UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD.
Petitioner

v.

RED ROCK ANALYTICS, LLC
Patent Owner

Patent No. 7,346,313

PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 7,346,313

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Ex. 1021	L. Sundstrom, *et. al.*, "Quantization analysis and design of a digital predistortion linearizer for RF power amplifiers," *IEEE Transactions on Vehicular Technology*, vol. 45, no. 4 at pp. 707-19 (Nov 1996).
Ex. 1022	S. Chetwani and A. Papandreou-Suppappola, "Time-varying interference suppression in communication systems using time-frequency signal transforms," *Conference Record of the Thirty-Fourth Asilomar Conference on Signals, Systems and Computers*, vol. 1 at 460-64 (2000).
Ex. 1023	Barnes & Noble web page for S. Haykin, Communication Systems, 4th ed. (2000), https://www.barnesandnoble.com/w/communicationsystemssimonhaykin/1117165032
Ex. 1024	*Red Rock Analytics, LLC*'s infringement claim chart asserting U.S. Patent No. 7,346,313 against Samsung, from *Red Rock Analytics, LLC v. Samsung Electronics Co. Ltd.*, Case No. 2-17-cv-00101 (E.D. Tex.)
Ex. 1025	S. Haykin, Communication Systems, 3rd ed. (1994) ("*Haykin-94*")

I. INTRODUCTION

Samsung Electronics Co., Ltd. ("Petitioner") requests *inter partes* review of claims 7, 11-21, 44, and 48-58 ("the challenged claims") of U.S. Patent No. 7,346,313 ("the '313 patent") (Ex. 1001), which, according to PTO records, is assigned to Red Rock Analytics, LLC ("Patent Owner"). For the reasons discussed below, the challenged claims should be found unpatentable and canceled.

II. MANDATORY NOTICES

Real Parties-in-Interest: Petitioner identifies the following as the real parties-in-interest: Samsung Electronics Co., Ltd.; Samsung Electronics America, Inc.; Samsung Semiconductor, Inc.; and Samsung Austin Semiconductor, LLC.

Related Matters: The '313 patent is at issue in *Red Rock Analytics, LLC v. Samsung Electronics Co. Ltd.*, Case No. 2-17-cv-00101 (E.D. Tex.) and in *Unified Patents Inc. v. Red Rock Analytics, LLC*, IPR2017-01490 (PTAB). Petitioner is concurrently filing two other petitions – one challenging claims 1-6 and 38-43 of the '313 patent and another petition challenging claims 22, 26-37, 59, and 63-74 of the '313 patent.

Counsel and Service Information: Lead counsel is Naveen Modi (Reg. No. 46,224), and Backup counsel are (1) Joseph E. Palys (Reg. No. 46,508), (2) Paul M. Anderson (Reg. No. 39,896), (3) Chetan R. Bansal (Limited Recognition No. L0667), and (4) Arvind Jairam (Reg. No. 62,759). Service information is Paul

Hastings LLP, 875 15th St. N.W., Washington, D.C., 20005, Tel.: 202.551.1700, Fax: 202.551.1705, email: PH-Samsung-Redrock-IPR@paulhastings.com. Petitioner consents to electronic service.

III. PAYMENT OF FEES

The PTO is authorized to charge any fees due during this proceeding to Deposit Account No. 50-2613.

IV. GROUNDS FOR STANDING

Petitioner certifies that the ’313 patent is available for review and Petitioner is not barred or estopped from requesting review on the grounds identified herein. Petitioner notes that the one-year deadline under 35 U.S.C. § 315(b) started to run no earlier than February 3, 2017. Because February 3, 2018 was a Saturday, the one-year bar date under § 315(b) was extended to February 5, 2018. *See* 35 U.S.C. § 21(b); 37 C.F.R. § 1.7(a).

V. PRECISE RELIEF REQUESTED AND GROUNDS RAISED

The challenged claims should be canceled as unpatentable based on the following grounds:

Ground 1: Claims 7, 15, 16, 21, 44, 52, 53, and 58 are unpatentable under pre-AIA 35 U.S.C. § 103(a) based on U.S. Patent No. 6,898,252 (“*Yellin*”) (Ex. 1005) in view of U.S. Patent No. 6,272,322 (“*Su*”) (Ex. 1006);

Ground 2: Claims 11, 17, 48, and 54 are unpatentable under pre-AIA 35 U.S.C. § 103 based on *Yellin*, *Su*, and Faulkner, M., *et al.*, "Automatic Adjustment of Quadrature Modulators," *Electronics Letters*, vol. 27 no. 3, at 214-16 (1991) ("*Faulkner*") (Ex. 1012);

Ground 3: Claims 12, 13, 18, 19, 49, 50, 55, and 56 are unpatentable under pre-AIA 35 U.S.C. § 103 based on *Yellin*, *Su*, and U.S. Patent No. 4,613,976 ("*Sewerinson*") (Ex. 1016); and

Ground 4: Claims 14, 20, 51, and 57 are unpatentable under pre-AIA 35 U.S.C. § 103 based on *Yellin*, *Su*, *Sewerinson*, and S. Haykin, Communication Systems, 4th ed. (2000) ("*Haykin*") (Ex. 1017).

The '313 patent issued from U.S. Application No. 10/379,352 filed on March 4, 2003. (Ex. 1001, Cover.) The '313 patent claims the benefit of U.S. Provisional Application No. 60/361,630 ("the '630 provisional"), filed March 4, 2002. (*See* Ex. 1001, 2nd Certificate of Correction.) *Yellin* issued May 24, 2005 and was filed July 21, 2000. *Su* issued on August 7, 2001 and was filed February 4, 2000. Even assuming that the claims of the '313 patent are entitled to the filing date of the '630 provisional, which Petitioner does not concede, *Yellin* and *Su* are prior art under pre-AIA 35 U.S.C. § 102(e).

Faulkner was published in 1991 in a well-known publication ("*Electronics Letters*"). This can be seen, for example, at the bottom of each page of *Faulkner*.

(Ex. 1012, 214-16.) Given that it was published in a well-known publication in 1991, over twelve years before the filing date of the ’313 patent, *Faulkner* qualifies as prior art under pre-AIA 35 U.S.C. § 102(b). In fact, *Faulkner* was cited by other articles well-before the ’630 provisional was filed. (*See, e.g.*, Ex. 1020, 450 (reference 2); Ex. 1021, 719 (reference 6); *see also* Ex. 1002, ¶16, n.2.)

Sewerinson issued September 23, 1986 and qualifies as prior art under § 102(b). *Haykin* was published in 2000 and is prior art under pre-AIA 35 U.S.C. § 102(b). (*See, e.g.,* Ex. 1017 at 4 (Library of Congress date stamp of “May 22, 2000”; Ex. 1023 (“Pub. Date: 01/28/2000”).) In fact, *Haykin* was cited by other articles that were published well before the ’640 provisional was filed. (*See, e.g.*, Ex. 1022 at 464 (reference 7).)

Yellin, *Su*, *Faulkner*, *Sewerinson*, and *Haykin* were not considered by the Patent Office during prosecution of the ’313 patent. (*See, e.g.*, Ex. 1001, Cover (References Cited section); Ex. 1004.)

VI. LEVEL OF ORDINARY SKILL

A person of ordinary skill in the art (“POSITA”) at the time of the alleged invention of the ’313 patent would have had at least a Master’s degree in electrical engineering or a similar discipline, and at least one to two years of work experience in the design and analysis of radio frequency communication systems.

(Ex. 1002, ¶¶19-20.)[1] More education can substitute for practical experience and vice versa.

VII. OVERVIEW OF THE '313 PATENT AND THE PRIOR ART

A. Technology Overview

The '313 patent is directed to balancing gain between in-phase and quadrature (I and Q) channels in a transceiver, e.g., a direct-conversion or heterodyne transceiver. (Ex. 1001, Abstract; Ex. 1002, ¶¶21-44.) Such transceivers were well known long before the alleged invention of the '313 patent, and techniques for balancing the gain of the I and Q channels of such transceiver were well known. (Ex. 1002, ¶21-44.)

B. The '313 Patent

The '313 patent acknowledges in its background section that it was known prior to the alleged invention of the '313 patent that the gains provided in the I and Q channels had to be balanced in transmitters and receivers of transceivers such as heterodyne and direct-conversion transceivers. (Ex. 1001, 1:19-60; Ex. 1002, ¶45.)

The '313 patent discloses a "preferred embodiment of a typical transceiver incorporating the present invention" with respect to Figure 4. (Ex. 1001, 4:60-62.)

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[1] Petitioner submits the declaration of R. Jacob Baker, Ph.D., P.E. (Ex. 1002), an expert in the field of the '313 patent. (Ex. 1002, ¶¶1-18; Ex. 1003.)

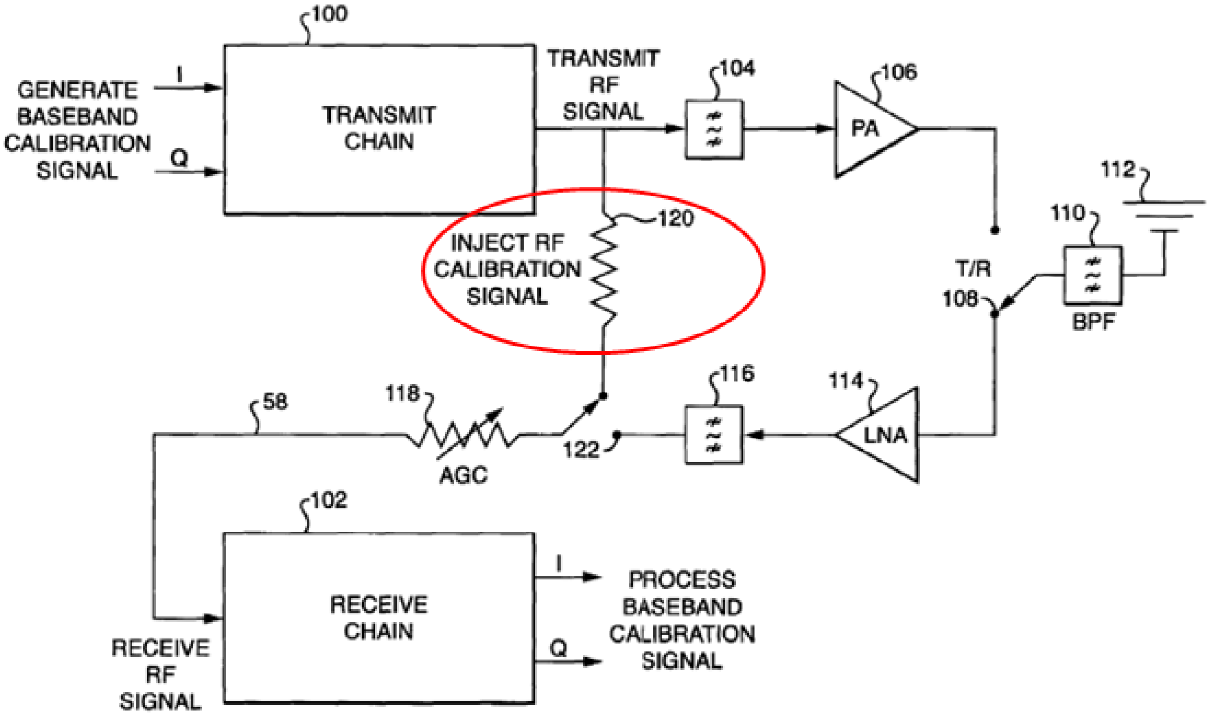

FIG. 4

(Ex. 1001, FIG. 4 (annotated); Ex. 1002, ¶46.)

Figure 4 of the ’313 patent “shows a typical transceiver comprising the transmit and receive chains of FIG. 1 or FIG. 2” (Ex. 1001, 8:10-11), which are acknowledged as being prior art components (*id.*, 4:48-52, 6:23-24, 6:48 (“conventional designs as shown in FIG. 1”), 6:57-58). The ’313 patent explains that “[t]he only additional circuitry required for calibration is that to provide injection of the calibration signal from RF transmit output to RF receive input.” (*Id.*, 8:39-41; Ex. 1002, ¶¶47-49.)

A calibration signal is applied at the baseband transmit input of the transmit chain, and the calibration signal is converted to RF either directly or after conversion to an intermediate frequency. (Ex. 1002, ¶¶48-55.) After conversion to RF, the calibration signal is provided to the receive chain. (*Id.*) According to the ’313 patent, calibration is performed by minimizing an observable indicator of gain imbalance. (Ex. 1001, 5:61-65; Ex. 1002, ¶¶48-55.)

C. *Yellin*

Yellin relates to a communication device that transmits and receives data using both I and Q channels. (Ex. 1002, ¶¶57-75.) For example, *Yellin* discloses an apparatus 300 shown in figure 2 that includes both transmitting and receiving functions.

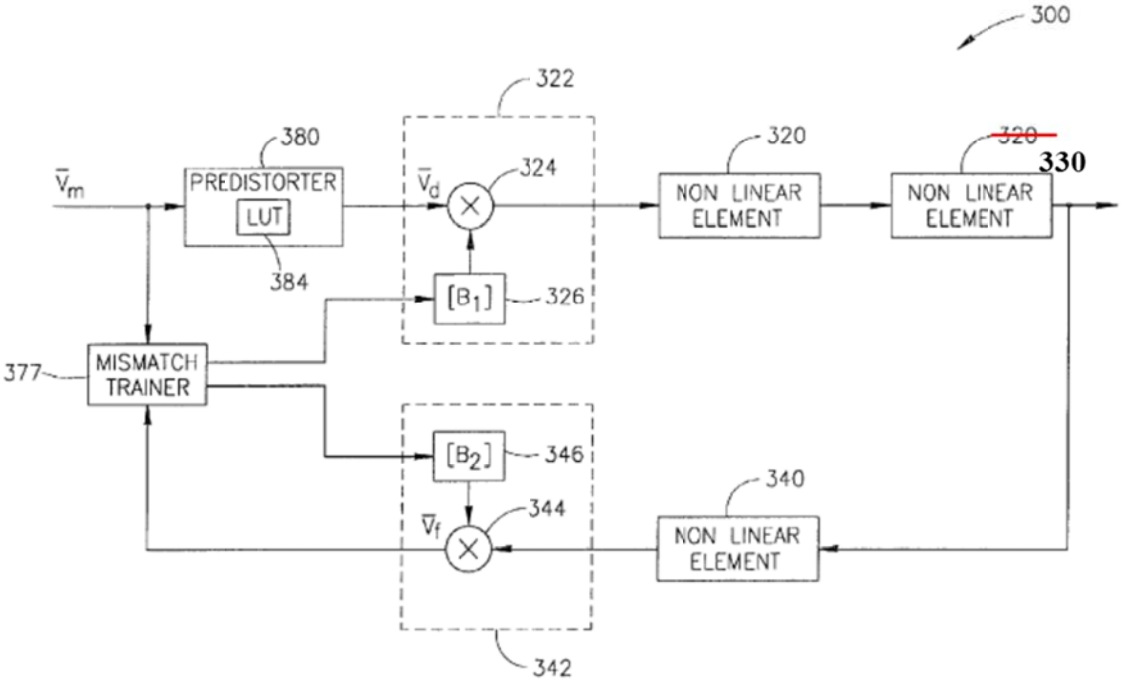

FIG.2

(Ex. 1005, FIG. 2 (annotated); Ex. 1002, ¶ 57[2].)

