Petitioner
Ericsson Inc. and
Telefonaktiebolaget LM Ericsson

U.S. Patent No. 7,269,127

IPR2014-01185

October 21, 2015

Andrew Lowes

Clint Wilkins, Ph.D.

Exhibit ERIC-1037
IPR2014-01185

Summary of Challenges

References	Claims Challenged
Schmidl and Arslan	1-3, 5
Schmidl, Arslan, and Kim	4, 6-10
Schmidl, Arslan, Kim, and Heiskala	17

(Decision to Institute, p. 7)

- Claim 1 is the only independent claim

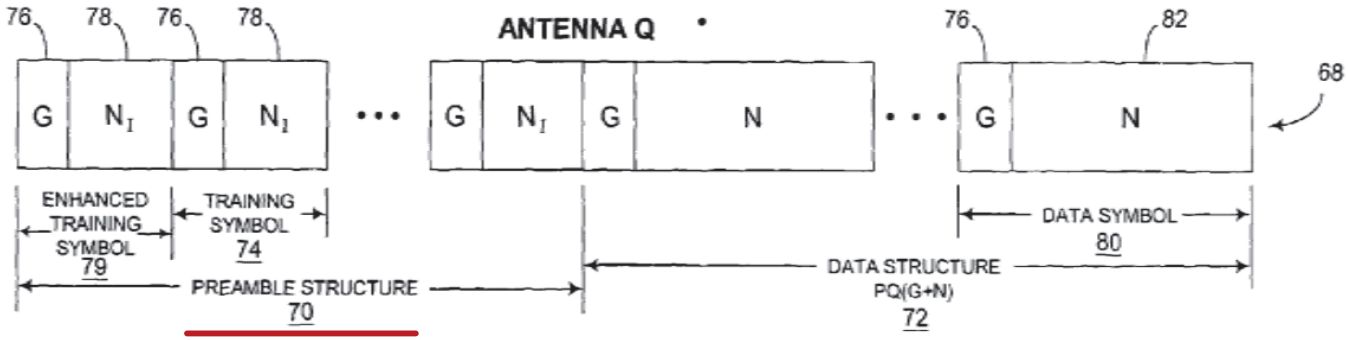
Purported invention – directed to new preamble structures

Therefore, there is a need for an efficient preamble structure that provides time and frequency synchronization, estimation of parameters such as noise variance and channel parameters, and low PAPR when used with SISO and MIMO communication systems.

SUMMARY OF THE INVENTION

The present invention provides a system for providing efficient preamble structures for use in single-input, single-output (SISO) and multi-input, multi-output (MIMO) communication systems. Briefly described, one embodiment of

('127 patent, 3:13-24, cited in Petition for IPR, p. 3)



(portion of '127 patent, Fig. 6, illustrated in Petition for IPR, p. 3)

Claim 1 –Disputed Elements

1. A transmitter of a communication system, the transmitter comprising:

an encoder having a pilot/training symbol inserter, the pilot/training symbol inserter configured to insert pilot symbols into data blocks and to combine training symbols with the data blocks;

at least one modulator, each modulator having an inverse discrete Fourier transform (TDFT) stage and a cyclic prefix inserter, each modulator outputting a frame structure comprising a preamble structure and a data structure, the preamble structure comprising at least one training symbol and an enhanced training symbol; and

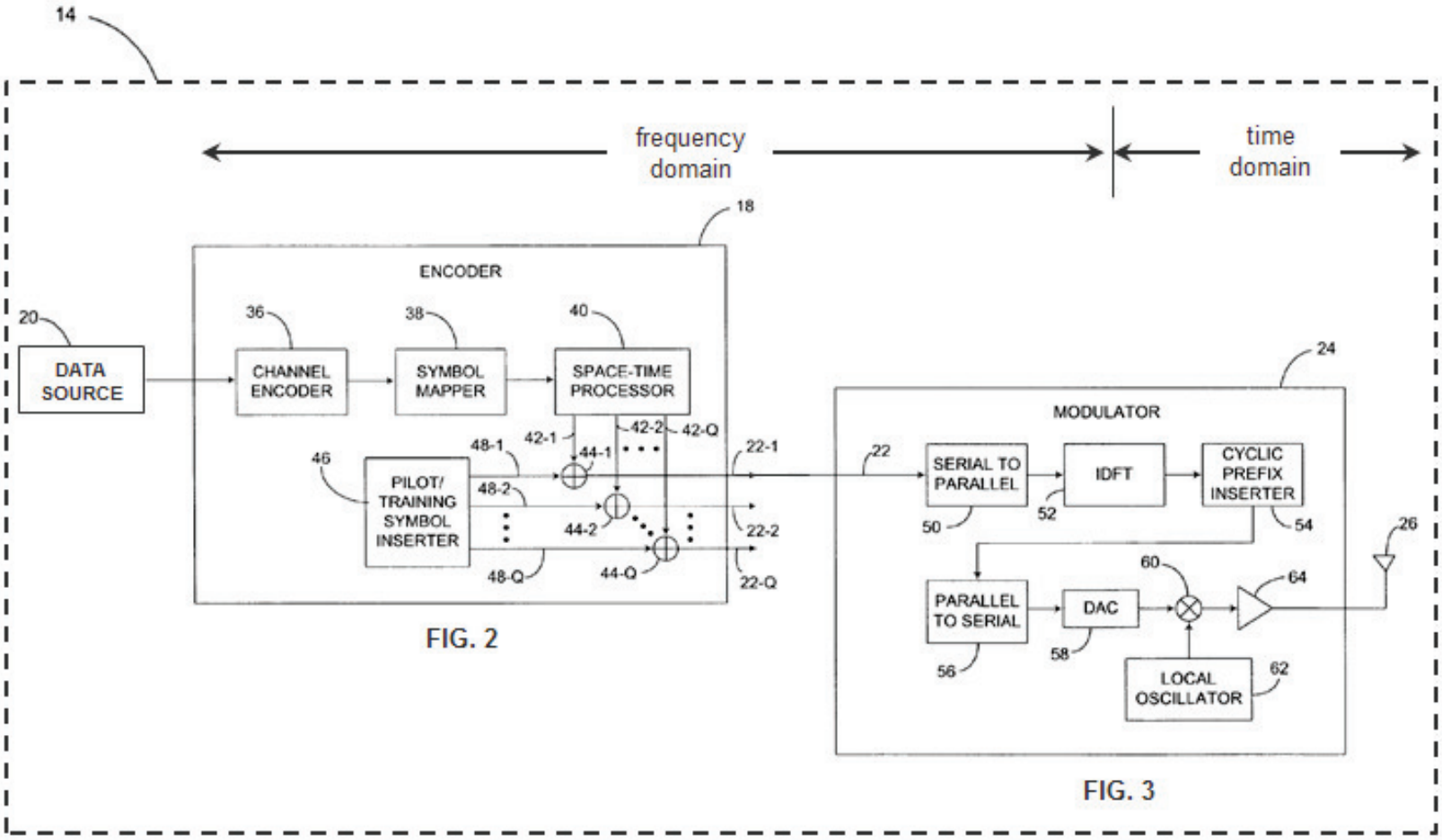
at least one transmit antenna, each transmit antenna corresponding to a respective one or the at least one modulator. each transmit antenna transmitting the frame structure output from the corresponding modulator, wherein the enhanced training symbol is a single symbol.

Disputed elements

Unrebutted that preamble structure including enhanced training symbol is disclosed by prior art

(Petitioner Reply, p. 1)

Frequency Domain and Time Domain



(PO Response, p. 15, combines '127 patent, Figs. 2 and 3)

Positions regarding claim term "insert pilot symbols into data blocks"

Petitioner

- Claim term does encompass embodiments that result in a separate OFDM pilot symbol in the time domain (reasons provided in next slides) (Reply, p. 9)

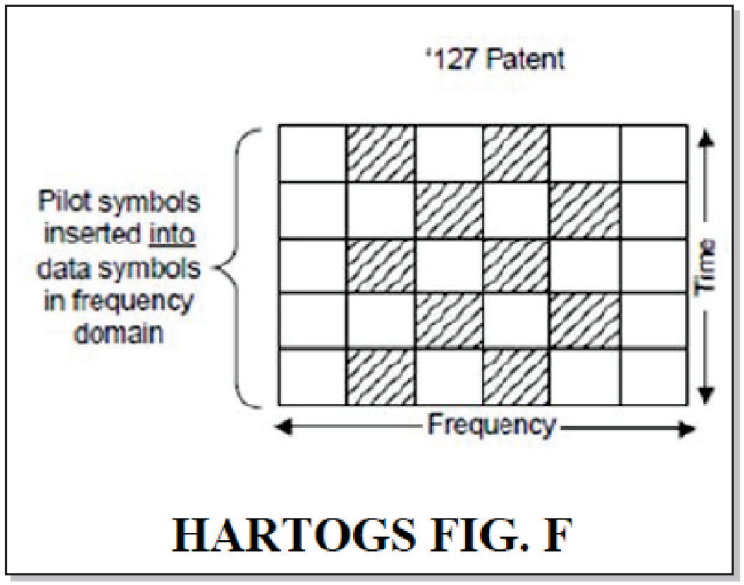
Patent Owner

"Petitioner's construction would include an OFDM symbol inserted between data symbols, rather than frequency domain samples inserted into data blocks." (Prelim. Resp., p. 18)

