UNITED STATES PATENT AND TRADEMARK OFFICE

_____

BEFORE THE PATENT TRIAL AND APPEAL BOARD

_____

MURATA MANUFACTURING CO., LTD

Petitioner

_____

IPR2025-00384
U.S. Patent No. 7,489,914

PETITION FOR *INTER PARTES* REVIEW UNDER 35 U.S.C. § 312 AND 37 C.F.R. § 42.104

TABLE OF CONTENTS

PETITIONER'S EXHIBIT LIST

EX1001	U.S. Patent No. 7,489,914
EX1002	Prosecution History of U.S. Patent No. 7,489,914
EX1003	Second Declaration of Matthew B Shoemake under 37 C.F.R. § 1.68
EX1004	*Curriculum Vitae* of Matthew B Shoemake
EX1005	U.S. Patent No. 6,128,508 ("Francisco")
EX1006	JP 2001-267466 ("JP466") including original Japanese language document, English translation, and Translator's certification
EX1007	European Patent Application EP 1 189 345 A2 ("Okubora")
EX1008	U.S. Patent Appl. Publ. No. 2002/0118067 ("Hirayama")
EX1009	U.S. Patent No. 5,995,814 ("Yeh")
EX1010	Design and Implementation of High-Q Passive Devices for Wireless Applications Using System-On-Package (SOP) Based Organic Technologies, by Sidharth Dalmia, 2003 ("Dalmia")
EX1011	Concurrent Multiband Low-Noise Amplifiers—Theory, Design, and Applications," Hashemi et al., IEEE Transactions On Microwave Theory And Techniques, Vol. 50, No. 1, January 2002 ("Hashemi")
EX1012	*Fundamentals of Microsystems Packaging*, Rao Tummala, McGraw-Hill, Table of Contents and Chapter 11
EX1013	*Reserved*
EX1014	U.S. Patent No. 6,825,818
EX1015	U.S. Patent No. 5,457,734
EX1016	U.S. Patent No. 5,406,615

EX1017	*RF Microelectronics*, Behzad Razavi, Prentice Hall PTR, 1998
EX1018	U.S. Patent No. 5,821,820
EX1019	US Patent Application Publication No. 2002/0030545
EX1020	European Patent Application Publication No. EP 0 851 576 A2
EX1021	A CMOS RF Bandpass Low Noise Amplifier for Multi-band Wireless Communication Applications, Mou et al., IEEE, 2002
EX1022	*The Wiley Electrical and Electronics Dictionary*, Steven M. Kaplan, 2004, pp. 628, 662, 630
EX1023	RF Characterization of a low cost multichip packaging technology for monolithic microwave and millimeter wave integrated circuits, Jayaraj et al., IEEE, 1995
EX1024	JP 2001345648 ("JP648") including original Japanese language document, English translation, and Translator's certification
EX1025	NIST Technical Note 1520, "Dielectric and Conductor-Loss Characterization and Measurements on Electronic Packaging Materials, 2001
EX1026	US Patent Application Publication No. 2004/0127182
EX1027	Embedded Passive Technology Implementation in RF Applications, Savic et al., IPC Printed Circuits Expo, 2002
EX1028	US Patent Application Publication No. 2004/0113719
EX1029	US Patent Application Publication No. 2003/0063427
EX1030	*Microwave Engineering Second Edition*, David M. Pozar, Wiley, 1998
EX1031	Datasheet NE38018, NEC, 2000
EX1032	Characterization of Liquid Crystal Polymer for High Frequency System-in-a-Package Applications, Zou et al., IEEE Transactions On Advanced Packaging, Vol. 25, No. 4, 2002

EX1033	Liquid Crystal Polymers (LCP) for High Performance SOP Applications, 2002 Proceedings. 8th International Advanced Packaging Materials Symposium (Cat. No.02TH8617), Stone Mountain, GA, USA, 2002
EX1034	*Microwave Transistor Amplifiers Analysis and Design*, Second Edition, Guillermo Gonzalez, Wiley, 1997
EX1035	Complaint NDGA-1-24-cv-05268-1
EX1036	United States District Courts: Federal Court Management Statistics-Comparison within Circuit (September 30, 2024)
EX1037	JPA H06-97315 including original Japanese language document, English translation, and Translator's certification
EX1038	Declaration Dr. Sylvia Hall-Ellis
EX1039	Declaration of H. Stewart (ProQuest)
EX1040	U.S. Application No. 10/402,313 and applications referred to therein

I. INTRODUCTION

Pursuant to 35 U.S.C. §§311, 314(a), and 37 C.F.R. §42.100, Murata Manufacturing Co., Ltd ("Petitioner") respectfully requests that the Board review and cancel as unpatentable under (pre-AIA) 35 U.S.C. §103(a) claims 1-2 and 4-20 (hereinafter, "Challenged Claims") of U.S. 7,489,914 ("the '914 Patent," EX1001).

The '914 Patent describes a multi-band device having passive components formed in an organic substrate. As shown below and confirmed in the Declaration of Dr. Matthew B. Shoemake (EX1003, EX1004), these concepts were well known. Therefore, the references presented in this Petition render obvious the Challenged Claims.

II. GROUNDS FOR STANDING

Petitioner certifies that the '914 Patent is eligible for *inter partes* review (IPR) and that Petitioner is not barred or estopped from requesting IPR challenging the patent claims. 37 C.F.R. §42.104(a).

III. NOTE

Petitioner cites to exhibits' original page numbers. **Emphasis** in quoted material has been added. Claim terms are presented in *italics*.

IV. BACKGROUND

The '914 Patent relates to multi-band radio frequency (RF) devices. This section describes background technology related to the claimed subject matter. Dr.

Shoemake also describes relevant background technology predating the '914 Patent, which is cited as appropriate below. *See* EX1003, ¶¶1-46.

Well before the '914 Patent, there was a recognized need for devices within a communication system to operate over multiple RF bands. EX1003, ¶¶26-30 (citing EX1005; EX1015-EX1018; EX1009; discussing multiple band operations.) One technique to avoid increases in cost and size while providing multi-band operation was to reuse components across bands. EX1003, ¶¶30-31 (citing EX1005; EX1009; EX1011; EX1016-EX1020; discussing use of passives and/or RF devices at different frequencies). Amplifiers, necessary in both transmit and receive portions (together, a transceiver) of an RF device, were a target for such reuse. EX1003, ¶31 (citing EX1005; EX1008-EX1009; EX1011; EX1021). Amplifiers have a core amplifying device, typically a transistor, providing gain, and passives (resistors, capacitors, inductors) arranged in a network to provide biasing and matching for inputs and outputs of the core amplifying device. EX1003, ¶¶32-35.

There was a recognized need for packaging technologies to support good electrical performance in a small footprint. EX1003, ¶36. RF devices commonly used substrates having "low permittivity, interconnections made of high-conductive metals, high wiring density, and embedded passive circuit elements." EX1025, p. 2. A typical configuration of such a substrate is illustrated below.

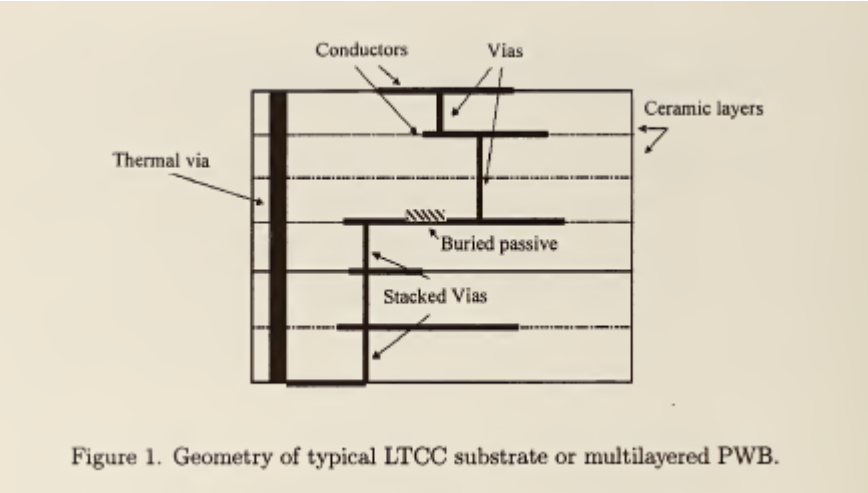


Figure 1. Geometry of typical LTCC substrate or multilayered PWB.

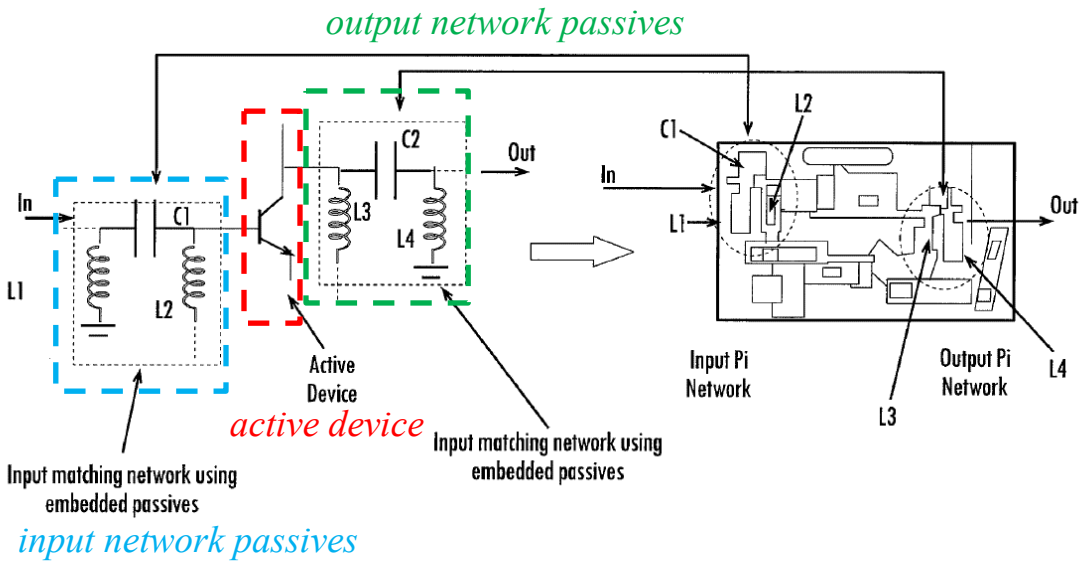
EX1025, p. 10

This illustration is a multilayer substrate formed by stacking or laminating multiple layers together where conductor patterns formed on the layers provide interconnections and "[b]uried" or "embedded passive circuit components." EX1003, ¶¶39-46 (citing EX1025; EX1012; EX1037; discussing embedded passives). Organic-based and ceramic-based substates were well-known options. EX1003, ¶46 (citing EX1024-EX1025; EX1012; EX1037).

V. SUMMARY OF THE '914 PATENT

The '914 Patent relates to RF transceivers operable at multiple RF bands, *i.e.*, multi-band transceivers, and suggests reuse of components at the different frequencies. EX1001, 1:23-27, 2:8-20. FIG. 35 illustrates a low-noise amplifier

(LNA) with an active device (a bipolar junction transistor) and matching networks at its input and output. EX1001, 24:10-27.[1]



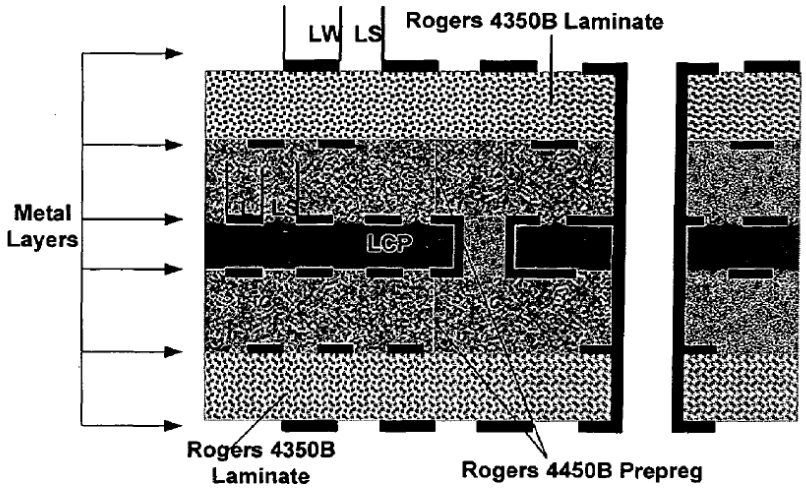
EX1001, FIG. 35 (annotated)

See also, EX1003, ¶¶47-52.

The '914 Patent describes embedded passives formed in an organic substrate to reduce the form factor of a module. EX1001, 24:38-46, 58-63. FIG. 38A illustrates six metal layers, where metal layers on each surface of a liquid crystal polymer (LCP) layer may contain passives such as inductors, while the additional metal layers on laminate or additional LCP layers may contain additional components or

[1] The label of network L3, L4, C2 should read "Output matching network." EX1003, ¶52.

function as ground shields. EX1001, 25:4-12.



EX1001, FIG. 38A

See also, EX1003, ¶¶53-54 (discussing conventional substrate material).

VI. PROSECUTION HISTORY

The Examiner rejected a subset of pending claims in a single action, which was overcome by Applicants' amendment, shown by claim 1's recitation of passive networks located at the input and "output of the active device."

1. (Currently Amended) A multi-band RF device operable at a first frequency and a second frequency different from the first frequency, comprising:

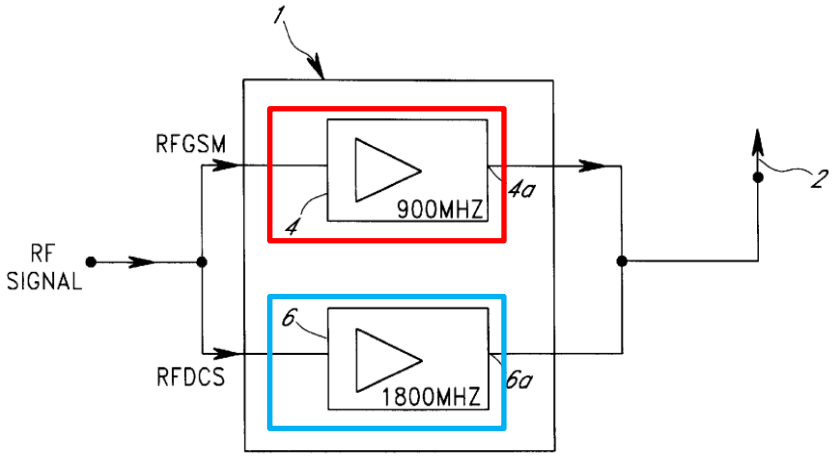
an active device;

a first passive network in communication with the active device, the first passive network comprising a first matching network at an input of the active device;

a second passive network in communication with the active device, the second passive network comprising a second matching network at an output of the active device; and

an organic-based substrate having at least two metal layers, wherein the two metal layers are patterned to form at least a portion of the first passive network and the second passive network, wherein impedances of the first and second passive networks are different at the first frequency than the second frequency.

EX1002, p. 45. In contrast, the relied-upon prior art (USP 6,075,995) had two separate amplifiers (4, 6), each operable at a different frequency and each with its own passive networks and active device. EX1002, pp. 57-58.



USP 6,075,995, FIG 1
(annotated)

See also, EX1003, ¶¶55-58.

VII. EFFECTIVE PRIORITY DATE OF THE '914 PATENT

The '914 Patent is based on an application filed April 25, 2005, which [1] claims priority to a Provisional application No. 60/565,254 ("Prov. '254") filed April 23, 2004, and [2] represents that it is a continuation-in-part (CIP) of Application No. 10/402,313 ("'313 Appl.") filed Mar. 28, 2003 (issued as USP 6,900,708). The first ([1]) priority claim is not at issue here. Petitioner will show the Challenged Claims are not entitled to priority of the CIP ([2]) because the '313 Appl. does not provide written description for the Challenged Claims.

Effective Filing Date: The Challenged Claims are, at best, only entitled to the effective filing date of the Prov. '254 (April 23, 2004).[2] This is the earliest possible date where a description of the *multi-band RF device* (claim 1) or the correlating *multi-band low noise amplifier for use in an RF application* (claim 5) having *an active device* configured as recited in the Challenged Claims is described. EX1003, ¶¶59-67.

[2] The written description support in the Prov. '254 is not challenged here as the relied upon prior art predates the Prov. '254 filing by at least one year. Petitioner maintains the right to challenge in other proceedings.

For a claim in a later-filed application to be entitled to the filing date of an earlier application, the earlier application must provide written description support for the claimed subject matter. *Anascape, Ltd. v. Nintendo of Am. Inc.*, 601 F.3d 1333, 1337 (Fed. Cir. 2010). To satisfy the written description requirement, "the disclosure of the earlier application, the parent, must reasonably convey to one of skill in the art that the inventor possessed the later-claimed subject matter at the time the parent application was filed." *Tronzo v. Biomet, Inc*., 156 F.3d 1154, 1158 (Fed. Cir. 1998).

As confirmed by Dr. Shoemake, no written description exists in the '313 Appl. for *a multi-band RF device* including *an active device* as recited in independent claim 1 or *a multi-band low noise amplifier for use in an RF application* including an *active device* as recited in independent claim 5. EX1003, ¶¶59-67. The '313 Appl. is entitled "Integrated **passive** devices fabricated utilizing multi-layer, organic laminates" and is directed to dielectric filters. EX1040, p. 4. These filters do not include *an active device*. EX1003, ¶¶62-63. Filter circuit diagrams (FIGS. 1A and 1B) form the basis of the discussion in the '313 Appl.; each shows a dielectric bandpass filter 10/110 made up of only passive components (*e.g.*, inductors 12, 14, capacitor 16, 18 or inductors 112). *Id*; EX1040, pp. 1-13, 41.

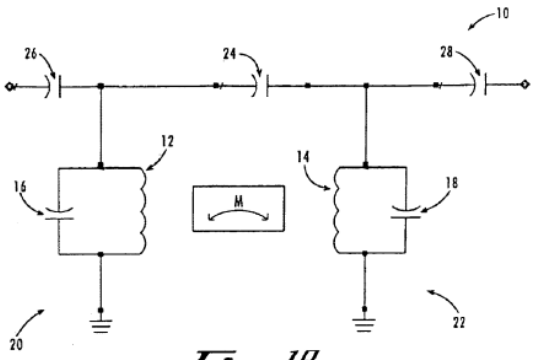


Fig. 1A

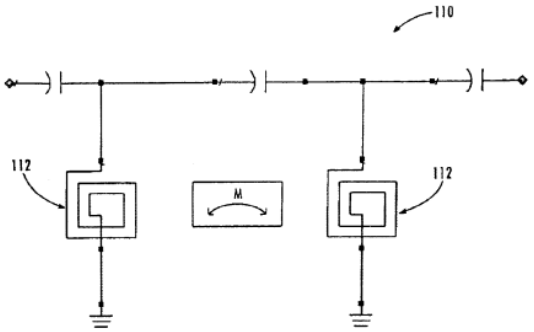


Fig. 1B

EX1037, p. 41

There is no written description (express, implicit, or inherent) of an *active device* as claimed in the '914 Patent. *Id*. Notably, '914 Patent's FIG. 35, which is labeled an LNA, is not in the '313 Appl. Moreover, there is no written description (express, implicit, or inherent) in the '313 Appl. of a multi-band device, multi-band operation, or multi-frequency resonant circuits providing for operation at multiple frequencies. *Id*. The '313 Appl. discusses just the opposite, a filter having a single center frequency. EX1003, ¶63 (explaining "Bluetooth/WLAN filter" operates at a single frequency of 2.4 GHz).

