Polarization Effect in 10GbE Transmission over Multimode GI-Fiber

Application to 10GBASE-LRM

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Background and Motivation

- All transmission experiments done at 10GbE over MMF at Infineon labs showed strong dependency upon fiber layout, manipulation and twisting.
- The same experiment setup using EDC samples over 200m gave controversial performances just after close measurement repetitions.
- Polarization effects have been addressed since last few months in order to explain those phenomena and to find quantitative conclusions on the performance fluctuation encountered during experiments.

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Polarization Effects at 10GbE over Multimode GI-Fibers

- Objective:

  Analysis of polarization dependent effects in the transmission over multimode fibers

  – Evaluation of root causes

  – Estimation of relevance and power penalty

- Starting point:

  Common agreement today is that polarization effects in multimode fiber transmission are related to mode selective loss (MSL) and can be described as part of modal noise (MN)

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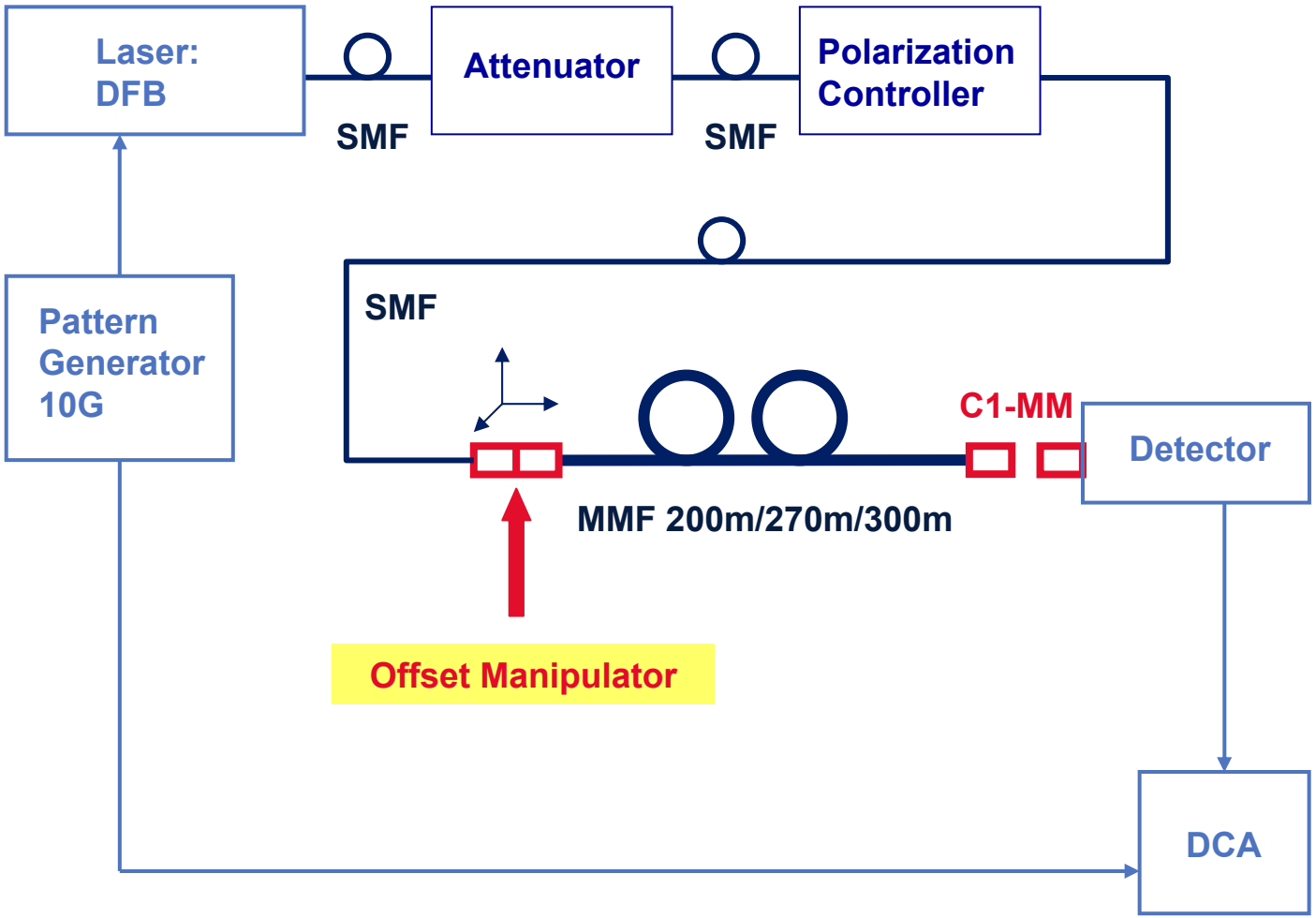
Outline of the Experiments

- **Two different launching conditions**
  1. Micromanipulator controlled offset launch
  2. Standard offset patchcord for 62.5µm and 50µm GI fibers.
- **Two different multimode GI fibers**
  1. Fiber #1: Siecor 62.5µm benchmark MMF at Infineon labs.
  2. Fiber #2: Corning 50µm OM3 grade multimode fiber
  3. Fiber #3: Siecor 62.5µm (875MHz*km, 270m)
- **Three different experimental setup**
  1. Transmission tests with controlled offset launch using single link fiber without any connector.
  2. Transmission tests with standard offset patchcord using single link fiber without any connector.
  3. Transmission tests using standard offset patchcord over various lengths of a Siecor 62.5µm benchmark fiber.