Each input vector V_m includes a real part (I_m) and an imaginary part (Q_m). The vectors V_m are provided to a sequence of non-linear elements 320, 330, and 340 as shown in figure 2, where the non-linear elements can be RF elements such as, for example, a modulator and a demodulator. (Ex. 1005, 3:11-15, 4:10-15.) More specifically, *Yellin* discloses that non-linear element 320 is an IQ modulator and non-linear element 340 is an IQ demodulator. (*Id.* 3:11-22.) The IQ modulator (non-linear element 320) modulates the received IQ vectors onto a high frequency carrier (e.g., RF frequency). (Ex. 1002, ¶¶58-61.) The high frequency data output by non-linear element 320 is injected into IQ demodulator (non-linear element 340), which demodulates the received high frequency signal into baseband IQ vectors. (Ex. 1005, 3:65-66, 4:14-15, 10:5-10, FIG. 2; Ex. 1002, ¶62.)

Yellin discloses that the apparatus 300 shown in figure 2 suffers from IQ mismatch, which can include IQ gain imbalance and phase errors caused by distortions in non-linear elements 320 and 340. (Ex. 1005, 1:18-36, 3:8-11, 3:15-22; Ex. 1002, ¶¶63-66.) The parameters in the matrices 326 and 346 of IQ

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[2] As explained by Dr. Baker, figure 2 of *Yellin* includes a typographical error because while two non-linear elements are labeled as "320," the last non-linear element should have been labeled as "330." (Ex. 1002, ¶57.)

correction units 322 and 342 are set by a mismatch trainer 377 in order to correct these gain and phase mismatch distortions caused by the non-linear elements 320 and 340. (Ex. 1005, 3:15-47; Ex. 1002, ¶¶67-75.)

VIII. CLAIM CONSTRUCTION

A claim in an unexpired patent that will not expire before a final written decision is issued in an IPR receives the "broadest reasonable construction in light of the specification of the patent in which it appears." 37 C.F.R. § 42.100(b). The '313 patent has not expired and will not expire before a final written decision will be issued. Thus, for purposes of this proceeding, the claims of the '313 patent should be given their broadest reasonable construction.

The Board, however, only construes the claims when necessary to resolve the underlying controversy. *Toyota Motor Corp. v. Cellport Sys., Inc.*, IPR2015-00633, Paper No. 11 at 16 (Aug. 14, 2015) (citing *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999)). Petitioner submits that for purposes of this proceeding, the terms of the challenged claims should be given their plain and ordinary meaning under the broadest reasonable interpretation (BRI) standard.[3] (Ex. 1002, ¶56.)

IX. DETAILED EXPLANATION OF GROUNDS

As discussed below, the challenged claims are unpatentable in view of the prior art.

A. Ground 1: *Yellin* in View of *Su* Renders Obvious Claims 7, 15, 16, 21, 44, 52, 53, and 58

1. Claim 7

a) [7.pre] "A transceiver system comprising:"

To the extent the preamble is limiting, *Yellin* in combination with *Su* discloses or suggests this feature. (Ex. 1002, ¶¶85-101.) *Yellin* discloses an apparatus 300 in figure 2 that transmits and receives data. (*Id.*)

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[3] Because of the different claim interpretation standards used in this proceeding and in district courts, any claim interpretations submitted or implied herein for the purpose of this proceeding are not binding upon Petitioner in any litigation related to the '313 patent. Moreover, Petitioner does not concede that the challenged claims are not invalid under one or more sections of 35 U.S.C. § 112, which is something that cannot be pursued in this proceeding under the Rules.

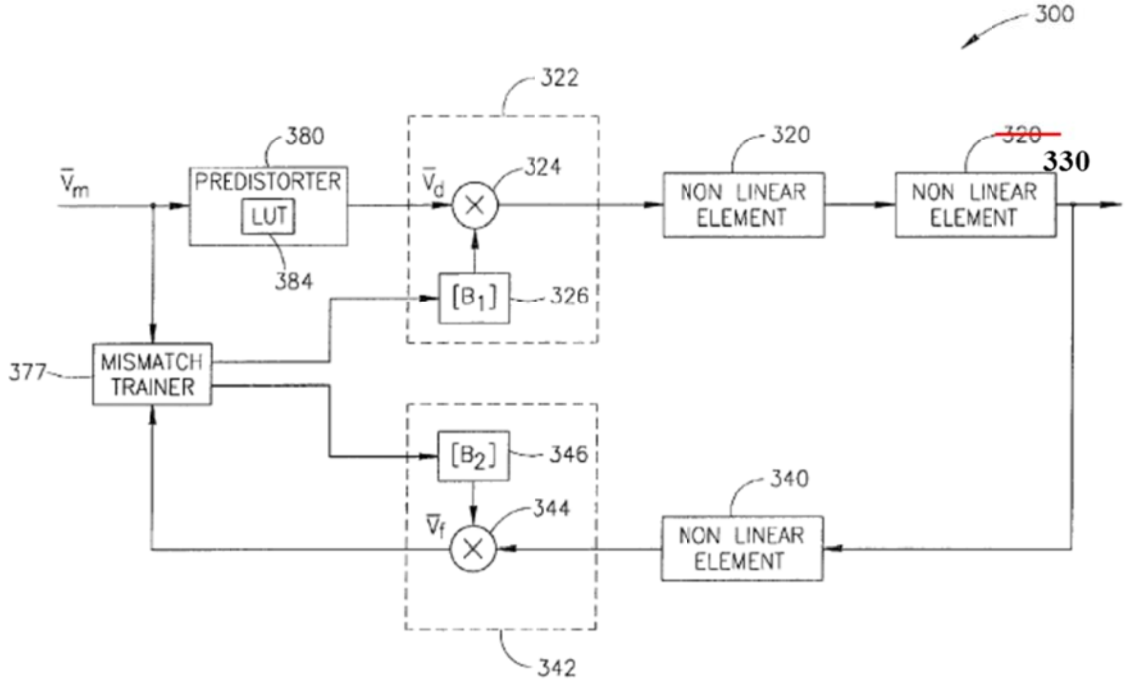

FIG.2

(Ex. 1005, FIG. 2 (annotated); Ex. 1002, ¶86.)

With respect to data transmission, *Yellin* discloses that a "vector of signals $V_m = (I_m, Q_m)$, formed of a real part I_m and an imaginary part Q_m is provided to a sequence of non-linear elements 320, 330, and 340 . . . ." (Ex. 1005, 3:11-15.) The IQ vectors V_m (and more specifically, IQ vectors V_d, which are predistorted versions of IQ vector V_m) are received by non-linear element 320, which *Yellin* explains is an IQ modulator.[4] (*Id.,* 3:11-22, 3:48-51, FIG. 2.) The IQ modulator modulates received IQ vectors V_d onto a high frequency carrier (e.g., RF frequency). (*Id.,* 4:14-15 ("the non-linear elements comprise RF elements"); *see also id.,* 1:5-29 (describing the role of an IQ modulator as modulating baseband I and Q components onto a high frequency carrier).) Therefore, *Yellin* discloses transmitting data because data received on the I and Q channels is transmitted by modulating the IQ channel data onto a high frequency carrier (e.g., an RF carrier). (Ex. 1002, ¶¶58-61, 87.)

With respect to data reception, *Yellin* discloses that the transmitted high frequency data is injected into non-linear element 340, which is an "IQ demodulator." (Ex. 1005, FIG. 2, 3:21-22.) Non-linear element 340 outputs IQ vectors by demodulating the received high frequency signal, and the IQ vectors are gain and phase calibrated by IQ correction unit 342 resulting in IQ vectors V_f. (*Id.,* 3:65-66, 4:14-15, 10:5-10, FIG. 2; Ex. 1002, ¶88.) The IQ vectors V_f are output to a mismatch trainer 377. (Ex. 1005, FIG. 2, 4:31-41.) Therefore, *Yellin* discloses

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[4] The gain and the phase of the IQ vector V_d are calibrated by IQ correction unit 322 prior to the vector being provided to non-linear element 320. (Ex. 1005, 3:23-35; Ex. 1002, ¶87, n.3.)

receiving data because the high frequency data is demodulated and provided to the mismatch trainer 377. (Ex. 1002, ¶¶62, 88.)

While *Yellin's* apparatus 300 in figure 2 includes both transmit and receive chains, *Yellin* does not explicitly refer to apparatus 300 as a "transceiver." To the extent Patent Owner contends that apparatus 300 is not a "transceiver," it would have been obvious to implement *Yellin*'s apparatus 300 as a "transceiver" in view of *Su*. (*Id.*, ¶¶89-92) *Su* discloses an exemplary configuration of such a transceiver in figures 2A and 2B, which illustrate the configuration of a mobile device. (*Id.*, ¶¶76-79, 90; Ex. 1006, 4:30-40.)

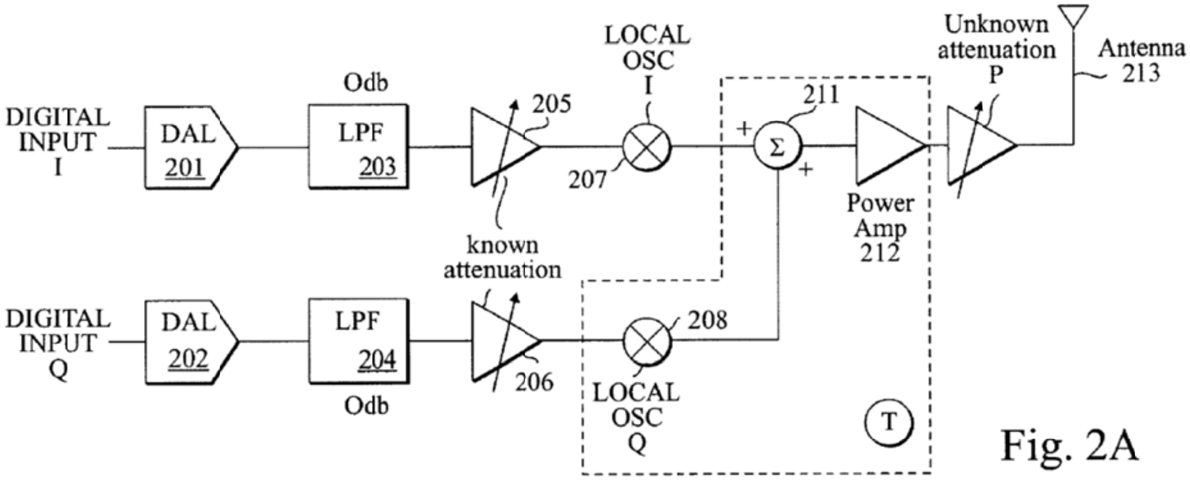

Fig. 2A

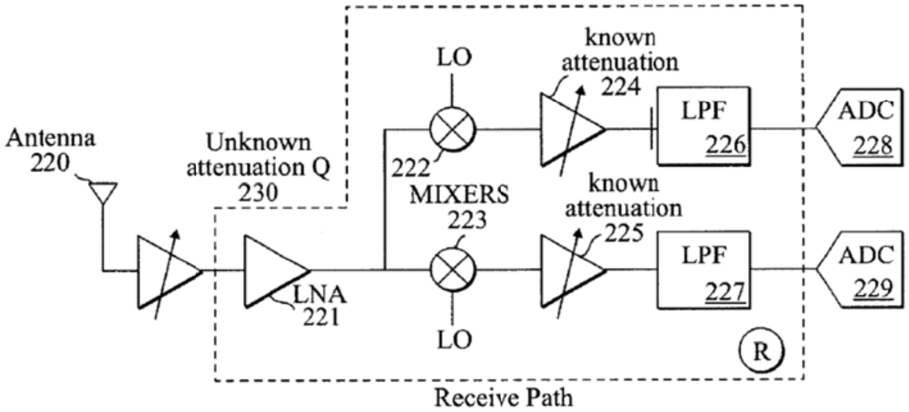

Fig. 2B

(Ex. 1006, FIGS. 2A, 2B.)

A POSITA would have looked to *Su* to refine the teachings of *Yellin* because, for instance, both *Yellin* and *Su* disclose techniques for improving the performance of wireless communication devices. (Ex. 1002, ¶91.) Indeed, *Yellin* explicitly contemplates the applicability of its teachings to wireless devices such as handsets, which correspond to the mobile devices in *Su*. (*Id.*; Ex. 1005, 9:57-61; Ex. 1006, 4:30-34.) Having looked to *Su*, the POSITA would have recognized that *Yellin*'s apparatus 300 in figure 2 could be implemented as a transceiver without deviating from *Yellin*'s IQ mismatch correction technique. (Ex. 1002, ¶91.) The POSITA would have recognized that while apparatus 300 is not explicitly stated as being a "transceiver," it includes a transmit chain and receive chain like those found in a typical transceiver as evidenced by both *Su* and the '313 patent. (*Id.*)

Moreover, a POSITA would have been motivated to implement apparatus 300 as a transceiver because doing so would have increased the utility of the apparatus 300 with minimal modifications. (*Id.*, ¶¶92-94, 96-99.) Indeed, *Yellin* discloses calibrating the I-Q mismatch in both the transmit and receive chains (*see infra* Section IX.A.1(e)), thereby providing a fully calibrated receive chain capable of receiving RF signals and providing output vectors V_f in the form of IQ data. (Ex. 1002, ¶93.) Furthermore, a POSITA would have been motivated to combine the teachings of *Yellin* and *Su* because *Yellin* discloses techniques for correcting IQ mismatch in the transmit and receive chains, and *Su* discloses transmit/receive chains having distinct I and Q channels. (*Id.*, ¶95; *infra Section* IX.A.1(e); Ex. 1006, FIGS. 2A, 2B.) *Yellin* discloses that the apparatus of figure 2 can be used with transmitters, receivers, or "any other apparatus which suffers from IQ mismatch" (Ex. 1005, 3:8-11), and the '313 patent confirms that direct-conversion transceivers suffer from IQ mismatch. (Ex. 1002, ¶95; *see also* Ex. 1001, 1:37-45.) Therefore, combining *Yellin* and *Su* would have allowed for I-Q mismatch cancellation as disclosed in *Yellin* in a direct-conversion transceiver as disclosed in *Su*. (Ex. 1002, ¶95.)

Accordingly, it would have been obvious to a POSITA to implement the apparatus in figure 2 of *Yellin* as a transceiver like in *Su*. *KSR Int'l Co. v. Teleflex, Inc.,* 550 U.S. at 416-21 (2007). Indeed, a modification of *Yellin* based on *Su* such that *Yellin*'s apparatus 300 is implemented as a "transceiver" would have simply constituted the application of a known technique (*Yellin*'s IQ mismatch correction) to a known device (a transceiver like in *Su*) according to known methods (*Yellin* discloses IQ mismatch correction for both transmitters and receivers) to yield predictable results (I-Q gain imbalance reduction in a transceiver) and hence, would have been obvious to a POSITA. (Ex. 1002, ¶100.) *See KSR,* 550 U.S. at 416-17.

