

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

MURATA MANUFACTURING CO., LTD

Petitioner

IPR2025-00383
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**

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PETITIONER’S EXHIBIT LIST

EX1001	U.S. Patent No. 7,489,914
EX1002	Prosecution History of U.S. Patent No. 7,489,914
EX1003	Declaration of Matthew B. Shoemake under 37 C.F.R. § 1.68
EX1004	<i>Curriculum Vitae</i> 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 Application Publication No. 2002/0118067 (“Hirayama”)
EX1009	U.S. Patent No. 5,995,814 (“Yeh”)
EX1010	<i>Reserved</i>
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
EX1012	<i>Fundamentals of Microsystems Packaging</i> , Rao Tummala, McGraw-Hill, Table of Contents and Chapter 11, 2001
EX1013	<i>Reserved</i>
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	<i>RF Microelectronics</i> , 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	<i>The Wiley Electrical and Electronics Dictionary</i> , 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 Passives 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	<i>Microwave Engineering Second Edition</i> by 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	<i>Microwave Transistor Amplifiers Analysis and Design</i> , 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	<i>Reserved</i>
EX1039	<i>Reserved</i>
EX1040	<i>Reserved</i>

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) transceivers. 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, ¶¶1-42.

A. Multi-Band Devices

In the first generation of mobile devices, the communication system operated in a single frequency band—800 MHz, referred to as cellular band. EX1003, ¶24. However, by the 1990s, well before the '914 Patent, additional frequency spectrum was allocated for such communications including the 1800 MHz band, referred to as the personal communication systems (PCS) band. As additional spectrum was allocated, a need arose for these mobile devices (e.g., personal telephones) to operate at multiple frequencies. EX1003, ¶¶23-28 (discussing multi-band communication devices citing EX1001, 1:29-47; EX1009; EX1015-EX1017).

One early technique implemented to provide multi-band functionality relied upon separate sets of components assigned to each band and disparate signal paths for each frequency. EX1003, ¶¶27-28 (citing EX1009, 1:39-46; EX1005; EX1016-EX1018 recognizing single to dual-band evolution of devices). This led to devices with increased size and cost. EX1003, ¶27 (discussing costs and complexity of dedicated frequency paths). Recognizing these challenges, and driven by the growing demand for portable devices supporting multiple bands while remaining cost-effective and efficient, market forces recognized a need for re-use of components in multi-band devices. EX1003, ¶¶27-28 (discussing implementing

component reuse at multiple bands citing EX1005; EX1008-EX1009; EX1018; EX1020-EX1021).

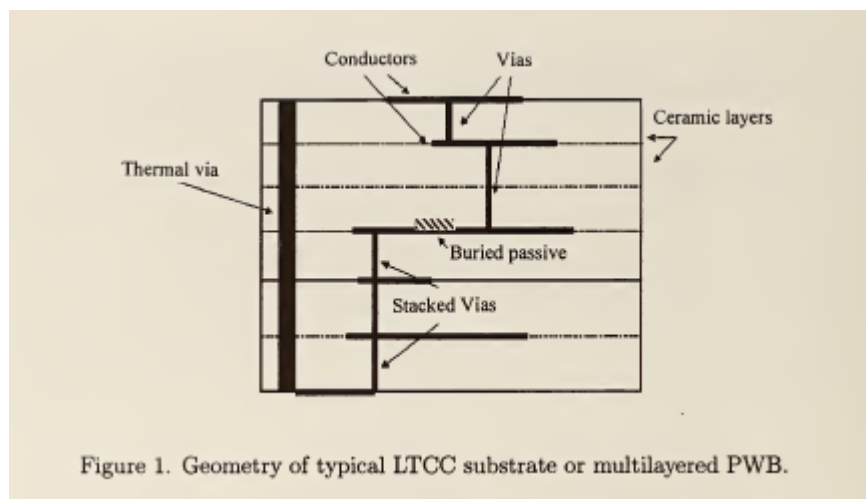
B. Transceivers

The RF circuitry section of a mobile device includes transmit and receive portions, together forming a transceiver, with an antenna for conveying the respective signals. Amplifiers are an important building block of the transceiver as they are coupled with the antenna in each of the transmit and receive paths. EX1003, ¶¶29-32 (citing EX1017). That is, the receiver portion includes an amplifier (low-noise amplifier (LNA)) boosting the incoming signal while minimizing noise; the transmit portion includes an amplifier (power amplifier (PA)) similarly boosting the signal for sufficient transmission. Amplifiers are comprised of a core amplifying device, typically a transistor, to provide the gain, and passive components (resistors, capacitors, inductors) arranged in a network to provide biasing and matching associated with the core amplifying device. *Id.*

C. Packaging

Similar to market forces driving component reuse, there was a recognized need for packaging technologies to provide transceiver components with good electrical performance in a small footprint package. EX1003, ¶¶33-35 (discussing market forces, yield, and regulatory approval and citing EX1023; EX1026). Generally, substrates provide foundation material and have “low permittivity,

interconnections made of high-conductive metals, high wiring density, and embedded passive circuit elements.” EX1025, p. 2. *See also*, EX1003, ¶¶36-42 (discussing substrates, permittivity, interconnected buried passive components and citing EX1012; EX1025; EX1037). A typical configuration of such a substrate is illustrated below.



EX1025, p. 10

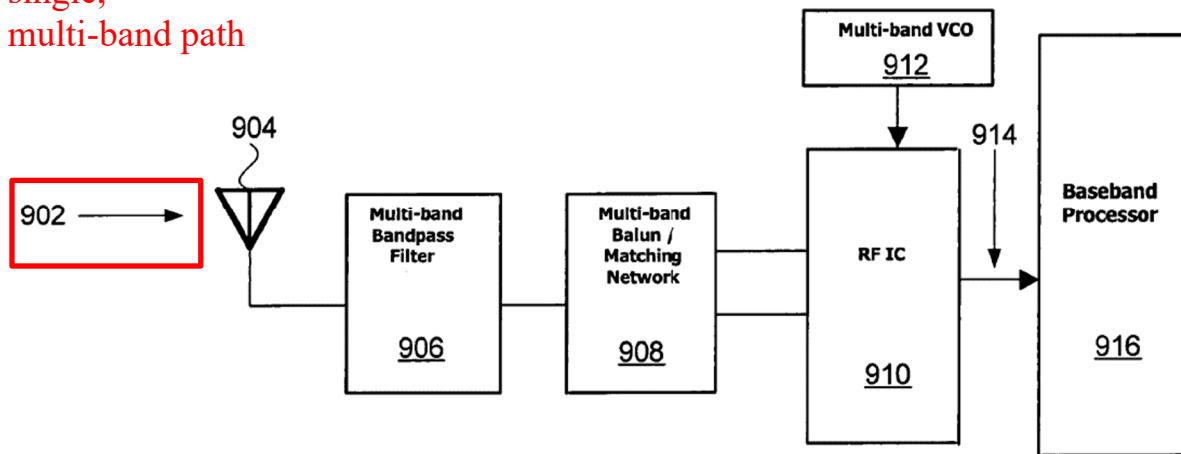
The substrate above is a multilayer substrate formed by stacking or laminating multiple layers together. POSITA understand that buried passive or embedded passive circuit components means that passive components (such as resistors, capacitors and inductors) are formed in the substrate. EX1003, ¶¶38-39 (illustrating known embedded passives citing EX1025; EX1012). There are numerous benefits to embedding passives. EX1003, ¶¶40-41 (discussing including reducing size, increased quality, and reliability). For example, suitable dielectric materials (e.g.,

sufficiently “low permittivity”) of the substrate allow for limiting signal loss in the conductor interconnections (metal lines and vias) and passive components. EX1003, ¶¶41-42. Organic substrates such as polyimide-based substrates (*e.g.*, polytetrafluoroethylene (PTFE) or Teflon) and ceramic-based (*e.g.*, aluminum oxide) substrates were well-known options prior to the '914 Patent. EX1003, ¶¶41-42 (citing EX1025, EX1037). Further, embedding passives within those organic substrates was also well-known. EX1003, ¶¶38-43 (citing, *e.g.*, EX1025, Figure 1 (PWB substrate); EX1012, Figure 11.2 (“Embedded into Organic Board”); EX1037, Fig. 3 illustrating embedded inductors, [0016] (“organic material that configures the substrate”).

V. SUMMARY OF THE '914 PATENT

The '914 Patent relates to RF transceivers operable at multiple RF bands, *i.e.*, multi-band transceivers. EX1001, 1:23-27. FIG. 15, below, illustrates a receiver portion using only a single path for multiple band frequencies, which is contrasted with different paths for each frequency band (*compare* FIG. 14). EX1001, 17:18-20, 16:53-61.

single,
multi-band path

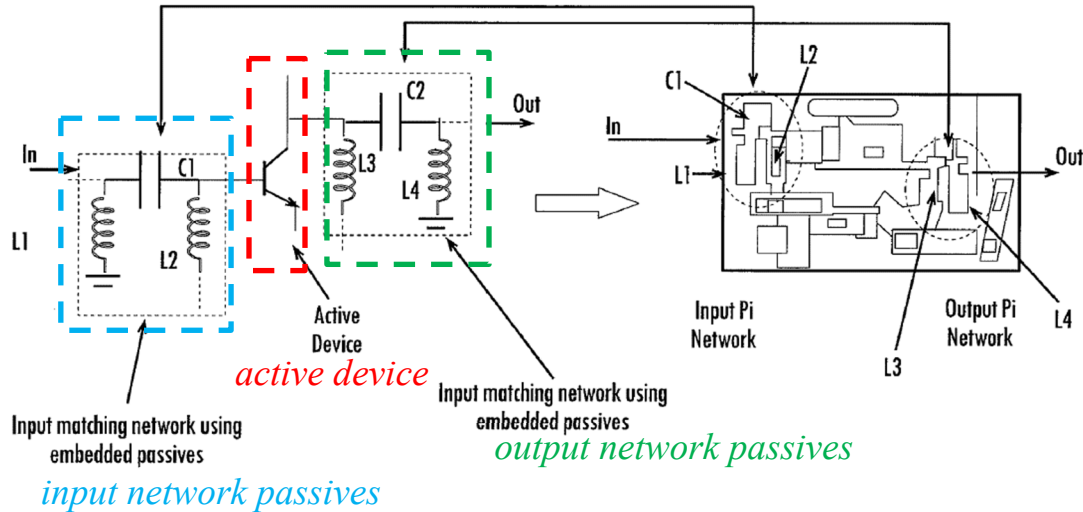


EX1001, FIG. 15
(annotated)

The '914 Patent suggests multi-band RF transceiver topologies can reuse components at different frequencies and gives examples of a voltage controlled oscillator (VCO) and a low noise amplifier (LNA). EX1001, 2:8-20.

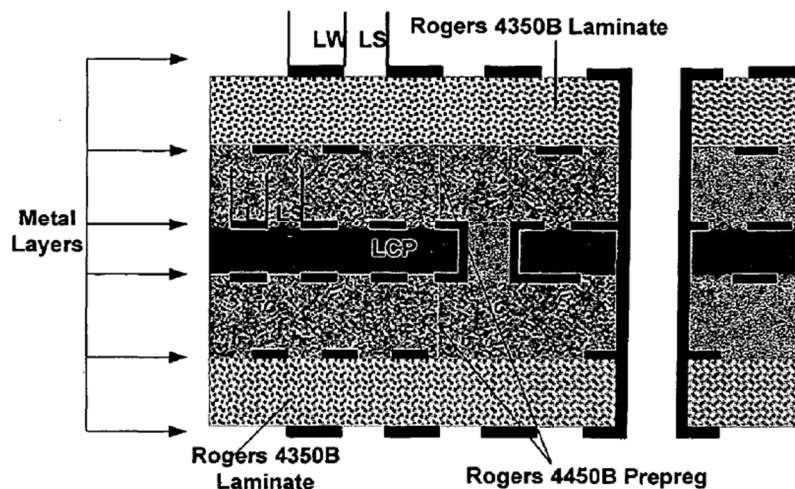
FIG. 35 illustrates an LNA with an active device (shown as a bipolar junction transistor) and matching networks at its input and output. EX1001, 24:10-27.¹ The matching networks are labeled as including embedded passives.

¹ The label of the network including L3, L4, C2 should read an “Output matching network using embedded passives.” EX1003, ¶48.



EX1001, FIG. 35
(annotated)

The '914 Patent describes embedded passives formed in an organic substrate to reduce the form factor of the 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 function as ground shields. EX1001, 25:4-12.



EX1001, FIG. 38A

“Rogers 4350B” and “Rogers 4450B” shown in FIG. 38A are materials from Rogers Corporation commonly used in the industry. EX1003, ¶50 (citing EX1025). *See also*, EX1003, ¶¶43-50.

VI. PROSECUTION HISTORY

The Patent Office issued a restriction requirement between claims to “multi-band low noise amplifier [LNA] [of] Fig. 35” and “multi-band oscillator [of] Fig. 16A and 27.” EX1002, p. 94. Applicant elected the LNA embodiment. EX1002, p. 88. Following rejection of then-pending claims over U.S. Patent 6,075,995 and its multi-band functionality provided by two separate amplifiers with respective passive networks, Applicant amended its claims to include “the first [second] passive network...at an input [output] of the active device.” EX1002, pp. 56-61, 44-51.

A Notice of Allowance copying each element of the independent claims issued.

EX1002, pp. 33-37. *See also*, EX1003, ¶¶51-54.

VII. EFFECTIVE PRIORITY DATE OF THE '914 PATENT

The '914 Patent is based on an application filed April 25, 2005, which claims priority to a provisional application filed April 23, 2004, and asserts to be a continuation-in-part of U.S. Patent No. 6,900,708 filed on Mar. 28, 2003. Determining whether the '914 Patent is entitled to an earlier priority date is unnecessary with respect to **this** petition as all of the cited and relied-upon prior art in these challenges predate March 2003. Petitioner does not waive any right or opportunity it may have to dispute the priority date of the '914 Patent in this or another forum where the issue is relevant. Concurrently, a second *inter partes* review (IPR2025-00384) is filed challenging the priority date.

VIII. LEVEL OF ORDINARY SKILL IN THE ART

Persons of Ordinary Skill in The Art (“POSITA”) in March 2003 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, ¶¶55-56.

X. RELIEF REQUESTED AND THE REASONS FOR THE REQUESTED RELIEF

Petitioner asks that the Board institute a trial for *inter partes* review and cancel 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. 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 are embodied in the Accused Products.”) *See* EX1035, p. 38.² A finding that the Challenged Claims (1-2 and 4-20) are unpatentable in this proceeding will resolve the parties’ dispute in the co-pending litigation and obviate any need for a

² Petitioner does not challenge claim 3, which is directed to an oscillator.

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

B. Statutory grounds for challenges³

Grounds	Claims	Basis (Pre-AIA)
#1	1-2, 5, 12-20	35 U.S.C. § 103 over Francisco and JP466
#2	4, 6	35 U.S.C. § 103 over Francisco and JP466 and Hirayama
#3	7-11	35 U.S.C. § 103 over Francisco and JP466 and Okubora

- U.S. 6,128,508 was filed Dec. 27, 1996 and issued Oct. 3, 2000 (EX1005, “**Francisco**”); qualifies as prior art under (pre-AIA) 35 U.S.C. §102(b).
- JP 2001-267466A was published September 28, 2001, (EX1006, “**JP466**”) qualifies as prior art under (pre-AIA) 35 U.S.C. §102(b).
- EP 1 189 345 A2 filed September 13, 2001, and published March 20, 2002 (EX1007, “**Okubora**”) qualifies as prior art under 35 U.S.C. §102(b).
- U.S. 2002/0118067 filed February 22, 2002 and published August

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).

29, 2002 (EX1008, “**Hirayama**”) qualifies as prior art under 35 U.S.C. §§102(a), 102(e).

Petitioner also cites below to additional prior art as evidence of the background knowledge of POSITA and to provide contemporaneous context to support Petitioner’s assertions regarding 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) (affirming the use of “supporting evidence relied upon to support the challenge”), *see also*, EX1003, ¶¶24-60.

C. Ground 1

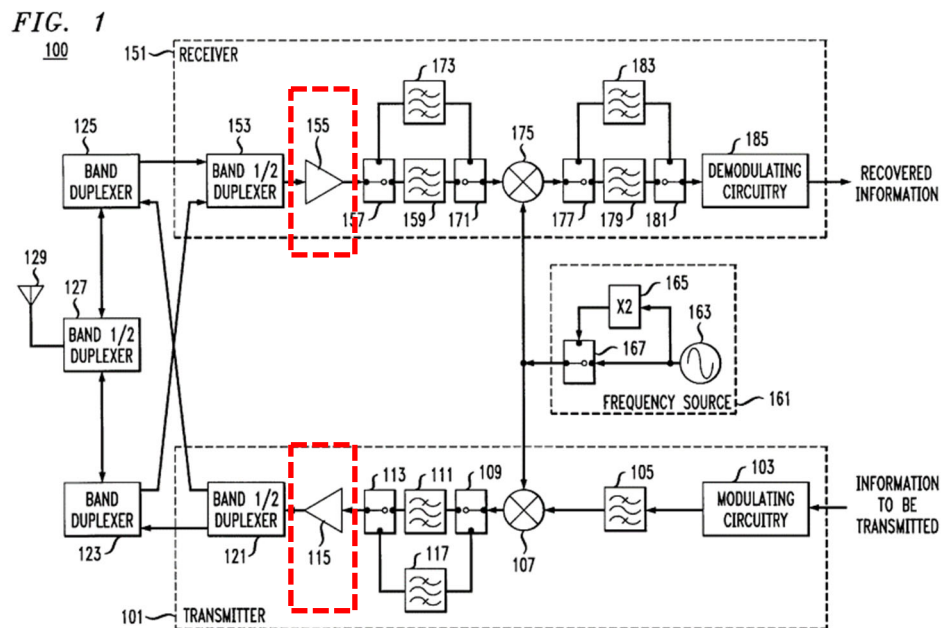
1. Francisco (EX1005)

Francisco relates generally to “communications systems, and more particularly to those systems using amplifiers to transmit signals over multiple frequency bands.” EX1005, 1:5-7. Driven by a need to improve “the multi-band radiotelephone, so that the circuit utilizes the space more efficiently, and is less expensive and more reliable,” Francisco describes “multiple prior-art amplifiers each handling communications with only one frequency band” can be replaced with a single multi-band amplifier. *See* EX1005, 1:42-46, 62-67. The single “multi-band amplifier in a communications system [is employed] to scale the signal level of a signal communicated over one of multiple frequency bands.” EX1005, 1:50-53.

