

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

TCL ELECTRONICS HOLDINGS LTD. and TCL INDUSTRIES HOLDINGS
CO., LTD.,
Petitioners,

v.

INTELLECTUAL VENTURES I LLC,
Patent Owner.

Case IPR2024-01244

U.S. PATENT NO. 7,623,439

**DECLARATION OF NADER BAGHERZADEH, PH.D. IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW**

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TABLE OF EXHIBITS

Exhibit No.	Description
1001	U.S. Patent No. 7,623,439 (the “’439 Patent”)
1002	Certified File History of the ’439 Patent
1003	Declaration of Dr. Nader Bagherzadeh
1004	<i>Curriculum Vitae</i> of Dr. Nader Bagherzadeh
1005	U.S. Patent No. 6,842,487 (“Larsson”)
1006	Stefan Kaiser and Armin Dammann, “ <i>Low Complex Standard Conformable Antenna Diversity Techniques for OFDM Systems and Its Application to the DVB-T System</i> ,” 2002 International ITG Conference on Source and Channel Coding, January 2002 (“Kaiser”)
1007	WIPO International Publication No. WO 2005/041441 (“Bauch”)
1008	Institute of Electrical and Electronics Engineers’, “Supplement to IEEE Standard for Information Technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: High-speed Physical Layer in the 5 GHZ Band,” IEEE 1999 (“IEEE”)
1009	<i>Intellectual Ventures I LLC et al. v. Lenovo Group Limited</i> , Case No. 6:23-cv-00307-ADA, Dkt. 60, Claim Construction Order (May 28, 2024) (“Lenovo Order”)
1010	<i>Intellectual Ventures I LLC v. TCL Electronics Holdings Ltd, et al.</i> , Case No. 6:23-cv-00309-ADA, Dkt. 35, Corrected Joint Claim Construction Statement (June 18, 2024) (“Joint Claim Construction Statement”)
1011	WIPO International Publication No. WO 2005/081481 (“Auer”)
1012	U.S. Patent Pub. No. US 2005/0265275 (“Howard”)
1013	U.S. Patent Pub. No. US 2002/0122499 (“Kannan”)
1014	Y.J. Liu, <i>Introduction to OFDM Receiver Design and Simulation</i> (2020) (“Liu”)
1015	Affidavit of Nathaniel E Frank-White (“Frank-White Affidavit”)

DECLARATION OF NADER BAGHERZADEH, PH.D.

1. I, Nader Bagherzadeh, make this declaration in connection with the proceeding identified above.

2. I have been retained on behalf of Petitioners TCL Electronics Holdings Ltd. and TCL Industries Holdings Co., Ltd. (“TCL”) to offer my expert opinions with respect to the invalidity of U.S. Patent 7,623,439 (the “’439 Patent”).

3. I am being compensated for my time in connection with this inter partes review (IPR) at my standard consulting rate of \$700 per hour plus reasonable expenses. No part of my compensation depends on the outcome of this proceeding.

4. I have been asked to provide my opinions as to whether claims 1-21 (the “Challenged Claims”) of the ’439 Patent are invalid from the perspective of a person having ordinary skill as of May 20, 2004.

5. In preparing this declaration, I have reviewed the ’439 Patent (EX1001), the file history of the ’439 Patent (EX1002), and all other materials referenced in this declaration. I have relied upon my education, training, knowledge, and experience in the art, and have considered the viewpoint of a person of ordinary skill in the art (POSITA) as of the dates listed above.

6. All emphasis and annotations below are added, unless noted otherwise.

I. BACKGROUND AND QUALIFICATIONS

7. I summarize in this section my educational background, career history, and other relevant qualifications. My curriculum vitae is EX1004.

8. I am currently a professor in the Department of Electrical Engineering and Computer Science at the University of California, Irvine. I have held this position since 2003. Previously, I held the position of Professor and Chair of Electrical Engineering and Computer Science (ECE) at the University of California, Irvine, from 1998 to 2002. Prior to that I was an Associate Professor in the ECE Department at the University of California, Irvine from 1993 to 1997. Prior to that I was an Assistant Professor in the ECE Department at the University of California, Irvine from 1987 to 1992.

9. I earned a Ph.D. in Computer Engineering from the University of Texas at Austin in 1987. I earned a Master of Science degree in Electrical Engineering from the University of Texas at Austin in 1979, with a focus on communications theory and signal detection algorithms. I earned a Bachelor of Science degree, with honors, in Electrical Engineering from the University of Texas at Austin in 1977.

10. I have over 45 years of experience in the Electrical Engineering and Computer Science field. That experience includes holding the position of Member of Technical Staff, No. 5 ESS Hardware/Software T1 Line Interface Design at AT&T Bell Labs from 1980 to 1984. In this position I received the Outstanding Achievement award from AT&T Bell Labs in 1984. While at Bell Labs I developed T1 line framing and error monitoring algorithms that were stored on electrically erasable programmable read-only memory (EEPROM)—a charge based non-volatile memory which is considered the predecessor to contemporary flash memory. Additionally, I designed the microprocessor-based board that included the EEPROM among many other components for directly interfacing the T1 line.

11. In 2002, I received the Best Paper award in Institute of Electrical and Electronics Engineers (IEEE) Transactions on Very Large Scale Integration (VLSI) Design related to task scheduling for multicore processors. I also received another Best Student Paper award co-authored with my doctoral students in the proceedings of Asia and South Pacific Design Automation Conference (ASPDAC) '02. In 2020, I received the Best Paper award in the proceedings of the IEEE International Conference on Edge Computing (EDGE).

12. In 2014, I received the Khwarizmi International Award and became an IEEE Fellow. In 2015, I received Professor of the Year for the Department of

Electrical Engineering and Computer Science at the University of California at Irvine.

13. I have particular experience in optimizing the efficiency of wireless communication systems. I was a co-founder of a startup called Morpho Technologies that was targeted for designing a Software-Defined Radio using Coarse Grain Reconfigurable Architecture (CGRA). In that capacity, I evaluated the algorithm efficiency and power consumption of using CGRA for wireless baseband and base station algorithms. The MorphoSys architecture was aimed at replacing the custom designed baseband processing for mobile devices. Having an SDR was a novel idea, since upgrading to a revised baseband algorithm required only a software update, similar to the operating system update of a cellular phone device. This unique approach would have eliminated the need to tape out a new chip when there is a new functionality, a design error fix, or algorithm revision. I had to evaluate the efficiency of key baseband kernels using our programmable solution. Because of my unique contributions to the MorphoSys project, I became a Fellow of the IEEE and received a best paper award. Additionally, this project resulted in training and subsequently graduating 10 doctoral students across the globe and receiving additional funds from government agencies and industries.

14. Morpho Technologies also focused on the design and development of low power and high-performance digital signal processors (DSPs) for mobile

applications. As part of my duties as the chief technologist for the company, I evaluated patents, technical reports, presentations related to memory chip designs, DSPs, and parallel processing algorithms for mobile platforms, which included OFDM algorithms.

15. For Morpho, I designed, developed, and tested the key components of a Coarse Grain Reconfigurable Architecture (CGRA), including the memory block responsible for exchanging data between the host processor and the multicore processor (SIMD array processor). I used this architecture to show the efficiency of mapping an OFDM algorithm as part of a DVB-T receiver onto the Morpho architecture.

16. I also designed the main data storage of the microcontroller (a reduced instruction set computer, or “Tiny RISC”) that was used for storing temporary data between the Tiny RISC and the array processor, based on SRAM technology, which is a type of volatile memory. I was one of the primary contributors for the prototype board design of the Morpho chip, which utilized DRAMs, field-programmable gate arrays (FPGAs), flash memory and other prototype board components.

17. Over the past 45+ years, my research has focused on hardware, software, and VLSI design of low-power and high-performance multicore computer systems for wireless communication applications in mobile systems,

computer graphics processing, 3D integrated circuits, memory structures (e.g., static random-access memory (SRAM), dynamic random-access memory (DRAM), flash memory, and register files), Network-on-Chip (NoC), and AI accelerators.

18. Since joining the University of California, Irvine in 1987, I have been teaching, researching, and consulting regarding almost all aspects of high-performance computer systems, including but not limited to VLSI design, computer architecture, parallel implementation of computationally critical applications such as wireless communication signal processing and error correcting schemes, DRAMs, SRAMs, low power design, and interfacing multicores.

19. Over the course of my career, I have supervised more than 45 doctoral students and 30 masters' students who have taken key positions in the electrical engineering and computer engineering sector. I have served as post-doctoral advisor for more than 10 scholars that worked with my research group. Three of my doctoral students under my guidance worked on processor architectures for parallelizing OFDM computations of the DVB-T standard. Our project goal was to have a single chip programmable solution for a DVB-T receiver. DVB-T is a standard for Digital Video Broadcasting developed by ETSI (European Telecommunication Standards Institute) where OFDM is used for the physical layer. The work involved converting the DVB-T into the fixed-point domain and

simulating its performance by mapping key kernels such as Viterbi, FFT, RS, synchronization, OFDM, MPEG, and other related kernels onto our novel MorphoSys architecture. Since Forward Error Correction (FEC) is critical to error free operation of wireless communication, a portion of our effort on the DVB-T receiver focused on comparing different coding schemes such as convolutional, turbo, RS and LDPC.

20. As part of my teaching and research experience, I have been responsible for developing circuits, electronic modules, and related architectures for a variety of multicore systems for high performance and low power applications, which are considered critical for modern wireless platforms such as Wi-Fi routers, cellular phones, and TVs. For example, I designed the memory block responsible for managing out-of-order execution of data registers corresponding to different threads in the multithreaded superscalar DSP that was developed at University of California, Irvine. I also designed the original temporary data storage subcomponents for the VLIW integer processor (ViPER) and the original Tiny RISC processor. ViPER was considered the very first ever VLIW processor designed using Metal Oxide Semiconductor Implementation Service (MOSIS) 1.2-micron technology that included memory and logic circuits. I have also done extensive work on the design of efficient data correction schemes using reconfigurable computing based on the Morpho parallel array architecture.

21. In 2006, I analyzed the hardware implementation of low-density parity-check (LDPC) as a consultant for a local flash memory module design company. In this capacity, with the help of one of my doctoral students, we modeled the hardware and evaluated the computation complexity of using an application-specific integrated circuit (ASIC) for implementing LDPC on a flash memory-based board. LDPC is one of the main Forward Error Correction (FEC) schemes used in current memory and wireless systems for detecting and correcting bits that have changed from their original intended value because of various forms of noise interference.

22. Throughout my career, I have worked on many aspects of computer architecture optimizations, encompassing hardware, processor allocation and scheduling on 2D NoC array, and software techniques. Ideas based on NoC design, modeling, and evaluation have been the hallmark of my research work for more than 15 years. I also extended my original ideas toward three-dimensional (3D) NoC and demonstrated some of the advantages of 3D integrated circuit (IC) design as well as potential complications that could arise from the thermal footprint of these architectures. NoC uses packet switching communication across a network of routers to facilitate core-to-core and core-to-memory communications. My main contributions have been on the critical aspects of NoC and IC design, including router design, through-silicon via (TSV) cross talk, power efficiency, task mapping

and scheduling onto NoC, aging of ICs, and other related topics. Due to the expansion in the number of cores on modern cellular phone ICs, the bus based design that has been around for over 25 years is not scalable to integrate 100s of cores. Therefore, there is a significant effort to incorporate 3D NoCs to overcome the limitations of 2D bus-based designs. My seminal work in the area of 3D NoC IC design for applications in wireless systems has been one of my recent accomplishments in the domain of processor design for wireless systems.

23. Additionally, I have extensive research experience and publications in parallelizing algorithms such as OFDM, FEC, and other signal processing applications using reconfigurable computing and instruction level parallelism. The focus of our work on OFDM was for designing a software-defined DVB-T receiver. The advantage of a software-defined architecture over an ASIC design is that any changes to the standard algorithm can be easily handled by updating the program on our reconfigurable hardware, whereas an ASIC requires a complete redesign, taking months of testing and verification. Our approach exploits the inherent parallelism in key DVB-T receiver kernels, including the OFDM algorithm, and meets the time-to-market and low-power requirements.

24. I have been involved in numerous research projects, journal articles, and books. The specific research projects, journal articles, and books may be found in my Curriculum Vitae, which is attached to my Declaration as Appendix A. Over

the years, I have also received funding accumulating over eight million dollars. The specific funding and associated projects may be found in my Curriculum Vitae.

II. LEGAL STANDARDS

25. I am not a lawyer or legal expert, and I do not offer any opinions regarding applicable legal standards. Below, I set forth my understanding of the law as it has been explained to me by counsel, and I have applied this understanding in forming my opinions in this declaration.

26. I understand from counsel that, to invalidate a patent claim as obvious in the context of an IPR proceeding, the petitioner bears the burden of showing by a preponderance of the evidence that the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious to a person of ordinary skill in the art to which the subject matter pertains at the time the claimed invention was made. Factors relevant to the determination of obviousness include (1) the scope and content of the prior art, (2) the level of ordinary skill in the art at the time of the invention, (3) differences between the claimed invention and the prior art, and (4) “secondary considerations” or objective evidence of obviousness or non-obviousness.

27. I understand from counsel that obviousness can be established by showing that a person of ordinary skill in the art would have combined or modified the teachings of the prior art to produce the claimed invention and would have had a reasonable expectation of success in achieving the claimed subject matter. There is no requirement that the prior art provide an express teaching, suggestion, or motivation to combine elements of the prior art. Rather, the petitioner in an IPR must identify some apparent reason why a person of ordinary skill in the art would have combined the elements or concepts from the prior art in the same way as in the claimed invention when considered as a whole. The motivation to combine may be implicit and may be found in the knowledge of a person of ordinary skill in the art, from the nature of the problem to be solved, market demand, or common sense. I am informed that some non-exclusive rationales that may support a conclusion of obviousness include:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of known technique to improve similar devices (methods, or products) in the same way;
- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

- “Obvious to try” – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- 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 are predictable to one of ordinary skill in the art; and
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

28. I understand from counsel that a determination regarding obviousness must be based on the knowledge possessed by a person of ordinary skill in the art at the time when the invention was made, and one should not consider in hindsight what is known today or what is learned from the teachings of the patent. Thus, it is inappropriate to use hindsight reconstruction of references to reach the claimed invention without any explanations as to how or why the references would be combined to produce the claimed invention.

29. I understand from counsel that an obviousness analysis cannot be based on nonanalogous art. The rationale behind this rule is that when art is directed to a different purpose than a claimed invention, an inventor would have less motivation or occasion to consider it. Art is analogous when it is from the same field of endeavor as the claimed invention, or if the art is not from the same field of endeavor, when it is reasonably pertinent to the particular problem faced

by the inventor. To be “reasonably pertinent,” art must “logically commend itself” to an inventor’s attention in considering his problem.

III. PRIORITY DATE AND LEVEL OF ORDINARY SKILL IN THE ART

30. I have been asked by counsel to perform my analysis from the perspective of one of ordinary skill in the art as of May 20, 2004 (the claimed priority date on the face of the patent). None of my opinions would change if a somewhat earlier priority date is adopted.

31. In my opinion, a person of ordinary skill in the art (“POSITA”) at the time of the ’439 Patent would have at least a Bachelor’s degree in electrical engineering, computer engineering, computer science, or a related field, with at least two or more years of experience in the field of wireless communication systems and protocols, with more education substituting for work experience and vice versa. I have applied this ordinary level of skill in my analysis, but none of my opinions would change if a somewhat higher or lower level of skill is adopted.

32. I have been qualified as at least a person of ordinary skill in the art since well before May 2004. I have also interacted extensively with and taught persons of ordinary skill in the art. My opinions set forth in this declaration are presented from the standpoint of one skilled in the art. Thus, where I specify in the analysis below that I am rendering my opinion, it should be understood that my

opinion is from the perspective of a person having the level of ordinary skill in the art as of the priority date above.

IV. OVERVIEW OF OPINIONS

33. Below is a summary of my opinions as reflected in the more detailed analysis below:

Ground	Claims	Basis
I	1-21	Obvious over Kaiser in view of Bauch and IEEE ¹
II	1-21	Obvious over Larsson in view of IEEE

V. CLAIM CONSTRUCTION

34. I understand that in construing or interpreting a patent claim, the words of the claim are normally given their ordinary and customary meaning, which is the meaning that words would have had to a person of ordinary skill in the art in question at the time of the invention. The person of ordinary skill in the art is deemed to read the claim term in the context of not only the particular claim in which the disputed term appears, but also in the context of the entire patent, including the other claims and the specification, as well as the prosecution history of the patent. I understand that this is referred to as “intrinsic” evidence.

¹ Both Grounds are supported by a POSITA’s knowledge as evidenced by, among other things, the applicant-admitted prior art, as discussed further below.

35. For purposes of this declaration, I understand that a court in the Western District of Texas has construed the term “cyclically advancing the first OFDM packet by shifting the samples in a first direction” as “cyclically advancing the first OFDM packet by shifting the samples in the direction of transmission.” *See* EX1009 at 8. Although that construction was adopted in a difference case, I understand that Petitioners and Patent Owner agreed in their Joint Claim Construction Statement in the parallel litigation (the “Texas Litigation” as defined below) that this construction is appropriate. *See* EX1010. I have applied that construction in my analysis.

36. In the parallel litigation between Petitioners and Patent Owner, I understand there is a dispute regarding the order of operations for Claim 1. I understand that Petitioners contend that the first step in Claims 1 (“generating a first OFDM packet...”) must occur before the second step (“cyclically advancing the first OFDM packet...”), and the same dispute regarding ordering similarly applies to the corresponding functions recited in Claims 8 and 19. I understand that Patent Owner disputes this construction. My analysis applies regardless of which construction is adopted.

37. I further understand from counsel that inventors may draft their claims as a means or step for performing a specified function, but that they must also disclose in the specification the structure that performs the function, or that claim

is indefinite. I also understand that construing a means-plus-function claim requires identifying the claimed function and determining what structure, if any, disclosed in the specification corresponds to the claimed function. I further understand that a term with a computer-implemented function must have a clearly linked structure in the form of an algorithm. I understand that if I cannot identify such an algorithm, the term lacks a clearly linked structure and is therefore indefinite. I further understand that a general purpose computer cannot be the structure for a computer-implemented function because this amounts to purely functional claiming.

38. I understand that Petitioners propose the following constructions for the means-plus-function terms in Claim 19, which I have applied in my analysis for purposes of this declaration only²:

Limitation	Structure	Function
19[a]	Transmit processor performing the algorithm disclosed	Generating a first OFDM packet for transmission including a guard interval portion and a symbol data portion each compromised

² My opinion does not analyze whether the '439 Patent discloses sufficient structure to satisfy 35 USC § 112. Rather, I have assumed the structure and function set out in the table above, as provided by Petitioner, is the construction of the corresponding terms from Claim 19 and applied that construction in my analysis.

	in the 802.11 standard	of a plurality of samples
19[b]	Transmit processor performing the algorithm disclosed in elements 804-806 of Figure 8 of the '439 Patent	Cyclically advancing the first OFDM packet including a guard interval portion and a symbol data portion each compromised of a plurality of samples 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 we 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
19[c]	Radio transmitter performing the algorithm disclosed in the 802.11 standard	Converting the first OFDM packet and the shifted version of the OFDM packet to corresponding radio signals
19[d]	Transmit processors performing the algorithm disclosed in the 802.11 standard	Substantially simultaneously causing the transmission of the first OFDM packet and the shifted version of the OFDM packet

39. I am not presently aware of any other terms that need to be construed to resolve the controversy presented by the prior art asserted herein.

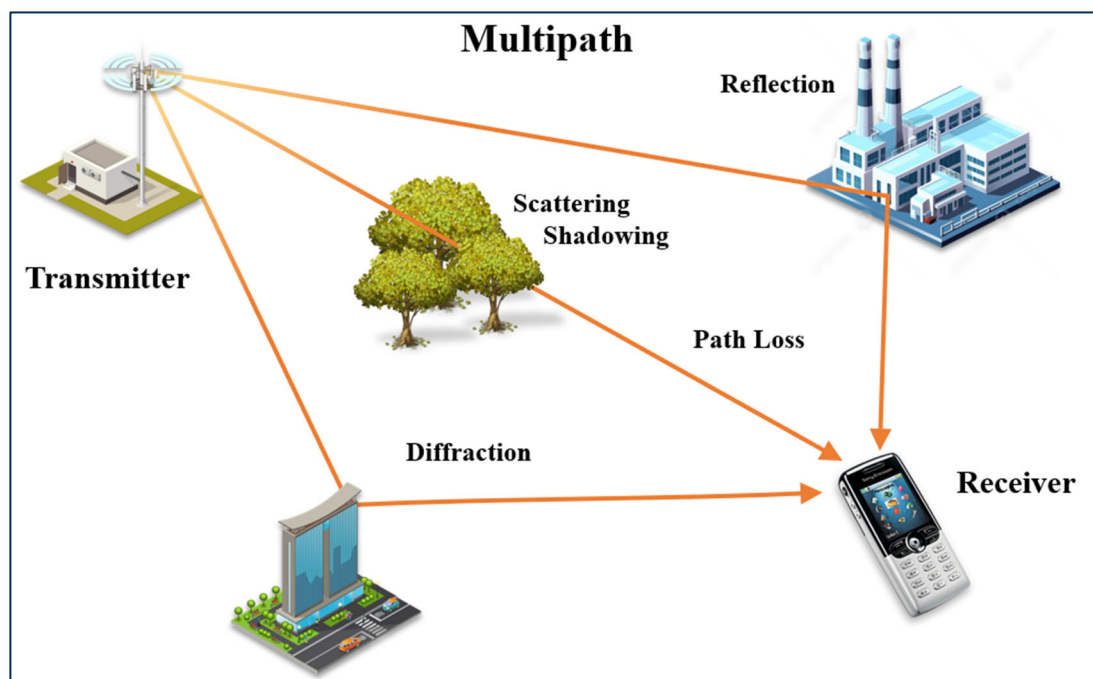
VI. OVERVIEW OF THE '439 PATENT

A. Background of the Technology

40. Orthogonal Frequency Division Multiplexing (OFDM) is a digital multi-carrier modulation technique used in various wireless communication

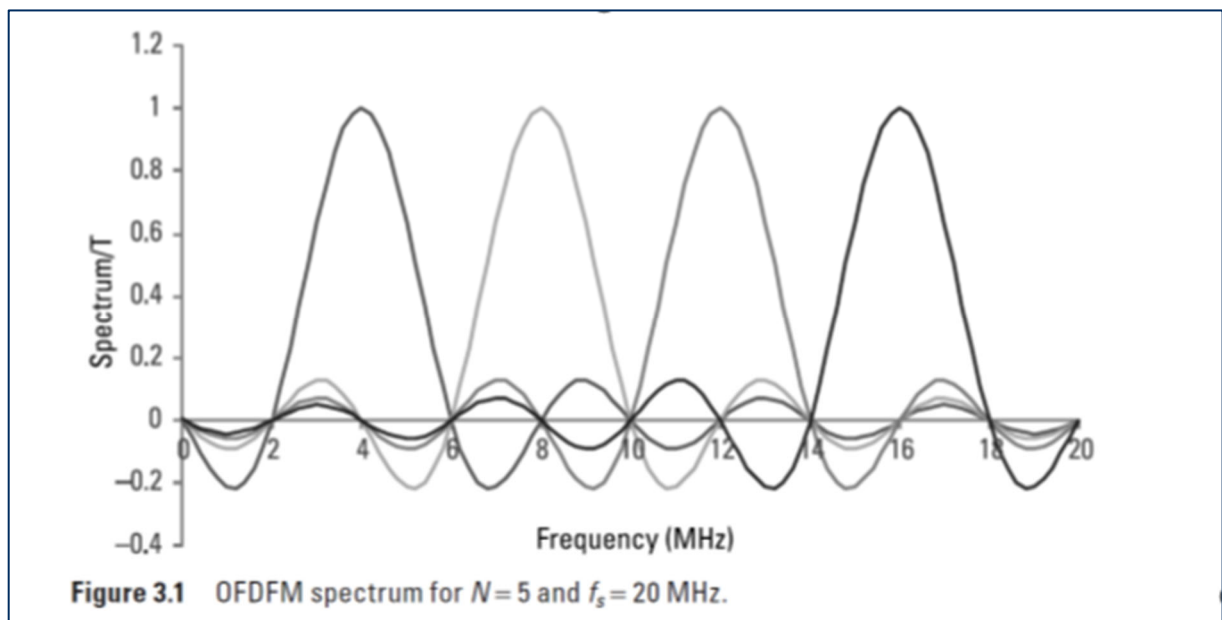
standards. It is known for its efficiency in handling high data rates and its robustness against multipath interference. Multipath fading is a phenomenon in wireless communication where the transmitted signal reaches the receiver through multiple paths due to reflection, diffraction, and scattering.

41. Reflection occurs when signals bounce off large obstacles such as buildings, mountains, and walls, creating multiple reflected paths. Diffraction occurs when signals encounter sharp edges, aperture, or corners, they bend around the obstacle and create additional paths. Scattering occurs when small objects like trees, vehicles, or even atmospheric particles can scatter the signal in various directions. These multiple paths can cause the signal to experience constructive and destructive interference, leading to variations in the signal amplitude, phase, and arrival time as shown in the below created image.



42. Three basic OFDM principles include multi-carrier modulation, orthogonality, and Fast Fourier Transform (“FFT”), and Inverse Fast Fourier Transform (“IFFT”).

43. OFDM uses multi-carrier modulation, which means that OFDM divides the available spectrum into multiple orthogonal sub-carriers. Each sub-carrier is modulated with a low data rate stream, effectively transforming a wideband channel into several narrowband channels. OFDM divides the available wideband (spectrum) of a single carrier into multiple narrowband subcarriers. By partitioning higher bandwidth carrier into many narrowband carriers, lower frequencies are used for modulating the symbols (data). The subcarriers are orthogonal to each other which means their peak frequencies do not interfere with each other, as shown in the figure below:



EX1014 at 58. Shown above, the 20 MHz broadband is divided into 5 narrowband subcarriers with equal frequencies that have peaks at different spectrum frequencies. So, a broadband carrier (20 MHz) is divided into 5 narrowband subcarriers (4 MHz). OFDM is highly resistant to multipath fading and ISI which is a very common problem in wireless systems. By spreading the data across many subcarriers, the impact of frequency selective fading is minimized.

44. A key feature of OFDM is the orthogonality of the sub-carriers, which carry the information stream. This means that the sub-carriers are mathematically orthogonal to each other, which helps in minimizing interference between them. The orthogonality ensures that even though sub-carriers overlap in the frequency domain, they do not interfere with each other, allowing for efficient spectrum usage. To prove that two signals are orthogonal, you show that their inner product over the specified interval is zero. This involves computing the integral of their product and demonstrating that the result is zero. For sinusoidal functions with different frequencies, this orthogonality naturally results from their periodic nature and the properties of the sine and cosine functions. This means the peak value of the subcarrier frequency response which corresponds to the amplitude of the subcarrier at certain frequency is highest for only one of the subcarriers.

45. IFFTs and FFTs are critical components in OFDM systems that are used to modulate and demodulate the data onto the sub-carriers, respectively.

