

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

<i>In re</i> patent of Steve Shattil	§	REQUEST FOR <i>EX PARTE</i>
	§	REEXAMINATION
U.S. Patent No. 10,200,227	§	
	§	Attorney Docket No.: 50348.111
Filed: December 31, 2016	§	
	§	
Priority: May 14, 2002	§	
	§	Customer No.: 27683
Issued: Feb. 5, 2019	§	
	§	Proceeding No.: <i>to be assigned</i>
Title: PRE-CODING IN	§	
MULTI-USER MIMO	§	
	§	

REQUEST FOR EX PARTE REEXAMINATION

Mail Stop *Ex Parte* Reexam
Hon. Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Pursuant to the provisions of 35 U.S.C. §§ 301-307, Unified Patents, LLC (“Requester”) hereby requests an *ex parte* reexamination of claims 1-7 and 9-29 of United States Patent No. 10,200,227 (“the ’227 Patent,” EX1001), which issued on February 5, 2019, to Steve Shattil, resulting from U.S. Patent Application No. 15/396,567 filed on December 31, 2016, claiming priority to U.S. Patent Application No. 14/168,466 (issued as U.S. Patent No. 9,819,449), U.S. Patent Application No. 11/187,107 (issued as U.S. Patent No. 8,670,390), U.S. Patent Application No. 10/145,854 (issued as U.S. Patent No. 8,094,611), and U.S. Provisional Application No. 60/598,187. U.S. Patent Application No. 10/145,854 is the earliest of the listed filed applications, and it was filed on May 14, 2002. The ’227 Patent is presently assigned to Genghiscomm Holdings, LLC (“Genghiscomm”). One assignment to Genghiscomm is recorded in the U.S. Patent and Trademark Office (“USPTO”) at reel/frame 041752/0508 and another assignment to Genghiscomm is recorded in the USPTO at reel/frame 059709/0683.

Requester submits that this Request presents prior art references and analysis that are non-cumulative of the prior art that was before the Examiner during the original prosecution of the '227 Patent and that claims 1-7 and 9-29 of the '227 Patent are invalid over these references. Requester therefore requests that an order for reexamination and an Office Action rejecting claims 1-7 and 9-29 be issued.

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I. INTRODUCTION

The '227 Patent “relates generally to wireless communication networks, and more specifically to spread Orthogonal Frequency Division Multiplexing [OFDM].” '227 Patent (EX1001), 1:27-29. Although the '227 Patent has over 77 columns of disclosure, the figure on the face of the '227 Patent, Figure 30A, is a succinct representation of features that appear in the claims, particularly a discrete Fourier transform (DFT) 3021 followed by a subcarrier mapping 3022. The subcarrier mapping 3022 is followed by an inverse Fast Fourier Transform 3023, which, as discussed herein, is an implementation of an inverse Discrete Fourier Transform (IDFT).

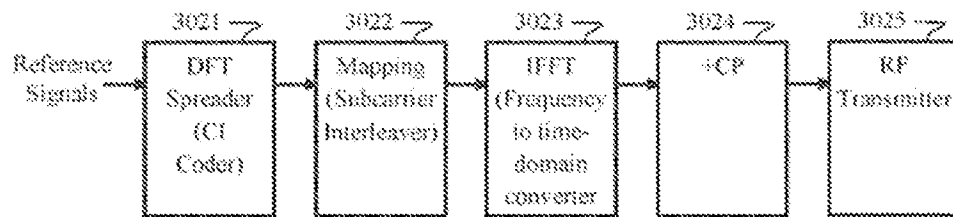


Figure 30A

'227 Patent (EX1001), Fig. 30A

The signal processing may produce a transmission signal that “can have low peak to average power ratio (PAPR).” '227 Patent (EX1001), 8:64-9:1.

As shown herein, the prior art Laroia presents the same sequence of processing – DFT, followed by a subcarrier mapping (labeled as “Zero insertion”), followed by IDFT, in Figures 4B and 5B. Figure 4B is reproduced below for reference.

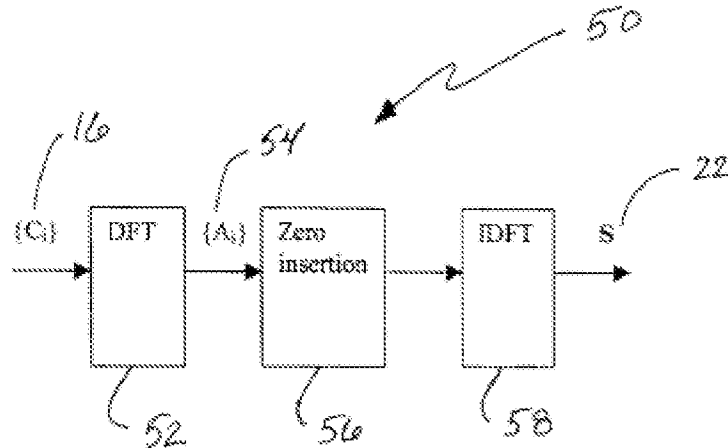


FIG. 4B

Laroia (EX1004), Fig. 4B

Furthermore, similar to the '227 Patent, Laroia forms its transmitted signal to achieve the same objective – reducing the peak-to-average power ratio. *See* Laroia (EX1004), Abstract (“A method for reducing the peak-to-average ratio in an OFDM communication signal is provided.”).

Although the claims of the '227 Patent are couched in mathematical terms used in signal processing – such as “invertible transform,” “complex-valued spreading matrix,” “superposition” of OFDM subcarriers, etc. – these are conventional operations used in DFTs and other OFDM signal processing, and Laroia alone renders obvious many of the claimed features (with the other similar prior art presented herein disclosing any remaining elements).

II. STATEMENT POINTING OUT SUBSTANTIAL NEW QUESTIONS OF PATENTABILITY

Prior to describing the substantial new questions of patentability presented in this Request, provided below is an overview of technology relevant to the '227 Patent, an overview of the '227 Patent and its prosecution history, a discussion of claim construction, and a listing of the prior art being discussed in this Request.

A. Technology Background

The '227 Patent generally relates to a wireless communication system and method that employs Orthogonal Frequency Division Multiplexing (OFDM). A basic building block in signal processing, known as an inverse Fast Fourier Transform (IFFT), is used for OFDM modulation.

Geier (EX1003), ¶32 (citing Singh (EX1016)). An IFFT is an efficient implementation of an inverse Discrete Fourier Transform (IDFT). *Id.* (citing Jacobsen (EX1014)). An IFFT has a counterpart known as a Fast Fourier Transform (FFT), and the two are inverses of each other. Likewise, the DFT and IDFT are inverses of each other. The FFT, IFFT, DFT, and IDFT each operate on a vector of complex values to produce a vector of complex values. For example, Singh presents an OFDM transmitter, reproduced below in Figure 3, illustrating the use of an IFFT to produce OFDM blocks. Singh (EX1016), 5:12 (“FIG. 3 is a block diagram of an OFDM transmitter...”). According to Singh, “[t]he IFFT 54 inverse Fourier transforms the parallel QAM symbols into OFDM blocks of OFDM samples.” Singh (EX1016), 7:26-28; Geier (EX1003), ¶32.

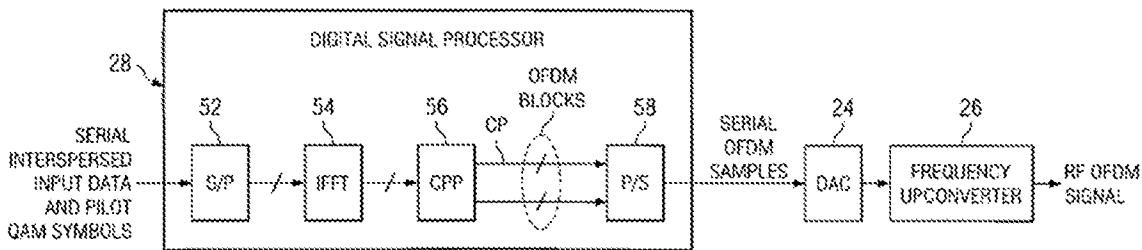


FIG. 3

Singh (EX1016), Fig. 3

The '227 Patent assumes that a person of ordinary skill in the art (POSITA) is familiar with OFDM modulation, such as an OFDM signal being made up of a group of subcarriers in frequency. Indeed, a POSITA was familiar with OFDM, subcarriers, and multi-carrier modulation. Geier (EX1003), ¶33 (citing Van Nee (EX1009)).

The '227 Patent makes repeated references to “complex” values. *See, e.g.*, '227 Patent (EX1001), 74:16-18 (“The result of the subcarrier mapping is a set of complex subcarrier amplitudes...”). A POSITA would have understood such complex numbers and complex arithmetic, as complex signal representation and manipulation was part of the prior art for wireless communications. Geier (EX1003), ¶34 (citing Singh (EX1016) and Thoumy (EX1005)).

Wireless communication involves mapping bits to symbols, which may be represented by complex numbers. Thoumy provides an example of complex signal representation of QAM signals, mapping two bits to one of four symbols. Thoumy (EX1005), 26:38-41; Geier (EX1003), ¶35. Thoumy’s complex values are annotated onto Figure 19 below, and real and imaginary values

(in this example, real values are +1 and -1, and imaginary values are +j, and -j) are indicated on each axis. Each QAM symbol is represented by a complex value on a two-dimensional coordinate plane, with the X-axis representing real numbers and the Y-axis representing imaginary numbers, and a QAM symbol indicated using a real-valued component and an imaginary-valued component. Geier (EX1003), ¶36.

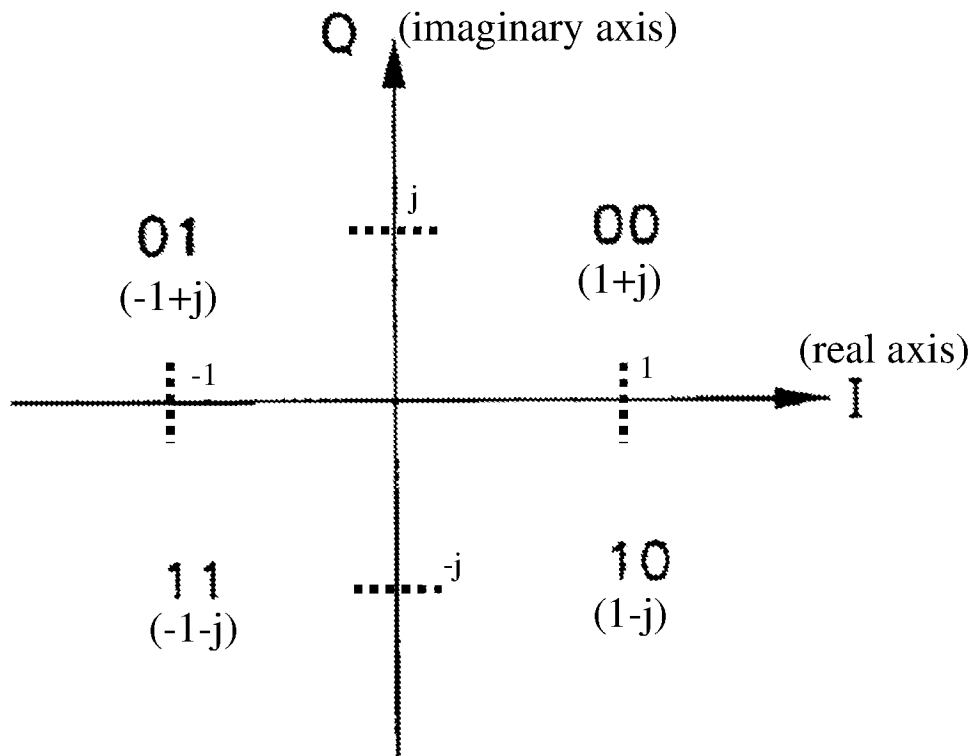


FIG. 19

Thoumy (EX1005), Fig. 19 (annotated)

When represented in vector form, these symbols have an associated magnitude (amplitude) and phase. Complex signal representation meshes well with the fact that wireless signals are modulated onto a sinusoidal carrier signal, in which the sinusoidal carrier has phase and/or amplitude information that represents the underlying digital information. Geier (EX1003), ¶37 (citing Thoumy (EX1005), Figure 19).

B. Summary of the '227 Patent

Although the '227 Patent has over 77 columns of disclosure, Fig. 30A, the figure on the face of the '227 Patent, is a succinct representation of features that appear in the claims of the '227 Patent.

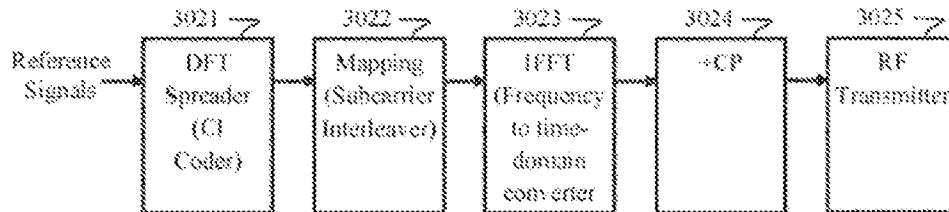


Figure 30A

'227 Patent (EX1001), Fig. 30A

Figure 30A is a “block diagram of a transmitter” and includes a DFT “spreader” 3021, which may be implemented by an N-point DFT, followed by a subcarrier mapping 3022, followed by an IFFT 3023, which performs “OFDM modulation.” See '227 Patent (EX1001), 70:56-60, 71:25-26, 71:30-34; Geier (EX1003), ¶38.

Figure 31 is also representative of claimed features, illustrating a “spread-DFT” 3102, followed by a “symbol-to-subcarrier mapping” 3103, followed by an “M-point inverse DFT (e.g., IFFT...)” 3104). The input to the “spread-DFT” 3102 is a sequence of complex numbers representing one of several possible modulation formats. '227 Patent (EX1001), 73:23-30. As explained in Section II.A (Technology Background), “complex” values were well understood in the art. The “spread-DFT” 3102 may be implemented by an N-point DFT. '227 Patent (EX1001), 73:41-42 (“Spread-DFT source code segment 3102 can be configured to perform an N-point DFT...”). And the “M-point inverse DFT,” such as an IFFT 3104, was understood to be an OFDM modulator. Geier (EX1003), ¶39.

Therefore, the '227 Patent presents a few examples of a DFT, followed by subcarrier mapping, followed by an OFDM modulator, such as an IDFT or IFFT. Notably, Laroia presents the same sequence of processing in Figures 4B and 5B. Figure 4B is reproduced below for reference, also illustrating the sequence of a DFT, followed by a method of subcarrier mapping

known as “zero insertion,” followed by an IDFT for OFDM modulation. Geier (EX1003), ¶40; Laroia (EX1004), [0053].

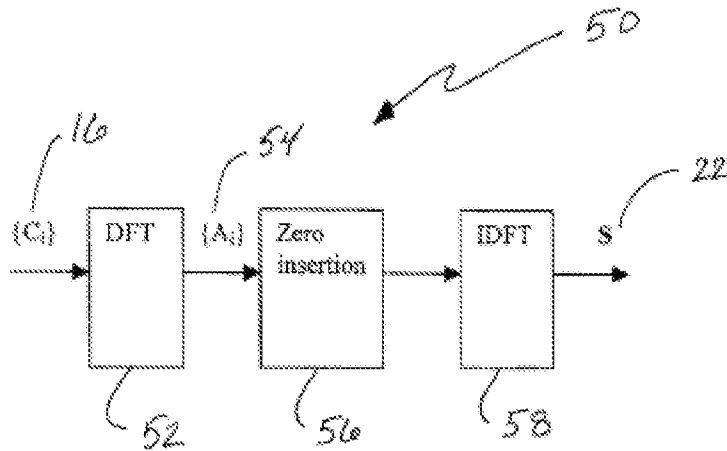


FIG. 4B

Laroia (EX1004), Fig. 4B

Exemplary claims 1 and 2 of the '227 Patent present an “invertible transform,” followed by “mapping,” followed by “modulating,” wherein the “invertible transform comprises an N-point” DFT, and the “modulating comprises performing an M-point inverse-DFT.” Claims 1 and 2 are reproduced below with the terms shown above underlined for convenience. Geier (EX1003), ¶41.

1. A non-transitory computer-readable medium including computer-readable program code stored thereon, the computer-readable program code configured to be executed by at least one processor to implement a method for generating an Orthogonal Frequency Division Multiplexing (OFDM) transmission signal, the method comprising:

employing an invertible transform to spread a plurality of data symbols with complex-valued coefficients to generate a plurality of spread data symbols;

mapping the spread data symbols to a plurality of OFDM subcarriers; and

responsive to the mapping, modulating the spread data symbols onto the plurality of OFDM subcarriers to produce the OFDM transmission signal comprising a superposition of the OFDM subcarriers, wherein employing the

invertible transform is configured to provide the superposition with a reduced peak-to-average power ratio.

2. The non-transitory computer-readable medium recited in claim 1, wherein the invertible transform comprises an N-point discrete Fourier Transform (DFT), and the modulating comprises performing an M-point inverse-DFT, wherein $M > N$.

C. Prosecution History of the '227 Patent and Related Patents

The '227 Patent issued from U.S. Application No. 15/396,567, filed on December 31, 2016. The application leading to the '227 Patent claims priority to the following chain of continuation-in-part applications:

- U.S. Patent Application No. 14/168,466 (issued as U.S. Patent No. 9,819,449), filed Jan. 30, 2014;
- U.S. Patent Application No. 11/187,107 (issued as U.S. Patent No. 8,670,390), filed July 22, 2005; and
- U.S. Patent Application No. 10/145,854 (issued as U.S. Patent No. 8,094,611), filed May 14, 2002.

The application that led to the '227 Patent also claims priority to U.S. Provisional Patent Application No. 60/598,187.

In a first non-final office action, certain claims were rejected under 35 U.S.C. § 112 as being indefinite, and all claims (claims 1-29) were rejected on the basis of a statutory double-patenting rejection as claiming the same invention as claims 1-29 of related U.S. Patent No. 9,768,842. EX1002, pp. 296-299. In response, Applicant amended the claims to address the Section 112 rejections, and argued that, based on the amendments, the double-patenting rejection should be withdrawn. *Id.*, pp. 355-365.

In the next Office Action, all claims (claims 1-29) were again rejected on the basis of nonstatutory obviousness-type double patenting as being unpatentable over claims 1-29 of U.S. Patent No. 9,768,842. *Id.*, pp. 368-378. Certain claim terms were also presumed to invoke 35 U.S.C. § 112(f). In response, a terminal disclaimer was filed with respect to U.S. Patent No. 9,768,842, and claim 1 was amended to avoid invoking 35 U.S.C. 112(f). *Id.*, pp. 396. The next action was a Notice of Allowance. *Id.*, pp. 399-406.

Since the '227 Patent and U.S. Patent No. 9,678,842 are linked via a double-patenting rejection and terminal disclaimer, the prosecution history of U.S. Patent No. 9,678,842 (EX1007) is of interest. Therefore, turning to the prosecution history of U.S. Patent No. 9,768,842, in the first office action, the claims were rejected on the basis of nonstatutory double patenting as being unpatentable over claims of co-pending Application No. 15/396,567 (the application that matured into the '227 Patent) and U.S. Patent No. 9,485,063. EX1007, pp. 1-6. This was the only rejection. In response, Applicant filed a terminal disclaimer with respect to Application No. 15/396,567 and U.S. Patent No. 9,485,063. *Id.*, pp. 8-9.

Turning to the prosecution history of U.S. Patent No. 9,485,063 (EX1008), in a first non-final office action, most claims were rejected as anticipated by U.S. Patent Pub. No. 2016/0006594 (Persson, EX1006), and others were rejected as obvious in view of Persson. EX1008, pp. 11-14. The Examiner focused on Figure 5 of Persson and associated discussion. *Id.* at 11-12. Note that the Examiner pointed to—and applicant did not dispute—a block 520 with a DFT 522 in Figure 5 of Persson (reproduced below) as being “an OFDM spreader configured to spread a plurality of reference-signal symbols with Fourier coefficients...”

3. **Claim(s) 1-3, 5, 7, 9, 13, 14, 17-20, 25** is/are rejected under pre-AIA 35 U.S.C. 102(e) as being anticipated by Persson et al. (US 2016/0006594) (hereinafter Persson).

Re claim 1, Persson discloses:

“an OFDM spreader configured to spread a plurality of reference-signal symbols with Fourier coefficients to generate a Discrete Fourier Transform (DFT)-spread reference signal” (Fig. 5, element 520; para. 0037, 0038, 0040);

Id. at 11.

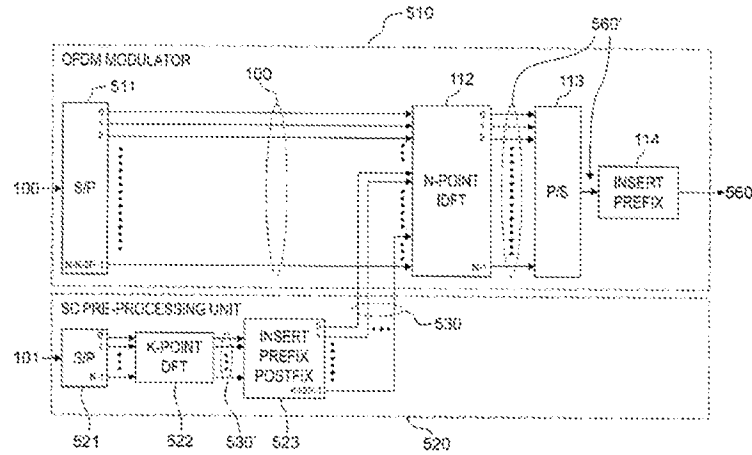


FIG. 5

Persson (EX1006), Fig. 5

The subject matter of claim 8 was indicated as allowable. EX1008 at 18. In response, Applicant amended independent claims 1, 13, and 24 to include the subject matter of claim 8 and intervening claim 7. The subject matter of claim 8, the limitation indicated as allowable, is as follows:

8. The OFDM transmitter recited in claim 7, wherein the at least one predetermined time-domain signal characteristic comprises at least one of a plurality of uniformly spaced pulse waveforms and a signal with low peak-to-average power ratio.

Id. at 3. In the context of issued claim 1, the limitation appears as follows (underlining added to show the subject matter of claim 8):

1. An OFDM transmitter, comprising:

an OFDM spreader configured to spread a plurality of reference-signal symbols with Fourier coefficients to generate a Discrete Fourier Transform (DFT)-spread reference signal;

a mapper configured to map the DFT-spread reference signal to a plurality of OFDM subcarriers; and

an OFDM modulator configured to modulate the DFT-spread reference signal onto the plurality of OFDM subcarriers to produce an OFDM transmission signal,

wherein the OFDM transmission signal comprises a superposition of the OFDM subcarriers, and

wherein the OFDM spreader is configured to provide the superposition with at least one predetermined time-domain signal characteristic comprising at least one of a plurality of uniformly spaced pulse waveforms and a signal with low peak-to-average power ratio.

EX1011, claim 1. Therefore, the prior art Persson reference was shown to teach DFT spreading, mapping, and modulating the DFT-spread signal onto a plurality of OFDM subcarriers to produce an OFDM transmission signal, wherein the OFDM transmission signal comprises a superposition of the OFDM subcarriers. Geier (EX1003), ¶¶42-47.

The prior art reference Laroia likewise teaches these features, and additionally teaches that the DFT spreading is performed with the express purpose of reducing peak-to-average power ratio. Geier (EX1003), ¶47.

Laroia was not considered or made of record during prosecution of the '227 Patent, but the issued patent corresponding to Laroia (U.S. Pat. 7,295,509) was included in an information disclosure statement (IDS) and is listed in the References Cited, but was not listed with a "*" to indicate "cited by Examiner." There were five information disclosure statements submitted prior to the first office action during prosecution. EX1002, pp. 182-193 (first IDS), pp. 203-225 (second IDS), pp. 251-255 (third IDS), pp. 279-282 (fourth IDS), and pp. 285-289 (fifth IDS). The issued patent corresponding to Laroia (U.S. Pat. No. 7,295,509) was submitted together with 131 other patent references, 50 patent publication references, and 33 non-patent literature references in an IDS on Jan 4, 2017. EX1002, pp. 203-225. A continuation-in-part of Laroia (U.S. Patent No. 9,130,180) was submitted together with 59 other patent references and numerous other references in the first IDS on Jan. 3, 2017. *See* EX1002, pp. 182-193. No other applications related to Laroia appear on the face of the '227 Patent.

U.S. Patent Nos. 9,768,842 and 9,485,063 were cited in double-patenting rejections in the '227 prosecution history. Similar to the '227 Patent, the patent corresponding to Laroia is cited on the face of each of U.S. Patent Nos. 9,768,842 (EX1010) and 9,485,063 (EX1011) but was not listed with a "*" to indicate "cited by Examiner." Neither Laroia nor the patent that issued from it (U.S. Pat. No. 7,295,509), nor any other Laroia counterpart, was applied in a rejection during prosecution of the related patents linked via terminal disclaimer. Geier (EX1003), ¶¶48-49.

D. Claim Construction

The '227 Patent has expired, with the earliest non-provisional in the priority chain having been filed on May 14, 2002 and patent term having been adjusted 44 days. Therefore, the *Phillips* standard for claim construction applies. *See In re CSE-System Int'l, Inc.*, 832 F.3d 1335, 1341 (Fed. Cir. 2016) (“[W]hen an expired patent is subject to reexamination, the traditional *Phillips* construction standard attaches.”). Under the *Phillips* standard, words of a claim are given their “ordinary and customary meaning,” which is “the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention, i.e., as of the effective filing date of the patent application.” *Phillips v. AWH Corp.*, 415 F.3d 1303, 1312-13 (Fed. Cir. 2005) (*en banc*). However, only those claim terms that are in controversy need to be construed, and only to the extent necessary to resolve the controversy. *See Nidec Motor Corp. v. Zhongshan Broad Ocean Motor Co.*, 868 F.3d 1013, 1017 (Fed. Cir. 2017). For the purpose of this reexamination, no claim terms require express construction. Geier (EX1003), ¶26.

E. Listing of Prior Art Patents and Printed Publications

The '227 Patent is part of a chain of continuity via three continuation-in-part applications tracing back to App. No. 10/145,854, filed on May 14, 2002. Without conceding that the '227 Patent is entitled to this earliest priority date, all the prior art used herein is prior art relative to the earliest possible priority date of the '227 Patent of May 14, 2002.

Reexamination of claims 1-7 and 9-29 of the '227 Patent¹ is requested in view of the following references:

Exhibit 1004 (“Laroia”) U.S. Patent Application Publication No. 2002/0172213 to Rajiv Laroia, et al., filed March 15, 2001, which is prior art at least under pre-AIA

¹ The '227 Patent claims priority to some applications dated before the America Invents Act (March 16, 2013) and some applications dated after the AIA. It is assumed for the purposes of this Request that all claims of the '227 Patent are entitled to the benefit of the earliest possible priority date of May 14, 2002, so the pre-AIA framework is assumed to apply. However, both AIA statutes and pre-AIA statutes are cited in this Section II.E to show that all references are prior art, regardless of which of the pre-AIA or AIA statutory frameworks apply.

35 U.S.C. § 102(e). (Laroia is also prior art under AIA 35 U.S.C. § 102(a)(2).)

Exhibit 1005 (“Thoumy”) U.S. Patent No. 7,039,120 to Francois Thoumy, et al., filed on November 30, 1999, which is prior art at least under pre-AIA 35 U.S.C. § 102(e). (Thoumy is also prior art under AIA 35 U.S.C. § 102(a)(2).)

Exhibit 1016 (“Singh”) U.S. Patent No. 7,139,320 to Manoneet Singh, et al., filed October 11, 2001, is prior art at least under pre-AIA 35 U.S.C. § 102(e). (Singh is also prior art under AIA 35 U.S.C. § 102(a)(2).)

Exhibit 1017 (“Larsson”) U.S. Patent No. 6,842,487 to Peter Larsson, filed September 22, 2000, which is prior art at least under pre-AIA 35 U.S.C. § 102(e). (Larsson is also prior art under AIA 35 U.S.C. § 102(a)(2).)

Exhibit 1018 (“Li”) U.S. Patent No. 6,904,283 to Xiaodong Li, et al., filed on April 17, 2001, which is prior art at least under pre-AIA 35 U.S.C. § 102(e). (Li is also prior art under AIA 35 U.S.C. § 102(a)(2).)

Exhibit 1019 (“Cimini”) U.S. Patent No. 6,891,792 to Leonard Cimini, et al., filed on May 14, 1999, which is prior art at least under pre-AIA 35 U.S.C. § 102(e). (Cimini is also prior art under AIA 35 U.S.C. § 102(a)(2).)

As demonstrated below, Laroia, Thoumy, Singh, Larsson, Li, and Cimini present substantial new questions of patentability.

F. Laroia, Thoumy, Singh, Larsson, Li, and Cimini Present Substantial New Questions of Patentability

Laroia alone renders obvious claims 1-3, 5, and 6, as shown in Section IV.A. below. The Examiner did not substantively address Laroia, or any of its related counterparts, with respect to the claims during prosecution of the ’227 Patent. Therefore, Laroia presents a substantial new question of patentability, and a reasonable examiner would consider the reference important in determining whether claims 1-3, 5, and 6 are patentable.

Laroia was not considered or made of record during prosecution of the ’227 Patent. The issued patent corresponding to Laroia (U.S. Pat. 7,295,509) is included in the “References Cited” section, but it was only provided via an information disclosure statement and was not applied in any rejection. Moreover, there were five information disclosure statements submitted prior to the first office action during prosecution. The issued patent corresponding to Laroia was submitted together with 131 other patent references, 50 patent publication references, and 33 non-patent literature references in an IDS on Jan 4, 2017. *See* EX1002, pp. 203-225.

Furthermore, as explained in Section III, the '227 Patent is part of a large patent family involving over 50 related patent applications. *See* EX1020. Five patents related to the '227 Patent were also checked for evidence of the consideration of Laroia or its counterpart. *See* Section III. A counterpart to Laroia is listed on the face of these patents, but there is no indication that they were used in rejections during prosecution. To the best of Requester's knowledge, neither Laroia nor any of its counterparts were applied in a rejection during prosecution of any of these patents.

