

100BASE-T1L PCS Receive Function

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- ▶ This presentation presents an update to the text for PCS Receive required for the draft
 - The text in section 190.3.4 PCS Receive function of draft 1.0 is really just a placeholder to provide some context for the PCS transmit and PMA training sections which are pretty complete
 - The details, tables and state diagrams for PCS Receive are missing, see the editor's note on page 73

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<i>Editor's Note (to be removed prior to Working Group Ballot):</i>	36
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The text below is part of the description of the PCS Receive, but lacks the requirements and description	38
of the PCS Receive state diagram operation which needs to be decided before that text can be written.	39
Contributions are requested to fill out PCS Receive requirements before text is filled out here.	40

- ▶ This presentation describes the operation of PCS Receive function including the tables and state diagram
- ▶ This presentation also provides the text for the draft, showing the changes required

- ▶ The PCS Receive function shall conform to the PCS Receive state diagram in Figure 190-13B
 - When RS-FEC is enabled for the link, the PHY Receive function shall implement the RFER monitor state diagram of Figure 190-13C
- ▶ PCS Receive operation - TRAIN
 - When `pcs_rx_mode` is TRAIN, the PCS Receive function checks the received PAM2 symbols and signals the reliable acquisition of the descrambler by setting `scr_status` to OK
 - When config is LEADER, and `loc_rcvr_status` is OK, the PCS Receive function monitors the received PAM2 symbols to determine whether the link partner is signaling reliable operation of its receive link
 - Once reliable operation of the receive link for the remote FOLLOWER is detected, this is communicated to the PHY Control function by setting `rem_flr_rcvr_status` to OK
 - When the remote PHY is sending formatted training frames the PCS Receive function attains frame and block synchronization based on the formatted training frame
 - The formatted training frame includes an alignment bit every 192 PAM2 16 symbols, which is aligned with the PCS partial frame boundary, as well as an `InfoField`, which is inserted into every 16th PCS partial frame
 - The PCS Receive function signals the detection of a valid `InfoField` to the PHY Control function by setting `rx_info_frame` to TRUE

► PCS Receive operation – NORMAL

- When `pcs_rx_mode` is NORMAL, the PCS Receive function applies the inverse of the encoding processes described in [190.3.3 PCS Transmit function](#)
- Every $2N$ RX_CLK cycles an $(8N+1)B$ block is received and is decoded to generate a list of N characters each of which represents either a data octet or a control symbol
- These characters are mapped one at a time into `rx_char` which is processed in accordance with Figure 190–13B to generate signals at the MII

► PCS Receive operation – error conditions

- The PCS Receive function incorporates several means to detect error conditions
 - The PCS Receive state diagram detects packets that are not preceded by start-of-packet control symbols or are not followed by end-of-packet control symbols
 - When RS-FEC is enabled for the link, the RS-FEC frame error ratio (RFER) monitor process, monitors the reliability of the RS decoder and asserts `hi_rfer` to indicate an excessive RS- FEC frame error ratio
 - The PCS Receive function may use these detected error conditions to determine whether it is operating reliably and generates `pcs_status` accordingly

► PCS Receive operation – invalid characters

- Errors during transmission can cause invalid characters to be received that could not have been transmitted
- Received characters shall be identified as invalid characters in the following cases:
 - The received character represents a control symbol with the numerical value 0x00
 - The received character represents the control symbol /LI/ when EEE is not enabled for the link
 - The received character is declared to be invalid due to a block error
 - Invalid received characters are replaced with characters representing /E/ before the processing shown in [Figure 190–13B PCS Receive state diagram](#) is performed

► PCS Receive operation – block errors

- Errors during transmission can cause block errors during decoding
 - While an $(8N + 1)B$ block is being decoded an invalid pointer can be encountered
 - In this case all received characters from the corresponding octet position to the end of the block are replaced with characters representing /E/
 - If an $(8N + 1)B$ block contains information from the payload of an RS-FEC codeword that cannot be decoded due to uncorrectable errors all characters are replaced with characters representing /E/

PCS Receive Operation

► PCS Receive operation – character decoding

- The PCS Receive function decodes each received character into two MII transfers and following Table 190–5p5
- For example **/Tu2/** corresponds to an end of frame occurring on a non byte aligned boundary, where the last data nibble is 0x2
 - This is replaced by a normal MII nibble transfer encoding the data value 0x2
 - Followed by normal inter-frame signaling
 - RX_DV = 0 and RX_ER = 0

