

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

SAMSUNG ELECTRONICS CO., LTD. AND SAMSUNG ELECTRONICS
AMERICA, INC.,
Petitioner,

v.

GENGHISCOMM HOLDINGS LLC,
Patent Owner

Case: IPR2025-00899
U.S. Patent No. 11,431,386

**DECLARATION OF HARRY V. BIMS, Ph.D. IN SUPPORT OF
PETITION FOR *INTER PARTES* REVIEW**

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TABLE OF EXHIBITS

Exhibit	Description
1001	U.S. Patent No. 11,431,386
1002	Declaration of Harry Bims, Ph.D.
1003	Angela Doufexi, et al., <i>Design Considerations and Initial Physical Layer Performance Results for a Space Time Coded OFDM 4G Cellular Network</i> , In The 13th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (Vol. 1, pp. 192-196). IEEE (Sept. 18, 2002) (“Doufexi”).
1004	Dirk Galda & Hermann Rohling, <i>A Low Complexity Transmitter Structure for OFDM-FDMA Uplink Systems</i> , Vehicular Technology Conference. IEEE 55 th Vehicular Technology Conference, vol. 4, pp.1737-1741 (May 6, 2002) (“Galda”).
1005	Stefan Kaiser, <i>Multi-Carrier CDMA Mobile Radio Systems – Analysis and Optimization of Detection, Decoding, and Channel Estimation</i> , VDI-Verlag, Dusseldorf, Germany (Jan. 1998) (ISBN 3-18-353110-0) (“Kaiser”)
1006	Lucent Technologies, <i>Proposed Baseline OFDM Systems for Study</i> , 3GPP TSG-RAN1 #28 bis, R1-02-01246 (Oct. 8-9, 2002) (“Lucent”).
1007	Andres Bury & Jurgen Linder, <i>Comparison of Amplitude Distributions for Hadamard Spreading and Fourier Spreading in Multi-Carrier Code Division Multiplexing</i> , Globecom ’00-IEEE. Global Telecommunications Conference, Vol. 2, pp.857-860 (Nov. 27, 2000) (“Bury”)
1008	Kwang-Cheng Chen, et al., <i>A Programmable Architecture for OFDM-CDMA</i> , IEEE Communications Magazine, pp.76-82 (Nov. 1999) (“Chen”)
1009	José Francia, <i>Proposal for an OFDM-based 802.16.3 Air Interface Physical Layer</i> , IEEE 802.16.3c-00/44 (Oct. 30, 2000)
1010	John Langley, <i>PHY Layer System Proposal for Sub 11 GHz BWA Having SC-FDE and OFDM Modules</i> , IEEE802.16.3c-01/31r2 (Mar. 12, 2001).
1011	U.S. Patent Application Publication No. 2003/0081538 to Walton et al.

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1012	Declaration of Sylvia Hall-Ellis, Ph.D.
1013	Hermann Rohling, et al., <i>Broad-Band OFDM Radio Transmission for Multimedia Applications</i> , Proceedings of the IEEE, Vol. 87, No. 10, Oct. 1999 (“Rohling”)
1014	Stephen B. Weinstein, <i>The History of Orthogonal Frequency-Division Multiplexing</i> , IEEE Communications Magazine, pp.26-35 (Nov. 2009).
1015	Richard van Nee & Ramjee Prasad, <i>OFDM for Wireless Multimedia Communications</i> (Artech House 2000).
1016	Karsten Brünighaus & Herman Rohling, <i>Multi-carrier spread spectrum and its relationship to single-carrier transmission</i> , Vehicular Technology Conference. IEEE 48 th Vehicular Technology Conference, vol. 3, pp.2329-2332 (May 18-21, 1998) (“Brünighaus”).
1017	File History of U.S. Patent Application No. 17/105,574 as obtained from Patent Center
1018	File History of U.S. Patent Application No. 15/283,881 as obtained from Patent Center (excerpts).
1019	File History of U.S. Patent Application No. 14/967,633 as obtained from Patent Center (excerpts).
1020	File History of U.S. Patent Application No. 14/168,466 as obtained from Patent Center.
1021	File History of U.S. Patent Application No. 11/187,107 as obtained from Patent Center (excerpts).
1022	File History of Provisional No. 60/589,187
1023	File History of U.S. Patent Application No. 10/145,854 as obtained from Patent Center (excerpts).
1024	U.S. Patent No. 8,670,390
1025	U.S. Patent No. 8,750,264
1026	U.S. Patent No. 9,048,897
1027	U.S. Patent No. 11,201,644
1028	File History of U.S. Patent Application No. 15/786,270 as obtained from Patent Center (excerpts)

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1029	File History of U.S. Patent Application No. 15/396,567 as obtained from Patent Center (excerpts)
1030	File History of U.S. Patent Application No. 14/727,769 as obtained from Patent Center (excerpts)
1031	File History of U.S. Patent Application No. 14/276,309 as obtained from Patent Center (excerpts)
1032	File History of U.S. Patent Application No. 12/545,572 as obtained from Patent Center (excerpts)
1033	U.S. Patent Application Publication No. 2015/0256308 to Ma et al. (“Ma”)
1034	Declaration of Craig Bishop
1035	3GPP TS 36.306 V8.0.0 (2007-12) (Release 8)
1036	File History of U.S. Patent Application No. 15/489,644 as obtained from Patent Center (excerpts)
1037	File History of U.S. Patent Application No. 15/149,382 as obtained from Patent Center (excerpts)
1038	3GPP TS 36.211 V8.8.0 (2009-09) 3 rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation (Release 8)
1039	Exhibit 1 to Plaintiff’s P.R. 3-1(c) Infringement Contentions (U.S. Pat. No. 9,768,842)
1040	Marco Breiling, et al., <i>Peak-Power Reduction in OFDM without Explicit Side Information</i> , 5 th Int’l OFDM-Workshop 2000 (Hamburg/Germany), Sept. 2000, pp.28-1 to 28-4.
1041	EP 0 734 132 A2 to Kabushiki Kaisha Toshiba (“Toshiba”)
1042	U.S. Patent No. 6,597,745 to Dowling
1043	Gerhard P. Fettweis, et al., <i>A Time Domain View to Multi-Carrier Spread Spectrum</i> , IEEE 6 th Int’l Symposium on Spread-Spectrum & Applications (ISSSTA 2000), (Sept. 6-8, 2000) (pre-print)

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1044	Armin Dekorsy & Volker Kuehn, <i>Exploiting Time and Frequency Diversity by Iterative Decoding in OFDM-CDMA Systems</i> , Seamless Interconnection for Universal Services, Global Telecommunications Conference. GLOBECOM'99, Vol. 5, pp.2576-2580 (Dec. 5, 1999).
1045	Volker Kuehn, et al., <i>Channel Coding Aspects in an OFDM-CDMA System</i> , ITG FACHBRICHT, pp.31-36 (Jan. 2000).
1046	Docket Control Order, <i>Genghiscomm Holdings, LLC v. Samsung Elecs., Am., Inc.</i> , No. 2:24-cv-0242-RWS-RSP, Dkt. 25 (Sept. 24, 2024).
1047	Complaint, <i>Genghiscomm Holdings, LLC v. Samsung Elecs., Am., Inc.</i> , No. 2:24-cv-0242-RWS-RSP, Dkt. 1 (Apr. 12, 2024).
1048	Ka-Hou Chan, <i>A General Method for Generating Discrete Orthogonal Matrices</i> , IEEE Access, Vol. 9, pp.120380-120391 (Sept. 7, 2021).
1049	Interview Agenda from U.S. Patent Application No. 16/194,290 (obtained from Patent Center)
1050	U.S. Patent No. 6,671,287
1051	U.S. Patent No. 6,785,258 to Garcia, Jr., et al. ("Garcia")
1052	Jack Dongarra, et al., <i>Guest editors introduction to the top 10 algorithms</i> , Computing in Science & Engineering 2(01) (2000), pp.22-23.
1053	U.S. Patent No. 6,263,017 to Miller
1054	U.S. Patent No. 6,175,551 to Awater et al.
1055	U.S. Patent No. 5,204,876 to Bruckert et al.
1056	3GPP TS 36.211 V8.7.0 (2009-05) 3 rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical Channels and Modulation (Release 8)
1057	David Astély, et al., <i>LTE: The Evolution of Mobile Broadband</i> , IEEE Communications Magazine, pp.44-51 (Apr. 2009).
1058	M. Rinne, et al., <i>LTE, the radio technology path towards 4G</i> , Computer Communications 33 (2010) pp.1984-1906 (2010)

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1059	Declaration of Gary Swatzell including Exhibits A-D
1060	Guidance on USPTO’s recission of “Interim Procedure for Discretionary Denials in AIA Post-Grant Proceedings with Parallel District Court Litigation” (Mar. 24, 2025).
1061	Docket Control Order, <i>Slyde Analytics LLC v. Apple Inc.</i> , No. 2:24-cv-00331-RWS-RSP, Dkt. 46 (E.D. Tex. Sept. 23, 2024)
1062	Docket Control Order, <i>Innomemory, LLC v. Truis Financial Corp.</i> , No. 2:24-cv-00146-RWS-RSP, Dkt. 38 (E.D. Tex. Sept. 24, 2024)
1063	Docket Control Order, <i>Husky Injection Molding Systems Ltd. V. Ningbo Ao Sheng Mold Co., Ltd. D/B/A Aosimi</i> , No. 2:24-cv-00348-RWS-RSP, Dkt. 46 (E.D. Tex. Oct. 21, 2024)
1064	Docket Sheet for <i>Partec Ag, et al v. Microsoft Corporation</i> , No. 2:24-cv-00433 (downloaded Mar. 25, 2025).
1065	Combined asserted patents in <i>Genghiscomm Holdings, LLC v. Samsung Elecs., Am., Inc.</i> , No. 2:24-cv-0242-RWS-RSP, Dkt. 25 (Sept. 24, 2024).
1066	File History of U.S. Patent Application No. 16/796,888 as obtained from Patent Center (excerpts).
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1070	Results of Docket Navigator Search for ’842 Patent
1071	The title page, page V, page 14, pages 32-24, pages 130-137, page 140, and page 150 of Kaiser, Stefan. <i>Multi-Carrier CDMA Mobile Radio Systems - Analysis and Optimization of Detection, Decoding, and Channel Estimation</i> . Doctoral Dissertation. Department of Computer Science and Engineering, Technische Universität München. Dusseldorf, Germany: Verein Deutscher Ingenieure (VDI) Verlag, ©1998. Obtained from the University of Mannheim Library in Mannheim Germany.
1072	Results of Docket Navigator Search for the ’227 Patent

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1073	A. Gusmão, et al., <i>Comparison of Two Modulation Choices for Broadband Wireless Communications</i> , VTC2000-Spring. 2000 IEEE 51 st Vehicular Technology Conference Proceedings, Vol. 2, pp.1300-1305 (May 15, 2000).
1074	Exhibit 4 to Plaintiff's P.R. 3-1(c) Infringement Contentions (U.S. Pat. No. 11,075,786)
1075	U.S. Patent No. 11,700,162 to Shattil
1076	Simon Haykin, <i>Communication Systems</i> (4 th Ed. John Wiley & Sons, Inc. 2001) (Chapter 4)
1077	U.S. Patent No. 7,436,896
1078	Results of Docket Navigator Search for '786 Patent
1079	Results of Docket Navigator Search for '568 Patent
1080	U.S. Patent Application No. 16/940,383 Electronic Acknowledgment Receipt and Certificate of Correction
1081	File History of U.S. Patent Application No. 16/940,383 as obtained from Patent Center.
1082	U.S. Patent No. 10,644,916
1083	U.S. Patent No. 10,574,497
1084	U.S. Patent No. 10,015,034
1085	U.S. Patent No. 9,800,448
1086	U.S. Patent No. 9,628,231
1087	Exhibit 6 to Plaintiff's P.R. 3-1(c) Infringement Contentions (U.S. Pat. No. 11,252,005)
1088	Results of Docket Navigator Search for '005 Patent
1089	Exhibit 7 to Plaintiff's P.R. 3-1(c) Infringement Contentions (U.S. Pat. No. 11,381,285)
1090	File History of U.S. Patent Application No. 17/183,114 as obtained from Patent Center (excerpts)
1091	File History of U.S. Patent Application No. 12/328,917 as obtained from Patent Center (excerpts)

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1092	File History of U.S. Patent Application No. 13/116,984 as obtained from Patent Center (excerpts)
1093	U.S. Patent No. 10,014,882
1094	U.S. Patent No. 7,430,257 to Shattil (“Shattil-257”)
1095	Search Results for Patent Applications of Steve Shattil
1096	Results of Docket Navigator Search for ’285 Patent
1097	Exhibit 8 to Plaintiff’s P.R. 3-1(c) Infringement Contentions (U.S. Pat. No. 11,424,792)
1098	Results of Docket Navigator Search for ’792 Patent
1099	International Application Publication No. WO 02/054537 to Shattil (“Shattil-537”).
1100	Request for Certificate of Correction from U.S. Patent No. 10,673,758 (withdrawn after issuance)
1101	Request for Certificate of Correction from U.S. Patent No. 10,389,568
1102	Request for Certificate of Correction from U.S. Patent No. 10,778,492
1103	Request for Certificate of Correction for U.S. Patent No. 11,025,468
1104	File History of U.S. Patent Application No. 16/916,901 as obtained from Patent Center
1105	File History of U.S. Patent Application No. 16/426,240 as obtained from Patent Center
1106	Results of Docket Navigator Search for ’508 Patent
1107	File History of U.S. Patent Application No. 17/015,576 as obtained from Patent Center (excerpts)
1108	Kjetil Jacobsen, <i>Ubiquitous Devices United: Enabling Distributed Computing Through Mobile Code</i> , 1999 ACM Symposium on Applied computing, pp.399-404 (Feb. 1999)
1109	Wolfram MathWorld, “Complex Conjugate” (Apr. 18, 2025)
1110	Michael D. Alder, <i>An Introduction to Complex Analysis for Engineers</i> (Jun. 3, 1997).

I, Harry V. Bims, Ph.D., declare as follows:

I. Introduction

1. I am over the age of 21 and am competent to make this declaration.
2. I have been retained on behalf of Petitioner Samsung Electronics Co., Ltd. (“Samsung”) to provide my opinions regarding the validity of claims 1-3, 5-8, 10-12, 14-17, 19-21, and 23-26 (the “Challenged Claims”) of U.S. Patent No. 11,431,386 (EX1001, the “’386 patent”). I submit this declaration based on my personal knowledge and in support of Samsung’s *inter partes* review Petition (the “Petition”) against the ’386 patent.
3. I have been asked to provide my independent analysis of the ’386 patent, in light of the materials cited below and my knowledge and experience in this field during the relevant period. I have been asked to consider whether the references cited in the Petition render obvious the invention described by the Challenged Claims.
4. I am being compensated at my normal hourly rate for my time. My compensation is not contingent in any way on the content of my analysis or the outcome of this proceeding. I am not and never have been an employee or agent of Samsung.
5. My opinions are based on my study, experience, and background discussed below, informed by my extensive experience regarding the subject matter

of the '386 patent and the related prior art. For more than 30 years, since approximately 1981, I have studied, designed, and worked in the field of telecommunications, including wireless communications. During this period, I have designed and implemented various products involving cellular communication technology.

II. Qualifications

6. My findings are also based on my education as an electrical engineer. I received a B.S. in Computer and Systems Engineering from Rensselaer Polytechnic Institute in 1985.

7. I received an M.S. in Electrical Engineering in 1988 and a Ph.D. in Electrical Engineering in 1993, both from Stanford University. As a graduate student, I studied the principle of Digital Communications theory, including data modulation and demodulation, signal constellations and lattices, channel estimation, equalization, filtering, precoding, synchronization, and trellis coding.

8. My Ph.D. thesis addressed the application of trellis coding and precoding to a digital modulation system, and was titled “Trellis Coding for Multi-Level, Partial Response Continuous Phase Modulation with Precoding.”

9. After receiving my Ph.D. in 1993, I worked for Glenayre Technologies – Wireless Access Group, where I worked on applications for wireless communication, including inventing, designing, and building a patented two-way

pager test system and co-developing a wireless application protocol.

10. In January of 1999, I launched a technology consulting company, Protocomm Systems Inc., which focuses on the development of advanced wireless communications protocols and related software implementations for wireless product companies.

11. From 1999 to 2001, I was also the Director of Software Architecture for Symmetry Communications System. In this position, I was responsible for the software architecture for core SGSN (Serving GPRS Support Node) and GGSN (Gateway GPRS Support Node) products for the GPRS (Generic Packet Radio Services) market. I also held management responsibility for the Firmware, Hardware, Performance, and Systems Engineering Groups.

12. In 2001, I developed a business plan for building network infrastructure for Institute of Electrical and Electronics Engineers (“IEEE”) 802.11 standard (“Wi-Fi”) enterprise networks, and then later that year founded AirFlow Networks, Inc. where I invented and received eleven patents on a distributed antenna system design for wireless networks, based on the 802.11 wireless local area network specification.

13. I am currently the President of Protocomm Systems, LLC and Bims Laboratories, LLC, both of which I founded. As the President of Bims Laboratories, I perform technical research in wireless technology standards, such as UMTS, LTE/4G, 5G, Wi-Fi, Bluetooth, and other network communication protocols. I am

named as an inventor of twenty-three telecommunications related patents.

14. In addition, I am a named Technical Expert and former Vice-Chair and Secretary of the IEEE 802.16 Working Group, which develops technical standards for the wireless protocol commonly known as WiMax. I am also a voting member of the IEEE 802.11 Working Group (which develops technical standards for WiFi), and the IEEE 802.15 Working Group (which develops standards for a variety of specialty wireless networks). Within the IEEE 802.15 Working Group, I am the technical editor for IEEE 802.16t, an amendment to the WiMAX standard that supports long-range wireless networks for the railroad industry. Within the IEEE 802.11 Working Group, I routinely participate and vote on discussions relating to the design of wireless communications, including packet prioritization, transmission, acknowledgment, and retransmission.

15. Attached as Appendix A is my curriculum vitae, which includes a more detailed statement of my professional qualifications, including education, publications, honors and awards, professional activities, consulting engagements, and other relevant experience.

III. Materials Considered

16. As described in more detail below, based on my experiences, I understand and know the capabilities of a person of ordinary skill in the art of the '386 patent in August 2004, when the provisional application to which the '386

patent claims priority was filed. I have relevant personal knowledge and experience, in addition to working directly with many such persons in these fields during that time frame.

17. I have also relied on my review and analysis of the prior art cited in the Petition, information provided to me in connection with this case, and information I have independently reviewed.

18. In forming my opinions, I have been asked to review the '386 patent including the specification and the Challenged Claims. I have also considered the materials cited herein, including those itemized in the Table of Exhibits that precedes this declaration.

19. My opinions are based on the materials I reviewed and my knowledge and professional judgment. My opinions have also been guided by my understanding of how a person of ordinary skill in the art would have understood the claims of the '386 patent in the relevant time frame.

20. I also understand from counsel that the prior art references cited herein qualify as prior art under U.S. law.

21. In my analysis below, emphasis in my citations has been added unless otherwise noted. Likewise, annotations to images and figures (typically highlighting of various colors) has been added unless otherwise noted.

22. I reserve the right to supplement and amend any of my opinions in this

declaration based on documents, testimony, and other information that becomes available to me after the date of this declaration.

IV. Legal Standards

23. I am not a lawyer. My understanding of the legal standards to apply in reaching the conclusions in this declaration is based on discussions with counsel for Petitioner, my experience applying similar standards in other patent-related matters, and my reading of the documents submitted in this proceeding. In preparing this declaration, I have tried to faithfully apply these legal standards to the challenged claims.

24. I have been informed that there are two ways in which prior art may render a patent claim unpatentable. First, I have been informed that the prior art can “anticipate” a claim. Second, I have been informed that the prior art can render a claim “obvious” to a person of ordinary skill in the art. I understand that a claim is patentable if it was not anticipated and would not have been obvious by the prior art at the effective filing date of the patent. In this declaration, I only address obviousness.

25. I have been informed that a dependent claim is a patent claim that refers back to another patent claim. I have been informed that a dependent claim includes all of the limitations of the claim to which it refers.

26. I have been asked to provide my opinions as to whether the cited prior

art renders obvious the Challenged Claims of the '386 patent from the perspective of a person of ordinary skill in the art at the '386 patent's earliest possible effective filing date in August 2004, as described in more detail below.

