multi-track Integrated Spiral Inductor" to James Chang ("Chang"). *See*, EX-1017, [Fig. 28d]. As Chang explains, vias can be used in a multi-layer inductor to couple a bottom track to one or more tracks disposed in layers above it. *Id*., [39:12-14]. In this case, vias can be used to couple tracks

together at the beginning of an inductor winding, at the end of the inductor winding, and along the length of the track. *Id.*, [39:9-15]. The vias can be used "in as many places as possible along the length of each track to couple the layers." *Id.*, [39:29-32]. This is illustrated below.



Id., [Fig. 28d].

As shown above, multiple vias (labeled V2, V3, and V4) are used to connect the different metal layers M2, M3, M4, and M5. Vias can also be in the form of lines as depicted throughout Figure 1 of Yang below.

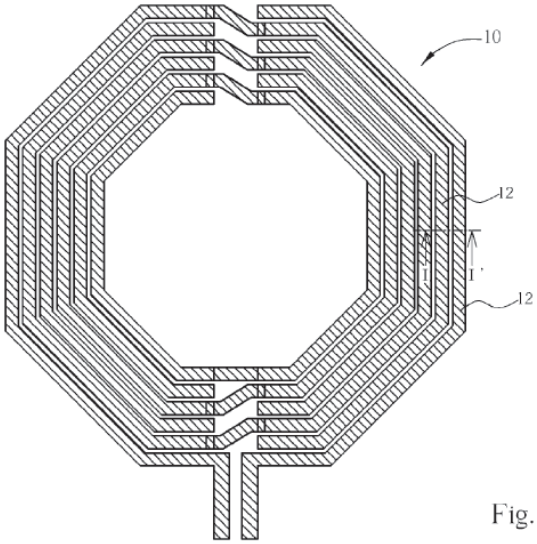
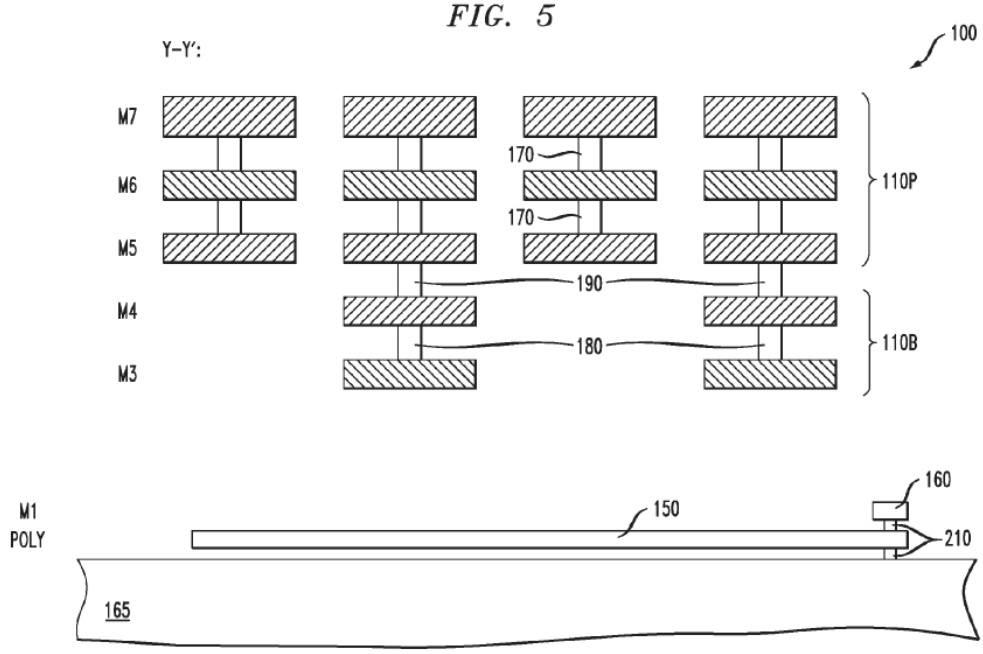


Fig. 1

EX-1007, [Fig. 1].

82. Another example is illustrated in U.S. Patent Application Pub. No. US 2008/0074229 published on Mar. 27, 2008 by Shahriar Moinian et al. ("Moinian") (EX-1018). Moinian explains that metal segments can be "electrically connected together by a multiplicity of contact vias 170 so that they are connected in parallel with each other (i.e., they are shunted)." EX-1018, [0023]. It also explains that vias can be used for the cross-over bridges as well. *Id.* Using vias to connect segments on various metal layers was very well-known and is illustrated in Moinian below.

FIG. 5



Id., [Fig. 5].

I. Shape of Inductors and Symmetry

83. The various shapes of inductors and their respective trade-offs were very well known far before the priority date of the ’245 patent. A few of these configurations are shown below:

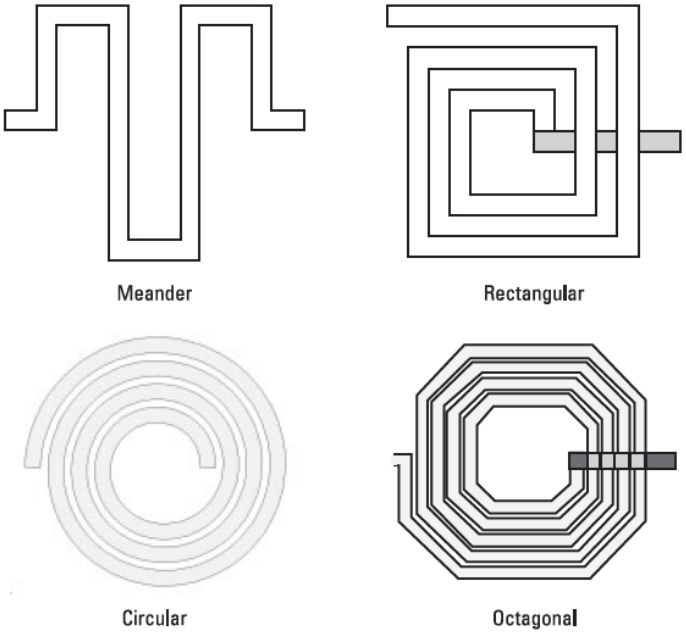


Figure 3.1 Two-dimensional inductor types: (a) meander, (b) rectangular, (c) circular, and (d) octagonal.

EX-1016.009.

84. The circular geometry has the best electrical performance of these shapes, whereas meander line inductors are seldom used. *Id.*, .008. The trade-offs between these various configurations were well-known in the art, and some of the major advantages and disadvantages of each shape is shown in the table below. *Id.* SRF in the table stands for self-resonance frequency and is defined as the point where the inductive reactance ("AC resistance") and the parasitic capacitance reactance become equal and opposite in sign. *Id.*, .006-.007.

Table 3.1
Two-Dimensional Inductor Configurations and Their Features

Configuration	Advantage	Disadvantage
Meander line	Lower eddy current resistance	Lowest inductance and SRF
Rectangular	Easy layout	Lower SRF
Octagonal	Higher SRF	Difficult layout
Circular	Highest SRF	Difficult layout

Id., .009, Table 3.1.

85. In addition to advantages listed in the table, the circular and octagonal structures also have slightly higher Q factors than the rectangular and meander shapes. EX-1010.066, .074. When constructing a layout, for a given inductance value, it is best to have the highest possible values of Q and SRF in the smallest possible area of an inductor using standard process techniques. EX-1016, .010.

86. Numerous inductor layout techniques for enhancing the Q-factor of an inductor were well-known in the art. *Id.*, .011. These include the factors below.

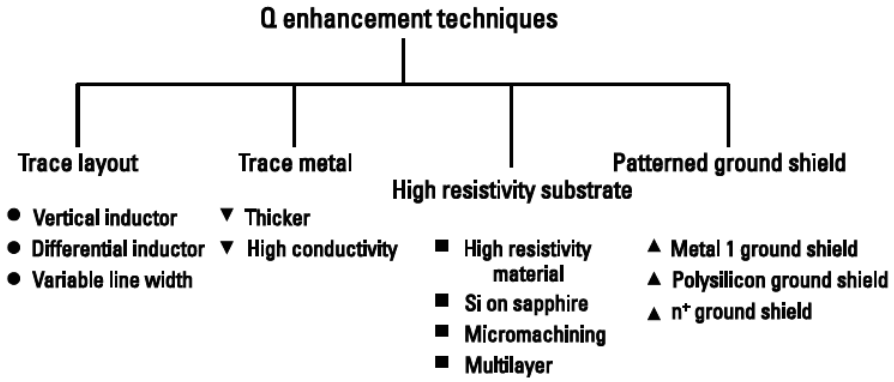
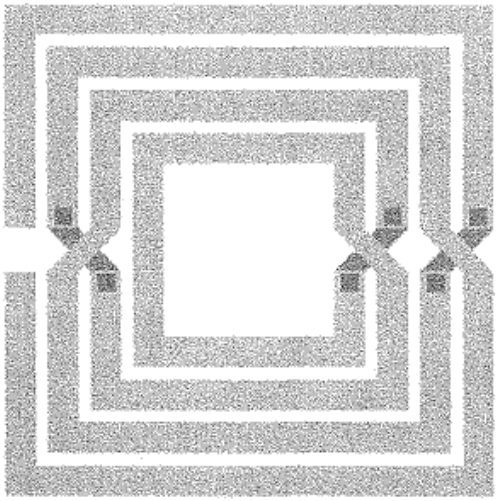


Figure 3.8 *Q*-Enhancement techniques for inductors on Si substrate.

Id., .011, Fig. 3.8.

87. Further, to enhance a spiral inductor's performance, the need to create symmetry is well known, particularly for differential inductors that are chosen for their higher Q-factor. *See* EX-1009.024-.025. A POSITA would have generally understood that in the context of inductors, symmetric simply means that it has a shape that can be divided into two equal parts. In a typical spiral, it is difficult to find a symmetric center point since the electric fields on the outer turns tend to fringe, resulting in an "inductive center" that does not correspond to the "capacitive" center. *Id.*, .024. Also, the "inductive" center does not correspond to the "resistive" center due to the non-uniform mutual magnetic coupling. *Id.* To solve this problem, designers began proposing symmetric structures such as the ones below. *Id.*, 024-.025. Note that in this configuration, each turn involves a metal-level interchange, a process that requires vias. *Id.*, .025.



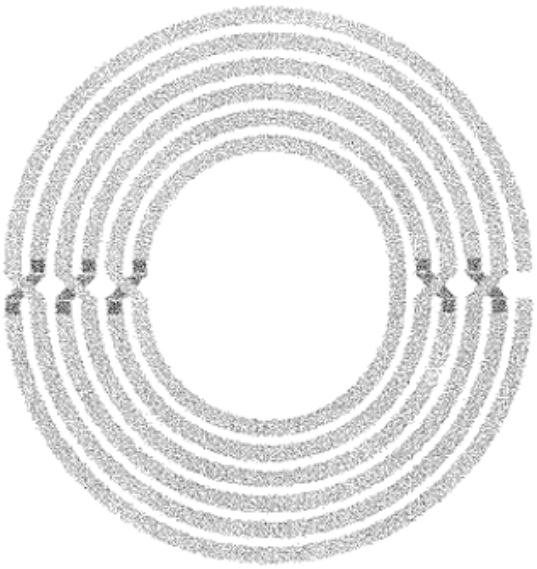


Figure 2.10. A symmetric spiral inductor. *Figure 2.11.* A symmetric polygon spiral inductor.

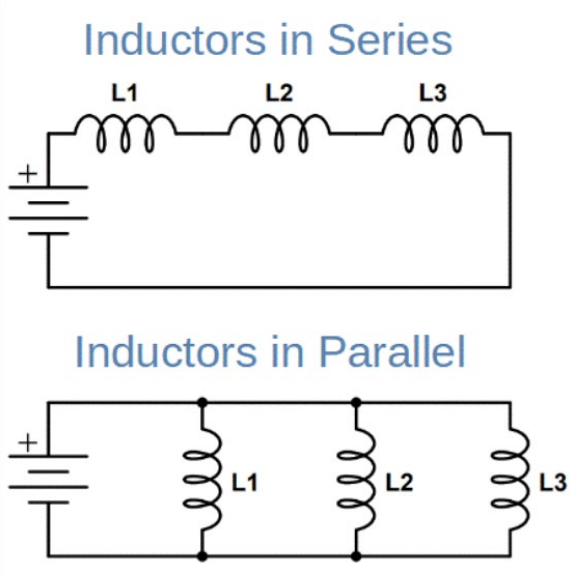
Id., .026-.027, Figs. 2.10, 2.11.

88. One of the biggest benefits of this symmetrical spiral design is that it has a natural geometric center that coincides with the electrical center point. *Id.*, .024-.025. This is needed in differential circuits as points that can be grounded or connected to supply without disturbing the differential signal. *Id.*, .025-.026.

J. Serial (in series) versus Shunt (in parallel) windings

89. As integrated circuit processes began offering many metal layers, two simple approaches developed to utilize the metal layers. EX-1009.026. These approaches were "to connect multiple spiral inductors in series or in shunt." *Id.*; *see also*, EX-1029.011. Generally speaking, a serial winding is created when two or more inductor windings are constructed in series. EX-1009.026-.028.

Alternatively, a shunt winding is created when two or more inductor windings are constructed in parallel. *Id.* I include a basic image below to illustrate inductors in series versus in parallel.



90. As noted in the literature, "[e]nhanced Q multilevel spirals generally consist of identical spirals placed on multiple metallization layers and shunted together by vias." EX-1030.007. Figure 2 depicts such a multilevel structure with shunted elements.

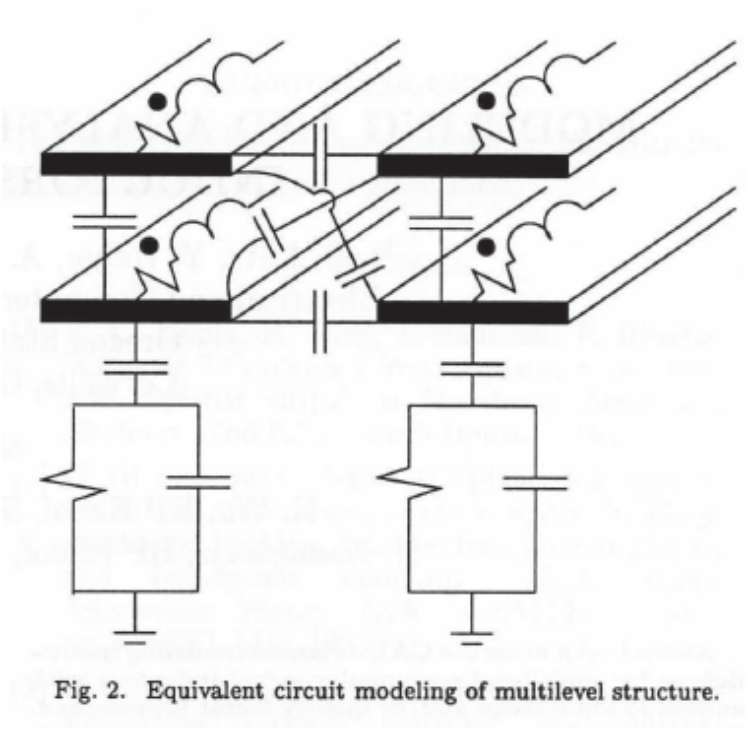


Fig. 2. Equivalent circuit modeling of multilevel structure.

Id., .008, Fig. 2.

91. The tradeoffs between these two winding types were well-known. *See* EX-1009.026-.028. For example, for a series winding, N spirals in series increases the series resistance which is typically bad for its Q-factor. *Id.*, .026-.027. However, the inductance value increases faster due to the mutual magnetic coupling. *Id.*, .027. Thus, the series connection approaches an N^2 increase in inductance, and the Q factor can potentially increase by a factor of N. *Id.* Alternatively, in the shunt connection, the series resistance drops which is good for

the Q-factor. *Id.* But the inductance of the mutually coupled inductors drops. *Id.* Taken together, its Q factor still improves by a factor of N. *Id.*, 28.

92. In practice, both the series and shunt connections offer a Q-factor improvement. *Id.* But both design options have drawbacks at high frequencies. *Id.* For example, the series connection suffers from high interwinding capacitance, which lowers the self-resonance frequency thus lowering the maximum frequency of operation of the device. *Id.* Alternatively, the shunt connection moves the devices closer to the substrate where capacitive current injection into the substance may dominate the loss of the device. *Id.*

93. These are all design choices, and the two approaches were well-known in the art. An example of a serial winding is shown below, where "two or more spirals on different layers [are] placed in series to increase the inductance[.]" EX-1010.077.

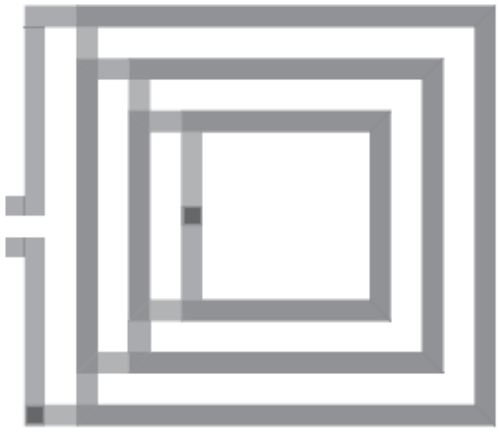


Figure 6.15 A multi-layer square spiral inductor is formed by connecting a spiral from the top layer to a spiral on the next level. Each spiral is wound so as to reinforce the magnetic field of the other. This is easily generalized to three or more layers.

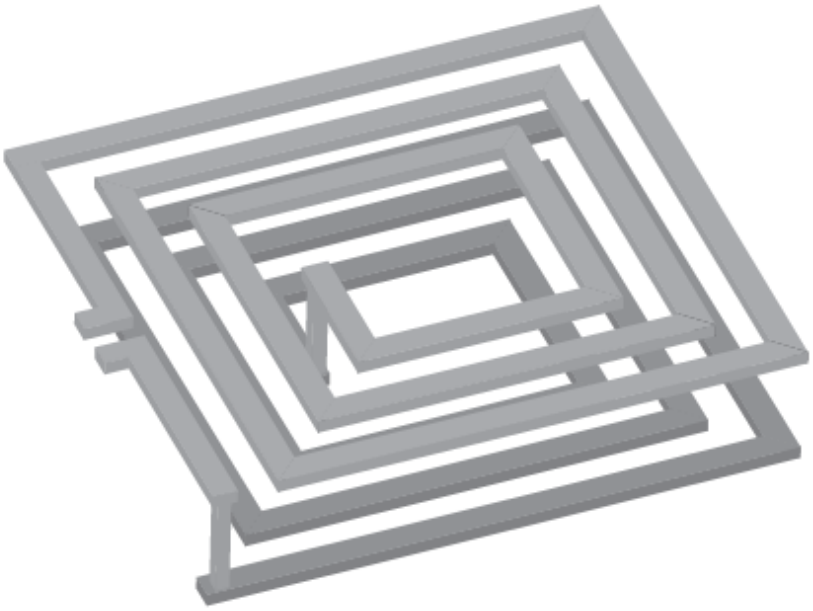
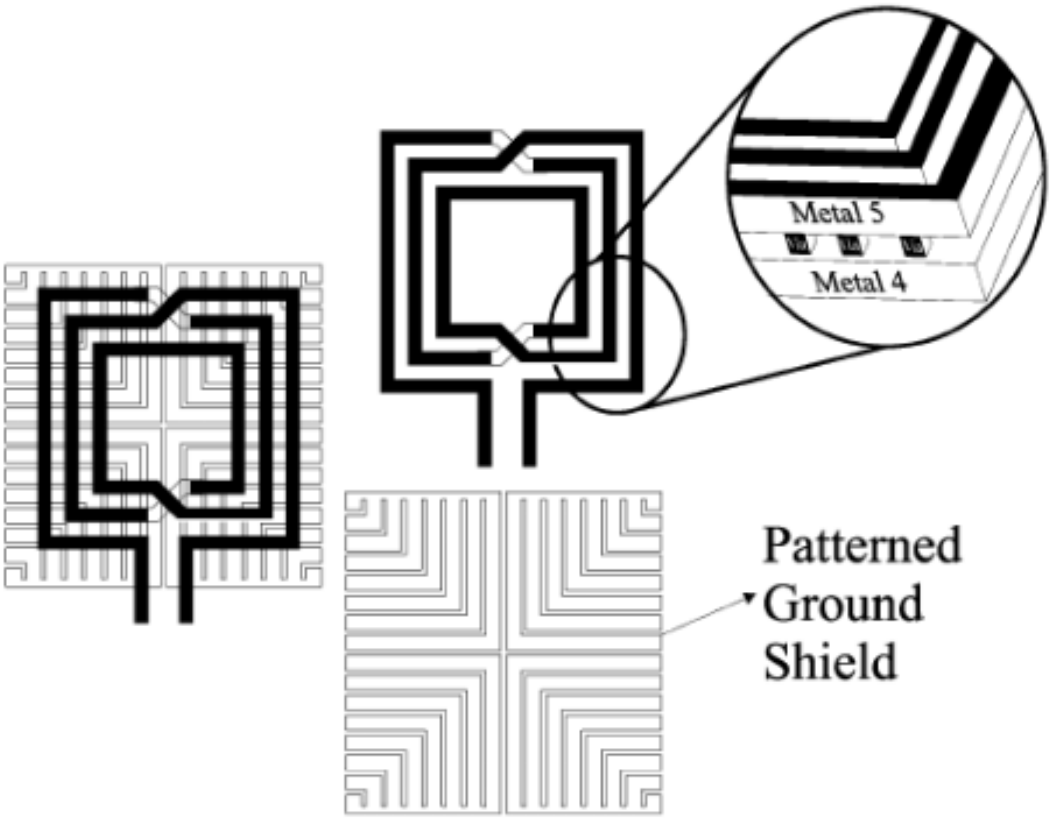


Figure 6.16 A three-dimensional view of the multi-layer series connected spiral shown in Fig. 6.15. The via thickness is exaggerated for illustration.

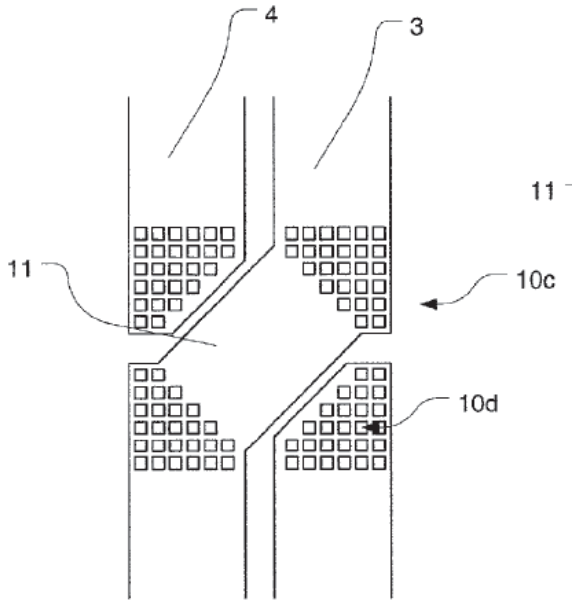
Id., Figs. 6.15, 6.16.

94. Alternatively, a shunt winding is shown below where "the spirals [are connected] in parallel, to realize an effectively thicker conductor. Many vias are employed to strap the layers together … lower[ing] the resistance with a small impact on the inductance value …." *Id.*, .077-.078. "As area constraints mitigate the use of wider tracks, thicker tracks may be used … by joining metal layers using multiple vias to create a thicker metal track and, hence, a stacked metal inductor." EX-1012.006. This is accomplished in a parallel fashion, as shown below.



Id.

95. These vias can be used "in as many places as possible along the length of each track to couple the layers[,]" and thereby "the series resistance loss tends to be decreased due to increased conductor thickness[,]" as explained by U.S. Patent No. 6,885,275. EX-1017, [39:23-25, 30-32]. Further, these vias can also be placed adjacent to the crossovers as explained by U.S. Patent No. 6,794,977 to Christensen (EX-1006), and illustrated in its Figure 6(a), where the vias are labeled 10d. EX-1006, [0012], [0035].

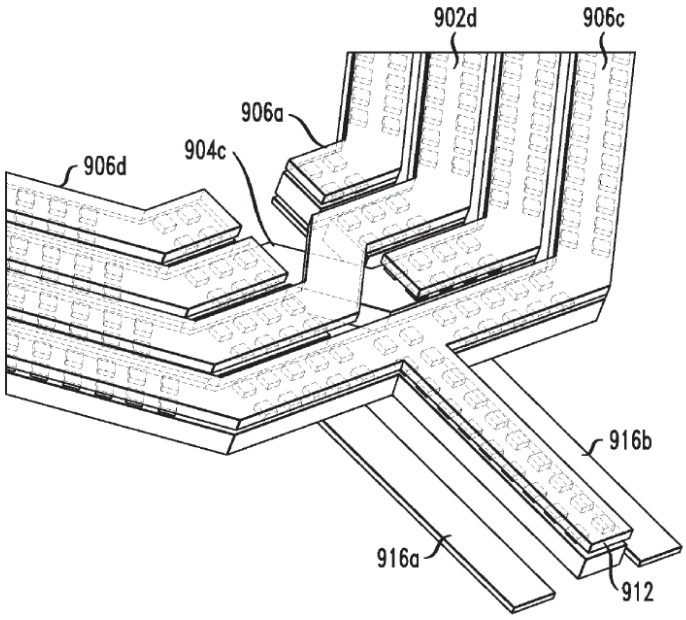


(a)

Id., [Fig. 6(a)].

96. This is also illustrated in U.S. Patent No. 7821,372 filed on Dec. 31, 2008, titled "On-Chip Transformer Balun Structures" to Chen Ho-Hsiang ("Ho-Hsiang") (EX-1005).

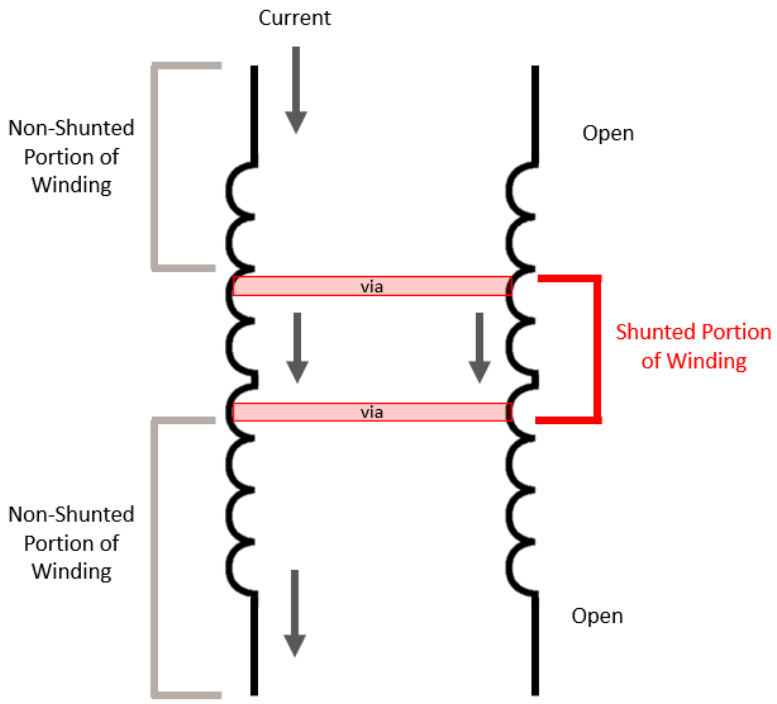
FIG. 9B



EX-1005, [Fig. 9B].

97. To further refine the understanding of shunt winding, it is helpful to look at the definition of "shunt" in a dictionary. Webster's New World College Dictionary, Fourth Edition (2009), defines "shunt" as "a conductor connecting two points in a circuit in parallel so that an additional pathway is created for the current." EX-1020.003; *see also*, Encyclopedia of Electronics, 2d (McGraw-Hill 1990) (EX-1021.004) ("The term shunt refers to a parallel connection of one component across another component or group of components."). Thus, a POSITA would have understood that for an entire winding to be a shunt winding, it must be pinned (by vias) to the second winding at the ends. This would make the two windings entirely shunted. Only the portions of the upper and lower windings that form a span between vias are in parallel and shunted. Anything not between the

vias are simply an open circuit. I have created the below image to illustrate the definition of a shunt winding and how it would operate in practice.



V. THE '245 PATENT

A. Background

98. The background of the invention section of the '245 Patent states that it relates to a "stacked structure of a spiral inductor, and more particularly, to a stacked structure for improving quality factor by making use of metal layers of a crossover region as shunt windings." EX-1001, [1:7-10]. It explains with respect to the prior art:

> As IC manufacturing processes are developing with a trend for system on chip (SOC) design, passive elements such as integrated inductors or integrated transformers have been widely integrated in high-

frequency integrated circuits. Since IC manufacturing processes usually adopt a structure with Silicon-based substrates, substrate loss and metal loss of the integrated inductors/integrated transformers will affect their quality factor. And more particularly, metal loss is the main cause that most immediately affects the inductor properties.

Id., [1:12-20].

99. The ’245 Patent acknowledges that symmetric inductors were common at the time and they could include multiple metal layers as a winding of the inductor. *Id.*, [1:21-25]. The use of vias and a crossover region were also known. *Id*. But it argues that prior art inductors had disadvantages, namely the “parasitic resistor will be restricted by the single metal layer, a conductivity of the crossover region, a number of the vias, and the resistance of the vias.” *Id.*, [1:26-28]. One solution the ’245 Patent points to, is to increase the widths of the winding, but that would occupy more chip area. *Id.*, [1:28-30]. The ‘245 Patent acknowledges that the prior art came up with a solution to this, “a structure with multiple metal layers in parallel.” *Id.*, [1:31-32].

100. The ’245 Patent discloses a specific version of that prior art solution. It states that an embodiment (which mirrors the claim language) is the following:

According to an embodiment of the present invention, a stacked structure of a spiral inductor is provided. The stacked structure of the

spiral inductor includes ***a first metal layer***, ***a second metal layer***, ***a first set of vias***, and ***a second set of vias***. The first metal layer includes a first segment, a second segment, and a third segment being connected to the first segment, wherein a layout direction of the third segment is different from a layout direction of the first segment and a layout direction of the second segment. The second metal layer is positioned under the first metal layer. The second metal layer includes a fourth segment, a fifth segment, and a sixth segment being connected to the fifth segment, wherein a layout direction of the sixth segment is different from a layout direction of the fourth segment and a layout direction of the fifth segment. The first set of vias connects the first segment with the fourth segment. The second set of vias connects the second segment with the fifth segment. Herein the first segment, the fourth segment, and the first set of vias construct ***a first shunt winding***; the second segment, the fifth segment, and the second set of vias construct ***a second shunt winding***; and the third segment and the sixth segment construct ***a crossover region***. The spiral inductor may be a symmetric spiral inductor.

Id., [1:45-2:3].

101. While such a solution was specific, ***it was not novel***. All of these elements, e.g., the multiple metal layers, vias, shunt windings, and crossover regions, were well known at the time. Indeed, even the use of specific layout directions was well known and obvious to utilize. For instance, a POSITA would have recognized that it would have been obvious to use a third segment with a layout direction that is different than the first and second segments because it is part of a crossover.

102. Figure 2 of the ’245 Patent demonstrates how the embodiment set forth above could be constructed. For instance, it depicts different segments, vias, and a crossover region. As the specification notes, Fig. 2 is a symmetric spiral inductor that has a first shunt winding labeled 330, a second shunt winding labeled 340, and a crossover region labeled A1. *Id.*, [4:22-25].

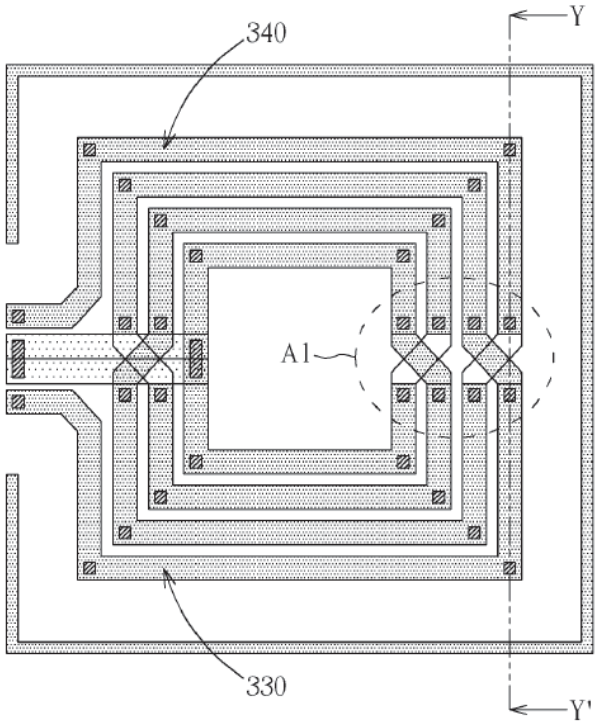


FIG. 2

Id., [Fig. 2].

B. Prosecution History

103. The application that led to the ’245 patent was filed as United States Patent Application No. 12/773,024 (“the ’024 Application”) (EX-1002) and it resulted in a first office action allowance. ’024 Application, Notice of Allowability. Notably, the prior art relied on herein was not considered by the Examiner during prosecution.

C. Overview of the Challenged Claims

104. Claim 1 of the ’245 Patent is reproduced below. The claim is directed to a structure of a spiral inductor containing two metal layers, each with three

segments. Segments on different layers are connected using vias which construct shunt windings.

Claim 1. A structure of a spiral inductor, comprising:

a first metal layer, comprising:

a first segment;

a second segment; and

a third segment, connected to the first segment, wherein a layout direction of the third segment is different from a layout direction of the first segment and a layout direction of the second segment;

a second metal layer, being positioned under the first metal layer, the second metal layer comprising:

a fourth segment;

a fifth segment; and

a sixth segment, connected to the fifth segment, wherein a layout direction of the sixth segment is different from a layout direction of the fourth segment and a

layout direction of the fifth segment;

a first set of vias, for connecting the first segment with the fourth segment; and

a second set of vias, for connecting the second segment with the fifth segment;

wherein the first segment, the fourth segment and the first set of vias construct a first shunt winding; the second segment, the fifth segment and the second set of vias construct a second shunt winding; and the third segment and the sixth segment construct a crossover region.

105. Dependent claim 2 requires the third and sixth segments to be positioned between the first/second and fourth/fifth segments respectively.

106. Dependent claim 3 requires the first thickness of the first metal layer to be greater than a second thickness of the second metal layer.

107. Dependent claim 4 requires that the spiral inductor further comprises a third metal layer being positioned under the second metal layer, a structure of the third metal layer is the same as a structure of the second metal layer, and the first thickness of the first metal layer is greater than a third thickness of the third metal layer.

108. Dependent claim 5 requires that the first thickness of the first metal layer is equal to a second thickness of the second metal layer.

109. Dependent claim 8 requires the spiral inductor be a symmetric spiral inductor.

110. Dependent claim 9 requires the spiral inductor be a shape whereby the first shunt winding and the second shunt winding is substantially a rectangle, an octagon, or a circle.

VI. CLAIM CONSTRUCTION

111. I understand that AMD has the right to assert in litigation that its proposed constructions are proper and that certain terms are indefinite, and I do not concede, by providing my opinions herein, that the challenged claims are of definite scope or properly described. I understand that, while the PTAB is not permitted statutorily to invalidate patents for indefiniteness in *inter partes* review, the PTAB may nevertheless invalidate a potentially indefinite patent for obviousness so long as it can ascertain that the prior art falls within the scope of the patent.

112. For the purposes of this declaration, I have provided the following construction for the claim term "shunt winding." My construction is based on how I understand Patent Owner construes these terms in light of the Infringement Contentions it served in the co-pending ITC litigation. *See*, EX-1022.

A. "shunt winding"

113. For purposes of this declaration, it is my opinion that "shunt winding" should be construed as "windings in parallel." The '245 Patent specification mentions the term "shunt winding" a few times. In the background section it states that the present invention makes use of "metal layers of a crossover region as shunt windings." EX-1001, [1:7-10]. The patent explains that in one embodiment the "first segment, the fourth segment, and the first set of vias construct a first shunt

winding." *Id.*, [1:64-66]. In another embodiment, "the first segment and the fourth segment construction a first shunt winding." *Id.*, [1:17-18].

114. With respect to Fig. 2 (left image below), the specification identifies the first and second shunt windings as 330 and 340 respectively. *Id.*, [4:22-24]. With respect to Fig. 6B (right image below), the specification identifies the first and second shunt windings as 620 and 630 respectively. *Id.*, [6:27-28].

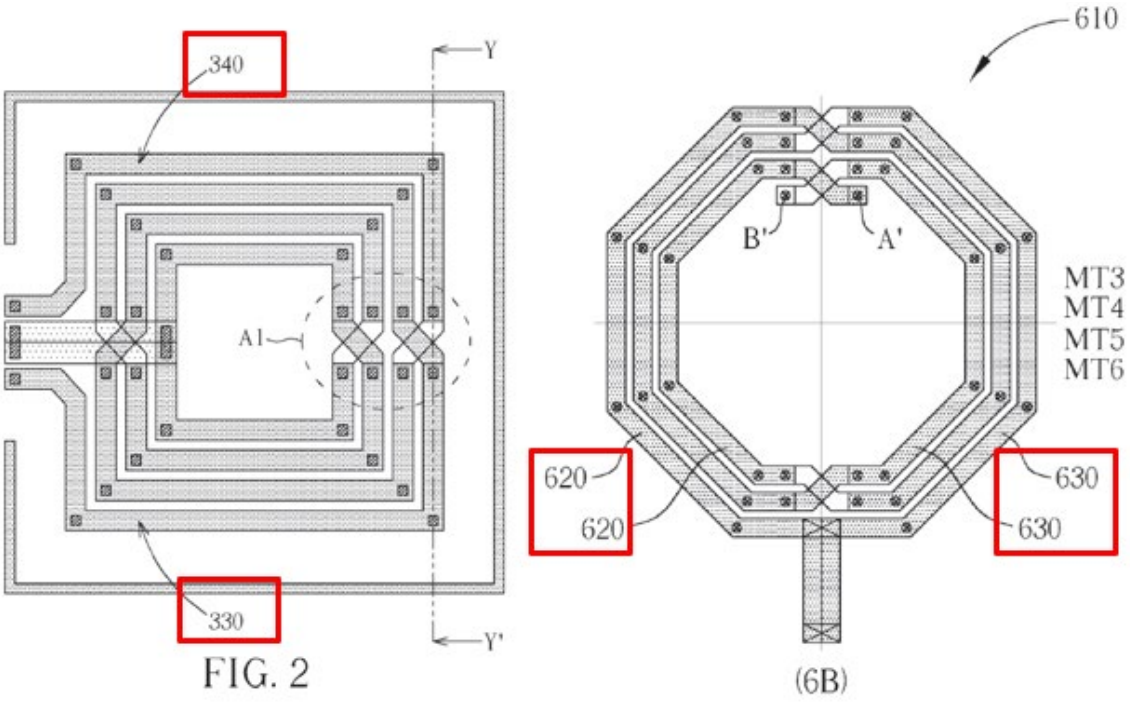


FIG. 2 (6B)

Id., [Figs. 2 (left), 6B (right)] (annotations added).

115. The '245 Patent distinguishes a "shunt winding" from a "serial winding." Specifically, it states that "[t]he symmetric spiral inductor 500 is a multi-layer stacked spiral inductor combining the first inductor 510 (***i.e., the serial winding***) with the second inductor 610 (***i.e., the shunt winding***) …" *Id.*, [6:14-17]. This is depicted in Figs. 6A and 6B below.

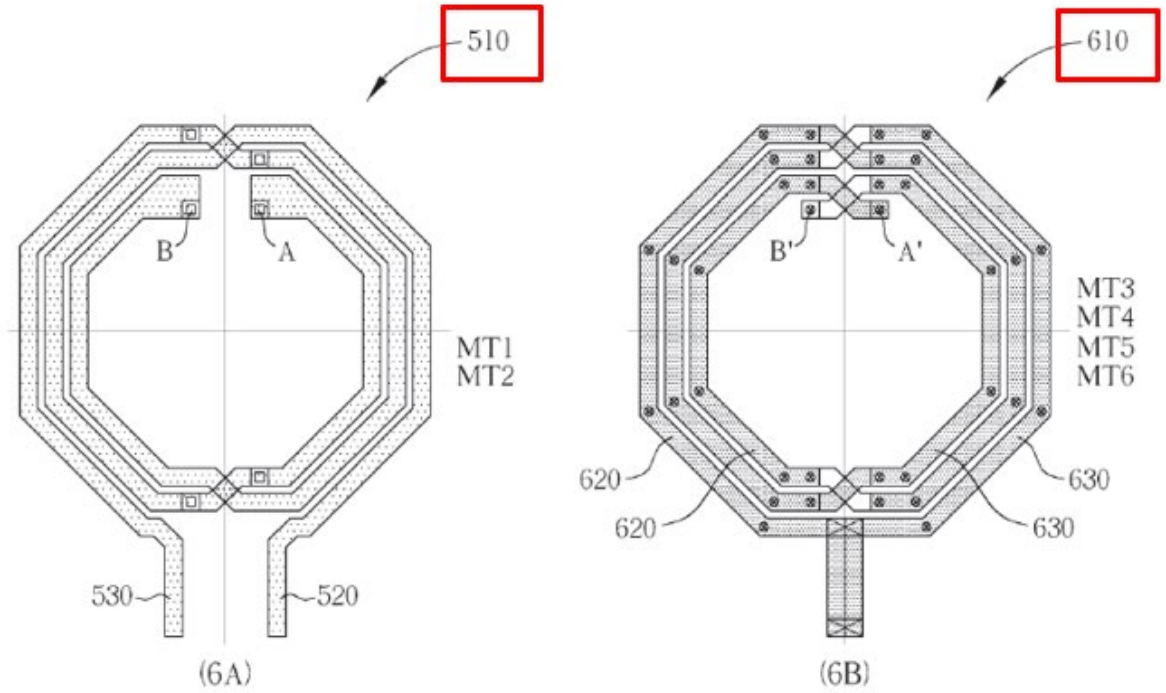


FIG. 6

Id., [Figs. 6A, 6B] (annotations added).

116. This distinction between a shunt winding and a winding in series is consistent with how a POSITA would have understood the term "shunt winding." As I explained prior, a serial winding is generally created when two or more inductor windings are constructed ***in series***. *See*, § IV.J discussion *supra*. Alternatively, a shunt winding is created when two or more inductor windings are constructed ***in parallel***. *Id.*

117. This is consistent with how the Inventors and Realtek both interpret the claim language. For instance, a Taiwanese priority document demonstrates that "shunt winding" refers to a "parallel winding." In the Taiwanese priority application, the two terms are used interchangeably. The priority document reads

in relevant part that "the first set of dielectric vias 110 form a first **parallel winding (shunt winding)** 130 of a spiral inductor 100 …" EX-1023.009 (emphasis added). In fact, "parallel" and "shunt" winding are used interchangeably in the claim language in the priority application itself, as shown below.

1. A stacked structure of a spiral inductor, comprising:

a first metal layer comprising:

a first segment;

a second segment and

a third segment connected to the first segment, a layout direction of the third segment being different from a layout direction of the second segment

a second metal layer laid out below the first metal layer comprising:

a fourth segment·

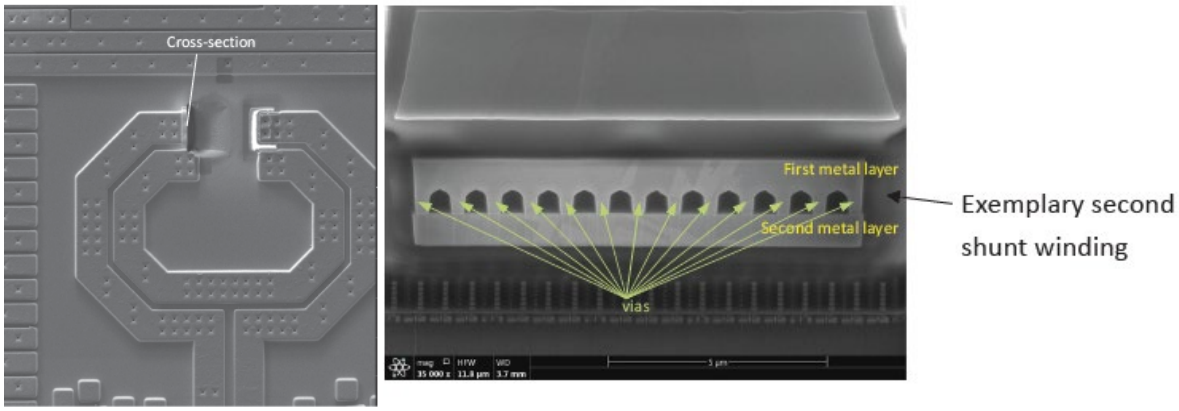
a fifth segment and

a sixth segment connected to the fifth segment a layout direction of the sixth segment being different from a layout direction of the fourth segment a first set of dielectric vias, connecting the first segment to the fourth segment and a second set of dielectric vias, connecting the second segment to the fifth segment wherein the first segment, the fourth segment and the first set of dielectric vias form a first parallel winding (shunt winding)- the second segment, the fifth segment: and the

second set of dielectric vias form a second shunt winding· and the third segment and the sixth segment form a crossover area.

Id., .023 (emphasis added).

118. Further, Patent Owner identifies the following windings as constituting a shunt winding.



EX-1022.014 (annotations retained).

119. Beyond dictionaries, patents and technical articles confirm my understanding of the meaning of "shunt windings." For example, Moinian (EX-1018) discloses an "inductor device in an integrated circuit" that has a "first, a second, a third, and a fourth metallization layer." EX-1018, [0006]. Moinian teaches that the inductor windings "comprise metal lines built into the M5-M7 metallization layers" and the metal lines of the inductor are "electrically connected together by a multiplicity of contact vias 170 so that they are ***connected in parallel with each other (i.e., they are shunted.)***". *Id*., [0022]-[0023] (emphasis added). Lutz (EX-1030) is a paper published in 1999 in the 1999 IEEE MTT-S

International Microwave Symposium Digest." EX-1030.001. Lutz discloses "multilevel spiral inductors for RFICs" (*id*., .007) and teaches that "parallel-connected spirals" are those that use "two metallization layers ***in parallel and shunted together*** by vias (MLS)." *Id*., .009 (emphasis added).

120. Accordingly, for purposes of this proceeding, my opinion is that a POSITA would have understood the term "shunt winding" to mean "windings in parallel."

VII. GROUND 1: OBVIOUSNESS BASED ON HO-HSIANG

121. Ho-Hsiang discloses multi-layer inductors used for on-chip transformer balun structures. The inductor structures disclosed in Ho-Hsiang are materially the same as the inductor claimed in the '245 patent, particularly in light of how Realtek itself interprets the claim language.

Claim 1

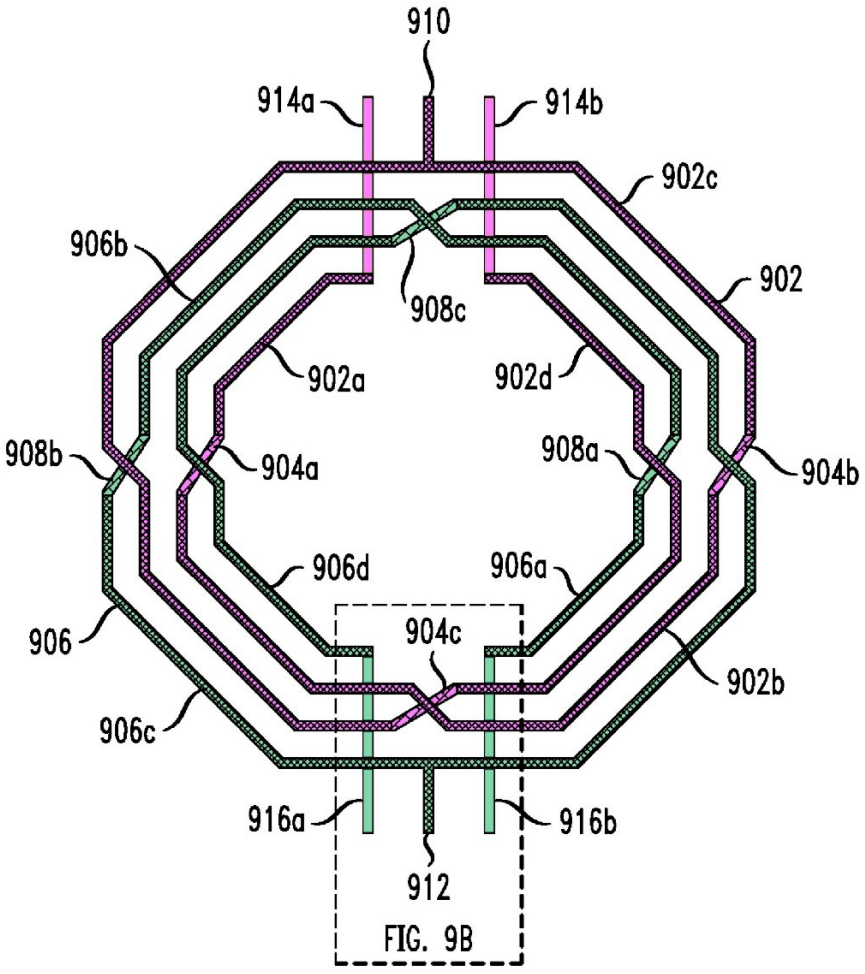
1.1 A structure of a spiral inductor, comprising:

122. To the extent this preamble of claim 1 is a limitation, Ho-Hsiang discloses a spiral inductor. For instance, Ho-Hsiang discloses that "primary inductor 302 has a center tap 310 connected to winding segment 302c located at the outer portion of the BALUN300, and center tap 312 is connected to winding segment 306c located at the outer part of BALUN 300." EX-1005, [4:42-46]. While Ho-Hsiang is directed to transformers, a POSITA would have recognized that a transformer is simply a device made of two or more inductors. *See*, § IV.C

discussion *supra*. In particular, Ho-Hsiang shows a transformer including two inductors in Fig. 9A.

123. Fig. 9A, shown below, includes a first inductor (902) and a second inductor (906), referred to as "windings." *See, e.g.*, EX-1005, [6:10-29]. For clarity, I have highlighted the two inductor structures of the transformer in Fig. 9A. Inductor 902 is highlighted in pink and inductor 906 is highlighted in green.

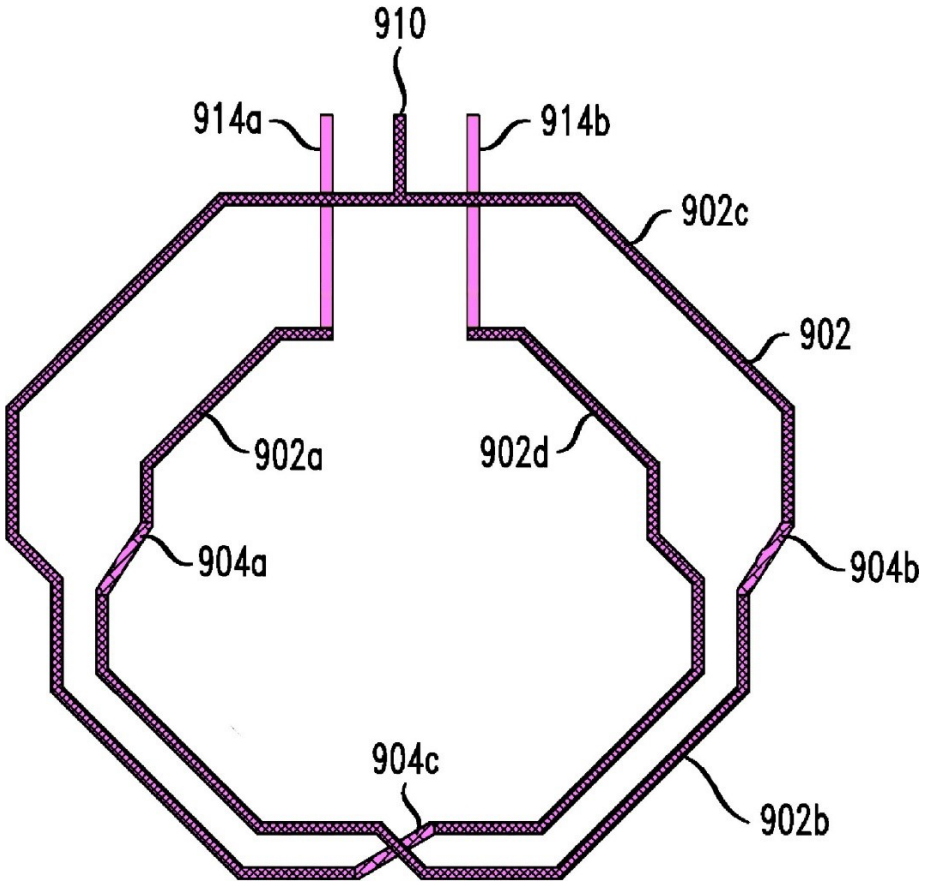
FIG. 9A



Id., [Fig. 9A] (emphasis added).

