

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. IPR2025-00727

U.S. Patent No. 7,035,345

**Declaration of James Proctor, Jr. in Support of
Petition for *Inter Partes* Review of U.S. Patent No. 7,035,345**

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IPR PETITION FOR U.S. PATENT NO. 7,035,345

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

1. I have been retained on behalf of T-Mobile USA, Inc., AT&T Mobility LLC, Cellco Partnership d/b/a Verizon Wireless, Ericsson Inc., and Nokia of America Corporation (“Petitioners”) as an independent technical expert in this proceeding before the United States Patent and Trademark Office (“PTO”) regarding U.S. Patent No. 7,035,345 (the “’345 Patent”). I have been asked to consider whether certain references disclose or suggest the features recited in Claims 1-11 of the ’345 Patent (the “Challenged Claims”). My opinions are set forth below.

1. Background and Qualifications

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

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

4. I am a named inventor on more than 325 issued U.S. patents, and more than 700 international patent publications. A number of these patents and patent applications are specifically related to the subject matter of the ’345 Patent (e.g., cancelation or predistortion of intermodulation products in wireless transceivers,

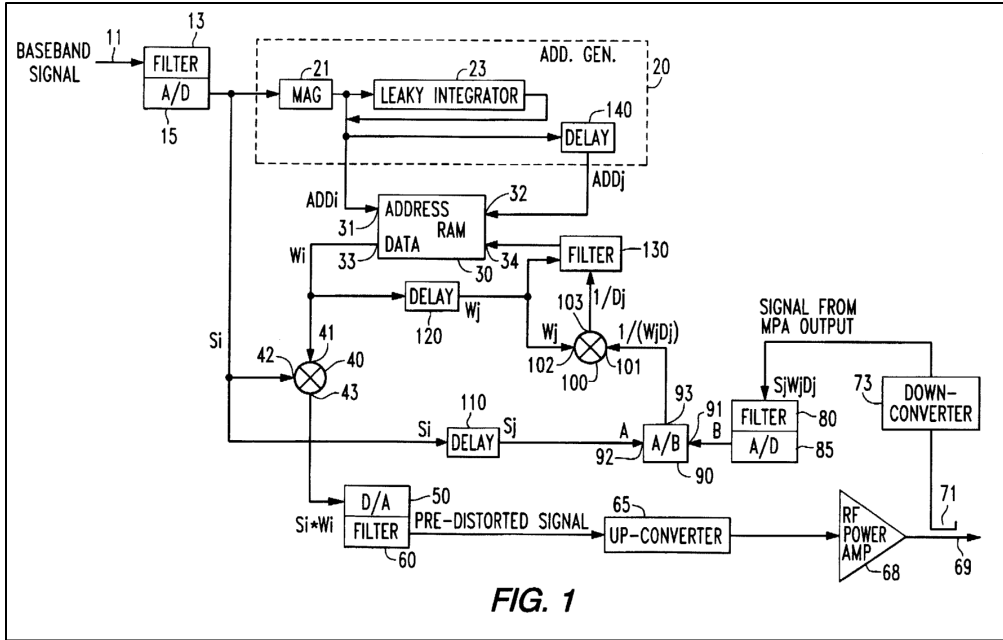
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related components such as correlators and closed loop control for gain and phase, and delay alignment). For example, I am a named inventor on the following patents:

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

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

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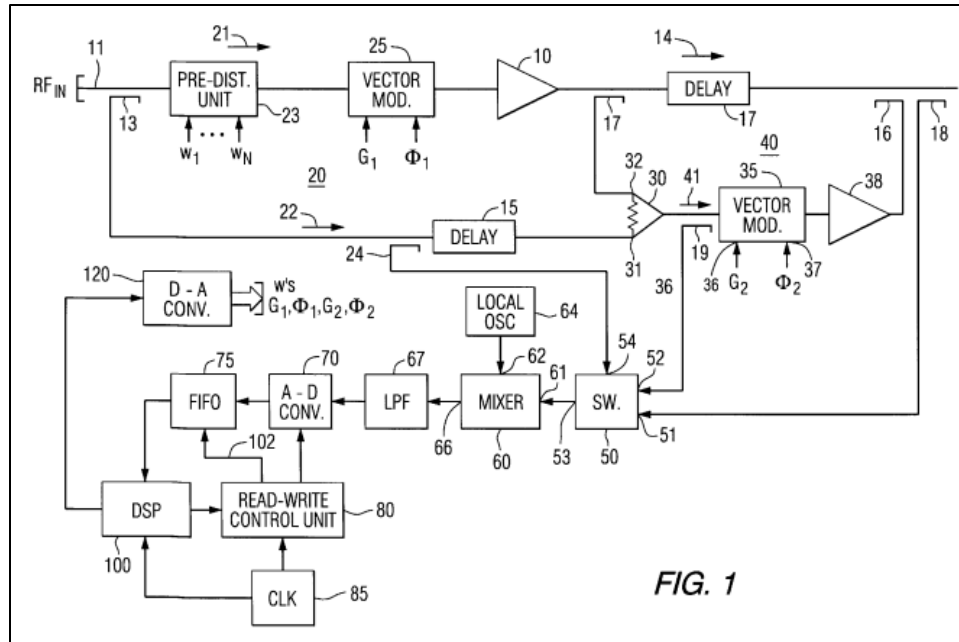


('338 Patent, Fig. 1.)

5. Relevant to the '345 Patent, the '338 Patent discloses many related concepts for power amplifier linearization including a digital pre-distorter utilizing a look-up table (30) based upon the magnitude of the input signal (21), and includes two look-up table outputs (i.e. two tables) to impart gain and phase predistortion. The '338 Patent further compensates for memory effects (23) of the amplifier. The '338 Patent and its family have been cited over 115 times during the prosecution of other inventors' patents.

6. Another example of my relevant experience is U.S. Patent No. 6,078,216 (the “216 Patent”), which discloses performing pre-distortion on a signal using feedback signals. Fig. 1 is set forth below:

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('216 Patent, Fig. 1.)

7. Like the '345 Patent, the '216 Patent discloses performing pre-distortion on an RF modulated signal (23), and control of the pre-distorter (23) via a DAC (120) based upon feedback signals (51, 52, 53) including from the output of the amplifier (52 and 51). Additionally, the '216 Patent discloses adjusting the pre-distorter to minimize intermodulation in adjacent sub-bands (e.g. adjacent channel interference, or "ACI") based upon meeting industry or regulatory requirements. The '216 Patent has been cited over 45 times during prosecution of other inventors' patents.

8. I received my BSEE (Bachelor of Science, Electrical Engineering) from the University of Florida (1991) and my MSEE (Master of Science, Electrical Engineering) from the Georgia Institute of Technology (1992), which focused on

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digital signal processing. From 1986 to 1991, while at the University of Florida, I interned with Harris Corporation in various roles including mechanical design, software development and digital design. From 1991 to 1992, while at Georgia Institute of Technology, I worked at the Georgia Tech Research Institute (GTRI) as a graduate research assistant, performing software development on classified government programs.

9. From 1993 to 1995, while working again for Harris Corporation, I designed various cellular communications systems for voice, data and tracking/location services. Many of these systems advanced the developing and future communications technologies of the day including IS-95, W-CDMA, and LTE.

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

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11. From 1998 to 2002, I served as the Director of Strategic and Technical Marketing at Tantivy Communications, a venture capital-funded 3G cellular data and chip set company. At Tantivy, I helped to architect and standardize the I-CDMA Spread Spectrum Systems Air Interface Standard (T1P1.4). I also developed both wireless access terminals and base stations that complied with the standard. The base stations utilized various IP protocols, and interfaced with the wire line network utilizing IP over Ethernet. Additionally, I participated in and provided technical contributions to 3GPP/3GPP2 standardization efforts related to the development of CDMA2000 and 1xEV-DO. This work resulted in me being a named inventor on more than 150 U.S. patents and applications.

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

13. From 2007 to 2009, I consulted as a principal engineer for Qualcomm Inc. as part of the acquisition of WiDeFi's technology. While at Qualcomm, I

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worked with its corporate R&D division and developed consumer 3G and 4G cellular coverage enhancement systems utilizing WiDeFi's baseband interference cancellation technologies. My responsibilities included working with international cellular operators on product requirements, detailed W-CDMA simulations, Long Term Evolution ("LTE") systems analysis, and participation in prototype product realization. I am currently a named inventor on roughly 45 issued U.S. patents or patent applications assigned to Qualcomm.

14. From 2010 to the present, I have served as managing director and co-founder of Proxicom Wireless, LLC, which has developed and continues to develop cloud-based, mobile social networking and mobile payments technology based upon the proximity and location of mobile devices. Proxicom currently holds twelve issued U.S. patents and multiple pending patent applications, of which I am a named inventor. Significant aspects of Proxicom's technology involve a mobile device's use of short-range wireless technologies (802.11, near field communications, Bluetooth) in combination with cellular data links (3G/WCDMA or 4G/LTE, for example) to facilitate frictionless interactions via a wireless networked central cloud server.

15. Since 2007, I also have been the principal of Proctor Consulting, LLC. In this role, I have been a consultant relating to wired, wireless, and cellular communication and technologies, start-up companies and intellectual property. I

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have also been involved with numerous patent infringement, patent validity, and patent analysis assignments for public and private companies in the wired, wireless, and cellular networking industries.

16. Additionally, I have worked and consulted for both cellular infrastructure and device focused companies (Spectrian, Qualcomm, Fastback Networks), and defense contractors (Harris Corporation), where I developed covert-tracking and location technologies involving CDMA and smart-antenna technologies.

17. In several of the above-detailed roles, I have been responsible for the development of business plans, product development plans, product development budgets, and product bill of materials estimations. I have been responsible for numerous product development teams, including schedule and costs of the development process at various stages of my career. For example, at Tantivy Communications, I ran a joint development of I-CDMA cellular base stations in Seoul, Korea that were used in a field trial in that country. Additionally, as founder and CEO of WiDeFi, Inc., I was responsible for similar such activities, as required to raise venture capital funding and reporting to the board of directors.

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2. Compensation

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

3. Materials Considered

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

4. Legal Standards

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

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

22. I have further been informed by Counsel that a patent claim is obvious under 35 U.S.C. § 103, and therefore invalid, if the claimed subject matter, as a

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whole, would have been obvious to a POSITA as of the priority date of the patent based on one or more prior art and/or the knowledge of a POSITA. I have been further informed by Counsel that a claim is invalid under 35. U.S.C. § 102 if it is anticipated, which requires that every element of a claim is disclosed in a single prior art reference, arranged as in the claim.

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

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

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

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

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- i. whether the combination involves the known work in one field of endeavor prompting variations of it for use in either the same field or a different one based on design incentives or other market forces, where the variations are predictable to a POSITA;
- j. whether there is some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill in the art to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention;
- k. whether the combination requires modifications that render the prior art unsatisfactory for its intended use;
- l. whether the combination requires modifications that change the principle of operation of the reference;
- m. whether the combination is reasonably expected to be a success;
and
- n. whether the combination possesses the requisite degree of predictability at the time the invention was made.

26. I have been informed by Counsel that in determining whether a combination of prior art references renders a claim obvious, it is helpful to consider whether there is some teaching, suggestion, or motivation to combine the references and a reasonable expectation of success in doing so. I have further been informed

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by Counsel that the existence of an explicit teaching, suggestion or motivation to combine known elements of the prior art is a sufficient, but not a necessary, condition to a finding of obviousness. This so-called “teaching-suggestion-motivation” test is not the exclusive test and is not to be applied rigidly in an obviousness analysis.

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

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

5. Level of Ordinary Skill in the Art

29. I have reviewed the relevant disclosures of the Patent-in-Suit (the '345 Patent) as well as relied on the documents identified above, and on my education

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and experience, to arrive at my opinions regarding the level of a person of ordinary skill in the art.

30. In my opinion, a person of ordinary skill in the art (“POSITA”) in the field of the ’345 Patent in the relevant time frame would have been someone with at least (1) a bachelor’s degree in electrical engineering or a related field, and (2) either (a) a master’s degree in electrical engineering or a related field, or (b) two or more years of work or research experience in wireless communications and, in particular, power amplification of radio signals.

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

32. I met the definition of a POSITA in the relevant time frame. I also had greater knowledge and experience than a POSITA in the relevant time frame. I render my opinions, however, from the perspective of a POSITA, based on my knowledge and research and teaching experience. Indeed, my opinions concerning the ’345 Patent and the prior art are from the perspective of a POSITA.

6. State of the Art Relevant to the '345 Patent

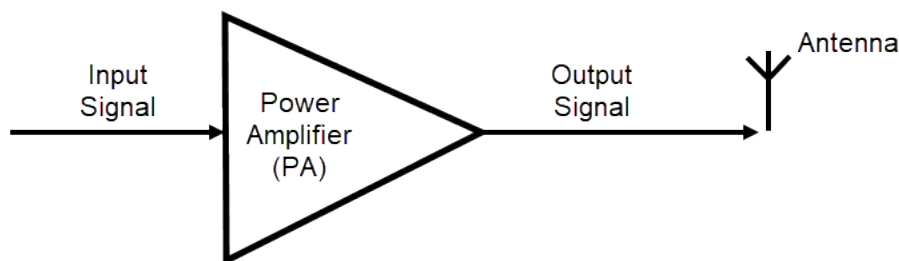
33. Below, I provide a brief summary of the background technology and the state of the art as of the priority date of the '345 Patent as context for understanding the disclosure and claims of the '345 Patent.

6.1 The Technology: Digital Predistortion

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

6.1.1 Power Amplifiers Introduce Distortion

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

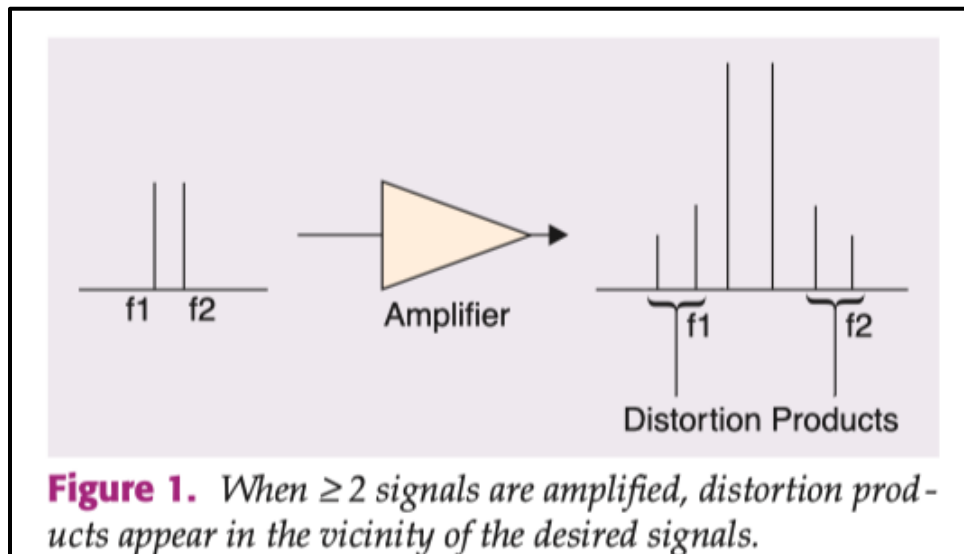


An input signal’s power level is amplified to a higher power level after it passes through the PA to create an output signal. After this amplification, the output signal is transmitted using an antenna.

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

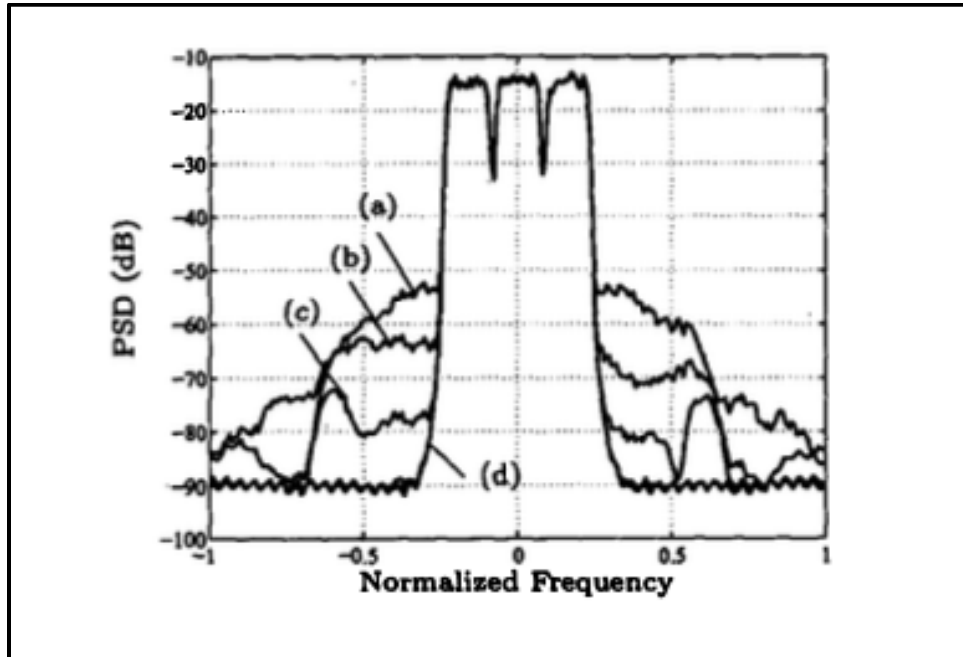
37. Below is a figure showing spectrum spreading:



(Katz, at Fig. 1.) Above, two signals f_1 and f_2 are input to the power amplifier, which causes distortions: the signals appearing outside of their intended frequency channels.

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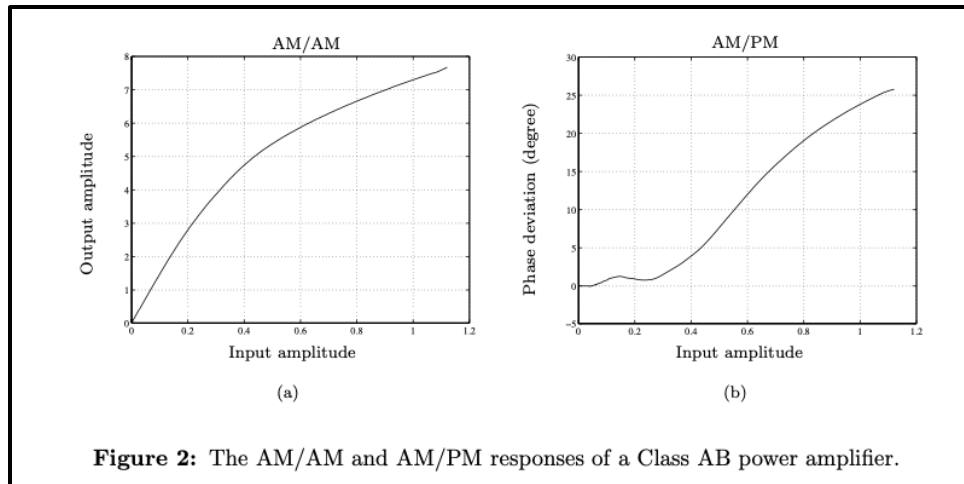
38. The same effect occurs for modulated input signals composed of multiple frequencies within a given channel, as shown in the following figure:



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

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

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

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

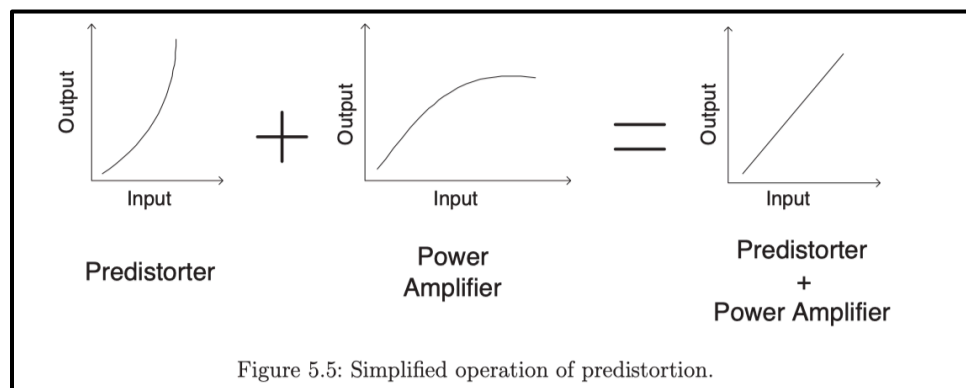
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modulation, causing phase modulation (“PM”) in the output signal, called “AM-to-PM” distortion.

6.1.2 Predistortion Mitigates the Power Amplifier’s Distortion

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

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



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

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

6.1.3 Analog and Digital Predistortion

43. Predistortion may be implemented digitally ("digital predistortion" or "DPD") or using analog circuitry ("analog predistortion" or "APD"). While there are numerous differences between analog and digital predistortion, a key distinction is the manner in which these systems model PA distortion. For example, a conventional analog predistorter using polar or rectangular feedback approaches may perform predistortion using RF feedback signals corresponding to the input and output of the PA. Analog circuitry, such as envelope detectors or phase detectors, may then be used to determine the differences between the RF feedback signals. An error signal resulting from these differences corresponding to the distortion produced by the PA would then be combined with the original RF input in order to generate an RF predistorted signal. Thus, conventional approaches predistort signals in the RF domain and do not require D/A or A/D converters which are needed in a DPD system.

44. Digital predistortion, by contrast, may model PA distortion in the baseband or digital domain using sophisticated algorithms and mathematical models

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that are implemented in digital hardware such as a Field Programmable Gate Array (FPGA), or software using a digital signal processor (“DSP”). DPD may still make use of RF feedback from the PA; however, one or more digital receivers are needed to translate the RF feedback signals to digital baseband or an intermediate frequency (“IF”) in order to model the distortion.

45. Long before the introduction of DPD, digital receivers and techniques for representing analog signals as digital data were well-known. (Oppenheim, at 86.) For example, it has long been understood that a digital signal may be represented by its real and imaginary waveform components, or “complex envelope,” which is commonly referred to as the in-phase (*I*) and quadrature (*Q*) components of the bandpass waveform. (Couch, at 4.2.) As a result, digital receiver components such as downconverters, A/D converters, demodulators, and other baseband processing circuitry, has played a critical role in DPD since at least the early 1990s. (Cavers 1990, at 2024-2025.)

6.2 Relevant Communication Theory

6.2.1 Baseband Signals, Passband Signals, and Modulation

46. A baseband waveform is defined as a signal having a spectral magnitude that is non-zero for frequencies in the vicinity of the origin (i.e., $f = 0$) and negligible elsewhere. (Couch, at 4.2.) Baseband signals are typically low-frequency signals that occupy the frequency range starting from zero up to a certain

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maximum frequency, and include the original digital information or data that needs to be transmitted.

47. A bandpass waveform has a spectral magnitude that is non-zero for frequencies in some band concentrated about a frequency $f = \pm f_c$, where $f_c \gg 0$. The spectral magnitude is negligible elsewhere. f_c is commonly referred to as the carrier frequency. (Couch, at 4.2.) Bandpass waveforms occupy a specific range of frequencies (typically centered around a higher frequency) and are used to facilitate transmission over long distances and through various media. Examples of bandpass signals include radio frequency (“RF”) and intermediate frequency (“IF”) signals.

48. Modulation is the process of varying a digital baseband signal in order to create a bandpass waveform with a carrier frequency f_c . (*Id.*) This is typically accomplished by combining the baseband signal with a higher frequency carrier signal to create a bandpass waveform. The bandpass signal is often called the *modulated* signal ($s(t)$), and the baseband source signal is called the *modulating* signal ($m(t)$). In essence, modulation transforms baseband signals representing the original data into bandpass signals for efficient transmission.

6.2.2 Envelope Detection and Use in Look-up Table (“LUT”) Based Predistorters

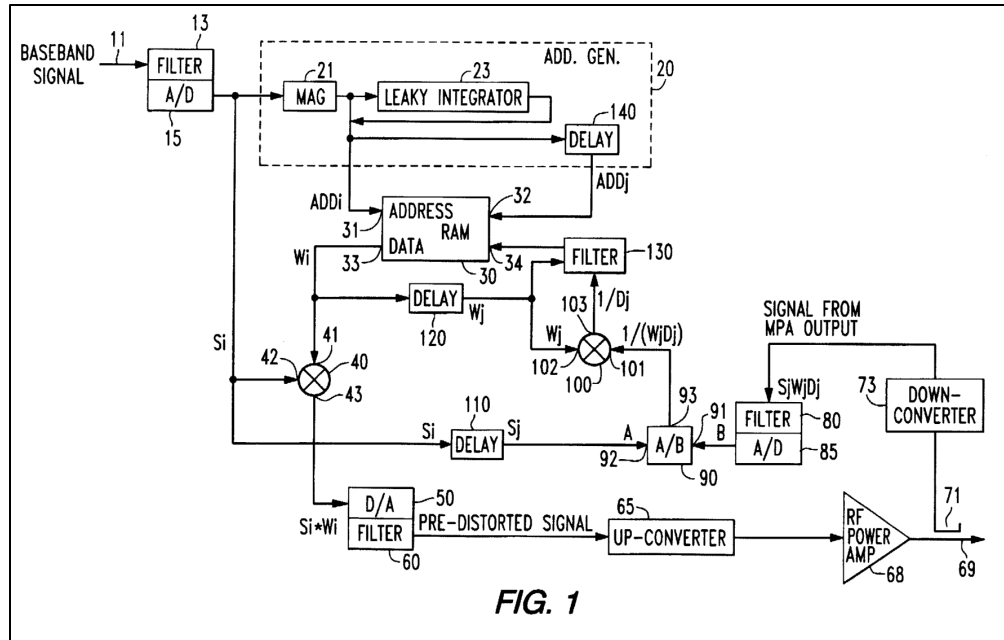
49. An envelope detector is an electronic circuit that is used to extract the instantaneous amplitude (or magnitude) of a high frequency signal, such as an RF waveform. The input signal is rectified, typically using a diode, which allows

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current to pass only in one direction. This process converts the AC signal into a pulsed DC signal. A capacitor and resistor are then commonly used to smooth out the pulsed DC signal, effectively filtering out the high-frequency components and leaving the envelope of the original signal.

50. In digital predistortion, it was well-known to use an envelope detector to measure the amplitude of the RF signal before it enters the PA. The detected envelope would then be used to index a look-up table (“LUT”) that contains pre-calculated values (i.e., predistortion coefficients) to counteract the PA’s nonlinearities. The predistorter then applies these values to the input signal, effectively predistorting it before it enters the PA. As discussed above and below, predistortion techniques commonly utilize feedback signals (e.g., based on the input and output to the PA) in order to further improve the accuracy of the predistortion. As one example, the ’338 Patent discloses an exemplary envelope detector (21) for use with digital pre-distortion:

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(’338 Patent, at Fig. 1.)

6.2.3 Complex Envelope Theory

51. A digital baseband signal is expressed by a “complex envelope” consisting of two components: the in-phase (I) component and the quadrature (Q) component. These components combine to form a complex signal, where the I component is the real part and the Q component is the imaginary part.

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Theorem. Any bandpass waveform may be represented by

$$v(t) = \text{Re}\{g(t)e^{j\omega_c t}\} \quad (4-1a)$$

where $\text{Re}\{\cdot\}$ denotes the real part of $\{\cdot\}$, $g(t)$ is called the *complex envelope* of $v(t)$, and f_c is the associated carrier frequency, $\omega_c = 2\pi f_c$. Furthermore, two other equivalent representations are[†]

$$v(t) = R(t) \cos[\omega_c t + \theta(t)] \quad (4-1b)$$

and

$$v(t) = x(t) \cos \omega_c t - y(t) \sin \omega_c t \quad (4-1c)$$

where

$$\begin{aligned} g(t) &= x(t) + jy(t) = |g(t)|e^{j\angle g(t)} \\ &\equiv R(t)e^{j\theta(t)} \end{aligned} \quad (4-2)$$

[†]The symbol $\equiv$ denotes an equivalence and the symbol $\triangleq$ denotes a definition.

and

$$x(t) = \text{Re}\{g(t)\} \equiv R(t) \cos \theta(t) \quad (4-3a)$$

$$y(t) = \text{Im}\{g(t)\} \equiv R(t) \sin \theta(t) \quad (4-3b)$$

$$R(t) \triangleq |g(t)| \equiv \sqrt{x^2(t) + y^2(t)} \quad (4-4a)$$

$$\theta(t) \triangleq \angle g(t) = \tan^{-1}\left(\frac{y(t)}{x(t)}\right) \quad (4-4b)$$

The waveforms $g(t)$, $x(t)$, $y(t)$, $R(t)$, and $\theta(t)$ are *all* baseband waveforms and, *except* for $g(t)$, they are all real waveforms. $R(t)$ is a nonnegative real waveform.

