IEEE 802.11
Wireless Access Method and Physical Specification

Title: **Proposed Revision to 94/068**
FHSS PLCP Sublayer - 2nd Edition

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Introduction
This submission contains a proposed revision of section 3 of the FH PHY working draft standard as represented by document 94/068. This supersedes submission 94/103 which was not accepted in the May 1994 meeting. Note that even if this revision is adopted to replace section 3 of 94/068, it is still subject to detailed review and section-by-section voting by the FH PHY sub-group before presentation to the PHY group and the full 802.11 plenary. The changes fall into three categories:

1) Renumbering: The numbering of section 3.x is changed to 9.2.x consistent with the new outline of 93/020 and the proposed outline modification to 94/068.
2) Corrections
   a) Inconsistencies in primitive names and their usage.
   b) Inconsistencies between state machines, timing diagrams, and related text.
   c) Minor text errors.
3) Additions
   a) Definition of PLCP header including PLCP Signaling Field, PLCP_PDU Length Word, and Header Error Check.
   b) Data bias suppression encoding and decoding algorithm using 16-bit blocks as a place holder.
   c) Template CS state machine to illustrate separation of receive and CS functions.
   d) Clarification of insufficiently defined concepts and procedures.

Additions are identified by underlines; deletions by strike-thrus. Paragraph numbering changes are not marked. All other corrections are presented by a combination of deletions and additions.

9.2. FHSS Physical Layer Convergence Procedure Sublayer

9.2.1 Introduction (OPEN). This section provides a convergence procedure ~~in which the~~ to map MAC PDUs ~~are mapped~~ into a ~~framing~~ frame format designed for FHSS radio transceivers. ~~The physical layer convergence procedure describes in how MPDUs are~~ The procedures for transmission, carrier sense, and reception are defined for both single and dual antenna diversity radios. The procedures for radios with more than two antennas are not explicitly defined but must adhere to the same constraints as the dual antenna model.

9.2.2 Physical Layer Convergence Procedure Frame Format (OPEN). ~~Doc 2xx~~ The PLCP Frame Format provides for the asynchronous transfer of MAC Layer MPDU from any transmitting node to all receiving nodes within the wireless LAN. The PLCP frame format illustrated in Figure 9.2-1 consists of three parts: a PLCP Preamble, a PLCP Header, and a PLCP_PDU. The PLCP Preamble provides a period of time for several receiver functions. These functions include antenna diversity, clock and data recovery and data delineation of the PLCP Header and the PLCP_PDU. The PLCP Header is used to specify the length of the MPDU field and support any PLCP management information. The PLCP_PDU contains the MPDU data modified by the MPDU data whitener.
~~**3.3 PLCP Field Definitions** The PLCP packet illustrated in Figure 3-1 contains three distinct fields: PLCP Preamble, PLCP Header, and the MPDU PLCP_PDU.~~

PLCP Preamble		PLCP Header			PLCP_PDU
Sync	Start Frame Delimiter	PSF	PLW	Header Error Check	
80 bits	16 bits	6 bits	10 bits	16 bits	Variable number of octets

Figure 9.2-1. PLCP Frame Format

9.2.2.1 PLCP Preamble (OPEN). The PLCP preamble contains two separate sub-fields; the sync field and the start frame delimiter (SFD), to allow the PHY circuitry to reach steady state demodulation and synchronization of bit clock and frame ~~epoch~~ start.

9.2.2.1.1 Sync ~~Field~~ (OPEN). The preamble sync field is a 10-octet field containing an alternating zero-one pattern, starting with zero, to be used by the PHY sub-layer to detect a signal to receive, select an antenna if diversity is utilized, and to reach steady-state frequency offset correction and synchronization with the received packet timing.

9.2.2.1.2 Start Frame Delimiter (OPEN). The start frame delimiter (SFD) consists of the 16-bit word TBD. The MSB of the start frame delimiter ~~pattern~~ follows the last bit of the sync pattern~~-and indicates the start of the MPDU. The first bit following the frame field start frame delimiter is the first bit~~

~~included in the scrambling~~. The start frame delimiter defines the frame timing.

9.2.2.2 PLCP Header Field Format (OPEN). The PLCP Header field contains three separate sub-fields: ~~a TBD MPDU length word, a TBD PLCP signaling field, and a TBD PLCP header error check/correction field~~ a 6-bit PLCP Signaling Field (PSF), a 10-bit PLCP PDU Length Word (PLW), and a 16-bit PLCP Header Error Check (HEC) field.

