

UNITED STATES PATENT AND TRADEMARK OFFICE

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BEFORE THE PATENT TRIAL AND APPEAL BOARD

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LENOVO (UNITED STATES) INC.,

Petitioner,

v.

INTELLECTUAL VENTURES I, LLC

Patent Owner.

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Case IPR2024-01224  
U.S. Patent No. 7,623,439

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**DECLARATION OF DR. GARY LOMP IN SUPPORT OF  
PATENT OWNER'S PRELIMINARY RESPONSE**

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I, Dr. Gary Lomp, do hereby declare:

## **I. INTRODUCTION**

1. I am making this declaration at the request of Intellectual Ventures I, LLC (“Intellectual Ventures”) in the matter of the *Inter Partes* Review (“IPR”) proceedings before the United States Patent and Trademark Office (“USPTO”) of U.S. Patent No. 7,623,439 (“the ‘439 Patent”) to provide expert technical opinions with respect to the ‘439 Patent.

2. I am being compensated for my work in this matter at my standard hourly rate of \$450 for such consulting services. My compensation in no way depends on the outcome of this case, and I have no financial interest in the outcome.

3. In preparing this Declaration, I considered the following materials, the subject matter of which are all within the scope of my education and professional experience:

- The ‘439 Patent, Ex. 1001;
- The Prosecution History of U.S. Patent No. 7,623,439, Ex. 1002;
- The Petition for *Inter Partes* Review of U.S. Patent No. 7,623,439 (“Pet.”);
- Declaration of Dr. Zhi Ding, Ex. 1004;
- “On the Equivalence of Space-Time Block Coding with Multipath Propagation and/or Cyclic Delay Diversity in OFDM” by Dammann *et al.* (Dammann), Ex. 1005;
- U.S. Patent No. 5,961,575 to Hervin *et al.*, Ex. 1002;

- U.S. Patent No. 6,842,487 (Larrison), Ex. 2003;
- Armin Dammann and Stefan Kaiser, “Standard conformable antenna diversity techniques for OFDM and its application to the DVB-T system,” in *Proceedings IEEE Global Telecommunications Conference (GLOBECOM 2001)*, November 2001, pp. 3100–3105 (Dammann-IEEE), Ex. 2004; and
- U.S. Provisional Application No. 60/572,481, filed on May 20, 2004, Ex. 2010.

## II. PROFESSIONAL BACKGROUND

4. Based on my qualifications, education, knowledge, expertise, experience, and work background, I believe I am qualified to offer opinions relating to the technology described in the ‘439 Patent. Exhibit 2002 is a copy of my current *curriculum vitae* (“CV”), detailing my education and experience. Additionally, the following overview of my background pertains to my qualifications for providing expert testimony in this matter.

5. I am currently an Adjunct Professor in Wireless Communications at the NYU Tandon School of Engineering and President of TekTactiks, a research and expert consulting company. My job duties include directing and performing research in, and technical evaluation of, advanced communication system design, especially new cellular technologies. I have over 45 years of experience in the field of wireless telecommunications, including advanced military communications systems, commercial satellite, WiFi and cellular systems research and development. I have over 15 years of experience in providing expert services in the field of wireless

telecommunications. I hold Ph.D., Master's and Bachelor's degrees in Electrical Engineering, all from the Polytechnic Institute of New York (now part of NYU Tandon School of Engineering).

6. I am a named inventor on over 100 issued U.S. Patents in the field of wireless telecommunications. Most of these patents pertain to wireless communication, including communication system architecture, communication system signal processing and communication system protocols.

7. In addition to my technical experience in the field of wireless communications systems, I have been a principal and executive in multiple wireless technology corporations. In the late 1980s and early 1990s, I was Vice President and Chief Scientist at SCS Mobilecom, a wireless company that developed new technology based on spread spectrum technologies and advanced signal processing (DSP) techniques. Following the acquisition of SCS Mobilecom by InterDigital Communications, Corporation in 1992, I held various leadership roles at InterDigital, including General Manager of the Wireless Products Business Unit and Executive Vice President and Chief Technology Officer, where I helped develop 2G and 3G technologies. After InterDigital, I served in leadership positions at several wireless startups, including Symbol Technologies (where I led the Wide Area Wireless technology division), LayerOne Wireless Technologies Inc. (where I served as CEO) and incNetworks (where I served as CTO). I am also the Founder and President of

The TekTacktics Group, Inc. a private company that has provided expert services and telecommunications consulting in the Telecommunications industry for the past 15 years.

8. In terms of commercial research and development (R&D) experience, I have worked extensively on the design and optimization of radio frequency (RF) communications systems for enhanced capacity and service coverage. A further object of my work has been to realize systems that are “converged” or are ingredients in a converged network concept. Convergence means the technical integration of heterogeneous services (such as voice, data, and multimedia) and heterogeneous radio technologies (macrocellular, microcellular, WiFi, cordless phone) into a seamless operating unit. This work requires cross functional design in which the respective heterogeneous technologies are made to interoperate.

9. During this career activity, I have had first-hand knowledge and exposure to numerous discussions, and debates in support of the advancement of new wireless technologies and paradigms. These new technologies addressed various air interface methods, including orthogonal frequency division multiplexing (OFDM) and Orthogonal Frequency Division Multiple Access (OFDMA), a closely related method of utilizing the OFDM format to provide shared access. My current research includes the presently evolving 5G cellular concept, which incorporates, among other things, MIMO-OFDM/OFDMA processing. As outlined above, my involvement in

wireless R&D has also drawn me to fundamental system architecture issues and philosophies including the functional portioning of the overall wireless network. I have had the benefit of collaboration and debate with numerous top tier innovators, from many industry-leading organizations in the field. In particular, I have detailed knowledge and recollection of the atmosphere surrounding the ongoing wireless technology revolution that began in the late 1980s and continues to the present day, including the period surrounding the present invention, and also including attempts by interested parties across the globe to promulgate and protect preferred ideas and intellectual property.

10. With respect to the technologies relevant to the '439 Patent, my experience includes research, design and/or development of optimized radio communication systems comprising signal processing algorithms, computer code (software and firmware) and hardware circuits for the purpose of performing necessary signal detection, synchronization and demodulation, including channel equalization (of multipath channels) that is required in many applications. A representative (but not all-inclusive) example of the type of algorithms I have expertise in, which are relevant to the '439 patent, can be seen in US Patent 7406120-B1, entitled "Transmission Channel Impulse Response Estimation Using Fast Algorithms." The problem addressed there is relevant to the placement of the FFT

window referred to in the '439 patent, although my patent did not involve the notion of cyclic shift diversity.

11. I also have extensive experience in the particular modulation technique to which the '439 patent is applicable, OFDM, and related OFDMA and SC-OFDM. This experience includes basic research on the particular difficulties a multipath channel presents in the OFDM communication environment, especially in dispersive channel conditions.

12. In addition to specific expertise and experience in the art of OFDM and related formats, I am, furthermore, an expert in statistical signal processing algorithms and their performance, technology generally included under the heading Detection and Estimation Theory. Notable contributions to this aspect of radio communication in multipath channel conditions include both SISO- and MIMO-based optimal equalizer algorithms, including the first general treatment of equalization for offset modulation formats (such as O-QPSK).

13. To place the experience I have in the context of innovation and invention, I have been involved throughout my career in the evolution of many basic radio communication technologies since their inception, such as MIMO, Multiuser Detection, and FEC coding advances, such as Turbo and LDPC, and soft output decoders such as the Soft Output Viterbi Algorithm (SOVA). A significant portion of the engineering design work I have performed has entailed the introduction of

new techniques to provide capabilities that had not existed previously, such as a recently deployed novel baseband processor capable of robust demodulation and combining of signal components received on two antennas, respectively, at very low signal to noise ratios.

14. My CV contains further details on my education, experience, publications, and other qualifications to render an expert opinion in this case. Ex. 2002.

### **III. RELEVANT LEGAL STANDARDS**

15. I have been asked to provide my opinion as to whether certain claims of the '439 Patent are obvious over Dammann in combination with Hervin.

16. The opinions I am expressing in this report involve the application of my knowledge and experience to the evaluation of certain references with respect to the '439 patent. My formal knowledge of patent law is no different than that of any lay person. Therefore, I have requested the attorneys from Volpe Koenig, who represent Intellectual Ventures, to provide me with guidance as to the applicable patent law in this matter. The paragraphs below express my understanding of how I must apply current principles related to patent validity to my analysis.

17. I understand that an IPR is a proceeding before the USPTO for evaluating the patentability of an issued patent's claims based on prior-art patents and printed publications.

18. I understand that the claims of a patent are reviewed from the point of view of a hypothetical person of ordinary skill in the art (“POSITA”) at the time of the filing of the patent. The “art” is the field of technology to which a patent relates.

19. I understand that in determining whether a patent claim is anticipated or obvious in view of the prior art, the Patent Office must apply the *Phillips* standard to construe the claims.

20. I understand that, in this proceeding, Petitioners have the burden of proving that the challenged claims of the '439 Patent are unpatentable by a preponderance of the evidence. I understand that “preponderance of the evidence” means that a fact or conclusion is more likely true than not true.

21. I understand that there are two ways in which prior art may render a patent claim unpatentable. First, the prior art can “anticipate” the claim. Second, the prior art can render the claim “obvious” to a POSITA. I understand that for an invention claimed in a patent to be patentable, it must not be anticipated and must not be obvious based on what was known before the invention was made. For purposes of this Declaration only, I have applied the definition of a POSITA proposed in the Petition.

22. I understand that a patent claim may be invalid as “anticipated” under 35 U.S.C. § 102 if each and every limitation of the claim as construed by the court is found, either expressly or inherently, in a single prior art reference, such as a

publication or patent, that predates the claimed subject matter. I also understand that a patent claim may be invalid as obvious under 35 U.S.C. § 103 if the differences between the subject matter claimed and the prior art are such that the claimed subject matter as a whole would have been obvious to a POSITA at the time the invention was made. I also understand that several factual inquiries underlie a determination of obviousness. These inquiries include (1) the scope and content of the prior art, (2) the level of ordinary skill in the field of the invention, (3) the differences between the claimed invention and the prior art, and (4) any objective evidence of non-obviousness (i.e., “secondary considerations”).

23. I also understand that, when a party alleges obviousness based on a combination of references, that party should identify a reason why a POSITA would have been motivated to combine the asserted references in the manner recited in the claims and to explain why a POSITA would have had a reasonable expectation of success in making such combinations.

24. I understand that an obviousness analysis permits the application of “common sense” in examining whether a claimed invention would have been obvious to a POSITA. For example, I understand that combining familiar elements according to known methods and in a predictable way may suggest obviousness when such a combination would yield nothing more than predictable results. And I understand a party asserting obviousness should still provide a specific motivation to combine the

references as recited in the claims and explain why one would have reasonably expected to succeed in doing so.

25. I understand that one indicator of non-obviousness is when a prior art reference leads in a different direction or discourages that combination, recommends steps that would not likely lead to the patent's result, or otherwise indicates that a seemingly inoperative device would be produced.

26. I have also been asked to provide my opinion as to whether certain claims of the '439 Patent are supported by the disclosure of its Provisional Application (Ex. 2010) (the "Provisional Application.")

27. I understand that in order for a patent claim is supported, the specification must contain a written description of the invention, and the manner and process of making and using it, so as to enable any person skilled in the art to which it pertains, to make and use the same.