Modulation is the step for using a carrier wave to encode information for transmission to the receiver. The process of transfer data can be done by changing the amplitude of the carrier (AM), the frequency of the carrier (FM) or the phase of the carrier (PM). Generally, the carrier frequency is higher than the information frequency because of transmission efficiency for long distances. Demodulation is the reverse of modulation where the encoded information is retrieved from the carrier signal. IFFT is used at the transmitter to convert the frequency domain data into time domain, and FFT is used at the receiver to revert the time domain data back into the frequency domain. IFFT is a mathematical transformation that converts the data represented in the frequency domain to the original time domain. The IFFT takes all the frequency components and converts them to time varying signals and outputs the sum of these signals using the subcarriers. These time varying signals are ultimately sent to the antenna for transmission in the air, after having them upconverted from the baseband frequency to the designated higher frequency.

46. The supplement to IEEE Supplement to Standard 802.11a-1999 discusses mapping of coefficients to samples, for example as pictured below:

The common way to implement the inverse Fourier transform, as shown in Equation (3), is by an inverse Fast Fourier Transform (IFFT) algorithm. If, for example, a 64-point IFFT is used, the coefficients 1 to 26 are mapped to the same numbered IFFT inputs, while the coefficients -26 to -1 are copied into IFFT inputs

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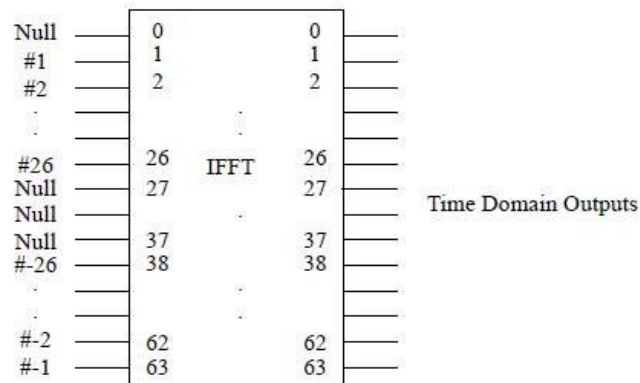
Authorized licensed use limited to: IEEE Staff. Downloaded on June 17, 2024 at 14:41:32 UTC from IEEE Xplore. Restrictions apply.

11

IEEE
Std 802.11a-1999

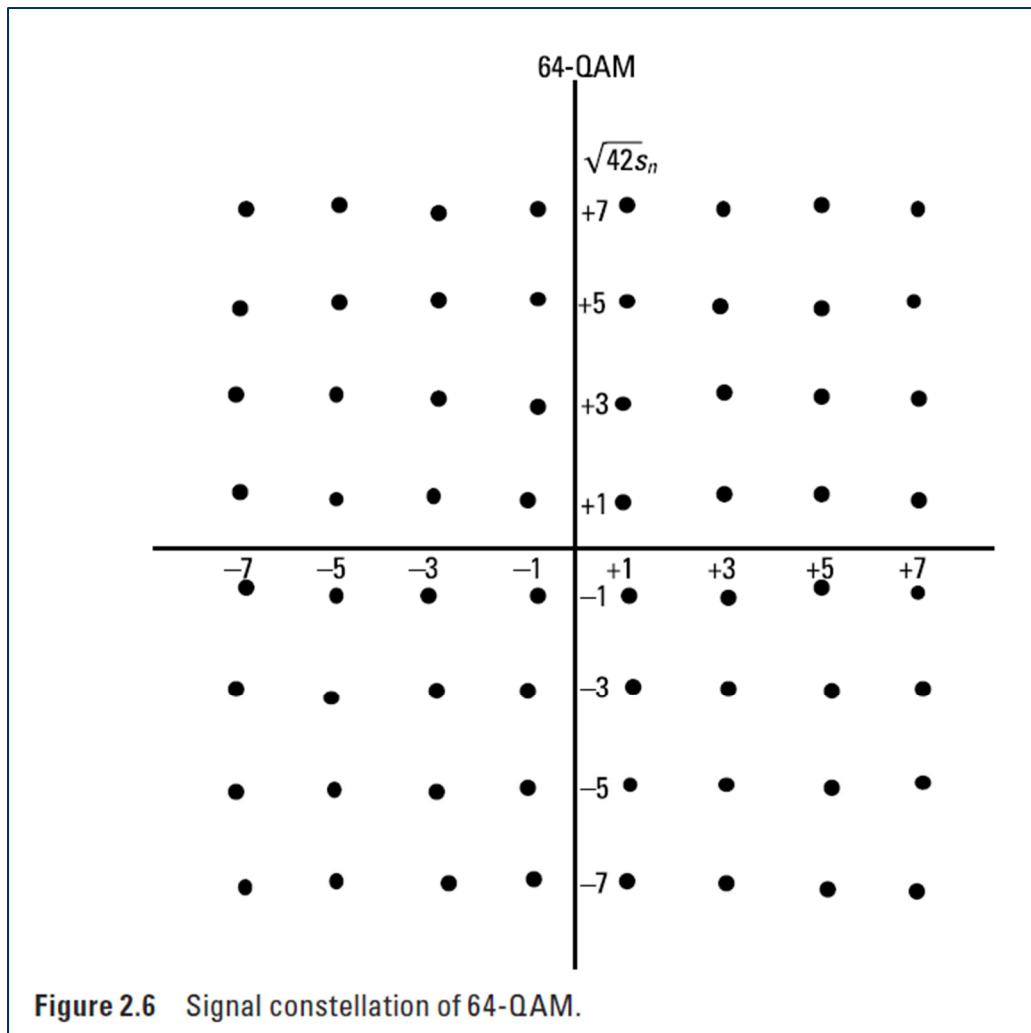
SUPPLEMENT TO IEEE STANDARD FOR INFORMATION TECHNOLOGY—

38 to 63. The rest of the inputs, 27 to 37 and the 0 (dc) input, are set to zero. This mapping is illustrated in Figure 109. After performing an IFFT, the output is cyclically extended to the desired length.



EX1008 at 23-24.

47. As shown above, QAM-64 generates 2^6 or 64 constellations representing a stream of 6 bits of input data for transmission, called QAM symbols. These 64 symbols represent the input data stream and become inputs to the IFFT. Coefficients are mapped to 64 sampled data points representing an OFDM symbol:

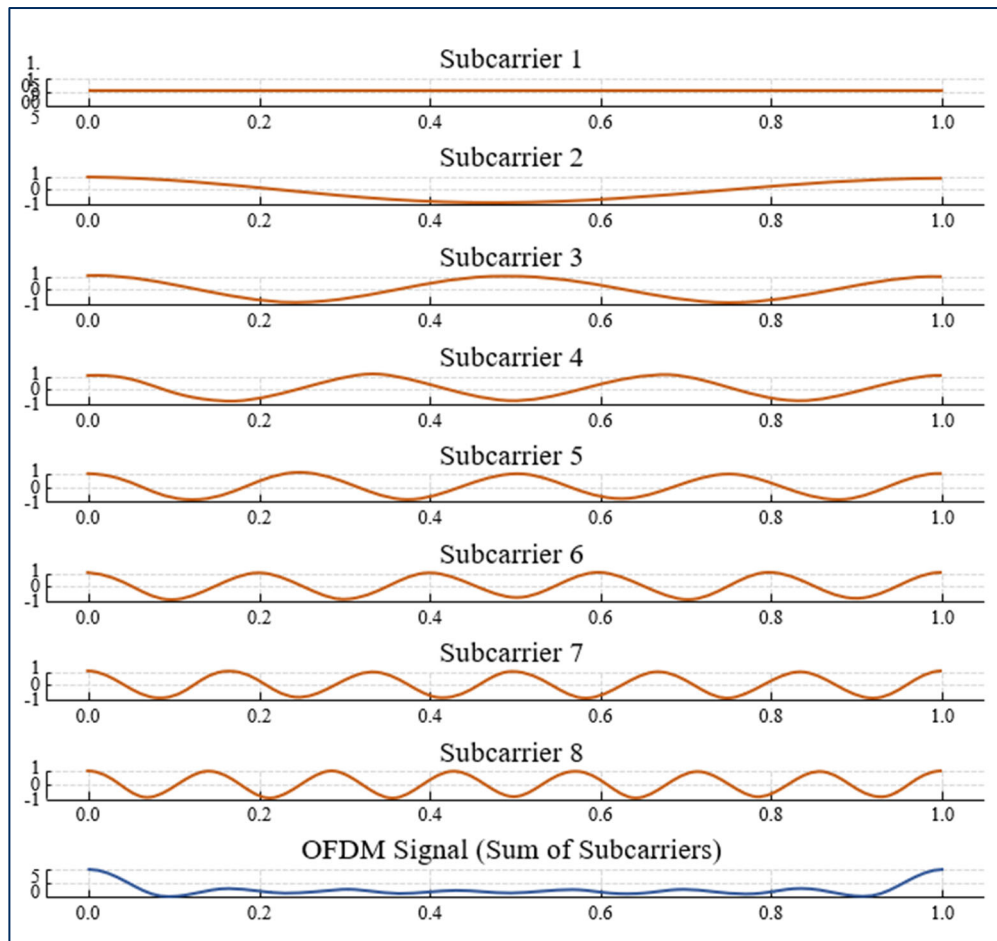


EX1014 at 47.

48. Using a subcarrier allocation, the QAM symbols are allocated to different subcarriers. Each QAM symbol represents the amplitude and phase of the 6-bit input data. Then, these symbols are allocated to different subcarriers. The modulated symbols are placed into an array, typically of size N, where N is the number of subcarriers. This array forms the input to the IFFT.

49. Thus, an OFDM symbol is a time-domain signal generated by combining multiple modulated subcarriers, each carrying an OFDM symbol. The

use of orthogonality, cyclic prefix, and IFFT ensures that the OFDM symbol is robust to channel impairments like multipath fading and inter-symbol interference, making OFDM a highly efficient and reliable modulation scheme for modern communication. The IFFT is used at the transmitter to convert the frequency domain representation of the data on each subcarrier into a time-domain OFDM symbol. Each subcarrier is modulated with a portion of the data, and the combined signal is transmitted. At the receiver, the signal is demodulated to retrieve the individual subcarrier components, allowing for efficient and robust data transmission even in multipath environment. A figure of OFDM subcarriers is shown below in this generated image:



The first eight subplots above show individual subcarrier signals where the x-axis is time and the y-axis is amplitude or the signal strength at time t . Each subcarrier is a sinusoidal wave with a unique frequency. The last subplot shows the OFDM signal, which is the sum of all the subcarriers.

50. There are several advantages that OFDM system has over the single carrier broadband approach. For example, OFDM is highly resistant to multipath fading and inter-symbol interference (ISI), common issues in wireless communications. ISI occurs when one symbol interferes with adjacent symbols resulting in distortion and loss of data integrity and reliability. By spreading the

data across many sub-carriers, the impact of frequency-selective fading is minimized. Also, in OFDM, equalization can be performed on each sub-carrier independently, simplifying the process compared to single-carrier systems. Further, the orthogonality of sub-carriers allows for tight spacing, leading to high spectral efficiency and utilization. This makes OFDM an attractive choice for modern communication systems that require high data rates, as discussed below.

51. Channel fading refers to the variations in the strength or quality of a wireless signal as it travels through the communication medium (such as air). These variations are caused by obstacles, reflections, and other environmental factors that can disrupt or alter the signal. Flat fading is a type of channel fading where all the frequency components of the transmitted signal experience the same amount of fading.

52. OFDM is widely used in various communication standards. Wi-Fi standards IEEE 802.11a/g/n/ac/ax use OFDM to provide high-speed wireless networking, Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB) systems use OFDM to deliver audio and video content, and LTE (4G) and NR (5G) technologies employ OFDM to support high data rate mobile communications via cellular networks.

53. Due to the use in the above industries, OFDM uses various techniques to improve signal reliability and quality in wireless communication systems. Those

techniques include spatial diversity and frequency diversity (the subject matter of the '439 Patent).

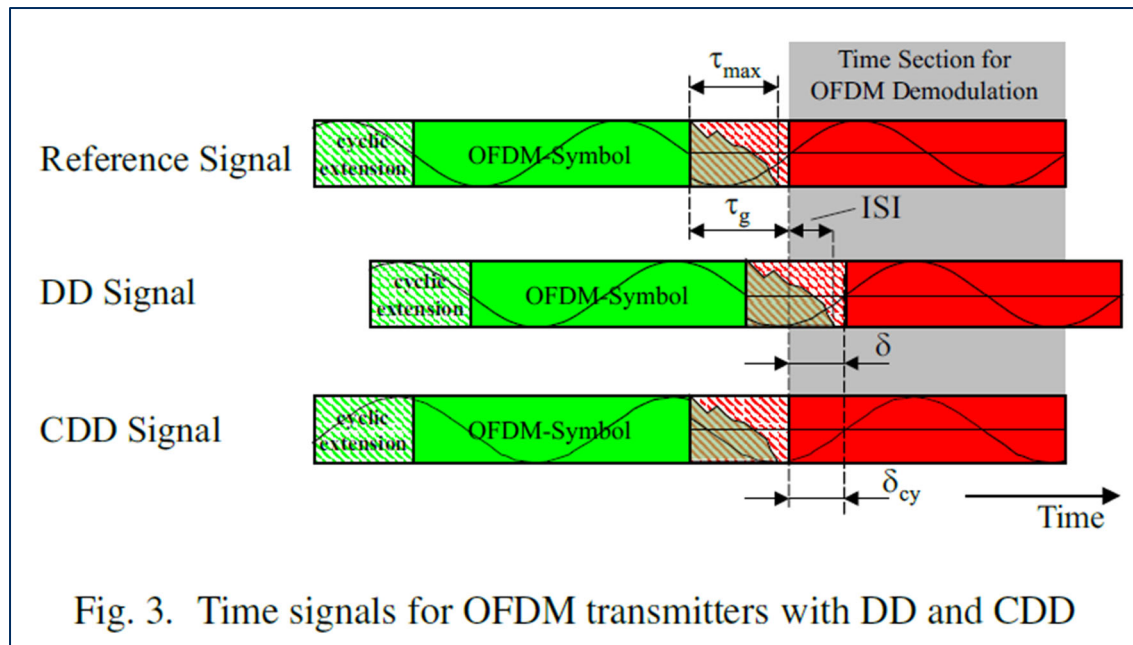
54. Spatial Diversity relates to the use of multiple antennas at the transmitter, receiver, or both, to transmit and receive signals over multiple distinct spatial paths. This technique exploits the multipath propagation of radio waves, where signals take different paths to reach the receiver due to reflections, scattering, and diffraction. By using multiple antennas spaced apart, the likelihood that all paths will experience deep fades at the same time is reduced, thus increasing the reliability and range of the communication system.

55. Linear Delay Diversity (LDD) is a form of spatial diversity used for OFDM to improve the robustness of the communication system against fading and multipath interference. The main idea behind LDD, for multi antenna transmitter system, is to transmit multiple delayed copies of the OFDM symbol from different antennas. This introduces diversity into the transmission, which can enhance the performance in multipath environments. The receiver captures a combination of these delayed signals where the signals experience different fading conditions and multipath effects. This approach helps in combating the effects of deep fades and ensures that even if some versions of the signal are severely attenuated, others might still be received clearly. The delays can help in spreading out the multipath components, reducing the likelihood of significant Inter-Symbol Interference (ISI).

56. Frequency Diversity, on the other hand, takes advantage of the fact that the fading characteristics of a wireless channel vary with frequency. In OFDM, the entire bandwidth is divided into many narrowband subcarriers, each carrying a portion of the data. Since these subcarriers are orthogonal to each other, they experience independent fading. Coding across these subcarriers allows the system to combat frequency-selective fading, as the impact of deep fades on some subcarriers can be mitigated by the good condition of others. This results in improved performance over channels with frequency-selective fading.

57. Cyclic Delay Diversity (CDD) is a form of frequency diversity to enhance performance in multipath fading environments. It works by introducing a cyclic shift to the OFDM data symbols transmitted on different antennas, effectively transforming spatial diversity into frequency diversity. Cyclic Delay Diversity works as follows:

58. The figure below shows the position of OFDM symbols for a SISO for DD and CDD:



EX1006 at 2. One the main advantages of CDD over DD is that no additional delay is introduced, and the CDD OFDM symbol is transmitted at the same time as the original OFDM symbol.

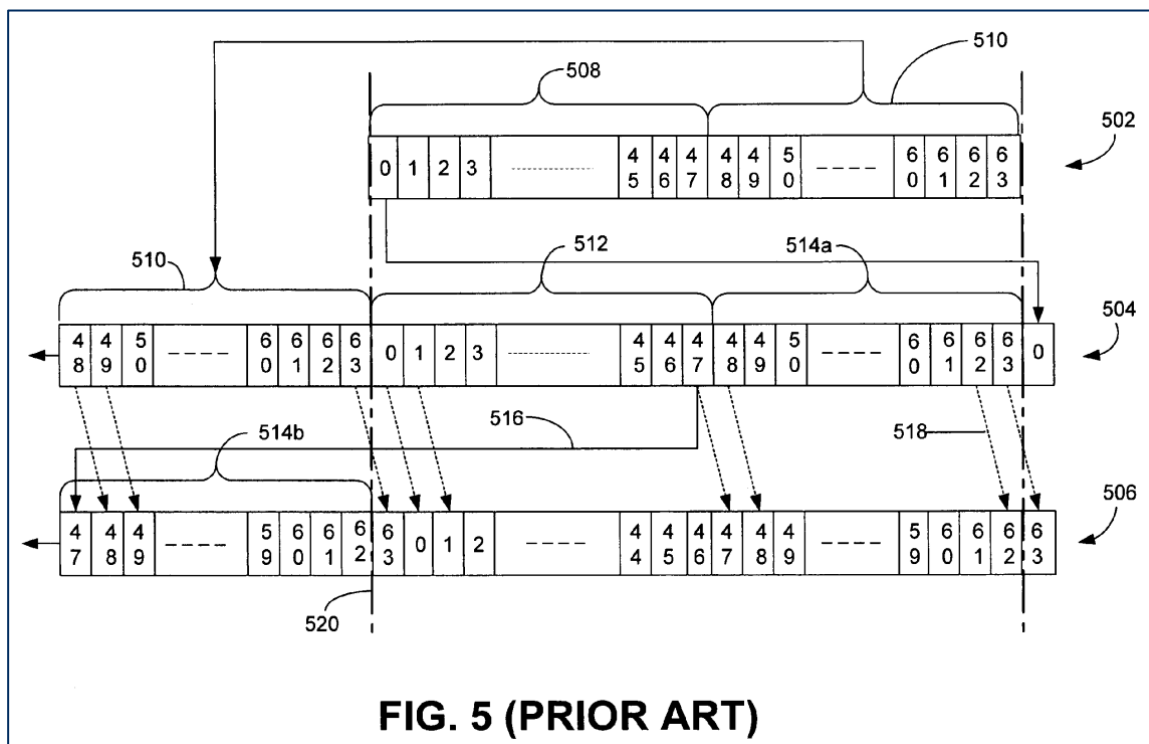
59. The Channel Impulse Response (CIR) is a concept in telecommunication and signal processing to describe the behavior of a communication channel at the receiver. It analyzes the response of the channel to a brief input signal (an impulse) and shows channel characteristics such as attenuation, delay, distortions. In theory, signal impulses (transmissions) that are created at the same time should arrive at the receiver together if there is no multipath or objects in between the transmitter and receiver. However, due to multipath and objects reflecting the signal, impulse responses are detected at the receivers in turn, depending on which signal took the quickest path.

B. Purported Invention

60. In my opinion, the '439 Patent is directed to a minor modification of well-known, standardized wireless communication systems using OFDM as described above. *See* EX1001 at 1:18-23 (“Wireless communication systems are widely deployed to provide various types of communication, such as voice, data, and so on. These systems may be based on code division multiple access (CDMA), time division multiple access (TDMA), orthogonal frequency division multiplex (OFDM), or some other multiplexing techniques.”).

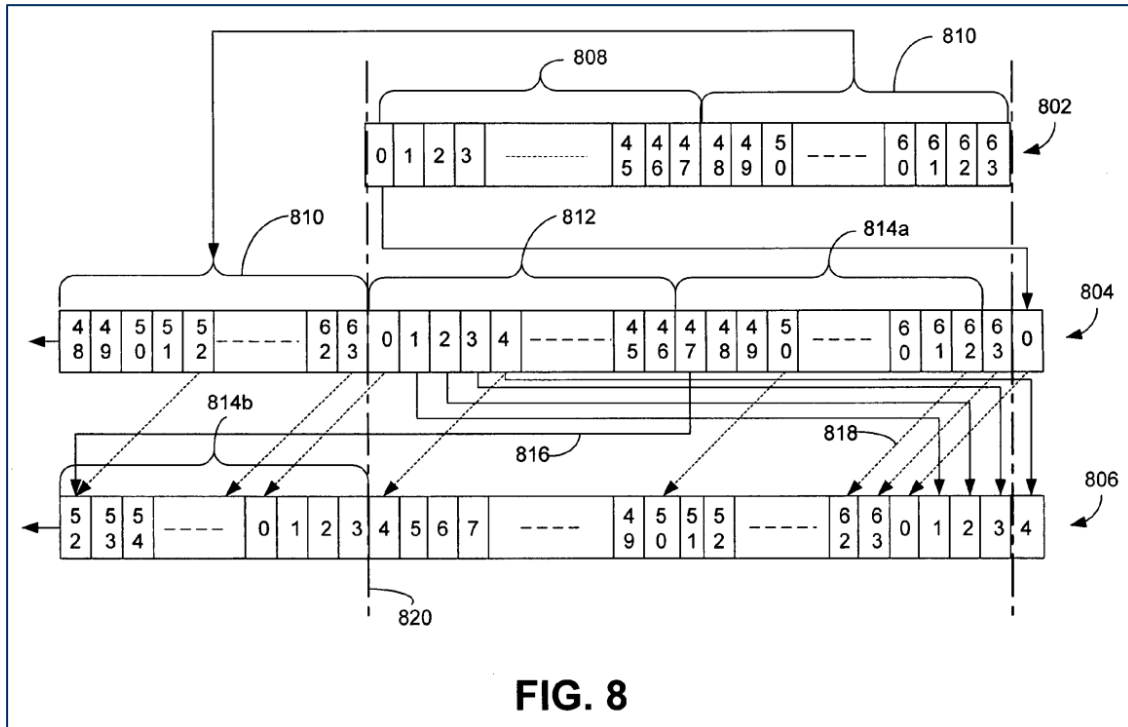
61. I discussed above in the Background section that a POSITA would have been aware of “cyclic delay diversity,” as the '439 Patent discusses. The '439 Patent illustrated in Figure 5 points to a system implementing cyclic delay diversity as prior art. In the first row 502 of Figure 5 of the '439 Patent, 64 data samples (numbered 0 through 63) that comprise the useful data portion of a larger packet are shown. *See id.* at 3:58-61 (“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.”). A POSITA would understand that these samples are amplitude and phase of the selected subcarriers. In the second row 504, the 16 data samples comprising the guard interval (which is an additive technique used in conjunction with cyclic delay diversity) are shown as being prepended to the front of the packet (element 510), where the samples from the guard interval are copied

from the last 16 data samples at the end of the useful data portion (also element 510). *See id.* at 3:61-65 (“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. This next set of samples comprises 64 samples of symbol data 512 and 16 samples corresponding to the guard interval 514a.”). In the third row 506, a cyclic delay, or shift, is shown, wherein the symbols at the front of the useful data portion are shifted one sample backwards. *See id.* at 3:65-4:4 (“The third tier 506 represents a 1-sample cyclic delay shift. As shown, a delay of 1 sample results 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. at Fig. 5.

62. The '439 Patent's claimed invention also shifts samples as shown in Figure 5, but in the opposite direction. In contrast with admitted prior art Figure 5 where the samples shifted to the right of the figure (opposite the direction of transmission, as indicated by the horizontal arrows on the far left), the '439 Patent's purported invention as shown in Figure 8 shifts samples to the left of the figure (in the direction of transmission)³:



³ Figure 5 depicts a one-sample shift whereas Figure 8 depicts a four-sample shift, but the magnitude of the shifts is arbitrary and not claimed in the purported invention.

Id. at Fig. 8.

63. The hardware required to shift samples, the pre-processing components and algorithms that creates the samples to shift, and the post-processing that transmits the shifted samples and packets were all well-known before May 20, 2004. For example, the notion of shifting samples using CDD has been known and has been part of the IEEE 802.11 wireless standard since at least 1999. The '439 Patent purports to advance the start of the art by shifting the samples in the forward direction (a so-called “cyclic advance”) as opposed to how they were shifted by the admitted prior art (a “cyclic delay”).

64. The '439 Patent confirms what a POSITA would have known, that “[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.” *Id.* at 8:5–8. And that “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.” *Id.* 8:13–18. In other words, the '439 Patent’s claimed invention of a cyclic advance is admittedly identical to a correspondingly large (or small) cyclic delay. *See id.* A POSITA would have recognized that, and therefore would not have considered the purported invention innovative. The shift of sample data

moves the allocated subcarrier from the original designation to the new one after the shift. Therefore, the amplitude and phase that was obtained from the QAM 64 will be applied to a new subcarrier. Without loss of generality, the results of the analog waveform which is the sum of all the subcarriers will be the same.

C. Prosecution History

65. I have reviewed the prosecution history of the '439 Patent. *See* EX1002. To the extent my opinion is impacted by that history, I have addressed it below in my detailed analysis of each Ground.

VII. SUMMARY OF THE PRIOR ART

A. Larsson

66. Larsson is a U.S. patent titled “Cyclic Delay Diversity for Mitigating Intersymbol Interference in OFDM Systems.” *See* EX1005 at Cover. Larsson discusses OFDM wireless communication systems that “employ transmission diversity when transmitting symbols which have a guard interval, [and] the multiple versions of the transmitted symbols have the samples of the transmitted symbols shifted relative to each version transmitted.” *Id.*, at Abstract. Larsson expressly teaches cyclical shifting in either the direction of delay or advance, at the POSITA’s election. *See id.* at 9:41-47 (“Although exemplary embodiments of the present invention are described above as implementing cyclic delay by shifting samples from the end of an OFDM symbol into the beginning of the OFDM symbol, the present invention can also be implemented so that the samples from

the beginning of the OFDM symbol are shifted into the end of the OFDM symbol.”).

67. In my opinion, Larsson is analogous prior art. Larsson is analogous prior art because it is in the same field as the ’439 Patent⁴, and it is also analogous prior art because it is directed to the same problem as the ’439 Patent in using diversity techniques to reduce error rates in OFDM communication systems. *See id.* at, e.g., 1:6–10 (“The present invention relates to transmission diversity. More particularly, the present invention relates to mitigating intersymbol interference in systems which employ delay transmit diversity.”).