Table 190–5p5— Character decoding

Received Character	Even Transfer			Odd Transfer		
	RX_DV	RX_ER	RXD<3:0>	RX_DV	RX_ER	RXD<3:0>
/E/	1	1	0000	1	1	0000
/I/	0	0	0000	0	0	0000
/Su/	0	0	0000	1	0	0101
/Tp/	0	0	0000	0	0	0000
/LI/	0	1	0001	0	1	0001
/R/	0	1	0100	0	1	0100
/Sp/	1	0	0101	1	0	0101
/Tu0/	1	0	0000	0	0	0000
/Tu1/	1	0	0001	0	0	0000
/Tu2/	1	0	0010	0	0	0000
/Tu3/	1	0	0011	0	0	0000
/Tu4/	1	0	0100	0	0	0000
/Tu5/	1	0	0101	0	0	0000
/Tu6/	1	0	0110	0	0	0000
/Tu7/	1	0	0111	0	0	0000
/Tu8/	1	0	1000	0	0	0000
/Tu9/	1	0	1001	0	0	0000
/TuA/	1	0	1010	0	0	0000
/TuB/	1	0	1011	0	0	0000
/TuC/	1	0	1100	0	0	0000
/TuD/	1	0	1101	0	0	0000
/TuE/	1	0	1110	0	0	0000
/TuF/	1	0	1111	0	0	0000
Data Value ROCT<7:0>	1	0	ROCT<3:0>	1	0	ROCT<7:4>

► PCS Receive operation – block lock

- Clauses 149 / 165 have a **block_lock** variable defined as follows

When the PCS Synchronization process has obtained synchronization, the RS-FEC frame error ratio (RFER) monitor process monitors the signal quality and asserts **hi_rfer** to indicate excessive RS-FEC frame errors. If 40 consecutive RS-FEC frame errors are detected, the **block_lock** flag is de-asserted. The **block_lock** flag is re-asserted upon detection of a valid RS-FEC frame. When **block_lock** is asserted and **hi_rfer** is de-asserted, the PCS Receive process continuously accepts blocks. The PCS Receive process monitors these blocks and generates RXD <31:0> and RXC <3:0> on the 25GMII.

- Hence, in the case of high RFER **block_lock** is set FALSE but may subsequently become TRUE again

► In this clause we are proposing a different approach

- This is partially motivated by the desire to have a common approach with or without RS-FEC
- When RS-FEC is enabled, the link will not come up unless the RS-FEC is operating correctly
- Once the link comes up, if there is high RFER the PCS is expected to set **pcs_status** to NOT_OK, which is expected to cause **loc_rcvr_status** to become NOT_OK and thus cause the link to drop
- We do not try to recover from a situation where the RS-FEC is operating unreliably
- The fastest and most robust recovery is to drop the link and restart Auto-Negotiation