(Couch, at 4.2)

52. As shown above, the “complex envelope” of a bandpass signal $g(t)$ may be represented by $x(t) + jy(t)$, which corresponds to the “real” waveform components mapped onto the cosine and sine components of equation 4-1c above. These components represent the in-phase (I) and quadrature (Q) components of the bandpass waveform, respectively. Equations 4-3a and 4-3b show that these components may be demodulated from the carrier frequency by multiplying each

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by their in-phase and quadrature carrier frequency components, resulting in two real baseband waveforms that each represent a portion of the bandpass envelope.

53. As discussed above, modulation is the process of converting a baseband signal to its passband counterpart. Modulation varies certain parameters of a carrier signal (e.g. a sinusoid) according to the baseband signal, which may be the in-phase and quadrature signals. For example, in one type of digital modulation called *quadrature amplitude modulation (QAM)*, a passband signal is constructed by impressing separate information bits on each of the quadrature carriers, $\cos(2\pi f_c t)$ and $\sin(2\pi f_c t)$.

$$x_l(t) = x_c(t) + jx_s(t) \quad (2.5.9)$$

$x_c(t)$ and $x_s(t)$ are lowpass signals, called *in-phase* and *quadrature* components of the bandpass signal $x(t)$. Substituting for $x_l(t)$ and rewriting $z(t)$, we obtain

$$\begin{aligned} z(t) &= x(t) + j\hat{x}(t) \\ &= x_l(t)e^{j2\pi f_0 t} \\ &= (x_c(t) + jx_s(t))e^{j2\pi f_0 t} \\ &= (x_c(t) \cos(2\pi f_0 t) - x_s(t) \sin(2\pi f_0 t)) \\ &\quad + j(x_c(t) \sin(2\pi f_0 t) + x_s(t) \cos(2\pi f_0 t)) \end{aligned} \quad (2.5.10)$$

Equating the real and imaginary parts, we have

$$x(t) = x_c(t) \cos(2\pi f_0 t) - x_s(t) \sin(2\pi f_0 t) \quad (2.5.11)$$

(Proakis, at 2.5.)

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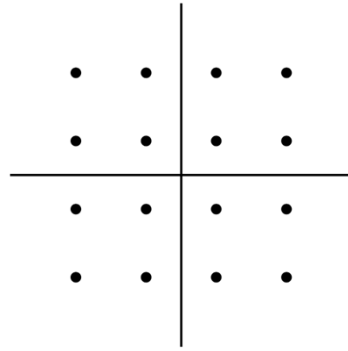


Figure 7.21 $M = 16$ -QAM signal constellation.

(Proakis, at §7.3.3., Figure 7.21.) A QAM modulator is depicted below:

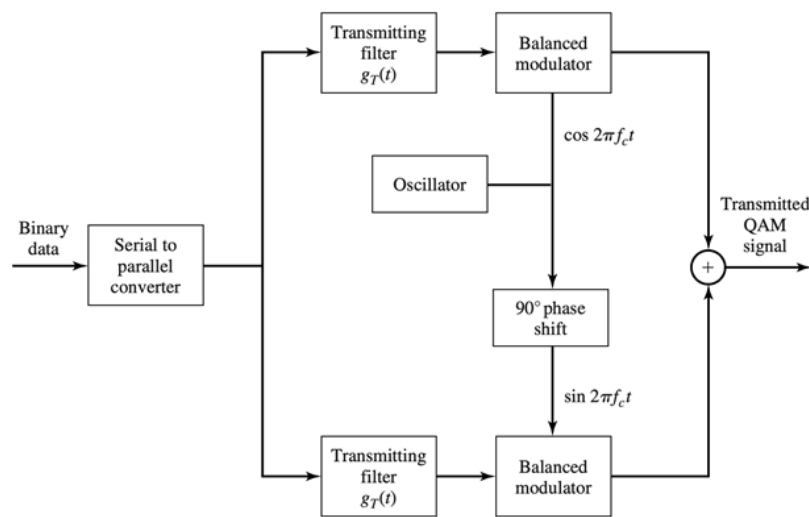


Figure 7.22 Functional block diagram of modulator for QAM.

(Proakis, at Figure 7.22.) The value mapped on the topmost branch of the QAM modulator of Figure 7.22 results in the real/in-phase component ($x_c(t)$) and the value mapped onto the lower branch results in the imaginary/quadrature component ($x_s(t)$) of equation 2.5.9, forming the QAM constellation of Figure 7.21 above.

54. This complex envelope representation may be utilized for in-phase and quadrature mappings to represent sets of points in a modulation symbol, referred to

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as a constellation, utilizing a quadrature modulator as described above. Such signals are passed through a channel, received at a demodulator, and detected.

55. Complex baseband signals have long been used in digital communications systems, such as in the modulation and demodulation processes in systems like QAM, in order to allow processing of the original signal without any modulation to a higher frequency. (Couch, at 4.2; Proakis, at §2.5, Eq. 2.5.9, §7.3.3., Figure 7.21, Figure 7.22.)

6.2.4 Indirect Learning for Predistortion

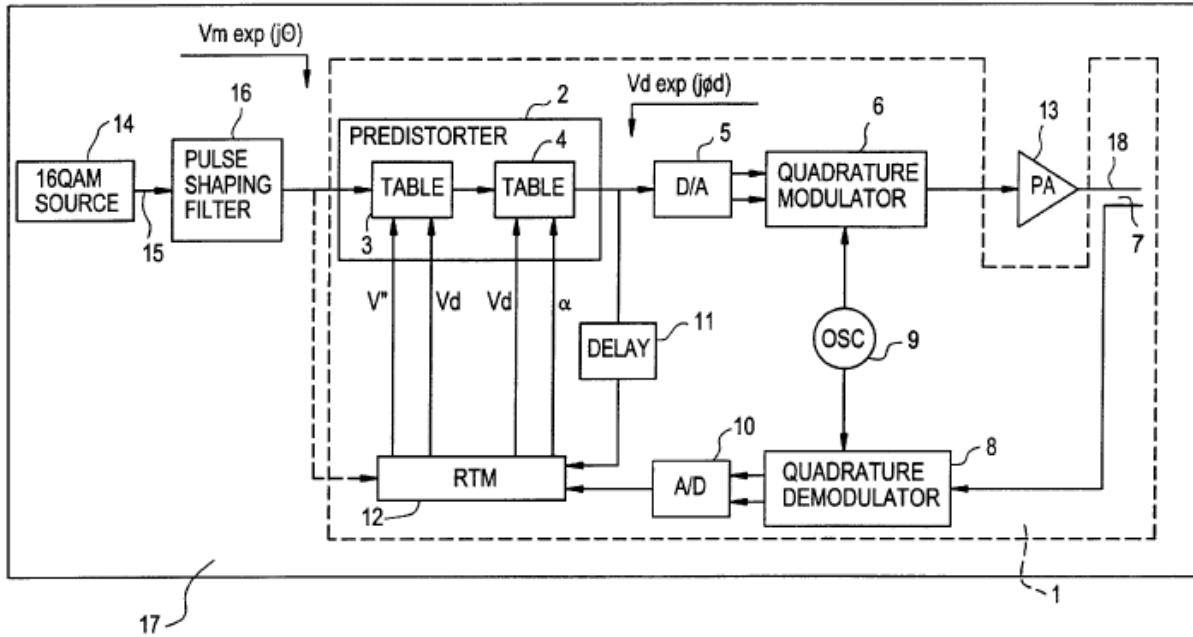
56. Adaptation or learning architectures for digital predistortion methods were generally categorized as one of two primary types: direct and indirect learning.

57. To develop a model of the nonlinearities introduced by the PA, a direct learning architecture uses feedback from the output of the PA and the *input* to the predistorter (prior to predistortion). In contrast, an indirect learning architecture uses the output of the PA and the *output* from the predistorter (prior to amplification).

58. Direct and indirect learning architectures were widely discussed and formed the two main feedback mechanisms a POSITA would have considered when implementing DPD. For example, a POSITA would have been aware of at least the following examples of indirect learning algorithms (in addition to the specific grounds discussed below).

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FIG.1



(Jeckeln, at Fig. 1.)

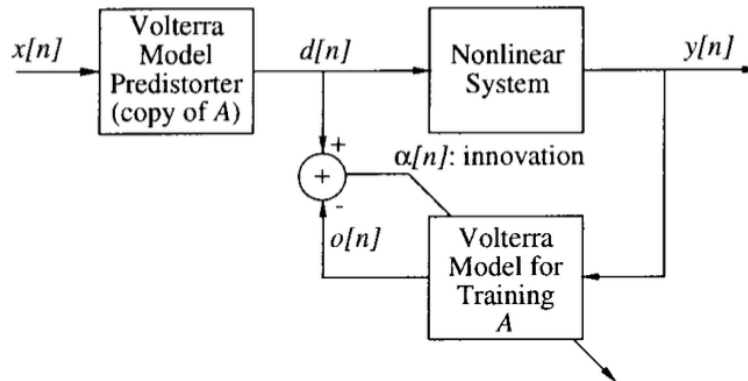


Fig. 1. The training architecture of the Volterra series model predistorter.

(Eun, at pp. 223-227, Fig. 1.)

6.2.5 Adjacent Channel Power and Adjacent Channel Power Ratio

59. There are stringent regulatory controls on the amount of interference that a transmitter can cause to neighboring channels. (Agilent 1311, at 24.) Adjacent Channel Power (“ACP”) refers to the amount of power leakage from a carrier signal’s main channel into neighboring frequency channels (often referred to as “offset” channels). The following figure illustrates a typical carrier channel and offset channel configuration.

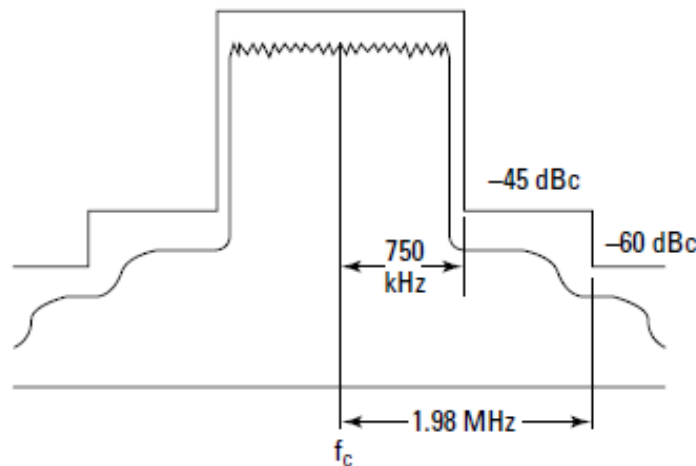


Figure 20. IS-97 spurious emissions test limits

(*Id.* at 24, Fig. 20.) Adjacent Channel Power Ratio (“ACPR”) typically refers to the ratio between the average power in the carrier signal’s main channel relative to the offset channels, and is often used as a figure of merit for measuring the performance of the transmitter device under test.

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60. ACP limits are specified by industry and regulatory standards, such as IS-95 (CDMA), cdma2000, and W-CDMA. These limits are referred to as the ACP “mask.” Any spurious emissions outside of the specified mask will interfere with adjacent channels and limit system performance. (*Id.* at 24.) For example, the IS-97 standard specifies the ACP mask for the IS-95 (CDMA) protocol as follows:

16 **10.5.1.3 Minimum Standard**

17 **10.5.1.3.1 Suppression Inside Cellular Band**

18 For all frequencies within the cellular base station transmit band between 869 and 894
19 MHz which are also within the specific bands allocated to the operator's system, the total
20 spurious emissions measured in a 30 kHz resolution bandwidth shall be attenuated below
21 the mean output power level in accordance with the following schedule:

22 (a) For offset frequencies greater than 750 kHz from the CDMA Channel center
23 frequency, at least 45 dB

24 (b) For offset frequencies greater than 1.98 MHz from the CDMA Channel center
25 frequency, at least 60 dB

(IS-97, at 10-7.) As shown above, the ACP mask for the IS-95 standard is expressed in terms of ACPR—i.e., the ratio between the center channel and offset channels.

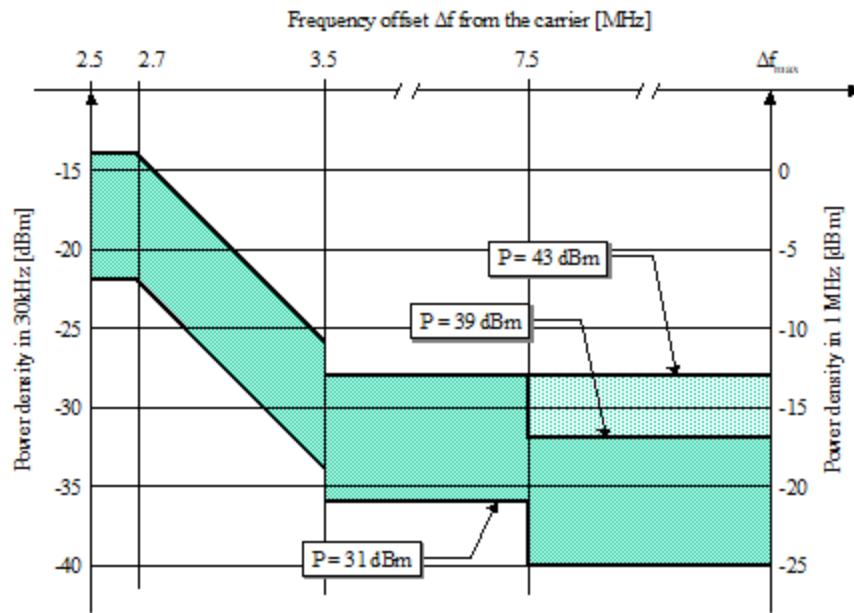
61. Other standards such as GSM/EDGE and W-CDMA utilize ACP and/or ACPR to define the ACP limits.

6.6.2 Out of band emission

Out of band emissions are unwanted emissions immediately outside the channel bandwidth resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions. This out of band emission limit is specified in terms of a spectrum emission mask or adjacent channel power ratio for the transmitter.

(3GPP, at 14 (annotated).)

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(*Id.* at 15.) Consistent with this understanding, the terms “ACP” and “ACPR” were often used interchangeably depending on context during the relevant time period. (*Id.*; Agilent 1312, at 19 (“The measurement of spectrum [sic] due to modulation and wideband noise can be thought of as an adjacent channel power (ACP) measurement although several adjacent channels are tested.”).)

Adjacent Channel Power Ratio (ACP)

The leakage of a transmitter into adjacent channels can be measured quickly and easily. Enter the channel spacing and channel bandwidth, and activate the adjacent channel power measurement. The spectrum analyzer computes and displays the ACP ratio of both the lower and upper adjacent channels, marking the higher of the two. The absolute carrier power is read out and vertical lines on the display mark the channel bandwidth edges.

(HP User’s Guide, at p. 4-45.) (defining “Adjacent Channel Power Ratio” or “ACP”).

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7. Overview of the '345 Patent

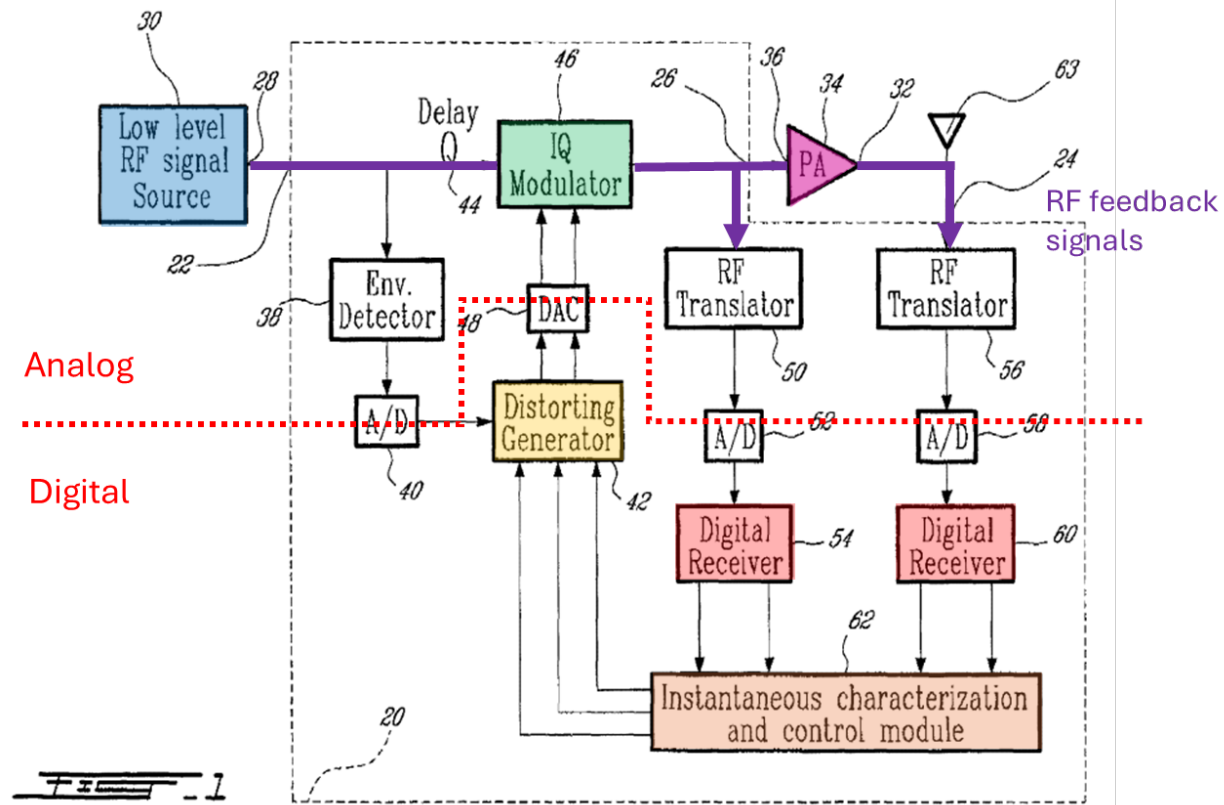
62. The '345 Patent is entitled “Adaptive predistortion device and method using digital receiver.” The '345 Patent issued on April 25, 2006 from U.S. Patent Application No. 09/877,608, which was filed on June 8, 2001.

7.1 Description of the Alleged Invention

63. The '345 Patent relates to systems and methods for predistorting an RF modulated signal from a signal source to a PA in order to produce an amplified output signal. ('345 Patent, 2:54-59.) The '345 Patent states that, although predistortion techniques for both analog and digital implementations were well-known at the time, “[i]n most cases, linearizer designers have no access to baseband signal; hence they found themselves confined to use traditional Radio-frequency (hereinafter ‘RF’) analog predistortion techniques.” (*Id.* at 1:62-2:23, 2:27-31.) The claimed predistortion device and methods purport to address this concern of only having access to the analog RF signal—not the digital baseband signal—“[b]y taking advantage of the digital receiver technology to digitally translate signal [sic] from RF to baseband” such that “the predistorting device of the invention performs the instantaneous characterization of the memoryless nonlinearity in baseband to supply a correlated predistortion function.” (*Id.* at 2:49-50, 5:8-13.)

64. Figure 1 depicts an exemplary embodiment of the claimed predistorting device:

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(*Id.* at Fig. 1 (annotated).) As shown in Figure 1, the claimed digital receivers 54 and 60 (red) can be implemented in predistortion systems having an analog, RF signal source (blue). (*Id.*) The digital receivers are used to process the analog feedback signals (purple) corresponding to (1) the RF signal provided to the PA input 36, and (2) the RF output signal of the PA (second input 24). (*Id.*)

65. The instantaneous characterization and control module 62 (orange) then compares the feedback signals to determine the PA's distortion effects. (*Id.* at 5:48-51, Fig. 1.) More specifically, the module 62 correlates the amplitude and phase characteristics of the PA input and output signals in order to yield the PA's predistortion function. (*Id.*, 5:66-6:13.) The module 62 then updates the amplitude

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and phase LUT of the distorting generator 42 (yellow) so the quadrature modulator 46 (green) correctly pre-distorts future RF signals. (*Id.* at 6:13-20; Fig. 1.) This characterization process is adaptively performed to ensure that the PA efficiently and adequately reproduces the amplified signal at higher powers. (*Id.* at 8:12-19.)

7.2 Prosecution History

66. The application that resulted in the '345 Patent was filed on June 8, 2001. On January 12, 2005, the Examiner issued a first non-final Office Action rejecting pending claims 1-3, 8, 16 and 17 as obvious in view of U.S. Patent Application Publication 2001/0014592 ("Helms"), and further in view of U.S. Patent No. 6,246,286 ("Persson"). ('345 File History at 75-76.) The Examiner explained that "Helms discloses all of the subject matter . . . except for specifically teaching the look-up tables which is an ***amplitude and phase*** look-up table." ('345 FH at 77, 79 (emphasis added).) The Examiner stated that it would have been obvious to modify the look-up table ("LUT") of Helms with Persson's teachings of an "amplitude" and "phase" LUT in order to more effectively compensate for distortion effects of a PA while simultaneously decreasing power consumption. (*Id.* at 77.) Pending dependent claims 4-7 and 9-15 were also rejected—but the Examiner indicated that these claims would have been allowed if rewritten in independent form. (*Id.* at 80.)

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67. In its July 12, 2005 Response, Applicant sought to distinguish Helms on the grounds that “[t]he claimed invention calls for the synthesis of the predistorted signal using only one LUT for the whole communication signal . . . in sharp contrast with Helms’ method of generating the predistorted signal using multiples LUT [sic], i.e. one LUT per carrier.” (*Id.* at 101.) Additionally, Applicant sought to distinguish Persson arguing, *inter alia*, that Persson’s method extracts the amplitude and phase characteristics of the distorted signal using analog circuits, whereas the claimed methods perform this characterization digitally. (*Id.* at 101-02.)

68. In a September 6, 2005 Final Rejection, the Examiner rejected these arguments. (*Id.* at 111.) The Applicant cancelled the rejected claims and amended pending claims 4-7 and 9-15 to include all of the limitations of the base independent claims, after which the Office issued a Notice of Allowance.² (*Id.* at 143-148.)

7.3 Challenged Claims

69. This Declaration addresses Claims 1-11 of the ’345 Patent, which I have been informed by Counsel are the Challenged Claims. I have added indices of the form 1[pre], 1[a], 1[b], (etc.), to the claim limitations for ease of reference, and listed the claim limitations in the table attached as Exhibit C to this declaration.

² I understand that claims 4, 6, 9, 11, 13 and 15 referenced during prosecution correspond to independent claims 1, 3, 5, 7, 9, and 11, as issued, respectively.

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70. As explained in detail below, Claims 1-11 of the '345 Patent would have been obvious in view of the prior art.

8. Overview of the Prior Art

8.1 Wright

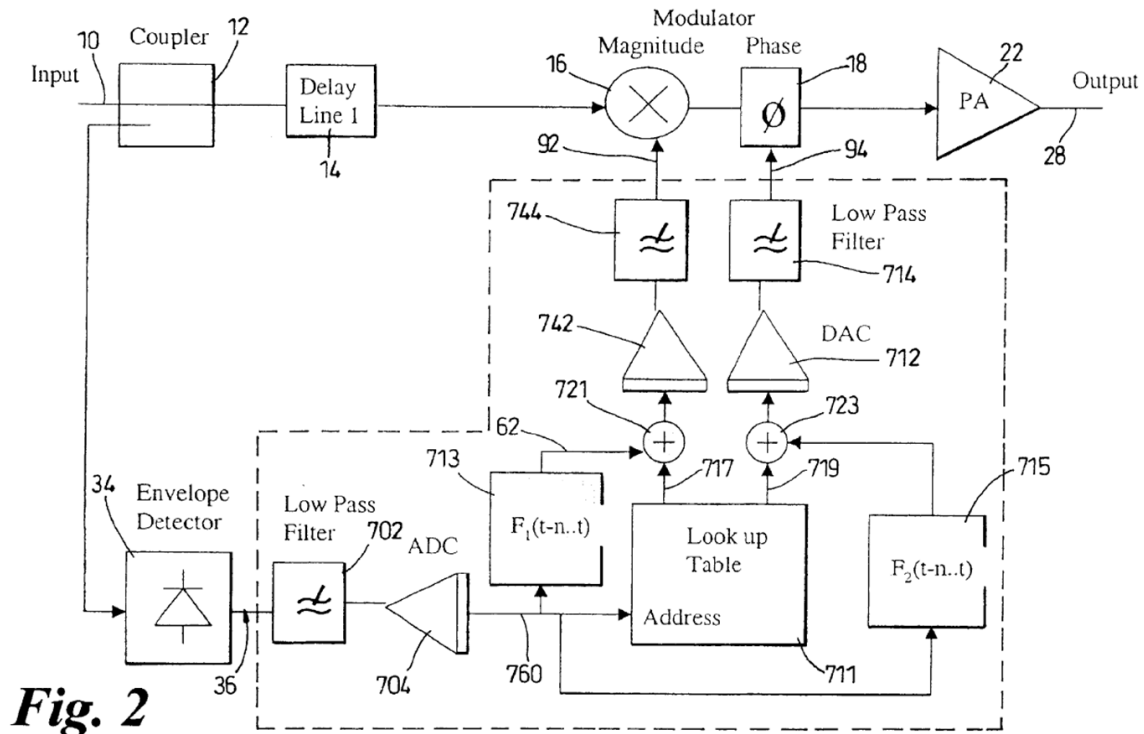
71. Wright discloses improved systems and methods for digitally predistorting wideband signals. (Wright, Abstract, 1:22-30.) Wright explains that then-existing predistortion systems failed to accurately account for distortion effects based on the past inputs to the PA (“memory effects”), which may be caused by, among other things, fluctuations in the PA’s temperature variations. (*Id.* at 2:9-17.) Wright discloses using a compensation circuit, including a Digital Compensation Signal Processor (“DCSP”) and Adaptive Control Processing and Compensation Estimator (“ACPCE”), that indexes the predistorter’s LUT based on the input transmission signal, which allows the accuracy of the predistortion model to be increased. (*Id.* at 2:35-3:7.) Wright’s predistortion technique could be adapted for both systems having a digital baseband input signal as well as those having an analog RF input signal. (*Id.* at 43:33-39.)

8.2 Booth

72. Booth discloses an improved digital predistortion system for analog RF transmitters. (Booth, Abstract, 2:40-51.) Booth teaches a digital predistortion system that considers both instantaneous distortion effects as well as memory effects to more accurately predistort the signal. (*Id.* at 2:40-62.) Booth explains that the

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memory effects can be greatly mitigated while adding little additional cost to the PA's arrangement. (*Id.*)



(Booth, 7:5-32, Fig. 2.)

8.3 Leyendecker

73. Leyendecker discloses an improved predistortion system for wireless transmitters. (Leyendecker, 2:57-60, 2:66-3:5.) Leyendecker recognized that predistorting a signal using only the instantaneous power or magnitude does not completely reflect the distortion caused by an amplifier. (*Id.* at 9:4-18.) Leyendecker teaches a dynamic, “memory effect” model that considers past power or magnitude of PA inputs to more accurately model distortion. (*Id.*)

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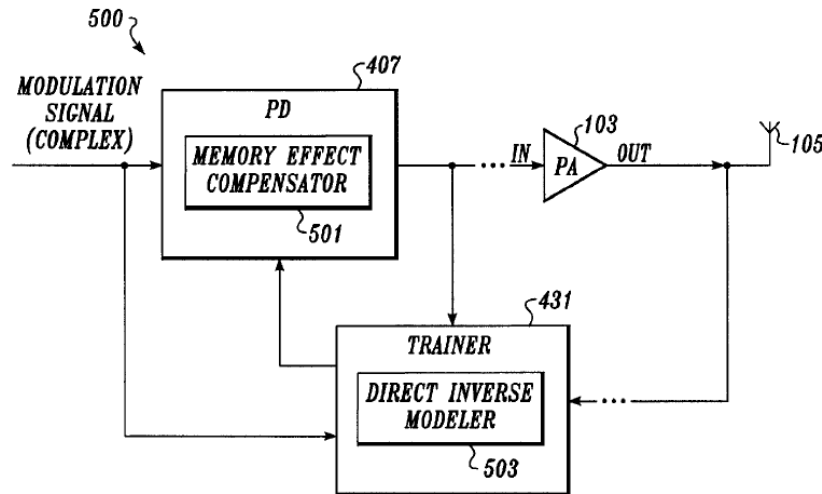


Fig. 5

(*Id.* at Fig. 5.)

