The variables dc_balance_error, eop_error and codeword_error shall remain OFF at all times other than those specified in the above error-detecting rules.

The codeword_error=ON indication for a (possibly negated) code group not found in the code table shall set RX_ER during the transfer of both affected data nibbles across the MII.

The dc_balance_error=ON indication for a code group shall set RX_ER during the transfer of both affected data nibbles across the MII.

The eop_error=ON indication shall set RX_ER during the transfer of the last decoded data nibble of the previous octet across the MII. That is at least one RX_CLK period earlier than the requirement for codeword_error and dc_balance_error.

These timing requirements imply consideration of implementation delays not specified in the PCS Receive state diagram.

RX_DV is asserted coincident with the transmission across the MII of valid packet data, including the clause 4 MAC SFD, but not including the 100BASE-T4 end-of-packet delimiters eop1-5. When a packet is truncated due to early de-assertion of carrier_status, an RX_ER indication shall be generated and RX_DV shall be de-asserted, halting receive processing. The PCS Receive Function may use any of the existing signals codeword_error, dc_balance_error, or eop_error to accomplish this function.

23.2.1.4 PCS Error Sense function

The PCS Error Sense function performs the task of sending RX_ER to the MII whenever rxerror_status=ERROR is received from the PMA sublayer or when any of the PCS decoding error conditions occur. The PCS Error Sense function shall conform to the PCS Error Sense state diagram in figure 23-10.

Upon detection of any error, the error sense process shall report RX_ER to the MII before the last nibble of the clause 4 MAC frame has been passed across the MII. Errors attributable to a particular octet are reported to the MII coincident with the octet in which they occurred.

The timing of rxerror_status shall cause RX_ER to appear on the MII no later than the last nibble of the first data octet in the frame.

23.2.1.5 PCS Carrier Sense function

The PCS Carrier Sense function shall perform the function of controlling the MII signal CRS according to the rules presented in this clause.

While link_status = OK, CRS is asserted whenever rx_crs=ON or TX_EN=1, with timing as specified in 23.11.2, and table 23-6.

23.2.1.6 PCS Collision Presence function

A PCS collision is defined as the simultaneous occurrence of tx_code_vector≠IDLE and the assertion of carrier_status=ON while link_status=OK. While a PCS collision is detected, the MII signal COL shall be asserted, with timing as specified in 23.11.2 and table 23-6.

At other times COL shall remain de-asserted.

23.2.2 PCS interfaces

23.2.2.1 PCS–MII interface signals

The following signals are formally defined in 22.2.2. Jabber detection as specified in 22.2.4.2.12 is not required by this standard.

Table 23-1—MII interface signals

Signal name	Meaning
TX_CLK	Transmit Clock
TXD<3:0>	Transmit Data
TX_ER	Forces transmission of illegal code
TX_EN	Frames Transmit Data
COL	Collision Indication
CRS	Non-Idle Medium Indication
RX_CLK	Receive Clock
RXD<3:0>	Receive Data
RX_DV	Frames Receive SFD and DATA
RX_ER	Receive Error Indication
MDC	Management Data Clock
MDIO	Management Data

23.2.2.2 PCS–Management entity signals

The management interface has pervasive connections to all functions. Operation of the management control lines MDC and MDIO, and requirements for managed objects inside the PCS and PMA, are specified in clauses 22 and 30, respectively.

The loopback mode of operation shall be implemented in accordance with 22.2.4.1.2. The loopback mode of operation loops back transmit data to receive data, thus providing a way to check for the presence of a PHY.

No spurious signals shall be emitted onto the MDI when the PHY is held in power-down mode as defined in 22.2.4.1.5 (even if TX_EN is ON) or when released from power-down mode, or when external power is first applied to the PHY.

23.2.3 Frame structure

Frames passed from the PCS sublayer to the PMA sublayer shall have the structure shown in figure 23-6. This figure shows how ternary symbols on the various pairs are synchronized as they are passed by the PMA_UNITDATA.indicate and PMA_UNITDATA request messages. Time proceeds from left to right in the figure.

In the frame structure example, the last 6T code group, DATA N, happens to appear on transmit pair BI_D3. It could have appeared on any of the three transmit pairs, with the five words eop1 through eop5 appended afterward as the next five octets in sequence. The end of packet as recognized by the PCS is defined as the end of the last ternary symbol of eop1. At this point a receiver has gathered enough information to locate the last word in the packet and check the dc balance on each pair.

If the PMA service interface is exposed, data carried between PCS and PMA by the PMA_UNITDATA.indicate and PMA_UNITDATA request messages shall have a clock in each direction. Details of the clock

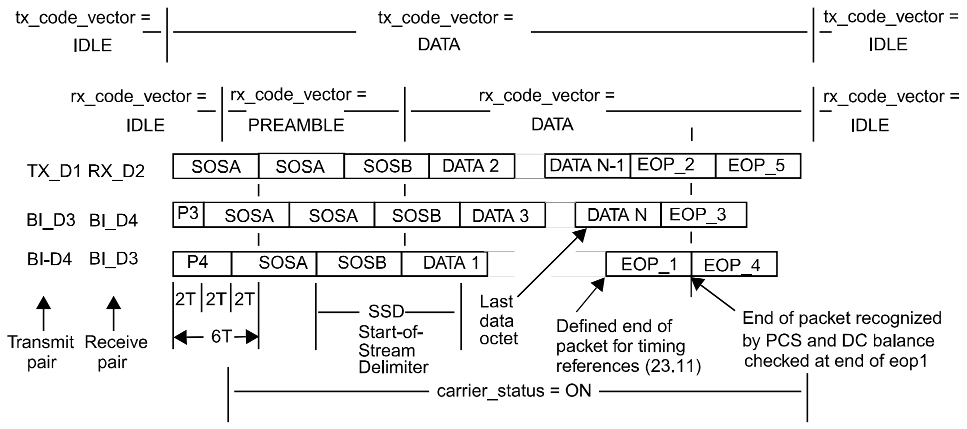


Figure 23-6—PCS sublayer to PMA sublayer frame structure

implementation are left to the implementor. The choice of binary encoding for each ternary symbol is left to the implementor.