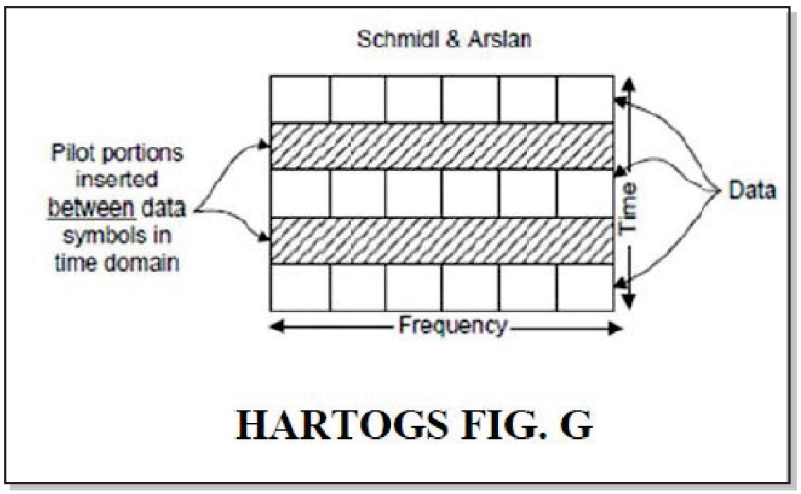
"Since pilot symbols are periodically placed within data blocks in the frequency domain, and are not 'continuous sections of symbols' in the time domain like training blocks (*id.* at 7:30-31) …" (Prelim. Resp., p. 17)

"Pilot symbols are not placed on every sub-channel, but instead are 'intermittently inserted into the data symbols' ('127 patent, 11:45–46) to refine the calibration." (Resp., p. 21)

Entire frequency-domain block could be filled with pilots



HARTOGS FIG. F



HARTOGS FIG. G

(Hartogs Fig. F and G illustrated in PO Response, pp. 25 and 26, respectively)

10 Q. Is there a limit to how many bills [*sic* – pilots]
11 could be adjacent to one another in a
12 particular data block the way you've
13 represented it here?
14 A. Only -- I'd say the only limitations
15 here are put up by the cleverness of the
16 implementer. Obviously, if you get to the
17 point where you have the entire block filled
18 with pilots, then it really has just become
19 another training symbol and you probably have
20 enough information to just reinitialize your
21 transmission.

(Hartogs Dep. Tr., 148:10-21, cited in Petitioner Reply, p. 6)

Petitioner's expert illustrates embodiment consistent with claim 1

Embodiment includes separate pilot symbols in time domain

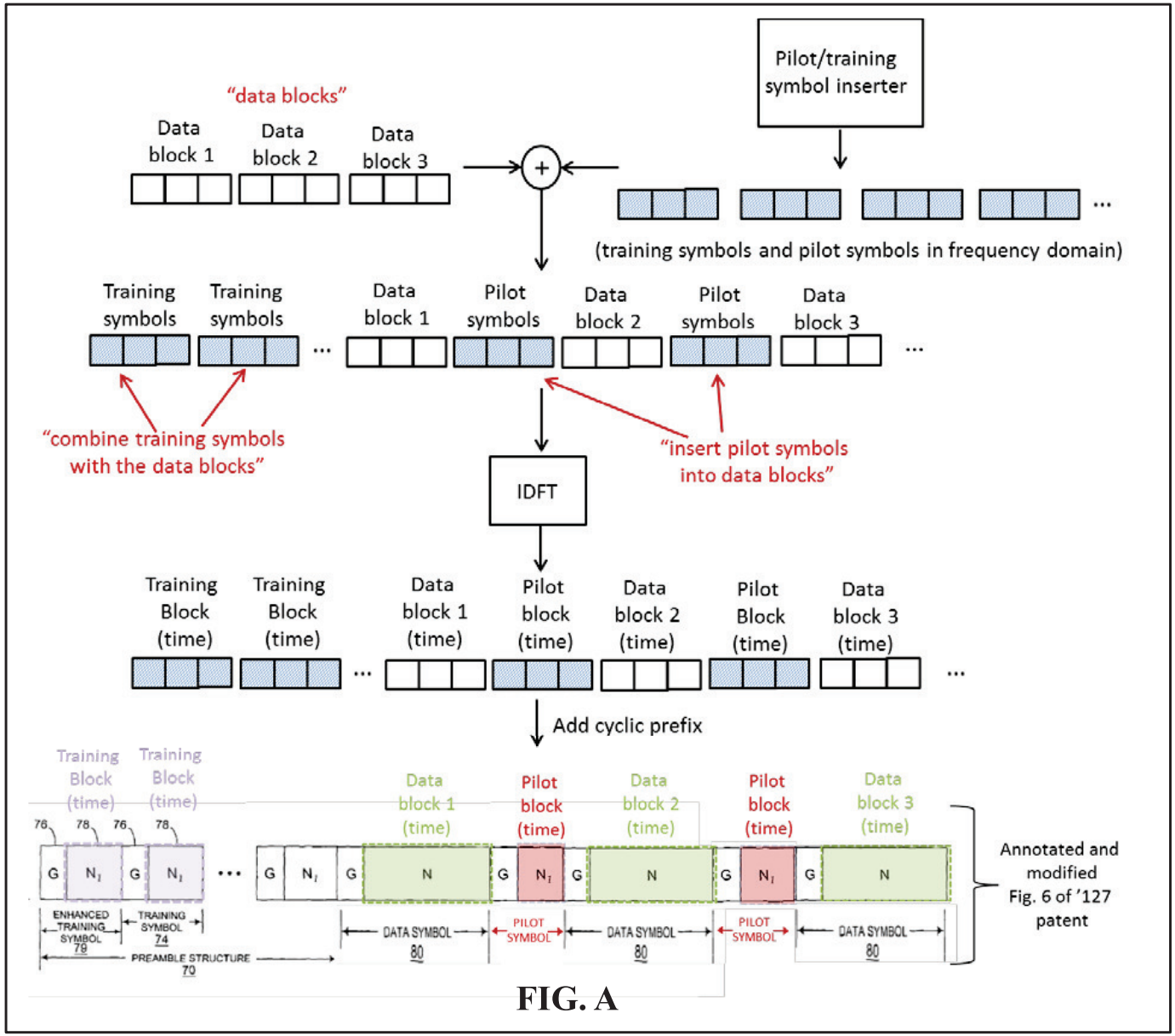


FIG. A

(Supp. Haas Decl. (ERIC-1036), ¶12, reproduced in Petitioner Reply, p. 10

’127 patent disclosure regarding “pilot symbol”

[A] Mody Provisional (U.S. Provisional App. 60/322,786, incorporated by reference in ’127 patent)

(cited in Petitioner Reply, pp. 4-5, PO Motion for Observations, pp. 10-14, and Petitioner Response to PO Motion for Observations, pp. 2, 3, 6, 7, 10-15)

[B] ’127 patent, 7:26-50

(7:26-34 cited in PO Response, pp. 9, 10 and 14 and Petition for IPR, p. 23; 7:26-39 cited in Response to Motion for Observations, pp. 8 and 10-11; 7:40-45 cited in Petitioner Reply, pp. 12-13; 7:47-50 cited in Response to Motion for Observations, pp. 9)

[C] ’127 patent, 11:44-47 and Fig. 6

(11:45-47 cited in PO Response, p. 9; 11:44-47 cited in Petitioner Reply, p. 7)

[A] – Mody Provisional

Mody Provisional (ERIC-1035) incorporated by reference

This application is related to U.S. provisional application entitled "Efficient Training and Synchronization Sequence Structures for MIMO OFDM," having Ser. No. 60/322,786, filed Sep. 17, 2001, which is entirely incorporated herein by reference.

('127 patent, 1:14-17, cited in Petitioner Reply, p. 2)

PO's expert never considered Mody Provisional

Q. And you'll see at the very top there's a section called "Cross-reference to Related Applications." You'll see there are a couple of applications there.

A. I do see that.

Q. And those are incorporated by reference.

A. Okay.

Q. Did you review those documents?

...

