Macro Bending Loss in Single Mode Optical Fibre Cable for Long Haul Optical Networks

Prajwalasimha S N¹, Kamalesh V N²
¹Dept. Of Digital Electronics & Communication Systems, Visvesvaraya Technological University, Mysore, Karnataka, India
²Professor & Special Officer, Dept. Of P G Studies, Visvesvaraya Technological University, Mysore, Karnataka, India

Abstract—This paper deals with reduction of signal attenuation due to macro bending in a long haul optical network by making use of G 657 single mode optical fibre standards. Four G 657 single mode fibre standards are defined. Bending characteristics of each G 657 single mode fibre standard is discussed along with G 652, G653, G 654, G655 and G656 single mode fibre standards.

Keywords—Signal attenuation, Macro bending, Optical network, Single mode fibre, Bending characteristics.

I. INTRODUCTION

Radiative loss occurs due to bending of optic fibre cable. The light ray under goes multiple number of total internal reflections inside the fibre at the point of bending and escapes from cladding. For each standard of optical fibre cable, a typical value of bending radius is specified over which the signal attenuation increases exponentially. For G 652 standards, 0.5 dB of signal attenuation is observed at 1550 nm for a bending radius of 37.5 mm and for 100 number of turns [1]. If a G 652 fibre standard of length 200 m is subjected for bending at every metre in a zigzag path, it under goes 200 number of semicircular turns or we can say 100 number of circular turns. The typical value of attenuation for 100 number of turns is 0.5 dB. When an input power of 200 mW is launched into the fibre, only 0.63 μW or less than that is received at a distance of 10 Km. Similar result occurs with G 653, G 654, G 655 and G 656 fibre standards [2]-[5]. This can be minimized by making use of G 657 fibre standard.

II. LITERATURE REVIEW


ITU_T G.654 [3] describes the geometrical, mechanical and transmission attributes of a single mode optical fibre and cable which has the zero-dispersion wavelength around 1300 nm wavelength, and which is loss-minimized and cut-off wavelength shifted at around the 1550 nm wavelength region. ITU_T G.655 [4] describes the geometrical, mechanical, and transmission attributes of a single-mode optical fibre which has the absolute value of the chromatic dispersion coefficient greater than some non-zero value throughout the wavelength range from 1530 nm to 1565 nm. This dispersion reduces the growth of non-linear effects which are particularly deleterious in dense wavelength division multiplexing systems. ITU_T G.656 [5] describes the geometrical, mechanical, and transmission attributes of a single-mode optical fibre which has the positive value of the chromatic dispersion coefficient greater than some non zero value throughout the wavelength range of anticipated use 1460-1625 nm. This dispersion reduces the growth of non-linear effects which are particularly deleterious in dense wavelength division multiplexing systems. Gerd Keiser [6] has given an overview of fundamental communication concept and defined the different spectral bands which describes varies operational wavelength regions used in optical communication G. P. Agrawal [7] has described the signal attenuation at various optical bands. ITU_T G.657 [8] to support this optimization by recommending strongly improved bending performance compared with the existing ITU_T G.652 single-mode fibre and cables. This is done by means of two categories of single-mode fibres, one of which, category A, is fully compliant with the ITU_T G.652 single mode fibres and can be deployed throughout the access network. The other, category B, is not necessarily compliant with recommendation ITU_T G.652 but is capable of low values of macro bending losses at very low bend radii and is intended for use inside buildings or near buildings. These category B fibres are system compatible with ITU_T G.657.A fibres in access networks.
III. SIGNAL ATTENUATION

In a long haul optical network, the signal attenuates due to material absorption, scattering and radiative losses. Attenuation due to material absorption can be minimized by selecting the appropriate wavelength. The attenuation due to material absorption is minimum at C-band and maximum at S-band [6].

Scattering loss occurs due to impurities present in the core and cladding material composition. Minimum scattering loss is observed at C-band. Radiative losses occur due to bending of optic fibre cable. Micro bending and macro bending losses are two types of radiative losses observed in the fibres. Micro bending losses can be minimized by making use of armoured cables.

