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

PETITION FOR *INTER PARTES* REVIEW OF U.S. PATENT NO. 8,078,561

UNDER 35 U.S.C. §§ 311-319 AND 37 C.F.R. § 42.100 *ET SEQ*.

TABLE OF CONTENTS

PETITIONERS' EXHIBIT LIST

Exhibit No.	Document
1001	U.S. Patent No. 8,078,561 ("the '561 Patent")
1002	Prosecution History of U.S. Application No. 11/999,264, filed December 7, 2007, which issued as the '561 Patent
1003	U.S. Provisional Patent Application No. 60/872,132, filed December 1, 2006, to which the '561 Patent may claim priority
1004	Taijun Liu, Slim Boumaiza, Member and Fadhel M. Ghannouchi, *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")
1005	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 (March 2004) ("Ding")
1006	Declaration of Gordon MacPherson (IEEE) re Lui reference
1007	Declaration of Fred Rascoe (Georgia Tech Library) re Ding reference
1008	Tong Wang and Jacek Ilow, *Compensation of Nonlinear Distortions with Memory Effects in OFDM Transmitters*, IEEE Communications Society, Globecom (2004) ("Wang")
1009	P.L. Gilabert, G. Montoro and E. Bertran, *On the Wiener and Hammerstein Models for Power Amplifier Predistortion*, IEEE, AMC2005 Proceedings (2005) ("Gilabert")
1010	P. Crama and Y. Rolain, "Broadband measurement and identification of a Wiener–Hammerstein model for an RF

Exhibit No.	Document
	amplifier," in 60th ARFTG Conf. Dig., Washington, DC, Dec. 5–6, 2002, pp. 49–57 ("Crama")
1011	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")
1012	Yucai Zhu, "Estimation of an N-L-N Hammerstein-Wiener Model," 15th Triennial World Congress (Barcelona, Spain) (2002) ("Zhu")
1013	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")
1014	Allen Katz, *Linearizing and Reducing Distortions in Power Amplifiers* (IEEE Microwave Magazine, Dec. 2001) ("Katz")
1015	Lei Ding, Raviv Raich, G. Tong Zhou, A Hammerstein Predistortion Linearization Design Based on the Indirect Learning Architecture ("Raich")
1016	Nazim Ceylan, *Linearization of Power Amplifiers by Means of Digital Predistortion* (2005) ("Ceylan")
1017	Alan Oppenheim and Ronald Schafer, "Discrete-Time Signal Processing" (Prentice Hall 1989) ("Oppenheim")
1018	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")

Exhibit No.	Document
1019	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")
1020	Declaration of James Proctor, Jr. ("Proctor")
1021	Curriculum Vitae of James Proctor, Jr.
1022	Table of Challenged Claims
1023	Docket Control Order, *Smart RF Inc. v. AT&T Mobility LLC et al.*, Case No. 2:24-cv-00195-JRG, Dkt. No. 41 (E.D. Tex. June 21, 2024)
1024	Federal Court Management Statistics - Profiles, June 30, 2024, *available at* https://www.uscourts.gov/sites/default/files/2024-11/fcms_na_distprofile0630_2024.pdf
1025	Order Granting Nokia's Motion to Intervene as a Defendant, *Smart RF Inc. v. AT&T Mobility LLC et al.*, Case No. 2:24-cv-00195-JRG, Dkt. No. 57 (E.D. Tex. Aug. 8, 2024)
1026	Order Granting Ericsson's Motion to Intervene as a Defendant, *Smart RF Inc. v. AT&T Mobility LLC et al.*, Case No. 2:24-cv-00195-JRG, Dkt. No. 56 (E.D. Tex. Aug. 8, 2024)

I. INTRODUCTION

Petitioners T-Mobile USA, Inc. ("T-Mobile"), AT&T Mobility LLC ("AT&T"), Cellco Partnership d/b/a Verizon Wireless ("Verizon"), Ericsson Inc. ("Ericsson") and Nokia of America Corporation ("Nokia") (collectively, "Petitioners") respectfully request *inter partes* review of claims 1-22 (the "Challenged Claims") of U.S. Patent No. 8,078,561 ("the '561 Patent," Ex. 1001) in accordance with 35 U.S.C. §§ 311-319 and 37 C.F.R. § 42.100 *et seq.* The '561 Patent generally relates to wireless radio systems and techniques for signal predistortion prior to amplification and, specifically, to the use of both a dynamic weak nonlinear ("DWNL") and static strong nonlinear ("SSNL") component to perform the predistortion. But by the time the '561 Patent's provisional application was filed in 2006, these practices were already well-known.

Not only were these techniques well-known, but more than one year before the '561 Patent's named inventors filed their patent application, the purported inventors published an article in the IEEE Transactions on Microwave Theory and Techniques (referred to herein as "Lui," Ex. 1004), disclosing what was later claimed. This article is relied upon in each ground of unpatentability set forth herein.

This Petition, associated exhibits and the Declaration of James Proctor, Jr. (Ex. 1020, submitted herewith) establish the invalidity of the Challenged Claims under 35 U.S.C. § 103(a) (pre-AIA).

II. GROUNDS FOR STANDING (37 C.F.R. § 42.104(a))

Petitioners certify pursuant to 37 C.F.R. § 42.104(a) that the ’561 Patent is available for *inter partes* review, and that Petitioners are not barred or estopped from requesting *inter partes* review based on the grounds identified herein.

III. IDENTIFICATION OF CHALLENGE (37 C.F.R. § 42.104(b)) AND RELIEF REQUESTED (37 C.F.R. § 42.22(a))

A. Identification of Prior Art

Ex. 1004[1] – Lui was published in November 2005, and is prior art to the ’561 Patent under 35 U.S.C. §§ 102(a) and 102(b) (pre-AIA).

Ex. 1005[2] – Ding was published in March 2004, and is prior art to the ’561 Patent under 35 U.S.C. §§ 102(a) and 102(b) (pre-AIA).

---

[1] The Declaration submitted herewith at Ex. 1006 establishes the authenticity and public availability of Lui.

[2] The Declaration submitted herewith at Ex. 1007 establishes the authenticity and public availability of Ding.

Neither Lui nor Ding were evaluated during the prosecution of the ’561 Patent.

B. Statutory Grounds Upon Which the Challenge is Based

#	Challenged Claims	35 U.S.C. §	Prior Art
1	1, 4-6	103	Lui
2	2, 7-10, 15-18	103	Lui
3	3, 11-14, 19-22	103	Lui, Ding

C. Requested Relief

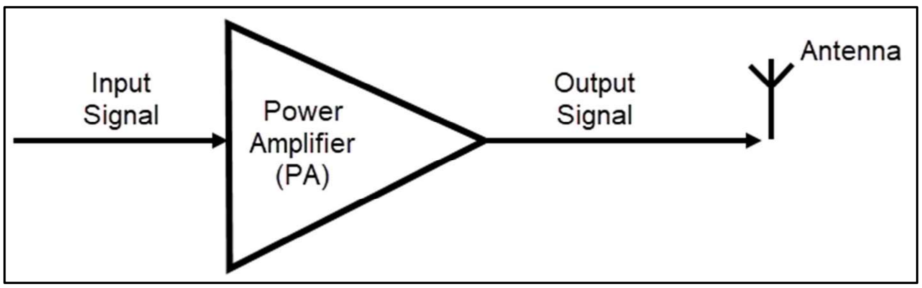
Petitioners respectfully request institution of an *inter partes* review pursuant to 37 C.F.R. § 42.108 and cancellation of the Challenged Claims of the ’561 Patent.

IV. OVERVIEW OF DIGITAL PREDISTORTION

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

A. Power Amplifiers Introduce Distortion

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



(Proctor¶ 29.) An input signal's power level is amplified to a higher power level after it passes through the PA to create an output signal. (Proctor¶ 29.) After this amplification, the output signal is transmitted using an antenna. (Proctor¶ 29.)

All PAs suffer a common problem: when they amplify a signal, they distort that signal to some degree. (Proctor¶ 30.) That distortion may take the form of (1) spectrum spreading or spectral regrowth; or (2) in-band distortion within the frequencies of the signal itself, which damages the signal's quality. (Proctor¶ 30.) When charted, these distortions can also appear as non-linear curves, where the non-linear curvature represents the distortions that the PAs introduce:

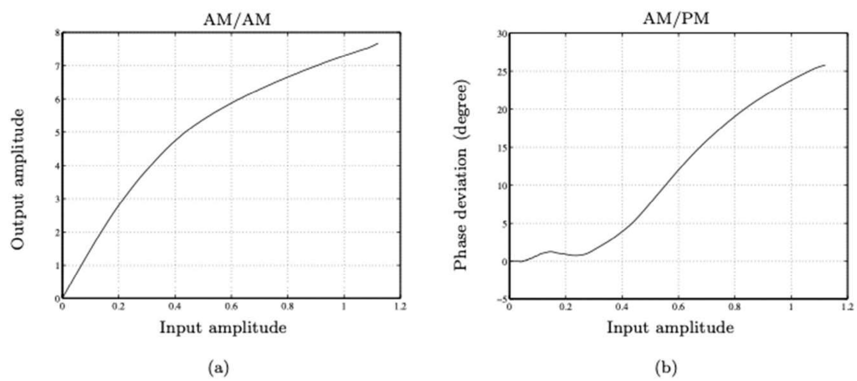


Figure 2: The AM/AM and AM/PM responses of a Class AB power amplifier.

(Ding, Fig. 2.) The above figures depict the relationship of a PA's output to the input signal's amplitude. (Proctor¶ 32.) 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. (Proctor¶ 32.) 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"). (Proctor¶ 32.) This effect results in a distortion of the output signal that is referred to as "AM to AM." (Proctor¶ 32.)

Plot (b) depicts the phase imparted to the output signal based upon the input signal's amplitude. (Proctor¶ 33.) 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. (Proctor¶ 33.) 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. (Proctor¶ 33.)

B. Predistortion Mitigates the Power Amplifiers' Distortion

To mitigate their PA's distortion, radios will *pre*distort the input signals before they are sent to the PA. (Proctor¶ 34.) 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 signals. (Proctor¶ 34.) 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." (Proctor¶ 34.) This figure illustrates a predistorter's operation in a simplified way:

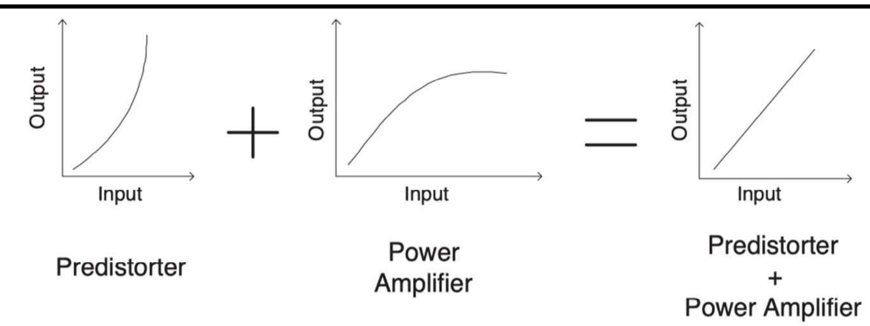


Figure 5.5: Simplified operation of predistortion.

(Ceylan (Ex. 1016), Fig. 5.5; Proctor¶ 34.)

1. "Dynamic" vs. "Static" Predistortion

Predistortion can be either "dynamic" or "static." (Proctor¶ 37.) Dynamic predistortion accounts for variations in the PA's distortions over time, which may change based on the PA's previously amplified signals, temperature and age. (Proctor¶ 37.) When a PA distorts signals based on previous amplified signals, it is said to be experiencing "memory effects" of those previous amplified signals.[3] (Proctor¶ 37.)

Static predistortion will predistort based on firm rules that do not change over time, and does not account for those memory effects. (Proctor¶ 38.) These rules may be held in lookup tables ("LUTs"), where an input signal's amplitude or phase is used to lookup the correct static predistortion to apply. (Proctor¶ 38.)

2. "Strong" vs. "Weak" Distortion

"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. (Proctor¶ 39.)

---

[3] 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. (Proctor¶ 37, n.2.)

3. “Linear” vs. “Nonlinear” Predistortion

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

4. Weiner and Hammerstein Models

The Weiner and Hammerstein models are (and were) common examples of predistorters:

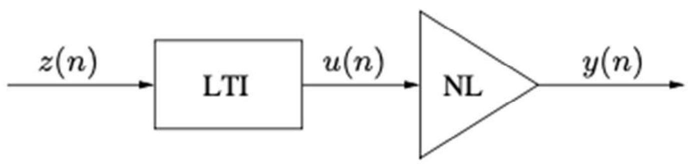


Figure 6: The Wiener Model.