27. I have been informed that in *inter partes* review proceedings, such as this one, the party challenging the patent bears the burden of proving unpatentability by a preponderance of the evidence. I understand that a preponderance of the evidence means “more likely than not.”

28. For purposes of this declaration, I have been asked to provide my opinions on issues regarding unpatentability. I have been informed of the following legal standards, which I have applied in forming my opinions.

A. Level of Ordinary Skill

29. I understand that my assessment of the claims of the '386 patent must be undertaken from the perspective of what would have been known or understood by a person having ordinary skill in the art, reading the '386 patent on its priority date and in light of the specification and file history of the '386 patent. I will refer to such a person as a “POSITA.”

30. I understand that my analysis and opinions expressed in this declaration must be rendered based on the perspective of a POSITA as of the priority date of the '386 patent. I also understand that a POSITA is a hypothetical person who is presumed to know the relevant art at the time of the alleged invention claimed in the

31. I further understand that in determining the level of ordinary skill in the art, I am to consider factors including:

- the type of problems encountered in the art or field of invention,
- prior art solutions to those problems,
- the rapidity with which innovations are made,
- sophistication of the technology, and
- the educational level of active workers in the field.

32. I have been instructed to assume a person of ordinary skill in the art is not a specific real individual, but rather a hypothetical individual having the qualities reflected by the factors discussed above.

33. I understand that a POSITA is a person of ordinary creativity, but not an automaton, and that a POSITA can often fit multiple patents or prior art references together like pieces of a puzzle as a result of this ordinary creativity. I also understand that I may consider the inferences and creative steps that a POSITA would employ. In addition, I understand that a POSITA would necessarily have been capable of understanding the scientific and engineering principles applicable to the pertinent art. I also understand that when I consider what would have been obvious to a POSITA, I am not considering what would have been obvious to me at the time, nor to the inventors, judges, laymen, those skilled in other arts, or to geniuses in the

B. Prior Art

34. I have been advised and understand that the information used to evaluate whether an invention was new and not obvious when made is generally referred to as “prior art.” I understand that prior art includes patents and printed publications that existed before the earliest claimed priority date or the earliest filing date of the patent (which I have been informed is also called the “effective filing date”).

35. I have been informed and understand that a patent or published patent application is prior art if it was filed before the effective filing date of the claimed invention.

36. I have also been informed and understand that a printed publication is prior art if it was publicly available before the earliest filing date and could be located by a POSITA exercising reasonable diligence.

C. Anticipation

37. I understand that a patent is invalid as anticipated if each and every feature of the claim is found, expressly or inherently, in a single item of prior art. I understand that anticipation by inherent disclosure is appropriate only when a prior art reference necessarily includes or discloses the unstated claim element. I also understand that the discovery of a new or previously unreported or unappreciated

property of a prior art composition, or of a scientific explanation for how a prior art composition operates, does not make the prior art composition patentably new to the entity or person that discovered the new property or mode of operation. I further understand that there is no requirement that a POSITA would have recognized the inherent disclosure at the time of the invention.

38. For anticipation by a prior art publication or document, I understand that the reference's description must enable a POSITA to practice the claimed invention without undue experimentation.

D. Obviousness

39. I understand that a claim may be invalid if the subject matter described by the claim as a whole would have been obvious to a POSITA in view of a prior art reference, or in view of a combination of references at the time the claimed invention was made. Therefore, I understand that obviousness is determined from the perspective of a POSITA, and that the asserted claims of the patent should be read from the point of view of such a person at the time the claimed invention was made. I further understand that a POSITA is assumed to know and to have all relevant prior art in the field of endeavor covered by the patent in suit and all analogous prior art. I understand that obviousness in an *inter partes* review proceeding is evaluated using a preponderance of the evidence standard, which means that the claims must be more likely obvious than nonobvious.

40. I also understand that an analysis of whether a claimed invention would have been obvious should be considered in light of the scope and content of the prior art, the differences (if any) between the prior art and the claimed invention, and the level of ordinary skill in the pertinent art involved. I understand as well that a prior art reference should be viewed as a whole. I understand that in considering whether an invention for a claimed combination would have been obvious, I may assess whether there are apparent reasons to combine known elements in the prior art in the manner claimed in view of interrelated teachings of multiple prior art references, the effects of demands known to the design community or present in the marketplace, and/or the background knowledge possessed by a POSITA. I also understand that other principles may be relied on in evaluating whether a claimed invention would have been obvious, and that these principles include the following:

- A combination of familiar elements according to known methods is likely to be obvious when it does no more than yield predictable results;
- When a device or technology is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or in a different one, so that if a POSITA can implement a predictable variation, the variation is likely obvious;
- If a technique has been used to improve one device, and a POSITA would have recognized that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill;
- An explicit or implicit teaching, suggestion, or motivation to combine two prior art references to form the claimed combination may demonstrate

obviousness, but proof of obviousness does not depend on or require showing a teaching, suggestion, or motivation to combine;

- Market demand, rather than scientific literature, can drive design trends and may show obviousness;
- One of the ways in which a patent's subject can be proved obvious is by noting that there existed at the time of invention a known problem for which there was an obvious solution encompassed by the patent's claims;
- Any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed;
- "Common sense" teaches that familiar items may have obvious uses beyond their primary purposes, and in many cases a POSITA will be able to fit the teachings of multiple patents together like pieces of a puzzle;
- A POSITA is also a person of ordinary creativity, not an automaton;
- A patent claim can be proved obvious by showing that the claimed combination of elements was "obvious to try," particularly when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions such that a POSITA would have had good reason to pursue the known options within his or her technical grasp; and
- One should be cautious of using hindsight in evaluating whether a claimed invention would have been obvious.

41. I have been informed that the relevant time for considering whether a claim would have been obvious to a person of ordinary skill in the art is the time of invention. For my obviousness analysis, counsel for Petitioner instructed me to assume that the effective filing date is August 2, 2004, and that I should assume this is the date of invention for the Challenged Claims. My opinions would not change if I assumed a later date of invention.

V. Claim Construction

42. I understand that claim terms in an IPR are generally interpreted according to their ordinary and customary meaning. I further understand that the claims are read in light of the patent's specification and that claims themselves often provide significant guidance as to the meaning of a particular term. I also understand that extrinsic evidence may be helpful when construing a claim term, but that it is less relevant than the intrinsic evidence and is often unreliable.

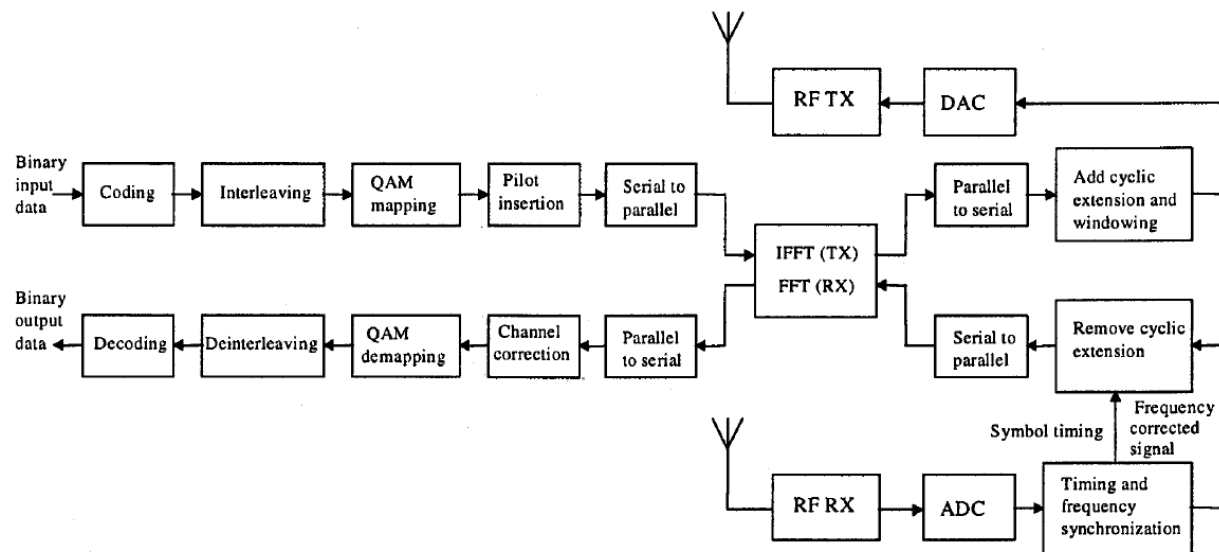
43. The prior art discussed herein would disclose the Challenged Claims under any reasonable constructions, and thus, I believe no formal claim constructions are required.

VI. The '386 Patent

A. General Overview and Background Concepts

44. The '386 patent relates to OFDM wireless communications and processes used in the context of OFDM. OFDM is many decades old.

45. For example, a Prasad textbook from 2000 illustrates an example of an OFDM transceiver:



EX1015-Prasad, 48.

46. OFDM signals are formed at a transmitter using an inverse Fourier transform. It was typical to implement such an inverse transform using a computationally efficient technique called an inverse fast Fourier transform (“IFFT”). EX1015-Prasad, 42, 47-48.

47. After the IFFT, a guard interval including a cyclic prefix was also typically added to minimize intersymbol interference (“ISI”) and intercarrier interference (“ICI”). EX1015-Prasad, 39-40.

48. OFDM signals are received and processed at a receiver using reverse operations compared to the transmitter. For example, where the IFFT of the transmitter modulates data onto subcarriers, the receiver uses an FFT to demodulate the subcarriers. Similarly, the transmitter typically performs other actions including coding, interleaving, and adding a cyclic prefix while the receiver conventionally

performs opposite actions on the data from the transmitter, including removing the cyclic prefix, deinterleaving, and decoding. EX1015-Prasad, 47-48.

49. It was also well known that OFDM systems suffer from high peak-to-average power ratios (“PAPR” or “PAR”). EX1013-Rohling, 1780; EX1014-Weinstein, 31-32. The ’386 patent purports to reduce PAPR in OFDM systems by spreading input data using complex-valued codes, referred to as “CI codes” or “orthogonal polyphase CI codes” obtained from a discrete Fourier transform (“DFT”). EX1001-386 Patent, 48:55-59, 49:3-8, 68:5-40, FIGs. 29A-29B. In the ’386 patent, “CI” is short for “Carrier Interferometry.” *Id.* CI codes include DFT spreading codes, which can be used to reduce PAPR. EX1001-386 Patent, 68:37-40 (“Since rows and columns of the basic CI code matrix resemble the vectors of complex values used in DFTs, the subcarrier weights w_1 to w_N can be calculated using a fast transform algorithm.”).

50. This, too, was known to persons of ordinary skill in that art (“POSITAs”) that OFDM systems exhibited high PAPR, and techniques for reducing that high PAPR were known in the technical literature, including some of the references relied on herein. Indeed, various publications described using DFT spreading codes to reduce PAPR in OFDM systems years before the earliest claimed effective filing date of August 2, 2004 associated with the ’386 patent.

51. For example, in 1998, Brüninghaus (EX1016) observed that when an

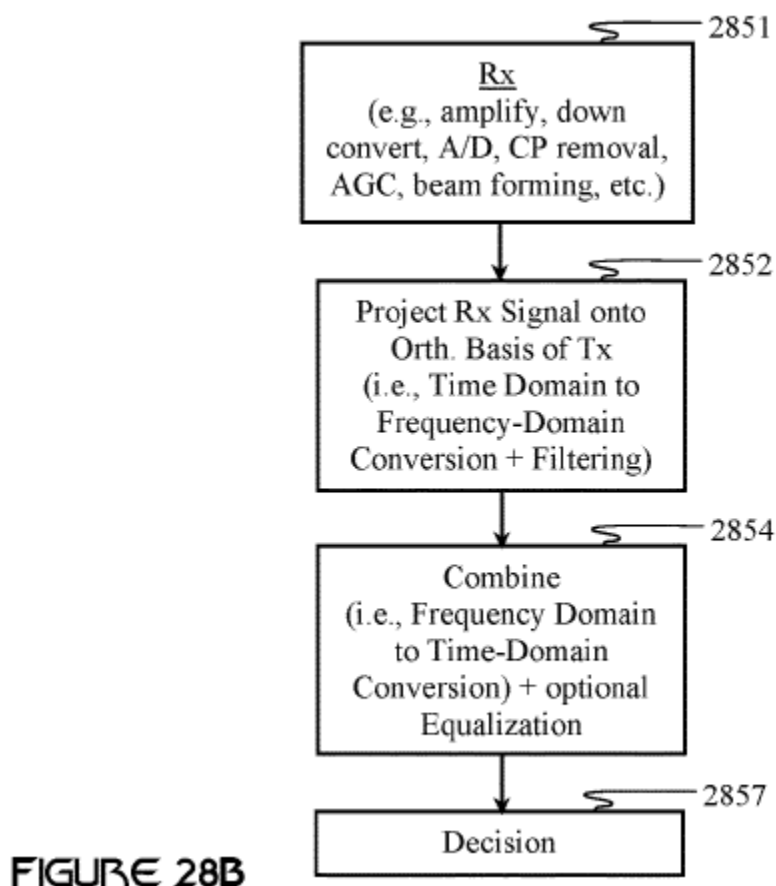
“FFT matrix” is used “as a spreading matrix for OFDM-CDM” signals, this “leads to a single-carrier system with guard interval.” EX1016-Brüninghaus, 2332.

52. Similarly, in 2000, Bury (EX1007) explains that “Fourier spreading” can be “implemented by a discrete Fourier transform (DFT) operation” and the resulting transmission can have a “much lower” PAPR. EX1007-Bury, 857.

53. And by 2002, Galda (EX1004) had built on Brüninghaus’s work to show “how an OFDM-FDMA uplink system can be combined with a user data spreading technique based on the DFT spreading matrix to reduce the PAR of the uplink signal without increasing the computational complexity of the transmitter.” EX1004-Galda, 1738; *see also* 1741 (identifying reference [3] as the Brüninghaus reference, EX1016 herein).

54. The ’386 patent’s independent claims are generally directed to methods, apparatuses, and computer program products for receiving an OFDM signal transmitted by a user device in a wireless network, including determining subcarriers assigned to the user device, converting the OFDM signal to frequency-domain values, and decoding those frequency-domain values to recover data symbols encoded by the user device. EX1001-386 Patent, claims 1, 10, 19. The claimed decoding step uses codes that are “inverse to, complex-conjugate of, or complementary to” the codes utilized by the user device (e.g., on the transmitter side). *Id.*

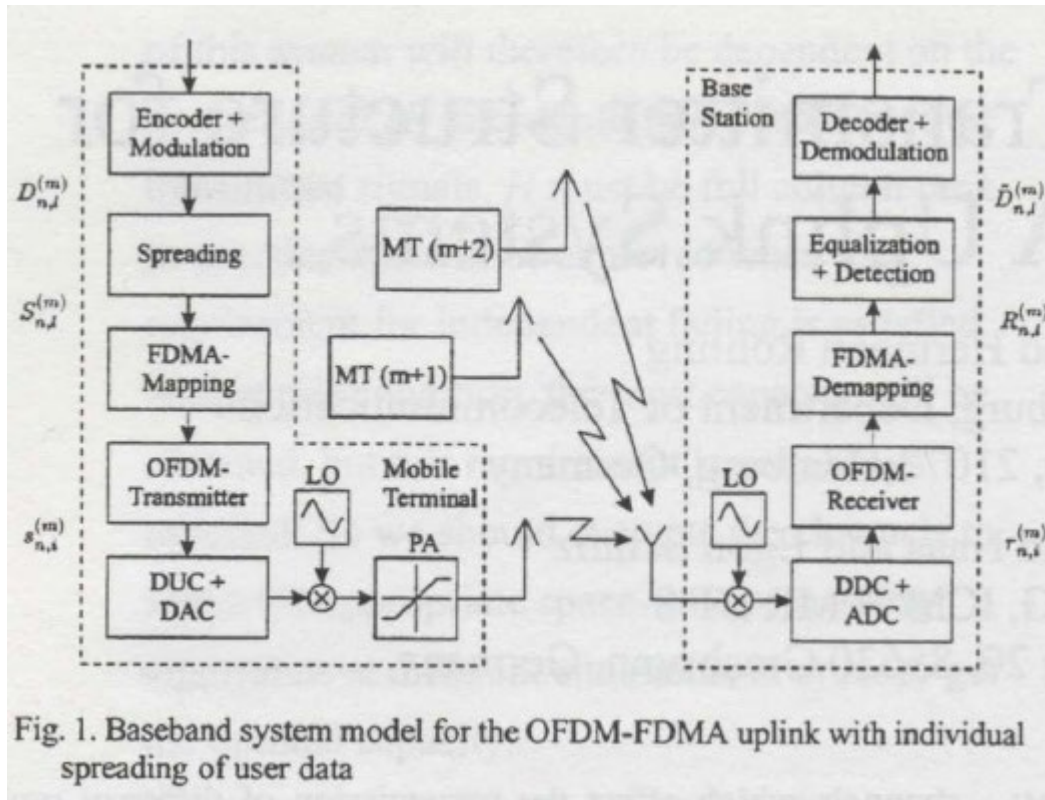
55. FIG. 28B “illustrates a CI reception method and apparatus”:



EX1001-386 Patent at FIG. 28B and 7:2. The first “receiver step” initially processes the signal received from the transmitter. Next, the signal is converted from a time-domain signal to a frequency-domain signal and filtered. The frequency-domain signal is then converted from the frequency-domain to the time-domain, and optionally equalized. The ‘386 patent notes that “a CI decoder may include an equalizer.” The final “Decision” block in the FIG. 28B diagram includes “recovering symbols,” which is also referred to in the ‘386 patent as estimating the data originally

encoded by the transmitter. EX1001-386 Patent, 67:27-48; 31:38-39; 64:13-15; 66:24-30; 67:65-67.

56. A POSITA would have been familiar with these receiver operations in wireless communications. For example, Galda describes a wireless communication system that includes a transmitter side (“Mobile Terminal”) that processes a signal for transmission and a receiver side (“Base Station”) that performs reverse processing of the signal, as shown in Fig. 1:



EX1004-Galda, Fig. 1. On the left of the diagram, the transmitter processes user data symbols (denoted by “ $D_{n,l}^{(m)}$ ” in Fig. 1) by spreading the data symbols with a DFT, FDMA-Mapping the spread data symbols, using an IFFT to modulate the spread data

symbols onto subcarriers, etc. On the right of the diagram, the receiver processes the signal from the transmitter by using an FFT to split the signal into subcarrier channels, FDMA-Mapping, equalization, etc., to recover / estimate the user data symbols (denoted by symbols “ $\tilde{D}_l^{(m)}$ ” in Fig. 1). EX1004-Galda, 1738-40; *see also* Fig. 6(a).

57. Thus, a POSITA would have been familiar with OFDM signal receiver methods to process signals and recover user data transmitted in a network.

B. Prosecution History and Effective Filing Date

58. I provide a very brief background on the prosecution history below, as it relates to the '386 patent.

59. A provisional patent application number 60/598,187 was filed on August 2, 2004. The other patent applications in the chain, 14/727,769, 14/276,309, 12/545,572, and 11/187,107 all include claims about inventions concerning cooperative networking or procedures involving more than one wireless terminal working with one or more other wireless terminals. Application number 17/105,576 was filed on November 26, 2020, and eventually issued as the '386 patent.

60. Because the references relied on in the accompanying IPR petition and in this opinion are dated before the earliest provisional patent application date in August 2004, I have not been asked to opine on whether the '386 patent claims are supported in the original provisional patent application or any of the other patent

C. The Challenged Claims

61. The Challenged Claims of the '386 patent are claims 1-3, 5-8, 10-12, 14-17, 19-21, and 23-26. Claims 1, 10, and 19 are independent claims.

D. Person of Ordinary Skill in the Art (“POSITA”)

62. A POSITA in the August 2004 time frame would have had either a Master’s degree in electrical engineering or a related field, or a Bachelor’s degree in electrical engineering or a related field with three years of experience in wireless communication systems, signal processing, and related technologies. A POSITA would have been familiar with the use of Orthogonal Frequency Division Multiplexing (OFDM) and Orthogonal Frequency Division Multiple Access (OFDMA) in evolving wireless communication standards and 3GPP standards. Techniques including discrete Fourier transform (“DFT”) spreading, modulation comprising the use of inverse discrete Fourier transforms (“IDFT”), and cyclic prefix/guard interval insertion would have been well known to a POSITA.

