5.4.5 Descrambler

Each codeword shall be descrambled prior to decoding. Descrambling is implemented as the modulo 2 addition of RS-FEC codeword and the same pseudo-noise sequence PN-5280 defined for the scrambler (see 5.4.4).

5.4.6 Reed-Solomon decoder

The Reed-Solomon decoder extracts the message symbols from the codeword, correcting them as necessary, and discards the parity symbols. The message symbols correspond to 20 x 257-bit Transmission Words.

The Reed-Solomon decoder shall be capable of correcting any combination of up to t=7 symbol errors in a codeword. It shall also be capable of indicating when a codeword contains errors but was not corrected (e.g., it contains a number of errors in excess of the error correction capability).

5.4.7 256B/257B to 64B/66B transcoder

The transcoder reconstructs a group of 4 x 66-bit Transmission Words from each received 257-bit Transmission Word.

The 4 x 66-bit Transmission Words, denoted as rx_coded_j<65:0> where j=0 to 3, shall be derived from each 257-bit Transmission Word rx_xcoded<256:0> as defined in IEEE 802.3bj-201X 91.5.2.5. As the first 5 bits of rx_xcoded<256:0> are not scrambled, the step defined in 802.3bj that derives rx_xcoded from rx_scrambled is not performed on those bits.

Editors Note 2 - CWC: Is “codeword” (no space between “code” and “word”) used above a new term that needs definition? Or can it be rewritten as “code word”.

5.5 Transmitter Training Signal

5.5.1 Overview

An FC-0 standard (e.g., FC-SB-5) may specify the use of the Transmitter Training Signal. The Transmitter Training Signal shall not be used for communication of Fibre Channel frames.

The Transmitter Training Signal is a transmission code that enables active feedback from a receiver to a transmitter to assist in adapting the transmitter to the characteristics of the link that connects them. Adjustable transmitter coefficients are supported. The use and effect of each coefficient is specified in FC-PI-x. It is expected that two FC_Ports on a link will concurrently send the Transmitter Training Signal allowing each FC_Port to evaluate the received signal quality and recommend adjustments to the transmitter of the other FC_Port. The Transmitter Training Signal may be sent to communicate information without doing transmitter training.

The Transmitter Training Signal allows enabling of Forward Error Correction (FEC) (see 5.3). FEC is optional for 16GFC and mandatory for 32GFC. FEC negotiation is not performed for 32GFC links and 128GFC links. The Transmitter Training Signal allows enabling parallel lane support (see table 16) by setting Training Frame Control field bit 10 to one, if a lane is capable of running at 32GFC speeds.

The Transmitter Training Signal shall be a repeating series of Transmission Words, each containing two elements (see figure 28):

~~The Transmitter Training Signal is a transmission code that enables active feedback from a receiver to a transmitter to assist in adapting the transmitter to the characteristics of the link that connects them. Adjustable transmitter coefficients are supported. The use and effect of each coefficient is specified in FC-PI-x. In addition, the Transmitter Training Signal allows enabling of 64B/66B with Forward Error Correction (FEC) (see 5.3). It is expected that two FC_Ports on a link will concurrently send the Transmitter Training Signal, allowing each FC_Port to evaluate the received signal quality and recommend adjustments to the transmitter of the other FC_Port. The Transmitter Training Signal shall be a repeating series of Transmission Words, each containing two elements (see figure 28):~~

1) A Training Frame (see 5.5.2), which carries recommended adjustments to the transmitter of the receiving FC_Port based on the quality of the signal detected at the receiver of the sending FC_Port. The information in the Training Frame is encoded so as to increase its likelihood of reliable communication when the transmitter is not optimally adjusted for the link; and
2) A Training Pattern (see 5.5.3), which allows the receiving FC_Port to formulate recommended adjustments to the transmitter of the sending FC_Port. The Training Pattern is encoded so as to challenge the ability to reliably recover it when the transmitter is not optimally adjusted for the link.

