PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: KEVIN J. ZIMMER
COOLEY LLP
1299 PENNSYLVANIA AVENUE, NW
SUITE 700
WASHINGTON, DC 20004

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

		Date of mailing *(day/month/year)* 29 NOV 2016
Applicant's or agent's file reference COHE01501WO		**FOR FURTHER ACTION** See paragraph 2 below
International application No. PCT/US 16/39662	International filing date *(day/month/year)* 27 June 2016 (27.06.2016)	Priority date *(day/month/year)* 27 June 2015 (27.06.2015)
International Patent Classification (IPC) or both national classification and IPC IPC(8) - H04L 27/26, H04L 1/06 (2016.01) CPC - H04L25/0202, H04L25/0226, H04L5/0048		
Applicant COHERE TECHNOLOGIES, INC.		

1. This opinion contains indications relating to the following items:

- [x] Box No. I Basis of the opinion
- [ ] Box No. II Priority
- [ ] Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- [x] Box No. IV Lack of unity of invention
- [x] Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- [ ] Box No. VI Certain documents cited
- [ ] Box No. VII Certain defects in the international application
- [ ] Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1 *bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer:
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	03.11.2016	Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:
   - [X] the international application in the language in which it was filed.
   - [ ] a translation of the international application into ________________ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. [ ] This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. [ ] With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:
   a. [ ] forming part of the international application as filed:
      - [ ] in the form of an Annex C/ST.25 text file.
      - [ ] on paper or in the form of an image file.

   b. [ ] furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. [ ] furnished subsequent to the international filing date for the purposes of international search only:
      - [ ] in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).
      - [ ] on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. [ ] In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

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Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees the applicant has, within the applicable time limit:

   ☒ paid additional fees.

   ☐ paid additional fees under protest and, where applicable, the protest fee.

   ☐ paid additional fees under protest but the applicable protest fee was not paid.

   ☐ not paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☒ not complied with for the following reasons:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-11 and 21-23 are drawn to transmitting data using two-dimensional array of modulation symbols using M mutually orthogonal waveforms.

Group II: Claims 12-20 are drawn to an automated method of wirelessly communcicating data.

Group III: Claims 24-25 are drawn to a method of receiving data over a wireless communication channel.

Group IV: Claims 26-35 are drawn to a method of providing a modulated signal useable in a signal transmission system.

Group V: Claims 36-43 are drawn to a method and apparatus for receiving a modulated signal.

The inventions listed as Groups I-V do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special technical features:

Group I requires a wireless transmitter; a processor; and a memory including program code executable by the processor, the program code including code for causing the processor to: receiving a plurality of information and data symbols; and transmitting the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands not required by the other groups.

Group II requires an array containing a plurality of data symbols onto at least one symplectic analysis compatible manifold distributed over a column time axis of length T and row frequency axis of length F, thereby producing at least one information manifold; transforming said at least one Information manifold according to a two-dimensional symplectic-like Fourier transform, thereby producing at least one two-dimensional Fourier transformed Information manifold; and transmitting each at least one two-dimensional Fourier transformed Information manifold by: over all frequencies and times of said two-dimensional Fourier transformed Information manifold, selecting a transmitting time slice of duration proportional to Tu, where u= l/N, and passing those frequencies in said two-dimensional Fourier transformed Information manifold corresponding to said transmitting time slice through a bank of at least M different, nonoverlapping, narrow-band frequency filters, and transmitting resulting filtered waveforms as a plurality of at least M simultaneously transmitted mutually orthogonal waveforms, over different transmitted time intervals, until an entire two-dimensional Fourier transformed Information manifold has been transmitted not required by other groups.

---See Continuation on Supplemental page---

4. Consequently, this opinion has been established in respect of the following parts of the international application:

   ☐ all parts.

   ☒ the parts relating to claims Nos. 1-11 & 21-23, 36-43

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Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-11, 21-23, 36-43	YES
	Claims	None	NO
Inventive step (IS)	Claims	1-11 , 21-23, 37, 39, 41 and 43	YES
	Claims	36, 38, 40 and 42	NO
Industrial applicability (IA)	Claims	1-11, 21-23, 36-43	YES
	Claims	None	NO

2. Citations and explanations:

Claims 36, 38, 40 and 42 lack an inventive step under PCT Article 33(3) as being obvious over WO 2014/004585 A1 to Hadani et al. (hereinafter Hadani '585).