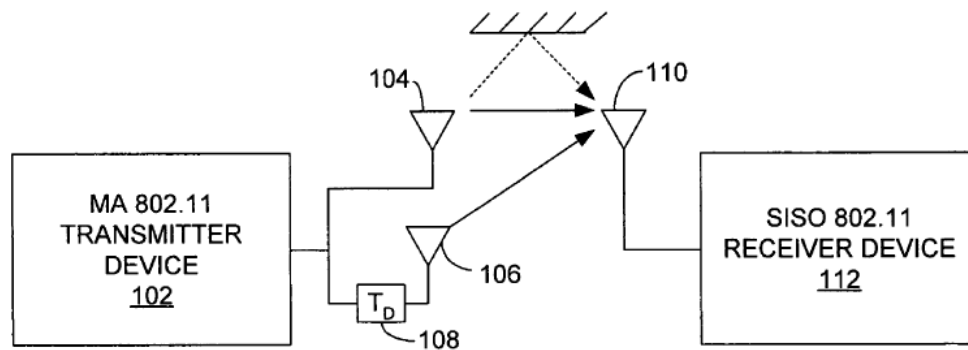
#### **IV. SPECIFICATION OF '439 PATENT**

##### **A. Background**

##### **1. The Problem Of Multi-Path When Implementing Multiple Antenna OFDM Transmitters In A Mixed Environment With Single-Input, Single Output Legacy Receivers**

25. The '439 Patent is focused on the problem presented by multi-path signals when OFDM transmitters with multiple antennas are implemented in a mixed environment that still uses single-input, single output (SISO) legacy OFDM

receivers. Ex. 1001, 1:27-32 ("there is a need to consider legacy receivers (e.g., single-input, single output (SISO), OFDM receivers) and the design challenges concomitant with implementing transmitters with multiple antennas in an environment that still uses legacy receivers.") Figure 1 illustrates a mixed environment where an OFDM transmitter with multiple antennas is used with a SISO legacy receiver:

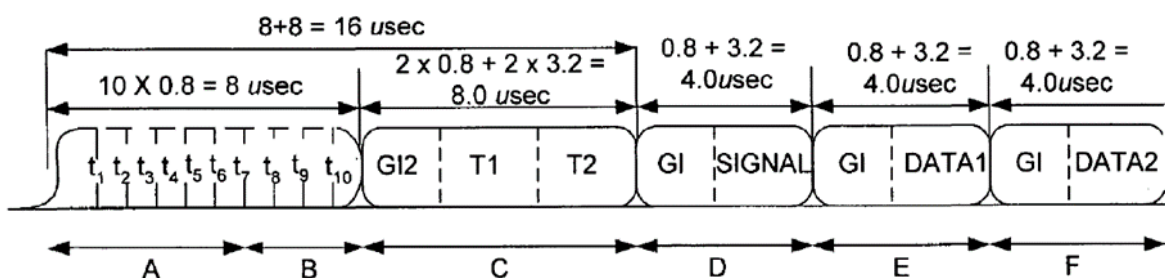


26. The multiple antenna (MA) transmitter device 102 includes antennas 104 and 106, while the SISO receiver device 112 includes only a single antenna 110. *Id.*, 1:38-42. "The same signals transmitted from antennas 104 and 106 may follow direct paths and multi-paths to antenna 110." *Id.*, 1:40-42. Such multiple-path signals can result "from reflections off of objects in the environment or from multiple antennas" and can cause destructive interference of the same signals in the SISO receiver. *Id.*, 1:42-46. Figure 1 employed a technique known as "linear diversity" for mitigating "destructive interference from multi-path signals" by "equip[ing] one of the antennas 104 and 106 with a time delay element 108." *Id.*, 1:46-56. As discussed

more fully below, linear diversity was problematic because, *inter alia*, it resulted in consumption of the guard interval. *Id.*, 3:47-49.

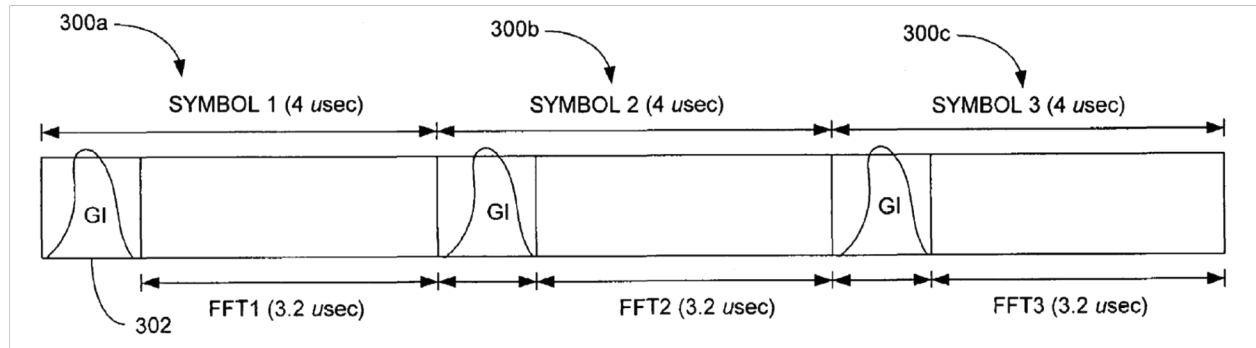
## 2. Existing OFDM Packet and Symbol Structures

27. Figure 2 of the '439 Patent depicts an OFDM packet structure used for transmission of information between MA transmitter device 102 and SISO receiver device 112. *Id.*, 1:57-60.



28. Section A includes short training signals that "provide signal detection, automatic gain control (AGC), and diversity selection functionality," and Section B includes short training signals that "provide coarse frequency offset estimation and timing synchronization." *Id.*, 1:66-2:4. With respect to Section C, "the SISO receiver device 112 determines the guard interval and symbol location (and FFT placement) through an acquisition process that includes a correlation of the known pattern corresponding to ... section C of the OFDM packet." *Id.*, 3:22-25. Section D "contains data rate and packet length information. *Id.*, 2:6-8. "Sections E and F are OFDM symbols." *Id.*, 2:8-9.

29. Figure 3A of the '439 Patent depicts three "exemplary OFDM symbols" in the time domain. *Id.*, 2:13-16. Each exemplary OFDM corresponds, e.g., to sections E or F from Figure 2:



30. Each OFDM symbol includes a guard interval 302, which provides a buffer between symbols. The '439 Patent explains that "multipath is equivalent to echoes," and the guard intervals "comprise a zone built into an OFDM symbol" into which "echoes from a preceding OFDM symbol are positioned." *Id.*, 2:17-21. "Such echoes cause inter-symbol interference." *Id.*, 2:21. The guard intervals are inserted in the OFDM symbol by the MA transmitter device 102, and "are used to capture unwanted multipath-induced inter-symbol interference at the SISO receiver device 112." *Id.*, 2:21-26.

31. In the 802.11 implementation depicted in Figure 3A, each OFDM symbol is approximately 4 μsec in duration and includes 80 samples: the guard interval consumes 16 samples and the data portion comprises 64 samples. *Id.*, 2:26-

30. Processing of the OFDM signal involves placement of the FFT, and occurs as follows in the receiver:

... Fast Fourier transforms (FFT) applied at the SISO receiver device 112 (e.g., 64-point FFT) occur (or are placed) in the 3.2 ( $\mu$ sec) interval of each OFDM symbol 300. That is, the SISO receiver device 112 discards the 0.8  $\mu$ sec duration guard interval 302 on each received 4  $\mu$ sec OFDM symbol, leaving 3.2  $\mu$ sec of signal (which comprises all of the information of the OFDM symbol) to FFT. No echoes are included in the 3.2  $\mu$ sec interval (inter-symbol interference free). Thus, reference to "placing" or "to place" or "placement" of the FFT is understood to comprise a process or method of extracting the correct 3.2  $\mu$ sec from each 4  $\mu$ sec interval for implementing the FFT. *Id.*, 2:30-41 (emphasis added).

### **3. FFT Placement With Linear Diversity**

32. As explained in the '439 Patent, "[l]inear delay diversity results in true delays that exhibits a behavior from a receiver perspective that is indistinguishable from true multi-path (e.g., the situation where the signal bounces off an object and arrives at the SISO receiver device 112 with a time delay due to the greater path distance traveled)." *Id.*, 3:42-47. Figures 4A and 4B of the '439 Patent illustrate how a SISO receiver operates in this context.

33. Figure 4A of the '439 Patent (shown below) depicts an example of "partial packet structures 200a and 200b, each having three symbols 300 (designated as symbol 1, symbol 2, and symbol 3) comprising guard intervals 302. Packet structure 200b is a delayed version of packet structure 200a. Packet structure 200b

is delayed (e.g., by delay element 108) a time delay duration designated as  $t_D$ ." *Id.*, 3:10-15.

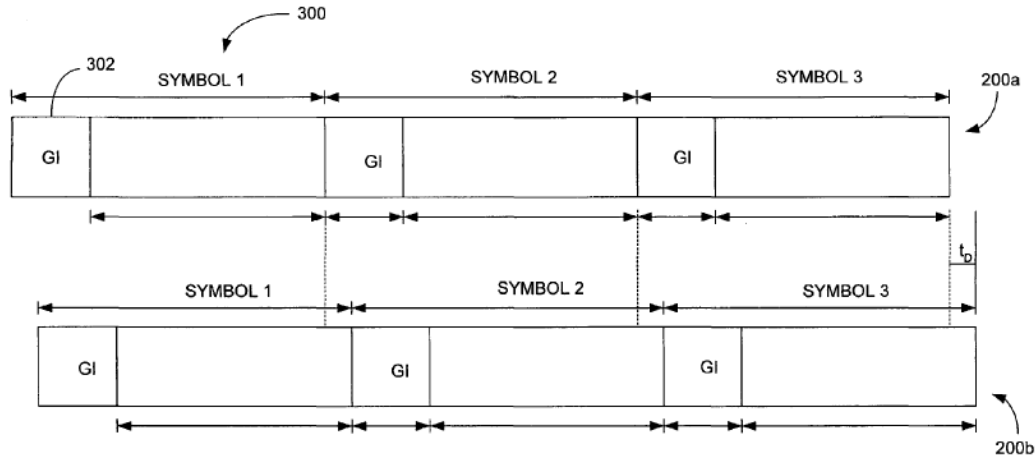


**FIG. 4A (PRIOR ART)**

34. FIG. 4B (shown below) "illustrates a single received signal (comprising the addition of the two transmit signals corresponding to packet structures 200a and 200b) output from the single receive antenna 110." *Id.*, 3:19-22.

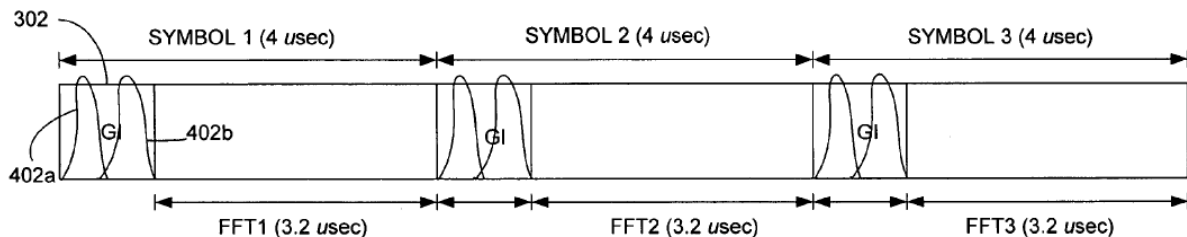


**FIG. 4B (PRIOR ART)**

35. As noted above, "[t]he SISO receiver device 112 determines the guard interval and symbol location (and FFT placement) through an acquisition process that includes a correlation of the known pattern" corresponding to the long training symbol in section C of the OFDM packet 200 (FIG. 2). *Id.*, 3:22-26. "With the time

delay ( $t_D$ ) (or with multi-path), two impulse responses (402a and 402b) are detected" and "FFT placement is accomplished by using the impulse response(s) to center the guard interval 302 on the transients so that inter-symbol interference ISI is minimized." *Id.*, *Id.*, 3:35-41. "[W]ith linear delay diversity, complete destructive interference is avoided, but at the expense of the consumption of the guard intervals 302." *Id.*, 3:47-49.