Although a counterpart to Laroia was identified during prosecution as part of an extensive list of references in various IDSs, "[t]he existence of a substantial new question of patentability is not precluded by the fact that a patent or printed publication was previously cited by or to the Office or considered by the Office." 35 U.S.C. 303(a). "The substantial new question of patentability may be based on art previously considered by the Office if the reference is presented in a new light or a different way that escaped review during earlier examination." MPEP § 2216. Laroia is presented herein in a new light or a different way that escaped review during examination.

As shown herein, Laroia alone renders obvious many of the claims. For example, Figure 30A of the '227 Patent is a succinct representation of claimed features illustrating a DFT, followed by subcarrier mapping, followed by an OFDM modulator, such as an IDFT or IFFT (e.g., which is essentially the same sequence recited in independent claims 1, 11, and 22 of the '227 Patent, where a DFT is an example of the claimed "*invertible transform*" as shown herein, such as in claim 2). For example, Laroia presents the same sequence of processing in its Figure 4B as the '227 Patent claims (DFT 52, followed by mapping DFT outputs to certain subcarriers and setting the remaining subcarriers to zero, referred to as zero insertion 56, followed by IDFT 58), reproduced below. In addition, the DFT and subcarrier mapping in Laroia are performed with the express purpose of reducing peak-to-average power ratio, which is a feature added in a related application to the '227 Patent to gain allowance of the claims, where the related application was used in an obviousness-type double-patenting rejection in the '227 prosecution history.

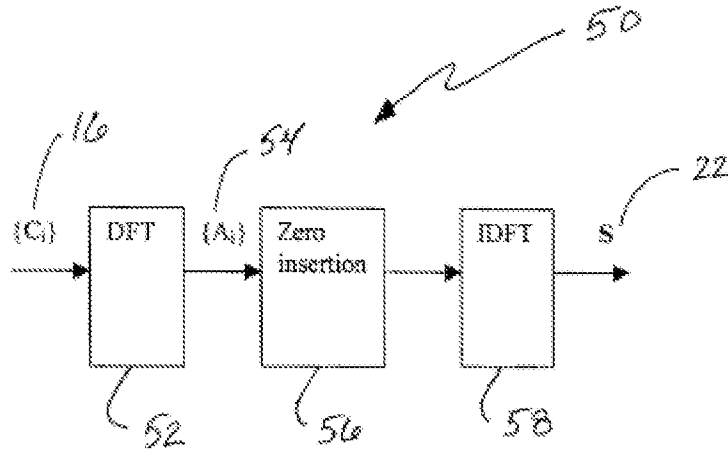


FIG. 4B

Laroia, Fig. 4B

In addition, none of Thoumy, Singh, Larsson, Li, or Cimini was cited or applied during prosecution of the '227 Patent.

As shown below, Requester submits that the prior art references Laroia, Thoumy, Singh, Larsson, Li, and Cimini raise “substantial new question[s] of patentability” because “the teaching of the (prior art) patents and printed publications is such that a reasonable examiner would consider the teaching to be important in deciding whether or not the claim is patentable.” *See* MPEP § 2242 (emphasis in original).

The present Request proposes the following rejections based on Laroia, Thoumy, Singh, Larsson, Li, and Cimini:

Proposed Rejection A1: Claims 1-3, 5, and 6 are obvious over Laroia under 35 U.S.C. § 103(a).

Proposed Rejection A2: Claims 1-3, 5, 6, 11, 12, 14, 18, and 20-27 are obvious over Laroia, and Thoumy under 35 U.S.C. § 103(a).

Proposed Rejection A3: Claims 4 and 9 are obvious over Laroia and Singh under 35 U.S.C. § 103(a).

Proposed Rejection A4: Claims 4, 9, 15, and 16 are obvious over Laroia, Thoumy, and Singh under 35 U.S.C. § 103(a).

Proposed Rejection A5: Claim 10 is obvious over Laroia and Larsson under 35 U.S.C. § 103(a).

Proposed Rejection A6: Claims 10 and 19 are obvious over Laroia, Thoumy, and Larsson under 35 U.S.C. § 103(a).

Proposed Rejection A7: Claims 13 and 29 are obvious over Laroia, Thoumy, and Li under 35 U.S.C. § 103(a).

Proposed Rejection A8: Claim 7 is obvious over Laroia and Cimini under 35 U.S.C. § 103(a).

Proposed Rejection A9: Claims 7, 17, and 28 are obvious over Laroia, Thoumy, and Cimini under 35 U.S.C. § 103(a).

In brief:

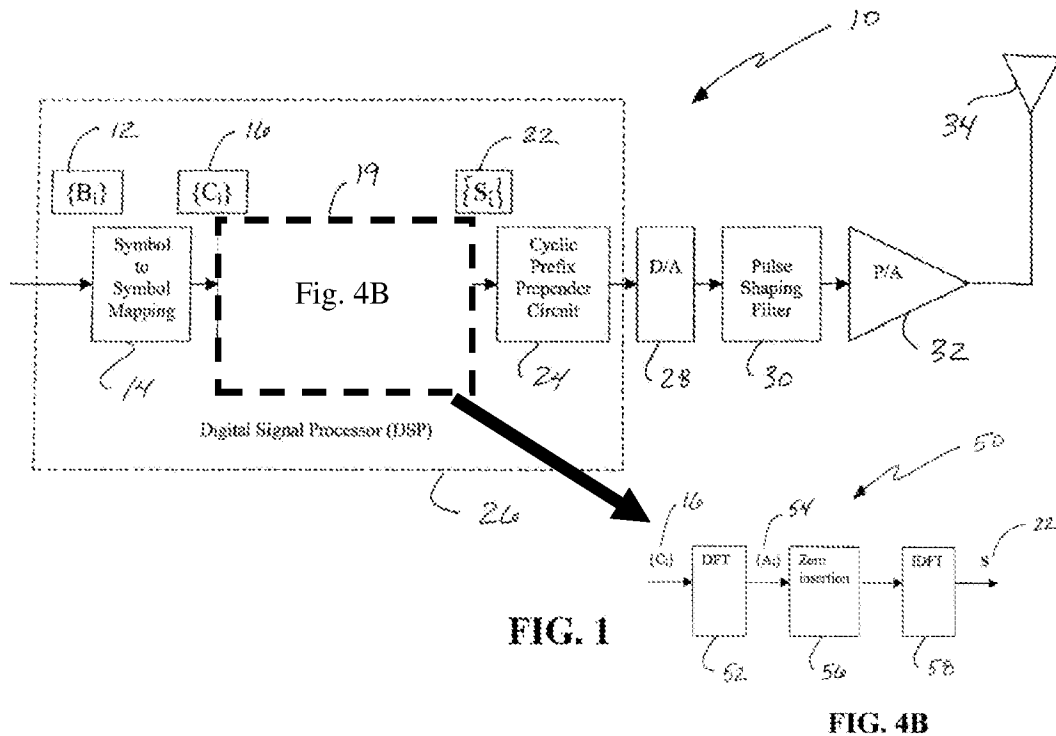
- Laroia alone discloses or renders obvious claims 1-3, 5, and 6 as explained above. The DFT and subcarrier mapping in Laroia are performed with the express purpose of reducing peak-to-average power ratio, which is a feature added in an application related to the '227 Patent to gain allowance of the claims, where the related application was used in an obviousness-type double-patenting rejection in the '227 prosecution history. (*See* Section II.C.)
- Thoumy presents a conventional method of calculating a DFT, such as the DFT in Laroia, to the extent that a POSITA did not already possess this knowledge. Laroia presents use of a DFT in an OFDM system and discusses the inputs and outputs of a DFT block, but does not present the calculations that occur in a DFT. Thoumy provides these implementation details.
- Singh describes the interspersing of pilot symbols among data symbols prior to OFDM modulation for the purpose of channel estimation and synchronization. Singh is used to address dependent claims 4 and 9 that relate to the use of “*reference-signal symbols*,” such as pilot symbols.

- Larsson describes the use of cyclic delay diversity in OFDM systems. Larsson is used to address dependent claims 10 and 19 that relate to “*cyclic delay diversity (CDD)*.”
- Li describes selecting subcarriers for transmission in OFDM systems based on channel quality. Li is used to address dependent claims 13 and 19 that relate to selecting subcarriers based on a “*measured channel quality*.”
- Cimini describes adding a cyclic prefix, a cyclic suffix, and a guard interval to an OFDM signal. Cimini is used to address dependent claims 7, 17, and 28 that relate to appending “*at least one of a cyclic prefix, a postfix, and a guard interval to the OFDM transmission signal*.”

The analysis of the references is supported by a declaration from technical expert James Geier (EX1003).

(i) Laroia

Laroia is directed to methods for “reducing the peak-to average ratio in an OFDM communication signal.” Laroia (EX1004), Abstract. According to Laroia, one way of forming OFDM signal samples $\{S_i\}$ is “by directly applying one or more predetermined discrete interpolation functions to the mapped complex symbols 19.” Laroia (EX1004), [0036]. One of these “discrete interpolation functions” is presented in Figure 4B. Laroia (EX1004), [0053] (“The collective procedure of DFT, zero insertion and IDFT is one way of implementing the discrete interpolation functions.”). Laroia’s OFDM communication system in Figure 1 is modified below to show the placement of Figure 4B within the OFDM communication system, as described in Laroia’s disclosure reviewed above. Geier (EX1003), ¶¶50-51.



Laroia (EX1004), Fig. 1 with Fig. 4B (annotated)

Laroia's disclosure of DFT (52), followed by zero insertion and mapping to subcarriers (56), followed by performing an IDFT (58) is similar to an embodiment in the '227 Patent:

...the processor performs **N-point DFT spreading on the N data symbols** to generate a set of N DFT-spread components of the N data symbols. The processor **then maps the N DFT-spread components of the N data symbols to N subcarriers** of a set of M subcarriers ($M > N$) to generate a set of complex subcarrier amplitudes. The processor **performs an M-point inverse discrete Fourier transform**, such as an inverse fast Fourier transform (IFFT), on the set of complex subcarrier amplitudes...

'227 Patent (EX1001), 72:41-49 (emphasis added); Geier (EX1003), ¶51.

Laroia is analogous art to the '227 Patent for two reasons: (1) it is in the same field of endeavor as the '227 Patent, and (2) it is reasonably pertinent to at least one problem faced by the inventor of the '227 Patent. Geier (EX1003), ¶52.

First, Laroia is analogous art to the '227 Patent because it is in the same field of endeavor as the '227 Patent of wireless communication networks.'227 Patent (EX1001), 1:25-29 ("The present invention relates generally to wireless communication networks..."); Laroia (EX1005), [0005] ("[E]xisting OFDM techniques are not well suited for a wireless multiple access communication network [so] ... it is desirable to provide an OFDM technique which reduces the peak-to-average ratio of the signal to be transmitted."). Geier (EX1003), ¶53.

Second, Laroia is analogous art to the '227 Patent because it is also reasonably pertinent to at least one problem faced by the inventor of the '227 Patent. One problem faced by the inventor of the '227 Patent is the reduction of peak-to-average power ratio (PAPR):

CI-OFDM can be configured as a DFT pre-coded OFDMA scheme. CI OFDM is distinctly different from prior-art OFDMA, for example, because of the DFT pre-coding (e.g., spreading) of the symbols in the transmitter...The use of CI-OFDM transmission techniques by UEs is described herein because **lower PAPR greatly benefits mobile terminals in terms of transmit power efficiency.**

'227 Patent (EX1001), 72:53-66 (emphasis added). The use of a DFT applied to symbols in a transmitter is allegedly "distinctly different from prior-art OFDMA" and results in "lower PAPR [that] greatly benefits mobile terminals." *Id.* Thus, one problem faced by the inventor is reducing PAPR (and this is accomplished via use of a DFT). Geier (EX1003), ¶54.

Likewise, Laroia addresses the same problem of reducing PAPR: "A method for **reducing the peak-to-average ratio** in an OFDM communication signal is provided." Laroia (EX1004), Abstract (emphasis added); *see also* [0005] ("[I]t is desirable to provide an OFDM technique which reduces the peak-to-average ratio of the signal to be transmitted."). And, as explained herein, Laroia employs a DFT, such as in Figure 4B above, to reduce PAPR. *See, e.g., infra* analysis of claim element [1.4]. Geier (EX1003), ¶55.

(ii) Thoumy

As explained herein, Laroia alone discloses or renders obvious every element of claims 1-3, 5, and 6. Laroia alone also discloses or renders obvious every element of independent claims 11 and 22, except for a single element, which is rendered obvious by Laroia in view of Thoumy. Additionally, Thoumy was not cited or applied during prosecution of the '227 Patent. As shown herein, claims 1-3, 5, 6, 11, 12, 14, 18, and 20-27 are rendered obvious over Laroia combined with Thoumy. Therefore, Thoumy presents a substantial new question of patentability, and a reasonable

examiner would consider the reference important in determining whether claims 1-3, 5, 6, 11, 12, 14, 18, and 20-27 are patentable.

Thoumy relates to wireless communications and presents “the conventional method of calculating a discrete Fourier transform [DFT],” Thoumy (EX1005), 15:64-66, in the context of OFDM systems, *id.*, 7:60-61 (“This invention aims to perform a variety of OFDM transmissions...”). The output of a DFT is given by the following equation, where $[x_0, x_1, \dots, x_{n-1}]$ is an n -point vector of an input signal sequence $\{x(n)\}$:

$$\begin{bmatrix} X_0 \\ X_1 \\ X_2 \\ \dots \\ X_{n-1} \end{bmatrix} = \frac{1}{\sqrt{n}} \begin{bmatrix} 1 & 1 & 1 & \dots & 1 \\ 1 & W & W^2 & \dots & W^{n-1} \\ 1 & W^2 & W^4 & \dots & W^{2(n-1)} \\ \dots & \dots & \dots & \dots & \dots \\ 1 & W^{(n-1)} & W^{2(n-1)} & \dots & W^{(n-1)(n-1)} \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ \dots \\ x_{n-1} \end{bmatrix}.$$

Thoumy (EX1005), 16:10-18. The DFT matrix is given by

$$M = \frac{1}{\sqrt{n}} \begin{bmatrix} 1 & 1 & 1 & \dots & 1 \\ 1 & W & W^2 & \dots & W^{n-1} \\ 1 & W^2 & W^4 & \dots & W^{2(n-1)} \\ \dots & \dots & \dots & \dots & \dots \\ 1 & W^{(n-1)} & W^{2(n-1)} & \dots & W^{(n-1)(n-1)} \end{bmatrix}$$

where W forming the basis of elements of the matrix is given by

$$W = \exp(-j2\pi/n)$$

Thoumy (EX1005), 16:6-18; Geier (EX1003), ¶¶57-58.

Thoumy is analogous art to the '227 Patent for two reasons: (1) it is in the same field of endeavor as the '227 Patent, and (2) it is reasonably pertinent to at least one problem faced by the inventor of the '227 Patent. Geier (EX1003), ¶59.

First, Thoumy is in the same field of endeavor as the '227 Patent of wireless communication networks. '227 Patent (EX1001), 1:25-29 (“The present invention relates generally to wireless communication networks...”); Thoumy (EX1005), 1:9-10 (“The invention relates to the transmission of information in the form of an electromagnetic signal.”); (“... a first implementation of the invention, a data source 10 and a multi-carrier modulator 50 which transmits the data to a radiofrequency (RE) [sic] transmitter 60.”); 25:16-17 (“The radio module 2044 is equipped with a radio antenna 2046.”). Geier (EX1003), ¶60.

Second, Thoumy is reasonably pertinent to at least one problem faced by the inventor of the '227 Patent. One problem faced by the inventor of the '227 Patent is how to reduce peak-to-average power (PAPR) ratio. '227 Patent (EX1001), 72:53-66. Likewise, Thoumy focuses on this same problem. Thoumy (EX1005), 1:10-15 (“In particular, the invention concerns the allocation of carrier frequencies for transmission systems using multi-carrier type modulation and the process for **reducing the ratio of peak amplitude to mean amplitude usually required in transmission systems using multi-carrier type modulation.**”); 7:60-62 (“The invention aims to perform a variety of OFDM transmissions involving **minimization of the maximum value for the peak-to-mean ratios** of the symbols transmitted...” (emphasis added)). Geier (EX1003), ¶61.

Finally, reasons to combine Laroia and Thoumy are provided below in the analysis of claim elements in which Laroia and Thoumy are combined.

(iii) Singh

Singh is combined with Laroia to address limitations added by dependent claims 4, 9, 15, and 16, which relate to the use of “*reference-signal symbols*.” Additionally, Singh was not cited or applied during prosecution of the '227 Patent. As shown herein, limitations added by dependent claims 4, 9, 15, and 16 are rendered obvious over Laroia combined with Singh. Therefore, Singh presents a substantial new question of patentability, and a reasonable examiner would consider the reference important in determining whether claims 4, 9, 15, and 16 are patentable.

The '227 Patent explains that pilot symbols are examples of reference signals. '227 Patent (EX1001), 21:47-55; 22:58 61 (“In one aspect of the invention, each UE transmits **a known reference signal 311, such as one or more ... pilot signals...**”) (emphasis added). Likewise, Singh describes the use of pilot symbols, as discussed below. Geier (EX1003), ¶63.

Singh describes the interspersing of pilot symbols among data symbols prior to OFDM modulation for the purpose of channel estimation and synchronization. Singh (EX1016), 1:9-12

(“The invention relates to orthogonal frequency division multiplex (OFDM) communication systems and more particularly to synchronization and channel estimation for an OFDM communication system.”); 2:56-65 (Describing the use of “temporal” and “frequency domain” “pilot-assisted time synchronization, frequency synchronization, and/or channel estimation.”). Synchronization and channel estimation are important in OFDM systems in order to provide for reliable communication, as explained in Singh. *Id.*, 1:14-26; *see also* 8:53-57 (“Both the time synchronization and the frequency synchronization must both occur in order for the receiver 14A-B to properly process the QAM symbols from the received RF OFDM signal.”). Geier (EX1003), ¶¶64-65.

In order to provide for synchronization and channel estimation, pilot symbols are interspersed with data symbols in the transmitter prior to the IFFT that generates an OFDM symbol:

The serial-to-parallel 52 converts **symbol blocks of interspersed data and pilot QAM symbols** and the guard band QAM symbols from the QAM symbol encoder 22 from serial to parallel. ...

... **The IFFT 54 inverse Fourier transforms the parallel QAM symbols into OFDM blocks of OFDM samples.**

Singh (EX1016), 7:12-28 (emphasis added); Geier (EX1003), ¶66.

In the receiver, the received pilot symbols are used for time synchronization, frequency synchronization, and channel estimation. First, the received pilot symbols are used to compute a correlation function/channel impulse response (CIR), which is an estimate of the channel. Singh (EX1016), 8:30-36. Time and frequency offsets are tested to maximize the correlation function/channel impulse response (CIR), which, as shown above, is computed using the pilot symbols. Singh (EX1016), 8:53-65. Finally, the channel impulse response (computed from pilot symbols) is used in an equalizer in the receiver, which compensates for the effects of the channel. Singh (EX1016), 9:30-35 (“The equalizer 66 uses the channel estimates for equalizing the QAM symbols...”); Geier (EX1003), ¶67.

Singh is analogous art to the ’227 Patent for two reasons: (1) it is in the same field of endeavor as the ’227 Patent, and (2) it is reasonably pertinent to at least one problem faced by the inventor of the ’227 Patent. Geier (EX1003), ¶68.

First, Singh is analogous art to the '227 Patent because it is in the same field of endeavor as the '227 Patent of wireless communication networks. '227 Patent (EX1001), 1:25-29 (“The present invention relates generally to wireless communication networks...”); Singh (EX1016), 1:9-12 (“The invention relates to orthogonal frequency division multiplex (OFDM) communication systems and more particularly to synchronization and channel estimation for an OFDM communication system.”); 5:54-63; 7:1-4 (“The antenna section 44 converts the transmitter RF OFDM signal from a conducted form to an airwave form and converts the received RF OFDM signal from an airwave form to a conducted form.”). Geier (EX1003), ¶69.

Second, Singh is analogous art to the '227 Patent because it is also reasonably pertinent to at least one problem faced by the inventor of the '227 Patent. One problem faced by the inventor of the '227 Patent is facilitating synchronization, as the inventor was focused on “providing a superposition signal that facilitates synchronization.” '227 Patent (EX1001); 70:9-15. Likewise, Singh is reasonably pertinent to facilitating synchronization. Singh (EX1016), 1:9-12 (“The invention relates to orthogonal frequency division multiplex (OFDM) communication systems and more particularly to synchronization and channel estimation for an OFDM communication system.”). Geier (EX1003), ¶70.

Finally, reasons to combine Laroia and Singh are provided below in the analysis of claim elements in which Laroia and Singh are combined.

(iv) Larsson

Larsson is combined with Laroia to address limitations added by dependent claims 10 and 19, which relate to providing “*cyclic delay diversity (CDD)*.” Additionally, Larsson was not cited or applied during prosecution of the '227 Patent. As shown herein, limitations added by dependent claims 10 and 19 are rendered obvious over Laroia combined with Larsson. Therefore, Larsson presents a substantial new question of patentability, and a reasonable examiner would consider the reference important in determining whether claims 10 and 19 are patentable.

Larsson relates to “transmit diversity,” and in particular “systems which employ delay transmit diversity.” Larsson (EX1017), 1:6-10. Delay transmit diversity refers to “employing a set of M of transmit antennas each of which transmit delayed versions of a symbol to be transmitted.” *Id.*, 2:22-26. The use of this type of diversity beneficially “helps prevent the symbol being transmitted from being corrupted by flat Rayleigh fading.” *Id.*, 5:1-4. However, one drawback is “the total delay spread between all of the antenna paths can be no more than the duration of the

cyclic prefix minus the duration of the inherent channel delay spread.” *Id.*, 5:4 7; Geier (EX1003), ¶73.

In order to address the problems with delay diversity while retaining its benefits, Larsson introduces a cyclic delay on each antenna path, a technique that it refers to as cyclic delay diversity. More specifically, Larsson presents “a method and/or an apparatus for transmitting a symbol, wherein the symbol is split among a plurality of antenna paths. **In each antenna path the samples of the symbol are cyclically shifted a predetermined number of positions.**” Larsson (EX1017), 5:20-25 (emphasis added); *see also* Title (“**Cyclic delay diversity** for mitigating intersymbol interference in OFDM systems”) (emphasis added); Geier (EX1003), ¶74.

Larsson is analogous art to the ’227 Patent for two independent reasons: (1) it is in the same field of endeavor as the ’227 Patent, and (2) it is reasonably pertinent to at least one problem faced by the inventor of the ’227 Patent. Geier (EX1003), ¶75.

First, Larsson is analogous art to the ’227 Patent because it is in the same field of endeavor as the ’227 Patent of wireless communication networks. ’227 Patent (EX1001), 1:25-29 (“The present invention relates generally to wireless communication networks...”); Larsson (EX1017), 5:20-25 (Larsson presents “a method and/or an apparatus for transmitting a symbol, wherein the symbol is split among a plurality of antenna paths.”). As a further example, Larsson is concerned with mitigating problems with radio transmissions. Larsson (EX1017), 1:11-33 (discussing OFDM addressing issues with “radio transmissions”); Geier (EX1003), ¶76.

Second, Larsson is analogous art to the ’227 Patent because it is also reasonably pertinent to at least one problem faced by the inventor of the ’227 Patent. One problem faced by the inventor of the ’227 Patent is “enhancing transmit diversity” (e.g., by adding cyclic delay diversity). ’227 Patent (EX1001), 75:33-76:17. Likewise, Larsson enhances transmit diversity by employing cyclic delay diversity. Larsson (EX1017), 6:26-28 (“The present invention is directed to transmission diversity, and more specifically to mitigating ISI by employing a cyclic delay in a transmission diversity system.”); Geier (EX1003), ¶77.

Reasons to combine Laroia and Larsson are provided below in the analysis of claim elements in which Laroia and Larsson are combined.

(v) **Li**

Li is combined with Laroia to address limitations added by dependent claims 13 and 29, which relate to subcarriers selected based on a “*measured channel quality*.” Additionally, Li was

not cited or applied during prosecution of the '227 Patent. As shown herein, limitations added by dependent claims 13 and 29 are rendered obvious over Laroia combined with Li. Therefore, Li presents a substantial new question of patentability, and a reasonable examiner would consider the reference important in determining whether claims 13 and 29 are patentable.

Li explains that the basic format of OFDM may be used, while at the same time allowing different subscribers to transmit simultaneously using different subcarriers, a multiple-access scheme known as Orthogonal frequency division multiple access (OFDMA).

Orthogonal frequency division multiple access (OFDMA) is another method for multiple access, using the basic format of OFDM. In OFDMA, multiple subscribers simultaneously use different subcarriers, in a fashion similar to frequency division multiple access (FDMA).

Li (EX1018), 1:31-39; *see also* 1:58-59 (“Within one cell, the subscribers can be coordinated to have different subcarriers in OFDMA.”); Geier (EX1003), ¶80.

In Li, “[a] method and apparatus for subcarrier selection for systems is described.” Li (EX1018), 2:13-14. In Li, subcarriers are grouped into clusters of subcarriers. Li (EX1018), 5:18-21 (“FIG. 1A illustrates multiple subcarriers, such as subcarrier 101, and cluster 102. A cluster, such as cluster 102, is defined as a logical unit that contains at least one physical subcarrier, as shown in FIG. 1A.”); Geier (EX1003), ¶81.

Li describes subcarrier cluster allocation on the downlink in which:

each subscriber continuously monitors the reception of the pilot symbols and measures the SINR and/or other parameters, including inter-cell interference and intra-cell traffic, of each cluster (processing block 102). Based on this information, each subscriber selects one or more clusters with good performance (e.g., high SINR and low traffic loading) relative to each other and feeds back the information on these candidate clusters to the base station through predefined uplink access channels (processing block 103).

Li (EX1018), 5:46-51. In other words, a subscriber device selects one or more clusters with good performance (such as high SINR) and feeds back the information to the base station for downlink selection through an access channel. Likewise, Li discloses that the base station may use communications received over the access channel to measure uplink SINR levels for each

subcarrier and select which subcarriers are used on the uplink. Li (EX1018), 3:54-65; Geier (EX1003), ¶¶82-83.

Li is analogous art to the '227 Patent for two reasons: (1) it is in the same field of endeavor as the '227 Patent, and (2) it is reasonably pertinent to at least one problem faced by the inventor of the '227 Patent. Geier (EX1003), ¶84.

First, Li is analogous art to the '227 Patent because it is in the same field of endeavor as the '227 Patent of wireless communication networks. '227 Patent (EX1001), 1:25-29 (“The present invention relates generally to wireless communication networks...”); Li (EX1018), 1:11-15 (“The invention relates to the field of wireless communications; more particularly, the invention relates to multi-cell, multi-subscriber wireless systems using orthogonal frequency division multiplexing (OFDM).”). Geier (EX1003), ¶85.

Second, Li is analogous art to the '227 Patent because it is also reasonably pertinent to at least one problem faced by the inventor of the '227 Patent. One problem faced by the inventor of the '227 Patent is selecting which subcarriers to use. '227 Patent (EX1001), 44:18-24 (“[C]ertain subcarriers may be selected to optimize one or more operational parameters... Sets of subcarriers may be selected with respect to the types of services being provided.”). Likewise, Li is reasonably pertinent to selecting which subcarriers to use. Li (EX1018), 2:13-14 (“A method and apparatus for subcarrier selection for systems is described.”); Geier (EX1003), ¶86.

Reasons to combine Laroia and Li are provided below in the analysis of claim elements in which Laroia and Li are combined.

(vi) Cimini

Cimini is combined with Laroia to address limitations added by dependent claims 7, 17, and 28, which relate to appending “*at least one of a cyclic prefix, a postfix, and a guard interval to the OFDM transmission signal.*” Additionally, Cimini was not cited or applied during prosecution of the '227 Patent. As shown herein, limitations added by dependent claims 7, 17, and 28 are rendered obvious over Laroia combined with Cimini. Therefore, Cimini presents a substantial new question of patentability, and a reasonable examiner would consider the reference important in determining whether claims 7, 17, and 28 are patentable.

Cimini provides an “OFDM Overview.” Cimini (EX1019), 2:24-4:17. Cimini explains that in forming an OFDM signal, “extra samples are prepended and appended to the transformed waveform. These ‘cyclic prefix’ and ‘cyclic suffix’ samples make the transmitted signal more

robust against time dispersion and timing offset.” *Id.*, 2:64-3:1. Cimini also explains that “[t]wo other segments that are added to the IFFT waveform are the windowed section and the guard interval. The guard interval is a period during which the transmitted samples are all zero. At the expense of a slightly reduced transmission efficiency, the presence of this guard interval helps to ensure that the samples received during a given OFDM block are not contaminated with delayed samples from a previous block.” *Id.*, 3:29-36. Thus, Cimini describes the use of a cyclic prefix, a cyclic suffix, and a guard interval in forming an OFDM waveform. Geier (EX1003), ¶89.

Cimini is analogous art to the ’227 Patent for two reasons: (1) it is in the same field of endeavor as the ’227 Patent, and (2) it is reasonably pertinent to at least one problem faced by the inventor of the ’227 Patent. Geier (EX1003), ¶90.

First, Cimini is analogous art to the ’227 Patent because it is in the same field of endeavor as the ’227 Patent of wireless communication networks. ’227 Patent (EX1001), 1:25-29 (“The present invention relates generally to wireless communication networks...”); Cimini (EX1019), 1:34-45 (Cimini focuses on techniques for “OFDM synchronization.” “Analysis and simulation have shown good performance in the presence of noise and channel delay dispersion, impairments that are the harshest in a wireless environment.”). Geier (EX1003), ¶91.

Second, Cimini is analogous art to the ’227 Patent because it is also reasonably pertinent to at least one problem faced by the inventor of the ’227 Patent. One problem faced by the inventor of the ’227 Patent is mitigating interference due to multipath delay and interference caused from one transmitted block to another. ’227 Patent, 74:34-38 (“A cyclic-prefix appending source code segment 3105 appends a set of symbols (e.g., a cyclic prefix, a postfix, and/or a guard interval) to the sequence of complex time-domain symbols in order to prevent inter-block interference (MI) due to multipath delay.”). Likewise, Cimini is also directed to mitigating “time dispersion,” as a result of multi-path delay, 2:64-3:1, and interference caused from one transmitted block to another, *Id.*, 3:29-36 (“At the expense of a slightly reduced transmission efficiency, the presence of this guard interval helps to insure that the samples received during a given OFDM block are not contaminated with delayed samples from a previous block.”); Geier (EX1003), ¶92.

