

DECLARATION OF JAMES PROCTOR, JR. IN SUPPORT OF
IPR PETITION FOR U.S. PATENT No. 8,078,561

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

**T-MOBILE USA, INC., AT&T MOBILITY LLC, CELLCO PARTNERSHIP
D/B/A VERIZON WIRELESS, ERICSSON INC. AND NOKIA OF
AMERICA CORPORATION**

Petitioners,

v.

SMART RF INC.

Patent Owner.

Case No. IPR2025-00612

U.S. Patent No. 8,078,561

Declaration of James Proctor, Jr. in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 8,078,561

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I, James Proctor, Jr., declare and state as follows:

1. I have been retained on behalf of T-Mobile USA, Inc., AT&T Mobility LLC, Cellco Partnership d/b/a Verizon Wireless, Ericsson Inc., and Nokia of America Corporation (“Petitioners”) as an independent technical expert in this proceeding before the United States Patent and Trademark Office (“PTO”) regarding U.S. Patent No. 8,078,561 (the “’561 Patent”). I have been asked to consider whether certain references disclose or suggest the features recited in Claims 1-22 of the ’561 Patent (the “Challenged Claims”). My opinions are set forth below.

1. Background and Qualifications

2. In this section, I summarize my educational background, work experience and other relevant qualifications. A more detailed recitation of my professional qualifications and background is set forth in my Curriculum Vitae, attached hereto as Exhibit A.

3. I have worked as an engineer and entrepreneur in the field of wireless communications for over 25 years, and have been involved with various aspects of wireless communications for the duration of my career.

4. I am a named inventor on more than 325 issued U.S. patents, and more than 700 international patent publications. A number of these patents and patent applications are specifically related to the subject matter of the ’561 Patent (e.g., cancelation or predistortion of intermodulation products in wireless transceivers,

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related components such as correlators and closed loop control for gain and phase, and delay alignment). For example, I am a named inventor on the following patents:

U.S. Pat. No.	Title	Priority Date
5,898,338	Adaptive digital predistortion linearization and feed-forward correction of RF power amplifier	1996-09-20
5,929,704	Control of RF error extraction using auto-calibrating RF correlator	1998-20-20
6,078,216	Aliased wide band performance monitor for adjusting predistortion and vector modulator control parameters of RF amplifier	1998-03-31
9,306,658	Method and apparatus for a spectrally compliant cellular communication system	1999-12-20
7,272,169	Reverse link correlation filter in wireless communication systems	2000-02-23
7,002,902	Method and system for economical beam forming in a radio communication system	2000-02-24
9,775,115	Antenna control system and method	2000-12-01
6,911,879	Electronic phase shifter with enhanced phase shift performance	2001-01-31

Particularly, U.S. Patent. No. 5,898,338 discloses a system which corrects for a power amplifier's intermodulation distortion using pre-distortion and/or feed-forward techniques. Fig. 1 is set forth below:

FIG. 1

6. From 1993 to 1995, while working again for Harris Corporation, I designed various cellular communications systems for voice, data and tracking/location services. Many of these systems advanced the developing and

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future communications technologies of the day, including IS-95, W-CDMA and LTE.

7. From 1995 to 1998, I worked at Spectrian in advanced development and technical marketing roles. At Spectrian, I interfaced with Nortel's and Qualcomm's product management and performed advanced technology development and systems analysis. I also designed IS-95 CDMA and GSM base station power amplifiers and control electronics, and received several patents associated with advanced linearization techniques for the reduction of transmitted intermodulation distortion within multicarrier and single carrier amplifiers and transceivers. These techniques included both analog/RF as well as digital linearization approaches.

8. From 1998 to 2002, I served as the Director of Strategic and Technical Marketing at Tantivy Communications, a venture capital-funded 3G cellular data and chip set company. At Tantivy, I helped to architect and standardize the I-CDMA Spread Spectrum Systems Air Interface Standard (T1P1.4). I also developed both wireless access terminals and base stations that complied with the standard. The base stations utilized various IP protocols, and interfaced with the wire line network utilizing IP over Ethernet. Additionally, I participated in and provided technical contributions to 3GPP/3GPP2 standardization efforts related to the development of

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CDMA2000 and 1xEV-DO. This work resulted in me being a named inventor on more than 150 U.S. patents and applications.

9. From 2002 to 2007, I held various positions at WiDeFi, Inc., a company I co-founded, including President, CEO, CTO and board member. As the CEO, my responsibilities included advanced development of platform technologies. This led to me being a named inventor on over 25 U.S. patents and patent applications for wireless technology components, including a frequency translating TDD repeater, a same frequency repeater architecture for TDD/FDD-based systems, and physical layer multi-stream MIMO repeater technology. WiDeFi provided wireless home networking products based on WiFi and cellular technologies.

10. Currently, I am serving as the Managing Director at Proctor Consulting, LLC, which provides early stage market and technology consulting services within the communications market space. I am also currently serving as the Managing Director of Proximcom Wireless, a company pioneering proximity-based mobile technologies.

2. Compensation

11. I am being compensated at my standard hourly rate of \$600 per hour for my work performed in connection with this matter. My compensation does not depend in any way upon the outcome of this matter.

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3. Materials Considered

12. In forming my opinions, I have relied on the documents in the list attached as Exhibit B to this declaration.

4. Legal Standards

13. I am not an attorney and offer no legal opinions. For the purposes of this Declaration, I have been informed by Counsel about certain aspects of the law that are relevant to my analysis, as summarized below.

14. I have been informed by Counsel that the first step in an invalidity analysis involves construing the claims, as necessary, to determine their scope. I have also been informed by Counsel that claims are generally given their ordinary and custom meaning as understood by a person of ordinary skill in the art (“POSITA”) at the time of the invention, in light of the patent’s claims, specification and file history. I have additionally been informed by Counsel that claim construction is a matter of law and that the final claim constructions for this proceeding will be determined by the Patent Trial and Appeal Board (“PTAB”).

15. I have further been informed by Counsel that a patent claim is obvious under 35 U.S.C. §103, and therefore invalid, if the claimed subject matter, as a whole, would have been obvious to a POSITA as of the priority date of the patent based on one or more prior art and/or knowledge of a POSITA. I have been further informed by Counsel that a claim is invalid under 35. U.S.C. § 102 if it is anticipated,

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which requires that every element of a claim is disclosed in a single prior art reference, arranged as in the claim.

16. I have additionally been informed by Counsel that an obviousness analysis must consider (1) the scope and content of the prior art, (2) the differences between the claims and the prior art, (3) the level of ordinary skill in the pertinent art, and (4) secondary considerations, if any, of non-obviousness (such as unexpected results, commercial success, long-felt but unmet need, failure of others, copying by others, and skepticism of experts).

17. I have been informed by Counsel that a prior art reference may be combined with other references to disclose each element of the invention under 35 U.S.C. § 103. I have further been informed by Counsel that a reference may also be combined with the knowledge of a POSITA, and that this knowledge may be used to combine multiple references. I have further been informed by Counsel that a POSITA is presumed to understand the relevant prior art. I have also been informed by Counsel that the obviousness analysis may take into account the inferences and creative steps that a POSITA would employ.

18. In determining whether a prior art reference would have been combined with other prior art or other information known to a POSITA, I have been informed by Counsel that the following principles may be considered:

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- a. whether the references to be combined involve non-analogous art;
- b. whether the references to be combined are in different fields of endeavor than the alleged invention in the Patent;
- c. whether the references to be combined are reasonably pertinent to the problems to which the inventions of the Patent are directed;
- d. whether the combination is of familiar elements according to known methods that yields predictable results;
- e. whether a combination involves the substitution of one known element for another that yields predictable results;
- f. whether the combination involves the use of a known technique to improve similar items or methods in the same way that yields predictable results;
- g. whether the combination involves the application of a known technique to a prior art reference that is ready for improvement, to yield predictable results;
- h. whether the combination is “obvious to try”;
- i. whether the combination involves the known work in one field of endeavor prompting variations of it for use in either the same

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field or a different one based on design incentives or other market forces, where the variations are predictable to a POSITA;

- j. whether there is some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention;
- k. whether the combination requires modifications that render the prior art unsatisfactory for its intended use;
- l. whether the combination requires modifications that change the principle of operation of the reference;
- m. whether the combination is reasonably expected to be a success;
and
- n. whether the combination possesses the requisite degree of predictability at the time the invention was made.

19. I have been informed by Counsel that in determining whether a combination of prior art references renders a claim obvious, it is helpful to consider whether there is some teaching, suggestion, or motivation to combine the references and a reasonable expectation of success in doing so. I have further been informed by Counsel that the existence of an explicit teaching, suggestion or motivation to combine known elements of the prior art is a sufficient, but not a necessary,

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condition to finding of obviousness. This so-called “teaching-suggestion-motivation” test is not the exclusive test and is not to be applied rigidly in an obviousness analysis.

20. I have been informed by Counsel that “a person of ordinary skill in the art” is a hypothetical person to whom an expert in the relevant field could assign a routine task with reasonable confidence that the task would be successfully carried out. I have also been informed by Counsel that evidence of the level of ordinary skill in the art can be found in the patent-in-question.

21. I have been informed by Counsel that a method claim is composed of a series or sequence of steps, each of which state an operation to be performed. I am further informed by Counsel that the sequential arrangement of the steps is not important unless it is essential to the invention itself, and to determine whether the steps recited in a method claim must be performed in the sequence in which they appear in the claim in order, one must look to the nature of the steps themselves and to the written description of the method in the specification.

5. Level of Ordinary Skill in the Art

22. I have reviewed the relevant disclosures of the Patent-in-Suit (the ’561 Patent) as well as relied on the documents identified above, and on my education and experience, to arrive at my opinions regarding the level of a person of ordinary skill in the art.

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23. In my opinion, a person of ordinary skill in the art in the field of the '561 Patent in the relevant time frame would have been someone with at least (1) a bachelor's degree in electrical engineering or a related field, and (2) either (a) a master's degree in electrical engineering or a related field, or (b) two or more years of work or research experience in wireless communications and, in particular, power amplification of radio signals

24. In determining the level of ordinary skill in the art, I considered, for example, the type of problems encountered in the art, prior art solutions to those problems, the rapidity with which innovations were made, the sophistication of the technology, and the educational level of active workers in the field.

25. I met the definition of a POSITA in the relevant time frame. I also had greater knowledge and experience than a POSITA in the relevant time frame. I render my opinions, however, from the perspective of a POSITA, based on my knowledge and research and teaching experience. Indeed, my opinions concerning the '561 Patent and the prior art are from the perspective of a POSITA.

6. Overview of the '561 Patent

26. Below, I provide a brief summary of the background technology and the state of the art as of the priority date of the '561 Patent as context for understanding the disclosure and claims of the '561 Patent.

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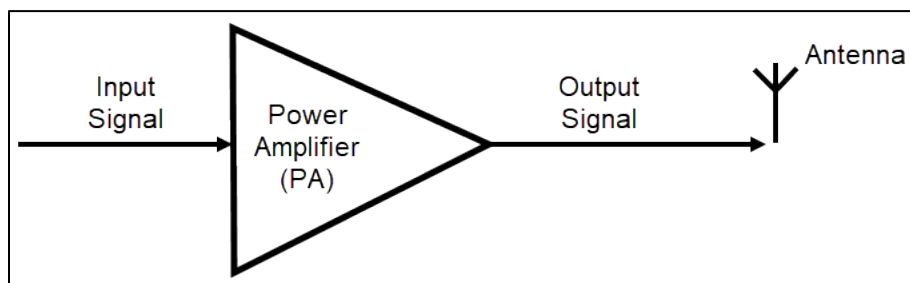
27. The '561 Patent claims priority to a U.S. Provisional Application No. 60/872,132, filed on December 1, 2006.

6.1 The Technology: Digital Predistortion

28. Radios take input information and produce modulated radio frequency signals that are amplified to a higher power level before transmission over antennas to receivers. The amplification step uses a power amplifier (“PA”), which may cause distortion of the signal. “Predistortion” is a technique used to counteract the PA’s signal distortion before transmission by the antenna.

6.1.1 Power Amplifiers Introduce Distortion

29. Wireless transmitters use PAs to increase the power at which a signal is transmitted. PAs are typically noted as triangles in circuit diagrams, such as the one below:

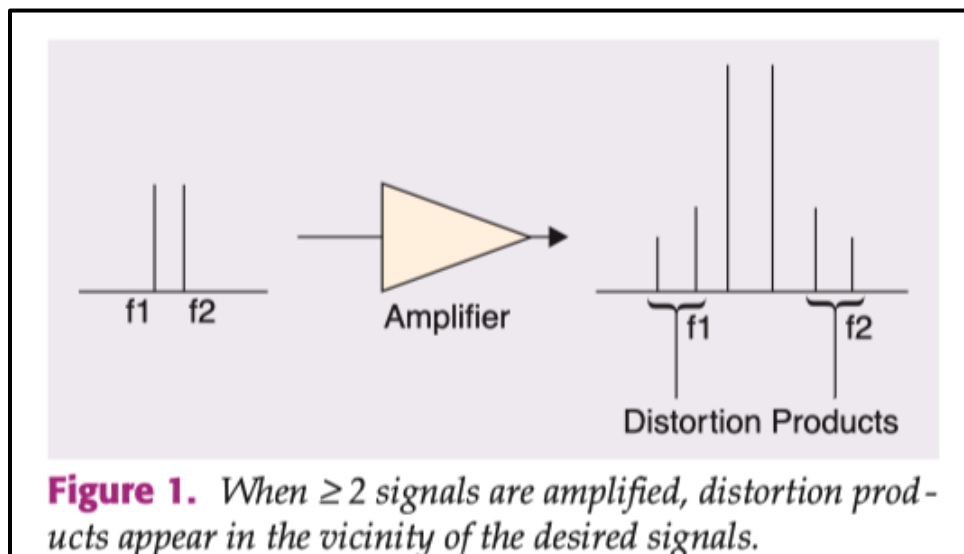


An input signal’s power level is amplified to a higher power level after it passes through the PA to create an output signal. After this amplification, the output signal is transmitted using an antenna.

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30. All PAs suffer a common problem: when they amplify a signal, they distort that signal to some degree. That distortion may take the form of (1) spectrum spreading or spectral regrowth (i.e., the signal input to the PA is spread across frequencies beyond the channel(s) over which it permitted to be transmitted, which results in so-called adjacent channel interference (“ACI”)); or (2) in-band distortion (or more accurately called “in-channel distortion”) within the frequencies of the signal itself, which damages the signal’s quality.

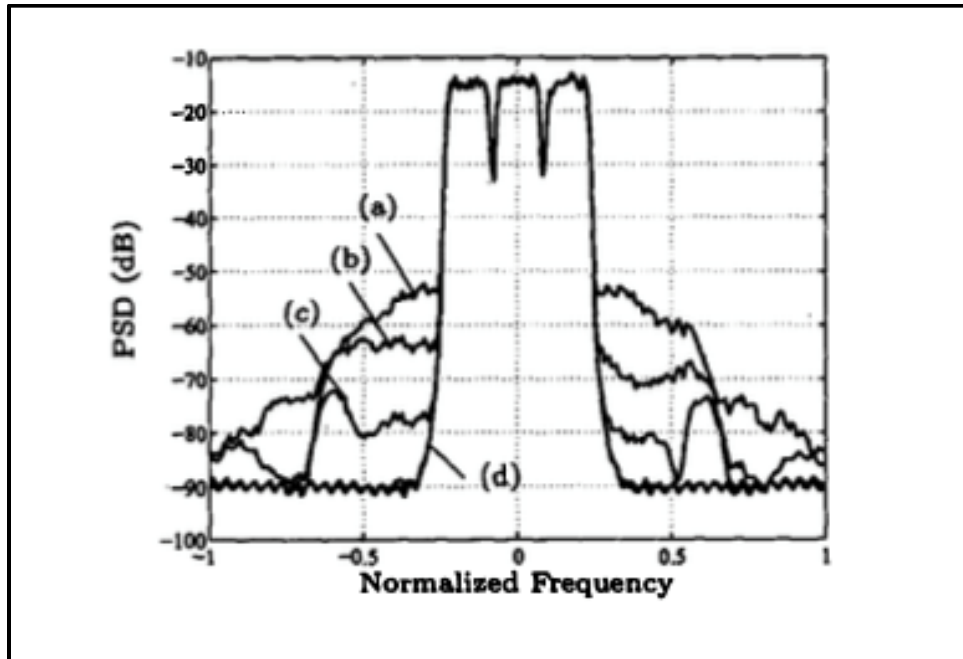
31. Below is a figure showing spectrum spreading:



(Katz, at Fig. 1.) Above, two signals are input to the power amplifier, which causes distortions: the signals appearing outside of their intended frequency channels.

32. The same effect occurs for modulated input signals composed of multiple frequencies within a given channel, as shown in the following figure:

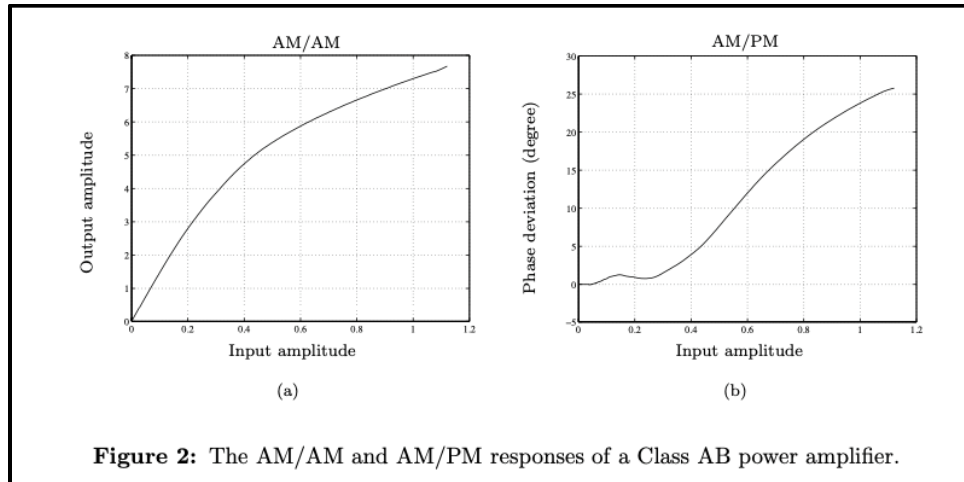
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(Raich, Fig. 3.) In the above figure, the input signal is labeled (d), while the output of the amplifier with distortion is labeled (a).¹ When charted, these distortions can also appear as non-linear curves, where the non-linear curvature represents the distortions that the PAs introduce:

¹ Plots (b) and (c) show different pre-distortion schemes attempting to compensate for the distortions to “linearize” the amplifier.

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(Ding, Fig. 2.) The above figures depict the relationship of a PA's output to the input signals' amplitude. An ideal PA would proportionally increase the amplitude of a signal, referred to as the amplifier's "gain," to produce a perfectly straight-sloped line in Plot (a), rather than the depicted curved line, which results in different amplification levels depending upon the input level. Such an amplifier might multiply the input amplitude by a factor of ten as a signal changes its amplitude (referred to as "amplitude modulation," or "AM"). This effect results in a distortion of the output signal that is referred to as "AM to AM."

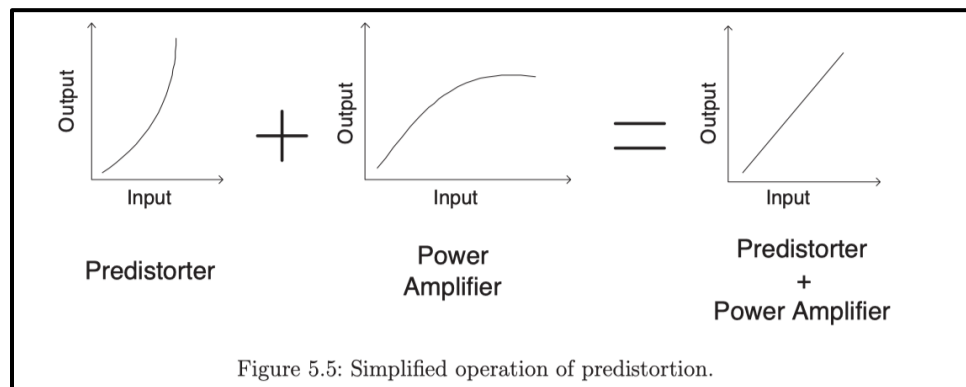
33. Plot (b) depicts the phase imparted to the output signal based upon the input signal's amplitude. Here, an ideal PA would have a flat line such that any additional phase imparted to the output signal would be constant, not depending upon the input level. The depicted curved line indicates that the additional phase added to the signal will change depending on the input signal's amplitude

modulation, causing phase modulation (“PM”) in the output signal, called “AM to PM” distortion.

6.1.2 Predistortion Mitigates the Power Amplifiers’ Distortion

34. To mitigate their PA’s distortion, radios will *predistort* the input signals before they are sent to the PA. The predistortion begins by “modeling” the PA’s distortion effects. Using knowledge of what kind of distortion a given PA is likely to introduce, a radio can predistort input signals such that their later distortion is largely canceled in the output signal. Because distortion introduces a non-linear gain curve to an input signal, and predistortion seeks to linearize that curve, predistorting input signals is sometimes called “linearization.”

35. This figure illustrates a predistorter’s operation in a simplified way:



(Ceylan, Fig. 5.5.) The figure shows AM/AM correction done by a predistorter. The AM to AM curve of the predistorter is designed so that it compensates for the AM to AM curve of the power amplifier resulting in a linearized power amplifier output (a straight sloped line).

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36. In general, a similar correction is also done for phase (AM/PM), discussed above, by adding a phase to the input signal opposite of the phase shift due to the PA. Any additional phase imparted to the output signal should be a constant (flat line), independent of the input signals amplitude.

6.1.2.1 “Dynamic” vs. “Static” Predistortion

37. Predistortion can be either “dynamic” or “static.” Dynamic predistortion accounts for variations in the PA’s distortions over time. Those distortions may change based on the PA’s previously amplified signals, temperature and age. When a PA distorts signals based on previous amplified signals, it is said to be experiencing “memory effects” of those previous amplified signals.²

38. Static predistortion does not account for those memory effects, but will instead ignore the changing characteristics of the power amplifier. Static predistortion will predistort based on firm rules that do not change over time. These rules may be held in lookup tables (“LUTs”), where an input signal’s amplitude or

² Predistorters may use finite impulse-response filters (“FIRs”) that account for previous transmissions within a fixed amount of time, and constitute the “memory” of dynamic predistortion. “Finite” refers to the FIRs’ ability to “look back” a set amount of time and account for a finite number of previous transmissions. “Impulse response” refers to the memory effects present in the PA.

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phase is used to lookup the correct static predistortion to apply. (*See Ding, 55* (“Note that if the power *amplifier is static* and its AM/AM and AM/PM characteristics are known, then a predistorter *constructed using the LUT is sufficient.*”).)

6.1.2.2 “Strong” vs. “Weak” Distortion

39. “Strong” distortion refers to distortion that has a large effect on the signal relative to other distortion; whereas “weak” distortion refers to distortion that has a smaller effect on the signal relative to other distortion. A predistortion module that addresses strong distortive effects would likewise be “strong”; and a predistortion module that addresses weak distortive effects would likewise be “weak.”

6.1.2.3 “Linear” vs. “Nonlinear” Predistortion

40. As discussed above, predistortion aims to reduce the distortions of a PA, which may include both linear and non-linear distortions of a signal. In order to compensate for a non-linear distortion, non-linear pre-distortion is used. As a result, “nonlinear” can also refer to the type of predistortion occurring.

6.1.2.4 Wiener and Hammerstein Models

41. The Wiener and Hammerstein models are (and were) common examples of predistorters:

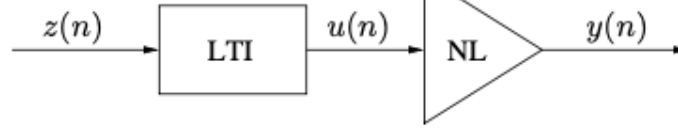


Figure 6: The Wiener Model.

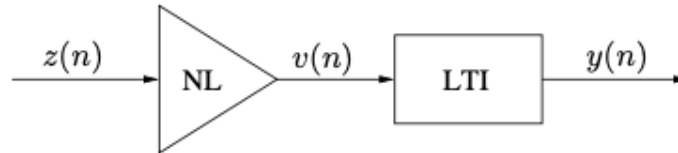


Figure 7: The Hammerstein Model.

(Ding, Fig. 8.) The Wiener model is a linear time-invariant (“LTI”)³ system followed by a memoryless nonlinearity (NL). The Hammerstein model is a memoryless nonlinearity followed by an LTI system.