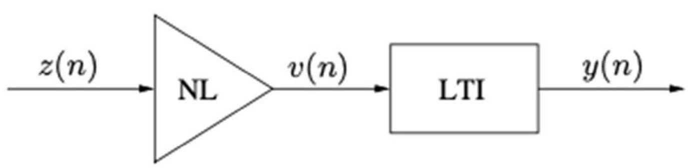


Figure 7: The Hammerstein Model.

(Ding, Fig. 8; Proctor¶ 41.) The Wiener model is a linear time-invariant ("LTI")[4] system followed by a memoryless nonlinearity (NL). (Proctor¶ 41.) The Hammerstein model is a memoryless nonlinearity followed by an LTI system. (Proctor¶ 41.)

V. OVERVIEW OF THE '561 PATENT

The '561 Patent is entitled, "Nonlinear behavior models and methods for use thereof in wireless radio systems." The '561 Patent issued on December 13, 2011 from U.S. Patent Appl. No. 11/999,264, filed on December 3, 2007. The '561 Patent claims priority to U.S. Provisional Appl. No. 60/872,132, filed on December 1, 2006.[5]

---

[4] An LTI system in this context refers to a digital filter (e.g., a FIR filter). (Oppenheim (Ex. 1017), 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; Proctor¶ 41, n.3.)

[5] Petitioners do not concede that the Challenged Claims are entitled to the benefit of the provisional application, but regardless, all art identified by Petitioners antedates December 1, 2006.

A. Specification

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.)

1. Alleged Problem: Inefficient Predistortion

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.)

“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.)

2. Alleged Solution: Coupling Dynamic and Static Nonlinear Predistortion Modules

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 proposes a model that couples "a dynamic weak nonlinear (DWNL) module, which models dynamic week [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.)

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***[6] in the presence of a modulated communication signal."). *See also id.* at 2:18-46.) The "plurality of nonlinear dynamic FIR-based

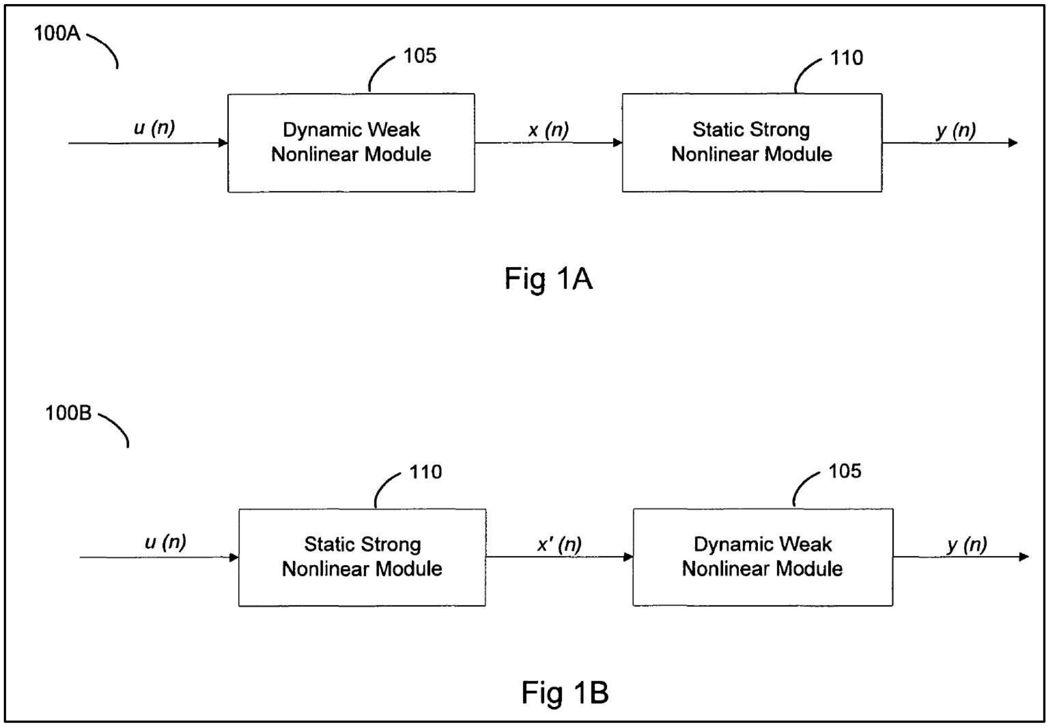
---

[6] All emphasis added unless otherwise noted.

filters" model the PA's memory effects by accounting for previous transmissions' effects on the PA. (Proctor¶ 47.) The DWNL module is said to be "weak" because it models less significant nonlinearities relative to the SSNL module. (Proctor¶ 47.)

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 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. (Proctor¶ 48.)

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.



('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.)

3. Challenged Claims

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).

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

B. Prosecution History

The '561 Patent's prosecution history is submitted as Ex. 1002. The application that issued as the '561 Patent, U.S. Application No. 11/999,264, was filed on December 7, 2007. It claims priority to U.S. Provisional Application No. 60/872,132, filed on December 1, 2006, which is submitted as Ex. 1003.

On March 28, 2011, the application faced a Non-Final Rejection. In a June 28, 2011 response, the Applicant made no amendments to the pending claims, but instead provided argument in response to the rejection. On August 12, 2011, the application received a Notice of Allowance.

As discussed in Section X.A, it was material error that the Examiner did not address the Challenged Claims at least in view of the technical disclosures and teachings of Lui and Ding, which render those claims invalid.

C. Priority Date

The '561 Patent claims priority to U.S. Provisional Patent Application No. 60/872,132, filed on December 1, 2006 and submitted as Ex. 1003. All prior art relied upon for the grounds of unpatentability addressed in this Petition pre-date this provisional filing date.

VI. LEVEL OF ORDINARY SKILL IN THE ART

For purposes of this *inter partes* review, Petitioners assert that a hypothetical person having ordinary skill in the art ("POSITA") in the context of the '561 Patent 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 filed, or (b) two or more years of work or research experience in wireless communications and, in particular, power amplification of radio signals. (Proctor¶ 23.)

VII. CLAIM CONSTRUCTION (37 C.F.R. § 42.104(b)(3))

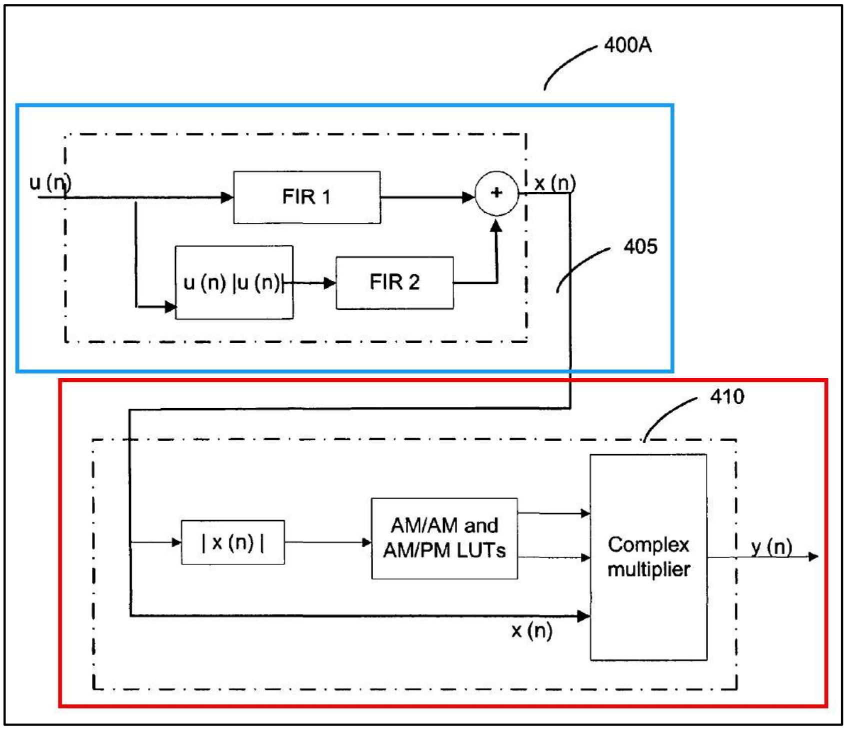
In an *inter partes* review, claims are "construed using the same claim construction standard that would be used to construe the claim in a civil action under 35 U.S.C. § 282(b)." (37 C.F.R. § 42.100(b).) Claims must be given their ordinary and customary meaning as understood by one of ordinary skill in the art at the time of the invention in light of the specification and the prosecution history pertaining to the patent. *Id. See also Phillips v. AWH Corp.*, 415 F.3d 1303, 1312-1313 (Fed. Cir. 2005) (*en banc*); 83 Fed. Reg. 51,340. For the purposes of this Petition, Petitioners propose several constructions below to aid the Board's review; however, these constructions simply articulate the plain-and-ordinary meanings of phrases that, although they may not be used in common parlance, were well-understood to a person of ordinary skill. All other claim terms should be given their plain and ordinary meaning as would be understood in the context of the '561 Patent's disclosure.

A. "Wiener predistorter" (Claim 15)

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." (Proctor¶ 54.)

First, the 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; Proctor¶ 55.) In other words, the dynamic module is followed by the static module, just as is the well-known (unmodified) Wiener predistorter. (Proctor¶ 55.)

Second, the specification also makes clear that, in an augmented Weiner 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***."); Proctor¶ 56.) This too parallels well-known and unmodified Wiener models. (*See* Lui, Fig. 3; Proctor¶ 56.). The specification's figures also show that an augmented Weiner 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; Proctor¶ 56.)

Third, extrinsic sources further confirm that a Weiner predistorter has a dynamic module followed by a static module. (Proctor¶ 57.) Ding refers to a

"Wiener model" as "a linear time-invariant (LTI)[7] [dynamic linear] system ***followed by*** a memoryless [static] nonlinearity (NL)[,]" and depicts it in Figure 6:

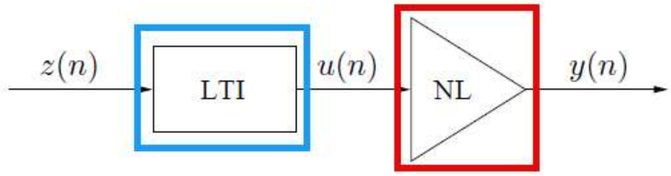


Figure 6: The Wiener Model.

(Ding, 11-12, Fig. 7; Proctor¶ 57.) Zhu states that a "Wiener model is a nonlinear model with a linear dynamic block followed by a static nonlinear function." (Zhu (Ex. 1012), 1.) Emara-Shabaik states that "the Wiener model [] is composed of a linear dynamic system followed by a static nonlinearity[.]" (Emara-Shabaik (Ex. 1013), 606.) Wang teaches that "[a] nonlinear system with memory is considered to be a Wiener system if it can be represented by a linear dynamic subsystem (linear time invariant (LTI) filter) followed by a zero-memory nonlinear subsystem[.]" (Wang (Ex. 1008), 2399.)

