

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

Zebra Technologies Corporation

Petitioner

v.

Intellectual Ventures I LLC

Patent Owner

Inter Partes Review No.

IPR2024-00883

Patent No. 7,623,439

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I, Zhi Ding, declare as follows:

I. Introduction

1. I am an independent consultant. I am over eighteen years of age, and I would otherwise be competent to testify as to the matters set forth herein if I am called upon to do so.

2. I have prepared this Declaration for consideration by the Patent Trial and Appeal Board in the *Inter Partes* Review of U.S. Patent No. 7,623,439 (“the ’439 Patent”).

3. I provide this Declaration at the request of and have been retained by Kilpatrick Townsend & Stockton LLP, which represents Zebra Technologies Corporation (“Zebra”) in connection with the above-captioned *Inter Partes* Review. I have been informed and understand that Zebra contends that claims 1-3, 7-11, 13-16, and 18 of the ’439 Patent are invalid.

4. I am being compensated at an hourly rate of \$820 per hour. My compensation is not dependent on the outcome of or any issue in relation to the above-captioned *Inter Partes* Review, and I have no interest in either party.

5. In forming my opinions, I relied on my knowledge, education, experience, and training in the field and on documents and information referenced in this Declaration.

II. Qualifications

6. My curriculum vitae (“CV”) is attached hereto as Exhibit 1004 and provides an accurate identification of my background and experience.

7. I presently hold the title of Distinguished Professor in the Department of Electrical and Computer Engineering at the University of California, Davis. Before my appointment on July 1, 2020, I held the position of professor for the prior 23 years and have served as a faculty member at several United States universities for over 33 years. I am also a private technical consultant on various technologies related to information systems. In total, I have more than three decades of research experience on a wide range of topics related to data communications and signal processing.

8. I earned my Bachelor of Science degree in 1982 in wireless engineering from the Nanjing Institute of Technology (later renamed as Southeast University) in Nanjing, China. I earned my Master of Science degree in 1987 in electrical engineering from the University of Toronto in Toronto, Canada. I earned my Ph.D. in 1990 in electrical engineering from Cornell University in Ithaca, New York.

9. My responsibilities as a Professor at University of California, Davis, include classroom instruction on various topics of communication systems and signal analysis, as well as mentoring undergraduate students and supervising graduate students in their research and development efforts on various topics related

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to digital communications. I have directly supervised such research and development works ranging from signal detection to wireless networking. As the chief academic advisor, I have also directly supervised the completion of over 20 Masters' theses and over 30 Ph.D. dissertations on various topics related to digital communications. I have served full time as a faculty member at three major research universities in the United States over the past 30 years, including Auburn University from 1990 to 1998, University of Iowa from 1999 to 2000, and University of California, Davis, from 2000 to present.

10. Since 1990, I have been selected as the principal investigator of multiple highly competitive federal and local research grants, including more than twenty major research projects supported by the National Science Foundation and two research projects funded by the U.S. Army Research Office. These competitive research projects focused on developing more efficient and effective digital communication transceivers, networks, and signal processing tools. I have also participated in several large-scale projects supported by the Defense Advanced Research Projects Agency (DARPA) with teams of researchers. I have applied for, and received support from, other federal, state, and industry sponsors.

11. I have published over 210 peer-reviewed research articles in premier international journals, in addition to over 240 refereed technical articles at top international conferences on communications and information technologies.

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According to Google Scholar, my published works have been cited by over 13,000 times by peers. I also authored two books on communications technologies. My most recent book, coauthored with B.P. Lathi, is entitled, “Modern Digital and Analog Communication Systems,” 5th edition, and was published by the Oxford University Press in 2018. The 4th edition of this book (published in 2009) had been widely adopted as an introductory textbook to communication systems.

12. In addition to the over 450 published technical papers that have been cited over 20,000 times according to Google Scholar, I am also co-inventor of 7 issued U.S. patents on communication technologies.

13. I am a member of the Institute of Electrical and Electronics Engineers (IEEE) and was elevated to the grade of Fellow in January 2003 for contributions made in signal processing for communication. The IEEE is the world’s largest professional society of engineers, with over 400,000 members in more than 160 countries. The IEEE has led the development of many standards for modern digital communications and networking, most notably, the IEEE 802 series of network standards. The IEEE Grade of Fellow is conferred by the Boards of Directors upon a person with an extraordinary record of accomplishments in any of the IEEE fields of interest. The total number selected in any one year does not exceed one-tenth of one percent of the total voting Institute membership.

14. I have served the IEEE in the following capacities:

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15. Chief Information Officer of the IEEE Communications Society from Jan. 2018 to present.

16. Chief Marketing Officer of the IEEE Communications Society from Jan. 2020 to present.

17. General Chair of the 2016 IEEE International Conference on Acoustics, Speech, and Signal Processing, the flagship conference of the IEEE Signal Processing Society.

18. Chair of the Steering Committee for the IEEE Transactions on Wireless Communications from 2008 to 2010.

19. Distinguished Lecturer of the IEEE Communications Society from January 2008 to December 2009.

20. Technical Program Chair of the 2006 IEEE Globecom, one of two flagship annual IEEE Communication Society conferences.

21. Distinguished Lecturer of the IEEE Circuits and Systems Society from 2004 to 2005.

22. Associate Editor of the IEEE Transactions on Signal Processing from 1994 to 1997 and from 2001 to 2004.

23. Member of the IEEE Statistical Signal and Array Processing for Communications Technical Committee from 1993 to 1998.

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24. Member of the IEEE Signal Processing for Communications Technical Committee from 1998 to 2004.

25. In 2012, I received the Wireless Communications Technical Committee Recognition Award from the IEEE Communications Society, an award given to a person with a high degree of visibility and contribution in the field of “Wireless and Mobile Communications Theory, Systems, and Networks.” I received the 2020 Education Award from the IEEE Communications Society. According to the Society, this award “recognizes distinguished and significant contributions to education within the Society’s technical scope.”

26. I have also served as a technical consultant for the telecommunication industry. For example, in 1995 I consulted for Analog Devices, Inc., on the development of the first generation DOCSIS cable modem systems. I have also consulted for other companies, including Nortel Networks and NEC US Laboratories. I worked as a visiting faculty research fellow at NASA Glenn Research Center in 1992 and at U.S. Air Force Wright Laboratory in 1993. I have served on multiple review panels of the National Science Foundation to evaluate competitive research proposals in the field of communication. I have also reviewed a large number of research proposals at the request of the National Science and Engineering Research Council (NSERC) of Canada as an expert panelist from 2010 to 2013, and

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also at the request of the Research Grant Council (RGC) of Hong Kong as an external reviewer.

27. I have served as an expert witness or consulting expert on a number of matters related to intellectual property, mostly in the arena of telecommunications, including cellular communications, Wi-Fi technologies, Bluetooth, and optical communications. For example, since 2007, I have been engaged to work on various litigations involving cellular, WiFi, Bluetooth, Cable modems, DSL broadband, and optical communication networks. Many of my expert works related to the standard essentiality of patents with respect to the 3GPP 2G/3G/4G/5G technical specifications, the IEEE 802.11 standards, and the Bluetooth standards. I have provided testimonies at court trials or hearings in a number of jurisdictions, both in the United States and internationally. I have submitted declarations to PTAB as expert on a number of inter partes reviews of challenged patents.

III. Summary of Legal Issues

28. I am not a lawyer. Thus, in expressing my opinions and considering the subject matter of the claims of the '439 Patent, I am relying upon certain legal principles that counsel has explained to me.

A. Obviousness

29. First, I understand that for an invention claimed in a patent to be found patentable, it must be, among other things, new and not obvious from what was known before the invention was made.

30. I understand the information that is used to evaluate whether an invention is new and not obvious is generally referred to as “prior art” and generally includes patents and printed publications (e.g., books, articles, product manuals, company publications, etc.).

31. I understand that in this proceeding the Petitioner has the burden of proving that the claims of the patents-at-issue are obvious in view of the prior art by a preponderance of the evidence. I understand that “a preponderance of the evidence” is evidence sufficient to show that a fact is more likely true than it is not true.

32. I understand that in this proceeding, the information that may be evaluated is limited to patents and printed publications. My analysis below compares the claims to patents and printed publications that I understand are prior art to the patents-at-issue.

33. I have been informed and understand that a claim is obvious in light of the prior art if the difference or differences between the claimed subject matter and the prior art are such that the subject matter as a whole would have been obvious, at

the time the invention was made, to a person having ordinary skill in the art. I have been informed and understand that the Supreme Court provided an outline for analyzing obviousness in which it rejected an earlier test in favor of an “expansive and flexible approach” using “common sense.” I have also been informed and understand that the Supreme Court explained that under the correct analysis, any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed. I have also been informed and understand that the Supreme Court explained that “[t]he combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results.” I further have been informed and understand that the Court pointed to other factors that may show obviousness. These factors included the following principles:

- a. combination that unites old elements with no change in their respective functions is unpatentable. As a result, the combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results,
- b. a predictable variation of a work in the same or a different field of endeavor is likely obvious if a person of ordinary skill would be able to implement the variation,

- c. an invention is obvious if it is the use of a known technique to improve a similar device in the same way, unless the actual application of the technique would have been beyond the skill of the person of ordinary skill in the art. In this case, a key inquiry is whether the improvement is more than the predictable use of prior art elements according to their established functions,
- d. an invention is obvious if there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims,
- e. inventions that were “obvious to try” — chosen from a finite number of identified, predictable solutions, with a reasonable expectation of success — are likely obvious,
- f. known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations would have been predictable to one of ordinary skill in the art, and
- g. an explicit teaching, suggestion, or motivation in the art to combine references, while not a requirement for a finding of obviousness, remains “a helpful insight” in determining upon which a finding of obviousness may be based.

B. Claim Construction

34. I have been informed and understand that in an *inter partes* review claim terms are construed according to their ordinary and customary meaning as understood by one of ordinary skill in the art in view of the specification and the prosecution history of the patent.

C. Level of Skill in the Art

35. I have been informed and understand that a person of ordinary skill in the art is a hypothetical person who is presumed to have known the relevant art at the time of the alleged invention. I have been informed and understand that factors that may be considered in determining the level of ordinary skill in the art may include: (A) the type of problems encountered in the art; (B) prior art solutions to those problems; (C) the rapidity with which innovations are made; (D) the sophistication of the technology; and (E) the educational level of active workers in the field

IV. The '439 Patent

36. The '439 Patent is entitled "Cyclic Diversity Systems and Methods" and was filed on May 4, 2005. I have been informed that the earliest claimed priority date of the '439 Patent is May 20, 2004. I have been informed that each of the prior art references I address herein was available prior to that date, thus I have not analyzed whether each claim of the '439 Patent is entitled to an earlier priority date.

A. Person of Ordinary Skill in the Art of the '439 Patent

37. The field of the '439 Patent relates to “communication systems, and, more particularly, ... to wireless communication systems and methods. '439 Patent at 1:14-16.

38. In my opinion, a person of ordinary skill in the art (“POSITA”) with respect to '439 Patent, as of the date of the purported invention, would have had a bachelor’s degree in electrical engineering, computer engineering, or the equivalent, from an accredited program, and two or more years of experience with wireless communications networks. More practical experience could qualify one not having the aforementioned education as a POSITA, while a higher level of education could offset lesser experience.