42. It was well known at the time of the alleged priority date of the ’561 Patent that memoryless nonlinearity predistorter modules, including those within the

³ An LTI system in this context refers to a digital filter (e.g., a FIR filter). (Oppenheim, 21 (“a linear time-invariant system (which we will sometimes abbreviate as LTI) is completely characterized by its impulse response, $h[n]$, in the sense that, given $h[n]$, it is possible to ... compute the output $y[n]$ due to any input $x[n]$.”), 31.) Ding’s Equations 13 (for the Wiener model) and 17 (for the Hammerstein model) disclose the LTI system as a FIR filter. (Ding, 11.)

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Weiner and the Hammerstein predistorters, were commonly characterized by static AM/AM and AM/PM curves, including those implemented using LUTs. (See Gilabert, 1 (“Most of the digital predistorters proposed in the recent past years have been modeled using *memoryless* techniques, aiming at compensat[ing] the instantaneous *nonlinear behavior* of the PA, characterized by the AM/AM and AM/PM *static curves*.”); Ding, 55 (“Note that if the power *amplifier is static* and its AM/AM and AM/PM characteristics are known, then a predistorter *constructed using the LUT is sufficient*.”).) Furthermore, the LTI predistorter modules, including those within the Weiner and Hammerstein predistorters, were often implemented using adaptive techniques to achieve a dynamic linear module to accompany the memoryless nonlinear predistorter modules. (See Sun, 1130 (“[A] more efficient compensation method based on *adaptive* identification is proposed in this paper under the assumption that the Wiener model can describe the linear dynamics followed by the nonlinearity of static part of HPA[.]”).)

6.2 Specification

43. The '561 Patent relates to “a behavioral model for wide-band radio frequency transmitters” that could be used for “baseband predistortion of dynamic nonlinear systems, such as wideband wireless transmitters and power amplifiers.” ('561 Patent, Abstract.)

6.2.1 Alleged Problem: Inefficient Predistortion

44. The patent first identifies the well-known problem of “nonlinear distortions that may be exhibited by the radio frequency (RF) transmitters, especially the power amplifier (PA) stage.” (’561 Patent, 1:23-26.) These “nonlinearities may cause several complications in the wireless digital system and significantly complicate design of such systems[,]” including “dilation/spreading of the spectrum of the input signal, which may cause adjacent channel interference” and “in-band distortions which deteriorate the integrity of the transmitted signal[.]” (’561 Patent, 1:32-39.)

45. “Accurate modeling of the RF transmitters” is critical to “minimiz[ing] the effects of such distortion sources,” and the ’561 Patent is critical of “several prior art models of dynamic nonlinear systems.” (’561 Patent, 1:39-43.) The patent states that (1) “one common problem of such models is in the identification procedure of the parameters of their different modules”; (2) “the known models and procedures encounter high complexity and/or low accuracy”; and (3) existing models “frequently do not account for the strong memory effects exhibited by the transmitter/PA.” (’561 Patent, 1:44-50.)

6.2.2 Alleged Solution: Coupling Dynamic and Static Nonlinear Predistortion Modules

46. The ’561 Patent states that “there is a need for a new dynamic nonlinear system model that overcomes limitations of the prior art behavioral models,” and

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proposes a model that couples “a dynamic weak nonlinear (DWNL) module, which models dynamic weak [sic] nonlinearities of the system, and a static strong nonlinear (SSNL) module, which models static strong nonlinearities of the system.” (’561 Patent, Abstract, 1:50-52.) These models are then “implemented” in “baseband predistortion of dynamic nonlinear systems[.]” (’561 Patent, Abstract.)

47. The “dynamic weak nonlinear module” models nonlinearities in the output signal related to the power amplifier’s memory effects. (’561 Patent, 2:24-27 (“the DWNL module may be implemented as a plurality of nonlinear dynamic FIR-based filters *which account for low- and high-order memory effects caused by dynamic properties of the transmitter*⁴ in the presence of a modulated communication signal.”). *See also id.* at 2:18-46.) The “plurality of nonlinear dynamic FIR-based filters” model the PA’s memory effects by accounting for previous transmissions’ effects on the PA. The DWNL module is said to be “weak” because it models less significant nonlinearities relative to the SSNL module.

48. The “static strong nonlinear module” models nonlinearities that do not account for the power amplifier’s memory effects. (’561 Patent, 2:3-7.) “[T]he SSNL module may be implemented as a AM/AM and AM/PM lookup table[.]” (’561 Patent, 2:3-7. *See also id.* at 2:18-46.) In practice, the SSNL module would

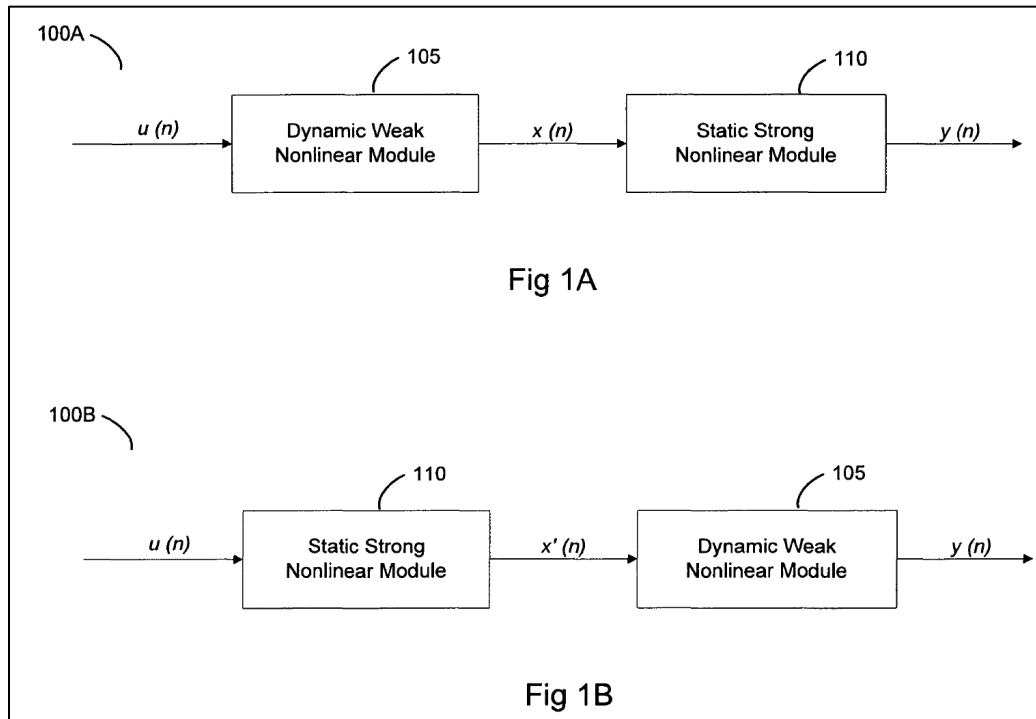
⁴ All emphasis added unless otherwise noted.

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receive an input signal, then use the input signal's amplitude to determine which stored amplitude modulation (AM) and/or phase modulation (PM) to apply to the input signal to compensate for the PA's AM and/or PM distortion. ('561 Patent, 2:3-7. *See also id.* at 2:18-46.) The SSNL module is said to be "strong" because it models a more significant level of nonlinearity relative to the DWNL module, in particular at the higher input amplitude levels, which results in a more significant level of distortion of the output signal. (*See Ding*, 16 ("In general, power amplifier characteristics do not change rapidly with time; changes in the power amplifier characteristics are often due to temperature drift and aging, which have long time constants. . . . When the predistorter coefficients have been found and it is believed that the power amplifier characteristics are hardly changing, the setup [] can be run in open loop.").)

49. Figures 1A and 1B show two possible designs: one where a DWNL module is connected to a SSNL module; and another where the two modules are arranged in reverse order.

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(’561 Patent, 3:59-4:41, Figs. 1A, 1B. *See also id.* at 3:1-6, 6:9-64, Figs. 4A, 4B.)

Figure 1A shows “an augmented Wiener predistorter” (where a dynamic module is followed by a static module); and Figure 1B shows “an augmented Hammerstein predistorter” (where a static module is followed by a dynamic module). (’561 Patent, 2:18-46.)

6.3 Challenged Claims

50. This Declaration addresses Claims 1-22 of the ’561 Patent, which I have been informed by Counsel are the Challenged Claims. I have added indices of the form 1[pre], 1[a], 1[b], etc. to the claim limitations for ease of reference, and listed the claim limitations in the table attached as Exhibit C to this declaration.

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51. The Challenged Claims are largely directed to systems where DWNL and SSNL modules are connected in either order. For example, claim 7 recites a DWNL module followed by a SSNL module (what it calls an “augmented” Weiner predistorter) (as shown in Figure 1A above):

7. A predistorter for nonlinear wireless system, the predistorter comprising:

a dynamic nonlinear predistorter module; and

a static nonlinear predistorter module coupled to the dynamic nonlinear predistorter module such that an output of the dynamic nonlinear predistorter module is input to the static nonlinear predistorter module.

Claim 11 simply reverses the order of the modules (what it calls an “augmented” Hammerstein predistorter) (as shown in Figure 1B):

11. A predistorter for nonlinear wireless system, the predistorter comprising:

a static nonlinear predistorter module; and

dynamic nonlinear predistorter module coupled to the static nonlinear predistorter module such that an output of the static nonlinear predistorter module is input to the dynamic nonlinear predistorter module.

Claim 1 includes both DWNL and SSNL modules, but does not require them to be in any order. The dependent claims add limitations relating to what each module is composed of (claims 4-6, 8-10, 12-14) and the relative positioning of the modules (claims 2, 3).

52. As explained in detail below, Claims 1-22 of the '561 Patent would have been obvious in view of the prior art.

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7. Claim Construction

53. I have been informed by Counsel that the petitioners have offered the following proposed constructions for purposes of their Petition:

Claim Term	Petitioners' Proposed Construction
Wiener predistorter (claim 15)	"predistorter where a dynamic module is followed by a static module"
Hammerstein predistorter (claim 19)	"predistorter where a static module is followed by a dynamic module"
dynamic nonlinear first order nonlinear predistorter module (claims 15, 19)	"a dynamic predistortion module that includes a nonlinear function with a first-power exponent"

7.1 "Wiener predistorter" (Claim 15)

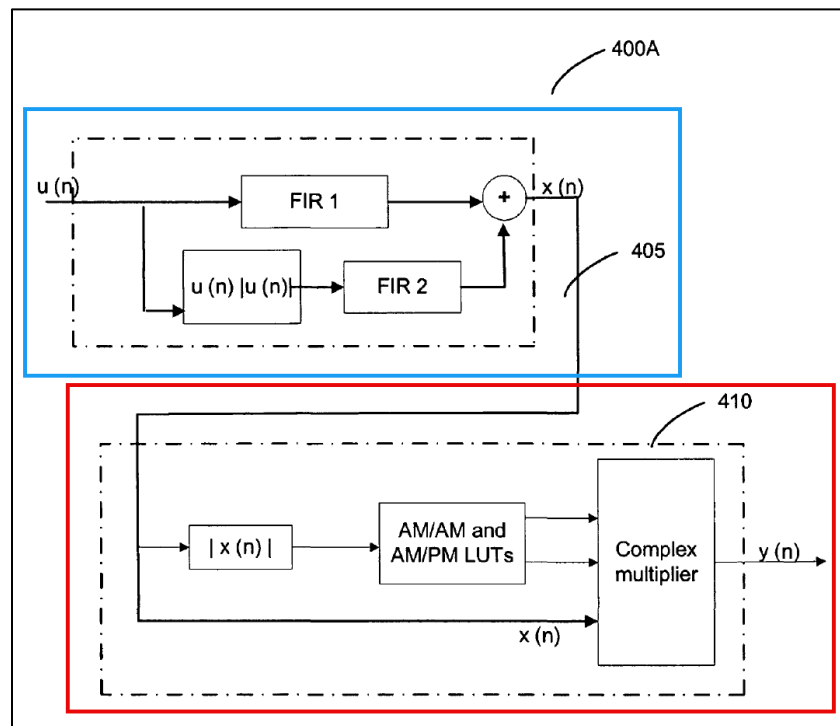
54. In my opinion, a POSITA at the time of the '561 Patent's filing would have understood a "Wiener predistorter" to mean a "predistorter where a dynamic module is followed by a static module."

55. First, Claim 15 makes clear that in the "augmented Wiener predistorter," the "output of the dynamic nonlinear predistorter module is input to the static nonlinear predistorter module." ('561 Patent, cl. 15.) In other words, the

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dynamic module is followed by the static module, just as is the well-known (unmodified) Wiener predistorter.

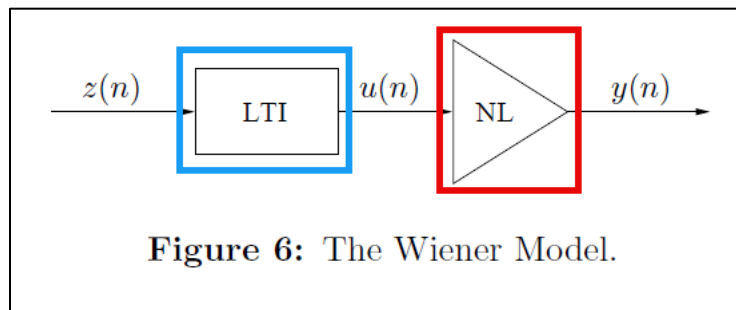
56. Second, the specification also makes clear that, in an augmented Wiener predistorter, a dynamic module is followed by a static module. ('561 Patent, 2:22-24 (“The augmented *Wiener predistorter* includes *a DWNL module followed by a SSNL module.*”).) This too parallels well known and unmodified Wiener models. (See Lui, Fig. 3.). The specification’s figures also show that an augmented Wiener predistorter is composed of a dynamic module (blue) is followed by a static module (red):



('561 Patent, 6:14-17 (“FIG, 4A illustrates an example embodiment of the augmented Wiener predistorter. The predistorter 400A includes a DWNL module

405 followed by a SSNL module 410.”), 3:1-3 (“FIG. 4A is a schematic diagram of one example embodiment of an augmented *Wiener predistorter* implemented using first-order forward LBG model[.]”).), Figs. 1A, 4A.)⁵

57. Third, extrinsic sources further confirm that a Wiener predistorter has a dynamic module followed by a static module. Ding refers to a “Wiener model” as “a linear time-invariant (LTI)⁶ [dynamic linear] system *followed by* a memoryless [static] nonlinearity (NL)[.]” and depicts it in Figure 6:



(Ding, 11-12, Fig. 7.) Zhu states that a “Wiener model is a nonlinear model with a linear dynamic block followed by a static nonlinear function.” (Zhu, 1.) Emara-Shabaik states that “the Wiener model [] is composed of a linear dynamic system followed by a static nonlinearity[.]” (Emara-Shabaik, 606.) Wang teaches that “[a] nonlinear system with memory is considered to be a Wiener system if it can be

⁵ It is my opinion that the term “LBG model” was not a known term within the art. This term is likely an acronym of the last names of the inventors listed on the ’561 Patent: *Liu*, *Boumaiza* and *Ghannouchi*. (See ’561 Patent, cover.)

⁶ See Section 6.1.2.3.

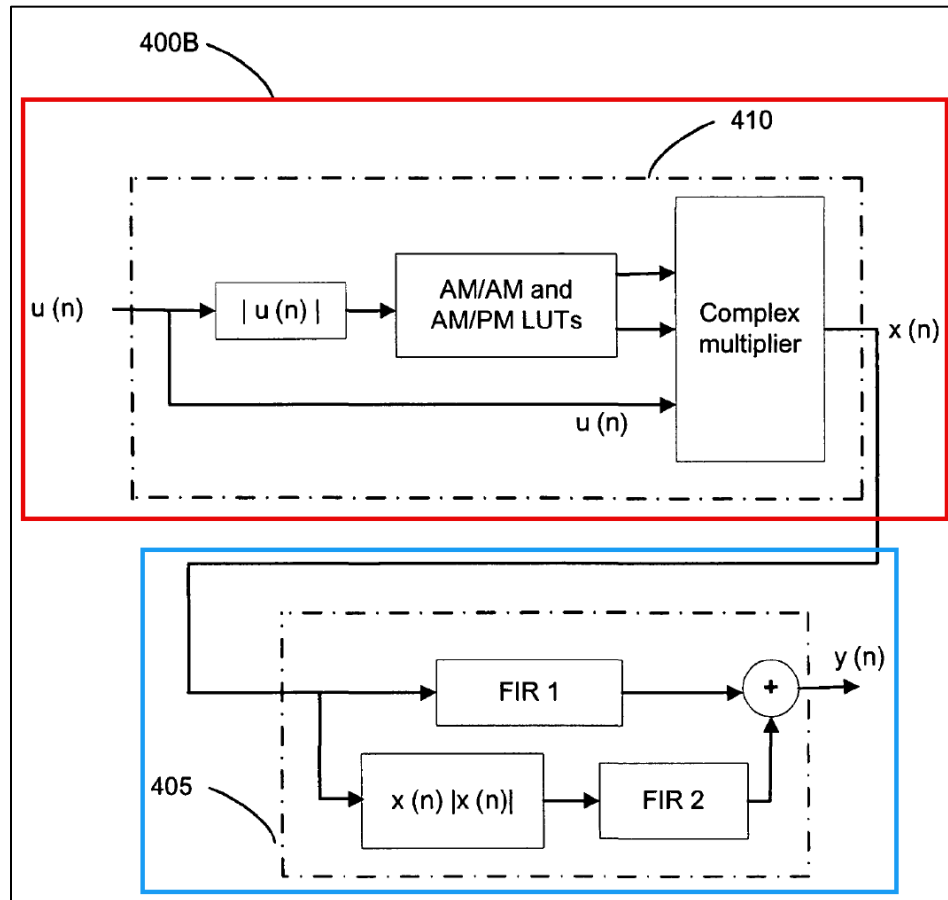
represented by a linear dynamic subsystem (linear time invariant (LTI) filter) followed by a zero-memory nonlinear subsystem[.]” (Wang, 2399.)

7.2 “Hammerstein predistorter” (Claim 19)

58. In my opinion, a POSITA at the time of the ’561 Patent’s filing would have understood a “Hammerstein predistorter” to mean a “predistorter where a static module is followed by a dynamic module” – i.e., the inverse of the Weiner predistorter.

59. First, the Claim 19 makes clear that in the augmented “Hammerstein predistorter,” the “output of the static nonlinear predistorter module is input to the dynamic nonlinear predistorter module.” (’561 Patent, cl. 19.) In other words, the static module is followed by the dynamic module in an augmented Hammerstein predistorter, just as in the unmodified Hammerstein predistorter discussed above.

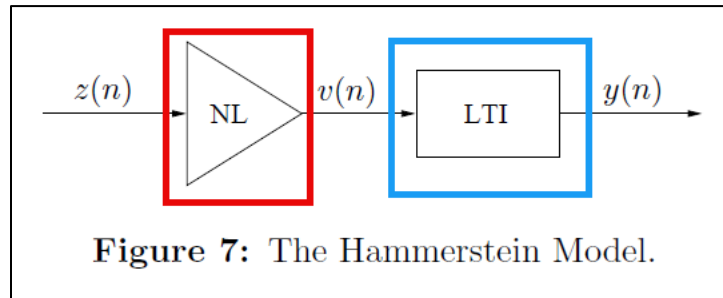
60. Second, the specification also makes clear that, in an augmented Hammerstein predistorter, a static module is followed by a dynamic module. (*See, e.g., ’561 Patent, 2:37-40* (“In one example embodiment, the augmented Hammerstein predistorter may include *a SSNL module followed by a DWNL module.*”), (“In another example embodiment, a first-order *reverse LBG model* may be used to implement an augmented *Hammerstein predistorter*[.]).) The specification’s figures also show that a Hammerstein predistorter is composed of a static module (red) followed by a dynamic module (blue):



(’561 Patent, 6:53-56 (“FIG, 4B illustrates one example embodiment of the augmented Hammerstein Predistorter. Predistorter 400B includes *a SSNL module 410 followed by a DWNL module 405.*”), 3:4-6 (“FIG. 4B is a schematic diagram of one example embodiment of an augmented *Hammerstein predistorter* implemented using first-order *reverse LBG model*[.]”), 7:11-17, Figs. 1B, 4B.)

61. Third, extrinsic sources further confirm that a Hammerstein predistorter has a dynamic module followed by a static module. Ding explains that “[t]o

construct a Hammerstein predistorter, the approach taken by [25]⁷ uses a gradient method *to first identify the Wiener system and then find the Hammerstein predistorter as its inverse.*” (Ding, 17.) “The Hammerstein model is a memoryless nonlinearity followed by an LTI system[.]” and shown in Figure 7:



(Ding, 12-13, Fig. 7.) Zhu states that “a Hammerstein model has nonlinear block followed by a linear dynamic block.” (Zhu, 1.) Emara-Shabaik states that “[t]he Hammerstein model is composed of a dynamic linear block following a static nonlinearity.” (Emara-Shabaik, 606.) Wang teaches that “[t]he Hammerstein system consists of the same subsystems as the Wiener system, however the subsystems are connected in the reverse order[.]” (Wang, 2399.)

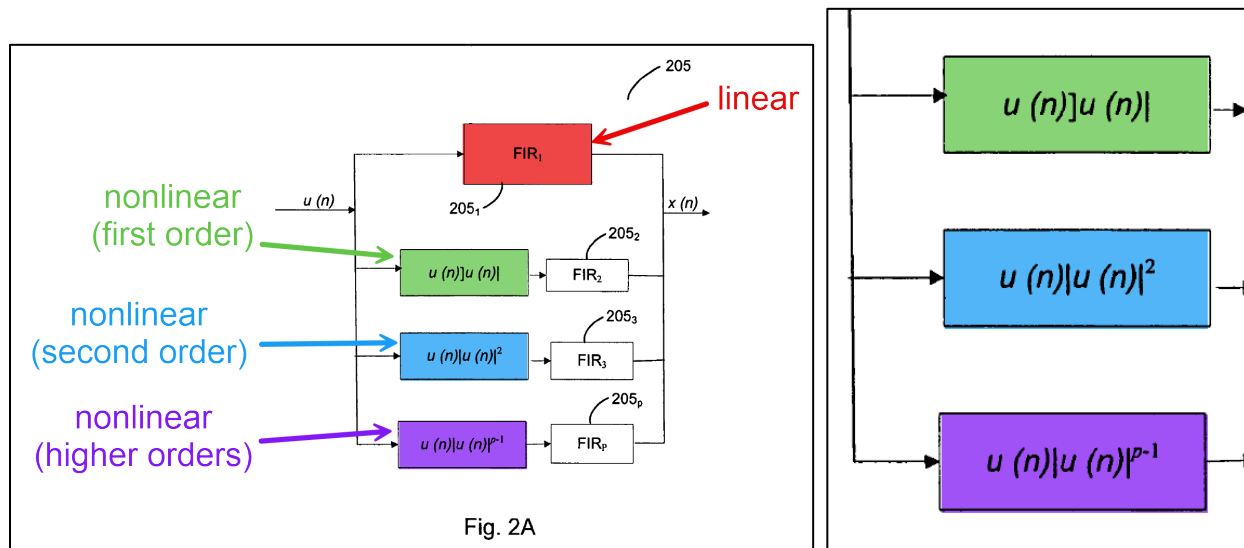
7.3 “dynamic nonlinear first order predistorter module” (Claims 15, 19)

62. In my opinion, a POSITA at the time of the '561 Patent's filing would have understood a “dynamic nonlinear first order nonlinear predistorter module” to

⁷ This reference is a citation to Kang at pages 522-26.

mean “a dynamic predistortion module that includes a nonlinear function with a first-power exponent.”⁸

63. First, the specification matches this construction. Figure 2A “depicts one example embodiment of implementation of a DWNL module[,],” where the DWNL is “implemented as a finite impulse response (FIR) filter-based *multi-branch non-linear structure*”:



(’561 Patent, 4:24-41, Fig. 2A (annotated and enlarged) (note “|” typo in magnitude for first-order function).) The “linear FIR filter” is shown in the red box. (’561 Patent, 4:28-33 (“DWNL module 200 includes a number of parallel branches in

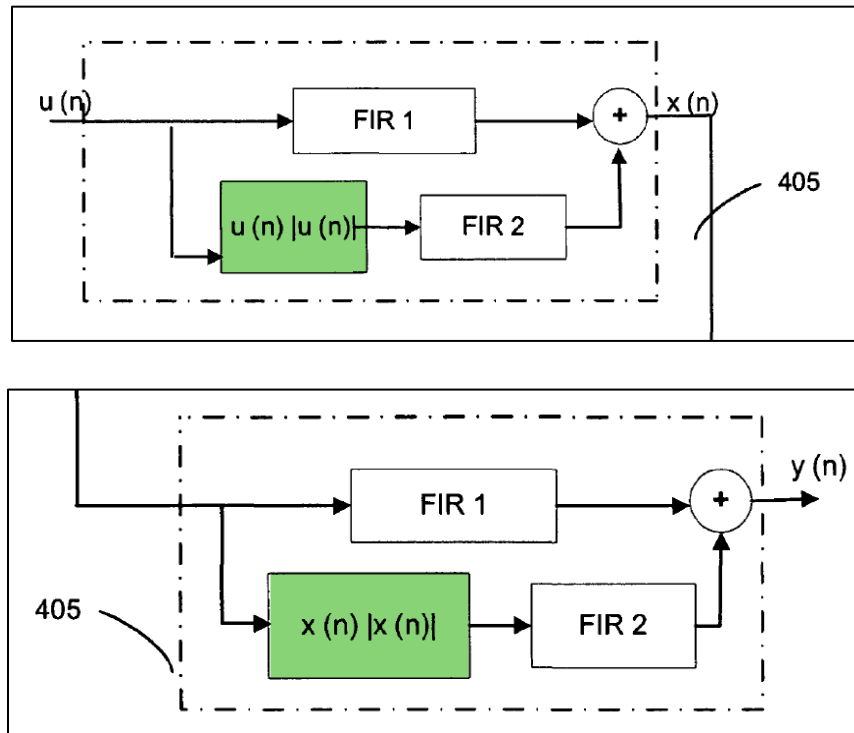
⁸ Any value raised to its first power is equal to the original value (e.g., $x^1 = x$), so the first-order exponent is often not included in functions, as is the case in Figure 2A.

