

# Generic Requirements for Singlemode Fiber Optic Switches

## Contents

[Telcordia GR-1073 - Documentation Information](#)

1. Introduction.....	1-1
1.1 Purpose and Scope .....	1-2
1.2 Target Audience .....	1-2
1.3 Structure of This Document .....	1-3
1.4 Requirements Terminology .....	1-3
1.5 Requirement Labeling Conventions .....	1-4
1.5.1 Numbering of Requirement and Related Objects .....	1-4
1.5.2 Requirement, Conditional Requirement, and Objective Object Identification .....	1-4
2. General Information .....	2-1
2.1 Switch Description .....	2-1
2.2 Optical Switch Types.....	2-2
2.2.1 Transparent Optical Switches .....	2-2
2.2.2 Passive Optical Switches .....	2-2
2.2.3 Wavelength Selective Optical Switches .....	2-2
2.2.4 Optical Routing Subsystems .....	2-3
2.2.5 All-Optical Switches .....	2-3
2.3 Switch and Port Nomenclature .....	2-3
2.4 Switch Performance .....	2-4
2.5 Switch Configurations.....	2-5
2.6 Optical Switch Attributes and Definitions.....	2-5
2.6.1 Optical Switching Matrix Architectures .....	2-7
2.6.2 Optical Switching Matrix Blocking Characteristics .....	2-9
2.7 Optical Switch Technology.....	2-11
2.7.1 Opto-Mechanical .....	2-11
2.7.1.1 Micro-Electromechanical Optical Switches.....	2-11
2.7.1.2 Piezoelectric Optical Switches .....	2-12
2.7.2 Electro-Optic Switches .....	2-12
2.7.3 Acousto-Optic Switches .....	2-12
2.7.4 Thermo-Optic Switches .....	2-12
2.7.5 Magneto-Optic Switches .....	2-13
2.7.6 Liquid Crystal Optical Switches .....	2-13
2.7.7 Semiconductor Gate Array Optical Switches .....	2-13
2.7.8 Total Internal Reflection Based Optical Switches .....	2-14
2.8 Optical Switch Applications .....	2-14
2.8.1 Optical Protection Switching .....	2-14
2.8.1.1 AM-VSB Video.....	2-18
2.8.2 Remote Fiber Testing Systems (RFTSs) .....	2-18
2.8.3 Reconfigurable Optical Network Elements .....	2-20
3. General and Design Criteria .....	3-1

3.1	Documentation.....	3-1
3.1.1	General Documentation .....	3-1
3.2	Switch Marking, Packaging and Shipping.....	3-3
3.3	Physical Design Criteria.....	3-3
3.3.1	Optical Fiber .....	3-3
3.3.2	Optical Connectors .....	3-4
3.3.3	Materials .....	3-5
3.3.3.1	Toxicity.....	3-5
3.3.3.2	Corrosion Resistance.....	3-5
3.3.3.3	Dissimilar Metals.....	3-5
3.3.3.4	Flammability .....	3-5
3.3.4	Mounting .....	3-6
4.	Optical Performance Criteria and Measurement Procedures.....	4-1
4.1	Overview .....	4-2
4.1.1	Qualification Options .....	4-2
4.1.2	1xN and MxN Optical Switches .....	4-3
4.1.3	Unidirectional and Bi-directional Operation .....	4-4
4.1.4	Optical Passband .....	4-5
4.1.4.1	Optical Passband Guidelines .....	4-6
4.1.4.2	Optical Passband Measurement .....	4-7
4.2	Optical Parameters and Acceptance Criteria.....	4-8
4.2.1	Insertion Loss .....	4-9
4.2.1.1	Generic Insertion Loss Criteria .....	4-10
4.2.1.2	Insertion Loss Guidelines.....	4-11
4.2.1.2.1	Insertion Loss Guidelines for 1310 nm Band Operation.....	4-11
4.2.1.2.2	Insertion Loss Guidelines for 1550 nm Band Operation.....	4-11
4.2.1.2.3	Insertion Loss Guidelines for Dual-Band and Wideband Operation .....	4-11
4.2.1.3	Vendor Published Data Acceptance Criteria .....	4-12
4.2.1.4	Insertion Loss Measurement.....	4-12
4.2.2	Uniformity .....	4-12
4.2.2.1	Generic Uniformity Criteria .....	4-14
4.2.2.2	Uniformity Guidelines.....	4-14
4.2.2.2.1	Uniformity Guidelines for Single Band Operation.....	4-14
4.2.2.2.2	Uniformity Guidelines for Dual Band and Wideband Operation .....	4-15
4.2.2.3	Vendor Published Data Acceptance Criteria .....	4-15
4.2.2.4	Uniformity Measurement .....	4-15
4.2.3	Wavelength Flatness .....	4-15
4.2.3.1	Generic Wavelength Flatness Criteria .....	4-16
4.2.4	Crosstalk .....	4-17
4.2.4.1	Generic Crosstalk Criteria.....	4-18
4.2.4.2	Crosstalk Measurement.....	4-18

