

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

PATENT OWNER'S RESPONSE

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Exhibit No.	Description
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	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.

Patent Owner, Realtek Semiconductor Corporation, (“Realtek”), respectfully submits this Patent Owner Response (“POR”) pursuant to 37 C.F.R. § 42.120 to the *Inter Partes Review* (“IPR”) petition (“Petition”) filed by Petitioner Advanced Micro Devices, Inc. (“AMD” or “Petitioner”) for claims 1–5, 8, and 9 (“Challenged Claims”) of U.S. Patent 7,936,245 (“the ’245 Patent”, Ex. 1001).

I. Introduction

The Challenged Claims are patentable over Petitioner’s invalidity challenges as the Petition fails to demonstrate by a preponderance of the evidence that the challenged claims are obvious over the cited art.

The Petition includes the following three grounds with respect to the Challenged Claims of the ’245 Patent:

- Ground 1: Claims 1, 2, 5, 8 and 9 are obvious based on U.S. Patent No. 7,821,372 (“*Ho-Hsiang*”) (Ex. 1005);
- Ground 2: Claims 1, 2, 8 and 9 are obvious based on US Patent No. 6,794,977 (“*Christensen*”) (Ex. 1006); and
- Ground 3: Claims 1–4, 8 and 9 are obvious based on U.S. Patent App. Pub. No. 2009/0002114 (“*Yang*”) (Ex. 1007).

Petitioner’s arguments that the Challenged Claims are obvious over *Ho-Hsiang*, *Christensen*, and *Yang* respectively, fail for several reasons. Namely, *Yang*

is missing several material limitations directed to the crossover region of the Challenged Claims, and *Ho-Hsiang* and *Christensen* are directed to precise improvements in the design and structures of balun and planar transformers, respectively, and do not at all relate to improvements to or optimization of the stacked structure of a spiral inductor, which is the invention disclosed and claimed in the '245 Patent.

Petitioner provides no motivations or reasons why a POSITA would look to references disclosing strategies to improve the function of planar or balun transformers and modify those transformers in an attempt to design a stacked structure of a spiral inductor to achieve high Q and low resistance, the stated objective of the claimed invention of the '245 Patent. *See Immunex Corporation v. Sandoz Inc.*, 964 F.3d 1049, 1066–67 (Fed. Cir. 2020) (holding the district court did not error in considering the therapeutic benefits of the biologic when finding there was no motivation to combine references even though the therapeutic benefits were not claimed, but were a stated objective of the claimed invention).

In all three grounds, Petitioner impermissibly relies on hindsight, identifies individual figures in isolation, and proposes modifications that are unsupported by the references themselves or the background art. *See In re Wesslau*, 353 F.2d 238, 241 (C.C.P.A. 1965); *accord Eli Lilly & Co. v. Actavis Elizabeth LLC*, 435 F. App'x

917, 920–21 (Fed. Cir. 2011); *see also Polaris Industries, Inc. v. Arctic Cat, Inc.*, 882 F.3d 1056, 1068 (Fed. Cir. 2018) (“[T]he prejudice of hindsight bias often overlooks that the genius of invention is often a combination of known elements which in hindsight seems preordained.”) (citations and quotations omitted). The Challenged Claims are not obvious in view of any of the asserted prior art references, and Patent Owner respectfully requests that the Board find that the Petition fails to demonstrate the Challenged Claims are unpatentable.

II. Background and Overview of the Technology

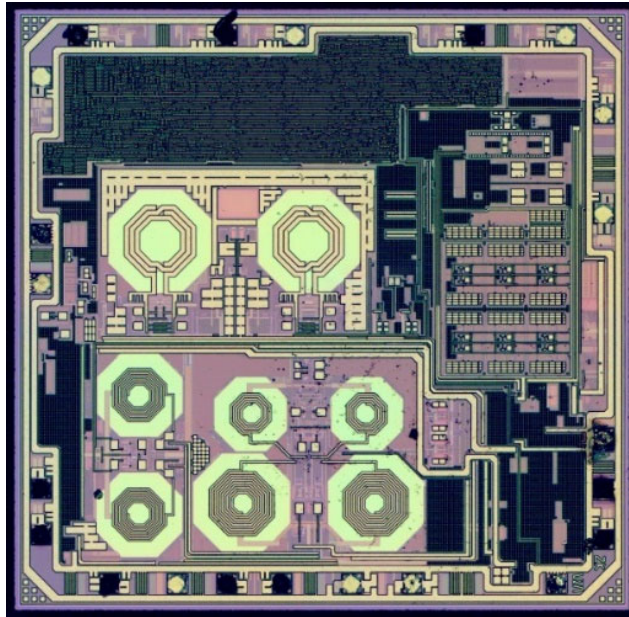
A. Prior Art Inductors and the Problems Addressed by the '245 Patent

An inductor is a passive two-terminal electrical component that stores energy in the form of a magnetic field and typically consists of an insulated wire or metal trace wound into a coil. Ex. 2003, ¶ 38. Inductors serve to oppose changes in current flow. *Id.* When an electric current is applied from a power source, an inductor stores energy in its magnetic field. *Id.* When the current flow changes, the magnetic field induces a voltage that opposes the current change. *Id.* Inductance or L , quantifies how strongly an inductor opposes changes in current and is defined as the ratio between flux linkage and current $L = \frac{\lambda}{i}$ where flux linkage λ increases when the inductor's magnetic field passes through (or “links”) additional turns in the inductor's winding. *Id.* An inductor with more turns, for example, will have a higher

flux linkage for the same current, and can better impede the flow of current since it has higher inductance. *Id.*

Integrated inductors are important components in radio frequency integrated circuits (RFICs). *Id.*, ¶ 39. RF inductors handle radio frequency signals (20 kHz – 300 GHz), which are much higher in frequency than typical alternating or direct (AC or DC) current used by electric utilities. *Id.* Along with capacitors and resistors, RF inductors are essential components of resonant (and tunable) circuitry in radio communication devices. *Id.* Inductors are also critical for isolating DC power supplies from RF signals. *Id.*

As devices such as smart phones become more advanced, space on the chips is increasingly more valuable. *Id.*, ¶ 40. Although necessary, inductors can be quite large and take up a lot of valuable real estate on the chip. *Id.* The exemplary die photograph below is illustrative of the amount of valuable space taken up by the inductors, shown as octagonal spiral windings. *Id.* At the time of the '245 Patent invention, large inductors were thought to be unavoidable because of a fundamental tradeoff between surface area and performance, where performance is measured by the “quality factor” or Q. *Id.*



Ex. 2006.

Q is an important figure of merit for an inductor. Ex. 1009, 16; Ex. 1011, 2. For an inductor, only the energy stored in the magnetic field is of interest, and Q is defined as the ratio of maximum energy stored in the inductor to the energy dissipated per cycle:

$$Q = 2\pi \times \frac{\text{energy stored}}{\text{energy dissipated per cycle}}$$

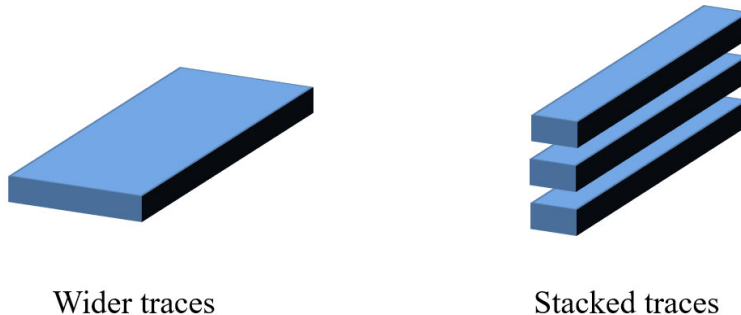
Ex. 2003, ¶ 41. Q describes how well an inductor performs as an energy-storage element. *Id.*, ¶ 42. Ideally, an inductor should work as a pure energy-storage element (Q approaches infinity), while in reality parasitic resistance (dissipation) and capacitance of the inductor reduces Q. *Id.*; Ex. 1009, 16–17; Ex. 1011, 5. This is because the parasitic resistance dissipates stored energy and parasitic capacitance

reduces inductance. Ex. 1009, 16–18; Ex. 2003, ¶ 42. From a design perspective, Q is directly related to the series resistance (R_s) of the equivalent circuit of an inductor. Ex. 2003, ¶ 42. Metal resistivity gives rise to series resistance (R_s), and it is always desirable to reduce the resistance in order to improve Q . *Id.*; *see also* Ex. 1009, 16; Ex. 1017, 41:21–22.

Among the strategies to improve Q of an inductor, decreasing the resistance of the metal traces is one option. Ex. 2003, ¶ 43. In an off-chip setting, it may be possible to use wiring made of less-resistive metal for an immediate resistance reduction. *Id.* However, material re-selection is generally not possible on-chip, since the metals used in the layer stack of a given chip manufacturing process are typically pre-determined by the foundry and cannot be changed by the designer. *Id.* Further, the vertical thicknesses of the metals are also pre-determined by the foundry, so the designer only has control of the width and length of the wires. *Id.* Thus, the designer is left with two options to reduce the resistance of a wire: make the wire wider, make the wire shorter, or both. *Id.*

Widening a wire or trace is akin to adding lanes of traffic to a road, which increases the number of vehicles that can travel on the roadway simultaneously at a given speed: the additional width of wire introduces more room for charge carriers to flow, thus reducing resistance. *Id.*, ¶ 44. In addition, while the actual thickness of

each individual metal layer cannot be changed, traces in multiple layers can be stacked and connected together vertically through vias in order to create an effectively thicker, and thus less resistive, trace. *Id.* In keeping with the roadway traffic analogy, this would be like building a multi-layer bridge, thus allowing for more lanes of traffic, as illustrated below. *Id.*

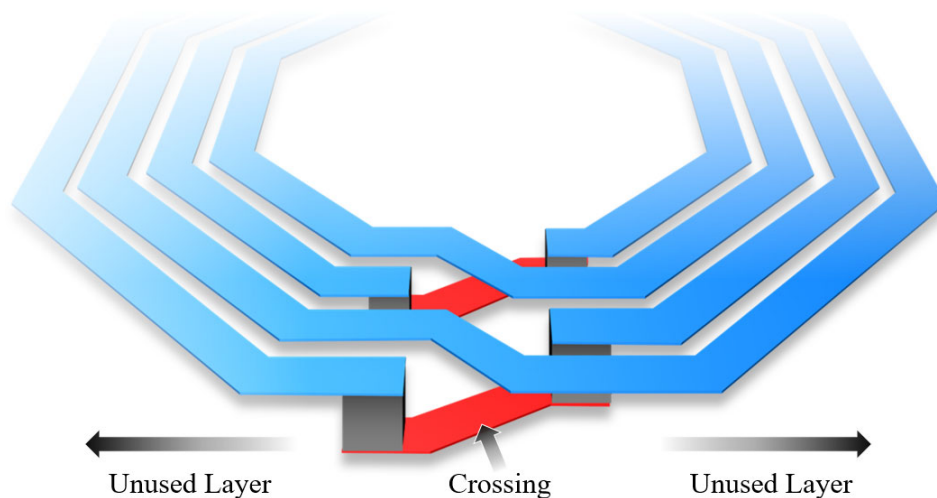


Reducing the length of wire used can be difficult, because achieving a target value of inductance will require some minimum length of wire in order to capture sufficient magnetic flux, but the result is that inductors should, as a general principle, be wound in such a way that each turn of the inductor circumscribes as much area as possible. *Id.*, ¶ 45. Shapes with poor area-to-perimeter ratios should, in general, be avoided. *Id.*; *see also* Ex. 1010, 66.

As the background of the '245 Patent acknowledges, stacking metal traces as a way to improve Q was known in the prior art. Ex. 1001, 1:31–36. However, a recognized drawback of the stacking method was that stacking could not be implemented in places where the inductor needed to cross over itself. *Id.* 1:36–41;

Ex. 2003, ¶ 46. In effect, prior art inductors could not achieve their full potential because of the way that they handled the crossings with separate metal layers. *Id.*

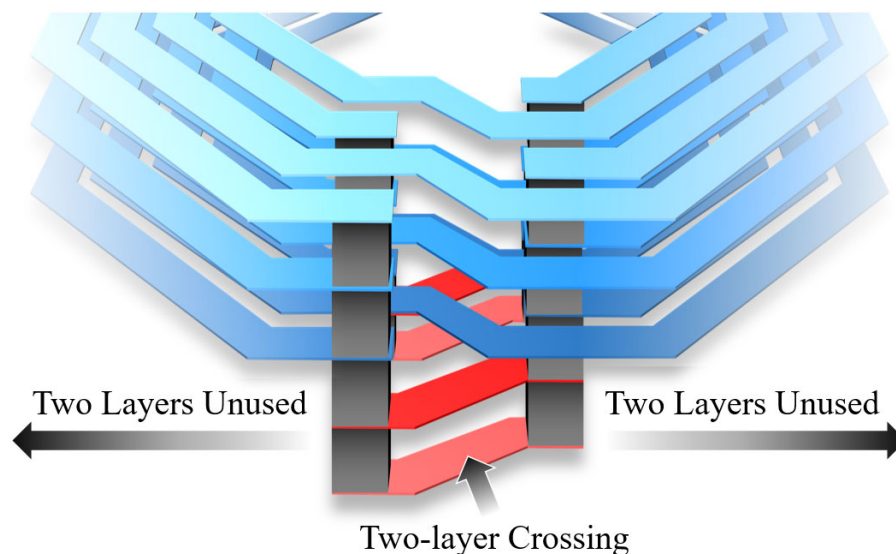
Inductors in the prior art handled crossings using structures such as a single-layer underpass or bridge, which would utilize a separate metal layer to cross under the layer used for the winding, as shown in the image below in red. Ex. 2003, ¶¶ 47, 63; *see also* Ex. 1001, 1:22–28; Ex. 1013, 1:55–58, Fig. 2.



