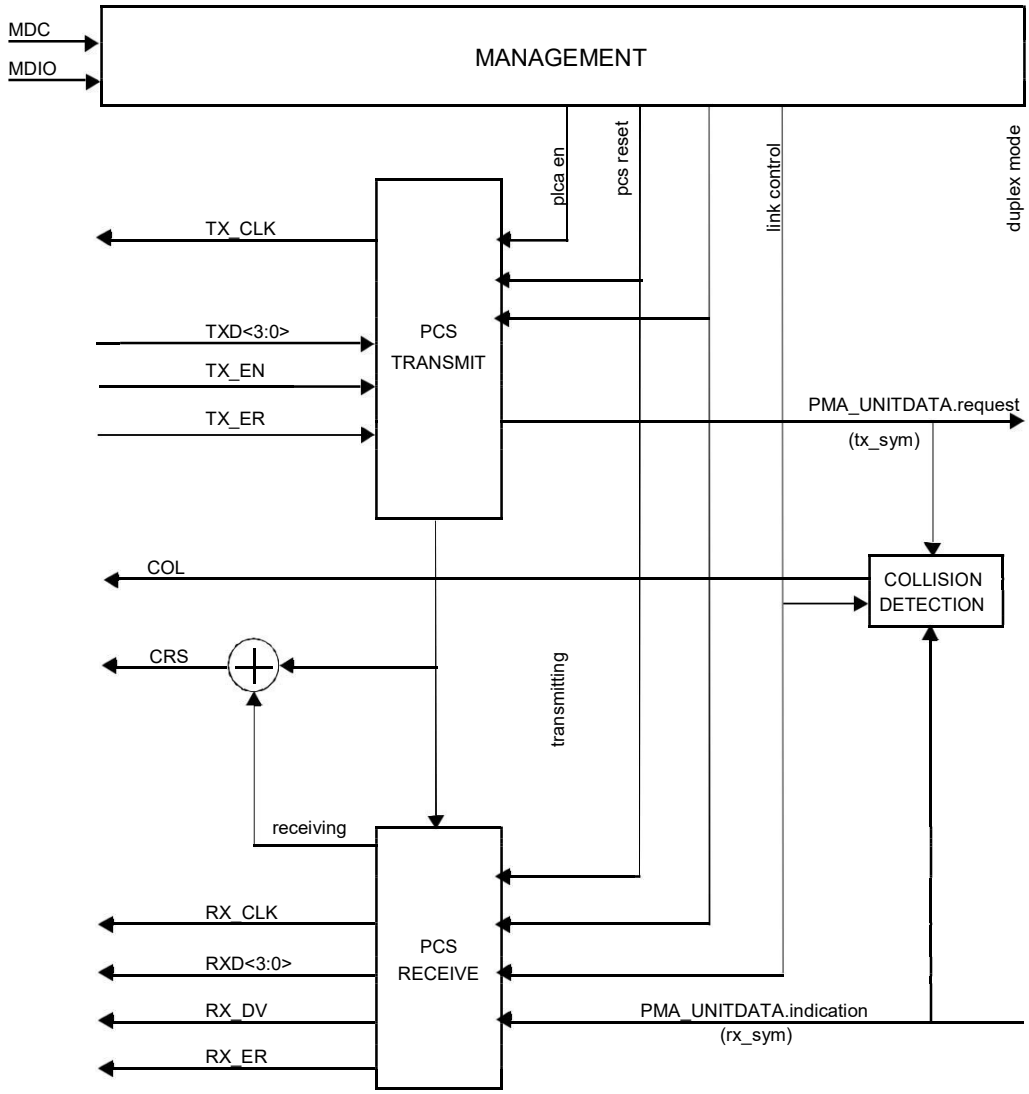


Figure 147–3—PCS reference diagram

147.3.2 PCS Transmit

147.3.2.1 PCS Transmit overview

The PCS Transmit function shall conform to the PCS Transmit state diagram in Figure 147–4 and Figure 147–5, and the associated state variables, functions, timers and messages.

In each symbol period, PCS Transmit generates a symbol tx_sym conveyed to the PMA, where tx_sym is a five-bit vector. The PMA encodes tx_sym, LSB first, into a DME stream over the wire pair BI_DA at a nominal symbol clock frequency specified in 147.5.3.4.

Upon the assertion of TX_EN, the PCS Transmit function passes a group of two SYNC symbols to the PMA, followed by two SSD symbols, which replaces the first 16 bits of the packet preamble. Following the second SSD, TXD<3:0> is encoded into 5B symbols using encoding rules specified in Table 147–1, until TX_EN is deasserted.