63. A POSITA would have recognized that DFT-spreading was used to reduce peak-to-average power ratio, including as compared to other spreading codes like Walsh-Hadamard codes, as detailed further with respect to the prior art discussed herein.

64. Additional techniques and tools understood by a POSITA are discussed

65. I have also been asked whether the level of ordinary skill in the art changes if the effective filing date is later—such as in 2020. In my opinion the level of ordinary skill of a POSITA would, if anything, be higher based on advances in technology. But, for the purposes of the opinions I provide in this declaration, the level of skill in the art would not change in any ways material to my opinions.

VII. Overview of the Prior Art

66. I understand that the Petition addresses the following grounds, of which Ground 1 is based on anticipation and Grounds 2 through 4 are based on obviousness. As noted above, my opinion only addresses obviousness.

Ground	'386 Patent Claim	Basis
Grounds 1-2	1-3, 5-8, 10-12, 14-17, 19-21, and 23-26	International Publication No. WO 2002/054537 A1 (“Shattil-537”)
Ground 3	1 and 6-8	Galda in view of Brüninghaus
Ground 4	10, 15-17, 19, and 24-26	Galda in view of Brüninghaus and Dowling

67. I provide a brief overview of the prior art references identified in the Petition below.

A. Shattil-537 (EX1099)

68. Shattil-537 is an International Application Publication that was published on July 11, 2002. EX1099-Shattil-537, cover.

69. Shattil-537 describes a system and method for performing carrier interferometry (also referred to as “CI”) using CI codes that “include families of orthogonal polyphase codes.” EX1099-Shattil-537, Abstract; 1:6-8 (“The present invention relates to Carrier Interferometry (CI). More specifically, the invention relates to applications of CI to multicarrier processing, such as Fourier transforms and coding.”). Shattil-537 explains that CI symbols can include codes derived from a Fourier transform. *Id.*, 24:15-20. Weights (also referred to as CI symbol values) can be applied to data symbols as shown in FIG. 22:

	$s_0()$	$s_1()$	$s_2()$	$s_{N-1}()$
$w_1 = \Sigma():$	$e^{i2\pi(0)(0)/(N-1)}$	$e^{i2\pi(1)(0)/(N-1)}$	$e^{i2\pi(2)(0)/(N-1)}$	$e^{i2\pi(N-1)(0)/(N-1)}$
$w_2 = \Sigma():$	$e^{i2\pi(0)(1)/(N-1)}$	$e^{i2\pi(1)(1)/(N-1)}$	$e^{i2\pi(2)(1)/(N-1)}$	$e^{i2\pi(N-1)(1)/(N-1)}$
$w_3 = \Sigma():$	$e^{i2\pi(0)(2)/(N-1)}$	$e^{i2\pi(1)(2)/(N-1)}$	$e^{i2\pi(2)(2)/(N-1)}$	$e^{i2\pi(N-1)(2)/(N-1)}$
$w_N = \Sigma():$	$e^{i2\pi(0)(N-1)/(N-1)}$	$e^{i2\pi(1)(N-1)/(N-1)}$	$e^{i2\pi(2)(N-1)/(N-1)}$	$e^{i2\pi(N-1)(N-1)/(N-1)}$

EX1099-Shattil-537, FIG. 22.

70. This figure appears to include a typographical error. The same figure was present in at least some of applications related to the '386 patent. In those other applications, a document was submitted to the Patent Office to fix an error in the denominator of the exponent term. Namely, “N-1” should be “N” as indicated in

these other documents. *See* EX1102-COC Req for 468 Patent, 14; EX1100-COC Req for 758 Patent, 7; EX1101-COC Req for 568 Patent, 12; EX1103-COC Req for 492 Patent, 3. The Patent Owner represented that the changes are typographical and do not add new matter. Therefore, this Figure should be interpreted as illustrating DFT coefficients, which typically have a denominator “N” instead of “N-1”.

71. Shattil-537 also describes applying various “CI Parameters” including “Carrier Selection,” and “Carrier Spacing” to the CI transceiver to adapt the operation of the transceiver. EX1099-Shattil-537, 19:20-24, 20:8-9. Shattil-537 describes adjustable carrier spacings and also describes the relationship between carrier spacing and symbol duration:

- “A number of N samples are represented by equally spaced time intervals, such as $\Delta t1$ and $\Delta t2$, corresponding to integer multiples of a desired waveform’s period $T_s = 1/f_s$.” EX1099-Shattil-537, 8:19-20.
- “A process for separating a received signal into orthogonal waveforms may utilize knowledge of carrier separations f_s (and, thus, $T_s = 1/f_s$) of a transmitted multicarrier signal.” EX1099-Shattil-537, 8:12-14.
- “The symbol interval T_s is provided with respect to the relationship $T_s = 1/f_s$ such that at least one data symbol on at least one carrier can be separated from interfering data symbols on one or more carriers that are orthogonal to the desired carrier(s).” EX1099-Shattil-537, 10:8-10.

- “[T]he selector/accumulator 1004 may control symbol duration T_s (i.e., carrier separation f_s).” EX1099-Shattil-537, 14:29-30, FIG. 14.

72. Shattil-537 discloses transceivers and receivers that can receive and process CI signals, such as the CI transceiver shown in FIG. 24:

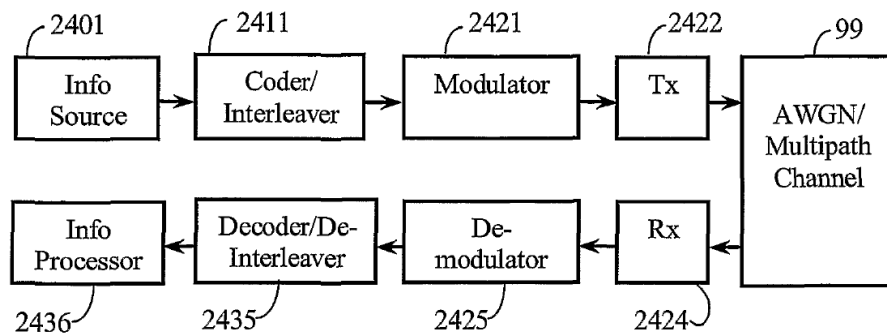


FIG. 24

EX1099-Shattil-537, FIG. 24.

73. In relation to FIG. 24, Shattil-537 explains: “A receiver 2424 couples the transmitted signals from the channel 99. A demodulator 2425 retrieves symbols from the received signal. A CI decoder/de-interleaver 2435 decodes (and de-interleaves, if necessary) the received symbols into information symbols that are optionally processed in an information processor or sink 2436.” EX1099-Shattil-537, 27:26-30.

74. Shattil-537 is analogous to the '386 Patent because both relate to “Carrier Interferometry,” which includes the ability to select subcarriers to achieve a predetermined spectral response. EX1001-386 Patent, 48:55-61; EX1099-Shattil-

537, 1:6-8. But for the typographical error discussed above (“N” instead of “N-1” in the denominator), Shattil-537 and the ’386 patent show how polyphase CI codes are applied to subcarriers to generate “weights” in essentially the same way:

$$\begin{array}{c}
 \begin{array}{cccc}
 d_1() & d_2() & d_3() & d_N() \\
 w_1 = \Sigma(): & e^{j2\pi(0)(0)(N)} & e^{j2\pi(1)(0)(N)} & e^{j2\pi(2)(0)(N)} & e^{j2\pi(N-1)(0)(N)} \\
 w_2 = \Sigma(): & e^{j2\pi(0)(1)(N)} & e^{j2\pi(1)(1)(N)} & e^{j2\pi(2)(1)(N)} & \dots & e^{j2\pi(N-1)(1)(N)} \\
 w_3 = \Sigma(): & e^{j2\pi(0)(2)(N)} & e^{j2\pi(1)(2)(N)} & e^{j2\pi(2)(2)(N)} & \dots & e^{j2\pi(N-1)(2)(N)} \\
 \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
 w_N = \Sigma(): & e^{j2\pi(0)(N-1)(N)} & e^{j2\pi(1)(N-1)(N)} & e^{j2\pi(2)(N-1)(N)} & \dots & e^{j2\pi(N-1)(N-1)(N)}
 \end{array}
 \end{array}$$

FIGURE 29B

$$\begin{array}{c}
 \begin{array}{cccc}
 s_0() & s_1() & s_2() & s_{N-1}() \\
 w_1 = \Sigma(): & e^{j2\pi(0)(0)(N-1)} & e^{j2\pi(1)(0)(N-1)} & e^{j2\pi(2)(0)(N-1)} & e^{j2\pi(N-1)(0)(N-1)} \\
 w_2 = \Sigma(): & e^{j2\pi(0)(1)(N-1)} & e^{j2\pi(1)(1)(N-1)} & e^{j2\pi(2)(1)(N-1)} & e^{j2\pi(N-1)(1)(N-1)} \\
 w_3 = \Sigma(): & e^{j2\pi(0)(2)(N-1)} & e^{j2\pi(1)(2)(N-1)} & e^{j2\pi(2)(2)(N-1)} & e^{j2\pi(N-1)(2)(N-1)} \\
 \vdots & \vdots & \vdots & \vdots & \vdots \\
 w_N = \Sigma(): & e^{j2\pi(0)(N-1)(N-1)} & e^{j2\pi(1)(N-1)(N-1)} & e^{j2\pi(2)(N-1)(N-1)} & e^{j2\pi(N-1)(N-1)(N-1)}
 \end{array}
 \end{array}$$

FIG. 22

EX1001-386 Patent, FIG. 29B; EX1099-Shattil-537, FIG. 22.

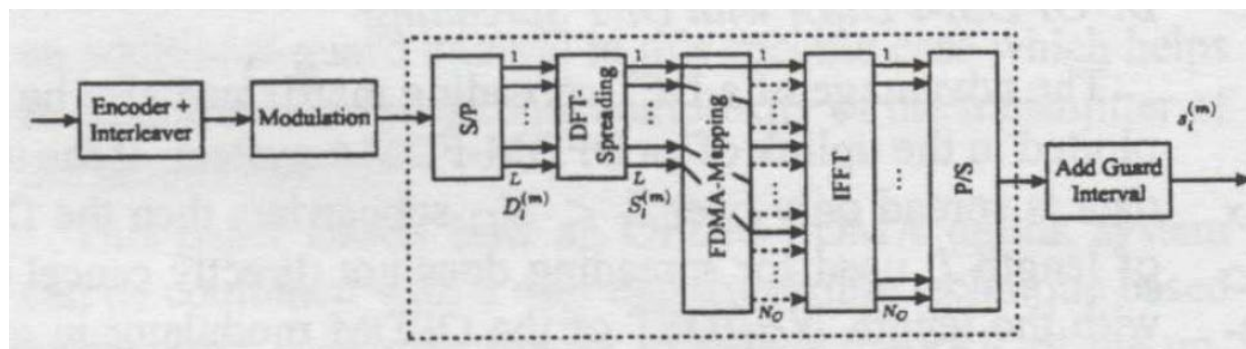
75. Therefore, Shattil-537 and the ’386 patent are in the same field and Shattil-537 is reasonably pertinent to problems that the inventor was allegedly seeking to solve. This is because Shattil-537 describes the use of the same techniques on multicarrier signals as the ’386 Patent.

B. Galda (EX1004)

76. Galda is an article published in proceedings for the IEEE’s 55th Vehicular Technology Conference. The papers published in these proceedings were available by at least May 6, 2002, as well as during the conference (between May 6 and 9, 2002) for review and purchase. EX1059-Swatzell-Decl. In particular, I understand from counsel that the conference proceeding papers were distributed to attendees at the conference, the conference was open to the public, there were no

confidentiality restrictions, and the papers were available for review and purchase there as well. I understand this means that Galda qualifies as prior art. I also understand that the Galda reference itself was available in engineering libraries by at least June 26, 2002, as well as available from the IEEE website by at least August 7, 2002. I also understand that Galda was cataloged and categorized by subject matter, including “mobile communication systems.” This categorization would have enabled a POSITA interested in wireless communication systems, signal processing, and related technologies to find Galda through reasonably diligent search efforts. Thus, I understand that Galda qualifies as prior art.

77. Galda discloses an OFDM transmitter that reduces PAPR (PAR) using “OFDM-FDMA multiple access ... combined with a data spreading technique based on a Discrete Fourier Transform spreading matrix using only the user specific subcarriers.” EX1004-Galda, 1737. In addition to being shown in Figure 1, Galda’s transmitter is illustrated in Fig. 6(a).



78. Galda also discloses receivers and receiver functions. For example, Galda notes that a receiver can process a “received time signal,” i.e., a signal in the time domain, “by ... calculating the Fourier transformation (FFT) which splits the time signal into the orthogonal subcarrier channels and finally selecting the user specific complex valued symbols $R_l^{(m)}$ at the FFT output.” “An estimate of data symbols $\tilde{D}_l^{(m)}$ can then be calculated independently for each user by applying any single- or multi-code detection techniques.” Galda describes these techniques as “well known from OFDM-CDMA receiver structures.” EX1004-Galda, 1738-39.

79. Galda is analogous art to the '386 Patent because it relates to techniques for receiving an OFDM signal that is transmitted by a mobile device in a wireless network and that uses “complex values used in DFTs” to spread data symbols before OFDM modulation. EX1001-386 Patent, Abstract, 68:37-40; EX1004-Galda, 1737-1739, Fig.1. Like the '386 patent, Galda's signal processing includes a receiver that performs operations to reverse signal processing done in the transmitter. EX1004-Galda, 1738-40; *see* EX1001-386 Patent, Abstract; *see also* 67:13-48, FIGS. 28A-28B. Galda is also analogous because one of the problems facing the inventor was “bandwidth limitations. EX1001-386 Patent, 8:40-42, 9:29-34. Galda addresses the same problem. EX1004-Galda, 1737. Also, the '386 patent and Galda both reduce

peak-to-average power ratios with DFT spreading code techniques. EX1001, 48:55-59; EX1004, pp.1737, 1738, 1741; EX1002, ¶¶77, 79.

C. Brüninghaus (EX1016)

80. Brüninghaus is a conference paper from the 48th IEEE Vehicular Technology Conference held in May 1998. EX1016-Brüninghaus, 1. Exhibit 1016 was obtained from the Linda Hall Library. EX1012-Ellis-Decl, ¶72. It was cataloged into that library as of July 16, 1998. EX1012-Ellis-Decl, ¶75. It was cataloged by subject matter including “Mobile communication systems \$v Congresses,” which would have been sufficient to allow for a POSITA to locate Brüninghaus based on subject matter. EX1012-Ellis-Decl, ¶77. As a further indication of its accessibility to those skilled in the art, Brüninghaus has been cited in other scholarly works. EX1073-Gusmão, 1305 (reference [7]); EX1004-Galda, 1741 (reference [3]); EX1007-Bury, 860 (reference [4]). Brüninghaus is thus prior art under pre-AIA §102(b) or post-AIA §102(a)(1).

81. Brüninghaus describes that “[t]he combination of orthogonal frequency division multiplexing (OFDM) and code division multiplexing (CDM) has found great interest during the last few years.” EX1016-Brüninghaus, 2329. Brüninghaus also discloses that “[s]ince the single-carrier system which results from an OFDM-CDM system with Fourier spreading matrix is a special case of an OFDM-CDM system, the same detection algorithms can be applied and the same performance can

be expected.” EX1016-Brüninghaus, 2330. “In case of a Fourier spreading matrix, despreading in the receiver is achieved by an inverse Fast-Fourier matrix, i.e. $[H]^H = [\text{IFFT}]$.” EX1016-Brüninghaus, 2330.

82. Brüninghaus is analogous to the '386 patent's techniques for receiving an OFDM signal that was transmitted by a mobile device in a wireless network, including using “columns of a Fourier matrix” to spread the data symbols before OFDM modulation. EX1001-386 Patent, Abstract, 68:37-40; EX1016-Brüninghaus, 2329, 2332. Brüninghaus is also analogous because one of the problems facing the inventor was to reduce PAPR (peak-to-average power ratio) in OFDM systems, including by using DFT spreading codes, EX1001-386 Patent, 48:55-59, 68:35-40, and Brüninghaus describes a problem in OFDM as being “a high dynamic which requires a linear power amplifier in the transmitter” and a solution of “reduc[ing] the signal dynamic” with a “Fourier-matrix” for spreading, EX1016-Brüninghaus, 2330.

D. Dowling (EX1042)

83. Dowling is U.S. Patent No. 6,597,745, which was filed on April 6, 1999 and issued July 22, 2003. EX1042-Dowling, cover. I understand Dowling qualifies as prior art.

84. Dowling discloses multicarrier modulation and OFDM systems that may be implemented as software modules. Such modules execute on programmable processor architectures; in other words, transmitters, receivers, and precoders may

be implemented in either hardware or software. EX1042-Dowling, 3:46-50, 5:66-6:1.

85. Dowling is also analogous art to the '386 patent at least because both are in the field of wireless communications, and more specifically relate to multicarrier systems. EX1042-Dowling, Abstract, 1:6-12 (“field” relates to “data transmission,” more specifically to a “precoder” for multicarrier (e.g., OFDM) systems, as well as related “multi-carrier transmitter and receiver structures”), 21:62-64 (invention “applied to other FFT based multicarrier modulation and OFDM systems.”); *see* EX1001-386 Patent, 48:55-60 (“aspects provide a multicarrier protocol”); 49:3-8 (“communication protocol that ... provides the low-PAPR benefits of single-carrier modulation to multicarrier communication systems”).

VIII. GROUND 1 and 2: 1-3, 5-8, 10-12, 14-17, 19-21, and 23-26 are (Ground 1) anticipated by or (Ground 2) obvious over Shattil-537

A. Challenged Claims

1. Independent Claim 1

[1Pre] “A method for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, comprising:”

86. Shattil-537 teaches the preamble.

87. Shattil-537 discloses: “CI filtering may be performed by receivers designed for multicarrier transmission protocols, such as OFDM[.]” EX1099-Shattil-537, 8:26-29; *see also* 1:29 (“CI may also be applied to orthogonal frequency

division multiplexing.”). Shattil-537 also claims “[a] method of performing CI processing of at least one received single-carrier signal ... including ... providing for decomposition of the at least one received single-carrier signal into a plurality of CI components” EX1099-Shattil-537, 36:17-21; *see also* 5:16-18 (defining “CI Components” to be “CI carriers or CI symbol values,” the latter of which “are complex values (or weights) for a plurality of CI carriers”), 17:31-18:3 (“FIG. 15C illustrates a CI reception method.”), 21:20-21 (“CI codes may be applied to ... OFDM”), 21:29-31 (“Multicarrier signals may be defined by any set of substantially orthogonal diversity parameters” such as “frequency....”).

88. Shattil-537’s reception methods include receiving OFDM signals transmitted by a user device in a wireless network. For example, Shattil-537 describes a “CI transmitter adapted to generate at least one CI-coded information signal,” that can then be “coupled to a transmission system 2102 that may include a pre-transmission processor (not shown),” EX1099-Shattil-537, 24:30-34, and describes “the many wireless applications of the invention” as including “cellular communications,” EX1099-Shattil-537, 2:20-21. A POSITA would have understood that such cellular communications applications include transmitters on user cellular phones, which correspond to “a user device in a wireless network” as stated in 1Pre. Cellular phones were “becoming ubiquitous” by the earliest claimed effective filing date of the ’386 patent of August 2, 2004. EX1108-Jacobsen, 399 (“cellular phones

... are becoming ubiquitous”)). Therefore, it would have been obvious to implement the CI techniques described by Shattil-537 in a transmitter within a user device.

89. Thus, Shattil-537 teaches the preamble.

[1A] “determining a plurality of subcarrier frequencies allocated to the user device;”

90. Shattil-537 teaches this limitation.

91. Shattil-537 discloses a process it calls “[c]arrier selection,” which is an example of determining subcarrier frequencies. Shattil-537 explains that carrier selection can be performed on the transmitter side or on the receiver side: “Carrier selection may include either or both transmit-side carrier selection with respect to one or more predetermined CI carrier parameters to generate at least one transmit signal and receive-side carrier selection to decompose at least one signal into CI components.” EX1099-Shattil-537, 5:8-10.

