BroadR-Reach® Definitions for Communication Channel

Version 2.0

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This measurement specification shall be used as a standardized common scale for evaluation of general RF requirements for a physical layer communication channel to enable BroadR- Reach™ 100Mbps Technology.

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1 Introduction

1.1 Scope

The intention of this specification is to present the general RF requirements for a physical layer communication channel according to Figure 1-1 to enable BroadR- Reach™ 100Mbps Technology using unshielded twisted pair (UTP) cables for Automotive Ethernet applications. These requirements are related to signal integrity and EMC behavior of the communication channel.

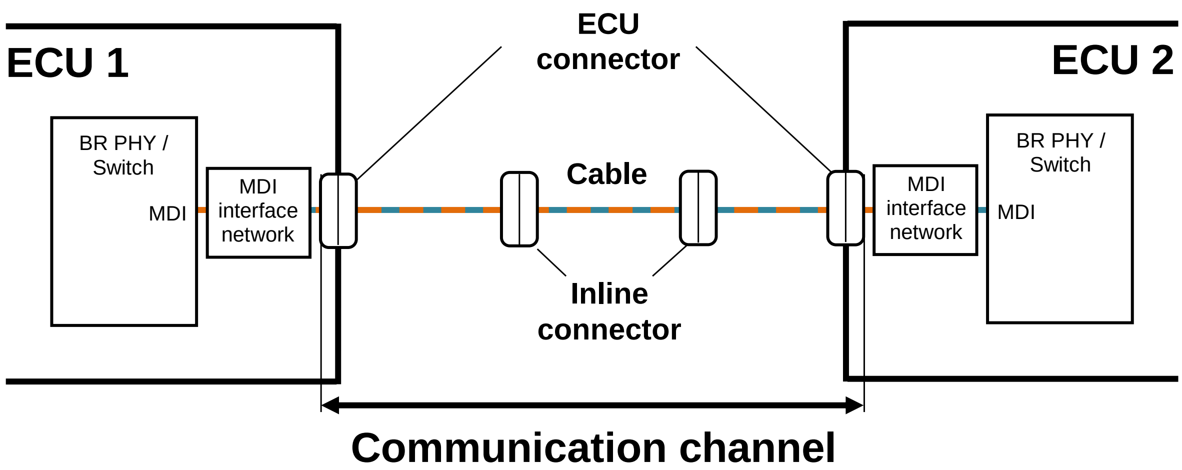


Figure 1-1: Definition of communication channel

This document defines various parameters to be tested for the complete communication channel between two Ethernet nodes and also for cables and connectors as a single part of this communication channel. It contains test procedures, test setups and limits and shall be used as a standardized common scale for evaluation of complete link segments and for evaluation of used types of cables and connectors.

Some functional parameters for the communication channel are required parameters as they are also stated in [2]. All limits for other functional and EMC relevant parameters are also required, unless it is not otherwise specified by the customer (OEM). The customer also defines the special test set-ups used to evaluate the communication channel parameters using this test specification. A test wiring harness can be specified by the customer for evaluation or comparison of different solutions for setting up a communication channel configuration.

Other requirements on cables and connectors like mechanical and climatic stress depend on the customer's definition and are not the focus of this document.

1.2 References

[1] IEEE 802.3: 2008, Section 2: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) access method and Physical Layer specifications, Fast Ethernet specification

[2] Broadcom / OPEN ALLIANCE: BroadR-Reach® Physical Layer Transceiver Specification For Automotive Applications, Version 3.2

[3] DIN EN 50173-1, Information technology – Generic cabling systems – Part 1: General requirements

[4] DIN EN 61935-1, Testing of balanced communication cabling in accordance with ISO/IEC 11801 – Part 1: Installed cabling (IEC 46/217A/CDV: 2007)

[5] DIN EN 50289-1-1, Communication cables, Electrical specifications for test methods

[6] ISO/IEC 11801: 2nd Edition – Information technology – Generic cabling for customer premises – 2002

[7] DIN EN 60512 – Connectors for electronic equipment – Tests and Measurement – 2002

[8] ISO/IEC 60603-7-7, Annex J

[9] IEC 61156-1: Multicore and symmetrical pair/quad cables for digital communication- part 1: Generic specification – 2007

[10] ISO554: Standard atmospheres for conditioning and/or testing – Specifications – 1976

[11] IEC 62153-1-1: Metallic communication cables test methods Part 1-1: Electrical - Measurement of the pulse/step return loss in the frequency domain using the Inverse Discrete Fourier Transformation (IDFT) – 2003

1.3 List of abbreviations and definitions

AFEXT	Alien Far End Crosstalk loss
AFEXTDC	Alien Far End Cross conversion loss Common to Differential
AFEXTDS	Alien Far End Cross conversion loss Single ended to Differential
ANEXT	Alien Near End Crosstalk loss
ANEXTDC	Alien Near End Cross conversion loss Common to Differential
ANEXTDS	Alien Near End Cross conversion loss Single ended to Differential
BR	BroadR-Reach®
CC	Communication Channel
CIDM	Characteristic Impedance Differential mode
CUT	Cable under Test
ECU	Electronic Control Unit
ES	Environment System
IL	Insertion Loss
LCL	Longitudinal Conversion Loss
LCTL	Longitudinal Conversion Transmission Loss
PS	Power Sum
PSAACRF	Power Sum Attenuation to Alien Crosstalk Ration Far End
PSANEXT	Power Sum Alien Near End Crosstalk loss
RL	Return Loss
RT	room temperature
SCC	Standalone Communication Channel
S-Parameter	Scattering Parameter
VNA	Vector Network Analyzer
WCC	Whole Communication Channel

2 General Definitions and Requirements

All definitions for communication channel, cables and connectors are valid for any temperature, intended to use in application and standard atmosphere condition[1]. In general, measurements are required at least at the operating temperatures -40°C, 23°C and 105°C. If the communication channel is specified for a higher operating temperature (e.g. 125°C) the maximum temperature has to be measured additionally. Depending on defined test procedure measurements are partly reduced to 23°C ambient temperature (RT). All measurements at communication channel, cables and connectors are required before and after the standard mechanical and climatic stress tests according to customer requirements.