FIG. 1 illustrates system 100 including transmitter 101 and receiver 151

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multi-band LNA 155

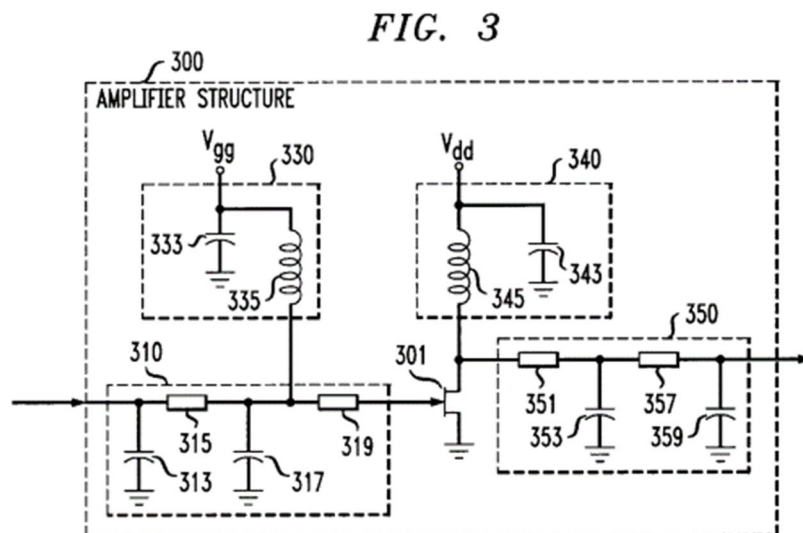


multi-band
power amplifier
115

EX1005, FIG. 1
(annotated)

FIG. 3 illustrates an amplifier structure 300 used for each multi-band

amplifier—multi-band power amplifier (PA) 115 and multi-band LNA 155. EX1005, 5:24-29. Each of multi-band PA 115 and multi-band LNA 155 is “[a]dvantageous[.]...with respect to its prior art counterpart, [.] less expensively and bulky, and more reliable due to use of at least fewer [.] amplifiers.” EX1005, 3:66-4:2, 4:43-46 (“Like amplifier 115, LNA 155 **replaces two prior art LNAs** which would otherwise be employed to handle cellular receive signals and PCS receive signals separately”). The amplifier structure 300 includes field effect transistor (FET) 301 having a gate terminal connected to input matching network 310 and gate bias circuit 330 as well as a drain terminal connected to drain bias circuit 340 and output matching network 350. EX1005, FIG. 3, 5:30-36.



EX1005, FIG. 3

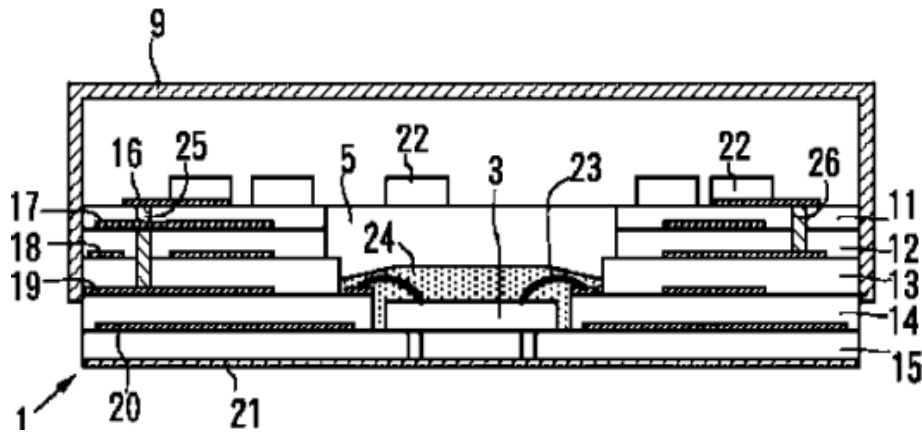
See also, EX1003, ¶¶61-64.

2. JP466 (EX1006)

Like Francisco, JP466 is directed to signal amplification “used in a communication equipment transmitter of a mobile phone, or the like.” EX1006, [0001]. JP466 suggests implementing communication circuits such as its amplifier in a module, which can reduce size of the passives and mitigate the generation of a standing waves. EX1006, [0011]-[0022].

To form an amplifier (described in the context of a power amplifier), a dielectric substrate is used and its semiconductor amplifying element such as a FET is mounted directly on the substrate, while passive components such as “**a matching circuit...**[and] part of an FET bias circuit (resistor, capacitor)...and the like, are **arranged on each layer of the dielectric substrate.**” EX1006, [0006]. The substrate, by using a dielectric material having a high relative permittivity ϵ_r , obtains an amplifier module in which the length of the conductor pattern is reduced, the outer shape of the dielectric substrate is reduced, and electromagnetic coupling between patterns is suppressed. EX1006, [0018]-[0025]. The dielectric substrate includes multiple, stacked dielectric substrates (11 to 15), which are also referred to as “layer[s].” EX1006, [0006], [0051]-[0053], FIG. 5. Passives such as resistors, capacitors, inductors and other impedance elements may be formed as conductor patterns on the surface of dielectric layers 11 to 15, thus embedded within the

substrate 1. EX1006, [0053].



EX1006, FIG. 5

For example, conductor patterns 18 and 17 on a dielectric substrate/layers 13 and 12 form capacitors. *See* EX1006, [0054]-[0055], FIGS. 5-7. Likewise, strip lines in conductor pattern 20 form inductors on dielectric substrate/layer 15. *See* EX1006, [0057], FIGS. 5, 9. *See also*, EX1003, ¶¶65-70 (discussing JP466).

3. Reasons to Combine Francisco and JP466

POSITA would have been motivated to combine the teachings of Francisco, which is silent as to the implementation of its amplifier, with JP466's multilayer substrate having passive components (capacitors and inductors) formed in layers of its substrate that form matching and bias circuits coupled at inputs and outputs of an active device. EX1003, ¶¶71-90. In particular, POSITA would have been motivated

to combine the teachings of Francisco and JP466 to produce the obvious, beneficial, and predictable results of utilizing JP466's substrate with embedded passive components to form a module implementing Francisco's amplifier circuit. *Id.*

Francisco and JP466 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. *See* EX1003, ¶72, EX1001, 1:29-47; EX1005, 1:11-25; EX1006, [0003]. In particular, each of Francisco, JP466 and the '914 Patent are directed to an amplifier. EX1001, 2:14-16; EX1006, [0003]; EX1005, 1:5-61. Further, Francisco and JP466 are analogous art because each is directed to a same problem faced by the '914 Patent's inventors—decreasing the size of RF devices. EX1006, [0007]-[0016]; EX1005, 1:42-46; EX1001, 1:58-62. And POSITA would have been motivated to combine the teachings of Francisco and JP466 for multiple reasons, as discussed below. EX1003, ¶¶73-85.

First, Francisco's amplifier is intended to be used in a system such as a mobile phone. Due to Francisco's silence, POSITA are faced with a question of implementing Francisco's circuit for such an application. POSITA would readily turn to substantially similar circuits and their implementation. A common technique for providing RF circuitry amplifier circuit was a module. EX1003, ¶¶33-42, 73-74. Implementation as a module as taught in JP466 was merely applying a "prevalent, perhaps even predominant, method" of performing a given task in the art. *Randall*

Mfg. v. Rea, 733 F.3d 1355, 1363 (Fed. Cir. 2013).

Second, POSITA would have been motivated to implement JP466's substrate, along its teachings of embedding the passives within its substrate, in order to recognize a benefit of reducing device size. EX1003, ¶¶75-77; EX1006, [0011], [0014], [0094]. There was a well-recognized motivation to decrease the size of the circuit, as well as the components thereof, when implementing an RF device. EX1003, ¶75 (citing EX1006, [0007], EX1005, 1:38-47). One common way to achieve this reduction was use of system-on-package (SoP) configurations typical in the industry prior to the '914 Patent. EX1003, ¶75 (citing EX1025, p. 8 ("The ability to include components into the modules reduces the number of interconnects which increases reliability and reduces the size and the cost.")). As Francisco's amplifier includes multiple passive components, POSITA would recognize that providing these components within the substrate of a module, as taught by JP466, reduces the need for separate, discrete passive components, which take up additional area on the system board. EX1003, ¶¶74-75. This is merely implementing a known technique of embedding passive components in the substrate to provide to a benefit of efficient use of vertical space by positioning on the passives on multiple layers. *Id.* Providing passive components embedded in the substrate also reduces system assembly costs and system level planning. *Id.* (discussing rest of bill of materials (RBOM) cost reduction, planning, quality testing).

POSITA would also recognize a benefit of implementing JP466's teachings is allowing for a reduction in passive component size. EX1003, ¶¶75-76. JP466 describes benefits of decreasing the size of a passive (inductor) by embedding it within the substrate's dielectric. EX1006, [0064], [0070], [0075]; EX1003, ¶¶75-77 (explaining higher relative permittivity material impacts size).

Third, POSITA would have been motivated to implement JP466's teachings and the configuration of the passive components embedded therein for benefits electrical performance of the device. EX1003, ¶¶77-83. As discussed above, JP466's substrate provides dielectric material surrounding passives, which provides for efficient performance. *Id.* (discussing efficient signal transmission and preventing standing waves, EX1006, [0063], [0066]). Embedding components within JP466's substrate material makes it possible for a "high Q value can also be acquired." EX1006, [0080]; EX1003, ¶81 (explaining high Q value means lower losses and better high frequency performance). Further, embedding passives allows for benefits to the system design process by reducing variables that would otherwise arise from interfaces with discrete components. EX1003, ¶82 (discussing tolerances for component placement, package variations citing EX1027).

Fourth, POSITA would have been motivated to implement JP466's teachings to achieve quality and reliability benefits of JP466's substrate material. EX1003, ¶84 (discussing weight, cracking, delamination benefits citing EX1028). JP466 teaches

its substrate is less prone to cracking or delamination providing increased mechanical strength and reliability. EX1006, [0026], [0079].

In summary, POSITA would have been motivated to apply JP466's teachings when implementing Francisco's amplifier because doing so would beneficially (1) provide details as to the implementation of Francisco's circuit suitable for its intended use in a communication system, (2) provide for a reduction in size of the RF device and components thereof, (3) provide benefits with respect to the electrical performance, and (4) provide a substrate quality that reduces delamination and cracking issues. EX1003, ¶85.

The results of combining Francisco's device with JP466's substrate would have been predictable and had a reasonable expectation of success given both Francisco and JP466 relate to similar device types performing the same function. EX1003, ¶¶86-90 (describing each amplifier with active device, matching circuit, bias circuits forming a circuit block citing EX1006, [0003]; EX1005, FIGS. 3, 4). Moreover, JP466's substrate configuration was common practice in RF devices. EX1003, ¶90 (citing EX1025; EX1029; EX1037 (illustrating organic substrate with embedded passives)).

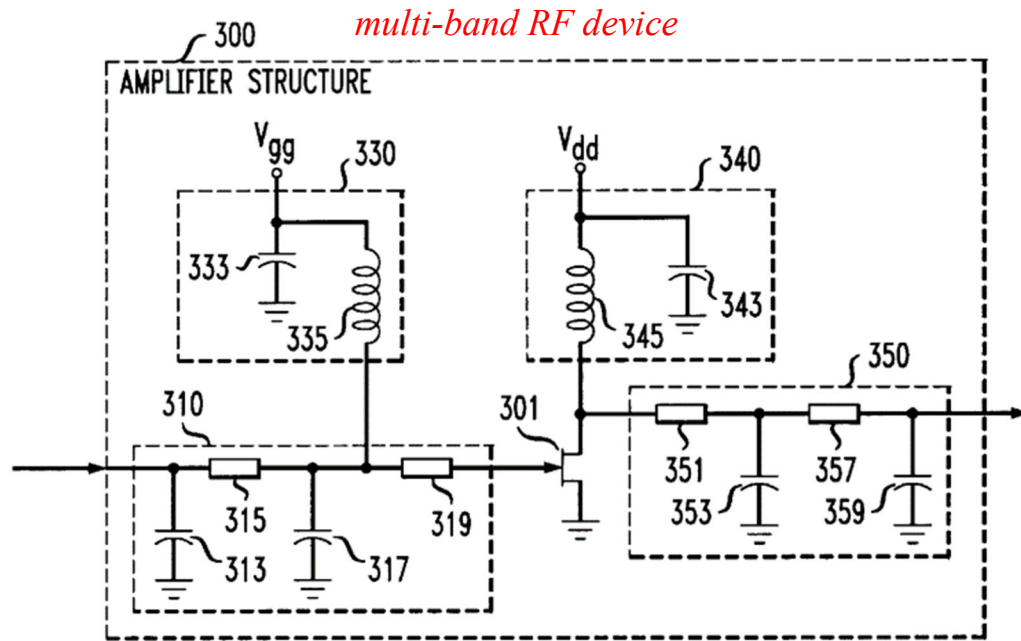
4. Claim 1

[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, Francisco discloses it. EX1003, ¶¶91-103.

As discussed above, Francisco introduces a communication system 100, such as a portable radiotelephone for wireless communications over multiple frequency bands (*i.e.*, multi-band). EX1005, 2:19-26, 1:14-16. The communication system 100 includes an antenna coupled with transmitter and receiver, each including components of filters, oscillators, switches, and amplifiers to process RF signals at multiple bands. EX1005, 2:48-49, 2:63-3:55, FIG. 1; EX1003, ¶93 (discussing conventional transceiver building blocks). The system 100 operates “over **a first set of frequency bands** [e.g., cellular band], and a **second set of frequency bands** [e.g., PCS band].” EX1005, 2:20-26. *See also*, EX1005, FIG. 2, 2:27-47. These specific frequency bands are exemplary and not limited by Francisco. EX1005, 7:45-52. Thus, Francisco teaches a system, and RF devices therein as discussed below, *operable at a first frequency* (e.g., cellular band, ~800 MHz) and *a second frequency* (e.g., PCS band, ~1800MHz), which is *different from the first frequency*. EX1005, 1:10-25.

The amplifier structure 300 of FIG. 3 is *a multi-band RF device* implemented in the system 100 in both transmit and receive paths; the structure 300 receives and processes signals in each of multiple bands. EX1005, 5:23-29.



EX1005, FIG. 3
(annotated)

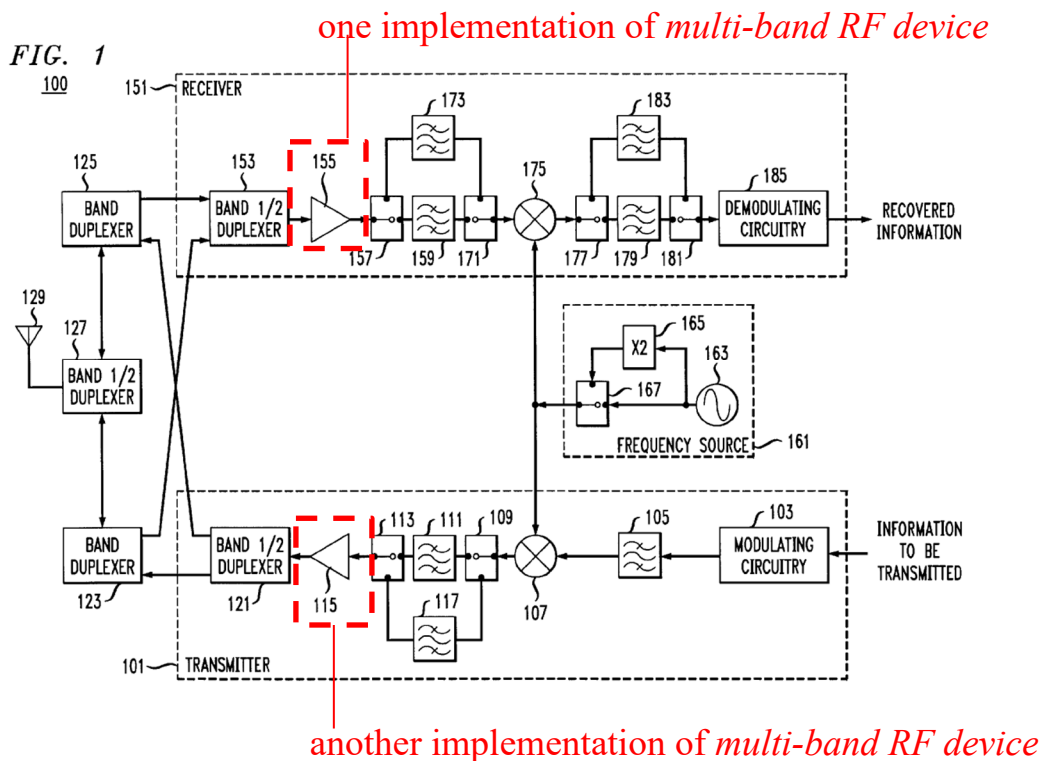
The amplifier structure 300, *a multi-band RF device*, operates at multiple frequencies as low noise amplifier (LNA) 155 in the receive path of the system 100, and in a second implementation, the amplifier structure 300, *a multi-band RF device*, operates at multiple frequencies as power amplifier 115 in the system's transmit path.⁴ In each position, the amplifier is *operable* to achieve a designed gain to signals

⁴ POSITA understand low-noise amplifiers, *e.g.*, LNA 155, and power amplifiers, *e.g.*, PA 115, are used on the receive and transmit sides of transceivers, respectively. EX1003, ¶¶29-31, 62-64, 98. Both types of amplifiers perform a similar function,

in *first* and *second frequency* bands and thus, is a *multi-band RF device*. EX1003, ¶99. Francisco explains that “unlike a prior art power amplifier which provides a desired gain to a signal within only a particular transmit band, amplifier 115 provides, in an efficient manner, a **desired gain to a signal within any one of the many discrete transmit bands.**” EX1005, 3:56-62. *See also*, EX1005, 4:48-51 directed to LNA. An amplifier is the same device as described in ’914 Patent as one example of a *multi-band RF device*. *See* EX1001, dependent claim 4, 2:14-16 (“low noise amplifiers”), *see also*, 23:60-24:36.