Dr. Shoemake has also reviewed the applications purportedly incorporated by

reference in the ’313 Appl. and confirmed these materials do not provide written description support for the Challenged Claims of the ’914 Patent. EX1003, ¶¶64-67. These materials are again directed to passives. *Id*. To any extent these materials mention an active device or component that may include an active device, the disclosures lack written description of a *multi-band* configuration or operation of such a device. *Id*. Additionally, the ’313 Appl.’s incorporation by reference lacks any particularity. “To incorporate material by reference, the host document must identify with **detailed particularity** what specific material it incorporates and clearly indicate where that material is found in the various documents.” *Zenon Envtl., Inc. v. U.S. Filter Corp*., 506 F.3d 1370, 1378-1379 (Fed. Cir. 2007) (quoting *Cook Biotech Inc. v. Acell, Inc*., 460 F.3d 1365, 1376 (Fed. Cir. 2006)).

For the reasons summarized above and as further detailed by Dr. Shoemake (EX1003, ¶¶59-67), the Challenged Claims are not entitled to priority of the ’313 Appl. and have an effective filing date of no earlier than April 23, 2004.

VIII. LEVEL OF ORDINARY SKILL IN THE ART

Persons of Ordinary Skill in The Art (“POSITA”) in April 2004 would have had a working knowledge of RF communications that is pertinent to the ’914 Patent, including RF transceivers. POSITA would have had a bachelor’s degree in electrical engineering or an equivalent, and three years of professional experience relating to

communication systems. Additional education, such as a master's or doctorate degree, can substitute for professional experience. EX1003, ¶¶16-18.

IX. CLAIM CONSTRUCTION

Claim terms in IPR are construed according to their "ordinary and customary meaning" to those of skill in the art. 37 C.F.R. §42.100(b). Petitioner submits that, for the purposes of this proceeding and the grounds presented herein, no claim term requires express construction. *Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). *See also*, EX1003, ¶¶68-69.

X. RELIEF REQUESTED AND THE REASONS FOR THE REQUESTED RELIEF

Petitioner requests institution of trial for *inter partes* review and cancelation of the Challenged Claims in view of the analysis below.

XI. IDENTIFICATION OF HOW THE CLAIMS ARE UNPATENTABLE

A. Challenged Claims

Petitioner challenges claims 1-2 and 4-20 ("Challenged Claims"). Patent Owner has relied upon these claims in its complaint ("[a]ll the elements of **at least** claims 1, 2, 11[-]16 of the '914 Patent.") *See* EX1035, p. 38. A finding that the Challenged Claims are unpatentable in this proceeding will resolve the parties' dispute in the co-pending litigation and obviate any need for a trial regarding the

'914 Patent, substantially reducing the time and expense of that litigation for all parties.

B. Statutory grounds for challenges[3]

Grounds	Claims	**Basis** (Pre-AIA)
#1	1-2 and 4-20	35 U.S.C. §103(a) over Yeh and Dalmia
#2	1-2 and 4-20	35 U.S.C. §103(a) over Dalmia and Hashemi

- U.S. Patent No. 5,995,814 was filed June 13, 1997 and issued November 30, 1999 (EX1009, "Yeh"); qualifies as prior art under 35 U.S.C. §102(b).
- "Design and Implementation of High-Q Passive Devices for Wireless Applications Using System-On-Package (SOP) Based Organic Technologies," Sidharth Dalmia, published at least March 31, 2003 ("Dalmia," EX1010); qualifies as prior art under 35 U.S.C. §102(b) to the earliest effective filing date of April 23, 2004. *See also*, EX1038, ¶¶1-49, 58-67; EX1039, pp. 1-4.
- "Concurrent Multiband Low-Noise Amplifiers—Theory, Design, and Applications," January 2002 ("Hashemi," EX1011); qualifies as prior art under 35 U.S.C. §102(b). *See also*, EX1038, ¶¶1-57, 65-67.

[3] Petitioner relies on the combined teachings of the references and not on a physical incorporation of elements. *See In re Mouttet*, 686 F.3d 1322, 1332 (Fed. Cir. 2012).

Additional cited prior art evidences background knowledge of POSITA and provides context to what POSITA would have understood from the prior art in the grounds. *See Yeda Research v. Mylan Pharm. Inc.*, 906 F.3d 1031, 1041-1042 (Fed. Cir. 2018). *See also*, EX1003, ¶¶70-73.

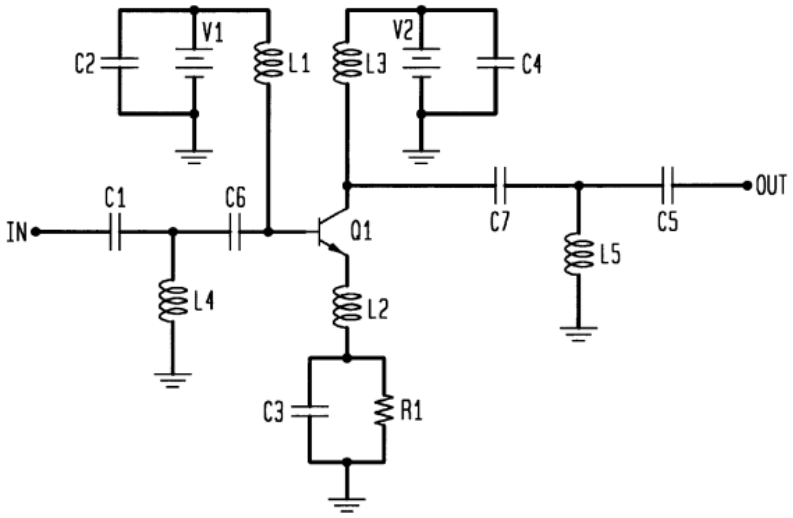
C. Ground 1

1. Yeh

Yeh recognizes the desire for mobile telephones and other wireless communication services to operate in more than one frequency band. EX1009, 1:13-28. "In order to minimize the cost and complexity of the front end radio-frequency (RF) circuitry in these multi-band portable terminals, it would be highly desirable to provide a single low-noise amplifier at the front end that can, for example, amplify both the 900 MHz and 1.8 GHz frequency bands." EX1009, 1:29-34.

Given this desire, Yeh provides "a simple and inexpensive low-noise amplifier which can provide excellent performance in two or more frequency bands…[where] input and output matching networks are used to provide respective input and output matches for the amplifier" in these frequency bands. EX1009, 1:66-2:4. FIG. 1 provides a schematic diagram illustrating a low-noise amplifier ("LNA") having an input terminal IN, a transistor Q1 providing a gain, and an output terminal OUT; FIG. 5 provides the same amplifier with additional elements of its input and output matching networks illustrated. EX1009, 6:1-42 (input matching network

including C1, L4, C6, L1; output matching network including C5, L5, C7, L3).



EX1009, FIG. 5

"The input and output matching networks thus each utilize four elements to provide narrowband matches at 900 MHz and 1.8 GHz, with certain elements of the matching networks also serving DC isolation and bias functions." EX1009, 6:43-47. *See also*, EX1003, ¶¶74-75.

2. Dalmia

Dalmia is an academic Thesis presented by Sidharth Dalmia, a named inventor of the '914 Patent. Dalmia was not cited in the '914 Patent prosecution. *See* EX1001, (56). As indicated in EX1039 (declaration of H. Stewart, ProQuest), Dalmia's full text was loaded into searchable ProQuest® Digital Dissertations and

Theses database (PQDT) and publicly available as of March 31, 2003. EX1039, pp. 1-4 (including text searching (p. 2) and availability details of Dalmia (p. 3)). The declaration of Dr. Hall-Ellis also confirms the public availability of Dalmia by the end of March 2003 as "received, cataloged, and indexed at the Georgia Institute of Technology Library, placed in the custody of [University Microfilms] UMI, and made part of the OCLC bibliographic database." EX1038, ¶¶11-49, 58-67 (including Attachments). Thus, Dr. Hall-Ellis opines that "EX1010 was published and accessible to the public no later than March 6, 2003" and that POSITA would have had access to the document. EX1038, ¶64. Dr. Shoemake confirms that dissertations were a typical reference consulted by POSITA, as well ProQuest being a typical resource used by POSITA in searching for and identifying teachings in the art. EX1003, ¶¶76-79; *see also*, EX1038, ¶¶11-49, 58-67.

Thus, because the '914 Patent is entitled to a priority date no earlier than April 23, 2004, Dalmia is prior art under (pre-AIA) 35 U.S.C. §102(b). Dalmia is a prior art reference published, publicly available, and readily accessible to be located by POSITA exercising reasonable diligence as discussed above. *See* EX1039; EX1038 (declarations on availability).

Dalmia recognizes "[d]iscrete passive components such as inductors, resistors, capacitors, filters, and resonators currently dominate the component count in most RF…products…[and] the cost of all the components on total product cost

can be significant." EX1010, p. 3. "A method for eliminating the surface mount discrete components is by embedding the passive components into the layers of the package or board as shown in Figure 1.1 [below,]" and Dalmia enumerates the numerous benefits of such integration of passive components. EX1010, p. 4.

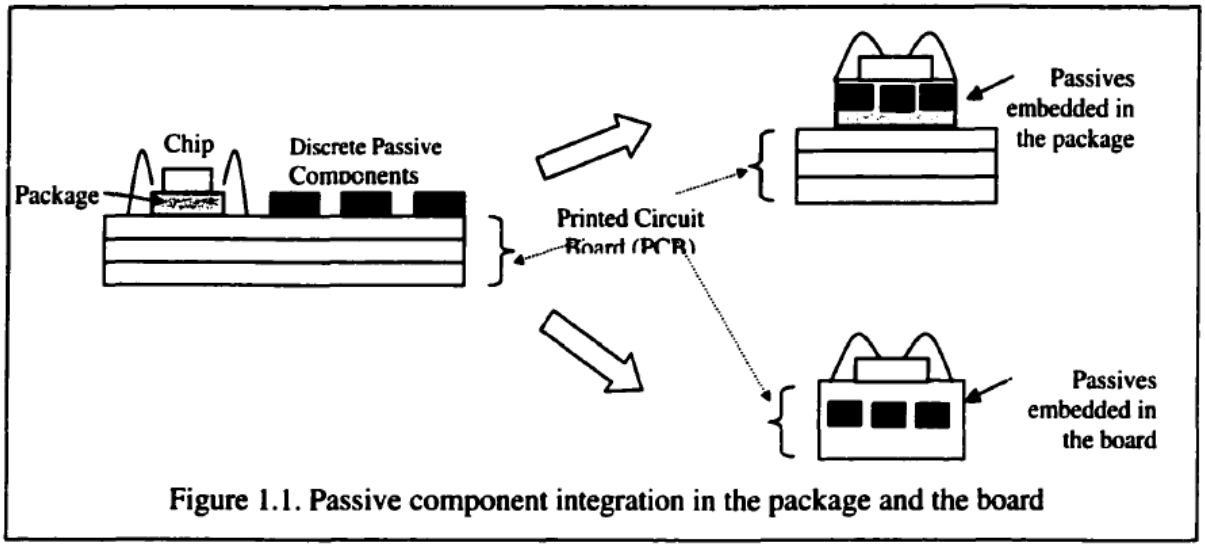


Figure 1.1. Passive component integration in the package and the board

EX1010, p. 4.

Dalmia recognizes embedding passive components had been implemented on various substrate types including ceramic, dielectric films deposited on a base substrate, and a "current technology of choice—a laminated, organic substrate—each substrate type having respective trade-offs in their implementation. EX1010, pp. 12-16.

The laminated, organic substrate provides for layers of organic dielectrics (with conductors formed thereon) laminated together. EX1010, pp. 12-15, Appendix

A. Dalmia discusses the implementation of embedding passive components for RF applications including suggesting its use for an amplifier. "The work done in this chapter shows the feasibility of using embedded inductors and capacitors such as those fabricated in previous chapters for their use in LNA and oscillator applications using organic technology." EX1010, p. 133. Fig. 6.4[4] is illustrative of such an LNA where "[t]he input and output of the transistor are matched [] by using L-C 'pi' networks, which are entirely embedded in the package[.]" EX1010, pp. 136-137.

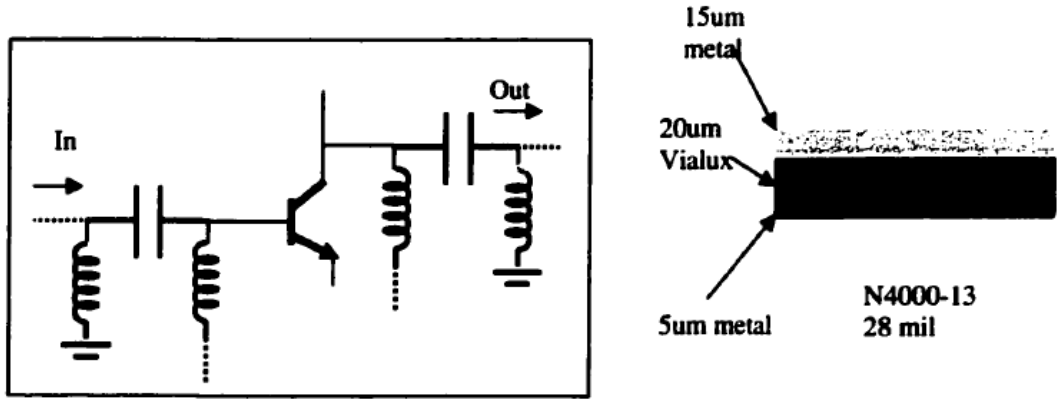


Fig 6.4. a) Integrated LNA, with impedance transformation networks
b) Cross-section of testbed

EX1010, p. 137

[4] Vialux™ is an epoxy-glass composite that is an organic-based substrate. *See* EX1010, pp. 12-13, 15.

3. Reasons to Combine Yeh and Dalmia

POSITA would have been motivated to combine the teachings of Yeh's low-noise amplifier and passives (capacitors and inductors of its matching networks) with Dalmia's technique of providing a module including passives embedded in an organic-based multilayer substrate. EX1003, ¶¶80-100. In particular, POSITA would have been motivated to combine the teachings of Yeh and Dalmia to produce the obvious, beneficial, and predictable results of utilizing Dalmia's substrate with embedded passives to form a module implementing Yeh's amplifier circuit as discussed below. *Id*.

Yeh and Dalmia are analogous art to the '914 Patent because they are in the same field of endeavor, pertaining to the transmit and receive functionality of RF communication devices such as personal mobile phones. EX1003, ¶81; EX1001, 1:29-47; EX1009, 1:5-10; EX1010, xviii. In particular, each of Yeh, Dalmia and the '914 Patent are directed to configurations of an amplifier component of such an RF device. EX1001, 2:14-16; EX1009, 1:5-10; EX1010, xviii, Chapter VI, 6.1-6.2. Further, Yeh and Dalmia are analogous art because each is directed to a same problem faced by the '914 Patent's inventor—decreasing the size of RF devices. EX1010, pp. 3-4 ("[r]eduction in circuit board area"); EX1009, 1:50-56; EX1001, 1:58-62.

Yeh suggests limiting inductance/capacitance values of its passives in some

embodiments to "facilitate possible monolithic integration with the bipolar transistor." EX1009, 2:30-34. POSITA would have understood monolithic to suggest passives on a semiconductor (silicon) substrate (integrated on-chip) with the transistor. EX1003, ¶82. However, Dalmia cautions against this monolithic integration, recognizing "a purely monolithic approach can involve too many performance compromises[.]" EX1010, p. 1. In particular, losses in the silicon substrate and the thin metallization used in forming the chip limit the performance of inductors and capacitors. EX1010, pp. 5-6, pp. 131-132 (LNA with passives within package substrate that improves performance over on-chip integration). Moreover, a "primary disadvantage" of on-chip integration "is that passive devices such as inductors consume a major part of the expensive silicon area." EX1010, p. 5. These disadvantages were well-recognized by POSITA. EX1003, ¶¶82-85 (explaining quality factor (Q) impact of losses of passives impacted by surrounding material, discussing substrate costs citing EX1012).

Second, understanding the drawbacks of passives on a silicon substrate, POSITA would have been motivated to implement Yeh's amplifier using Dalmia's package substrate and its teachings of embedding passives within that substrate. EX1003, ¶¶86-92. Dalmia details numerous benefits of such a configuration. EX1010, p. 4 (reducing costs, reducing inventory, board area, weight, increasing reliability, and enhancing ease of design). POSITA would have recognized benefits

of embedding passive components. EX1003, ¶¶86-89 (tolerances for discrete component placement, package and I/O package type variations (*i.e.*, parasitics, resistance) in discrete components citing EX1027, reliability, quality). POSITA would have also recognized that use of suitable dielectric materials (*e.g.*, with low loss tangent) found in Dalmia's substrate was desirable to limit signal distortion and/or loss. EX1003, ¶¶88-92.

Third, it would have been obvious to implement Dalmia's teachings of a package substrate as a laminated, organic substrate, which it refers to as MCM-L technology, because Dalmia recognizes this was "currently the technology of choice." EX1010, p. 12. As such, it is merely an obvious application of a "prevalent, perhaps even predominant method" of performing a given task in the art. EX1003, ¶¶93-95; *see also, Randall Mfg. v. Rea*, 733 F.3d 1355, 1356 (Fed. Cir. 2013). Dalmia also recognizes numerous benefits of this technology including a low material cost and "organic/polymer dielectrics offer the benefits of low dielectric constant [], leading to higher signal propagation speeds[.]" EX1010, p. 13. POSITA would have recognized use of low dielectric polymers as taught by Dalmia is well-suited for applications including high-frequency devices. EX1003, ¶¶36-46, 90-99 (permittivity and RF application).

In particular**,** Dalmia recognizes benefits of "[a] new breed of polymer laminate dielectrics are emerging to fill the gap between low-cost epoxy dielectrics

and high-end, expensive materials like polytetrafluoroethylene (PTFE). These include polyphenyl ether (PPE) based materials, **liquid crystalline polymers (LCP)**, and lower cost polymer and ceramic filled composites." EX1010, p. 14. Dalmia suggests performance benefits regarding the Q factor for passives when using Zyvex™, an LCP material, are greater than other available materials such as ceramic. EX1010, p. 15 (low loss).