#### **4. Use Of Small Cyclic Delays**

36. The use of a small cyclic delay was known to somewhat improve compatibility between MA transmitters and legacy receivers. *Id.*, 3:50-52 ("With cyclic delay diversity, each tone or subcarrier is cyclically shifted (e.g., in the baseband processing portion of the MA transmitter device 102, FIG. 1) by a defined amount of samples, resulting in a circular shift of all of the samples involved.") Figure 5 of the '439 Patent illustrates this prior technique, which employed a small cyclic delay, i.e., a delay of 1 sample:

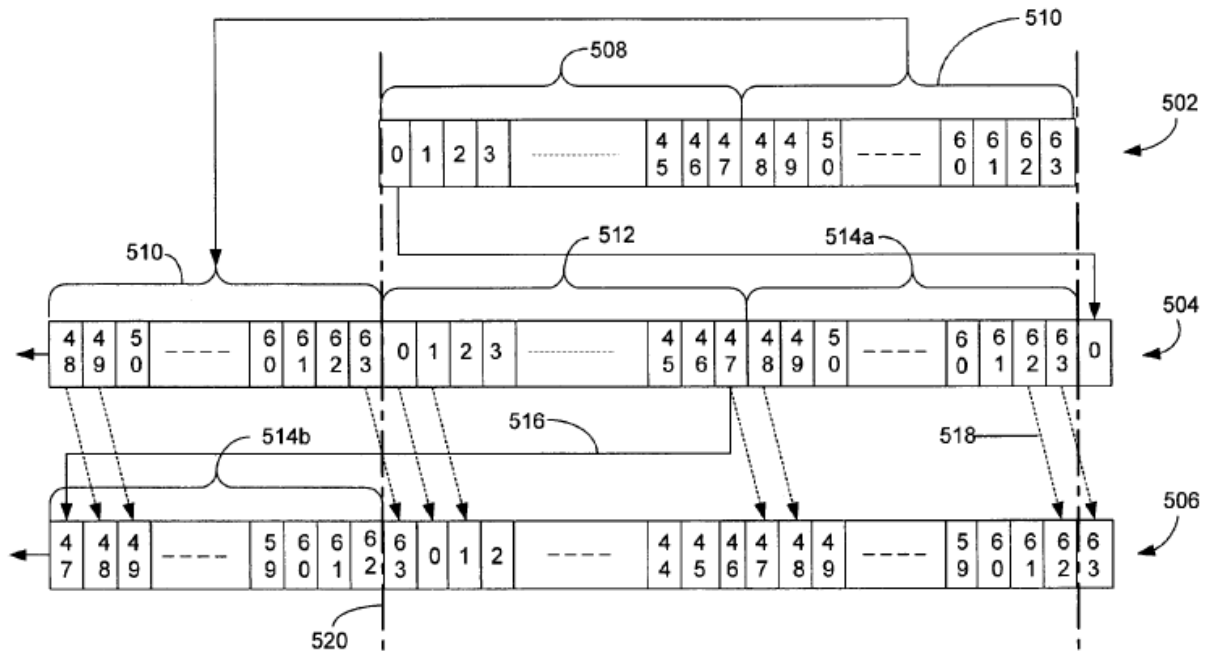


**FIG. 5 (PRIOR ART)**

37. The first tier 502 includes 80 total samples: 64 samples of symbol data 508 and 16 samples used for guard interval 510. "The second tier 504 is simply an extension of the first tier, showing the guard interval 510 corresponding to samples 510 adjacent to the next set of samples." *Id.*, 3:58-63. "This next set of samples comprises 64 samples of symbol data 512 and 16 samples corresponding to the guard interval 514a." *Id.*, 3:63-65. The third tier 506 depicts a small 1-sample cyclic delay shift, resulting in "a delay of 1 sample in the guard interval 514b preceding the 80 sample symbol in the third tier 506, starting with sample 4/7, as indicated by line 516. All of the other samples are likewise shifted as represented by the dotted arrow-head lines 518." *Id.*, 3:66-4:4. As explained in the '439 Patent, from "a receiver

standpoint, the guard intervals 510, 514b remain aligned. ... The samples used for each guard interval are different after a cyclic shift, but the guard intervals still remain as 16 samples." *Id.*, 4:5-10 (emphasis added).

38. Significantly, the prior art techniques described by the '439 Patent in connection with Figure 5 were limited to the implementation of small cyclic delays, e.g., a 1-sample delay.

## **5. Small Cyclic Delays Were Problematic Because They Resulted In "Spoofing" The Receiver**

39. As explained in the '439 Patent, one problem with small cyclic delays involved the placement of the FFT window in the acquisition process:

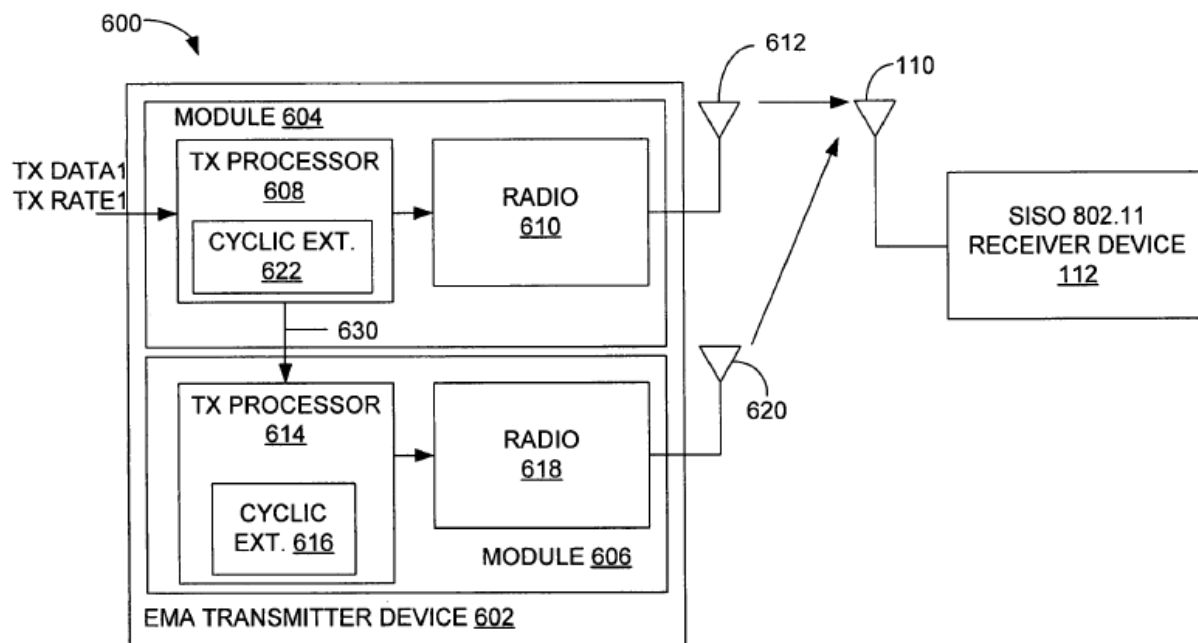
... When correlation occurs at the SISO receiver device 112 (FIG. 1), the sample shifting is detected, such shifting being indistinguishable from the sample shifting that occurs in linear delay diversity. In other words, the impulse response appears to shift directly with the cyclic shift. However, the true location of the guard interval does not change because the MA transmitter device 102 (FIG. 1) is using cyclic shifts. This can spoof the SISO 20 receiver device 112 such that the FFT placement is erroneous. That is, the SISO receiver device 112 may shift the FFT over in a manner that spills over to the subsequent guard interval. *Id.*, 4:12-22 (emphasis added).

40. Not surprisingly, and as explained later in the '439 Patent, small cyclic delays resulted in a relatively high packet error rate. *Id.*, 8:24-41 and Fig. 9.

## **B. Detailed Description**

41. The '439 Patent discloses a novel cyclic diversity method that employs a small cyclic advance, in contrast to a small cyclic delay. In particular, the claimed

cyclic advance has a duration that is "less than [the] duration of the guard interval," (see, e.g., claim 1). This *small* cyclic advance "enables legacy receivers to experience improved packet error rate performance when compared to conventional diversity mechanisms." *Id.* 4:31-34 and 5:37-41. Figure 6 illustrates an embodiment of a transmitter device for implementing the small cyclic advance diversity technique, together with the legacy receiver device 112 (described in association with Figure 1):



42. Module 604 includes a transmit (TX) processor 608 that performs encoding, interleaving, mapping, and OFDM symbol generation and processing. As part of symbol generation and processing, a cyclic extension module 622 implements cyclic advance diversity. *Id.*, 6:6-14. Module 606 comprises components and

functionality similar to module 604, including a transmit processor 614 and a cyclic extension module 616, which operate in a similar manner to cyclic extension module 622. *Id.*, 6:28-33. "In operation, transmit processors 608 and 614 encode and interleave the incoming data ...[and] map the interleaved data into respective sub-carrier channels as frequency domain symbols." *Id.*, 6:42-47. Next, "[i]nverse fast Fourier transform (IFFT) logic in baseband processing circuitry of the transmit processors 608 and 614 performs an inverse fast Fourier transformation on the frequency domain symbols to create OFDM symbols." *Id.*, 6:47-51.

43. FIG. 8 illustrates an implementation of a 4-sample cyclic advance diversity technique according to the '439 Patent:

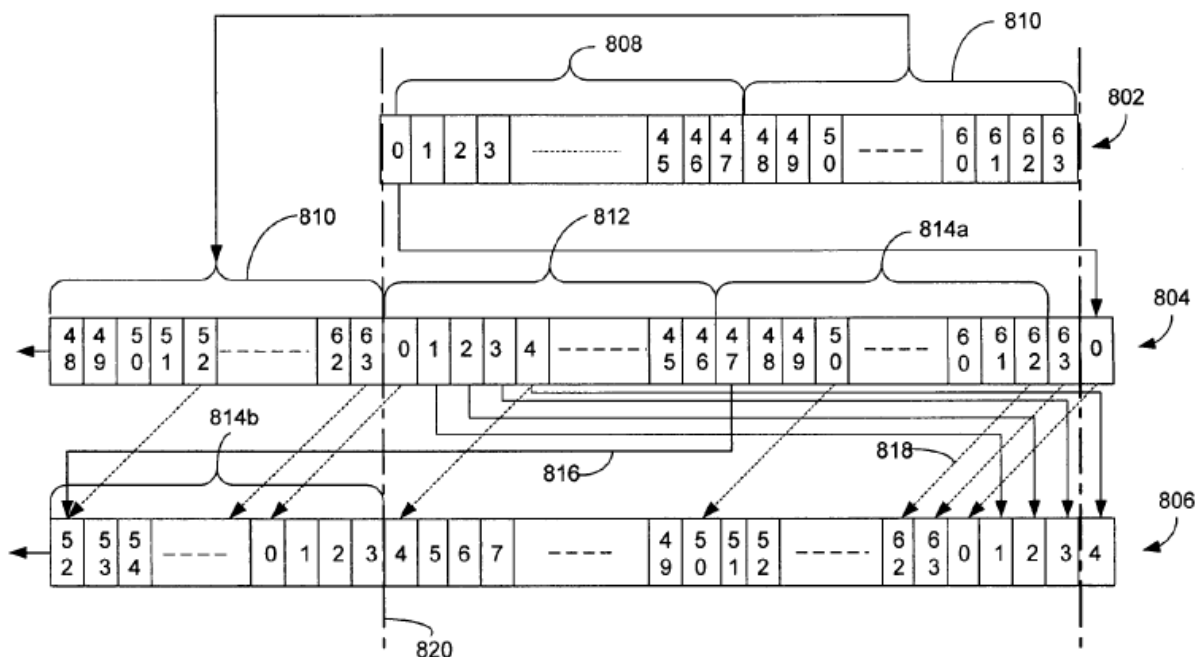


**FIG. 8**

44. The first tier 802 represents 80 total samples: 64 samples of symbol data 808 and 16 samples used for guard interval 810. "The second tier 804 is simply an extension of the first tier 802, showing the guard interval corresponding to samples 810 adjacent to the next set of samples. This next set of samples comprises 64 samples of symbol data 812 and 16 samples corresponding to the guard interval 814a." *Id.*, 7:33-40. The third tier 806 depicts a 4-sample cyclic advance shift, resulting "in the guard interval 814b preceding the 80 sample symbol in the third tier 806 starting with sample 5/2, as represented by line 816. All of the other samples are likewise shifted as represented by the dotted arrow-head lines 818." *Id.*, 7:40-46. "From a receiver standpoint, the guard intervals 810, 814b remain aligned, as represented by the dashed line 820." *Id.*, 7:47-48.