Regarding claim 36, Hadani '585 discloses:
A method of receiving a modulated signal, the method comprising (Abstract disclosing a system and method of providing a modulated signal useable in a signal transmission system):
receiving a plurality of signal components of the modulated signal (para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms));
generating, by performing an demodulation operation using the plurality of signal components (FIG. 7A and para [00192] disclosing an exemplary method 700 for demodulating OTFS -modulated data over a wireless link such as the communication channel 32),
a plane of estimated time-frequency modulation symbols (para [0325] disclosing RF down converter 3725 demodulates the second received signal and passes the demodulated received second data stream Dr to a first OTFS decoder 3730-1 and a second OTFS decoder 3730-2. The first OTFS decoder 3730-2 decodes the received second signal using the base t matrix that was used to transmit the first data stream. The second OTFS decoder 3730-2 decodes the echo-canceled data stream using a base r matrix that the other transmitter used to encode the second data stream. The output of the first OTFS decoder 3730-1 is fed back as a residual error signal to the echo canceller 3705 in order to tune the two dimensional estimate of the reflected echoes channel. The output of the second OTFS decoder 3730-2 is an estimate of the second data stream from the other transmitter. The capability to obtain an estimate of the echo channel in both frequency and time is a significant advantage of the OTFS technique, and facilitates full-duplex communication over a common frequency band in a manner not believed to be possible using prior art methods); and
providing an estimated data frame by performing an inverse of a two dimensional time-frequency transformation with respect to the plane of estimated time-frequency modulation symbols (para [0019] disclosing using a decoding matrix, an inverse transformation operation with respect to elements of the received data frame so as to yield a non-transformed matrix, and generating, based upon the non-transformed matrix, a recovered data frame comprising an estimate of the original data frame).
Hadani '585 does not explicitly disclose in the embodiment above that:
The demodulation is a OFDM operation.
However, Hadani '585 discloses:
A high-level representation is provided of a conventional transceiver 4300 which could be utilized in the wireless communication system 100 of FIG. 1. The transceiver 4300 could, for example, operate in accordance with established protocols for time-division multiple access (TDMA), code-division multiple access (CDMA) or orthogonal frequency-division multiple access (OFDM) systems (FIG. 43, para [00110]).
It would have been obvious to a person of ordinary skill in the art to have included the OFDM demodulation for the above method since it allows for the use of two dimensional modeling for all types of transmission system (See para [00111]).

Regarding claim 38, Hadani '585 discloses:
A method of receiving a modulated signal, the method comprising (Abstract disclosing a system and method of providing a modulated signal useable in a signal transmission system):
receiving a plurality of signal components of the modulated signal (para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms));
generating, by performing a demodulation operation using the plurality of signal components (FIG. 7A and para [00192] disclosing an exemplary method 700 for demodulating OTFS -modulated data over a wireless link such as the communication channel 32),
a plane of estimated time-frequency modulation symbols (para [0325] disclosing RF down converter 3725 demodulates the second received signal and passes the demodulated received second data stream Dr to a first OTFS decoder 3730-1 and a second OTFS decoder 3730-2. The first OTFS decoder 3730-2 decodes the received second signal using the base t matrix that was used to transmit the first data stream. The second OTFS decoder 3730-2 decodes the echo-canceled data stream using a base r matrix that the other transmitter used to encode the second data stream. The output of the first OTFS decoder 3730-1 is fed back as a residual error signal to the echo canceller 3705 in order to tune the two dimensional estimate of the reflected echoes channel. The output of the second OTFS decoder 3730-2 is an estimate of the second data stream from the other transmitter. The capability to obtain an estimate of the echo channel in both frequency and time is a significant advantage of the OTFS technique, and facilitates full-duplex communication over a common frequency band in a manner not believed to be possible using prior art methods); and (continued)
---See Continuation on Supplemental Page---

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Box No. IV - Lack of Unity of Invention

Group III requires receiving M mutually orthogonal waveforms included within M frequency sub-bands; demodulating the M rnutually orthogonal waveforms to recover an estimate of a two dimensional array of OTFS symbols; and decoding the two-dimensional array of OTFS symbols in order to generate an estimte of an NxM array containing a plurality of infonnation symbols, the NxM array having been encoded prior to tramnnission of the data by spreading each of the plurality of information symbols with respect to both time and frequency not required by the other groups.