(*See also infra* Sections IX.A.1(b)-(f) for the remaining limitations of this claim.)

b) [7.a] "A. a transmit chain including: a signal generator for generating a baseband transmit signal; baseband I-Q amplification subsystem for providing baseband amplification of the baseband transmit signal; a direct-conversion subsystem for converting the baseband transmit signal to an RF transmit signal, and an RF transmit signal port;"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶¶102-21.) As discussed above, *Yellin* and *Su* disclose or suggest implementing apparatus 300 of *Yellin's* figure 2 as a transceiver. (*See supra* Section IX.A.1(a).) Such a transceiver would have included a transmit chain, and a POSITA would have understood the transmit chain would have included at least a signal generator, a baseband amplification system, a direct-conversion subsystem, and an RF transmit signal port as recited in claim 7. (Ex. 1002, ¶102.) Indeed, as admitted by the '313 patent, the claimed transmit chain and the elements therein are conventional and were well known in the art.[5] (Ex. 1001, 6:45-48; *see also id.*, 4:48-50, 6:24, 6:36, FIGS. 1A-1B.)

i. "a signal generator for generating a baseband transmit signal"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶¶103-04.) *Yellin* discloses that "[m]any transmitters transmit digital information values that are generated in base band" where the "base band digital values are modulated onto a carrier high frequency signal." (Ex. 1005, 1:5-11.) As shown in figure 2, *Yellin* discloses vectors V_m provided to IQ correction unit 322. *Yellin* discloses that each vector includes a real part I_m and an imaginary part

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[5] Other than the claims and summary of the invention parroting the claim language, there is no mention of "a signal generator," a "baseband amplification subsystem," "a direct-conversion subsystem," or "an RF transmit signal port" in the '313 specification.

Q_m. (Ex. 1005, 3:11-15.) A POSITA would have understood that vectors V_m are a baseband signal and constitute a "baseband transmit signal." (Ex. 1002, ¶103.) Indeed, POSITA would have understood that because non-linear element 320 is described as an "IQ modulator" (Ex. 1005, 3:21-22) whose output is an RF signal (*infra* Section IX.A.1(b)(iii)), the input to such an IQ modulator would be a baseband signal. (Ex. 1002, ¶103; Ex. 1005, 1:5-11 (describing that baseband values modulated onto a high frequency by a modulator).) Therefore, the IQ vectors being transmitted through predistorter 380 and IQ correction unit 322 must be at baseband, which confirms that I-Q vectors V_m are a "baseband transmit signal." (Ex. 1002, ¶103.)

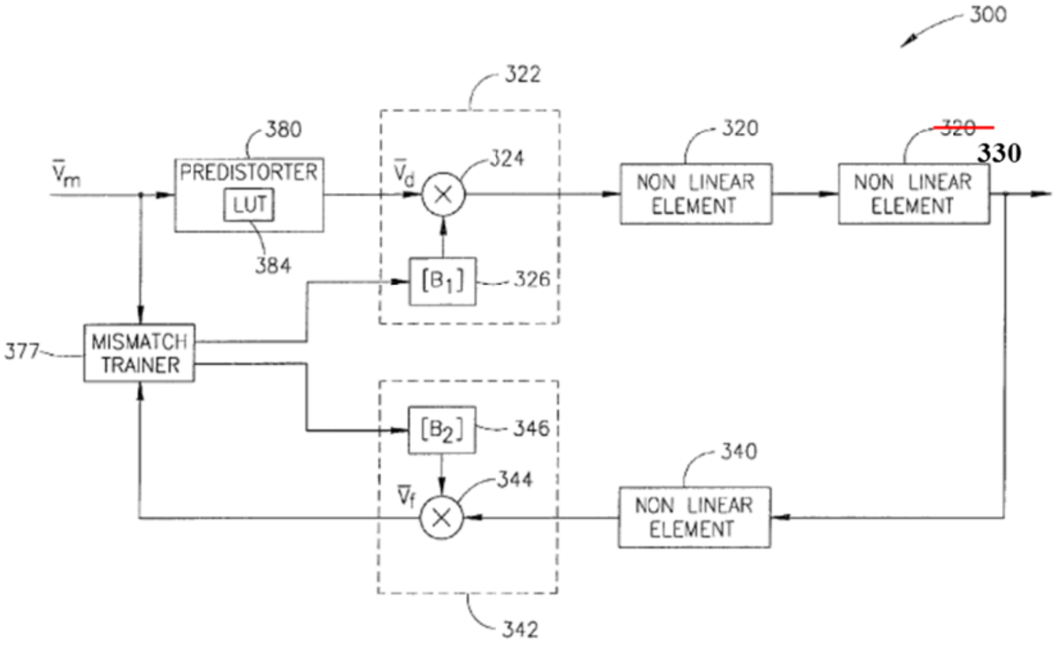

FIG.2

(Ex. 1005, FIG. 2 (annotated); Ex. 1002, ¶103.)

Yellin does not explicitly disclose what device generates vectors V_m in apparatus 300, but a POSITA would have understood that the vectors must be generated by some device or circuitry. (Ex. 1002, ¶104.) Indeed, figure 2 of *Yellin* is no different from figure 4 of the '313 patent in that figure 4 simply discloses an incoming I-Q signal without identifying any particular "signal generator" for generating such I-Q signals. (*Id.*; *see* Ex. 1001, FIG. 4; *see also generally id.*) Regardless, *Yellin* describes circuitry that generates I-Q vectors V_m in figure 1A. (Ex. 1002, ¶104.) As shown in figure 1A, the combination of modulator 32, interpolator 36, and interpolator 38 generates vectors V_m and therefore is a "signal generator" as recited in claim 7.[6] (Ex. 1001, FIG. 1A, 1:65—2:14; Ex. 1002, ¶104.)

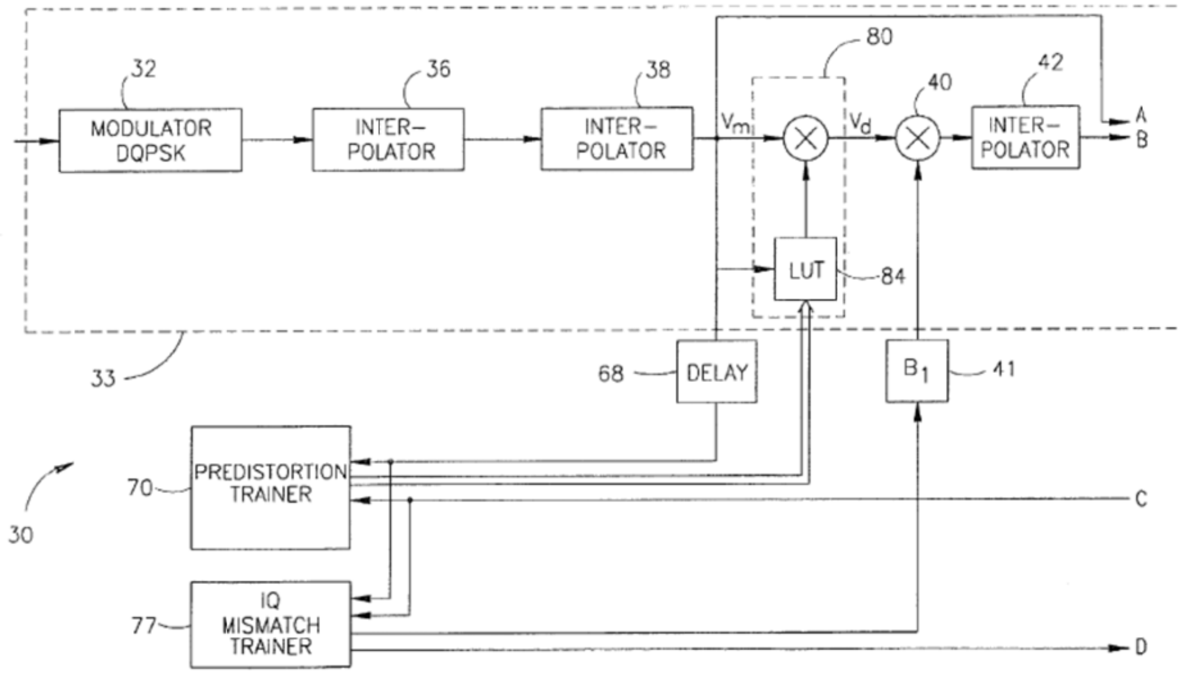

FIG.1A

(Ex. 1005, FIG. 1A.)

A POSITA would have understood that the disclosure of figure 1A applies to figure 2 of *Yellin* at least because *Yellin* describes that "[a]pparatus 300 may be for example a communication device, such as transmitter 30 of FIGS. 1A and 1B . .

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[6] The '313 patent does not identify or provide an example of the claimed "signal generator." (Ex. 1002, ¶104, n.4.)

. .” (Ex. 1005, 3:8-11.) As such, the *Yellin-Su* combination discloses or suggests a “signal generator for generating a baseband transmit signal.” (Ex. 1002, ¶104.)

ii. “baseband I-Q amplification subsystem for providing baseband amplification of the baseband transmit signal”

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶¶105-09.) As discussed above, *Yellin* discloses baseband I-Q vectors V_m are provided to non-linear element 320 after pre-distortion by predistorter 380 and gain/phase calibration by I-Q correction unit 322. (*Supra* Sections IX.A.1(a), (b)(i); *see also* Ex. 1005, FIG. 2.) Non-linear element 320 up-converts the received baseband I-Q vectors to a high frequency signal (e.g., RF frequency carrier). (Ex. 1002, ¶¶58-61, 105.) *Yellin* does not explicitly disclose a baseband amplifier that amplifies the baseband I-Q vectors prior to up-conversion by non-linear element 320. (Ex. 1002, ¶105.) But *Su* discloses attenuators 205 and 206 (“baseband I-Q amplification subsystem”) that alter the gain of the baseband I-Q signals in the transmit chain prior to modulation to RF frequency. (Ex. 1006, 4:35-62, FIG. 2.) *Su* makes clear that attenuators 205 and 206 can either amplify (increase) or attenuate (decrease) the magnitude of the signals. (Ex. 1002, ¶105, 107.)

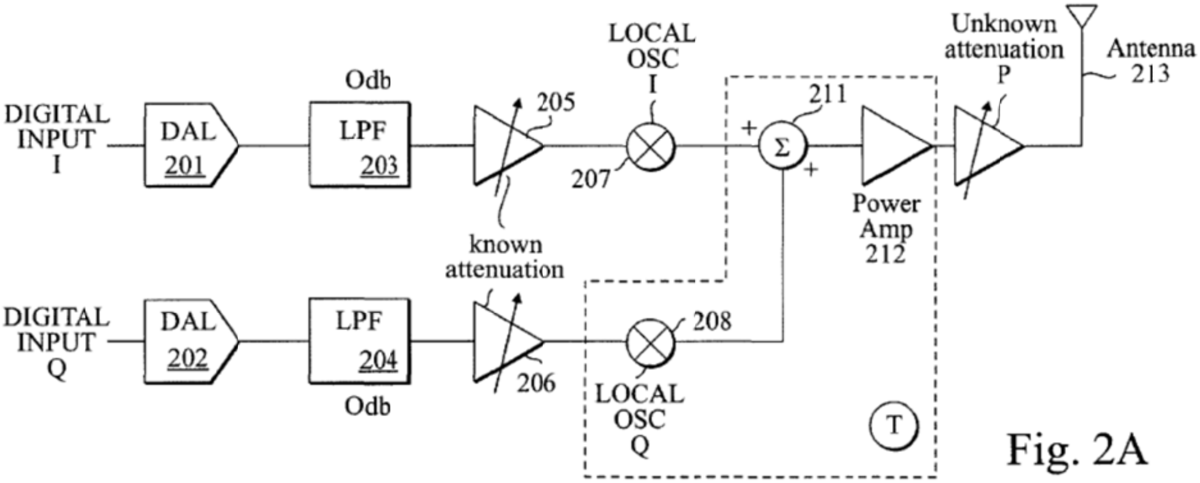

Fig. 2A

(Ex. 1006, FIG. 2A.)

Su's disclosure is no different than the admitted prior art in the '313 patent. (Ex. 1002, ¶106.)

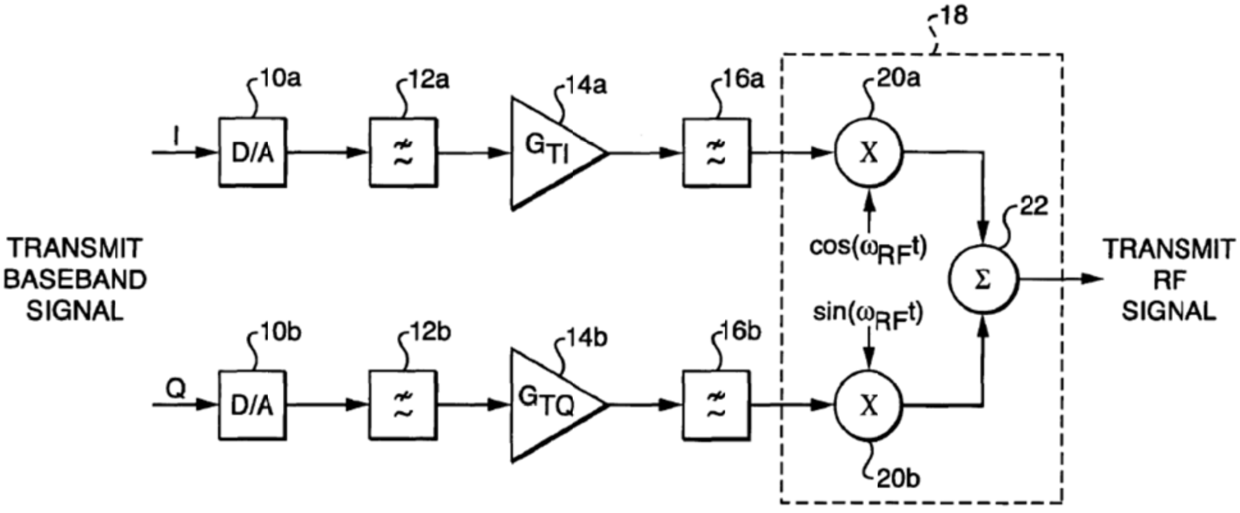

FIG. 1A
(PRIOR ART)

(Ex. 1001, FIG. 1A.)

As discussed above in Section IX.A.1(a), a POSITA would have found it obvious to combine the teachings of *Yellin* and *Su* to implement *Yellin*'s apparatus 300 as a "transceiver." The POSITA would have also found it obvious to include attenuators 205 and 206 in *Yellin*'s apparatus 300, where the attenuators amplify the I-Q vectors before the up-conversion from baseband to high frequency by non-linear element 320. (Ex. 1002, ¶108.) For instance, including such baseband amplification circuitry was well-known at the time of the alleged invention and used in a "typical transceiver" as evidenced by both *Su* and the '313 patent. (*Id.*) A POSITA would have been motivated to include such amplification circuitry in the transmit chain in *Yellin* to amplify the baseband I-Q vectors V_m in order to bring the input signals provided to the modulator to a particular level that avoids distortion that can interfere with data transmission. (*Id.*)

Indeed, the inclusion of such baseband I-Q amplification circuitry in *Yellin*'s transmit chain would have been nothing more than a combination of known elements (*Yellin*'s apparatus 300 and circuitry that amplifies baseband I-Q signals like attenuators 205, 206) according to known methods (placing amplification circuitry prior to up-conversion of the baseband I-Q vectors to high frequency by non-linear element 320) yielding the predictable result of a transceiver that includes a transmit chain having circuitry for amplifying baseband I-Q vectors. (*Id.*, ¶108.) *See KSR*, 550 U.S. at 416. Inclusion of such amplification circuitry would not have negatively impacted *Yellin*'s IQ calibration technique. (Ex. 1002, ¶109.)

iii. "a direct-conversion subsystem for converting the baseband transmit signal to an RF transmit signal"

The *Yellin-Su* combination discloses or suggests this feature. (Ex. 1002, ¶¶110-20.) As discussed above, *Yellin*'s non-linear element 320 in apparatus 300 receives IQ vectors at baseband and modulates them onto a high frequency carrier. (*See supra* Section IX.A.1(a).) *Yellin* discloses that the high frequency carrier is an "RF" carrier. (Ex. 1002, ¶110.) For instance, *Yellin* explains that "the non-linear elements comprise RF elements." (Ex. 1005, 4:14-15.) *Yellin* further explains that the V_f vectors in FIG. 2 "pass through additional or less RF elements," which further confirms that the signal received by non-linear element 340 is an "RF" signal, which indicates that the signal output by non-linear element 320 is an "RF" signal. (*Id.*, 10:5-9; Ex. 1002, ¶110.)