~~**3.3.2.1 PLCP Header**. The MPDU length word is used by the receiving terminal to determine the last bit in the packet. The length is passed down from the MAC as a parameter within the PHY_DATA.request primitive. The length represents the TBD (octet/16 bit word) count of the MPDU packet including the HEC check field.~~

9.2.2.2.~~2~~1 PLCP Signaling Field (OPEN). The 6-bit PLCP Signaling Field (PSF) is ~~TBD bits and indicates TBD~~ defined in Table 9.2-1. The PSF is transmitted MSB first (bit 5) and LSB (bit 0) last.

Bit	Parameter Name	Parameter Values	Description
5	Reserved	Reserved	Reserved
4	Reserved	Reserved	Reserved
3	Reserved	Reserved	Reserved
2	Reserved	Reserved	Reserved
1	Reserved	Reserved	Reserved
0	Reserved	Reserved	Reserved

Table 9.2-1. PLCP Signaling Field Bit Descriptions

9.2.2.2.2 PLCP PDU Length Word (OPEN). The PLCP PDU Length Word (PLW) is passed down from the MAC as a parameter within the PHY DATA.request primitive in the transmitting terminal. The PLW represents the number of octets contained in the MPDU packet. Its valid states are 000h - 3FFh, representing counts of zero to 1023 bytes. The PLW is transmitted MSB first and LSB last. The PLW is used by the receiving terminal to determine the last bit in the packet.

9.2.2.2.3 ~~PLCP~~ Header Error Check Field (OPEN). ~~The PLCP header error check field is a 16 bit field generated by TBD method.~~ The Header Error Check (HEC) field is a 16-bit BCH type error detection and correction field. The HEC uses the CCITT 16-bit CRC generator polynomial as follows.

$$F(x) = x^{16}+x^{12}+x^{5}+1$$

At the transmitter, the polynomial is seeded to FFFFh prior to beginning the calculation. The 16-bit remainder after performing the BCH calculation is inverted and placed in the HEC field MSB first to LSB last. At the receiver, the polynomial again is seeded to FFFFh prior to beginning the calculation. The BCH calculation is then performed on the received PLCP Header including the HEC field. If the remainder of this calculation is identically 1D0Fh, no errors were detected in the B PDU

HDR. If the remainder is not 1D0Fh, an error exists. In the case of an error, the value in the remainder can be used to identify the bits that are erred for optional error correction. The CCITT 16-bit CRC can detect up to 6 random bit errors and all burst errors of length 16 or less in the PLCP Header.

9.2.2.3 PLCP_PDU MPDU Data Whitener (OPEN). The PLCP_PDU data whitener uses a TBD scrambling and a TBD#/TBD# bias suppression encoding algorithm ~~TBD scrambling/stuffing is used~~ to randomize the data from highly redundant patterns and to minimize the data DC bias and maximum run lengths. The data whitening starts with the first bit of the PLCP_PDU which follows the last bit of the PLCP Header. The specific method used is ~~TBD~~ defined in section 9.2.3.1. The format of the packet after data whitening is as shown in Figure 9.2-2.

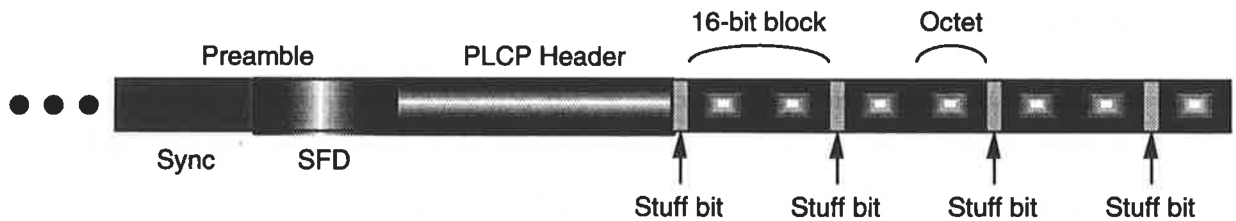

Figure 9.2-2 PLCP_PDU Data Whitener Format.
(17/16 encoding shown for example only; actual numbers are TBD)

9.2.3 PLCP Transmit Procedure (OPEN). The PLCP transmit procedure is executed immediately upon receiving a PHY_DATA.request from the MAC layer. The CSMA/CA protocol is performed by the MAC with the PHY PLCP in the carrier sense mode prior to executing the transmit procedure.

