Design of 300 Meter Installed 62.5 um Fiber for Longwave 10GbE

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Abstract
300 Meter Installed 62.5 um Fiber for 10GbE

- **Optical Link Design Parameters**
  - Jitter budget
  - Power budget
  - Bandwidth budget
- **Critical Parameters for Installed 62.5 um Fibers**
  - Bandwidth budget - critical parameter
  - Bandwidth solutions
- **Design**
  - Installed base fiber bandwidth data
  - Analysis of the bandwidth data
  - Mode restricted DMD waveforms
  - DMD solutions
- **Recommendations**
  - Recommend 300 meter installed 62.5 um fibers for 10GbE
  - Installed 62.5 um Fiber without MC
  - Installed 62.5 um fiber with Circle MC

Optical Link Design Parameters
300 meter Installed 62.5 um Fiber for 10GbE

- **Jitter Budget**
  - T = DJ + RJ (at given BER) + CJ(clock jitter)
  - T = 320 ps -- 4-bit at 3.125 Gbps
  - Deskew required
  - Jitter budget assigned -- not critical
- **Power Budget**
  - Pin > Pmin (receiver sensitivity + ISI)
  - ISI loss < 0.5 dB for a well designed link -- Gimlet's Equation
  - Power budget assigned -- not critical
- **Bandwidth Budget**
  - 0.8 T => (tT^2 + tF^2 + tR^2)^0.5
  - Required fiber BW >0.8xBit Rate = 2.5 GHz -- to meet BER requirement
  - Bandwidth budget -- critical

Critical Parameters for Installed Fibers
300 meter Installed 62.5 um Fiber for 10GbE

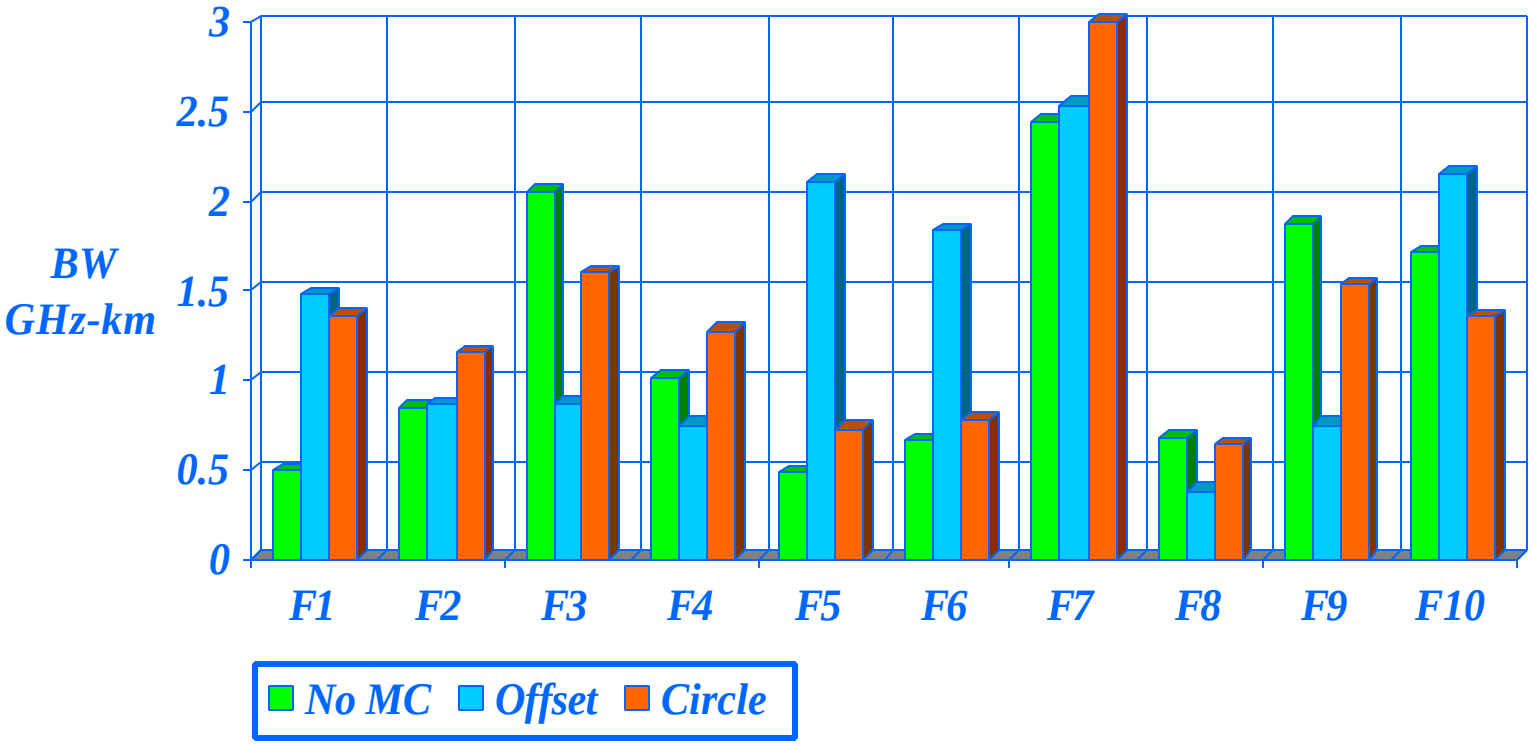
- **Bandwidth Budget - Critical Parameter**
  - Required fiber BW > 2.5x300/1000 = 750 MHz-km
  - tF <= 440/2500 = 176 ps
  - BW(OFL) 500MHz-km < 750 MHz-km -- critical
  - DMD reduces BW -- critical
  - Limited BW data of installed fibers -- critical