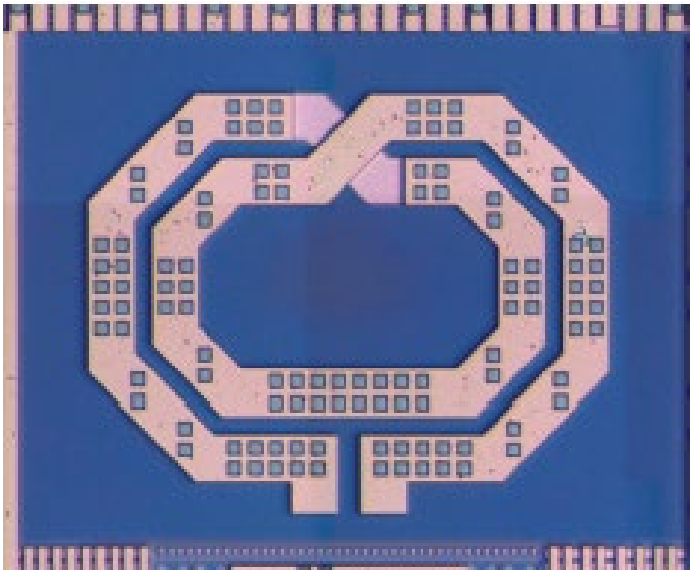
124. A POSITA would have understood that both inductor structures above (highlighted in pink and green respectively) are spiral inductors in the shape of an octagon. For clarity, I have modified Figure 9A to only show the inductor which I previously highlighted in pink. For my analysis in subsequent paragraphs, I will focus on that inductor (of which, relevant portions are also shown in Figure 9B). The below image shows the pink inductor by itself.

FIG. 9A



Id., [Fig. 9A] (modified to show only the inductor in pink, which I will focus on in subsequent paragraphs).

125. The shape of the inductor structures above is consistent with what Realtek has argued is a "spiral inductor structure," shown below, and also in the shape of an octagon.



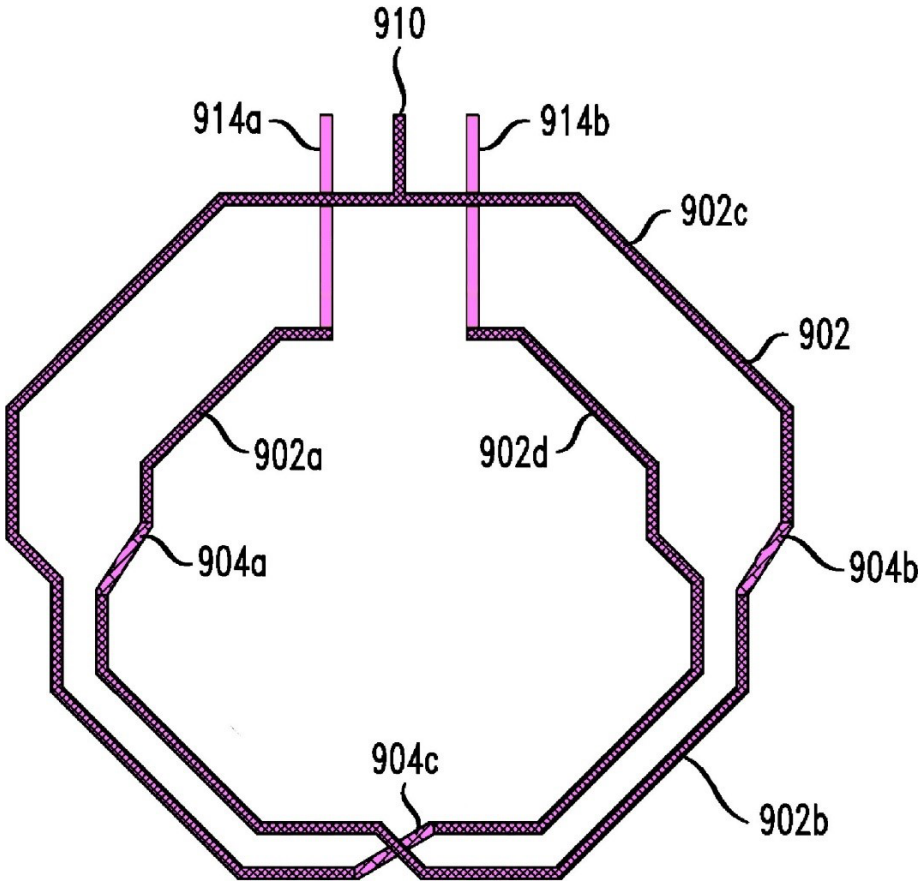
EX-1022.007.

1.2 a first metal layer, comprising:

126. A POSITA would have understood that this limitation describes a winding of the inductor being located on one metal layer, e.g., above a semiconductor substrate. This is discussed in Ho-Hsiang, which in the Summary of the Invention states that "[i]n one embodiment, an electronic device includes a first winding having a first port and a second port. The first winding formed in a first ***metal layer*** formed over a semiconductor substrate." EX-1005, [2:11-15] (emphasis added). More specifically, with respect to Figs. 9A, 9B, and 9C, Ho-Hsiang discloses that a "transformer 900 includes a ***primary winding 902***

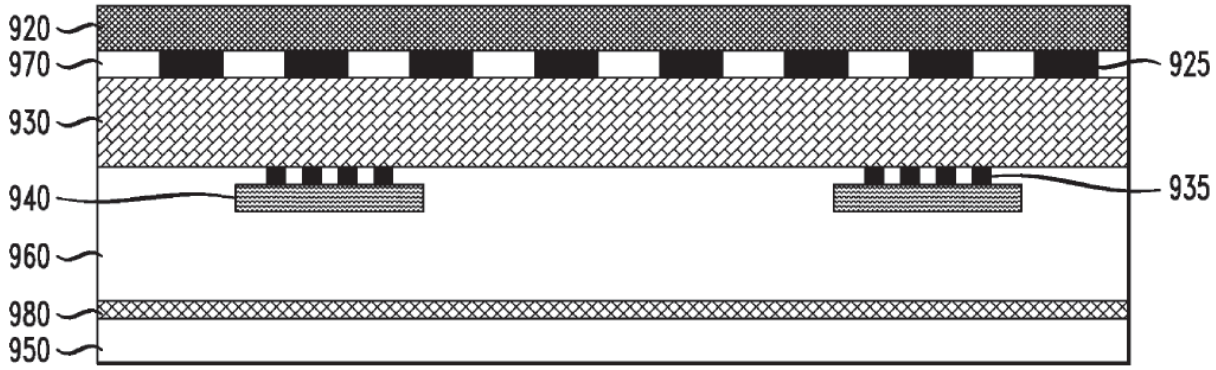
comprising winding segments 902a, 902b, and 902c, which may be formed on a ***first metal layer 920*** and a second metal layer 930." *Id.*, [6:13-17]. The winding segments of 902 are shown in pink in Fig. 9A below, formed in the first metal layer 920, as shown in Fig. 9(c).

FIG. 9A



Id., [Fig. 9A] (top view modified to only show the inductor I am focused on).

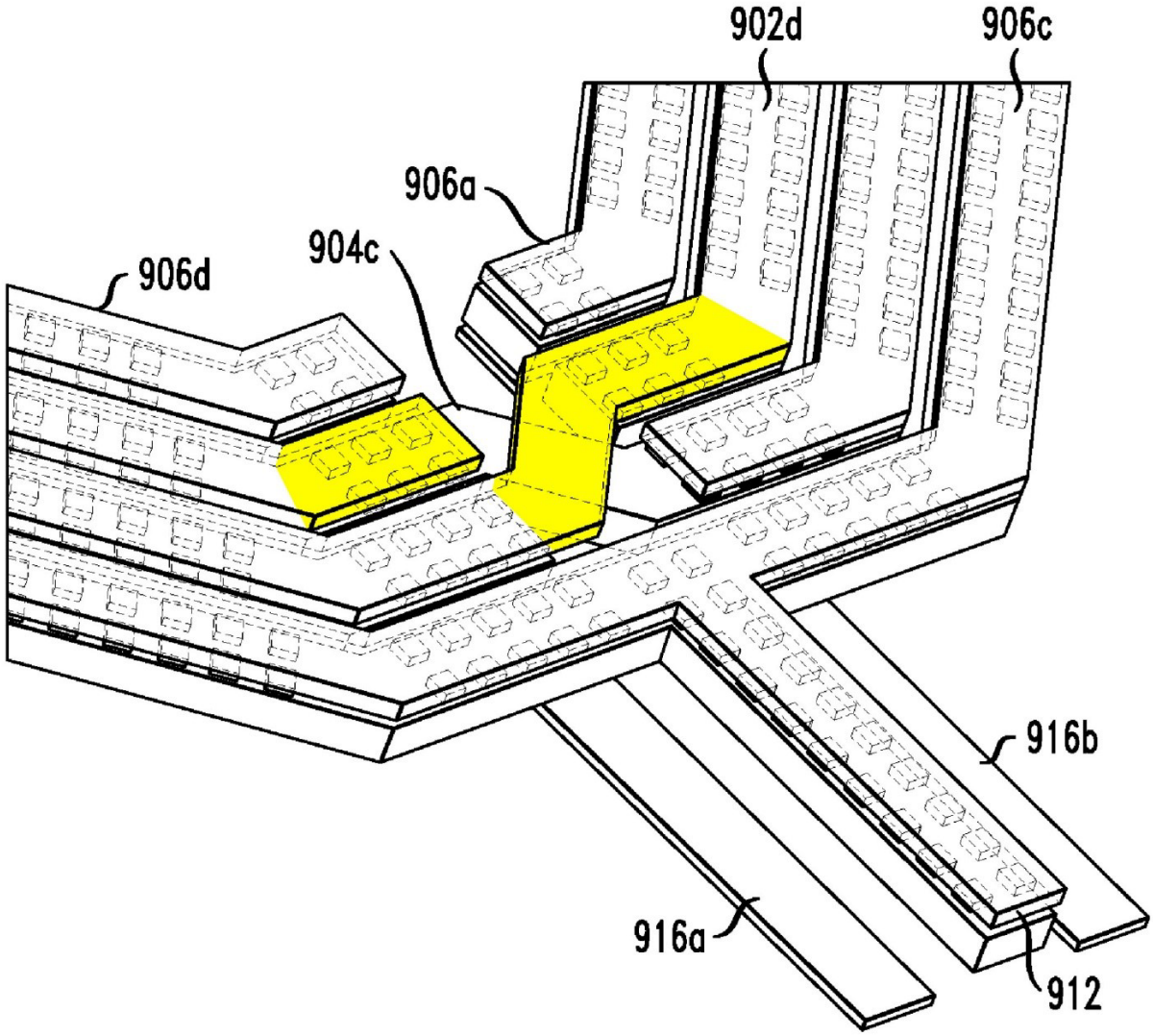
FIG. 9C



Id., [Fig. 9C]. Ho-Hsiang describes that Fig. 9C is a "cross-sectional view of the transformer 900 illustrated in Fig. 9A. As shown in Fig. 9C, the ***two metal layers 920***, 930 are vertically stacked over one another." *Id.*, [6:30-32] (emphasis added).

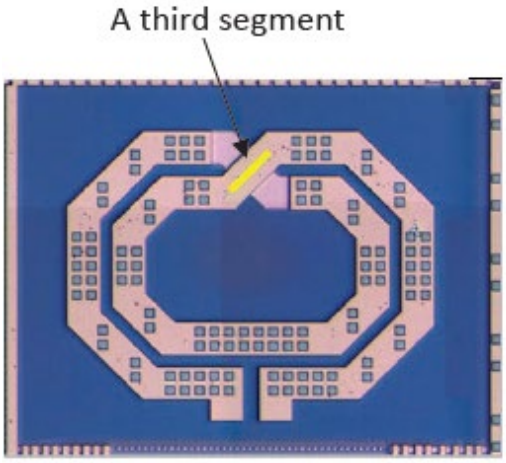
127. As Ho-Hsiang discloses, the at least some of the winding segments of 902 (e.g., 902a, 902b, 902c) are on the "first metal layer 920." *Id*., [6:15-17]. Additionally, crossover or "bridge" segments (e.g., 904a, 904b, and 904c) may be placed on the first metal layer ***or*** the second metal layer as described in Ho-Hsiang. *Id.*, [6:17-19]. This is depicted, for example, in Fig. 9B, which is an "isometric cross-sectional view of the transformer shown in Fig. 9A." *Id*., [2:66-67]. Fig. 9B is shown below, with exemplary portions of the inductor winding that are on the first metal layer highlighted in yellow.

FIG. 9B



Id., [Fig. 9B] (emphasis added).

128. This is consistent with how Realtek has interpreted the claim language. As shown below, Realtek has emphasized (also in yellow highlight) a "third segment" (a top crossover region) as being on the first metal layer.



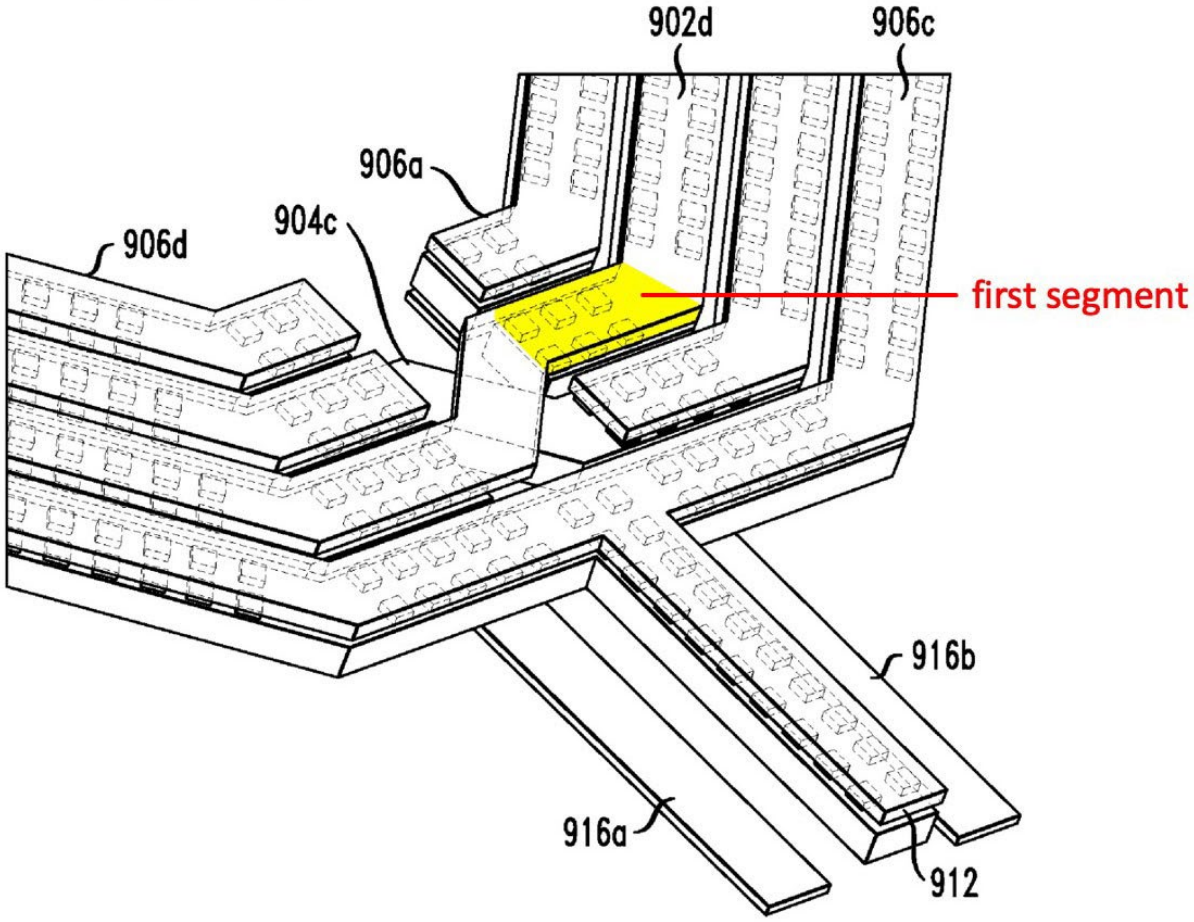
EX-1022.009 (emphasis retained).

1.3 a first segment

129. A POSITA would have understood that this limitation describes a portion or "segment" of the winding of the inductor that is on the first metal layer. The specification of the '245 patent does not appear to specifically define the term "segment" and thus I will analyze the claim language using its plain and ordinary meaning. A POSITA would have understood that a segment is a distinct portion of the winding. For example, I have highlighted a first segment of the Fig. 9B inductor below, in yellow.[1]

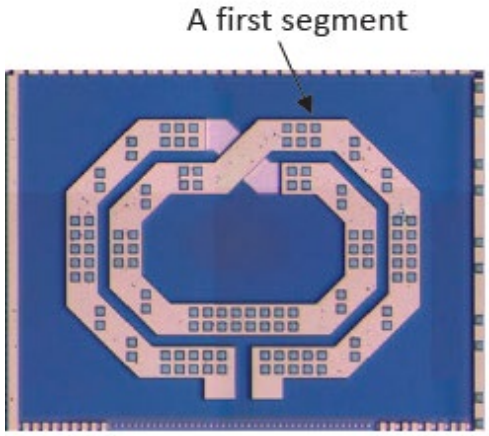
[1] For consistency, going forward I will highlight the first (upper) metal layer in yellow, including all segments of this layer. I will highlight the second (lower) metal layer in blue, including all segments of that layer.

FIG. 9B



EX-1005, [Fig. 9B] (cross-sectional view with emphasis added).

130. This interpretation is consistent with how Realtek interprets the segments (e.g., the first segment) of the winding on the first metal layer, as shown below.

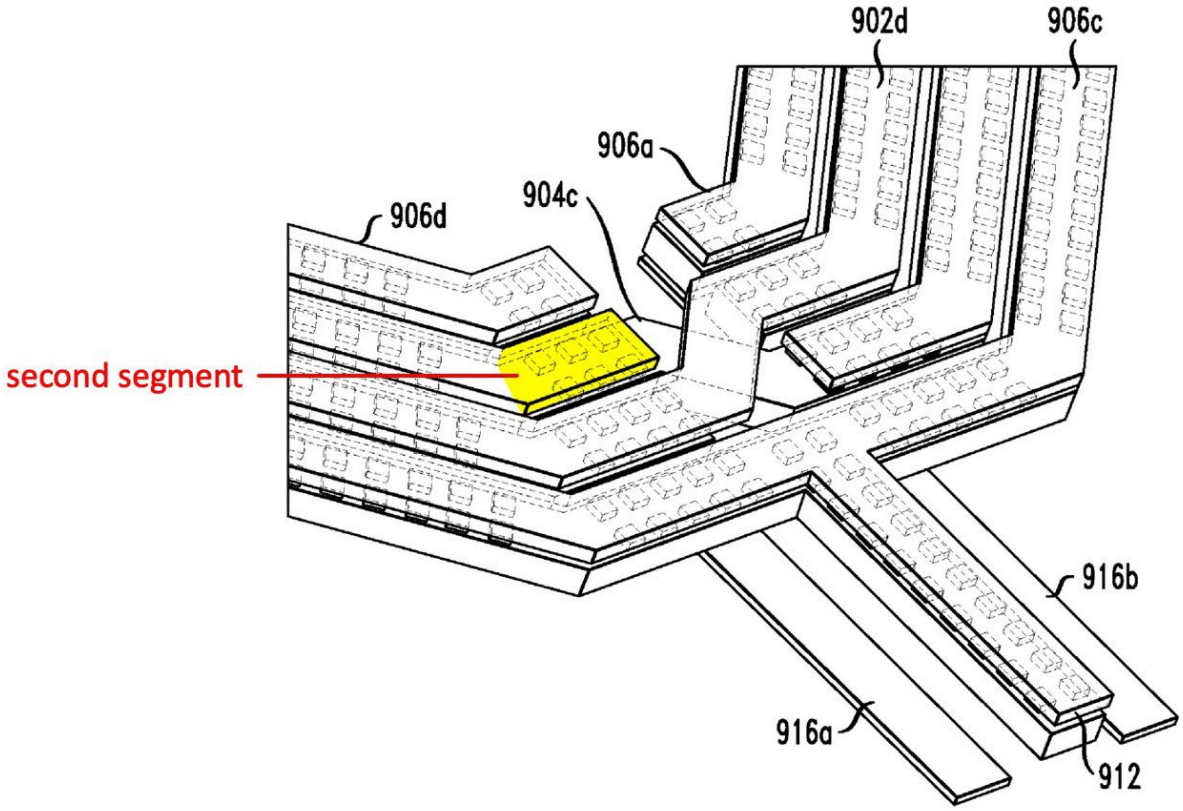


EX-1022.008 (emphasis retained).

1.4 a second segment; and

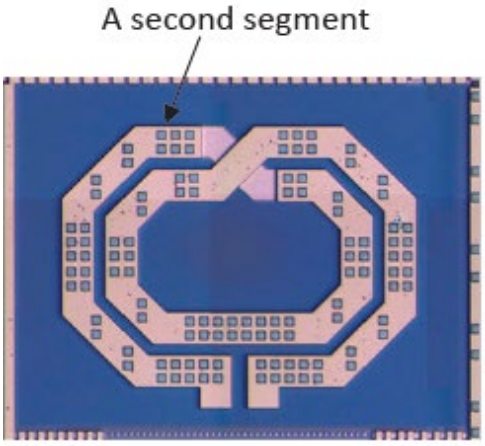
131. A POSITA would have understood that this limitation describes a second portion or "segment" of the winding of the inductor that is on the first metal layer, which is distinct from the first segment. I have highlighted the second segment of the Fig. 9B inductor below in yellow.

FIG. 9B



EX-1005, [Fig. 9B] (cross-sectional view with emphasis added).

132. This interpretation is consistent with how Realtek interprets the segments (e.g., the second segment) of the winding on the first metal layer, as shown below.



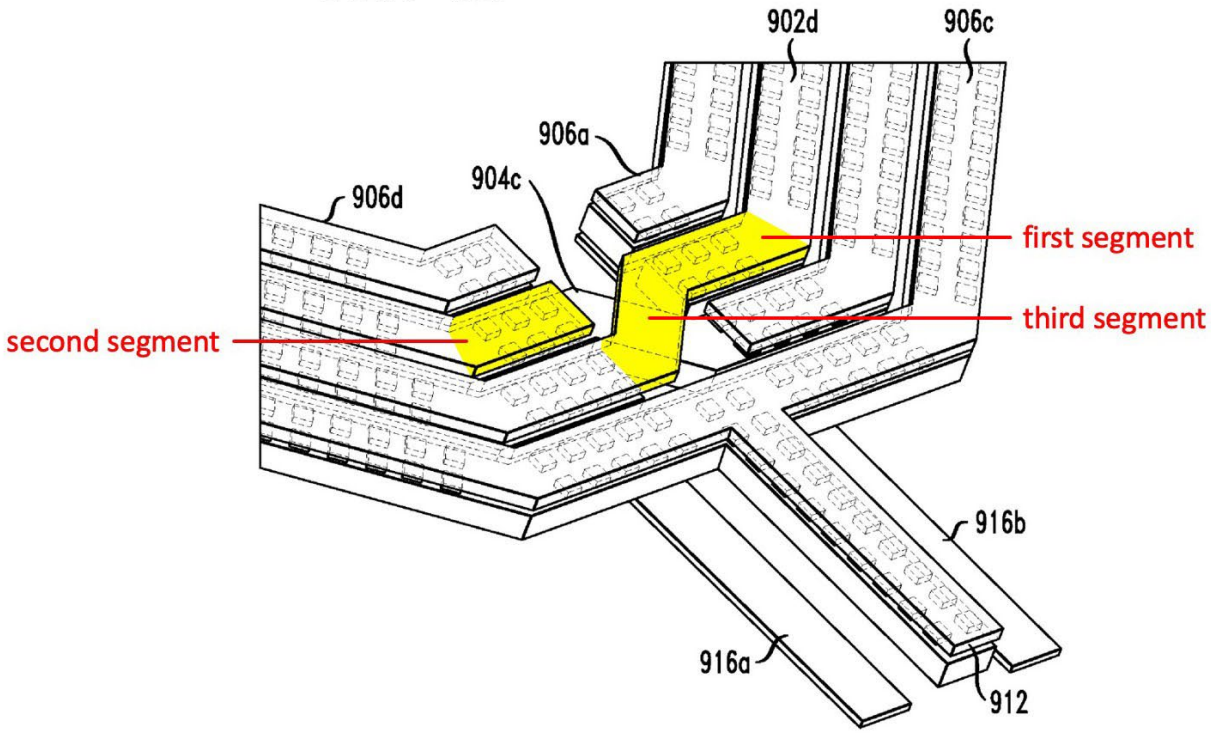
EX-1022.008 (emphasis retained).

1.5 a third segment, connected to the first segment, wherein a layout direction of the third segment is different from a layout direction of the first segment and a layout direction of the second segment;

133. A POSITA would have understood that the "third segment" is another portion of the winding found on the first metal layer that is directly physically connected to the first segment. Additionally, a POSITA would have understood that "wherein a layout direction of the third segment is ***different*** from a layout direction of the first segment and a layout direction of the second segment" means that the third segment is angled in a different direction, e.g., the axis of the third segment is offset from the other two.

134. Ho-Hsiang discloses such a third segment as shown below. In the image below, I have highlighted the third segment in yellow as well. As can be seen, the third segment is angled in a different direction than the first and second segments in yellow.

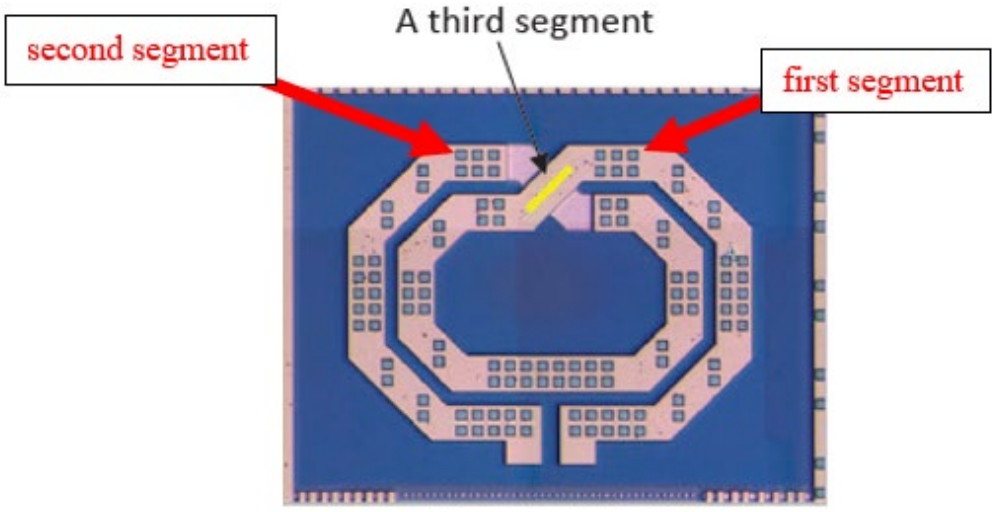
FIG. 9B



EX-1005, [Fig. 9B] (cross-sectional view with emphasis added).

135. As can be seen, the "third segment" is another portion of the winding found on the first metal layer and it is directly physically connected to the first segment.

136. This is consistent with how Realtek is interpreting the claim language. As shown below, Realtek points to the yellow highlighted portion of the winding as being the third segment, which is connected to the first segment and is positioned in a different layout direction than the first and second segments.



EX-1022.009 (annotation retained in yellow and added in red).

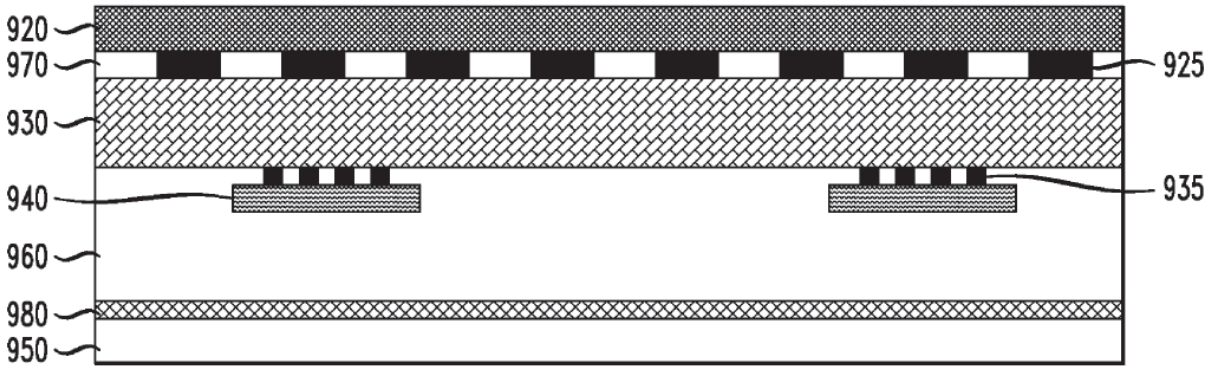
137. In the figure above, I have also added pointers showing the first and second segments. It is clear that Figs. 9A and 9B of Ho-Hsiang disclose the first, second, and third segments in a manner that is materially identical to what Realtek points to as the first, second, and third segments.

138. It is also clear that the inductor of Ho-Hsiang meets the "layout direction" claim limitation, because a POSITA would have recognized that the claim language does not require that the crossover (or "third segment") be positioned in any particular way, other than in a layout direction that is ***different*** from the layout direction of the first and second segments. This is the case in Ho-Hsiang because the third segment is positioned at an angle that is different than the first and second segments while still being connected to the first segment.

1.6 a second metal layer, being positioned under the first metal layer, the second metal layer comprising

139. A POSITA would have understood that "a second metal layer, being positioned under the first metal layer" simply means that the second metal layer is physically underneath the first metal layer. This is the case in Ho-Hsiang. Specifically, with respect to Figs. 9B and 9C, Ho-Hsiang includes a first metal layer 920 and "a second metal layer 930," formed below the first layer. *See*, EX-1005, [6:15-23]; [Fig. 9C] below.

FIG. 9C

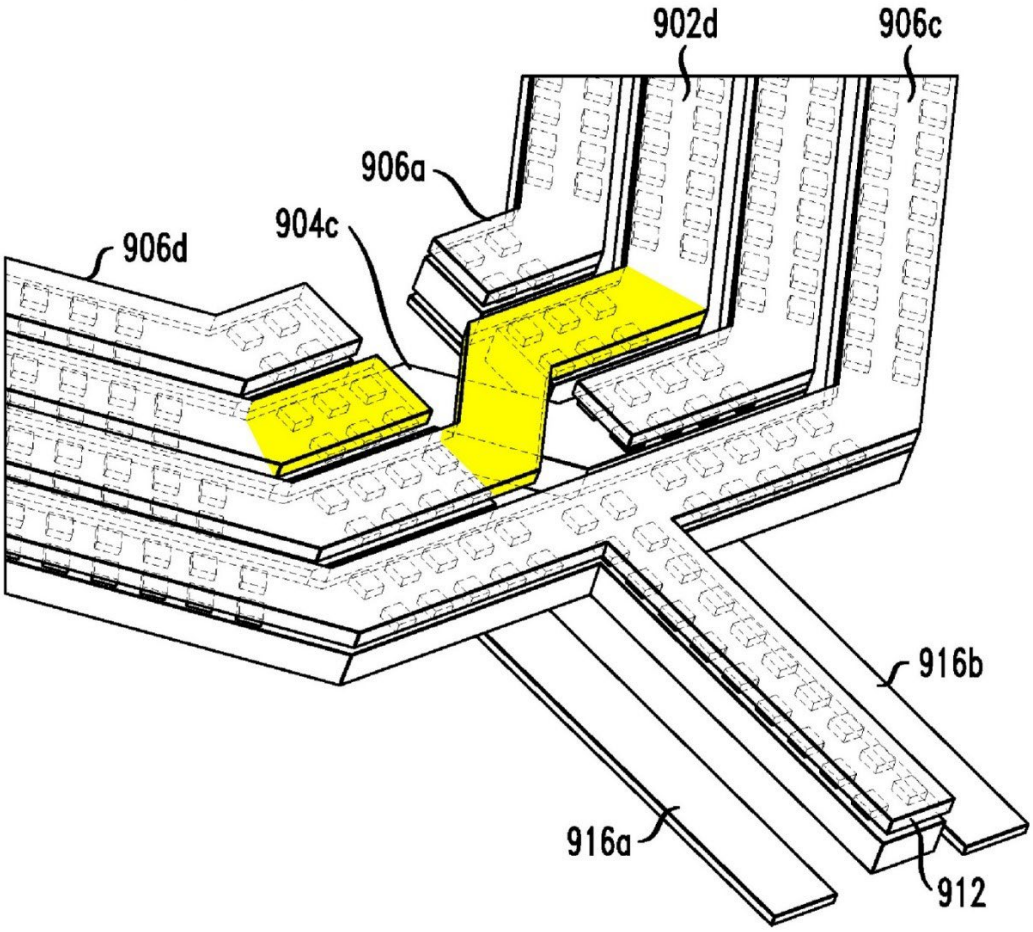


Id., [Fig. 9C] (showing "second metal layer 930" below "first metal layer 920"); [6:15-23].

140. Fig. 9B is described as "an isometric cross-sectional view" of Fig. 9A. *Id.*, [2:66-67]. Such a cross-sectional view allows us to better see the metal layers (as opposed to the top-level view of Fig. 9A, in which only the first metal layer on top is visible but for small crossover segments of the second layer that are not

directly underneath the top layer). With respect to Fig. 9B, I have again highlighted the top metal layer below (in yellow in the first and second images), which includes segments 1, 2, and 3, which I previously discussed.

FIG. 9B

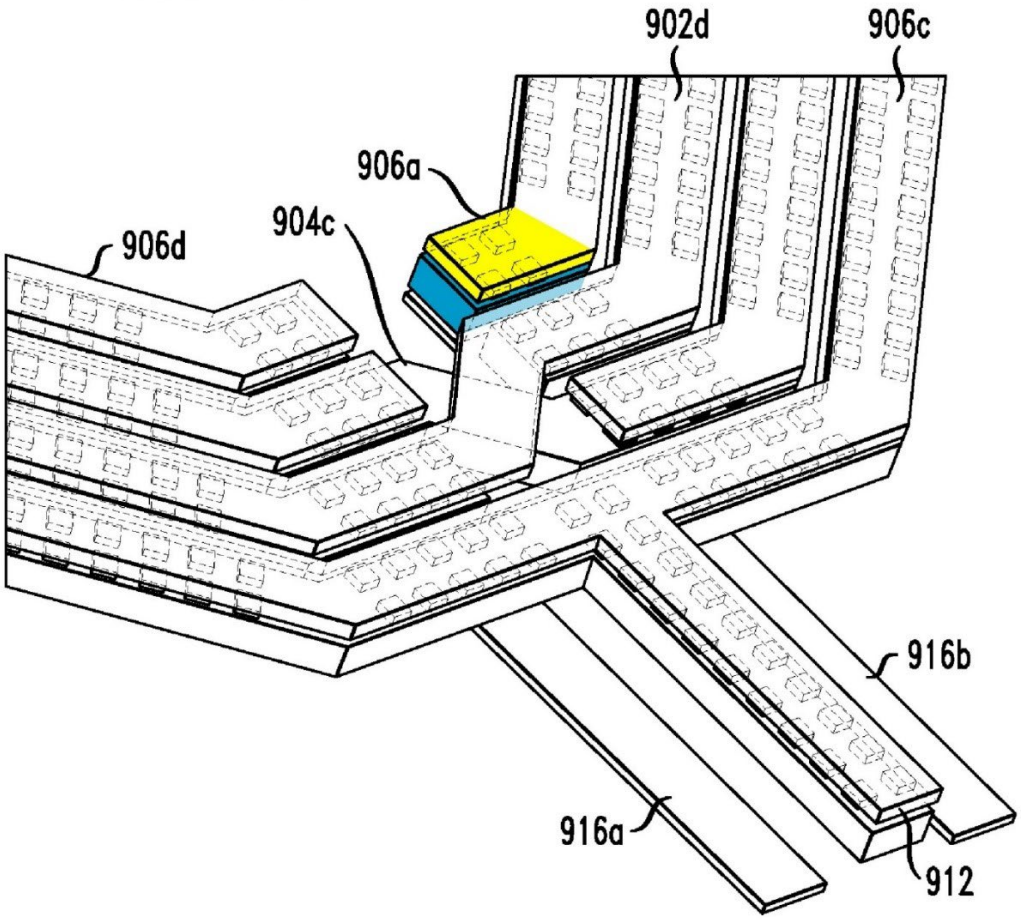


Id., [Fig. 9B] (annotations added).

141. A POSITA would have understood that the stacked structure includes the "second metal layer" (identified as 930 and shown in FIG. 9C) below this layer. I have highlighted multiple layers in Fig. 9B below. The yellow highlight

represents the top, or "first," metal layer. The blue highlight represents the lower, or "second," metal layer.

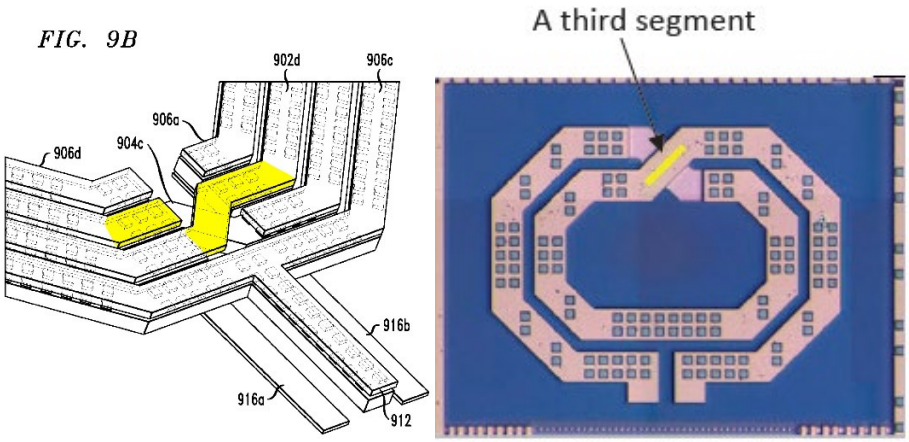
FIG. 9B



Id., [Fig. 9B] (cross-sectional view with emphasis added).

142. Because the third segment (shown again below) of the winding on the first metal layer is a crossover on the top, first metal layer, and the other crossover (which I will discuss in subsequent paragraphs) is physically below it, the second metal layer containing the other crossover (labeled 904c in Fig. 9B) is positioned

under the (yellow) first metal layer. This is how Realtek also interprets the claim language, as shown on the image on the right below.

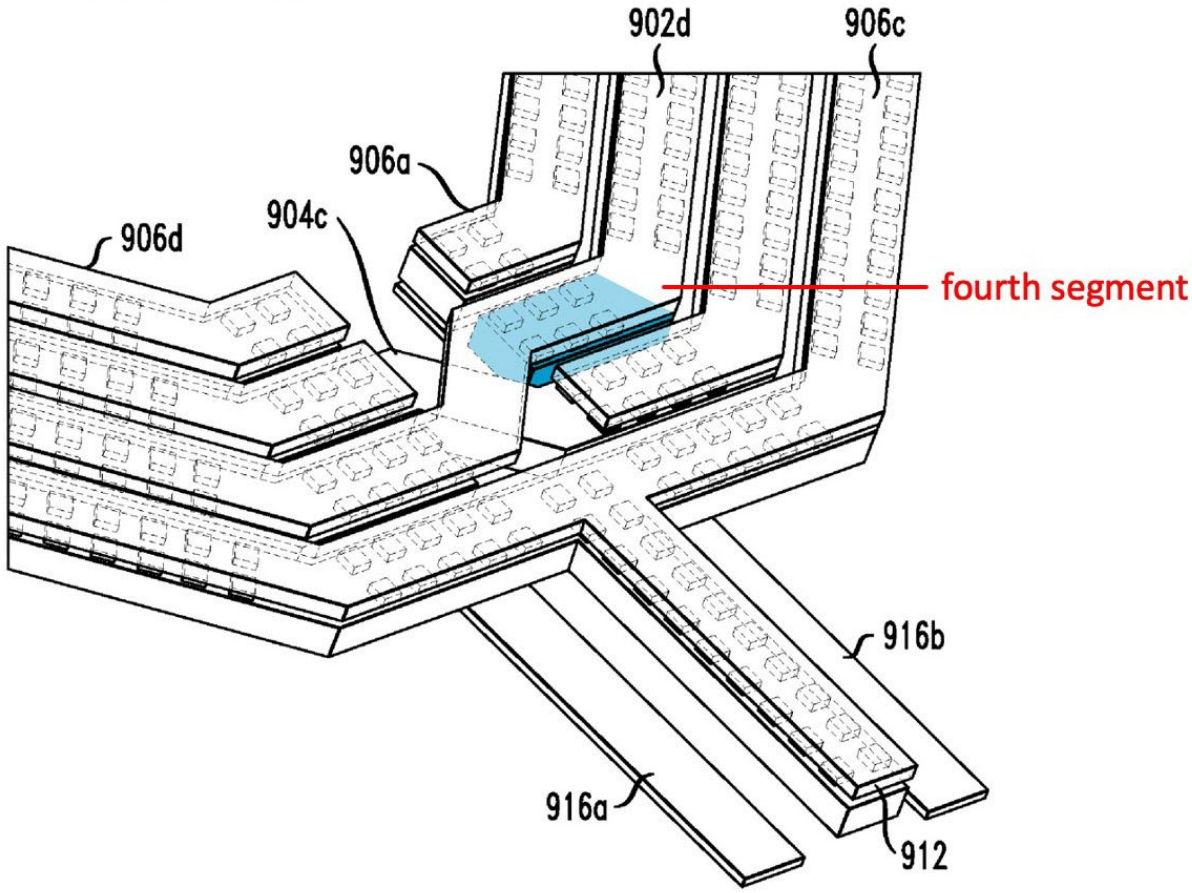


Id., [Fig. 9B] (left with emphasis added); EX-1022.009 (right).

1.7 A fourth segment

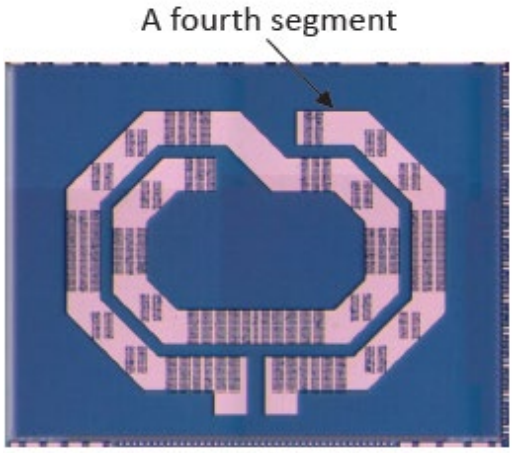
143. A POSITA would have understood that the second metal layer contains a fourth segment. I have highlighted the fourth segment of the Fig. 9B inductor below in blue. As is visible from the image below, the fourth segment is directly underneath the first segment (not colored so the fourth segment remains visible).

FIG. 9B



EX-1005 [Fig. 9B] (cross-sectional view with emphasis added).

144. This interpretation is consistent with how Realtek interprets the segments (e.g., the fourth segment) of the winding on the second metal layer, as shown below.

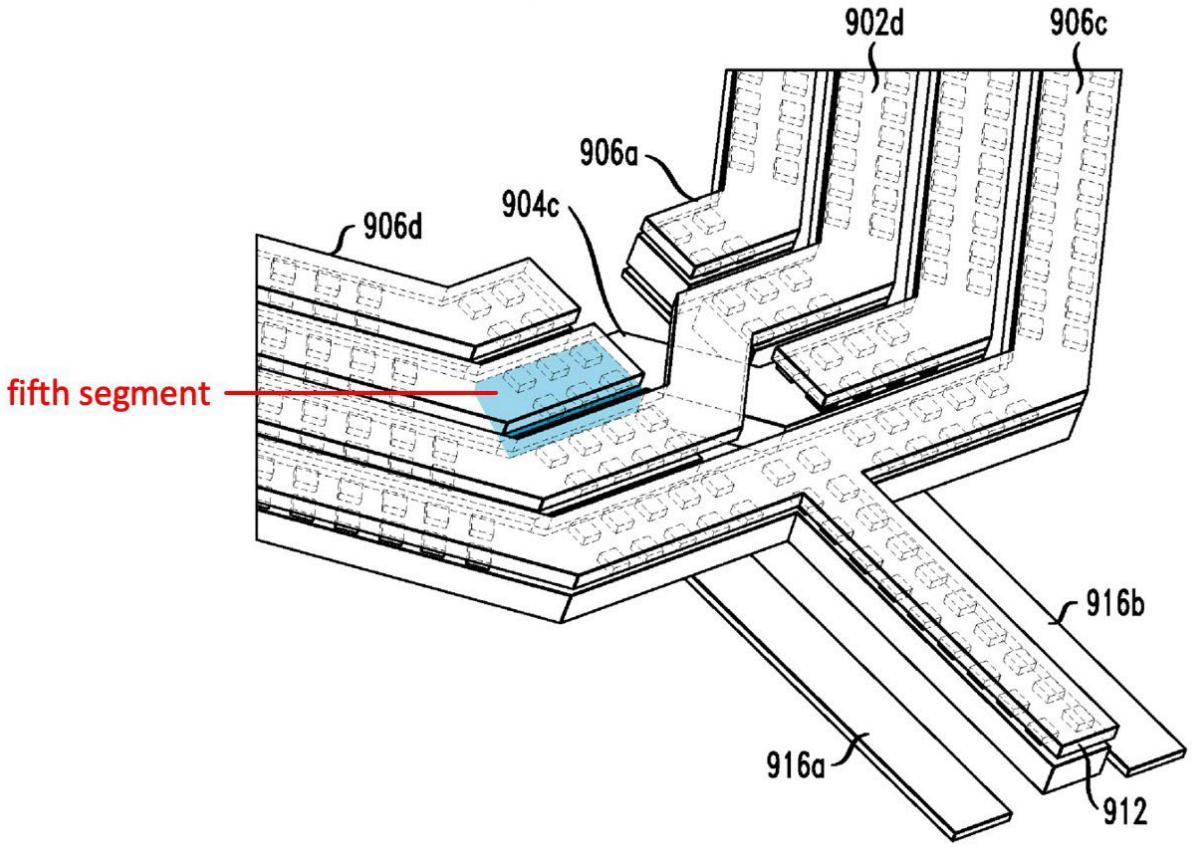


EX-1022.010 (annotation retained). Note that in the above figure, the top metal layer has been removed.

1.8 A fifth segment; and

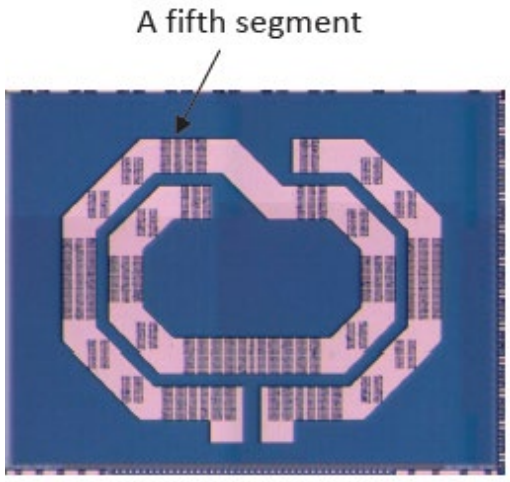
145. A POSITA would have understood that this limitation describes a fifth portion or "segment" of the winding of the inductor that is on the second metal layer, which is distinct from the fourth segment. I have highlighted the fifth segment of the Fig. 9B inductor below in blue. Again, this is directly underneath the second segment (not colored).

FIG. 9B



EX-1005, [Fig. 9B] (cross-sectional view with annotations added).

146. This interpretation is consistent with how Realtek interprets the segments (e.g., the fifth segment) of the winding on the second metal layer, as shown below.



EX-1022.010 (emphasis retained).

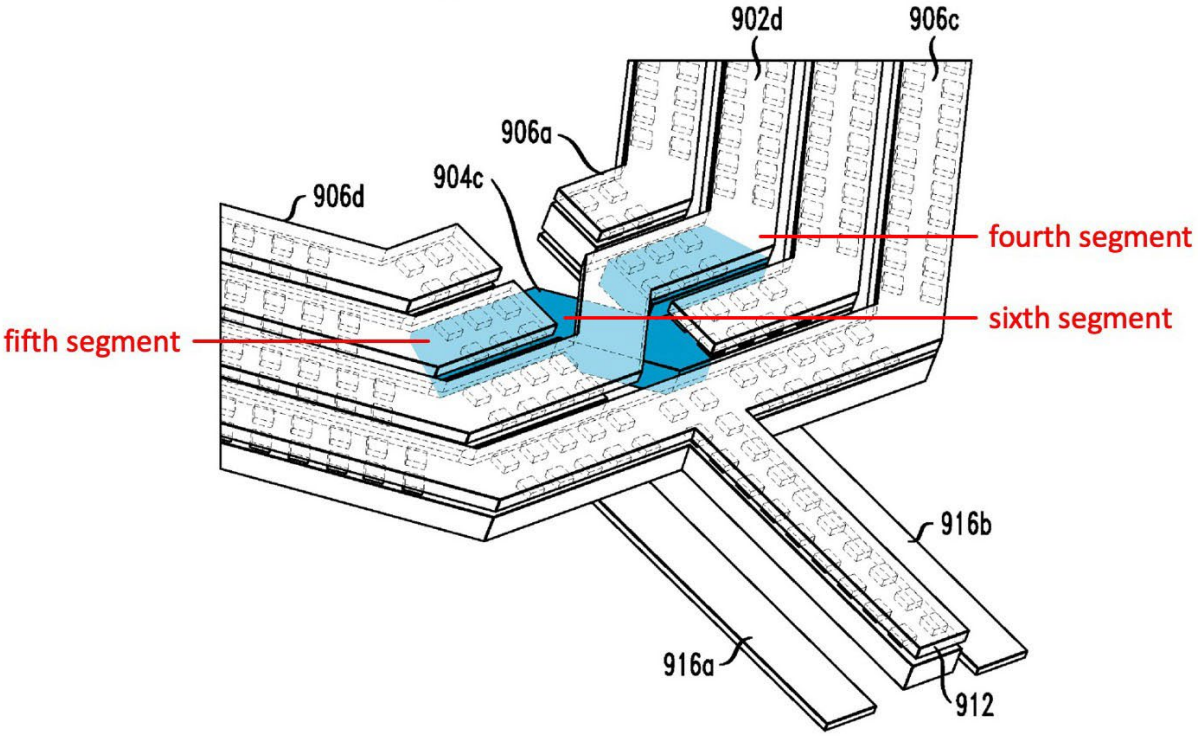
1.9 a sixth segment, connected to the fifth segment, wherein a layout direction of the sixth segment is different from a layout direction of the fourth segment and a layout direction of the fifth segment;

147. A POSITA would have understood that the "sixth segment" is another portion of the winding found on the second metal layer that is directly physically connected to the fifth segment. Additionally, a POSITA would have understood that "wherein a layout direction of the sixth segment is ***different*** from a layout direction of the fourth segment and a layout direction of the fifth segment" means that the sixth segment is angled in a different direction, e.g., the axis of the sixth segment is offset from the other two (like it was with respect to the third segment – the crossover on the upper metal layer).