FIG. 1 is illustrative of this system implementation of *multi-band RF device* discussed above:

just in different places in the signal chain and do so with same structures though the value of the components may vary. *Id.*; EX1005, 5:23-6:7.



EX1005, FIG. 1 (annotated)

See also, EX1005, 3:36-55.

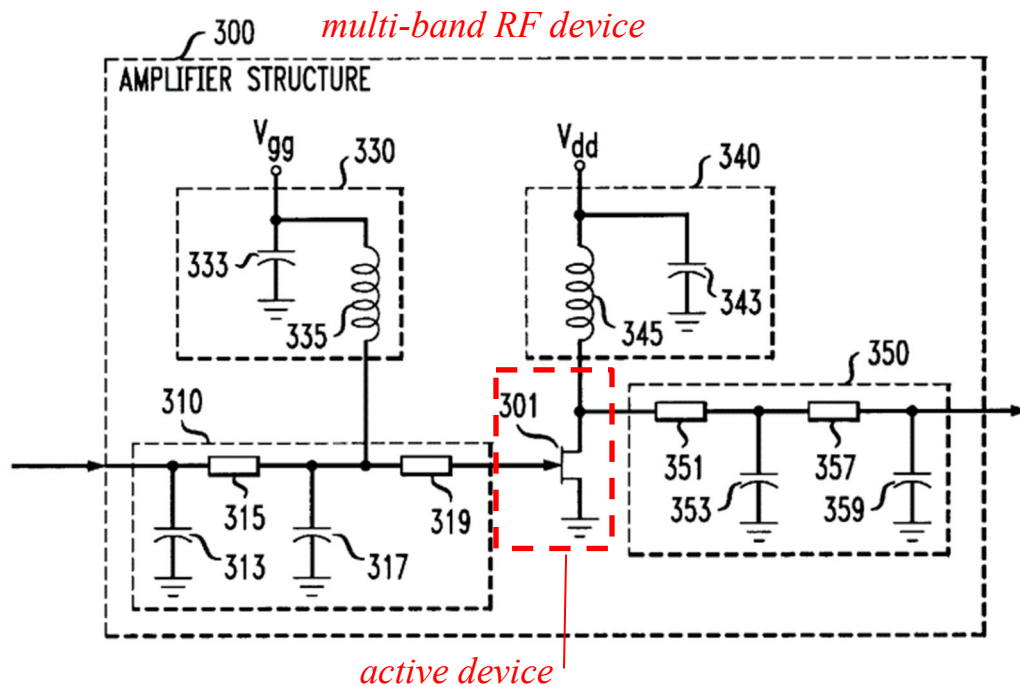
Francisco explains the benefits of using each amplifier to produce signal gain at multiple bands is reduction in components in the multi-band system. “[A]mplifier 115 replaces two prior art power amplifiers which would otherwise be employed to handle signals within cellular Xmt band 201 and PCS Xmt band 205 separately. Advantageously, with multi-band power amplifier 115[,]...[system 100] is less expensive and bulky, and more reliability due to the use of at least fewer power amplifiers.” EX1005, 3:62-4:2. See also, EX1005, 4:43-46. This is the same advantage recognized by the ’914 Patent. See EX1001, 2:8-16 (“in certain

circumstances, can be reused at different frequency ranges, thereby reducing the number of components required.”)

Thus, Francisco discloses the *multi-band RF device* of [1.0]. EX1003, ¶¶91-103.

[1.1] *an active device*;

As discussed above, Francisco’s amplifier structure 300 is a *multi-band RF device* and it includes field effect transistor (FET) 301, which is *an active device*. EX1003, ¶¶104-110. “As shown in FIG. 3, central to amplifier structure 300 is **field effect transistor (FET) 301**.” EX1005, 5:30-31. This configuration of *an active device* is the same as the ’914 Patent. EX1001, 27:20-21 (“the active device is a field effect transistor”). The *active device* of Francisco also performs the same function of receiving a signal input from a passive network (*e.g.*, input matching network 310), producing gain and amplifying the signal, which is output to another passive network (*e.g.*, output matching network 350). EX1003, ¶¶107-109 (discussing transistor in circuit).



EX1005, FIG. 3
(annotated)

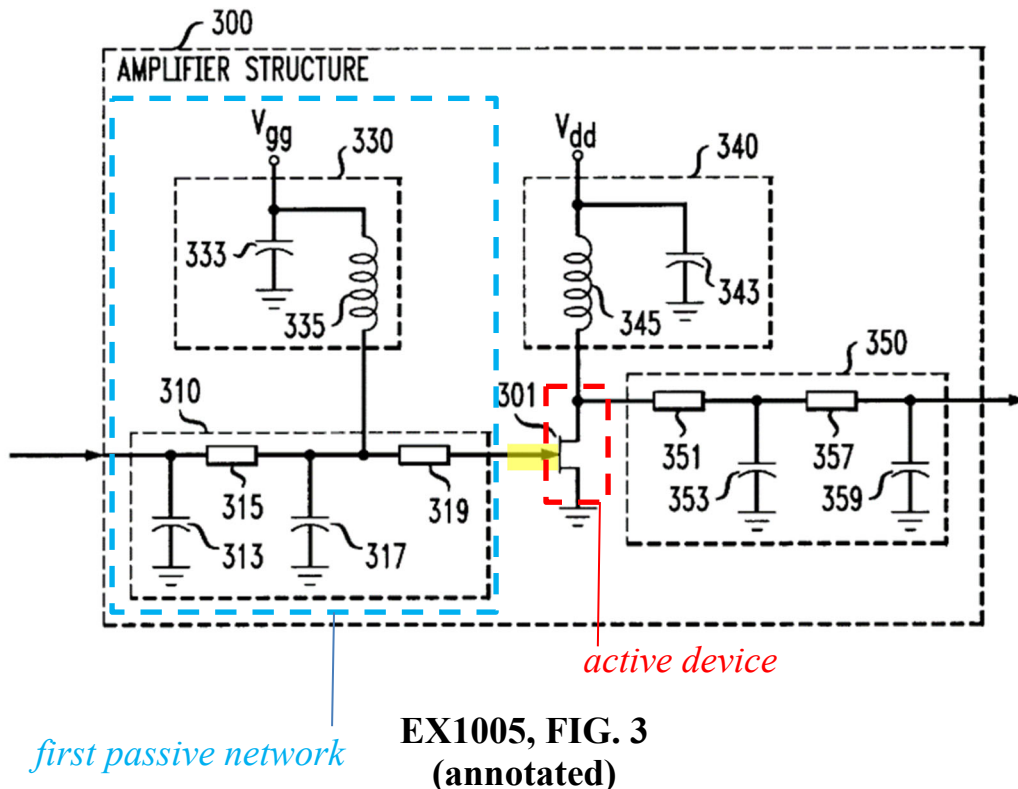
Thus, Francisco discloses *an active device* of [1.1]. EX1003, ¶¶104-110.

[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;

Francisco’s amplifier structure 300, *multi-band RF device*, includes *a first passive network* as recited in [1.2]. EX1003, ¶¶111-122.

Francisco describes an “input matching network 310” and coupled “gate bias circuit 330” that together provide *a first passive network*. EX1005, FIG. 3, 5:31-40. This, like the ’914 Patent’s similarly positioned passive network, is a network comprising inductors and capacitors and providing a matching functionality.

EX1003, ¶112 citing EX1001, FIG. 35, 24:20-36.



The input matching network 310 and gate bias circuit 330, the *first passive network*, is *in communication* with FET 301, the *active device*. In particular, matching network 310 is connected to one of the FET terminals (*i.e.*, the gate). EX1003, ¶113; EX1005, FIG. 3, 5:32-34 (“**gate terminal** [of FET 301] is **connected** to **input matching network 310** coupled to **gate bias circuit 330**.”), 5:44-45 (“Transmission line 319 **connects** both **capacitor 317** [of matching network 310] and circuit 330 to the **gate terminal of transistor 301**.”) This connection provides *communication* of the input signal through the passive network to the FET 301. *Id.*

Francisco's *first passive network* comprises a *first matching network* of at least "input matching network 310." EX1005, 6:57-61, FIG. 3. A matching network refers to an impedance matching, which is the function of Francisco's "input **matching** network 310" that "provides an optimum input **impedance match** over the multiple bands of interest (in this instance the cellular and PCS transmit bands for amplifier 115, or the cellular and PCS receive bands for LNA 155)." EX1003, ¶114, EX1005, 6:57-61. *See also*, EX1005, 5:65-6:65 discussing the values of the passive networks for application as LNA 155 and PA 115.

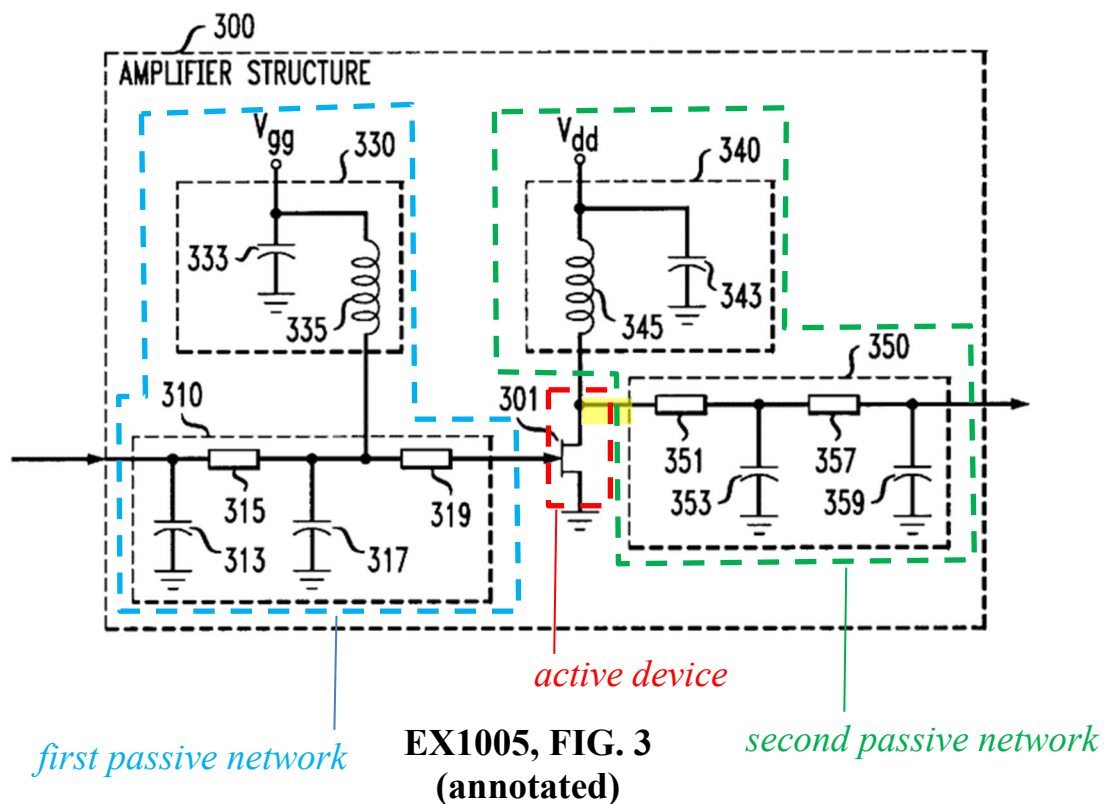
The *first passive network*, including gate bias circuit 330 and matching network 310, is *at an input of the active device* illustrated (1) by the connection highlighted in FIG. 3 above (without intervening components), (2) by Francisco's description of network 310 as an "**input** matching network," and (3) by POSITA's understanding of functionality in the context of an amplifier. EX1003, ¶¶115-121 (discussing bias circuit setting quiescent point and matching network).

Thus, Francisco discloses the *first passive network* of [1.2]. EX1003, ¶¶111-122.

[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

Francisco's amplifier structure 300, *a multi-band RF device*, discussed above includes a *second passive network* as in [1.3]. EX1003, ¶¶123-131.

Francisco describes a “drain bias circuit 340” and “output matching [circuit] 350” that together provide a *second passive network*. EX1005, FIG. 3, 5:34-36. Francisco’s network comprises inductors and capacitors and provides matching functionality, just as provided in the ’914 Patent. EX1003, ¶124 (citing EX1001, FIG. 35).



The *second passive network*, including drain bias circuit 340 and output matching circuit 350, is *in communication* with the *active device* of [1.1], FET 301. EX1003, ¶125; EX1005, 5:34-36 (“The drain terminal of [FET 301] is **connected** to drain bias circuit 340 and also to output matching network 350.”), 5:58-59

(“Transmission line 351 in network 350 **connects** the drain terminal of transistor 301 to capacitor 353 [of output matching network 350].”) The connection is for communication of an output signal from the FET. EX1003, ¶125.

The *second passive network* comprises output matching circuit 350, which is a *second matching network*. Francisco describes “output **matching** network 350 provides an optimum output impedance match over the same bands [e.g., cellular and PCS]” and thus, provides a *second matching network*. EX1005, 6:61-63; EX1003, ¶126.

Francisco’s *second passive network* of drain bias circuit 340 and output matching network 350 is *at an output of the active device* (FET 301) as illustrated (1) by highlighted interconnection in FIG. 3, (2) by Francisco’s description of an “**output** matching network,” (EX1005, 6:12-20) and (3) by POSITA’s understanding of functionality of the network. EX1003, ¶¶127-130 (discussing purpose and components of Francisco’s structure 300).

Thus, Francisco discloses *the second passive network* of [1.3]. EX1003, ¶¶123-131.

[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,

Francisco in view of JP466 renders obvious this element. EX1003, ¶¶132-146.

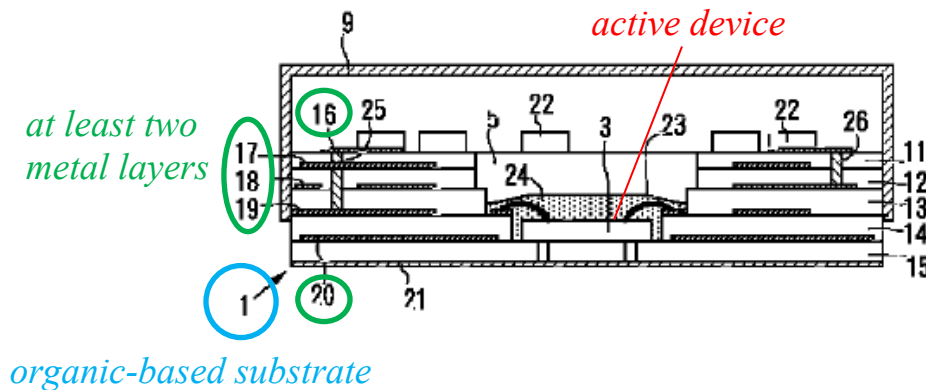
As discussed, Francisco discloses implementing its amplifier structure 300,

multi-band RF device, to provide multi-band functionality for “radiotelephones.” EX1005, 1:25-45. The common way of providing circuit components for such an application is on a substrate that provides foundation material. EX1003, ¶¶75, 133, 33-42 (discussing modules and SoP). As discussed in the reasons to combine above, POSITA would have reason to turn to the teachings of JP466, which describes a similar circuit, to implement the circuits of Francisco.

Just like Francisco, JP466 teaches an amplifier module including passive networks in communication with an active device (*e.g.*, a FET). EX1006, FIG. 3. JP466 details providing the amplifier on a substrate, which includes multiple, stacked layers (“a laminated dielectric substrate”), where passive components of the amplifier (*e.g.*, “matching circuit...bias circuit”) are “arranged on each layer of the dielectric substrate” as a “conductor pattern.” EX1006, [0006]. JP466’s embedding passives as conductive patterns in a multi-layer dielectric substrate is a common technique. EX1003, ¶¶33-42, 90, 134-139 (citing EX1030; EX1025; EX1037 discussing passives formed on metal layers of package or module substrates).

JP466’s FIG. 5 shows a cross-sectional view of an amplifier module having a dielectric substrate 1 and an active device of semiconductor chip 3 (*e.g.*, a FET). The dielectric substrate 1 has a stacked configuration including first to fifth dielectric

substrates/layers 11 to 15 stacked.⁵ EX1006, [0051]-[0052]. Each layer of substrate 1 (labeled 11-15) has a *metal layer*, shown by conductor patterns 16, 17, 18, 19, 20. EX1003, ¶136 (citing EX1006, FIGS. 6-9 showing patterns; EX1007; EX1025; EX1037 showing conductor patterns are metal). Thus, JP466’s dielectric substrate 1 provides *at least two metal layers*.