PCS Receive Operation

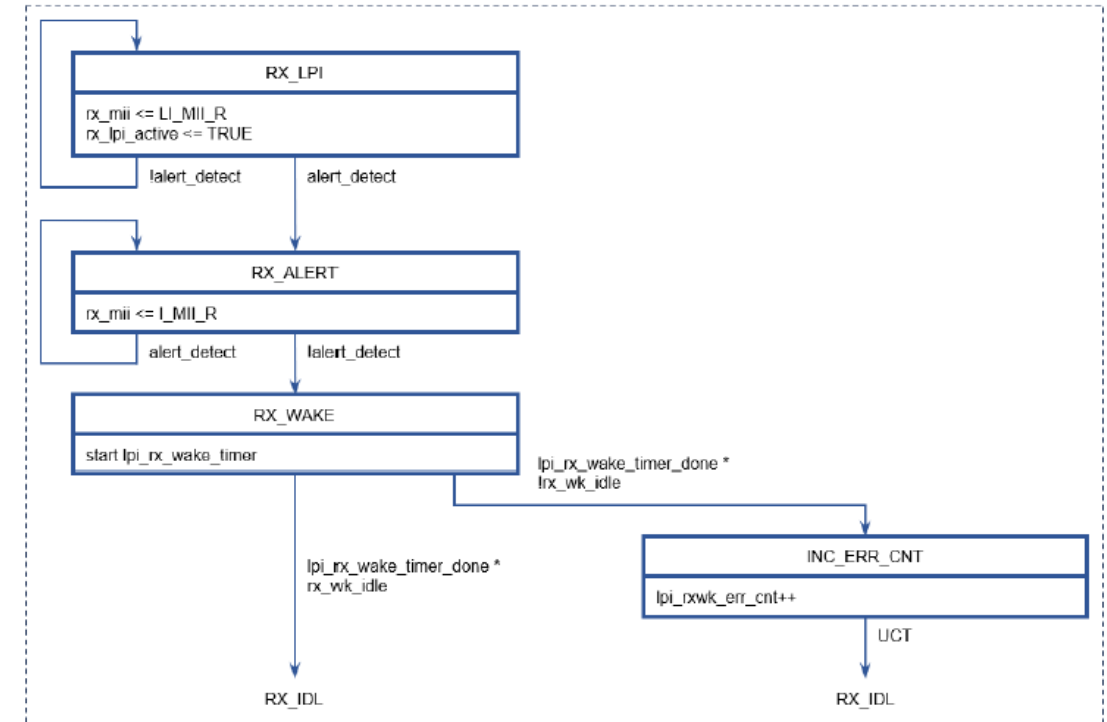
► PCS Receive function – LPI

- In the RX_LPI state the PHY continuously signals **Assert LPI** at the MII receive pins
- When **alert_detect** become TRUE the state diagram transitions to RX_ALERT and **Normal inter-frame** is signaled at the MII

alert_detect

Boolean variable that is set TRUE when the PCS Receive state diagram of Figure 190–13B is in the RX_LPI state or the RX_ALERT state and a sequence of symbols is received from the PMA via the rx_symb parameter that is consistent with alert signaling, as specified in 190.3.7.4. It is set FALSE otherwise.

- Once wake signaling appears at the PMA to PCS interface **alert_detect** become FALSE and the state diagram transitions to RX_WAKE
 - The **lpi_rx_wake_timer** allows the wake signal to propagate through the PCS receive path
 - When RS-FEC is enabled the propagation delay is large
 - Once the **lpi_rx_wake_timer** expires the PCS receive function checks that the last 8 receive characters are all // control symbols, and if not, the wake error counter is incremented

