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Consideration on the use of OTDRs to measure return loss of single-mode optical fibre connections

Examen de l'utilisation de la réflectométrie optique dans le domaine temporel (OTDR) pour la mesure de l'affaiblissement de réflexion des connexions en unimodal

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English Version

Consideration on the use of OTDRs to measure return loss of single-mode optical fibre connections

Examen de l'utilisation de la réflectométrie optique dans le domaine temporel (OTDR) pour la mesure de l'affaiblissement de réflexion des connexions en unimodal

Überlegungen zur Verwendung von OTDRs zur Messung der Rückflussdämpfung von Einmoden-LWL-Verbindungen

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European Committee for Electrotechnical Standardization
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CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

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European foreword

This document (CLC/TR 50682:2018) has been prepared by CLC/TC 86BXA "*Fibre optic interconnect, passive and connectorised components*".

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Introduction

The introduction of new types of optical fibre (i.e. ITU-T G.657, EN 60793-2-50 B6 type) and the differences between manufacturers' products cause a spread of up to 3 dB in the backscatter values (Bs) of available telecommunications single mode fibre. The variation in this parameter can lead to large differences in measured return loss (RL) of connections. This can give issues in field measurement where the fibre type and manufacturer may be unknown and the Bs may not be updated for each measurement in the OTDR.

To evaluate the real impact of this spread of backscatter vales on return loss measurement, a Round Robin Test (RRT) was designed by CLC TC86BXA in 2015. "Black-box" connections (i.e. closed boxes with a connection of two plugs and fibre with similar or different B_s values) were circulated for testing in 2016 and 2017 around several laboratories. The result of this Round Robin is intended to contribute to future specification of return loss requirements on optical components.

1 Scope

The purpose of this document is to describe a round robin on return loss of single mode optical fibre connections. This includes the description of the samples, the test procedures and test instrumentation, results and conclusions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 61300-3-6:2009, *Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3-6: Examinations and measurements - Return loss*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
return loss
RL
ratio of the power (Pi) incident on, or entering, the DUT to the total power reflected (Pr) by the DUT, expressed in decibels

3.2
backscatter value
B_S
backscattering level of the OTDR trace is a constant (K) that includes both the Rayleigh backscattering of the fibre and the OTDR pulse duration

4 Description of Samples

The Device Under Test (DUT) was an optical fibre-to-fibre connection, protected by a box, making the connection inaccessible to the user. The patch cords used in the DUTs were provided by different manufacturers to ensure a mix of fibres. The plugs in the connection were either SC/APC or SC/PC style which were terminated on single fibre cable 50 m in length, and the free ends were terminated with SC/APC plugs in order to create input/output ports. All the combinations were chosen in order to have a connection RL between 55 dB and 60 dB. Some of these connections were made by mixing fibres with similar B_S and others using different B_S.

Ten DUTs (black boxes) were made in total. The samples were packed and transported in such a way as to minimize performance changes during the round robin test and retested at the end of the RRT.

In Table 1, the fibre manufacturers, fibre types and mode field diameters (MFD) of the samples used in the RRT are listed, together with the backscatter values at 1 310 nm and 1 550 nm. It can be noted that the difference among B_S values is higher at 1 310 nm (~ 2,6 dB), than at 1 550 nm (~ 0,7 dB).

Table 1 — B_S and mode field diameter (MFD) values of fibres obtained from manufacturers' publicly available datasheets

