Receiver yield vs. distance prediction using MMF emulation and simulation

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Outline

- Statistical model – Recap of Cambridge/Agilent approach
- Summary of Cambridge EDC bounding case and constrained results
- Testing a receiver – Use of a MMF emulator to predict yield vs. distance
- Emulator requirements
- Parallel BERT realization of emulator
- Simulation may also be used to predict yield vs. distance
- Conclusions

Statistical model – Recap of Cambridge/Agilent approach (from penty_1_0104)

Model of "bad" population

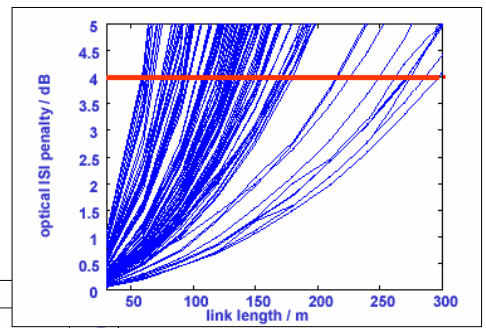
- Model fiber responses for given launch and refractive index profile;
- 81 refractive index profiles, each with 1310nm launch at 3 offsets;
- Calibrate responses to represent bad 5% of installed channels
- Resulting ("81 Fiber") impulse responses publicly available (cunningham_1_0304)

Collection of ISI Penalty curves

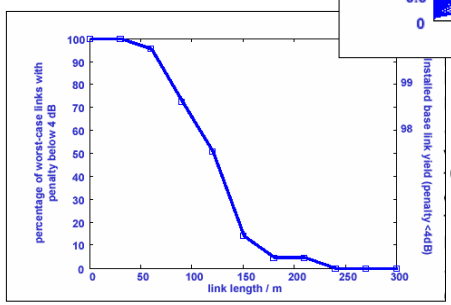
- For each channel, compute ISI power penalty vs. length

Yield vs. distance

- Derive yield vs. distance relationship



Example collection of ISI penalty curves, from penty_1_0104.