In summary, POSITA would have been motivated to apply Dalmia's teachings when implementing Yeh's amplifier (Yeh-Dalmia) because doing so would beneficially (1) minimize performance compromises by avoiding formation on a silicon substrate, (2) provide benefits with respect to electrical performance (e.g., Q factor), (3) achieve system-level efficiencies from embedding passive components in a package substrate, and (4) implement a common, cost-effective technology. EX1003, ¶¶80-96.

The results of combining Yeh's device with Dalmia's substrate would have been predictable, and POSITA would have had reasonable expectations of success given both Yeh and Dalmia relate to substantially similar device types performing the substantially same function. EX1003, ¶¶97-99 (describing each as amplifier with transistor and matching circuits and comparing EX1009, FIG. 5; EX1010, Chapter VI including Fig. 6.4). Dalmia promotes very high-Q "embedded inductors [and capacitors] in epoxy based organic substrates" including those "for RF

communication standards such as GSM (900 MHz and 1800 MHz).” EX1010, pp. 30-31. These are the passives and operational frequencies of Yeh. Moreover, such a substrate configuration was common practice for RF devices. EX1003, ¶¶98-99 (citing EX1025; EX1029; EX1012; EX1037 illustrating organic substrate with embedded passives).

Dalmia illustrates a “test bed” (Fig. 6.4b) including two metal layers and a dielectric layer. EX1010, p. 137. POSITA would understand the circuit architecture of Fig. 6.4a could be readily implemented using a substantially similar substrate having any number layers, including, for example, that of Dalmia’s Fig. 3.14. EX1003, ¶100 (explaining that additional layers provide for further vertical integration and routing path options). Adding layers is mere duplication of parts. *See in re Harza*, 274 F.2d 669 (CCPA 1960).

4. Claim 1

[1.0] ***A multi-band RF device operable at a first frequency and a second frequency different from the first frequency, comprising:***

Yeh discloses the preamble to the extent it is limiting. EX1003, ¶¶101-110.

Yeh “relates generally to **electronic circuits for use in wireless communication systems**, and more particularly to a **low-noise amplifier** which is capable of operation in **multiple frequency bands**, such as the 900 MHz and 1.8 GHz bands of a personal communication services (PCS) wireless system.” EX1009,

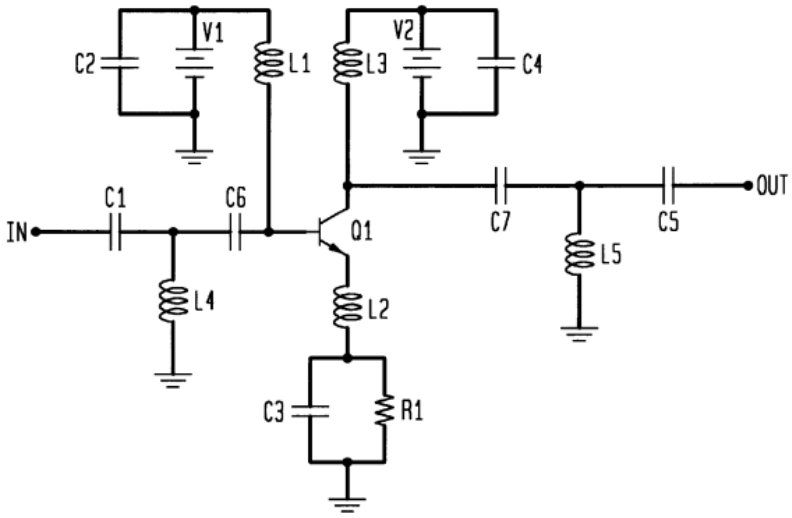
1:5-10. *See also*, EX1009, Abstract.

Yeh's low-noise amplifier constitutes a *multi-band RF device*, because the amplifier receives and provides gain to a signal in two or more different operating radio frequency (RF) bands, exemplified by 900 MHz and 1.8 GHz. EX1009, 1:24-2:40, 5:31-46, 9:14-10:32. In particular, "FIG. 5 shows the low-noise amplifier of FIG. 1 with illustrative input and output matching networks...These matching networks each utilize a set of four elements to provide narrowband matches for **both the 900 MHz and 1.8 GHz frequency bands**." EX1009, 5:32-36.[5] The dual-band functionality of the amplifier is also illustrated in Yeh's FIGS. 2-4, which show the amplifier's performance for multiple bands, while "suppress[ing] the gain outside these frequency bands." EX1009, 5:6-31; EX1003, ¶¶104-107 (explaining FIGS. 2-4; EX1022 defining RF).

Thus, Yeh's amplifier in FIG. 5 is a *multi-band RF device*, including an active device and input and output matching networks discussed in the following elements.

[5] FIG. 1 shows the amplifier (FIG. 5) "without input and output matching networks." EX1009, 1:60-62.

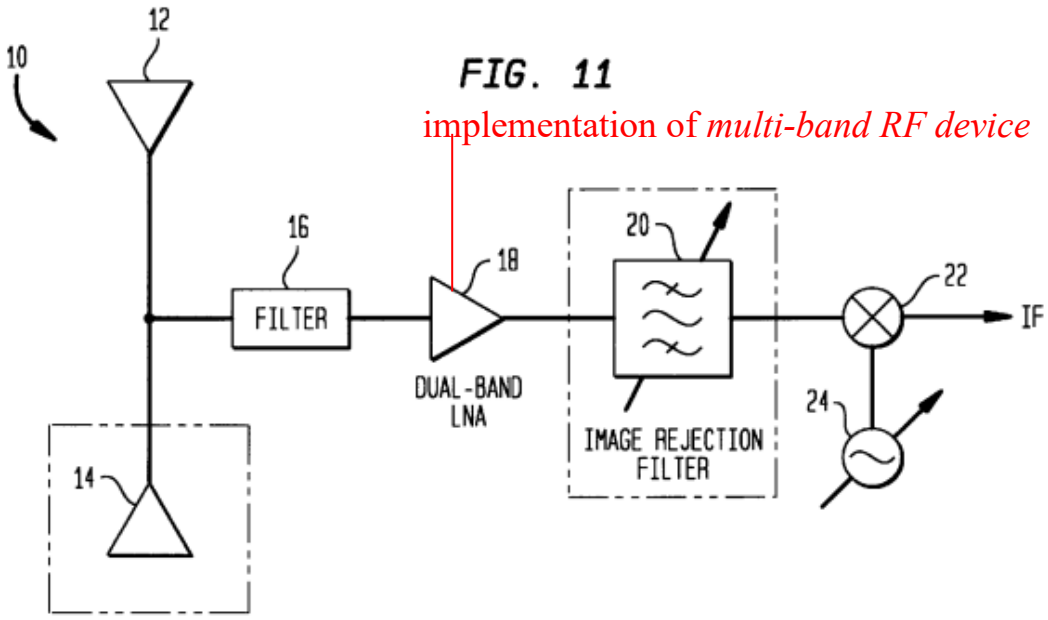
multi-band RF device



EX1009, FIG. 5
(annotated)

Frequency bands 900 MHz and 1.8 GHz provide examples of a *first frequency* and a *second frequency* respectively, the second frequency *different from the first frequency*. However, Yeh's *first frequency* and *second frequency* are not limited to these particular bands. EX1009, 3:24-57.

A receiver 10 of FIG. 11 receives and downconverts signals in two different bands by providing antennas for each of a *first frequency* (*e.g.*, 900 MHz), and a *second frequency*, (*e.g.*, 1.8 GHz). EX1009, 9:14-21. FIG. 5's amplifier, the *multi-band RF device*, is suggested for implementation as amplifier 18. EX1009, 9:29-31.



EX1009, FIG. 11
(annotated)

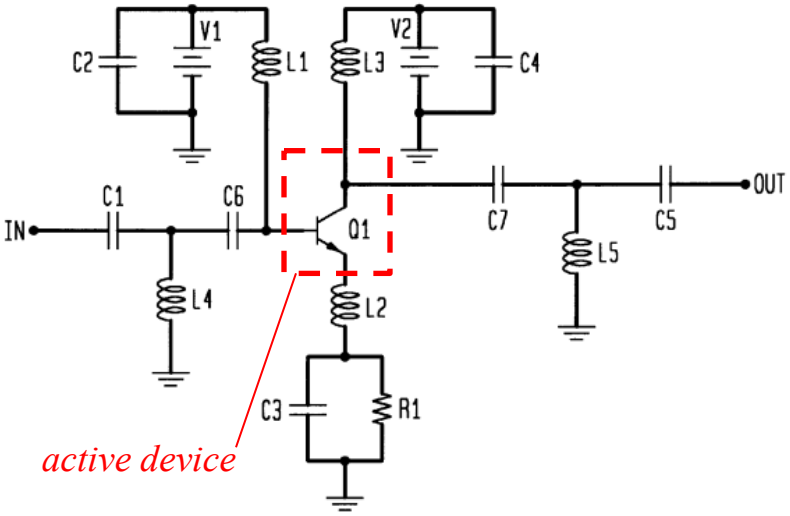
Thus, Yeh discloses the *multi-band RF device* of [1.0]. EX1003, ¶¶101-110.

[1.1] ***an active device;***

Yeh's amplifier is a *multi-band RF device* ([1.0]) including a transistor Q1, which is *an active device*. EX1003, ¶¶111-116. "The low-noise amplifier includes a single amplification stage [of] an n-p-n bipolar junction **transistor Q1**…other suitable transistors, including…field effect transistors (FETs)…could also be used for transistor Q1[.]" EX1009, 3:64-66. Yeh's suggested *active device* configurations—bipolar junction transistor (BJT) or FET—are the same as in the '914 Patent. *See* EX1001, 27:1-21.

multi-band RF device

FIG. 5

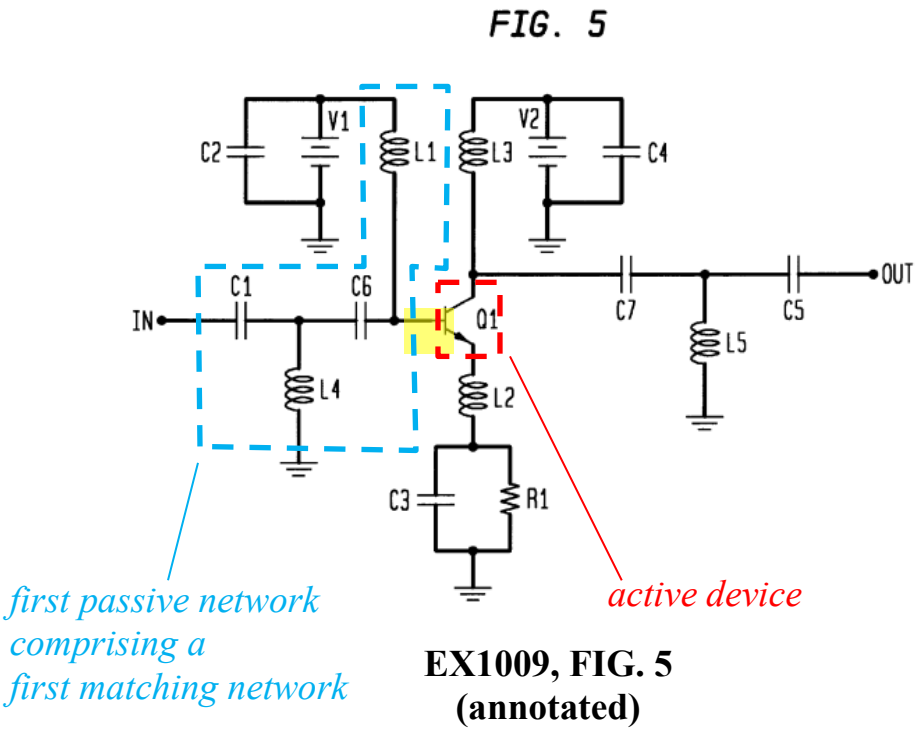


EX1009, FIG. 5
(annotated)

Thus, Yeh discloses *an active device* of [1.1]. EX1003, ¶¶111-116.

[1.2] ***a first passive network in communication with the active device, the first passive network comprising a first matching network at an input of the active device;***

Yeh's *multi-band RF device* of FIG. 5 includes *a first passive network* as recited in this element. EX1003, ¶¶117-128. In particular, passives including capacitors C1, C6 and inductors L1, L4 and their interconnections provide a *first passive network*. EX1009, 4:14-31, 6:1-47.



EX1009, FIG. 5 (annotated)

EX1003, ¶118.

Yeh describes this *first passive network* includes[6] *a first matching network*. "FIG. 5 shows the low-noise amplifier [] with illustrative **input** and output **matching networks** in accordance with the invention. These **matching networks** each utilize

[6] The claim term does not require constituents other than a *first matching circuit*. Nonetheless, if PO alleges an additional circuit/element is necessary, POSITA would have recognized that inductor L1 (and thus the *first passive network*) also participates in a larger biasing circuit. EX1003, ¶119; EX1009, 6:43-47.

a set of **four elements** to provide narrowband matches for both the 900 MHz and 1.8 GHz frequency bands." EX1009, 5:32-36. "The **input matching network** includes **capacitors C1 and C6, and inductors L1 and L4**…This embodiment utilizes a set of four elements for the matching networks of both input and output because two frequencies need to be matched." EX1009, 6:2-8; EX1003, ¶119 (matching refers to impedance matching).

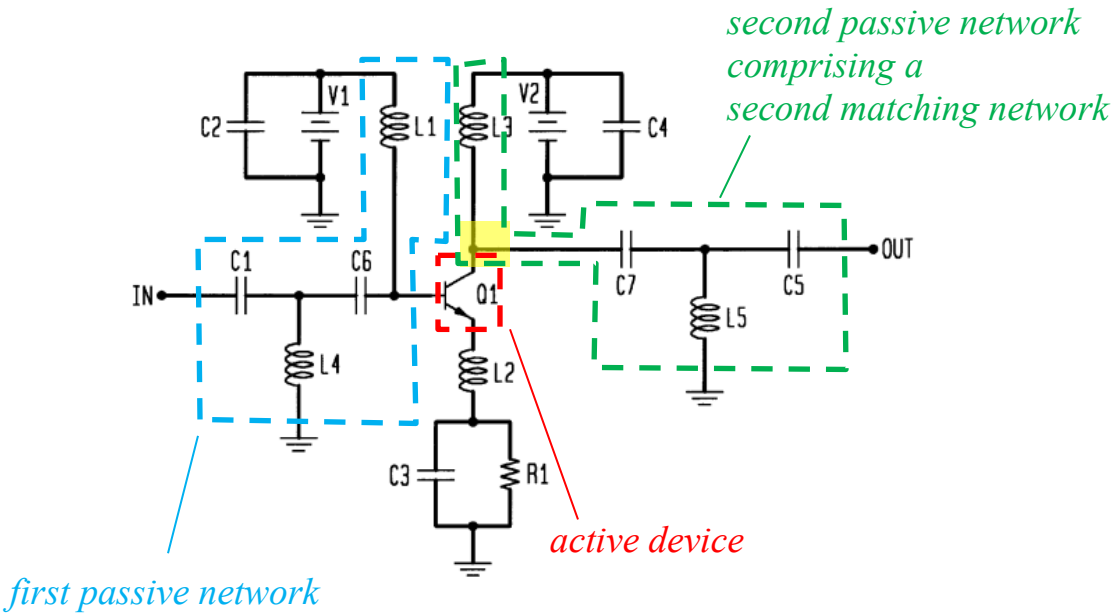
The *first passive network* is *in communication* with transistor Q1, the *active device*, and the *first matching network* of the *first passive network* (passives C1, C6, L1, L4) is *at an input of the* transistor Q1, *active device*. This is illustrated by the schematic of FIG. 5, by Yeh's description of the passive components as an "**input** matching network," and POSITA's understanding of the passive network's function in the context of the amplifier. EX1003, ¶¶120-127. Yeh describes passives of the *first passive network/first matching network* (including C1, L1) are connected to and *in communication* with its active device transistor Q1. EX1009, 4:14-20 ("an **input series capacitor C1 connected between an input terminal IN of the amplifier and the base terminal of transistor Q1** [*active device*]…**The base of Q1** [*active device*] **is connected via an inductor L1**..."); 6:18-25 ("[T]he DC bias for the **base of Q1 [active device]** is provided through **inductor L1 of the input matching network**…DC isolation for the amplifier input is provided using **capacitor C1 of the input matching network**[.]"). Yeh also recognizes "[t]he **input** and output

matching networks thus each utilize four elements to provide narrowband matches at 900 MHz and 1.8 GHz, with certain elements of the matching networks also **serving DC isolation and bias functions**." EX1009, 6:43-47. POSITA would recognize DC isolation and bias are functions associated with *communication* with the transistor Q1. EX1003, ¶121.

Thus, Yeh discloses the *first passive network* of [1.2]. EX1003, ¶¶117-128.

[1.3] ***a second passive network in communication with the active device, the second passive network comprising a second matching network at an output of the active device; and***

Yeh discloses its *RF multi-band device* ([1.0]) also includes a *second passive network*. EX1003, ¶¶129-137. Passive components of capacitors C5, C7 and inductors L3, L5 and their interconnections provide a *second passive network*. EX1009, 4:22-48, 6:4-47.



EX1009, FIG. 5
(annotated)

EX1003, ¶130.

Yeh describes its *second passive network* includes[7] *a second matching network*. "FIG. 5 shows the low-noise amplifier [] with…**output matching networks**…[using] a **set of four elements** to provide narrowband matches for both the 900 MHz and 1.8 GHz frequency bands." EX1009, 5:32-36. "The **output matching network** includes **capacitors C5 and C7, and inductors L3 and L5**.

[7] *See supra*, note 6. Inductor L3 (and thus the *second passive network*) also participates in a larger biasing circuit. EX1003, ¶131; EX1009, 6:43-47.

This embodiment utilizes a set of four elements for the matching networks of both input and output because two frequencies need to be matched." EX1009, 6:4-8. *See also*, EX1003, ¶131.

The *second passive network* is in *communication with the active device* (transistor Q1) and the *second matching network* (passives C5, C7, L3, L5) of the *second passive network* is *at an output of the* transistor Q1. This is illustrated by the schematic of FIG. 5, by Yeh's description of the passive components as an "**output** matching network," and POSITA's understanding of the passive network's function in the context of the amplifier. EX1003, ¶¶132-136. Yeh describes components of its *second passive network/second matching network* including passives C5, L3 are connected to and in *communication* with its *active device* transistor Q1. *See* EX1009, 4:38-40 ("[a]n output DC blocking capacitor C5 is **connected between the collector of transistor Q1** and an output terminal OUT of the amplifier."), 6:20-25 ("the **DC bias** for the collector of **Q1** is **provided through inductor L3** of the output matching network…DC isolation for the amplifier output is provided using capacitor C5 of the output matching network.") Yeh also recognizes its "output matching network[] [uses] four elements to provide narrowband matches at 900 MHz and 1.8 GHz, with certain elements of the matching networks also serving **DC isolation and bias functions**." EX1009, 6:43-47. POSITA would recognize DC isolation and bias are functions associated with *communication* with transistor Q1. EX1003, ¶¶133-

136.