148. Ho-Hsiang discloses such a sixth segment as shown below. In the image below, I have highlighted the sixth segment in blue. I have highlighted the

fourth and fifth segments, previously discussed, in blue as well. As can be seen, the sixth segment in blue is angled in a different direction than the fourth and fifth segments. Some of the sixth segment is shown in darker blue to emphasize the fact that there is no top metal layer directly above it in those portions of the sixth segment.

FIG. 9B

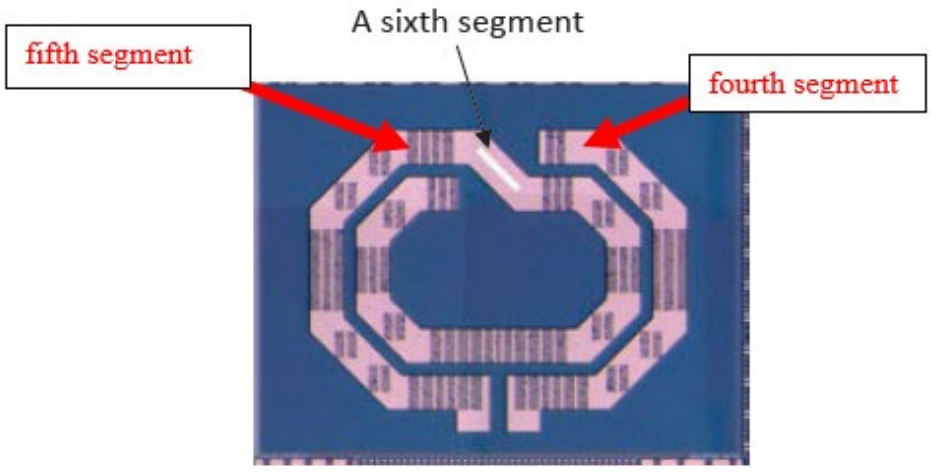


EX-1005, [Fig. 9B] (cross-sectional view with annotations added).

149. As can be seen in the image above, the "sixth segment" is another portion of the winding found on the second metal layer and it is directly physically connected to the fifth segment on its left side.

150. This is consistent with how Realtek is interpreting the claim language. As shown below, Realtek points to the white highlighted portion of the winding as

being the sixth segment, which is connected to the fifth segment and is positioned in a different layout direction than the fourth and fifth segments.



EX-1022.010 (annotations retained in white and added in red).

1.10 A first set of vias, for connecting the first segment with the fourth segment; and

151. A POSITA would have understood that Ho-Hsiang discloses a first set of vias for connecting the first segment with the fourth segment. Ho-Hsiang shows these vias in Figs. 9B and 9C, which are additional views of Fig. 9A, as I previously discussed. Fig. 9C is a "cross-sectional view of the transformer 900 illustrated in Fig. 9A." EX-1005, [6:30-31]. The specification further states:

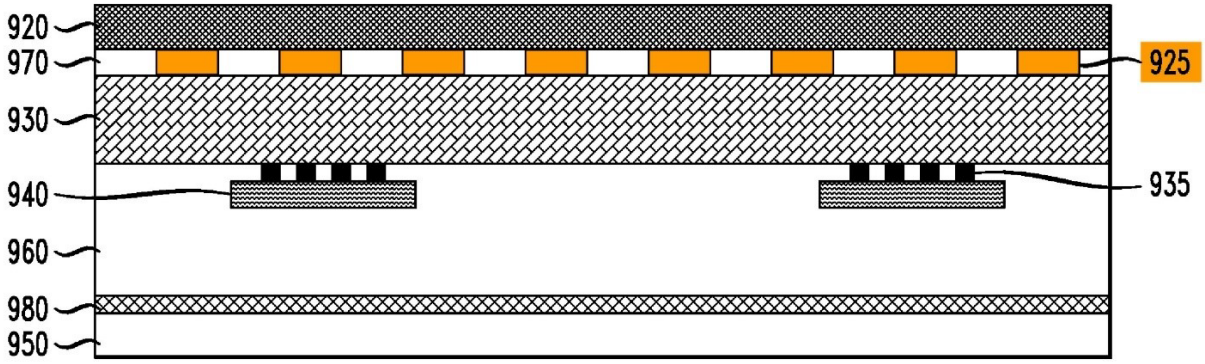
> As shown in FIG. 9C, the two metal layers 920, 930 are vertically stacked over one another. In some embodiments, ***metal layers 920 and 930 are connected by one or more vias*** 925 formed in a first dielectric layer 970 that separates metal layers 920 and 930. A third metal layer

940 is formed below the first and second metal layers 920,930 in dielectric layer 960. Examples of dielectric materials suitable for these layers include, but are not limited to, SiO, PSG, BPSG, and SiN. In some embodiments, one or more vias 935 may connect the second metal layer 930 and the third metal layer 940.

Id., [6:31-41].

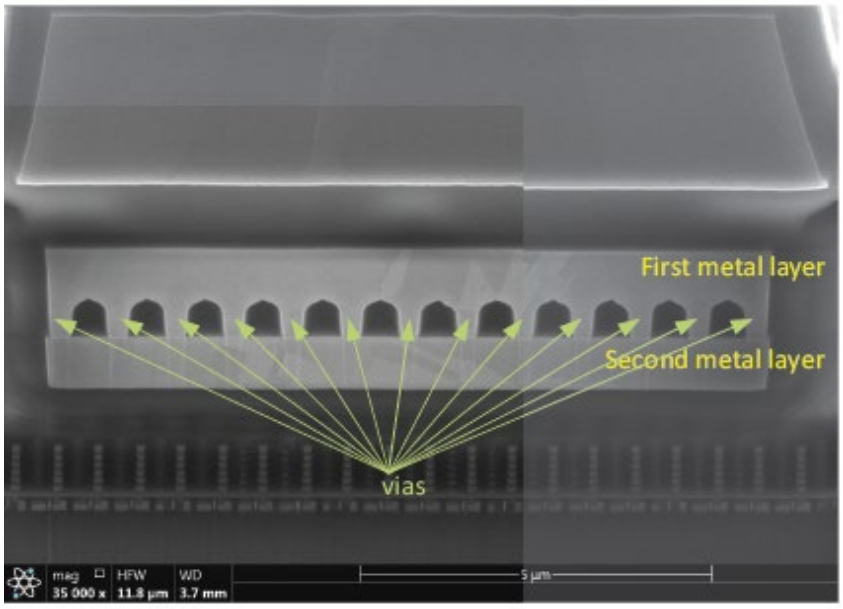
152. The vias (925) connect metal layer 1 (where the first segment resides) with metal layer 2 (where the fourth segment resides) This is shown in Fig. 9C below. I have highlighted vias 925 in orange.

FIG. 9C



Id., [Fig. 9C] (emphasis added).

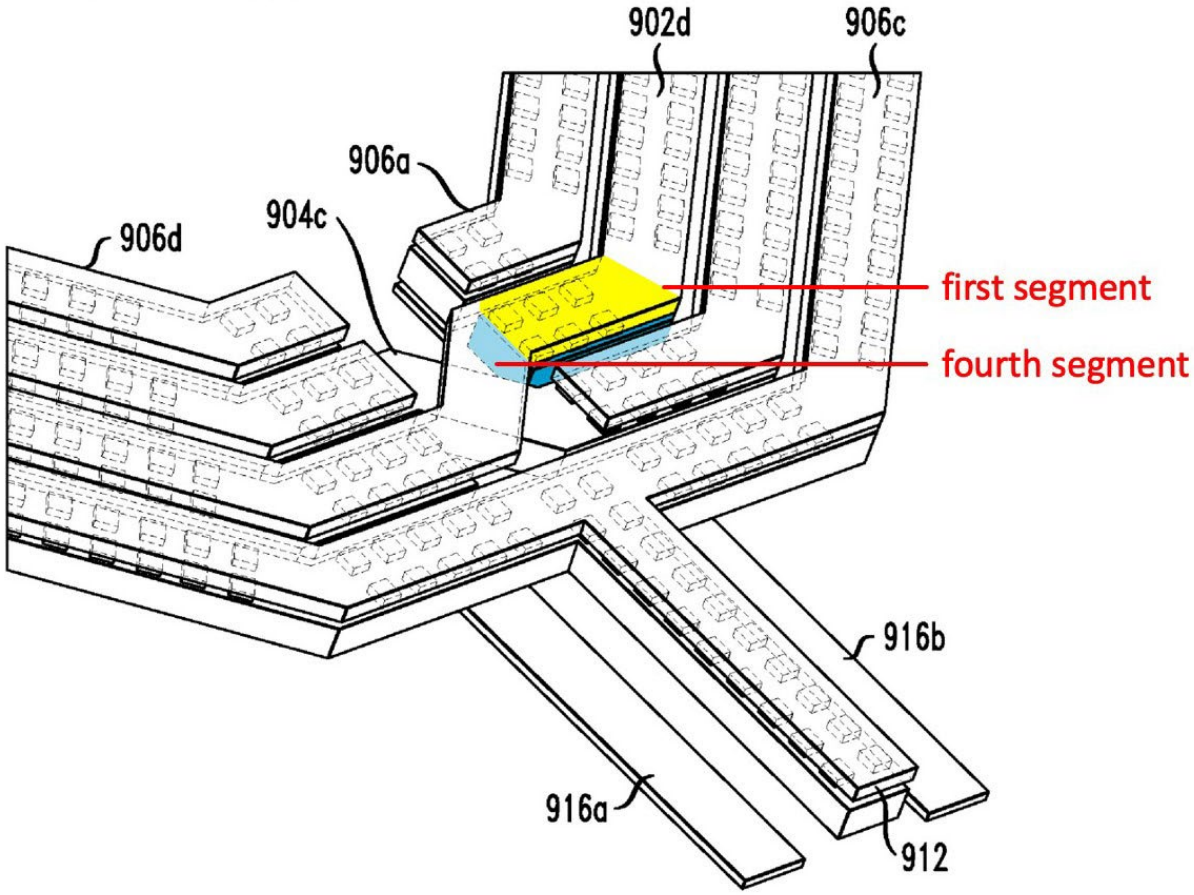
153. This is consistent with Realtek's interpretation of the vias. Below, Realtek depicts a cross-sectional view showing vias consistent with its interpretation of the claim language.



EX-1022.012 (emphasis retained).

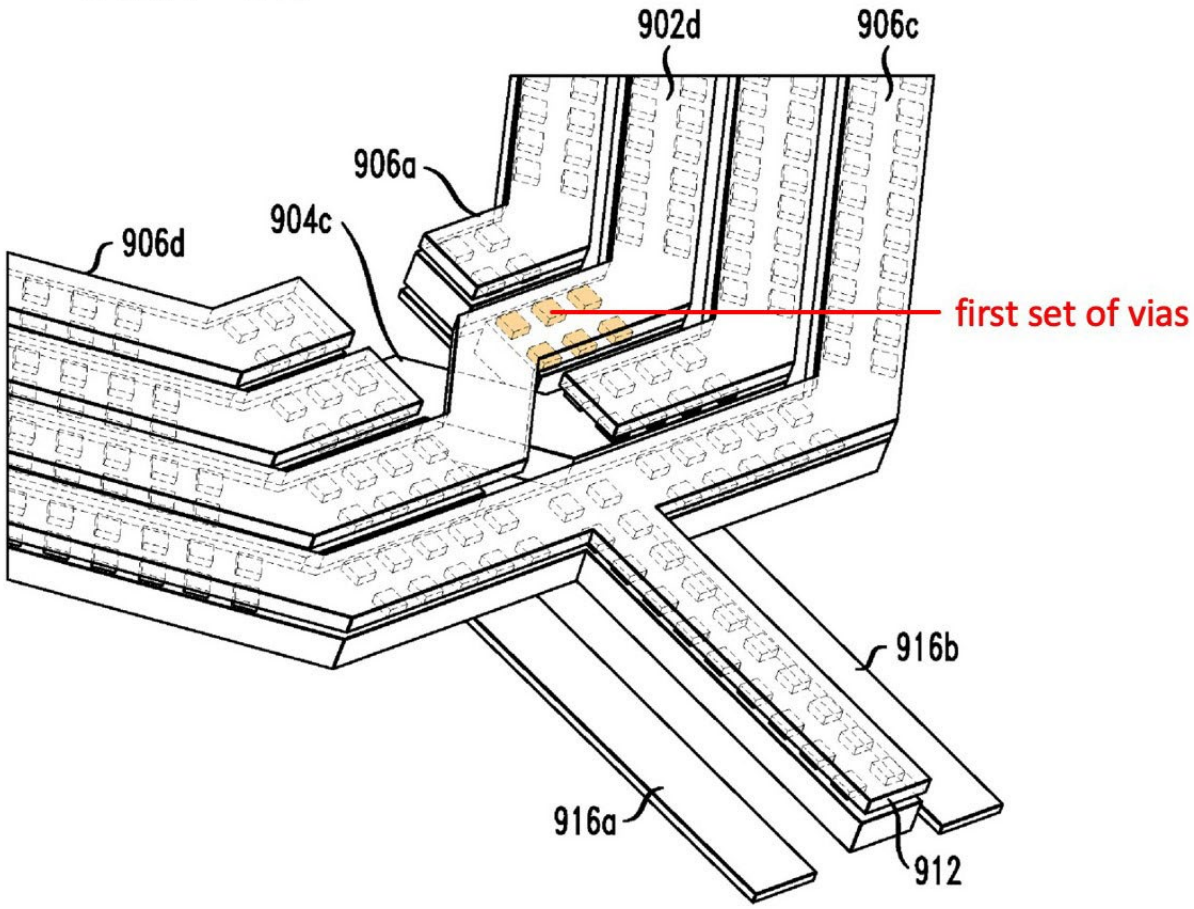
154. Furthermore, the positioning of the vias connects the first and fourth segments specifically, as shown in Fig. 9B. As I discussed prior, the first and fourth segments are to the right of the crossover structure. The vias are shown in Fig. 9B, highlighted in orange below. A POSITA would have understood that the squares running through the winding represent the vias, which connect the first and second metal layers (and therefore the first and fourth segments) consistent with Ho-Hsiang's description of Fig. 9C. *See, e.g.,* EX-1005, [6:31-41]. I have reproduced Fig. 9B twice immediately below. The first and fourth segments are shown in Fig. 9B below in yellow and blue, respectively. The vias are highlighted in orange.

FIG. 9B



Id., [Fig. 9B] (cross-sectional view with emphasis added).

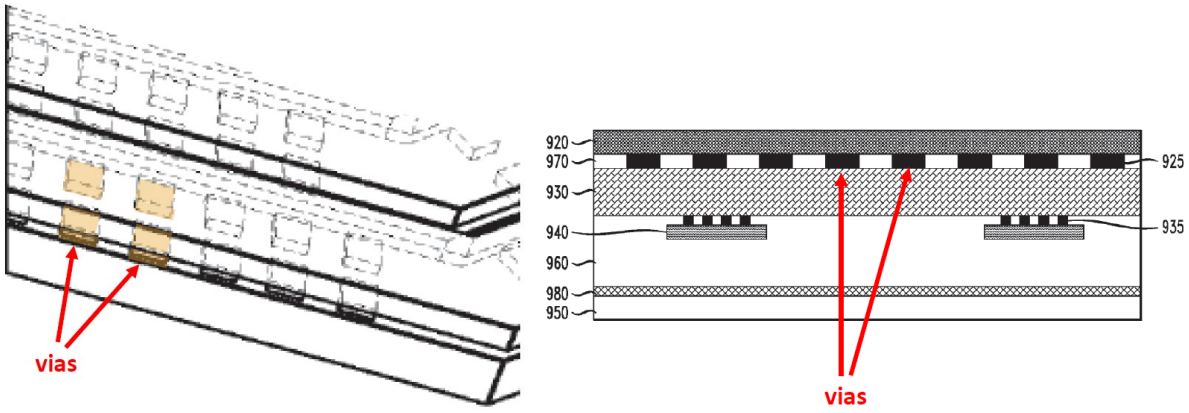
FIG. 9B



Id., [Fig. 9B] (cross-sectional view with emphasis added).

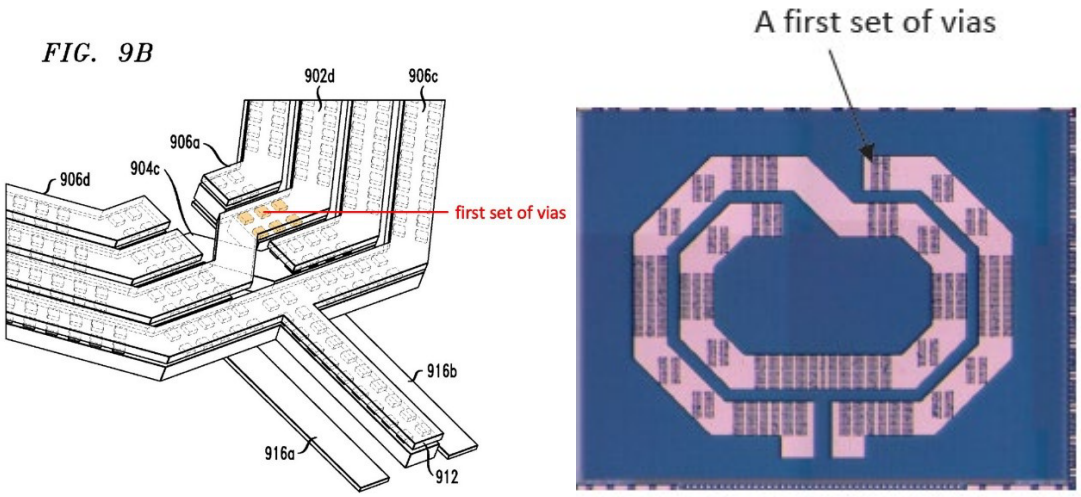
155. A POSITA would have understood that the boxes shown throughout Fig. 9B (and emphasized in orange with respect to the first set of vias) are the same types of vias shown in Fig. 9C. Not only does the specification emphasize this fact (*see id.*, [6:31-41]), but it is visually apparent when zooming in on Fig. 9B as I have done below. In the Fig. 9B image below (left) you can see an exposed side of the various layers. It would have been clear to a POSITA that the black lines correspond to the boxes which represent the vias. These clearly correspond to the

black dashes marked 925 of Fig. 9C (right), which are identified as vias (*see* Ho-Hsiang, 6:30-35). More specifically, with respect to the illustration below, the two boxes highlighted in orange in Fig. 9B on the left correspond to the vertical black lines 925 in Fig. 9C on the right, which are identified as vias. *Id.*, [6:31-41]. To be clear, the images below are for illustration purposes only. The other boxes represent vias as well.



Id., [Fig. 9B] (partial image on left with annotations added); [Fig. 9C] (right with annotations added).

156. Furthermore, the set of vias (highlighted below in the left image) of Fig. 9B is positioned in a location consistent with how Realtek interprets the claim language. For example, Realtek argues that the first set of vias is located at the first segment/fourth segment near the third segment (below image on the right).



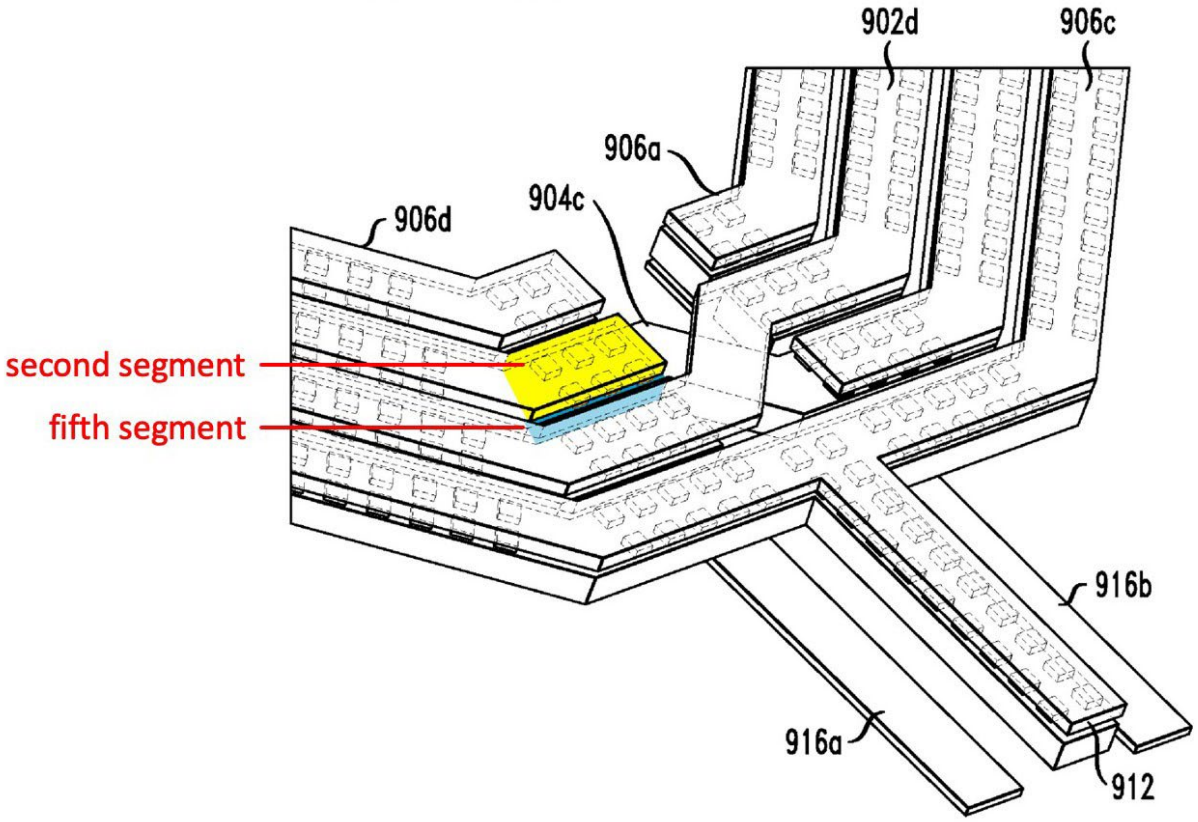
Id., [Fig. 9B] (emphasis added on left); EX-1022.011 (emphasis retained on right).

1.11 A second set of vias, for connecting the second segment with the fifth segment;

157. A POSITA would have understood that Ho-Hsiang discloses a second set of vias for connecting the second segment with the fifth segment for the same reasons I previously discussed with respect to the first set of vias. I incorporate my analysis by reference herein. Ho-Hsiang shows these vias in Figs. 9B and 9C, which both relate to Fig. 9A as I discussed previously.

158. In the image below, I show the second segment on the first metal layer (emphasized in yellow) above the fifth segment (emphasized in blue) on the second metal layer.

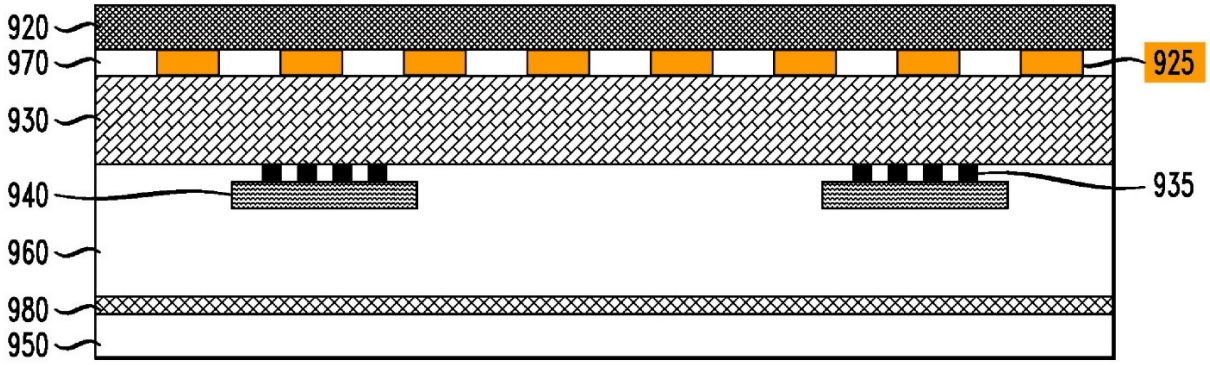
FIG. 9B



EX-1005, [Fig. 9B] (cross-sectional view with emphasis added).

159. The vias (925) connect metal layer 1 (where the second segment resides) with metal layer 2 (where the fifth segment resides). This is shown in Fig. 9C below, which I have again highlighted in orange.

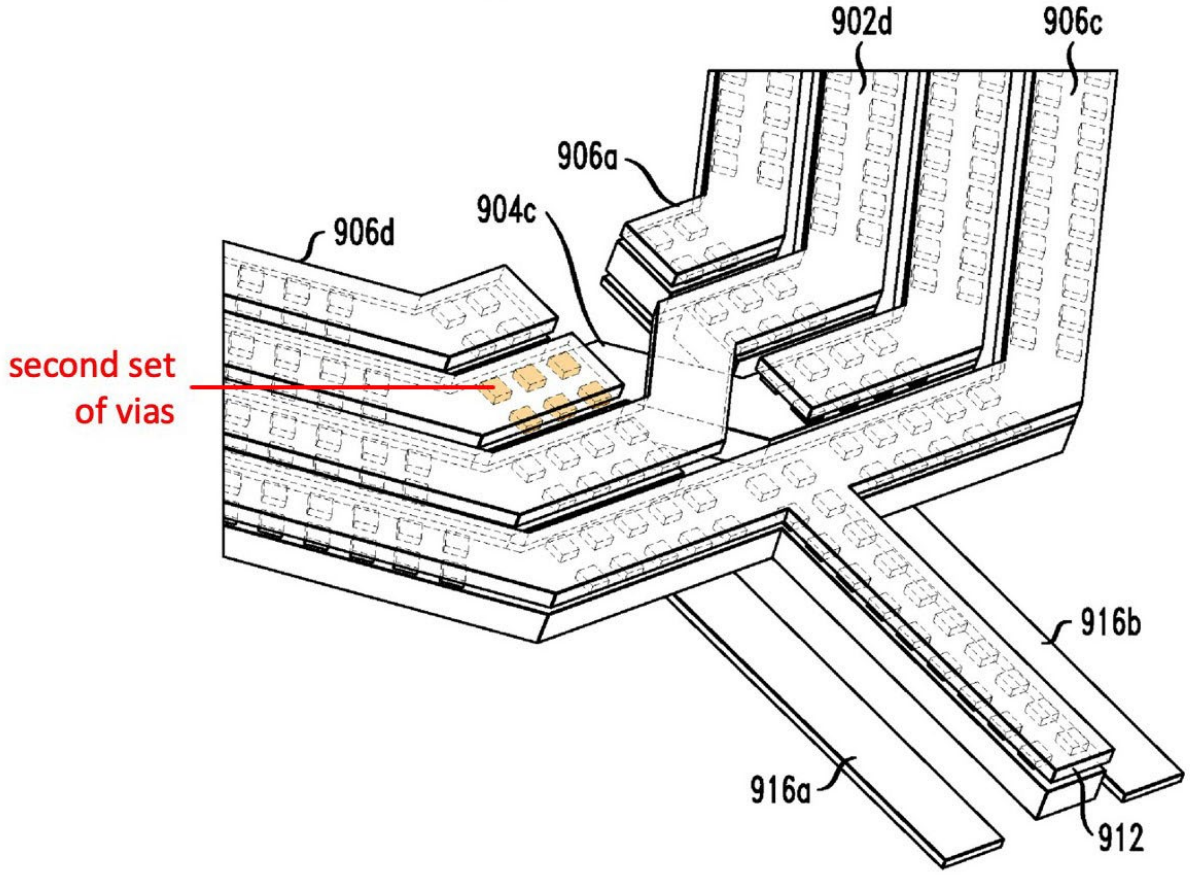
FIG. 9C



Id., [Fig. 9C] (emphasis added).

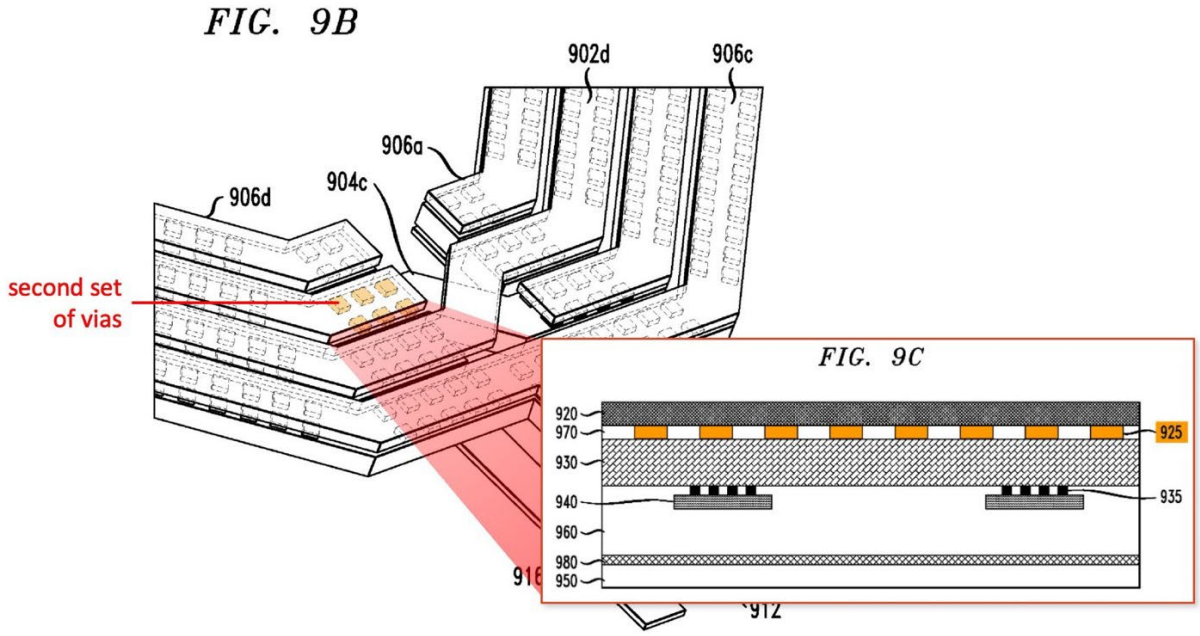
160. Again, a POSITA would have understood that the squares running through the winding represent the vias, which connect the first and second metal layers consistent with Ho-Hsiang's description of Fig. 9C. *See, e.g., id.*, [6:31-41]. I have emphasized these vias in orange in the image below.

FIG. 9B



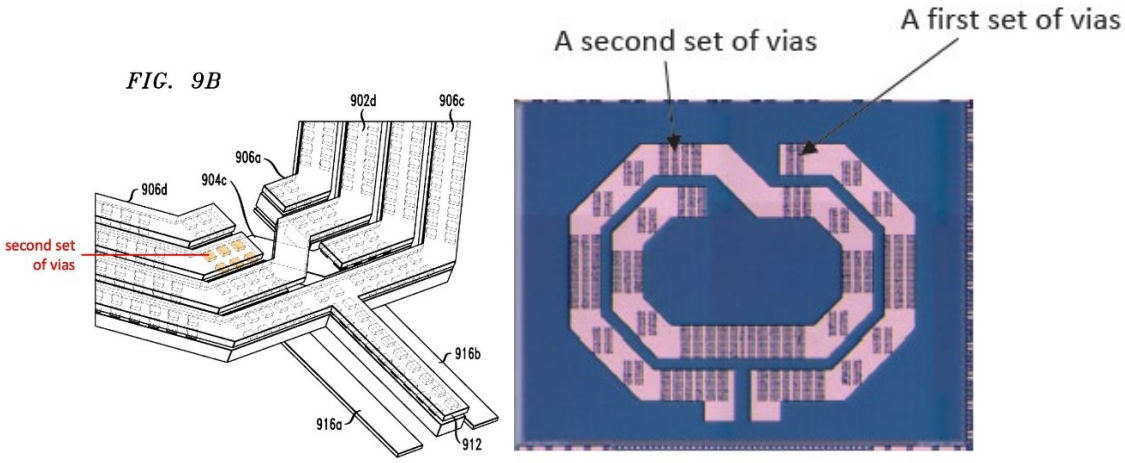
Id., [Fig. 9B] (cross-sectional view with emphasis added).

161. These are the same types of vias discussed with respect to Fig. 9C. I have emphasized this below.



Id., [Figs. 9B and 9C] (emphasis added).

162. Furthermore, the set of vias (highlighted above) of Fig. 9B is positioned in a location consistent with how Realtek interprets the claim language. For example, Realtek argues that the second set of vias is located at the second segment/fifth segment near the third segment.



Id., [Fig. 9B] (emphasis added on left); EX-1022.012 (emphasis retained on right).

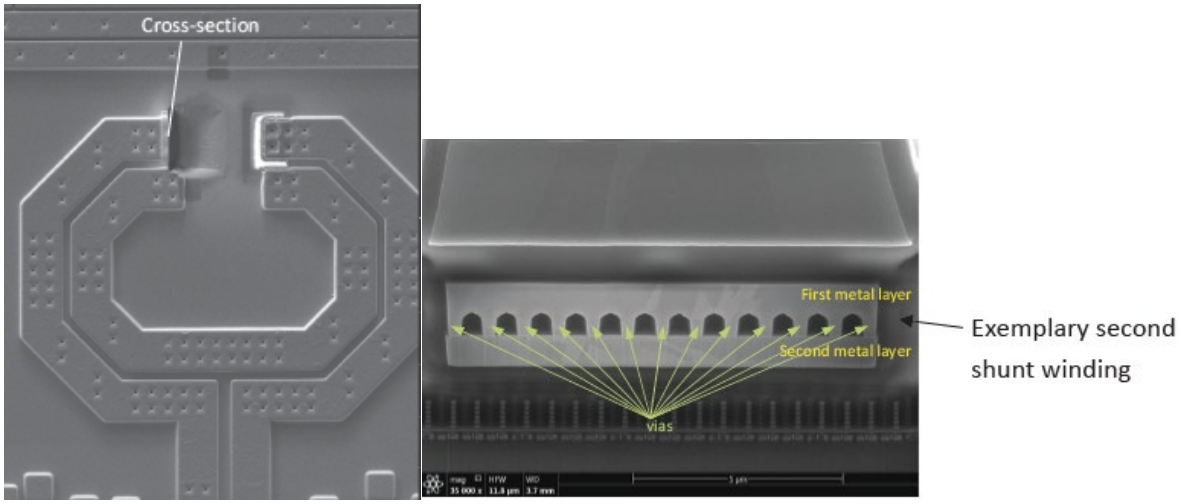
1.12 wherein the first segment, the fourth segment and the first set of vias construct a first shunt winding;

163. As I discussed previously, a POSITA would have understood that a "shunt winding" means windings in parallel. *See*, § VI.A discussion *supra*. Realtek interprets the claim language to be that a first segment connected to fourth segment by vias on two metal layers forms a shunt winding. It specifically argues that a first segment, fourth segment, and first set of vias with a "substantially similar structure" to the image below constructs a shunt winding.

> The cross-section images below show that the second segment, the fifth segment, and the second set of vias construct an exemplary second shunt winding. (On information and belief, a cross section taken in the area of the first segment, the fourth segment, and the first set of vias, would show a substantially similar structure, thereby establishing that the first segment, the fourth segment and the first set of vias construct an exemplary first shunt winding.

EX-1022.013 (emphasis added in highlight).

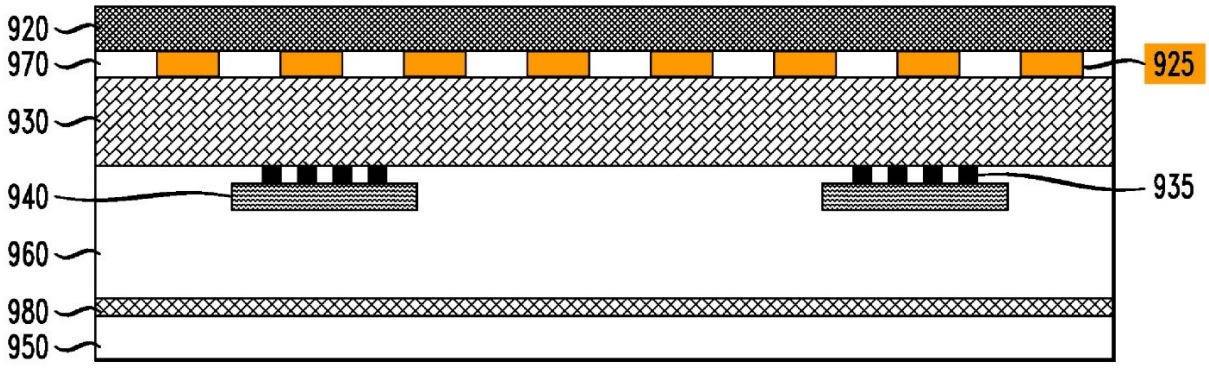
164. The structure referenced in the cross-section images below shows, e.g., a first and fourth segment in parallel (one above the other on a first and second metal layer respectively) with vias connecting the first and second metal layers. Similarly, the second and fifth segments are in parallel (one above the other on a first and second metal layer respectively) with vias connecting the first and second metal layers.



EX-1022.014 (emphasis retained).

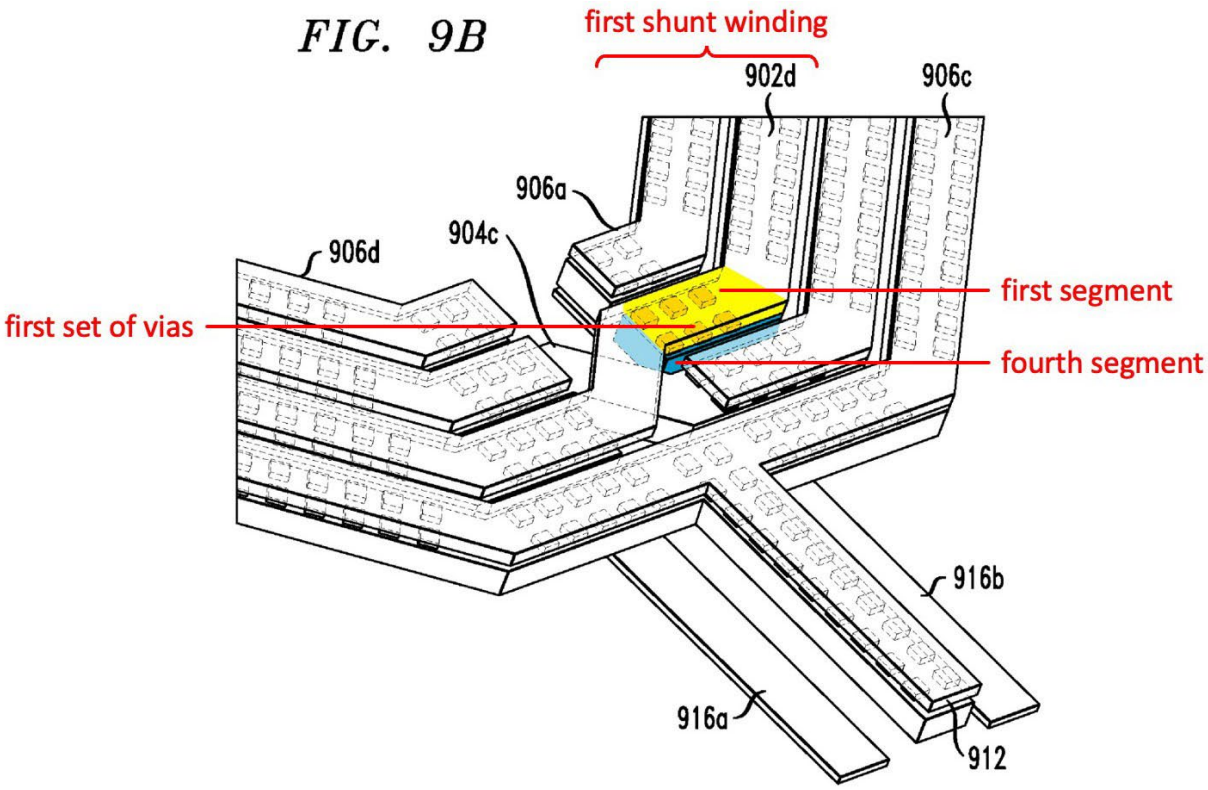
165. Ho-Hsiang discloses such a shunt winding. For instance, as discussed prior, Ho-Hsiang discloses vias connecting a first and fourth segment (*see* Fig. 9C below).

FIG. 9C



EX-1005, [Fig. 9C] (emphasis added).

166. This winding runs in parallel, with a set of vias (highlighted in orange below) connecting the two metal layers at the first (highlighted in yellow) and fourth (highlighted in blue) segments.



Id., [Fig. 9B] (cross-sectional view with emphasis added).

167. A POSITA would have recognized that the first segment, the fourth segment, and the first set of vias of Ho-Hsiang construct a shunt winding, at least based on Realtek's interpretation of the claim language. This is because the two metal layers which contain the first and fourth segments clearly run in parallel (as seen above with one directly on top of the other) and a first set of vias connects them, creating a shunt winding.

168. As noted, a POSITA would have recognized that the two windings on the first and second metal layers form shunt windings because they are in parallel. Being in parallel means that the entire inductor loops are tied together in parallel.

This means that each end of each inductor must be connected to the corresponding end of the other inductor.

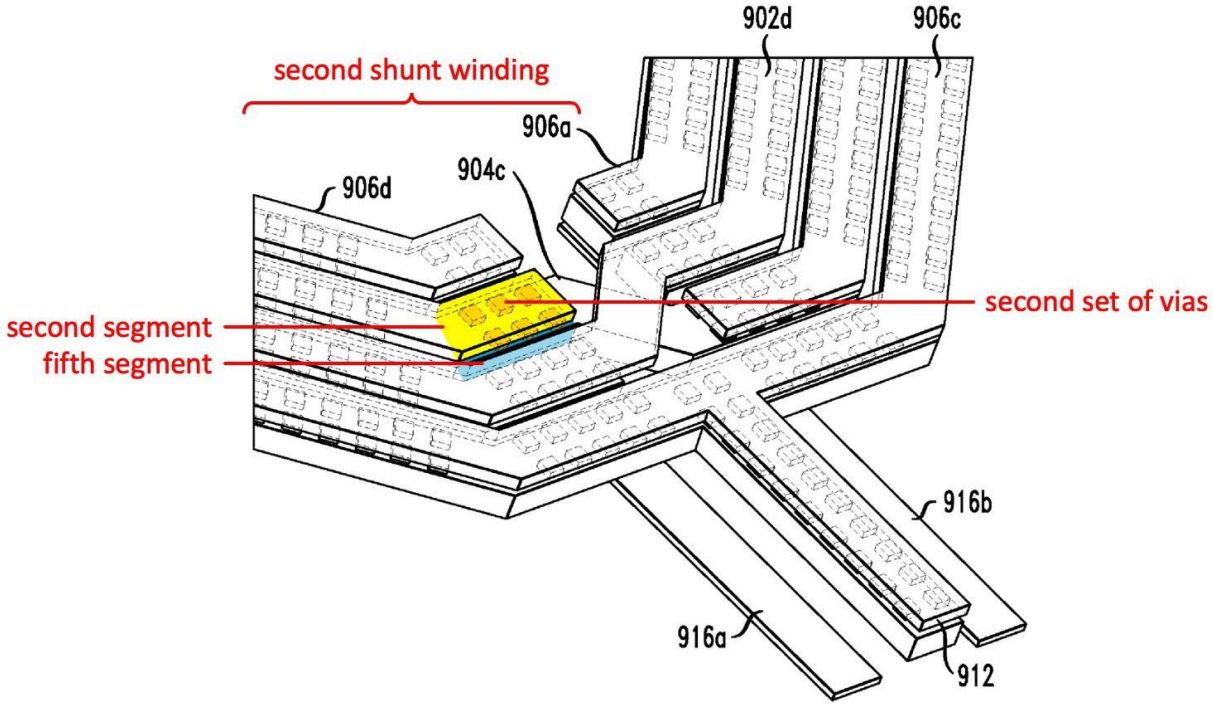
169. By connecting the first segment and fourth segment by vias, then portions of those segments which are linked by vias are in parallel and shunted. Shunting just those segments (segments 1 and 4) is all that is required by the claim, and that requirment is precisely met by Ho-Hsiang. Ho-Hsiang includes additional vias connecting the winding segments throughout the inductor structure, as well (as shown by the vias boxes in Fig. 9B, which span the entire inductor structure).

1.13 wherein the second segment, the fifth segment and the second set of vias construct a second shunt winding;

170. For the same reasons I discussed with respect to the first shunt winding, which I incorporate herein by reference, it is my opinion that a POSITA would have recognized that the second and fifth segments along with the second set of vias, which connects the two segments, would together construct a second shunt winding as depicted below. The two layers at the second and fifth segments are in parallel and a second set of vias runs through them, creating a shunt consistent with the claim language.

171. The winding (below) runs in parallel with a set of vias (highlighted in orange below) connecting the two metal layers at the first (highlighted in yellow) and fourth (highlighted in blue) segments.

FIG. 9B



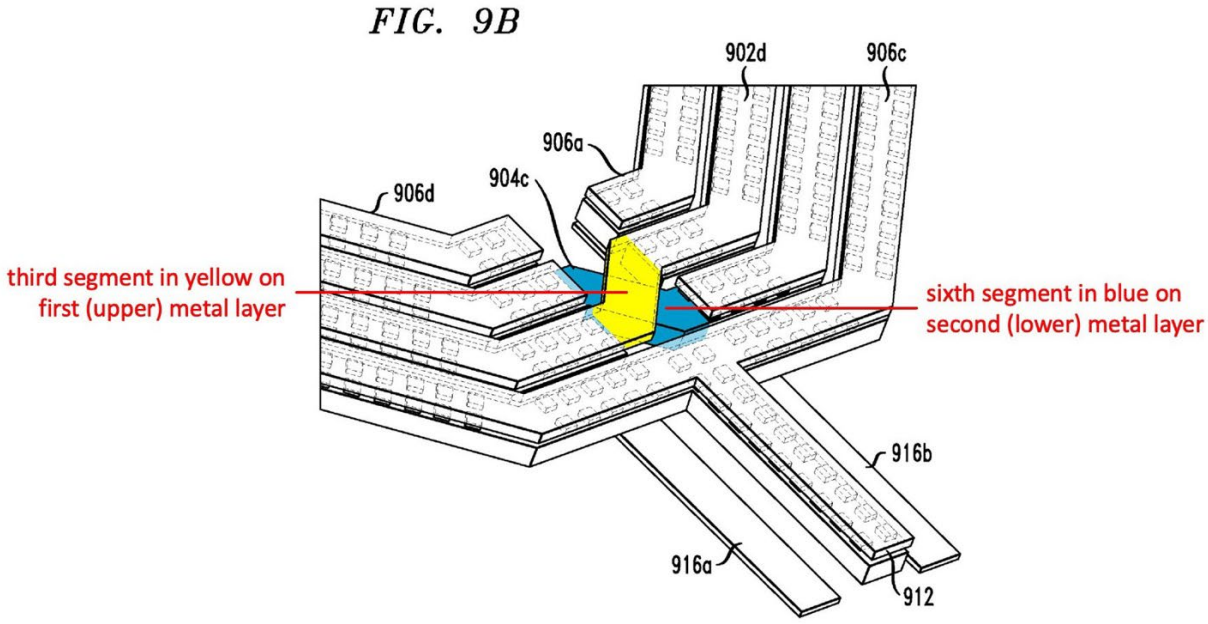
Id., [Fig. 9B] (cross-sectional view with emphasis added).

172. A POSITA would have recognized that the second segment, the fifth segment, and the second set of vias of Ho-Hsiang construct a shunt winding, at least based on Realtek's interpretation of the claim language as I discussed prior. In sum, this is because the two metal layers which contain the second and fifth segments clearly run in parallel (as seen above with one directly on top of the other) and a second set of vias connects them, creating a shunt winding.

1.14 and the third segment and the sixth segment construct a crossover region.

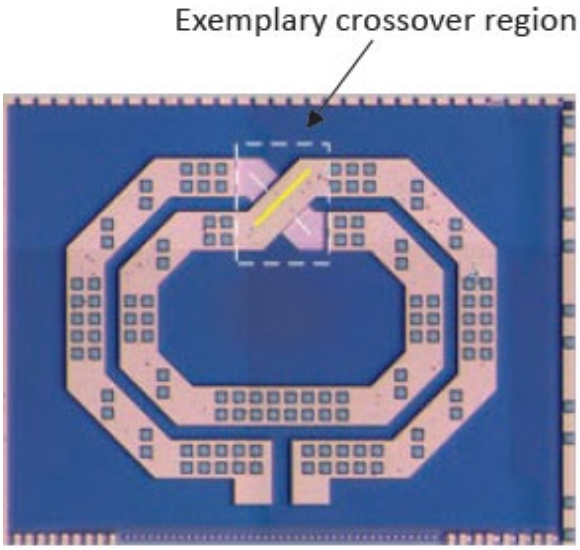
173. Lastly, claim 1 requires that the third and sixth segments construct a crossover region. A POSITA would have recognized that this is disclosed in Ho-

Hsiang. Again referencing Figs. 9A and 9B this becomes apparent. As shown below, the crossover region is formed where the third segment (highlighted in yellow) crosses over the sixth segment (highlighted in blue).



Id., [Fig. 9B] (cross-sectional view emphasis added).

174. A POSITA would have understood that because one segment of the winding (the third segment) crosses over another segment (the sixth segment), the third and sixth segments form (or "construct") a crossover region. This is consistent with how Realtek interprets the claim language as well, as shown below.



EX-1022.014 (emphasis retained).

Claim 2

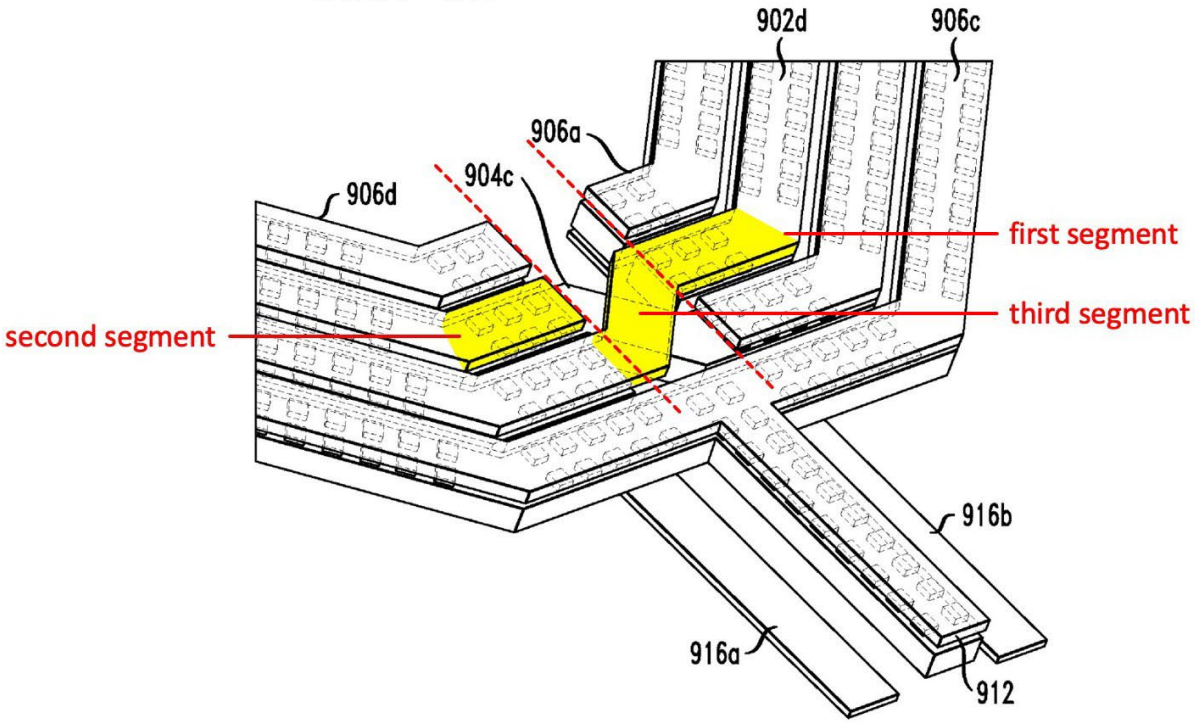
2.1 The structure of the spiral inductor of claim 1, wherein the third segment is positioned between the first segment and the second segment;

175. A POSITA would have understood that the structure of the spiral inductor includes a third segment that is positioned between the first segment and the second segment. The language "positioned between the first segment and the second segment" simply means that the third segment is in between those two segments.

