CLAIMS

1. A phase tracking reception method for a wireless communication system, the method comprising:

initiating processing of a preamble of a wireless frame, the preamble including a plurality of very high throughput (VHT) long training fields (LTFs);

for a first VHT-LTF of the plurality of VHT-LTFs, estimating a one dimensional channel response for each pilot tone of the first VHT-LTF;

for each subsequent VHT-LTF of the plurality of VHT-LTFs,

estimating a one dimensional channel response for each pilot tone of the subsequent VHT-LTF;

estimating a phase rotation based on all estimated one dimensional channel responses; and

applying a correction based on the phase rotation to a plurality of data tones of the preamble of the wireless frame to generate a plurality of corrected data tones for a downstream processing.

2. The method of Claim 1 wherein the downstream processing comprises calculating a channel estimation for a plurality of receive and transmit antennas using the plurality of corrected data tones.

3. The method of Claim 1 wherein the downstream processing is performed after estimating the one dimensional channel response for a last VHT-LTF and estimating the phase rotation based on all estimated one dimensional channel responses including a last one dimensional channel response corresponding to the last VHT-LTF.

4. The method of Claim 1 further including buffering one dimensional channel responses for estimating the phase rotation.

5. The method of Claim 1 further including modeling pilot tones by computing:

$$r_{n,l}(k) = \exp(j\theta_l) \cdot s(k) \sum_{m=1}^{M} h_{n,m}(k)$$

wherein l is an index of an OFDM long training symbol, k is an index of a tone, s(k) is a channel training sequence, M is a number of transmitters in the wireless communication system, m is an index of a transmitter in the wireless communication system, n is an index of a receiver in the wireless communication system, and h is a channel response.

6. The method of Claim 5 wherein the estimating the one dimensional channel response for each pilot tone includes computing:

$$\hat{h}_n(k) = r_{n,l}(k) / s(k)$$ and

the estimating the phase rotation based on all estimated one dimensional channel responses includes computing:

$$\hat{\theta}_l = \sum_{k \in \{pilottones\}} \sum_{n=1}^{M} r_{n,l}(k) \cdot \hat{h}_n(k) .$$

7. The method of Claim 6 wherein the applying the correction includes computing:

$$\tilde{r}_{n,l}(k) = r_{n,l}(k) \cdot \hat{\theta}_l$$

8. (Cancelled)

9. (Cancelled

10. A wireless communication apparatus comprising:

a plurality of antennas operable for receiving and transmitting signals, wherein the signals are partitioned into frequency bins;

a transmit chain coupled to the antennas;

a receive chain coupled to the antennas, wherein the receive chain is configured to process preambles of a wireless frame, each preamble including a plurality of very high throughput (VHT) long training fields (LTFs), wherein the receive chain comprises:

a first circuit for estimating a one dimensional channel response for each pilot tone of a first VHT-LTF and for each subsequent VHT-LTF;

a second circuit for estimating a phase rotation based on all estimated one dimensional channel responses; and

a third circuit for applying a correction based on the phase ~~error~~ rotation to a plurality of data tones of the preamble of the wireless frame to generate a plurality of corrected data tones for a downstream processing circuit.

11. The apparatus of Claim 10 wherein the downstream processing circuit is configured to calculate a channel estimation for a plurality of receive and transmit antennas using the plurality of corrected data tones.

12. The apparatus of Claim 10 wherein the first circuit is configured to model pilot tones by computing:

$$r_{n,l}(k) = \exp(j\theta_l) \cdot s(k) \sum_{m=1}^{M} h_{n,m}(k)$$

wherein l is an index of an OFDM long training symbol, k is an index of a tone, s(k) is a channel

training sequence, M is a number of transmitters in the wireless communication system, m is an index of a transmitter in the wireless communication system, n is an index of a receiver in the wireless communication system, and h is a channel response.