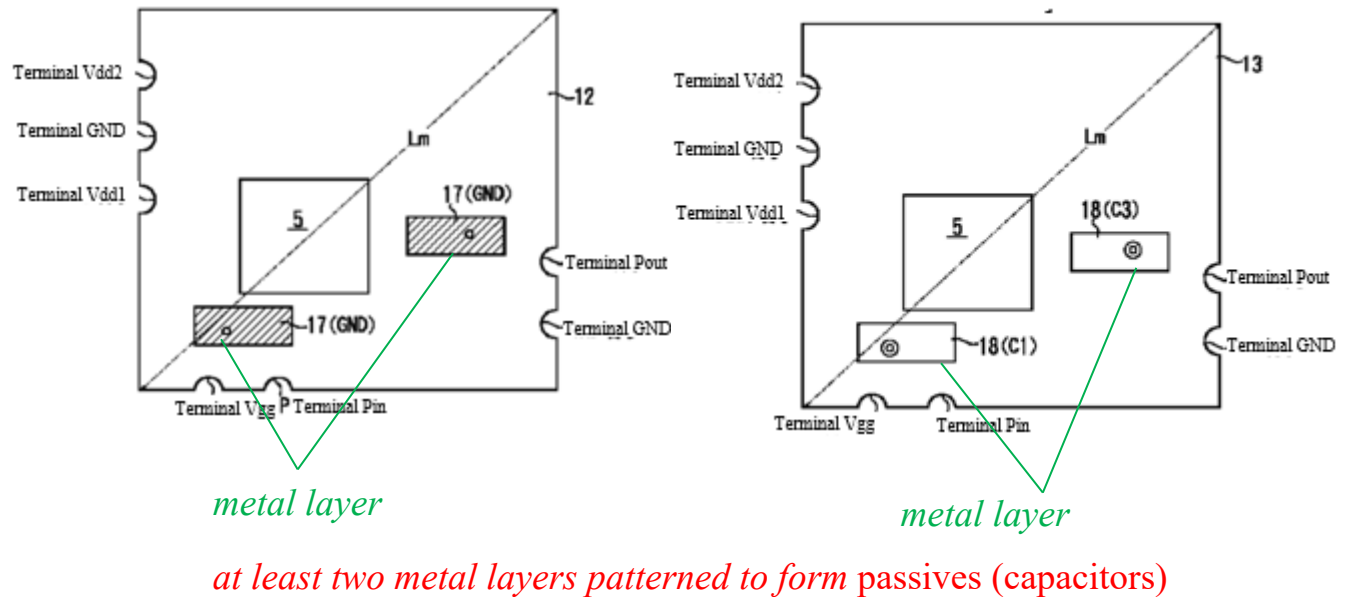


EX1006, FIG. 5
(annotated)

JP466’s conductor patterns (*at least two metal layers*) are *patterned to form at least a portion* of the passive networks of its amplifier. EX1006, [0053]-[0055]; EX1003, ¶¶137-138. One example is the *at least two metal layers* shown in FIGS. 6

⁵ This is the same configuration as the ’914 Patent which states “[t]he term ‘substrate’... consists of a multilayer stackup...” EX1001, 24:49-53.

and 7 that provide conductor patterns (17, 18) forming capacitors (C1 and C3) of the amplifier's passive networks.

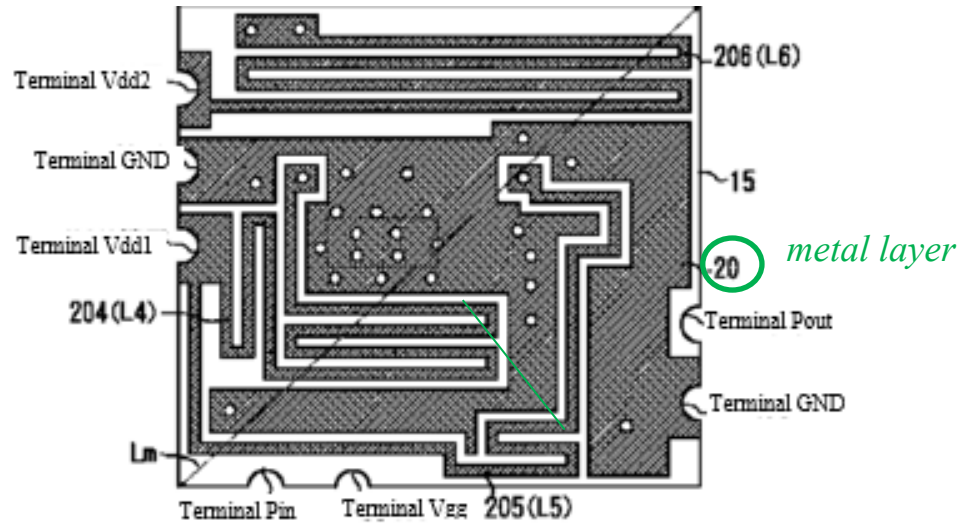


**EX1006, FIGS. 6 and 7
(annotated)**

Francisco's *first passive network* of [1.2] and *second passive network* of [1.3] include similar capacitors. EX1005, 5:38-40, 8:51-64, FIG. 3. Thus, POSITA would have been motivated to form these substantially similar passives (capacitors) using JP466's technique and thus, *two metal layers patterned to form at least a portion of the first passive network and the second passive network* of Francisco. EX1003, ¶¶139-140.

As another example, JP466's FIG. 9 illustrates layer (15) of the substrate 1

having conductor pattern (20) (*metal layer*) patterned into strip lines 204, 205 and 206 forming inductors (L4, L5 and L6) of the amplifier's passive networks. EX1006, [0055], [0057], [0093].

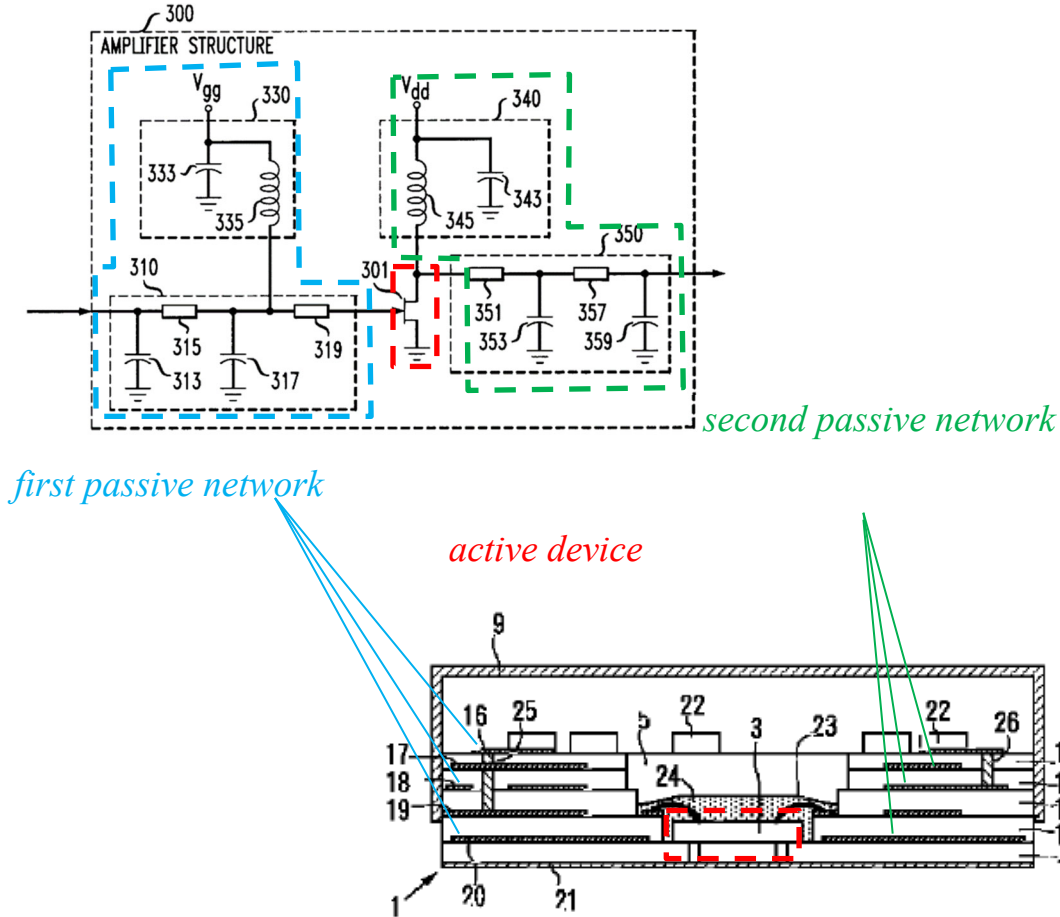


a metal layer patterned to form a passive (inductor)

EX1006, FIG. 9
(annotated)

Francisco's passive networks, see [1.2]-[1.3], also include inductance elements. EX1005, 5:40-64 (discussing inductors and transmission lines). Thus, POSITA would have been motivated to form Francisco's passives (*e.g.*, inductors) using JP466's technique and thus, *two metal layers patterned to form at least a portion of the first passive network and the second passive network*. EX1003, ¶¶141-142 (describing inductors formed on a plurality of layers citing EX1024).

JP466 describes these examples as non-limiting. EX1006, [0053] (“There are no particular limitations to how the circuit components are arranged, but one possible example is shown below.”) POSITA would recognize that components of each of the passive networks of Francisco are readily formed using the plurality of metal layers available in JP466’s substrate. EX1003, ¶142. In light of JP466’s teachings, POSITA would have reasons to *form at least a portion of the first passive network and the second passive network* of Francisco, such as the capacitors and inductors of the biasing and matching networks, by providing a 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* as shown in JP466.



EX1005, FIG. 3 EX1006, FIG. 5
(annotated)

EX1003, ¶¶142-143 (discussing exemplary predictable location indicated).

JP466's dielectric substrate 1 is an *organic-based substrate*. EX1003, ¶¶144-146. JP466 describes that “[u]nlike conventional [substrates] formed using ceramic material,” its substrate includes “**organic** resin material.” EX1006, [0026], [0079]. JP466 describes an example of a polyvinyl benzyl ether compound, which is an organic material. EX1006, [0080]; EX1003, ¶144. In one example, JP466 describes

polyvinyl benzyl ether compound (organic) is 70% by volume of a composite. EX1006, [0083]; EX1003, ¶144 citing EX1007, [0035] illustrating mixture including ceramic provides an organic substrate, EX1001, 11:1-4.

Thus, Francisco and JP466's disclosure of an organic substrate with passives formed on at least two metal layers, renders obvious [1.4a]. EX1003, ¶¶132-146.

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

Francisco discloses this element. EX1003, ¶¶147-172.

As discussed above, Francisco illustrates a multi-band amplifier 300, *multi-band RF device*, with *first and second passive networks* each comprising capacitors and at least one inductor. See [1.0]-[1.3]. And as detailed in [1.0], this amplifier is used to "scale the signal level of a signal communicated over one of multiple frequency bands." EX1005, 1:50-54.

...the multi-band amplifier uses **an input network to achieve a selected input impedance**, and an **output network to achieve a selected output impedance**. The values of the input and output impedances are selected such that the **gain values afforded** by the multi-band amplifier to the components of the communication signal within the **multiple frequency bands** are significantly higher than the gain values to the signal components outside those bands.

EX1005, 1:53-61. Thus, Francisco's passive networks perform the same function as the '914 Patent of minimizing noise and maximizing power gain over multiple

frequency bands. EX1003, ¶149 (citing EX1001, 24:10-14; EX1005, 5:65-6:65). The *impedances of the first and second passive networks are different at the first frequency than the second frequency* as evidenced in at least three ways discussed below.

First, Francisco's passive networks are inductor-capacitor (LC) circuits and POSITA understand these circuits present different impedance to signals having different frequencies. EX1003, ¶148. Because signals at each of a first frequency and differing second frequency (*e.g.*, ~800 MHz and ~1800 MHz) are provided to Francisco's passive networks and because these passive networks are frequency-dependent LC circuits, POSITA would recognize that the impedances of the passive networks are different at different *first* and *second* frequencies. EX1003, ¶¶148-155 (defining impedance and explaining that impedance of inductors, capacitors, and LC circuits comprising inductors and capacitors varies with frequency; citing EX1014, 1:18-61 ("Matching circuits are widely used to transform the impedance of the various components within a circuit to a target impedance....The impedances of the components and the matching circuits are frequency dependent.")). In particular, Dr. Shoemake explains that capacitors and inductors contribute to reactance of a circuit and that reactance is a frequency dependent component of impedance. EX1003, ¶¶151-155.

Thus, the *first passive network* of Francisco, which includes capacitors and inductors, has a first impedance at a received *first frequency* ($f1$) ([1.0]), i.e., impedance $Z_A(f1)$ and a second impedance at a received *second frequency* ($f2$), i.e., $Z_A(f2)$, which is different from $Z_A(f1)$ because Z_A [impedance] is a function of the frequency and has different values when the frequency changes. *Id.* Similarly, the *second passive network* of Francisco, which includes capacitors and inductors, has a first impedance at a received *first frequency* ($f1$) ([1.0]), i.e., $Z_B(f1)$ and a second impedance at a received *second frequency* ($f2$), i.e., $Z_B(f2)$, which is different from $Z_B(f1)$ because Z_B is a function of the frequency and has different values when the frequency changes. *Id.*

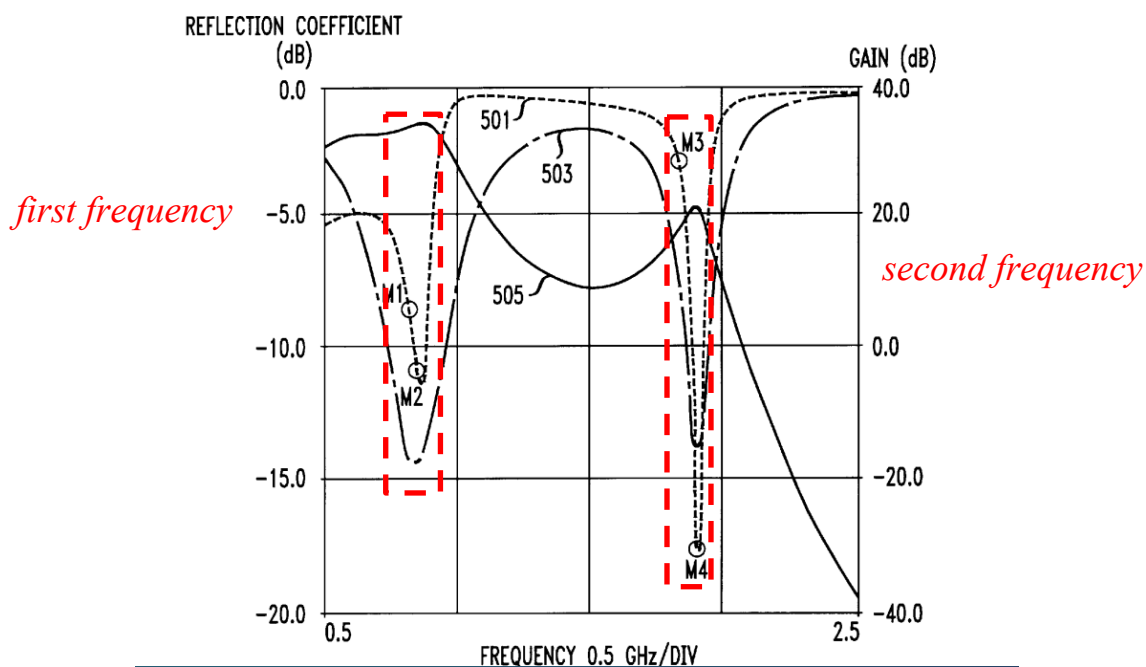
Second, POSITA would have had reason and motivation to select components of the *first passive network* and the *second passive network* such that the impedances of each of the first passive network and the second passive network are different at different frequencies. EX1003, ¶¶156-177 (discussing since impedance of components matched by the first/second passive networks vary with frequency, performance considerations for proper matching drive ensuring different impedances citing EX1034). POSITA desire to match the impedance with the subsequent component in the system. EX1003, ¶156. As the components to which the matching networks are matching have an impedance that varies with frequency, so would POSITA desire for the first passive network and the second passive

network to provide different impedances at each of the first and second frequencies. EX1003, ¶¶156-177. For example, Francisco's input matching network (*first passive network*) seeks to match source impedance of an upstream component to the input impedance of an amplifying transistor so as to minimize noise. Francisco teaches this matching is performed by achieving the optimal amount of reflection (Γ_{opt}); this necessarily means that the input matching networks will have two different impedances at the two different frequencies to have the required reflection coefficients. EX1003, ¶¶156-177 (citing EX1031, a transistor datasheet illustrating Γ_{opt} varies by frequency). Given Francisco's impedance matching in the input network to minimize noise involves optimizing, for each frequency band, signal reflection (Γ), which is a frequency dependent characteristic of the transistor, and that so-optimizing would cause POSITA to configure Francisco's *first passive network* (at transistor input) to provide a frequency dependent impedance (Z_A) given the known relationship between Z_A and Γ . *Id.* (explaining Francisco's treatment of reflection to minimize noise in receiver bands 203 and 207 at transistor input).

Likewise, impedance matching in the output network involves configuring Francisco's *second passive network* (at transistor output) to present a load that is the conjugate of the transistor output impedance so as to match impedance, and thereby maximize power transfer, on each of the frequency bands. EX1003, ¶¶166-167 (explaining Francisco's desire for an impedance over bands 203 and 207

corresponding to the complex conjugate of transistor output impedance and S22 parameter). To achieve the desired impedance matching in the *first passive network* (at transistor input) and the *second passive network* (at transistor output), POSITA would understand that impedances at the *first frequency* (first band) and the *second frequency* (second band) will necessarily be different. EX1003, ¶¶168-177.