45. The small cyclic advance disclosed in the '439 Patent reduced the problem of receiver "spoofing" that plagued small cyclic delays (shown in Figure 5). As explained in the '439 Patent:

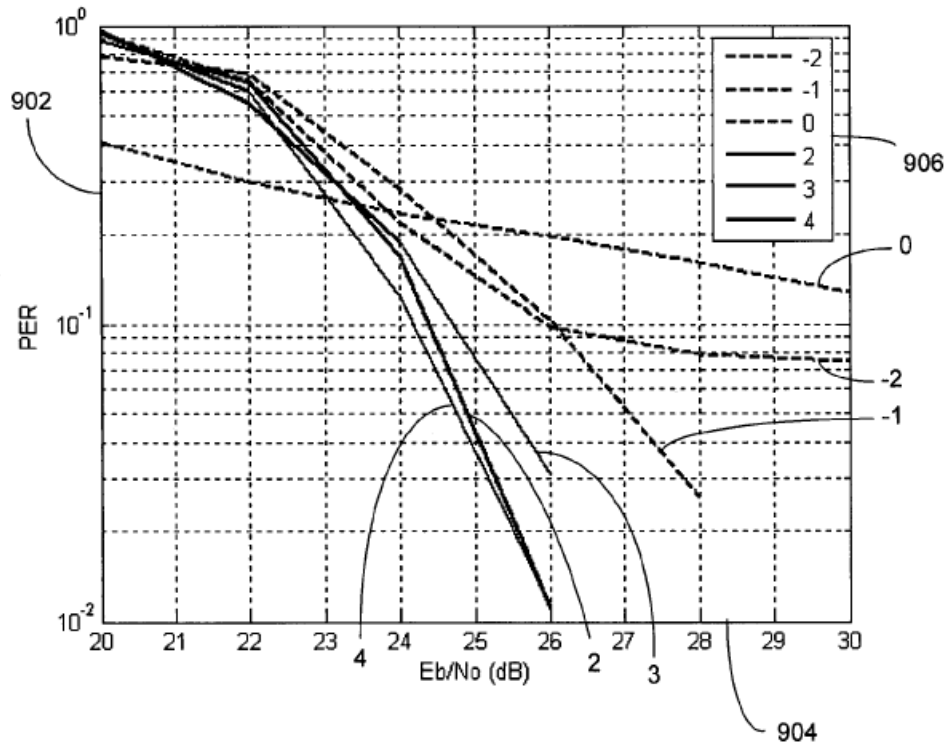
[U]nlike cyclic delay diversity, cyclic advance diversity does not result in net shifting of the FFT. That is, the FFT placement remains substantially centered and unshifted. ...

As is shown below, small cyclic advances are preferred over small cyclic delays ...

... small cyclic advances are superior to small cyclic delays. *Id.*, 7:51-8:23 (emphasis added).

### C. Experimental Data Included In Specification

46. The '439 Patent included experimental testing data (see Figure 9) demonstrating that a small cyclic advance of 2, 3 or 4 samples had a reduced packet error rate when compared to small cyclic delays of 1 or 2 symbols. *Id.*, 8:34-49.



47. Figure 9 demonstrates the superior performance of the small cyclic advance disclosed in the '439 Patent as compared to the performance of the small cyclic delay in the prior art as illustrated in Figure 5.<sup>1</sup> The Petition fails to address

<sup>1</sup> While the detailed description of the '439 Patent noted that "mathematically, a small cyclic advance of 100 nsec is identical or equivalent to a large delay of 3100 nsecs," (*id.*, 8:6-10 (emphasis added)), the '439 Patent did not disclose that a large delay was in the prior art. The prior art labelled as Figure 5 does not include a large delay (e.g., a delay with a duration greater than the guard interval) -- rather Figure

-- let alone dispute -- these experimental results. Although the Petition argues (incorrectly) that cyclic advances "were well known to be equivalent" to cyclic delays (e.g., Petition, 27), the Petition does not dispute that the two perform differently. Ex. 1001, 8:21-23 ("What has been determined experimentally is that small cyclic advances are superior to small cyclic delays"); and 7:51-55 ("[U]nlike cyclic delay diversity, cyclic advance diversity does not result in net shifting of the FFT. That is, the FFT placement remains substantially centered and unshifted.") (emphasis added). The Petition does not dispute that the '439 Patent was the first reference to identify these performance advantages, nor does the Petition argue that these performance advantages were predictable.

## **V. PROSECUTION HISTORY OF '439 PATENT**

48. The primary reference applied by the Examiner during prosecution was U.S. Patent No. 6,842,487 (Larsson) (Ex. 2003). Much like the prior art identified in Figure 5 of the '439 Patent, Larsson disclosed the use of small cyclic delays (e.g., a 1-sample delay and a 3-sample delay). For example, Figure 8 of Larsen depicts a 1-sample delay:

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5 shows only a small delay, e.g., a 1-sample delay. This important distinction is borne out in the prosecution history, discussed in the next section.

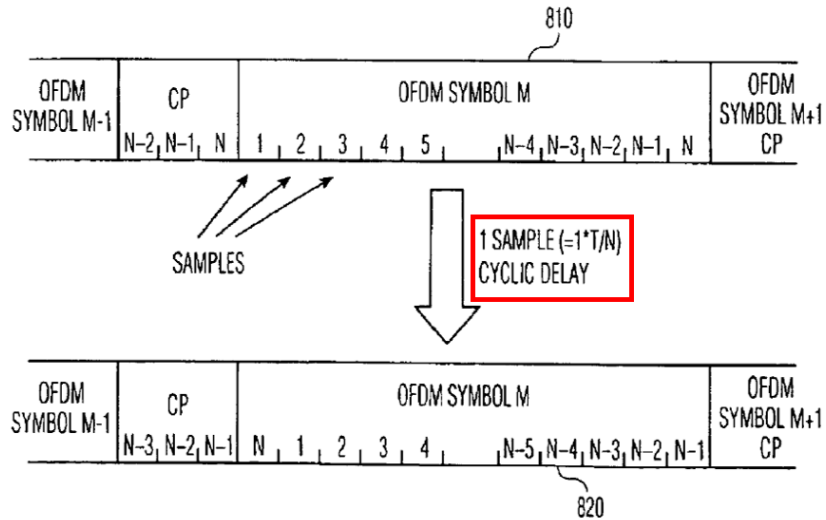


FIG. 8

Ex. 2003, Fig. 8 (red box added).

49. In describing Figure 8, Larsson also referred to a small 3-sample delay:

FIG. 8 illustrates two OFDM symbols wherein a cyclic delay is implemented between the two symbols being transmitted in a transmission diversity scheme. Assume that OFDM symbol M 810 is transmitted over the antenna that has no cyclic delay and that OFDM symbol M 820 is transmitted over an antenna which has a cyclic delay of one sample. As can be seen by comparing OFDM symbols 810 and 820, the cyclic delay is implemented by shifting samples from the end of the OFDM symbol into the beginning of the OFDM symbol and adding a cyclic prefix by copying the last in samples of the OFDM symbol. For example, if a cyclic delay of three samples were implemented, the OFDM symbol transmitted over the third antenna would have the last three samples of the OFDM symbol shifted into the first three slots of the OFDM symbol and the remaining samples in the OFDM symbol would be shifted three places to the right. Then the last n samples of the OFDM symbol are copied and placed in the cyclic prefix, wherein n represents the number of samples in the cyclic prefix for a particular system. Ex. 2003, 6:39-58 (emphasis added).

50. In the First Office Action, the Examiner rejected claim 1 as anticipated by Larsson, reasoning that the claimed small cyclic advance (less than a guard interval) was met by Larsson:

Regarding claims 1, 9 and 21, Larsson teaches ... performing a periodic cyclic advancing operation on one or more sections of the OFDM packet corresponding to a second transmit antenna (performing cyclic delay operation on the same OFDM symbol corresponding to a second transmit antenna Ant 2 TX, as shown on Fig. 8 and 9 by shifting the OFDM samples, as described on 6:40-57), wherein the duration of the periodic cyclic advance operation is less than a guard interval (performing 1 sample cyclic delay operation, which is less than the cyclic prefix, identified as guard interval on 1:30-32, as the length of the cyclic prefix (CP) is three samples, as clearly shown on Fig. 8). Ex. 1002, 144-145 (emphasis added).

51. The applicant responded by arguing that Larsson's cyclic delay was distinguishable from the claimed cyclic advance. Ex. 1002, 135 (emphasis added). The Examiner was not persuaded, and issued a Final Office Action maintaining the rejection over Larsson. The Examiner argued that advancing inherently included delaying:

... Applicant argues that Larsson does not teach "cyclically advancing" limitations of the independent claims, but teaches only "cyclically delaying", making the claims patentable over Larsson.

Examiner respectfully disagrees.

Larsson teaching is directed to delaying  $n-1$ ,  $n$ ,  $n+1$  OFDM symbols for antenna ANT 2, inherently advancing  $n-1$ ,  $n$ ,  $n+1$  OFDM symbols for antenna Ant 1, ... Ex. 1002, 125 (emphasis added).

52. The Applicant next filed a Request for Continued Examination where claim 1 was cancelled and new independent claim 24 was added. In accompanying

remarks, the Applicant again articulated the distinction between a cyclic advance and a cyclic delay:

In rejecting claims 1, 9, and 21, the Examiner asserted that "advancing a portion of the signal is always relative to the other copy/duplicate of the signal, which is delayed, as advancing signal in time is physically impossible." ... As further described in specification, paragraph 0040 and Figure 8, the "cyclical advancement" set forth in the claims is accomplished by shifting the samples of the OFDM symbol in a direction opposite to that described by the prior art. Such "cyclical advancement" is imparted to the "one or more shifted versions of the OFDM packet" relative to the original OFDM packet. ...

\* \* \*

... Larsson describes applying a "cyclic delay" to an OFDM symbol by "shifting samples from the end of the OFDM symbol into the beginning of the OFDM symbol and adding a cyclic prefix by copying the last n samples of the OFDM symbol." See Larsson, column 6, lines 45-49 and Figure 8. Larsson, however, does not appear to suggest the "cyclical advancements" be applied to the OFDM packet as set forth in claim 24. In fact, as described in the specification, the "cyclic delay" described by Larsson would cause the legacy receiver to shift the FFT window into the subsequent symbol and thereby cause intersymbol interference since the intentional cyclic delay is "indistinguishable from the sample shifting that occurs in linear delay diversity" from the receiver standpoint. On the contrary, during the acquisition process, the cyclical advancement as set forth in claim 24 would cause the impulse responses corresponding to the shifted versions of the OFDM packet to occur before the impulse response of the unshifted OFDM packet, thereby preventing the erroneous alignment of the FFT window. Ex. 1002, 98-100 (emphasis added).

53. In the next Office Action, the Examiner rejected claim 24 as obvious over Larsson in view of Admitted Prior Art. The Examiner reiterated the argument that Larsson's cyclic delay inherently included a cyclic advance:

Larsson teaches cyclical operation of shifting of a portion of the OFDM signal from the symbol end to the symbol beginning, which results in advancement of the shifted portion and in delay of the other portion of the symbol, pushed back by the advanced portion, as disclosed on 5:20-40. Therefore, Applicant's emphasis on the advancing data in the cyclical shift is not a patentable feature over similar cyclical shift operation of Larsson, wherein some portion of the symbol is advanced and other portion of the symbol is delayed. Ex. 1002, 72 (emphasis added).

54. The Applicant responded by reiterating previous arguments, including that "as described in the specification, the 'cyclic delay' described by Larsson would cause the legacy receiver to shift the FFT window into the subsequent symbol and thereby cause intersymbol interference." In this regard, the Applicant argued:

The Larsson reference fails to suggest or disclose every element of the claims, as amended. Larsson describes applying a "cyclic delay" to an OFDM symbol by "shifting samples from the end of the OFDM symbol into the beginning of the OFDM symbol and adding a cyclic prefix by copying the last n samples of the OFDM symbol." See Larsson, column 6, lines 45-49 and Figure 8. Larsson, however, does not appear to suggest the "cyclical advancements" be applied to the OFDM packet as set forth in claim 24 and Fig. 8. In fact, as described in the specification, the "cyclic delay" described by Larsson would cause the legacy receiver to shift the FFT window into the subsequent symbol and thereby cause intersymbol interference since the intentional cyclic delay is "indistinguishable from the sample shifting that occurs in linear delay diversity" from the receiver standpoint.