B. "Hammerstein predistorter" (Claim 19)

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

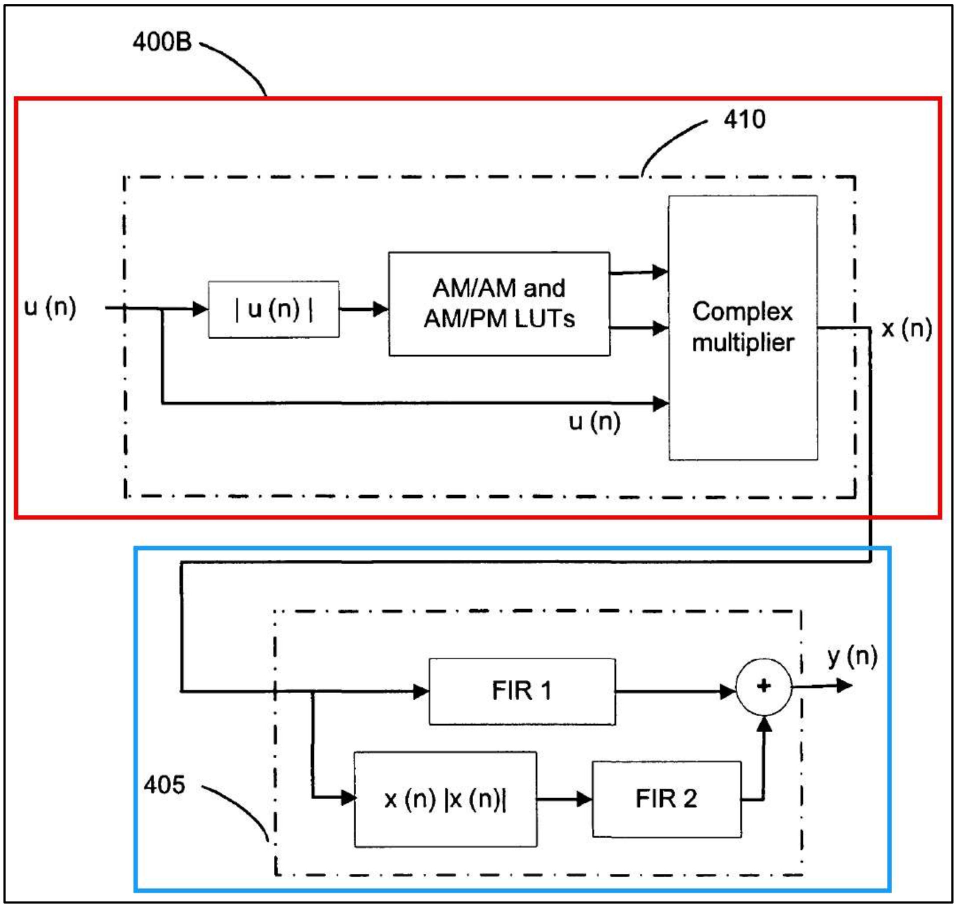
---

[7] *See* Section IV.B.3.

followed by a dynamic module" – i.e., the inverse of the Weiner predistorter. (Proctor¶ 58.)

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; Proctor¶ 59.) 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. (Proctor¶ 59.)

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***[.]); Proctor¶ 60.) 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; Proctor¶ 60.)

Third, extrinsic sources further confirm that a Hammerstein predistorter has a dynamic module followed by a static module. (Proctor¶ 61.) Ding explains that "[t]o construct a Hammerstein predistorter, the approach taken by [25][8] uses a gradient method ***to first identify the Wiener system and then find the Hammerstein predistorter as its inverse***." (Ding, 17; Proctor¶ 61.) "The Hammerstein model is a memoryless nonlinearity followed by an LTI system[,]" and shown in Figure 7:

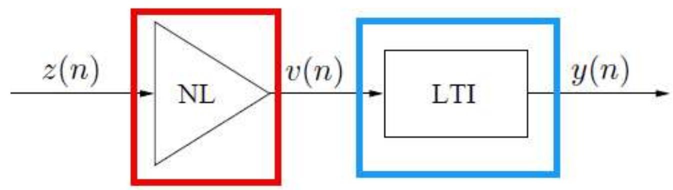


Figure 7: The Hammerstein Model.

(Ding, 12-13, Fig. 7; Proctor¶ 61.) 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.)

[8] This reference is a citation to Kang at pages 522-26.

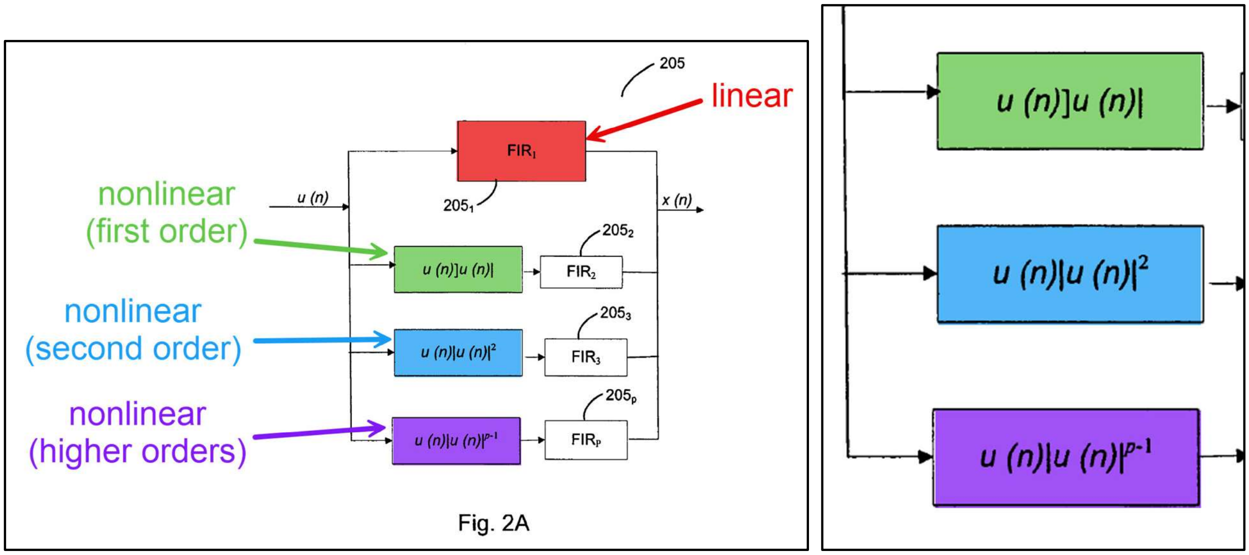
C. "dynamic nonlinear first order predistorter module" (Claims 15, 19)

A POSITA at the time of the '561 Patent's filing would have understood a "dynamic nonlinear first order nonlinear predistorter module" to mean "a dynamic predistortion module that includes a nonlinear function with a first-power exponent."[9] (Proctor¶ 62.)

First, the specification matches this construction. (Proctor¶ 62.) 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***":

---

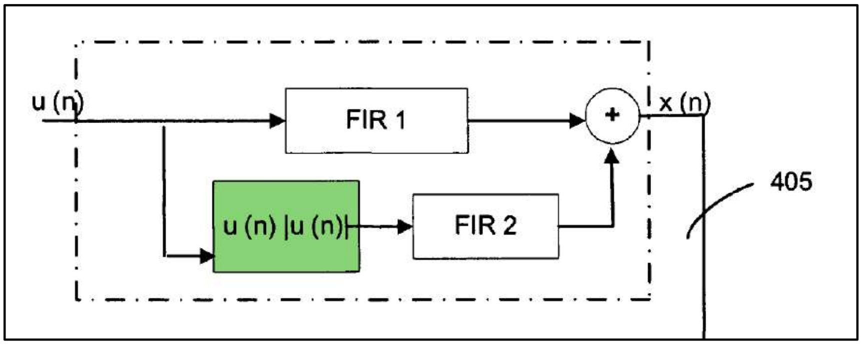
[9] Any value raised to its first power is equal to the original value (e.g., $x^1 = x$), so the first-order exponent is often not included in functions, as is the case in Figure 2A. (Proctor¶ 62, n.8.)

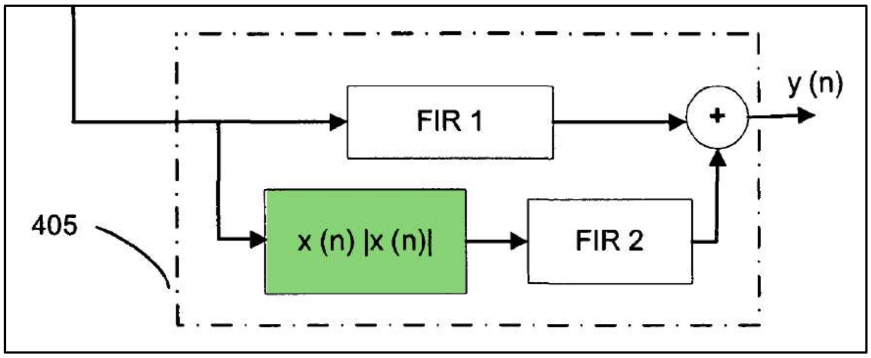


('561 Patent, 4:24-41, Fig. 2A (annotated and enlarged) (note "]" typo in magnitude for first-order function); Proctor¶ 63.) The "linear FIR filter" is shown in the red box. ('561 Patent, 4:28-33 ("DWNL module 200 includes a number of parallel branches in which the first branch includes a linear FIR filter 205_1 ..."); Proctor¶ 63.) 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 205_2-205_p."); Proctor¶ 63.) 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. (Proctor¶ 63.) 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." (Proctor¶ 63.)[10]

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. (*See* '561 Patent, 3:1-7; Proctor¶ 64.) 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)|). (Proctor¶ 64.) 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:

[10] 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."); Proctor¶ 63, n.10.)





('561 Patent, 3:1-7, Figs. 4A (top, annotated), 4B (bottom, annotated); Proctor¶ 64.)

VIII. OVERVIEW OF THE PRIOR ART

A. Lui

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 models is in the identification procedure of the parameters of their different modules. Furthermore, the known models and procedures encounter high complexity and/or low accuracy. Moreover, they frequently do not account for the strong memory effects exhibited by the transmitter/PA. Thus, in most cases, they are not appropriate for implementation in broadband adaptive communications systems. ('561 Patent, 1:42-52.)	The common difficulty for the previous models is in the identification procedure of the parameters of their different modules. The above-mentioned models and procedures encounter high complexity and/or low accuracy. In most cases, they are not appropriate for implementation in adaptive communications systems. (Lui, 3579.)

Lui proposes "a new augmented Weiner model that is capable of accurately modeling wide-band RF transmitters[.]" (Lui, 3578-79. *See also id.* at 3578-79; Proctor¶ 66.) Lui's Figure 3 shows a "Weiner transmitter model diagram" from the prior art:

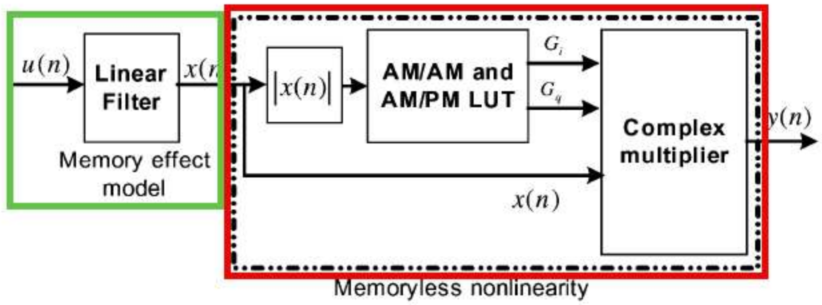


Fig. 3. Wiener transmitter model diagram from [8].

(Lui, 3580, Fig. 3; Proctor¶ 66.) This model consists "of a ***dynamic linear filter*** [annotated in green] followed by a static nonlinear block [annotated in red][.]" (Lui, 3580, Fig. 3; Proctor¶ 66.) In other words, this previous Weiner model's dynamic module accounted only for ***linear*** distortion sources – as opposed to ***nonlinear*** distortion sources. (Proctor¶ 66.)

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; Proctor¶ 67.) Lui's proposed model addresses this alleged shortcoming by adding a dynamic ***nonlinear*** model, which is shown in the blue box in Figure 17:

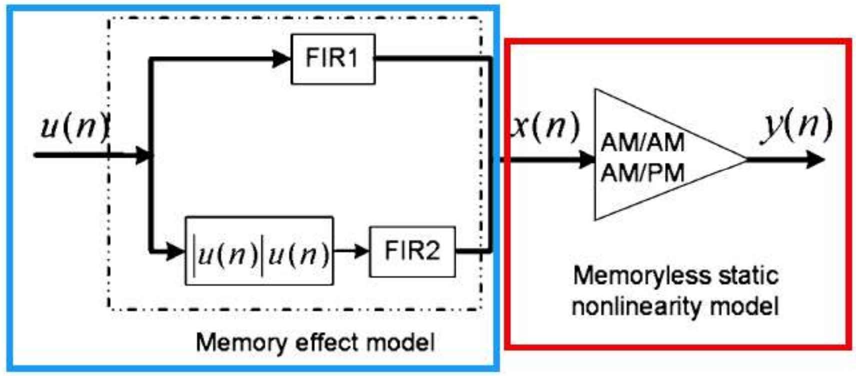


Fig. 17. Augmented Wiener transmitter model diagram.

(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."); Proctor¶ 67.)

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; Proctor¶ 68.) As with 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; Proctor¶ 68.) 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; Proctor¶ 68.)