If optional OAM channel is supported (oam_en = ON), the 15 bit OAM data (oam_txdata) replaces part of the packet preamble starting at the 34th bit (included) from TX_EN asserted, overriding the TXD<3:0> content as shown in figure 147-4.

Following the deassertion of TX_EN, the PCS Transmit generates a special code ESD, followed by either ESDOK or ESDERR when a transmit error is encountered.

The 10BASE-T1S has one special 5B symbol 'I' (binary vector of 1,1,1,1,1) which represents SILENCE. When the PHY is operating in half-duplex multidrop mode, the PMA Transmit functions shall put the PMD into a high impedance state on reception of this symbol from the PCS Transmit. When operating in point-to-point mode, the PMA shall drive a zero voltage level on the line on receipt of the 'I' symbol.

147.3.2.2 Variables

pcs_reset

The pcs_reset parameter set by the PCS Reset function.
Values: ON or OFF

pcs_txen

The TX_EN signal of the MII as specified in 22.2.2.3.
When set to FALSE transmission is disabled.
When set to TRUE transmission is enabled.
Values: TRUE or FALSE

pcs_txer

The TX_ER signal of the MII as specified in 22.2.2.5.
When set to FALSE it indicates a non-errored transmission.
When set to TRUE it indicates an errored transmission.
Values: TRUE or FALSE

pcs_txd

The TXD signal of the MII as specified in 22.2.2.4.
This signal represents a 4B data nibble to be transmitted.

plca_en

The plca_en signal described in 148.4.5.2.
When the optional PLCA RS is not implemented, plca_en shall be set to OFF

tx_cmd

5B symbol to be transmitted when the PCS Transmit function is in SILENT state. The tx_cmd variable is assigned according to PLCA RS signaling over MII interface, as defined in 22.2.2.4, 148.4.3.1.1, and 148.4.3.1.2. The following mapping shall be used (see also Table 147–1):
- tx_cmd <= 'N' when a BEACON request is asserted
- tx_cmd <= 'J' when a COMMIT request is asserted
- tx_cmd <= 'I' otherwise.
When PLCA capabilities are not supported or disabled, tx _cmd shall be set to the special 5B symbol 'I' (binary vector of 1,1,1,1,1) representing SILENCE.

tx_sym

5B symbol to transmit, generated from the MII data or directly passed from tx_cmd in SILENT state when optional PLCA reconciliation sublayer is implemented.

transmitting

This variable is set in the PCS Transmit state, as described in Figure 147–4.
When this variable is set to TRUE it indicates a transmission is ongoing.
Values: TRUE or FALSE

err

This variable is set in the PCS Transmit state, as described in Figure 147–4 and Figure 147–5.
This variable is used to detect and latch a pcs_txer = TRUE condition during data trans-

mission; if such error is detected, an ESDERR symbol is sent at the end of transmission. Values: TRUE or FALSE

link_control

This variable is generated by management or set by default. When set to FALSE all PCS functions are switched off and no data can be sent or received. Values: TRUE or FALSE

oam_en Defines whether OAM transmission is enabled. This variable is set by MDIO or equivalent functionality. If OAM is not supported, this variable shall be set to OFF. Values: ON or OFF

oam_txdata 15 bits OAM data to be sent over the packet preamble. This variable is set by MDIO or equivalent functionality. If OAM is not supported or not enabled, the content of this variable is undefined.
Values:

txcnt general purpose counter for the PCS transmit function

SYNC

5B symbol defined as ‘J’ in 4B/5B encoding (see also Table 147–1)

SSD

5B symbol defined as ‘H’ in 4B/5B encoding (see also Table 147–1)

ESD

5B symbol defined as ‘T’ in 4B/5B encoding (see also Table 147–1)

ESDERR

5B symbol defined as ‘K’ in 4B/5B encoding (see also Table 147–1)

ESDOK

5B symbol defined as ‘R’ in 4B/5B encoding (see also Table 147–1)

SILENCE

5B symbol defined as ‘I’ in 4B/5B encoding (see also Table 147–1)