B. Bauch

68. Bauch is a WIPO International Publication titled “Apparatus and Method for Cyclic Delay Diversity.” *See* EX1007 at Cover. Bauch discusses an OFDM wireless communication system that is capable of “cyclical[ly] shifting a multi-user signal” where the “cyclical shift allows a full exploitation of spatial diversity.” *Id.* at Abstract (“An apparatus for generating a transmit signal from a multi-user signal comprises a cyclic shift element for cyclical shifting a multi-user

⁴ *See* EX1001 at 1:14-16 (“The present disclosure is generally related to communication systems, and, more particularly, is related to wireless communication systems and methods.”).

signal to obtain the transmit signal, wherein the cyclic shift element is operative for cyclical shifting a set of values comprised by the multi-user signal by a predetermined number of values, wherein the predetermined number of values is determined by the number of user signals. The inventive user dependent cyclical shift allows a full exploitation of spatial diversity.”). Like Larsson, Bauch expressly teaches cyclical shifts in either direction, at the POSITA’s election. *See id.* at 22:30-23:1 (“As depicted in Fig. 4, the means 522 for introducing the delay are respectively operative to perform a left-shift. Alternatively, the means 522 may be operative to perform a right-shift.”).

69. In my opinion, Bauch is analogous prior art. Bauch is prior art because it is in the same field as the ’439 Patent, and it is also prior art because Bauch is directed to the same problem as the ’439 Patent in using diversity techniques to reduce error rates in OFDM communication systems. *See id.* at, *e.g.*, 3:10-11 (“In wireless communications, transmit diversity techniques are used in order to mitigate the detrimental effects of fading.”).

C. Kaiser

70. Kaiser is a conference paper titled “Low Complex Standard Conformable Antenna Diversity Techniques for OFDM Systems and its Application to the DVB-T System.” *See* EX1006 at 1. Kaiser is from the 2002 International ITG Conference on Source and Channel Coding and was publicly

available by February 2002, and in no event later than March 31, 2003. EX1015 at 1-11. Kaiser investigates “different antenna diversity concepts, which can be easily applied to orthogonal frequency division multiplexing (OFDM) systems.” *See* EX1006 at Abstract. These “diversity concepts” include, in particular, cyclic delay diversity that tracks with Figure 5 of the ’439 Patent. *See id.* at 1 (“In this paper we will investigate standard conformable antenna diversity techniques, which are well suited for the extension of existing standardized OFDM systems. Section II introduces diversity techniques for both transmitter and receiver. At this, the main idea is to increase the frequency selectivity of the resulting channel transfer function by specific cyclic delays at the transmitter and/or receiver antennas.”). In my opinion, as discussed further below, Kaiser teaches all of the background structures and processes underlying cyclical delay.

71. In my opinion, Kaiser is analogous prior art. Kaiser is analogous prior art because it is in the same field as the ’439 Patent, and Kaiser is also analogous prior art because it is directed to the same problem as the ’439 Patent in using diversity techniques to reduce error rates in OFDM communication systems. *See id.* (“Because of the poor error performance of OFDM in multipath environments, it is necessary for wireless communications systems to use techniques like interleaving and channel coding in addition to OFDM. ... Section II introduces diversity techniques for both transmitter and receiver. At this, the main idea is to

increase the frequency selectivity of the resulting channel transfer function by specific cyclic delays at the transmitter and/or receiver antennas.”).

D. IEEE

72. IEEE is a supplement to IEEE Standard 802.11a-1999. *See* EX1008 at Cover. IEEE adds Clause 17 to the base standard, *id.* at 15, which “specifies the PHY entity for an orthogonal frequency division multiplexing (OFDM) system and the additions that have to be made to the base standard to accommodate the OFDM PHY.” *Id.* IEEE teaches the underlying standards by which OFDM systems were generally expected to have complied with, including when applying cyclical shifting techniques in order to reduce interference during transmission. *See id.* at 22 (“Shifting the time by T_{GUARD} creates the ‘circular prefix’ used in OFDM to avoid ISI from the previous frame. Three kinds of T_{GUARD} are defined: for the short training sequence ($= 0 \mu s$), for the long training sequence ($= T_{GI2}$), and for data OFDM symbols ($= T_{GI}$). (Refer to Table 79”).), Table 79 (“Timing-related parameters”), Figure 108 (“Illustration of OFDM frame with cyclic extension and windowing for (a) single reception or (b) two receptions of the FFT period”).

73. In my opinion, IEEE is analogous prior art. IEEE is analogous prior art because it is in the same field as the ’439 Patent, and IEEE is also analogous art because it is directed in part to the same problem as the ’439 Patent in using diversity techniques to reduce error rate in OFDM communication systems. *Id.* at,

e.g., 15 (“This clause specifies the PHY entity for an orthogonal frequency division multiplexing (OFDM) system and the additions that have to be made to the base standard to accommodate the OFDM PHY.”); *id.* at 19 (“The encoding process is composed of many detailed steps, which are described fully in later subclauses, as noted below.”); *id.* at Figure 110 (“OFDM training structure”).

VIII. GROUNDS

A. Ground I: Claims 1-21 Are Rendered Obvious Over Larsson In View Of IEEE

1. Claim 1

74. In my opinion, Larsson in view of IEEE renders obvious Claim 1.

a. Limitation 1[preamble]: A method for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:

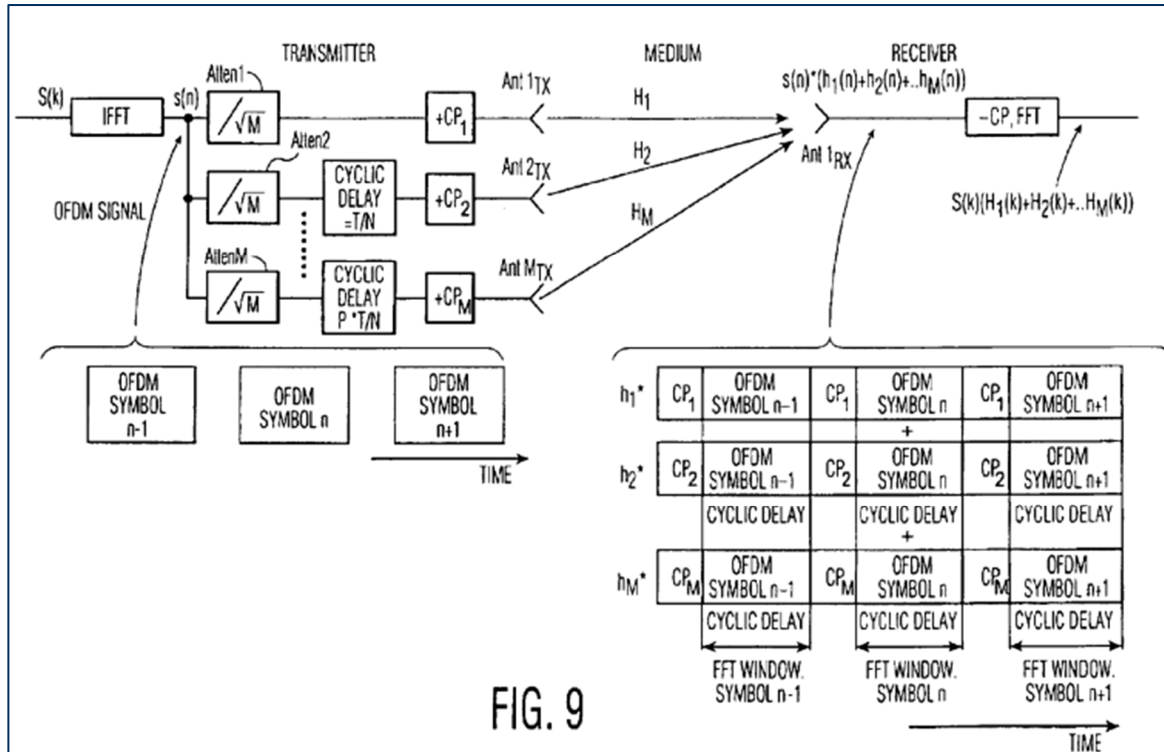
75. In my opinion, Larsson teaches the preamble. Larsson’s Figure 9, for example, shows multiple OFDM signals being transmitted. *See* EX1005 at Fig. 9. Larsson further teaches the method by which those OFDM signals are generated and transmitted. *See, e.g., id.* at 6:58-60 (“FIG. 9 illustrates a transmitter and receiver which operate according to a OFDM transmission scheme employing transmitter diversity.”).

b. Limitation 1[a][i]: generating a first OFDM packet for transmission

76. In my opinion, Larsson teaches this limitation. The OFDM packet represents a sequence of fields that contribute to the transmission of information.

The packet is structured, using fields, to efficiently transmit OFDM symbols for wireless systems. These fields include short training symbols, used for signal detection, AGC, diversity selection functionality, synchronization, long training symbol, header, guard interval, and finally OFDM symbols. These fields include information about modulation scheme, packet length, and other related information. It also includes a data field which includes the actual data packed in one or more OFDM symbols. A POSITA would have known this by using the applicable IEEE standards, and a POSITA would have been expected to comply with those standards. Most, if not all, OFDM systems would have transmitted data in packet form.

77. Larsson's Figure 9, for example, depicts OFDM packets (*e.g.*, OFDM SYMBOL n) that are illustrated as leaving from the TRANSMITTER through a MEDIUM to the RECEIVER, such that the first OFDM packet is for transmission:

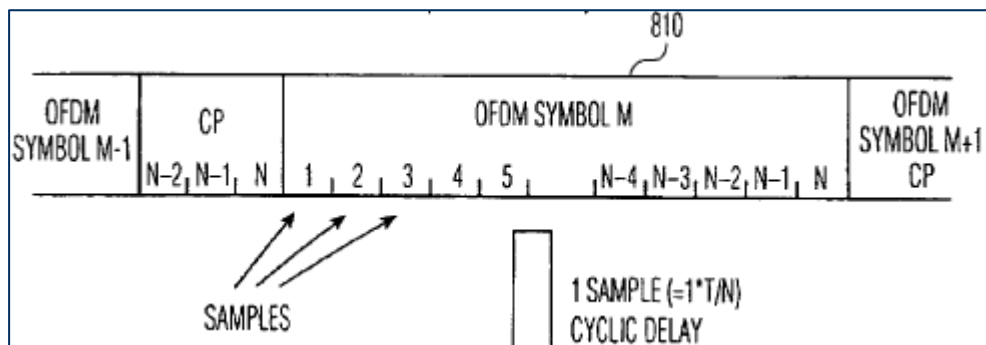


See id. at Fig. 9.

c. Limitation 1[a][ii]: including a guard interval portion and a symbol data portion each comprised of a plurality of samples

78. In my opinion, Larsson teaches this limitation. A guard interval's samples between consecutive OFDM symbols help reduce interference that could be the result of multipath fading and other sources of signal interference. A POSITA would use a guard interval because it was standard at the time of the '439 Patent. The symbol data portion, as described in the background above, contains the samples that make up the symbol data. A POSITA would have known this and used this arrangement due to the IEEE wireless standards at the time.

79. As shown, for example, in the below cropped portion of Larsson's Figure 8, the first OFDM packet includes a guard interval (corresponding to the "CP" in the figure, where "CP" stands for cyclic prefix and which Larsson teaches is a guard interval) and a symbol data portion (corresponding to samples 1 through N in the OFDM SYMBOL M portion), that are each comprised of a plurality of samples:



See id. at Fig. 8 (cropped), 1:29-32 ("To maintain the condition of perfect orthogonality between subcarriers in a multipath environment, a guard interval, or cyclic prefix (CP), is inserted before the transmission of each symbol."); *see also id.* at, e.g., Abstract ("A last number of samples of the transmitted symbol are copied and placed in the guard interval which precedes the symbol. The guard interval and the symbol are transmitted to a receiver."). As Larsson teaches and a POSITA would recognize, the OFDM SYMBOL M portion corresponds to the symbol data portion because it is not the guard interval / cyclic prefix and is instead useful data signal. *See id.* at, e.g., 5:11-13 ("Accordingly, since the longer

the cyclic prefix the less usable bandwidth is available for transmission of data, cyclic prefixes are typically kept as short as possible.”).

d. Limitation 1[b][i]: cyclically advancing the first OFDM packet by shifting the samples in a first direction

80. In my opinion, Larsson teaches this limitation. The shift of sample data moves the allocated subcarrier from the original designation to the new destination after the shift. This shift would move the sample data to an adjacent position by one or more steps. Therefore, the amplitude and phase that was obtained from the QAM 64 will be applied to a new subcarrier (a new sample location). The results of the analog waveform which is the sum of all the subcarriers will be the same under the applicable assumptions. A POSITA would understand this due to the standard application of shifts to OFDM frames as discussed in the IEEE standards at the time of the claimed invention.

81. While Larsson primarily discusses cyclic delay of the first OFDM packet by shifting the samples in a direction (in Figure 8, for example), Larsson teaches cyclical shifting in *either* direction:

Although exemplary embodiments of the present invention are described above as implementing cyclic delay by shifting samples from the end of an OFDM symbol into the beginning of the OFDM symbol, *the present invention can also be implemented so that the samples from the beginning of the OFDM symbol are shifted into the end of the OFDM symbol.*

See id. at 9:41–47 (emphasis added). Larsson refers to a shift in the first direction

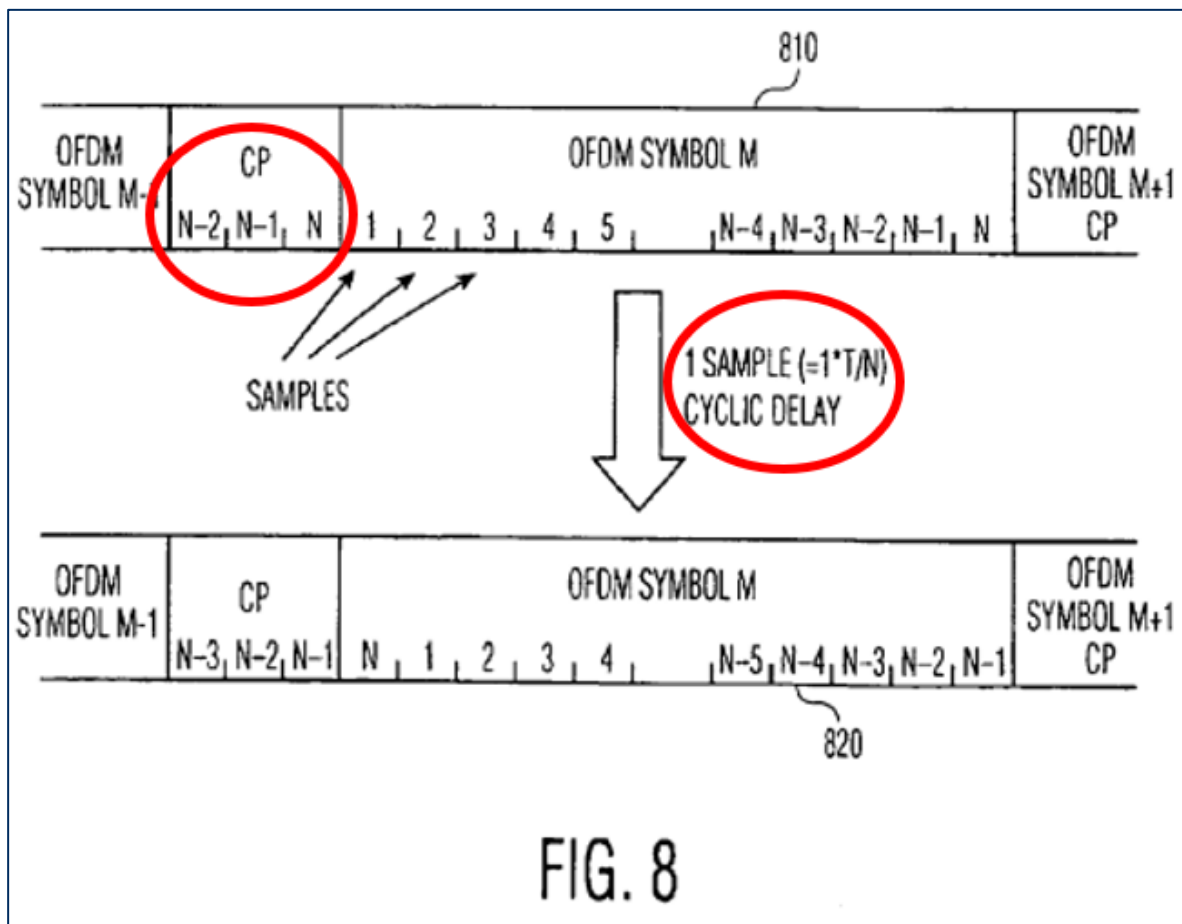
described above as a cyclic delay⁵, so a POSITA would recognize that a shift in the opposite direction is a cyclical advance. A POSITA would understand that a cyclic delay is a shift in the opposite direction as the signal transmission direction (which is what makes it a delay), so a cyclic advance is necessarily a shift in the direction of signal transmission because a cyclic advance is a shift in the opposite direction as a cyclic delay.

e. Limitation 1[b][ii]: an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM packet for transmission

82. In my opinion, Larsson teaches this limitation. In accordance with the IEEE standard, 16 samples for the guard interval would have been obvious. So, a shift less than that sample duration would be a shift of less than 16 samples. Larsson's Figure 8, for example, "illustrates two OFDM symbols wherein a cyclic" shift is implemented relative to the first OFDM packet to generate a shifted version of the first OFDM packet for transmission. *See id.* at 6:39–49 ("FIG. 8 illustrates two OFDM symbols wherein a cyclic delay is implemented between the two

⁵ *See* EX1005 at 6:45–48 ("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 n samples of the OFDM symbol.").

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 n samples of the OFDM symbol.”). Larsson teaches that this cyclic shift is just “1 SAMPLE” long, while Larsson’s CP (cyclic prefix / guard interval) is illustrated as being three samples long:



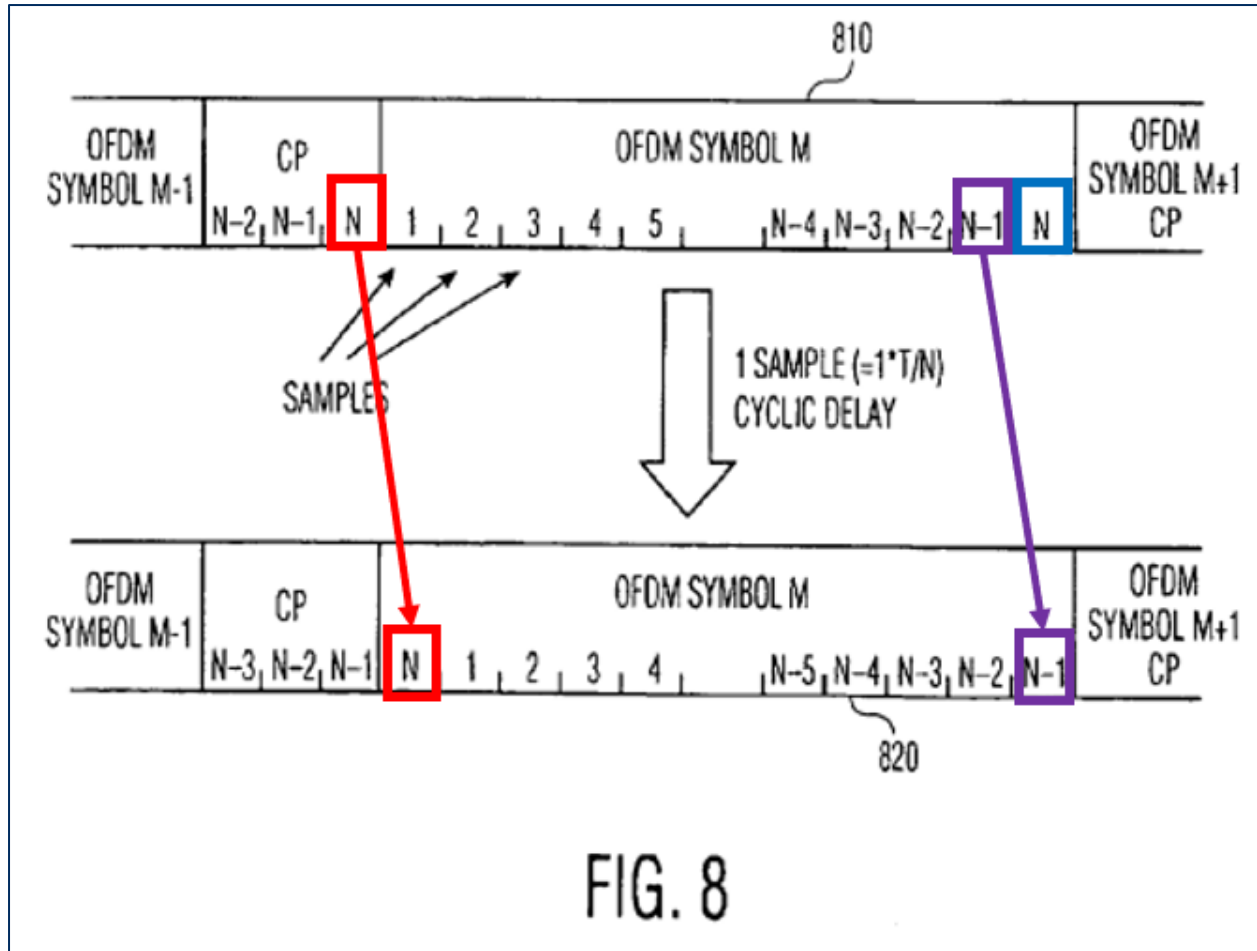
See id. at Fig. 8 (annotated). The 1-sample cyclic shift taught by Larsson is therefore less than the 3-sample duration illustrated in the guard interval and less than the 16 samples contemplated by the standard. This shift generates the shifted version of the first OFDM packet (as seen in the bottom half of Figure 8, for example), and the shifted version (as well as the unshifted version) for transmission because Figure 8 represents “two OFDM symbols ... being transmitted.” *See id.* at 6:39–41 (“FIG. 8 illustrates two OFDM symbols wherein a cyclic delay is implemented between the two symbols being transmitted in a transmission diversity scheme.”).

- f. Limitation 1[b][iii]: 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**

83. In my opinion, Larsson teaches this limitation. The sampled data that is packed in a symbol can be moved from their current position by shifting to the right or left. So if original sampled data was (for example, in very simplified terms) “12345,” if you shift to the right by one position, then the new sequence of sampled data will be “51234,” and if this is done in the opposite direction, the resulting pattern will be “23451.” This shift of one sample would shift the guard interval by the same amount, because guard intervals could have obviously been

created by copying the last n-number (e.g., 16) of samples of an OFDM frame. Using the example above, if the guard interval was 2 samples, then a one-sample advance, e.g., a shift from “12345,” with original guard interval of “45,” to “23451” would create a new guard interval for the shifted-version of “51,” where one sample (1) is new (shifted into the guard interval), and one sample (4) was removed from the guard interval. A one-sample delay would result in a sample sequence of “51234” and a guard interval of “34.” A POSITA would have known that the shifting could have been implemented in this way.

84. As shown in Larsson’s Figure 8 which illustrates delay, a non-zero number of samples from the guard interval are shifted into the symbol data portion, which shifts the same number of samples towards the end, which shifts the same number of samples out:



See id. at Fig. 8 (annotated). In cyclic advance where the shift is in the opposite direction (which is also taught but not illustrated in Larsson), the opposite would occur. As a POSITA would recognize: A non-zero number of samples from the symbol data portion of the first OFDM packet would be shifted into the guard interval, and the same number of samples in the guard interval portion would be shifted out of the guard interval. In the case of cyclic advance, the CP will have the lower samples (1), as opposed to the upper samples for the cyclic delay (N-3).

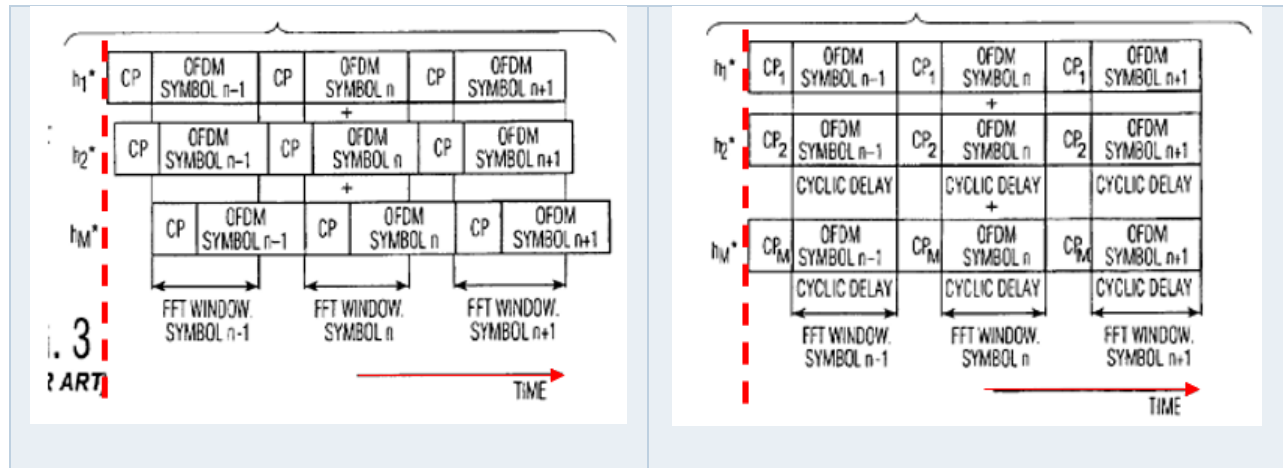
- g. Limitation 1[c]: substantially simultaneously transmitting the first OFDM packet and the shifted version of the OFDM packet.**

85. In my opinion, Larsson teaches, or at least renders obvious, this limitation. A POSITA would obviously have looked to IEEE standard-compliant OFDM transmission systems and understand that they transmitted cyclically shifted frames “substantially simultaneously” as the unshifted frame, because otherwise they would have been using a liner delay system, which is a different approach to transmit diversity as explained in detail in the Background section above.

86. Larsson teaches that, after generating the shifted version of the OFDM packet, the “transmitter then transmits symbols from the various antennas,” and does not teach any delay nor a different time or trigger for transmitting the symbols, such that a POSITA would understand this teaches, or at least renders obvious, substantially simultaneous (if not actually simultaneous) transmission. *See id.* at 8:5-6. This suggestion is confirmed by comparing, for example, Larsson’s Figure 3 (which is not relied upon for the teachings mapped to the claim limitations above), which shows a lag between received packets when a time delay is applied, relative to Larsson’s Figure 9 (which is relied upon in this Petition), which shows no time lag at the receiver between the original and shifted OFDM packets, further teaching, or at least rendering obvious, that the packets were transmitted at least substantially at the same time:

Figure 3 – Time Delay

Figure 9 – No Time Delay



See *id.* at Figs. 3 & 9 (annotated, cropped).