One problem with the underpasses or bridges taught in the prior art is that the inductor does not fully utilize the available layers, particularly the layer utilized solely for the underpass, i.e. the lower (red) layer in the illustration above. *Id.*, ¶ 48. Utilizing an underpass on a separate metal layer results in unused space that otherwise could be used for another metal layer for the blue traces shown in the above figure. *Id.* As previously explained, space on chips is very valuable, and because the layers of metal are being created anyway it is extremely wasteful to have

layers that do not contribute to optimizing Q. *Id.* An analogy would be: a parking garage was built, but because of the design, cars are unable to park on one entire level because it is solely used to connect levels of the parking garage. *Id.*

Stacked inductors of the prior art also included multiple layered crossings that also utilized separate metal layers for the crossings. *Id.*, ¶ 49; *see e.g.*, Ex. 1018, Figs. 2, 5; ¶¶ [0006], [0022]. Shown below is an example of a stacked spiral inductor of the prior art with two-layer crossings (underpasses) that are separate from the winding layers. Ex. 2003, ¶ 49. In this design, two separate metal layers are underutilized, i.e., two levels of the parking garage are unavailable for parking cars. *Id.*

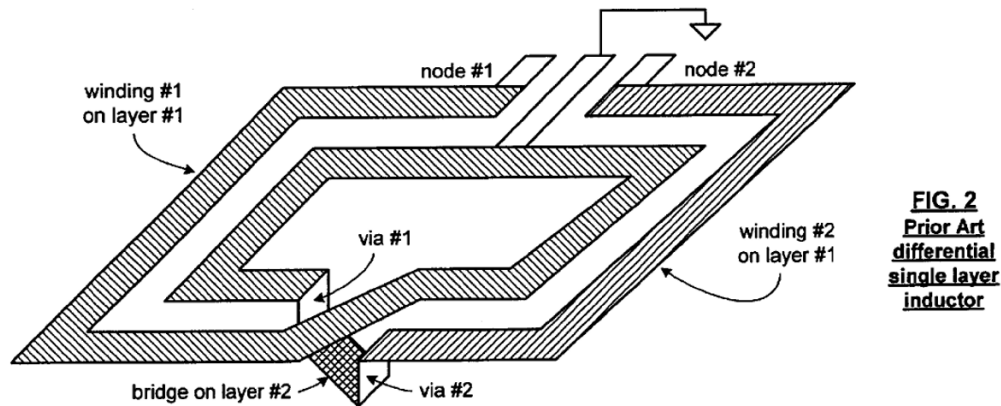


Importantly, among the references relied upon in the Petition's Background of the Technology section that disclose inductors, the inductors are all single or

multi-layered with bridges or underpasses on metal layers that are separate from the layers of the windings (as illustrated above). *Id.*, ¶ 50. This is the same well-known, but problematic inductor design described as prior art in the background section of the '245 Patent. Ex. 1001, 1:31–421; *see e.g.*, Petition, 20 (citing Ex. 1009, Figs. 2–10, 2–11), 15 (citing Ex. 1011; *see id.*, 3 (“An underpass contact at a lower metal level and a via connection are used to bring the inner end of the coil to the outside.”)), 15–15 (citing Ex. 1013, Fig. 2), 17–18 (citing Ex. 1017, Fig. 28d; *see also id.*, 39:5–6 (“A pass through track 2854 is disposed in a layer to provide access to the end of an inner turn.”)), 18 (citing Ex. 1018; *see id.*, ¶ [0021] (“The bridge portions allow the inductor winding to cross-over itself.”)).

Importantly, Petitioner’s expert agrees that it was well-known that inductors of the prior art used bridges or underpasses on a separate metal layer than the windings (connected to the windings above or below by vias) as crossovers to “close a circuit.” Ex. 2005, 30:12–31:11, 58:3–8. For example, Dr. Prucnal testified that U.S. Patent No. 6,759,937 to Kyriazidou (Ex. 1013), filed in 2002, discloses a single-layer inductor (shown below) that uses a bridge or underpass on a separate layer from the main winding in order to accomplish a crossover. Ex. 2005, 27:23–28:18; *see* Ex. 1013, 1:55–58 (“FIG. 2 illustrates a single layered differential inductor having 1st and 2nd windings (Windings #1 and #2) on one layer (Layer #1). Winding

#1 is coupled to Winding #2 via a bridge on Layer #2 and interconnecting vias #1 and #2.”); *see also* Ex. 2003, ¶ 50.



Ex. 1013, Fig. 2.

In addition, Dr. Prucnal also testified that U.S. Patent Pub. No. 2008/0074229 A1 to Moinian et al. (Ex. 1018), filed in 2006 and cited as prior art in the '245 Patent¹, discloses a stacked inductor 100 with primary winding portions 110P (shown below), located on three metal layers (M5–M7) and bridge portions 110B, located below on two separate metal layers (M3–M4). Ex. 1018, ¶¶ [0021]–[0022]; Figs. 2, 5; Ex. 2003, ¶ 51; *see* Ex. 2005, 34:13–44:9; *see id.* 43:22–44:2 (“Q. And then below those three windings, you’ve got two layers of a bridge that closes the circuit of this inductor; is that correct? A. There are two layers of a bridge, and presumably, the purpose of that bridge is to complete that circuit.”).

¹ Ex. 1001, 1:31–34; Ex. 2005, 55:12–56:4.

FIG. 2

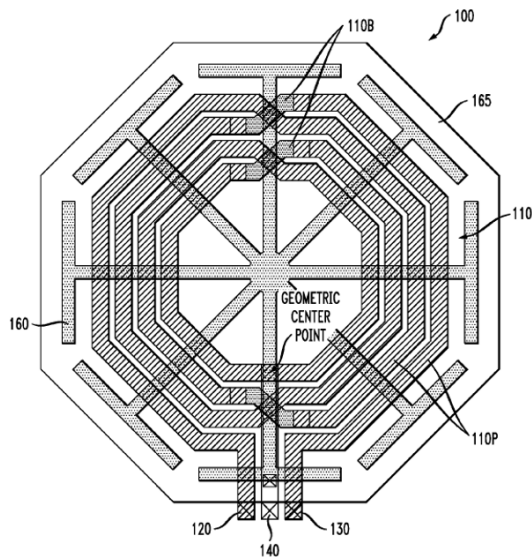
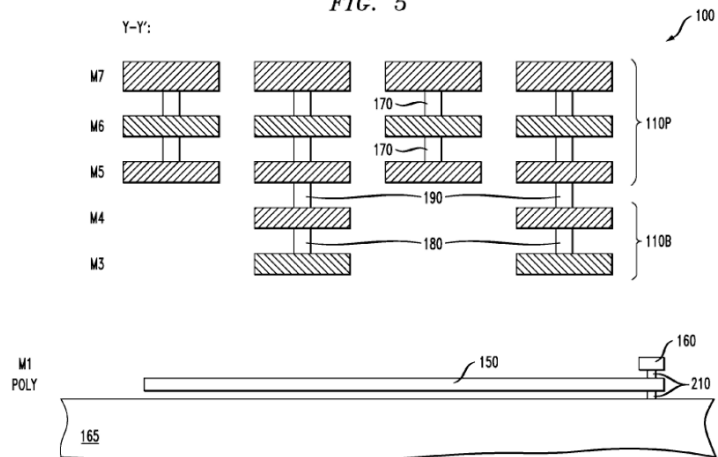


FIG. 5



Ex. 1018, Figs. 2, 5.

As explained above, all of the prior art inductor structures relied on by Petitioner as background art employ the use of an underpass or bridge on a separate metal layer than the windings to construct a crossover region, which is precisely the problematic design sought to be improved by the inventors of the ‘245 Patent to optimize Q of the inductors. Ex. 2003, ¶¶ 47, 49–52; *see also* Petition, 16–20. Importantly, Petitioner’s expert acknowledges that these crossings of the prior art inductors did not utilize the metal layers of the windings, which is the improved design set forth in the Challenged Claims of the ‘245 Patent. Ex. 2005, 56:5–59:19. Petitioner’s expert further agrees that unlike the prior art inductor structures the stacked spiral inductor of the Challenged Claims lowers resistance and improves Q by utilizing metal layers of the windings as crossovers, a design feature not present

in the prior art, which allows the two parallel traces to form shunt windings on both sides of the crossover region. *Id.* at 62:4–23.

B. The '245 Patent Invention

The invention of the '245 Patent changed the legacy tradeoff between area and performance by using crossing layers to create parallel paths for current. Ex. 2003, ¶ 53. These parallel paths—called “shunt windings” in the Challenged Claims of the '245 Patent—improve Q because they decrease the resistance of the inductor winding. *Id.* The inductor structure of the Challenged Claims of the '245 Patent allowed for (1) smaller inductors that have the same performance (measured as Q) as larger inductors; or (2) the same size inductors with enhanced performance (increased Q). *Id.*

Regarding prior art inductors, the '245 Patent explains that whether an inductor has a single metal layer structure or a structure with multiple metal layers in parallel, Q cannot be optimized because the metal layers of crossover regions are separate from the metal layers of the windings. Ex. 1001, 1:36–41. In contrast, the inductor structure of the Challenged Claims of the '245 Patent optimizes Q by using the metal layers of the crossover region to construct shunt windings. Ex. 1001, 1:7–10; 6:1–5; Ex. 2003, ¶¶ 54–57. As a result, parasitic resistors of the inductors are not restricted by conductivity of the crossover region, the number of the vias, and the

resistance of the vias. Ex. 1001, 6:5–7; *see* Ex. 2003, ¶ 54.

The '245 Patent innovatively changed the tradeoff between area and performance by making use of the metal layers of the crossover region as shunt windings, rather than utilizing a separate layer to form an underpass or bridge. Ex. 2003, ¶ 55. The structure of the stacked inductor claimed in the '245 Patent allowed for smaller inductors, which could achieve better performance/higher Q. *Id.*

Specifically, **Claim 1** recites:

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*.

Ex. 1001, claim 1 (emphasis added). The result of the structure of a spiral inductor of Claim 1 of the '245 Patent is that a “spiral inductor with multiple stacked metal layers can obtain an optimum quality factor by making use of metal layers of a crossover region as shunt windings.” *Id.*, 9:22–24.

In addition to independent claim 1, Petitioner challenges the following dependent claims of the '245 Patent (Claim 1 together with Claims 2-5, 8 and 9, the “Challenged Claims”):

2. The structure of the spiral inductor of claim 1, wherein the third segment is positioned between the first segment and the second segment; and the sixth segment is positioned between the fourth segment and the fifth segment.
3. 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.
4. The structure of the spiral inductor of claim 3, 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.

5. 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.
8. The structure of the spiral inductor of claim 1, wherein the spiral inductor is a symmetric spiral inductor.
9. 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.

Id., claims 2–5, 8–9.

As discussed below, none of the cited prior art or background references teach, disclose, or suggests the combination of features recited in the Challenged Claims of the '245 Patent.

C. Fundamental Differences Between Inductors and Transformers

An inductor is an impedance device with two terminals that is part of a single circuit. Ex. 2003, ¶ 58. An inductor impedes changes in current, since a change in current will produce a voltage response that opposes the change in current. *Id.* In an IC context, inductor designers generally seek to optimize Q within a given footprint. *Id.*; Ex. 1010, 66.

Transformers, on the other hand, are electrical devices used to transfer energy between two or more circuits. Ex. 2003, ¶ 59. A basic transformer consists of two magnetically coupled windings that share magnetic flux. *Id.* AC in one winding (called the “primary”) creates a changing magnetic field that induces a current in the other winding (the “secondary”). *Id.* A core made of iron or ferrite can connect the two coils, but higher frequency devices in IC’s work without a magnetic core. Transformers have two main roles: transformation and isolation. *Id.* As an example of transformation, the voltage of the secondary can be higher or lower than the voltage that drives the primary and is determined by the ratio of turns in the primary and secondary coils. *Id.* Isolation means there is no direct current between the primary and secondary windings, which are said to be “galvanically isolated” when they do not touch. *Id.* Isolation allows a shift in DC voltage level between the primary and secondary circuits. *Id.*

Key design goals for transformers include symmetry and coupling. *Id.*, ¶ 60. Symmetry is especially important when a transformer is intended to operate in a balanced manner, where voltage and/or current on one terminal is equal and opposite with respect to another terminal. *Id.* In such applications, symmetric layout preserves the match between electrical characteristics viewed from different terminals. *Id.*

The magnetic coupling between two coils of a transformer—quantified by the

coupling coefficient k —also is an important parameter to evaluate the performance of the transformer. *Id.*, ¶ 61; Ex. 1010, 100. Greater overlap area and tighter packing of the primary and secondary coils of a transformer result in a larger coupling coefficient. Ex. 2003, ¶ 61. A simple formula for coupling coefficient k is given as follows:

$$k = \frac{M}{\sqrt{L_p L_s}}$$

where, M is the mutual inductance between the primary and secondary coils, and L_p and L_s are the self-inductances of the primary and secondary windings. *Id.*

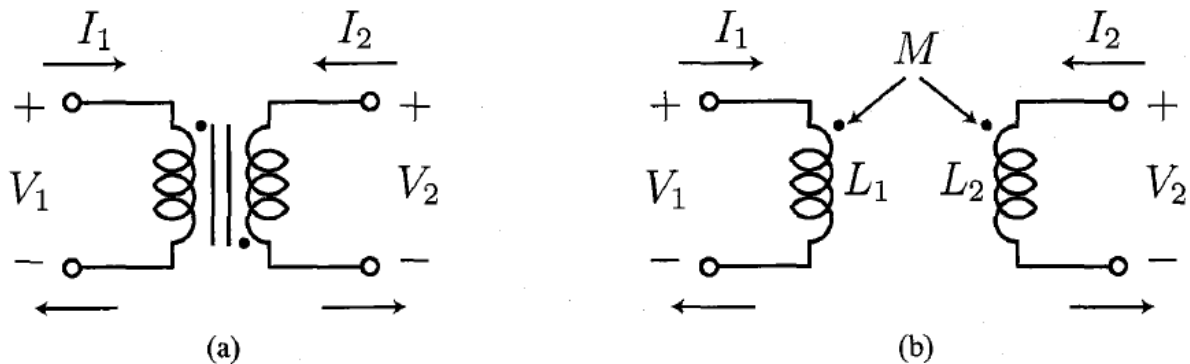


Figure 10.1 (a) Schematic symbol for an ideal transformer. (b) Two coupled inductors form a non-ideal transformer.

Ex. 1010, 98.