Thus, Yeh discloses *the second passive network* of [1.3]. EX1003, ¶¶129-137.

[1.4a] ***an organic-based substrate having at least two metal layers, wherein the two metal layers are patterned to form at least a portion of the first passive network and the second passive network,***

Yeh in view of Dalmia (Yeh-Dalmia) renders obvious this element. EX1003, ¶¶138-148, 80-100. POSITA would have reason to implement Yeh's amplifier circuit on an *organic-based substrate* such as Dalmia's with embedded passives formed on patterned metal layers as discussed in Section XI.C.3.

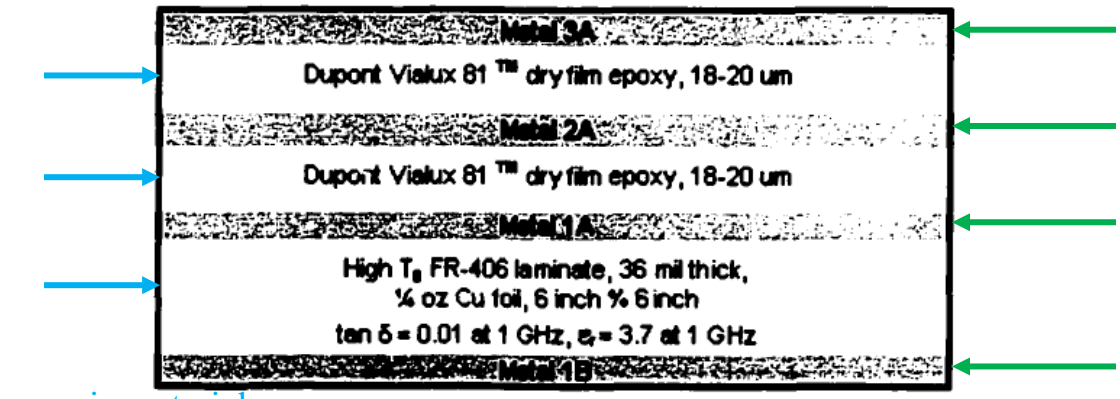
Dalmia describes an *organic-based substrate*, which it refers to as laminated multi-chip module (MCM-L), and which provides an RF device with its passives embedded in the substrate. *See* EX1010, p. xviii, pp. 3-4 (embedding passive components), pp. 12-16 (MCM-L), pp. 30-31 (MCM-L technology in RF devices including amplifiers). In particular, Dalmia's MCM-L substrate is an *organic-based substrate* with an organic core and a plurality of organic material laminates (layers) each with copper line patterns formed thereon to form a stack.

> A thick copper-cladded [] FR-4 **organic substrate (epoxy-glass fiber composite)** is used as the core laminate. Etching copper, which is **cladded on the laminates**…forms the **line patterns**. **Each copper level is insulated from the other using thin-film epoxy-glass composites**...**The layers of conductors and organic dielectrics are laminated together**...

EX1010, pp. 12-13. Recognition of "[e]ach copper level" indicates *at least two metal layers*. *See also*, EX1010, p. xviii ("multi-layer sequential build-up"); Figure 3.14 illustrating more than two metal layers (Metal 1B, 1A, 2A, 3A), Appendix A forming multiple copper layers.

Dalmia's Appendix A details forming such a substrate. EX1010, pp. 155-156 (describing "[t]he first conductor layer is then patterned…and a thin dielectric laminate dry film is laminated…to insulate the conductor layers [such as] DuPont's Vialux™, Asahi PPE™ and Rogers Zyvex™.") Dalmia's exemplary dielectric materials forming its substrate are organic. For example, Dalmia describes Rogers Zyvex™ as liquid crystal polymer (LCP) based, which is the same organic suggested by the '914 Patent. *See* EX1001, 2:18-20, claim 11. The '914 Patent confirms Dalmia's PPE and DuPont's Vialux™ are "organic dielectric substrate" materials. EX1001, *e.g.*, 11:1-2, 15:17-21.

Dalmia's Figure 3.14 provides an exemplary multi-layer substrate cross-section, where shaded areas represent *at least two metal layers* (metal 1A-metal 3A) and each of Vialux and FR-406 are *organic* materials. EX1010, pp. 12.



EX1010, p. 12 (annotated)

EX1003, ¶¶140-145. Dalmia uses the patterned copper layers (*the two metal layers*) to provide "embedded passives such as inductors, capacitors, filters and resonators." EX1010, p. xviii. *See also*, e.g., EX1010 (system-on-package (p. 2), embedded passives (pp. 3-5 and Figure 1.1)).

POSITA would have been motivated to *form at least a portion of the first passive network and the second passive network* of Yeh's amplifier using the patterned copper layers of Dalmia's substrate as this is just what Dalmia teaches. EX1003, ¶¶146-147. Like Yeh, Dalmia describes an LNA with passive matching networks at the input and output of a transistor including "high Q **embedded** inductors and capacitors." EX1010, pp. 136-140. These passive matching networks are "**entirely embedded** in the package[.]" *Id*. Embedded passives are those formed on multiple layers of laminated substrates (*at least two metal layers*). EX1003,

¶¶146-147 (citing EX1010, pp. 36, 66, 102, 156, illustrating multiple patterned metal layers and citing EX1006, EX1012, EX1026-EX1030, EX1037 illustrating common practice of defining embedded passives by patterned metal layers.)

Yeh in combination with Dalmia's teachings directed to organic substrate and formation of passive network on metal layers embedded in that substrate renders obvious [1.4a]. EX1003, ¶¶138-148.

[1.4b] ***wherein impedances of the first and second passive networks are different at the first frequency than the second frequency.***

Yeh discloses this element. EX1003, ¶¶149-162.

As discussed in [1.0]-[1.3], Yeh discloses a multi-band amplifier with *first and second passive networks* receiving and operating on signals of a *first frequency* and a *different*, *second frequency*. Thus, Yeh's passive networks perform the same function as suggested by '914 Patent—minimizing noise and maximizing power gain over multiple frequency bands. EX1003, ¶¶123-124, 151 (citing EX1009, Abstract 5:49-6:65 discussing gain and noise figure at operating in two bands). The *impedances* of these *first and second passive networks are different at the first frequency than the second frequency* as evidenced in multiple ways. EX1003, ¶¶149-162.

First, because signals at each of a first frequency and differing second frequency (*e.g.*, 900 MHz and 1.8 GHz) are provided to Yeh's passive networks and

because these passive networks are circuits comprising capacitors and inductors, POSITA would recognize the impedances of the passive networks are *different* at *first* and *second frequenc[ies]*. EX1003, ¶¶152-157 (impedance values for inductors and capacitors are a function of frequency). In particular, capacitors and inductors contribute to reactance of a circuit and that reactance is a frequency dependent component of impedance. *Id*. Thus, Yeh's *first passive network*, which includes capacitors and inductors, has a first impedance at a *first frequency* (*f1*) ([1.0]), *i.e.*, $\boldsymbol{Z}_A(f1)$ and has a second impedance at a *second frequency* (*f2*), *i.e.*, $\boldsymbol{Z}_A(f2)$ received by the network. *Id*. Similarly, Yeh's *second passive network*, which includes capacitors and inductors, has a first impedance at a *first frequency* (*f1*) ([1.0]), i.e., $\boldsymbol{Z}_B(f1)$ and a second impedance at a *second frequency* (*f2*), *i.e.*, $\boldsymbol{Z}_B(f2)$ received by the network. *Id*. (citing EX1014, 1:18-61 ("[m]atching circuits…transform the impedance" and "impedances of the components and the matching circuits are frequency dependent.")).

Second, Yeh recognizes its passives have a different impedance at the *first frequency* than at the *second frequency*. An embodiment of Yeh's FIG. 5 provides:

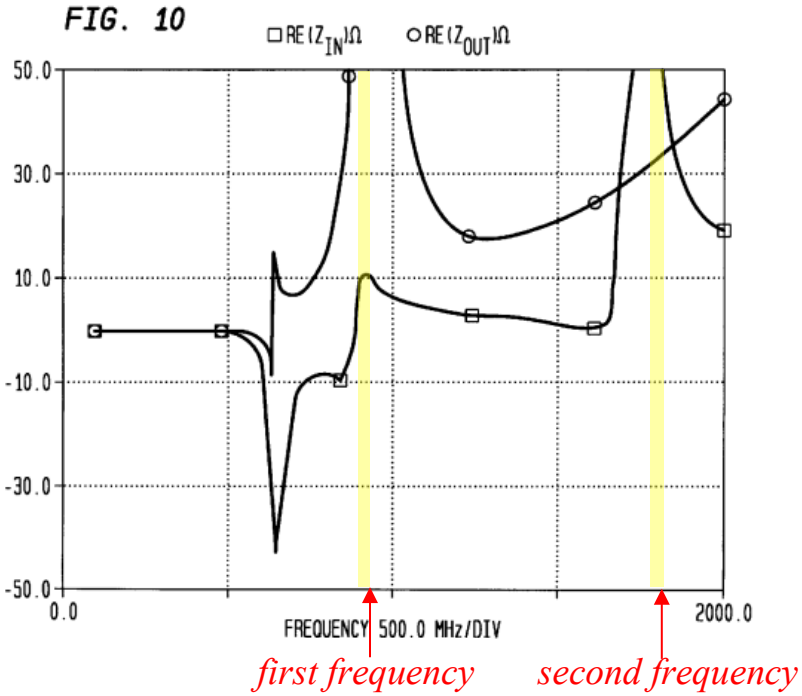
Element	Value	Z or Y at 900 MHz	Z or Y at 1.8 GHz
C1	9.07 pF	Z = –j 0.39	Z = –j 0.20
C6	3.69 pF	Z = –j 0.96	Z = –j 0.48
L1	7.60 nH	Y = –j 1.16	Y = –j 0.58
L4	4.79 nH	Y = –j 1.84	Y = –j 0.92

Input Matching Network

Element	Value	Z or Y at 900 MHz	Z or Y at 1.8 GHz
C5	0.80 pF	Z = –j 4.42	Z = –j 2.21
C7	1.46 pF	Z = –j 2.53	Z = –j 1.26
L3	8.16 nH	Y = –j 1.05	Y = –j 0.52
L5	10.0 nH	Y = –j 0.88	Y = –j 0.44

Output Matching Network

EX1009, 6:66-7:20 (annotated). These tables show the differing impedances (**Z**) of constituent elements (capacitors and inductors) at 900MHz and 1.8GHz, respectively. EX1003, ¶¶158-160 (noting Y, admittance, is 1/Z and frequency-dependent Z for individual elements results in frequency-dependent Z for a matching network). For example, as Yeh illustrates relative to FIG. 10, "the real parts of the input impedance Z_{IN} and the output impedance Z_{OUT} of the exemplary low-noise amplifier from about 100 MHz to 2.0 GHz" that the impedance is different at the first and second frequency. EX1009, 8:31-57.



EX1009, FIG. 10
(annotated)

EX1003, ¶¶159-160 (explaining Yeh's FIG. 10 shows the impedance of each network is different at the two frequencies, *e.g.*, a real part of impedance for the input matching circuit at 900 MHz is about 10Ω and at 1.8 GHz is more than 50Ω; a real part of the impedance for the output matching network at 900 MHz is more than 50Ω, and at 1.8 GHz is less than 50Ω). *See also*, EX1003, ¶161 (matching different impedances for each band to provide noise and gain performance benefits in context of Yeh's FIGS. 3-4).

Therefore, Yeh discloses [1.4b]. EX1003, ¶¶149-163.

Thus, Yeh's low-noise amplifier circuit in combination with Dalmia's

packaging technique renders obvious claim 1. EX1003, ¶¶74-163.

5. Claim 2

[2.0] ***The multi-band RF device of claim 1, wherein the first and second passive networks comprise resonant circuits, and wherein the impedances of the first and second networks comprise reactance.***

Yeh-Dalmia renders obvious claim 1, and Yeh discloses [2.0]. EX1003, ¶¶164-174.

As discussed at [1.2]-[1.3], Yeh provides *first* and *second passive networks*, each including inductors and capacitors. Inductors and capacitors are each *resonant circuit[]* components. EX1003, ¶¶165-171 (explaining a resonant circuit is one designed to oscillate and a typical resonant circuit includes an inductor and capacitor).

Similarly, Yeh's passive networks' impedances *comprise reactance*. EX1003, ¶¶172-173 (explaining reactance is the opposition alternating current flow due to the presence of inductance and capacitance). Yeh's passive networks of [1.2]-[1.3] include inductors and capacitors and thus *comprise reactance*. *Id*. (reactance of Yeh's Figs. 5-6 and matching reflection coefficient).

Thus, Yeh-Dalmia renders obvious claim 2. EX1003, ¶¶164-174.

6. Claim 4

[4.0] ***The multi-band RF device of claim 1, wherein the active device is a bipolar junction transistor and wherein the multiband device is a low noise amplifier operable for providing power gain at the first frequency and the second***

frequency.

Yeh-Dalmia renders obvious claim 1, and Yeh discloses [4.0]. EX1003, ¶¶175-178.

Yeh's *active device* ([1.1]) is "an n-p-n **bipolar junction transistor** Q1…configured in a chip package….Other suitable transistors, including but not limited to p-n-p **bipolar junction transistors**…could also be used for transistor Q1..." EX1009, 3:64-4:13. *See also*, EX1009, FIG. 5.

As shown in [1.0], Yeh's multi-band device is *a low noise amplifier* (EX1009, 3:1-3, 3:58-64) *operable at the first frequency and the second frequency*. This operation provides a *power gain* at each frequency as it provides a "narrowband match [for each frequency]…which provides a **desired gain**, noise figure or other performance measure over one band of an amplifier **operating in two or more bands**, while suppressing gain between the bands." EX1009, 3:49-53. *See also*, EX1009, 6:47-65 illustrating gain at multiple frequencies, 8:6-8 ("the gain is about 18 dB in the 900 MHz band and about 15 dB in the 1.8 GH band."). POSITA would understand "gain" in context of a low noise amplifier is *power gain*. EX1003, ¶177.

Thus, Yeh-Dalmia renders obvious claim 4. EX1003, ¶¶175-178.

7. Claim 11

[11.0] ***The multi-band R[F] device of claim 1, wherein the organic-based substrate comprises liquid crystalline polymer.***

Yeh-Dalmia renders obvious claim 1, and Dalmia discloses its organic-based substrate comprises *liquid crystalline polymer*. EX1003, ¶¶179-183.

As in [1.4a] and Section XI.C.3., POSITA would implement Yeh's *multi-band RF device* on Dalmia's *organic-based substrate*. "[L]iquid crystalline polymers (LCP)" are one of Dalmia's suggested organic materials. EX1010, p. 14.

Table 1.2. Common Low Dielectric Polymers and their Electrical Properties

Material	ε_r *(1 GHz)*	*Tanδ @ 1 GHz*
Dupont Vialux™(epoxy-glass based))	3.3-3.7	0.015-0.025
Asahi A-PPE™ (PPE based)	3.5	0.007
Rogers Zyvex™ (LCP based)	2.95	0.002
Polymer ceramic composites	10.75	0.08-0.1

EX1010, p. 15
Table 1.2 (Annotated).

Dalmia continues to describe benefits of Zyvex™, a commercially available LCP based material, including its low loss nature, quality factor for capacitors formed embedded therein, lower-cost, and desirable dielectric constant. EX1010, pp. 14-16. POSITA would have been motivated to employ Dalmia's LCP based material to obtain high quality (Q) passive devices for RF systems. EX1003, ¶181. LCP was a well-known choice for substrates. EX1003, ¶182 (EX1032-EX1033, EX1023 using LCP in substrates).

Thus, Yeh-Dalmia renders obvious claim 11. EX1003, ¶¶179-183.

8. Claim 12

[12.0] ***The multi-band R[F] device of claim 1, wherein the active device is a field effect transistor.***

Yeh-Dalmia renders obvious claim 1, and Yeh discloses [12.0]. EX1003, ¶¶184-187.

As in [1.1], Yeh describes a suitable transistor for its a*ctive device* is *a field effect transistor* (FET). EX1009, 4:1-13 ("…suitable transistors, including….field effect transistors (FETs)…"). The design choice between FET and BJT for LNAs was well known with known benefits. EX1003, ¶186 (lower cost FET processes and citing EX1017).

Thus, Yeh-Dalmia renders obvious claim 12. EX1003, ¶¶184-187.

9. Claim 13

[13.0] ***The multi-band RF device of claim 1, wherein the first passive network comprises a component embedded in the organic-based substrate.***

Yeh-Dalmia renders obvious claim 1 and limitation [13.0]. EX1003, ¶¶188-194.

As in [1.2], [1.4a], Dalmia describes an *organic-based substrate* having first passive matching network (including *components* such as capacitors and inductors) formed by patterned metal layers in the multi-layer *organic-based substrate*. The passives are *embedded* as they are defined in metal layer(s) positioned on dielectric,

organic layers, which are stacked to form the substrate; this is the same configuration as the '914 Patent.[8] Dalmia suggests an input matching network be "**entirely embedded** in the package[.]" EX1010, p. 136. Thus, POSITA would provide *a component* of Yeh's *first passive network*, which includes an input matching network ([1.2]), on a patterned metal layer *embedded* in Dalmia's organic-based substrate for the reasons discussed above. EX1003, ¶¶191, 139-147, 80-100. Further, embedding the components leads to numerous benefits such as assembly ease and cost and size. EX1010, p. 4.

[8] EX1001, 24:49-53 ("The term 'substrate'…consists of a **multilayer stackup**..."), 24:64-68 discussing multi-layer stackups.