Group IV requires performing a two dimensional time-frequency transformation of a data frame including a plurality of information symbols into a plane of time-frequency modulation symbols; and generating a modulated signal using a Heisenberg transform or multicarrier filter bank (MCFB) modulator or OFDM modulator not required by the other groups.

Group V requires receiving a plurality of signal components of the modulated signal; generating, by performing an OFDM demodulation operation using the plurality of signal components, a plane of estimated time-frequency modulation symbols; and providing an estimated data frame by performing an inverse of a two dimensional timefrequency transformation with respect to the plane of estimated time-frequency modulation symbols not required by the other groups.

Common Technical Features (Fail to Unify Inventions)
There is no feature common to all groups.

The only feature shared by Groups I-III that would otherwise unify the groups is an NXM array that has been encoded with a plurality of symbols. However, these shared technical features do not represent a contribution over prior art, because the shared technical features are disclosed by WO 2014004585 A1 to Hadani et al. (hereinafter, 'Hadani'). Hadani discloses an NXM array that has been encoded with a plurality of symbols (para [0020], [0207]-[0208]).

As the shared technical features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

Groups I-V therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.

Continuation of:
Citations and Explanation:
---Claim 38 continued---
providing an estimated data frame by performing an inverse of a two dimensional time-frequency transformation with respect to the plane of estimated time-frequency modulation symbols (para [0019] disclosing using a decoding matrix, an inverse transformation operation with respect to elements of the received data frame so as to yield a non-transformed matrix, and generating, based upon the non-transformed matrix, a recovered data frame comprising an estimate of the original data frame).
Hadani '585 does not explicitly disclose in the embodiment above that: The demodulation is a MCFB operation.
However, Hadani '585 in a different embodiment discloses:
a transmitter 4404 of the first OTFS transceiver 4400 includes two-dimensional spreading block 4408, an FFT block 4410 and first and second time- frequency tiling elements 4412, 4414. The first and second time-frequency tiling elements 4412, 4414 are configured to effect time-frequency tiling of the two-dimensionally spread input data and may, for example, be implemented using one or more filter banks. The two-dimensional spreading block 4408 and FFT block 4410 cooperatively effect spreading of the two-dimensional input data by performing a series of operations using, for example, a spreading kernel selected from a wide family of unitary matrices (FIG. 44A, para [0343]).
It would have been obvious to a person of ordinary skill in the art to have included the filter bank for the various channels for the above method since it allows for efficient time-frequency tiling (See para [00343]).

Regarding claim 40, Hadani '585 discloses: A receiver apparatus, the apparatus comprising (Abstract disclosing a system and method of providing a modulated signal useable in a signal transmission system):
a receiver front end, the receiver front end being configured to receive a plurality of signal components of a modulated signal ((para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms) and FIG. 7a and para [0192] disclosing the receiver);
an demodulator (FIG. 7A and para [00192] disclosing an exemplary method 700 for demodulating OTFS -modulated data over a wireless link such as the communication channel 32),
configured to generate a plane of estimated time-frequency modulation symbols based upon the plurality of signal components (para [0325] disclosing RF down converter 3725 demodulates the second received signal and passes the demodulated received second data stream Dr to a first OTFS decoder 3730-1 and a second OTFS decoder 3730-2. The first OTFS decoder 3730-2 decodes the received second signal using the base t matrix that was used to transmit the first data stream. The second OTFS decoder 3730-2 decodes the echo -canceled data stream using a base r matrix that the other transmitter used to encode the second data stream. The output of the first OTFS decoder 3730-1 is fed back as a residual error signal to the echo canceller 3705 in order to tune the two dimensional estimate of the reflected echoes channel. The output of the second OTFS decoder 3730-2 is an estimate of the second data stream from the other transmitter. The capability to obtain an estimate of the echo channel in both frequency and time is a significant advantage of the OTFS technique, and facilitates full-duplex communication over a common frequency band in a manner not believed to be possible using prior art methods) ; and an OTFS post-processing unit operative to provide an estimated data frame (para [0325]),
the OTFS post-processing unit performing an inverse of a two dimensional time-frequency transformation with respect to the plane of estimated time-frequency modulation symbols (para [0019] disclosing using a decoding matrix, an inverse transformation operation with respect to elements of the received data frame so as to yield a non-transformed matrix, and generating, based upon the non-transformed matrix, a recovered data frame comprising an estimate of the original data frame).
Hadani '585 does not explicitly disclose in the embodiment above that: The demodulation is a OFDM operation.
However, Hadani '585 discloses:
A high-level representation is provided of a conventional transceiver 4300 which could be utilized in the wireless communication system 100 of FIG. 1. The transceiver 4300 could, for example, operate in accordance with established protocols for time-division multiple access (TDMA), code-division multiple access (CDMA) or orthogonal frequency-division multiple access (OFDM) systems (FIG. 43, para [00110]).
It would have been obvious to a person of ordinary skill in the art to have included the OFDM demodulation for the above method since it allows for the use of two dimensional modeling for all types of transmission system (See para [00111]).

