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Chromatic Dispersion Compensation in Super-PON Networks with FBG-Based, Multi-Channel Chromatic Dispersion Compensators

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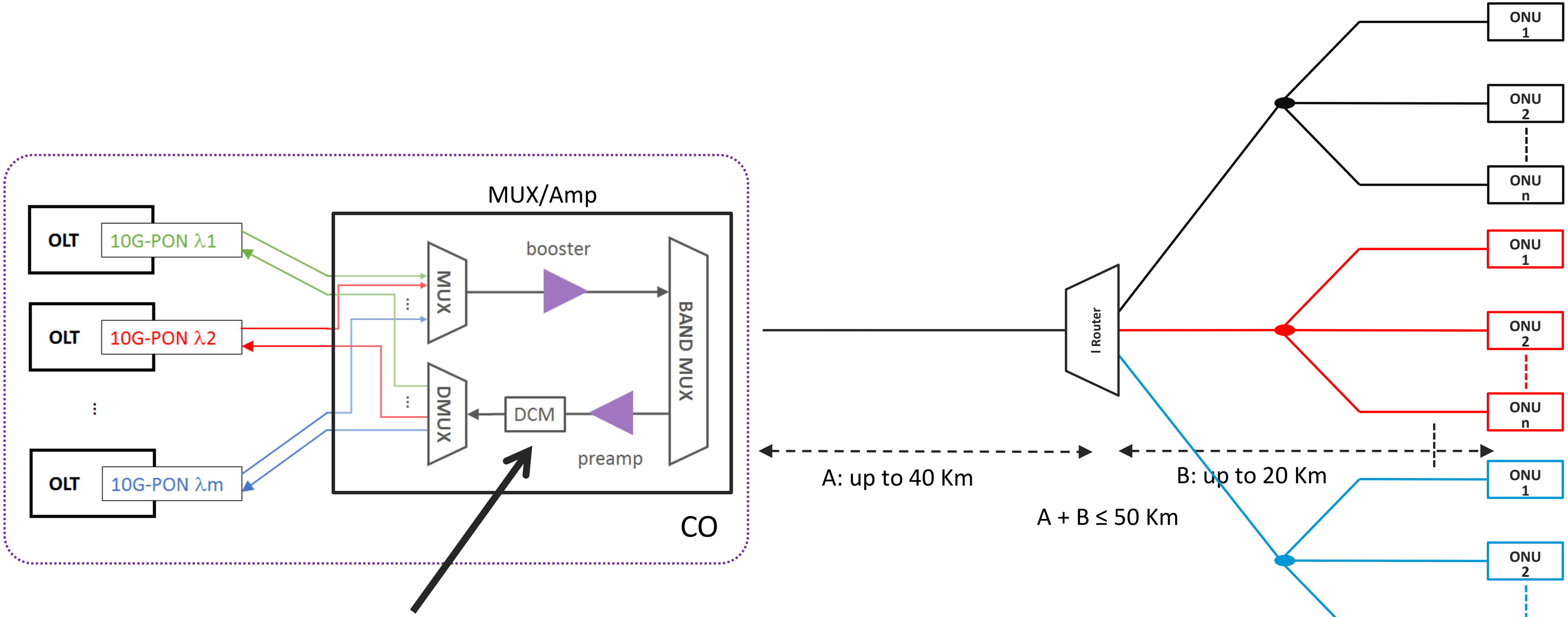
Why is chromatic dispersion important for Super-PON?

- The standard data rate in Super-PON networks will be 10 Gb/s and will likely increase in the future
- DML lasers are preferred in ONUs because of their lower cost compared to EML lasers
- When DML lasers are used in ONUs, CD must be compensated in the link between the ONUs and the OLT

P802.3cs Super-PON Architecture (with DCM)



Dispersion Compensation Module (DCM)

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Brief description of topic

- Chromatic dispersion (CD) must be managed in the link between the ONU and the OLT in Super-PON networks.
- There are several mature solutions available to compensate CD, including dispersion compensating fiber (DCF) and fiber Bragg grating (FBG) based dispersion compensators.
- Low insertion loss, small form factor and ultra low latency make FBG-based, multi-channel dispersion compensators the preferred CD compensation solution in Super-PON networks.
- FBG-based dispersion compensators are a simple, mature and cost-effective solution.