1. Experimental Setup with Controlled Offset Launch



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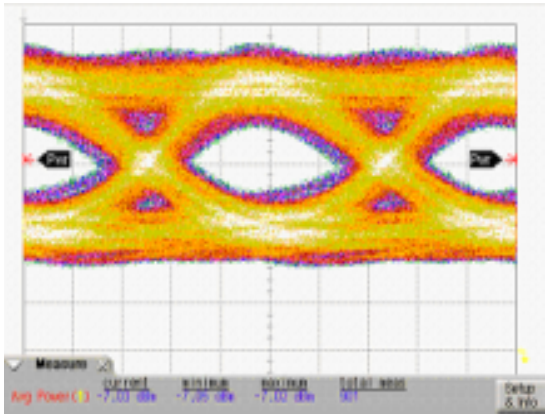
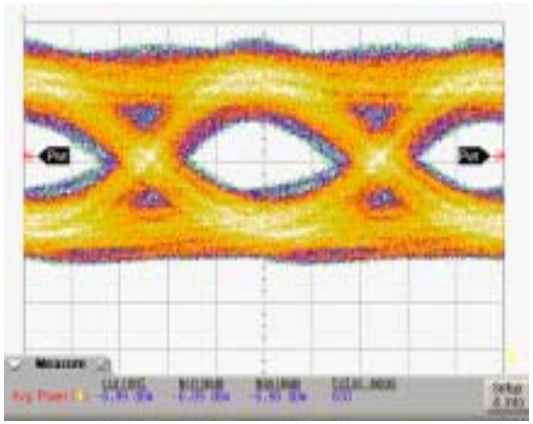
1. Controlled Offset Launch – Fiber #1: Central launch

Siecor 62.5µm benchmark MMF (BW~500MHz*km at 1310nm) → 200m

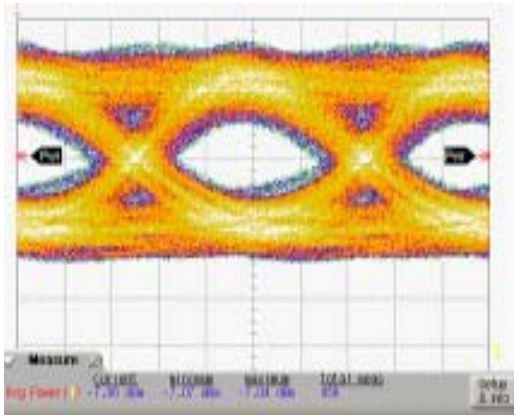
Polarization ⊥



Polarization 45°



Polarization ||



Result: No influence of polarization on transmission performance

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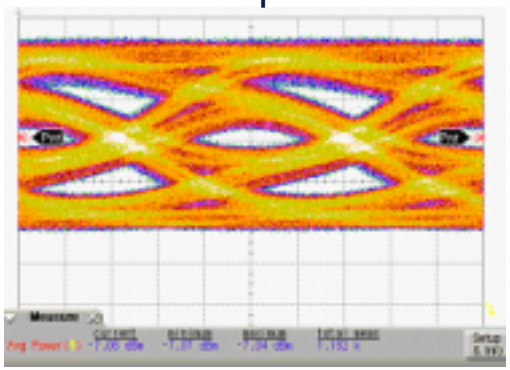
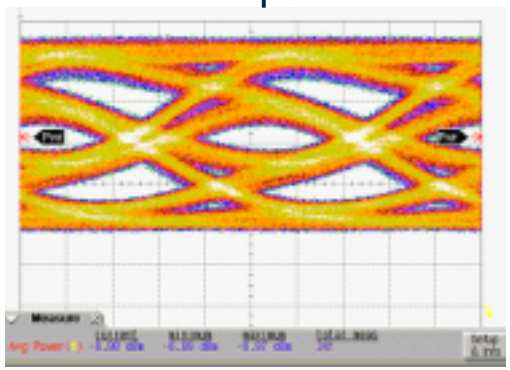
1. Controlled Offset Launch – Fiber #1: Offset launch