176. This is clearly the case in Ho-Hsiang. In the image below, I have highlighted the third segment in yellow. As can be seen, the third segment is positioned in between the first and second segments (also in yellow). I have emphasized the positioning further by marking the end of the first and second

segments with a dashed red line. The third segment is clearly positioned in between the first and second segments.

FIG. 9B



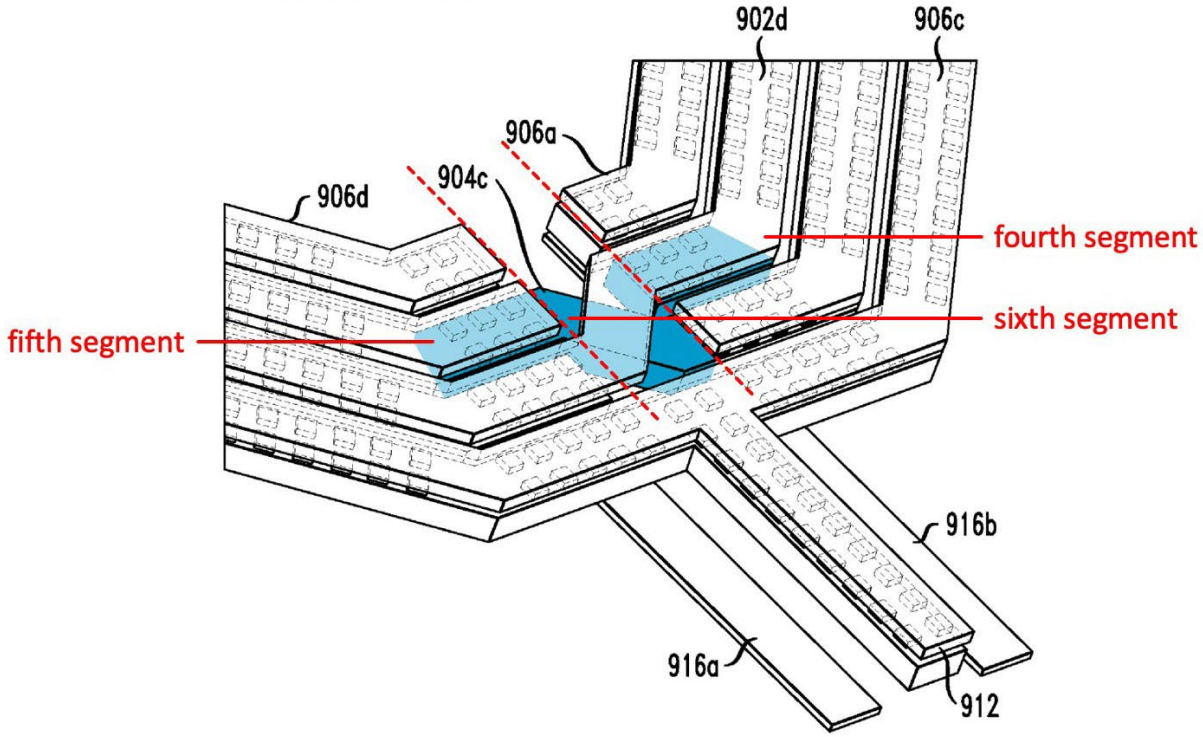
EX-1005, [Fig. 9B] (cross-sectional view with emphasis added).

2.2 and the sixth segment is positioned between the fourth segment and the fifth segment.

177. Similarly, a POSITA would have understood that the structure of the spiral inductor includes a sixth segment that is positioned between the first segment and the second segment. The language "positioned between the fourth segment and the fifth segment" simply means that the sixth segment is in between those two segments.

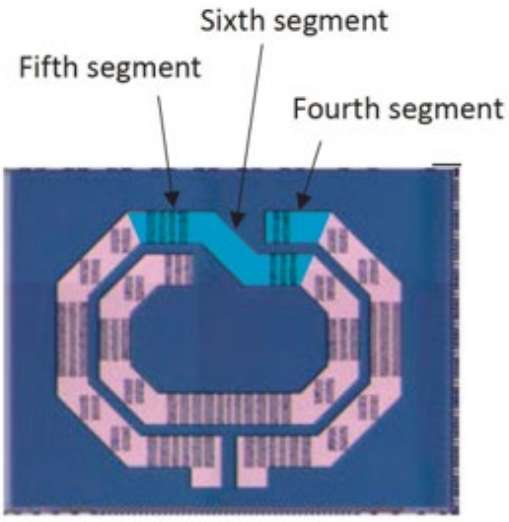
178. In the image below, I have highlighted the sixth segment in blue. As can be seen, the sixth segment is positioned in between the fourth and fifth segments (also in blue). I have emphasized the positioning further by marking the end of the fourth and fifth segments with a dashed red line. The sixth segment is clearly positioned in between the fourth and fifth segments.

FIG. 9B



Id., [Fig. 9B] (cross-sectional view with emphasis added).

179. This is also how Realtek interprets the claim language, as depicted below.



EX-1022.015 (emphasis added in blue).

Claim 5

5.1 The structure of the spiral inductor of claim 1, wherein a first thickness of the first metal layer is equal to a second thickness of the second metal layer.

180. A POSITA would have understood that the structure of the spiral inductor of Ho-Hsiang includes a first metal layer with a thickness equal to the thickness of the second metal layer. This is the case with respect to Figure 9, which I have been discussing. Ho-Hsiang states that "in some embodiments," the first metal layer 920 has a thickness of approximately one micron" and the "second metal layer 930 has a thickness of approximately three microns." EX-1005, [6:43-46]. However, a POSITA would have known, and Ho-Hsiang explicitly says that "[o]ne skilled in the art will understand that the … thickness of the first, second,

and third metal layers 920, 930, and 940 ***may be varied***." *Id.*, [6:47-50]. A POSITA would therefore have understood that the Fig. 9A-C embodiment of Ho-Hsiang leaves the thickness of the metal layers to be a design choice for those practicing the disclosure.

181. With respect to the Figure 2 embodiment (which is very similar to the 9 embodiment), Ho-Hsiang teaches that "the primary and secondary windings 202, 206 are formed on a first metal layer 220 which has a thickness ***between one and three microns*** and a second metal layer 230 having a thickness b***etween one an[d] three microns***. One skilled in the art will understand that the primary and secondary windings 202, 206 may be formed on metal layers having other thicknesses." EX-1005, [3:23-28] (emphasis added).

182. Further, using metal layers of the same thickness for forming the windings of an inductor was known for decades before the filing date of the 245 patent. For example, Soyuer (EX-1025) was published in 1995 and discloses "multilevel monolithic inductors in silicon technology." EX-1025.001. Soyuer shows such an inductor in Fig. 1:

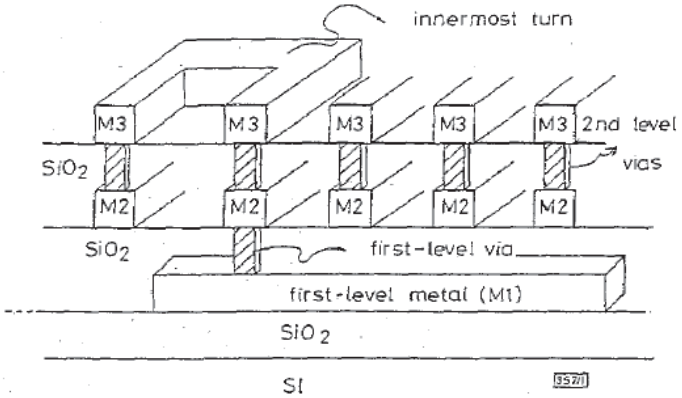


Fig. 1 *Cross-section of four-turn M2//M3 inductor with M1 cross-under (not drawn to scale)*

EX-1025, Fig. 1. While Fig. 1 is labeled "not drawn to scale," in fact the representation of the thicknesses of metal levels M3 and M2 is accurate because Soyuer specifically states that "the levels M2 and M3 have a thickness of 1 μm." *Id*., .002.

183. Accordingly, Soyeur confirms that by at least 1995, a POSITA understood that, consistent with Ho-Hsiang's teachings, the thickness of the metal layers was a design choice and a POSITA would have found it obvious to use the same thickness for the metal layers forming a multi-level inductor.

184. Lastly, the '245 patent itself includes several claims discussing the thickness of the metal layers. Claim 3 requires the thickness of the first metal layer to be greater than the thickness of the second metal layer. *See*, EX-1001, [Claim 3]. Claim 5 requires the first and second metal layers to be equal in thickness. *See*, EX-1001, [Claim 5]. I cannot find any discussion in the '245 Patent explaining why one thickness or another of any particular metal layer would be critical to the purported invention. Therefore, a POSITA would have concluded that the '245 Patent also considers the metal layer thicknesses to be a design choice. A POSITA would also have understood this to be an obvious matter of

design choice because it would give a chip designer more flexibility in designing other elements of the chip.

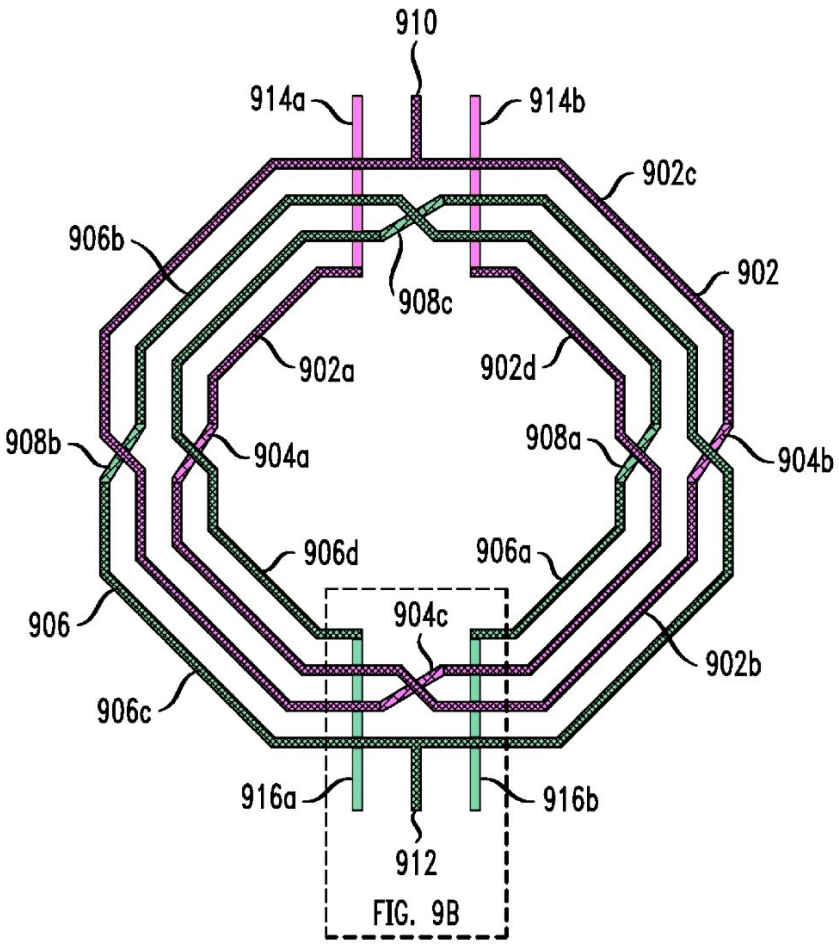
Claim 8

8.1 The structure of the spiral inductor of claim 1, wherein the spiral inductor is a symmetric spiral inductor.

185. A POSITA would have understood that the inductor I have been discussing is a "symmetric" or "symmetrical" inductor. A POSITA would generally have understood that in the context of inductors, symmetric simply means that it has a shape that can be divided into two equal parts along one axis. Each side would roughly be a mirror image of the other.

186. The inductor in Figs. 9A-C (highlighted in pink below) certainly meets this definition. Whether divided in half vertically or horizontally, the two halves are identical in shape.

FIG. 9A



EX-1005, [Fig. 9A] (emphasis added).

187. Indeed, Ho-Hsiang explicitly states that the structures it discloses are symmetrical. The very first paragraph of the specification reads:

> The disclosed system and method relate to transformers and balanced-to-unbalanced (BALUN) devices. More specifically, the disclosed system and method relate to on-chip ***symmetrical*** transformers and BALUN devices.

Id., [1:6-9] (emphasis added).

188. The specification elaborates that "FIG. 1A illustrates a conventional coplanar ***symmetric*** transformer 100 having a 2:2 turn ratio." *Id.*, 1:24-25 (emphasis added). As clearly shown below, the symmetric transformer of Fig. 1A is materially identical to Fig. 9A, the set of transformer I have been discussing.

FIG. 1A
(PRIOR ART)

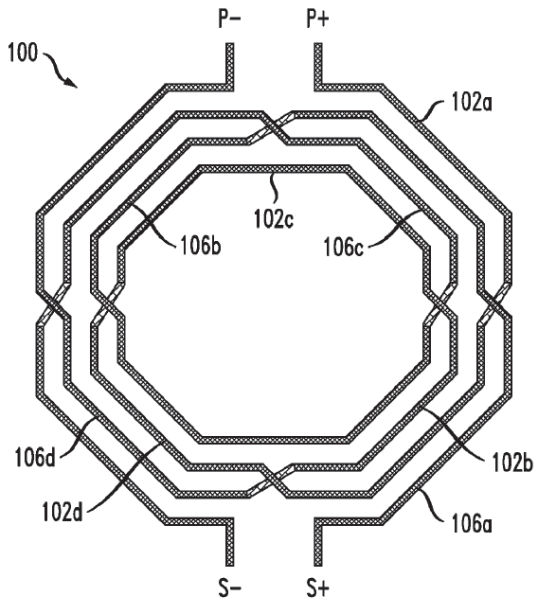
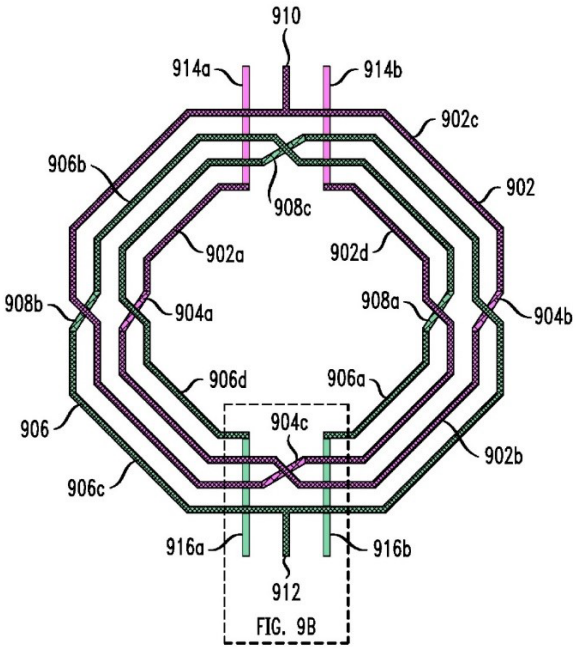


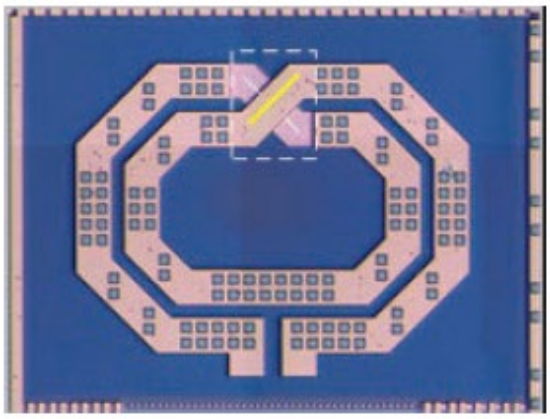
FIG. 9A



Id., [Fig. 1A] (left); [Fig. 9A] (right with emphasis added).

189. With regard to the symmetric transformers above, because a transformer is simply two or more inductors (in this case two), a POSITA would have recognized that the individual inductors comprising the transformer must ***also be*** symmetrical to maintain the overall symmetry.

190. This is also how Realtek interprets the claim language, as it articulates that "[t]he spiral inductor is a symmetric spiral inductor as depicted in the image below."



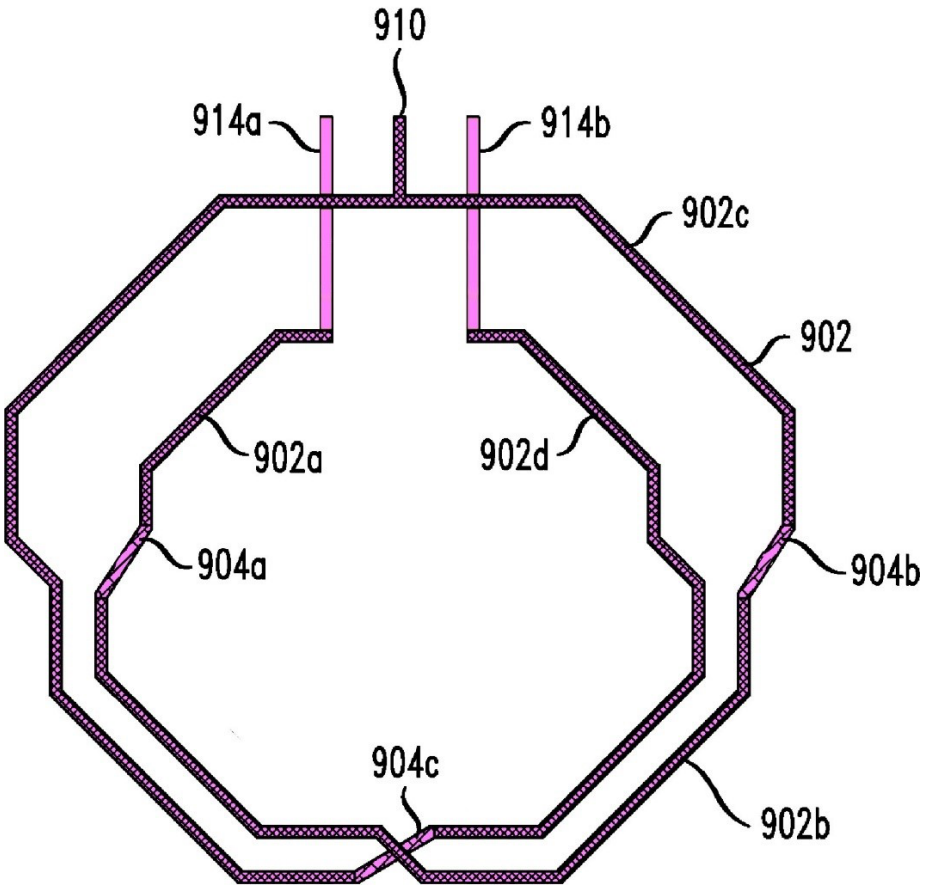
EX-1022.015-.016 (emphasis retained).

Claim 9

9.1 The structure of the spiral inductor of claim 1, wherein a shape of the first shunt winding and the second shunt winding is substantially a rectangle, an octagon, or a circle.

191. A POSITA would have understood that the structure of the spiral inductor of Ho-Hsiang which includes the first and second shunt windings (as I previously discussed), is substantially in the shape of an octagon, as shown below.

FIG. 9A



EX-1005, [Fig. 9A] (modified to show only the inductor in pink).

VIII. GROUND 2: OBVIOUSNESS BASED ON CHRISTENSEN

192. Christensen discloses multi-layer inductors used in an on-chip transformer structure. The inductor structures disclosed in Christenson are like the inductor claimed in the '245 patent, particularly in light of how Realtek itself interprets the claim.

193. For example, Figure 1 in Christensen depicts a 1:1 ratio transformer according to its invention, as shown below. EX-1006, [2:19-20].

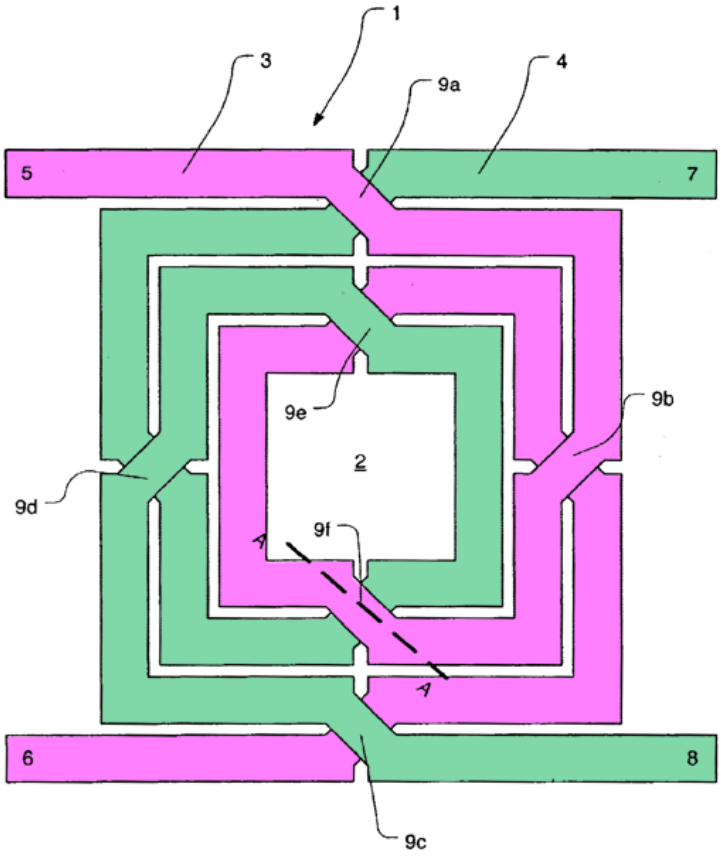


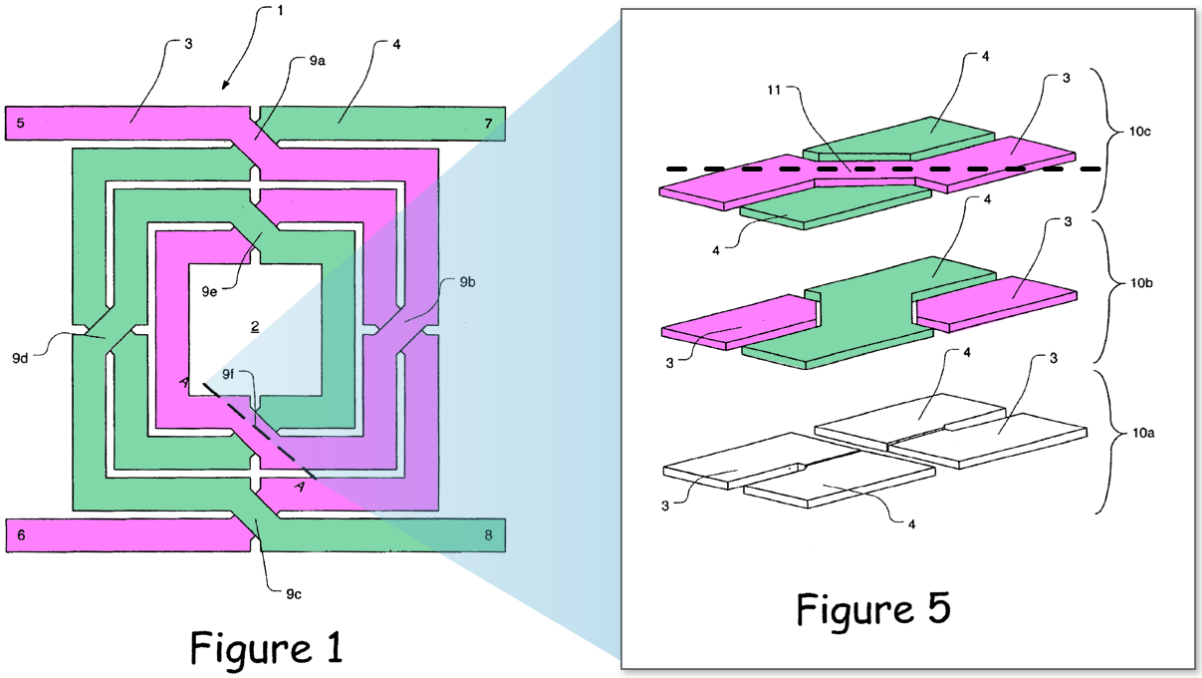
Figure 1

Id., [Fig. 1] (annotated).

194. Christensen explains that the disclosed transformer comprises a primary winding 3 (Pink) and a secondary winding 4 (Green). Christenson, 2:53-58. A POSITA would have recognized each of these windings to be an inductor because it would understand that a transformer is simply a device made of two or more inductors. *See*, § IV.J discussion *supra*. Christensen even characterizes a transformer as several inductors, and it uses the terms inductor and winding

interchangeably. For example, when describing the prior art, Christensen states that it was a well-known layout technique to "plac[e] the primary and secondary windings one above the other in different interconnect layers…. Generally, however, the ***two inductors*** are not balanced." *Id.*, [1:9-16] (emphasis added). It states shortly after that "[t]ransformers employing [] symmetrical ***inductors*** are shown …. These transformers comprise the turns of ***each inductor***…." *Id.*, [1:19-25] (emphasis added).

195. With that said, one of the novel features disclosed in Christensen is the crossovers. Christensen explains that one of the drawbacks of the prior art is that it had "a complex layout" that was undesirably lossy and difficult to match the electrical properties of the windings. *Id.*, [1:26-28]. However, an object of Christensen was to provide an improved structure, "wherein each full turn of each winding … is effected by one self-crossing and two crossings of each other winding …." *Id.*, [1:31-42]. This is depicted in the figures below. Figure 5 is "an exploded view of a cross-over of the transformer of Fig. 1." *Id.*, [2:28-29].



Id., [Fig. 1] (annotated, left); [Fig. 5] (annotated, right).

196. Christensen explains that "the spiralling of the windings 3, 4 is achieved by cross-overs ***9a, . . . , 9f*** where they either cross themselves or the other winding. The paths crossing at these crossovers 9s [sic, a], … 9f swap radial positions." *Id.*, [3:6-9] (emphasis added). It describes the location of each of these crossovers in detail. *See id.,* [3:10-43]. Christensen does not label every crossover in the figures, however, instead focusing on showing and describing cross-over 9f as illustrative of the cross-over structures. A POSITA would have understood that this is because the structure shown and described in Figures 4, 5, and 6 is representative of and applies to all crossovers used in the disclosed invention.

197. To further support this point, the descriptions given for Figures 4, 5, and 6 generically refer to the "cross-overs" and not to one in particular. *Id.*, [2:25-

26] ("FIG. 4 is a sectional view along AA ***of a cross-over*** of the transformer of FIG. 1") (emphasis added); *id.*, [2:27-28] ("Fig. 5 is an exploded view ***of a cross-over*** of the transformer of Fig. 1") (emphasis added); *id.*, [2:30-34] ("FIG. 6(*a*) illustrates a layer ***of a crossover*** of the transformer of FIG. 1 and FIG. 6(*b*) illustrates a layer ***of a conventional crossover***; FIG. 6(*c*) illustrates a layer ***of an alternative crossover*** for a transformer according to the present invention;") (emphasis added).

198. A POSITA would thus have understood that the characteristics of the crossover structures of Figures 4, 5, and 6 apply to all the crossovers. I have circled these crossovers of Fig. 1 below.

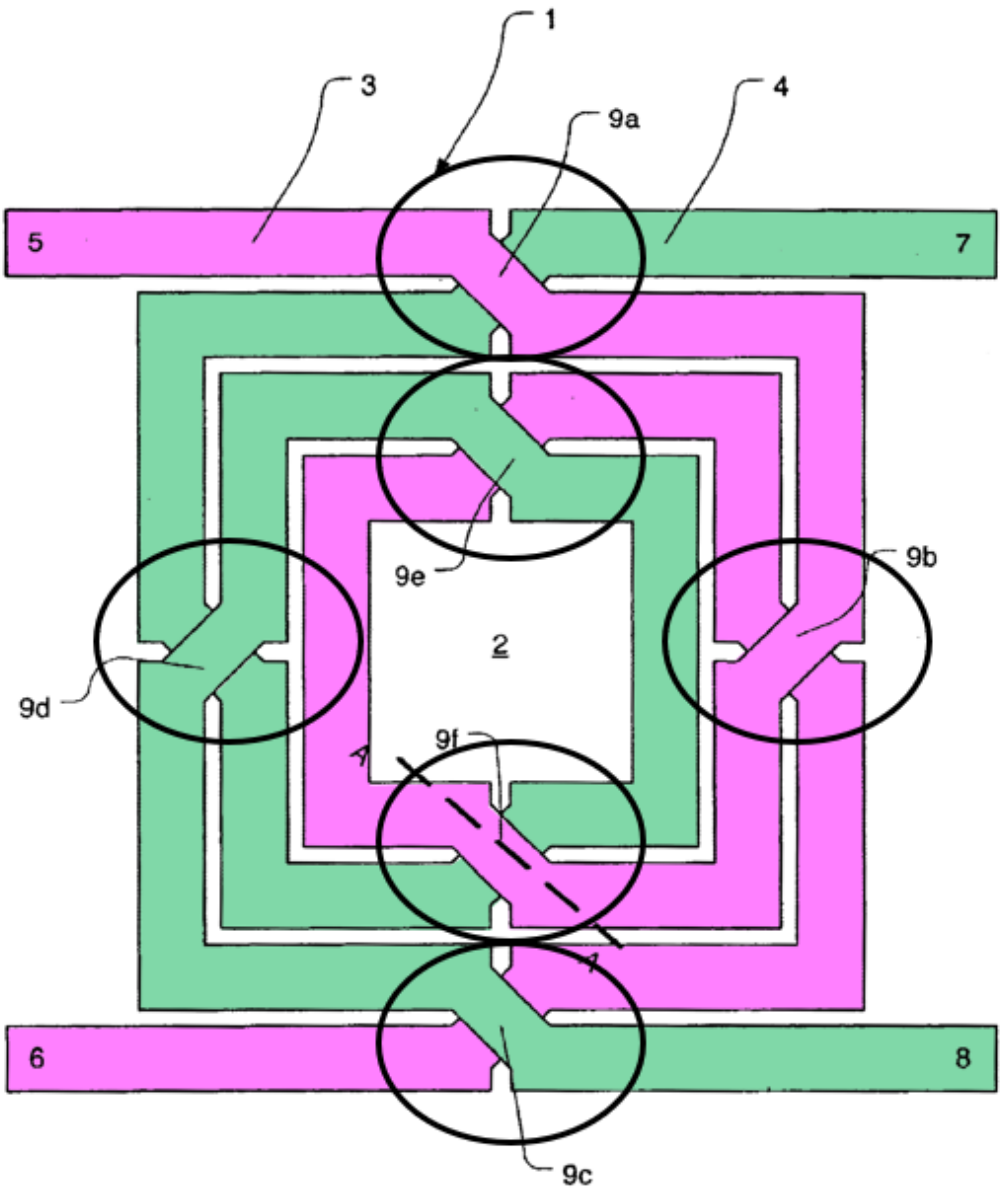


Figure 1

Id., [Fig. 1] (annotated)

199. Thus, for my analysis, we can focus on cross-over 9b of the primary winding 3 (the pink inductor). This is shown below.

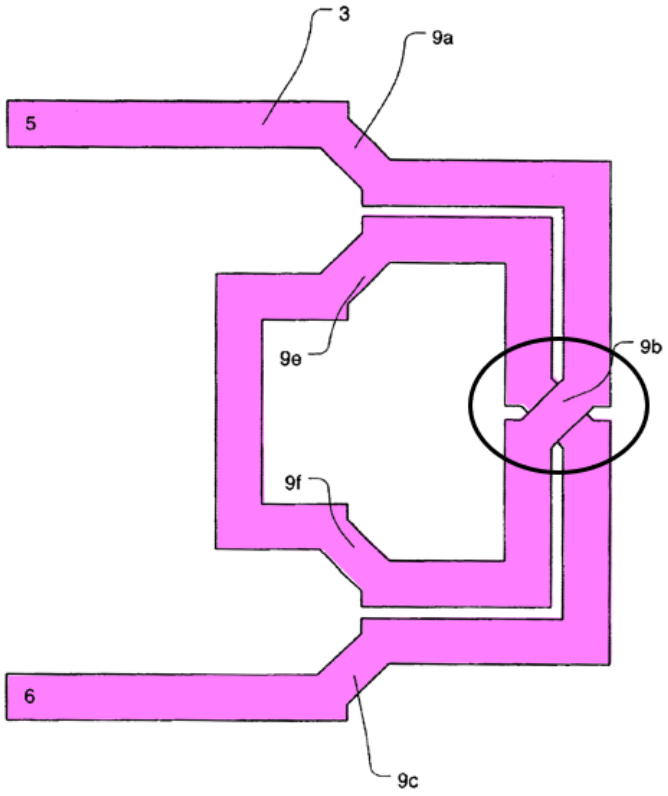


Figure 2

Id., [Fig. 2] (annotated).

Claim 1

1.1 A structure of a spiral inductor, comprising:

200. To the extent this preamble of claim 1 is a limitation, Christenson discloses a spiral inductor. As I previously discussed, Christensen is directed to transformers and a POSITA would have recognized that a transformer is simply a device made of two or more inductors (called windings in Christensen). *See*, § IV.C; *see also* discussion of Christensen *supra*. Furthermore, Christensen discloses spiral inductor structures. For instance, Christensen discloses that "[t]he primary winding 3 ***spirals in*** from the first terminal 5 and then out to the second terminal 6.

The secondary winding 4 ***spirals in*** from the third terminal 7 and then out to the fourth terminal 8 in a similar manner." EX-1006, [2:65-3:2] (emphasis added). It also states that "[t]he ***spiralling of the windings 3, 4*** is achieved by crossovers 9 a, . . . , 9 f where they either cross themselves or the other winding." *Id.*, [3:6-9] (emphasis added); *see also, id.*, [3:10-43].

201. The two inductors described in Christensen are shown below in Figure 1.

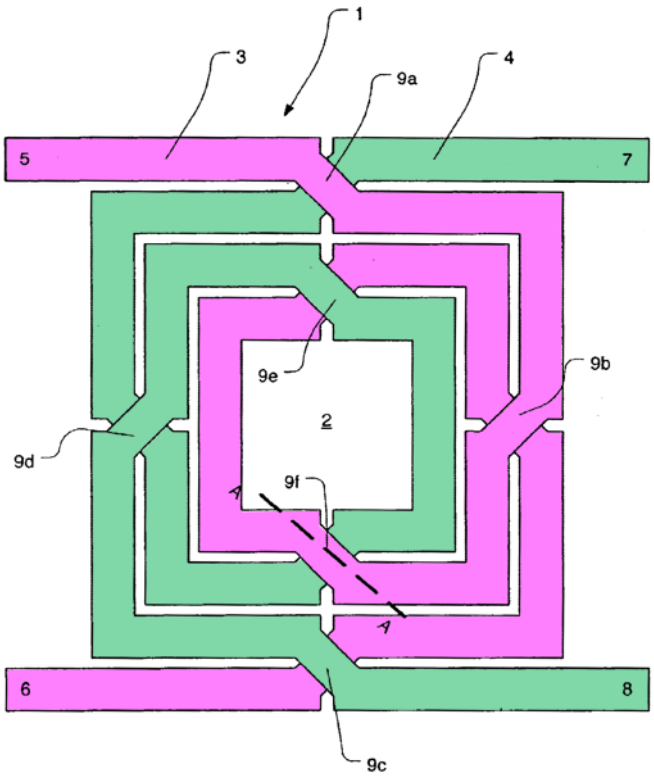


Figure 1

Id., [Fig. 1] (annotated)

202. A POSITA would have understood that both inductor structures (highlighted in green and pink respectively) are spiral inductors. The pink spiral

inductor (winding 3), as shown below in Figure 2, will be used for my further analysis of the claims.

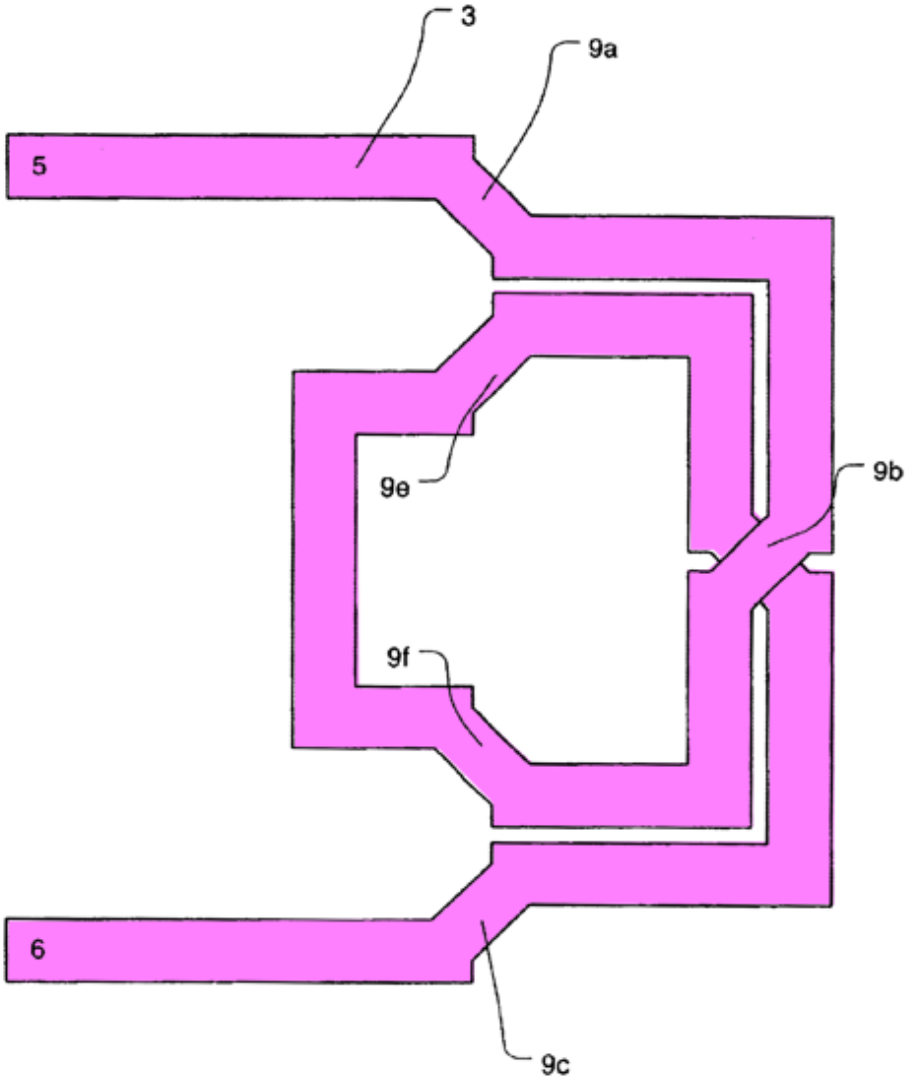


Figure 2

Id., [Fig. 2] (annotated).

203. The shape of the inductor structures above is similar to what Realtek has argued constitutes a "spiral inductor structure." This is shown below.

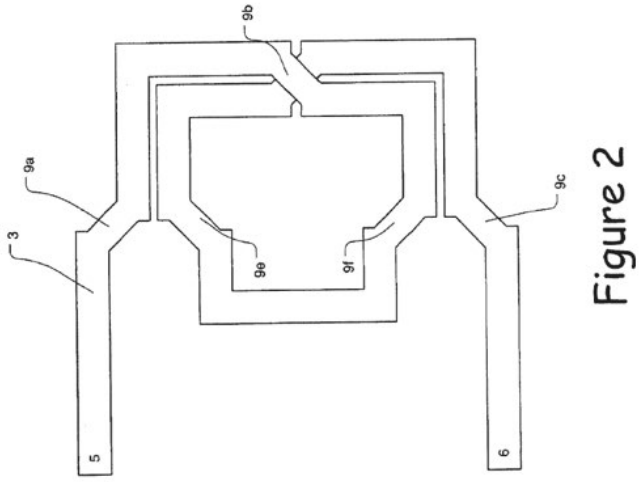
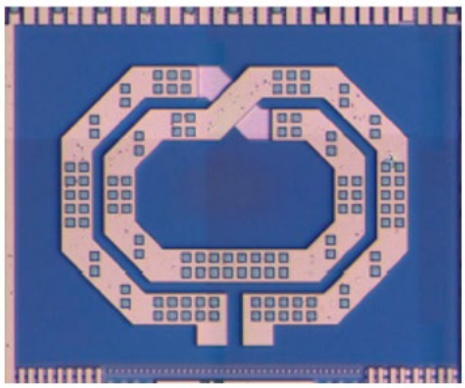


Figure 2



Id., [Fig. 2] (left, rotated); EX-1022.007 (right).

1.2 a first metal layer, comprising:

204. As I stated prior, a POSITA would have understood that this limitation describes a winding of the inductor being located on one metal layer, e.g., above a semiconductor substrate. This is disclosed in Christenson.

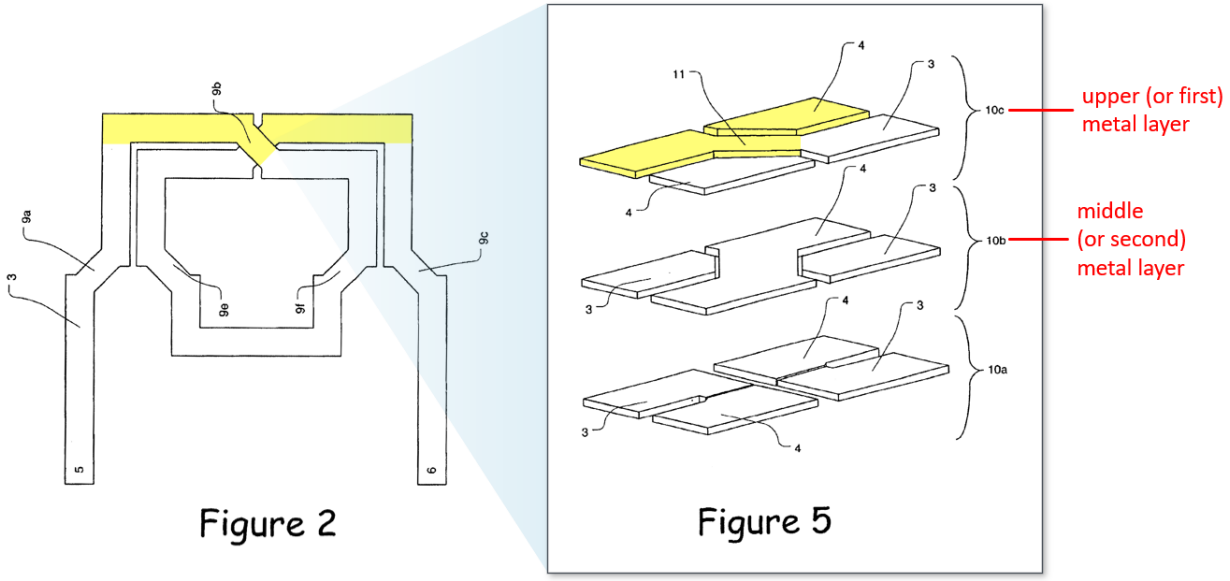
205. Christensen states the following with respect to Figure 5.

> Referring also to FIG. 5 which shows the sixth crossover 9f, the primary and secondary windings 3, 4 are each formed from tracks in ***three conductor (metal or polysilicon) layers 10a, 10b, 10c***. SiO_2 layers (no[t] shown) separate the conductor layers 10a, 10b, 10c. The conductors of ***the conductor layers 10a, 10b, 10c*** forming the primary winding 3 are bonded by arrays of vias 10d (see FIG. 4) adjacent to the crossovers and, optionally at other locations. Similarly, the conductors

of ***the conductor layers 10a, 10b, 10c*** forming the secondary winding 4 are bonded by arrays of vias 10d (see FIG. 4) adjacent to the crossovers and, optionally at other locations.

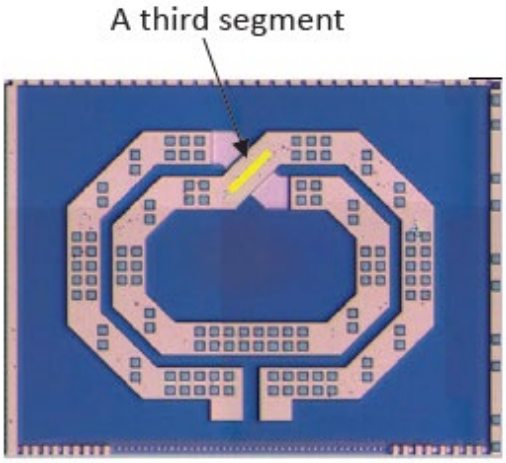
EX-1006, [3:43-55] (emphasis added).

206. A POSITA would therefore have understood that conductive metal layer 10c in Christensen is a first metal layer, as shown below in yellow.



Id., [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

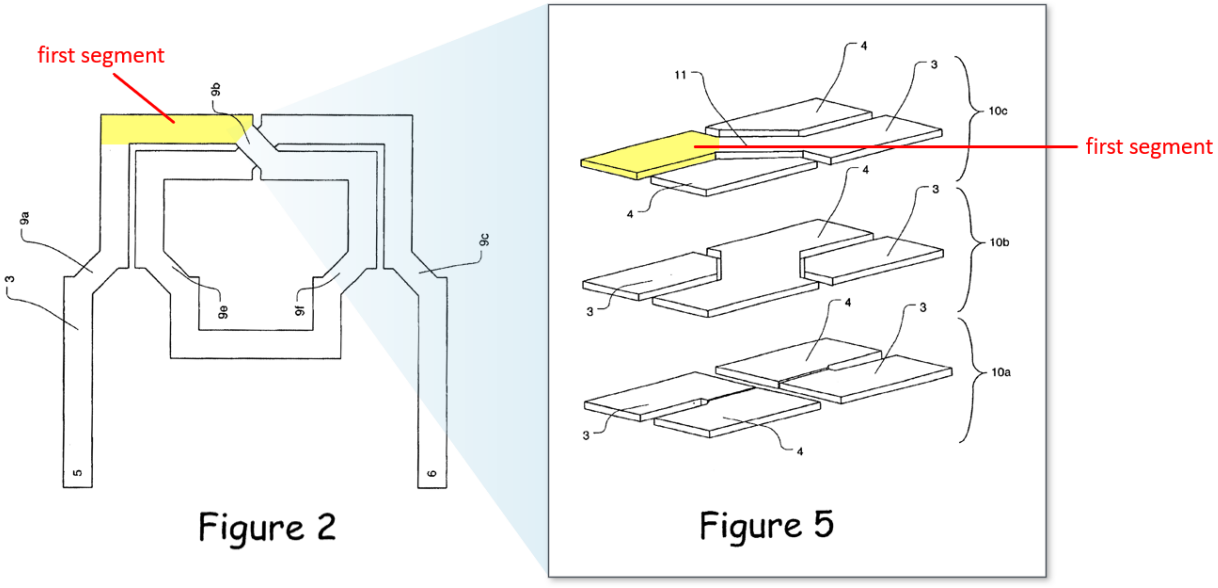
207. This is consistent with how Realtek has interpreted the claim language. As shown below, Realtek has emphasized (in yellow highlight) the "third segment" as the top crossover being on the first metal layer.



EX-1022.009 (emphasis retained).

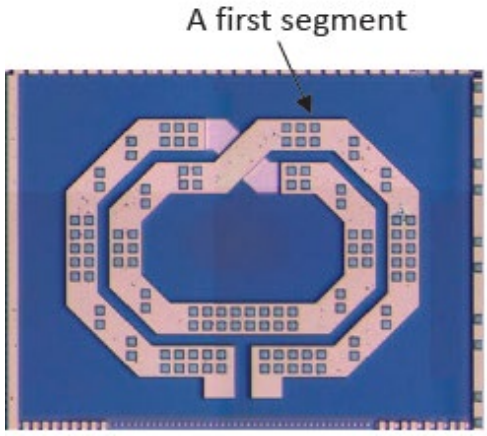
1.3 a first segment

208. As I discussed prior, a POSITA would have understood that this limitation describes a portion or "segment" of the winding of the inductor that is on the first metal layer. I have highlighted the first segment of the Fig. 2 inductor in Christensen below, in yellow.



EX-1006, [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

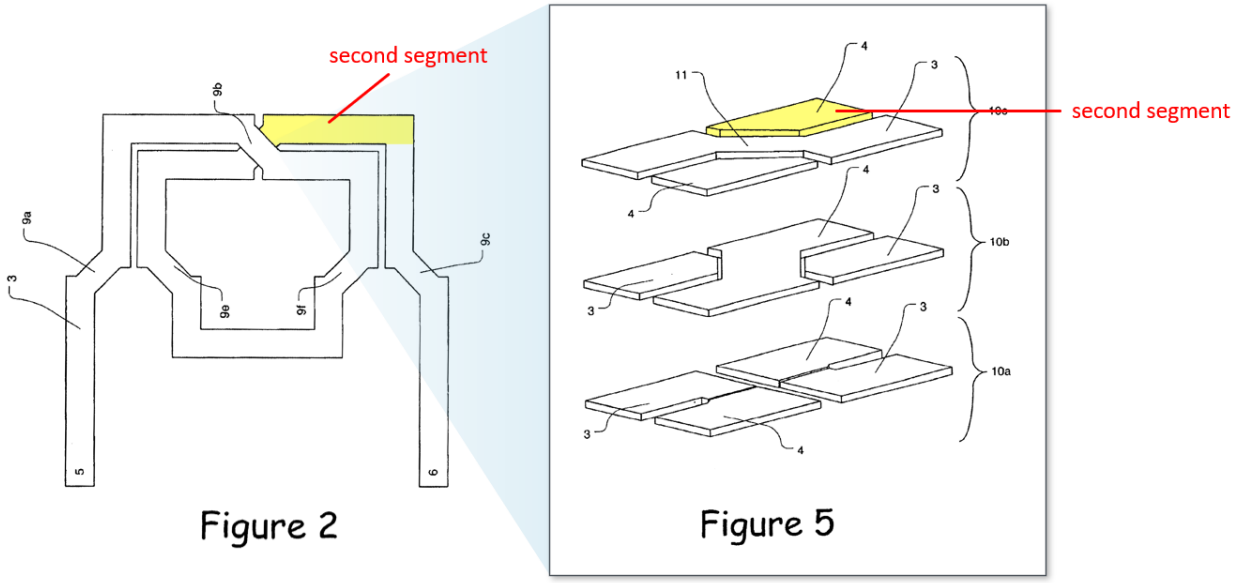
209. This interpretation is consistent with how Realtek interprets the segments (e.g., the first segment) of the winding on the first metal layer, as shown below.



EX-1022.008 (emphasis retained).

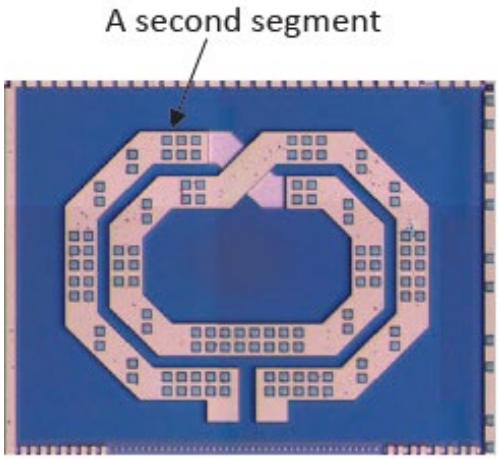
1.4 a second segment; and

210. A POSITA would have understood that this limitation describes a second portion or "segment" of the winding of the inductor that is on the first metal layer, which is distinct from the first segment. I have highlighted the second segment of the Fig. 2 inductor below in yellow.