The following frame elements appear in figure 23-6 (ternary symbols are transmitted leftmost first):

SOSA	The succession of six ternary symbols: `[ 1 -1 1 -1 1 -1]`, which is the result of encoding the constant sosa.
SOSB	The succession of six ternary symbols: `[ 1 -1 1 -1 -1 1]`, which is the result of encoding the constant sosb.
P3	The succession of two ternary symbols: `[ 1 -1]`.
P4	The succession of four ternary symbols: `[ 1 -1 1 -1]`.
DATA	A 6T code group that is the result of encoding a data octet in a packet that is not part of the clause 4 MAC preamble or SFD.
EOP1-5	A 6T code group that is the result of encoding one of the end-of-packet patterns eop1-5.

23.2.4 PCS state diagrams

The notation used in the state diagrams follows the conventions of 21.5. Transitions shown without source states are evaluated continuously and take immediate precedence over all other conditions.

23.2.4.1 PCS state diagram constants

Register tsr may take on any of the nine constant values listed below (sosa through eop5, bad_code, and zero_code). These values are used to describe the functional operation of the coding process.

NOTE—Implementors are under no obligation to implement these constants in any particular way. For example, some implementors may choose to implement these codes as special flag bits attached to MII TXD nibble registers. Other implementors may choose to implement insertion of these codes on the downstream side of the coder function, using precoded 6T sequences.

All 6T code words are sent leftmost ternary symbol first.

sosa	A constant that encodes to:	[1 -1 1 -1 1 -1].
sosb	A constant that encodes to:	[1 -1 1 -1 -1 1].
eop1	A constant that encodes to:	[1 1 1 1 1 1].
eop2	A constant that encodes to:	[1 1 1 1 -1 -1].
eop3	A constant that encodes to:	[1 1 -1 -1 0 0].
eop4	A constant that encodes to:	[-1 -1 -1 -1 -1 -1].
eop5	A constant that encodes to:	[-1 -1 0 0 0 0].
bad_code	A constant that encodes to:	[-1 -1 -1 1 1 1].
zero_code	A constant that encodes to:	[0 0 0 0 0 0].

23.2.4.2 PCS state diagram variables

codeword_error

Indicates reception of invalid 6T code group.

Values:	ON and OFF
Set by:	PCS Receive; error-detecting rules

dc_balance_error

Indicates reception of dc coding violation.

Values:	ON and OFF
Set by:	PCS Receive; error-detecting rules

eop

Indicates reception of eop1.

A state variable set by the decoding operation. Reset to OFF when in PCS Receive state AWAITING INPUT. When the decoder detects eop1 on any pair, it sets this flag ON. The timing of eop shall be adjusted such that the last nibble of the last decoded data octet in a packet is the last nibble sent across the MII by the PMA Receive state diagram with RX_DV set ON.

Values:	ON and OFF
Set by:	PCS Receive; error-detecting rules

eop_error

Indicates reception of data with improper end-of-packet coding.

Values:	ON and OFF
Set by:	PCS Receive; error-detecting rules

ih2, ih4, and ih3 (input holding registers)

A set of holding registers used for the purpose of holding decoded data octets in preparation for sending across the MII one nibble at a time. One register is provided for each of the three receive pairs RX_D2, BI_D4, and BI_D3, respectively.

Value:	octet
Set by:	PCS Receive

Each time the PCS Receive function decodes a 6T code group, it loads the result (an octet) into one of the ih2-4 registers. These three registers are loaded in round-robin fashion, one register being loaded every two ternary symbol times.

The PCS Receive state diagram reads nibbles as needed from the ih2-4 registers and stuffs them into RXD.

ohr1, ohr3, and ohr4 (output holding registers)

(See figure 23-7.) A set of shift registers used for the purpose of transferring coded 6T ternary symbol groups one ternary symbol at a time into the PMA. One register is provided for each of the three transmit pairs TX_D1, BI_D3, and BI_D4, respectively.

Value:	6T code group. Each of the six cells holds one ternary symbol (i.e., –1, 0, or 1).
Set by:	PCS Transmit

Each time the PCS Transmit function encodes a data octet, it loads the result (a 6T code group) into one of the ohr registers. Three registers are loaded in round-robin fashion, one register being loaded every two ternary symbol times. The PCS shall transmit octets on the three transmit pairs in round-robin fashion, in the order TX_D1, BI_D3, and BI_D4, starting with TX_D1.

The PMA_UNITDATA request (DATA) message picks the least significant (rightmost) ternary symbol from each ohr register and sends it to the PMA, as shown below. (Note that 6T code words in annex 23A are listed with lsb on the left, not the right.)

tx_code_vector[TX_D1] = the LSB of ohr1, also called ohr1[0]

tx_code_vector[BI_D3] = the LSB of ohr3, also called ohr3[0]

tx_code_vector[BI_D4] = the LSB of ohr4, also called ohr4[0]

After each PMA_UNITDATA request message, all three ohr registers shift right by one ternary symbol, shifting in zero from the left. The PCS Transmit function loads a new 6T code group into each ohr immediately after the last ternary symbol of the previous group is shifted out.

At the beginning of a preamble, the PCS Transmit function loads the same value (sosa) into all three output holding registers, which causes alternating transitions to immediately appear on all three output pairs. The result on pairs BI_D3 and BI_D4 is depicted by code words P3 and P4 in figure 23-6.

pcs_reset

Causes reset of all PCS functions when ON.

Values:	ON and OFF
Set by:	PCS Reset

rx_crs

A latched asynchronous variable. Timing for the MII signal CRS is derived from rx_crs.

Values:	ON and OFF
Set ON when:	carrier_status changes to ON
Set OFF when	either of two events occurs: carrier_status changes to OFF, or detection of eop1, properly framed, on any of the lines RX_D2, BI_D4, or BI_D3

Additionally, if, 20 ternary symbol times after rx_crs falls, carrier_status remains set to ON then set rx_crs=ON.

NOTE—A special circuit for the detection of eop1 and subsequent de-assertion of rx_crs, faster than the full 8B6T decoding circuits, is generally required to meet the timing requirements for CRS listed in clause 23.11.

tsr (transmit shift register)

(See figure 23-7.) A shift register defined for the purpose of assembling nibbles from the MII TXD into octets.

Values:	The variable tsr always contains both the current nibble of TXD and the previous nibble of TXD. Valid values for tsr therefore include all octets. Register tsr may also take on any of the nine constant values listed in 23.2.4.1.
Nibble order:	When encoding the tsr octet, the previous TXD nibble is considered the least significant nibble.
Set by:	PCS Transmit

During the first 16 TX_CLK cycles after TX_EN is asserted, tsr shall assume the following values in sequence regardless of TXD: sosa, sosa, sosa, sosa, sosa, sosa, sosa, sosa, sosa, sosa, sosb, sosb, sosb, sosb, sosb, sosb. This action substitutes the 100BASE-T4 preamble for the clause 4 MAC preamble. The PCS Transmit state diagram samples the tsr only every other clock, which reduces the number of sosa and sosb constants actually coded to 5 and 3, respectively.