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

87. In my opinion, Larsson in view of IEEE renders this claim obvious.

The IEEE standard mandates that the guard interval is 800 nanoseconds:

Parameter	Value
N_{SD} : Number of data subcarriers	48
N_{SP} : Number of pilot subcarriers	4
N_{ST} : Number of subcarriers, total	52 ($N_{SD} + N_{SP}$)
ΔF : Subcarrier frequency spacing	0.3125 MHz (=20 MHz/64)
T_{FFT} : IFFT/FFT period	3.2 μ s ($1/\Delta F$)
$T_{PREAMBLE}$: PLCP preamble duration	16 μ s ($T_{SHORT} + T_{LONG}$)
T_{SIGNAL} : Duration of the SIGNAL BPSK-OFDM symbol	4.0 μ s ($T_{GI} + T_{FFT}$)
T_{GI} : GI duration	0.8 μ s ($T_{FFT}/4$)
T_{GI2} : Training symbol GI duration	1.6 μ s ($T_{FFT}/2$)
T_{SYM} : Symbol interval	4 μ s ($T_{GI} + T_{FFT}$)
T_{SHORT} : Short training sequence duration	8 μ s ($10 \times T_{FFT}/4$)
T_{LONG} : Long training sequence duration	8 μ s ($T_{GI2} + 2 \times T_{FFT}$)

See EX1008 at 21 (Table 79: “T_{GI}: GI duration” set at “0.8 μs” which is 800 nanoseconds), 36 (Table 86: “Guard Interval” again limited to “0.8 μs”). As discussed above in the context of Claim 1[b][ii], Larsson expressly teaches that the cyclical shift of the OFDM packet should be for an amount less than a sample duration of the guard interval. Thus, in order to comply with the IEEE standard, Larsson’s system would obviously have cyclically advanced the OFDM packet for a duration of less than 800 nanoseconds, which is the duration of the guard interval portion of the IEEE standard.

88. It would have been obvious to a POSITA to apply the IEEE standard to the system of Larsson. As a POSITA would have known, systems and methods that did not comply with the IEEE 802.11 standard were significantly less useful and valuable because they would presumptively not be compatible with other systems. In other words, non-standards-compliant systems were markedly less useful because customers who purchased non-standards-compliant equipment would be locked into a single supplier, which would create dependency risk for the customer (*e.g.*, risk in supply chain disruptions, risk of price hikes, *etc.*) and potentially preclude communications with other networks. As a POSITA would have been aware, this is a very undesirable situation for customers, which is why standards are developed in the first place. Thus, it would have been obvious for Larsson to incorporate the 802.11 standard taught by IEEE.

89. A POSITA also would have had a reasonable expectation of success in doing so because complying with the IEEE standard would have been common and expected. It would have been expected of a POSITA to become familiar with the standard as part of their work experience because the standard underpinned the development of most commercial equipment. Moreover, Larsson does not teach that its system is not compatible with the IEEE standard. Larsson is specifically built on the standard in view of its admitted prior art teachings in Figures 1-7 that align with the OFDM standard set forth in IEEE. *See* EX1005 at Figs. 1-7.

3. Claim 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.

90. In my opinion, Larsson in view of IEEE renders this claim obvious. A shift less than one half a guard interval duration means a shift of less than 8-samples in the standard 16-sample guard interval system. In a 3-sample guard interval system, the shift would be less than 1.5 samples (1 sample realistically).

91. Larsson teaches shifting by just one sample, while even the illustrated guard interval duration in Larsson's Figure 8 is three samples long. *See id.* at Fig. 8. One half of three (one half of the illustrated guard interval duration) is 1.5 samples, so Larsson's teaching of shifting by only one sample is a cyclical shift of the first OFDM packet for a duration of less than one half of the sample duration of

the guard interval. And as discussed above in Claim 1[b][i], this shift would be a cyclical advance in the asserted embodiment.

- 4. Claim 4: The method of claim 1, further comprising a legacy receiver, and wherein the cyclical advancements of the shifted version of the OFDM packet cause the legacy receiver to produce a plurality of impulse responses in an acquisition process, and wherein each of the first OFDM packet and the shifted version of the OFDM packet corresponds to one of the plurality of impulse responses.**

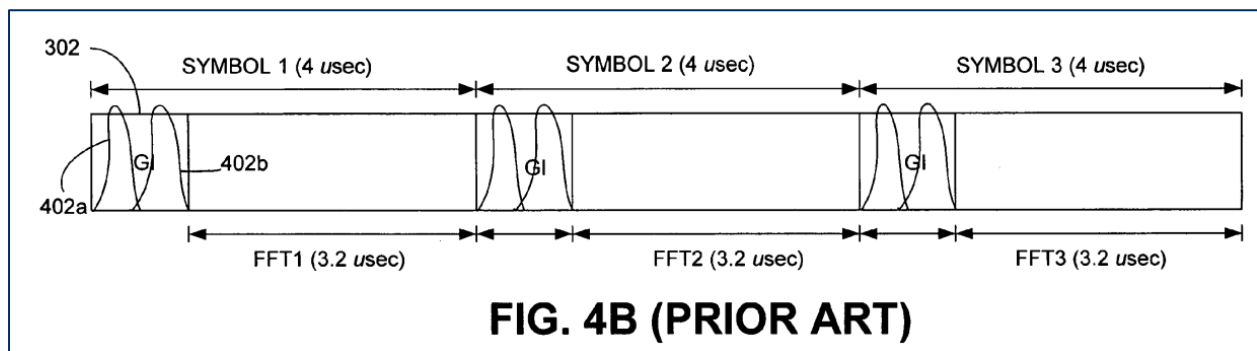
92. In my opinion, Larsson in view of IEEE renders this limitation obvious. Legacy receivers are simply receivers that do not contain multiple antennas. These receivers relate to single-in-single-out (SISO) technology. This claim is about Long Training Symbol (LTS) and the impulse responses they cause at the receiver. Both the shifted and unshifted OFDM symbols contain LTS's that are used to synchronize the receiver with the incoming signals, help with channel estimation, and aligning receiver with the transmitter for a particular channel. Impulse response characterizes how the channel modifies a transmitted signal. This is covered in the IEEE standard, and both symbols would cause an impulse response. Thus, a POSITA would have this knowledge by using and applying the applicable wireless standards at the time of the claimed invention.

93. As a POSITA would have been aware and the '439 Patent admits, "there is a need to consider legacy receivers (e.g., single-input, single output (SISO), OFDM receivers)," because not all network participants upgrade their

equipment at the same time; accordingly, the POSITA would have obviously accounted for participants in the wireless network using legacy receivers, such as SISO receivers. *See* EX1001 at 1:27-32 (“However, 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.”). The Applicant admitted such a system was prior art in (for example) Figure 1, and therefore a POSITA would have found it obvious and expected that a transmitter system such as Larsson in view of IEEE would be communicating with a legacy SISO receiver. *See id.* at Fig. 1.

94. As a POSITA would have known and as the '439 Patent admits was prior art, when there is time delay between two transmitted packets corresponding to a single signal, the delay causes the SISO receiver to produce a plurality (in this example, two) impulse responses as part of its acquisition process, where the unshifted packet and delayed packet each correspond to one of the impulse responses. *See id.* at 3:26-36 (“Legacy receivers may perform a channel impulse response (CIR) estimate using the LTS. The LTS is designed to elicit an impulse response when correlated with multi-path, thus resulting in a multi-path profile. In the absence of a time delay (or in the absence of multi-path), the response to a received packet is an impulsive correlation (which would be shown as a single

impulse 402a in the guard interval 302), enabling proper timing or synchronization of the received signal and proper placement of the FFT. With the time delay (t_D) (or with multi-path), two impulsive responses (402a and 402b) are detected.”). That is what is pictured in Figure 4B of the '439 Patent, which is admitted prior art, where each of bumps 402a and 402b correspond to one of the impulse responses:



See id. at Fig. 4B. But as a POSITA also would have understood, these two impulse responses are not produced by the legacy SISO receiver only in response to a time delay, rather they also would have been produced in response to a cyclic delay, given the substantially overlapping purposes and effect of time delays and cyclic delays, especially when multipath and reflection occurs.

95. As the '439 Patent explains, two impulse responses are produced in response to a cyclic delay. *See id.* at 4:11-15 (“However, one problem with cyclic delay diversity involves the acquisition process described earlier. 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.”). The impulse responses caused by a cyclic delay “spoof” the receiver to believe it is seeing linear delay diversity (“LDD”), rather than cyclic delay, which appears as two different impulses in time. *See id.* at 4:11-22 (noting that the impulse response “is indistinguishable from” Linear Delay Diversity in time) (“However, one problem with cyclic delay diversity involves the acquisition process described earlier. 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 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.”); *see also* EX1011 at 36:22-37:30, Fig. 3 (illustrating a plurality of impulse responses in a legacy receiver when cyclic delay diversity is applied in a legacy SISO receiver) (“In the following, the resulting SISO channel model for CDD-OFDM [Cyclic Delay Diversity – OFDM], i.e. the resulting SISO channel being overserved by the receiver will be examined. ... Fig. 3 shows an effective channel impulse response.... As is depicted in Fig. 3, the effective channel impulse response comprises N_T channel impulse responses, wherein $N_T - 1$ channel impulse

responses are delayed with respect to a first channel impulse response.”). As a result, the receiver shifts the FFT to the right because it uses the impulse responses to improperly center the guard interval, as it would in a Linear Delay Diversity system. *See* EX1001 at 4:16–19 (“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 “erroneous placement” can cause the FFT to “spill[] over to the subsequent guard interval.” *Id.* 4:17–22 (“This can spoof the SISO 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.”). Here, because Larsson’s teaching of cyclical advance would be applied (instead of cyclic delay), it would be the cyclical advancements that would lead to the plurality of impulse responses, for the same reasons that prior art cyclic delay would have led to the plurality of impulse responses. *See id.* at 8:13-18. Thus, the “identical signal” created by Larsson’s cyclic advance would produce a plurality of impulse responses. *See id.* at 8:13-21 (“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).”).

96. The OFDM symbol and the shifted ones are sent to the receiver. The symbols are known to the receiver, hence any variations will provide a CIR without actually sending in short pulses. These two symbols do the job. The channel estimation is used to mitigate multipath and other channel specific sources of error. A POSITA would therefore have expected that the cyclical shift of the shifted version of the OFDM packet would cause the legacy receiver to produce a plurality of impulse responses in its acquisition process (as opposed to just one impulse response). Because Larsson’s teaching of cyclical advance would be applied (as opposed to its teaching of a cyclical delay), it would be the cyclical advancements that would lead to the plurality of impulse responses. *See id.* at 8:13-18 (“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.”). Thus, for the same reasons that a cyclical delay would have produced a plurality of impulse responses, the identical signal created by a cyclic advance would have produced a plurality of impulse responses.

5. Claim 5: The method of claim 4, wherein an impulse response corresponding to the shifted version of the OFDM

packet occurs earlier in time than an impulse response corresponding to the first OFDM packet.

97. In my opinion, Larsson in view of IEEE renders this limitation obvious. Multipath fading is a phenomenon in wireless communication where the transmitted signal reaches the receiver through multiple paths due to:

Reflection: Signals bounce off large obstacles such as buildings, mountains, and walls, creating multiple reflected paths.

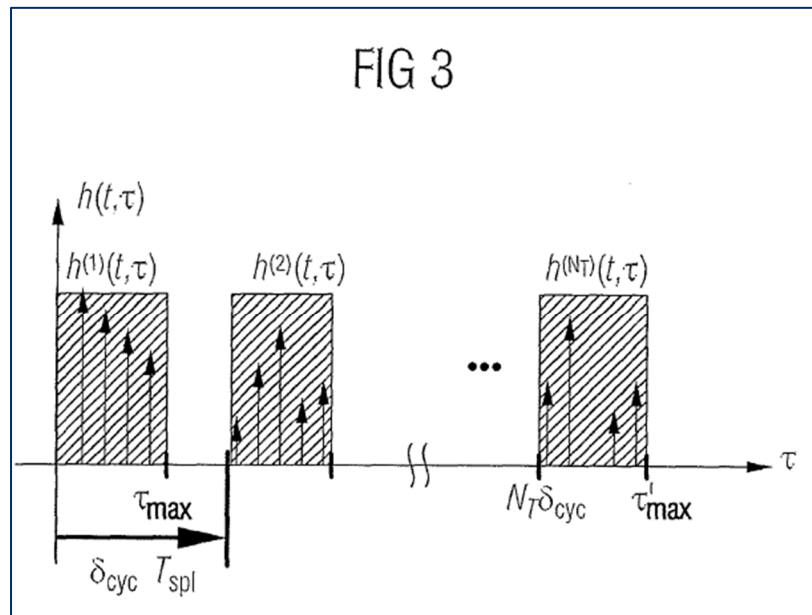
Diffraction: When signals encounter sharp edges, aperture, or corners, they bend around the obstacle and create additional paths.

Scattering: Small objects like trees, vehicles, or even atmospheric particles can scatter the signal in various directions.

98. These multiple paths can cause the signal to experience constructive and destructive interference, leading to variations in the signal amplitude, phase, and arrival time. Thus, any system that sends multiple packets would expect to cause a response from the cyclically shifted packet before the unshifted packeted, at some point.

99. The applicant-admitted prior art confirms that, with the time delayed signal, the impulse response corresponding to the delayed version of the OFDM packet occurs later in time than the impulse response corresponding to the reference, unshifted OFDM packet. *See id.* at 3:30-38 (“In the absence of a time delay (or in the absence of multi-path), the response to a received packet is an

impulsive correlation (which would be shown as a single impulse 402a in the guard interval 302), enabling proper timing or synchronization of the received signal and proper placement of the FFT. With the time delay (t_D) (or with multi-path), two impulsive responses (402a and 402b) are detected. The FFT is placed after the detection of the second impulse response 402b.”), Fig. 4B (undelayed signal corresponds to 402a impulse response, while delayed signal corresponds to 402b impulse response later in time). A POSITA would have known that the same was true if the delay were a cyclic delay, instead of a time delay as discussed above in Claim 4.

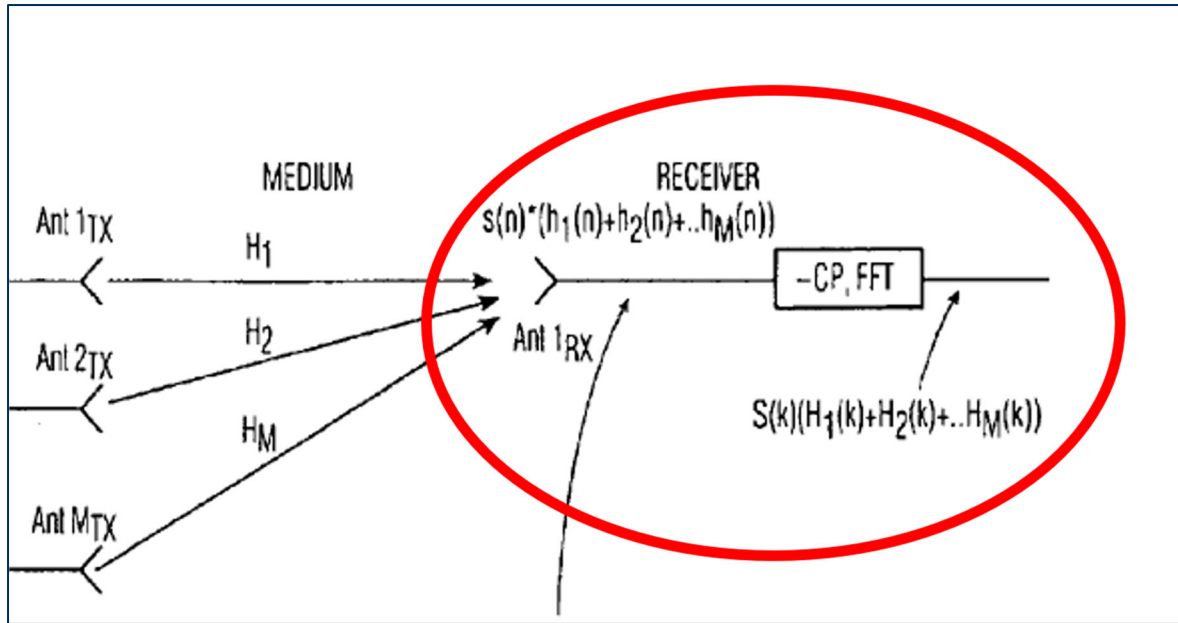


See EX1011 at 36:22-37:30 (“In the following, the resulting SISO channel model for CDD-OFDM [Cyclic Delay Diversity – OFDM], i.e. the resulting SISO channel being overserved by the receiver will be examined. ... Fig. 3 shows an

effective channel impulse response.... As is depicted in Fig. 3, the effective channel impulse response comprises NT channel impulse responses, wherein NT - 1 channel impulse responses are delayed with respect to a first channel impulse response.”); *id.* at Fig. 3. But in this Ground, the cyclic shift is a cyclic advance as taught by Larsson, rather than a cyclic delay, so as a POSITA would have expected, the impulse response associated with the cyclically advanced OFDM packet would occur earlier in time than the impulse response corresponding to the unshifted OFDM packet—the opposite of how the impulse response of a cyclically delayed packet appears later in time than the impulse response of the unshifted OFDM packet.

6. Claim 6: The method of claim 4, wherein the legacy OFDM receiver is a single-input, single-output (SISO) receiver device.

100. In my opinion, Larsson in view of IEEE renders this limitation obvious. *See* Claim 4. As shown below, Larsson specifically contemplates using a single-input, single-output (SISO) receiver device:

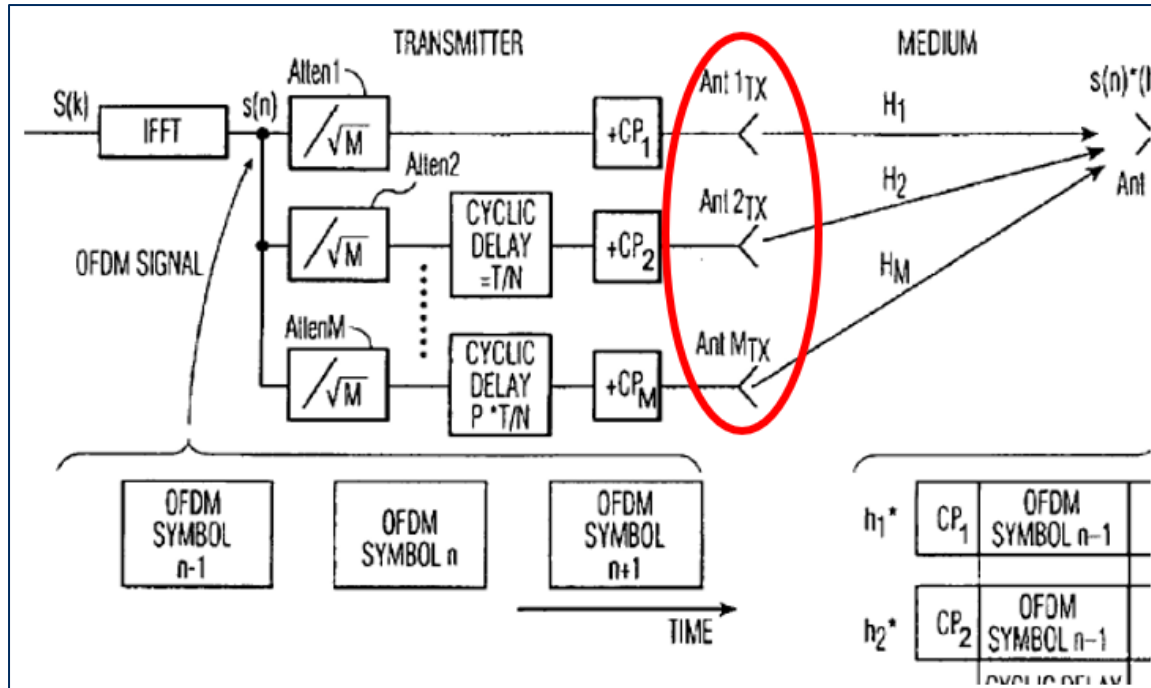


See EX1005 at Fig. 9 (cropped, annotated), 9:56–60. Thus, a POSITA would have recognized that SISO is a legacy system compatible with Larsson in view of IEEE.

See Claim 4; See EX1001 at 1:27-29, Fig. 1.

7. **Claim 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.**

101. In my opinion, Larsson in view of IEEE renders this limitation obvious. Larsson teaches that the original and shifted OFDM packets are “then transmitted through the respective antennas” (plural), which can be seen, for example, in Larsson’s Figure 9 as “Ant” (short for antenna) TX (short for transmitter) numbered 1 through M:



See EX1005 at Fig. 9 (cropped, annotated), 7:10-11.

8. Claim 8:

102. In my opinion, Larsson in view of IEEE renders this claim obvious.

- a. **Limitation 8[preamble]: A signal transmitting system for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:**

103. In my opinion, Larsson teaches the preamble. Larsson's signal transmitting system is shown, for example, in Larsson's Figure 9, and as discussed above in Claim 1[preamble], that system effects a method for transmitting OFDM signals. See *id.* at Fig. 9.

- b. **Limitation 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 comprised of a plurality of samples;**

104. In my opinion, Larsson teaches, or at least renders obvious, this limitation. As discussed above (and incorporated herein by reference) in the context of Claim 1[a][i]-[ii], Larsson teaches generating a first OFDM packet for transmission including a guard interval portion and a symbol data portion each comprised of a plurality of samples. *See* § VIII.A.1.b-c. There must have been, or at least obviously would have been, a processor in order to process the signal as taught by Larsson because otherwise the signal could not be processed as Larsson teaches. For example, other prior art such as Bauch, explains that “[a]t a receiver, the user streams are separated by explicitly exploiting the transmit diversity provided by a processing of the transmit signal.” EX1007 at 4:21-22. Bauch would include a transmit processor because it processes the signal for transmission because, stating unsurprisingly, “[i]n order to generate transmit diversity, cyclic delay diversity may be applied for transmitting data simultaneously from different transmit antennas, wherein each data stream associated with a transmit antenna has a delay with respect to the other data streams.” *See id* at 4:24-28.

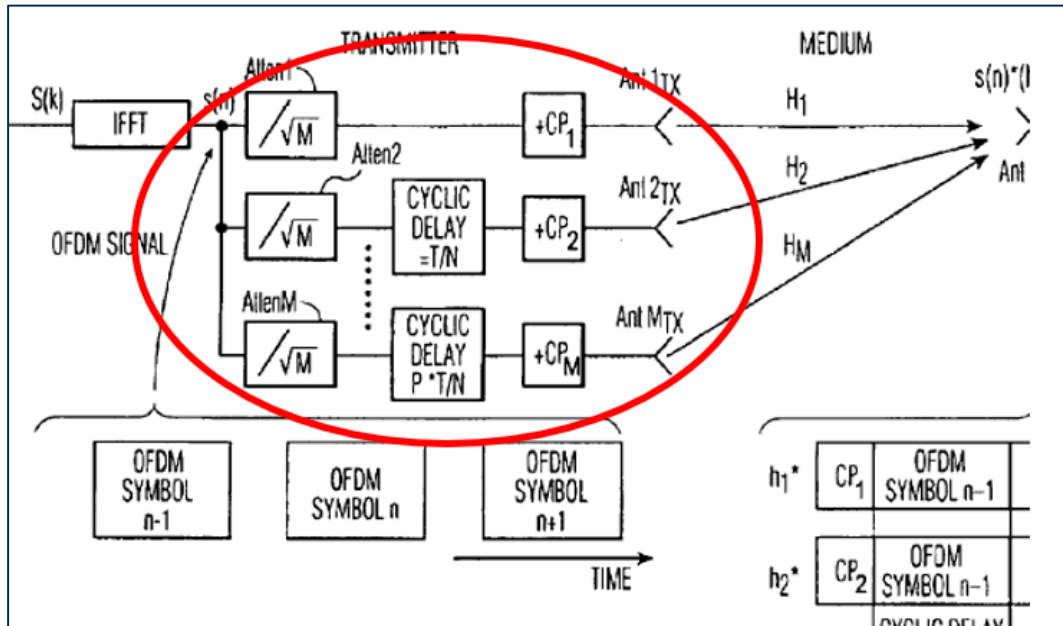
- c. **Limitation 8[b]: a second transmit processor for cyclically advancing the first OFDM packet by shifting the samples in a first direction an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM packet for transmission in which at least 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;

105. In my opinion, Larsson in view of IEEE renders this limitation obvious. As discussed above (and incorporated herein by reference) in the context of Claim 1[b][i]-[iii], Larsson in view of IEEE renders obvious 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. *See* § VIII.A.1.d-f. A POSITA would understand that such functions are performed by a second transmit processor that processes the signal for transmission because there must have been, or at least obviously would have been, a processor to process the shifted signal as taught by Larsson. And that second processor is a second transmit processor because it processes the signal for transmission. *See id.*

106. The “first transmit processor” is the code that generates the first OFDM packet in accordance with Claim 8[a], while the “second transmit processor” is the code that generates the shifted version of the first OFDM packet in accordance with Claim 8[b]. These obviously would have been different code

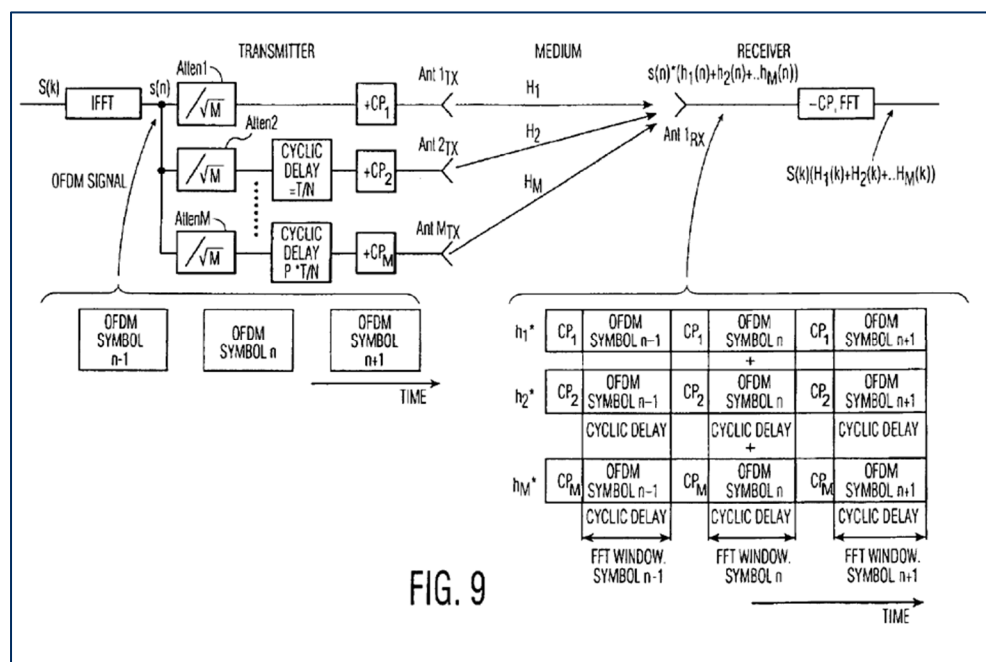
modules, for at least two reasons. First, Larsson teaches that the cyclic shift is performed separately in “each [different] antenna path,” and there are multiple such paths distinctly illustrated in (for example) Figure 9:



See EX1005 at Fig. 9, 7:64-66 (“In each antenna path the samples are shifted one sample point, relative to the previous antenna path, to the right in the OFDM symbol (step 1225).”). A POSITA would therefore have understood Larsson to be teaching separate code modules for “each” antenna path rather than one module for every path; otherwise, the figures would have been diagrammed differently if only one transmit processor module were processing all the packets. *See id.* Second, as a POSITA would recognize, different code modules could be processed in parallel and thus more quickly. Having two different code modules for the two transmit processors would therefore speed up the system, rather than relying on a single

transmit processor for all the processing which could lead to system bottlenecks.

