

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

ADVANCED MICRO DEVICES, INC.,
Petitioner

v.

REALTEK SEMICONDUCTOR CORPORATION
Patent Owner

CASE: IPR2023-00789
U.S. PATENT NO. 7,936,245

DECLARATION OF PAUL R. PRUCNAL, PH.D.

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I. INTRODUCTION

1. I am making this reply declaration at the request of Advanced Micro Devices, Inc. (“AMD”) in connection with the petition for *inter partes* review (IPR2023-00789) submitted by Petitioner regarding U.S. Patent No. 7,936,245 (“the ’245 Patent”). 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.

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 (my “Initial Declaration”)
1004	<i>Curriculum Vitae</i> 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, <i>Spiral Inductors on Silicon – Status and Trends (Invited Article)</i> , International Journal of RF and Microwave Computer-Aided Engineering, V. 8, No. 6, 422-432 (Nov. 1998)

Exhibit No.	Description
1012	O.H. Murphy et al., <i>Design of Multiple-Metal Stacked Inductors Incorporating an Extended Physical Model</i> , 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, <i>Lumped Elements for RF and Microwave Cicuits</i> , 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	<i>Webster's New World College Dictionary</i> , Fourth Edition, 2009 (excerpt)
1021	<i>Encyclopedia of Electronics</i> , 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, <i>Differential Signals Rules to Live By</i> , 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, <i>On the Design of RF Spiral Inductors on Silicon (Invited Paper)</i> , IEEE Transactions on Electron Devices, V. 50, No. 3 (Mar. 2003)
1030	R. Lutz, <i>Modeling and Analysis of Multilevel Spiral Inductors for RFICS</i> , IEEE MTT-S Int'l Microwave Symposium Digest V. 1 (Jun. 1999)
1031	Not Reviewed
1032	Not Reviewed
1033	Not Reviewed
1034	Not Reviewed

Exhibit No.	Description
1035	January 19, 2024 Initial Determination on Violation of Section 337 and Recommended Determination on Remedy and Bond (Public Version)
1036	U.S. Patent No. 7,656,264 to Hsu
1037	April 18 Deposition Transcript of Dr. Joshua Phinney, Ph.D.
1038	PTO Classification Definitions – Class 336 Inductor Devices https://www.uspto.gov/web/patents/classification/uspc336/defs336.pdf (last visited May 1, 2024)
2001	<i>In the Matter of Certain Integrated Circuits, Components thereof, and Products Containing the Same</i> , Inv. No. 337-TA-1350, Order No. 21: Construing Terms of the Asserted Patents (July 25, 2023)
2002	Dae-Hee Weon et al., <i>High Performance 3-D Helical RF Transformers</i> , IEEE MTT-S Microwave Symposium digest. IEEE MTT-S International Microwave Symposium, Jun. 2007, 1897–1900
2003	Declaration of Joshua Phinney, Ph.D.
2004	CV of Joshua Phinney, Ph.D.
2005	Final Deposition Transcript of Paul Prucnal, Ph.D., dated January 25, 2024
2006	Wikimedia Commons Image, https://commons.wikimedia.org/wiki/File:Fake-NRF24L01P-HD.jpg . (last visited Feb. 8, 2024). 2007
2007	Mohan et al., <i>Modeling and characterization of on-chip transformers</i> , International Electron Devices Meeting 1998. Technical Digest (Cat. No.98CH36217), 1998, 531–534.

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. In particular, I have reviewed EX-2003, the Declaration of Joshua Phinney, Ph.D., which I respond to herein.

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. As discussed in my previous declaration (EX-1003), 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.

5. I have reviewed Dr. Phinney's opinions regarding a POSITA. EX-2003, ¶¶ 35-37. My opinions herein would not be affected if a POSITA is defined using either my or Dr. Phinney's definition. Moreover, I satisfied the definition of a POSITA long before the filing date of the application leading to the '245 Patent. I consider myself an expert in the relevant field of technology for the '245 Patent.

II. QUALIFICATIONS AND COMPENSATION

6. My qualifications and compensation are laid out in my Initial Declaration which I incorporate herein by reference. *See*, EX-1003.

III. RELEVANT LEGAL STANDARDS

A. Obviousness

7. My understanding regarding obviousness is set forth in my Initial Declaration which I incorporate herein by reference. *See*, EX-1003.

B. Construing the Meaning of Claim Terms

8. I understand that in an order dated July 25, 2023, in an ITC investigation involving these same parties and this same patent, Administrative Law Judge Cameron Elliot construed “[a] structure of a spiral inductor” in claim 1 of the ’245 Patent as limiting. *See*, EX-2003, ¶ 32, *citing* Ex-2001, 17. I also understand that the Board agrees, because “[w]ithout the preamble, the body of claim 1 does not recite a structurally complete invention.” Decision (Paper No. 9) at 11.

IV. PROCEDURAL HISTORY

A. ITC Investigation No. 337-TA-1350

9. Both Dr. Phinney and I have evaluated invalidity issues concerning the ’245 Patent in a related International Trade Commission (“ITC”) Investigation: *In the Matter of Certain Integrated Circuits, Components thereof, and Products Containing the Same*, Inv. No. 337-TA-1350.

10. I understand that on January 19, 2024, Administrative Law Judge Cameron Elliot (“ALJ Elliot”) issued an “Initial Determination” in that matter. *See*, EX-1035. Among other issues, he considered the validity of the ’245 Patent. *See*, EX-1035.051-.088. In his opinion, ALJ Elliot substantively considered three pieces of prior art: two commercially-available products (Qualcomm RFR6122 and Marvell 88W8686) and one U.S. patent (U.S. Patent No. 6,794,977 to Christensen) (“Christensen”). *Id.* In my opinion, ALJ Elliot correctly found all the claims in dispute at the ITC (claims 1, 2 and 8) to be invalid based on each of the three references. *Id.*

11. At the ITC, Dr. Phinney focused on the fact that some of these references (Christensen and the Marvell 88W8686) disclosed transformers, and he made many of the same arguments that he has made in his declaration here (EX-2003), which I address herein.

12. The Marvell 88W8686 reference related to a transformer containing two inductors. ALJ Elliot summarized Realtek and Dr. Phinney’s arguments regarding the transformer issue as follows:

Realtek offers a few points of opposition which are entirely unpersuasive. First, Realtek argues the spiral circuit element in the 88W8686 is a transformer and therefore not “a spiral inductor.” CIB at 37 (citing Hr’g Tr. (Phinney) at 1222:24-1223:3); CRB at 14-15. Realtek states, “[t]he evidence is clear that the intended use of Marvell

is as a transformer and in order to use it as an inductor, as suggested by Dr. Prucnal, it would need to be modified.” *Id.* at 15. In making this argument, Realtek completely avoids discussing that body of evidence and testimony assembled by AMD establishing that transformers consist of two inductors, with the technique being to run a first current through one, creating a magnetic field, thereby inducing a second current in the next inductor, as shown in the following textbook:

10.3 Coupled inductors as transformers

Ideal transformers are an abstraction as all real transformers deviate from ideal behavior in one form or another. As shown in Fig. 10.1b, real transformers are implemented as coupled inductors. As we have learned already, if two inductors are coupled magnetically, then

$$V_1 = j\omega L_1 I_1 + j\omega M I_2 \quad (10.5)$$

$$V_2 = j\omega M I_1 + j\omega L_2 I_2 \quad (10.6)$$

....

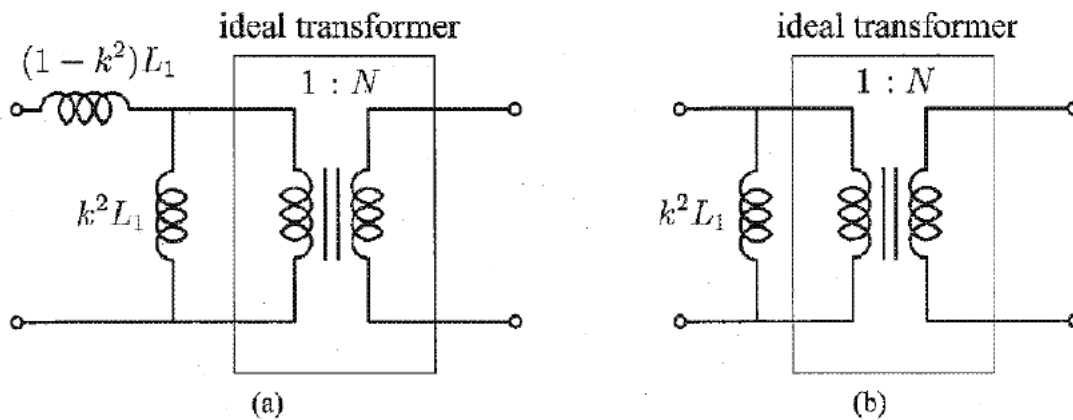


Figure 10.4 (a) Equivalent circuit model for two coupled inductors. (b) Approximation of (a) valid for two tightly coupled inductors ($k \rightarrow 1$).

When two inductors are tightly coupled ($k \approx 1$), then it's sometimes useful to view the coupled inductors as a perfect transformer marred by parasitics. In fact, it's not difficult to

RX-0200.99-101; see JX-0080 at 1:9-16 (“On-chip transformers are relatively rare in silicon RF integrated circuits and make use of a few well-known layout techniques, *e.g.*, placing the primary and secondary windings one above the other in different interconnect layers. . . . Transformers employing such symmetrical inductors are shown in [references].”); RIB at 56-59 (citations omitted).

EX-1035.073-74.

13. It is my opinion that Dr. Phinney makes the same flawed arguments again here. And much like at the ITC, Dr. Phinney has avoided discussing the body of evidence I have assembled establishing that transformers consist of two inductors. ALJ Elliot correctly pointed out that “[o]n cross-examination,

Dr. Phinney eventually admitted [the] basic engineering principle” that a transformer is simply two inductors:

Q. And do you agree that **you can put that inductor together with another inductor and create a transformer?**

A. **You could do that.**

Q. And so then do you agree that a transformer can be two inductors?

A. **You could build it that way if you wanted.**

Q. Well, I’m not asking if you can build it that way. I’m saying **do you agree a transformer can be two inductors?**

A. **Yeah**, you could stack, just, one right on top of the other and call one winding and the other a second winding.

. . . .

