Ad-hoc activity report
"Channel link model for 10G EPON"

S. Ten

Corning Incorporated
Science and Technology Division

M. Hajduczenia

Siemens Networks S.A.
COM D1 R

General information [1]

- Chartered tasks
  - Update the existing Excel spreadsheet to reflect the 10G transmission channel impairments:
    - last version accepted by EFM – available online at the following address: http://ieee802.org/3/efm/public/tools/EFM0_0_2.7.xls
    - Spreadsheet aligned to 802.3ae D3.2, D3.3 available online at http://ieee802.org/3/ae/public/adhoc/serial_pmd/documents/10GEPBud3_1_16a.xls
  - Include splitter loss in the overall channel loss figure
  - Account for downstream video overlay @ 1550 nm
  - Account for SBS and SRS due to analog signal transmission at high power levels

General information [2]

- Participants & activities
  - 24 participants registered for the ad-hoc
  - Low response rate – either very esoteric topic or due to Xmas period ☺
- Individual tasks
  - No tasks were chartered this time – the ad-hoc was too focused to distribute the effort into smaller issues
- Conference calls
  - None scheduled
- Additional activities:
  - Initial draft of the IEEE – ITU translation matrix. Requires more work and a lot more feedback from people

Splitter loss
Fibre cable loss
Other minor changes

S. Ten

Corning Incorporated
Science and Technology Division

CORNING
Discovering Beyond Imagination

M. Hajduczenia

Siemens Networks S.A.
COM D1 R

SIEMENS

Splitter loss [1]

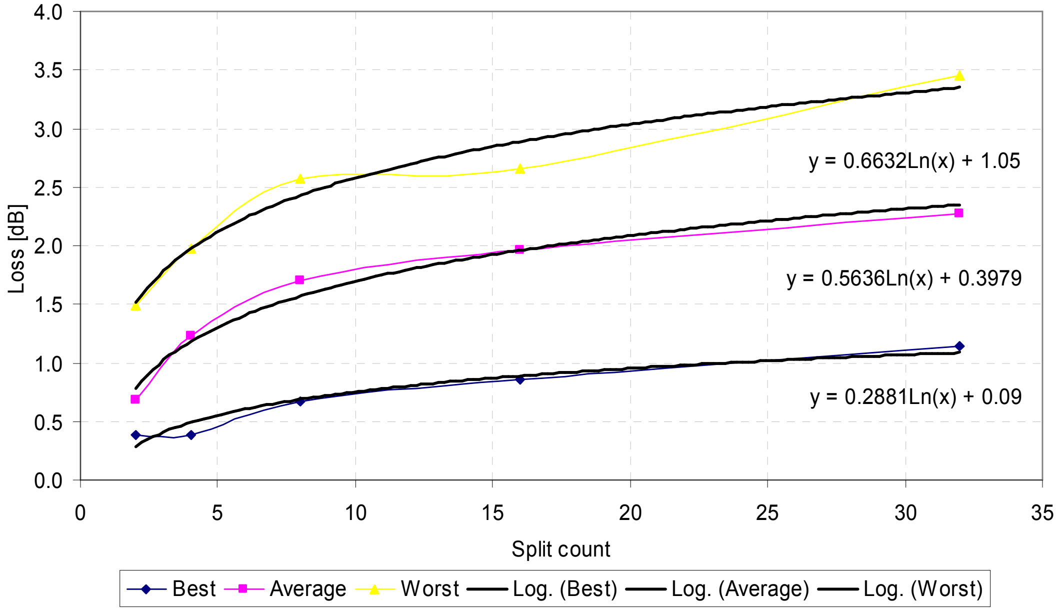
- Reused the data on splitter loss, collected for task 1 of ad-hoc on higher split ratio – see “Task 1: Channel insertion loss for 1x64 and 1x128 split EPONs” at http://www.ieee802.org/3/av/public/2006_11/3av_0611_hajduczenia_1.pdf
- The excess loss approximation curves were dervied for best vase, worst case and average splitters.
- The splitter related loss is calculated as a total of ideal loss and average excess loss:

$$\mathrm{Add\_Ins\_Loss} = 10 \cdot \log(\mathrm{N}) + 0.5636 \cdot \ln(N) + 0.3979$$

where: **0.5636·ln(*N*)+0.3979** is the approximation curve for average excess loss against the split count *N*

Splitter loss [2]

Approximation curves:



New L8 cell:

=10*LOG($L$5)+$AM$121*LN($L$5)+$AN$121

where:

- L5 is the split count
- $AM$121 is the first approximation coeff.
- $AN$121 is the second approximation coeff