Fibre Manufacturer	Fibre type	Mode Field Diameter (µm)	B_S (dB @ 1310 nm)	B_S (dB @ 1550 nm)
CORNING	SMF-28e+ LL (G.652.D) SMF-28 Ultra (G.652.D & G.657.A1) SMF-28e+ (G.652.D)	9,2 ± 0,4 at 1 310 nm 10,4 ± 0,5 at 1 550 nm	-77,0	-82,0
	SMF-28 (G.652.D)	9,2 ± 0,4 at 1 310 nm 10,4 ± 0,8 at 1 550 nm	-77,0	-82,0
DRAKA	Elite Bendbright-XS (G.657.A2&B2)	8,8 ± 0,4 at 1 310 nm 9,8 ± 0,5 at 1 550 nm	-79,1	-81,4
DRAKA	ESMF (G.652.D)	9,0 ± 0,4 at 1 310 nm 10,1 ± 0,5 at 1 550 nm	-79,4	-81,7
OFS	AllWave FLEX ZWP (G.652.D & G.657.A1)	8,9 ± 0,4 at 1 310 nm 9,9 ± 0,5 at 1 550 nm	-79,6	-82,1

5 Test

16 different laboratories (Table 2) tested the return loss of the DUTs. Not every laboratory performed all of the tests. Each of them was required to set their commercial OTDRs to the B_S values reported in EN 61300-3-6:2009 (i.e. $B_s \cong 80$ dB for 1 310 nm, $B_s \cong 82{,}5$ dB for 1 550 nm).

Each connection (i.e. each box) was tested from both entry ports and data was reported on a dedicated form. The pulse width was not prescribed and could be chosen by each laboratory, depending on the OTDR available. Where possible, it was recommended to avoid the use of a launch fibre, to limit further uncertainty factors.

Table 2 — Laboratories involved in testing the samples

CommScope, Belgium	LEMO F.O.U.R, UK
CommScope, Netherlands	Optokon, a.s., Czech Republic
Corning Cable Systems Polska Sp. z o.o., Poland	Optotec, Italy
Diamond SA, Switzerland	Orange Poland, Poland
EXATEL S.A., Poland	Reichle de Massari, Switzerland
FibreFab Ltd, UK	SQS Vlaknova optika a.s., Czech Republic
HARTING AG & Co. KG, Germany	TDE, Germany
Huber+Suhner AG, Switzerland	TIM, Italy
Instytut Łączności, Poland	

6 Test results

The combination of the variability in B_s and the typical commercial OTDR return loss accuracy of +/- 2 dB can lead to a measurement variation of up to 5 dB.

The samples were retested at the end of the RRT by the originating laboratory and were found to have few significant changes in characteristics. See Table 3. Boxes 5, 9 and 10 had the highest changes.

Table 3 — Test results before and after the round robin

Sample No — OTDR Launching Port	Connection Type	Measured RL [dB] Before Testing		Measured RL [dB] After Testing		RL Difference [dB] (Before-After)	
		1 310 nm	1 550 nm	1 310 nm	1 550 nm	1 310 nm	1 550 nm
Box 1 - Port A	SC/APC	55,2	57,0	55,7	56,1	-0,6	0,9
Box 1 - Port B	SC/APC	56,0	57,4	56,3	56,9	-0,3	0,5
Box 2 - Port A	SC/APC	57,8	59,4	57,4	58,3	0,4	1,1
Box 2 - Port B	SC/APC	58,1	59,4	57,4	58,3	0,7	1,1
Box 3 - Port A	SC/APC	57,9	59,4	57,3	58,8	0,6	0,6
Box 3 - Port B	SC/APC	56,8	59,5	56,5	57,7	0,3	1,8
Box 4 - Port A	SC/APC	57,5	59,6	57,3	58,1	0,2	1,5
Box 4 - Port B	SC/APC	56,4	58,2	56,3	57,7	0,1	0,5
Box 5 - Port A	SC/APC	58,3	59,8	58,2	58,5	0,1	1,3
Box 5 - Port B	SC/APC	58,4	60,2	58,4	57,5	0,0	2,7
Box 6 - Port A	SC/APC	56,9	58,3	57,3	58,5	-0,4	-0,2
Box 6 - Port B	SC/APC	57,2	58,0	56,4	57,9	0,8	0,1
Box 7 - Port A	SC/APC	58,9	60,7	59,1	60,0	-0,2	0,7
Box 7 - Port B	SC/APC	59,0	60,5	58,8	60,4	0,2	0,1
Box 8 - Port A	SC/APC	57,2	58,4	56,6	58,4	0,6	0,0
Box 8 - Port B	SC/APC	56,2	57,3	55,4	57,5	0,8	-0,2
Box 9 - Port A	SC/PC	55,9	56,8	56,2	57,8	-0,3	-1,0
Box 9 - Port B	SC/PC	55,2	56,1	56,3	57,0	-1,2	-1,0
Box 10 - Port A	SC/PC	63,1	61,1	59,5	61,2	3,6	-0,1
Box 10 - Port B	SC/PC	61,2	60,2	60,0	61,0	1,2	-0,8