Q. Okay. But you agree you can put Figure 2.10 together with another exact same inductor that looks like Figure 2.10 and create a transformer?

A. Yeah, I think you asked me about that, about like putting just one inductor structure and then another one above it, and could you use that as a transformer. Is that what you’re asking?

Q. And that’s a yes?

A. Yeah, you could put one on top of the other and call one a primary winding and the other a secondary.

EX-1035.074-075, *citing* Hr’g Tr. (Phinney) at 1237:25-1239:18 (testimony of Dr. Phinney) (emphasis added).

14. The Christensen patent that ALJ Elliot considered in the ITC proceedings is the same reference that forms the basis of my analysis for Ground 2

here. At the ITC, Realtek and Dr. Phinney made similar arguments regarding transformers versus inductors as Dr. Phinney articulates here, before the PTAB. In my opinion, ALJ Elliot also correctly rejected these arguments. He summarized his opinion as follows:

Realtek challenges Christensen's use of spiral inductors within a transformer as failing to meet the preamble, "a structure of a spiral inductor." CIB at 29-30 ("Christensen does not teach a structure of a spiral inductor. Rather, Christensen is directed to planar transformers with intermingled windings."). See CRB at 5-6. For the reasons explained above with respect to the Marvell 88W8686 chip, this is not persuasive. A transformer contains two inductors so as to enable one to induce current in the other. And while Realtek and Dr. Phinney are careful to describe the two paths in Christensen as "windings" and not "inductors," Christensen's disclosure shows the otherwise well-understood identity of these structures:

On-chip transformers are relatively rare in silicon RF integrated circuits and make use of a few well-known layout techniques, *e.g.* placing the primary and secondary windings one above the other in different interconnect layers. While some of these techniques ensure symmetry in the sense that the primary and secondary parts are identical. Generally, however, the two inductors are not balanced.

A more symmetrical layout comprises inward and outward spiralling paths which cross twice in all but the outer and inner turns which contain only one crossing. Transformers employing such symmetrical inductors are shown in Simburger, W. et al., "A Monolithic 3.7W Silicon Power Amplifier with 59% PAE at 0.9 GHz", 1999 IEEE International Solid-State Circuits Conference, TP 13.6. These transformers comprise the turns of each inductor arranged in one or more blocks, which are arranged coaxially.

EX-1035.084 citing Christensen (EX-1006), [1:9-25]. As shown above, during the ITC hearing, as he has here at the PTAB, Dr. Phinney was careful to call the two paths in Christensen “windings” and not “inductors,” but Christensen’s disclosure shows the basic engineering principle that these “windings” are in fact inductors. And as depicted in his testimony above, Dr. Phinney understands (as anyone with a basic understanding of electrical engineering would) that a transformer may be made up of two inductors and you could refer to one as a first winding and the other as a second winding.

Q. Well, I’m not asking if you can build it that way. I’m saying **do you agree a transformer can be two inductors?**

A. **Yeah, you could stack, just, one right on top of the other and call one winding and the other a second winding.**

EX-1035.074 (emphasis added).

15. In sum, the ALJ considered Realtek and Dr. Phinney’s arguments that transformers do not include or disclose inductors and did not find them credible. I agree. The ’245 Patent claims at issue relate to the “structure” of an inductor. As I explained in detail in my opening declaration, structurally, a transformer is simply two or more inductors. If one or both of those inductors meets the structural limitations of the ’245 Patent claims, then it does not matter if that inductor is exists on its own, is found in a transformer, or in some other circuit type.

V. BACKGROUND OF THE TECHNOLOGY

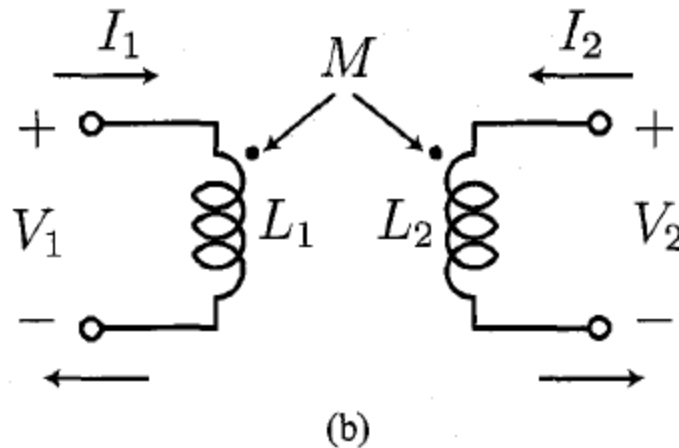
16. In my Initial Declaration, I discussed the basics of inductors and how inductance is measured. In particular, one application for inductors is in transformers, which are widely used in RF circuits. EX-1010.097. As I explained in my initial declaration, a transformer is two magnetically coupled inductors. *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. *Id.*, .097. This ideal equation is shown below.

$$V_2 = NV_1$$

Id.

17. 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 (electromagnetic force) 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.*

18. 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.



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

VI. THE '245 PATENT

A. Background

19. 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]. I again point out the above paragraph of the '245 Patent for two reasons.

20. ***First***, a POSITA would not have found it particularly surprising that the '245 Patent discusses transformers with reference to the prior art as they are in the same field of endeavor. As I have explained, and will do so in further detail herein, a transformer is simply two or more inductors. The structure of a transformer structure therefore comprises two or more inductor structures. Thus, when looking to design a new type of inductor structure, a POSITA would naturally have looked to references disclosing transformers and transformer structures, in addition to inductors and inductor structures. This is demonstrated in the file history of the '245 Patent itself, as shown below:

INFORMATION DISCLOSURE STATEMENT BY APPLICANT (Not for submission under 37 CFR 1.99)	Application Number	12773024
	Filing Date	2010-05-04
	First Named Inventor	Kai-Yi Huang
	Art Unit	2811
	Examiner Name	N/A
	Attorney Docket Number	REAP0577USA

	1						
NON-PATENT LITERATURE DOCUMENTS							
Examiner Initials*	Cite No	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc), date, pages(s), volume-issue number(s), publisher, city and/or country where published.					
/TN/	1	DESIGN, SIMULATION AND APPLICATIONS OF INDUCTORS AND TRANSFORMERS FOR SI RF ICs, ALI M. NIKNEJAD AND ROBERT G. MEYER, 2000, P.22-24, Kluwer Academic Publishers, Distributors for North, Central and South America. no date					
EXAMINER SIGNATURE							
Examiner Signature	/Tuyen Nguyen/				Date Considered	12/20/2010	
*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through a citation if not in conformance and not considered. Include copy of this form with next communication to applicant.							

EX-1002.016 (emphasis added in highlight).

21. One of the references cited by the Examiner also specifically relates to transformers:

Notice of References Cited	Application/Control No. 12/773,024		Applicant(s)/Patent Under Reexamination HUANG ET AL.	
	Examiner TUYEN T. NGUYEN		Art Unit 2832	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-4,816,784	03-1989	Rabjohn, Gordon G.	333/24R
*	B	US-7,656,264	02-2010	Hsu et al.	336/223
*	C	US-7,525,407	04-2009	Lee et al.	336/200
*	D	US-7,721,414	05-2010	Sia et al.	29/602.1
*	E	US-6,426,267	07-2002	Liou, Ping	438/319
*	F	US-6,355,535	03-2002	Liou, Ping	438/381
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

EX-1002.013 (emphasis added in highlight).

22. U.S. Patent No. 7,656,264 to Hsu et al. is titled “High Coupling Factor Transformer and Manufacturing Method Thereof.” EX-1036.01. And Hsu itself listed inductor references on the first page of the patent:

Alireza Zolfaghari et al. “Stacked Inductors and Transformers in CMOS Technology” published in Journal of Solid-State Circuit, vol. 36, No. 4, p. 620-628, Apr. 2001.

Id. This supports my opinion that transformers are in the same field of endeavor as inductors, both now and that the time of the filing of the '245 Patent application. This is particularly the case where, as here, the scope of the patent relates to the inductor's structure and not its functionality.

23. **Second**, though the functionality of inductors is not claimed in the '245 Patent, the paragraph cited above [1:12-20] discusses quality factor, substrate

loss, and metal loss with reference to **both** inductors and transformers. This is because, despite Dr. Phinney's assertions to the contrary, many of the very same considerations are present for inductors **and** transformers (such as metal loss, substrate loss, and quality factor, among others).

VII. DR. PHINNEY'S DISCUSSION REGARDING FUNDAMENTAL DIFFERENCES BETWEEN INDUCTORS AND TRANSFORMERS

24. Dr. Phinney's declaration contains a lengthy discussion regarding the so called "fundamental differences between inductors and transformers." *See*, EX-2003, ¶¶ 58-66. Dr. Phinney's discussion repeats many of the same arguments he made at the ITC that ALJ Elliot rejected. And importantly, he again ignores the numerous pieces of scientific literature I included in my Initial Declaration which discuss the basic principle that a transformer is merely two inductors (referred to as "inductors," "inductor windings" and/or "windings").

A. Dr. Phinney Ignores the fact that a Transformer Contains Inductor Structures

25. As an initial matter, Dr. Phinney's discussion focuses almost entirely on the functionality of inductors and transformers rather than the structures of these components. As I discussed prior, the '245 Patent (including every claim) is focused on designing a particular **structure** of an inductor. *See*, EX-1001, claims 1-20 (disclosing that every claim starts with: "[t]he **structure** of a/the spiral inductor." This would have immediately informed a POSITA that transformer art

would be relevant to the claims because it is indisputable that a transformer is simply two or more inductors, and therefore the structure of those inductors found in transformers would be pertinent to the '245 Patent claims.

