Connector Transfer Matrix

December 22, 2004

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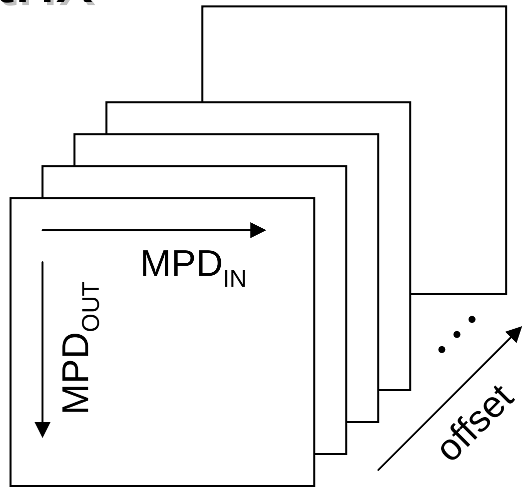

- Connector transfer matrix: ctm(i,j,k)
  - i → indexes output MPD
  - j → indexes input MPD
  - k → indexes connector offset
    - 0 → 12μm, 0.5μm steps for 62.5μm fiber
    - 0 → 9μm, 0.5μm steps for 50μm fiber
- Mode-Groups
  - 62.5μm fiber: 21 mode-groups computed, 18 used in simulations
  - 50μm fiber: 12 mode-groups computed, 10 used in simulations
- Examples:
  - MPDs are Matlab column vectors
  - MPD for 5.5μm offset

```
MPD_out = ctm_62(1:18,1:18,12)*MPD_in;
```

  - MPD for 4.3μm offset using linear interpolation

```
ctmi = interp1([0:0.5:12],permute(ctm_62,[3 1 2]),4.3,'linear');
MPD_out = squeeze(ctmi)*MPD_in;
```

Fiber model and the scalar wave equation

- The electric field in the fiber assumed to be in the form:

$$\Psi(r,\phi,z) = \psi_{l,q}(r,\phi)\exp(i\beta z) \qquad \psi_{l,q}(r,\phi) = R_{l,q}(r)e^{-il\phi}$$

- Radial component R and propagation constant β are a solution to the scalar wave equation

$$\left[\frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r} + k_0^2 n^2(r) - \frac{l^2}{r^2} - \beta^2\right] R_{l,q}(r) = 0$$

- Connector transfer matrix
  - Compute overlap integral for each mode
  - Assume equal power distribution among modes within input mode-groups
  - Sum intensities to form output mode-group coupling coefficients

Computation of the connector transfer matrix

- Find coupling coefficient between modes of two fibers:

$$c_{l_1,q_1;l_2,q_2} = \int_A \psi^{*}_{l_1,q_1} \, \psi_{l_2,q_2} \, dA$$

- Find elements of the connector matrix

$$C_{PMN}(i,j) = \frac{1}{j} \sum_{\substack{1 \\ 2q_1+l_1+1=i}}^{M} \; \sum_{\substack{1 \\ 2q_2+l_2+1=j}}^{M} | c_{l_1,q_1;l_2,q_2} |^2$$

- MPD in receiving fiber:

$$\mathbf{MPD}_2 = \mathbf{C}_{PMN} \times \mathbf{MPD}_1$$

Simulation Assumptions

- 62.5μm fiber
  - r_0 = 31.25μm → core radius
  - n_1 = 1.5 → index of refraction at r = 0μm
  - Δ = 0.017183 → relative index difference → n_2 = 1.474 (index at r= r_0)
  - α = 1.97 → index profile exponent (no index perturbations)
  - λ = 1310nm
- OM2 fiber
  - r_0 = 25μm
  - n_1 = 1.48
  - Δ = 0.0095
  - α = 2.0 (no index perturbations)
  - λ = 1310nm
- OM3 fiber
  - r_0 = 25μm
  - n_1 = 1.45
  - Δ = 0.010
  - α = 2.0 (no index perturbations)
  - λ = 1310nm