147.3.2.3 Function

ENCODE

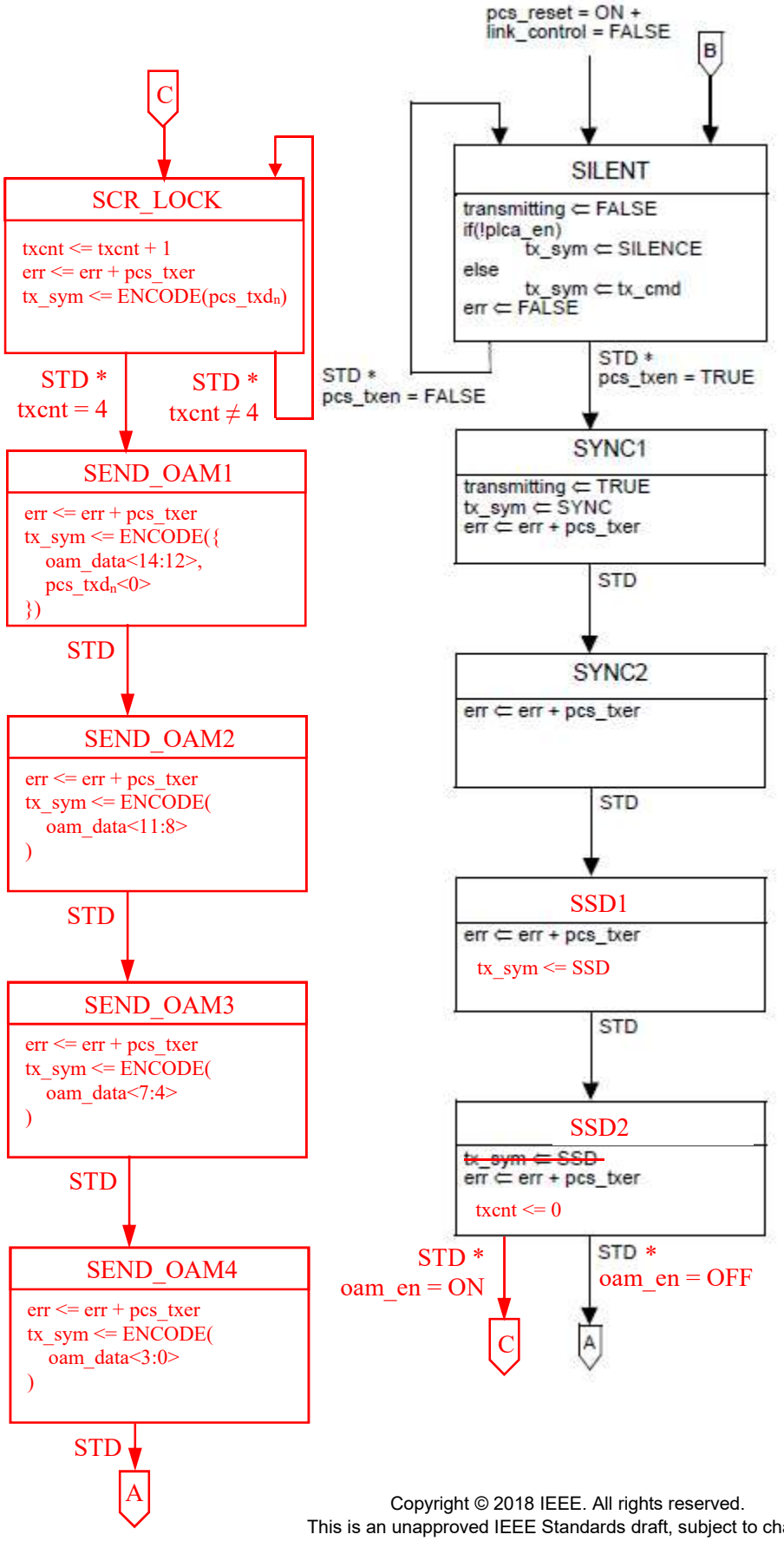
In the PCS transmit process, this function takes as its arguments four bits of input data and returns the corresponding 5B symbol as defined in Table 147–1.

Table 147–1—4B/5B Encoding

Name	4B	5B	Name	4B	5B	Special function
0	0000	11110	I	N/A	11111	SILENCE
1	0001	01001	J	N/A	11000	SYNC
2	0010	10100	K	N/A	10001	ESDERR
3	0011	10101	T	N/A	01101	ESD
4	0100	01010	R	N/A	00111	ESDOK
5	0101	01011	H	N/A	00100	SSD

Table 147–1—4B/5B Encoding *(continued)*

Name	4B	5B	Name	4B	5B	Special function
6	0110	01110	N	N/A	01000	BEACON
7	0111	01111				
8	1000	10010				
9	1001	10011				
A	1010	10110				
B	1011	10111				
C	1100	11010				
D	1101	11011				
E	1110	11100				
F	1111	11101				