On the contrary, during the acquisition process of the claimed invention, the cyclical advancement as set forth in claim 24 would cause the impulse responses corresponding to the shifted versions of the OFDM packet to occur before the impulse response of the unshifted OFDM packet, thereby preventing the erroneous alignment of the FFT window. This is due to the directional shift as set forth in Fig. 8, ... Ex. 1002, 52 (emphasis added).

55. The next Office Action included an Examiner's amendment together with a Notice of Allowance. Specifically, the Examiner's amendment (reproduced in part below) further clarified the distinction between the small cyclic advance (less than the guard interval) being claimed and Larsson's small cyclic delay:

24. (Currently Amended) A method for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising: ...  
cyclically advancing the first OFDM packet by shifting the samples in a first direction an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM packet for transmission in which at least a non-zero number of the samples from the symbol data portion of the first OFDM packet are shifted into the guard interval portion of the shifted version and a same non-zero number of samples from the guard interval portion of the first OFDM packet are shifted out of the guard interval portion of the shifted version ... Ex. 1002, 37.

56. In summary, the distinction between a small cyclic delay (as shown in Larsson) and the claimed small cyclic advance was thoroughly vetted during prosecution, and the Examiner found that this distinction (as recited in the amended claims) was patentable. Among other points, the Applicant emphasized during prosecution that, "as described in the specification, the 'cyclic delay' described by Larsson would cause the legacy receiver to shift the FFT window into the subsequent symbol and thereby cause intersymbol interference." Ex. 1002, 52.

## **VI. CLAIMS OF '439 PATENT**

57. The claims of the '439 Patent capture the small cyclic advance invented by Applicant. Claim 1 is representative:

A method for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:

generating a first OFDM packet for transmission including a guard interval portion and a symbol data portion each comprised of a plurality of samples;

cyclically advancing the first OFDM packet by shifting the samples in a first direction an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM packet for transmission in which at least a non-zero number of the samples from the symbol data portion of the first OFDM packet are shifted into the guard interval portion of the shifted version and a same non-zero number of samples from the guard interval portion of the first OFDM packet are shifted out of the guard interval portion of the shifted version; and

substantially simultaneously transmitting the first OFDM packet and the shifted version of the OFDM packet (emphasis added).

58. Two aspects of the claim language are worthy of note. First, the claim specifies that the cyclical advance involves shifting samples from the symbol data portion of a packet into the guard interval portion of such packet.<sup>2</sup> Second, the claim specifies that the shift is small, i.e., less than the duration of the guard interval portion. Claim 8 (the other independent claim challenged in the Petition) contains analogous limitations.

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<sup>2</sup> In the district court, the claim limitation that recites "cyclically advancing the first OFDM packet by shifting the samples in a first direction" was construed as "cyclically advancing the first OFDM packet by shifting the samples in the direction of transmission." Ex. 2005, 6-7 (emphasis added).

## VII. PRIOR ART RELIED ON IN PETITION

59. The Petition advances a single Ground against independent Claims 1 and 8 of the '439 Patent, i.e., that such claims are obvious over "Dammann and Hervin in view of the knowledge of a POSITA." Petition, 4.

### A. Dammann

60. As its primary reference, the Petition relies on a technical paper by Dammann (Ex. 1005), which is alleged to have been presented at a conference in Florence, Italy, on February 27, 2002 (Dammann). Petition, 20-21. Like the Larsson reference applied during prosecution, this paper is directed to small cyclic delays.

61. Specifically, Dammann teaches that its cyclic delays only work when the size of the delay is small, i.e., less than the guard interval:

The cyclic extension allows different OFDM symbols to be decoded without intersymbol interference when

$$T_{Guard} \geq \delta_{max} (\geq \delta_1)$$

$T_{Guard}$  is the period of the cyclic extension [i.e., the guard interval], and  $\delta_{max}$  is the maximum multi-path delay for the channel. Ex. 1005, at 2.

Thus, Dammann requires that  $T_{Guard} \geq \delta_{cy}$ , i.e., cyclic delays that are smaller than the guard interval.

62. Dammann begins its discussion of cyclic delay diversity (CDD) by referring back to an earlier paper by the same author that described the CDD techniques in more detail:

Below we will briefly introduce the application of CDD to OFDM systems as described in detail in [8].

\* \* \*

- [8] Armin Dammann and Stefan Kaiser, "Standard conformable antenna diversity techniques for OFDM and its application to the DVB-T system," in *Proceedings IEEE Global Telecommunications Conference (GLOBECOM 2001)*, November 2001, pp. 3100–3105. Ex. 1005, 1 and 5 (emphasis added).

63. The Petition neglected to include Dammann's earlier paper (Dammann - IEEE) (Ex. 2004) as an exhibit. The Dammann-IEEE paper further demonstrates that the CCD techniques being "briefly introduced" in Dammann were limited to small cyclic delays. In this regard, Dammann-IEEE stated that the delay in samples ( $\delta_l$ ) was governed by the following equation:

$$\delta_\ell \leq N_g - \tau_{max}, \quad \ell = 1, \dots, M - 1,$$

Where  $\delta_l$  "denotes a simple time delay in samples," and " $N_g$  and  $\tau_{max}$  are the guard interval and maximum channel delay in samples, respectively." Ex. 2004, at 2. This equation plainly requires that the delay in samples ( $\delta_l$ ) be smaller than guard interval ( $N_g$ ). After setting forth the above equation, Dammann-IEEE states that "[i]f that condition does not hold, intersymbol interference (ISI) occurs." Ex. 2004, 2. Since ISI must be avoided, a POSITA would have understood that the cyclic delays taught by Dammann-IEEE were necessarily small (less than the guard interval). Since Dammann (relied on in the Petition) was only "briefly introducing" the application

of cyclic delay diversity as described in Dammann-IEEE, it is clear that Dammann is similarly directed to cyclic delays that are smaller than the guard interval.

## **B. Hervin**

64. U.S. Patent No. 5,961,575 (Hervin)(Ex. 1006) is the other reference relied on in the Petition for challenging independent Claims 1 and 8 of the '439 Patent. Hervin teaches that arithmetic shift/rotate operations can be used internally within a microprocessor to effect division and multiplication operations. From Hervin:

The present invention generally relates to microprocessors and, more particularly, to a microprocessor having a multiple stage shifter which selectively performs preprocessing and shift/rotate/pass operations to produce improved performance of shift/rotate operations thereby.

\* \* \*

Digital circuitry for performing arithmetic operations such as shift and/or rotate operations have long been known in the art. In a shift operation, data stored in a storage device, commonly referred to as a shift register, is moved relative to the boundaries of the device. An arithmetic shift right effects a divide by 2 operation while an arithmetic shift left effects a multiply by 2 operation. In a circular shift operation, also known as a rotate, the rightmost and leftmost positions in the shift register are treated as being adjacent during the shift. A rotate operation may be a rotate left (or "ROL") operation in which all of the bits of an operand are shifted left by one or more positions and the most significant bits are shifted around to become the least significant bits or a rotate right (or "ROR") operation in which all of the bits of the operand shifted right by one or more positions and the least significant bits are shifted around to become the most significant bits.

\* \* \*

The present invention is directed to a circuit for performing arithmetic operations which both reduces the number of interconnections necessary to provide a combined shifter/rotator circuit

while eliminating the need for a preconditioning unit used to pre-process byte and word sized operands to be used in shift/rotate operations performed in 32-bit architectures. Ex. 1006, 1:7-29 and 2:7-13 (emphasis added).

65. Hervin discloses nothing more than the use of cyclic rotations (right or left) to perform arithmetic computations within a microprocessor. The Petition does not contend otherwise. In contrast to the '439 Patent, Hervin is not directed to OFDM (or any other wireless communication system) and therefore makes no mention of the application of diversity in such systems. It strains the imagination that a POSITA seeking to address the problems stated in the '439 Patent -- e.g., reducing unwanted multipath-induced inter-symbol interference (Ex. 1001, 2:24-25) -- would look to Hervin's methods for internally performing arithmetic computations within a microprocessor for a solution.

### **C. Knowledge of a POSITA**

66. In addition to Dammann and Hervin, the Petition relies on what it asserts as the "knowledge of a POSITA" in its obviousness analysis. For example, the Petition predicates both its motivation to combine argument and its mapping of Element [1B] on the unsupported assertion that "it was well known in the art that cyclic delay performs the equivalent operation as a cyclic advancement," repeating this mantra (in sum or substance) multiple times throughout the Petition. See, e.g., Petition, at pages 27, 38 and 42. The Petition does not support its assertion that this proposition "was well known in the art" with any reference from the prior art.

Instead, the Petition improperly cites to teachings from the *Detailed Description* of the '439 Patent for this proposition. The Detailed Description of the '439 Patent is not evidence of what "was well known in the art."

### **VIII. THE PETITION FAILS TO DEMONSTRATE A REASONABLE LIKELIHOOD OF SUCCESS ON THE MERITS**

67. The Petition relies on the combination of Dammann and Hervin, in view of the knowledge of a POSITA, in challenging independent Claims 1 and 8. See Petition, 4. This combination is deficient, as described below.

#### **A. The Petition Improperly Relies On The Detailed Description Of The '439 Patent As Evidence Of The Prior Art**

68. The Petition argues that "[a] person of ordinary skill in the art would have been motivated to modify Dammann based on the disclosure of Hervin" because *the Detailed Description of the '439 Patent* taught that "left cyclic shifts (i.e., cyclic advances) were well known to be equivalent to right cyclic shifts (i.e., cyclic delays)." Petition, 26-27. Specifically, the Petition relies on the following passage *from the Detailed Description of the '439 Patent* for its argument that left cyclic shifts were "well known to be equivalent" to right cyclic shifts:

Due to the periodic nature of OFDM subcarriers, mathematically, a small cyclic advance of 100 nsec is identical or equivalent to a large delay of 3100 nsecs (the OFDM symbol waveform repeats with a period of 3.2  $\mu$ sec or 3200 nsec). In other words, 3100 nsec is a periodic equivalent to 100 nsec. Likewise, a small delay of 100 nsec is identical to an advance of 3100 nsec, again due to the periodic nature of the OFDM symbol 300 (e.g., FIG. 3). Thus, a signal received by the SISO receiver device 112 (FIG. 6) having a cyclic advance of 100 nsec or a signal having a cyclic

delay of 3100 nsec is processed as an identical signal from the perspective of the SISO receiver device 112, since the EMA transmitter device 602 (FIG. 6) transmits the identical signal in each case. Since a circular shift is indeed circular, the FFT placement is at the same position shifting in either direction (100 nsec advance, 3100 nsec delay).

Petition, 27, *citing* Ex. 1001 at 8:5-21.

69. Separately, in purporting to map element [1B] to the prior art, the Petition again asserts that "it was well known in the art that cyclic delay performs the equivalent operation as a cyclic advancement," again repeating the identical block quote (set forth above) from the *from the Detailed Description of the '439 Patent* as evidence of such. Petition, 37, *quoting* Ex. 1001 at 8:5-21.

70. The Detailed Description of the '439 Patent is not prior art, and is not evidence that it was "well known in the art that cyclic delay performs the equivalent operation as a cyclic advancement."<sup>3</sup> Petition, 27 and 37. The predicate for both the motivation to combine and mapping of Element [1B] set forth in the Petition -- i.e., that left cyclic shifts were "well known to be equivalent" to right cyclic shifts -- is therefore completely unsupported.

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<sup>3</sup> To be clear, the cited passage from the '439 Patent teaches that a small cyclic advance (100 nsec) is equivalent to a large cyclic delay (3100 nsec). The passage does not teach that a small cyclic advance (e.g., 100 nsec) is equivalent to a small cyclic delay (e.g., 100 nsec). A small cyclic advance (e.g., 100 nsec) is not equivalent to a small cyclic delay (e.g., 100 nsec).

71. Furthermore, in its assertion, the Petitioner *ignores key qualifiers* in the quoted description. Specifically, the '439 patent states that “mathematically, a *small* cyclic advance ... is identical or equivalent to a *large* delay.” Ex.1001, 8:5-9. Thus, notwithstanding the fact that detailed description is not prior art, contrary to Petitioner’s erroneous assertion, the '439 patent does not say or imply categorically that any left cyclic shift is equivalent to any right cyclic shift.