Yellin is, however, silent on the internal details of non-linear element 320, and does not explicitly state whether non-linear element 320 converts directly from baseband to RF, or whether it uses an intermediate frequency while converting from baseband to RF. (Ex. 1002, ¶111.) A POSITA would have understood that because an intermediate conversion stage is not shown in non-linear element 320 (i.e., there is no mention of an intermediate frequency), non-linear element 320 performs *direct* conversion from baseband to RF, and therefore, *Yellin* discloses "a direct-conversion subsystem for converting the baseband transmit signal to an RF transmit signal." (*Id.*, ¶111.)

To the extent Patent Owner contends that *Yellin* does not disclose "a direct-conversion subsystem," *Su* discloses such a feature, and as explained below, it would have been obvious to use a "direct-conversion subsystem" in the transmit chain of the *Yellin-Su* transceiver. (*Id.*, ¶112.)

Su discloses a direct-conversion transceiver that includes a transmit path (figure 2A) that converts directly from baseband to RF and a receive path (figure 2B) that converts directly from RF to baseband. (Ex. 1006, 2:38-39, FIGS. 2A-2B, 4:35-40 ("direct up conversion technique (zero IF)"); Ex. 1002, ¶113.)

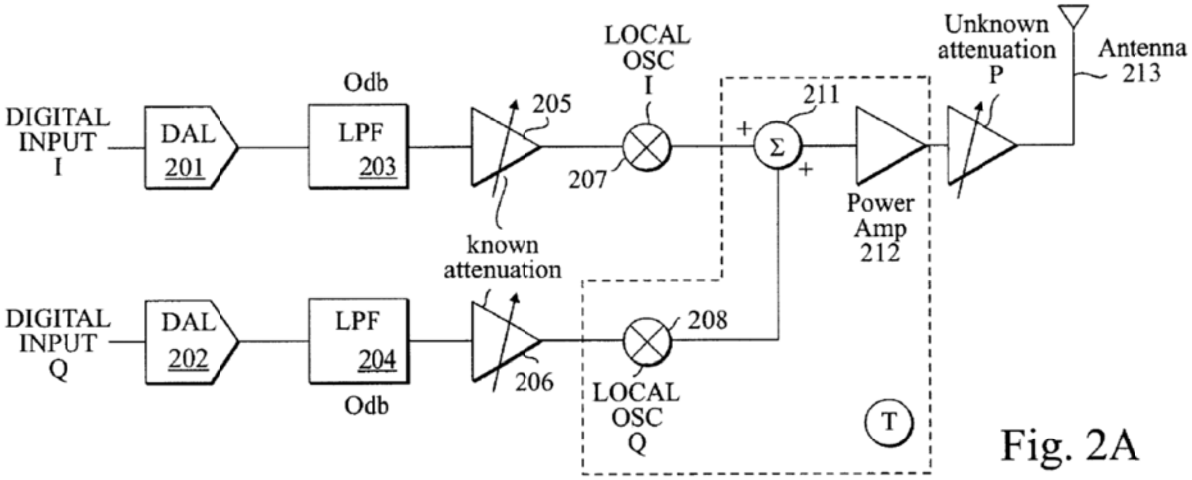

Fig. 2A

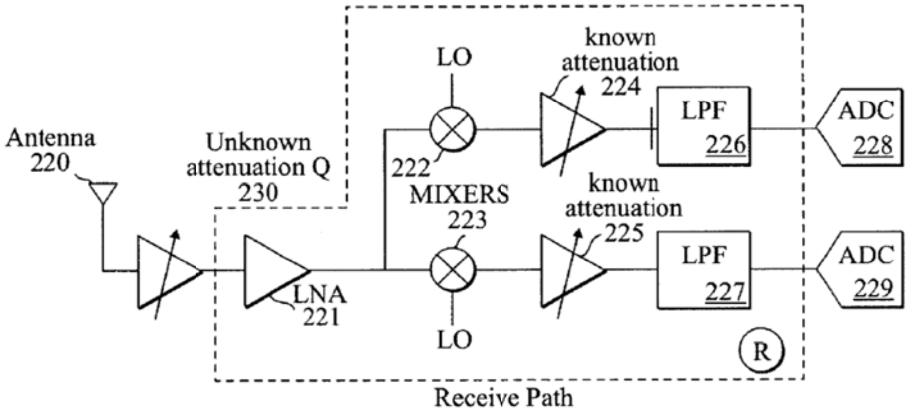

Fig. 2B

(Ex. 1006, FIGS. 2A, 2B.)

Specifically, figure 2A of *Su* discloses digital I-Q signals as the input to the transmit chain. (*Id.*, FIG. 2A.) A POSITA would have understood that these "digital" signals are baseband signals, which is further confirmed by figure 6 of *Su*. (*Id.,* FIG. 6; Ex. 1002, ¶114.) The baseband I-Q signals are up-converted to RF by mixers 207 and 208 that mix the I-Q signals with oscillating signals from local oscillators 209 and 210, respectively. (Ex. 1006, 4:55-60.) The outputs of mixers 207 and 208 are added by combiner 211 before being provided to a power amplifier 212. (*Id.*) A POSITA would have understood that mixers 207, 208, and combiner 211 constitute "a direct-conversion subsystem for converting the baseband transmit signal to an RF transmit signal" because they convert a baseband I-Q signal *directly* (i.e., without an intervening conversion to IF) to RF prior to transmission. (Ex. 1002, ¶¶114-15.) Indeed, the combination of these three elements is similar to the combination of components in modulator 18 in the prior art transmission chain of figure 1A (a "direct-conversion transceiver") in the '313 patent. (*Id.*; *see also* Ex. 1001, 6:22-35.)

In view of the above, a POSITA would have found it obvious to implement non-linear element 320 as "a direct-conversion subsystem" in the *Yellin-Su* combination. (Ex. 1002, ¶116.) The POSITA would have understood that baseband to RF conversion circuitry would have been included in *Yellin*'s non-linear element 320 to accomplish the disclosed conversion from baseband to RF, and further understood that it was well known to accomplish the conversion using a combination of mixers and an adder as disclosed in both *Su* and the '313 patent. (*Id.*) Therefore, to accomplish *Yellin*'s purpose of conversion from baseband to RF, a POSITA would have been motivated to implement non-linear element 320 as a "direct-conversion subsystem" similar to that in *Su*. (*Id.*)

Indeed, a modification of *Yellin* based on *Su* such that *Yellin*'s non-linear element is implemented as a "direct-conversion subsystem" would have simply constituted the application of a known technique (*Su*'s direct-conversion subsystem) to a known device (non-linear element 320 in *Yellin*) according to known methods (including direct conversion circuitry like in figure 7 of *Su* in non-linear element 320 in *Yellin*) to yield predictable results (I-Q gain imbalance reduction in a direct-conversion transceiver) and hence would have been obvious to a POSITA. (Ex. 1002, ¶117.). *See KSR,* 550 U.S. at 416-17.

Moreover, such a modification would not have negatively impacted *Yellin*'s IQ calibration technique. (Ex. 1002, ¶118.) A POSITA would have understood that *Yellin*'s disclosure lends naturally combination with *Su* because *Yellin* discloses the figure 2 apparatus can be used with "any other apparatus which suffers from IQ mismatch" (Ex. 1005, 3:8-11), and as the '313 patent confirms, direct-conversion transceivers (like in *Su*) were known to suffer from IQ mismatch. (Ex. 1002, ¶119; Ex. 1001, 1:37-45.)

Moreover, a POSITA would have been motivated to implement non-linear element 320 as a direct-conversion subsystem because it would have resulted in a direct-conversion transceiver, and at the time of the alleged invention, it was known that direct-conversion transceivers could be integrated on chip and were popular for integrated circuits used in low-cost equipment. (Ex. 1002, ¶120; *see also* Ex. 1001, 1:15-24.)

iv. “an RF transmit signal port”

A POSITA would have understood that the *Yellin-Su* combination discloses or suggests this feature. (Ex. 1002, ¶121.) For instance, the output port of non-linear element 320 is an “an RF transmit signal port” because as discussed above, non-linear element 320 outputs an RF signal. (*Supra* Section IX.A.1(b)(iii).)

c) [7.b] “B. a receive chain including: an RF receive port for receiving an RF receive signal; a direct-conversion subsystem for converting the RF receive signal to a baseband receive signal; a baseband I-Q amplification subsystem for providing amplification of the baseband receive signal;”

Yellin in combination with *Su* discloses or suggests these features. (Ex. 1002, ¶¶122-39.) As discussed above, *Yellin* and *Su* disclose or suggest implementing apparatus 300 of figure 2 in *Yellin* as a transceiver. (*See supra* Section IX.A.1(a).) Such a transceiver includes a receive chain, and a POSITA would have understood that the receive chain would have included at least an RF receive port, a direct-conversion subsystem, a baseband I-Q amplification subsystem, and a processor for processing of the baseband receive signal as recited in claim 7. (Ex. 1002, ¶¶122.) Indeed, as admitted by the ’313 patent, the claimed receive chain and the elements therein are conventional and were well known in the art at the alleged time of the invention.[7] (Ex. 1001, 6:45-48; *see also id.*, 4:48-50, 6:24, 6:36, FIGS. 1A-1B.)

i. "an RF receive port for receiving an RF receive signal"

A POSITA would have understood that the *Yellin-Su* combination discloses or suggests this feature. (Ex. 1002, ¶123.) For instance, *Yellin* explains that "the non-linear elements comprise RF elements." (Ex. 1005, 4:14-15.) *Yellin* further explains that the V_f vectors in FIG. 2 "pass through additional or less RF elements," which further confirms that the signal injected into non-linear element 340 is an "RF" signal. (*Id.,* 10:5-9; Ex. 1002, ¶123.) Hence, a POSITA would have understood that the input port of non-linear element 340 is an "an RF receive port for receiving an RF receive signal." (Ex. 1002, ¶123.)

ii. "a direct-conversion subsystem for converting the RF receive signal to a baseband receive signal"

The *Yellin-Su* combination discloses or suggests this feature. (Ex. 1002, ¶¶124-32.) As discussed above, an RF signal is injected into non-linear element

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[7] Other than the claims and summary of the invention parroting the claim language, there is no mention of "an RF receiving port," "at least one stage of frequency conversion," a "conversion subsystem," or a "baseband I-Q amplification subsystem" in the '313 specification.

340. (*Supra* Section IX.A.1(c)(i).) Non-linear element 340 is an "IQ demodulator" and outputs I-Q vectors. (Ex. 1002, ¶124; Ex. 1005, 3:21-22.) The I-Q vectors output by non-linear element 340 are multiplied by matrix B_2 in the IQ correction unit 342, which outputs I-Q vectors V_f. (Ex. 1005, FIG. 2, 3:23-35.) The I-Q vectors V_f take the same form as IQ vectors V_m, i.e., they have a real part I_f and an imaginary part Q_f. (*Id.*, 3:11-13, 3:48-51, 3:65.) Therefore, I-Q vectors V_f are baseband I-Q vectors, and accordingly, a POSITA would have understood the I-Q vectors output by non-linear element 340 are also at baseband. (Ex. 1002, ¶ 124.) Hence, the I-Q vectors output by non-linear element 340 constitute a "baseband receive signal" and non-linear element 340 discloses "converting the RF receive signal to a baseband receive signal." (*Id.*)

Yellin, however, is silent with respect to the internal details of non-linear element 340, and does not explicitly state whether non-linear element 340 converts directly from RF to baseband, or whether it uses an intermediate frequency while converting from RF to baseband. (*Id.*, ¶125.) A POSITA would have understood that because an intermediate conversion stage is not shown in non-linear element 340 (i.e., there is no mention of an intermediate frequency), non-linear element 340 performs a *direct* conversion from RF to baseband, and therefore *Yellin* discloses "a direct-conversion subsystem for converting the RF receive signal to a baseband receive signal." (*Id.*, ¶125.)

To the extent Patent Owner contends that *Yellin* does not disclose "a direct-conversion subsystem," *Su* discloses such a feature and it would have been obvious to use a "direct-conversion subsystem" in the receive chain of the *Yellin-Su* transceiver. (*Id.*, ¶126.)

Figures 2A and 2B of *Su* show a direct-conversion transceiver in which signals are converted directly between RF and baseband. (Ex. 1006, 4:35-39; Ex. 1002, ¶127.) With respect to the receive chain (figure 2B), *Su* discloses a direct conversion from RF to digital I-Q baseband values. (Ex. 1002, ¶127.) For instance, *Su* discloses that the received signal is mixed with mixers 222 and 223, and then provided to analog-to-digital converters 228 and 229 after filtering and amplification. (Ex. 1006, 5:1-9, FIG. 2B.)

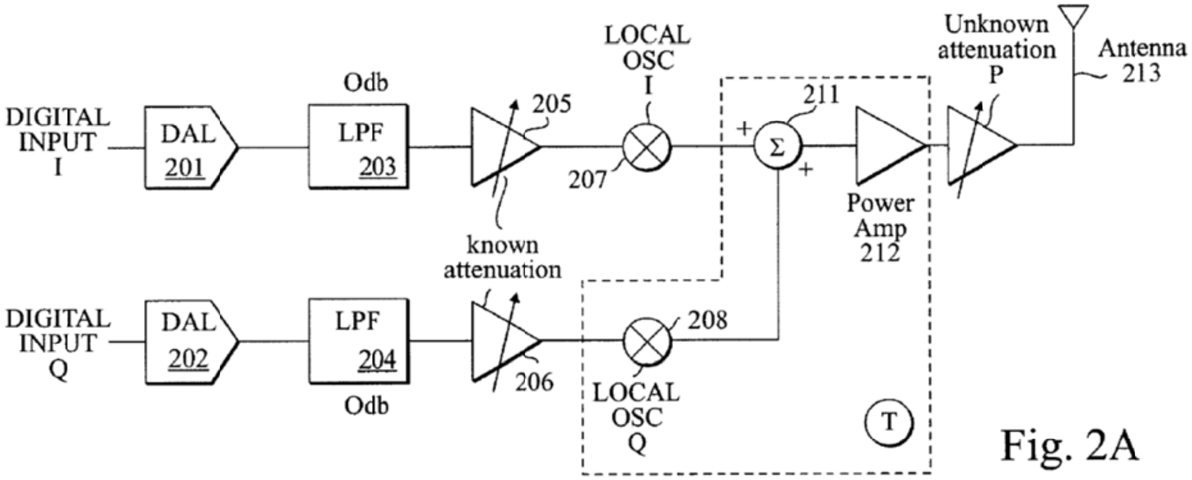

Fig. 2A

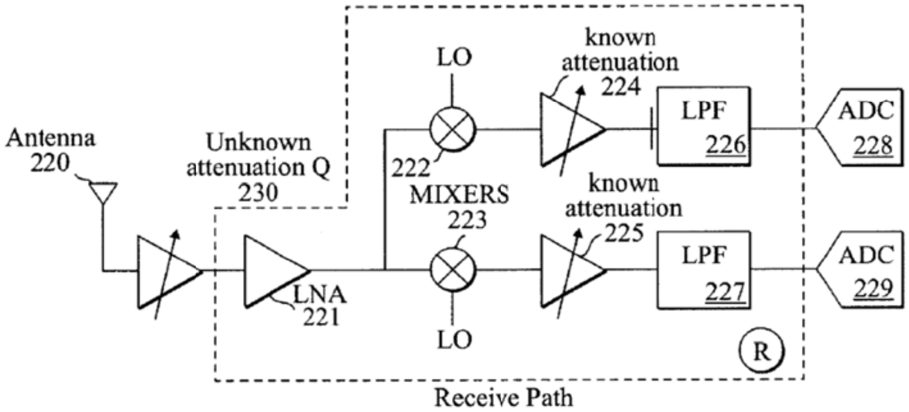

Fig. 2B

(*Id.*, FIGS. 2A, 2B.)