13. The apparatus of Claim 10 wherein the first circuit is configured to estimate the one dimensional channel response for each pilot tone by computing:

$\hat{h}_n(k) = r_{n,l}(k)/s(k)$ and the second circuit is configured to estimate the phase rotation based on all estimated one dimensional channel responses by computing:

$$\hat{\theta}_l = \sum_{k\in(pilottimes)} \sum_{n=1}^{M} r_{n,1}(k) \cdot \hat{h}_n(k) .$$

14. The apparatus of Claim 10 the third circuit is configured to apply the correction by computing:

$\tilde{r}_{n,l}(k) = r_{n,l}(k) \cdot \hat{\theta}_l$.

15. The apparatus of Claim 10 wherein the transmit chain comprises:

a circuit configured for compiling a transmission data stream;

a circuit configured for distributing a preamble and a payload from the compiled transmission data stream into a plurality of parallel spatial streams, wherein a set of identical information is mapped to the preamble in the plurality of parallel spatial streams for estimating a set of channel characteristics and a phase error on reception; and

a circuit configured for transmitting the plurality of parallel spatial streams using a plurality of radio frequency transceivers.

CLAIMS

1. A phase tracking reception method for a wireless communication system, the method comprising:

initiating processing of a preamble of a wireless frame received by multiple space time streams, the preamble including a plurality of very high throughput long training fields (VHT-LTFs), each of the VHT-LTFs including pilot tones and data tones, wherein the pilot tones are the same for the multiple space time streams;

for a first VHT-LTF of the plurality of VHT-LTFs, estimating a first one dimensional channel response for each of the pilot tones of the first VHT-LTF;

for a second VHT-LTF of the plurality of VHT-LTFs, estimating a second one dimensional channel response for each of the pilot tones of the second VHT-LTF;

estimating a first phase rotation in response to the first and second one dimensional channel responses; and

applying a phase correction to the data tones of the second VHT-LTF in response to the first phase rotation, thereby generating a plurality of corrected data tones for a downstream processing.

2. The method of Claim 1 wherein the downstream processing comprises calculating a channel estimation for a plurality of receive and transmit antennas using the plurality of corrected data tones.

3. The method of Claim 1 further including modeling pilot tones by computing:

$$r_{n,1}(k) = \exp(j\theta_1) \cdot s(k) \sum_{m=1}^{M} h_{n,m}(k)$$

wherein θ_1 is a phase rotation of an OFDM long training symbol, k is an index of a tone, s(k) is a channel training sequence, M is a number of transmitters in the wireless communication system, m is an index of a transmitter in the wireless communication system, n is an index of a receiver in the wireless communication system, and h is a channel response.

4. The method of Claim 3 wherein the estimating the one dimensional channel response for each pilot tone includes computing:

$$\hat{h}_n(k) = r_{n,1}(k)/s(k)$$

and

the estimating the first phase rotation based on all estimated one dimensional channel responses includes computing:

$$\hat{\theta}_1 = \sum_{k \in \{\text{pilot tones}\}} \sum_{n=1}^{N} r_{n,1}(k) \cdot \hat{h}_n(k)$$

wherein n is an index of a receiver in the wireless communication system, and N is a number of receivers in the wireless communication system.

5. The method of Claim 4 wherein the applying the

phase correction includes

$$\tilde{r}_{n,1}(k) = r_{n,1}(k) \cdot \hat{\theta}_1$$

computing:

6. The method of Claim 5 wherein a the downstream

$$\hat{H} = \tilde{R} \cdot P^T (P \cdot P^T)^{-1}$$

processing includes computing:

wherein $\tilde{R}$ is a received signal matrix with phase correction, P is a multiple-input multiple-output (MIMO) training cover sequence, and P^T is a matrix transposition of P.

7. The method of Claim 1, further comprising:

for a third VHT-LTF of the plurality of VHT-LTFs, estimating a third one dimensional channel response for each of the pilot tones of the third VHT-LTF;

estimating a second phase rotation in response to the first, second and third estimated one dimensional channel responses; and

applying a second phase correction to the data tones of the third VHT-LTF in response to the second phase rotation, thereby generating a second plurality of corrected data tones for the downstream processing.

8. The method of Claim 1, wherein a MIMO training cover sequence is not applied to the pilot tones.

9. The method of Claim 1, wherein a receive signal matrix (R matrix) is applied to the pilot tones, wherein all rows of the R matrix are identical.