Regarding claim 42, Hadani '585 discloses: A receiver apparatus, the apparatus comprising (Abstract disclosing a system and method of providing a modulated signal useable in a signal transmission system):
a receiver front end, the receiver front end being configured to receive a plurality of signal components of a modulated signal (para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms) and FIG. 7a and para [0192] disclosing the receiver);
a demodulator (FIG. 7A and para [00192] disclosing an exemplary method 700 for demodulating OTFS -modulated data over a wireless link such as the communication channel 32),
configured to generate a plane of estimated time-frequency modulation symbols based upon the plurality of signal components (para [0325] disclosing RF down converter 3725 demodulates the second received signal and passes the demodulated received second data stream Dr to a first OTFS decoder 3730-1 and a second OTFS decoder 3730-2. The first OTFS decoder 3730-2 decodes the received second signal using the base t matrix that was used to transmit the first data stream. The second OTFS decoder 3730-2 decodes the echo -canceled data stream using a base r matrix that the other transmitter used to encode the second data stream. The output of the first OTFS decoder 3730-1 is fed back as a residual error signal to the echo canceller 3705 in order to tune the two dimensional estimate of the reflected echoes channel. The output of the second OTFS decoder 3730-2 is an estimate of the second data stream from the other transmitter. The capability to obtain an estimate of the echo channel in both frequency and time is a significant advantage of the OTFS technique, and facilitates full-duplex communication over a common frequency band in a manner not believed to be possible using prior art methods);and
an OTFS post-processing unit operative to provide an estimated data frame (para [0325]),
the OTFS post-processing unit performing an inverse of a two dimensional time-frequency transformation with respect to the plane of estimated time-frequency modulation symbols (para [0019] disclosing using a decoding matrix, an inverse transformation operation with respect to elements of the received data frame so as to yield a non-transformed matrix, and generating, based upon the non-transformed matrix, a recovered data frame comprising an estimate of the original data frame). (continued)
---See Continuation on Supplemental Page---

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Citations and Explanation:
--Claim 42 continued---
Hadani '585 does not explicitly disclose in the embodiment above that: The demodulation is a MCFB operation.
However, Hadani '585, in a different embodiment discloses:
a transmitter 4404 of the first OTFS transceiver 4400 includes two-dimensional spreading block 4408, an FFT block 4410 and first and second time- frequency tiling elements 4412, 4414. The first and second time-frequency tiling elements 4412, 4414 are configured to effect time-frequency tiling of the two-dimensionally spread input data and may, for example, be implemented using one or more filter banks. The two-dimensional spreading block 4408 and FFT block 4410 cooperatively effect spreading of the two-dimensional input data by performing a series of operations using, for example, a spreading kernel selected from a wide family of unitary matrices (FIG. 44A, para [0343]).
It would have been obvious to a person of ordinary skill in the art to have included the filter bank for the various channels for the above method since it allows for efficient time-frequency tiling (See para [00343]).

Claims 1-11 , 21-23, 37, 39, 41 and 43 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest the subject matter.

Regarding claims 1-11 and 21-23, the prior art is exemplified by: Hadani '585 and US 2014/0169441 A1 to Hadani et al. (hereinafter Hadani '441) and US 2011/0126071 A1 to Han et al. (hereinafter Han).

