

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

APPLE INC.
Petitioner

v.

LIONRA TECHNOLOGIES LTD
Patent Owner

Case No. IPR2023-00796
U.S. Patent No. 7,260,141

**PETITION FOR *INTER PARTES* REVIEW
OF U.S. PATENT NO. 7,260,141**

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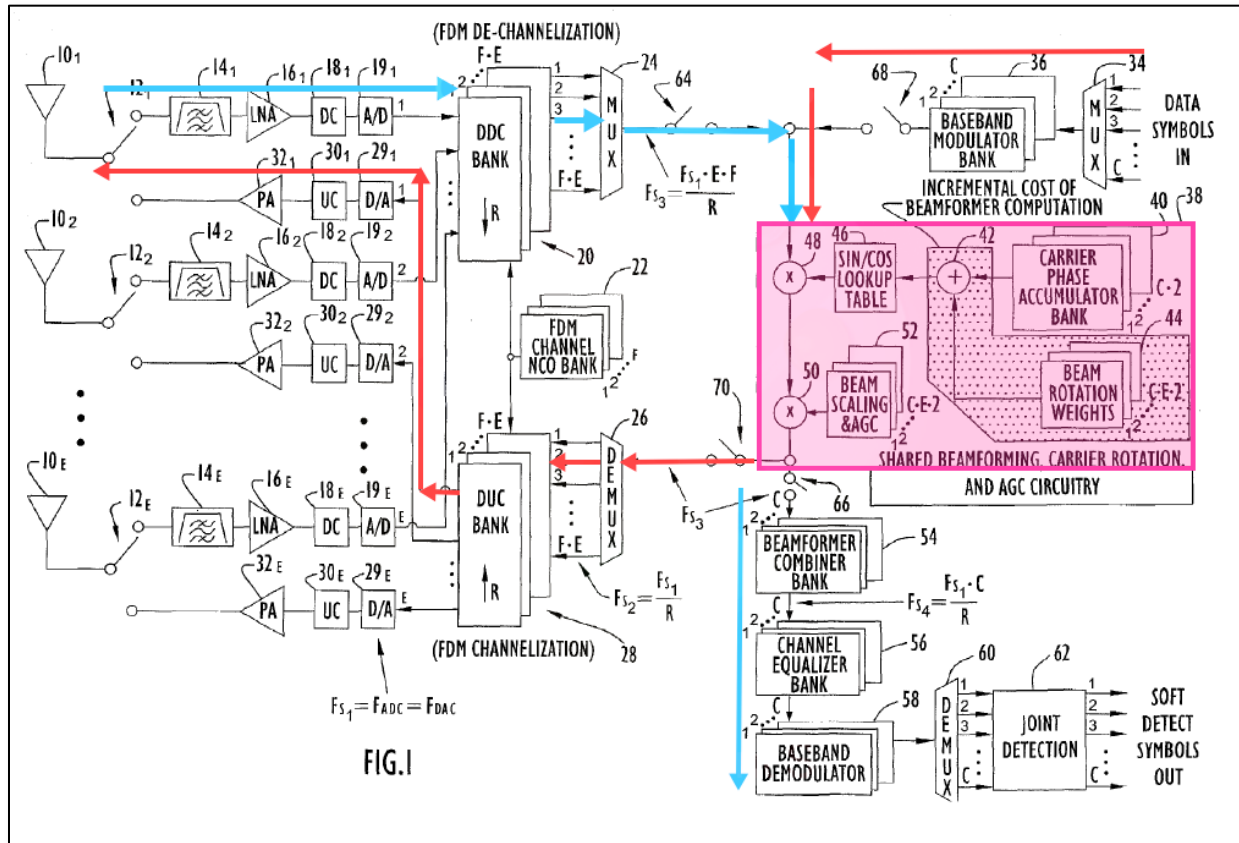
I. INTRODUCTION

Petitioner Apple Inc. (“Petitioner”) requests *Inter Partes* Review (“IPR”) of Claims 1-4, 7-10, and 18-22 (the “Challenged Claims”) of U.S. Patent No. 7,260,141 (“the ’141 Patent”).

II. SUMMARY OF THE ’141 PATENT

A. The ’141 Patent’s Alleged Invention

The ’141 Patent is generally directed to a beamforming transceiver that processes signals to/from each antenna element individually at baseband. ’141 Patent (Ex. 1001), Abstract. The described architecture uses a single shared baseband processor to process both transmit and receive signals on a per-channel basis. *Id.* at 3:33–44, 3:56–60. This architecture is depicted in FIG. 1 below with a sample receive path annotated blue, a sample transmit path annotated red, and the shared processor annotated pink:



Id. at FIG. 1 (annotated).

Beamforming using phased array antennas was well-known in the art. *See, e.g.,* '141 Patent File History (Ex. 1002), 217. Beamforming controls energy from an antenna array via signal processing to shape the radiated energy (i.e., steering gain in some directions while producing nulls or attenuation in other directions). '141 Patent, 1:49–55. An important component of the required signal processing applies phase shifts to signals on a per-antenna element basis. *Id.* at 1:64–67. By choosing the relative phasing of the signals for each antenna element properly, those signals will add in phase in a given direction and cancel in other directions, forming

a directed antenna beam. *Id.* 1:64–67. Beamforming can be performed in either the transmit or receive direction, and the '141 Patent describes both.

Shared baseband processor 38 is responsible for applying phase shifts to the baseband signals for both beamforming and for what the patent refers to as “carrier phase.” *Id.* at 7:63-8:19. As discussed in the proposed ground below, a POSITA would understand the latter adjustment is more commonly referred to as carrier phase offset (CFO) compensation between sending and receiving devices. Phase adder 42 is used to combine the beamforming phase adjustment and carrier phase adjustment such that both features are accommodated in a single phase adjustment for each baseband signal. *Id.* at 8:10–14.

B. Prosecution History of the '141 Patent

The '141 Patent issued from U.S. Application Serial No. 10/084,614 (the “'614 Application”), filed on February 28, 2002, which claims priority to a provisional application filed on February 28, 2001. '141 Patent (Ex. 1001). For purposes of this proceeding only, Petitioner applies February 28, 2001 as the priority date.

In response to the Examiner’s first non-final rejection, the Applicant added and amended claims, clarifying that the claimed baseband signals were digital baseband signals and arguing no combination of the cited art taught applying phases to the signals to account for both beamsteering and carrier phase of individual

antenna elements. '141 Patent File History (Ex. 1002), 231–43. In response to the Examiner's second non-final rejection, the Applicant added and amended claims, clarifying that the beamforming and carrier phase rotations correspond to individual antenna elements and arguing that none of the art taught applying phases to the digital baseband signals to account for both beamsteering and carrier phase of *individual* antenna elements. *Id.* at 284–95. In response to the Examiner's third (final) rejection, the Applicant argued that it was unknown in digital beamforming to apply a carrier signal to a digital baseband signal on an element-by-element basis and that the prior art did not disclose this concept. *Id.* at 328–31.

In response to the Examiner's fourth (non-final) rejection, Applicant amended the claims to clarify that the claimed shared baseband processor applies a “single phase adjustment to each of the digital baseband signals to jointly account for both” beamforming and carrier phase rotation. *Id.* at 351.

C. A Person of Ordinary Skill in the Art

A person of ordinary skill in the art (“POSITA”) at the time of the '141 Patent would have had a bachelor's degree in electrical engineering or equivalent from an accredited academic program with at least two years of work experience in the field

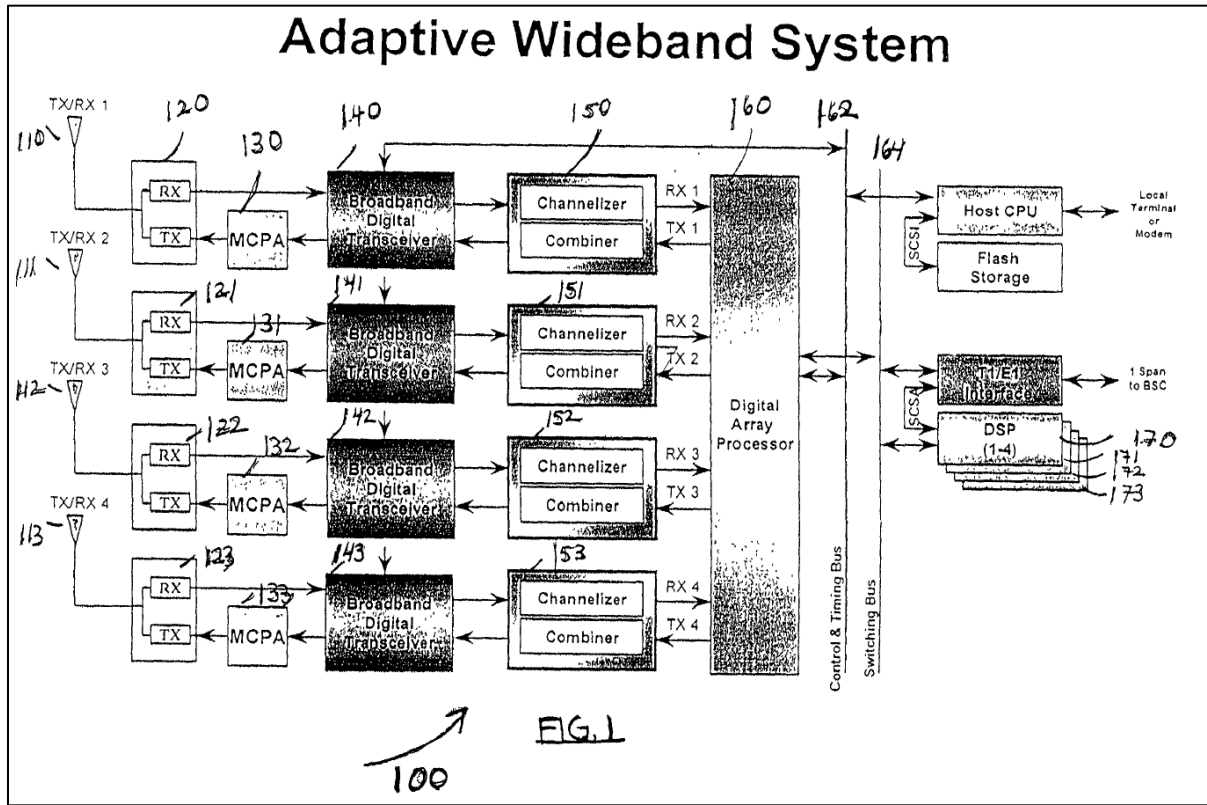
of wireless communications. Additional education or experience might substitute for the above requirements. *Dec.* ¶¶35–37.¹

III. OVERVIEW OF THE PRIOR ART

A. *Williams’s Disclosure*

U.S. Patent Publication No. 2002/0042290 to Williams et al. (“*Williams*”) teaches a digital baseband beamforming system that performs a calibration process to improve the beamforming accuracy. *Williams* (Ex. 1004) ¶¶4, 13–17, 20. *Williams’s* system includes a base transceiver station (BTS) having an adaptive antenna array and at least one remote device which communicates with the BTS. *Id.* at ¶20. *Williams’s* BTS is shown below:

¹ Citations to “*Dec.*” correspond to the supporting declaration of Dr. Zhi Ding, Exhibit 1003.



Id. at FIG. 1. As illustrated, *Williams*'s adaptive antenna array comprises a plurality of antenna elements 110–113 (collectively 110). Each element of *Williams*'s adaptive antenna array has a corresponding transmit apparatus chain and receive apparatus chain comprising discrete physical hardware elements, which introduce phase and frequency errors in each individual chain. *Id.* at ¶14, 36. One goal of *Williams*'s system is to account for these errors to properly perform beamforming and to transmit a coherent signal. *Id.* at ¶14–17. To measure the phase and frequency errors, *Williams* teaches a remote device which uses a “loopback” mode to measure signal shifts for both the transmit and receive apparatus chains. *Id.* at ¶¶55–56. Using

these signal shifts, the BTS calculates calibration factors that are applied at baseband to correct for any phase/frequency errors. *Id.* at ¶¶37, 55–57.

All incoming and outgoing signals pass through digital array processor 160, which is responsible for applying beamforming adjustments. *Id.* at ¶37, FIG. 1. Processor 160 adds calibration factors to the beamforming adjustments (referred to as angular weighting factors) to allow for a single phase adjustment per signal that calibrates and beamforms. *Id.* at ¶¶36–37.

Because *Williams*, like the '141 Patent, discloses a digital wireless communications system, *Williams* is in the same field of endeavor as the '141 Patent. Further, *Williams* is pertinent to a problem sought to be solved by the '141 Patent—performing beamforming at baseband on a per-antenna element basis. *Compare Williams* ¶¶13–17, 33, 37–39, *with* '141 Patent, Abstract, 1:49–67, 3:39–44, 3:56–60, 7:4–9, 8:46–50, 9:32–36. Accordingly, *Williams* is analogous art to the '141 Patent. Dec. ¶¶65–67.

B. *Williams* is § 102(e) Prior Art

Williams, published on April 11, 2002, claims priority to U.S. Provisional Application No. 60/239,859 (the “*Williams-Provisional*”) filed on October 11, 2000. *Williams* (43), (63); *Williams-Provisional* (Ex. 1005). *Williams* was neither cited nor discussed during prosecution of the '141 Patent. '141 Patent, (56).

The claim chart below demonstrates that *Williams*'s claim 1 is supported by *Williams-Provisional*. Therefore, *Williams* is prior art under at least 35 U.S.C. § 102(e) (pre-AIA) based on *Williams-Provisional*'s filing date. *Dynamic Drinkware, LLC v. Nat'l Graphics, Inc.*, 800 F.3d 1375, 1381 (Fed. Cir. 2015); *Polaris Indus., Inc. v. Arctic Cat Inc.*, IPR2016-01713, Paper 9 at 13 (Feb. 27, 2017) (“[O]nly one claim in the prior art patent needs to have support in the provisional.”).

<i>Williams</i> (Ex. 1004)	Supporting Disclosure from <i>Williams-Provisional</i> (Ex. 1005) ²
1. In a wireless communication system having at least one remote device for communicating with a base transceiver station (BTS) and a plurality of mobile stations,	This invention relates to the field of <i>RF communication systems</i>³... P. 3 One method for increasing the efficiency and performance <i>of a cellular system</i> is through the use of adaptive antenna arrays (“adaptive arrays”). P. 3 In the preferred embodiment, <i>a remote wireless translating repeater (“translating repeater”) may be used as the remote device</i> for calibration of an adaptive antenna array included in BTS 200. P. 14-15 The <i>translating repeater receives and re-transmits</i> loopback signals <i>which are received by all antenna elements of the BTS</i> adaptive array. P. 16 When <i>a mobile user accesses the cellular network</i> using a RACH, the BTS 200 will assign the mobile user one of the 8 SDCCHs, unless the mobile is a GPRS mobile. P. 30

² All citations are to *Williams-Provisional* (Ex. 1005).

³ Unless otherwise noted, all emphasis is added by Petitioner.