9.2.3.1 Transmit State Machine (OPEN). The PLCP transmit procedure illustrated in Figure 9.2-~~2~~3 includes functions that must be performed prior to, during, and after MPDU data transmission. Before transmitting the first MPDU data bit, the PLCP shall send a PHY_TXBUSY.indicate (STATUS=busy) message to the MAC; switch the PHY PMD circuitry from receive to transmit state; ramp on the transmit power amplifier in the manner prescribed in Section 4 (PMD specification); and transmit the preamble sync pattern and start frame delimiter, and PLCP header. The PLCP shall generate the PLCP header as defined in Section 9.2.2.2 (PLCP Header) in sufficient time to send the bits at their designated bit slot time. The PLCP shall add the PLCP header to the start of the PLCP_PDU data. During transmission of the MPDU PLCP_PDU data, each bit of the MPDU passed down from the MAC shall be processed by the ~~TBD scrambling/ stuffing~~ data whitening state machine defined in Figure 9.2-3a. ~~and~~ A counter shall be maintained to indicate the last bit of the MPDU. The PLCP_PDU data bytes are processed and transmitted MSB first and LSB last. After the last bit of the MPDU is sent PLCP_PDU data has completed propagation through the radio and been transmitted onto the air, the PLCP shall ramp turn off the power amplifier in the manner prescribed in the PMD section and send a PHY_TXBUSY.indicate(STATUS=idle) message to the MAC layer.