74. Leyendecker also teaches using digital receivers to convert signals from analog to digital to aid the digital predistortion. (*Id.* at 6:13-41.) For example, a digital receiver downconverts, digitizes and demodulates the RF signal to digital baseband in order to produce the signal's complex envelope that is used in the predistortion. (*Id.*) Leyendecker also explains that the digital receivers may provide additional digital filtering and/or decimation processes. (*Id.* at 6:66-7:8.)

8.4 Jin

75. Jin discloses an adaptive digital predistorter for use in an RF transmitter. (Jin, 1:19-21.) More specifically, Jin discloses a “pre-distortion adjustment circuit . . . that optimizes the ACP profile of an RF power amplifier to

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fully use the ACP profile under the applicable RF communication standard.” (*Id.* at 2:30-33.)

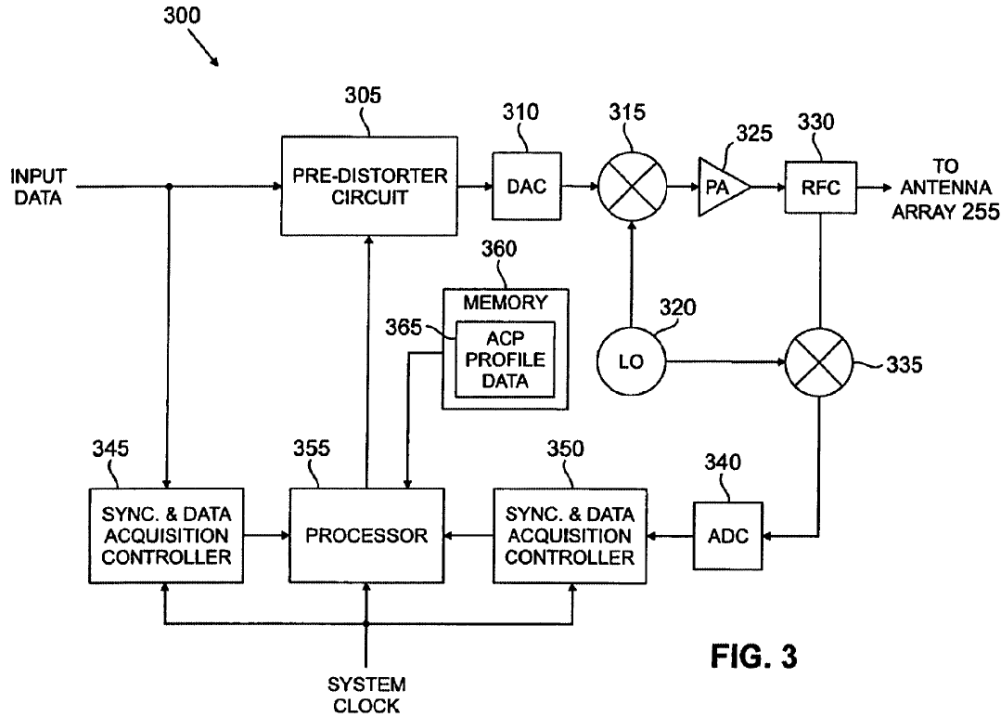


FIG. 3

(*Id.* at Fig. 3.)

76. Jin explains that “[g]enerally speaking, the actual ACP profile of an RF PA is not the same as the ACP profile required by the standard[,]” so “there is a need for RF power controllers that make RF power amplifiers more efficient by utilizing the available ACP noise margins.” (*Id.* at 1:62-64, 2:22-25.) To resolve this problem, Jin discloses an ACP minimization sub-step “that samples the RF transmitter input and output signals, and synchronizes and compares the samples to each other and to the ACP profile of an applicable standard.” (*Id.* at 6:4-9.)

9. Grounds of Unpatentability

77. I am informed by Counsel that Claims 1-11 of the '345 Patent are challenged. As explained below, an element-by-element analysis of the Challenged Claims demonstrates that they are disclosed or taught by the prior art.

9.1 Ground 1: Claims 1, 2, 5-8, and 11 Are Obvious Based on Wright

Claims 1, 2, 5-8, and 11 are directed to the use of two or more digital receivers to perform digital predistortion on an analog, RF input signal. The '345 Patent concedes that both analog predistortion and digital predistortion were well-known in the art. ('345 Patent, 1:51-2:23.) As discussed above and as shown in Wright, the concept of using digital receivers to create a complex representation of an RF signal was also well-known to a POSITA. (*See, e.g.*, Sections 6.2.3 and 8.3.) For the reasons below, Wright discloses and/or renders obvious each and every limitation of Claims 1, 2, 5-8, and 11.

9.1.1 Claim 1

9.1.1.1 1[pre]: An adaptive method for predistorting an RF modulated signal, to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said method comprising the steps of:

78. In my opinion, if the preamble is limiting, then Wright teaches 1[pre]. Wright teaches “a wideband predistortion system and associated methods for compensating for nonlinear characteristics of a power amplifier.” (Wright, 2:23-27.) Wright explains that its predistortion system may process multiple feedback

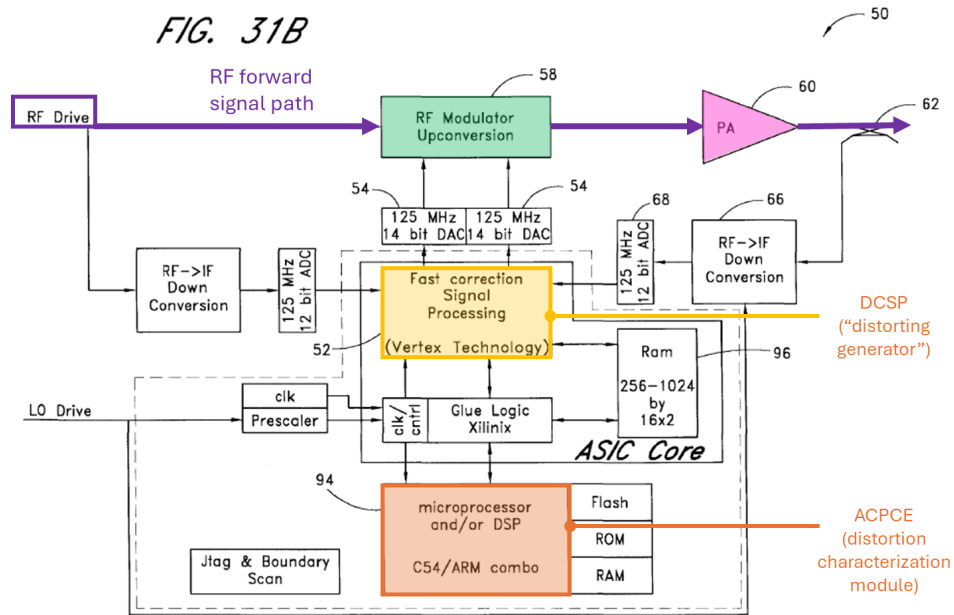
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signals in order to generate correction signals, which are in turn used to predistort the RF input to cancel the PA's distortion. (*Id.* at 8:18-28, 43:34-39, Fig. 31B.)

9.1.1.2 1[a]: predistorting the RF modulated signal to be transmitted using an I/Q modulator interposed between the signal source and the input of the power amplifier, and controlled by means of amplitude and phase look-up tables stored in a distorting generator;

79. In my opinion, Wright discloses generating a predistorted RF signal based on feedback received from an RF input signal as well as feedback from the input and output of the PA. (Wright, 8:18-28.) Wright's "I/Q modulator" is the "RF Modulator Upconversion" block shown below in green. (Wright, 12:21-40, 43:33-39, Fig. 31B.) As Wright explains, in a system having a RF-input signal, the DCSP (yellow) outputs correction coefficients to the I/Q modulator (green), which applies these vectors to the RF signal (purple) in order to generate a RF predistorted signal. (*Id.*) The RF predistorted signal is then supplied to the PA (pink). (*Id.*)

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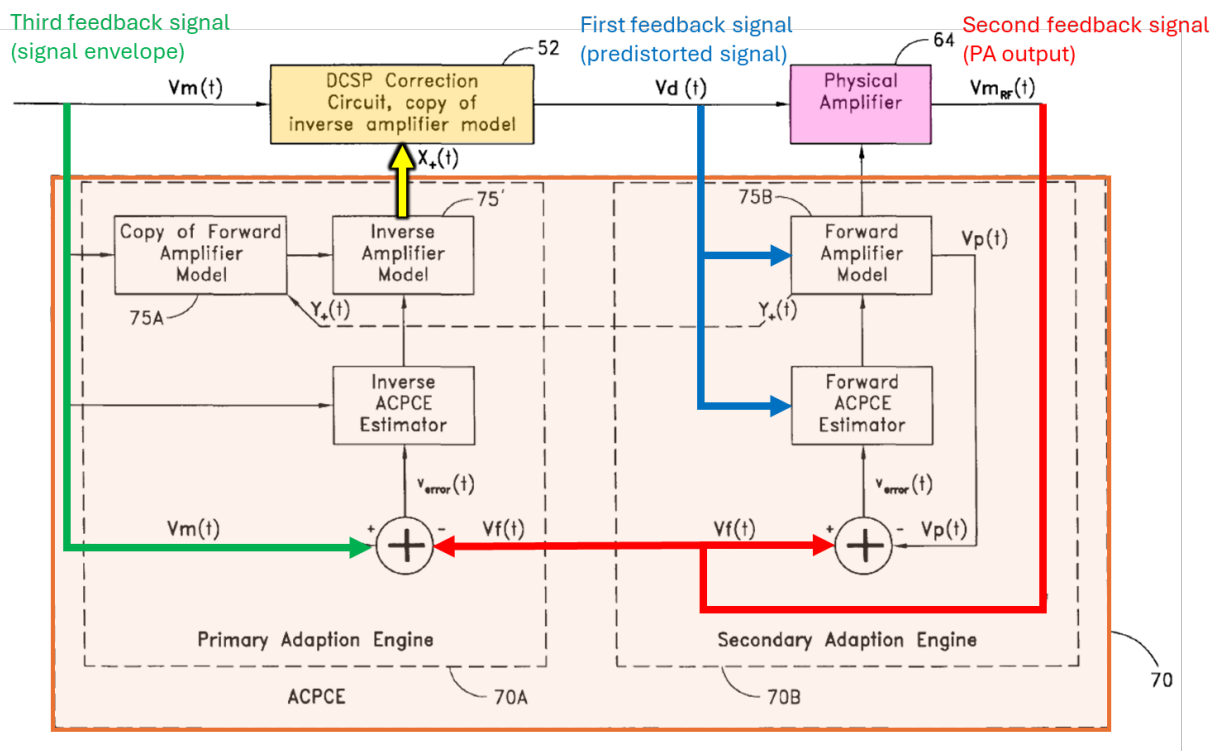
(Wright, 11:41-12:7, 12:28-37, 43:33-39, Fig. 31B (annotated).)

80. In my opinion, the "DCSP" is the Digital Compensation Signal Processor, which uses a LUT indexed by multiple dimensions of an input signal (e.g., instantaneous magnitude (amplitude) and phase characteristics). (Wright, 10:45-49, 11:41-12:7, 12:30-40.) A POSITA would have understood that the multi-dimensional LUT in Wright could easily be implemented as multiple one-dimensional LUTs, as Wright itself confirms that the DCSP table may be implemented using any appropriate type of data structure and may include one or multiple LUTs. (Wright, 2:27-35, 11:53-12:7, 12:8-20.)

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9.1.1.3 1[b]: producing, via a first digital receiver, a first feedback signal in response to the RF predistorted signal;

81. In my opinion, Wright teaches that the digital predistortion system may utilize three feedback signals in order to model the PA nonlinearity. (Wright, 41:44-42:47, Fig. 30.) These signals are translated into a complex baseband signal (i.e., the in-phase (I) and quadrature (Q) signal components representing the signal's real and imaginary values, respectively, for the modeling step. (Wright, 9:38-44, 10:30-44, 41:44-57. *See also*, Sections 6.2.1-6.2.2, *supra*.)



(Wright, 41:44-42:47, Fig. 30 (annotated).) Wright explains that the predistorted signal (“first feedback signal,” blue) is supplied to the Adaptive Control Processing and Compensation Estimator (“ACPCE,” orange), which estimates the distortion

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parameters and updates the DCSP (yellow). (Wright, 17:32-36, 41:44-42:47.) The ACPCE may be implemented in a system having an RF-input. (Wright, 8:39-48, 43:33-39 (explaining that, for an RF embodiment, “the core DCSP and ACPCE processes are identical with a few minor modifications to accommodate the imperfections of the input downconversion process and the digital drive circuitry.”), 60:15-21, Fig. 31B.)

9.1.1.3.1 Wright Renders Obvious a First Digital Receiver

82. In my opinion, although Wright does not expressly disclose that the first feedback signal is supplied to the ACPCE using a digital receiver, this step would have been obvious to a POSITA. In an RF-in/RF-out system (such as in Wright’s Fig. 31B), the RF signal samples (e.g., the RF predistorted signal) must be converted to its complex baseband representation before processing. (Wright, 9:38-44, 43:33-39, Fig. 31B. *See also*, Sections 6.2.1-6.2.2, *supra*.) This is because the ACPCE is implemented digitally and cannot accept an analog input. (Wright, 41:44-57, 43:33-39, Figs. 30, 31B.)

83. A POSITA would have known that this conversion could be achieved in only one of two ways: using an analog I/Q demodulator or using a digital receiver. Further, it was well-known to a POSITA that using an analog I/Q demodulator may introduce additional distortion not attributed to the PA, but digital receivers avoid this problem. (*See, e.g.*, Lohtia, at pp. 65-71 (“Analogue quadrature modulators and

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demodulators have three major impairments; namely, gain imbalance, phase imbalance, and dc offset. These impairments generate spurious signals that will degrade the performance of a baseband feedback linearization method.”); Cavers 1997, at pp. 456-466, Figs. 2-6 (explaining that quadrature modulator (and demodulator) errors will limit the amount of correction a predistorter can provide); Cavers 1990, at pp. 2024-2029 (“This paper has described a digital conversion receiver featuring digitization at a low intermediate frequency, followed by DSP-based extraction of the complex envelope components. It eliminates the problems of DC offset and phase and gain imbalance encountered in analog direct conversion designs. . . . In the future, with the increased speed of DSP chips, we would anticipate that more receiver systems will incorporate DSP-based architectures.”). *See also* Section 9.3.1.2., *infra*.) Thus, in my opinion, it would have been obvious to use digital receiver to convert the RF signal to complex baseband and a POSITA would have been motivated to do so.

84. Wright even supplies the digital receiver, which it uses to translate RF signals to complex baseband elsewhere. (Wright, 10:30-44 (“Thus, the real RF passband signal, $V_{m_{rf}}(t)$, is translated to a complex baseband equivalent signal, $V_f(t)$, which may be used by the ACPCE 70.”), 43:22-33 (“The output of the downconversion block 66 is appropriately sampled by the ADC 68 to capture IF data, and is converted to complex baseband by digital quadrature conversion

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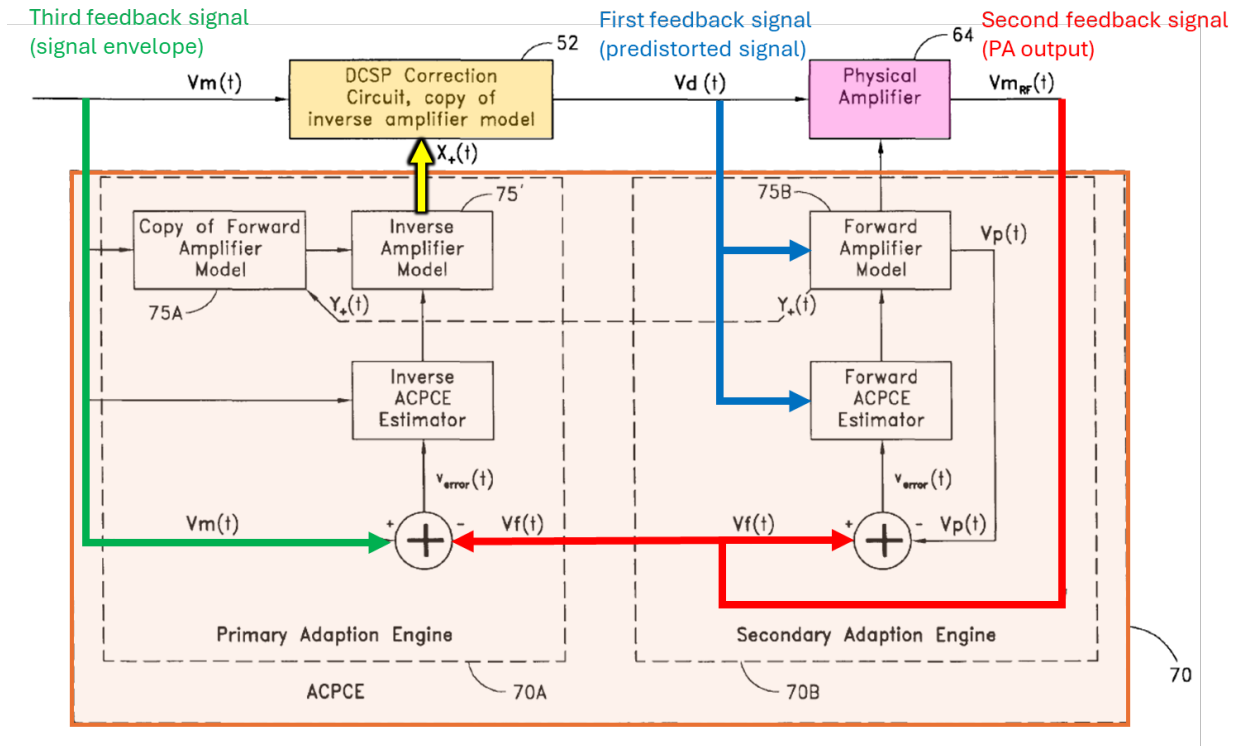
circuitry (not shown)').) More specifically, Wright teaches downconverting the RF signal to IF, performing analog-to-digital conversion, and using digital quadrature conversion circuitry ("digital receiver") to produce a complex baseband signal. (Wright, 43:22-39.) Thus, like the '345 Patent, Wright uses a digital receiver to translate RF signals to complex baseband. ('345 Patent at Fig. 1.)

85. In my opinion, a POSITA would have understood that Wright's digital receiver would be (and indeed needed to be) applied to the ACPCE process shown in Figure 30 to digitally translate the RF predistorted signal in the exemplary hardware of Figure 31B to produce the "first feedback signal." (Wright, 8:39-48 (explaining Fig. 31B depicts a hardware implementation of the DCSP and ACPCE processes), 43:33-39.) Thus, Wright teaches this element in my opinion.

9.1.1.4 1[c]: producing, via a second digital receiver, a second feedback signal in response to the RF amplified output signal from the power amplifier;

86. In my opinion, Wright discloses using a digital receiver to convert the real RF passband signal, $V_{mrf}(t)$ ("second feedback signal," red) to complex baseband. (Wright, 9:38-10:9, 10:30-42; *see* Section 9.1.1.3.)

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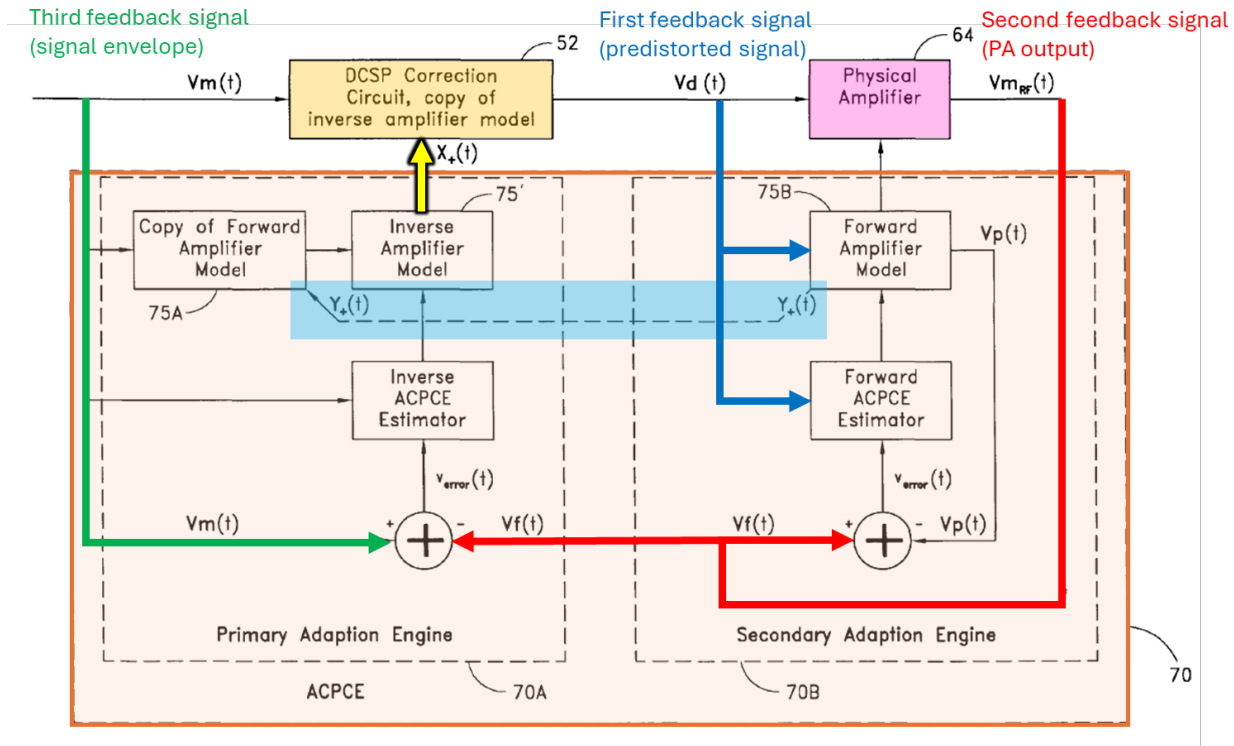


(Wright, 41:44-42:47, Fig. 30 (annotated).)

9.1.1.5 1[d]: modeling the power amplifier in response to the first and second feedback signals; and

87. In my opinion, Wright discloses that the ACPCE models the PA using the feedback signals. (Wright, 9:11-20 (“The ACPCE uses these samples to compute compensation parameters that are provided to the DCSP along an update and control path 86.”), 10:45-49.)

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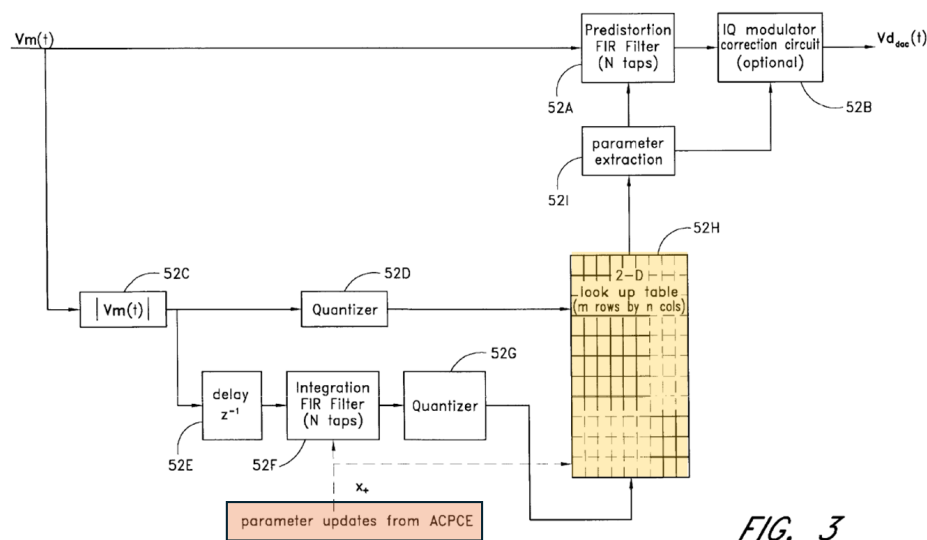


(Wright, 41:44-42:47, Fig. 30 (annotated).) As shown in Figure 30, the ACPCE's secondary adaptation engine 70B compares the amplifier's output signal $V_f(t)$ ("second feedback signal," red) with the predistorted signal $V_d(t)$ ("first feedback signal," blue) via a Forward Amplifier Model 75B, Forward ACPCE Estimator, and subtraction junction (purple). (*Id.* at 41:52-57.) The subtraction junction models the PA by estimating the error signal ($V_{error}(t)$) between the first and second feedback signals that is then used to adapt the "Forward Amplifier Model" 75B. (*Id.*) The secondary adaptation engine 70B then provides information from the Forward Amplifier Model to the primary adaptation engine 70A, which uses this information (signal " $Y_t(t)$ ", light blue) to determine the predistortion coefficients that will compensate for any PA nonlinearity. (Wright, 41:58-63.) The updated predistortion

coefficients are then supplied to the DCSP correction circuit (“distorting generator,” yellow). (*Id.*)

9.1.1.6 1[e]: updating the predistortion amplitude and phase look-up tables in response to said modeling of the power amplifier,

88. In my opinion, Wright discloses that the predistortion coefficients determined by the ACPCE during the modeling stage are provided to the DCSP, and are then used to update the amplitude and phase LUT(s). (Wright, 41:58-63.)



(Wright, 11:41-62 (“FIG. 3 illustrates the various functional units of the DCSP 52. ... An important aspect of the design is the use of **a multi-dimensional look up table 52H to store correction coefficients...**” (emphasis added)), 13:51-54 (“As depicted by the vector X_t in FIG. 3, the ACPCE 70 periodically **updates the correction coefficients stored within the look-up table 52H**” (emphasis added)), Fig. 3 (annotated).) To the extent this claim is understood to require only one LUT, Wright

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discloses this as well. (*Id.* See also, Section 9.1.1.2, *supra.*) Thus, Wright discloses updating the LUT(s) (yellow) of the DCSP in response to the predistortion coefficients calculated by the ACPCE (orange) during the modeling stage. (*Id.*)

9.1.1.7 1[f]: wherein said second feedback signal includes the complex envelope of the RF amplified output signal, and

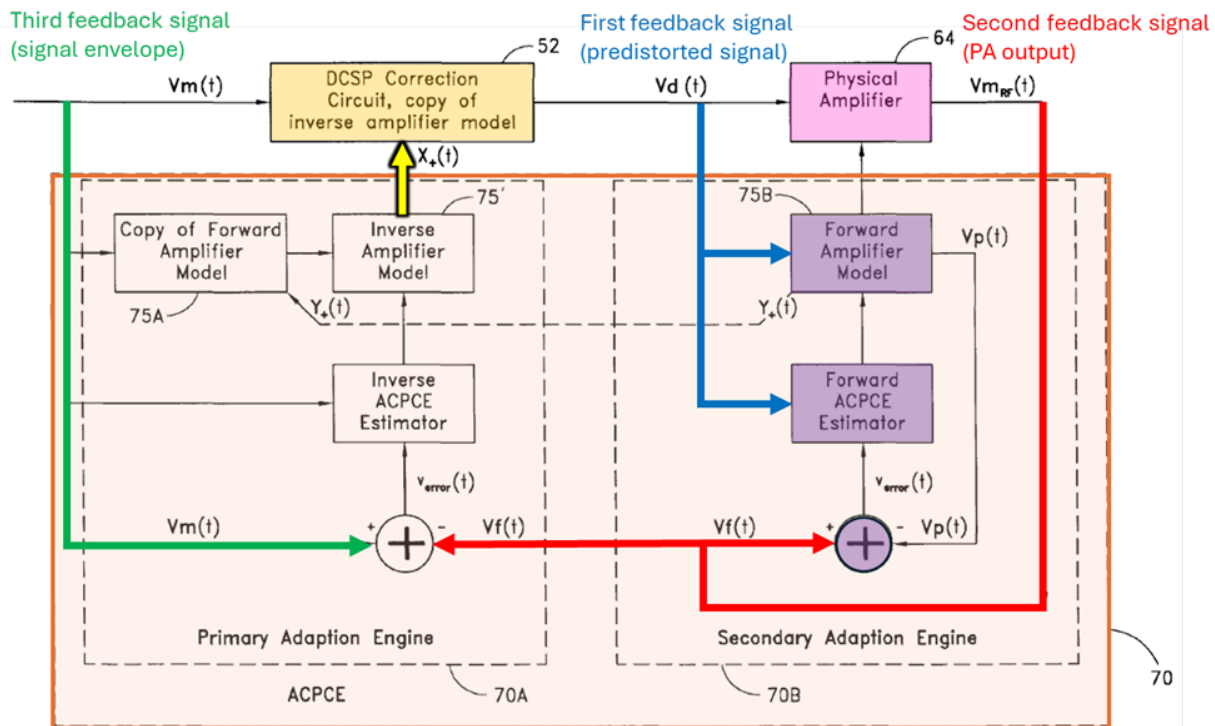
89. In my opinion, Wright discloses producing, via a digital receiver, a second feedback signal $V_f(t)$ (the complex envelope of the RF amplified output signal) in response to the PA output. (Wright, 10:30-49 (“Thus the real RF passband signal, $V_{f_r}(t)$ [“RF amplified output”], is translated to a complex baseband equivalent signal, $V_f(t)$ [“second feedback signal”], which may be used by the ACPCE 70.”). See also Sections 6.1.1-6.1.2, 9.1.1.4.) The “complex baseband equivalent signal” is the RF amplified signal’s complex envelope.