A. Oh, I'm sorry. I meant the second provisional. I'm sorry, I had not looked at the second provisional.

(Hartogs Dep. Tr., 21:5-25, cited in Petitioner Reply, p. 7)

[A] Disclosure regarding "pilot symbol" – Mody Provisional

Mody Provisional discloses separate pilot symbols in time domain

Mody Provisional

ceived demodulated OFDM symbol). Pilots in the form of known OFDM symbols are sent for at least Q symbol periods (QT_s) in order to obtain a unique solution for the channel coefficient estimates. If the pilots are sent for more than Q symbol periods then we would obtain a Least Squares (LS) solution at an expense of a larger overhead. The OFDM symbol period is given by $T_s = NT + T_g$ where $1/T$ is the sample rate into the OFDM modulator (bit rate for BPSK modulation).

(Mody Provisional (ERIC-1035), incorporated by reference into '127 patent and cited in Petitioner Reply, p. 5)

Petitioner Expert

OFDM modulator." ERIC-1035, p. 2. Since the pilot symbols are "known OFDM symbols," this implies that they are known to the receiver, do not contain any user data in the frequency domain, and contain only pilot symbols in the frequency domain. Thus, Mody Provisional discloses separate OFDM pilot symbols in the time domain.

(Supp. Haas Decl., ¶ 6, cited in Petitioner Reply, p. 5)

[B] Disclosure regarding "pilot symbol" – '127 patent, 7:26-50

The term pilot blocks, as used in this description, refers to symbols provided by the pilot/training symbol inserter **46**, which are inserted periodically into the data blocks. Typically, pilot symbols may be inserted at any point in the data blocks. The term training blocks refers to one or more continuous sections of symbols provided by the pilot/training symbol inserter **46**. Training blocks are preferably inserted into preamble structures at the beginning of the frame structures and transmitted once per frame structure. However, training blocks may also be inserted in other parts of the signal structures, such as the middle or end of the frame structures. Preambles (or preamble structures) are symbol structures formed of training blocks inserted at the beginning of the frame.

Pilot blocks are typically transmitted with data blocks to calibrate (i.e., synchronize) the receiver **16** to the transmitter **14** on a small scale. This calibration, or synchronization, accounts for the time varying nature of the channel **12**, for example. Training symbols, however, are typically used to periodically calibrate the receiver **16** to the transmitter **14**. The training symbols may be unique for each sub-channel. Moreover, different sets of training symbols and/or pilot blocks may be provided by the pilot/training symbol inserter **46**, depending on the operating criteria of the communication system **10**, which may be determined by the user.

[B-1]

[B-2]

(7:26-34 cited in PO Response, pp. 9, 10 and 14 and Petition for IPR, p. 23; 7:26-39 cited in Response to Motion for Observations, pp. 8 and 10-11; 7:40-45 cited in Petitioner Reply, pp. 12-13; 7:47-50 cited in Response to Motion for Observations, pp. 9)

[B-1] Disclosure regarding "pilot symbol" – '127 patent, 7:26-39

The term pilot blocks, as used in this description, refers to symbols provided by the pilot/training symbol inserter **46**, which are inserted periodically into the data blocks. Typically, pilot symbols may be inserted at any point in the data blocks. The term training blocks refers to one or more continuous sections of symbols provided by the pilot/training symbol inserter **46**. Training blocks are preferably inserted into preamble structures at the beginning of the frame structures and transmitted once per frame structure. However, training blocks may also be inserted in other parts of the signal structures, such as the middle or end of the frame structures. Preambles (or preamble structures) are symbol structures formed of training blocks inserted at the beginning of the frame.

Pilot symbols/ pilot blocks

Training symbols/ training blocks

[B-2] Disclosure regarding "pilot symbol" – '127 patent, 7:40-45

Pilot blocks are typically transmitted with data blocks to calibrate (i.e., synchronize) the receiver **16** to the transmitter **14** on a small scale. This calibration, or synchronization, accounts for the time varying nature of the channel **12**, for example. Training symbols, however, are typically used to periodically calibrate the receiver **16** to the transmitter **14**.

(7:40-45 cited in Petitioner Reply, pp. 12-13)

Petitioner's Expert – '127, 7:40-45 implies separate pilot symbol in time domain

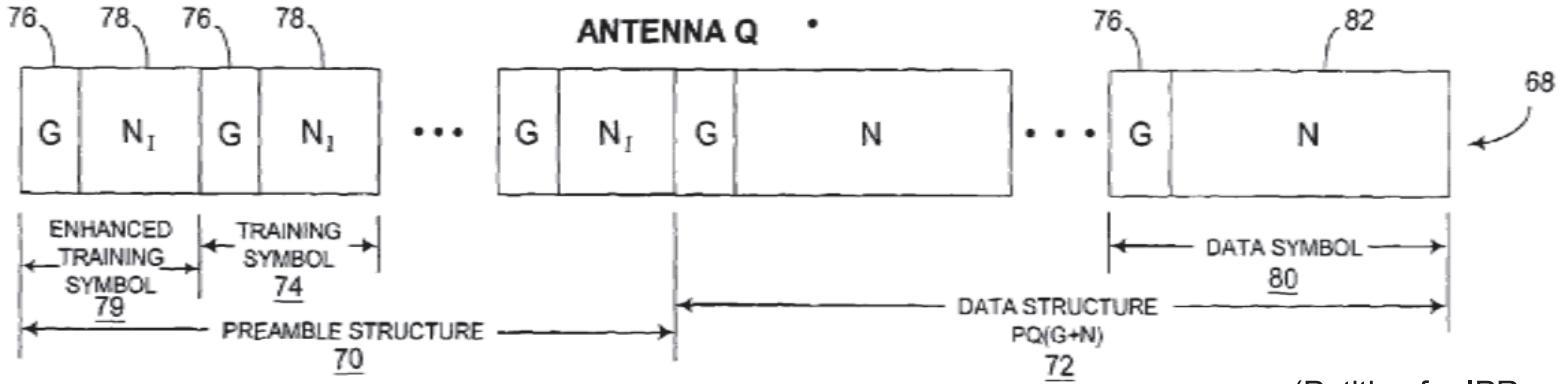
ERIC-1001, 7:40-45. Training symbols are used for initial synchronization at the beginning of a transmission. This is why, for example, multiple training symbols are shown at the beginning of a transmission in Fig. 6 of the '127 patent, with the first one of the training symbols being an "enhanced" training symbol, whereas for periodic calibration after initial synchronization as few as one pilot symbol in the time domain (from multiple pilot symbols in the frequency domain) may be used for periodic calibration. The "small scale" referred to in the above passage from the '127 patent is a small-time scale. By contrast, the training symbols synchronize on a "large (time) scale" because a transmitter and receiver are typically not synchronized before a transmission starts.

(Supp. Haas Decl., ¶ 14, cited in Petitioner Reply, p. 13)

[C] Disclosure regarding "pilot symbol" – '127 patent, 11:44-47 and Fig. 6

'127 patent supports discrete OFDM pilot symbols in the time domain (Petitioner Reply, p. 7)

'127 patent – FIG. 6 (partial)



(Petition for IPR, p. 3, illustrates '127 patent, Fig. 6 (partial))

'127 patent – pilot symbols "omitted from FIG. 6 for simplicity"

positive integer. Although omitted from FIG. **6** for simplicity, pilot symbols may also be intermittently inserted into the data symbols **80** by the pilot/training symbol inserter **46**, as discussed above.

('127 patent, 11:44-47, cited in Petitioner Reply, p. 7)

[C] Disclosure regarding "pilot symbol" – '127 patent, 11:44-47 and Fig. 6

PO's expert does not know how pilot symbols would be shown in Fig. 6 of '127 patent

Q. Okay. Well, the patent states that the pilot symbols are omitted from figure 6 for simplicity. How would one represent pilot symbols in figure 6 if one wished to do so?

A. I don't know.

Q. Could you represent a pilot symbol in figure 6?

A. Nothing -- certainly, nothing comes to mind. I'd be willing to consider something

(Hartogs Dep. Tr., 130:11-19, cited in Petitioner Reply, p. 8)

[C] Disclosure regarding “pilot symbol” – ’127 patent, 11:44-47 and Fig. 6

Petitioner Expert Cross-Examination

In -- in Column 11 of -- of the '127 patents -- patent in Line 44 to 47, "Although immediate from Figure 6 for simplicity, pilot symbols may also be intermittently inserted into data symbols (80) by the pilot/training symbol inserter (46) as discussed above."