A POSITA would have understood that mixers 222 and 223 constitute "a direct-conversion subsystem for converting the RF receive signal to a baseband receive signal" because they convert a received RF signal *directly* (i.e., without an intervening conversion to IF) to baseband. (Ex. 1002, ¶128.) Indeed, the pair of mixers 222 and 223 is similar to those included in the demodulator 30 of the prior art configuration in figure 1B in the '313 patent. (*Id.*; *see also* Ex. 1001, 6:22-35.)

In view of the above, a POSITA would have found it obvious to implement non-linear element 340 as "a direct-conversion subsystem" in the *Yellin-Su* combination. (Ex. 1002, ¶129.) For instance, a POSITA would have understood that RF to baseband conversion circuitry would have been included in *Yellin*'s non-linear element 340 to accomplish the disclosed conversion from RF to baseband, and that it was well known to accomplish that conversion using a pair of mixers as disclosed in both *Su* and the '313 patent. (*Id.*) Therefore, to accomplish *Yellin*'s purpose of conversion from RF to baseband, a POSITA would have been motivated to implement non-linear element 340 as a "direct-conversion subsystem" similar to that in *Su*. (*Id.*)

Indeed, a modification of *Yellin* based on *Su* such that *Yellin*'s non-linear element 340 is implemented as a "direct-conversion subsystem" would have simply constituted the application of a known technique (*Su*'s direct-conversion subsystem) to a known device (non-linear element 340 in *Yellin*) according to known methods (including direct conversion circuitry like in *Su* figure 2B in non-linear element 340 in *Yellin*) to yield predictable results (I-Q gain imbalance reduction in a direct-conversion transceiver) and hence, would have been obvious to POSITA. (Ex. 1002, ¶ 129) *See KSR*, 550 U.S. at 416-17. Moreover, such a modification would not have negatively impacted *Yellin*'s IQ calibration technique. (Ex. 1002, ¶130.) A POSITA would have understood that *Yellin*'s disclosure lends naturally to combination with *Su* because *Yellin* discloses the apparatus of figure 2 can be used with "any other apparatus which suffers from IQ mismatch" (Ex. 1005, 3:8-11), and as confirmed by the '313 patent, direct-conversion transceivers (like in *Su*) were known to suffer from IQ mismatch. (Ex. 1002, ¶131; Ex. 1001, 1:37-45.)

Moreover, a POSITA would have been motivated to implement non-linear element 340 as a direct-conversion subsystem because doing so would have resulted in a direct-conversion transceiver, and at the time of the alleged invention, it was known that direct-conversion transceivers could be integrated on chip and were popular for integrated circuits used in low-cost equipment. (Ex. 1002, ¶131; *see also* Ex. 1001, 1:15-24.)

iii. "baseband I-Q amplification subsystem for providing amplification of the baseband receive signal"

Yellin in combination with *Su* discloses or suggests this feature. (Ex. 1002, ¶¶133-39.) *Yellin* does not explicitly disclose a baseband amplifier that amplifies the baseband receive signal in the context of the apparatus 300 of figure 2. But *Su* discloses using attenuators 224 and 225 ("baseband I-Q amplification subsystem") to provide amplification to the output of the mixers 222 and 223. (Ex. 1006, 5:1-9, FIG. 2B; *see also* Ex. 1002, ¶139.)

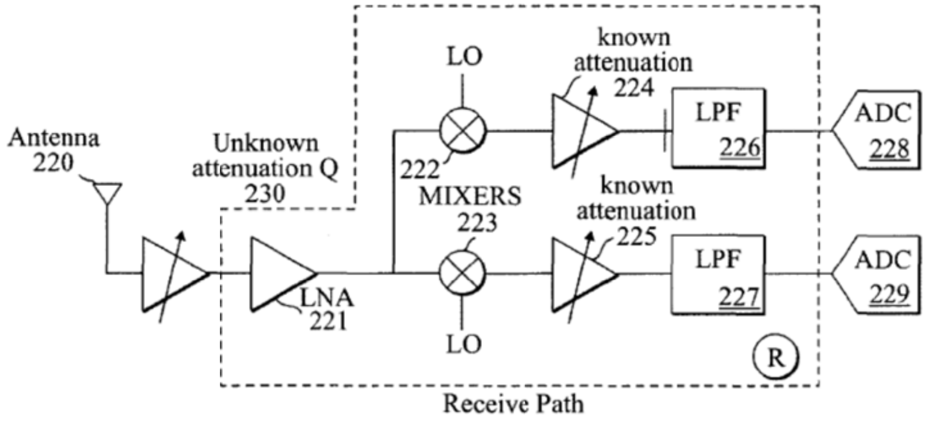

Fig. 2B

(*Id.*, FIG. 2B.)

Su's disclosure is no different than the admitted prior art shown below in figure 1B of the '313 patent. (Ex. 1002, ¶134.)

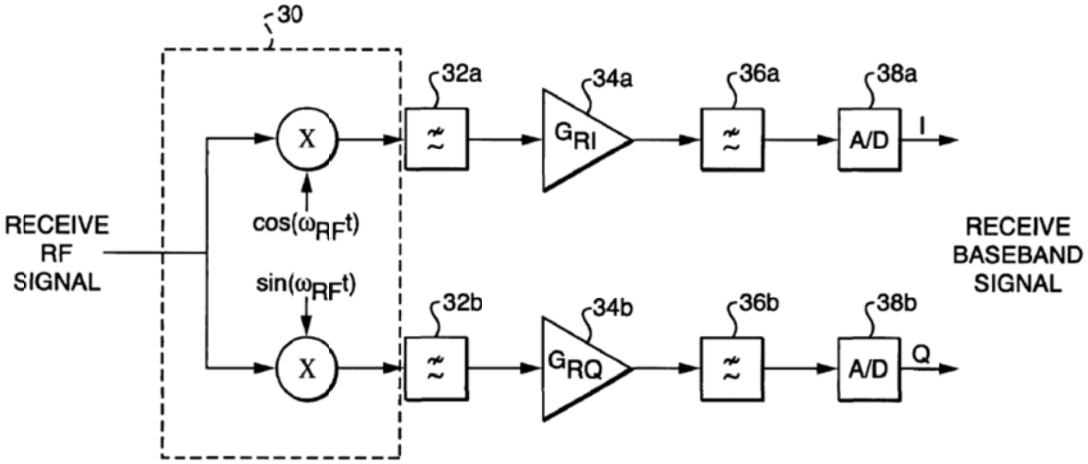

FIG. 1B
(PRIOR ART)

(Ex. 1001, FIG. 1B.)

As discussed above in Section IX.A.1(a), a POSITA would have found it obvious to combine the teachings of *Yellin* and *Su* in order to implement *Yellin*'s apparatus 300 as a "transceiver." A POSITA would have also found it obvious to include circuitry (e.g., attenuators similar to 224 and 225 in *Su*) in *Yellin*'s apparatus 300. (Ex. 1002, ¶135.) For instance, including such baseband amplification circuitry was well-known and used in a "typical transceiver" as evidenced by both *Su* and the '313 patent. (*Id.*) A POSITA would have been motivated to include such amplification circuitry in the receive chain in *Yellin* to amplify the baseband I-Q vectors output by non-linear element 340 to ensure sufficient signal strength to provide accuracy in the subsequent analog to digital conversion. (*Id.*, ¶¶135-37.)

Indeed, the inclusion of such baseband I-Q amplification circuitry in *Yellin*'s receive chain would have nothing more than a combination of known elements (*Yellin*'s apparatus 300 and circuitry that amplifies baseband I-Q signals like attenuators 224 and 225 in *Su*) according to known methods (placing the amplification circuitry after down-conversion of the RF signal to baseband I-Q vectors by non-linear element 340) yielding the predictable result of a transceiver that includes a receive chain having circuitry for amplifying baseband I-Q vectors. (*Id.*, ¶ 139.) *KSR*, 550 U.S. 398, 416. Inclusion of such amplification circuitry would not have negatively impacted *Yellin*'s IQ calibration technique. (Ex. 1002, ¶139.)

d) [7.c] "a processor for processing of the baseband receive

> signal as required for the normal function of the transceiver, and"

The *Yellin-Su* combination discloses or suggests this feature. (Ex. 1002, ¶¶140-41.) As discussed above in Section IX.A.1(c), I-Q vectors output by non-linear element 340 constitute a "baseband receive signal." The I-Q vectors are input to IQ correction unit 342, which outputs I-Q vectors V_f. (Ex. 1002, ¶140; *supra* Section IX.A.1(a), Ex. 1005, FIG. 2.) *Yellin* discloses that I-Q vectors V_f are processed by mismatch trainer 377. (*See, e.g.,* Ex. 1005, 4:1-15; *infra* Section IX.A.1(e).) *Yellin* further discloses that components such as the mismatch trainer are implemented on a processor such as a digital signal processor (DSP). (Ex. 1002, ¶140; Ex. 1005, 9:40-47 (explaining that trainer 77 in figure 1A is implemented on a DSP).) Therefore, *Yellin* discloses a "processor for processing of the baseband receive signal."[8] (Ex. 1002, ¶140.)

Moreover, a POSITA would have understood that because the combined *Yellin-Su* system is a "transceiver," the DSP would also process received V_f values

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[8] Patent Owner's infringement contentions do not treat the "processor" as part of the receive chain. (*See* Ex. 1024, 24-26.) But even if one were to assume that the processor was included in the receive chain, that would not impact the analysis presented as the inclusion of the processor in the receive chain is simply an arbitrary grouping of components.

during normal operation of the transceiver (i.e., when the transceiver is not in a calibration mode). (*Id.*, ¶141.) Indeed, *Yellin* explains that the calibration process is executed "periodically" or when conditions have deteriorated such that calibration is necessary. (Ex. 1005, 9:25-30.) Therefore, a POSITA would have understood that when the "transceiver" is operating in normal mode (i.e., non-calibration mode), the DSP would process the received data (which is received in the form of RF but converted to I-Q vectors V_f by non-linear element 340 and IQ correction unit 342) in order to determine the contents of the received data. (Ex. 1002, ¶141.)

e) [7.d] "C. a calibration subsystem including: a calibration RF signal generator for generating a calibration RF signal as a baseband transmit signal; a signal path for injecting the calibration RF signal from the RF transmit signal port to the RF receive signal port; a processor for processing the baseband receive calibration RF signal to form an observable indicator of I-Q imbalance; and a channel gain adjuster for varying the differential I-Q gain in the transmit and receive chains independently"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶¶142-55.) As explained below, the *Yellin-Su* system discloses the claimed "calibration subsystem" because the combined system includes the claimed "calibration RF signal generator," "signal path," "processor," and "channel gain adjuster."

i. "a calibration RF signal generator for generating a calibration RF signal as a baseband transmit signal"

As discussed above in Section IX.A.1(b)(iii), *Yellin* discloses that the output of non-linear element 320 is an "RF" signal. *Yellin* further discloses that "RF" signal is a "calibration" RF signal because the "RF" signal output by non-linear element 320 is utilized to calibrate the IQ mismatch in the transmit and receive chains. (Ex. 1002, ¶¶143-45; *see also infra* Sections IX.A.1(e)(iii)-(iv).) Specifically, *Yellin* discloses that non-linear element 340 outputs IQ vectors V_f based on the injected RF signal, and the output IQ vectors V_f are used by mismatch trainer 377 to calibrate (i.e., observe and correct) the IQ mismatch in the transmit and receive chains. (*See infra* Sections IX.A.1(e)(iii)-(iv).)

Yellin further discloses that the "calibration RF signal" output by non-linear element 320 is generated "as a baseband transmit signal" because the I-Q vectors V_m received by non-linear element 320 are at baseband. (Ex. 1002, ¶144; *supra* Section IX.A.1(b)(i).) As discussed above, the combination of modulator 32, interpolator 36, and interpolator 38 in figure 1A of *Yellin* generates baseband I-Q vectors V_m, and is a "signal generator." (*Supra* Section IX.A.1(b)(i).) Therefore, the same combination of modulator 32, interpolator 36, and interpolator 36 is also a "calibration RF signal generator" because it outputs baseband I-Q vectors that are converted to the "calibration RF signal."[9] (Ex. 1002, ¶144.)

To the extent that Patent Owner contends that the "calibration RF signal generator" must be different from the "signal generator" (recited in claim element [7.a]), *Yellin* would still disclose claim element [7.d]. Specifically, the combination of modulator 32, interpolator 36, and interpolator 38 would constitute a "calibration RF signal generator" when *Yellin* performs calibration of the I-Q mismatch, whereas the same combination would constitute a "signal generator" under normal operation of *Yellin*'s device, i.e., when the apparatus is not in calibration mode. (Ex. 1002, ¶145.) This is contemplated by *Yellin* because it discloses performing the "mismatch cancellation . . . periodically and/or when the transmission conditions of transmitter 30 change substantially." (Ex. 1005, 9:25-29.)

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[9] The '313 patent provides no explanation or example of a "calibration RF signal generator" or a "signal generator." (Ex. 1002, ¶144, n.5.) While claim 7 uses these terms, the '313 patent provides no reason to distinguish between the two terms. Indeed, a POSITA would have understood that the two terms can refer to the same device. (*Id.*)

ii. "a signal path for injecting the calibration RF signal from the RF transmit signal port to the RF receive signal port"

As discussed above, *Yellin* discloses that non-linear element 320 outputs a "calibration RF signal," which is input to non-linear element 340. (*See supra* Section IX.A.1(e)(i).) Therefore, the signal path from the output ("RF transmit signal port") of non-linear element 320 to the input ("RF receive signal port") of non-linear element 340 is "a signal path for injecting the calibration RF signal from the RF transmit signal port to the RF receive signal port." (Ex. 1005, FIG. 2; Ex. 1002, ¶146.) In the combined *Yellin-Su* system, this path would include, among other things, non-linear element 330 and a switch similar to switch 102 in *Su*. (Ex. 1002, ¶146; *supra* Section IX.A.1(a) (discussing combination of *Yellin* and *Su*).)

iii. "a processor for processing the baseband receive calibration RF signal to form an observable indicator of I-Q imbalance; and"

As discussed above in Section IX.A.1(c)(ii), I-Q vectors V_f constitute a "baseband receive signal." *Yellin* further discloses that non-linear element 340 outputs I-Q vectors V_f based on the signal injected into non-linear element 340 at its RF receive signal port, and as discussed above, this received signal is a "calibration RF signal." (*See* Ex. 1005, 3:64-65, 10:5-9.) Therefore, I-Q vectors V_f constitute a "baseband receive calibration RF signal" because they are baseband vectors generated from the calibration RF signal. (Ex. 1002, ¶147.)

