Startup protocol for 10GBASE-T

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Outline

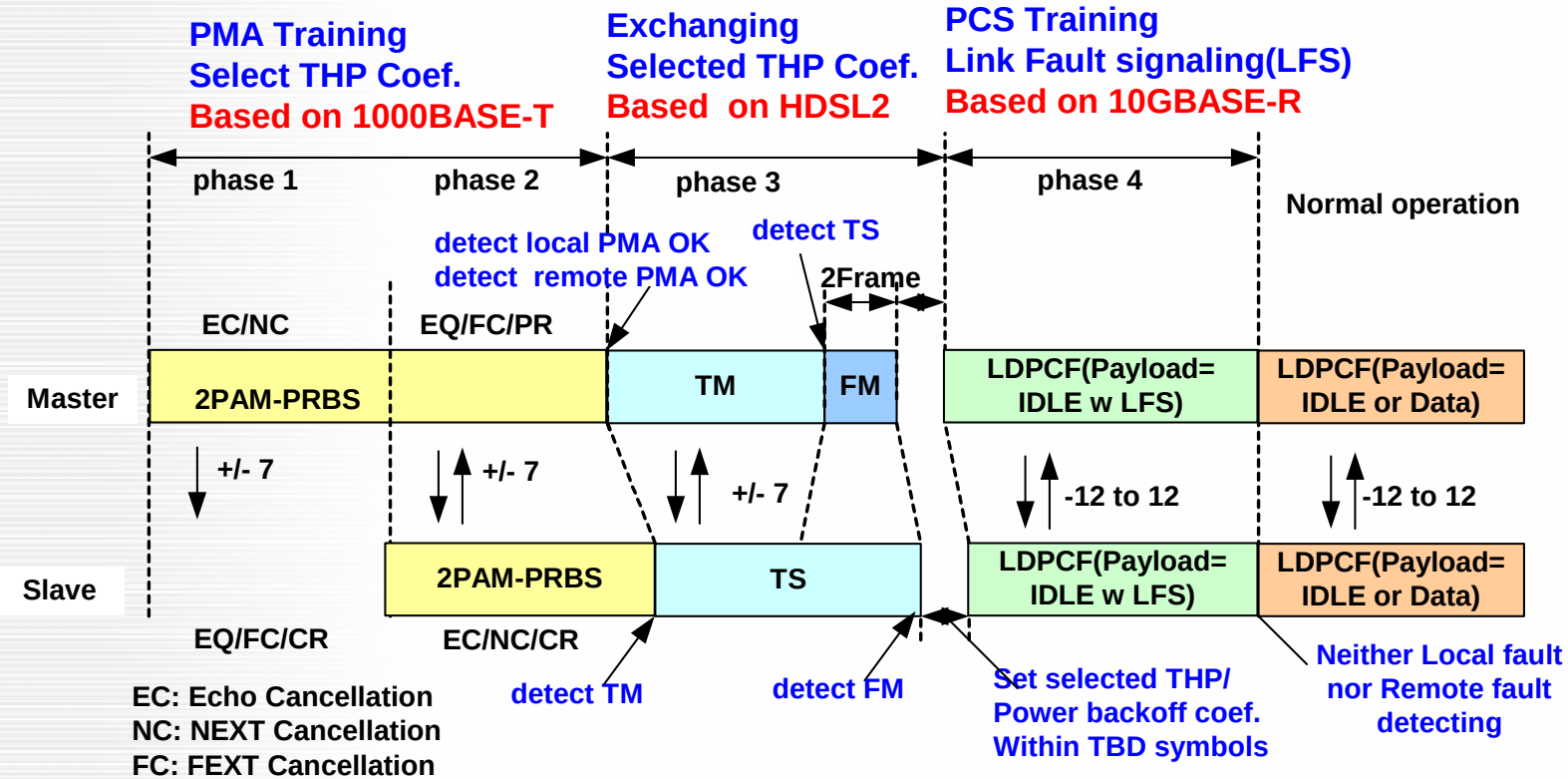
- Objectives
- Startup sequence
- State diagram
- PMA training signal
- THP/Power backoff coef. exchang frame
- Conclusion

Objectives

- Recover timing and adaptive filter coefficients
- Establish polarity correction, pair swap, pair deskew
- Establish LDPC block boundary
- Select THP coef. and power backoff coef.