107. In order to exploit the parallelism for generating multiple OFDM symbols, a POSITA would obviously have used a separate hardware processor for each transmit block. A POSITA would have generally found obvious to use a high-performance, low-power microprocessor that manages combining all the related fields and store them in the memory. The stored data would have been converted from digital to analog for the RF transmit circuit to output towards the receiver antenna. Any POSITA designing an OFDM transmission system would obviously have used a processor because the OFDM system requires digital computations, which must be performed by a processor. Having separate transmit processors allows for concurrency for a multiple antenna design as depicted in Figure 9 of Larsson:



EX1005 at Fig. 9. This would speed up the system, and it was common in the art to implement multi-antenna transmitter devices in this manner. A POSITA would therefore have had a reasonable expectation of success in implementing the system in such a manner because there is no reason the code must be implemented on one physically singular processor, and further because it was common to implement them in this manner in view of the known benefits described above.

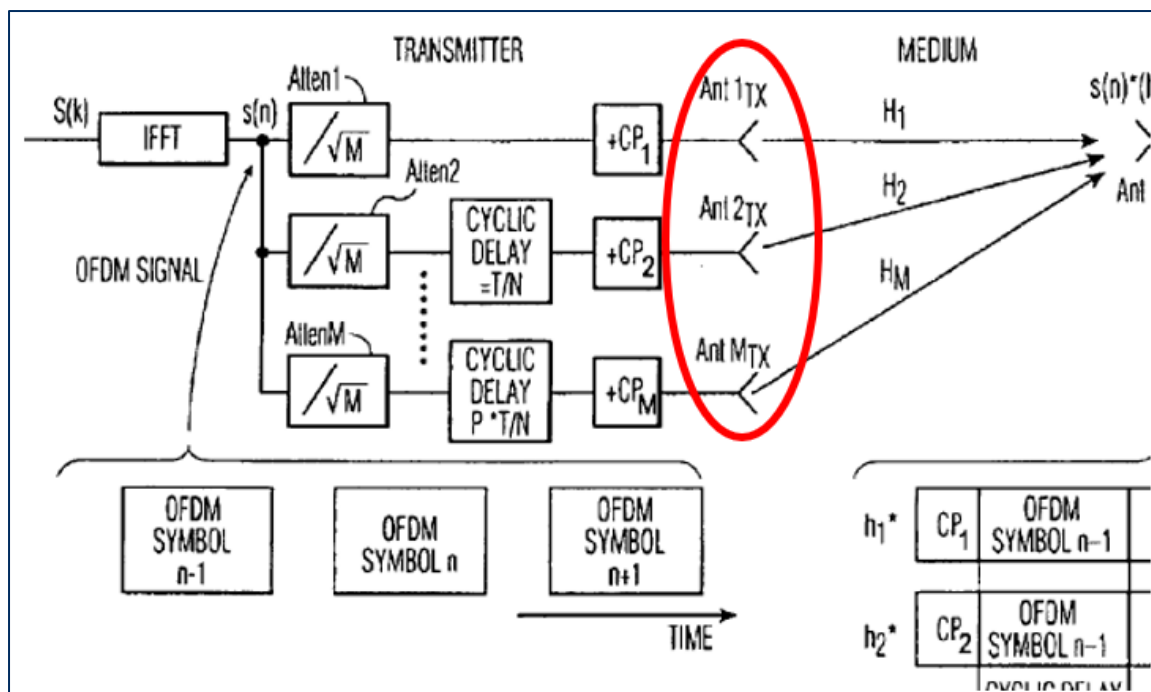
d. Limitation 8[c]: a plurality of radio transmitters for converting the OFDM packet and the shifted version of the OFDM packet to corresponding radio signals;

108. In my opinion, Larsson in view of IEEE renders this limitation obvious. Larsson's system is, after all, a "radio communication system," so its signals must be converted into radio signals. *See* EX1005 at, *e.g.*, cl. 1 ("In a radio communication system, a method of transmitting a signal, comprising the steps of...."). IEEE confirms that this is how Larsson would have operated and a POSITA would have obviously operated accordingly. *See* EX1008 at 20. A POSITA would have known there was a conversion of the completed OFDM packets (both the unshifted OFDM packet and the shifted version) to radiofrequency, or RF, signals for transmission. And as shown in Larsson's Figure 9, this would require a plurality of radio transmitters, one for each antenna shown in Figure 9 because "each" OFDM packet proceeds along its own "antenna path." *See* EX1005 at Fig. 9, 7:62-66 ("In each antenna path the symbol is attenuated by

the square root of the number of antennas (step 1220). In each antenna path the samples are shifted one sample point, relative to the previous antenna path, to the right in the OFDM symbol (step 1225).”).

e. Limitation 8[d]: and a plurality of radio antennas correspondingly coupled to the plurality of radio transmitters for transmitting the radio signals;

109. In my opinion, Larsson teaches this limitation. The plurality of radio antennas can be seen, for example, in Larsson’s Figure 9, described as “Ant” (short for antenna) TX (short for transmitter) numbered 1 through M:



EX1005 at Fig. 9 (cropped, annotated), 7:10-11 (“The symbol is then transmitted through the respective antennas.”). The arrows (H_1 through H_M) indicate to a POSITA that these radio signals are being transmitting. *See id.* at Fig. 9, 8:5-6 (“The transmitter then transmits the symbols from the various antennas (step

1235).”). A POSITA would understand that the signals are radio signals because, again, Larsson’s system is a “radio communication system.” *See id.* at cl. 1 (“In a radio communication system, a method of transmitting a signal, comprising the steps of....”). And each of these radio antennas would be correspondingly coupled to the plurality of radio transmitters that converted the OFDM packets into radio signals in the first place, as that is how the radio antennas obtain the radio signals they are taught as transmitting and because each radio antenna is on its own, distinct “antenna path” such that it would be understood to be coupled to a corresponding radio transmitter. *See id.* at Fig. 9, 7:61-62 (“The time domain symbol is sent along each antenna path (step 1215).”).

- f. Limitation 8[e]: 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.**

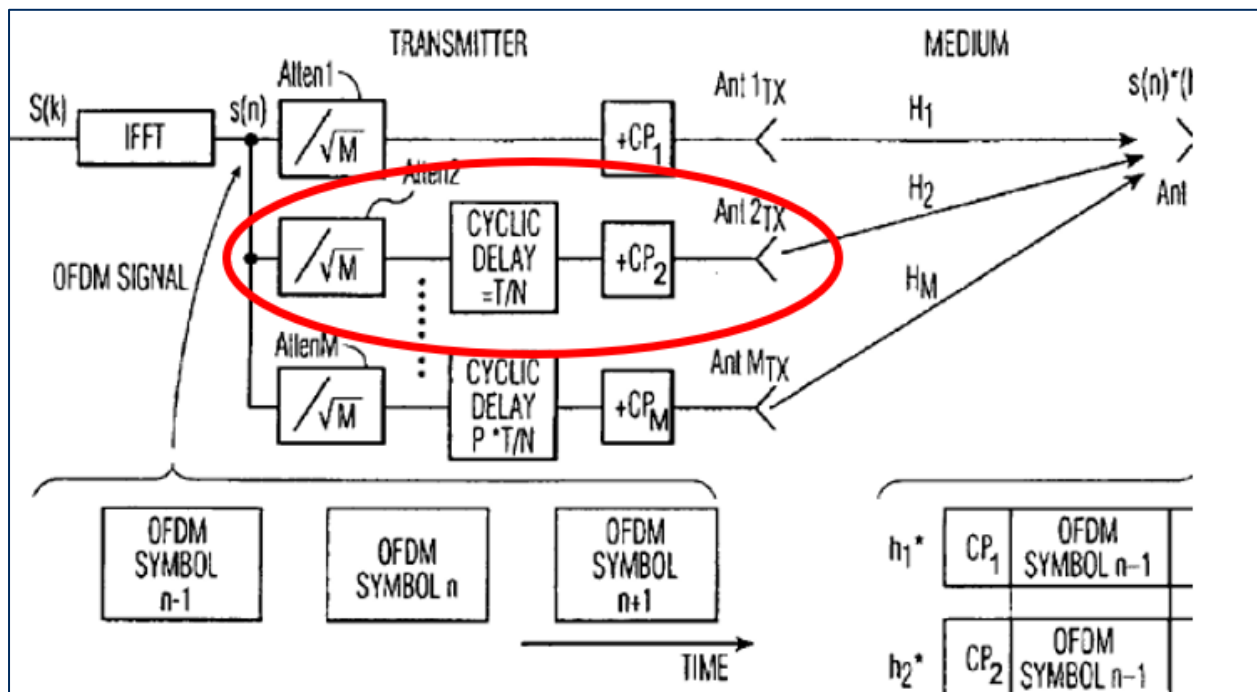
110. In my opinion, Larsson teaches this limitation. As discussed above (and incorporated herein by reference) in the context of Claim 1[c], Larsson teaches substantially simultaneously transmitting the first OFDM packet and the shifted version of the OFDM packet. *See* § VIII.A.1.g. The system components that are configured to substantially simultaneously cause that transmission are the first transmit processor and the second transmit processor, since those are the processors that generate the first (unshifted) OFDM packet and the shifted version

of the OFDM packet, as discussed above in the context of Claim 8[a] and [b]. These packets are transmitted via corresponding transmitters and antennas, as Larsson illustrates in, for example, Figure 9. *See* EX1005 at Fig. 9.

9. Claim 9: The system of claim 8, wherein each of the first and second transmit processors includes a cyclic extension module for performing cyclical advancements.

111. In my opinion, Larsson in view of IEEE renders this claim obvious.

112. As can be seen, for example, in Larsson's Figure 9, "each antenna path" has its own processing applied to it by its respective transmit processor, and that includes a cyclic extension module for performing cyclic shifts:



See id. at Fig. 9 (cropped, annotated), 7:64-8:5 ("In each antenna path the samples are shifted one sample point, relative to the previous antenna path, to the right in the OFDM symbol (step 1225). For example, in the first antenna path the samples

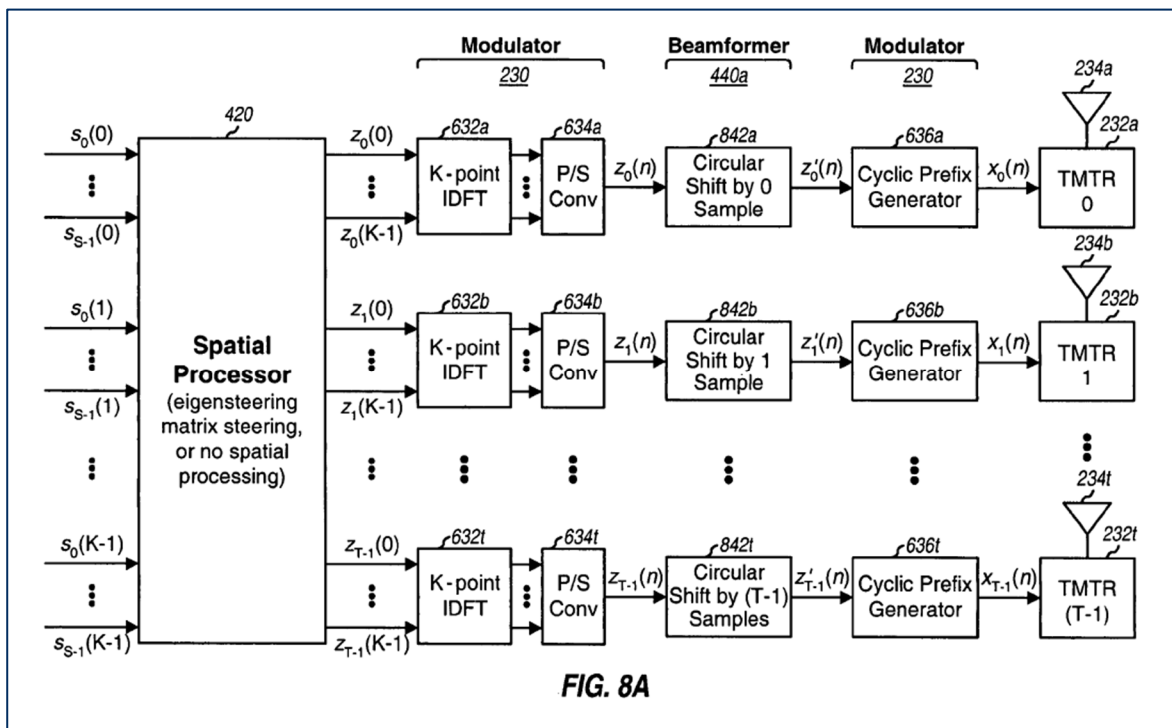
are not shifted, while in the sixth antenna path the samples are shifted five spaces. In each antenna path after the samples have been shifted, a cyclic prefix is added (step 1230). The cyclic prefix added in each antenna path includes the last *n* samples of the end of the OFDM symbol.”). Although the cyclic extension module in Larsson’s Figure 9 is illustrated as performing a cyclic delay, in the asserted (but unillustrated) embodiment of Larsson that shifts packets in the other direction, the cyclic extension module would perform cyclic advancements.

113. The cyclic extension module for performing cyclic shifts associated with the first transmit processor is not expressly illustrated in Larsson’s Figure 9. However, the first transmit processor does still add a cyclic prefix. *See id.* at 8:3-4 (“The cyclic prefix added in each antenna path includes the last *n* samples of the end of the OFDM symbol.”). And although its application for cyclic shifting is not illustrated (because there is no cyclic shift of the first OFDM packet itself), the cyclic extension module would at least obviously have had such ability.

114. This would have been an obvious design choice to a POSITA. A POSITA would have understood that the system would be limited if any of the transmitters would not be capable of shifting the OFDM symbols. A POSITA would be motivated to design a system where all of the transmitters are capable of performing the basic functions to transmit the OFDM symbols. Further, a POSITA would design the system for flexibility in case of failure. If one transmitter failed

and could not shift the OFDM packet, but still could generate the packet, the system could switch which transmitter is generating and transmitting the original signal, and which is transmitting the shifted signal.

115. A POSITA would have known that it was obvious at the time to build systems in this matter. For example, in Fig. 8A of EX1012, there are t OFDM modulators for the t transmit antennas. The column designated as the beamformer, 440a, handles T circular shifts of the K points OFDM symbol, ranging from a 0-sample shift to a $T-1$ sample shift. This includes the reference signal, which is transmitted with a 0-sample circular shift. As pictured, the system still has the ability to shift the sample all transmitters:



EX1012 at Fig. 8A.

116. It also would have been surprising for a POSITA to use a specific transmitter for one specific signal path and a different transmitter for the rest. That approach would have made the system less resilient to antenna failures as discussed above and required more customization between branches.

117. I note that the Examiner recognized this basic knowledge during prosecution of the '439 Patent. *See* EX1002 at 1051 (“It would have been obvious to one of ordinary skill in the art at the time the invention was made to use shifting of OFDM symbols on all paths of the system of Larsson in view of Admitted Prior Art as a design choice, [so that] the system will work without [the] use of unshifted OFDM symbol[s] and with any number of paths in the system.”).

10. Claim 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.

118. In my opinion, Larsson in view of IEEE renders this claim obvious. As discussed above (and incorporated herein by reference) in the context of Claim 3, Larsson in view of IEEE renders obvious cyclically advancing the OFDM packet for a duration of less than one half of the sample duration of the guard interval. *See* § VIII.A.3. This Claim 10 is the system counterpart to method Claim 3, and it is the cyclic extension modules identified in Claim 9 that perform the method steps claimed in Claim 3. Larsson teaches that each of the cyclic extension modules corresponding to the first and second transmit processors would have

been configured to shift one sample, thus satisfying this claim. *See* EX1005 at 7:64-8:5 (“In each antenna path the samples are shifted one sample point, relative to the previous antenna path, to the right in the OFDM symbol (step 1225). For example, in the first antenna path the samples are not shifted, while in the sixth antenna path the samples are shifted five spaces. In each antenna path after the samples have been shifted, a cyclic prefix is added (step 1230). The cyclic prefix added in each antenna path includes the last *n* samples of the end of the OFDM symbol.”).

11. Claim 11: 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 approximately 800 nanoseconds.

119. In my opinion, Larsson in view of IEEE renders this claim obvious. As discussed above in the context of Claim 2, Larsson in view of IEEE would be configured to cyclically advance the OFDM packet for a duration of less than approximately 800 nanoseconds, as taught by IEEE in order to comply with the standard. *See* § VIII.A.2. Each of the cyclic extension modules in the system of Larsson in view of IEEE would therefore obviously have been so configured because each of them should be able to comply with the IEEE standard. In other words, it makes no sense to have some cyclic extension modules comply with the IEEE standard while others do not.

12. Claim 12: The system of claim 8, wherein the first transmit processor is configured to receive incoming data and interleave the received data into a plurality of sub-carrier channels.

120. In my opinion, Larsson in view of IEEE renders this claim obvious. Interleaving is the process of arranging the data in a noncontiguous manner, so having sequential data is minimized. By spreading out the data, interleaving enforces adjacent data to be part of different code words, used for error correction, which helps the error correction algorithms to identify and correct errors more efficiently. By spreading the errors across different symbols, interleaving converts burst errors into random errors, which are easier to correct using Forward Error Correction (FEC) codes. If the data stream is interleaved over several OFDM symbols, a burst error affecting one OFDM symbol will only affect a few bits from each original data block.

121. Larsson teaches that a POSITA would have “recognized that to reduce the effects of channel impairments on a transmitted signal forward error correction (FEC) coding and interleaving can be performed on the transmitted signal.” *See* EX1005 at 8:10-13. IEEE confirms that this was part of the standard. *See* EX1008 at 29 (“All encoded data bits shall be interleaved by a block interleaver with a block size corresponding to the number of bits in a single OFDM symbol, N_{CBPS} .”). IEEE describes this interleaving in its overview, indicating that the received data is interleaved into a plurality of sub-carrier channels. *See id.* at 20 (noting that the

“interleaved data” in step (i) is subsequently “mapped hereafter into OFDM subcarriers numbered [listing the plurality of sub-carrier numbers]”).

122. Therefore, the claimed interleaving would have been expected by, and obvious to, a POSITA in order to ensure that Larsson’s system complied with the IEEE standard.

13. Claim 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.

123. In my opinion, Larsson in view of IEEE renders this claim obvious. An IFFT module takes QAM symbols and generates amplitude and phase for the assigned subcarriers. An IFFT is used on the side of the transmitter to convert the frequency domain data into time domain, and FFT is used at the receiver to revert the time domain data back into the frequency domain. IFFT is a mathematical transformation that converts the data represented in the frequency domain to the original time domain. The IFFT takes all the frequency components and converts them to time varying signals and outputs the sum of these signals using the subcarriers. These time varying signals are ultimately sent to the antenna for transmission in the air, after having them upconverted from the baseband frequency to the designated frequency.

124. Larsson teaches that in a “conventional transmitter and receiver which operate according to” an OFDM system, the “transmitter takes a symbol

S(k) and performs an inverse fast Fourier transform (IFFT) to convert the symbol to be transmitted from the frequency domain into the time domain.” *See* EX1005 at 1:33-37. Such interleaving was well-understood, routine, and conventional, such that Larsson incorporated it into his own claimed system in order to generate the OFDM symbols to be transmitted. *See id.* at, e.g., cl. 5 (“The method of claim 1, further comprising the steps of: applying error protection coding to the signal; interleaving the samples, wherein the samples are interleaved such that after de-interleaving, subcarriers with a lowest correlation are placed in positions next to each other; performing an inverse Fast Fourier Transform on the interleaved coded symbols to form a resultant signal; and providing the resultant signal to each of the antenna paths.”). IEEE confirms that IFFT was the “common way to implement” this process of taking incoming data (processed upstream in other ways) and generating the OFDM symbols from that data, and that it would have been done by “each” transmit processor. *See* EX1008 at 20 (“For each group of subcarriers -26 to 26, convert the subcarriers to time domain using inverse Fourier transform.”), 23.

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

125. In my opinion, Larsson in view of IEEE renders this claim obvious. Baseband signal is the original signal unmodulated that has not been modulated to

higher frequencies before being transmitted by the antenna. This is done because to transmit the data, it has to be elevated to higher frequencies for the RF circuit.

126. IEEE teaches a multi-step overview of the process and step (n) confirms that the up-conversion from “baseband” to “RF” (radiofrequency) occurs after the creation of the OFDM symbol to which the shift is applied (*see* steps (l)-(m)), such that the transmit processors must perform their cyclical shifts on baseband signals, as a POSITA would have expected. *See id.* at 20 (“l) For each group of subcarriers -26 to 26 , convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Refer to 17.3.5.9 for details. m) Append the OFDM symbols one after another, starting after the SIGNAL symbol describing the RATE and LENGTH.”).

15. Claim 15: The system of claim 8, wherein the first and second transmit processors include application specific integrated circuits (ASICs).

127. In my opinion, Larsson in view IEEE renders this claim obvious. A POSITA would obviously have chosen an ASIC to implement the alleged invention of '439 Patent because there are well known advantages for using hardware specific approaches. ASIC was known to be well-targeted for those applications where the computation requirement and power consumption

efficiency is not satisfactorily met by purely software solutions. The ASIC approach is a direct implementation of the data flow graph of the communications kernels such as FEC, IFFT, FFT, and other computationally complex kernels. In general, the choice of ASIC versus other approaches is purely a design specification matter to the POSITA, and the advantages and disadvantages of one choice versus another (each of which may have been suitable in different circumstances based on considerations like price, desired performance, energy efficiency considerations) would have been known to a POSITA.

128. The transmit processor must be implemented on some kind of physical processor, and an ASIC was an obvious choice (among a very limited set of fundamental processor types, such as CPUs, GPUs, FPGAs, and ASICs) to a POSITA for its speed. *See* EX1013 ¶ 26 (“Communication device 300 can be any communication device capable of engaging in a wireless OFDM communication, such as but not limited to a cellular telephone or a base station. Preferably, communication device 300 ... is capable of being a transmitting communication device or a receiving communication device. Communication device 300 includes an antenna 302 that is coupled to each of a receiver 304 and a transmitter 306. Receiver 304 and transmitter 306 are further coupled to a signal processing unit 308, which signal processing unit 308 is further coupled to each of a data source 310 and a data sink 312. ... 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 as a programmable logic array (PLA) or an application specific integrated circuit (ASIC). Alternatively, 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.”) During prosecution, the Examiner pointed out that ASICs were a well-known and obvious choice by which to implement processing requirements in systems such as Larsson’s. *See* EX1002 at 1053 (“Official notice is taken that using ASIC, FPGA or firmware stored in memory for a method or system implementation are well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to add using ASIC, FPGA or firmware stored in memory to the system of Larsson in view of Admitted Prior Art to implement the described method and system using well known approaches.”).

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

129. In my opinion, Larsson in view of IEEE renders this claim obvious. A transmitter is 802.11 compliant if it complies with the standard. To know this, a POSITA would simply consult the applicable standard at the time of the ’439 Patent’s claimed invention. A POSITA would implement this system using a

compliant device because otherwise, others would be very hesitant to use the designed system that is not comparable with the known standard. For example, consumers would be hesitant to buy a gas-powered vehicle that cannot use any of the standard octane levels available at gas stations.

130. As discussed above in Claim 2, a POSITA would have been highly motivated to ensure that Larsson's system complied with the IEEE 802.11 standard. *See* § VIII.A.2. And a POSITA would have understood that Larsson's teaching of cyclical advancement, as an alternative to cyclical delay, would not have affected its compliance with the IEEE 802.11 standard. As the '439 Patent recognizes, cyclic advance can be applied in a manner that is "identical or equivalent" to the cyclic delay, so from the perspective of compliance with the standard, there is no impact in applying Larsson's cyclic advance technique instead of its cyclic delay technique. *See* EX1001, 8:5-9 ("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)."); *id.* at 8:13-18 ("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.").

17. Claim 17: The system of claim 8, wherein the first and second transmit processors include field programmable gate arrays (FPGAs).

131. In my opinion, Larsson in view of IEEE renders this claim obvious. FPGA is another method of designing a hardware component similar to ASIC, except that FPGA can be programmed to change its functionality without having to redesign a new ASIC. It is not as power- or performance-efficient as an ASIC, but it is another route for realizing hardware, when for instance some of the parameters of the algorithm are not fully finalized and one may have to change the hardware before locking the design into an ASIC. A POSITA would have been well aware of this design choice and would have implemented the FPGA in a system that required more flexibility than an ASIC (for example).

132. The transmit processor must be implemented on some kind of physical processor, and an FPGA was an obvious choice (among a very limited set of fundamental processor types, such as CPUs, GPUs, ASICs, and FPGAs) to a POSITA for its speed. During prosecution, the Examiner noted that FPGAs were a well-known and obvious choice by which to implement processing requirements in systems such as Larsson's. See EX1002 at 1053 ("Official notice is taken that using ASIC, FPGA or firmware stored in memory for a method or system implementation are well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to add

using ASIC, FPGA or firmware stored in memory to the system of Larsson in view of Admitted Prior Art to implement the described method and system using well known approaches.”).

18. Claim 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.

133. In my opinion, Larsson in view of IEEE renders this claim obvious. The firmware refers to the stored set of instructions for a programmable solution. POSITA would have considered this approach for embedded systems such as mobile wireless devices.

134. As a POSITA would have been aware, using firmware stored in a memory device that is executed by a suitable instruction execution system is a common way to use a CPU. The transmit processor must be implemented on some kind of physical processor (among a very limited set of fundamental processor types, such as CPUs, GPUs, ASICs, and FPGAs), and firmware was an obvious choice to a POSITA because CPUs were readily available off the shelf and thus inexpensive, and also because programming such firmware was a basic part of a POSITA’s knowledge, for example from computer science courses. During prosecution, the Examiner noted that using firmware stored in a memory to implement the executable instructions were a well-known and obvious choice by which to implement processing requirements in systems such as Larsson’s. *See*

EX1002 at 1053 (“Official notice is taken that using ASIC, FPGA or firmware stored in memory for a method or system implementation are well known and expected in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made to add using ASIC, FPGA or firmware stored in memory to the system of Larsson in view of Admitted Prior Art to implement the described method and system using well known approaches.”).

19. Claim 19

135. In my opinion, Larsson in view of IEEE renders this claim obvious.

- a. **19[preamble]: A signal transmitting system for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:**

136. In my opinion, Larsson teaches the preamble. *See* Claim 8[preamble].

- b. **19[a]: means 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;**

137. In my opinion, Larsson in view of IEEE renders this limitation obvious. By reference to Claim 8[a], the algorithm by which the transmit processor for generating a first OFDM packet would generate that packet is that disclosed in the IEEE 802.11 standard because it would have been obvious for Larsson’s system to comply with the IEEE 802.11 standard. *See* Claim 16.