	A BTS regularly transmits a ‘neighbor list’ over a control channel <i>that mobile users use</i> to determine the frequencies to scan adjacent cells. P. 34 To ensure <i>the mobile periodically transmits to the BTS</i> so that the BTS can determine the location <i>mobile users</i> and assess the interference environment... P. 36.
said BTS having an adaptive antenna array including a plurality of antenna elements,	One method for increasing the efficiency and performance of a cellular system is through the use of <i>adaptive antenna arrays</i> (“adaptive arrays”). P. 3 Thus, <i>an adaptive antenna array</i> can increase the cell size <i>that a given BTS</i> can serve. P. 4 <i>An antenna array consists of N identical antenna elements</i> arranged in a particular geometry. P. 4 <i>BTS 200 shown includes a 4 element antenna array</i> 210-213 (hereafter 210). P. 10
a method for determining calibration factors for respective transmit and receive paths associated with each of said antenna elements, comprising the steps of:	This invention relates to the field of RF communication systems, and more particularly <i>to a system and method for calibration of adaptive antenna arrays</i>. P. 3 Each adaptive array antenna array element requires a separate transceiver chain for operation of the adaptive array. Thus, <i>each antenna element is provided a dedicated receiver apparatus chain and transmit apparatus chain</i>. PP. 5–6. Accurate <i>real-time calibration</i> is required for all receive and transmit apparatus... Thus, <i>for an adaptive antenna array</i> to function properly, <i>frequent calibration of the various transmit and receive apparatus chains</i> should be performed. P. 7 Therefore, there is a need for a method <i>to calibrate all transmit apparatus chains and receive apparatus</i>

	chains without the addition of dedicated calibration hardware such as near and/or far-field transmit sources or receivers. P. 8 In another calibration method, a translating repeater is placed (or if already used in the cellular system, utilized) at a known location with respect to BTS 200. P. 21 Relative signal shift values between each antenna receive apparatus chain adjusted for free space path differences between the translating repeater and the various antenna elements allows the determination of calibration factors which enable the BTS 200 to compensate for variations between the uplink path transfer function for each receive apparatus chain. The BTS 200 may also determine calibration factors for each transmit apparatus chain using this method. P. 22.
transmitting a downlink signal from said BTS to said remote device from each of said antenna elements;	To initiate of the calibration process, the translating repeater is signaled by the BTS to enter a loopback mode. In the loopback mode, received signals are frequency shifted by the translating repeater and then redirected back to the BTS. P. 21 The BTS 200 transmits a loopback signal, such as a GSM access burst, from each antenna element, one at a time. The translating repeater receives and re-transmits loopback signals which are received by all antenna elements of the BTS adaptive array. P. 16 All signals transmitted from each antenna element are received by the translating repeater. P. 21 To initiate the calibration process, the translating repeater is signaled to enter a loopback mode. The BTS transmits differing calibration signals (e.g. tones) from each of its antenna elements, all at a first carrier frequency. A composite calibration signal having the plurality of tones is received by the translating repeater and looped back (frequency shifted) to the BTS. P. 24

retransmitting from said remote device said downlink signals back to said BTS as at least one uplink signal;	The BTS 200 transmits a loopback signal, such as a GSM access burst, from each antenna element, one at a time. The <i>translating repeater receives and re-transmits loopback signals</i> which are received by all antenna elements of the BTS adaptive array. P. 16 All signals transmitted from each antenna element are received by the translating repeater. In the loopback mode, <i>the translating repeater mixes the individual signals containing the individual tones to form a composite signal containing all the tones...</i> The single frequency shifted composite signal containing all the <i>tones is transmitted by the translating repeater and received by the adaptive antenna array</i>. P. 21-22 To initiate of the calibration process, the translating repeater is signaled by the BTS to enter a loopback mode. In the loopback mode, <i>received signals are frequency shifted by the translating repeater and then redirected back to the BTS</i>. P. 21
receiving said uplink signal at said BTS, and	The method requires the total delay and magnitude shift (collectively the “signal shift”) for a round trip (TD) of a loopback signal transmitted <i>and received by BTS 200</i> to be measured. P. 15 The translating repeater receives and re-transmits loopback signals which <i>are received by all antenna elements of the BTS adaptive array</i>. P. 16 The single frequency shifted composite signal containing all the tones is transmitted by the translating repeater <i>and received by the adaptive antenna array</i>. P. 22
determining calibration factors for said respective transmit and receive paths.	These composite amplitude and phase errors in a given antenna signal path can be captured... and <i>a set of receive and transmit calibration factors calculated to equalize... the various receive and transmit apparatus chains</i>. P. 6

	<i>[T]he adaptive antenna system will have both transmit and a receive calibration factors.... P. 7</i> Signal shifts for each receive apparatus chain may be measured <i>and calibration factors determined from resulting receive apparatus chain signal shifts</i> measured from receipt of any one of the returned loopback signals originally transmitted by BTS from any antenna element. P. 16 <i>[T]ransmit apparatus chain calibration factors can be determined. ... Since signal shifts are frequency dependent, the calibration process for both transmit and receive apparatus chains are generally repeated for all carrier frequencies supported by BTS 200. Once the receive and transmit chain calibration factors are calculated and stored by the BTS... P. 17</i> Relative signal shift values between each antenna <i>receive apparatus chain... allows the determination of calibration factors</i> which enable the BTS 200 to compensate for variations between... <i>each receive apparatus chain. The BTS 200 may also determine calibration factors for each transmit apparatus chain using this method. P. 22</i>
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Additionally, all portions of *Williams* cited in the proposed ground below appear substantially identically in *Williams-Provisional*. Accordingly, the disclosure relied on to meet challenged claim limitations is entitled to *Williams-Provisional's* filing date.

C. Overview of *Fulton*

U.S. Patent No. 5,604,768 to Fulton (“*Fulton*”) (Ex. 1006) was filed on December 21, 1994, issued on February 18, 1997, and is prior art to the ’141 Patent under at least 35 U.S.C. § 102(a) and (e) (pre-AIA). *Fulton* (22), (45). *Fulton* was neither cited nor discussed during prosecution of the ’141 Patent. ’141 Patent, (56).

Fulton relates to radio communication systems with accurate frequency and phase control. *Fulton*, 1:11–16, 1:52–65, 3:22–25. *Fulton* teaches multiple embodiments of a radio system containing a continuous data demodulator, which in turn contains a “rotator” that applies a phase rotation to a digital baseband signal. *See, e.g., id.* at 10:66–11:29. One embodiment is depicted in Fig. 10 below:

3:22–30, 11:44–54, *with* ’141 Patent, Abstract, 1:49–67, 3:39–44, 3:56–60, 7:4–9, 8:46–50, 9:32–36. Accordingly, *Fulton* is analogous art to the ’141 Patent. Dec. ¶¶77–79.

D. Overview of *Trott*

U.S. Patent No. 6,836,673 to Trott (“*Trott*”) (Ex. 1007) was filed on December 22, 2000, issued on December 28, 2004, and is prior art to the ’141 Patent under at least 35 U.S.C. § 102(e) (pre-AIA). *Trott* (22), (45). *Trott* was neither cited nor discussed during prosecution of the ’141 Patent. ’141 Patent, (56).

Trott relates to mitigating co-channel and inter-channel interference in antenna arrays with signal weighting. *Trott*, Abstract. *Trott* envisions utilizing its invention in “systems wherein beamforming strategy is dynamically determined based on a changing signal and interference environment.” *Id.* at 9:19–21.

Because *Trott*, like the ’141 Patent, discloses a digital wireless communications system, *Trott* is in the same field of endeavor as the ’141 Patent. *Compare Trott*, Abstract, 6:20–41, 7:3–13, 7:25–32, *with* ’141 Patent, Abstract, 1:49–67, 3:39–44, 3:56–60, 7:4–9, 8:46–50, 9:32–36. Accordingly, *Trott* is analogous art to the ’141 Patent. Dec. ¶¶82–84.

IV. PROCEDURAL REQUIREMENTS UNDER 37 C.F.R. § 42.104

A. Standing Under 37 C.F.R. § 42.104(A)

Petitioner certifies that the ’141 Patent is available for IPR and that Petitioner is not barred or estopped from requesting an IPR challenging the claims of the ’141

Patent. Specifically, (1) Petitioner is not the owner of the '141 Patent, (2) Petitioner has not filed a civil action challenging the validity of the claim of the '141 Patent, and (3) this Petition is filed less than one year after the Petitioner was served with a complaint alleging infringement of the '141 Patent.

B. Challenge Under 37 C.F.R. § 42.104(B) and Relief Requested

In view of the prior art and evidence presented, claims 1-4, 7-10, and 18-22 of the '141 Patent are unpatentable and should be cancelled. 37 C.F.R. § 42.104(b)(1). Further, based on the prior art references identified below, IPR of the Challenged Claims should be granted. 37 C.F.R. § 42.104(b)(2).

Proposed Ground of Unpatentability	Exhibits
<u>Ground 1:</u> Claims 1-4, 7-10, 18, 19, and 22 are obvious under pre-AIA 35 U.S.C. § 103 over <i>Williams</i> in view of <i>Fulton</i> .	Ex. 1004 Ex. 1006
<u>Ground 2:</u> Claims 20 and 21 are obvious under pre-AIA 35 U.S.C. § 103 over <i>Williams</i> in view of <i>Fulton</i> and in further view of <i>Trott</i> .	Ex. 1004 Ex. 1006 Ex. 1007

Section IV identifies where each element of the Challenged Claims is found in the prior art. 37 C.F.R. § 42.104(b)(4). The exhibit numbers of the evidence relied upon to support the challenges are provided above and the relevance of the evidence to the challenges raised is provided in Section IV. 37 C.F.R. § 42.104(b)(5). **Exhibits 1001-1031** are also attached.

C. Claim Construction Under 37 C.F.R. § 42.104(B)(3)

In this proceeding, claims are interpreted under the same standard applied by Article III courts (i.e., the *Phillips* standard). *See* 37 C.F.R. § 42.100(b); *see also* 83 Fed. Reg. 197 (Oct. 11, 2018); *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312 (Fed. Cir. 2005) (*en banc*). Under this standard, words in a claim are given their plain meaning, which is the meaning understood by a person of ordinary skill in the art in view of the patent and file history. *Phillips*, 415 F.3d 1303, 1312–13.

In the parallel litigation, Patent Owner contends that no claim language requires express construction. For purposes of this petition, Petitioner proposes that the Board apply Patent Owner’s position and not expressly construe any claim language. *Western Digital Corporation v. Spex Technologies, Inc.*, IPR2018-00084, Paper 14, *11 (PTAB Apr. 25, 2018).

V. THE CHALLENGED CLAIMS ARE UNPATENTABLE

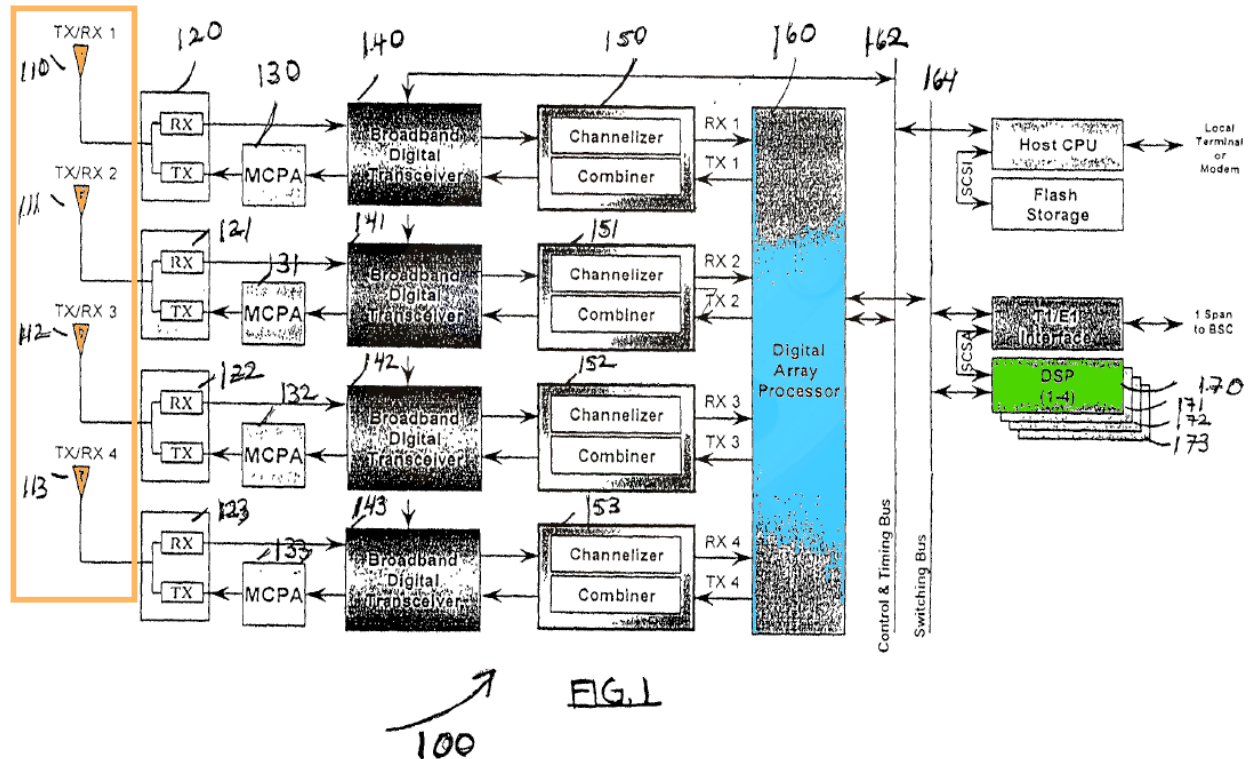
A. Ground 1: Claims 1-4, 7-10, 18, 19, and 22 are obvious under pre-AIA 35 U.S.C. § 103 over *Williams* in view *Fulton*.

i. Claim 1

[1(P)] An apparatus for modulating and demodulating signals transmitted and received via an electronically steerable phased array antenna comprising a plurality of antenna elements, the apparatus comprising:

Williams teaches the preamble. *Williams* discloses a “base transceiver station (BTS) having **an adaptive antenna array**[.]” *Williams* ¶20, FIG. 1. Annotated FIG. 1, below, illustrates BTS 100.

Adaptive Wideband System



Id. at FIG. 1 (annotated).

Williams’s BTS 100 modulates and demodulates signals, as claimed. Namely, BTS 100 includes four identical DSP 170–173 (collectively 170), whose “processed (*modulated and encoded*) outputs are supplied to the digital array processor 160[.]”

Id. at ¶39. Similarly, during reception, “DSP 170 receives the signal components ... output by the digital array processor 160 and *demodulates these signals* to recover the combined beamformed communication signal.” *Id.* at ¶38, FIG. 1.

Williams also teaches an electronically steerable adaptive antenna array (i.e., phased array antenna) comprised of a plurality of antenna elements. *Williams*’s BTS 100 “includes a 4 element antenna array,” and *Williams* teaches “BTS 100 can have

any number of antenna elements provided at least two elements are provided.” *Id.* at

¶33. Thus, *Williams* teaches BTS 100’s adaptive antenna array is comprised of a plurality of antenna elements (annotated orange, above).

Williams also teaches that its adaptive antenna arrays are electronically steerable. *Williams* teaches that its antenna arrays provide increased antenna gain and digital beamforming. *Id.* at ¶¶7–8 (“By ***steering*** a beam and positioning multiple nulls, an adaptive array is able to reduce ... interference.”). *Williams* describes a standard beamforming approach:

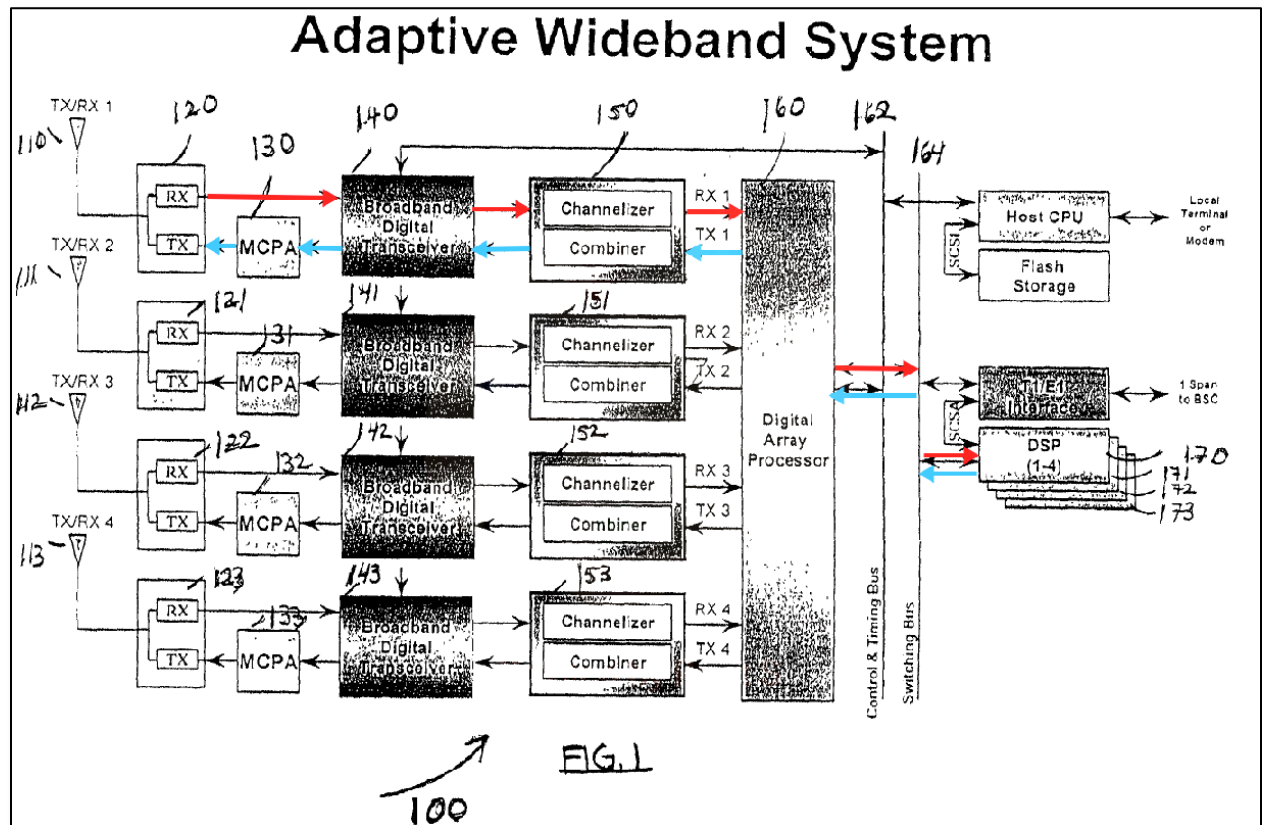
For any given geometry, ***the phases and amplitudes of the currents exciting the array*** ... determine the gain of the array in a certain direction. ***The phases and amplitudes of the currents on the antenna array elements can be electronically adjusted*** such that ... maximum gain is achieved in that direction.

Id. at ¶10. Although *Williams* does not expressly describe its antenna as a “phased array” antenna, a POSITA would have understood that the terms “adaptive array” and “adaptive phased array” were interchangeably used in the art to describe the same technology. Dec. ¶¶86–88 (discussing Ex. 1008, Mark C. Roh, “A Base Station Smart Antenna System for CDMA Cellular,” Massachusetts Institute of Technology, 1997).