92. Shattil-537 describes the process of “decomposing a single-carrier signal into a plurality of component values representing overlapping narrowband carrier signals” as including using a “predetermined time interval” called “ T_s ” (referred to as the “sample period” by Shattil-537) to specify “a set of orthogonal frequencies f_n .” EX1099-Shattil-537, 16:25-31; *see also* 9:32-33. This is an example of how Shattil-537 performs a step of determining (i.e., selecting) a plurality of subcarrier frequencies.

93. In another example, Shattil-537 explains that: “A received signal is decomposed 1504 into a plurality of CI carriers. Carrier properties, such as frequency selection, frequency spacing, and complex weighting are selected, at least in part, with respect to the channel estimates.” EX1099-Shattil-537, 17:17-19. A POSITA would find it obvious that carrier frequency selection would include selection of subcarrier frequencies. For example, Shattil-537 also notes that “[e]ach carrier may be modulated with one or more CI code chip encoded subcarriers.” EX1099-Shattil-537, 21:26-27. Therefore, selecting the carrier / subcarrier frequencies as disclosed in Shattil-537 is an example of “determining a plurality of subcarrier frequencies” as in Limitation 1A.

94. The subcarrier frequencies that are selected in Shattil-537’s are “allocated to the user device” because the transmitter and receiver are used to identify “desirable and/or undesirable spectral regions,” which includes “a spectral range 1412 allocated to another user, application, or system.” EX1099-Shattil-537, 17:6-7, 17:16-17, 16:35-17:2. Shattil-537 describes multicarrier transmission involving “phase-shift coding [that] may be accomplished” by modulating “[e]ach carrier ... with one or more CI code chip encoded subcarriers.” EX1099-Shattil-537, 21:20-27.

95. Therefore, a POSITA would have understood that the determination of the subcarriers, as described in Shattil-537, determines the subcarriers “allocated to

the user device” because it excludes subcarriers that are “allocated to another user, application, or system” at the receiver. EX1099-Shattil-537, 16:35-17:2.

96. Thus, Shattil-537 teaches this limitation.

[1B] “converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and”

97. Shattil-537 teaches this limitation.

98. Shattil-537 discloses that “CI may also be applied to [OFDM]” and “N-point transforms used in OFDM, such as fast Fourier transforms (FFTs) and inverse FFTs (IFFTs), essentially map one set of data symbols onto another set of data symbols.” EX1099-Shattil-537, 1:29-31. This is an example of “converting the OFDM signal to a plurality of frequency-domain values.” This is shown in further detail in connection with Shattil-537’s Figure 18, which shows “[r]eceived signals” (“Rx I&Q,” referring to in-phase and quadrature-phase signals) that “are separated into orthogonal components by an FFT processor 1821.” EX1099-Shattil-537, 19:25-26.

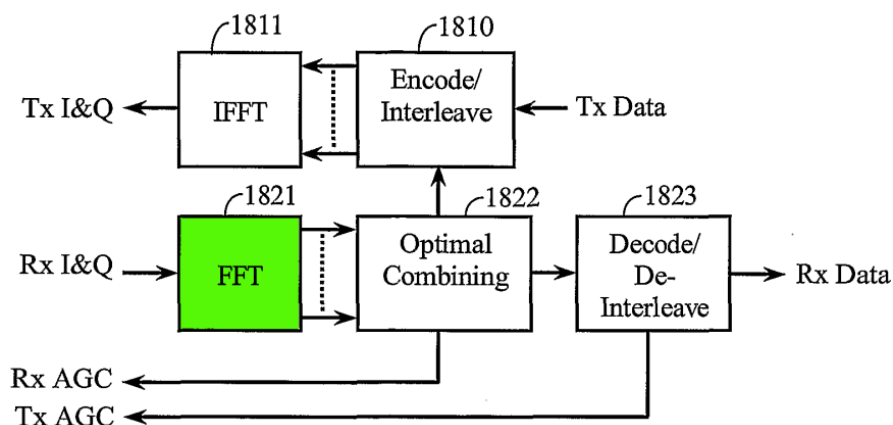


FIG. 18

EX1099-Shattil-537, FIG. 18.

99. Shattil-537 teaches that a FFT converts “a time-domain signal” $x(t)$ into a frequency-domain expression, $X(f_n)$. EX1099-Shattil-537, 11:7-18. Shattil-537 further explains that “[w]hen a signal is decomposed into carrier components, each carrier frequency f_n is associated with a complex-valued symbol v_n Fourier transforms or equivalent operations may be performed.” EX1099-Shattil-537, 16:25-30. Thus, in Shattil-537, the OFDM time signal from the transmitter is decomposed into frequency domain values in the form of “complex-valued symbol[s] v_n ,” which correspond to the subcarrier frequencies, namely “each carrier frequency f_n is associated with a complex-valued symbol v_n ”. EX1099-Shattil-537, 16:25-30. These frequency domain values (complex-valued symbols (v_n)) are referred to in Shattil-537 as “CI symbol values,” which “are complex values (or weights).” Shattil-537 also sometimes abbreviate these values as “w” when

describing the CI coding processes. EX1099-Shattil-537, 5:16-18; 25:18-36.

100. Thus, Shattil-537 teaches this limitation.

[1C] “decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies; and”

101. Shattil-537 teaches this limitation.

102. Shattil-537 explains that, as with typical OFDM systems, “[e]ach transform of a transform pair provides the basis for mixing symbols together to form a code that can be reversed by the complementary transform.” EX1099-Shattil-537, 1:31-33. For example, with reference to FIG. 18, Shattil-537 describes an “Encoder/Interleaver software module 1810” in a transmitter and a complementary “Decoder/De-interleaver 1823” in a receiver. EX1099-Shattil-537, 19:25-31:

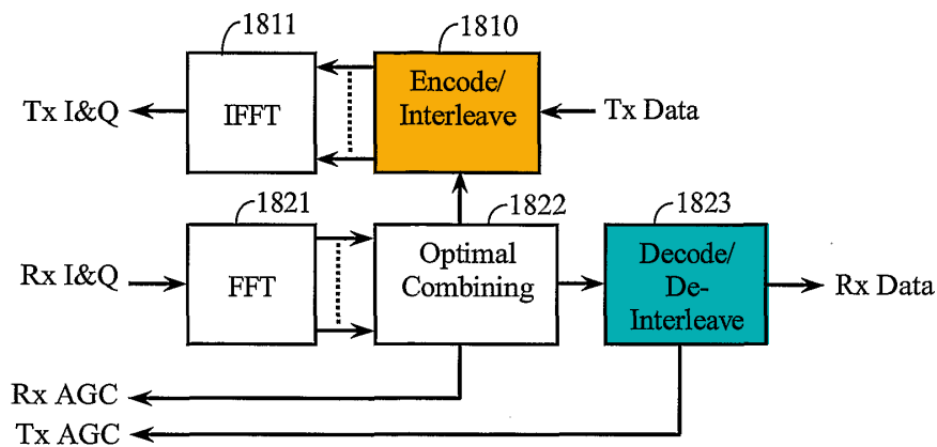


FIG. 18

EX1099-Shattil-537, FIG. 18.

103. Shattil-537 discloses that “CI-coded symbols may be decoded by

correlating a coded signal with a complex-conjugate code.” EX1099-Shattil-537, 22:23-24. Therefore, a POSITA would recognize that Shattil-537’s decoder decodes the frequency-domain values to recover data symbols that were encoded by the user device on the subcarrier frequencies.

104. Shattil-537 describes more details about the decoding process with reference to FIGS. 22 and 23. FIG. 22 illustrates a “relationship between CI symbol values w_n and data symbols s_n .”

	$s_0()$	$s_1()$	$s_2()$	$s_{N-1}()$
$w_1 = \Sigma():$	$e^{i2\pi(0)(0)/(N-1)}$	$e^{i2\pi(1)(0)/(N-1)}$	$e^{i2\pi(2)(0)/(N-1)}$	$e^{i2\pi(N-1)(0)/(N-1)}$
$w_2 = \Sigma():$	$e^{i2\pi(0)(1)/(N-1)}$	$e^{i2\pi(1)(1)/(N-1)}$	$e^{i2\pi(2)(1)/(N-1)}$	$e^{i2\pi(N-1)(1)/(N-1)}$
$w_3 = \Sigma():$	$e^{i2\pi(0)(2)/(N-1)}$	$e^{i2\pi(1)(2)/(N-1)}$	$e^{i2\pi(2)(2)/(N-1)}$	$e^{i2\pi(N-1)(2)/(N-1)}$
$w_N = \Sigma():$	$e^{i2\pi(0)(N-1)/(N-1)}$	$e^{i2\pi(1)(N-1)/(N-1)}$	$e^{i2\pi(2)(N-1)/(N-1)}$	$e^{i2\pi(N-1)(N-1)/(N-1)}$

2201
2203

EX1099-Shattil-537, FIG. 22.

105. This figure includes CI symbols in the form of weights w_n on the left that are the combination of a CI code (also referred to as “values derived from ... a Fourier transform”) in the center of the matrix and the data symbol s_n along the top of the matrix. EX1099-Shattil-537, 25:18; 24:18-20. To decode the coded CI symbols in the receiver, Shattil-537 explains: “Decoding may include any

appropriate inverse of the coding operation represented by FIG. 22. For example, to extract an n^{th} data symbol value s_n , from a vector of received CI symbol values w , the complex conjugate of a vector of the n^{th} phase space (or CI code) values $\underline{w}_n$ may be correlated with the received CI symbol vector w .” EX1099-Shattil-537, 25:33-36.

106. Thus, Shattil-537 “decodes the plurality of frequency-domain values” in the form of “CI symbol values w ,” which are also described as “complex values (or weights),” or more generically, “complex-valued symbol v_n .” This decoding process recovers “a plurality of data symbols” in the form of “data symbol value[s] s_n ,” which are encoded on the subcarrier frequencies by the user device / transmitter using CI coding techniques and which are reversed by the receiver. EX1099-Shattil-537, 26:4-19 (describing the process of processing “received CI symbols w'_n to produce data-symbol estimates 2301”).

107. Thus, Shattil-537 teaches this limitation.

[1D] “wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.”

108. Shattil-537 teaches this limitation.

109. Shattil-537’s user device uses a set of complex-valued codes to produce the OFDM signal as set forth in this limitation. Then I will explain how the receiver of Shattil-537 decodes the coded superposition signal.

110. First, the transmitter of Shattil-537 uses “a set of complex-valued codes” in the form of “[a] basic CI code c_m ,” which shapes “the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.” Shattil-537 discloses: “The basic family of CI codes is generated from an $M \times M$ matrix of elements having phases ϕ_{mn} ” and “[a] basic CI code c_m can include a row or column vector consisting of terms

$$c_m = e^{im\phi'} \sum_{n=0}^{N-1} e^{imn\phi} \hat{n}$$

where $\phi = 2\pi/M$ and $\phi' = 2\pi f_o/f_s M$.” EX1099-Shattil-537, 20:17-30.

111. Substituting $2\pi/M$ for ϕ , as described in Shattil-537, the term $e^{imn\phi}$ is $e^{\frac{i2\pi mn}{M}}$ (m n being column/row matrix indices). After correcting for the typographical error in the figure as noted above, this term resembles the “CI code chip values” provided in Shattil-537’s FIG. 22:

	$s_0()$	$s_1()$	$s_2()$	$s_{N-1}()$
$w_1 = \Sigma():$	$e^{i2\pi(0)(0)/(N-1)}$	$e^{i2\pi(1)(0)/(N-1)}$	$e^{i2\pi(2)(0)/(N-1)}$	$e^{i2\pi(N-1)(0)/(N-1)}$
$w_2 = \Sigma():$	$e^{i2\pi(0)(1)/(N-1)}$	$e^{i2\pi(1)(1)/(N-1)}$	$e^{i2\pi(2)(1)/(N-1)}$	$e^{i2\pi(N-1)(1)/(N-1)}$
$w_3 = \Sigma():$	$e^{i2\pi(0)(2)/(N-1)}$	$e^{i2\pi(1)(2)/(N-1)}$	$e^{i2\pi(2)(2)/(N-1)}$	$e^{i2\pi(N-1)(2)/(N-1)}$
$w_N = \Sigma():$	$e^{i2\pi(0)(N-1)/(N-1)}$	$e^{i2\pi(1)(N-1)/(N-1)}$	$e^{i2\pi(2)(N-1)/(N-1)}$	$e^{i2\pi(N-1)(N-1)/(N-1)}$

112. Each data symbol along the top of the matrix (e.g., $s_0()$) is multiplied by a vector of CI codes in the matrix to generate weights w_I to w_N (also referred to in Shattil-537 as “complex-valued symbol v_n ” or “CI symbol values”). Shattil-537 thus shows “complex-valued codes” because of the presence of i in the codes, which is the mathematical symbol for $\sqrt{-1}$, making the codes complex-valued.

113. Shattil-537’s CI codes are used “to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon,” as stated in the limitation 1D. Shattil-537 explains that: “Each code chip value is analogous to a complex weight applied to a particular CI carrier. A superposition of these carriers produces a CI waveform bearing the data symbol value s_n , such as a particular pulse position.” Shattil-537 continues: “A CI superposition waveform bearing multiple data-symbol/pulse-position characteristics can be created by applying weights to CI carriers that correspond to sums of carrier weights for each data-symbol/pulse-position.” EX1099-Shattil-537, 25:24-29; FIG. 22.

114. Therefore, Shattil-537 describes generating a pulse waveform at “a particular pulse position.” The “pulse waveform” at the particular pulse position has one data symbol impressed thereon. EX1099-Shattil-537, 25:24-29; FIG. 22.

115. This is consistent with the ’386 patent, which shows an example of how

the waveforms are shaped in FIGS. 22A and 22B:

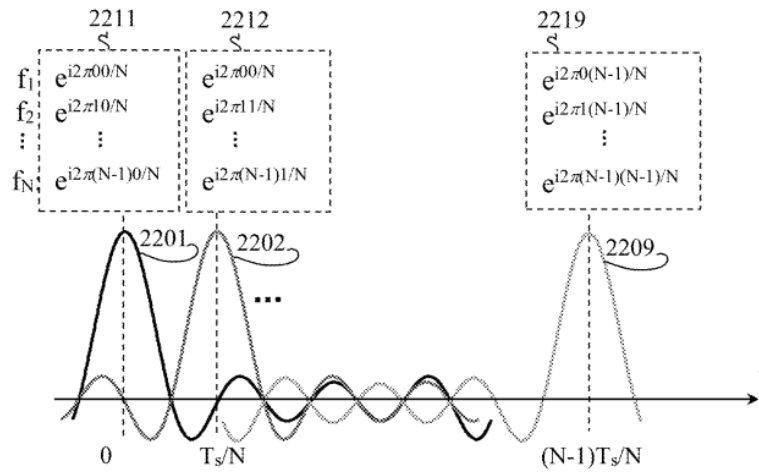


FIGURE 22A

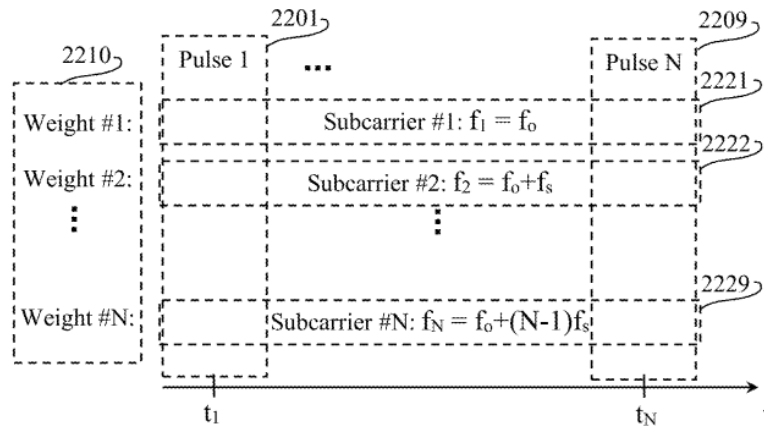


FIGURE 22B

EX1001-386 Patent, FIGS. 22A-22B. As highlighted in FIG. 22A of the '386 Patent, the columns of CI code chips correspond to cyclic-shifted waveforms.

116. Shattil-537 similarly says that the “CI code chip values are arranged in columns with respect to phase spaces, such as phase space column (2201)” and that

the phase spaces are “analogous to a pulse position.” EX1099-Shattil-537, 25:18-20.

117. After the weights are produced, they are OFDM modulated, such as by the “IFFT 1811” of Shattil-537’s Figure 18 or the IFFT 2703 of Figure 27A. This results in the production of a superposition signal, which can be wirelessly transmitted. EX1099-Shattil-537, FIGS. 18, 27A, 19:20-24, 32:4-5.

118. Based on these disclosures, a POSITA would have recognized that generating Shattil-537’s “CI symbols” that are “derived from at least one invertible transform function, such as a Fourier transform” would produce “cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.” A POSITA would have appreciated that the claimed waveform would result from applying codes derived from a Fourier transform to data symbols discussed by Shattil-537.

119. In Shattil-537’s receiver, the superposition signal created at the transmitter is received decoding at the receiver “may include any appropriate inverse of the coding operation...” EX1099-Shattil-537, 25:33. Shattil-537 explains that the “inverse” can use complex-conjugate codes. For example, Shattil-537 states that “CI-coded symbols may be decoded by correlating a coded signal with a complex-conjugate code.” EX1099-Shattil-537, 25:33; *see also* 22:23-24 (“CI-coded symbols may be decoded by correlating a coded signal with a complex-conjugate code.”). Shattil-537 also discloses that “to extract an n^{th} data symbol value s_n , from a vector

of received CI symbol values w , the complex conjugate of a vector of the n^{th} phase space (or CI code) values $\underline{w}_n$ may be correlated with the received CI symbol vector w .” EX1099-Shattil-537, 25:33-36. Therefore, a POSITA would have understood that Shattil-describes receiving a CI-coded data symbol (or “weight” w) and using a complex-conjugate code to recover the data symbol value s_n . Therefore, Shattil-537 teaches that “decoding employs a plurality of codes that are inverse to, complex-conjugate of ... the complex-valued codes that the user device employs,” as stated in Limitation 1D.

120. Thus, Shattil-537 teaches this limitation.

121. Therefore, Shattil-537 teaches and renders obvious claim 1.

2. Independent Claims 10 and 19

[10Pre] “An apparatus for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the apparatus comprising:”

[10A] “at least one processor; and”

[10B] “a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory including a set of instructions stored thereon and executable by the at least one processor for:”

[19Pre] “A computer program product for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the computer program product comprising a non-transitory computer readable storage device having computer readable program code stored therein, said program code containing instructions executable by one or more processors of a computer system for:”

122. Shattil-537 teaches 10Pre, Limitation 10A, Limitation 10B, and 19Pre.

These preambles and limitations all relate to computer implementation of the same method as in claim 1.

123. Shattil-537 discloses a “software-controlled” transceiver apparatus that includes “an Encoder/Interleaver software module 1810 that generates weights provided to an IFFT processor 1811.” EX1099-Shattil-537, 19:20-22; FIGS. 18 & 19. “The IFFT may be adaptable with respect to control signals provided by other software modules, such as the Encoder 1810.” *Id.*, 19:23-24. Shattil-537 also discloses that “IFFT 1811 may include a signal processing software module.” *Id.*, 19:22. Physical layer properties of the transceiver can be controlled by “a software defined-controller 1901 that processes one or more system requirements 1911 and/or one or more channel characteristics 1912 to control one or more CI parameters 1902 in a radio transceiver 1903.” *Id.*, 20:3-5; FIG. 19.

124. The “physical-layer functions” of Shattil-537 are “performed via software-controlled processes, such as application programs residing in one or more memory spaces of one or more processing units.” EX1099-Shattil-537, 19:11-19. Shattil-537’s “processing unit” refers to “a computer processing unit, such as a microprocessor device, a main frame, a work station, a computer network, and/or a stand-alone computer.” EX1099-Shattil-537, 6:30-31. Shattil-537 also discloses a “memory space,” which is described as referring to “a disk drive, tap drive, VD, DVD, flash memory, or any other data storage media or device.” EX1099-Shattil-

125. Shattil-537's "software-controlled transceiver" illustrated in Figure 18 and 19 is an apparatus that is "for receiving an OFDM signal transmitted by a user device in a wireless network," as stated in 10Pre and 19Pre. For example, Shattil-537 explains that its invention has "many wireless applications" including "cellular communications." EX1099-Shattil-537, 2:20-21. Shattil-537's application programs/software stored in memory spaces correspond to "a non-transitory computer-readable memory storing one or more instructions" as stated in 10B and "a non-transitory computer readable storage device having computer readable program code stored therein [and] containing instructions" as stated in 19Pre.