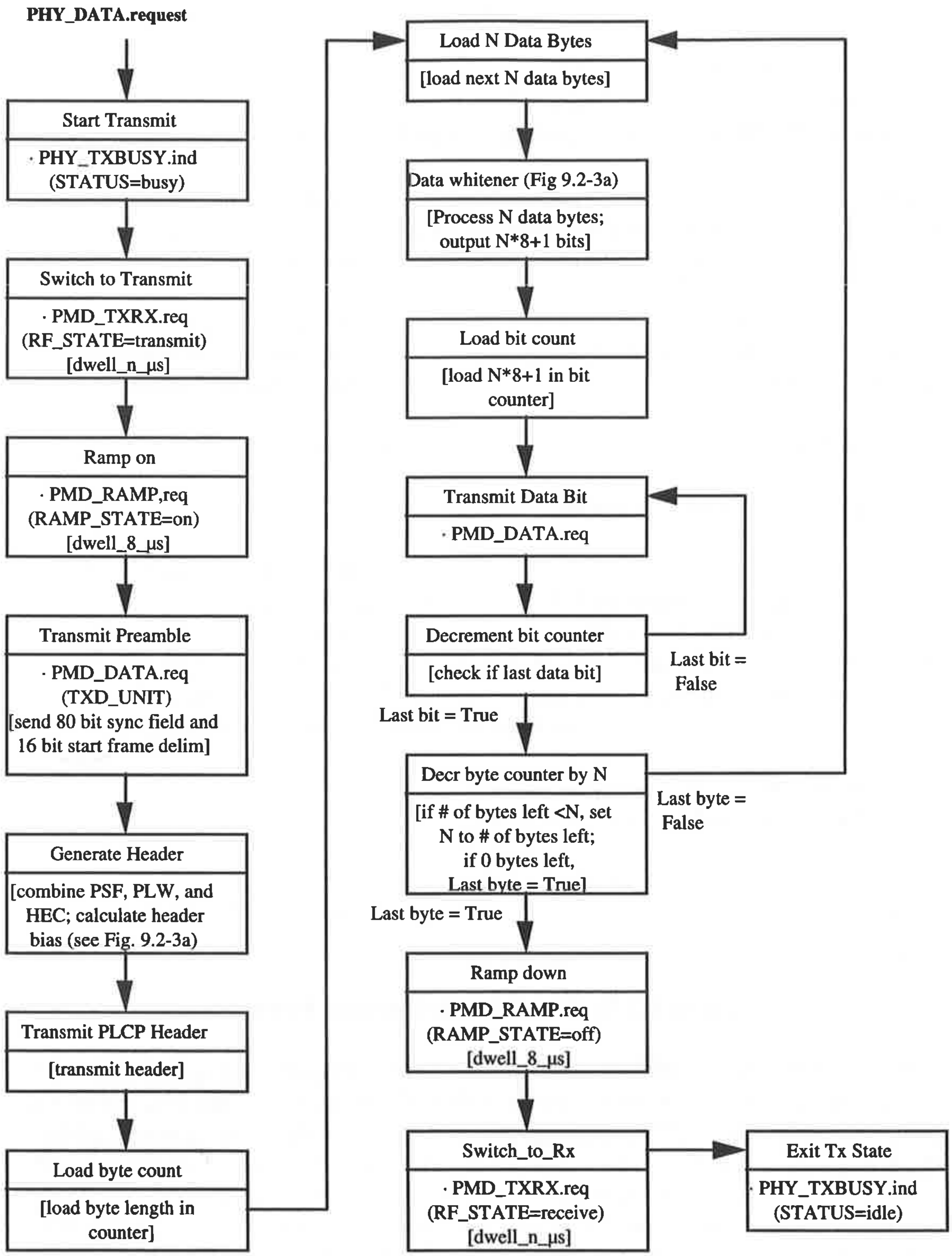

Figure 9.2-3 Transmit State Machine

```
Data Whitener Encoding Algorithm:
      If stuff bit = 1 = next block is inverted; 0 = not inverted
      Accumulate PLCP Header; begin stuffing on first bit of the PLCP_PDU

Input parameter: number_of_MPDU_bytes;                /* can be even or odd */
number_of_blocks_in_packet = truncate{(number_of_MPDU_bytes + 1) / 2 };
                              /* no padding is necessary for odd number of bytes */

Read in header {b(1),...,b(32)};                      /* b(1) is first bit in */
header_bias = 2 [Sum{b(1),...,b(32)}] - (32);         /* calculate bias in header */
Transmit {b(1),...,b(32)};                            /* no stuffing on header */

accum=header_bias;                               /* initialize accum */

For n = 1 to number_of_blocks_in_packet
{
      b(0) = 0;                                       /* b(0) is the stuff bit */
      N = min(2, # of bytes remaining) * 8;      /* N= block size in bits */
      Read in next block {b(1),...,b(N)};             /* b(n) = 0, 1 */
      bias_next_block = 2 [Sum{b(0),...,b(N)}] - (N+1);  /* calculate bias with b(0) */
      If {[accum * bias_next_block > 0] then          /* if accum and bias of next
                                    block has the same sign, then invert block */
       {
            Invert {b(0),...,b(N)};
            bias_next_block = - bias_next_block;
       }
      accum = accum + bias_next_block;
      transmit {b(0),...,b(N)};                       /* b(0) is first bit out */
}
```

Figure 9.2-3a Data Whitener Encoding Procedure

9.2.3.2 Transmit State Timing (OPEN). The transmit timing illustrated in Figure 9.2-4 is defined from the instant that the PHY_DATA.request is received from the MAC layer. The PLCP shall send a PHY_TXBUSY.indicate (STATUS=busy) message to the MAC within 1 µs of receipt of the PHY_DATA.request. The PMD circuitry shall be switched from receive to transmit and settled within TBD µs. The power amplifier shall be turned on and settled within the specified range about the final transmit power level 8 µs after the receive to transmit switch time. The PLCP preamble shall be transmitted at 1 Mbps and be completed within 96 µs. The ~~scrambling/stuffing~~ data whitening algorithm shall be enabled with the first bit following the preamble start frame delimiter and continue to the end of the MPDU. The PLCP header shall be transmitted at 1 Mbps and be completed within ~~TBD bit times~~ 32 µs. The variable length ~~MPDU~~ PLCP_PDU shall be transmitted at the selected data rate. Each byte of the MPDU data shall be sent with the most significant bit of each byte first and the least significant bit last. After the last bit of the ~~MPDU~~ PLCP PDU data has ~~been transmitted~~ completed propagation through the radio and been transmitted onto the air, the PLCP shall turn off the power amplifier and be less than the specified off-mode transmit power in 8 µs. At the end of the power amplifier ramp down period, the PLCP shall send a PHY_TXBUSY.indicate(STATUS=idle) message to the MAC layer and switch the PMD circuitry from transmit to receive. Upon completion of the transmit procedure, the PLCP shall return to the PLCP carrier sense procedure.