Finally, *Williams* teaches that the signals BTS 100 modulates/demodulates are transmitted and received via the adaptive antenna array (i.e., adaptive phased array

antenna). “Each antenna element has a dedicated receive apparatus chain....”

Williams, ¶34 (depicted in red below). Similarly, “[e]ach antenna element has a dedicated transmit apparatus chain....” *Id.* at ¶39 (depicted in blue below).



Id. at FIG. 1 (annotated).

“For the receive path ... **DSP 170** receives the signal components ... from each receive apparatus chain output by the digital array processor 160 **and demodulates these signals....**” *Id.* at ¶38. “System operation in the transmit direction is quite similar to the receive direction.... DSPs 170 are associated with specific antenna elements 110 and a specific frequency channel for processing ...

communication *signals to be transmitted*.... Their processed (*modulated and encoded*) outputs are supplied to the digital array processor 160[.]” *Id.* at ¶39.

[1(a)] a baseband modulator configured to modulate outbound digital baseband signals to be transmitted via the phased array antenna;

As set forth above with reference to [1(pre)], BTS 100 includes DSPs 170, which modulate outbound signals to be transmitted.

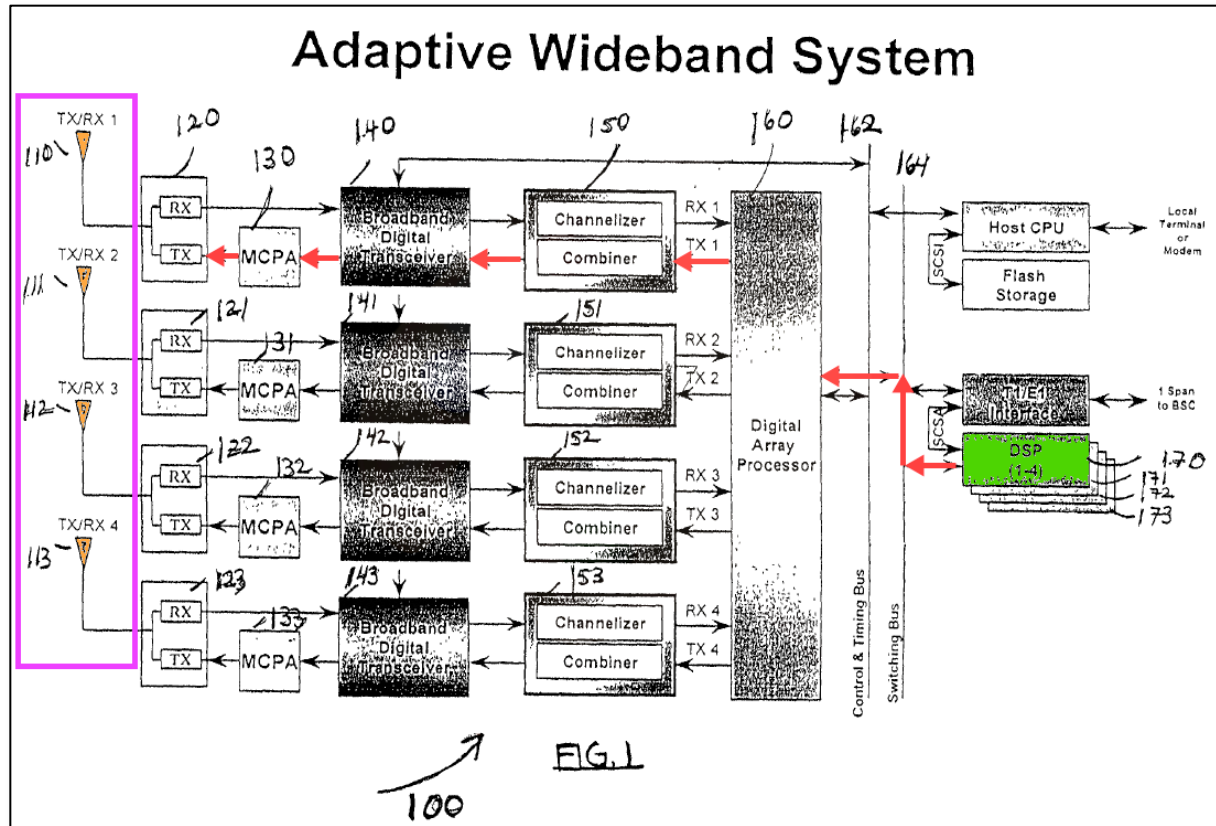
In the transmit direction, *Williams* teaches “DSPs 170 *are associated with specific antenna elements 110* and a specific frequency channel for processing ... communication *signals to be transmitted*.... Their processed (*modulated and encoded*) outputs are supplied to the digital array processor 160[.]” *Williams*, ¶39. In turn, the outputs of digital array processor 160 are input into a combiner 150, which outputs into a broadband digital transceiver 140, followed by multi-carrier power amplifier 130, RF elements 120, and ultimately antenna elements 110 for radiation and transmission (collectively, a “transmit apparatus chain,” depicted in blue in the above annotated FIG. 1). *Id.* at ¶40. *Williams* also teaches transmitting these signals via a phased array antenna, as set forth above with reference to [1(pre)].

Williams also discloses that DSPs 170 modulate digital baseband signals. “For the transmit path, the phase and amplitude net weighting factors are preferably applied after the DSP 170 (*modulation*) and before the XMUX 150 (digital combiner). *At these points in the signal path, each signal ... is a baseband signal*

having an I and Q representation.” *Id.* at ¶39. Thus, *Williams* teaches DSPs 170 are baseband modulators, as claimed.

Williams also teaches these baseband signals are digital because the baseband signals are being operated upon by DSPs 170 (i.e., **digital** signal processors) and XMUX 150 (**digital** combiners). *Id.* at ¶39. Further, *Williams* teaches “a receive apparatus chain may include an antenna element, cables ... and **an analog-to-digital converter, assuming the processing is digital.**” *Id.* at ¶14. *Williams* then teaches “a **digital** beamforming base transceiver station (BTS)... includ[ing] a 4 element antenna array....” *Id.* at ¶33. Finally, *Williams* teaches “broadband digital transceiver 140 performs A/D conversion” in the receive direction. *Id.* at ¶35. Because *Williams* teaches “operation in the transmit direction is quite similar to the receive direction[,]” and broadband digital transceiver 140 is part of the transmit apparatus chains as well, a POSITA would have understood the transmit-direction baseband signals from DSPs 170 are also digital. Dec. ¶¶89–91.

In sum, *Williams* teaches **DSPs 170** (i.e., **digital** signal processors) **modulate** outbound digital baseband signals, which are passed through their respective **transmit apparatus chains** until they reach **antenna elements 110**. *Williams*, ¶¶39–40. Annotated FIG. 1, below, depicts an example transmit apparatus chain in **red**.



Id. at FIG. 1 (annotated). Antenna elements 110 collectively form BTS 100's adaptive antenna array, and collectively transmit the signals modulated by DSPs 170. *Id.* at ¶¶20, 33, 40. Thus, Williams's DSPs 170, either individually or collectively, are "a baseband modulator configured to modulate outbound digital baseband signals to be transmitted via the phased array antenna[.]" as claimed.

[1(b)] a baseband demodulator configured to demodulate incoming digital baseband signals generated from signals received via the phased array antenna; and

As set forth above with reference to [1(pre)], BTS 100 includes DSPs 170, which demodulate incoming signals received via the adaptive antenna array.

Williams teaches each receive apparatus chain begins with antenna elements 110, which collectively form the adaptive array antenna: “BTS 100 shown includes a 4 element antenna array [] (hereafter 110).” *Williams*, ¶33, FIG. 1. “**Each antenna element** has a dedicated receive apparatus chain comprising filter/duplexer 120[], broadband digital transceiver 140[], channelizer/combiner 150[] and associated connectors **inclusive of digital signal processors 170[]**.” *Id.* at ¶34. *Williams* then discloses “**baseband digital signals**, respectively associated with each antenna element 110, can then [be] communicated to a processor, such as digital array processor 160.” *Id.* at ¶35. *Williams* continues, “[f]or the receive path ... **DSP 170 receives** the signal components ... **from each receive apparatus chain output by the digital array processor 160 and demodulates these signals** to recover the combined beamformed communication signal.” *Id.* at ¶38.

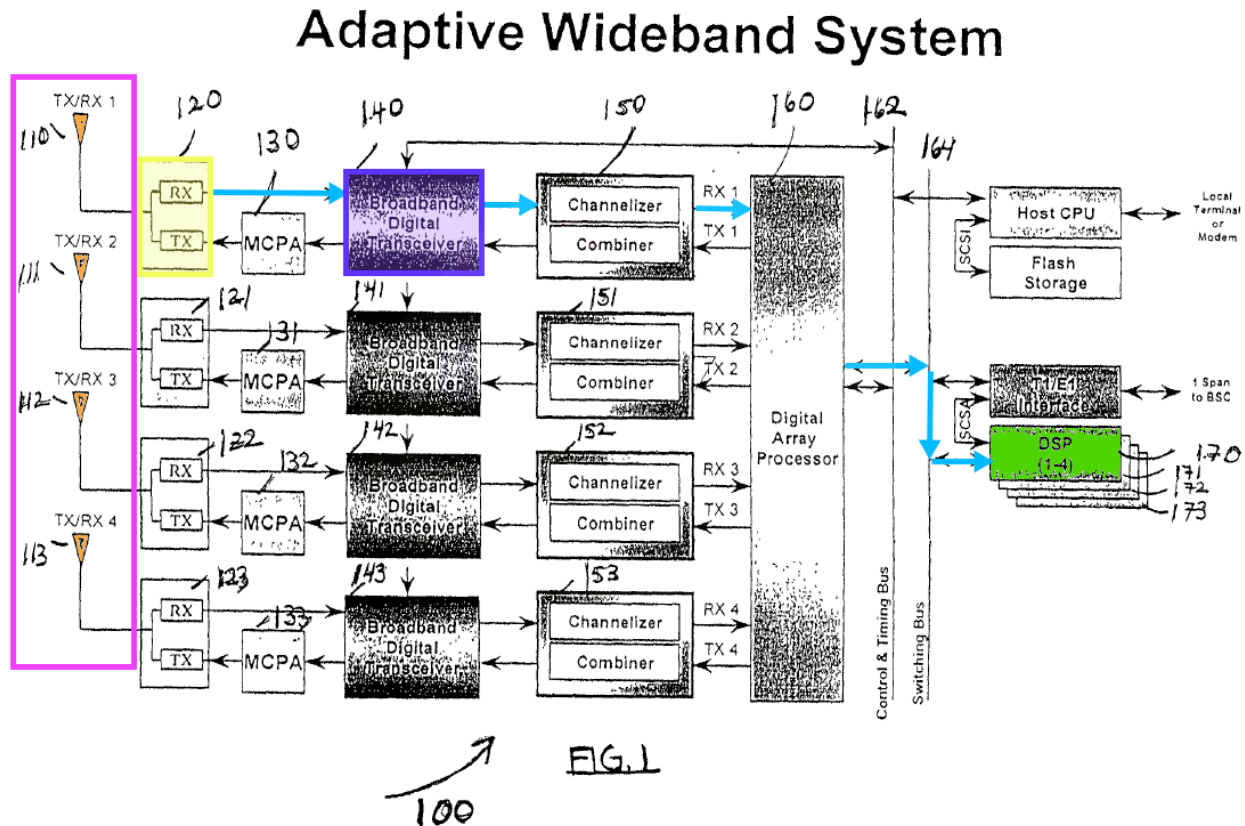
And as set forth above with reference to [1(pre)] and [1(a)], antenna elements 110 collectively comprise an adaptive antenna array (i.e., the claimed phased array antenna). *Id.* at ¶¶7–9 (explaining how an adaptive antenna array functions, and “[a]n antenna array consists of N identical antenna elements arranged in a particular geometry”), 20 (“The system includes a base transceiver station (BTS) **having an adaptive antenna array...**”), 33 (“BTS 100 shown includes a 4 element antenna array [] (hereafter 110).”). Thus, *Williams* teaches DSPs 170 demodulate incoming

signals received via the phased array antenna (i.e., *Williams*'s adaptive antenna array), as claimed.

Williams also teaches DSPs 170 operate on digital baseband signals generated from signals received via the phased array antenna. First, “[f]ilter/duplexer 120 performs amplification, filtering and down conversion to IF of received RF signals.” *Id.* at ¶34. Then, “broadband digital transceiver 140 performs A/D conversion then digitally down-converts received signals. The multi-channel digital signal ... is separated by channelizer 150 *into baseband digital signals* having an I and Q representation for each active channel.” *Id.* at ¶35. *Williams* continues, “[t]he baseband digital signals ... can then [be] communicated to a processor, such as *digital* array processor 160.” *Id.* at ¶35. Finally, *Williams* teaches “DSP 170 receives the signal components ... output by the digital array processor 160 and demodulates these signals to recover the combined beamformed communication signal.” *Id.* at ¶38. Since all signals in the receive apparatus chain following broadband digital transceiver 140 are digital baseband signals, DSPs 170 demodulate digital baseband signals generated from signals received via the phased array antenna, as claimed.

In sum, *Williams* teaches **DSPs 170** (i.e., *digital* signal processors) *demodulate* incoming digital baseband signals, which are received from their respective **transmit apparatus chains** originating at **antenna elements 110**. *Williams*

¶¶34–35, 38. Annotated FIG. 1, below, depicts an example receive apparatus chain in blue.

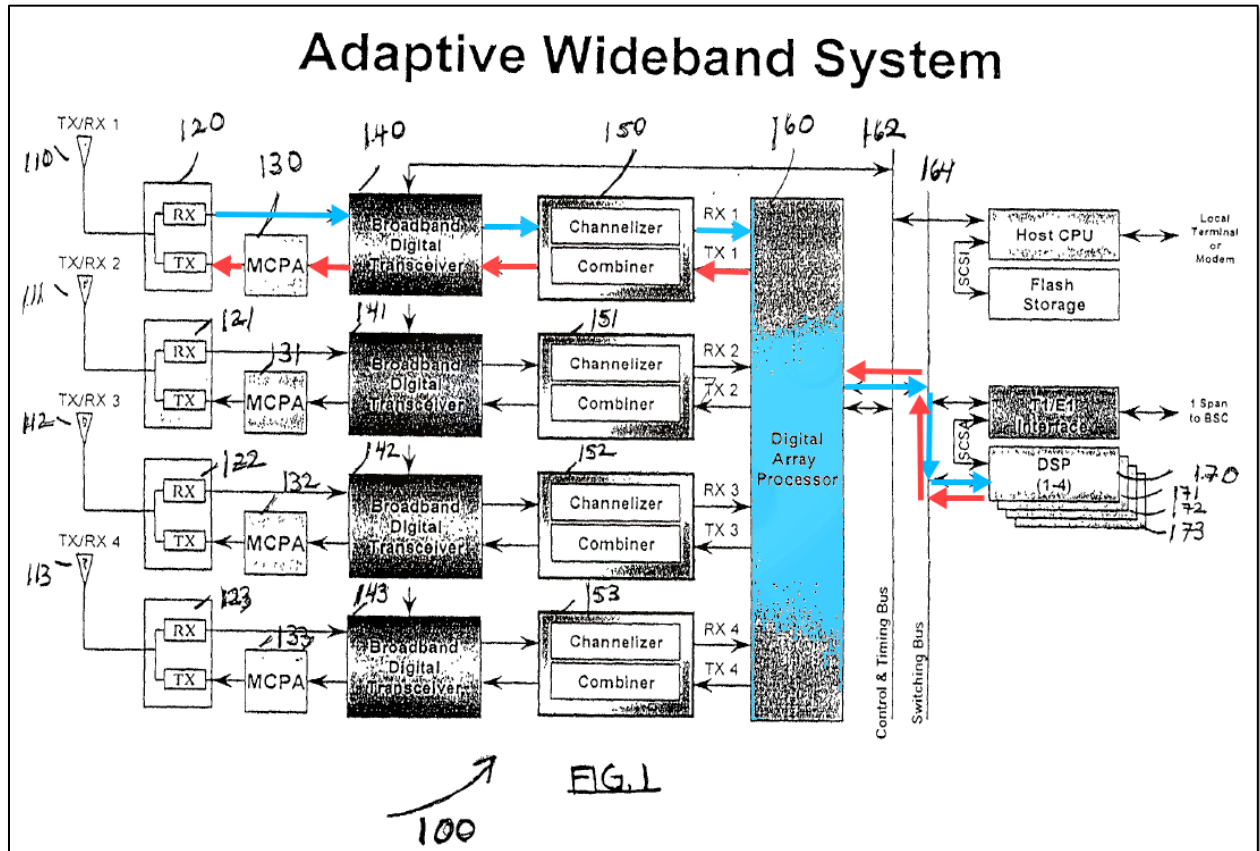


Id. at FIG. 1 (annotated). Antenna elements 110 collectively form BTS 100's adaptive antenna array, which generates signals as it receives incoming RF signals. *Id.* at ¶¶33–34, Dec. ¶¶95–96. These RF signals are downconverted in filter/duplexer 120 (yellow) to IF, and further downconverted and digitized in broadband digital transceiver 140. Williams ¶35. Broadband digital transceiver 140 outputs digital baseband signals, which pass through channelizer 150, digital array processor 160, and which are ultimately input into DSPs 170, which demodulate the incoming digital baseband signals. Williams, ¶¶34–35, 38. Thus, Williams's DSPs 170, either

individually or collectively, are “a baseband demodulator configured to demodulate incoming digital baseband signals generated from signals received via the phased array antenna[,],” as claimed.

