9.4 Link Speed Negotiation/Transmitter Training flow diagram for 128GFC

9.4.1 Overview

This clause defines Link Speed Negotiation and Transmitter Training for 128GFC. For this clause the following terms are used:

Module Client Side: Electrical Interface between the Module and the Local Host ASIC.

Module Line Side: Optical Interface between the Local and Remote Module.

Squelch: Light is still present but modulation is removed by flat lining the data.

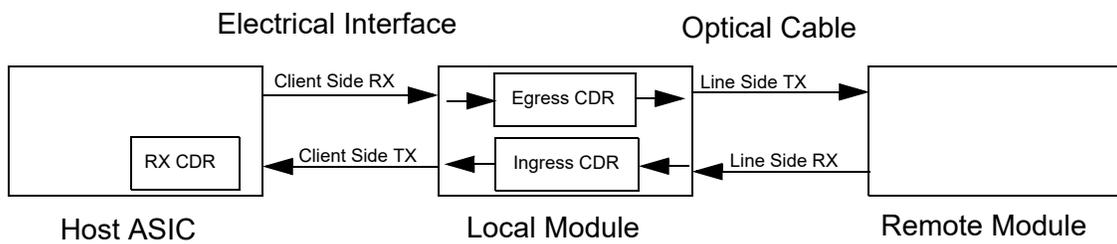An example of these terms is shown in figure 60.

Figure 60 - Module and Interface Example

9.4.2 Link Speed Negotiation/Transmitter Training

An example of the flow as the link moves from LSN to Transmitter Training for 128GFC links is shown is figure 61.
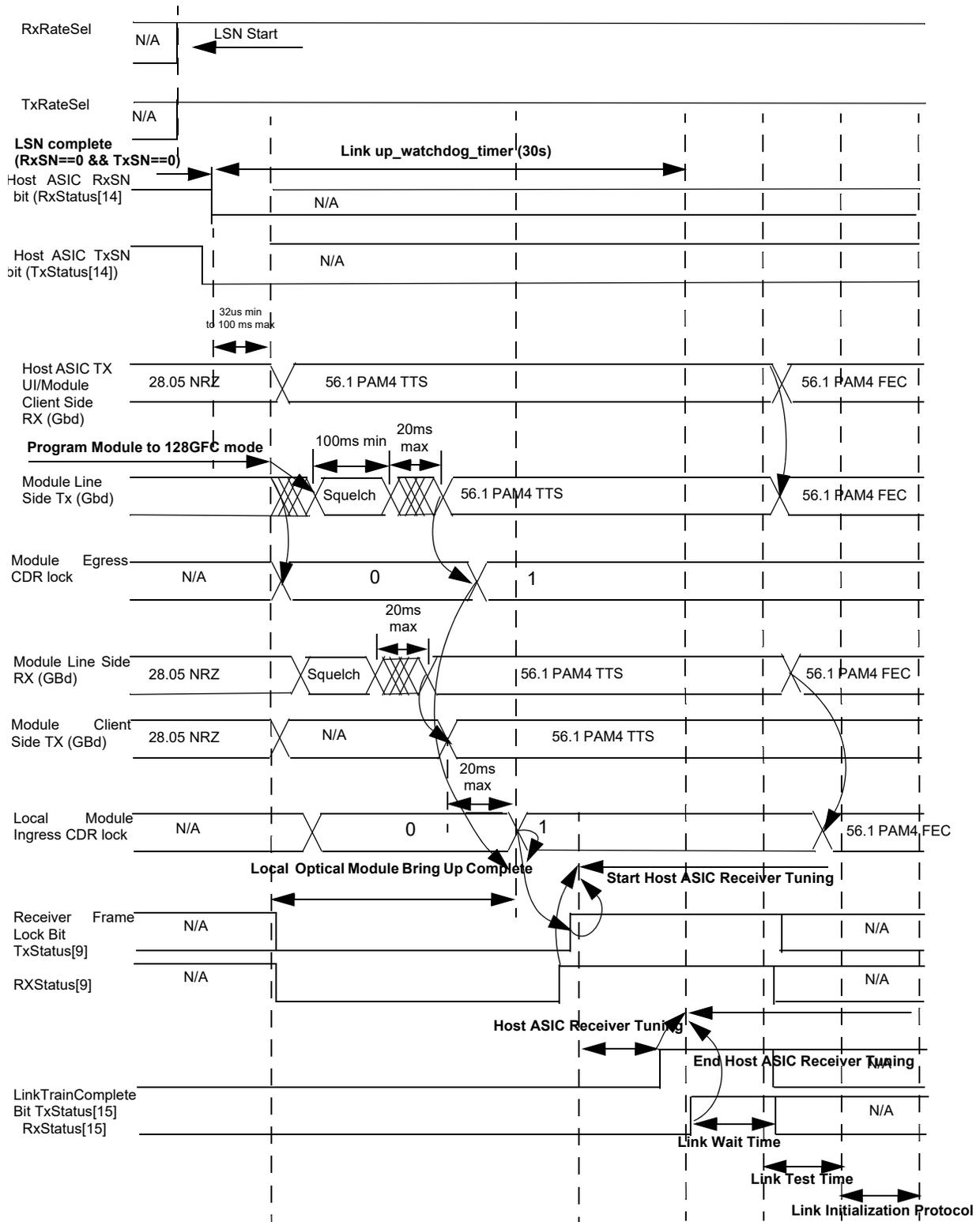
RxRateSel