Regarding claim 1, Hadani '585 discloses:
A method of transmitting data over a communication channel, the method comprising (Abstract disclosing a system and method of providing a modulated signal useable in a signal transmission system):
receiving a plurality of information symbols (para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms)):
encoding an NxM array containing the plurality of information symbols into a two-dimensional
array of modulation symbols (FIG. 39C and 39D and para [0207] disclosing a basis frame that has N vectors of length M where M is greater than N. The resulting basis frames include NxM elements. FIG. 39D illustrates an incomplete basis frame including N-1 columns and M-k rows, where 1 and k are greater than or equal to one); and
by spreading each of the plurality of information symbols with respect to both time and frequency (para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms) and FIG. 28 and para [0224] disclosing an example of how transmitting both cyclically time shifted waveforms and cyclically frequency shifted waveforms can be useful to help a receiver 2806 (such as the OTFS receiver 455) effect both time and frequency compensation of the received signal to compensate for both echo reflections and frequency shifts - in this example Doppler effect frequency shifts).
Hadani '585 does not explicitly disclose:
transmitting the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.

Regarding claim 1, Hadani '441 discloses:
A method of transmitting data over a communication channel, the method comprising (Abstract disclosing method of receiving data including receiving, on one or more carrier waveforms, signals representing a plurality of data elements of an original data frame wherein each of the data elements are represented by cyclically time shifted and cyclically frequency shifted versions of a known set of waveforms and para [0018] disclosing transmitting data):
receiving a plurality of information symbols (para [0018] disclosing that OTFS contemplates that frames of N2 symbols are transmitted (often over a relatively longer time interval). With OTFS modulation, each data symbol or element that is transmitted is extensively spread in a novel manner in time, frequency and/or spectral shape space. At the receiving end of the connection, each data symbol is resolved based upon substantially the entire frame of N2received symbols);
encoding an NxM array containing the plurality of information symbols into a two-dimensional array of modulation symbols (para [0025] disclosing that this form of the OTFS method contemplates formation of an NxN data frame matrix having N2 symbols or elements and multiplication of this data frame by a first NxN time-frequency shifting matrix and para [0144] disclosing a frame of data may be considered to be a reference to the NxN or N2 matrix such as the one shown above, where at least some elements in the matrix may be zero or null elements. In some embodiments, a frame of data could be non-square, or NxM, where Nis not equal to M),
by spreading each of the plurality of information symbols with respect to both time and frequency (para [0018]).
Hadani '441 does not disclose:
transmitting the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.

Regarding claim 1, Han discloses:
A method of transmitting data over a communication channel, the method comprising (Abstract disclosing method and an apparatus of transmitting information in a wireless communication system are provided):
receiving a plurality of information symbols (para [0010] disclosing a method of transmitting information in a wireless communication system, carried in a transmitter, is provided. The method includes transmitting first information based on a first resource index through a first antenna during a first interval and transmitting second information based on a second resource index through a second antenna during the first interval and para [0017] disclosing information symbols);
encoding by spreading each of the plurality of information symbols with respect to both time and frequency (para [0141] disclosing If the resource includes the frequency domain sequence and the time domain sequence, the frequency domain sequence and the time domain sequence are used to spread the symbol in a two-dimensional time-frequency domain (frequency domain and time domain)). (continued)

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of:
Citations and Explanation:
--Claim 1 (Han) continued--
Han does not disclose:
encoding an NxM array containing the plurality of information symbols into a two-dimensional array of modulation symbols and transmitting the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.

Therefore, the prior art of record does not teach or fairly suggest the subject matter claimed.
Specifically, none of the prior art, alone or in combination discloses:
transmitting the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.

Claims 2-5 meet the criteria set out in PCT Article 33(2)-(3) as depending from Claim 1.

Regarding claim 6, Hadani '585 discloses:
An automated method of wireless communication over a data channel, the method comprising (Abstract disclosing a system and method of providing a modulated signal useable in a signal transmission system):
receiving a plurality of data symbols (para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms)):
encoding an NxM two-dimensional array containing the plurality of data symbols into a two-dimensional array of modulation symbols (FIG. 39C and 39D and para [0207] disclosing a basis frame that has N vectors of length M where M is greater than N. The resulting basis frames include NxM elements. FIG. 39D illustrates an incomplete basis frame including N-1 columns and M-k rows, where 1 and k are greater than or equal to one),
by spreading each of the plurality of data symbols using a set of cyclically time-shifted and frequency-shifted basis functions (para [0019] disclosing a method of receiving data. The method of this aspect includes receiving, on one or more carrier waveforms, signals representing a plurality of data elements of an original data frame wherein each of the data elements are represented by cyclically time shifted and cyclically frequency shifted versions of a known set of waveforms, generating, based upon the signals, a received data frame having a first dimension of at least N elements and a second dimension of at least N elements, where N is greater than one, wherein the first dimension corresponds to a frequency shift axis and the second dimension corresponds to a time shift axis); and
Hadani '585 does not disclose:
transmitting the two-dimensional array of modulation symbols using M mutually orthogonal wireless waveforms included within M frequency sub-bands.