Siecor 62.5µm benchmark MMF (BW~500MHz*km at 1310nm) → 200m

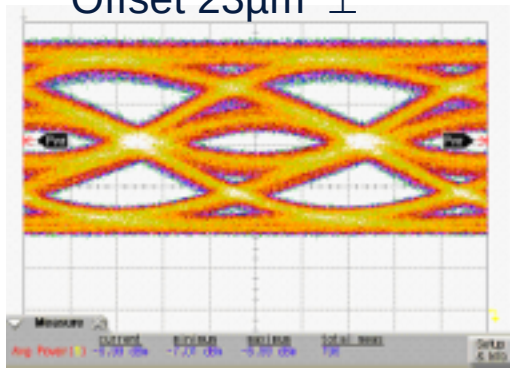
Offset 17µm ⊥



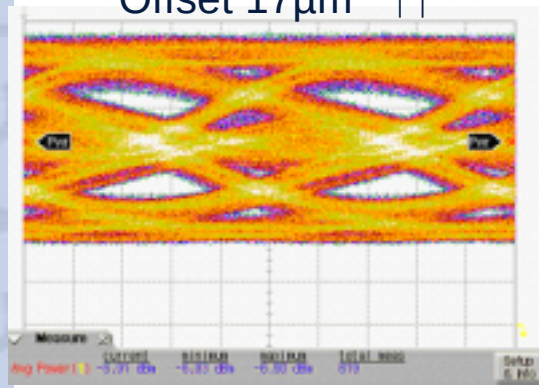
Offset 20µm ⊥



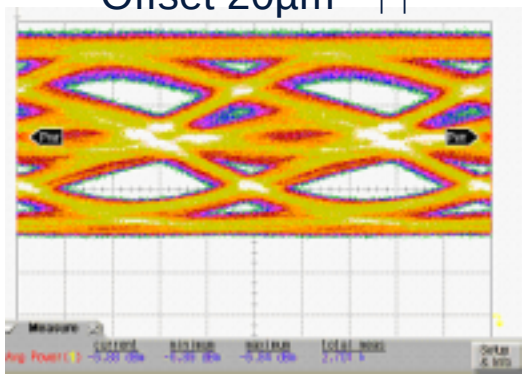
Offset 23µm ⊥



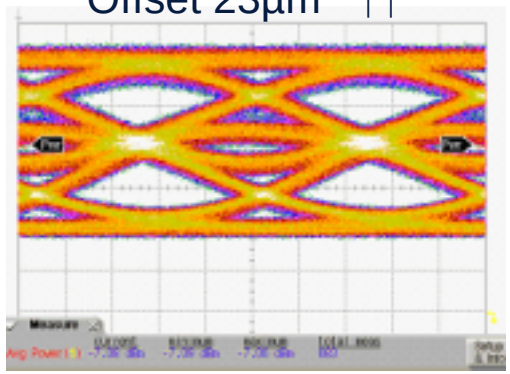
Offset 17µm ||



Offset 20µm ||



Offset 23µm ||



Result: Strong influence of polarization on transmission performance without any mode selective loss

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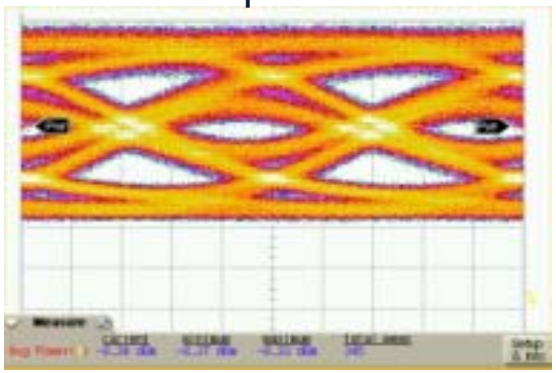
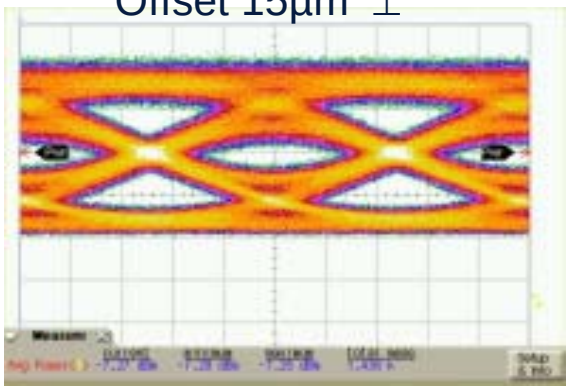
1. Controlled Offset Launch – Fiber #2: Offset launch