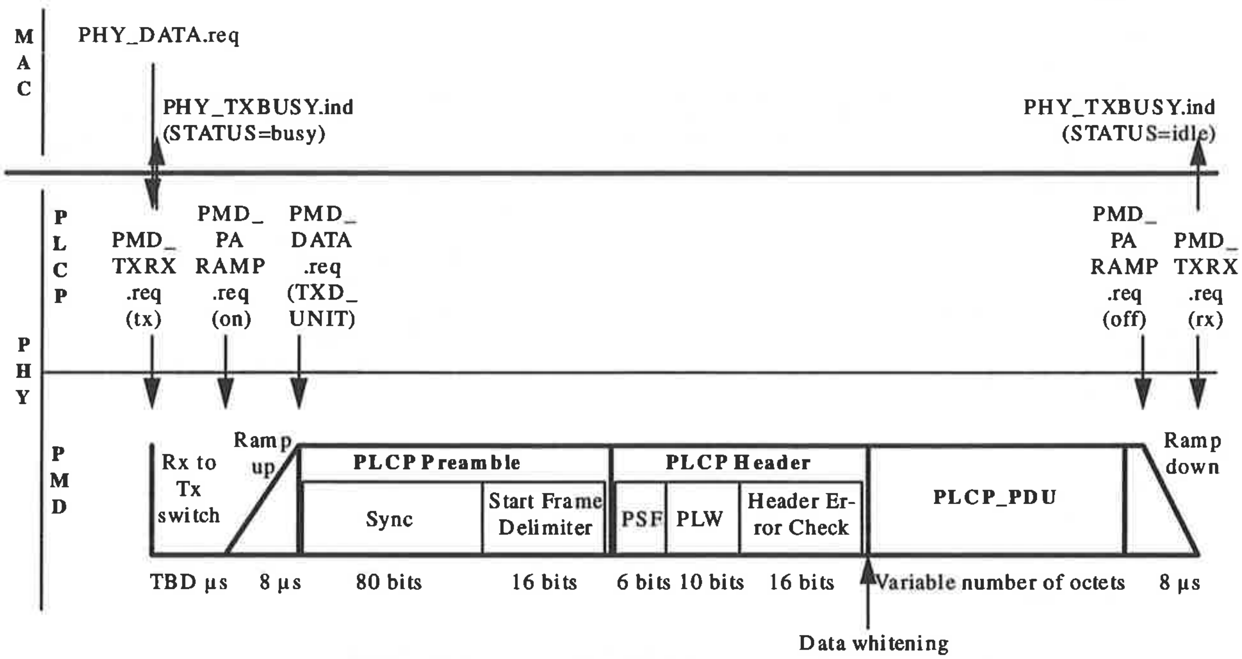

Figure 9.2-4 Transmit State Timing

9.2.4 Carrier Sense Procedure (OPEN). Add Text

9.2.4.1 Carrier Sense With Diversity (OPEN). Add Text

9.2.4.1.1 Carrier Sense With Diversity State Machine (OPEN). Add Text

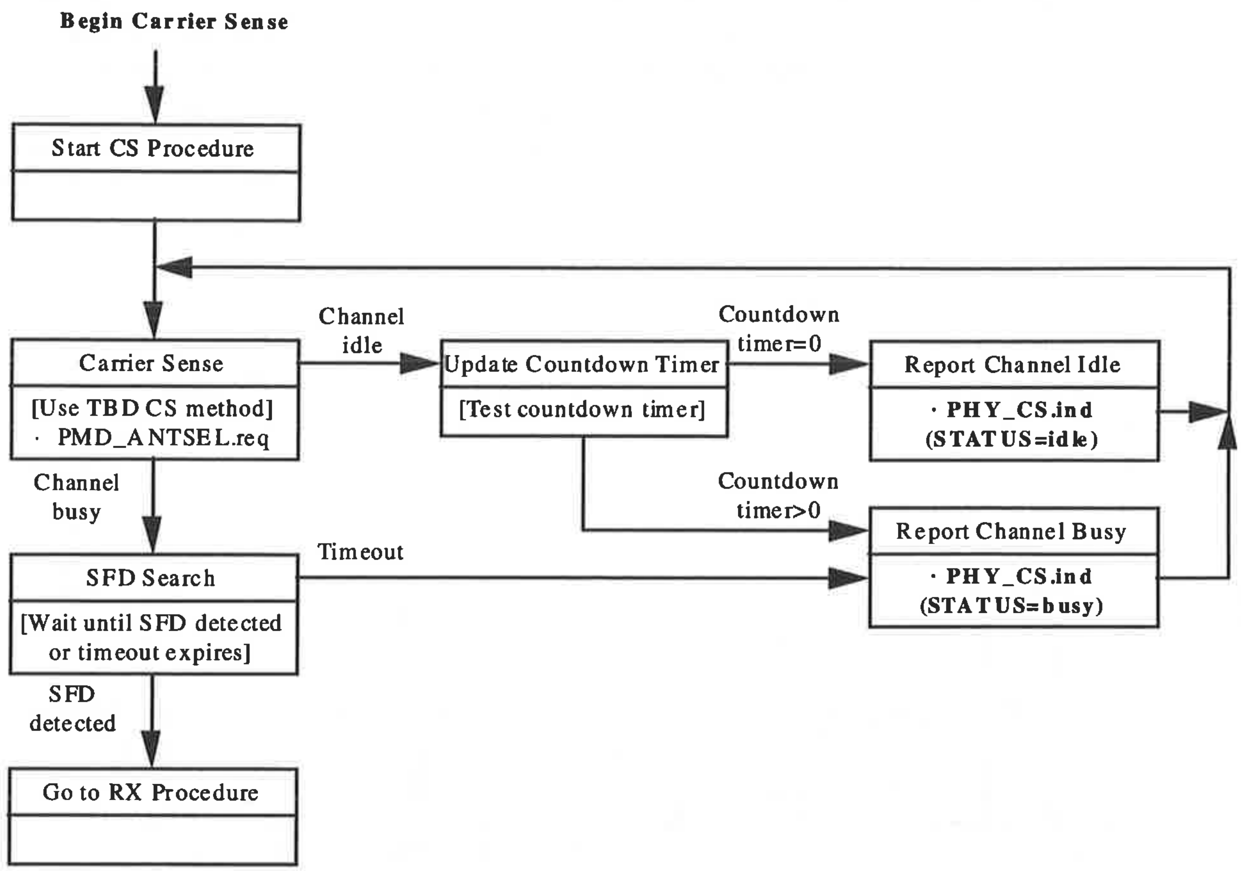

Figure 9.2-5 Carrier Sense with Diversity State Machine

9.2.4.1.2 Carrier Sense With Diversity State Timing (OPEN). Add Text

TBD

Figure 9.2-6 Carrier Sense with Diversity State Timing

9.2.4.2 Carrier Sense Without Diversity (OPEN). Add Text

9.2.4.2.1 Carrier Sense Without Diversity State Machine (OPEN). Add Text

TBD

Figure 9.2-7 Carrier Sense without Diversity State Machine

9.2.4.2.2 Carrier Sense Without Diversity State Timing (OPEN). Add Text

TBD

Figure 9.2-8 Carrier Sense without Diversity State Timing

9.2.5 PLCP Receive Procedure (OPEN). The PLCP receive procedure is invoked by the PHY PLCP carrier sense procedure upon detecting a portion of a preamble followed by the start frame delimiter.

9.2.5.1 Receive State Machine (OPEN). The PLCP receive procedure shown in Figure 9.2-9 includes functions that must be performed while receiving the PLCP header and the ~~MPDU~~ PLCP_PDU data. The PLCP receive procedure begins upon detection of a complete start frame delimiter in the carrier sense procedure. The PLCP shall read in the 32-bit PLCP header and perform an error check using the header error check field. Immediately upon detection of a valid PLCP header, ~~start of the PLCP receive procedure~~ the PLCP shall send a PHY_RXBUSY.indicate (STATUS=busy) message to the MAC layer. ~~While receiving the PLCP header, the PLCP shall read the TBD length word, TBD PHY signaling field, and TBD FEC field, and