Start up sequence

Exchanging THP and power backoff coef at startup

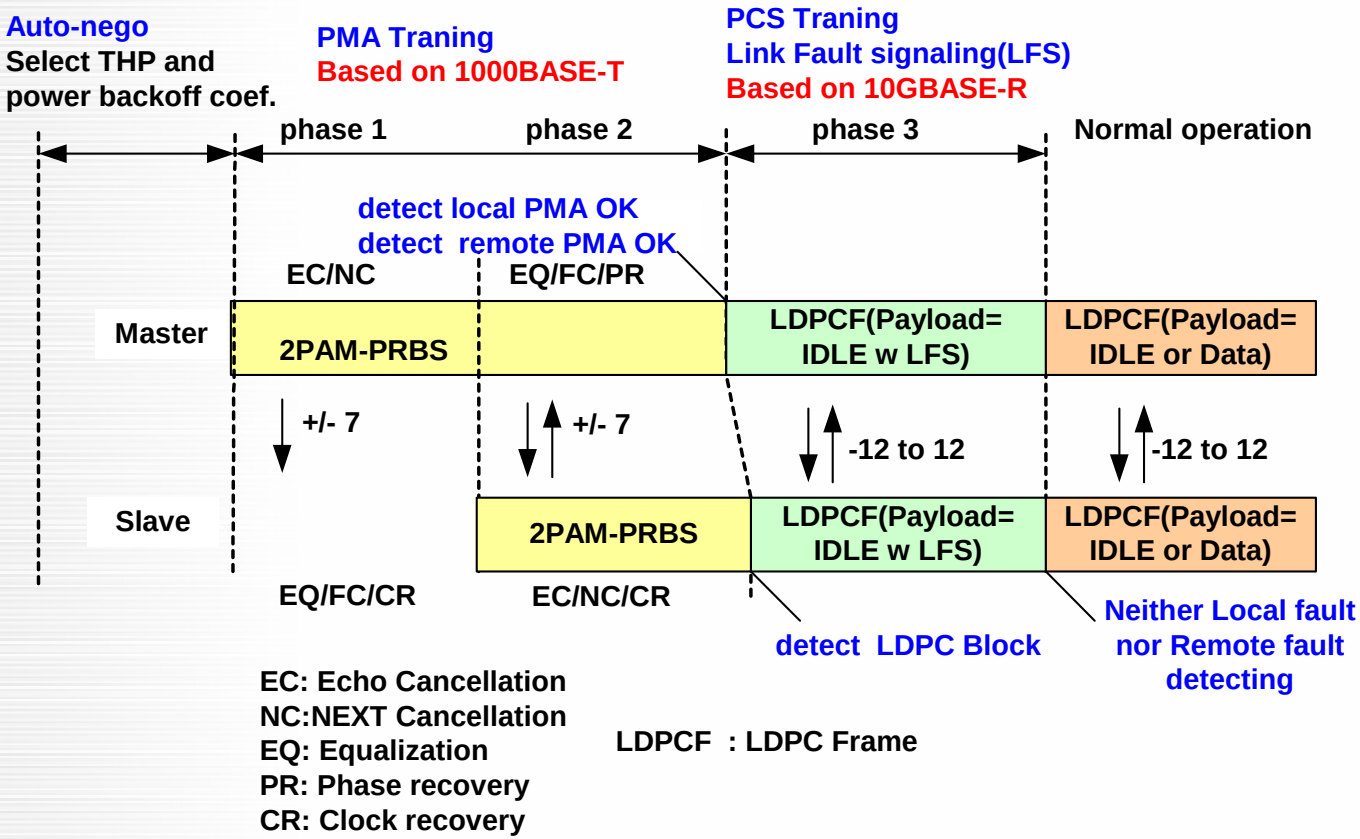


EC: Echo Cancellation
NC: NEXT Cancellation
FC: FEXT Cancellation
EQ: Equalization
PR: Phase recovery
CR: Clock recovery