Other changes

- Cells [A15:X34] were reconstructed:
  – right now the analyzed system reach is always between 1 and L3 kms – there is little interest for system performance above L3 kms.
  – individual examination points are spaced evenly in the examined distance (see formula below)
- New structure for cells [A18:A34]
  =(($L$3-$L$4)/16*(ROW($A18)-ROW($A$18))+$L$4)
- The chart **“Power penalties vs. distance …”** has now automatic X and Y axes scaling to adjust to the changes in the target distance and the resulting parameter values

Fibre loss [1]

- Current fibre attentuation values are inaccurate for the PON fibre plant, which was mostly deployed after the year 2000.
- Measurement results (see ITU-T Series G Supplement 39 from 02/2006, section 10.2 “Statistical design of loss” – see page 8 – as well as ITU-T G.695 from 01/2005 – see page 9) indicate that the fiber loss accounted for in the current Excel spreadheet is overly pessimistic (at least 50% too high)
- **Proposal: update the fiber attentuation values applicable for 10G EPON spreadsheet – the worst-case scenario installed fibre base is way better than the assumed values.**

Table 10-3 – Core network attenuation coefficient statistics												
CWDM centre wave-length (nm)	**Cables installed before 1990**				**Cables installed around 2000**				**Cables installed in 2003**			
	Fibre attenuation (dB/km)		**Splice loss –2 km between splices (dB/km)**		**Fibre attenuation (dB/km)**		**Splice loss –2 km between splices (dB/km)**		**Fibre attenuation (dB/km)**		**Splice loss –2 km between splices (dB/km)**	
	Ave	**Stdv**	**Ave**	**Stdv**	**Ave**	**Stdv**	**Ave**	**Stdv**	**Ave**	**Stdv**	**Ave**	**Stdv**
1271	0.408	0.017	0.041	0.037	0.392	0.018	0.025	0.025	0.382	0.005	0.025	0.025
1291	0.384	0.016	0.041	0.036	0.368	0.017	0.024	0.024	0.359	0.005	0.024	0.024
1311	0.368	0.015	0.041	0.036	0.346	0.016	0.024	0.024	0.337	0.004	0.024	0.024
1331	0.341	0.015	0.041	0.035	0.326	0.015	0.024	0.024	0.317	0.004	0.024	0.024
1351	0.329	0.015	0.041	0.034	0.307	0.019	0.023	0.023	0.291	0.004	0.023	0.023
1371	0.586	0.127	0.041	0.034	0.439	0.137	0.023	0.023	0.323	0.026	0.023	0.023
1391	0.720	0.197	0.041	0.033	0.509	0.210	0.022	0.022	0.342	0.041	0.022	0.022
1411	0.436	0.074	0.041	0.033	0.348	0.082	0.022	0.022	0.280	0.016	0.022	0.022
1431	0.316	0.028	0.041	0.032	0.277	0.033	0.022	0.022	0.248	0.006	0.022	0.022
1451	0.269	0.017	0.041	0.031	0.246	0.018	0.021	0.021	0.230	0.004	0.021	0.021
1471	0.240	0.015	0.041	0.030	0.226	0.012	0.021	0.021	0.216	0.003	0.021	0.021
1491	0.225	0.017	0.041	0.030	0.213	0.012	0.021	0.021	0.205	0.003	0.021	0.021
1511	0.216	0.018	0.041	0.029	0.204	0.010	0.020	0.020	0.197	0.003	0.020	0.020
1531	0.210	0.020	0.041	0.028	0.198	0.010	0.020	0.020	0.191	0.003	0.020	0.020
1551	0.207	0.022	0.042	0.028	0.194	0.010	0.019	0.019	0.186	0.003	0.019	0.019
1571	0.206	0.025	0.043	0.029	0.192	0.010	0.019	0.019	0.184	0.004	0.019	0.019
1591	0.211	0.027	0.045	0.032	0.195	0.010	0.018	0.018	0.187	0.004	0.018	0.018
1611	0.220	0.028	0.049	0.034	0.203	0.010	0.018	0.018	0.194	0.004	0.018	0.018

