Analog Equalization for Step-Index Polymer Optical Fiber (SI-POF)

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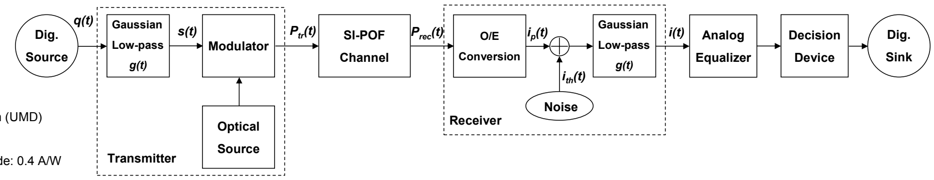
1. SI-POF Transmission System

Parameter:

- $P_{tr}(t)$ = 1 mW
- uniform mode distribution (UMD)
- attenuation: 180 dB / km
- responsivity of photo diode: 0.4 A/W

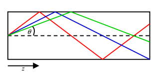


2. Simulation Model for SI-POF

Starting point : time dependant power flow equation (Gloge):

$$\frac{\partial P}{\partial z} = -\alpha(\theta)P - \tau_{rel}(\theta)\frac{\partial P}{\partial t} + \frac{D}{\theta}\frac{\partial}{\partial \theta}\left(\theta\frac{\partial P}{\partial \theta}\right)$$

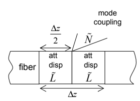
mode dependant attenuation — modal dispersion — mode coupling



fourier transform

$$p(\theta,z,\omega) = \Im\{P(\theta,z,t)\}$$

$$\frac{\partial p}{\partial z} = \underbrace{-(\alpha(\theta)+j\omega\tau_{rel}(\theta))p}_{\tilde{L}\cdot p} + \underbrace{\frac{D}{\theta}\frac{\partial}{\partial \theta}\left(\theta\frac{\partial p}{\partial \theta}\right)}_{\tilde{N}\cdot p}$$



$$p(\theta,z+\Delta z,\omega) \approx \exp\{\tfrac{\Delta z}{2}\tilde{L}\}\exp\{\Delta z\tilde{N}\}\exp\{\tfrac{\Delta z}{2}\tilde{L}\}p(\theta,z,\omega)$$

$$p(\theta,z+\Delta z,\omega) \approx \exp\{\tfrac{\Delta z}{2}\tilde{L}\}\exp\{\Delta z\tilde{N}\}\exp\{\tfrac{\Delta z}{2}\tilde{L}\}p(\theta,z,\omega)$$

inverse fourier transform

$$P(\theta,z_0,t) = \Im^{-1}\{p(\theta,z_0,\omega)\}$$

$$P(\theta,z_0,t)$$

impulse response

$$h(t)\big|_{z=z_0} = \int_{\theta=0}^{\theta=\theta_{max}} P(\theta,z_0,t)\,d\theta$$

Power distribution

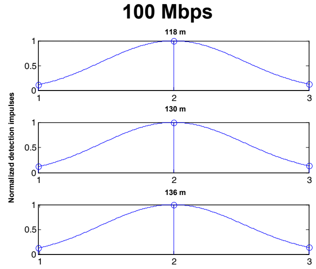
$$P(\theta)\big|_{z=z_0} = \int_{t=0}^{t=t_{max}} P(\theta,z_0,t)\,dt$$

3. Analog Equalization

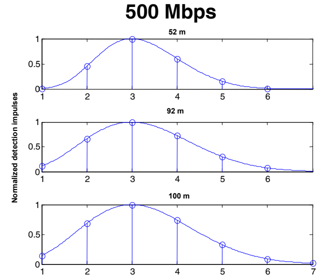
- analog equalizer based on trellis
- up to 10 x smaller, or,
- up to 100 x more power efficient compared to digital equalizer
- processes reliability information
- requires no A/D conversion

4. Simulation Results

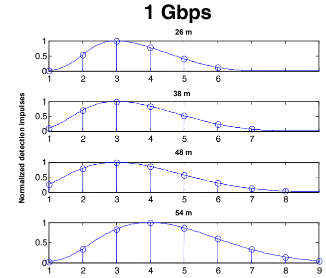
100 Mbps



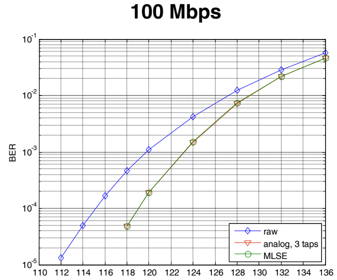
500 Mbps



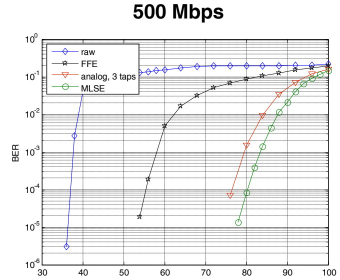
1 Gbps



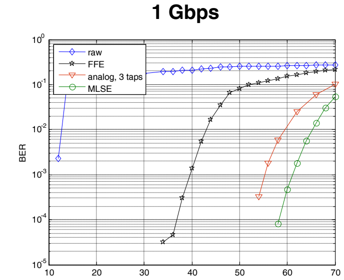
100 Mbps



500 Mbps



1 Gbps



100 Mbps

- analog equalizer with 4 states
- equivalent to 4 state MLSE equalizer
- only moderate increase of reach (performance is noise limited)

500 Mbps

- analog equalizer with 4 states increases reach from 36 m to 74 m
- MLSE equalizer with up to 64 states allows only 4 m more

1 Gbps

- analog equalizer with 4 states increases reach from 11 m to 53 m
- MLSE equalizer with up to 256 states allows only 6 m more

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