For all parts of the communication channel the RF requirements are defined in terms of the following RF and S- Parameter:

Topic	Parameter	Comment
Impedance		
CIDM	Z_{RF}	Characteristic impedance differential mode (TDR measurement)
Single channel characteristics (port 1,2)		
RL	S_{dd11} , S_{dd22}	Return Loss (differential mode)
IL	S_{dd21}	Insertion Loss (differential mode)
LCL	S_{dc11} , S_{dc22}	Longitudinal Conversion Loss
LCTL	S_{dc12}, S_{dc21}	Longitudinal Conversion Transmission Loss
Cross talk single channel and other signals (channels / port 3 to port x)		
ANEXT	S_{dd31} , S_{ddx1}	Alien Near End Cross Talk (pair to pair or single ended to pair)
AFEXT	S_{dd32} , S_{ddx2}	Alien Far End Cross Talk (pair to pair or single ended to pair)
PSANEXT		Power Sum Alien Near End Crosstalk loss
PSAACRF		Power Sum Attenuation to Alien Crosstalk Ration Far End
AFEXTDC / AFEXTDS	S_{dc31} , S_{dcx1} S_{ds31} , S_{dsx1}	Alien Near End Cross conversion loss Common to Differential Alien Near End Cross conversion loss Single ended to Differential
AFEXTDC / AFEXTDS	S_{dc32} , S_{dcx2} S_{ds32} , S_{dsx2}	Alien Far End Cross conversion loss Common to Differential Alien Far End Cross conversion loss Single ended to Differential

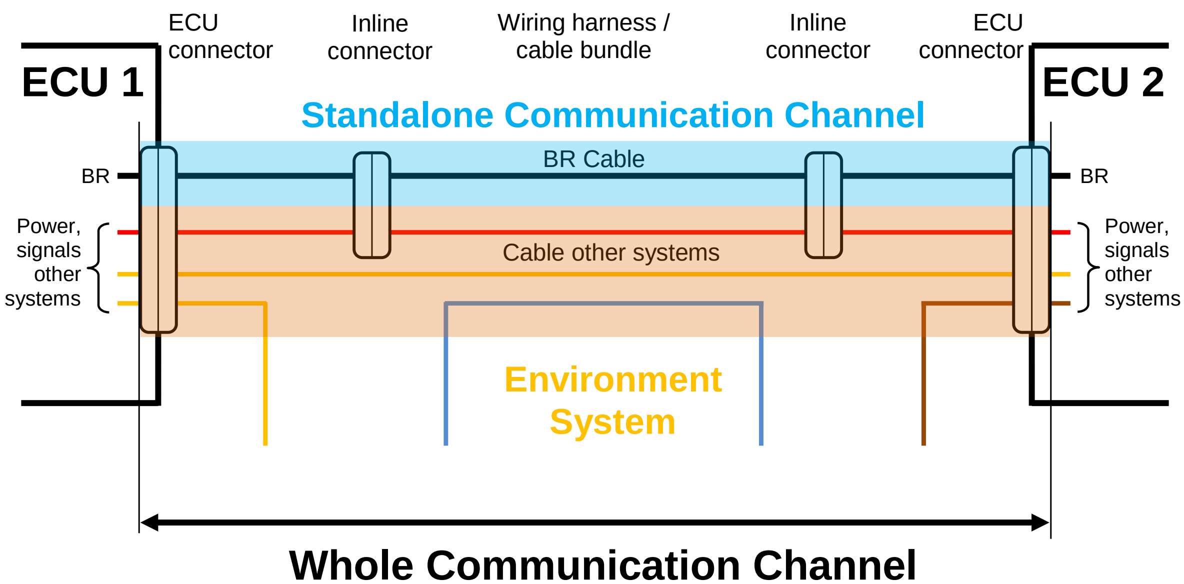
Table 2 -1: Definitions for RF and S- Parameter

[1] Standard atmosphere conditions based on ISO554-1976

In principle the limits for S-Parameter are valid in the frequency range 1 MHz ≤ f ≤ 66 MHz. For LCL, LCTL, AFEXTDC, AFEXTDS, ANEXTDC and ANEXTDS limits are valid up to f = 200 MHz. The measurements should be done up to f = 1000 MHz for information purpose.

3 Model for Communication Channel and Environment System

In this document the complete electrical wired connection between 2 ECUs with Ethernet interface is defined as Whole Communication Channel (WCC).



Note: The number of inline connectors is only an example. A maximum number of 4 inline connectors is defined for automotive application.

Figure 3-1: Model for communication channel

In opposite to general definitions of Open Alliance – in this document the wire-to-board connector belongs to the communication channel.

The maximum length of WCC is not defined. It depends on the characteristics of each single component. These components should be chosen to achieve a typical length of 15m and in maximum 4 inline connectors for car applications.

To consider the electromagnetic interaction of WCC with its environment a model consisting of Standalone Communication Channel (SCC) and an Environment System (ES) is used. This interaction can occur as cross talk in multi-pin connectors or in multi-pair cables or between SCC cable and other cables inside the wiring harness bundle.

