MAKERERE UNIVERSITY

COLLEGE OF ENGINEERING, DESIGN, ART AND TECHNOLOGY

SCHOOL OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

LABORATORY AND SIMULATION MEASUREMENTS TO INVESTIGATE ATTENUATION IN OPTICAL FIBRES

BY

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2010/HD16/2116U

A DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE IN ELECTRICAL ENGINEERING OF MAKERERE UNIVERSITY

DECEMBER 2013

ABSTRACT

Optical fibre communication systems have revolutionized the telecommunications industry and have played a major role in the advent of the information technology. Optical fibres have largely replaced copper wire communications in core networks because of their advantages over electrical transmission. More data than ever before is being transmitted through hair-thin optical fibres and to accomplish this feat, elaborate optical fibre networks are needed. In these networks, fibres stretch over longer distances and this poses a threat to signal strength which introduces attenuation. Attenuation along with dispersion is one of the major factors responsible for signal degradation of an optical signal as it propagates along an optical waveguide. A light signal propagating through the fibre is subjected to various scattering and absorption phenomena that are responsible for diminishing the intensity of the signal. The attenuation properties of the fibre are very important since they play a role in determining the maximum transmission distance for an optical signal and also govern the required maximum repeater-less separation between the transmitter and the receiver.

In this dissertation, different types and causes of attenuation in optical fibres were investigated. In addition, attenuation in different types of optical fibres, in relation to transmission distance was measured. The optical time domain reflectometer (OTDR) was used for attenuation measurements. This technique gave access to only one end of the fibre under test (FUT). In addition, it provided extra information about the FUT, like length dependence of the fibre on attenuation, insertion loss of defects, and location of fault occurring in the fibre fabrication. Polarization mode dispersion (PMD) measurements were used as a measure of attenuation and the two PMD methods used were frequency domain method (Jones matrix eigen analysis) and interferometric (Traditional interferometry and Generalized interferometry) method. The effect of macro bending was investigated in different types of fibres. Simulations were run using OptiSystem to demonstrate attenuation on transmission distances of the optical fibre. To achieve this, different parameters such as; Bit Error Rate (BER), Quality factor (Q-factor) and Eye-diagrams were used to determine the attenuation on the optical fibre.

The results obtained using the OTDR show a reduction in transmitted power as the transmission distance was increased. More power loss was observed at 1310 nm than at 1550 nm. It was shown that single mode fibre (SMF-28) and low water peak (LWP) fibre are better for optical signal transmission in areas where bending of optical fibres is unavoidable compared to the Large Effective Area Fibre (LEAF-fibre). This was because LEAF-fibre exhibited more power loss at a bend diameter of 1.8 cm than the other two types and it has a large effective area. The PMD was seen to accumulate with the transmission distance hence a measure of attenuation. In modern single mode fibres, mode coupling is intentionally introduced to mitigate PMD through fibre twisting and during the manufacturing process through bidirectional spinning, hence reduction in attenuation of the optical signal. Using simulations as a measure of attenuation to demonstrate the OTDR, it was observed that the BER increased with transmission distance, the Q-factor decreased with the increase in the optical fibre length and the Eye height was observed to get distorted as the transmission distance was increased. To demonstrate Macro bend effects in optical fibres, it was observed that the Eye height decreased with increase in the attenuation power of the attenuator. To demonstrate PMD, Q-factor was observed to increase with distance and with PMD. The Eye height increased with increase in PMD. The simulation results compare well with the laboratory measurements.

In summary, a wavelength of 1550 nm is recommended for transmission in the telecommunication industry. The angled end face connectors are recommended to their counterpart with a flat end face. This is because the angled end face connectors ensure that light reflects do not return the laser source, but instead leaks up in to the cladding where it is dissipated. In the case of Uganda, this has installed a G. 652 Fibre Optic Cable with challenges such as high levels of chromatic dispersion and low dispersion distance. Using the OTDR results, this showed that attenuation and dispersion are a problem for long haul transmission. Wave Division Multiplexing repeaters are recommended for a G. 652 Fibre Optic Cable as it can have its capacity increased from 2.5 Gbs^{-1} to a 10 Gbs^{-1} capacity when repeaters are placed every after 60 km.

Key words: Attenuation, Polarization mode dispersion, Single mode fibre, Transmission.