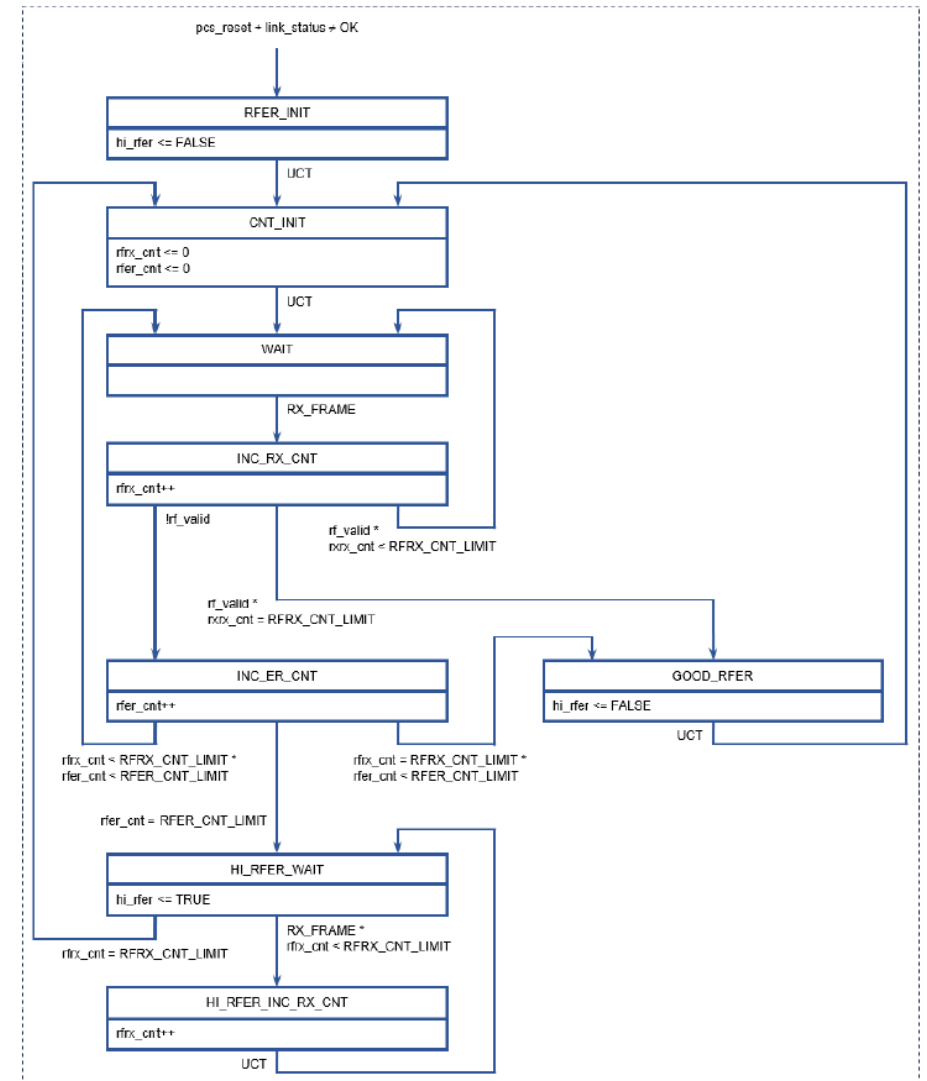


NOTE—This figure is mandatory when EEE is enabled for the link.

Figure 190–13B—PCS Receive state diagram, part b

PCS Receive Operation

- ▶ PCS Receive function – RFER monitor
- ▶ This is based on clause 149 Figure 149-15 with some differences
 - RFER monitoring does not begin until the link is up
 - PHY control was designed to synchronize link establishment
 - We do not have a **block_lock** signal
 - Under conditions of high RFER the link drops and we restart Auto-Negotiation
 - In clause 149 the counters are reset when we enter receive LPI mode
 - We pause the counters but do not reset them



NOTE—This figure is mandatory when RS-FEC is enabled for the link.

Figure 190-13C—RFER monitor state diagram

Proposed Text for the Draft

- ▶ The following slides include the proposed changes to the text of draft 1.0 required for the draft
 - A number of sections, tables and state diagrams are completely new and are shown inside a **blue** outline text box □ with a 'New Text' or 'New Figure' or 'New Table' pointer
 - Some sections have existing text that has been completely rewritten, in these cases the new text (inside □) is shown side by side with the original text inside a **red** outline text box □
 - Original text boxes have a header IEEE P802.3dg™/D1.0, 29th April 2025
 - Original text included for reference that is being kept, is shown inside a **brown** outline text box □
- ▶ Note that there are additional Tables and Figures
 - The same numbering is used for existing tables and figures as used in draft 1.0 so that reference to existing draft 1.0 tables and figures is easier
 - New proposed figures have been given numbers 5p5, 13A, 13B and 13C , so that figures 14 and above have the same figure numbers as draft 1.0
 - The tables and figures will be renumbered in the draft
 - Reference to table or figures whose number will change in the draft are show in **red**

Proposed Text for the Draft – PCS Receive

► Text changes for section 190.3.4 PCS Receive function

- Replace text on page 73, lines 41 to 51 and page 74, lines 1 to 7



190.3.4 PCS Receive function

The PCS Receive function shall conform to the PCS Receive state diagram in Figure 190–13B. When RS-FEC is enabled for the link, the PHY Receive function shall implement the RFER monitor state diagram of Figure 190–13C.

When the pcs_rx_mode parameter is TRAIN, the PCS Receive function checks the received PAM2 symbols and signals the reliable acquisition of the descrambler state by setting the scr_status parameter of the PMA_SCRSTATUS.request primitive to OK.

When the pcs_rx_mode parameter is TRAIN, and the config parameter is LEADER, and the loc_rcvr_status parameter is OK, the PCS Receive function monitors the received PAM2 symbols to determine whether the link partner is signaling reliable operation of its receive link. Once reliable operation of the receive link for the remote FOLLOWER is detected, this is communicated to the PHY Control function by setting the rem_flr_rcvr_status parameter of the PMA_REMFLRRXSTATUS.request primitive to OK.

When the pcs_rx_mode parameter is TRAIN, and the loc_rcvr_status parameter is OK, and the remote PHY is sending formatted training frames, the PCS Receive function attains frame and block synchronization based on the formatted training frame. The formatted training frame includes an alignment bit every 192 PAM2 symbols, which is aligned with the PCS partial frame boundary, as well as an InfoField, which is inserted into every 16th PCS partial frame. The PCS Receive function signals the detection of a valid InfoField to the PHY Control function by setting the rx_info_frame parameter of the PMA_RXINFOFRAME.request primitive to TRUE.