39. In my opinion, a POSITA would have found the claims of the '439 Patent obvious in view of the prior art discussed here. Further, as I explain above, I have the relevant educational background and I have worked in the technical area of the '439 Patent for many years. As of May 20, 2004, which I understand to be the earliest date of the alleged invention, I was a person of ordinary skill in the art.

B. Construction of Claim Terms of the '439 Patent

40. As explained in further detail below, under any reasonable construction, the claims are obvious in view of the prior art I address herein. Thus, I

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do not separately offer an opinion with respect to the proper construction of the terms of the claims of the '439 Patent.

V. Materials Considered

41. In forming my opinions, in addition to my knowledge and experience, I have considered the following documents and things that I have obtained, or that have been provided to me:

Exhibit	Description
1001	U.S. Patent No. 7,623,439 (“the '439 Patent”)
1002	Prosecution History of U.S. Patent No. 7,623,439
1005	“On the Equivalence of Space-Time Block Coding with Multipath Propagation and/or Cyclic Delay Diversity in OFDM” by Dammann <i>et al.</i>
1006	U.S. Patent No. 5,961,575 to Hervin <i>et al.</i>
1007	U.S. Publication No. 2002/0122499 to Kannan <i>et al.</i>

42. In addition to the documents above, in forming the opinions expressed below, I have also considered my own knowledge and experience based upon my education and work in the field of wireless communication systems, as described above and in my *curriculum vitae* (Ex. 1004).

VI. State of the Art as of May 20, 2004

A. Cyclic Advancement

43. As the '439 Patent itself explains, cyclic delay and advancement both accomplish the exact same result because of their *cyclic* nature. It would have been well known to a POSITA that the cyclic guard intervals and the OFDM symbols are periodic, as shown in Figure 3A below (labeled “PRIOR ART”).

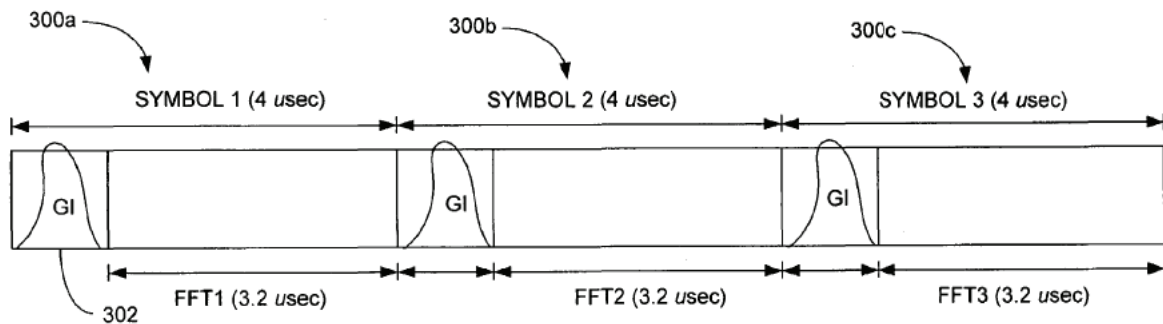


FIG. 3A (PRIOR ART)

44. Thus, from the viewpoint of the recipient, “[d]ue 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 μsec or 3200 nsec).” Ex. 1001 at 8:5-9 (emphasis added). “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).” Ex. 1001 at 8:10-13. A POSITA would have understood that “nsec” refers to the time unit of nano-second. One nano-second is 10^{-9} of a second.

B. Dammann

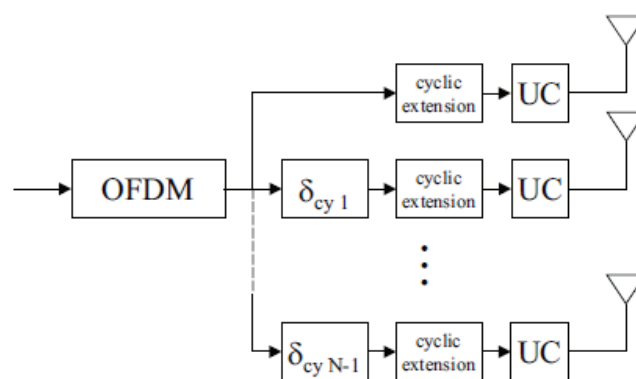
45. I have been informed that Dammann is prior art to the '439 Patent.

46. Dammann begins by acknowledging “the poor error performance of OFDM in multipath environments.” Dammann at §1. Dammann teaches that “spatial diversity is [an] effective way to improve the error performance of wireless radio systems,” and proposes the same for use in an OFDM wireless system such as IEEE

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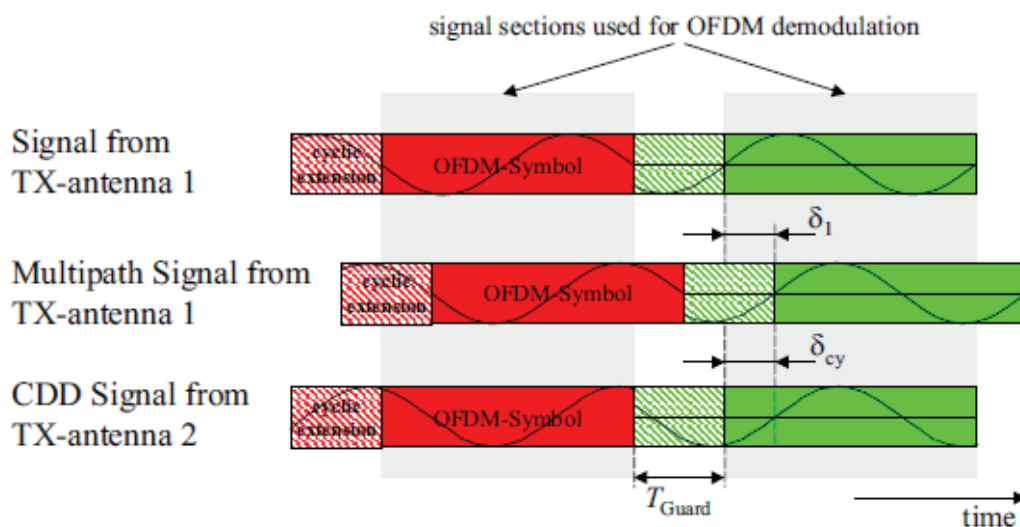
802.11a Wi-Fi. Dammann at §1. Dammann teaches “[an] approach to achieve spatial diversity effects for OFDM systems are techniques like Delay Diversity, *Cyclic Delay Diversity* or Phase Diversity” Dammann at §1. Dammann focuses on the Cyclic Delay Diversity (“CDD”) technique.

47. According to Dammann, “Fig. 1 [below] shows the block diagram of an N -antenna OFDM transmitter with CDD. The OFDM modulated signal is transmitted over N antennas, whereas the particular signals only differ in an antenna specific cyclic shift. After cyclic shifting, a cyclic prefix is inserted to avoid intersymbol interference and maintain subcarrier orthogonality for multipath channels. The functional block “UC” performs an upconversion of the signals from the baseband into RF-band. $\delta_{cy\ n}$, $n = 1, \dots, N - 1$, denote cyclic shifts of the OFDM symbol in the time domain.” Dammann at §2.1.



Dammann at Fig. 1.

48. Dammann further teaches transmitting an OFDM time signal from a first antenna, called TX-antenna 1, and at the same time, transmitting a cyclically shifted version of that OFDM time signal from a second antenna, called TX-antenna 2. Dammann at §2.2. Figure 2 of Dammann depicts these transmissions and the cyclic extension that a POSITA would have understood to be the cyclic GI.



Dammann at Fig. 2.

C. Cyclic Delay

49. The '439 Patent includes a total of thirteen figures, but acknowledges that the majority of those figures simply show what was in the prior art. In particular, the '439 Patent describes that each of Figures 1-2, 3A, 3B, 4A, 4B, and 5 are all prior art, including for each of those figures, an express notation that the Figure itself is

prior art. An example of this admission is shown below, with respect to Figure 5 (labeled “PRIOR ART”).

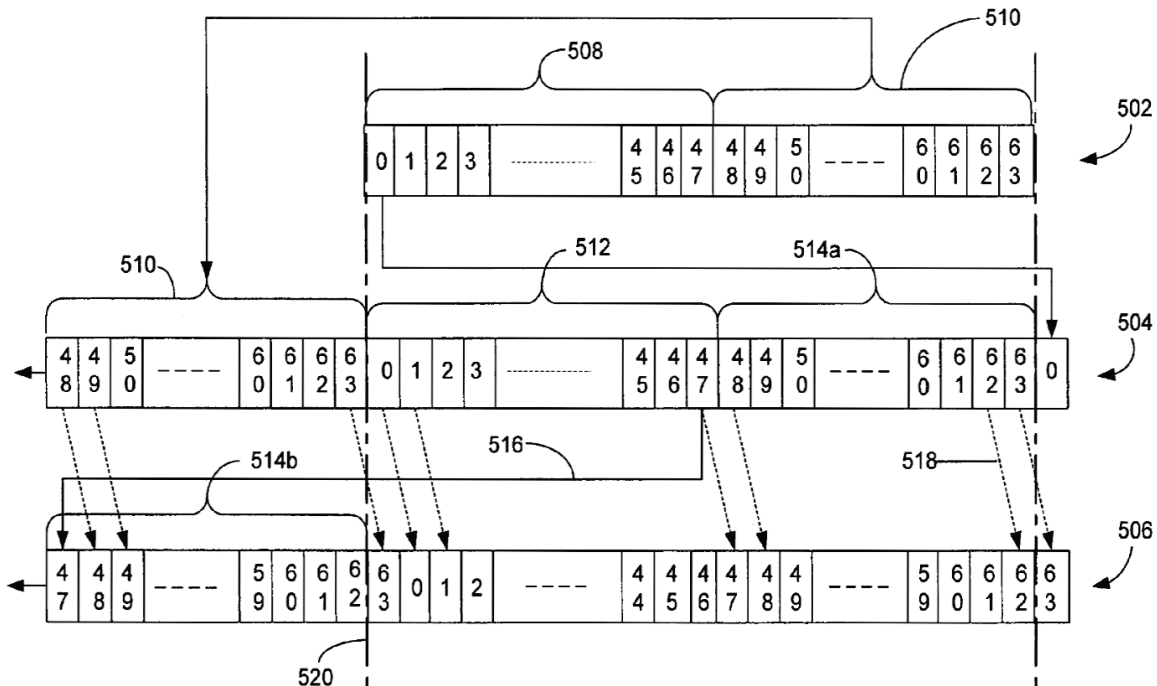


FIG. 5 (PRIOR ART)

439 Patent, Fig 1.

50. Importantly, this includes an express acknowledgement that diversity through *cyclic delay or cyclic shift*, was well known in the art. The '439 Patent explains that Figure 1 below (labeled “PRIOR ART”) is “a block diagram that illustrates ... a mixed antenna transmitter device/legacy environment” with two antennas 104 and 106, and a time delay element 108 placed in line with the second antenna, antenna 106.