B. Ding

Ding is a 2004 Ph.D. thesis that, among other things, "propose[s] novel predistorters and their parameter extraction algorithms." (Ding, xiii; Proctor¶ 69.) 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:

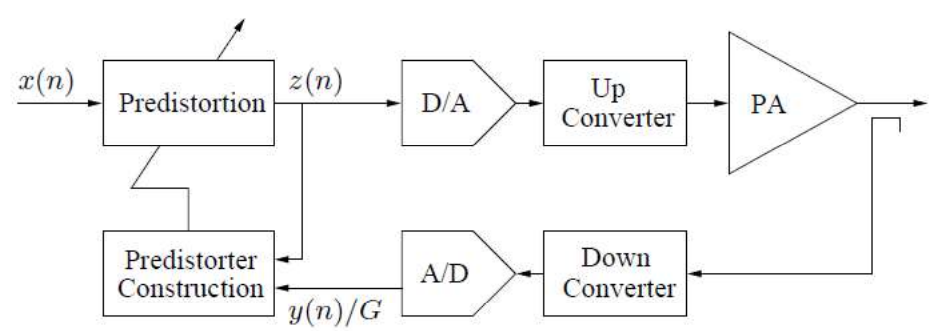


Figure 1: Digital Predistortion System Diagram

(Ding, 1, Fig. 1; Proctor¶ 69.) 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; Proctor¶ 69.)

Like the '561 Patent and Lui, Ding focuses on the dynamic, memory-based distortions. (Proctor¶ 70.) 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; Proctor¶ 70.)

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

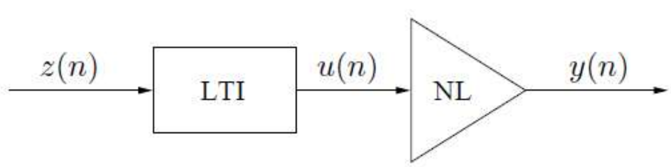


Figure 6: The Wiener Model.

(Ding, 11-12, Fig. 7; Proctor¶ 71.) The formulas underlying a Weiner model are below:

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

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

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

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

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; Proctor¶ 71.)

Ding teaches that "To construct a Hammerstein predistorter, the approach taken by [Kang (Ex. 1019)] uses a gradient method ***to first identify the Wiener system and then find the Hammerstein predistorter as its inverse***." (Ding, 17; Proctor¶ 72.) "The Hammerstein model is a memoryless nonlinearity followed by an LTI system[,]" and shown in Figure 7:

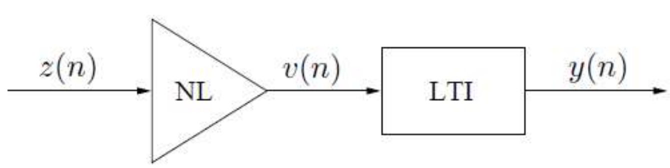


Figure 7: The Hammerstein Model.

(Ding, 12-13, Fig. 7; Proctor¶ 72.) The formulas underlying a Hammerstein model are below:

> 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; Proctor¶ 72.)

IX. GROUNDS OF UNPATENTABILITY

As evidenced by the references cited below, a POSITA at the time of the ’561 Patent’s filing understood that it would be possible to couple DWNL and SSNL modules together (in either order) to model a radio’s power amplifier and use that model to predistort input signals. (Proctor¶¶ 73-149.) Under the Grounds below, Lui, either alone (as understood by a POSITA) or in view of Ding, arrived at the same solution claimed by the ’561 Patent before its priority date. (Proctor¶¶ 73-149.) Thus, there is a reasonable likelihood that Petitioners will show that Claims 1-22 of the ’561 Patent are not patentable.

Ground 1 addresses Claim 1 of the ’561 Patent, which does not require any particular ordering of the DWNL and SSNL modules, and several of its dependent claims. Next, Ground 2 addresses those claims directed to augmented Weiner models and predistorters (i.e., where the DWNL module *is followed by* the SSNL module). Ground 3 addresses those claims directed to augmented Hammerstein models and predistorters (i.e., where the SSNL module *is followed by* the DWNL module).

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

Claims 1 and 4-6 would have been obvious in view of Lui to a person of ordinary skill at the time of the ’561 Patent’s filing. (Proctor¶ 74.) *Game & Tech. Co. v. Activision Blizzard Inc.*, 926 F.3d 1370, 1381 (Fed. Cir. 2019) (“[A] patent can be obvious in light of a single prior art reference if it would have been obvious to modify that reference to arrive at the patented invention.”); *SIBIA Neurosciences, Inc. v. Cadus Pharmaceutical Corp.*, 225 F.3d 1349, 1356 (Fed. Cir. 2000) (“In appropriate circumstances, a single prior art reference can render a claim obvious.”). Specifically, and as explained in greater detail below, claim 1 recites first and second modules to “characterize” certain system characteristics, and it would have been obvious for a POSITA to try a simple modification to make Lui’s DWNL and SSNL modules "characterize" the claimed "dynamic nonlinear" and "static nonlinear" characteristics of the system, respectively. (Proctor¶ 74.)

Lui itself implies that predistorters and their models seek to characterize nonlinear characteristics of a system before attempting to correct them. (Proctor¶ 75.) 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 that (or at a minimum found it obvious that) "properties" in this context refers to the transmitter's "characteristics." (Lui, 3585; Proctor¶ 75.) 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; Proctor¶ 75.) As discussed below, 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."); Proctor¶ 75.)

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. (Proctor¶ 76.) Claims 1 and 4-6 are therefore rendered obvious in view of Lui.

1. Claim 1

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

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

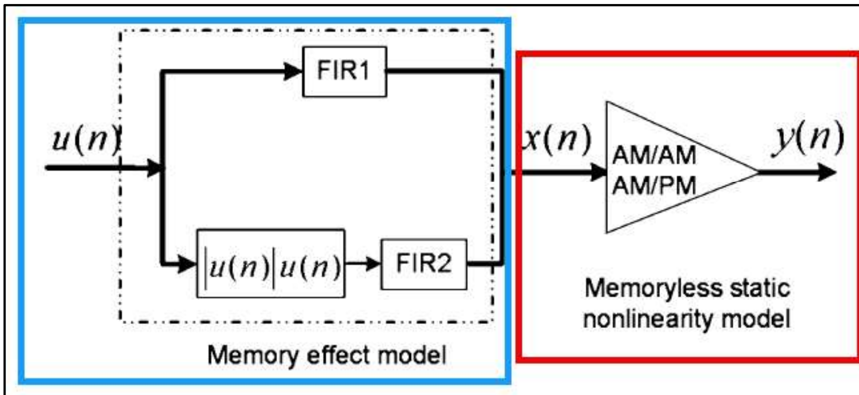


Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 3584-85, Fig. 17; Proctor¶ 78.) 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***."); Proctor¶ 78.)

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

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. (Proctor¶ 79.) This module is the DWNL module, is annotated in blue below (left), and substantially mirrors the '561 Patent's Figure 4A below (right):

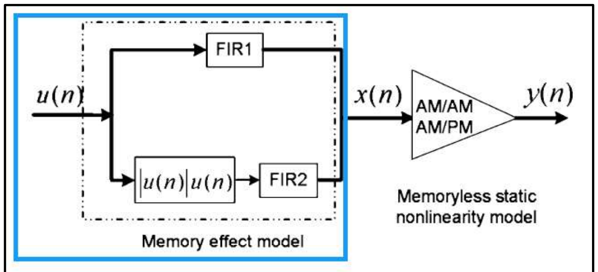
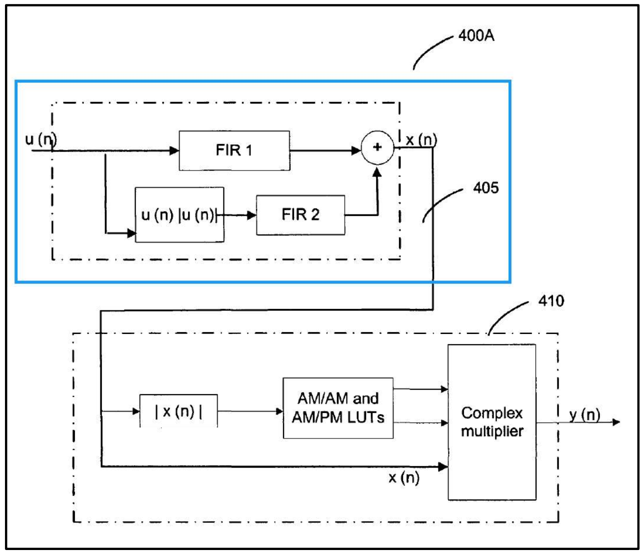


Fig. 17. Augmented Wiener transmitter model diagram.



(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 schematic diagram of one example embodiment of an augmented Wiener predistorter implemented using first-order forward LBG model[.]"), Figs. 1A, 4A; Proctor¶ 79.) Lui's Figure 16 reproduces the DWNL module on its own:

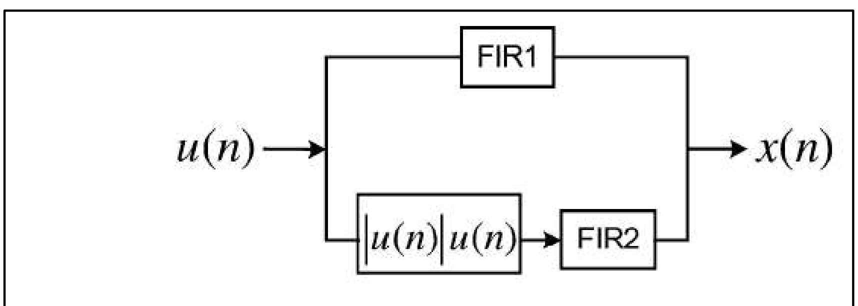


Fig. 16. Dynamic memory-effect model.

(Lui, 3584-85, Fig. 16; Proctor¶ 79.)

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; Proctor¶ 80.) 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; Proctor¶ 80.) 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. (Proctor¶ 80.)

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:

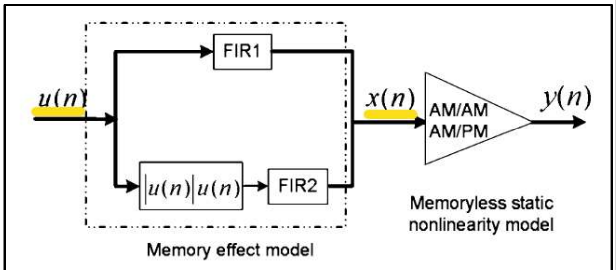
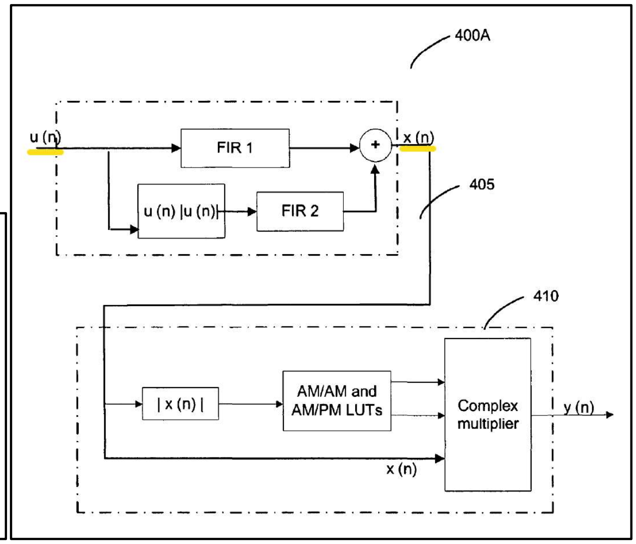


Fig. 17. Augmented Wiener transmitter model diagram.



(Lui, 3584-85, Fig. 17; ’561 Patent, 3:1-3, 6:14-17, Figs. 1A, 4A; Proctor¶ 81.) 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; Proctor¶ 81.)

c. 1[b] a second module characterizing static nonlinear characteristics of the nonlinear system, wherein the second module includes an input and an output;

Lui discloses a second module that one of ordinary skill would have understood to characterize static nonlinear characteristics of the system. (Proctor¶

82.) 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:

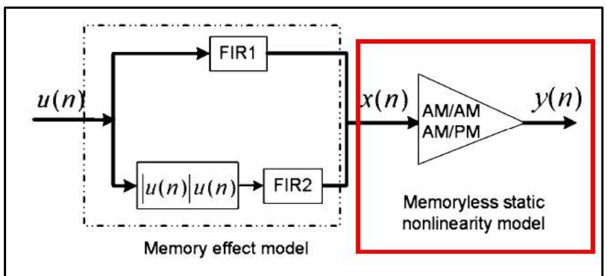
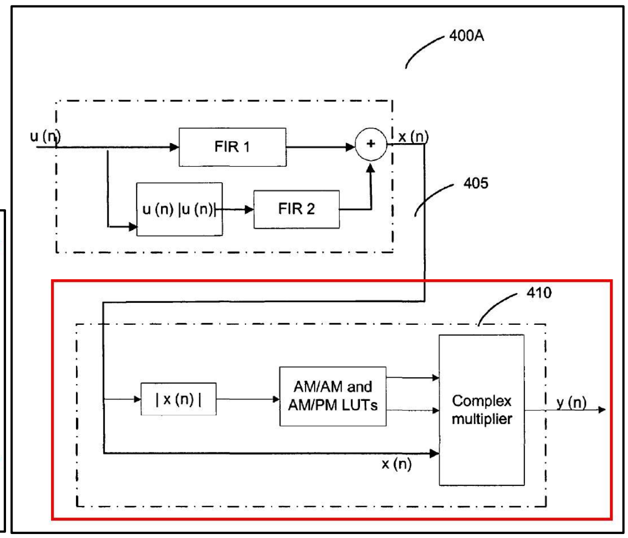


Fig. 17. Augmented Wiener transmitter model diagram.