126. Shattil-537's modules can be implemented in software modules, as explained above. For example, Shattil-537's software modules are instructions that are stored in "memory spaces"—i.e., "non-transitory computer-readable memory"—including, for example, "flash memory[] or any other data storage media or device." EX1099-Shattil-537, 6:23-24. The instructions defining the various modules can be executed in Shattil-537 by the claimed one or more processors because Shattil-537 describes using a "processing unit" such as a "microprocessor device" to execute software modules. EX1099-Shattil-537, 6:30-31. This is consistent with how a POSITA would have understood the operation of software-based radios, such as those described in Shattil-537 as shown, for example, by Chen,

which describes instructions stored in memory executed by a processor for a multi-mode modem. *See generally* EX1008-Chen.

127. As I outline below, the software instructions of the transceiver of Shattil-537 cause the method steps of claims 10 and claim 19 to be performed.

128. Thus, Shattil-537 teaches the preambles and limitations 10Pre, 10A, 10B, and 19Pre.

[10Ci] “determining a plurality of subcarrier frequencies allocated to the user device;”

[19A] “determining a plurality of subcarrier frequencies allocated to the user device;”

129. Shattil-537 teaches these limitations for the reasons provided above regarding limitation 1A.

[10Cii] “converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and”

[19B] “converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and”

130. Shattil-537 teaches these limitations for the reasons provided above regarding limitation 1B.

[10Ciii] “decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies; and”

[19C] “decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies; and”

131. Shattil-537 teaches these limitations for the reasons provided above regarding limitation 1C.

[10Civ] “wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.”

[19D] “wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.”

132. Shattil-537 teaches these limitations for the reasons provided above regarding limitation 1D.

133. Therefore, Shattil-537 also teaches and renders obvious claims 10 and 19.

3. Dependent Claims

[Claim 2] “The method of claim 1, wherein each of the plurality of codes employed for decoding comprises a different vector of linear phase offsets.”

[Claim 11] “The apparatus of claim 10, wherein each of the plurality of codes employed for decoding comprises a different vector of linear phase offsets.”

[Claim 20] “The computer program product of claim 19, wherein each of the plurality of codes employed for decoding comprises a different vector of linear phase offsets.”

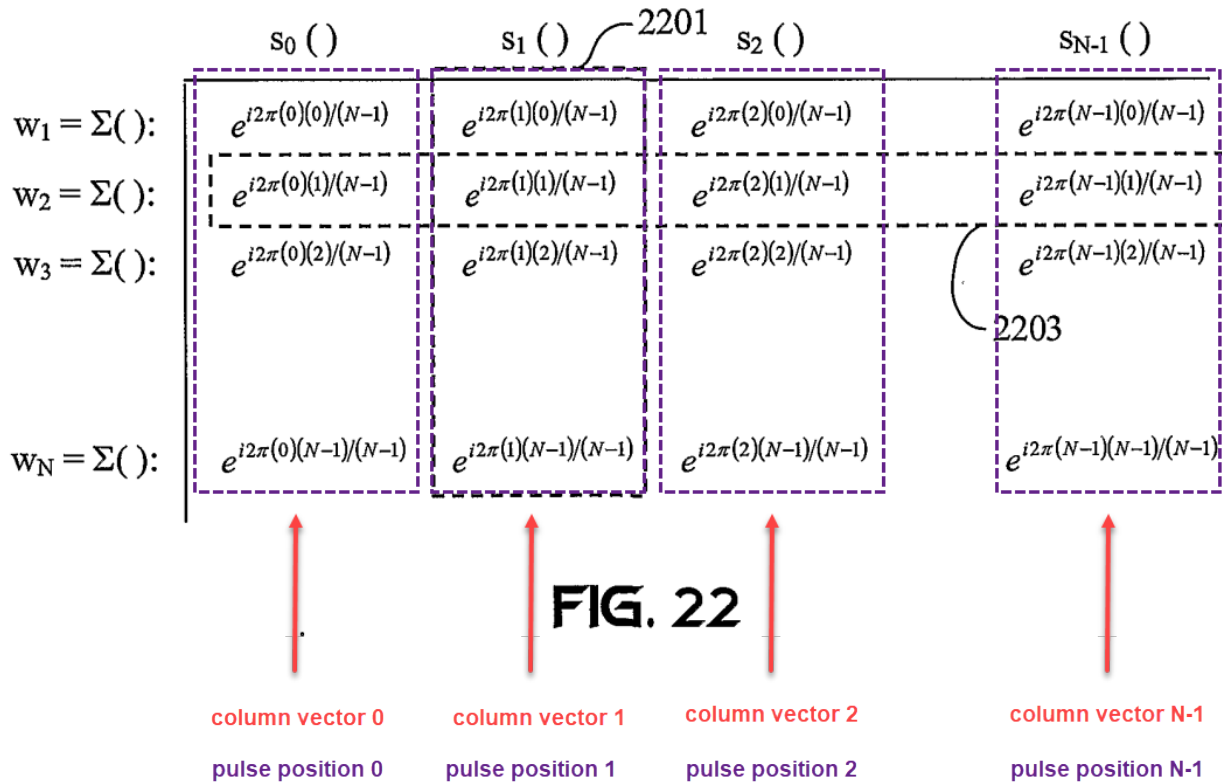
134. Shattil-537 teaches these limitations.

135. As I explained above in connection with limitation 1D, Shattil-537 discloses Shattil-537 discloses: “The basic family of CI codes is generated from an $M \times M$ matrix of elements having phases ϕ_{mn} ” and “[a] basic CI code c_m can include a row or column vector consisting of terms

$$c_m = e^{im\phi'} \sum_{n=0}^{N-1} e^{imn\phi} \hat{n}$$

where $\phi=2\pi/M$ and $\phi'=2\pi f_o/f_s M$,” where “m” and “n” refer to the column/row matrix index. EX1099-Shattil-537, 20:17-30.

136. Referring to its FIG. 22, Shattil-537 explains that “CI code chip values are arranged in columns with respect to phase spaces, such as phase space (column) 2201.” EX1099-Shattil-537, 25:18-21. These phase spaces are also referred to as “pulse positions” in Shattil-537. EX1099-Shattil-537, 25:20-26. As shown below (and applying corrections to the DFT codes by replacing “N” with “N-1” in the denominator, as I explained above), each column of “CI code chip values” in the matrix of Shattil-537’s FIG. 22 represents a different vector of linear phase offsets because they shift the frequency components in time by the same (or “linear”) amount.



EX1099-Shattil-537, FIG. 22 (with corrections and annotations). As annotated and as explained by Shattil-537, each column vector in the matrix represents a pulse position. Therefore, the encoding/interleaving process performed by the transmitter in Shattil-537 uses codes that comprise different vectors of linear phase offsets.

137. As I discussed above in connection with Limitation 1D, the decoding performed by the receiver of Shattil-537 uses an operation that is inverse to the encoding process. For example, Shattil-537 notes that “complex conjugate” codes may be used to decode. EX1099-Shattil-537, 25:33-36.

138. A POSITA would understand that the complex conjugate of a complex

code refers to flipping the sign of an imaginary part of a complex number. For example, the complex conjugate of $x+iv$ (with “i” being the imaginary unit defined as $i = \sqrt{-1}$) would be $x-iv$. In a matrix form (as in FIG. 22 of Shattil-537), the complex conjugate simply transposes the matrix, or in other words reflects the matrix “about the principal diagonal” of the matrix. EX1110-Alder, 22-23.

139. When the complex-conjugate of the matrix values shown in Shattil-537’s FIG. 22 are taken for the decoding process, each of the complex conjugates of the codes used for encoding (i.e., the decoding codes) would be a different vector of linear phase offsets to recover the original data symbols. In other words, a POSITA would understand that since the original encoding matrix (e.g., FIG. 22 of Shattil-537) includes vectors of linear phase offsets (e.g., with constant offsets between each adjacent pulse position), which it does as explained above, then the decoding matrix also includes vectors with different linear phase offsets.

140. Thus, Shattil-537 renders obvious claims 2, 11, and 20.

[Claim 3] “The method of claim 1, wherein the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal, and each of the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts.”

[Claim 12] “The apparatus of claim 10, wherein the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal, and each of the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts.”

[Claim 21] “The computer program product of claim 19, wherein the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal, and each of the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts.”

141. Shattil-537 teaches these limitations.

142. There are two parts to each of these claims. I will first explain how Shattil-537 discloses that “the cyclic-shifted waveforms have cyclic shifts that cause the cyclic-shifted waveforms to be orthogonal.” Then I will explain how Shattil-537 discloses that “each of the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts.”

143. In connection with the first part of these claims, Shattil-537 discloses: “A sample period of $T_s = 1/f_s$ provides overlapping frequencies f_n (shown in FIG. 14B) that have an incremental frequency separation of f_s .” EX1099-Shattil-537, 16:27-31. Shattil-537 also explains: “The sample period T_s is a predetermined time interval in which samples are collected and processed. Fourier transforms or equivalent operations may be performed. The period T_s specifies a set of orthogonal frequencies f_n .” EX1099-Shattil-537, 16:27-31. The cyclic shifts between the “phase

spaces” or “pulse positions” of Shattil-537 “may be orthogonal.” EX1099-Shattil-537, 25:18-21. The “superposition of carriers” to which code chips are applied are described in Shattil-537 as producing “a CI waveform bearing the data symbol value s_n , such as at a particular pulse position.” EX1099-Shattil-537, 25:18-26. The different cyclic shifts are associated with the symbol duration T_s , in such a way that the waveforms are orthogonal ($T_s=1/f_s$). .

144. Turning to the second part of claims 3, 12, and 21—“each of the plurality of codes employed for decoding comprises a set of linear phase offsets that corresponds to one of the cyclic shifts”—Shattil-537 explains that “CI code chip values are arranged in columns with respect to phase spaces, such as phase space (column) 2201,” and these phase spaces “may be analogous to pulse positions.” EX1099-Shattil-537, 25:18-21.

145. Each column of “CI code chip values” used for encoding, or in other words, each column vector of CI codes in FIG. 22 of Shattil-537, comprises a different vector of linear phase offsets because these columns are used to shift the frequency components in time by equal amounts (e.g., differences between the adjacent column vectors represent a linear change) due to the equal spacings between the subcarriers as shown, for example, in Shattil-537’s FIGS. 14A and 14B (below) where the subcarriers are equally spaced by subcarrier spacing f_s :

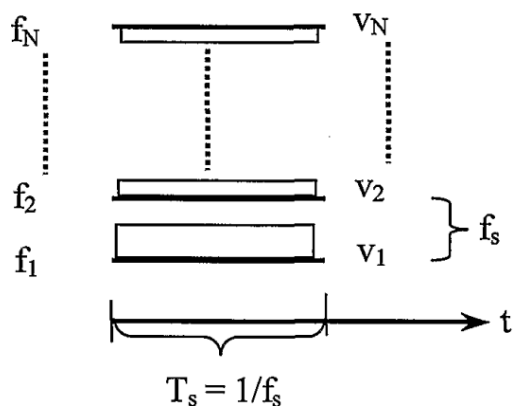


FIG. 14A

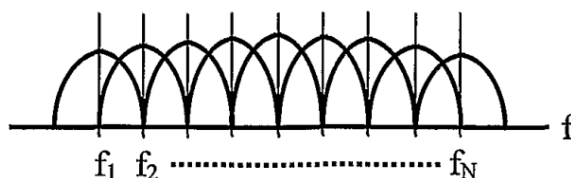


FIG. 14B

EX1099-Shattil-537, FIGS. 14A-14B.

146. Based on these disclosures, a POSITA would have understood that each of the codes—whether used for encoding or decoding—comprises a set of linear phase offsets in the same way as is illustrated in, for example, FIG. 22A of the '386 Patent:

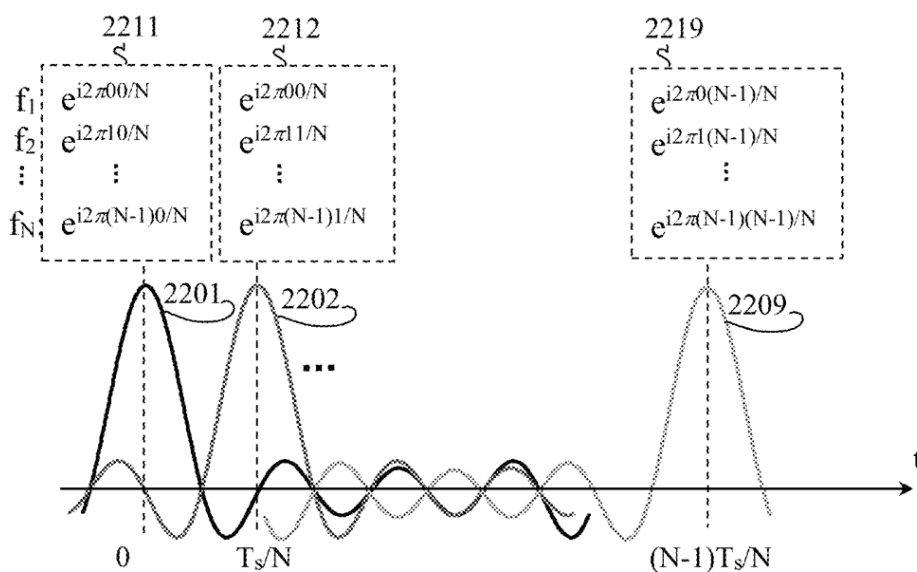


FIGURE 22A

EX1001-386 Patent, FIG. 22A. Here, the linear phase offsets applied by the Fourier spreading codes/polyphase Fourier codes constitute a single-frequency waveform that corresponds to one of the shifted CI pulse waveforms as shown.

147. Therefore, Shattil-537's encoding/interleaving module in the transmitter uses codes that include respective sets of linear phase offsets that correspond to the cyclic shifts.

148. As I explained above and as Shattil-537 confirms, the decoding module of the receiver uses the inverse (e.g., "complex conjugate") of the encoding codes. A POSITA would understand that when the complex-conjugate of the matrix values shown in FIG. 22 are taken, the complex conjugate code vectors (i.e., the inverse code vectors used in the receiver) likewise would each include a set of linear phase offsets that corresponds to one of the cyclic shifts. EX1099-Shattil-537, 25:33-36. In other words, it would have been obvious to a POSITA to use vectors of code values with linear phase offsets in the receiver to recover the original data symbols.

149. Thus, Shattil-537 renders obvious claims 3, 12, and 21.

[Claim 5] “The method of claim 1, wherein the plurality of subcarrier frequencies has a frequency spacing f_s , and the plurality of cyclic-shifted waveforms are periodic over a symbol interval $T_s=1/f_s$.”

[Claim 14] “The apparatus of claim 10, wherein the plurality of subcarrier frequencies has a frequency spacing f_s , and the plurality of cyclic-shifted waveforms are periodic over a symbol interval $T_s=1/f_s$.”

[Claim 23] “The computer program product of claim 19, wherein the plurality of subcarrier frequencies has a frequency spacing f_s , and the plurality of cyclic-shifted waveforms are periodic over a symbol interval $T_s=1/f_s$.”

150. Shattil-537 teaches these limitations.

151. Shattil-537 discloses that “[a] sample period of $T_s = 1/f_s$ provides overlapping frequencies f_n (shown in FIG. 14B) that have an incremental frequency separation of f_s ” and “[t]he period T_s specifies a set of orthogonal frequencies f_n .” EX1099-Shattil-537, 16:27-31. Solving for the separation f_s , the expression of Shattil-537 can be rewritten as $f_s = 1/T_s$. As I have discussed above in connection with claim 3 and as explained by Shattil-537, the plurality of cyclic shifted waveforms are orthogonal to one another. EX1099-Shattil-537, 25:20-21 (“The phase spaces (e.g., pulse positions) may be orthogonal”). A POSITA would understand that pulses are orthogonal when they are an integer multiple (“incremental”) of the frequency spacing f_s , or otherwise expressed as $1/T_s$. EX1015-Prasad, 22 (“[T]he carriers are linearly independent (i.e., orthogonal) if the carrier spacing is a multiple of $1/T$,” where the “symbol period” is represented by “ T .”).

152. Thus, Shattil-537 renders obvious claims 5, 14, and 23.

[Claim 6] “The method of claim 1, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.”

[Claim 15] “The apparatus of claim 10, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.”

[Claim 24] “The computer program product of claim 19, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.”

153. Shattil-537 teaches these limitations.

154. Shattil-537 discloses that when CI is applied to OFDM, “N- point transforms used in OFDM, such as fast Fourier transforms (FFTs) and inverse FFTs (IFFTs), essentially map one set of data symbols onto another set of data symbols.” EX1099-Shattil-537, 1:29-31. Shattil-537’s FIG. 18, reproduced and highlighted below, shows “[r]eceived signals” (“Rx I&Q”) that “are separated into orthogonal components by an FFT processor 1821”:

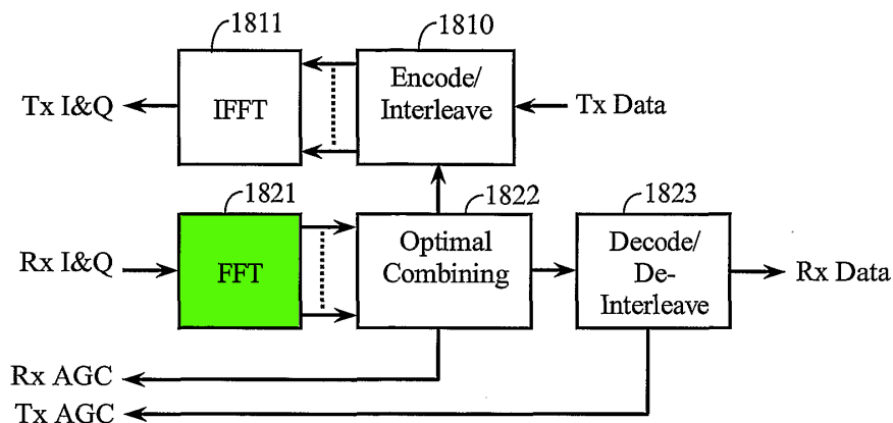


FIG. 18

EX1099-Shattil-537, FIG. 18; 19:25-26.

155. The “IFFT 1811” of the transmitter side produces “a time-domain

signal” $x(t)$, which the FFT 1821 of the receiver side converts into a frequency-domain expression, $X(f_n)$. EX1099-Shattil-537, 11:7-18. As I discussed in more detail above with in connection to Limitation 1B, the FFT 1821 is used for converting the OFDM signal to frequency-domain values. It would have been well-known to a POSITA that the FFT of Shattil-537’s receiver is a type of discrete Fourier transform (DFT). For example, the ’386 Patent itself notes that a DFT can be “implemented with a fast transform algorithm, such as a fast Fourier transform.” EX1001-386 Patent, 60:60-63.

156. Thus, Shattil-537 renders obvious claims 6, 15, and 24.

[Claim 7] “The method of claim 1, further comprising removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.”

[Claim 16] “The apparatus of claim 10, wherein the non-transitory computer-readable memory further includes instructions stored thereon and executable by the at least one processor for removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.”

[Claim 25] “The computer program product of claim 19, wherein the non-transitory computer-readable storage device further includes instructions stored therein and executable by the one or more processors for removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.”