- **Bandwidth Solutions**
  - Actual fiber BW (EMB) > 500 MHz-km at long-wave
  - Mode conditioner to improve DMD effect
  - Use EMB for link design
  - Collect field data to establish EMB

Installed Base Fiber Bandwidth Data

300 Meter Installed 62.5 um Fiber for 10GbE

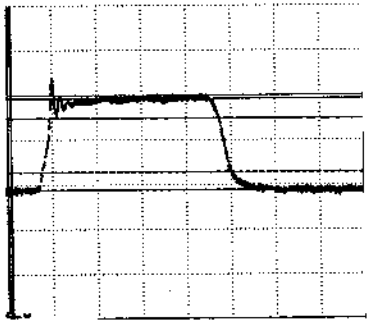
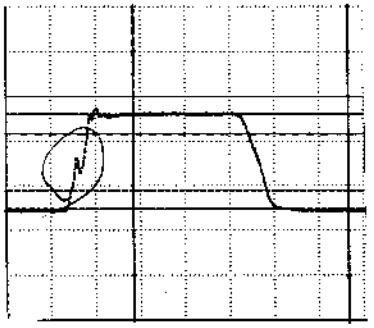
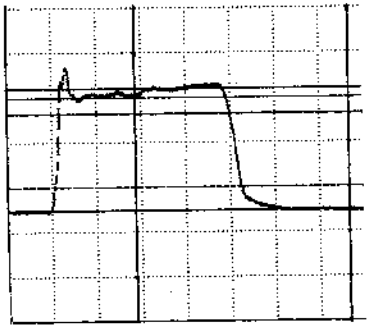
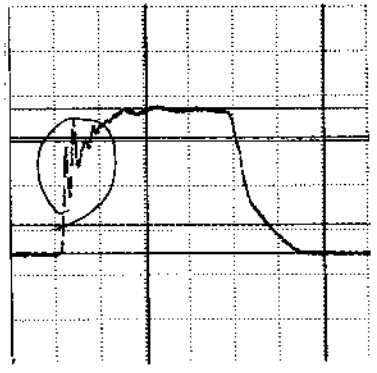
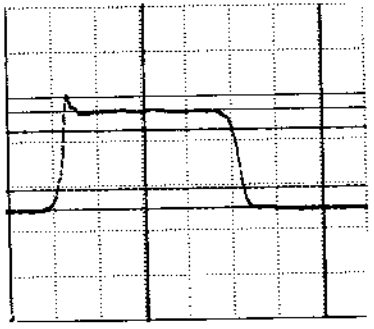
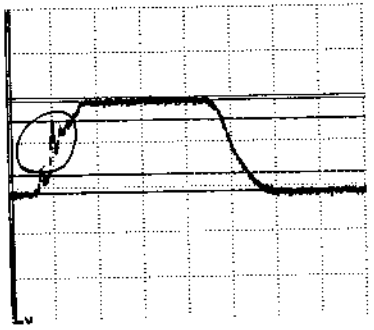
TIA Round-Robin Sample Fibers



Analysis of the Bandwidth Data
300 Meter Installed 62.5 um Fiber for 10GbE

- All but F8 Exceed 750 MHz-km Using Mode-conditioner
  - F8 (673 MHz-km) -- excessive DMD, may be discarded
- Some Failed without Mode-conditioner
  - F1, F5, F6, -- BW < 750 MHz-km
- Offset Mode-conditioner may Reduce BW
  - F3, F4, F9 – reduce BW
- Circle (Dough-nut) Mode-conditioner No BW Reduction
  - Better expectation of EMB – average reflective-index of small area
  - F10 a good fiber –minor reduction to 1.3 GHz-km by averaging

Mode Restricted DMD Waveforms
300 Meter Installed 62.5 um Fiber for 10GbE

	No MC	Offset	Circle
F3	 2. GHz-km	 0.87 GHz-km	 1.6 GHz-km
F5	 0.47 GHz-km	 2.11 GHz-km	 0.75 GHz-km

DMD Solutions

300 Meter Installed 62.5 um Fiber for 10GbE

- **DMD Effects**
  - Center of a refractive-index profile defected
  - Low BW, plateau on rise-time
  - Excessive BER
- **Offset Mode Conditioner**
  - Offset the launch spot from center to avoid defection
  - BW improved -- offset spot with normal profile
  - BW not improved -- offset spot with defected profile
  - BW not predictable -- drastic BW improvement, or reduction
- **Circle (Dough-nut) Mode Conditioner**
  - Launch a circle area to average DMD effects
  - BW improved – high BW across-the-board
  - BW improvement predictable -- gradual BW improvement
- **Excessive DMD**
  - No BW improvement -- neither mode-conditioner can help
  - Excessive BER -- discard fiber (very small% of installed fibers)

Recommendations
300 Meter Installed 62.5 um Fiber for 10GbE

- **Recommend 300 meter Installed 62.5 um Fiber for 10GbE**
  - **Fibers without DMD meet BW requirements**
  - **Fibers with DMD -- resolve DMD with recommended procedures**
- **Installed 62.5 um Fiber without Mode-conditioner (MC)**
  - **Use all installed fibers without MC**
  - **Fibers with excessive TCP-retries – add either MC**
  - **Discard fibers with MC having excessive TCP-retries – very small % of installed fibers**
- **Installed 62.5 um Fiber with Circle Mode-conditioners**
  - **Add circle (dough-nut) MC to all installed fibers**
  - **Discard fibers with MC having excessive TCP-retries – very small % of installed fibers**