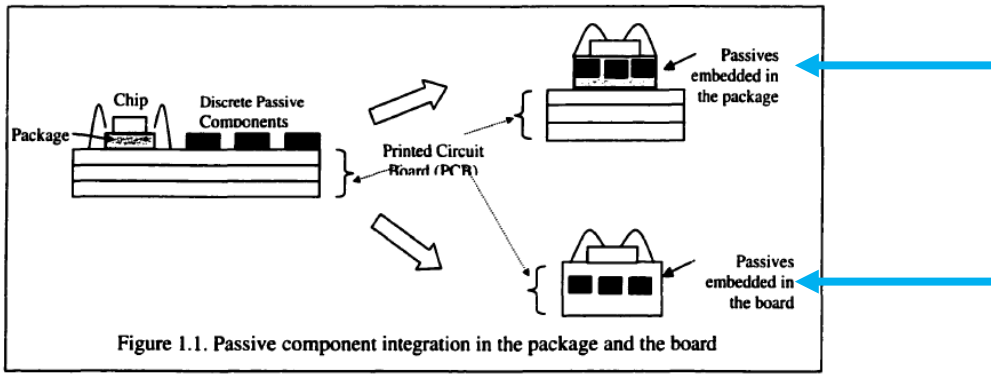


Figure 1.1. Passive component integration in the package and the board

example *embedded* metal layers patterned to form components (passives)

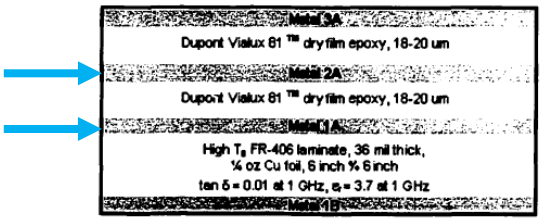


Figure 3.14 Cross-section for Multi-layer Substrate

EX1010, pp. 4, 66
(annotated)

EX1003, ¶192. This was a common technique for defining passives. EX1003, ¶193 (embedded passives citing EX1006, EX1012, EX1025, EX1029, EX1037).

Thus, Yeh-Dalmia render obvious claim 13. EX1003, ¶¶188-194.

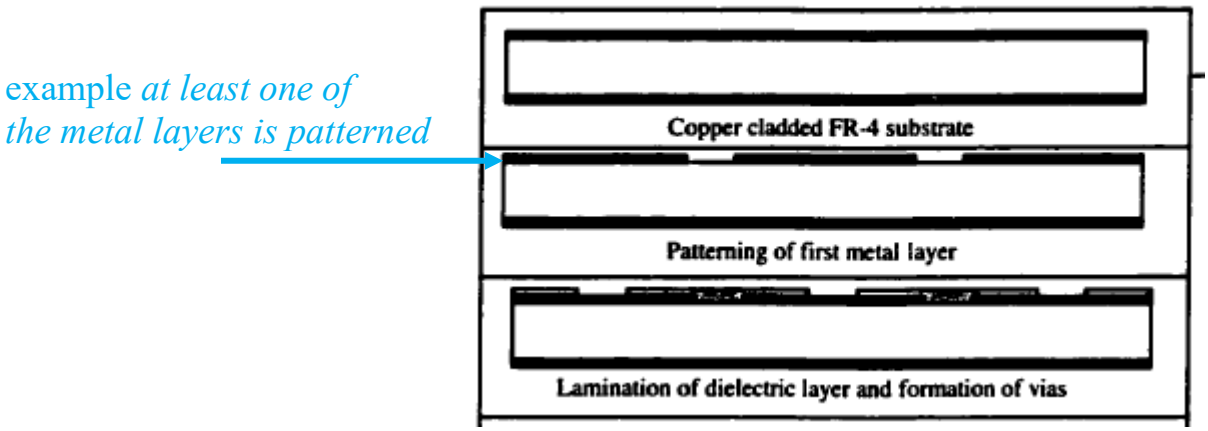
10. Claim 14

[14.0]*The multi-band R[F] device of claim 1, wherein at least one of the metal layers is patterned to form at least a portion of a component included in the first passive network.*

Yeh-Dalmia renders obvious claim 1 and [14.0]. EX1003, ¶¶195-197.

As in [1.4a] and [13.0], Dalmia describes a plurality of *patterned* copper layers (*metal layers*) within its multi-layer substrate that are *patterned to form*

passives, rendering obvious so-forming *a component included in the first passive network* of Yeh. In particular, Dalmia describes depositing metal (copper) and patterning the metal by etching "line **patterns**" to form components. EX1010, pp. 13, 66, Appendix A (pp. 155-156). Dalmia suggests the "entirety" of an input matching network is provided by such layers. EX1010, p. 136.



EX1010, p. 136 (portion)
(annotated)

Thus, POSITA would have been motivated to pattern at *least one of the metal* (copper) *layers* to *form at least a portion of a component* (*e.g.*, capacitor or inductor) of Yeh's similarly composed *first passive network* using Dalmia's technique. Claim 14 is therefore rendered obvious by Yeh-Dalmia. EX1003, ¶¶188-197, 80-100.

11. Claim 15

[15.0] ***The multi-band R[F] device of claim 1, wherein the second passive network comprises a component embedded in the organic-based substrate.***

Yeh-Dalmia renders obvious claim 1 and [15.0]. EX1003, ¶¶198-201.

As in [1.4a] and [13.0], Dalmia describes an *organic-based substrate* with embedded passives, such as capacitors or inductors of LNA matching networks. Dalmia suggests an output matching network be "**entirely embedded** in the package[.]" EX1010, p. 136. Thus, POSITA would have been motivated to define *a component* of Yeh's *second passive network*, which is similarly an output matching network ([1.3]), as a patterned copper layer *embedded in* an *organic-based substrate* as taught by Dalmia, and claim 15 is rendered obvious by Yeh-Dalmia. EX1003, ¶¶188-201, 80-100.

12. Claim 16

[16.0] ***The multi-band RF device of claim 1, wherein at least one of the metal layers is patterned to form at least a portion of a component included in the second passive network.***

Yeh-Dalmia renders obvious claim 1 and [16.0]. EX1003, ¶¶202-204.

As in [1.4a] and [13.0]-[15.0], Dalmia describes a plurality of *patterned* copper layers (*metal layers*) within its laminated substrate on which an "entirety" of an output matching network is *form[ed]*. *See* EX1010, p. 136. Thus, for reasons analogous to those for [15.0], POSITA would have *formed at least a portion of a component* (*e.g.*, capacitor or inductor) of Yeh's similarly composed *second passive network* that is also an output matching network ([1.3]) using Dalmia's technique, and claim 16 is rendered obvious by Yeh-Dalmia. EX1003, ¶¶188-204, 80-100.

13. Claim 5

[5.0] ***A multi-band low noise amplifier for use in an RF application, comprising:***

To the extent this element is limiting, Yeh discloses it. EX1003, ¶¶205-207.

Yeh "relates generally to **electronic circuits for use in wireless communication systems [*RF application*]**, and more particularly to a **low-noise amplifier** which is capable of operation in **multiple frequency bands**, such as the 900 MHz and 1.8 GHz bands of a personal communication services (PCS) wireless system [*RF application*]." EX1009, 1:5-10. *See also*, EX1009, FIG. 5, 5:32-6:65, 1:13-14 discussing "cellular telephones and other wireless communications services." Yeh's low noise amplifier is *a multi-band low noise amplifier* for this reason and as further detailed at [1.0].

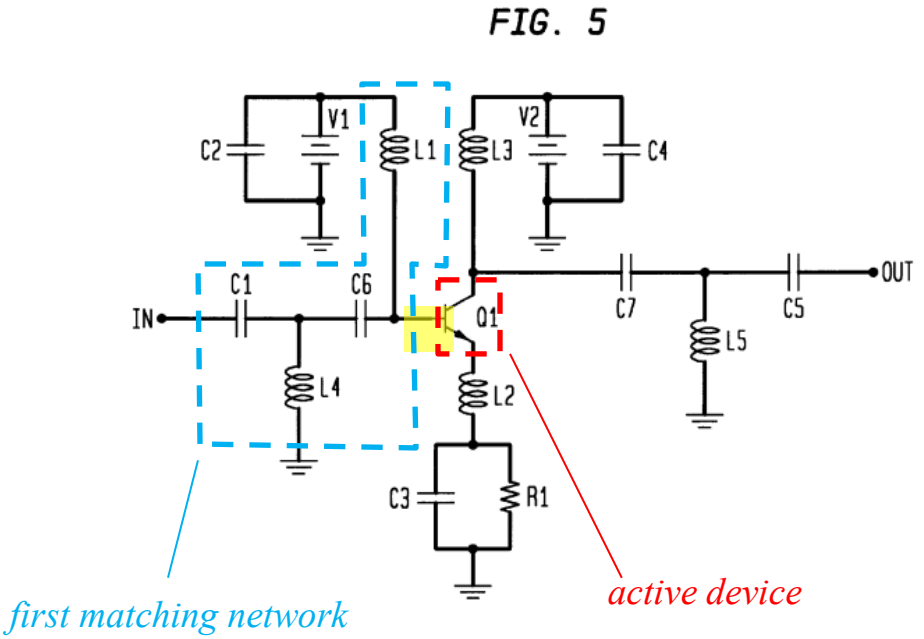
[5.1] ***an active device;***

Yeh discloses a transistor Q1, *active device*, of the multi-band amplifier structure of FIG. 5 as shown in [1.1]. EX1003, ¶208. *See, e.g.*, EX1009, 3:60-4:13; FIGS. 1, 5.

[5.2] ***a first matching network in communication with the active device, wherein an impedance of the first matching network at a first frequency is different than the impedance of the first matching network at a second frequency;***

Yeh discloses its *multi-band low noise amplifier* includes *a first matching network*: "FIG. 5 shows the low-noise amplifier [] with illustrative **input**…**matching network** [*a first matching network*] in accordance with the

invention [that includes] a set of four elements to provide narrowband matches for both the 900 MHz and 1.8 GHz frequency bands." EX1009, 5:32-36. *See also*, EX1009, 6:2-8, 4:14-31, 6:1-47 and discussion at [1.2].



EX1009, FIG. 5
(annotated)

EX1003, ¶¶209-210. The *first matching network* (C1, C6, L1, L4) is *in communication* with transistor Q1, *active device*. This is illustrated by the schematic of FIG. 5, by Yeh's description of the passives including as an "input matching network," and by POSITA's understanding of the passive network's function in the context of the amplifier. EX1003, ¶¶210-211 (citing EX1009, 4:14-20; 6:18-25 (C1 connected to base of Q1, which also is connected to L1; 6:43-47 (DC isolation and

bias functions)). This is *communication* as recited in '914 Patent. *See* EX1003, ¶¶123-127 (citing EX1001, Fig. 35, 24:20-35 inductor-capacitor network for matching).

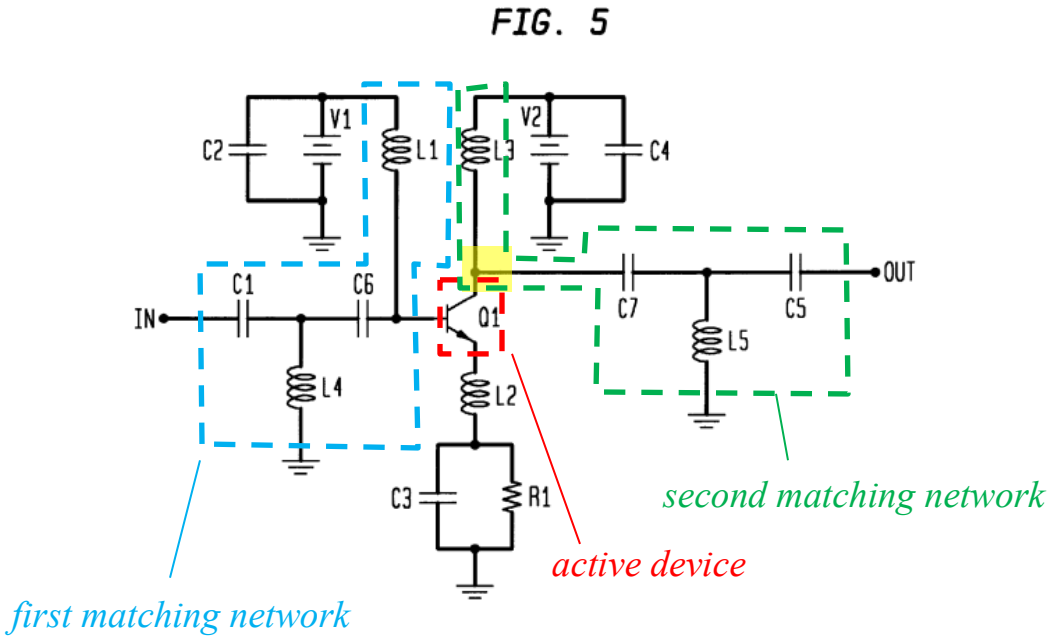
Yeh also discloses *an impedance* of *the first matching network at a first frequency is different than the impedance of the first matching network at a second frequency* as shown in [1.4b]. EX1003, ¶¶212, 150-161. As discussed above, Yeh's *first matching network* operates on signals in two distinct frequency bands. *See* [5.0], [1.0], [1.4b]. POSITA would have recognized an inductor-capacitor network such in Yeh's *first matching network* has a different impedance at different frequencies; and Yeh also recognizes the frequency-varying impedances in a Table at column 7 and FIGS. 3-4 and 10. EX1003, ¶¶212, 150-161.

Thus, Yeh discloses this element. EX1003, ¶¶209-213.

[5.3] ***a second matching network in communication with the active device, wherein an impedance of the second matching network at the first frequency is different than the impedance of the second matching network at the second frequency; and***

Yeh discloses its *multi-band low noise amplifier* includes *a second matching network* that is an "output matching network" having "a set of four elements to provide narrowband matches for both the 900 MHz and 1.8 GHz frequency bands" shown in FIG. 5. EX1009, 5:32-36. In particular, "[t]he **output matching network** includes capacitors C5 and C7, and inductors L3 and L5. This embodiment utilizes

a set of four elements for the matching networks of both input and output because two frequencies need to be matched." EX1009, 6:4-8. *See also*, EX1009, 4:22-48, 6:4-47, discussion at [1.3].



EX1009, FIG. 5
(annotated)

EX1003, ¶¶214-215. The *second matching network* (C5, C7, L3, L5) is in communication with transistor Q1, *active device*. This is illustrated by the schematic of FIG. 5, by Yeh's description of the passives including an "output matching network," and by POSITA's understanding of the passive network's function in the context of the amplifier. EX1003, ¶¶216-218 (citing EX1009, 4:38-40, 6:20-47 (C5 and L3 connected to Q1, which is connected to L3 and circuit providing DC isolation

and bias functions)). *See also*, EX1003, ¶¶129-136.

Yeh discloses *an impedance of the second matching network at the first frequency is different than the impedance of the second matching network at the second frequency* as shown in [1.4b]. EX1003, ¶¶218, 150-161. As discussed above, Yeh's *second matching network* operates on signals of a *first* and a distinct, *second frequency* bands. *See* [5.0], [1.0], [1.4b]. POSITA would have recognized an inductor-capacitor network such as the *second matching network* has a different impedance at different frequencies; and Yeh describes this in its Table at column 7 and FIGS. 3-4, 10. EX1003, ¶¶218, 150-161.

Thus, Yeh discloses this element. EX1003, ¶¶214-219.

[5.4a] ***a multi-layer organic-based substrate having at least one metal layer, wherein the first matching network and the second matching are formed on the at least one metal layer and wherein the active device is mounted on the multi-layer organic substrate,***

First, as discussed above in [1.4a], [14], [16], Dalmia describes *a multi-layer organic-based substrate* of multiple stacked organic, dielectric layers that includes patterned copper layers (*at least one metal layer*) that form passives of input/output matching networks. *See* [1.4a]. As explained in [1.4a], [13]-[16], and Section XI.C.3, it would have been obvious to *form[]* passives of Yeh's *first matching network* and *second matching network*, using copper layers of Dalmia's multi-layer organic-based substrate. EX1003, ¶¶220, 139-148, 188-204.

Second, Dalmia describes its module includes *mount[ing]* a chip *on the multi-layer organic substrate*. Figure 1.1 illustrates embedded passives and a mounted chip.

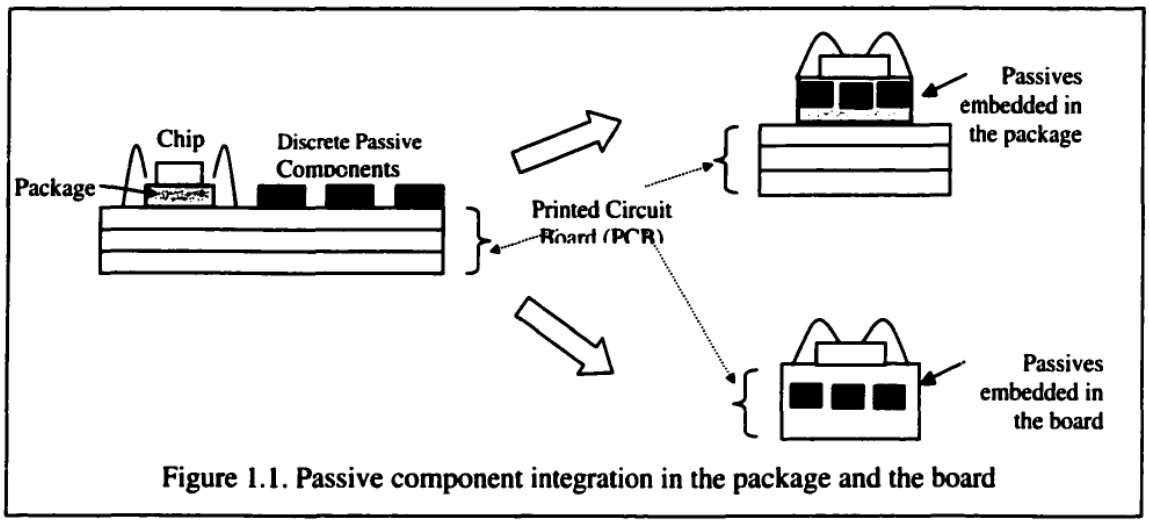


Figure 1.1. Passive component integration in the package and the board

EX1010, p. 5

Yeh describes its transistor Q1 is "configured in a chip package." EX1009, 3:66-4:1. Thus, POSITA would have been motivated to place Yeh's transistor Q1, its *active device* in a chip package, *mounted on the multi-layer organic substrate* as illustrated in Dalmia. EX1003, ¶¶221-222. *See also*, EX1037, FIG. 5 (transistor T mounted on organic substrate 10 having embedded passives 11, 12).

[5.4b] ***thereby allowing the an [sic] output of the multi-band low noise amplifier to have desired power gains at the first frequency and the second frequency based at least in part on each of the first and second matching networks having***

the different reactance at the first frequency and the second frequency.[9]

Yeh discloses *allowing an output of* its amplifier *to have desired power gains at the first frequency and the second frequency based at least in part on each of the first and second matching networks having the different reactance at the first frequency and the second frequency*. As discussed in [1.4b], Yeh discloses a multi-band amplifier, which "can provide a narrowband match for two frequency bands utilizing a single set of elements, thereby improving the amplifier performance while reducing its cost and complexity." EX1009, 5:44-48. "The term 'narrowband match' as used herein refers to a match which provides a **desired [power] gain,** noise figure or other performance measure **over one band** of an amplifier operating in **two or more bands**, while suppressing gain between the bands." EX1009, 3:49-53; *see* EX1003, ¶¶223-224.