Third, Francisco's FIG. 5 shows a multi-band power amplifier performance in a transmit role (*i.e.*, amplifier 115). EX1003, ¶¶178-180 (explaining FIG. 5's applicability to low-noise amplifier). The graph illustrates difference in reflection coefficient between frequencies for the amplifier circuit. EX1005, 7:5-19.



EX1005, FIG. 5
(annotated)

POSITA would understand FIG. 5 illustrates reduced (and different) return loss

(501) at the input and reflection coefficients (503) at the output at the 850 MHz and 1.9 GHz bands and that gain (505) shaping presents local maxima around the 850 MHz and 1.9 GHz bands. EX1003, ¶¶179-180. These illustrated characteristics are further evidence that different impedances are presented by the matching networks for the different frequency bands. EX1003, ¶180 (otherwise POSITA would not expect to see the gain peak independently for the two different bands and the reflection coefficients also have local minimums).

Therefore, Francisco discloses [1.4b]. EX1003, ¶¶147-181.

Thus, Francisco and its amplifier structure 300 in combination with JP466's disclosure of an organic substrate with embedded passives renders obvious claim 1. EX1003, ¶¶61-182.

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.*

Francisco and JP466 render obvious claim 1, and Francisco further teaches limitation [2.0]. EX1003, ¶¶183-192.

As discussed in [1.2] and [1.3], Francisco provides *first* and *second passive networks*, each including inductors and capacitors. **First**, as a fundamental matter, inductors and capacitors are electronic components that contribute *reactance*, *i.e.*,

the imaginary⁶ component of a complex impedance, in an interconnected network of components that forms an electrical circuit. EX1003, ¶¶184, 152-153, 190-191. The presence of inductors and/or capacitors in the first and second passive networks of Francisco demonstrates that *impedances of the first and second networks comprise reactance. Id.*

Inductors and capacitors are common components of *resonant circuits*—indeed, they are the components that make a circuit resonant. EX1003, ¶¶185-189 (explaining that a resonant circuit is a circuit that is designed to oscillate at one or more frequencies and that it is the inductive and capacitive components of a complex impedance that contribute to resonance). Dr. Shoemake explains that a circuit is generally considered resonant if the inductive and capacitive components balance each other resulting in maximum energy transfer or specific behavior such as amplification, oscillation, or selective filtering at a particular frequency, *i.e.*, a resonant frequency. *Id.* For example, a classical LC circuit will resonate when the

⁶ POSITA would have understood impedance (Z) to be mathematically expressed as a complex (real and imaginary number) quantity, $Z = R + jX$, consisting of a real part (R), where R is the resistance, and an imaginary part ($+jX$ or $-jX$), where X is the reactance. A positive reactance ($+jX$) corresponds to inductance while a negative reactance ($-jX$) corresponds to capacitance. EX1003, ¶¶184-185, 152-153.

inductance and capacitance sum to near zero. This condition occurs at an angular frequency of ω_0 , where $\omega_0 = \frac{1}{\sqrt{LC}}$, and L and C are reactive (inductive and capacitive) components of a complex impedance. *Id.*

Francisco describes its *first and second passive networks* in a way that makes it clear to POSITA they form *resonant circuits*. EX1003, ¶¶185-189. Specifically, as POSITA would recognize, to provide gain in a desired signal band, the reactance of an input matching network should cancel, thereby enabling the lowest power dissipation via resistance and oscillatory behavior between inductive and capacitive components in the network. *Id.* Thus, in Francisco's circuit, POSITA would understand that the *first and second passive networks* (which respectively include input and output matching networks) are each designed to resonate in the two frequency bands for operation (pass bands) and to avoid resonance in the stop bands. *Id.* (explaining cellular and PCS bands in Francisco's design). Francisco's teaching of achieving conjugate source and load impedances for the transistor in an output (EX1005, 6:15-17) is a teaching of resonance for the pass bands in the *second passive network*. *Id.* (explaining the mathematics of resonance in an electrical circuit).

Moreover, for Francisco's *first passive network*, POSITA would understand the input matching circuit is designed to resonate in the pass bands while also

minimizing noise. EX1003, ¶¶187-190. Francisco's FIG. 5 (*see supra*, at [1.4b]) demonstrates local maxima in gain at both 900 MHz and 1.85 MHz and therefore that the *first passive network*, including its input matching circuit, like the *second passive network* is designed to resonate in the pass bands. These peaks indicate resonant behavior. *Id.* The fact reflections are low at the same frequencies also indicates resonance in the *first passive network*, including its input matching circuit, as the imaginary parts of the impedances are canceling and thus minimizing the overall impedance. *Id.*

Thus, the *first and second passive networks* of Francisco *comprise resonant circuits*, the *impedances* thereof *comprise reactance*, and Francisco in view of JP466 renders obvious claim 2. EX1003, ¶¶183-192.

6. Claim 12

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

Francisco and JP466 render obvious claim 1, and Francisco also discloses this element. EX1003, ¶¶193-195.

As discussed in [1.1], Francisco discloses an *active device that is a field effect transistor*. “As shown in FIG. 3, central to amplifier structure 300 is **field effect transistor (FET) 301**.” EX1005, 5:30-31. *See also*, EX1006, FIG. 3, [0003] (“FET”), [0006], [0032].

Thus, claim 12 is rendered obvious by Francisco and JP466. EX1003, ¶¶193-195.

7. 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.*

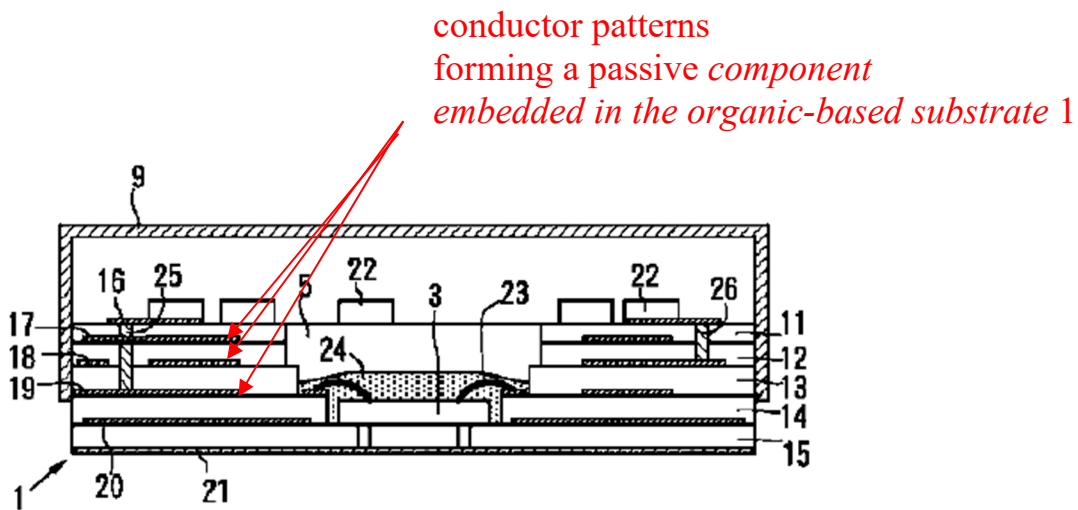
Francisco and JP466 render obvious claim 1, and the combination also renders obvious this element. EX1003, ¶¶196-204.

As discussed in [1.4a], JP466 discloses an amplifier module with a dielectric substrate that is an *organic-based substrate*. EX1006, [0003], [0093]. JP466 illustrates *embedd[ing]* passives including capacitors and inductors of its amplifier's passive network within this organic-based substrate. That is, JP466 forms capacitors and inductors (each a *component*) in patterned conductor layers 16-20 (metal layers) disposed within a stack of dielectric layers 11-15 making up its substrate 1. See EX1006, FIG. 5, 6-9, [0053]. This is the same configuration as the '914 Patent.⁷

The [1.4a] analysis further details exemplary passives (*e.g.*, capacitors and

⁷ EX1001, 24:49-53 (“The term ‘substrate’ in each of the above diagrams consists of a multilayer stackup...”), 24:64-68 (“FIGS. 38A-38F provide exemplary multilayer stackups...The embedded passives can be of microstrip, stripline...”); EX1003, ¶199.

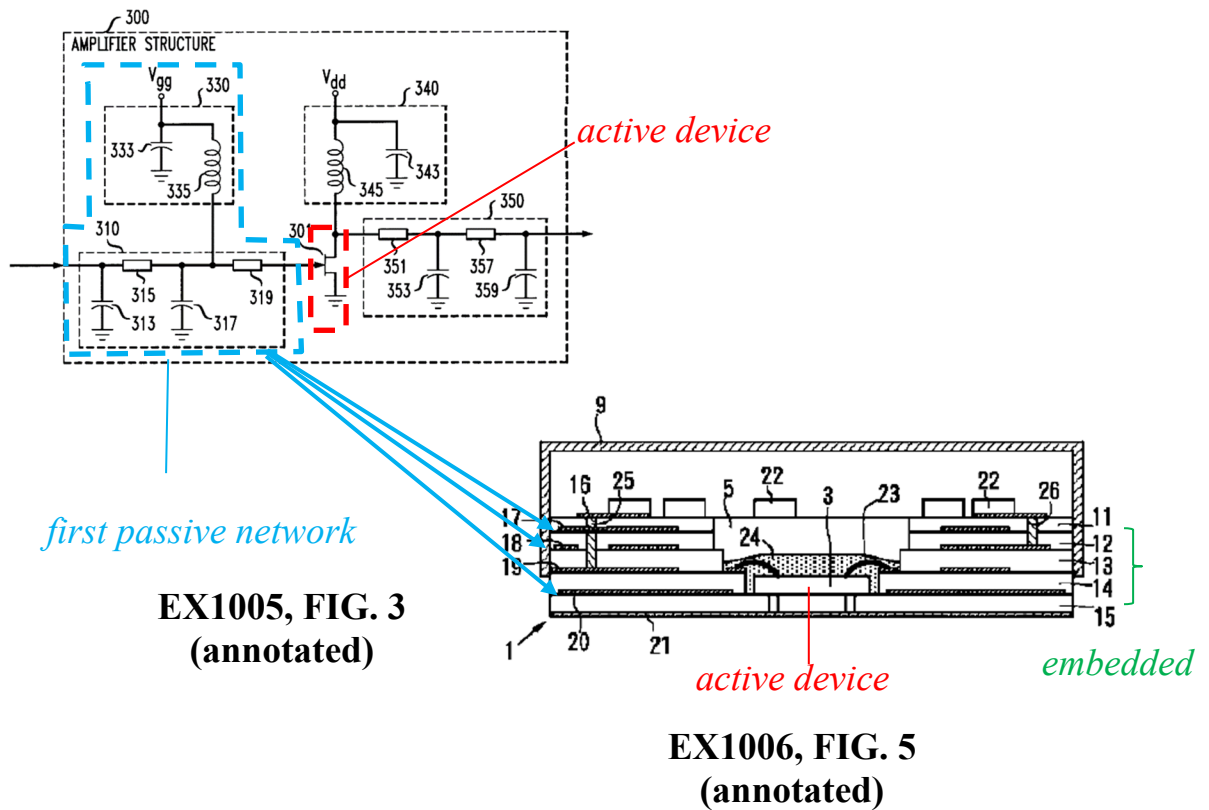
inductors) formed of these patterned conductor layers including, in one example, inductors (each *a component*) formed as conductor pattern 20, which is illustrative of a *component embedded in the dielectric substrate 1, the organic-based substrate*. EX1006, FIGS. 5, 9, [0051], [0057]; *see also* (conductor patterns 17, 18 forming capacitors (also each *a component embedded in the organic-based substrate*), [0055], FIGS. 5-7).



EX1006, FIG. 5
(annotated)

As discussed above, POSITA would have had reason to, and recognized benefits of, forming components (capacitors and/or inductors/transmission lines) of Francisco's *first passive network* ([1.3]) using JP466's technique of patterned metal layers (*e.g.*, conductors 17, 18, 20) on a dielectric layer (*e.g.*, dielectric substrates 15-11) to *embed[] the passive component in the organic-based substrate*. *See also*, EX1003,

¶¶197-203 (discussing electrical field, signal leakage, trace length, foreign material benefits to embedding components).



EX1003, ¶201. JP466 explicitly recognizes advantages to forming an inductor *embedded* within the substrate including prevention of signal leakage to the outside and efficient signal transmission. EX1006, [0062]-[0068]. Further, “the use of a dielectric material with the high relative dielectric constant ϵ_r shortens the pattern length of the striplines 204, 205, and 206, which makes it possible to make the external form of the dielectric substrate smaller.” EX1006, [0064]. POSITA would recognize these same advantages in embedding a passive component of Francisco’s

first passive network within JP466's dielectric substrate 1, an *organic-based substrate*. EX1003, ¶202 (explaining “inductive choke 335” is an inductor and advantages of embedding passive components in high dielectric constant substrate).

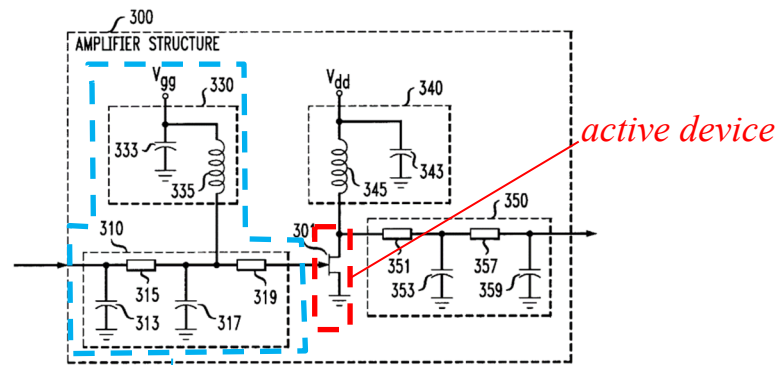
Thus, claim 13 is rendered obvious by Francisco in view of JP466. EX1003, ¶¶196-204.

8. 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.*

Francisco and JP466 render obvious claim 1, and the combination also renders obvious this element. EX1003, ¶¶205-208.

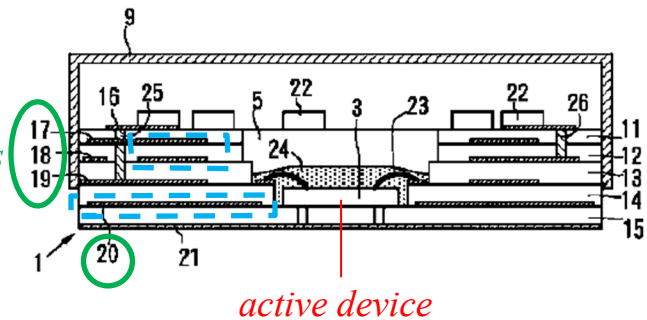
As discussed in [1.4a] and [13.0], JP466 teaches forming conductor patterns (16-20) that form component(s) of a passive network. One or more of these conductor patterns provides *at least one of the metal layers that is patterned*, to form at least *a portion of a passive (a component)* of a passive network. For the reasons discussed above, POSITA would have had reason and recognized benefit to providing *at least a portion of a component* of Francisco's *first passive network* of [1.2] using JP466's technique.



first passive network

metal layers

EX1005, FIG. 3
(annotated)

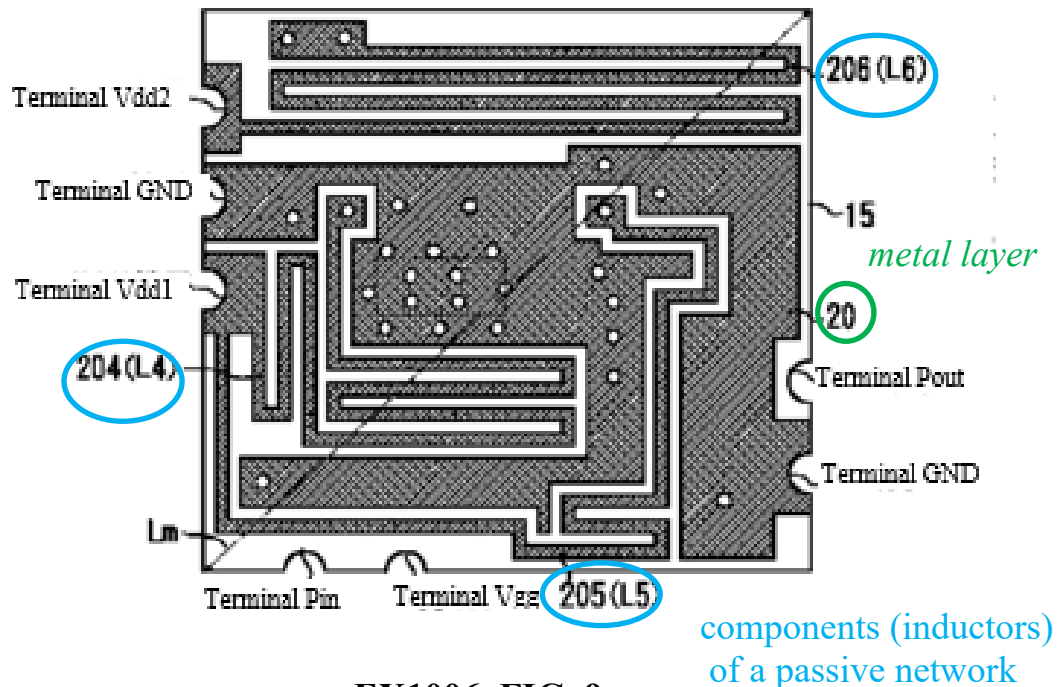


active device

EX1006, FIG. 5
(annotated)

EX1003, ¶¶206-207.

In one example, JP466 describes conductor pattern 20, which is a *metal layer[] patterned* into strip lines forming inductors, which are *component[s]* of its passive network. EX1006, [0057]. Figure 9 is illustrative.