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190.3.4 PCS Receive function

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

The text below is part of the description of the PCS Receive, but lacks the requirements and description of the PCS Receive state diagram operation which needs to be decided before that text can be written. Contributions are requested to fill out PCS Receive requirements before text is filled out here.

When the pcs_rx_mode parameter is TRAIN, the PCS Receive function checks the received PAM2 symbols and signals the reliable acquisition of the descrambler state by setting the scr_status parameter of the PMA_SCRSTATUS.request primitive to OK.

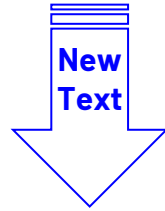
When the pcs_rx_mode parameter is TRAIN, and the config parameter is LEADER, the PCS Receive function continuously monitors the loc_rcvr_status parameter. Once loc_rcvr_status is set to OK, the PCS Receive function monitors the received PAM2 symbols to determine whether the link partner is signaling reliable operation of its receive link. Once reliable operation of the receive link for the remote PHY is detected, this is communicated to the PHY Control function by setting the rem_rcvr_status parameter of the PMA_REMRXSTATUS.request primitive to OK.

When the pcs_rx_mode parameter is TRAIN, the PCS Synchronization process continuously monitors the loc_rcvr_status parameter. When loc_rcvr_status is set to OK, the PCS Synchronization process accepts

symbols via the PMA_UNITDATA.indication primitive. It attains frame and block synchronization based on the formatted training frame structure and conveys received blocks to the PCS Receive process. The PCS Synchronization process sets the block_lock flag to indicate whether the PCS has obtained synchronization. The formatted training frame includes an alignment bit every 192 PAM2 symbols, which is aligned with the PCS partial frame boundary, as well as an InfoField, which is inserted in the 16th PCS partial frame. When the PCS Synchronization process is synchronized to this pattern, block_lock is asserted.

Proposed Text for the Draft – PCS Receive

- ▶ Continue text changes for section 190.3.4 PCS Receive function
 - Replace text on page 74, lines 14 to 25



When the pcs_rx_mode parameter is NORMAL, the PCS Receive function applies the inverse of the encoding processes described in 190.3.2 and depicted in Figure 190–5. Every 2N RX_CLK cycles an (8N+1)B block is received and is decoded to generate a list of N characters each of which represents either a data octet or a control symbol. These characters are mapped one at a time into the rx_char structure which is processed in accordance with Figure 190–13B to generate signals at the MII.

The PCS Receive function incorporates several means to detect error conditions. The PCS Receive state diagram detects packets that are not preceded by start-of-packet control symbols or are not followed by end-of-packet control symbols. When RS-FEC is enabled for the link, the RS-FEC frame error ratio (RFER) monitor process monitors the reliability of the RS decoder and asserts hi_rfer to indicate an excessive RS-FEC frame error ratio. The PCS Receive function may use these detected error conditions to determine whether it is operating reliably and generates the pcs_status variable accordingly. The precise algorithm for generation of pcs_status is implementation dependent.

IEEE P802.3dg™/D1.0, 29th April 2025

When the pcs_rx_mode parameter is NORMAL, the RS-FEC frame error ratio (RFER) monitor process monitors the signal quality and asserts hi_rfer to indicate excessive RS-FEC frame errors. If 40 consecutive RS-FEC frame errors are detected, the block_lock flag is de-asserted. The block_lock flag is re-asserted upon detection of a valid RS-FEC frame. When block_lock is asserted and hi_rfer is de-asserted, the PCS Receive process continuously accepts blocks. The PCS Receive process monitors these blocks and generates RXD <3:0>, RX_DV and RX_ER on the MII.

190.3.4.1 Frame and block synchronization

190.3.4.2 PCS Receive descrambler

190.3.4.3 Valid and invalid blocks

Proposed Text for the Draft – PCS Receive

► Text for section 190.3.4.1 Invalid characters / 190.3.4.2 Block errors

► New section, insert the following text for section 190.3.4.1



190.3.4.1 Invalid characters

When the pcs_rx_mode parameter is NORMAL, the PCS Receive function applies the inverse of the encoding processes described in 190.3.2 to generate a list of N received characters every 2N RX_CLK cycles as described in 190.3.4. Errors during transmission can cause invalid characters to be received that could not have been transmitted. Received characters shall be identified as invalid characters in the following cases:

- a) The received character represents a control symbol with the numerical value 0x00.
- b) The received character represents the control symbol /LI/ when EEE is not enabled for the link.
- c) The received character is declared to be invalid due to a block error as specified in 190.3.4.2.