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which the first branch includes a linear FIR filter 205₁ . . .”).) The nonlinear FIR filters are below the linear FIR filter. (’561 Patent, 4:28-33 (“ . . . in the parallel branches, the input signal $u(n)$ is multiplied by its magnitude $|u(n)|$, in order to generate even-order and odd-order distortions that will be applied to FIR filters 205₂-205_p.”).) The “order” of the input signal’s magnitude is equal to its exponent, so the function highlighted in blue is “second-order” because it is raised to the second power. Because the function in green is raised to the implied power of one (that is, no exponent is shown and therefore to the first power), that function is “first-order.”⁹

64. Figures 4A and 4B confirm the understanding that the function $u(n)|u(n)|$ is a “nonlinear first order” function because the nonlinear term ($|u(n)|$) is raised to the first power. Because an equation’s order is equal to the term having the highest exponent, the figure below depicts a first order system with respect to the nonlinear term (the absolute value term, $|u(n)|$). The specification confirms that both figures show a “first-order” model, and only the first-order nonlinear function (highlighted in green) is shown in the figures:

⁹ The functions highlighted in blue and purple in Fig. 2 describes all orders above the first-order, but these may not be needed. (’561 Patent, 4:33-41 (“In some embodiments, a limited number of branches are enough to obtain an accurate memory effect model because only weak nonlinearities modeled.”).)



(’561 Patent, 3:1-7, Figs. 4A (top, annotated), 4B (bottom, annotated).)

8. Overview of the Prior Art

8.1 Lui

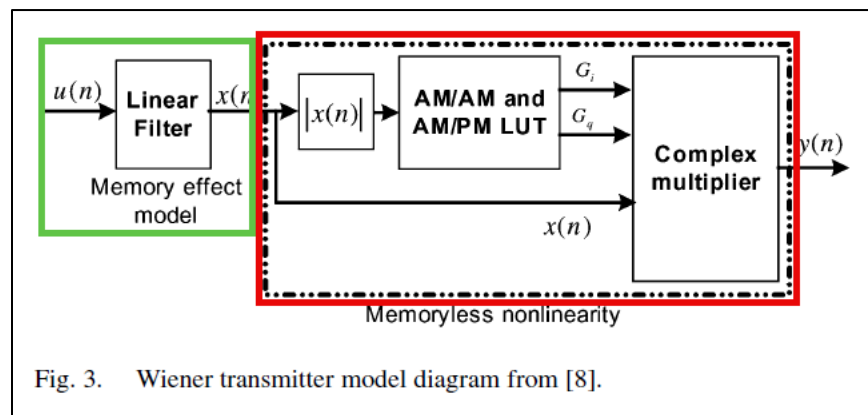
65. Lui was published in November 2005. (Lui, 3578.) Lui has the exact same three authors as the ’561 Patent’s named inventors, so it is unsurprising that Lui identifies the same issue as the ’561 Patent using nearly identical language (underlined below):

’561 Patent	Lui
There are several prior art models of dynamic nonlinear systems. However, one common problem of such <u>models is in the identification procedure of the parameters of their different modules.</u> Furthermore, the known <u>models and</u>	The common difficulty for the previous <u>models is in the identification procedure of the parameters of their different modules.</u> The above-mentioned <u>models and procedures encounter high complexity and/or low accuracy. In</u>

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<u>procedures encounter high complexity and/or low accuracy.</u> Moreover, they frequently do not account for the strong memory effects exhibited by the transmitter/PA. Thus, <u>in most cases, they are not appropriate for implementation in broadband adaptive communications systems.</u> (’561 Patent, 1:42-52.)	<u>most cases, they are not appropriate for implementation in adaptive communications systems.</u> (Lui, 3579.)
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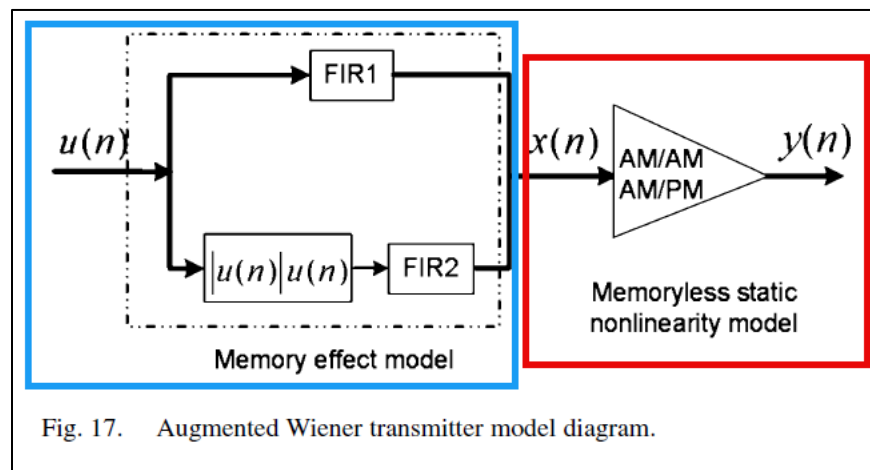
66. Lui proposes “a new augmented Wiener model that is capable of accurately modeling wide-band RF transmitters[.]” (Lui, 3578-79. *See also id.* at 3578-79.) Lui’s Figure 3 shows a “Wiener transmitter model diagram” from the prior art:



(Lui, 3580, Fig. 3.) This model consists “of a **dynamic linear filter** [annotated in green] followed by a static nonlinear block [annotated in red][.]” (Lui, 3580, Fig. 3.) In other words, this previous Wiener model’s dynamic module accounted only for *linear* distortion sources – as opposed to *nonlinear* distortion sources.

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67. Lui criticizes the “linear FIR filter in the Wiener model” for precisely this limitation: it “takes into account the frequency response around the carrier frequency (linear distortion) and not the nonlinear even-order distortion sources.” (Lui, 3584.) Lui’s proposed model addresses this alleged shortcoming by adding a dynamic **nonlinear** model, which is shown in the blue box in Figure 17:



(Lui, Fig. 17 (annotated).) This “augmented” dynamic model includes the same “linear FIR filter” as in the prior art (FIR1), but also adds “a new parallel branch” where “the input signal $u(n)$ is multiplied by its magnitude $|u(n)|$ and applied to another FIR filter [FIR2]” to create “a **weak nonlinear dynamic** FIR-based filter.” (Lui, 3585, Fig. 17. *See also id.* (“The second-order terms are introduced to the dynamic memory-effect model in such a way as to make it able to mimic memory effects more accurately.”).)

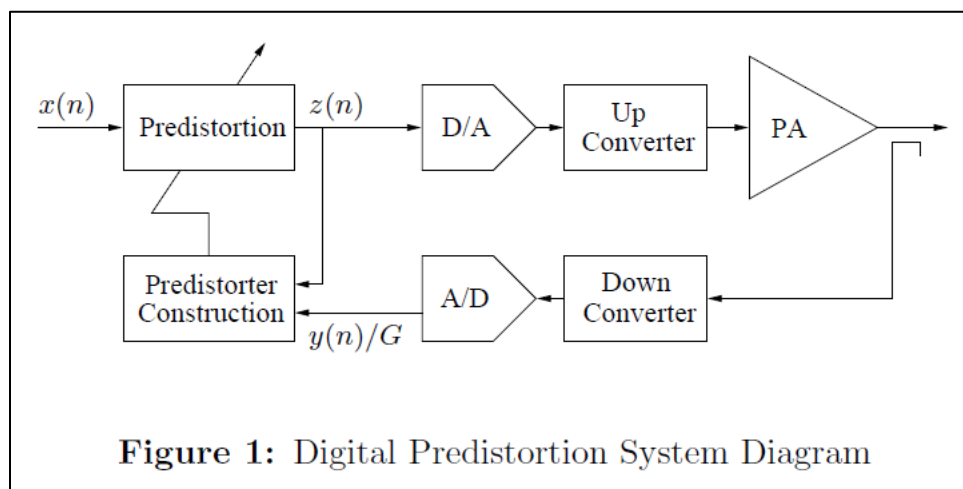
68. Lui’s proposed model is, like the ’561 Patent, “a cascade of a **dynamic weak nonlinear** model and a strong nonlinear static model.” (Lui, 3585.) As with

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the '561 Patent, the DWNL module (shown in blue above) is “a weak *nonlinear* dynamic FIR-based filter” that is a “memory-effect model, which takes into account the dynamic properties of the transmitters in the presence of the modulated communications signal[,]” where “second-order terms are introduced to the dynamic memory-effect model in such a way as to make it able to mimic memory effects more accurately.” (Lui, 3585.) Also as with the '561 Patent, the SSNL module (shown in red above) is “based on the smoothed AM/AM and AM/PM characteristics of the transmitters,” and “is normally implemented by using lookup tables.” (Lui, 3585.)

8.2 Ding

69. Ding is a 2004 Ph.D. thesis that, among other things, “propose[s] novel predistorters and their parameter extraction algorithms.” (Ding, xiii.) Ding states that “among all linearization techniques, digital predistortion is one of the most cost effective[,]” and shows a basic “Digital Predistortion System” at Figure 1:

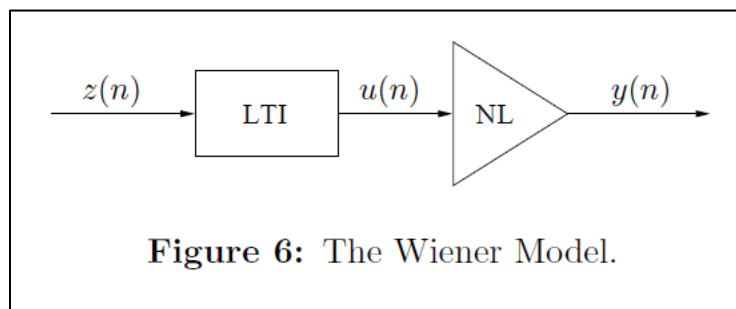


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(Ding, 1, Fig. 1.) Ding also acknowledges that, because “the power amplifier characteristics may change over time because of temperature drift, component aging, etc.[,]” “the predistorter should also have the ability to adapt to these changes.” (Ding, 1-2.)

70. Like the '561 Patent and Lui, Ding focuses on the dynamic, memory-based distortions. Ding criticizes “[d]igital predistortion implementations in the current literature” because they focus on the static predistortion module (i.e., “on the power amplifier that has a **memoryless nonlinearity**; i.e., the current output depends only on the current input through a nonlinear mechanism”), and contends that “digital predistorters also need to have memory [i.e., dynamic] structures.” (Ding, 2.)

71. Ding discloses several dynamic structures for predistorters, including those found within Wiener and Hammerstein models. (Ding, 11-13, Figs. 6, 7.) “The Wiener model is a linear time-invariant (LTI) [dynamic linear] system followed by a memoryless [static] nonlinearity (NL)[,]” and shown in Figure 6:



(Ding, 11-12, Fig. 7.) The formulas underlying a Wiener model are below:

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$$u(n) = \sum_{l=0}^{L-1} a_l z(n-l), \quad (13)$$

$$y(n) = \sum_{\substack{k=1 \\ k \text{ odd}}}^K b_k u(n) |u(n)|^{k-1}, \quad (14)$$

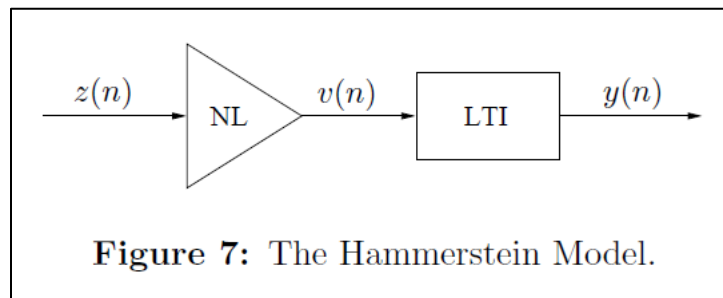
where a_l are the impulse response values of the LTI block and b_k are the coefficients of the odd-order polynomial describing the memoryless nonlinearity. Substituting (13) into (14) gives

$$y(n) = \sum_{\substack{k=1 \\ k \text{ odd}}}^K b_k \left[\sum_{l=0}^{L-1} a_l z(n-l) \right] \left| \sum_{l=0}^{L-1} a_l z(n-l) \right|^{k-1}. \quad (15)$$

The Wiener model was used by Clark *et al.* [11] to model the power amplifier with memory effects, where improvements in modeling accuracy were observed when the Wiener model replaces the memoryless polynomial model.

(Ding, 11.)

72. Ding teaches that “To construct a Hammerstein predistorter, the approach taken by [Kang] uses a gradient method *to first identify the Wiener system and then find the Hammerstein predistorter as its inverse.*” (Ding, 17.) “The Hammerstein model is a memoryless nonlinearity followed by an LTI system[,]” and shown in Figure 7:



(Ding, 12-13, Fig. 7.) The formulas underlying a Hammerstein model are below:

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The Hammerstein model is a memoryless nonlinearity followed by an LTI system (see Fig. 7). The two subsystems in this model are described by

$$v(n) = \sum_{\substack{k=1 \\ k \text{ odd}}}^K b_k z(n) |z(n)|^{k-1}, \quad (16)$$

$$y(n) = \sum_{l=0}^{L-1} c_l v(n-l), \quad (17)$$

where b_k are the coefficients for the memoryless nonlinearity and c_l are the impulse response values of the LTI system. Substitution of (16) into (17) leads to

$$y(n) = \sum_{l=0}^{L-1} c_l \sum_{\substack{k=0 \\ k \text{ odd}}}^K b_k z(n-l) |z(n-l)|^{k-1}. \quad (18)$$

(Ding, 13.)

9. Grounds of Unpatentability

73. I am informed by Counsel that Claims 1-22 of the '561 Patent are challenged. As explained below, an element-by-element analysis of the Challenged Claims demonstrates that they are disclosed or taught by the prior art.

9.1 Ground 1: Claims 1 and 4-6 Are Rendered Obvious by Lui and Further in View of a POSITA

74. In my opinion, Claims 1 and 4-6 would have been obvious to a person of ordinary skill at the time of the '561 Patent's filing. Specifically, it would have been obvious for a POSITA to try a simple modification to make the DWNL and SSNL modules "characterize" the "dynamic nonlinear" and "static nonlinear" characteristics of the system, respectively.

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75. Lui itself implies that predistorters and their models seek to characterize nonlinear characteristics of a system before attempting to correct them. Specifically, Lui states that “the dynamic weak nonlinear model is composed of the new inclusive memory-effect model, which takes into account the *dynamic properties of the transmitters* in the presence of the modulated communications signal[,]” and a POSITA would have understood “properties” in this context to refer to the transmitter’s “characteristics.” (Lui, 3585.) With regard to the static module, Lui states that “static nonlinearity can be characterized by the lookup tables based on the AM/AM and AM/PM curves of the transmitter” in prior art static modules, which are used in predistorters. (Lui, 3580.) As discussed above, Lui also discloses characterizing the transmitters with regard to static nonlinearity. (Lui, 3585 (“[t]he strong nonlinear model, based on the smoothed AM/AM and AM/PM *characteristics* of the transmitters, is normally implemented by using lookup tables.”).)

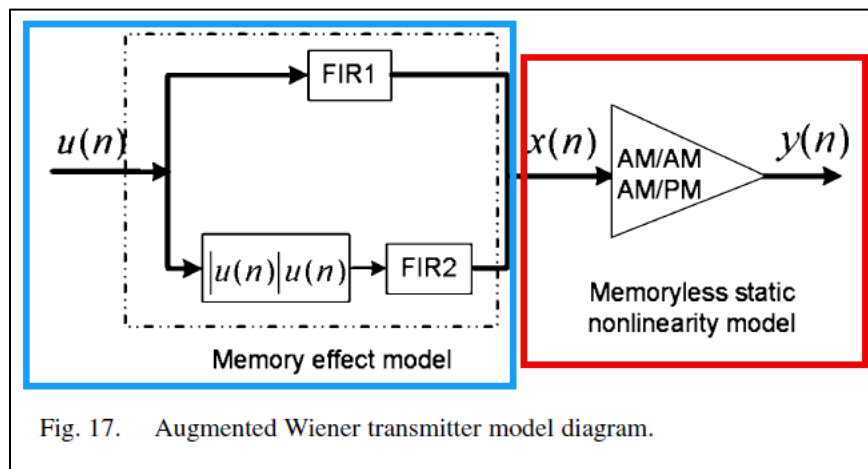
76. Accordingly, one of ordinary skill in the art reading Lui would have found it obvious to ensure that the reference’s DWNL and SSNL both take into account and also characterize the claimed “dynamic nonlinear” and “static nonlinear” characteristics of the system.

77. Accordingly, in my opinion, Claims 1 and 4-6 are therefore rendered obvious in view of Lui.

9.1.1 Claim 1

9.1.1.1 1[pre] A behavioral model of a nonlinear dynamic system, the model comprising:

78. To the extent that preambles are limiting, it is my opinion that Lui discloses the preamble's limitations. After criticizing other proposed solutions in the prior art, Lui states that it is presenting "a new augmented Wiener model that is capable of accurately modeling wide-band RF transmitters in a 3G context[.]" (Lui, 3578-79.) Lui calls this new behavioral model an "Augmented Wiener *Behavioral Model*," and it includes both DWNL (blue) and SSNL (red) modules:

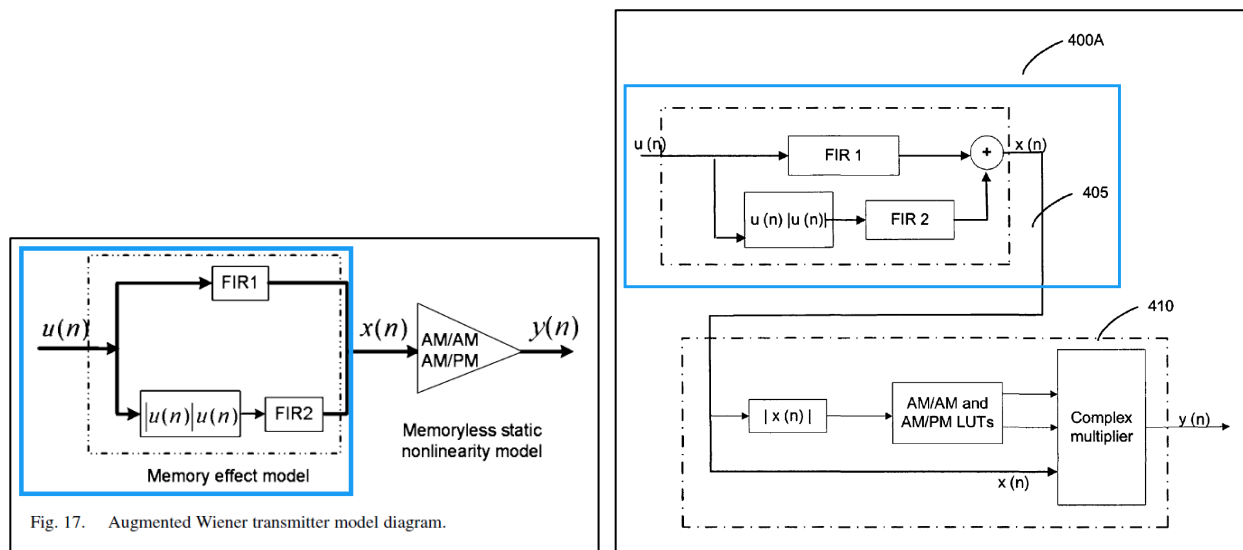


(Lui, 3584-85, Fig. 17.) Lui discloses modeling a dynamic nonlinear system: "The *dynamic weak nonlinear model* is composed of the new inclusive *memory-effect model*, which takes into account *the dynamic properties of the transmitters* in the presence of the modulated communications signal." (Lui, 3586, Fig. 17. See also Lui, 3579 (the "new comprehensive memory-effect model" "is able to account for linear distortion (frequency response near the carrier) and weak *nonlinear distortion*

due *to baseband frequency response, harmonic loading conditions, and trap effects that might occur in semiconductor devices.*”).) In my opinion, this limitation is met.

9.1.1.2 1[a] a first module characterizing dynamic nonlinear characteristics of the system, wherein the first module includes an input and an output; and

79. In my opinion, Lui’s behavioral model includes a first module that one of ordinary skill would have understood to, or at a minimum found it obvious to, characterize dynamic nonlinear characteristics of the system. This module is the DWNL module, is annotated in blue below (left), and substantially mirrors the ’561 Patent’s Figure 4A below (right):

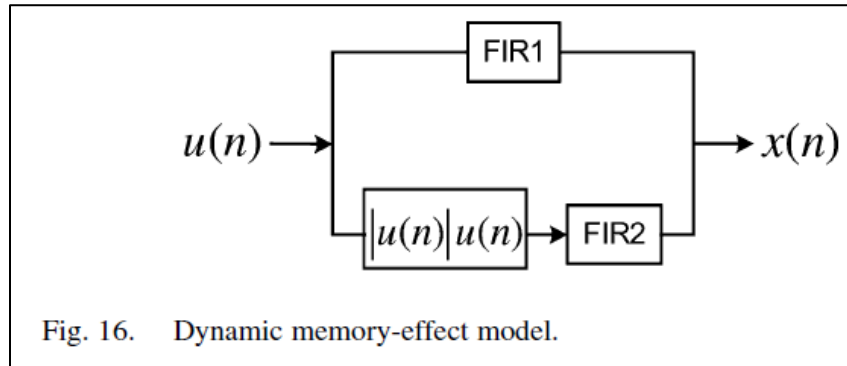


(Lui, 3584-85, Fig. 17; ’561 Patent, 6:14-17 (“FIG, 4A illustrates an 15 example embodiment of the augmented Wiener predistorter. The predistorter 400A includes a *DWNL module 405* followed by a SSNL module 410.”), 3:1-3 (“FIG. 4A is a

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schematic diagram of one example embodiment of an augmented Wiener predistorter implemented using first-order forward LBG model[.]”), Figs. 1A, 4A.)