9.1.1.8 1[g]: wherein said modeling step includes the discrimination of the complex envelope of the first feedback signal referenced to the complex envelope of the second feedback signal to yield a predistortion function correlated to a behaviour of the power amplifier including nonlinearities and memory effects.

90. In my opinion, Wright discloses that the system converts the RF feedback signals to complex baseband using digital receivers. (See Sections 6.1.1-6.1.2, 9.1.1.3-9.1.1.4; Wright, 9:38-54, 43:22-33.) Wright further explains that the ACPCE compares the complex envelopes of the first and second feedback signals

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(i.e., the complex baseband equivalent signals) in order to yield a predistortion function of the PA. (See Section 9.1.1.5.) For example, Wright discloses that the secondary adaptation engine of the ACPCE includes “a subtraction junction [purple] that generates an error signal between the physical amplifier’s output signal $V_f(t)$ [“second feedback signal,” red] and the forward amplifier model’s output signal $V_p(t)$ ” based upon the first feedback signal ($V_d(t)$) via Forward Amplifier Model 75B, blue). (Wright, 41:52-57.)



(Wright, 41:44-42:47, Fig. 30 (annotated).) As Wright explains, the error signal is used to adaptively model the PA and update the primary adaptation engine 70A,

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which in turn generates the inverse amplifier model coefficients to send to the DCSP (“distorting generator,” yellow) to account for the PA’s nonlinearities. (*Id.*)

91. Wright further explains that the ACPCE updates the parameters used by the integration filter 52F in order to accurately compensate for “memory effects.” (Wright, 2:9-17, 8:49-54, 13:51-54, 13:17-21, 14:24-42.) A POSITA would have understood that the term “memory effects” as used in the ’345 Patent refers generally to distortion effects produced by past stimulus to the PA. This was a well-understood phenomena in the field of RF transmitters at the time. As Wright explains, “memory effects are often caused by fluctuations in amplifier transistor die temperatures which occur as the result of variations in the amplitude of the signal being amplified.” (Wright, 2:9-17.)

92. Methods for compensating for memory effects were well-known to a POSITA long before the ’345 Patent. Wright, for example, teaches using an Finite Impulse Response (“FIR”) filter based on the past inputs to the PA in order to estimate current transistor die temperatures and compensate for memory effects. (Wright, 14:24-43.) This is but one technique that a POSITA would have used to compensate for memory effects, and Wright discloses other techniques as well. (*Id.* at 14:49-67.)

93. Thus, in my opinion, Wright renders obvious each element of claim 1.

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9.1.2 Claim 2

9.1.2.1 2. An adaptive method as recited in claim 1, wherein said modeling step is done in real time.

94. In my opinion, Wright renders claim 1 obvious. (See Section 9.1.1.) Further, Wright discloses that the modeling step is performed “in real time.” (Wright, 9:11-20 (“[T]he ACPCE 70 receives signal samples along two *real time* data paths . . . The ACPCE uses these samples to compute compensation parameters that are provided to the DCSP.”), 11:41-45, 13:51-61 (“The term ‘correction parameters’ references generally to filter coefficients and any other dynamic values that are used in the *real-time predistortion process*”).)

95. Thus, in my opinion, Wright renders obvious claim 2.

9.1.3 Claim 5

9.1.3.1 5[pre]-5[e]

96. While claim 5 recites a “device” and claim 1 recites a “method,” all of claim elements 5.pre.-5.e. are substantially similar to corresponding limitations for claim 1. Below is a chart disclosing the initial limitations of claim 5 that correspond to those in claim 1.

Claim 1	Corresponding limitations of Claim 5
1.[pre] An adaptive method <u>for predistorting an RF modulated signal, to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output</u>	5[pre] An adaptive device <u>for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an</u>

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<u>signal</u> , said method comprising the steps of:	<u>amplified output signal</u> , said adaptive device comprising:
[1.a] <u>predistorting the RF modulated signal to be transmitted using an I/Q modulator interposed between the signal source and the input of the power amplifier</u> , and <u>controlled by means of amplitude and phase look-up tables stored in a distorting generator</u> ;	[5.a] <u>an I/Q modulator interposed between the signal source and the input of the power amplifier</u> ; [5.b] <u>a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase</u> ;
[1.b] <u>producing, via a first digital receiver, a first feedback signal in response to the RF predistorted signal</u> ;	[5.c] <u>a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator</u> ;
[1.c] <u>producing, via a second digital receiver, a second feedback signal in response to the RF amplified output signal from the power amplifier</u> ;	[5.d] <u>a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier</u> ;
[1.d] <u>modeling the power amplifier in response to the first and second feedback signals</u> ; and	[5.e] <u>a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals</u> and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier[.]
[1.e] <u>updating the predistortion amplitude and phase look-up tables in response to said modeling of the power amplifier</u> ,	[5.e] <u>a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and</u>

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	<u><i>to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier[.]</i></u>
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97. In my opinion, claim elements 5.pre-5.e. are substantively identical to the corresponding (color-coded) limitations of claim 1, with the only distinction being that claim elements 5.pre.-5.e. identify the structural “device” or apparatus components which perform the methods and/or steps recited in the corresponding limitations of claim 1. For example, while claim element 1[b] recites the step of producing, “via a digital receiver,” a first feedback signal in response to an RF predistorted signal, corresponding claim element 5[c] recites a “digital receiver” (i.e., the corresponding structure) that “produc[es] a first feedback signal in response to the RF predistorted signal.” A POSITA would have understood these limitations to be substantively similar. In the same manner, in my opinion, each of claim elements 5.pre-5.e. is substantively similar to the corresponding limitations of claim 1 as identified above.

98. For the reasons discussed above, in my opinion, elements 5.pre.-5.e. are taught by Wright. (See Sections 9.1.1.1-9.1.1.6.)

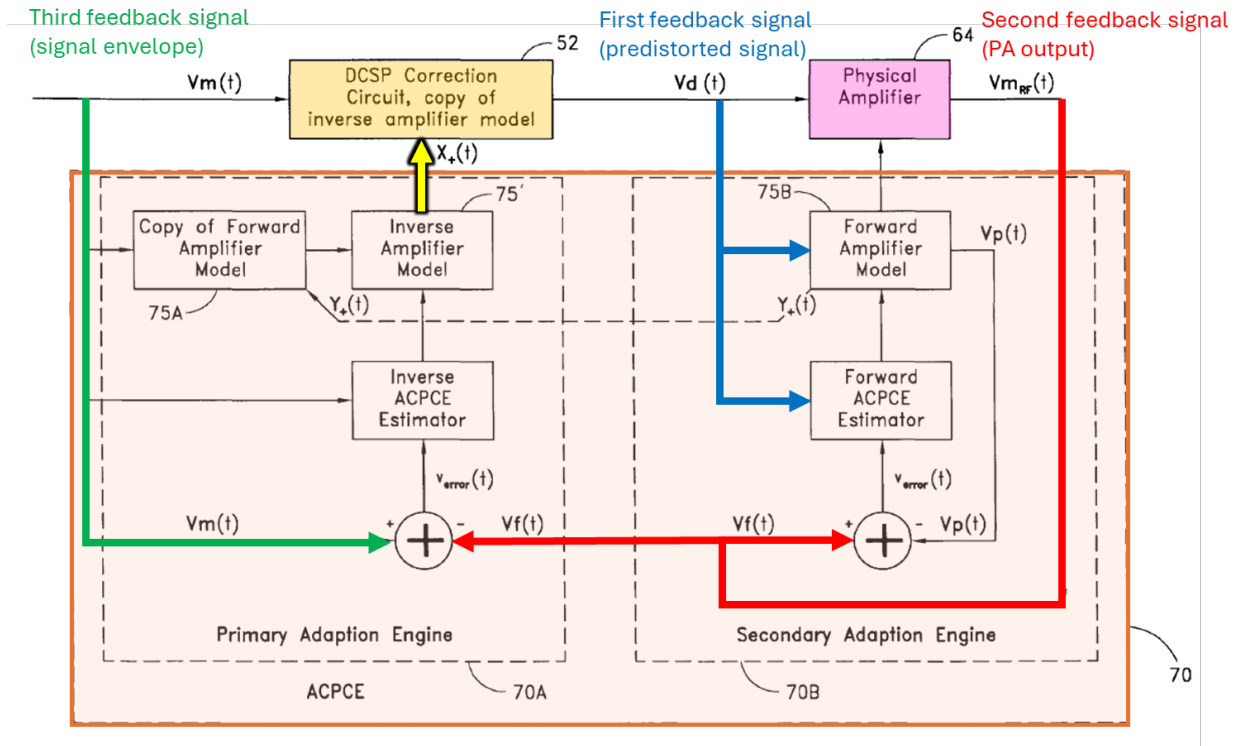
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9.1.3.2 5[f]: wherein said look-up tables of said distorting generator are indexed by an envelope detector that detects the envelope of the signal to be transmitted before predistortion.

99. In my opinion, Wright explains that the DCSP distorting generator's LUT(s) store predistortion coefficients, "with each dimension indexed by a different respective characteristic of the input signal $V_m(t)$ " (e.g., "table 52H is preferably indexed in one dimension (e.g., rows) by the instantaneous magnitude (amplitude) of the input signal $V_m(t)$ "). (Wright, 11:53-62.) A POSITA would have understood that the "instantaneous magnitude" or "amplitude" of a signal is the "envelope of the signal." (*See* Section 6.2.2, *supra*.)

100. Wright discloses generating a third feedback signal (shown below in green) corresponding to the input signal $V_m(t)$. (Wright, 41:44-42:47.)

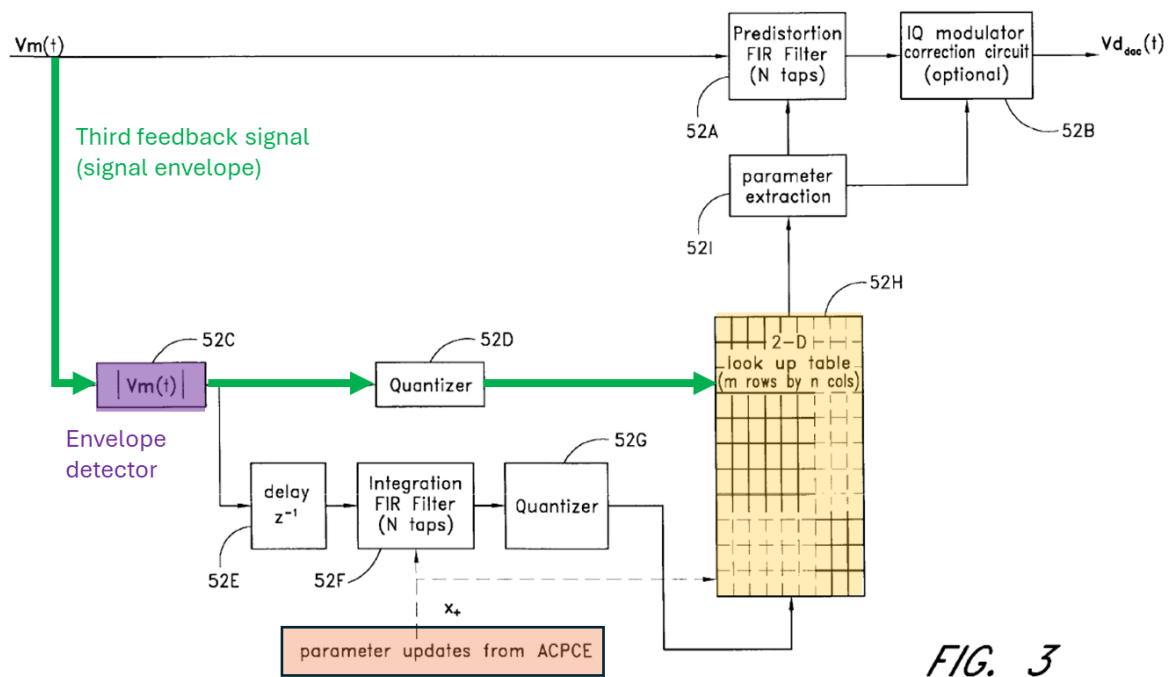
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(Wright, 41:44-42:47, Fig. 30 (annotated).)

101. With reference to Figure 3 (DCSP) below, a rectification block 52C (“envelope detector,” purple) determines the envelope of the input signal $V_m(t)$. (Wright, 11:41-62, 12:54-67 (“To compute the lookup table addressing indices, the magnitude (or power) [“envelope”] of the input signal $V_m(t)$ is initially computed in block 52C.”).)

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(Wright, 11:41-62, Fig. 3 (annotated).) Quantizers 52D and 52G use this information from the envelope detector to index the LUT(s). (Wright, 13:3-16.)

102. Thus, in my opinion, Wright renders obvious claim 5.

9.1.4 Claim 6

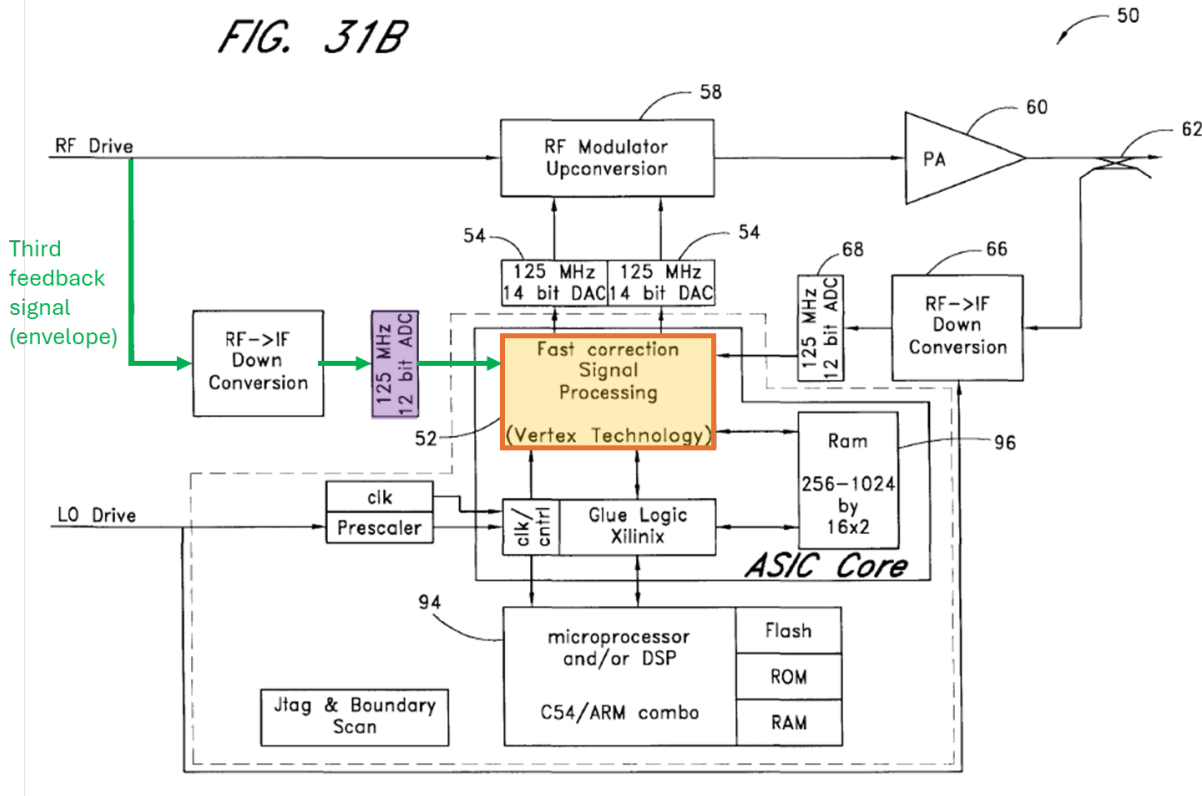
9.1.4.1 6. An adaptive device as recited in claim 5, wherein said envelope detector indexes the distorting generator via an analog to digital converter.

103. In my opinion, Wright renders claim 5 obvious. (See Section 9.1.3.)

Wright further discloses that the envelope detector indexes the predistorter LUT *via an analog to digital converter*. Wright teaches that the third feedback (RF) signal passes through an ADC (purple) before it is used to index the distorting generator. (Wright, Fig. 31B.)

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FIG. 31B



(Wright, 11:53-62, 43:33-39, Fig. 31B.) As discussed above, the envelope detector receives the digitized third feedback signal from the ADC and uses it to index the distorting generator's LUT. (See Section 9.1.3.2.) In my opinion, this limitation is met.

9.1.5 Claim 7

9.1.5.1 7[pre]-7[e]:

104. Claim elements 7.pre.-7.e. are identical to the corresponding limitations for claim 5.³ For the reasons discussed above, in my opinion, elements 7.pre.-7.e. are taught by Wright. (See Sections 9.1.1.1-9.1.1.6, 9.1.3.1.)

³ In my opinion, the initial limitations of claim 7 that correspond to those in claims 1 and 5 are as follows:

9.1.5.2 7[f]: wherein said look-up tables of said distorting generator are indexed by data from a third digital receiver that down-converts the signal to be transmitted to baseband.

105. Wright teaches that the digital predistortion system may utilize three feedback signals to model the PA nonlinearity, and that the third feedback signal (which may be an RF signal, as previously discussed) is used to index the LUT with the input signal's instantaneous magnitude (or envelope). (*See* Sections 9.1.1.3, 9.1.3.2.)

7[pre]An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said adaptive device comprising:

[7.a] an I/Q modulator interposed between the signal source and the input of the power amplifier;

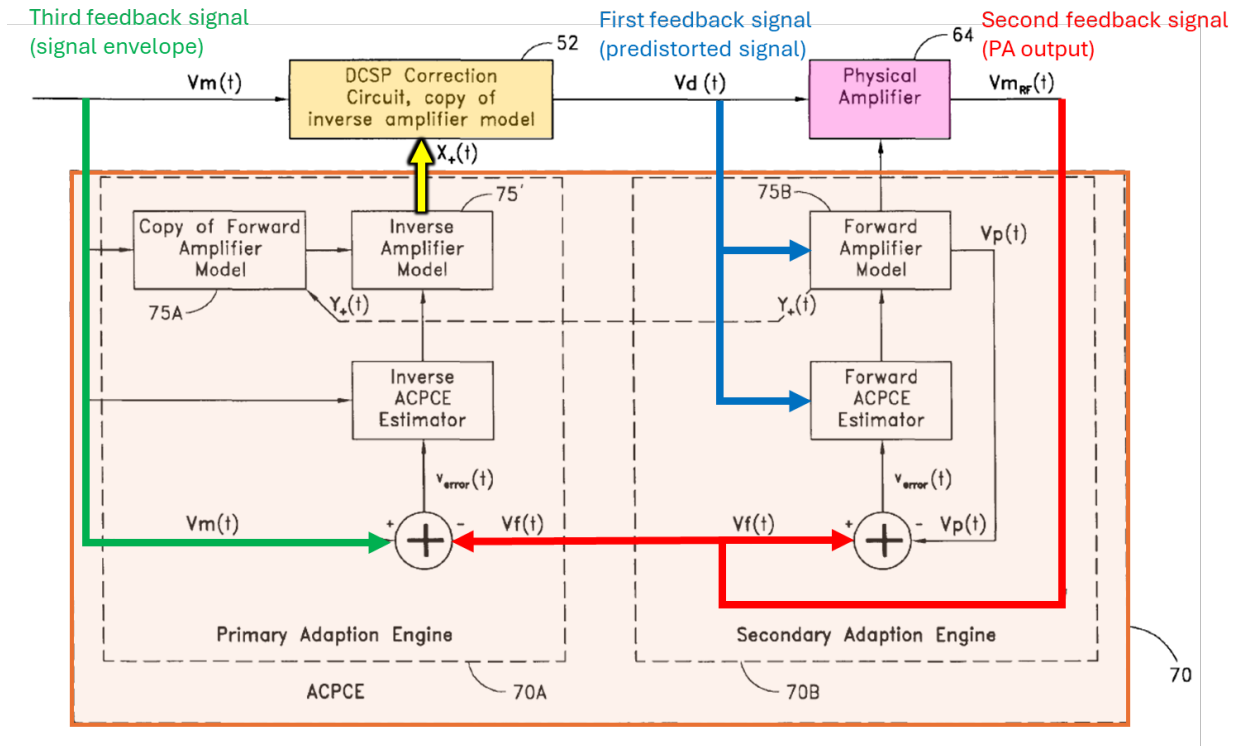
[7.b] a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;

[7.c] a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;

[7.d] a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;

[7.e] a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier[.]

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(Wright, 41:44-42:47, Fig. 30 (annotated).)

**9.1.5.2.1 Wright Renders Obvious the LUT(s)
Being Indexed by Data From a Third Digital
Receiver**

106. In my opinion, although Wright does not expressly disclose that the third feedback (RF) signal is supplied to the ACPCE (“control module”) using a digital receiver, a POSITA would understand this step would be obvious for the reasons previously addressed. (See Section 9.1.1.3.1.) Thus, Wright teaches using a third digital receiver to generate the complex baseband signal and index the LUT(s) and renders claim 7 obvious. (Wright, 11:53-62, 43:33-39.)

9.1.6 Claim 8

9.1.6.1 An adaptive device as recited in claim 7, wherein the data from said third digital receiver is supplied to said control module that indexes said distorting generator accordingly.

107. In my opinion, Wright discloses that the ACPCE (“control module”) indexes the DCSP distorting generator’s LUT(s) using a third feedback signal via a digital receiver. (See Sections 9.1.5, 9.1.3.2.) Wright additionally explains that a rectification block 52C (“envelope detector”) determines the instantaneous magnitude of the input signal $V_m(t)$, which is then passed on to the quantizers 52D and 52G that use this information to index the LUT(s). (Wright, 11:41-62, 12:54-67, 13:3-16. See also, Section 9.1.3.2, *supra*.)

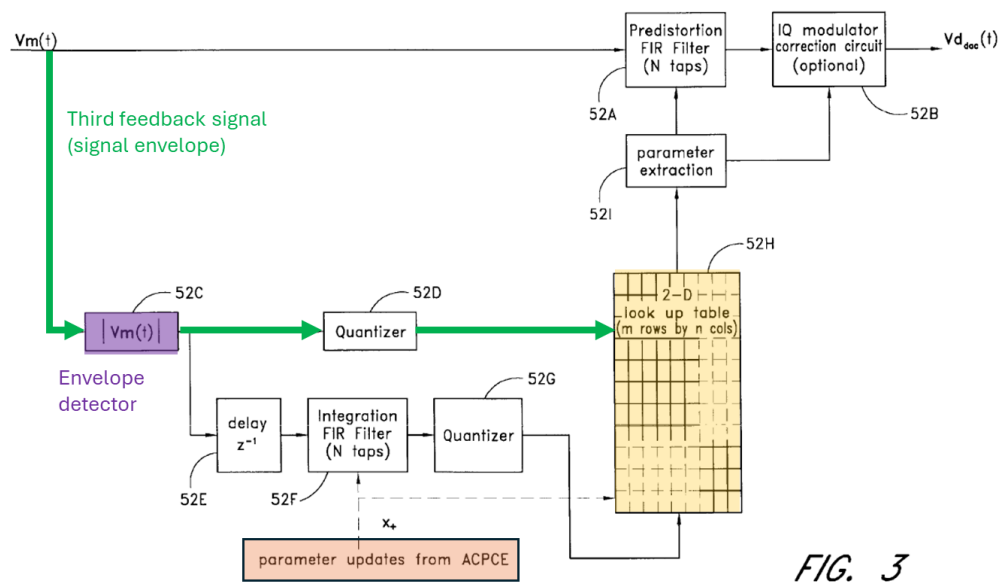


FIG. 3

(Wright, 11:41-62, Fig. 3 (annotated).)

108. Thus, in my opinion, Wright renders claim 8 obvious.

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9.1.7 Claim 11

9.1.7.1 11[pre]-11[e]:

109. Claim elements 11.pre.-11.e. are identical to the corresponding limitations for claim 5.⁴ For the reasons discussed above, in my opinion, elements 11.pre.-11.e. are taught by Wright. (*See* Sections 9.1.1.1-9.1.1.6, 9.1.3.1.)

⁴ In my opinion, the initial limitations of claim 11 that correspond to those in claims 1 and 5 are:

11[pre] An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said adaptive device comprising:

[11.a] an I/Q modulator interposed between the signal source and the input of the power amplifier;

[11.b] a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;

[11.c] a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;

[11.d] a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;

[11.e] a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier[.]

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9.1.7.2 11[f]: wherein said control module is further configured as to insert an adequate delay between the first feedback signal and the second feedback signal.

110. In my opinion, Wright teaches inserting a delay into the first feedback loop to ensure the first feedback signal is synchronized with the second feedback signal. Wright teaches that the ACPCE (“control module”) models the PA by calculating the delay between the reference signal $V_m(t)$ (“third feedback signal”) and the amplified output signal $V_f(t)$ (“second feedback signal”). (Wright, 29:35-39, 11:47-52, Fig. 3 (“delay” block 52E).) The calculated delay is then used to “ensure[] that the predicted amplifier model’s output waveform, $V_p(t)$ [based upon “first feedback signal” $V_d(t)$ via Forward Amplifier Model 75B], is synchronized in time and matched in amplitude and phase with the output of the external amplitude and) phase with the output of the external amplifiers signal $V_f(t)$ [“second feedback signal”].” (Wright, 30:48-61.)

111. Thus, in my opinion, Wright renders claim 11 obvious.

9.2 GROUND 2: Claims 3, 4, 9, and 10 Are Obvious Based on Wright and Jin

112. Claims 3, 4, 9, and 10 (the “ACP Claims”) each pertain to the concept of using Adjacent Channel Power (“ACP”) as a linearity metric to control predistortion. (’345 Patent, 1:17-30, 7:61-63, cls. 3, 4, 9, 10.) The ACP Claims

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perform the predistortion based on an Adjacent Channel Power Ratio (“ACPR”) measurement sub-step. (*Id.*)

113. As discussed above and below, in my opinion, the concept of ACP and ACPR was well-known in the art at the time, and contemporaneous wireless communication protocols (e.g., the IS-95, cdma2000 or WCDMA standards) placed strict limits on the permissible amount of ACP that a transmitter may produce. Moreover, the use of an ACP/ACPR measurement sub-step in a digital predistortion system was well-known to a POSITA at the time.⁵ For example, it was well-known that the use of an ACP “mask” helped ensure that the transmitter’s ACP levels were maintained within the limits established by the standard. (Jin, 1:30-38.)

114. Jin discloses an ACP measurement sub-step designed for use in digital predistortion systems, such as Wright’s digital predistorter. (Jin, 6:5-16.) Jin teaches measuring the ACP present in feedback signals and updating the predistorter to ensure that the signal maximizes the ACP limits available under an applicable wireless standard. (*Id.*) In this way, Jin explains that the power efficiency of the PA can be improved while still conforming to the standard. (*Id.*)

⁵ In my opinion, at the time, the terms ACP and ACPR were used interchangeably, particularly in the context of CDMA systems. (See Section 6.2.4, *supra.*)

9.2.1 Motivation to Combine

115. In my opinion, a POSITA would have been motivated to combine the teachings of Jin with Wright. More specifically, it would have been obvious to incorporate Jin's teachings regarding an adaptive ACPR measurement sub-step into the digital predistortion techniques of Wright.

116. Wright and Jin attempt to solve the same problem: using digital predistortion techniques to compensate for PA distortion, including distortion attributed to past inputs to the PA (i.e., memory effects). (Wright, 2:9-20; Jin, 1:19-21 (describing "an adaptive digital pre-distortion circuit for use in an RF transmitter"); *see* Sections 8.1, 9.1.1.8 (discussing "memory effects").)