Invalid received characters shall be replaced with characters representing /E/ before the processing shown in Figure 190–13B is performed.

► New section, insert the following text for section 190.3.4.2



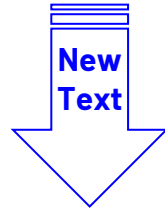
190.3.4.2 Block errors

While an $(8N + 1)B$ block is being decoded an invalid pointer can be encountered. In this case all received characters from the corresponding octet position to the end of the block are declared to be invalid and handled as specified in 190.3.4.1.

If an $(8N + 1)B$ block contains information from the payload of an RS-FEC codeword that cannot be decoded due to uncorrectable errors, then all received characters in that block are declared to be invalid and handled as specified in 190.3.4.1.

Proposed Text for the Draft – PCS Receive

- Text for section 190.3.4.3 Character decoding
 - New section, insert the following text for section 190.3.4.3



190.3.4.3 Character decoding

The PCS Receive function decodes each received character into two MII transfers and shall follow Table 190-5p5.

- New table, Table 190-5p5– Character decoding



Table 190-5p5– Character decoding

Received Character	Even Transfer			Odd Transfer		
	RX_DV	RX_ER	RXD<3:0>	RX_DV	RX_ER	RXD<3:0>
/E/	1	1	0000	1	1	0000
/I/	0	0	0000	0	0	0000
/Su/	0	0	0000	1	0	0101
/Tp/	0	0	0000	0	0	0000
/LI/	0	1	0001	0	1	0001
/R/	0	1	0100	0	1	0100
/Sp/	1	0	0101	1	0	0101
/Tu0/	1	0	0000	0	0	0000
/Tu1/	1	0	0001	0	0	0000
/Tu2/	1	0	0010	0	0	0000
/Tu3/	1	0	0011	0	0	0000
/Tu4/	1	0	0100	0	0	0000
/Tu5/	1	0	0101	0	0	0000
/Tu6/	1	0	0110	0	0	0000
/Tu7/	1	0	0111	0	0	0000
/Tu8/	1	0	1000	0	0	0000
/Tu9/	1	0	1001	0	0	0000
/TuA/	1	0	1010	0	0	0000
/TuB/	1	0	1011	0	0	0000
/TuC/	1	0	1100	0	0	0000
/TuD/	1	0	1101	0	0	0000
/TuE/	1	0	1110	0	0	0000
/TuF/	1	0	1111	0	0	0000
Data Value ROCT<7:0>	1	0	ROCT<3:0>	1	0	ROCT<7:4>

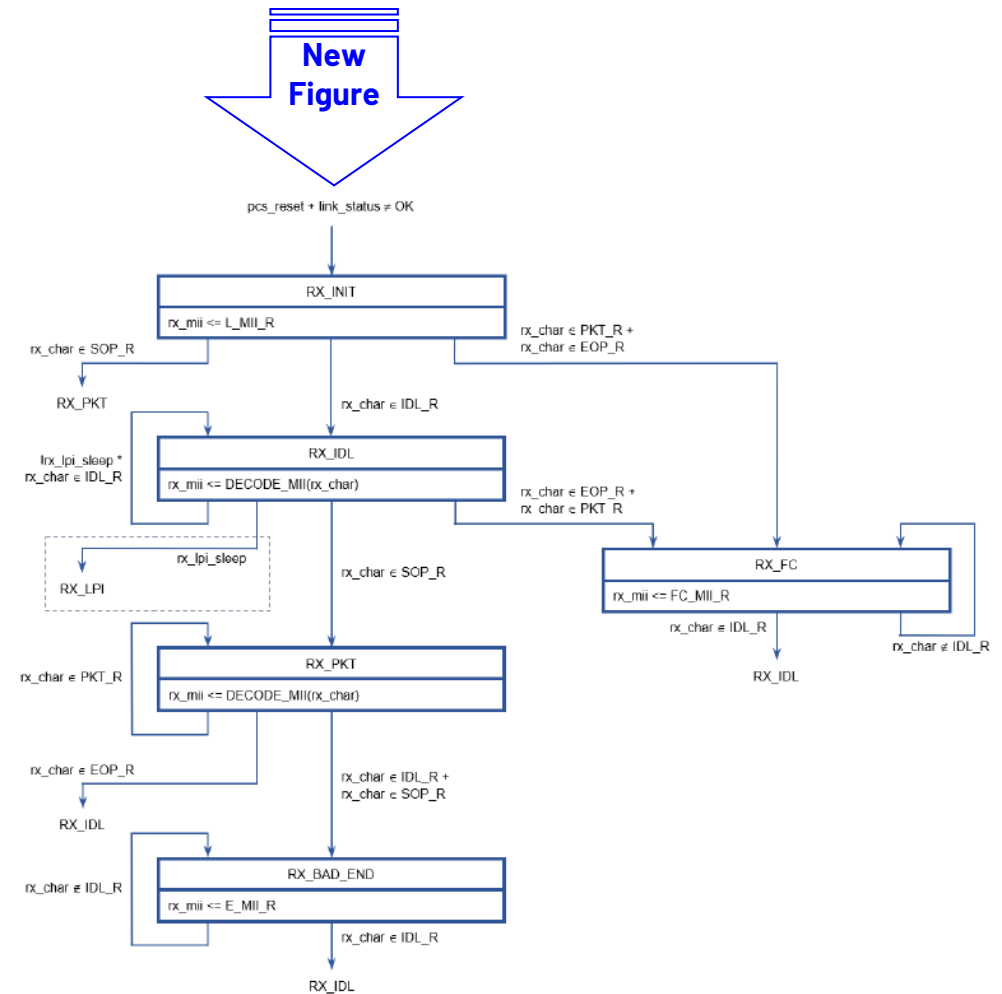
Proposed Text for the Draft –State Diagrams