Lui’s Figure 16 reproduces the DWNL module on its own:

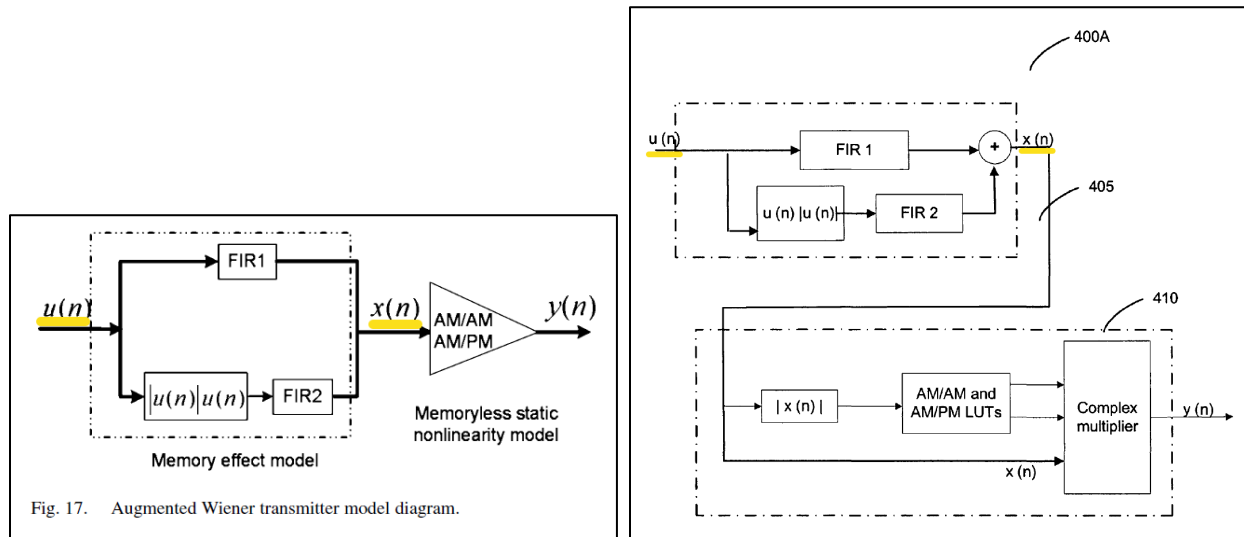


(Lui, 3584-85, Fig. 16.)

80. Both Figures 16 and 17 show the DWNL module’s FIR2 filter, which represents “a weak nonlinear dynamic FIR-based filter” that allow the DWNL module “to *mimic memory effects more accurately.*” (Lui, 3585-86, Figs. 16, 17.) The DWNL module’s “new inclusive memory-effect model” “*takes into account the dynamic properties of the transmitters* in the presence of the modulated communications signal.” (Lui, 3585, Figs. 16, 17.) By mimicking the system’s memory effects and taking into account the dynamic properties of transmitters, one of ordinary skill would have understood and found it obvious to ensure that the DWNL module characterizes dynamic nonlinear characteristics of the system.

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81. In my opinion, this DWNL module also includes an input and an output, underlined in yellow below (left), and Figure 4A below (right) of the '561 Patent shows identical inputs and outputs to the DWNL module:



(Lui, 3584-85, Fig. 17; '561 Patent, 3:1-3, 6:14-17, Figs. 1A, 4A.) The DWNL module's input and output are also described in Lui's Equation 21:

B. Augmented Wiener Model Identification

Assuming that the two FIR filters have M_1 and M_2 taps, respectively, the input signal $u(n)$ and output signal $x(n)$ of the dynamic filter block in Fig. 17 can be written as follows:

$$x(n) = \sum_{i=0}^{M_1-1} a_i u(n-i) + \sum_{i=0}^{M_2-1} b_i |u(n-i)| u(n-i) \quad (21)$$

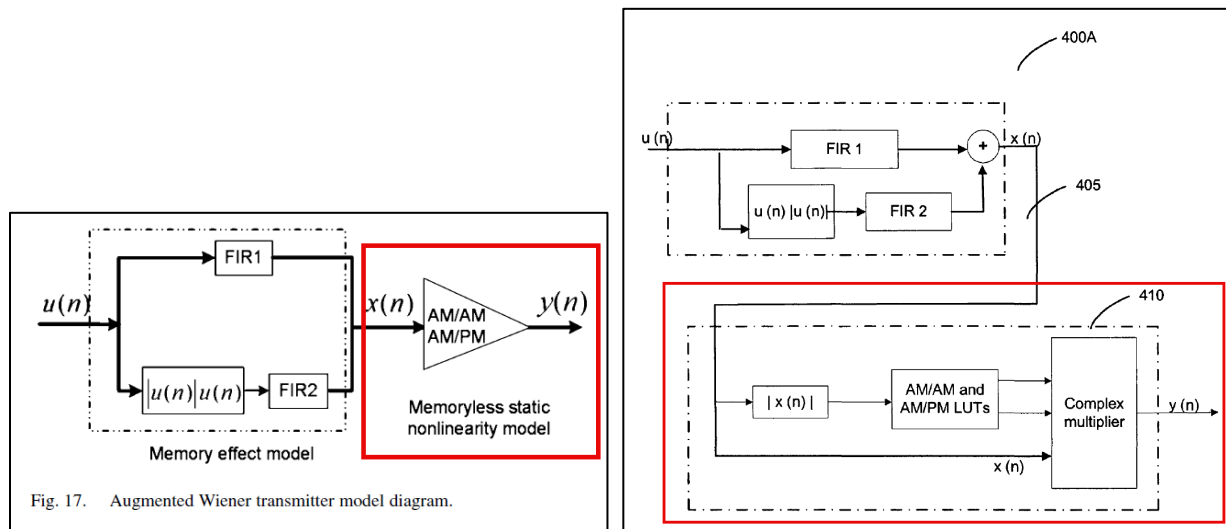
where M_1 and M_2 denote the memory depth of the model.

(Lui, 3586.) In my opinion, this limitation is met.

**9.1.1.3 1[b] a second module characterizing static
nonlinear characteristics of the nonlinear system,**

wherein the second module includes an input and an output;

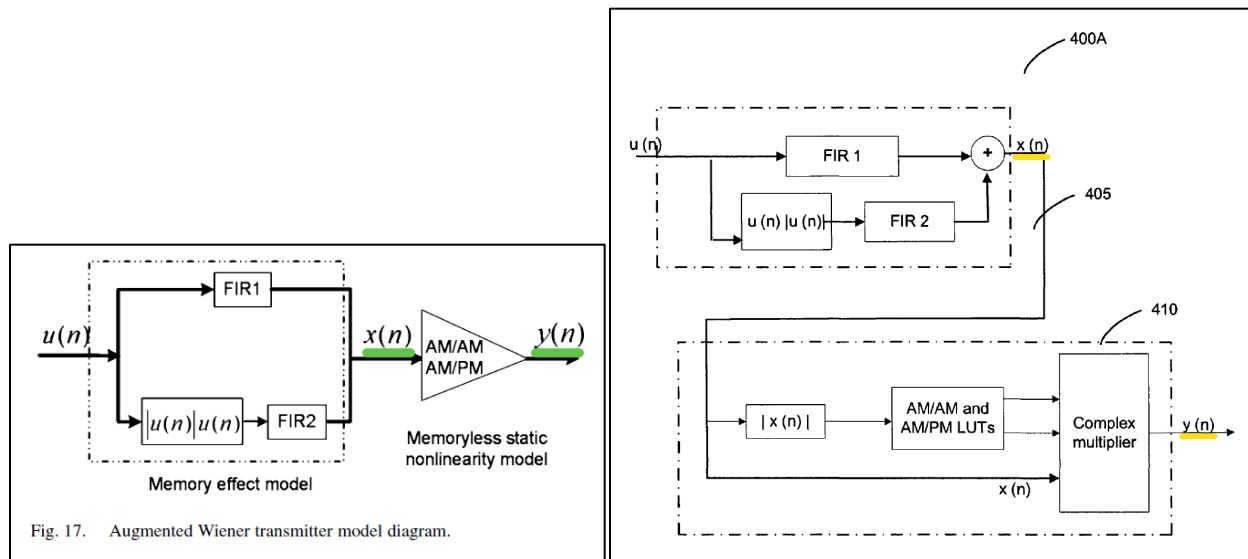
82. In my opinion, Lui discloses a second module that one of ordinary skill would have understood to characterize static nonlinear characteristics of the system. This module is the SSNL module (annotated in red below (left)), and the '561 Patent's Figure 4A below (right) likewise shows an SSNL module with AM/AM and AM/PM lookup tables:



(Lui, 3584-85, Fig. 17; '561 Patent, 6:14-17 ("FIG. 4A illustrates an example embodiment of the augmented Wiener predistorter. The predistorter 400A includes a DWNL module 405 followed by a **SSNL module 410**."), 3:1-3 ("FIG. 4A is a schematic diagram of one example embodiment of an augmented Wiener predistorter implemented using first-order forward LBG model[.]").), Figs. 1A, 4A.) Lui's SSNL module is a "[m]emoryless static nonlinear model," and thus characterizes the static nonlinear characteristics of the nonlinear system. (Lui, 3584-

85, Fig. 17.) Lui states that “[t]he strong nonlinear model, based on the smoothed AM/AM and AM/PM characteristics of the transmitters, is normally implemented by using lookup tables[,]” and its use of lookup tables confirms that the SSNL module characterizes the static nonlinear characteristics. (Lui, 3585, Fig. 17.)

83. In my opinion, this SSNL module also includes an input and an output, underlined in green below (left), and Figure 4A below (right) of the ’561 Patent shows identical inputs and outputs to the SSNL module:



(Lui, 3584-85, Fig. 17; ’561 Patent, 3:1-3, 6:14-17, Figs. 1A, 4A.) In Figure 17, the SSNL module takes as input the DWNL module’s output. Lui states that Equation 2 describes the function of the SSNL, and both input $x(n)$ and output $y(n)$ are present:

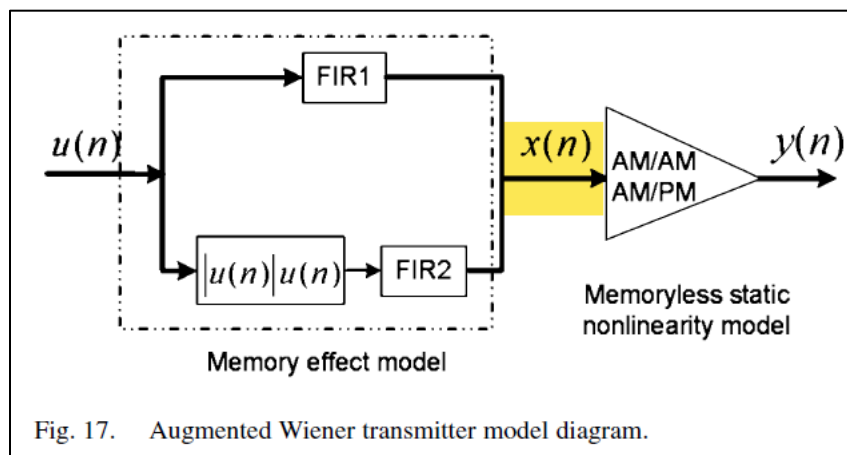
$$y(n) = (G_i + jG_q)x(n) = Gx(n) \quad (2)$$

where $G = G_i + jG_q$ denotes the memoryless complex gain of the transmitter that depends only on the instantaneous magnitude of $x(n)$,

(Lui, 3580, 3585 (“After removing the strong static nonlinearity using [Equation] (2) . . .”), Fig. 2 (omitting description of other equation).) In my opinion, this limitation is met.

9.1.1.4 1[c] wherein the first module is coupled to the second module.

84. In my opinion, Lui shows the first (DWNL) module coupled to the second (SSNL) module. This coupling is shown in Figure 17, where the output of the DWNL module is fed into the SSNL module as input:



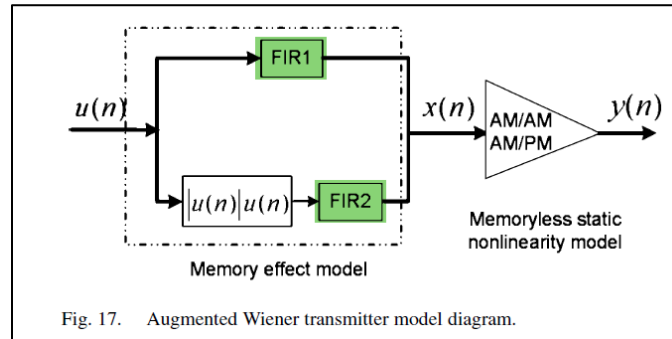
(Lui, 3584-85, Fig. 17.) Lui refers to its model as “a cascade of a dynamic weak nonlinear model and a strong nonlinear static model.” (Lui, 3585.) Lui also discusses the DWNL module performing its function before passing its output to the SSNL module. (See Section 9.1.1.2.) In my opinion, this limitation is met.

9.1.2 Claim 4

Claim 4. The model of claim 1 wherein the first module comprises a nonlinear finite impulse response-based memory effect system and the second module comprises a look-up table-based nonlinear memoryless system.

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85. In my opinion, Lui's model's first (DWNL) module includes "a nonlinear finite impulse response-based memory effect system[.]" The finite impulse response (FIR) elements are highlighted in green in Figure 17 below:



(Lui, 3579 ("finite impulse response (FIR) filter"), 3584-85, Fig. 17.) Lui's Equation 21 shows that the FIRs include "M1 and M2 taps" that "denote the memory depth of the model":

B. Augmented Wiener Model Identification

Assuming that the two FIR filters have M_1 and M_2 taps, respectively, the input signal $u(n)$ and output signal $x(n)$ of the dynamic filter block in Fig. 17 can be written as follows:

$$x(n) = \sum_{i=0}^{M_1-1} a_i u(n-i) + \sum_{i=0}^{M_2-1} b_i |u(n-i)| u(n-i) \quad (21)$$

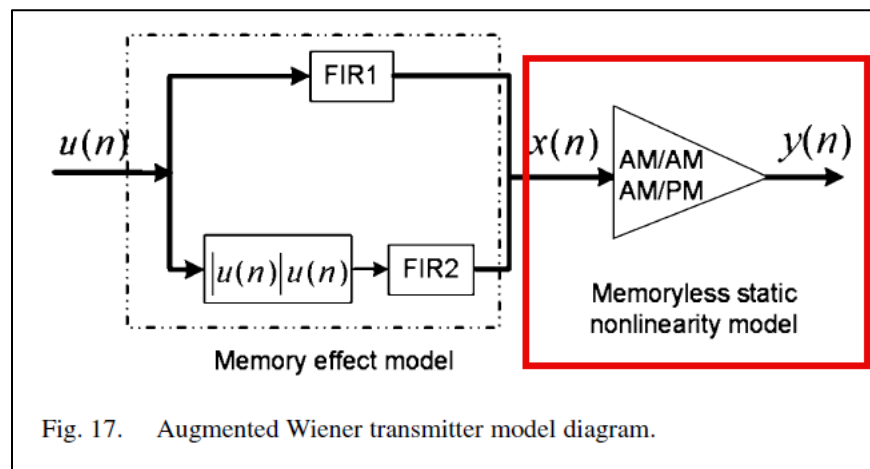
where M_1 and M_2 denote the memory depth of the model.

(Lui, 3585 ("The dynamic weak nonlinear model is composed of the new inclusive *memory-effect* model, which takes into account the dynamic properties of the transmitters in the presence of the modulated communications signal.").) The first term of Equation 21 (also the top branch in Figure 17) comprises FIR1, and is "linear" because the input signal is not multiplied by itself $[u(n-i)]$; whereas the second term

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of Equation 21 (the lower branch of Figure 17) above is a nonlinear FIR system, because it is the combination of a non-linear function $[|u(n)| * u(n)]$ as an input to a FIR filter (FIR2 of Fig. 17). Thus the second branch of Figure 17 results in a nonlinear FIR system because the combination is “nonlinear”: the input signal is multiplied by its magnitude $[|u(n - i)|u(n - i)]$, and filtered using FIR2. In other words, each of FIR1 and FIR2 are LTI systems by themselves, but FIR2 is made a nonlinear system because of its input.

86. In my opinion, Lui’s model’s second (SSNL) module includes “a look-up table-based nonlinear memoryless system.” Lui’s Figure 17 shows a “[m]emoryless static *nonlinearity* module”:



(Lui, 3584-85 (“The strong nonlinear model, based on the smoothed *AM/AM* and *AM/PM* characteristics of the transmitters, is normally implemented by using *lookup tables*.”), Fig. 17.) In my opinion, this limitation is met.

9.1.3 Claim 5

Claim 5. The model of claim 1 wherein the first module is a dynamic weak nonlinear model and the second module is a static strong nonlinear model.

87. Claim 5 requires a **dynamic weak** nonlinear module and a static **strong** nonlinear module – Lui discloses both, in my opinion. First, Lui discloses a dynamic weak nonlinear module:

- “the linear FIR filter in the conventional Wiener model, as described in Section V, is replaced by a **weak nonlinear dynamic** FIR-based filter.” (Lui, 3585.)
- “This augmented Wiener model is a cascade of a **dynamic weak nonlinear model** and a strong nonlinear static model.” (Lui, 3585.)
- “The **dynamic weak nonlinear model** is composed of the new inclusive memory-effect model, which takes into account the dynamic properties of the transmitters in the presence of the modulated communications signal.” (Lui, 3585.)
- “. . . an augmented Wiener model has been proposed, where the linear FIR filter is replaced with a **weak** nonlinear filter structure.” (Lui, 3586.)

(See also Section 9.1.1.2.) Second, Lui discloses a static strong nonlinear module:

“This augmented Wiener model is a cascade of a dynamic weak nonlinear model and a **strong nonlinear static model**. The **strong nonlinear model**, based on the smoothed AM/AM and AM/PM characteristics of the transmitters, is normally implemented by using lookup tables.

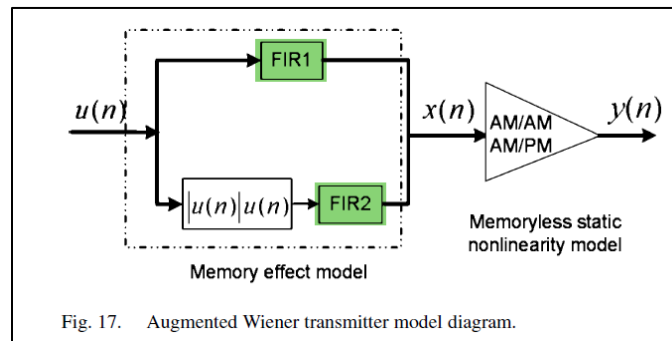
(Lui, 3585. See also Section 9.1.1.3.) In my opinion, this limitation is met.

9.1.4 Claim 6

Claim 6. The model of claim 1 wherein the first module comprises a finite impulse response filter-based multi-branch nonlinear system and the second module comprises two look-up tables, each look-up table dependent on the magnitude of the input signal.

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88. In my opinion, as discussed in Section 9.1.2 with regard to Claim 4, Lui discloses a DWNL module that includes a FIR filter. Claim 6 adds that the module must include “a finite impulse response filter-based multi-branch nonlinear system[,]” and Lui discloses such a system. As shown in Figure 17, the DWNL module includes multiple branches, each with its own FIR filter:



(Lui, 3579 (“finite impulse response (FIR) filter”), 3584-85, Fig. 17.) As discussed above, the DWNL module is a nonlinear system. (See Section 9.1.1.2.)

89. In my opinion, as discussed above in Section 9.1.2 with regard to Claim 4, Lui discloses a SSNL module that uses two lookup tables. Those two lookup tables use the input signal’s (1) AM (amplitude modulation) to lookup a corresponding respective AM (amplitude modulation) and (2) PM (phase modulation) to use while predistorting the signal. (See Lui, 3579 (discussing, with respect to the prior art, “the output of the memoryless transmitter model only depends on the magnitude of the current input signal, this model is represented by the transmitter amplitude-modulation/amplitude-modulation (AM/AM) and

amplitude-modulation/phase-modulation (AM/PM) lookup table model in this work.”).) Lui further discloses the inputs of the look-up tables. (Lui, 3581 (“These entries encompass the in-phase and the quadrature components (G_i and G_q) of the complex compression gain corresponding to different magnitude values of $x(n)$.”).) These inphase and quadrature values correspond to real and imaginary complex number representation of AM/AM (gain) and AM/PM (phase) tables. In my opinion, this limitation is met.

9.2 Ground 2: Claims 2, 7-10 and 15-18 (Claims Directed to Weiner Models and Predistorters) Are Rendered Obvious by Lui and Further in View of a POSITA

90. Claims 2, 7-10 and 15-18 (the “Weiner Claims”) are expressly directed to Weiner models and predistorters, or those predistorters where the dynamic module is followed by a static module. In my opinion, as discussed below, it would have been obvious to a person of ordinary skill in the art to implement Lui’s proposed structure: an augmented Weiner arrangement.

9.2.1 Claim 7

9.2.1.1 7[pre] A predistorter for nonlinear wireless system, the predistorter comprising:

91. To the extent the preamble is limiting, Claim 7 recites a “predistorter” while Claim 1 recites a “behavioral model,” but these two elements are interrelated because a predistorter uses a behavioral model to perform its function. (’561 Patent, 1:57-60 (“Also disclosed are various implementation of the *behavioral model for*

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purpose of baseband predistortion of dynamic nonlinear systems . . .”). *See also* Section 9.1.1.1.)

Claim 1	Claim 7
1[pre] A <u>behavioral model</u> of a <u>nonlinear dynamic system</u> , the model comprising:	7[pre] A <u>predistorter for nonlinear wireless system</u> , the predistorter comprising:

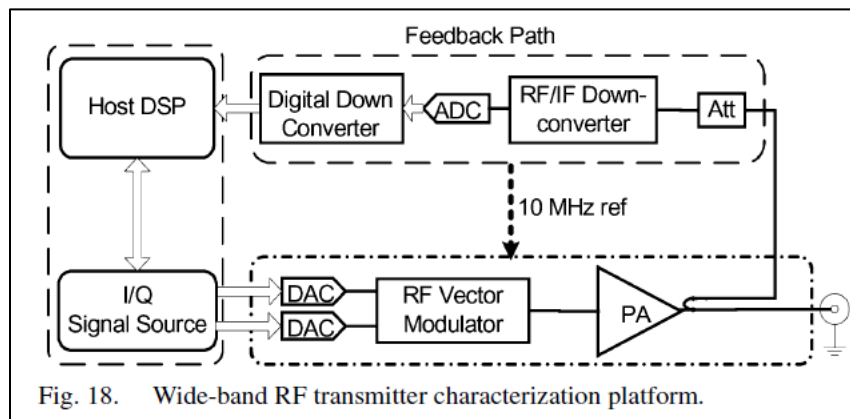
Lui states that it proposes “a robust *modeling technique* for *memoryless wide-band radio frequency transmitters*.” (Lui, 3578.) Such transmitters regularly use predistorters.

92. Lui further discloses building a predistorter that uses and validates its model. (Lui, 3585 (“VII. Experimental Setup and Newly Proposed Model Validation”).). “The validation of the newly proposed model was carried out by *preceding the transmitter with its memoryless nonlinear inverse function*[.]” which describes the predistortion technique of inverting the model to anticipate the PA’s distortive effects. (Lui, 3585 (“VII. Experimental Setup and Newly Proposed Model Validation”).) Moreover, a POSITA would understand that “annulling” the distortion from the test transmitter based upon inverting a model is describing predistortion. (Lui, 3579 (“annulling the spectrum regrowth caused by the static nonlinearity, so as to validate the performance of the Wiener models in the prediction of memory effects”), 3586 (“based on annulling the spectrum regrowth that is caused

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by static nonlinearity with the help of cascading the inverse of the complex memoryless model”).)

93. Furthermore, the performance of Lui’s model as a whole was assessed for its purported effectiveness in a predistorter. (Lui, 3586 (“the effectiveness of the proposed augmented Wiener model and its identification procedure was assessed” . . . “The spectrum comparison results between the different transmitter models and the transmitter prototype reveal that the proposed augmented Wiener transmitter model outperforms other models”).) “The wide-band RF transmitter characterization platform used in this study is shown in Fig. 18”:



(Lui, 3585, Fig. 18.) In my opinion, this limitation is met.

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9.2.1.2 7[b]¹⁰ a static nonlinear predistorter module;

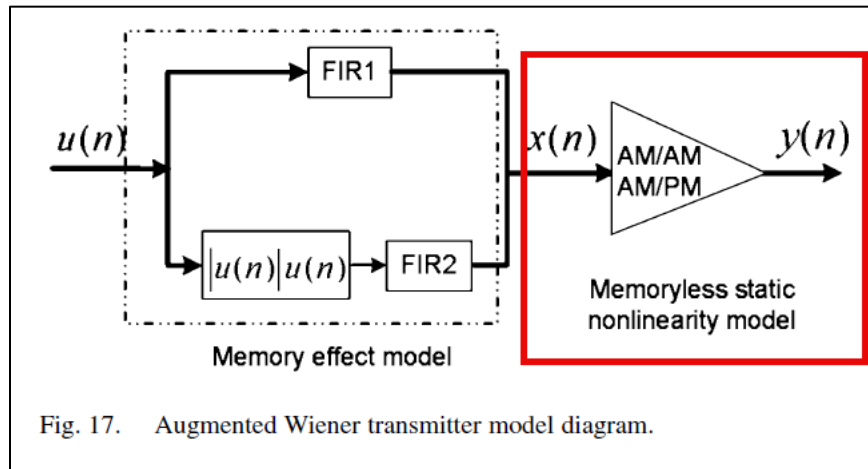
94. Limitation 7[b] recites “a static nonlinear predistorter module,” whereas Claim 1 recites a module that characterizes “static nonlinear characteristics of the nonlinear system”:

Claim 1	Claim 7
1[b] a second <u>module characterizing static nonlinear characteristics of the nonlinear system</u> , wherein the second module includes an input and an output;	7[b] a <u>static nonlinear predistorter module</u> ;

Here, the difference between Claims 1 and 7 is the same as discussed in Section 9.2.1.1: Claim 1 is directed to the predistorter’s model, whereas Claim 7 is directed to the predistorter that uses the model.

