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Enclosed application parts are:

	Spec w/Claims	Number of Pages
X	Spec w/o Claims	Number of Pages 5
	Formal drawings	Number of Sheets
	Informal drawings	Number of Sheets
	Other	Number of Pages

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TITLE OF INVENTION: Scalable and Backwards Compatible Preamble for 11n

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Was this invention made under a Government contract? x No ___ Yes

Identify contract and the Government agency:

Please charge $160 to the deposit account of Texas Instruments Incorporated, Account No. 20-0668.
An original and two copies are enclosed.

Respectfully submitted,

Wade James Brady III

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9/5/03
Date

DRAFT

Scalable and Backwards Compatible Preamble for IEEE 802.11n

1 Introduction

The preamble for the IEEE 802.11n Standard involves a design that is backwards compatible, has low overhead and is scalable to multiple antennas. At the receiver, knowledge of the number of transmit antennas is not available ahead of time posing a unique problem for the design of the 802.11n preamble.

In this document we present a novel invention which solves the aforementioned problems allowing for backwards compatibility and scalability to multiple transmit antennas.

2 Notation

The following notation has been followed in the figures below.

- **LS**: OFDM symbol generated by the 53 subcarriers given by $L_{-26, 26}$ = {1, 1, –1, –1, 1, 1, –1, 1, –1, 1, 1, 1, 1, 1, 1, –1, –1, 1, 1, –1, 1, –1, 1, 1, 1, 1, 0, 1, –1, –1, 1, 1, –1, 1, –1, 1, –1, –1, –1, –1, –1, 1, 1, –1, –1, 1, –1, 1, –1, 1, 1, 1, 1}. (*identical to 11a*)
- **LS1:** OFDM symbol generated by the 53 subcarriers given by $L1_{-26, 26}$ = {1, -1, –1, 1, 1, -1, –1, -1, –1, -1, 1, -1, 1, -1, 1, 1, –1, -1, 1, 1, 1, 1, 1, -1, 1, -1, 0, 1, 1, –1, -1, 1, 1, 1, 1, 1, 1, –1, 1, –1, 1, 1, -1, –1, 1, 1, 1, 1, 1, 1, -1, 1, -1}. (*odd tones of negative frequency of 11a are negated and even tones of positive frequency are negated*)
- **-LS**: OFDM symbol generated by the 53 subcarriers given by $L_{-26, 26}$ = -1x{1, 1, –1, –1, 1, 1, –1, 1, –1, 1, 1, 1, 1, 1, 1, –1, –1, 1, 1, –1, 1, –1, 1, 1, 1, 1, 0, 1, –1, –1, 1, 1, –1, 1, –1, 1, –1, –1, –1, –1, –1, 1, 1, –1, –1, 1, –1, 1, –1, 1, 1, 1, 1}. (*all tones of 11a are negated*)
- **-LS1:** OFDM symbol generated by the 53 subcarriers given by $L1_{-26, 26}$ = -1x{1, -1, –1, 1, 1, -1, –1, -1, –1, -1, 1, -1, 1, -1, 1, 1, –1, -1, 1, 1, 1, 1, 1, -1, 1, -1, 0, 1, 1, –1, -1, 1, 1, 1, 1, 1, 1, –1, 1, –1, 1, 1, -1, –1, 1, 1, 1, 1, 1, 1, -1, 1, -1}. (*even tones of negative frequency of 11a are negated and odd tones of positive frequency are negated*)

- **SIG_L:** Legacy signal field (modulated as in 802.11n standard)

- **SIG_L1:** SIG_L with odd tones of negative frequencies and even tones of positive frequencies negated

- **SIG_N:** 11n signal field (modulated as in Texas Instrument's draft standard)

- **SIG_N1:** SIG_N with odd tones of negative frequencies and even tones of positive frequencies negated

- **GI2:** Twice the appropriate cyclic prefix before the long sequences in pre-SIGNAL preamble