- c. **19[b]: means for cyclically advancing the first OFDM packet including a guard interval portion and a symbol data portion each compromised of a plurality of samples 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 we 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;

138. In my opinion, Larsson in view of IEEE renders this limitation obvious. *See* Claim 8[b].

- d. 19[c]: means for convening the first OFDM packet and the shifted version of the OFDM packet to corresponding radio signals; and**

139. In my opinion, Larsson in view of IEEE renders this limitation obvious. By reference to Claim 8[c], the algorithm by which the radio transmitters would convert those packets is that disclosed in the IEEE 802.11 standard because it would have been obvious for Larsson's system to comply with the IEEE 802.11 standard. *See* Claim 16.

- e. 19[d]: means for substantially simultaneously causing the transmission of the first OFDM packet and the shifted version of the OFDM packet.**

140. In my opinion, Larsson in view of IEEE renders this limitation obvious. By reference to Claim 8[e], the algorithm by which the transmit processors would cause substantially simultaneous transmission is that disclosed in

the IEEE 802.11 standard because it would have been obvious for Larsson's system to comply with the IEEE 802.11 standard. *See* Claim 16.

20. Claim 20: The system of claim 19, wherein the cyclic advance has a duration less than one of half of sample duration of the guard interval of the OFDM packet.

141. In my opinion, Larsson in view of IEEE renders this claim obvious. *See* Claims 3, 10. As discussed above (incorporated herein) in the context of Claim 3, Larsson in view of IEEE renders obvious a cyclic advance with a duration less than one of half of [sic] sample duration of the guard interval of the OFDM packet because Larsson teaches a one sample shift, with a three-sample guard interval. *See* EX1005 at 7:64-8:5 (“In each antenna path the samples are shifted one sample point, relative to the previous antenna path, to the right in the OFDM symbol (step 1225). For example, in the first antenna path the samples are not shifted, while in the sixth antenna path the samples are shifted five spaces. In each antenna path after the samples have been shifted, a cyclic prefix is added (step 1230). The cyclic prefix added in each antenna path includes the last n samples of the end of the OFDM symbol.”).

21. Claim 21: The system of claim 19, further comprising a legacy receiver, and wherein the cyclical advancements of the shifted version of the OFDM packet cause the legacy receiver to produce a plurality of impulse responses in an acquisition process, and wherein each of the first OFDM packet and the shifted version of the OFDM packet corresponds to one of the plurality of impulse responses.

142. In my opinion, Larsson in view of IEEE renders this claim obvious. *See* Claim 4. Referencing Claim 4, Larsson in view of IEEE renders obvious a legacy receiver because as a POSITA would have been aware and the '439 Patent admits, “there is a need to consider legacy receivers (e.g., single-input, single output (SISO), OFDM receivers),” because not all network participants upgrade their equipment at the same time; accordingly, the POSITA would have obviously accounted for participants in the wireless network using legacy receivers. *See* EX1001 at 1:27-29 (“However, 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.”).

143. As discussed above, Cyclical advancements, as delays, cause the legacy receiver to produce a plurality of impulse responses in an acquisition process, and each of the first OFDM packet and the shifted version of the OFDM packet would correspond to one of the plurality of impulse responses because the impulse response “is indistinguishable from ... linear delay diversity.” EX1001 at 4:5-22 (“From a receiver standpoint, the guard intervals 510, 514 b remain aligned, as represented by the dashed line 520. In other words, with cyclic delay diversity, guard intervals are not consumed as they are in linear delay diversity. The samples

used for each guard interval are different after a cyclic shift, but the guard intervals still remain as 16 samples. However, one problem with cyclic delay diversity involves the acquisition process described earlier. 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 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.”).

B. Ground II: Claims 1-21 Are Obvious Over Kaiser In View Of Bauch And IEEE

1. Claim 1

144. In my opinion, Kaiser in view of Bauch and IEEE renders obvious Claim 1.

a. Limitation 1[preamble]: A method for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:

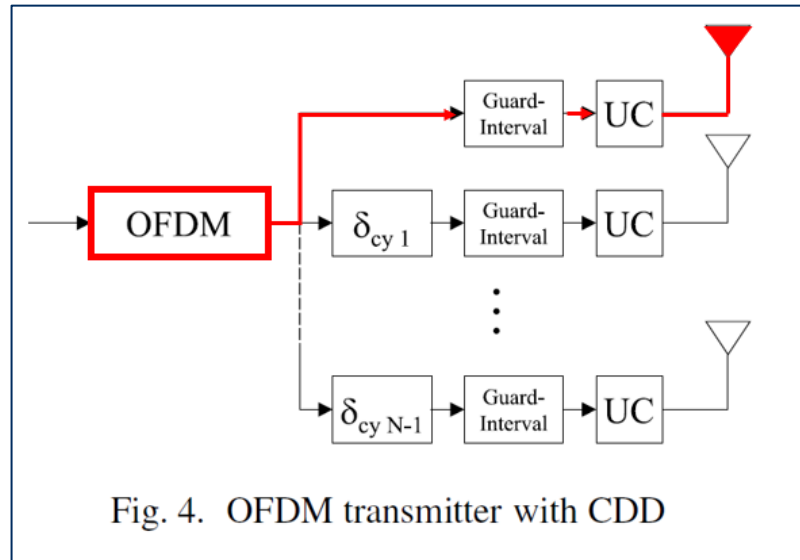
145. In my opinion, Kaiser teaches the preamble. For example, Kaiser teaches that its “Fig. 4 shows the block diagram of an *N*-transmitter-antenna OFDM system with CDD.” *See* EX1006 at 2. That section of Kaiser and the

portions discussed below teach the steps of a method for using that transmitter to transmit OFDM signals. *See id.* at 2-4 (“The OFDM modulated signal is transmitted over N antennas, whereas the particular signals only differ in an antenna specific cyclic shift. After cyclic shifting, the guard interval is inserted. The functional block “UC” again does upconversion of the signals from the baseband into RF-band.”).

b. Limitation 1[a][i]: generating a first OFDM packet for transmission

146. In my opinion, Kaiser teaches this limitation. The OFDM packet represents a sequence of fields that contribute to the transmission of information. The packet is structured using fields to efficiently transmit OFDM symbols for wireless systems. These fields include short training symbols used for signal detection, AGC, diversity selection functionality, synchronization, long training symbol, header, guard interval, and finally OFDM symbols. These fields include information about modulation scheme, packet length, and other related information. They also contain a data field which includes the actual data packed in one or more OFDM symbols. A POSITA would have known this by using the applicable IEEE standard, and a POSITA would have been expected to comply with those IEEE standards. Most if not all OFDM systems would have transmitted data in packet form.

147. For example, Kaiser’s Figure 4 shows a first OFDM packet that is generated, which proceeds onwards to the antenna (represented by the red-annotated triangle on the right-hand side of the figure):

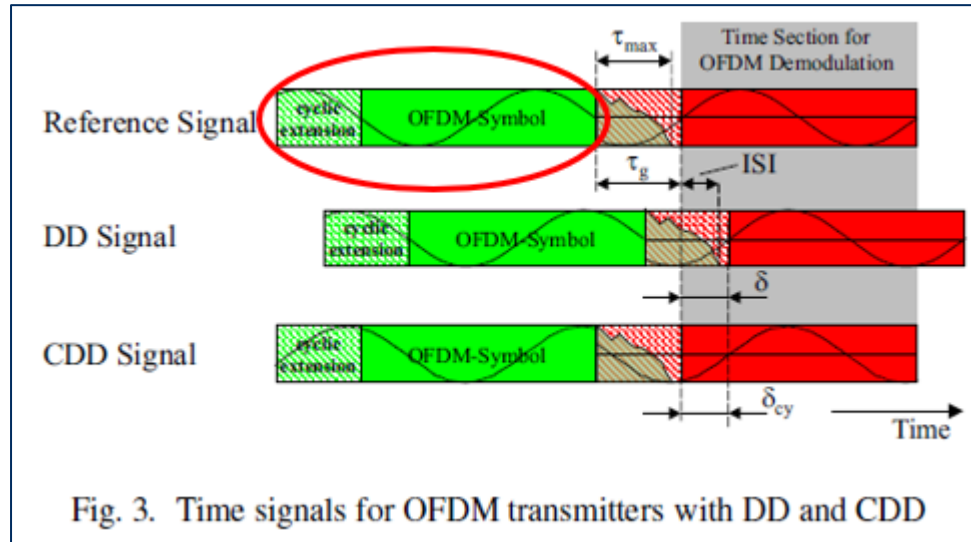


See id. at Fig. 4 (annotated). The process of generating this first OFDM packet would have been known to a POSITA and is described, for example, in Kaiser’s Figure 9. *See id.* at Fig. 9. A POSITA would also have recognized that the first OFDM signal that is transmitted is a first OFDM packet because Kaiser’s OFDM system is a packet-based transmission system. *See id.* at, e.g., 5 (Kaiser’s technique, “CDD increases channel selectivity and therefore decreases the occurrence of packet errors” for the OFDM packets that it transmits).

- c. **Limitation 1[a][ii]: including a guard interval portion and a symbol data portion each comprised of a plurality of samples**

148. In my opinion, Kaiser teaches this limitation. I incorporate herein by reference my description above from Ground I, Limitation 1[a][ii] regarding the structure of the OFDM packets, guard intervals, and symbol data.

149. For example, in Kaiser’s Figure 3, the first, green-highlighted packet in the “Reference Signal” (which is the first OFDM packet generated) includes an “OFDM Symbol” data portion and, prepended to that OFDM symbol in time, a “cyclic extension”:



See id. at Fig. 3 (annotated). The prepended “cyclic extension” is a cyclic prefix, which Kaiser explains serves as a “guard interval.” *See id.* at 2 (“Fig. 3 illustrates the difference between DD and CDD in the time domain and shows the transmission of 2 consecutive OFDM symbols with their cyclic prefixes as guard intervals.”); *see also* EX1001 at, e.g., 2:67-3:3 (discussing the prior art standards and OFDM symbols, that “subcarrier time samples are allowed to ‘pre-spin’ out 16

samples, resulting in guard intervals being created as cyclic extensions of the spin of the subcarrier time samples”).

150. In my opinion, a POSITA would have recognized that the OFDM packet’s guard interval portion and symbol data portion were comprised of a plurality of samples. The ’439 Patent explains that in the prior art IEEE 802.11 standard, there were “80 samples in an OFDM symbol waveform” and “the guard interval 302 consumes 16 samples ([and] the data portion comprising 64 samples).” *See* EX1001 at 2:26-30. Thus, the guard interval portion and symbol data portion of the first OFDM packet (and all the other OFDM packets) are comprised of a plurality of samples, in accordance with the IEEE standard.

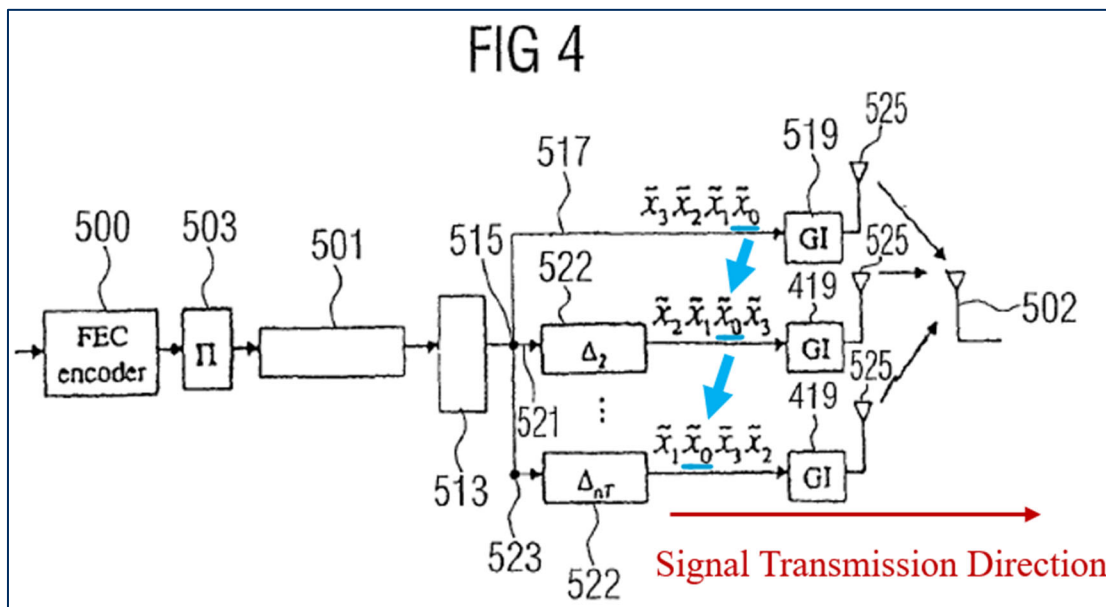
d. Limitation 1[b][i]: cyclically advancing the first OFDM packet by shifting the samples in a first direction

151. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. I incorporate herein my description regarding cyclical shifts from Ground I, Limitation 1[b][i].

152. Kaiser teaches cyclically delaying (but not cyclically advancing) the first OFDM packets by shifting the samples in a direction. For example, Kaiser teaches that the “OFDM symbols of the CDD signal can be generated from the reference signal OFDM symbols just by applying a cyclic time shift of δ_{cy} to the reference signals’ OFDM symbols.” *See* EX1006 at 2. As a POSITA would

recognize and as the '439 Patent admits was prior art, this is simply the standard operation of cyclic delay, which involved cyclically delaying the first OFDM packet by shifting the samples in a first direction. *See* EX1001 at, *e.g.*, Fig. 5, 3:50-4:4.

153. Bauch teaches cyclically advancing the packet by shifting the samples in the other direction. As background, Bauch's Figure 4 first teaches cyclically delaying the first OFDM packet (represented by unshifted signal 517) by shifting the samples in the direction opposite of signal transmission, just like Kaiser's Figure 3 and just like the '439 Patent admits was standard in the prior art:



See EX1007 at Fig. 4 (annotated), 22:23-23:2 (“Due to the shift introduced by the means 522, the copy of the transformed signal provided via the signal path 521 is

shifted by one coefficient⁶.”). Because the samples are shifted to the left of Bauch’s Figure 4, Bauch refers to this method of shifting as “perform[ing] a left-shift.” *Id.* at 22:30–32 (“As depicted in Fig. 4, the means 522 for introducing the delay are respectively operative to perform a left-shift.”). Bauch then teaches shifting in the opposite direction: “Alternatively, the means 522 may be operative to perform a right-shift.” *Id.* at 22:30-23:1. As a POSITA would recognize, cyclically shifting the samples in the opposite direction of a delay (which is a “left-shift” in Bauch) is a cyclic advance (which is a “right-shift” in Bauch). *Id.* at 22:30-23:1 (“As depicted in Fig. 4, the means 522 for introducing the delay are respectively operative to perform a left-shift. Alternatively, the means 522 may be operative to perform a right-shift.”).

154. As established above, Kaiser already teaches cyclically delaying the first OFDM packet by shifting the samples in a direction, and Bauch then teaches cyclically advancing the OFDM packet by shifting the samples in a first direction that is the opposite direction of the delay shift taught by Kaiser.

⁶ As a POSITA would recognize, Bauch’s reference to shifting “coefficients” corresponds to shifting “samples” in view of how coefficients are mapped to samples pursuant the IEEE standard. *See* EX1008 at 23, 24, 86.

Thus, Kaiser in view of Bauch teaches cyclically advancing the first OFDM packet by shifting the samples in a first direction.

155. A POSITA would have been motivated to apply Bauch's teachings to Kaiser and would have had a reasonable expectation of success in doing so for a number of reasons. For example, Bauch expressly teaches that its disclosure should be applied to Kaiser's system:

An increased frequency selectivity without exceeding the guard interval can be achieved introducing a cyclic delay diversity, as described in: ... A. Dammann and S. Kaiser, "Low complex standard conformable antenna diversity techniques for OFDM systems and its application to the DVB-T system", 4th International ITG Conference on Source and Channel Coding, pages 253-259, January 2002 [*i.e.* "Kaiser"]... In accordance with the teachings of the above documents, a delay is introduced in a cyclic manner such that the guard interval is not exceeded.

EX10at 3:31-4:14. It therefore comes as no surprise to see that the relevant portions of Kaiser's and Bauch's systems are so similar. *Compare, e.g.*, EX1006 at Fig. 4, *with* EX1007 at Fig. 4 (similar transmission systems). Thus, a POSITA would have been motivated to apply Bauch's teaching of a "right-shift" (cyclical advance) to Kaiser's system because Bauch's system is expressly intended to be applied to Kaiser's system, and the similarities between the two evidence a reasonable expectation of success in combining them.

156. A POSITA also would have been motivated to apply Bauch's teaching of a "right-shift" (cyclical advance) to Kaiser's system that uses cyclical delay

because, as the '439 Patent recognizes, a small cyclic advance is “identical or equivalent” to a large cyclic delay, and vice versa. *See* EX1001 at 8:5-18 (“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).”). Therefore, there are two mathematically identical ways to do what Kaiser’s system does, so it would have been obvious to try either of those two options because they are equivalent. Both options would obviously have been equally acceptable to a POSITA, and both are expressly contemplated by Bauch as being applied to Kaiser’s system to evidence a reasonable expectation of success. *See* EX1007 at 22:30-23:1 (“As depicted in Fig. 4, the means 522 for introducing the delay are respectively operative to perform a left-shift. Alternatively, the means 522 may be operative to perform a right-shift.”).

e. Limitation 1[b][ii]: an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM packet for transmission

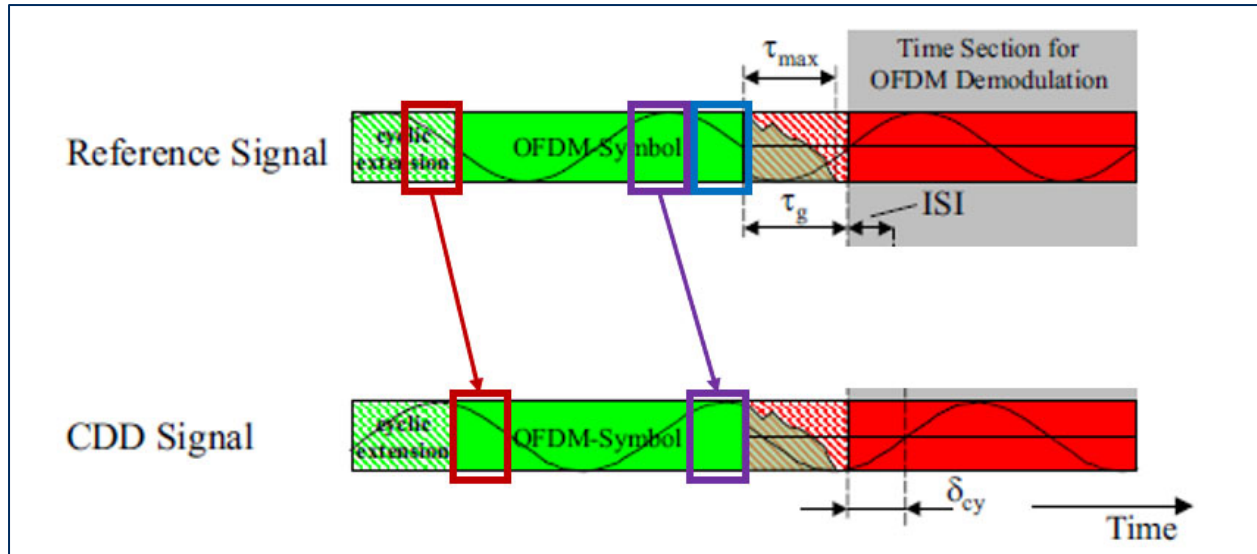
157. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. An obvious choice for the sample duration of the guard interval would have been 16 samples, which fits within applicable IEEE standards. So, a shift less than that sample duration would be a shift of less than 16 samples. Bauch teaches that in “accordance with the teachings of [Kaiser], a delay is introduced in

a cyclic manner such that the guard interval is not exceeded,” which a POSITA would understand to mean a shift of fewer samples than the guard interval duration. *Id.* at 4:11–14. Kaiser teaches that this shift is used to generate a shifted version of the first OFDM packet for transmission, as represented by the CDD Signal in Kaiser’s Figure 3 and, for example, in the shifted signals in Kaiser’s Figure 4. *See* EX1006 at Figs. 3-4.

- f. Limitation 1[b][iii]: 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**

158. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. I incorporate herein by reference my discussion from Ground I, Limitation 1[b][iii] regarding the mechanics of shifting samples.

159. In Kaiser’s cyclic delay shift, a non-zero number of **samples from the guard interval are shifted into the symbol data portion**, which **shifts the same number of samples towards the end**, which **shifts the same number of samples out**:



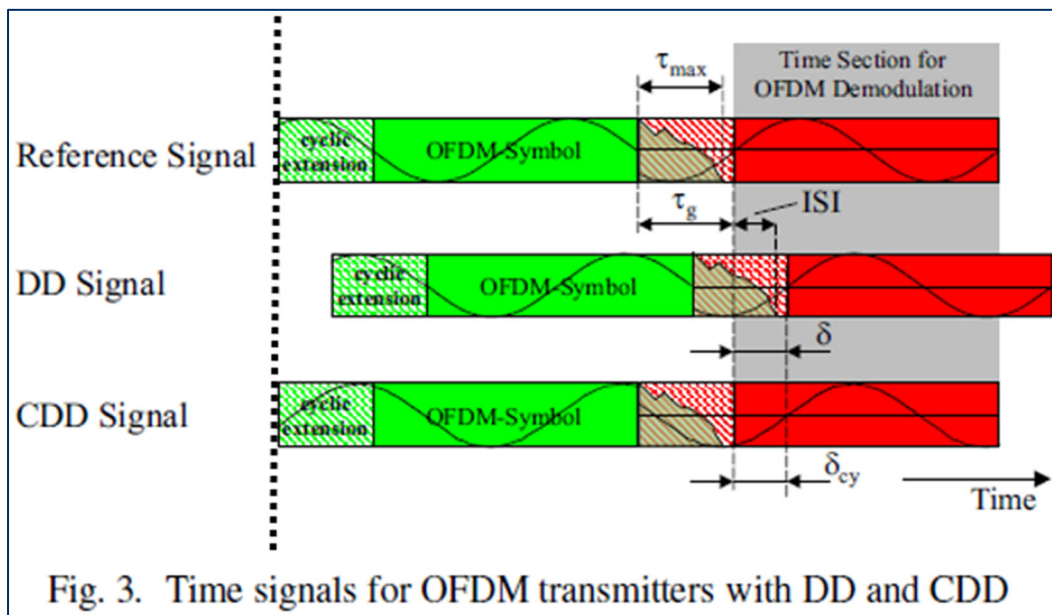
See id. at Fig. 3 (annotated, modified). When Bauch's teaching of cyclic advance is applied to Kaiser, the shift would be in the opposite direction: A non-zero number of samples from the symbol data portion would be shifted into the guard interval, and the same non-zero number of samples from the guard interval would be shifted out. Kaiser expressly teaches that the shift in the guard interval and the symbol data is the same magnitude, δ_{cy} . *See id.* at 2. The '439 Patent also admits it was known in the prior art for the shifts to be the same number of samples. *See* EX1001 at Fig. 5 (shifting the same number of samples into and out of the guard interval).

g. Limitation 1[c]: substantially simultaneously transmitting the first OFDM packet and the shifted version of the OFDM packet.

160. In my opinion, Kaiser teaches this limitation. A POSITA would look to IEEE standard-compliant OFDM transmission systems and understand that they transmitted cyclically shifted frames "substantially simultaneously" as the

unshifted frame, because otherwise they would have been using a liner delay system, which is a different transmission diversity scheme as described in more detail in the Background section.

161. As shown, for example, in Kaiser's Figure 3, both the Reference Signal (the first, unmodified OFDM packet) and the CDD Signal (the cyclically shifted version of the first OFDM packet) are sent simultaneously in time, in contrast to the Delay Diversity Signal (DD Signal) that is not transmitted simultaneously and instead follows the original Reference Signal in time based on time delay shift:



See EX1006 at Fig. 3 (annotated). Bauch confirms that a POSITA would understand that Kaiser's "cyclic delay diversity may be applied for transmitting data simultaneously from different transmit antennas." See EX1007 4:24–28 ("In

order to generate transmit diversity, cyclic delay diversity may be applied for transmitting data simultaneously from different transmit antennas, wherein each data stream associated with a transmit antenna has a delay with respect to the other data streams.”).

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

162. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. The IEEE standard mandates that the guard interval is 800 nanoseconds.

Table 79—Timing-related parameters	
Parameter	Value
N_{SD} : Number of data subcarriers	48
N_{SP} : Number of pilot subcarriers	4
N_{ST} : Number of subcarriers, total	52 ($N_{SD} + N_{SP}$)
ΔF : Subcarrier frequency spacing	0.3125 MHz (=20 MHz/64)
T_{FFT} : IFFT/FFT period	3.2 μ s ($1/\Delta F$)
$T_{PREAMBLE}$: PLCP preamble duration	16 μ s ($T_{SHORT} + T_{LONG}$)
T_{SIGNAL} : Duration of the SIGNAL BPSK-OFDM symbol	4.0 μ s ($T_{GI} + T_{FFT}$)
T_{GI} : GI duration	0.8 μ s ($T_{FFT}/4$)
T_{GI2} : Training symbol GI duration	1.6 μ s ($T_{FFT}/2$)
T_{SYM} : Symbol interval	4 μ s ($T_{GI} + T_{FFT}$)
T_{SHORT} : Short training sequence duration	8 μ s ($10 \times T_{FFT} / 4$)
T_{LONG} : Long training sequence duration	8 μ s ($T_{GI2} + 2 \times T_{FFT}$)

See EX1008 at 21 (Table 79: “ T_{GI} : GI duration” set at “0.8 μ s” which is 800 nanoseconds), 36 (Table 86: “Guard Interval” again limited to “0.8 μ s”). As discussed above in the context of Claim 1[b][ii], Kaiser and Bauch both expressly

teach that the cyclical shift of the OFDM packet would be for an amount less than a sample duration of the guard interval. Thus, in order to comply with the standard, Kaiser's system would obviously have cyclically advanced the OFDM packet (given Bauch's teachings) for a duration of less than 800 nanoseconds (given IEEE's teachings), which is the duration of the guard interval portion of the standard.

163. It would have been obvious to a POSITA to apply the IEEE standard to the system of Kaiser and Bauch. As a POSITA would have known, systems and methods that did not comply with the IEEE 802.11 standard were significantly less useful and valuable for the same reasons as described above in Section VIII.A.2. Thus, it would have been obvious for the system of Kaiser and Bauch to incorporate the 802.11 standard taught by IEEE.

164. A POSITA also would have had a reasonable expectation of success in doing so, because Kaiser's system is expressly intended to and does comply with the IEEE 802.11 standard. *See* EX1006 at, *e.g.*, Abstract ("The focus is on standard compatibility, i.e. this scheme[] can be implemented to already existing OFDM systems without changing the standards."), 6 ("The presented antenna diversity schemes can easily be implemented in existing OFDM systems without changing the standards or the receivers.").

3. Claim 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.

165. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. A shift less than one half a guard interval duration means a shift of less than 8-samples in the standard 16-sample guard interval system. In a 3-sample guard interval system, the shift would be less than 1.5 samples (1 sample realistically).

