

## Increasing capacity on multimode fiber

Multimode fiber has been installed since the early '70<sup>th</sup> as a convenient manner of providing bandwidth to buildings and campuses. Since then, the need for higher bandwidth has increased tremendously, leaving the original OM1/OM2 multimode fiber as a showstopper for further expansion of the network.

This Application Note presents various ways to increase the throughput of existing multimode fiber.

### Limitations

OM1 (62,5  $\mu\text{m}$ /125 $\mu\text{m}$ ) and OM2 (50  $\mu\text{m}$ /125  $\mu\text{m}$ ) fiber have been dominating the local area domain until recently, providing throughput of up to 100 Mbps for up to 2 km with LED based modules. In 1998 IEEE specified the VCSEL laser succeeding the LED laser.

As shown in the below table both OM1 and OM2 fiber have limitations to their throughput. Some of these limits have been increased with the introduction of OM3 (standardized 2002), OM4 (2009) and OM5 (2016).

Table 1: Average distances on MMF (Wikipedia: Multi-mode\_optical\_fiber)

| Bandwidth | Protocol     | OM1   | OM2   | OM3   | OM4   | OM5   |
|-----------|--------------|-------|-------|-------|-------|-------|
| 1 Gb/s    | 1000BASE-SX  | 275 m | 550 m | ---   | ---   | ---   |
| 10 Gb/s   | 10GBASE-SR   | 33 m  | 82 m  | 300 m | 400 m | 400 m |
| 100 Gb/s  | 100GBASE-SR4 | ---   | ---   | 70 m  | 100 m | 100 m |

### 1 Gb: Extended SFP

Itectra offers a long distance 1 Gb transceiver with 1310 nm wavelength and extended reach capabilities up to 1 km. on older multimode fiber installations (OM1/OM2). This SFP will allow you, on the fly, to expand the capacity on older fiber installations to 1 Gb/s by only replacing the SFP's.

### 10Gb: Various methods

#### Mode Conditioning Patch Cord

For best performance on OM1 and OM2 IEEE recommends the use of a Mode Conditioning Patch Cord (MCPC). This features a SMF to MMF launch cord (Tx), coupled with a MMF Rx cord. Different offsets in the SMF/MMF splice are required for 50  $\mu\text{m}$  and 62.5  $\mu\text{m}$  multimode fiber. Engineers have found that an offset of 17  $\mu\text{m}$  ~ 23  $\mu\text{m}$  can achieve an effective modal bandwidth equivalent to the overfill launch method for 62.5  $\mu\text{m}$  multimode fiber. And an offset of 10  $\mu\text{m}$  ~ 16  $\mu\text{m}$  is good for 50  $\mu\text{m}$  multimode fiber.

#### AROONA STAR

For higher bandwidth and/or longer distances Itectra offers the AROONA STAR portfolio from Cailabs. AROONA STAR offers MPLC (Multi-Plane Light Conversion) which filters out the modal dispersion introduced by the multimode fiber. By installing one or several AROONA STAR on the path the distance can be increased to several thousand meters, and the bandwidth can be increased up to 100 Gb/s.

AROONA STAR covers transmission between the O- and L-band. For cases featuring longer distances, higher bandwidth and/or with many patches, it is recommended to utilize an EML laser, as this laser type features a higher Extension Ratio (ER) tolerance.

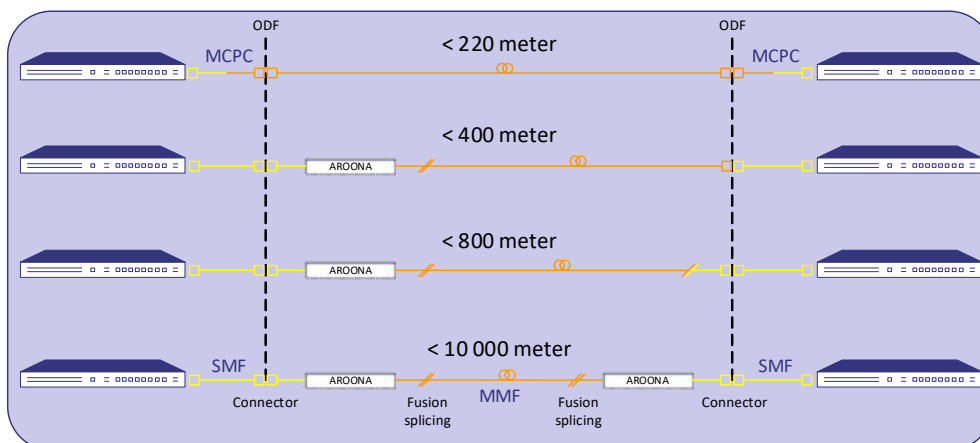
## Performance

Performance on multimode fiber installations may vary due to fiber cuts, splices, dispersion etc. Thus, disturbing the signal. This may impact the performance in various manners.

Table 2: Extended distances on MMF (Cailabs, Wikipedia: Multi-mode\_optical\_fiber)

| Bandwidth             | Products                   | OM1/OM2    | OM3        | OM4/OM5    |
|-----------------------|----------------------------|------------|------------|------------|
| 1 Gb/s                | 1 Gb Extended SFP          | 1 km       | 1 km       | 1 km       |
|                       | 2xAROONA STAR              | 10 km      | 10 km      | 10 km      |
| 10 Gb/s <sup>1</sup>  | MCPC                       | 220 m      | ---        | ---        |
|                       | 1xAROONA STAR <sup>2</sup> | 800 m      | 800 m      | 800 m      |
|                       | 2xAROONA STAR <sup>2</sup> | 10 km      | 10 km      | 10 km      |
| 100 Gb/s <sup>1</sup> | 1xAROONA STAR <sup>2</sup> | 800 m      | 800 m      | 800 m      |
|                       | 2xAROONA STAR <sup>2</sup> | ca. 1.5 km | ca. 1.5 km | ca. 1.5 km |

The above table shows recommended distances on different multimode fiber installations through different technologies. The below sketch depicts the recommended set-up to minimize traffic disturbance and maximize covered distances. Real tests are recommended to be done in all cases.



## Case stories and datasheets

Please refer to our case stories for more information on how to expand the reach and through-put on MMF.

In our [case story](#) “Mangedobling af båndbredde og distance på multimode fiber”, the municipality of Frederikssund maximized the utilization of their MMF.

Please refer to our [datasheets](#) for detailed information or contact Itectra for more information on the various products.

## Ordering information

Please contact Itectra for more information on the various solutions on different distances with different multimode fibers and connectors. Itectra also features a variety of optical modules featuring both DML and EML lasers.

<sup>1</sup> Please utilize EML based modules for best result. Given values are average, and will vary due to surface condition, numbers and quality of splices, production conditions, purity etc.

<sup>2</sup> By utilizing AROONA STAR any MMF is comparable with SMF. I.e. there is not difference between OM1 / OM2 / OM3 / OM4 / OM5