x.x.x FEC encoding process

The {1000BASE-T1} stream is Reed-Solomon (RS) encoded using a (450, 406) code over GF(512) for forward error correction (FEC). This code can correct up to t = 22 symbol errors per RS code block.

The RS encoder implementation is described in this subclause. A systematic encoder is utilized to implement a (450,406) RS code over GF(512). The primitive polynomial used to form the field GF(512) is:

$$p(x) = x^9 + x^4 + 1$$

with a primitive element $\alpha = 02_{HEX}$ satisfying $p(\alpha) = 0$.

The RS code generator polynomial used by encoder is

$$\begin{aligned} g(x) &= (x+\alpha^0)(x+\alpha)(x+\alpha^2)\cdots(x+\alpha^{43}) \\ &= x^{44} + \alpha^{217}x^{43} + \alpha^{328}x^{42} + \alpha^{11}x^{41} + \alpha^{57}x^{40} + \alpha^{33}x^{39} + \alpha^{434}x^{38} + \alpha^{193}x^{37} + \alpha^{46}x^{36} + \alpha^{66}x^{35} \\ &+ \alpha^{314}x^{34} + \alpha^{25}x^{33} + \alpha^{70}x^{32} + \alpha^{16}x^{31} + \alpha^{381}x^{30} + \alpha^{10}x^{29} + \alpha^{452}x^{28} + \alpha^{395}x^{27} + \alpha^{35}x^{26} + \alpha^{419}x^{25} \\ &+ \alpha^{510}x^{24} + \alpha^{7}x^{23} + \alpha^{447}x^{22} + \alpha^{50}x^{21} + \alpha^{85}x^{20} + \alpha^{37}x^{19} + \alpha^{207}x^{18} + \alpha^{99}x^{17} + \alpha^{199}x^{16} + \alpha^{311}x^{15} \\ &+ \alpha^{214}x^{14} + \alpha^{403}x^{13} + \alpha^{500}x^{12} + \alpha^{498}x^{11} + \alpha^{319}x^{10} + \alpha^{114}x^{9} + \alpha^{137}x^{8} + \alpha^{327}x^{7} + \alpha^{100}x^{6} + \alpha^{253}x^{5} \\ &+ \alpha^{320}x^{4} + \alpha^{317}x^{3} + \alpha^{166}x^{2} + \alpha^{98}x + \alpha^{435} \end{aligned}$$

Inputs to the RS encoder consists of 406, 9-bit symbols, starting with first symbol m_{405} and ending with last symbol m_0. For each group of 9-bit output from the PCS encoder $m_{i,0}, m_{i,1}, \cdots, m_{i,8}$, where $m_{i,0}$ is the first bit in time and $m_{i,8}$ is the last bit in time, they are mapped to a RS symbol $m_i = (m_{i,0}, m_{i,1}, \cdots, m_{i,8})$ with the field representation $m_{i,8}\alpha^8 + m_{i,7}\alpha^7 + \cdots + m_{i,1}\alpha + m_{i,0}$.

The message polynomial input to the encoder is described by:

$$m(x) = m_{405}x^{405} + m_{404}x^{404} + \cdots + m_1x + m_0$$

This message polynomial is first multiplied by x^{44}, and then divided by the generator polynomial g(x) to form a remainder, described by:

$$r(x) = r_{43}x^{43} + r_{42}x^{42} + \cdots + r_1x + r_0$$

The generated code word can now be presented by the following polynomial:

$$c(x) = m_{405}x^{449} + m_{404}x^{448} + \cdots + m_1x^{45} + m_0x^{44} + r_{43}x^{43} + r_{42}x^{42} + \cdots + r_1x + r_0$$

The output from the RS encoder is:

$$m_{405}m_{404}\cdots m_1m_0r_{43}r_{421}\cdots r_1r_0$$

where the order is from left to right.

x.x.x. **Two dimensional PAM3 and 3B2T mapping**

After RS encoding, the output bits stream of the encoder (with or without doing scramble) must be mapped to a 2-dimensional (2-D) PAM3 ternary stream. The 2-D PAM3 constellation and the mapping are described in this subclause.

Denote the output bit stream of the RS encoder (with or without scramble) by

$x_0, x_1, x_2, \cdots, x_{3k}, x_{3k+1}, x_{3k+1}, \cdots, x_{4047}, x_{4048}, x_{4049}$, where x_0 is the first bit out from the encoder. The three bits tuple $(x_{3k+2}, x_{3k+1}, x_{3k})$, where x_{3k} is the least significant bits (LSB), must be mapped to a ternary pair (y_{k+1}, y_k) in a 2-D PAM3 constellation, where y_k is transmitted first. The final transmitted ternary sequence is $y_0, y_1, \cdots y_{2k}, y_{2k+1}, \cdots, y_{2698}, y_{2699}$, where the first transmitted ternary symbol is y_0 .

The detailed 2-D PAM3 constellation and the 3-bit to 2 ternary (3B2T) mapping are depictured in Figure xxx.a.

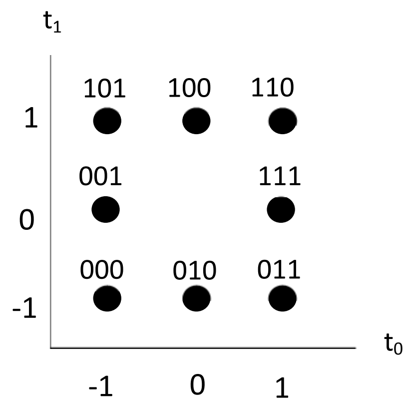

Figure xxx.a 2-D PAM3 constellation and 3B2T mapping

Moreover, the ordering of the three bits and its corresponded two ternaries is described in Table xxx.x, where $(x_{3k+2}, x_{3k+1}, x_{3k}) = (b_2, b_1, b_0)$ and $(y_{k+1}, y_k) = (t_1, t_0)$, $k = 0,1,\ldots,149$

$b_2b_1b_0$	$t_1\ t_0$
000	-1 -1
001	0 -1
010	-1 0
011	-1 +1
100	+1 0
101	+1 -1
110	+1 +1
111	0 +1

Table xxx.b 3B2T mapping and ordering