Based on figures like the one shown above, Dr. Prucnal opines that a transformer is merely two inductors coupled together. Ex. 1003, ¶¶ 55–57. However, there are some critical distinctions. *See* Ex. 2003, ¶ 62. Transformers are subject to

design considerations distinct from and irrelevant to inductors. *Id.* Certain structural modifications must be made to individual windings of a transformer in order to allow them to couple and function together as a transformer that undermine the windings functionality as inductors. *Id.*

The structural modifications necessary to the windings of a transformer serve the primary goal of allowing the windings to intertwine, such that the coupling coefficient k between the windings is maximized. *Id.*, ¶ 65. Additionally, underpass structures have to be introduced to allow the primary and secondary windings to cross over each other, and increased spacing must be introduced between the turns of each winding such that the other winding can thread through the evacuated routing lane. *Id.* These types of structural modifications of the windings necessary to construct transformers are taught and disclosed by *Christensen* and *Ho-Hsiang*. *Id.*, ¶¶ 63, 65. These same structural modifications to the windings result in compromised flux linkage in each *individual* winding, thus reducing the inductance each *individual* winding realizes relative to the costs of its parasitic resistance and capacitance, which in turn results in inferior Q of each *individual* winding. *Id.*, ¶¶ 64–65. In sum, the Q of the *individual* windings is sacrificed in order to achieve acceptable coupling (k) for the transformer structure, which places the goals of inductor and transformer design in opposition. *Id.*, ¶ 65.

Further, 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 windings in a transformer. *Id.*, ¶ 66. The modifications required to maximize coupling substantially *degrade* the performance of each *individual* winding, and as such a POSITA would not be inclined to consider the teachings of a transformer structure when seeking to improve the design of an *individual* (rather than coupled) inductor with optimized Q. *Id.*

Given the distinct functional objectives and structural designs of transformers as compared to inductors, a POSITA, even at the time of the invention of the '245 Patent, would not have been motivated to consider, or modify, the transformer arts in an effort to improve the structural design and function of an inductor. *Id.*, ¶ 66. In fact, utilizing the transformer arts would have been counterproductive to designing a spiral inductor to reduce the layout area, lower resistance and optimize Q—the stated objective of the '245 Patent—because the structural modifications necessary to couple windings as taught and required by the transformer arts necessarily increases the footprint and series resistance and negatively impacts the Q of each individual winding. Ex. 1001, 1:21–41.

III. Person Having Ordinary Skill in the Art

A person of ordinary skill in the art of this technology at the time of the invention 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. Ex. 2003, ¶ 35. Someone with additional education but less professional experience may qualify as a POSITA, such as 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. *Id.*, ¶¶ 35–37.

IV. Claim Construction

In an order dated July 25, 2023, in an ITC investigation involving the same parties and the same patent, Administrative Law Judge Cameron Elliot construed “[a] structure of a spiral inductor” in the preamble of claim 1 of the '245 Patent as limiting. *See In the Matter of Certain Integrated Circuits, Components thereof, and Products Containing the Same*, Inv. No. 337-TA-1350, Order No. 21, 16 (July 25, 2023) (Ex. 2001, 18). As the Order correctly held, because (a) the “spiral inductor” of the preamble provides an antecedent basis for the Challenged Claims, and (b) the “spiral inductor” is critical to the claimed inventions, the preamble is a material limitation of the Challenged Claims. *Id.*, 17; *see also* Ex. 2003, ¶¶ 30–32, 34. Based

on the record thus far, the Board agrees “that the term ‘spiral inductor’ recited in the preamble is limiting.” Decision (Paper No. 9), 11; Ex. 2003, ¶ 33.

V. Non-Obviousness of the Patent’s Stated Purpose

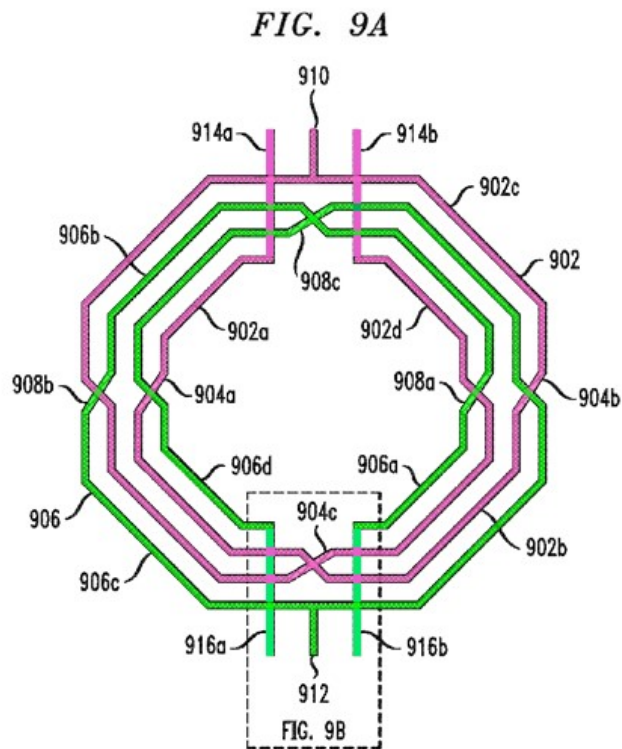
“In appropriate circumstances, a single prior art reference can render a claim obvious. However, there must be a showing of a suggestion or motivation to modify the teachings of that reference to the claimed invention in order to support the obviousness conclusion.” *SIBIA Neurosciences, Inc. v. Cadus Pharmaceutical Corp.*, 225 F.3d 1349, 1356 (Fed. Cir. 2000) (citations omitted). However, “the prior art as a whole must be considered [and t]he teachings are to be viewed as they would have been viewed by one of ordinary skill.” *In re Hedges*, 783 F.2d 1038, 1041 (C.C.P.A. 1986). Furthermore, “[i]t is impermissible within the framework of section 103 to pick and choose from any one reference only so much of it as will support a given position, to the exclusion of other parts necessary to the full appreciation of what such reference fairly suggests to one of ordinary skill in the art.” *Id.* (quotations and citations omitted). Importantly, the same inquiry must be carried out in the context of a purported obvious motivation to combine references or motivation to modify a reference. *In re Fritch*, 972 F.2d 1260, 1266 (Fed. Cir. 1992).

VI. The Petition Fails to Establish by a Preponderance of the Evidence that the Challenged Claims Would Have Been Obvious

A. Ground 1: *Ho-Hsiang*

Ho-Hsiang teaches and discloses improved symmetrical on-chip planar balun transformer designs. Ex. 1005, 3:13–14; Ex. 2003, ¶ 71. The *Ho-Hsiang* planar transformer windings are designed to intermingle on the same metal layers. Ex. 1005, 6:10–14; Ex. 2003, ¶¶ 68–69. Specifically, the transformers serve to perform two functions, impedance transformation and balanced-to-unbalanced transformation, neither of which would be relevant to the stated objectives of the inventors of the '245 Patent—design of a multi-layer (not planar) spiral inductor (not a transformer) with a reduced footprint (not planar/interwoven) and optimized Q (not coupled). Ex. 2003, ¶ 67. Unlike the spiral inductor of the '245 Patent, the transformer structure taught and disclosed in *Ho-Hsiang* is not designed to store energy nor is it designed to reduce the footprint of its windings or optimize Q of its windings.

Planar transformers like those disclosed in *Ho-Hsiang* comprise two coils or windings that are closely intermingled, as shown below. Ex. 2003, ¶ 69.



Ex. 1005, Fig. 9A (annotated to highlight the primary winding 902 in pink and the secondary winding 906 in green). *Ho-Hsiang* teaches and discloses various configurations of intermingled windings having different turn ratios, including windings having a non-integer numbers of turns. *Id.*, 5:7–9; Figs. 2–9. In addition, the intermingled windings are designed such that the ports of the primary winding 914a, 914b are connected to the innermost portion of the winding and are disposed externally, the ports 916a, 916b of the secondary winding 906 are connected to the innermost or outermost portion of the winding, and that center taps (if present; 910, 912) are located on the outermost portion of each winding. *Id.*, Figs. 2–9; cls. 1, 4–6, 15, 17–18. *Ho-Hsiang* also teaches that the various design configurations results

in improvements in reliability of the transformers and allows for greater flexibility with respect to where the transformers may be located on a chip in relation to other circuits. *Id.*, 4:11–14, 4:53–54, 6:56–64.

1. *Ho-Hsiang* Teaches Away from the Claimed Inductor Structure of the '245 Patent

“In appropriate circumstances, a single prior art reference can render a claim obvious. However, there must be a showing of a suggestion or motivation to modify the teachings of that reference to the claimed invention in order to support the obviousness conclusion.” *SIBIA Neurosciences*, 225 F.3d at 1356 (citations omitted). As explained above, *Ho-Hsiang* is directed to planar transformers (not stacked inductors). Transformers serve a very different purpose in ICs compared to inductors. Ex. 2003, ¶¶ 58–59. The motivations underlying certain construction and structural design choices of the *Ho-Hsiang* transformers (increase reliability and greater on-chip flexibility) differs from those motivations underlying construction and structural design choices of the spiral inductors of the Challenged Claims (reducing footprint and series resistance while optimizing Q). This is particularly evident for *planar* transformers such as those disclosed by *Ho-Hsiang*, which require coupling of windings through intermingling on the same metal layers, which necessarily increases the footprint of each winding and compromises the Q of each individual winding.

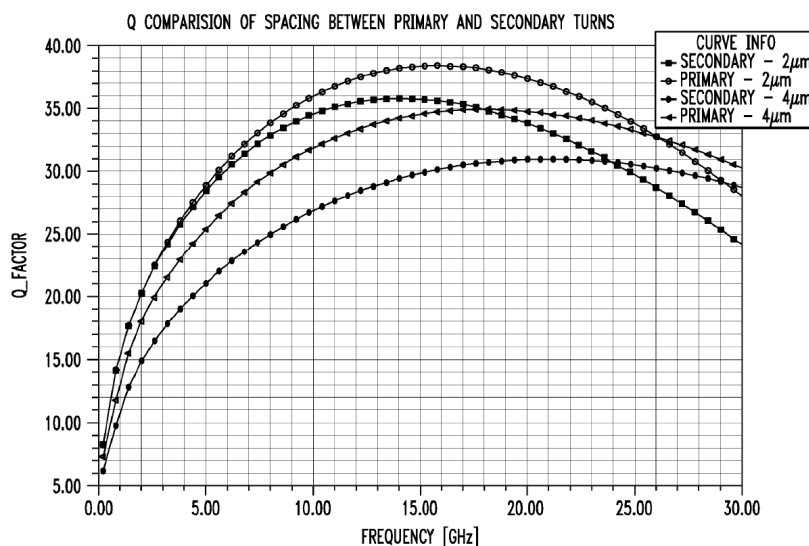
It might be obvious for a POSITA to look to the structures disclosed in *Ho-Hsiang* in order to improve the function and flexibility of **a planar transformer**, but not to improve the design of a stacked spiral inductor to reduce the footprint, lower resistance, and optimize Q. For example, *Ho-Hsiang* teaches:

In some embodiments, the transformers and BALUNS have ***improved reliability*** as the current density at the center of the devices which in turn reduces the likelihood of electromigration. In some embodiments, the transformers and BALUNS enable the ports of the primary and secondary windings to be located at various angles from one another providing ***improved flexibility*** with respect to where the transformers or BALUNS may be located on a chip in relation to other circuits. Additionally, the transformers and BALUNS may include windings with non-integer numbers of turns ***enabling the voltage to be stepped up or down at various increments*** using fewer windings and chip space.

Id., 6:56–67 (emphasis added); Ex. 2003, ¶¶ 72, 76–77.

Ho-Hsiang presents a workable solution to improve the Q of planar transformers by ***increasing the thickness of the metal layers*** (as shown in Fig. 10, reproduced below), and teaches that it is beneficial to ***use fewer metal layers*** because it reduces the number of processing steps. *See* Ex. 1005, Fig. 10 (reproduced below), 3:36–46, 6:53–55; Ex. 2003, ¶ 73.

FIG. 10

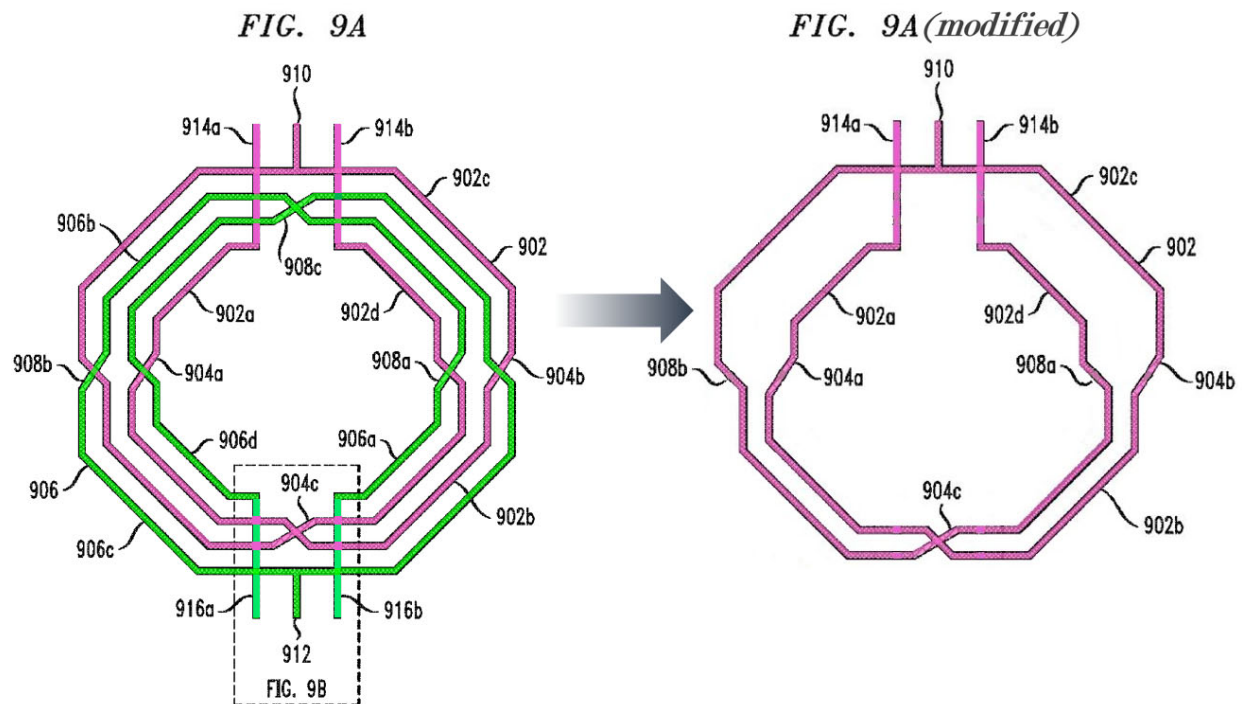


While these teachings are directed to improvements in planar transformer design, none of these teachings would motivate a POSITA to consider or rely on the various structures disclosed in *Ho-Hsiang* in the design of a stacked spiral inductor with a reduced footprint, lower resistance, and optimized Q, as disclosed and claimed in the '245 Patent. In fact, *Ho-Hsiang*'s teachings—thicker and fewer metal layers—are counterintuitive and teach away from the objective of the '245 Patent—to design a stacked inductor with a reduced footprint, lower resistance, and optimize Q. Ex. 2003, ¶ 74. “An inference of nonobviousness is especially strong where the prior art’s teachings undermine the very reason being proffered as to why a person of ordinary skill would have combined the known elements.” *DePuy Spine, Inc. v. Medtronic Sofamor Danek, Inc.*, 567 F.3d 1314, 1325 (Fed. Cir. 2009); *see also Immunex*, 964 F.3d at 1066–67.