Yellin discloses that the output I-Q vectors V_f are used by mismatch trainer 377 to calibrate (i.e., observe and correct) the matrices B_1 and B_2 in the transmit and receive chains, respectively, by setting the values of θ_1, β_1, θ_2, β_2. (Ex. 1005, 3:64-65, 4:1-5, 4:32-51.) *Yellin* discloses that mismatch trainer 377 determines values for θ_1, β_1, θ_2, and β_2 that minimize a cost function. (Ex. 1005, 4:41-48; *see also infra* Section IX.A.1(f).) As discussed below, the "cost function" constitutes an "observable indicator of I-Q imbalance." Therefore, mismatch trainer 377 performs the function of "processing the baseband receive calibration RF signal to form an observable indicator of I-Q imbalance," as recited in claim element [7.d.]. (Ex. 1002, ¶148.)

Yellin explains that non-linear elements 320 and 340 suffer from "IQ mismatch distortions" that can be modeled by equation 1 (reproduced below). (Ex. 1005, 3:15-20, 1:17-29.)

$$\bar{V}_q = \begin{pmatrix} I_q \\ Q_q \end{pmatrix} = \begin{bmatrix} \cos(\varphi) & \sin(-\varphi) \\ b\sin(-\varphi) & b\cos(\varphi) \end{bmatrix} \begin{pmatrix} I_d \\ Q_d \end{pmatrix}$$

In this equation, the gain mismatch between the I and Q channels is "1-b." (Ex. 1002, ¶ 149-50; *see also id.*, ¶¶63-66.) *Yellin* describes correcting this I-Q gain mismatch. (Ex. 1002, ¶¶ 67-75.) Ex. 1005, 3:15-17, 3:23-26.)

Specifically, *Yellin* explains that "IQ correction units 322 and 342 comprise respective multipliers 324 and 344 which correct the distortions of the respective modulator/demodulator," i.e., non-linear element 320 (modulator) and non-linear element 340 (demodulator). (Ex. 1005, 3:23-26.) Multiplier 324 multiplies the input I-Q vectors V_d by a matrix B_1 having variables θ_1 and β_1 while multiplier 344 multiplies I-Q vectors output by non-linear element 340 by a matrix B_2 having variables θ_2 and β_2. (*Id.,* 3:26-35, FIG. 2.) *Yellin* explains that mismatch trainer 377 adjusts the value of matrices B_1 and B_2 by changing the values of θ_1, β_1, θ_2, β_2 such that the IQ *gain* and phase imbalance of both non-linear elements 320 and 340 is corrected. (Ex. 1005, 3:35-47, 4:16—5:29, FIG. 3; Ex. 1002, ¶151.) For instance, mismatch trainer 377 selects values for θ_1 and β_1 such that IQ correction unit 322 (more specifically, multiplier 324) cancels out the phase and *gain imbalance* of non-linear element 320. (Ex. 1005, 3:35-47 ("the distortion of non-linear element[] 320 . . . [is] substantially compensated for, as $A_iB_i \approx I$ (I being the 2x2 identity matrix) for i = 1").) Similarly, mismatch trainer 377 selects values for θ_2 and β_2 such that IQ correction unit 342 (more specifically, multiplier 344 therein) cancels out the phase and *gain imbalance* of non-linear element 340. (Ex. 1005, 3:35-47 ("the distortion of non-linear element[] . . . 340 . . . [is] substantially compensated for, as $A_iB_i \approx I$ (I being the 2x2 identity matrix) for i = []2").)

Yellin discloses that mismatch trainer 377 determines the above values for θ_1, β_1, θ_2, and β_2 that cancel the *gain* and phase imbalances of non-linear elements 320 and 340 by determining values for θ_1, β_1, θ_2, and β_2 that minimize a cost function. (Ex. 1005, 4:41-48; *see also infra* Section IX.A.1(f).) Therefore, the "cost function" constitutes an "an observable indicator of I-Q imbalance" because minimizing the cost function provides values of θ_1, β_1, θ_2, and β_2 that cancel out the IQ mismatch of non-linear elements 320 and 340. (Ex. 1002, ¶152.) Accordingly, mismatch trainer 377 ("a processor") performs the function of "processing the baseband receive calibration RF signal to form an observable indicator of I-Q imbalance," as recited in claim element [7.d.] because it forms the cost function using V_f ("baseband receive calibration RF signal"). (*Id.*)

iv. "a channel gain adjuster for varying the differential I-Q gain in the transmit and receive chains independently"

Mismatch trainer 377 also acts as a "channel gain adjuster" because it varies "the differential I-Q gain in the transmit and receive chains independently."[10] (Ex. 1002, ¶153.) As discussed above, the mismatch trainer adjusts the values of θ_1, β_1, θ_2, β_2 (and therefore, matrices B_1 and B_2) such that the I-Q *gain* and phase imbalance of both non-linear elements 320 and 340 is effectively set to zero. (*Id.*; *see also* Ex. 1005, 3:40-47.) As also discussed above, non-linear element 320 is part of the "transmit chain" and non-linear element 340 is part of the "receive chain." (*See supra* Sections IX.A.1(b), (c).) Therefore, mismatch trainer 377 varies "the differential I-Q gain in the transmit and receive chains" because it

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[10] As explained above, *Yellin*'s mismatch trainer 377 corresponds to both the "processor" (Section IX.A.1(e)(iii)) and the "channel gain adjuster." The '313 patent provides no explanation or example of the claimed "processor" or "channel gain adjuster." While claim 7 uses both of these terms, the '313 patent provides no suggestion that the same element could not perform the recited functions for both these claim features. Indeed, a POSITA would have understood that the two terms can refer to the same element, and in any case *Yellin* would have suggested to a POSITA that two different aspects of the same element (e.g., a DSP executing the functions of mismatch trainer 377) can perform the respective functions. (Ex. 1002, ¶153.)

varies and reduces the difference between the I and Q gains such that the difference is effectively set to zero. (Ex. 1002, ¶153.)

Yellin further discloses that the mismatch trainer 377 "independently" varies the differential I-Q gain in the transmit and receive chains, as recited in claim element [7.d]. (Ex. 1002, ¶154.) *Yellin* discloses that mismatch trainer 377 collects a predetermined number of vector pairs (V_m, V_f), estimates values of θ_1, β_1, θ_2, β_2 that minimize a cost function for the collected vector pairs, and assigns the estimated values of θ_1, β_1, θ_2, β_2 to the respective matrices B_1 (associated with the transmit chain) and B_2 (associated with the receive chain). (Ex. 1005, 4:32-51.) This process of accumulation, estimation, and assignment is "repeated for a predetermined number of repetitions." (*Id.,* 4:57-59, FIG. 3.) During each repetition (i.e., accumulation, estimation, and assignment) "mismatch trainer 377 . . . adjusts the values of θ_1, β_1, θ_2, β_2 . . . ." (*Id.,* 4:1-5.) *Yellin* discloses that as an alternative to adjusting all four parameters (θ_1, β_1, θ_2, β_2) concurrently in a single repetition, "only a sub group of parameters (θ_1, β_1, θ_2, β_2) are adjusted while others are kept constant during that repetition." (*Id.,* 5:3-8.) For instance, during a first repetition or a sequence of first repetitions, "parameters (θ_1, β_1) are adjusted" while (θ_2, β_2) are kept constant, and during a second repetition or a sequence of second repetitions, "parameters (θ_2, β_2) are adjusted" while (θ_1, β_1) are kept constant. (*Id.,* 5:8-15.) Therefore, *Yellin* discloses "independently" calibrating transmit chain parameters (θ_1, β_1) and receive chain parameters (θ_2, β_2) because *Yellin* discloses keeping the transmit chain parameters constant while varying the receive chain parameters, and vice-versa. (Ex. 1002, ¶154.)

As explained above, by calibrating θ_1 and β_1 the I-Q gain imbalance (i.e., "differential I-Q gain") in the transmit chain is varied, and similarly by calibrating θ_2 and β_2, the I-Q gain imbalance (i.e., "differential I-Q gain") in the receive chain is varied. Given that *Yellin* discloses calibrating (θ_1, β_1) and (θ_2, β_2) independently, *Yellin* discloses that the mismatch trainer 377 varies "the differential I-Q gain in the transmit and receive chains *independently*" (emphasis added). (Ex. 1002, ¶155.)

f) [7.e] "wherein the calibration RF signal includes a calibration cycle, and the calibration cycle determines transmitter I-Q gain settings which minimize an observable indicator while holding receive I-Q gain settings constant, and which in turn determines receiver I-Q gain settings which minimizes the observable indicator while holding the transmit I-Q gain settings constant."

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶¶156-65.) As discussed above in Section IX.A.1(e), *Yellin* discloses calibrating the transmit chain parameters θ_1, β_1, θ_2, β_2 using the calibration RF signal. As also discussed above in Section IX.A.1(e), calibrating or changing the transmit chain parameters (θ_1, β_1) calibrates the IQ gain imbalance in the transmit chain and similarly, calibrating or changing the receive chain parameters (θ_2, β_2)

calibrates the IQ gain imbalance in the receive chain. (Ex. 1002, ¶156.) *Yellin* discloses a specific example in which the transmit chain parameters (θ_1 and β_1) are calibrated while the receive chain parameters (θ_2 and β_2) are held constant, followed by calibration of the receive chain parameters (θ_2 and β2) while the transmit chain parameters (θ_1 and β_1) are held constant. (*See id.*; Ex. 1005, 5:3-15.) *Yellin* repeats the cycle of calibrating transmit chain parameters (θ_1, β_1), thereby calibrating the transmit chain gain imbalance, followed by calibrating receive chain parameters (θ_2, β_2), thereby calibrating the receive chain gain imbalance. (*Id.*, 5:16-18 ("additional repetitions are performed thereafter, in which parameters (θ_1, β_1) and/or (θ_2, β_2) are re-adjusted, for example, alternately").)

In view of the above, *Yellin* discloses a "calibration cycle," as recited in claim element [7.e] because it discloses a cycle in which the transmit chain I-Q gain imbalance is calibrated followed by calibration of the I-Q gain imbalance in the receive chain, where that cycle is repeated. (Ex. 1002, ¶¶157-58.) This conclusion is consistent with the '313 patent, which discloses that a single "calibration cycle" includes varying the transmit and receive chain gains. (Ex. 1001, 11:17-23 ("convergence of the [calibration] process might require several basic cycles of calibration, each comprising a transmit and a receive variation of gain . . . .").) The conclusion is also consistent with the language of claim 7, in which the "calibration cycle determines transmitter I-Q gain settings . . . while holding receive I-Q gain settings constant, and . . . determines receiver I-Q gain settings . . . while holding the transmit I-Q gain settings constant." *Yellin's* cyclical calibration where a cycle includes transmit chain calibration followed by receive chain calibration is consistent with the calibration cycle of transmit chain calibration followed by receive chain calibration recited in claim 7. Moreover, *Yellin* discloses that the "calibration RF signal includes a calibration cycle" because as discussed in Section IX.A.1(e), the transmit and receive chain gain imbalances are calibrated using the data received in the calibration RF signal. (Ex. 1002, ¶159.) *Yellin* also discloses that the calibration RF signal "includes" a calibration cycle for additional reasons. (*Id.*, ¶¶160-62.)

Yellin also discloses that the "the calibration cycle determines transmitter I-Q gain settings . . . , and . . . determines receiver I-Q gain settings . . . ." (Ex. 1002, ¶163.) As discussed above, changing (θ_1, β_1) calibrates the I-Q gain imbalance of the transmit chain, and changing (θ_2, β_2) calibrates the I-Q gain imbalance of the receive chain. Therefore, (θ_1, β_1) are "transmitter I-Q gain settings" while (θ_2, β_2) are "receiver I-Q gain settings," as recited in claim element [7.e].

Furthermore, *Yellin* discloses that mismatch trainer 377 determines values for θ_1, β_1, θ_2, and β_2 that minimize a cost function ("observable indicator"). (Ex. 1005, 4:41-48; *see also supra* Section IX.A.1(e)(iii).) *Yellin* performs this determination in the "estimation (104)" step, which is part of a single repetition.

(*Id.*; *see also id.,* FIG. 3; *supra* Section IX.A.1(e)(iii).) As an alternative to determining all four parameters (θ_1, β_1, θ_2, β_2) concurrently, *Yellin* discloses determining (θ_1, β_1) that minimizes the cost function while holding (θ_2, β_2) constant. (*Supra* Section IX.A.1(e)(iv); Ex. 1005, 5:4-15 (explaining that the "estimation (104)" step is implemented on a subset of θ_1, β_1, θ_2, and β_2).) Therefore, *Yellin* discloses that "the calibration cycle determines transmitter I-Q gain settings which minimize an observable indicator while holding receive I-Q gain settings constant." (Ex. 1002, ¶164.)

After determining (θ_1, β_1), the mismatch trainer 377 determines (θ_2, β_2) that minimizes the cost function while holding (θ_1, β_1) constant. (Ex. 1005, 5:11-15; *see* discussion above and in Section IX.A.1(e)(iv).) Therefore, *Yellin* discloses that "the calibration cycle . . . in turn determines receiver I-Q gain settings which minimizes the observable indicator while holding the transmit I-Q gain settings constant." (Ex. 1002, ¶165.)

2. Claim 15

a) [15.a] "A transceiver system according to claim 7, wherein the calibration RF signal includes successive calibration cycles, and successive calibration cycles are used to refine or maintain I-Q balance."

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶166.) As discussed above in Section IX.A.1(f), *Yellin* discloses that a single calibration cycle—which includes calibrating the transmit gain followed by calibrating of the receive gain—is repeated. For instance, *Yellin* discloses calibrating the transmit chain parameters (θ_1 and β_1) while the receive chain parameters (θ_2 and β_2) are held constant, followed by calibration of the receive chain parameters (θ_2 and β_2) while the transmit chain parameters (θ_1 and β_1) are held constant. (Ex. 1005, 5:3-15.) *Yellin* repeats the cycle of calibrating transmit chain parameters (θ_1, β_1), thereby calibrating the transmit chain gain imbalance, followed by calibrating receive chain parameters (θ_2, β_2), thereby calibrating the receive chain gain imbalance. (*Id.,* 5:16-18 ("additional repetitions are performed thereafter, in which parameters (θ_1, β_1) and/or (θ_2, β_2) are re-adjusted, for example, alternately").) Therefore, *Yellin* discloses "successive calibration cycles are used to refine or maintain I-Q balance." Given that these calibration cycles are performed using the data received in the calibration RF signal, *Yellin* discloses that the calibration RF signal includes successive calibration cycles. (*See supra* Section IX.A.1(f).)

3. Claim 16

a) [16.pre] "A transceiver system comprising:"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶167; *supra* Section IX.A.1(a).)

b) [16.a] "A. a transmit chain including: a signal generator for generating a baseband transmit signal; baseband I-Q amplification subsystem for providing baseband amplification of the baseband transmit signal; direct-

> conversion subsystem for converting the baseband transmit signal to an RF transmit signal, and including an RF transmit signal port;"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶168; *supra* Section IX.A.1(b).)