26. Indeed, it is noteworthy that Dr. Phinney could not cite one piece of evidence (a patent, white paper, electrical engineering book, etc.) that states the opposite—that a transformer is not two or more inductors. Instead, the one piece of literature he cited confirms the basic principle that a transformer is merely two or more inductors. The white paper cited by Dr. Phinney titled, “Modeling and Characterization of On-Chip Transformers” by Sunderarajan S. Mohan et al, mentions several times that a transformer is simply multiple inductors. *See*, EX-2007.01-03. For instance, Mohan discloses the following transformer figures 1(a) through (e):

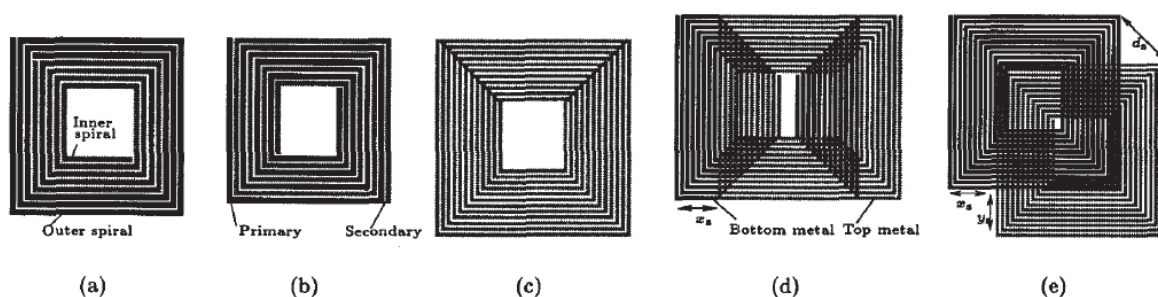


Figure 1: On-chip transformer realizations. (a) Tapped, (b) interleaved, (c) stacked with top spiral overlapping the bottom one, (d) stacked with top and bottom spirals laterally shifted, (e) stacked with top and bottom spirals diagonally shifted.

EX-2007.03. In describing some of these figures, Mohan makes clear that the transformers consist of at least two inductors. For instance, with respect to Figs. 1(a), 1(d), and 1(e):

The tapped transformer (Fig. 1.a) is best suited for three-port applications. It permits a variety of tapping ratios to be realized. This transformer relies only on lateral magnetic coupling. All windings can be implemented with the top metal layer, thereby minimizing port-to-substrate capacitances. Since the two inductors occupy separate regions, the self-inductance is maximized while the port-to-port capacitance is minimized. Unfortunately, this spatial separation also leads to low mutual coupling ($k \approx 0.3 - 0.5$).

...

separation will reduce k by less than 5%. One can also trade off reduced coupling for reduced capacitance by displacing the centers of the stacked inductors (Fig. 1.d,1.e).

EX-2007.01.

27. Similarly, EX-2002 is a white paper titled “High Performance 3-D Helical RF Transformers,” which Dr. Phinney previously included as an exhibit to a rebuttal expert report on validity in the ITC Investigation. It specifically discloses that:

On chip transformers in RF circuits are typically implemented using two planar spiral inductors that are interweaved together. There are

EX-2002.02.

B. Transformers and Inductors have Similar Design Considerations

28. Dr. Phinney implies in his declaration that the design considerations between inductors and transformers are fundamentally at odds with each other.

This is not the case. Dr. Phinney states that “[a]n inductor is an impedance device with two terminals that is part of a single circuit” and that “[i]n an IC context, inductor designers generally seek to efficiently utilize scarce available area to maximize Q within a given footprint.” EX-2003, ¶ 58 (emphasis retained). He goes on: “[t]ransformers, on the other hand, are electrical devices used to transfer energy between two or more circuits.” EX-2003, ¶ 59 (emphasis retained). But the mere fact that an inductor may be part of a single circuit and a transformer may involve two or more circuits, does not mean that there are not similar design considerations.

29. For instance, as I discussed earlier, in the '245 Patent itself confirms that substrate loss, metal loss and quality factor are considerations when designing both inductors and transformers. EX-1001, [1:12-20]. Dr. Phinney does not dispute this:

Q So one of the problems, which is a problem that you've heavily discussed which is **metal loss, substrate loss, Q factor, relates to both inductors and transformers, doesn't it?**

THE WITNESS: Loss can relate to transformers. If you – if you have energy, it enters a transformer and it goes to heat, it's not going to be recoverable.

EX-1037, 66:2-10 (emphasis added, objection removed); *see also, id.*, 63:8-19 (Dr. Phinney further testified that “... substrate loss and metal loss can affect both types of structures [i.e., inductors and transformers].”).

30. Dr. Phinney explains that “[k]ey design goals for transformers include symmetry and coupling.” EX-2003, ¶ 60. He elaborates that “[w]hen transformer windings are intermingled to improve coupling, each winding includes structural modifications *particular to its use as transformer windings*. These structural modifications to the windings of a transformer run counter to the goals of inductor design because the modifications do not optimize Q.” *Id.*, ¶ 62 (emphasis retained). However, as just explained, transformers and inductors both take into account metal loss, substrate loss, and optimizing Q. The mere fact that windings may be intermingled or take into account coupling does not mean that all other design considerations are ignored. Indeed, a POSITA would have understood that a chip layout must account for many competing design considerations, not merely one in isolation. For instance, an inductor or transformer may need to be designed to account for other components that need to be utilized on the layout. Moreover, like transformers, inductors are often also designed to be symmetric. This is the case in the ’245 Patent (*see, e.g.*, EX-1001, Figs. 2, 5, 6, 10, and 11) and Yang (*see, e.g.*, EX-1007, Fig. 1). Indeed, the previously discussed Mohan reference depicts numerous transformer structures which include symmetrical inductor structures.

For instance, as shown below, transformers 1(d) and 1(e) appear to be largely symmetrical structures while the two inductors of the transformer structures each appear to be symmetrical as well—for instance, each inductor of 1(e) appears to be a square.

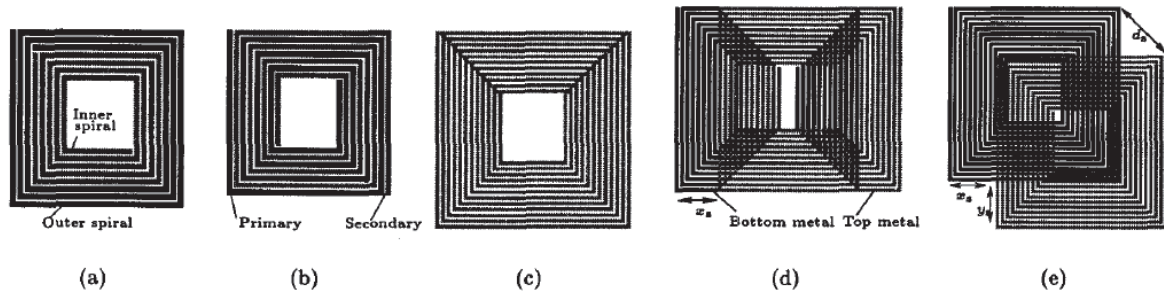


Figure 1: On-chip transformer realizations. (a) Tapped, (b) interleaved, (c) stacked with top spiral overlapping the bottom one, (d) stacked with top and bottom spirals laterally shifted, (e) stacked with top and bottom spirals diagonally shifted.

EX-2007.03.

31. Dr. Phinney also argues that “a POSITA would already know how to design a better performing inductor than one could ascertain from the isolated winding of a transformer that is structurally modified for coupling. Dr. Prucnal’s opinion to the contrary is akin to saying you can arrive at the optimal design for a motorcycle by cutting a car down the middle and utilizing the design of its two halves.” EX-2003, ¶ 62. This analogy is off base. *Two inductors can indeed create a transformer, but two motorcycles cannot create a car.* This flawed analogy only confirms the weakness of Dr. Phinney’s arguments.

32. Dr. Phinney appears to be looking at the problem backwards as made clear by his car analogy—a person designing motorcycles might not look to car

design because motorcycles are not part of the design process for manufacturing cars. On the other hand, as I have explained, and Dr. Phinney appears to admit, a transformer is created by putting two inductors together. Therefore, a POSITA would indeed have looked to transformer designs when considering designs for inductors. EX-1035.074-075 (Q. And do you agree that **you can put that inductor together with another inductor and create a transformer? A. You could do that.**”). That inductors and transformers might each have their own chapter of EX-1010 (EX-2003, ¶ 64) does not change the fact that transformers are created using inductors. *See, e.g.*, EX-1010.097-.99.

33. Dr. Phinney also argues that “a POSITA would understand individual inductors must be substantially modified, in a manner deleterious to their function as inductors, in order to be used as one of the coils in a transformer.” EX-2003, ¶ 66. I disagree. Indeed, he cites Mohan for this proposition, but as I just discussed, Figs. 1(a)-(e) of Mohan depict various transformers with inductor structures that appear entirely symmetrical. *See*, EX-2007.03 (Figs. 1(a)-(e)). And as will be made clear in the following paragraphs, the inductors of Ho-Hsiang and Christensen are symmetric. Nor do any of the inductor structures I have identified in Grounds 1-2 need to be modified in any way in order to satisfy the claim limitations of the ’245 Patent.

VIII. GROUND 1: OBVIOUSNESS BASED ON HO-HSIANG

34. 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 structure of the inductor claimed in the '245 patent.

Claim 1

1.1 A structure of a spiral inductor, comprising:

35. Dr. Phinney appears to only dispute that Ho-Hsiang discloses the preamble limitation, “[a] structure of a spiral inductor.” His primary argument being that “*Ho-Hsiang* is directed to planar “transformers and balanced-to-unbalanced (BALUN) devices.” EX-2003, ¶ 67. However, Dr. Phinney ignores the fact that Ho-Hsiang is also directed to inductor structures. Figures 5-8 specifically relate to inductors. *See*, EX-1005, [2:52-63]. And while Dr. Phinney attempts to distinguish the “windings” of a transformer from “inductor” structures (EX-2003, ¶ 68), Ho-Hsiang uses the two terms interchangeably, as was widely known in the art and is consistent with all of the background art I have discussed. For instance, with reference to Figure 3, it states that “[b]oth the **primary winding 302** and the secondary winding 306 have a center tap 310, 312 connected to the outermost portion of the BALUN 306. For example, **primary inductor 302** has a center tap 310 connected to winding segment 302c located at the outer portion of the BALUN300...” EX-1005, [4:40-46] (emphasis added).