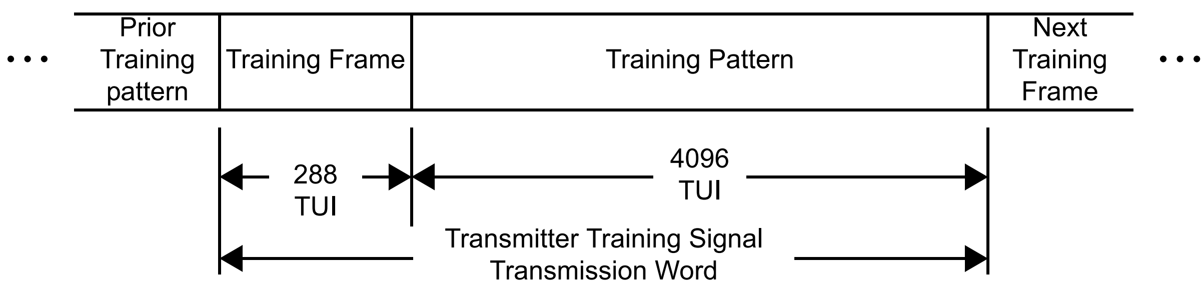
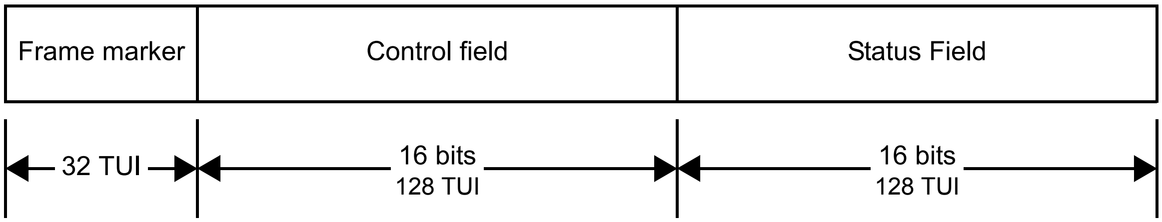


Figure 28 - Transmitter Training Signal

5.5.2 Training Frame

The Training Frame is the element of a Transmitter Training Signal that communicates training information from a receiver to a transmitter. A Training Frame comprises a 32 TUI frame marker followed by a 128 TUI Control field followed by a 128 TUI Status field (see figure 29).

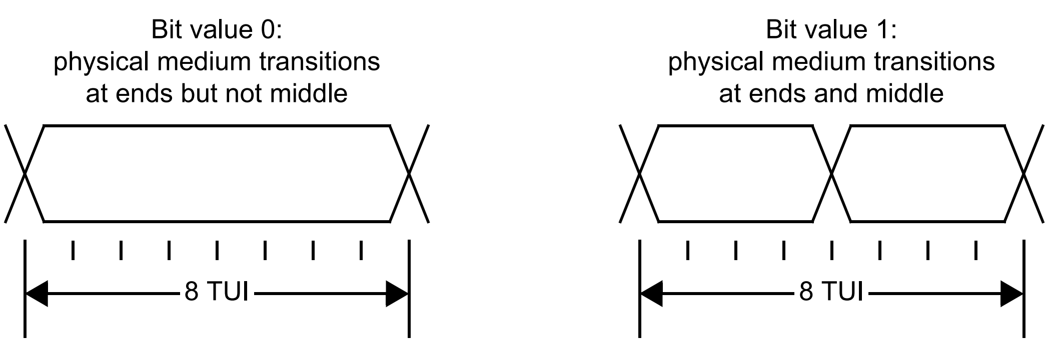


NOTE Each bit of information in the Control field and the Status field is differential Manchester coded in an 8 TUI interval.

Figure 29 - Training Frame format

The Training Frame is intended to communicate information if the transmitter is not optimally adjusted for the link and the selected link speed. The Training Frame also carries information as to whether the physical interface supports parallel lanes, whether FEC is supported, and if the extended marker is implemented. Information in the Training Frame shall be encoded using differential Manchester coding at one eighth the nominal bit rate of the selected link speed (see figure 30).

~~The Training Frame is intended to communicate information when the transmitter may not be optimally adjusted for the link and the selected link speed. Information in the Training Frame therefore shall be encoded using differential Manchester coding at one eighth the nominal bit rate of the selected link speed (see figure 30).~~



NOTE Each bit of information in the Control field and the Status field is differential Manchester coded in an 8 TUI interval.