The Petition fails to provide particular reasons why a POSITA would be motivated to modify or rely on the teachings of *Ho-Hsiang*, other than for the abstract reason that the disclosed planar transformers are comprised of two coils or windings. *See In re Dembiczak*, 175 F.3d 994, 999 (Fed. Cir. 1999) (explaining the evidence showing a suggestion, teaching, or motivation to combine [or modify] must be clear and particular; broad conclusory statements regarding the teaching of references, standing alone, are not evidence). Aside from the fact that the windings of the *Ho-Hsiang* planar transformers include a crossing region, Petitioner and its expert do not provide any clear or particular reasons why it would be obvious to a POSITA to utilize or modify the teachings of *Ho-Hsiang* to design the stacked structure of a spiral inductor of the Challenge Claims with a reduced footprint, lower resistance and optimized Q (the stated goal of the '245 Patent). The Federal Circuit has made “clear that the best defense against the subtle but powerful attraction of a hindsight-based obviousness analysis is rigorous application of the requirement for a showing of the teaching or motivation to combine [or modify] prior art references.” *Id.* Therefore, the reference must be considered for its teaching as a whole, and as a whole *Ho-Hsiang* teaches away from the Challenged Claims of the '245 Patent and its stated goals. *See Hedges*, 783 F.2d at 1041.

2. A POSITA Would Not be Motivated to Modify the Planar Transformer of *Ho-Hsiang* or Rely on an Isolated Winding

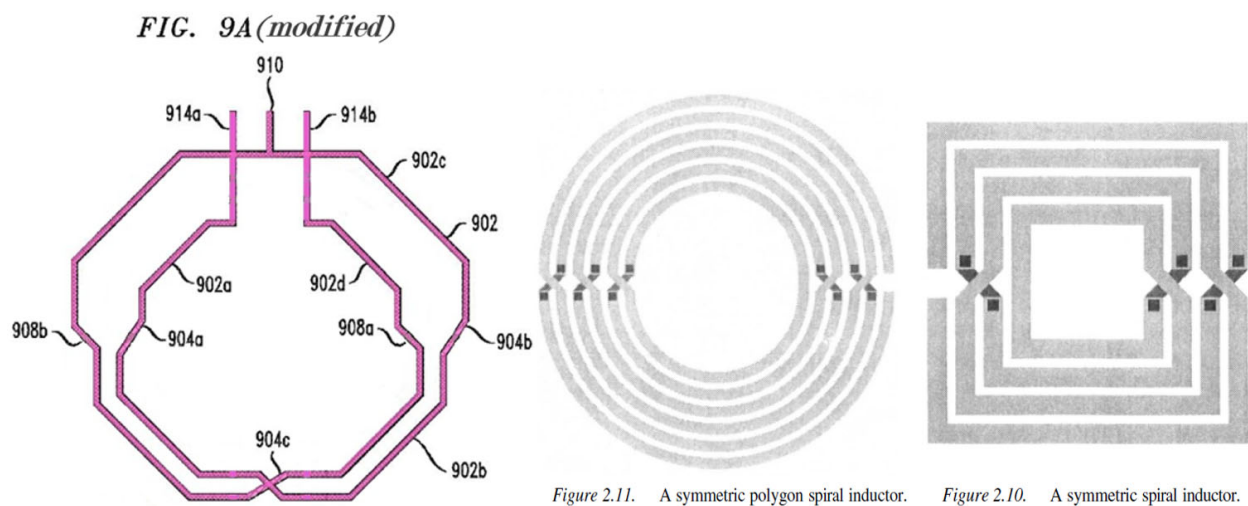
In an effort to show that *Ho-Hsiang* discloses or renders obvious each element of the Challenged Claims under § 103, Petitioner modifies one of *Ho-Hsiang*'s planar transformers (disclosed in Fig. 9A) by isolating the primary winding 902, as shown below. See Petition, 33, 31 n.5; Ex. 2003, ¶ 70.



Ex. 1005, Fig. 9A (modified and annotated). Petitioner does not explain why a POSITA would ignore the explicit teachings and goals of *Ho-Hsiang* and simply look at the structural features of its windings in isolation for the purposes of designing a stacked structure of a spiral inductor with a reduced footprint, lower resistance, and optimized Q as taught and disclosed in the '245 Patent. Petitioner

also fails to acknowledge the design characteristics of planar transformers that affect the structural features of the individual windings themselves—many of which undermine the stated goals of the '245 Patent, i.e., designing an inductor with reduced footprint, lower resistance, and optimized Q. Ex. 2003, ¶ 93.

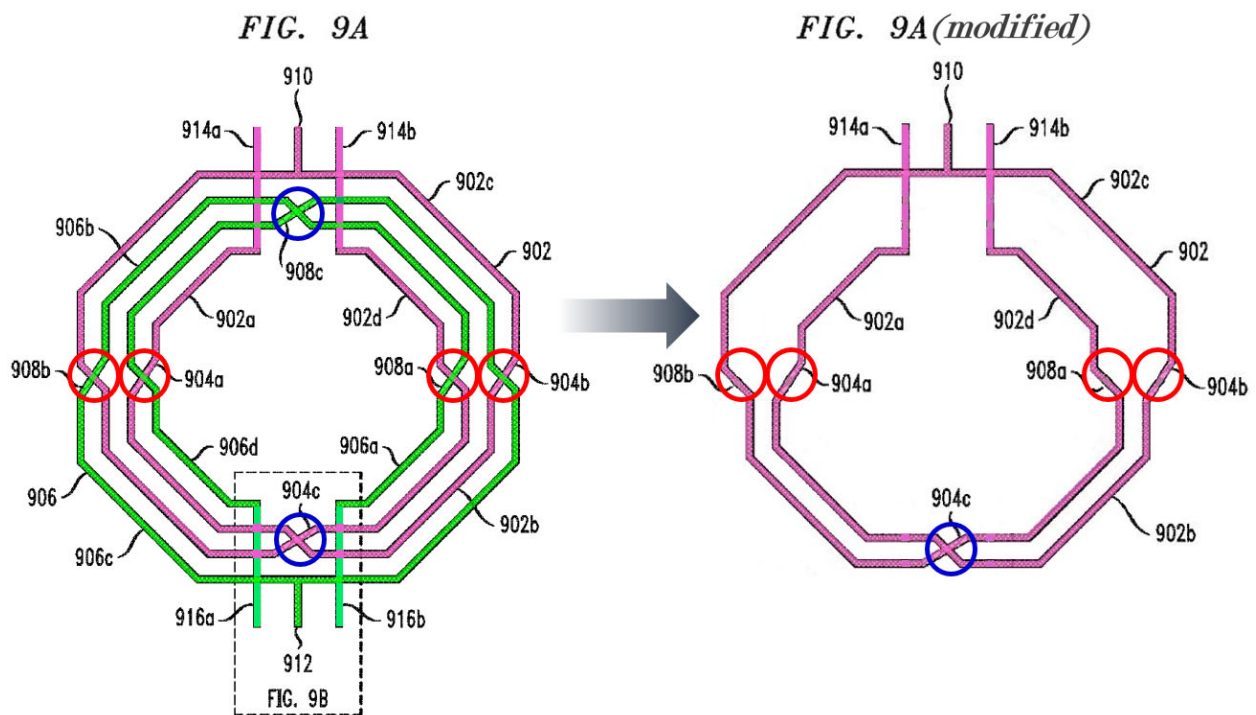
These undesirable structural features are readily apparent in the isolated windings as illustrated and annotated by Petitioner. First, the isolated primary winding 902 of *Ho-Hsiang*, as shown below, reveals a structure with a somewhat unusual, meandering geometry as compared to the geometry of inductors disclosed in the prior art, which are typically more compact and uniform. *See* Petition, 16, 19–20; *see also* Ex. 1003, 38.; Ex. 2003, ¶ 78.



Compare Ex. 1005 (Fig. 9A, modified and annotated) with Ex. 1009, 26–27 (Figs. 2.10–2.11). Specifically, the modified or isolated winding of *Ho-Hsiang* (shown above in pink on the left) has non-uniform spacing between the turns of the windings

and an overall larger footprint than a typical circular or even square prior art inductors (shown above in gray on the right). Ex. 2003, ¶ 78; *see also* Ex. 1003, 38 (citing Ex. 1016, Fig. 3.1). A POSITA, at the time of the invention of the '245 Patent, would understand that this is a result of the intermingling required by the two windings to increase coupling necessary to construct a reliable planar transformer. Ex. 2003, ¶¶ 78, 91; Ex. 2005, 66:25–67:20. When the windings are considered in isolation, there is no need to interweave another winding on the same metal layers and the structure becomes undesirable for use as an inductor in an IC where real estate on the chip is a premium. In addition to the increased surface area of the isolated winding, the increased distance between the turns of the windings at the top of image in the figure above (e.g., distance between winding segments 902c and 902d) will result in a loss of flux linkage from the outer winding. Ex. 2003, ¶¶ 79, 91. Thus, not only does the irregular geometry of the isolated winding not fully utilize the surface area, but it also negatively impacts the potential inductance. *Id.* A POSITA would expect that a modified or isolated winding from a planar transformer such as those disclosed in *Ho-Hsiang*, will possess an irregular geometry that negatively impacts the footprint and inductance, and therefore, would not achieve the goals of the '245 Patent to design an inductor with reduced surface area, lower resistance and optimized Q. *Id.*, ¶ 80.

In addition to the irregular geometry, planar transformers with intermingled windings will lose a number of the crossings if the windings are separated or viewed in isolation. As shown below, four crossings between the two windings, 908b, 904a, 908a, 904b (red circles) are lost in primary winding 902, leaving only one self-crossing 904c (blue circle). Ex. 2003, ¶ 82. Because the intermingled windings of the *Ho-Hsiang* planar transformer share the same two metal layers (920, 930), the windings will only occupy a single metal layer at the crossings (red circles).



Ex. 1005, Fig. 9A (modified and annotated). Specifically, *Ho-Hsiang* explains that primary winding 902 is located on both the first metal layer 920 and the second metal layer 930, but only comprises one metal layer (the second metal layer 930) at the bridges or crossings 904a, 904b, 908a, and 908b (red circles). *Id.*, 6:13–29.

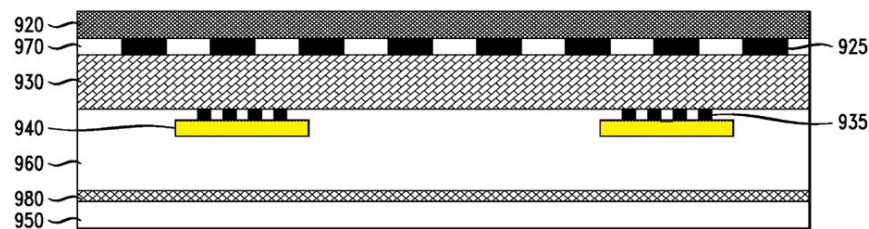
Therefore, the modified planar transformer or isolated winding would have gaps in the second metal layer 930, at certain locations, namely 904a, 904b, 908a, and 908b (red circles). Accordingly, the isolated winding of *Ho-Hsiang* would not be shunted at 904a, 904b, 908a, and 908b (red circles) due to the gaps or breaks in the second metal layer. Any shunting of the isolated windings of the planar transformer in *Ho-Hsiang* terminates at the gaps and breaks. Ex. 2003, ¶ 83. While these breaks or gaps in the second metal layer are critical and beneficial for intermingling the windings of a planar transformer, the same gaps compromise the structure of an inductor resulting in increased resistance and decreased Q, which is the opposite of the stated objectives of the '245 Patent. *Id.*, ¶¶ 83–84.