- ▶ Section 190.3.8.2 State diagrams
 - State Diagrams and text for the PCS receive
 - Add intro text



The PCS Receive state diagram shown in Figure 190–13B controls the conversion of received characters to signals at the MII. It evaluates the exit conditions for the current state exactly once for every 2 cycles of RX_CLK except for the INC_ERR_CNT UCT exit condition, which is evaluated immediately after the INC_ERR_CNT state actions are complete.

- New Figure 190–13B—PCS Receive state diagram, part a

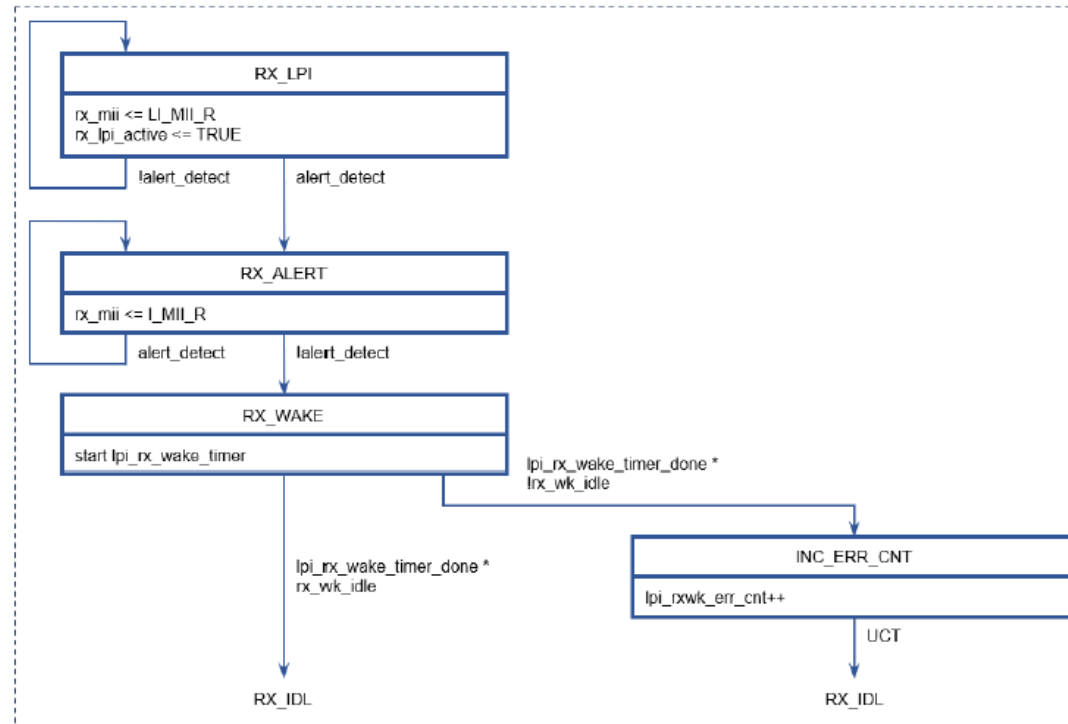


NOTE—Signals and functions shown with dashed lines are only required when EEE is enabled for the link.