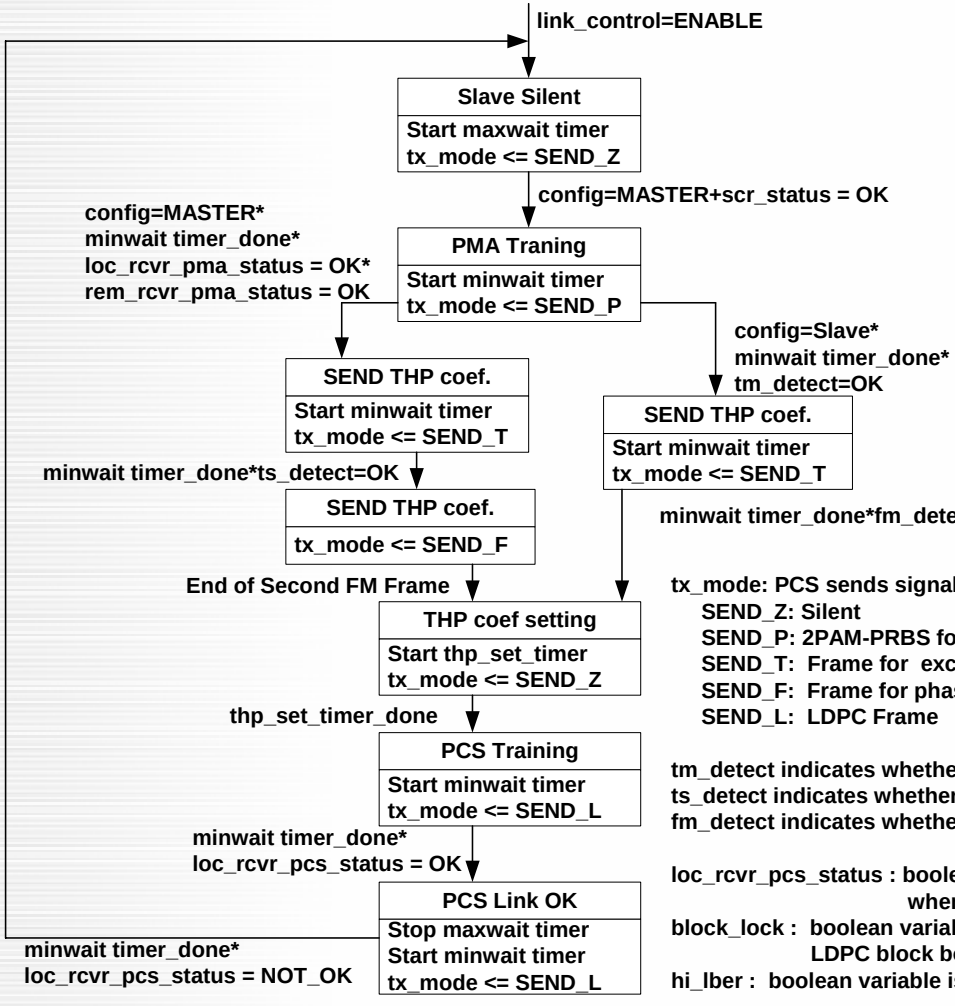
TM/TS : Frame for exchanging THP coefficients
FM : Frame for phase3 termination
LDPCF : LDPC Frame

Startup sequence (Cont)

If THP and power backoff coef. is selected at AN, Coef exchange sequence can be eliminated.