4.2.5	Directivity .....	4-18
4.2.5.1	Generic Directivity Criteria.....	4-20
4.2.5.2	Directivity Measurement .....	4-20
4.2.6	Return Loss .....	4-21
4.2.6.1	Generic Return Loss Criteria .....	4-22
4.2.6.2	Return Loss Measurement.....	4-22
4.2.7	Polarization Sensitivity .....	4-22
4.2.7.1	Generic Polarization Sensitivity Criteria.....	4-22
4.2.7.2	Polarization Sensitivity Measurement .....	4-23
4.2.8	Polarization Dependent Loss .....	4-23
4.2.8.1	Generic PDL Criteria.....	4-24
4.2.8.2	PDL Measurement .....	4-24
4.2.9	Differential Group Delay .....	4-24
4.2.9.1	Generic DGD Criteria.....	4-24
4.2.9.2	DGD Measurement.....	4-25
4.2.10	Control Stability .....	4-25
4.2.10.1	Generic Control Stability Criteria .....	4-25
4.2.10.2	Control Stability Measurement.....	4-25
4.2.11	Repeatability .....	4-26
4.2.11.1	Effective Switching Cycle .....	4-26
4.2.11.2	Generic Repeatability Criteria.....	4-26
4.2.11.3	Repeatability Measurement .....	4-26
4.2.12	Maximum Allowable Optical Power .....	4-27
4.2.12.1	Generic Maximum Allowable Optical Power Criteria .....	4-27
4.2.12.2	Maximum Allowable Power Measurement .....	4-27
4.2.13	Switching Time .....	4-27
4.2.13.1	General.....	4-27
4.2.13.2	Switch Cycling and Other Control Signal Parameters .....	4-28
4.2.13.3	Generic Switching Time Criteria.....	4-29
4.2.13.4	Switching Time Measurement .....	4-30
5.	Environmental and Mechanical Criteria and Test Procedures.....	5-1
5.1	Environmental and Mechanical Criteria Summary .....	5-1
5.2	Environmental and Mechanical Test Procedures.....	5-4
5.2.1	Transportation, Storage, and Handling Tests .....	5-4
5.2.1.1	Damp Heat.....	5-4
5.2.1.2	Temperature Cycling Test.....	5-4
5.2.1.3	Vibration Test.....	5-5
5.2.1.4	Mechanical Shock (Impact) Test.....	5-5
5.2.2	Fiber Integrity Tests .....	5-6
5.2.2.1	Flex Test.....	5-7
5.2.2.2	Twist Test.....	5-8
5.2.2.3	Side Pull.....	5-8
5.2.2.3.1	Monitored Side Pull.....	5-9
5.2.2.4	Cable Retention Test.....	5-9

5.2.3	Operational Performance Test .....	5-10
5.2.3.1	Temperature-Humidity Cycle (CO Environment).....	5-11
5.2.3.2	Temperature-Humidity Cycle (UNC Environment) ..	5-13
5.2.4	Durability Test .....	5-15
6.	Optical Switch Reliability Assessment Program .....	6-1
6.1	Purpose .....	6-1
6.2	Test Samples Pedigree .....	6-2
6.3	Test Sample Size .....	6-2
6.4	Device Analysis .....	6-3
6.5	Reliability Test Pass/Fail Criteria .....	6-3
6.6	Reliability Test Procedures .....	6-3
6.6.1	Mechanical Endurance Tests .....	6-4
6.6.1.1	Vibration Test.....	6-4
6.6.1.2	Mechanical Shock Test.....	6-4
6.6.2	Environmental Endurance Tests .....	6-5
6.6.2.1	Damp Heat Test.....	6-5
6.6.2.2	Dry Heat Test .....	6-6
6.6.2.3	Low Temperature Test.....	6-6
6.6.2.4	Temperature Cycling Test.....	6-7
6.6.2.5	Humidity Cycling Test .....	6-7
6.6.2.6	Long Term Reliability.....	6-8
Appendix A:	The Transfer Matrix .....	A-1
A.1	Definitions .....	A-1
A.2	Relation to Optical Parameters.....	A-2
A.3	Example .....	A-3
Appendix B:	Temperature and Relative Humidity .....	B-1
Appendix C:	Lot Tolerance Percent Defective (LTPD).....	C-1
Appendix D:	Alternative Return Loss Measurement Procedure.....	D-1
References.....	References.....	References-1
Acronyms .....	Acronyms.....	Acronyms-1
Glossary .....	Glossary.....	Glossary-1