117. A POSITA would have looked to Jin to supplement Wright because the requirement that RF transmitters comply with regulatory standards regarding the ACP permissible levels was a well-known problem at the time, which Wright acknowledges. (Wright, 1:35-38 ("[S]uch distortion products typically extend outside the bandwidth originally occupied by the signal, ***potentially causing interference in adjacent channels.***".)) Indeed, even before the introduction of DPD linearization techniques, POSITAs understood that it was critical for RF linearizers to follow regulatory requirements. Jin provides a solution to meet RF regulations. (Jin, Abstract, 2:28-41.)

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118. A POSITA would have also been motivated to combine Jin with Wright because Jin discloses how to optimize the PA's power consumption while staying within defined ACP limits. (Jin, 1:24-38.) A POSITA would have understood that then-existing predistortion techniques that utilize ACP masks, while effective at maintaining power below the ACP limits, resulted in a PA output that is dictated by the most stringent frequency points while other frequencies under the ACP profile remained underutilized. (Jin, 2:9-16.) Jin would have provided a solution to a POSITA by teaching an ACP measurement sub-step that determines the pre-distortion adjustment needed to optimize the PA output while maintaining ACP noise within the ACP limits defined by the standard. (Jin, 6:4-16.)

119. While Wright discloses improved techniques to more precisely model distortion within an RF transmitter, it does not directly provide a solution for optimizing ACP noise margins as described by Jin. (Jin, 2:9-25.) As a result, a POSITA would have recognized that even in the improved predistortion systems of Wright, "there may still be relatively large ACP noise margins at many other frequencies," such that the power amplifier "is not optimized to make full usage of the ACP profile under the applicable standard." (Jin, 2:12-15.) Thus, a POSITA would have been motivated to combine Jin's disclosure with the predistortion teachings of Wright.

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120. A combination of Jin with Wright would have been well within the capability of a POSITA because the combination requires only using prior art elements according to their established functions. As with Wright, Jin's solution is intended for use in digital predistortion systems. (Jin, 6:4-16 (explaining the present invention "may be implemented in any type of digital modulation scheme"), 6:57-59 ("Those skilled in the art will recognize that the above-described modulation and amplification steps are common operations in conventional RF transmitters.").) Further, Jin's ACP measurement technique simply involves evaluating an additional characteristic of a feedback signal—namely, ACP—using a Fast Fourier Transform (FFT), which was a well-known signal processing technique. (Jin, 8:1-5.) A POSITA would have known that the use of FFT-based vector spectrum analyzers to convert a time-domain waveform into its corresponding frequency domain components was well-known and had been widely used in DPD transmitters since at least the early 1990s. (*See e.g.*, Jin, 8:1-6 (Equation 1); Agilent 1311, at 24 ("When making in-channel and adjacent-channel measurements, a vector signal analyzer provides excellent accuracy for power measurements. . . . Vector signal analyzers digitize an IF signal, not its amplitude envelope, and thus can compute phase as well as amplitude with the FFT (Fast Fourier Transform) process."). *See also*, Section 6.2.5, *supra*.) Thus, it would have been simple and well-within the capabilities of a POSITA to configure the DSP to implement any digital signal filters needed for the

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processor to compare the feedback signals with the ACP profile data as described by Jin.

121. Thus, in my opinion, it would have been obvious to a POSITA to combine Jin's teaching with Wright.

9.2.2 Claim 3

9.2.2.1 3[pre]-3[e]:

122. Claim elements 3.pre.-3.e. are identical to the corresponding limitations for claim 1.⁶ For the reasons discussed above, in my opinion, elements 3.pre.-3.e. are taught by Wright. (*See* Sections 9.1.1.1-9.1.1.6.)

⁶ In my opinion, the initial limitations of claim 3 that correspond to those in claim 1 are:

3[pre] An adaptive method for predistorting an RF modulated signal, to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said method comprising the steps of:

[3.a] predistorting the RF modulated signal to be transmitted using an I/Q modulator interposed between the signal source and the input of the power amplifier, and controlled by means of amplitude and phase look-up tables stored in a distorting generator;

[3.b] producing, via a first digital receiver, a first feedback signal in response to the RF predistorted signal;

[3.c] producing, via a second digital receiver, a second feedback signal in response to the RF amplified output signal from the power amplifier;

[3.d] modeling the power amplifier in response to the first and second feedback signals; and

[3.e] updating the predistortion amplitude and phase look-up tables in response to said modeling of the power amplifier[.]

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9.2.2.2 3[f]: wherein said updating step is done when a linearity metric adjacent channel power ratio (ACPR) measurement sub-step indicates that the predistorting step is not adequate to meet predetermined ACPR standards.

123. In my opinion, Jin discloses an ACPR measurement sub-step that updates the predistorter when the predistorting step is insufficient to comply with ACPR requirements. (Jin, 6:26-43.) In my opinion, Jin uses the terms “ACP” (Adjacent Channel Power”) and “ACPR” (Adjacent Channel Power Ratio) interchangeably. (*See also*, Section 6.2.5, *supra*.) For example, Jin explains that the disclosed techniques may be used to ensure compliance with the ACPR limits established by the IS-95 (CDMA) wireless communication protocol. (Jin, 2:3-8, 6:38-43.) As discussed above, the IS-95 ACPR minimum standards (ACP mask) are set forth in the IS-97 standard (also referenced in the ’345 Patent). (IS-97, at 1-1 (“These standards share the purpose of IS-95, “Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System” (and subsequent revisions thereof) by assuring that a mobile station can obtain service in any cellular system that meets the compatibility requirements of IS-95.”); ’345 Patent, 9:47-53.) As shown below, the IS-97 ACP mask is defined in terms of ACPR—i.e., the ratio between the main channel and offset channels—rather than the total power of the channels.

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10.5.1.3 Minimum Standard

10.5.1.3.1 Suppression Inside Cellular Band

For all frequencies within the cellular base station transmit band between 869 and 894 MHz which are also within the specific bands allocated to the operator's system, the total spurious emissions measured in a 30 kHz resolution bandwidth shall be attenuated below the mean output power level in accordance with the following schedule:

- (a) For offset frequencies greater than 750 kHz from the CDMA Channel center frequency, at least 45 dB
- (b) For offset frequencies greater than 1.98 MHz from the CDMA Channel center frequency, at least 60 dB

(IS-97, at 10-7.)

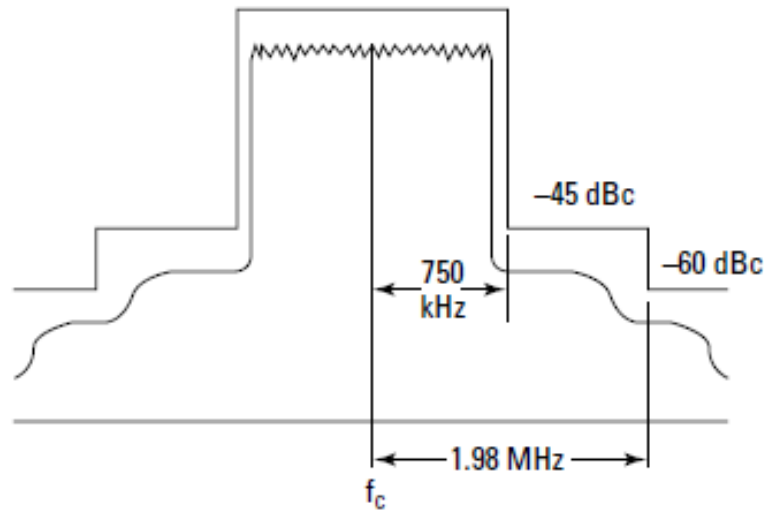
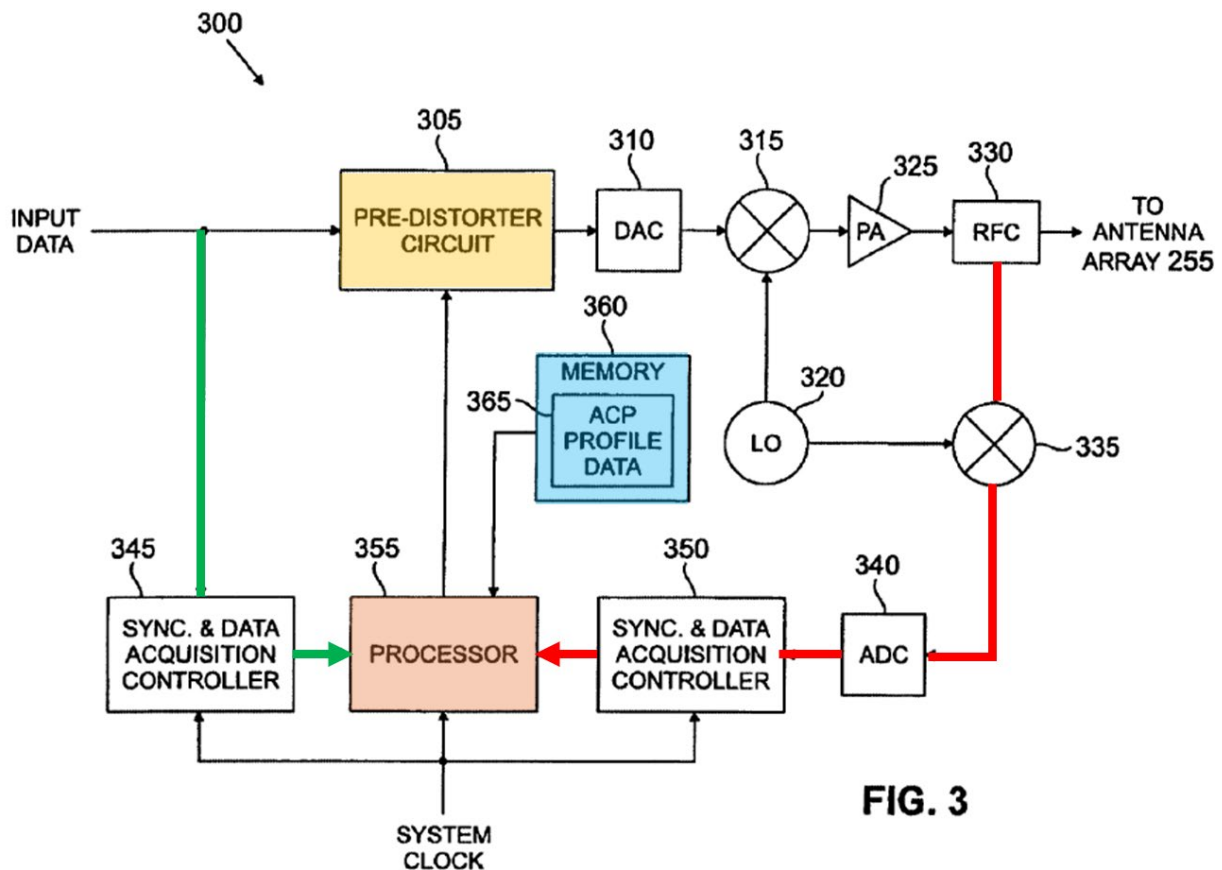


Figure 20. IS-97 spurious emissions test limits

Agilent 1311, p. 24 (explaining that the IS-95 standard specifies relative values (e.g., dBc or dB) that the spurious emissions must stay below).) A POSITA thus would have known that the IS-95 / IS-97 ACP limits are defined in terms of ACPR, and that Jin—by disclosing techniques for determining compliance with the IS-95 ACP profile—teaches measuring the ACPR to determine compliance with the IS-95 / IS-97 standard.

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124. Jin explains that the RF transmitter includes “a pre-distortion adjustment feedback loop that samples the input data signal and a corresponding part of the RF output signal, *compares the samples to each other and to the accepted ACP profile*, and generates a pre-distortion adjustment signal that is added to subsequent samples of the input signal data.” (Jin, 6:26-32.) Jin further teaches that ACP profile data (corresponding to the ACPR standard of the applicable wireless protocol) is stored in memory for use in the measurement sub-step. (Jin, 6:32-43.)



(Jin, 6:17-43, Fig. 3 (depicting “memory 360” (annotated in blue) for storing ACP profile data).)

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125. As Jin explains, ACP measurement feedback signals corresponding to the PA input and output (green and red arrows) are received by an “input synchronization and data acquisition controller 345” and “output synchronization and data acquisition controller 350.” (Jin, 6:32-38.) Processor 355 (orange) first compares the feedback signals to determine the scaling factor of the PA. (Jin, 7:63-67.) Next, the processor compares the feedback signals with the ACP profile data stored in memory 360 (blue). (Jin, 7:63-67.) This may be accomplished using a FFT to determine the ACP values of the feedback signal at a discrete set of frequency points corresponding to the particular standard. (Jin, 8:1-5.) Using this information, the processor calculates a “predistortion adjustment value” that is provided to the predistorter (yellow). (Jin, 7:63-67.) The predistorter then adjusts the original input signal so that the PA “may be saturated to the point with the adjacent channel power noise is driven close to, but not over the limits allowed in the ACP profile.” (Jin, 9:26-30.)

126. Jin also discloses updating the predistorter using the “predistortion adjustment value” when the measured ACP indicates that the predistortion is not adequate to meet predetermined ACP standards. (Jin, 7:63-67, 8:58-9:37.) For example, Jin explains that using the feedback signals, the processor determines whether the out-of-band distortion of the amplified output signal is within the specified ACP profile limits. (Jin, 10:4-30.) The processor then executes a series of

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functions to determine an optimization algorithm and produce a “distortion adjustment parameter” that adjusts the signal to be transmitted so that the PA is driven close to (but not over) the ACP profile limits. (Jin, 8:58-9:37.) As Jin explains, the adjustment parameters are updated in order to adaptively control the predistortion in response to changes in the RF transmitter over time. (Jin, 9:38-64, Fig. 5.) Thus, Jin discloses this element.

127. Thus, in my opinion, Wright in view of Jin renders claim 3 obvious.

9.2.3 Claim 4

9.2.3.1 4. An adaptive method as recited in claim 3, wherein said linearity metric ACPR measurement sub-step is done via a digital receiver that includes a first channel tuned to a mean frequency and a second channel that is tuned to a predetermined offset frequency, said linearity metric ACPR measurement sub-step including comparing an average power at the mean frequency and at the predetermined offset frequency.

128. In my opinion, Jin, either in combination with Wright and/or further in view of the knowledge of a POSITA, renders obvious each and every limitation of claim 3. (*See* Section 9.2.2.) Wright discloses or, at minimum, renders obvious using digital receivers to capture the predistorted input to the PA (first feedback signal) and amplified output of the PA (second feedback signal). (*See* Sections 9.1.1.3-9.1.1.4.) In addition, Jin discloses or renders obvious performing the ACPR

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measurement sub-step by comparing an average power at a mean frequency and at an offset frequency.

9.2.3.1.1 Single Reference Obviousness

129. To determine the ACP “noise margin” and derive an ACP optimization function, Jin performs a FFT on the feedback signals to compare the feedback signals to each other and the ACP profile at a set of frequency points specified by the communication standard. (Jin, 8:1-5; *see* Section 9.2.2.2.) Neither Jin nor Wright expressly discloses that these frequency points include a “mean frequency” and a “predetermined offset frequency;” but a POSITA, in my opinion, would have considered this element to be obvious in view of Jin’s teachings.

130. A POSITA would have understood that the required ACP mask (or ACPR standard) is defined by industry standards and government regulations. For instance, as discussed above, the IS-97 standard defines the required ACP mask for the IS-95 standard (*see* Jin, 6:38-43; ’345 Patent, 9:47-53) and identifies the ACPR limits for the main and offset channels as follows:

10.5.1.3 Minimum Standard

10.5.1.3.1 Suppression Inside Cellular Band

For all frequencies within the cellular base station transmit band between 869 and 894 MHz which are also within the specific bands allocated to the operator’s system, the total spurious emissions measured in a 30 kHz resolution bandwidth shall be attenuated below the mean output power level in accordance with the following schedule:

- (a) For offset frequencies greater than 750 kHz from the CDMA Channel center frequency, at least 45 dB
- (b) For offset frequencies greater than 1.98 MHz from the CDMA Channel center frequency, at least 60 dB

(IS-97, at 10-7.)

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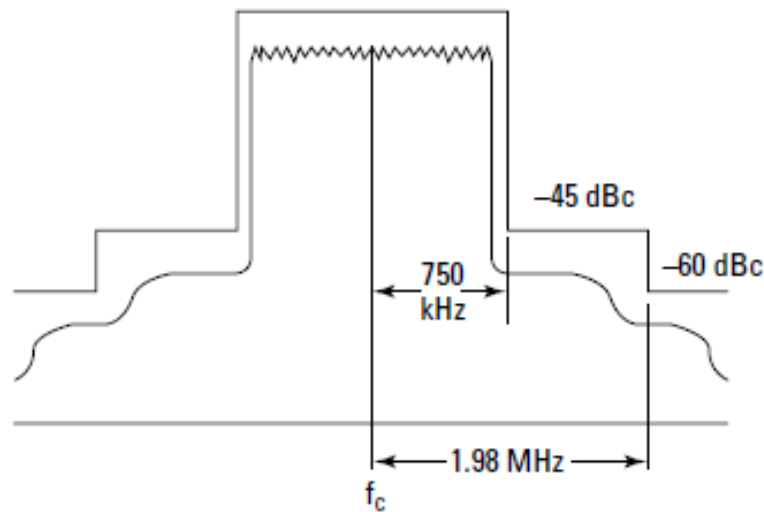


Figure 20. IS-97 spurious emissions test limits

(Agilent 1311, at 24, Fig. 20 (explaining that the IS-95 standard specifies relative values (e.g., dBc or dB) that the spurious emissions must stay below).) As shown above, and explained by Jin, the ACP profile is divided into multiple frequency blocks (starting from the center channel f_c) over which the permissible power density varies. (*Id.*; Jin, 2:3-8.) Using IS-95 as an example, Jin teaches measuring the ACP at each block defined by the standard, including the main transmit channel (“a first channel tuned to a mean frequency”) and the predetermined offset frequencies (“a second channel” tuned to a “predetermined offset”) in order to determine whether the PA is operating within the specified ACPR limits. (Jin, 6:4-9, 6:38-43, 6:66-7:6, 7:63-8:5.)

131. Indeed, this technique for determining ACPR for RF transmitters was well-known in the art. As a result, a POSITA would have known to compare the

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average power of the ACP profile's main transmit channel to the measured value of an adjacent channel in order to evaluate whether the ACPR complies with the applicable wireless standard, as discussed by Jin. (Jin, 8:1-23.) At a minimum, a POSITA would have known that comparing the average power of the main transmit channel to the measured value of an adjacent channel was a standard technique for measuring ACPR, such as for the purpose of determining compliance with the IS-95 standard. (*See also*, Section 6.2.5, *supra*.)

132. Thus, in my opinion, Jin together with Wright discloses and render obvious claim 4.

9.2.4 Claim 9

133. Claim elements 9.pre.-9.e. are identical to the corresponding limitations for claims 1 and 5.⁷ For the reasons discussed above, in my opinion, elements 9.pre.-9.e. are taught by Wright. (*See* Sections 9.1.1.1-9.1.1.6, 9.1.3.1.)

⁷ Claim 9 recites:

9.[pre] An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said adaptive device comprising:

[9.a] an I/Q modulator interposed between the signal source and the input of the power amplifier;

[9.b] a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;

[9.c] a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;

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134. While claim 9 recites a “device” and claim 3 recites a “method,” claim element 9.f. is substantially similar to corresponding limitations for claim element 3.f. Below is a chart disclosing the correspondence between claim element 9.f and claim element 3.f.

Claim Element 3.f	Claim Element 9.f.
3[f] . . . wherein said updating step is done <u>when a linearity metric adjacent channel power ratio (ACPR) measurement sub-step indicates that the predistorting step is not adequate to meet predetermined ACPR standards.</u>	9[f] . . . wherein said control module is so configured as to update said amplitude and phase look-up tables <u>when an adjacent channel power ratio (ACPR) measurement indicates that the predistortion made by said predistorting generator is not adequate to meet predetermined ACPR standards.</u>

135. In my opinion, claim element 9.f is substantively identical to the corresponding (color-coded) limitations of claim element 3.f., with the only distinction being that claim element 9.f. identifies the structural “device” or apparatus components which perform the methods and/or steps recited in the

[9.d] a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;

[9.e] a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier,

[9.f] wherein said control module is so configured as to update said amplitude and phase look-up tables when an adjacent channel power ratio (ACPR) measurement indicates that the predistortion made by said predistorting generator is not adequate to meet predetermined ACPR standards.

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corresponding limitations of claim 3. For example, while claim element 3.f. recites the step of “updating” the LUTs, corresponding claim element 9.f. recites a “control module” that is “configured as to update said amplitude and phase look-up tables” (i.e., the corresponding structure (Wright’s “ACPCE”)) in accordance with the common ACPR measurement step (indicated by red underlining, above) shared by both claim elements. A POSITA would have understood these limitations to be substantively similar.

136. For the reasons discussed above, in my opinion, Jin discloses this element. (See Sections 9.2.2.2 and 9.2.3.)

9.2.5 Claim 10

137. While Claim 10 recites a “device” and claim 4 recites a “method,” claim 10 is substantially similar to corresponding limitations for claim 4. Below is a chart identifying the corresponding limitations between claim 10 and claim 4.

Claim 4	Claim 10
4. <u>An adaptive method as recited in claim 3, wherein said linearity metric ACPR measurement sub-step is done via a digital receiver that includes a first channel tuned to a mean frequency and a second channel that is tuned to a predetermined offset frequency, said linearity metric ACPR measurement sub-step including comparing an average power at the mean frequency and at the predetermined offset frequency.</u>	10. <u>An adaptive device as recited in claim 9, wherein said ACPR measurement is done via said second digital receiver that includes a first channel tuned to a mean frequency and a second channel that is tuned to a predetermined offset frequency, said ACPR measurement including comparing an average power at the means frequency and at the predetermined offset frequency.</u>

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138. In my opinion, claim 10 is substantively identical to the corresponding (color-coded) limitations of claim 4, with the only distinction being that claim 10 identifies the structural “device” or apparatus components which perform the methods and/or steps recited in the corresponding limitations of claim 4. For example, claim 4 recites an adaptive “method,” whereas claim 10 recites an adaptive “device.” A POSITA would have understood any remaining differences between claims 4 and 10 were negligible and would have further understood the corresponding (color-coded) limitations were substantively identical.

139. For the reasons discussed above, in my opinion, Jin discloses this element. (*See* Sections 9.1.3.1 and 9.2.3-9.2.4.)

9.3 GROUND 3: Claims 1, 2, 5, 6, and 11 Are Obvious Based on Booth in Combination with Leyendecker.

140. Claims 1, 2, 5, 6, and 11 are directed to the use of two or more digital receivers to perform digital predistortion on an analog, RF input signal. Booth likewise discloses performing digital predistortion on an analog, RF input signal. (Booth, Abstract.) Booth explains that the performance achievable in conventional predistortion systems “has been limited by the difficulty of matching the complex distortion characteristics of typical power amplifier devices with simple analogue pre-distortion networks.” (Booth, 1:66-2:3.) To solve this problem, Booth provides improved techniques for performing digital predistortion on analog input signals to achieve low system cost and high efficiency. (Booth, 2:31-36.)

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141. Leyendecker describes a “direct inverse” (or indirect modeling architecture) digital predistortion method that compensates for PA distortion and memory effects. (Leyendecker, 2:66-3:21, 9:1-3, 13:45-51, Figs. 12 & 15. *See also*, Section 6.2.4, *supra*.) The indirect modeler digitally translates RF feedback signals into their respective complex (i.e., digital) signal envelopes to increase the accuracy of the predistortion. (*Id.* at 19:56-64, 20:40-64.) Leyendecker explains that indirect modeling avoids the computational complexity of conventional schemes, and “serves to free up resources and reduce processing time and power consumption.” (Leyendecker, 3:8-16.)

142. As explained below, in my opinion, it would have been obvious to a POSITA to try the simple modification of including Leyendecker’s indirect modeler and digital receivers into Booth’s predistortion system. As a result, Booth in view of Leyendecker renders obvious claims 1, 2, 5, 6, and 11.

9.3.1 Motivation to Combine

143. In my opinion, a POSITA would have been motivated to combine the teachings of Leyendecker with Booth.

144. Both references identify the same problem: how to compensate for distortion in RF transmitters, including distortion attributed to past inputs to the PA. Specifically, both references explain that past inputs to the PA negatively affect the accuracy of the predistortion. (Booth, 2:52-55 (“As well as exhibiting instantaneous

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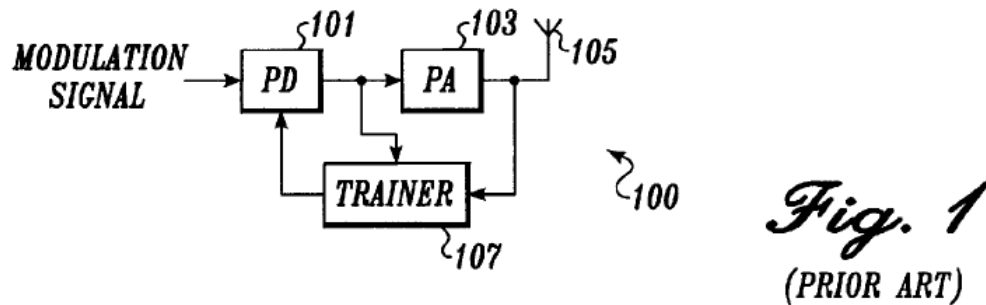
amplitude and/or phase distortion effects a power amplifier will generally exhibit distortion effects based on the past history of the input signal.”); Leyendecker, 2:26-30 (“modeling the power amplifier transfer characteristic using only the instantaneous power or magnitude does not completely accurately predict the distortion caused by the power amplifier”), 9:18-22.) Further, Booth expressly identifies Leyendecker as relevant prior art. (Booth, (56).)

145. Booth and Leyendecker identify the same solution: accounting for the PA’s memory effects, or using information regarding the past signal inputs to the PA in order to improve the predistortion. (Booth, 8:63-9:4 (explaining that samples of the signal envelope are used to address the predistorter LUT to “compensate for memory dependent distortion effects in the amplifier”); Leyendecker, 9:40-46 (disclosing a predistorter that “provides the predistortion functionality as a function of both the instantaneous power or magnitude envelope and the power or magnitude envelopes of previous modulation signal samples.”).)

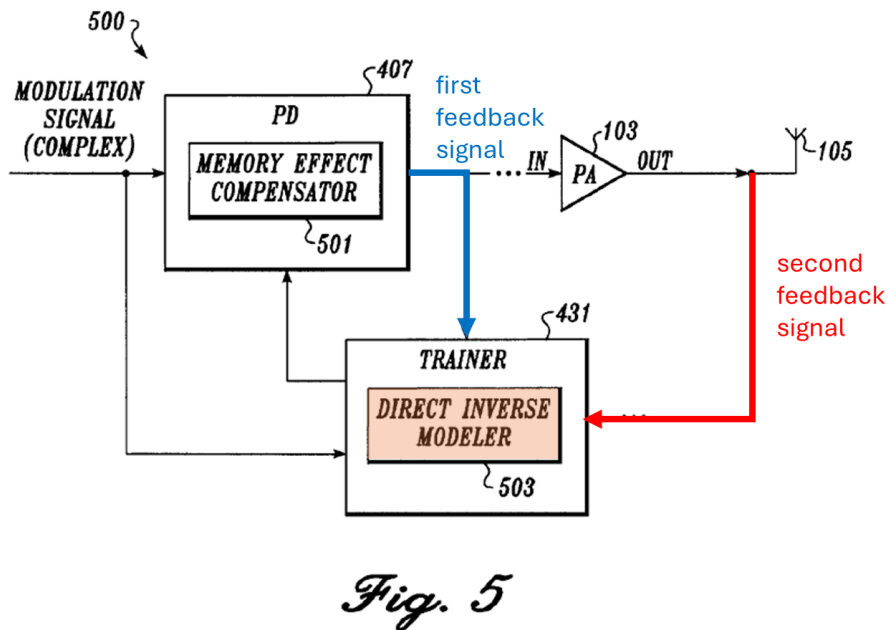
146. Leyendecker adds two elements that Booth does not explicitly disclose: (1) a “direct inverse modeler” (hereafter, “indirect model”) subsystem, and (2) the use of digital receivers for translating RF signals to complex baseband signals. (Leyendecker, 9:55-10:15, 20:19-39.) As explained below, in my opinion, a POSITA would have been motivated to combine each of these features into Booth and could have done so successfully.

9.3.1.1 Combining Booth with Leyendecker's indirect model

147. In my opinion, a POSITA would have been motivated to incorporate Leyendecker's indirect model into Booth's predistortion system given the well-known advantages indirect models provide over direct models. (Leyendecker, 1:38-58 (explaining that indirect models were well-known in the art), Fig. 1.)