Reasons to combine Laroia and Cimini are provided below in the analysis of claim elements in which Laroia and Cimini are combined.

III. DISCRETIONARY DENIAL UNDER 35 U.S.C. § 325(d) IS UNWARRANTED

Although the Office has the ability to discretionarily deny a request for reexamination under 35 U.S.C. § 325(d), *see In re Vivint, Inc.*, 14 F.4th 1342, 1354 (Fed. Cir. 2021), discretionary denial of this Request is unwarranted.

There have been no IPRs or reexaminations filed against the '227 Patent, and none of the art presented herein was applied in a rejection during prosecution of the '227 Patent. While the issued patent corresponding to Laroia (U.S. Patent No. 7,295,509), and another related patent (U.S. Patent No. 9,130,180, a continuation-in-part of Laroia's underlying application), were included on information disclosure statements (IDSs) and are listed on the face of the '227 Patent in the References Cited, neither Laroia family member was substantively addressed by an examiner or applied in any office action. Further, there were five IDSs submitted during prosecution prior to the first office action during prosecution of the '227 Patent. *See* EX1002, pp. 182-193 (first IDS), pp. 203-225 (second IDS), pp. 251-255 (third IDS), pp. 279-282 (fourth IDS), and pp. 285-289 (fifth IDS). The issued patent corresponding to Laroia (U.S. Patent No. 7,295,509) was submitted together with 131 other patent references and numerous other references in the second IDS on Jan. 4, 2017. *See* EX1002, pp. 203-225. A continuation-in-part of Laroia (U.S. Patent No. 9,130,180) was submitted together with 59 other patent references and numerous other references in the first IDS on Jan. 3, 2017. *See* EX1002, pp. 182-193. No other applications related to Laroia appear on the face of the '227 Patent.

The '227 Patent is part of a large patent family involving over 50 related patent applications, *see* EX1020. Requester attempts to reasonably identify the relevant related patents or applications to search for evidence of consideration of Laroia or any of Laroia's family members (including patent counterpart U.S. Patent No. 7,295,509), focusing on the following patents for the reasons given below: U.S. Patent Nos. 8,670,390; 9,485,063; 9,768,842; 9,819,449; and 10,673,758. Three of these patents – U.S. Patent Nos. 8,670,390, 9,819,449, and 10,673,758 – are patents corresponding to the applications listed in the chain of continuity on the face of the '227 Patent. The other two patents – U.S. Patent Nos. 9,485,063 and 9,768,842 – are the only patents cited in obviousness-type double patenting rejections during prosecution of the '227 Patent, as explained in Section II.C. Laroia's patent counterpart (U.S. Pat. 7,295,509) is listed on the face of these patents, but there is no indication that Laroia or any of its counterparts were used in rejections during prosecution (i.e., the Laroia counterpart is not listed on the face of any of these patents with

a “*” to indicate “cited by Examiner”). To the best of Requester’s knowledge, neither Laroia nor any of its counterparts were applied in a rejection during prosecution of any of these patents, as summarized below.²

- Neither Laroia nor any of its counterparts are listed on the face of U.S. Pat. No. 8,670,390.
- Laroia’s patent counterpart is listed on the face of U.S. Patent No. 9,485,063, but it was not substantively addressed during prosecution.
- Laroia’s patent counterpart is listed on the face of U.S. Patent No. 9,768,842, but it was not substantively addressed during prosecution.³
- Neither Laroia nor any of its counterparts are listed on the face of U.S. Patent No. 9,819,449.
- Neither Laroia nor any of its counterparts are listed on the face of U.S. Patent No. 10,673,758.

The Office of Patent Legal Administration has explained that the framework for discretionary denial under § 325(d) in *Advanced Bionics, LLC v. MEDEL Elektromedizinische Geräte GmbH*, IPR2019-01469, Paper 6 (PTAB Feb. 13, 2020) (precedential) (“*Advanced Bionics*”) and *Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 (PTAB Dec. 15, 2017) (precedential as to § III.C.5, first paragraph) (“*Becton*”) applies to *inter partes* review (IPR) proceedings but not to *ex parte* reexamination proceedings. See Reexam Petition Decision, No. 90/014,801, at p. 6 (August 31, 2022) (explaining that *Advanced Bionics* and the “*Becton* factors were specifically formulated to apply to AIA trial proceedings, not to *ex parte* reexamination proceedings”). Nonetheless, *Advanced Bionics* and *Becton* provide a useful

² The face of each of these patents was searched for the lead inventor name “Laroia” to identify all patent applications by the Laroia to cast a wide net.

³ Note that U.S. Patent No. 6,473,418 to Laroia et al. is also listed on the face of U.S. Patent Nos. 9,768,842 and 10,200,227 (but was not substantively addressed during prosecution). Regardless, U.S. Patent No. 6,473,418 is not part of the same family as the Laroia reference (EX1004).

basis for the analysis of a reference that was considered during prosecution only as part of an IDS and confirm that discretionary denial is unwarranted.

Advanced Bionics explains that the Patent Trial and Appeal Board uses the two-part framework in evaluating discretionary denial under § 325(d):

(1) whether the same or substantially the same art previously was presented to the Office or whether the same or substantially the same arguments previously were presented to the Office; and

(2) if either condition of first part of the framework is satisfied, whether the petitioner has demonstrated that the Office erred in a manner material to the patentability of challenged claims.

Advanced Bionics at 8. If the first part is satisfied and the petitioner fails to make a showing of Office error in the second part, “the Director generally will exercise discretion not to institute *inter partes* review.” *Id.* at 8-9.

Advanced Bionics explains that a reference provided in an IDS satisfies the first part of the framework. *Id.* at 7-8 (“Previously presented art includes... art provided to the Office by an applicant, such as on an Information Disclosure Statement (IDS)...”).

With respect to the second part of *Advanced Bionics*, the application of Laroia herein demonstrates error by the Office in overlooking Laroia’s teachings. Factors presented in *Becton* “provide useful insight into how to apply the [*Advanced Bionics*] framework,” *Advanced Bionics* at 9, and confirm that discretionary denial is unwarranted. Factors (c), (e), and (f), listed below, “relate to whether the petitioner has demonstrated a material error by the Office.” *Id.* at 10.

(c) the extent to which the asserted art was evaluated during examination, including whether the prior art was the basis for rejection;

...

(e) whether petitioner has pointed out sufficiently how the examiner erred in its evaluation of the asserted prior art; and

(f) the extent to which additional evidence and facts presented in the petition warrant reconsideration of the prior art or arguments.

Becton at 17-18 (emphasis added). With respect to factor (c), Laroia and its counterparts were not the basis for a rejection and there is no discussion in the record of prosecution of the ’227 Patent or any of the relevant ’227 Patent family members cited above of Laroia’s teachings. Regarding

factor (e), the claim mappings presented herein demonstrate how the examiner erred in the consideration of a Laroia counterpart by failing to provide any rejections based on Laroia. Regarding factor (f), as shown herein, Laroia's disclosure, particularly with respect to Figures 4B and 5B, demonstrate that Laroia alone discloses or renders obvious many claim features, warranting the substantive consideration of Laroia, which was not made during prosecution.

In sum, even if Laroia or its counterparts are considered to have been previously "presented" to the Office under the first part of the *Advanced Bionics* framework (even though the Laroia counterparts were included in IDS documents with hundreds of other references), Laroia was not used as the basis for rejection of any claim, and the analysis herein mapping Laroia's teachings to the claims demonstrates error by the Office. Thus, discretionary denial is unwarranted.

In addition, none of Thoumy, Singh, Larsson, Li, or Cimini were considered during prosecution of the '227 Patent. Thoumy supplies additional context regarding the teachings of Laroia regarding a DFT; and Singh, Larsson, Li, and Cimini address limitations in certain dependent claims.

For these reasons, discretionary denial of this Request is unwarranted.

IV. DETAILED EXPLANATION OF THE PERTINENCE AND MANNER OF APPLYING THE PRIOR ART REFERENCES TO EVERY CLAIM FOR WHICH REEXAMINATION IS REQUESTED

A. Summary of Proposed Rejections of the Claims

The present request presents proposed rejections based on the references Laroia, Thoumy, Singh, Larsson, Li, and Cimini.

Requester notes that each of the proposed rejections below are based on obviousness under 35 U.S.C. § 103(a). Requester notes that, even if there are minor differences between cited disclosures of the prior art and the claimed concepts, the claims are still obvious, as a POSITA would not have appreciated "some new synergy" or unexpected results from the limitations given the disclosures of the prior art and the general knowledge of a POSITA. *KSR Intern. Co. v. Teleflex Inc.*, 550 US 398, 417 (2007). When compared with the prior art described below and in light of the knowledge of a POSITA, any "differences between the claimed invention and the prior art are such that the claimed invention as a whole would have been obvious before the effective filing date of the claimed invention to a person having ordinary skill in the art to which the claimed invention pertains." 35 U.S.C. § 103.

The proposed rejections are listed below and are described in further detail in the analysis that follows below.

Rejection	Art	Claims Challenged
Proposed Rejection A1	Laroia	1-3, 5, 6
Proposed Rejection A2	Laroia and Thoumy	1-3, 5, 6, 11, 12, 14, 18, 20-27
Proposed Rejection A3	Laroia and Singh	4, 9
Proposed Rejection A4	Laroia, Thoumy, and Singh	4, 9, 15, 16
Proposed Rejection A5	Laroia and Larsson	10
Proposed Rejection A6	Laroia, Thoumy, and Larsson	10, 19
Proposed Rejection A7	Laroia, Thoumy, and Li	13, 29
Proposed Rejection A8	Laroia and Cimini	7
Proposed Rejection A9	Laroia, Thoumy, and Cimini	7, 17, 28

B. Proposed Rejection A1: Claims 1-3, 5, and 6 are obvious over Laroia under 35 U.S.C. § 103(a).

(i) Claim 1⁴

[1.0] A non-transitory computer-readable medium including computer-readable program code stored thereon, the computer-readable program code configured to be executed by at least one processor to implement a method for generating an Orthogonal Frequency Division Multiplexing (OFDM) transmission signal, the method comprising:

Laroia discloses or renders obvious claim element [1.0].

First, Laroia discloses an OFDM communication system 10 including a digital signal processor 26 (*processor*) to generate an OFDM signal (*a method for generating an OFDM transmission signal*). Laroia (EX1004), [0035] (“Referring to FIG. 1, an orthogonal frequency division multiplexing (OFDM) communication system 10 is shown.”).

⁴ Emphasis added throughout unless otherwise specified. All claim language is indicated in italics.

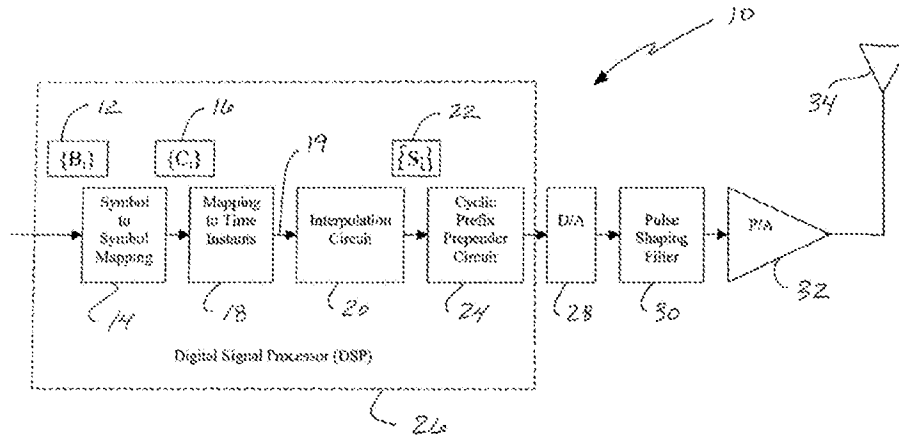


FIG. 1

Laroia (EX1004), Fig. 1

In one implementation of the **OFDM communication system 10**, the symbol-to-symbol mapping circuit 14, the time instant mapping circuit 18, the interpolation circuit 20, and the cyclic prefix circuit 24 are **implemented in a digital signal processor (DSP) 26**, and may include a combination of hardware modules and/or software modules.

Laroia (EX1004), [0037]. Geier (EX1003), ¶95.

The output of cyclic prefix inserter 24 in Figure 1 is an example digital *OFDM transmission signal*, of which samples $\{S_i\}$ are a part, and the output of the power amplifier 32 is also an example analog *OFDM transmission signal*. For example, Laroia explains: “The cyclic prefix circuit 24 operates to copy and prepend the last portion of the digital signal sample vector S 22 to **the beginning of the OFDM symbol duration.**” Laroia (EX1004), [0036]; Geier (EX1003), ¶96.

Laroia’s digital signal processor is an example of a *processor to implement a method for generating an OFDM transmission signal* as claimed. Laroia’s “hardware modules” are also an example of a *processor to implement a method for generating an OFDM transmission signal*. Geier (EX1003), ¶97.

Second, Laroia discloses a *non-transitory computer-readable medium including computer-readable program code stored thereon, the computer-readable program code configured to be executed by at least one processor*.

Specifically, with reference to Fig. 2A, below, Laroia teaches that the interpolation circuit 20 of the digital signal processor (DSP) 26 includes memory 23 for storing instructions for the disclosed OFDM communication process.

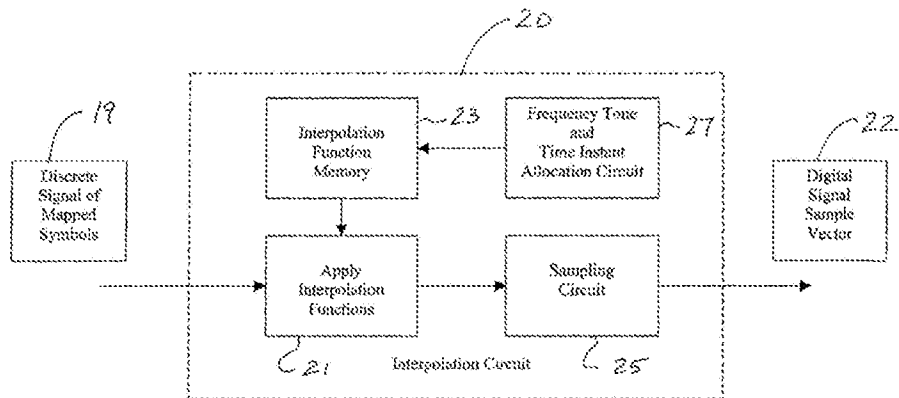


FIG. 2A

Laroia (EX1004), Fig. 2A

The interpolation functions may be precomputed and stored in an **interpolation function memory 23** connected to the interpolation function module 21. ... The frequency tone and time instant allocation circuit 27 also defines the prescribed time instants distributed over the time domain symbol duration, which can also be **stored in the interpolation function memory 23 for use by** the interpolation function module 21 as well as other modules within **the DSP 26**.

Laroia (EX1004), [0038]; Geier (EX1003), ¶¶98-99.

Laroia further teaches an example implementation of the disclosed “discrete interpolation function” for producing signal samples S at 22 in Figure 2A that are part of the OFDM signal (implemented using the DSP 26 and memory 23):

[T]he digital signal samples 22 are formed by directly applying one or more predetermined discrete interpolation functions to the mapped complex symbols 19.

Laroia (EX1004), [0036].

The collective procedure of DFT, zero insertion and IDFT is one way of implementing the discrete interpolation functions.

Laroia (EX1004), [0053] (illustrated in Figure 4B). This procedure of DFT, zero insertion, and IDFT, illustrated in Figure 4B, for generating an OFDM signal is discussed more extensively below for the remaining claim elements of claim 1. Geier (EX1003), ¶100.

Thus, Laroia's interpolation function memory 23 stores instructions for the DSP (processor) to generate an OFDM signal and is an example of a *non-transitory computer-readable medium including computer-readable program code stored thereon, the computer-readable program code configured to be executed by at least one processor*, as claimed. Geier (EX1003), ¶101.

For these reasons, Laroia discloses or renders obvious a *non-transitory computer-readable medium including computer-readable program code stored thereon* [e.g., memory 23], *the computer-readable program code configured to be executed by at least one processor* [e.g., DSP 26] *to implement a method for generating an Orthogonal Frequency Division Multiplexing (OFDM) transmission signal* [illustrated in Figures 1, 2A, and 4B], as recited in [1.0]. Geier (EX1003), ¶102.

[1.1] employing an invertible transform to spread a plurality of data symbols with complex-valued coefficients to generate a plurality of spread data symbols;

Laroia discloses or renders obvious claim element [1.1].

Specifically, with reference to Figure 4B, below, Laroia teaches that an “M-point Discrete Fourier Transform (DFT)” is performed on a set of M complex data symbols $\{C_i\}$ to generate a vector of symbols $[A_1, \dots, A_M]$ (Laroia (EX1004), [0053]), which is an example of *employing an invertible transform [DFT] to spread a plurality of data symbols [data symbols $\{C_i\}$] with complex-valued coefficients to generate a plurality of spread data symbols* [a vector of symbols $[A_1, \dots, A_M]$]. Laroia describes a second embodiment at [0062] and illustrated in Figure 5B, and the discussion herein applies equally to that embodiment. Geier (EX1003), ¶104.

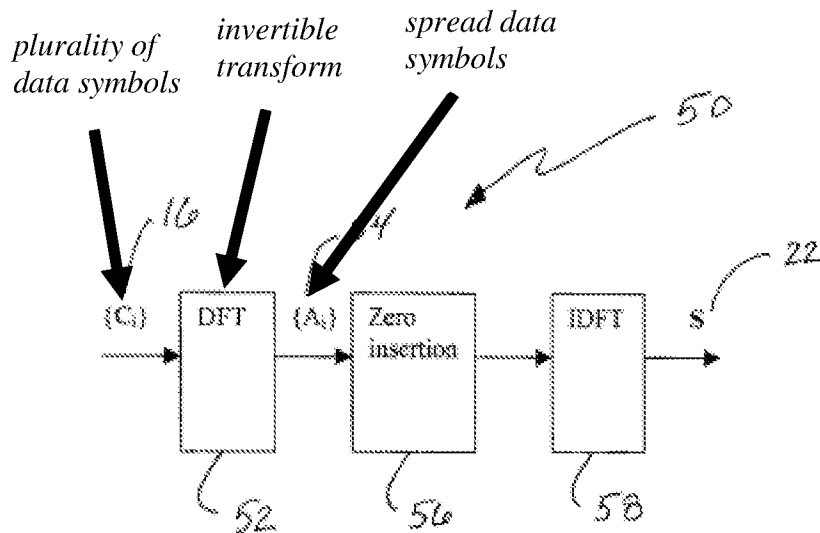


FIG. 4B

Laroia, Fig. 4B (annotated)

Claim 2 of the '227 Patent confirms that an M-point DFT, as used in Laroia, is one example of an *invertible transform*:

The non-transitory computer-readable medium recited in claim 1, wherein **the invertible transform comprises an N-point discrete Fourier Transform (DFT)**...

'227 patent (EX1001), claim 2; Geier (EX1003), ¶105.

Further, although Laroia does not use the term “spreading” to describe the DFT output, the '227 Patent confirms, and a POSITA would have known, that applying a DFT to symbols is an example of “spreading” the symbols. Geier (EX1003), ¶106. Thus, Laroia’s disclosure of performing an M point DFT on a set of data symbols generates an example of the claimed *plurality of spread data symbols*:

In one aspect, for a group of N data symbols of a reference signal, the processor performs **N-point DFT spreading on the N data symbols to generate a set of N DFT-spread components of the N data symbols.**

'227 Patent (EX1001), 72:41-44; *see also* 65:2-3 (“...the spreading matrix S is just an N×N DFT matrix...”). Thus, applying a DFT to data symbols is an example of *spread[ing] a plurality of data symbols* to generate a *plurality of spread data symbols*. Geier (EX1003), ¶106.

Setting aside that the '227 Patent equates a DFT with spreading, it would have been obvious or understood by a POSITA that each of Laroia's symbols is "spread" over the DFT outputs in the sense that each output of the DFT is a linear combination of all the input data symbols, weighted by the DFT values, as shown below. Thus, each data symbol contributes in some way, or is *spread*, to all the outputs of the DFT. Geier (EX1003), ¶107.

A DFT is such a fundamental and well-known building block of digital signal processing that knowledge of DFT implementation would have formed part of the background knowledge of a POSITA. Geier (EX1003), ¶108. Various prior art patent references refer to a DFT in the context of OFDM. For example, Thoumy is an example of a wireless communication reference that presents "the conventional method of calculating a discrete Fourier transform," Thoumy (EX1005), 15:64-66, in the context of OFDM systems, *id.*, 7:60-61 ("This invention aims to perform a variety of OFDM transmissions..."). Thoumy explains that the "DFT operation can be represented by" multiplication of an input set of symbols organized as a vector multiplied by a matrix of complex values. *Id.*, 16:1-19 ("A discrete Fourier transform can be represented by the multiplication of a complex vector U by a matrix" whose elements are complex numbers). As another example, Dowling refers to a known computer program that implements a DFT and "is equivalent to" multiplication of an input vector by a "DFT matrix" having complex values. Dowling (EX1015), 7:11-25; Geier (EX1003), ¶108.

In other words, it was obvious or understood in the art that a DFT applied to complex input symbols, such as Laroia's DFT applied to its input of "complex data symbols C_i ," may be implemented by organizing the complex symbols into a vector and multiplying the vector by a DFT matrix (having complex values) to produce an output vector. Geier (EX1003), ¶109. The elements of a DFT, such as a DFT matrix, are example *complex-valued coefficients*. Each element of the vector (DFT) output is a linear combination of the input vector, weighted by complex DFT values, such that each input is *spread* over all the outputs. Thoumy (EX1005), 16:1-5 ("A discrete Fourier transform can be represented by the multiplication of a complex vector U by a matrix, **which corresponds well to the obtaining of a series of linear combinations of the components of the initial complex vector.**"); Geier (EX1003), ¶109.

Thus, Laroia's DFT (*invertible transform...with complex-valued coefficients*) that is applied to a set of M complex data symbols $\{C_i\}$ (*a plurality of data symbols*) to generate an vector of symbols $[A_1, \dots, A_M]$, each of which is a linear combination of the symbols $\{C_i\}$ (*a plurality*

of spread data symbols) discloses or renders obvious *employing an invertible transform to spread a plurality of data symbols with complex-valued coefficients to generate a plurality of spread data symbols*. Geier (EX1003), ¶110.

[1.2] mapping the spread data symbols to a plurality of OFDM subcarriers; and

Laroia discloses or renders obvious claim element [1.2].

Laroia teaches that it was understood in conventional OFDM techniques to use a step of mapping data symbols to tones/subcarriers. Laroia (EX1004), [0004] (“In prior OFDM techniques, an OFDM signal is first constructed in the frequency domain by **mapping symbols of a constellation to prescribed frequency tones.**”) Laroia’s OFDM “tones” are the same as the claimed *subcarriers* because a POSITA would have understood that the terms “tone” and “subcarrier” are used synonymously in the context of OFDM. *See, e.g.*, Geier (EX1003), ¶112 (quoting Van Nee (EX1009), 1:22-24 (“As such, multi-carrier transmission systems use **OFDM modulation to send data bits in parallel over multiple subcarriers (also called tones or bins).**”)). The ’227 Patent confirms that the terms “tone” and “subcarrier” are synonymous in the OFDM context: “If OFDM is employed, this means that multiple parallel spatial subchannels can occupy the same set of **OFDM subcarriers, or tones.**” ’227 Patent (EX1001), 8:10-12; Geier (EX1003), ¶112.

Further, Laroia teaches that after the step of DFT spreading, the *spread data symbols* are mapped to M subcarriers. Specifically, Laroia teaches an OFDM technique wherein the M spread data symbols are mapped to a subset M of N OFDM subcarriers/tones and zeros are inserted in the remaining N-M subcarriers/tones (referred to as “zero insertion”)

The vector $[A_1, \dots, A_M]$ **54 output by the DFT circuit 52 is then expanded to a new vector of length N (the total number of time instants in the discrete signal vector S) by zero insertion at block 56.** More specifically, this process involves putting the kth symbol A_k to the $i(k)^{\text{th}}$ element of the new vector, for $k=1, \dots, M$, where $f_{i(k)}$ is the k^{th} tone allocated to the transmitter, and inserting zeros in all the remaining elements.

Laroia (EX1004), [0053]. The “kth tone allocated to the transmitter” refers to the value of the kth subcarrier of an OFDM transmission. Geier (EX1003), ¶113. Laroia’s teachings apply specifically to OFDM transmission. *See, e.g., id.*, Title (“Signaling method in an OFDM multiple access

system”) and Technical Field at [0002] (“This invention relates to an orthogonal frequency division multiplexing (OFDM) communication system.”); Geier (EX1003), ¶113.

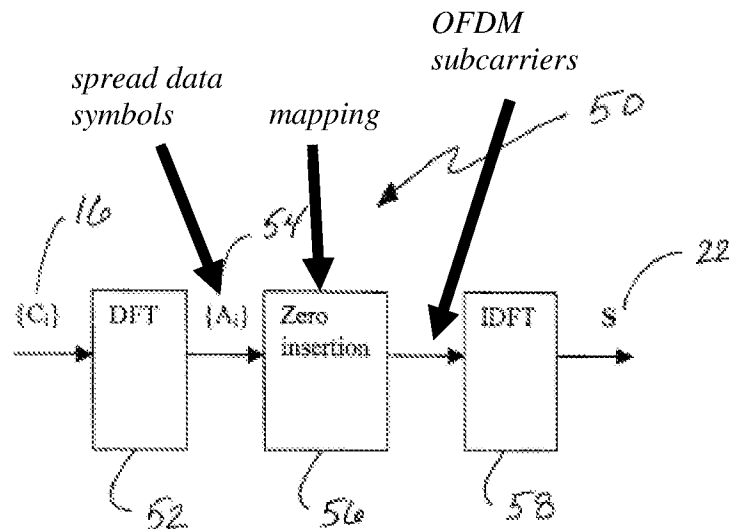


FIG. 4B

Laroia, Fig. 4B (annotated).

Laroia’s process of “putting the k th symbol A_k to the $i(k)^{\text{th}}$ element of the new vector, for $k=1, \dots, M$, where $f_{i(k)}$ is the k th tone allocated to the transmitter, and inserting zeros in all the remaining $[N-M]$ elements” is an example of mapping the spread data symbols A_k for $1, \dots, M$ to a plurality (N) of OFDM “tones”/subcarriers prior to performing an IDFT, thereby disclosing or rendering obvious *mapping the spread data symbols to a plurality of OFDM subcarriers*, as claimed. Geier (EX1003), ¶114.

[1.3] responsive to the mapping, modulating the spread data symbols onto the plurality of OFDM subcarriers to produce the OFDM transmission signal comprising a superposition of the OFDM subcarriers,

Laroia discloses or renders obvious claim element [1.3].

Claim 2 of the ’227 Patent provides an example of the claimed *modulating as comprising performing an M -point inverse-DFT, wherein $M > N$* . This is exactly what Laroia discloses, where the M of Laroia is equal to the N of the ’227 Patent, and the N of Laroia is equal to the M of the ’227 Patent, i.e., the labels for the same quantities (arbitrary letters representing integers) are switched.

The vector $[A_1, \dots, A_M]$ 54 output by the DFT circuit 52 is then expanded to a new vector of length N (the total number of time instants in the discrete signal vector S) by zero insertion at block 56. More specifically, this process involves putting the k th symbol A_k to the $i(k)^{\text{th}}$ element of the new vector, for $k=1, \dots, M$, where $f_{i(k)}$ is the k^{th} tone allocated to the transmitter, and inserting zeros in all the remaining elements. Finally, **an IDFT circuit 58 performs an N -point inverse discrete Fourier transform on the resulting vector** (after zero insertion) to obtain the digital signal sample vector S .

Laroia, [0053]. Laroia's "N-point inverse discrete Fourier transform" is an example of *modulating the spread data symbols onto the plurality of OFDM subcarriers*, according to claim 2. Geier (EX1003), ¶116.

Figure 4B of Laroia is annotated below using language from claim 1. The IDFT immediately follows the mapping to OFDM subcarriers and is integral to creating OFDM signal samples S , so the IDFT (*modulating*) is necessarily *responsive to the mapping*. Geier (EX1003), ¶117.

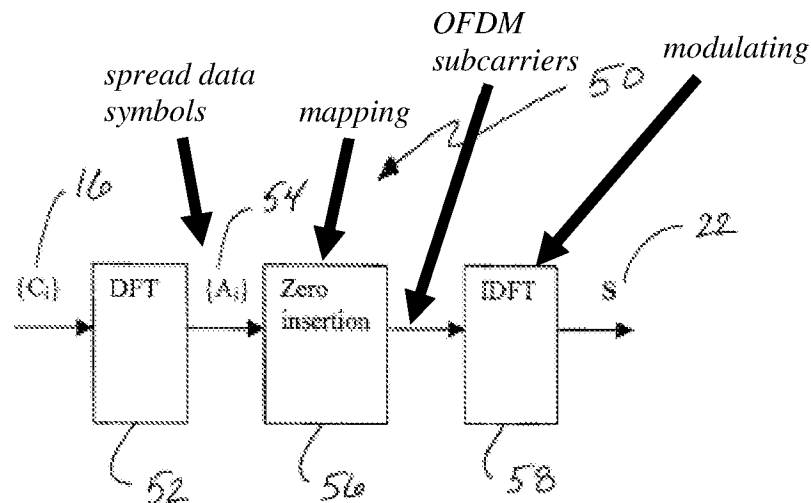


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated).

As discussed in the analysis of claim element [1.0], Laroia discloses an example OFDM communication system in Figure 1, illustrating digital signal samples $\{S_i\}$ obtained from complex symbols $\{C_i\}$.

