Security Level:

100G EPON wavelength plan analysis

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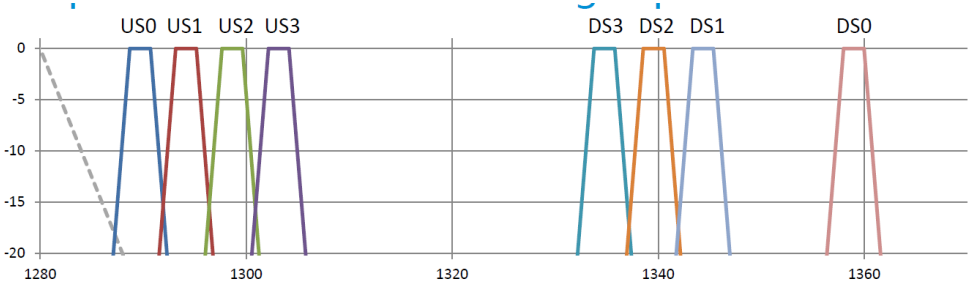
Background

- Last meeting in Huntington , it was agreed that all the downstream and upstream wavelength for 100G EPON should be specified in O band . Then only plan A and plan B are on the deck.

- This contribution continue to optimize the existing plan A and Plan B, and analyze their pros and concerns.

Plan A0

guo_3ca_1_0117.pdf



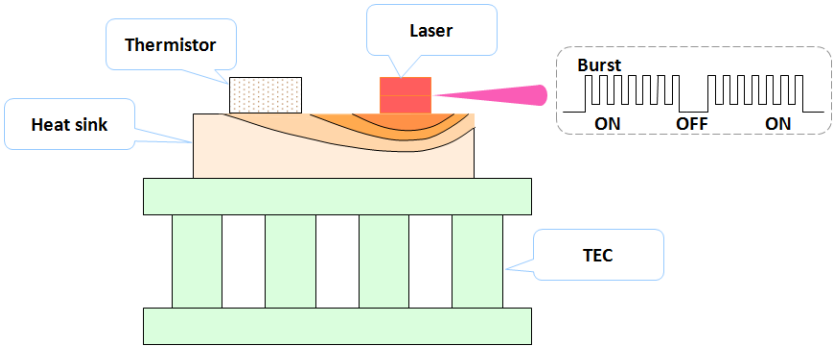
	Center freq	Center WL
US0	232.450	1289.707
US1	231.650	1294.161
US2	230.850	1298.646
US3	230.050	1303.162

	Center freq	Center WL
DS3	224.600	1334.784
DS2	223.800	1339.555
DS1	223.000	1344.361
DS0	220.600	1358.987

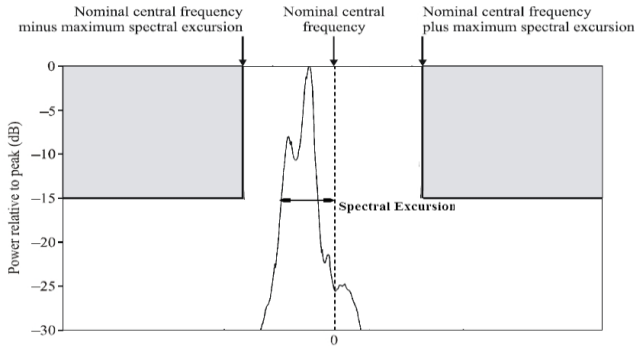
- Key features:
  - 800GHz channel spacing, 2nm channel width
  - WDM coexist with 10G EPON
- Cons:
  - First channel must use cooled DML, the first 25G ONUs can't be really low cost
  - The width of upstream channel is only 2nm, which will result in high cost of ONU transmitter
  - Even first 25G PON can't coexist with GPON, less likely share the industry chain with ITU PON