Yeh's amplifier function of providing a *desired power gain* is *based at least in part on each of the first and second matching networks* (input and output matching networks) *having the different reactance at the first frequency and the second frequency*. EX1003, ¶225. This is because in Yeh, the first and second matching

[9] This limitation is construed as best understood, indefiniteness is not an issue raised by this Petition and does not preclude review of the claims. Petitioner may argue indefiniteness in other forums.

networks operate in the first frequency band to match the impedance of the components in the path relative to that frequency, and operate in the second frequency band to match the (different) impedance of the path relative to that frequency facilitating gain in each band ([1.4b]); it necessarily follows the *reactance* of these passive networks (with their capacitor and inductors) are different at each frequency. EX1003, ¶¶225, 150-161, 165-173. As discussed in [2.0], the networks comprising inductors and capacitors have *different reactance* at different frequencies. *Id*. Moreover, the LNA's *desired power gain* at respective frequences is *based* on the *different reactances* of the matching networks at such frequencies. *Id*.

Thus, claim 5 is rendered obvious by Yeh's low-noise amplifier including as illustrated in FIG. 5 in view of Dalmia's teachings of forming passives of an LNA using metal layers embedded in an organic-based substrate (Yeh-Dalmia). EX1003, ¶¶205-226.

14. Claim 6

[6.0] ***The multi-band amplifier of claim 5, wherein the active device is a bipolar junction transistor.***

Yeh-Dalmia renders obvious claim 5; Yeh discloses the *active device* of [5.1] is a *bipolar junction transistor*: "The low-noise amplifier includes…an n-p-n **bipolar junction transistor Q1**…" EX1009, 3:64-66. *See also*, EX1010, pp. 136-

137. Thus, Yeh-Dalmia renders obvious claim 6. EX1003, ¶¶227-228.

15. Claim 7

[7.0] ***The multi-band amplifier of claim 5, wherein the multi-layer organic-based substrate comprises at least one of hydrocarbon and liquid crystalline polymer.***

Yeh-Dalmia renders obvious claim 5, and Dalmia discloses [7.0]. EX1003, ¶¶229-232.

As discussed in [1.4a], [5.4a], and [11.0], it would have been obvious to provide Yeh's amplifier with Dalmia's *organic-based substrate*, which includes a *liquid crystalline polymer* (LCP). *See* EX1010, pp. 14-15; EX1003, ¶¶139-148, 179-182, 220-222.

To the extent PO argues this claim requires both at least one hydrocarbon and at least one LCP, it would have been obvious to include both compositions. Dalmia describes layers of its multi-layer substrate include different materials. *See*, *e.g.*, EX1010, Figure 3.14. LCP and hydrocarbons (*e.g.*, Rogers 4350B (EX1001, 24:51-52)) were well-known substrate materials. EX1003, ¶231 (citing EX1007, EX1023, EX1032-EX1033, EX1010, use as substrate materials). Thus, POSITA would have recognized use of hydrocarbons and LCP to form a laminate organic-based substrate was merely using a known material for its known function to produce a predictable result of a dielectric substrate. *Id.*

Thus, Yeh-Dalmia renders obvious claim 7. EX1003, ¶¶229-232.

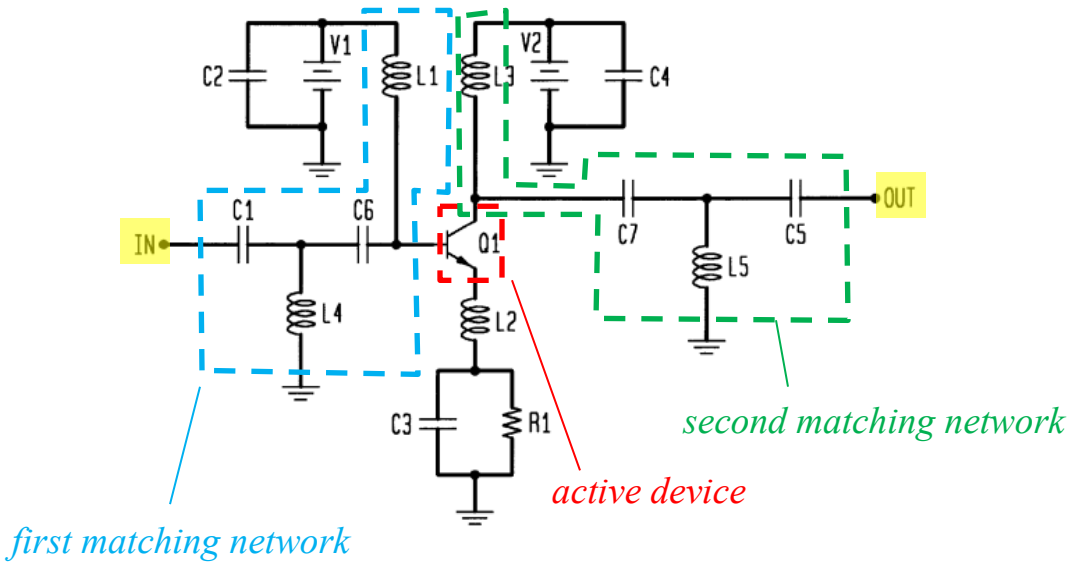
16. Claim 8

[8.0] ***The multi-band amplifier of claim 7, wherein the first matching network is positioned at an input of the multi-band amplifier and the second matching network is positioned at an output of the multi-band amplifier.***

Yeh-Dalmia renders obvious claim 7, and Yeh discloses [8.0]. EX1003, ¶¶233-235.

Yeh illustrates an input matching network, *first matching network* ([5.2]), which is *positioned at an input* of the multi-band amplifier. EX1009, FIG. 5 ("IN"), 5:32-6:15. Yeh also illustrates an output matching circuit, *second matching network* ([5.3]), *positioned at an output* of the amplifier. EX1009, FIG. 5 ("OUT"), 5:32-6:15.

FIG. 5



EX1009, FIG. 5
(annotated)

EX1003, ¶234. Thus, Yeh-Dalmia renders obvious claim 8. EX1003, ¶¶233-235.

17. Claim 9

[9.0]*The multi-band amplifier of claim 8, wherein the first matching network minimizes the noise figure for the multi-band amplifier at the input at both the first frequency and the second frequency.*

Yeh-Dalmia renders obvious claim 8, and Yeh discloses [9.0]. EX1003, ¶¶236-239.

Yeh describes its input matching network, *first matching network* ([5.2]), *minimizes the noise figure for the* amplifier *at the input at both the first frequency and the second frequency*. EX1003, ¶¶237-238. First, POSITA would recognize the

performance goal of the input matching network of a low noise amplifier is to *minimize the noise figure* at each operation frequency, here two frequencies, *at the input*. *Id.* Second, Yeh discloses its input matching network, *first matching network*, operates to provide "a match which provides a **desired** gain, **noise figure** or other performance measure over one band of an amplifier **operating in two or more bands**, while suppressing gain between the bands." EX1009, 3:49-53, 5:31-47. *See also*, EX1003, ¶238 (minimizing noise figure as goal considering competing design factors, EX1001, 24:11-14).

Thus, Yeh-Dalmia renders obvious claim 9. EX1003, ¶¶236-239.

18. Claim 10

[10.0]*The multi-band amplifier of claim 9, wherein the second matching network maximizes the desired power gains for the multi-band amplifier at the output at both the first frequency and the second frequency.*

Yeh-Dalmia renders obvious claim 9, and Yeh discloses [10.0]. EX1003, ¶¶240-243.

Yeh describes its output matching network, *second matching network* ([5.3]), *maximizes the desired power gains* for its amplifier *at the output at both the first frequency and the second frequency*. EX1003, ¶¶241-242. First, POSITA would recognize the performance goal of the output matching network of an LNA is to maximize the power gain at the output at the operation frequency, here two frequencies. *Id*. Second, Yeh discloses its output matching network, *second*

matching network, operates to provide "a match which provides a **desired gain**, **noise figure** or other performance measure over one band of an amplifier **operating in two or more bands**, while suppressing gain between the bands." EX1009, 3:49-53, 5:31-47. *See also*, EX1003, ¶241 (*maximizing* power gains in context of design factors).

Thus, Yeh-Dalmia renders obvious claim 10. EX1003, ¶¶240-243.

19. Claim 17

[17.0] ***The multi-band amplifier of claim 5, wherein the first matching network comprises a component embedded in the organic-based substrate.***

Yeh-Dalmia renders obvious claim 5 and also this limitation as discussed in [13.0], which shows it was obvious to embed a passive (*component*) of Yeh's input matching network, *first matching network* ([5.2]), in Dalmia's multi-layer *organic-based substrate* by forming the passive using a metal layer of the stack of layers. EX1003, ¶¶244, 139-148, 188-193; EX1010, pp. 136-137 (input matching network "entirely embedded in the package.").

Thus, Yeh-Dalmia renders obvious claim 17. EX1003, ¶¶244-245.

20. Claim 18

[18.0] ***The multi-band amplifier of claim 5, wherein at least one of the metal layers is patterned to form at least a portion of a component included in the first matching network.***

Yeh-Dalmia renders obvious claim 5 and this element as discussed in [14.0], which shows it was obvious *to form at least a portion* of a passive such as an inductor or capacitor (*component*) of Yeh's input matching network, *first matching network* ([5.3]), in Dalmia's *patterned* copper layers (*at least one metal layer*) of its multi-layer *organic-based substrate*. EX1003, ¶246, 139-148, 196; EX1010, pp. 136-137 (forming passives), pp. 13, 155 (metal patterns).

Thus, Yeh-Dalmia renders obvious claim 18. EX1003, ¶¶246-247.

21. Claim 19

[19.0] ***The multi-band amplifier of claim 5, wherein the second matching network comprises a component embedded in the organic-based substrate.***

Yeh-Dalmia renders obvious claim 5 and also this limitation as discussed in [15.0], which shows it was obvious to embed a passive (*component*) of Yeh's output matching network, *second matching network* ([5.3]), in Dalmia's organic-based substrate by forming the passive in a metal layer of the multi-layer substrate. EX1003, ¶¶248, 139-148, 199-200; EX1010, pp. 136-137 (output matching network "entirely embedded in the package."). Thus, Yeh-Dalmia renders obvious claim 19. EX1003, ¶¶248-249.

22. Claim 20

[20.0] ***The multi-band amplifier of claim 5, wherein at least one of the metal layers is patterned to form at least a portion of a component included in the second matching network.***

Yeh-Dalmia renders obvious claim 5 and this limitation as discussed in [16.0], which shows it was obvious *to form at least a portion* of a passive such as an inductor or capacitor (*component*) of Yeh's output matching network, *second matching network* ([5.3]), in Dalmia's *patterned* copper layer(s) of an organic-based substrate. EX1003, ¶¶250, 139-148, 203; EX1010, pp. 136-137 (forming passives), pp. 13, 155 (metal patterns). Thus, Yeh-Dalmia renders obvious claim 20. EX1003, ¶¶250-251.

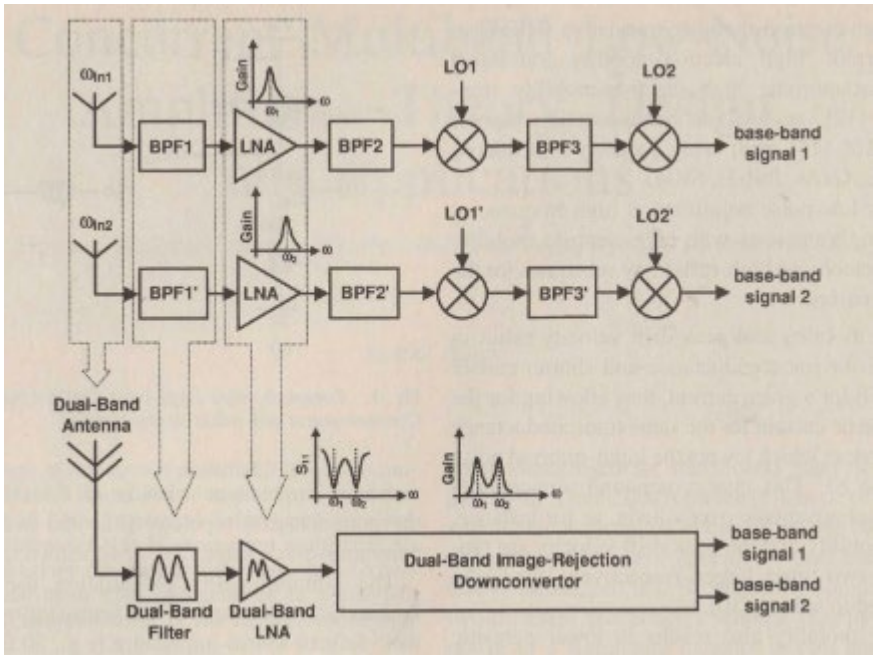
D. Ground 2

1. Dalmia

See Section XI.C.2.

2. Hashemi

Historically, receiver architectures operated at a single frequency with independent signal paths for different frequencies, which increased cost, footprint, and power dissipation. EX1011, p. 288; EX1003, ¶¶253, 27-31. Hashemi however discloses multifrequency impedance matching for a "concurrent dual-band receiver architecture" capable of simultaneous operation at two-different frequencies. EX1011, p. 288. In particular, Hashemi teaches design evolution to "multiband [low noise amplifier] LNAs [that] provide simultaneous narrow-band input matching and gain at multiple frequency bands, while maintaining low noise." *Id*.



EX1011, p. 290, Fig. 2

3. Reasons to Combine Dalmia and Hashemi (Dalmia-Hashemi)

POSITA would have been motivated to combine the teachings of Dalmia and Hashemi (Dalmia-Hasemi) to produce the obvious, beneficial, and predictable results of utilizing Hashemi's suggestion of achieving simultaneous impedance matching for multiple distinct frequencies applied to Dalmia's LNA module having passives embedded in an organic-based substrate to provide multi-band functionality of the LNA. EX1003, ¶¶254-261.

Dalmia and Hashemi are analogous art to the '914 Patent because they are in the same field of endeavor, pertaining to the transmit and receive functionality of RF communication devices such as personal mobile phones. EX1003, ¶255; EX1001,

1:29-47; EX1010, xviii, EX1011, p. 288. Each of Hashemi, Dalmia and the '914 Patent are directed to configurations of an amplifier. EX1001, 2:14-16; EX1011, p. 288; EX1010, xviii, Chapter VI, 6.1, 6.2. Further, Hashemi and Dalmia are analogous art because each is directed to a same problem faced by the '914 Patent's inventor—decreasing device size. EX1010, pp. 3-4 ("[r]eduction in circuit board area"), EX1011, p. 288 (footprint); EX1001, 1:58-62.

Multi-band operation and reduction of component count in implementation of this functionality, were well-understood market drivers. *See* EX1011, p. 288 (dual-band transceivers); Section IV; EX1003, ¶¶256, 27-31. Dalmia recognizes the existence of multiple bands for wireless communications and the desirability to implementing high quality components for such bands. EX1010, pp. 30, 121. Dalmia invites modification of its amplifier by suggesting its use in "**multiband applications** with embedded passives in organic substrates." EX1010, p. 131, Chapter VI, title.

Hashemi describes benefits of using an amplifier for processing signals of multiple bandwidths. In particular, Hashemi allows for a dual-band receiver architecture that reuses components (*e.g.*, of an LNA) without requiring separate paths for each band. EX1011, pp. 288, 290, Figure 2. In doing so, concurrent multiple band functionality for the LNA allows for "simultaneous operation at two-different frequencies without dissipating twice as much power[.]" EX1011, p. 288.

Thus, POSITA would have reason to implement Hashemi's techniques to gain improvements in power dissipation and provide for component reuse. EX1003, ¶257. Implementing Hashemi's concurrent multiband LNA, rather than separate LNAs dedicated to a specific band, also saves on "cost and footprint." EX1011, p. 288; *see also*, EX1003, ¶258 (citing EX1005; EX1009-EX1011, Section IV, and drive for smaller devices).

Thus, POSITA would have been motivated to apply Hashemi's teachings when implementing Dalmia's amplifier because doing so would beneficially allow for multi-band functionality, reduce the power consumption relative to use of two separate transceiver paths, allow for component reuse, and provide benefits with respect to cost and footprint. EX1003, ¶¶256-261.

The results of combining Dalmia and Hashemi would have been predictable, and POSITA would have had reasonable expectations of success given both Dalmia and Hashemi relate to the same device—LNAs—each performing the amplification function in an RF communication system. EX1003, ¶260. Dual-band LNAs were also well-known in the art. *Id*. (citing EX1005, EX1009, EX1021). To the extent Hashemi suggests implementation of its LNA in CMOS technology, it does not so require, and Dalmia details performance considerations motivating POSITA to embed passives in a substrate rather than within a CMOS chip. EX1003, ¶260; Section XI.C.3.

4. Claim 1

[1.0] ***A multi-band RF device operable at a first frequency and a second frequency different from the first frequency, comprising:***

To the extent the preamble is limiting, Dalmia and Hashemi discloses it. EX1003, ¶¶262-267.

Dalmia discloses an *RF device* of a low-noise amplifier (LNA): "In any wireless architecture, the first active device of the RF frontend is the LNA…to detect the incoming signal, as well as having a good input impedance matching circuit." EX1010, p. 133. "The basic LNA architecture consists of an active device with impedance transformation networks at the input and output." EX1010, p. 134.