EX-1006, [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

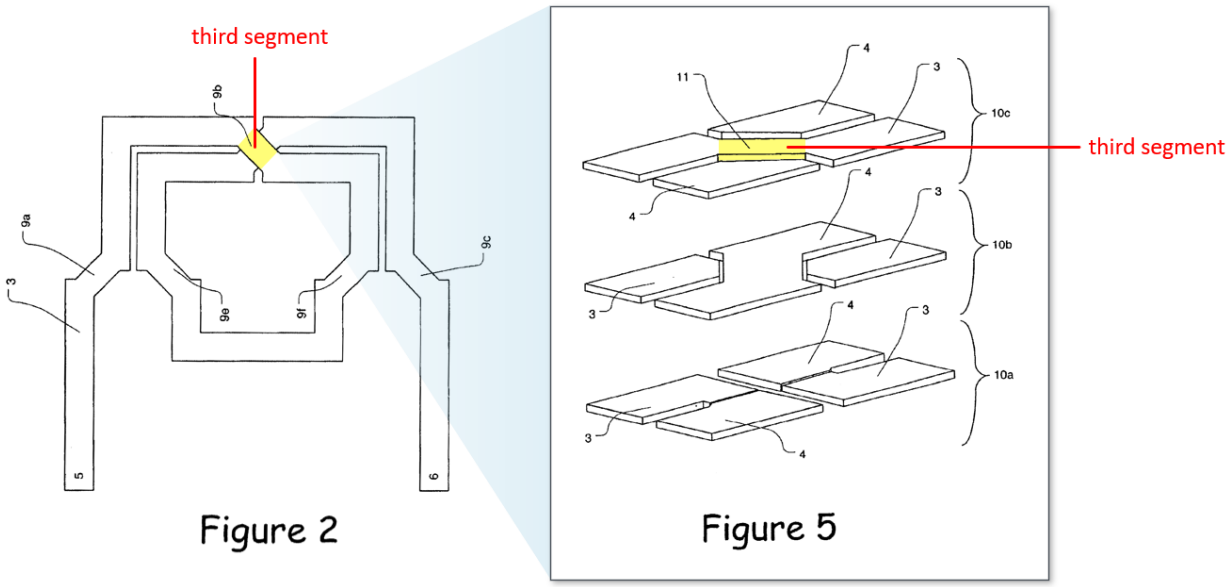
211. This interpretation is consistent with how Realtek interprets the segments (e.g., the second segment) of the winding on the first metal layer, as shown below.



EX-1022.008 (emphasis retained).

1.5 a third segment, connected to the first segment, wherein a layout direction of the third segment is different from a layout direction of the first segment and a layout direction of the second segment;

212. A POSITA would have understood that the "third segment" is another portion of the winding found on the first metal layer that is directly physically connected to the first segment. Additionally, a POSITA would have understood that "wherein a layout direction of the third segment is ***different*** from a layout direction of the first segment and a layout direction of the second segment" means that the third segment is angled in a different direction, e.g., the axis of the third segment is offset from the other two. Christensen discloses such a third segment as shown below.



EX-1006, [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

213. As the figures illustrate, the "third segment" is another portion of the winding found on the first metal layer. Further, as shown below, the third segment is directly physically connected to the first segment on its left side, and the third segment is angled in a different direction than the first and second segments in yellow. The dashed lines illustrate these different layout directions.

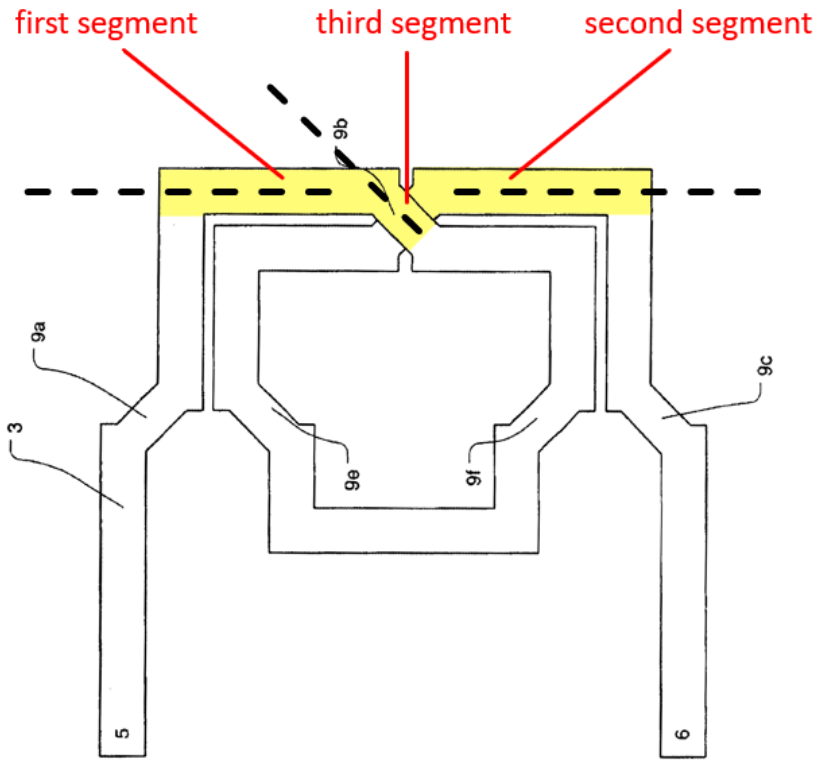
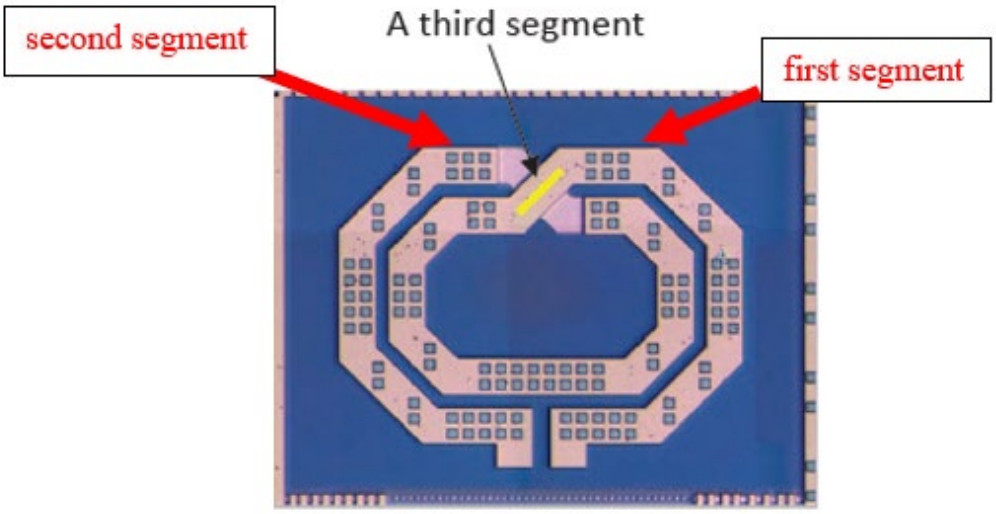


Figure 2

Id., [Fig. 2] (annotated, rotated)

214. This is consistent with how Realtek is interpreting the claim language. As shown below, Realtek points to the yellow highlighted portion of the winding as being the third segment, which is connected to the first segment and is positioned in a different layout direction than the first and second segments.



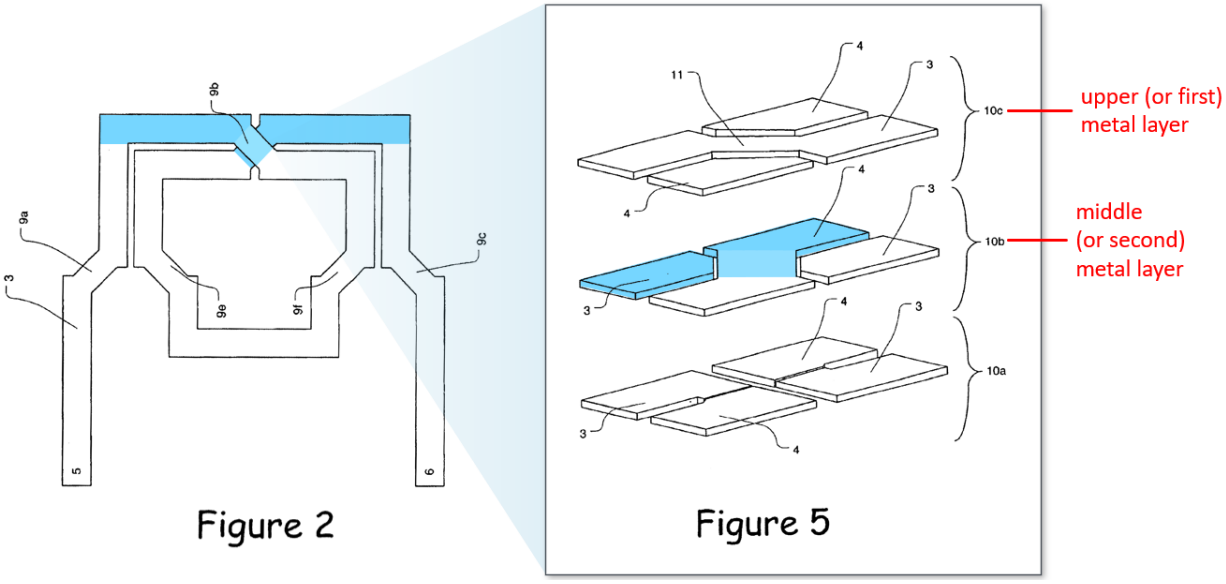
EX-1022.009 (emphasis retained in yellow and added in red)

215. In the figure above, I have added pointers showing the first and second segments. As is clear, what Realtek points to is materially identical to Fig. 2 of Christensen. The first segment is simply on the left side in Christensen because the crossover of the upper metal layer in Christensen is oriented in the opposite direction as the crossover of the lower metal layer in the Realtek exhibit.

216. A POSITA would have recognized that orienting the crossover from left to right or vice versa is simply a design choice. Furthermore, a POSITA would have recognized that the claim language does not require that the crossover (or "third segment") be positioned any particular way, other than in a layout direction that is distinct from the layout direction of the first and second segments. This is the case in Christensen because it is positioned at an angle that is different than the first and second segments while still being connected to the first segment.

1.6 a second metal layer, being positioned under the first metal layer, the second metal layer comprising

217. A POSITA would have understood that "a second metal layer, being positioned under the first metal layer" simply means that the second metal layer is physically underneath the first metal layer. This is the case in Christensen as shown in Fig. 5 below. Here, I have highlighted the second metal layer 10b in blue which a POSITA would have understood is positioned underneath the first metal layer 10c, as is clear from the figure.



EX-1006, [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

218. In fact, Christensen describes 10c as an "upper" layer, 10b as a "middle" layer, and 10a as the "lowest" layer. *Id.*, [3:55-61]. Therefore, it would have been clear to a POSITA that the first metal layer 10c ("upper" layer) is above the second metal layer 10b ("middle" layer). *See also*, *id.*, [Fig. 4] (clearly showing

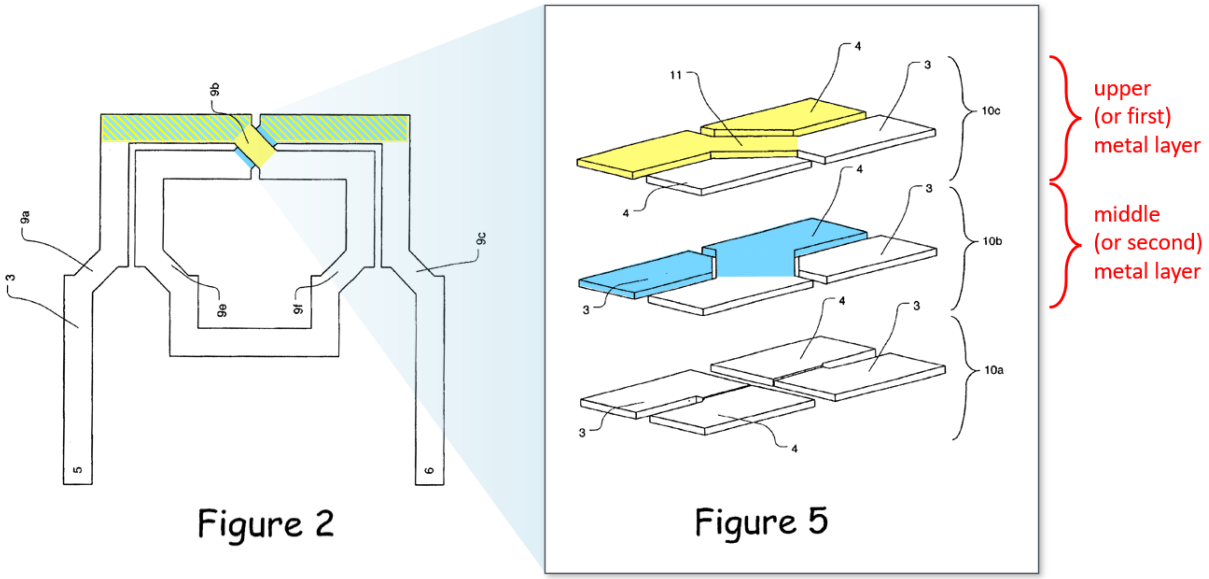
metal layer 10c above 10b and bonded by vias) The lowest conductive layer 10a is a capacitive shield and is not necessary for our analysis of this claim.

> 219. Further explanation of Figure 5 and the metal layers is shown below. Referring also to FIG. 5 which shows the sixth crossover 9 f, the primary and secondary windings 3, 4 are each formed from tracks in ***three conductor (metal or polysilicon) layers 10a, 10b, 10c***. SiO_2 layers (no[t] shown) separate the conductor layers 10a, 10b, 10c. The conductors of ***the conductor layers 10a, 10b, 10c*** forming the primary winding 3 are bonded by arrays of vias 10d (see FIG. 4) adjacent to the crossovers and, optionally at other locations. Similarly, the conductors of ***the conductor layers 10a, 10b, 10c*** forming the secondary winding 4 are bonded by arrays of vias 10d (see FIG. 4) adjacent to the crossovers and, optionally at other locations.

Id., [3:43-55] (emphasis added).

220. Christensen also explains that "[t]he middle and upper layers 10b, 10c ***are mirror images*** and provide the crossings for the secondary and primary windings 3, 4 respectively." *Id.*, [3:59-61] (emphasis added). It explains that the windings are formed "from a plurality of stacked conductive paths, the paths forming each winding being united by vias." *Id.*, [1:57-59]. Thus, a POSITA would have understood that the upper metal layer (10c) and middle metal layer (10b) are

stacked above one another and mirror each other. I have included a depiction of both the first metal layer (10c) and the second metal layer (10b) in the figures below.



Id., [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated)

221. As depicted above, the third segment (shown again below) of the first metal layer is a crossover on the higher metal layer, and the other crossover on the second metal layer (which I will discuss in subsequent paragraphs) is physically below it. This is how Realtek also appears to interpret the claim language, as shown on the image on the right below.

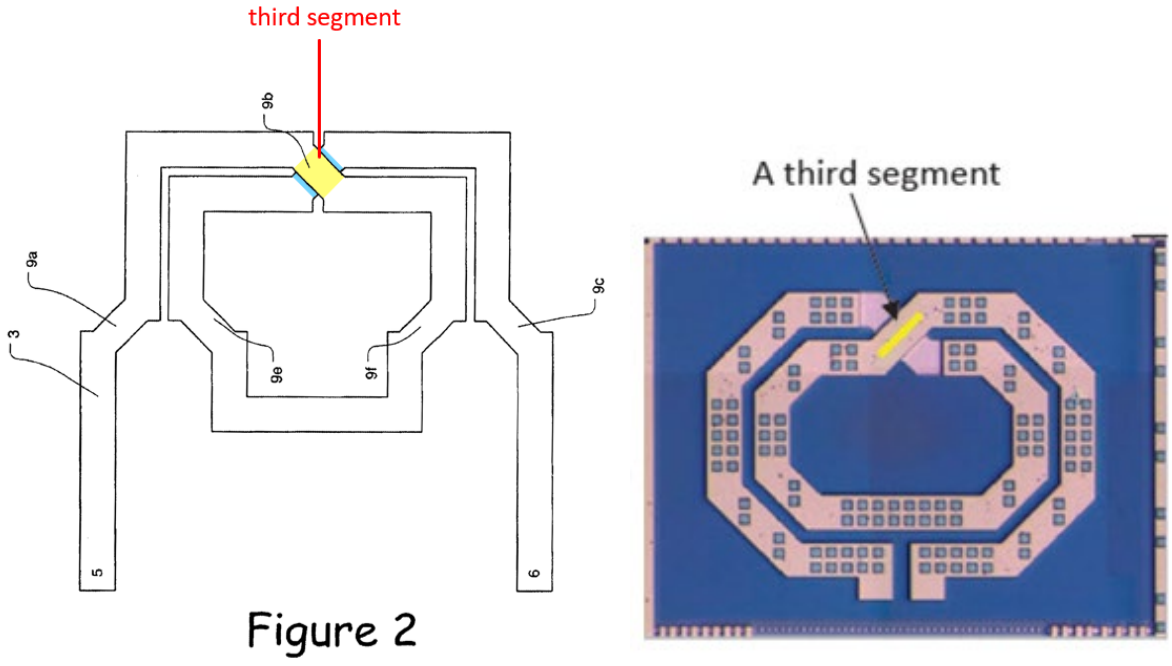


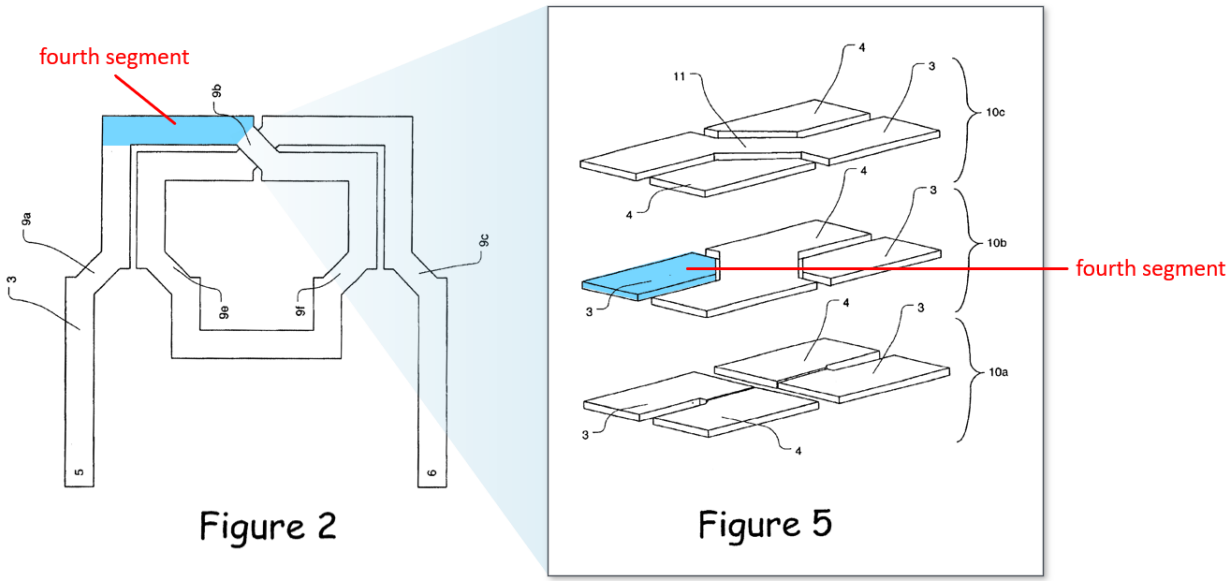
Figure 2

Id., [Fig. 2] (left, annotated, and rotated); EX-1022.009 (right, emphasis retained).

222. As previously explained, the only difference between the images is that the crossover is oriented in the opposite direction. However, this difference is immaterial to the analysis because a POSITA would have recognized that orienting the crossover from left to right or vice versa is simply a design choice and is not required by the claims. *See*, *e.g.*, my analysis with respect to the third segment limitation *supra*.

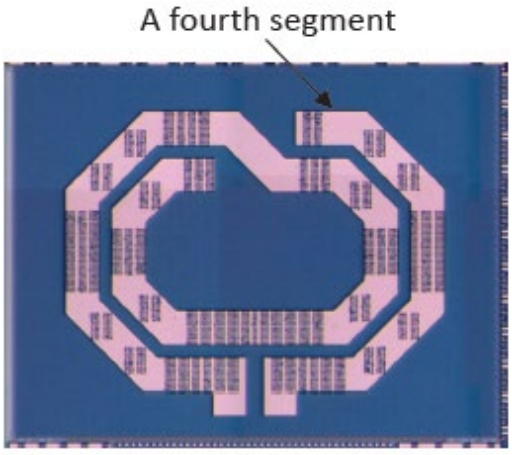
1.7 A fourth segment

223. A POSITA would have understood that the second metal layer contains a fourth segment. I have highlighted the fourth segment of the Fig. 2 inductor below.



Id., [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

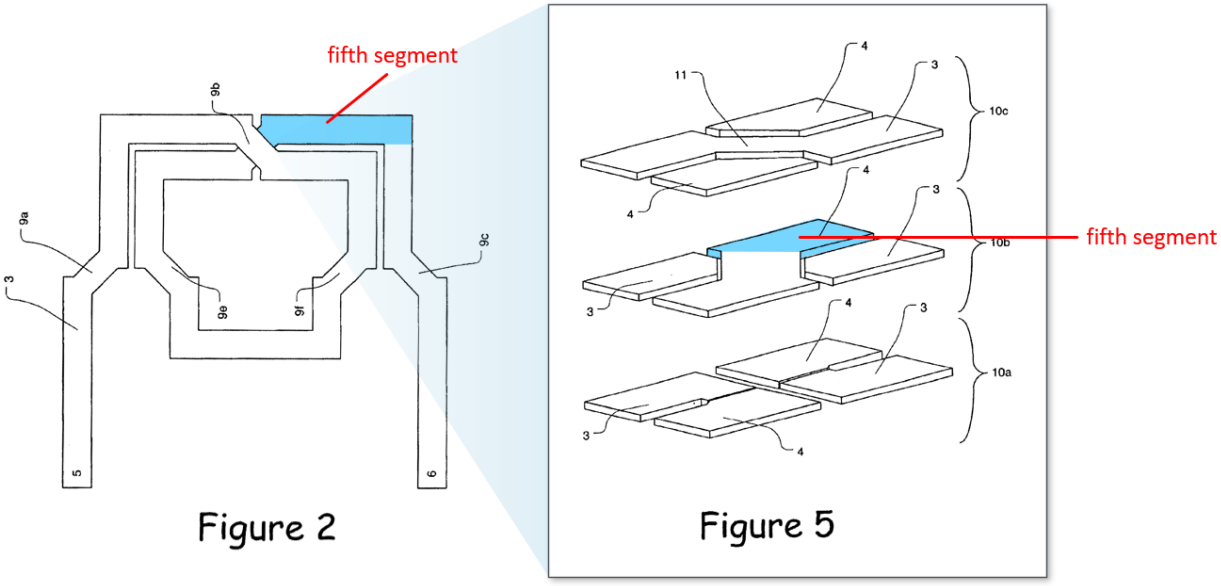
224. This interpretation is consistent with how Realtek interprets the segments (e.g., the fourth segment) of the winding on the second metal layer, as shown below.



EX-1022.010 (emphasis retained).

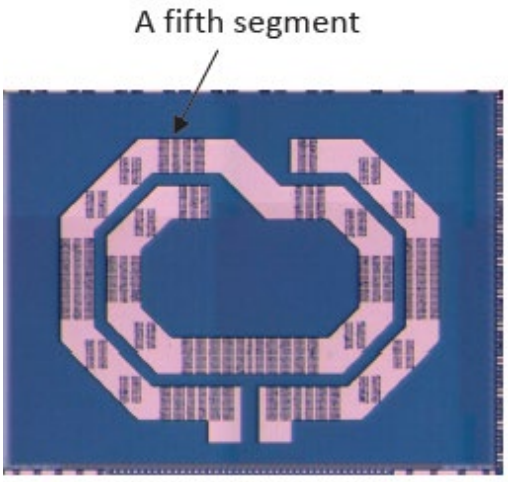
1.8 A fifth segment

225. A POSITA would have understood that this limitation describes a fifth portion or "segment" of the winding of the inductor that is on the second metal layer, which is distinct from the fourth segment. I have highlighted the fifth segment of the Fig. 2 inductor below.



EX-1006, [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

226. This interpretation is consistent with how Realtek interprets the segments (e.g., the fifth segment) of the winding on the second metal layer, as shown below.

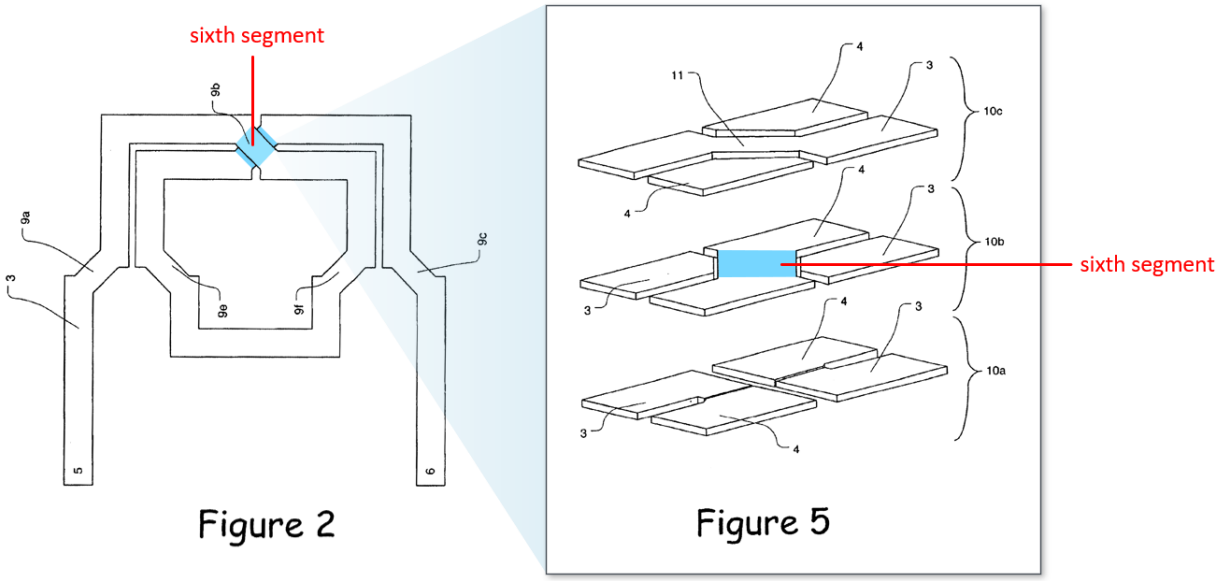


EX-1022.010 (emphasis retained).

1.9 a sixth segment, connected to the fifth segment, wherein a layout direction of the sixth segment is different from a layout direction of the fourth segment and a layout direction of the fifth segment;

227. A POSITA would have understood that the "sixth segment" is another portion of the winding found on the second metal layer that is directly physically connected to the fifth segment. Additionally, a POSITA would have understood that "wherein a layout direction of the sixth segment is ***different*** from a layout direction of the fourth segment and a layout direction of the fifth segment" means that the sixth segment is angled in a different direction, e.g., the axis of the third segment is offset from the other two.

228. Christensen discloses such a sixth segment as shown below. In the image below, I have highlighted the sixth segment in blue.



EX-1006, [Fig. 2] (left, annotated, and rotated); Fig. 5 (right, annotated).

229. As the figures make clear, the "sixth segment" is another portion of the winding found on the second metal layer. Further, as shown below, the sixth segment is directly physically connected to the fifth segment on its right side and is angled in a different direction than the fourth and fifth segments in blue. The dashed lines illustrate these different layout directions.

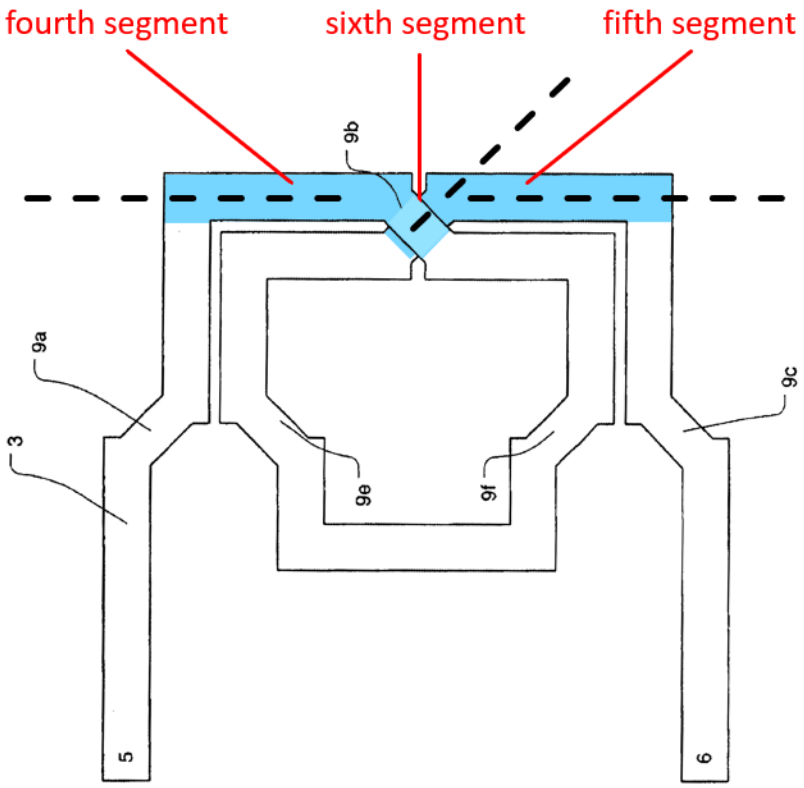
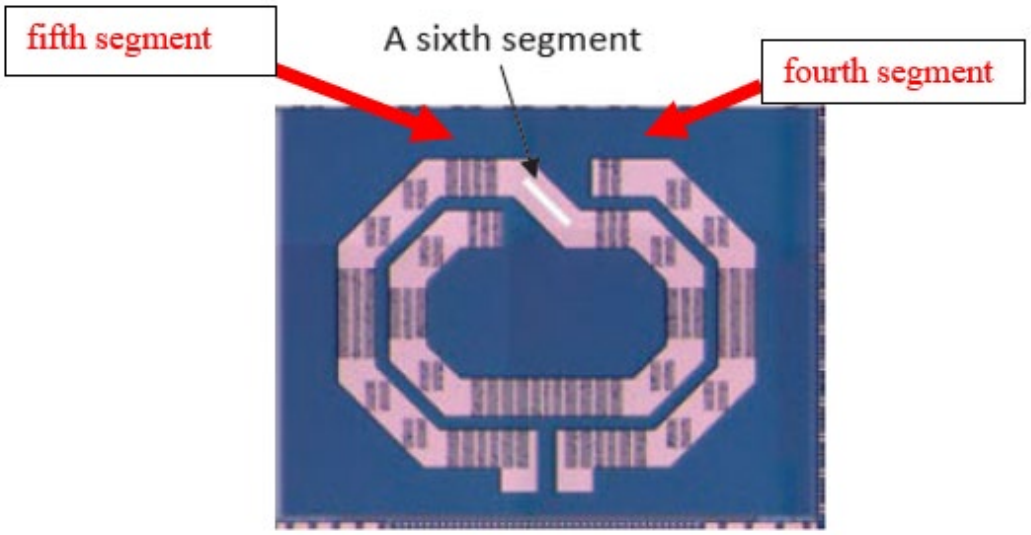


Figure 2

Id., [Fig. 2] (annotated, rotated).

230. This is consistent with how Realtek is interpreting the claim language. As shown below, Realtek points to the white highlighted portion of the winding as being the sixth segment, which is connected to the fifth segment and is positioned in a different layout direction than the fourth and fifth segments.



EX-1022.010 (emphasis retained in white and added in red).

1.10 A first set of vias, for connecting the first segment with the fourth segment; and

231. A POSITA would have understood that Christensen discloses a first set of vias for connecting the first segment with the fourth segment. As I previously explained, Christensen discloses a first metal layer (10c) and a second metal layer (10b). Christensen explains that these metal layers are bonded by vias, as explained below and illustrated in Figure 4 in orange.

> Referring also to FIG. 5 which shows the sixth crossover 9f, the primary and secondary windings 3, 4 are each formed from tracks in three conductor (metal or polysilicon) layers 10a, 10b, 10c. SiO_2 layers (no shown) separate the conductor layers 10a, 10b, 10c. The conductors of ***the conductor layers 10a, 10b, 10c forming the primary winding 3 are***

bonded by arrays of vias 10d (see FIG. 4) adjacent to the crossovers and, optionally at other locations. Similarly, the conductors of ***the conductor layers 10a, 10b,10c forming the secondary winding 4 are bonded by arrays of vias 10d (see FIG. 4)*** adjacent to the crossovers and, optionally at other locations.

EX-1006, [3:43-55] (emphasis added).

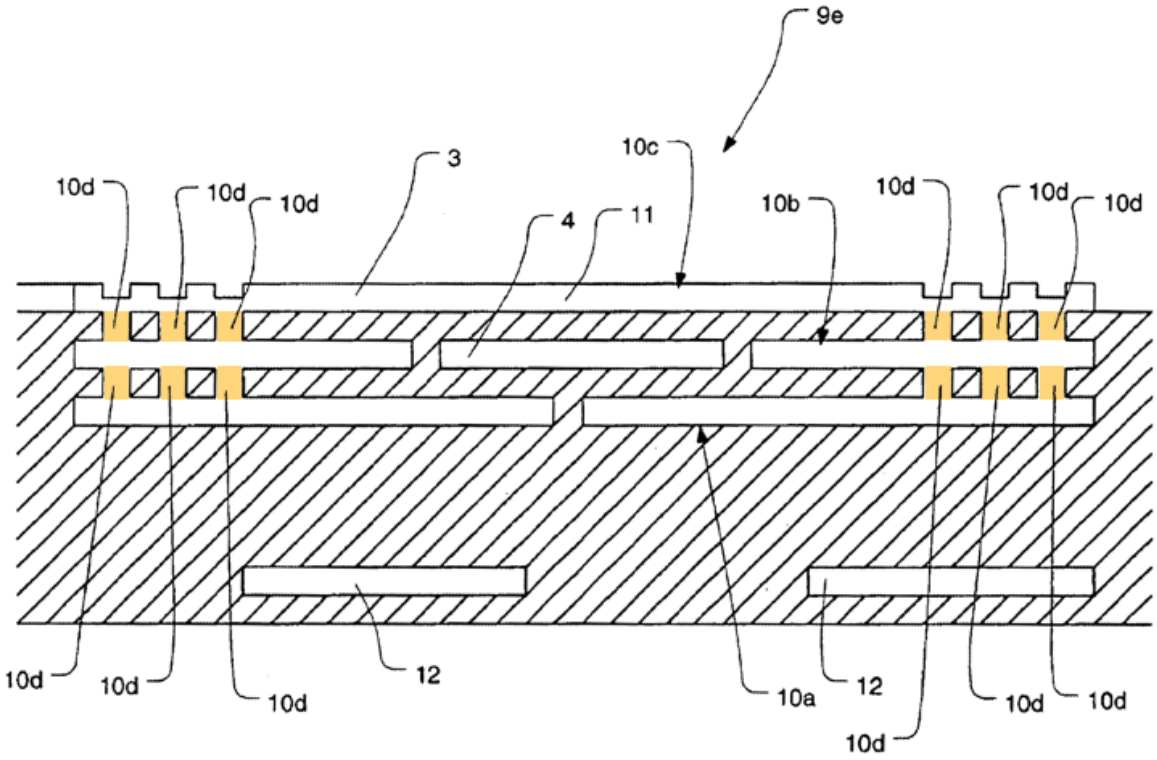


Figure 4

Id., [Fig. 4] (annotated).

232. I show a side-by-side of Figure 1 and 4 below to provide context for Figure 4's labels. Figure 4 shows a sectional view along AA of cross-over 9f. *Id.*, [2:25-27]. Vias (in orange) are located on both sides of the crossover.

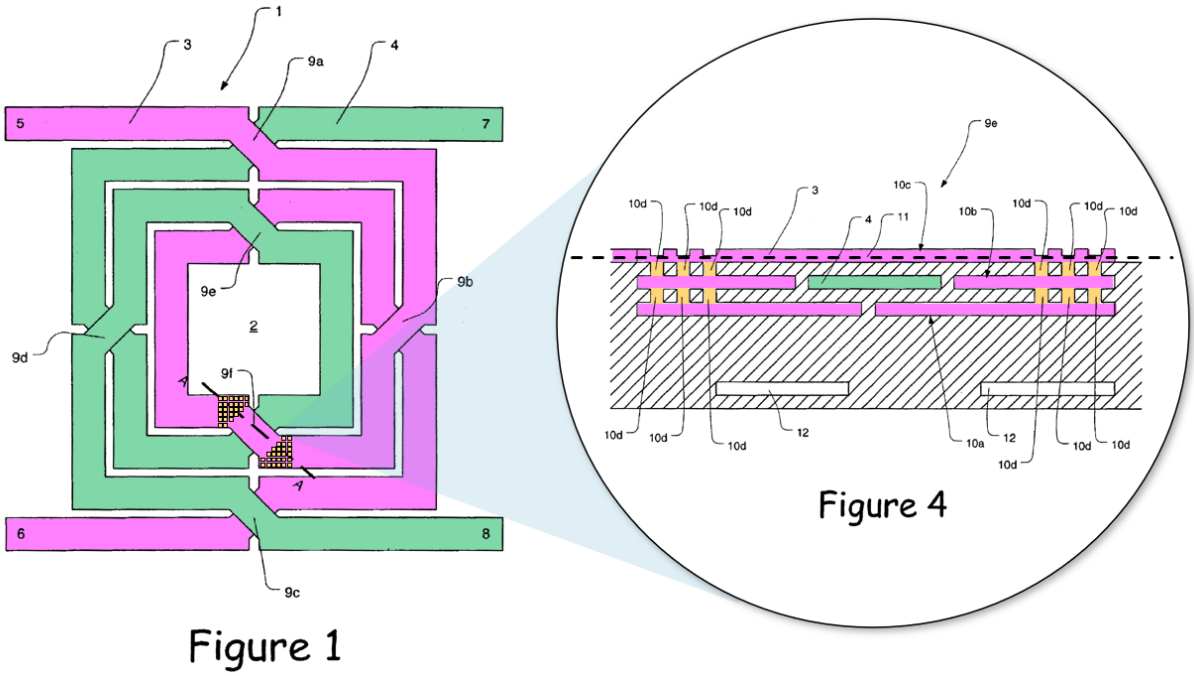


Figure 1

Figure 4

Id., [Fig. 1] (left, annotated); [Fig. 4] (right, annotated).

233. This is further depicted in Figure 6(a) below giving a top-view of the vias used to join the metal layers together near cross-overs. As Christensen explains, "[p]referably, uniting vias are located adjacent to said crossings." *Id.*, [2:1-2].

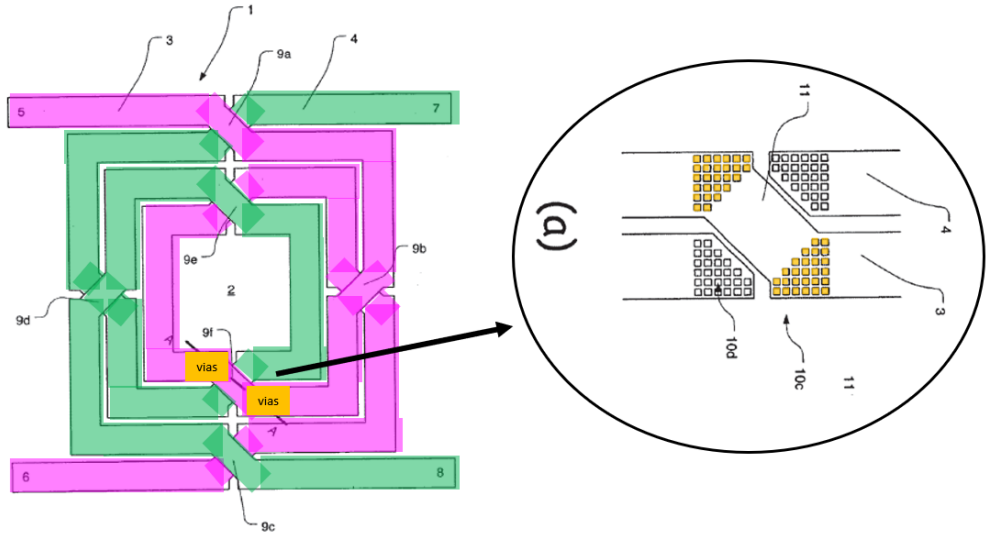


Figure 1

Id., [Fig. 1] (left, annotated); [Fig. 6(a)] (right, annotated).

234. As I previously explained in detail, although the labels in Figures 4, 5, and 6 refer to crossover 9f, a POSITA would have understood this to be merely exemplary and that the disclosed structure of Figures 4, 5, and 6 would also apply to the other crossovers as well. *See*, discussion of Christensen *supra*. Thus, a POSITA would have understood that vias are located adjacent to all crossovers, as I have depicted in Fig. 1 below. As can be seen, and as a POSITA would have expected, the crossovers are adjacent to each and every crossover in a similar manner (annotated in orange).

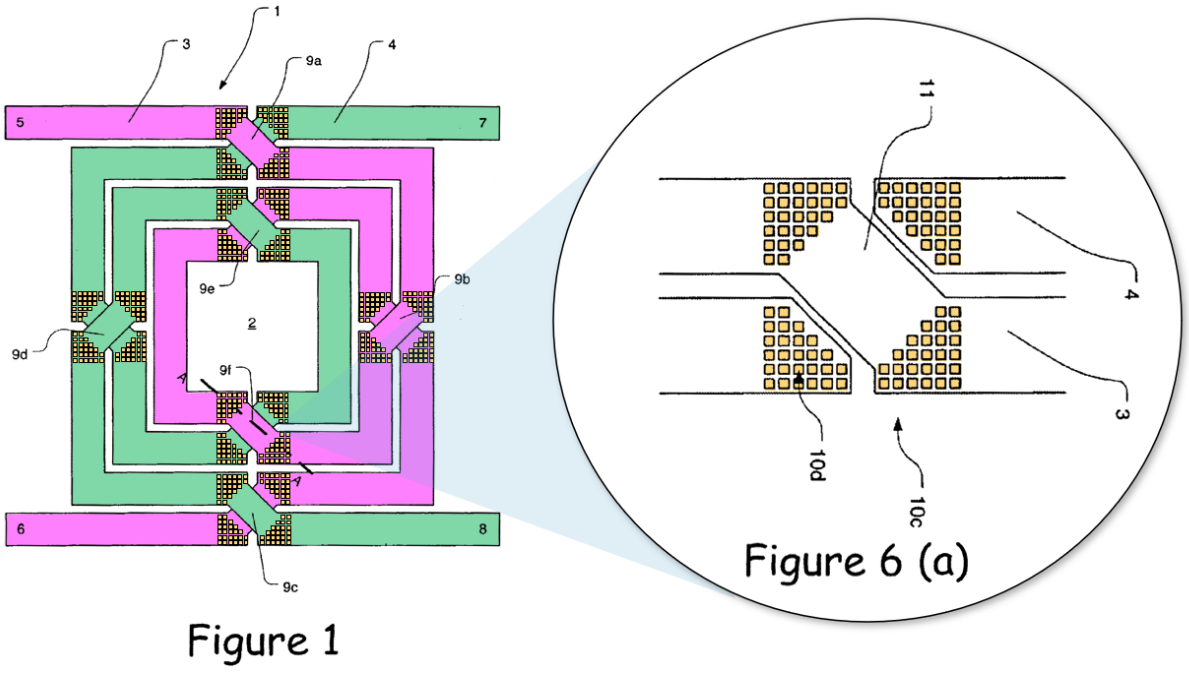
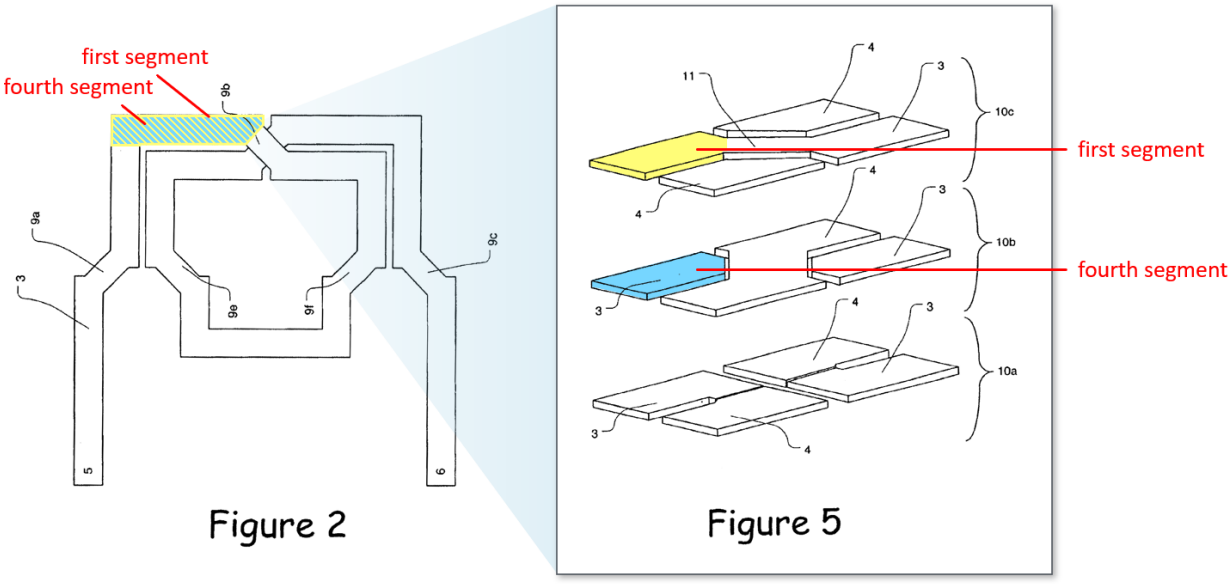


Figure 1

Figure 6 (a)

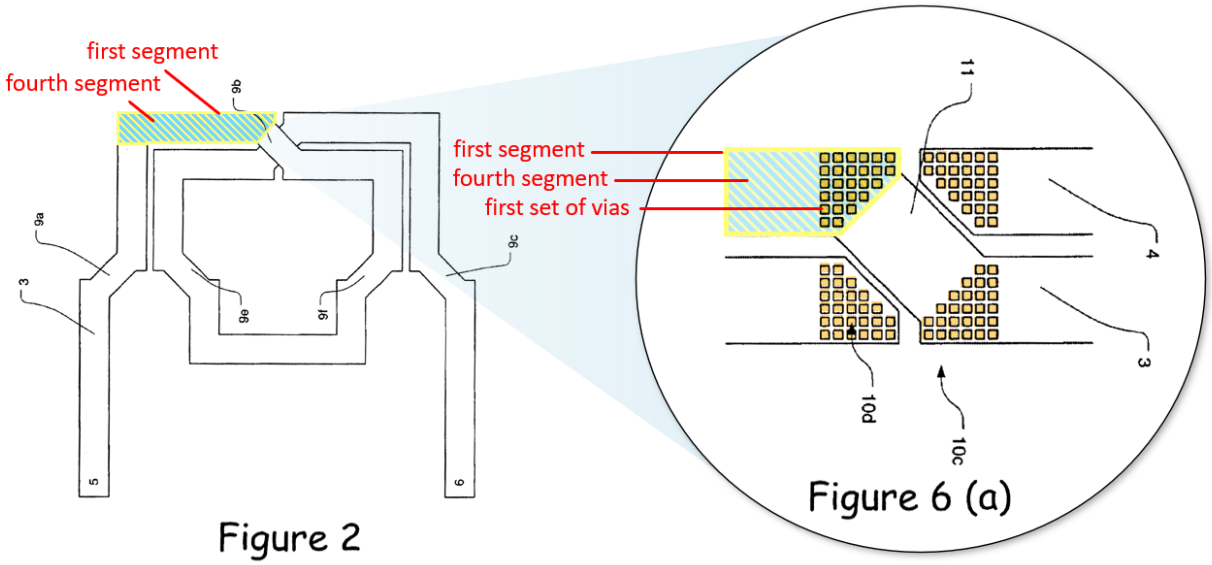
EX-1006, [Fig. 1] (left, annotated); [Fig. 6(a)] (right, annotated).

235. With that said, a POSITA would have understood that Christensen discloses a first set of vias for connecting the first segment with the fourth segment. The first segment in the first metal layer and the fourth segment in the second metal layer are directly above one another, as previously explained and shown below.



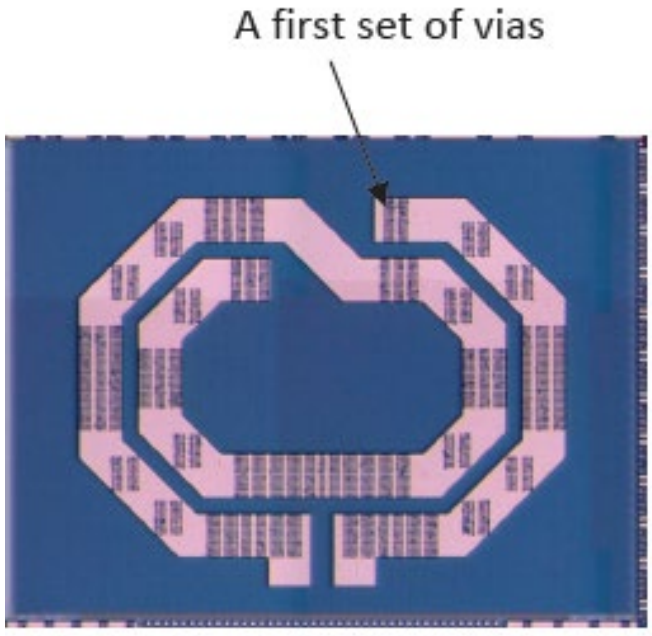
Id., [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

236. A POSITA would have understood that vias connect these two segments (further shown below). As Christensen explains, "The conductors of the conductor layers 10a, 10b, 10c forming the primary winding 3 are bonded by arrays of vias 10d (see FIG. 4) adjacent to the crossovers and, optionally at other locations." *Id.*, [3:47-51].



Id., [Fig. 2] (left, annotated, and rotated); [Fig. 6a] (right, annotated, rotated, and zoomed in).

237. The first set of vias shown are positioned in a location consistent with how Realtek interprets the claim language. For example, Realtek argues that the first set of vias is located adjacent to the crossover.

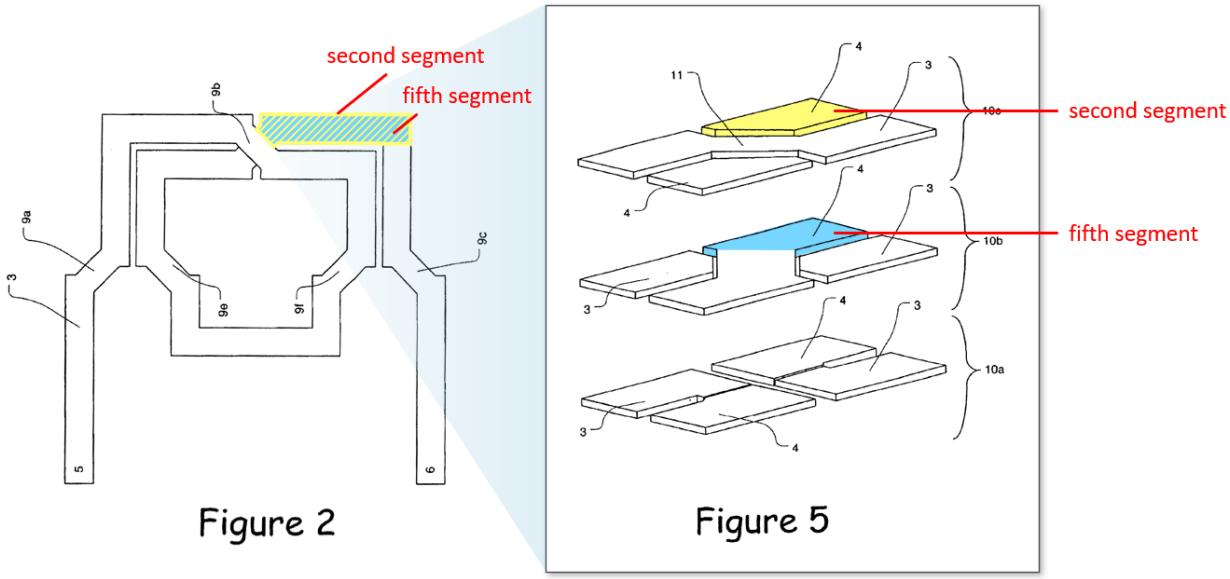


EX-1022.011 (emphasis retained on right).

