



Technology Training that Works

Practical Fibre Optics and Interfacing Techniques to Industrial Ethernet and Wireless

Contents

Preface ix

1	Introduction	1
1.1	Historical background to fibre optics	2
1.2	Comparison of fibre optic and copper cabling systems	3
2	Definitions and Fundamental Principles	7
2.1	Transmitters, receivers and communication channels	7
2.2	Types of communication channels	9
2.3	Communications channel properties	10
2.4	Data transmission modes	16
2.5	Light	18
2.6	The electromagnetic spectrum	19
2.7	Revisiting copper cables	20
2.8	Factors affecting copper cable performance	22
2.9	Coaxial cable	23
2.10	Twisted pair cable	25
2.11	Sources of interference and noise on cables	30
3	Theory of Fibre Optic Transmission	35
3.1	Fundamental principles of operation	35
3.2	The light transmission nature of glass	42
3.3	Numerical aperture	43
3.4	Modal propagation in fibres	46
3.5	Bandwidth	57
3.6	Wave division multiplexing	58
3.7	Effects on optical signal transmission	58
3.8	Other losses	64



Technology Training that Works

3.9	Other types of fibres	64
3.10	Fabrication of fibres	65

4	Fibre Optic Cable Construction	69
----------	---------------------------------------	-----------

4.1	Basic cable construction objectives	69
4.2	Fibre tensile ratings	70
4.3	Cable structural elements	70
4.4	Central member	71
4.5	Strength members	71
4.6	Fibre housing	72
4.7	Moisture barrier	75
4.8	Cable sheaths	75
4.9	Cable armoring	75
4.10	Classes of fibre optic cables	75

5	Connecting Fibres	83
----------	--------------------------	-----------

5.1	Optical connection issues	83
5.2	Fibre end preparation	89
5.3	Splicing fibres	90
5.4	Connectors	95
5.5	Optical couplers	100

6	Optical Drivers and Detectors	103
----------	--------------------------------------	------------

6.1	Optical sources	103
6.2	Light emitting diodes (LED)	103
6.3	Laser diodes	107
6.4	Optical transmitter modules	110
6.5	Laser safety considerations	111
6.6	Optical detectors	111
6.7	Pin photodiodes	111
6.8	Avalanche photodiodes	113
6.9	Optical receiver modules	115
6.10	Optical amplifiers	116

7	Installing Fibre Optic Cables	119
----------	--------------------------------------	------------

7.1	Initial preparation for a cable installation	119
7.2	General installation rules and procedures	122



Technology Training that Works

7.3	Indoor cable installations	134
7.4	Outdoor cable installations	136
7.5	Other installation methods	137
7.6	Splicing trays/organizers and termination cabinets	139

8 Fibre Optic System Design **145**

8.1	Initial design considerations	145
8.2	Design loss calculations	150
8.3	Design bandwidth calculations	156

9 Testing of Fibre Optic Systems **161**

9.1	Fundamental concepts of optical measurement	161
9.2	Standard fibre optic tests	164
9.3	Other fibre optic tests	173

10 Technologies that use Optical Fibres **177**

10.1	Communications systems	178
10.2	Local area network applications	180
10.3	MAN and WAN applications	183
10.4	Sensors	189
10.5	Bundled fibre applications	191

11 Interfacing Fibre to Copper **193**

11.1	Ethernet Media Converter Copper to Fibre Optic	193
11.2	Link Fault Pass-through (LFP) and Far End Fault (FEF)	194
11.3	Fiber Optic Converter Switches	195
11.4	Case Study - Hybrid Network	196

Appendix A Glossary **199**

Appendix B Practical sheets **221**

Appendix C Self-test questions **227**



Technology Training that Works

Appendix D Industrial Ethernet	233
Appendix E Troubleshooting	243
Appendix F Troubleshooting Ethernet	257
Appendix G Moxa White Paper	271