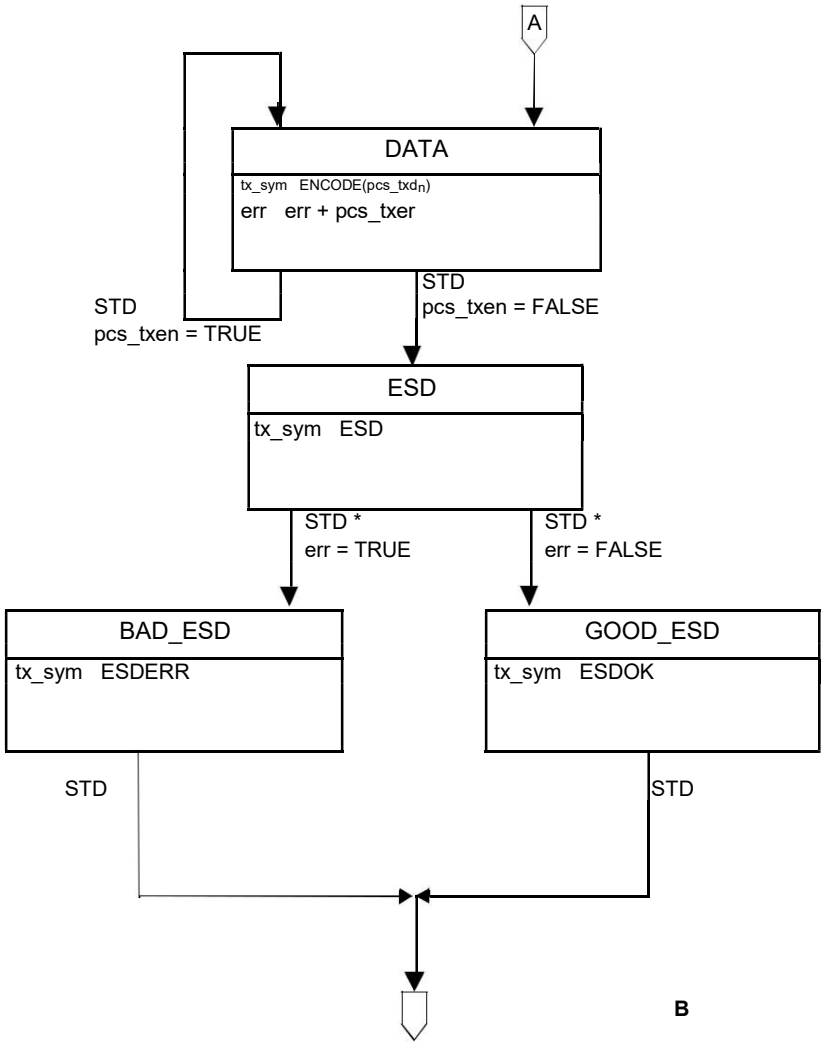


Figure 147–5—PCS Transmit state diagram (2 of 2)

147.3.2.4 Abbreviations

STD

Alias for 5B symbol timer done, synchronous to PCS TX clock.

147.3.3 PCS Receive overview

The PCS Receive function shall conform to the PCS Receive state diagram in Figure 147–6 and Figure 147– 7, and associated state variables.

Note: A JAB state machine as the one defined for the 10BASE-T1L PHY in Clause 146 is not required for the 10BASE-T1S PHY because even in case of mis-detection of the ESD special symbol, the actual end of a transmission can still be detected by the PMA exploiting the absence of DME activity on the line. In fact, during idle period (i.e. when no data is being transmitted), the PMD is either driving a constant zero voltage level or put into high impedance state, depending on the operating mode (see 147.5.1).

The finite state machine defined in Figure 147–6 is triggered by the reception of a SYNC symbol ~~'J'~~ from the PMA Receive function and waits for two SSD symbols ~~'K'~~ to start regenerating the packet preamble whose start has been replaced with the SYNC, SYNC, SSD, SSD sequence (that is a J/J/H/H 5B sequence) by the PCS Transmit functions as described in Figure 147–4. ~~Following the SSD marker there are four states before the DATA state to accomplish this task.~~

After the last SSD is received, the PCS Receive function discards the next eight symbols which shall instead be used to achieve lock of the self-synchronizing scrambler. Afterward, regardless of whether the optional OAM channel support is enabled or not, the PCS Receive function decodes one more symbol containing the last bit needed for scrambler locking and the first three most significant bits of the optional OAM field. The remaining bits of the optional OAM fields are then decoded from the next three 5B symbols.

During the time the PCS Receive function is decoding data for the scrambler locking and for optionally receiving the OAM bits, the special value 5 is conveyed to the MII via the pcs_rxd variable, thus rebuilding the original preamble transmitted by the MAC.

Eventually the PCS Receive function switches to the DATA state where 5B symbols are being decoded and conveyed to the MAC via MII interface as appropriate.

The DATA state, in which 5B symbols are decoded into MII data, is left when ESD followed by either ESDOK or ESDERR symbol is encountered or when the PMA detects SILENCE on the media (e.g. the transmitter prematurely stops data transmission).