During the first 10 TX_CLK cycles after TX_EN is de-asserted, tsr shall assume the following values in sequence, regardless of TXD: eop1, eop1, eop2, eop2, eop3, eop3, eop4, eop4, eop5, eop5. This action appends the 100BASE-T4 end-of-packet delimiter to each pair. The PCS Transmit state diagram samples the tsr only every other clock, which reduces the number of eop1-5 constants actually coded to 1 each.

Except for the first 16 TX_CLK cycles after TX_EN is asserted, any time TX_ER and TX_EN are asserted, tsr shall assume the value bad_code with such timing as to cause both nibbles of the affected octet to be encoded as bad_code. If TX_ER is asserted at any time during the first 16 TX_CLK cycles after TX_EN is asserted, tsr shall during the 17th and 18th clock cycles assume the value bad_code.

If TX_EN is de-asserted on an odd nibble boundary, the PCS shall extend TX_EN by one TX_CLK cycle, and behave as if TX_ER were asserted during that additional cycle.

Except for the first 10 TX_CLK cycles after TX_EN is de-asserted, any time TX_EN is not asserted, tsr shall assume the value zero_code.

tx_extend

A latched, asynchronous state variable used to extend the TX_EN signal long enough to ensure complete transmission of all nonzero ternary symbols in eop1-5.

Values:	ON and OFF
Set ON upon:	rising edge of TX_EN
Set OFF upon	either of two conditions: a) In the event of a collision (COL is asserted at any time during transmission) set tx_extend=OFF when TX_EN de-asserts. b) In the event of no collision (COL remains de-asserted throughout transmission) set tx_extend=OFF upon completion of transmission of last ternary symbol in eop4.

NOTES

1—The 6T code group eop5 has four zeroes at the end. The 6T code group eop4 contains the last nonzero ternary symbol to be transmitted.

2—The effect of a collision, if present, is to truncate the frame at the original boundary determined by TX_EN. Noncolliding frames are extended, while colliding frames are not.

23.2.4.3 PCS state diagram timer

tw1_timer

A continuous free-running timer.

Values:	The condition tw1_timer_done goes true when the timer expires.
Restart when:	Immediately after expiration (restarting the timer resets condition tw1_timer_done).
Duration:	40 ns nominal.

TX_CLK shall be generated synchronous to tw1_timer (see tolerance required for TX_CLK in 23.5.1.2.10).

On every occurrence of tw1_timer_done, the state diagram advances by one block. The message PMA_UNITDATA request is issued concurrent with tw1_timer_done.

23.2.4.4 PCS state diagram functions

encode()

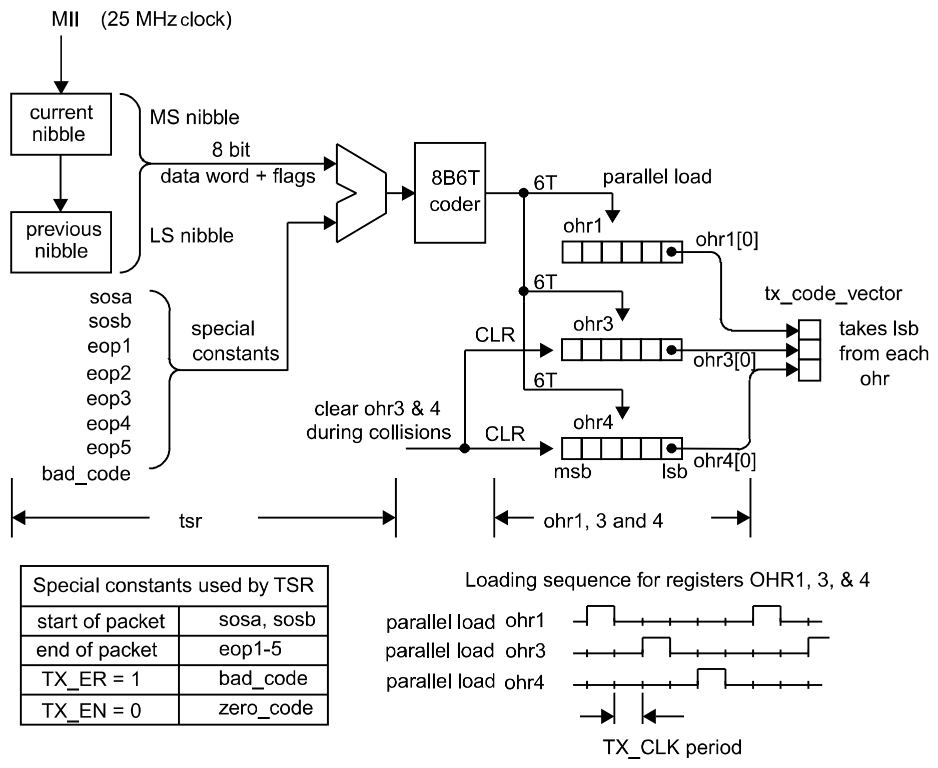
The encode operation of 23.2.1.2.

Argument:	octet
Returns:	6T code group

decode()

The decode operation of 23.2.1.3.

Argument:	6T code group
Returns:	octet



Special constants used by TSR	
start of packet	sosa, sosb
end of packet	eop1-5
TX_ER = 1	bad_code
TX_EN = 0	zero_code