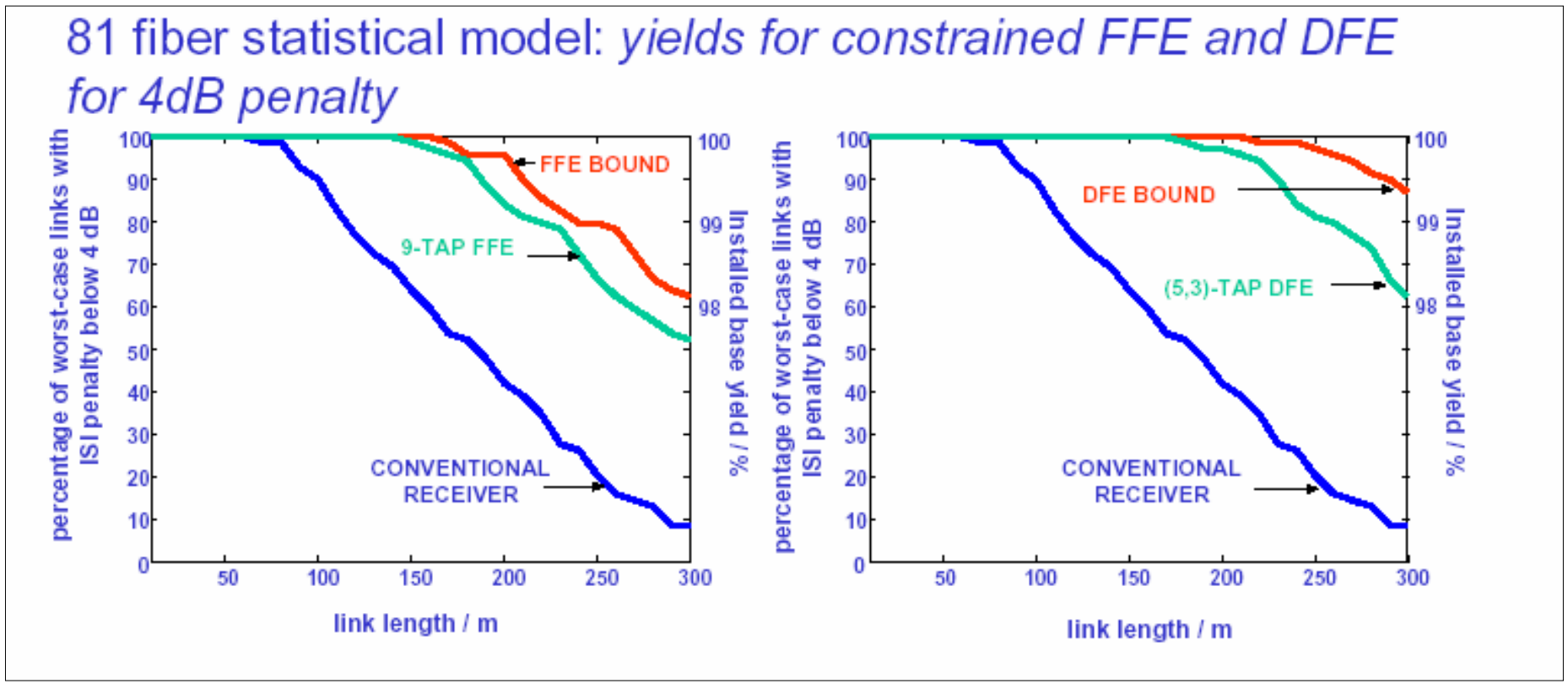


Example yield curves, from penty_1_0104

Similar fiber analysis presented in pepeljugoski_1_0104

Summary of Cambridge EDC bounding case and constrained results (from penty_2_0104)

- Yield vs. distance for several receivers, for 1310nm offset launched into 62.5μm MMF:



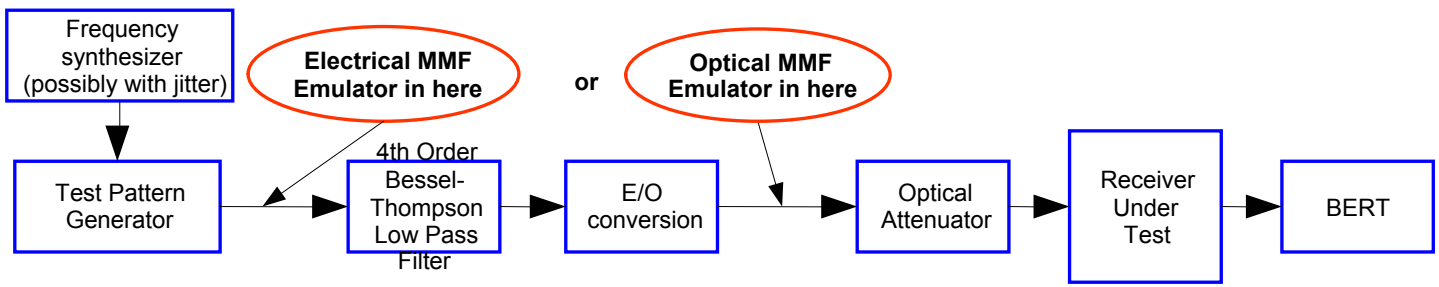
From page 18 of penty_2_0104

Testing a receiver – Use of a MMF emulator to predict yield vs. distance

Measurement across sufficiently large population of fibers is not realistic.

MMF-Emulators have been proposed to put a receiver through its paces.

- Both electronic and optical MMF Emulation methods have been proposed (bhatt_1_0104 and kirkpatrick_1_0104):



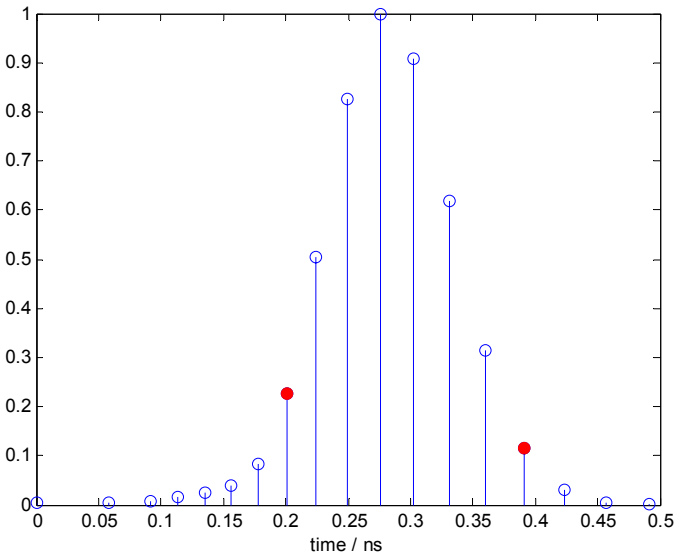
Emulation enables:

- Power penalty determination for each of the "81 Fiber" impulse responses, for different link lengths (bottacchi_3_0104);
- Leading to **yield vs. distance curve;**
- Test of receiver ability to track **dynamically changing fiber response**.