The core diameter is around 10 µm and cladding diameter is 125 µm. Fibres produce maximum attenuation in the O-band and minimum in the C-band.

IV. G 657 A STANDARDS

The G 657 A single mode optical fibres are characteristics with a cut off wave length of 1260 nm.

Attenuation of 0.25 dB at 1550 nm wavelength and 1 dB at 1625 nm wavelength are observed due to fibre bending with a radius of 15 mm for 10 turns. Attenuation of 0.75 dB at 1550 nm wavelength and 1.5 dB at 1625 nm wavelength are observed due to fibre bending with a radius of 10 mm for 1 turn in G 657 A1 standards.

Attenuation of 0.03 dB at 1550 nm wavelength and 0.1 dB at 1625 nm wavelength are observed due to fibre bending with a radius of 15 mm for 10 turns. Attenuation of 0.1 dB at 1550 nm wavelength and 0.2 dB at 1625 nm wavelength are observed due to fibre bending with a radius of 10 mm for 1 turn. Attenuation of 0.5 dB at 1550 nm wavelength and 1 dB at 1625 nm wavelength are observed due to fibre bending with a radius of 7.5 mm for 1 turn in G 657 A2 standards.

V. G 657 B STANDARDS

The G 657 B single mode optical fibres are characteristics with a cut off wave length of 1260 nm. The core diameter is around 10 µm and cladding diameter is 125 µm. Fibres produce maximum attenuation in the O-band and minimum in the C-band.

Attenuation of 0.03 dB at 1550 nm wavelength and 0.1 dB at 1625 nm wavelength are observed due to fibre bending with a radius of 15 mm for 10 turns. Attenuation of 0.1 dB at 1550 nm wavelength and 0.2 dB at 1625 nm wavelength are observed due to fibre bending with a radius of 10 mm for 1 turn. Attenuation of 0.5 dB at 1550 nm wavelength and 1 dB at 1625 nm wavelength are observed due to fibre bending with a radius of 7.5 mm for 1 turn in G 657 B2 standards.
VII. Conclusion

This paper gives an overview of reduction of signal attenuation due to fibre bending in long haul optical networks using G 657 fibre standards. G 657 A2 and G 657 B1 fibre standards produce very less attenuation for more number of turns with more bending radius. G 657 A1 fibre standards produce slightly more attenuation compare to other G 657 standards. G 657 B2 fibre standards produce very less attenuation at very less bending radius.

REFERENCES

TABLE I
Attenuation Summary of Various Single Mode Fiber Standards

<table>
<thead>
<tr>
<th>Fiber Standard</th>
<th>Bending Radius</th>
<th>No. of Turns/ Km</th>
<th>Attenuation (Km)</th>
<th>Initial Power</th>
<th>Final Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>G 652</td>
<td>37.5 mm</td>
<td>100</td>
<td>0.5 dB</td>
<td>30</td>
<td>200 mW ≤ 6.3 µW</td>
</tr>
<tr>
<td>G 653, 654, 655, 656</td>
<td>30 mm</td>
<td>100</td>
<td>0.5 dB</td>
<td>30</td>
<td>200 mW ≤ 6.3 µW</td>
</tr>
<tr>
<td>G 657 A1</td>
<td>15 mm</td>
<td>10</td>
<td>0.25 dB</td>
<td>30</td>
<td>200 mW ≤ 35.5 µW</td>
</tr>
<tr>
<td>G 657 A2</td>
<td>15 mm</td>
<td>10</td>
<td>0.03 dB</td>
<td>30</td>
<td>200 mW ≤ 162 µW</td>
</tr>
<tr>
<td>G 657 B2</td>
<td>15 mm</td>
<td>10</td>
<td>0.03 dB</td>
<td>30</td>
<td>200 mW ≤ 162 µW</td>
</tr>
<tr>
<td>G 657 B3</td>
<td>10 mm</td>
<td>1</td>
<td>0.03 dB</td>
<td>30</td>
<td>200 mW ≤ 162 µW</td>
</tr>
</tbody>
</table>