The '245 Patent teaches a stacked inductor structure that makes use of the metal layers of a crossover region as shunt windings resulting in optimized Q. Ex. 1001, 1:7–10, 1:37–41. A POSITA would not look to prior art references directed to planar transformers to design an inductor structure with optimized Q because a POSITA would know that, due to the intermingling necessary for a planar transformer, the individual windings, in addition to their irregular geometry, contain numerous breaks or gaps in the metal layers that prohibit shunting at those locations, which undermines the stated objective of the inventors of the '245 Patent—utilizing

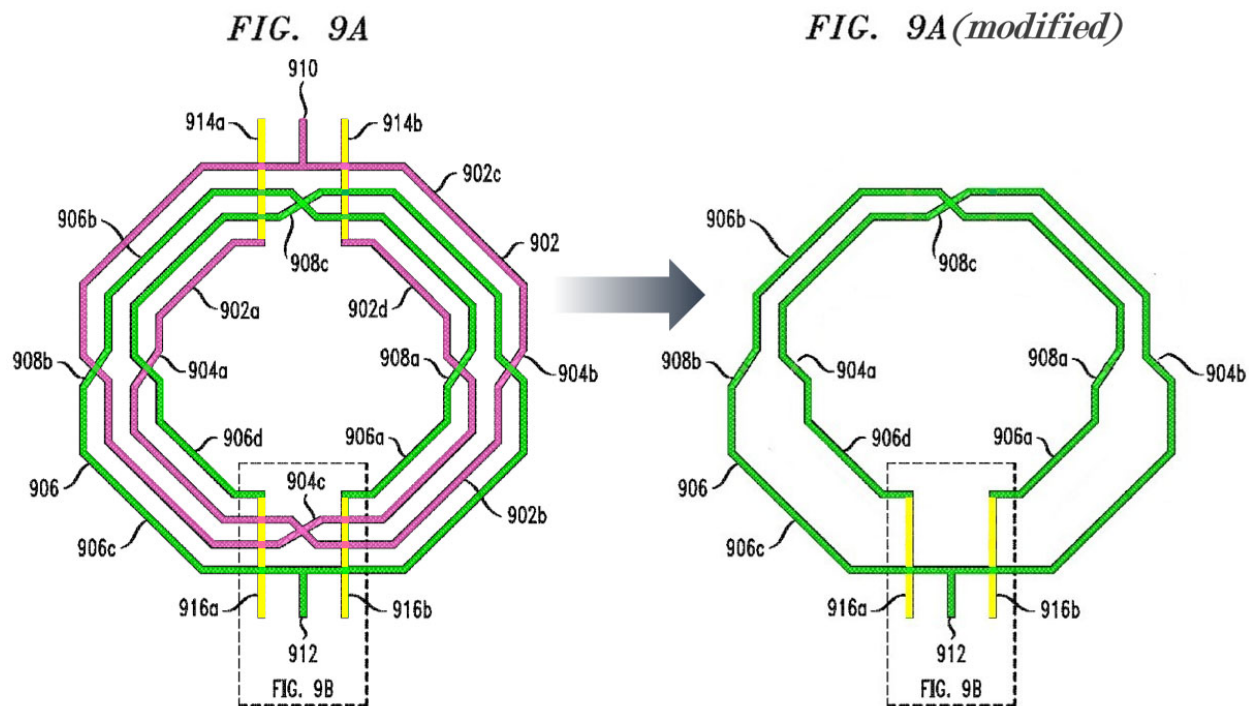
the full metal layers of the crossover to form shunt windings to reduce footprint, lower resistance and optimize Q.

Furthermore, the specific planar transformer disclosed in *Ho-Hsiang* have other structural features that result in underutilized metal layers, which negatively impact the ability to optimize Q of an inductor. Ex. 2003, ¶ 85. Specifically, *Ho-Hsiang* explains that the transformer shown in Figs. 9A–9C utilizes three metal layers. Ex. 1005, 6:12–13. The portions that are located on the third metal layer 940 are identified as input ports 914a, 914b, 916a, and 916b. *Id.*, 6:24–29.

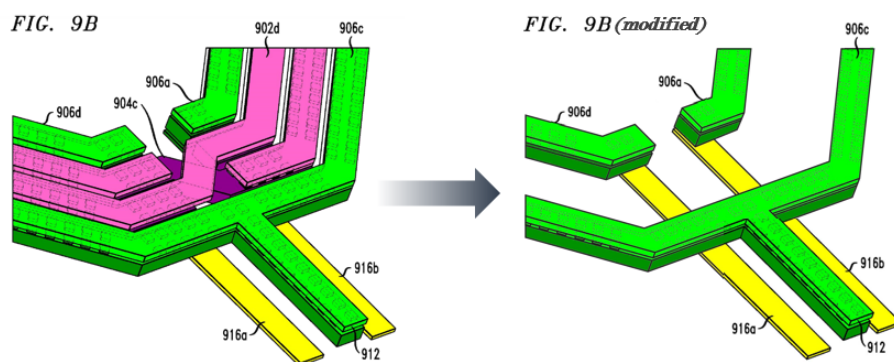
FIG. 9C



Id., Fig. 9C (annotated: third metal layer 940 shown in yellow). These input ports are shown in yellow in the figures below and are the ***only structures present on the third metal layer***. *Id.*; see also Ex. 2005, 74:23–76:2; Ex. 2003, ¶ 86. This is a result of *Ho-Hsiang*'s teaching that two sets of ports are connected to the innermost portion of the windings and are disposed externally on metal layer 3. Ex. 1005, 6:24–29; Figs. 9A–9C.



Id., Fig. 9A (modified and annotated).



Id., Fig. 9B (modified and annotated).

When the windings of the planar transformer shown in Figs. 9A–9C are viewed in isolation, it is clear that they suffer from underutilized layers, which is one of the problems the '245 Patent sought to solve. Ex. 2003, ¶¶ 87, 90. Thus, similar

to the prior art inductors described previously, the structure of the isolated winding of the planar transformer in *Ho-Hsiang* would need to be redesigned in order to optimize Q and fully utilize the metal layers of the windings. *Id.*, ¶¶ 87–88.

A POSITA would understand that the isolated winding of the *Ho-Hsiang* planar transformer would be a poorly functioning inductor, even compared to typical inductors well-known in the prior art, such as those that the '245 Patent sought to improve. *Id.*, ¶ 84. Petitioner's reliance on the purported teachings of an isolated winding of a planar transformer in *Ho-Hsiang* simply goes against the stated objective of the claimed invention of the '245 Patent, an optimized inductor structure that has a small footprint and is able to achieve low resistance and optimize Q. *Id.*, ¶¶ 89, 94.

3. The Modified *Ho-Hsiang* Transformer Would No Longer Work for its Intended Purpose

Even if it was possible to use an isolated winding of the planar transformer in *Ho-Hsiang* as a standalone inductor, the proposed modification of the *Ho-Hsiang* planar transformers to isolate its windings is inappropriate for an obviousness inquiry because the proposed modification renders the *Ho-Hsiang* transformer inoperable for its intended purpose. Ex. 2003, ¶ 75; see *Fritch*, 972 F.2d at 1266. For example, in *In re Gordon*, Appellants appealed a decision from the Board affirming the examiners rejection of claims directed to a blood filter assembly as obvious in

view of a single prior art reference. 733 F.2d 900, 900–1 (Fed. Cir. 1984). The Board held that it would have been obvious to turn the strainer apparatus of the prior art upside down to have both the claimed inlet and outlet at the bottom, rather than at the top. *Id.* at 902. The Federal Circuit disagreed, finding that it was not obvious from a fair reading of the reference as a whole to turn the prior art apparatus upside down. *Id.* Specifically, the Federal Circuit noted that the prior art reference taught that the strainer apparatus relies in part on gravity to achieve its stated goal. *Id.* Therefore, there was no suggestion in the prior art reference itself to modify the strainer apparatus. *Id.* The Federal Circuit further explained that if the prior art “apparatus were turned upside down, it would be rendered inoperable for its intended purpose.” *Id.* The same can be said here.

Like the prior art apparatus in *Gordon*, there is no suggestion in *Ho-Hsiang* that it would be desirable to isolate one of the windings of the transformer and attempt to use it as an inductor. Further, the isolated winding from *Ho-Hsiang*, on which Petitioner relies for its obviousness argument, would be inoperable as a balun transformer, which is the intended purpose of the transformer structure taught and disclosed in *Ho-Hsiang*. Additionally, an isolated winding from *Ho-Hsiang* would be undesirable as an inductor, which is the intended purpose of the '245 Patent.

Petitioner's expert agrees having testified that the isolated winding of *Ho-Hsiang* would not work as a transformer. Ex. 2005, 89:18–91:4.

In summary, the Petition has failed to establish by a preponderance of the evidence that the Challenged Claims would have been obvious based on *Ho-Hsiang*.

B. Ground 2: *Christensen*

Christensen teaches and discloses improvements in planar transformer designs for use in integrated circuits. Ex. 1006, 1:31–33; Ex. 2003, ¶ 95. The planar transformers taught and disclosed in *Christensen* are specifically designed with interwoven windings that share the same metal layers. Ex. 2003, ¶ 96. These planar transformers are designed to perform the function of changing voltage levels, which is not relevant to the stated objectives of the inventors of the '245 Patent—design of a multi-layer (not planar) stacked inductor (not transformer) with a reduced footprint (not planar) and optimized Q (not coupled). *Id.* Unlike the spiral inductor of the '245 Patent, the transformer structure taught and disclosed in *Christensen* is not designed to store energy nor is it designed to reduce footprint of its windings or optimize Q of its windings. *Id.*

As discussed above, planar transformers, like those disclosed in *Christensen* comprise two or more coils or windings that are closely intermingled. Ex. 1006, 1:36–38, 4:34–35.

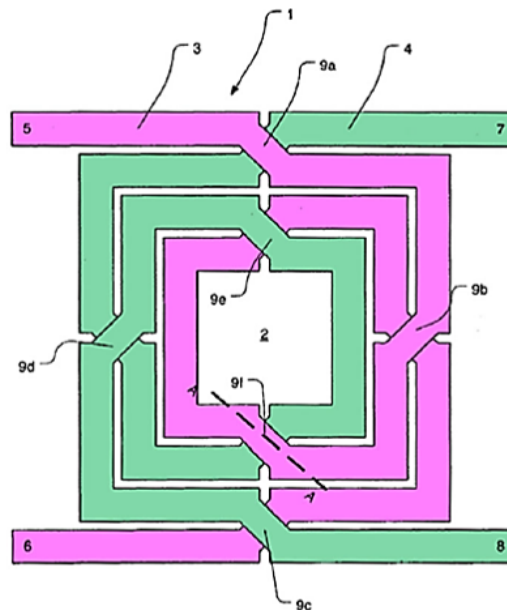


Figure 1

Id., Fig. 1 (annotated to highlight the primary winding 3 in pink and the secondary winding 4 in green). *Christensen* teaches that transformers used in ICs in the prior art “make use of a few very well-known layout techniques, e.g. placing the primary and secondary windings one above the other in different interconnect layers.” *Id.*, 1:9-12; Ex. 2003, ¶ 97. *Christensen* explains that while these layouts ensure the primary and secondary parts are identical, they are not balanced, which is undesirable. Ex. 1006, 1:12–15; Ex. 2003, ¶ 97. *Christensen* also describes more symmetrical layouts in the prior art, such as Stimburger transformers, that cross windings twice in all but the outer and inner turns, which only cross once. Ex. 1006, 1:16–28; Ex. 2003, ¶ 98. *Christiansen* explains these more symmetrical transformers

have complex layouts, are undesirably lossy, and that it is difficult to match the electrical properties of the windings. *Id.*

Christensen addresses these problems with prior art transformers by providing specific configurations of tightly intermingled windings in order to achieve rotational or mirror symmetry. Ex. 1006, 4:60–63; Ex. 2003, ¶ 99. *Christensen* explains that these structural designs comprise inward and outward spiraling paths that result in each full turn of each winding being affected by one self-crossing and two crossings with the other intermingled winding. Ex. 1006, 1:37–41.

1. *Christensen* Teaches Away from the Claimed Inductor Structure of the '245 Patent

As explained above, the motivations underlying certain structural design choices and the construction of the *Christensen* transformers differs from the design objectives of the inductors of the Challenged Claims (reduce footprint, lower series resistance and optimize Q). This is particularly evident for planar transformers such as those disclosed by *Christensen*, which require coupling of windings through intermingling, which necessarily increases the footprint of each winding and negatively impacts the Q of each winding, both of which are counterproductive to the stated goals of the '245 Patent.

Christensen teaches how to improve the function of a *planar transformer*, not how to improve the design of a stacked spiral inductor to reduce its footprint and

resistance while optimizing its Q. For example, *Christensen* teaches that the intermingled windings having the same number of turns and that each full turn of the intermingled portion is affected by one self-crossing and two inter-winding crossings. Ex. 1006, 1:38–45; Ex. 2003, ¶ 100. With respect to the crossings, Christensen further teaches, “the crossings should be positioned so as to ***assist in balancing the electrical properties of the windings*** [and a]rrangements having ***rotational or mirror symmetry are preferred*** for this reason.” Ex. 1006, 4:60–63 (emphasis added); Ex. 2003, ¶ 101.

Christensen’s teachings are directed to improvements in planar transformer design and none of these teachings (or any other statements in *Christensen*) suggest to a POSITA that the planar transformer structures would be useful for improving the design of an inductor to reduce its footprint while optimizing its Q through the use of a crossover region to construct shunt windings. *Id.*, ¶ 102. *Christensen* teaches nothing about the structure or function of inductors or how to design an inductor to reduce its footprint and resistance while optimizing Q. *Id.*, ¶ 103. Petitioner points to nothing in *Christensen* or any other prior art reference that would suggest to or motivate a POSITA to consider or rely on the design choices taught to improve the function of a planar transformer in order to achieve the stated objectives of the ’245 Patent, particularly given, as previously discussed, the design choices taught to

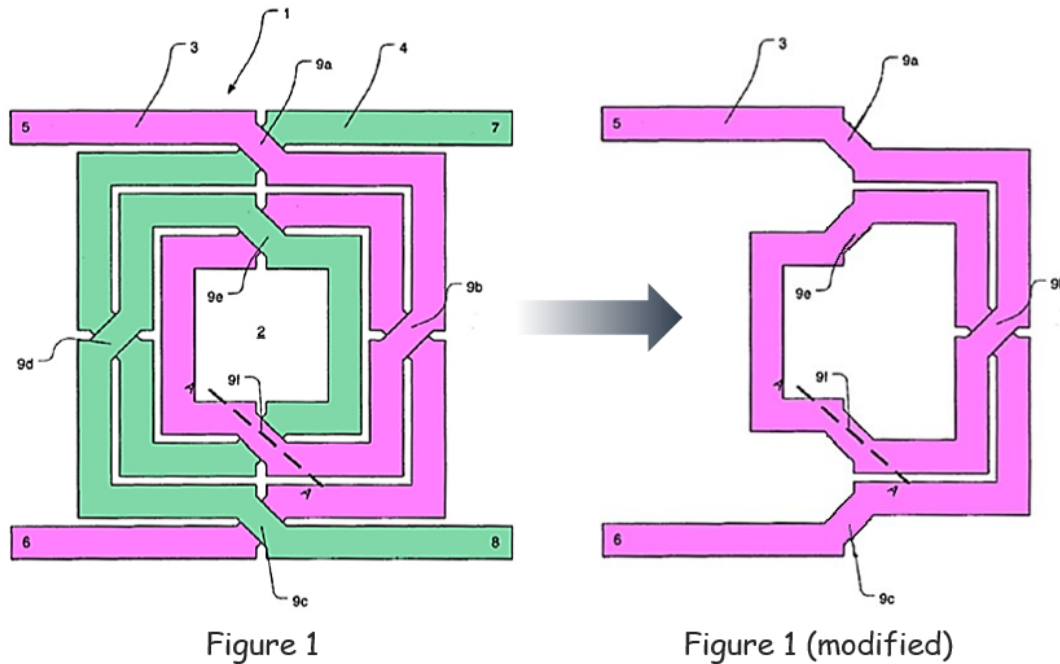
improve the function of a planar transformer would be counterproductive to the inductor design objectives of the '245 Patent. *Id.* “An inference of nonobviousness is especially strong where the prior art’s teachings undermine the very reason being proffered as to why a person of ordinary skill would have combined the known elements.” *DePuy Spin*, 567 F.3d at 1325; *see also Immunex*, 964 F.3d at 1066–67 (holding the district court did not error in considering the therapeutic benefits of the biologic when finding there was no motivation to combine references even though the therapeutic benefits were not claimed, but were a stated objective of the claimed invention).