95. As discussed in Section 9.2.1.1, Lui discloses the behavioral model as well as a static nonlinear predistorter that uses the behavioral model, and Section 9.2.1.2 describes that predistorter’s function. The static nonlinear predistorter module’s model is shown in Figure 17, and is annotated in red below:

¹⁰ This Section addresses Limitation 7[b] before Limitation 7[a].



(Lui, 3584-85, Fig. 17.)

96. Lui's validation of its behavioral model expressly uses a static predistorter to isolate the memory effects of its proposed augmented Wiener behavioral model. Lui states that "the validation of the newly proposed model was carried out by *preceding the transmitter with its memoryless nonlinear inverse function*[,] which describes using a static (i.e., "memoryless") predistorter. (Lui, 3586.) The purpose of predistorting to address memoryless effects alone was to, "concentrate on the capability of the new model in *predicting memory effects*[(i.e., dynamic effects),]" so Lui could evaluate how well it was modeling the transmitter's memory effects. (Lui, 3586.)¹¹ In my opinion, this limitation is met.

¹¹ With reference to Figures 19 and 20, Lui concludes that its proposed model "can predict the memory effects of the transmitter more accurately than the conventional Wiener model." (Lui, 3586.)

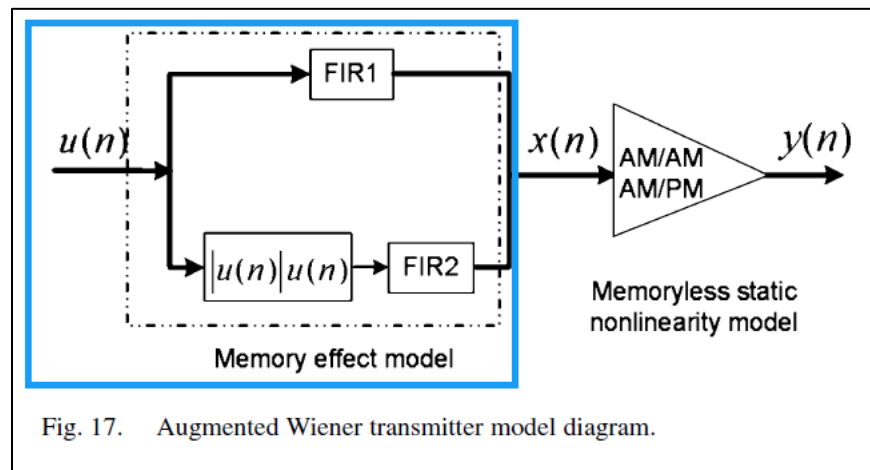
9.2.1.3 7[a] a dynamic nonlinear predistorter module; and

97. Limitation 7[a] recites a “dynamic nonlinear predistorter module,” whereas Claim 1 recites a “module” that characterizes “dynamic nonlinear characteristics of the system”:

Claim 1	Claim 7
1[a] a first <u>module characterizing dynamic nonlinear characteristics of the system</u> , wherein the first module includes an input and an output; and	7[a] a <u>dynamic nonlinear predistorter module</u> ; and

Here, the difference between Claims 1 and 7 is the same as discussed in Section 9.2.1.1: Claim 1 is directed to the predistorter’s model, whereas Claim 7 is directed to the predistorter that uses the model.

98. As discussed in Section 9.2.1.1, Lui discloses the behavioral model as well as a predistorter that uses the behavioral model, and Section 9.1.1.2 describes the dynamic nonlinear module’s function. The dynamic nonlinear module’s model is shown in Figure 17, and is annotated in blue below:



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(Lui, 3584-85, Fig. 17.) Limitation 7[a] also requires that “the first module includes an input and an output,” which Lui discloses, as discussed in Section 9.1.1.2. In my opinion, this limitation is met.

9.2.1.4 Single-Reference Obviousness Under § 103

99. Although Lui does not expressly disclose a dynamic predistorter, in my opinion, the limitation is obvious under 35 U.S.C. § 103. Specifically, it would have been obvious for a POSITA to use Lui’s dynamic model to build a dynamic predistorter that incorporates the model.

100. A POSITA would have understood that predistorters incorporate models to perform their functions. This is because a predistorter’s model dictates how that component performs its predistortion of an input signal. Indeed, the entire point of Lui was to build a model for use in predistorters.

101. This modification would have been minimal, and achieved with a reasonable expectation of success, because predistorters were already well-known in the art, as Lui acknowledges. (Lui, 3578-79 (surveying the prior art), 3585-86 (building a static predistorter for evaluation of the proposed model), 3586-87 (citing references describing predistorters). *See also* Section 9.2.1.2.) The modification would require only taking Lui’s dynamic model and incorporating it into the predistorter Lui built for validation – or some other predistorter, several common types of which were well-known at the time. (Wang, 2399 (“there are two

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commonly used systems, referred to as the Wiener and Hammerstein nonlinear systems,” and states that these are “*relatively simple subsystems* with structures which *are known a priori*.”), Gilabert, 2 (“the Hammerstein and Wiener models are *two simple but effective possibilities* for describing the PA and/or the predistorter nonlinear behavior taking into account memory effects.”).)

102. In addition, it would have been obvious for a POSITA to try incorporating Lui’s dynamic model into a predistorter to judge the model’s usefulness and build an allegedly better predistorter. Indeed, Lui did something similar by creating a static predistorter to perform its testing and validation of its model. (Lui, 3585-86 (building a static predistorter for evaluation of the proposed model). *See also* Section 9.2.1.2.) Wang likewise shows a POSITA identifying models before building and testing predistorters. (Wang, 2399-403.) Gilabert also shows a POSITA evaluating models, including them in predistorters and examining the results. (Gilabert, 1-4.)

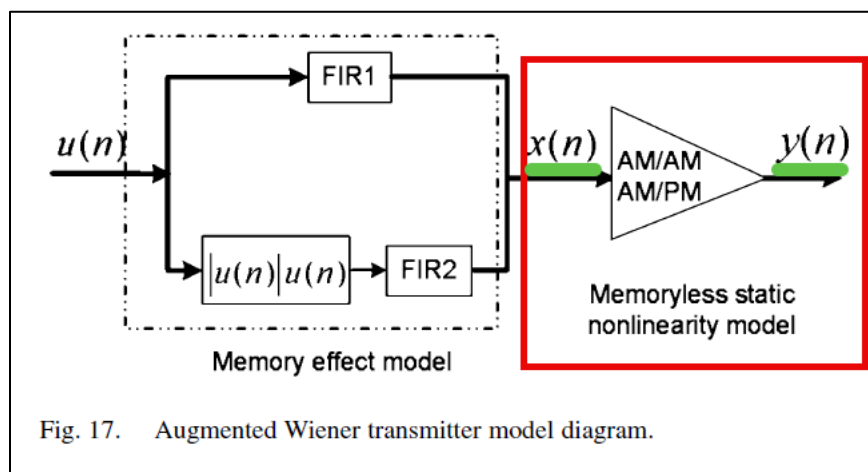
103. Lui suggests that a POSITA should use its dynamic model in a predistorter. This is because Lui contends that the “main objective” of wireless communications “remains ensuring a good quality of signal at the receiver side, the optimization of the channel capacity (in bits per hertz),” and realized that predistortion was a well-known technique to achieve that objective. (Lui, 3578 (“the coexistence of linear and nonlinear distortion sources in the RF transmitter chains

compromises their performances in terms of error vector magnitude and adjacent channel power ratio (ACPR)).) Lui even proposes that its “augmented Wiener model” could be used to improve predistortion. (Lui, 3578 (“The *minimization of the effects of such distortion sources* relies primarily on *accurate modeling of the RF transmitters.*”).) As a result, a POSITA would have used Lui’s proposed augmented Wiener behavioral model with a predistorter address the distortions.

104. In view of the above, in my opinion, it would have been obvious for a POSITA to use Lui to build a predistorter that incorporated Lui’s model.

**9.2.1.5 7[c] [a static nonlinear predistorter module]
coupled to the dynamic nonlinear predistorter
module such that an output of the dynamic
nonlinear predistorter module is input to the static
nonlinear predistorter module.**

105. In my opinion, Lui’s “Augmented Wiener Behavioral Model” has the DWNL module coupled to the SSNL module, as discussed in Section 9.1.1.4. This coupling is shown below in Figure 17:



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(Lui, 3584-85, Fig. 17.)

106. Furthermore, Figure 17 shows the SSNL module taking $x(n)$ as input, which is the DWNL module's output. Lui's Equation 2 also shows the SSNL module taking $x(n)$ as input and:

$$y(n) = (G_i + jG_q)x(n) = Gx(n) \quad (2)$$

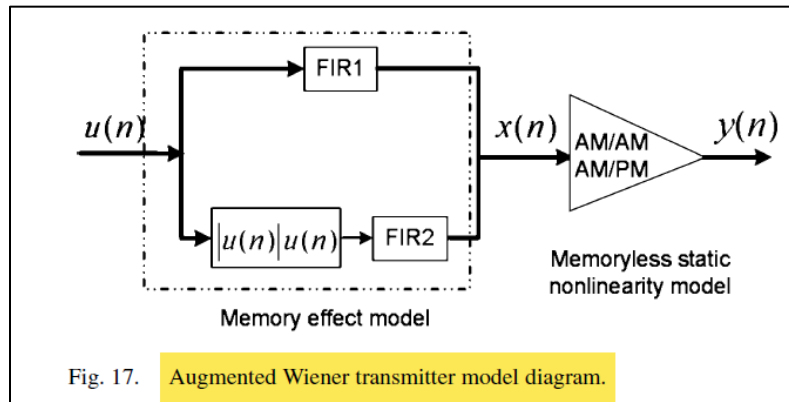
where $G = G_i + jG_q$ denotes the memoryless complex gain of the transmitter that depends only on the instantaneous magnitude of $x(n)$,

(Lui, 3580, 3585 (“After removing the strong static nonlinearity using [Equation] (2) . . .”), Fig. 2 (omitting description of other equation).) Moreover, as discussed in Section 9.1.1.3, Lui's and the '561 Patent's figures are substantially identical and include the same input and outputs to the modules. In my opinion, this limitation is met.

9.2.2 Claim 15

9.2.2.1 15[pre] An augmented Wiener predistorter, the predistorter comprising:

107. To the extent the preamble is limiting, it is my opinion that Lui discloses an “augmented Wiener predistorter.” Lui proposes “a new augmented Wiener model” for use in a predistorter. (Lui, 3579, 3584-86 (detailing the augmented Wiener predistorter's performance).) Figure 17 shows the “Augmented Wiener transmitter model”:



(Lui, 3584-85, Fig. 17.) The model is “augmented” because the dynamic module accounts for nonlinearities that are not caught by linear filters. (Lui, 3584-85 (“the linear FIR filter in the conventional Wiener model, as described in Section V, is replaced by a weak nonlinear dynamic FIR-based filter.”).) In my opinion, this limitation is met.

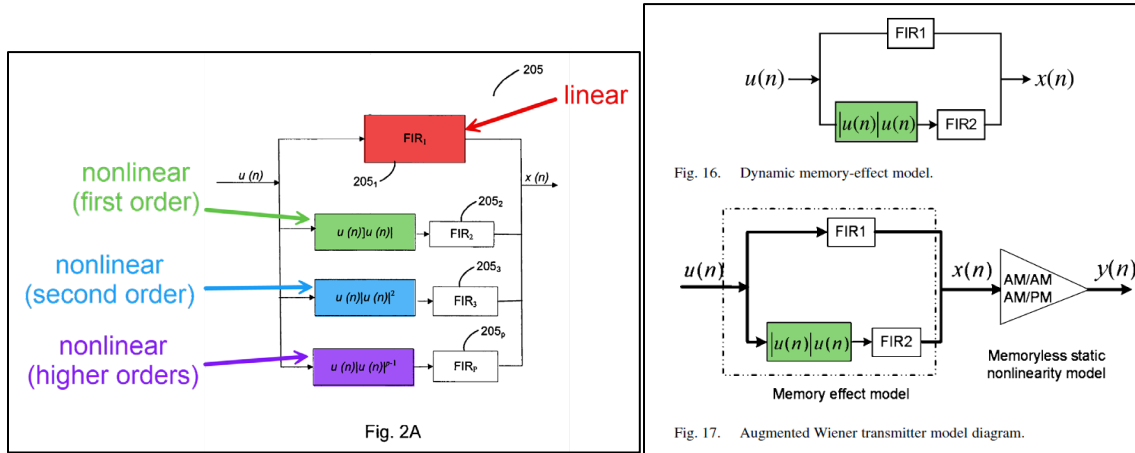
9.2.2.2 15[a] a dynamic nonlinear first order predistorter module; and

108. As discussed in Sections 9.1.1.2 and 9.2.1.3, it is my opinion that Lui discloses a dynamic nonlinear model, and it would have been obvious to a POSITA to use that model to build a dynamic nonlinear predistorter. Limitation 15[a] adds that the module must be a “dynamic nonlinear *first order* predistorter module,” which means “a dynamic predistortion module that includes a nonlinear function *with a first-power exponent.*” (Section 7.3.)

109. Lui includes the exact same dynamic nonlinear first order predistorter module as claimed in the '561 Patent, where the function $u(n)|u(n)|$ includes the

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magnitude of the input signal ($|u(n)|$) raised to the first-power exponent. Below is Figure 2A from the '561 Patent on the left and Lui's figures 16 and 17 on the right, both of which have an identical dynamic nonlinear first order function (highlighted in green) in their predistorter module:



(Lui, 4:24-41, Fig. 2A (annotated) (note “]” typo in magnitude for first-order function); Lui, Figs. 16, 17 (annotated).) Lui's dynamic nonlinear function is also expressed as a first-order function, where the magnitude of the input signal ($|u(n)|$) is raised to the first-power exponent:

Assuming that the two FIR filters have M_1 and M_2 taps, respectively, the input signal $u(n)$ and output signal $x(n)$ of the dynamic filter block in Fig. 17 can be written as follows:

$$x(n) = \sum_{i=0}^{M_1-1} a_i u(n-i) + \sum_{i=0}^{M_2-1} b_i |u(n-i)|u(n-i) \quad (21)$$

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(Lui, 8585 (annotated).) Lui states that its functions include “the *first-* and second-*order terms* of the input signals[.]” (Lui, 3585.) In my opinion, this limitation is met.

**9.2.2.3 15[b] a static nonlinear predistorter module
coupled to the dynamic nonlinear predistorter
module such that an output of the dynamic
nonlinear predistorter module is input to the static
nonlinear predistorter module.**

110. Limitation 15[b] is identical to Limitation 7[c]. For the reasons discussed in Section 9.2.1.4, it is my opinion that Lui discloses Limitation 15[b].

**9.2.3 Claim 2. The model of claim 1, wherein the first module is
coupled to the second module such that an output of the
first module is input to the second module.**

111. As discussed in Section 9.2.1.4, it is my opinion that Lui discloses the first module being coupled to the second module, and the output of the first module is input to the second module.

9.2.4 Claims 8-10 and 16-18

Claim 8. The predistorter of claim 7 wherein the dynamic nonlinear predistorter is a finite impulse response-based memory effect predistorter and the static nonlinear predistorter is a look-up table-based memoryless predistorter.

112. Claim 8 is dependent upon Claim 7 (discussed at Section 9.2.1), and because this claim is substantially similar to Claim 4 (discussed at Section 9.1.2), this claim is likewise invalid in my opinion.

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Claim 9. The predistorter of claim 7 wherein the dynamic nonlinear predistorter is a dynamic weak nonlinear predistorter and the static nonlinear predistorter is a static strong nonlinear predistorter.

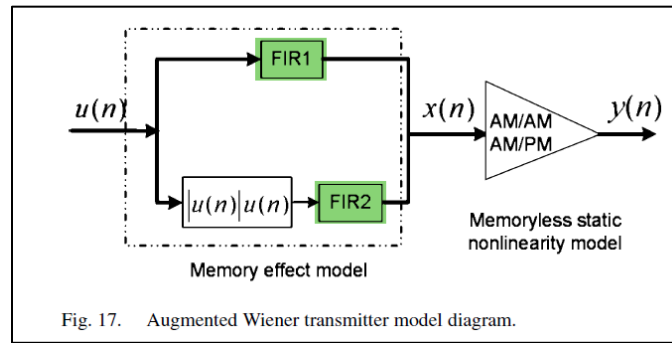
113. Claim 9 is dependent upon Claim 7 (discussed at Section 9.2.1), and because this claim is substantially similar to Claim 5 (discussed at Section 9.1.3), this claim is likewise invalid in my opinion.

Claim 10. The predistorter of claim 9 wherein the dynamic weak nonlinear predistorter is implemented as a finite impulse response filter-based multi-branch nonlinear structure embedded within a polynomial like series and the static strong nonlinear predistorter includes two look-up tables, each look-up table depends on the magnitude of a current input signal.

114. Claim 10 is dependent upon Claim 9 (discussed above), and because this claim is substantially similar to Claim 6 (discussed at Section 9.1.4), this claim is likewise invalid in my opinion.

115. Claim 10 adds that the DWNL predistorter “is implemented as a finite impulse response filter-based multi-branch ***nonlinear structure embedded within a polynomial like series***[,]” which Lui also discloses. As discussed in Section 9.1.4, the nonlinear structure embedded within a polynomial like series is shown in Lui’s Figure 17, where the FIR1 (linear) and FIR2 (nonlinear) systems are arranged in a multi-branch, polynomial like series:

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(Lui, 3579 (“finite impulse response (FIR) filter”), 3584-85, Fig. 17) Lui’s Equation 21 likewise shows a multi-branch, polynomial like series, including the FIRs’ “M1 and M2 taps” that “denote the memory depth of the model”:

B. Augmented Wiener Model Identification

Assuming that the two FIR filters have M_1 and M_2 taps, respectively, the input signal $u(n)$ and output signal $x(n)$ of the dynamic filter block in Fig. 17 can be written as follows:

$$x(n) = \sum_{i=0}^{M_1-1} a_i u(n-i) + \sum_{i=0}^{M_2-1} b_i |u(n-i)| u(n-i) \quad (21)$$

where M_1 and M_2 denote the memory depth of the model.

(Lui, 3585, Fig. 17.)

Claim 16. The predistorter of claim 15 wherein the dynamic nonlinear predistorter is a finite impulse response-based memory effect predistorter and the static nonlinear predistorter is a look-up table-based memoryless predistorter.

116. Claim 16 is dependent upon Claim 15 (discussed at Section 9.2.2), and because this claim is substantially similar to Claim 4 (discussed at Section 9.1.2), this claim is likewise invalid in my opinion.

Claim 17. The predistorter of claim 15 wherein the dynamic nonlinear predistorter is a dynamic weak nonlinear predistorter and the static nonlinear predistorter is a static strong nonlinear predistorter.

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117. Claim 17 is dependent upon Claim 15 (discussed at Section 9.2.2), and because this claim is substantially similar to Claim 5 (discussed at Section 9.1.3), this claim is likewise invalid in my opinion.

Claim 18. The predistorter of claim 17 wherein the dynamic weak nonlinear predistorter is implemented as a finite impulse response filter-based multi-branch nonlinear structure and the static strong nonlinear predistorter includes two look-up tables, each look-up table depends on the magnitude of a current input signal.

118. Claim 18 is dependent upon Claim 17 (discussed above), and because this claim is substantially similar to Claim 6 (discussed at Section 9.1.4), this claim is likewise invalid in my opinion.

9.3 Ground 3: Claims 3, 11-14 and 19-22 (Claims Directed to Hammerstein Models and Predistorters) Are Rendered Obvious by Lui and Further in View of a POSITA and Ding

119. Claims 3, 11-14 and 19-22 (the “Hammerstein Claims”) are directed to Hammerstein predistorters, or those predistorters where the static module is followed by a dynamic module.¹² Although Lui proposes an “Augmented Weiner” – not Hammerstein – model, Lui expressly acknowledges the existence of Hammerstein predistorters. (See Lui, 3579 (referencing a paper where the author “developed a nonlinear model with memory based on the *Hammerstein structure*

¹² Other claims, discussed above, are directed to Weiner predistorters, or those where a dynamic module is followed by a static module.

(static nonlinearity + linear filter) to predict the behavior of a power amplifier”),
3587 (citing a paper titled, “Broadband measurement and identification of a Wiener–
Hammerstein model for an RF amplifier,” by P. Crama and Y. Rolain).) The ’561
Patent also acknowledges that Hammerstein predistorters existed as of the patent’s
filing. (’561 Patent, 2:32-35 (“an augmented Hammerstein predistorter is disclosed
implemented using a first-order reverse LBG model”).)

120. As discussed below, it is my opinion that it would have been obvious
to a person of ordinary skill in the art to implement Lui’s proposed structure in both
a Weiner and Hammerstein arrangements – either under single-reference
obviousness or in combination with Ding.

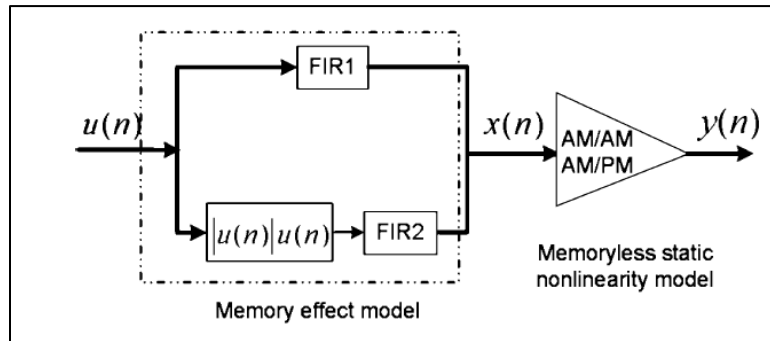
9.3.1 Single-Reference Obviousness Under § 103

121. In my opinion, Lui renders the Hammerstein Claims obvious under 35
U.S.C. § 103. Specifically, it would have been obvious for a POSITA to make the
only modification of Lui necessary to meet the Hammerstein Claims: placing the
SSNL module before the DWNL module.

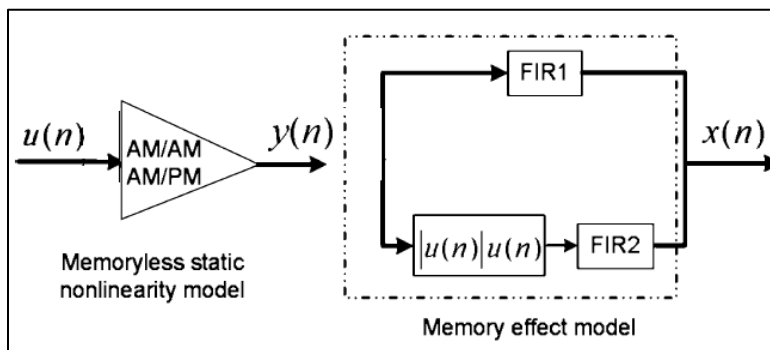
122. This modification would have been minimal because Lui already
discloses all necessary elements, if not in the same order as the Hammerstein Claims,
and there would have been a finite number of identified, predictable solutions to the
arrangement of predistortion modules. (*See* Sections 9.1 to 9.1.2.) The modification
to Lui would require the only other arrangement of the DWNL and SSNL modules:

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having the SSNL module followed by the DWNL. In practical terms, Lui's $u(n)$ input to the DWNL module would become the input to the SSNL module, and the SSNL module's $y(n)$ output would become the new input to the DWNL module. The original Weiner model is below:



(Lui, Fig. 17.) And a depiction of what this modified, Hammerstein model would look like is below:



(Lui, Fig. 17 (modified).) Because all of $u(n)$, $x(n)$ and $y(n)$ are of the same type (digital samples representing signals), and share a common sample index (n) , the modified model would function without further changes.