Corning OM3 grade 50µm multimode fiber (BW~900MHz*km at 1310nm) → 300m

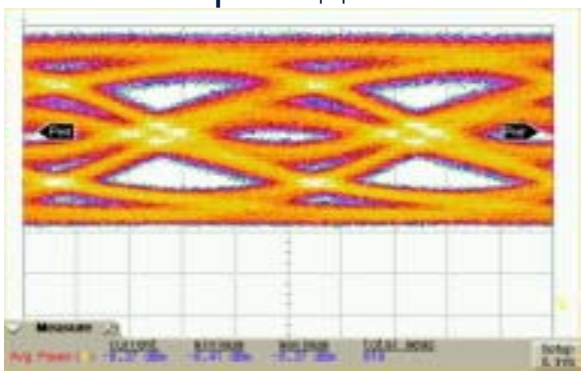
Offset 10µm ⊥



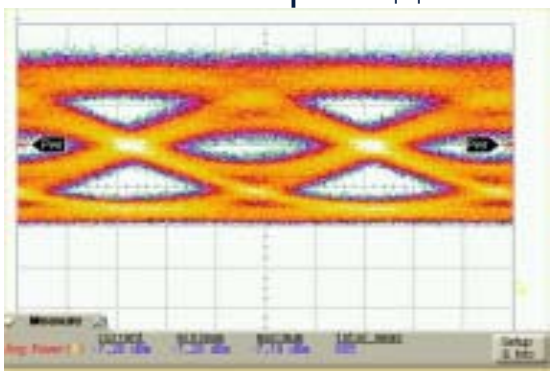
Offset 15µm ⊥



Offset 10µm ||



Offset 15µm ||



Result: Very low Influence of polarization on transmission performance

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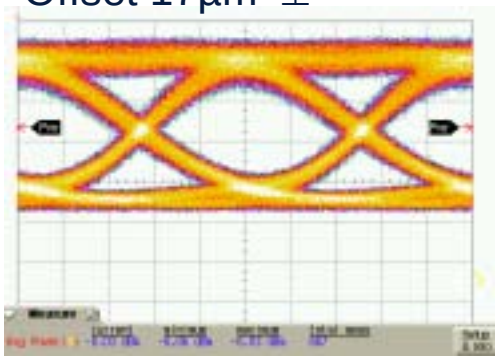
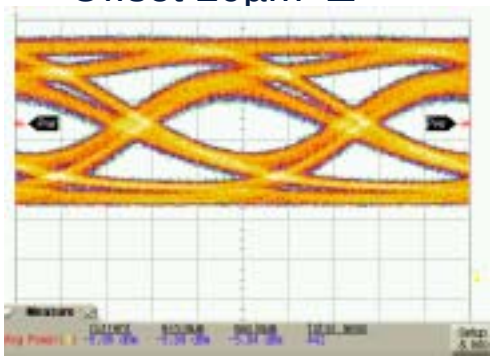
1. Controlled Offset Launch – Fiber #3: Offset launch

Siecor 62.5µm MMF (BW~875MHz*km at 1310nm) → 270m

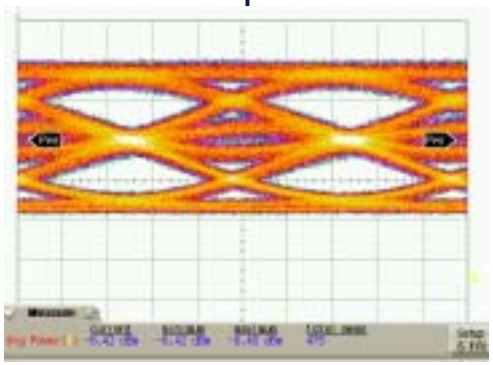
Offset 17µm ⊥



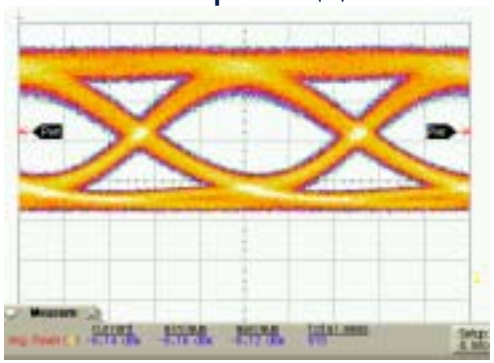
Offset 20µm ⊥



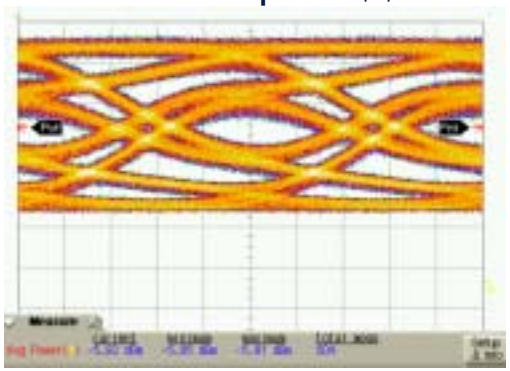
Offset 23µm ⊥



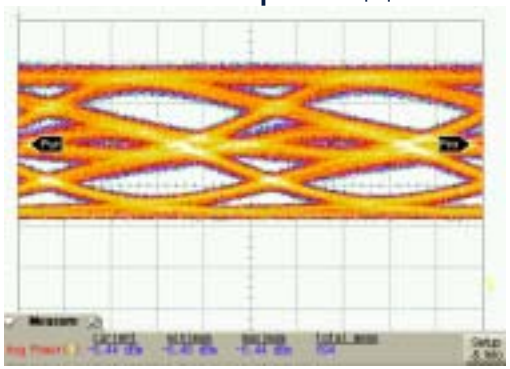
Offset 17µm ||



Offset 20µm ||



Offset 23µm ||



Result: Strong influence of offset position, polarization sensitivity of transmission performance for 20µm and 23µm offset.