perform a TBD error check/correction. If the PLCP header is free or corrected of errors,~~ The PLCP shall set a PLCP_PDU byte/bit counter to indicate the last bit of the packet, receive the ~~MPDU~~ PLCP_PDU data bits and perform the ~~TBD descrambling/ unstuffing~~ data whitening procedure shown in Figure 9.2-9a on each ~~MPDU~~ PLCP_PDU bit. After the last ~~MPDU~~ PLCP_PDU bit is received, the PLCP shall send a PHY_DATA.indicate~~(length, data)~~ message and a PHY_RXBUSY.indicate (STATUS=idle) message to the MAC layer. Upon completion of receiving a packet, the PLCP shall exit the receive procedure and return to the PLCP carrier sense procedure with TIME_REMAINING=0.

If the PLCP header contains uncorrectable errors, the PLCP shall ~~send a PHY_RXERROR. indicate message to the MAC layer and exit the receive procedure~~ immediately set the byte/bit counter to zero, complete the receive procedure with a PHY_DATA.indicate(LENGTH=0, DATA=0, RXERROR=header violation) and a PHY_RXBUSY.indicate (STATUS=idle) to the MAC, and return to the carrier sense procedure with TIME_REMAINING=0. If the signal is interrupted for any reason, the PLCP shall immediately complete the receive procedure with a PHY_DATA.indicate(LENGTH, DATA, RXERROR=carrier lost) and a PHY_RXBUSY.indicate (STATUS=idle) to the MAC, and return to the carrier sense procedure with TIME_REMAINING= byte/bit count remaining. If any other error was detected during the reception of the packet, the PLCP shall immediately complete the receive procedure with a PHY_DATA.indicate(LENGTH, DATA, RXERROR=header violation) and a PHY_RXBUSY.indicate (STATUS=idle) to the MAC, and return to the carrier sense procedure with TIME_REMAINING=byte/bit count remaining.