(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 schematic diagram of one example embodiment of an augmented Wiener predistorter implemented using first-order forward LBG model[.]"), Figs. 1A, 4A; Proctor¶ 82.) 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; Proctor¶ 82.) 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; Proctor¶ 82.)

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:

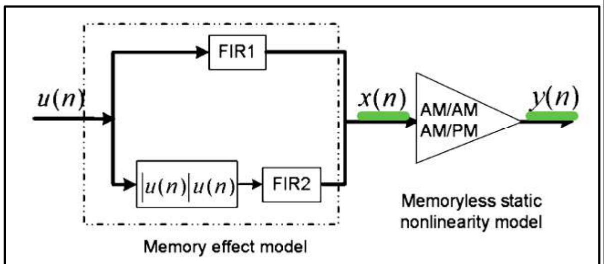
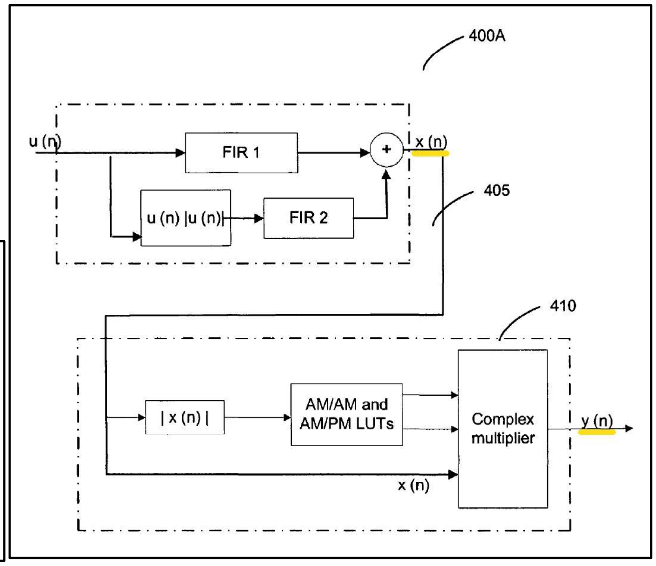


Fig. 17. Augmented Wiener transmitter model diagram.



(Lui, 3584-85, Fig. 17; ’561 Patent, 3:1-3, 6:14-17, Figs. 1A, 4A; Proctor¶ 83.) In Figure 17, the SSNL module takes as input the DWNL module’s output. (Proctor¶ 83.) Lui states that Equation 2 describes the function of the SSNL, and both input x(n) and output y(n) are present:

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

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); Proctor¶ 83.)

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

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

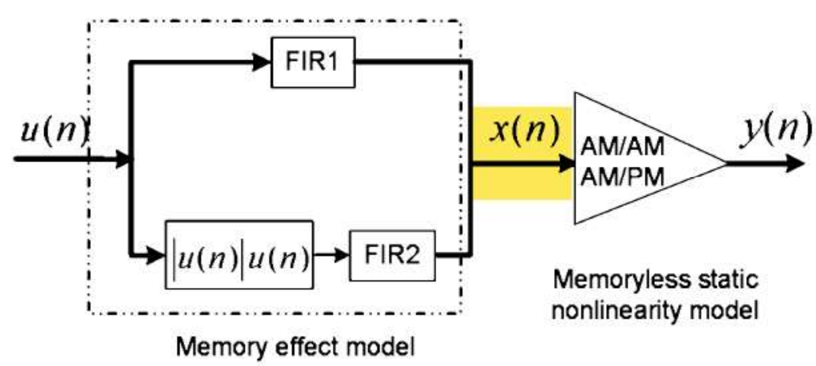


Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 3584-85, Fig. 17; Proctor¶ 84.) Lui refers to its model as "a cascade of a dynamic weak nonlinear model and a strong nonlinear static model." (Lui, 3585; Proctor¶ 84.) Lui also discusses the DWNL module performing its function before passing its output to the SSNL module. (*See* Section IX.B.1.e.)

2. Claim 4[11]

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.

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

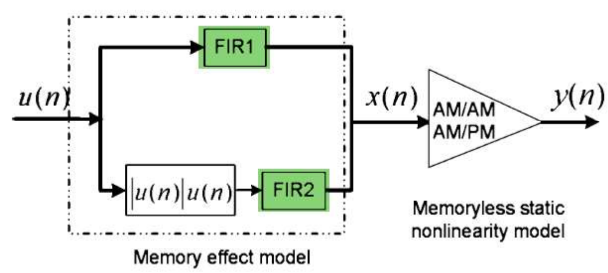


Fig. 17. Augmented Wiener transmitter model diagram.

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

[11] For each dependent claim, Petitioners incorporate all argument above relating to those claims upon which the dependent claim depends.

> *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."); Proctor¶ 85.) 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 of Equation 21 (the lower branch of Figure 17) above is a non-linear FIR system because it is the combination of a nonlinear function [|*u(n)*|**u(n)*] as an input to a FIR filter (FIR2 of Fig. 17). (Proctor¶ 85.) 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. (Proctor¶ 85.)

Lui's model's second (SSNL) module includes "a look-up table-based nonlinear memoryless system." (Proctor¶ 86.) Lui's Figure 17 shows a "***[m]emoryless*** static ***nonlinearity*** module":

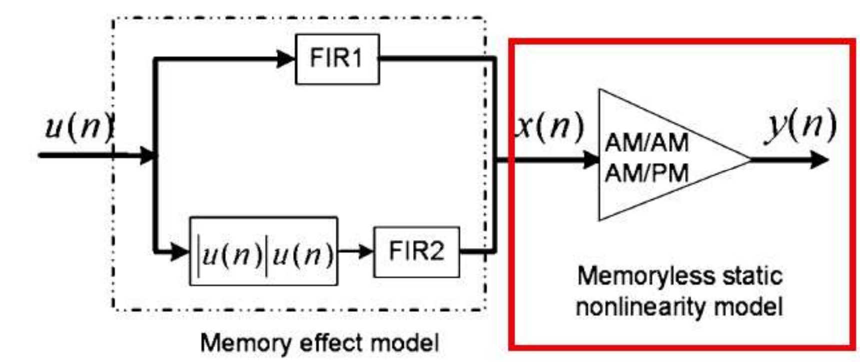


Fig. 17. Augmented Wiener transmitter model diagram.

(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; Proctor¶ 86.)

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.

Claim 5 requires a ***dynamic weak*** nonlinear module and a static ***strong*** nonlinear module – Lui discloses both. (Proctor¶ 87.) 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; Proctor¶ 87.)
- "This augmented Wiener model is a cascade of a ***dynamic weak nonlinear model*** and a strong nonlinear static model." (Lui, 3585; Proctor¶ 87.)

- "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; Proctor¶ 87.)

- "... an augmented Wiener model has been proposed, where the linear FIR filter is replaced with a ***weak*** nonlinear filter structure." (Lui, 3586; Proctor¶ 87.)

(*See also* Section IX.A.1.b.) 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; Proctor¶ 87. *See also* Section IX.A.1.c.)

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.

As discussed in Section IX.A.2 with regard to Claim 4, Lui discloses a DWNL module that includes a FIR filter. (Proctor¶ 88.) Claim 6 adds that the module must include "a finite impulse response filter-based multi-branch nonlinear system[,]" and Lui discloses such a system. (Proctor¶ 88.) As shown in Figure 17, the DWNL module includes multiple branches, each with its own FIR filter:

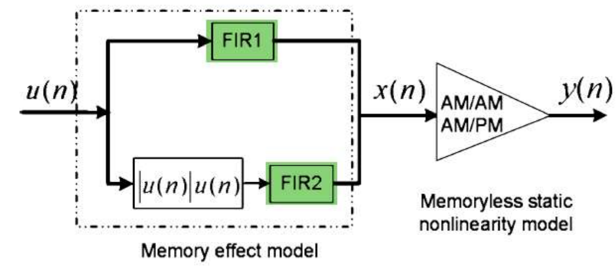


Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 3579 ("finite impulse response (FIR) filter"), 3584-85, Fig. 17; Proctor¶ 88.) As discussed above, the DWNL module is a nonlinear system. (*See* Section IX.A.1.b.)

As discussed above in Section IX.A.2 with regard to Claim 4, Lui discloses a SSNL module that uses two lookup tables. (Proctor¶ 89.) 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) 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."); Proctor¶ 89.) 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)*."); Proctor¶ 89.) These inphase and quadrature values correspond to real and imaginary complex number representation of AM/AM (gain) and AM/PM (phase) tables. (Proctor¶ 89.)

B. 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

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. (Proctor¶ 90.) 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. (Proctor¶ 90.)

1. Claim 7

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

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 purpose of baseband predistortion*** of dynamic nonlinear systems ..."); Proctor¶ 91. *See also* Section IX.A.1.a.)

Claim 1	Claim 7
1[pre] A **behavioral model** of **a nonlinear dynamic system**, the model comprising:	7[pre] A **predistorter for nonlinear wireless system**, 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. (Proctor¶ 91.)

Lui further discloses building a predistorter that uses and validates its model. (Lui, 3585 ("VII. Experimental Setup and Newly Proposed Model Validation"); Proctor¶ 92). "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"); Proctor¶ 92.) 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 by static nonlinearity with the help of cascading the inverse of the complex memoryless model"); Proctor¶ 92.)

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"); Proctor¶ 93.) "The wide-band RF transmitter characterization platform used in this study is shown in Fig. 18":

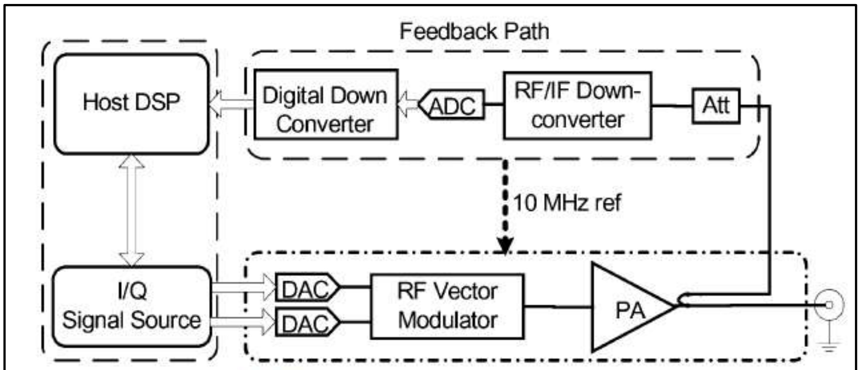


Fig. 18. Wide-band RF transmitter characterization platform.

(Lui, 3585, Fig. 18; Proctor¶ 93.)

b. 7[b][12] a static nonlinear predistorter module;

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

---

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

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

Here, the difference between Claims 1 and 7 is the same as discussed in Section IX.B.1.a: Claim 1 is directed to the predistorter's model, whereas Claim 7 is directed to the predistorter that uses the model. (Proctor¶ 94.)

As discussed in Section IX.B.1.a, Lui discloses the behavioral model as well as a static nonlinear predistorter that uses the behavioral model, and Section IX.A.1.c describes that predistorter's function. (Proctor¶ 95.) The static nonlinear predistorter module's model is shown in Figure 17, and is annotated in red below:

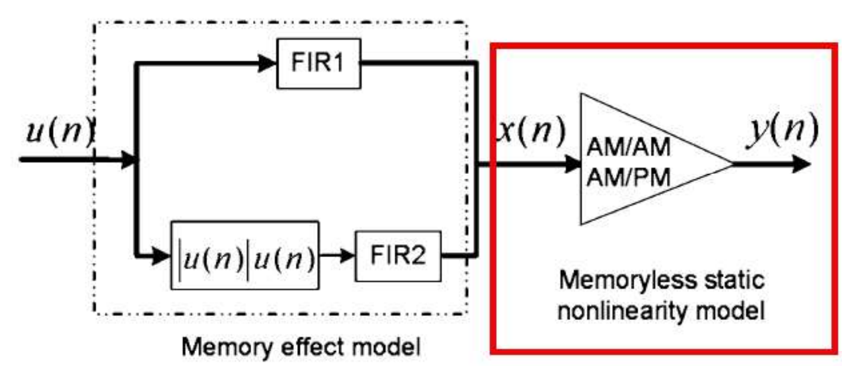


Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 3584-85, Fig. 17; Proctor¶ 95.)