Figure 23-7—PCS Transmit reference diagram

23.2.4.5 PCS state diagrams

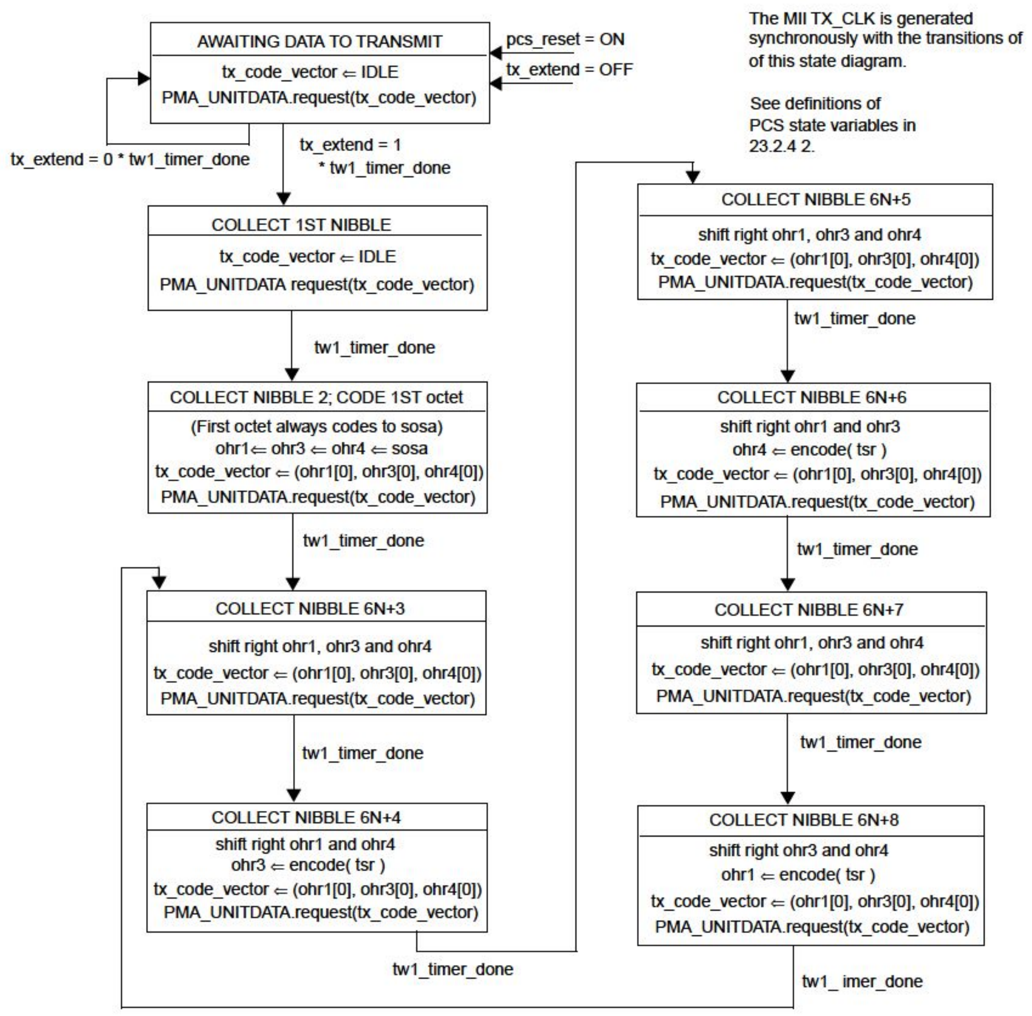

The MII TX_CLK is generated synchronously with the transitions of of this state diagram.
See definitions of PCS state variables in 23.2.4 2.
AWAITING DATA TO TRANSMIT
tx_code_vector ⇐ IDLE
PMA_UNITDATA.request(tx_code_vector)
pcs_reset = ON
tx_extend = OFF
tx_extend = 0 * tw1_timer_done
tx_extend = 1 * tw1_timer_done
COLLECT 1ST NIBBLE
tx_code_vector ⇐ IDLE
PMA_UNITDATA request(tx_code_vector)
tw1_timer_done
COLLECT NIBBLE 2; CODE 1ST octet
(First octet always codes to sosa)
ohr1⇐ ohr3 ⇐ ohr4 ⇐ sosa
tx_code_vector ⇐ (ohr1[0], ohr3[0], ohr4[0])
PMA_UNITDATA.request(tx_code_vector)
tw1_timer_done
COLLECT NIBBLE 6N+3
shift right ohr1, ohr3 and ohr4
tx_code_vector ⇐ (ohr1[0], ohr3[0], ohr4[0])
PMA_UNITDATA.request(tx_code_vector)
tw1_timer_done
COLLECT NIBBLE 6N+4
shift right ohr1 and ohr4
ohr3 ⇐ encode(tsr)
tx_code_vector ⇐ (ohr1[0], ohr3[0], ohr4[0])
PMA_UNITDATA.request(tx_code_vector)
tw1_timer_done
COLLECT NIBBLE 6N+5
shift right ohr1, ohr3 and ohr4
tx_code_vector ⇐ (ohr1[0], ohr3[0], ohr4[0])
PMA_UNITDATA.request(tx_code_vector)
tw1_timer_done
COLLECT NIBBLE 6N+6
shift right ohr1 and ohr3
ohr4 ⇐ encode(tsr)
tx_code_vector ⇐ (ohr1[0], ohr3[0], ohr4[0])
PMA_UNITDATA.request(tx_code_vector)
tw1_timer_done
COLLECT NIBBLE 6N+7
shift right ohr1, ohr3 and ohr4
tx_code_vector ⇐ (ohr1[0], ohr3[0], ohr4[0])
PMA_UNITDATA.request(tx_code_vector)
tw1_timer_done
COLLECT NIBBLE 6N+8
shift right ohr3 and ohr4
ohr1 ⇐ encode(tsr)
tx_code_vector ⇐ (ohr1[0], ohr3[0], ohr4[0])
PMA_UNITDATA.request(tx_code_vector)
tw1_ imer_done

