

Upstream Burst Delimiter and Sync Pattern Assignment

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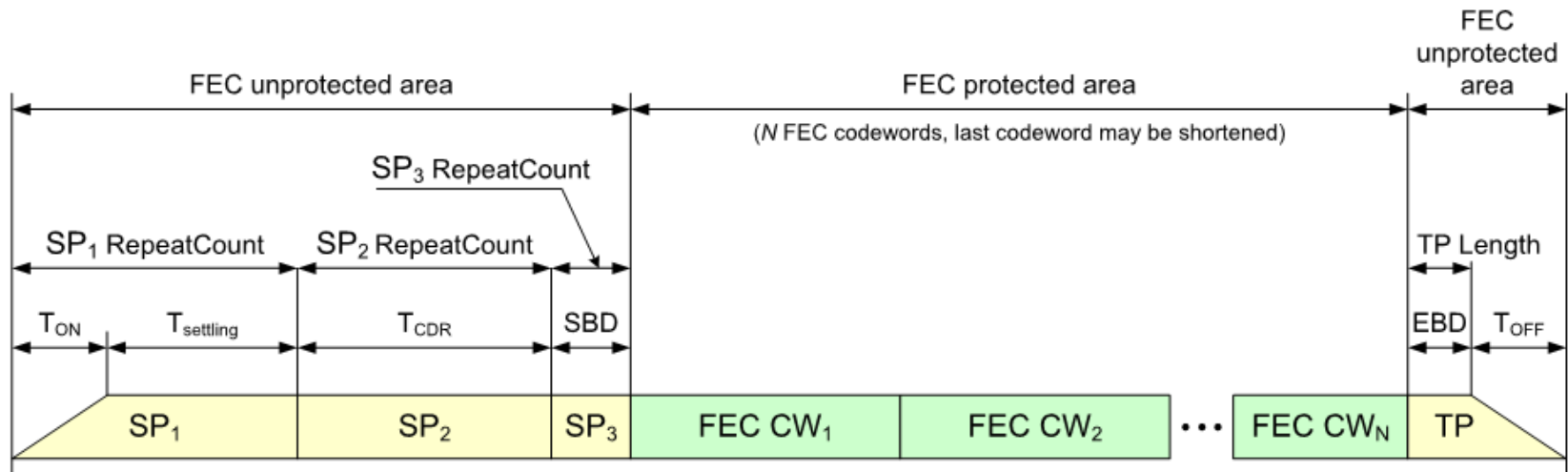
- ❑ Glen Kramer, Broadcom (co-author)

- ❑ In January 2018, several contributions on upstream burst delimiter selection were reviewed
 - [kramer_3ca_2_0118.pdf](#)
 - [effenberger_3ca_1_0118.pdf](#)
 - [hajduczenia_3ca_1_0118.pdf](#)
- ❑ It was observed that different OLT Receiver implementations may favor different bit sequences for achieving the optimal receiver settling (AGC) and clock & data recovery (CDR) performance.
- ❑ There was an agreement to allow the OLT to announce the desired sync patterns to the registering ONUs and to require the ONUs to use the announced patterns in their upstream burst transmissions.
- ❑ This presentation provides the details of such operation

Burst Synchronization Patterns

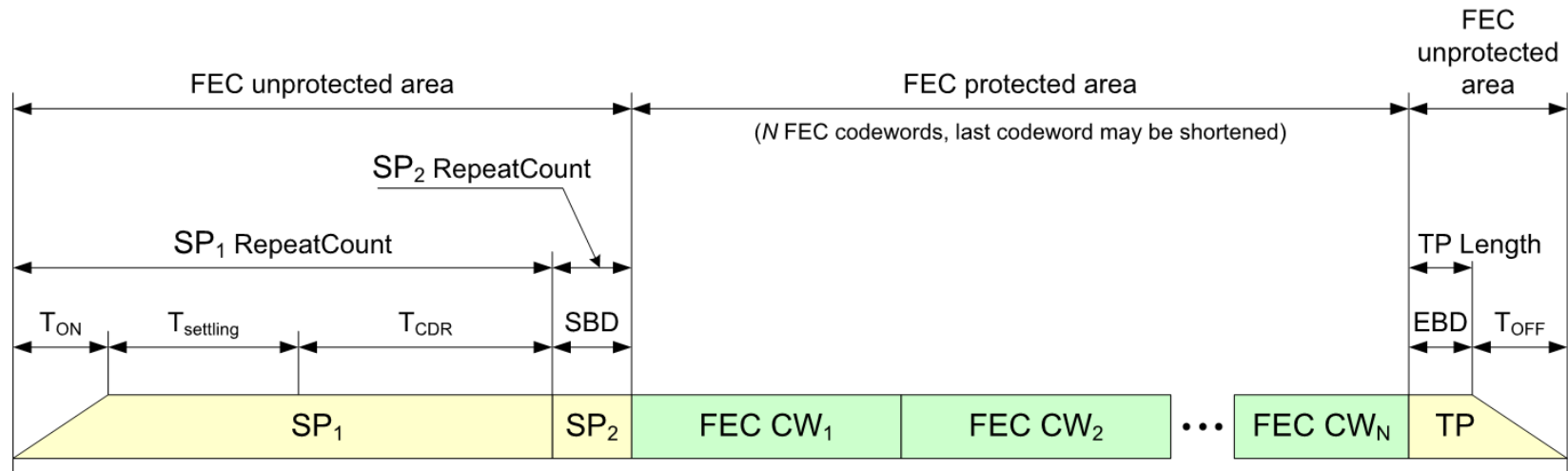
- ❑ Generally, to optimize the receiver performance, two patterns are needed to be selected: one for the AGC and another for CDR.
- ❑ In order to delineate the burst synchronization sequence from the scrambled and FEC-encoded data portion of a burst, an additional *Start-of-Burst Delimiter* (SBD) pattern is specified.
- ❑ While SBD does not directly affect the OLT receiver performance, its choice is dependent on the preceding CDR pattern, therefore SBD pattern should be announced by the OLT as well
 - To be reliably detected, the SBD should provide high Hamming distance against the CDR pattern and against any combination of CDR tail + SBD head.
- ❑ Thus, in general, three patterns need to be announced by the OLT:
 1. Sync pattern for AGC
 2. Sync pattern for CDR
 3. Sync pattern for SBD
- ❑ In some implementations, AGC and CDR patterns may be the same, so only two patterns need to be announced.