PHY Control State Diagram

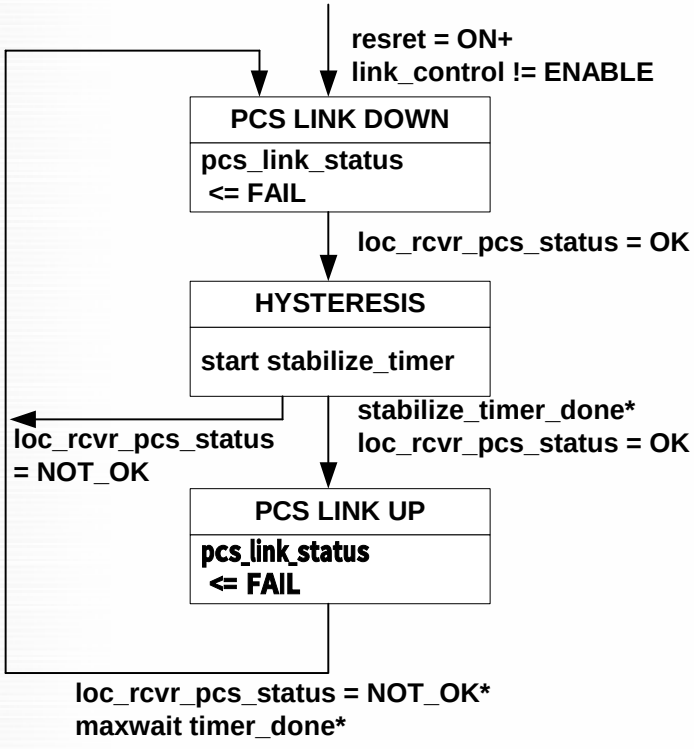


tx_mode: PCS sends signal according to this varlable
- SEND_Z: Silent
- SEND_P: 2PAM-PRBS for PMA Training
- SEND_T: Frame for exchanging THP coefficients(TM/TS)
- SEND_F: Frame for phase3 termination(FM)
- SEND_L: LDPC Frame

tm_detect indicates whether TM frame is detected or not
ts_detect indicates whether TM frame is detected or not
fm_detect indicates whether FM frame is detected or not

loc_rcvr_pcs_status : boolean variable is set OK when PCS status is OK(block_lock * ! hi_lber)
block_lock : boolean variable is set ture when reciever acquires LDPC block boundary
hi_lber : boolean variable is asserted true when the lber_cnt exceed TBD.

PCS Link Monitor State Diagram



The valiable pcs_link_status and link_control are designated as link_control_(10GigT) and link_status_(10GigT), respectively, by Auto-negotiation Arbitration state diagram (Fig28-16)

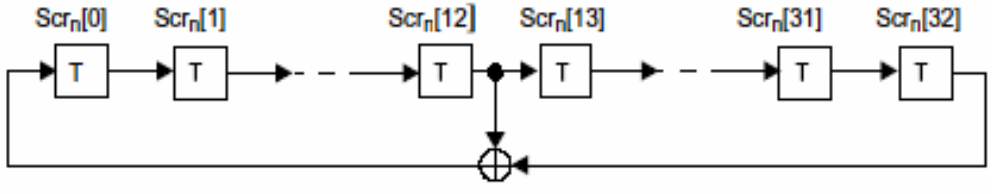
PMA Training signal

Objective:

- **Recover timing and adaptive filter coefficients**
- **Establish polarity correction, pair swap, pair deskew**

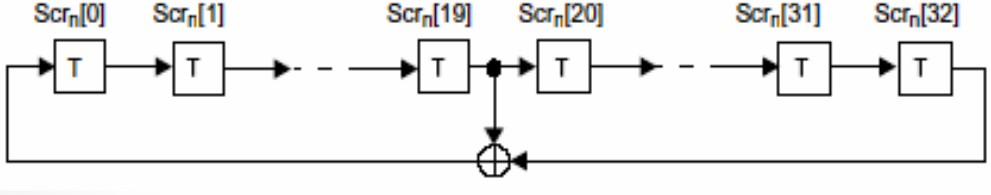
Side stream scrambler: (ref IEEE802.3 40.3.1.3.1)

Side-stream scrambler employed by the MASTER PHY



$$g_m(x)=1+x^{13}+x^{33}$$

Side-stream scrambler employed by the SLAVE PHY



$$g_s(x)=1+x^{20}+x^{33}$$

PMA Training signal (cont')