123. The modification of moving the SSNL module before the DWNL module would also have been obvious to try. The authors of Lui were attempting to

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develop a predistorter “that is capable of accurately modeling wide-band RF transmitters.” (Lui, 3579.) A POSITA would have experimented with a Hammerstein predistorter because its arrangement of DWNL and SSNL modules was known and used in the art for predistortion. Indeed, rearranging predistorters from Wiener predistorters to Hammerstein predistorters was and is a common, standard modification. For example, as discussed in Sections 8.2 and 9.3.1, Ding discloses Wiener and Hammerstein predistorters as two common solutions to the same problem. Ding then teaches “[t]o construct a Hammerstein predistorter, the approach taken by [25] uses a gradient method *to first identify the Wiener system and then find the Hammerstein predistorter as its inverse.*” (Ding, 17.) Wang likewise confirms that “there are two commonly used systems, referred to as the Wiener and Hammerstein nonlinear systems,” and states that these are “relatively simple subsystems with structures which are known a priori.” (Wang, 2399.) Wang further states that “[t]he Hammerstein system consists of *the same subsystems* as the Wiener system, however the subsystems are *connected in the reverse order*[.]” (Wang, 2399.) Gilabert is in accord with other references, stating that “the Hammerstein and Wiener models are two simple but effective possibilities for describing the PA and/or the predistorter nonlinear behavior taking into account memory effects.” (Gilabert, 2.) Gilabert likewise teaches reversing the Wiener and Hammerstein components: “Hammerstein models are composed by a memoryless

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nonlinearity followed by a linear time-invariant system, as it is shown in Fig. 3. While the Wiener model (Fig. 3) consists of *the same subsystems but connected in the reverse order.*” (Gilabert, 2.)¹³

124. In addition, as discussed above in Section 9.3.2.1, Lui even acknowledges the existence of Hammerstein models as an alternative solution to the problem of dynamic-, or memory-based distortion, so it would have been obvious for a person of ordinary skill to reverse the modules’ order. *See Ruiz*, 234 F.3d at 665 (“[a] motivation to combine may be found in the prior art references themselves”). The articles that Lui cites demonstrate that it was both well-known and simple to develop predistorters based on either the Weiner or Hammerstein models, and making the straightforward modification to Lui to create a Hammerstein model would have been obvious to a person of ordinary skill.

125. In view of the above, in my opinion, it would have been obvious for a POSITA to modify Lui to utilize a Hammerstein model instead of a Weiner model.

¹³ Just a few months after Lui was published, its authors proposed an “Augmented Hammerstein Predistorter” that simply switches the order of Lui’s DWNL and SSNL modules. (See Boumaiza, 1343-48, Fig. 7.)

9.3.2 Obvious by Lui in View of Ding Under 35 U.S.C. § 103

126. In my opinion, all Limitations of the Hammerstein Claims are taught or suggested in Lui in view of Ding.

9.3.2.1 Motivations to Combine

127. In my opinion, a POSITA would have been motivated to combine the teachings of Ding with Lui.

128. Both references identify the same problem: distortion in telecommunications networks. Lui recognized that “*linear and nonlinear distortion sources* in the RF transmitter chains compromises” the performance of “multicarrier *code-division multiple-access* and *orthogonal frequency-division multiplexing*.” (Lui, 3578.) Ding discusses the problem as, “newer transmission formats, such as *wideband code division multiple access (WCDMA)* and *orthogonal frequency division multiplexing (OFDM)*, have high peak to average power ratios, i.e., large fluctuations in their signal envelopes. . . . To improve the power amplifier efficiency *without compromising its linearity, power amplifier linearization is essential*.” (Ding, 1.)

129. Ding and Lui also identify the same solution: modeling the power amplifier and applying predistortion before power amplification. (Lui, 3578 (“The minimization of the effects of such distortion sources relies primarily on accurate modeling of the RF transmitters.”); Ding, 1 (“Among all linearization techniques,

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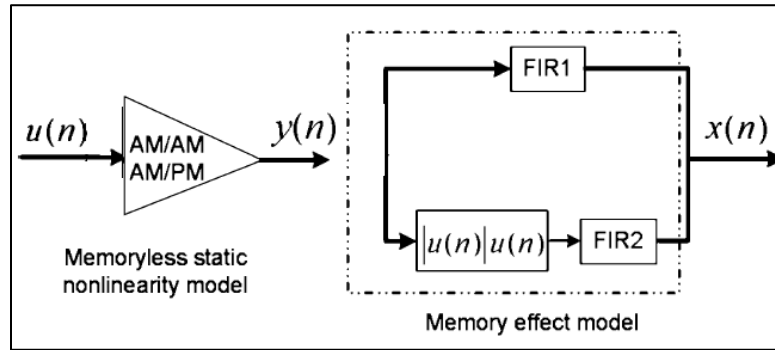
digital predistortion is one of the most cost effective[.]”).) Both Lui and Ding contend that the dynamic portion of modeling or predistortion has been overlooked in the literature in favor of static (or “memoryless”) nonlinearity, and should be improved. (Lui, 3584 (“*weak nonlinearities still exist even after deembedding static and strong nonlinearity from the measured data.* For this reason, *it is not sufficient to model these weak nonlinearities with a linear filter*, as is normally done in conventional Wiener models.”); Ding, 2 (“Digital predistortion implementations in the current literature *mostly focus on the power amplifier that has a memoryless nonlinearity*; i.e., the current output depends only on the current input through a nonlinear mechanism.”).)

130. Ding and Lui both offer solutions to allegedly improve the dynamic modeling of a predistortion system, albeit in somewhat different ways. Ding proposes, alongside a Weiner model, a Hammerstein model that places the dynamic module after the static module. (Ding, 17-25.) Lui proposes an “Augmented Weiner Behavioral Model” that increases the complexity of the dynamic module. (Lui, 3584-85, Figs. 16, 17.)

131. Moreover, in my opinion, modifying Lui to incorporate Ding’s Hammerstein arrangement would be simple. Ding explains that a Hammerstein model is just the “inverse” of a “Weiner system[.]” (Ding, 17.) In other words, all of the information contained in a Weiner model could be used in its inverse, the

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Hammerstein model. As a result, inverting Lui's "Augmented Weiner Behavioral Model" would have been achieved with a reasonable expectation of success and involved simply switching the order of the dynamic and static modules:



(Lui, Fig. 17 (modified).)

132. In my opinion, it would have also been obvious to try inverting Lui's "Augmented Weiner Behavioral Model" because both (1) Weiner and Hammerstein models were well-known in the art; and (2) POSITAs understood that the models were closely related and inversions of each other. Ding's accounting of prior attempts to model and predistort with memory effects includes *both* Weiner and Hammerstein models, and Ding states that a Hammerstein model is just the "inverse" of its Weiner counterpart. (Ding, 3 ("For a power amplifier with memory effects, *various models are available* to capture the behavior of the power amplifier, which include the Volterra series, *the Wiener model, the Hammerstein model*, and the Wiener-Hammerstein model."), 10-16.)

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133. Here, there are just two components (the DWNL and SSNL modules) that can only be arranged in two configurations (Weiner or Hammerstein).

134. Lui acknowledges the existence of Hammerstein models as an alternative solution to the problem of dynamic-, or memory-based distortion. Lui cites one paper that “proposed a method that estimates the Wiener *and Hammerstein structures* based on a frequency-domain identification procedure using special multisine signals.” (Lui, 3578-79 (citing Crama, 49–57.)) Lui cites another paper that “developed a nonlinear model with memory based on *the Hammerstein structure (static nonlinearity + linear filter)* to predict the behavior of a power amplifier for a fourth-generation mobile communications system.” (Lui, 3579 (citing Jantunen, 328–31).) The articles that Lui cites demonstrate that it was both well-known and simple to develop predistorters based on either the Weiner or Hammerstein models, and making the straightforward modification to Lui to create a Hammerstein model would have been obvious to a person of ordinary skill, and achieved with a reasonable expectation of success.

135. Lui specifically cites a different paper by Ding’s author (Lei Ding) and G. T. Zhou, “Effects of even-order nonlinear terms on power amplifier modeling and predistortion linearization,” IEEE Trans. Veh. Technol., vol. 53, no. 1, pp. 156–162 (Jan. 2004). This citation shows that a POSITA reading Lui would have been exposed to Lei Ding’s other works, which include the Ding secondary reference. In

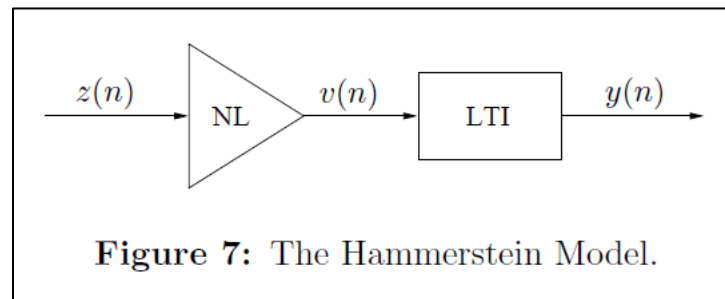
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addition, the citation shows that Lui and Ding were in the same field of endeavor, making it more likely that a POSITA would be motivated to combine the references.

136. Additional, and more specific, reasons for combining these references are discussed below with respect to specific claim features.

9.3.2.2 Lui in View of Ding

137. In my opinion, a POSITA would have been motivated to combine Ding with Lui for the reasons set forth in Section 9.3.2.1. Ding discloses a Hammerstein model and predistorter. Ding states that, “The Hammerstein model is a memoryless nonlinearity followed by an LTI system[,]” and shows an example in Figure 7:



(Ding, 12-13, Fig. 7.) The formulas underlying a Hammerstein model are below:

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The Hammerstein model is a memoryless nonlinearity followed by an LTI system (see Fig. 7). The two subsystems in this model are described by

$$v(n) = \sum_{\substack{k=1 \\ k \text{ odd}}}^K b_k z(n) |z(n)|^{k-1}, \quad (16)$$

$$y(n) = \sum_{l=0}^{L-1} c_l v(n-l), \quad (17)$$

where b_k are the coefficients for the memoryless nonlinearity and c_l are the impulse response values of the LTI system. Substitution of (16) into (17) leads to

$$y(n) = \sum_{l=0}^{L-1} c_l \sum_{\substack{k=0 \\ k \text{ odd}}}^K b_k z(n-l) |z(n-l)|^{k-1}. \quad (18)$$

(Ding, 13.)

138. Further, Ding teaches how to convert Lui’s “Augmented Weiner Behavioral Model” into a Hammerstein model. Specifically, Ding teaches that “[t]o construct a Hammerstein predistorter, the approach taken by [Kang] uses a gradient method *to first identify the Wiener system and then find the Hammerstein predistorter as its inverse.*” (Ding, 17.)

9.3.2.3 Claim 11

A predistorter for nonlinear wireless system, the predistorter comprising:

a static nonlinear predistorter module; and

dynamic nonlinear predistorter module coupled to the static nonlinear predistorter module such that an output of the static nonlinear predistorter module is input to the dynamic nonlinear predistorter module.

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139. In my opinion, Claim 11 is substantially similar to Claim 7,¹⁴ but it requires that the SSNL module come after the DWNL module “such that an output of the static nonlinear predistorter module is input to the dynamic nonlinear predistorter module” (i.e., a Hammerstein predistorter). As discussed in Sections 8.2 and 9.3.2.2, Ding discloses a Hammerstein predistorter. (Ding, 10-16.) For the reasons discussed above in Section 9.3.1, it would have been obvious for a person of ordinary skill to modify Lui to create a Hammerstein predistorter as claimed in Claim 11. Moreover, as discussed in Section 9.1.1.3, Lui’s and the ’561 Patent’s figures are substantially identical and include the same input and outputs to the modules. In my opinion, this limitation is met.

9.3.2.4 Claim 19

An augmented Hammerstein predistorter, the predistorter comprising:

a static nonlinear predistorter module; and

a dynamic nonlinear first order predistorter module coupled to the static nonlinear predistorter module such that an output of the static nonlinear predistorter module is input to the dynamic nonlinear predistorter module.

¹⁴ Lui discloses all limitations of Claim 7 in my opinion, as discussed in Section 9.2.1.

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140. In my opinion, Claim 19 is substantially similar to Claim 15,¹⁵ but it requires that the SSNL module come after the DWNL module “such that an output of the static nonlinear predistorter module is input to the dynamic nonlinear predistorter module” (i.e., a Hammerstein predistorter). This language mimics the final limitation of Claim 11, which is addressed in Section 9.3.2.3. For the reasons discussed above in Section 9.3.1, it would have been obvious for a person of ordinary skill to modify Lui to create a “Hammerstein predistorter” as claimed in Claim 19.

141. As discussed in Sections 8.2 and 9.3.2.2, Ding discloses a Hammerstein predistorter. (Ding, 10-16.) Claim 19 also requires that the “dynamic nonlinear” predistorter be a “first order” predistorter, a limitation which Lui discloses as discussed in Section 9.2.2.2.

142. Claim 19 also requires that the “Hammerstein predistorter” be “augmented.” Lui’s model is “augmented” because the dynamic module accounts for nonlinearities that are not caught by linear filters. (Lui, 3584-85 (“the linear FIR filter in the conventional Wiener model, as described in Section V, is replaced by a weak nonlinear dynamic FIR-based filter.”).) In my opinion, this limitation is met.

**9.3.2.5 Claim 3. The method of claim 1, wherein the
second module is coupled to the first module such**

¹⁵ Lui discloses all limitations of Claim 7 in my opinion, as discussed in Section 9.2.1.

that an output of the second module is input to the first module.

143. Claim 3 describes a Hammerstein arrangement of the static nonlinear predistorter module and the dynamic nonlinear predistorter module. As discussed in Section 9.3.1, it is my opinion that Lui (either alone or in combination with other references) discloses such an arrangement of the modules.

9.3.2.6 Claims 12-14, 20-22

Claim 12. The predistorter of claim 11 wherein the dynamic nonlinear predistorter module is a finite impulse response-based memory effect predistorter module and the static nonlinear predistorter is a look-up table-based memoryless predistorter module.

144. Claim 12 is dependent upon Claim 11 (discussed at Section 9.3.2.3), and because this claim is substantially similar to Claim 4 (discussed at Section 9.1.2), this claim is likewise invalid in my opinion.

Claim 13. The predistorter of claim 11 wherein the dynamic nonlinear predistorter module is a dynamic weak nonlinear predistorter module and the static nonlinear predistorter is a static strong nonlinear predistorter module.

145. Claim 13 is dependent upon Claim 11 (discussed at Section 9.3.2.3), and because this claim is substantially similar to Claim 5 (discussed at Section 9.1.3), this claim is likewise invalid in my opinion.

Claim 14. The predistorter of claim 12 wherein the dynamic weak nonlinear predistorter is implemented as a finite impulse response filter-based multi-branch nonlinear structure and the static strong nonlinear predistorter includes two look-up tables, each look-up table depends on the magnitude of a current input signal.

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146. Claim 14 is dependent upon Claim 12 (discussed above), and because this claim is substantially similar to Claim 6 (discussed at Section 9.1.4), this claim is likewise invalid in my opinion.

Claim 20. The predistorter of claim 19 wherein the dynamic nonlinear predistorter module is a finite impulse response-based memory effect predistorter module and the static nonlinear predistorter is a look-up table-based memoryless predistorter module.

147. Claim 20 is dependent upon Claim 19 (discussed at Section 9.3.2.4), and because this claim is substantially similar to Claim 4 (discussed at Section 9.1.2), this claim is likewise invalid in my opinion.

Claim 21. The predistorter of claim 19 wherein the dynamic nonlinear predistorter module is a dynamic weak nonlinear predistorter module and the static nonlinear predistorter is a static strong nonlinear predistorter module.

148. Claim 21 is dependent upon Claim 19 (discussed at Section 9.3.2.4), and because this claim is substantially similar to Claim 5 (discussed at Section 9.1.3), this claim is likewise invalid in my opinion.

Claim 22. The predistorter of claim 21 wherein the dynamic weak nonlinear predistorter is implemented as a finite impulse response filter-based multi-branch nonlinear structure and the static strong nonlinear predistorter includes two look-up tables, each look-up table depends on the magnitude of a current input signal.

149. Claim 22 is dependent upon Claim 21 (discussed above), and because this claim is substantially similar to Claim 6 (discussed at Section 9.1.4), this claim is likewise invalid in my opinion.

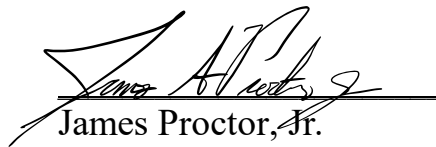
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10. Conclusion

150. For the reasons discussed in detail above, it is my opinion that all of the Challenged Claims are invalid in view of the prior art.

151. I reserve the right to supplement my opinions in the future to respond to any arguments or positions that the Patent Owner may raise, taking account of new information as it becomes available to me.

152. I declare that all statements made herein of my knowledge are true to the best of my knowledge, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.


James Proctor, Jr.

Dated: February 12, 2025

Exhibit A

(Curriculum Vitae)

James A. Proctor Jr.

1680 North Riverside Drive, Indialantic, FL 32903 - (321) 271-8411 - jproctor@ieee.org

EDUCATION

Georgia Institute of Technology, Atlanta, Georgia M.S. Electrical Engineering
Graduated: September 1992
Interests: Digital Signal Processing, Communications, Optics

The University of Florida, Gainesville, Florida B.S. Electrical Engineering
Graduated: May 1991
Minor Studies: Business
Honors & Activities: PI ETA SIGMA Honor Society
ALPHA LAMBDA DELTA Freshman Honor Society
ETA KAPPA NU National Electrical Engineering Fraternity

Skills & Achievements

- Successfully led Qualcomm / WiDeFi integration efforts resulting in a new product effort within Qualcomm related to the 3G/4G Market
- Co-founded WiDeFi and successfully raised >\$14M of venture funding
- Generated intellectual property and product strategy leading to the acquisition of two companies (WiDeFi, and Tantivy Communications), contributing to > \$100M of revenue
- Performed extensive customer and industry business development to provide support for innovative product definition, requirement definition, and customer support for business plan and forecasts (Qualcomm, WiDeFi, and Tantivy Communications)
- Led and coached many R&D teams to refine and de-risk innovative wireless concepts
- Led cross functional product teams to deliver high volume ready prototypes
- Ability to balance market, programmatic, and technical concerns and refine clear strategy and actionable plans
- Generated >325 issued US Patents Currently and >700 international patent publications
- Have spoken at numerous public events: industry, venture, and technical
- Strong communication and technical skills

Work Experience

Proctor Consulting, LLC **December 2008 - Present**

- Early stage market and technology strategy
 - o Interim CTO/Team Member, business development/validation
 - o Roadmap / IP development
 - o Advisory Board Member
- Technical / Market Consultant
 - o Fastback Networks, Audigence, Peregrine Semiconductor
- Intellectual property portfolio analysis within the communications market space
 - o Market / Product Applicability, Claims Chart Development and Analysis, Valuation
 - o Expert Witness Consulting in Wireless Communications (WiFi, WoWiFi, 2G-GSM, 3G-C2K/WCDMA, 4G/LTE, VoLTE, 5G/NR, and associated networks)

Proximcom Wireless. Co-Founder, Managing Director **November 2011 – Present**

- Proximity based mobile technology utilizing a centralized trusted third party
- Development of foundational Intellectual Property (17+ US Patents)
- Enabling technology applicable to a variety of proximity based applications including highly secure: Mobile Payments, Electronic Coupons and Loyalty, Rating and Reviews, Social Commerce

Qualcomm Inc., Principal Engineer (Consulting)**October 2007 - October 2009**

- Technical and Business development leadership of a consumer level 3G wireless repeater product concept based upon WiDeFi's technology during the integration
- Provided technical leadership in architecture development
 - o Defined initial architecture approach for the wireless repeater concept based upon WiDeFi's technology
 - o Worked with technical team to refine approach and achieve "key proof points"
- Performed Business Development with International Wireless Operators
 - o Worked closely with business development from ESG and QCT divisions
 - o Developed bottoms up forecast with the top international wireless operators for consumer repeater products.
 - o Refined product features to meet carrier's requirements
- Market Analysis to estimate Market Size and Competitive Landscape
- Named inventor on 44+ Issued or pending patents for Qualcomm on wireless repeater concepts

WiDeFi, Inc., EVP/CTO, and Co-Founder, Director**August 2005 - October 2007**

- Focused on aligning WiDeFi's technology and product roadmaps to customer and market drivers
 - o Strategic and Technical Marketing, Product Definition
 - o Market Analysis to estimate Market Size and Competitive Landscape
 - o Collaborated with customers and internal team to define and pursue product/customer opportunities (Retail Wi-Fi, Mesh Repeater, VoiP over Wi-Fi Repeater, Cellular Repeaters, Wi-Max Repeaters, In-Building Distribution Systems)
 - o Customer Development from initial contact, joint testing, first purchase order, to new product introduction
 - o Contributed to and managed WiDeFi's IP portfolio
 - o Pursued fund raising from corporate and venture capital communities

WiDeFi, Inc., President, CEO, and Co-Founder, Director**July 2002 - August 2005**

- Led WiDeFi from inception to the recruitment of an expansion-stage CEO.
- Principal duties:
 - o Direct Fundraising of initial seed and Series A Venture Capital
 - o General Management (Finance, Business Administration, Legal/Contracts and Organizational Development/Recruiting)
 - o Coordination of Board of Directors and Investors
 - o Sales (WiDeFi was Cash Flow positive prior to venture investment)

Tantivy Communications**April 1998 - June 2002****Director of Strategic and Technical Marketing**

- Business Development/Technical Due Diligence
- Represented Tantivy in a wide range of Wireless Broad Band Industry Conferences
- Intellectual Property Management and Strategy
 - o Represented Tantivy's Patents and their value to External Companies
 - o Performed Validity, Infringement, and Value Analysis of Tantivy Patents for non-Tantivy products
- Industry Standards Representation for 3G Technologies
 - o TIA/3GPP2, Over 15 Technical Contributions/Papers
 - o T1P1 (3GPP Member)
- Project Management of an International Technology Transfer Team (S Korea)
- Performed System Architecture and Analysis

Spectrian, Advanced Development and Technical Marketing**1995 - April 1998**

- Interfaced with NORTEL/Qualcomm's Product Management
- Performed Advanced Technology Development/Systems Analysis

**Harris Corp. GCSD,
Senior Engineer Signal Processing Section, Modems Group**

September 1992 - 1995

Georgia Tech Research Institute, CSITL

June 1991 - August 1992

Harris Corp.. ISD, Electro-optics, Co-op

May 1990 - August 1990

- Acousto-optic signal processing

Standards Development

- Participated in architecting "Internet CDMA" (I-CDMA)
- Jointly led establishment of the Committee T1, working group T1P1.4 "WWINA" standardization effort, which stands for "Wireless Wideband Internet Access"
 - o T1 Approved this system as the T1.723-2002 standard
- ATIS approved as **ATIS0700723-2002 I-CDMA Spread Spectrum Systems Air Interface Standard**
- Participated in 3GPP2 Standards Developments (including 15+ technical contributions)

Intellectual Property

- More than 325 Issued U.S. Patents
- More than 700 Issued or Pending International Patent Applications (WIPO)
- Patents Cited at the USPTO more than 6000 times
- 55+ Patents Assigned to Intel
- 45+ Patents Assigned to Qualcomm
- 16+ Patents designated as "Standards Essential" for UMTS (WCDMA)
- 6+ Patents designated as "Standards Essential" for LTE

Testifying Expert Experience

SPH Am., LLC v. Acer, Inc., 09CV02535-CAB MDD, 2012 WL 1344515 (S.D. Cal. Apr. 18, 2012).

Testifying Expert offering opinions on validity for the defense. The technology related to WCDMA modulation techniques. Resulted in settlement prior to trial.

WI-LAN USA, INC. and WI-LAN INC. v. ELEFONAKTIEBOLAGET LM ERICSSON and ERICSSON INC., Case No. I:12-23569-Civ (S.D. FL)

Testifying expert offering opinions on infringement for the defense. The technology involved LTE "contention free" handover (CFRA), and Media Access Control (MAC) layer messaging for Quality of Service (QOS). Resulted in a summary judgement finding of non-infringement for the defense, and settlement after appeal.

U.S. ETHERNET INNOVATIONS, LLC. V. STMICROELECTRONICS, INC.,
Civil Action No. 6:12-cv-4181-MHS-JDL

Testifying expert offering opinions on both validity and infringement for the defense. The technology related to Ethernet devices. Resulted in settlement prior to trial.

UNWIRED PLANET. V. SQUARE, INC.,

Case No. 3:13-CV-00579-RCJ-WGC, DISTRICT OF NEVADA,
Case CBM2014-00156, Case IPR2014-01164, Case IPR2014-01165, UNITED STATES PATENT TRIAL AND APPEAL BOARD,

Provided testimony related to claim construction, and validity for the defense. The technology was related to location based services (LBS). The case resulted in a finding by the Patent Trial and Appeal Board of unpatentability of all asserted claims.