EX1006, FIG. 9
(annotated)

See also, EX1006, FIGS. 6-7 having conductor patterns 17, 18 forming capacitors of a passive network. It would have been obvious to form the similarly configured and functioned *component* (e.g., capacitor and/or inductor/transmission line) of the *first passive network* of Francisco using JP466's technique for the reasons discussed in claim 1. EX1003, ¶¶206-207.

Thus, claim 14 is rendered obvious by Francisco and JP466. EX1003, ¶¶205-208.

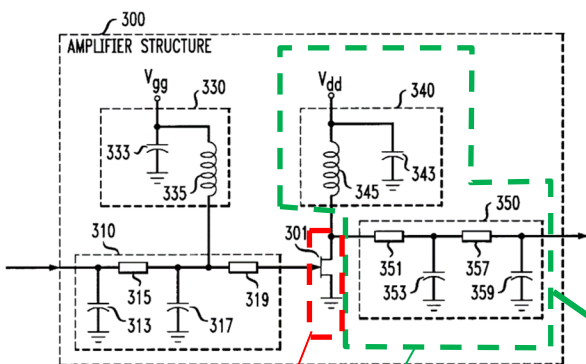
9. Claim 15

[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.

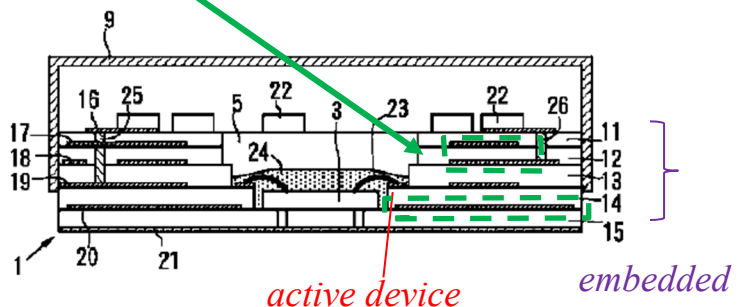
Francisco and JP466 render obvious claim 1, and also this element. EX1003,

¶¶209-212.

As discussed in [1.4a], [13.0], JP466 describes a dielectric substrate 1, an *organic-based substrate*, having conductor patterns *embedded* therein patterned to provide *a component (e.g., a passive)* of its passive network. EX1006, [0093]. The analysis with respect to the first passive network ([13.0]) applies equally to the *second passive network*. That is, Francisco in view of JP466 discloses *a component* such as a capacitor or inductor of the *second passive network* ([1.3]) formed of a conductor layer *embedded* in JP466's organic-based substrate 1.



active device
second passive network



active device *embedded*

EX1005, FIG. 3
(annotated)

EX1006, FIG. 5
(annotated)

EX1003, ¶¶210-211. The position of the passives in the substrate is not limited to

that illustrated in JP466 or annotated above. EX1003, ¶211 (describing possible substrate locations with respect to the drain terminal of the active device).

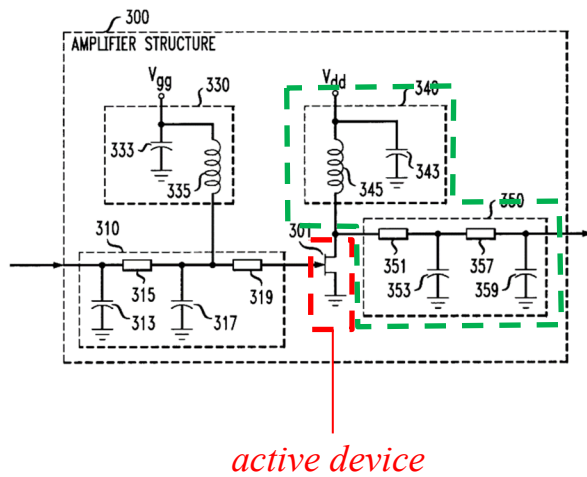
Thus, claim 15 is rendered obvious by Francisco in view of JP466. EX1003, ¶¶209-212.

10. Claim 16

[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 second passive network.*

Francisco in view of JP466 renders obvious claim 1 and also this element. EX1003, ¶¶206-209.

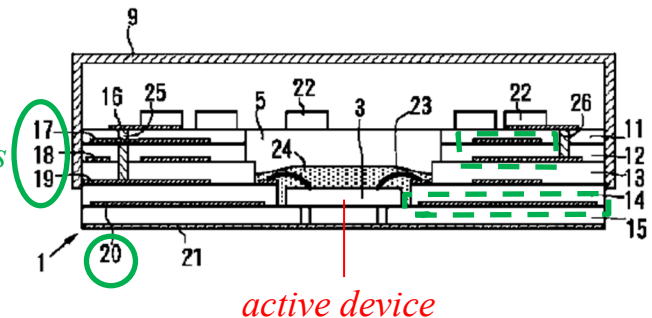
As discussed in [1.4a] and [14.0], JP466 suggests that *at least one of the metal layers*, illustrated by conductor patterns formed in its dielectric substrate 1, is *patterned to form* passive network components. As also described above, it would have been obvious to use JP466's technique to *form at least a portion of a component* (e.g., inductor/transmission line or capacitor) of the *second passive network* of Francisco ([1.3]) by pattern[ing] one or more metal layers.



EX1005, FIG. 3
(annotated)

first passive network

metal layers



EX1006, FIG. 5
(annotated)

EX1003, ¶¶214-215 (describing possible conductor pattern locations with respect to the drain of active device). The formation of the components of the *second passive network* is the same as those of the *first passive network* discussed above in claim 14.

Thus, claim 16 is rendered obvious by Francisco and JP466. EX1003, ¶¶213-216.

11. Claim 5

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

To the extent this element is limiting, Francisco discloses it. EX1003, ¶¶217-

220.

Francisco's amplifier structure 300, as discussed in [1.0], implements “multi-band low noise amplifier (LNA) 155” of communication system 100 of Francisco, and thus is *a multi-band low noise amplifier*. EX1005, 4:28-32, 5:23-36. This communication system 100 uses the amplifier for *an RF application* as shown by its operation at first and second frequencies (*e.g.*, cellular and PCS frequency bands), also discussed in [1.0]. *See also*, EX1005, 1:11-24 (discussing “radiotelephone”); EX1003, ¶¶218-219 (citing EX1022 defining RF).

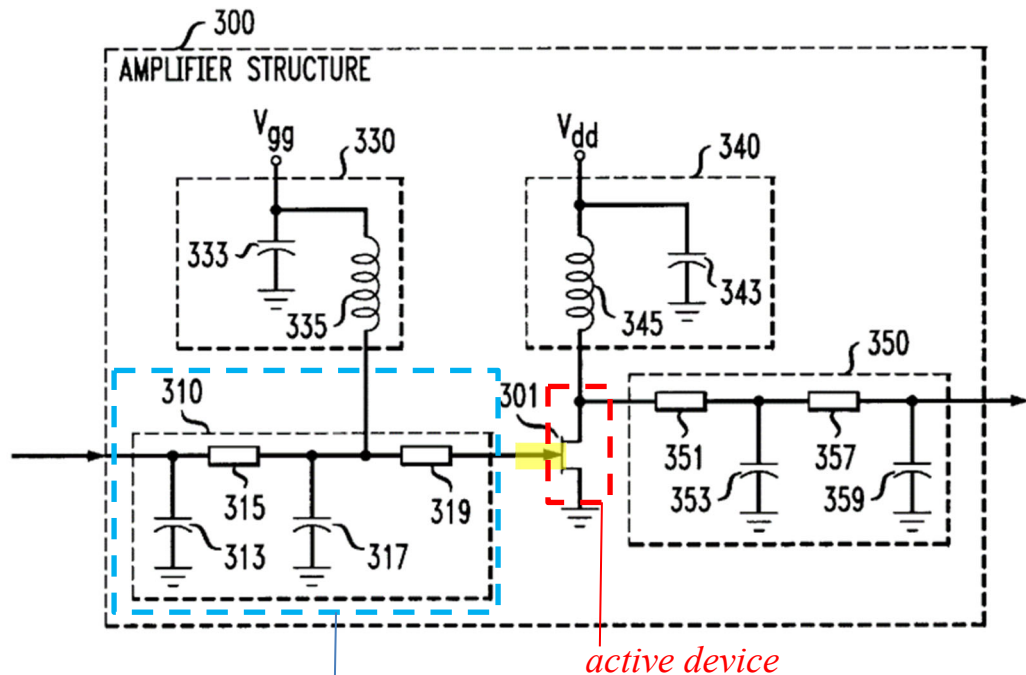
Thus, Francisco teaches [5.0]. EX1003, ¶¶217-220.

[5.1] *an active device*;

Francisco discloses a transistor 301 of the multi-band amplifier structure 300 that provides *an active device* as shown in [1.1] and thus, discloses this element. EX1003, ¶221.

[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*;

Francisco describes an “input matching network 310” that provides a *first matching network*. EX1005, 5:30-36; *see also*, [1.2]. Francisco labels this a “matching network” and describes its function as matching impedances of adjacent components. EX1005, 6:1-9, 6:26-56. *See also*, EX1003, ¶¶222, 114-121.



first matching network EX1005, FIG. 3
(annotated)

EX1003, ¶222. The input matching network 310 is *in communication* with the FET 301, the *active device*. EX1003, ¶223. In particular, the matching network 310 is connected to a gate terminal of the FET. EX1005, FIG. 3, 5:32-45. This connection provides for *communication* of a signal from the input matching network to the FET. EX1003, ¶¶223, 107-108, 113-121.

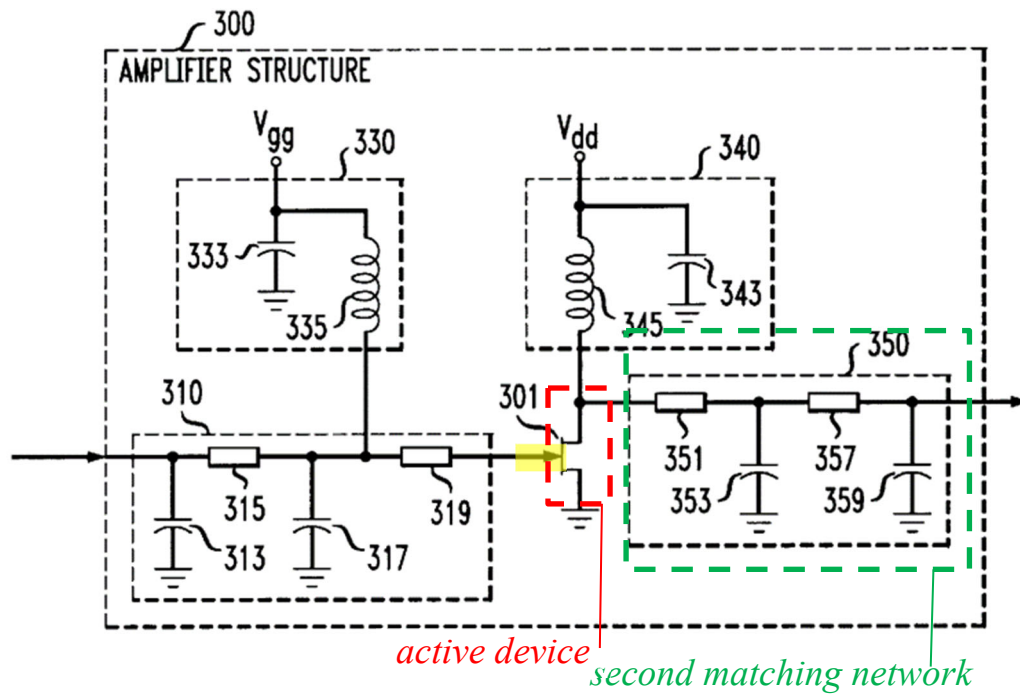
As discussed in [1.4b], the impedance of the input matching network is different at a *first frequency* (e.g., cellular) than a *second frequency* (e.g., PCS). EX1003, ¶¶224-225, 148-181. For example, Francisco explicitly states what POSITA would recognize—a desire to have the input matching circuit match the

optimal reflection coefficient of the active device (transistor 301). EX1003, ¶¶148-181 (citing EX1031); EX1005, 5:65-6:19. Since the *first matching network* must match to two different reflection coefficients for the first and second frequencies, respectively, the impedance of the matching network must be different at the different frequencies. *Id.* (different matched coefficients, different impedance).

Thus, Francisco teaches this element. EX1003, ¶¶222-226, 111-121, 148-181.

[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*

Francisco describes an “output matching network 350” that provides a *second matching network*. EX1005, 5:30-36. *See also*, [1.3]. Francisco labels this a “matching network” and describes its function of matching impedances of adjacent components. EX1005, 6:12-40. The output matching network *is in communication with* the FET 301, *the active device*, as shown by the connection in the architecture below and understood by the function of the network 350. EX1003, ¶¶227-228, 123-131.



EX1005, FIG. 3
(annotated)

EX1003, ¶227. As discussed in [1.4b], the impedance of Francisco's second matching network is different at a *first frequency* (e.g., cellular) than a *second frequency* (e.g., PCS). Dr. Shoemake explains that output impedance of the active device is related to S22 parameter of the transistor, which the ratio of the reflected signal at the output of the transistor, which varies with frequency. EX1003, ¶¶229, 148-181. This means the output matching circuit must have different impedances with different frequencies to provide suitable matching. *Id.*

Thus, Francisco teaches this element. EX1003, ¶¶227-230, 123-131, 148-180.

[5.4a] *a multi-layer organic-based substrate having at least one metal layer,*

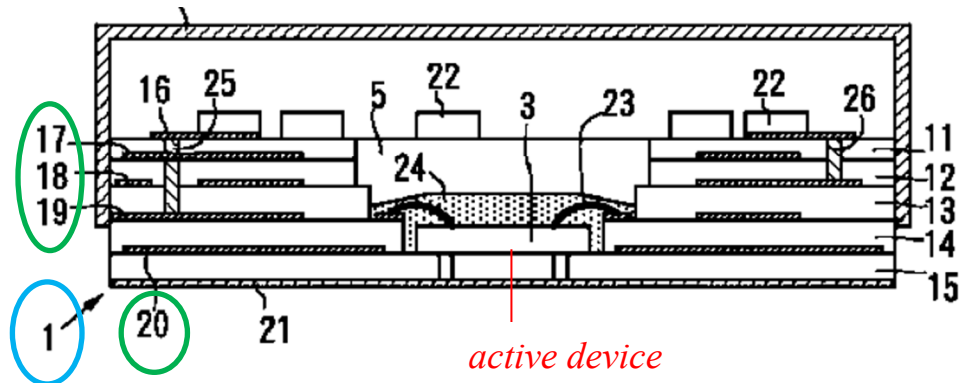
wherein the first matching network and the second matching⁸ are formed on the at least one metal layer and wherein the active device is mounted on the multi-layer organic substrate,

First, as discussed in [1.4a], [14], [16], JP466 describes a substrate 1, *a multi-layer organic-based substrate*, having *at least one metal layer* illustrated by conductor patterns 16-20, where passives of matching networks are formed on the metal layer(s). As also discussed above, it would have been obvious to form Francisco's passive components, including those of the *first matching network* and the *second matching network*, on at least one of conductor patterns 16-20 (*at least one metal layer*) of JP466's substrate 1.

Second, JP466 describes “[t]he semiconductor amplifying element of FET, or the like, is mounted directly on the dielectric substrate as a bare chip, or packaged using a resin mold and then mounted on the dielectric substrate.” EX1006, [0006]. The “chip 3” mounted on the multi-layer organic substrate 1 in FIG. 5 is illustrative. *See also*, EX1006, [0052], [0060], FIGS. 4-5.

⁸ Petitioner construes this claim to receive a *second matching network* for purposes of this Petition.

at least one metal layer



multi-layer organic-based substrate

EX1006, FIG. 5
(annotated)

As JP466 illustrates forming FET configured as chip 3 mounted on the multi-layer organic substrate 1, it would have been obvious to implement the same configuration and form the similar FET 301 of Francisco, the *active device*, mounted on the multi-layer organic substrate. EX1003, ¶¶232-233. Mounting the active device on a multilayer organic substrate having embedded passives was common practice for an LNA. See EX1037, Abstract, [0037], [0073]-[0078]; FIGS. 5-6.

[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

Francisco teaches *allowing an output of the multi-band low noise amplifier to have desired power gains at the first frequency and the second frequency*. As discussed above ([1.0], [1.4b]), Francisco illustrates a multi-band low noise amplifier (LNA) operable over multiple frequencies. An LNA operable over multiple frequencies means that it provides the *desired power gains* at each of the multiple frequencies as this is the LNA's function. EX1003, ¶¶234-236 (citing EX1005, 1:50-56 ("scale[s] the signal level of a signal communicated over one of multiple frequency bands.")).

POSITA would have recognized Francisco's power gains are *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*. This is because POSITA understanding different first and second frequency bands are each provided to the first and second passive networks, it necessarily follows that the *reactance* of each of the passive networks is different at each frequency. EX1003, ¶¶234-236 (referring to analysis of [1.4b] and [2.0] which discusses Francisco teaching different

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

impedances for different frequencies, the differing imaginary components of these different impedances being reactance).

Thus, claim 5 is rendered obvious by Francisco in view of the teachings of JP466 of embedding passive components in an organic-based substrate. EX1003, ¶¶217-237.

12. 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.*

Claim 5 is rendered obvious by Francisco and JP466, which also render obvious this claim. POSITA would have applied JP466's teachings to Francisco's input matching network 310, *first matching network*, and formed *a component* (a passive) of Francisco's network on a metal layer (JP466's conductor pattern) *embedded* in JP466's organic-based substrate for the reasons discussed with reference to [1.4a], [13.0]. EX1003, ¶¶238, 196-204, 133-145; EX1006, FIGS. 5, 7-9. Thus, Francisco and JP466 render obvious claim 17. EX1003, ¶238.

