Background

The upstream burst signal in 10G-EPON system has the following structure,

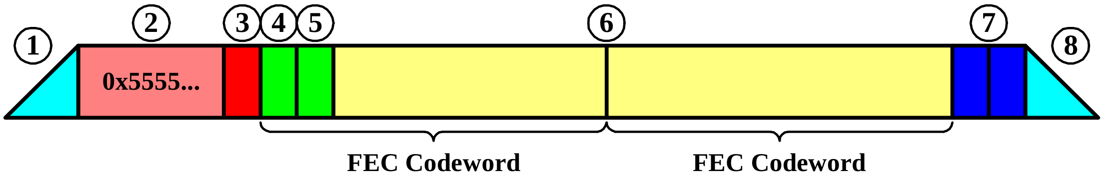

Figure1 Burst structure

① **Laser turn on**
② **High frequency pattern: fast AGC and CDR**
③ **66 bits burst delimiter: indicates the start of a FEC codeword**
④ **1st scrambled IDLE block: uses for scrambler re-sync**
⑤ **2nd scrambled IDLE block: delineates the first packet**
⑥ **FEC codewords: RS(255,223)**
⑦ **2x66bits EOB: indicates the end of the burst**
⑧ **Laser turn off**

The 66-bit burst delimiter has 32 Zeros and 34 Ones. It has a minimum Hamming distance of **32** with the **0x5555...** preamble. It is also interesting to know that if the preamble sequence is **0x0000... + 0x5555...**, the minimum Hamming distance between the burst delimiter and the composite preamble is **30**. The threshold value for a close match could be set up to 12, which means we are allowing 11 bit errors for the BD.

The end of burst (EOB) delimiter, that we are proposing is a 2 66-bit blocks (132 bits) of 0x0000…. The threshold value for a close match could be set up to 10.

Now assuming the bit error probability is *p* then the bit correct probability is *1-p.*

Lost (missed) Burst

When a burst arrives, the correlator searches for the Burst Delimiter, assuming we set the threshold to be 12. Then at least 12 errors in the Burst Delimiter will cause to lose a burst.

$$P_{lost\_burst} = \sum_{i=12}^{66} C_{66}^{i}(10^{-3})^{i}(1-10^{-3})^{(66-i)} \approx 4.6834\mathrm{e} - 24$$

The average burst rate for 10G EPON systems could be considered as 100kburst/sec.

$$MTT\_burst\_lost = \frac{1}{P_{lock}} \times 10^{-5}(s) \approx 2.1352 \times 10^{18} s$$

Since this is longer than the lifetime of the universe, it seems sufficient.

False Lock

The event for false lock to happen is that there is a 66 bits bogus data to be closely matched with the BD, assuming a threshold of 12, at least 55 bits need to match the BD.

Case1

The worst case is that the OLT is constantly looking at an empty upstream.

A)

If it is a noise channel then we can assume a random and i.i.d 66 bits data, the probability for a bit to be "0" or "1" is 0.5. The same case as in ⑧.

$$P_{false\_lock} = \sum_{i=55}^{66} C_{66}^{i} (0.5)^{i} (0.5)^{66-i} \approx 1.800725e-8$$

$$MTT\_false\_lock = \frac{1}{P_{false-lock}} \times 64 \times 10^{-10}(s) \approx 0.3554(s)$$

This time is rather short. So, the conclusion from this is that the PMD should be designed such that lack of input to the receiver does not result in random data being produced. The receiver should produce all zeroes in this case.

B)

If the channel is pretty clean and we know it should be all Zeros and the Burst Delimiter has 34 "1"s and 32"0"s. The threshold is set to be 12, then

$$P_{false\_lock} = \sum_{i=23}^{34} \left[C_{34}^{i} (10^{-3})^{i} (1-10^{-3})^{34-i} \cdot \sum_{j=0}^{11+i-34} C_{32}^{j} (10^{-3})^{j} (1-10^{-3})^{32-j} \right] \approx 2.831e-61$$

$$MTT\_false\_lock = \frac{1}{P_{false-lock}} \times 64 \times 10^{-10}(s) \approx 2.2601 \times 10^{52}(s)$$

This time is very long, so it will never happen.