Fiber Bragg grating-based multi-channel chromatic dispersion compensators

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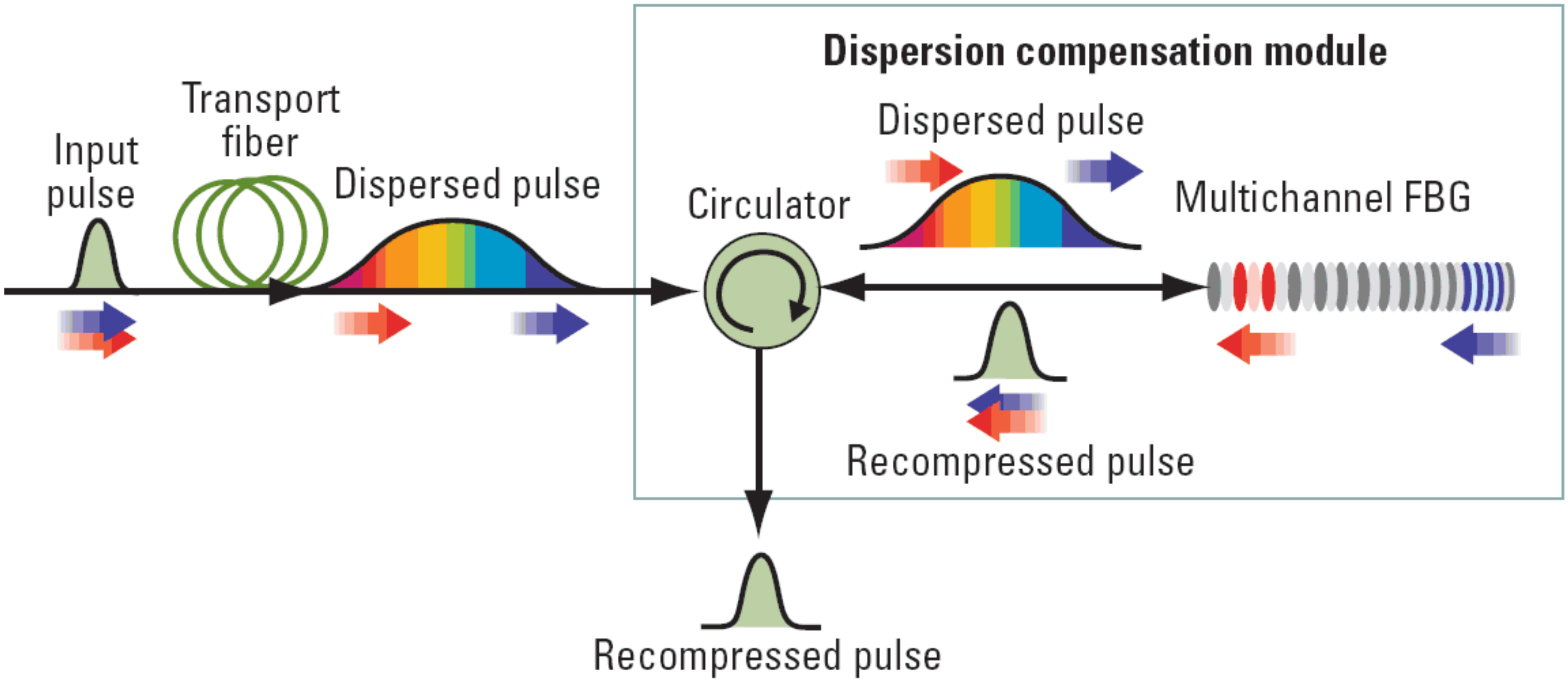
How they work