1.11 A second set of vias, for connecting the second segment with the fifth segment;

238. A POSITA would have understood that Christensen discloses a second set of vias for connecting the second segment with the fifth segment for the same reasons I previously discussed with respect to the first set of vias. I incorporate my analysis by reference herein.

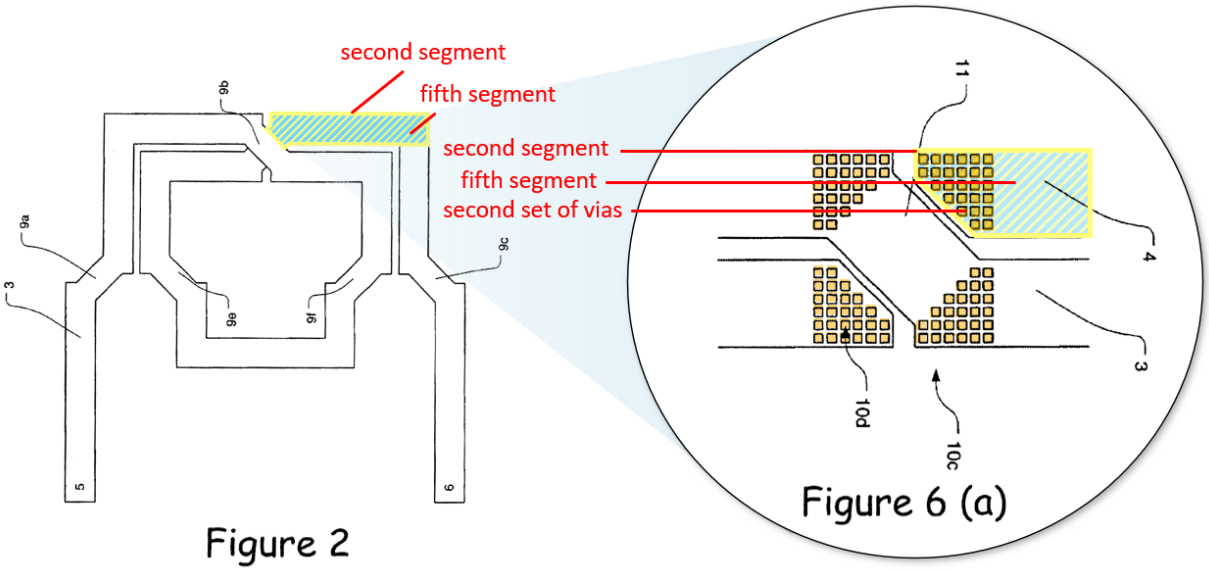
239. As I previously explained, the second segment in the first metal layer and the fifth segment in the second metal layer are directly above one another as shown below.



EX-1006, [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

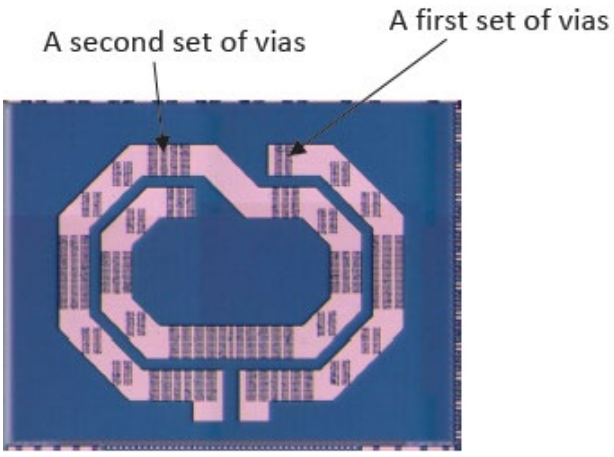
240. A POSITA would have understood that vias connect these two segments (further shown below). As Christensen explains, "The conductors of the conductor layers 10a, 10b, 10c forming the primary winding 3 are bonded by

arrays of vias 10d (see FIG. 4) adjacent to the crossovers and, optionally at other locations." *Id.*, [3:47-51].



Id., [Fig. 2] (left, annotated, and rotated); [Fig. 6a] (right, annotated, rotated, and zoomed in).

241. The second set of vias are positioned in a location consistent with how Realtek interprets the claim language. For example, Realtek argues that the second set of vias is located adjacent to the crossover.



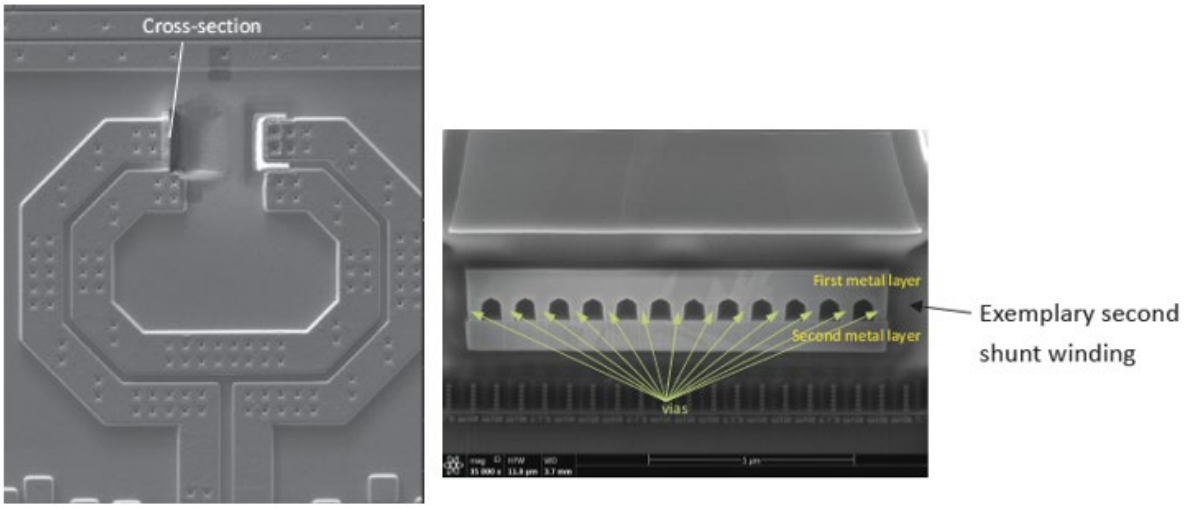
EX-1022.012 (emphasis retained).

1.12 wherein the first segment, the fourth segment and the first set of vias construct a first shunt winding

242. A POSITA would have understood that Christensen discloses a first shunt winding that is constructed of the first segment, the fourth segment, and the first set of vias. As I discussed previously, a POSITA would have understood that a "shunt winding" means windings in parallel. *See*, § VI.A discussion *supra*. Realtek interprets the claim language to be that a first segment connected to fourth segment by vias on two metal layers forms a shunt winding. It specifically argues that a first segment, fourth segment, and first set of vias with a "substantially similar structure" to the image below constructs a shunt winding.

> The cross-section images below show that the second segment, the fifth segment, and the second set of vias construct an exemplary second shunt winding. (On information and belief, a cross section taken in the area of the first segment, the fourth segment, and the first set of vias, would show a substantially similar structure, thereby establishing that the first segment, the fourth segment and the first set of vias construct an exemplary first shunt winding.

EX-1022.013 (emphasis added in highlight).



Id., .014 (emphasis retained).

243. Christensen discloses such a shunt winding. For instance, as I discussed prior, Christenson discloses vias connecting a first segment that is directly above a fourth segment. This is depicted below, where the first segment is yellow, the fourth segment is blue, and the vias are orange.

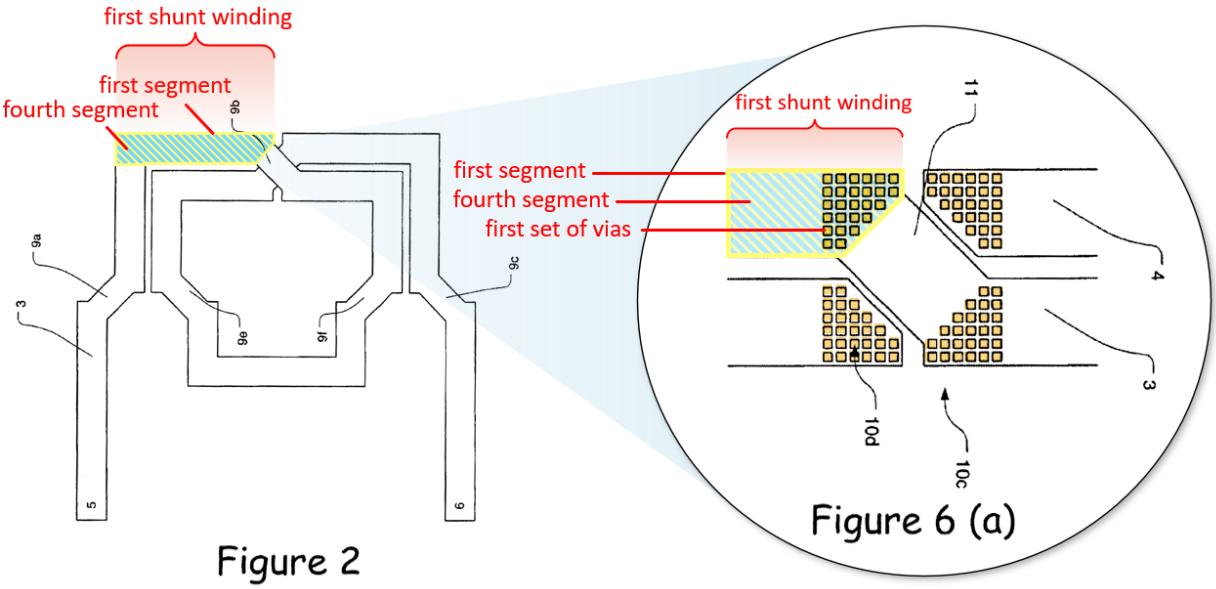


Figure 2

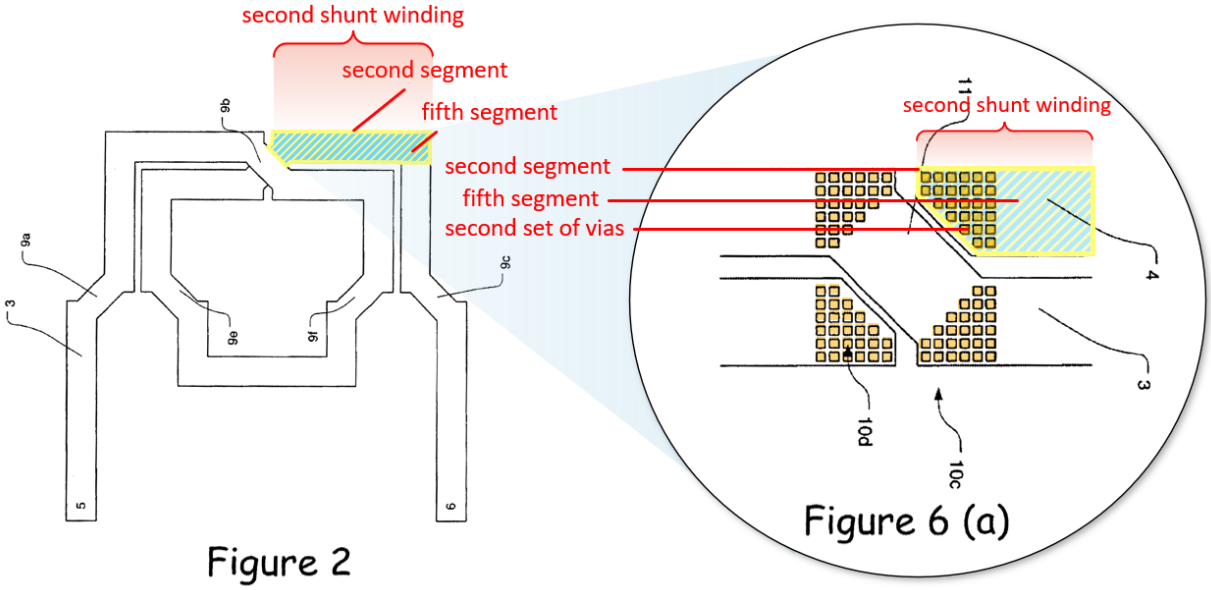
Figure 6 (a)

EX-1006, [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated, rotated, and zoomed in)

244. A POSITA would have recognized that Christensen shows a first shunt winding in the precise manner Realtek interprets the claim language. The structure above shows a first and fourth segment in parallel (one above the other on a first and second metal layer respectively) with vias connecting the first and second metal layers. Similarly, the second and fifth segments are in parallel (one above the other on a first and second metal layer respectively) with vias connecting the first and second metal layers as I will discuss with respect to the next limitation.

1.13 wherein the second segment, the fifth segment and the second set of vias construct a second shunt winding

245. For the same reasons I discussed with respect to the first shunt winding, which I incorporate herein by reference, a POSITA would have recognized that Christensen discloses a second shunt winding that is constructed of the second segment, the fifth segment, and the second set of vias which connects the segments. And as previously discussed, a POSITA would have recognized that the second segment and fifth segment are above one another in parallel with vias connecting them. This is depicted below, where the second segment is yellow, the fifth segment is blue, and the vias are orange.



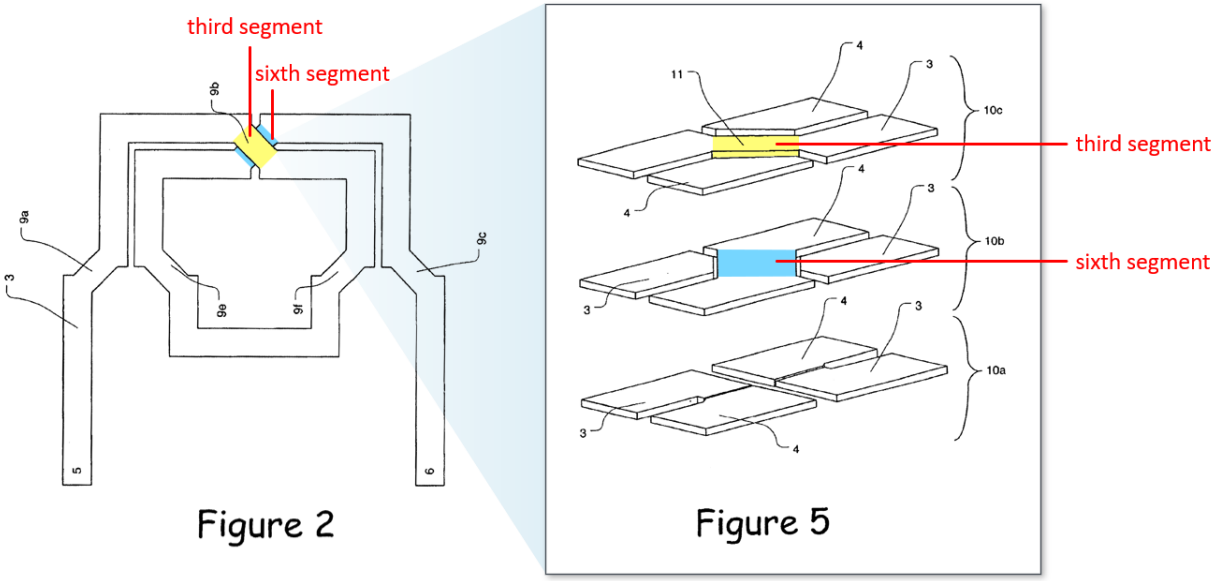
EX-1006, [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated, rotated, and zoomed in).

246. A POSITA would have recognized that Christensen shows a second shunt winding in the precise manner Realtek interprets the claim language. The structure above shows a second and fifth segment in parallel (one above the other on a first and second metal layer respectively) with vias connecting the first and second metal layers.

1.14 and the third segment and the sixth segment construct a crossover region.

247. Lastly, claim 1 requires that the third and sixth segments construct a crossover region. A POSITA would have recognized that this is disclosed in Christensen. This is apparent in Figures 2 and 5 as shown below. The crossover

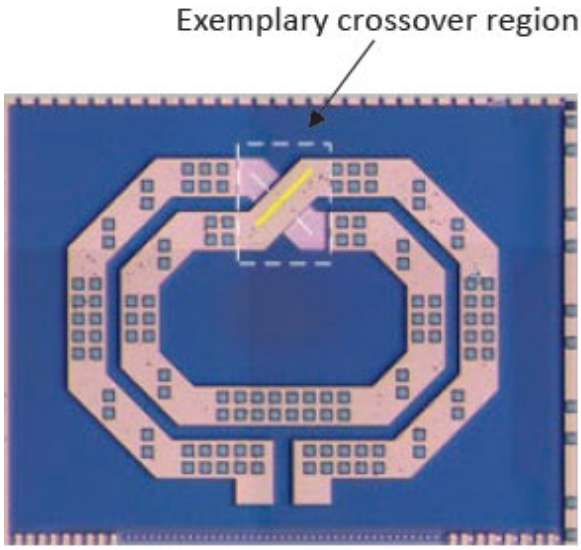
region is formed where the third segment (highlighted in yellow) crosses over the sixth segment (highlighted in blue).



Id., [Fig. 2] (left, annotated, and rotated); [Fig. 5] (right, annotated).

248. A POSITA would have understood that because one segment of the winding (the third segment) crosses over another segment (the sixth segment), the third and sixth segments form (or "construct") a crossover region. This is consistent with how Realtek interprets the claim language as well, as shown below.

249. As I previously explained, the only difference between Figure 2 in Christianson and Realtek's interpretation (shown below) is that the crossover is oriented in the opposite direction. However, a POSITA would have recognized that this difference is not material to the analysis, because orienting the crossover from left to right or vice versa is simply a design choice and is not required by the claims. *See*, discussion of limitation 1.5 *supra*.



EX-1022.014 (emphasis retained).

Claim 2

2.1 The structure of the spiral inductor of claim 1, wherein the third segment is positioned between the first segment and the second segment;

250. A POSITA would have understood that the structure of the spiral inductor includes a third segment that is positioned between the first segment and the second segment. The language "positioned between the first segment and the second segment" simply means that the third segment is in between those two segment.

251. This is the case in Christenson. In the image below, I have highlighted the third segment in yellow. The third segment is positioned in between the first and second segments (also in yellow) as is emphasized by the dashed red lines.

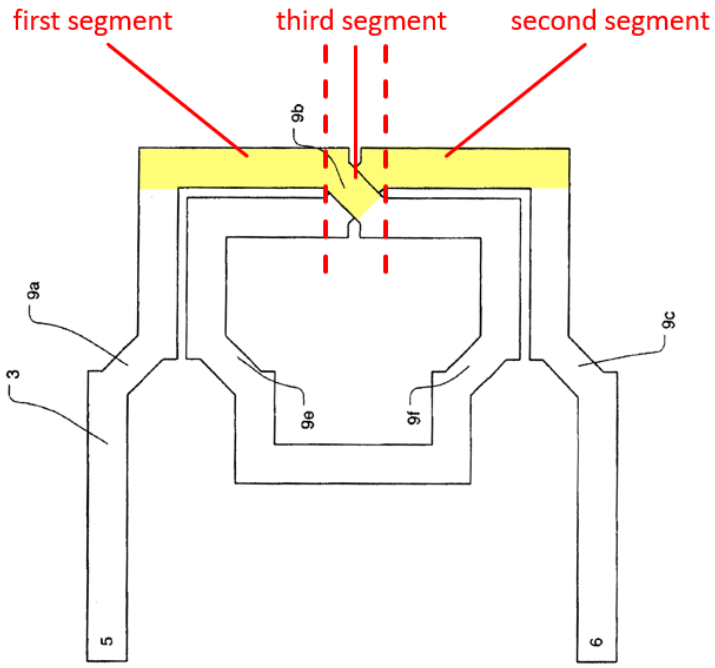


Figure 2

EX-1006, [Fig. 2] (annotated, rotated).

252. To the extent that Realtek argues that the claim requires that the third segment be fully in between the first and second segments, I disagree. The plain language of the claim does not support that construction. That some portion of a structure overlaps with its neighboring structures on the left and right does not mean that the structure is not "positioned between" them. For example, a tree that is planted between two other trees and has branches extending into the branches of the other trees is still positioned between them, notwithstanding some overlap. Further, with respect to the design of the third segment shown in Christensen Fig. 2, a POSITA would have understood that this is merely a design choice that would be easily modifiable so as to have no overlap with the first and second segments.

For example, Figure 6 discloses several different cross-over orientations, one of which shows the entirety of the third segment being positioned between the first and second segments. This is illustrated in 6(b) below. The difference between orientation 6(a) (which I have been using) and 6(b) is that in 6(a), the segments are chamfered at their ends to enable them to terminate closer to the bridge. *See* EX-1006, [3:62-4:8]. This decreases the length of the bridge, and thus decreases its resistance. *Id.* However, Christensen recognizes that traditional non-chamfered segments can be used. *Id.* Thus, a POSITA would have understood that this is merely a design choice.

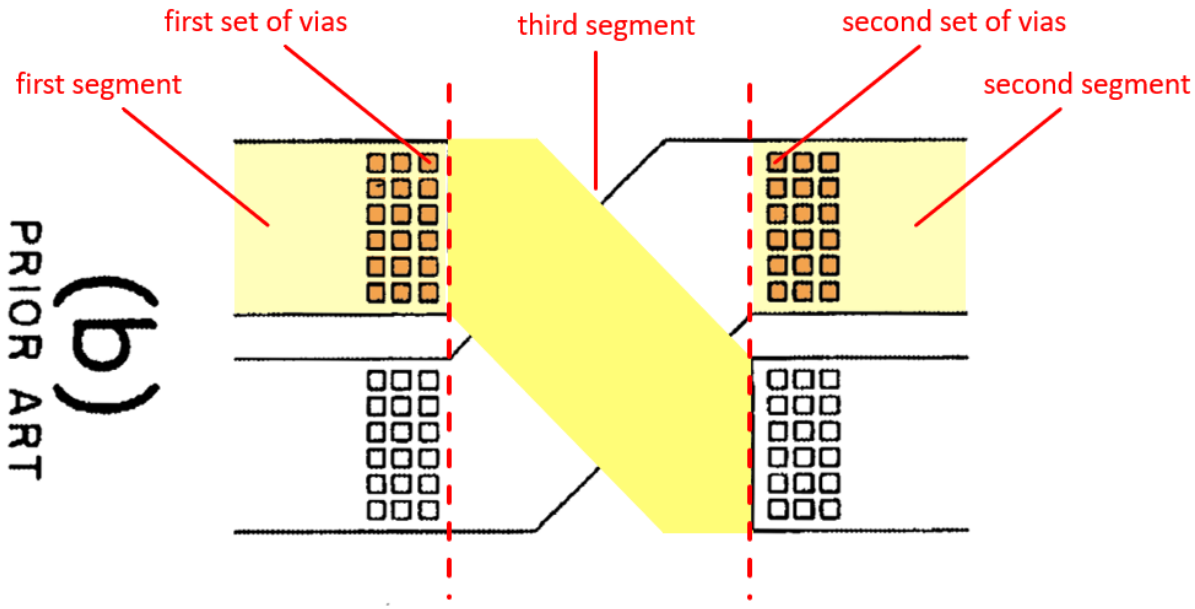


Figure 6

Id., [Fig. 5] (annotated, rotated, and zoomed in).

2.2 and the sixth segment is positioned between the fourth segment and the fifth segment.

253. Similarly, a POSITA would have understood that the structure of the spiral inductor includes a sixth segment that is positioned between the fourth segment and the fifth segment. The language "positioned between the fourth segment and the fifth segment" simply means that the sixth segment is in between those two segments.

254. This is clearly the case in Christenson. In the image below, I have highlighted the sixth segment in blue. The sixth segment is positioned in between the fourth and fifth segments (also in blue) as is emphasized by the dashed red lines. The blue sixth segment is underneath the other crossover segment and is thus only partially visible in the image below.

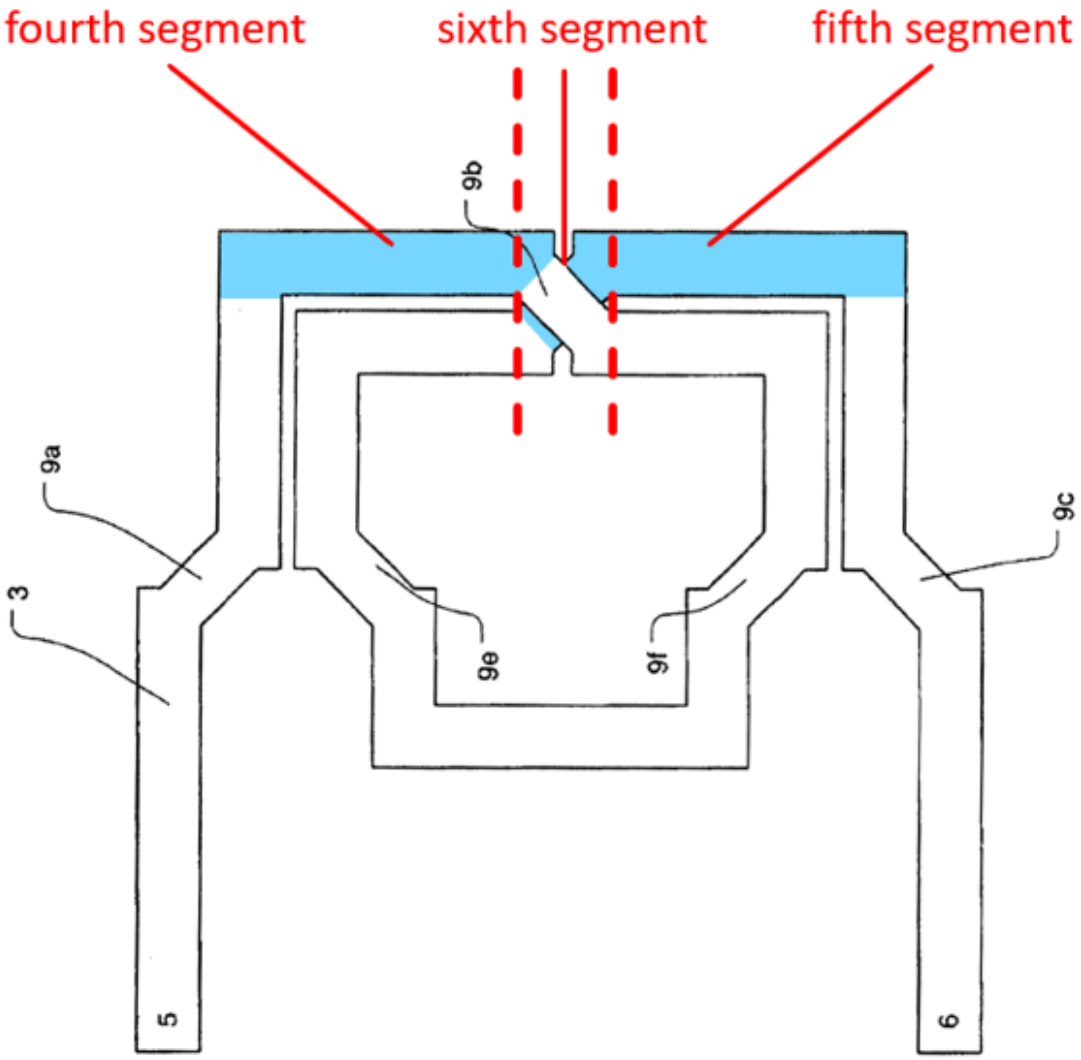


Figure 2

Id., [Fig. 2] (annotated, rotated).

255. As I previously explained, to the extent the claim requires that the sixth segment be fully in between the fourth and fifth segments, a POSITA would have understood that this is merely a design choice. For example, Figure 6 discloses several different cross-over orientations, one of which shows the shows

the entire sixth segment being positioned between the fourth and fifth segments. This is illustrated in 6(b) below. The difference between orientation 6(a) (which I have been using) and 6(b) is that in 6(a), the segments are chamfered at their ends to enable them to terminate closer to the bridge. *See id.*, [3:62-4:8]. This decreases the length of the bridge, and thus its resistance. *Id.* However, Christensen recognizes that traditional non-chamfered segments can be used. *Id.* Thus, a POSITA would have understood that this is merely a design choice.

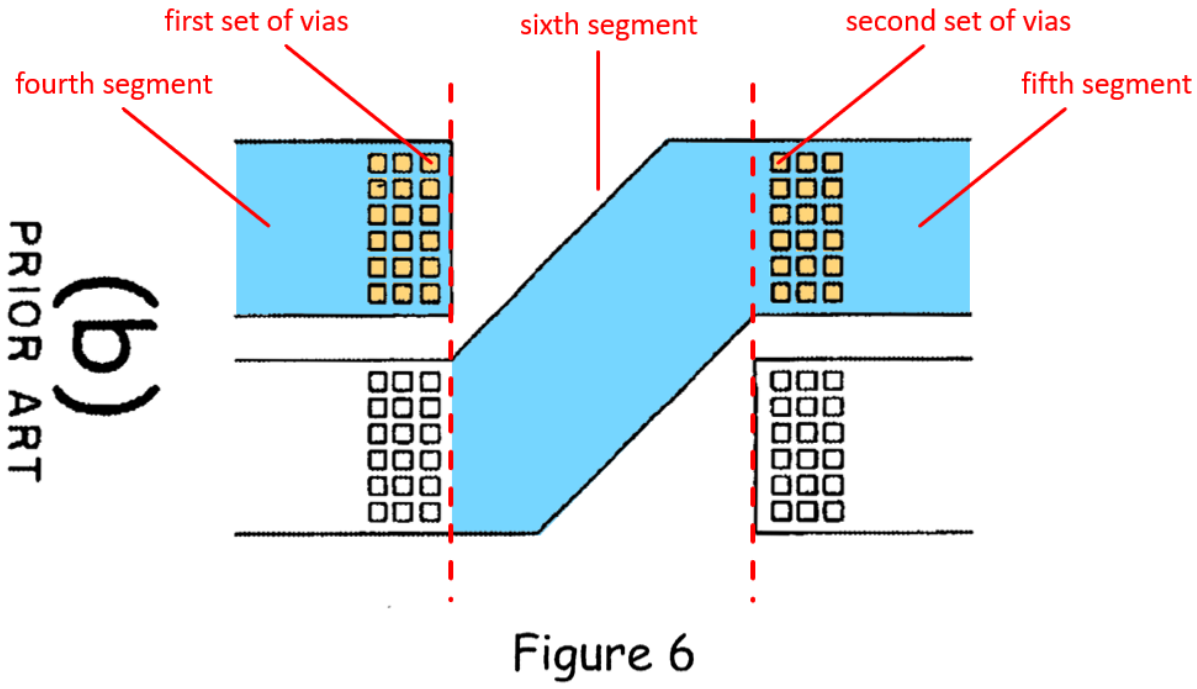
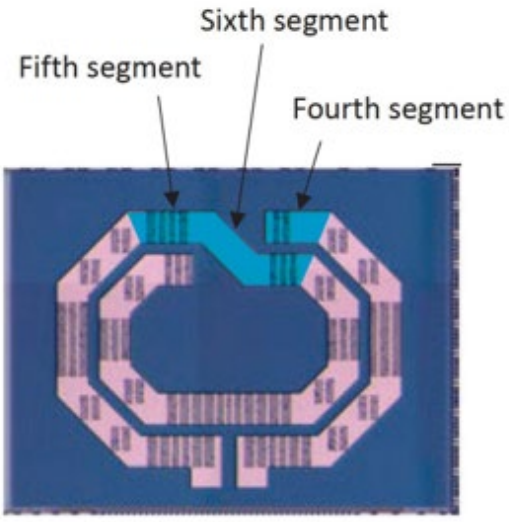


Figure 6

Id., [Fig. 5] (annotated, rotated, and zoomed in).

256. This is also how Realtek interprets the claim language, as depicted below.



EX-1022.015 (emphasis added in blue).

Claim 8

8.1 The structure of the spiral inductor of claim 1, wherein the spiral inductor is a symmetric spiral inductor.

257. A POSITA would have understood that the inductor I have been discussing is a "symmetric" or "symmetrical" inductor. A POSITA would generally have understood that in the context of inductors, symmetric simply means that it has a shape that can be divided into two equal parts along one axis. Each side would roughly be a mirror image of the other. This does not mean there needs to be ***perfect*** symmetry or that it can be divided into two equal parts both vertically and horizontally (or any other angle), the '245 Patent makes that clear, as I will discuss in subsequent paragraphs.

258. The inductors in Fig. 1 of Christensen (and Fig. 2) certainly meet this definition. Whether divided in half vertically or horizontally, the two halves are identical in shape.

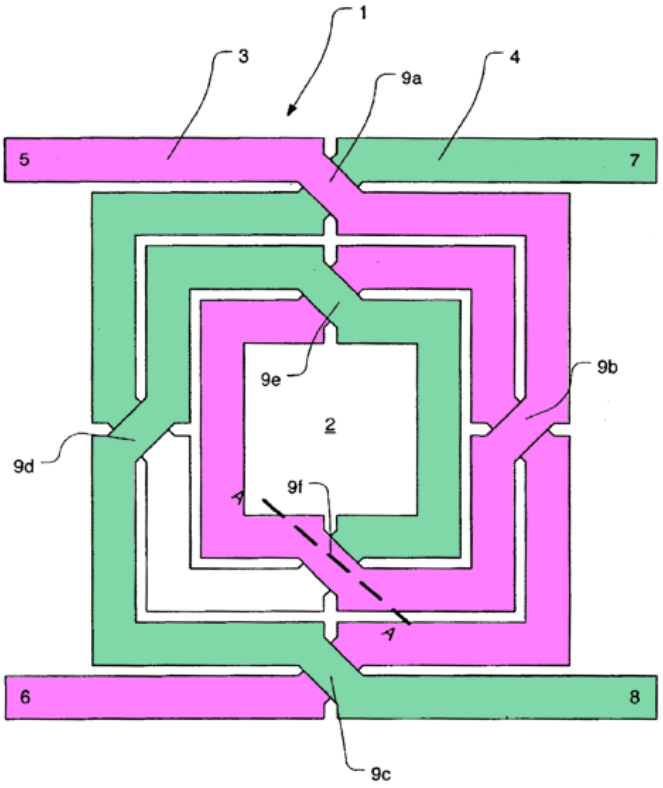


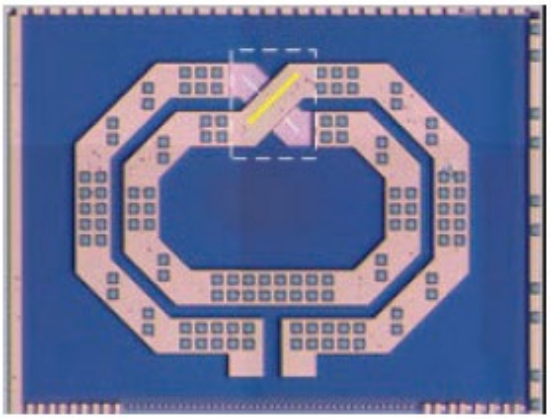
Figure 1

EX-1006, [Fig. 1] (annotated).

259. Christensen further states that "[a]s a general rule, the crossings should be positioned so as to assist in balancing the electrical properties of the windings. Arrangements ***having rotational or mirror symmetry are preferred*** for this reason." *Id.*, [4:60-63].

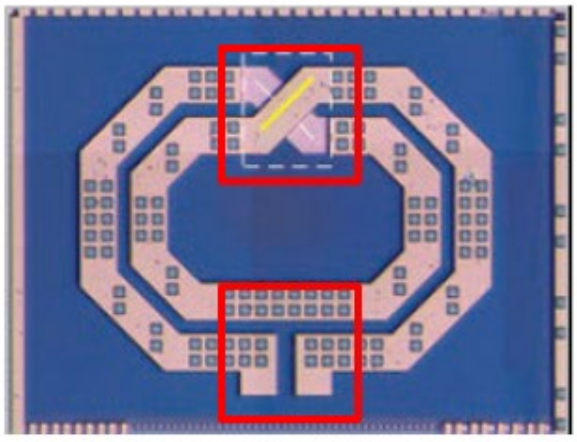
260. This is also how Realtek interprets the claim language, as depicted in the text and accompanying image below.

The spiral inductor is a symmetric spiral inductor as depicted in the image below:



EX-1022.015-.016 (emphasis retained).

261. Notably, ***perfect*** symmetry is not required by the claim language based on the Figures of the '245 patent as well as Realtek's interpretation of the claim. The figure above, which Realtek argues meets the claim language shows seemingly perfect symmetry on the left and right sides but does not demonstrate perfect symmetry on the top and bottom (the top includes crossovers whereas the bottom includes terminals, which I have emphasized with red boxes).



EX-1022.015-.016 (emphasis added).

262. This is similarly the case in both Figure 2 of the ’245 Patent and Figure 2 of Christensen. I show this below. If I run a line through the middle of both figures, it is clear that the top and bottom halves of the ’245 Patent Figure 2 and Christensen Figure 2 are substantially identical and thus symmetrical. This would not be the case if the line ran vertically, as both figures contain crossovers on one side and terminals on the other.

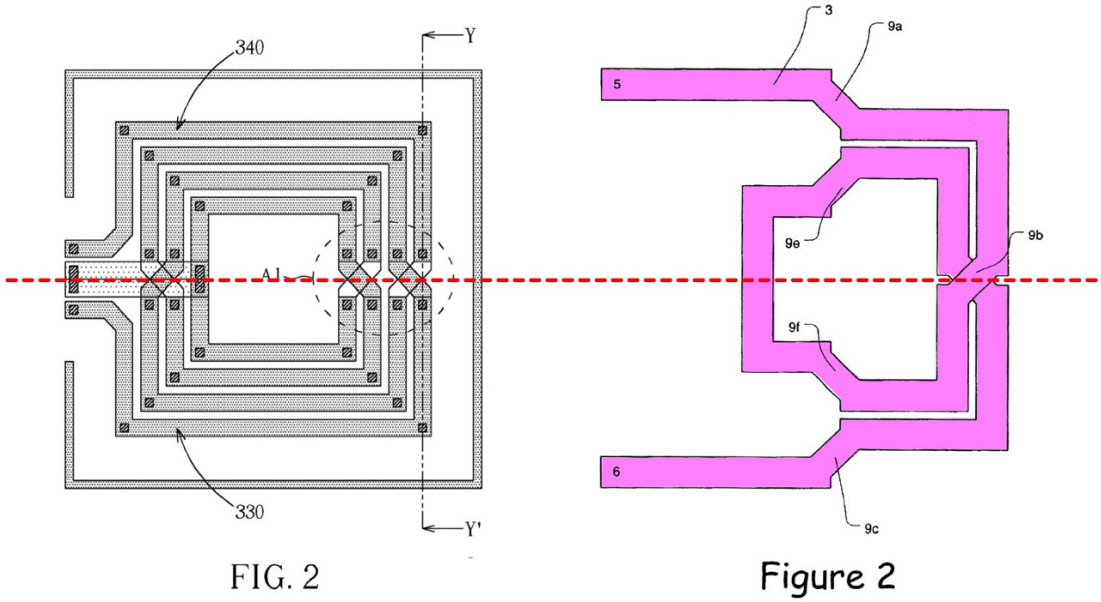


FIG. 2 Figure 2

EX-1001, [Fig. 2] (left, annotated); EX-1006, [Fig. 2] (right, annotated).

263. Christensen further states that “It will be appreciated that may further modifications may be made to the described embodiments, for example the use of shapes other than square, ***e.g. octagons***, without departing from the spirit and scope of the appended claims.” EX-1006, [4:64-67] (emphasis added). A POSITA would have recognized that an octagon is a symmetrical shape. As I discussed

previously, an octagon is simply a shape that has eight lines of symmetry as well as rotational symmetry in the order of eight. In other words, it is a symmetrical figure with eight equal sides. Indeed, claim 9 of the '245 patent itself seems to contemplate this, as it claims "***The structure of the spiral inductor*** of claim 1, wherein a shape of the first shunt winding and the second shunt winding is substantially a rectangle, ***an octagon***, or a circle." EX-1001, [claim 9] (emphasis added). In other words, a POSITA would have understood that the '245 Patent contemplates a spiral inductor that may not be smooth or circular but rather is ***octagonal*** with windings that are on multiple layers and shunted. This is also supported by Realtek's interpretation above, which similarly shows an octagon shape.

Claim 9

9.1 The structure of the spiral inductor of claim 1, wherein a shape of the first shunt winding and the second shunt winding is substantially a rectangle, an octagon, or a circle.

264. A POSITA would have understood that the structure of the spiral inductor of Christensen which includes the first and second shunt windings (as I previously discussed), is substantially in the shape of a rectangle, as shown below.

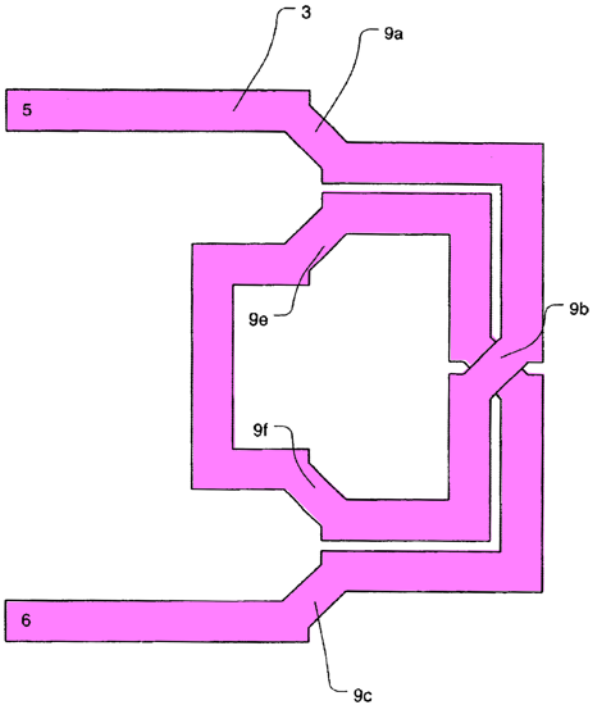


Figure 2

EX-1006, [Fig. 2] (annotated).

265. Additionally, as I previously discussed, Christensen states that "It will be appreciated that may further modifications may be made to the described embodiments, for example the use of shapes other than square, ***e.g. octagons***, without departing from the spirit and scope of the appended claims." EX-1006, [4:64-67] (emphasis added).

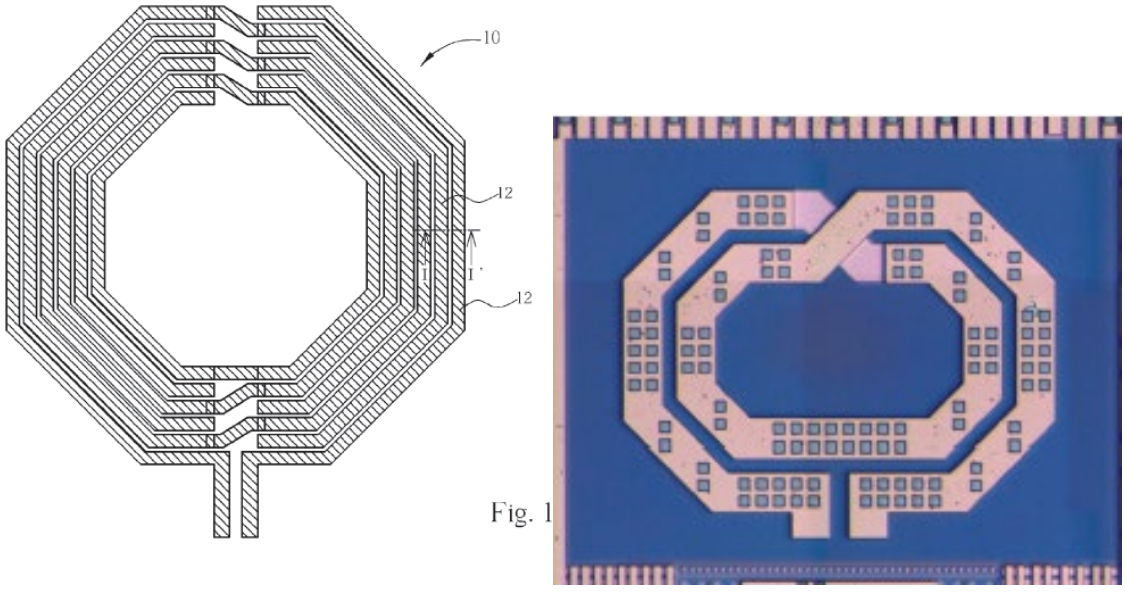
IX. GROUND 3: OBVIOUSNESS BASED ON YANG

266. Yang discloses a symmetrical (octagon shaped) inductor. The inductor structure disclosed in Yang is materially the same as the inductor claimed in the '245 patent, particularly in light of how Realtek itself interprets the claim language.

Claim 1

1.1 A structure of a spiral inductor, comprising:

267. To the extent this preamble of claim 1 is a limitation, Yang discloses a spiral inductor. The title of Yang is "Integrated Inductor." Furthermore, Yang specifically states that "[i]t is understood that although the integrated inductor 10 of the embodiment is demonstrated in the form of octagon shape. The integrated inductor can also be formed of any other suitable shapes, for example, spiral shape..." EX-1007, [0019]. The inductor disclosed in Fig. 1 of Yang is in the form of an octagon much like what Realtek claims to be a spiral inductor as I depict below.



Id., [Fig. 1] (left); EX-1022.007 (right).

1.2 a first metal layer, comprising:

268. As I stated prior, a POSITA would have understood that this limitation describes a winding of the inductor being located on one metal layer, e.g., above a semiconductor substrate. Yang specifically discloses a first metal layer, stating that "[a]ccording to the claimed invention, an integrated inductor has a winding is provided. The winding includes a ***first level metal layer*** inlaid in a first dielectric layer, a ***second level metal layer*** inlaid in a second dielectric layer above the first dielectric layer…" EX-1007, [0009] (emphasis added); *see also*, *id.*, [0020]-[0024] (further elaborating on the metal layers used in the Fig. 1 embodiment).

269. I have emphasized both the "first" and "second" metal layers in the citation above because claim 1 of the '245 patent requires that the second metal layer be positioned under the first metal layer. In Yang, the "second" metal layer is above the first layer. A POSITA would have understood that this is simply a naming convention. A POSITA could refer to the higher layer as the "first" or "second" layer to distinguish the two. A POSITA would have understood that the "second metal layer" of Yang meets the "first metal layer" of claim 1 of the '245 patent because it refers to the higher metal layer of the inductor structure.

270. This is also shown in Fig. 2 of Yang, which I have reproduced and highlighted below. Fig. 2 is a "sectional perspective view" of Fig. 1. *Id.*, [0013]. In other words, it is a cross-sectional view that depicts the layers of Fig. 1. Two of the windings (12) of Fig. 1 are depicted in Fig. 2. *See id.*, [0018]. The upper layer

of Fig. 2 is aluminum and I have emphasized it in yellow with respect to the two windings (12). A POSITA would have understood that aluminum is a type of metal. Below this layer is another metal layer, which I have emphasized in blue with respect to the two windings on the layer just below aluminum layer (20).

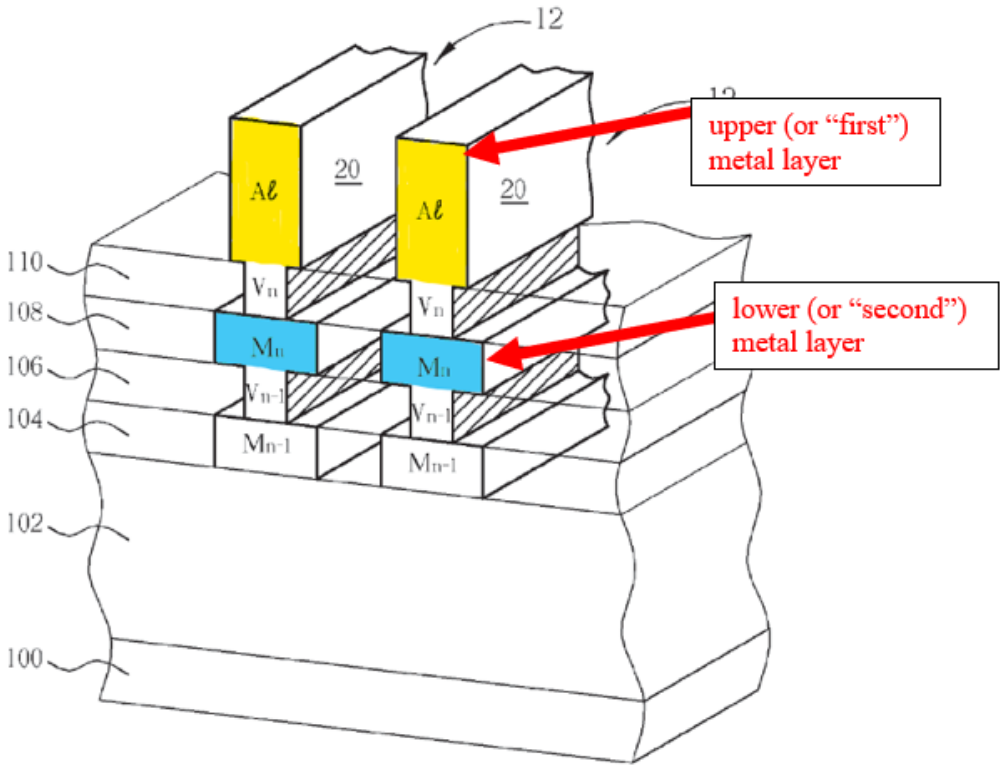


Fig. 2

Id., [Fig. 2] (emphasis added).

271. I have also visually depicted several segments of this first metal layer using the top view image of the inductor in Fig. 1.

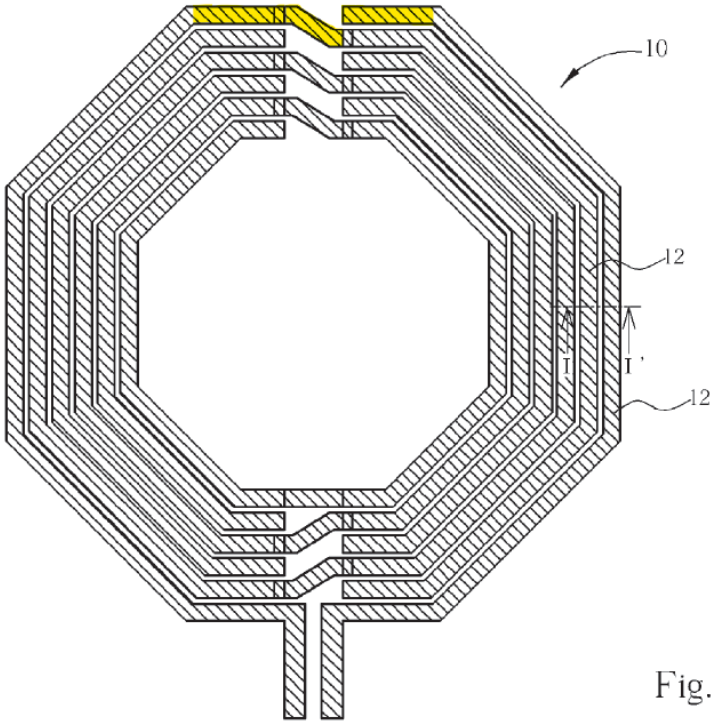


Fig. 1

Id., [Fig. 1] (emphasis added).

272. The specification of Yang confirms the use of a first metal layer. It states that "[a]s shown in FIG. 1 and FIG. 2, each winding 12 of the integrated inductor 10 having a vertical metal stack includes, in the order of metal layer M_{n-1}, via plug layer V_{n-1}, metal layer M_n, via plug layer V_n and an ***aluminum layer 20***." *Id.*, [0020] (emphasis added). A POSITA would have understood that this means multiple metal layers (up to n)[2] can be placed below the aluminum metal layer (20) and above the substrate level (100). A POSITA would have understood that the

[2] The specification notes that "preferably, n ranges between 4 and 8 (n=4-8)." *Id.*, [0017]. In other words there are four to eight metal layers total.

inductor windings (of Figure 1) extend into the additional metal layers such as layer M_{n-1} shown in Figure 2, and that additional metal layers (e.g., layer M_{n-2}) would exist below that layer. But for purposes of my analysis, I will only focus on the top two levels (aluminum layer 20 and metal layer M_n) on dielectric layer 108. *See id.*, [0025].

1.3 a first segment

273. As I stated prior, a POSITA would have understood that this limitation describes a portion or "segment" of the winding of the inductor that is on the first metal layer. I have highlighted the first segment of the Fig. 1 inductor below, in yellow.