- **GI:** Appropriate cyclic prefix before each symbol

3 Backwards Compatible Preamble

3.1 1 TX Antenna

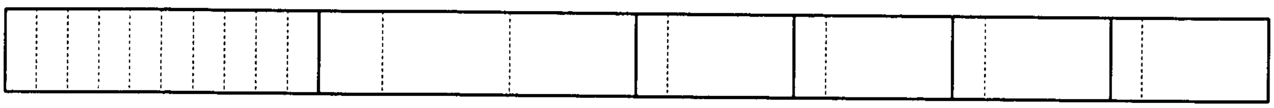

Figure 1: Preamble for 1 transmit antenna

- Packet Detection, AGC, coarse frequency offset, and boundary detection are done during the short sequence.
- FFT placement, fine frequency offset, and Channel estimation are done during the long sequence.
- The legacy Signal field sets the reserved bit to say that it is a HT mode.
- The new signal field gives more information (like new coding, new pilots, num Tx antennas, etc).

3.2 2 TX Antennas

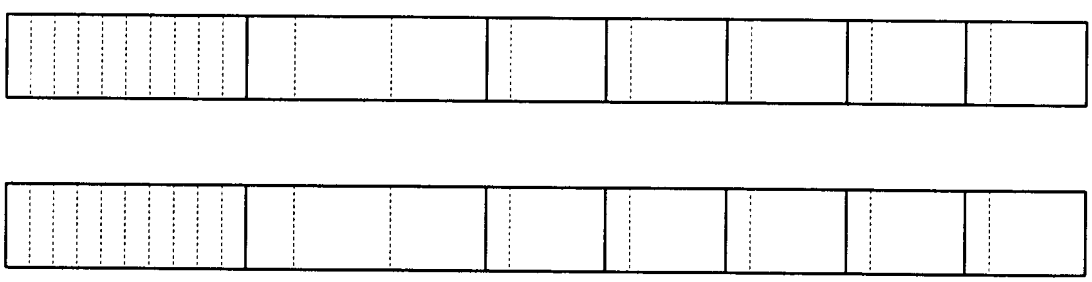

Figure 2: Preamble for 2 transmit antennas

- Channel estimation is done during the long sequence.
- Channel Estimation is performed independently on the even and odd tones.
    - For the even tones, the channel estimated is (H1+H2)
    - For the odd tones it is (H1-H2).
    - Assuming that the rank of channel is small (H1+H2) and (H1-H2) are estimated on all the tones and hence H1 and H2.

3.3 3 TX Antennas

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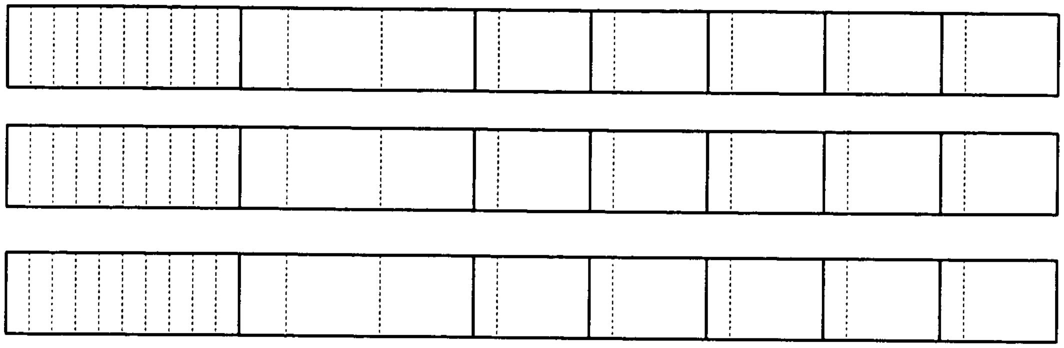