N/A

LSN Start

TxRateSel

N/A

**LSN complete
(RxSN==0 && TxSN==0)**

Host ASIC RxSN bit (RxStatus[14]

Link up_watchdog_timer (30s)

N/A

Host ASIC TxSN bit (TxStatus[14])

N/A

32us min to 100 ms max

Host ASIC TX UI/Module Client Side RX (Gbd)

28.05 NRZ

56.1 PAM4 TTS

56.1 PAM4 FEC

Program Module to 128GFC mode

100ms min

20ms max

Module Line Side Tx (Gbd)

Squelch

56.1 PAM4 TTS

56.1 PAM4 FEC

Module Egress CDR lock

N/A

0

1

20ms max

Module Line Side RX (GBd)

28.05 NRZ

Squelch

56.1 PAM4 TTS

56.1 PAM4 FEC

Module Client Side TX (GBd)

28.05 NRZ

N/A

56.1 PAM4 TTS

20ms max

Local Module Ingress CDR lock

N/A

0

1

56.1 PAM4 FEC

Local Optical Module Bring Up Complete

Start Host ASIC Receiver Tuning

Receiver Frame Lock Bit TxStatus[9]

N/A

N/A

RXStatus[9]

N/A

N/A

Host ASIC Receiver Tuning

End Host ASIC Receiver Tuning

LinkTrainComplete Bit TxStatus[15] RxStatus[15]

N/A

Link Wait Time

Link Test Time

Link Initialization Protocol

Figure 61 - Link speed negotiation to Transmitter Training for 128GFC links

During the LSN (Link Speed Negotiation) sequence, each transmitter sends a series of Transmitter Training Signal (TTS) frames for predefined time periods (t_txcycl) to advertise the speeds it supports. Each receiver concurrently samples the received TTS at the speeds it supports for predefined sub-intervals (t_rxcycl) of t_txcycl in an attempt to lock to the received TTS.

Simplified timing diagrams of the LSN sequence, along with associated timing parameters, are illustrated in figure 62 and figure 63. Once a common speed for both sides of the Host ASIC is determined (e.g. both sides achieve frame lock and support the speed indicated by the Extended Marker field), each side sets its Training Frame Status bit 14 (i.e., SN) to zero which signals LSN sequence completion. For details of the LSN sequence see clause 8.