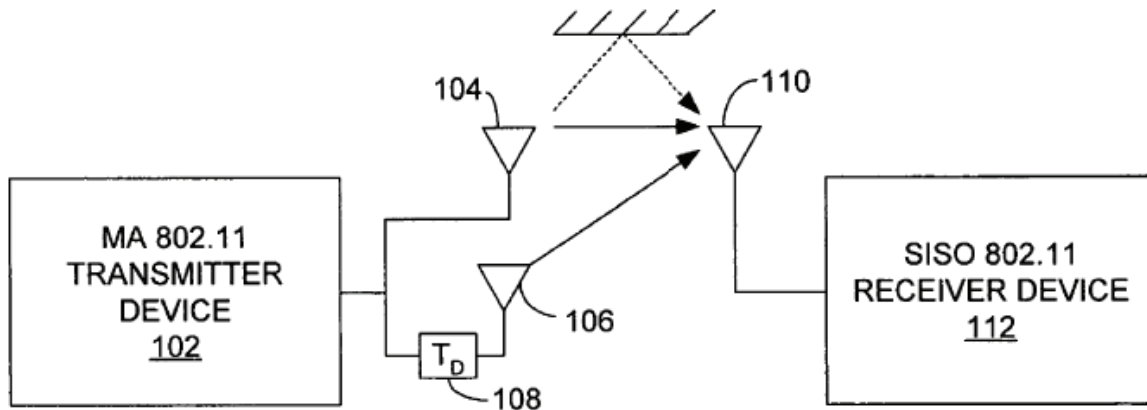


FIG. 1
(PRIOR ART)

'439 Patent, Fig. 1.

51. Then, with respect to Figure 1 (labeled "PRIOR ART"), the '439 Patent provides an introduction concerning cyclic delay and its well-known benefits. The

'439 Patent notes, with respect to prior art Figure 1, that:

The same signals transmitted from antennas 104 and 106 may follow direct paths and multi-paths to antenna 110." Normally, multiple-path signals (e.g., resulting from reflections off of objects in the environment or from multiple antennas) can result in either partial or complete constructive interference or destructive interference of the same signals in a SISO receiver. One mechanism to avoid or mitigate completely destructive interference from multi-path signals is to equip one of the antennas 104 and 106 with a time delay element 108 (or provide a delay through a baseband processing section of the MA transmitter device 102). From the perspective of the SISO receiver device 112, the time delay element 108 appears to cause the signal sent from antenna 106 to reach antenna 110 later than the same signal sent from antenna 104. This technique is often referred to as linear delay diversity

'439 Patent, col. 1:40-55.

D. Hervin

52. I have been informed that Hervin is prior art to the '439 Patent.

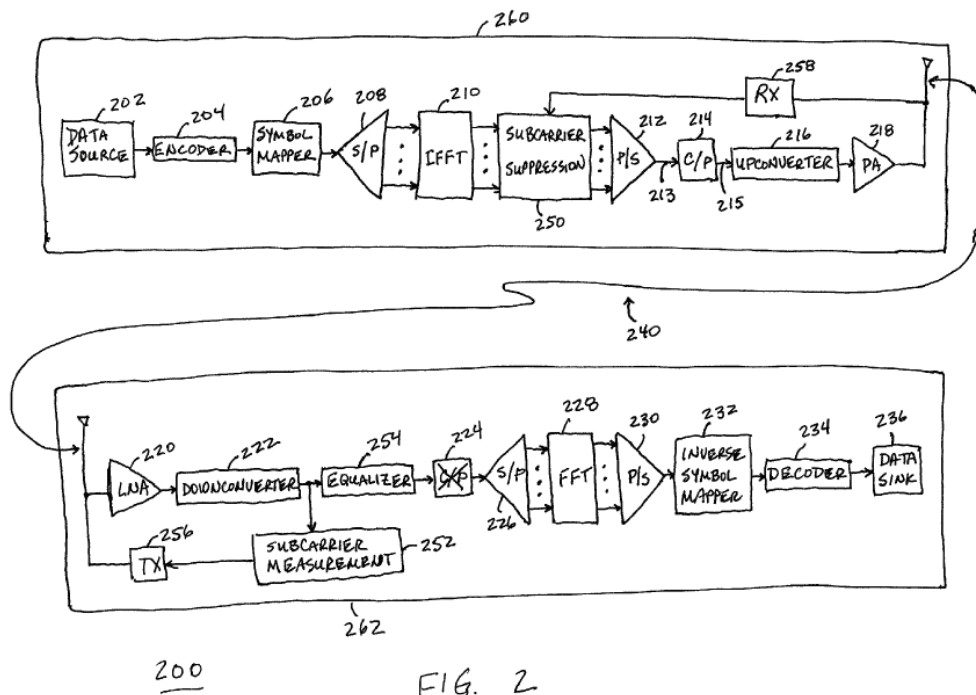
53. Hervin teaches a “[c]ircuit for performing arithmetic operations in a 32-bit architecture,” which includes “a five stage shift and rotate circuit coupled between first and second 32-bit busses in the following sequence: an 8-bit shift and rotate circuit, a 16-bit shift and rotate circuit, a 1-bit shift and rotate circuit, a 2-bit shift and rotate circuit and a 4-bit shift and rotate circuit.” Hervin at Abstract.

54. Hervin notes that, “[i]n a circular shift operation, also known as a rotate,” ... “[the] 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.” Hervin at 1:19-30. And, given the circular nature of a cyclic shift, Hervin further notes that the same circuit can perform both “rotate left and rotate right” operations. Hervin at 8:61-65.

E. Kannan

55. I have been informed that Kannan is prior art to the '439 Patent.

56. Kannan teaches a “method and apparatus for error reduction in an orthogonal modulation system.” Kannan, Title. Specifically, Kannan teaches a “communication system 200,” depicted in Figure 2 below, which “includes a transmit side 260 and a receive side 262, as shown.” Kannan at [0025].



Kannan at Fig. 2.

57. Kannan further teaches that its “signal processing unit 308 performs the functions of each of blocks 204-214, 224-234, and 250-254” in Figure 2, which include, among other things, “orthogonal modulator 210” for performing “inverse fast Fourier transform (IFFT),” cyclic prefix (C/P) adder 214 that appends a guard band interval, or cyclic prefix, to signal 213 to produce output signal 215,” and “C/P

adder 214” which “conveys output signal 215 to an upconverter 216 that upconverts signal 215 from a baseband frequency to a transmit frequency.” Kannan at [0026].

VII. A POSITA Would Have Been Motivated to Modify Dammann Based on the Disclosure of Hervin.

58. A person of ordinary skill in the art would have been motivated to modify Dammann based on the disclosure of Hervin. Dammann teaches cyclically shifting an “OFDM time signal” to be transmitted by “TX-antenna 1” (the recited “first OFDM packet for transmission”) by shifting the samples therein an amount of time defined as δ_{cy} to generate a “2nd CDD OFDM time signal” to be transmitted by “TX-antenna 2.” Dammann at §2.2. As acknowledged by the ’439 Patent, owing to the cyclic nature, left cyclic shifts (i.e., cyclic advances) were well known to be equivalent to right cyclic shifts (i.e., cyclic delays) as taught by Dammann:

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 μ 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).

Ex. 1001 at 8:5-21.

59. It was thus well known in the art that cyclic delay performs the equivalent operation as a cyclic advancement. And, it would have been obvious to modify Dammann based on the disclosure of Hervin, which expressly discloses both left cyclic shifts (i.e., cyclic advances) and right cyclic shifts (i.e., cyclic delays).

60. In particular, Hervin notes that, “[i]n a circular shift operation, also known as a rotate,” ... “[the] 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.” Hervin at 1:19-30.

61. Thus, Hervin expressly discloses cyclic advancement, and in my opinion, a POSITA would have been motivated to include cyclic advancement in the system described by Dammann because doing so provides additional cyclic diversity. Such cyclic diversity improves data transmission in multi-input/multi-output antennas through reducing collisions and thereby increasing transmission quality and speed. Additionally, there 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.

62. Further, a person of ordinary skill in the art would have been motivated to make this modification because the change can be made without changing any of the hardware. Indeed, as Hervin explains, given the circular nature of a cyclic shift, the same circuit can perform both “rotate left and rotate right” operations. Ex. 1006 at 8:61-65. Thus, a person of ordinary skill in the art would have known how to make this change, e.g., through altering transmission firmware to advance a signal, and would have been motivated to do so to provide additional cyclic diversity.

VIII. A POSITA Would Have Been Motivated to Modify the Dammann-Hervin Combination According to the Disclosure of Kannan.

63. It is my opinion that a person of ordinary skill in the art would have been motivated to modify the Dammann-Hervin combination based on the disclosure of Kannan. I give the following reasons to support my opinion. *First*, Dammann and Kannan are in the same field of endeavor, i.e., OFDM wireless systems. *See, e.g.*, Dammann at §1; Kannan at Abstract. Consequently, a POSITA would have had a reasonable expectation of success in combining their various disclosures to produce a more reliable OFDM wireless system by utilizing the cyclic delay diversity with multiple transmit antennas. Furthermore, it was well within the technical ability of a POSITA at the time to combine the improvements to OFDM wireless systems described in Dammann and Kannan.

64. *Second*, Dammann recognizes certain major challenges with OFDM wireless transmission in multipath environments, such as poor error performance. Damman recognizes that “(f)or many scattering environments, spatial diversity is another effective way to improve the error performance of wireless radio systems”. Dammann at §1. Those same challenges are also recognized in Kannan. Kannan at [0008]-[0010]. For example, Kannan notes that there was a need “for a method and apparatus that can reduce error in a transmitted signal and maintain a symbol error rate at an acceptable level under conditions of excessive multipath delay.” Ex. 1007 at [0010]. Kannan aims to address those challenges by using components such as an Inverse Fast Fourier Transform module, a cyclic prefix adder, and a baseband signal upconverter. *See, e.g.*, Kannan at [0026]. Those same components are used in Dammann as well. *See, e.g.*, Dammann at §2.1; Fig. 1. A person of ordinary skill in the art would have been motivated to include the additional functionality taught by Kannan to the Dammann-Hervin combination to overcome those major challenges, including increasing error performance and improving data reception accuracy. Additionally, as discussed herein, Kannan provides numerous hardware implementation details that are directly applicable to the system of Dammann, but lacking hardware implementation detail in Dammann. *See, e.g.*, Ex. 1007 at [0026].

65. A POSITA thus would have been motivated and found it obvious to combine Dammann and Kannan.

IX. The Prior Art Renders Every Element of Claims 1-3, 7-11, 13, 15, 16, and 18 of the '439 Patent Obvious.

66. In the analysis below I break down the elements of claims 1-3, 7-11, 13, 15, 16, and 18 of the '439 Patent and demonstrate that each of these elements were known in the art before May 20, 2004, the earliest possible priority date of the '439 Patent.

A. Transmitting Orthogonal Frequency Division Multiplexing (OFDM) Signals Was Well Known in the Art (Claims 1Pre, 8Pre)

67. A POSITA would have recognized that this claim element is obvious in view of Dammann and the knowledge of a POSITA. That this element was well-known is confirmed by Dammann, which discloses that “**(OFDM) ... is a suitable technique for broadband transmission** in multipath fading environments and is implemented in new broadcast standards like terrestrial digital video broadcasting (DVB-T) ... as well as wireless local area network (WLAN) standards ... such as HIPERLAN/2 or IEEE 802.11a.” Dammann at §1. Dammann further discloses that “[t]he **OFDM modulated signal is transmitted over N antennas**, whereas the particular signals only differ in an antenna specific cyclic shift.” Dammann at §2.1.