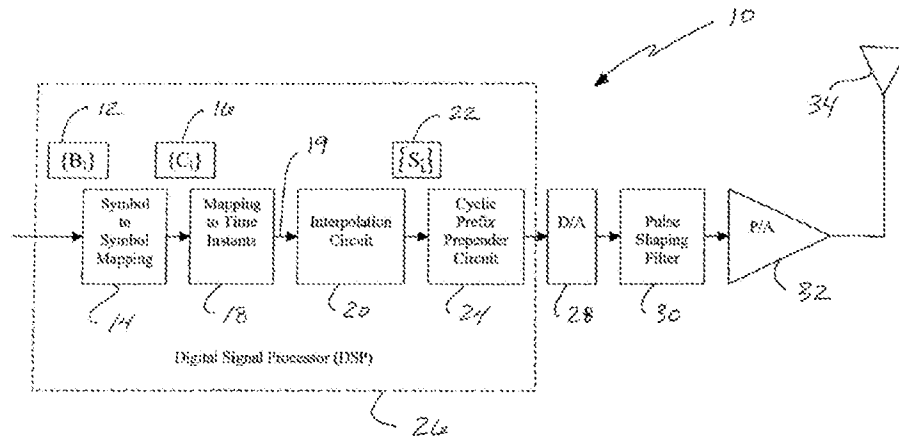
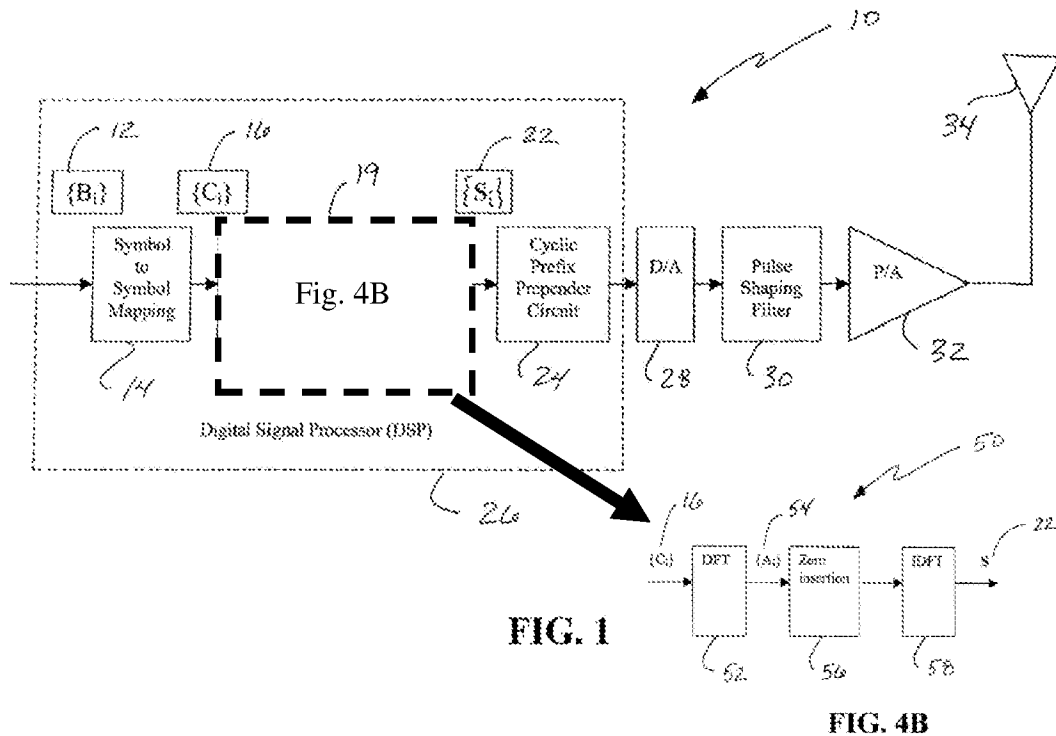


FIG. 1

Laroia (EX1004), Fig. 1

According to Laroia, one way of forming the samples $\{S_i\}$ is “by directly applying one or more predetermined discrete interpolation functions to the mapped complex symbols 19.” Laroia (EX1004), [0036]. One of these “discrete interpolation functions” is presented in Figure 4B. *Id.*, [0053] (“The collective procedure of DFT, zero insertion and IDFT is one way of implementing the discrete interpolation functions.”). Laroia’s OFDM communication system in Figure 1 is modified below to show the placement of Figure 4B within the OFDM communication system, as would have been understood based on Laroia’s disclosure above. Geier (EX1003), ¶118.



Laroia (EX1004), Fig. 1 with Fig. 4B (annotated)

Therefore, *modulating the spread data symbols onto the plurality of OFDM subcarriers*, as performed in Figure 4B, is performed *to produce the OFDM transmission signal*. The output of cyclic prefix inserter 24 in Figure 1 is an example digital *OFDM transmission signal*, of which samples {S_i} are a part, and the output of the power amplifier 32 is an example analog *OFDM transmission signal*. Geier (EX1003), ¶118.

Next, Laroia's IDFT forms a weighted sum of the input vector [A₁ , ... , A_M] (OFDM subcarrier amplitudes), thereby disclosing or rendering obvious *a superposition of the OFDM subcarriers*. Geier (EX1003), ¶119. Laroia's description of basic OFDM confirms this understanding: **"after being transformed by the IDFT or IFFT, the resultant time domain signal samples are the weighted sum of all the [input] symbols."** Laroia, [0004]. Laroia also expresses the continuous-time output as a linear combination (superposition) of the amplitudes [A₁ , ... , A_M]:

$$CF(t) = \sum_{k=1}^M A_k e^{j2\pi f_{i(\lambda)} t}$$

Laroia (EX1004), [0042]; Geier (EX1003), ¶119.

The '227 Patent specification uses the term “superposition” but sheds little light on what it means, but patents related to the '227 Patent confirm Requester’s understanding of the term *superposition*. The '227 Patent is part of a family that stems from a continuation-in-part of U.S. App. 10/145,854, filed May 14, 2002, which published as U.S. Patent Pub. No. 2008/0095121 (EX1012). U.S. Patent Pub. No. 2008/0095121 provides examples of a *superposition* of signals, including a weighted sum:

A combiner, as used herein, describes any system, device, and/or algorithm adapted to combine a plurality of signals, samples, or symbol values. **A combiner may combine multiple carriers or signal values to generate a superposition signal. A combiner may provide weights to carriers or signal values to generate one or more superposition signals...**

U.S. Patent Pub. No. 2008/0095121 (EX1012), [0111].

FIG. 1 A illustrates a basic form of CI in which a plurality of CI carrier sets 105A, 105B, and 105C each have phase fronts aligned at a specific time t_1 , t_2 , and t_3 , respectively. **A plurality of superposition signals 110A, 110B, and 110C result from a summation of each carrier set 105A, 105B, and 105C, respectively.**

U.S. Patent Pub. No. 2008/0095121 (EX1012), [0137].

The [**superposition**] signal 110A results from an **addition of N carriers** that have a uniform frequency separations.

U.S. Patent Pub. No. 2008/0095121 (EX1012), [0140]; *see also* related U.S. Patent No. 9,819,449 (EX1013), 28:6-13; Geier (EX1003), ¶120.

Thus, the '227 Patent family confirms that an example *superposition of the OFDM subcarriers* is a weighted sum of the OFDM subcarriers.

Another, albeit unrelated, patent by the same inventor – Steve Shattil – confirms that the output of an IDFT (or IFFT) of an OFDM modulator (e.g., inverse DFT) generates a superposition of subcarriers:

The output of the inverse DFT 705 is an OFDM transmission signal comprising a superposition of modulated subcarriers.

U.S. Patent No. 11,700,162 (EX1021), 24:44-46. Although Laroia does not use the term *superposition*, this is exactly what Laroia discloses. Geier (EX1003), ¶¶122-123.

Thus, Laroia's disclosure of performing an IDFT on the complex subcarrier amplitudes $[A_1, \dots, A_M]$ (*modulating the spread data symbols onto the plurality of OFDM subcarriers the spread data symbols*), performed in response to the mapping (*responsive to the mapping*), to generate a time-domain signal S (*to produce the OFDM transmission signal*) (each sample of which is a weighted sum of $[A_1, \dots, A_M]$) (*superposition of the OFDM subcarriers*) discloses or renders obvious *responsive to the mapping, modulating the spread data symbols onto the plurality of OFDM subcarriers to produce the OFDM transmission signal comprising a superposition of the OFDM subcarriers*. Geier (EX1003), ¶124.

[1.4] wherein employing the invertible transform is configured to provide the superposition with a reduced peak-to-average power ratio.⁵

Laroia discloses or renders obvious claim element [1.4].

The *superposition* in claim element [1.4] refers to the antecedent *the OFDM transmission signal comprising a superposition of the OFDM subcarriers* in claim element [1.3]. Laroia's techniques reduce the peak-to-average ratio of *the OFDM transmission signal* thereby also reducing the peak-to-average ratio of *the superposition*.

Laroia's main objective is "reduc[ing] the peak-to-average power ratio of the [OFDM] signal to be transmitted" so that the signal was more amenable for transmission on "handheld wireless communication devices or terminals." Laroia (EX1004) [0005]; *see also* Abstract ("A method for reducing the peak-to-average ratio in an OFDM communication signal is provided.").

⁵ Note that there may be a question as to whether claim element [1.4] should be given patentable weight. *Texas Instruments v. US Intern. Trade Com'n*, 988 F. 2d 1165, 1172 (Fed. Cir. 1993) ("A 'whereby' clause that merely states the result of the limitations in the claim adds nothing to the patentability or substance of the claim."). However, this issue need not be decided. Assuming *arguendo* that claim element [1.4] has patentable weight, Laroia discloses or renders obvious claim element [1.4].

Geier (EX1003), ¶127. Laroia teaches that its method of constructing the OFDM transmission signal, Signal S, in the time domain using a DFT (*invertible transform*), as described above with reference to Figure 4B, advantageously significantly reduces the peak-to-average power ratio, as illustrated in Figure 4E:

FIG. 4E is a graph showing the **reduced peak-to-average ratio** of the resulting digital signal sample vector when the symbols are mapped in the time domain using the technique of FIGS. 4A-4C.

Laroia (EX1004), [0023].

FIG. 4E illustrates the resulting small signal variation and **low peak-to-average ratio** of the digital signal sample vector S 66 associated with the transmitted OFDM signal 68. As will be appreciated by comparing FIGS. 4D and 4E, **mapping the constellation of complex symbols 16 in the time domain produces an OFDM signal 68 having a significantly reduced peak-to-average ratio.**

Id., [0057]. Laroia explains the drawbacks of a high peak-to-average power ratio as “highly inefficient” and resulting in “short battery life” and “more expensive power amplifiers.” Laroia (EX1004), [0005]. Thus, reducing peak-to-average power ratio results in increased efficiency, longer battery life, and less expensive components. Geier (EX1003), ¶128.

For comparison purposes, Laroia presents Figure 4D, illustrating a “large peak-to-average ratio” when symbols are mapped as in “prior OFDM systems.” Laroia (EX1004), [0022]. Figures 4D and 4E are presented below to illustrate the benefits of Laroia’s teachings on reducing peak-to-average ratio. Figure 4D illustrates a conventional OFDM signal generated without using Laroia’s method (as in “prior OFDM systems”), *id.*, resulting in a high peak-to-average ratio value (labeled “Large signal variation”), while Figure 4E illustrates that the time-domain signal using the techniques of Figure 4B (and equivalently Figures 4A and 4C) has a low peak-to-average value (“Small signal variation”). Geier (EX1003), ¶129.

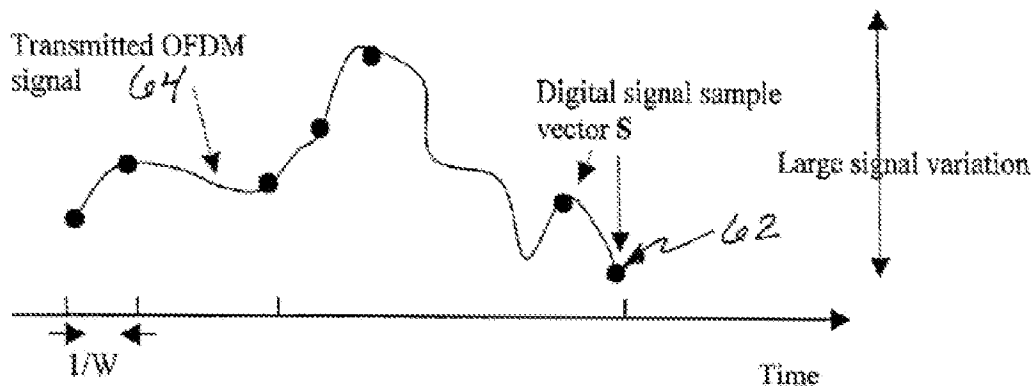


FIG. 4D

Laroia (EX1004), Fig. 4D

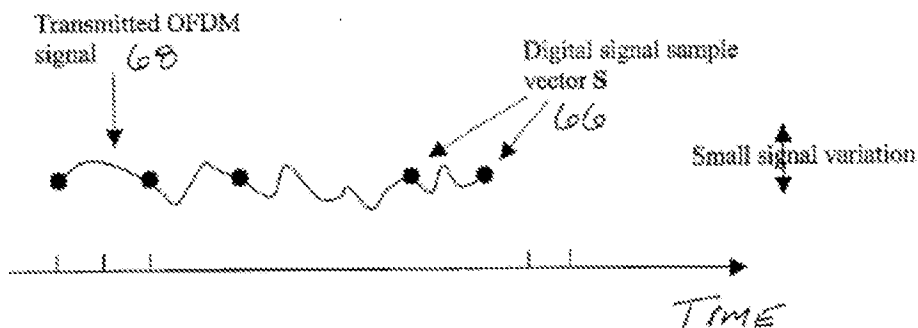


FIG. 4E

Laroia (EX1004), Fig. 4E

In yet another embodiment, Laroia also teaches that its method of constructing the signal using a DFT (an *invertible transform*), as described above with reference to Figure 5B, also advantageously reduces the peak-to-average power ratio:

FIG. 5D is a graph showing the **reduced peak-to-average ratio** of the resulting digital signal sample vector when the symbols are mapped in the time domain using the technique of FIGS. 5A-5C.

Laroia (EX1004), [0027].

FIG. 5D illustrates the resulting small signal variation and **low peak-to-average ratio** of the digital signal sample vector S 74 associated with the transmitted OFDM

signal 76. As will be appreciated by comparing FIGS. 4D and 5D, **mapping the constellation of complex symbols 16 in the time domain produces an OFDM signal 76 having a significantly lower peak-to-average ratio.**

Laroia (EX1004), [0065]; Geier (EX1003), ¶130.

Moreover, for additional context, Laroia teaches that the “[a]ppropriate interpolation functions 42” are selected such that the “desirable low peak-to-average ratio property substantially preserved for the continuous function and for the digital signal samples 22.” Laroia (EX1004), [0049]; Geier (EX1003), ¶131. Laroia’s techniques for generating the digital signal samples 22, as described in [0053] and [0062] with respect to Figures 4B and 5B, respectively, result in the “desirable low peak-to-average ratio.” For example, “[t]he collective procedure of DFT, zero insertion and IDFT is one way of implementing the discrete interpolation functions,” Laroia, [0053], referring back to the “[a]ppropriate interpolation functions” in [0049] that result in the “desirable low peak-to-average ratio.” Geier (EX1003), ¶132.

For these reasons, Laroia therefore discloses that the DFT as applied in Figures 4B and 5B (*invertible transform*) is configured to provide the superposition with a reduced peak-to-average power ratio as claimed. Geier (EX1003), ¶133.

(ii) **Claim 2**

2. The non-transitory computer-readable medium recited in claim 1, [2.1] wherein the invertible transform comprises an N-point discrete Fourier Transform (DFT), and the modulating comprises performing an M-point inverse-DFT, wherein $M > N$.

Laroia discloses or renders obvious claim element [2.1].

As a preliminary matter, where the '227 Patent uses the variable "*N*," to refer to the DFT, Laroia uses the variable "*M*"; and where the '227 Patent uses the variable "*M*" to refer to the IDFT, Laroia uses the variable "*N*". In other words, these references switch the variables used in disclosing the same concepts. Geier (EX1003), ¶135.

First, Laroia discloses *the invertible transform comprises an N-point discrete Fourier Transform (DFT)*. As discussed in the analysis of claim element [1.1], with reference to Fig. 4B, below, Laroia teaches that an “M-point Discrete Fourier Transform (DFT)” is performed on a set of *M* complex data symbols {*C_i*} to generate an vector of symbols [*A₁* , ... , *A_M*], Laroia, [0053], which is an example of *the invertible transform comprises an N-point discrete Fourier Transform (DFT)*, where the variable “*M*” of Laroia is the same as the variable *N* claimed by the '227 Patent

(Laroia describes a second embodiment at [0062] and illustrated in Figure 5B, and the discussion herein applies equally to that embodiment.) Geier (EX1003), ¶136.

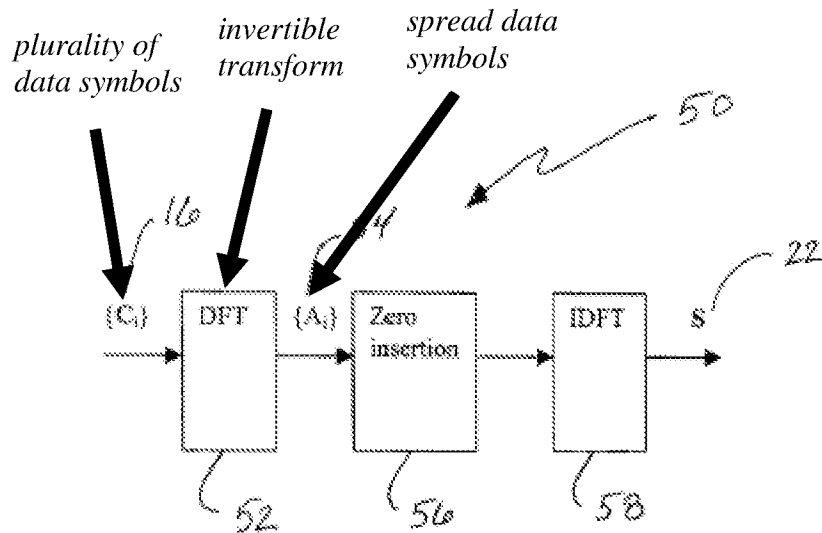


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated)

Second, as discussed in the analysis of claim element [1.3], Laroia explains that “an IDFT circuit 58 performs an N-point inverse discrete Fourier transform on the resulting vector.” Laroia (EX1004), [0053]. Laroia’s “N-point inverse discrete Fourier transform” is an example *performing an M-point inverse-DFT*. Geier (EX1003), ¶137.

Third, the size of the IDFT in Laroia (N) is larger than the size of the DFT (M). Laroia (EX1004), [0053] (“[A]n M-point discrete Fourier transform (DFT)” is used, and “[t]he vector $[A_1, \dots, A_M]$ 54 output by the DFT circuit 52 is then **expanded to a new vector of length N**...Finally, an IDFT circuit 58 performs an N-point inverse discrete Fourier transform on the resulting vector.”). The variable “N” of Laroia (size of IDFT) is the same as the variable “M” claimed by the ’227 Patent (size of IDFT). In Laroia, N (size of IDFT) $> M$ (number of symbols $\{A_i\}$, and size of DFT), which implies $M > N$, using the labels of the claim. Geier (EX1003), ¶138.

Therefore, Laroia discloses that an “M-point Discrete Fourier Transform (DFT)” is performed on a set of M complex data symbols $\{C_i\}$ (“N” of the claim) to generate an vector of symbols $[A_1, \dots, A_M]$, and an “N-point inverse discrete Fourier transform” (M of the claim) is

performed on an “expanded” vector consisting of zeros and symbols $[A_1, \dots, A_M]$, Laroia (EX1004), [0053], thereby disclosing or rendering obvious *the invertible transform comprises an N -point discrete Fourier Transform (DFT), and the modulating comprises performing an M -point inverse-DFT, wherein $M > N$* . Laroia’s N (claimed M) is greater than Laroia’s M (claimed N). Geier (EX1003), ¶139.

(iii) **Claim 3**

3. The non-transitory computer-readable medium recited in claim 1,

[3.1] wherein the modulating comprises performing an inverse fast Fourier transform.

As discussed in the analysis of claim element [1.3] and claim 2, Laroia discloses or renders obvious that *the modulating comprises performing an M -point inverse-DFT*.

It was well known that an IFFT is an efficient way to implement an IDFT and produces the same output. For example, Laroia treats the IDFT and IFFT as equivalent processes:

In prior OFDM techniques, an OFDM signal is first constructed in the frequency domain by mapping symbols of a constellation to prescribed frequency tones. The signal constructed in the frequency domain is then **transformed to the time domain by an inverse discrete Fourier transform (IDFT) or inverse fast Fourier transform (IFFT)** to obtain the digital signal samples to be transmitted.

... However, after **being transformed by the IDFT or IFFT**, the resultant time domain signal samples are the weighted sum of all the symbols....

Laroia (EX1004), [0004]. Thus, the use of the IDFT or IFFT were known design choices available to a POSITA for generating an OFDM signal, according to Laroia, disclosing that Laroia’s IDFT may instead be implemented using an IFFT, thereby disclosing claim element [3.1]. Geier (EX1003), ¶¶140-141.

To the extent that Laroia’s disclosure of an IDFT and IFFT as alternatives does not disclose the use of an IFFT in Laroia’s embodiment in Figure 4B, a POSITA would have been motivated to replace the IDFT block in Figure 4B with an IFFT because an IFFT is a more efficient version of the IDFT. Other contemporaneous prior art confirms that FFT algorithms are efficient ways to implement the DFT (similarly IFFT are efficient ways to implement the IDFT). Geier (EX1003), ¶142 (citing Jacobsen (EX1014), [0016] (“Any form of inverse discrete Fourier transform (IDFT) can be used to perform the inverse transform operation. The IFFT is preferred, however, because it is the most computationally efficient method available.”)). Further, a POSITA would have had

a reasonable expectation of success in implementing the IFFT in Laroia's system because Laroia discloses the IDFT and IFFT as alternatives to produce the same output. Geier (EX1003), ¶142.

Thus, Laroia's disclosure that its IDFT (*modulating*) in Figure 4B may equally be implemented using an IFFT, according to Laroia's teachings, with the understanding that the IFFT is a more efficient version of the IDFT, discloses or renders obvious *the modulating comprises performing an inverse fast Fourier transform*. Geier (EX1003), ¶143.

(iv) **Claim 5**

5. The non-transitory computer-readable medium recited in claim 1, [5.1] wherein the plurality of OFDM subcarriers comprise at least one of contiguous OFDM subcarriers and equally spaced non-contiguous OFDM subcarriers.

Laroia discloses or renders obvious claim element [5.1].

As an initial matter, regarding the term *at least one of contiguous OFDM subcarriers and equally spaced non-contiguous OFDM subcarriers*, there is a rebuttable presumption that the meaning of claim terms in the form "at least one of A and B" is "at least one of A and at least one of B." See *SuperGuide Corp. v. DirecTV Enters., Inc.*, 358 F.3d 870, 874-75, 885-86 (Fed. Cir. 2004). Thus, claim terms in the form "at least one of A and B" are presumed to mean "at least one of A and at least one of B," unless there is something in the specification or prosecution history that indicates otherwise to rebut the presumption.

Embodiments in the specification indicate that *plurality of OFDM subcarriers* comprise *contiguous OFDM subcarriers* or (not necessarily and) *equally spaced non-contiguous OFDM subcarriers*. For example, the '227 Patent recites:

Different users may be assigned to different sets of subcarriers to provide for OFDMA. For example, the '163 application discloses that the OFDM subcarriers can be selected as a block of contiguous subcarriers, or the OFDM subcarriers can be non-contiguous.

'227 Patent (EX1001), 69:13-17. There is no embodiment in the '227 Patent in which subcarriers assigned to a device include both contiguous subcarriers and non-contiguous subcarriers. Therefore, the *SuperGuide* presumption does not appear to apply. Regardless, Laroia renders obvious claim element [5.1], even under the narrowest understanding of the claim as requiring *contiguous OFDM subcarriers* and *equally spaced non-contiguous OFDM subcarriers* at the same time. Therefore, no construction of the term is necessary. Geier (EX1003), ¶146.

Laroia discloses that its plurality of OFDM subcarriers (tones) is contiguous: “Referring to FIG. 4A, one implementation of the OFDM communication system 10 allocates tones $f_{i(1)}$, $f_{i(2)}$, . . . , $f_{i(M)}$ to the transmitter associated with the communication system that are a subset of **contiguous tones** in the tone set $f_1, f_2, \dots, f_F$.” Laroia (EX1004), [0050]; *see also* [0008]. By disclosing contiguous OFDM subcarriers, Laroia discloses or renders obvious *the plurality of OFDM subcarriers comprise at least one of contiguous OFDM subcarriers* Geier (EX1003), ¶147.

In another embodiment, Laroia discloses that its plurality of OFDM subcarriers (tones) is *equally-spaced*:

As part of OFDM system 10, tones, $f_{i(1)}, f_{i(2)}, \dots, f_{i(M)}$, allocated to the transmitter associated with the communication system, are a subset of **equally-spaced tones** in the tone set $f_1, f_2, \dots, f_F$. Therefore, $f_{i(k)} = f_0 + (k-1)L\Delta$, for $k=1, \dots, M$, and L is a positive integer number representing the spacing between two adjacent allocated frequency tones.⁶

Laroia (EX1004), [0059]; *see also* [0009]. The quantity Δ is the “spacing between” tones. *Id.*, [0003]. Thus, if $L=1$, the tones are contiguous. *See id.*, [0050]. If $L>1$, the tones are not contiguous (*non-contiguous*). For example, when $L=2$, every other tone is allocated to the transmitter (i.e., tones located at frequencies $f_0, f_0+2\Delta, f_0+4\Delta$, etc.), while the remaining tones (i.e., tones located at frequencies $f_0+\Delta, f_0+3\Delta, f_0+5\Delta$, etc.) are available for other transmitters. By disclosing equally-spaced non-contiguous OFDM subcarriers, Laroia discloses *the plurality of OFDM subcarriers comprise ... equally spaced non-contiguous OFDM subcarriers*. Geier (EX1003), ¶148.

Thus, Laroia renders obvious claim element [5.1] under the assumption that the *SuperGuide* interpretation is rebutted.

Laroia also renders obvious claim element [5.1] if both *contiguous OFDM subcarriers* and *equally spaced non-contiguous OFDM subcarriers* are required to be assigned to a device at the same time.

⁶ There is a typo corrected in the quotation from Laroia. The equation is recited as “ $f_{i(k)} = f_0 + (k-1)L\Delta$ ” in Laroia. Laroia (EX1004), [0059]. It would have been understood that the equation is $f_{i(k)} = f_0 + (k-1)L\Delta$. Geier (EX1003), ¶148.

In OFDM systems, in order “to provide multiple access communication, [] different users are allocated different orthogonal tones within a frequency bandwidth to transmit data at the same time.” Laroia (EX1004), [0003]. A transmitter may be “allocated a number of contiguous tones,” or “a number of equally-spaced tones,” as examples. *Id.*, [0008]-[0009]. Thus, at a given time, one user may be assigned a contiguous portion of the available subcarriers (contiguous tones) and a second user may be assigned a portion of the available subcarriers that are non-contiguous (equally-spaced tones), yielding a patchwork or subcarriers that have been assigned. If a third user desires to transmit at the same time as the aforementioned two users, in order to assign enough subcarriers (a larger number of subcarriers yields a higher data rate), it would have been obvious to try assigning both contiguous and non-contiguous (equally spaced) sets of subcarriers to the third user to ensure that the third user has a sufficient number of subcarriers. In other words, as more and more users are added to the system, it becomes more difficult to assign only contiguous or only equally-spaced subcarriers to a new user, making it obvious to try assigning both contiguous and equally spaced subcarriers to a user. For example, if there are N total subcarriers in a system, a user may be assigned $N/4$ contiguous subcarriers and some number of equally spaced non-contiguous subcarriers from the remaining $3N/4$ subcarriers. Geier (EX1003), ¶151.

A POSITA would have had a reasonable expectation of success of assigning contiguous and equally-spaced subcarriers to a user for transmission at a given time. Laroia specifies that an M -point DFT is used to generate M outputs, assigned to M frequency tones. Laroia (EX1004), [0053]. It is straightforward to assign a subset of the M outputs to contiguous tones/subcarriers and the remaining subset of M outputs to equally-spaced subcarriers, with zero values in the remaining $N-M$ subcarriers. The N -point IDFT used to create the OFDM signal works in the same way, regardless of what values are assigned to different subcarriers. Geier (EX1003), ¶152.

Thus, Laroia discloses or renders obvious claim element [5.1], even if the claim is interpreted as requiring *contiguous OFDM subcarriers* and *equally spaced non-contiguous OFDM subcarriers* to be assigned to a device at the same time. Geier (EX1003), ¶153.

(v) **Claim 6**

6. The non-transitory computer-readable medium recited in claim 1, [6.1] further comprising computer-readable program code configured to perform pulse-shaping module to provide the OFDM transmission signal with a predetermined pulse shape.

Laroia discloses or renders obvious claim element [6.1].

As discussed in claim element [1.0], Laroia's output of cyclic prefix inserter 24 in Figure 1 is an example digital *OFDM transmission signal*, of which samples $\{S_i\}$ are a part, and the output of the power amplifier 32 is also an example analog *OFDM transmission signal*. Geier (EX1003), ¶155.

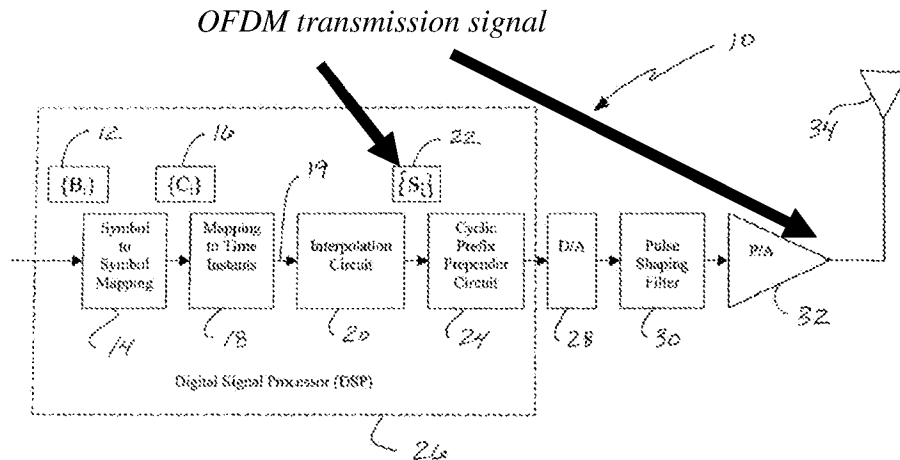


FIG. 1

Laroia (EX1004), Fig. 1 (annotated)

Laroia also discloses the use of a pulse shaping filter 30 (*perform pulse-shaping module*) applied to the OFDM transmission signal $\{S_i\}$ to provide the output of the power amplifier 32 (another *OFDM transmission signal*) with a predetermined pulse shape (*perform pulse-shaping module to provide the OFDM transmission signal with a predetermined pulse shape*):

The resulting digital signal samples 22 with the prepended cyclic prefix are converted to an analog signal by a digital to analog converter 28. The resulting analog signal is further processed by a pulse shaping filter 30, the output of which is modulated to a carrier frequency, and amplified by a power amplifier unit 32 for transmission through an antenna 34.