Figure 23-8—PCS Transmit state diagram

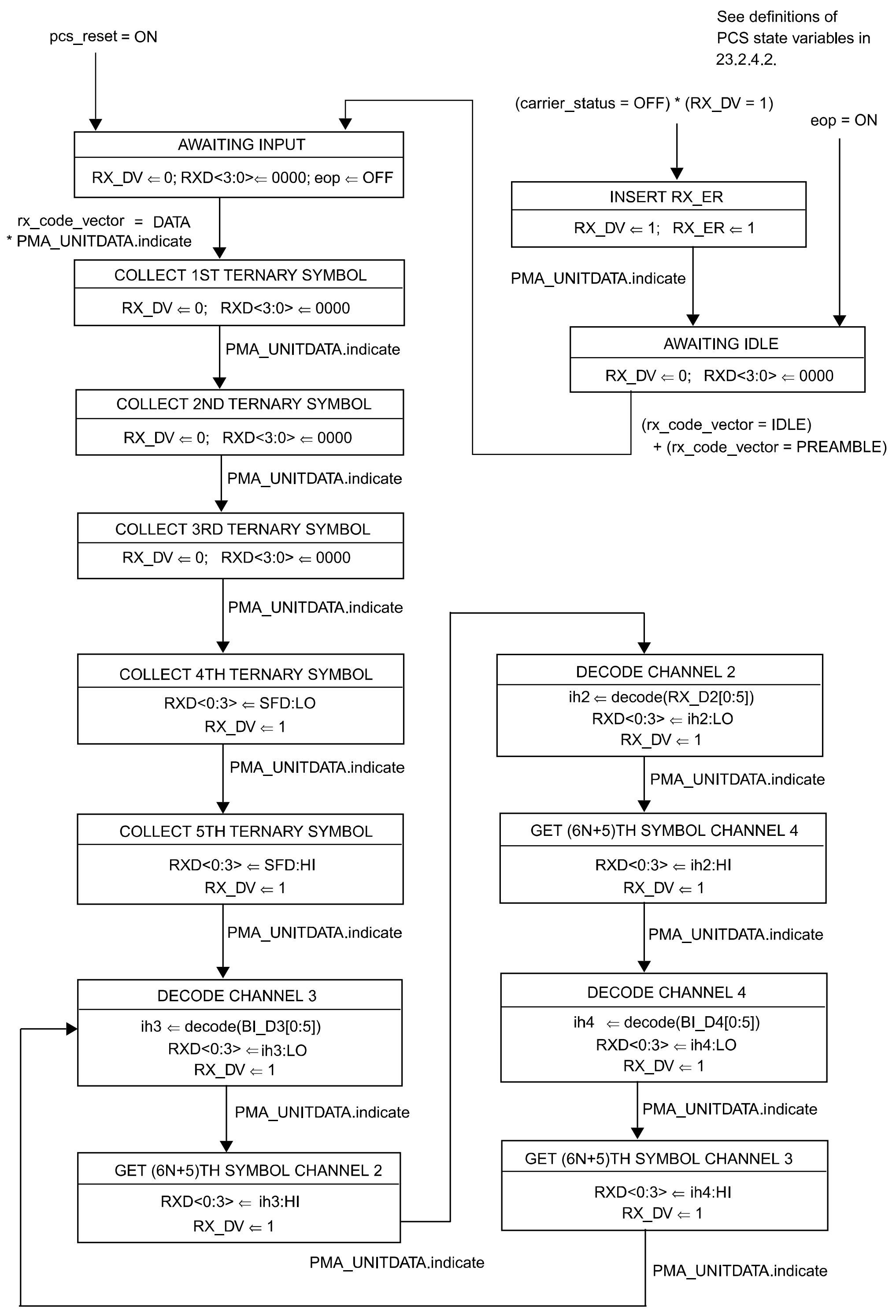


Figure 23-9—PCS Receive state diagram

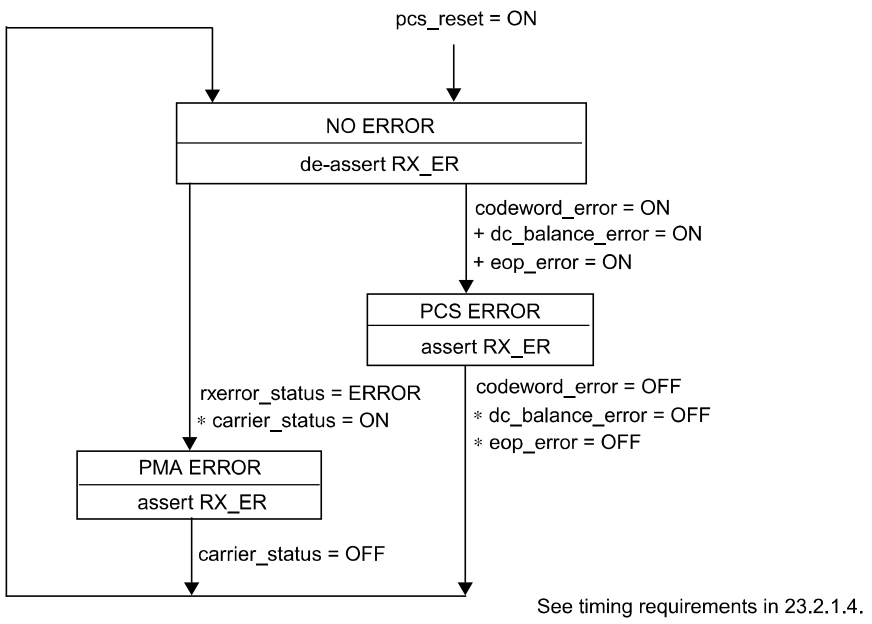


Figure 23-10—PCS Error Sense state diagram

23.2.5 PCS electrical specifications

The interface between PCS and PMA is an abstract message-passing interface, having no specified electrical properties.

Electrical characteristics of the signals passing between the PCS and MII may be found in clause 22.

23.3 PMA service interface

This clause specifies the services provided by the PMA to either the PCS or a Repeater client. These services are described in an abstract manner and do not imply any particular implementation.

The PMA Service Interface supports the exchange of code vectors between the PMA and its client (either the PCS or a Repeater). The PMA also generates status indications for use by the client.

The following primitives are defined:

PMA_TYPE.indicate
PMA_UNITDATA.request
PMA_UNITDATA.indicate
PMA_CARRIER.indicate
PMA_LINK.indicate
PMA_LINK request
PMA_RXERROR.indicate

23.3.1 PMA_TYPE.indicate

This primitive is generated by the PMA to indicate the nature of the PMA instantiation. The purpose of this primitive is to allow clients to support connections to the various types of 100BASE-T PMA entities in a generalized manner.

23.3.1.1 Semantics of the service primitive

PMA_TYPE.indicate (pma_type)

The pma_type parameter for use with the 100BASE-T4 PMA is T4.

23.3.1.2 When generated

The PMA shall continuously generate this primitive to indicate the value of pma_type.

23.3.1.3 Effect of receipt

The client uses the value of pma_type to define the semantics of the PMA_UNITDATA.request and PMA_UNITDATA.indicate primitives.

23.3.2 PMA_UNITDATA.request

This primitive defines the transfer of data (in the form of tx_code_vector parameters) from the PCS or repeater to the PMA.

23.3.2.1 Semantics of the service primitive

PMA_UNITDATA.request (tx_code_vector)

When transmitting data using 100BASE-T4 signaling, the PMA_UNITDATA.request conveys to the PMA simultaneously the logical output value for each of the three transmit pairs TX_D1, BI_D3, and BI_D4. The value of tx_code_vector during data transmission is therefore a three-element vector, with one element corresponding to each output pair. Each of the three elements of the tx_code_vector may take on one of three logical values: 1, 0, or –1, corresponding to the three ternary possibilities +, 0, and - listed for each ternary symbol in the 8B6T code table (see annex 23A).