The Petition fails to provide particular reasons why a POSITA would be motivated to rely on the teachings of *Christensen*, other than for the abstract reason that the disclosed planar transformers are comprised of two windings. *See Dembiczak*, 175 F.3d at 999 (explaining the evidence showing a suggestion, teaching, or motivation to combine [or modify] must be clear and particular; broad conclusory statements regarding the teaching of references, standing alone, are not evidence). Aside from the fact that the windings of the *Christensen* planar transformers include a number of crossings, Petitioner and its expert do not provide any clear or particular reasons why it would be obvious to a POSITA to utilize or modify the teachings of *Christensen* to design the stacked structure of a spiral

inductor of the Challenge Claims with a reduced footprint, lower resistance, and optimized Q. The Federal Circuit has made “clear that the best defense against the subtle but powerful attraction of a hindsight-based obviousness analysis is rigorous application of the requirement for a showing of the teaching or motivation to combine [or modify] prior art references.” *Id.* Therefore, the reference must be considered for its teaching as a whole, and as a whole *Christensen* teaches away from the Challenged Claims of the '245 Patent and its stated goals because the design objectives of a planar transformer are in opposition to the design objectives of the inductor of the Challenged Claims of the '245 Patent. Ex. 2003, ¶ 92; *see Hedges*, 783 F.2d at 1041.

2. A POSITA Would Not be Motivated to Modify the Planar Transformer of *Christensen* or Rely on an Isolated Winding

Similar to *Ho-Hsiang*, Petitioner relies on an isolated winding (primary winding 3) of one of *Christensen*'s planar transformers (disclosed in Figs. 1–7) in an effort to show that *Christensen* discloses or renders obvious each element of the Challenged Claims under § 103. *See* Petition, 70.



Ex. 1006, Fig. 1 (modified and annotated); *see also id.*, Figs. 2–3. Petitioner fails to explain why a POSITA would ignore the explicit teachings and goals of *Christensen* and simply look at the structural features of its windings in isolation for the purposes of designing a stacked structure of a spiral inductor with a reduced footprint, lower resistance and optimized Q as taught and disclosed in the '245 Patent. Ex. 2003, ¶ 105. Nothing in *Christensen* suggests that a POSITA would be motivated to separate the windings, then use a single isolated winding of the transformer as an “inductor.” *Id.*, ¶ 104. In fact, *Christensen*’s teachings are counterintuitive to the objectives of the '245 Patent because the isolated windings contain structural modifications that are necessary to maximize coupling in a planar transformer but that in isolation

increase the footprint of the winding, degrade the performance of the winding, and decrease the quality factor of the winding as a standalone inductor.

Petitioner also fails to acknowledge the characteristics of planar transformers that run counter to the goals of the '245 Patent. *Id.*, ¶ 116. The undesirable structural features of the windings isolated from the planar transformers of *Christensen* are readily apparent upon review of the isolated windings illustrated and annotated by Petitioner. First, the isolated primary winding 3 of *Christensen*, as shown below, reveals a structure with a somewhat unusual, meandering geometry as compared to the geometry of inductors disclosed in the prior art. *See* Petition, 16, 19–20; *see also* Ex. 1003, 38; Ex. 2003, ¶ 107.

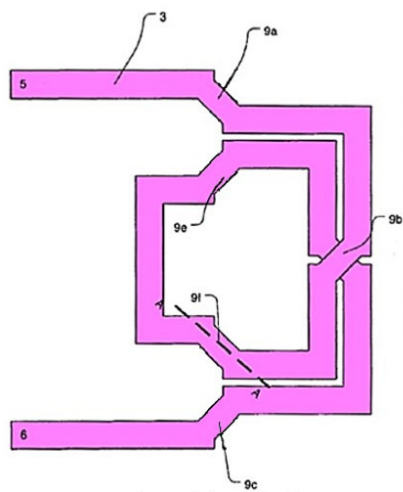


Figure 1 (modified)

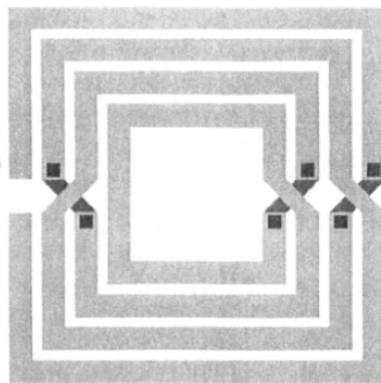


Figure 2.10. A symmetric spiral inductor.

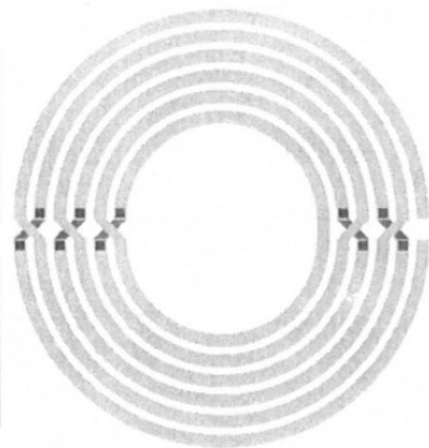


Figure 2.11. A symmetric polygon spiral inductor.

Compare Ex. 1006 (Fig. 1, modified and annotated) with Ex. 1009, 26–27 (Figs. 2.10–2.11). Specifically, the isolated winding 3 of *Christensen* shown above, has non-uniform spacing between the turns of the windings, particularly on the left side,

and an overall larger footprint than a typical circular or even square prior art inductors (also shown above). Ex. 2003, ¶ 107. A POSITA, at the time of the '245 invention, would understand that these structural irregularities are the result of the intermingling required by the two windings to increase coupling necessary to construct a balanced planar transformer with rotational or mirror symmetry. Ex. 2005, 66:25–67:20.

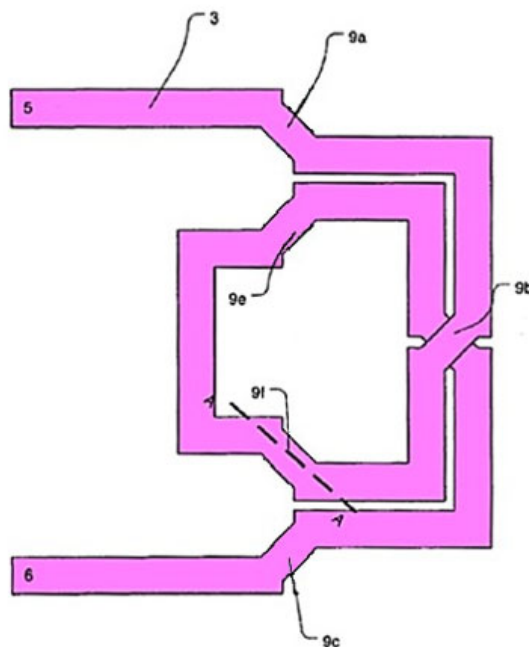


Figure 1 (modified)

Ex. 1006, Fig. 1 (modified and annotated; *see also* Fig. 2).

When the windings of *Christensen's* planar transformers are considered in isolation, the structure becomes undesirable for use as an inductor in an IC where real estate on the chip is a premium. In addition to the increased surface area of the

isolated winding, the large unoccupied area between terminals 5 and 6 and the innermost winding will result in a loss of flux linkage from the outer winding. Ex. 2003, ¶ 107. Thus, not only does the irregular geometry not fully utilize the surface area, but it also negatively impacts potential inductance. *Id.*, ¶ 107. Consequently, a POSITA would expect that a modified or isolated winding from a planar transformer, such as those disclosed in *Christensen*, will possess an irregular geometry that negatively impacts the footprint and inductance, and therefore, would not achieve the goals of the '245 Patent to reduce surface area, lower resistance, and optimize Q. *Id.*, ¶ 110

In addition to the irregular geometry, planar transformers with intermingled windings will lose a number of the crossings if the windings are separated or viewed in isolation from the planar transformer. *Id.*, ¶ 108. As shown below, when primary winding 3 is isolated from the transformer, four crossings of the windings 9a, 9e, 9f, and 9c (red circles) are lost in primary winding 3, leaving only one self-crossing 9b (blue circle). *Id.*, ¶ 106. The interwoven windings of the *Christensen* planar transformer share the same three metal layers (10c–10a), but the individual windings occupy only a single metal layer at the crossings of the two windings (red circles). *Id.*

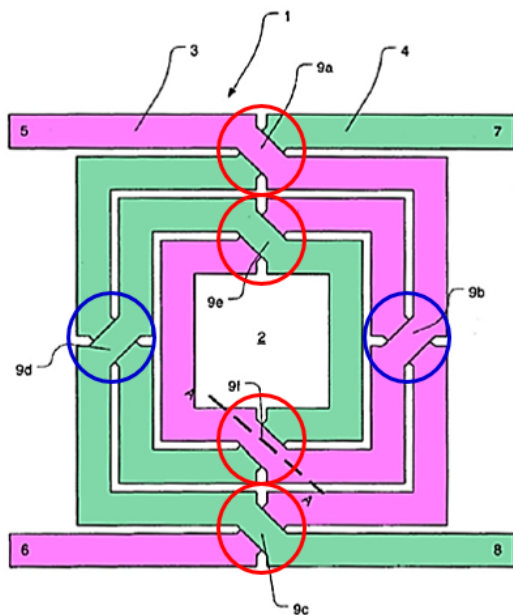


Figure 1

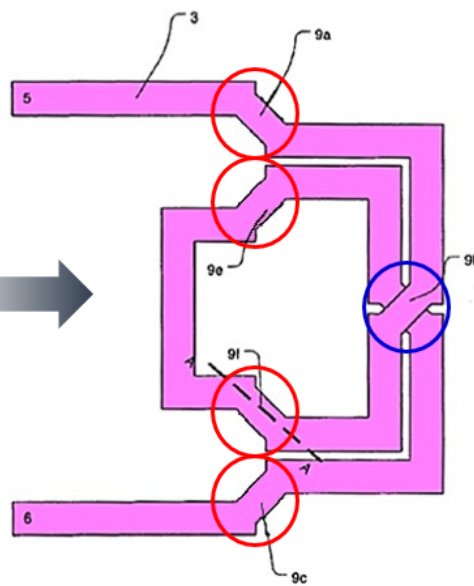


Figure 1 (modified)

Id., Fig.1 (modified and annotated); *see also id.*, Fig. 2. Christensen explains that at the bridges or crossings 9a, 9e, 9f, and 9c (red circles) “the currents of the primary and secondary windings 3, 4 are carried in respective single conductor layers 10c, 10b[,]” as opposed to three layers 10a–10c, as shown in Fig. 5 below (depicting crossing 9f). *Id.*, 4:4–8, 3:43–61; Ex. 2003, ¶ 114. Therefore, the isolated winding 3 of *Christensen* would not be shunted at 9a, 9e, 9f, and 9c (red circles) due to the gaps or breaks in one of the metal layers of the winding, as shown below.

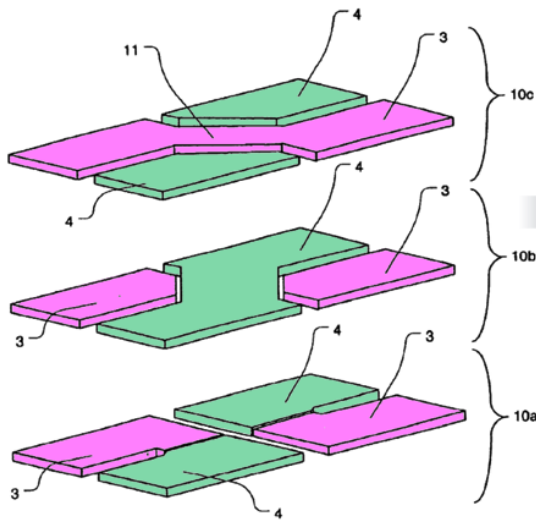


Figure 5

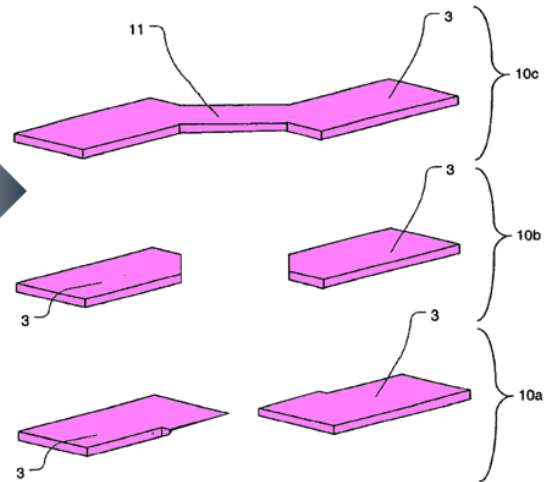


Figure 5 (modified)

Ex. 1006, Fig. 5 (modified and annotated); *see also id.* Fig. 4. While these breaks or gaps in the second and third metal layers are critical and beneficial for intermingling the windings of a planar transformer, the same gaps prohibit the isolated windings from being shunted at those locations and consequently prevent the isolated winding from being shunted along its length. Petitioner's proposed modification of the *Christensen* teaches away from the stated objective of the claimed invention, an optimized inductor structure that is able to achieve low R_s and high Q , due to the unnecessary gaps in the isolated windings that degrade performance of the isolated winding as an inductor and decrease its Q . Any purported shunting of the isolated windings of the planar transformer in *Christensen* terminates at the gaps and breaks resulting in increased resistance and degraded performance for use as an inductor. *Id.*, ¶ 115; *see also* Ex. 2005, 104:15–106:14. Ultimately, the modifications

necessary to couple the windings in the planar transformer of *Christensen* compromise the structure of the isolated winding for use as an efficient inductor. Ex. 2003, ¶ 115.