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1. Controlled Offset Launch: Summary

- Polarization has no effect on central launch after 200m of Siecor 62.5µm benchmark MMF.
- Polarization has slight effect on offset launch after 300m of Corning OM3 grade MMF.
- Polarization has strong effect on offset launch after 200m of Siecor 62.5µm benchmark MMF.

Launch → / Fiber ↓	Central (0µm)	Controlled offset (17-23µm) (10-16µm)
F1: Siecor 62.5µm	NO	STRONG
F2: Corning OM3	NO	WEAK

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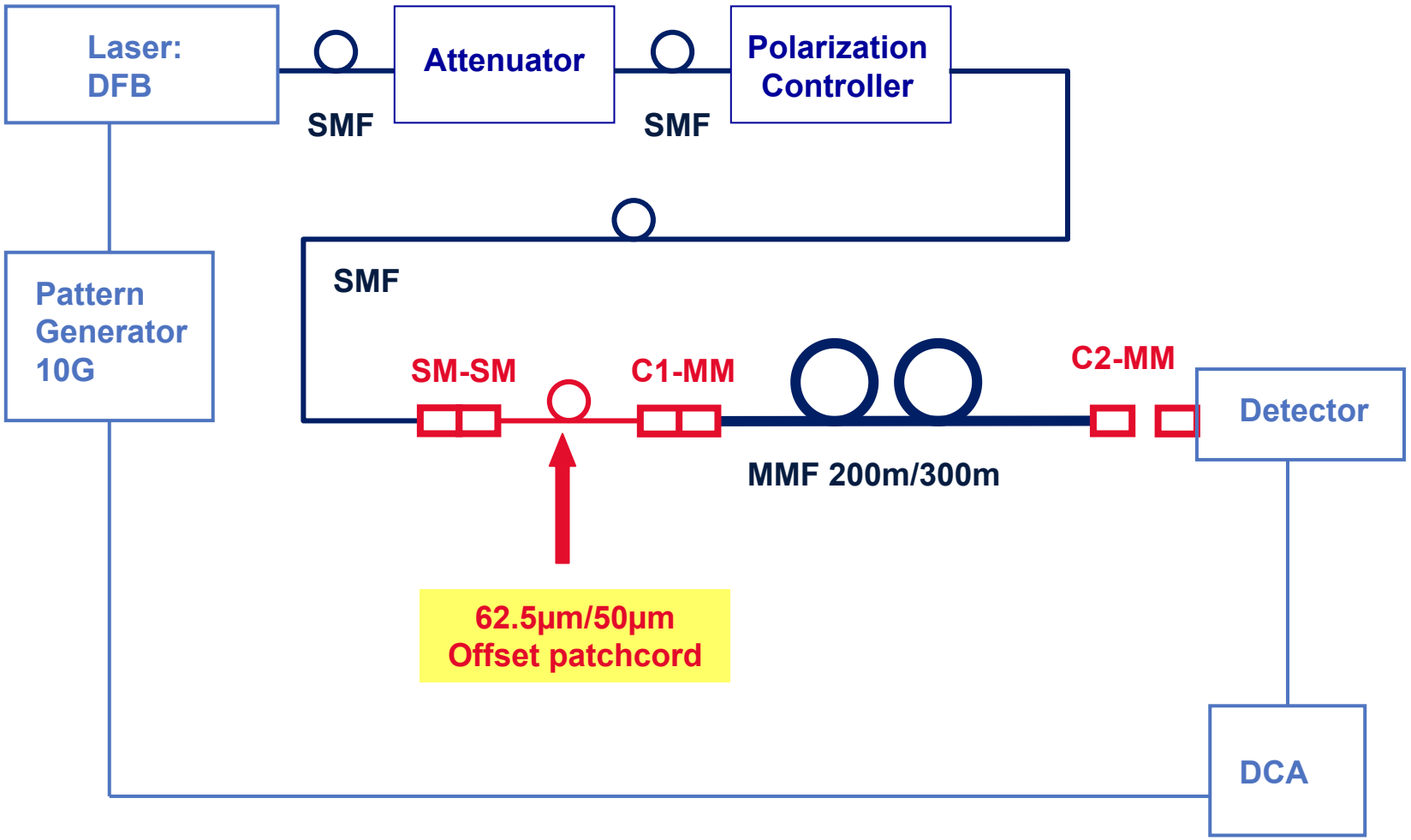
2. Experimental Setup with Standard Offset Patchcord