157. Shattil-537 teaches these limitations.

158. FIG. 27B of Shattil-537 shows “general steps of a reception process of the present invention,” which includes “various reception processes” including “but

not limited to Cyclic prefix removal ...”:

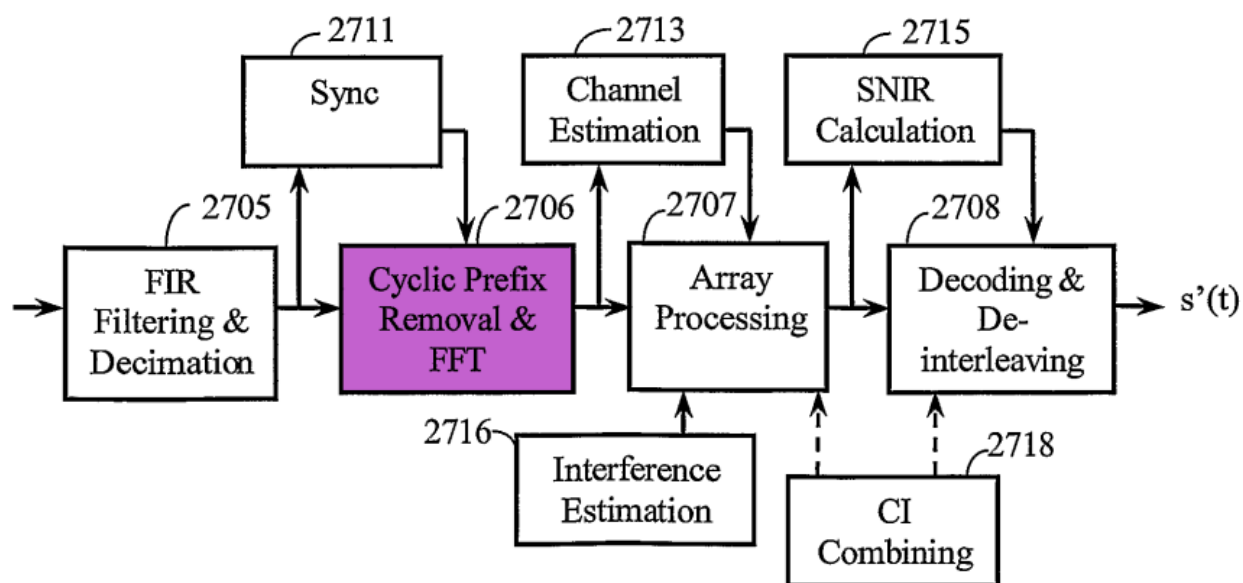


FIG. 27B

EX1099-Shattil-537, FIG. 27B, 32:15-19. This process of cyclic prefix removal is mentioned in Shattil-537 before the FFT process (“Cyclic Prefix Removal & FFT”), in keeping with typical operation of an OFDM receiver. EX1099-Shattil-537, FIG. 27B; *see also* 32:15-19. Notably, this order of operations in the receiver is opposite the “IFFT & Cyclic prefix” of the transmitter according to conventional signal processing. EX1099-Shattil-537, FIG. 27A, *see also* 32:4-6 (“Optionally, a cyclic prefix may be added to the coded data symbols.”). Therefore, a POSITA would have found it obvious to remove the cyclic prefix first to recover the coded data symbols in the receiver.

159. Other references also describe the process of removing a cyclic prefix

prior to the FFT in the receiver. For example, the Prasad textbook includes a diagram with “Remove cyclic extension” shown as occurring before the “FFT (RX)” to mirror the “Add cyclic extension” occurring after the “IFFT (TX)” in the transmitter:

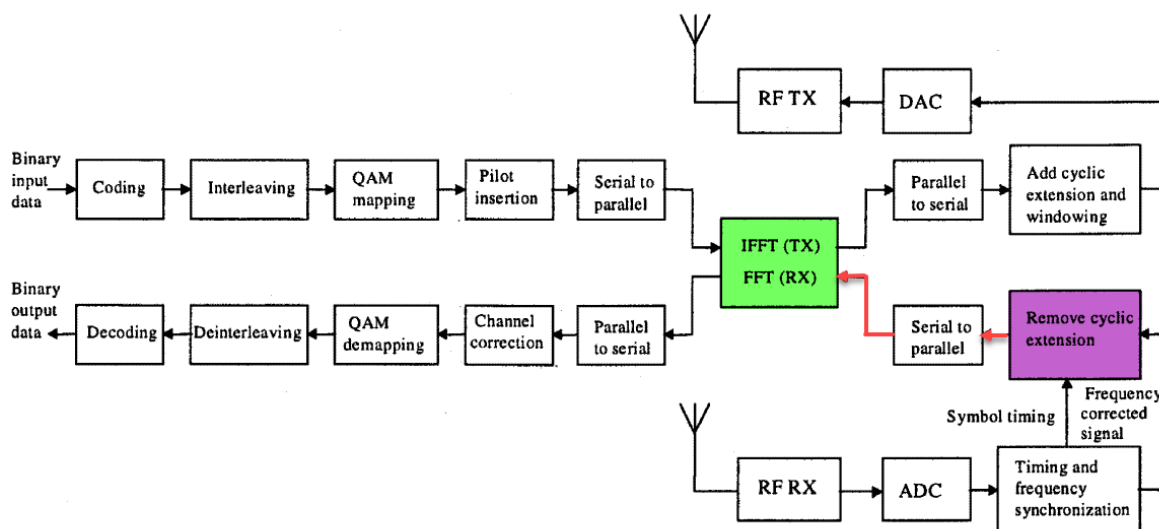


Figure 2.14 Block diagram of an OFDM transceiver.

EX1015-Prasad, 48.

160. Thus, Shattil-537 renders obvious claims 7, 16, and 25.

[Claim 8] “The method of claim 1, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.”

[Claim 17] “The apparatus of claim 10, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.”

[Claim 26] “The computer program product of claim 19, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.”

161. Shattil-537 teaches these limitations.

162. First, as I outlined above with reference to the preamble of claim 1 and with reference to Limitation 1C, Shattil-537 discloses receiving and converting an OFDM signal and converting the OFDM signal into frequency-domain values. For example:

- “CI filtering may be performed by receivers designed for multicarrier transmission protocols, such as OFDM[.]” EX1099-Shattil-537, 8:26-29.
- “CI may also be applied to orthogonal frequency division multiplexing.” EX1099-Shattil-537, 1:29.
- “A method of performing CI processing of at least one received single-carrier signal ... including ... providing for decomposition of the at least one received single-carrier signal into a plurality of CI components” EX1099-Shattil-537, 36:17-21.
- “CI Components are CI carriers or CI symbol values. CI symbol values are complex values (or weights) for a plurality of CI carriers.” EX1099-Shattil-537, 5:16-18.
- “FIG. 15C illustrates a CI reception method.” EX1099-Shattil-537, 17:31-18:3.
- “CI codes may be applied to ... OFDM” EX1099-Shattil-537, 21:20-21.

- “Multicarrier signals may be defined by any set of substantially orthogonal diversity parameters” such as “frequency...”. EX1099-Shattil-537, 21:29-31.

163. The term “OFDM,” both conventionally and in Shattil-537 and the ‘386 patent, refers to “orthogonal frequency division multiplexing.” EX1099-Shattil-537, 1:29; EX1001-386 Patent, Abstract, claims 1, 10, 19.

164. Shattil-537’s OFDM receiver processes are designed for multiple access for multiple user devices. For example, Shattil-537 describes a “CI decoder” that “may perform ... multiple-access decoding.” EX1099-Shattil-537, 31:15-17; *see also* 32:33-34 (“Decoding may include ... multiple access ... and/or other decoding processes.”). The term “multiple access” refers to accessing a shared spectrum by multiple user devices. For example, Shattil-537 discloses that it is “desirable to avoid certain spectral ranges, such as a spectral range 1412 allocated to another user....” EX1099-Shattil-537, 16:35-36. This is illustrated in FIG. 14C, where “[f]requency ranges characterized by ... frequency allocations to other systems, applications, and/or users are avoided”:

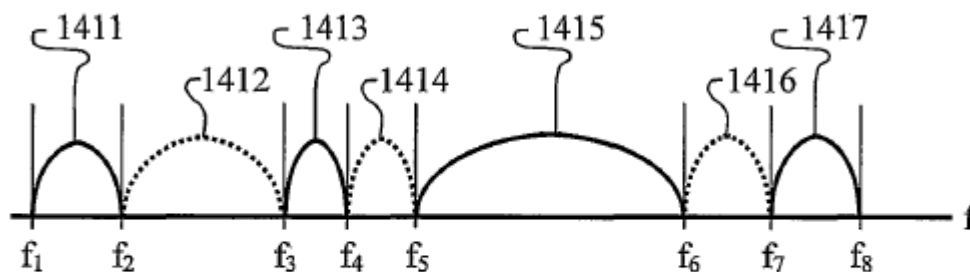


FIG. 14C

EX1099-Shattil-537, 4:2-3; FIG. 14C. This figure shows “a desired spectral profile for a particular communication channel,” where each of the “spectral ranges 1411, 1413, 1415, and 1417” does not overlap with the others, and avoids “spectral range 1412 allocated to another user.” EX1099-Shattil-537, 16:33-36.

165. Thus, a POSITA would understand that, in Shattil-537, the spectrum is shared by multiple users, which would each be allocated a different spectral range within the spectrum. Accordingly, it would have been obvious to a POSITA to receive communications on Shattil-537’s multiple access OFDM system to provide for communications from multiple user devices. In addition to Shattil-537’s own disclosure suggesting multiple-access OFDM, a POSITA would understand that multiple users using the system would have readily expanded the usefulness of Shattil-537 to allow more than one device to communicate.

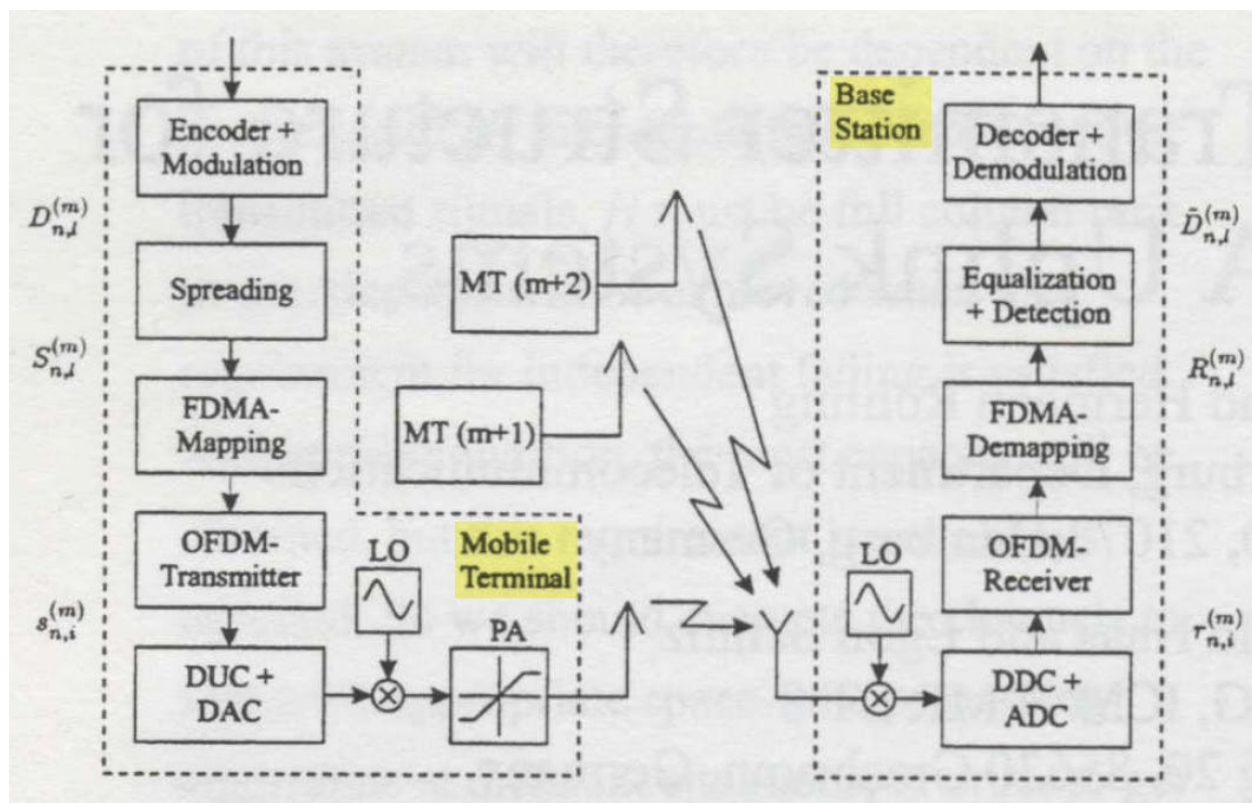
166. Thus, Shattil-537 renders obvious claims 8, 17, and 26.

IX. GROUND 3: Claims 1 and 6-8 are obvious over Galda in view of Brüninghaus

A. Reasons for Combining Prior Art

167. Ground 3 relies on Galda in view of Brüninghaus and addresses claims 1 and 6-8.

168. Galda generally describes an “[OFDM] transmission technique” that includes “a data spreading technique based on a [DFT] spreading matrix.” EX1004-Galda, 1737, Abstract. Galda shows in its Figure 1 a “Mobile Terminal” with a transmitter communicating with a “Base Station” with a receiver:



EX1004-Galda, 1738 (Fig. 1).

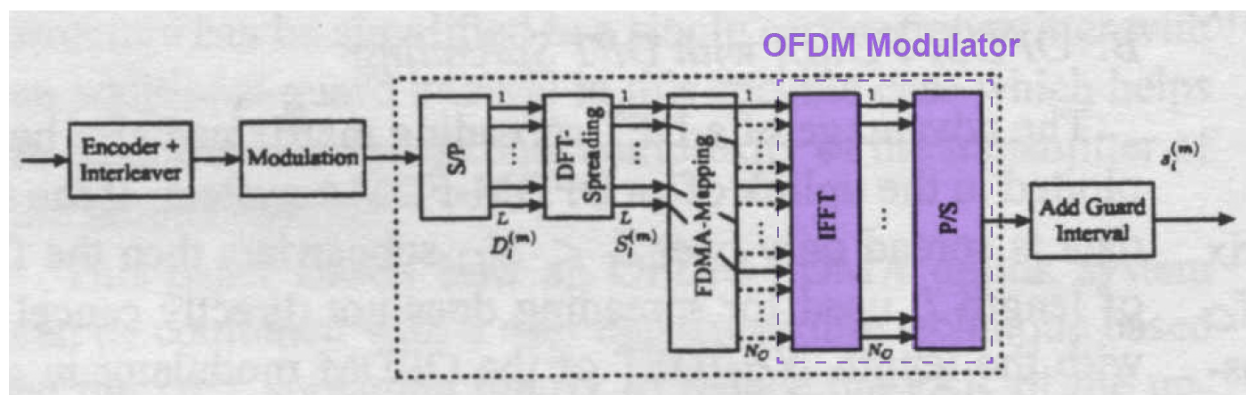
169. The Mobile Terminal of Galda Figure 1 includes several blocks or

modules for processing signals, including “Spreading,” “FDMA-Mapping,” and “OFDM-Transmitter” blocks.

170. Galda describes using “the [DFT] matrix ... for spreading the vector $\vec{D}$ of length $L = N_c$ [and block $D_{n,l}^{(m)}$] over all subcarriers of an OFDM system.”

EX1004-Galda, 1739. Galda’s DFT spreading uses a plurality of complex-valued codes (“ L orthogonal code vectors $\vec{C}_l$ ”) that shape the interference patterns of a superposition signal as I explain in detail below in connection with Limitation 1D.

171. Galda discloses using an IFFT to modulate DFT spread data symbols onto the L subcarriers:



EX1004-Galda, 1740 (Fig. 6(a)).

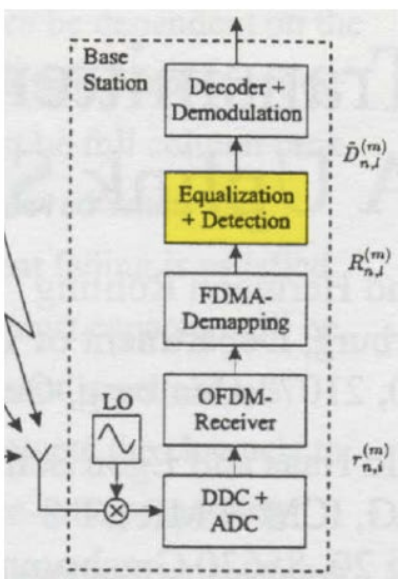
172. At the Base Station / receiver, Galda discloses processing a “received time signal” “by ... calculating the Fourier transformation (FFT) which splits the time signal into the orthogonal subcarrier channels and finally selecting the user specific complex valued symbols $R_l^{(m)}$ at the FFT output.” EX1004-Galda, 1738.

Galda then explains that “[a]n estimate of data symbols $\tilde{D}_l^{(m)}$ can then be calculated independently for each user by applying any single- or multi-code detection techniques.” EX1004-Galda, 1738-39. Galda recognizes that these techniques “are well known from OFDM-CDMA receiver structures.” EX1004-Galda, 1739.

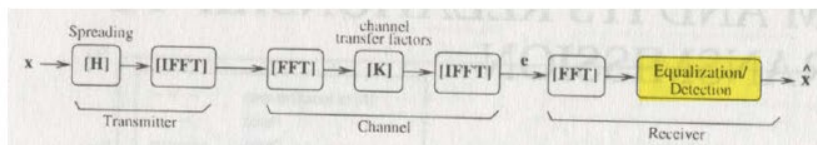
173. Galda does not specifically mention or describe these well-known OFDM receiver techniques, including using codes that are “inverse to, complex-conjugate of, or complementary to” the DFT spreading codes used at the transmitter to decode the frequency domain values to recover the data symbols. However, using complex-conjugates of DFT spreading codes to recover data symbols from frequency-domain values was a known technique. For example, Brüninghaus (which was cited by Galda as reference [3]), does describe this.

174. Like Galda, Brüninghaus’s receiver includes a block called “Equalization/Detection” as shown below.

Galda's Receiver

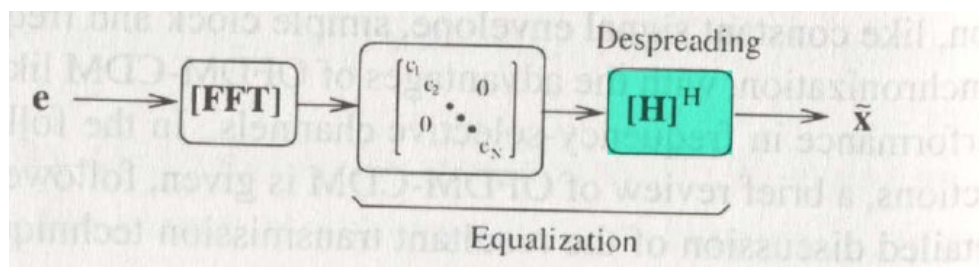


Brüninghaus's Receiver



EX1004-Galda, 1738; EX1016-Brüninghaus, 2330.

175. While Galda says that “any single- or multi-code detection techniques” can be used in the receiver, Galda does not show the implementation details that may be used to recover data symbols. Brüninghaus provides details of how to recover data symbols (such as $\tilde{D}_{n,l}^{(m)}$ in Galda) when DFT spreading is used in a transmitter. For example, Brüninghaus shows:



EX1016-Brüninghaus, 2330 (Fig. 4).

176. This figure of Brüninghaus shows “despreading” by application of “an

inverse Fast-Fourier matrix $[H]^H$.” EX1016-Brüninghaus, 2329-30. Here, the superscript “ H ” reflects the Hermitian transpose, which is also known as the “conjugate transpose.” See EX1077-896 Patent, 2:2-3 (“The Hermitian transpose of a matrix A, denoted by A^H , is the complex conjugate transpose of A.”). It was well known to a POSITA that a Hermitian transpose is the same as complex conjugate transpose. *Id.* The Patent Owner’s US Patent No. 11,700,162 similarly recognizes that “[t]he conjugate transpose is also known as the adjoint matrix, adjugate matrix, Hermitian adjoint, or **Hermitian transpose**.” EX1075-162 Patent, 21:59-61. Therefore, Brüninghaus’s receiver uses codes that are “inverse to, complex-conjugate of, or complementary to” the DFT spreading codes $[H]$ because it uses the complex conjugate transpose of matrix $[H]$, or $[H]^H$.

177. A POSITA considering Galda would have been motivated to look to other known solutions to reverse the spreading operation at Galda’s receiver and, at Galda’s recommendation, would have looked for “any [known] single- or multi-code detection techniques.” EX1004-Galda, 1738-39. A POSITA would have appreciated that Brüninghaus is identified as a reference in Galda and provides a known detection technique to reverse the DFT spreading operation. EX1004-Galda, 1741 (reference [3]); EX1016-Brüninghaus, 2330. A POSITA would have been motivated to use Brüninghaus’s complex conjugate transpose of matrix $[H]$, or $[H]^H$, in Galda’s “Equalization + Detection” block to reverse the spreading operation (also referred

to as “despreading” in Brüninghaus) in the receiver and recover the data symbols.