The feedback of ES to SCC can be separated into different zones:

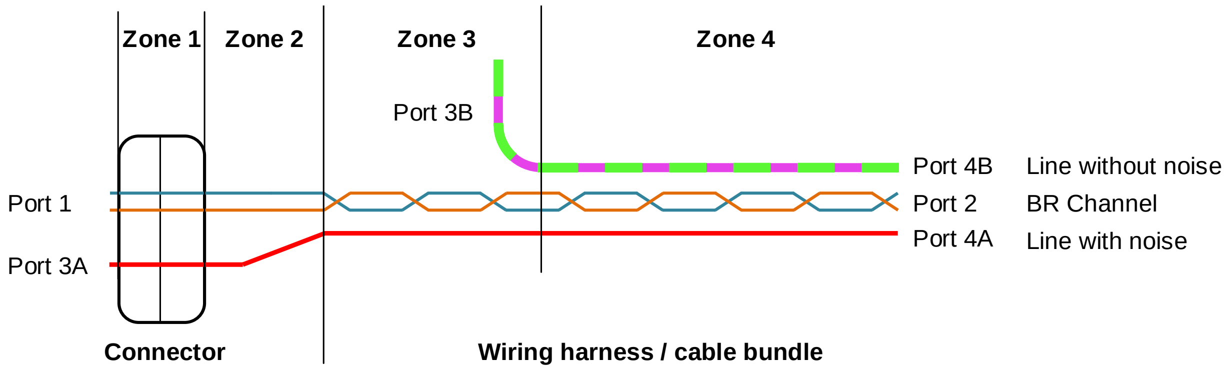


Figure 3-2: Zone concept for interaction between Environment System (ES) to Standalone Communication channel (SCC)

Table 3 -1 provides an overview on the defined coupling zones and examples for dominant disturbing sources and related S-Parameter for each coupling zone.

Zone	Interaction / Cross talk to differential mode port 1 / port 2 (SCC)	Dominant disturbing source (if present)	Related S-Parameter (exemplary)
1	Multi-pin connector	Line(s) with high common mode noise	Port 3A: S_{dc13A} (S_{ds13A})
2	Connecting area connector – cable - untwist region outside connector (valid for ECU connector and inline connector)	Line(s) with high common mode noise	Port 3A: S_{dc13A} (S_{ds13A})
3	Connecting area connector – cable - twist region outside connector	Line(s) with high common mode noise	Port 3A: S_{dc13A} (S_{ds13A})
4	Cable bundle wiring harness	Line(s) without common mode noise and other communication lines	Port 3A: S_{dc13A} (S_{ds13A}) Port 3B: S_{dd13B} Port 4B: S_{dd14B}

Table 3 -1: Coupling zone definitions

Depending on the use configuration in real application the WCC will contain of a combination or a subset of the defined zones.

For evaluation the WCC it should be tested as a complete system (including all zones). For analyses and optimization or evaluation of single parts of WCC the zone can be tested separately.

4 Test and Measurement definitions

4.1 General definitions

For all measurements a vector network analyzer (VNA) and a TDR measurement system in combination with a test fixture with the following parameters shall be used:

Parameter	Equipment	Parameter	Value
Mixed Mode S-Parameter	VNA	Type:	4- port vector network analyzer
		System impedance:	50 Ω
		Frequency range:	f = 0.3 – 1000 MHz (in minimum)
Characteristic Impedance (CIDM)	TDR Test system	Type:	2 channel differential mode
		System impedance:	50 Ω single ended / 100 Ω differential mode
		Rise time:	Pulse generator: ≤ 25 ps internal (≤ 100 ps at test fixture) Analyzer: no filter / 700 ps internally adjustable (used digital filter characteristic of test equipment)
All	Test fixture	Depending on the used test standard (see special definitions for cables and connectors)	

Table 4 -1: Required measurement equipment

4.2 VNA measurement precautions and recommended settings

To assure a high degree of reliability for transmission measurements, the following precautions are required (DIN EN 61935-1):

1. The reference plane of the calibration shall coincide with the measurement reference plane. In case of differences the magnitude of errors shall be determined.
2. Consistent resistor loads shall be used for each pair throughout the test sequence.
3. The alignment of cable under test shall be chosen as defined for the single tests und must be fixed throughout the test sequence.
4. Cable and adapter discontinuities, as caused by physical flexing, sharp bends and restraints shall be avoided before, during and after the tests.
5. Coaxial, balanced lead and traces at the test fixture shall be kept as short as possible to minimize resonance and parasitic effects.
6. Overload conditions of the network analyzer shall be avoided.

To achieve high degree of comparability of test results the VNA settings given in Table 4 -2 are recommended. The used VNA setting for each parameter of Table 4 -2 shall be documented in the test report.

Parameter	Value
Sweep f_{Start}	300 kHz
Sweep f_{Stop}	1 GHz
Sweep type	Logarithmic
Sweep points	1600
Output power	minimum -10 dBm
Measurement bandwidth	100 Hz
Logic Port Impedance Differential Mode	100 Ω
Logic Port Impedance Common Mode	200 Ω
Data calibration kit (VNA)	used kit for calibration
Averaging function	16 times
Smoothing function	deactivated

Table 4 -2: Recommended VNA settings

4.3 Presentation of measurement results

Test results should be documented in the following way:

- Documentation of test conditions (e.g. humidity, temperature, cable length)
- Pictures of test set-up and test fixture
- Results for S- Parameter
  - Result as dB value with related limit
  - Diagram with logarithmic frequency axis up to minimal f = 1000 MHz
- Results for TDR- Measurements
  - Result as differential impedance (Ohms) with related limit
  - Measurement result and corrected data (according to Annex B) should be presented in one diagram in the following format:
    - Linear scale for X- axis in time
    - Linear scale for additional X- axis in length (m, calculated using 2/3 of c_0 or real phase velocity of cable / connector and correction of double way of pulse propagation)

4.4 Cable evaluation

4.4.1 General

All required measurements are based on ISO/IEC 11801, 2nd edition.

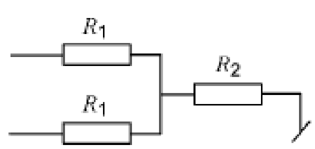
In opposite to the definitions of ISO/IEC 11801 2nd edition, the cable to be measured should have a length of (10 ± 0.05) m. Measurements with a standard cable length of 25m are also possible. If 10m test cable length if not possible because of the manufacturing process, tests at a shorter cable length can be done but must be agreed between the supplier and the customer.