68. Further, the '439 Patent admits that this claim element was known in the prior art, including with respect to admitted prior art Figure 5, a schematic diagram showing cyclically shifting a first OFDM signal 504 by one sample to generate a second OFDM signal 506, each for transmission. Ex. 1001 at 3:57-58.

Both 504 and 506 are cyclically generated from an original OFDM signal 502 of 64 samples (“0” to “63”). By adding a cyclic shifted guard interval 510 (or 514a) consisting of 16 samples (“48” to “63”), the first OFDM signal 504 of 80 samples is generated, which is cyclic-shifted by one sample delay (i.e., to the right) to generate the second OFDM signal 506, also of 80 samples.

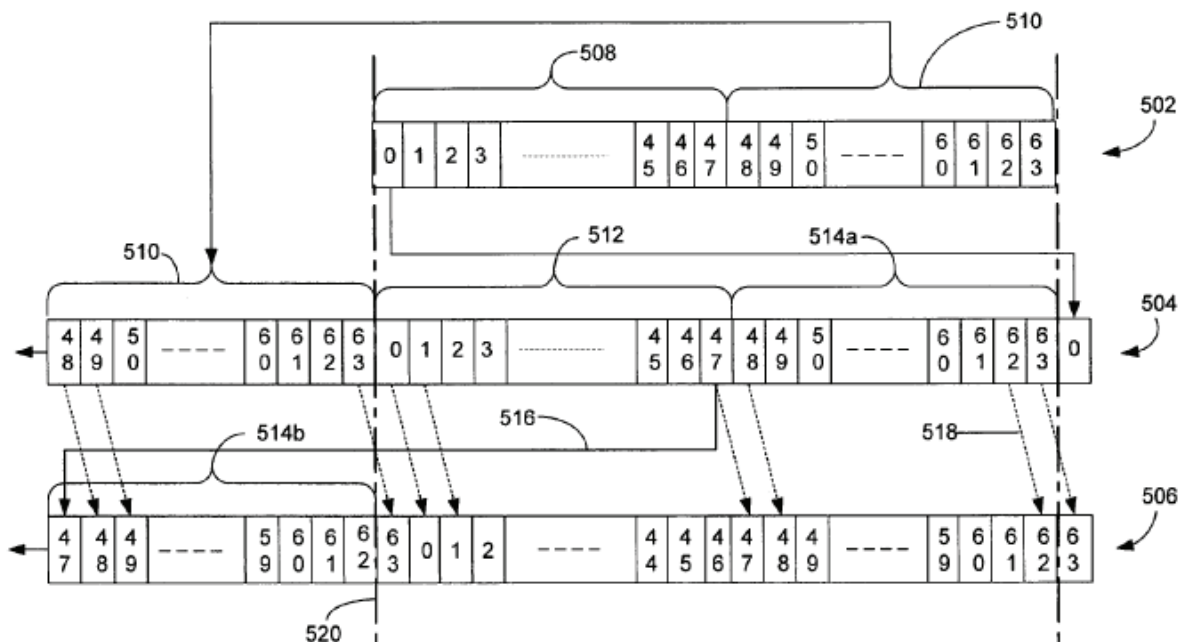
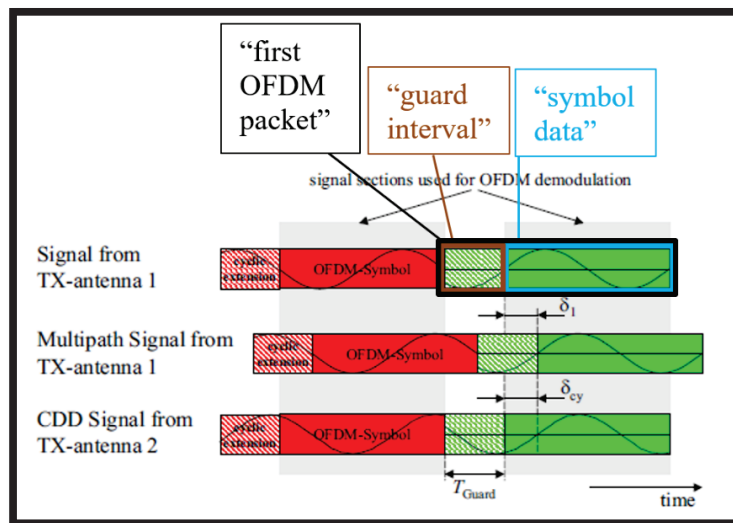


FIG. 5 (PRIOR ART)

69. The patent notes that the “first tier 502 represents 80 total samples comprising 64 samples of symbol data 508 and 16 samples that are used for a guard interval 510” and “[t]he third tier 506 represents a 1-sample cyclic delay shift” of the OFDM signal of first tier 502. Ex. 1001 at 3:58-66.

B. Generating OFDM Packets Using IFFT Was Well Known in the Art (Claims 1A, 8A, and 13)

70. A POSITA would have recognized that this claim element is obvious in view of Dammann and the knowledge of a POSITA. Dammann discloses generating and transmitting “an OFDM time signal” from “TX-antenna 1” (the recited “first OFDM packet for transmission”) including a “cyclic extension” with a period of “ T_{Guard} ” (the recited “guard interval portion”) and a “signal section” (the recited “symbol data portion”) each comprised of “OFDM time domain symbols” (the recited “plurality of samples”). Dammann at §2.2.



Dammann at Fig. 2 (annotated).

71. Further, the '439 Patent admits that this claim element was known in the prior art, including with respect to admitted prior art Figure 5, a schematic diagram showing cyclically shifting a first OFDM signal by one sample to generate a second, shifted OFDM signal, each for transmission. Ex. 1001 at 3:57-58.

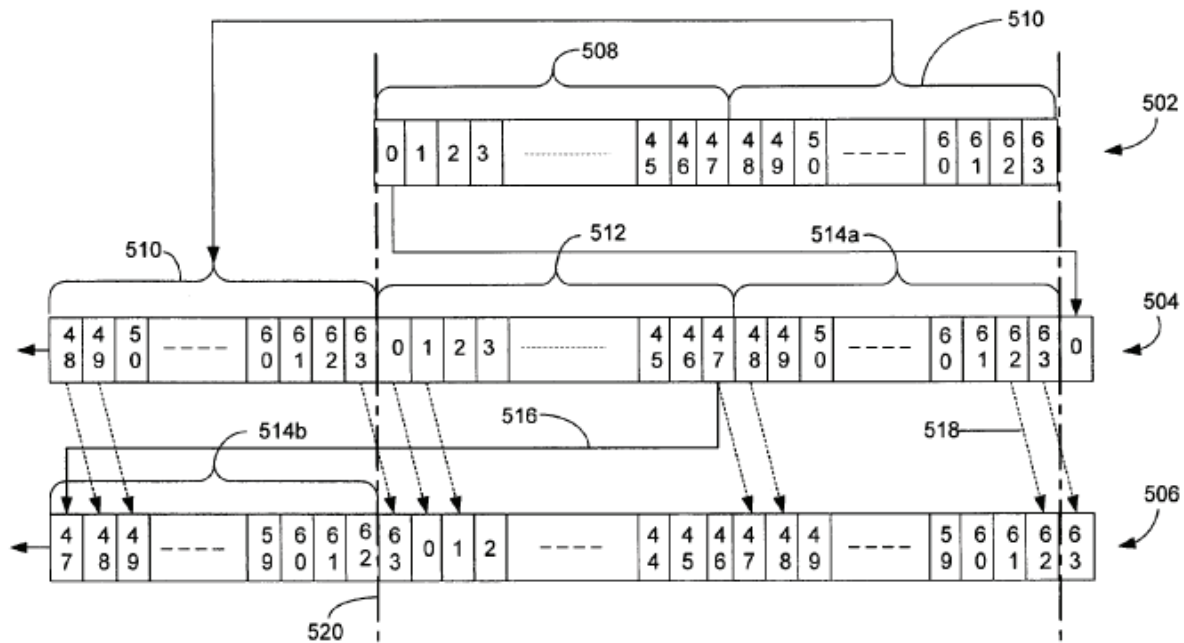


FIG. 5 (PRIOR ART)

72. The patent notes that the “first tier 502 represents 80 total samples comprising 64 samples of symbol data 508 and 16 samples that are used for a guard interval 510” and “[t]he third tier 506 represents a 1-sample cyclic delay shift” of the OFDM signal of first tier 502. Ex. 1001 at 3:58-66.

73. A POSITA would have understood that that an OFDM signal is modulated, or generated, using the Inverse Fast Fourier Transform process. Indeed, immediately following the words “Orthogonal frequency division multiplexing (OFDM)” in Dammann’s “Introduction” section, Dammann cites a paper entitled “Data Transmission by Frequency Division Multiplexing Using the Discrete Fourier Transform.” It would have been well known to a POSITA that the Discrete Fourier

Transform refers to two implementations: the Fast Fourier Transform (FFT) and inverse Fast Fourier Transform (IFFT). Thus, a POSITA would have understood that Dammann discloses that each of Dammann’s “transmit processors further includes an Inverse Fast Fourier (IFFT) module for generating OFDM symbols from incoming data.”

74. Further, the '439 Patent admits that this claim element was known in the prior art. The patent explains with respect to Figure 2 below (labeled “PRIOR ART”), that “[t]he packet structure 200 is generated in a baseband processing section (e.g., in or in cooperation *with an inverse fast Fourier transform (IFFT) operation*) of the MA transmitter device 102” Ex. 1001 at 1:62-65. For example, Figure 2 of the '439 Patent admits that the packet 200 contains a signal segment C comprising a guard interval GI2 of $1.6\mu\text{sec}$ in duration and a data portion T1 plus T2 of $6.4\mu\text{sec}$ in duration.

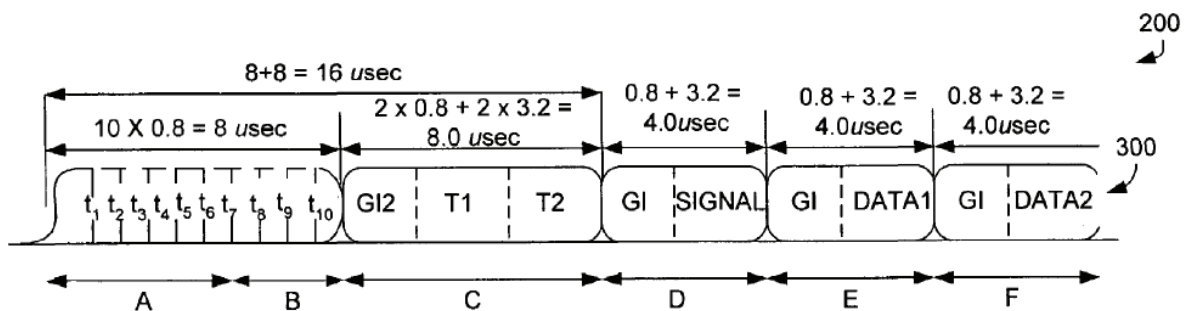


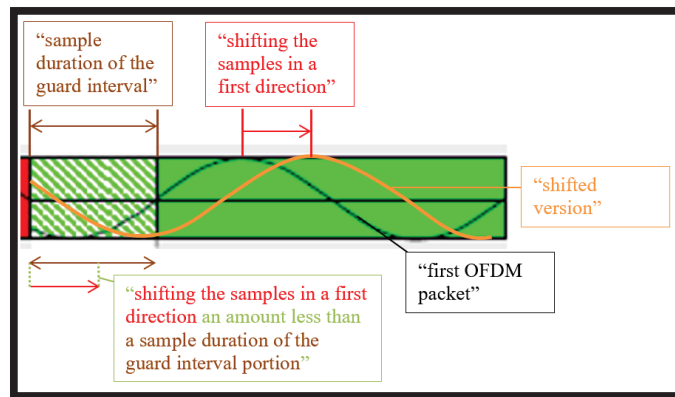
FIG. 2 (PRIOR ART)

75. Thus, Dammann and the knowledge of a POSITA teach that “the plurality of transmit processors further includes an Inverse Fast Fourier (IFFT) module for generating OFDM symbols from incoming data.”

