SMF Channel Dispersion Penalty Specification Proposal

IEEE P802.3dj Optics Ad Hoc

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Background

- ITU-T G.652 codes, used in all IEEE 802.3 SMF optical standards, define ZDW (Zero Dispersion Wavelength) from 1300 to 1324nm.
- ZDW in 1300 – 1305nm or 1319-1324nm is rarely seen in modern applications.
- Requiring the full spec range unnecessarily burdens transceiver cost and power.
- Over the past decade, we have proposed to update the ZDW spec and/or how it is used in the ITU-T and IEEE 802.3, for example:

  https://www.ieee802.org/3/cu/public/May19/cole_3cu_01a_0519.pdf [ieee802.org]

  https://www.ieee802.org/3/df/public/22_11/cole_3df_01a_2211.pdf.
- We keep trying:

  Frank Effenberger will raise consideration of G.652 fibers in the ITU-T this April.
- There must be fundamental reason(s) for the lack of progress.
- Let's step back and understand what's going on.

SMF Manufacturing Observations

- Fiber has been manufactured for over 50 years.
- It is a highly complex process, requiring massive R&D, extensive measurements and continuous improvement.
- Fiber manufacturing requires the latest techniques, most importantly statistical process control.
- Link parameters of interest like dispersion are not controlled directly (there is no dispersion knob) but are determined by complex interaction of many other fiber parameters whose measurement generates large datasets enabling statistical process control.
- Is there confirmation that fiber manufacturers use modern practices?

Top Fiber Cable Manufacturers Quality System Confirmation

	ISO 9001	Lean Six Sigma or ISO 13053*	Confirmation By Web Search	Confirmation by an Individual(s)
Sumitomo	Yes	Yes	Yes	Yes
Corning	Yes	Yes	Yes	Yes
Prysmian	Yes	Yes	Yes	No
CommScope	Yes	Yes	Yes	Yes
Zhongtian (ZTT)	Yes	Yes	Yes	Yes
Hengtong (JHPCCL)	Yes	Yes	Yes	Yes
Furukawa (OFS)	Yes	Yes	Yes	Yes
Fujikura	Yes	Yes	Yes	Yes
Belden	Yes	Yes	Yes	No
Yangtze (YOFC)	Yes	Yes	Yes	Yes
Shanghai (SDGI)	Yes	Yes	Yes	Yes