The cable under test should be assembled on a conductive drum with 10mm isolation ($\varepsilon_r \leq 1.4$). The conduction drum is connected with ground potential of the test set-up and simulates the common mode reference surface for the cable. The separation of each single winding of test cable should be in minimum 30mm. See Annex A - Extended Test Set-up definitions for more details.

4.4.2 Adaptation and matching

During measurement all pairs of the cable have to be matched to the characteristic impedance (differential $|Z_{diff}|$ and common mode $|Z_{com}|$). The characteristic differential mode impedance is 100 Ω and must be matched in any case by physical impedances. The mean common mode impedance of the defined test setup is 200 Ω and should be validate by a TDR measurement. It should be matched using internal common mode correction function of VNA or using an external matching circuit for the measured pair. In case of using an external matching circuit its attenuation have to be considered for measurement.

In case of multi pair cables, the other not measured pair(s) should be terminated using a matching circuit as shown below:



$$R_1 = \frac{|Z_{\mathrm{diff}}|_{nom}}{2}$$

$$R_2 = |Z_{\mathrm{com}}|_{nom} - \frac{|Z_{\mathrm{diff}}|_{nom}}{4}$$

Figure 4-1: Resistor values for termination concept

The DC value of the used termination resistors has to be in a tolerance range of +/- 1 %.

The common mode termination points of all matching circuits should be connected to the ground reference surface (conductive drum).

An appropriate test fixture according to ISO/IEC 11801 shall be used to contact the single wires of the cable under test with the measurement equipment. The used test fixture must have low insertion loss, high symmetry between the two different lines of a pair and very good matching to 50 Ω single ended impedance. The test fixture or design hints for it should be supported by the cable manufacturer.

4.4.3 Definition of Measurement Reference Plane for Cable Tests

For evaluation of cable RF parameter the measurement reference planes are defined at the end of the cable under test / connection point of cable with the test fixture according to Figure 4-2. The measurement reference point can be shifted to the RF connector of the test fixture, if the electrical characteristics of the test fixture are calibrated and corrected for measurement or have no significant impact to measurement results.

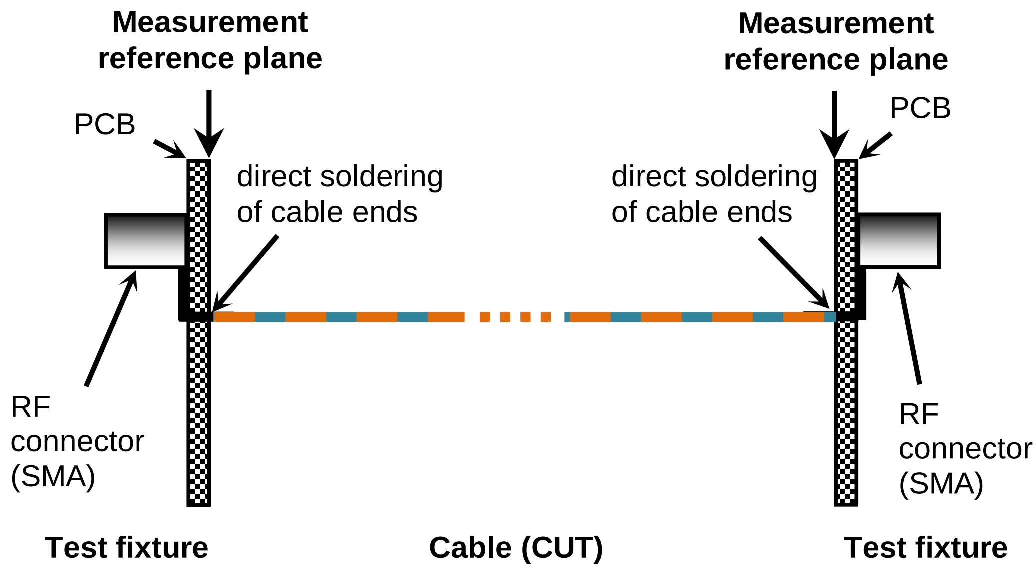


Figure 4-2: Measurement reference planes for cables

4.5 Connector evaluation

4.5.1 General

All required measurements for connector evaluation are based on the actual version of:

- DIN ISO - IEC 60512 Edition 25 and
- IEC 60603-7-7, Annex J

In case of multi-pin connectors (more than 2 pins) all pairs intended to use for BroadR-Reach® communication have to be evaluated for SCC. In principle the cross talk in between these pins and all other pins of the connector have to be evaluated (according to ES definition). It can be reduces to the critical pins next to BroadR-Reach® pins. This reduction should be agreed between supplier and customer.

A test fixture according to IEC 60512 – chapter 25 is required. An example is given in Annex A.2. The used test fixture must have lowest insertion loss, high symmetry between different lines of a pair and very good matching to 50 Ω single ended impedance. The test fixture or design hints for it should be supported by the connector manufacturer.

4.5.2 Definition of Measurement Reference Plane for Connector Tests

For evaluation of connectors (ECU connector and inline connector) the measurement reference planes are defined at the geometric boundary of electrical contact system of the connector according to Figure 4-3. The needed crimps for contacting the test fixture with the connector are defined as part of the connector. The measurement reference point can be shifted to the RF connector of the test fixture if the electrical characteristics of the test fixture are calibrated and corrected for measurement or have no significant impact to measurement results.