Laroia (EX1004), [0036]. It would have been obvious to a POSITA that the purpose of a pulse-shaping filter is to *provide the OFDM transmission signal with a predetermined pulse shape*. Pulse shaping is used in OFDM, for example, to prevent the radiated OFDM signal from producing interference outside of its assigned channel. Geier (EX1003), ¶155 (citing Cimini (EX1019)).

Therefore, Laroia discloses or renders obvious claim element [6.1]. Geier (EX1003), ¶157.

C. Proposed Rejection A2: Claims 1-3, 5, 6, 11, 12, 14, 18, and 20-27 are obvious over Laroia in view of Thoumy under 35 U.S.C. § 103(a).

(i) Claim 1

The analysis of all elements of claim 1 are identical to Proposed Rejection A1, except for the analysis of claim element [1.1], which is presented below. For all other elements of claim 1, see Proposed Rejection A1.

[1.1] employing an invertible transform to spread a plurality of data symbols with complex-valued coefficients to generate a plurality of spread data symbols.

As explained in Section IV.B (Proposed Rejection A1), Laroia discloses or renders obvious claim element [1.1]. As explained below, Laroia in view of Thoumy also renders obvious claim element [1.1].

As explained in the analysis of claim element [1.1] in Section IV.B, with reference to Fig. 4B, below, Laroia teaches that an “M-point Discrete Fourier Transform (DFT)” is performed on a set of M complex data symbols $\{C_i\}$ to generate a vector of symbols $[A_1, \dots, A_M]$ (Laroia (EX1004), [0053]), which is an example of *employing an invertible transform [DFT] to spread a plurality of data symbols [data symbols $\{C_i\}$] with complex-valued coefficients to generate a plurality of spread data symbols [a vector of symbols $[A_1, \dots, A_M]$]*. Laroia describes a second embodiment at [0062] and illustrated in Figure 5B, and the discussion herein applies equally to that embodiment. Geier (EX1003), ¶160.

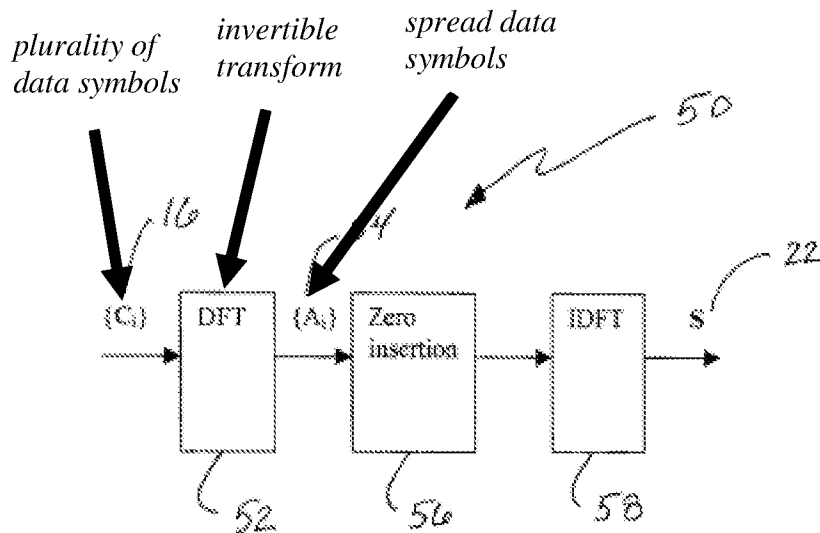


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated)

Claim 2 of the '227 Patent confirms that an M-point DFT, as used in Laroia, is one example of an *invertible transform*:

The non-transitory computer-readable medium recited in claim 1, wherein **the invertible transform comprises an N-point discrete Fourier Transform (DFT)**...

'227 Patent (EX1001), claim 2.

Further, although Laroia does not use the term *spreading* to describe the DFT output, the '227 Patent confirms that applying a DFT to symbols is an example of *spreading* the symbols:

In one aspect, for a group of N data symbols of a reference signal, the processor performs **N-point DFT spreading on the N data symbols to generate a set of N DFT-spread components of the N data symbols.**

'227 Patent (EX1001), 72:41-44; *see also* 65:2-3 ("...the spreading matrix S is just an $N \times N$ DFT matrix..."). Thus, applying a DFT to data symbols is an example of *spread[ing] a plurality of data symbols*" to generate a "*a plurality of spread data symbols*." Geier (EX1003), ¶161.

Setting aside that the '227 Patent equates a DFT with spreading and also that claim element [1.1] would have been obvious in view of Laroia alone (per Section IV.B), it would have also been obvious in view of Thoumy that Laroia's DFT (*invertible transform*) *spreads a plurality of data*

symbols (Laroia's symbols $\{C_i\}$ input to the DFT 52) with complex-valued coefficients (Thoumy's DFT matrix) to generate a plurality of spread data symbols (Laroia's DFT output $\{A_i\}$). Geier (EX1003), ¶162.

Thoumy is an example of a wireless communication reference that presents "the conventional method of calculating a discrete Fourier transform," Thoumy (EX1005), 15:64-66, in the context of OFDM systems, *id.*, 7:60-61 ("This invention aims to perform a variety of OFDM transmissions..."). As explained by Thoumy, an n-point DFT, such as in Laroia, can be represented as a matrix multiplication. Thoumy presents "a conventional method of calculating a discrete Fourier transform," such that "[a] discrete Fourier transform can be represented by the multiplication of a complex vector U by a matrix...". Thoumy (EX1005), 15:64-16:2; Geier (EX1003), ¶163.

More specifically, an n-point DFT, such as in Laroia, "can be represented by the equation"

$$\begin{bmatrix} X_0 \\ X_1 \\ X_2 \\ \dots \\ X_{n-1} \end{bmatrix} = \frac{1}{\sqrt{n}} \begin{bmatrix} 1 & 1 & 1 & \dots & 1 \\ 1 & W & W^2 & \dots & W^{n-1} \\ 1 & W^2 & W^4 & \dots & W^{2(n-1)} \\ \dots & \dots & \dots & \dots & \dots \\ 1 & W^{(n-1)} & W^{2(n-1)} & \dots & W^{(n-1)(n-1)} \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ \dots \\ x_{n-1} \end{bmatrix},$$

where the vector comprising $x_0, x_1, x_2, \dots, x_{n-1}$ is an n-point vector of the input signal sequence $\{x(n)\}$. Thoumy (EX1005), 16:6-18. The elements W of the DFT matrix are based on powers of the complex number

$$W = \exp(-j2\pi/n)$$

Thoumy (EX1005), 16:6-18. Applying the teachings of Thoumy in the context of Laroia, the data symbols $\{C_i\}$ in Figure 4B are multiplied by the DFT matrix shown above (having complex-valued coefficients) to generate the output $\{A_i\}$. Geier (EX1003), ¶164.

In other words, Thoumy explains that a DFT of complex symbols, such as the DFT of Laroia applied to "complex data symbols C_i ," may be implemented by organizing the complex symbols into a column vector of length n and multiplying the vector by an n -dimensional DFT matrix to produce an output vector. Geier (EX1003), ¶165. The rows of Thoumy's DFT matrix are

example *complex-valued coefficients*. Each element of the output vector is a linear combination of the input vector, weighted by the elements of a corresponding row of the DFT matrix, thus showing how each of Laroia's data symbols $\{C_i\}$ is *spread* over all of the outputs $\{A_i\}$. Thoumy further confirms this understanding. Thoumy (EX1005), 16:1-5 ("A discrete Fourier transform can be represented by the multiplication of a complex vector U by a matrix, which corresponds well to the obtaining of a series of linear combinations of the components of the initial complex vector."); Geier (EX1003), ¶165.

A POSITA would have been motivated to combine Laroia and Thoumy to use Thoumy's teachings regarding the details of a DFT to yield the obvious, predictable, and beneficial result of providing detail on how to implement Laroia's DFT. Laroia presents the input to its "DFT circuit" as "complex data symbols C_i " and output " $A_1, \dots, A_M$ " computed through "an M-point discrete Fourier transform (DFT)." Laroia (EX1004), [0053]. Laroia assumes that the reader is familiar with a DFT, so Laroia does not present the underlying details of how a DFT is computed, focusing only representing the input $\{C_i\}$ and output $\{A_i\}$ of the DFT. Thoumy beneficially provides the missing details of what occurs inside of Laroia's DFT block to convert $\{C_i\}$ to $\{A_i\}$. Geier (EX1003), ¶166.

Implementing Laroia's DFT using Thoumy's teachings represents combining prior art elements (implementing Laroia's DFT using Thoumy's matrix form) according to known methods to yield the predictable result of implementing Laroia's DFT. Geier (EX1003), ¶167.

A POSITA would have had a reasonable expectation of success in implementing Laroia's DFT using Thoumy's DFT teachings because Laroia describes the use of a DFT in the context of OFDM communications, Laroia (EX1004), [0002] (OFDM) and Figure 4B (DFT), and Thoumy describes the mathematics underlying the DFT, also in the context of OFDM communications, Thoumy (EX1005), 1:62-2:5 (OFDM) and 16:1-32 (DFT and inverse DFT). Thoumy describes its teachings as "**the conventional method of calculating a discrete Fourier transform,**" Thoumy (EX1005), 15:65, further underscoring that its teachings regarding the DFT are routine. Geier (EX1003), ¶168.

In summary, Laroia's DFT, implemented using Thoumy's matrix calculations (*invertible transform...with complex-valued coefficients*) and being applied to a set of M complex data symbols $\{C_i\}$ (*a plurality of data symbols*) to generate an vector of symbols $[A_1, \dots, A_M]$ (*a plurality of spread data symbols*), discloses or renders obvious *employing an invertible transform*

to spread a plurality of data symbols with complex-valued coefficients to generate a plurality of spread data symbols. Geier (EX1003), ¶169.

(ii) Claims 2, 3, 5, and 6

Each of these claims depends from claim 1. As discussed in Section IV.B (Proposed Rejection A1), Laroia renders obvious claim 1. As discussed in this Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy also renders obvious claim 1.

See the analysis in Section IV.B (Proposed Rejection A1) for the analysis of limitations added by dependent claims 2, 3, 5, and 6. As shown in Section IV.B, Laroia discloses or renders obvious the limitations added by these claims.

(iii) Claim 11

[11.0] A method, comprising:

Laroia discloses *a method*. For example, Laroia recites: “A method for reducing the peak-to-average ratio in an OFDM communication signal is provided.” Laroia (EX1004), Abstract; *see also* Title, [0053], [0068], and Figures 1 and 4B. Geier (EX1003), ¶172.

[11.1] performing an invertible transform, comprising multiplying a plurality of data symbols by a complex-valued spreading matrix to produce a plurality of spread symbols;

Laroia alone, and also Laroia in view of Thoumy, discloses or renders obvious claim element [11.1].

Claim element [11.1] is similar to claim element [1.1], as illustrated in the following table, showing the claim elements side-by-side.

[11.1] performing an invertible transform, comprising multiplying a plurality of data symbols by a complex-valued spreading matrix to produce a plurality of spread symbols	[1.1] employing an invertible transform to spread a plurality of data symbols with complex-valued coefficients to generate a plurality of spread data symbols
---	---

Both elements include *an invertible transform* to operate on *a plurality of data symbols* to generate *a plurality of spread data symbols*. Claim element [11.1] includes the detail of *multiplying a plurality of data symbols by a complex-valued spreading matrix*. Much of the analysis of claim

element [1.1] in Proposed Rejection A2 applies here and relevant portions are presented below. Geier (EX1003), ¶175.

With reference to Fig. 4B, below, Laroia teaches that an “M-point Discrete Fourier Transform (DFT)” is performed on a set of M complex data symbols $\{C_i\}$ to generate an vector of symbols $[A_1, \dots, A_M]$ (Laroia (EX1004), [0053]), which is an example of *performing an invertible transform ... to produce a plurality of spread symbols*. Laroia describes a second embodiment at [0062] and illustrated in Figure 5B, and the discussion herein applies equally to that embodiment. Geier (EX1003), ¶176.

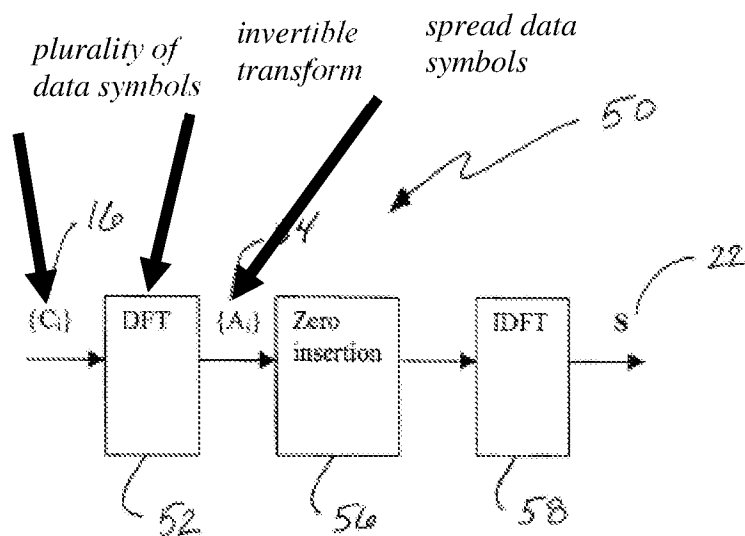


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated)

As a POSITA would have known, and as the '227 Patent confirms, a DFT, as used in Laroia, is an example of an *invertible transform*:

The non-transitory computer-readable medium recited in claim 1, wherein **the invertible transform comprises an N-point discrete Fourier Transform (DFT)...**

'227 patent (EX1001), claim 2; Geier (EX1003), ¶177. Furthermore, claim 18 of the '227 Patent confirms that Laroia's "M-point Discrete Fourier Transform (DFT)" is an example *spreading matrix*:

The method recited in claim 11, wherein **the spreading matrix comprises an N-point Discrete Fourier Transform (DFT)**...

'227 Patent (EX1001), claim 18; *see also* 72:41-44 (“In one aspect, for a group of N data symbols of a reference signal, the processor performs **N-point DFT spreading on the N data symbols to generate a set of N DFT-spread components of the N data symbols.**”). Geier (EX1003), ¶177.

Thus, Laroia’s disclosure that an “M-point Discrete Fourier Transform (DFT)” is performed on a set of M complex data symbols $\{C_i\}$ to generate an vector of symbols $[A_1, \dots, A_M]$ (Laroia (EX1004), [0053]), discloses or renders obvious *performing an invertible transform, comprising multiplying a plurality of data symbols by a complex-valued spreading matrix to produce a plurality of spread symbols*. Geier (EX1003), ¶178.

In addition, to the extent it is argued that Laroia does not disclose or render obvious implementing a DFT using a complex-valued matrix, Thoumy provides this teaching. Thoumy (EX1005), 15:64-16:2 (Thoumy presents “a conventional method of calculating a discrete Fourier transform,” such that “[a] **discrete Fourier transform can be represented by the multiplication of a complex vector U by a matrix...**”). Thoumy is a wireless communication reference that presents “the conventional method of calculating a discrete Fourier transform,” Thoumy (EX1005), 15:64-66, in the context of OFDM systems, *id.*, 7:60-61 (“This invention aims to perform a variety of OFDM transmissions...”). Geier (EX1003), ¶179.

As explained by Thoumy, an n-point DFT, such as in Laroia, “can be represented by the equation”

$$\begin{bmatrix} X_0 \\ X_1 \\ X_2 \\ \dots \\ X_{n-1} \end{bmatrix} = \frac{1}{\sqrt{n}} \begin{bmatrix} 1 & 1 & 1 & \dots & 1 \\ 1 & W & W^2 & \dots & W^{n-1} \\ 1 & W^2 & W^4 & \dots & W^{2(n-1)} \\ \dots & \dots & \dots & \dots & \dots \\ 1 & W^{(n-1)} & W^{2(n-1)} & \dots & W^{(n-1)(n-1)} \end{bmatrix} \begin{bmatrix} x_0 \\ x_1 \\ x_2 \\ \dots \\ x_{n-1} \end{bmatrix}.$$

where the vector comprising $x_0, x_1, x_2, \dots, x_{n-1}$ is an n-point vector of the signal sequence $\{x(n)\}$. Thoumy (EX1005), 16:6-18. The elements **W** of the DFT matrix are based on powers of the complex number

$$W=\exp(-j2\pi/n)$$

Thoumy (EX1005), 16:6-18. Thus, Laroia's plurality of data symbols $\{C_i\}$ multiplied by Thoumy's DFT matrix having complex values as shown above (powers of complex value W) to produce a plurality of spread symbols $\{A_i\}$ represents *multiplying a plurality of data symbols by a complex-valued spreading matrix to produce a plurality of spread symbols*, as claimed. Geier (EX1003), ¶180.

In other words, Thoumy explains that a DFT applied to complex symbols, such as the DFT of Laroia applied to "complex data symbols C_i ," may be implemented by organizing the complex symbols into a vector of length n and multiplying the vector by an n -dimensional DFT matrix (having complex coefficients) to produce an output vector. The DFT matrix is an example *complex-valued spreading matrix*. Each element of the output vector is a linear combination of the input vector, weighted by the elements of a corresponding row of the DFT matrix, yielding *a plurality of spread symbols*. Geier (EX1003), ¶181.

Thus, Laroia's DFT and also Laroia-Thoumy's DFT (*invertible transform...complex-valued spreading matrix*) multiplied by a vector of M complex data symbols $\{C_i\}$ (*a plurality of data symbols*) to generate an vector of symbols $[A_1, \dots, A_M]$ (*a plurality of spread symbols*) discloses or renders obvious *performing an invertible transform, comprising multiplying a plurality of data symbols by a complex-valued spreading matrix to produce a plurality of spread symbols*. Geier (EX1003), ¶182.

A POSITA would have been motivated to combine Laroia and Thoumy to use Thoumy's teachings regarding the details of a DFT to yield the obvious, predictable, and beneficial result of providing detail on how to implement Laroia's DFT. Laroia presents the input to its "DFT circuit" as "complex data symbols C_i " and output " $A_1, \dots, A_M$ " computed through "an M -point discrete Fourier transform (DFT)." Laroia (EX1004), [0053]. Laroia assumes that the reader is familiar with a DFT, so Laroia does not present the underlying details of how a DFT is computed, focusing only representing the input $\{C_i\}$ and output $\{A_i\}$ of the DFT. Thoumy beneficially provides the missing details of what occurs inside of Laroia's DFT block to convert $\{C_i\}$ to $\{A_i\}$. Geier (EX1003), ¶183.

A POSITA would have had a reasonable expectation of success in implementing the DFT in Laroia using the calculations presented in Thoumy. Laroia and Thoumy are directed to OFDM systems. Laroia (EX1004), [0002] ("This invention relates to an orthogonal frequency division

multiplexing (OFDM) communication system...”); Thoumy (EX1005), 7:60-61 (“This invention aims to perform a variety of OFDM transmissions...”); Furthermore, as explained previously, Laroia discloses use of a DFT in an OFDM communication system, and Thoumy presents “**the conventional method** of calculating a discrete Fourier transform [DFT],” Thoumy (EX1005), 15:64-66. Thus, Laroia represents exactly the type of system to which Thoumy’s teachings apply. Geier (EX1003), ¶184.

Implementing Laroia’s DFT in its OFDM system using Thoumy’s teachings regarding how to calculate a DFT, particularly in OFDM systems, represents combining prior art elements (Laroia’s OFDM system with DFT, where the DFT is implemented using Thoumy’s teachings) according to known methods to yield the predictable result of Laroia’s system operating exactly as Laroia describes to produce OFDM signals. Geier (EX1003), ¶185.

Accordingly, Laroia combined with Thoumy renders obvious claim element [11.1].

[11.2] mapping the plurality of spread symbols to a plurality of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers; and

Laroia discloses or renders obvious claim element [11.2]. Claim element [11.2] is substantially the same as claim element [1.2], as shown in the side-by-side comparison in the table below.

[11.2] mapping the plurality of spread symbols to a plurality of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers	[1.2] mapping the spread data symbols to a plurality of OFDM subcarriers
--	--

Therefore, see the analysis of claim element [1.2] in Proposed Rejection A1. Geier (EX1003), ¶187.

[11.3] modulating the plurality of spread symbols onto the plurality of OFDM subcarriers to produce a spread OFDM signal to be transmitted into a wireless channel, wherein the spread OFDM signal comprises a superposition of the OFDM subcarriers, and

Laroia discloses or renders obvious claim element [11.3].

Claim element [11.3] is substantively the same as claim element [1.3], as shown in the side-by-side comparison in the table below.

[11.3] modulating the plurality of spread symbols onto the plurality of OFDM subcarriers to produce a spread OFDM signal to be transmitted into a wireless channel, wherein the spread OFDM signal comprises a superposition of the OFDM subcarriers	[1.3] responsive to the mapping, modulating the spread data symbols onto the plurality of OFDM subcarriers to produce the OFDM transmission signal comprising a superposition of the OFDM subcarriers
--	---

The *OFDM transmission signal* of claim element [1.3] is an example of the *spread OFDM signal* of claim element [11.3] because the signal is an OFDM signal formed from spread symbols. The *spread OFDM signal* of claim element [11.3] is *to be transmitted into a wireless channel* because Laroia's signals are transmitted via an antenna 34, as shown in Figure 1. Geier (EX1003), ¶¶189-190.

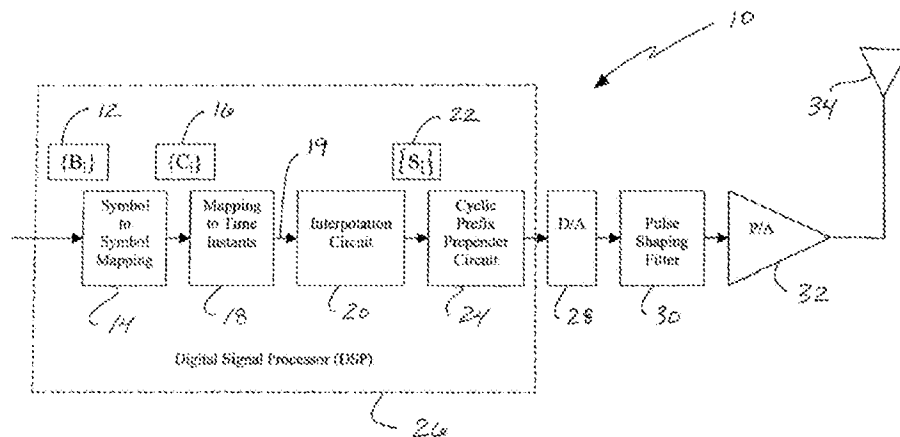


FIG. 1

Laroia (EX1004), Fig. 1

Accordingly, for the same reasons presented in the analysis of claim element [1.3] (in Proposed Rejection A1) and with the additional detail above, Laroia discloses or renders obvious claim element [11.3]. Geier (EX1003), ¶191.

[11.4] wherein the complex-valued spreading matrix is configured to provide the superposition with a reduced peak-to-average power ratio (PAPR).

Laroia discloses or renders obvious claim element [11.4].

Claim element [11.4] is substantively the same as claim element [1.4], as shown in the side-by-side comparison in the table below.

[11.4] wherein the complex-valued spreading matrix is configured to provide the superposition with a reduced peak-to-average power ratio (PAPR).	[1.4] wherein employing the invertible transform is configured to provide the superposition with a reduced peak-to-average power ratio.
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As explained in the analysis of claim element [11.1], Laroia's DFT, implementing using a matrix as shown in Thoumy, is an example *complex-valued spreading matrix*. And as explained in the analysis of claim element [1.4] (in Proposed Rejection A1), Laroia's DFT is also an *invertible transform that is configured to provide the superposition with a reduced peak-to-average power ratio*. For the same reasons, Laroia's method of constructing the signal (including the DFT), as described with reference to Figure 4B (and also the embodiment in Figure 5B) advantageously reduces the peak-to-average power ratio and therefore *is configured to provide the superposition with a reduced peak-to-average power ratio (PAPR)*. Geier (EX1003), ¶¶192-193.

(iv) **Claim 12**

12. The method recited in claim 11,

[12.1] wherein the plurality of OFDM subcarriers is a subset of subcarriers, the subset comprising at least one of a block of contiguous subcarriers, and a set of non-contiguous subcarriers.

Laroia combined with Thoumy renders obvious claim 11.

Laroia discloses or renders obvious claim element [12.1].

As discussed in the analysis of claim element [5.1], no construction of the term *at least one of a block of contiguous subcarriers, and a set of non-contiguous subcarriers* is necessary because Laroia renders the term obvious, even under the narrowest construction. Geier (EX1003), ¶197.

Laroia discloses that its plurality of OFDM subcarriers (tones) to which *a plurality of spread symbols* are mapped (see claim element [11.2]) are a subset of subcarriers:

Referring to FIG. 4A, one implementation of the OFDM communication system 10 allocates tones $f_i(1)$, $f_i(2)$, . . . , $f_i(M)$ [*plurality of OFDM subcarriers*] to the transmitter associated with the communication system that are **a subset of contiguous tones** in the tone set $f_1, f_2, \dots, f_F$. [*a subset of subcarriers, the subset comprising at least one of a block of contiguous subcarriers*]

Laroia (EX1004), [0049]; Geier (EX1003), ¶198.

For example, regarding the embodiment in Figure 4B, Laroia explains: The vector $[A_1, \dots, A_M]$ 54 output by the DFT circuit 52 is then expanded to a new vector of length N (the total number of time instants in the discrete signal vector S) by zero insertion at block 56. More specifically, this process involves putting the k th symbol A_k to the $i(k)^{\text{th}}$ element of the new vector, for $k=1, \dots, M$, where $f_{i(k)}$ is the k^{th} tone allocated to the transmitter, and inserting zeros in all the remaining elements.

Laroia, [0053]. The vector $[A_1, \dots, A_M]$ represents amplitudes of M subcarriers (*plurality of OFDM subcarriers*) and the remaining $N-M$ subcarriers are set to zero, meaning M is a subset of N subcarriers (*a subset of subcarriers, the subset comprising at least one of a block of contiguous subcarriers*). Geier (EX1003), ¶198.

As explained in the analysis of claim element [5.1], it would have been obvious in view of Laroia to assign a *block of contiguous subcarriers* and a *set of non-contiguous subcarriers* to a device at the same time. Geier (EX1003), ¶199.

For these reasons, Laroia discloses or renders obvious *wherein the plurality of OFDM subcarriers is a subset of subcarriers, the subset comprising at least one of a block of contiguous subcarriers, and a set of non-contiguous subcarriers*. Geier (EX1003), ¶200.

(v) **Claim 14**

14. The method recited in claim 11,

[14.1] wherein the mapping is configured to provide the spread OFDM signal with reduced PAPR.

Laroia combined with Thoumy renders obvious claim 11.

Laroia discloses or renders obvious claim element [14.1].

As explained extensively herein, Laroia's technique starts with a set of M complex data symbols $\{C_i\}$ and yields a set of N complex signal samples $\{S_i\}$. Laroia's technique involves applying an M -point DFT on the complex data symbols, yielding a set of M complex values $\{A_i\}$, which are then mapped to a subset M of a total of N subcarriers for IDFT processing. *See* Laroia, [0053] and Figure 4B. The combination of Laroia's M -point DFT (*complex-valued spreading matrix* element [11.1]) and the mapping $\{A_i\}$ to subcarriers (*mapping* element [11.2]) is configured to provide an OFDM signal (*spread OFDM signal*) with a reduced peak-to-average power ratio, or PAPR. Geier (EX1003), ¶203.

As explained in the analysis of claim element [1.4] (which also focuses on a *reduced peak-to-average power ratio*), Laroia's main objective is "reduc[ing] the peak-to-average power ratio of the [OFDM] signal to be transmitted" so that the signal was more amenable for transmission on "handheld wireless communication devices or terminals." Laroia (EX1004) [0005]; *see also* Abstract ("A method for reducing the peak-to-average ratio in an OFDM communication signal is provided."). Geier (EX1003), ¶204.

Therefore, Laroia discloses or renders obvious *the mapping* [referring to claim element 11.2] *is configured to provide the spread OFDM signal with reduced PAPR*. Geier (EX1003), ¶205.

(vi) **Claim 18**

18. The method recited in claim 11, [18.1] wherein the spreading matrix comprises an N-point Discrete Fourier Transform (DFT), and the modulating comprises employing an M-point inverse-DFT, and wherein $N < M$.

Laroia combined with Thoumy renders obvious claim 11.

Laroia in view of Thoumy renders obvious claim element [18.1].

First, as explained in the analysis of claim element [11.1], Laroia in view of Thoumy renders obvious the use of a *spreading matrix* to generate an *N-point DFT*. Geier (EX1003), ¶208.

Second, as discussed in the analysis of claim element [1.3], Laroia recites:

More specifically, this process involves putting the k th symbol A_k to the $i(k)^{\text{th}}$ element of the new vector, for $k=1, \dots, M$, where $f_{i(k)}$ is the k^{th} tone allocated to the transmitter, and inserting zeros in all the remaining elements. Finally, **an IDFT circuit 58 performs an N-point inverse discrete Fourier transform on the resulting vector** (after zero insertion) to obtain the digital signal sample vector S .