RF device

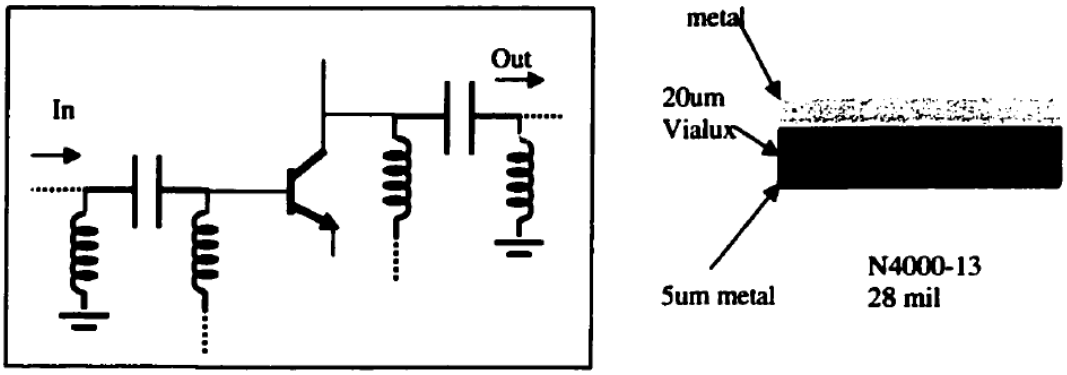


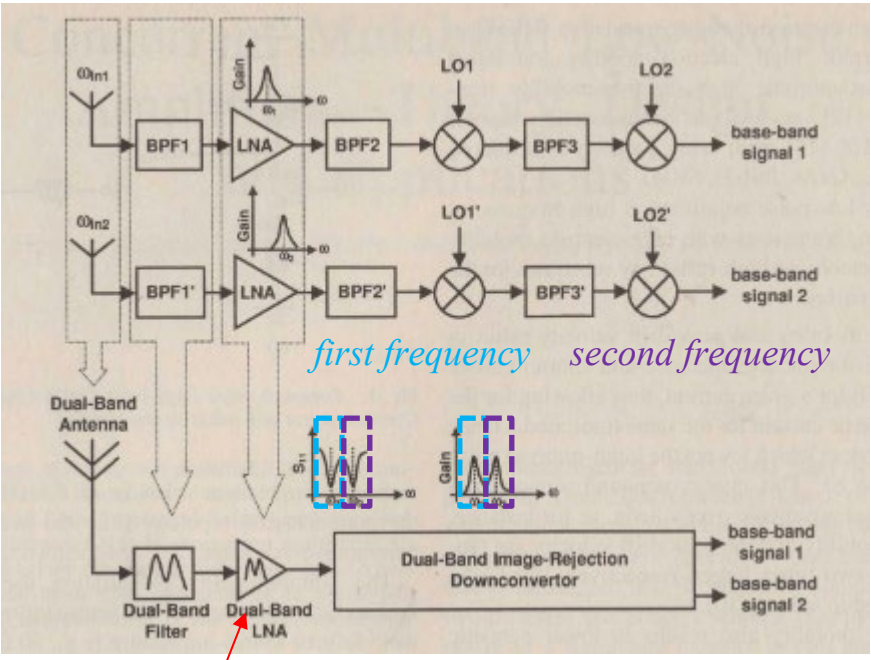
Fig 6.4. a) Integrated LNA, with impedance transformation networks
b) Cross-section of testbed

EX1010, p. 137 (annotated)

Though Dalmia describes this LNA for "PCS (1.9GHz) applications,"

(EX1010, p. 133), it is found within a chapter directed to "multiband applications." EX1010, p. 131. As discussed above, POSITA would have had reason to provide Dalmia's LNA with functionality for multi-band operation at *a first frequency* and *a second frequency different from the first frequency* in light of Hashemi's teachings of multi-band LNAs. EX1003, ¶¶254-264.

Hashemi discloses "a concurrent **dual-band LNA** that provides simultaneous gain and matching two bands." EX1011, p. 290. Hashemi's Fig. 2 illustrates the evolution from a single-band LNA such as Dalmia's, to a dual-band LNA, a *multi-band RF device*.



EX1011, Fig. 2, p. 290 (annotated)

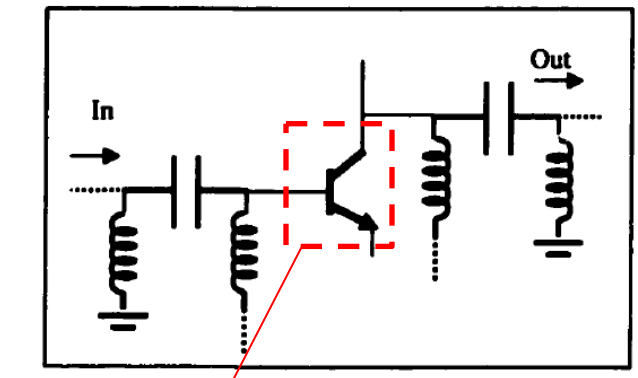
Hashemi recognizes the active device of an LNA (*see* [1.1]) inherently "can be used at multiple frequencies simultaneously." EX1011, p. 291. Hashemi explains that in single-band LNAs "passive networks are used to shape the response…of the active device in the [single] frequency domain to achieve gain and matching at the [single] frequency of interest." *Id*. Hashemi teaches these passive networks can instead be implemented to provide "matching at **multiple distinct frequencies**." EX1011, pp. 291-292. Hashemi details the RF engineering principles (*e.g.*, equations and design parameters) to implement dual-band LNAs recognizing "numerous topologies" could achieve such functionality. EX1011, p. 292. In contrast, the '914 Patent makes mention of a supposed dual-band nature of its LNA in only single sentence of its disclosure. EX1003, ¶¶266, 49-51 (citing EX1001, 24:16-18).

Thus, Dalmia-Hashemi renders obvious the *multi-band RF device* of [1.0]. EX1003, ¶¶262-267.

[1.1] ***an active device;***

Dalmia's LNA includes a transistor, *an active device*.

RF device



active device

EX1010, FIG. 6.4 (portion)
(annotated)

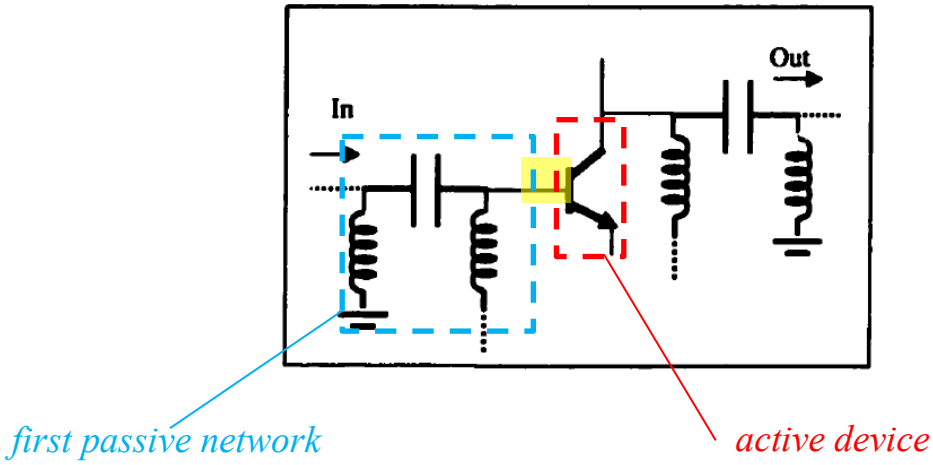
Dalmia suggests an *active device* of a "discrete HBFP-0420 dual emitter transistor," which is a bipolar junction transistor (BJT). EX1010, p. 136; *see also*, EX1003, ¶¶268-269; EX1011, pp. 289-290 (FET and BJT active devices for dual-band LNAs).

[1.2] ***a first passive network in communication with the active device, the first passive network comprising a first matching network at an input of the active device;***

Dalmia-Hashemi illustrates its *multi-band RF device* includes *a first passive network* as recited in [1.2]. EX1003, ¶¶270-272.

Dalmia's LNA has a *first passive network* of "high Q embedded inductors and

capacitors." EX1010, p. 136. The *first passive network* includes a *first matching network*: "The **input** and output of the transistor are **matched**…using L-C **'pi' networks**." EX1010, p. 136. This is the same input matching network as described in the '914 Patent. EX1003, ¶270 (citing EX1001, FIG. 35 ("Pi network")).



EX1010, Figure 6.4 (portion)
(annotated)

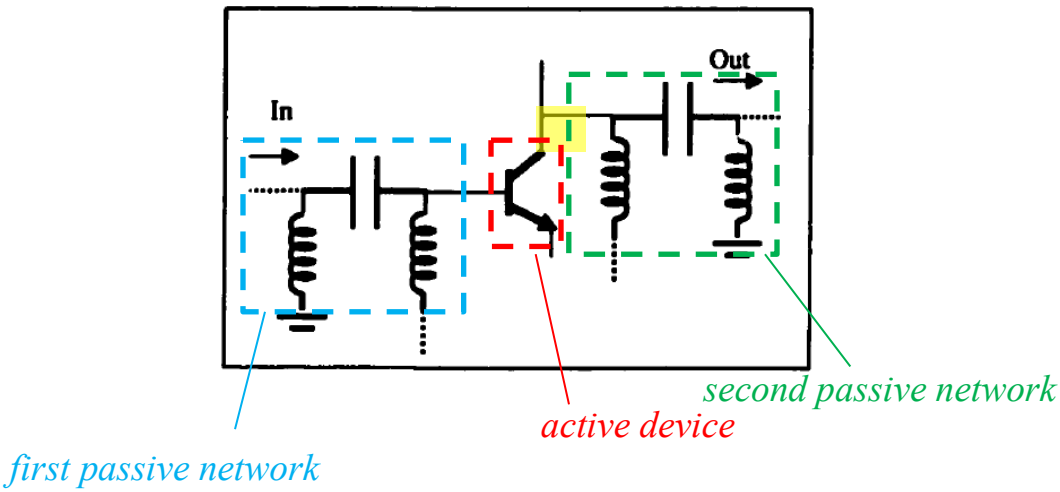
Dalmia's *first passive network* is in *communication with* its transistor (*active device*), and *the first matching network* is at *an input of the active device*, which is illustrated in Figure 6.4. EX1003, ¶¶270-271 (discussing highlighted connection and "In", Dalmia's description of the network at the "input [] of the transistor" (p. 136), and function of the matching network). Hashemi also recognizes, in the dual-band context, that this *communication* with the active device remains. EX1011, p. 291 ("passive networks are [] to shape the response…of the active device in the

frequency domain to achieve gain and matching at the frequency of interest."). Hashemi's techniques for "design [of] multiband input matching networks" may change the impedance design of the network, but the network continues to perform the matching functionality and is in communication with and at the input of the active device. EX1011, p. 292. Thus, Dalmia-Hashemi renders obvious this element. EX1003, ¶¶270-272.

[1.3] ***a second passive network in communication with the active device, the second passive network comprising a second matching network at an output of the active device; and***

Dalmia-Hashemi discloses its *multi-band RF device* includes *a second passive network* as recited here. EX1003, ¶¶273-275.

Dalmia's LNA has a *second passive network* of "high Q embedded inductors and capacitors." EX1010, p. 136. The *second passive network* includes a *second matching network*: "The…**output** of the transistor [is] **matched** to 50Ω by using L-C **'pi' network**[]." EX1010, p. 136. *See also*, EX1003, ¶¶273-275 (discussing correspondence with Pi network of '914 Patent).



EX1010, Figure 6.4 (portion)
(annotated)

Id. The *second passive network* is in *communication with* the transistor (*active device*), and *the second matching network* is at *an output of the active device*. This is illustrated in Figure 6.4 and confirmed by Dalmia's description of "output" and the function of such a matching network. EX1003, ¶¶274-275. As discussed above, Hashemi teachings applied to Dalmia's output passive network allow for impedance matching for multiple frequencies. EX1011, p. 296. While the impedance design may change, the *second passive network* continues to perform the matching functionality and be in communication with and at the output of the active device when applying Hashemi's dual-band teachings. EX1003, ¶275. Thus, Dalmia-Hashemi renders obvious *the second passive network* of [1.3]. EX1003, ¶¶273-275.

[1.4a] ***an organic-based substrate having at least two metal layers, wherein the***

two metal layers are patterned to form at least a portion of the first passive network and the second passive network,

Dalmia discloses this limitation as detailed in [1.4a] (Ground 1), as both of Dalmia's LNA passive networks are formed "**entirely embedded** in the package[.]" EX1010, p. 136. EX1003, ¶¶139-148. This means the passives (*e.g.*, inductors and capacitors) of each of the *first* and *second passive network[s]* ([1.2], [1.3]) are formed by copper patterns (*at least two metal layers*) on multiple layers of an *organic-based substrate*. *See* [1.4a], [13.0]-[16.0]; EX1010, pp. 12-13, Figure 3.14, Figure 3.15, Figure 4.3, Appendix A discussing patterning copper layers.[10] Thus, Dalmia teaches this element. EX1003, ¶¶276-278.

[1.4b] ***wherein impedances of the first and second passive networks are different at the first frequency than the second frequency.***

As discussed above, it would have been obvious to implement Hashemi's teachings to configure the *first and second passive networks* in Dalmia's LNA to operate at a *first frequency* and a *second frequency*. *See* [1.0]-[1.3], Section XI.D.3.

Dalmia-Hashemi's *first* and *second passive networks* comprise inductors (L)

[10] POSITA would have recognized the circuit of Fig. 6.4a could be readily implemented on Dalmia's substrate having any number of metal and dielectric laminate layers, including, for example, that of Dalmia's Fig. 3.14. This is merely applying related implementation teachings to an identified circuit architecture.

and capacitors (C). EX1003, ¶279 (citing EX1010, pp. 136-137, Fig. 6.4; EX1011, pgs. 290-292, Fig. 1). As the impedance of an inductor varies (*i.e.*, increases) with frequency and impedance of a capacitor varies (*i.e.*, decreases) with frequency, the impedance of the components and the circuits (first/second passive networks) they comprise are different at the two frequencies. EX1003, ¶¶279-285. This is discussed in detail in Section XI.C.4.[1.4b]. Accordingly, POSITA would have understood Dalmia-Hashemi's *first passive network* ([1.2]) and *second passive network* ([1.3]) have *impedances* that *are different at the first frequency than the second frequency*.

Moreover, Hashemi recognizes passive networks must provide matching with respect to neighboring components within the signal path. *See* EX1011, p. 291 ("impedance looking into…input of…LNA should be power matched (i.e., complex conjugate matched)[] to…impedance of the preceding stage for maximum signal power transfer."). To perform the LNA's function of providing power gain in two operational bands, impedance of the matching networks differs at different frequencies because the networks' functions are to provide matching to the different frequency-dependent impedances (input and output) of the active device. EX1003, ¶¶286-307 (citing EX1034, EX1031 to illustrate frequency-dependence of active device impedances). Because the input and output impedances of the active device are different at different frequencies, so too are the matched impedances of the first and second passive networks. EX1003, ¶¶286-307.

Thus, Dalmia's low-noise amplifier in combination with Hashemi's technique to provide for dual-band operation of the amplifier renders obvious claim 1. EX1003, ¶¶252-308.

5. Claim 2

[2.0] ***The multi-band RF device of claim 1, wherein the first and second passive networks comprise resonant circuits, and wherein the impedances of the first and second networks comprise reactance.***

Dalmia-Hashemi renders obvious claim 1 and [2.0]. EX1003, ¶¶309-311.

As discussed at [1.2]-[1.3], Dalmia-Hashemi provides *first* and *second passive networks*. Each includes inductors and capacitors, which are *resonant circuit[]* components. EX1003, ¶¶310, 165-173 (explaining resonant circuit is circuit designed to oscillate and typical resonant circuit includes inductors and capacitors). Hashemi confirms this: "To achieve highest gain and selectivity at the frequencies of interest, it is desirable to use a **multiresonant** load at the **output** whose impedance is maximum at the frequencies of interest."). EX1011, p. 296. Hashemi's passive network is designed to be resonant in both bands of interest. EX1003, ¶310 (citing EX1011, p. 297, Figure 12 showing S11 (input reflection coefficient) being low at two different frequencies (2.45 GHz and 5.25 GHz) with amplitude gain being high). Thus, Dalmia-Hashemi's *first* and *second passive networks* of [1.2]-[1.3], having inductors and capacitors, each *comprise reactance*.

Thus, Dalmia-Hashemi renders obvious claim 2. EX1003, ¶¶309-311.

6. Claim 4

[4.0] ***The multi-band RF device of claim 1, wherein the active device is a bipolar junction transistor and wherein the multiband device is a low noise amplifier operable for providing power gain at the first frequency and the second frequency.***

Dalmia-Hashemi renders obvious claim 1 and [4.0]. EX1003, ¶¶312-314. Dalmia and Hashemi each disclose a *bipolar junction transistor* as an *active device*. EX1003, ¶312 (citing EX1010, EX1011 each with BJT-based LNAs).

Further, Dalmia-Hashemi discloses a low-noise amplifier *operable for providing power gain at the first frequency and the second frequency*. Providing power gain is the standard function of an amplifier. EX1003, ¶¶313, 176-177; [4.0](Ground 1). Implementing Hashemi's teachings regarding dual-band operation means the power gain is provided in the *first frequency and the second frequency*. *Id*. Hashemi explains "[t]hese new concurrent multiband LNAs provide simultaneous narrow-band input matching and **gain** at **multiple frequency bands**, while maintaining low noise." EX1011, p. 288.

Thus, Dalmia-Hashemi renders obvious claim 4. EX1003, ¶¶312-314.

7. Claim 11

[11.0] ***The multi-band R[F] device of claim 1, wherein the organic-based substrate comprises liquid crystalline polymer.***

Dalmia-Hashemi renders obvious claim 1, and Dalmia discloses its *organic-based substrate* comprises *liquid crystalline polymer* as discussed in [11.0](Ground 1). EX1003, ¶¶315, 180-182 (LCP).

Thus, Dalmia-Hashemi renders obvious claim 11. EX1003, ¶¶315-316.

8. Claim 12

[12.0] ***The multi-band R[F] device of claim 1, wherein the active device is a field effect transistor.***

Dalmia-Hashemi renders obvious claim 1, and Hashemi discloses that "field-effect transistors (FETs)" are a known alternative to bipolar transistors for an LNA *active device*. EX1011, pp. 288-89, p. 292, fn. 2; EX1003, ¶¶318-319, 186 (transistor configurations).

Thus, Dalmia-Hashemi renders obvious claim 12. EX1003, ¶¶317-320.

9. Claim 13 and 15

[13.0 [15.0]] ***The multi-band R[F] device of claim 1, wherein the first [second] passive network comprises a component embedded in the organic-based substrate.***

Dalmia-Hashemi renders obvious claim 1 and these claims. EX1003, ¶¶321-326. As discussed above in [1.4a](Grounds 1, 2) and in [13.0]/[15.0](Ground 1), Dalmia describes an *organic-based substrate* and embedding *a component* (passives such as capacitors, inductors) of each of the *first passive network* (input matching network ([1.2])) and *second passive network* (output matching network ([1.3]))

within its *organic-based substrate* by defining the component using patterned copper layers. EX1003, ¶¶321-326, 139-148, 189-203. This configuration remains in the Dalmia-Hashemi multi-band device. *Id*.

Thus, Dalmia-Hashemi renders obvious claims 13 and 15. EX1003, ¶¶321-326.

10. Claims 14 and 16

[14.0 [16.0]]*The multi-band R[F] device of claim 1, wherein at least one of the metal layers is patterned to form at least a portion of a component included in the first [second] passive network.*

Dalmia-Hashemi renders obvious claim 1 and these claims. EX1003, ¶¶323-329.

As discussed in [1.4a](Ground 1 and 2) and in [14.0]/[16.0](Ground 1), Dalmia describes patterning *at least one of the metal layers* (etching copper layers) to form a copper line/pattern on each of a plurality of dielectric layers that form its *organic-based substrate*; the copper pattern forms *at least a portion of a component* (a passive—capacitor or inductor) of each of the *first passive network* ([1.2], input matching network) and the *second passive network* ([1.3], output matching network) of its amplifier. EX1003, ¶¶323-329, 139-148, 189-203 (citing EX1010, pp. 136-137 (passives), Appendix A (patterning metal layers)). This configuration remains in the Dalmia-Hashemi multi-band device. *Id*.