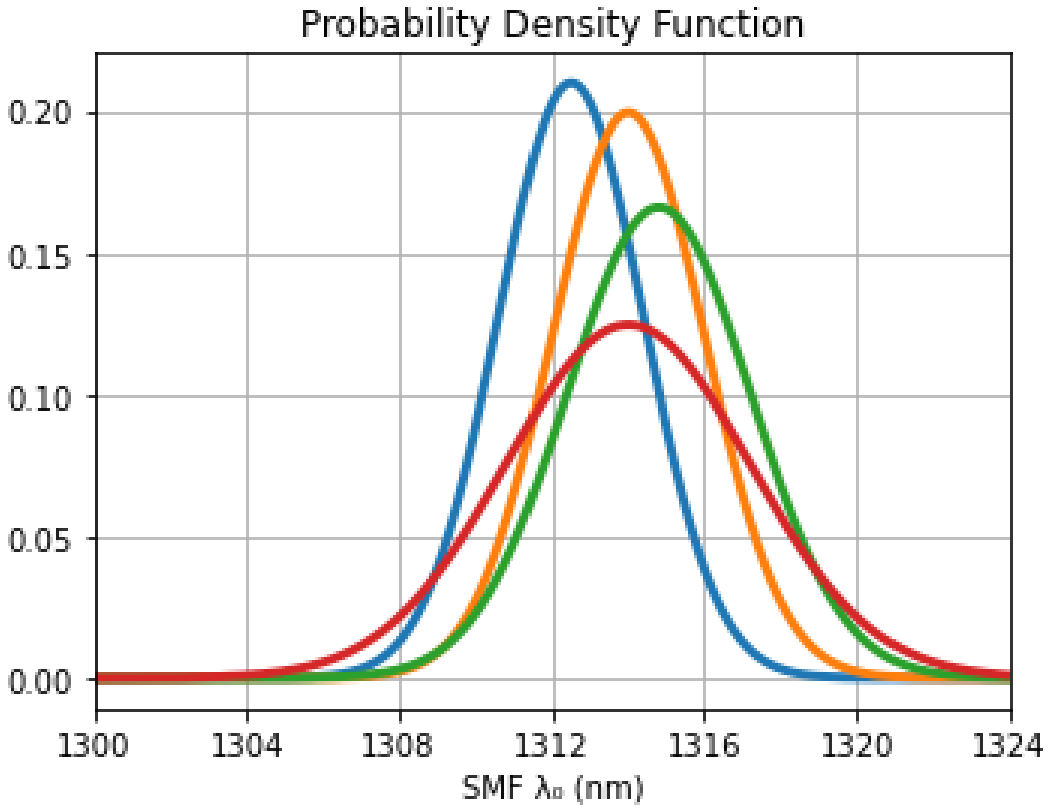
* or equivalent

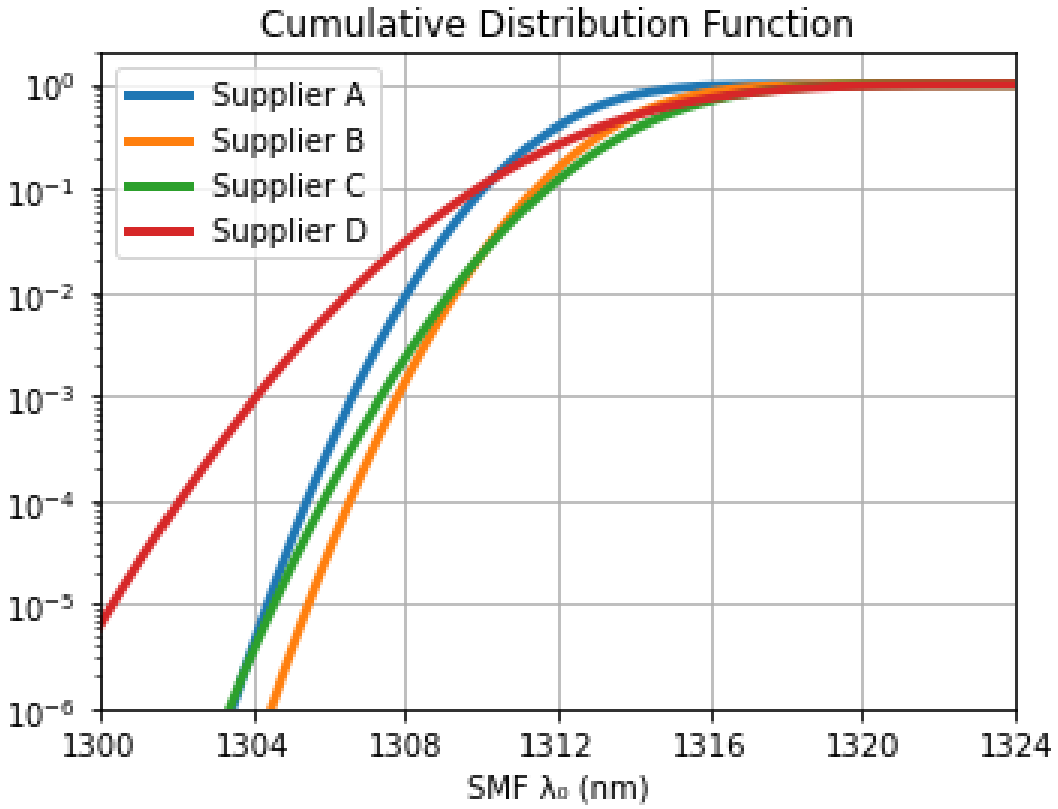
What do G.652 Codes Mean to Fiber Manufacturers?

- G.652 ZDW spec is a SMF manufacturing process limit:
  - Min = 1300nm
  - Max = 1324nm.
- Confirmation by 8 suppliers at ITU-T SG15/Q5 meeting in Nov. 2016.

  https://www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-G.652-201611-I!!PDF-E&type=items [itu.int]
- A Six Sigma process, with the above limit has the following normal distribution:
  - Mean = 1312nm
  - Mean variation: $\pm$1.5nm
  - Sigma = 2nm.
- Is there confirmation this is a good model?

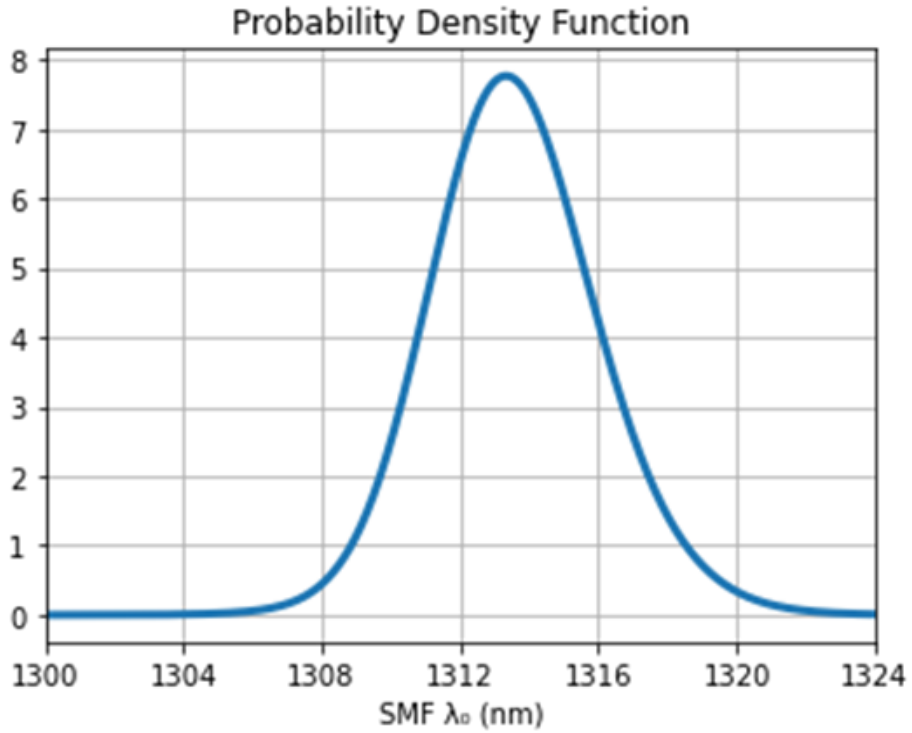
Data from Four SMF Suppliers Representing ~50% Market Share