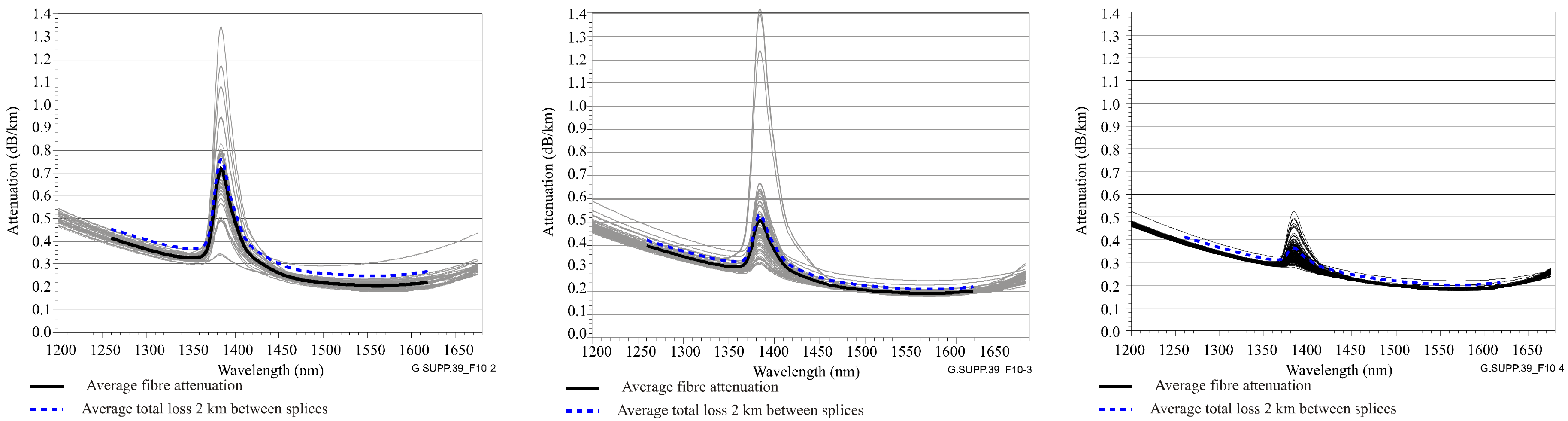
NOTE 1 – Within each interval, centre wavelength ±6.5 nm, the highest value is used.
NOTE 2 – The 6 OTDR wavelengths used are: 1241 nm, 1310 nm, 1383 nm, 1550 nm, 1625 nm and 1642 nm.

These values were obtained by combining measurements of the attenuation coefficient of underground and buried optical fibre cables at 1550 nm and 1625 nm with full spectrum measurements of uncabled fibres and with the limits specified in ITU-T Rec. G.652.

Nominal central wavelength (nm)	G.652.A&B cable		G.652.C&D cable	
	Minimum attenuation coefficient (dB/km)	Maximum attenuation coefficient (dB/km)	Minimum attenuation coefficient (dB/km)	Maximum attenuation coefficient (dB/km)
1271	0.392	0.473	0.385	0.470
1291	0.370	0.447	0.365	0.441
1311	0.348	0.423	0.352	0.423
1331	0.331	0.425	0.340	0.411
1351	0.320	0.476	0.329	0.399
1371	x	x	0.316	0.386
1391	x	x	0.301	0.372
1411	x	x	0.285	0.357
1431	0.263	0.438	0.269	0.341
1451	0.250	0.368	0.254	0.326
1471	0.238	0.327	0.240	0.312
1491	0.229	0.303	0.229	0.300
1511	0.221	0.290	0.220	0.290
1531	0.215	0.283	0.213	0.283
1551	0.211	0.278	0.209	0.277
1571	0.208	0.276	0.208	0.273
1591	0.208	0.278	0.208	0.275
1611	0.208	0.289	0.212	0.283

Fibre loss [2]

- Fibre cables recently were subject to intensive research and development, improving their attenuation



Measured fibre attenuation and splice loss in installed G.652 A&B cable – cables installed before 1990 (a), around 2000 (b) and in 2003 (c)

(ITU-T Series G Supplement 39 from 02/2006, section 10.2)

SIEMENS

CORNING

New Excel spreadsheet features [5]

- The SRS induced power penalty is only calculated for downstream channel transmission – SRS occurs only for co-propagating digital and analog data streams
- Upstream channel is unaffected – no entries for SRS induced power penalty
- The Cr coefficient is 0-order approximated and the resulting SRS induced power penalty should be treated as worst case scenario estimation in the target digital signal transmission window

Conclusions [1]

- Several new features were added to the Excel based channel link model to account for:
  - presence of the splitter in the signal path
    - A new way of calculating splitter loss is proposed (based on real measurement data from data sheets)
    - Splitter loss is calculated based on the split count
  - SRS induced power penalty
    - SRS 0-order approximation was carried out for the 1470-1530 nm window
- SBS induced power penalty is still pending implementation
- Overview of the fibre attenuation figures is proposed – the existing values seem exorbitant for PON systems

Conclusions [2]

- We need more time to properly evaluate the SBS model and implement it completely in the Excel spreadsheet
  - Dynamic and static models need revision
  - Exact implementation strategies needs to be examined with D. Piers and other group participants
- Dynamic SRS model may need consideration
  - Right now the model assumes DC operation
  - We do not account for 10G digital channel above 1550 nm
- Impact of the digital transmission on channel on the video overlay (see 3av_0701_effenberger_2.pdf)
  - Do we need it?
  - If so, how do we include that in the target Excel document ?