An example LSN Tx rate change timing diagram is shown in figure 62.
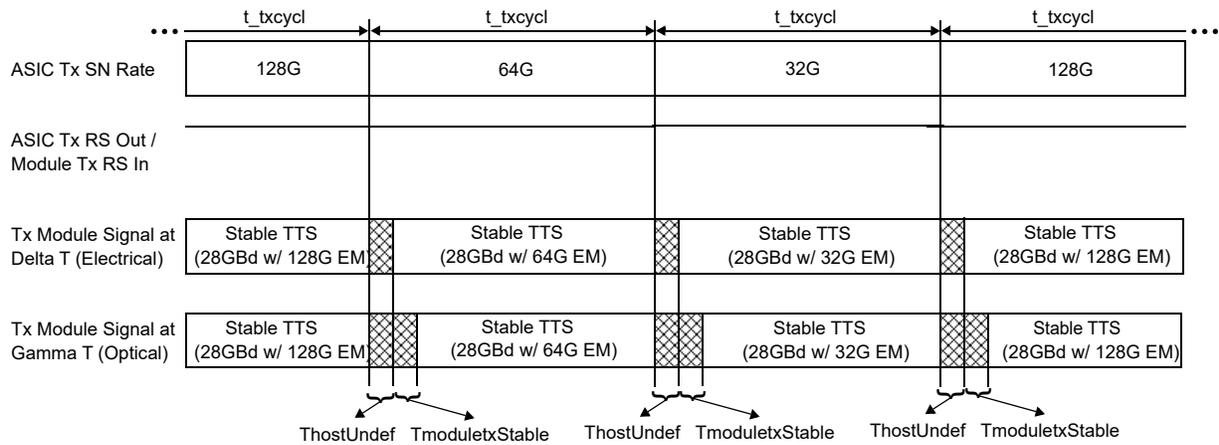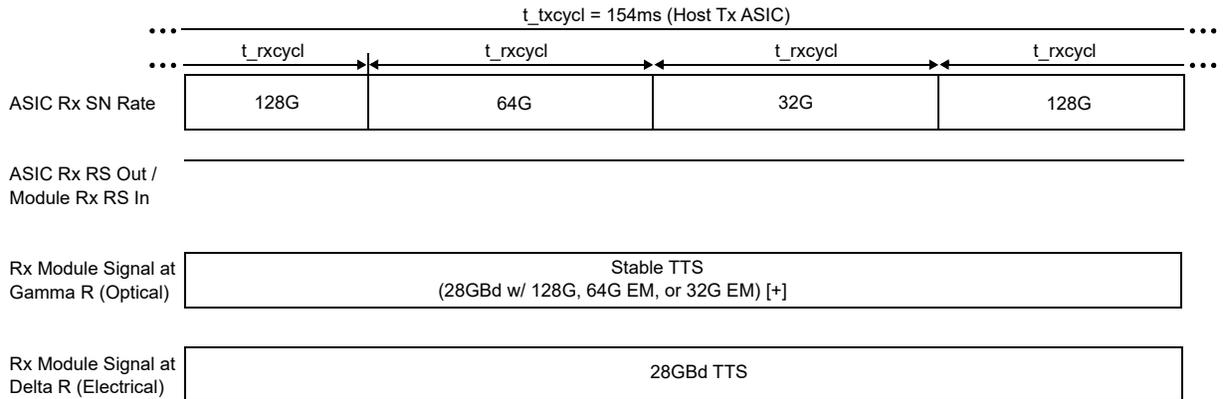

Figure 62 - Example LSN Tx rate change timing diagram

An example LSN Rx rate change timing diagram is shown in figure 63.

	t_txcycl = 154ms (Host Tx ASIC)			
	t_rxcycl	t_rxcycl	t_rxcycl	t_rxcycl
ASIC Rx SN Rate	128G	64G	32G	128G
ASIC Rx RS Out / Module Rx RS In				
Rx Module Signal at Gamma R (Optical)	Stable TTS (28GBd w/ 128G, 64G EM, or 32G EM) [+]			
Rx Module Signal at Delta R (Electrical)	28GBd TTS			

[+] Total time for Stable TTS signal at Gamma R (Optical) during a given Host Tx ASIC LSN speed cycle t_txcycl:
149ms (i.e. t_txcycl - MAX[ThostUndef + TmoduletxStable]) to 154ms (i.e. t_txcycl - MIN[ThostUndef + TmduletxStable])

Figure 63 - Example LSN Rx rate change timing diagram

The Host ASIC shall transmit the TTS for LSN for a minimum of 32us (i.e., lsn_end_wait_timer) after LSN sequence completion.

The Host ASIC starts transmitting the 56.1 Gbaud TTS frame for 128GFC within a maximum time of 100ms (i.e., lsn_end_training_start_timer) from LSN sequence completion. The TTS Control field Extended Marker [15:14] and TTS Status fields SN [14] and TF [12] remain the same value to ensure the TTS frame is decoded properly when tuning of the Host ASIC parameters is started.