Generation of bits Syn[3:0]

$$Sy_n[0] = Scr_n[0]$$

$$Sy_n[1] = g(Sy_n[0]) = Scr_n[3] \wedge Scr_n[8]$$

$$Sy_n[2] = g(Sy_n[1]) = Scr_n[6] \wedge Scr_n[16]$$

$$Sy_n[3] = \begin{cases} g(Sy_n[2]) \wedge Sy_n[0] = Scr_n[9] \wedge Scr_n[14] \wedge Scr_n[19] \wedge Scr_n[24] \wedge Scr_n[0] & if\ (loc\_rcvr\_pma\_status = NG) \\ g(Sy_n[2]) \wedge Sy_n[1] = Scr_n[9] \wedge Scr_n[14] \wedge Scr_n[19] \wedge Scr_n[24] \wedge Scr_n[1] & else \end{cases}$$

$$g(x) = x^3 + x^8$$

Generation of Transmit symbol vector

$$A = \begin{cases} 7\ if\ (Sy_n[0] = 0) \\ -7\ else \end{cases} \quad B = \begin{cases} 7\ if\ (Sy_n[1] = 0) \\ -7\ else \end{cases}$$

$$C = \begin{cases} 7\ if\ (Sy_n[2] = 0) \\ -7\ else \end{cases} \quad D = \begin{cases} 7\ if\ (Sy_n[3] = 0) \\ -7\ else \end{cases}$$

This PMA training signal can meet objectives of polarity correction, pair swap, pair deskew.

PMA Training signal (cont')

Polarity correction

$$Ry_n[x] \wedge Ry_{n-13}[x] \wedge Ry_{n-33}[x] = \begin{cases} 0 \text{ (polarity = OK)} \\ 1 \text{ (polarity = NG)} \end{cases} (x = 0,1,2,3)$$

$Ry_n[x]$: **PAM2 demapping data of Lane x**

Pair swap, deskew

$$Ry_n[x] \wedge Ry_{n-3}[x-1] \wedge Ry_{n-8}[x-1] = \begin{cases} 0 \text{ (skew = OK)} \\ 0/1 \text{ (skew = NG)} \end{cases} (x = 1,2)$$

if (remote side PMA status = NG)

$$Ry_n[3] \wedge Ry_{n-3}[2] \wedge Ry_{n-8}[2] \wedge Ry_n[0] = \begin{cases} 0 \text{ (skew = OK)} \\ 0/1 \text{ (skew = NG)} \end{cases}$$

else

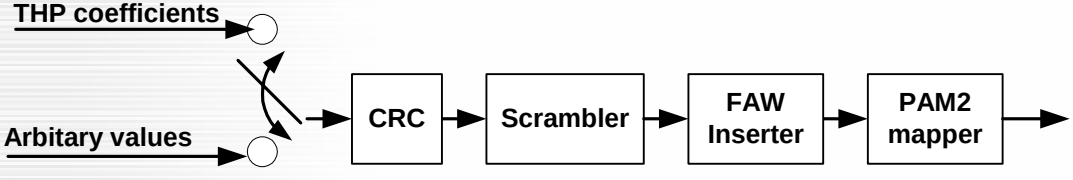
$$Ry_n[3] \wedge Ry_{n-3}[2] \wedge Ry_{n-8}[2] \wedge Ry_n[1] = \begin{cases} 0 \text{ (skew = OK)} \\ 0/1 \text{ (skew = NG)} \end{cases}$$

By using the relationship, PMA status of remote side receiver (rem_rcvr_pma_status) can be detected

Parameter exchanging Frame

	4bits(TBD)	TBD	16bits
TM/TS	Frame Sync Word	Selcted THP coefficients Selected Power backoff coefficients etc...	CRC
FM	Frame Sync Word*	arbitary values	CRC

The frame sync word of FM Frame shall be reversed in time



CRC generator polynomial : $g(x)=x^{16}+x^{12}+x^5+1$

Scrambler Polinomial : $g(x)=x^{23}+x^5+1$ **(Master)**

$g(x)=x^{23}+x^{18}+1$ **(Slave)**

Ref. ITU-T G.991.2 "Single-pair high-speed digital subscriber line(SHDL)" Sec .7.2