Figure 30 - Differential Manchester coding

The beginning of a Training Frame shall be signaled by a frame marker. A frame marker shall be transmitted by holding the physical medium signal at logical “1” for 16 TUI followed by holding the physical medium at logical “0” for 16 TUI. This is a deliberate violation of one eighth rate differential Manchester coding, and carries no information (see figure 31).

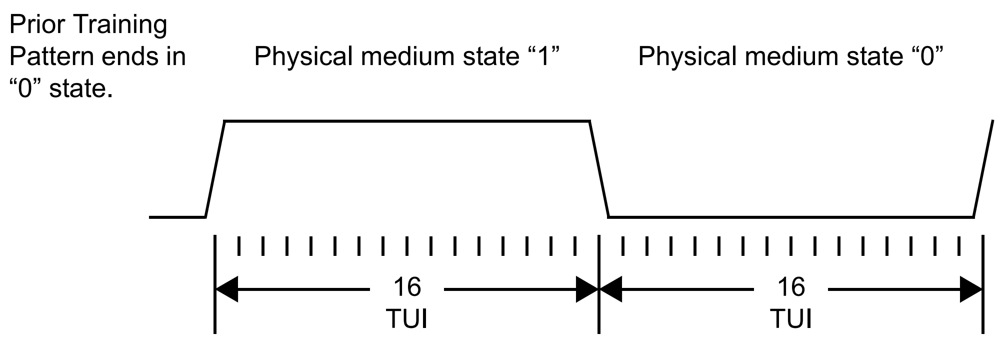


Figure 31 - Frame marker signal

The Control field and the Status field each contain 16 bits of information (i.e., each contain 128 TUI of differential Manchester coded information). The information in these fields shall be transmitted so that more significant encoded information bits are transmitted before less significant encoded information bits. The electrical characteristics of the Transmitter Training Signal are specified in an FC-0 standard, and when indicated in this standard, are indicated informatively.

An extended marker was added for 32GFC because the 16GFC Training Frame Control field looks the same as the 32GFC frame marker and a 32GFC port could synchronize on the 16GFC Training Frame Control field. The extended marker is 16UI of alternating highs and lows to uniquely identify 32GFC. 32GFC locks onto the frame marker plus extended marker to preclude the potential of a false lock at 16GFC speeds.

Fields in the Control field shall be set as specified in table 16. Fields in the Status field shall be set as specified in table 17. For the use of these fields, see clause 9.

Table 16 - Training Frame Control field

Bits	Field name	Content
15-14	Extended Marker	Set to 11b: Extended marker for 32GFC. Set to 10b: reserved. Set to 01b: reserved. Set to 00b: for 16GFC. ~~Reserved~~
13	Preset	Set to one: the transmitter should set all coefficients to preset values. Set to zero: no transmitter action advised.
12	Initialize	Set to one: The ~~T~~transmitter should set all coefficients to initialize values. Set to zero: no transmitter action.
11	FECReq	Set to one: the FC_Port is requesting the use of Forward Error Correction (FEC) (see 5.3) in association with 64B/66B. Set to zero: the FC_Port is directing not to use Forward Error Correction (FEC) in association with 64B/66B.
10~~-6~~	Parallel Lane Support	Set to one: parallel lanes are supported. Set to zero: parallel lanes are not supported.
~~10~~9-6		Reserved
5-4	C1Upd	Set to 11b: reserved. Set to 10b: transmitter should decrement coefficient 1 one step. Set to 01b: transmitter should increment coefficient 1 one step. Set to 00b: transmitter should not change coefficient 1.
3-2	C0Upd	Set to 11b: reserved. Set to 10b: transmitter should decrement coefficient 0 one step. Set to 01b: transmitter should increment coefficient 0 one step. Set to 00b: transmitter should not change coefficient 0.
1-0	C-1Upd	Set to 11b: reserved. Set to 10b: transmitter should decrement coefficient -1 one step. Set to 01b: transmitter should increment coefficient -1 one step. Set to 00b: transmitter should not change coefficient -1.

h) if an L_Port configured for speed negotiation is attached to a loop, the L_Port either:
   A) is being attached to a port in the loop that presents a single speed and does not perform speed negotiation; or
   B) is being attached to a port in the loop that completes the speed negotiation algorithm described here before inserting the L_Port into the loop.