PRISM TECHNOLOGIES LLC. V. T-MOBILE USA, INC., Case No. 12-CV-124

Testifying expert at trial, and deposition offering opinions on both validity and infringement for the defense. The technology was related to SIM/USIM/ISIM based authentication in UMTS, LTE, and IMS networks. The case resulted in a jury verdict of non-infringement.

FASTVDO LLC. V. AT&T Mobility LLC, AT&T Services, Inc., and Apple Inc.,
Case No. 3:16-cv-00385-H-WVG

Engaged by Apple as the testifying expert offering opinions on infringement for the defense. The technology was related to Forward Error Correction (FEC) and voice codecs in GSM and WCDMA standards, including detailed FEC performance simulations. The case was concluded based upon an IPR outcome finding unpatentable subject matter by the PTAB.

BLACKBERRY LIMITED V. BLU PRODUCTS, INC.,
Case No.: 16-23535-CIV-MORENO

Engaged by Blackberry as the testifying expert offering opinions on infringement for the plaintiff. The technology involved WCDMA and battery saving techniques in Radio Resource Control (RRC) states. The case was settled between the parties prior to trial.

CELLULAR COMMUNICATIONS EQUIPMENT LLC V. AT&T Inc., and Apple Inc.
Case No.: 2:15-cv-00576-RWS-RSP

Engaged by Apple as the testifying expert offering opinions on validity and benefits of the alleged inventions for the defense. The technology involved Media Access Control (MAC) messaging for LTE (Power Headroom Reporting) and LTE Advanced (CSI reporting for Carrier Aggregation). The case resulted in summary judgement for the defense.

GENERAL ACCESS SOLUTIONS, LTD. v. Sprint Corporation et al.
Civil Action No. 2:16-cv- 00465 (E.D. Tex.) and PTAB Proceedings (IPR2017-01885 (Patent 7,173,916 B2) IPR2017-01887 (Patent 6,891,810 B2) IPR2017-01889 (Patent 7,230,931 B2),

Engaged by Sprint to provide expert testimony relating to claim construction, and validity for the defense before the Patent Trial and Appeal Board (PTAB) relating to an Inter Partes Review petition, providing multiple expert declarations, and deposition testimony. The technology related to Adaptive Modulation and Coding (AMC) in a wireless system; Adaptive Beamforming, Sectorization, and Multi-Input Multi-Output (MIMO). All trials were instituted by the PTAB Board, with a finding of all petitioned claims unpatentable for two of the three patents.

TC TECHNOLOGY LLC. V., Sprint Corporation and Sprint Spectrum, L.P
Case 1:16-cv-00153-RGA

Engaged by Sprint to provide expert testimony relating to validity and infringement by the defense, in the district of Delaware. The technology related to OFDMA and SC-FDMA use in the LTE uplink, for multiplexing transmissions from different UEs utilizing mutually exclusive OFDM subcarriers. The matter was resolved.

Mobility Workx, LLC v T-Mobile US, Inc.
Civil Action No. 4:17-cv-00567-ALM

Retained by the defendant, and provided declarations and deposition for claim construction, engaged for both invalidity and non-infringement analysis and testimony. This matter relates to LTE handover, and Mobile IP. The case was settled between the parties prior to trial.

Mobility Workx, LLC v Cellco Partnership d/b/a Verizon Wireless

Case No. 4:17-cv-872-ALM

Retained by the defendant, engaged for both invalidity and non-infringement analysis and testimony. This matter relates to LTE handover, and Mobile IP. The case further related to 3GPP compliance testing techniques. This matter was resolved during trial preparation.

Uniloc USA, Inc., et al. v. Apple Inc.

No. 18-cv-158 and 18-cv-161, engaged by Apple as a technical and testifying expert. This matter relates to Quality of Service aspect of 3G UMTS (WCDMA), and the request and allocation of uplink resources in LTE. The matter was stayed, pending result of PTAB IPR Trial.

Wi-LAN v. LG

Case No. Case No.: 3:18-cv-01577-H-BGS

Engaged by LG as a technical and testifying expert. The technology involved LTE “contention free” handover (CFRA), Media Access Control (MAC) layer messaging for bandwidth management and Quality of Service (QOS). This matter was resolved.

Fractus, S.A. v. Sprint Communications Company, L.P. et al.

Civil Action No. 2:18-cv-00135 (E.D. Tex.), Engaged by Sprint and Verizon Wireless as a technical and testifying expert for invalidity. The technology involved design aspects of antenna element placement in multiband antenna arrays for use at cellular base stations. This matter was resolved.

Wilson Electronics, LLC v. Cellphone-Mate, Inc. dba SureCall

Case No. 2:17-cv- 00305-DB (District of Utah)

Retained by the Wilson Electronics, and engaged for both invalidity and non-infringement analysis and testimony in both district court and in ITU proceedings. This matter relates to cellular multi-band wireless signal boosters / repeaters. This matter was resolved.

Sol IP, LLC v Joint Defense Group (AT&T, Ericsson, Nokia, Sprint, Verizon)

Civil Action No. 2:18-cv-00526 (E.D. Tex.)

Retained by each of the defendants, and engaged to provide testimony relating to infringement of the asserted claims for 8 of the asserted patents. The subject matter related to random access, paging, resource allocation, and carrier aggregation in LTE. The matter was resolved.

Polaris PowerLED Technologies, LLC v. TCL Corporation, et al., C.D. California Civil Action No.: 8:20-cv-00127-JVS-DFMBGL Ref. No.: 16725-7 and 16725-8

Engaged by TCL and Hisense to provide expert testimony in district court and to provide a declaration as an expert in an Inter Party Review (IPR) proceeding before the U.S Patent Trial and Appeals Board. The subject matter related to power supply circuitry for use in backlight displays and U.S. Pat. No 11,011,752. The IPR was instituted, and the proceedings were terminated following settlement.

SmartSky Networks v. Wireless Systems Solutions, LLC; DAG Wireless Solutions, et al., M.D. North Carolina (Case No. 1:20-cv-00834-NCT-LPA), and related arbitration proceedings

Engaged by SmartSky to provide expert testimony related to a trade secret dispute in district court, and an arbitration proceeding. The technology related to air to ground internet service for aircraft using a proprietary LTE derived system including airborne radios and ground stations allowing for increased range and velocity beyond that which can be provided by standards based LTE systems. The system includes advanced UE and eNodeB architectures, and modified LTE protocols. I provided expert reports and declarations in both district court and arbitration. I further provided live testimony before an arbitration panel. The arbitration panel found in favor of SmartSky, achieving a successful injunction against WSS/DAG.

Dali Wireless v. JMA Wireless, Civil Action 1:99-mc-09999

Engaged by JMA Wireless to provide several declarations as an expert in an Inter Party Review (IPR) proceeding before the U.S Patent Trial and Appeals Board, and further testimony relating to the district court cases. The subject matter related to in-building wireless signal distribution systems utilizing digital network (CPRI / IP packetized) interfaces and as well as LTE eNodeB architectures. This matter was resolved pending expert discovery.

Dali Wireless v. Corning Optical Communications LLC, No. 3:20-cv-06469 (N.D. Cal.) and Dali Wireless, Inc. v. Corning Incorporated et al., No. 6:20-cv-00827 (W.D. Tex.)

Engaged by Corning to provide several declarations as an expert in an Inter Party Review (IPR) proceeding before the U.S Patent Trial and Appeals Board and further testimony relating to the district court cases. The subject matter related to distributed antenna systems for in-building wireless signal distribution as well as intercell frequency reuse and interference management techniques. This matter was resolved pending expert discovery.

Flexiworld Technologies, Inc. v. Amazon.com, Inc., et al., Case No. 6:20-cv-00553-ADA (W.D. Texas), and Case No. 2:21-cv-01055-DGE (W.D. Washington, Tacoma)

Engaged by Amazon to provide testimony for district court matter in the Western District of Texas. The matter related to approaches for mobile devices to utilize Bluetooth to interface with smart speakers and servers, allowing for the request of content to be played by an output device (speaker) based upon specific requests, including in some cases voice requests. This matter was transferred to Western District of Washington, Tacoma Division and remains pending.

WSOU Investments, LLC d/b/a Brazos Licensing and Development v. Huawei Technologies Co., Ltd. et al., 6:20-cv-00544 (W.D. Tex.)

Engaged by Huawei to provide expert testimony in district court. The matter related to LTE protocols and signaling, Hybrid ARQ, and scheduling of retransmissions relative to new transmissions from a UE to an eNodeB. I provided a claim construction declaration, prior to the matter being resolved.

Ericsson, Inc. IPR petition of 7,532,865, (TOT Power Control, S.L. Patent Owner)

Engaged by Ericsson, Inc. to provide a declaration as an expert in an Inter Party Review (IPR) proceeding before the U.S Patent Trial and Appeals Board, relating to US. Pat. No. 7,532,865. The matter involved "outer loop" power control techniques in WCDMA systems or other mobile devices.

Sierra Wireless et al. IPR petition of 7,215,653 (Sisvel, Patent Owner).

Engaged by Sierra Wireless to provide a declaration as an expert in an Inter Party Review (IPR) proceeding before the U.S. Patent Trial and Appeals Board, relating to US. Pat. No. 7,215,653. This matter involved the control of uplink data rates and power control in a CDMA system called 1xEV-DO developed within the 3GPP2 standards, in which I personally participated. The IPR was instituted by the PTAB, and all claims were found unpatentable.

KAIFI LLC v. T-Mobile US, Inc. et al., Case No. 2:20-cv-281-JRG (E.D. Tex.)

Engaged by T-Mobile to provide expert testimony for both (in)validity and (non)infringement for a district court matter in the Eastern District of Texas. The matter involved a mobile device's roaming between an outdoor cellular / LTE networks and an indoor Wi-Fi network. It further included approaches for the LTE core network to perform the selection of transmission paths of VoLTE and VoWiFi signals involving the LTE core (EPC), including the ePDG, and IMS networks. This matter settled.

KAIFI LLC v. Verizon Wireless, et al., Civil Action No. 2:20-cv-00280-JRG (E.D. Tex.)

Engaged by Verizon to provide expert testimony relating to (in)validity for a district court matter in the Eastern District of Texas. The matter involved a mobile device's roaming between an outdoor cellular / LTE networks and an indoor Wi-Fi network. It further included approaches for the LTE core network to perform the selection of transmission paths of VoLTE and VoWiFi signals involving the LTE core (EPC), including the ePDG, and IMS networks. This matter settled.

NEO Wireless, LLC v. DELL Technologies Inc. and DELL Inc., Case No. 6:21-cv-024-ADA (W.D. Tex.)

Engaged by Dell to provide expert testimony relating to claim construction, (in)validity and (non)infringement in the Western District of Texas, Waco Division. The matter involved LTE and 5G devices and standards aspects including signaling aspect associated with: OFDM/OFDMA, resource scheduling and frame structures, random access and ranging, transmit diversity and beamforming signaling. This matter was settled by the parties.

American Patents v. Xerox., Case No. 6:21- cv-636-ADA. (W.D. Tex.)

Engaged by Xerox to provide expert testimony relating to claim construction, (in)validity and (non)infringement in the Western District of Texas, Waco Division. The matter involved IEEE802.11 (WiFi) based systems relating to a number of patents, including Time and frequency synchronization in multi-input, multi-output (MIMO) systems, the assessment and management of interference in 802.11 systems. This matter was resolved.

TurboCode. v. Dell Technologies Inc. and Dell Inc., Case No. Civil Action No. 6:21-cv-359 (W.D. of Tex.)
Engaged by Dell to provide expert testimony relating to claim construction, (in)validity and (non)infringement in the Western District of Texas, Waco Division. The matter involved 3G / WCDMA use and implementations of Turbo Coding in wireless transmission and reception. This matter was settled by the parties.

XR Communications d/b/a Vivato Technologies v. Microsoft Corporation, Case No: 6:21-cv-695 (WDTX)
Engaged by Microsoft to provide expert testimony relating to claim construction, (in)validity and (non)infringement in the Western District of Texas. The matter involved the use of transmit beamforming, channel estimation and diversity techniques in IEEE802.11n, 802.11AC, and 802.11AX systems (WiFi). This matter was settled by the parties.

Finesse Wireless, LLC v. AT&T Mobility LLC; Cellco Partnership d/b/a Verizon Wireless; Nokia of America Corporation; Ericsson Inc., Case No. 2:21-CV-00063-JRG (E.D. TX).
Engaged by Nokia to provide expert testimony relating to claim construction, (in)validity and (non)infringement in the Eastern District of Texas. The matter involved aspects of LTE and 5G infrastructure relating to the cancelation of radio frequency intermodulation distortion produced in a transmitter from the receiver of the same base station, and involving both passive intermodulation (PIM) and active intermodulation from Power amplifiers (PA).

VoIP-Pal.com, Inc. v. T-Mobile USA, Inc., Case No. 6:21-cv-00674-ADA (WDTX)
Engaged by T-Mobile to provide expert testimony relating to claim construction, (in)validity and (non)infringement in the Western District of Texas. The matter involved approaches for roaming in a mobile network and the use of access codes to authorize access to voice over Wi-Fi (VoWiFi)/VoIP over the internet. The technology involved T-Mobile's 4G network infrastructure involving access utilizing the ePDG, and IMS networks. The case further related to historical VoWiFi systems including T-Mobile's HotSpot@Home, Unlicensed Mobile Access (UMA), 3GPP Generic Access (GAN), IMS/SIP, and voice call Continuity (VCC). The court found non-infringement during summary judgement.

GODO KAISHA IP BRIDGE v Ericsson and Nokia
Case No. 2:21-CV-213-JRG, Case No. 2:21-CV-215-JRG (E.D. TX).
Engaged by Nokia and Ericsson to provide expert testimony relating to claim construction, (in)validity and (non)infringement in the Eastern District of Texas. The matter involved aspects of LTE and 5G infrastructure relating to the channel state information (CSI/CQI) configuration and triggering for periodic and aperiodic, wideband and sub-band reports from LTE/NR UEs. This matter was settled prior to trial.

Microsoft Corporation, IPR petition of '414, '763, '988, '890 (Lemco Corporation, Patent Owner).
Engaged by Microsoft Corporation to provide several declarations as an expert in Inter Party Review (IPR) proceedings before the U.S. Patent Trial and Appeals Board, relating to US. Pat. Nos. 7,653,414, 7,548,763, 7,855,988, and 9,191,980. These matters involved distributed cellular network infrastructure architectures. The patents relate to software implementations of cellular network infrastructure, including a distributed mobile architecture server and a distributed mobile architecture gateway. This matter remains pending.

Ozmo v. Dell
Case No: 6:22-cv-00642-ADA (WDTX)
Engaged by Dell to testimony related to claim construction, (in)validity and (non)infringement relating to U.S Pat. Nos. 8,599,814; 9,264,991; 10,873,906; 11,012,934; 11,122,504; and 11,252,659 and share common provisional applications. The subject matter of the patents relate to seamlessly integrating short-range wireless personal area networks ("WPANs") into longer-range wireless local area networks. ("WLANs").

XR Communications d/b/a Vivato Technologies v. ASUSTek Computer Inc., Computer Inc.
Case No: 6:21-cv-00622-ADA (WDTX)
Engaged by ASUSTek to provide expert testimony relating to claim construction, (in)validity and (non)infringement in the Western District of Texas. The matter involved the use of transmit beamforming, channel estimation and diversity techniques in IEEE802.11n, 802.11ac, and 802.11ax systems (WiFi). This matter was settled.

Cobblestone Wireless, LLC v AT&T, T-Mobile, and Verizon.
Case No: 2:2-cv-00474, 2:23-cv-00477, 2:23-cv-00478 (E.D. Tex.)
Engaged by Joint Defense Group (including Nokia and Ericsson) to provide several declarations as an expert in Inter Party Review (IPR) proceedings before the U.S. Patent Trial and Appeals Board. Provided declarations for US Pat. Nos. 9,094,888, 8,554,196, 10,368,361, 8,891,347. I was further engaged to provide expert testimony relating to Interparty claim construction, (in)validity and (non)infringement in the Eastern District of Texas. The matter involved

various aspects of 3GPP LTE and 5G transmit beamforming, including: handoff, beam and frequency resource management, beam management and selection, adaptation based upon Channel State information (CSI). This matter remains pending.

Samsung v. Cobblestone Wireless, LLC.

Engaged by Samsung to provide several declarations as an expert in Inter Party Review (IPR) proceedings before the U.S. Patent Trial and Appeals Board. Provided declarations for US Pat. Nos. 9,094,888, 8,554,196, 10,368,361, 8,891,347. The matter involved various aspects of 3GPP LTE and 5G transmit beamforming, including: handoff, beam and frequency resource management, beam management and selection, adaptation based upon Channel State information (CSI). This matter remains pending.

Lenovo (United States) Inc. v. ASUSTeK Computer Inc.; ASUS Computer International.

Case No.: 23-CV- 5892 (N.D. Cal.), ITC matter Inv. No. 337-TA-1382

Engaged by AsusTek to provide opinions regarding claim construction, validity and infringement of U.S. Pat. Nos. 7,792,066 and 10,952,203. The technology included Wake on Wireless Lan utilizing magic packets and the PS mode of 802.11 devices, personal computer architecture and power states (APM,ACPI). The technology further included the use of trigger based uplink OFDMA resource allocation in WiFi 6 (802.11AX). The ITC trial resulted in a finding of non-infringement for AsusTek.

Mobility Workx LLC v. AT&T Inc., et al.

Case No. 4:23-cv-00594 (E.D. Tex.)

Engaged by AT&T to provide opinions regarding claim construction, validity and infringement of U.S. Pat. Nos. 7,697,508, 8,213,417, and 7,231,330. This matter relates to LTE / WiFi handover, and Mobile IP, and related test equipment. This matter remains pending.

XR Communications d/b/a Vivato Technologies v. Joint Defense Group (AT&T Services Inc., AT&T Mobility LLC, AT&T Corporation, T-Mobile USA, Inc., Verizon Communications, Inc., Cellco Partnership dba Verizon Wireless, Nokia of America Corporation, and Ericsson, Inc.)

Case No. 2:23-cv-202 (EDTex – Lead Case), Case No. 2:23-cv-203, and Case No. 2:23-cv-204

Engaged by defendants to provide opinions regarding claim construction, validity and infringement of U.S. Pat. Nos. 10,715,235, 10,594,376, 7,177,369, 8,289,939, and 8,737,511. The matter involved the use of transmit beamforming, channel estimation and MIMO and diversity techniques in 3GPP 5G NR systems in 3GPP Releases 15, 16 and 17 within the gNB infrastructure, and UEs. This matter remains pending.

Pegasus Wireless Innovation LLC v. Joint Defense Group (Cellco Partnership d/b/a Verizon Wireless, Verizon Business Network Services LLC, Verizon Corporate Services Group Inc., TracFone Wireless, Inc., AT&T Corp., AT&T Services, Inc., AT&T Mobility LLC, AT&T Mobility II LLC, New Cingular Wireless PCS, LLC, Cricket Wireless LLC, T-Mobile USA, Inc., Sprint Solutions LLC, Sprint Spectrum LLC, Ericsson Inc., and Nokia of America Corporation)

Case No. 2:23-cv-00640-JRG (EDTex - Lead Case), Case No. 2:23-cv-00638-JRG, Case No. 2:23-cv-00639-JRG

Engaged by defendants to provide opinions regarding claim construction, validity and infringement of U.S. Pat. Nos. 11,627,631, 10,181,931, 10,616,932, 11,405,942, 10,594,460, 10,721,118, 11,219,000, 10,638,463, 9,894,644, and 10,009,161. The patents relate to various aspects of 3GPP LTE and 5G NR radio access networks including: allocating resources in machine type communications (MTC), 5G Network Slices, Radio Resource Control (RRC) Signaling, Bandwidth part (BWP) configuration, MAC layer control signaling, and channel quality indicators (CQI) and modulation and code rate allocations. This matter remains pending.

List of Issued U.S. Patents

United States Pat. No.	Title
5,550,549	Transponder system and method
5,687,196	Range and bearing tracking system with multipath rejection
5,898,338	Adaptive digital predistortion linearization and feed-forward correction of RF power amplifier
5,929,704	Control of RF error extraction using auto-calibrating RF correlator
5,949,283	Adaptive digital predistortion linearization and feed-forward correction of RF power amplifier
5,960,047	System and method for transmitting information signals
6,078,216	Aliased wide band performance monitor for adjusting predistortion and vector modulator control parameters of RF amplifier
6,100,843	Adaptive antenna for use in same frequency networks
6,212,220	Method and apparatus for creating non-interfering signals using non-orthogonal techniques
6,222,832	Fast Acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
6,239,756	Antenna array with housing
6,301,291	Pilot symbol assisted modulation and demodulation in wireless communication systems
6,304,215	Method of use for an adaptive antenna in same frequency networks
6,362,790	Antenna array structure stacked over printed wiring board with beamforming components
6,388,999	Dynamic bandwidth allocation for multiple access communications using buffer urgency factor
6,396,456	Stacked dipole antenna for use in wireless communications systems
6,400,317	Method and apparatus for antenna control in a communications network
6,404,386	Adaptive antenna for use in same frequency networks
6,421,336	Variable rate orthogonally coded reverse link structure
6,448,938	Method and apparatus for frequency selective beam forming
6,452,913	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
6,456,835	Arbitration method for high power transmissions in a code division multiple access system
6,473,036	Method and apparatus for adapting antenna array to reduce adaptation time while increasing array performance
6,515,635	Adaptive antenna for use in wireless communication systems
6,518,920	Adaptive antenna for use in same frequency networks
6,542,481	Dynamic bandwidth allocation for multiple access communication using session queues
6,545,990	Method and apparatus for a spectrally compliant cellular communication system
6,545,994	Access probe acknowledgment including collision detection to avoid oversetting initial power level
6,563,809	Subscriber-controlled registration technique in a CDMA system
6,600,456	Adaptive antenna for use in wireless communication systems
6,614,776	Forward error correction scheme for high rate data exchange in a wireless system
6,678,260	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
6,707,804	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
6,785,323	Variable rate coding for forward link
6,788,268	Method and apparatus for frequency selective beam forming
6,792,290	Method and apparatus for performing directional re-scan of an adaptive antenna
6,801,564	Reverse link correlation filter in wireless communication systems
6,804,223	Reverse link pilot integrated with block codes
6,873,293	Adaptive receive and omnidirectional transmit antenna array
6,888,504	Aperiodic array antenna
6,888,807	Applying session services based on packet flows

6,894,653	Low cost multiple pattern antenna for use with multiple receiver systems
6,904,079	Access channel structure for wireless communication system
6,911,879	Electronic phase shifter with enhanced phase shift performance
6,917,581	Use of orthogonal or near orthogonal codes in reverse link
6,917,642	Method for using a non-orthogonal pilot signal with data channel interference cancellation
6,925,070	Time-slotted data packets with a preamble
6,928,064	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
6,933,887	Method and apparatus for adapting antenna array using received predetermined signal
6,937,562	Application specific traffic optimization in a wireless link
6,940,842	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
6,941,152	Wireless subscriber network registration system for configurable services
6,954,448	Alternate channel for carrying selected message types
6,956,840	Power control protocol for highly variable data rate reverse link of a wireless communication system
6,973,140	Maximizing data rate by adjusting codes and code rates in CDMA system
6,989,797	Adaptive antenna for use in wireless communication systems
6,992,546	Electronic phase shifter with enhanced phase shift performance
7,002,902	Method and system for economical beam forming in a radio communication system
7,006,428	Method for allowing multi-user orthogonal and non-orthogonal interoperability of code channels
7,006,483	Qualifying available reverse link coding rates from access channel power setting
7,009,559	Method and apparatus for adapting antenna array using received predetermined signal
7,015,773	Electronic phase shifter with enhanced phase shift performance
7,034,759	Adaptive receive and omnidirectional transmit antenna array
7,072,316	Subscriber-controlled registration technique in a CDMA system
7,079,523	Maintenance link using active/standby request channels
7,092,430	Method for using a non-orthogonal pilot signal with data channel interference cancellation
7,113,786	Antenna adaptation to manage the active set to manipulate soft hand-off regions
7,145,964	Maximizing data rate by adjusting codes and code rates in CDMA system
7,176,844	Aperiodic array antenna
7,184,417	Power control protocol for highly variable data rate reverse link of a wireless communication system
7,187,904	Frequency translating repeater with low cost high performance local oscillator architecture
7,200,134	Wireless area network using frequency translation and retransmission based on modified protocol messages for enhancing network coverage
7,215,297	Adaptive antenna for use in wireless communication systems
7,218,623	Coded reverse link messages for closed-loop power control of forward link control messages
7,221,664	Transmittal of heartbeat signal at a lower level than heartbeat request
7,224,685	Method of detection of signals using an adaptive antenna in a peer-to-peer network
7,227,907	Antenna adaptation comparison method for high mobility
7,230,935	Physical layer repeater with selective use of higher layer functions based on network operating conditions
7,233,627	Method for searching pilot signals to synchronize a CDMA receiver with an associated transmitter
7,233,771	Non-frequency translating repeater with downlink detection for uplink and downlink synchronization
7,253,783	Low cost multiple pattern antenna for use with multiple receiver systems
7,272,169	Reverse link correlation filter in wireless communication systems
7,289,827	Method and apparatus for performing directional re-scan of an adaptive antenna
7,308,285	Antenna adaptation in a time division duplexing system
7,366,154	Forward error correction scheme for high rate data exchange in a wireless system
7,394,791	Multi-detection of heartbeat to reduce error probability
7,425,928	Method and apparatus for frequency selective beam forming
7,426,241	Variable rate coding for forward link
7,428,263	Method for using a non-orthogonal pilot signal with data channel interference cancellation