36. Dr. Phinney next reiterates his argument that there are fundamental differences between inductors and transformers. As I discussed *supra*, I disagree that any of these differences are pertinent, because both devices have considerations regarding metal loss, substrate loss, and quality factor. *See*, § VII. Moreover, Ho-Hsiang, like the '245 Patent, relates to the structure of such devices. It includes “BALUN Structures” in the title of the patent and then specifically refers to BALUNs containing inductors. EX-1005, [1:1-4, 2:52-63]. Moreover, Dr. Phinney admits that structurally, a transformer is two inductors. EX-1037, 48:20-49:10.

37. I have been informed that EX-1038 (PTO Classification Definitions) represents an excerpt from the U.S. Patent and Trademark Office classification system that was in place when the '245 Patent was filed. In that document the PTO itself repeatedly refers to transformers in its “CLASS 336, INDUCTOR DEVICES” classification. *See, e.g.*, EX-1038, generally. It similarly lumps inductors and transformers together in its glossary. EX-1038.07.

38. I understand that Dr. Phinney disagrees with the PTO’s guidance. When asked about the above guidance, he testified:

Q: Do you think that the PTO is inaccurate here?

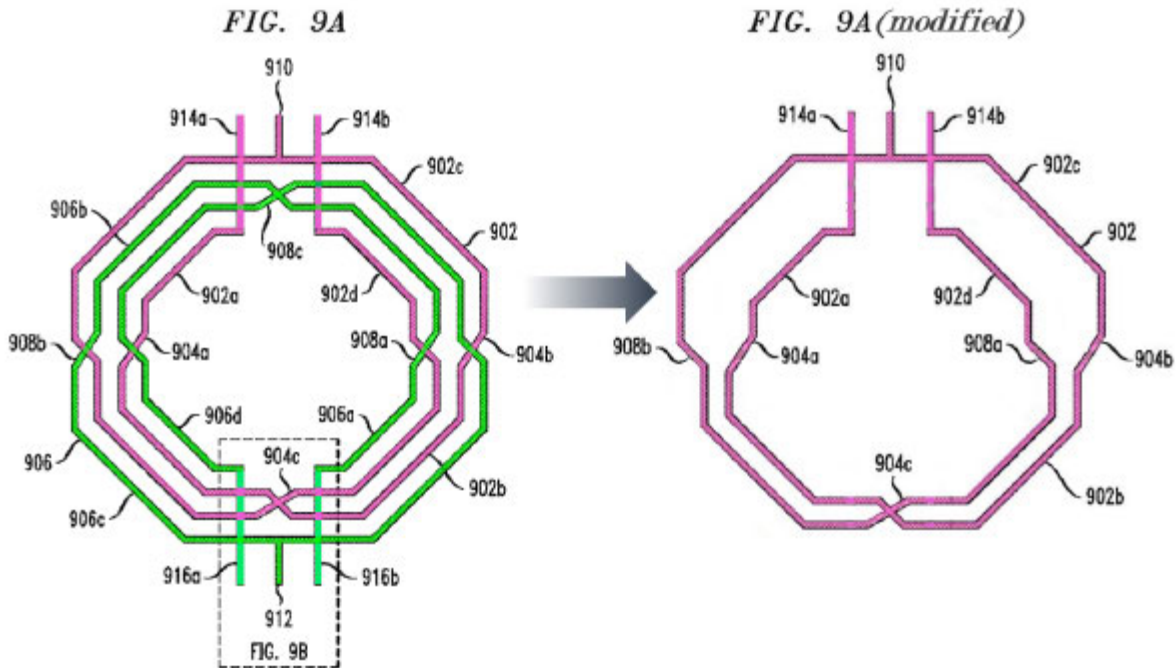
A: It’s – it’s a little bit old-timey in how it’s talking there. You know, we don’t, for instance – in magnetics, **we don’t talk about the primary inductor and the secondary inductor.** We talk – and what’s

really important though is how inductors and transformers differ from a design standpoint. But this is just not in line with the way these words are used in education for a person of ordinary skill.

EX-1037, 107:11-21 (emphasis added).

39. In disputing the PTO's classification system including transformers and inductors together, Dr. Phinney again argues that engineers and educators do not think about transformers as having a primary inductor and secondary inductor. I completely disagree. I have been an educator in the field for decades and, consistent with the myriad technical references I have cited to in my Initial Declaration and herein *supra*, this is exactly how a POSITA would have thought about a transformer from a design standpoint. In my opinion, the PTO is correct to reference transformers with inductor devices in its Class 336 guidance. References like Ho-Hsiang, which is listed as class 336 (*see* EX-1005, p. 1) are plainly in the same field of endeavor as the '245 Patent (also class 336, *see* EX-1001, p. 1) because they both disclose inductors.

40. This brings me to my next point. Dr. Phinney argues that “[t]here is nothing in *Ho-Hsiang* to suggest that a POSITA would be motivated to modify the transformer of *Ho-Hsiang* (illustrated below on the left) by separating the windings of the planar transformer, and then only utilizing a single, isolated winding as a spiral inductor.”



EX-2003, ¶ 70. However, as is clear from the image on the right, I have not changed the **actual structure** of the primary inductor in pink, I have simply isolated it to show its structure more clearly. Dr. Phinney agrees that I have not actually changed the winding in any way. EX-1037, 73:22-74:25. As such, a POSITA would have fairly looked to the structure of that inductor when considering inductor designs.

41. Next, Dr. Phinney argues that “*Ho-Hsiang* teaches away from the claimed ’245 Patent invention because it presents a means to improve the Q_s of both the primary and secondary windings by increasing the thickness of the metal layers on which both windings are formed.” EX-2003, ¶ 73. I disagree that teaching that increasing the thickness of the metal layers on which the windings are formed somehow teaches away from the ’245 Patent. This is simply an additional

technique that can be implemented. Moreover, I find Dr. Phinney's argument perplexing given that the '245 Patent itself teaches increasing the thickness of the metal layers of the inductor device. *See*, EX-1001, claims 13-15:

13. The structure of the spiral inductor of claim 10, wherein a first thickness of the first metal layer is greater than a second thickness of the second metal layer.

14. The structure of the spiral inductor of claim 13, wherein the spiral inductor further comprises a third metal layer; a structure of the third metal layer is the same as a structure of the second metal layer; both the third metal layer and the second metal layer are positioned above or under the first metal layer; and the first thickness of the first metal layer is greater than a third thickness of the third metal layer.

15. The structure of the spiral inductor of claim 10, wherein a first thickness of the first metal layer is equal to a second thickness of the second metal layer.

42. Notably, claim 13 articulates that in one implementation, the first metal layer is thicker than the second metal layer. Claim 14 articulates that the first metal layer and second metal layer (the two claimed layers) are each thicker than the third metal layer. Lastly, claim 15 articulates that the first and second metal layers are equal in thickness. Thus, the '245 Patent at least contemplates scenarios in which the first and second metal layers are of equal thickness, while also being greater in thickness than a third underlying layer (in order to implement both claims 14 and 15 in a single device). Thus, while Dr. Phinney argues that "[a] POSITA would have known that simply thickening the metals in a standard IC

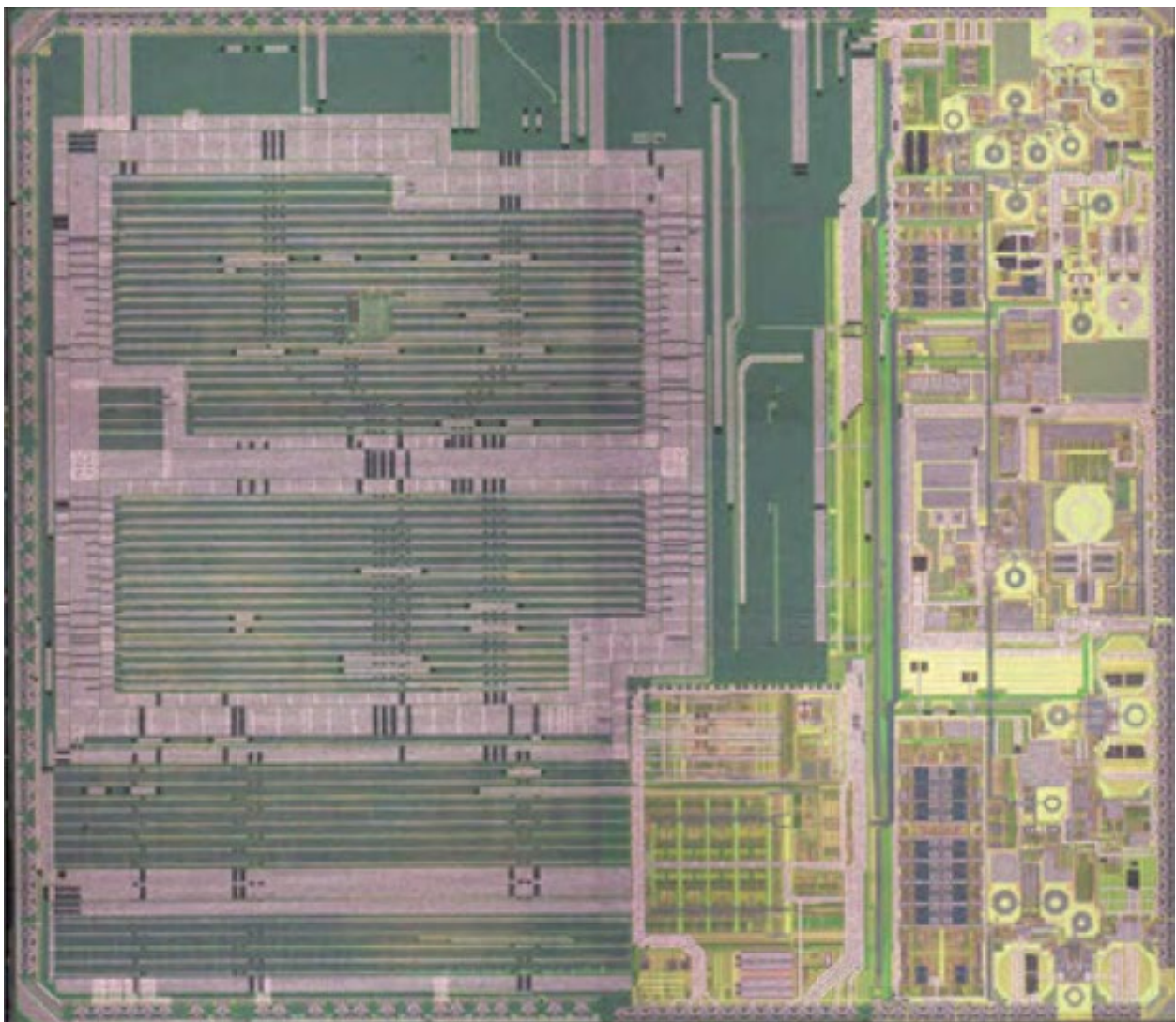
process is not an option available to the individual designer” (EX-2003, ¶ 74), it is precisely what is claimed in the ’245 Patent and thus I disagree that such similar disclosures in Ho-Hsiang somehow teach away from the ’245 Patent. Indeed, such similar teachings demonstrate the similar design considerations found in Ho-Hsiang and the ’245 Patent, which a POSITA would have expected because both disclose inductors, and both discuss quality factor. *See*, EX-1001, [1:7-10], EX-1005, [6:53-67].