Burst structure, 3 zones



- ❑ Size of each shown region is in multiples of 257-bit blocks
- ❑ Four separate regions of FEC unprotected area are defined:
 - Sync Pattern SP_1 (covers $T_{on} + T_{settling}$)
 - Sync Pattern SP_2 (covers T_{CDR})
 - Sync Pattern SP_3 (covers Start-of-Burst Delimiter)
 - Terminating Pattern TP (covers End-of-Burst Delimiter + T_{off})
- ❑ SP_1 , SP_2 , and SP_3 values and their durations are announced by the OLT
- ❑ End-of-Burst Delimiter (EBD) is not configurable (fixed in spec). EBD uses one 257-bit block of all zeros (similar to 10G-EPON)

Burst structure, 2 zones



- ❑ Size of each shown region is in multiples of 257-bit blocks
- ❑ Four separate regions of FEC unprotected area are defined:
 - Sync Pattern SP₁ (covers $T_{on} + T_{settling} + T_{CDR}$)
 - Sync Pattern SP₂ (covers Start-of-Burst Delimiter)
 - Terminating Pattern TP (covers End-of-Burst Delimiter + T_{off})
- ❑ SP₁ and SP₂ values and their durations are announced by the OLT
- ❑ End-of-Burst Delimiter (EBD) is not configurable (fixed in spec). EBD uses one 257-bit block of all zeros (similar to 10G-EPON)

High-Level Protocol Overview

- ❑ OLT broadcasts SP_1 , SP_2 , and optionally SP_3 patterns to registering ONUs during the initial MPCP Discovery using SYNC_PATTERN MPCPDUs before issuing the DISCOVERY_GATE.
 - Each SP pattern is announced using a separate SYNC_PATTERN MPCPDUs
- ❑ The required durations for SP_1 , SP_2 , and SP_3 periods are announced in the DISCOVERY_GATE MPCPDU.
 - SP_1 should allow for the maximum T_{on} time, since the actual T_{on} time for a given ONU is not known before the discovery.
 - Also, since the RTTs and, therefore, the exact burst arrival times, are not known, the OLT may decide to require longer SP_1 and/or SP_2 periods.
- ❑ ONU always uses SP values and durations announced by OLT.
- ❑ When the OLT receives the REGISTER_REQ MPCPDU from an ONU, it learns some characteristics of that ONU, such as the actual T_{on} time, RTT, and receive power level (or ONU's power class)
- ❑ Based on learned ONU-specific information, the OLT may announce different patterns or the durations to individual ONUs.
 - New patterns are announced by sending SYNC_PATTERN MPCPDUs on unicast PLID
 - New durations are provisioned as part of the REGISTER MPCPDU

SYNC_PATTERN MPCPDU / 1

- ❑ Used to announce the value of Synchronization Pattern (SP) to ONUs
- ❑ *SpInfo* carries information on SP pattern in this MPCPDU:
 - **Bit 0-1:** *SpIndex* (value 1, 2, 3), indicating which SP period is carried in this SYNC_PATTERN message ($SP_{1/2/3}$)
 - **Bit 3-4:** *SpCount* (value 2 or 3), indicating how many SYNC_PATTERN messages are expected in announcement sequence
 - **Bit 7:** *SpBalanced* (value 0 or 1). Balanced bit sequence may be more suitable for some OLT Rx implementations. But 257-bit pattern cannot be perfectly balanced. When the *SpBalanced* bit is set to 1, rather than repeating $SP+SP\dots SP$ N times, the ONU shall alternate SP and its inverted value \overline{SP} N times ($SP+\overline{SP}+SP+\overline{SP}\dots$).
 - **Bit 15:** SP bit 0 (first bit of the SP value)
 - Other bits reserved / set to 0 on transmit