7,433,340	Staggering forward and reverse wireless channel allocation timing
7,447,187	Reverse link pilot integrated with block codes
7,463,200	Directional antenna configuration for TDD repeater
7,463,201	Aperiodic array antenna
7,480,280	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
7,483,473	Access channel structure for wireless communication system
7,496,072	System and method for controlling signal strength over a reverse link of a CDMA wireless communication system
7,502,351	Alternate channel for carrying selected message types
7,502,424	Maximizing data rate by adjusting codes and code rates
7,528,789	Adaptive antenna for use in wireless communication systems
7,529,264	Use of orthogonal or near orthogonal codes in reverse link
7,551,663	Use of correlation combination to achieve channel detection
7,580,674	Intelligent interface for controlling an adaptive antenna array
7,586,880	Method of detection of signals using an adaptive antenna in a peer-to-peer network
7,592,969	Multiple-antenna device having an isolation element
7,593,380	Variable rate forward error correction for enabling high performance communication
7,602,749	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
7,613,227	Reverse link correlation filter in wireless communication systems
7,701,903	Power control protocol for highly variable data rate reverse link of a wireless communication system
7,733,285	Integrated, closely spaced, high isolation, printed dipoles
7,746,830	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
7,773,566	System and method for maintaining timing of synchronization messages over a reverse link of a CDMA wireless communication system
7,787,408	Wireless repeater with master/slave configuration
7,826,437	Variable rate coding for enabling high performance communication
7,889,702	Time-slotted data packets with a preamble
7,893,889	Multiple-antenna device having an isolation element
7,907,513	Superimposed composite channel filter
7,907,891	Physical layer repeater utilizing real time measurement metrics and adaptive antenna array to promote signal integrity and amplification
7,911,985	Automatic gain control and filtering techniques for use in on-channel repeater
7,911,993	Method and apparatus for allowing soft handoff of a CDMA reverse link utilizing an orthogonal channel structure
7,916,772	Method for searching pilot signals to synchronize a CDMA receiver with an associated transmitter
7,936,728	System and method for maintaining timing of synchronization messages over a reverse link of a CDMA wireless communication system
7,936,736	Enforcing policies in wireless communication using exchanged identities
7,944,845	Application specific traffic optimization in a wireless link
7,990,904	Wireless network repeater
8,023,885	Non-frequency translating repeater with downlink detection for uplink and downlink synchronization
8,027,642	Transmission canceller for wireless local area network
8,045,536	Forward error correction scheme for high rate data exchange in a wireless system
8,059,727	Physical layer repeater configuration for increasing MIMO performance
8,060,009	Wireless local area network repeater with automatic gain control for extending network coverage
8,068,474	Variable rate coding for enabling high performance communication
8,072,944	Staggering forward and reverse wireless channel allocation timing
8,072,958	Reverse link pilot integrated with block codes
8,078,100	Physical layer repeater with discrete time filter for all-digital detection and delay generation
8,089,913	Physical layer repeater with selective use of higher layer functions based on network operating conditions
8,090,359	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,090,616	Visual identification information used as confirmation in a wireless communication
8,095,067	Frequency translating repeater with low cost high performance local oscillator architecture

8,111,645	Wireless local area network repeater with detection
8,116,239	Use of a filter bank in an adaptive on-channel repeater utilizing adaptive antenna arrays
8,116,749	Protocol for anonymous wireless communication
8,121,535	Configuration of a repeater
8,122,134	Reducing loop effects in a wireless local area network repeater
8,134,980	Transmittal of heartbeat signal at a lower level than heartbeat request
8,139,546	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
8,155,096	Antenna control system and method
8,175,120	Minimal maintenance link to support synchronization
8,194,783	Variable rate coding for a forward and reverse link
8,204,140	Subscriber unit and method for variable forward error correction (FEC) decoding
8,238,912	Non-intrusive detection of enhanced capabilities at existing cellsites in a wireless data communication system
8,259,687	Dynamic bandwidth allocation for multiple access communications using buffer urgency factor
8,259,744	Use of orthogonal or near orthogonal codes in reverse link
8,265,630	Antenna adaptation to manage the active set to manipulate soft hand-off regions
8,274,954	Alternate channel for carrying selected message types
8,285,201	Wideband echo cancellation in a repeater
8,315,294	Method for searching pilot signals to synchronize a CDMA receiver with an associated transmitter
8,321,542	Wireless channel allocation in a base station processor
8,358,969	Feedback delay control in an echo cancellation repeater
8,363,590	Physical layer repeater with roaming support based on multiple identifiers
8,369,277	Signaling for wireless communications
8,369,842	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,370,955	Enforcing policies in wireless communication using exchanged identities
8,374,592	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,385,305	Hybrid band intelligent backhaul radio
8,385,818	Delay control to improve frequency domain channel estimation in an echo cancellation repeater
8,385,896	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,385,913	Using a first wireless link to exchange identification information used to communicate over a second wireless link
8,422,540	Intelligent backhaul radio with zero division duplexing
8,437,329	Variable rate coding for enabling high performance communication
8,437,330	Antenna control system and method
8,463,255	Method and apparatus for a spectrally compliant cellular communication system
8,467,353	Time-slotted data packets with a preamble
8,467,363	Intelligent backhaul radio and antenna system
8,477,665	Method in a wireless repeater employing an antenna array for interference reduction
8,498,234	Wireless local area network repeater
8,502,733	Transmit co-channel spectrum sharing
8,503,926	IQ imbalance compensation in interference cancellation repeater using a zero-IF radio architecture
8,509,268	Minimal maintenance link to support sychronization
8,509,835	Reverse link initial power setting using effective radiated power message to compute path loss
8,521,862	Wireless channel allocation in a base station processor
8,526,401	Power control protocol for highly variable data rate reverse link of wireless communication system
8,537,656	Method for compensating for multi-path of a CDMA reverse link utilizing an orthogonal channel structure
8,542,623	Use of RF reference in a digital baseband interference cancellation repeater
8,553,610	Interference cancellation repeater incorporating a non-linear element
8,559,379	Method and apparatus for mitigating oscillation between repeaters
8,576,805	Subscriber-controlled registration technique in a CDMA system

8,582,552	Maintaining a maintenance channel in a reverse link of a wireless communications system
8,599,906	Closed form calculation of temporal equalizer weights used in a repeater transmitter leakage cancellation system
8,605,702	Maintaining a maintenance channel in a reverse link of a wireless communications system
8,619,837	Use of adaptive antenna array in conjunction with an on-channel repeater to improve signal quality
8,630,211	Hybrid radio architecture for repeaters using RF cancellation reference
8,638,839	Intelligent backhaul radio with co-band zero division duplexing
8,638,877	Methods, apparatuses and systems for selective transmission of traffic data using orthogonal sequences
8,649,418	Enhancement of the channel propagation matrix order and rank for a wireless channel
8,676,131	Method and apparatus for allowing soft handoff of a CDMA reverse link utilizing an orthogonal channel structure
8,687,606	Alternate channel for carrying selected message types
8,709,092	Periprosthetic fracture management enhancements
8,737,343	Coded reverse link messages for closed-loop power control of forward link control messages
8,755,360	Method and apparatus for a spectrally compliant cellular communication system
8,755,473	Method and apparatus for detecting rapid changes in signaling path environment
8,774,079	Repeater techniques for multiple input multiple output utilizing beam formers
8,787,248	Method in a wireless repeater employing an antenna array including vertical and horizontal feeds for interference reduction
8,790,321	Apparatus, system, and method for harvesting improved bone graft material with reamer-irrigator-aspirator (RIA) device
8,792,458	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
8,811,367	Qualifying available reverse link coding rates from access channel power setting
8,824,442	Intelligent backhaul radio with adaptive channel bandwidth control
8,830,977	Reverse link pilot integrated with block codes
8,842,642	Transmitting acknowledgement messages using a staggered uplink time slot
8,849,186	Repeater communication using inserted low power sequences
8,849,698	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,861,429	Selective carrier amplification in a wireless repeater
8,885,688	Control message management in physical layer repeater
8,897,340	Enhancement of the channel propagation matrix order and rank for a wireless channel
8,908,654	Dynamic bandwidth allocation for multiple access communications using buffer urgency factor
8,937,874	Adjusting repeater gains based upon received downlink power level
8,942,216	Hybrid band intelligent backhaul radio
8,948,235	Intelligent backhaul radio with co-band zero division duplexing utilizing transmitter to receiver antenna isolation adaptation
8,958,457	Channel structure for a wireless communication system
8,964,909	Maximizing data rate by adjusting codes and code rates
8,989,762	Advanced backhaul services
9,014,118	Signaling for wireless communications
9,019,930	Coded reverse link messages for closed-loop power control of forward link control messages
9,020,009	Inserted pilot construction for an echo cancellation repeater
9,020,621	Network based media enhancement function based on an identifier
9,038,129	Enforcing policies in wireless communication using exchanged identities
9,042,400	Multi-detection of heartbeat to reduce error probability
9,135,612	Proximity detection, virtual detection, or location based triggering of the exchange of value and information
9,161,164	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
9,179,240	Transmit co-channel spectrum sharing
9,185,604	Qualifying available reverse link coding rates from access channel power setting
9,210,616	Application specific traffic optimization in a wireless link
9,225,395	Antenna control system and method
9,226,295	Hybrid band radio with data direction determined by a link performance metric
9,237,209	Time-slotted data packets with a preamble

9,247,510	Use of correlation combination to achieve channel detection
9,252,857	Embedded control signaling for wireless systems
9,294,222	Variable rate coding for forward and reverse link
9,301,274	Minimal maintenance link to support synchronization
9,306,658	Method and apparatus for a spectrally compliant cellular communication system
9,306,703	Variable rate coding for enabling high performance communication
9,307,532	Signaling for wireless communications
9,325,398	Method for installing a backhaul radio with an antenna array
9,325,477	Alternate channel for carrying selected message types
9,345,523	Periprosthetic fracture management enhancements
9,363,759	Power control protocol for highly variable data rate reverse link of a wireless communication system
9,369,235	Maximizing data rate by adjusting codes and code rates
9,374,822	Method for installing a hybrid band radio
9,397,808	Reverse link pilot integrated with block codes
9,398,120	Time-slotted data packets with a preamble
9,456,376	Subscriber-controlled registration technique in a CDMA system
9,456,428	Method and apparatus for allowing soft handoff of a CDMA reverse link utilizing an orthogonal channel structure
9,460,433	Proximity detection, virtual detection, or location based triggering of the exchange of value and information
9,490,918	Zero division duplexing MIMO backhaul radio with adaptable RF and/or baseband cancellation
9,496,915	Use of orthogonal or near orthogonal codes in reverse link
9,497,761	Qualifying available reverse link coding rates from access channel power setting
9,522,066	Periprosthetic fracture management enhancements
9,525,923	Multi-detection of heartbeat to reduce error probability
9,554,061	Smart hub
9,555,169	Apparatus for harvesting improved bone graft material utilizing an implantable biodegradable filter
9,572,163	Hybrid band radio with adaptive antenna arrays
9,577,733	Method for installing a backhaul link with multiple antenna patterns
9,655,062	System and method for coordination of wireless maintenance channel power control
9,661,583	Reverse link initial power setting using effective radiated power message to compute path loss
9,686,713	Application specific traffic optimization in a wireless link
9,686,790	Signaling for wireless communications
9,713,019	Self organizing backhaul radio
9,713,157	Method for installing a backhaul link with alignment signals
9,775,115	Antenna control system and method
9,780,930	Communicating reference and data information in a wireless network
9,781,626	Wireless channel allocation in a base station processor
9,807,714	Minimal maintenance link to support synchronization
9,832,664	Receiving and transmitting reverse link signals from subscriber units
9,867,101	Method and apparatus for allowing soft handoff of a CDMA reverse link utilizing an orthogonal channel structure
9,872,196	Subscriber-controlled registration technique in a CDMA system
9,876,530	Advanced backhaul services
9,913,271	Qualifying available reverse link coding rates from access channel power setting
9,913,722	Periprosthetic fracture management enhancements
9,924,468	Antenna control system and method
9,936,500	Transmitting acknowledgement messages using a staggered uplink time slot
9,954,635	Variable rate coding for enabling high performance communication
9,974,116	Handoff to base station having enhanced capabilities
10,057,700	Smart hub

10,063,363	Zero division duplexing MIMO radio with adaptable RF and/or baseband cancellation
10,064,144	Use of correlation combination to achieve channel detection
10,129,888	Method for installing a fixed wireless access link with alignment signals
10,153,885	Alternate channel for carrying selected message types
10,204,357	Proximity detection, virtual detection, or location based triggering of the exchange of value and information
10,211,940	Use of orthogonal or near orthogonal codes in reverse link
10,237,760	Self organizing backhaul radio
10,284,253	Advanced backhaul services
10,286,123	Removable biocompatible substrate filter for a reaming and collection device
10,299,218	System and method for coordination of wireless maintenance channel power control
10,306,635	Hybrid band radio with multiple antenna arrays
10,356,782	Embedded control signaling for self-organizing wireless backhaul radio and systems
10,357,370	Periprosthetic fracture management enhancements
10,390,311	Maintaining a maintenance channel in a reverse link of a wireless communications system
10,638,468	Qualifying available reverse link coding rates from access channel power setting
10,687,161	Smart hub
10,687,950	Periprosthetic shoulder fracture repair
10,700,733	Advanced backhaul services
10,708,918	Electronic alignment using signature emissions for backhaul radios
10,735,979	Self organizing backhaul radio
10,736,110	Method for installing a fixed wireless access link with alignment signals
10,762,532	Proximity detection, virtual detection, or location based triggering of the exchange of value and information
10,805,887	Maintaining a maintenance channel in a reverse link of a wireless communications system
10,821,030	Apparatus and method for a temperature released adhesive structure for use with bandages
10,874,520	Combination intra-medullary and extra-medullary fracture stabilization with aligning arm
10,932,267	Hybrid band radio with multiple antenna arrays
10,966,201	Embedded control signaling for self-organizing wireless backhaul radio and systems
11,000,380	Combination intra-medullary and extra medullary fracture stabilization with aligning arm
11,013,605	Combination intra-medullary and extra medullary fracture stabilization with aligning arm
11,074,615	Efficient and secure communication using wireless service identifiers
11,219,527	Combination intra-medullary and extra-medullary fracture stabilization with aligning arm
11,238,499	Proximity detection, virtual detection, or location based triggering of the exchange of value and information
11,260,164	Negative pressure wound therapy dressing and related apparatus
11,303,322	Advanced backhaul services
11,310,614	Smart Hub
11,334,918	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
11,343,060	Zero division duplexing MIMO radio with adaptable RF and/or baseband cancellation
11,343,684	Self organizing backhaul radio
11,437,740	Removable biocompatible substrate filter for a reaming and collection device
11,443,344	Efficient and secure communication using wireless service identifiers
11,6333,217	Reduction and fixation apparatus for calcaneal fracture
11,684,518	Apparatus and method for a temperature released adhesive structure for use with bandages
11,687,971	Efficient and secure communication using wireless service identifiers
11,723,776	Periprosthetic shoulder fracture repair
11,995,685	Efficient and secure communication using wireless service identifiers
12,002,070	Proximity detection, virtual detection, or location based triggering of the exchange of value and information
12,081,950	Smart Hub
D532780	Wireless repeater housing

Exhibit B

(Materials Considered)

DECLARATION OF JAMES PROCTOR, JR. IN SUPPORT OF
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List of Materials Considered

- a. The '561 Patent
- b. The '561 Patent's File History (U.S. Application No. 11/999, 264)
- c. U.S. Provisional Application No. 60/872,132
- d. *Deembedding Static Nonlinearities and Identifying and Modeling Memory Effects in Wide-Band RF Transmitters*, IEEE Transactions on Microwave Theory and Techniques, VOL. 53, NO. 11, (Nov. 2005) ("Lui")
- e. Lei Ding, *Digital Predistortion of Power Amplifiers for Wireless Applications*, A Thesis Presented to the Academic Faculty, School of Electrical and Computer Engineering, Georgia Institute of Technology ("Ding")
- f. Tong Wang and Jacek Ilow, Compensation of Nonlinear Distortions with Memory Effects in OFDM Transmitters, IEEE Communications Society, Globecom (2004) ("Wang")
- g. P.L. Gilabert, G. Montoro and E. Bertran, On the Wiener and Hammerstein Models for Power Amplifier Predistortion, IEEE, AMC2005 Proceedings (2005) ("Gilabert")
- h. P. Crama and Y. Rolain, "Broadband measurement and identification of a Wiener–Hammerstein model for an RF

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amplifier,” in 60th ARFTG Conf. Dig., Washington, DC, Dec. 5–6, 2002, pp. 49–57 (“Crama”)

- i. P. Jantunen, G. Gamez and T. Laakso, “Measurements and modeling of nonlinear power amplifiers,” in Proc. 6th Nordic Signal Processing Symp., Meripuisto, Espoo, Finland, Jun. 9–11, 2004, pp. 328–331 (“Jantunen”)
- j. Yucai Zhu, “Estimation of an N-L-N Hammerstein-Wiener Model,” 15th Triennial World Congress (Barcelona, Spain) (2002) (“Zhu”)
- k. Hosam E. Emara-Shabaik, Mohammed S. Ahmed and Khaled H. Al-Ajmi, “Wiener-Hammerstein Model Identification-Recursive Algorithms,” JSME International Journal Series C, Vol. 45, No. 2 (2002) (“Emara-Shabaik”)
- l. Allen Katz, Linearizing and Reducing Distortions in Power Amplifiers (IEEE Microwave Magazine, Dec. 2001) (“Katz”)
- m. Lei Ding, Raviv Raich, G. Tong Zhou, A Hammerstein Predistortion Linearization Design Based on the Indirect Learning Architecture (“Raich”)
- n. Nazim Ceylan, Linearization of Power Amplifiers by Means of Digital Predistortion (2005) (“Ceylan”)

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- o. Alan Oppenheim and Ronald Schaffer, “Discrete-Time Signal Processing” (Prentice Hall 1989) (“Oppenheim”)
- p. Taijun Liu, Slim Boumaiza, Member and Fadhel M. Ghannouchi, Augmented Hammerstein Predistorter for Linearization of Broad-Band Wireless Transmitters (IEEE Transactions ON Microwave Theory and Techniques, VOL. 54, NO. 4, APRIL 2006) (“Boumaiza”)
- q. Kang, H. W., Cho, Y. S., and Youn, D. H., “On compensating nonlinear distortions of an OFDM system using efficient adaptive predistorter,” IEEE Trans. Commun., vol. 47 (Apr. 1999) (“Kang”)
- r. Lei Ding, Lianming Sun and A. Sano, “Adaptive nonlinearity predistortion schemes with application to OFDM system,” IEEE, pp. 1130-1135 (2003) (“Sun”)

Exhibit C

(Challenged Claims)

DECLARATION OF JAMES PROCTOR, JR. IN SUPPORT OF
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Table of Challenged Claims

1[pre]	A behavioral model of a nonlinear dynamic system, the model comprising:
1[a]	a first module characterizing dynamic nonlinear characteristics of the system, wherein the first module includes an input and an output; and
1[b]	a second module characterizing static nonlinear characteristics of the nonlinear system, wherein the second module includes an input and an output;
1[c]	wherein the first module is coupled to the second module.
2	The model of claim 1, wherein the first module is coupled to the second module such that an output of the first module is input to the second module.
3	The method of claim 1, wherein the second module is coupled to the first module such that an output of the second module is input to the first module.
4	The model of claim 1 wherein the first module comprises a nonlinear finite impulse response-based memory effect system and the second module comprises a look-up table-based nonlinear memoryless system.
5	The model of claim 1 wherein the first module is a dynamic weak nonlinear model and the second module is a static strong nonlinear model.
6	The model of claim 1 wherein the first module comprises a finite impulse response filter-based multi-branch nonlinear system and the second module comprises two look-up tables, each look-up table dependent on the magnitude of the input signal.

7[pre]	A predistorter for nonlinear wireless system, the predistorter comprising:
7[a]	a dynamic nonlinear predistorter module; and
7[b]	a static nonlinear predistorter module coupled to the dynamic nonlinear predistorter module such that an output of the dynamic nonlinear predistorter module is input to the static nonlinear predistorter module.
8	The predistorter of claim 7 wherein the dynamic nonlinear predistorter is a finite impulse response-based memory effect predistorter and the static nonlinear predistorter is a look-up table-based memoryless predistorter.
9	The predistorter of claim 7 wherein the dynamic nonlinear predistorter is a dynamic weak nonlinear predistorter and the static nonlinear predistorter is a static strong nonlinear predistorter.

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10	The predistorter of claim 9 wherein the dynamic weak nonlinear predistorter is implemented as a finite impulse response filter-based multi-branch nonlinear structure embedded within a polynomial like series and the static strong nonlinear predistorter includes two look-up tables, each look-up table depends on the magnitude of a current input signal.
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11[pre]	A predistorter for nonlinear wireless system, the predistorter comprising:
11[a]	a static nonlinear predistorter module; and
11[b]	dynamic nonlinear predistorter module coupled to the static nonlinear predistorter module such that an output of the static nonlinear predistorter module is input to the dynamic nonlinear predistorter module.
12	The predistorter of claim 11 wherein the dynamic nonlinear predistorter module is a finite impulse response-based memory effect predistorter module and the static nonlinear predistorter is a look-up table-based memoryless predistorter module.
13	The predistorter of claim 11 wherein the dynamic nonlinear predistorter module is a dynamic weak nonlinear predistorter module and the static nonlinear predistorter is a static strong nonlinear predistorter module.
14	The predistorter of claim 12 wherein the dynamic weak nonlinear predistorter is implemented as a finite impulse response filter-based multi-branch nonlinear structure and the static strong nonlinear predistorter includes two look-up tables, each look-up table depends on the magnitude of a current input signal.

15[pre]	An augmented Wiener predistorter, the predistorter comprising:
15[a]	a dynamic nonlinear first order predistorter module; and
15[b]	a static nonlinear predistorter module coupled to the dynamic nonlinear predistorter module such that an output of the dynamic nonlinear predistorter module is input to the static nonlinear predistorter module.
16	The predistorter of claim 15 wherein the dynamic nonlinear predistorter is a finite impulse response-based memory effect predistorter and the static nonlinear predistorter is a look-up table-based memoryless predistorter.

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17	The predistorter of claim 15 wherein the dynamic nonlinear predistorter is a dynamic weak nonlinear predistorter and the static nonlinear predistorter is a static strong nonlinear predistorter.
18	The predistorter of claim 17 wherein the dynamic weak nonlinear predistorter is implemented as a finite impulse response filter-based multi-branch nonlinear structure and the static strong nonlinear predistorter includes two look-up tables, each look-up table depends on the magnitude of a current input signal.

19[pre]	An augmented Hammerstein predistorter, the predistorter comprising:
19[a]	a static nonlinear predistorter module; and
19[b]	a dynamic nonlinear first order predistorter module coupled to the static nonlinear predistorter module such that an output of the static nonlinear predistorter module is input to the dynamic nonlinear predistorter module.
20	The predistorter of claim 19 wherein the dynamic nonlinear predistorter module is a finite impulse response-based memory effect predistorter module and the static nonlinear predistorter is a look-up table-based memoryless predistorter module.
21	The predistorter of claim 19 wherein the dynamic nonlinear predistorter module is a dynamic weak nonlinear predistorter module and the static nonlinear predistorter is a static strong nonlinear predistorter module.
22	The predistorter of claim 21 wherein the dynamic weak nonlinear predistorter is implemented as a finite impulse response filter-based multi-branch nonlinear structure and the static strong nonlinear predistorter includes two look-up tables, each look-up table depends on the magnitude of a current input signal.