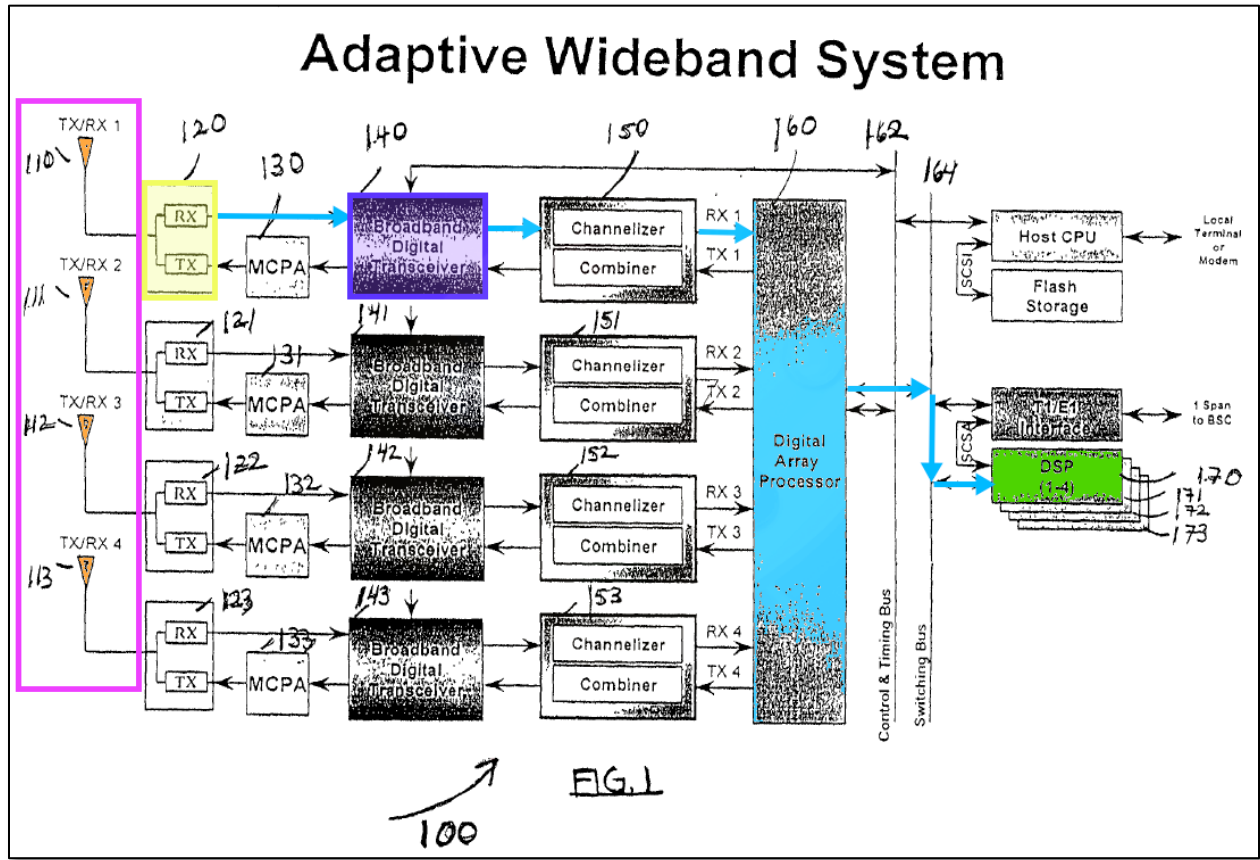
[1(c)] a shared baseband processor configured to receive digital baseband signals including the modulated outbound digital baseband signals and the incoming digital baseband signals,

Williams's digital array processor 160 is a shared baseband processor that performs beamforming and gain control for all channels in both the transmit and receive directions. *Williams*, ¶¶37 (“digital array processor 160 can adjust the baseband digital signals received from and for transmission by each antenna element 110 to beamform each active channel”), 10 (“For any given geometry, the phases and amplitudes of the currents exciting the array elements as well as the number of array elements determine the gain of the array in a certain direction”). Furthermore, as depicted in FIG. 1 below, both **transmit** and **receive** paths pass through **digital array processor 160**.



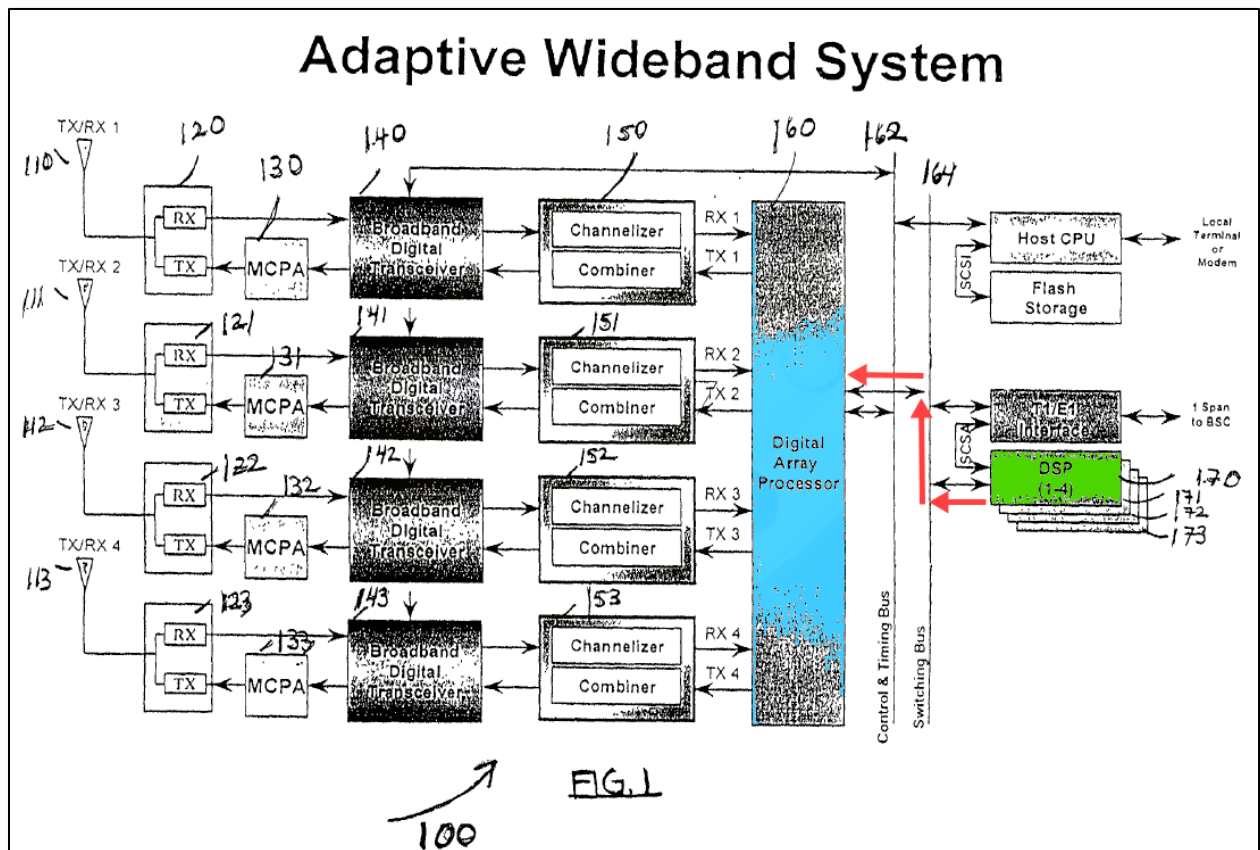
Id. at FIG. 1 (annotated).

The modulated outbound signals and incoming signals processed by **digital array processor 160** are baseband signals. With respect to the receive direction, BTS 100's **adaptive antenna array** receives incoming signals and passes those signals to filter/duplexer 120 (yellow) for downconversion to IF, as depicted in FIG. 1 below:



Id. at FIG. 1 (annotated). IF signals pass along the blue line (indicating an example receive apparatus chain) to **broadband digital transceiver 140**. *Id.* at ¶35, FIG. 1. “The **broadband digital transceiver 140** performs A/D conversion then digitally down-converts received signals. *The multi-channel digital signal* output by the broadband digital transceiver 140 is separated by channelizer 150 *into baseband digital signals* having an I and Q representation for each active channel.” *Id.* at ¶35. The signals exiting channelizer 150, in turn, “can then [be] communicated to a processor, such as **digital array processor 160**.” *Id.* at ¶35. Thus, digital array processor receives the incoming digital baseband signals, as claimed.

Williams's transmit direction is similar. Namely, *Williams* teaches “**DSPs 170** are associated with specific antenna elements 110 and a specific frequency channel for processing ... communication *signals to be transmitted*.... Their processed (*modulated and encoded*) outputs are supplied to the digital array processor 160[.]” *Id.* at ¶39. This is illustrated in annotated FIG. 1 below:



Id. at FIG. 1 (annotated). “For the transmit path, the phase and amplitude net weighting factors are preferably applied after the DSP 170 (*modulation*) and before the XMUX 150 (digital combiner). *At these points in the signal path, each signal ... is a baseband signal* having an I and Q representation.” *Id.* at ¶39. Accordingly,

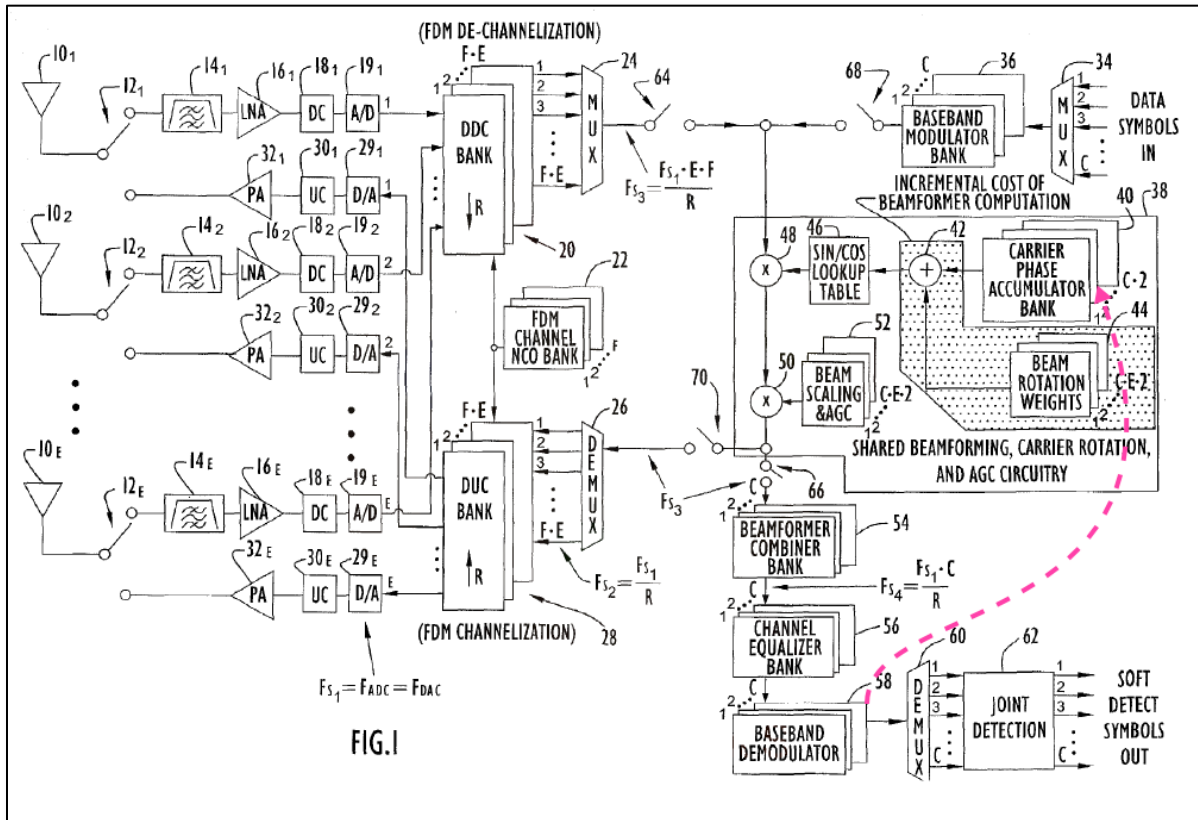
Williams teaches digital array processor 160 receives modulated outbound digital baseband signals, as claimed.

[1(d)] said shared baseband processor applying a single phase adjustment to each of the digital baseband signals to jointly account for both beamforming phase rotation and carrier phase rotation of individual antenna elements.

As demonstrated above with respect to claims [1(a)], [1(b)], and [1(c)], *Williams* teaches digital array processor 160 processes digital baseband signals. Similarly, as demonstrated above with respect to claim [1(c)], digital array processor 160 is a shared baseband processor, as claimed. As set forth below, *Williams* teaches that its shared baseband processor applies beamforming phase rotations to signals in both transmit and receive directions and also teaches that this phase rotation is combined (i.e., summed) with a calibration factor such that only a single phase adjustment is made to account for both beamforming and calibration. As further set forth below, a POSITA would have been motivated to supplement *Williams* with the carrier phase rotation disclosed by *Fulton* to correct for carrier phase offset and would have been motivated to implement this phase rotation summed with *Williams*'s beamforming adjustment. Before addressing this combination, however, it is helpful to briefly discuss the meaning of the claimed carrier phase rotation in the '141 Patent.

'141 Patent's Carrier Phase Rotation

Regarding “carrier phase rotation[,]” the '141 Patent explains “to support signal modulation and demodulation, baseband processors typically perform the functions of carrier phase tracking (involving carrier phase rotation) and automatic gain control...” '141 Patent, 7:4–7. “In the receive case, the NCO's of the carrier phase accumulator bank 40 respectively track the carrier phase of the signal in each of the C user channels based on feedback from a phase discriminator within the corresponding baseband demodulator 58.” *Id.* at 9:32-36. A POSITA would understand this to mean that baseband demodulator 58's phase discriminator measures the difference between the received signal's carrier phase and the expected carrier phase, and provides feedback regarding this difference to phase accumulator bank 40. Dec. ¶98. This feedback is depicted in annotated FIG. 1 below:



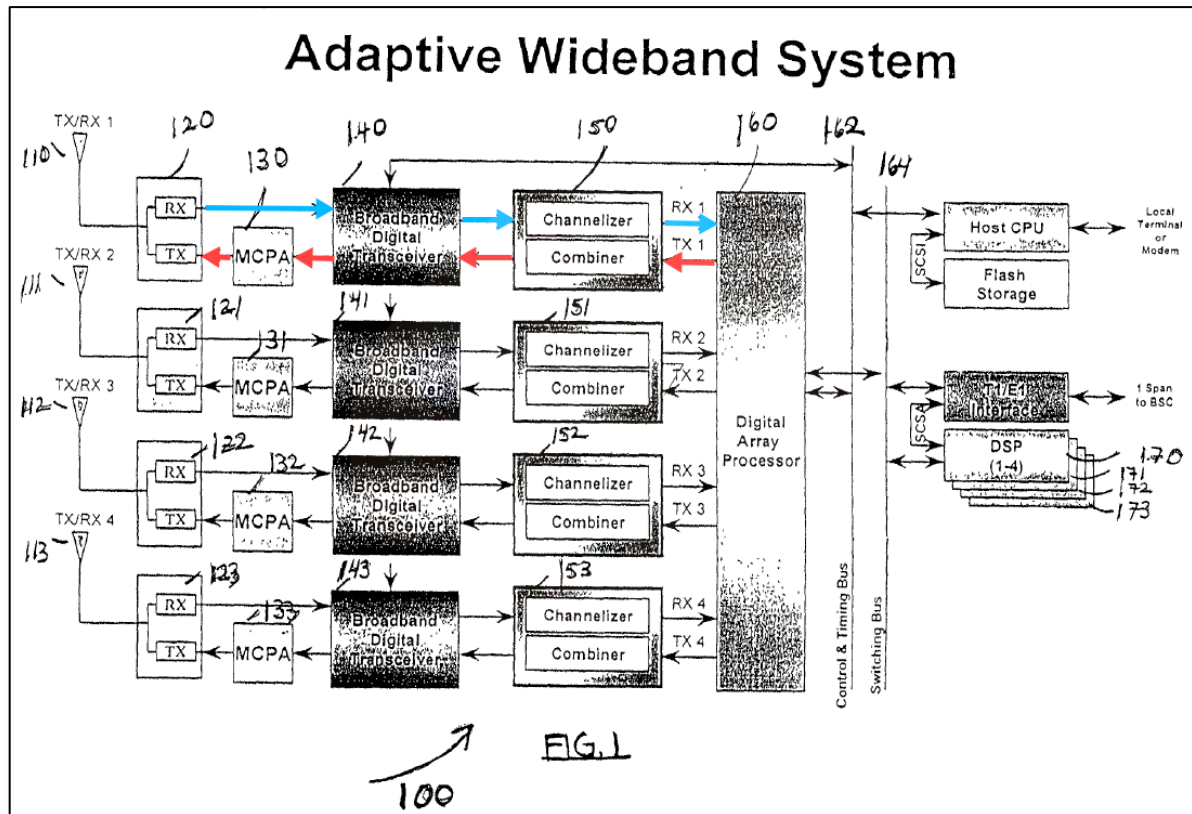
Id. at FIG. 1 (annotated). A POSITA would understand this process of accounting for phase offset is generally referred to as accounting for carrier phase offset (CFO). Dec. ¶¶46–47, 98–99. Although the Challenged Claims appear to require a carrier phase adjustment in the transmit direction, the '141 Patent does not provide detail about calculating or applying carrier phase rotation in the transmit direction. Further, a POSITA would have understood that CFO is generally accounted for only in the received path and not in the transmit direction. *Id.* That said, as discussed below, *Fulton's* disclosed process does perform phase adjustments in both the transmit and receive directions to account for CFO.