ONU channel width impact

ONU burst mode wavelength drifting can be : 0.3~0.4nm



ONU DML laser spectrum extension after modulation ~0.4nm@15dB

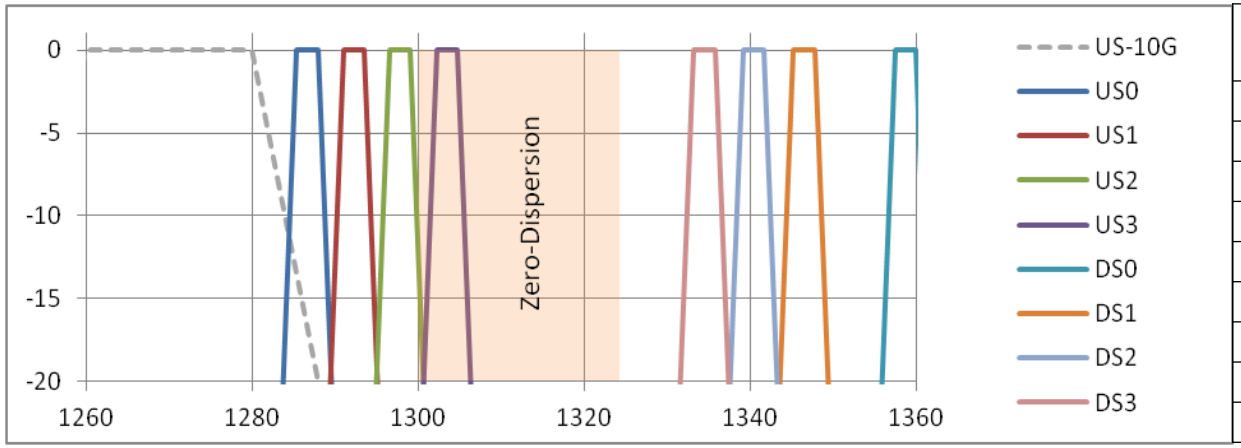


Central Wavelength Tolerance	±3nm	± 2nm	± 1.5nm	± 1nm	± 0.5nm
1st vendor's view	X	1.2X	1.6X	2.3X	3.5X
2nd vendor's view	Y	1.4Y	--	2.1Y	--

Note: the spectrum extension , such as by modulation, burst mode wavelength drifting , hasn't been taken account in here.

So 2nm upstream wavelength width only allows : ~ +/-0.6nm central wavelength distribution tolerance of the laser

Revised plan A1

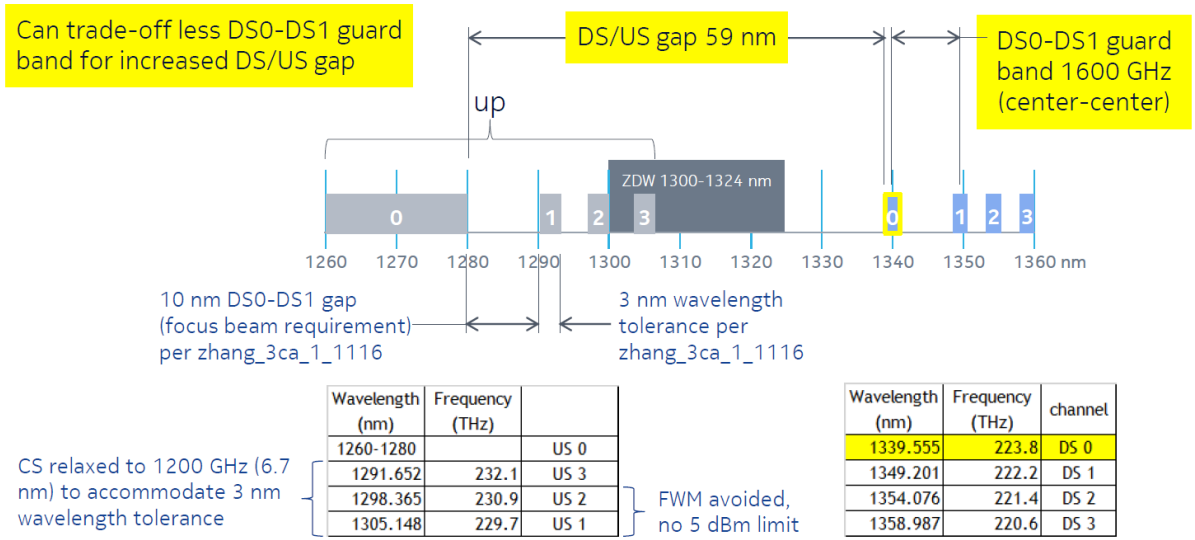


	Center freq	Center WL	PB width
US0	233.00	1286.66	2.5
US1	232.00	1292.21	2.5
US2	231.00	1297.80	2.5
US3	230.00	1303.45	2.5
DS0	220.65	1358.68	2.5
DS1	222.65	1346.47	2.5
DS2	223.65	1340.45	2.5
DS3	224.65	1334.49	2.5

- Key features:
  - 1000GHz channel spacing, 2.5nm channel width
  - WDM coexist with 10G EPON
  - 25/25G, 100/25G can still coexist with GPON by external WDM1r (liu_3ca_2_0317)
- Cons:
  - First channel must use cooled DML, the first 25G ONUs can't be really low cost
  - upstream wavelength is very close to 10G EPON, it needs an elaborate designed external WDM1r to coexist with 10G EPON