The variables, functions, and timers used in Figure 147–5 are defined as below. For the definition of pcs_reset, SILENCE, SYNC, SSD, ESD, ESDOK and ESDERR see 147.3.2.2.

147.3.3.1 Variables

receiving

This variable is set in the PCS Receive state, as described in Figure 147–6 and Figure 147–7.
When it is set to TRUE it indicates that a data reception is ongoing.
Values: TRUE or FALSE

duplex_mode

This variable indicates whether the PHY is configured for full-duplex operation (DUPLEX_FULL) or half-duplex operation (DUPLEX_HALF). This variable is set after bit 8 in MDIO register 0 defined in Table 22-7.

pcs_rxdv

The RX_DV signal of the MII as specified in 22.2.2.7.

pcs_rxer

The RX_ER signal of the MII as specified 22.2.2.10.

pcs_rxd

PCS decoded data synchronous to RX_CLK.

oam_rxdata

15 bits OAM data retrieved from packet preamble. This variable is intended to be available for reading via MDIO or similar interface. If OAM transmission is not supported or not enabled by the link partner, the content of this variable is undefined.

RXn

Received 5b symbol generated by PMA receive at time n.

SILENCE

The 5B symbol defined as 'I' in 4B/5B encoding.

147.3.3.2 Functions

DECODE

nts a 5B symbol from PMA and returns the corresponding 4B MII data as defined in Table 147–1. If a viola-tion of the encoding rules is detected, PCS Receive asserts the signal RX_ER for at least one symbol period.

147.3.3.3 Abbreviations

RSCD	Alias for Receive Symbol Conversion Done, synchronous to PCS RX clock

.