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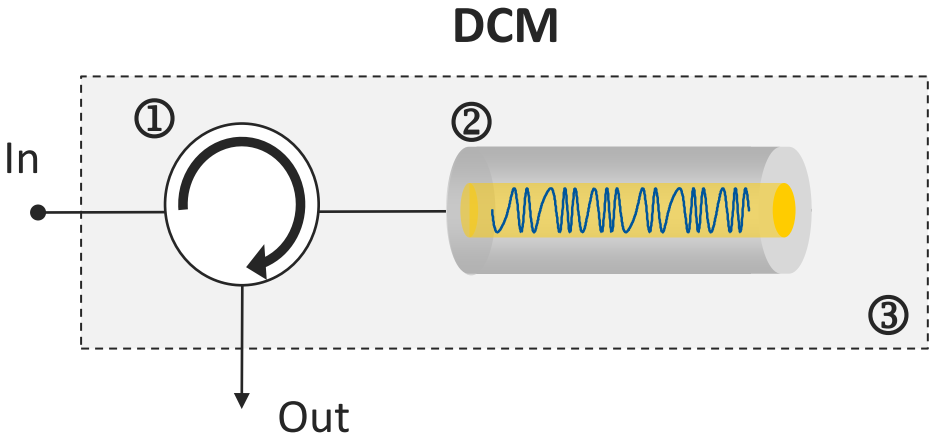
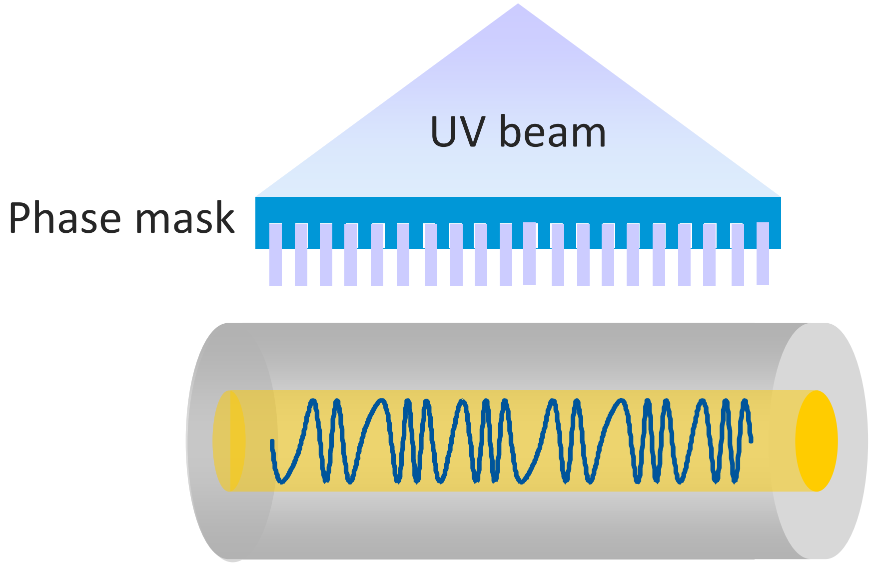
How they are made

1. **Optical circulator**
2. **Channelized fiber Bragg grating in athermal package**
3. **Optional outer housing**



How they are made

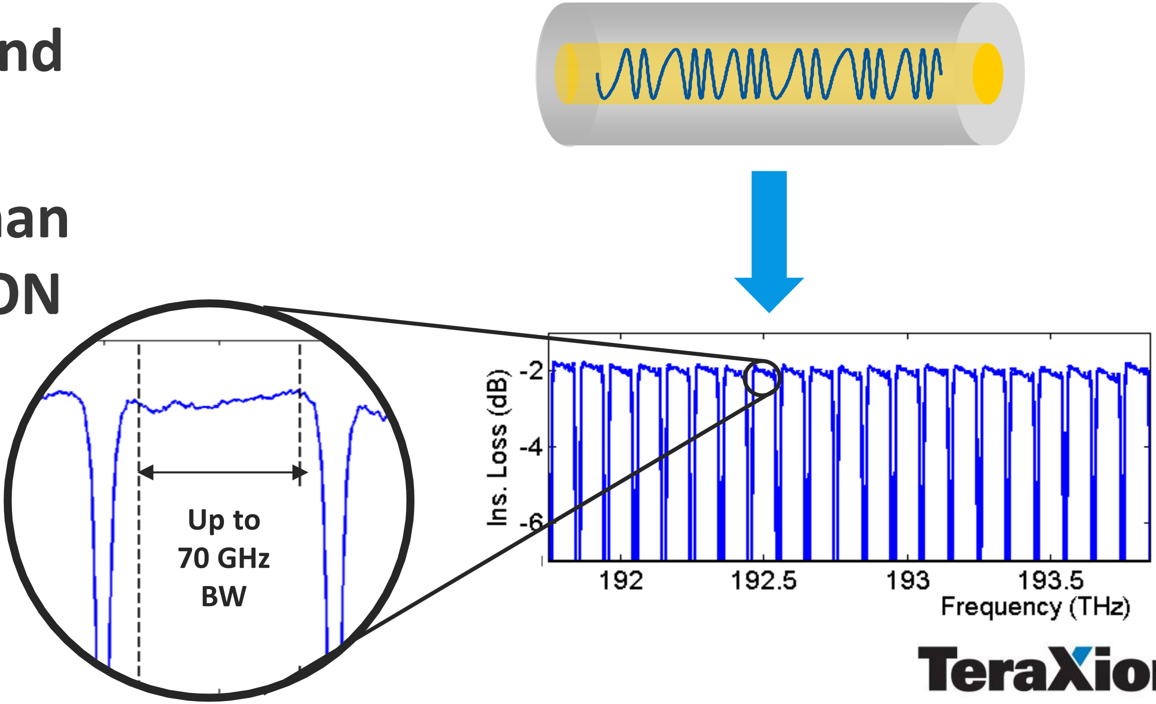
- The complexity of the multi-channel FBG is encoded into optimized phase masks
- Single UV beam exposure
- Easy to manufacture in large volumes
- Robust manufacturing process