166. Bauch teaches shifting just a single coefficient, which as explained in the Background section above, maps to a single time-domain sample. *See* EX1007 at 22:25-23:1 (“Due to the shift introduced by the means 522, the copy of the transformed signal provided via the signal path 521 is shifted by one coefficient. Accordingly, the copy of the transformed signal corresponding to the signal path 523 is shifted by one coefficient with respect to the shifted copy corresponding to the signal path 521.”) Further, the ’439 Patent explains that cyclical shifts of one sample were known in the art. *See* EX1001 at Fig. 5. In the system of Kaiser in view of Bauch and IEEE, such shift would be a cyclical advance of the OFDM packet of one sample, as explained in Claim 1[b][i]. And as the ’439 Patent admits was part of the IEEE prior art standard, the guard interval portion was 16 samples. *See* EX1001 at 2:26-30 (“In an 802.11 implementation, each symbol 300 is approximately 4 microseconds (μ sec) in duration. For instance, of the 80 samples in an OFDM symbol waveform, the guard interval 302 consumes 16 samples (the

data portion comprising 64 samples).”). Cyclically advancing the OFDM packet by just one sample is less than the duration of one half of the sample duration of guard interval (whether that is 1.5 samples or 8 samples), such that this limitation is satisfied.

- 4. Claim 4: The method of claim 1, further comprising a legacy receiver, and wherein the cyclical advancements of the shifted version of the OFDM packet cause the legacy receiver to produce a plurality of impulse responses in an acquisition process, and wherein each of the first OFDM packet and the shifted version of the OFDM packet corresponds to one of the plurality of impulse responses.**

167. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. Receivers that do not contain multiple antennas would have been considered legacy receivers at the time of the purported invention. These receivers relate to single-in-single-out (SISO) technology. As a POSITA would have known, Long Training Symbol (LTS) would have caused impulse responses these legacy receivers. Both the shifted and unshifted OFDM symbols contain LTS's that are used to synchronize the receiver with the incoming signals, help with channel estimation, and aligning receiver with the transmitter for a particular channel. Impulse response characterizes how the channel modifies a transmitted signal. This is covered in the IEEE standard, and both symbols would cause an impulse response. Thus, a POSITA would have this knowledge by using and applying the applicable wireless standards at the time of the claimed invention.

168. A POSITA would have been motivated to incorporate the legacy SISO receiver depicted in the '439 Patent's Figure 1 admitted prior art, as well as all of the known and admitted prior art operation of that receiver with respect to impulse responses, into the system of Kaiser in view of Bauch and IEEE for the same reasons as a POSITA would have been motivated to do so with the system of Larsson and IEEE, and would have had the same expectation of success. *See* Ground I, Claim 4.

5. Claim 5: The method of claim 4, wherein an impulse response corresponding to the shifted version of the OFDM packet occurs earlier in time than an impulse response corresponding to the first OFDM packet.

169. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. Multipath fading is a phenomenon in wireless communication where the transmitted signal reaches the receiver through multiple paths due to:

Reflection: Signals bounce off large obstacles such as buildings, mountains, and walls, creating multiple reflected paths.

Diffraction: When signals encounter sharp edges, aperture, or corners, they bend around the obstacle and create additional paths.

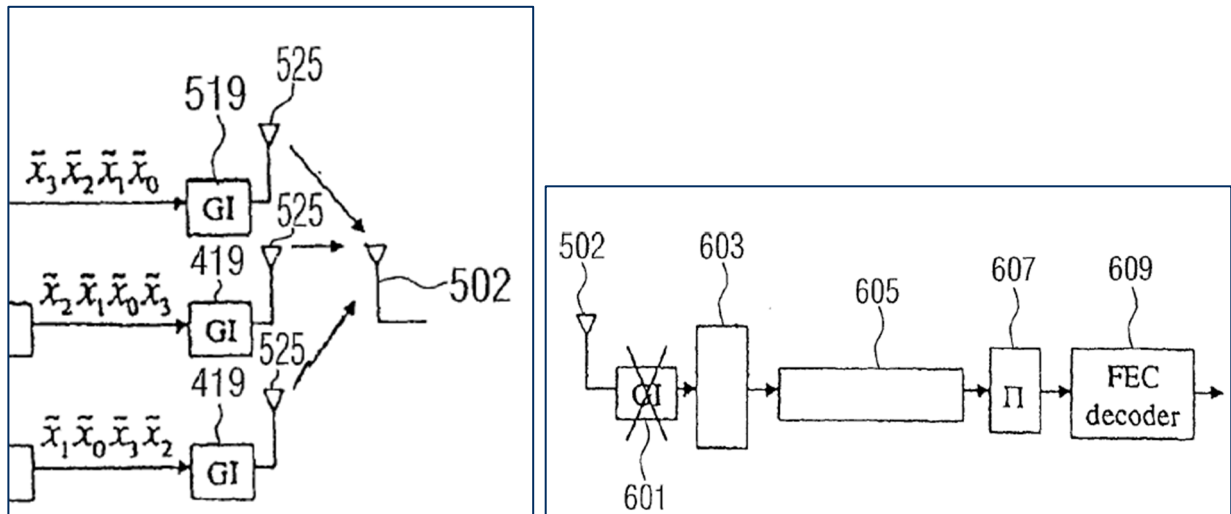
Scattering: Small objects like trees, vehicles, or even atmospheric particles can scatter the signal in various directions.

170. The analysis is essentially the same as in Ground I, Claim 5 (incorporated herein by reference), since the legacy SISO receiver incorporated in

both grounds is the same one that is taught in the '439 Patent's Figure 1 AAPA, which operates the same way in both grounds (as a POSITA would have known and is explained, for example, in the AAPA related to the '439 Patent's description of Figure 4B).

6. Claim 6: The method of claim 4, wherein the legacy OFDM receiver is a single-input, single-output (SISO) receiver device.

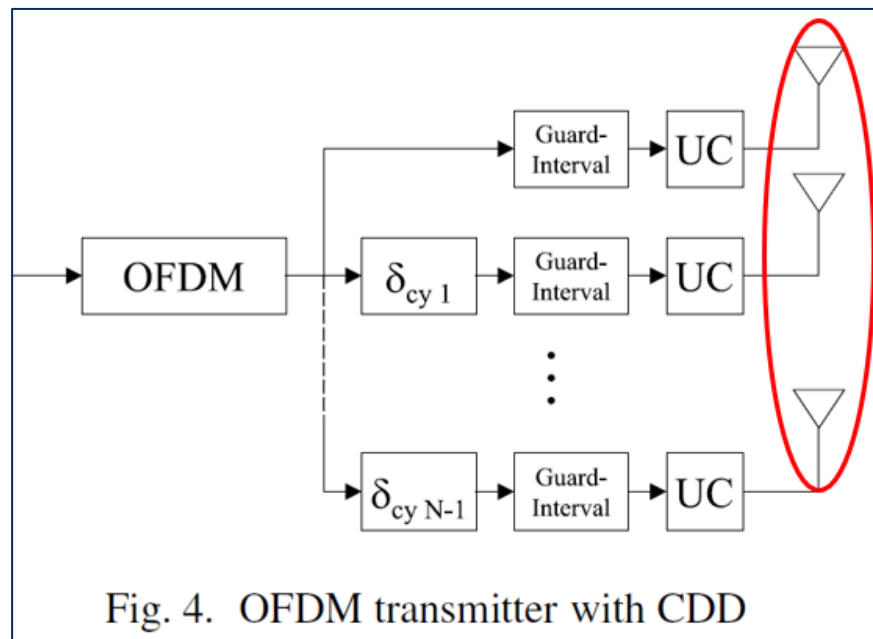
171. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious because Bauch also teaches a legacy SISO receiver device with receiver antenna 502:



EX1007 at 4:28–29 (“At the receiver, a single receive antenna ... can be applied.”), *id.* at Figs. 4 and 5 (cropped). The analysis is therefore substantially the same as in Ground I, Claim 6.

7. **Claim 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.**

172. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. The Reference Signal (corresponding to the first OFDM packet) and the CDD Signal (corresponding to the cyclically shifted version of the OFDM packet) in Kaiser's Figure 3 are transmitted by a multiple-antenna transmitter device that has N number of antennas, represented by the downward-facing triangles:



See EX1006 at Fig. 4 (annotated), 2 (“Fig. 4 shows the block diagram of an N -transmitter-antenna OFDM system with CDD. The OFDM modulated signal is transmitted over N antennas, whereas the particular signals only differ in an antenna specific cyclic shift.”).

8. Claim 8

173. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious.

a. Limitation 8[preamble]: A signal transmitting system for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:

174. In my opinion, Kaiser teaches the preamble. For example, Kaiser teaches that its “Fig. 4 shows the block diagram of an N -transmitter-antenna OFDM system with CDD. The OFDM modulated signal is transmitted over N antennas, whereas the particular signals only differ in an antenna specific cyclic shift.” *See id.* at 2.

b. Limitation 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 comprised of a plurality of samples;

175. In my opinion, Kaiser teaches, or at least renders obvious, this limitation. As discussed above (and incorporated herein by reference) in the context of Claim 1[a][i]-[ii], Kaiser teaches generating a first OFDM packet for transmission including a guard interval portion and a symbol data portion, each comprised of a plurality of samples. *See* § VIII.B.1.b-c. There must have been, or at least obviously would have been, a processor in order to process the signal as taught by Kaiser because otherwise the signal could not be processed as Kaiser teaches. And that processor is a transmit processor because it processes the signal

for transmission, rather than processing the received signal. *See also* Ground I, Limitation 8[a] (my description of why it would have been obvious that there would have been a first transmit processor).

- c. **Limitation 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 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;**

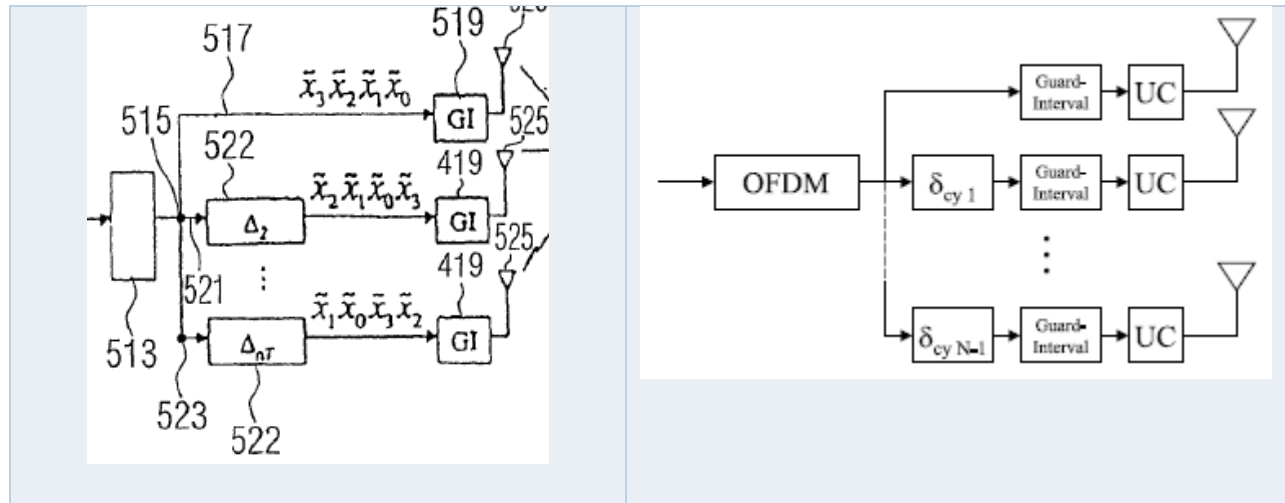
176. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. As discussed above (and incorporated herein by reference) in the context of Claim 1[b][i]-[iii], Kaiser in view of Bauch renders obvious cyclically advancing the first OFDM symbol by shifting the samples in a first direction an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM symbol for transmission in which at least a non-zero number of the samples from the symbol data portion of the first OFDM symbol 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 symbol are shifted out of the guard interval portion of the shifted version. *See* § VIII.B.1.d-f.

177. A POSITA would understand that such functions are performed by a second transmit processor that processes the signal for transmission because there must have been, or at least obviously would have been, a processor in order to generate the shifted signal as taught by Kaiser because otherwise the signal could not be processed as taught by Kaiser. And that second processor is a second transmit processor because it processes the signal for transmission.

178. The “first transmit processor” is the code that generates the first OFDM symbol in accordance with Claim 8[a], while the “second transmit processor” is the code that generates the shifted version of the first OFDM symbol in accordance with Claim 8[b]. These obviously would have been different code modules, for at least two reasons. First, both Kaiser’s Figure 4 and Bauch’s Figure 4 illustrate the cyclic shift as being applied on a separate path connected to a separate antennas relative to the first (unshifted) OFDM symbol, and therefore a POSITA would have understood both Kaiser and Bauch to be teaching two separate transmit processor modules rather than one; otherwise, the figures would have been diagrammed differently if only one transmit processor were processing both packets:

Bauch Fig. 4 (Excerpt)

Kaiser Fig. 4



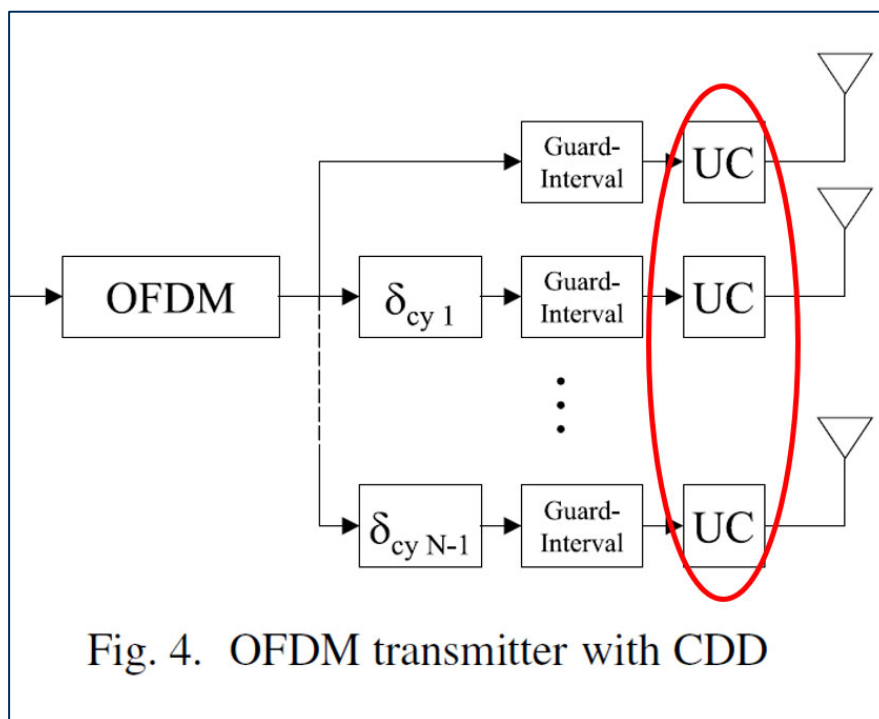
See EX1007 at Fig. 4 (cropped); EX1006 at Fig. 4 (cropped). And second, as a POSITA would recognize, different code modules could be processed in parallel and thus more quickly. Having different code modules for the transmit processors would therefore speed up the system, rather than relying on a single transmit processor for all the processing which could lead to system bottlenecks.

179. As noted above, the '439 Patent does not require that the claimed “first transmit processor” and “second transmit processor” are two physically separate processor devices. See Ground I, Claim 8[b]. But if this limitation is construed to require physically distinct transmit processors, Kaiser in view of Bauch renders this obvious. As shown above in both Kaiser’s and Bauch’s Figure 4, the shifted OFDM symbol is generated separately on a different transmit path to a different physical antenna, apart from the first (non-shifted) OFDM symbol that is provided to another antenna. Thus, a POSITA would have understood, or at least found obvious, that Kaiser and Bauch were both suggesting the use of physically

separate transmit processors associated with physically separate antennas. A POSITA would have been motivated to try this approach, known that this was common in the art, and had a reasonable expectation of success for the same reasons discussed above in Ground I, Claim 8[b]. § VIII.A.8.c.

d. Limitation 8[c]: a plurality of radio transmitters for converting the OFDM packet and the shifted version of the OFDM packet to corresponding radio signals;

180. In my opinion, Kaiser teaches this limitation. Kaiser’s Figure 4 depicts a plurality of radio transmitters that perform the function of “UC” blocks, about which Kaiser teaches: “The functional block ‘UC’ again does upconversion of the signals from the baseband into RF-band”:

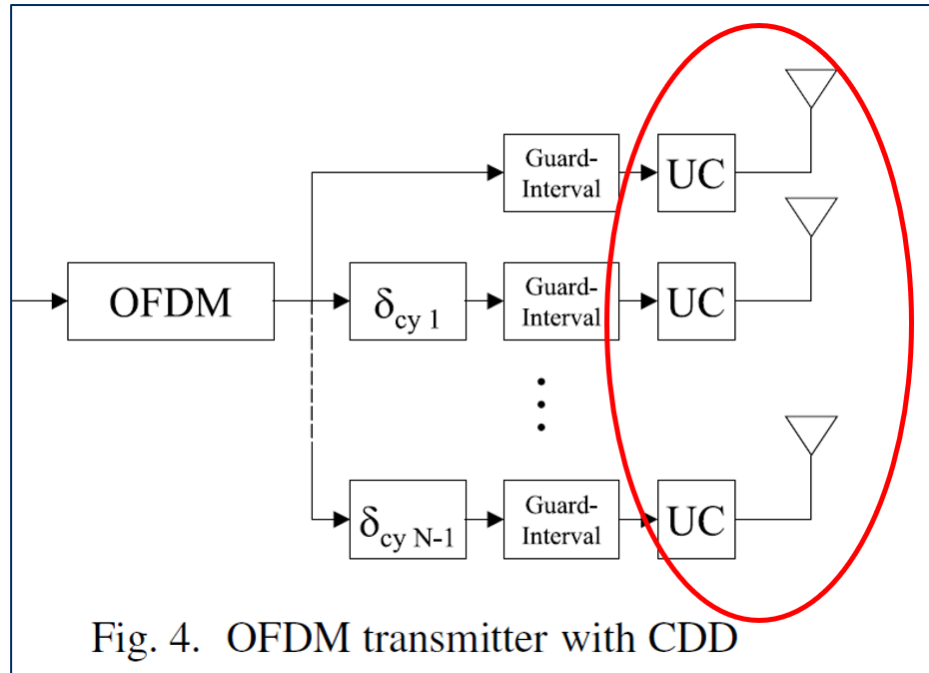


See EX1006 at 2, Fig. 4 (annotated). A POSITA would understand that “RF-band”

refers to signals in the electromagnetic band corresponding to radiofrequency, or “radio signals.” Thus, as a POSITA would expect, Kaiser converts the first (unshifted) OFDM packet and the shifted version of the OFDM packet from data in the baseband to a radio signal so that the signals can be transmitted via radiofrequency waves, and that conversion is performed by Kaiser’s radio transmitters corresponding to the “UC” blocks.

e. Limitation 8[d]: and a plurality of radio antennas correspondingly coupled to the plurality of radio transmitters for transmitting the radio signals;

181. In my opinion, Kaiser teaches this limitation. For example, Kaiser’s Figure 4 teaches a plurality of radio antennas (represented by the downward-pointing triangle, as a POSITA would recognize) that are coupled (as indicated by the direct line connection) to the plurality of radio transmitters (that perform the “UC” block function as discussed in the prior limitation, among others):

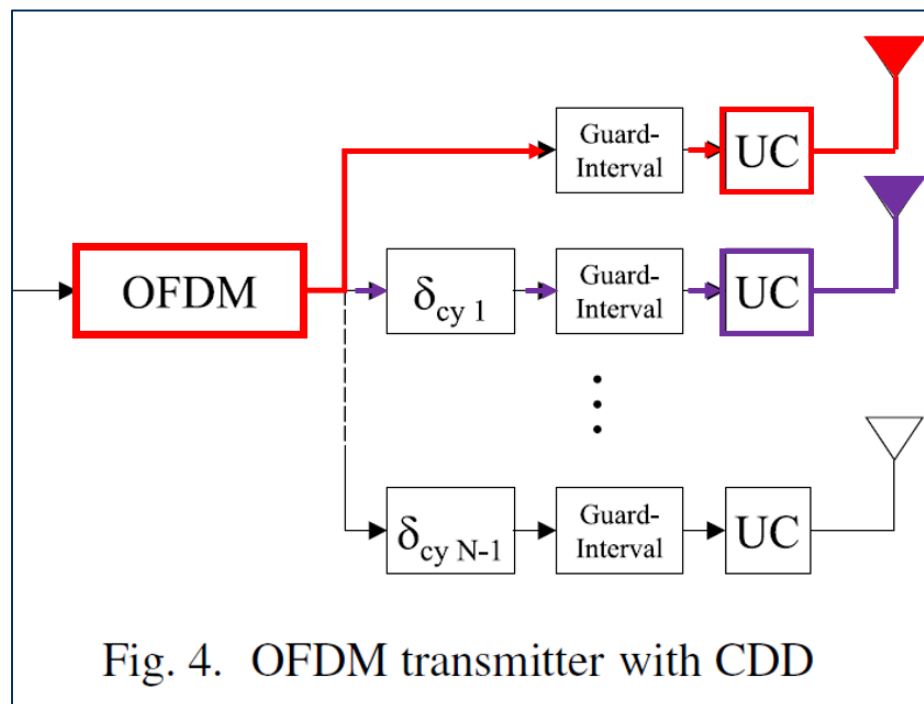


See id. at 2, Fig. 4 (annotated). Kaiser teaches that the plurality of radio antennas is for transmitting the radio signals, as expected given their function and the purpose of the system. *See id.* at 2. (“The OFDM modulated signal is transmitted over N antennas, whereas the particular signals only differ in an antenna specific cyclic shift.”).

- f. **Limitation 8[e]: 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.**

182. In my opinion, Kaiser teaches this limitation. As discussed above (and incorporated herein by reference) in the context of Claim 1[c], Kaiser teaches substantially simultaneously transmitting the first OFDM packet and the shifted

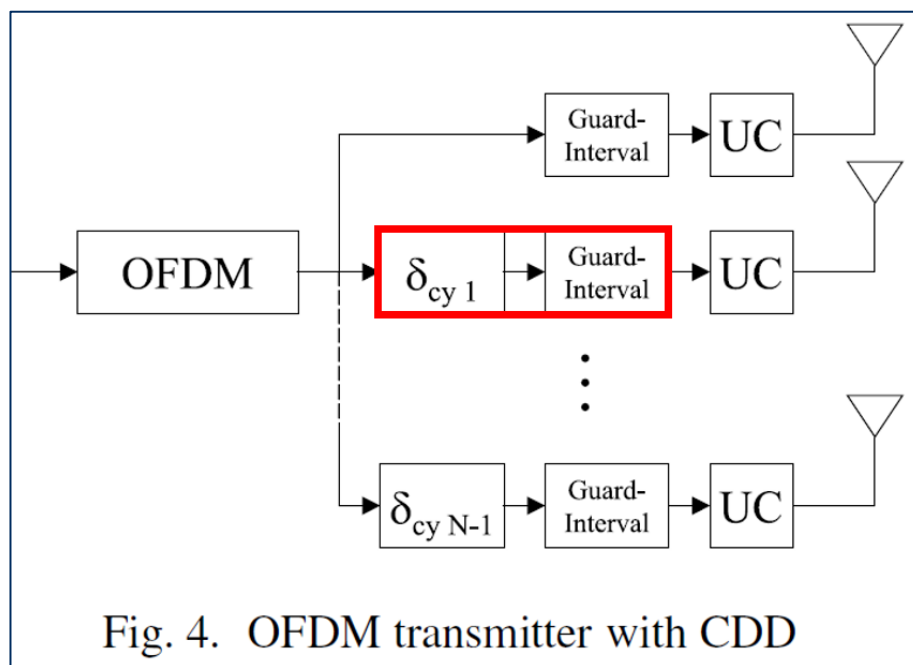
version of the OFDM packet. See § VIII.B.1.g. The system components that are configured to substantially simultaneously cause that transmission are the first transmit processor and the second transmit processor, since those are the processors that generate the first (unshifted) OFDM packet and the shifted version of the OFDM packet, as discussed above in the context of Claim 8[a] and [b]. And these packets are transmitted via corresponding transmitters and antennas, as illustrated for example in the annotated version of Kaiser’s Figure 4 below, showing the first (unshifted) OFDM packet transmitted via the corresponding transmitter (“UC” block) and antenna in red, while the shifted version of the OFDM packet is transmitted via the corresponding transmitter and antenna in purple:



See EX1006 at Fig. 4 (annotated).

9. Claim 9: The system of claim 8, wherein each of the first and second transmit processors includes a cyclic extension module for performing cyclical advancements.

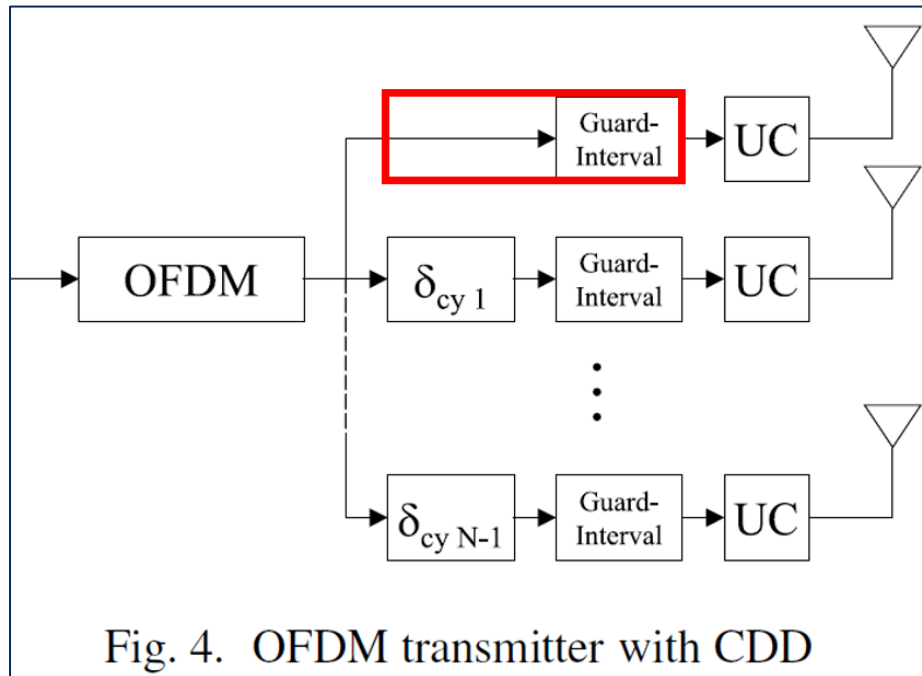
183. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. As noted above, Kaiser's cyclic extensions are used as guard intervals, as a POSITA would have expected. *See id.* at 2 ("Fig. 3 illustrates the difference between DD and CDD in the time domain and shows the transmission of 2 consecutive OFDM symbols with their cyclic prefixes as guard intervals."). The cyclic extension module for performing cyclical shifts is within the second transmit processor depicted in Kaiser's Figure 4:



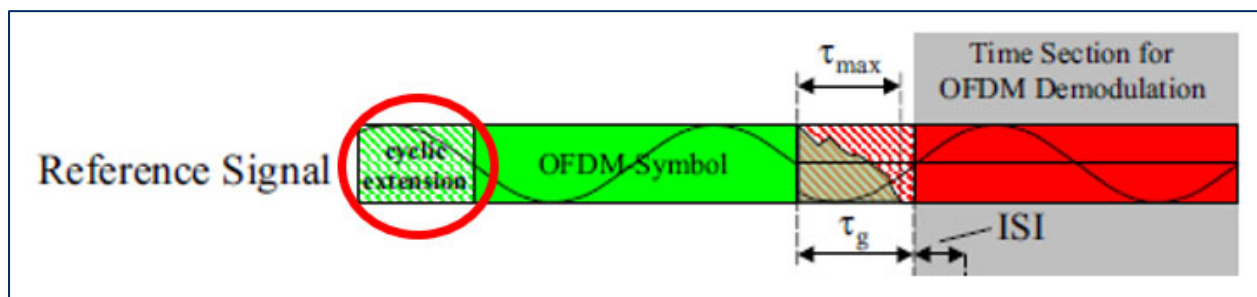
See id. at Fig. 4 (annotated). Applying Bauch's cyclical advancement teaching to Kaiser as proposed in this ground means that the cyclic extension module in the

second transmit processor would be for performing cyclical advancement, not only cyclical delay (as in Kaiser). *See* Claim 8[b].