Laroia (EX1004), [0053]. The "N-point inverse discrete Fourier transform" is an example of *performing an M-point inverse-DFT*. Further, the M of Laroia is equal to the N of the '227 Patent and the N of Laroia is equal to the M of the '227 Patent, i.e., the labels for quantities are switched. As discussed regarding claim 2, in Laroia, N (size of IDFT) $> M$ (number of symbols $\{A_k\}$, and size of DFT), which implies $N < M$, using the labels of the claim. Geier (EX1003), ¶209.

Therefore, Laroia discloses that "M-point Discrete Fourier Transform (DFT)" is performed on a set of M complex data symbols $\{C_i\}$ to generate an vector of symbols $[A_1, \dots, A_M]$, and an "N-point inverse discrete Fourier transform" is performed on a vector consisting of zeros and

symbols $[A_1, \dots, A_M]$ (Laroia (EX1004), [0053]), thereby disclosing or rendering obvious *wherein the spreading matrix comprises an N -point Discrete Fourier Transform (DFT), and the modulating comprises employing an M -point inverse-DFT, and wherein $N < M$* . Geier (EX1003), ¶210.

(vii) **Claim 20**

20. The method recited in claim 11,

[20.1] further comprising pulse shaping to provide the OFDM transmission signal with a predetermined pulse shape.

Laroia combined with Thoumy renders obvious claim 11.

Claim element [20.1] is substantially the same as claim element [6.1], as shown in the side-by-side comparison below, with substantively the same claim language underlined.

[20.1] further comprising <u>pulse shaping to provide the OFDM transmission signal with a predetermined pulse shape</u>	[6.1] further comprising computer-readable program code configured to perform <u>pulse-shaping module to provide the OFDM transmission signal with a predetermined pulse shape</u>
---	--

Therefore, see the analysis of claim element [6.1]. Geier (EX1003), ¶212.

(viii) **Claim 21**

21. A User Equipment configured to perform the method recited in claim 11.

As explained above in the analysis of claim 11 (Proposed Rejection A2), Laroia combined with Thoumy renders obvious *the method recited in claim 11*. For example, as explained in the analysis of claim element [11.1], Laroia discloses circuitry for implementing a DFT, followed by a mapping of symbols to subcarriers, followed by an IDFT in Figure 4B, and Thoumy adds details about how Laroia's DFT is implemented. Geier (EX1003), ¶213.

Laroia discloses or renders obvious a *user equipment configured to perform the method recited in claim 11*.

The '227 Patent discloses that *a user equipment* may be a handheld wireless communication device or terminal. '227 Patent (EX1001), 13:12-19 ("User Equipment (UE), as used herein, may be fixed or mobile and comprises any device used directly by an end user (or client device) to communicate in a radio access network. For example, a UE may be a cellular handset, a laptop equipped with a mobile broadband adaptor, a wearable computer, a PDA, a tablet,

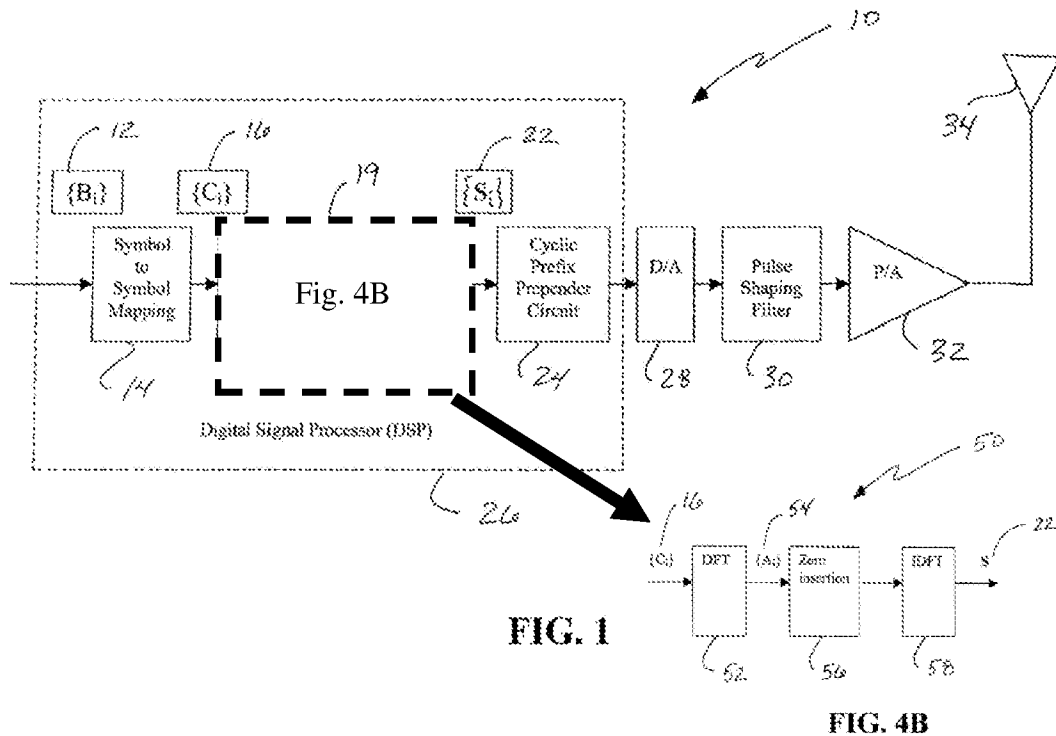
or any other user device configured to communicate with a Wireless Wide Area Network (WWAN).”). Geier (EX1003), ¶215.

Laroia discloses, or at least renders obvious, that its teachings are for implementation on user equipment, e.g., handheld wireless communication devices or terminals. Laroia (EX1004), [0005]. Indeed, Laroia explains that its disclosure may be particularly advantageous when implemented in such user equipment:

The large power requirements result in short battery life and more expensive power amplifiers **for handheld wireless communication devices or terminals**. Accordingly, it is desirable to provide an OFDM technique which reduces the peak-to-average ratio of the signal to be transmitted, while simultaneously taking advantage of the larger communication bandwidth offered by an OFDM communication system.

Laroia (EX1004), [0005]; Geier (EX1003), ¶216.

As explained in the analysis of claim element [1.3] in Proposed Rejection A1, Laroia’s wireless OFDM communication system in Figure 1 is modified below to show the placement of Figure 4B within the OFDM communication system. The wireless OFDM communication system is representative of a handheld wireless communication device or terminal. Geier (EX1003), ¶217.



Laroia (EX1004), Fig. 1 with Fig. 4B (annotated)

Therefore, Laroia discloses or renders obvious a *user equipment configured to perform the method recited in claim 11*. Geier (EX1003), ¶218.

(ix) Claim 22

[22.0] An apparatus comprising:

Laroia discloses claim element [22.0].

For example, Laroia discloses an OFDM communication system 10. Laroia (EX1004), [0035] (“Referring to FIG. 1, an orthogonal frequency division multiplexing (OFDM) communication system 10 is shown.”). Geier (EX1003), ¶220.

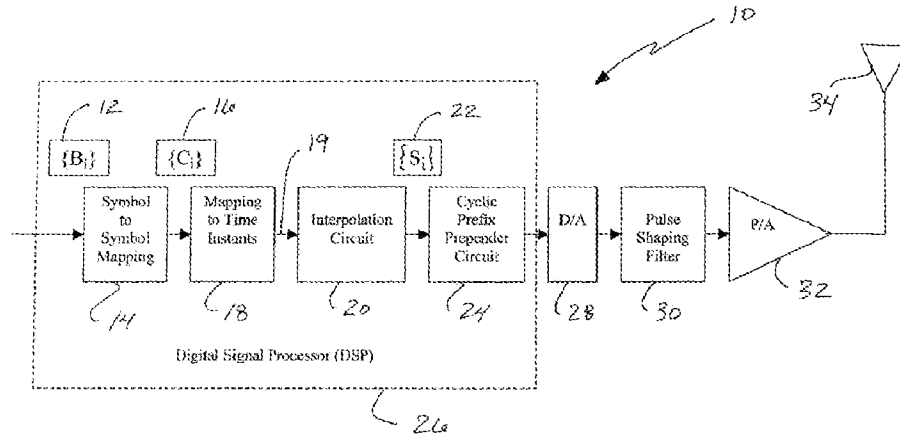


FIG. 1

Laroia (EX1004), Fig. 1

Laroia's OFDM communication system 10 is an example *apparatus*, thereby disclosing claim element [22.0]. Geier (EX1003), ¶220.

[22.1] a processor; and

Laroia discloses or renders obvious claim element [22.1].

For example, Laroia's OFDM communication system 10 includes a digital signal processor 26 (*processor*):

In one implementation of the **OFDM communication system 10**, the symbol-to-symbol mapping circuit 14, the time instant mapping circuit 18, the interpolation circuit 20, and the cyclic prefix circuit 24 are **implemented in a digital signal processor (DSP) 26, and may include a combination of hardware modules and/or software modules.**

Laroia (EX1004), [0037]. Laroia's digital signal processor is an example of a *processor* as claimed.

Laroia's "hardware modules" are also an example of a *processor*. Geier (EX1003), ¶222.

[22.2] a non-transitory memory coupled to the processor, the non-transitory memory including a set of instructions stored therein and executable by the processor to:

Laroia discloses or renders obvious claim element [22.2].

For example, with reference to Fig. 2A, below, Laroia teaches that the interpolation circuit 20 of the digital signal processor (DSP) 26 includes memory for storing instructions for the disclosed OFDM communication process. Geier (EX1003), ¶224.

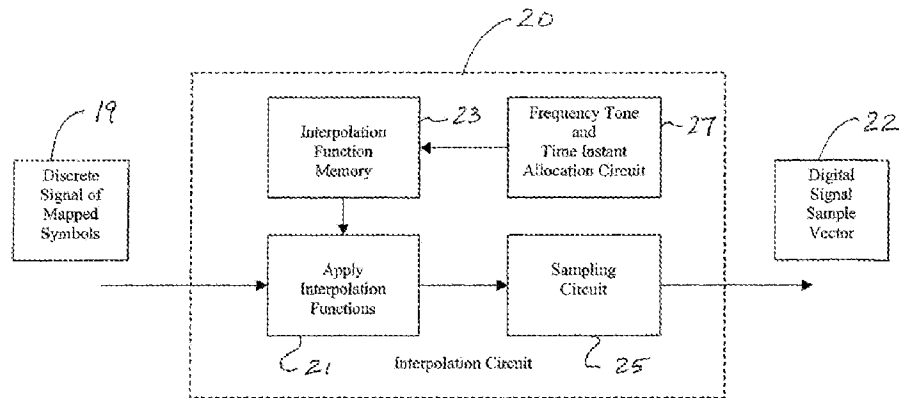


FIG. 2A

Laroia (EX1004), Fig. 2A

The interpolation functions may be precomputed and stored in an **interpolation function memory 23** connected to the interpolation function module 21. ... The frequency tone and time instant allocation circuit 27 also defines the prescribed time instants distributed over the time domain symbol duration, which can also be **stored in the interpolation function memory 23 for use by** the interpolation function module 21 as well as other modules within **the DSP 26**.

Laroia (EX1004), [0038]; Geier (EX1003), ¶224.

Laroia further teaches an example of an implementation of the disclosed interpolation function (implemented using the DSP 26 and memory 23):

The collective procedure of DFT, zero insertion and IDFT is one way of implementing the discrete interpolation functions.

Laroia (EX1004), [0053]. This interpolation function is discussed more extensively below for the remaining claim elements of claim 22. Geier (EX1003), ¶225.

A POSITA would have understood that the memory for storing OFDM instructions disclosed by Laroia is an example of a non-transitory memory (*a non-transitory memory coupled*

to the processor) storing instructions to be executed by the processor (*processor*). Geier (EX1003), ¶226.

[22.3] perform an invertible transform on a set of data symbols to generate a plurality N of spread data symbols, the invertible transform comprising complex-valued spreading codes;

Laroia discloses or renders obvious claim element [22.3]. Laroia combined with Thoumy also discloses or renders obvious [22.3].

First, for the reasons presented in the analysis of claim element [11.1] above, Laroia discloses or renders obvious *perform an invertible transform on a set of data symbols to generate a plurality N of spread data symbols*. Claim elements [11.1] and [22.3] are presented below to show that *perform an invertible transform on a set of data symbols to generate a plurality N of spread data symbols* is broader than [11.1]. Geier (EX1003), ¶228.

[22.3] perform an invertible transform on a set of data symbols to generate a plurality N of spread data symbols	[11.1] performing an invertible transform, comprising multiplying a plurality of data symbols by a complex-valued spreading matrix to produce a plurality of spread symbols
--	---

Thus, for the reasons provided in the analysis of [11.1], Laroia discloses or renders obvious *perform an invertible transform on a set of data symbols to generate a plurality N of spread data symbols*. Geier (EX1003), ¶229.

Second, as discussed in the analysis of claim elements [1.1] and [11.1] Laroia’s DFT (and also Laroia-Thoumy’s DFT) was understood as having *complex-valued coefficients* ([1.1]) and as representing a *complex-valued spreading matrix* ([11.1]). The rows or columns of Laroia’s (or Laroia-Thoumy’s) DFT matrix are example *complex-valued spreading codes*, depending on how the vector of symbols $\{A_i\}$ is arranged, because the matrix “spreads” each symbol A_i over the OFDM subcarriers. Geier (EX1003), ¶230.

As explained in the analysis of claim element [1.1], Thoumy explains that a DFT of complex symbols, such as the DFT of Laroia applied to “complex data symbols C_i ,” may be implemented by organizing the complex symbols into a column vector of length n and multiplying the vector by an $n \times n$ DFT matrix to produce an output vector. The rows of the DFT matrix are example *complex-valued spreading codes*. Each element of the output vector is a linear

combination of the input vector, weighted by the elements of a corresponding row of the DFT matrix. Geier (EX1003), ¶231.

Thus, Laroia's DFT and also Laroia-Thoumy's DFT (*invertible transform comprising complex-valued spreading codes*) applied to a set of M complex data symbols $\{C_i\}$ (*a set of data symbols*) to generate an vector of symbols $[A_1, \dots, A_M]$ (*a plurality N of spread data symbols*) discloses or renders obvious *perform an invertible transform on a set of data symbols to generate a plurality N of spread data symbols, the invertible transform comprising complex-valued spreading codes*. Geier (EX1003), ¶232.

[22.4] map the N spread data symbols to at least N subcarriers of a plurality M of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers to generate a set of complex subcarrier amplitudes; and

Laroia discloses or renders obvious claim element [22.4].

For the reasons presented in the analysis of claim element [1.2] and [11.2], Laroia discloses *map the N spread data symbols to at least N subcarriers of a plurality M of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers*. Geier (EX1003), ¶234.

Claim elements [22.4] and [11.2] are compared below.

[22.4] map the N spread data symbols to at least N subcarriers of a plurality M of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers ...	[11.2] mapping the plurality of spread symbols to a plurality of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers
--	--

Laroia's symbols at the output of the DFT " $[A_1, \dots, A_M]$," when mapped to "tones"/subcarriers, as described in Laroia, also represent *a set of complex subcarrier amplitudes*, as claimed. The values " $[A_1, \dots, A_M]$ " are complex values because they represent the multiplication of a complex vector of symbols $\{C_i\}$ by a DFT matrix, which has complex values. Each of the complex values " $[A_1, \dots, A_M]$ " is mapped to a different subcarrier as an input to an IDFT. Thus, each of Laroia's values " $[A_1, \dots, A_M]$ " represents a *complex subcarrier amplitude* because each element represents an amplitude of a different subcarrier and the amplitudes are complex values. Geier (EX1003), ¶236.

In fact, Laroia's description of mapping symbols $[A_1, \dots, A_M]$ to subcarriers is substantially identical to one of the embodiments in the '227 Patent, which recites:

A symbol-to-subcarrier mapping source code segment 3103 **maps each of the N DFT outputs of x to one of M ($M > N$) orthogonal subcarriers. ... The result of the subcarrier mapping is a set of complex subcarrier amplitudes, where N of the amplitudes are non-zero.**

'227 Patent, 74:4-18. This is substantially identical to the process described in Laroia at [0053]. Geier (EX1003), ¶237.

Thus, Laroia discloses or renders obvious *map the N spread data symbols to at least N subcarriers of a plurality M of Orthogonal Frequency Division Multiplexing (OFDM) subcarriers to generate a set of complex subcarrier amplitudes.* Geier (EX1003), ¶238.

[22.5] perform an M-point inverse discrete Fourier transform (IDFT) on the set of complex subcarrier amplitudes to generate a time-domain sequence to be transmitted into a wireless channel, the time-domain sequence comprising a superposition of the OFDM subcarriers,

Laroia discloses or renders obvious claim element [22.5].

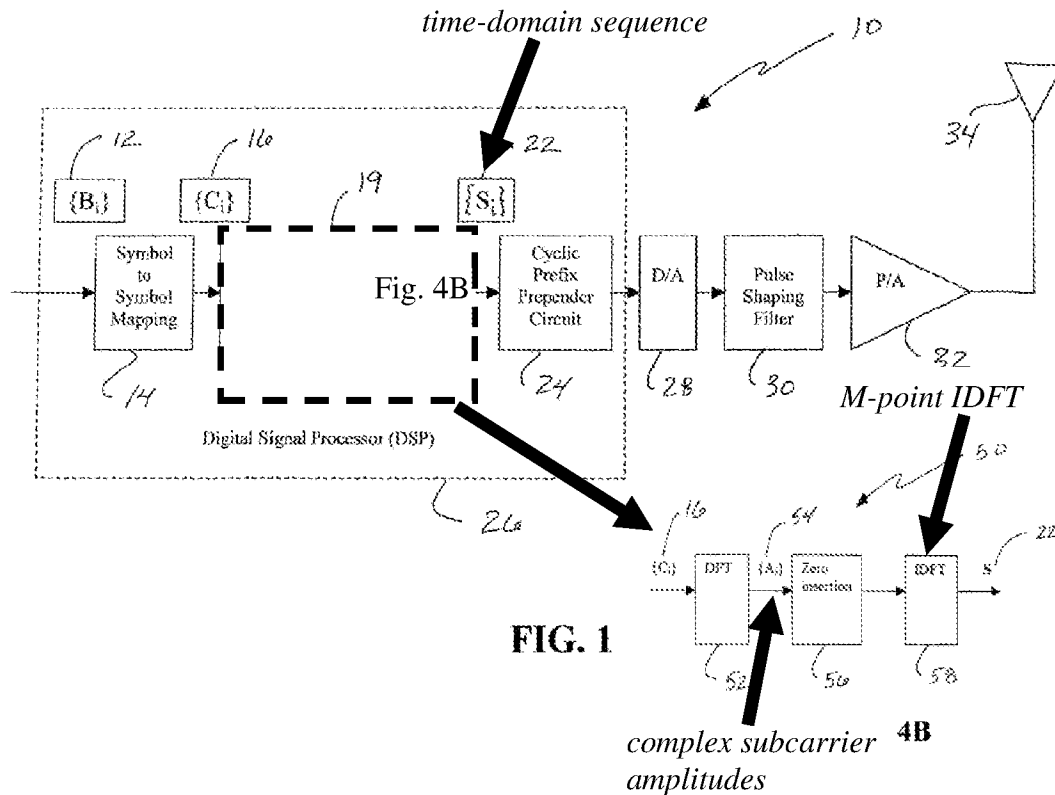
Claim element [22.5] has substantial overlap with claim elements [11.3] and [18.1], as shown in the table below.

[22.5] perform an M-point inverse discrete Fourier transform (IDFT) on the set of complex subcarrier amplitudes to generate a time-domain sequence to be transmitted into a wireless channel, the time-domain sequence comprising a superposition of the OFDM subcarriers	[11.3] modulating the plurality of spread symbols onto the plurality of OFDM subcarriers to produce a spread OFDM signal to be transmitted into a wireless channel, wherein the spread OFDM signal comprises a superposition of the OFDM subcarriers [18.1] ... the modulating comprises employing an M-point inverse-DFT, and wherein $N < M$
---	---

Claim element [11.3] uses the term *a spread OFDM signal to be transmitted into a wireless channel*, whereas claim element [22.5] uses the term *a time-domain sequence to be transmitted into a wireless channel*. Geier (EX1003), ¶240.

First, the *OFDM transmission signal* of claim element [1.3] is an example of the *spread OFDM signal* of claim element [11.3] and the *time-domain sequence to be transmitted into a wireless channel* because the signal is an OFDM signal formed from spread symbols. The *spread OFDM signal* of claim element [11.3] is *to be transmitted into a wireless channel* because Laroia's

signals are transmitted via an antenna 34, as shown in Figure 1 (modified with Figure 4B, as explained in the analysis of claim element [1.3]). Geier (EX1003), ¶241.



Laroia (EX1004), Fig. 1 with Fig. 4B (annotated)

Second, the signal vector S , consisting of samples $\{S_i\}$, represents samples transmitted at successive time instants (*a time-domain sequence to be transmitted into a wireless channel*). Laroia (EX1004), [0053] (“The vector $[A_1, \dots, A_M]$ 54 output by the DFT circuit 52 is then expanded to a new vector of length N (the **total number of time instants in the discrete signal vector S**) by zero insertion at block 56.”); *see also* Figure 4E, reproduced below, showing values of sample vector S versus time. Geier (EX1003), ¶242.

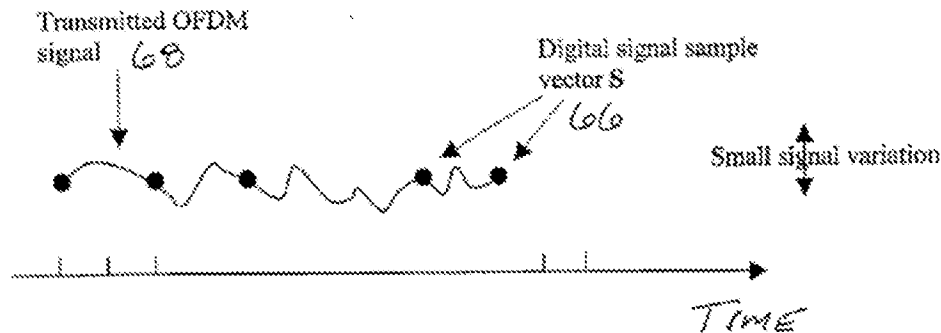


FIG. 4E

Laroia (EX1004), Fig. 4E

Third, Laroia's time-domain OFDM signal samples S represent a *superposition of OFDM subcarriers* for reasons given in claim element [1.3]. Geier (EX1003), ¶243.

For these reasons, Laroia discloses or renders obvious claim element [22.5]. Geier (EX1003), ¶244.

[22.6] wherein the invertible transform is configured to provide the superposition with a reduced peak-to-average power ratio.

Claim element [22.6] is substantially the same as claim element [1.4]. Therefore, Laroia discloses or renders obvious claim element [22.6] for the reasons given in the analysis of claim element [1.4]. Geier (EX1003), ¶245.

(x) Claim 23

23. The apparatus recited in claim 22,

[23.1] wherein the N subcarriers comprise at least one of contiguous OFDM subcarriers and non-contiguous OFDM subcarriers.

Laroia combined with Thoumy renders obvious claim 22.

Claim element [23.1] is broader than claim element [5.1], as shown in the table below (e.g., unlike [5.1], [23.1] does not require that the *non-contiguous OFDM subcarriers* be *equally spaced*).

[23.1] wherein the N subcarriers comprise at least one of contiguous OFDM subcarriers and non-contiguous OFDM subcarriers	[5.1] wherein the plurality of OFDM subcarriers comprise at least one of contiguous OFDM subcarriers and equally spaced non-contiguous OFDM subcarriers
---	---

Therefore, Laroia discloses or renders obvious claim element [23.1] for at least the reasons given in the analysis of claim element [5.1]. Geier (EX1003), ¶¶247-248.

(xi) Claim 24

24. The apparatus recited in claim 22,

[24.1] configured to reside on a User Equipment.

Laroia combined with Thoumy renders obvious claim 22.

Regarding claim element [24.1], see the analysis of claim 21, where it is explained that Laroia discloses that its techniques provide advantages when implemented on “handheld wireless communication devices or terminals,” Laroia (EX1004), [0005], which are examples of *User Equipment*, thereby disclosing or rendering obvious claim element [24.1]. Geier (EX1003), ¶250.

(xii) Claim 25

25. The apparatus recited in claim 22,

[25.1] wherein $M > N$.

Laroia combined with Thoumy renders obvious claim 22.

Regarding claim element [25.1], see the analysis of claim element [2.1], where it is demonstrated that the size of Laroia’s IDFT (size M) is greater than the size of Laroia’s DFT (*invertible transform* of claim 22 of size N). Geier (EX1003), ¶252.

(xiii) Claim 26

26. The apparatus recited in claim 22,

[26.1] wherein the IDFT comprises an inverse fast Fourier transform.

Laroia combined with Thoumy renders obvious claim 22.

Regarding claim element [26.1], see the analysis of claim element [3.1], where it is shown that it would have been obvious to implement Laroia’s IDFT as an IFFT, thereby disclosing or rendering obvious claim element [26.1]. Geier (EX1003), ¶254.

(xiv) **Claim 27**

27. The apparatus recited in claim 22,

[27.1] wherein the non-transitory memory further comprises instructions to perform pulse-shaping on at least one of a set of signals, the set comprising the plurality of spread data symbols and the time-domain sequence, in order to provide the superposition with a predetermined pulse shape.

Laroia combined with Thoumy renders obvious claim 22.

Claim element [27.1] is similar to claim element [6.1], both focusing on performing *pulse-shaping*, as shown in the table below.

[27.1] wherein the non-transitory memory further comprises instructions to perform pulse-shaping on at least one of a set of signals, the set comprising the plurality of spread data symbols and the time-domain sequence, in order to provide the superposition with a predetermined pulse shape	[6.1] further comprising computer-readable program code configured to perform pulse-shaping module to provide the OFDM transmission signal with a predetermined pulse shape
--	---

As explained in the analysis of claim element [6.1], referring to Figure 1, Laroia discloses the use of a pulse shaping filter 30 (“perform pulse-shaping”) applied to the OFDM transmission signal {S_i} (which represents an example *time-domain sequence*) to provide the output of the power amplifier 32 with a predetermined pulse shape. Laroia’s Figure 1 is annotated below with claim language. Further discussion of generating the *time-domain sequence* (i.e., *the time-domain sequence comprising a superposition of the OFDM subcarriers*) is provided in the analysis of claim elements [22.5] and [1.3]. Geier (EX1003), ¶¶256-257.

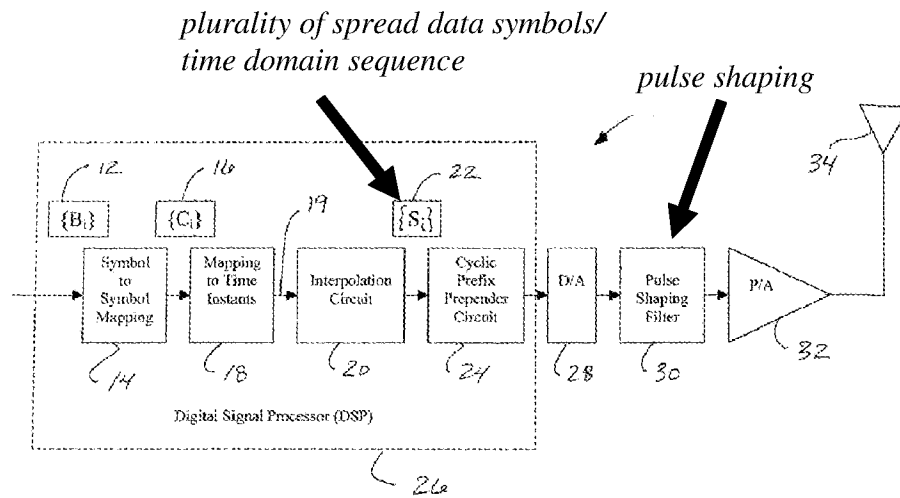


FIG. 1

Laroia (EX1004), Fig. 1 (annotated)

As discussed in the analysis of claim elements [11.1] and [22.3], in arriving at the OFDM signal $\{S_i\}$, the DFT of Laroia is an *invertible transform* that generates the *spread data symbols* as an intermediate step toward producing $\{S_i\}$. Laroia's disclosure of applying a pulse shaping filter 30 to the time-domain sequence (that comprises a *superposition of the OFDM subcarriers to provide the superposition with a predetermined pulse shape* discloses or renders obvious claim element [27.1]. Geier (EX1003), ¶258.

D. Proposed Rejections A3 and A4: Claims 4 and 9 are obvious over Laroia combined with Singh under 35 U.S.C. § 103(a) (Rejection A3); Claims 4, 9, 15, and 16 are obvious over Laroia combined with Thoumy and Singh under 35 U.S.C. § 103(a) (Rejection A4).

(i) Claim 4

4. The non-transitory computer-readable medium recited in claim 1, [4.1] wherein the data symbols comprise reference-signal symbols, which comprise at least one of known training symbols and synchronization symbols.

As discussed in Section IV.B (Proposed Rejection A1), Laroia alone renders obvious claim 1. As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy also renders obvious claim 1.

As an initial matter, regarding the term *at least one of known training symbols and synchronization symbols*, as explained the analysis of claim 5 (in Proposed Rejection A1), there is a rebuttable presumption that the meaning of a claim term in the form “at least one of A and B” is “at least one of A and at least one of B.” However, there is no need to further analyze the meaning of claim element [4.1] and whether the presumption can be rebutted, because the prior art discloses claim element [4.1] even under this most narrow understanding that both *known training symbols* and *synchronization symbols* are required. Geier (EX1003), ¶260.

Laroia combined with Singh renders obvious claim element [4.1].

Laroia describes the internal workings of the conversion of data symbols to an OFDM symbol having samples $S/22$, as illustrated in Figure 4B. Figure 4B is annotated below, using the language of claim elements [1.1] and [1.2], as explained in the analysis of those claim elements. Geier (EX1003), ¶262.