Regarding claim 6, Hadani '441 discloses:
An automated method of wireless communication over a data channel, the method comprising (Abstract disclosing method of receiving data including receiving, on one or more carrier waveforms, signals representing a plurality of data elements of an original data frame wherein each of the data elements are represented by cyclically time shifted and cyclically frequency shifted versions of a known set of waveforms and para [0018] disclosing transmitting data):
receiving a plurality of data symbols (para [0018] disclosing that OTFS contemplates that frames of N2 symbols are transmitted (often over a relatively longer time interval). With OTFS modulation, each data symbol or element that is transmitted is extensively spread in a novel manner in time, frequency and/or spectral shape space. At the receiving end of the connection, each data symbol is resolved based upon substantially the entire frame of N2 received symbols);
encoding an NxM two-dimensional array containing the plurality of data symbols into a two-dimensional array of modulation symbols (para [0025] disclosing that this form of the OTFS method contemplates formation of an NxN data frame matrix having N2 symbols or elements and multiplication of this data frame by a first NxN time-frequency shifting matrix and para [0144] disclosing a frame of data may be considered to be a reference to the NxN or N2 matrix such as the one shown above, where at least some elements in the matrix may be zero or null elements. In some embodiments, a frame of data could be non-square, or NxM, where N is not equal to M),
by spreading each of the plurality of data symbols using a set of cyclically time-shifted (para [0018] and para [0023] disclosing a first form of the OTFS method, the data from a single symbol is convolved and partitioned across multiple time slices, and ultimately transmitted as a series of time slices, on a per time slice basis. When this transmission scheme is used the cyclically-shifting frequency is accomplished over a plurality of time spreading intervals).
Hadani '441 does not disclose:
Spreading using the set of cyclically time-shifted and frequency-shifted basis functions and
transmitting the two-dimensional array of modulation symbols using M mutually orthogonal wireless waveforms included within M frequency sub-bands.

Regarding claim 6, Han discloses:
An automated method of wireless communication over a data channel, the method comprising (Abstract disclosing method and an apparatus of transmitting information in a wireless communication system are provided):
receiving a plurality of data symbols (para [0010] disclosing a method of transmitting information in a wireless communication system, carried in a transmitter, is provided. The method includes transmitting first information based on a first resource index through a first antenna during a first interval and transmitting second information based on a second resource index through a second antenna during the first interval and para [0017] disclosing information symbols);
Han does not disclose:
encoding an NxM two-dimensional array containing the plurality of data symbols into a two-dimensional array of modulation symbols
by spreading each of the plurality of data symbols using a set of cyclically time-shifted and frequency-shifted basis functions; and
transmitting the two-dimensional array of modulation symbols using M mutually orthogonal wireless waveforms included within M frequency sub-bands. (continued)

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Continuation of:
Citations and Explanation: (claim 6 continued)
Therefore, the prior art of record does not teach or fairly suggest the subject matter claimed.
Specifically, none of the prior art, alone or in combination discloses: transmitting the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.

Claims 7-11 meet the criteria set out in PCT Article 33(2)-(3) as depending from Claim 6.

Regarding claim 21, Hadani '585 discloses: A communication device, comprising (Abstract disclosing a system and method of providing a modulated signal useable in a signal transmission system):
a wireless transmitter (para [0010] disclosing a signal transmitter includes an input port, an output port, a processor and a memory including program code executable by the processor);
a processor (para [0010]); and a memory including program code executable by the processor, the program code including code for causing the processor to (para [0010]):
receive a plurality of information symbols (para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms));
encode an NxM array containing the plurality of information symbols into a two dimensional array of modulation symbols FIG. 39C and 39D and para [0207] disclosing a basis frame that has N vectors of length M where M is greater than N. The resulting basis frames include NxM elements. FIG. 39D illustrates an incomplete basis frame including N-1 columns and M-k rows, where 1 and k are greater than or equal to one),
by spreading each of the plurality of information symbols with respect to both time and frequency (para [0020] disclosing a new signal modulation technique which involves spreading data symbols over a large range of times, frequencies, and/or spectral shapes (waveforms) and FIG. 28 and para [0224] disclosing an example of how transmitting both cyclically time shifted waveforms and cyclically frequency shifted waveforms can be useful to help a receiver 2806 (such as the OTFS receiver 455) effect both time and frequency compensation of the received signal to compensate for both echo reflections and frequency shifts - in this example Doppler effect frequency shifts).
Hadani '585 does not disclose:
transmit the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.