Plan B0

harstead_3ca_1_0117

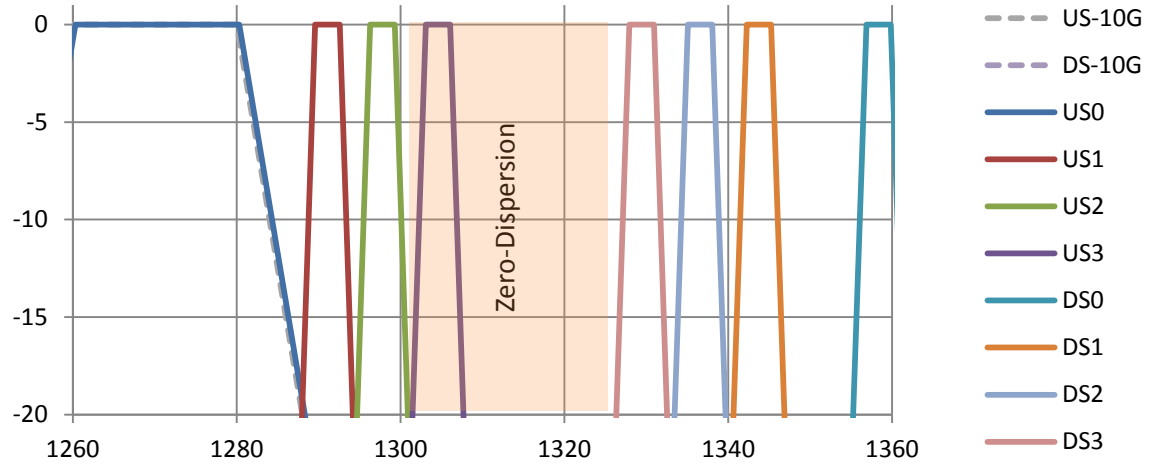


Wavelength (nm)	Frequency (THz)	
1260-1280		US 0
1291.652	232.1	US 3
1298.365	230.9	US 2
1305.148	229.7	US 1

Wavelength (nm)	Frequency (THz)	channel
1339.555	223.8	DS 0
1349.201	222.2	DS 1
1354.076	221.4	DS 2
1358.987	220.6	DS 3

- Key features:
  - 800GHz channel spacing for downstream, 1200GHz for upstream
  - 25G ONU can be uncooled
  - TDM coexist with 10G EPON
  - 25/25G, 100/25G can coexist with GPON by WDM
- Cons:
  - TDM coexistence will result in multi-rate receiver in OLT, which will bring in extra complexity
  - TDM coexistence will result in lower upstream bandwidth efficiency

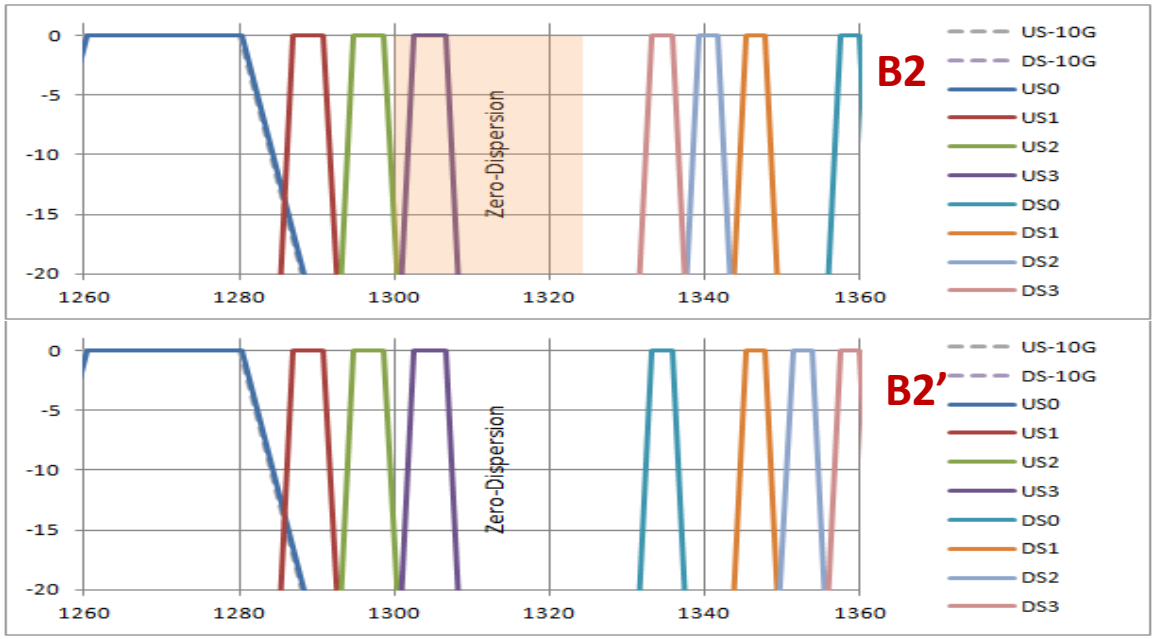
Revised plan B (plan B1)