Figure 3: Preamble for 3 transmit antennas

- Channel estimation is done during the long sequence and new long seq.
- Channel Estimation is performed as follows
  - During the long seq
    - For the even tones, the channel estimated is (H1 + H2 + H3)
    - For the odd tones it is (H1 + H2 – H3).
    - Assuming that the rank of channel is small (H1 + H2 + H3) and (H1 + H2 – H3) are estimated on all the tones and hence (H1 + H2) and H3
  - During the new long seq
    - For the even tones, the channel estimated is (H1 - H2 + H3)
    - For the odd tones it is (H1 - H2 – H3).
    - Assuming that the rank of channel is small (H1 - H2 + H3) and (H1 - H2 – H3) are estimated on all the tones and hence (H1 - H2) and H3
  - From both the above steps we could estimate H1, H2, and H3

3.4 4 TX Antennas

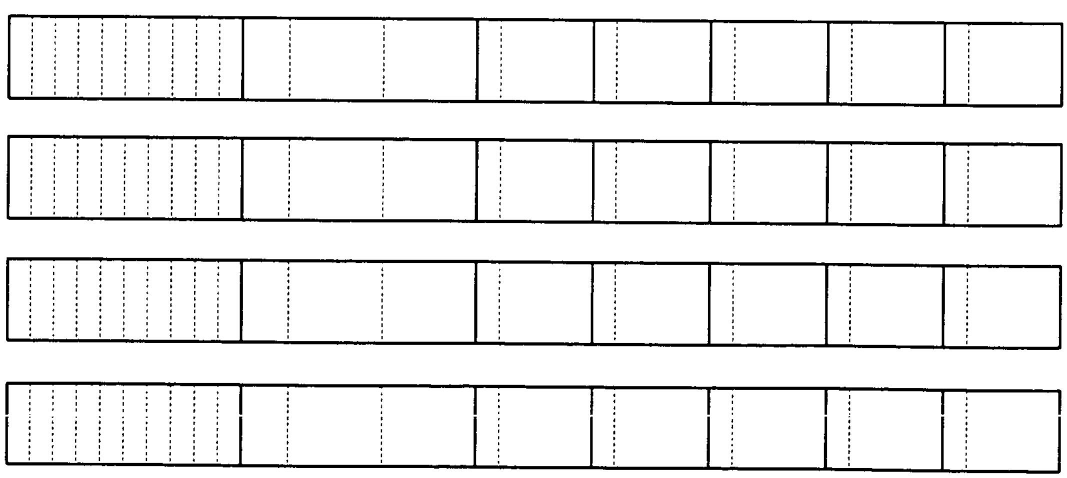

Figure 4: Preamble for 4 transmit antennas

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- Channel Estimation is performed as follows
  - During the long seq
    - For the even tones, the channel estimated is ((H1 + H2) + (H3 + H4))
    - For the odd tones it is ((H1 + H2) – (H3 + H4)).
    - Assuming that the rank of channel is small ((H1 + H2) + (H3 + H4)) and ((H1 + H2) – (H3+H4)) are estimated on all the tones and hence (H1 + H2) and (H3 + H4)
  - During the new long seq
    - For the even tones, the channel estimated is ((H1 - H2) + (H3 - H4))
    - For the odd tones it is ((H1 - H2) – (H3 - H4)).
    - Assuming that the rank of channel is small ((H1 - H2) + (H3 - H4)) and ((H1 - H2) – (H3 – H4)) are estimated on all the tones and hence (H1 - H2) and (H3 – H4)
  - From both the above steps we could estimate H1, H2, H3, and H4

3.5 Some Fine Points

- The above preamble provides a nice upgrade to a 2x2 system with minimal overhead. The overhead for going to 3x3 and 4x4 is an addition of an extra long sequence (channel estimation sequence). In some sense it says that 2x2 is better than the rest and is clean.
- The new long seq is not the same as 11a, it is structured more like a couple of OFDM symbols. This helps in accommodating some of the delay of decoding SIGNAL fields. It is not clear if we need two repeats.
- The receiver always processes the odd and even tones of channel estimation sequence separately. If it so happens to be a SISO system, one could just average the two individual estimates.
- No issues with AGC or radio as all the TX chains are always on.

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