(Leyendecker, 1:38-58, Fig. 1 (“Prior art” indirect model). *See also*, Section 6.2.4, *supra*.)

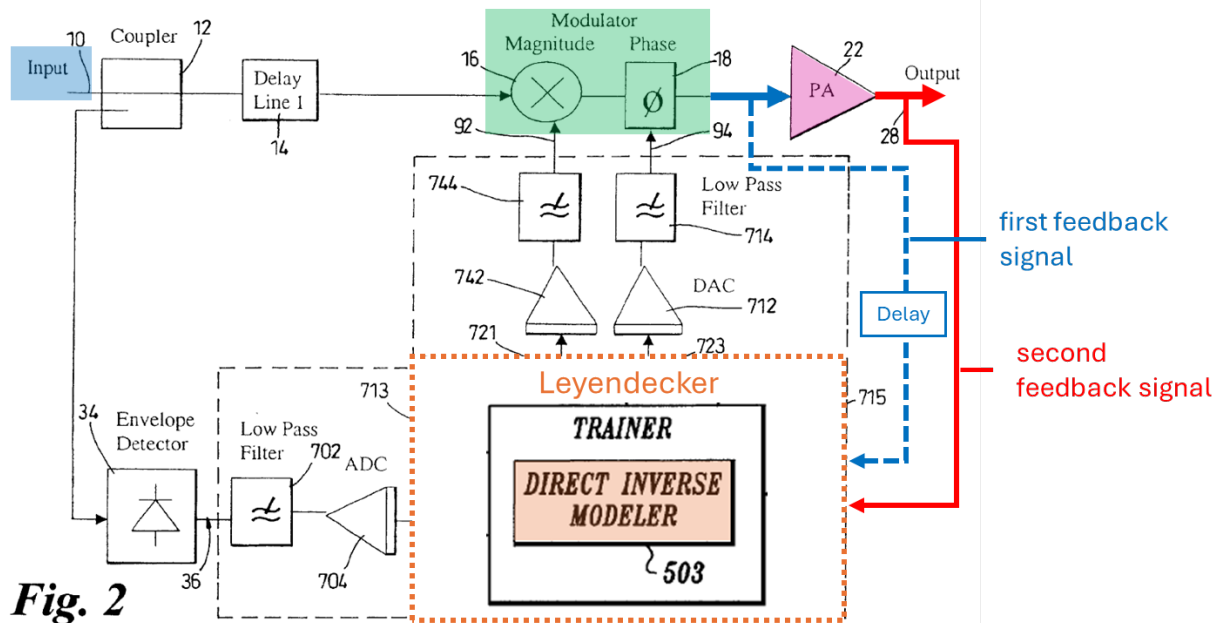


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(Leyendecker, 9:55-10:15, Fig. 5 (annotated).) For example, a POSITA would have known that indirect modeling avoids the “computationally intensive mathematical inversion process,” and “enable[es] the trainer to calculate the inverse characteristic of the power amplifier at a relatively high sample rate in real time.” (See Leyendecker, 10:5-9, 13:56-59.) Leyendecker confirms that indirect modeling was “conventional” in digital predistortion systems (Leyendecker, 1:42-58), and a POSITA would have been motivated to use indirect modeling in Booth’s predistortion system to achieve the advantages described by Leyendecker—e.g., to reduce processing time and enable “real-time” predistortion.

148. This modification would have been simple for a POSITA to implement. As an initial matter, Booth implicitly confirms that its predistorter may be modified to include multiple feedback signals *in addition to* the envelope feedback signal. (Booth, 2:63-65 (“It should be noted that the pre-distortion processor may take into account other inputs than the [envelope feedback] linear function when distorting the input signal.”).) Further, Booth already teaches sampling the RF output of the PA. (Booth, 11:5-15.) Thus, the only modification to Booth’s transmitter needed to implement Leyendecker’s indirect model is a way to sample the RF predistorted signal (“first feedback signal,” blue), as shown below:

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(Booth, 7:5-22, Fig. 2 (as modified by Leyendecker).) It would have been well-
within the abilities of a POSITA to make the necessary changes to implement
Leyendecker’s indirect model in Booth’s transmitter.

149. For example, a POSITA would have known how to implement a
directional coupler to sample Booth’s predistorted RF signal. (Booth, 7:5-9.) A
POSITA also would have known how to implement a “delay” in the predistorted RF
feedback signal to ensure that the first and second feedback signals are synchronized.
(Booth, 7:18-22; Leyendecker, 9:40-46.) And, as discussed below, a POSITA would
have known how to use a digital receiver to convert the RF predistorted signal (first
feedback signal) and RF output of the PA (second feedback signal) to complex

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baseband in order to implement Leyendecker's indirect modeler. (Leyendecker, 20:19-39.)

150. Thus, in my opinion, the disclosures of Booth, Leyendecker, and the knowledge of a POSITA provide all the information necessary to implement Leyendecker's indirect trainer model in Booth's predistorter, such that a POSITA would have been able to successfully implement this modification.

9.3.1.2 Combining Booth with Leyendecker's Digital Receiver

151. In my opinion, it also would have been obvious to a POSITA to use Leyendecker's digital receiver to translate feedback signals from RF to complex baseband signals. It was well-known to a POSITA that analog components in an RF feedback signal path (e.g., I/Q demodulators, down-converters, and filter components) may introduce distortion not attributed to the PA. (*See e.g.*, Section 9.1.1.3.1, *supra*.) Leyendecker explains, for example, that "intermodulation products and other distortion . . . located in the desired broadcast RF channel . . . adversely affects the training of the predistorter," and that this distortion "is not only generated by the nonlinearity of the power amplifier, but also from other low frequency sources." (Leyendecker, 19:31-38.) Leyendecker solves this issue using a digital receiver that removes the in-band distortion from an RF feedback signal using a combination of digital demodulation, filtering, and other digital signal processing steps. (Leyendecker, 19:56-64, 20:40-64.)

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152. Booth's predistorter design, as modified by Leyendecker's indirect modeler (described above), would require sampling and converting multiple RF signals (namely, the input and output of the PA) to complex baseband in order to characterize the PA nonlinearity. (*See also* Section 9.3.1.1.) A POSITA would have been motivated to implement Leyendecker's digital receiver in Booth's system to avoid the well-known distorting effects associated with analog demodulation and filtering techniques, thereby further improving the accuracy of the predistortion. A POSITA would have understood that this modification was particularly suitable where Booth has been modified to include the indirect trainer of Leyendecker. Under such circumstances, a POSITA would have considered it obvious to include Leyendecker's digital receivers to simplify the integration of Leyendecker's trainer into Booth's predistortion system.

153. Modifying Booth to incorporate Leyendecker's digital receiver would have been simple and achieved with a reasonable expectation of success. As Leyendecker explains, the digital receiver merely adds routine processing steps on a received RF signal in order to minimize intermodulation products and other sources of in-band distortion. (Leyendecker, 19:31-64.) Leyendecker explains that a POSITA would have known how to implement these processing steps using conventional DSP circuitry. (Leyendecker, 18:58-19:11.) In my opinion, a POSITA

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would thus be reasonably likely to succeed in incorporating Leyendecker's digital receiver into Booth's transmitter.

9.3.2 Claim 1

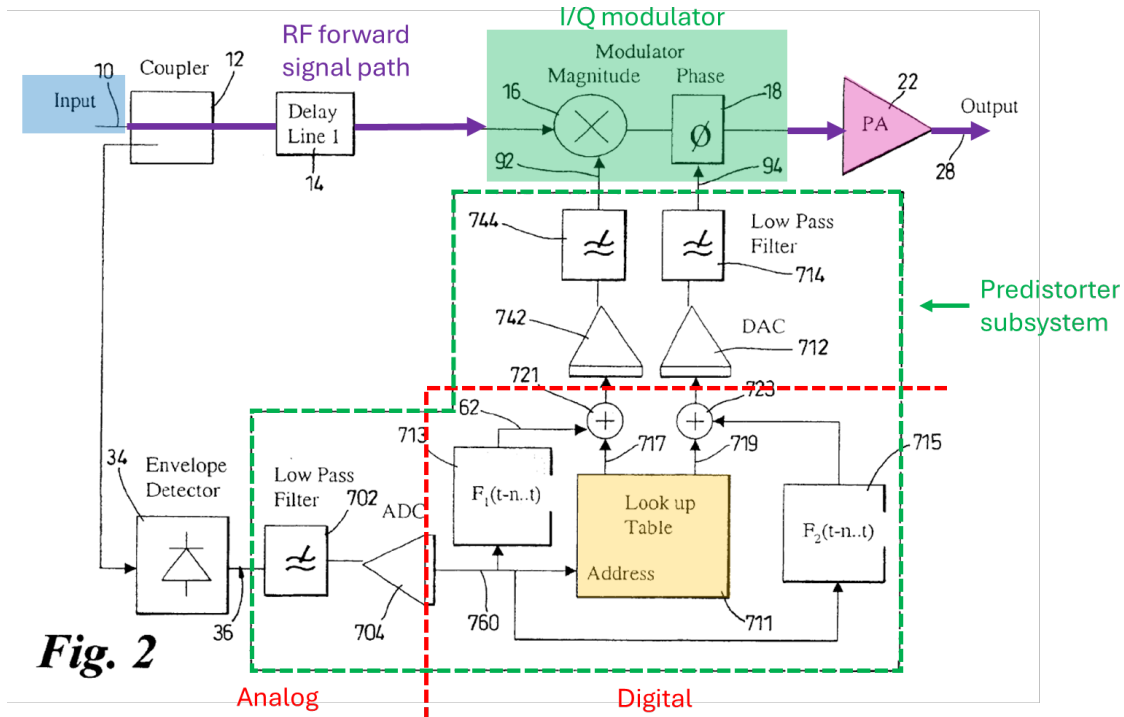
9.3.2.1 1[pre]: An adaptive method for predistorting an RF modulated signal, to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said method comprising the steps of:

154. If the preamble is limiting, then Booth discloses 1[pre] in my opinion. Booth teaches "an amplifier arrangement for amplifying an input radio frequency (RF) signal to generate an output RF signal" that utilizes an adaptive digital pre-distorter to compensate for distortion. (Booth, 1:5-6, 2:40-51, 5:6-48, Fig 2.) Booth explains that the predistortion system processes multiple feedback signals to generate "correction signals," that in turn are used to predistort the RF input to compensate for PA distortion. (*Id.* at 7:5-32.)

9.3.2.2 1[a]: predistorting the RF modulated signal to be transmitted using an I/Q modulator interposed between the signal source and the input of the power amplifier, and controlled by means of amplitude and phase look-up tables stored in a distorting generator;

155. Booth discloses a digital predistortion system that generates amplitude and phase correction signals based on feedback received from the RF input and output signals of the PA for predistorting the input signal. (Booth, 7:13-22.) Figure 2, below, generally depicts the input signal's path:

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(Booth, 7:5-32, Fig. 2 (annotated).) The RF input signal (blue) is initially split via a directional coupler into a delay line and a feedback signal. (*Id.*) The feedback signal passes through an envelope detector 34 and then to the predistorter sub-system (green dashes). (Booth, 7:33-36.) The predistorter compares the signal envelope to a second feedback signal corresponding to the PA output (not shown) and generates error correction signals 92 and 94 using an amplitude and phase lookup table (yellow). (Booth, 8:47-59, 11:5-19.) An I/Q modulator (green) uses the error correction signals to predistort the RF input signal. (Booth, 7:23-32.) The predistorted RF signal is then supplied to the PA (pink). (Booth, 7:5-9, Fig. 1.)

156. Thus, in my opinion, Booth discloses this element.

9.3.2.3 1[b]: producing, via a first digital receiver, a first feedback signal in response to the RF predistorted signal;

157. Booth discloses using an I/Q modulator to generate a predistorted RF modulated signal. (See Section 9.3.2.2.) Leyendecker discloses sampling the output of the predistorter (input to the PA) and providing that predistorted signal (first feedback signal) to the trainer in order to calculate the inverse transfer characteristics of the PA. (Leyendecker, 9:52-10:5, Fig. 5.)

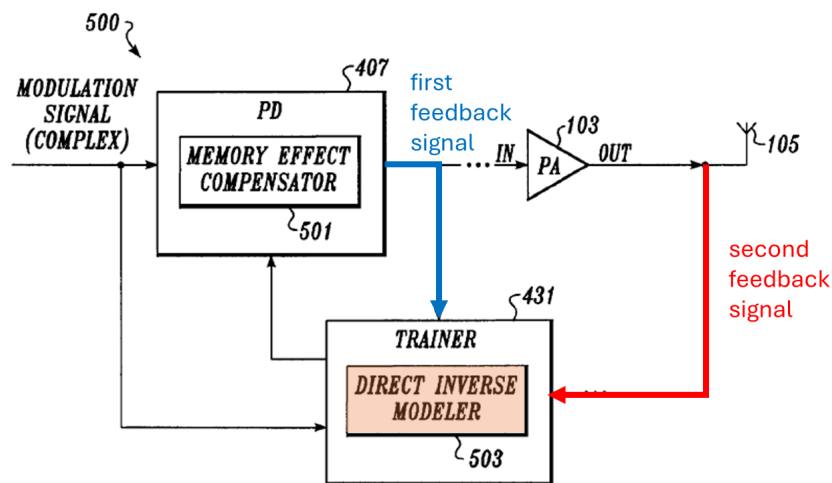
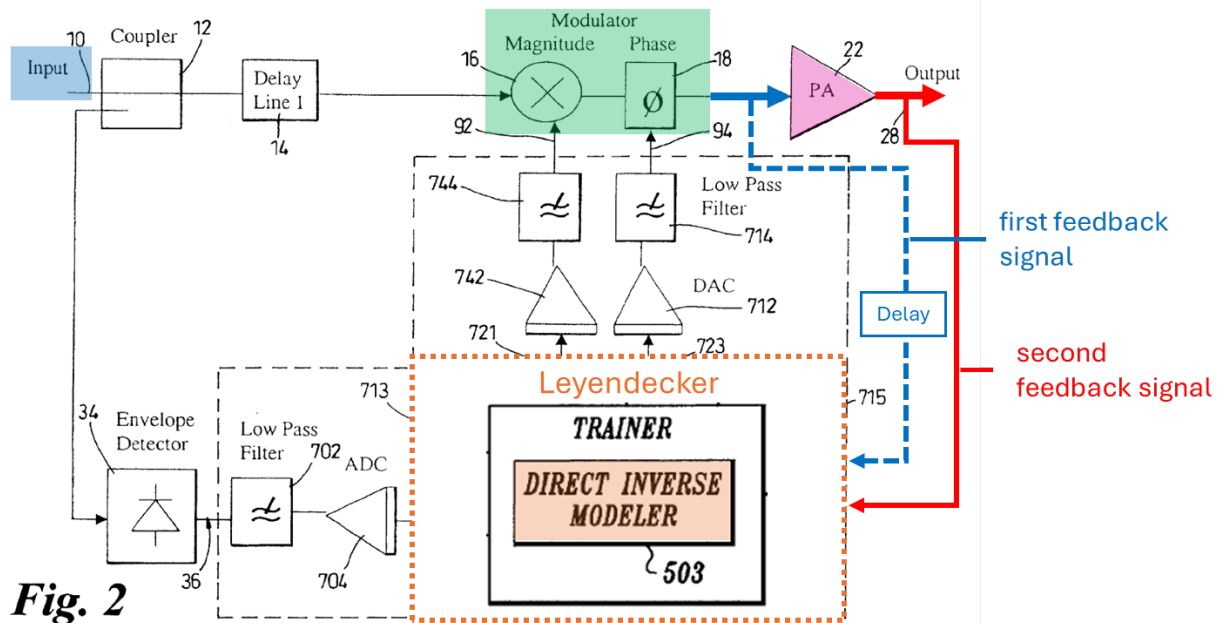


Fig. 5

(Leyendecker, 9:55-10:15, Fig. 5 (annotated).) Thus, in my opinion, Leyendecker discloses producing a first feedback signal in response to the RF predistorted signal.

158. In my opinion, a POSITA would have understood that implementing Leyendecker's indirect modeler in Booth's predistortion system would require sampling the RF predistorted signal ("first feedback signal," blue) as shown below:

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(Booth, 7:5-22, Fig. 2 (annotated and modified by Leyendecker). See Section 9.3.1.1.) Leyendecker discloses using a digital receiver to produce an RF feedback signal. (Leyendecker, 8:28-45.) The RF feedback loop utilizes a coupler to redirect a portion of the RF signal to an analog downconverter, which translates the RF feedback signal to IF. (Leyendecker, 6:12-30.) The IF signal is then converted to digital “using a conventional A-D converter 424.” (Leyendecker, 6:32-38.) Next, digital demodulation and decimation is performed on the digital feedback signal using conventional, commercially-available circuitry. (Leyendecker, 6:38-41, 8:33-38 (“In a preferred embodiment, the digital quadrature demodulator is implemented using a Xilinx 4003 field programmable gate array (FPGA) that has been configured to perform the digital quadrature demodulation.”), 8:39-45.)

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159. Figure 4 depicts using Leyendecker's digital receiver to produce a feedback signal with respect to the amplified output of the PA. (Leyendecker, 6:12-41, 6:66-7:8, Fig. 4.)

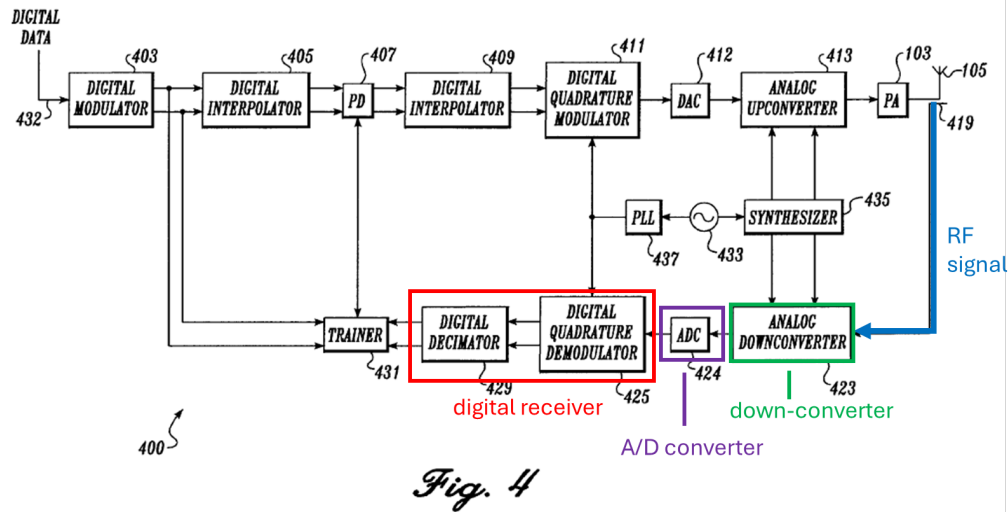
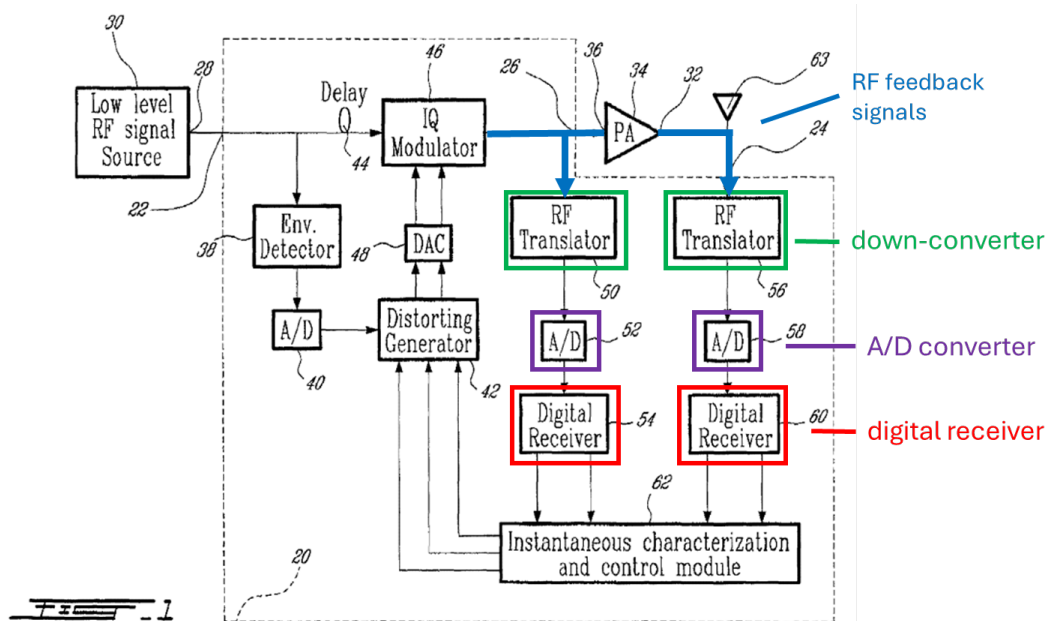


Fig. 4

(Leyendecker, Fig. 4 (annotated.)) This is the same RF signal sampling process described by the '345 Patent. (345 Patent, 5:59-62, 6:29-31, 14:16-22.)



('345 Patent, Fig. 1 (annotated.))

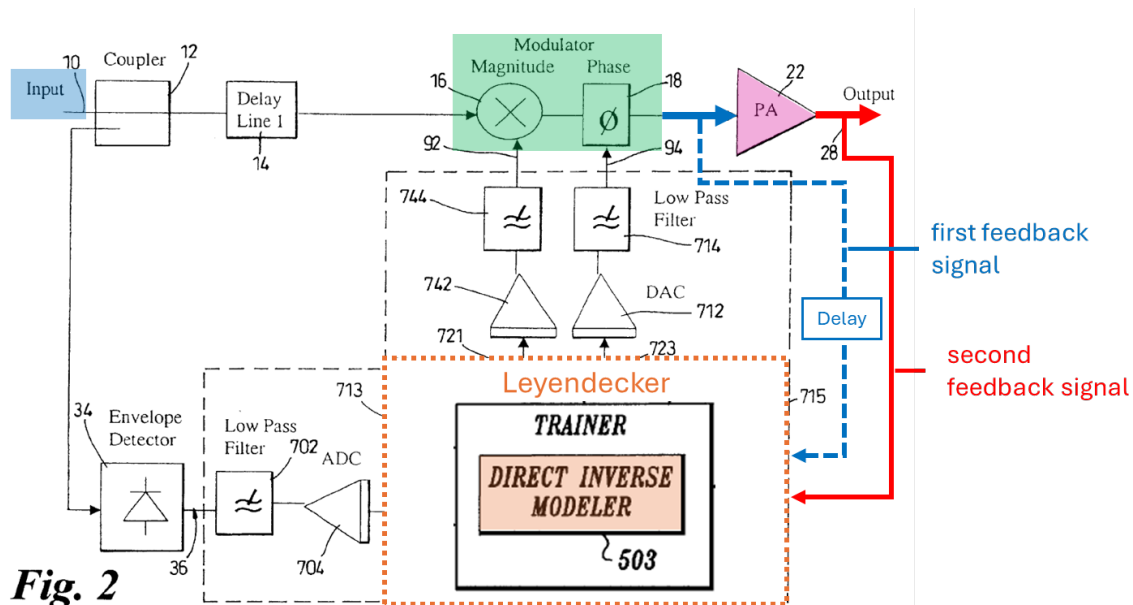
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160. As explained above, in my opinion, a POSITA would have known that Leyendecker's digital receiver would be obvious to include to generate the complex baseband signal for the RF predistorted signal (first feedback signal) required by Leyendecker's indirect predistortion model. (See Sections 6.2.4 and 9.3.1.2.)

161. Thus, the combination of Booth and Leyendecker discloses this element in my opinion.

9.3.2.4 1[c]: producing, via a second digital receiver, a second feedback signal in response to the RF amplified output signal from the power amplifier;

162. As discussed above, Booth discloses sampling the RF amplified output of the PA using a directional coupler and providing corresponding feedback (“second feedback signal”) to the predistortion system. (See Section 9.3.2.1; Booth, 11:5-15, Fig. 7.)



(Booth, 7:5-22, Fig. 2 (as modified by Leyendecker).)

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163. Leyendecker also teaches that the trainer “receives and stores from the digital decimator . . . *complex digital signals that are scaled down, downconverted, and digitized samples of the power amplifier output signals.*” (Leyendecker, 13:45-49 (emphasis added).) As discussed above, Leyendecker teaches using a digital receiver to translate the RF amplified output of the PA into the complex baseband signal to be used by the trainer. (Leyendecker, 8:28-50; *see* Section 9.3.2.3.)

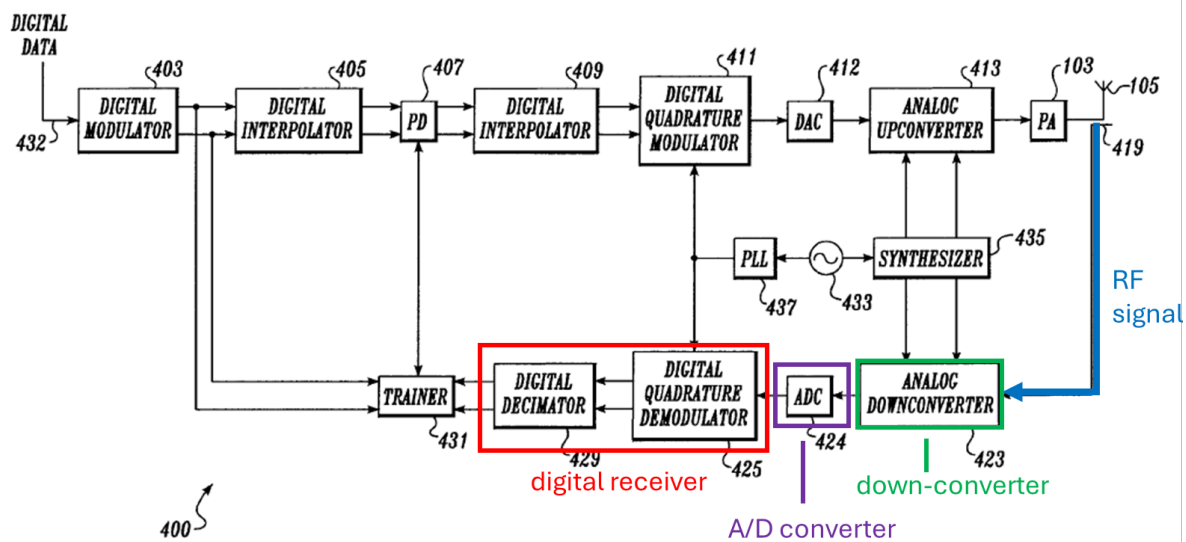


Fig. 4

(Leyendecker, 8:28-50, Fig. 4.) Thus, in my opinion, Leyendecker discloses this element.

9.3.2.5 1[d]: modeling the power amplifier in response to the first and second feedback signals; and

164. Leyendecker explains that its trainer subsystem 605 “periodically receives ‘batches’ of data containing the modulation signal samples, power amplifier input signal samples [first feedback signal] and power amplifier output signal

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samples [second feedback signal]” that it uses to model the PA and generate an inverse signal. (Leyendecker, 10:26-39.) The trainer comprises a “solver” that processes this feedback signal data “to generate the complex parameters used to update the LUT of the predistorter.” (Leyendecker, 13:66-14:1, 13:40-42, 14:55-59.)

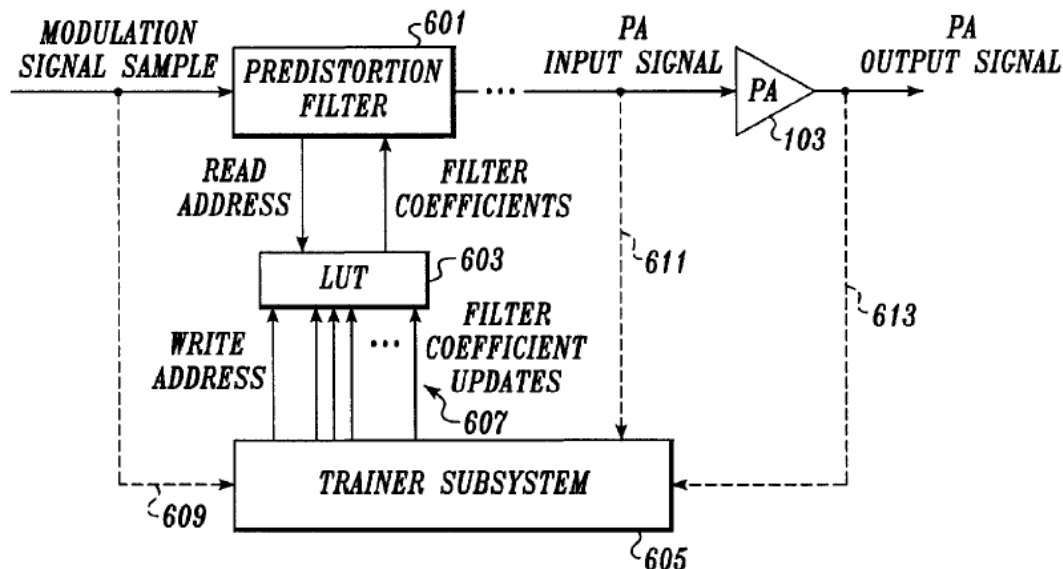


Fig. 6

(Leyendecker, 10:16-39, Fig. 6.)