Thus, Dalmia-Hashemi renders obvious claims 14 and 16. EX1003, ¶¶323-

329.

11. Claim 5

[5.0] ***A multi-band low noise amplifier for use in an RF application, comprising:***

[5.1] ***an active device;***

Dalmia-Hashemi renders obvious *a multi-band low noise amplifier* with *an active device* of a transistor, which is used in *RF application* as discussed in [1.0]-[1.1] (Ground 2). EX1003, ¶¶330, 262-269.

[5.2] ***a first matching network in communication with the active device, wherein an impedance of the first matching network at a first frequency is different than the impedance of the first matching network at a second frequency;***

[5.3] ***a second matching network in communication with the active device, wherein an impedance of the second matching network at the first frequency is different than the impedance of the second matching network at the second frequency; and***

Dalmia-Hashemi renders obvious a *first matching network* of passive components *in communication with* its transistor (*active device*) as discussed above in [1.2](Ground 2) and a *second matching network* of passive components *in communication with* its transistor (*active device*) as discussed above in [1.3](Ground 2). EX1003, ¶¶270-275. Further, the multi-band LNA of Dalmia-Hashemi has *an impedance of the first matching network [and an impedance of the second matching network]* that *at a first frequency is different than the impedance of* the respective matching network *at a second frequency*. As discussed in [1.4b], this is because the matching networks of Dalmia-Hashemi comprise capacitors and inductors, which

have a frequency response, and because Hashemi describes maximum power gain is afforded by matching the frequency-dependent impedance of components in the path (*e.g.*, the transistor at its input and output, as well as upstream and downstream components). EX1003, ¶¶331-335, 279-307, 152-161 (discussing frequency response). Frequency dependence of the matched to impedances dictates frequency dependency of the matching network impedances. *Id*. (addressing frequency dependence in the context of analysis for both [1.4b] and [5.2], [5.3]).

Thus, Dalmia-Hashemi renders obvious [5.2] and [5.3]. EX1003, ¶¶331-335.

[5.4a] ***a multi-layer organic-based substrate having at least one metal layer, wherein the first matching network and the second matching are formed on the at least one metal layer and wherein the active device is mounted on the multi-layer organic substrate,***

First, as discussed above in [1.4a] and [14.0]/[16.0](Grounds 1, 2), Dalmia describes patterned copper (*at least one metal layer*) on laminated layers of *a multi-layer organic-based substrate*, where input and output passive network components are formed on the copper layers. EX1003, ¶¶336, 138-148, 196, 203; EX1010, pp. 66, 155-156. **Second**, as discussed in [5.4a] (Ground 1), Dalmia discloses a chip is *mounted on the multi-layer organic substrate*. EX1010, p. 2; EX1003, ¶¶337, 221-222.

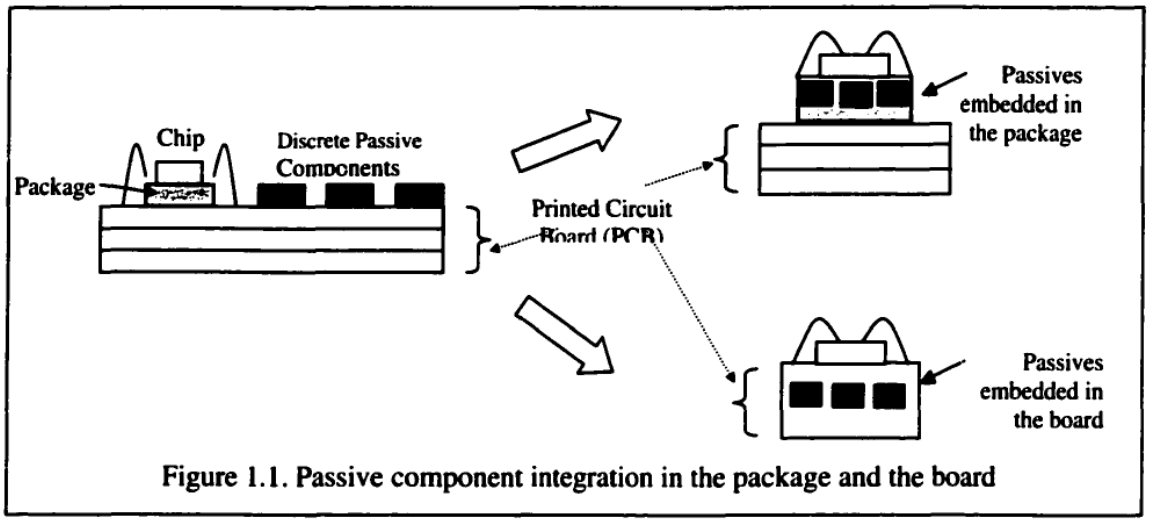


Figure 1.1. Passive component integration in the package and the board

EX1010, p. 2

POSITA would have been motivated to place Dalmia's transistor, *active device*, of its LNA circuit *mounted on the multi-layer organic substrate* as suggested in its own Figure 1.1. *Id*. Dalmia suggests the active device (*e.g.,* BJT) is a discrete component suitable for mounting onto the substrate. EX1010, pp. 140, 149. *See also*, EX1037, FIG. 5.

[5.4b] ***thereby allowing the an [sic] output of the multi-band low noise amplifier to have desired power gains at the first frequency and the second frequency based at least in part on each of the first and second matching networks having the different reactance at the first frequency and the second frequency.***

Dalmia-Hashemi discloses this element as discussed in [1.4b], [2.0] and [4.0](Ground 2). *See* EX1003, ¶¶338-341, 279-310. Hashemi recognizes implementing its multiband teachings achieves desired power gains at each of the *first* and *second frequenc[ies]*. EX1011, p. 291 ("achieve simultaneous **power** and noise matching in a **concurrent multiband** LNA."), p. 296 ("To achieve…**highest**

gain and selectivity at…frequencies of interest, it is desirable to use a multiresonant load at the output whose impedance is maximum at…frequencies of interest.") As discussed in [1.4b], [2.0], [4.0](Ground 2), this gain results from the matching networks having different reactance. EX1003, ¶¶338-341, 279-310 (imaginary part of impedance corresponds to reactance).

Thus, claim 5 is rendered obvious by Dalmia in view of the multi-band techniques of Hashemi. EX1003, ¶¶330-341.

12. Claim 6

[6.0] ***The multi-band amplifier of claim 5, wherein the active device is a bipolar junction transistor.***

Dalmia-Hashemi renders obvious claim 5; Dalmia (like Hashemi) discloses an active device, Q1, as a *bipolar junction transistor*. *See* [4.0](Ground 2). Thus, Dalmia-Hashemi renders obvious claim 6. EX1003, ¶¶342-344, 312.

13. Claim 7

[7.0] ***The multi-band amplifier of claim 5, wherein the multi-layer organic-based substrate comprises at least one of hydrocarbon and liquid crystalline polymer.***

Dalmia-Hashemi renders obvious claim 5, and Dalmia discloses [7.0]. EX1003, ¶¶345-347. As discussed in [1.4a] and [11.0] (Grounds 1, 2), Dalmia provides a *multi-layer organic-based substrate* and an exemplary composition of *liquid crystalline polymer*. *See* EX1003, ¶¶139-148 (organic-based substrate), 180-182 (discussing LCP). To the extent both a hydrocarbon and LCP are required, it

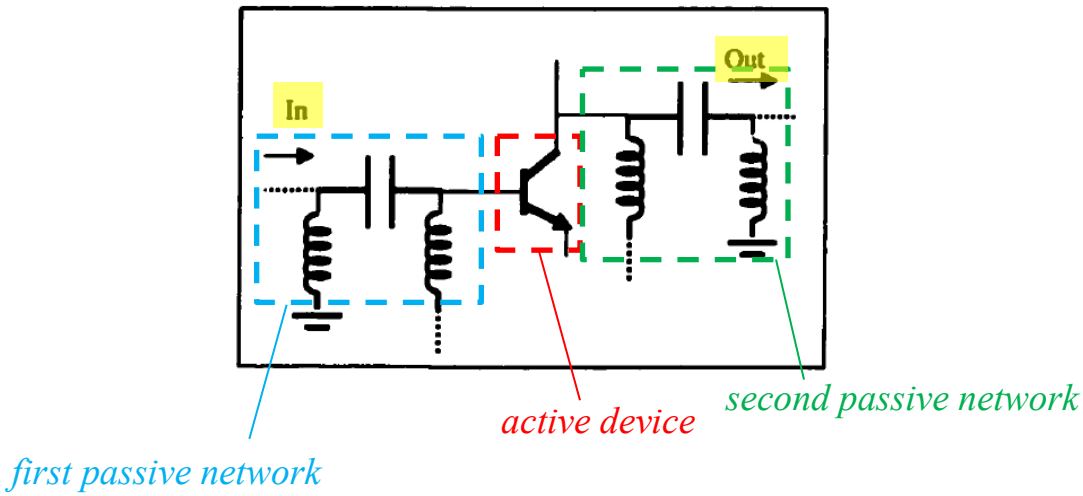
would have been obvious for Dalmia's organic substrate, which includes multiple layers having different compositions, to include both the commonly used hydrocarbon **and** LCP as discussed in [7.0](Ground 1). EX1003, ¶¶345-346, 231; *see also,* EX1010, Figure 3.14, p. 150. Thus, claim 7 is obvious in light of Dalmia and Hashemi. EX1003, ¶¶345-347.

14. Claim 8

[8.0] ***The multi-band amplifier of claim 7, wherein the first matching network is positioned at an input of the multi-band amplifier and the second matching network is positioned at an output of the multi-band amplifier.***

Dalmia-Hashemi renders obvious claim 7 and [8.0]. EX1003, ¶¶348-351.

The *first matching network* ([5.2]) is *positioned* at *an input* of the low-noise amplifier and *second matching network* ([5.3]) is positioned at *an output* of the low-noise amplifier.



EX1010, p. 137 (portion)
(annotated)

EX1003, ¶349. This configuration remains when implementing Hashemi's multi-band teachings. EX1003, ¶350 (citing EX1011, pp. 291-296, and discussing LNA "input" and "output").

Thus, Dalmia-Hashemi renders obvious claim 8. EX1003, ¶¶348-351.

15. Claim 9

[9.0] ***The multi-band amplifier of claim 8, wherein the first matching network minimizes the noise figure for the multi-band amplifier at the input at both the first frequency and the second frequency.***

Dalmia-Hashemi renders obvious claim 8 and [9.0]. EX1003, ¶¶352-355.

POSITA would have recognized the goal of Dalmia's LNA input matching network (*first matching network* ([5.2]) is to minimize the *noise figure at the input* for the operation frequency. EX1010, p. 137 ("input pi is designed for minimum noise figure [presented to] the transistor"); EX1003, ¶¶353-354, 357. Implementing Hashemi's techniques to provide a multi-band LNA provides for "simultaneous narrow-band gain and **minimum NF** at **two frequencies**" where an implementation of which demonstrated "superior NF" performance. EX1011, pp. 297-298.

Thus, Dalmia-Hashemi renders obvious claim 9. EX1003, ¶¶352-355.

16. Claim 10

[10.0] ***The multi-band amplifier of claim 9, wherein the second matching network maximizes the desired power gains for the multi-band amplifier at the output at both the first frequency and the second frequency.***

Dalmia-Hashemi renders obvious claim 9 and [10.0]. EX1003, ¶¶356-359.

POSITA would have recognized Dalmia's *second matching network* ([5.3]) of the LNA has a goal of *maximiz[ing] the desired power gains at the output* for the operation frequency. EX1010, p. 136 ("output pi is designed for maximum power transfer"); EX1003, ¶357. Implementing Hashemi's dual-band techniques provides "simultaneous **gain**…at **two bands**" while providing "a low NF [noise factor] *while* maintaining high gain." EX1011, pp. 290, 292, note 5. *See also*, EX1011, Figs. 2, 10, 12, pp. 297-298.

Thus, Dalmia-Hashemi renders obvious claim 10. EX1003, ¶¶356-359.

17. Claims 17 and 19

[17.0 [19.0]] ***The multi-band amplifier of claim 5, wherein the first [second] matching network comprises a component embedded in the organic-based substrate.***

Dalmia-Hashemi renders obvious claim 5 and these elements, *see* [13.0] and [15.0] (Ground 2). *See* EX1003, ¶¶189-200 (embedding matching network components, citing EX1010, p. 136). Thus, Dalmia-Hashemi renders obvious claims 17 and 19. EX1003, ¶¶360-363.

18. Claims 18 and 20

[18.0 [20.0]] ***The multi-band amplifier of claim 5, wherein at least one of the metal layers is patterned to form at least a portion of a component included in the first [second] matching network.***

Dalmia-Hashemi renders obvious claim 5 and these elements, *see* [14.0] and [16.0] (Ground 2). *See* EX1003, ¶¶196-203 (discussing Dalmia's copper lines patterning passives). Thus, Dalmia-Hashemi renders obvious claims 18 and 20. EX1003, ¶¶361-364.

XII. NO BASIS FOR DENIAL OF INSTITUTION

A. No basis for 35 U.S.C. § 325(d) denial

The combinations of references presented in the grounds below have not previously been presented to the Office. Neither Yeh, nor Dalmia, nor Hashemi were cited or considered by the Examiner during prosecution of the '914 Patent. Accordingly, discretionary denial under 35 U.S.C. § 325(d) is not appropriate.

B. No basis for denial under 35 U.S.C. §314/*Fintiv* factors

The Board balances six factors in considering denial under § 314. *Apple Inc. v. Fintiv, Inc*., IPR2020-00019, Paper 11 (Mar. 20, 2020) (precedential). These factors strongly favor institution as this Petition presents compelling evidence of unpatentability of all Challenged Claims. The district court case is in its very early stages, without a scheduling order or opening of fact discovery, as Patent Owner just filed the complaint in November 2024. *See* EX1035. Petitioner has diligently worked to prepare the petitions. The current average time-to-trial for the district court hearing the co-pending litigation is 34.5 months. EX1036 (Georgia Northern District median time-to-trial); *In re Apple Inc.*, 979 F.3d 1332, 1350 (Fed. Cir. 2020). Here, the final written decision is due August 2026, well before the expected trial date.

C. Discretionary denial under *General Plastic* is not appropriate

The '914 Patent has not been challenged in any prior IPR petition, so none of *General Plastic* discretionary institution factors apply. *See General Plastic Indus. Co., Ltd. v. Canon Kabushiki Kaisha*, IPR2016-01357, Paper 19 at 16 (Sept. 6, 2016) (Section II.B.4.i. precedential).

XIII. CONCLUSION

Petitioner has established a reasonable likelihood that the Challenged Claims are unpatentable.

Respectfully submitted,

Dated: February 10, 2025

/*David W. O'Brien*/

David W. O'Brien, Reg. No. 40,107
Lead Counsel for Petitioner
HAYNES AND BOONE, LLP
2801 N. Harwood St. Suite 2300
Dallas, Texas 75219
Customer No. 27683

XIV. MANDATORY NOTICES

A. Real party-in-interest

Pursuant to 37 C.F.R. §42.8(b)(1), Petitioner certifies that the real party-in-interest is Murata Manufacturing Co., Ltd. (the petitioner) and Murata Electronics North America, Inc.

B. Related matters

Pursuant to 37 C.F.R. §42.8(b)(2), to the best knowledge of the Petitioner, the '914 Patent is or was involved in the following cases:

Case Heading	Number	Court	Filed
Georgia Tech Research Corporation v. *Murata Electronics North America, Inc. et al.*	NDGA-1-24-cv-05268	NDGA	Nov. 17, 2024

Petitioner is also concurrently filing another petition for *inter partes* review ("IPR") of claims 1-2 and 4-20 of the '914 Patent.

C. Lead and back-up counsel and service information

Lead Counsel
David O'Brien
HAYNES AND BOONE, LLP
2323 Victory Ave. Suite 700
Dallas, TX 75219
Phone: (512) 867-8457
Fax: (214) 200-0853
david.obrien.ipr@haynesboone.com
USPTO Reg. No. 40,107

Back-up Counsel
Kelly Gehrke Lyle
HAYNES AND BOONE, LLP
2801 N. Harwood St. Suite 2300
Dallas, TX 75201
Phone: (512) 867-8528
Fax: (214) 200-0853
kelly.lyle.ipr@haynesboone.com
USPTO Reg. No. 62,332

Greg Michelson
HAYNES AND BOONE, LLP
2801 N. Harwood St. Suite 2300
Dallas, TX 75201

Phone: (949) 202-3022
Fax: (214) 200-0853
greg.michelson.ipr@haynesboone.com
USPTO Reg. No. 44,940

Hong Shi
HAYNES AND BOONE, LLP
2801 N. Harwood St. Suite 2300
Dallas, TX 75201

Phone: (512) 867-8440
Fax: (214) 200-0853
hong.shi.ipr@haynesboone.com
USPTO Reg. No. 69,009

Please address all correspondence in this proceeding to lead and back-up counsel. Petitioner consents to service in this proceeding by email at the addresses above.

CERTIFICATE OF WORD COUNT

Pursuant to 37 C.F.R. §42.24(d), Petitioner hereby certifies, in accordance with and reliance on the word count provided by the word-processing system used to prepare this Petition, that the number of words in this paper is 13,931. Pursuant to 37 C.F.R. §42.24(d), this word count excludes the table of contents, table of authorities, mandatory notices under §42.8, certificate of service, certificate of word count, appendix of exhibits, and any claim listing.

Dated: February 10, 2025

/*David W. O'Brien*/
David W. O'Brien, Reg. No. 40,107
Lead Counsel for Petitioner

CERTIFICATE OF SERVICE

The undersigned certifies that, in accordance with 37 C.F.R. § 42.6(e) and 37 C.F.R. § 42.105, service was made on Patent Owner as detailed below.

Date of service	February 10, 2025
Manner of service	FEDERAL EXPRESS
Documents served	Petition for *Inter Partes* Review Under 35 U.S.C. § 312 and 37 C.F.R. § 42.104 of U.S. 7,489,914; Petitioner's Notice Ranking Petitions and Explaining Material Differences Between Petitions for U.S. Patent No. 7,489,914; Power of Attorney; Petitioner's Exhibit List; Exhibits EX1001-EX1012, EX1014-EX1040
Persons served	THOMAS | HORSTEMEYER, LLP 3200 WINDY HILL ROAD, SE SUITE 1600E ATLANTA, GA UNITED STATES

/David W. O'Brien/
David O'Brien, Reg. No. 40,107
Lead Counsel for Petitioner