With respect to the self-crossings, Petitioner further argues that Figs. 4–6 of *Christensen* apply not only to the bridges of 9f, 9a, 9c, 9e, but also to the self-crossings 9b and 9d. Petition at 71–93. However *Christensen* does not expressly teach or disclose the structure of the self-crossings 9b and 9d of the individual windings. Figs. 4–6 are specific to the inter-winding crossing at 9f, and all three figures label both windings 3 and 4 in the images. Ex. 2003, ¶¶ 111–113; *see also* Ex. 1006, 2:25–34, 3:34–55, 3:62–4:8. A POSITA would appreciate that balanced electrical properties of the windings only dictate that crossing 9b and 9d be the same, but do not preclude the use of the third metal layer or underlying metal layers at these self-crossings. Ex.2003, ¶ 113.

The '245 Patent teaches a stacked inductor structure that makes use of the metal layers of a crossover region as shunt windings resulting in optimized Q. Ex. 1001, 1:7–10, 1:37–41. A POSITA would not look to prior art references directed to planar transformers to design an inductor structure with optimized Q because a POSITA would know that, due to the intermingling necessary for a planar transformer, the individual windings, in addition to their irregular geometry, contain

numerous breaks or gaps in the metal layers that prohibit shunting at those locations, which undermines the stated objective of the inventors of the '245 Patent—utilizing the full metal layers of the crossover to form shunt windings to reduce footprint, lower resistance and optimize Q.

In conclusion, a POSITA would understand that the isolated winding of the *Christensen* planar transformer would be a poorly functioning inductor, even compared to typical inductors well-known in the prior art, such as those that the '245 Patent sought to improve. Petitioner's reliance on the purported teachings of an isolated winding of a planar transformer in *Christensen* simply goes against the stated objective of the claimed invention of the '245 Patent, designing an optimized inductor structure that has a small footprint and is able to achieve low resistance and optimize Q.

3. The Modified *Christensen* Transformer Would No Longer Work for its Intended Purpose

Even if it was possible to use an isolated winding of the planar transformer in *Christensen* as a standalone inductor, the proposed modification of the *Christensen* planar transformers to isolate its windings is inappropriate for an obviousness inquiry because the proposed modification renders the *Christensen* transformer inoperable for its intended purpose. Ex. 2003, ¶ 119; *see Fritch*, 972 F.2d at 1266. *See Gordon*, 733 F.2d at 900–1 (finding that it was not obvious from a fair reading

of the reference as a whole to turn the prior art apparatus upside down and even if the “apparatus were turned upside down, it would be rendered inoperable for its intended purpose.”).

Like the prior art apparatus in *Gordon*, there is no suggestion in *Christensen* that it would be desirable to isolate one of the windings of the planar transformer and attempt to use it as an inductor. For example, *Christensen* teaches improvements to the structural design of the planar transformer such as utilizing a self-crossing and four crossings of the intermingled windings in order to achieve rotational or mirror symmetry. Ex. 1006, 1:37–41, 4:60–63; Ex. 2003, ¶ 111. The isolated winding from *Christensen* would have none of the crossings of the intermingled windings and would not achieve the rotational or mirror symmetry taught by *Christensen*. Ex. 2003, ¶ 111. The isolated winding of *Christensen* would be inoperable as a planar transformer, which is the intended purpose of the structures taught and disclosed in *Christensen*, and would be undesirable as an inductor with lower footprint, lower resistance and optimized Q, which is the intended purpose of the '245 Patent. Petitioner's expert agrees having testified that the isolated winding of *Christensen* would not work as a transformer as *Christensen* intended. Ex. 2005, 108:7–109:8.

In summary, the structural modifications required to be made to the individual windings of the planar transformer in *Christensen* serve the primary goal of allowing

the windings to intertwine, such that the coupling coefficient k between the windings is maximized in the planar transformer. Ex. 2003, ¶ 109. But these same modifications to the structure of the windings in *Christensen* result in compromised flux linkage, reduced inductance and inferior Q of the individual windings, all of which runs counter to the stated objectives of the '245 Patent. *Id.*

Ultimately, the Q of the individual coupled windings of the planar transformer in *Christensen* has been sacrificed in order to achieve acceptable coupling (k) for the transformer structure, which places the goals of the transformer design in *Christensen* in opposition to the goals of the inductor design of the '245 Patent. Ex. 2003, ¶ 117. Further, a POSITA would understand that windings must be substantially modified in a manner deleterious to their function as inductors in order to be properly coupled in a transformer, and that such modifications required to maximize coupling substantially degrade the performance of each individual winding as an inductor. Ex. 2003, ¶ 118. As such, a POSITA would not be inclined to consider the teachings of *Christensen*'s planar transformer structures when seeking to improve the design of a multi-layer inductor with optimized Q. *Id.* ¶ 120.

Accordingly, Petition fails to establish by a preponderance of the evidence that the Challenged Claims would have been obvious based on *Christensen*.

C. Ground 3: *Yang*

Yang teaches and discloses a differential inductor with multi-turn windings. Ex. 1007, Abstract, ¶ [0018]. *Yang* includes only two drawings (both reproduced below). Fig. 1 shows a top view of an exemplary differential inductor 10 with multi-turn windings, and Fig. 2 is a sectional perspective view taken along line I–I' of Fig. 1. *Id.*, Figs. 1–2; Ex. 2003, ¶ 121.

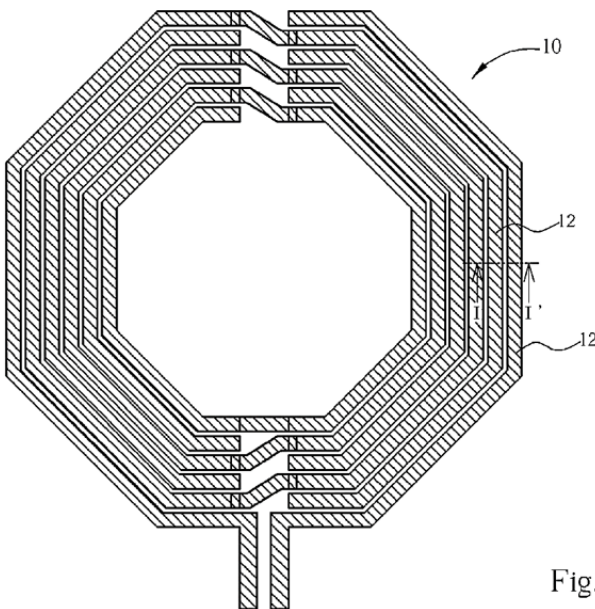


Fig. 1

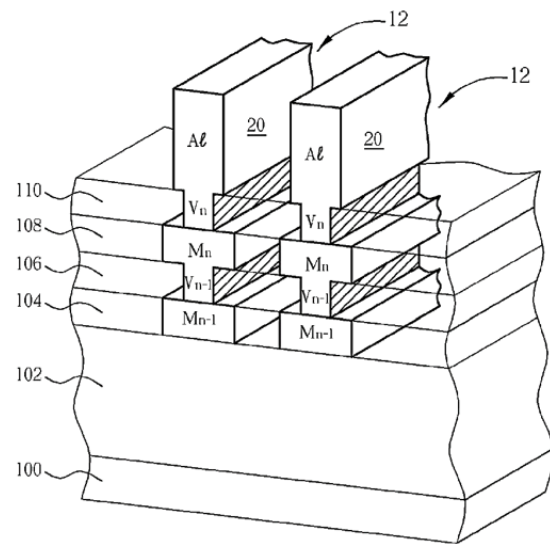


Fig. 2

1. ***Yang* Does Not Explicitly or Inherently Disclose or Teach the Sixth Segment and Crossover Region of the Challenged Claims**

It is indisputable that *Yang* contains no explicit disclosure of a sixth segment on the second metal layer or a crossover region as required by the Challenged Claims. Ex. 2003, ¶ 122. The “sixth segment” and “crossover region” of the Challenged Claims simply do not exist in *Yang. Id.* Specifically, the Challenged

Claims require “a second metal layer ... comprising: ... a sixth segment, connected to the fifth segment.” *Id.*, ¶ 123. Petitioner fails to point to any language from the disclosure of *Yang* to teach or suggest the claimed sixth segment or crossover region. *Yang* makes no mention of a sixth segment or crossover region. *Id.*, ¶ 124. *Yang* does not illustrate a sixth segment or crossover region. *Id.* *Yang* also does not suggest or even imply a sixth segment on the second metal layer or a crossover region as required by the Challenged Claims.

Petitioner argues that a sixth segment, physically connected to the fifth segment on the second metal layer, would be required in order to maintain proper electrical conductivity among the windings;² however, this statement and conclusion is simply false as acknowledged by Petitioner’s own expert. Ex. 2005, 30:12–31:11, 58:3–8. Petitioner’s expert agrees it was well known that inductors of the prior art used bridges or underpasses on a separate metal layer than the windings (connected to the windings by vias) as crossovers to “close a circuit.” Ex. 2005, 30:12–31:11, 58:3–8. The prior art inductor structures identified by Petitioner in its background of the art all utilize an underpass or bridge on a separate metal layer than the windings. *See Supra* II.A; Ex. 2003, ¶¶ 47, 49–52; *see also* Petition, 16–20. Accordingly, a

² *See* Petition, 114.

bridge or underpasses on a separate metal layer from the windings is all that would be required to maintain proper electrical conductivity among the windings in *Yang*. Ex. 2003, ¶ 126; Ex. 2005, 30:12–31:11, 58:3–8. Other than improper hindsight, nothing in *Yang* or the prior art suggests the precise structure of the Challenged Claims, wherein the metal layers of the crossover region are utilized to construct shunt windings, would be necessary or required to maintain proper electrical conductivity among the windings of *Yang*. To conclude otherwise is simply improper hindsight.

Petitioner also argues that a POSITA would have understood that the purported “sixth segment” would be “directly under the top layer crossover [] except oriented in a different direction to allow connection to the next segment of the coil” as shown in the annotated and modified image below, creating a crossover region that is symmetrical. Petition, at 116 (“symmetrical inductors 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.”); Ex. 2003, ¶ 127.



Yang, Fig. 1 (portion, modified) (EX-1007) (annotated)

Petition, 116.

However, Petitioner's argument that a POSITA would understand that *Yang* would require the precise structure of a sixth segment and crossover region of the Challenged Claims because of symmetry again is based on nothing more than improper hindsight. Nothing in *Yang* or the background inductor art on which Petitioner relies teaches, much less requires, the sixth segment and crossover region of the Challenged Claims to maintain symmetry. The background art includes plenty of symmetrical inductors that did not utilize the metal layers of the claimed crossover region to construct the first and second shunt windings of the Challenged Claims. *See e.g.*, Ex. 1009, 27–28 (Figs. 2.10–2.11); Ex. 1013, Figs. 2–3; Ex. 1015, Fig. 3; Ex. 1017, Fig. 28b-1; Ex. 1018, Figs. 1–2. More specifically, the symmetrical inductors of the prior art utilized bridges and underpasses on separate metal layers than the windings without impacting the desired symmetry. *See e.g.*, Ex. 1009, 27 (Fig. 2.11); Ex. 1018, Figs. 1–2. Therefore, symmetry does not necessitate that a

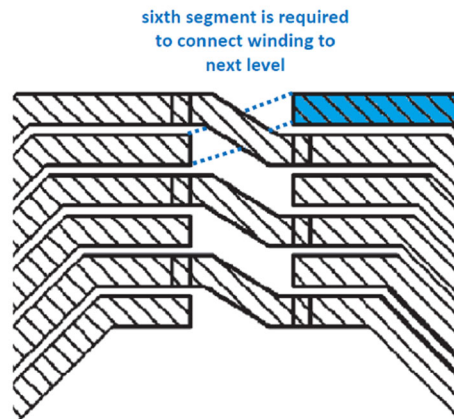
sixth segment be on the second metal layer or that the metal layers of the windings be used for the crossover region as required by the Challenged Claims. Therefore, the sixth segment and crossover region of the Challenged claims are not inherently or necessarily present in *Yang*. See *PAR Pharmaceutical, Inc. v. TWI Pharmaceuticals, Inc.*, 773 F.3d 1186, 1195 (Fed. Cir. 2014) (“[I]nherency must be limited when applied to obviousness, and is present only when the limitation at issue is the ‘natural result’ of the combination of prior art elements.”)

The background inductor art simply taught use of an underpass on a separate metal layer to close the circuit in symmetrical inductors (*see Supra* Section II.A), and that crossover structure was precisely the crossover design the inventors of the ’245 Patent sought to improve. Accordingly, *Yang* does expressly or inherently disclose or teach sixth segment and crossover region of the Challenged Claims.

2. No Motivation to Modify *Yang* to Add the Sixth Segment and Crossover Region of the Challenged Claims

“In appropriate circumstances, a single prior art reference can render a claim obvious. However, there must be a showing of a suggestion or motivation to modify the teachings of that reference to the claimed invention in order to support the obviousness conclusion.” *SIBIA Neurosciences*, 225 F.3d at 1356 (citations omitted). Petitioner seemingly argues that it would be obvious to a POSITA to modify *Yang* and add a sixth segment connected to the fifth segment on the second

metal layer to construct a crossover region, see exemplary annotated and modified figure below. *See e.g.*, Petition, 114–116, 125, 127–28, 130 (reproducing numerous annotated and modified images from *Yang*); *see also* Ex. 2003, ¶ 125.



Yang, Fig. 1 (partial) (EX-1007) (annotated)

Petition, 115.