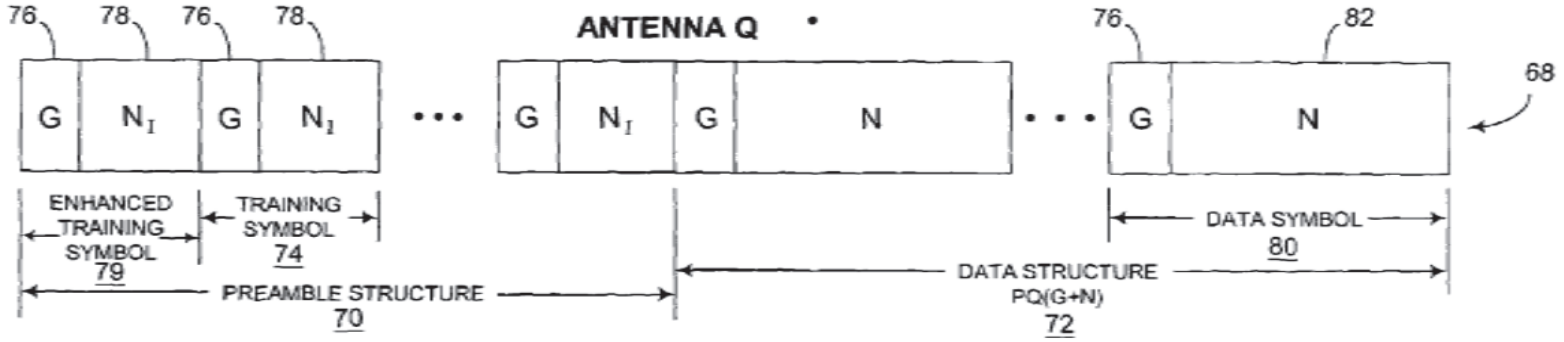
So if you take Figure 6 -- more precisely, one frame of Figure 6, which is Number 68, one of the 68s, and modify it to -- not to omit the pilot symbols as Figure 6 does, then the result would be something similar to my bottom of Figure A.

(Second Haas Dep. Tr. (Ex. 2011), 32:18-33:5, cited in Response to PO’s Observations, No. 6)

[C] Disclosure regarding "pilot symbol" – '127 patent, 11:44-47 and Fig. 6

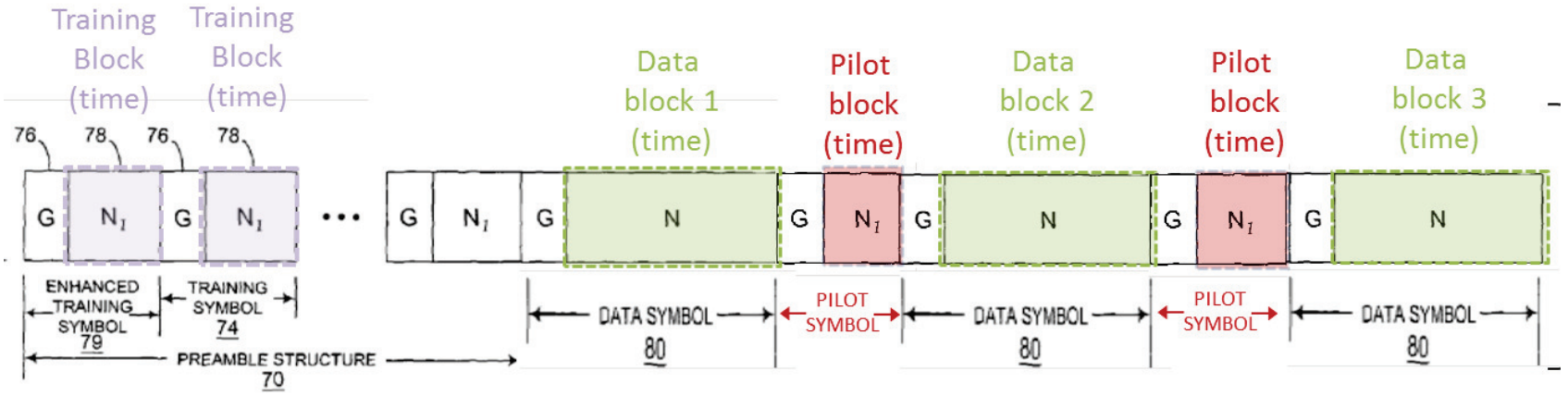
Petitioner's expert illustrates OFDM pilot symbols in modified Fig. 6 of '127 patent

Fig. 6



('127 patent, Fig. 6, illustrated in, inter alia, Petition for IPR, p. 20 and Decision to Institute, p. 4)

Annotated and modified Fig. 6, according to Petitioner's Expert



(Supp. Haas Decl., ¶12, cited in Petitioner Reply, p. 10

[C] Petitioner's expert illustrates an embodiment consistent with claim 1

Illustrative example of how pilot symbols would appear in Fig. 6 of '127 patent

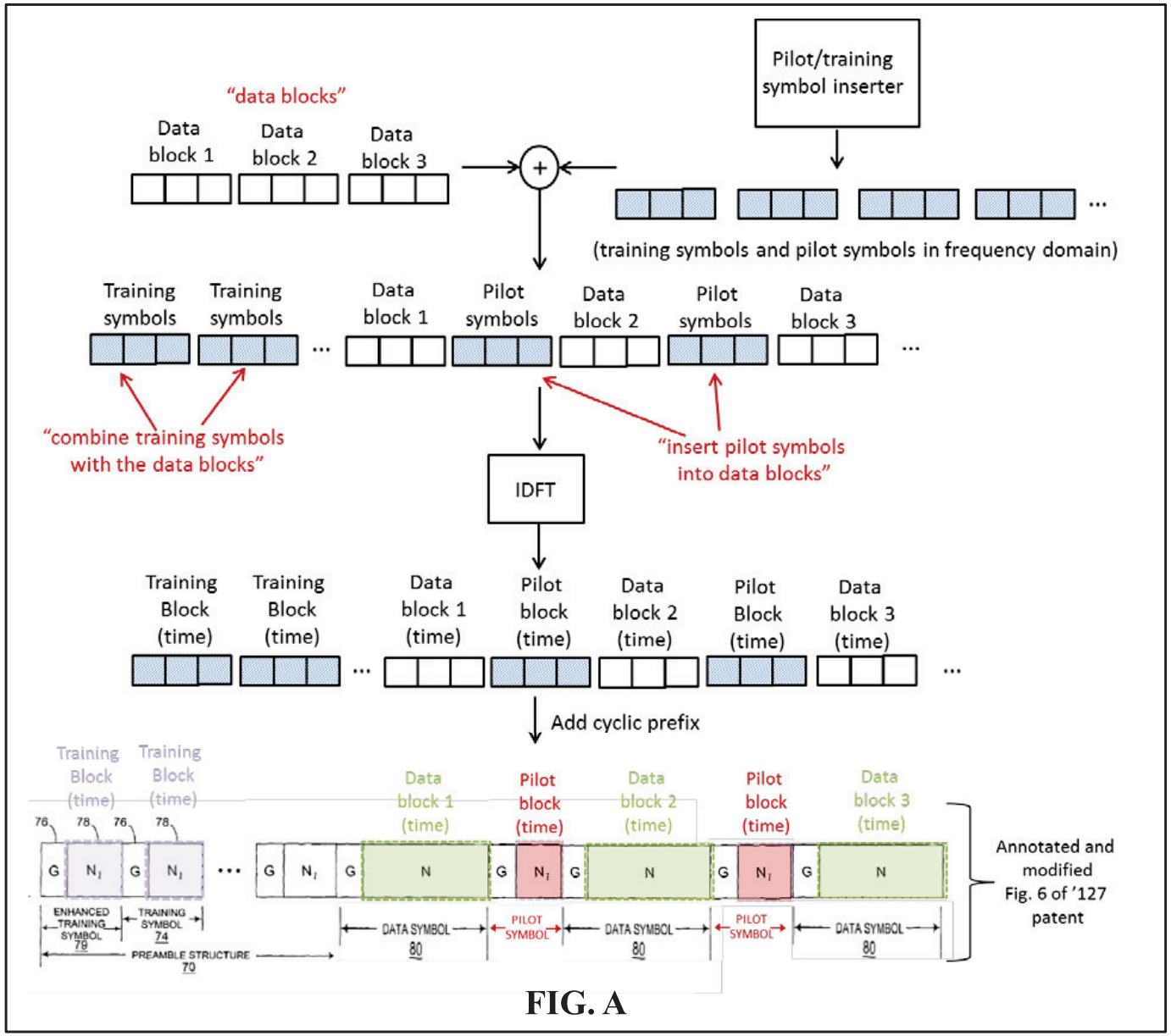


FIG. A

(Supp. Haas Decl., ¶12, reproduced in Petitioner Reply, p. 10

Summary of prior art applied to claim 1

Claim Element	Reference
[1.0] A transmitter of a communication system, the transmitter comprising:	Schmidl
[1.1] an encoder having a pilot/training symbol inserter, the pilot/training symbol inserter configured to insert pilot symbols into data blocks and to combine training symbols with the data blocks;	Schmidl + Arslan
[1.2] at least one modulator,	Schmidl
[1.2.1] each modulator having an inverse discrete Fourier transform [IDFT] stage and a cyclic prefix inserter,	Schmidl
[1.2.2] each modulator outputting a frame structure comprising a preamble structure and a data structure	Schmidl
[1.2.3] the preamble structure comprising at least one training symbol and an enhanced training symbol;	Schmidl
[1.3] and at least one transmit antenna,	Schmidl
[1.3.1] each transmit antenna corresponding to a respective one [of] the at least one modulator,	Schmidl
[1.3.2] each transmit antenna transmitting the frame structure output from the corresponding modulator,	Schmidl
[1.3.3] wherein the enhanced training symbol is a single symbol.	Schmidl