43. Dr. Phinney additionally argues that he understands “that the Federal Circuit has clarified that a proposed modification is not obvious when the modification renders the prior art reference inoperable for its intended purpose. An isolated winding of the *Ho-Hsiang* transformer would not function as a transformer.” EX-2003, ¶ 75. This argument does not make sense when considering the fact that I have proposed **no** modification to the *Ho-Hsiang* structure. I have instead shown that, as disclosed, there is an inductor structure in *Ho-Hsiang* that meets the limitations of the challenged claims. Contrary to Dr. Phinney’s argument, I am not removing or isolating that inductor from *Ho-Hsiang* nor have I argued that a single inductor can act as a transformer. The challenged claims all require a “structure of a spiral inductor” and that is what I have shown is disclosed in *Ho-Hsiang*.

44. Dr. Phinney also argues that the isolated inductor of Ho-Hsiang has a “somewhat unusual, meandering geometry as compared to the inductors disclosed in the prior art.” EX-2003, ¶ 78. He reasons that the isolated inductor of Ho-Hsiang has “non-uniform spacing between turns of the winding and is implemented over a larger footprint than necessary especially when compared to a typical circular, polygonal, or even square prior art inductors.” EX-2003, ¶ 79. Notably, the challenged claims of the ’245 Patent do not require an inductor that is perfectly symmetric or that minimizes footprint, as Dr. Phinney agrees. EX-1037, 75:1-76:6, 133:14-134:3. And Figure 9A of Ho-Hsiang has mirror symmetry. EX-1037, 76:13-77:8. Indeed, I understand that Dr. Phinney does not dispute that claims 8 and 9 are satisfied by Ho-Hsiang (apart from his dispute about the preamble element of claim 1). EX-2003, 17:6-10. Therefore, there is no dispute that, despite its supposed “meandering” shape, the inductor of Ho-Hsiang is both symmetric and generally an octagon shape.

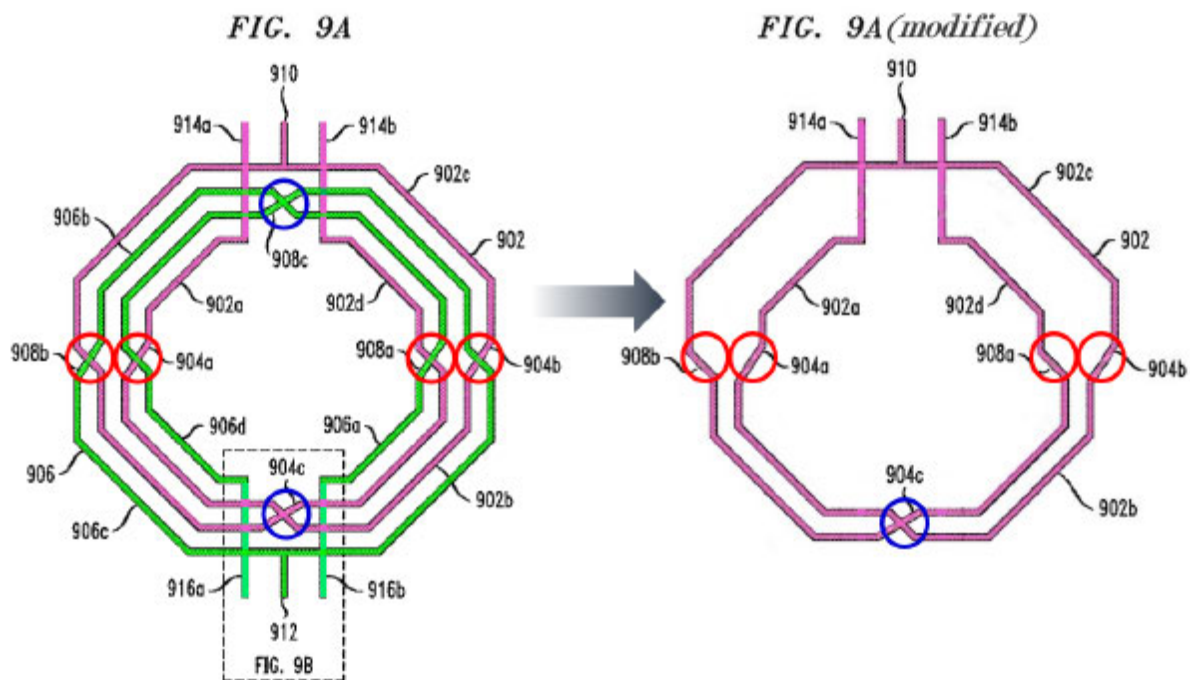
45. Moreover, Dr. Phinney’s focus on “irregular geometry” (EX-2003, ¶¶ 80, 82-83, 90), “unnecessary gaps” e.g., at the crossings (EX-2003, ¶¶ 81-82), and “underutilized metal layers” (¶¶ 85-88) is both irrelevant and ignores practical design constraints. It is irrelevant because there is nothing in the challenged claims that prevents the structure of the Ho-Hsiang inductor from reading on the limitations. It is impractical because a POSITA would have understood that there

are many components in a typical circuit beyond just inductor structures and thus many design considerations that must be considered beyond just creating a perfectly symmetric inductor structure which also impact the circuit footprint and may result in gaps between various components. As seen below, the layout of a typical IC chip has many meandering components that must all fit together on the layout.



EX-1035.056.

46. Moreover, perfect symmetry (which in any event is not shown or claimed in the '245 Patent) is hard to attain. Dr. Phinney's focus, for instance, on crossovers causing irregularities in the shape of the inductor ignores the reality that the mere presence of crossovers at all (e.g., as found in the '245 Patent itself) will cause some level of irregularity. Dr. Phinney argues that, as shown below with respect to Ho-Hsiang, the "single isolated winding with four locations [is] designed to accommodate the crossovers between the transformer's two windings, 908b, 904a, 908a, 904b [are shown] (red circles)."



EX-2003, ¶ 82.

47. However, As Dr. Phinney testified, the presence of crossovers in any form will cause some level of asymmetry. *See*, EX-1037, 75:5-76:6 ("A: So this is

– it’s a little bit nuanced because **wherever there’s a crossing, there’s never perfect symmetry**”); *id.*, 72:22-73:10 (emphasis added). Yet, perfect symmetry is not required and as discussed *supra*, Dr. Phinney admits Ho-Hsiang’s inductor is symmetric within the meaning of the ’245 Patent.

48. Lastly, Dr. Phinney reiterates the same general arguments about the functionality of inductors versus transformers and how the inductors of Ho-Hsiang are not designed to optimize Q, among other things. EX-2003, ¶¶ 89, 91-94. However, the challenged claims do not require optimizing Q or anything else related to the functionality of the inductor **structure**. This is evidenced by the fact that Dr. Phinney testified that during the ITC proceeding he opined that certain AMD products infringed the ’245 claims, but he did not analyze the Q factor of those products at all, and he only considered their structures. EX-1037, 23:2-24:5. Moreover, Dr. Phinney has provided no evidence that the inductors of a transformer would not still **operate as inductors**, only that in his opinion they would not be optimally performing inductors.

49. In short, the claims of the ’245 Patent relate to inductor structures. A transformer includes inductor structures. That the inductors are components of a larger structure is not relevant. A POSITA could have easily looked at one of the inductors to assess its structure, as I did for Ho-Hsiang, and find every element of claims 1, 5, 8, and 9 in Ho-Hsiang. And given the general understanding of a

POSITA that a transformer is simply two inductors, a POSITA would have certainly looked at references like Ho-Hsiang, which disclose transformer and inductor structures., when considering the design of inductor structures.

IX. GROUND 2: OBVIOUSNESS BASED ON CHRISTENSEN

50. Christensen also discloses multi-layer inductors used in an on-chip transformer structure. The inductor structures disclosed in Christensen are like the inductor claimed in the '245 Patent, as ALJ Elliot correctly found. EX-1035.084.

51. Dr. Phinney's arguments about Christensen are largely duplicative of his arguments regarding Ho-Hsiang. Dr. Phinney again argues that Christensen relates to transformers and that, e.g., isolating one inductor would increase footprint and cause structural irregularities while not optimizing Q. EX-2003, ¶¶ 95-111, 116-120. I incorporate my discussion *supra* outlining why a POSITA would have looked to transformer art regarding inductor structures herein. *See*, § VII and § VIII *supra*. Similar to my analysis of Ho-Hsiang, I focused on one inductor in Christensen and did not change the *actual structure* of that inductor in any way.