## List of Figures

Figure 2-1.	Functional Block Diagram of an Optical Switch.....	2-2
Figure 2-2.	(a) 1xN Switch, (b) MxN switch.....	2-4
Figure 2-3.	Symbols for Switches: (a) 1x1 or Single Pole Single Throw (SPST), (b) 1x2 or Double Pole Single Throw (DPST), (c) 2x2 Switch in Bar State, (d)2x2 Switch in Cross State, (e) 1xN Switch, (f) MxN switch.....	2-6
Figure 2-4.	Crossbar Architecture (an example 8x8 switch) .....	2-8
Figure 2-5.	8-Stage Planar Architecture (an example 8x8 switch) .....	2-8
Figure 2-6.	Benes Architecture (an example 8x8 switch).....	2-9
Figure 2-7.	Three Stage Clos Architecture (an example 8x8 switch).....	2-9
Figure 2-8.	Examples of Blocking and Non-blocking Matrices.....	2-10
Figure 2-9.	1:1 ODP Architecture with N=3.....	2-15
Figure 2-10.	Optical Power Loss Detection System Functional Diagram.....	2-16
Figure 2-11.	B SHR/4 with Passive Protection Ring (PPR).....	2-17
Figure 2-12.	B SHR/4 with PPR and Cable-cut Between the Hub and CO-3.....	2-17
Figure 2-13.	Generic RFTS System .....	2-18
Figure 2-14.	Non-Service Interrupting RFTS by (a) Monitoring Spare Fibers and (b) Using WDM.....	2-19
Figure 2-15.	Optical Bridging Test Access Unit (OBT AU).....	2-19
Figure 2-16.	Schematic Representation of the Basic Functionality of an OADM (only one transmission direction shown) .....	2-20
Figure 2-17.	Schematic Representation of the Basic Functionality of a WSXC (Refer to GR-3009-CORE) .....	2-21
Figure 4-1.	1xN Switch Schematic .....	4-3
Figure 4-2.	MxN Switch Schematic.....	4-3
Figure 4-3.	1xN Switch Unidirectional and Bi-directional Qualification .....	4-5
Figure 4-4.	MxN Optical Switch Unidirectional and Bi-directional Qualification.....	4-6
Figure 4-5.	Switch Minimum Passband Example .....	4-8
Figure 4-6.	Example of Insertion Loss $IL_{ij}(1)$ , $IL_{ij}$ , and $IL$ .....	4-10
Figure 4-7.	Uniformity Measurement Example .....	4-13
Figure 4-8.	Wavelength Flatness Measurement Example.....	4-16
Figure 4-9.	Crosstalk ( $XT_{ij}$ ) Measurement Setup Example .....	4-19
Figure 4-10.	Directivity ( $D_{ij}$ ) Measurement Setup Example.....	4-21
Figure 4-11.	Configuration for Measuring Polarization Sensitivity .....	4-23
Figure 4-12.	$S_{ON}$ and $S_{OFF}$ Switching Time Matrices.....	4-28
Figure 4-13.	Switch-on and Switch-off Time Definitions .....	4-28
Figure 4-14.	Control and Optical Signal Transients.....	4-29
Figure 5-1.	Transmission Measurement Facility .....	5-10
Figure 5-2.	Temperature-Humidity Cycling Test Profile (CO) .....	5-12
Figure 5-3.	Temperature-Humidity Cycling Test Profile (UNC) .....	5-14
Figure 6-1.	Thermal Profile of Humidity Cycling Test .....	6-8
Figure D-1.	Reflectance Measurement Model and Calibration.....	D-1
Figure D-2.	1xN Return Loss Test Configuration .....	D-2

Figure D-3. MxN Return Loss Test Configuration..... D-2

## List of Tables

Table 4-1.	Switch Optical Performance Criteria.....	4-1
Table 4-2.	Optical Passband Guidelines .....	4-6
Table 5-1.	Optical Switch Environmental and Mechanical Criteria and Test Conditions .....	5-2
Table 5-2.	Tensile Loads for Fiber Integrity Tests .....	5-6
Table 6-1.	Optical Switch Reliability Criteria and Test Conditions .....	6-2
Table 6-2.	Suggested Measurement Schedule for Reliability Assessment for Static Applications .....	6-9
Table B-1.	Relative Humidity as a Function of Temperature and Absolute Humidity .....	B-1
Table C-1.	LTPD Sampling Plan .....	C-1