C. Cyclically Advancing OFDM Packets, Including by Cyclic Extension Modules, Was Well Known in the Art (Claims 1B, 8B, 9)

76. A POSITA would have recognized that this claim element is obvious in view of the combination of Dammann and Hervin in view of the knowledge of a POSITA. Dammann teaches cyclically shifting the “OFDM time signal” to be transmitted by “TX-antenna 1” (the recited “first OFDM packet for transmission”) by shifting the samples therein an amount of time defined as δ_{cy} to generate a “2nd CDD OFDM time signal” to be transmitted by “TX-antenna 2.” Dammann at §2.2.

77. For ease of interpretation, the below figure was produced by taking the “CDD signal from TX-antenna 2” (the recited “shifted version of the first OFDM packet” in yellow) and superimposing the same on the “Signal from TX-antenna 1” (the recited “first OFDM packet” in **black**).



Dammann at Fig. 2 (altered as described).

78. As shown, the cyclic shift/delay value δ_{cy} is less than the sample duration of the guard interval portion.

79. Additionally, as shown, in Dammann, 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 the same non-zero number of samples from the guard interval portion of the first OFDM packet are shifted out of the guard interval portion into the data portion of the shifted version. This is simply describing the process of cyclic shifts/delays. As both the '439 Patent (*see* Ex. 1001 at Figure 5) and Dammann demonstrate, right cyclic shifts (i.e., cyclic delay) were well known in the art.

80. Further, as described in the '439 Patent, left cyclic shifts (i.e., cyclic advances) were well known to a POSITA to be equivalent to right cyclic shifts (i.e., cyclic delays):

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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 μ 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).

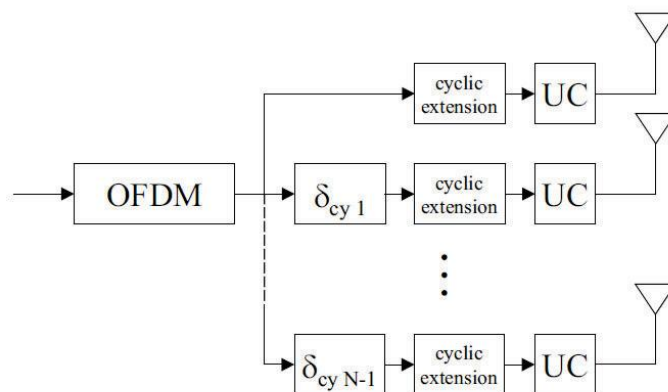
Ex. 1001 at 8:5-21.

81. Thus, Dammann and the '439 Patent both disclose the concept of cyclic delay, and it was well known to a person of ordinary skill in the art that cyclic delay performs the equivalent operation as a cyclic advancement. Thus, a POSITA would have recognized that cyclic delay discloses or renders obvious cyclic advancement as recited by this claim.

82. Further, as I have discussed above, it would have been obvious to modify Dammann based on the disclosure of Hervin, which expressly discloses both left cyclic shifts (i.e., cyclic advances) and right cyclic shifts (i.e., cyclic delays). In particular, Hervin notes that, “[i]n a circular shift operation, also known as a rotate,” ... “[the] 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

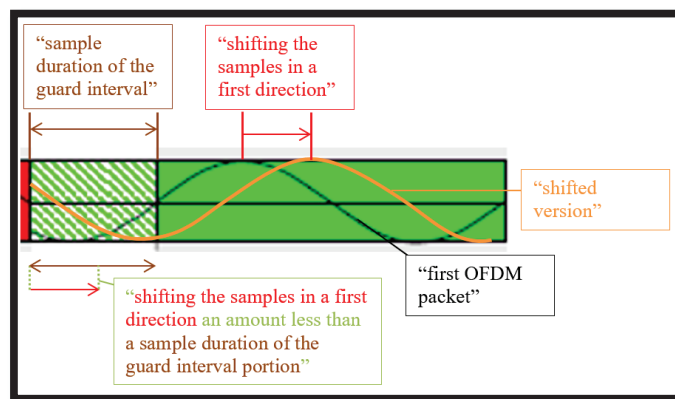
(or “ROR”) operation in which all of the bits of the operand shifted right by one or more positions and the least significant bits are shifted around to become the most significant bits.” Hervin at 1:19-30. Thus, Hervin expressly discloses cyclic advancement, and in my opinion, a POSITA would have been motivated to include cyclic advancement in the system including cyclic shift described by Dammann to achieve cyclic diversity. Indeed, as Hervin explains, given the circular nature of a cyclic shift, the same circuit can perform both “rotate left and rotate right” operations. Hervin at 8:61-65.

83. Additionally, Figure 1 of Dammann below shows a separate cyclic extension module for each packet to be substantially simultaneously transmitted. A POSITA would have understood and found it obvious that each of these modules would have been included in the respective transmit processors recited in claim 8.



D. Cyclically Advancing OFDM Packets For a Duration Less Than Half the Guard Interval (800 Nanoseconds) Was Well Known in the Art (Claims 1B, 2, 3, 8B, 10, 11)

84. In my opinion, a POSITA would have recognized that this claim element is obvious in view of the Dammann-Hervin combination and the knowledge of a POSITA. As I explained with respect to Claim 1B, Dammann discloses cyclically shifting the OFDM packet an amount less than the “sample duration of the guard interval” portion, and can be seen in Dammann’s Figure 2 below, this amount is also less than one half of the sample duration of the guard interval portion.



Dammann at Fig. 2 (annotated).

85. It would have been obvious to advance, rather than delay, the same amount (less than one half of the sample duration of the guard interval portion) because as I have explained, left cyclic shifts (i.e., cyclic advances) were well known to be equivalent to right cyclic shifts (i.e., cyclic delays). *See* Claim 1B.

86. Additionally, it was commonly known to select a cyclic shift duration that was less than one half of the sample duration of the guard interval portion. For

example, Figure 5 of the '439 Patent (labeled “PRIOR ART”) depicts shifting the OFDM packet by a single sample, while the guard interval portion consists of 16 samples. Ex. 1001 at 3:57-61.

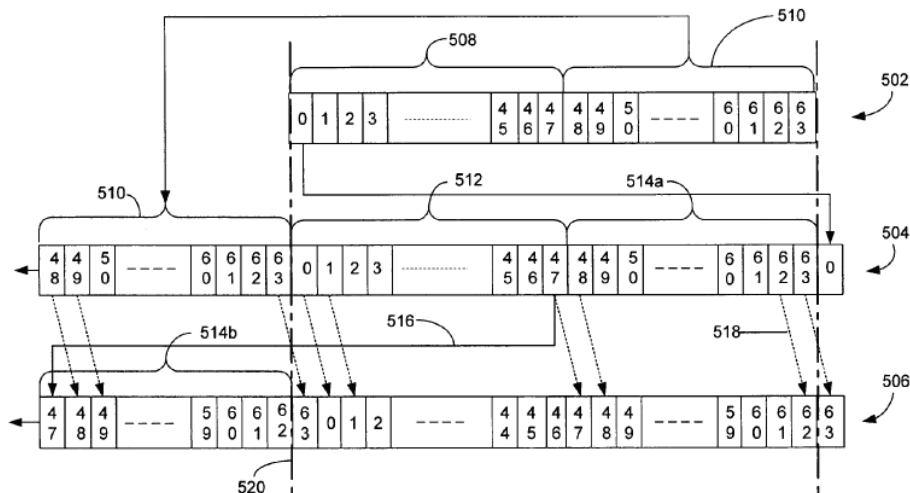


FIG. 5 (PRIOR ART)

87. Guard intervals, such as those employed by the 802.11a standard, were commonly known to be 800 nanoseconds (i.e., 0.8 μ sec) long. The '439 Patent acknowledges this, noting “an 802.11 compliant WLAN transmitter device may transmit a packet with a guard interval having a duration of approximately 800 nsec.” Ex. 1001 at 7:66-8:2. Kannan further teaches that 0.8 μ s (same as 800 nanoseconds) was the standard duration for a guard interval by the time of the claimed invention:

Typically, the appending of a **cyclic prefix comprises an appending of the last T_g seconds** of each OFDM symbol as a prefix to itself. **Preferably T_g is a preassigned length of 16 taps, or 0.8 μ s**; however, those of ordinary skill in the art realize that the preassigned length of the cyclic prefix is up to the designer of the system as the designer

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weighs the greater protection afforded by a longer cyclic prefix against the inefficiency of a longer prefix.

Kannan at [0040].

Preferably, composite communication channel 400 appears to be a communication channel with a multipath delay of, at most, **a length of the cyclic prefix** (i.e., 16 taps, wherein each tap corresponds to a sampling of a signal, and at a sampling rate of 20 MHz 16 taps corresponds to a delay of **0.8 μs**), although, in the alternative, the design of composite communication channel 400 may be oriented to any tolerable multipath delay.

Kannan at [0044].

88. A POSITA would have understood that, shifting the OFDM packet for a duration of less than the guard interval (approximately 800 nanoseconds or 0.8 μsec) ensures that the two signals do not cause excessive inter-symbol interference at the recipient device. Indeed, as the '439 Patent explains with respect to Figure 3A (labeled "PRIOR ART"):

Each OFDM symbol 300 comprises a guard interval (GI) 302, which provides a buffer between symbols 300. That is, multipath is equivalent to echoes, and the guard intervals 302 comprise a Zone built into an OFDM symbol 300 into which echoes from a preceding OFDM symbol are positioned. Such echoes cause inter-symbol interference. The guard intervals 302 are inserted in the OFDM symbol 300 in the baseband processor portion of the MA transmitter device 102 (FIG. 1), and are used to capture unwanted multipath induced inter-symbol interference at the SISO receiver device 112 (FIG. 1).

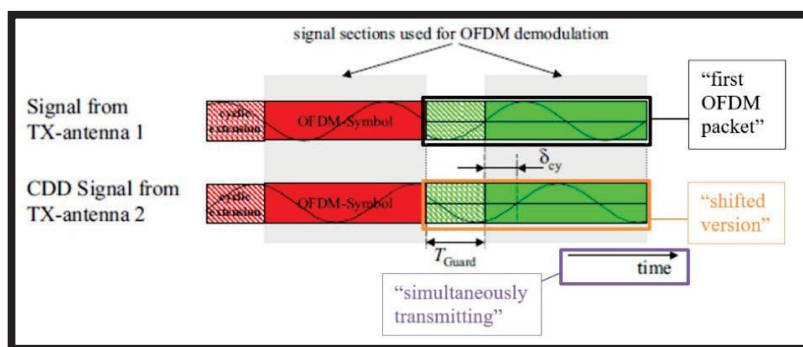
Ex. 1001 at 2:16-26.