13. 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.*

Claim 5 is rendered obvious by Francisco and JP466, which also render obvious this claim. EX1003, ¶¶239-240. JP466 discloses *metal layers* of conductor

patterns 16-20 that are *patterned to form at least a portion of a passive (component) of matching network*—a technique that would have been obvious to apply to a component of the input matching network 310 of Francisco, *the first matching network*, for the benefits of size, surrounding dielectric, quality, and reliability, as explained with reference to [1.4a], [14.0]. EX1003, ¶¶ 239-240, 205-208, 133-145. Thus, Francisco and JP466 render obvious claim 18. EX1003, ¶¶ 239-240.

14. 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.*

Claim 5 is rendered obvious by Francisco and JP466, which also render obvious this claim. As discussed in [15.0], it would have been obvious to use JP466's technique of forming passive components using conductor patterns 17-20 of dielectric layers 12-15 of a substrate 1 to form components of output matching network 350 of Francisco, *the second matching network*. In doing so, passive components are *embedded* in substrate 1, an *organic-based substrate*. EX1003, ¶¶ 241-242, 209-212, 133-145. Thus, claim 19 is obvious in light of Francisco and JP466. EX1003, ¶¶ 241-242.

15. 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.*

Claim 5 is rendered obvious by Francisco and JP466, which also renders obvious this claim. As discussed in [16.0], it would have been obvious to use JP466's conductor patterns 16-20, which are *at least one of the metal layers patterned to form at least a portion of a component (passive) of the output matching network 350 of Francisco, the second matching network*. EX1003, ¶¶243-244, 213-215, 133-145. Thus, claim 20 is obvious in light of Francisco and JP466. EX1003, ¶¶243-244.

D. Ground 2 - Francisco, JP466 and Hirayama

1. Hirayama

Hirayama is directed to and describes circuits “which can be suitably applied to an amplifier circuit for a dual band” mobile terminal such as a mobile telephone. EX1008, (54), [0002], [0004]. Hirayama recognizes previous dual band implementations used “two amplifiers (i.e., transistors 1501 and 1502) which are matched according to [separate] frequencies[,]” which “increases the area of a chip, and further, induc[es] an increase in cost.” EX1008, [0005]-[0006]. In contrast, with a goal of reducing cost and size, Hirayama's amplifier “can be used at two frequency bands” to “enable[] the impedance to be converted at both of the two frequencies.” EX1008, [0007], [0071]. Hirayama describes its multi-band amplifier can “be applied to the case where an active element constituting the amplifier is either a **bipolar transistor or a field effect transistor** in the same manner, thus providing

the matching circuit for converting the impedance into an optimum impedance at either of the two frequencies.” EX1008, [0072].

2. Reasons to combine Francisco and JP466

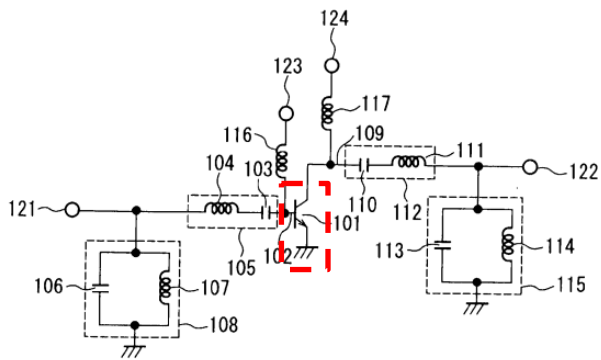
Reasons to combine JP466’s teachings to implement Francisco’s amplifier structure (Francisco-JP466) are detailed in Ground 1.

3. Reasons to combine Francisco-JP466 and Hirayama

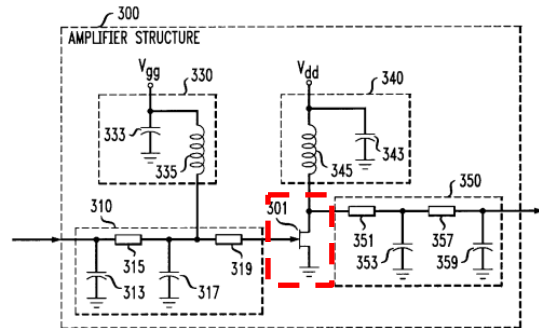
POSITA would have been motivated to combine the teachings of Francisco-JP466 and Hirayama for multiple reasons, including to produce the obvious, beneficial, and predictable results of providing a bipolar junction transistor (BJT) as an active device of the amplifier of a RF communication system. EX1003, ¶¶245-258.

Francisco-JP466 and Hirayama are in the same field of endeavor as the ’914 Patent as they are related to RF devices suitable for personal communication devices, and further, each is directed to amplifiers of that system. EX1003, ¶¶250-251; EX1008, [0004], [0002]; EX1005, 1:5-7, 1:36-46; EX1001, 1:23-27, 2:14-16. Not only are Francisco-JP466, Hirayama and ’914 Patent in the same field of endeavor, but they are reasonably pertinent to a problem faced by the inventor of the ’914 Patent of avoiding duplication of components for multi-band frequency systems through component reuse. EX1008, [0006]-[0007]; EX1001, 1:48-61, 2:8-13; EX1005, 1:25-46, 1:62-67.

Francisco and Hirayama describe a substantially similar structure—a multi-band amplifier having a three-terminal active device (*i.e.*, a transistor) with passive components at its input and output, wherein the amplifier functions to obtain gain at multiple bands. EX1003, ¶252 (comparing Francisco’s FIG. 3 and Hirayama’s FIG. 1, each having an active device with a first terminal connected to an input network of passives, a second terminal connected to an output network of passives, and a third terminal connected to ground).



EX1007, FIG. 1
(annotated)



EX1005, FIG. 3
(annotated)

Employing a bipolar junction transistor (BJT) as suggested by Hirayama is merely applying a known technique (forming an active device of an amplifier as a BJT) to a substantially similar active device of a multi-band amplifier device (Francisco’s amplifier structure 300) ready for improvement (*e.g.*, improvement in gain as discussed below). EX1003, ¶253; *Intel Corp. v. PACT XPP Schweiz AG*, 61 F.4th 1373, 1380–81 (Fed. Cir. 2023) (“[t]here is a motivation to combine when a

known technique ‘has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way,’ using the ‘prior art elements according to their established functions.’”)

The choice of the type of active device for RF devices was well-known to a system designer. EX1003, ¶¶254-256 (discussing personal experience with transistor selection, citing EX1019, EX1011, EX1017 each discussing alternative transistors for amplifiers, and describing differing characteristics of transistors that provide the same fundamental operation). Hirayama itself recognizes that transistor type is a design option by suggesting that the active element of its amplifier can be a BJT or FET. EX1008, [0072], [0128].

POSITA would recognize that there are only a limited number of choices for a transistor structure, with BJT and FET being two common choices. EX1003, ¶256. Implementations of amplifiers with bipolar junction transistors (BJT) were well-known. EX1003, ¶254 (citing EX1019-EX1020, EX1009, all implementing BJTs in multi-band amplifiers). Moreover, for applications in which amplifier figures of merit, such as gain, noise figure and linearity, would have been important, POSITA would have been motivated to choose a BJT. EX1003, ¶¶256-257 (noting higher gain, greater linearity, higher transition frequency advantages).

The results would have been predictable and there would have been a reasonable expectation of success in the combination because Francisco-JP466 and

Hirayama describe similar amplifiers for use in similar systems. Any modification needed to the teachings of Francisco, including implementing changes to the passive networks, to accommodate the teachings of Hirayama, would have been within the level of ordinary skill in the art. EX1003, ¶258 (citing EX1005, 6:7-56 (“[t]he values of the individual components...can be readily determined by well-known methods.”), EX1017; EX1029). Moreover, Hirayama itself suggests the interchangeability of the transistors in an amplifier are well within the skills of POSITA. EX1008, [0128].

4. Claim 4

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

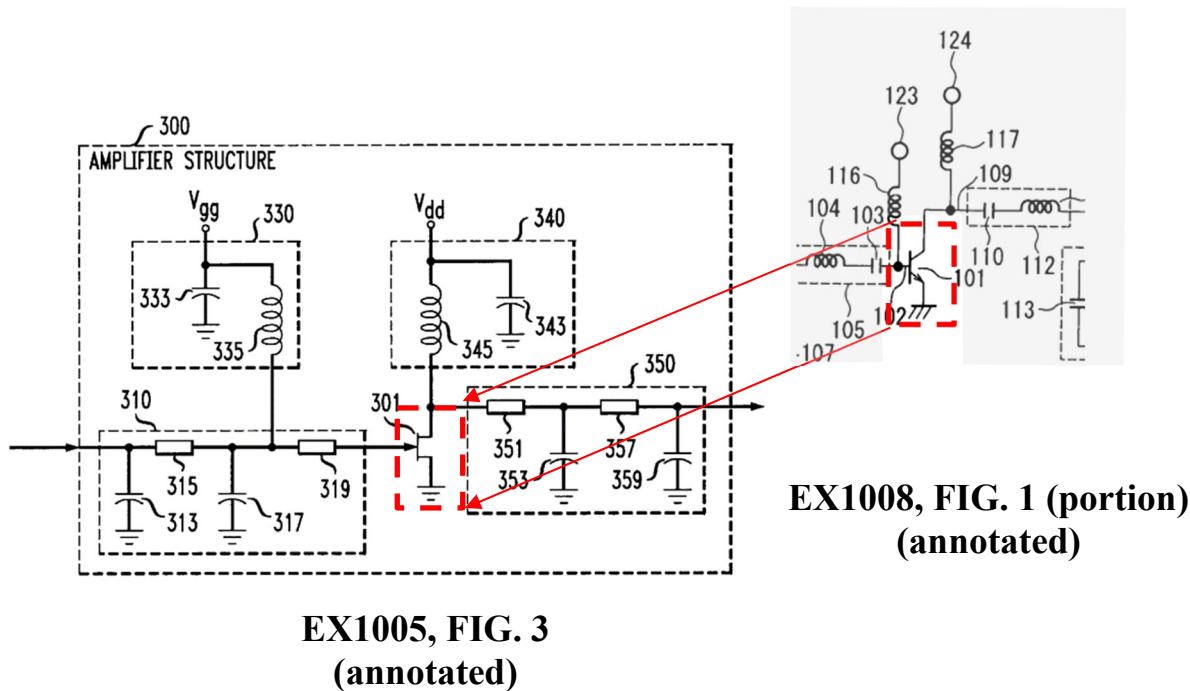
Francisco-JP466 renders obvious claim 1, and Francisco-JP466 further in view of Hirayama render obvious this element. EX1003, ¶¶259-265.

First, Francisco describes its active device broadly as “a transistor.” EX1005, 8:8-9. While Francisco’s specification discusses a field-effect transistor (FET) configuration, Francisco is not so limited. *See* EX1005, 8:11-54 (claim 1 broadly reciting “amplifying element,” claim limiting to “a transistor,” and claim 3 further narrowed to “a field effect transistor (FET).”) Under a claim differentiation framework and POSITA’s understanding, Francisco does not limit the configuration

of its transistor to a FET. EX1003, ¶260.

Further, as discussed above, it would have been obvious to provide the transistor of Francisco as a bipolar junction transistor (BJT) as shown in Hirayama. Hirayama describes that an amplifier can use an active device of a “bipolar transistor or a field effect transistor.” EX1008, [0014]. In particular, Hirayama describes its techniques to allow operation of an amplifier at multiple frequencies “can be applied to the case where an active element constituting the amplifier is **either a bipolar transistor or a field effect transistor** in the same manner, thus providing the matching circuit for converting the impedance into an optimum impedance at either of the two frequencies.” EX1008, [0072].

Hirayama suggests design trade-offs between gain performance and cost would motivate POSITA to use a BJT device in the amplifier: “The amplifier circuit of a **high gain** can be achieved in the **case of the use of the bipolar transistor** ...The optimum device can be appropriately selected according to the specifications required for the system.” EX1008, [0128]. Thus, it would have been obvious provide the active device of Francisco as a bipolar transistor as suggested by Hirayama. EX1003, ¶¶261-262.



EX1003, ¶263 (discussing POSITA’s approach to modifying circuit between FET and BJT with respect to the matching network).

Second, as discussed in [1.0], Francisco teaches its amplifier structure 300 provides “multi-band **low noise amplifier (LNA)** 155” in system 100. EX1005, 4:48-57, 5:24-29. The LNA 155 provides a *low noise amplifier* and is *operable for providing power gain at the first frequency and the second frequency*. EX1005, 4:47-48 (“**multi-band LNA** 155 provides an appropriate **gain** to the received signal.”), 7:57-58. The referred-to gain is a *power gain* and, as discussed above, the signals received by multi-band LNA 155 are of both the first and second frequency. EX1003, ¶264. Thus, Francisco teaches that its amplifier structure operates as an

LNA that receives and provides power gain for both the *first frequency* (e.g., cellular) and the *second frequency* (e.g., PCS). *See also*, EX1005, FIGS. 3, 5, 7:54-8:8, Abstract. And by applying Hirayama's BJT, the respective power gains can be increased. EX1003, ¶264.

Francisco, JP466 and Hirayama render obvious claim 4. EX1003, ¶¶259-265.

5. Claim 6

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

Francisco-JP466 renders obvious claim 5, and in light of Hirayama's further teaching, it would have been obvious to implement Francisco's active device as a bipolar junction transistor as discussed above for [4.0]. Thus, claim 6 is rendered obvious by Francisco, JP466 and Hirayama. EX1003, ¶¶259-266.

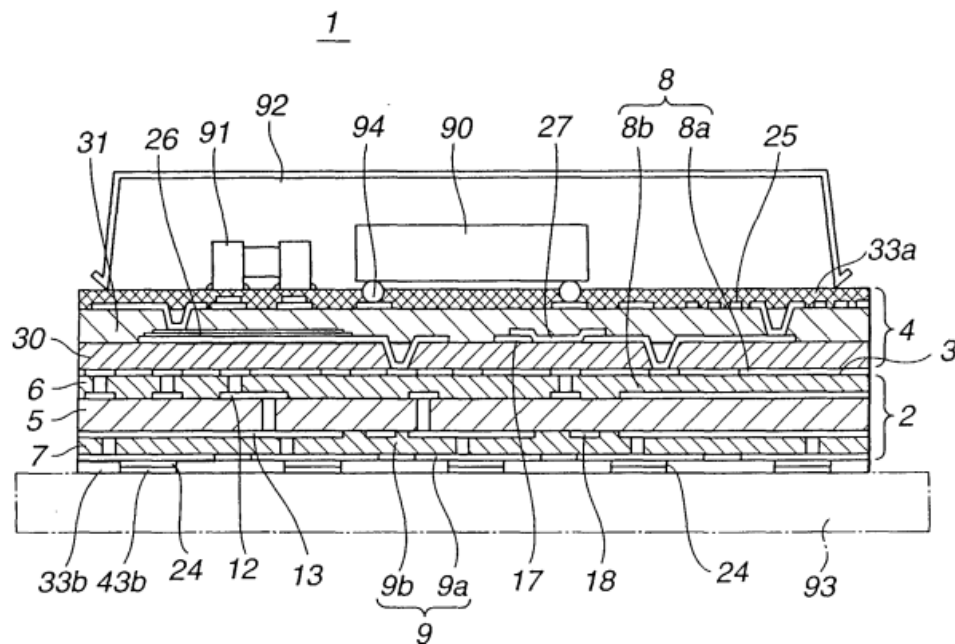
E. Ground 3 - Francisco, JP466, and Okubora

1. Okubora

Okubora is entitled "[h]igh frequency module device and method for [its preparation]" and describes devices for electronic equipment such as portable telephones. EX1007, (54), [0001]. Okubora also recognizes that communication systems for such equipment are reliant on various high frequency bands. EX1007, [0002]-[0005]. When implementing RF transmission/reception circuits, Okubora recognizes challenges to using silicon and glass substrates and in response provides

“a high frequency module in which a high precision passive elements or a high density wiring layer is formed on a base substrate formed of inexpensive organic resin to improve the function, as well as to reduce the thickness and size and to lower the production cost.” EX1007, [0024].

Okubora illustrates a module that includes a high frequency integrated circuit (IC) 90 on core substrate 5, which also has a high frequency device layer 4 including first and second insulating layers 30 and 31 with passives, such as an inductor 25, a capacitor 26 and a resistor 27. *See* EX1007, FIG. 7, [0059]-[0075] (method of fabricating in FIG. 8 with corresponding cross-sectional views in FIGS. 9-21).



EX1007, FIG. 7

The substrate, including core substrate 5 and layers 30 and 31 each are formed of a material of low dielectric constant and low $\tan \delta$ (loss tangent). EX1007, [0035], [0048], [0054]; EX1003, ¶269 (explaining $\tan \delta$ is a measure of the energy loss within a dielectric material, here substrate material, when used in an RF substrate). One of the preferred materials with low loss tangent suggested by Okubora is liquid crystal polymer (LCP). *Id.*

2. Reasons to combine Francisco and JP466 (Francisco-JP466)

Reasons to combine Francisco and JP466 are detailed in Ground 1.