Between packets, the 100BASE-T4 PMA layer sends the 100BASE-T4 idle signal, TP_IDL_100. The PCS informs the PMA layer that it is between packets, thus enabling the PMA idle signal, by setting the tx_code_vector parameter to IDLE.

For pma_type 100BASE-T4, the tx_code_vector parameter can take on either of two forms:

IDLE	A single value indicating to the PMA that there is no data to convey. The PMA generates link integrity pulses during the time that tx_code_vector = IDLE.
DATA	A vector of three ternary symbols, one for each of the three transmit pairs TX_D1, BI_D3, and BI_D4. The ternary symbol for each pair may take on one of three values, 1, 0, or –1.

The ternary symbols comprising tx_code_vector, when they are conveyed using the DATA format, are called, according to the pair on which each will be transmitted, tx_code_vector[BI_D4], tx_code_vector[TX_D1], and tx_code_vector[BI_D3].

23.3.2.2 When generated

The PCS or Repeater client generates PMA_UNITDATA.request synchronous with every MII TX_CLK.

For the purposes of state diagram descriptions, it may be assumed that at the time PMA_UNITDATA request is generated, the MII signals TX_EN, and TX_ER, and TXD instantly become valid and that they retain their values until the next PMA_UNITDATA request.

In the state diagrams, PMA_UNITDATA.request is assumed to occur at the conclusion of each tw1 wait function.

23.3.2.3 Effect of receipt

Upon receipt of this primitive, the PMA transmits the indicated ternary symbols on the MDI.

23.3.3 PMA_UNITDATA.indicate

This primitive defines the transfer of data (in the form of rx_code_vector parameters) from the PMA to the PCS or repeater during the time that link_status=OK.

23.3.3.1 Semantics of the service primitive

PMA_UNITDATA.indicate (rx_code_vector)

When receiving data using 100BASE-T4 signaling, the PMA_UNITDATA.indicate conveys to the PCS simultaneously the logical input value for each of the three receive pairs RX_D2, BI_D4, and BI_D3. The value of rx_code_vector during data reception is therefore a three-element vector, with one element corresponding to each input pair. Each of the three elements of the rx_code_vector may take on one of three logical values: 1, 0, or –1, corresponding to the three ternary possibilities +, 0, and - listed for each ternary symbol in the 8B6T code table (see annex 23A).

Between packets, the rx_code_vector is set by the PMA to the value IDLE.

From the time the PMA asserts carrier_status=ON until the PMA recognizes the SSD pattern (not all of the pattern need be received in order for the PMA to recognize the pattern), the PMA sets rx_code_vector to the value PREAMBLE.

For pma_type 100BASE-T4, the rx_code_vector parameter can take on any of three forms:

IDLE	A single value indicating that the PMA has no data to convey.
PREAMBLE	A single value indicating that the PMA has detected carrier, but has not received a valid SSD.
DATA	A vector of three ternary symbols, one for each of the three receive pairs RX_D2, BI_D3, and BI_D4. The ternary symbol for each pair may take on one of three values, 1, 0, or –1.

The ternary symbols comprising rx_code_vector, when they are conveyed using the DATA format, are called, according to the pair upon which each symbol was received, rx_code_vector[BI_D3], rx_code_vector[RX_D2], and rx_code_vector[BI_D4].

23.3.3.2 When generated

The PMA shall generate PMA_UNITDATA.indicate (DATA) messages synchronous with data received at the MDI.

23.3.3.3 Effect of receipt

The effect of receipt of this primitive is unspecified.

23.3.4 PMA_CARRIER.indicate

This primitive is generated by the PMA to indicate the status of the signal being received from the MDI. The purpose of this primitive is to give the PCS or repeater client the earliest reliable indication of activity on the underlying medium.

23.3.4.1 Semantics of the service primitive

PMA_CARRIER.indicate (carrier_status)

The carrier_status parameter can take on one of two values: OFF or ON, indicating whether the incoming signal should be interpreted as being between packets (OFF) or as a packet in progress (ON).

23.3.4.2 When generated

The PMA shall generate this primitive to indicate the value of carrier_status.

23.3.4.3 Effect of receipt

The effect of receipt of this primitive is unspecified.

23.3.5 PMA_LINK.indicate

This primitive is generated by the PMA to indicate the status of the underlying medium. The purpose of this primitive is to give the PCS or repeater client or Auto-Negotiation algorithm a means of determining the validity of received code elements.

23.3.5.1 Semantics of the service primitive

PMA_LINK.indicate (link_status)

The link_status parameter can take on one of three values: FAIL, READY, or OK:

FAIL	The link integrity function does not detect a valid 100BASE-T4 link.
READY	The link integrity function detects a valid 100BASE-T4 link, but has not been enabled by Auto-Negotiation.
OK	The 100BASE-T4 link integrity function detects a valid 100BASE-T4 link, and has been enabled by Auto-Negotiation.

23.3.5.2 When generated

The PMA shall generate this primitive to indicate the value of link_status.

23.3.5.3 Effect of receipt

The effect of receipt of this primitive is unspecified.

23.3.6 PMA_LINK.request

This primitive is generated by the Auto-Negotiation algorithm. The purpose of this primitive is to allow the Auto-Negotiation algorithm to enable and disable operation of the PHY.

23.3.6.1 Semantics of the service primitive

PMA_LINK request (link_control)

The link_control parameter can take on one of three values: SCAN_FOR_CARRIER, DISABLE, or ENABLE.

SCAN_FOR_CARRIER	Used by the Auto-Negotiation algorithm prior to receiving any fast link pulses. During this mode the PHY reports link_status=READY if it recognizes 100BASE-T4 carrier from the far end, but no other actions are enabled.
DISABLE	Used by the Auto-Negotiation algorithm to disable PHY processing in the event fast link pulses are detected. This gives the Auto-Negotiation algorithm a chance to determine how to configure the link.
ENABLE	Used by Auto-Negotiation to turn control over to the PHY for data processing functions. This is the default mode if Auto-Negotiation is not present.

23.3.6.2 Default value of parameter link_control

Upon power-on, reset, or release from power-down, the link_control parameter shall revert to ENABLE. If the optional Auto-Negotiation algorithm is not implemented, no PMA_LINK.request message will arrive and the PHY will operate indefinitely with link_control=ENABLE.