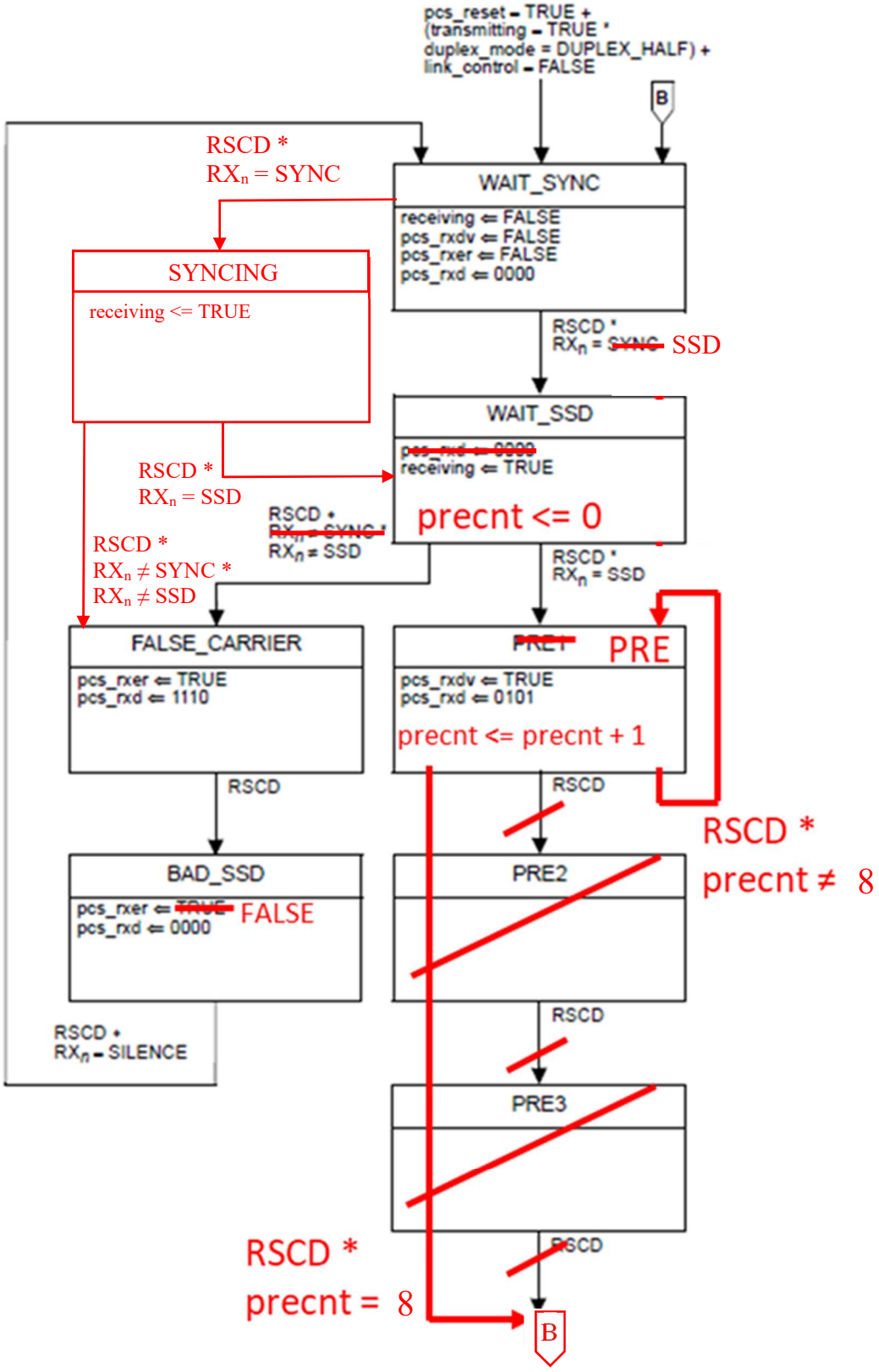


Figure 147–6—PCS Receive state diagram (1 of 2)

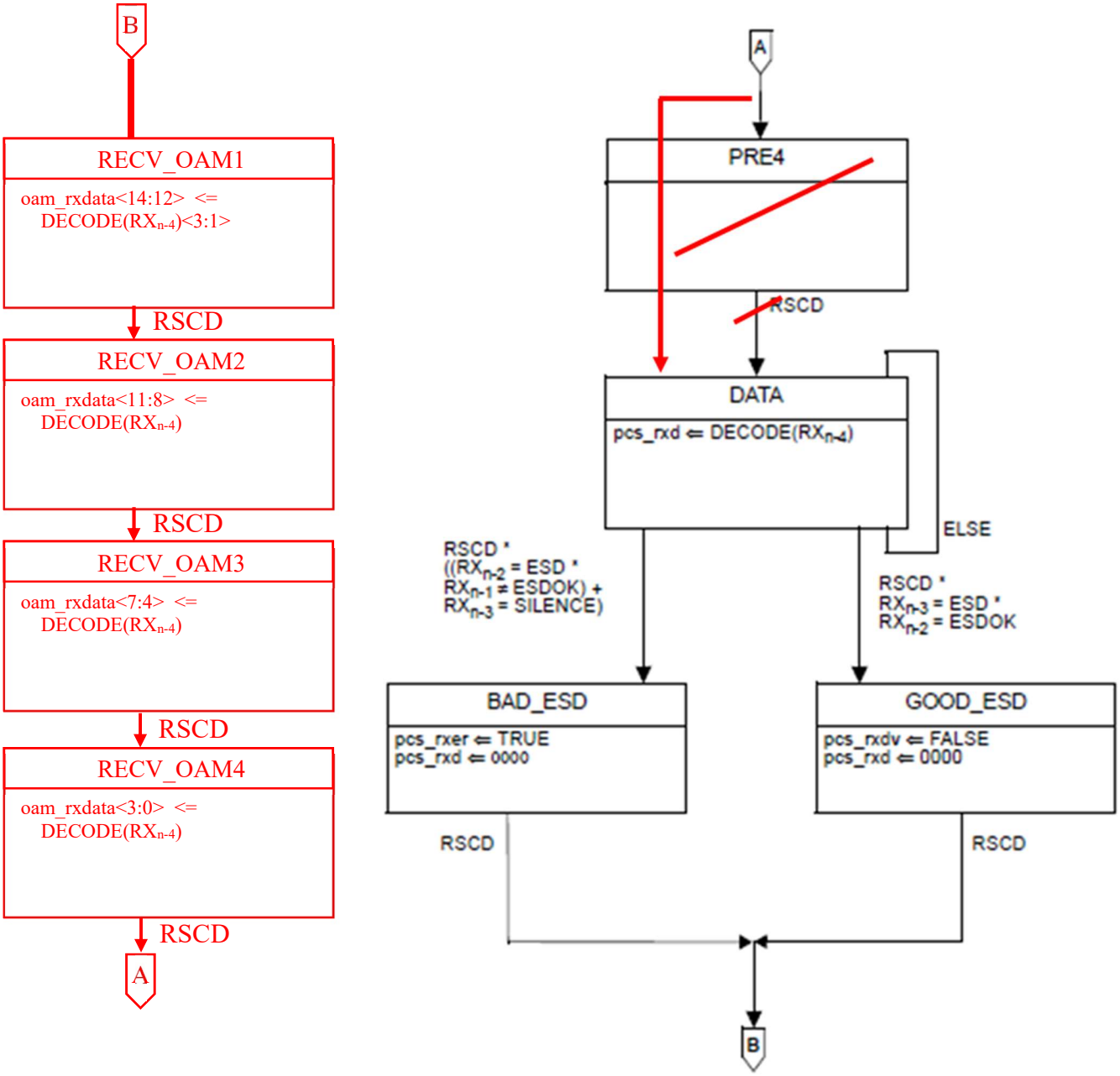


Figure 147–7—PCS Receive state diagram (2 of 2)