SYNC_PATTERN MPCPDU

Destination Address	6
Source Address	6
Length/Type = 0x8808	2
Opcode = 0x0018	2
Timestamp	4
SpInfo	2
SpValue	32
Padding	6
FCS	4

SYNC_PATTERN MPCPDU /2

□ *SpValue* structure

- Bits 1 through 256 of Sync Pattern saved into 32-octets wide data field *SpValue*, right adjusted. Bit 0 of Sync Pattern saved into *SpInfo* field (see previous slide for details).
- The same encoding is used for SP_1 , SP_2 , and SP_3 fields

Octet	Value (binary)
0	SP<8:1>
...	...
30	SP<248:241>
31	SP<256:249>

DISCOVERY_GATE

- ❑ Changes to DISCOVERY_GATE MPCPDU to carry Discovery Repeat values for individual SP zones.
- ❑ *Repeat Count* indicates how many times the given 257-bit SP value field is transmitted during Discovery Window transmission.
- ❑ Separate repeat count value for SP_1 , SP_2 , and SP_3 sync pattern zones. When only two zones are present, SP_3 repeat count is set to 0.

Destination Address	6
Source Address	6
Length/Type = 0x8808	2
Opcode = 0x0017	2
Timestamp	4
Channel Assignment	1
Start Time	4
Discovery Grant Length	3
Reserved	2
Discovery Information	2
Repeat Count SP_1	2
Repeat Count SP_2	2
Repeat Count SP_3	2
Pad	22
FCS	4

REGISTER MPCPDU

- ❑ Changes to REGISTER MPCPDU to carry Granting Repeat values for individual sync pattern zones.
- ❑ *Repeat Count* indicates how many times the given 257-bit SP value field is transmitted during regular granting operation.
- ❑ Separate repeat count value for SP_1 , SP_2 , and SP_3 sync pattern zones. When only two zones are present, SP_3 repeat count is set to 0.
- ❑ Laser On/Off Time fields are removed (in .3ca, the ONUs do not need to subtract optical overhead from the received grant length).

Destination Address	6
Source Address	6
Length/Type = 0x8808	2
Opcode = 0x0015	2
Timestamp	4
Assigned Port (PLID)	2
Assigned Port (MLID)	2
Flags	1
Reserved	2
Echo Pending Grants	1
Repeat Count SP_1	2
Repeat Count SP_2	2
Repeat Count SP_3	2
Pad	26
FCS	4

- ❑ OLT announces SP values using SYNC_PATTERN MPCPDU before issuing DISCOVERY_GATE MPCPDU
- ❑ SYNC_PATTERN MPCPDUs are sent on broadcast PLID during the discovery process. OLT may change SP values for individual ONU after the discovery sending SYNC_PATTERN MPCPDUs on unicast PLID.
- ❑ Each SP value is announced using a separate SYNC_PATTERN MPCPDU.
- ❑ The OLT may announce 2 or 3 SP values (as indicated by SP Count field):
 - **SP Count = 3**: SP_1 for laser_on and AGC, SP_2 for CDR, and SP_3 for SBD
 - **SP Count = 2**: SP_1 for laser_on+AGC+CDR, SP_2 for SBD.
- ❑ OLT may announce different SP values (or even different counts of SP values) for different discovery attempts.
- ❑ OLT announces SP value repeat in DISCOVERY_GATE MPCPDU for Discovery Window, and in REGISTER MPCPDU for granting operation.

- ❑ Unregistered ONUs always process and store the last-announced SP values (SP values may change from one discovery attempt to another).
- ❑ ONUs do not validate the SP values or acknowledge the SYNC_PATTERN MPCPDUs received from the OLT.
- ❑ An unregistered ONU shall not respond to a DISCOVERY_GATE MPCPDU until a full set the SP values (as indicated by SP Count field) is received from the OLT.
- ❑ Once registered, ONU stops listening and acting on SYNC_PATTERN MPCPDUs sent on broadcast PLID, but may still receive SYNC_PATTERN MPCPDU(s) on unicast PLID.

Proposed default SP settings

- ❑ By default, OLT uses two SP zones (SpCount = 2):
 - **SP₁**
 - Covers laser_on period, AGC, and CDR
 - Duration: $T_{\text{on}} + T_{\text{receiver_settling}} + T_{\text{CDR}}$, in units of 257-bit blocks
 - SpValue: 0x1-55-...-55
 - SpBalanced = True (1)
 - **SP₂**
 - Covers SBD
 - Duration: 1
 - SpValue: 0x1-BF-40-18-E5-C5-49-BB-59
-6B-F8-D8-12-D8-58-E4-AB
-40-BF-E7-1A-3A-B6-44-A6
-94-07-27-ED-27-A7-1B-54
 - SpBalanced = False (0)
- ❑ Vendors may overwrite any and all of the above parameters. Care should be taken to ensure that there is sufficient Hamming distance between the CDR and SBD patterns