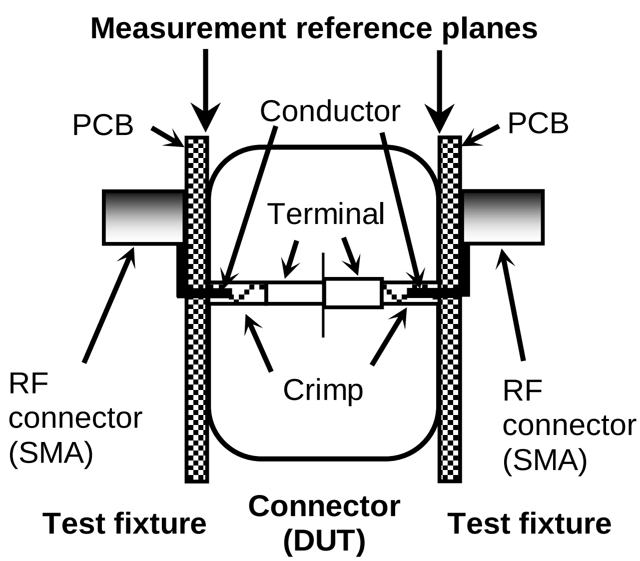


Figure 4-3: Measurement reference planes for connectors

4.6 Whole Communication Channel evaluation

4.6.1 General

All required measurements for WCC evaluation should be done in accordance with test and measurement definitions for cables and connectors. For complete evaluation all parts of the intended application shall be included into the test set-up. The untwisted area at the connectors must be configured as in the same manner as possible for mass production. All potential interactions between SCC and ES according to Table 3 -1 should be included into the test setup. If the WCC configuration consists of more than one SCCs, all SCCs have to be evaluated separately. In this case the second (others) SCC(s) is part of ES from first SCC point of view.

Test at WCC configuration are required only for 23°C ambient temperature (RT).

> <u>Comment:</u>
> Due to technical limitation for climatic chambers tests of Whole Communication Channel configuration are not required for high or low temperatures. Cables and connectors can have temperature depending characteristics and will be tested.

Because of required measurements only at RT and possible temperature dependent value for IL of the used cable the measurement result for IL must be corrected for fixed frequencies f = 1, 10, 16, 33 and 66 MHz in the following way:

$$IL_{WCC\_\max temp} = IL_{WCC\_RT} + \left(IL_{Cable\_\max temp/m} - IL_{Cable\_RT/m}\right) * l$$

with:

$IL_{WCC\_max\ temp}$	Value Insertion Loss for measured WCC configuration at maximum temperature
IL_{WCC_RT}	Value Insertion Loss for measured WCC configuration at RT
$IL_{cable\_max\ temp}/m$	Value Insertion Loss per meter for measured cable at maximum temperature
IL_{cable_RT}/m	Value Insertion Loss per meter for measured cable at RT
l	length of measured WCC configuration

4.6.2 Enhanced definitions for test set-up

All parts of evaluated WCC configuration should be placed on a (10 ± 0.5) mm isolation support ($\varepsilon_r \leq 1.4$) over an enlarged ground reference plane (minimum 1x2 m). The ground reference plane should overlap all parts of the test configuration with in minimum 30mm (3 times height over reference ground plane). In general the distance between all parts of the evaluated communication channel should be also in minimum 30mm (3 times height over reference ground plane). For small configurations the cables should be route in a straight way. For large configurations the cable segments should be arranged as a meander between the connectors to avoid parasitic couplings at test setup. Take care that the minimum blending radius doesn't go below the minimum value for used cable type. The orientation of ECU and Inline connectors should be in main orientation that means horizontal to ground plane. The ground reference of the used test fixtures shall be low-impedance connected to the ground reference plane.

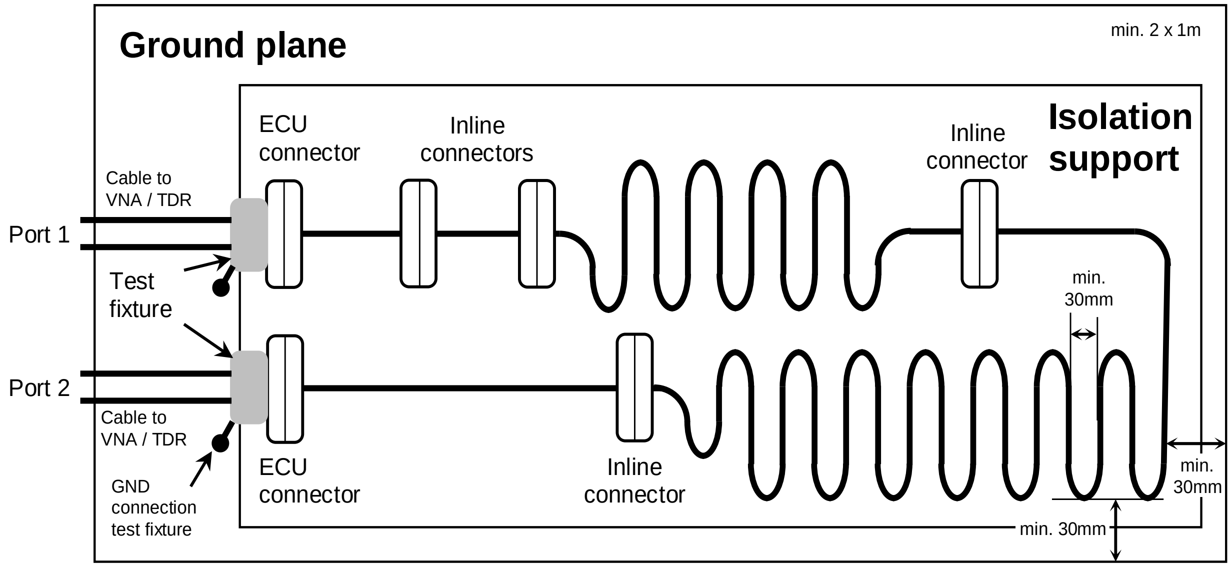


Figure 4-4: Example for test set-up for WCC evaluation

4.6.3 Definition of Measurement Reference Plane for Tests at WCC Configurations

For evaluation of the WCC configuration the measurement reference planes are defined at the geometric boundary of the electrical contact system of the ECU connector at both sides of the channel. See Figure 4-3 and Figure 4-5 for more details. An appropriate test fixture for connectors shall be used to contact the ports of the WCC configuration with the measurement equipment.