**B. Petitioner's Assertion That Cyclic Advancement Would Provide "Additional" Diversity As Compared To Cyclic Delay Lacks Support And Is Conclusory**

72. Having erroneously concluded that it was left cyclic shifts were "well known to be equivalent" to right cyclic shifts, the Petition argues that a POSITA would have been motivated to modify the cyclic delay in Dammann to a cyclic advancement because doing so would provide *additional* diversity. From the Petition:

Hervin expressly discloses cyclic advancement, and as Dr. Ding testifies, a POSITA would have been motivated to include cyclic advancement in the system described by Dammann because doing so provides *additional* cyclic diversity. Petition, 28, citing, Ex. 1003 at ¶61.

73. However, aside from this conclusory statement, Petitioner's expert (Dr. Ding), provides *no* evidence (or reasoning) supporting his assertion that *additional*

diversity would be achieved by modifying the cyclic delay in Dammann to a cyclic advancement.

74. Even assuming that his conclusory assertion about "additional" diversity was supported by a rationale underpinning, Petitioner's expert fails to explain why a POSITA would have been motivated to introduce further diversity in Dammann's system. Dammann's transmitter already implemented diversity (see, Ex. 1005, at Figure 1). Petitioner's expert does not explain why a POSITA would have been motivated to add still further "additional" diversity to Dammann's system. For example, Petitioner's expert fails to identify any problem (that a POSITA would have recognized) with Dammann's transmitter that would have been addressed by adding still further diversity to the system.

75. Finally, again assuming that his conclusory assertion about "additional" diversity was supported, Petitioner's expert has provided no evidence that it was known in the art that modifying a cyclic delay to a cyclic advancement would achieve additional diversity, or that a POSITA would have recognized such to be this case. Without knowledge or recognition by a POSITA that such "additional" diversity would be achieved, a POSITA would not have been motivated to modify the cyclic delay in Dammann as alleged.

**C. The Petition Fails To Demonstrate That "Implementing Cyclic Shift Diversity" Was A Problem In Search Of A Solution, Or That The Results Of The Claimed Cyclic Advancement Techniques Were Predictable**

76. According to the Petition:

[T]here would have been a finite number of identified, predictable solutions for equivalently implementing cyclic shift diversity – indeed only two solutions: cyclical delay and cyclical advancement. Ex. 1003, at ¶61. Thus, it would have been obvious to a person of ordinary skill in the art to try cyclic advancement, in particular given that the other solution, cyclic delay, is admitted to be in the prior art by the '439 Patent. Petition, 28.

77. The Petition does not identify any problem (driven by design need or market pressure) having a finite number of identified, predictable solutions. Instead, the Petition alleges that there were "a finite number of identified, predictable solutions for equivalently implementing cyclic shift diversity." Petition, 28.

78. However, "equivalently implementing cyclic shift diversity" is not a statement of a "problem." Nor was the use of cyclic advancement an identified solution to "implementing cyclic shift diversity." Dammann does not identify cyclic advancement for "implementing cyclic shift diversity," and Hervin does not mention or even address the "problem" of "implementing cyclic shift *diversity*" at all.

79. Nor has the Petition ~~demonstrated~~ that the results of cyclic advancement were predictable. As noted above, the Petition does not dispute that the small cyclic advances claimed have unexpected advantages over the small cyclic delays in the prior art. 1001, 8:21-23 ("What has been determined experimentally is

that small cyclic advances are superior to small cyclic delays"); and 7:51-55 ("[U]nlike cyclic delay diversity, cyclic advance diversity does not result in net shifting of the FFT. That is, the FFT placement remains substantially centered and unshifted.") (emphasis added). The Petition does not allege that these performance advantages were "predictable" because they were not.

**D. The Petition Fails To Demonstrate That There Were A Finite Number Of Predictable Solutions For Eliminating Multi-Path Inter-Symbol Interference**

88. The problem addressed by the '439 Patent was that SISO receivers functioned poorly when cyclic delays were used. As discussed below, the reason for this poor performance was not known in the prior art. Nor had the prior art identified any predictable solutions for improving upon the poor performance of cyclic delays.

**1. The Problem Was That Cyclic Delays Did Not Work Well With SISO Receivers**

89. The background the '439 Patent explained that "in systems utilizing multiple-antenna devices, there is a need to consider legacy receivers (e.g., single-input, single output (SISO), OFDM receivers) and the design challenges concomitant with implementing transmitters with multiple antennas in an environment that still uses legacy receivers." Ex. 1001, 1:27-31. The '439 Patent explained that linear delay diversity had been proposed to address these challenges but was inadequate because it (i) "results in true delays that exhibits a behavior from a receiver perspective that is indistinguishable from true multi-path" and, (ii) comes

"at the expense of consumption of the guard interval." *Id.*, 3:42-49. The '439 Patent explained that another proposed "technique used to make MA transmitters compatible with legacy receiver devices is referred to as cyclic delay diversity." *Id.*, 3:50-52. However, the inventors of the '439 Patent discovered, that cyclic delays did not work well with SISO receivers. The '439 patent notes that cyclic delay techniques performed relatively poorly when used with SISO receivers, and explains that this was due to suboptimal positioning of the FFT window. *See*, Section VIII(D)(2), below. Nothing in the patent specification – or in the alleged prior art cited by Petitioner – suggests that the relatively poor performance of SISO receivers or its underlying cause was known in the art at the time of the invention.

**2. The Reason That Cyclic Delays Did Not Work Well With SISO Receivers Was Discovered By The Inventors Of The '439 Patent And Not Known In The Prior Art**

90. The prior art had not identified that cyclic delays were deficient. Nor had the prior art identified any reasons why cyclic delays were deficient. Rather, it was the inventors of the '439 Patent who discovered that the "problem with cyclic delay diversity involves the acquisition process" where "the impulse response appears to shift directly with the cyclic shift" which "can spoof the SISO receiver device 112 such that the FFT placement is erroneous." *Id.*, 4:5-22.

**3. The Petition Has Failed To Demonstrate That There Was A Finite Number Of Predictable *Identified* Solutions For Fixing The Unknown Problem That SISO Receivers Did Not Function Well With Cyclic Delays**

91. Neither the problem addressed by the '439 Patent (that SISO receivers did not work well with cyclic diversity) nor the underlying reason for that problem (errors caused by the acquisition process) were known in the art. The Petition does not proffer evidence that any solutions had been identified for addressing the problem that SISO receivers did not work well with cyclic diversity, or for addressing the underlying reason for that problem, namely errors caused by the acquisition process.

92. In addition, there is no evidence that cyclic advancement was identified in the prior art as a solution for addressing the problem that SISO receivers did not work well with cyclic diversity. In fact, there is no evidence that cyclic advancement was identified at all in the prior art in the context of wireless systems.

**E. Dammann Would Have Discouraged A POSITA From Making The Modification Suggested By Petitioner**

93. Dammann teaches that its cyclic delays only work when the size of the delay is small, i.e., less than the guard interval:

The cyclic extension allows different OFDM symbols to be decoded without intersymbol interference when

$$T_{Guard} \geq \delta_{max} (\geq \delta_1)$$

$T_{Guard}$  is the period of the cyclic extension [i.e., the guard interval], and  $\delta_{max}$  is the maximum multi-path delay for the channel. Ex. 1005, at 2.

Thus, Dammann requires that  $T_{Guard} \geq \delta_{cy}$ , i.e., cyclic delays that are smaller than the guard interval.

94. Assuming for purposes of argument that the teaching in the '439 Patent that a small cyclic advance is equivalent to a large cyclic delay<sup>4</sup> was known in the art (it was not), and that the converse was also known, i.e., that a large cyclic advance is equivalent to a small cyclic delay, then Dammann's requirement that its cyclic delay be small (smaller than the guard interval) would have translated to a requirement that any cyclic advance must be large in order to work. The knowledge that a cyclic advance needed to be large in order to work would have actually discouraged a POSITA from trying the small cyclic advance claimed in the '439 Patent. Thus, in view of Dammann's explicit teachings, a POSITA would not have been motivated to try the modification proposed by Petitioner.

**F. Petitioner Has Failed To Demonstrate That Hervin Is Analogous Art**

95. I have been informed that two separate tests define the scope of analogous prior art: (1) whether the art is from the same field of endeavor, regardless of the problem addressed, and, (2) if the reference is not within the field of the inventor's endeavor, whether the reference still is reasonably pertinent to the particular problem with which the inventor is involved. In the present case,

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<sup>4</sup> Ex. 1001 at 8:5-21.

Petitioner has not shown that Hervin satisfies either test. Moreover, as explained below, it is clear that Hervin fails to meet either test for analogous prior art.

96. With respect to the first test, the '439 Patent and Hervin are from different fields of endeavor. More particularly, the '439 Patent is directed to the field of multipath effects in OFDM wireless systems (Ex. 1001, e.g., 1:28-31), while Hervin is directed to the field of arithmetic computations within a 32-bit microprocessor architecture. Ex. 1006, 2:7-13 ("The present invention is directed to a circuit for performing arithmetic operations which both reduces the number of interconnections necessary to provide a combined shifter/io rotator circuit while eliminating the need for a preconditioning unit used to pre-process byte and word sized operands to be used in shift/rotate operations performed in 32-bit architectures.") These are clearly different fields of endeavor. The Petition does not contend otherwise.

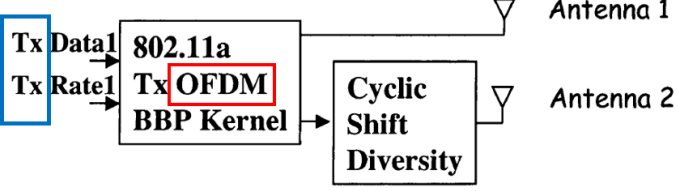
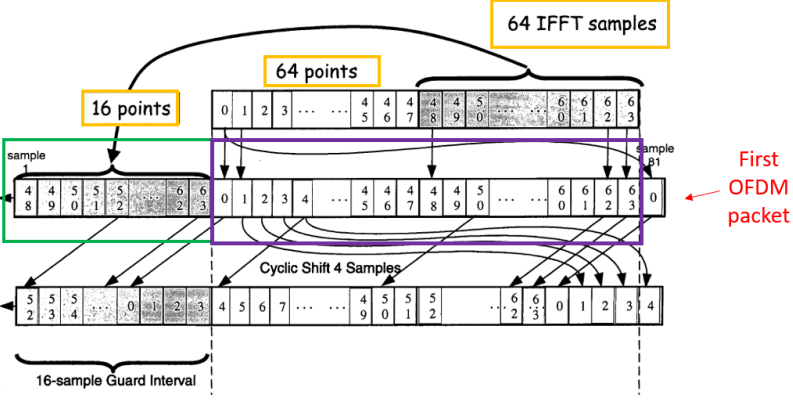
97. With respect to the second test, Hervin is not reasonably pertinent to the particular problems addressed by the '439 Patent, e.g., that cyclic delays did not work well with SISO receivers. I have been informed that a 'reasonably pertinent' reference is one that an ordinarily skilled artisan would reasonably have consulted in seeking a solution to the problem that the inventor was attempting to solve, and that a reference is reasonably pertinent if it is one which, because of the matter with

which it deals, logically would have commended itself to an inventor's attention in considering his problem.

98. Hervin would not have logically commended itself to an inventor's attention in considering the problem that cyclic delays did not work well with SISO receivers. Hervin is not directed to directed to OFDM (or any other wireless communication system). Hervin does not mention multipath effects or inter-symbol interference; nor does Hervin address the application of diversity in such systems. Accordingly, a POSITA seeking to address the problems in the '439 Patent would not have looked to Hervin's methods for internally performing arithmetic computations within a microprocessor for the solution. Again, the Petition does not contend otherwise.