If the transmitter training is being run across an optical link, the optical module shall be programmed to run at the 128GFC data rate upon expiration of the lsn_end_training_start_timer. After completion of optical module programming, the Host ASIC will wait for the optical module to indicate that it is ready to transmit and receive data at the 128GFC data rate by reading appropriate status bits in the optical module. Once the optical module indicates a ready status, the Host Electrical Transceiver shall acquire lock to the 128GFC TTS frame.

If the transmitter training is being run across an electrical link the steps related to optical module programming and checking for status shall not be executed. Instead the Host Electrical Transceiver shall attempt to acquire lock to the 128GFC TTS frame upon expiration of the lsn_end_training_start_timer.

When programmed to 128GFC mode, the module will squelch data on it's line side till it has achieved lock to the 128GFC PAM4 TTS signal being transmitted by the Host ASIC. This is done to prevent the CDR on the remote side acquiring lock to a bad signal. The minimum squelch time shall be 100ms (i.e., min_squelch_timer). After the minimum squelch time has elapsed, the module may start transmitting valid PAM4 TTS data at 56.1GB and start transmitting valid PAM4 TTS data at 56.1 GBaud at the Line Side Tx. Between the transmission of squelch data and valid 56.1GBaud PAM4 TTS data, there can be a maximum period of 20ms of undefined data (i.e., t_undef_end_squelch_timer). On the Local Module Client Side, the module must declare CDR lock status as set, a minimum of 20ms after the Host ASIC has started transmitting valid data on the Client Side Tx at 56.1GBaud (i.e., min_datavld_lock_timer).

Once lock is achieved to the 128GFC TTS frame in the Host Electrical Transceiver, the Host ASIC shall set Training Frame Status Field Bit 9 (i.e., Receiver Frame Lock) to let the remote side know that it has achieved lock to the TTS signal. When it receives Training Frame Status Field Bit 9 (i.e., Receiver Frame Lock) from the remote side, this indicates that tuning of the Host ASIC parameters can start, and the max_wait_timer shall be started.

When the Host ASIC determines that tuning of link parameters is complete it shall set Training Frame Status Field Bit 15 (i.e., Receiver Ready) to one. When Training Frame Status Field Bit 15 in both the transmitted and received TTS is one, then Transmitter training is complete. The process from LSN complete to Transmitter Training complete must be completed before linkup_watchdog_timer expires.

The Host ASIC will now enter the LINK_READY state (see IEEE 802.3cd D2.2 figure 136-7). From the Link Ready state, upon expiration of the link_wait_timer, the Host ASIC will move to the Link Quality Check State Machine (see 9.2.3.7) to perform a Link test. FEC is mandatory for 128GFC links, so exchanged FEC capability bits are ignored while performing the Link test.

lsn_end_wait_timer: this timer is started after LSN sequence completion. The Host ASIC sends additional TTS frames until this timer expires to ensure that the remote link partner receives a sufficient number of training frames to detect the link state. The minimum value of this timer shall be 32us.

lsn_end_training_start_timer: this timer is started after LSN sequence completion. The Host ASIC starts switching its Host Electrical Transceiver to transmit the TTS frames (see 5.8 from T11-2022-00285-v000) for 128GFC transmitter training after meeting the requirements specified in lsn_end_wait_timer and must complete this switch before lsn_end_training_start_timer expires. The maximum value of this timer shall be 100ms. The only modulation that shall be transmitted is128GFC PAM4 TTS by the Host ASIC from completion of the lsn_end_training_start_timer until the expiration of the link_wait_timer.

max_wait_timer: this timer sets the limit on how long transmitter training is allowed to operate to find the optimal transmit coefficients and receiver adaptive equalization values for reliable link operation. For 128GFC links, the value of the max_wait_timer shall be 15 seconds.

linkup_watchdog_timer: this timer is started upon LSN sequence completion. This timer sets the maximum amount of time from LSN complete to transmitter training complete. The value of this timer shall be set to 30 seconds.

link_wait_timer: a timer that limits the duration in which the transmitter will transmit the Transmitter Training Signal at fixed settings after the remote FC_Port indicates training complete to ensure that remote FC_Port correctly detects the local interface state. The link_wait_timer expires between 32us and 96us from the time it is started.

min_squelch_timer: This defines the minimum period that the module must squelch the signal on its line side when it switches to 128GFC mode. The value of this timer shall be set to 100ms.

min_datavld_lock_timer: The value of this timer shall be set to 20ms.

t_undef_end_squelch_timer: The value of this timer shall be set to 20ms.