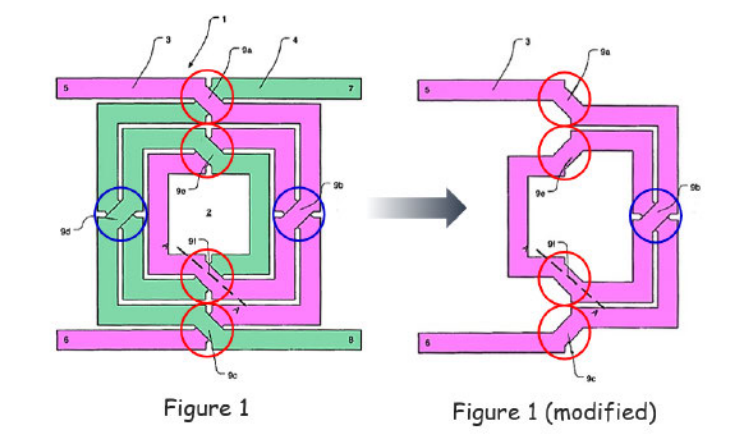
52. Moreover, Dr. Phinney simply ignores the fact that Christensen (another 336-classified reference) discloses inductors. Indeed, the very first paragraphs of Christensen, under "Background of the Invention" state: "On-chip transformers are relatively rare in silicon RF integrated circuits and make use of a

few well-known layout techniques, e.g. placing the primary and secondary windings one above the other ... Generally however, **the two inductors** are not balanced.” EX-1006, [1:9-16] (emphasis added). It goes on: “[a] more symmetrical layout comprises inward and outward spiralling paths which cross twice in all but the outer and inner turns which contain only one crossing.

Transformers employ[] such symmetrical inductors ... [and] the turns of each inductor [are] arranged in one or more blocks, which are arranged coaxially.” EX-1006, [1:16-25] (emphasis added).

53. Indeed, in finding the asserted claims (claims 1, 2, and 8) invalid, the ALJ at the ITC cited the above disclosure of Christensen and noted that “while Realtek and Dr. Phinney are careful to describe the two paths in Christensen as ‘windings’ and not ‘inductors,’ Christensen’s disclosure shows the otherwise well-understood identity of these structures.” EX-1035.084.

54. Additionally, Dr. Phinney argues that I apply “*Christensen*’s Figs. 4–6 to the self-crossings 9d and 9b in an effort to incorporate structural features not explicitly disclosed, when *Christensen* does not teach or disclose the structure of the self-crossing.” EX-2003, ¶ 112. In essence, he argues that Christensen “is focused on the crossings of the two windings (red circles below) ... and does not explicitly teach or disclose anything about the self-crossings of the individual windings 9d or 9b (blue circles below).”



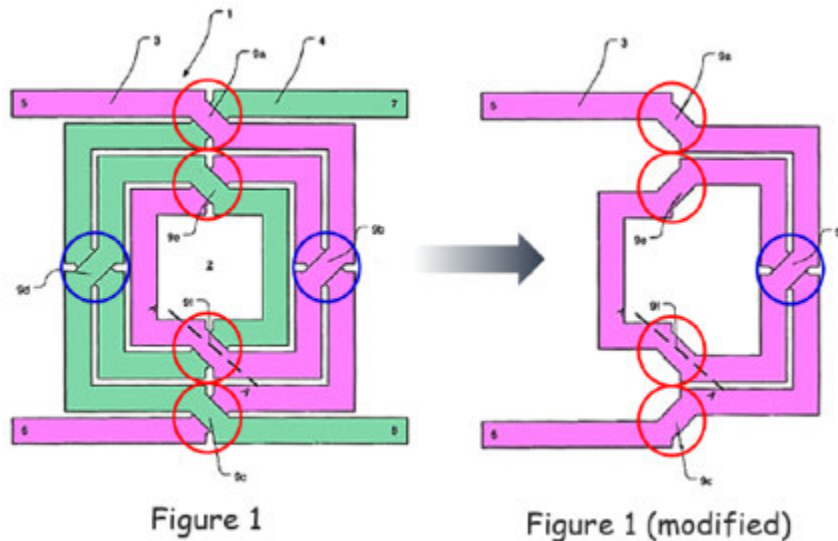
EX-2003, ¶ 111; *see also, id.*, ¶ 113.

55. In other words, Dr. Phinney believes the disclosures of Christensen related to the red circles (e.g., vias near the crossings) would not apply to the blue circles because those are self-crossings (i.e., the inductor crosses over itself rather than a different inductor). This argument was also rejected at the ITC by ALJ Elliot. EX-1035.084-.085. There is simply no basis for a POSITA to have believed that the exemplary Fig. 6(a) would not apply to all the crossings. Christensen makes clear that Fig. 6(a) illustrates “a layer of a crossover,” clearly implying that it relates to multiple crossovers and in no way limiting it to some but not all the crossovers. EX-1006, [2:30-31]. Indeed, Dr. Phinney admits that the crossovers of Christensen would have vias near them, including the inductor’s self-crossing at 9b:

Q: Okay. And you see – and like we just discussed you’d expect those crossings to have vias, correct?

A: Yeah, I'd expect those to have vias, they were shown explicitly in 9f.

Q: Okay. For whatever reason you would not expect, in your opinion, there to be vias in the two blue circles, correct?



[EX-2003, ¶ 111 (added for reference)]

A: No, I think I answered that **I'd expect to be vias there**. I'm just saying that the crossings wouldn't necessarily have the same form as when we see the crossings of winding 3 and 4 because the symmetry requirement there of 3 with 4 doesn't exist. You only need to have symmetry of 9b with respect to 9d.

Q: Okay. Got it. So you would expect there to be vias generally where – in the region where you have those blue circles?

A: Yeah, I think that they could be there if there's three layers at least.

Q: Okay. And so that would apply to the blue circle on the right side in the Figure 1 modified, correct? You would expect there to be vias over there?

MR. PARKER: Objection, form.

THE WITNESS: Yeah, I think that's – that's right. They can be optionally in many places as we saw and it's just that we don't have explicitly shown to us the self-crossing regions in Christensen.

EX-1037, 153:24-155:3.

56. Given this testimony, it is not even clear what Dr. Phinney is disputing. Claim 1 of the '245 Patent merely requires that vias connect the first segment with the fourth segment and the second segment with the fifth. Because Dr. Phinney admits that these vias would be located near crossing 9b, that demonstrates that the claim language is satisfied, as I depicted in my Initial Declaration, because the vias near crossover 9b connect the first and fourth segments as well as the second and fifth segments, as again depicted below.