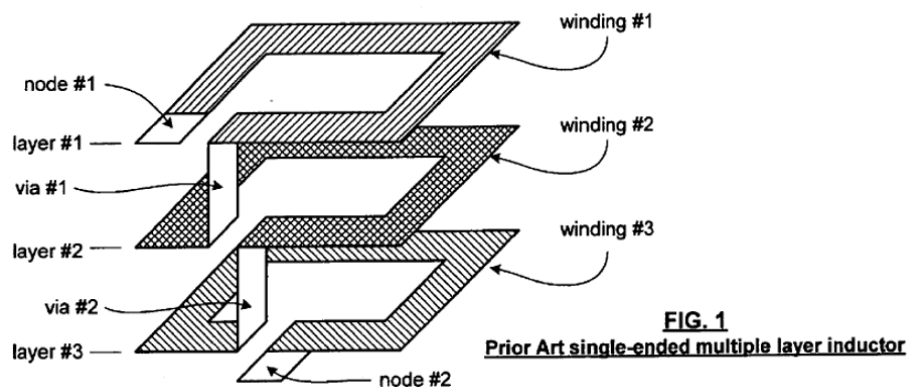
As mentioned previously, Petitioner contends a POSITA would be motivated to make this modification because “without a crossover connected to the fifth segment, the winding would not connect to the next loop and would simply be an open metal line. ... A POSITA would therefore have understood that in *Yang*, the second layer crossover ... would be directly under the top layer crossover ... Further, a POSITA would have understood that symmetrical inductors 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. ... a POSITA would have expected *Yang* to also have a symmetric crossover pattern.” Petition, 114–17.

However, none of the inductor art cited by Petitioner utilized a sixth segment on the second metal layer of the winding to form a crossover region as required by the Challenged Claims. None of the inductor art cited by Petitioner utilized the metal layers of a crossover region to construct shunt windings. Instead, all of the prior art inductor designs (Chang, Moinian, Kyriazidou, etc.)³ on which Petitioner relies teach and utilize crossings with an underpass or bridge on a separate metal layer than the winding layers, which is precisely the crossover design the inventors of the '245 Patent sought to improve. Ex. 2003, ¶¶ 128–130; *see also Supra* Section II.A.

Contrary to Petitioner's arguments, a sixth segment and crossover region as claimed would not be *inherent* or *necessary* to the disclosed structure in *Yang* because a POSITA would know how to connect different loops of a winding based on the separate metal layer underpass crossings taught by the background inductor art cited throughout the Petition. Ex. 2003, ¶¶ 128, 132. For example, *Yang* discloses

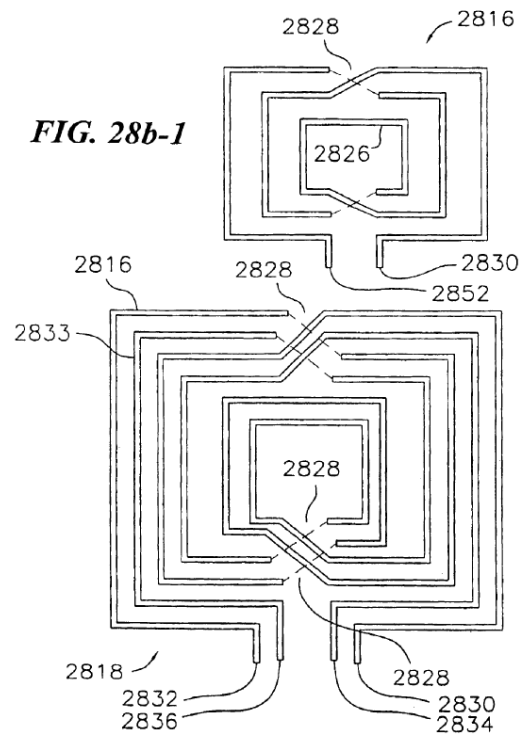
³ See e.g., Ex. 1017 (Chang), Fig. 28b-1, 38:10–15 (“a 3-turn symmetric inductor. . . [a] series of phantom lines 2828 indicate tracks on a different layer, connected to a track shown by a solid line using one or more vias.”); Ex. 1018 (Moinian), Fig. 2, 5, ¶ [0022] (“The primary winding portions 110P of the inductor winding 110 comprise metal lines built into the M5-M7 metallization levels. The bridge portions 110B, on the other hand, comprise metal lines built into the M3 and M4 metallization levels.”); Ex. 1013 (Kyriazidou), Fig. 2, 1:55–58 (“a single layered differential inductor having 1st and 2nd windings (Windings #1 and #2) on one layer (Layer #1). Winding #1 is coupled to Winding #2 via a bridge on Layer #2 and interconnecting vias #1 and #2.”).

that “[t]he invention is also applicable to single-ended type inductors.” Ex. 1007, ¶ [0019]. The Petition on page 16 shows a prior art single-ended multiple layer inductor (reproduced below) from Kyriazidou where a number of vertical vias (*i.e.*, vertical vias #1, #2, and #3) are implemented to connect three winding layers of a multi-layer inductor.



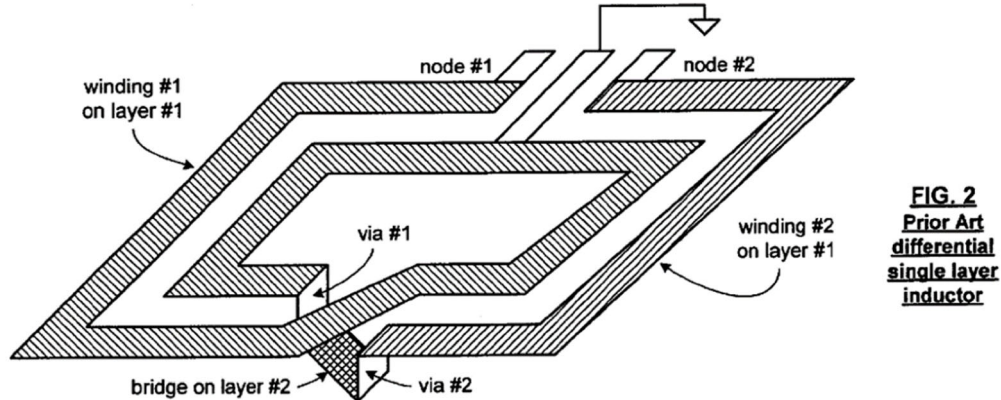
Petition, 16 (Ex. 1013, Fig. 1).

Petitioner’s other examples of background inductor art demonstrate that the “sixth segment” and “crossover region” of the Challenged Claims are not necessary or required for connecting the different metal layers in *Yang*, and that instead a simple underpass on a separate metal layer would be used. Ex. 2003, ¶ 131. For example, U.S. Patent No. 6,885,275 to Chang, filed on Jan. 28, 2000, teaches the use of an underpass 2828 on a separate metal layer to interconnect the ends of turns in inductor 2816, as illustrated below. Ex. 1017, 38:10–15.



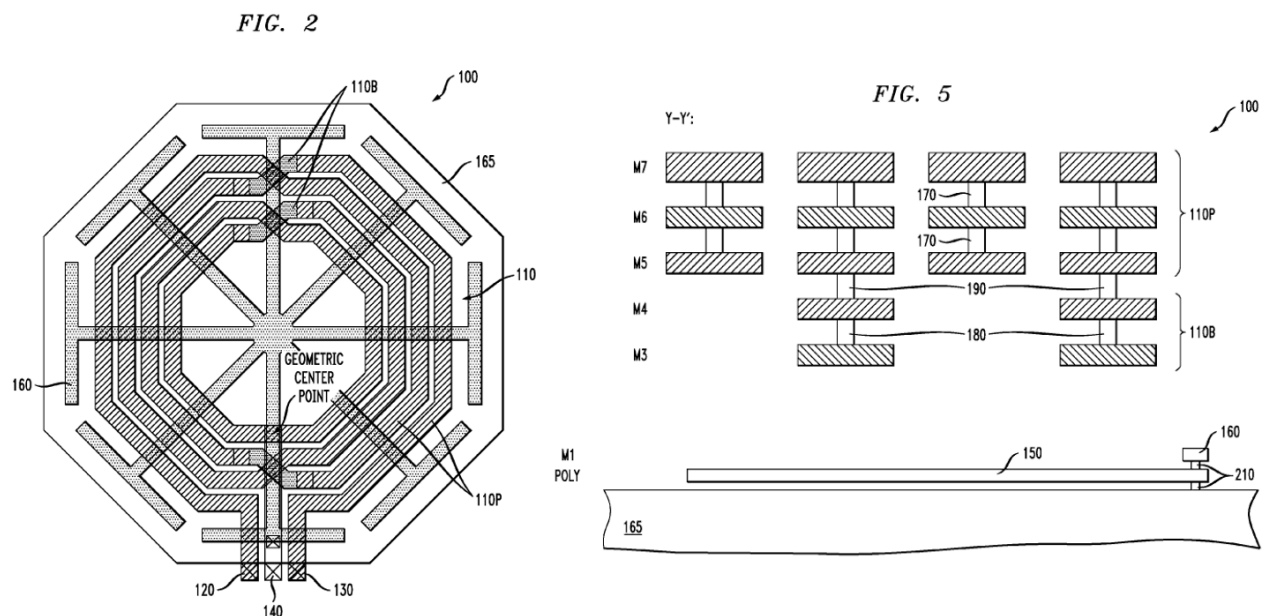
Id., Fig. 28b-1; 38:13–15 (“A series of phantom lines 2828 indicate tracks on a different layer, connected to a track shown by a solid line using one or more vias.”).

As another example, U.S. Patent No. 6,759,937 to Kyriazidou, filed in 2002, discloses a single-layer inductor (shown below) that uses a bridge or underpass on a separate layer from the main winding in order to accomplish a crossover. Ex. 1013, 1:55–58.



Petition, 16 (Ex. 1013, Fig. 2).

Additionally, U.S. Patent Pub. No. 2008/0074229 A1 to Moinian et al., filed in 2006 and cited as background art in the '245 Patent, discloses a stacked inductor 100 (shown below) with primary winding portions 110P, located on three metal layers (M5–M7) and bridge portions 110B, located below on two separate metal layers (M3–M4). Ex. 1018, ¶¶ [0021]–[0022].



Id., Fig. 2, 5.

Importantly, Petitioner's expert agrees it was well known that inductors of the prior art used bridges or underpasses on a separate metal layer than the windings (connected to the windings above or below by vias) as crossovers to "close a circuit." Ex. 2005, 30:12–31:11, 58:3–8. For example, Dr. Prucnal testified Kyriazidou Ex. 1013, Fig. 2) discloses a single-layer inductor that uses a bridge or underpass on a separate layer from the main winding in order to accomplish a crossover. Ex. 2005, 27:23–28:18. In addition, Dr. Prucnal testified that Moinian (Ex. 1018, Figs. 2, 5) and cited as background art in the '245 Patent⁴, discloses a stacked inductor 100 with primary winding portions 110P, located on three metal layers (M5–M7) separate and distinct from the bridge portions 110B, located below on two separate metal layers (M3–M4). Ex. 2005, 34:13–44:9.

Importantly, Petitioner's expert acknowledged that these common underpass and bridge crossings of the prior art inductors did not utilize the metal layers of the windings as required by the Challenged Claims. *Id.*, 56:5–59:19.; Ex. 2003, ¶ 131. And Petitioner's expert agreed an underpass as used in the background art could be used to complete the circuit in *Yang*. See Ex. 2005, 131:21–132:5 ("Well, but there needs to be an underpass to complete the circuit, and whatever layer that underpass

⁴ Ex. 1001, 1:31–34; Ex. 2005, 55:12–56:4.

is formed in would then be the sixth segment. In other words, the sixth segment doesn't have to be on the second layer. It could be on a different layer. But there needs to be a sixth segment to complete the circuit.”).

Yang does not even disclose or teach that the differential inductor of Fig. 1 is an open circuit. However, even if it was and a POSITA was motivated to close the open circuit, Petitioner states no reason why a POSITA would be motivated to use the sixth segment or crossover region of the Challenged Claims as opposed to an underpass or bridge on a separate metal layer, which was the well-known crossing design utilized in prior art inductors.

The only rationale for the proposed modification to the *Yang* disclosure (adding the “sixth segment” to *Yang*’s Fig. 1) is to target the Challenged Claims. This is classic hindsight predicated on improper picking, choosing, and taking editorial liberties with the isolated disclosures in *Yang* to invalidate the Challenged Claims. *See In re Wesslau*, 353 F.2d at 241; *Eli Lilly*, 435 F. App’x at 920–21; *see also Polaris*, 882 F.3d at 1068 (“[T]he prejudice of hindsight bias often overlooks that the genius of invention is often a combination of known elements which in hindsight seems preordained.”) (citations and quotations omitted). Accordingly, aside from hindsight, there is nothing in *Yang* or the background inductor art cited

by Petitioner that teaches or discloses adding a sixth segment and crossover as required by the Challenged Claims to the inductor structure taught in *Yang*.

For the reasons described above, Petitioner has also not shown that “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,” (claim 1) and that “. . . the sixth segment is positioned between the fourth segment and the fifth segment . . .” (claim 2) would be obvious to a POSITA. For the same reasons *Yang* does not render obvious a symmetrical inductor, as required by claim 8.

Thus, a POSITA would not have found the Challenged Claims to be obvious based on *Yang* given its failure to disclose these material limitations of the Challenged Claims. The Petition fails to establish by a preponderance of the evidence that the Challenged Claims would have been obvious over *Yang*.

VII. Conclusion

For the reasons set forth above, Petitioner has failed to satisfy its burden that the Challenged Claims are invalid, and the Board should confirm the patentability of the Challenged Claims.

Dated: February 8, 2024

Respectfully submitted,

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CERTIFICATION UNDER 37 C.F.R. § 42.24(d)

Under the provisions of 37 C.F.R. § 42.24(d), the undersigned hereby certifies that the word count for the foregoing Patent Owner's Response totals 12,701 words, which is less than the 14,000 words allowed under 37 C.F.R. § 42.24(b)(2).

Dated: February 8, 2024

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CERTIFICATE OF SERVICE

I hereby certify that on February 8, 2024, I caused a true and correct copy of the foregoing to be served on the following counsel for Petitioner by electronic mail to the following email address:

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