89. A POSITA would thus use a cyclic advancement or delay of less than the length of the cyclic prefix.

E. Transmitting an OFDM Packet and a Shifted OFDM Packet, Substantially Simultaneously, Was Well Known in the Art (Claims 1C, 8C, 8E)

90. A POSITA would have recognized that this claim element is obvious in view of Dammann and the knowledge of a POSITA. Dammann teaches substantially simultaneously transmitting the “Signal from TX-antenna 1” (the recited “first OFDM packet”) and the “CDD signal from TX-antenna 2” (the recited “shifted version of the OFDM packet”). Dammann teaches that “an OFDM time signal with cyclic extension – as commonly used for OFDM systems – is transmitted from antenna 1 (TXantenna 1)” and that “we transmit a 2nd CDD OFDM time signal from TX-antenna 2.” Dammann at §2.2.

91. Additionally, Dammann teaches that the two packets are transmitted substantially simultaneously from the two TX antennas. For ease of interpretation, the below figure was altered to show only the “Signal from TX-antenna 1” and the “CDD signal from TX-antenna 2.”



Dammann at Fig. 2 (modified as described).

92. Since the drawing for each packet shares the same time axis and scale, the two packets are transmitted at least substantially simultaneously.

93. Further, the '439 Patent admits that this claim element was known in the prior art, including with respect to admitted prior art Figure 5, a schematic diagram showing cyclically shifting a first OFDM signal by one sample to generate a second, shifted OFDM signal, each for transmission. Ex. 1001 at 3:57-58.

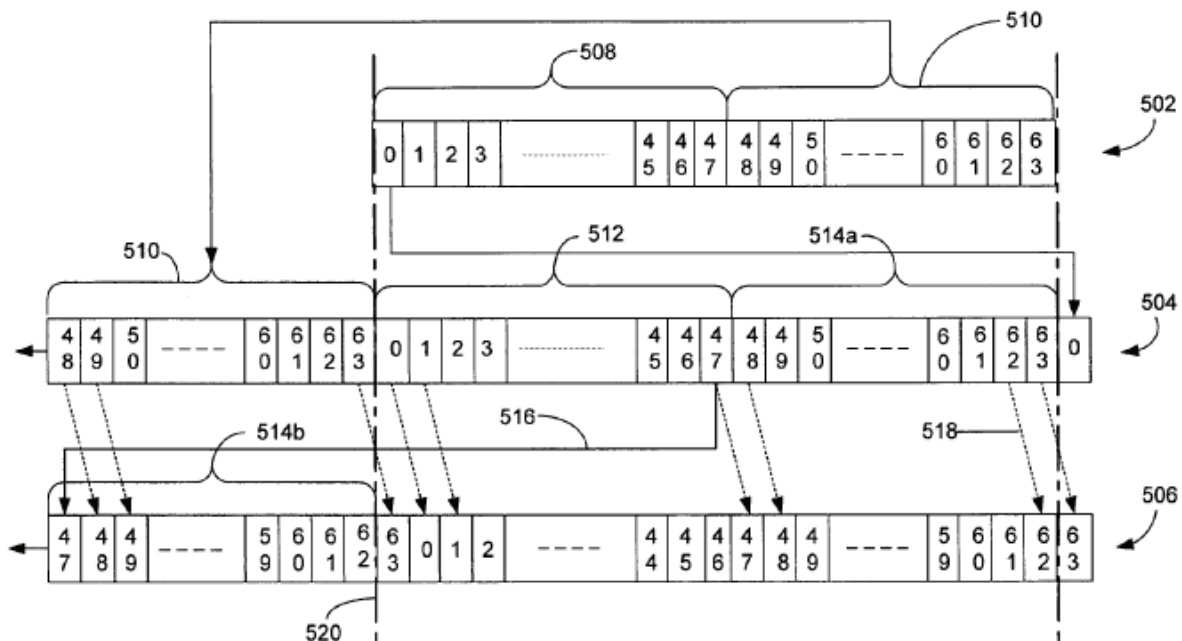
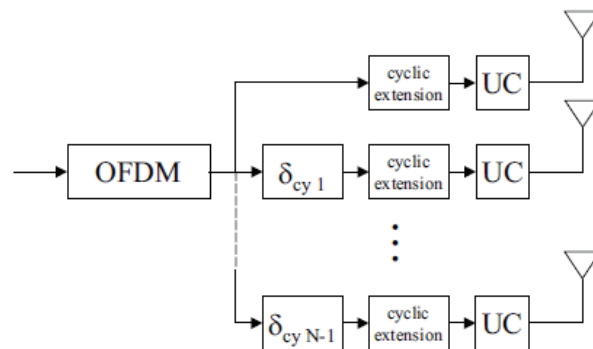


FIG. 5 (PRIOR ART)

94. The patent notes that, “[f]rom a receiver standpoint, the guard intervals 510, 514 *b* remain aligned, as represented by the dashed line 520” (Ex. 1001 at 4:5-6), meaning the first OFDM packet and the shifted version of the OFDM packet are transmitted at substantially the same time.

F. Radio Transmitters and Antennas for Converting OFDM Packets to Radio Signals and Transmitting Were Well Known in the Art (Claims 1C, 1D, 7, 8C, 8D)

95. A POSITA would have recognized that this claim element is obvious in view of Dammann and the knowledge of a POSITA. Dammann teaches “[w]e assume that an OFDM time signal with cyclic extension – as commonly used for OFDM systems – is transmitted from antenna 1 (TX-antenna 1).” Dammann at §2.2. Dammann further teaches “[n]ow we transmit a 2nd CDD OFDM time signal from TX-antenna 2” and that “the OFDM time domain symbols, transmitted from TX-antenna 2, are built by a cyclic shift δ_{cy} of the respective OFDM time domain symbols at TX-antenna 1.” Dammann at §2.2. Dammann depicts the multiple antennas in Figure 1.



Dammann at Fig. 1.

96. Further, the '439 Patent admits that this claim element was known in the prior art. The patent explains with respect to Figure 1 below (labeled “PRIOR ART”), that “an 802.11 compliant (e.g., 802.11a, 802.11g) *multi-antenna (MA)*

transmitter device 102 is shown in communication with a SISO 802.11 receiver device 112,” that “[t]he MA transmitter device 102 comprises *antennas 104 and 106*,” and that “[o]ne mechanism to avoid or mitigate completely destructive interference from multi-path signals is to equip one of the antennas 104 and 106 with a time delay element 108 (or provide a delay through a baseband processing section of the MA transmitter device 102).” Ex. 1001 1:34-50.

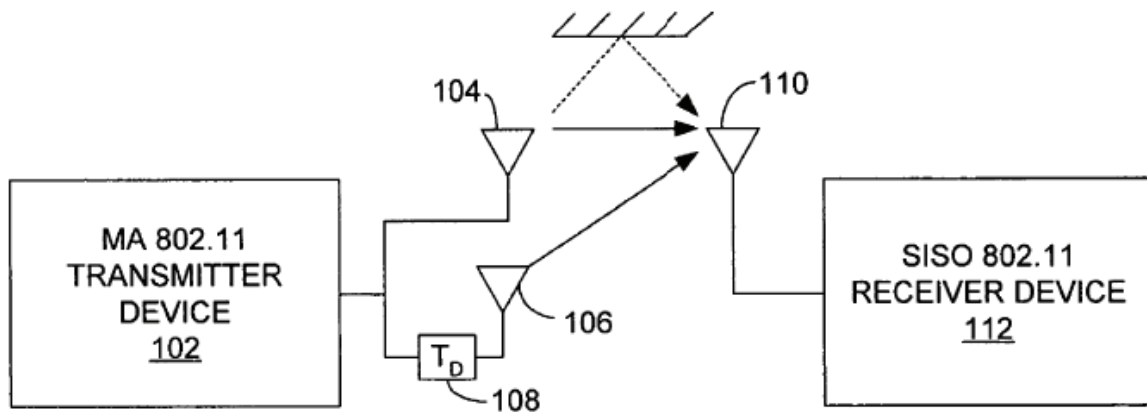
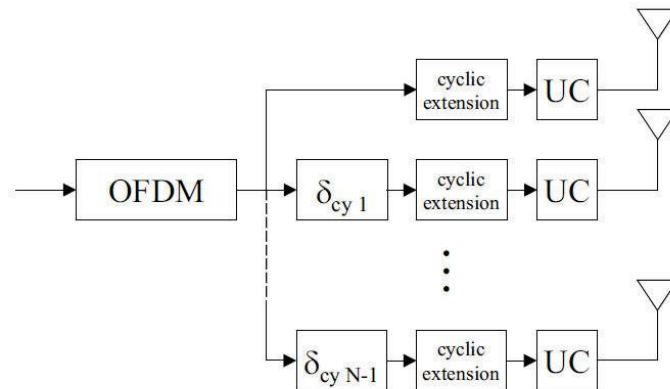


FIG. 1
(PRIOR ART)

97. Thus, Dammann and the knowledge of a POSITA teach that the recited “the first OFDM packet” and the recited “shifted version of the OFDM packet” are transmitted from a transmitter device having multiple antennas.

G. Baseband Signals and 802.11 Compliance Were Well Known in the Art (Claims 14 and 16)

98. Dammann discloses that “functional block ‘UC’” in Figure 1 “performs an upconversion of the signals from the baseband into the RF-band.” Ex. 1005 at §2.1. Thus, a POSITA would have understood that the signals to the left of functional blocks “UC” in Figure 1 are baseband signals that have undergone cyclical shifts.



99. Additionally, Dammann discloses that “[o]rthogonal frequency division multiplexing (OFDM) ... is a suitable technique for broadband transmission in multipath fading environments and is implemented in new broadcast standards like terrestrial digital video broadcasting (DVB-T) [3] as well as wireless local area network (WLAN) standards [4] such as HIPERLAN/2 or *IEEE 802.11a*.” Dammann at §1.

H. ASICs and Firmware Were Well Known in the Art (Claims 15 and 18)

100. It is my opinion that a POSITA would have recognized that this claim element is obvious in view of the Dammann-Hervin combination as modified by Kannan and the knowledge of a POSITA. Although Dammann discloses the recited “first and second transmit processors,” it does not teach the physical architecture of those processors. However, a POSITA would have been motivated to implement the recited transmit processors as application specific integrated circuits (“ASICs”). An ASIC is an integrated circuit (“IC”) chip customized for a particular use, rather than intended for general-purpose use. Indeed, Kannan teaches that, “[a]s those skilled in the art are aware, the various functions of signal processing unit 308 as described herein may be implemented in hardware circuitry, such as a programmable logic array (PLA) or *an application specific integrated circuit (ASIC).*” Kannan at [0026].