Disputed elements

Schmidl

Schmidl discloses an encoder, modulator, and antenna

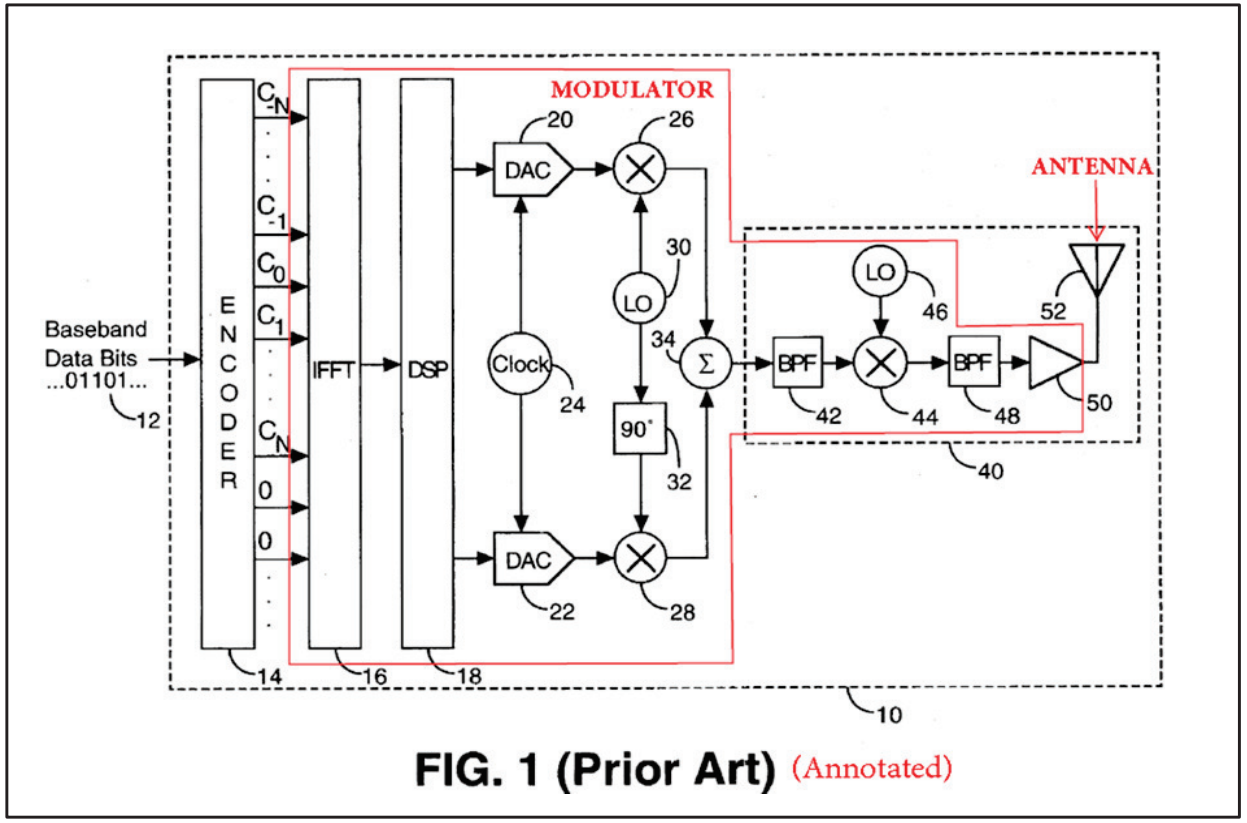


FIG. 1 (Prior Art) (Annotated)

(Schmidl, Fig. 1 (annotated), illustrated in Haas Decl. (ERIC-1009), ¶ 47 and included in Petition for IPR, pp. 28 and 31)

Schmidl's OFDM transmitter comprises an encoder that receives data bits as input and creates a sequence of frequency-domain sub-symbols to form a data frame including a first training symbol and a second training symbol that are combined with a plurality of data symbols. *See id.* FIGs. 1 (14) and 6, 1:42-49 and 1:63-67. For

(Petition for IPR, p. 28)

Schmidl discloses training symbol placement

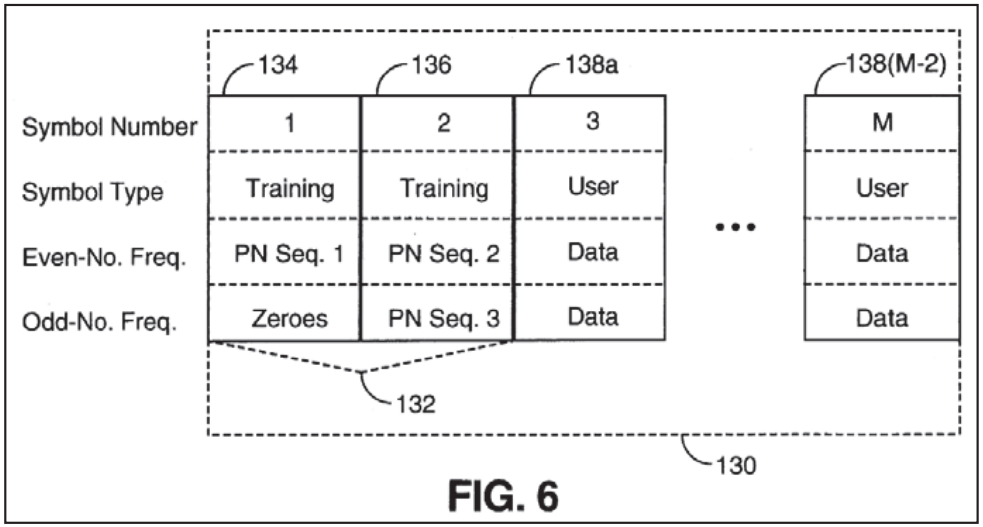


FIG. 6

(Schmidl, Fig. 6, cited in Petition for IPR, p. 28 and Decision to Institute, p. 10)

FIG. 6 illustrates the placement of a training sequence within a data frame and also illustrates the contents of the

(Schmidl, 11:66-67, cited in Decision to Institute, p. 10)

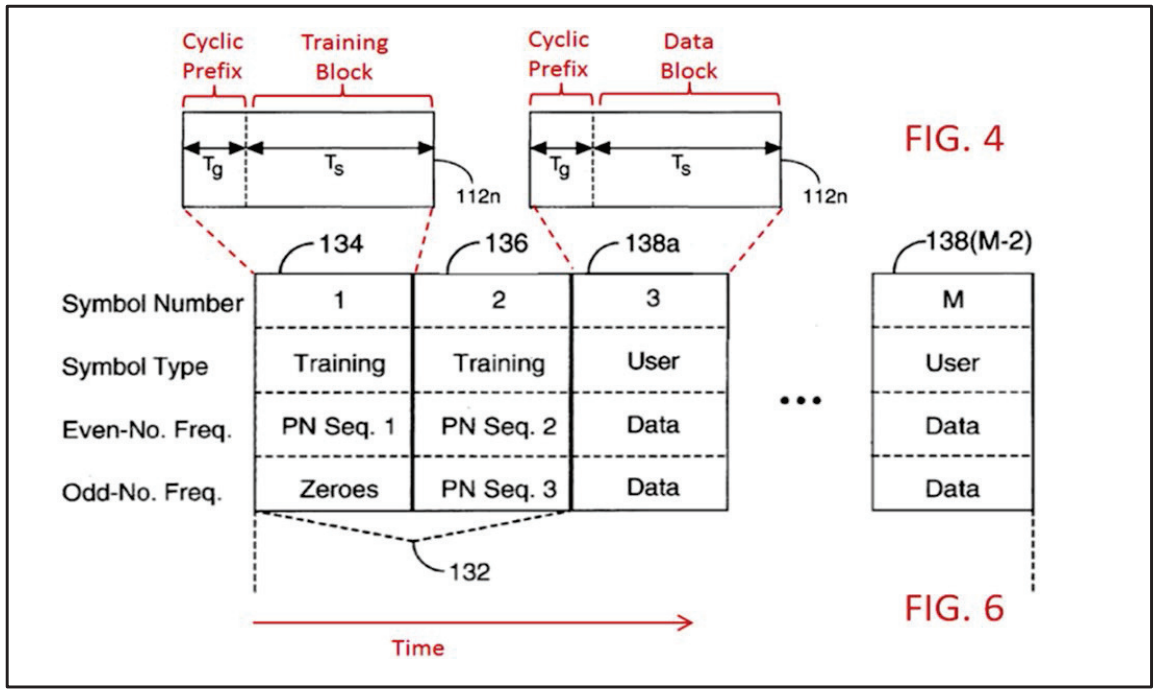
Training symbols **134** and **136** are preferably placed at the beginning of data frame **130** as shown in the figure.