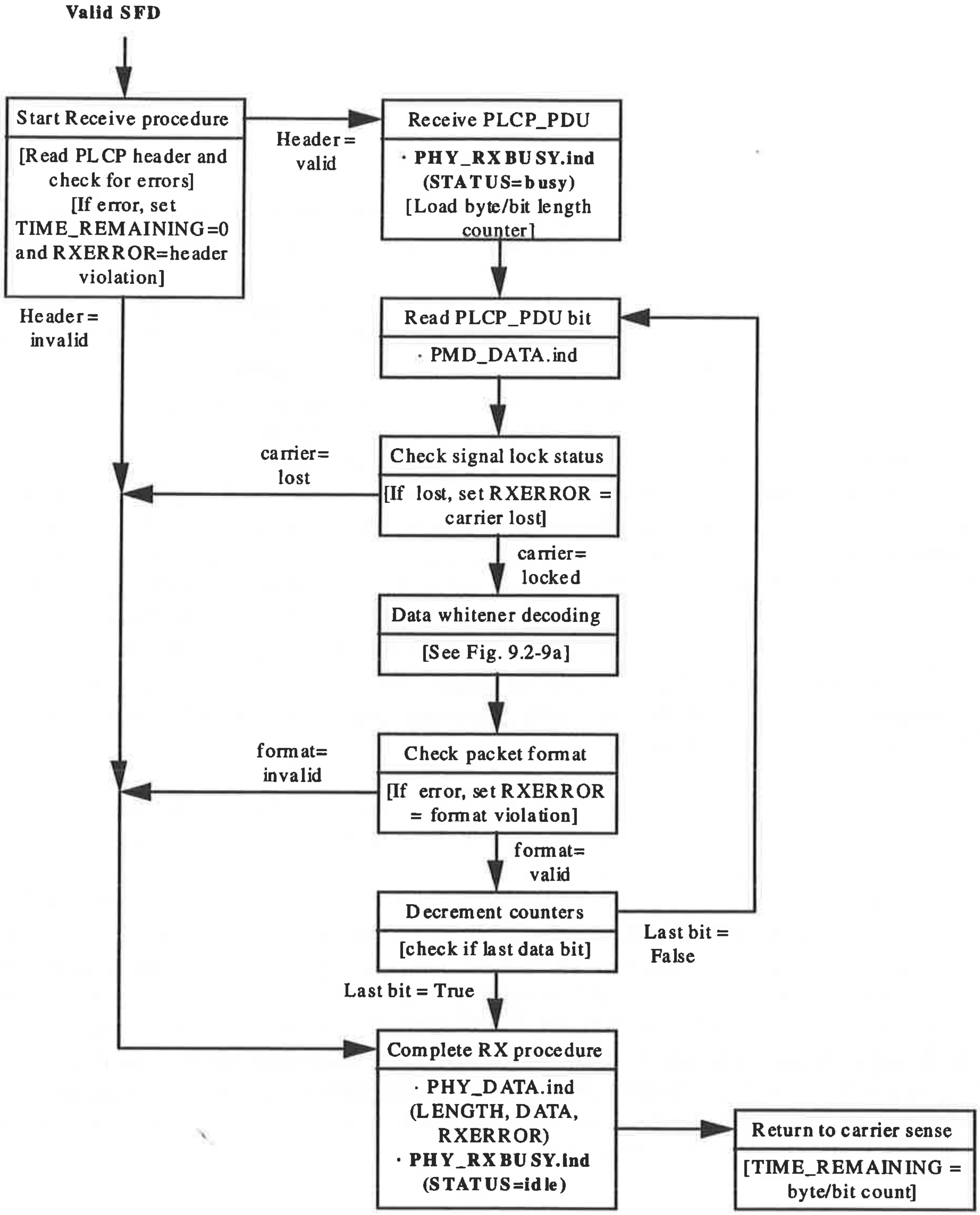

Figure 9.2-94 Receive State Machine

```
Data Whitener Decoding Algorithm:
    If stuff bit = 1 = next block is inverted; 0 = not inverted
    Algorithm begins on first bit of PLCP Header following the start frame delimiter;
    accumulate PLCP Header; begin stuffing on first bit of the PLCP_PDU

Read in header {b(1),...,b(32)};                              /* b(1) is first bit in */
accum = 2 [Sum{b(1),...,b(32)}] - (32);                       /* calculate bias in header */

Verify header error check (HEC);             /*not part of bias suppression algorithm*/
Get number_of_MPDU_bytes from header;                         /* can be even or odd */
number_of_blocks_in_packet = truncate{(number_of_MPDU_bytes + 1) / 2 };

For n = 1 to number_of_blocks_in_packet
{
    N = min(2, # of bytes remaining) * 8;            /* N= block size in bits */
    Read in next block {b(0),...,b(N)};                       /* b(n) = 0, 1 */
    bias_next_block = 2 [Sum{b(0),...,b(N)}] - (N+1);  /* calculate bias with b(0) */
    accum = accum + bias_next_block;
    If (accum < -32 or accum > +32) send bias error indication to MAC;

    If {[b(0)=1] then Invert {b(1),...,b(N)};                 /* if invert bit=true */
    Send {b(1),...,b(N)} to MAC
}
```