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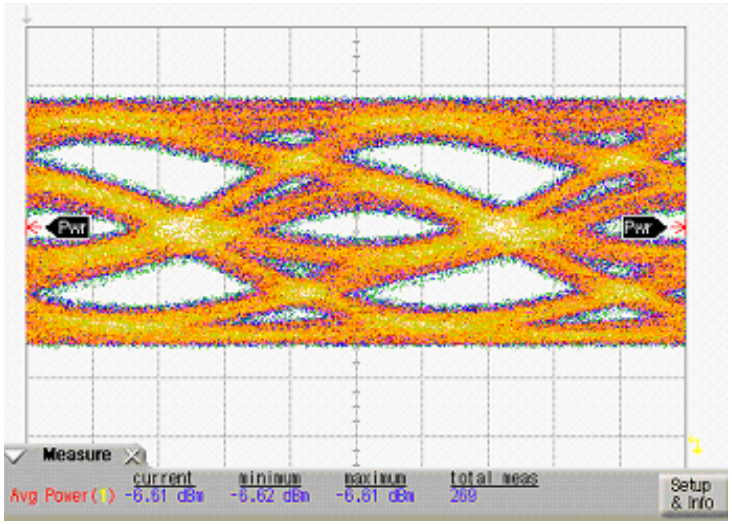
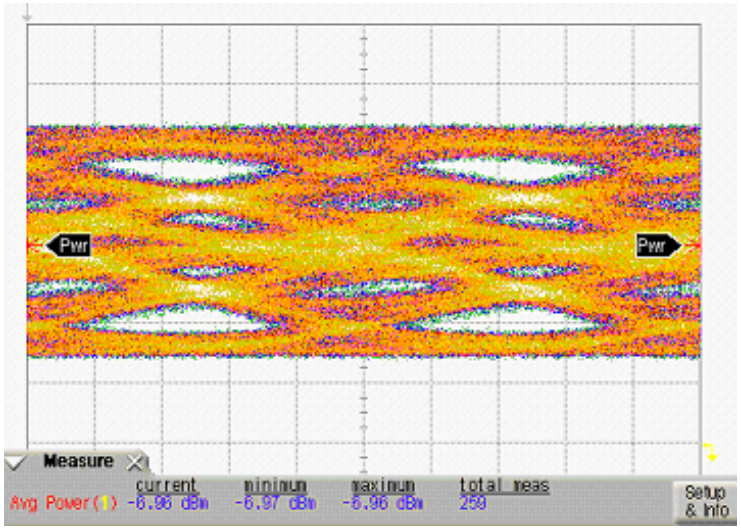
2. Standard Offset Patchcord – Fiber #1

Siecor 62.5µm benchmark MMF (BW~500MHz*km at 1310nm) → 200m

Polarization ⊥



Polarization ||

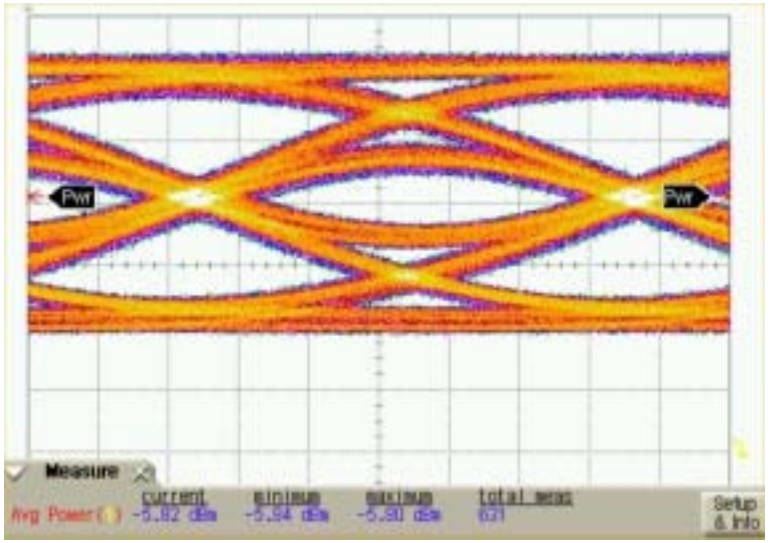


Result: Strong influence of polarization on transmission performance

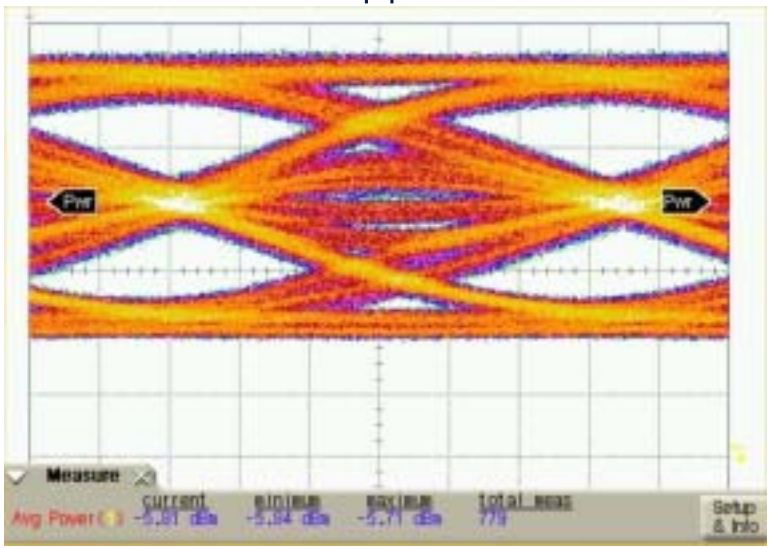
2. Standard Offset Patchcord – Fiber #2

Corning OM3 grade 50µm multimode fiber (BW~900MHz*km at 1310nm) → 300m

Polarization ⊥



Polarization ||



Result: Strong influence of polarization on transmission performance

2. Standard Offset Patchcord: Summary

- Polarization has strong effect using standard offset patchcord for both 200m of Siecor 62.5µm benchmark MMF and 300m of Corning OM3 grade MMF.
- **Using standard offset patchcord makes 300m transmission highly sensitive to input polarization even using Corning OM3 grade MMF.**