Williams's Teachings

Williams's digital array processor 160 applies a beamforming phase rotation to each of the digital baseband signals on an antenna element-by-element basis. First, with respect to beamforming, *Williams* teaches “[f]or any given [antenna array] geometry, the phases and amplitudes of the currents exciting the array elements as well as the number of array elements determine the gain of the array in a certain direction.” *Williams*, ¶10. *Williams* likewise teaches “digital beamforming” wherein “[t]he phases and amplitudes of the currents . . . on the antenna array elements can be electronically adjusted such that . . . maximum gain is achieved in that direction.” *Id.*

Second, *Williams* applies phase rotations on an antenna element-by-element basis to achieve/adjust beamforming. *Williams* teaches the “multi-channel digital signal output by the broadband digital transceiver 140 *is separated* by channelizer 150 *into baseband digital signals* having an I and Q representation *for each active channel*.” *Id.* at ¶35. Further, “[t]here is preferably one channelizer 150 *provided for each antenna element 110*.” *Id.* at ¶35. Exiting channelizer 150, “[t]he baseband digital signals, *respectively associated with each antenna element 110*, can then [be] communicated to... digital array processor 160.” *Id.* at ¶35. Finally, “digital array processor 160 *can adjust the baseband digital signals* received from and for transmission *by each antenna element 110 to beamform each active channel*.” *Id.*

at ¶37. Further, *Williams*'s FIG. 1 depicts each of the **transmit** and **receive** apparatus chains, and their corresponding signals, entering digital array processor 160 separately (i.e., with the signals from each receive/transmit apparatus chain entering/exiting the processor independently of the remaining apparatus chains).



Id. at FIG. 1 (annotated). Thus, *Williams* teaches digital array processor 160 applies the claimed beamforming phase rotation to each of the digital baseband signals to account for beamforming phase rotation of individual antenna elements, as contemplated and claimed in the '141 Patent.

Williams also teaches a calibration process, which accounts for phase and frequency differences that occur in the distinct signal paths for each antenna element.

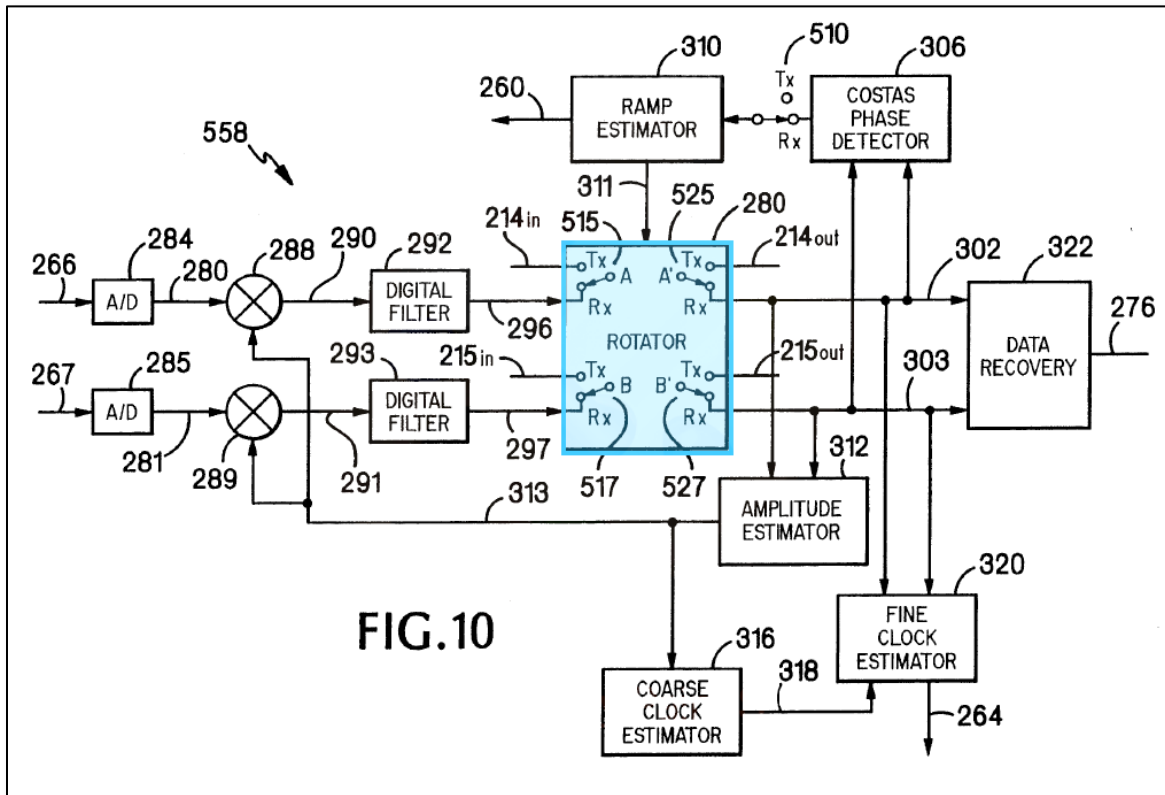
Indeed, one goal of *Williams*'s system is to account for these signal path errors to properly perform beamforming and to transmit a coherent signal. *Id.* at ¶14–17. To measure the phase and frequency errors, *Williams* teaches a remote device which uses a “loopback” mode to measure signal shifts for both the transmit and receive apparatus chains. *Id.* at ¶¶55–56. Using these signal shifts, the BTS calculates calibration factors that are applied at baseband to correct for any phase/frequency errors. *Id.* at ¶¶37, 55–57. As noted above, all incoming and outgoing signals pass through digital array processor 160, which is responsible for applying beamforming adjustments. *Id.* at ¶37, FIG. 1. Processor 160 adds calibration factors to the beamforming adjustments (referred to as angular weighting factors) to allow for a single phase adjustment per signal that calibrates and beamforms. *Id.* at ¶¶36–37.

Although *Williams* does add and jointly apply its beamforming and calibration phase adjustments, it does not teach in detail whether a carrier phase adjustment is also applied in this single phase adjustment. As set forth below, a POSITA would have been motivated to do so pursuant to *Fulton*'s teachings, because a POSITA would have recognized that carrier phase rotation (i.e., CFO compensation) would be an issue facing many transmission systems. Dec. ¶46–47, 98, 102–07.

Fulton's Teachings

Fulton teaches a method and system for frequency synchronized bidirectional radio communications. *Fulton*, 4:6–8. In the receive direction, *Fulton*'s system

utilizes a continuous data demodulator 558 (depicted in detail below in FIG. 10). *Id.* at 11:55–56.

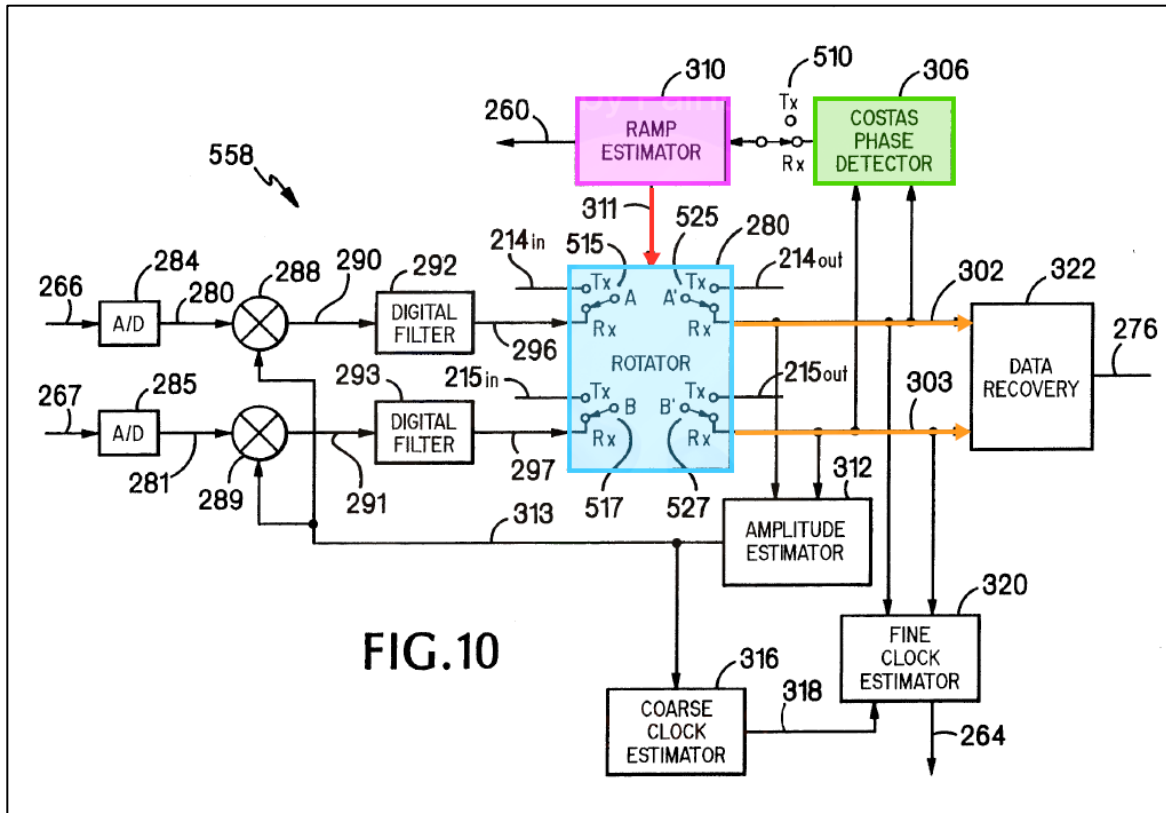


Id. at FIG 10 (annotated). Continuous data demodulator 558 includes rotator 280, which intakes digital baseband signals and “rotates” them by angle ϕ , which corresponds to the carrier phase offset of the input signal. *Id.* at 9:44–55.⁴

⁴ During reception, *Fulton*’s continuous data demodulator 558 depicted in FIG. 10 “functions as described above in connection with FIG. 5.” *Fulton*, 11:56–59. Accordingly, *Fulton*’s FIG. 5 teachings are cited to teach the reception operation of *Fulton*’s FIG. 10 embodiment.

Fulton's rotator 280 operates on digital baseband signals. Namely, *Fulton* teaches that received “[s]ignals 266 and 267 from analog filters 254 are **converted to digital** at the two A/D converters 284 and 285” to produce digital signals 280 and 281 respectively. *Id.* at 9:37–40. *Fulton* also teaches “analog filters 254 [] process the signals 250 and 251 ... to produced [sic] **filtered baseband signals 266 and 267**” *Id.* at 9:1-4. In turn, *Fulton* teaches “filtered signals 296 and 297 are sent to inputs A and B, respectively, of a rotator [280].” *Id.* at 9:44–45. Accordingly, *Fulton*'s rotator 280 receives and operates on digital baseband signals.

As in the '141 Patent, *Fulton* teaches a feedback process through which phase error is detected in the received signals and accounted for via phase rotation. Namely, “[t]he frequency **and phase** of the baseband signals 250 and 251, and thereby the frequency and **phase errors** of the carrier synthesizer 212 or VCXO 248, **are measured by the continuous data demodulator [558.]**” *Id.* at 9:11–14. Within continuous data demodulator 558, *Fulton* teaches “Costas phase detector 306 determines the amount of quadrature signal in signal 302 (or equivalently, the amount of in-phase signal in signal 303). Ramp estimator 310 generates a **phase error signal 311** which controls the amount of rotation ϕ performed by the rotator [280] such that signals 302 and 303 become the in-phase and quadrature components, respectively, of the transmission.” *Id.* at 9:55–62.



Id. at FIG. 10 (annotated). Using **phase error signal 311**, “[r]otator [280] accomplishes the effect of phase-locking within the continuous data demodulator [558][.]” *Id.* at 9:66–10:1; Dec. ¶¶75–76, 101. “Phase locking” was a well-known technique which can be used to correct carrier phase offset. Dec. ¶¶76, 101; *see Fulton*, Abstract.

In the Fig. 10 embodiment, *Fulton* teaches that rotator 280 can also operate in the transmit direction to correct for phase error. *Fulton*, 11:56–57, 11:66–12:1. In the transmit case, *Fulton* teaches “a rotation of the baseband data signals 214in and 215in using a **rotator 280** controlled by the **control signal 311** from the **ramp estimator 310**[.]” *Fulton*, 11:3–7. “The baseband data signals 214in and 215in input

to the transmit rotator 280 are provided by the digital filters 208[.]” *Fulton*, 11:12–14. *Fulton* teaches “the control signal 311 controls the transmit rotator 280 continuously,” and “[t]he amount of rotation ϕ produced by the transmit rotator 280 is controlled by a control signal 311 produced by the receiver-side ramp generator 310.” *Fulton*, 11:16–19, 11:33–34.

Thus, *Fulton* teaches applying a phase adjustment to digital baseband signals to account for carrier phase rotation using a single processor shared between both transmission and reception, as claimed.

Motivation to Combine Williams and Fulton

For several reasons, a POSITA would have been motivated and found it obvious to incorporate the functionality of *Fulton*’s rotator 280 in *Williams*’s digital array processor 160. Dec. ¶¶102–07. First, a POSITA would have recognized that *Fulton*’s phase error correction performed in rotator 280 would benefit *Williams*’s communications system in the same way it benefits *Fulton*, correcting for phase error in transmitted and received signals at baseband via a feedback loop. Dec. ¶¶103–04; *KSR Int’l Co. v. Teleflex Inc.*, 550 U.S. 398, 417 (2007) (“[I]f a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious[.]”). A POSITA would have recognized that such functionality would be desirable to implement in *Williams*’s system because it would provide for greater

accuracy in signal transmission and reception, which in turn may provide greater throughput due to less need to retransmit incorrectly received signals. Dec. ¶103. *Fulton* expressly identifies as an object of its invention providing a “high throughput” radio system and “to provide a low-cost method of generating a high accuracy transmission carrier[.]” *Fulton*, 2:6–7, 2:15–17; Dec. ¶103. Furthermore, *Fulton* identifies “an object of this invention is to simplify the circuitry of a receiver ... by providing a reception circuit which is coupled to the transmission circuit to produce transmission carrier stabilization[.]” *Fulton*, 2:45–49.

Supporting the conclusion that it would have been obvious to benefit *Williams*’s system with *Fulton*’s CFO correction techniques *Williams* and *Fulton* describe “similar devices,” and a POSITA would have had a reasonable expectation of success in making the proposed combination due to the similarities in their function and architecture. For example, both *Williams* and *Fulton* describe methods and systems for calibrating wireless radio communication signals to account for phase errors. *Williams* ¶20, 42; *Fulton*, 9:55–62, 11:16–19, 11:33–34; Dec. ¶104. Further, at the time of the ’141 Patent’s purported invention, phased array (or adaptive phased array, or adaptive array) antenna systems were well-known in the art for the advantages they provide in terms of signal gain, minimizing signal interference, and more. Dec. ¶¶39–41, 105. Thus, given the popularity of phased array antenna technology at the time, a POSITA would have recognized that *Fulton*

and *Williams* are compatible and the proposed combination would have been well within the skillset of a POSITA. Dec. ¶¶105. Additionally, both *Fulton* and *Williams* teach correcting the phase of transmitted and received signals. Just as *Williams* teaches calibrating signals traveling along varying transmit apparatus chains such that the signals are received simultaneously (phase), *Fulton* teaches feeding back phase and frequency errors to minimize and correct those errors. Compare *Williams* ¶¶42–44, 56–57, with *Fulton*, 9:11–19, 9:55–10:2.