> c) [16.b] "B. a receive chain including: an RF receive port for receiving an RF receive signal; direct-conversion subsystem for converting the RF receive signal to a baseband receive signal; baseband I-Q amplification subsystem for providing amplification of the baseband receive signal;"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶169; *supra* Section IX.A.1(c).)

> d) [16.c] "a processor for processing of the baseband receive signal as required for the normal function of the transceiver;"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶170; *supra* Section IX.A.1(d).)

> e) [16.d] "C. a calibration subsystem including; a calibration RF signal generator for generating a calibration RF signal as a baseband transmit signal; a signal path for injecting the calibration RF signal from the RF transmit signal port to the RF receive signal port; a processor for processing the baseband receive calibration RF signal to form an observable indicator of I-Q imbalance; and,"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶171; *supra* Section IX.A.1(e).)

f) [16.e] "D. a channel gain adjuster for varying the differential I-Q gain in the imbalanced chain,"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶¶172-73; *supra* Section IX.A.1(e)(iv).) Although there is no antecedent basis for "the imbalanced chain," it is assumed to be referring to either the transmit chain or the receive chain, and as explained in Section IX.A.1(e)(iv), *Yellin* discloses varying the differential I-Q gain in each of the transmit and receive chains independently and therefore discloses this feature.

g) [16.f] "wherein the calibration RF signal includes a calibration cycle, and the calibration cycle determines transmitter I-Q gain settings which minimize an observable indicator while holding receive I-Q gain settings constant, and which in turn determines receiver I-Q gain settings which minimizes the observable indicator while holding the transmit I-Q gain settings constant."

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶174; *supra* Section IX.A.1(f).)

4. Claim 21

a) [21.a] "A transceiver system according to claim 16, wherein successive calibration cycles are used to refine or maintain I-Q balance."

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶175; *supra* Section IX.A.2.)

5. Claim 44

a) [44.pre] "A method of calibrating a transceiver system

> for transmitting and receiving data using both I and Q channels and comprising"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶176; *supra* Section IX.A.1(a).)

> b) [44.a] "(a) a transmit chain including a signal generator for generating a baseband transmit signal; baseband I-Q amplification subsystem for providing baseband amplification of the baseband transmit signal; direct-conversion subsystem for convening the baseband transmit signal to an RF transmit signal, and including an RF transmit signal port; and"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶177; *supra* Section IX.A.1(b).)

> c) [44.b] "(b) a receive chain including an RF receive port for receiving an RF receive signal; direct-conversion subsystem for converting the RF receive signal to a baseband receive signal; baseband I-Q amplification subsystem for providing amplification of the baseband receive signal; a processor for processing of the baseband receive signal as required for the normal function of the transceiver,"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶178; *supra* Sections IX.A.1(c), (d).) Petitioner understands that the recited processor is not a part of the receive chain based on the structure of similar claims, including, for example, claim 7. But even if one were to assume that the processor was included in the receive chain, that would not impact the analysis presented as the inclusion of the processor in the receive chain is simply an arbitrary grouping of components. Moreover, while the ’313 patent discloses a receive chain, there is no indication that a processor is included in the receive chain. (*See* Ex. 1001, FIG. 1B.)

d) [44.c] “the method comprising: generating a calibration RF signal as a baseband transmit signal; and injecting the calibration RF signal from the RF transmit signal port to the RF receive signal port; processing the baseband receive calibration RF signal to form an observable indicator of I-Q imbalance; and varying the differential I-Q gain in the transmit and receive chains independently”

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶179; *supra* Section IX.A.1(e).)

e) [44.d] “wherein the calibration RF signal includes a calibration cycle, and further including using the calibration cycle so as to determine the transmitter I-Q gain settings so as to minimize the observable indicator while holding the receive I-Q gain settings constant, and determining the receiver I-Q gain settings so as to minimize the observable indicator while holding the transmit I-Q gain settings constant.”

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶180; *supra* Section IX.A.1(f).)

6. Claim 52

a) [52.a] “A method according to claim 44, wherein the calibration RF signal includes successive calibration cycles, and further including using the successive calibration cycles to refine or maintain I-Q balance.”

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶181; *supra* Section IX.A.2.)

7. Claim 53

a) [53.pre] "A method of calibrating a transceiver system comprising"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶182; *supra* Section IX.A.1(a).)

b) [53.a] "(a) a transmit chain including a signal generator for generating a baseband transmit signal; baseband I-Q amplification subsystem for providing baseband amplification of the baseband transmit signal; a direct-conversion subsystem for converting the baseband transmit signal to an RF transmit signal, and an RF transmit signal port; and"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶183; *supra* Section IX.A.1(b).)

c) [53.b] "(b) a receive chain including an RF receive port for receiving an RF receive signal; a direct-conversion subsystem for converting the RF receive signal to a baseband receive signal; baseband I-Q amplification subsystem for providing amplification of the baseband receive signal; processing of the baseband receive signal as required for the normal function of the transceiver,"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶184; *supra* Sections IX.A.1(c), (d), IX.A.5(c).)

d) [53.c] "the method comprising generating a calibration RF signal as a baseband transmit signal; injecting the calibration RF signal from the RF transmit signal port to

> the RF receive signal port; processing the baseband receive calibration RF signal to form an observable indicator of I-Q imbalance; and"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶185; *supra* Section IX.A.1(e).)

> e) [53.d] "varying the differential I-Q gain in the imbalanced chain so as to adjust the gain;"

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶¶186-87; *supra* Section IX.A.1(e)(iv).) Although there is no antecedent basis for "the imbalanced chain," it is assumed to be referring to either the transmit chain or the receive chain, and as explained in Section IX.A.1(e)(iv), *Yellin* discloses varying the differential I-Q gain in each of the transmit and receive chains independently and therefore discloses this feature.

> f) [53.e] "wherein the calibration RF signal includes a calibration cycle, and further including using the calibration cycle so as to determine transmitter I-Q gain settings so as to minimize an observable indicator while holding receive I-Q gain settings constant, and determining receiver I-Q gain settings so as to minimize the observable indicator while holding transmit I-Q gain settings constant."

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶188; *supra* Section IX.A.1(f).)

8. Claim 58

> a) [58.a] "A method according to claim 53, further including using successive calibration cycles to refine or

maintain I-Q balance."

The combined *Yellin-Su* system discloses or suggests this feature. (Ex. 1002, ¶189; *supra* Section IX.A.2.)

B. Ground 2: *Yellin*, *Su*, and *Faulkner* Render Obvious Claims 11, 17, 48, and 54

1. Claim 11

a) [11.a] "A transceiver system according to claim 7, wherein the calibration RF signal includes a sequence of pulses taking on purely real or imaginary values at any instant."

Yellin in combination with *Su* and *Faulkner* discloses or suggests this feature. (Ex.1002, ¶¶193-202.) In the *Yellin-Su* combined system discussed above, the IQ values I_m and Q_m provided in the input vectors V_m correspond to real (I) and imaginary (Q) values. (Ex. 1005, 3:11-13.) While *Yellin* and *Su* do not expressly disclose that a sequence of pulses taking on purely real or imaginary values at any instant are provided on the I and Q channels corresponding to vectors V_m, *Faulkner* discloses this feature, and a POSITA would have found it obvious, in light of *Faulkner*, to utilize a sequence of pulses taking on purely real or imaginary values in a combined *Yellin-Su-Faulkner* system. (Ex.1002, ¶191.)

Faulkner, like *Yellin*, is concerned with correcting mismatch (e.g., gain mismatch and phase mismatch) between the I and Q channels in RF quadrature modulators. (Ex. 1012, 214; Ex. 1002, ¶192 (explaining I-Q gain and phase mismatch correction in *Yellin*).) In order to correct the gain mismatch, *Faulkner* discloses measuring the gain along real and imaginary axes, where such measurement uses test vectors that are purely real values or purely imaginary values. (Ex. 1012, 215; Ex.1002, ¶192.) Specifically, *Faulkner* discloses "[t]est vectors (*A*, 0) and (0, *A*) are separately applied and the amplitudes of the resulting outputs measured," where a POSITA would have understood that *A* represents a non-zero value. (Ex. 1012, 215.) *Faulkner* uses the measured amplitudes to modify the gain on one of the channels (i.e., the I or the Q channel) in order to eliminate the I-Q gain mismatch. (*Id.*; Ex.1002, ¶192.)

The test vectors (*A*, 0) and (0, *A*) are purely real or purely imaginary because each vector only includes a non-zero value in either the real (I) or imaginary (Q) portion of the vector. (Ex.1002, ¶193.) Thus, (*A*, 0) is purely real, and (0, *A*) is purely imaginary. (*Id.*) Such an understanding is consistent with Patent Owner's assertions in litigation in which it identifies the same (*A*, 0) and (0, *A*) vector sequence as allegedly corresponding to this claim feature. (Ex. 1024, 31.)

The use of such test vectors for I-Q mismatch calibration in which the pulses on the I and Q channels are purely real or purely imaginary was well-known as evidenced by other references. (Ex. 1002, ¶194 (citing Ex. 1015, 6:6-31).)

In view of *Faulkner*, it would have been obvious to a POSITA to include a sequence of pulses that includes purely real and purely imaginary values during the calibration process in the *Yellin-Su* system. (Ex.1002, ¶195.) *Yellin* discloses that calibration process in which IQ gain mismatch cancellation occurs for the circuit of figure 2 can include a "special transmission" of data values that "are chosen as best suited for mismatch cancellation." (Ex. 1005, 9:15-22.) *Yellin*, however, does not provide any details as to what such a "special transmission" would include or which data values are "best suited for mismatch cancellation." (Ex.1002, ¶195.) As discussed above, *Faulkner* teaches a well-known data sequence that is used for IQ gain mismatch calibration that includes values that are purely real (e.g., (A, 0)) and purely imaginary (e.g., (0, A)).

A POSITA would have looked to *Faulkner* to refine the teachings of *Yellin* because *Faulkner* discloses a method of reducing IQ gain imbalance. (Ex. 1002, ¶196.) Having looked to *Faulkner*, POSITA would have been motivated to include, during the IQ calibration process, a sequence of pulses on the input I and Q channels of non-linear element 320 in the *Yellin-Su* system such that the pulses take on purely real or purely imaginary values at any instance. (*Id.*) The POSITA would have been so motivated because (1) the use of such an input sequence of pulses was well-known (as evidenced by *Faulkner* and *Navid*), and (2) the use of such a sequence of input pulses would have provided the benefit of simplifying the computation of θ_1, β_1, θ_2, β_2 in I-Q correction units 322 and 342. (*Id.*, ¶¶197-200.)

Moreover, a POSITA could have done so without negatively affecting *Yellin*'s IQ mismatch correction technique. (*Id.,* ¶201.) Indeed, *Yellin* discloses that regular data signals generated in the normal use of the transmitter can be used for mismatch cancellation, thereby demonstrating that a specific sequence of data is not required for mismatch cancellation. (Ex. 1005, 9:15-18; Ex. 1002, ¶201.)

Indeed, the above modification of the *Yellin-Su* combination based on *Faulkner* would have simply constituted the application of a known technique (*Faulkner's* test vectors) to a known device (a transceiver like in *Yellin-Su* system) according to known methods (using the test vectors as a "special transmission" during the calibration process) to yield predictable results (I-Q gain imbalance reduction in a transceiver) and hence, would have been obvious to POSITA. (Ex. 1002, ¶202.) *See KSR,* 550 U.S. at 416-17.

2. Claims 17, 48, 54

The combined *Yellin-Su-Faulkner* system discloses or suggests the feature of these claims. (Ex. 1002, ¶¶203-05; *supra* Section IX.B.1.)

C. Ground 3: *Yellin*, *Su*, and *Sewerinson* Render Obvious Claims 12, 13, 18, 19, 49, 50, 55, and 56

1. Claim 12

a) [12.a] "A transceiver system according to claim 7, wherein the calibration RF signal includes a sampled phasor."

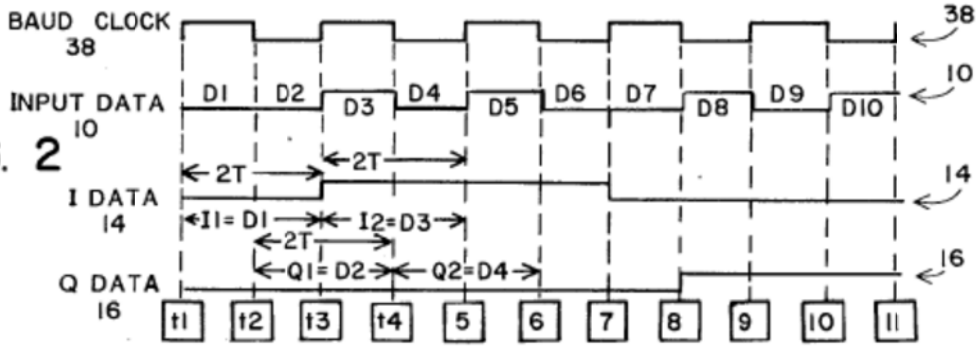
Yellin in combination with *Su* and *Sewerinson* discloses or suggests this feature. (Ex.1002, ¶¶206-15.) In the *Yellin*-*Su* combined system discussed above, the IQ values provided in the input vectors V_m correspond to real (I) and imaginary (Q) values. (Ex. 1005, 3:11-15.) *Yellin* further discloses that the IQ mismatch cancellation disclosed "is not limited to transmitters of any specific modulation method, but rather may be used with substantially any non-constant envelope modulation methods, including, but not limited to, MPSK, DPSK and QAM." (*Id.*, 9:61-65.) A POSITA would have understood that MPSK stands for phase shift keying (PSK) where the "M" represents a value indicating how many different data symbols are supported in the modulation, where M can be, for example, 2 for BPSK (binary = 2 symbols), 4 for *QPSK (quad = 4 symbols)*, or 8 for 8PSK (8 symbols). (Ex. 1002, ¶¶37-44, 207.) *Yellin* also specifically discloses an example modulation path that uses a "π/4 DQPSK (Differential Quadrature Phase Shift Keying) modulator." (Ex. 1005, 2:5-10.)

Sewerinson discloses QPSK modulation and in particular, discloses a QPSK modulator with reference to figure 1. (Ex. 1016, 3:41-46; Ex. 1002, ¶¶8-82, 208.)

Sewerinson states that in a “QPSK modulation system an input data signal may be broken into in-phase (I) and quadrature-phase (Q) pulse trains receiving odd and even numbered bits, respectively. These pulse trains are used to establish the amplitude and phase of the signal vector.” (Ex. 1016, 2:13-25.)

Figure 2 of *Sewerinson* discloses an input data stream divided among the I and Q channels.