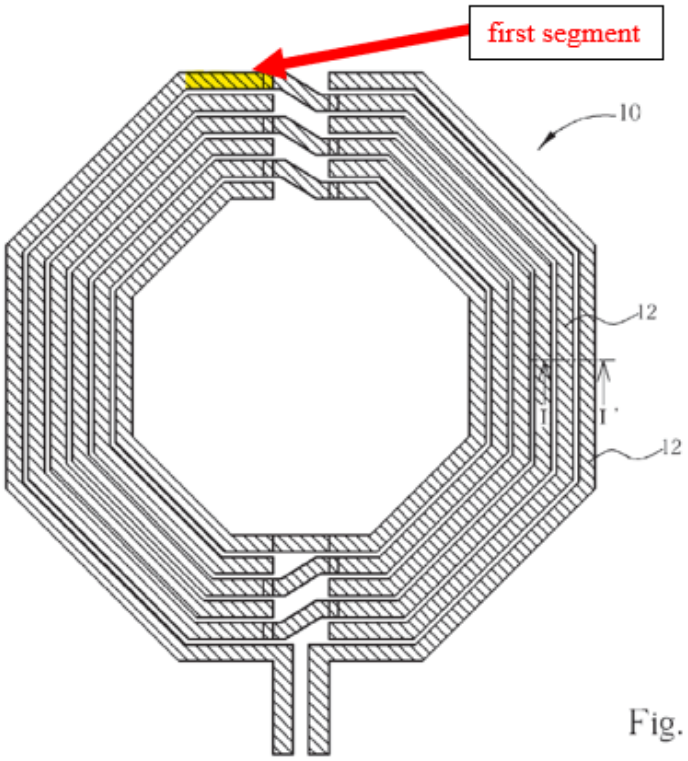
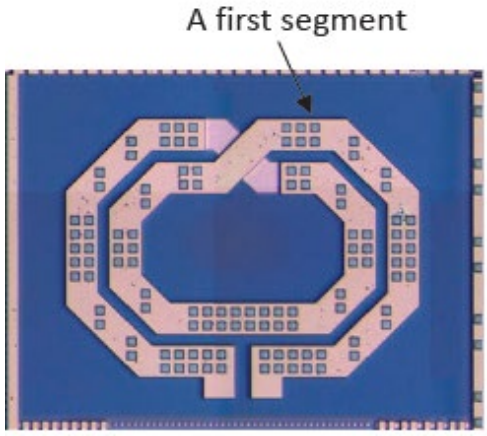


Fig. 1

Id., [Fig. 1] (emphasis added).

274. As I discussed previously, this interpretation is consistent with how Realtek interprets the segments (e.g., the first segment) of the winding on the first metal layer, as shown below.



EX-1022.008 (emphasis retained).

1.4 a second segment; and

275. A POSITA would have understood that this limitation describes a second portion or "segment" of the winding of the inductor that is on the first metal layer, which is distinct from the first segment. I have highlighted the second segment of the Fig. 1 inductor below in yellow.

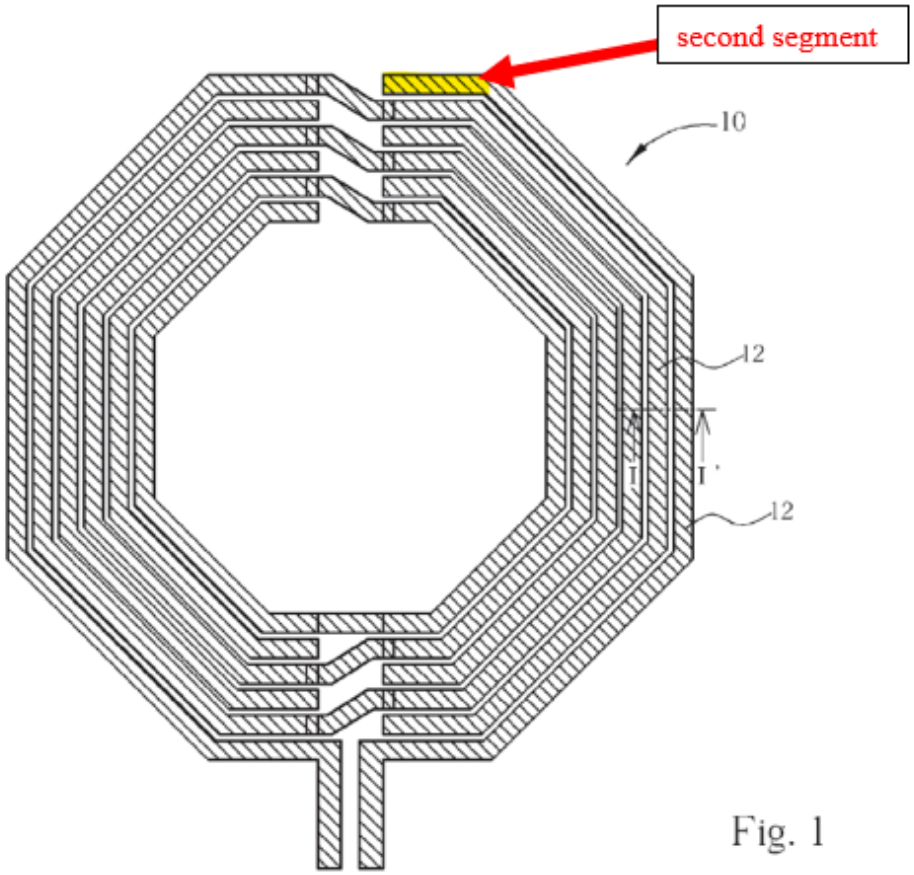
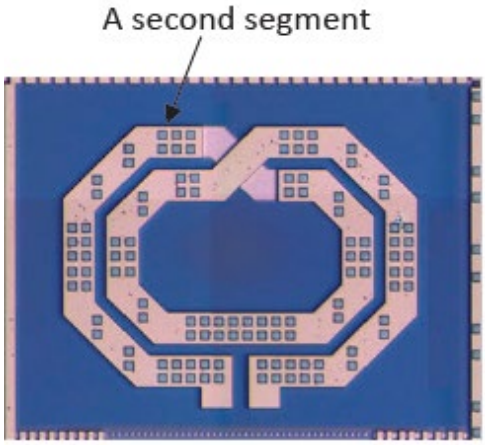


Fig. 1

EX-1007, [Fig. 1] (emphasis added).

276. This interpretation is consistent with how Realtek interprets the segments (e.g., the second segment) of the winding on the first metal layer, as shown below.



EX-1022.008 (emphasis retained).

1.5 a third segment, connected to the first segment, wherein a layout direction of the third segment is different from a layout direction of the first segment and a layout direction of the second segment;

277. A POSITA would have understood that the "third segment" is another portion of the winding found on the first metal layer that is directly physically connected to the first segment. Additionally, a POSITA would have understood that "wherein a layout direction of the third segment is ***different*** from a layout direction of the first segment and a layout direction of the second segment" means that the third segment is angled in a different direction, e.g., the axis of the third segment is offset from the other two.

278. Yang discloses such a third segment as shown below. In the image below, I have highlighted the third segment in yellow as well. As can be seen, the third segment is angled in a different direction than the first and second segments in yellow.

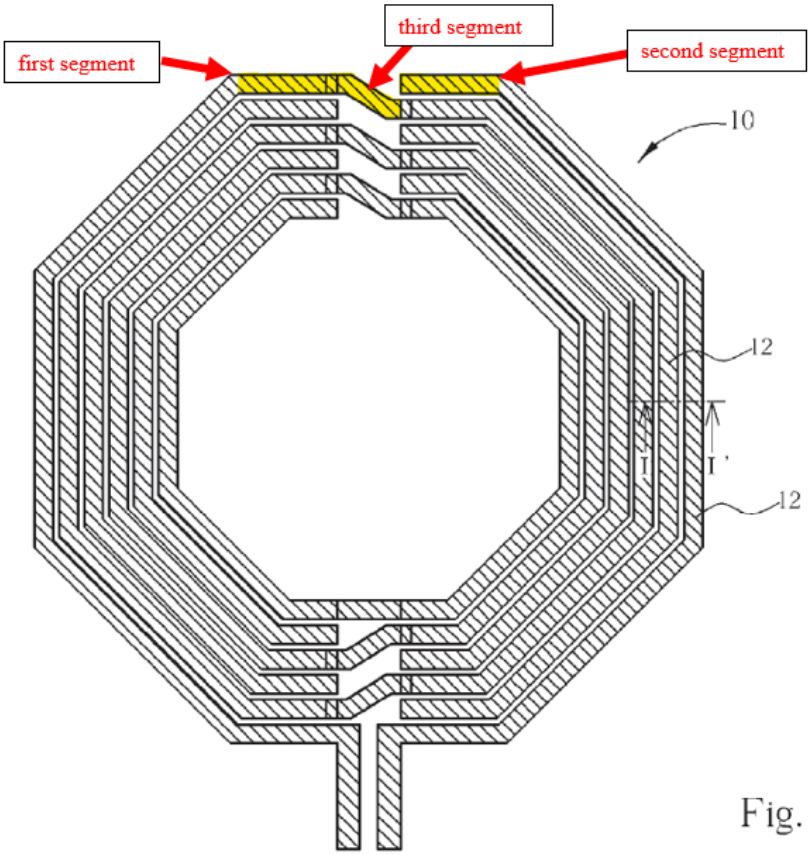
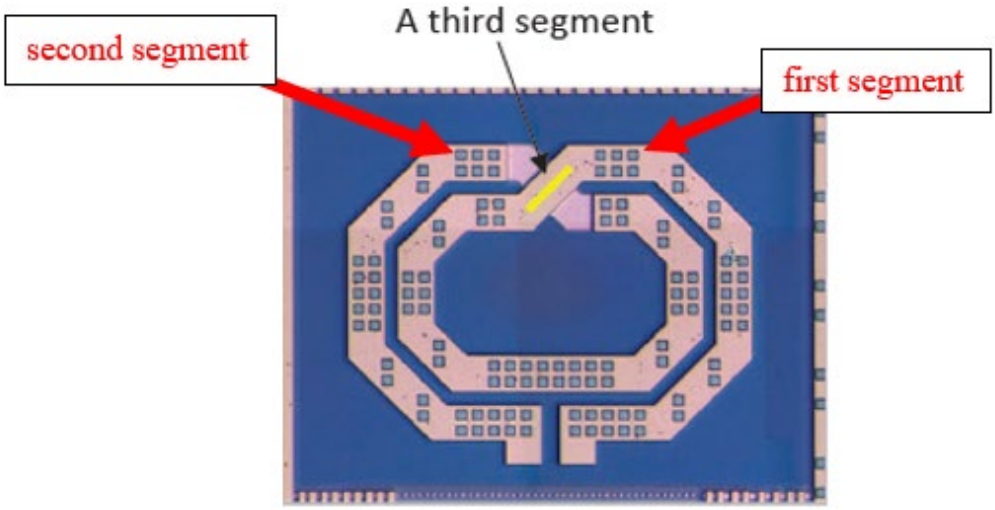


Fig. 1

EX-1007, [Fig. 1] (emphasis added).

279. As can be seen, the "third segment" is another portion of the winding found on the first metal layer and it is directly physically connected to the first segment on its left side.

280. This is consistent with how Realtek is interpreting the claim language. As shown below, Realtek points to the yellow highlighted portion of the winding as being the third segment, which is connected to the first segment and is positioned in a different layout direction than the first and second segments.



EX-1022.009 (emphasis retained in yellow and added in red).

281. In the figure above, I have also added pointers showing the first and second segments. As is clear, what Realtek points to is materially identical to Fig. 1 of Yang. The first segment is simply on the left side in Yang because the crossover of the upper metal (aluminum) layer in Yang is oriented in the opposite direction as the crossover of the lower metal layer in the Realtek exhibit.

282. A POSITA would have recognized that orienting the crossover from left to right or vice versa is simply a design choice. Furthermore, a POSITA would have recognized that the claim language does not require that the crossover (or "third segment") be positioned any particular way, other than in a layout direction that is distinct from the layout direction of the first and second segments. This is the case in Yang because it is positioned at an angle that is different than the first and second segments while still being connected to the first segment.

1.6 a second metal layer, being positioned under the first metal layer, the second metal layer comprising

283. A POSITA would have understood that "a second metal layer, being positioned under the first metal layer" simply means that the second metal layer is physically underneath the first metal layer. This is the case in Yang.

284. This is shown in Fig. 2 of Yang. I have highlighted the top metal layer (in yellow in Fig. 2) which includes segments 1, 2, and 3, which I previously discussed. A POSITA would have understood that the stacked structure includes a second metal layer below this layer (emphasized in blue in Fig. 2).

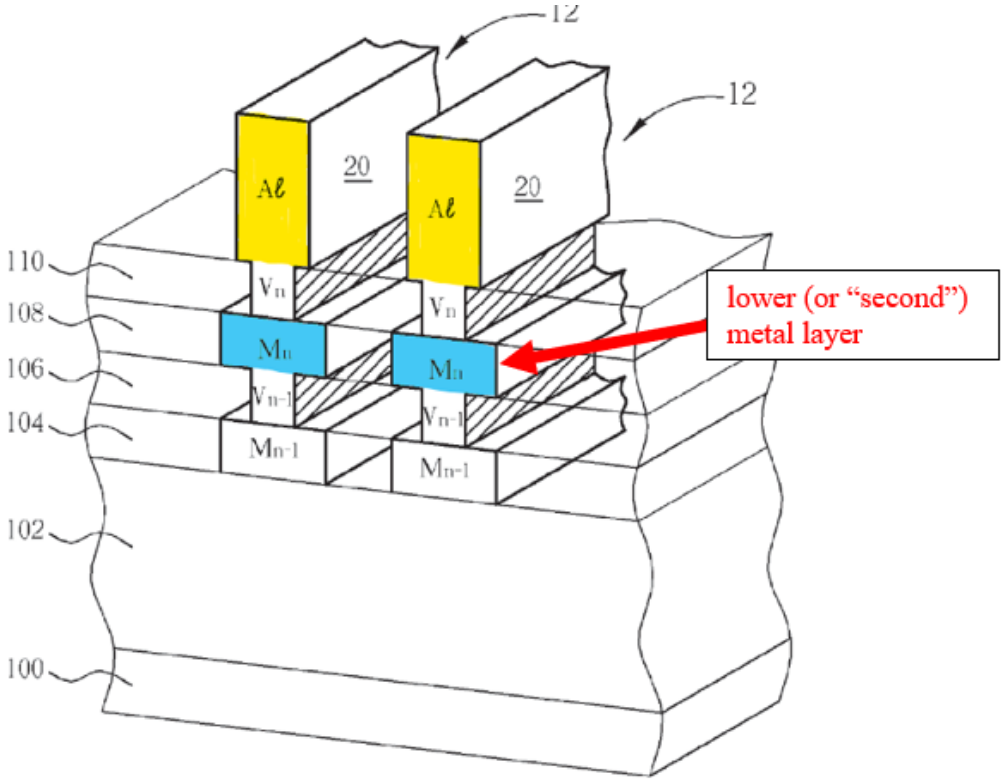
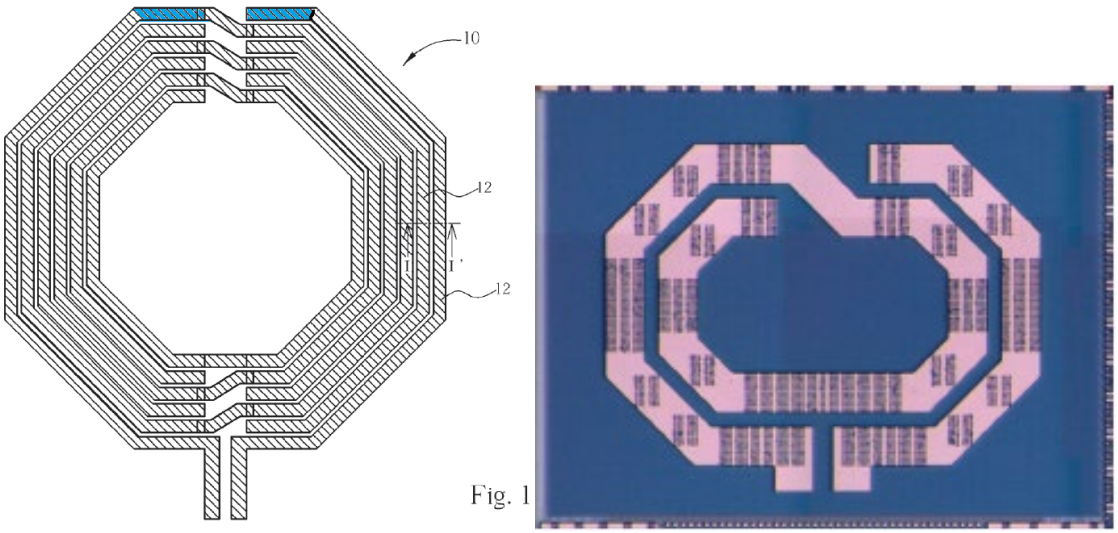


Fig. 2

EX-1007, [Fig. 2] (emphasis added).

285. A POSITA would have understood that the second metal layer I emphasized in blue above is positioned under the first metal layer (emphasized in yellow) because it is the layer closer to the substrate, which is marked as 100. *See id.*, [0020]. Furthermore, what I have emphasized in yellow, the "aluminum layer 20" is described as "overlying" layer M_n, the metal layer emphasized in blue. *Id*.

286. This is how Realtek also appears to interpret the claim language, as shown on the image on the right below.



EX-1007, [Fig. 1] (left with emphasis added); EX-1022.009 (right).

287. In the image above, I have emphasized the same portions of Fig. 1 that I emphasized with respect to the first metal layer (with the exception of the crossover section, which I will address later in my declaration). This is because Yang makes clear that the metal layer M_n, which I refer to as the second metal layer, includes the same windings underneath the windings of the aluminum (or

"first") metal layer. In particular, Yang states that "[a]s shown in FIG. 1 and FIG. 2, ***each winding 12 of the integrated inductor 10 having a vertical metal stack*** includes, in the order of metal layer M_{n-1}, via plug layer V_{n-1}, metal layer M_n, via plug layer V_n and an aluminum layer 20." EX-1007, [0020] (emphasis added).

288. A POSITA would have understood that this means the top metal layer (aluminum) and the metal layer (M_n) positioned directly underneath it are part of a stack that includes inductor windings. In other words, a POSITA would have understood that the windings of the aluminum layer and the metal layers below it (including M_n) are identical, with the exception of the crossover region. Thus, as shown in my markups below, the blue windings (M_n) are on a metal layer positioned right under the yellow windings (aluminum).

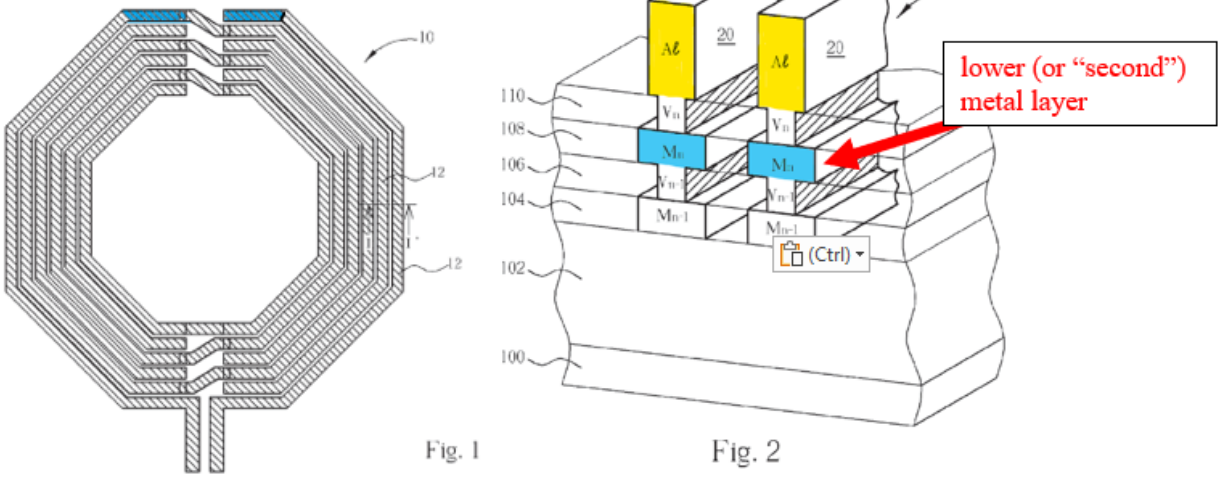


Fig. 1 Fig. 2

EX-1007 [Fig. 1] (emphasis added); [Fig. 2] (emphasis added). In other words, based on what is shown in Figure 2, a POSITA would understand there are inductor

windings in the metal layers that are directly below the top layer (shown in the top view of Figure 1). A POSITA would have therefore understood that while Figure 1 shows only the top layer, there are identical windings in the lower metal layers, with the exception of the crossover regions. As I discussed, the windings shown in Figure 2 (in blue) are on the metal layer M_n positioned under the yellow windings (aluminum).

1.7 A fourth segment

289. Based on the above understanding of the second metal as I just discussed, a POSITA would have understood that the second metal layer contains a fourth segment. I have highlighted the fourth segment of the Fig. 1 inductor below (left). This interpretation is consistent with how Realtek interprets the segments (e.g., the fourth segment) of the winding on the second metal layer, as also shown below (right).

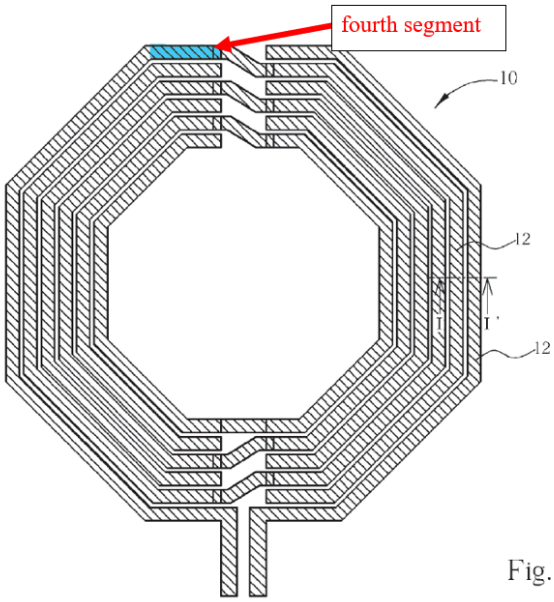
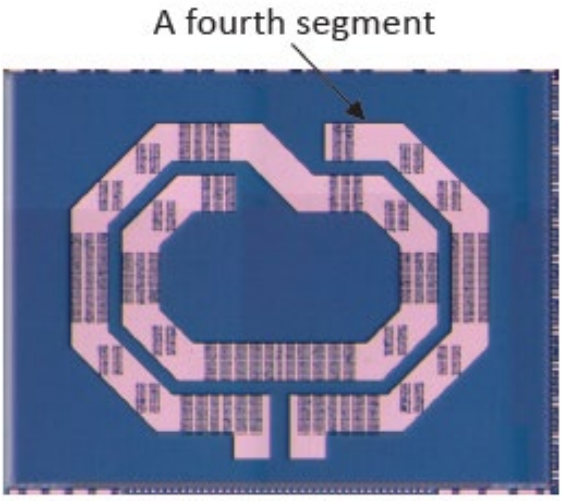


Fig. 1



EX-1007, [Fig. 1] (left, emphasis added); EX-1022.010 (right).

290. Similar to my discussion regarding the first segment, which I incorporate into my analysis here, the fourth segment is simply on the left side in Yang because the crossover of the lower metal layer (not visible in Fig. 1) is oriented in the opposite direction as the crossover of the lower metal layer in the Realtek exhibit.

1.8 A fifth segment; and

291. A POSITA would have understood that this limitation describes a fifth portion or "segment" of the winding of the inductor that is on the second metal layer, which is distinct from the fourth segment. I have highlighted the second segment of the Fig. 1 inductor below (left). This interpretation is consistent with how Realtek interprets the segments (e.g., the fifth segment) of the winding on the second metal layer, as also shown below (right).

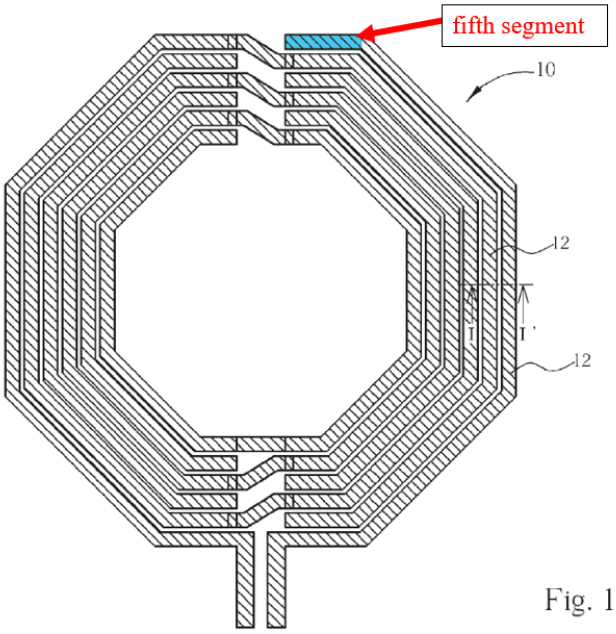
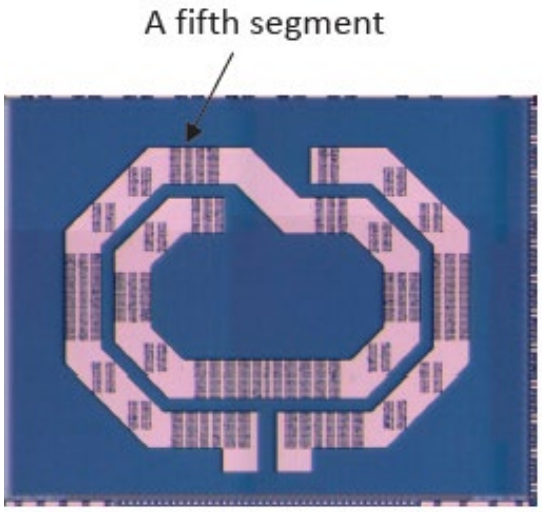


Fig. 1



EX-1007, [Fig. 1] (left, emphasis added); EX-1022.010 (right).

292. Again, the fifth segment is on the right side in Yang because the crossover of the lower metal layer (not visible in Fig. 1) is oriented in the opposite direction as the crossover of the lower metal layer in the Realtek exhibit.

retained).

1.9 a sixth segment, connected to the fifth segment, wherein a layout direction of the sixth segment is different from a layout direction of the fourth segment and a layout direction of the fifth segment;

293. A POSITA would have understood that the "sixth segment" is another portion of the winding found on the second metal layer that is directly physically connected to the fifth segment. Additionally, a POSITA would have understood that "wherein a layout direction of the sixth segment is ***different*** from a layout

direction of the fourth segment and a layout direction of the fifth segment" means that the sixth segment is angled in a different direction, e.g., the axis of the third segment is offset from the other two. We also know from subsequent limitations, that the sixth segment is part of a crossover region.

294. A POSITA would have understood that Yang inherently discloses such a sixth segment as shown below. I will discuss those reasons in the following paragraphs. First, I have highlighted where a POSITA would have understood the sixth segment to be, in blue. I have also highlighted the fourth and fifth segments, which I previously highlighted. As can be seen in the image below, the "sixth segment" is another portion of the winding found on the second metal layer (shown in blue) and it is directly physically connected to the fifth segment on its right side (also in blue).

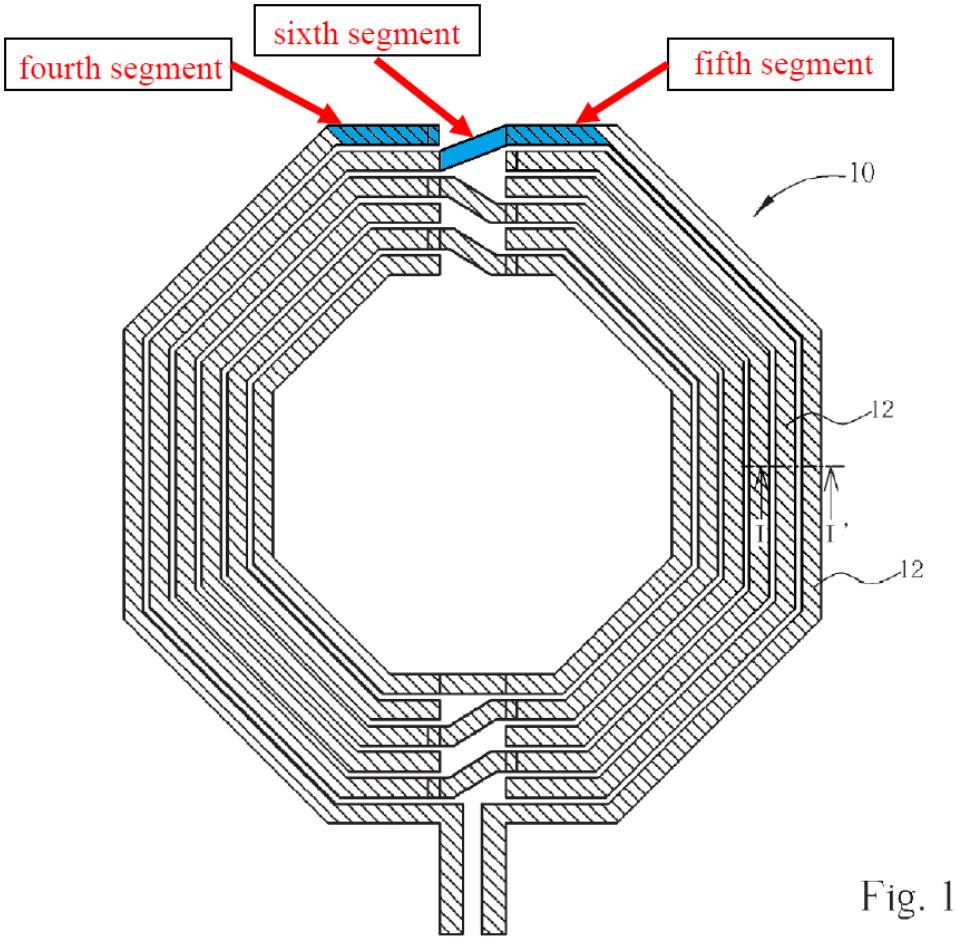
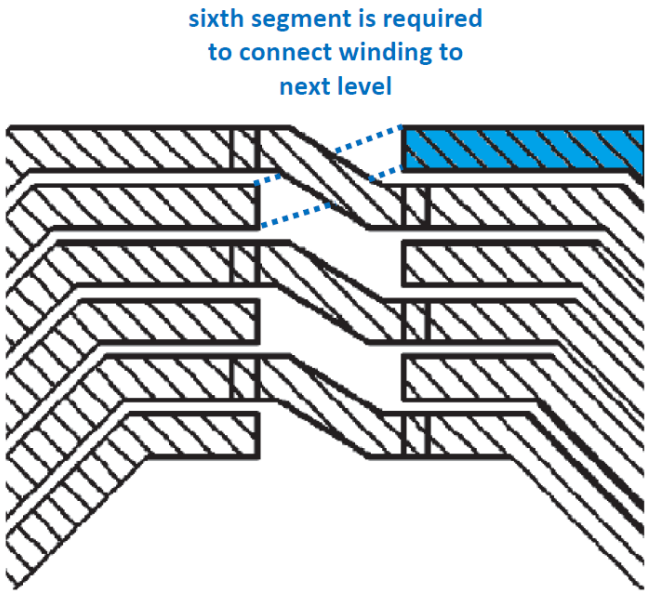


Fig. 1

EX-1007, [Fig. 1] (emphasis added).

295. There are multiple reasons why I believe a POSITA would have understood that Yang inherently discloses a sixth (crossover) segment as I have shown above. First, it would have been clear to a POSITA that without the sixth segment where I have put it (directly physically connected to the fifth segment), the inductor would not maintain proper electrical conductivity among the various windings (e.g., the two windings shown in Figs. 1 and 2 below). It would be an open circuit. I depict this issue below. Without a crossover connected to the fifth

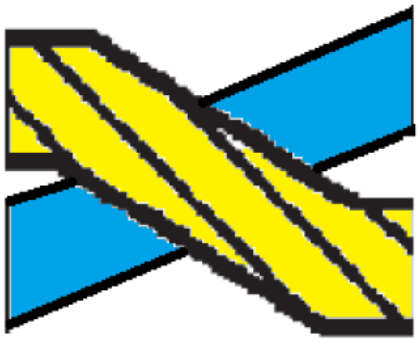
segment, the winding ***would not connect to the next loop***. This problem would also occur on the following loop and so on.



Id., [Fig. 1] (partial figure with emphasis added showing the second layer of Yang).

A POSITA would understand the need for the sixth segment (second crossover) to be the same as with the third segment (first crossover) shown in Figure 1 at the top metal layer (depicted in yellow). Without ***both*** of the crossover regions, the windings would be open circuits. Because of this, a POSITA would therefore have understood that in Yang, the second layer crossover (shown again in blue below) would be directly under the top layer crossover (shown again in yellow below) except oriented in a different direction to allow connection to the next segment of the coil. A POSITA would have understood this to be the standard way a crossover

is formed (as shown throughout my declaration with respect to prior art depicting crossovers).



Id., [Fig. 1] (partial figure with emphasis added).

296. Second, a POSITA would have understood that symmetrical inductors typically have crossovers which are also symmetrical, i.e., the two windings that form the crossover are equal in size, shape, and location, just mirror opposites of each other. This is the case for the '245 patent itself as depicted below. The crossover segments are in the red boxes.

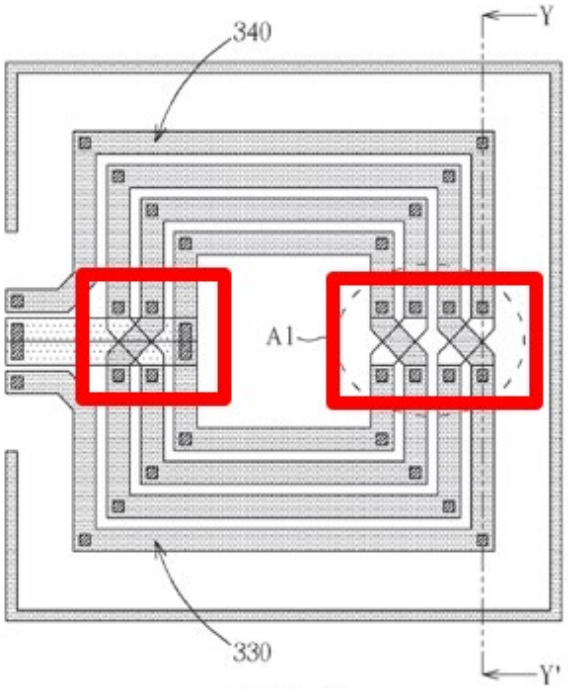
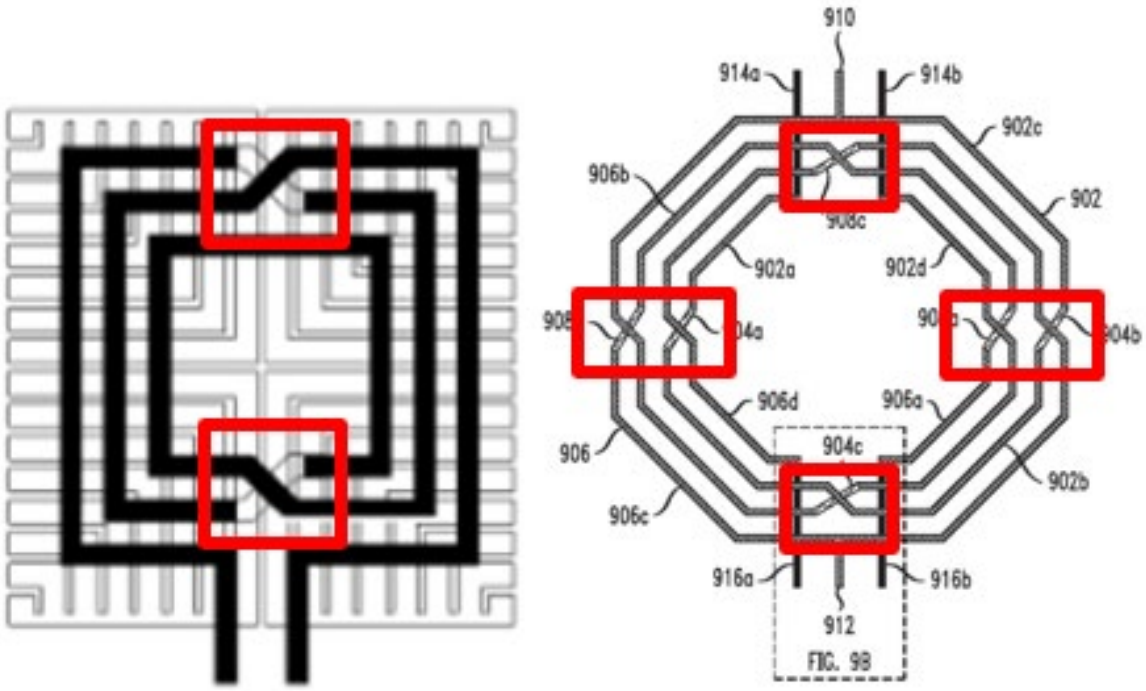


FIG. 2

EX-1001, [Fig. 2] (emphasis added in red).

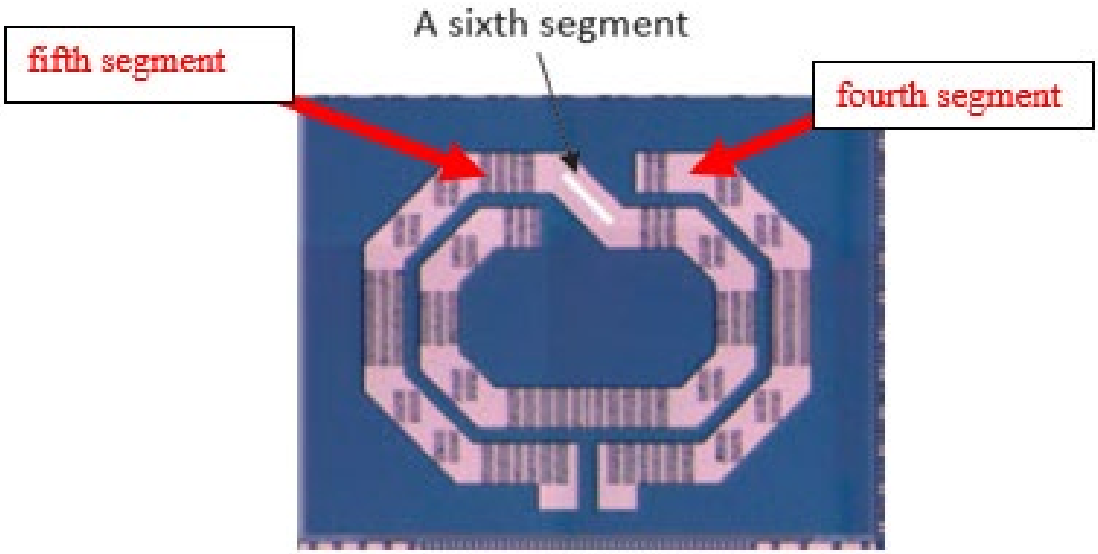
297. This is also the case in the basic inductor of Murphy as well as the octagon inductor of Ho-Hsiang. I have again emphasized the crossovers segments of those two inductors in red boxes below.



EX-1012.006 (left, emphasis added; EX-1005, [Fig. 9B] (right, emphasis added).

298. Thus, a POSITA would have expected the crossover of the inductor in Yang to also have a symmetric crossover pattern. The inductor in the preferred embodiment of Yang is an octagon. *See* EX-1007, [0019], [Fig. 1]. A POSITA would have understood that an octagon is simply a shape that has eight lines of symmetry as well as rotational symmetry in the order of eight. In other words, it is a symmetrical figure with eight equal sides. This means that Yang discloses a symmetrical inductor, and a POSITA would have expected such a symmetrical inductor to contain a symmetric crossover pattern as well, i.e., the two crossover segments would be mirror images of each other.

299. This is also consistent with how Realtek is interpreting the claim language. As shown below, Realtek points to the white highlighted portion of the winding as being the sixth segment, which is connected to the fifth segment and is positioned in a different layout direction than the fourth and fifth segments.



EX-1022.010 (emphasis retained in white and added in red).

1.10 A first set of vias, for connecting the first segment with the fourth segment; and

300. A POSITA would have understood that Yang discloses a first set of vias for connecting the first segment with the fourth segment. As I previously discussed, the first segment is on the first metal layer (aluminum) while the fourth segment is on the second metal layer (metal layer M_n). I depict these layers again below. As can be seen from Fig. 2 of Yang, the winding on the first layer is directly above the winding of the second layer.

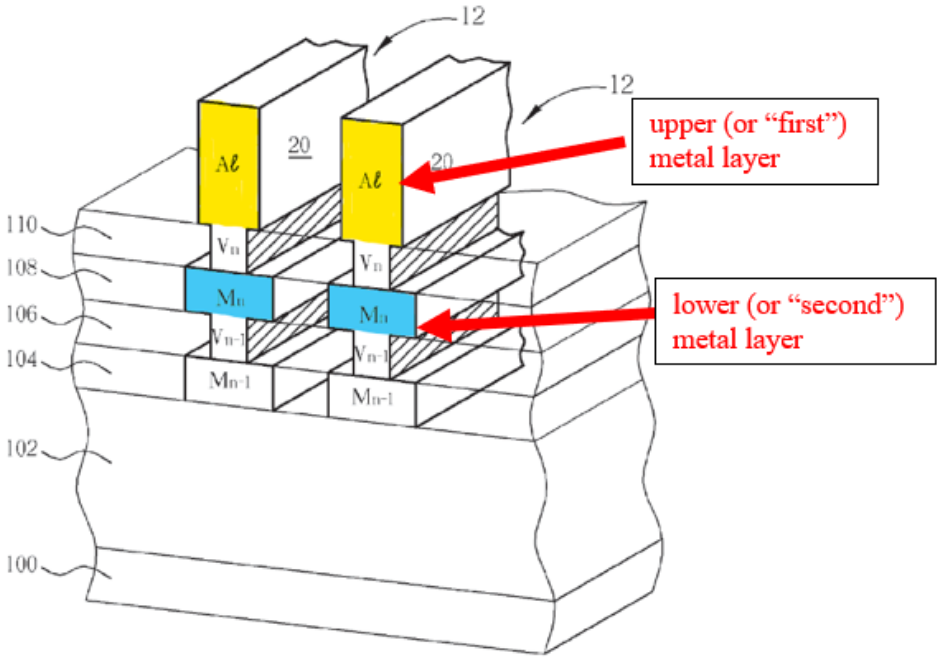


Fig. 2

EX-1007, [Fig. 2] (emphasis added).

301. Additionally, these layers are connected by vias marked as "V_n" in Fig. 2. *See id.*, ¶ 0017 ("The symbol 'V' refers to the via plug between two adjacent copper metal layers."). Yang explicitly makes this clear with respect to the aluminum first layer and the second metal layer underneath it. It states, "the via plug layer V, electrically connects the metal layer M, to the overlying aluminum layer 20." *Id.*, ¶ 0020. Yang further elaborates on the use of such vias:

> According to the preferred embodiment, the via plug layer V_n is comprised of aluminum and is integral with the aluminum layer 20. That is, the via plug layer V_n and the aluminum layer 20 are unitary. Structurally, the via plug layer V_n is inlaid into a

corresponding via slot (not explicitly shown) formed in an insulating layer 110 and the aluminum layer 20 is patterned above the insulating layer 110. The via plug layer V_n and the aluminum layer 20 can be formed concurrently with the conventional re-distribution layer (not shown).

Id., [0027].

302. I have highlighted this via connection (V_n) in Fig. 2 below in orange.

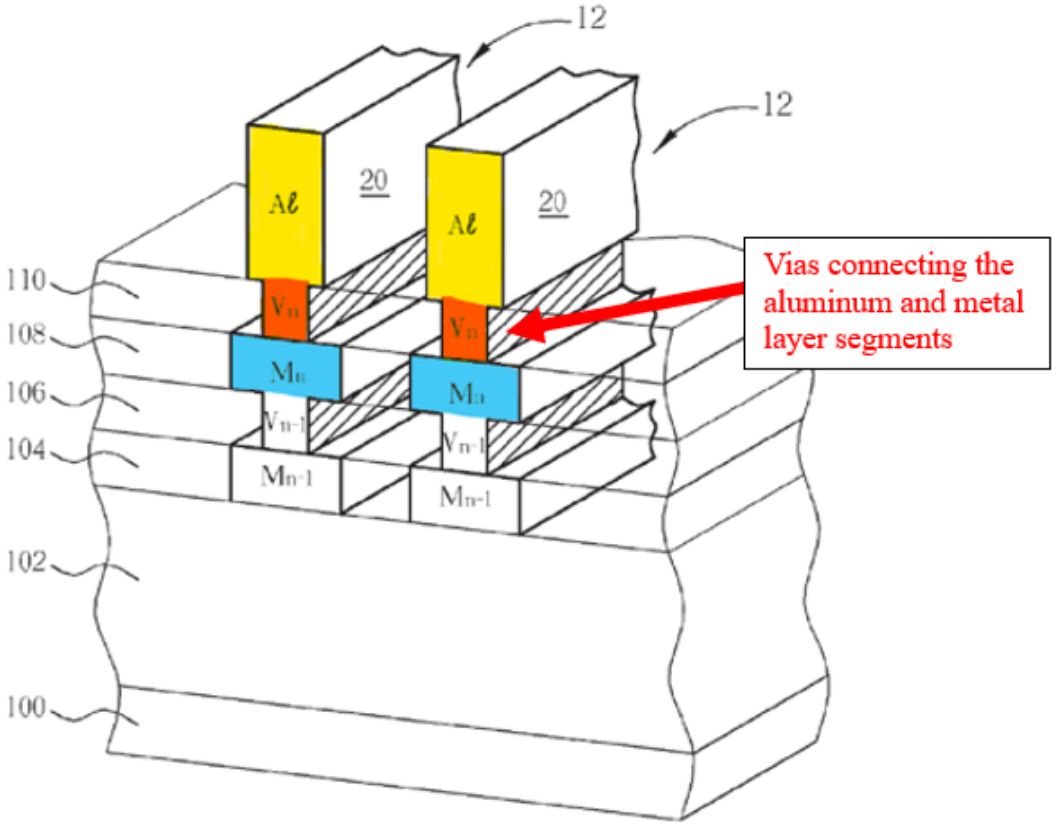


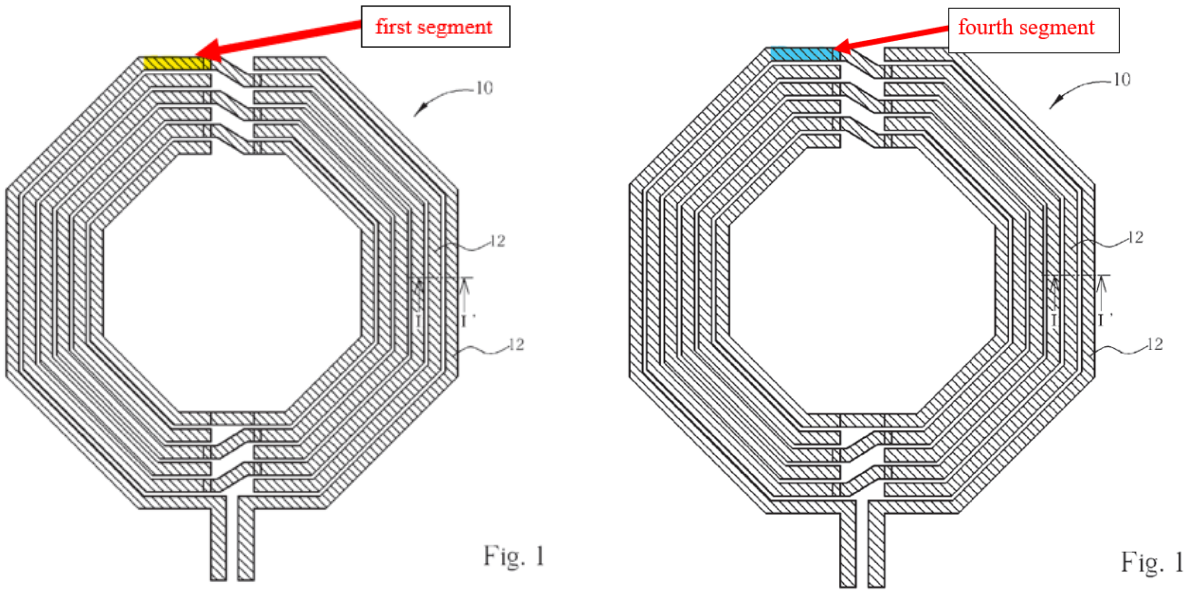
Fig. 2

Id., [Fig. 2] (emphasis added). Yang emphasizes that in "one aspect, the invention uses line-shaped via structure, instead of hole-shaped via plug" for connecting the

metal layers. *Id.*, [0014]. This is to reduce resistance as I will discuss below. Importantly though, Yang makes it clear that use of the line-shaped vias is only a preferred embodiment, and "is not intended to be a limitation of the invention." *Id.*, [0021]. Furthermore, Yang elaborates that "the pattern of the line-shaped via plug may include several segmented line-shaped patterns per winding." *Id.*, [0021]; *see also*, *id.*, [claim 15].

303. Given the above disclosure, a POSITA would have understood that the line-shaped via may be divided into multiple "segmented" lines. and there would be multiple via line segments (the claimed "set of vias") connecting the inductor segments. Alternatively, the number of via segments would correspond to the inductor segments (for instance, one via segment per inductor segment). A POSITA would have found either option to be obvious because Yang instructs that the "pattern of the line-shaped via plug may include several segmented line-shaped patterns per winding." Indeed, the vias are observed throughout Fig. 1, including in the first and fourth segments, as shown below. Because what I have labeled as the first segment is directly above the fourth segment (as I previously discussed and as shown in the Figures below), a POSITA would have found it obvious that vias would be connecting the two segments. Indeed, these segments connect to crossovers as also shown below. A POSITA would have understood that positioning the vias close to the crossover point reduces the length of the portion of

the crossover that is a single layer, thereby reducing its resistance. Reducing the resistance causes the Q factor of the inductor to increase. Thus, there is a clear and well-known benefit to locating vias in those specific segments.



Id., [Fig. 1] (emphasis added on left to show aluminum "first" metal layer and emphasis on right to show "second" metal layer).

304. The vias of Fig. 1 are shown in Fig. 2 as I have emphasized in orange below. These vias (V_n) are found between the aluminum (upper) and metal (lower) layer and are specifically shown in Fig. 1 in the first and fourth segments where the dashed lines are depicted.

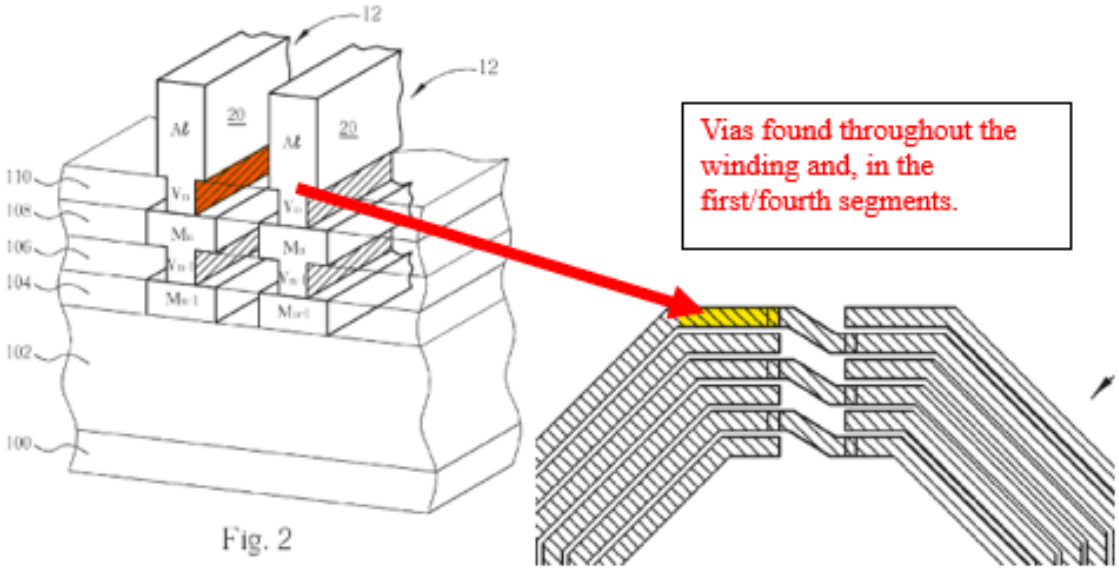


Fig. 2

Id., [Fig. 2] (left, emphasis added); [Fig. 1] (right, emphasis added).