PAM2 mapping

$$A=\begin{cases}7 \; if \; (TxTM < 4n >= 0)\\ -7 \; else\end{cases}$$

$$B=\begin{cases}7 \; if \; (TxTM < 4n+1 >= 0)\\ -7 \; else\end{cases}$$

$$C=\begin{cases}7 \; if \; (TxTM < 4n+2 >= 0)\\ -7 \; else\end{cases}$$

$$D=\begin{cases}7 \; if \; (TxTM < 4n+3 >= 0)\\ -7 \; else\end{cases}$$

Conclusion

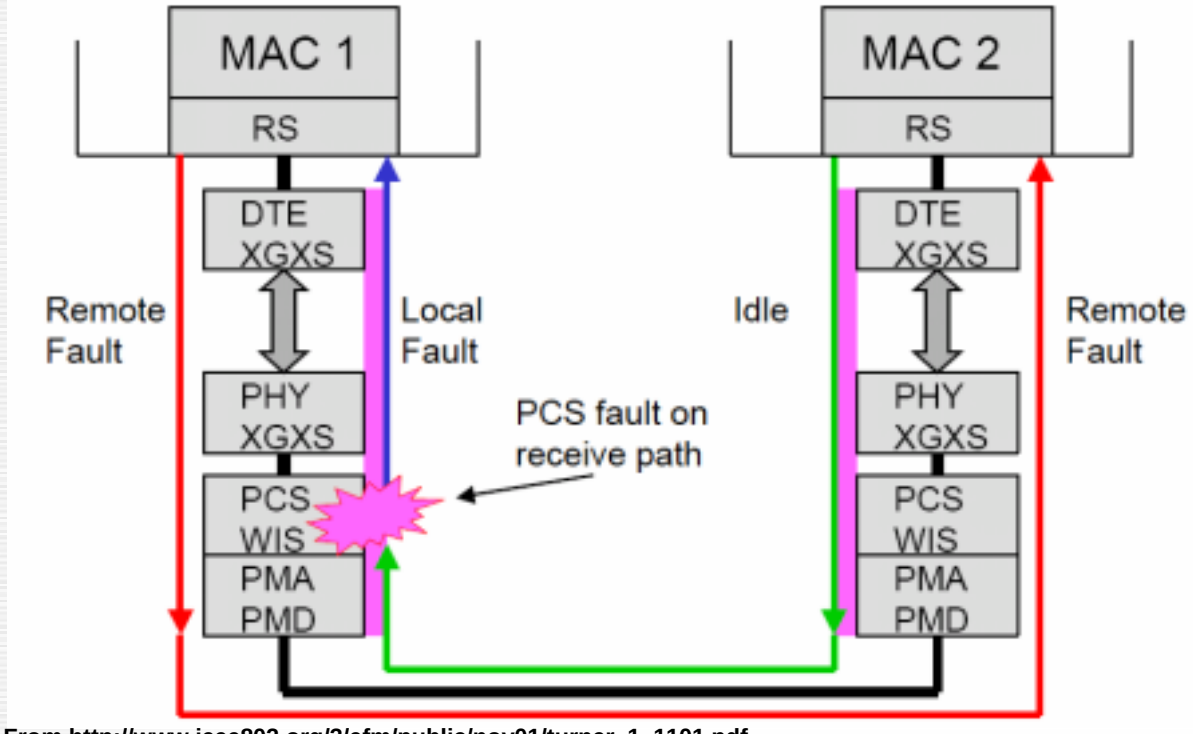
- Startup sequence
  1) Select predetermined or Programmable coefficients at startup
  2) Select predetermined coefficients at auto-negotiation

  TF needs further investigation about THP/Power backoff coef choosing method

- By using proposed PMA training signal, polarity correction, pair swap, pair deskew can be established

Backup

10GBASE-R Link fault signaling



From http://www.ieee802.org/3/efm/public/nov01/turner_1_1101.pdf

- Intermediate link elements initiate Local Fault(LF) and forward status message
- RS layer initiates Remote Fault(RF) status in response to reception of LF
- Link status should be "UP(OK to send packet)“ only when RS layer is detecting neither RF nor LF, that is, all sublayer's protocol is OK.