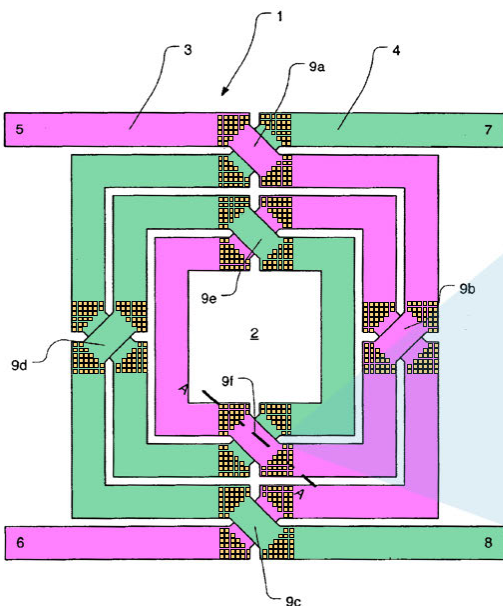


Figure 1

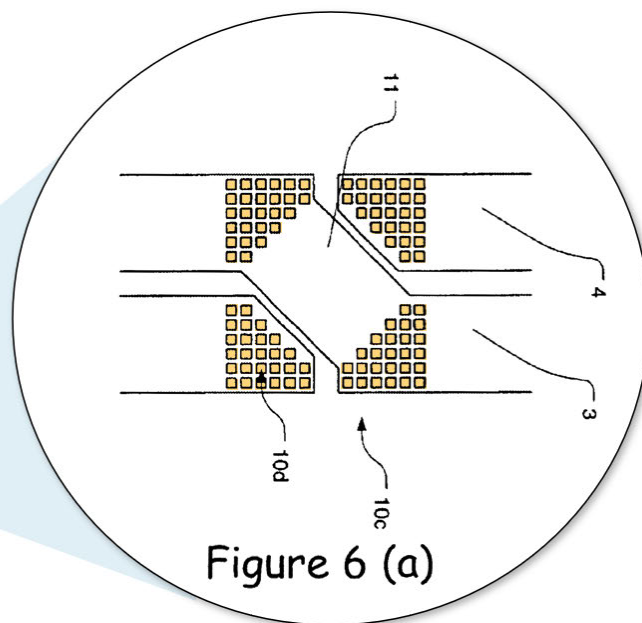
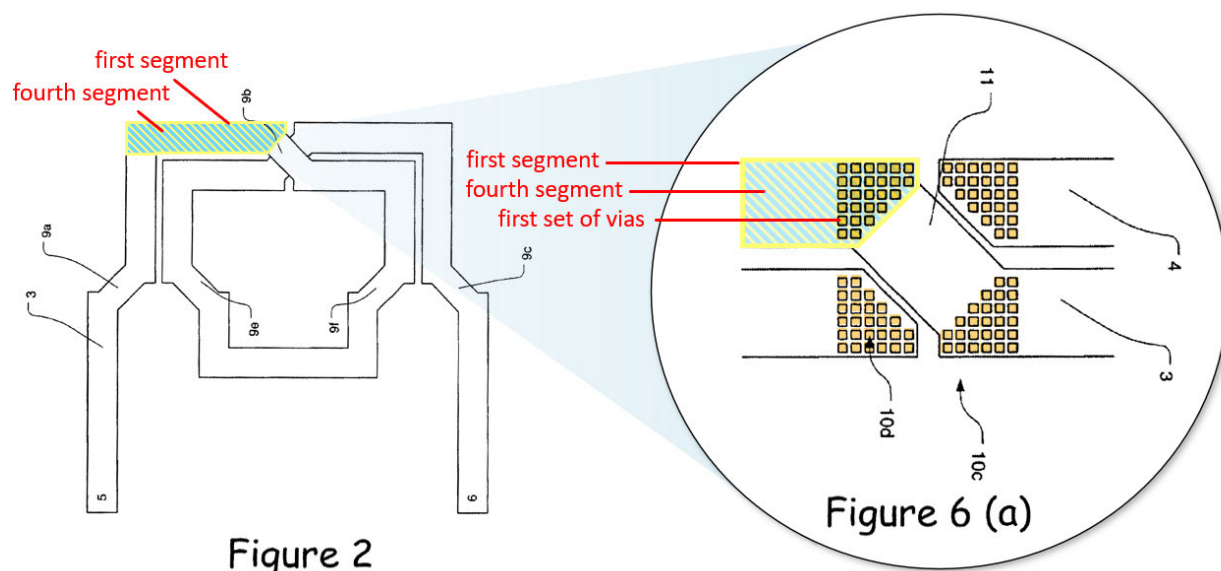
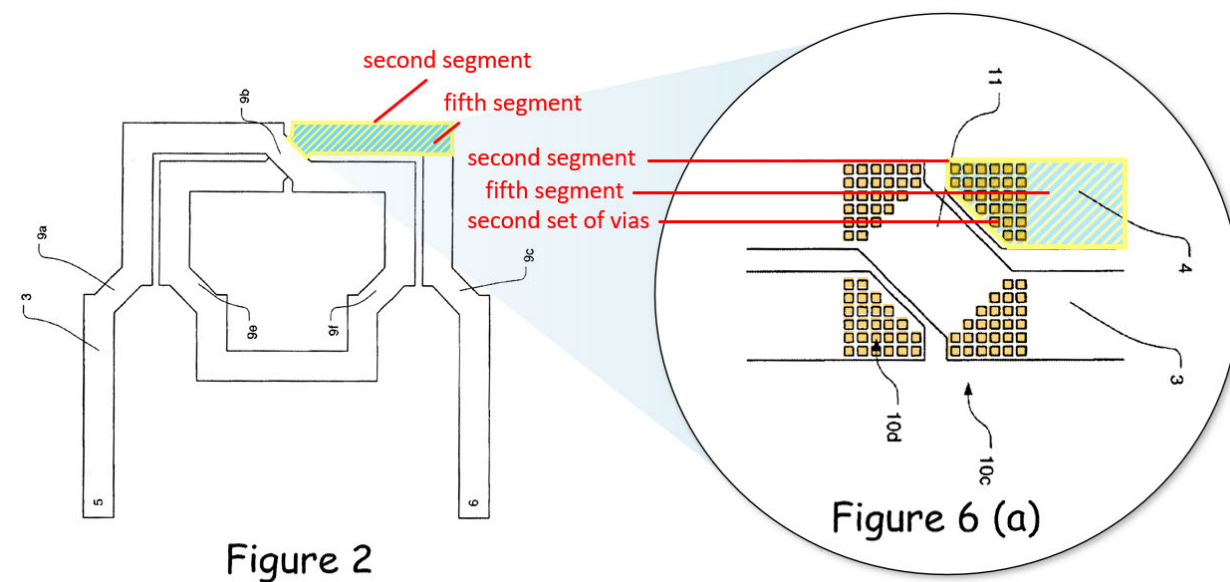


Figure 6 (a)

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

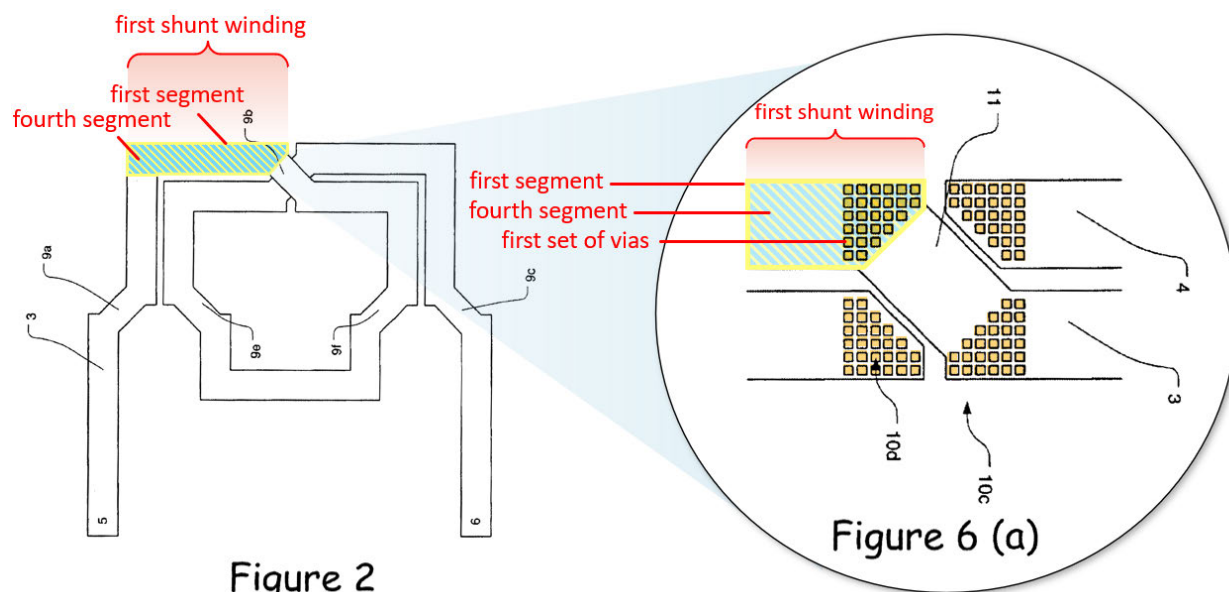


Id., [Fig. 2] (left, annotated, and rotated); [Fig. 6a] (right, annotated, rotated, and zoomed in).

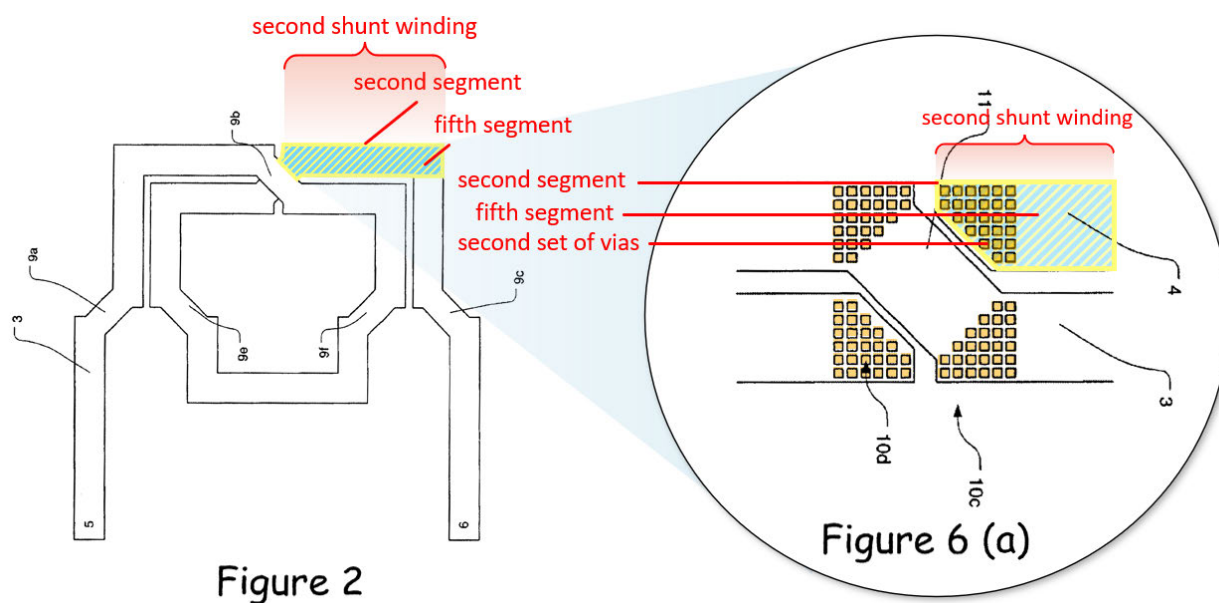


Id., [Fig. 2] (left, annotated, and rotated); [Fig. 6a] (right, annotated, rotated, and zoomed in).

57. Thus, there would be shunting at those locations, as I explained in my Initial Declaration.



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



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

X. GROUND 3: OBVIOUSNESS BASED ON YANG

58. Dr. Phinney's analysis concerning Ground 3 focuses on the fact that Yang does not explicitly disclose a sixth segment. EX-2003, ¶¶ 121-127.

59. Yang relates to an "Integrated Inductor," as suggested by its title. 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]. And it is not disputed that illustrative Figure 1 of Yang is missing a connection that would be needed to allow it to operate as an inductor. *See*, EX-1037, 158:9-18 ("Q: Right. There's something missing clearly, right, that it would need to be an inductor? A: I'd say that's right..."). There is also no dispute that the Yang inductor is generally symmetric. EX-1037, 155:8-157:11.

60. Thus, the question becomes how proper electrical conductivity is maintained in the Yang inductor. Because something is missing in Figure 1, the question is how a POSITA would have understood such conductivity is maintained. Dr. Phinney maintains that "a POSITA would simply use what was currently taught in the prior art, the use of an underpass on a separate metal layer to close the circuit." EX-2003, ¶ 128. He argues that use of such underpasses "could still have been implemented while substantially maintaining the inductor's symmetry." It is hard to visualize how the underpass would be formed in Yang, because Dr. Phinney

does not mark up the image of Yang to show where the underpass would form. However, a POSITA would have understood that there is no possible implementation that would be as symmetrical as forming a crossover as I have depicted it below (the sixth segment shown in blue with the third segment removed for illustrative purposes).