184. The cyclic extension module for performing cyclic shifts associated with the first transmit processor is not expressly illustrated in Kaiser's Figure 4:



See EX1006 at Fig. 4 (annotated). However, the first transmit processor does have a cyclic extension module, as Kaiser illustrates that even the Reference Signal (which corresponds to the first, unshifted OFDM packet) has a cyclic extension:



See id. at Fig. 3 (cropped, annotated). And although its application for cyclic

shifting is not illustrated, it would at least obviously have had such ability, and there would have been a reasonable expectation of success in ensuring that, for all of the same reasons as I explained multi-antenna OFDM transmitter systems would have had them in Ground I, Claim 9 (incorporated herein by reference).

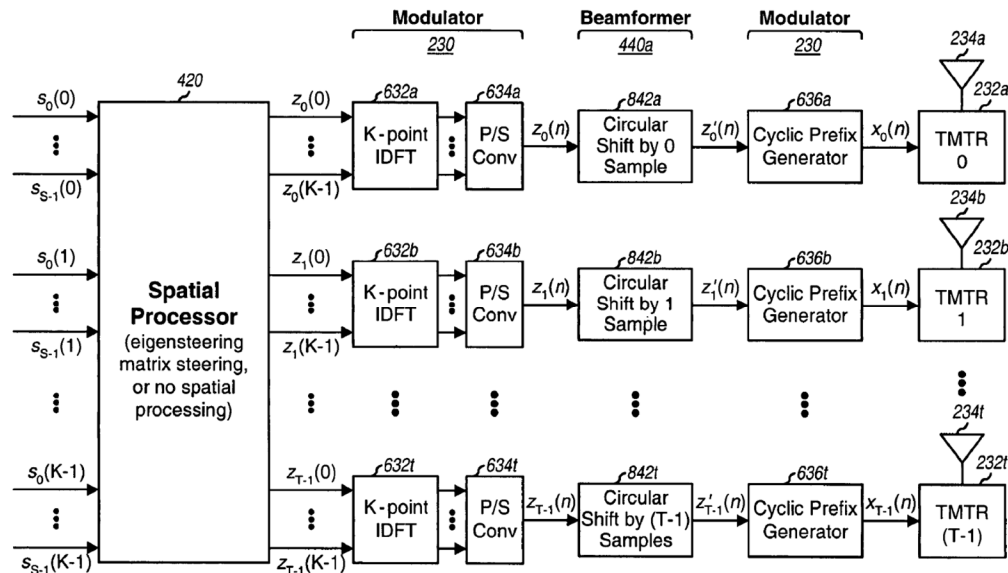


FIG. 8A

EX1012 at Fig. 8A (showing multiple antenna pathways, including an unshifted signal path that contains a module for performing a “Circular Shift by 0 Sample” indicating that the system has this capability and flexibility); *see* EX1002 at 1051 (Examiner: “It would have been obvious to one of ordinary skill in the art at the time the invention was made to use shifting of OFDM symbols on all paths ... as a design choice, [so that] the system will work without [the] use of un shifted OFDM symbol[s] and with any number of paths in the system.”). And, as with the cyclic extension module in the second transmit processor, the cyclic extension module in

the first transmit processor would have been for performing cyclical advancements once Bauch's teachings are applied, as opposed to only for performing cyclical delays as in Kaiser's unmodified system. *See* Claim 8[b].

10. Claim 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.

185. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. As discussed above (and incorporated herein by reference) in the context of Claim 3, Kaiser in view of Bauch renders obvious cyclically advancing the OFDM packet for a duration of less than one half of the sample duration of the guard interval. *See* § VIII.B.3. This Claim 10 is the system counterpart to method Claim 3, and it is the cyclic extension modules identified in Claim 9 that perform the method steps claimed in Claim 3.

186. Bauch only teaches cyclically shifting by one coefficient (in either direction), which is also less than one half of the sample duration of the guard interval, further confirming that a POSITA would have found it obvious that each of the cyclic extension modules should be configured to cyclically advance the OFDM packet for a duration of less than that. *See* EX1007 at 22:25-27 ("Due to the shift introduced by the means 522, the copy of the transformed signal provided via the signal path 521 is shifted by one coefficient.").

- 11. Claim 11: 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 approximately 800 nanoseconds.**

187. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. As discussed above in the context of Claim 2, Kaiser in view of Bauch and IEEE would be configured to cyclically advance the OFDM packet for a duration of less than approximately 800 nanoseconds, as taught by IEEE in order to comply with the standard. Each of the cyclic extension modules in the system of Kaiser in view of Bauch and IEEE would obviously have been so configured because each of them should obviously have been able to comply with the standard; in other words, a POSITA would have known it does not make sense to have some cyclic extension modules comply with the standard while others do not. And, as discussed above in the context of Claim 9, each of the cyclic extension modules would be configured to cyclically advance, even if that particular module is not being used at any given time for cyclical shifting.

- 12. Claim 12: The system of claim 8, wherein the first transmit processor is configured to receive incoming data and interleave the received data into a plurality of sub-carrier channels.**

188. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. Interleaving is the process of arranging the data in a noncontiguous manner, so having sequential data is minimized. By spreading out the data,

interleaving enforces adjacent data to be part of different code words, used for error correction, which helps the error correction algorithms to identify and correct errors more efficiently. By spreading the errors across different symbols, interleaving converts burst errors into random errors, which are easier to correct using Forward Error Correction (FEC) codes. If the data stream is interleaved over several OFDM symbols, a burst error affecting one OFDM symbol will only affect a few bits from each original data block. By spreading the errors across different symbols, interleaving converts burst errors into random errors, which are easier to correct using Forward Error Correction (FEC) codes. If the data stream is interleaved over several OFDM symbols, a burst error affecting one OFDM symbol will only affect a few bits from each original data block.

189. Kaiser teaches that because “of the poor error performance of OFDM in multipath environments, it is necessary for wireless communications systems to use techniques like interleaving.” *See* EX1006 at 1. Thus, as expected, Kaiser teaches a module that receives data (from the inner coding module) and interleaves the received data, as shown for example in Kaiser’s Figure 9. The data is interleaved into a plurality of sub-carrier channels. *See id.* at, *e.g.*, 5 (“The number of used carriers is $K = 1705$. This yields a subcarrier spacing”). IEEE confirms that this was part of the standard. *See* EX1008 at 29 (“All encoded data bits shall be interleaved by a block interleaver with a block size corresponding to the number

of bits in a single OFDM symbol, N_{CBPS} .”). Therefore, the claimed interleaving would have been expected by and obvious to a POSITA in order to ensure that Kaiser’s system complied with the IEEE standard, and further because Kaiser itself already performed such interleaving.

13. Claim 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.

190. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. As I described above, an IFFT module takes QAM symbols and generates amplitude and phase for the assigned subcarriers. An IFFT is used at the transmitter to convert the frequency domain data into time domain, and FFT is used at the receiver to revert the time domain data back into the frequency domain. IFFT is a mathematical transformation that converts the data represented in the frequency domain to the original time domain. The IFFT takes all the frequency components and converts them to time varying signals and outputs the sum of these signals using the subcarriers. These time varying signals are ultimately sent to the antenna for transmission in the air, after having them upconverted from the baseband frequency to the designated frequency.

191. Kaiser’s Figure 9 shows a series of data processing, such as coding and interleaving, followed by an “OFDM” functional block. *See* EX1006 at Fig. 9. Bauch teaches that, after this pre-processing, “OFDM is then implemented by

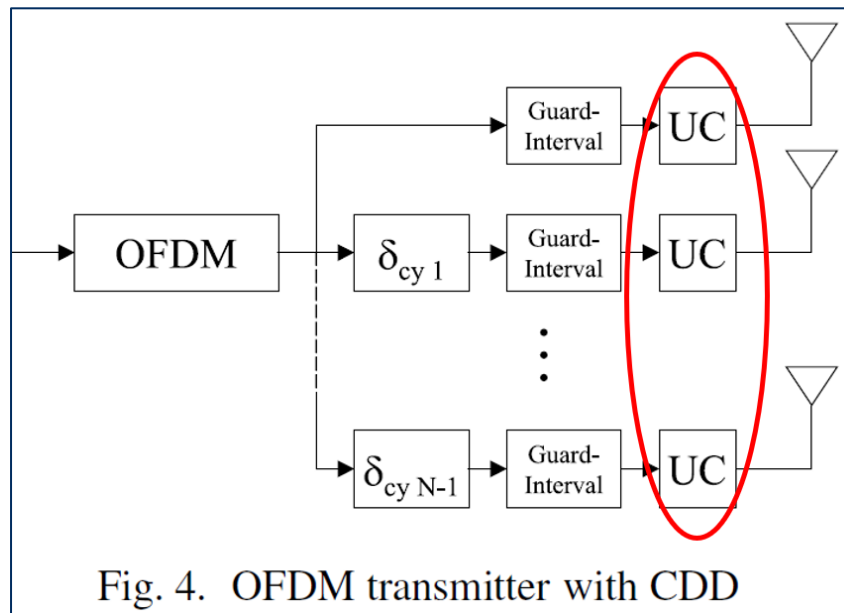
using the transformer 513 being operative to perform the inverse fast Fourier transform (IFFT) of size N_s , where N_s is the number of sub-carriers.” *See* EX1007 at 23:8-11. A POSITA would thus understand, or at least find obvious, that the way Kaiser creates the OFDM symbols from the incoming data represented by those pre-processing blocks is through a code module that performs IFFT functions because that is how Bauch teaches the OFDM symbols are created and that is how a POSITA would have been accustomed to doing so. *See id.* IEEE confirms that IFFT was the “common way to implement” this process, and thus would have, or at least obviously would have, been performed by Kaiser’s system. *See* EX1008 at 23 (“The common way to implement the inverse Fourier transform, as shown in Equation (3), is by an inverse Fast Fourier Transform (IFFT) algorithm.”). And each of the transmit processors would obviously have included such an IFFT module for generating OFDM symbols from the incoming data because otherwise they could not have transmitted OFDM signals and therefore would not be an “N-transmitter-antenna OFDM system” as Kaiser teaches. *See* EX1006 at 2.

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

192. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. Baseband signal is the original signal unmodulated that has not been modulated to higher frequencies before being transmitted by the antenna. This is

done because to transmit the data, it has to be elevated to higher frequencies for the RF circuit, as a POSITA would have known.

193. As shown in Kaiser, the “UC” blocks that perform “upconversion of the signals from the baseband into RF-band” are positioned after the cyclic shift blocks:



See id. at 2, Fig. 4 (annotated). Thus, as a POSITA would recognize, the first and second transmit processors perform their cyclic shifts (which is a cyclic advancement in Kaiser’s system after applying Bauch’s teaching) on baseband signals because the signal has not yet been upconverted into radiofrequency signals.

194. IEEE confirms that this is how the process was supposed to proceed. IEEE teaches a multi-step overview of the process, and step (n) confirms that the up-conversion from “baseband” to “RF” (radiofrequency) occurs after the creation

of the OFDM symbol to which the shift is applied (*see* steps (l)-(m)), such that the transmit processors must perform their cyclical shifts on baseband signals, as a POSITA would have expected. *See* EX1008 at 20 (“l) For each group of subcarriers -26 to 26 , convert the subcarriers to time domain using inverse Fourier transform. Prepend to the Fourier-transformed waveform a circular extension of itself thus forming a GI, and truncate the resulting periodic waveform to a single OFDM symbol length by applying time domain windowing. Refer to 17.3.5.9 for details. m) Append the OFDM symbols one after another, starting after the SIGNAL symbol describing the RATE and LENGTH. Refer to 17.3.5.9 for details.”).

15. Claim 15: The system of claim 8, wherein the first and second transmit processors include application specific integrated circuits (ASICs).

195. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. Kaiser’s transmit processors must be implemented on some kind of physical processor, and an ASIC was an obvious choice for the same reasons as discussed in Claim 15 in Ground I.

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

196. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. As discussed above in Claim 2, Kaiser expressly teaches that its system is compliant with the IEEE 802.11 standard. *See* EX1006 at, *e.g.*, Abstract (“The

focus is on standard compatibility, i.e. this schemes can be implemented to already existing OFDM systems without changing the standards”), 1 (“Orthogonal frequency division multiplexing (OFDM) is a suitable technique for broadband transmission in multipath fading environments and is implemented in new broadcast standards like digital audio broadcasting (DAB) or terrestrial digital video broadcasting (DVB-T) as well as wireless local area network (WLAN) standards such as HIPERLAN/2 or IEEE 802.11a”) (citations omitted), 6 (“The presented antenna diversity schemes can easily be implemented in existing OFDM systems without changing the standards or the receivers.”). Applying Bauch’s techniques to Kaiser’s system would not change the transmitter’s compliance with the IEEE 802.11 standard. As the ’439 Patent recognizes, the cyclic advance can be applied in a manner that is “identical or equivalent” to the cyclic delay, so from the perspective of compliance with the standard, there is no impact in applying Bauch’s technique to Kaiser. *See* EX1001 at 8:5-18 (“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).”).

- 17. Claim 17: The system of claim 8, wherein the first and second transmit processors include field programmable gate arrays (FPGAs).**

197. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. Kaiser's transmit processors must be implemented on some kind of physical processor, and an FPGA was an obvious choice for the same reasons as discussed in Claim 17 in Ground I.

18. Claim 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.

198. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. Kaiser's transmit processors must be implemented on some kind of physical processor, and firmware stored in a memory device and executed by a suitable instruction execution system was an obvious choice for the same reasons as discussed in Claim 18 in Ground I.

19. Claim 19

199. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious.

a. 19[preamble]: A signal transmitting system for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:

200. In my opinion, Kaiser teaches the preamble. *See* Claim 8[preamble].

b. 19[a]: means 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;

201. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. By reference to Claim 8[a], the algorithm by which the transmit processor for generating a first OFDM packet would generate that packet is the algorithm disclosed in the IEEE 802.11 standard because Kaiser's system is expressly intended to and does comply with the IEEE 802.11 standard. *See* Claim 16.

- c. **19[b]: means for cyclically advancing the first OFDM packet including a guard interval portion and a symbol data portion each compromised of a plurality of samples 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 we 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;**

202. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. *See* Claim 8[b].

- d. **19[c]: means for convening the first OFDM packet and the shifted version of the OFDM packet to corresponding radio signals; and**

203. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. By reference to Claim 8[c], the algorithm by which the radio transmitters would convert those packets is the algorithm disclosed in the IEEE

802.11 standard because Kaiser's system is expressly intended to and does comply with the IEEE 802.11 standard. *See* Claim 16.

- e. **19[d]: means for substantially simultaneously causing the transmission of the first OFDM packet and the shifted version of the OFDM packet.**

204. In my opinion, Kaiser in view of Bauch and IEEE renders this limitation obvious. By reference to Claim 8[e], the algorithm by which the transmit processors would cause substantially simultaneous transmission is the algorithm disclosed in the IEEE 802.11 standard because Kaiser's system is expressly intended to and does comply with the IEEE 802.11 standard. *See* Claim 16.

- 20. **Claim 20: The system of claim 19, wherein the cyclic advance has a duration less than one of half of sample duration of the guard interval of the OFDM packet.**

205. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. *See* Claims 3, 10. As discussed above (and incorporated herein by reference) in Claim 3, both the admitted prior art and Kaiser in view of Bauch and IEEE renders obvious a cyclic advance with a duration less than one of half of [sic] sample duration of the guard interval of the OFDM packet because Bauch teaches a one sample shift, and a standard guard interval is 16-samples. *See* EX1007 at 22:25-23:1; VIII.B.3.

- 21. **Claim 21: The system of claim 19, further comprising a legacy receiver, and wherein the cyclical advancements of the shifted version of the OFDM packet cause the legacy receiver to produce a plurality of impulse responses in an**

acquisition process, and wherein each of the first OFDM packet and the shifted version of the OFDM packet corresponds to one of the plurality of impulse responses.

206. In my opinion, Kaiser in view of Bauch and IEEE renders this claim obvious. *See* Claim 4. As discussed (incorporated herein) in Claim 4, Kaiser in view of Bauch and IEEE renders obvious a legacy receiver because as a POSITA would have been aware and the '439 Patent discusses, “there is a need to consider legacy receivers (e.g., single-input, single output (SISO), OFDM receivers),” because not all network participants upgrade their equipment at the same time; accordingly, a POSITA would have obviously accounted for those using legacy receivers. *See* EX1001 at 1:27-29 (“However, 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.”).

207. Cyclical advancements, as delays, cause the legacy receiver to produce a plurality of impulse responses in an acquisition process, and each of the first OFDM packet and the shifted version of the OFDM packet would correspond to one of the plurality of impulse responses because the impulse response “is indistinguishable from ... linear delay diversity” (a plurality of responses in time).

EX1001 at 4:5-22. Thus, Kaiser in view of Bauch and IEEE renders this claim obvious.

IX. OBJECTIVE INDICIA OF NON-OBVIOUSNESS

208. I understand that certain factors called “secondary considerations” or “objective indicia” of non-obviousness may support or rebut an assertion of obviousness of a claim. I understand that such secondary considerations include, among other things, commercial success of the alleged invention, skepticism of those having ordinary skill in the art at the time of the alleged invention, unexpected results of the alleged invention, any long-felt but unsolved need in the art that was satisfied by the alleged invention, the failure of others to make the alleged invention, praise of the alleged invention by those having ordinary skill in the art, and copying of the alleged invention by others in the field. I further understand that there must be a nexus—a connection—between any such secondary considerations and the purported invention.

209. I am not aware of any evidence of objective indicia with a nexus to the Challenged Claims of the '439 Patent that would support a finding of non-obviousness or otherwise impact my analysis.

210. I am not aware of any evidence of commercial success of any products due specifically to the alleged invention in the Challenged Claims, as

opposed to other factors that may have contributed to any commercial success of those products (if there is any commercial success at all), such as marketing.

211. I am not aware of skepticism by those having ordinary skill in the art at the time of the alleged invention regarding the possibility, utility, or success of the alleged invention of the Challenged Claims, nor am I aware of praise of the alleged invention in the Challenged Claims. Prior to my engagement by Petitioners for purposes of providing my opinion herein, I had never heard of the '439 Patent.

212. Patent Owner may contend that there is evidence of unexpected results in Figure 9 of the '439 Patent, but the patent's description of that figure does not evidence unexpected results. As noted above, the '439 Patent first teaches that, "mathematically, a small cyclic advance of 100 nsec is identical or equivalent to a [correspondingly] large delay" of 3100 nsecs where "(the OFM symbol waveform repeats with a period of ... 3200 nsec)" (EX1001 at 8:5-9), but later in the specification, the '439 Patent states: "Experimental testing has shown that legacy radios show significant performance gains in packet error rate with small advancements (e.g., 100 nsec) as opposed to large delays (e.g., that span an almost an entire FFT)." *Id.* at 8:24-27. These "performance gains" would be unexpected given the patent's prior admission that the two are mathematically identical. But the purported evidence cited by the patent (*see id.* at Figure 9) does not truly indicate any performance gains or compare any particular advance, e.g., 100 nsec,

with its corresponding, mathematically equivalent delay, e.g., 3200 nsec. In other words, it is not a like-for-like comparison.

213. Figure 9 of the '439 Patent “is a plot that illustrates packet error performance of cyclic advance diversity compared to cyclic delay diversity.” *Id.* at 8:27-29. Figure 9 purports to show that at a given power level, the packet failure rate is lower with cyclic advance than with cyclic delay. *See id.* at Fig. 9, *id.* at 8:29-34 (“In particular, FIG. 9 shows a plot 900 of the packet error performance (PER) on the y-axis 902 (0.1 corresponds to 10% PER), and the x-axis 904 is the E_b/N_0 ratio in decibels (dB), where E_b is the energy per information bit and N_0 is the (one-sided) noise power spectral density.”) But Figure 9 is neither a comparison of mathematically equivalent advances and delays, nor is it a comparison of small advances and large delays. Instead, the dashed lines in Figure 9 correspond to small cyclic delays of 1 and 2 samples⁷, while the solid lines correspond to slightly larger cyclic advances of 2, 3, and 4 samples. *See id.* at 8:34-40 (“The legend 906 shows numbers -2 through 0 and 2 through 4 . The numbers $2-4$ correspond to cyclic advance diversity of $2-4$ samples, respectively. Two (2) sample shifts is equal to 100 nsec, three (3) sample shifts are equal to 150 nsec,

⁷ The dashed line associated with 0 is the reference signal with no shift in either direction. *See* EX1001 at 8:40-42.

and four (4) samples shifts is equal to 200 nsec. The -1 and -2 are cyclic delays of 1-sample (50 nsec) and 2-samples (100 nsec), respectively.”). But as noted above, what is “identical or equivalent” are small cyclic advances with correspondingly large cyclic delays, which is the opposite of what is shown in Figure 9. *See id.* at 8:5-9 (“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).”).

214. In sum, Figure 9 does not illustrate “Experimental testing [of] small advancements (e.g., 100 nsec) as opposed to large delays,” rather it compares small delays (100 nsec) and small-but-slightly larger advancements (200 nsec). Had the testing been a comparison of small advancements (100 nsec) with correspondingly large delays (3100nsec) (or a comparison of large advancements to correspondingly small delays, or a comparison of the entire range of possible advancements and delays), a POSITA would have instead found “identical or equivalent” results, because, as the ’439 Patent admits, they are mathematically equivalent. *See id.* at 8:5-9 (“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).”). Thus, Figure 9 does not evidence any unexpected “performance gains” as the ’439 Patent asserts because it does not compare small

advances versus large delays. *See id.* at 8:24-27 (“Experimental testing has shown that legacy radios show significant performance gains in packet error rate with small advancements (e.g., 100 nsec) as opposed to large delays (e.g., that span an almost an entire FFT).”).

215. I am not aware of any long-felt but unsolved need in the art that was satisfied by the alleged invention of the Challenged Claims.

216. I am not aware of any failure by others to make the alleged invention of the Challenged Claims.

217. I am not aware of any copying of the alleged invention in the Challenged Claims. I understand from counsel that Patent Owner has accused Petitioners of infringing, but I further understand that Patent Owner has not alleged that Petitioners have specifically copied its patented technology.

X. CONCLUSION

218. Based on the above, it is my opinion that the Challenged Claims of the '439 Patent are obvious.

219. I hereby declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct, and that all statements made of my own knowledge are true and that all statements made on information and belief are believed to be true. I understand that willful false statements are punishable by fine or imprisonment or both. *See* 18 U.S.C. § 1001.

Date: July 31, 2024

Respectfully submitted,

A handwritten signature in black ink, appearing to read 'N. Bagherzadeh', with a long, sweeping horizontal stroke extending to the left.

Nader Bagherzadeh, Ph.D.

APPENDIX OF CHALLENGED CLAIMS

Claim Limitation	Claim Language
1[preamble]	A method for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:
1[a][i]	generating a first OFDM packet for transmission
1[a][ii]	including a guard interval portion and a symbol data portion each comprised of a plurality of samples
1[b][i]	cyclically advancing the first OFDM packet by shifting the samples in a first direction
1[b][ii]	an amount less than a sample duration of the guard interval portion to generate a shifted version of the first OFDM packet for transmission
1[b][iii]	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
1[c]	substantially simultaneously transmitting the first OFDM packet and the shifted version of the OFDM packet.
2	The method of claim 1, further comprising cyclically advancing the OFDM packet for a duration of less than approximately 800 nanoseconds.
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.
4	The method of claim 1, further comprising a legacy receiver, and wherein the cyclical advancements of the shifted version of the OFDM packet cause the legacy receiver to produce a plurality of impulse responses in an acquisition process, and wherein each of the first OFDM packet and the shifted version of the OFDM packet corresponds to one of the plurality of impulse responses.
5	The method of claim 4, wherein an impulse response corresponding to the shifted version of the OFDM packet occurs earlier in time than an impulse response corresponding to the first OFDM packet.
6	The method of claim 4, wherein the legacy OFDM receiver is a single-input, single-output (SISO) receiver device.

Claim Limitation	Claim Language
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.
8[preamble]	A signal transmitting system for transmitting orthogonal frequency division 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;
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 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 radio signals;
8[d]	and a plurality of radio antennas correspondingly coupled to the plurality of radio transmitters for transmitting the radio signals;
8[e]	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.
9	The system of claim 8, wherein each of the first and second transmit processors includes a cyclic extension module for performing cyclical advancements.
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.
11	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 approximately 800 nanoseconds.

Claim Limitation	Claim Language
12	The system of claim 8, wherein the first transmit processor is configured to receive incoming data and interleave the received data into a plurality of sub-carrier channels.
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.
14	The system of claim 8, wherein the first and second transmit processors perform the cyclical advancements on baseband signals.
15	The system of claim 8, wherein the first and second transmit processors include application specific integrated circuits (ASICs).
16	The system of claim 8, wherein the transmitter is an 802.11 compliant device.
17	The system of claim 8, wherein the first and second transmit processors include field programmable gate arrays (FPGAs).
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.
19[preamble]	A signal transmitting system for transmitting orthogonal frequency division multiplexing (OFDM) signals comprising:
19[a]	means 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;
19[b]	means for cyclically advancing the first OFDM packet including a guard interval portion and a symbol data portion each compromised of a plurality of samples 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 we 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;
19[c]	means for convening the first OFDM packet and the shifted version of the OFDM packet to corresponding radio signals; and

Claim Limitation	Claim Language
19[d]	means for substantially simultaneously causing the transmission of the first OFDM packet and the shifted version of the OFDM packet.
20	The system of claim 19, wherein the cyclic advance has a duration less than one of half of sample duration of the guard interval of the OFDM packet.
21	The system of claim 19, further comprising a legacy receiver, and wherein the cyclical advancements of the shifted version of the OFDM packet cause the legacy receiver to produce a plurality of impulse responses in an acquisition process, and wherein each of the first OFDM packet and the shifted version of the OFDM packet corresponds to one of the plurality of impulse responses.