178. A POSITA would have simply combined these prior art elements (Galda’s “Equalization + Detection” receiver block and Brüninghaus’s despreading block) according to known methods of using inverse, complex-conjugate codes to the codes used during spreading in an “Equalization” block as Brüninghaus to yield predictable results of recovering an estimate of the original data symbol ($\tilde{D}_{n,l}^{(m)}$).

179. A POSITA would have also found it obvious to apply Brüninghaus’s known technique of using the inverse, complex-conjugate to the DFT matrix used at the transmitter (i.e., using the “an inverse Fast-Fourier matrix $[H]^H$ ”) to despread the data in an equalization block of a receiver to Galda’s known receiver (more specifically, Galda’s “Equalization + Detection” receiver block) to provide for a technique to despread the data and recover the original data symbol ($\tilde{D}_{n,l}^{(m)}$). Using Brüninghaus’s inverse Fast-Fourier matrix would have allowed the spread data symbols to be despread and thus recovered, thus providing predictable results.

180. A POSITA would have reasonably expected success in using Brüninghaus’s complex-conjugate inverse Fast-Fourier matrix in Galda’s “Equalization + Detection” receiver block because it was well-known in the art for a receiver to use inverse (complex-conjugate) codes to reverse an operation performed in the transmitter on data symbols in wireless communications.

EX1004-Galda, 1739 (“single- or multi-code detection techniques can be applied which are well known from OFDM-CDMA receiver structures”); EX1016-Brüninghaus, 2329-30 (e.g., “In case of a Fourier spreading matrix, despreading in the receiver is achieved by an inverse Fast-Fourier matrix”). Using codes in a receiver that are inverse to the spreading codes used in the transmitter in order to recover data symbols in the receiver was a well-understood mathematical technique used to invert operations performed using coefficients of a matrix in communications.

B. Challenged Claims

1. Independent Claim 1

[1Pre] “A method for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, comprising:”

181. Galda in view of Brüninghaus teaches the preamble.

182. Galda shows and describes a “[b]aseband system model for the OFDM-FDMA uplink with individual spreading of user data.” In this model, an “OFDM-Transmitter” is involved with the sending of an OFDM signal by Galda’s “Mobile Terminal” in a wireless network and an “OFDM receiver” is for receiving the OFDM signal transmitted by the Mobile Terminal in the network:

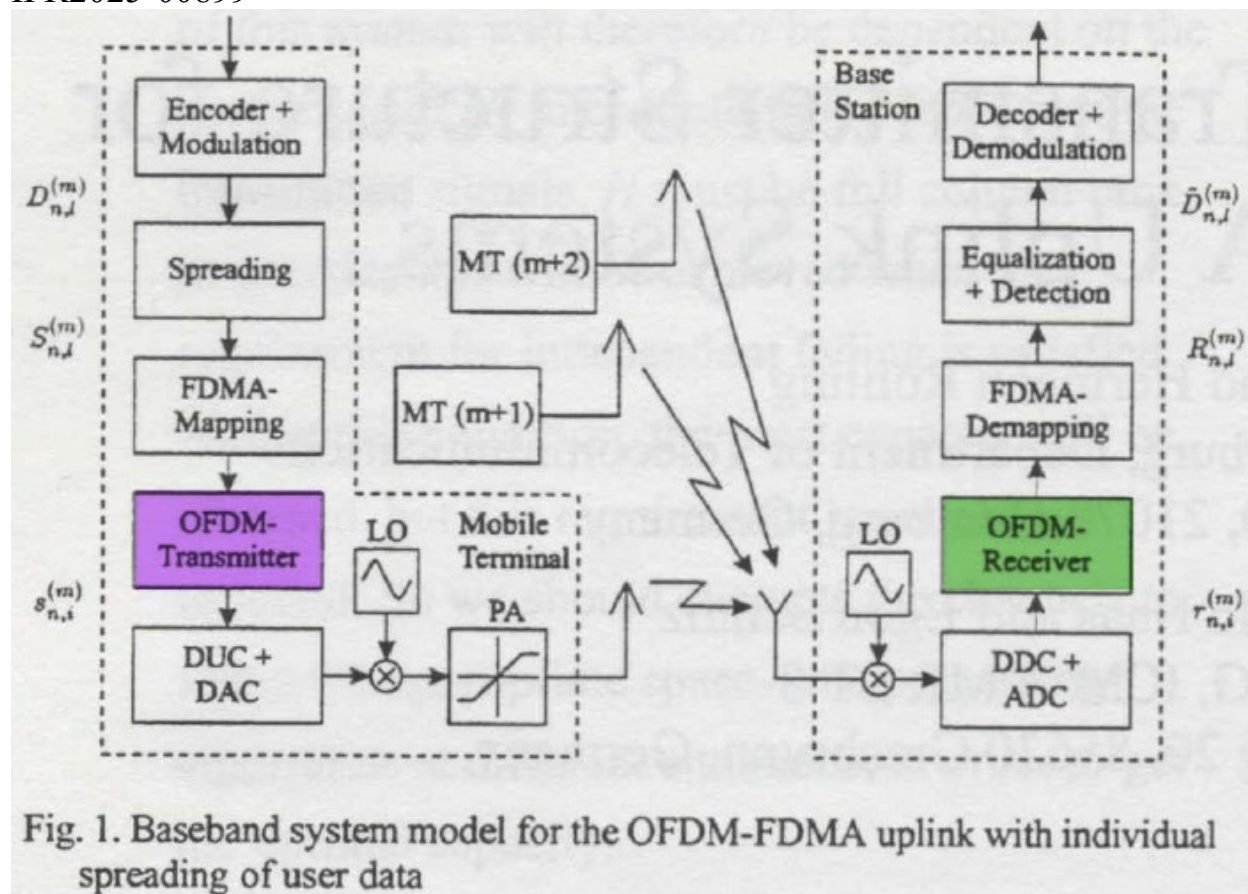


Fig. 1. Baseband system model for the OFDM-FDMA uplink with individual spreading of user data

EX1004-Galda, 1738 (Fig. 1).

183. Thus, Galda in view of Brüninghaus teaches the preamble.

[1A] “determining a plurality of subcarrier frequencies allocated to the user device;”

184. Galda in view of Brüninghaus teaches this limitation.

185. On the transmitter (user device) side, Galda discloses that an “OFDM-FDMA multiple access scheme” can be “combined with a data spreading technique based on a Discrete Fourier Transform (DFT) spreading matrix using only the user specific subcarriers.” “By allocating distinct sets of subcarriers to different users the

available bandwidth can be flexibly shared between different mobile terminals....”

EX1004-Galda, 1738.

186. Galda also discloses, “[i]f channel state information is not available the performance can be increased using an additional spreading over the subcarriers assigned to one user.” For example, “ M different users are considered and each user allocates L different subcarrier[s] exclusively. The total number of subcarrier[s] in the considered transmission system is $N_C = L \cdot M$.” EX1004-Galda, 1737-38. Thus, in Galda’s transmitter, each user signal is transformed and split (“spread”) into a set of subcarriers.

187. On the receiver side, Galda discloses receiving a time signal from a “user m ” and “calculating the Fourier transformation (FFT) which splits the time signal into the orthogonal subcarrier channels and finally selecting the user specific complex valued symbols $R_l^{(m)}$ at the FFT output. The user specific subcarrier set is located at subcarrier $k = m, m + M, \dots, m + (L - 1)M$ for user m .” EX1004-Galda, 1738-39.

188. Accordingly, by explaining that (1) subcarriers are uniquely allocated to users, (2) that the FFT in the receiver “splits the time signal into the orthogonal subcarrier channels,” and (3) spread symbols $R_l^{(m)}$ are selected, Galda teaches determining a plurality of subcarrier frequencies (“orthogonal subcarrier channels”

and “user specific subcarrier set”) allocated to the user device (device corresponding to “user m ”). This allows for the FFT to be performed, which prepares the signal for FDMA-Demapping to generate spread data symbols $R_{n,l}^{(m)}$ before despreading them.

189. The '386 patent itself also describes a similar process for the same purpose. For example, an FFT is used to determine the subcarriers allocated to a user in the '386 patent's receiver. EX1001-386 Patent, 67:52-55 (DFT, such as an FFT or “other types of filters” are used to “select one or more subcarrier components allocated to a particular user”).

190. Thus, Galda in view of Brüninghaus teaches this limitation.

[1B] “converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and”

191. Galda in view of Brüninghaus teaches this limitation.

192. More specifically, Galda teaches that its “OFDM time signal of user m ” is transmitted to the receiver where an FFT “splits the time signal into the orthogonal subcarrier channels.” A POSITA would understand that this splitting via FFT refers to converting the “OFDM time signal of user m ” to frequency-domain values in the form of “user specific complex valued symbols $R_l^{(m)}$ at the FFT output,” which correspond to the “orthogonal subcarrier channels” (another term for the plurality of subcarrier frequencies). These subcarrier frequencies are the frequencies allocated to user m . (“The user specific subcarrier set is located at subcarrier $k = m, m +$

$M, \dots, m + (L - 1)M$ for user m .”). EX1004-Galda, 1738

193. Thus, Galda in view of Brüninghaus teaches this limitation.

[1C] “decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies; and”

194. Galda in view of Brüninghaus teaches this limitation.

195. I will first explain how Galda discloses the second part of this limitation 1C, where the data symbols are encoded by the user device (e.g., transmitter) on subcarrier frequencies. Then I will explain how Galda describes decoding the frequency-domain values to recover these encoded data symbols.

196. Galda’s transmitter uses a DFT spreading technique to encode data symbols on subcarriers. For example, Galda generates “ L complex transmit symbols $S_l^{(m)}$,” by spreading “ L complex modulation symbols $D_l^{(m)}$, $l=0, \dots, L-1$ ” “over the L user-specifically allocated subcarrier.” Galda explains that this is done with a “unitary spreading matrix $[C]$ ” that includes “the elements of the discrete Fourier matrix.” EX1004-Galda, 1738-39. This process of creating the L complex transmit symbols by applying the DFT spreading matrix encodes the data symbols on subcarrier frequencies.

197. Galda’s receiver decodes frequency-domain values to recover the encoded data symbols. After discussing the use of FFT in the receiver to convert the received OFDM time signal into frequency-domain values (“complex valued

symbols $R_l^{(m)}$ ”), Galda discloses that “[a]n estimate of data symbols $\tilde{D}_l^{(m)}$ can then be calculated independently for each user by applying any single- or multi-code detection techniques.” EX1004-Galda, 1738-39.

198. Thus, Galda in view of Brüninghaus teaches this limitation.

[1D] “wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.”

199. Galda in view of Brüninghaus teaches this limitation.

200. This limitation 1D has two parts that refer to (1) the receiver decoding and (2) the transmitter / user device using codes to shape the OFDM signal. I will first explain how Galda discloses this transmitter action, then I will explain how the combined teachings of Galda and Brüninghaus disclose the corresponding receiver action. This tracks the order that signals are typically processed through a communication system with a transmitter and receiver.

201. First, on the transmitter side, Galda employs a plurality of complex-valued codes because it uses a “unitary spreading matrix” $[C]$, which has “elements of the discrete Fourier matrix” that Galda defines as $C_{i,j} = \frac{1}{\sqrt{L}} e^{j2\pi ij/L}$. EX1004-Galda, 1738-39.

202. Galda’s matrix $[C]$ includes “ L orthogonal code vectors $\vec{C}_l =$

$(C_{l,0}, C_{l,1}, \dots, C_{l,L})$ with $l = 0, \dots, L - 1$.” EX1004-Galda, 1738. Accordingly, “the elements of the discrete Fourier matrix” can be expressed as: $\vec{C}_l = \frac{1}{\sqrt{L}}(e^{j2\pi l0/L}, e^{j2\pi l1/L}, \dots, e^{j2\pi l(L-1)/L})$. EX1004-Galda, 1738-39. This shows that Galda uses a plurality of complex-valued codes $\vec{C}_l$ for the purpose of spreading data symbols, referred to by Galda as “L user modulation symbols $D_l^{(m)}$ ”). EX1004-Galda, 1738.

203. The codes $\vec{C}_l$, when applied to the data symbols, cause a phase rotation to the subcarrier values, which are the encoded data symbols (“L complex transmit symbols $S_l^{(m)}$ ”), and thus to the resulting superposition of cyclic-shifted pulse waveforms. The complex transmit symbols $S_l^{(m)}$ are IFFT processed to create an “OFDM time signal of user m ” that is expressed in Galda as

$$S_i^{(m)} = e^{j2\pi im/N_C} \frac{1}{\sqrt{L}} \sum_{l=0}^{L-1} S_l^{(m)} e^{-j2\pi il/L} \quad (3)$$

$$\text{for } i = -N_G, \dots, 0, \dots, N_C,$$

where the summation of subcarriers from $l = 0$ to L represents a superposition of the subcarriers modulated by the set of subcarrier values $S_l^{(m)}$ with l ranging from 0 to $L-1$. As one example, if $L=4$, Galda’s DFT spreading matrix takes on the following values:

$$[C] = \begin{bmatrix} C_{0,0} & C_{0,1} & C_{0,2} & C_{0,3} \\ C_{1,0} & C_{1,1} & C_{1,2} & C_{1,3} \\ C_{2,0} & C_{2,1} & C_{2,2} & C_{2,3} \\ C_{3,0} & C_{3,1} & C_{3,2} & C_{3,3} \end{bmatrix} = \begin{bmatrix} \frac{1}{2}e^{j\frac{2\pi(0)(0)}{4}} & \frac{1}{2}e^{j\frac{2\pi(0)(1)}{4}} & \frac{1}{2}e^{j\frac{2\pi(0)(2)}{4}} & \frac{1}{2}e^{j\frac{2\pi(0)(3)}{L}} \\ \frac{1}{2}e^{j\frac{2\pi(1)(0)}{4}} & \frac{1}{2}e^{j\frac{2\pi(1)(1)}{4}} & \frac{1}{2}e^{j\frac{2\pi(1)(2)}{4}} & \frac{1}{2}e^{j\frac{2\pi(1)(3)}{4}} \\ \frac{1}{2}e^{j\frac{2\pi(2)(0)}{L}} & \frac{1}{2}e^{j\frac{2\pi(2)(1)}{4}} & \frac{1}{2}e^{j\frac{2\pi(2)(2)}{4}} & \frac{1}{2}e^{j\frac{2\pi(2)(3)}{4}} \\ \frac{1}{2}e^{j\frac{2\pi(3)(0)}{4}} & \frac{1}{2}e^{j\frac{2\pi(3)(1)}{4}} & \frac{1}{2}e^{j\frac{2\pi(3)(2)}{4}} & \frac{1}{2}e^{j\frac{2\pi(3)(3)}{4}} \end{bmatrix}$$

These codes apply a set of carrier phases to Galda's subcarrier values $S_l^{(m)}$ where l ranges from 0 to $L-1$. This means that when the symbols are modulated onto the subcarriers, the resulting subcarriers exhibit the same phase shift imparted by the code.

204. When the phase shifted subcarriers undergo the OFDM modulation process associated with Galda's IFFT, the interference patterns of the superposition ($s_i^{(m)}$) are shaped to produce a plurality of cyclic-shifted waveforms that each have one of the data symbols modulated thereon. The passage below describes this in more detail:

The transmit time signal $s_i^{(m)}$ of user m in an OFDM-FDMA uplink using DFT spreading matrix and an equidistant subcarrier allocation results therefore in a periodic repetition of the complex user data symbol $D_l^{(m)}$ sequence including an added guard interval as cyclic prefix, shown in Fig. 5. This periodic data sequence is multiplied by a user specific complex signal $e^{j2\pi im/N_c}$

due to the user individual frequency shift by m subcarriers of the complete allocated subcarrier set. The number of periods inside a single OFDM symbol is equal to the spacing M of the subcarriers allocated to user m .

EX1004-Galda, 1739-40.

205. Galda also includes the following mathematical expressions for equally spaced subcarriers:

$$\begin{aligned}
 s_i^{(m)} &= e^{j2\pi im/N_C} \cdot \frac{1}{\sqrt{L}} \cdot \sum_{l=0}^{L-1} \sum_{v=0}^{L-1} C_{l,v} D_v^{(m)} e^{-j2\pi il/L} \\
 &= e^{j2\pi im/N_C} \cdot \frac{1}{L} \sum_{v=0}^{L-1} D_v^{(m)} \underbrace{\sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L}}_{= L \delta_L(v-i)} \\
 &= e^{j2\pi im/N_C} \cdot \sum_{v=0}^{L-1} D_v^{(m)} \delta_L(v-i) \\
 s_i^{(m)} &= e^{j2\pi im/N_C} \cdot D_{i \bmod L}^{(m)} \quad (7)
 \end{aligned}$$

EX1004-Galda, 1739.

206. In the expressions above, the plurality of complex-valued codes $\vec{C}_l$ (represented by their elements “ $C_{l,v}$ ” and highlighted blue) shape the interference patterns of the superposition (highlighted yellow) to produce a plurality of cyclic-shifted waveforms (each represented by “the periodic dirac pulse sequence $\delta_L()$ ” and highlighted green) that each have one of the data symbols (represented by

“ $D_v^{(m)}$ ” and highlighted pink) modulated thereon. Galda’s equation (7) above includes the following expression:

$$L \delta_L(v - i) = \sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L},$$

where $\delta_L(v - i)$ represents L cyclic-shifted waveforms produced from the interference patterns of the superposition $\sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L}$, and $\sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L}$ is a restructuring of $\sum_{l=0}^{L-1} C_{l,v} e^{-j2\pi il/L}$ shown in the first line of expression 7 that represents how the plurality of complex-valued codes $\vec{C}_l$ shape the interference patterns of the superposition of subcarriers to produce the L cyclic-shifted waveforms:

$$\sum_{l=0}^{L-1} \underbrace{e^{j2\pi lv/L}}_{C_{l,v} = \vec{C}_l} \cdot e^{-j2\pi il/L} = \sum_{l=0}^{L-1} e^{j2\pi(v-i)l/L} = L \delta_L(v - i).$$

EX1004-Galda, 1739.

207. $\delta_L(v - i)$ represents L cyclic-shifted waveforms defined as:

$$\delta_L(v - i) = \begin{cases} 1, & \text{for } v \bmod L = i \bmod L \\ 0, & \text{otherwise} \end{cases}$$

where v identifies each of the L cyclic-shifted waveforms as having a unique shift v , where $v = 0, \dots, L - 1$, i indexes the waveform samples, and L defines each cyclic-shifted waveform’s cyclic nature. For example, $\delta_L(0 - i)$ represents cyclic-shifted waveform that is equal to 1 whenever $i \bmod L = 0$, and $\delta_L(1 - i)$

represents different cyclic-shifted waveform that is equal to 1 whenever $i \bmod L = 1$.