8.4 Speed negotiation requirements on L_Ports

Removal of an L_Port from a loop shall not cause speed negotiation to occur on the remaining loop. This requirement applies even if the removal of the L_Port allows negotiation of a higher common speed.

As an option to negotiating each hub port per the algorithm, multiple speed hubs may be set to a single speed during speed negotiation by some out-of-band means.

8.5 Primitives

8.5.1 Overview

For FC_Ports that do not support the Transmitter Training Signal, either OLS or NOS (for ports operating in OLD_PORT State) or LIP (for ports not operating in OLD_PORT State) shall be the only signals transmitted during speed negotiation.

For FC_Ports that support the Transmitter Training Signal:

a) if the FC_Port is transmitting using media and speeds that support the Transmitter Training Signal (see FC-PI-x), then the Transmitter Training Signal shall be transmitted during speed negotiation;
b) if the Transmitter Training Signal (see 5.5.2) is transmitted during speed negotiation, then the SN field in the Training Status field shall be set to one;
c) if the FC_Port is transmitting using media and speeds that do not support the Transmitter Training Signal, then either OLS or NOS (for ports operating in OLD_PORT State) or LIP (for ports not operating in OLD_PORT State) shall be transmitted using the required frame transfer transmission code (see FC-PI-x) during speed negotiation;
d) if the FC_Port is receiving on media at speeds that support the Transmitter Training Signal, then Transmitter Training Signal Transmission Word synchronization shall be attempted during speed negotiation;
e) if the Transmitter Training Signal is received during speed negotiation, then the settings of fields in the Training Control field and the Training Status field shall be ignored; and
f) if the FC_Port is receiving on media at speeds that do not support the Transmitter Training Signal, then Transmission Word synchronization for the required frame transfer transmission code shall be attempted during speed negotiation.

If a PN_Port negotiates among multiple physical variants that use different transmission codes, the transmission code changes (e.g., from Transmitter Training Signal to 8B/10B and back) during speed negotiation, and the transmitter uses a different transmission code than the receiver at some times.

8.5.2 32GFC speed negotiation

For 32GFC the Transmitter Training Signal is used for speed negotiation. For copper links, transmitter training will be performed if requested. For optical links transmitter training shall not be used and this is communicated by setting the Training Frame Status field bit 12 to one which signals that the transmitter is operating with fixed coefficients. Bit 10 in the Control field of the Training Frame shall be set to zero during speed negotiation.

8.5.3 128GFC speed negotiation

For 128GFC links speed negotiation shall be performed independently on all lanes. A 128GFC link shall set bit 10 in the Control field of the Training Frame on every lane to one if it desires to come up as a 128GFC link. The state machine transitions for speed negotiation on a 128GFC link are as shown in figure 38.