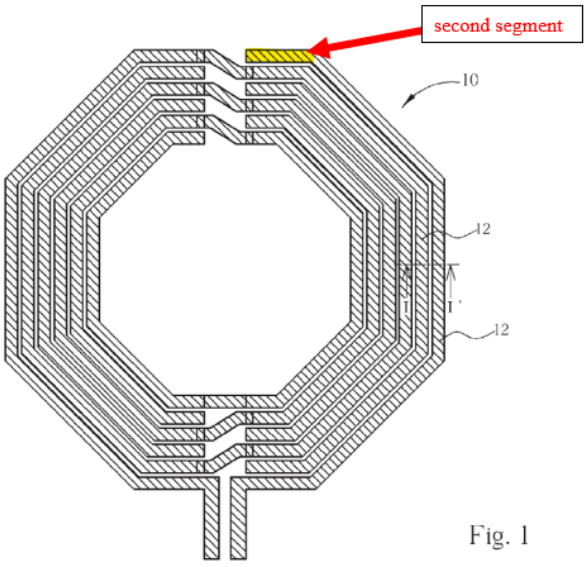
305. Furthermore, a POSITA would have understood the need to position vias connecting the first and fourth segments near the crossover point as shown in Fig. 1. This is because doing so would lower resistance and raise the quality factor Q. Lastly, a POSITA would have understood from Yang that the type and shape of vias was an obvious design choice and ***not*** limited to only a continuous line-shaped via. As I previously discussed, Yang teaches that via segments could be used instead. Yang heavily implies that via plugs are also acceptable, stating that in conventional designs "there are many via plugs deposed between conductive layers in a semiconductor device for electrically connect[ing] the conductive layers." *Id*. Yang also confirms that using an array of via plugs helps "reduce resistance." *Id*. Yang does not discourage a POSITA from using alternatives to the continuous-line via such as the obvious choices of via line segments and via plugs. Therefore, a

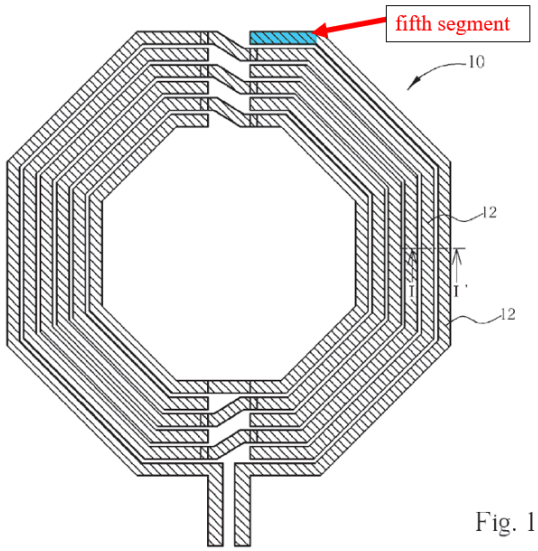
POSITA would understand that Yang discloses or at minimum renders obvious this limitation.

1.11 A second set of vias, for connecting the second segment with the fifth segment;

306. A POSITA would have understood that Yang discloses a second set of vias for connecting the second segment with the fifth segment. My analysis is similar to my discussion about the first set of vias, which I incorporate herein.

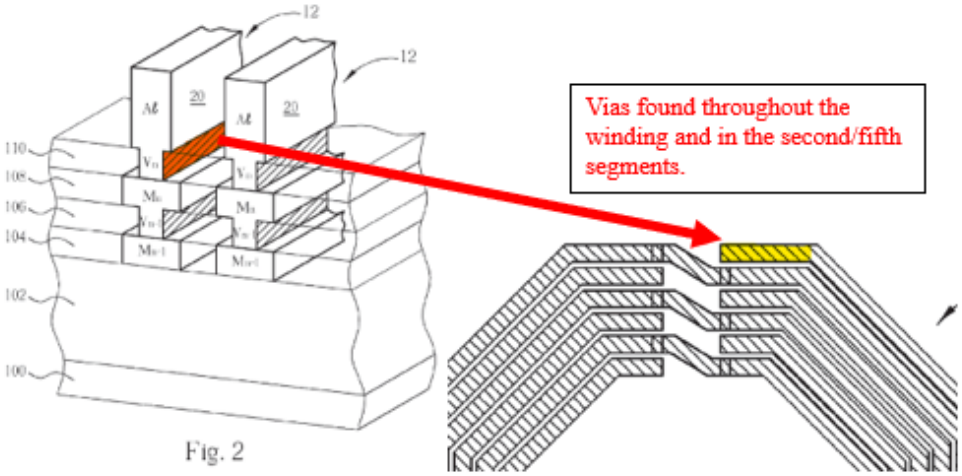
307. Because what I have labeled as the second segment is directly above the fifth segment (as I previously discussed and as shown in the Figures below), a POSITA would have understood it to be obvious that vias would be connecting the two segments.





Id., [Fig. 1] (emphasis added on left to show aluminum "first" metal layer and emphasis on right to show "second" metal layer).

308. As I discussed with respect to the previous limitation, the vias run throughout the entire winding of Fig. 1. The vias of Fig. 1 are shown in Fig. 2 as I have emphasized in orange below. These vias (V_n) are found between the aluminum (upper) and metal (lower) layer and are specifically shown in Fig. 1 in the second and fifth segments.



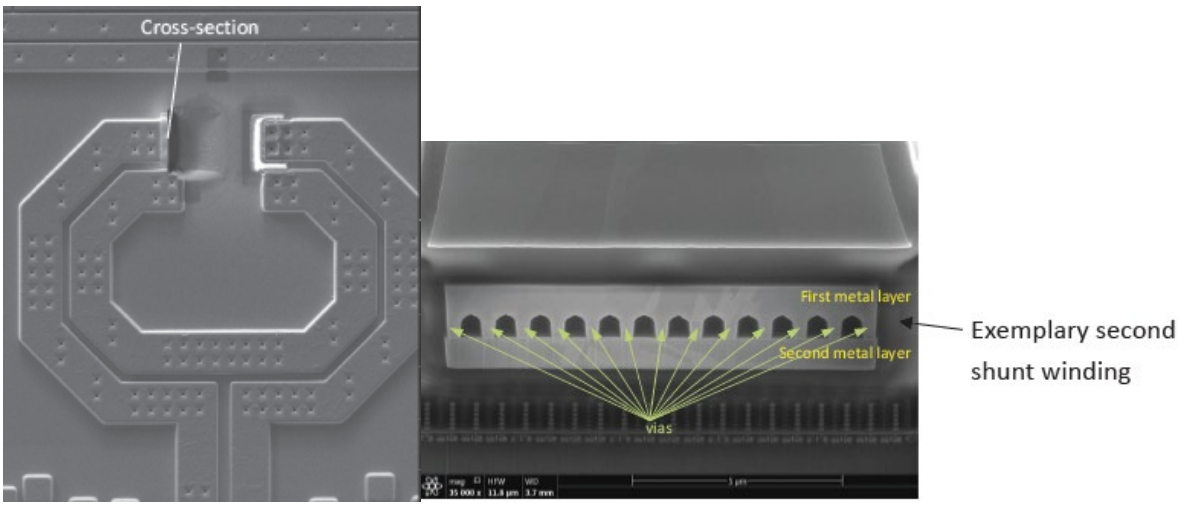
Id., [Fig. 2] (left, emphasis added); [Fig. 1] (right, emphasis added).

1.12 wherein the first segment, the fourth segment and the first set of vias construct a first shunt winding;

309. As I discussed *supra*, a POSITA would have understood that a "shunt winding" means windings in parallel. Realtek interprets the claim language to be that a first segment connected to fourth segment by vias on two metal layers forms a shunt winding. It specifically argues that a first segment, fourth segment, and first set of vias with a "substantially similar structure" to the image below constructs a shunt winding.

> The cross-section images below show that the second segment, the fifth segment, and the second set of vias construct an exemplary second shunt winding. (On information and belief, a cross section taken in the area of the first segment, the fourth segment, and the first set of vias, would show a substantially similar structure, thereby establishing that the first segment, the fourth segment and the first set of vias construct an exemplary first shunt winding.

EX-1022.013 (emphasis added in highlight).



Id., .014 (emphasis retained).

310. Yang discloses such a shunt winding. For instance, as I discussed prior, Yang discloses vias connecting a first and fourth segment. This is accomplished through vias shown in Figs. 1 and 2. Below, I have highlighted the first and fourth segments on the left side of the inductor (in green, which represents the yellow upper layer on top of the blue lower layer). The first segment is on the first metal layer in parallel to the fourth segment on the second metal layer (below the first segment). I have also emphasized (in orange) the vias that connect the

first and fourth segments as shown in Fig. 1 on the left. These are the same vias depicted in Fig. 2 on the right. I have again emphasized the vias in orange. As can be seen in Fig. 2, the vias connect the aluminum and metal layers, which are the first and second metal layers respectively. A POSITA would have recognized that the connection between these parallel windings on the first and fourth layers using vias construct a shunt winding.

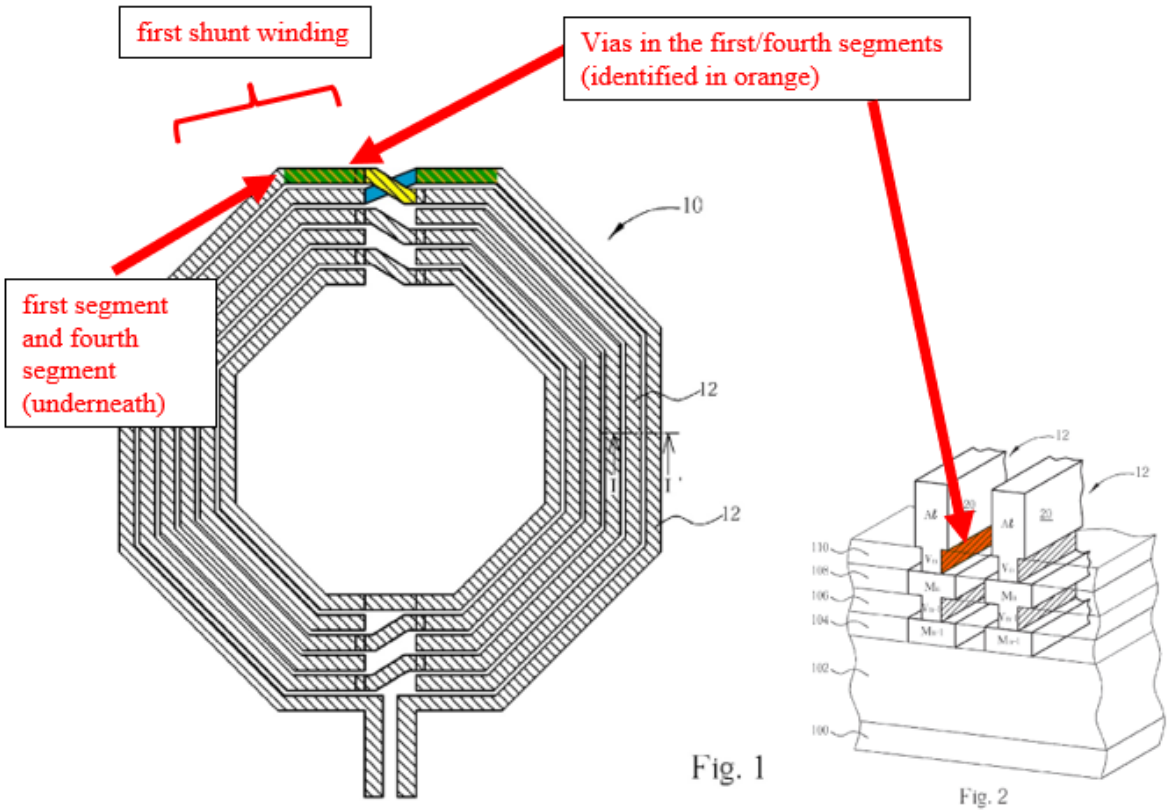


Fig. 1

Fig. 2

EX-1007, [Figs. 1 and 2] (emphasis added, showing a first and fourth segment, and vias constructing a first shunt winding).

311. A POSITA would have recognized that Yang shows a first shunt winding in the precise manner Realtek interprets the claim language. The structure

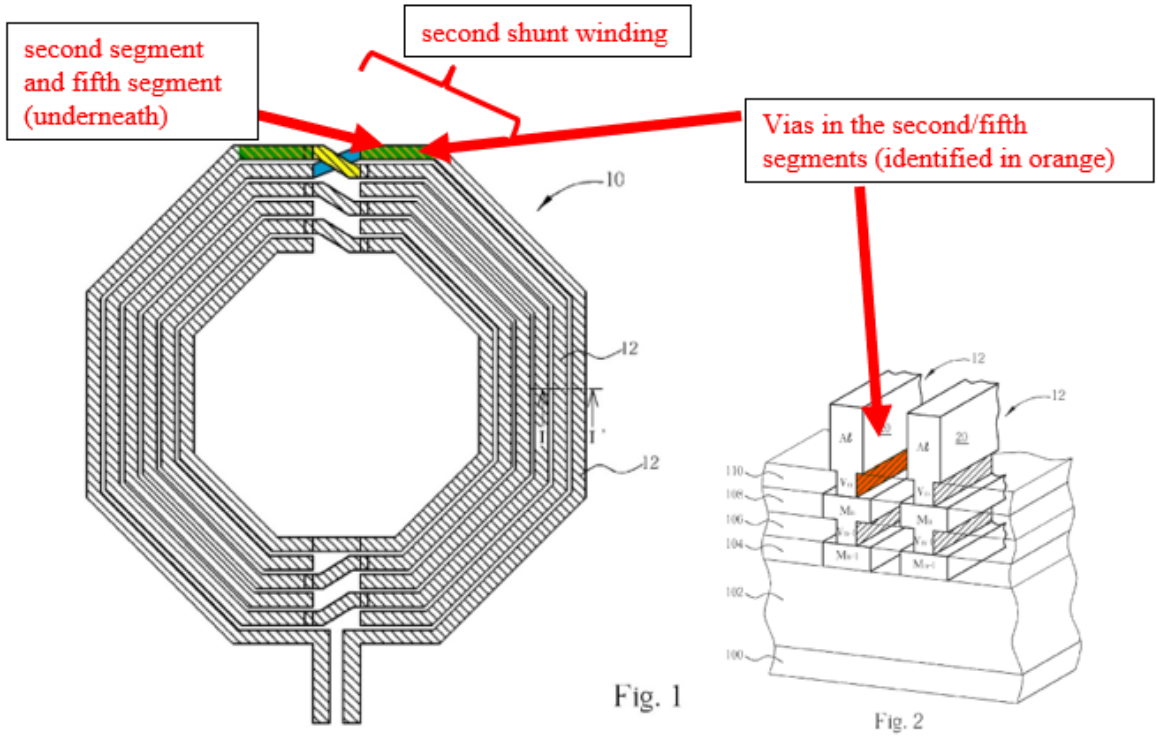
referenced in the top view and cross-section images above, shows e.g., a first and fourth segment in parallel (one above the other on a first and second metal layer respectively) with vias connecting the first and second metal layers. Similarly, the second fifth segments are in parallel (one above the other on a first and second metal layer respectively) with vias connecting the first and second metal layers as I will discuss with respect to the next limitation.

1.13 wherein the second segment, the fifth segment and the second set of vias construct a second shunt winding;

312. For the same reasons I discussed with respect to the first shunt winding, which I incorporate herein by reference, it is my opinion that a POSITA would have recognized that the second and fifth segments along with the second set of vias, which connects the two segments, would together construct a second shunt winding as depicted below. The two layers at the second and fifth segments are in parallel and a second set of vias runs through them, creating a shunt consistent with the claim language.

313. As shown again with respect to Figs. 1 and 2, Yang discloses vias connecting a second and fifth segment. I have highlighted the second and fifth segments on the right side of the inductor (in green, which represents the yellow upper layer on top of the blue lower layer). The second segment is on the first metal layer in parallel to the fifth segment on the second metal layer (below the

first segment). I have again emphasized (in orange) the vias connecting the second and fifth segments in Fig. 1. These are the same vias depicted in Fig. 2 on the right, also emphasized in orange. As can be seen in Fig. 2, the vias connect the aluminum and metal layers, which are the first and second metal layers respectively. A POSITA would have recognized that the connection between these parallel windings on the first and fourth layers using vias construct a shunt winding.



Id., [Figs. 1 and 2] (emphasis added, showing a second and fifth segment, and vias constructing a second shunt winding).

314. A POSITA would have recognized that the second segment, the fifth segment, and the second set of vias of Yang construct a shunt winding, at least based on Realtek's interpretation of the claim language as I discussed prior.

1.14 and the third segment and the sixth segment construct a crossover region.

315. Lastly, claim 1 requires that the third and sixth segments construct a crossover region. A POSITA would have recognized that this is disclosed in, or at a minimum rendered obvious by, Yang. Again referencing Fig. 1, this becomes apparent. As shown below, the crossover region is formed where the third segment (highlighted in yellow) crosses over the sixth segment (added per the discussion regarding the sixth segment above and highlighted in blue).

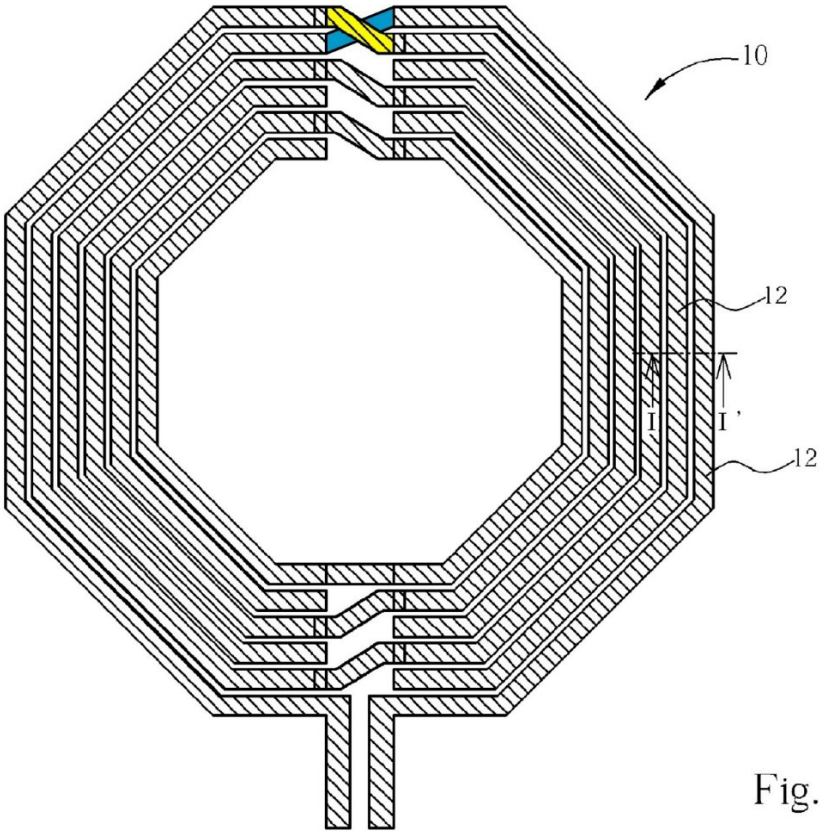
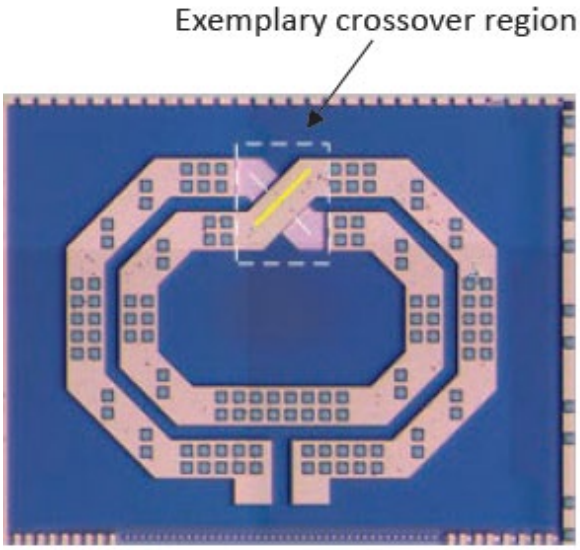


Fig. 1

Id., [Fig. 1] (emphasis added).

316. A POSITA would have understood that because one segment of the winding (the third segment) crosses over another segment (the sixth segment), the third and sixth segments form (or "construct") a crossover region. This is consistent with how Realtek interprets the claim language as well, as shown below.



EX-1022.014 (emphasis retained).

Claim 2

2.1 The structure of the spiral inductor of claim 1, wherein the third segment is positioned between the first segment and the second segment;

317. A POSITA would have understood that the structure of the spiral inductor includes a third segment that is positioned between the first segment and the second segment. The language "positioned between the first segment and the second segment" simply means that the third segment is in between those two segments.

318. This is clearly the case in Yang. In the image below, I have highlighted the third segment in yellow. As can be seen, the third segment is positioned in between the first and second segments (also in yellow). I have emphasized the positioning further by marking the end of the first and second

segments with a dashed red line. The third segment is clearly positioned in between the first and second segments.

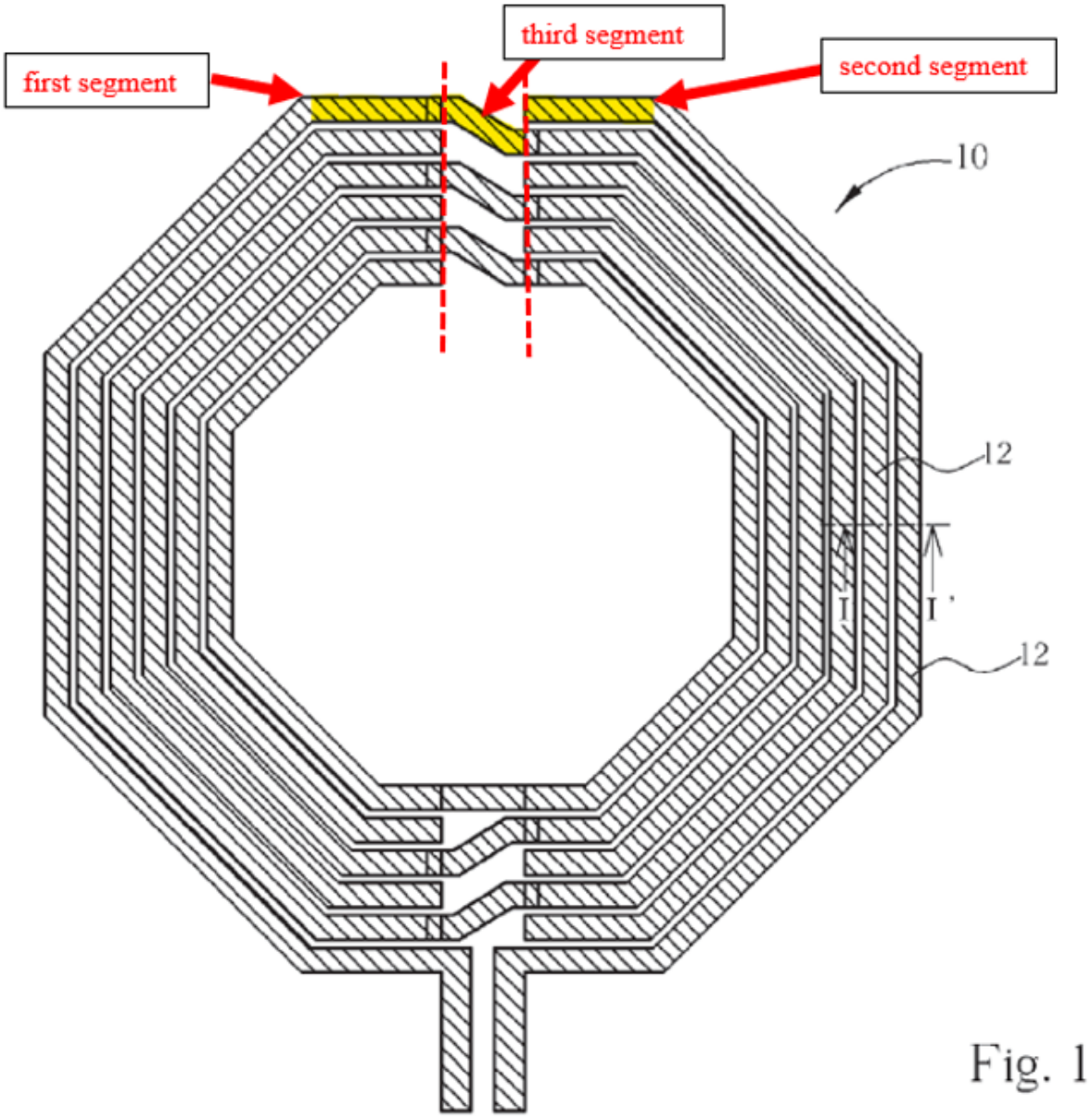


Fig. 1

EX-1007, [Fig. 1] (emphasis added).

2.2 and the sixth segment is positioned between the fourth segment and the fifth segment.

319. Similarly, a POSITA would have understood that the structure of the spiral inductor includes a sixth segment that is positioned between the first segment and the second segment. The language "positioned between the fourth segment and the fifth segment" simply means that the sixth segment is in between those two segments.

320. In the image below, I have highlighted where I previously showed the sixth segment to be (in blue). As can be seen, the sixth segment is positioned in between the fourth and fifth segments (also in blue). I have emphasized the positioning further by marking the end of the fourth and fifth segments with a dashed red line. The sixth segment is clearly positioned in between the fourth and fifth segments. To the extent that the sixth segment is not explicitly disclosed, a POSITA would have understood that it would inherently exist. A POSITA would have also understood that the size and shape of the crossover would be similar to, if not precisely the same size as the other crossover (segment 3). *See*, discussion of limitation 1.9 *supra* (discussing crossovers). Similarly, a POSITA would have understood that the sixth segment crossover would be in the same position as the other third segment crossover (i.e., between windings 1, 2, 4, and 5). *See, id*.

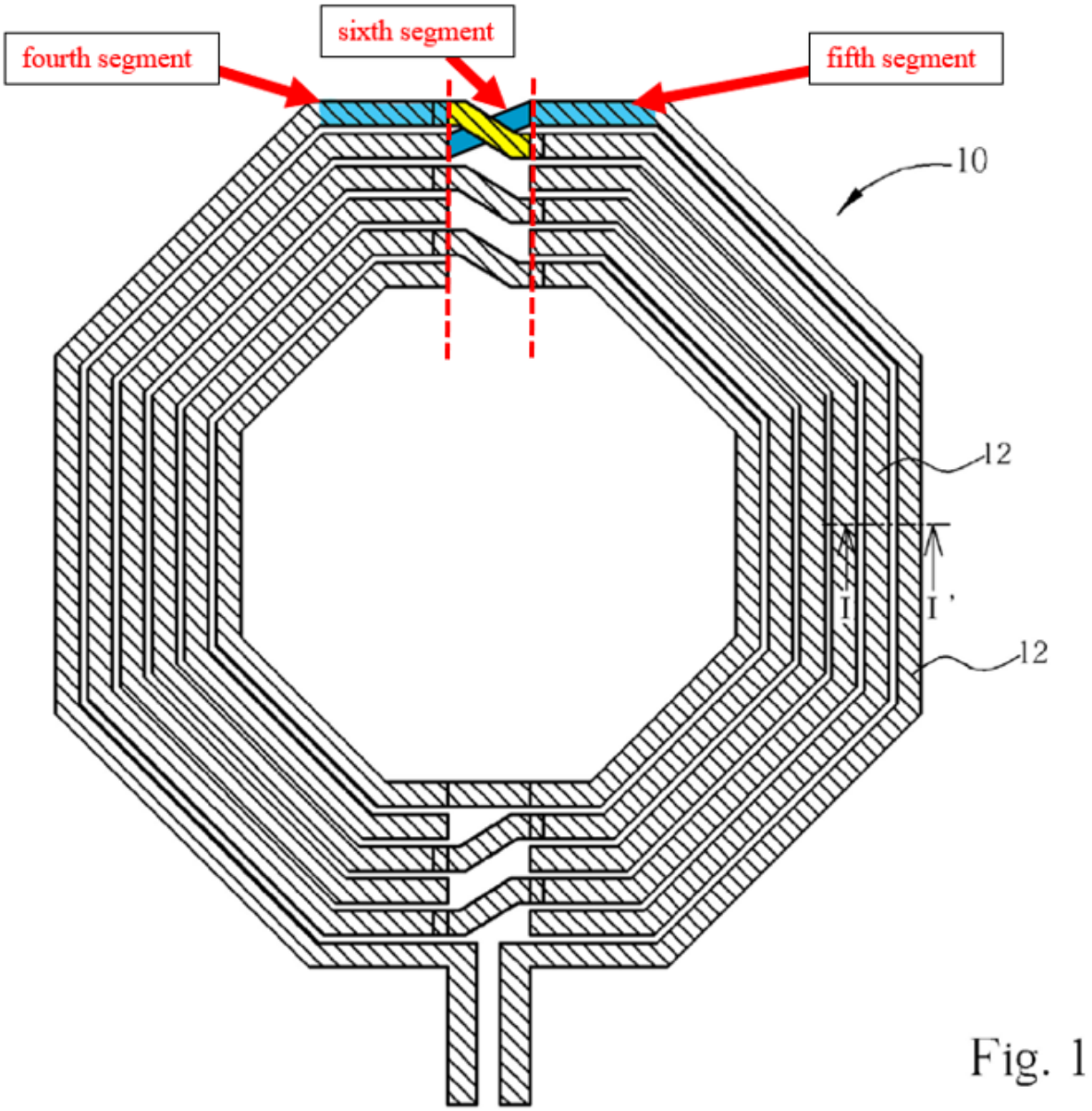
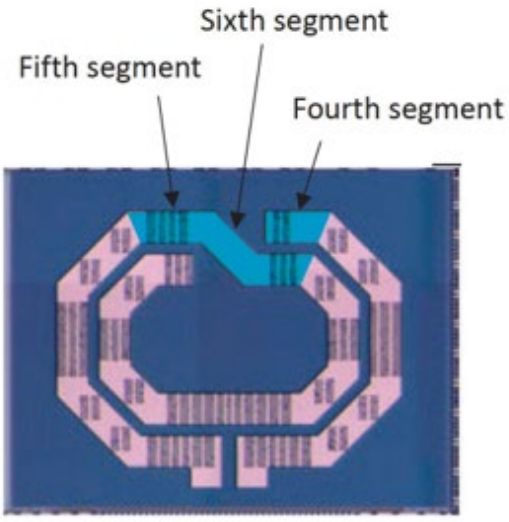


Fig. 1

EX-1007, [Fig. 1] (emphasis added).

321. This is also how Realtek interprets the claim language, as depicted below.



EX-1022.015 (emphasis added in blue).

Claim 3

3.1 The structure of the spiral inductor of claim 1, wherein a first thickness of the first metal layer is greater than a second thickness of the second metal layer.

322. A POSITA would have understood that the inductor of Yang which I have been discussing discloses this element. As I emphasized previously with respect to Yang Figure 2, the aluminum or "first metal layer" is shown in yellow in the image below, while the second metal layer is shown in blue. Clearly the first metal layer (yellow) is thicker than the second metal layer (blue) based upon visual inspection of the Figure alone. Because Fig. 2 is a cross-sectional view, as I previously explained, a POSITA would have understood that "thickness" is

assessed based on the layer's ***vertical*** thickness, which represents the thickness of the layer on the chip.

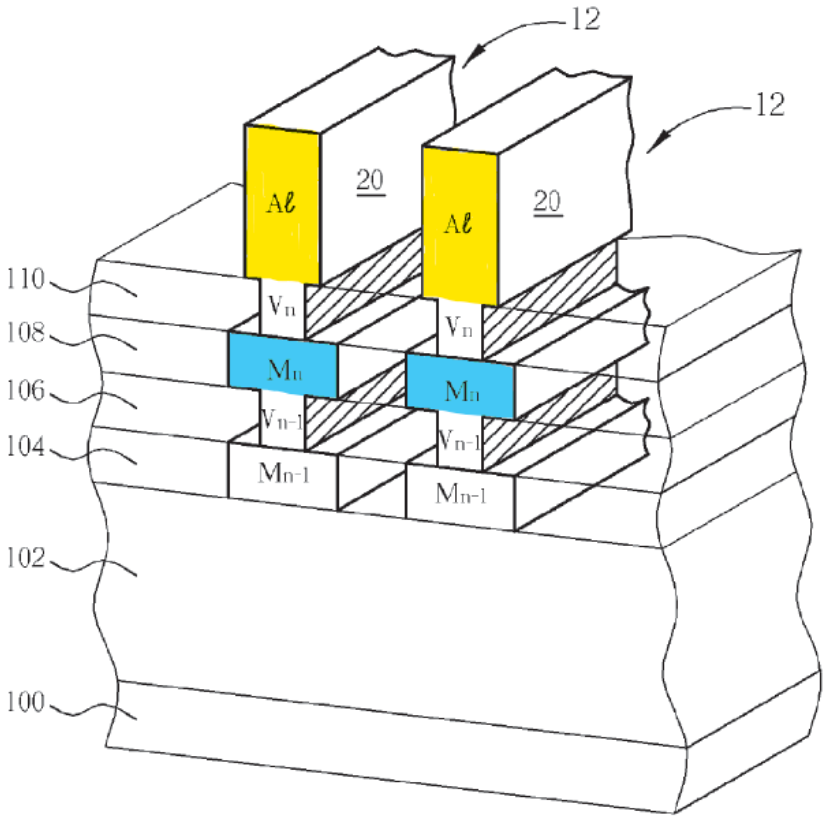


Fig. 2

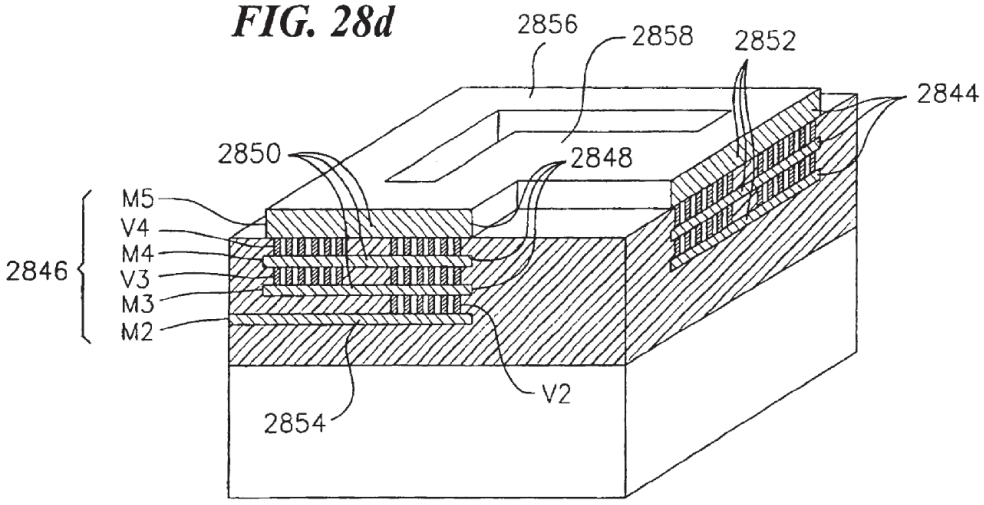
EX-1007, [Fig. 2] (emphasis added).

323. Furthermore, as Yang itself discusses, this technique was well known, easy, and commonplace in the art. The background section of Yang states that "integrated inductors fabricated by RF baseline process may have decreased resistance due to ***much thicker top metal layer*** (i.e., the topmost level of the damascene copper interconnection)." EX-1007, [0007] (emphasis added). It goes

on to explain that "***it is easier*** for one of the skilled in the art ***to implement a much thicker top metal layer*** than other metal layers." *Id.* (emphasis added).

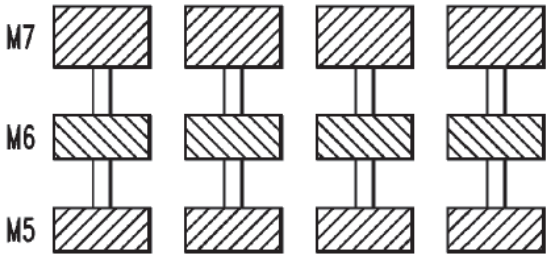
324. As stated above, a POSITA would have understood that in CMOS fabrication processes, the thickness of the top metal layer compared to the metal layers below it was a known design choice. As such, a POSITA would have readily recognized that, as in Yang, the thickness of the top metal layer in a multilevel inductor could be designed to be greater than the thickness of the metal layers below it.

325. For example, Chang (EX-1017) discloses a "multi-track spiral inductor … suitable for integration onto an integrated circuit, as one produced with a CMOS process." EX-1017, [36:51-53]. Chang depicts in Fig. 28d a cross-section of such a multi-level inductor, "disposed in multiple layers M5, M4, M3" with "via holes V2, V3, V4" to "couple the tracks in adjacent layers." *Id*., [38:63-37:9]. As shown below in Fig. 28d, the top metal layer M5 is clearly thicker than the immediate lower layers M4, M3, consistent with what Yang also discloses.



EX-1017, [Fig. 28d].

326. Similarly, Moinian (EX-1018) also discloses an "inductor device in an integrated circuit" that has a "first, a second, a third, and a fourth metallization layer." EX-1018, [0006]. As with Yang, Moinian teaches that the inductor windings "comprise metal lines built into the M5-M7 metallization layers" and the metal lines of the inductor are "electrically connected together by a multiplicity of contact vias 170 so that they are connected in parallel with each other (i.e., they are shunted)." *Id*., [0022]-[0023]. As shown in Fig. 3, a portion of which is reproduced below, the top metal layer M7 is thicker than the immediately lower metal layers M6, M5:



EX-1018, [Fig. 3] (partial view).

327. Finally, Burghartz (EX-1029) discusses the "design of RF spiral inductors on silicon" (Title) and discloses that a "four-metal level aluminum (Al) process" was used. EX-1029.006. As shown in Fig. 2(a) below, the top metal layer M4 is thicker than the M3 and M2 layers. Indeed, Burghartz explains that the "thickness of the metal layers and insulating-oxide layers are indicated." *Id*., .007. The thickness of top layer M4 is given as 1.0 μm and the thicknesses of layers M3 and M2 are given as 0.6 μm:

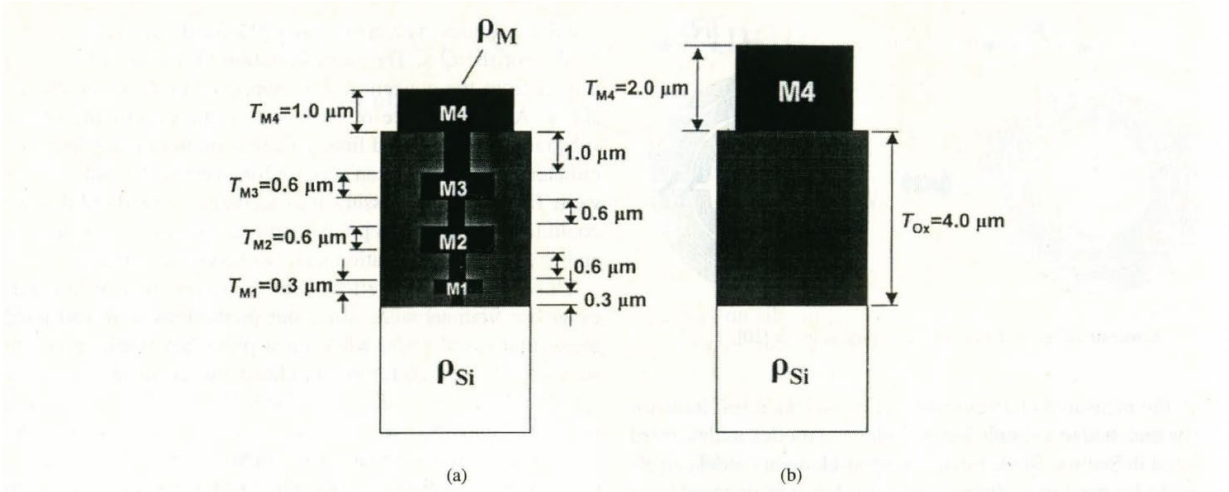


Fig. 2. Cross sections of a four-level metal interconnect stack with (a) all metal layers shown and (b) only a thicker top metal layer; the thickness of the metal layers and insulating oxide layers are indicated.

EX-1029.007, [Fig. 2].

328. These disclosures reinforce my opinion that thickness of the metal layers was a design choice, with a POSITA readily understanding that the thickness of the top metal layer may be either the same as or more than the thickness of the underlying layers.

Claim 4

4.1 The structure of the spiral inductor of claim 1, wherein the spiral inductor further comprises a third metal layer being positioned under the second metal layer, a structure of the third metal layer is the same as a structure of the second metal layer, and the first thickness of the first metal layer is greater than a third thickness of the third metal layer.

329. A POSITA would have understood that the inductor of Yang which I have been discussing discloses this element. As I emphasized previously with respect to Yang Figure 2, the aluminum or "first metal layer" is shown in yellow in the image below, while the second metal layer is shown in blue. Yang, discloses that "[a]s shown in FIG. 1 and FIG. 2, each winding 12 of the integrated inductor 10 having a vertical metal stack includes, ***in the order of metal layer M_{n-1},*** via plug layer V_{n-1}, metal layer M_n, via plug layer V_n and an aluminum layer 20." *Id.*, [0020] (emphasis added). A POSITA would have understood that this means

multiple metal layers (up to n)[3] can be placed below the aluminum metal layer (20) and above the substrate level (100). This includes layer M_{n-1} which is inlaid in dielectric layer 104. *See id.*, [0025]. I have emphasized M_{n-1}, which is a "third metal layer," in green.

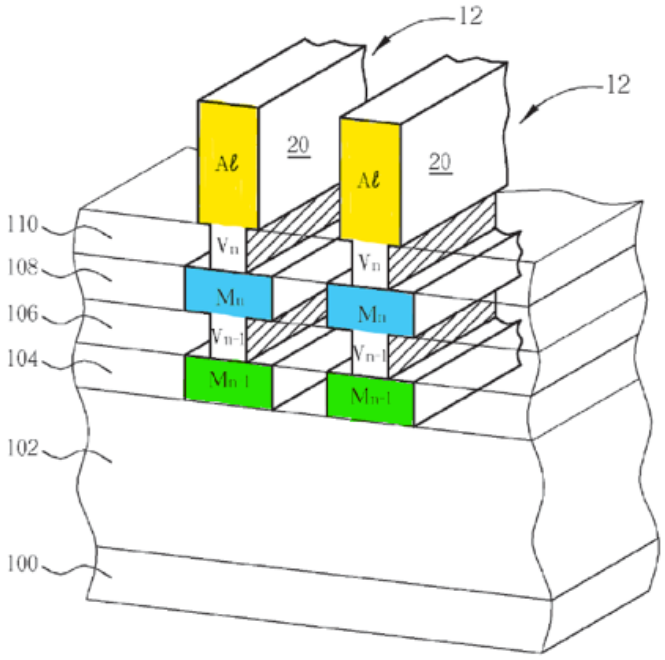


Fig. 2

EX-1007, [Fig. 2] (emphasis added).

330. As can be seen, this third metal layer in green is positioned below the second metal layer in blue. Lastly, the first metal layer is thicker than the second

[3] The specification notes that "preferably, n ranges between 4 and 8 (n=4-8)." *Id.*, [0017].

and third metal layers for the same reasons I discussed with respect to claim 3, my analysis of which I incorporate herein.

Claim 8

8.1 The structure of the spiral inductor of claim 1, wherein the spiral inductor is a symmetric spiral inductor.

331. A POSITA would have understood that the inductor in Yang I have been discussing is a "symmetric" or "symmetrical" inductor. A POSITA would generally have understood that in the context of inductors, symmetric simply means that it has a shape that can be divided into two equal parts. Each side would roughly be a mirror image of the other.

332. The inductor in Fig. 1 of Yang certainly meets this definition. Whether divided in half vertically or horizontally, the two halves are identical in shape.

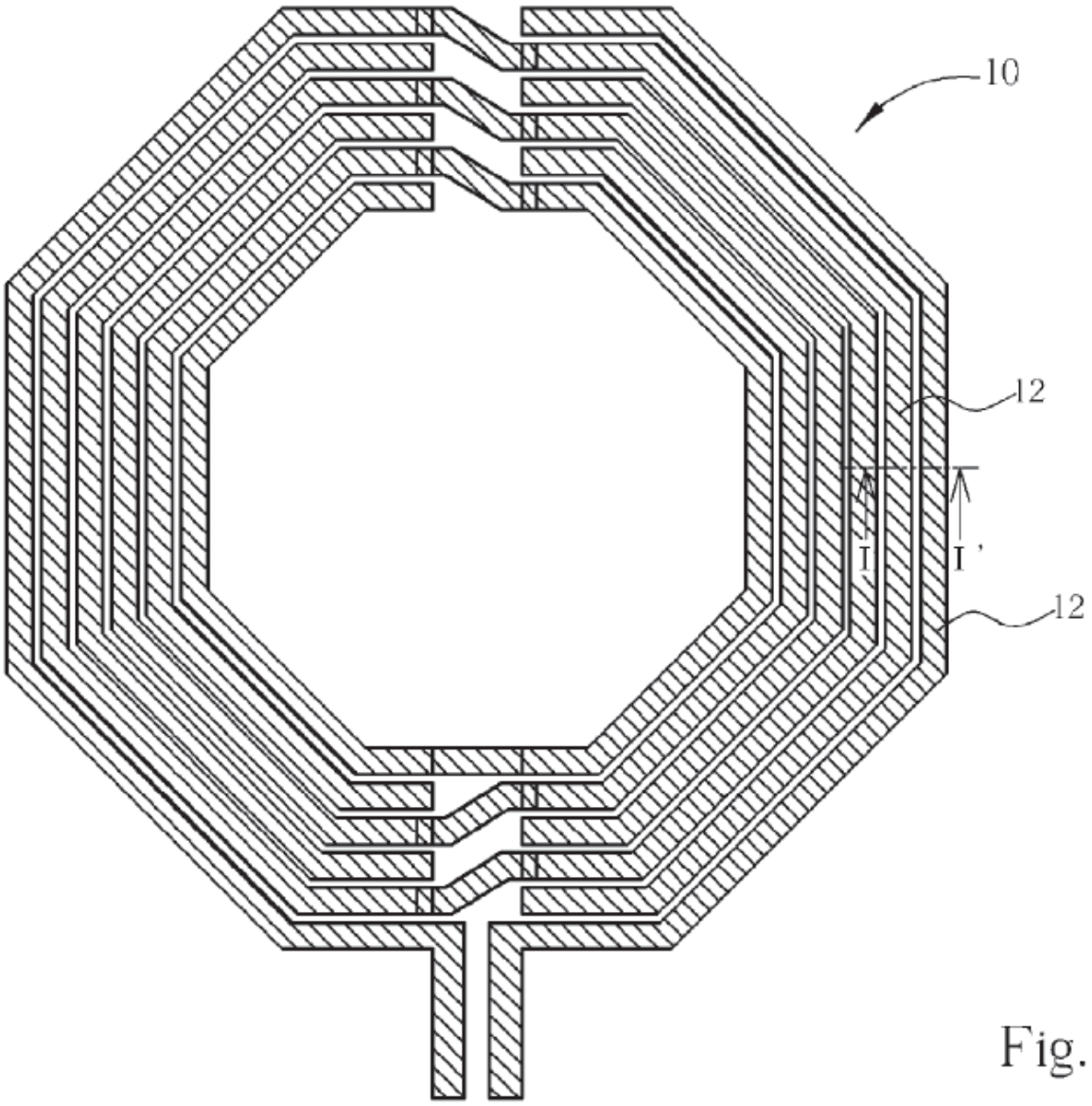
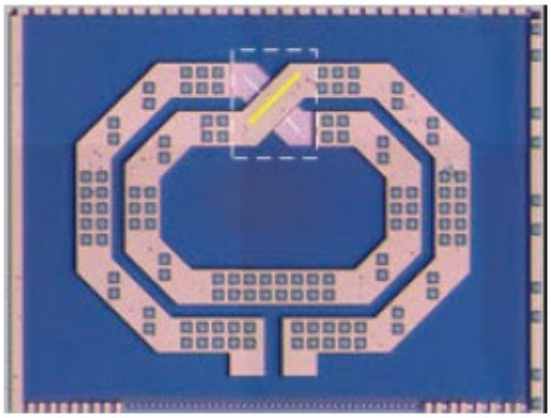


Fig. 1

EX-1007, [Fig. 1].

333. This is also how Realtek interprets the claim language, as depicted in the text and accompanying image below.

The spiral inductor is a symmetric spiral inductor as depicted in the image below:



EX-1022.015-.016 (emphasis retained).

334. In fact, Yang explicitly refers to the Fig. 1 as being "in the form of [an] octagon shape." EX-1007, [0019]. A POSITA would have recognized that an octagon is a symmetrical shape. As I discussed prior an octagon is simply a shape that has eight lines of symmetry as well as rotational symmetry in the order of eight. In other words, it is a symmetrical figure with eight equal sides. Figure 1 of Yang is generally in the form of an octagon. Thus, a POSITA would have understood that it has axes of symmetry.

335. Indeed, claim 9 of the '245 patent itself seems to contemplate this as it claims "***The structure of the spiral inductor*** of claim 1, wherein a shape of the first shunt winding and the second shunt winding is substantially a rectangle, ***an octagon***, or a circle." '245 Patent, [Claim 9] (emphasis added). In other words, a POSITA would have understood that the '245 Patent contemplates a spiral inductor that may not be smooth or circular but rather is ***octagonal*** with windings that are

on multiple layers and shunted. This is also supported by Realtek's interpretation above, which similarly shows an octagon shape.

Claim 9

9.1 The structure of the spiral inductor of claim 1, wherein a shape of the first shunt winding and the second shunt winding is substantially a rectangle, an octagon, or a circle.

336. A POSITA would have understood that the structure of the spiral inductor of Yang which includes the first and second shunt windings (as I previously discussed), is substantially in the shape of an octagon, as shown below.

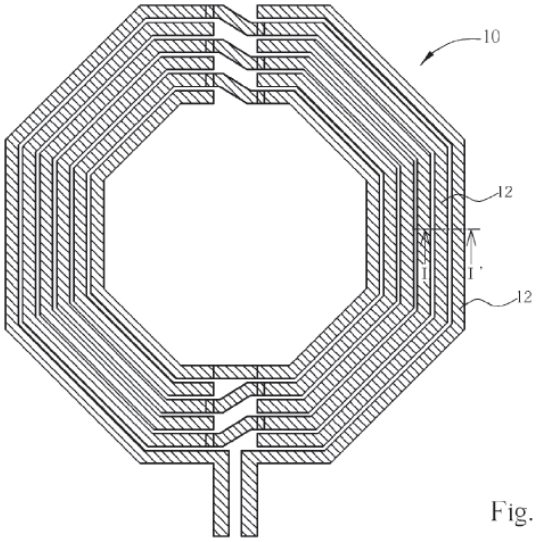


Fig. 1

EX-1007, [Fig. 1].

337. Indeed, Yang explicitly describes inductor 10 (as seen above) as an octagon. It states, "the integrated inductor 10 of the embodiment is demonstrated in the form of ***octagon shape***. EX-1007, [0019] (emphasis added).

X. JURAT

338. I 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 United States Code.

I declare under penalty of perjury that the foregoing is true and correct. Executed this 8th day of April, 2023 in Princeton, New Jersey.



Dr. Paul R. Prucnal