Launch / Fiber	Offset patchcord
Siecor 62.5µm	STRONG
Corning OM3	STRONG

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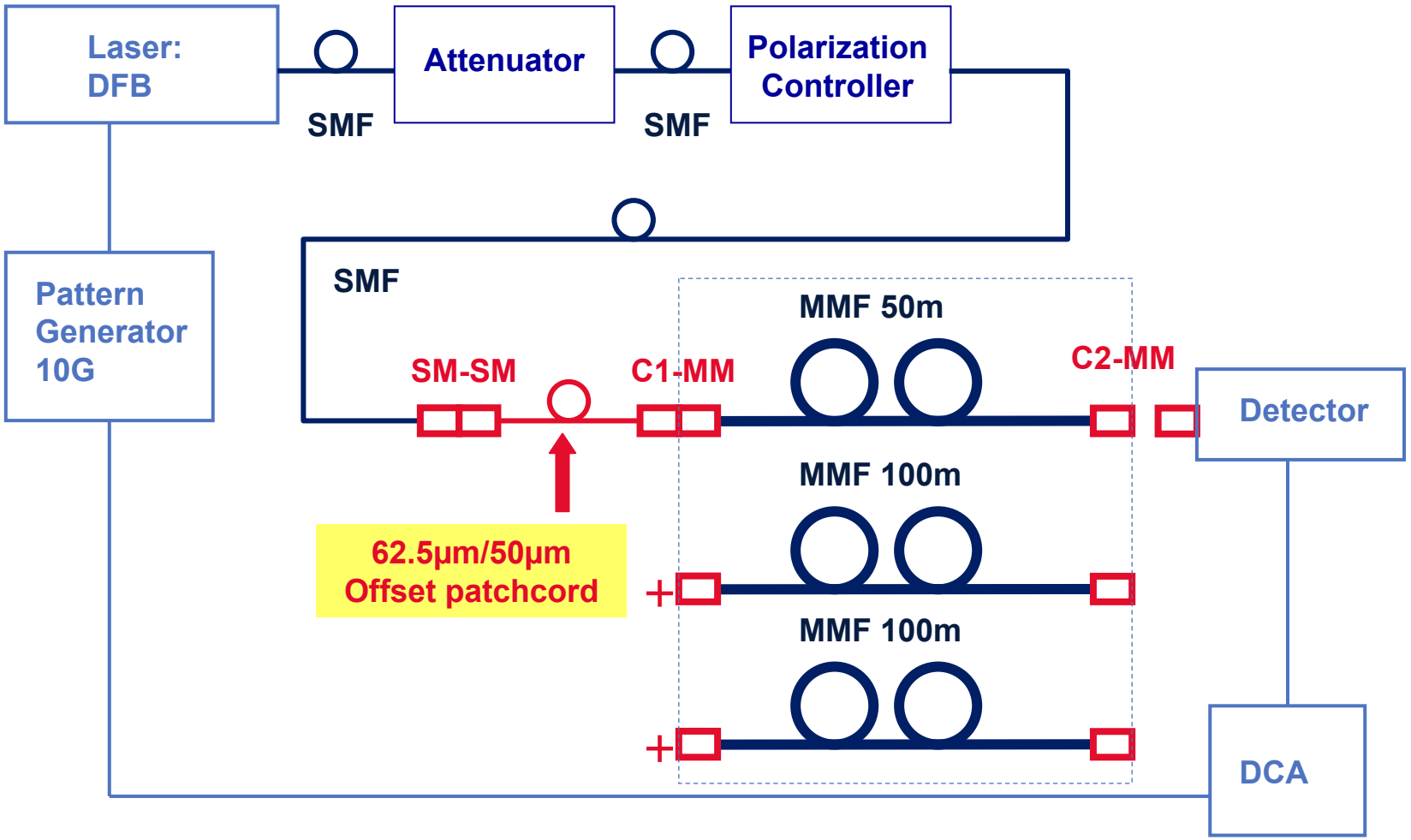
3. Experimental Setup with Standard Offset Patchcord