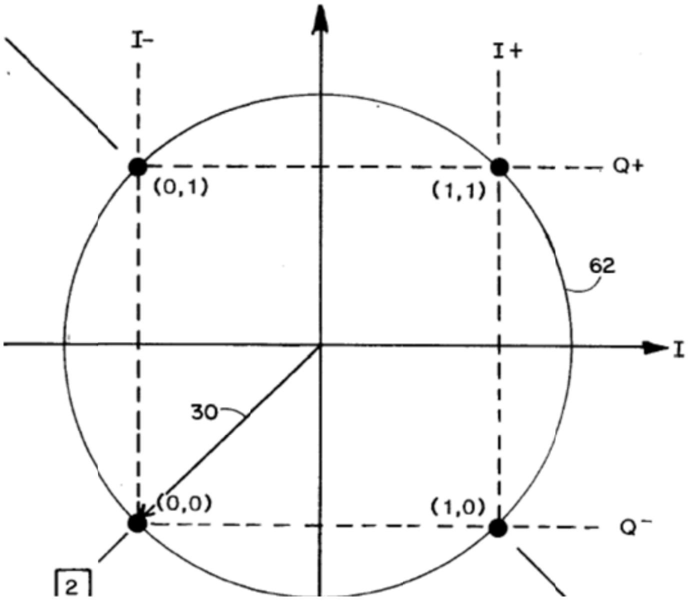
FIG. 2



(*Id.,* FIG. 2.)

The I-Q channel data can be represented in the complex plane where each combination of I and Q refers to a particular phase. (Ex. 1002, ¶209.) This is described in figure 5, which shows a constellation of I-Q values and the associated phase. As shown in figure 5, if the I-Q channel values are (1,1), then the output signal of the modulator will have a phase of 45° and similarly if the I-Q channel value is (0,0), the output signal of the modulator will have a phase of 225°. Therefore, a receiver is able to determine the transmitted data by looking at the phase of the incoming signal.

FIG. 5



(Ex. 1016, FIG. 5 (excerpted).)

As such, each I-Q vector is a "phasor." (*Id.*; *see also id.,* 4:28-29 ("signal vector or phasor 30").) The I-Q vector is a sampled phasor, as it can be one of four samples, that is, either a (1,1), (0,1), (0,0), or a (1,0) as seen above in figure 5. *Sewerinson* describes that the phase of the I-Q vector remains constant throughout a symbol interval (i.e., during the interval corresponding to two bits of input digital information). (*Id.,* 4:33-38.) Therefore, *Sewerinson* discloses a modulation method in which the input digital data is modulated to I-Q vectors, each of which is a "phasor" because each vector is associated with a particular phase. (Ex. 1002, ¶210.)

In the modulation method of *Sewerinson*, when an input data signal is transmitted, the signal transmitted includes a sampled phasor, where the sampled phasor indicates the data in the IQ data stream at a particular point in time. (Ex. 1002, ¶211.) For example, the phasor 30 having a phase of +225º in figure 5 of *Sewerinson* indicates an IQ data pair that includes a "0" in each of the I and Q pulse trains. (Ex. 1016, 8, 20-23 ("the phase will remain stationary at one of the rest points, e.g., (0,0) at +225º in figure 5"); Ex. 1002, ¶211.) For the example input data signal 10 shown in figure 2 of *Sewerinson*, the first two bits of data are "0" and therefore the phasor 30 shown in figure 5 (corresponding to +225º) is generated for those two bits. (Ex. 1016, 8, 11-24.)

A POSITA would have found it obvious to use the QPSK modulation method disclosed in *Sewerinson* in the *Yellin-Su* system. *Sewerinson*, like *Yellin* and *Su*, is concerned with IQ data transmission using modulation. (Ex. 1002, ¶212.) *Yellin* discloses that the IQ mismatch cancellation disclosed "is not limited to transmitters of any specific modulation method, but rather may be used with substantially any non-constant envelope modulation methods, including, but not limited to, MPSK, DPSK and QAM." (Ex. 1005, 9:61-65.) *Sewerinson* discloses a particular QPSK modulation method, and a POSITA would have understood that *Sewerinson's* modulation method could be used in the *Yellin-Su* combination. (Ex. 1002, ¶212.) Using *Sewerinson's* modulation method would have resulted in the calibration RF signal including sampled phasors as recited in claim 12 because the input data stream, including an input data stream corresponding to either regular data signals or a "special transmission" in which the signals are chosen because they are "best suited for mismatch cancellation" that is used during mismatch cancellation in *Yellin*, would be represented by sampled phasors. (Ex. 1005, 9:15-22; Ex. 1002, ¶212.) Indeed, a POSITA would have been motivated to use the QPSK modulation scheme in the *Yellin-Su* system because it was well known to provide "the best trade-off between power and bandwidth requirements among the various MPSK modulation protocols" and accordingly, was "widely used in practice." (Ex. 1002, ¶212; Ex. 1025, 554.)

A POSITA would have looked to *Sewerinson* to refine the teachings of the *Yellin-Su* combination because *Sewerinson* is concerned with IQ data transmission using modulation like the transmitters in both *Yellin* and *Su*. (Ex. 1002, ¶213.) Having looked to *Sewerinson*, POSITA would have recognized that the modulation method of *Sewerinson* could be used in the transceiver of the *Yellin-Su* combination without deviating from *Yellin*'s IQ mismatch correction technique. (*Id.*) Indeed, *Yellin* discloses that that the IQ mismatch cancellation disclosed "is not limited to transmitters of any specific modulation method" and gives examples of modulation methods similar to that disclosed in *Sewerinson*. (Ex. 1005, 9:61-65; Ex. 1002, ¶213.)

The POSITA would have recognized that *Sewerinson* discloses a known modulation method that could be applied to a transmitter, and that such a modulation method could be used to generate the input vectors V_m during calibration corresponding to IQ gain mismatch cancellation in the *Yellin-Su* system. (Ex. 1002, ¶214.)

Indeed, a modification of the *Yellin-Su* combination based on *Sewerinson* such that the calibration signal in the *Yellin-Su* combination includes a sampled phasor would have simply constituted the application of a known technique (*Sewerinson's* QPSK modulation method) to a known device (a transceiver like in *Yellin-Su*) according to known methods (generating the IQ vectors V_m using a QPSK modulation technique) to yield predictable results (I-Q gain imbalance reduction in a transceiver) and hence, would have been obvious to POSITA. (Ex. 1002, ¶215.) *See KSR,* 550 U.S. at 416-17.

2. Claim 13

a) [13.a] "A transceiver system according to claim 7, wherein the calibration RF signal includes a discrete phasor."

Yellin in combination with *Su* and *Sewerinson* discloses or suggests this feature. (Ex.1002, ¶216.) As discussed above with respect to claim 12, it would have been obvious to use the QPSK modulation method of *Sewerinson* in the transceiver of the *Yellin-Su* combination. (*Supra* Section IX.C.1.) As also discussed above with respect to claim 12, *Sewerinson's* modulation method represents IQ data pairs using phasors. (*Id.*) Specifically, the I-Q vector used to represent the IQ data in the modulation method of *Sewerinson* is a discrete phasor as it can take on the value of one of four individually separate and distinct phasors at a given time, that is, either a (1,1), (0,1), (0,0), or a (1,0) as seen above in figure 5. (Ex. 1002, ¶216.) As disclosed by *Sewerinson*, each of the phasors has a constant magnitude, and the phase of the phasor is used to represent the data in the input data stream. (Ex. 1016, 2:13-26.) As such, a discrete phasor having a particular phase and amplitude is used to represent the IQ data in the modulation method of *Sewerinson*. Therefore, the *Yellin-Su-Sewerinson* combination discussed above with respect to claim 12 discloses that "the calibration RF signal includes a discrete phasor" for reasons similar to those presented as to the calibration RF signal including a "sampled phasor." (Ex. 1002, ¶216.)

3. Claims 18, 49, 55

The combined *Yellin-Su-Sewerinson* system discloses or suggests the features of these claims. (Ex. 1002, ¶¶217, 219, 221; *supra* Section IX.C.1.)

4. Claims 19, 50, 56

The combined *Yellin-Su-Sewerinson* system discloses or suggests the features of these claims. (Ex. 1002, ¶¶218, 220, 222; *supra* Section IX.C.2.)

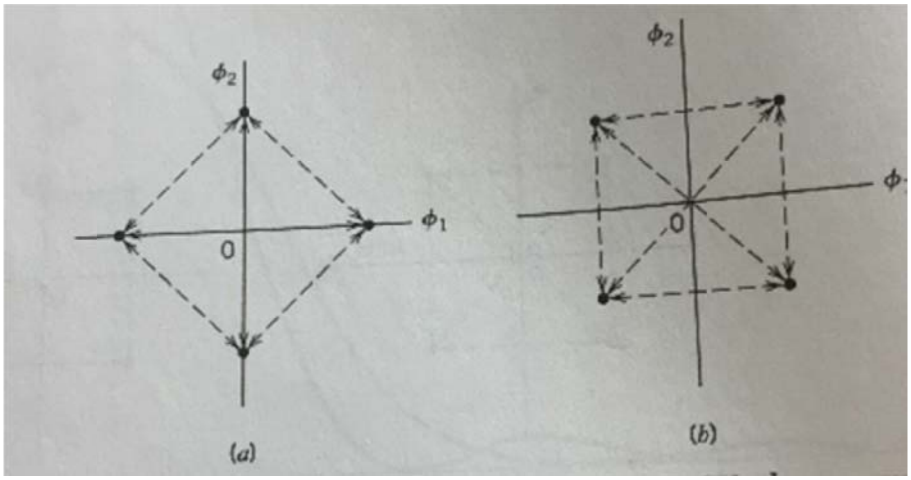
D. Ground 4: *Yellin*, *Su*, *Sewerinson*, and *Haykin* Render Obvious Claims 14, 20, 51, and 57

1. Claim 14

a) [14.a] "A transceiver system according to claim 7, wherein the calibration RF signal includes a discrete phasor comprising j^n or j^{-n}."

Yellin in combination with *Su*, *Sewerinson*, and *Haykin* discloses or suggests this feature. (Ex.1002, ¶¶223-29.) In the *Yellin-Su-Sewerinson* system discussed above with respect to claims 12 and 13, the IQ values provided in the input vectors V_m correspond to real (I) and imaginary (Q) values that are represented by phasors in the IQ plane using a QPSK modulation method as disclosed in *Sewerinson*. (*Supra* Section IX.C.1.) The discrete phasors shown in figure 5 of *Sewerinson* correspond to phases of +45º, +135º, +225º, and +315º. (Ex. 1016, 4:33-38.)

Haykin, which is a book entitled "Communication Systems" discloses "two commonly used signal constellations for QPSK":



(Ex. 1017, 362, FIG. 6.11; Ex. 1002, ¶225.)

The signal constellations shown in figure 5 of *Sewerinson* correspond to the QPSK modulation method having the phasors shown in figure 6.11(b) of *Haykin*, where the phasors are located at +45º, +135º, +225º, and +315º. (Ex. 1002, ¶226.) *Haykin* discloses that figure 6.11(a) presents another constellation diagram for QPSK in which the phasors used to represent the IQ data pairs are at 0º, +90º, +180º, and +270º. (Ex. 1017, 362.)

Assuming that they have a magnitude of 1, the phasors shown in the QPSK constellation diagram (a) in figure 6.11 of *Haykin* correspond to the points (1,0), (0,1), (-1,0), and (-1, -1) in the complex plane, where each point lies on either the real or imaginary axis. (Ex. 1002, ¶227.) Those points on the axes correspond to real + imaginary values of: (1 + 0j) = 1, (0 + j) = j, (-1 + 0j) = -1, and (0+-j) = -j. Those values (1, j, -1, -j) correspond to a discrete phasor of j^n where, for example, n is varied from 0 to 3 ($j^0=1$, $j^1 = j$, $j^2 = -1$, $j^3 = -j$). Therefore, a QPSK modulation method using the signal constellations of figure 6.11(a) of *Haykin* includes discrete phasors comprising j^n or j^{-n} as recited in claim 14.

Haykin discloses that a POSITA would have known that different phasors could be used to represent the data values in a QPSK modulation method such as that used in the *Yellin-Su-Sewerinson* system. (Ex. 1017, 362 ("two *commonly used* signal constellations for QPSK") (emphasis added); Ex. 1002, ¶228.) Specifically, *Haykin* discloses in figure 6.11(a) a set of QPSK constellations that include phasors corresponding to a discrete phasor of j^n, where that set of QPSK constellations would have been recognized by a POSITA as an alternative to the set of constellations shown in figure 5 of *Sewerinson*. (Ex. 1002, ¶228.)

Therefore, a POSITA would have found it obvious to use the set of signal constellations shown in figure 6.11(a) of *Haykin* in the QPSK modulation method of the *Yellin-Su-Sewerinson* combination. (Ex. 1002, ¶229.) *Haykin* discloses that the signal constellations in figure 6.11(a) and 6.11(b) were "commonly used" and therefore would have been understood by a POSITA as design choices that were available when using a QPSK modulation method. (*Id.*, ¶229; Ex. 1017, 362.) Accordingly, it would have been obvious to one of ordinary skill in the art to substitute the signal constellations in figure 6.11(a) of *Haykin* for those shown in figure 5 of *Sewerinson*, because those two QPSK signal constellations were known design choices and the modification would have produced the expected result of providing phasors used in representing the modulated data stream. *KSR*, 550 U.S. at 415, 419; *see also Kamstrup A/S v. Apator Miitors ApS*, IPR2015-01403, Paper No. 7 at 24-25 (Dec. 28, 2015) (finding obvious the substitution of one known mechanism for another in the absence of an unexpected result).

2. Claims 20, 51, 57

The combined *Yellin-Su-Sewerinson-Haykin* system discloses or suggests the features of these claims. (Ex. 1002, ¶230; *supra* Section IX.D.1.)

X. INSTITUTION SHOULD NOT BE DENIED BASED ON § 325(d)

The Board previously denied an IPR petition challenging the claims at issue here. *See Unified Patents Inc. v. Red Rock Analytics, LLC*, IPR2017-01490, Paper No. 18 at 20 (Dec. 20, 2017)). Although under 35 U.S.C. § 325(d) the Board may in its discretion deny institution if "the same or substantially the same prior art or arguments previously were presented to the Office," that is not the situation here. The instant petition relies on *Yellin* as the primary reference while the denied petition relied on a different prior art reference (U.S. Patent 6,940,916 to Warner *et al.*). Moreover, the previous petition was filed by a different petitioner. *General Plastic Industrial Co., Ltd. v. Canon Kabushiki Kaisha*, IPR2016-01357, Paper No. 19 at 19 (Sept. 6, 2017) (factor #1 for the § 314(a) analysis). The remaining factors related to exercise of discretion under § 314(a) are inapplicable here, because this is not a follow-on petition regarding the same patent by a previously unsuccessful petitioner.

XI. CONCLUSION

For the reasons given above, Petitioner requests institution of IPR for claims 7, 11-21, 44, and 48-58 of the '313 patent based on each of the grounds specified in this petition.

Respectfully submitted,

Dated: February 5, 2018

By: /Naveen Modi/
Naveen Modi (Reg. No. 46,224)

CERTIFICATE OF COMPLIANCE

Pursuant to 37 C.F.R. § 42.24(d), the undersigned certifies that the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 7,346,313 contains, as measured by the word-processing system used to prepare this paper, 13,826 words. This word count does not include the items excluded by 37 C.F.R. § 42.24 as not counting towards the word limit.

Respectfully submitted,

Dated: February 5, 2018
By: /Naveen Modi/
Naveen Modi (Reg. No. 46,224)
Counsel for Petitioner

CERTIFICATE OF SERVICE

I hereby certify that on February 5, 2018, I caused a true and correct copy of the foregoing Petition for *Inter Partes* Review of U.S. Patent No. 7,346,313 and supporting exhibits to be served via express mail on the Patent Owner at the following correspondence address of record as listed on PAIR:

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