The aim of using the same B_S value was not achieved, since some of the OTDRs used were not capable of setting this parameter. The collected data has been divided into two different groups, depending on the pulse width (short or long). Table 4 gives the main test parameters, as declared by each laboratory.

NOTE In this document, short pulse width is defined as ≤ 10 ns, long pulse width is defined as > 10 ns.

Table 4 — Main test parameters set on each OTDR by the laboratories.

	Short Pulse Width [a]				Long Pulse Width [b]			
OTDR Model	**Pulse Width [ns]**	**Fibre launch [m]**	**Bs @ 1 310 nm**	**Bs @ 1 550 nm**	**Pulse Width [ns]**	**Fibre launch [m]**	**Bs @ 1 310 nm**	**Bs @ 1 550 nm**
Ando AQ 7250	10	3	No info	No info				
Anritsu MW9040B					100	No info	80,0	82,5
Anritsu 9060A					100	-	80,0	82,5
Anritsu 9076 D1					20	-	80	82,5
Anritsu 9076 D1					50	-	80	82,5
Anritsu MT-9083A	3	3	78,5	81,5	20	3	78,5	81,5
Anritsu MT-9083B	10	-		81,5	20	-	78,5	
EXFO AXS-100	10	500	79,4	81,9				
EXFO AXS-100	10	4	79,4	81,9				
EXFO FTB-100B	10	4	79,4	81,9				
EXFO FTB-200	10	4	79,4	81,9				
EXFO FTB-7200D					100	250	80,0	82,5
EXFO FTB-730					50	-	80,0	82,5
EXFO FTB-1 FTB-730C-SM2-EA	10	-	80	82,5	30	-	80	82,5
EXFO FTB-1 FTB-730-23B-04B-OPM-EA	10	-	80	82,5	50	-	80	82,5
EXFO Maxtester 730C-SM2-EA	10	-	80	82,5	50	-	80	82,5
JDSU 3168	10	100	80,0	82,5				
JDSU MTS 6000					30	-	80,0	82,5
JDSU MTS 8000					30	3	81,0	81,0
Luciol LOR 200	2	-	80,0	82,5	30	3	80,0	82,5
NOYES OFL-250	10	4	79,4	81,9				
OPTOKON MOT-700D	10	1 000	80	80				
TEKTRONIX TFP2					20	382/913	80,0	82,5
Wavetek MTS5100	5	1 000	80,2	81,7	20	1 000	80,2	81,7
Yokogawa AQ1205F	10	-	80	82,5	50	-	80	82,5
Yokogawa AQ7270	10	1 000	No info	No info				
Yokogawa AQ7275	3	500	80,0	82,5				

[a] Short Pulse Width: 2, 3, 5 and 10 ns.
[b] Long Pulse Width: 20, 30, 50 and 100 ns.

In Table 5, the minimum and maximum values and the calculated mean and standard deviation values are given for each port of the test boxes.