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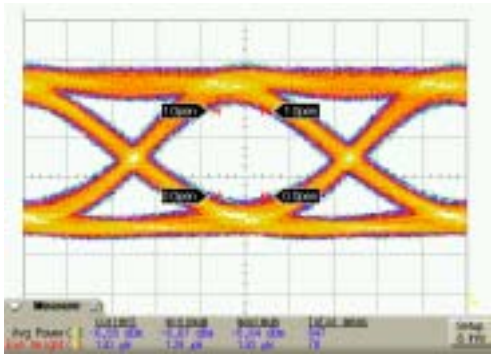
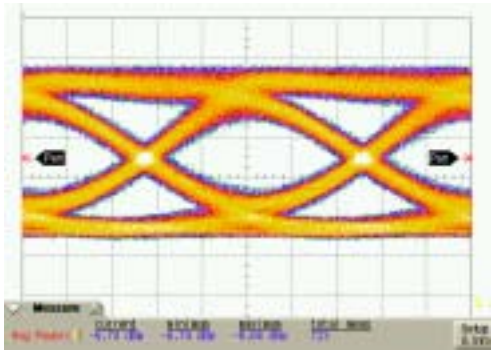
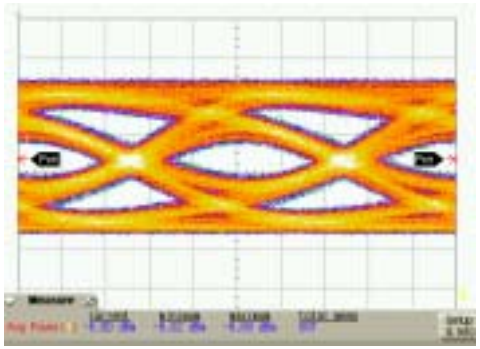
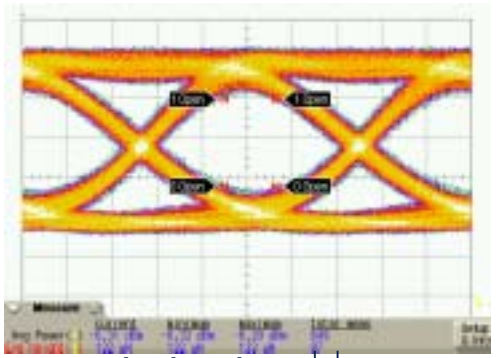
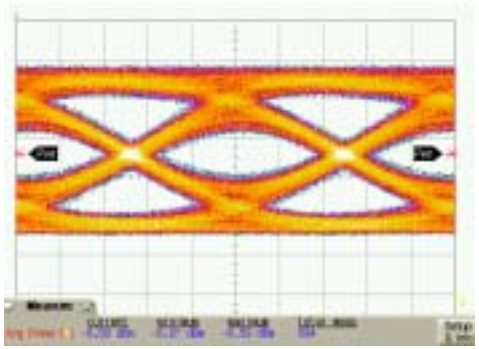
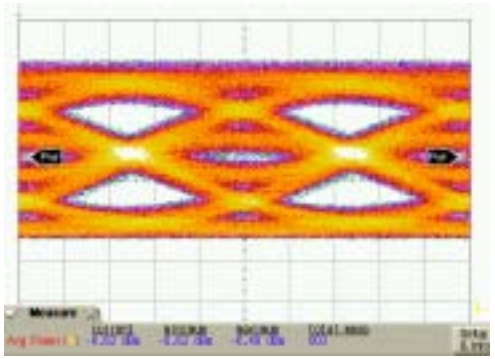
3. Standard Offset Patchcord – Fiber #1 several length

Siecor 62.5µm benchmark MMF (BW~500MHz*km at 1310nm)

50m	100m	150m
		
Polarization ⊥	Polarization ⊥	Polarization ⊥
		
Polarization ∥	Polarization ∥	Polarization ∥

Result: Polarization sensitivity is strongly dependent on the fiber length

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Summary of the Results

1. Polarization effect was not observed with center launch.
2. Polarization effect was observed with offset launch (both patchcord and controlled) using single link of Siecor 62.5µm benchmark MMF.
3. Polarization induced pulse distortion occurs in transmission without any mode selective loss due to connectors!
4. Polarization in multi-section Siecor 62.5µm benchmark MMF induced several dB of power penalty.
5. Polarization effect was very small in high grade fiber when controlled offset launch is applied.

Summary of the Results (continued)

6. Polarization effect was observed with Corning OM3 grade fiber when standard offset patchcord was used.
7. Standard fused offset patchcord can induce polarization effect by additional modes excitation and birefringence.

Polarization Sensitivity Conclusion

Launch → / Fiber ↓	Controlled Offset (17-23µm) (10-16µm)	Offset patchcord (17-23µm) (10-16µm)
Siecor 62.5µm	STRONG	STRONG
Corning OM3	WEAK ⟷	STRONG

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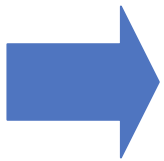
Proposed Explanations

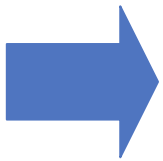
1. Different orientations of the linear polarization in controlled offset launch conditions are coupling to different mode groups which may have not the same speed.



Siecor 62.5µm benchmark MMF: large effect

Corning 50µm OM3 grade fiber : very small effect

2. Fusion splice in standard offset patchcord excites larger number of modes than controlled offset launch and it induces polarization dependent effects due to stress in the fusion area.



Siecor 62.5µm benchmark MMF: large effect

Corning 50µm OM3 grade fiber : large effect