208. When $N_C = 8$, $M = 4$, and $L = 2$, as in the example illustrated in Fig. 5 of Galda, $\delta_L(v - i)$ becomes $\delta_2(v - i)$ and $s_i^{(m)}$ may be expressed as

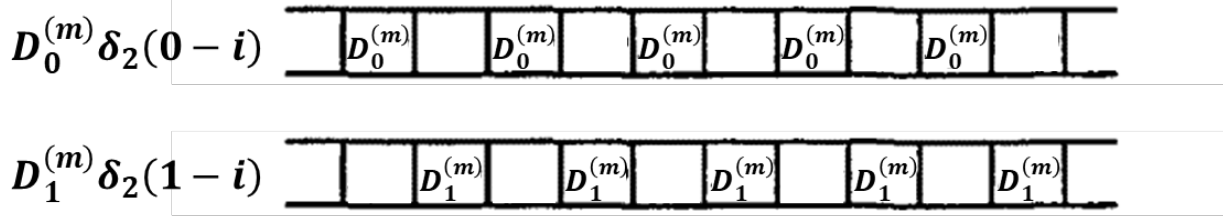
$$s_i^{(m)} = e^{j2\pi im/8} \cdot \sum_{v=0}^{2-1} D_v^{(m)} \delta_2(v - i)$$

$$= e^{j2\pi im/8} \left(D_0^{(m)} \delta_2(0 - i) + D_1^{(m)} \delta_2(1 - i) \right).$$

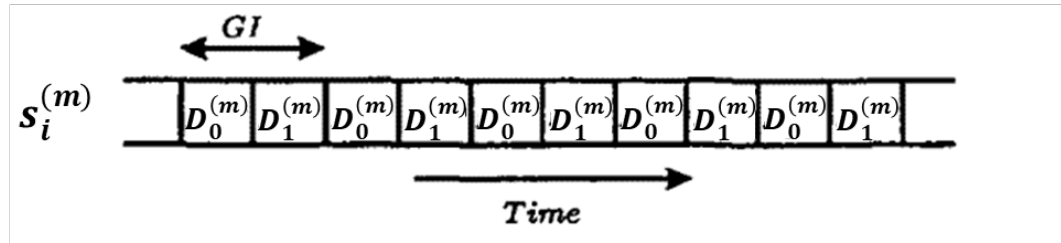
In this expression, $\delta_2(0 - i)$ represents cyclic-shifted waveform that has the data symbols $D_0^{(m)}$ modulated thereon, and $\delta_2(1 - i)$ represents a different cyclic-shifted waveform that has the data symbols $D_1^{(m)}$ modulated thereon. EX1004-Galda, 1739. In this example, $\delta_2(0 - i)$ is a cyclic-shifted waveform that is equal to 1 whenever $i \bmod 2 = 0$ (i.e., when $i = -2, 0, 2, 4, \text{ or } 6$), and $\delta_2(1 - i)$ is a cyclic-shifted waveform that is equal to 1 when $i \bmod 2 = 1$ (i.e., when $i = -1, 1, 3, 5, \text{ or } 7$) as shown visually below:

i		-2	-1	0	1	2	3	4	5	6	7	
$\delta_2(0 - i)$		1	0	1	0	1	0	1	0	1	0	
$\delta_2(1 - i)$		0	1	0	1	0	1	0	1	0	1	

209. Thus, $D_0^{(m)}\delta_2(0-i)$ and $D_1^{(m)}\delta_2(1-i)$ may be visualized as:



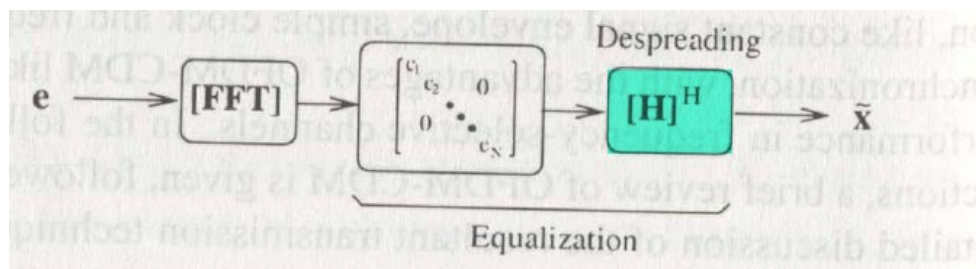
This corresponds to Galda's Fig 5. In other words, the expression $s_i^{(m)} = e^{j2\pi im/8} (D_0^{(m)}\delta_2(0-i) + D_1^{(m)}\delta_2(1-i))$ may be visualized in a simplified form, like the example shown in Fig. 5 of Galda, as the modified figure below shows:



210. A POSITA would have understood that Galda's Fig. 5 simplifies expression 7, and in doing so Galda omits the term " $e^{j2\pi im/8}$ " to illustrate the periodic repetition of the complex user data symbol $D_l^{(m)}$ sequence. The indices differ for a non-substantive reason, namely that the complex user data symbol $D_l^{(m)}$ sequence used in Galda's Fig. 5 is one-based indexing (i.e., ranges from 1 to L), rather than the zero-based indexing (i.e., ranges from 0 to $L-1$) as used in expression 7 and the examples provided above. This is a simple difference in nomenclature that does not impact the math or teachings in Galda.

211. Next, on the receiver side, Galda discloses that “data symbols $\tilde{D}_l^{(m)}$,” can be recovered “for each user by applying any single- or multi-code detection techniques,” and indicates that the recovery of the data symbols is performed by the “Equalization + Detection” block of Figure 1. EX1004-Galda, 1738-39. But Galda does not describe in detail a step of decoding that employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes, as in limitation 1D. Brüninghaus does describe this.

212. For example, Brüninghaus provides details of how to recover data symbols when DFT spreading is used in a transmitter. For example, Brüninghaus shows:



EX1016-Brüninghaus, 2330.

213. Brüninghaus explains that the “despreading” step uses “an inverse Fast-Fourier matrix $[\mathbf{H}]^H$.” EX1016-Brüninghaus, 2329-30 (Figs. 3 & 4). As explained above the superscript “ H ” represents the Hermitian transpose, which is also known as the “conjugate transpose” or the “complex conjugate transpose.” See EX1077-896 Patent, 2:2-3 (“The Hermitian transpose of a matrix A , denoted by A^H , is the

complex conjugate transpose of A .”). Therefore, Brüninghaus’s receiver employs codes that are “inverse to, complex-conjugate of, or complementary to” the DFT spreading codes $[H]$ because it uses the complex conjugate transpose of matrix $[H]$, referred to as $[H]^H$.

214. It would have been obvious to a POSITA to implement Brüninghaus’s complex-conjugate codes in Galda’s “Equalization + Detection” block to recover the original data symbols in the received information signals for the reasons I explained above in the “Reasons for Combining Prior Art” section related to Galda and Brüninghaus.

215. Thus, Galda in view of Brüninghaus teaches this limitation.

216. Therefore, Galda in view of Brüninghaus teaches and renders obvious claim 1.

2. Dependent Claims

[Claim 6] “The method of claim 1, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.”

217. Galda teaches this limitation.

218. More specifically, Galda teaches performing a fast Fourier transform (FFT) on an OFDM time signal to “split[] the time signal into the orthogonal subcarrier channels,” as discussed above with reference to Limitation 1B. EX1004-Galda, 1738.

219. A POSITA would have understood that an FFT is a type of discrete Fourier transform (DFT), which was both well known and conceded by the '386 patent itself. EX1001-386 Patent, 60:60-63 (“a DFT implemented with a fast transform algorithm, such as a fast Fourier transform”); *see also* EX1015-Prasad, 36.

220. Thus, Galda teaches and renders obvious claim 6.

[Claim 7] “The method of claim 1, further comprising removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.”

221. Galda teaches this limitation.

222. Galda discloses transmitter procedures to add a “guard interval as cyclic prefix” through DFT spreading and subcarrier allocation. EX1004-Galda, 1739-40. In particular, Galda states: “The transmit time signal $s_i^{(m)}$ of user m in an OFDM-FDMA uplink using DFT spreading matrix and an equidistant subcarrier allocation results therefore in a periodic repetition of the complex user data symbol $D_l^{(m)}$ sequence including an added guard interval as cyclic prefix, shown in Fig. 5.” EX1004-Galda, 1739-40; *see also* 1738 (“ N_G denotes the length of the guard interval which is inserted into the transmit time signal”).

223. The receiver of Galda “remov[es] the guard interval” and then “calculat[es] the Fourier transformation (FFT) which splits the time signal into the orthogonal subcarrier channels.” EX1004-Galda, 1738. As discussed above for

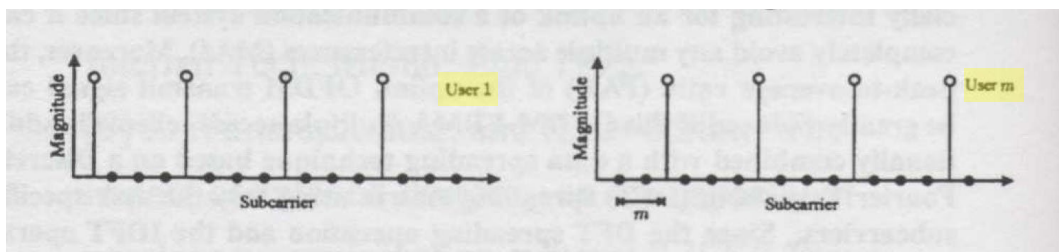
claim 1, clause [1B], the receiver using the FFT to split the time signal into the subcarrier channels is a process of converting the OFDM signal to the plurality of frequency-domain values.

224. Thus, Galda in view of Brüninghaus teaches and renders obvious claim 7.

[Claim 8] “The method of claim 1, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.”

225. Galda teaches this limitation.

226. More particularly, Galda’s transmitter system comprises N_C subcarriers, L subcarriers of which are allocated to a particular user. EX1004-Galda, 1738 (“In principle, the set of subcarrier assigned to each user can be composed of any L out of N_C subcarrier that have not been assigned to another user.”). Galda provides an example which shows different subcarriers assigned to User 1 as compared to User m :

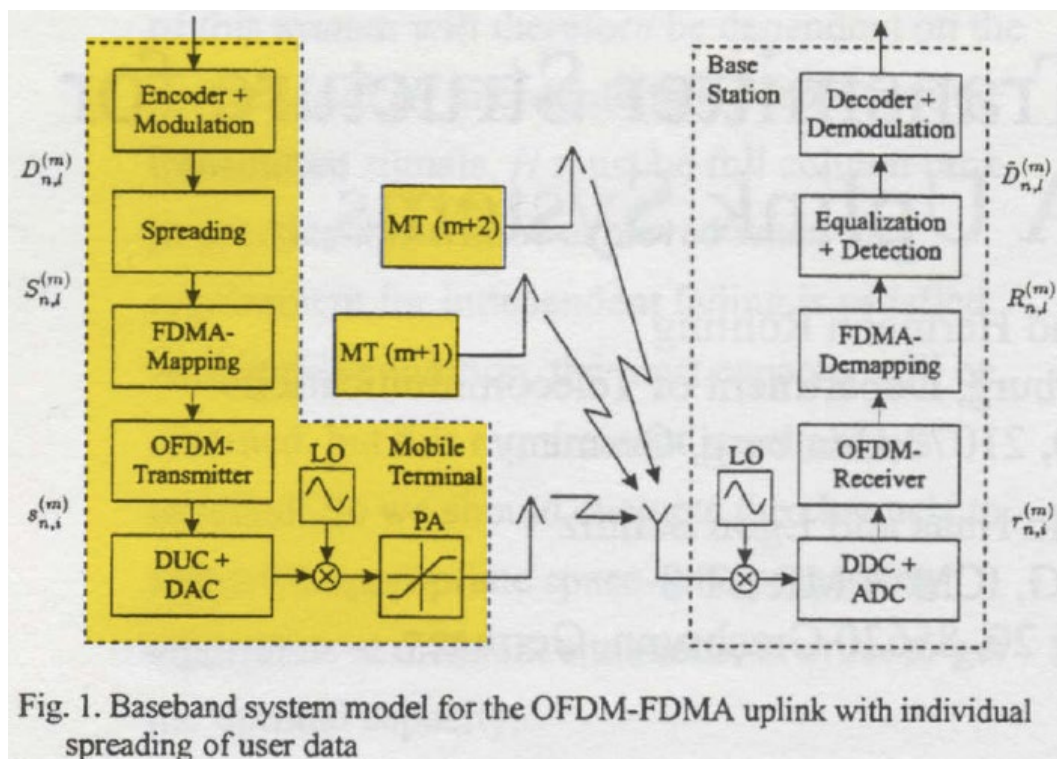


EX1004-Galda, 1738.

227. The figure above depicts orthogonal frequency division multiple access

for the users. This is part of the purpose of Galda's "OFDM-FDMA" scheme, which stands for "orthogonal frequency division-frequency division multiple access." EX1004-Galda, 1737 (referring to scheme as a "OFDM-FDMA multiple access scheme").

228. Galda also describes a receiver that performs an opposite / inverse function as the transmitter to receive and process signals from multiple users. For example, Figure 1 in Galda shows this as the transmitter sends signals from multiple users ("Mobile Terminal," "MT (m+1)," "MT (m+2)") to the receiver ("Base Station" and its "OFDM-Receiver"):



EX1004-Galda, 1738 (Fig. 1).

229. Thus, Galda teaches and renders obvious claim 9.

X. GROUND 4: Claims 10, 15-17, 19, and 24-26 are obvious over Galda in view of Brüninghaus and Dowling

A. Reasons for Combining Prior Art

230. Ground 4 relies on Galda in view of Brüninghaus and Dowling and addresses claims 10, 15-17, 19, and 24-26. These claims require a processor, memory, instructions stored in memory that are executed in a processor, computer-readable program code executed by a processor, and the like. Otherwise, these claims correspond to claims 1 and 6-8, as seen in the patent and in my analysis herein.

231. Galda and Brüninghaus do not explicitly state whether their OFDM receivers are implemented in hardware or a combination of hardware and software. Nevertheless, a POSITA would have understood that Galda in view of Brüninghaus would have needed to be implemented using at least one of these technologies. A POSITA would have found it obvious to implement Galda in view of Brüninghaus in software stored in memory coupled to a processor such that the software is executed by the processor.

232. More specifically, a POSITA would have understood that receivers could be implemented in hardware or software. The Dowling reference (EX1042-Dowling) provides one example by disclosing that its OFDM receiver including its

modulation techniques “may be implemented as software modules which execute on a programmable processor architecture.” EX1042-Dowling, 3:46-50; *see also* 5:66-6:1 (disclosing that the “transmitter, receiver and precoder may be implemented in hardware or software”); 21:62-64 (disclosing that the “present invention” is applicable to “FFT based multicarrier modulation and OFDM systems”).

233. In a software implementation, software is stored in memory, and is provided from memory to a processor for execution as was well known to a POSITA. Indeed, those skilled in the art were aware of “software radios” that used code in memory and processors to execute that code to provide flexibility in design and updating, as opposed to hardware which was significantly more difficult to upgrade because it is fixed in silicon. EX1008-Chen (describing OFDM-CDMA software radio); EX1011-Walton, 0124-25 (explaining that modulation “and other techniques” can be implemented in “hardware, software, or a combination thereof” and that “[t]he software codes may be stored in a memory unit...and executed by a processor”).

234. A POSITA would have been motivated and found it obvious to implement the disclosed receiving techniques as reflected in the combined teachings of Galda and Brüninghaus (as discussed above with reference to Ground 3) in a software radio (including code in memory and a processor coupled to memory to execute the code) rather than in specialized hardware. In particular, the use of

software and corresponding memory would have resulted in a more flexible system that could be modified and redesigned more easily.

235. Moreover, implementing the OFDM receiver of Galda in view of Brüninghaus using software and corresponding memory merely represented a simple substitution of one known element (a software-based receiver) for another (hardware implementation of same) to obtain predictable results (the same functionality performed in software rather than hardware). Likewise, implementing Galda in view of Brüninghaus using software and memory merely required a predictable use of prior art elements (software-based receiver components) according to their established functions (i.e., performing the same functions taught by Galda in view of Brüninghaus), and merely required applying a known technique (software implementation) to a known device (the receiver of Galda in view of Brüninghaus) ready for improvement (e.g., in the form of increased flexibility) to yield predictable results (a receiver using complex-conjugate of the DFT spreading codes used in a transmitter as reflected by Galda in view of Brüninghaus where the operations are implemented in software).

236. A POSITA also would have expected to succeed in making this combination. As I explain above, Galda in view of Brüninghaus discloses an OFDM receiver with the claimed features and defines the various mathematical operations for each of the components. Implementing these mathematical operations in

software would have required only routine knowledge because software is especially well-suited for performing mathematical operations. Given numerous disclosures indicating that those in the field were aware that various transceiver (transmitter and receiver) functions were able to be implemented in either hardware or software (both well-known alternatives), a POSITA would have reasonably expected success in achieving a software implementation using instructions stored on a memory for execution by a processor.

B. Challenged Claims

1. Independent Claims 10 and 19

[10Pre] “An apparatus for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the apparatus comprising:”

[10A] “at least one processor; and”

[10B] “a non-transitory computer-readable memory communicatively coupled to the at least one processor, the non-transitory computer-readable memory including a set of instructions stored thereon and executable by the at least one processor for:”

[19Pre] “A computer program product for receiving an Orthogonal Frequency Division Multiplexing (OFDM) signal transmitted by a user device in a wireless network, the computer program product comprising a non-transitory computer readable storage device having computer readable program code stored therein, said program code containing instructions executable by one or more processors of a computer system for:”

237. Galda in view of Brüninghaus and Dowling teaches these preambles and limitations.

238. First, Galda in view of Brüninghaus discloses 10Pre for the reasons provided above regarding 1Pre.

239. Galda in view of Brüninghaus and Dowling further discloses the elements set forth in 13A, 13B, and 25Pre. More particularly, Dowling teaches that many elements of an OFDM receiver including its modulation techniques “may be implemented as software modules which execute on a programmable processor architecture.” EX1042-Dowling, 3:46-50; *see also* 5:66-6:1 (disclosing that various elements may be implemented in hardware or software), 21:62-64 (disclosing that Dowling’s software radio teachings apply to elements including “FFT based multicarrier modulation and OFDM systems”).

240. In a software implementation, software is stored in memory, and is provided from memory to a processor for execution. A POSITA would have known that “software radios” were implemented by a processor executing code stored in memory, and that doing so provided desirable flexibility in design and the ability to update features of the radio as compared to hardware-only implementations that were more difficult to upgrade because they are fixed in silicon. EX1008-Chen (describing OFDM-CDMA software radio); EX1011-Walton, 0124-25 (explaining that modulation “and other techniques” can be implemented in “hardware, software, or a combination thereof” and that “[t]he software codes may be stored in a memory unit...and executed by a processor”). As I explain above, in consideration of Dowling, a POSITA would have found it obvious to implement the receiver of Galda in view of Brüninghaus in software stored on memory for execution by a processor

coupled to the memory as recited in claims 10 and 19.

241. Thus, Galda in view of Brüninghaus and Dowling teaches these preambles and limitations.

[10Ci] “determining a plurality of subcarrier frequencies allocated to the user device;”

[19A] “determining a plurality of subcarrier frequencies allocated to the user device;”

242. Galda in view of Brüninghaus teaches these limitations for the reasons provided above regarding limitation 1A.

[10Cii] “converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and”

[19B] “converting the OFDM signal to a plurality of frequency-domain values corresponding to the plurality of subcarrier frequencies; and”

243. Galda in view of Brüninghaus teaches these limitations for the reasons provided above regarding limitation 1B.

[10Ciii] “decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies;”

[19C] “decoding the plurality of frequency-domain values to recover a plurality of data symbols encoded by the user device on the plurality of subcarrier frequencies;”

244. Galda in view of Brüninghaus teaches these limitations for the reasons provided above regarding limitation 1C.

[10Civ] “wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.”

[19D] “wherein decoding employs a plurality of codes that are inverse to, complex-conjugate of, or complementary to a set of complex-valued codes that the user device employs to shape the OFDM signal into a superposition of cyclic-shifted pulse waveforms that each has one of the plurality of data symbols modulated thereon.”

245. Galda in view of Brüninghaus teaches these limitations for the reasons provided above regarding limitation 1D.

246. Thus, Galda in view of Brüninghaus and Dowling renders obvious claims 10 and 19.

2. Dependent Claims

[Claim 15] “The apparatus of claim 10, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.”

[Claim 24] “The computer program product of claim 19, wherein converting the OFDM signal to a plurality of frequency-domain values uses a discrete Fourier transform.”

247. Galda in view of Brüninghaus teaches these limitations for the reasons provided above regarding claim 6.

248. Thus, Galda in view of Brüninghaus and Dowling renders obvious claims 15 and 24.

[Claim 16] “The apparatus of claim 10, wherein the non-transitory computer-readable memory further includes instructions stored thereon and executable by the at least one processor for removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.”

[Claim 25] “The computer program product of claim 19, wherein the non-transitory computer-readable storage device further includes instructions stored therein and executable by the one or more processors for removing at least one of a guard interval, a cyclic prefix, and a cyclic postfix from the OFDM signal before converting the OFDM signal to the plurality of frequency-domain values.”

249. Galda in view of Brüninghaus teaches these limitations for the reasons provided above regarding claim 7.

250. Thus, Galda in view of Brüninghaus and Dowling renders obvious claims 16 and 25.

[Claim 17] “The apparatus of claim 10, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.”

[Claim 26] “The computer program product of claim 19, wherein converting the OFDM signal to the plurality of frequency-domain values provides for orthogonal frequency division multiple access for the user device and at least one other user device.”

251. Galda in view of Brüninghaus teaches these limitations for the reasons provided above regarding claim 8.

252. Thus, Galda in view of Brüninghaus and Dowling renders obvious claims 17 and 26.

XI. DECLARATION IN LIEU OF OATH

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. If called to testify as to the truth of the matters stated herein, I could and would testify competently.

I declare under penalty of perjury that the foregoing is true and correct.

April 25, 2025

A handwritten signature in black ink, appearing to read "Harry Bims", with a long horizontal flourish extending to the right.

Harry V. Bims, Ph. D.