Although *Williams*'s discussion focuses on internal phase compensation, a POSITA would have expected a system like *Williams* to incorporate some form of CFO compensation such as that described by *Fulton*. Indeed, one of *Williams*'s goals is to measure and compensate for phase offsets experienced by the transmit and receive paths within its system, proposing “[a] method for determining calibration factors for respective transmit and receive paths associated with an adaptive antenna array having a plurality of antenna elements[,]” wherein the base transceiver station “determines calibration factors for the respective antenna transmit and receive paths.” *Williams* ¶20. Specifically, *Williams* contemplates calibrating the received and transmitted signals to account for phase differences induced by the different hardware from the receive and transmit apparatus chains: “***both transmitted and received signals*** must be calibrated so that unweighted signals traveling along the various antenna apparatus chains from respective DSPs 170 to antenna element 110

each reach antenna element 110 (transmit) and DSPs 170 (receive) simultaneously (*phase*) and with the same amplitude.” *Williams* ¶42. Further, *Williams* notes “[a]daptive antenna array systems provide greater range over traditional technologies,” and that “[a]n adaptive array can [] increase user capacity over traditional antenna technology[.]” *Williams* ¶¶7–8. A POSITA would have recognized that by compensating for CFO, a more precise antenna beam can be formed, further increasing the range and user capacity of *Williams*’s system. Dec. ¶106. A POSITA would have recognized the benefits of further compensating for carrier phase offset experienced between the sending and receiving devices as described by *Fulton*. Dec. ¶106.

Finally, a POSITA would have been specifically motivated to implement *Fulton*’s phase feedback and correction (performed by rotator 280) in *Williams*’s digital array processor 160. Dec. ¶107. When combined as proposed, digital array processor 160 would then perform a further calibration (*Williams* ¶¶37, 83) calculation to account for carrier phase errors (i.e., carrier phase rotation) in addition to the calibration and beamforming calculations it already performs on an antenna element-by-antenna element basis, resulting in digital array processor 160 applying a single phase shift to jointly account for both beamforming phase rotation and carrier phase rotation of individual antenna elements, as claimed. Dec. ¶107. In other words, when deciding where to apply a baseband CFO phase adjustment per

Fulton’s teachings, a POSITA would have found it obvious to consolidate all the baseband phase adjustments into a single step. Indeed, *Williams* already teaches applying a multi-faceted signal adjustment accounting for both beamforming and calibration as a single “net weighting factor” created by adding phases and amplitudes of the separate corrections. *Williams* ¶36. Incorporating a third phase shift to *Williams*’s already consolidated phase adjustment would, accordingly, have been straightforward and yielded predictable results. Dec. ¶107.

ii. Claim 2

The apparatus of claim 1, wherein said digital baseband signals received by said shared baseband processor are time multiplexed, and said shared baseband processor operates on said digital baseband signals on a time-slot-by-time-slot basis.

Williams in view of *Fulton* teaches the apparatus of claim 1, as demonstrated above with respect to claims [1(pre)] through [1(d)]. And as demonstrated with respect to claims [1(c)] and [1(d)], *Williams* also teaches digital array processor 160 (i.e., the claimed shared baseband processor) receives and operates upon digital baseband signals. Relevant to Claim 2, *Williams* also teaches time multiplexing digital baseband signals, enabling time division multiplexing as in the ’141 Patent. *See, e.g.*, ’141 Patent, 12:65–67 (noting that “the baseband time-multiplexing and shared processing techniques described herein can be employed in systems using . . . TDMA [Time Division Multiple Access]”). Specifically, *Williams* teaches “[i]n the preferred embodiment of the invention, 96 channels are supported by BTS 100

through use of 12 RF carriers and **8 TDM time slots.**” *Williams* ¶41. *Williams* elaborates, “net weighting factors may be determined by the digital array processor 160 **and be separately applied to each active timeslot** to point a beam...” *Williams* ¶80.

In particular, *Williams* teaches “the phase and amplitude net weighting factors are preferably applied after the DSP 170 (modulation) and before the XMUX 150 (digital combiner)” (i.e., in digital array processor 160). *Williams* ¶39. The signals entering and exiting digital array processor 160 are single signals for each time slot and radio frequency. *See Williams* ¶¶36–39; Dec. ¶¶108–09. *Williams*’s time slots correspond to one of the 8 TDM time slots, and radio frequencies correspond to one of the 12 RF carriers: “[a]t these points in the signal path, each signal (**RF frequency and time slot**) is a baseband signal having an I and Q representation.” *Williams* ¶39. In the receive direction, XMUX 150 acts as a channelizer, and separates the incoming signals in each time slot (i.e., time multiplexed) by RF frequency and supplies them in a multiplexed manner to the digital array processor 160 (i.e., the claimed shared baseband processor). *Williams* ¶35, 38; Dec. ¶¶ 59, 110.

Williams also teaches the signals digital array processor 160 receives from DSPs 170 are time-multiplexed. *Williams* teaches “[i]n broadband applications, assuming multiple frequency channels are active at any given instant, received signals are multi-channel signals.” *Williams* ¶34. “DSPs 170 are associated with...

a specific frequency channel[.]” *Williams* ¶39. In the transmit direction, XMUX 150 operates as a combiner, combining the separate signals for each RF frequency and time slot output by digital array processor 160, and “forms a... **composite** multi-frequency signal[.]” *Williams* ¶40. Further, “[DSPs 170’s] processed (modulated and encoded) outputs are supplied to the digital array processor 160, which can apply appropriate net weighting factors to each active channel...” *Williams* ¶39. And digital array processor 160 applies such “net weighting factor[s]” (accounting for beamforming and calibration) “**for each... time slot** in TDM systems[.]” *Williams* ¶36. Furthermore, *Williams* teaches “a digital signal processor having sufficient processing speed may process multiple channels, such as all eight channels (**timeslots**) in GSM systems.” *Williams* ¶41. And as explained above, individual channels in a TDM system are time-multiplexed, with each channel being supported by its own RF carrier and TDM timeslot. *Williams* ¶41.

Therefore, *Williams* teaches the digital baseband signals entering digital array processor 160 are time-multiplexed in both the transmit and receive directions, with each signal corresponding to its discrete time slot in the TDM framework. Dec. ¶¶110–11. Likewise, *Williams* teaches digital array processor 160 operates on each of these time-multiplexed signals on a time-slot-by-time-slot basis, as claimed, since digital array processor 160 applies a “net weighting factor” “**for each... time slot** in TDM systems[.]” *Williams* ¶36.

iii. Claim 3

The apparatus of claim 1, wherein said baseband modulator receives data symbols from a plurality of user channels and supplies to said shared baseband processor a time-multiplexed stream of modulated digital data symbols from said plurality of user channels.

The '141 Patent does not elaborate on the meaning of “data symbols[.]” It refers to “data symbols for each of C user channels[.]” but does not identify any specific symbol type, modulation scheme, or any more specific teachings. '141 Patent, 6:16. Symbol-based communications were, however, well established and understood in the art. Fundamentally, payload data information (i.e., bits) are communicated over wireless channels by mapping those bits to a carrier wave. Dec. ¶112. In a basic scheme, Amplitude Shift Keying (ASK) uses different signal magnitudes to represent bits, e.g., zero or low magnitude for a “0” and high magnitude for a “1.” *Id.* The state of the carrier at a given point in time is referred to as a “symbol.” *Id.* While this two-state ASK example can only communicate one bit per symbol (i.e., either a 0 or a 1), higher order modulation schemes can map many more bits to each symbol (or carrier state). *Id.*

As explained above with respect to claims [1(pre)] through [1(d)], *Williams* teaches the apparatus of claim 1, DSPs 170 are the claimed baseband modulator, and digital array processor 160 is the claimed shared baseband processor. *See* Dec. ¶¶85–107. And as explained above with respect to claim 2, DSPs 170 supply a time-multiplexed stream of signals from a plurality of user channels to digital array

processor 160. *Williams* ¶41; see Dec. ¶¶108–11. Throughout its disclosure, *Williams* refers to the GSM as an exemplary wireless standard on which its system may be implemented. See, e.g., *Williams*, ¶¶37, 55-56. A POSITA would have understood that there were different GSM modulation schemes used over the course of its evolution. Dec. ¶113 (noting that EDGE evolution used 8-PSK). The original GSM modulation scheme, however, was binary Gaussian Minimum Shift Keying (GMSK), which is a modulation scheme that maps a single bit per symbol. Dec. ¶114. Using GMSK in *Williams*, a POSITA would have understood that the digital array processor 160 would have received a time-multiplexed stream of modulated digital data symbols from the DSP 170 modulators, corresponding to the plurality of user channels. Dec. ¶115. Indeed, converting user data (i.e., bits) into a symbol (i.e., a complex representation of the modulated data) is the role of a modulator in a system such as that described by *Williams*. *Id.*

Williams, however, notes that its invention is not limited to GSM, but could also be applied to CDMA or “other systems.” *Williams*, ¶84. Accordingly, a POSITA would have been motivated to explore other modulation schemes such as the QPSK modulation in CDMA systems, standardized by 3GPP for the 3rd generation UMTS cellular networks. Dec. ¶116 (discussing Ex. 1009, 3G TS 25.213 version 3.2.0 Release 1999 18 ETSI TS 125 213 V3.2.0 (2000-03)). A POSITA would also have been motivated to explore the modulation schemes used in other systems, including

those described by *Fulton*. In a preferred embodiment, *Fulton* teaches symbols corresponding to 2 bits each: “the demodulator 158 can handle data transmissions as short as 6 bits (3 symbols) in length.” *Fulton*, 6:25–27. *Fulton* further teaches using 9QPR modulation, where “data is encoded on both the sine and cosine (or in-phase and quadrature) components of a carrier.” *Fulton*, 5:4–6. *Fulton* teaches the 9QPR symbols correspond to values of +1, 0, and -1. *Fulton*, 7:8–10.

Motivation to Combine Williams and Fulton

For several reasons, a POSITA would have been motivated to implement *Fulton*’s 9QPR modulation scheme in *Williams*’s wireless communications system. First, a POSITA would have recognized *Fulton*’s symbol-based 9QPR modulation scheme would benefit *Williams* in the same way it benefits *Fulton*, increasing transmission and computational efficiency by decreasing the number of required operations to transmit the same amount of data, since each symbol corresponds to multiple bits. Dec. ¶118–19; *Fulton*, 6:24–26; *KSR*, 550 U.S. at 417. Indeed, 9QPR is a form of quadrature partial response (QPR) modulation, which was a well-known modulation scheme at the pertinent time. Dec. ¶118. As *Fulton* teaches, QPR involves transmitting symbols which correspond to multi-bit values, increasing the efficiency of a transmission compared to modulation schemes which do not use symbols and must instead transmit bits individually. *Id.* *Fulton* also states as a goal providing “a high through-put” system. *Fulton*, 2:6–9.

A POSITA would have recognized the same throughput hurdles faced *Williams* and would have further recognized that implementing *Fulton*'s symbol-based modulation scheme would have been one way to overcome such hurdles. Dec. ¶¶118–19. Similarly, a POSITA would have been interested in increasing *Williams*'s throughput, since one of *Williams*'s goals was to provide a more performant and efficient radio system. Dec. ¶119; *Williams* ¶6.

A POSITA would have also had a reasonable expectation of success in making the proposed combination due to the similarities in *Fulton*'s and *Williams*'s system architecture, both as explained above and in terms of the signals being processed in the two systems. Specifically, both *Williams*'s and *Fulton*'s systems separate component signals into in-phase (I) and quadrature (Q) components. *Compare Williams* ¶¶35 (“baseband digital signals having an I and Q representation”), 39 (“each signal... having an I and Q representation”), with *Fulton*, 5:4–6 (“data is encoded on both the... in-phase and quadrature[] components of a carrier”), 9:45–47 (“rotator 300 determines the amount spurious mixing of in-phase and quadrature components in signals 296 and 297”). Further, at the time of the '141 Patent's purported invention, symbol-based modulation schemes such as 9QPR were well-known in the art for the advantages they provided in terms of increased data throughput. Dec. ¶¶48–50, 117–18. Thus, given the popularity of such modulation schemes, a POSITA would have recognized that *Fulton*'s 9QPR modulation is

compatible with *Williams*'s communications system and the proposed combination would have been well-within the skillset of a POSITA. Dec. ¶¶116, 118–20. Thus, *Williams*'s system would implement symbol-based modulation at all points in the transmission/reception processes, including when input to and output from DSPs 170 (i.e., the claimed baseband modulator). Dec. ¶120. Accordingly, the proposed combination would have been straightforward to a POSITA and would have yielded the predictable results described. *Id.*

iv. Claim 4

The apparatus of claim 3, wherein, for each input digital data symbol, said baseband modulator generates a plurality of modulated digital data symbols in the time-multiplexed stream respectively corresponding to the plurality of antenna elements.

As demonstrated above with respect to claim 3, *Williams* alone and, in the alternative, *Williams* in view of *Fulton*, teach claim 3. *See* Dec. ¶¶112–20. Similarly, as demonstrated above with respect to claim 2, *Williams* in view of *Fulton* teaches DSP 170 generates and outputs a time-multiplexed stream of data. *See* Dec. ¶¶109. And as further demonstrated above with respect to claims [1(a)] and 3, DSP 170 (i.e., the claimed baseband modulator) inputs digital data symbols and outputs modulated digital data symbols. *See* Dec. ¶¶89–94, 112–20.

Williams's DSP 170 generates a plurality of such digital data symbols respectively corresponding to the plurality of antenna elements. As a starting point, one of the fundamental aspects of beamforming is that the same signal (i.e., a single

symbol) is simultaneously radiated from multiple antenna elements. Dec. ¶¶42, 121. Separate phase and amplitude shifts applied to each of those respective signals create a “beam” that focuses the radiated energy in a specific direction. *Id.* As explained above with respect to Claim 1, *Williams*’s digital array processor 160 applies beamforming adjustments to each of the baseband signals and adds calibration factor adjustments on a per-antenna element basis. *Williams*, ¶¶36-39. Accordingly, a POSITA would have understood that same signal (i.e., a single symbol) is processed multiple times by the digital array processor 160 in order to apply the separate and distinct beamforming and calibration adjustments on a per-antenna element basis. Dec. ¶122.

Williams teaches “DSPs 170 are associated with specific antenna elements 110.” *Williams* ¶39. “Their processed (modulated and encoded) outputs are supplied to the digital array processor 160, which can apply appropriate net weighting factors to each active channel and for each transmit apparatus chain associated with each antenna element 110.” *Williams* ¶39. *Williams* teaches “each [DSP board 170] may provide a plurality of digital signal processors per board.” *Williams* ¶41. Further, “a digital signal processor having sufficient processing speed may process multiple channels, such as all eight channels (timeslots) in GSM systems.” *Williams* ¶41. Accordingly, a POSITA would have understood *Williams*’s teachings encompass embodiments both where DSPs 170 and antenna elements 110 are paired 1:1, and

where an individual DSP 170 is paired to multiple (i.e., a plurality of) antenna elements 110. Dec. ¶¶123–24. (explaining two disclosed embodiments wherein a single DSP 170 handles operations for multiple antenna elements 110—a first in which a single DSP handles all channels and a second in which a single DSP board 170 comprises a plurality of DSPs which in turn each handle individual antenna elements).

Where each DSP is paired to a single antenna element, the array of DSPs 170, collectively, *generates a plurality of modulated digital data symbols in the time-multiplexed stream respectively corresponding to the plurality of antenna elements*, as claimed. In other words, for a given symbol, the collection of DSPs 170 will generate multiple copies—one copy of the symbol for each antenna element through which that data symbol is to be transmitted. Dec. ¶123. In the alternative *Williams* implementation in which a single DSP handles all antenna elements, a POSITA would have found it obvious for that DSP to generate modulated symbols separately for each signal to be processed by digital array processor 160. Dec. ¶124. Because the same signal (i.e., a single symbol) is processed multiple times by the digital array processor 160 in order to apply the separate and distinct beamforming and calibration adjustments on a per-antenna element basis, the consolidated DSP would generate multiple copies of each data symbol—one copy of the symbol for each antenna element through which that data symbol is to be transmitted.

v. Claim 7

The apparatus of claim 1, wherein said shared baseband processor comprises a multiplier which performs complex multiplication on digital baseband signals relating to a plurality of user channels in a time-multiplexed manner.