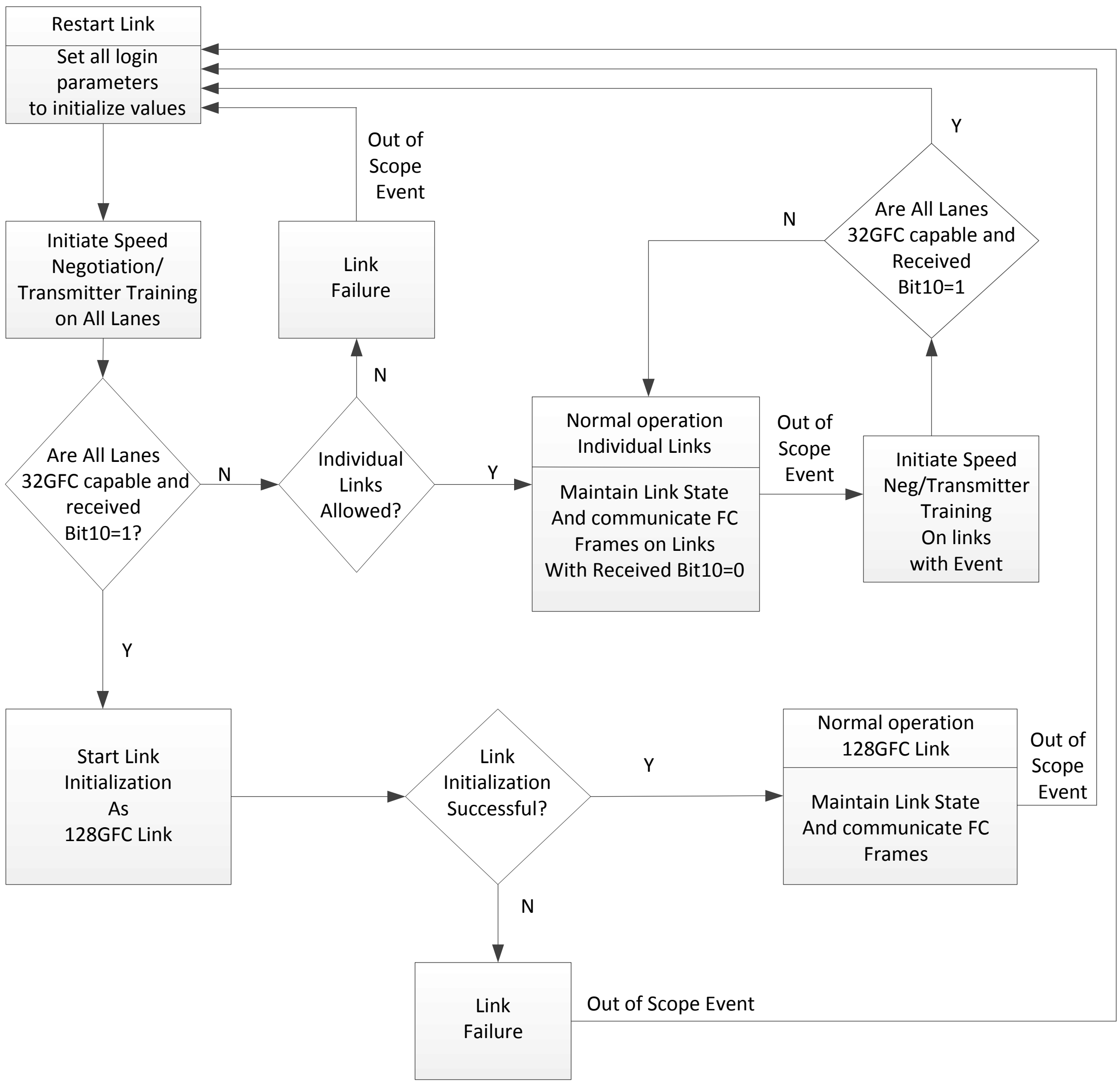


Figure 38 - 128GFC speed negotiation state machine

The 'Out of Scope Event' in the state diagram occurs if any ~~one or more~~ of the following conditions are true on ~~any of the lanes of~~ a 128GFC link:

a) Loss-of-Signal;
b) Loss-of-Synchronization;
c) ~~power cycle~~; or
d) ~~link reset~~.

If parallel lanes are supported as indicated by receiving Training Frame Control field bit 10 set to one on all lanes and all the lanes negotiate to a speed of 32GFC, then the link may operate at 128GFC. Link initialization shall be successful in order to enter normal operation as a 128GFC link. If Link initialization is unsuccessful as a 128GFC link, then the link transitions to the Link Failure State and transitions to the Restart Link state if an out of scope event occurs.

If any of the lanes do not support 32GFC or parallel lanes are not supported as indicated by receiving Training Frame Control field bit 10 set to 0 on any lane, then 128GFC is not supported and the lanes may operate as individual links at the highest negotiated speed. A four lane 128GFC link may support individual links of 16GFC and 32GFC. Support for individual 32GFC links is allowed only if the value of bit 10 in the Training Frame Control field received ~~from the link partner~~ is zero during speed negotiation.

If operating as individual links and one of the links becomes inoperable due to an out of scope event, then speed negotiation is performed only on the failed link. If at the end of speed negotiation, it is determined that the value of bit 10 in the Training Frame Control field received on all lanes of the 128GFC link is one, and all lanes are capable of operating at 32GFC, then the state machine transitions to the Restart Link state and speed negotiation is performed as a 128GFC link.

8.6 Speed negotiation algorithm

8.6.1 Algorithm overview

Figure 39 shows an overview of the speed negotiation algorithm. Dashed lines indicate optional features.