How they are made

One multi-channel FBG covers entire C-Band or L-Band

Bandwidth is more than sufficent for Super-PON requirements



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4 Key characteristics

1. **Low and fixed insertion loss**

Insertion loss at different compensation levels *

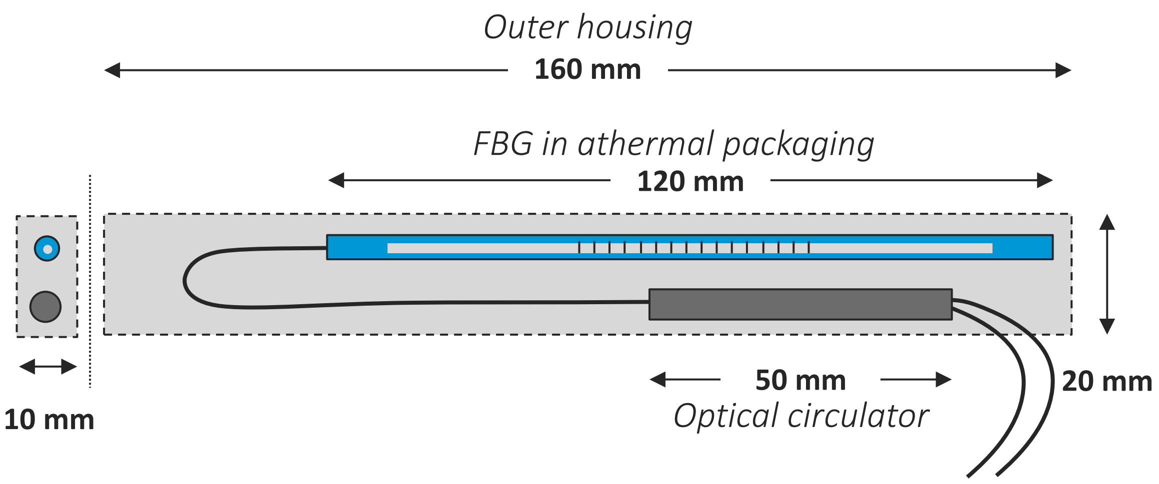
	20 km	30 km	40 km	50 km
DCF	2.6	3.3	4	4.7
FBG	3	3	3	3

* Expressed in km of G652.D fiber

4 Key characteristics

1. Low and fixed insertion loss
2. **Compact**

Typical FBG-based CD compensator dimensions



4 Key characteristics

1. Low and fixed insertion loss
2. Compact
3. **Low and fixed latency**

Fiber length and latency at different compensation levels

		10 km	20 km	30 km	40 km
DCF	Length (m)	1 000 – 1 460	2 000 – 2 920	3 000 – 4 380	4 000 – 5 840
DCF	Latency (µs)	4.95 – 7.22	9.89 – 14.44	14.83 – 21.65	19.78 – 28.87
FBG	Fiber length (m)	5.0	5.0	5.0	5.0
FBG	Latency (µs)	<0.025	<0.025	<0.025	<0.025

* Expressed in km of G652.D fiber

4 Key characteristics

1. Low and fixed insertion loss
2. Compact
3. Low and fixed latency
4. **No penalties induced by non-linear effects**

- Typically, 0.1 to 0.2 kilometer of DCF is required to compensate dispersion for each kilometer of G.652.D transmission fiber
- DCF is a specialty optical fiber with a very small mode field diameter prone to non-linear effects which translates to a power-dependent penalty
- FBG-based compensation typically adds only 5 meters of fiber

The penalty induced by non-linear effects in FBG-based dispersion compensators is thus negligible.

Benefits and applicability to Super-PON

Simple | Reliable | Cost-Effective

- **Totally passive**: no power, no control required
- **Simple to integrate**: Connect or splice two G.652.D fibers

Benefits and applicability to Super-PON

Simple | Reliable | Cost-Effective

- **Telcordia-qualified**
- **Mature**: Tens of thousands of units deployed in the last 15 years
- **Reliable:** Failure in time (FIT) = 44 failures per 1 billion hours*

* FIT 90% C.L. = 44, based on field return data

Benefits and applicability to Super-PON

Simple | Reliable | Cost-Effective

- **Two options to mitigate CD:**
  1. **Replace DML with EML in ONUs**
  2. **Add a FBG-based CD compensator to the CO**

- **Adding a FBG-based CD compensator in the CO is less expensive than replacing DML lasers in ONUs by EML lasers**

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by Patrick Lebeau, Product Line Manager

Questions?

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