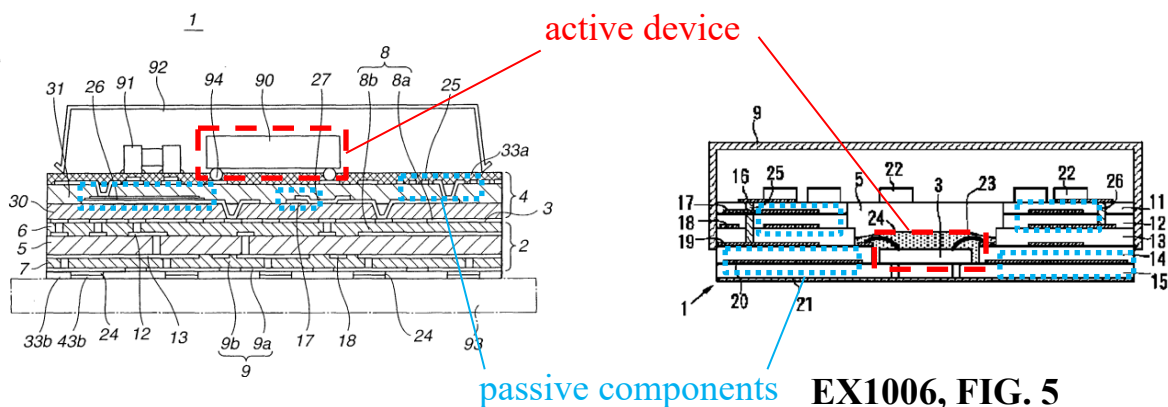
3. Reasons to combine Francisco-JP466 and Okubora

POSITA would have been motivated to combine Francisco-JP466 and the teachings of Okubora for multiple reasons, including to produce the obvious, beneficial, and predictable results of providing JP466's insulating substrate of Francisco-JP466 device comprising liquid crystalline polymer (LCP). EX1003, ¶¶267-279.

Francisco-JP466 and Okubora are in the same field of endeavor as the '914 Patent as they are related to transmit and receive circuits for RF devices suitable for personal communication, and in particular are directed to amplifiers and related passive components for those devices. EX1003, ¶272; EX1007, [0001]-[0006], FIG. 1; EX1005, 1:5-7, 1:36-46; EX1001, 1:23-27, 2:14-16. Like Francisco and JP466 discussed above, Okubora is also reasonably pertinent to a problem faced by the

inventor of the '914 Patent including reducing cost and size of packages of such devices. EX1001, 2:8-20, 24:37-46; EX1007, Abstract, [0006].

Francisco-JP466 and Okubora describe a substantially similar structure—RF transmit/receive circuitry having a core device (Francisco's amplifying element 101 or Okubora's IC 90) disposed on a multi-layer, organic insulating material substrate having passives (e.g., resistors, capacitors, inductors) embedded *within* its organic layers. EX1003, ¶¶273-274 (comparing Okubora at FIG. 7 to JP466 at FIG. 5).



Providing JP466 dielectric substrate 1 with Okubora's dielectric material disclosed in a substantially similar module is merely implementing a known material to perform its known function. EX1003, ¶275. Further, POSITA would recognize that there are a limited number of choices for dielectric material, with LCP being a well-known choice for dielectric materials of substrates in general, and RF devices

in particular. EX1003, ¶275 (citing LCP-based examples); EX1032, p. 503 (“LCP was introduced for multiplayer PCBs in 1995”); EX1023, p. 446 (“multilayer LCP”); EX1033, p. 249 (“LCP as a dielectric layer for the system-on-package process”).

POSITA would also have reason to implement the dielectric materials of JP466’s substrate due to LCP’s advantageous qualities including ease of use and material properties. EX1003, ¶276 (citing EX1007, [0048] (discussing coating uniformity); EX1033, p. 249 (“LCP’s have a high modulus, high melting temperatures, and good impact strength as a result of the fibrous nature of liquid crystal morphology.”); EX1023, p. 444 (discussing impermeable characteristics)). LCP was also recognized as a cost conscious material choice. *Id.*

In summary, POSITA would have been motivated to apply Okubora’s teachings when implementing the Francisco-JP466 device because doing so would beneficially (1) continue JP466’s goal of providing an organic dielectric material suitable for embedding high-quality passive components; (2) provide material that allows to maintain coating uniformity or thickness controllability as discussed in Okubora ([0048]), (3) provide benefits of LCP including moisture resistance and (4) provide a low cost option. EX1003, ¶277. Each of these reasons separately and together would have motivated POSITA. *Id.*

The results would have been predictable and there would have been a reasonable expectation of success in the combination because Francisco-JP466 and

Okubora describe similar devices for use in similar systems. EX1003, ¶¶278-279. JP466 describes an example using a polyvinyl benzyl ether compound as its organic resin material, which has a relative dielectric constant between 2.5 and 3.5 and a dielectric loss tangent in the range of 0.0025 to 0.005 (EX1006, [0081].) The relative dielectric constant of LCP is similarly about 3.0 and the value of the loss tangent of LCP is below 0.0045. *See* EX1032, p. 507 (characterization of LCP). Further, Dr. Shoemake explains the advantages to embedding passives discussed above with respect to JP466 apply here as well. EX1003, ¶278 (inductor reduction benefits of JP466 maintained with LCP material of Okubora).

Any modification needed to the teachings of Francisco-JP466 to accommodate the teachings of Okubora's material would have been within the level of ordinary skill in the art. EX1003, ¶279 (citing JP466's non-limiting disclosure that "[t]he dielectric substrate is preferably made..."). And Okubora itself suggests the interchangeability of the suitable dielectric materials. EX1007, 20:11-23 ("an organic material, **such as** benzocyclobutene, polyimide...liquid crystal polymer...exhibiting high frequency characteristics, thermal resistance, resistance against chemicals, uniform coating characteristics and thickness controlling characteristics.") Okubora also illustrates the interchangeability of substrate materials including "liquid crystal polymer (LCP)" and "a mixture of ceramics with an organic substrate." EX1007, [0036].

4. Claim 11

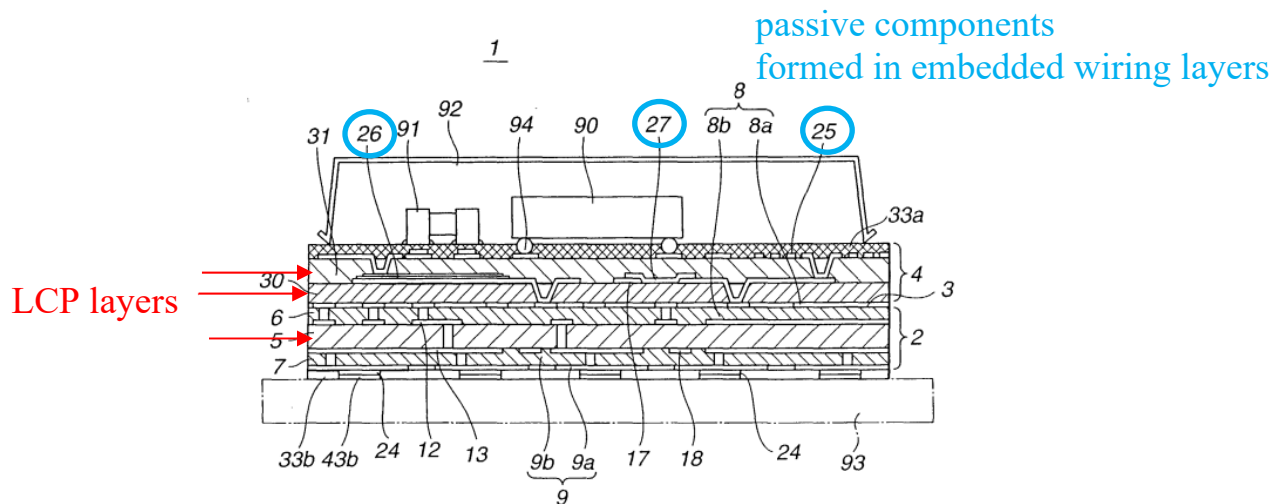
[11.0] *The multi-band R/F device of claim 1, wherein the organic-based substrate comprises liquid crystalline polymer.*

Francisco and JP466 render obvious claim 1, and Francisco-JP466 in view of Okubora render obvious this element. EX1003, ¶¶280-285.

As discussed in [1.4a], it would have been obvious to provide the multi-band RF device of Francisco using JP466's organic-based substrate. It would have also been obvious for that substrate to comprise a liquid crystalline polymer (LCP) in light of the teachings of Okubora. As discussed above in the reasons to combine Okubora above, LCP is a dielectric organic material known for use in substrates including RF devices well before the '914 Patent. Providing LCP as an organic, dielectric material in JP466's substrate is a simple substitution of one exemplary organic dielectric material for another where the materials have similar properties and are described as performing similar functions as discussed above and below. EX1003, ¶¶282-283.

Okubora describes a multi-layer substrate including multiple layers comprising liquid crystalline polymer (LCP). In particular, Okubora's "core substrate 5 is comprised of...a low dielectric constant and low $\tan\delta$, that is of superior high frequency characteristics, such as...liquid crystal polymer (LCP)[.]" EX1007, [0035]. Okubora describes its insulating layers (30, 31) formed on this core

substrate 5 also comprise LCP. EX1007, [0076], [0082]. Passive elements such as resistor 27, capacitor 26, and inductor 25 are formed on wiring layers on these LCP layers. EX1007, [0045]-[0056].



**EX1007, FIG. 7
(annotated)**

See also, EX1007, FIGS. 8-23. Thus, POSITA would have recognized using LCP in JP466's substrate for one or more of its layers (12, 13, 14, and/or 15), which are similarly configured, have similar dielectric properties, also include patterned conductors forming passives thereon. EX1003, ¶¶283-284.

Thus, Francisco, JP466, and Okubora render obvious claim 11. EX1003, ¶¶280-285.

5. 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.

Francisco and JP466 render obvious claim 5, and Francisco-JP466 in view of Okubora renders this claim obvious. EX1003, ¶¶286-289.

As discussed in [5.4a], it would have been obvious to provide multi-band RF device of Francisco with an organic-based substrate as taught by JP466. JP466 provides an example of polyvinyl benzyl ether compound, which is a chlorinated hydrocarbon. EX1003, ¶287. To the extent this claim is met by the use of a hydrocarbon alone, it is rendered obvious by Francisco and JP466. *Id.*

Additionally, as discussed in [11.0], it would have been obvious for JP466's substrate to comprise liquid crystalline polymer (LCP) in light of the teachings of Okubora. EX1003, ¶¶271-288. Thus, to the extent the claim requires both at least one a hydrocarbon and at least one LCP, it would have been obvious for the organic substrate to include a hydrocarbon and LCP. Okubora describes that multiple of its insulating compositions, including LCP, can be used together. *See* EX1007, 19:50-57 (“substrate formed of **one or more** materials selected from the group consisting of [hydrocarbons and **liquid crystal polymer**].” EX1003, ¶288.

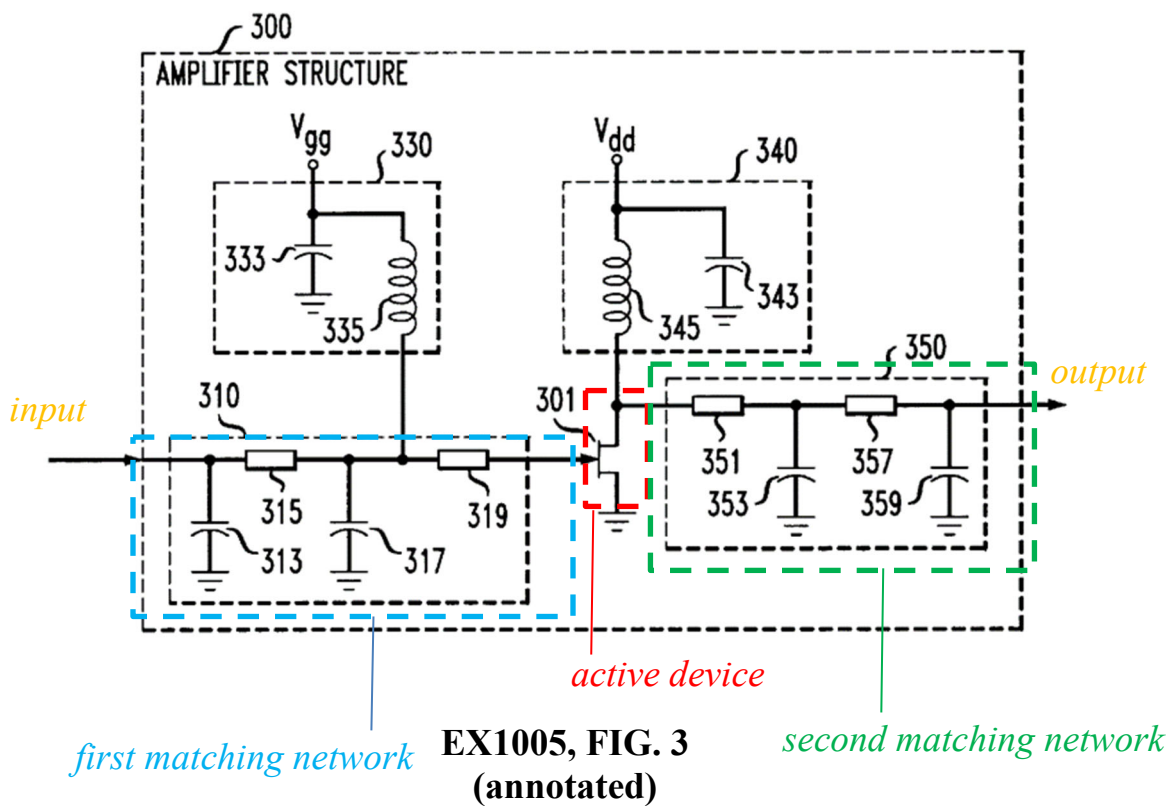
Thus, claim 7 is obvious in light of Francisco, JP466 and Okubora. EX1003, ¶¶286-289.

6. 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.*

Francisco-JP466 and Okubora renders obvious claim 7, and Francisco further discloses this element. EX1003, ¶¶290-293.

Francisco illustrates input matching circuit 310, *the first matching network* ([5.2]), *is positioned at an input of amplifier structure 300 (the multi-band amplifier)*. EX1005, FIG. 3, 5:30-45. Francisco also illustrates output matching circuit 350, *the second matching network* ([5.3]), *which is positioned at an output of amplifier structure 300 (the multi-band amplifier)*. EX1005, FIG. 3, 5:30-64.



EX1003, ¶291. Francisco confirms: “In accordance with the invention, the **multi-band amplifier** uses an **input network** to achieve a selected input impedance, and

an **output network** to achieve a selected output impedance....” EX1005, 1:50-61.

Thus, claim 8 is rendered obvious by Francisco, JP466 and Okubora. EX1003, ¶¶290-293.

7. 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.

Claim 8 is rendered obvious by Francisco-JP466 and Okubora, and Francisco further discloses this element. EX1003, ¶¶294-296.

Francisco discloses that the amplifier structure 300 (FIG. 3), a *multi-band amplifier*, receives and amplifies signals at multiple frequencies including the first frequency (*e.g.*, cellular) and the second frequency (*e.g.*, PCS) as discussed in [1.0] and [5.0]. Input matching network 310, *the first matching network*, minimizes the noise figure at each of these frequencies: “In **LNA 155**, **input matching network 310** is synthesized such that...giv[es] **minimum noise in Rcv bands 203 [cellular] and 207 [PCS]**.” EX1005, 6:1-7. *See also*, EX1003, ¶295.

Thus, claim 9 is rendered obvious by Francisco, JP466 and Okubora. EX1003, ¶¶294-296.

8. 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.

Claim 9 is rendered obvious by Francisco-JP466-Okubora, and Francisco further discloses this element. EX1003, ¶¶297-300.

Francisco teaches that its multi-band amplifier, illustrated by amplifier structure 300 of FIG. 3, receives and amplifies signals at multiple frequencies including the *first frequency* (e.g., cellular) and the *second frequency* (e.g., PCS) as discussed in [1.0] and [5.0]. Output matching network 350, *the second matching network*, maximizes the desired power gains at each of these frequencies. POSITA would recognize this to be the function of amplifier structure 300. EX1003, ¶298. Francisco explicitly describes this: “...unlike a prior art power amplifier which provides a **desired gain** to a signal within only a particular transmit band, amplifier 115 provides, in an efficient manner, **a desired gain** to a signal within **any one of the many discrete transmit bands**.” EX1005, 3:56-62, *see also*, 3:62-4:2. Francisco also confirms this is the function of the LNA 155 “...received signal, either a **cellular receive signal or PCS receive signal**, to multi-band low-noise amplifier (LNA) 155...[which receives cellular signals and PCS signals and provides] an **appropriate gain** to the **received signal**.” EX1005, 4:38-48.

Francisco also explicitly suggests *maximiz[ing]* power gains: “The **maximum power transfer** in the multiple bands of interest is thus achieved by amplifier structure 300 in accordance with the invention.” EX1005, 6:63-65.

Thus, claim 10 is rendered obvious by Francisco, JP466, and Okubora. EX1003, ¶¶297-300.

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. None of Francisco, JP466, or Hirayama were cited or considered by the Examiner during prosecution of the '914 Patent. A related application to Okubora (2002/0195270) is cited on the second page of the '914 Patent. Okubora was not discussed by the Examiner during the prosecution. And Okubora is used here in combination with Francisco and JP466, which were not cited, and for the dependent claim feature of a specific material type.

Accordingly, discretionary denial under 35 U.S.C. § 325(d) is not appropriate.

B. No basis for denial under U.S 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. Moreover, 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. Typical time-to-trial for the district court

hearing the co-pending litigation is 34.5 months. EX1036, p. 11 (median time-to-trial (civil), Georgia, Northern District); *In re Apple Inc.*, 979 F.3d 1332, 1350 (Fed. Cir. 2020). Here, the final written decision is due August 2026, more than a year 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 to this Petition. *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
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/David W. O'Brien/
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Lead Counsel for Petitioner

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
<i>Georgia Tech Research Corporation v. Murata Electronics North America, Inc. et al.</i>	NDGA-1-24-cv-05268	NDGA	Nov. 17, 2024

Petitioner is also concurrently filing a second 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

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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 13,579. 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/

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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-EX1009, EX1011-EX1012, EX1014-EX1037

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