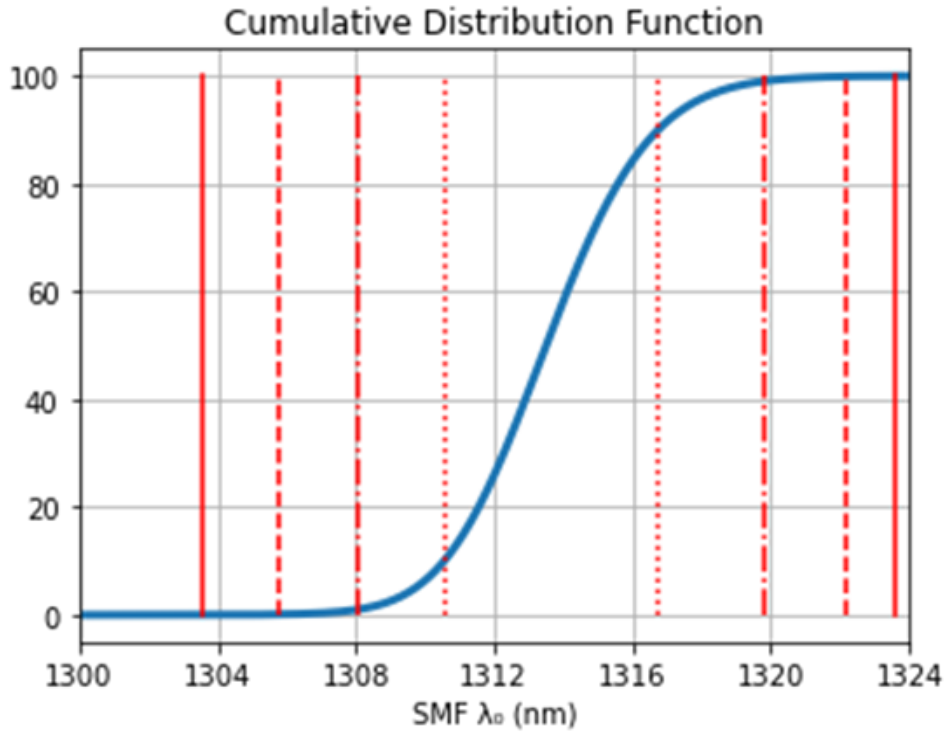




- Suppliers from China, Japan and United States
- Each PDF is normalized (same final CDF value)

Data from Four SMF Suppliers Combined by Market Share





ZDW Range
0.01% - 99.99%: 1303.6nm - 1323.6nm
0.10% - 99.90%: 1305.8nm - 1322.1nm
1.00% - 99.00%: 1308.1nm - 1319.8nm
10.00% - 90.00%: 1310.6nm - 1316.7nm

SMF ZDW Spec Change Implication to Fiber Manufacturers

- Example of previously proposed SMF ZDW spec change:
  - Min = 1300nm → 1306nm, and
  - Max = 1324nm → 1318nm.
- This would require a large and costly manufacturing process change:
  - Mean variation = ±1.5nm → ±0.75nm , and
  - Sigma = 2nm → 1nm.
- No wonder this has been vigorously opposed.
- G.652 codes should be unchanged: their ZDW limit is fine for manufacturing fiber.
- The problem is using the same limit for transceiver manufacturing:
  - Ex. transceiver testing requires rare SMF: 3.4 PPM best case, 3.2 PPT worst case
- The solution is different limit for transceiver design and manufacturing.

Link Budget Calculation and Dispersion Penalty Test Proposal

- Use realistic ZDW normal distribution in statistical link budget calculation:
  - $Mean_{min}$ = 1310.5nm (for most positive dispersion)
  - $Mean_{max}$ = 1313.5nm (for most negative dispersion)
  - Sigma = 2nm

  ex. https://www.ieee802.org/3/df/public/22_10/22_1012/rodes_3df_01b_221012.pdf#page=8.
- Use practical $\pm$2.25 sigma (~99%) ZDW values in TDECQ testing:
  - Min = 1306nm
  - Max = 1318nm.
- The dispersion penalty component of this TDECQ measurement may be slightly lower than the dispersion penalty component in the statistical link budget calculation.
- The difference, if any, must be shown by the calculation to be acceptable.

SMF Channel Dispersion Penalty Specification Proposal

Thank you