147.3.4 PCS Loopback

The PCS shall be placed in loopback mode when the loopback bit in MDIO register 3.0.14, defined in 45.2.3.1.2, is set to a one (or PCS loopback mode is enabled by a similar functionality if MDIO is not implemented). In this mode, the PCS shall accept data on the transmit path from the MII and return it on the receive path to the MII. Additionally, the PHY receive circuitry shall be isolated from the network medium, and the assertion of TX_EN at the MII shall not result in the transmission of data on the network medium. The PCS loopback data flow is illustrated in Figure 146–11.

147.3.5 Collision detection

When operating in half-duplex mode, the 10BASE-T1S PHY shall detect physical collisions on the media during data transmission. When collisions are detected, the PHY shall assert the signal COL on the MII for the duration of the collision or until TX_EN signal is FALSE.

A collision can be detected by monitoring the rx_sym parameter conveyed through the PMA_UNITDATA.indication primitive for a SYNC, SSD symbol sequence ~~(that is a J/K sequence)~~ and verify matching against the transmitted symbol sequence after the SSD symbol. A collision results in a mismatch in the symbol sequence.

Editor's Note (to be removed prior to draft 2.0):

Timeout for detecting collision needs to be added.

147.3.6 Carrier sense

When operating in half-duplex mode, the 10BASE-T1S PHY shall sense when the media is busy and convey this information to the MAC asserting the signal CRS on the MII as specified in 22.2.2.11.

CRS is generated by PCS Receive as the logical OR of the "transmitting" and "receiving" variables.

147.3.7 Optional support for PLCA Reconciliation Sublayer

When PLCA capabilities defined in Clause 148 are supported, the following applies.

147.3.7.1 Generation of BEACON indication

In compliance to 148.4.4.2.1, when PLCA RS operations are supported and enabled, the PHY shall notify the RS of a received BEACON indication by the means of MII interface as specified in 22.2.2.8.

When a sequence of at least two consecutive 'N' symbols is received (see Table 147–1), the MII signals RX_DV, RX _ER and RXD shall be set to the BEACON indication as shown in Table 22–2, overriding the current state. Override shall cease as soon as the currently received symbol is anything other than a 'N' code.

147.3.7.2 Generation of COMMIT indication

In compliance to 148.4.4.2.2, when PLCA RS operations are supported and enabled, the PHY shall notify the RS of a received COMMIT indication by the means of MII interface as specified in 22.2.2.8.

When a sequence of at least two consecutive 'J' symbols is received (see Table 147–1), the MII signals RX_DV, RX _ER and RXD shall be set to the COMMIT indication as shown in Table 22–2, overriding the current state. Override shall cease as soon as the currently received symbol is anything other than a 'J' code.

147.3.7.3 Optional generation of early receive indication

In compliance to 148.4.4.2.4, when PLCA RS operations are supported and enabled, the PHY may notify the RS of an early receive indication by the means of MII interface as specified in 22.2.2.11 and 22.2.2.12.

The generation of the early receive indication is optional and left to the implementer as long as the requirements defined in the mentioned clauses are met.

147.4 Physical Medium Attachment (PMA) Sublayer

Editor's Note (to be removed prior to draft 2.0):

The PMA Figure needs to be developed.

The PMA couples messages from the PMA service interface specified in 147.3.1 onto the 10BASE-T1S physical medium. The PMA provides both full duplex and half duplex communications to and from medium employing Differential Manchester Encoding. The interface between PMA and the baseband medium is the Medium Dependent Interface (MDI), which is specified in 147.9.

147.4.1 PMA Reset function

The PMA Reset function shall be executed whenever one of the two following conditions occur:

a) Power on (see 36.2.5.1.3).
b) The receipt of a request for reset from the management entity.

147.4.2 PMA Transmit function

Editor's Note (to be removed prior to draft 2.0):

The PMA transmit Figure needs to be developed.

TBD illustrates the signal flow of the 10BASE-T1S PMA Transmit function. During transmission, PMA_UNITDATA.request conveys to the PMA using tx_sym the value of the symbols to be sent over the single transmit pair.

DME uses the presence or absence of transitions between these two voltage levels to encode data, thus the polarity is irrelevant.