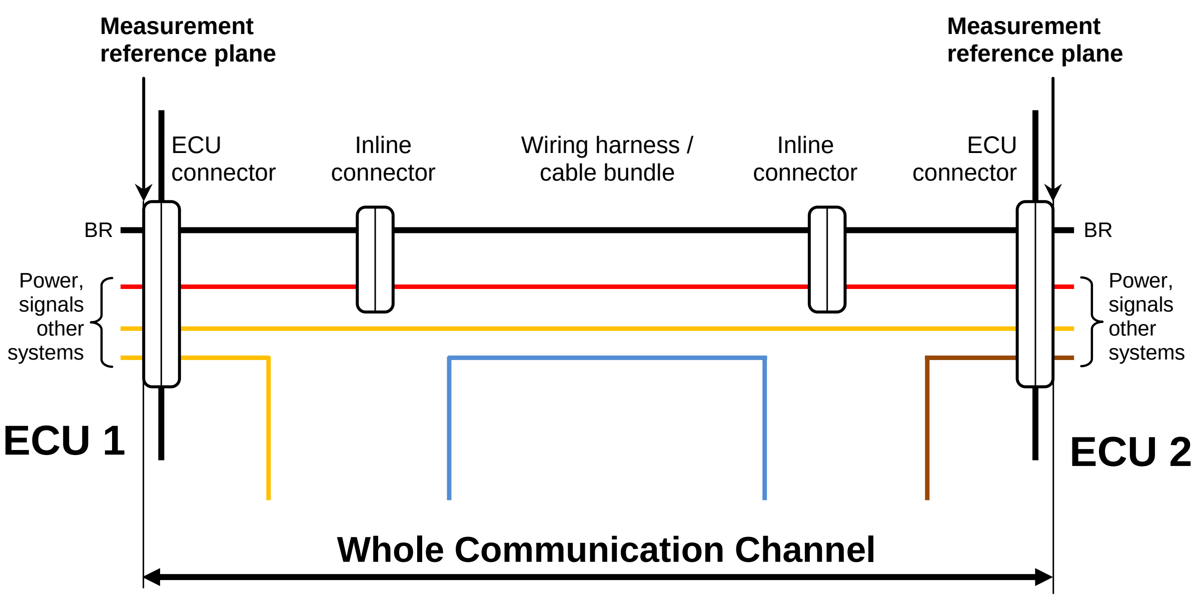


Figure 4-5: Measurement reference planes for WCC evaluation

For analysis of single parts of the communication channel (e.g. inline connector with corresponding untwisted area and cable) the measurement reference planes have to be adapted.

5 Requirements

Depending on implementation of BroadR- Reach™ 100Mbps physical layer communication channel different requirements are specified. The requirements on SCC are basic requirements in any case. If the Environment System (ES) have to be taken into account for evaluated implementation, the additional requirements for ES are valid, too.

For evaluation of the complete channel implementation the requirements for WCC must be used. To be able to setup a compliant BroadR- Reach™ 100Mbps channel implementation cables and connectors should be used, that fulfill the respective requirements.

5.1 Basic Requirements for Standalone Communication Channel (SCC)

5.1.1 Requirements for Cables (SCC)

For evaluation of twisted pair cable, intended to use for standalone communication Channel (SCC), test parameter and limits are required according to Table 5 -1. Depending on the maximum length of the SCC different limits are required for IL. All other limits are independent of SCC length.

Test parameter		Test standard	Limit (max. value for parameter)
CIDM	Z_{RF}	IEC 62153-1-1	100 Ω +/- 10 %, valid for 700 ps rise time evaluation $)_3$ Evaluation window: l = 0.5m to 1.5m, see $)_4$
IL $)_5$	S_{dd21} $)_2$	ISO/IEC 11801 DIN EN 50289-1-1	<u>Maximum length of SCC = 15m:</u> 1 MHz: 0.06 dB/m 10 MHz: 0,16 dB/m 33 MHz: 0.31 dB/m 66 MHz: 0.45 dB/m <u>Maximum length of SCC = 10m:</u> 1 MHz: 0.09 dB/m 10 MHz: 0,24 dB/m 33 MHz: 0.46 dB/m 66 MHz: 0.68 dB/m
RL	S_{dd11} , S_{dd22} $)_1$		1 MHz: 20.0 dB 20 MHz: 20.0 dB 66 MHz: 14.8 dB
LCL LCTL	S_{dc11} , S_{dc22} $)_1$ S_{dc21} , S_{dc12} $)_1$		1 MHz: 46.0 dB 50 MHz: 46.0 dB 200 MHz: 34.0 dB

$)_1$ linear axis for dB, linear interpolation for limit value at logarithmic frequency axis

$)_2$ logarithmic axis for dB, linear interpolation for limit value at logarithmic frequency axis

$)_3$ two measurements are required: systems rise time ≤ 25 ps for information purpose only, systems rise time 700 ps for limit comparison

$)_4$ refer to Figure 5-1 for evaluation window definition

$)_5$ for IL limits for cables, two classes of cable are specified, depending on maximum length of implemented SCC

Table 5 -1: Required parameter and limits for cables (SCC)