Regarding claim 21, Hadani '441 discloses: A communication device, comprising (300, FIG. 3A and para [0121] disclosing communication devices):
a wireless transmitter (315, FIG. 3A, para [0180]); a processor (2102, FIG.21A and para [0180] disclosing processors) ; and
a memory including program code executable by the processor, the program code including code for causing the processor to (para [0180] disclosing memory associated with processor 2102 storing various programs and routines):
receive a plurality of information symbols (para [0018] disclosing that OTFS contemplates that frames of N2 symbols are transmitted (often over a relatively longer time interval). With OTFS modulation, each data symbol or element that is transmitted is extensively spread in a novel manner in time, frequency and/or spectral shape space. At the receiving end of the connection, each data symbol is resolved based upon substantially the entire frame of N2received symbols);
encode an NxM array containing the plurality of information symbols into a two-dimensional array of modulation symbols (para [0025] disclosing that this form of the OTFS method contemplates formation of an NxN data frame matrix having N2 symbols or elements and multiplication of this data frame by a first NxN time-frequency shifting matrix and para [0144] disclosing a frame of data may be considered to be a reference to the NxN or N2 matrix such as the one shown above, where at least some elements in the matrix may be zero or null elements. In some embodiments, a frame of data could be non-square, or NxM, where N is not equal to M),
by spreading each of the plurality of information symbols with respect to both time and frequency (para [0018] and para [0023] disclosing a first form of the OTFS method, the data from a single symbol is convolved and partitioned across multiple time slices, and ultimately transmitted as a series of time slices, on a per time slice basis. When this transmission scheme is used the cyclically-shifting frequency is accomplished over a plurality of time spreading intervals).
Hadani '441 does not disclose:
transmit the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.

Regarding claim 21, Han discloses: A communication device, comprising (Abstract and FIG. 27 disclosing method and an apparatus of transmitting information in a wireless communication system are provided):
a wireless transmitter (50, FIG. 27, para [0208]);
a processor (51, FIG. 27, para [0208]); and
a memory including program code executable by the processor, the program code including code for causing the processor to (52, FIG. 27, para [0208] disclosing memory 52 is coupled with the processor 51 and configured to store a driving system, applications and general files):
receive a plurality of information symbols (para [0010] disclosing a method of transmitting information in a wireless communication system, carried in a transmitter, is provided. The method includes transmitting first information based on a first resource index through a first antenna during a first interval and transmitting second information based on a second resource index through a second antenna during the first interval and para [0017] disclosing information symbols).
Han does not disclose:
encode an NxM array containing the plurality of information symbols into a two-dimensional array of modulation symbols by spreading each of the plurality of information symbols with respect to both time and frequency; and
transmit the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.
Therefore, the prior art of record does not teach or fairly suggest the subject matter claimed.
Specifically, none of the prior art, alone or in combination discloses:
transmitting the two-dimensional array of modulation symbols using M mutually orthogonal waveforms included within M frequency sub-bands.

Claims 22-23 meet the criteria set out in PCT Article 33(2)-(3) as depending from Claim 21.
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In case the space in any of the preceding boxes is not sufficient.

Continuation of:
Citations and Explanation:
Regarding claims 37, 39, 41 and 43 the prior art is exemplified by Hadani '441 and US 2002/0181390 A1 to Mody et al. (hereinafter, 'Mody').