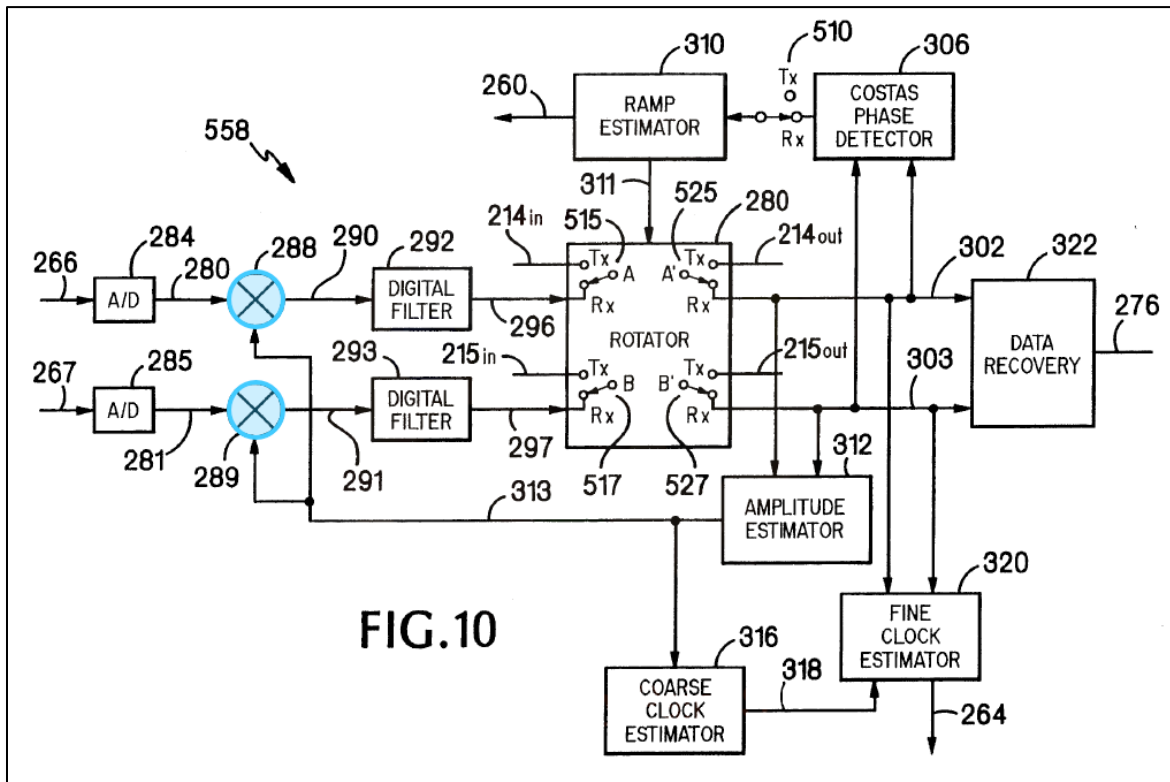
As demonstrated above with respect to claims [1(pre)] through [1(d)], 2, and 3, *Williams* in view of *Fulton* teaches the apparatus of claim 1 wherein digital array processor 160 (i.e., the claimed shared baseband processor) operates on digital baseband signals in a time-multiplexed manner. *See* Dec. ¶¶85–120. *Williams* teaches “signals output by DSP 170 to the digital array processor 160 are separate digital signals ***for each active channel*** (timeslot).” *Williams* ¶81. Digital array processor 160, in turn, “can apply appropriate net weighting factors ***to each active channel***[.]” *Williams* ¶39. Further, “[t]he digital array processor 160 calculates the optimum net weighting factors for the various transmit apparatus chains ***and places these net weighting factors in each of the channel’s transmit signal path*** at the digital array processor 160 to point the transmitted antenna beam[.]” *Williams* ¶81.

Williams teaches using “angle of arrival data determined for mobile users for all active timeslots for each RF carrier in a TDM system[.]” *Williams* ¶80. *Williams* also teaches “***96 channels are supported by BTS 100*** through use of 12 RF carriers and 8 TDM time slots.” *Williams* ¶41. Thus, a POSITA would have recognized that the plurality of channels (96) to which digital array processor 160 applies net weighting factors are user channels. Dec. ¶125; *Williams* ¶80.

The '141 Patent explains “[t]he largest cost-component of beamforming is the complex multiplication of each sample for each element with the beamforming weights.” ’141 Patent, 2:28–30. The ’141 Patent describes “a complex multiplier 48 for adjusting the phases of the input... baseband signals[,]” and which “simultaneously performs carrier tracking and beam phasing[.]” ’141 Patent, 8:17–19, 8:47–49.

Williams teaches “adjust[ing] the amplitude and phases of the individual [antenna] array currents” by placing “**complex weights**... in the signal path of each antenna element.” *Williams* ¶11. As explained above, digital array processor 160 applies a “net weighting factor[,]” which combines “angular weighting factors” “calibration factors[,]” to each signal. *Williams* ¶36. “Through application of net weighting factors... digital array processor 160 can adjust the baseband digital signals received from and for transmission... to beamform each active channel.” *Williams* ¶37. A POSITA would have understood *Williams* to teach the same complex multiplication described in the ’141 Patent, since *Williams* teaches applying “complex weights” to signals to perform beamforming. Dec. ¶126. A POSITA would have further understood that digital array processor 160 would contain a multiplier to perform such complex multiplication, since such multipliers were well-known, were a standard component in processors, and were a standard way of performing complex multiplication. Dec. ¶127.

To the extent *Williams* does not expressly teach the detail of such a multiplier to apply such a complex weight, it would have been obvious to implement such a multiplier. For example, *Fulton* teaches such multipliers 288 and 289 in FIG. 10, reproduced below. *Fulton*, 9:41.



Fulton, FIG. 10 (annotated). *Fulton*'s multipliers operate on complex digital baseband signals to adjust their amplitude and are of the same well-known type contemplated in the '141 Patent. *Fulton*, 8:62–64, 9:40–42; Dec. ¶128. A POSITA would have been motivated to implement *Fulton*'s multiplier for the reasons stated above, namely, because such multipliers were a well-known implement for

performing complex multiplication of the type contemplated by the '141 Patent and taught in *Williams*. Dec. ¶129.

vi. Claim 8

The apparatus of claim 1, wherein said shared baseband processor comprises a multiplier which performs complex multiplication on digital baseband signals associated with a plurality of individual antenna elements in a time-multiplexed manner.

As demonstrated above with respect to claims [1(pre)] through [1(d)], 2, 3, and 7, *Williams* in view of *Fulton* teaches the apparatus of claim 1 wherein digital array processor 160 (i.e., the claimed shared baseband processor) comprises a multiplier which performs complex multiplication on digital baseband signals in a time-multiplexed manner. *Williams* ¶81.

Williams also teaches the digital baseband signals are associated with a plurality of individual antenna elements. Specifically, *Williams* teaches “digital array processor 160 can adjust the baseband digital signals received from and for transmission ***by each antenna element 110*** to beamform each active channel.” *Williams* ¶37. In *Williams*’s disclosed embodiment, the adaptive antenna array is comprised of 4 antenna elements 110. *Williams* ¶34. Therefore, *Williams* teaches the digital baseband signals are associated with a plurality of individual antenna elements, as claimed. Dec. ¶130.

vii. Claim 9

[9(a)] The apparatus of claim 1, wherein said shared baseband processor comprises a beam scaling and power control processor configured to generate a time-multiplexed stream of gain control signals for digital baseband signals corresponding to individual antenna elements for each of a plurality of user channels, the gain control signals jointly accounting for power control and antenna element beam scaling; and

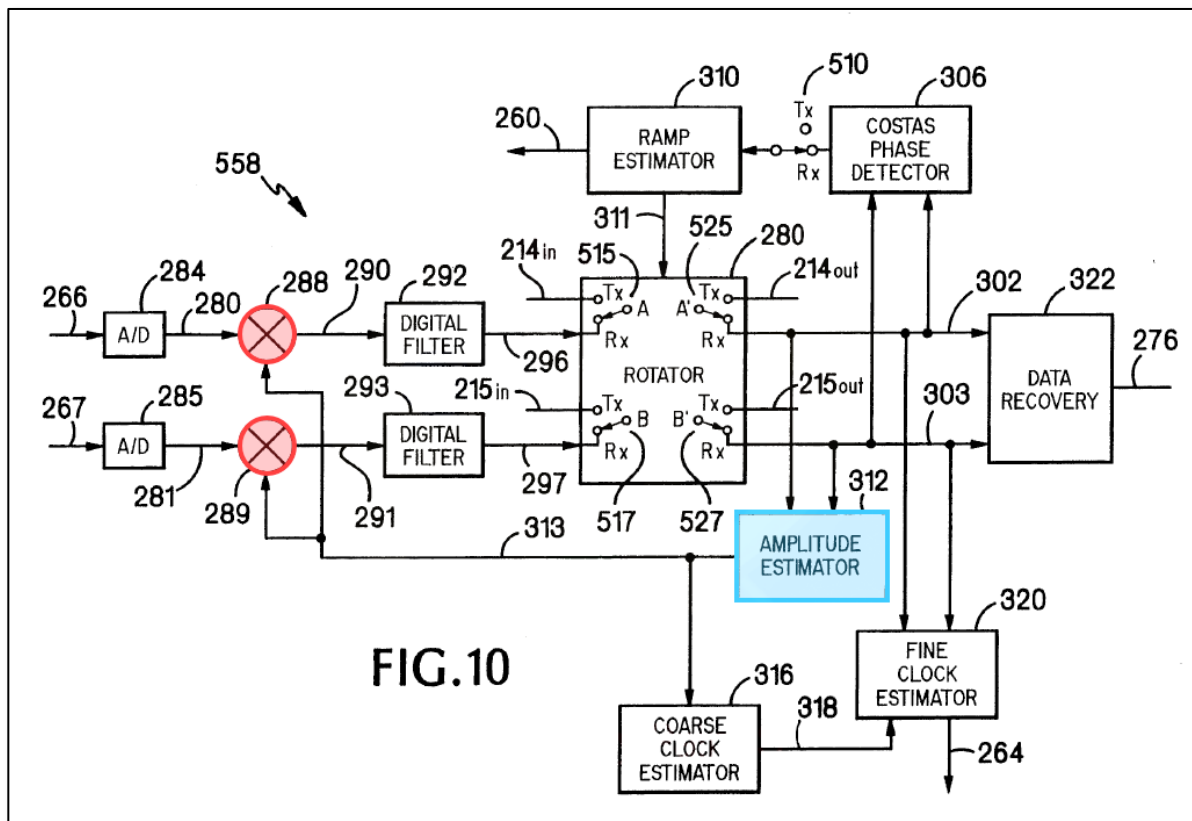
As demonstrated above with respect to claims [1(pre)] through [1(d)], *Williams* in view of *Fulton* teaches the apparatus of claim 1. *See* Dec. ¶¶85–107. Further, as demonstrated above with respect to claim 2, digital array processor 160 (i.e., the shared baseband processor) generates a time-multiplexed stream of signals. Dec. ¶¶108–11. As also demonstrated above with respect to claims 3 and 7, the digital baseband signals in the time-multiplexed stream correspond to each of a plurality of user channels. *See* Dec. ¶¶112–19, 125–30. And, as demonstrated above with respect to claims 4 and 8, *Williams* teaches the digital baseband signals correspond to individual antenna elements. *See* Dec. ¶¶121–24, 130. *Williams* also teaches the digital baseband signals in the time-multiplexed stream correspond to individual antenna elements for each of a plurality of user channels. *Williams* ¶37 (“digital array processor 160 can adjust the baseband signals received from and for transmission ***by each antenna element 110 to beamform each active channel***”).

The '141 Patent explains, the baseband signal exiting the beamforming adjustment in **complex multiplier 48** is amplitude adjusted “by a **scalar multiplier 50** based on scaling information received from beam scaling and **AGC/power control**

processor 52[.]” ’141 Patent, 8:20–23. It continues, “scaling processor 52 applies different scaling on a time-slot basis in accordance with the beam scaling to be applied to a particular antenna element[.]” ’141 Patent, 8:24–26. This arrangement is depicted in FIG. 1, reproduced below.

'141 Patent, FIG. 1 (annotated). The '141 Patent explains, “automatic gain control adjusts the signal level [(i.e., the amplitude)] to be within the operational range of downstream processing, simultaneously taking into account the relative scaling of the different antenna elements for proper beamforming.” '141 Patent, 8:29–34. Further, “the magnitude scaling component of beam weighting is incorporated into the existing AGC or power-control scalar multiplication.” '141 Patent, 8:50–53.

Fulton teaches “utiliz[ing] an automatic gain control algorithm to maintain a constant signal level over 24 dB of signal level variations.” *Fulton*, 10:3–5. Depicted in FIG. 10 below, *Fulton* teaches an amplitude estimator 312, which calculates the sum of the squares of signals 302 and 303 to generate an amplitude estimate. *Fulton*, 10:5–8.



Fulton, FIG. 10 (annotated). This amplitude estimate is fed back to inverse gain control **multipliers 288 and 289** to scale digital signals 280 and 281, “stabilizing the amplitude of signals 290 and 291.” *Fulton*, 10:8–10. This matches the ’141 Patent’s description of the claimed beam scaling and power control processor outputting gain control signals accounting for power control and scaling. Dec. ¶¶131–33.

A POSITA would have been motivated and found it obvious to implement *Fulton*'s amplitude estimator in *Williams*'s digital array processor 160. Dec. ¶¶134–37. Specifically, *Williams*'s digital array processor 160 already performs much of, if not all, the functionality of the claimed beam scaling and power control processor. Dec. ¶134. *Williams* teaches “identical signals for transmission passing through the different transmit apparatus chains ***will emerge with different amplitudes*** and phases.” *Williams* ¶14. Further, “[c]alibration factors are used ***to compensate for relative... amplitude variations*** that occur when signals traverse the various... receive apparatus chains[.]” *Williams* ¶36. Such calibration factors are added with angular weighting factors. Angular weighting factors are used to point the antenna beam in a certain direction. *Williams* ¶36. The combined result are net weighting factors, which “adjust the baseband digital signals” in the receive direction “to beamform each active channel” in digital array processor 160. *Williams* ¶¶36–37.

With respect to beamforming, *Williams* teaches “phases ***and amplitudes*** of the currents . . . on the antenna array elements can be electronically adjusted such that received signals from a certain direction add in phase, ***and maximum gain is achieved in that direction.***” *Williams* ¶10. *Williams* also teaches, with respect to power control, “[s]ince mobile subscribers cannot detect signals below a minimum threshold level of power, increasing antenna gain extends the distance a carrier wave can travel.” *Williams* ¶7. A POSITA would have recognized *Williams*'s disclosed

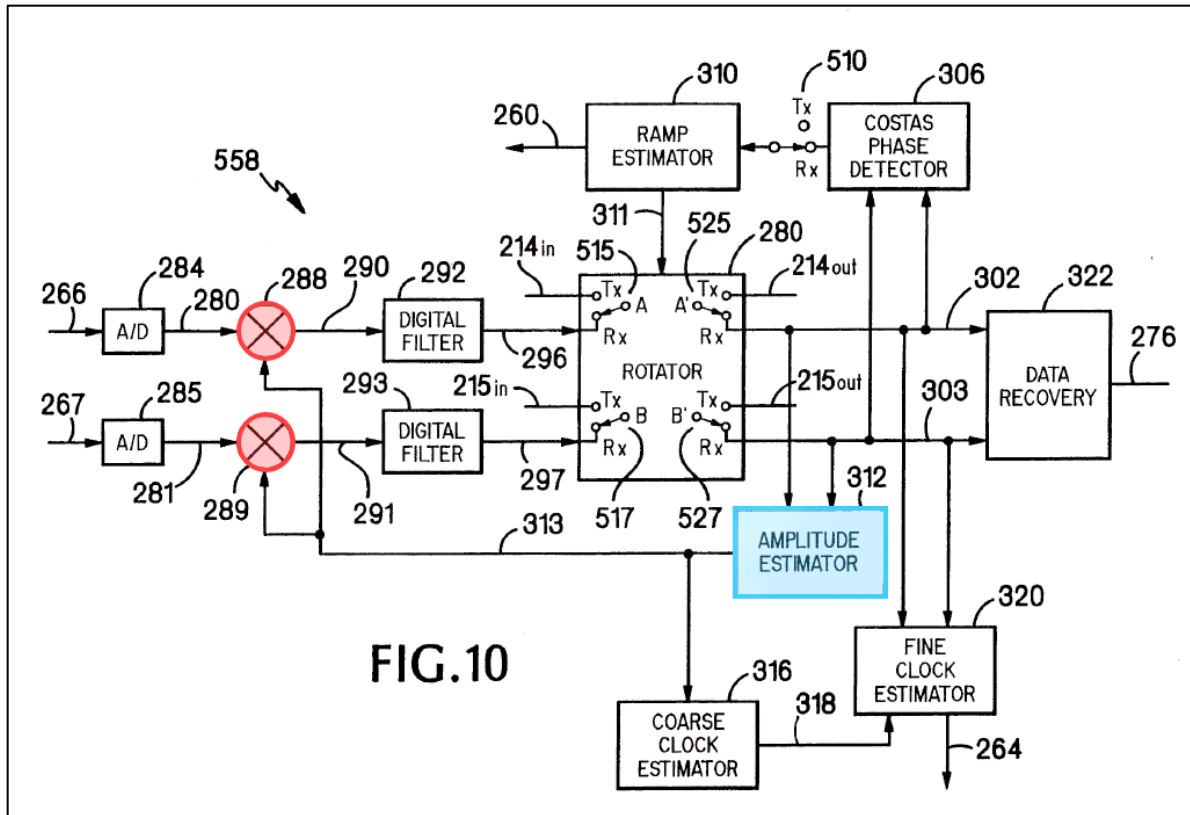
amplitude scaling functionality serves to adjust the beam gain in a given user direction, jointly accounting for power control and antenna element beam scaling, as described in the '141 Patent. Dec. ¶134–35.