(Schmidl, 12:16-17, cited in Petition for IPR, p. 12)

The preferred embodiment also comprises a second OFDM training symbol **136**, which in the preferred embodiment directly follows first OFDM training symbol **134**. Although the two symbols need not be placed next to each other, doing so minimizes the effect of time variation of the channel over the duration of the training sequence.

(Schmidl, 13:44-49, cited in Petition for IPR, p. 14)

Schmidl – transmitted frame includes OFDM training symbols



(Schmidl, Figs. 4 and 6, annotated as shown in Haas Decl., ¶ 43, cited in, *inter alia,* Petition for IPR, p. 7)

Schmidl discloses an encoder (Fig. 1(14)) to encode training symbols used to improve synchronization between an OFDM transmitter and an OFDM receiver. These training symbols are combined with data symbols (corresponding to "data blocks") in a transmitted data frame.

(Haas Decl., p. 44, cited in Petition for IPR, p. 28)

Schmidl's encoder creates and inserts training symbols

16. Schmidl's encoder 14 in Fig. 1 creates the training symbols: "since a 2^m -ary QAM encoder 14 is used to create first OFDM training symbol 134..." ERIC-1002, 13:16-18. This description together with the frequency contents of the symbols in the transmitted frame in Fig. 6 inform a POSA how the encoder 14 creates the training symbols. A POSA would have understood that the encoder 14 necessarily incorporates circuitry that inserts training symbols in the frequency domain such that training symbols in the time domain are produced. This circuitry is an example of a training symbol inserter.

(Supp. Haas Decl., ¶ 16, cited in Petitioner Reply, p. 14)

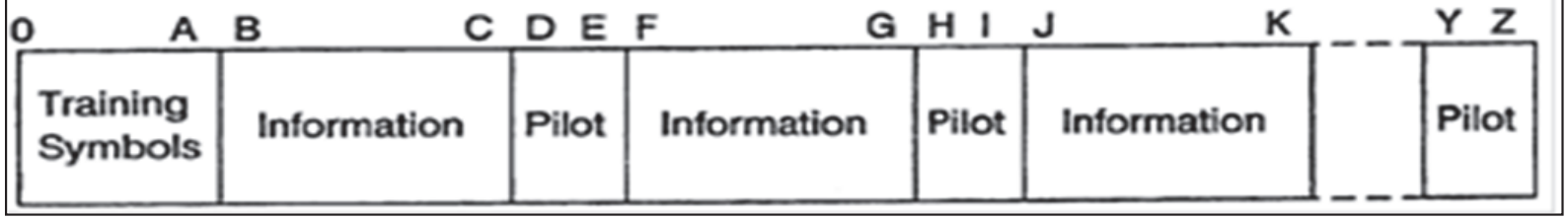
Arslan

Arslan discloses frames that include both training symbols and pilot symbols

FIG. **4** illustrates a frame structure which may be utilized with the present invention. As seen in FIG. **4**, the frame includes a synchronizing portion **0** to A using training symbols, information portions B–C, F–G and J–K and pilot portions D–E, H–I and Y–Z. According to the present invention, the pilot portions are interspersed between information portions so as to allow retraining of the adaptive channel estimator **30** during the frame. The synchronizing portion of the frame is a series of predefined symbols, from **0** to A in FIG. **4**, which are the same for each received frame. The information portion of the frame, from B to C, F to G and J to K, contains symbols which may vary from frame to frame and contain the information to be transmitted in the frame. The pilot portions of the frame, from D to E, H to I and Y to Z, contain predefined symbols which may be used to retrain the adaptive channel estimator **30**. As will be

(Arslan, 6:7-21, cited in Petition for IPR, pp. 14-15 and Petitioner Reply, pp. 15-16; 6:7-15 cited in Decision to Institute, p. 12)

FIG. 4



(Arslan, Fig. 4, shown in Decision to Institute, p. 12, Petition for IPR, pp. 15 and 28, and Peitioner Reply, p. 16)

Arslan

Training symbols and pilot symbols are inserted in a frame of data for synchronization

Training symbols

information contained in the received signal. Often, in wireless mobile radio systems, known data sequences are inserted periodically into the transmitted information sequences. Such data sequences are commonly called synchronizing sequences or training sequences and are typically provided at the beginning of a frame of data. Channel

(Arslan, 1:55-59, cited in Petition for IPR, p. 15 and Petitioner Response, p. 16)

Pilot symbols

The present invention utilizes pilot symbols inserted in a frame of data in a received signal to periodically retrain a

(Arslan, 5:26-27, cited in Petitioner Response, p. 16)

Synchronization

These and other objects of the present invention are provided by utilizing pilots in an information sequence to periodically retrain a channel estimator. Thus, a channel tracker may be synchronized using a synchronization sequence and then periodically retrained using known pilot symbols. Furthermore, the utilization of pilots may allow for

(Arslan, 3:1-6, cited in Haas Decl., ¶ 54 and Petition for IPR, p. 15)

Combination of Schmidl and Arslan

Combination renders obvious claim 1's "an encoder having a pilot/training symbol inserter … configured to insert pilot symbols into data blocks"

22. Arslan recognizes the benefit of including pilot symbols within the data transmission to maintain calibration and synchronization. Accordingly, it would have been obvious to use pilot symbols in Schmidl's system as separate time-domain symbols for tracking time variations to calibrate or synchronize the receiver to the transmitter by using time-domain pilot symbols. As discussed above, Schmidl discloses inserting at the beginning of data structures known symbols as training symbols for calibration and synchronization. It would have been obvious to create time-domain pilot symbols in Schmidl in the same manner as the time-domain training symbols are created in the Schmidl's encoder – that is, by inserting blocks of known pilot symbols in the frequency domain that would result in time-domain pilot symbols. The same circuitry in Schmidl's encoder 14 used to insert training symbols would be used to insert pilot symbols, resulting in the claimed "pilot/training symbol inserter configured to insert pilot symbols into data blocks."

(Supp. Haas Decl., ¶ 22, cited in Petitioner Reply, p. 17)

Claim 17

- Claim 1 recites:
  "a transmitter … comprising:
  an encoder …
  at least one modulator…
  at least one transmit antenna …"
- Claim 17 adds:
  "wherein the number of modulators and the number of antennas is two ..."

- There is no dispute that the combination of references discloses two encoders, two modulators and two antennas. (PO Response, pp. 28-29)
- Claim 17 depends from claim 1, and the dispute is over whether claim 1's limitation of "an encoder" should be interpreted to require only a single encoder. (Petitioner Reply, p. 19)

Claim 17

PO improperly reads limitations from specification into claim 17

- PO improperly limits claim 1 to the embodiment of Fig. 1, which illustrates a single encoder coupled to multiple modulators

(Petitioner Reply, p. 20)

- "A particular embodiment appearing in the written description may not be read into a claim when the claim language is broader than the embodiment." *Superguide Corp. v. DirecTV Enterprises, Inc*., 358 F.3d 870, 875 (Fed. Cir. 2004).

(Petitioner Reply, p. 19)

Claim 17

- Claim 1 recites “a transmitter … comprising: an encoder …”

- “ ‘[C]omprising’ is a term of art used in claim language which means that the named elements are essential, but other elements may be added and still form a construct within the scope of the claim.” *Genentech, Inc. v. Chiron Corp*., 112 F.3d 495, 501 (Fed. Cir. 1997).