Case2

The false lock is happen within ①+②+ (65bits of ③) as in Figure1. The preamble (or sync pattern) is defined as 0x5555…, the minimum Hamming distance between the BD and the ①+②+ (65bits of ③) is 32 and the threshold is defined as 12, then the worst case to be considered is when HD = 32.

$$P_{false\_lock\_single} = \sum_{i=21}^{32}\left[C_{32}^{i}(10^{-3})^{i}(1-10^{-3})^{32-i} \cdot \sum_{j=0}^{11+i-32} C_{34}^{j}(10^{-3})^{j}(1-10^{-3})^{34-j} \right] \approx 1.2767e-55$$

A)

If the preamble has the length of 800ns, then there 8065 cases of them. We could use the worst case as an upper bound of the P,

$$P_{false\_lock} = 8065 \times P_{false\_lock\_single} \approx 1.0297e-51$$

$$MTT\_false\_lock = \frac{1}{P_{false-lock}} \times 64 \times 10^{-10}(s) \approx 6.2154 \times 10^{42}(s)$$

B)

If the preamble has the length of 256+400+800ns, then there 14625 cases of them. We could use the worst case as an upper bound of the P,

$$P_{false\_lock} = 14625 \times P_{false\_lock\_single} \approx 1.867e-51$$

$$MTT\_false\_lock = \frac{1}{P_{false-lock}} \times 64 \times 10^{-10}(s) \approx 3.4275 \times 10^{42}(s)$$

These are again very long times. So long that we need not worry about them happening.

False Unlock

If we are considering the worst case, the OLT is looking at an infinite burst. Therefore, the data within this range could be considered as random and i.i.d, so the probability for a bit to be 0 and 1 is 0.5. Let’s assume that the threshold for this is T, then at lease 132-T bits need to match the EOB,

$$P_{false\_unlock\_single} = \sum_{i=132-T}^{132} C_{132}^{i}(0.5)^{i}(0.5)^{132-i}$$

We have calculated P_{false_unlock} for different T, and found out that the range for T should be $0 \leqslant T \leqslant 10$.

When T is 11,

$$P_{false\_unlock\_single} = \sum_{i=122}^{132} C_{132}^{i} (0.5)^{i} (0.5)^{132-i} \approx 6.2337e-26$$

$$MTT\_false\_unlock\_\mathrm{single} = \frac{1}{P_{false-unlock}} \times 2 \times 64 \times 10^{-10} (s) \approx 2.1175 \times 10^{17} (s)$$

which is longer than the half of the life of the universe. This should be sufficient.

Miss EOB

The Miss EOB is "armed" once the OLT is in lock with a burst, the threshold for the EOB is set to be 11 as in False_Unlock. Then it requires at lease 11 errors in the EOB to cause a miss.

$$P_{miss\_EOB} = \sum_{i=11}^{132} C_{132}^{i} (10^{-3})^{i} (1-10^{-3})^{(132-i)} \approx 3.0976e-18$$

The average burst rate for 10G EPON systems could be considered as 100kburst/sec.

$$MTT\_miss\_EOB = \frac{1}{P_{miss\_EOB}} \times 10^{-5} (s) \approx 3.228 \times 10^{12} s = 102359.2 years$$

While this time is pretty long, it is not quite up to our hero specification of L.O.U. However, since we are using all-zeroes, the search for EOB can get several chances to find the gap between the bursts. Depending on the OLT implementer's paranoia factor, it can schedule as long a guard time as it wishes to. 2 TQ of guard time would give us 5 blocks, and make the MTT of missed EOB much longer than the lifetime of the universe.