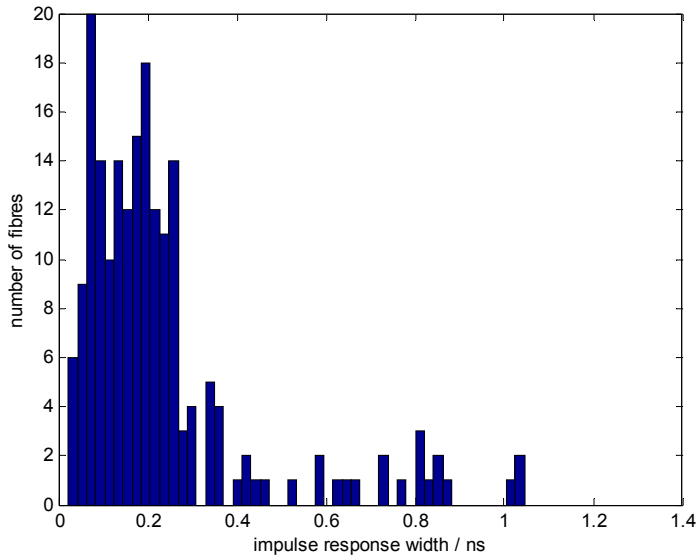
Emulator requirements

Statistics from “81 Fiber” responses at 300m (1310nm, offset launched) :

- Granularity of (unfiltered) response is about 25ps
- Impulse widths (from 10% of peak to 10% of peak) are mostly within 0.3ns, extending to 1ns in a few cases.



Typical impulse response (“width” indicated by red dots)

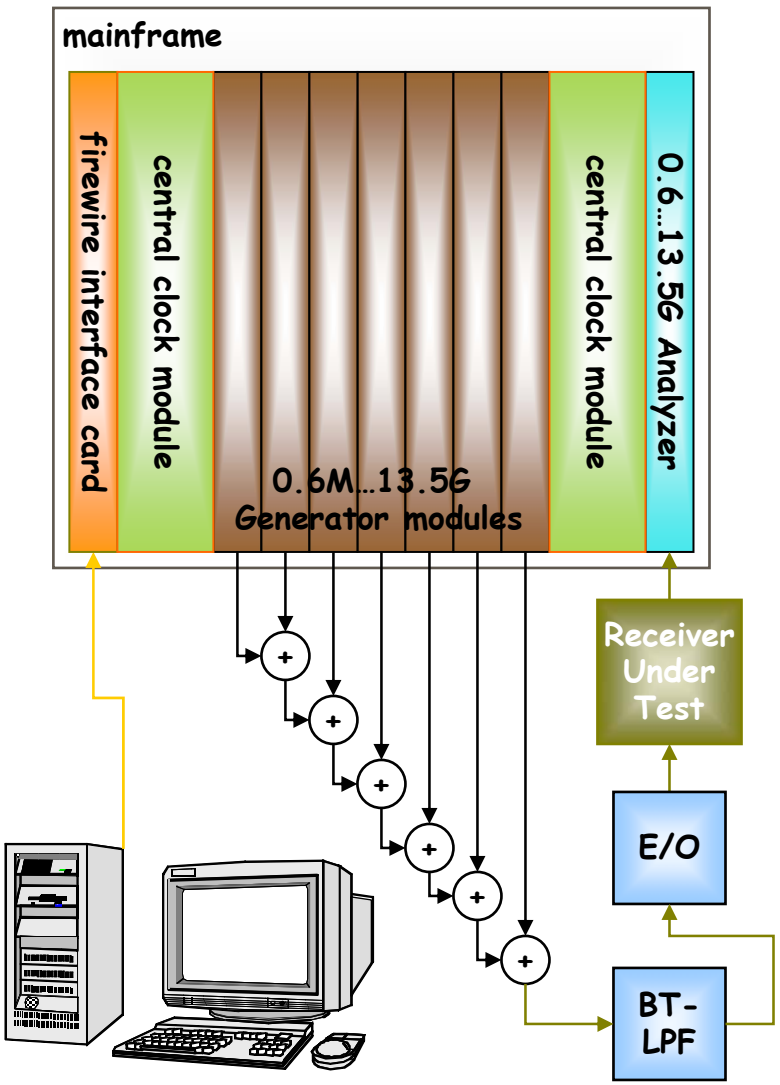


Distribution of impulse response “widths”

Emulator should:

- Run through all “81 Fiber” responses, at each length step, to measure BER vs. RX power stats;
- Enable/compute yield vs. distance stats for selected power RX power budget.
- Support sufficiently fast transients from response to response to emulate time-varying channels.