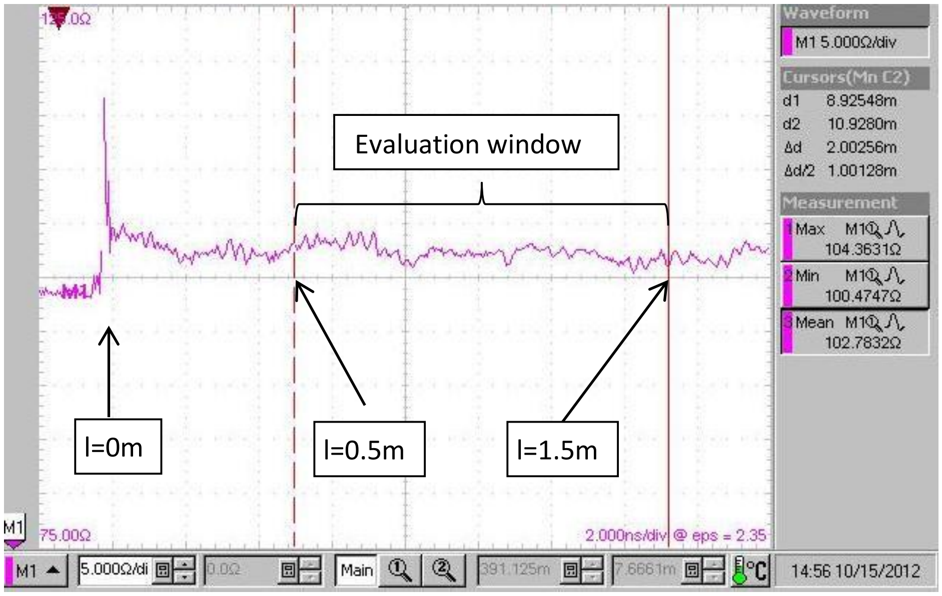


Figure 5-1: Example for TDR measurement with definition of evaluation window for CIDM limit at cables

5.1.2 Requirements for Connectors (SCC)

For evaluation of two pin connectors, intended to use for standalone communication Channel (SCC), test parameter and limits are required according to Table 5 -2.

Test parameter		Test standard	Limit (max. value for parameter)
Intra Pair Skew	$t_{intra\_pair\_x}$	IEC 60512-25-4	Only for information)3
CIDM	Z_{RF}	IEC 60512-25-7	100 Ω +/- 10 %, valid for 700 ps rise time evaluation)4
IL	S_{dd21})2	IEC 60512-25-2	1 MHz: 0.025 dB 10 MHz: 0,038 dB 33 MHz: 0.050 dB 66 MHz: 0.075 dB
RL	S_{dd11} , S_{dd22})1	IEC 60512-25-5	1 MHz: 38.0 dB 33 MHz: 38.0 dB 66 MHz: 30.5 dB
LCL LCTL	S_{dc11} , S_{dc22})1 S_{dc21} , S_{dc12})1	IEC 60603-7-7,Annex J	1 MHz: 46.0 dB 50 MHz: 46.0 dB 200 MHz: 34.0 dB

)1 linear axis for dB, linear interpolation for limit value at logarithmic frequency axis

)2 logarithmic axis for dB, linear interpolation for limit value at logarithmic frequency axis

)3 no limit applied, measurement result can be used for compensation of connector propagation delay skew at the layout of the ECU, if needed

)4 two measurements are required: systems rise time ≤ 25 ps for information purpose only, systems rise time 700 ps for limit comparison

Table 5 -2: Required parameter and limits for connectors (SCC)

5.1.3 Requirements for Whole Communication Channel Configuration (SCC part including Assembly)

For evaluation of complete WCC implementation, intended to use for Standalone Communication Channel (SCC), parameter and limits are required according to Table 5 -3.

Test parameter		Test standard	Limit (max. value for parameter)
CIDM	Z_{RF}	IEC 62153-1-1	100 Ω +/- 10 %, valid for 700 ps rise time evaluation)3,)4
IL)5	S_{dd21})1	ISO/IEC 11801 DIN EN 50289-1-1	1 MHz: 1.0 dB 10 MHz: 2.6 dB 33 MHz: 4.9 dB 66 MHz: 7.2 dB
RL	S_{dd11} , S_{dd22})2		1 MHz: 18.0 dB 20 MHz: 18.0 dB 66 MHz: 12.8 dB
LCL LCTL	S_{dc11} , S_{dc22})2 S_{dc21} , S_{dc12})2		1 MHz: 43.0 dB 33 MHz: 43.0 dB 50 MHz: 39.4 dB 200 MHz: 27.3 dB

)1 logarithmic axis for dB, linear interpolation for limit value at logarithmic frequency axis

)2 linear axis for dB, linear interpolation for limit value at logarithmic frequency axis

)3 Two measurements are required: systems rise time ≤ 25 ps for information purpose only, systems rise time 700 ps for limit comparison.

)4 For long channels the TDR measurement technique may lead to incorrect measuring results. To prevent getting faulty results either software based solutions of the TDR measurement device or the correction procedure given in Annex B – Correction Method for TDR Measurements should be used.
The limit is valid for $CIDM_{corrected}$ (t). Both results for $CIDM_{measured}$ (t) and $CIMD_{corrected}$ (t) must be given in the resulting diagram.

)5 Because of measurement at RT and possible temperature dependent IL value for used cable the limit is valid for the corrected measurement result according to section 4.6 of this document.

Table 5 -3: Required parameter and limits for whole channel (SCC)

5.2 Additional Requirements for Standalone Communication channel and Environment System (ES)

5.2.1 Requirements for Cables (ES)

Actually there are no requirement defined in this section.

5.2.2 Requirements for Connectors (ES)

For multi-pair connector evaluation, additionally to section 5.1.2 test parameter and limits are required according to Table 5 -4.

Test parameter)1		**Test standard**	**Limit (max. value for parameter)**
ANEXT/AFEXT	S_{dd31}, S_{ddx1}, S_{dd32}, S_{ddx2}	IEC 60512-25-1	1 MHz: 70.4 dB 16 MHz: 46.3 dB 33 MHz: 40.0 dB 66 MHz: 34.0 dB
Cross Talk Mode Conversion ANEXTDC/ANEXTDS AFEXTDC/AFEXTDS	S_{dc31}, S_{dcx1}, S_{ds31}, S_{dsx1} S_{dc32}, S_{dcx2}, S_{ds32}, S_{dsx2}	IEC 60603-7-7	1 MHz: 46.0 dB 50 MHz: 46.0 dB 100 MHz: 40.0 dB 200 MHz: 34.0 dB

)1 linear axis for dB, linear interpolation for limit value at logarithmic frequency axis

Table 5 -4: Additional required parameter and limits for connectors (ES)

5.2.3 Requirements for Whole Communication Channel Configuration (ES)

For evaluation of complete WCC implementation, additionally to section 5.1.3 parameter and limits are required according to Table 5 -5.