(Petitioner Reply, p. 20)

Claim 17

- PO argues that "claim 17's single encoder [is] coupled to multiple modulators and respective transmit antennas…" (PO Response, p. 34)
- However, claim 1 does not specify coupling between the encoder and the at least one modulator (Petitioner Reply, p. 20)
- PO's expert confirmed claim 17 does not specify coupling:

> Q. Does Claim 1 specifically, Claim 1, the language of Claim 1, does that describe any connection or linkage between an encoder and the modulators?
>
> A. I don't believe Claim 1 explicitly links the output of the encoder to the input of a modulator.

(Hartogs Dep. Tr., 69:10-16, cited in Petitioner Reply, p. 21)

Claim 17

Even PO's expert recognizes that multiple encoders can be utilized

Q. So is it now your testimony that there can be more than one encoder in the system claimed in Claim 1?

A. Conceptually, you know, conceptually not.

I'm going to do something that's going to scare the attorneys over on the left side of the table. If there's more than one encoder, they have to have a conspiracy to function. They can't function independently.

Q. So just so we're clear on that --

A. Uh-huh.

Q. -- Claim 1, the system claimed in Claim 1 can have more than one encoder as long as they conspire with one another?

MR. PICKARD: Object to form.

A. Conceptually, that's one encoder.

(Hartogs Dep. Tr., 66:6-22, cited in Petitioner Reply, p. 21)

Summary of Arguments

Claim 1

- Claim term “insert pilot symbols into data blocks” encompasses embodiments that result in a separate OFDM pilot symbol in the time domain
- Schmidl in view of Arslan renders obvious claim 1’s “an encoder having a pilot/training symbol inserter … configured to insert pilot symbols into data blocks”

Claim 17

- Claim 17 is satisfied by a showing of more than one encoder
- The combination of references discloses the encoder of claim 17

BACKUP SLIDES

“pilot symbol”

Petitioner’s expert – Mody Provisional uses term “pilot symbol” in same manner as ’127 patent

Q Okay. So is it possible that Exhibit 1035 uses the term "pilot" differently than it's being used in the '127 specification?

A There's nothing that would indicate to me that this is the case. The term "pilots" in the provisional Mody -- the use of the term "pilots" in the provisional Mody seems to be consistent with the use of the word "pilots" or the term "pilots" in the '127.

(Second Haas Dep. Tr., 52:3-10, cited in Response to PO’s Motion for Observations, No. 15)

"pilot symbol" – same structure as "training symbol" but symbols not necessarily identical

- Petitioner's expert – training blocks have same structure as pilot blocks but not necessarily same content, citing '127 patent, 7:47-50

(Response to PO's Motion for Observations, No. 12)

13 Moreover -- this is in Column 7, Line 47 --
14 moreover, different sets of training symbols in a pilot
15 and/or pilot blocks may be provided by the pilot training
16 symbol inserter (46), depending on the operating criteria
17 of the communication system (10). So if you say they're
18 identical, I cannot tell you if they're identical or not,
19 but I know at least the structure is the same, which is
20 that there is N, sub I, samples in the pilot block, and the
21 N, sub I, samples in the training symbol. And in both

(Second Haas Dep. Tr., 37:13-21, cited in Response to PO's Motion for Observations, No. 12)

Moreover, different sets of training symbols and/or pilot blocks may be provided by the pilot/training symbol inserter **46**, depending on the operating criteria of the communication system **10**, which may be determined by the user. 50

('127 patent, 7:47-50, cited in Response to PO's Motion for Observations, No. 12)

“pilot symbol” – used for synchronization

PO – “pilot symbol” is known symbol used for synchronization

> A “pilot symbol” is known to both the transmitter and receiver and is “transmitted with data blocks to calibrate (*i.e.*, synchronize) the receiver 16 to the transmitter 14 on a small scale.” (’127 patent, 7:40–42.) Both Petitioners’ and

(PO Response, pp. 17-18)

’127 patent

> Pilot blocks are typically transmitted with data blocks to calibrate (i.e., synchronize) the receiver **16** to the transmitter **14** on a small scale. This calibration, or synchronization, accounts for the time varying nature of the channel **12**, for

(’127 patent, 7:40-43 cited in Petitioner Reply, pp. 12-13)

Petitioner Expert Cross-Examination

> So pilot symbols do perform synchronization and it doesn't mean that the system has to be completely desynchronized before the pilot symbols are being used. So the system -- the system can be synchronized to some degree and the pilot symbols improve the synchronization further, and it's just synchronization.

(Second Haas Dep. Tr., 55:10-22, cited in Response to PO’s Motion for Observation, No. 14)

Disclosure regarding "pilot symbol" – '127 patent, 2:10-25

Pilot symbols have same structure as training symbols in time domain

Training symbols are typically added as prefixes to the data structures (e.g., at the beginning of frame structure) to enable training (i.e., time and frequency synchronization) between the transmitter and receiver of a MIMO communication system. These training symbols can be referred to as preambles and are part of the preamble structures. Space-time signal structures are constructed using STP for training symbols and data symbols individually. Furthermore, pilot structures (or pilots) are symbols that are also constructed by STP and have the same structure as preambles. However, instead of being placed as a prefix to the data structure, the pilot structures are periodically arranged within groups of data symbols. Certain properties incorporated into space-

('127 patent, 2:10-25, cited in Petitioner Reply, pp. 5-6)

Petitioner Expert

ERIC-1001, 2:10-25. Thus, pilot symbols have the same structure as training symbols (also known as preambles) in the time domain, but the pilot symbols are arranged within groups of data symbols, as opposed to being at the beginning of a transmission.

(Supp. Haas Decl., ¶7, cited in Petitioner Reply, p. 6)

’127 patent, Fig. 6 illustrates the time domain

PO expert cross-examination

> Q. All right. Figure 6 is illustrating OFDM symbols in the time domain; correct?
>
> A. Everything in figure 6 is in the time domain, yes.

(Hartogs Dep. Tr., 117:111-114, cited in Petitioner Reply, p. 8)

PO Expert – pilot symbols “sprinkled” into data blocks

> And data blocks, there are at least two types of data blocks, one that has a couple of pilot tones sprinkled in it and one of which does not, so -- and those are the inputs to FFT or the inverse FFT if you want to be more precise.

(Hartogs Dep. Tr., 93:6-11, cited in Petitioner Reply, p. 4)

Prosecution History

Claim 1 (original claim 2) amended to accept allowable subject matter in first OA

2. (currently amended) A ~~transistor~~ transmitter of a communication system, the transmitter comprising:

an encoder having a pilot/training symbol inserter, the pilot/training symbol inserter configured to insert pilot symbols into data blocks and to combine training symbols with the data blocks;

at least one modulator, each modulator having an inverse discrete Fourier transform (IDFT) stage and a cyclic prefix inserter, each modulator outputting a frame structure comprising a preamble structure and a data structure, the preamble structure comprising at least one training symbol and an enhanced training symbol; and

at least one transmit antenna, each transmit antenna corresponding to a respective one or the at least one modulator, each transmit antenna transmitting the frame structure output from the corresponding modulator, wherein the enhanced training symbol is a single symbol.

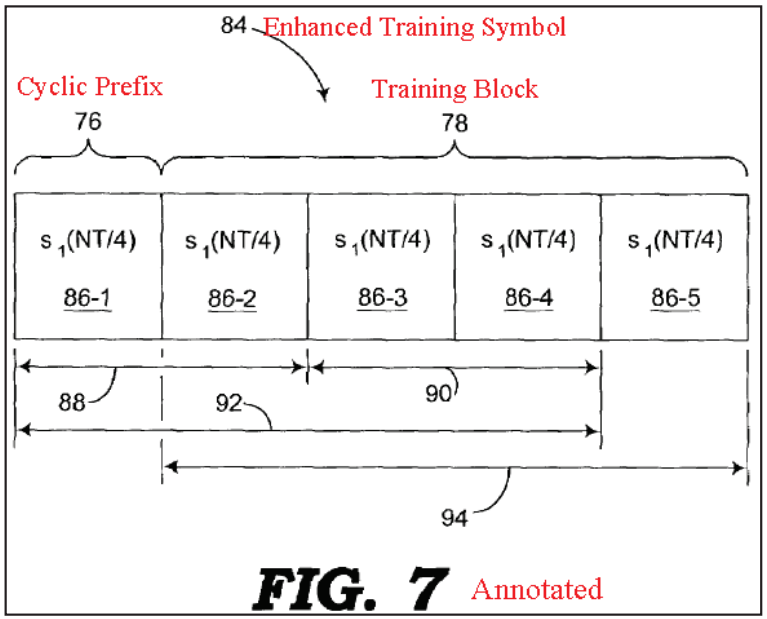
(Prosecution History, p. 59, cited in Petition for IPR, p. 10)

Enhanced Training Symbol (Time Domain)

'127 patent

> The enhanced training symbol **79** of length $G+N_f$ can be further subdivided into smaller sections for efficient synchronization and to perform frequency offset estimation over a wider range. The sequences contained in these sections are