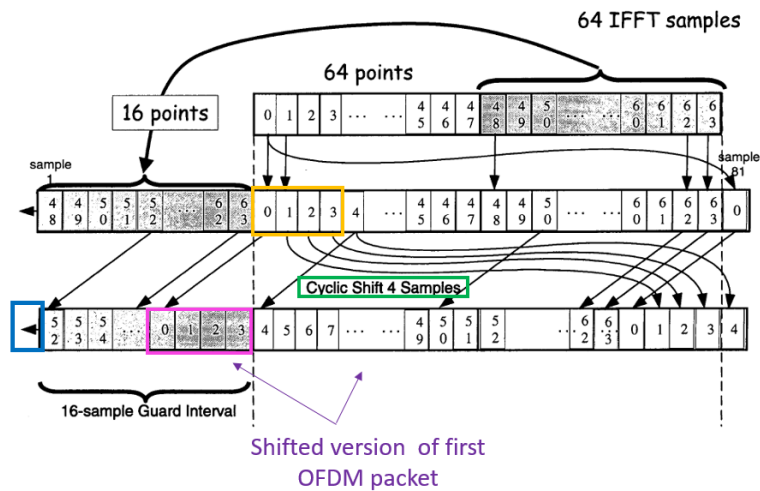
#### **IX. The Challenged Claims Are Supported By The Provisional Application Filed May 20, 2004**

99. As detailed in the color-coded claim charts below, all of the challenged claims of the '439 Patent are supported by U.S. Provisional Application No. 60/572,481, filed on May 20, 2004 (Ex. 2010).

| Claim Element                                                                                                                                                 | Support in Provisional Application                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>1. A method for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:</p>                                                     | <h3 data-bbox="548 342 1052 394">Two Antenna Tx Diversity</h3> <ul data-bbox="589 447 1344 657" style="list-style-type: none"> <li>• BBP: Baseband Processor</li> <li>• The radio would like to transmit the signal using two antennas</li> <li>• However, the two signals can destructive collide at the receive</li> <li>• The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna <ul style="list-style-type: none"> <li>– Each OFDM symbol is cyclically shifted</li> </ul> </li> </ul>  <p>The diagram shows a block diagram of a Two Antenna Tx Diversity system. On the left, a blue box contains 'Tx Data1' and 'Tx Rate1'. Arrows from these boxes point to a central box labeled '802.11a Tx OFDM BBP Kernel'. The 'Tx OFDM' text in this box is highlighted with a red rectangle. An arrow from the central box points to a box labeled 'Cyclic Shift Diversity'. From this box, two arrows point to 'Antenna 1' and 'Antenna 2', each represented by a triangle symbol.</p> <p>Provisional App., at Slide 4.</p> |
| <p>generating a first OFDM packet for transmission including a guard interval portion and a symbol data portion each comprised of a plurality of samples;</p> | <h3 data-bbox="524 1014 1060 1077">Example of Cyclic Advance Diversity:<br/>4-sample CAD</h3>  <p>The diagram illustrates Cyclic Advance Diversity (4-sample CAD) for 64 IFFT samples. It shows three sample sequences: a top sequence (0-63), a middle sequence (0-63), and a bottom sequence (0-63). The top sequence is divided into a 16-point guard interval (samples 0-15) and a 64-point data portion (samples 16-63). The middle sequence is a cyclic shift of the top sequence by 4 samples. The bottom sequence is a cyclic shift of the middle sequence by 4 samples. A '16-sample Guard Interval' is indicated at the bottom. A red arrow points to the first OFDM packet. The CONEXANT logo is visible in the top right corner.</p> <p>Provisional App., at Slide 8.</p>                                                                                                                                                                                                                                                                     |

cyclically advancing the first OFDM packet by shifting the samples in a first direction an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM packet for transmission in which at least a non-zero number of the samples from the symbol data portion of the first OFDM packet are shifted into the guard interval portion of the shifted version

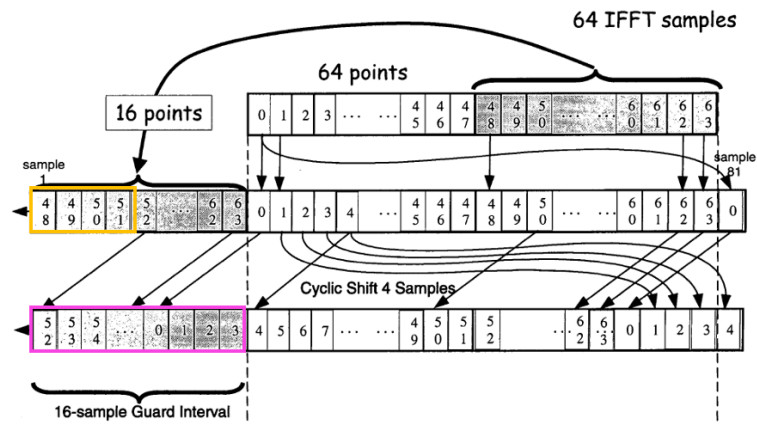
### Example of Cyclic Advance Diversity: 4-sample CAD



Provisional App., at Slide 8.

and a same non-zero number of samples from the guard interval portion of the first OFDM packet are shifted out of the guard interval portion of the shifted version; and

### Example of Cyclic Advance Diversity: 4-sample CAD

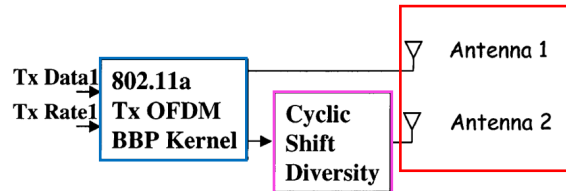


Provisional App., at Slide 8.

substantially simultaneously transmitting the first OFDM packet and the shifted version of the OFDM packet.

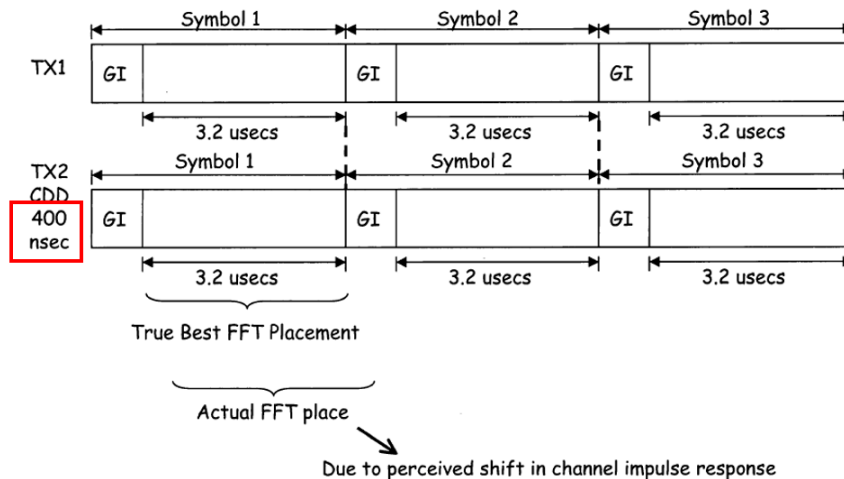
## Two Antenna Tx Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructively collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted



Provisional App., at Slide 4.

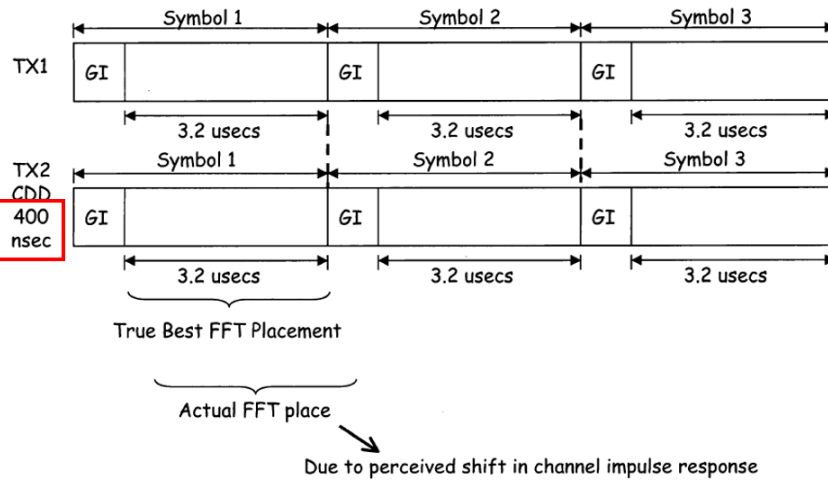
## Legacy Radios and Cyclic Shift Diversity



Provisional App., at Slide 11.

2. The method of claim 1, further comprising cyclically advancing the OFDM packet for a duration of less than approximately 800 nanoseconds.

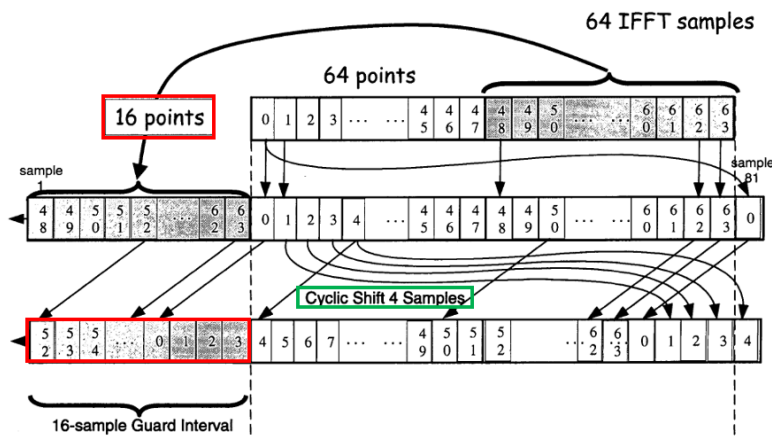
### Legacy Radios and Cyclic Shift Diversity



Provisional App., at Slide 11.

3. The method of claim 1, further comprising cyclically advancing the OFDM packet for a duration of less than one half of the sample duration of the guard interval portion.

### Example of Cyclic Advance Diversity: 4-sample CAD

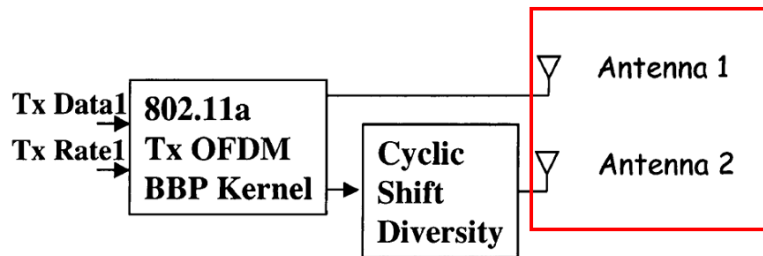


Provisional App., at Slide 8.

7. The method of claim 1, further comprising transmitting the first OFDM packet and the shifted version of the OFDM packet from a multiple-antenna transmitter device.

## Two Antenna Tx Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructive collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted

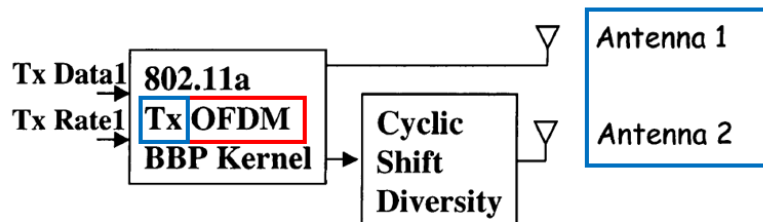


Provisional App., at Slide 4.