Accordingly, a POSITA would have recognized incorporating *Fulton's* amplitude estimator 312 as a straightforward and obvious way to implement *Williams's* described functionality within digital array processor 160. Dec. ¶136. Furthermore, a POSITA would have had a reasonable expectation of success in making the proposed combination due to the similarity of *Fulton's* amplitude estimator 312's amplitude (power and gain) scaling, and *Williams's* digital array processor's amplitude scaling. Dec. ¶137. Further, since amplitude estimator 312 is already a sub-component of a larger processing assembly, namely, continuous data demodulator 558, a POSITA would have understood that it could be incorporated into *Williams's* similar digital array processor 160, especially in light of the above combination from claim [1(d)] which already incorporates a portion of continuous data demodulator 558 into digital array processor 160. *Id.* Accordingly, the proposed combination would have been straightforward to a POSITA and would have yielded the predictable results described. *Id.*

[9(b)] a multiplier configured to adjust amplitudes of a time-multiplexed stream of digital baseband signals corresponding to the plurality of user channels in accordance with the gain control signals.

As demonstrated above with respect to claim 2, *Williams* in view of *Fulton* teaches a time-multiplexed stream of signals. *See* Dec. ¶¶108–11. Further, as demonstrated above with respect to claims 3, 7, and [9(a)], each of the time-multiplexed digital baseband signals in the time-multiplexed stream correspond to one of a plurality of user channels. *See* Dec. ¶¶112–20, 125–29, 131–37.

Fulton teaches multipliers 288 and 289, as demonstrated above with respect to claim [9(a)], which take as input the “magnitude of the estimate 313[,]” which in turn is generated by amplitude estimator 312. *Fulton*, 10:5–10. Multipliers 288 and 289 use this magnitude to “stabiliz[e] the amplitude of signals 290 and 291[,]” as depicted in *Fulton*’s FIG. 10, below.



Fulton, FIG. 10 (annotated). Accordingly, *Fulton*’s multipliers 288 and 289 adjust the amplitudes of digital baseband signals in accordance with the “magnitude of the estimate 313[,]” i.e., the claimed gain control signals. Dec. ¶131, 138; *Fulton*, 10:8–10.

As explained above with respect to claim [9(a)], a POSITA would have been motivated and found it obvious to incorporate *Fulton*’s amplitude estimator 312 into *Williams*’s digital array processor 160. Dec. ¶¶134–37. A POSITA likewise would have been motivated and found it obvious to incorporate one or more of *Fulton*’s accompanying multipliers 288 and 289 to fully incorporate the components’ functionality into *Williams*’s digital array processor 160. Dec. ¶139. Accordingly,

the proposed combination would have been straightforward to a POSITA and would have yielded the predictable results described above in connection with claim [9(a)].

Id.

viii. Claim 10

The apparatus of claim 1, further comprising: a baseband beamformer configured to receive time-multiplexed digital baseband signals from said shared baseband processor corresponding to individual antenna elements, said baseband beamformer forming a combined signal from said time-multiplex digital baseband signals.

As demonstrated above with respect to claims [1(pre)] through [1(d)], *Williams* in view of *Fulton* teaches the apparatus of claim 1. Further, as demonstrated above with respect to claim 2, digital array processor 160 (i.e., the shared baseband processor) outputs a time-multiplexed stream of digital baseband signals. And, as demonstrated above with respect to claims 4 and 8, *Williams* teaches individual digital baseband signals in the time-multiplexed stream correspond to individual antenna elements.

The '141 Patent describes “a beamformer combiner bank 54 which... combines at baseband the... antenna element signals... [T]he antenna element signals forming a particular receive antenna beam via their appropriate phase and amplitude adjustments are combined to realize the resultant signal received via the particular antenna beam.” '141 Patent, 9:60–66. *Williams* teaches DSP 170 “***receives the signal components*** adjusted with respective net weighting factors from each

receive apparatus chain *output by the digital array processor 160* and demodulates these signals to recover *the combined beamformed communication signal.*” *Williams* ¶38.

ix. Claim 18

The apparatus of claim 1, wherein said apparatus employs time division multiple access (TDMA) to transmit and receive signals.

As demonstrated above with respect to claims [1(pre)] through [1(d)], *Williams* in view of *Fulton* teaches the apparatus of claim 1. *See* Dec. ¶¶85–107. *Williams* further teaches digital array processor 160 applies a net weighting factor “for each... *time slot in TDM systems[.]*” *Williams* ¶36. *Williams* further teaches “96 channels *are supported by BTS 100* through use of 12 RF carriers and *8 TDM time slots.*” *Williams* ¶41. Similarly, “In a multi-carrier *BTS utilizing* 12 RF carriers and *8 TDMA time slots*, 96 full duplex channels of GSM are available.” *Williams* ¶75. *Williams* also teaches the separate time slots are allocated to multiple users (i.e., multiple access): “angle of arrival data determined for *mobile users for all active timeslots* for each RF carrier in a TDM system[.]” *Williams* ¶80; Dec. ¶140. Accordingly, a POSITA would have recognized *Williams* teaches the apparatus of claim 1 employs well-known TDMA techniques to transmit and receive signals. *Id.*

x. Claim 19

The apparatus of claim 1, wherein said apparatus employs frequency division multiple access (FDMA) to transmit and receive signals.

As demonstrated above with respect to claims [1(pre)] through [1(d)], *Williams* in view of *Fulton* teaches the apparatus of claim 1. *Williams* “assum[es] ***multiple frequency channels are active at any given instant[.]***” *Williams* ¶34. *Williams* teaches “DSPs 170 are ***associated with...a specific frequency channel*** for processing respective ones ***of a plurality of incoming...signals to be transmitted over respective frequency channels.***” *Williams* ¶39. Similarly, each processed baseband signal corresponds to an “***RF frequency*** and time slot[.]” *Williams* ¶39. Finally, *Williams* teaches transmitting a “composite multi-frequency signal” from antenna elements 110. *Williams* ¶40. *Williams* also teaches the separate frequencies are allocated to multiple users (i.e., multiple access): “angle of arrival data determined for ***mobile users for... each RF carrier*** in a TDM system[.]” *Williams* ¶80; Dec. ¶141–42. Accordingly, a POSITA would have recognized *Williams* teaches the apparatus of claim 1 employs well-known FDMA techniques to transmit and receive signals. Dec. ¶142.

xi. Claim 22

The apparatus of claim 1, wherein said apparatus is a modem.

The ’141 Patent explains “modem” is a portmanteau of “modulator/demodulator[.]” ’141 Patent, 3:33–34. The ’141 similarly describes the

claimed apparatus including “a baseband modulator” and a “baseband demodulator[.]” ’141 Patent, 7:42, 9:35–36. *Williams* teaches the apparatus is a modem, because *Williams* teaches the apparatus is a modulator/demodulator. Dec. ¶146. Namely, *Williams* teaches DSPs 170 modulate and demodulate incoming and outgoing signals. *Williams* ¶¶ 38–39. And as demonstrated above with respect to claims [1(pre)] through [1(d)], *Williams* in view of *Fulton* teaches the apparatus of claim 1. Therefore, *Williams* teaches the apparatus of claim 1, wherein said apparatus is a modem. See Dec. ¶146.

B. Ground 2: Claims 20–21 are obvious under pre-AIA 35 U.S.C. § 103 over *Williams* in view of *Fulton* and in further view of *Trott*.

xii. Claim 20

The apparatus of claim 1, wherein said apparatus is a field programmable gate array (FPGA).

As demonstrated above with respect to claims [1(a)] through [1(d)], *Williams* in view of *Fulton* teaches the apparatus of claim 1. *Williams* does not teach FPGAs. *Trott* teaches a base station apparatus to diminish co-channel and inter-channel interference in wireless communications systems through using adaptive array antennas. *Trott*, 5:13–15, 5:49–51. *Trott* teaches each of the processor elements may be “a digital signal processor, general purpose microprocessor, **FPGA**, ASIC, a combination thereof, etc.” *Trott*, 15:44–46. A POSITA would have been familiar with such processing options, including FPGAs, and would have been motivated to

implement the apparatus of claim 1 as a field programmable gate array for the numerous benefits associated with such devices, including the ability to change or tweak the apparatus's functionality after manufacturing. Dec. ¶144. For example, the FPGA brings the benefit of supporting updates to function with new communications standards without the need for new hardware. *Id.* Accordingly, a POSITA would have been motivated and found it obvious to implement the apparatus of claim 1 as a field programmable gate array (FPGA) as claimed. *Id.*

xiii. Claim 21

The apparatus of claim 1, wherein the apparatus is implemented via a very large scale integration (VLSI) circuit or an application specific integrated circuit (ASIC).

As demonstrated above with respect to claims [1(a)] through [1(d)], *Williams* in view of *Fulton* teaches the apparatus of claim 1. *Williams* does not teach ASICs or VLSIs. *Trott* teaches processors in a beamforming base station utilizing an adaptive antenna array may be “a digital signal processor, general purpose microprocessor, FPGA, ***ASIC***, a combination thereof, etc.” *Trott*, 15:44–46. A POSITA would have been familiar with such processing options, including ASICs, and would have been motivated to implement the apparatus of claim 1 as an application specific integrated circuit for the numerous benefits associated with such devices, including decreased size, cost, and power usage and increased performance all compared to standard off-the-shelf processors. Dec. ¶145. Accordingly, a

POSITA would have been motivated and found it obvious to implement the apparatus of claim 1 as an application specific integrated circuit (ASIC) as claimed.

Id.

VI. THE BOARD SHOULD NOT DENY INSTITUTION UNDER FINTIV

Under the “*Fintiv* factors,” the Board may consider parallel litigation, including an early trial date, in determining whether to institute under 35 U.S.C. § 314(a). *NHK Spring Co., Ltd., v. Intri-Plex Technologies, Inc.*, IPR2018-00752, 19–20 (PTAB Sept. 12, 2018) (precedential); *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, 2–3, 6 (PTAB Mar. 20, 2020) (precedential). Director Vidal recently issued a memorandum setting forth Interim *Fintiv* Guidance (“*Fintiv Memo*”).⁵ One component of this interim guidance clarifies that “the PTAB will not discretionarily deny institution of an IPR or PGR in view of parallel district court litigation where a petitioner stipulates not to pursue in a parallel district court proceeding the same grounds as in the petition or any grounds that could have reasonably been raised in the petition.” *Fintiv Memo*, 7. Referred to as a *Sotera* stipulation, “[t]his clarification avoids inconsistent outcomes between the PTAB and the district court and allows the PTAB to review grounds that the parallel district court litigation will not

⁵https://www.uspto.gov/sites/default/files/documents/interim_proc_discretionary_denials_aia_parallel_district_court_litigation_memo_20220621_.pdf.

resolve.” *Id.* at 7–8. Consistent with this new guidance, Petitioner stipulates that, if the instant IPR is instituted, it will not pursue in the parallel district court proceeding the same grounds as in the petition or any grounds that could have reasonably been raised in the petition. Accordingly, the Board should not discretionarily deny institution under *Fintiv*.⁶

The *Fintiv Memo* is “binding agency guidance” to the Board. *Fintiv Memo*, 3.

VII. CONCLUSION

For the foregoing reasons, Petitioner respectfully requests *inter partes* review of Claims 1-4, 7-10, and 18-22 of the ’141 Patent.

Respectfully submitted,

By: /s/ Paul R. Hart
Paul R. Hart, Reg. No. 59,646
Adam P. Seitz, Reg. No. 52,206

⁶ The Board recently confirmed that, pursuant to the *Fintiv Memo*, the remaining *Fintiv* factors need not be assessed where a petitioner agrees to a *Sotera* stipulation. IPR2022-00286, Paper 12 at 8-9 (“Because our analysis of Petitioner’s stipulation alone requires us to not exercise our discretion to deny institution under § 314(a), we need not address the parties’ remaining arguments as to application of the *Fintiv* factors to the facts in this case.”).

VIII. MANDATORY NOTICES UNDER 37 C.F.R. § 42.8(A)(1)

A. Real Party-In-Interest

Petitioner is the real party-in-interest. 37 C.F.R. § 42.8(b)(1).

B. Related Matters

Pursuant to 37 C.F.R. § 42.8(b)(2), Petitioner is aware of the following matter involving the '141 Patent:

- *Lionra Techs. Ltd. v. Apple Inc.*, No. 6-22-cv-00351 (W.D. Tex.).
- *Lionra Techs. Ltd. v. Samsung Electronics, Ltd. et al*, No. 1:22-cv-00100 (E.D. Tex.).
- *Lionra Techs. Ltd. v. Motorola Mobility LLC*, No. 1:22-cv-02231 (N.D. Ill.)
- *Lionra Techs Ltd. v. Google LLC*, No. 6:22-cv-00467 (W.D. Tex.).

C. Lead and Back-Up Counsel

Petitioner provides the following designation and service information for lead and back-up counsel. 37 C.F.R. § 42.8(b)(3) and (b)(4).

Lead Counsel	Back-Up Counsel
Paul R. Hart (Reg. No. 59,646) <u>Paul.Hart@eriseip.com</u> PTAB@eriseip.com <u>Postal and Hand-Delivery Address:</u> Erise IP, P.A. 5299 DTC Blvd., Ste. 1340 Greenwood Village, Colorado 80111 Telephone: (913) 777-5600 Fax: (913) 777-5601	Adam P. Seitz (Reg. No. 52,206) <u>Adam.Seitz@eriseip.com</u> PTAB@eriseip.com <u>Postal and Hand-Delivery Address:</u> Erise IP, P.A. 7015 College Blvd., Ste. 700 Overland Park, Kansas 66211 Telephone: (913) 777-5600 Fax: (913) 777-5601

APPENDIX OF EXHIBITS

Exhibit 1001	U.S. Patent No. 7,260,141 (“the ’141 Patent”)
Exhibit 1002	File History for U.S. Patent No. 7,260,141
Exhibit 1003	Declaration of Dr. Zhi Ding (“Dec.”)
Exhibit 1004	U.S. Patent Publication No. 2002/0042290 to Williams et al. (“ <i>Williams</i> ”)
Exhibit 1005	U.S. Provisional Application No. 60/239,859 (the “ <i>Williams-Provisional</i> ”)
Exhibit 1006	U.S. Patent No. 5,604,768 to Fulton (“ <i>Fulton</i> ”)
Exhibit 1007	U.S. Patent No. 6,836,673 to Trott (“ <i>Trott</i> ”)
Exhibit 1008	Mark C. Roh, “A Base Station Smart Antenna System for CDMA Cellular,” Massachusetts Institute of Technology, 1997
Exhibit 1009	3G TS 25.213 version 3.2.0 Release 1999 18 ETSI TS 125 213 V3.2.0 (2000-03)
Exhibit 1010	Dr. Zhi Ding Curriculum Vitae
Exhibit 1011	U.S. Patent No. 3,340,531 to Kefalas et al.
Exhibit 1012	U.S. Patent No. 3,500,422 to Cheston et al.
Exhibit 1013	Modern Dictionary of Elec. 7 th (excerpt)
Exhibit 1014	Newton’s Telecom Dictionary 16 (excerpt)
Exhibit 1015	U.S. Patent No. 6,795,424 to Kapoor et al.
Exhibit 1016	U.S. Patent No. 6,240,072 to Lo et al.
Exhibit 1017	U.S. Patent No. 6,052,085 to Hanson et al.
Exhibit 1018	Analysis of new and existing methods...IEEE
Exhibit 1019	Robust Frequency and Timing Synchronization for OFDM
Exhibit 1020	U.S. Patent No. 5,499,268 to Takahashi
Exhibit 1021	U.S. Patent No. 5,206,886 to Bingham
Exhibit 1022	Selecting Mixed Signal Components for Digital Communication Systems
Exhibit 1023	U.S. Patent No. 6,130,602 to O’Toole et al.
Exhibit 1024	U.S. Patent No. 7,039,372 to Sorrells et al.
Exhibit 1025	U.S. Patent No. 6,404,247 to Wang
Exhibit 1026	Understanding Offset 8-PSK Modulation for GSM EDGE
Exhibit 1027	Understanding and Enhancing Sensitivity in Receivers for Wireless Applications

Exhibit 1028	Characteristics of Digital Fixed Wireless Systems Below About 17 GHz
Exhibit 1029	A Complex Multiplier with Low Logic Depth
Exhibit 1030	The Roles of FPGAs in Reprogrammable Systems
Exhibit 1031	Cramming More Components onto Integrated Circuits

CERTIFICATION OF WORD COUNT

The undersigned certifies pursuant to 37 C.F.R. § 42.24 that the foregoing Petition for *Inter Partes* Review, excluding any table of contents, mandatory notices under 37 C.F.R. § 42.8, certificates of service or word count, or appendix of exhibits, contains 13,430 words according to the word-processing program used to prepare this document (Microsoft Word).

Dated: April 5, 2023

By: /s/ Paul R. Hart
Paul R. Hart, Reg. No. 59,646

COUNSEL FOR PETITIONER

CERTIFICATE OF SERVICE ON PATENT OWNER
UNDER 37 C.F.R. § 42.105

Pursuant to 37 C.F.R. §§ 42.6(e) and 42.105, the undersigned certifies that on April 5, 2023, a complete and entire copy of this Petition for *Inter Partes* Review including exhibits was provided via Federal Express to the Patent Owner by serving the correspondence address of record for the '835 Patent as listed on PAIR:

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Further, a courtesy copy of this Petition for *Inter Partes* Review was sent via email to Patent Owner's litigation counsel:

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