Lui's validation of its behavioral model expressly uses a static predistorter to isolate the memory effects of its proposed augmented Weiner behavioral model.

(Proctor¶ 96.) 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; Proctor¶ 96.) 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; Proctor¶ 96.)[13]

c. 7[a] a dynamic nonlinear predistorter module; and

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 **module characterizing dynamic nonlinear characteristics of the system**, wherein the first module includes an input and an output; and	7[a] a **dynamic nonlinear predistorter module**; and

[13] 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; Proctor¶ 96, n.11.)

Here, the difference between Claims 1 and 7 is the same as discussed in Section IX.B.1.a: Claim 1 is directed to the predistorter's model, whereas Claim 7 is directed to the predistorter that uses the model. (Proctor¶ 97.)

As discussed in Section IX.B.1.a, Lui discloses the behavioral model as well as a predistorter that uses the behavioral model, and Section IX.A.1.b describes the dynamic nonlinear module's function. The dynamic nonlinear module's model is shown in Figure 17, and is annotated in blue below:

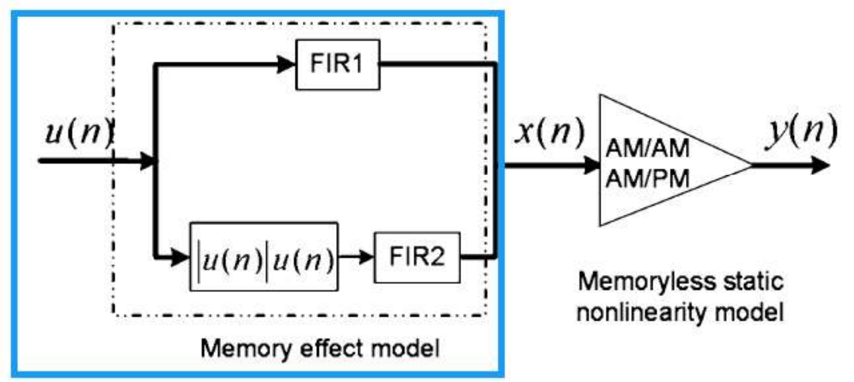


Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 3584-85, Fig. 17; Proctor¶ 98.) Limitation 7[a] also requires that "the first module includes an input and an output," which Lui discloses, as discussed in Section IX.A.1.b.

d. Single-Reference Obviousness Under § 103

Although Lui does not expressly disclose a dynamic predistorter, the limitation is obvious under 35 U.S.C. § 103. *Game & Tech.*, 926 F.3d at 1381;

SIBIA, 225 F.3d at 1356. Specifically, it would have been obvious for a POSITA to use Lui's dynamic model to build a dynamic predistorter that incorporates the model. (Proctor¶ 99.)

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

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); Proctor¶ 101. *See also* Section IX.B.1.b.) 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 ***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 (Ex. 1009), 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."); Proctor¶ 101.)

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. (Proctor¶ 102.) 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); Proctor¶ 102. *See also* Section IX.B.1.b.) 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.)

Lui suggests that a POSITA should use its dynamic model in a predistorter. (Proctor¶ 103.) 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 ..."); Proctor¶ 103.) 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 transmitte***rs."); Proctor¶ 103.) As a result, a POSITA would have used Lui's proposed augmented Wiener behavioral model with a predistorter address the distortions. (Proctor¶ 103.)

In view of the above, it would have been obvious for a POSITA to use Lui to build a predistorter that incorporated Lui's model. (Proctor¶ 104.)

e. 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.

Lui's "Augmented Wiener Behavioral Model" has the DWNL module coupled to the SSNL module, as discussed in Section IX.A.1.d. This coupling is shown below in Figure 17:

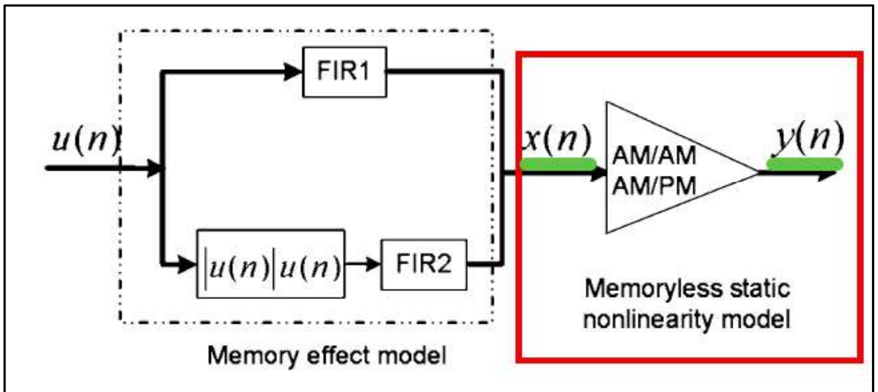


Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 3584-85, Fig. 17; Proctor¶ 105.)

Furthermore, Figure 17 shows the SSNL module taking x(n) as input, which is the DWNL module's output. (Proctor¶ 106.) 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); Proctor¶ 106.) Moreover, as discussed in Section A.1.c, Lui's and the '561 Patent's figures are substantially identical and include the same input and outputs to the modules. (Proctor¶ 106.)

2. Claim 15

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

To the extent the preamble is limiting, Lui discloses an "augmented Wiener predistorter." (Proctor¶ 107.) Lui proposes "a new augmented Weiner model" for use in a predistorter. (Lui, 3579, 3584-86 (detailing the augmented Wiener predistorter's performance); Proctor¶ 107.) Figure 17 shows the "Augmented Wiener transmitter model":

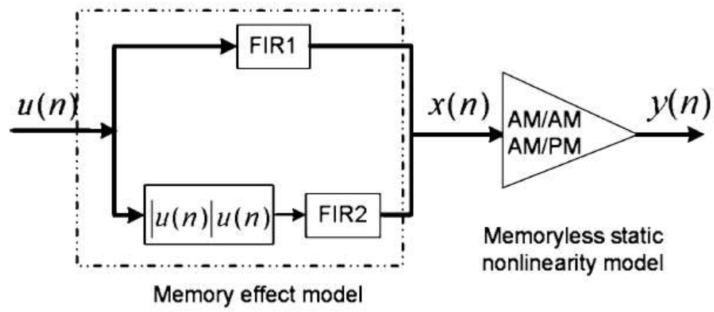


Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 3584-85, Fig. 17; Proctor¶ 107.) 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."); Proctor¶ 107.)

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

As discussed in Sections IX.A.1.b and IX.B.1.c, 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. (Proctor¶ 108.) 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 VII.C; Proctor¶ 108.)

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 magnitude of the input signal (|*u(n)*|) raised to the first-power exponent. (Proctor¶ 109.) 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:

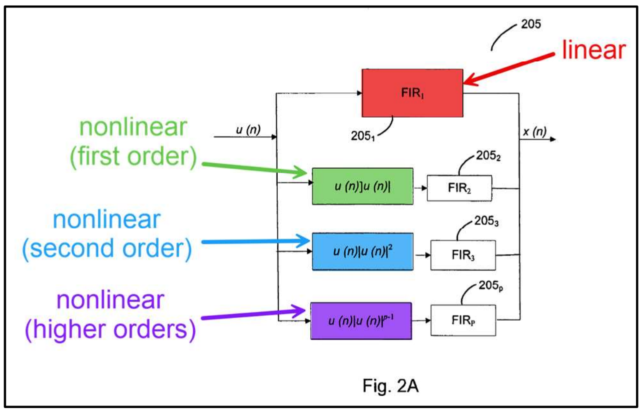


Fig. 2A

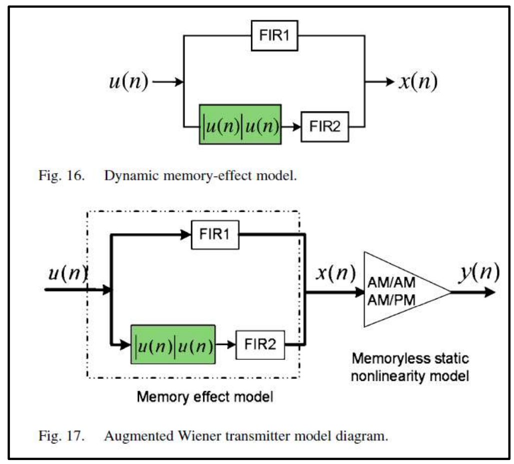


Fig. 16. Dynamic memory-effect model.

Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 4:24-41, Fig. 2A (annotated) (note “]” typo in magnitude for first-order function); Lui, Figs. 16, 17 (annotated); Proctor¶ 109.) 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:
>
> $$x(n) = \sum_{i=0}^{M_1-1} a_i u(n-i) + \sum_{i=0}^{M_2-1} b_i |u(n-i)| u(n-i) \quad (21)$$

(Lui, 8585 (annotated); Proctor¶ 109.) Lui states that its functions include “the ***first-*** and second-***order terms*** of the input signals[.]” (Lui, 3585; Proctor¶ 109.)

c. 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.

Limitation 15[b] is identical to Limitation 7[c]. (Proctor¶ 110.) For the reasons discussed in Section IX.B.1.e, Lui discloses Limitation 15[b]. (Proctor¶ 110.)

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.

As discussed in Section IX.B.1.e, Lui discloses the first module being coupled to the second module, and the output of the first module is input to the second module. (Proctor¶ 111.)

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.

Claim 8 is dependent upon Claim 7 (discussed at Section IX.B.1), and because this claim is substantially similar to Claim 4 (discussed at Section IX.A.2), this claim is likewise invalid. (Proctor¶ 112.)

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.

Claim 9 is dependent upon Claim 7 (discussed at Section IX.B.1), and because this claim is substantially similar to Claim 5 (discussed at Section IX.A.3), this claim is likewise invalid. (Proctor¶ 113.)

> *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****.*

Claim 10 is dependent upon Claim 9 (discussed above), and because this claim is substantially similar to Claim 6 (discussed at Section IX.A.4), this claim is likewise invalid. (Proctor¶ 114.) 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. (Proctor¶ 115.) As discussed in Section IX.A.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:

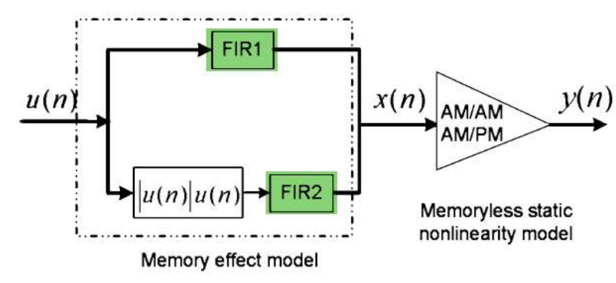


Fig. 17. Augmented Wiener transmitter model diagram.

(Lui, 3579 ("finite impulse response (FIR) filter"), 3584-85, Fig. 17; Proctor¶ 115.) 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; Proctor¶ 115.)

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.

Claim 16 is dependent upon Claim 15 (discussed at Section IX.B.2), and because this claim is substantially similar to Claim 4 (discussed at Section IX.A.2), this claim is likewise invalid. (Proctor¶ 116.)

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.

Claim 17 is dependent upon Claim 15 (discussed at Section IX.B.2), and because this claim is substantially similar to Claim 5 (discussed at Section IX.A.3), this claim is likewise invalid. (Proctor¶ 117.)

> *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.*

Claim 18 is dependent upon Claim 17 (discussed above), and because this claim is substantially similar to Claim 6 (discussed at Section IX.A.4), this claim is likewise invalid. (Proctor¶ 118.)