165. Thus, in my opinion, Leyendecker discloses this element.

9.3.2.6 1[e]: updating the predistortion amplitude and phase look-up tables in response to said modeling of the power amplifier,

166. In my opinion, Leyendecker discloses that “the trainer subsystem 605 . . . periodically updates the inverse characteristics of the power amplifier 103 by

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providing a write address and updated filter coefficients to the LUT 603,” as shown below:

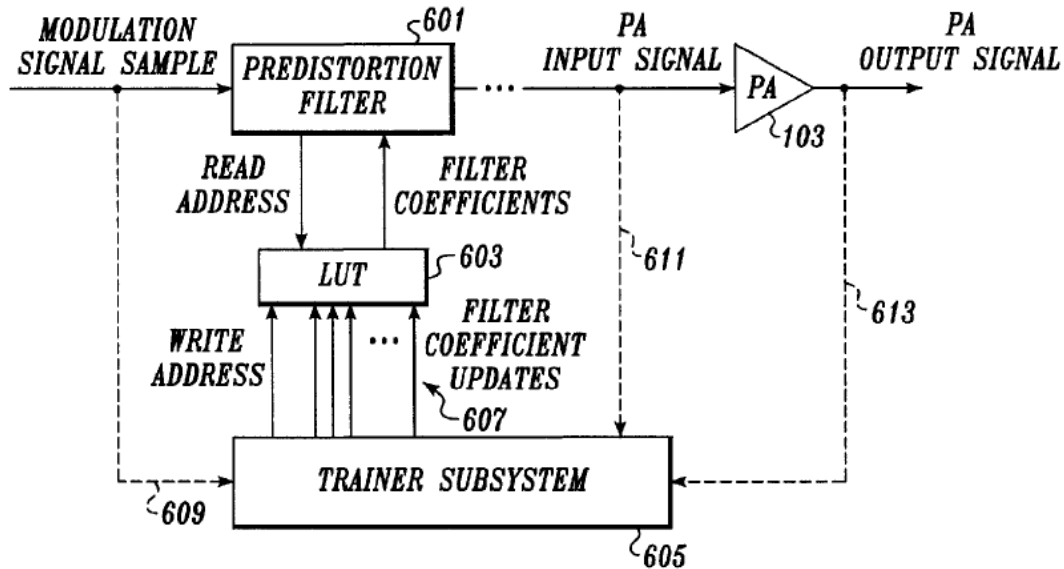


Fig. 6

(Leyendecker, 10:16-39, Fig. 6.) Leyendecker further explains that the LUT(s) may be indexed by amplitude and phase. (Leyendecker, 2:33-55, 11:10-28 (“the LUT 603 is indexed by the instantaneous power or magnitude [amplitude] of the modulation samples . . . [T]he LUT 603 may include additional dimensions or tables [and] . . . different tables may be used for different modulation schemes.”).)

9.3.2.7 1[f]: wherein said second feedback signal includes the complex envelope of the RF amplified output signal, and

167. In my opinion, Leyendecker discloses that that the trainer’s indirect modeler utilizes the complex envelopes (i.e., the *I* and *Q* signal components) of the first and second feedback signals in order to model the PA nonlinearity.

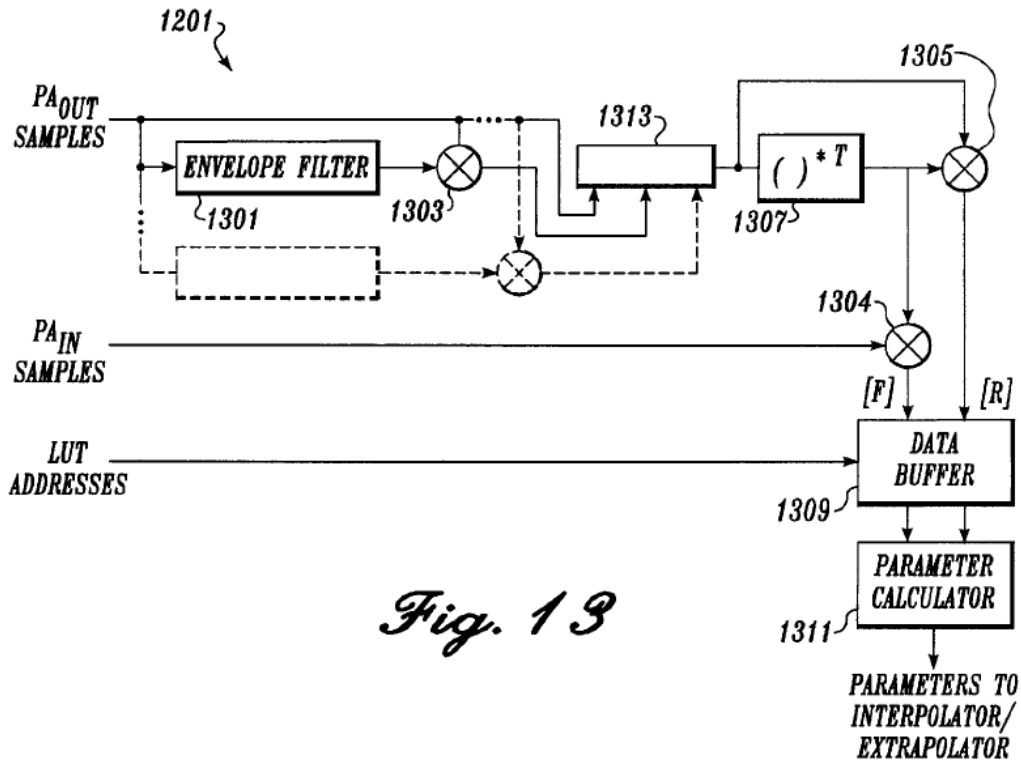
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(Leyendecker, 8:46-50, 13:45-65.) “The trainer 431 also receives and stores from the digital decimator 429 (FIG. 4) *complex digital signals* that are scaled down, downconverted and digitized samples *of the power amplifier output signals*. These signals are referred to as the PA_{out} samples.” (Leyendecker, 13:45-49 (emphasis added). See also, *id.* at 13:50-57 (explaining the trainer additionally receives the complex envelope of the PA_{in} samples (first feedback signal).) Leyendecker teaches that the complex envelope of the PA_{out} feedback signal is generated by the digital receiver. (*Id.* at 8:28-50.)

9.3.2.8 1[g]: wherein said modeling step includes the discrimination of the complex envelope of the first feedback signal referenced to the complex envelope of the second feedback signal to yield a predistortion function correlated to a behaviour of the power amplifier including nonlinearities and memory effects.

168. In my opinion, Leyendecker discloses that its trainer’s indirect model utilizes the complex envelopes of the first and second feedback signals to model the PA nonlinearity. (Leyendecker, 8:46-50, 13:45-65; Section 9.3.2.7.) For example, Leyendecker discloses that the trainer’s “solver 1201” cross-references the PA_{in} and PA_{out} samples using a “parameter calculator 1311” in order to calculate the complex parameters that are used to update the predistorter LUTs. (Leyendecker, 15:22-57, Fig. 13.)

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(Leyendecker, 15:22-65, Fig. 13.)

169. Leyendecker further explains that the trainer compensates for “memory effects.” (Leyendecker, 9:18-32.) More specifically, Leyendecker discloses that the trainer matches the PA_{in} (first feedback signal) and PA_{out} (second feedback signal) samples to the original modulation samples in order to model the PA distortion and memory effects. (Leyendecker, 13:40-65, 15:28-41.) Using the data that the trainer updates into the LUTs, a “predistortion filter 601 provides the predistortion functionality as a function of both the instantaneous power or magnitude envelope of the current modulation signal sample and *the power of magnitude envelopes of*

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previous modulation signal samples [i.e., memory effects].” (Leyendecker, 10:22-26 (emphasis added), Fig. 6.)

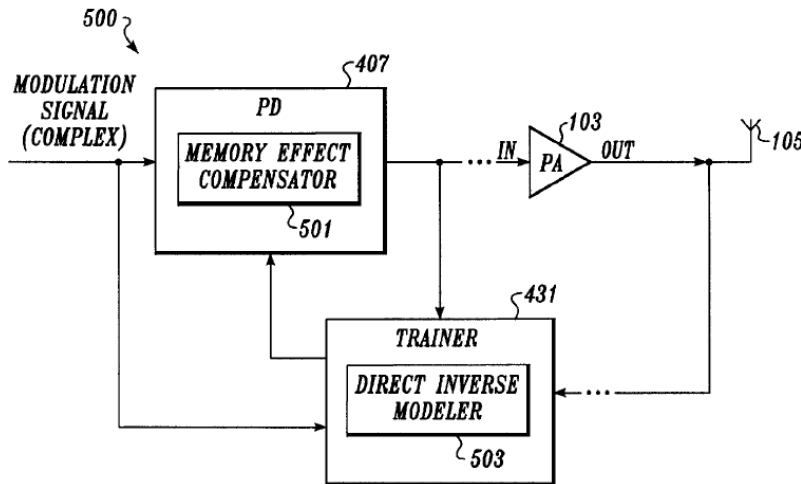


Fig. 5

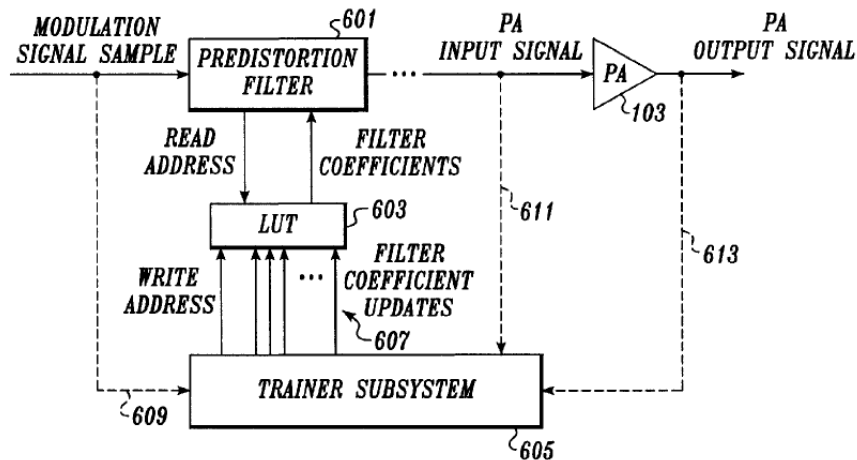


Fig. 6

(Leyendecker, 10:16-39, Fig. 5 (high-level diagram of memory effect compensator) and Fig. 6 (predistortion system of Fig. 5).)

170. Accordingly, in my opinion, Booth in view of Leyendecker renders claim 1 obvious.

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9.3.3 Claim 2

9.3.3.1 2. An adaptive method as recited in claim 1, wherein said modeling step is done in real time.

171. In my opinion, Booth and Leyendecker in combination renders claim 1 obvious. (*See* Section 9.3.2.) Further, Leyendecker discloses that the modeling step is performed “in real time.” As previously discussed, Leyendecker explains that an indirect model “enabl[es] the trainer to calculate the inverse characteristic of the power amplifier at a relatively high sample rate *in real time*.” (Leyendecker, 10:5-9, 13:56-59.) Indeed, as previously discussed, the real-time processing capability of Leyendecker’s indirect model is one of the primary reasons a POSITA would have been motivated to implement this model in Booth’s predistortion system. (Leyendecker, 3:8-16.)

172. Accordingly, in my opinion, Booth in view of Leyendecker renders obvious claim 2.

9.3.4 Claim 5

9.3.4.1 5[pre]-5[e]:

173. While claim 5 recites a “device” and claim 1 recites a “method,” all of claim elements 5.pre.-5.e. are substantially similar to corresponding limitations for claim 1.⁸ For the reasons discussed above, in my opinion, elements 5.pre.-5.e. are

⁸ In my opinion, the initial limitations of claim 5 that correspond to those in claim 1 are:

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taught by Booth in view of Leyendecker. (*See* Sections 9.1.3-9.1.3.1, *supra*; *see also*, Sections 9.3.2.1-9.3.2.6.)

9.3.4.2 5[f]: wherein said look-up tables of said distorting generator are indexed by an envelope detector that detects the envelope of the signal to be transmitted before predistortion.

174. Booth discloses that its RF modulated input signal is transmitted to an envelope detector via a directional coupler. (Booth, 7:5-12, Fig. 2.)

5[pre]: An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said adaptive device comprising:

[5.a] an I/Q modulator interposed between the signal source and the input of the power amplifier;

[5.b] a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;

[5.c] a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;

[5.d] a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;

[5.e] a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier[.]

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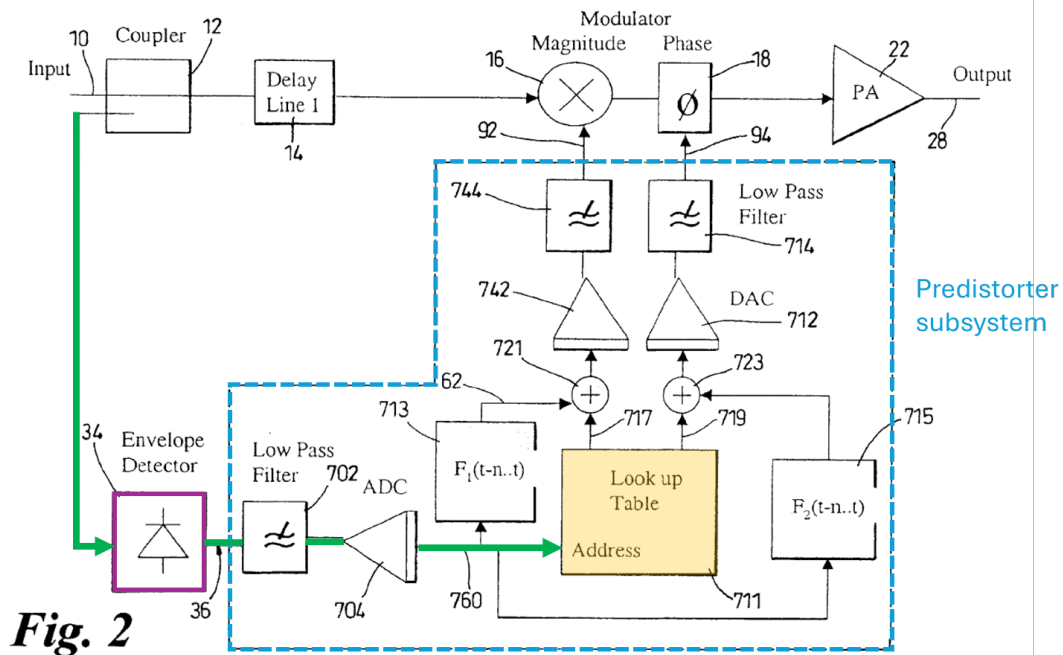


Fig. 2

(Booth, 7:5-41, Fig. 2 (annotated).) The envelope detector (purple) detects the magnitude of the RF modulated signal (“envelope of the signal,” green), which is provided to the digital predistorter (“distorting generator,” blue) and used to index the LUT (yellow). (*Id.* at 7:33-41.) Thus, Booth explains that before predistortion, “samples of the envelope $|x(t)|$ of the input (10) . . . are used to address the LUT (711).” (Booth, 8:63-67.)

175. Leyendecker also indexes the predistorter LUT(s) using the signal envelope. For example, Leyendecker explains that “the direct inverse modeling scheme of the present invention *indexes the LUT using the modulated input signals* instead of the potentially noisier output signals, which helps to increase the accuracy of the predistortion.” (Leyendecker, 3:16-21.) Leyendecker explains that “the

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trainer updates the predistorter with the ‘output sample-to-input sample’ gain and phase of the power amplifier, *indexed by the instantaneous power or magnitude of the modulation signal sample.*” (*Id.* at 9:66-10:5, 11:11-18.)

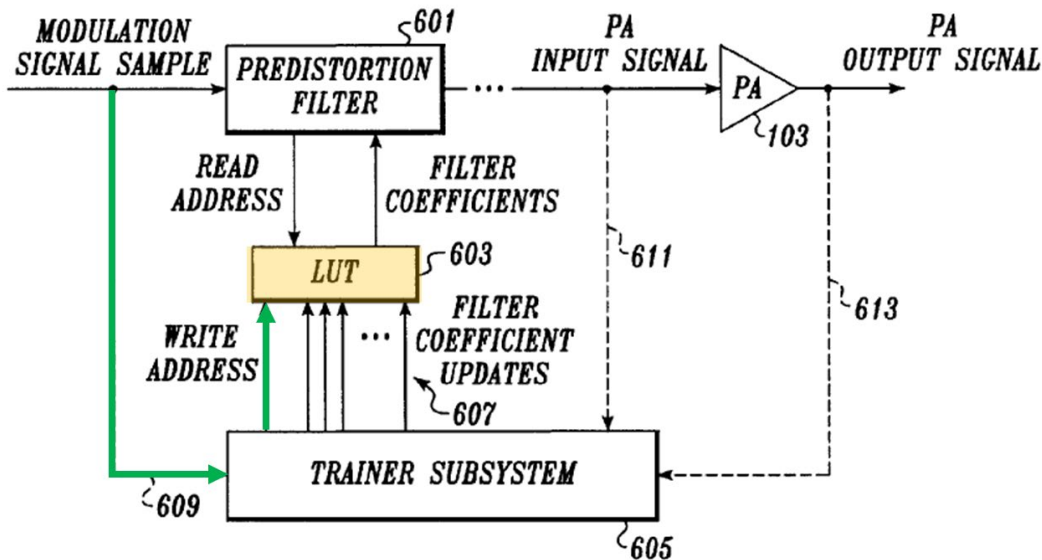
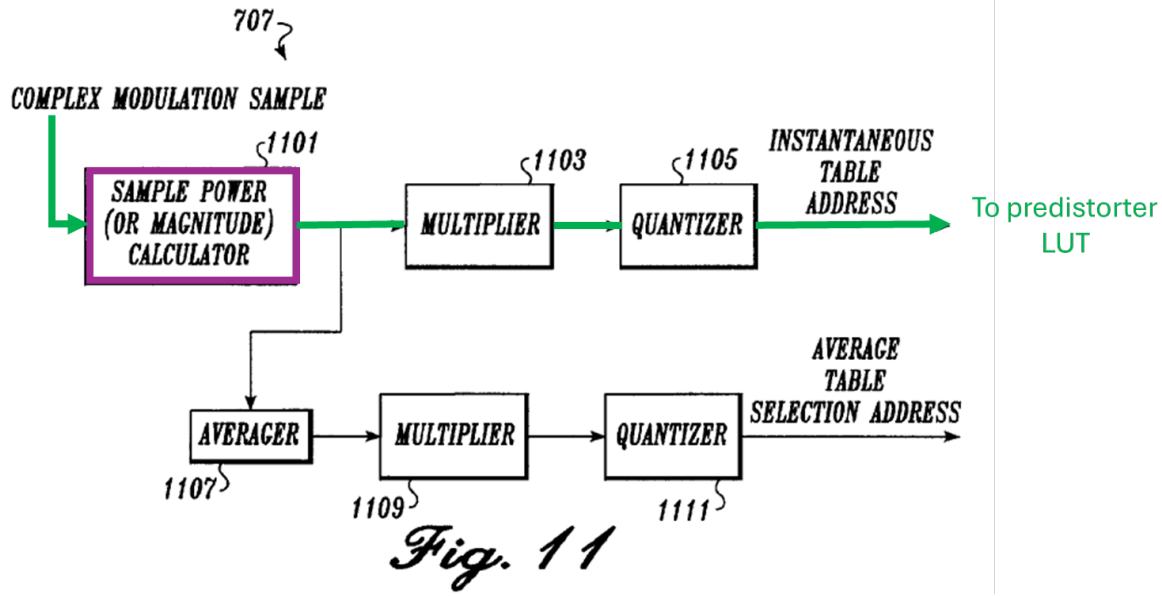


Fig. 6

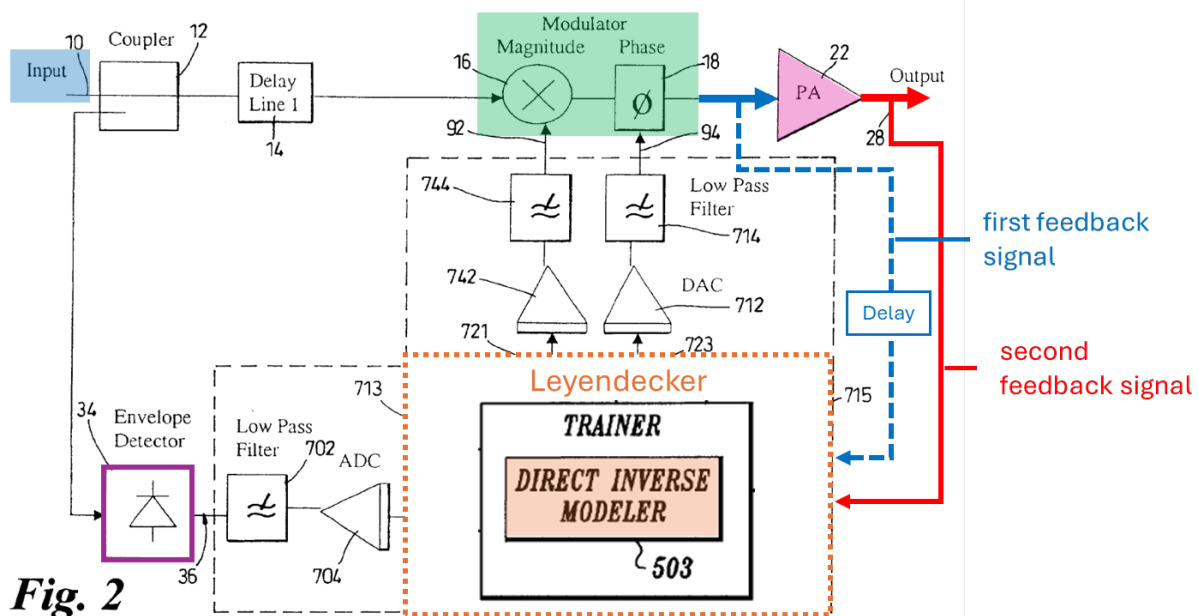
(*Id.* at 10:16-26, Fig. 6 (annotated).) The “instantaneous power or magnitude of the modulation signal sample” is the signal envelope. (*See* Sections 6.2.2-6.2.3, *supra.*) In order to generate the instantaneous power or magnitude of the modulation signal sample (“envelope of the signal,” green) from the complex modulation sample, Leyendecker teaches using a sample power or magnitude calculator (“envelope detector”). (Leyendecker, 12:58-67, Fig. 11.)

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(Leyendecker, 12:58-67, Fig. 11 (annotated; “envelope detector” in purple).)

176. Thus, in my opinion, both Booth and Leyendecker disclose using an envelope detector to index the predistorter LUT with the RF modulated input signal envelope.



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(Booth, 7:5-22, Fig. 2 (as modified by Leyendecker; “envelope detector” in purple).)

As previously discussed, it would have been well-within the abilities of a POSITA to implement this step in the combination of Leyendecker’s indirect model with Booth’s transmitter. (*See* Section 9.3.1.1.)

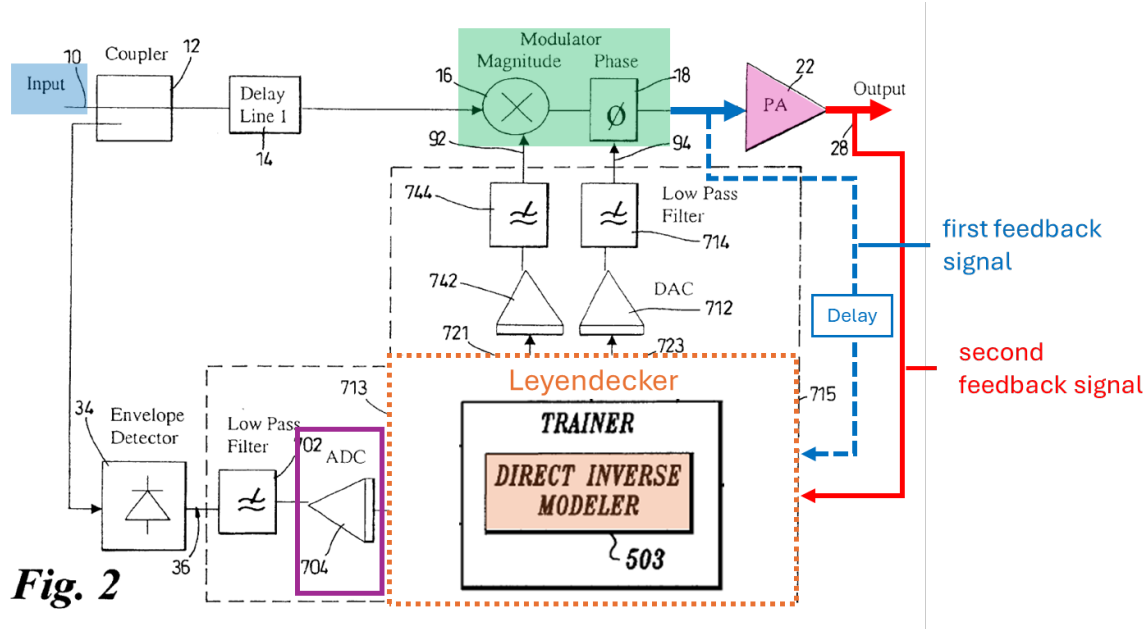
177. Thus, in my opinion, Booth in view of Leyendecker renders obvious claim 5.

9.3.5 Claim 6

9.3.5.1 6. An adaptive device as recited in claim 5, wherein said envelope detector indexes the distorting generator via an analog to digital converter.

178. Booth in view of Leyendecker renders claim 5 obvious, in my opinion. (*See* Section 9.3.4.) Booth further discloses that the envelope detector indexes the predistorter LUTs *via an analog to digital converter*. For example, Booth discloses that “the output of the envelope detector is connected to a digital pre-distortion subsystem.” (Booth, 7:11-13.) As shown in Booth Figure 2, the signal from the envelope detector is converted from analog (RF) to digital via an ADC (purple) so that the predistorter can process the data. (*Id.* at 7:5-13, Fig. 2.)

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(Booth, 7:5-36 (“The signal (36) from the envelope detector 34 is . . . digitised by an analogue to digital converter (ADC) (704).”), Fig. 2 (as modified by Leyendecker); See also Sections 6.2.2-6.2.3, *supra*.)

179. Thus, in my opinion, Booth in view of Leyendecker renders claim 6 obvious.

9.3.6 Claim 11

9.3.6.1 11[pre]-11[e]:

180. Claim elements 11.pre.-11.e. are identical to the corresponding limitations for claim 5.⁹ For the reasons discussed above, in my opinion, elements

⁹ In my opinion, the initial limitations of claim 11 that correspond to those in claims 1 and 5 are:

11[pre] An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier

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11.pre.-11.e. are taught by Booth in view of Leyendecker. (See Sections 9.1.3-9.1.3.1, 9.3.1-9.3.2.6, 9.3.4.1.)

9.3.6.2 11[f]: wherein said control module is further configured as to insert an adequate delay between the first feedback signal and the second feedback signal.

181. In my opinion, Leyendecker's trainer subsystem ("control module") inserts a delay into the first feedback loop to ensure the first feedback signal is synchronized with the second feedback loop. (Leyendecker, 8:51-60, 9:35-46 ("Because the timing and sampling is synchronized, the trainer 431 matches (by taking into account the delay through the intervening circuitry the input digital sample with the corresponding sample of the power amplifier output signal."), Fig.

having an output for delivering an amplified output signal, said adaptive device comprising:

[11.a] an I/Q modulator interposed between the signal source and the input of the power amplifier;

[11.b] a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;

[11.c] a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;

[11.d] a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;

[11.e] a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier[.]