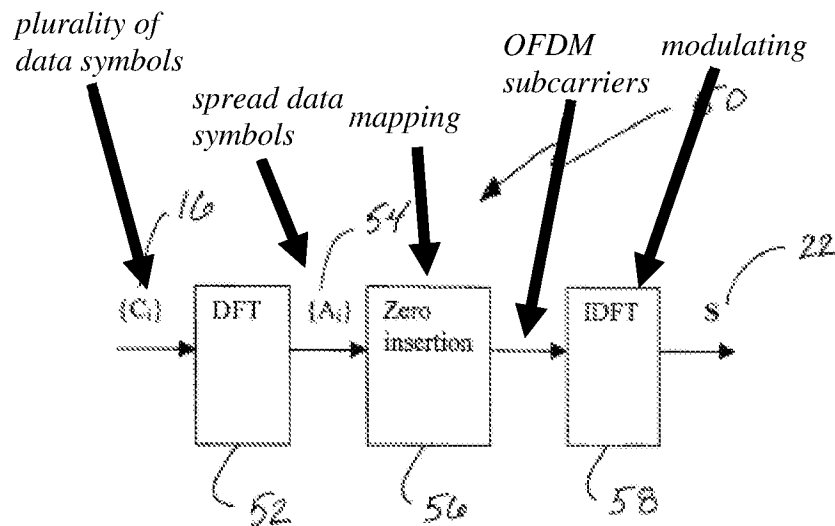


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated)

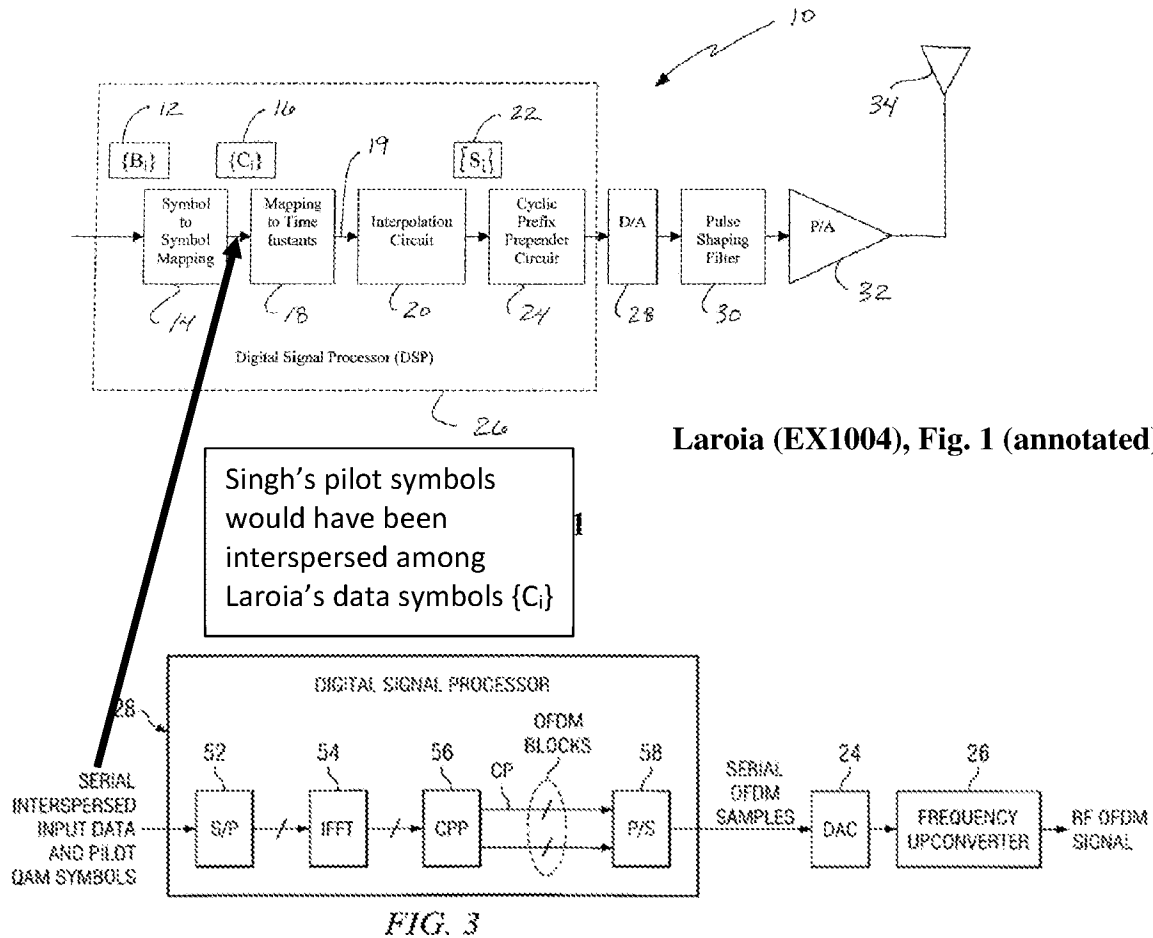
The '227 Patent specification uses only the term “synchronization signals,” not “synchronization symbols,” and the '227 Patent specification makes no distinction between training symbols and the function of synchronization (which presumably could also be performed using “synchronization symbols”) because training symbols may be used for synchronization. '227 Patent (EX1001), 41:22-25 (“Training symbols can be used for various purposes, including,

but not limited to, channel estimation, signal-quality estimation, and synchronization.”). Thus, the ’227 Patent specification makes no distinction between training symbols and synchronization symbols. Geier (EX1003), ¶263.

Singh describes the interspersing of pilot symbols among data symbols prior to OFDM modulation for the purpose of providing for both channel estimation and synchronization at the expense of a small amount of pilot symbol overhead. Singh (EX1016), 1:9-12 (“The invention relates to orthogonal frequency division multiplex (OFDM) communication systems and more particularly to synchronization and channel estimation for an OFDM communication system.”); 2:56-65 (Describing the use of “temporal” and “frequency domain” “**pilot-assisted** time synchronization, frequency synchronization, and/or channel estimation.”). Thus, Singh’s known pilot symbols, being used for both synchronization and channel estimation, are examples of both known *synchronization* symbols and *training* symbols. Geier (EX1003), ¶264.

A POSITA would have been motivated to intersperse Singh’s pilot symbols (i.e., *known training symbols and synchronization symbols*) among Laroia’s data symbols. Such a combination would have yielded the obvious, beneficial, and predictable result of a transmitted waveform with low peak-to-average power ratio (per Laroia) that also provides for accurate synchronization and channel estimation in a receiver thereby resulting in reliable communication with low bit error rate (per Singh). Geier (EX1003), ¶265.

A POSITA would have had a reasonable expectation of success in combining Laroia and Singh. Laroia and Singh present OFDM transmitter structures at various levels of detail, making it straightforward to understand how Singh’s pilot symbols would have been used in Laroia’s transmitter. For example, Laroia’s transmitter in Figure 1 is presented together with Singh’s transmitter in Figure 3, and the figures are annotated below to indicate where pilot symbols would have been introduced in Laroia’s transmitter. Geier (EX1003), ¶266.



Laroia (EX1004), Fig. 1 (annotated)

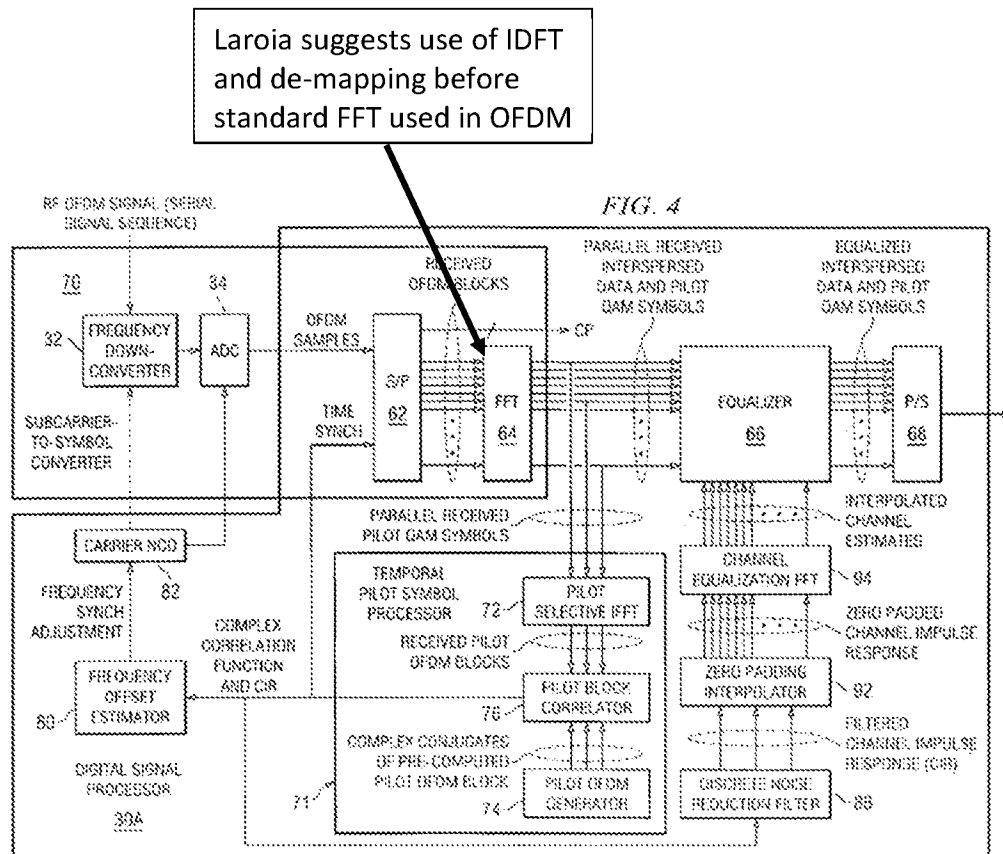
Singh (EX1016), Fig. 3 (annotated)

As shown, once Singh's pilot symbols are interspersed with Laroia's data symbols, Laroia's transmitter performs in exactly the same way. A small number of Laroia's data symbols C_i would have been replaced with pilot symbols, thereby yielding the same number M of total symbols in the set $\{C_i\}$. For example, the series of DFT, mapping, and IDFT in Figure 4B of Laroia would operate in the same way, except that the symbols input $\{C_i\}$ also include known pilot symbols. Therefore, since there is no change to Laroia's principle of operation, there would have been a reasonable expectation of success in including Singh's pilot symbols in Laroia's transmitter.

12. The method recited in claim 11, wherein the plurality of OFDM subcarriers is a subset of subcarriers, the subset comprising at least one of a block of contiguous subcarriers, and a set of non-contiguous subcarriers. Geier (EX1003), ¶267.

Interspersing Singh's pilot symbols with Laroia's data symbols in Laroia's transmitter represents combining prior art elements (pilot symbols and data symbols) according to known methods (generating pilot symbols and interspersing them with data symbols) to yield the obvious, beneficial, and predictable result of providing for synchronization and channel estimation in a receiver that inverts Laroia's OFDM signal formatting prior to synchronization and channel estimation using Singh's techniques, while maintaining Laroia's low peak-to-average power ratio in the transmitted signal. Geier (EX1003), ¶268.

From the receiver perspective, Laroia does not present the details of a receiver, relying on the knowledge of a POSITA to perform the inverse operations of what was performed in Laroia's transmitter (i.e., IDFT (inverse of DFT), followed by de-mapping, followed by IDFT (inverse of DFT)). These functions would have been implemented in Singh's receiver in a straightforward manner by using an IDFT and de-mapper in front of the FFT 64 (an efficient version of a DFT) in Singh's receiver of Figure 4. Geier (EX1003), ¶269.



Singh (EX1016), Fig. 4 (annotated)

The inclusion of pilot symbols together with data symbols in Laroia's processing is illustrated below, where the collection of symbols $\{C_i\}$ in Laroia is an example of the claimed *data symbols*. Geier (EX1003), ¶270.

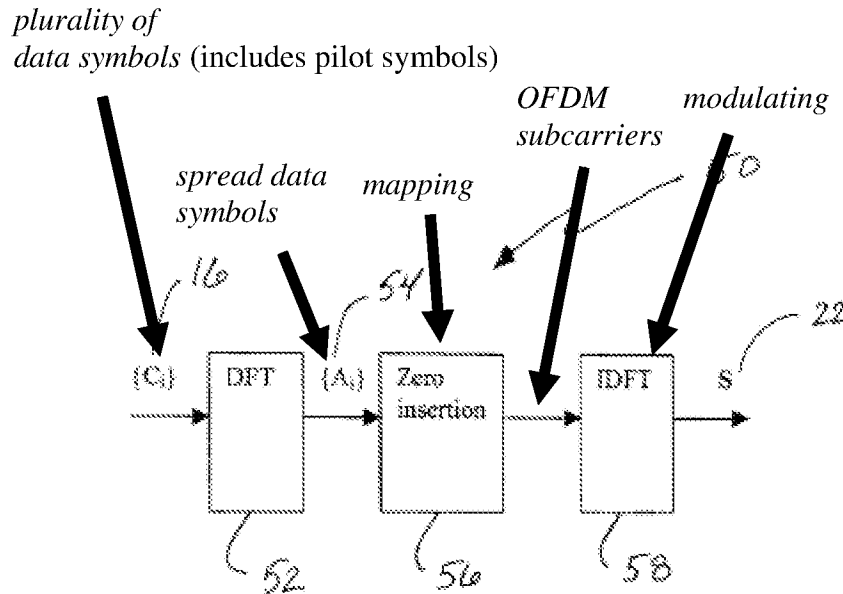


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated)

Singh's pilot symbols are examples of the claimed *reference-signal symbols*, as confirmed by the '227 Patent, which explains that pilot symbols are examples of reference signals. '227 Patent (EX1001), 21:47-55 ("A plurality of base transceiver stations (e.g., transmission points, or access points) is configured to transmit **reference signals 301**, which are measured by UEs to calculate channel state information 302. For example, the '850 application discloses that **reference signals, which include known** training sequences and **pilot signals**, are transmitted, and a channel model is developed by a receiver upon receiving the transmitted reference signals."); 22:58-61 ("In one aspect of the invention, each UE transmits **a known reference signal 311, such as one or more known** training sequences and/or **pilot signals**, which are described in the '850 application."); Geier (EX1003), ¶271.

Returning to Singh, Singh's pilot symbols are examples of both *training symbols* and *synchronization symbols*. According to the '227 Patent, "[f]or example, TDD enables channel reciprocity which can permit uplink reference signals, **such as training signals (e.g., pilot tones)** to be used to estimate the downlink channel." Furthermore, the pilot symbols of Singh are used

for the same purpose as *training symbols* and *synchronization symbols*, which is channel estimation and synchronization, as explained earlier. Geier (EX1003), ¶272.

Thus, the inclusion of Singh's pilot symbols with Laroia's data symbols in Laroia's processing, where the collection of symbols $\{C_i\}$ in Laroia is an example of the claimed *data symbols* and Singh's pilot symbols may be used for the same functions as *training symbols* and *synchronization symbols* (and therefore are examples of those symbols), including channel estimation and synchronization, renders obvious *wherein the data symbols comprise reference-signal symbols, which comprise at least one of known training symbols and synchronization symbols*. Geier (EX1003), ¶273.

(ii) **Claim 9**

9. The non-transitory computer-readable medium recited in claim 1, [9.1] wherein the plurality of data symbols are at least one of time-multiplexed with reference-signal symbols, frequency-multiplexed with reference-signal symbols, and code-multiplexed with reference-signal symbols.

As discussed in Section IV.B (Proposed Rejection A1), Laroia alone renders obvious claim 1. As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy also renders obvious claim 1.

As an initial matter, regarding the term *at least one of time-multiplexed with reference-signal symbols, frequency-multiplexed with reference-signal symbols, and code-multiplexed with reference-signal symbols*, as explained in the analysis of claim 5 (in Section IV.B, Proposed Rejection A1), there is a rebuttable presumption that the meaning of claim terms in the form “at least one of A and B” is “at least one of A and at least one of B.” This presumption is rebutted here for claim element [9.1]. Geier (EX1003), ¶275.

There is no embodiment in the '227 Patent specification in which *data symbols* and *reference-signal symbols* satisfy being *time-multiplexed*, *frequency-multiplexed*, and *code-multiplexed*. The only reference in the '227 Patent specification to “time-multiplexed,” “frequency-multiplexed,” and “code-division multiplexed” is the following, which does not demonstrate all three types of multiplexing being used at the same time for a given set of data symbols and reference-signal symbols:

In some aspects, the data symbols b can comprise symbols of a reference signal...

In some aspects, the reference signals are time-multiplexed with user-data signals.

In some aspects, the reference signals are frequency-multiplexed with user-data signals. In some aspects, the reference signals are code-division multiplexed with user-data signals.

'227 Patent (EX1001), 65:21-41. Furthermore, it would not be apparent to a POSITA from the disclosure of the '227 Patent to multiplex data symbols with reference signal symbols using time, frequency, and code division multiplexing. For example, if certain symbols from the same transmitter are multiplexed in time and/or frequency, there is no reason provided to add code division as an extra means to separate these symbols. Thus, the *SuperGuide* presumption is rebutted and only one of *time-multiplexed*, *frequency-multiplexed*, or *code-multiplexed* is required by the claim. Geier (EX1003), ¶276.

Laroia combined with Singh renders obvious claim element [9.1].

As explained in the analysis of claim element [4.1], it would have been obvious to intersperse the pilot symbols of Singh with Laroia's data symbols prior to the DFT in Laroia's receiver, as illustrated in annotated Figure 4B of Laroia, using claim language from claim 1, below. Geier (EX1003), ¶278.

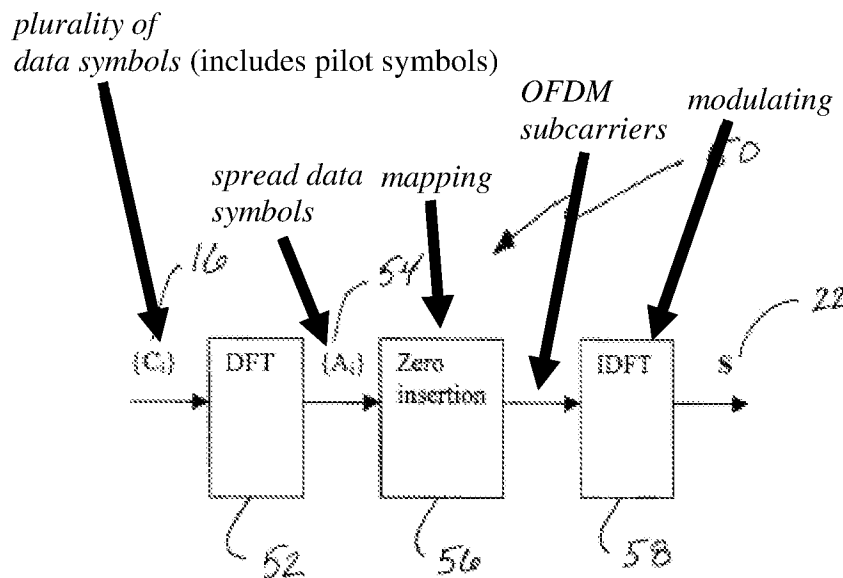


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated)

Singh's pilot symbols are an example of the claimed *reference-signal symbols*, as explained in the analysis of claim element [4.1]. Reasons for combining Laroia and Singh also are presented

in the analysis of claim element [4.1]. Furthermore, as was well-known in the art, symbols as they exist prior to the IDFT or IFFT in an OFDM modulator, such as before the IDFT 58 in Laroia (as explained in the analysis of claim element [3.1], an IFFT is the preferred form of the IDFT) were understood to exist in the frequency domain. For example, Singh explains that “it is a convention in the OFDM art to consider the QAM symbols to be frequency domain signals and to consider the OFDM samples to be time domain (temporal) signals,” Singh (EX1016), 7:37-41, where it was understood that QAM symbols exist pre-IFFT and OFDM samples exist post-IFFT. The pilot symbols are intermingled with Laroia’s QAM symbols $\{C_i\}$, thereby rendering obvious that the pilot symbols are *frequency-multiplexed* with Laroia’s data symbols, or equivalently rendering obvious claim element [9.1] (*wherein the plurality of data symbols are ... frequency-multiplexed with reference-signal symbols ...*). Geier (EX1003), ¶279.

(iii) Claim 15

***15. The method recited in claim 11,
[15.1] wherein at least one of the spreading matrix and the mapping is configured to provide a spread reference signal comprising a coherent superposition of reference symbol components on different subcarriers.***

As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy renders obvious claim 11.

Laroia combined with Thoumy and Singh renders obvious claim element [15.1].

Regarding the term *at least one of the spreading matrix and the mapping* as explained in Section IV.B (Proposed Rejection A1), there is a rebuttable presumption that the meaning of claim terms in the form “at least one of A and B” is “at least one of A and at least one of B.” There is no reason to address whether the presumption applies because the Laroia/Thoumy spreading matrix (DFT) and mapping together *provide a spread reference signal comprising a coherent superposition of reference symbol components on different subcarriers*. Geier (EX1003), ¶282.

As explained in the analysis of claim element [4.1], it would have been obvious to intersperse the pilot symbols of Singh with Laroia’s data symbols prior to the IDFT in Laroia’s receiver, as illustrated in annotated Figure 4B of Laroia, using claim language from claim 1, below, where the DFT 52 is implemented using a matrix, per Thoumy’s teachings (*spreading matrix*). Geier (EX1003), ¶283.

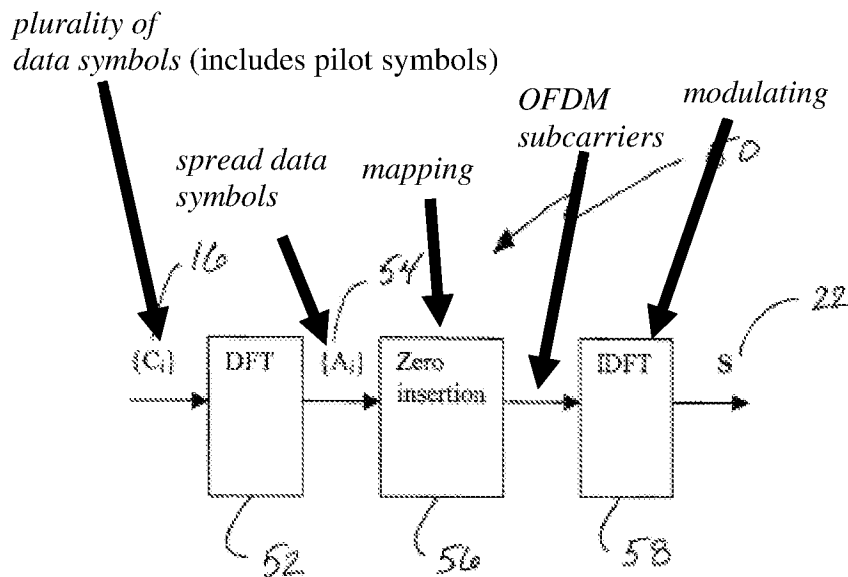


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated)

As explained in the analysis of claim element [1.3], the '227 Patent family confirms that an example *superposition of reference symbol components* is a linear combination of reference symbol components. *See, e.g.,* U.S. 9,819,449 (EX1013), 28:6-13 ("...the resulting aggregate signal (i.e., superposition) comprises a linear combination of the transmitted signals..."). Geier (EX1003), ¶284.

A POSITA would have understood that the output of Laroia's DFT is a weighted sum of the input symbols $\{C_i\}$ (which include pilot symbols and data symbols), thereby disclosing or rendering obvious that the DFT 52 (*spreading matrix*) and also the zero insertion 56 (*mapping*) are configured to *provide a spread reference signal comprising a coherent superposition of reference symbol components on different subcarriers*. Geier (EX1003), ¶285.

As explained in the analysis of claim element [1.1] in Proposed Rejections A1 and A2, a DFT is a fundamental and well-known building block of digital signal processing and knowledge of DFT implementation would have formed part of the background of a POSITA, and each element of the output vector of a DFT (such as DFT 52 in Laroia) is a linear combination of the input vector (inputs are a mix of pilot symbols (*reference-signal symbols*) and data symbols), weighted by the elements of a corresponding row of the DFT matrix, thereby yielding a *coherent superposition of*

reference symbol components on different subcarriers (each subcarrier input to Laroia's IDFT is a linear combination of the pilot and data symbols). Geier (EX1003), ¶286.

(iv) **Claim 16**

16. The method recited in claim 11,

[16.1] wherein the plurality of data symbols comprises at least one reference-signal symbol employed for at least one of synchronization and channel estimation.

As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy renders obvious claim 11.

Laroia combined with Singh renders obvious claim element [16.1].

As explained in the analysis of claim element [4.1], it would have been obvious to intersperse the pilot symbols of Singh with Laroia's data symbols prior to the DFT in Laroia's receiver, as illustrated in annotated Figure 4B of Laroia, using claim language from claim 1, below. Geier (EX1003), ¶289.

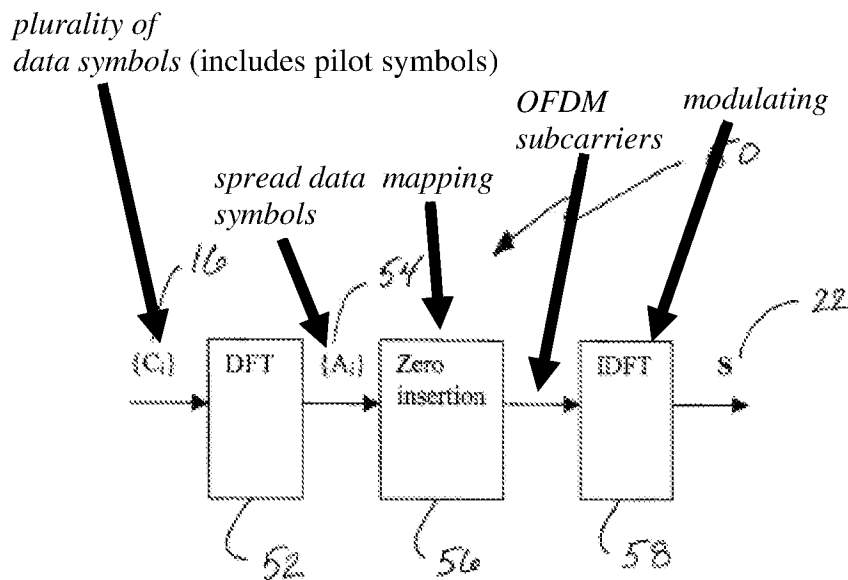


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated)

Singh's pilot symbols are an example of the claimed *reference-signal symbols*, as explained in the analysis of claim element [4.1]. Reasons for combining Laroia and Singh also are presented in the analysis of claim element [4.1]. Geier (EX1003), ¶290.

As further explained in the analysis of claim element [4.1], Singh describes the interspersing of pilot symbols among data symbols prior to OFDM modulation for the purpose of *synchronization* and *channel estimation*, disclosing both of the functions expressed in claim element [16.1]. Singh (EX1016), 1:9-12 (“The invention relates to orthogonal frequency division multiplex (OFDM) communication systems and more particularly to **synchronization and channel estimation** for an OFDM communication system.”); 2:56-65 (Describing the use of “temporal” and “frequency domain” “**pilot-assisted time synchronization, frequency synchronization, and/or channel estimation.**”). Geier (EX1003), ¶291.

Therefore, Laroia combined with Singh renders obvious that *the plurality of data symbols* (data and pilot symbols) *comprises at least one reference-signal symbol* (pilot symbol) *employed for at least one of synchronization and channel estimation* (used for synchronization and channel estimation). Geier (EX1003), ¶292.

E. Proposed Rejections A5 and A6: Claim 10 is obvious over Laroia combined with Larsson under 35 U.S.C. § 103(a) (Rejection A5); Claims 10 and 19 are obvious over Laroia combined with Thoumy and Larsson under 35 U.S.C. § 103(a) (Rejection A6).

(i) Claim 10

10. The non-transitory computer-readable medium recited in claim 1, [10.1] further comprising computer-readable program code to provide Cyclic Delay Diversity (CDD) to the OFDM transmission signal.

As discussed in Section IV.B (Proposed Rejection A1), Laroia alone renders obvious claim 1. As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy also renders obvious claim 1.

Laroia combined with Larsson renders obvious claim element [10.1].

In order to address the problems with delay diversity while retaining its benefits, Larsson introduces a cyclic delay on each antenna path, which it refers to as cyclic delay diversity. More specifically, Larsson presents “a method and/or an apparatus for transmitting a symbol, wherein the symbol is split among a plurality of antenna paths. In each antenna path **the samples of the symbol are cyclically shifted a predetermined number of positions.**” Larsson (EX1017), 5:20-25; *see also* Title (“**Cyclic delay diversity** for mitigating intersymbol interference in OFDM

systems”). As shown in the title, Larsson discloses the use of cyclic delay diversity (CDD) in OFDM systems. Geier (EX1003), ¶295.

For example, Larsson discloses providing cyclic delay diversity to an OFDM signal, as illustrated in Figure 9 reproduced and discussed below. As was understood in the art, Larsson’s IFFT generates an OFDM signal. *See, e.g.*, Larsson (EX1017), Figure 9 illustrating an “OFDM SIGNAL” at the output of an IFFT). After reproducing the signal at each of three antennas and attenuating the signals to normalize power, a cyclic delay is applied on some of the antennas, thereby *provid[ing] Cyclic Delay Diversity (CDD) to the OFDM transmission signal*. Geier (EX1003), ¶296.