C. 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

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.[14] (Proctor¶ 119.) 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 (static nonlinearity + linear filter)*** to predict the behavior of a power amplifier"), 3587 (citing a paper titled, "Broadband measurement and identification

---

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

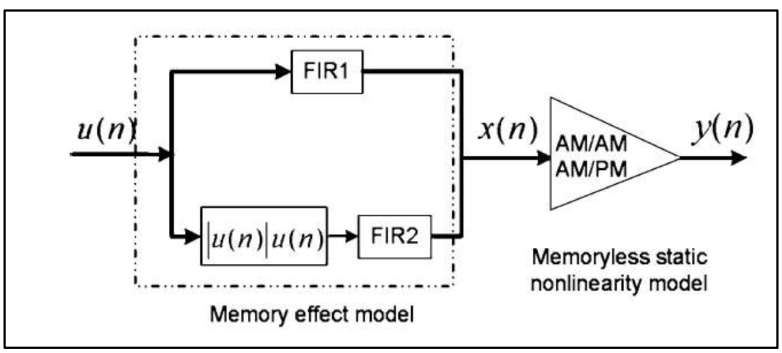
of a Wiener–***Hammerstein*** model for an RF amplifier," by P. Crama and Y. Rolain).) The '561 Patent also acknowledges that Hammerstein predistorters existed as of the patent's filing. ('561 Patent, 2:32-35 ("an augmented Hammerstein predistorter is disclosed implemented using a first-order reverse LBG model").)

As discussed below, 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.

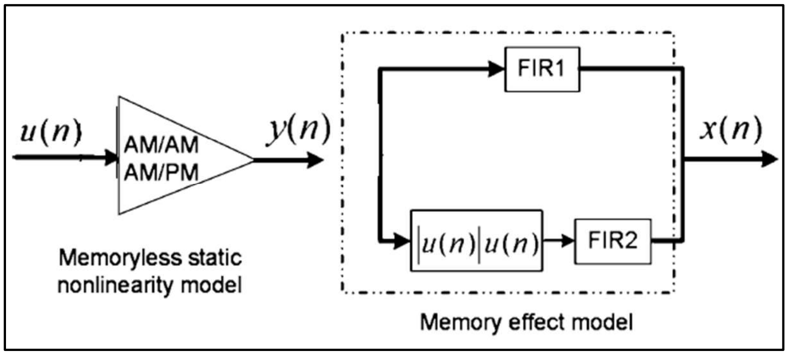
1. Single-Reference Obviousness Under § 103

Lui renders the Hammerstein Claims obvious under 35 U.S.C. § 103. *Game & Tech.*, 926 F.3d at 1381; *SIBIA*, 225 F.3d at 1356. 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. (Proctor¶ 121.)

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. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 420, 421 (2007) ("When … there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp. If this leads to the anticipated success, it is likely the product not of innovation but of ordinary skill and common sense."). (*See* Sections IX.A to IX.A.2; Proctor¶ 122.) The modification to Lui would require the only other arrangement of the DWNL and SSNL modules: having the SSNL module followed by the DWNL. (Proctor¶ 122.) 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. (Proctor¶ 122.) The original Weiner model is below:



(Lui, Fig. 17; Proctor¶ 122.) And a depiction of what this modified, Hammerstein model would look like is below:



(Lui, Fig. 17 (modified); Proctor¶ 122.) 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. (Proctor¶ 122.) If a POSITA can, as is the case here, "implement a predictable variation, § 103 likely bars its patentability." *KSR*, 550 U.S. at 417.

The modification of moving the SSNL module before the DWNL module would also have been obvious to try. (Proctor¶ 123.) The authors of Lui were attempting to develop a predistorter "that is capable of accurately modeling wide-band RF transmitters." (Lui, 3579; Proctor¶ 123.) 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. (Proctor¶ 123.) Indeed, rearranging predistorters from Weiner predistorters to Hammerstein predistorters was and is a common, standard modification. (Proctor¶ 123.) For example, as discussed in Sections VIII.B and IX.C.1, Ding discloses Weiner and Hammerstein predistorters as two common solutions to the same problem. (Proctor¶

123.) 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; Proctor¶ 123.) 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; Proctor¶ 123.) 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; Proctor¶ 123.) 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; Proctor¶ 123.) Gilabert likewise teaches reversing the Weiner and Hammerstein components: "Hammerstein models are composed by a memoryless 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; Proctor¶ 123.)[15]

In addition, as discussed above in Section IX.C.2.a, 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 v. A.B. Chance Co.*, 234 F.3d 654, 665 (Fed. Cir. 2000) ("[a] motivation to combine may be found in the prior art references themselves"). (Proctor¶ 124.) 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. (Proctor¶ 124.)

In view of the above, it would have been obvious for a POSITA to modify Lui to utilize a Hammerstein model instead of a Weiner model. (Proctor¶ 125.)

---

[15] 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 (Ex. 1018), 1343-48, Fig. 7.)

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

All Limitations of the Hammerstein Claims are taught or suggested in Lui in view of Ding. (Proctor¶ 126.)

a. Motivations to Combine

A POSITA would have been motivated to combine the teachings of Ding with Lui. (Proctor¶ 127.)

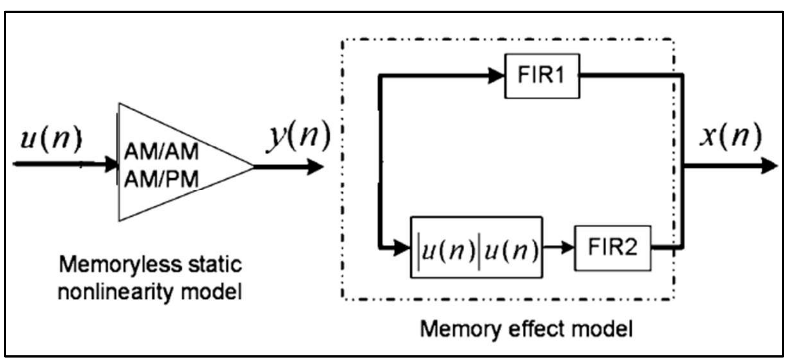
Both references identify the same problem: distortion in telecommunications networks. (Proctor¶ 128.) *See Tokai Corp. v. Easton Enterprises, Inc.*, 632 F.3d 1358, 1371 (Fed. Cir. 2011) ("We have consistently stated that courts may find a motivation to combine prior art references in the nature of the problem to be solved[.]") (citations omitted); *In re Kurzweil*, 4 F. App'x 823, 826 (Fed. Cir. 2001). 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; Proctor¶ 128.) 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; Proctor¶ 128.)

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, digital predistortion is one of the most cost effective[.]"); Proctor¶ 129.) 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."); Proctor¶ 129.)

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

Modifying Lui to incorporate Ding's Hammerstein arrangement would be simple. (Proctor¶ 131.) Ding explains that a Hammerstein model is just the "inverse" of a "Weiner system[.]" (Ding, 17; Proctor¶ 131.) In other words, all of the information contained in a Weiner model could be used in its inverse, the Hammerstein model. (Proctor¶ 131.) 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); Proctor¶ 131.) *See Tokai*, 632 F.3d at 1371-72 ("It would have been obvious to one of ordinary skill and creativity to adapt the safety mechanisms of the prior art ... In both the claimed invention and in [the prior art], the lighter is operated via sequential action of the finger and thumb; ***a mere reversal***

in the order of these actions does not confer patentability."); *Skedco, Inc. v. Strategic Operations, Inc*., 287 F. Supp. 3d 1100, 1138 (D. Or. 2018) (when there is "market pressure to solve a problem, ***and there are a finite number of identified, predictable solutions***, a POSA has motivation to 'pursue the known options within his or her technical grasp' and if this leads to anticipated success, it is likely not the product of innovation but of ordinary skill and common sense[.]") (quoting *KSR*, 550 U.S. at 421).

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. (Proctor¶ 132.) 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; Proctor¶ 132.)

A combination may be obvious to try when there are a "finite number of identified, predictable solutions[.]" *KSR*, 550 U.S. at 421. Here, there are just two components (the DWNL and SSNL modules) that can only be arranged in two configurations (Weiner or Hammerstein). (Proctor¶ 133.)

"A motivation to combine may be found in the prior art references themselves[,]" and Lui acknowledges the existence of Hammerstein models as an alternative solution to the problem of dynamic-, or memory-based distortion. *Ruiz*, 234 F.3d at 665. 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 (Ex. 1010); Proctor¶ 134.) 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 (Ex. 1011)); Proctor¶ 134.) 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. (Proctor¶ 134.)

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. (Proctor¶ 135.) In 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. (Proctor¶ 135.) *See Outdry Techs. Corp. v. Geox S.p.A.*, 859 F.3d 1364, 1369 (Fed. Cir. 2017) (affirming Board's finding of motivation to combine based, in part, on references' authors being "from the same field of endeavor").

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

b. Lui in View of Ding

A POSITA would have been motivated to combine Ding with Lui for the reasons set forth in Section IX.C.2.a. (Proctor¶ 137.) Ding discloses a Hammerstein model and predistorter. (Proctor¶ 137.) Ding states that, "The Hammerstein model is a memoryless nonlinearity followed by an LTI system[,]" and shows an example in Figure 7:

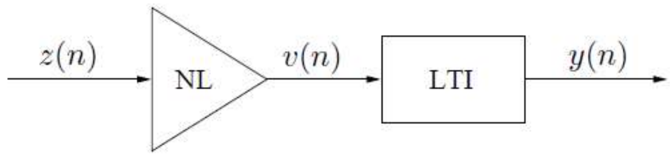


Figure 7: The Hammerstein Model.

(Ding, 12-13, Fig. 7; Proctor¶ 137.) The formulas underlying a Hammerstein model are below:

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; Proctor¶ 137.)

Further, Ding teaches how to convert Lui's "Augmented Weiner Behavioral Model" into a Hammerstein model. (Proctor¶ 138.) 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; Proctor¶ 138.)

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.

Claim 11 is substantially similar to Claim 7,[16] 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). (Proctor¶ 139.) As discussed in Sections VIII.B and IX.C.2.b, Ding discloses a Hammerstein predistorter. (Ding, 10-16; Proctor¶ 139.) For the reasons discussed above in Section IX.C.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. (Proctor¶ 139.) Moreover, as discussed in Section IX.A.1.c, Lui's and the '561 Patent's figures are substantially identical and include the same input and outputs to the modules. (Proctor¶ 139.)

[16] Lui discloses all limitations of Claim 7, as discussed in Section IX.B.1. (Proctor¶ 139, n.14.)

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.

Claim 19 is substantially similar to Claim 15,[17] 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). (Proctor¶ 140.) This language mimics the final limitation of Claim 11, which is addressed in Section IX.C.3. (Proctor¶ 140.) For the reasons discussed above in Section IX.C.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. (Proctor¶ 140.)

As discussed in Sections VIII.B and IX.C.2.b, Ding discloses a Hammerstein predistorter. (Ding, 10-16; Proctor¶ 141.) Claim 19 also requires that the "dynamic

[17] Lui discloses all limitations of Claim 7, as discussed in Section IX.B.1. (Proctor¶ 140, n.15.)

nonlinear" predistorter be a "first order" predistorter, a limitation which Lui discloses as discussed in Section IX.B.2.b.

Claim 19 also requires that the "Hammerstein predistorter" be "augmented." (Proctor¶ 142.) 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."); Proctor¶ 142.)

5. Claim 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.

Claim 3 describes a Hammerstein arrangement of the static nonlinear predistorter module and the dynamic nonlinear predistorter module. As discussed in Section IX.C.1, Lui (either alone or in combination with other references) discloses such an arrangement of the modules.

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.*

Claim 12 is dependent upon Claim 11 (discussed at Section IX.C.3), and because this claim is substantially similar to Claim 4 (discussed at Section IX.A.2), this claim is likewise invalid. (Proctor¶ 144.)

> *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.*

Claim 13 is dependent upon Claim 11 (discussed at Section IX.C.3), and because this claim is substantially similar to Claim 5 (discussed at Section IX.A.3), this claim is likewise invalid. (Proctor¶ 145.)

> *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.*

Claim 14 is dependent upon Claim 12 (discussed above), and because this claim is substantially similar to Claim 6 (discussed at Section IX.A.4), this claim is likewise invalid. (Proctor¶ 146.)

> *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.*

Claim 20 is dependent upon Claim 19 (discussed at Section IX.C.4), and because this claim is substantially similar to Claim 4 (discussed at Section IX.A.2), this claim is likewise invalid. (Proctor¶ 147.)

> *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.*

Claim 21 is dependent upon Claim 19 (discussed at Section IX.C.4), and because this claim is substantially similar to Claim 5 (discussed at Section IX.A.3), this claim is likewise invalid. (Proctor¶ 148.)

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.

Claim 22 is dependent upon Claim 21 (discussed above), and because this claim is substantially similar to Claim 6 (discussed at Section IX.A.4), this claim is likewise invalid. (Proctor¶ 149.)