Table 5 — Minimum, maximum, mean values — Standard deviation

	SHORT PULSE WIDTH — 1 310 nm				SHORT PULSE WIDTH — 1 550 nm				LONG PULSE WIDTH — 1 310 nm				LONG PULSE WIDTH — 1 550 nm			
	MIN [dB]	MAX [dB]	MEAN [dB]	STDEV [dB]	MIN [dB]	MAX [dB]	MEAN [dB]	STDEV [dB]	MIN [dB]	MAX [dB]	MEAN [dB]	STDEV [dB]	MIN [dB]	MAX [dB]	MEAN [dB]	STDEV [dB]
Box 1 Port A	53,4	60,3	55,7	2,07	54,6	60,5	56,3	1,65	53,7	58,2	54,8	1,00	54,3	59,2	55,9	1,14
Box 1 Port B	54,5	61,7	56,5	2,00	55,3	62,9	57,3	1,99	53,5	58,9	55,5	1,13	55,2	60,3	56,7	1,18
Box 2 Port A	56,5	61,7	58,4	1,59	57,6	64,6	59,3	1,73	55,4	61,5	57,5	1,33	57,7	62,8	58,9	1,26
Box 2 Port B	56,7	66,1	58,6	2,24	57,7	63,4	59,5	1,64	55,5	61,4	57,6	1,32	57,7	62,9	59,0	1,30
Box 3 Port A	56,3	63,4	58,4	1,86	57,4	62,4	59,2	1,49	55,3	61,2	57,5	1,35	55,5	62,8	58,8	1,54
Box 3 Port B	55,8	63,0	57,8	1,90	57,2	61,7	58,8	1,39	54,9	60,7	56,8	1,27	57,2	62,3	58,5	1,33
Box 4 Port A	56,0	61,3	57,9	1,62	57,4	65,8	59,2	2,02	55,1	60,9	57,1	1,30	57,3	62,4	58,8	1,25
Box 4 Port B	55,8	61,8	57,6	1,82	57,1	61,9	58,5	1,38	54,6	60,3	56,6	1,21	57,0	61,8	58,1	1,16
Box 5 Port A	55,5	62,6	57,9	2,06	56,0	63,7	58,7	2,10	55,1	60,2	56,8	1,19	56,9	61,1	58,2	1,13
Box 5 Port B	55,3	61,9	57,8	1,97	56,6	63,3	58,5	1,79	54,1	60,1	56,5	1,96	55,8	61,1	57,9	1,33
Box 6 Port A	55,3	65,4	57,8	2,44	56,3	62,8	58,2	1,80	55,3	60,0	56,8	1,11	56,0	61,8	57,9	1,30
Box 6 Port B	55,1	60,8	57,1	1,84	55,8	63,9	57,9	2,03	54,8	59,7	56,4	1,10	56,3	60,6	57,5	1,03
Box 7 Port A	58,3	67,8	60,2	2,20	59,3	65,4	61,3	1,56	57,5	63,1	59,2	1,26	59,2	64,7	60,8	1,24
Box 7 Port B	57,9	65,2	59,8	1,87	59,0	67,0	61,3	1,79	57,4	63,1	59,0	1,32	59,0	64,8	60,8	1,34
Box 8 Port A	54,7	60,8	57,3	1,86	55,6	61,8	57,8	1,81	54,7	59,7	56,3	1,14	56,1	61,1	57,4	1,22
Box 8 Port B	54,3	62,6	56,6	2,25	55,4	61,8	57,6	1,70	54,6	58,9	55,6	1,00	54,2	60,1	56,6	1,32
Box 9 Port A	55,5	64,9	57,2	2,27	56,0	62,3	57,8	1,70	54,5	60,2	56,1	1,30	56,3	60,7	57,4	1,13
Box 9 Port B	54,9	61,3	56,9	1,88	55,7	64,5	57,7	2,25	54,2	59,7	56,0	1,43	55,6	60,6	56,9	1,21
Box 10 Port A	59,2	66,6	61,9	1,91	59,3	72,2	62,4	2,66	58,8	64,8	60,9	1,68	59,7	64,6	61,7	1,30
Box 10 Port B	58,9	66,0	61,6	2,07	59,3	65,7	61,9	1,65	58,4	64,0	60,6	1,33	59,5	66,8	61,8	1,91