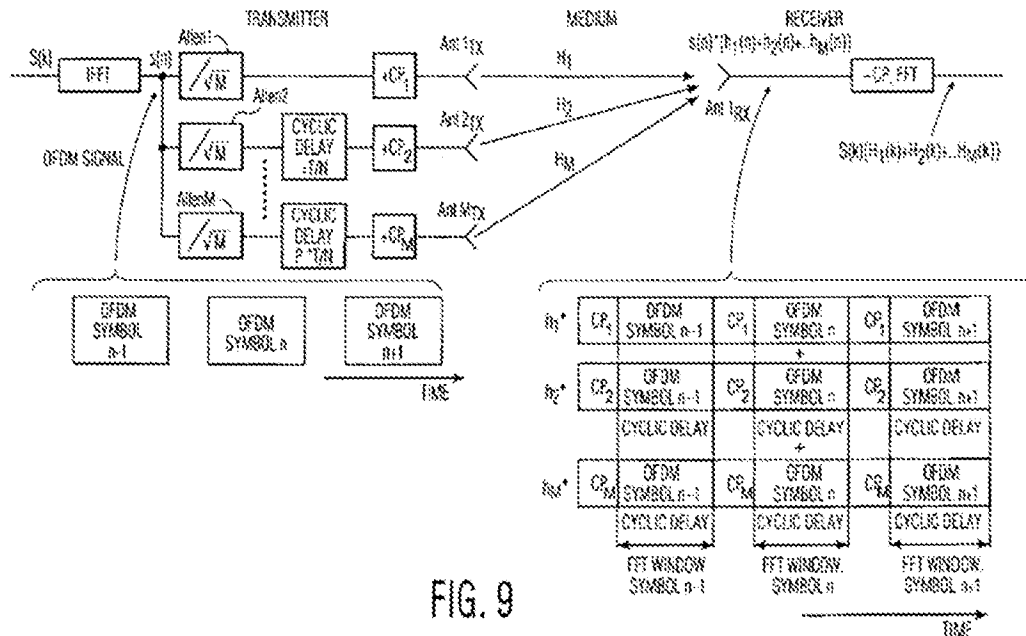


FIG. 9

Larsson (EX1017), Figure 9

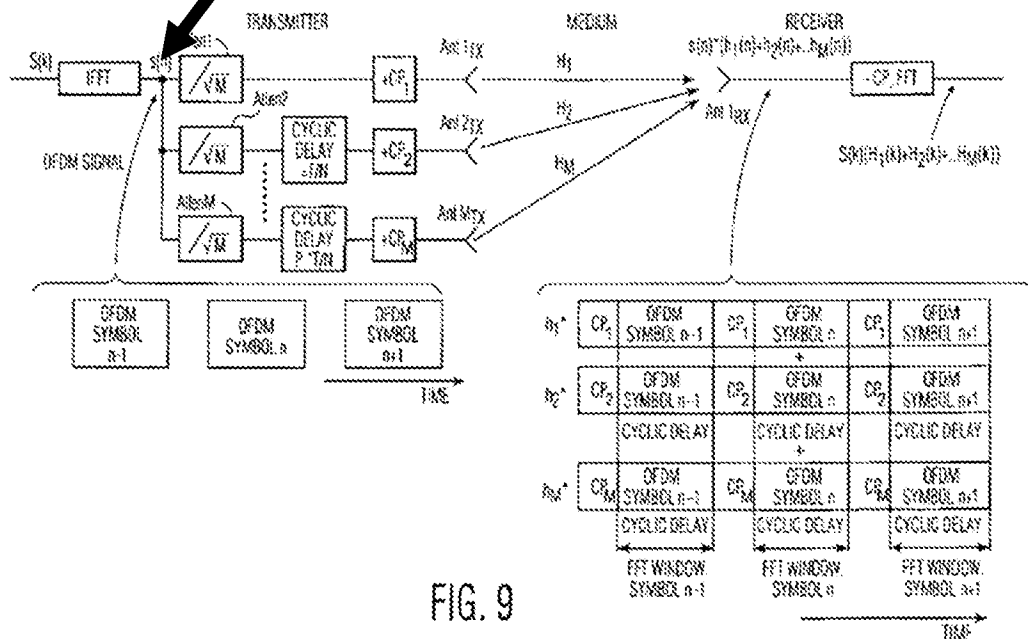
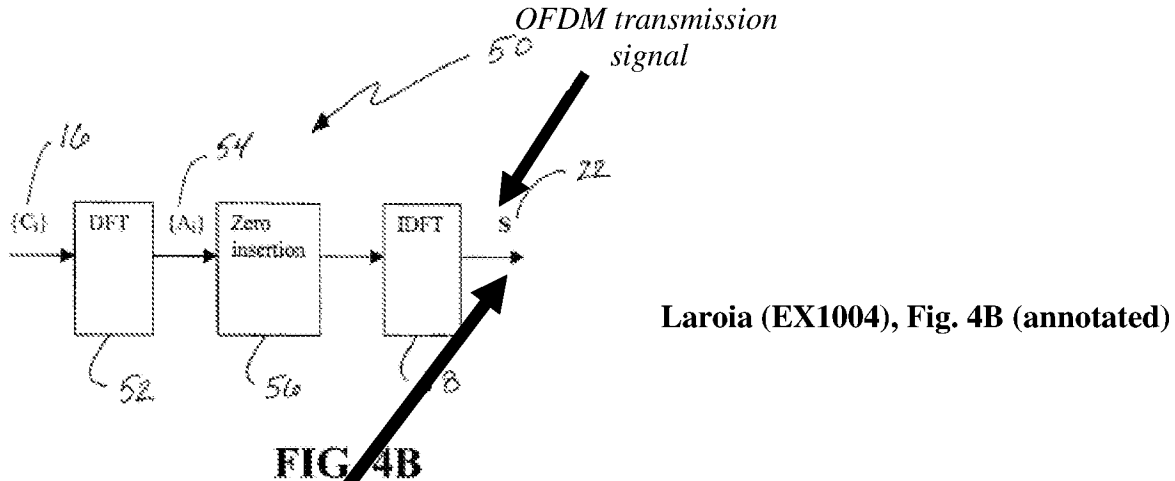
A POSITA would have been motivated to apply Larsson’s cyclic delay diversity for OFDM to the OFDM transmitter of Laroia to yield the obvious, predictable, and beneficial result of providing cyclic delay diversity to Laroia’s OFDM transmissions to mitigate intersymbol interference and corruption of the transmitted signal by multipath fading. Geier (EX1003), ¶297.

Larsson relates to “transmit diversity,” and in particular “systems which employ delay transmit diversity.” Larsson (EX1017), 1:6-10. Delay transmit diversity refers to “employing a set of M of transmit antennas each of which transmit delayed versions of a symbol to be transmitted.” *Id.*, 2:22-26. The use of this type of diversity beneficially “helps prevent the symbol being

transmitted from being corrupted by flat Rayleigh fading.” *Id.*, 5:1-4. However, one drawback is “the total delay spread between all of the antenna paths can be no more than the duration of the cyclic prefix minus the duration of the inherent channel delay spread.” *Id.*, 5:4-7; Geier (EX1003), ¶298.

To address the problems with delay diversity in multi-antenna transmission while retaining its benefits, Larsson introduces a cyclic delay on each antenna path, which it refers to as cyclic delay diversity. More specifically, Larsson presents “a method and/or an apparatus for transmitting a symbol, wherein the symbol is split among a plurality of antenna paths. In each antenna path **the samples of the symbol are cyclically shifted a predetermined number of positions.**” Larsson (EX1017), 5:20-25; *see also* Title (“**Cyclic delay diversity** for mitigating intersymbol interference in OFDM systems”). Geier (EX1003), ¶¶299-300.

A POSITA would have had a reasonable expectation of success in applying Larsson’s teachings to Laroia. It would have been straightforward to combine Laroia’s and Larsson’s techniques by employing multiple antennas with cyclic delays with Laroia’s system, as illustrated below, using Laroia’s Figure 4B and Larsson’s Figure 9. As shown, when combined, Laroia’s OFDM signal S (IDFT output) would have been fed into different antenna signal paths that implement cyclic delay diversity, just like Larsson’s IFFT output (an OFDM signal) is fed into different antenna signal paths. Such a system combines the benefits of Laroia (low peak-to-average power ratio on each antenna) and Larsson (mitigation of intersymbol interference and increased reliability). Geier (EX1003), ¶301.



Finally, implementing Larsson's teachings in Laroia's OFDM system represents combining prior art elements (Larsson's teachings regarding multiple antennas for OFDM transmission) according to known methods to yield the predictable result of Laroia's OFDM signals transmitted via Larsson's multiple antennas using cyclic delay diversity among the antennas. Geier (EX1003), ¶302.

Thus, Larsson's use of cyclic delay diversity (CDD) applied to Laroia's OFDM output/signal S (at output of IDFT) renders obvious *further comprising computer-readable*

program code to provide Cyclic Delay Diversity (CDD) to the OFDM transmission signal. Geier (EX1003), ¶303.

(ii) **Claim 19**

19. The method recited in claim 11,

[19.1] further comprising providing Cyclic Delay Diversity to the spread OFDM signal.

As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy renders obvious claim 11.

Claim element [19.1] is substantively similar to claim element [10.1], and the two claim elements are presented in the table below for comparison. Geier (EX1003), ¶305.

[10.1] further comprising computer-readable program code to provide Cyclic Delay Diversity (CDD) to the OFDM transmission signal.	[19.1] further comprising providing Cyclic Delay Diversity to the spread OFDM signal.
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As shown above, claim element [10.1] recites providing CDD to *the OFDM transmission signal*, whereas claim element [19.1] recites providing CDD to *the spread OFDM signal*. As explained in the analysis of claim element [11.3], the *OFDM transmission signal* of claim element [1.3] (and claim element [10.1]) is an example of the *spread OFDM signal* of claim element [11.3] (and claim element [19.1]) because the signal is an OFDM signal formed from spread symbols. Thus, Larsson's CDD is applied to the *spread OFDM signal* of Laroia in the same way and for the same reasons that CDD is applied to the *OFDM transmission signal* of claims 1 and 10, thereby rendering obvious claim element [10.1]. Geier (EX1003), ¶306.

F. Proposed Rejection A7: Claims 13 and 29 are obvious over Laroia combined with Thoumy and Li under 35 U.S.C. § 103(a).

(i) **Claim 13**

13. The method recited in claim 11,

[13.1] wherein the plurality of OFDM subcarriers is selected based on measured channel quality of the subcarriers.

As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy also renders obvious claim 11.

Laroia combined with Li renders obvious claim element [13.1].

As explained in the analysis of claim elements [11.2] and [1.2], complex values carried by *the plurality of OFDM subcarriers* are inputs to the IDFT in an OFDM transmitter, as shown in Figure 4B (from claim element [1.2]). Geier (EX1003), ¶309.

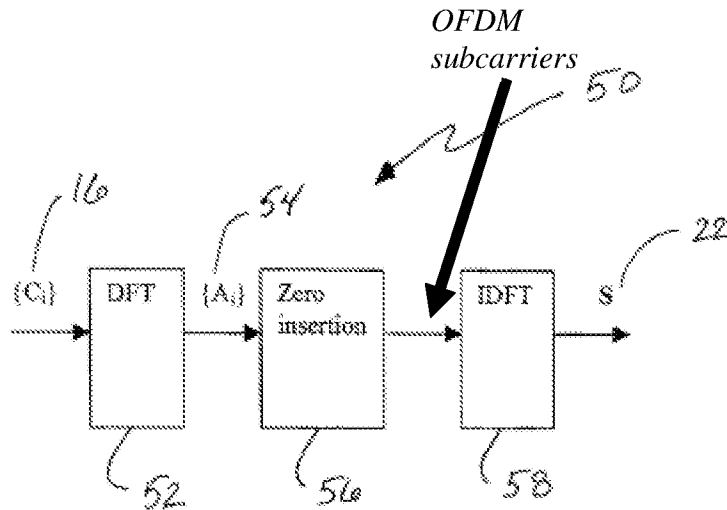


FIG. 4B

Laroia (EX1004), Fig. 4B (annotated).

As shown in the analysis of claim 21, the method of claim 11 may be implemented in *user equipment*, an example of which is a handheld wireless communication device, in which case the transmission from Figure 4B represents an uplink transmission (to a base station). As Li explains, the subcarriers used for transmission on the uplink are selected based on communications received over the access channel to measure uplink SINR levels for each subcarrier (*channel quality of the subcarriers*) and select which subcarriers are used on the uplink (*the plurality of OFDM subcarriers is selected based on measured channel quality of the subcarriers*), thereby rendering obvious claim element [13.1]:

In one embodiment, the feedback information for downlink subcarrier allocation is transmitted to the base station through the **uplink access channel**, which occurs in a short period every transmission time slot, e.g., 400 microseconds in every 10-millisecond time slot. **In one embodiment, the access channel occupies the entire frequency bandwidth. Then the base station can collect the uplink SINR of each subcarrier directly from the access channel. The SINR as well as the**

traffic load information on the uplink subcarriers are used for uplink subcarrier allocation.

For either direction, the base station makes the final decision of subcarrier allocation for each subscriber.

Li (EX1018), 3:54-65; Geier (EX1003), ¶¶310-311.

Accordingly, Li's subcarrier selection on the uplink to identify the subcarriers used in Laroia's transmissions, applied to Laroia's uplink transmissions where only a subset of subcarriers is used, renders obvious *wherein the plurality of OFDM subcarriers is selected based on measured channel quality of the subcarriers*. Geier (EX1003), ¶312.

A POSITA would have been motivated to apply Li's subcarrier selection to select the subcarriers to use in Laroia's OFDM transmitter for two reasons. First, such a combination would have yielded the obvious, beneficial, and predictable result of an OFDM transmitter that identifies for use subcarriers with high signal-to-interference plus noise (SINR) values, allowing mobile terminals in Laroia's system to access the OFDM bandwidth simultaneously over different subcarriers, thereby providing for reliable communications and increased efficiency. Geier (EX1003), ¶¶313-314.

Laroia focuses on transmissions from a subscriber allocated a subset of the available tones (subcarriers) in its system, without regard to how the base station assigns those subcarriers. For example, Laroia explains that M tones out of a total of F tones are allocated, and that, consistent with Li's OFDMA multiple-access technique:

[T]he number of allocated tones can be greater than the number of symbols to be transmitted. **The remaining frequency tones can be used by other transmitters within the communication system. This technique allows OFDM communication system 10 to operate as a multiple access communication system.**

Laroia (EX1004), [0040]. Using Laroia's example for Figure 4B, which is discussed extensively herein, complex values are assigned to M tones out of N, with zero values used for the remaining N-M tones. *See* Laroia (EX1004), [0053]. Thus, Laroia is compatible with Li's techniques, but Laroia is not concerned with how the M tones/subcarriers out of N are selected. Geier (EX1003), ¶315.

Li provides various channels for communication of control information in wireless networks, such as “uplink access channels.” Li (EX1018), 5:11-17. Li’s uplink access channel is used to communicate control information from a subscriber terminal, including “feedback information for downlink subcarrier allocation,” and the base station is also able to measure the “the uplink SINR of each subcarrier directly from the access channel. The SINR as well as the traffic load information on the uplink subcarriers are used for uplink subcarrier allocation.” Li (EX1018), 3:53-63; Geier (EX1003), ¶316.

Thus, Li provides a more complete set of channels and protocols for assignment of subcarriers to Laroia’s wireless terminals, thus providing implementation details for how subcarriers are selected and assigned to a wireless terminal. The selection of subcarriers is based on “SINR as well as the traffic load information on the uplink subcarriers,” which are measures of channel quality. Li (EX1018), 3:61-63. It would have been obvious, based on the more detailed discussion of downlink subcarrier selection, to select subcarriers as is done in the downlink, e.g., to select subcarriers having “e.g., high SINR and low traffic loading.” Li (EX1018), 5:50-52. A POSITA would have been motivated to select subcarriers in this manner in Laroia to provide more reliable communication. Geier (EX1003), ¶¶317-318.

Second, implementing Li’s techniques for subcarrier selection in Laroia’s system represents combining prior art elements (implementing Li’s subcarrier selection in Laroia’s OFDM system) according to known methods to yield the predictable results of providing implementation details for subcarrier selection in Laroia’s system (e.g., selecting which M subcarriers out of N to use). Geier (EX1003), ¶319.

Furthermore, a POSITA would have had a reasonable expectation of success in combining Laroia and Li in this way at least for the reasons explained above, but also because Laroia is an OFDM system that divides the subcarriers among different subscribers for multiple access, which is the type of system for which Li’s techniques apply. Geier (EX1003), ¶320.

(ii) Claim 29

29. The method recited in claim 22,

[29.1] wherein the at least N subcarriers is selected based on a measured channel quality.

As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy renders obvious claim 22.

Laroia combined with Li renders obvious claim element [29.1].

Claim element [29.1] is substantively the same as claim element [13.1], if not broader, as shown in the table below.

[13.1] wherein the plurality of OFDM subcarriers is selected based on measured channel quality of the subcarriers.	[29.1] wherein the at least N subcarriers is selected based on a measured channel quality.
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Thus, Laroia combined with Li render obvious claim element [29.1] for substantially the same reasons as claim element [13.1]. *See* analysis of claim element [13.1]. Geier (EX1003), ¶¶323-324.

G. Proposed Rejections A8 and A9: Claim 7 is obvious over Laroia combined with Cimini under 35 U.S.C. § 103(a) (Rejection A8); Claims 7, 17, and 28 are obvious over Laroia combined with Thoumy and Cimini under 35 U.S.C. § 103(a) (Rejection A9).

(i) Claim 7

7. The non-transitory computer-readable medium recited in claim 1, [7.1] further comprising computer-readable program code configured to append at least one of a cyclic prefix, a postfix, and a guard interval to the OFDM transmission signal.

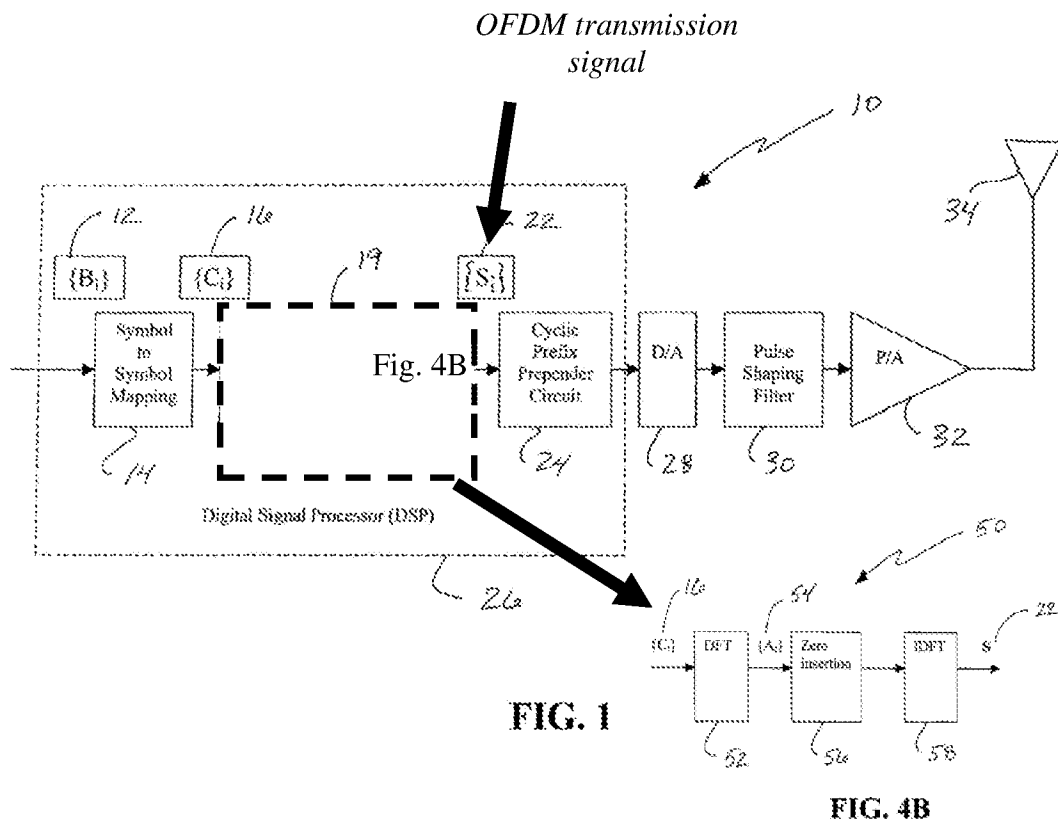
As discussed in Section IV.B (Proposed Rejection A1), Laroia alone renders obvious claim 1. As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy also renders obvious claim 1.

Laroia combined with Cimini discloses or renders obvious claim element [7.1].

As an initial matter, regarding the claim term *at least one of a cyclic prefix, a postfix, and a guard interval to the OFDM transmission signal*, as explained the analysis of claim 5 (in Proposed Rejection A1), there is a rebuttable presumption that the meaning of a claim term in the form “at least one of A and B” is “at least one of A and at least one of B.” There is no need to further analyze the meaning of claim element [7.1] and whether the resumption can be rebutted, because the prior art discloses claim element [7.1] even under this most narrow understanding that the claim requires all three of *a cyclic prefix, a postfix, and a guard interval* be appended. Geier (EX1003), ¶327.

As explained in the analysis of claim element [1.3], Laroia’s OFDM communication system in Figure 1 is modified below to show the placement of Figure 4B within the OFDM

communication system, as would have been understood based on Laroia's disclosure. Geier (EX1003), ¶328.



Laroia (EX1004), Fig. 1 with Fig. 4B

The OFDM communication system has a cyclic prefix circuit 24 that appends a cyclic prefix (a *cyclic prefix*) to the *OFDM transmission signal*:

The **cyclic prefix circuit 24** operates to copy and prepend the last portion of the digital signal sample vector S 22 to the **beginning of the OFDM symbol duration**.

The resulting digital signal samples 22 with the **prepended cyclic prefix** are converted to an analog signal by a digital to analog converter 28.

Laroia (EX1004), [0036]. Laroia's cyclic prefix is beneficially "used to compensate for the dispersion introduced by the channel response and by the pulse shaping filter used at the transmitter." *Id.*, [0003]; Geier (EX1003), ¶329.

Cimini goes a step further than Laroia in forming an OFDM signal to compensate for channel dispersion. Cimini describes not only the use of a cyclic prefix but also a cyclic suffix (*postfix*) and a guard interval (*guard interval*).

Cimini presents a section entitled “II. OFDM Overview.” Cimini (EX1019), 2:24-4:17. In the “OFDM Overview,” Cimini explains that in forming an OFDM signal, “extra samples are prepended and appended to the transformed waveform. These ‘cyclic prefix’ and ‘cyclic suffix’ samples make the transmitted signal more robust against time dispersion and timing offset.” *Id.*, 2:64-3:1. Cimini also explains that “[t]wo other segments that are added to the IFFT waveform are the windowed section and the guard interval. The guard interval is a period during which the transmitted samples are all zero. At the expense of a slightly reduced transmission efficiency, the presence of this guard interval helps to insure that the samples received during a given OFDM block are not contaminated with delayed samples from a previous block.” *Id.*, 3:29-36. Thus, Cimini describes the use of a cyclic prefix, a cyclic suffix, and a guard interval in forming an OFDM waveform. Geier (EX1003), ¶¶330-331.

A POSITA would have been motivated to add Cimini’s cyclic suffix and guard interval to Laroia’s OFDM signal (having a cyclic prefix) to yield the obvious, beneficial, and predictable result of an OFDM signal that is even more robust against channel dispersion and timing offset errors. Cimini explains the benefits of the use of a “cyclic suffix” as making the transmitted signal “more robust against time dispersion and timing offset” and the benefits of a “guard interval” as helping “to insure that the samples received during a given OFDM block are not contaminated with delayed samples from a previous block.” Cimini (EX1019), 2:64-3:1 and 3:29-36. These benefits accrue to Laroia’s OFDM signal in the same way as Cimini’s OFDM signal. Geier (EX1003), ¶332.

Implementing Cimini’s cyclic suffix and guard interval in Laroia’s OFDM waveform represents combining prior art elements according to known methods to yield the predictable result of an OFDM waveform that includes a cyclic prefix, a cyclic suffix, and a guard interval, making Laroia’s OFDM waveform more robust against channel dispersion and timing offset errors. Geier (EX1003), ¶333.

A POSITA would have had a reasonable expectation of success in implementing Cimini’s cyclic suffix and guard interval in Laroia’s OFDM signal because Cimini’s techniques explicitly

apply to forming OFDM signals for transmission. In other words, Laroia's OFDM system is the type of system to which Cimini's techniques apply. Geier (EX1003), ¶334.

Thus, Laroia's disclosure of a cyclic prefix circuit 24 that operates to copy and prepend the last portion of the digital signal sample vector S 22 to the beginning of the OFDM symbol duration (*cyclic prefix*), together with Cimini's teachings regarding the use of a cyclic suffix (*postfix*) and a guard interval discloses or renders obvious *further comprising computer-readable program code configured to append at least one of a cyclic prefix, a postfix, and a guard interval to the OFDM transmission signal*. In other words, Laroia combined with Cimini discloses claim element [7.1] even under the narrowest interpretation that each of *a cyclic prefix, a postfix, and a guard interval* are required. Geier (EX1003), ¶335.

(ii) Claim 17

17. The method recited in claim 11,

[17.1] further comprising appending at least one of a cyclic prefix, a postfix, and a guard interval onto the spread OFDM signal.

As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy renders obvious claim 11.

Laroia combined with Cimini renders obvious claim element [17.1]. See the analysis of claim element [7.1], which is substantially the same as claim element [17.1]. As explained in the analysis of claim 11, Laroia's OFDM transmission signal is an example of the *spread OFDM signal*. As explained in the analysis of claim element [7.1], it would have been beneficial to add a postfix and a guard interval to Laroia's OFDM transmission signal (which already has a cyclic prefix). Geier (EX1003), ¶337.

(iii) Claim 28

28. The apparatus recited in claim 22,

[28.1] wherein the non-transitory memory further comprises instructions to append at least one of a cyclic prefix, a postfix, and a guard interval to the time-domain sequence.

As discussed in Section IV.C (Proposed Rejection A2), Laroia combined with Thoumy renders obvious claim 22.

Laroia combined with Cimini renders obvious claim element [28.1]. See the analysis of claim element [7.1], which is substantially the same as claim element [28.1]. As explained in the

analysis of claim 22, Laroia's OFDM transmission signal is an example of the *time-domain sequence*. As explained in the analysis of claim element [7.1], it would have been beneficial to add a postfix and a guard interval to Laroia's OFDM transmission signal (which already has a cyclic prefix). Geier (EX1003), ¶339.

V. DISCLOSURE OF CONCURRENT LITIGATION AND REEXAMINATION PROCEEDINGS

The '227 Patent has been or is currently asserted in the following lawsuits.

- *GenghisComm Holdings, LLC v. Continental Automotive Systems, Inc.* 6-24-cv-00024 (W.D.Tex.), filed on January 16, 2024.
- *GenghisComm Holdings, LLC v. Doro AB*, 2-23-cv-00527 (E.D.Tex.), filed on November 17, 2023.
- *Genghiscomm Holdings, LLC v. TCL Communication, Inc.*, 2-23-cv-08949 (C.D.Ca.), filed on October 24, 2023.
- *GenghisComm Holdings, LLC v. LG Electronics USA, Inc. et al*, 3-23-cv-01363 (S.D.Ca.), filed Jul. 27, 2023.
- *GenghisComm Holdings, LLC v. Toyota Motor North America, Inc. et al*, 2-23-cv-00228 (E.D.Tex.), filed May. 24, 2023.
- *GenghisComm Holdings, LLC v. ASUSTeK Computer Inc.*, 2-22-cv-00066 (E.D.Tex), filed March 7, 2022. (An order granting a stay of all deadlines and a notice of settlement was issued on October 6, 2023.)
- *GenghisComm Holdings, LLC v. OnePlus Technology (Shenzhen) Co., Ltd.*, 6-22-cv-00245 (W.D.Tex.), filed March 7, 2022. (The docket indicates that the case settled on Feb. 16, 2023.)

The '227 Patent has not been challenged in an *inter partes* review or *ex parte* reexamination.

VI. CERTIFICATION REGARDING NO ESTOPPEL

In accordance with 37 C.F.R. § 1.510(b)(6), Requester hereby certifies that the estoppel provisions of 35 U.S.C. § 315(e)(1) or 35 U.S.C. § 325(e)(1) do not prohibit Requester from filing this Request.

VII. LIST OF EXHIBITS

Exhibit 1001	U.S. Patent No. 10,200,227
Exhibit 1002	File History of U.S. Patent No. 10,200,227
Exhibit 1003	Declaration of James Geier (“Geier”)
Exhibit 1004	U.S. Patent Application Publication No. 2002/0172213 to Laroia et al. (“Laroia”)
Exhibit 1005	U.S. Patent No. 7,039,120 to Thoumy et al. (“Thoumy”)
Exhibit 1006	U.S. Patent Pub. No. 2016/0006594 to Persson et al. (“Persson”)
Exhibit 1007	File History of U.S. Patent No. 9,768,842 (selected pages)
Exhibit 1008	File History of U.S. Patent No. 9,485,063 (selected pages)
Exhibit 1009	U.S. Patent No. 6,563,786 to Van Nee (“Van Nee”)
Exhibit 1010	U.S. Patent No. 9,768,842
Exhibit 1011	U.S. Patent No. 9,485,063
Exhibit 1012	U.S. Patent Pub. No. 2008/0095121
Exhibit 1013	U.S. Patent No. 9,819,449
Exhibit 1014	U.S. Patent Pub. No. 2002/0191630 to Jacobsen (“Jacobsen”)
Exhibit 1015	U.S. Patent No. 6,597,745 to E. Dowling (“Dowling”)
Exhibit 1016	U.S. Patent No. 7,139,320 to M. Singh et al. (“Singh”)
Exhibit 1017	U.S. Patent No. 6,842,487 to P. Larsson (“Larsson”)
Exhibit 1018	U.S. Patent No. 6,904,283 to X. Li et al. (“Li”)
Exhibit 1019	U.S. Patent No. 6,891,792 to L. Cimini et al. (“Cimini”)
Exhibit 1020	Patent family for U.S. Provisional App. 60/598,187, from USPTO Patent Center.
Exhibit 1021	U.S. Patent No. 11,700,162

VIII. CONCLUSION

For the reasons set forth above, it is clear that substantial new questions of patentability are raised in connection with claims 1-7 and 9-29 by this request for *ex parte* reexamination since claims 1-7 and 9-29 are rendered obvious in view of the above-listed prior art references. Therefore, Requester asks that this request for reexamination be granted and that claims 1-7 and 9-29 be cancelled.

As identified in the attached Certificate of Service and in accordance with 37 C.F.R. §§ 1.33(c) and 1.510(b)(5), a copy of the present request, in its entirety, is being served to the address of the attorney or agent of record.

Please direct all correspondence in this matter to the undersigned.

Respectfully submitted,

/Raghav Bajaj/

Raghav Bajaj

Registration No. 66,630

Attorney for Requester

Dated: February 9, 2024
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Facsimile: 214/200-0853
Attorney Docket No.: 50348.111

CERTIFICATE OF SERVICE

I hereby certify that this correspondence, all attachments, and any corresponding filing fee are being transmitted electronically via the United States Patent and Trademark Office Patent Center on February 9, 2024.

/Theresa Lowe/

Theresa Lowe