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5.) Leyendecker explains that this delay is necessary to compensate for the delay through the analog and digital stages, including the PA. (Leyendecker, 8:51-60, 13:59-65 (“The trainer 431 provides the proper delays and synchronization to match the PA_{in} samples and PA_{out} samples with the originating modulation signal samples.”).)

182. Thus, in my opinion, Booth in view of Leyendecker renders claim 11 obvious.

10. Conclusion

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

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

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

Dated: March 17, 2025



James Proctor, Jr.

EXHIBIT A
(Curriculum Vitae)

James A. Proctor Jr.

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

EDUCATION

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

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

Skills & Achievements

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

Work Experience

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

September 1992 - 1995

Georgia Tech Research Institute, CSITL

June 1991 - August 1992

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

May 1990 - August 1990

- Acousto-optic signal processing

Standards Development

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

Intellectual Property

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

Testifying Expert Experience

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

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

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

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

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

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

UNWIRED PLANET. V. SQUARE, INC.,

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Wi-LAN v. LG

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Samsung v. Cobblestone Wireless, LLC.

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

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

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

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

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

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

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

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

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

Case No. 2:23-cv-204 (EDTex, Member Case)

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

List of Issued U.S. Patents

United States Pat. No.	Title
5,550,549	Transponder system and method
5,687,196	Range and bearing tracking system with multipath rejection
5,898,338	Adaptive digital predistortion linearization and feed-forward correction of RF power amplifier
5,929,704	Control of RF error extraction using auto-calibrating RF correlator
5,949,283	Adaptive digital predistortion linearization and feed-forward correction of RF power amplifier
5,960,047	System and method for transmitting information signals
6,078,216	Aliased wide band performance monitor for adjusting predistortion and vector modulator control parameters of RF amplifier
6,100,843	Adaptive antenna for use in same frequency networks
6,212,220	Method and apparatus for creating non-interfering signals using non-orthogonal techniques
6,222,832	Fast Acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
6,239,756	Antenna array with housing
6,301,291	Pilot symbol assisted modulation and demodulation in wireless communication systems
6,304,215	Method of use for an adaptive antenna in same frequency networks
6,362,790	Antenna array structure stacked over printed wiring board with beamforming components
6,388,999	Dynamic bandwidth allocation for multiple access communications using buffer urgency factor
6,396,456	Stacked dipole antenna for use in wireless communications systems
6,400,317	Method and apparatus for antenna control in a communications network
6,404,386	Adaptive antenna for use in same frequency networks
6,421,336	Variable rate orthogonally coded reverse link structure
6,448,938	Method and apparatus for frequency selective beam forming
6,452,913	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
6,456,835	Arbitration method for high power transmissions in a code division multiple access system
6,473,036	Method and apparatus for adapting antenna array to reduce adaptation time while increasing array performance
6,515,635	Adaptive antenna for use in wireless communication systems
6,518,920	Adaptive antenna for use in same frequency networks
6,542,481	Dynamic bandwidth allocation for multiple access communication using session queues
6,545,990	Method and apparatus for a spectrally compliant cellular communication system
6,545,994	Access probe acknowledgment including collision detection to avoid oversetting initial power level
6,563,809	Subscriber-controlled registration technique in a CDMA system
6,600,456	Adaptive antenna for use in wireless communication systems
6,614,776	Forward error correction scheme for high rate data exchange in a wireless system
6,678,260	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
6,707,804	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
6,785,323	Variable rate coding for forward link
6,788,268	Method and apparatus for frequency selective beam forming
6,792,290	Method and apparatus for performing directional re-scan of an adaptive antenna
6,801,564	Reverse link correlation filter in wireless communication systems
6,804,223	Reverse link pilot integrated with block codes
6,873,293	Adaptive receive and omnidirectional transmit antenna array
6,888,504	Aperiodic array antenna
6,888,807	Applying session services based on packet flows
6,894,653	Low cost multiple pattern antenna for use with multiple receiver systems
6,904,079	Access channel structure for wireless communication system
6,911,879	Electronic phase shifter with enhanced phase shift performance
6,917,581	Use of orthogonal or near orthogonal codes in reverse link

6,917,642	Method for using a non-orthogonal pilot signal with data channel interference cancellation
6,925,070	Time-slotted data packets with a preamble
6,928,064	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
6,933,887	Method and apparatus for adapting antenna array using received predetermined signal
6,937,562	Application specific traffic optimization in a wireless link
6,940,842	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
6,941,152	Wireless subscriber network registration system for configurable services
6,954,448	Alternate channel for carrying selected message types
6,956,840	Power control protocol for highly variable data rate reverse link of a wireless communication system
6,973,140	Maximizing data rate by adjusting codes and code rates in CDMA system
6,989,797	Adaptive antenna for use in wireless communication systems
6,992,546	Electronic phase shifter with enhanced phase shift performance
7,002,902	Method and system for economical beam forming in a radio communication system
7,006,428	Method for allowing multi-user orthogonal and non-orthogonal interoperability of code channels
7,006,483	Qualifying available reverse link coding rates from access channel power setting
7,009,559	Method and apparatus for adapting antenna array using received predetermined signal
7,015,773	Electronic phase shifter with enhanced phase shift performance
7,034,759	Adaptive receive and omnidirectional transmit antenna array
7,072,316	Subscriber-controlled registration technique in a CDMA system
7,079,523	Maintenance link using active/standby request channels
7,092,430	Method for using a non-orthogonal pilot signal with data channel interference cancellation
7,113,786	Antenna adaptation to manage the active set to manipulate soft hand-off regions
7,145,964	Maximizing data rate by adjusting codes and code rates in CDMA system
7,176,844	Aperiodic array antenna
7,184,417	Power control protocol for highly variable data rate reverse link of a wireless communication system
7,187,904	Frequency translating repeater with low cost high performance local oscillator architecture
7,200,134	Wireless area network using frequency translation and retransmission based on modified protocol messages for enhancing network coverage
7,215,297	Adaptive antenna for use in wireless communication systems
7,218,623	Coded reverse link messages for closed-loop power control of forward link control messages
7,221,664	Transmittal of heartbeat signal at a lower level than heartbeat request
7,224,685	Method of detection of signals using an adaptive antenna in a peer-to-peer network
7,227,907	Antenna adaptation comparison method for high mobility
7,230,935	Physical layer repeater with selective use of higher layer functions based on network operating conditions
7,233,627	Method for searching pilot signals to synchronize a CDMA receiver with an associated transmitter
7,233,771	Non-frequency translating repeater with downlink detection for uplink and downlink synchronization
7,253,783	Low cost multiple pattern antenna for use with multiple receiver systems
7,272,169	Reverse link correlation filter in wireless communication systems
7,289,827	Method and apparatus for performing directional re-scan of an adaptive antenna
7,308,285	Antenna adaptation in a time division duplexing system
7,366,154	Forward error correction scheme for high rate data exchange in a wireless system
7,394,791	Multi-detection of heartbeat to reduce error probability
7,425,928	Method and apparatus for frequency selective beam forming
7,426,241	Variable rate coding for forward link
7,428,263	Method for using a non-orthogonal pilot signal with data channel interference cancellation
7,433,340	Staggering forward and reverse wireless channel allocation timing
7,447,187	Reverse link pilot integrated with block codes
7,463,200	Directional antenna configuration for TDD repeater
7,463,201	Aperiodic array antenna

7,480,280	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
7,483,473	Access channel structure for wireless communication system
7,496,072	System and method for controlling signal strength over a reverse link of a CDMA wireless communication system
7,502,351	Alternate channel for carrying selected message types
7,502,424	Maximizing data rate by adjusting codes and code rates
7,528,789	Adaptive antenna for use in wireless communication systems
7,529,264	Use of orthogonal or near orthogonal codes in reverse link
7,551,663	Use of correlation combination to achieve channel detection
7,580,674	Intelligent interface for controlling an adaptive antenna array
7,586,880	Method of detection of signals using an adaptive antenna in a peer-to-peer network
7,592,969	Multiple-antenna device having an isolation element
7,593,380	Variable rate forward error correction for enabling high performance communication
7,602,749	Fast acquisition of traffic channels for a highly variable data rate reverse link of a CDMA wireless communication system
7,613,227	Reverse link correlation filter in wireless communication systems
7,701,903	Power control protocol for highly variable data rate reverse link of a wireless communication system
7,733,285	Integrated, closely spaced, high isolation, printed dipoles
7,746,830	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
7,773,566	System and method for maintaining timing of synchronization messages over a reverse link of a CDMA wireless communication system
7,787,408	Wireless repeater with master/slave configuration
7,826,437	Variable rate coding for enabling high performance communication
7,889,702	Time-slotted data packets with a preamble
7,893,889	Multiple-antenna device having an isolation element
7,907,513	Superimposed composite channel filter
7,907,891	Physical layer repeater utilizing real time measurement metrics and adaptive antenna array to promote signal integrity and amplification
7,911,985	Automatic gain control and filtering techniques for use in on-channel repeater
7,911,993	Method and apparatus for allowing soft handoff of a CDMA reverse link utilizing an orthogonal channel structure
7,916,772	Method for searching pilot signals to synchronize a CDMA receiver with an associated transmitter
7,936,728	System and method for maintaining timing of synchronization messages over a reverse link of a CDMA wireless communication system
7,936,736	Enforcing policies in wireless communication using exchanged identities
7,944,845	Application specific traffic optimization in a wireless link
7,990,904	Wireless network repeater
8,023,885	Non-frequency translating repeater with downlink detection for uplink and downlink synchronization
8,027,642	Transmission canceller for wireless local area network
8,045,536	Forward error correction scheme for high rate data exchange in a wireless system
8,059,727	Physical layer repeater configuration for increasing MIMO performance
8,060,009	Wireless local area network repeater with automatic gain control for extending network coverage
8,068,474	Variable rate coding for enabling high performance communication
8,072,944	Staggering forward and reverse wireless channel allocation timing
8,072,958	Reverse link pilot integrated with block codes
8,078,100	Physical layer repeater with discrete time filter for all-digital detection and delay generation
8,089,913	Physical layer repeater with selective use of higher layer functions based on network operating conditions
8,090,359	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,090,616	Visual identification information used as confirmation in a wireless communication
8,095,067	Frequency translating repeater with low cost high performance local oscillator architecture
8,111,645	Wireless local area network repeater with detection
8,116,239	Use of a filter bank in an adaptive on-channel repeater utilizing adaptive antenna arrays
8,116,749	Protocol for anonymous wireless communication
8,121,535	Configuration of a repeater

8,122,134	Reducing loop effects in a wireless local area network repeater
8,134,980	Transmittal of heartbeat signal at a lower level than heartbeat request
8,139,546	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
8,155,096	Antenna control system and method
8,175,120	Minimal maintenance link to support synchronization
8,194,783	Variable rate coding for a forward and reverse link
8,204,140	Subscriber unit and method for variable forward error correction (FEC) decoding
8,238,912	Non-intrusive detection of enhanced capabilities at existing cellsites in a wireless data communication system
8,259,687	Dynamic bandwidth allocation for multiple access communications using buffer urgency factor
8,259,744	Use of orthogonal or near orthogonal codes in reverse link
8,265,630	Antenna adaptation to manage the active set to manipulate soft hand-off regions
8,274,954	Alternate channel for carrying selected message types
8,285,201	Wideband echo cancellation in a repeater
8,315,294	Method for searching pilot signals to synchronize a CDMA receiver with an associated transmitter
8,321,542	Wireless channel allocation in a base station processor
8,358,969	Feedback delay control in an echo cancellation repeater
8,363,590	Physical layer repeater with roaming support based on multiple identifiers
8,369,277	Signaling for wireless communications
8,369,842	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,370,955	Enforcing policies in wireless communication using exchanged identities
8,374,592	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,385,305	Hybrid band intelligent backhaul radio
8,385,818	Delay control to improve frequency domain channel estimation in an echo cancellation repeater
8,385,896	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,385,913	Using a first wireless link to exchange identification information used to communicate over a second wireless link
8,422,540	Intelligent backhaul radio with zero division duplexing
8,437,329	Variable rate coding for enabling high performance communication
8,437,330	Antenna control system and method
8,463,255	Method and apparatus for a spectrally compliant cellular communication system
8,467,353	Time-slotted data packets with a preamble
8,467,363	Intelligent backhaul radio and antenna system
8,477,665	Method in a wireless repeater employing an antenna array for interference reduction
8,498,234	Wireless local area network repeater
8,502,733	Transmit co-channel spectrum sharing
8,503,926	IQ imbalance compensation in interference cancellation repeater using a zero-IF radio architecture
8,509,268	Minimal maintenance link to support synchronization
8,509,835	Reverse link initial power setting using effective radiated power message to compute path loss
8,521,862	Wireless channel allocation in a base station processor
8,526,401	Power control protocol for highly variable data rate reverse link of wireless communication system
8,537,656	Method for compensating for multi-path of a CDMA reverse link utilizing an orthogonal channel structure
8,542,623	Use of RF reference in a digital baseband interference cancellation repeater
8,553,610	Interference cancellation repeater incorporating a non-linear element
8,559,379	Method and apparatus for mitigating oscillation between repeaters
8,576,805	Subscriber-controlled registration technique in a CDMA system
8,582,552	Maintaining a maintenance channel in a reverse link of a wireless communications system
8,599,906	Closed form calculation of temporal equalizer weights used in a repeater transmitter leakage cancellation system
8,605,702	Maintaining a maintenance channel in a reverse link of a wireless communications system
8,619,837	Use of adaptive antenna array in conjunction with an on-channel repeater to improve signal quality

8,630,211	Hybrid radio architecture for repeaters using RF cancellation reference
8,638,839	Intelligent backhaul radio with co-band zero division duplexing
8,638,877	Methods, apparatuses and systems for selective transmission of traffic data using orthogonal sequences
8,649,418	Enhancement of the channel propagation matrix order and rank for a wireless channel
8,676,131	Method and apparatus for allowing soft handoff of a CDMA reverse link utilizing an orthogonal channel structure
8,687,606	Alternate channel for carrying selected message types
8,709,092	Periprosthetic fracture management enhancements
8,737,343	Coded reverse link messages for closed-loop power control of forward link control messages
8,755,360	Method and apparatus for a spectrally compliant cellular communication system
8,755,473	Method and apparatus for detecting rapid changes in signaling path environment
8,774,079	Repeater techniques for multiple input multiple output utilizing beam formers
8,787,248	Method in a wireless repeater employing an antenna array including vertical and horizontal feeds for interference reduction
8,790,321	Apparatus, system, and method for harvesting improved bone graft material with reamer-irrigator-aspirator (RIA) device
8,792,458	System and method for maintaining wireless channels over a reverse link of a CDMA wireless communication system
8,811,367	Qualifying available reverse link coding rates from access channel power setting
8,824,442	Intelligent backhaul radio with adaptive channel bandwidth control
8,830,977	Reverse link pilot integrated with block codes
8,842,642	Transmitting acknowledgement messages using a staggered uplink time slot
8,849,186	Repeater communication using inserted low power sequences
8,849,698	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
8,861,429	Selective carrier amplification in a wireless repeater
8,885,688	Control message management in physical layer repeater
8,897,340	Enhancement of the channel propagation matrix order and rank for a wireless channel
8,908,654	Dynamic bandwidth allocation for multiple access communications using buffer urgency factor
8,937,874	Adjusting repeater gains based upon received downlink power level
8,942,216	Hybrid band intelligent backhaul radio
8,948,235	Intelligent backhaul radio with co-band zero division duplexing utilizing transmitter to receiver antenna isolation adaptation
8,958,457	Channel structure for a wireless communication system
8,964,909	Maximizing data rate by adjusting codes and code rates
8,989,762	Advanced backhaul services
9,014,118	Signaling for wireless communications
9,019,930	Coded reverse link messages for closed-loop power control of forward link control messages
9,020,009	Inserted pilot construction for an echo cancellation repeater
9,020,621	Network based media enhancement function based on an identifier
9,038,129	Enforcing policies in wireless communication using exchanged identities
9,042,400	Multi-detection of heartbeat to reduce error probability
9,135,612	Proximity detection, virtual detection, or location based triggering of the exchange of value and information
9,161,164	Exchanging identifiers between wireless communication to determine further information to be exchanged or further services to be provided
9,179,240	Transmit co-channel spectrum sharing
9,185,604	Qualifying available reverse link coding rates from access channel power setting
9,210,616	Application specific traffic optimization in a wireless link
9,225,395	Antenna control system and method
9,226,295	Hybrid band radio with data direction determined by a link performance metric
9,237,209	Time-slotted data packets with a preamble
9,247,510	Use of correlation combination to achieve channel detection
9,252,857	Embedded control signaling for wireless systems
9,294,222	Variable rate coding for forward and reverse link
9,301,274	Minimal maintenance link to support synchronization

9,306,658	Method and apparatus for a spectrally compliant cellular communication system
9,306,703	Variable rate coding for enabling high performance communication
9,307,532	Signaling for wireless communications
9,325,398	Method for installing a backhaul radio with an antenna array
9,325,477	Alternate channel for carrying selected message types
9,345,523	Periprosthetic fracture management enhancements
9,363,759	Power control protocol for highly variable data rate reverse link of a wireless communication system
9,369,235	Maximizing data rate by adjusting codes and code rates
9,374,822	Method for installing a hybrid band radio
9,397,808	Reverse link pilot integrated with block codes
9,398,120	Time-slotted data packets with a preamble
9,456,376	Subscriber-controlled registration technique in a CDMA system
9,456,428	Method and apparatus for allowing soft handoff of a CDMA reverse link utilizing an orthogonal channel structure
9,460,433	Proximity detection, virtual detection, or location based triggering of the exchange of value and information
9,490,918	Zero division duplexing MIMO backhaul radio with adaptable RF and/or baseband cancellation
9,496,915	Use of orthogonal or near orthogonal codes in reverse link
9,497,761	Qualifying available reverse link coding rates from access channel power setting
9,522,066	Periprosthetic fracture management enhancements
9,525,923	Multi-detection of heartbeat to reduce error probability
9,554,061	Smart hub
9,555,169	Apparatus for harvesting improved bone graft material utilizing an implantable biodegradable filter
9,572,163	Hybrid band radio with adaptive antenna arrays
9,577,733	Method for installing a backhaul link with multiple antenna patterns
9,655,062	System and method for coordination of wireless maintenance channel power control
9,661,583	Reverse link initial power setting using effective radiated power message to compute path loss
9,686,713	Application specific traffic optimization in a wireless link
9,686,790	Signaling for wireless communications
9,713,019	Self organizing backhaul radio
9,713,157	Method for installing a backhaul link with alignment signals
9,775,115	Antenna control system and method
9,780,930	Communicating reference and data information in a wireless network
9,781,626	Wireless channel allocation in a base station processor
9,807,714	Minimal maintenance link to support synchronization
9,832,664	Receiving and transmitting reverse link signals from subscriber units
9,867,101	Method and apparatus for allowing soft handoff of a CDMA reverse link utilizing an orthogonal channel structure
9,872,196	Subscriber-controlled registration technique in a CDMA system
9,876,530	Advanced backhaul services
9,913,271	Qualifying available reverse link coding rates from access channel power setting
9,913,722	Periprosthetic fracture management enhancements
9,924,468	Antenna control system and method
9,936,500	Transmitting acknowledgement messages using a staggered uplink time slot
9,954,635	Variable rate coding for enabling high performance communication
9,974,116	Handoff to base station having enhanced capabilities
10,057,700	Smart hub
10,063,363	Zero division duplexing MIMO radio with adaptable RF and/or baseband cancellation
10,064,144	Use of correlation combination to achieve channel detection
10,129,888	Method for installing a fixed wireless access link with alignment signals
10,153,885	Alternate channel for carrying selected message types

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

EXHIBIT B
(Materials Considered)

LIST OF MATERIALS CONSIDERED

- a. U.S. Patent No. 7,035,345 (“the ’345 Patent”)
- b. Prosecution History of U.S. Application No. 09/877,608, filed June 8, 2001, which issued as U.S. Patent No. 7,035,345 (“’345 File History”)
- c. U.S. Patent No. 6,587,514 (“Wright”)
- d. U.S. Patent No. 6,693,974 (“Jin”)
- e. U.S. Patent No. 6,512,417 (“Booth”)
- f. U.S. Patent No. 5,867,065 (“Leyendecker”)
- g. Allen Katz, “Linearization: Reducing Distortions in Power Amplifiers,” IEEE Microwave Magazine, Vol. 2, No. 4, pp. 37-49 (Dec. 2001) (“Katz”)
- h. Lei Ding, Raviv Raich, G. Tong Zhou, “A Hammerstein Predistortion Linearization Design Based on the Indirect Learning Architecture,” 2002 IEEE International Conference on Acoustics, Speech, and Signal Processing, Vol. 3, pp. 2689-2692 (May 2002) (“Raich”)
- i. 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 (Mar. 2004) (“Ding”)

DECLARATION OF JAMES PROCTOR, JR. IN SUPPORT OF
IPR PETITION FOR U.S. PATENT NO. 7,035,345

- j. Nazim Ceylan, *Linearization of Power Amplifiers by Means of Digital Predistortion*, Doctoral Thesis, Friedrich-Alexander-Universität Erlangen-Nürnberg (2005) (“Ceylan”)
- k. Alan Oppenheim and Ronald Schaffer, *Discrete-Time Signal Processing*, Prentice Hall (1989) (“Oppenheim”)
- l. L. W. Couch, *Digital and Analog Communication Systems*, 2nd Ed., Collier MacMillan, New York (1987) (“Couch”)
- m. J. Proakis, et al., *Communication Systems Engineering*, 2nd Ed., Pearson, (2002) (“Proakis”)
- n. U.S. Patent No. 6,072,364 (“Jeckeln”)
- o. C. Eun & E. J. Powers, “A new Volterra predistorter based on the indirect learning architecture,” *IEEE Transactions on Signal Processing*, Vol. 45, No. 1, pp. 223-227 (Jan. 1997) (“Eun”)
- p. Agilent AN 1311 Application Note, *Understanding CDMA Measurements for Base Stations and their Components*, Agilent Technologies (2000) (“Agilent 1311”)
- q. TIA/EIA/IS-97, *Recommended Minimum Performance Standards for Base Stations Supporting Dual-Mode Wideband Spread Spectrum Cellular Mobile Stations*, (Dec. 1997) (“IS-97”)

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IPR PETITION FOR U.S. PATENT NO. 7,035,345

- r. W-CDMA TS 25.104 v.3.0.0 3rd Generation Partnership Project (3GPP) Technical Specification Group (TSG) RAN WG4 UTRA (BS) FDD; Radio transmission and Reception (Oct. 1999) (“3GPP”)
- s. Agilent Application Note 1312, *Understanding GSM/EDGE Transmitter and Receiver Measurements for Base Transceiver Stations and their Components*, Agilent Technologies (2002) (“Agilent 1312”)
- t. User's Guide HP 8590 E-Series and L-Series Spectrum Analyzers, Hewlett Packard Co. (July 1998) (“HP User’s Guide”)
- u. A. Lohtia, P. A. Goud and C. G. Englefield, “Adaptive Digital Linearization of RF Power Amplifiers,” *Canadian Journal of Electrical and Computer Engineering*, Vol. 20, No. 2, pp. 65-71 (April 1995) (“Lohtia”)
- v. J. K. Cavers, “The effect of quadrature modulator and demodulator errors on adaptive digital predistorters for amplifier linearization,” *IEEE Transactions on Vehicular Technology*, Vol. 46, No. 2, pp. 456-466 (May 1997) (“Cavers 1997”)
- w. J. K. Cavers, et al., “A DSP-based alternative to direct conversion receivers for digital mobile communications,” *GLOBECOM '90: IEEE Global Telecommunications Conference and Exhibition*, San Diego, CA, USA, Vol. 3, pp. 2024-2029 (1990) (“Cavers 1990”)

EXHIBIT C
(Challenged Claims)

TABLE OF CHALLENGED CLAIMS

1[pre]	An adaptive method for predistorting an RF modulated signal, to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said method comprising the steps of:
1[a]	predistorting the RF modulated signal to be transmitted using an I/Q modulator interposed between the signal source and the input of the power amplifier, and controlled by means of amplitude and phase look-up tables stored in a distorting generator;
1[b]	producing, via a first digital receiver, a first feedback signal in response to the RF predistorted signal;
1[c]	producing, via a second digital receiver, a second feedback signal in response to the RF amplified output signal from the power amplifier;
1[d]	modeling the power amplifier in response to the first and second feedback signals; and
1[e]	updating the predistortion amplitude and phase look-up tables in response to said modeling of the power amplifier,
1[f]	wherein said second feedback signal includes the complex envelope of the RF amplified output signal, and
1[g]	wherein said modeling step includes the discrimination of the complex envelope of the first feedback signal referenced to the complex envelope of the second feedback signal to yield a predistortion function correlated to a behaviour of the power amplifier including nonlinearities and memory effects.
2	An adaptive method as recited in claim 1, wherein said modeling step is done in real time.

3[pre]	An adaptive method for predistorting an RF modulated signal, to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said method comprising the steps of:
3[a]	predistorting the RF modulated signal to be transmitted using an I/Q modulator interposed between the signal source and the input of the power amplifier, and controlled by means of amplitude and phase look-up tables stored in a distorting generator;
3[b]	producing, via a first digital receiver, a first feedback signal in response to the RF predistorted signal;
3[c]	producing, via a second digital receiver, a second feedback signal in response to the RF amplified output signal from the power amplifier;

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3[d]	modeling the power amplifier in response to the first and second feedback signals; and
3[e]	updating the predistortion amplitude and phase look-up tables in response to said modeling of the power amplifier,
3[f]	wherein said updating step is done when a linearity metric adjacent channel power ratio (ACPR) measurement sub-step indicates that the predistorting step is not adequate to meet predetermined ACPR standards.
4	An adaptive method as recited in claim 3, wherein said linearity metric ACPR measurement sub-step is done via a digital receiver that includes a first channel tuned to a mean frequency and a second channel that is tuned to a predetermined offset frequency, said linearity metric ACPR measurement sub-step including comparing an average power at the mean frequency and at the predetermined offset frequency.

5[pre]	An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said adaptive device comprising:
5[a]	an I/Q modulator interposed between the signal source and the input of the power amplifier;
5[b]	a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;
5[c]	a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;
5[d]	a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;
5[e]	a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier;
5[f]	wherein said look-up tables of said distorting generator are indexed by an envelope detector that detects the envelope of the signal to be transmitted before predistortion.

TABLE OF CHALLENGED CLAIMS

6	An adaptive device as recited in claim 5, wherein said envelope detector indexes the distorting generator via an analog to digital converter.
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7[pre]	An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said adaptive device comprising:
7[a]	an I/Q modulator interposed between the signal source and the input of the power amplifier;
7[b]	a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;
7[c]	a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;
7[d]	a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;
7[e]	a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier;
7[f]	wherein said look-up tables of said distorting generator are indexed by data from a third digital receiver that down-converts the signal to be transmitted to baseband.
8	An adaptive device as recited in claim 7, wherein the data from said third digital receiver is supplied to said control module that indexes said distorting generator accordingly.

9[pre]	An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said adaptive device comprising:
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9[a]	an I/Q modulator interposed between the signal source and the input of the power amplifier;
9[b]	a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;
9[c]	a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;
9[d]	a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;
9[e]	a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier,
9[f]	wherein said control module is so configured as to update said amplitude and phase look-up tables when an adjacent channel power ratio (ACPR) measurement indicates that the predistortion made by said predistorting generator is not adequate to meet predetermined ACPR standards.
10	An adaptive device as recited in claim 9, wherein said ACPR measurement is done via said second digital receiver that includes a first channel tuned to a mean frequency and a second channel that is tuned to a predetermined offset frequency, said ACPR measurement including comparing an average power at the means frequency and at the predetermined offset frequency.

11[pre]	An adaptive device for predistorting an RF modulated signal to be transmitted, supplied by a signal source to an input of a power amplifier having an output for delivering an amplified output signal, said adaptive device comprising:
11[a]	an I/Q modulator interposed between the signal source and the input of the power amplifier;
11[b]	a distorting generator including predistortion amplitude and phase look-up tables; said distorting generator controlling said I/Q modulator to predistort the RF modulated signal to be transmitted in amplitude and in phase;

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11[c]	a first digital receiver producing a first feedback signal in response to the RF predistorted signal from said I/Q modulator;
11[d]	a second digital receiver producing a second feedback signal in response to the RF amplified output signal from the power amplifier;
11[e]	a control module receiving said first and second feedback signals from said first and second digital receivers; said control module being so configured as to model the power amplifier in response to the first and second feedback signals and to update said amplitude and phase look-up tables of said distorting generator in response to a dynamic modeling of the power amplifier;
11[f]	wherein said control module is further configured as to insert an adequate delay between the first feedback signal and the second feedback signal.