X. THE BOARD SHOULD NOT EXERCISE ITS DISCRETION TO DENY INSTITUTION

A. The Board Should Not Deny Review Under 35 U.S.C. § 325(d)

None of the references relied upon herein was cited, discussed or applied in the '561 Patent's prosecution history, nor are the references the same or substantially the same as those considered during prosecution. (*See* Ex. 1002, 61, 100, 104.) Accordingly, the Board should not exercise its discretion under Section 325(d).

B. The Board Should Not Deny Review under 35 U.S.C. § 314(a)

The Challenged Claims have never been tested against the most relevant prior art. In view of the strong and compelling challenges set forth above and the three separate district court litigations, institution should not be discretionarily denied under Section 314(a). *See NHK Spring Co. v. Intri-Plex Techs., Inc.*, IPR2018-00752, Paper 8 at 19-20 (PTAB Sept. 12, 2018) (precedential); *Apple v. Fintiv, Inc.*, IPR2020-00019, Paper 11 at 13-14 (PTAB Mar. 20, 2020) (precedential). Should Patent Owner present a *Fintiv* challenge based on developments in the district court litigations after the filing of this Petition, Petitioners will seek to address those developments in greater detail.

Factor 1—a stay of the district court litigation—is neutral because, consistent with the PTAB's precedent, Petitioners have not moved to stay the district court litigations before filing this Petition. *See, e.g., Hulu, LLC v. SITO Mobile, Ltd.*, IPR2021-00298, Paper 11 at 10-11 (PTAB May 19, 2021). The PTAB has also explained that it will not speculate as to how any such motion would be resolved before one is filed, further confirming that this factor is neutral. *See Google, LLC v. Parus Holdings Inc.*, IPR2020-00847, Paper 9 at 12 (PTAB Oct. 21, 2020); *Fintiv*, IPR2020-00019, Paper 15 at 12 (PTAB May 13, 2020) (same).

Factor 2—the district court trial date and the Board's statutory deadline—should be considered to weight against discretionary denial (or at least be neutral) because jury selection is far in the future and is estimated to begin on November 17, 2025. (Ex. 1023, 2.) In addition, in view of the Director's recent guidance on *Fintiv*, the time to trial is not a dominating factor in the *Fintiv* analysis. *Memorandum for* *the Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation*, at 8 (June 21, 2022).

Even if jury selection were to proceed on November 17, 2025, jury selection would proceed with respect to only one of the three litigations. Each of the defendant Petitioners are entitled to separate trials, which will necessarily proceed on separate dates. As such, there are explicit and inherent uncertainties for this case given the number of parties involved and the number of trials regarding this patent. In addition, and because much can change in ten months, the current trial date does not support denial. *See Dish Network v. Broadband iTV*, IPR2020-01280, Paper 17 at 16 (PTAB Feb. 4, 2021) ("We cannot ignore the fact that the currently scheduled trial date is more than nine months away and much can change during this time.").[18]

[18] According to the June 2024 Federal Court Management Statistics, the median time frame from filing to trial of a civil litigation at the Eastern District of Texas is 21.6 months, which would push the trial dates to around January 2026 (Ex. 1024, 35). The Board will likely issue an institution decision in about six months, or around June 2025. A hearing would likely be held about nine months later in March 2026, and a final written decision ("FWD") should be issued in about June 2026 (twelve months after the institution date).

Moreover, given the existence of three litigations each with multiple parties, to include multiple intervenors, the likelihood that any trials will be scheduled serially, the potential length of the trials given the number of patents at issue (five) and claims at issue (73) and post-trial motions, it is likely that the district court litigations will not be complete before the final written decision in this matter.

Altogether, this factor weighs against discretionary denial.

Factor 3—investment in the district court litigations—weighs against discretionary denial. The district court litigations are in their early stages and the district court has not issued any substantive rulings in any case with respect to the '561 Patent. Infringement contentions were served on May 15, 2024, invalidity contentions were served on July 31, 2024, and the claim construction hearing is not scheduled until May 30, 2025. (*See* Ex. 1023, 5, 6.)

Altogether, there is much work to be done in the district court litigations and most, if not all, of the work will be well in the future. Accordingly, the district court will not invest significant resources related to the challenged patent prior to an institution decision. *See Fintiv*, IPR2020-00019, Paper 11 at 9-12; *DISH Network*, IPR2020-01280, Paper 17 at 18-21.

Factor 4—overlap between this proceeding and the district court proceedings—favors institution. Indeed, there will not be complete overlap between this IPR and the district court litigations because there are twenty-two '561 Patent claims asserted in this case and a total of seventy-three asserted for all patents in the related district court litigations. The district court will likely substantially reduce the asserted claims prior to trial, including some of the claims at issue here. This factor thus weighs against the Board exercising its discretion to deny.

Factor 5—overlapping parties—is neutral as it is "far from an unusual circumstance that a petitioner in *inter partes* review and a defendant in a parallel district court proceeding are the same." *Sand Revolution II LLC v. Continental Intermodal Group-Trucking LLC*, IPR2019-01393, Paper 24 at 12-13 (PTAB June 16, 2020).

Factor 6—other considerations—weighs strongly against discretionary denial. As detailed above in Section IX, this is a compelling case and the merits of the Petition are strong. Moreover, none of the grounds asserted herein were previously considered by either the Patent Office or the district court. *Cf. Comcast Cable Commn's, LLC v. Rovi Guides, Inc.*, IPR2019-00231, Paper 14 at 11 (PTAB May 20, 2019) (obviousness challenges not "previously considered by the Office or any court" weigh in favor of not denying institution); *Memorandum for the Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation*, at 4 (June 21, 2022). The '561 Patent is also currently asserted in three district court litigations. Institution of this IPR provides the opportunity for narrowing and simplifying the litigations for the district court.

XI. CONCLUSION

Petitioners have presented evidence that the subject matter of Claims 1-22 of the ’561 Patent was known in the art prior to the ’561 Patent’s priority date. Therefore, there is a reasonable likelihood that Petitioners will prevail as to each of these claims. *Inter partes* review of Claims 1-22 is therefore respectfully requested.

Dated: February 14, 2025

Respectfully submitted,

Holland & Knight LLP

/s/ Jacob K. Baron
Jacob K. Baron
Reg. No. 48,961

XII. MANDATORY NOTICES (37 C.F.R. § 42.8(b))

A. Real Parties In Interest (37 C.F.R. § 42.8(b)(1))

Petitioners T-Mobile, AT&T, Verizon, Ericsson and Nokia are real parties-in-interest ("RPIs"). In an abundance of caution, only for purposes of this proceeding, and only to the extent that Patent Owner contends that they should be named an RPI, Petitioners also identify the following entities as potential RPIs without conceding that they would satisfy the factually intensive RPI test: Sprint LLC, Sprint Solutions LLC, Sprint Spectrum LLC, T-Mobile USA, Inc., AT&T Services, Inc., AT&T Enterprises LLC,[19] Verizon Corporate Services Group Inc. and Telefonaktiebolaget LM Ericsson. In addition, some of the entities listed above out of an abundance of caution are holding companies that are legally and factually distinct from their subsidiaries (that may also be listed above and which maintain their own independent corporate status, identity, and structure) and have not provided any products or services that might be at issue in the underlying patent infringement lawsuit.

---

[19] Related-Matter Defendant AT&T Corp. has undergone a corporate transaction and is now merged and converted into AT&T Enterprises, LLC.

B. Related Matters (37 C.F.R. § 42.8(b)(2))

The ’561 Patent is asserted in the following co-pending litigations, all of which are in the District Court for the Eastern District of Texas:[20]

Case Caption	Case No.
Smart RF Inc. v. AT&T Mobility LLC.	2:24-cv-00195-JRG-RSP
Smart RF Inc. v. Verizon Wireless et al.	2:24-cv-00196-JRG-RSP
Smart RF Inc. v. T-Mobile US, Inc. et al.	2:24-cv-00197-JRG-RSP

C. Lead and Back-Up Counsel (37 C.F.R. § 42.8(b)(3))

Lead counsel: Jacob K. Baron (Reg. No. 48,961; Jacob.Baron@hklaw.com).

Backup counsel: Jacob W. S. Schneider (*pro hac vice* motion forthcoming; Jacob.Schneider@hklaw.com).

The mailing address for all PTAB correspondence is Holland & Knight LLP, 10 St. James Ave., 11th Floor, Boston, MA 02116.

D. Service Information (37 C.F.R. § 42.8(b)(4))

Please address all correspondence to lead counsel at the address above. Petitioners consent to electronic service at: Jacob.Baron@hklaw.com and ClientTeamSmartRFLitigation@hklaw.com.

[20] Ericsson and Nokia were not sued, but later joined as intervenor-defendants in the district court litigations against AT&T, Verizon and T-Mobile. (Exs. 1025, 1026.)

E. Fee for *Inter Partes* Review

The Director is authorized to charge the fee specified by 37 CFR § 42.15(a) to Deposit Account No. 50-2324.

XIII. CERTIFICATE OF SERVICE

The undersigned certifies that a complete copy of this Petition for *Inter Partes* Review of U.S. Patent No. 8,078,561 and all Exhibits and other documents filed together with this Petition were served on the official correspondence address for U.S. Patent No. 8,078,561 shown in Patent Center and Smart RF Inc.'s current litigation counsel:

Mark Wilson	Eric Green
James Crawford	Roy Salvagio
Dervis Magistre	Wayne Livingstone
Michael Stimson	Eagle Robinson
Rutherford Viguet	Catherine Garza
Richard Zembek	Tiffany Weksberg
Mark Garrett	Staphanie DeBrow
Gina Shishima	Darren Smith
Melissa Sistrunk	William Braxdale
David Ben-Meir	Jason Novak
Eric Hall	Daniel Prati
Michael Krawzsenek	Daniel Ford
Kay Colapret	Laurie Stellman
Robert Greeson	Barry Greenbaum
Michael Solomita	Allison Vagner
Adam Rehm	Robert Paladino
Stephen Guzzi	Erik Janitens
Roger Kuan	Katherine Falkenhagen
Tamsen Barrett	Thomas Orsak
Daniel Leventhal	Peter McLellan

Zachary Cleary
Rhiannon D'Agostin
Talbot Hansum
Michael Pohl
Mrinmoy Chakrabarti
Jeremy Albright
Alexander Katsulis
Apurv Gaurav
Hao Wu
Christine Emnett
Jason Freeck
Han Ling
Qinxi Guo
Sarah Eddy
Sangik Bae
Chad Wallis
Jiang Wu
Jaime Stark
Preeti Mehta
Alex Lucaciu
Isaiah Neve
Michael Mudrow
Nathanael Green

Aaron Ogden
Tomas Vasquez
Zaynab Salem
Norton Rose Fulbright US LLP
98 San Jacinto Blvd
Suite 1100
Austin, TX 78701

Patrick J. Conroy
Texas Bar No. 24012448
Ryan P. Griffin
Texas Bar No. 24053687
Jonathan H. Rastegar
Texas Bar No. 24064043
Nathan L. Levenson
Texas Bar No. 24097992
NELSON BUMGARDNER CONROY PC
2727 N. Harwood St., Suite 250
Dallas, TX 75201
pat@nelbum.com
ryan@nelbum.com
jon@nelbum.com
nathan@nelbum.com

ATTORNEYS FOR,
Smart RF Inc.

via FEDERAL EXPRESS overnight delivery, on February 14, 2025.

Dated: February 14, 2025

/s/ Jacob K. Baron

Jacob K. Baron (Reg. No. 48,961)
jacob.baron@hklaw.com
HOLLAND & KNIGHT LLP
10 Saint James Avenue; 11th Floor
Boston, MA 02116
Telephone: (617)523-2700

Facsimile: (617)523-6850

Counsel for T-Mobile USA, Inc., AT&T Services, Inc., Cellco Partnership d/b/a Verizon Wireless, Ericsson Inc. and Nokia of America Corporation

XIV. CERTIFICATE OF COMPLIANCE WITH 37 C.F.R. § 42.24

I hereby certify that this Petition complies with the word count limitation of 37 C.F.R. § 42.24(a)(1)(i) because the Petition contains 13,949 words, excluding the cover page and the parts of the Petition exempted by 37 C.F.R. § 42.24(a)(1).

Dated: February 14, 2025

<u>/s/ Jacob K. Baron</u>
Jacob K. Baron (Reg. No. 48,961)
jacob.baron@hklaw.com
HOLLAND & KNIGHT LLP
10 Saint James Avenue; 11th Floor
Boston, MA 02116
Telephone: (617)523-2700
Facsimile: (617)523-6850

Counsel for T-Mobile USA, Inc., AT&T Services, Inc., Cellco Partnership d/b/a Verizon Wireless, Ericsson Inc. and Nokia of America Corporation