Regarding claim 37, Hadani '441 discloses the method of claim 36.
Hadani '441 does not disclose: wherein the inverse of the two dimensional time-frequency transformation comprises a windowing operation and a symplectic Fourier transform.
However, Mody discloses a communication system, and in particular a wireless Orthogonal Frequency Division Multiplexing (OFDM) communication system, the present invention provides systems for estimating parameters of a channel across which a signal is transmitted (Abstract) and further discloses:
performing a windowing operation and a Fourier transform (FIG. 1 and para [0030] disclosing on the side of the receiver 10, a number "L" of receiving antennas 20 receives the transmitted signals, which are demodulated by a number L of respective OFDM demodulators 22 and claim 28 and para [0086] disclosing calculating a mean square error estimate of the channel estimates and para [0088] disclosing windowing operation and para [0089] disclosing Fourier transform).
Neither discloses: wherein the Fourier transform is a symplectic Fourier transform.

Therefore, the prior art of record does not teach or fairly suggest the subject matter claimed.
Specifically, none of the prior art, alone or in combination discloses: wherein the Fourier transform is a symplectic Fourier transform.

Regarding claim 39, Hadani '441 discloses the method of claim 38.
Hadani '441 does not disclose: wherein the inverse of the two dimensional time-frequency transformation comprises a windowing operation and a symplectic Fourier transform.
However, Mody discloses a communication system, and in particular a wireless Orthogonal Frequency Division Multiplexing (OFDM) communication system, the present invention provides systems for estimating parameters of a channel across which a signal is transmitted (Abstract) and further discloses:
performing a windowing operation and a Fourier transform (FIG. 1 and para [0030] disclosing on the side of the receiver 10, a number "L" of receiving antennas 20 receives the transmitted signals, which are demodulated by a number L of respective OFDM demodulators 22 and claim 28 and para [0086] disclosing calculating a mean square error estimate of the channel estimates and para [0088] disclosing windowing operation and para [0089] disclosing Fourier transform).
Neither discloses: wherein the Fourier transform is a symplectic Fourier transform.

Therefore, the prior art of record does not teach or fairly suggest the subject matter claimed.
Specifically, none of the prior art, alone or in combination discloses: wherein the Fourier transform is a symplectic Fourier transform.

Regarding claim 41, Hadani '441 discloses the receiver apparatus of claim 40.
Hadani '441 does not disclose: wherein the inverse of the two dimensional time-frequency transformation comprises a windowing operation and a symplectic Fourier transform.
However, Mody discloses a communication system, and in particular a wireless Orthogonal Frequency Division Multiplexing (OFDM) communication system, the present invention provides systems for estimating parameters of a channel across which a signal is transmitted (Abstract) and further discloses:
performing a windowing operation and a Fourier transform (FIG. 1 and para [0030] disclosing on the side of the receiver 10, a number "L" of receiving antennas 20 receives the transmitted signals, which are demodulated by a number L of respective OFDM demodulators 22 and claim 28 and para [0086] disclosing calculating a mean square error estimate of the channel estimates and para [0088] disclosing windowing operation and para [0089] disclosing Fourier transform).
Neither discloses: wherein the Fourier transform is a symplectic Fourier transform.

Therefore, the prior art of record does not teach or fairly suggest the subject matter claimed.
Specifically, none of the prior art, alone or in combination discloses: wherein the Fourier transform is a symplectic Fourier transform.

Regarding claim 43, Hadani '441 discloses the receiver apparatus of claim 42.
Hadani '441 does not disclose: wherein the inverse of the two dimensional time-frequency transformation comprises a windowing operation and a symplectic Fourier transform.
However, Mody discloses a communication system, and in particular a wireless Orthogonal Frequency Division Multiplexing (OFDM) communication system, the present invention provides systems for estimating parameters of a channel across which a signal is transmitted (Abstract) and further discloses:
performing a windowing operation and a Fourier transform (FIG. 1 and para [0030] disclosing on the side of the receiver 10, a number "L" of receiving antennas 20 receives the transmitted signals, which are demodulated by a number L of respective OFDM demodulators 22 and claim 28 and para [0086] disclosing calculating a mean square error estimate of the channel estimates and para [0088] disclosing windowing operation and para [0089] disclosing Fourier transform).
Neither discloses: wherein the Fourier transform is a symplectic Fourier transform.

Therefore, the prior art of record does not teach or fairly suggest the subject matter claimed.
Specifically, none of the prior art, alone or in combination discloses: wherein the Fourier transform is a symplectic Fourier transform.

Claims 1-11 and 21-23 and 36-43 have industrial applicability as defined by PCT Article 33(4) because the subject matter can be made or used in industry.