	Center freq	Center WL	PB width
US0	236.00	1270.00	20
US1	232.20	1291.10	3
US2	231.00	1297.80	3
US3	229.80	1304.58	3
DS0	220.700	1358.37	3
DS1	223.100	1343.76	3
DS2	224.300	1336.57	3
DS3	225.500	1329.46	3

- Key features:
  - Extend DS width to 3nm
  - Switch the first 25G DS to the longest wavelength
- Some thoughts:
  - Is it necessary to switch the 25G DS channel to the longest wavelength for plan B ?
  - “Extending DS channel width to 3nm” will result in narrower DS/US gap, disable coexistence between 100/25G EPON and GPON, while the benefit is not that clear (DS is continuous mode, EML spectrum extension is small)

Further revision on plan B (plan B2)



		Center freq	Center WL	PB width
B2&B2'	US0	236.00	1270.00	20
	US1	232.60	1288.88	4
	US2	231.20	1296.68	4
	US3	229.80	1304.58	4
B2	DS0	224.65	1334.49	2.5
	DS1	222.65	1346.47	2.5
	DS2	221.65	1352.55	2.5
	DS3	220.65	1358.68	2.5
B2'	DS0	220.65	1358.68	2.5
	DS1	222.65	1346.47	2.5
	DS2	223.65	1340.45	2.5
	DS3	224.65	1334.49	2.5

- Key features:
  - 1400GHz channel spacing and 4nm channel width for upstream, channel spacing looks more equal
  - 1000GHz channel spacing for downstream , 2.5nm channel width
  - DS0 is 1334.5nm, which has lower dispersion ,better component availability

Plan B1 vs Plan B2

	Plan B1	Plan B2	Impact
US channel width	3nm	4nm	•Considering the burst mode wavelength drifting and spectrum extension after modulation, 4nm will enable the ONU transmitter have a net +/-1.5nm central wavelength tolerance
DS0 channel width	3nm	2.5nm	•Downstream is continuous mode, no burst mode wavelength drifting effect, EML modulation spectrum extension is smaller than DML, the cost impact is negligible
DS0 wavelength	1358.7nm	1334.5nm	•1334.5nm has lower dispersion penalty, better component availability than 1358.7nm
Shortest Downstream wavelength	1329.5nm	1334.5nm	•Plan B2 has 5nm wider downstream and upstream gap than Plan B1, Plan B2 also enable the coexistence between 100/25G EPON and GPON.
DS0/US0 gap	77nm	53nm	•53nm DS/US gap is enough for 25G ONU's low cost already(funada_3ca_1_0117,liu_3ca_2_0117)
Upstream neighborhood channel guard band width	9.6nm 3.7nm 3.8nm	6.9nm 3.8nm 3.9nm	• Plan B2 looks to have better uniform channel spacing.

Plan A vs Plan B comparison：

	Pros	Cons
Plan A	• 25G,100G are decoupled with 10G PON • WDM coexistence has better upstream bandwidth efficiency, don't need triple rate receiver to coexist with 10/1G EPON • Four channels have better uniformity in 100G EPON, which will benefit the pre-amplifier design	• 25G ONU must be cooled， result in high cost • Due to the limited wavelength resource, upstream channel width is narrow • It's quite challenging for 25G EPON to coexist with GPON • Different upstream wavelength between 25/10G and 25/25G PON, which will result in complex OLT design
Plan B	• 25G ONU can be uncooled DML， which can make it really low cost • Wider upstream channel width, benefit the cost of all ONUs • Continue the traditional upgrade way in EPON series (OLT board replacement) • Same upstream wavelength between 25/10 and 25/25G • 25/25G and 100/25G can coexist with both 10G PON and GPON.	• Triple rate receiver will be needed ,if 10/1 and 10/10 EPON is required to be coexisted with. • TDM coexistence will result in lower upstream bandwidth efficiency , extra implementation complexity in OLT • Non-uniform upstream channel width will also bring some extra challenges for pre-amplifier design in OLT.

Summary :

- Some further revisions are suggested on plan A and Plan B.

- Pros and cons of plan A and Plan B are analyzed .

- Plan B has the main advantage of lower ONU cost, but will bring extra complexity and technical challenge in OLT. In order to support legacy 10G EPON (including 10/10 and narrow down 10/1 G EPON), no foreseeable impact of triple rate receiver on legacy 10G PONs should be confirmed as the first step.

Thank you

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