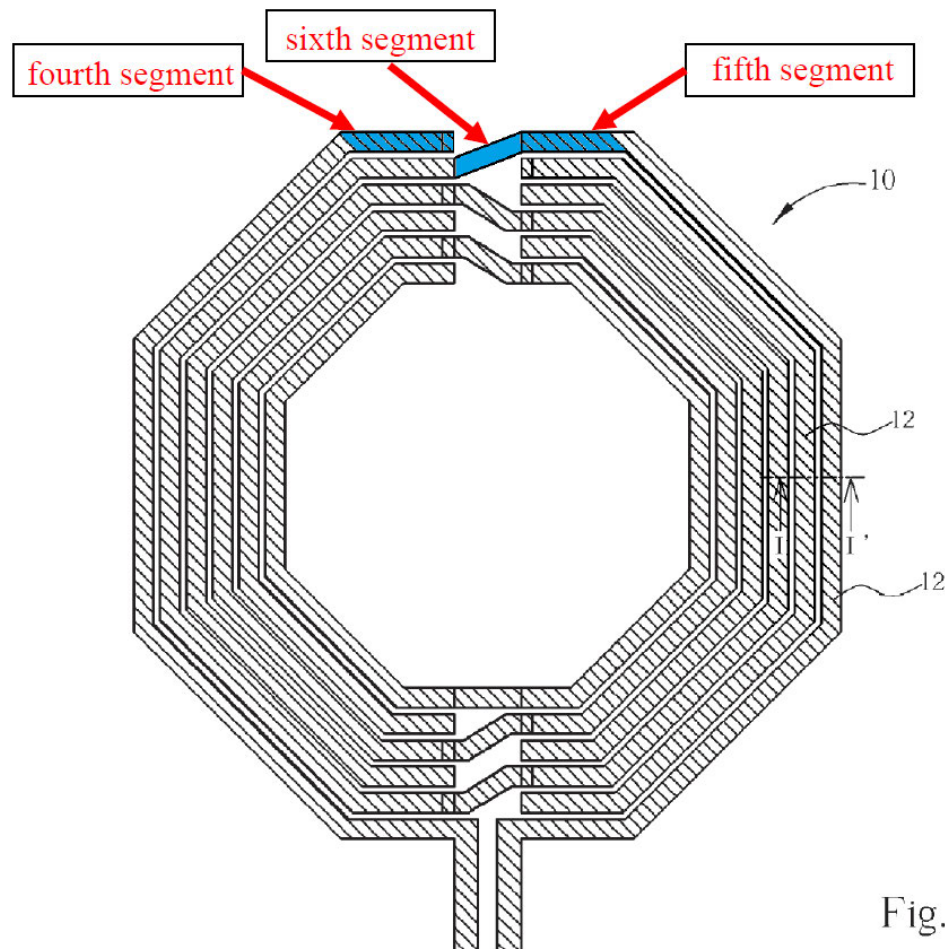
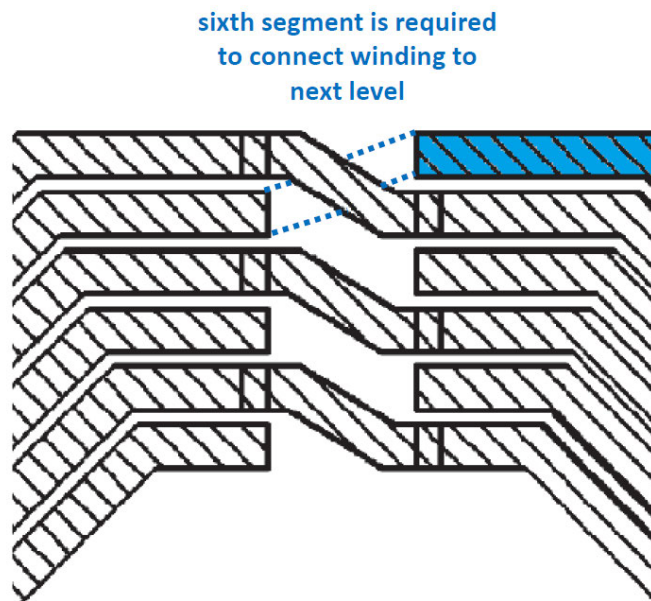


Fig. 1

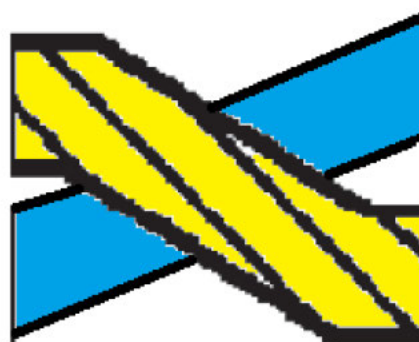
EX-1007, [Fig. 1] (emphasis added).

61. Without the blue 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. And as shown below, implementing a crossover in

this manner would maintain near perfect symmetry and as a basic manner of design structure, it would be the simplest and most logical way to maintain electrical conductivity.



EX-1007, [Fig. 1] (partial figure with emphasis added showing the second layer of Yang). A POSITA would have understood this to be the standard way a crossover is formed.



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

62. Such crossovers are standard in the art. The crossing segments form near perfect X-figures, as shown below.

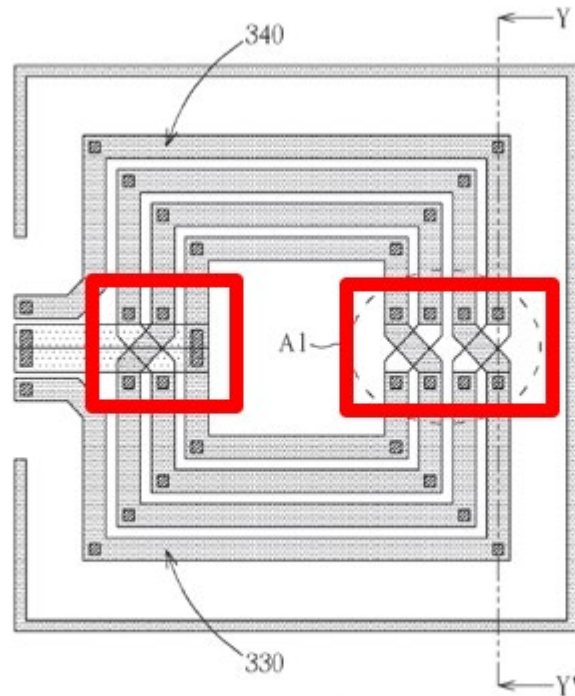
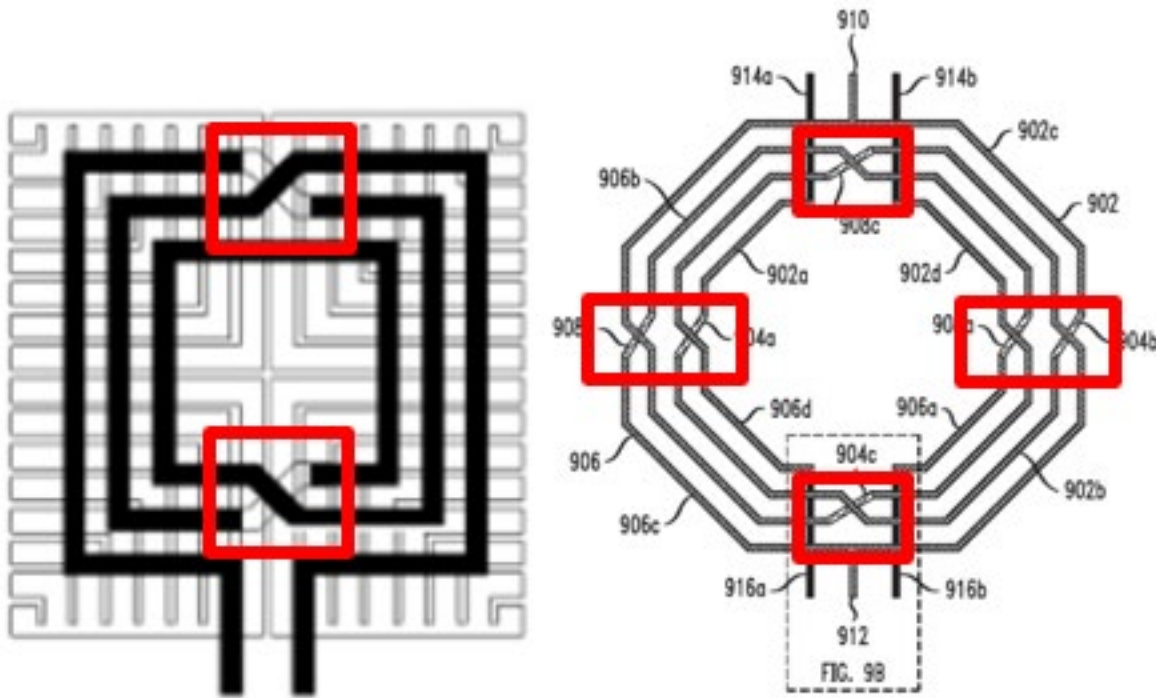


FIG. 2

EX-1001, [Fig. 2] (emphasis added in red); *see also*, EX-1037, 171:14-22

(agreeing the X's are symmetric).



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

63. Dr. Phinney agrees that the Yang inductor is largely symmetrical. A POSITA would have understood that using a symmetric crossover forming a near-perfect X would be the most logical way to maintain electrical conductivity in an otherwise completely symmetric octagonal inductor structure. *See, e.g.*, EX-1037, 196:17-198:24 (“A: Yeah. You’d like the two halves of the inductor to be as electrically identical as possible, hence you’d make them as symmetric as you could...”).

XI. JURAT

64. 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 1st day of May, 2024 in Princeton, New Jersey.

A handwritten signature in black ink, appearing to read "Paul Prucnal", written in a cursive style.

Dr. Paul R. Prucnal