8. A signal transmitting system for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:

## Two Antenna Tx Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructive collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted

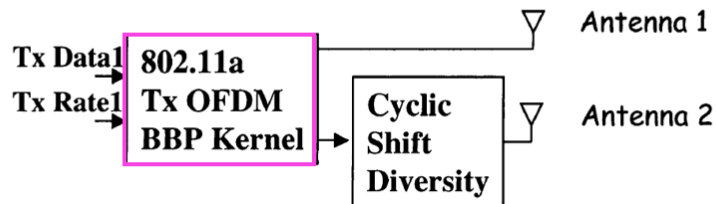


Provisional App., at Slide 4.

a first transmit processor for generating a first OFDM packet for transmission including a guard interval portion and a symbol data portion each comprised of a plurality of samples;

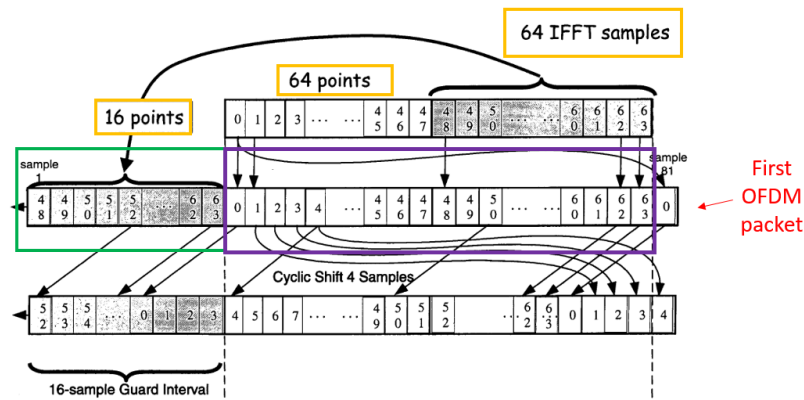
## Two Antenna Tx Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructively collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted



Provisional App., at Slide 4.

## Example of Cyclic Advance Diversity: 4-sample CAD

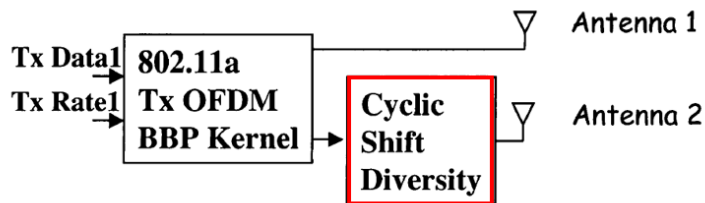


Provisional App., at Slide 8.

a second transmit processor for cyclically advancing the first OFDM packet by shifting the samples in a first direction an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM packet for transmission in which at least a non-zero number of the samples from the symbol data portion of the first OFDM packet are shifted into the guard interval portion of the shifted version and

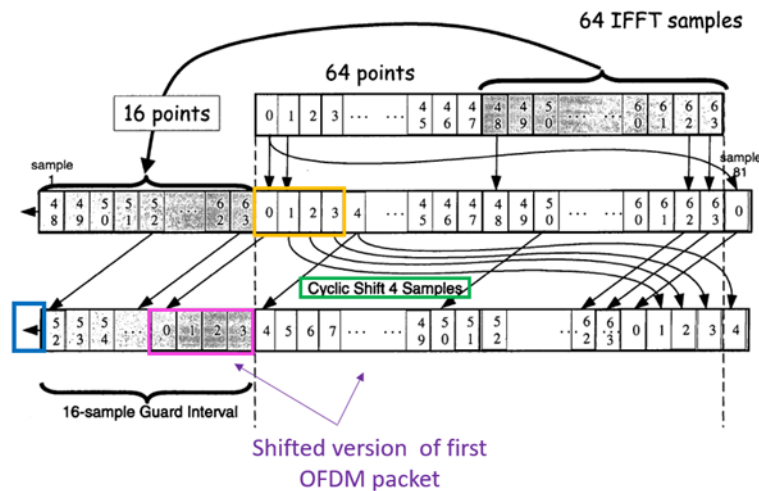
## Two Antenna Tx Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructively collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted



Provisional App., at Slide 4.

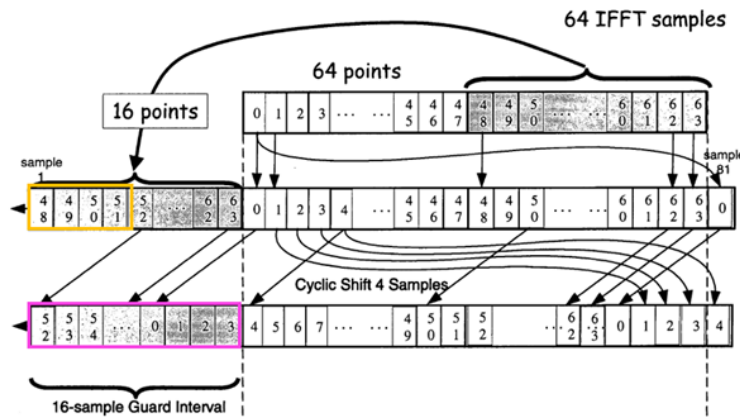
### Example of **Cyclic Advance Diversity:** **4-sample CAD**



Provisional App., at Slide 8.

a same non-zero number of samples from the guard interval portion of the first OFDM packet are shifted out of the guard interval portion of the shifted version;

### Example of Cyclic Advance Diversity: 4-sample CAD

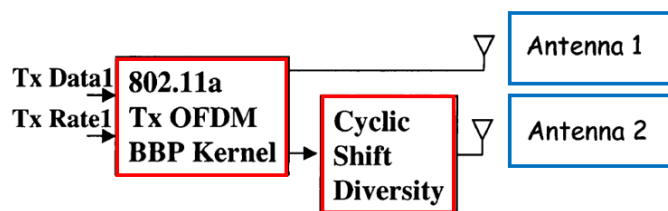


Provisional App., at Slide 8.

a plurality of radio transmitters for converting the OFDM packet and the shifted version of the OFDM packet to corresponding radio signals; and a plurality of radio antennas correspondingly coupled to the plurality of radio transmitters for transmitting the radio signals;

### Two Antenna Tx-Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructive collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted

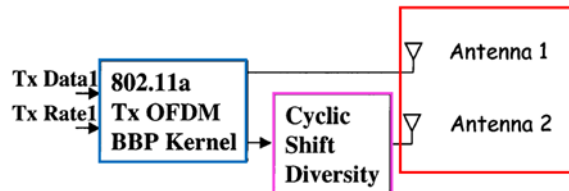


Provisional App., at Slide 4.

wherein the first transmit processor and the second transmit processor are configured to substantially simultaneously cause the transmission of the first OFDM packet and the shifted version of the OFDM packet via corresponding transmitters and antennas.

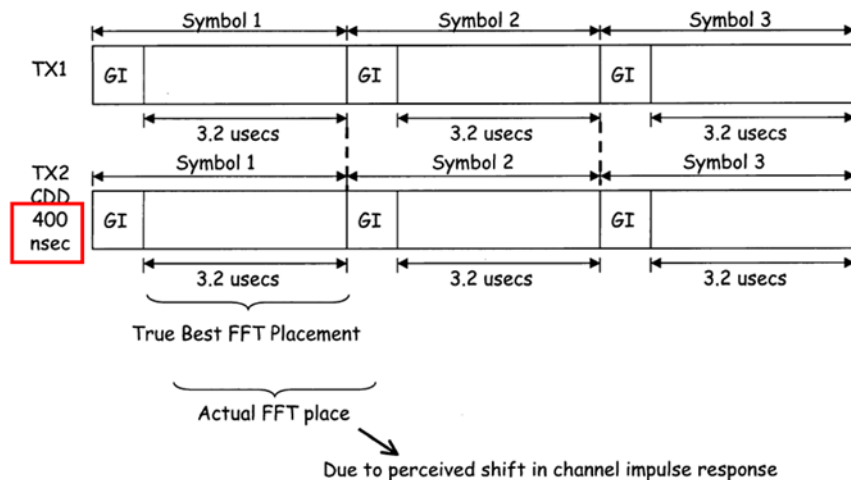
## Two Antenna Tx-Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructively collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted

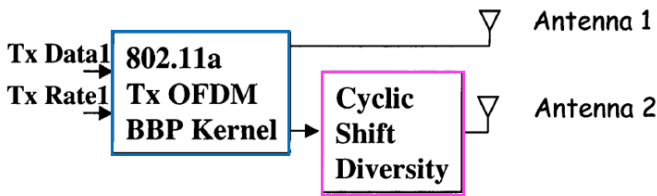


Provisional App., at Slide 4.

## Legacy Radios and Cyclic Shift Diversity



Provisional App., at Slide 11.

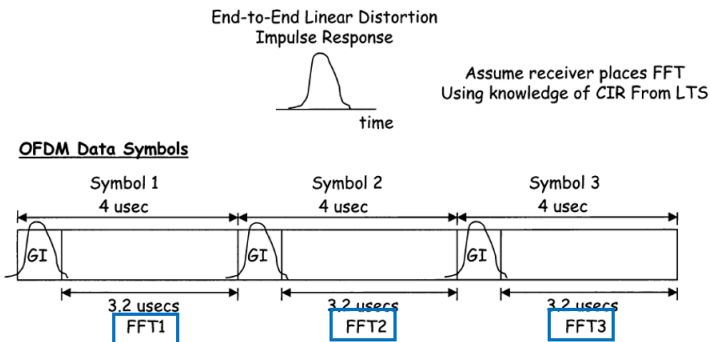
|                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>9. The system of claim 8, wherein each of the <b>first</b> and <b>second transmit processors</b> includes a cyclic extension module for performing cyclical advancements.</p>                                  | <h2 style="text-align: center;">Two Antenna Tx Diversity</h2> <ul style="list-style-type: none"> <li>• BBP: Baseband Processor</li> <li>• The radio would like to transmit the signal using two antennas</li> <li>• However, the two signals can destructive collide at the receive</li> <li>• The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna <ul style="list-style-type: none"> <li>– Each OFDM symbol is cyclically shifted</li> </ul> </li> </ul>  <p style="text-align: center;">Provisional App., at Slide 4.</p> |
| <p>10. The system of claim 9, wherein each of the cyclic extension modules is configured to cyclically advance the OFDM packet for a duration of less than one half of sample duration of the guard interval.</p> | <p>See, Claim 3.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

13. The system of claim 8, wherein each of the plurality of transmit processors further includes an Inverse Fast Fourier (IFFT) module for generating OFDM symbols from incoming data.

### Legacy Radios and Optimal FFT Placement



- Optimal FFT placement minimizes intersymbol interference
  - Decay transient from previous symbol
  - Start-up transient due to next symbol

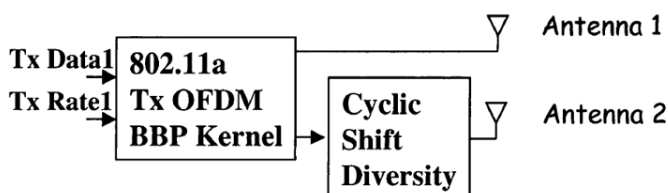


Provisional App., at Slide 5.

14. The system of claim 8, wherein the first and second transmit processors perform the cyclical advancements on baseband signals.

### Two Antenna Tx-Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructive collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted

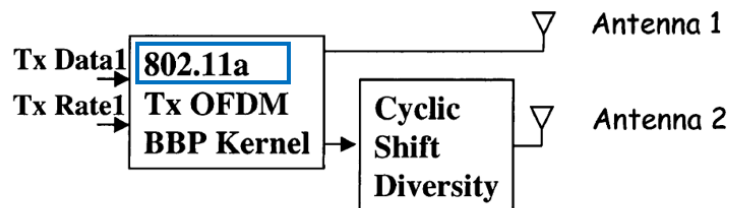


Provisional App., at Slide 4.

16. The system of claim 8, wherein the transmitter is an 802.11 compliant device.

## Two Antenna Tx Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructive collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted

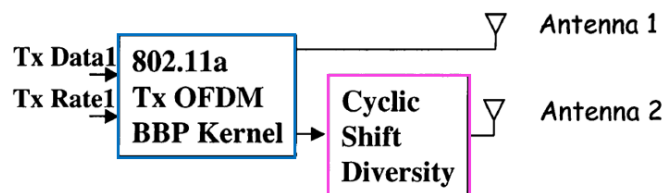


Provisional App., at Slide 4.

18. The system of claim 8, wherein the first and second transmit processors include firmware stored in a memory device and executed by a suitable instruction execution system.

## Two Antenna Tx Diversity

- BBP: Baseband Processor
- The radio would like to transmit the signal using two antennas
- However, the two signals can destructive collide at the receive
- The trick to avoid this is to use cyclic shift diversity on the 2<sup>nd</sup> antenna
  - Each OFDM symbol is cyclically shifted

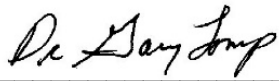


Provisional App., at Slide 4.

**X. DECLARATION**

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

Date: 13 November 2024

By: 

Dr. Gary Lomp