Figure 190–13B—PCS Receive state diagram, part a

Proposed Text for the Draft –State Diagrams

- ▶ Continue section 190.3.8.2 State diagrams
 - Continue State Diagrams for the PCS receive
 - New Figure 190–13B—PCS Receive state diagram, part b

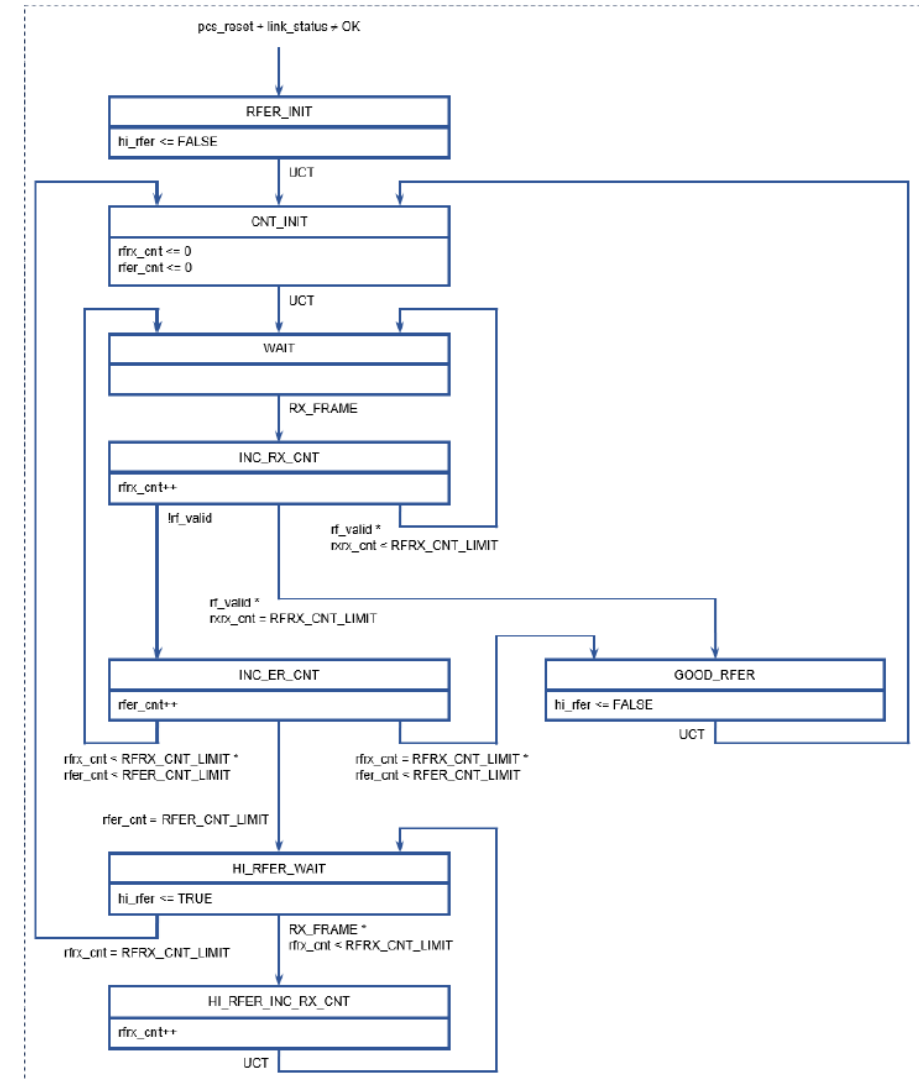


NOTE—This figure is mandatory when EEE is enabled for the link.

Figure 190–13B—PCS Receive state diagram, part b

Proposed Text for the Draft –State Diagrams

- ▶ Continue section 190.3.8.2 State diagrams
 - State Diagrams for the RFER monitor
 - New Figure 190–13C—RFER monitor state diagram



NOTE—This figure is mandatory when RS-FEC is enabled for the link.

Figure 190–13C—RFER monitor state diagram

- ▶ We have not had any presentation on the PCS Receive function and the text in draft 1.0 is just a placeholder
- ▶ This presentation describes the PCS Receive Operation and the main differences from previous clauses 149 and 165
- ▶ This presentation provides new text and tables for the PCS Receive function for the draft including the necessary state diagrams

Questions ?