101. Kannan teaches that its “signal processing unit 308 performs the functions of each of blocks 204-214, 224-234, and 250-254” in Figure 2, which include, among other things, “orthogonal modulator 210” for performing “inverse fast Fourier transform (IFFT),” cyclic prefix (C/P) adder 214 that appends a guard band interval, or cyclic prefix, to signal 213 to produce output signal 215,” and “C/P

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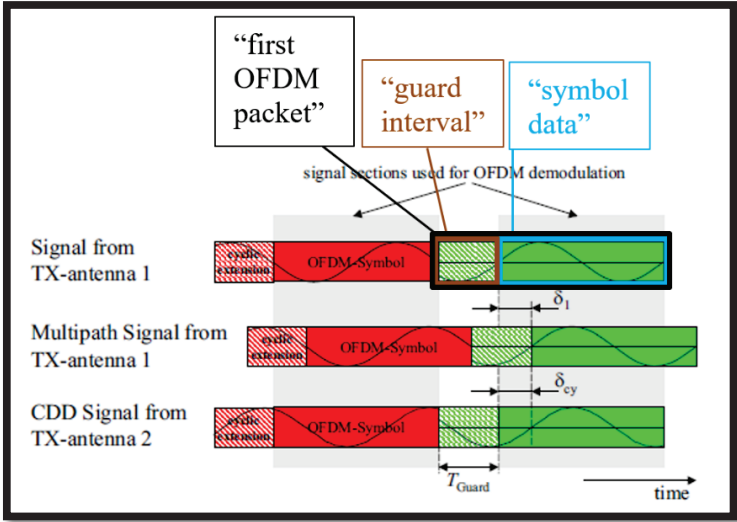
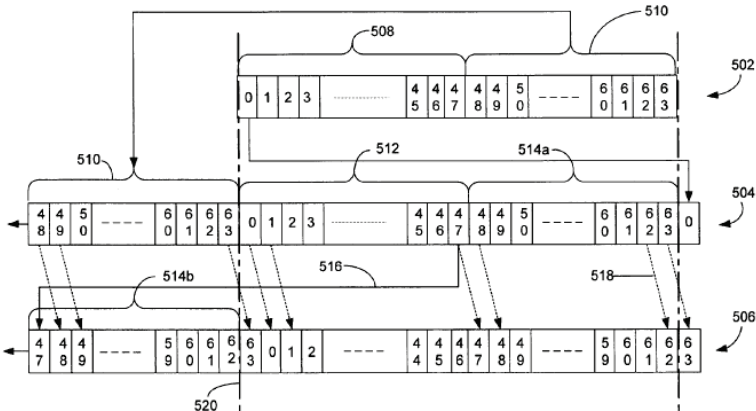
adder 214” which “conveys output signal 215 to an upconverter 216 that upconverts signal 215 from a baseband frequency to a transmit frequency.” Kannan at [0026].

102. Further, the ’439 Patent admits that this claim element was known in the prior art. The patent explains that, “[i]f implemented in hardware, [the] embodiments can be implemented with any or a combination of the following technologies, which are *all well known in the art*: a discrete logic circuit(s) having logic gates for implementing logic functions upon data signals, *an application specific integrated circuit (ASIC)* having appropriate combinational logic gates, a programmable gate array(s) (PGA), a field programmable gate array (FPGA), etc.” Ex. 1001 at 8:56-63.

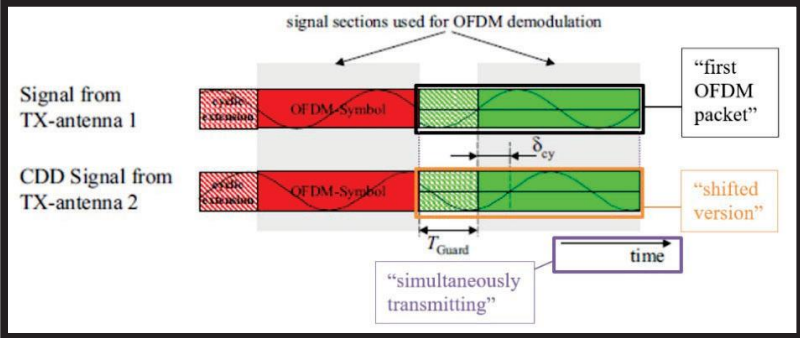
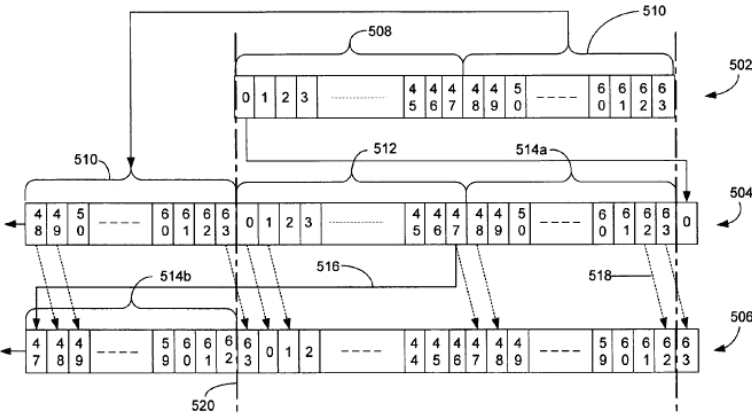
103. Additionally, although Dammann discloses the recited “first and second transmit processors,” it does not teach the physical architecture of those processors. However, a POSITA would have been motivated to implement the recited transmit processors with “firmware stored in a memory device and executed by a suitable instruction execution system.” Indeed, Kannan teaches that, “as those skilled in the art are further aware, the functions of one or more of blocks 204-214, 224-234, and 250-254 may be implemented in signal processing unit 308 by software executed by a processor, such as a microprocessor or a digital signal processor (DSP), that executes instructions and programs that are stored in an associated memory.” Ex. 1007 at [0026].

104. The obviousness of the challenged claims is further demonstrated by the claim chart below.

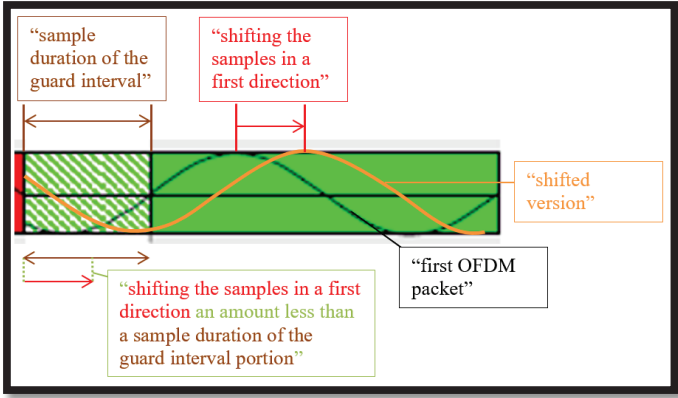
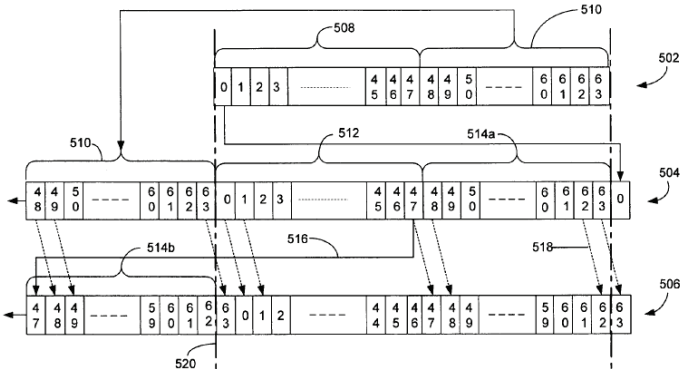
Claim	Disclosure
1[pre] A method for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:	“(OFDM) ... is a suitable technique for broadband transmission in multipath fading environments and is implemented in new broadcast standards like terrestrial digital video broadcasting (DVB-T) ... as well as wireless local area network (WLAN) standards ... such as HIPERLAN/2 or IEEE 802.11a.” Ex. 1005 at §1. “The OFDM modulated signal is transmitted over N antennas, whereas the particular signals only differ in an antenna specific cyclic shift.” Ex. 1005 at §2.1. FIG. 5 (PRIOR ART) Ex. 1001, Fig. 5.

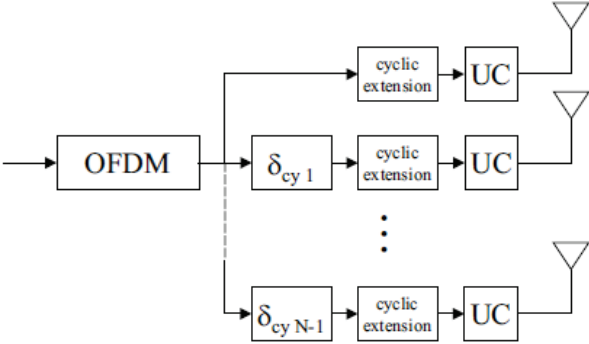
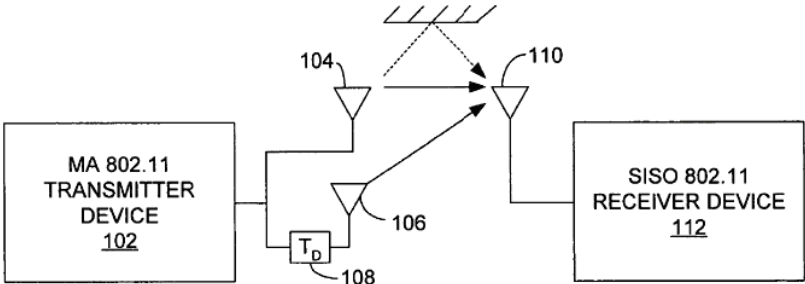
Claim	Disclosure
1[a] generating a first OFDM packet for transmission including a guard interval portion and a symbol data portion each comprised of a plurality of samples;	 The diagram illustrates three OFDM signals received from different antennas: 'Signal from TX-antenna 1', 'Multipath Signal from TX-antenna 1', and 'CDD Signal from TX-antenna 2'. Each signal is composed of a 'cyclic extension' (red hatched), an 'OFDM-Symbol' (red), a 'guard interval' (green hatched), and 'symbol data' (blue). The 'guard interval' and 'symbol data' portions are identified as 'signal sections used for OFDM demodulation'. Time offsets δ_1 and δ_{cy} are shown between the signals, and T_{Guard} is the duration of the guard interval. A 'time' axis is at the bottom. Ex. 1005 at Fig. 2 (annotated).  This diagram shows a multi-carrier signal structure with multiple subcarriers. The top section (508) shows a sequence of subcarriers with indices 0, 1, 2, 3, ..., 4, 5, 6, 7, 8, 9, ..., 6, 0, 1, 2, 3. Below this, there are several other sections labeled 510, 512, 514a, 514b, 516, 518, 520, 502, 504, and 506. These sections represent different parts of the signal, such as pilot tones, data, and guard bands. The diagram illustrates the complex structure of a multi-carrier signal in the prior art. FIG. 5 (PRIOR ART) Ex. 1001, Fig. 5.