10. A wireless communication apparatus comprising:

a plurality of antennas operable for receiving and transmitting signals, wherein the signals are partitioned into frequency bins;

a transmit chain coupled to the antennas;

a receive chain coupled to the antennas, wherein the receive chain is configured to process preambles of a wireless frame received by multiple space time streams, each preamble including a plurality of very high throughput long training fields (VHT-LTFs), each of the VHT-LTFs including pilot tones and data tones, wherein the pilot tones are the same for the multiple space time streams, wherein the receive chain comprises:

a first circuit for estimating a first one dimensional channel response for each of the pilot tones of a first VHT-LTF of the plurality of VHT-LTFs, and estimating a second one dimensional channel response for each of the pilot tones of a second VHT-LTF of the plurality of VHT-LFTs;

a second circuit for estimating a first phase rotation in response to the first and second one dimensional channel responses; and

a third circuit for applying a phase correction to the data tones of the second VHT-LTF in response to the first phase rotation, thereby generating a plurality of corrected data tones for a downstream processing circuit.

11. The apparatus of Claim 10 wherein the downstream processing circuit is configured to calculate a channel estimation for a plurality of receive and transmit antennas using the plurality of corrected data tones.

12. The apparatus of Claim 10 wherein the first circuit is configured to model pilot tones by computing:

$$r_{n,1}(k) = \exp(j\theta_1) \cdot s(k) \sum_{m=1}^{M} h_{n,m}(k)$$

wherein Θ_1 is a phase rotation of an OFDM long training symbol, k is an index of a tone, s(k) is a channel training sequence, M is a number of transmitters in the wireless communication apparatus, m is an index of a transmitter in the wireless communication apparatus, n is an index of a receiver in the wireless communication apparatus, and h is a channel response.

13. The apparatus of Claim 3 wherein the first circuit is further configured to estimate the one dimensional channel response for each pilot tone by computing:

$$\hat{h}_n(k) = r_{n,1}(k)/s(k)$$

and the second circuit is configured to estimate the phase rotation based on all estimated one dimensional channel responses by computing:

$$\hat{\theta}_1 = \sum_{k \in \{\text{pilot tones}\}} \sum_{n=1}^{N} r_{n,1}(k) \cdot \hat{h}_n(k)$$

wherein n is an index of a receiver in the wireless

communication apparatus and N is a number of receivers in the wireless communication apparatus.

14. The apparatus of Claim 13, wherein the third circuit is further configured to apply the phase correction by computing:

$$\tilde{r}_{n,1}(k) = r_{n,1}(k) \cdot \hat{\theta}_1$$

15. The apparatus of Claim 14 wherein the downstream processing circuit is configured to compute:

$$\hat{H} = \tilde{R} \cdot P^T (P \cdot P^T)^{-1}$$

wherein $\tilde{R}$ is a received signal matrix with phase correction, P is a multiple-input multiple-output (MIMO) training cover sequence, and P^T is a matrix transposition of P.

16. The wireless communication apparatus of Claim 10 wherein the transmit chain comprises:

a circuit configured for compiling a transmission data stream;

a circuit configured for distributing a preamble and a payload from the compiled transmission data stream into a plurality of parallel spatial streams, wherein a set of identical information is mapped to the preamble in the plurality of parallel spatial streams for estimating a set of channel characteristics and a phase error on reception ; and

a circuit configured for transmitting the plurality of parallel spatial streams using a plurality of radio frequency transceivers.

17. The wireless communication apparatus of Claim 16 wherein the set of identical information mapped to the preamble comprises a single stream of pilot tones mapped for the plurality of parallel spatial streams.

18. The apparatus of Claim 10, wherein

the first circuit is further configured for estimating a third one dimensional channel response for each of the pilot tones of a third VHT-LTF of the plurality of VHT-LTFs,

the second circuit is further configured for estimating a second phase rotation in response to the first, second and third estimated one dimensional channel responses, and

the third circuit is further configured for applying a second phase correction to the data tones of the third VHT-LTF in response to the second phase rotation, thereby generating a second plurality of corrected data tones for the downstream processing circuit.