N-tap low pass filtered data stream realized with Parallel BERT



Exemplified for N=7 allowing room for a BERT Analyzer in same mainframe

All generator channels generating the same signal

All black cables of same electrical length

Each channel delayed by 1UI vs its left neighbor minus delay of “blue” cable connection between the adders

Individual cable delays can easily be compensated by individual channel delay adjustment of Parallel BERT modules

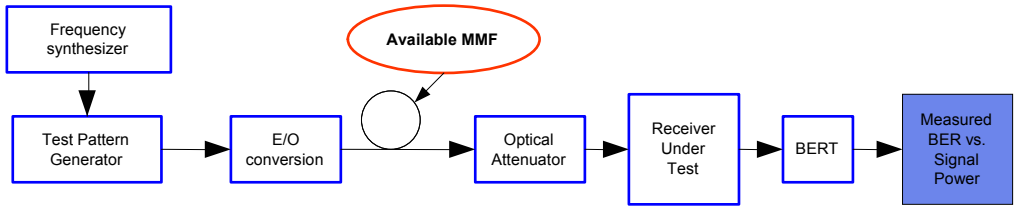
Coefficients of filter function adjustable +/- 36:1 through individual setting per module of channel amplitude of 50mV…1.8V and channel inversion

Earliest signal attenuated by 3dB x (n-1), latest signal attenuated by 3dB; alternative adder structures possible if coefficients require different weights

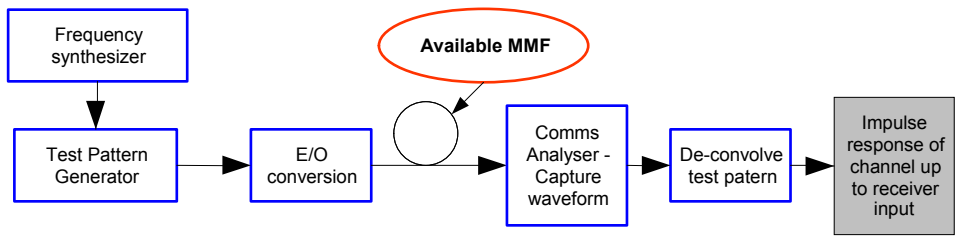
Simulation may also be used to predict yield vs. distance

Simulation requires receiver model to be verified against receiver hardware:

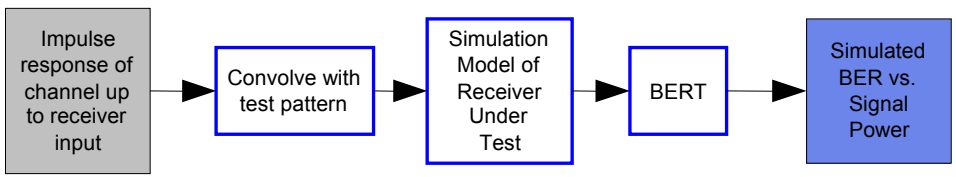
1) Using available MMF samples, measure receiver output BER vs. Signal Power:



2) Compute Response of Channel, up to Receiver input:



3) Simulate BER vs. Signal Power for the channel:



4) Verify that Measured and Simulated BER vs. Power curves match:

Having verified the receiver model, may predict yield vs. distance using the receiver model together with the "81 Fiber" responses.

Conclusion

- **Link Yield vs. Distance may be predicted, using ..**
  - Actual Receiver Hardware, together with
  - “81 Fiber” Impulse Responses
    - **Extendable to different launch methods**
- **Two Approaches Discussed ..**
  - Prediction using MMF emulation
    - **Potential test methodology for new receivers**
    - **Emulation may be implemented using a Parallel BERT**
  - Prediction using simulation
    - **Based upon validated receiver model**