('127 patent, 11:63-66, cited in Petition for IPR, pp. 5-6)



('127 patent, Fig. 7, annotated and illustrated in Petition for IPR, p. 6)

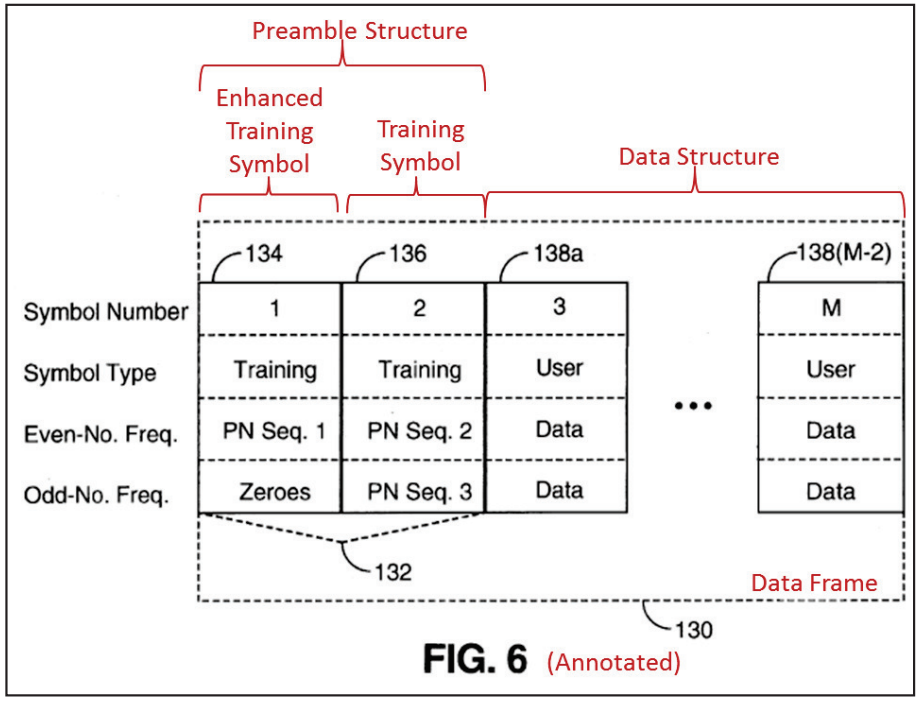
Board's construction of "enhanced training symbol"

> Accordingly, for purposes of this Decision, we construe an "enhanced training symbol" as "a training symbol, comprising a plurality of sections including repeated sequences, and providing at least a synchronization function."

(Decision to Institute, p. 9)

Schmidl discloses an "enhanced training symbol"

- Schmidl discloses transmission of two training symbols



(Schmidl, annotated Fig. 6, Petition for IPR, p. 29)

- Schmidl's first training symbol 134 has identical halves ("sections including repeated sequences")

numbered sub-carriers during the symbol interval. This
55 results in a time-domain OFDM symbol that has two iden-
tical halves since each of the even-numbered sub-carrier
frequencies repeats every half symbol interval, and there are
no odd-numbered sub-carrier frequencies to destroy this
time-domain half-symbol symmetry. First OFDM training

(Schmidl, 12:54-59, cited in Petition for IPR, p. 33 and Decision to Institute, pp. 11 and 14)

Schmidl discloses an "enhanced training symbol"

- Schmidl –first training symbol 134 used for synchronization

carrier frequency offset, Δf_c. To estimate symbol/frame timing in order to synchronize the receiver to the OFDM signal, the method of the present invention utilizes the time-domain symmetry properties of first OFDM training symbol **134**. Specifically, symbol/frame timing according to

(Schmidl, 14:16-20, cited in Decision to Institute, p. 14 and Petition for IPR, p. 13)

One of the key advantages of the present invention over the prior art is that it enables a receiver to accurately synchronize to the symbol/frame timing of an OFDM signal with the reception of just one symbol, first OFDM training symbol **134**. Additionally, establishing timing synchroniza-

(Schmidl, 14:27-31, cited in Decision to Institute, pp. 11 and 14 and Petition for IPR, p. 13)

- Conclusion – Board

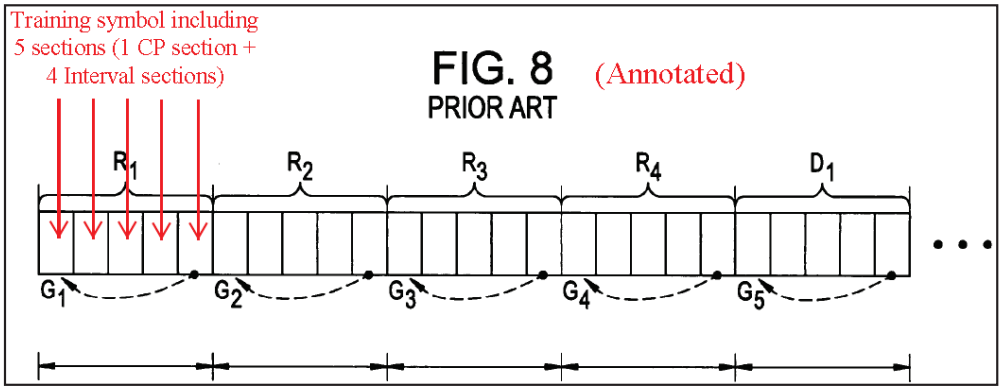
II.A *supra*. Schmidl's first OFDM training symbol performs synchronization, comprises a plurality of sections and has two identical halves, and, thus, discloses, teaches, and suggests the recited enhanced training symbol of claim 1.

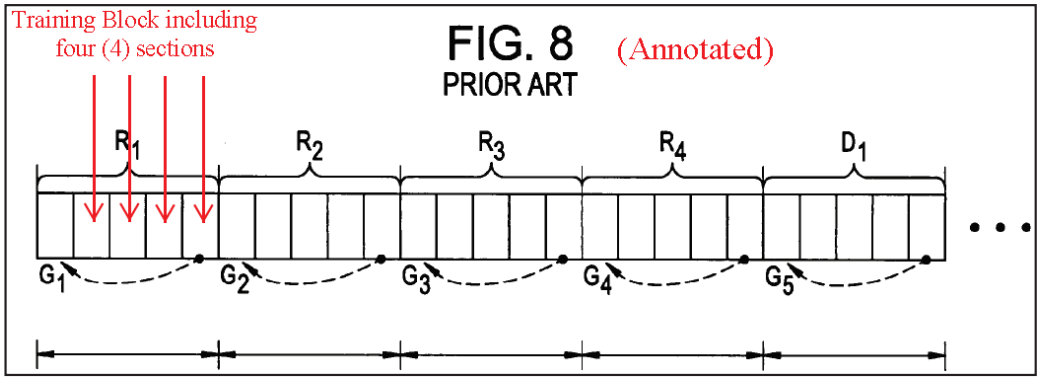
(Decision to Institute, pp. 13-14)

Kim – claims 4 and 6-10

- Kim discloses training symbol including training block having 64 samples divided into four equal sections and a cyclic prefix having 16 samples

(Petition for IPR, pp. 40-43)





(Annotated versions of Kim, Fig. 8, presented in Petition for IPR, pp. 17 and 42)

> Figure 8 depicts a data structure and, in particular, a signal architecture for a wireless network in an OFDM system. Ex. 1004, 2:22–24, 5:31–32. Guard intervals G1 through G5 are provided at the beginning of each training symbol R1 through R4 and data symbol D1. *Id.* at 2:24–26. In each of the symbols, the guard interval is N/4, where N=64, such that the length of the guard interval is 16. *Id.* at 2:32–34.

(Decision to Institute, p. 15)

Combination of Schmidl and Arslan

54. Based on the above discussion, Schmidl is directed at synchronization between wireless transmitters and receivers, and discloses that a transmitter transmits a signal having a frame structure comprising training symbols and data symbols. *See* ERIC-1002, 1:5-12. Also, Arslan is directed at utilizing pilot symbols inserted into the data symbols to maintain synchronization between wireless transmitters and receivers. *See* ERIC-1003, 3:1-6. Further, Arslan discloses a frame structure having training symbols combined with data symbols and pilot symbols inserted into the data symbols. *See id.* Fig. 4. Therefore, both Schmidl and Arslan are directed at improving synchronization between a wireless transmitter and a wireless receiver, and disclose frame structures including information for the same. Accordingly, it would have been obvious for one of ordinary skill in the art to apply the known technique of inserting pilot symbols into data symbols, as taught by Arslan, to the known frame structure of Schmidl to yield predictable results.

(Haas Decl., ¶ 54, cited in Petition for IPR, p. 30)