Figure 9.2-9a Data Whitener Decoding Procedure

9.2.5.2 Receive State Timing (OPEN). The receive state timing shown in Figure 9.2-10 is defined ~~at the end of the last bit of the~~ to begin upon detection of a complete start frame delimiter in the carrier sense procedure ~~when the PMD_FDET is generated~~. The PLCP shall read in the PLCP header and generate a PHY_RXBUSY.indicate message to the MAC layer within 1 μs of receiving the last bit of a valid PLCP header. The PLCP shall ~~read in the TBD MPDU length indicator and TBD PHY signaling field of the PLCP header and calculate and~~ preload the byte/bit ~~count in the~~ counter ~~within TBD of~~ prior to the last bit of a valid PLCP header ~~the length indicator. The PLCP shall read in the TBD header error check field and perform the check within TBD μs of the last bit of the error check field.~~ The PLCP shall begin receiving the variable length ~~MPDU~~ PLCP_PDU immediately after the end of the last bit of the PLCP header. The PLCP shall send the PHY_RXBUSY.indicate (STATUS=idle) and PHY_DATA.indicate messages within 1 μs of receiving the last PLCP_PDU data bit.

If there was an uncorrectable error in the PLCP header, the PLCP shall terminate the receive procedure within TBD μs of the ~~start~~ end of the ~~MPDU~~ PLCP header. If any other error was detected during the reception of the packet, the PLCP shall terminate the receive procedure within TBD μs of detecting the error.

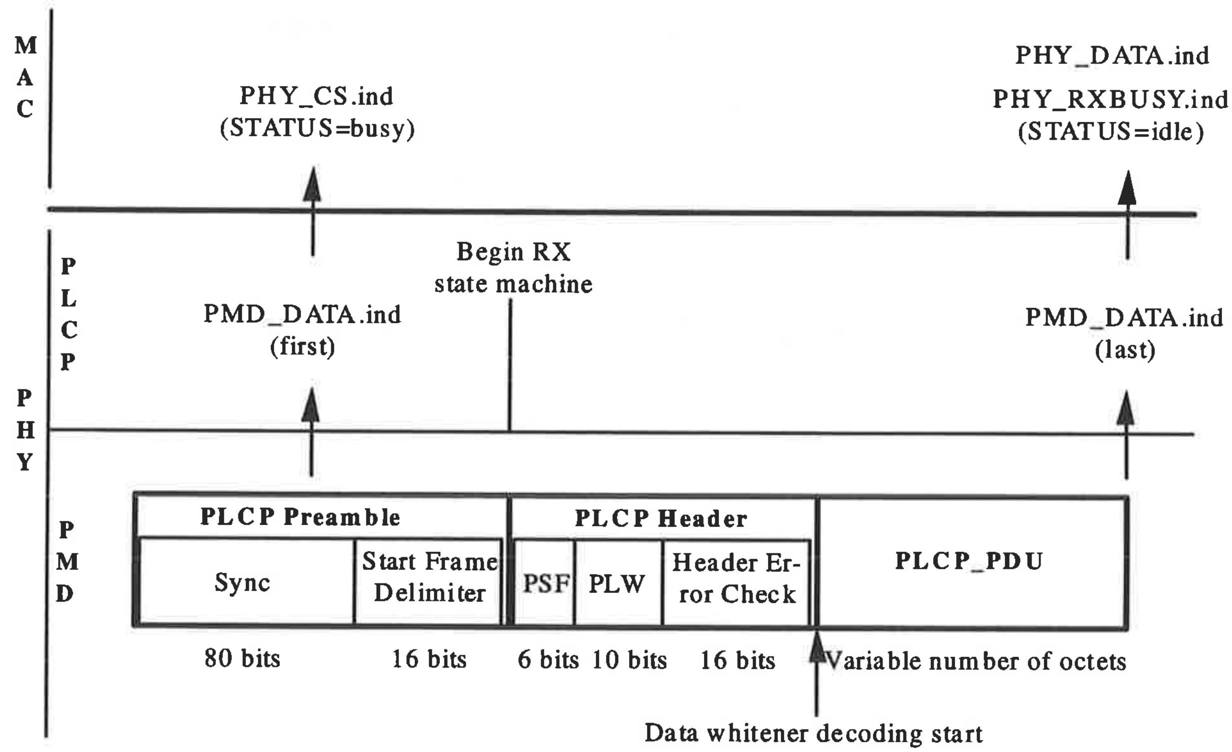

Figure 9.2-105 Receive Timing

Motion: Replace section 3.x (FHSS PLCP Sub-layer) of the FH PHY working draft document 94/068 with the contents in this submission.