The tx_ sym variable is a vector of 5 bits to be encoded, LSB first, using Differential Manchester Encoding (DME) rules defined below:

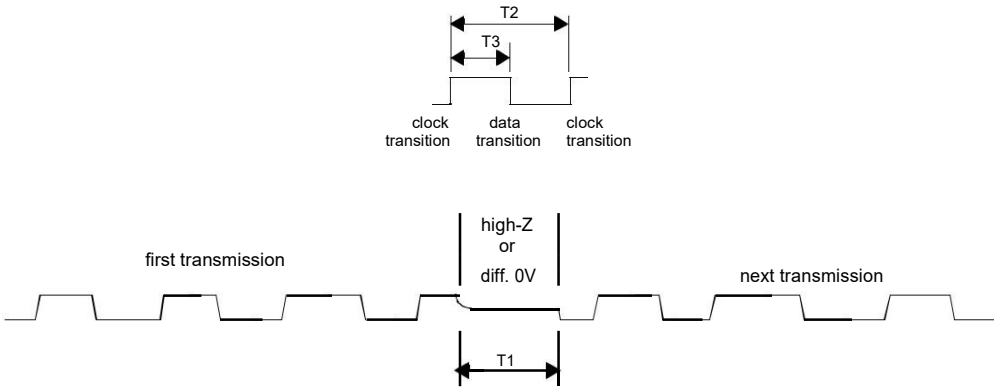


Figure 147–8—DME Encoding Scheme

Table 147–2—DME Timings

	Parameters	Min	Typ	Max	Units
T1	Delay between transmissions *	200			ns
T2	Clock transition to clock transition	TBD	80	TBD	ns
T3	Clock transition to data transition (data = 1)	TBD	40	TBD	ns

Editor's Note (to be removed prior to Working Group ballot):

Commenters are encouraged to improve the clarity of this requirement, including its relationship to the PCS state diagram, and whether it belongs in the PMA or the PCS

If the tx_sym parameter value is the special 5B symbol 'I', the PMD would act according to its operation mode, as follows:

a) When in multidrop mode, the PMD shall be put into high-impedance/Z state,

b) While in point-to- point mode, the PMD shall drive a differential voltage of 0 V (BI_DA+ = BI_DA-) instead

If tx_sym value is anything other than 'I' the following rules apply:

a) A "clock transition" shall always be generated at the start of each bit.

b) A "data transition" in the middle of a nominal bit period shall be generated if the bit to be transmitted is a logical '1'. Otherwise no transition shall be generated until next bit.

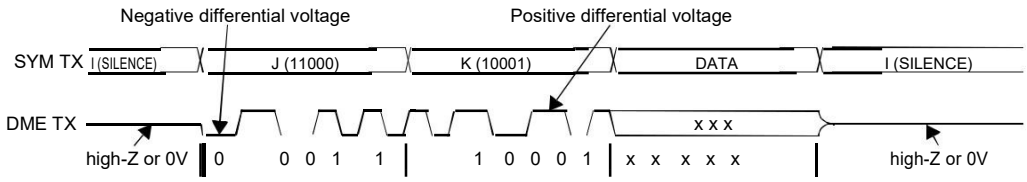


Figure 147–9—Example DME encoding of 5B symbols

147.4.3 PMA Receive function

Editor's Note (to be removed prior to draft 2.0):

The 10BASE-T1S PMA Receive function Figure needs to be developed.

TBD illustrates the signal flow of the 10BASE-T1S PMA Receive function. The 10BASE-T1S PMA Receive function comprises a single receiver (PMA Receive) for DME modulated signals on a single balanced pair, BI_DA. PMA Receive has the ability to translate the received signals on the single pair into the PMA _UNITDATA.indication parameter rx_sym. It detects 5B symbols from the signals received at the MDI and presents these sequences to the PCS Receive function.

The PMA receive function shall recover encoded clock and data information from the DME encoded stream received at the MDI. In order to accomplish this task, the PMA Receive shall achieve proper synchroniza-tion on both the DME stream and the 5B boundary.

At the start of each transmission, the symbol sequence J/J/H/H which replaces the first 20 bit of packet preamble is meant to allow the receiver to achieve such synchronization.

147.4.4 PMA Clock recovery

This PMA function recovers the clock from the received stream. PMA clock recovery outputs are used as input variables for other PMA functions.

147.5 PMA electrical specifications

This subclause defines the electrical characteristics of the PMA for a 10BASE-T1S Ethernet PHY.

Editor's Note (to be removed prior to draft 2.0):

Copy or reference clauses 146.5.1.1 and 146.5.1.2 here as they apply as well for 10BASE-T1S.