Characterisation of birefringence in optical fibres

Thesis submitted in accordance with the requirements of the University of Essex for the Degree of Doctor of Philosophy

by

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July 1997

Summary

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Polarisation mode dispersion has now become one of the main limiting factors in land based systems, and continues to be an issue in the design of submarine systems. This thesis describes a theoretical and experimental investigation of linear and twist induced circular birefringence and polarisation mode dispersion in single mode optical transmission fibre. The main original contributions described in this thesis are:

- An analytical solution has been obtained for the differential group delay (DGD) in the presence of elastic twist. This solution is in excellent agreement with the extensive set of DGD measurements reported here, and it allows the prediction of the optimum twist rate needed to minimise the DGD in an optical fibre.
- The DGD of different types of fibres: standard-step index fibres (S-SMFs), dispersion shifted fibres (DSFs), spun DSFs, erbium doped fibres (EDFs) and distributed EDFs (DEDFs) have been measured as a function of twist. Spun fibre showed the lowest initial DGD while the first reported measurements on DEDFs showed unacceptably large DGD values for high bit-rate soliton transmission.
- From simulation and measurement, an empirical equation has been obtained for commercial spun fibre manufactured with sinusoidal spin, which allows the determination of the minimum spin (RMS value) required to obtain a fibre with low DGD.
- A conventional OTDR has been modified to a polarimetric OTDR to analyse the backscattered SOP, and from this the birefringence characteristics are obtained along the fibre. A matrix-vector description has been developed to analyse POTDR data from fibres with twist. The developed theory has been verified by detailed experimental results, and it is shown that if twist is ignored when present, it can lead to a large error in the estimated values of birefringence and DGD obtained from such measurements.

Acknowledgement

The author wants to take this opportunity to acknowledge a number of people who have contributed to this work.

First I would like to express my grateful thanks to my supervisor Dr. A. S. Siddiqui for his friendly support, guidance and encouragement throughout the course of this thesis.

I would like especially to thank to Mr. J. G. Ellison, Mr. L. M. Gleeson and Dr. X. Shan for helping with measurements, numerous helpful discussions, and for being the best colleagues and friends during my time at Essex University.

Mr. E. S. R. Sikora and Mr. J. V. Wright from BT Laboratories, Martlesham Heath, UK for useful technical discussions, making available very valuable measurement equipment and for some financial support. Special thanks to Ed Sikora for being a good friend during the time I stayed in England and for always being supportive. Thanks Ed.

Dr. S. D. Walker and T. Ernst for their collaboration in the development of the new Essex polarimeter. Mr. T. Brotherstone and Mr. J.M. Rowland for their technical assistance and frequent help in moving equipment in and out of the tunnel. Mr. R. Taylor for the precise construction of all the essential metal work which was needed throughout the project. Mr. M. L. Sansom for taking the pictures during one of our tunnel sessions and digitally scanning them.

Dr. D. H. O. Bebbington and, from BT Labs, Dr. N. G. Walker for some helpful comments and useful discussions in developing the simulation program. The research students A. Altuncu for helping with the measurements of the DEDF and J. Lepley for carrying out some useful measurements characterising the performance of the Essex polarimeter.

Mr. M. G. Newton from the Physics Department for his help in finding the tunnel where we could perform our measurements without disturbance and Mr. B. F. Diamond also from the Physics Department for taking the electron microscope scans.

The Engineering and Physical Sciences Research Council (EPSRC) for the financial support of this work.

Dr. S. Barnes and Dr. D. Simeonidou from Alcatel Submarine Networks for making available measurement equipment and financial support during the last four months of this work. Mr. D. Curtis also from Alcatel Submarine Networks for some useful information of polarisation dispersion measurements taken on optical cables. Dr. A. J. Barlow of EG&G Fiber Optics for helpful discussions.

Dr. D. Williams from BT Labs for supplying us with valuable information about the fibres manufactured at BT Labs and Corning USA for kindly supplying us with some of the fibre we used in our experiments.

Many thanks should go to the people in my office: Anna, Noel and Shan for the friendly and supportive atmosphere during the time of my PhD research.

To my two sons Jonas and Lukas who I love, my mother and in remembrance of my father

> A man's heart plans his ways, but the Lord directs his steps.

> > Proverbs 16:9

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List of abbreviations

ASE	Amplified Spontaneous Emission
CA	Compensator-Analyser
ccw	Counter Clockwise
cw	Clockwise
DCF	Dispersion Compensating Fibre
DEDF	Distributed Erbium Doped Fibre
DGD	Differential Group Delay between the two possible orthogonal polarisation
	modes. Often normalised to length and given in ps/km
DOP	Degree of Polarisation
DPD	Differential Phase Delay
DR	Dynamic Range
DSF	Dispersion Shifted Fibre
EDF	Erbium Doped Fibre
EDFA	Erbium Doped Fibre Amplifier
GCA	General Compensator Analyser
GPIB	Genera Purpose Interface Bus
IM-DD	Intensity Modulation Direct Detection
JME	Jones Matrix Eigenanalysis
LCP	Left Circular Polarisation
LEP	Left Elliptical Polarisation
NEP	Noise Equivalent optical Power
NRZ	Non-Return-to-Zero
OTDR	Optical Time Domain Reflectometry
PDL	Polarisation Dependent Loss
PEM	Polarisation Eigen Modes
PDG	Polarisation Dependent Gain
PMD	Polarisation Mode Dispersion, mean DGD value over wavelength range.
	Often normalised to the square root of the fibre length and given in ps/\sqrt{km}
PSP	Principal States of Polarisation
RCP	Right Circular Polarisation
RMS	Rout Mean Square
RPM	Rotations Per Minute

Polarisation Optical Time Domain Reflectometry or also used as Polarimetric
Optical Time Domain Reflectometer.
Right Circular Polarisation
Return to Zero
Signal to Noise Ratio
State Of Polarisation
Standard Single Mode Fibre
Transatlantic system, Length ≈ 6400 km with optical amplifiers and operating
at 5 Gbit/sec
Wavelength Division Multiplexing
World Wide Web