Claim	Disclosure
1[b] 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	Ex. 1005 at Fig. 2 (annotated). 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 nsec (the OFDM symbol waveform repeats with a period of 3.2 μsec 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). Ex. 1001 at 8:5-21. “In a circular shift operation, also known as a rotate,” ... “[the] rotate operation may be a rotate left (or

Claim	Disclosure
the guard interval portion of the shifted version; and	“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.” Ex. 1006 at 1:19-30
1[c] substantially simultaneously transmitting the first OFDM packet and the shifted version of the OFDM packet.	 Ex. 1005 at Fig. 2 (annotated).  FIG. 5 (PRIOR ART) Ex. 1001, Fig. 5.

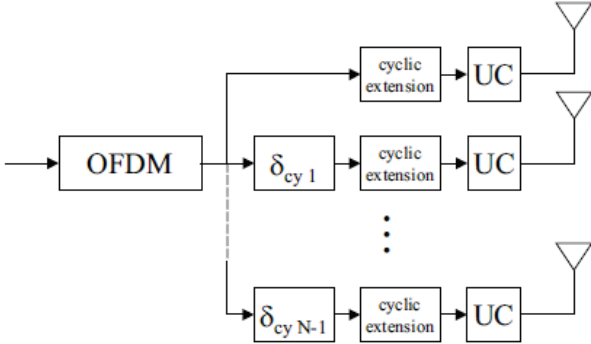
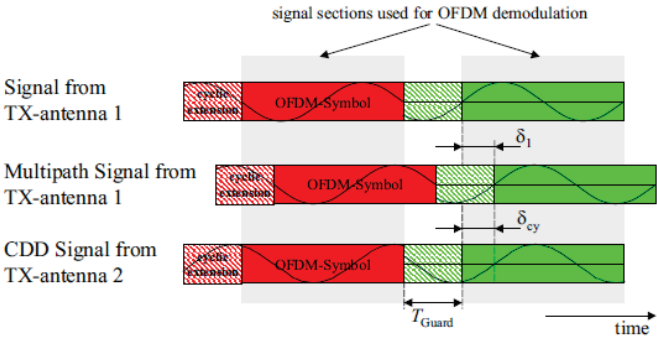
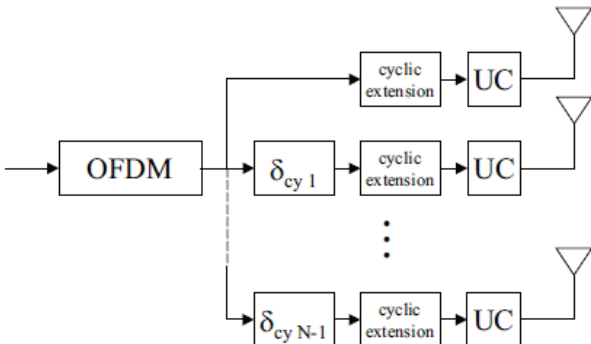
Claim	Disclosure
2 The method of claim 1, further comprising cyclically advancing the OFDM packet for a duration of less than approximately 800 nanoseconds.	“[A]n 802.11 compliant WLAN transmitter device may transmit a packet with a guard interval having a duration of approximately 800 nsec.” Ex. 1001 at 7:66-8:2. Typically, the appending of cyclic prefix comprises an appending of the last T_g seconds of each OFDM symbol as a prefix to itself. Preferably T_g is a preassigned length of 16 taps, or 0.8 μs; however, those of ordinary skill in the art realize that the preassigned length of the cyclic prefix is up to the designer of the system as the designer weighs the greater protection afforded by a longer cyclic prefix against the inefficiency of a longer prefix. Ex. 1007 at [0040]. Preferably, composite communication channel 400 appears to be a communication channel with a multipath delay of, at most, a length of the cyclic prefix (i.e., 16 taps, wherein each tap corresponds to a sampling of a signal, and at a sampling rate of 20 MHz 16 taps corresponds to a delay of 0.8 μs), although, in the alternative, the design of composite communication channel 400 may be oriented to any tolerable multipath delay. Ex. 1007 at [0044].

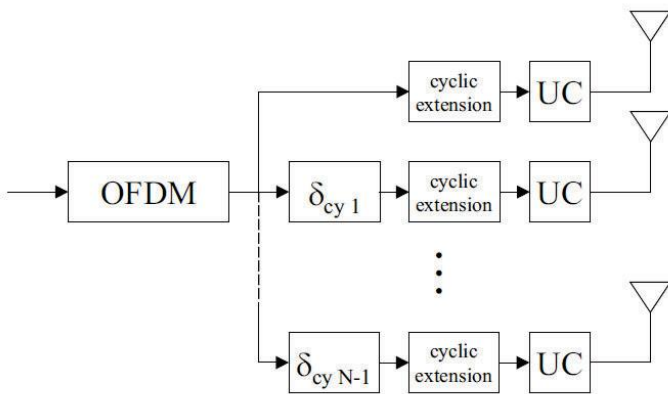
Claim	Disclosure
3 The method of claim 1, further comprising cyclically advancing the OFDM packet for a duration of less than one half of the sample duration of the guard interval portion.	 Ex. 1005 at Fig. 2 (annotated).  FIG. 5 (PRIOR ART) Ex. 1001, Fig. 5.
7 The method of claim 1, further comprising transmitting the first OFDM packet and the shifted version of the OFDM packet from a multiple-antenna	We assume that an OFDM time signal with cyclic extension – as commonly used for OFDM systems – is transmitted from antenna 1 (TX-antenna 1). Ex. 1005 at §2.2 “Now we transmit a 2nd CDD OFDM time signal from TX-antenna 2” and that “the OFDM time domain symbols, transmitted from TX-antenna 2, are built by a

Claim	Disclosure
transmitter device.	cyclic shift δ_{cy} of the respective OFDM time domain symbols at TX-antenna 1.” Ex. 1005 at §2.2  Ex. 1005, Fig. 1.  FIG. 1 (PRIOR ART) Ex. 1001, Fig. 1.
8[pre] A signal transmitting system for transmitting orthogonal frequency division	See Claim 1 Preamble.

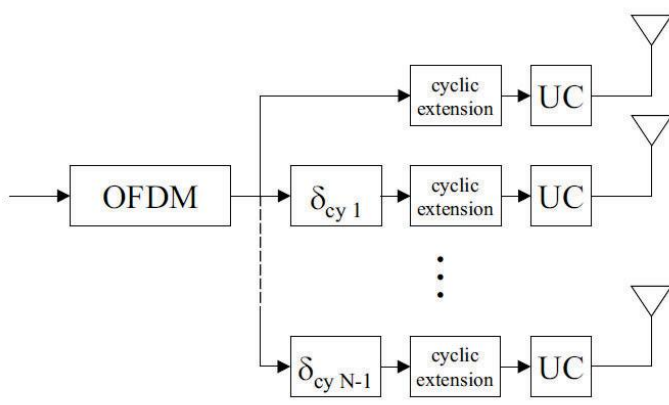
Claim	Disclosure
multiplexing (OFDM) signals comprising:	
8[a] a first transmit processor for generating a first OFDM packet for transmission including a guard interval portion and a symbol data portion each compromised of a plurality of samples;	<i>See Claim 1A.</i>
8[b] a second transmit processor 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	<i>See Claim 1B.</i>

Claim	Disclosure
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;	
8[c] a plurality of radio transmitters for converting the OFDM packet and the shifted version of the OFDM packet to corresponding	signal sections used for OFDM demodulation Signal from TX-antenna 1 Multipath Signal from TX-antenna 1 CDD Signal from TX-antenna 2 δ_1 δ_{cy} T_{Guard} time Ex. 1005, Fig. 2.

Claim	Disclosure
radio signals; and	 Ex. 1005, Fig. 1.
8[d] a plurality of radio antennas correspondingly coupled to the plurality of radio transmitters for transmitting the radio signals;	 Ex. 1005, Fig. 2.  Ex. 1005, Fig. 1.
8[e] wherein the first transmit processor and the second	See Claim 1C.

Claim	Disclosure
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.	
9 The system of claim 8, wherein each of the first and second transmit processors includes a cyclic extension module for performing cyclical advancements.	 Ex. 1005, Fig. 1.
10 The system of claim 9, wherein each of the cyclic extension modules is configured to cyclically	See Claim 3.

Claim	Disclosure
advance the OFDM packet for a duration of less than one half of sample duration of the guard interval.	
11 The system of claim 9, wherein each of the cyclic extension modules is configure to cyclically advance the OFDM packet for a duration of less than approximately 800 nanoseconds.	See Claim 2.
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	Immediately following the words “Orthogonal frequency division multiplexing (OFDM)” in Dammann’s “Introduction” section, Dammann cites a paper entitled “Data Transmission by Frequency Division Multiplexing Using the Discrete Fourier Transform.” Ex. 1003 at 73. <i>“The packet structure 200 is generated in a baseband processing section (e.g., in or in cooperation with an inverse fast Fourier transform (IFFT) operation) of the MA transmitter device 102”</i> Ex. 1001 at 1:62-65.

Claim	Disclosure
from incoming data.	
14 The system of claim 8, wherein the first and second transmit processors perform the cyclical advancements on baseband signals.	[F]unctional block ‘UC’” in Figure 1 “performs an upconversion of the signals from the baseband into the RF-band. Ex. 1005 at §2.1  Ex. 1005, Fig. 1. Fig. 1 shows the block diagram of an N-antenna OFDM transmitter with CDD. The OFDM modulated signal is transmitted over N antennas, whereas the particular signals only differ in an antenna specific cyclic shift. After cyclic shifting, a cyclic prefix is inserted to avoid inter-symbol interference and maintain subcarrier orthogonality for multipath channels. Ex. 1005 at §2.1
15 The system of claim 8, wherein the first and second	As those skilled in the art are aware, the various functions of signal processing unit 308 as described herein may be implemented in hardware circuitry, such

Claim	Disclosure
transmit processors include application specific integrated circuits (ASICs).	as a programmable logic array (PLA) or <i>an application specific integrated circuit (ASIC)</i>. Ex. 1007 at [0026] If implemented in hardware, [the] embodiments can be implemented with any or a combination of the following technologies, which are <i>all well known in the art</i>: a discrete logic circuit(s) having logic gates for implementing logic functions upon data signals, <i>an application specific integrated circuit (ASIC)</i> having appropriate combinational logic gates, a programmable gate array(s) (PGA), a field programmable gate array (FPGA), etc. Ex. 1001 at 8:56-63
16 The system of claim 8, wherein the transmitter is an 802.11 compliant device.	Orthogonal frequency division multiplexing (OFDM) ... is a suitable technique for broadband transmission in multipath fading environments and is implemented in new broadcast standards like terrestrial digital video broadcasting (DVB-T) [3] as well as wireless local area network (WLAN) standards [4] such as HIPERLAN/2 or <i>IEEE 802.11a</i>. Dammann at §1
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	[A]s those skilled in the art are further aware, the functions of one or more of blocks 204-214, 224-234, and 250-254 may be implemented in signal processing unit 308 by software executed by a processor, such as a microprocessor or a digital signal processor (DSP), that executes instructions and programs that are stored in an associated memory. Ex. 1007 at [0026]

Claim	Disclosure
instruction execution system.	

I hereby declare that statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true. Should further information become available to me as this matter proceeds, I may revise my opinions accordingly as necessary. I declare under penalty of perjury that the foregoing Declaration is true and correct.

Dated: May 1, 2024



Digitally signed by Zhi Ding
Date: 2024.05.01 13:35:44 -07'00'

Zhi Ding, Ph.D.