23.3.6.3 When generated

The Auto-Negotiation algorithm generates this primitive to indicate to the PHY how to behave.

Upon power-on, reset, or release from power down, the Auto-Negotiation algorithm, if present, issues the message PMA_LINK request (SCAN_FOR_CARRIER).

23.3.6.4 Effect of receipt

Whenever link_control=SCAN_FOR_CARRIER, the PHY shall enable the Link Integrity state diagram, but block passage into the state LINK_PASS, while holding rcv=DISABLE, and xmit=DISABLE. While link_control=SCAN_FOR_CARRIER, the PHY shall report link_status=READY if it recognizes 100BASE-T4 link integrity pulses coming from the far end, otherwise it reports link_status=FAIL.

Whenever link_control=DISABLE, the PHY shall report link_status=FAIL and hold the Link Integrity state diagram in the RESET state, while holding rcv=disable and xmit=DISABLE.

While link_control=ENABLE, the PHY shall allow the Link Integrity function to determine if the link is available and, if so, set rcv=ENABLE and xmit=ENABLE.

23.3.7 PMA_RXERROR.indicate

The primitive is generated in the PMA by the PMA Align function to indicate the status of the signal being received from the MDI. The purpose of this primitive is to give the PCS or repeater client an indication of a PMA detectable receive error.

23.3.7.1 Semantics of the service primitive

PMA_RXERROR.indicate (rxerror_status)

The rxerror_status parameter can take on one of two values: ERROR or NO_ERROR, indicating whether the incoming signal contains a detectable error (ERROR) or not (NO_ERROR).

23.3.7.2 When generated

The PMA shall generate this primitive to indicate whether or not each incoming packet contains a PMA detectable error (23.2.1.4).

23.3.7.3 Effect of receipt

The effect of receipt of this primitive is unspecified.

23.4 PMA functional specifications

The PMA couples messages from a PMA service interface (23.3) to the 100BASE-T4 baseband medium (23.6).

The interface between PCS and the baseband medium is the Medium Dependent Interface (MDI), specified in 23.7.

23.4.1 PMA functions

The PMA sublayer comprises one PMA Reset function and six simultaneous and asynchronous operating functions. The PMA operating functions are PMA Transmit, PMA Receive, PMA Carrier Sense, Link Integrity, PMA Align, and Clock Recovery. All operating functions are started immediately after the successful completion of the PMA Reset function. When the PMA is used in conjunction with a PCS, the RESET function may be shared between layers.

The PMA reference diagram, figure 23-11, shows how the operating functions relate to the messages of the PMA Service interface and the signals of the MDI. Connections from the management interface, comprising the signals MDC and MDIO, to other layers are pervasive, and are not shown in figure 23-11. The Management Interface and its functions are specified in clause 22.

23.4.1.1 PMA Reset function

The PMA Reset function shall be executed any time either of two conditions occur. These two conditions are power-on and the receipt of a reset request from the management entity. The PMA Reset function initializes all PMA functions. The PMA Reset function sets pma_reset <= ON for the duration of its reset function. All state diagrams take the open-ended pma_reset branch upon execution of the PMA Reset function. The reference diagrams do not explicitly show the PMA Reset function.

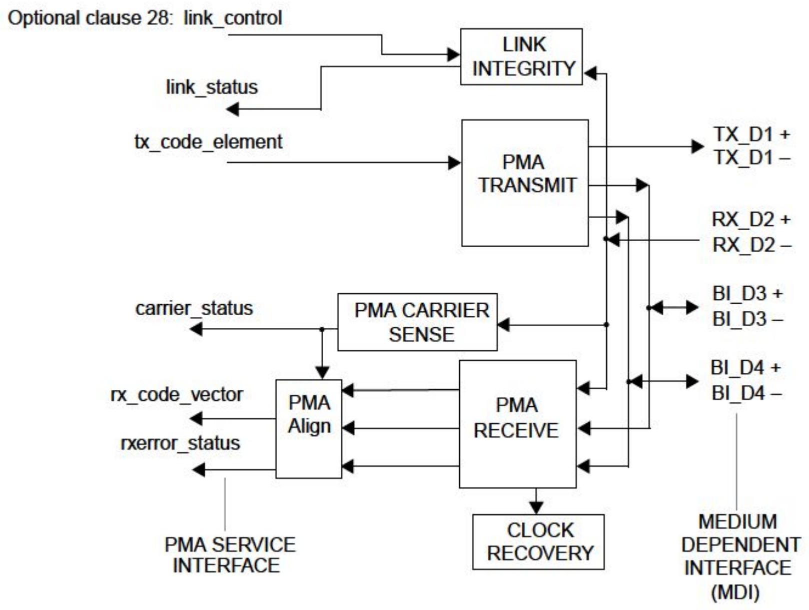


Figure 23-11—PMA reference diagram

23.4.1.2 PMA Transmit function

Except as provided for in the next paragraph, whenever (tx_code_vector=DATA)×(pma_carrier=OFF), the PMA shall transmit onto the MDI ternary symbols on pairs TX_D1, BI_D3, and BI_D4 equal to tx_code_vector[TX_D1], tx_code_vector[BI_D3], and tx_code_vector[BI_D4], respectively.

Whenever (tx_code_vector=DATA)×(pma_carrier=ON), the PMA shall transmit onto the MDI ternary symbols on pairs TX_D1, BI_D3, and BI_D4 equal to tx_code_vector[TX_D1], CS0, and CS0, respectively, and continue doing so until tx_code_vector=IDLE.

NOTE—This shuts off the transmitters on channels BI_D3 and BI_D4, and keeps them off, in the event of a collision. Shutting off the transmitters prevents overload and saturation of the transmitters, and also reduces the amount of near-end crosstalk present while monitoring for the end of carrier.

Whenever tx_code_vector=IDLE, an idle signal shall be transmitted on pair TX_D1 and silence on pairs BI_D3 and BI_D4. The idle signal consists of periods of silence (times where the differential output voltage remains at 0 mV ± 50 mV) broken by the transmission of link integrity test pulses.

The 100BASE-T4 idle signal is similar to the 10BASE-T idle signal, but with 100BASE-T4 ternary signal levels and a faster repetition rate. The 100BASE-T4 idle signal is called TP_IDL_100. The TP_IDL_100 signal shall be a repeating sequence formed from one 1.2 ms ± 0.6 ms period of silence (the time where the differential voltage remains at 0 mV ± 50 mV) and one link test pulse. Each link test pulse shall be a succession of two ternary symbols having logical values of –1 and 1 transmitted on pair TX_D1 using CS-1 and CS1 as defined in 23.4.3.1. Following a packet, the TP_IDL_100 shall start with a period of silence.

Transmission of TP_IDL_100 may be terminated at any time with respect to the link test pulse. It shall be terminated such that ternary symbols of the subsequent packet are not corrupted, and are not delayed any more than is specified in 23.11.

For any link test pulse occurring within 20 ternary symbol times of the beginning of a preamble, the zero crossing jitter (as defined in 23.5.1.2.5) of the link test pulse when measured along with the zero crossings of the preamble shall be less than 4 ns p-p.

NOTE—The above condition allows clock recovery implementations that optionally begin fast-lock sequences on part of a link integrity pulse to properly acquire lock on a subsequent preamble sequence.

Regardless of other considerations, when the transmitter is disabled (xmit=DISABLE), the PMA Transmit function shall transmit the TP_IDL_100 signal.

23.4.1.3 PMA Receive function

PMA Receive contains the circuits necessary to convert physically encoded ternary symbols from the physical MDI receive pairs (RX_D2, BI_D3 and BI_D4) into a logical format suitable for the PMA Align function. Each receive pair has its own dedicated PMA Receive circuitry.

The PHY shall receive the signals on the receive pairs (RX_D2, BI_D3, and BI_D4) and translate them into one of the PMA_UNITDATA.indicate parameters IDLE, PREAMBLE, or DATA with a ternary symbol error rate of less than one part in 10^8.

If both pma_carrier=ON and tx_code_vector=DATA, the value of rx_code_vector is unspecified until pma_carrier=OFF.

23.4.1.4 PMA Carrier Sense function

The PMA Carrier Sense function shall set pma_carrier=ON upon reception of the following pattern on pair RX_D2 at the receiving MDI, as measured using a 100BASE-T4 transmit test filter (23.5.1.2.3):

> Any signal greater than 467 mV, followed by any signal less than –225 mV, followed by any signal greater than 467 mV, all three events occurring within 2 ternary symbol times.

The operation of carrier sense is undefined for signal amplitudes greater than 4.5 V.

See 23.5.1.3.2 for a list of signals defined *not* to set pma_carrier=ON.

After asserting pma_carrier=ON, PMA Carrier Sense shall set pma_carrier=OFF upon receiving either of these conditions:

a) Seven consecutive ternary symbols of value CS0 on pair RX_D2.
b) (tx_code_vector=DATA) has not been true at any time since pma_carrier was asserted, *and* the 6T code group eop1 has been received, properly framed, on any of the lines RX_D2, BI_D4, or BI_D3, *and* enough time has passed to assure passage of all ternary symbols of eop4 across the PMA service interface.

NOTE—Designers may wish to take advantage of the fact that the minimum received packet fragment will include at least 24 ternary symbols of data on pair RX_D2. Therefore, once carrier is activated, it is not necessary to begin searching for seven consecutive zeroes until after the 24th ternary symbol has been received. During the time that the first 24 ternary symbols are being received, the near-end crosstalk from pairs BI_D3 and BI_D4, which are switched off during collisions, decays substantially.

While rcv=ENABLE, the PMA CARRIER function shall set carrier_status = pma_carrier.

While rcv≠ENABLE, the PMA CARRIER function shall set carrier_status = OFF.

This function operates independently of the Link Integrity function.

23.4.1.5 Link Integrity function

Link Integrity provides the ability to protect the network from the consequences of failure of the simplex link attached to RX_D2. While such a failure is present, transfer of data by the Transmit and Receive functions is disabled.

Link Integrity observes the incoming wire pair, RX_D2, to determine whether the device connected to the far end is of type 100BASE-T4. Based on its observations, Link Integrity sets two important internal variables:

a)	pma_type	variable is set to 100BASE-T4.
b)	link_status	variable is a parameter sent across the PMA Service interface.

The Link Integrity function shall comply with the state diagram of figure 23-12.

Four conditions gate the progression of states toward LINK_PASS: (1) reception of at least 31 link integrity test pulses; (2) reception of at least 96 more link integrity test pulses, or reception of carrier; (3) cessation of carrier, if it was present; (4) detection of equals link_control ENABLE.

While the PMA is not in the LINK_PASS state, the Link Integrity function sets rcv=DISABLE and xmit=DISABLE, thus disabling the bit transfer of the Transmit and Receive functions.

If a visible indicator is provided on the PHY to indicate the link status, it is recommended that the color be green and that the indicator be labeled appropriately. It is further recommended that the indicator be on when the PHY is in the LINK_PASS state and off otherwise.

23.4.1.6 PMA Align function

The PMA Align function accepts received ternary symbols from the PMA Receive function, along with pma_carrier. PMA Align is responsible for realigning the received ternary symbols to eliminate the effects of unequal pair propagation time, commonly called pair skew. PMA Align also looks for the SSD pattern to determine the proper alignment of 6T code groups, and then forwards PMA_UNITDATA.indicate (DATA) messages to the PCS. The SSD pattern includes referencing patterns on each of the three receive lines that may be used to establish the proper relationship of received ternary symbols (see figure 23-6).

NOTE—The skew between lines is not expected to change measurably from packet to packet.

At the beginning of each received frame, the PMA Carrier Sense function asserts pma_carrier=ON. During the preamble, the Clock Recovery function begins synchronizing its receive clock. Until clock is synchronized, data coming from the low-level PMA Receive function is meaningless. The PMA Align function is responsible for waiting for the receiver clock to stabilize and then properly recognizing the 100BASE-T4 coded SSD pattern. The PMA Align function shall send PMA_UNITDATA.indicate (PREAMBLE) messages to the PCS from the time pma_carrier=ON is asserted until the PMA is ready to transfer the first PMA_UNITDATA.indicate (DATA) message. Once the PMA Align function locates a SSD pattern, it begins forwarding PMA_UNITDATA.indicate (DATA) messages to the PCS, starting with the first ternary symbol of the first data word on pair BI_D3, as defined in figure 23-6. This first PMA_UNITDATA.indicate (DATA) message shall transfer the following ternary symbols, as specified in the frame structure diagram, figure 23-6:

rx_code_vector[BI_D3]first ternary symbol of first data code group

rx_code_vector[RX_D2]second ternary symbol prior to start of second data code group