Test parameter)1		Test standard	Limit (max. value for parameter)
PSANEXT)2		ISO/IEC 11801 DIN EN 50289-1-1	1MHz: 51.5dB 100MHz: 31.5dB
PSAACRF)2			1MHz: 56.5dB 100MHz: 16.5dB
Cross Talk Mode Conversion ANEXTDC/ANEXTDS AFEXTDC/AFEXTDS	S_{dc31}, S_{dcx1}, S_{ds31}, S_{dsx1} S_{dc32}, S_{dcx2}, S_{ds32}, S_{dsx2}		1 MHz: 43.0 dB 33 MHz: 43.0 dB 50 MHz: 39.4 dB 200 MHz: 27.3 dB

)1 linear axis for dB, linear interpolation for limit value at logarithmic frequency axis

)2 This limit is valid for any WCC implementation related to this document.
For comparison purpose of WCC implementation with specific cables and connector types a 4 – around 1 test setup according to Annex C – can be used.

Table 5 -5: Additional required parameter and limits for Whole Communication Channel configuration (ES)

Annex A - Extended Test Set-up definitions

A.1 Example for Cable Arrangement

The cable under test should be loose wound on a metallic drum with b = 10mm isolation ($\varepsilon_r \leq 1.4$) at drum outside. A loose winding of the CUT is required to avoid a mechanical impact to the cable during the test at low and high temperatures. Each winding should be separated by a minimum of a = 30mm which will eliminate inter-winding coupling for unscreened cables. The ground reference of the used test fixture for connecting the cable under test with the measurement equipment is low impedant shorted to the metallic drum at both ends.

The distance of windings at the drum arrangement is calculated as follows:

$$a = 3 * b$$

with: a distance between single windings of CUT

b thickness of isolation (equal to height above ground reference plane) = 10mm

An example for drum with loose wound unscreened cable is given in Figure A-1.

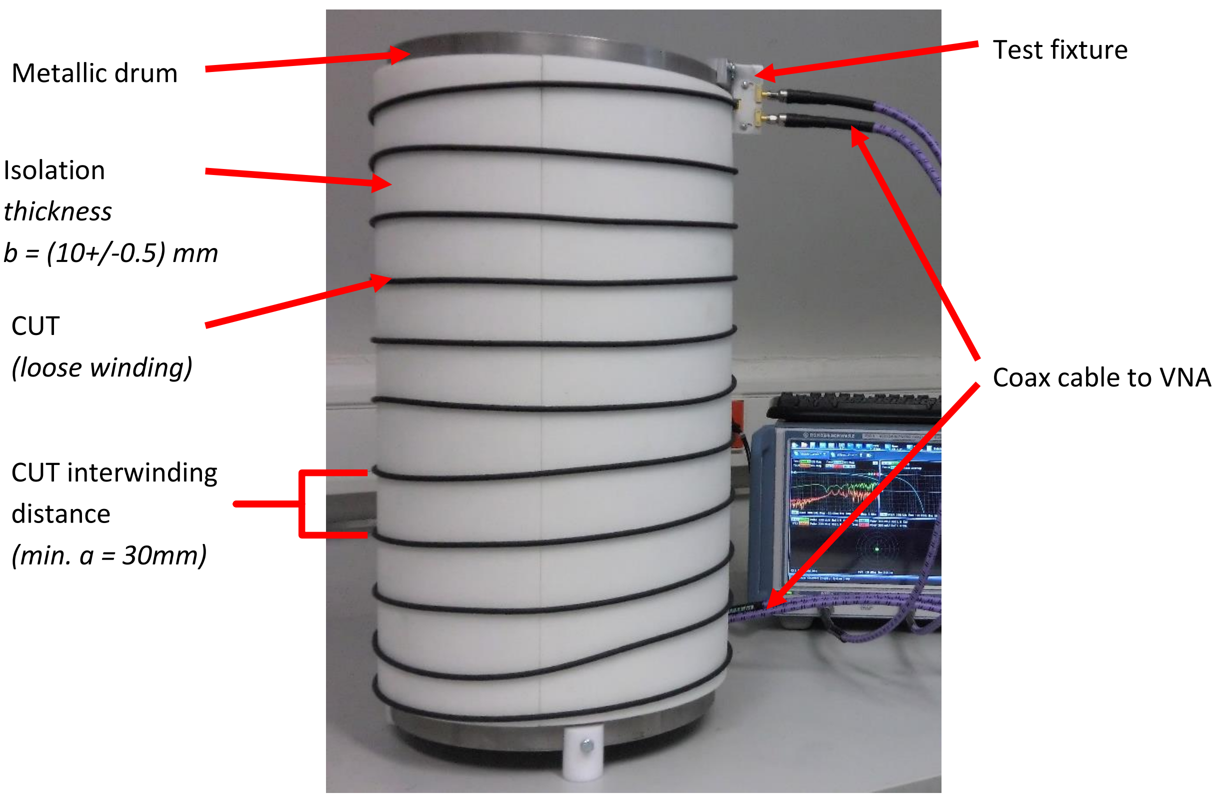


Figure A-1: Example for cable arrangement used for S- Parameter and TDR measurements

A.2 Example for Connector Text Fixture

The connector test fixture must provide an optimal connection of connector terminals with the measurement equipment. In order to avoid parasitic effects at the test fixture a printed circuit board should be used with impedance controlled traces (which should be as short as possible) and RF board connectors. An example for connector test fixture is given in Figure A-2.

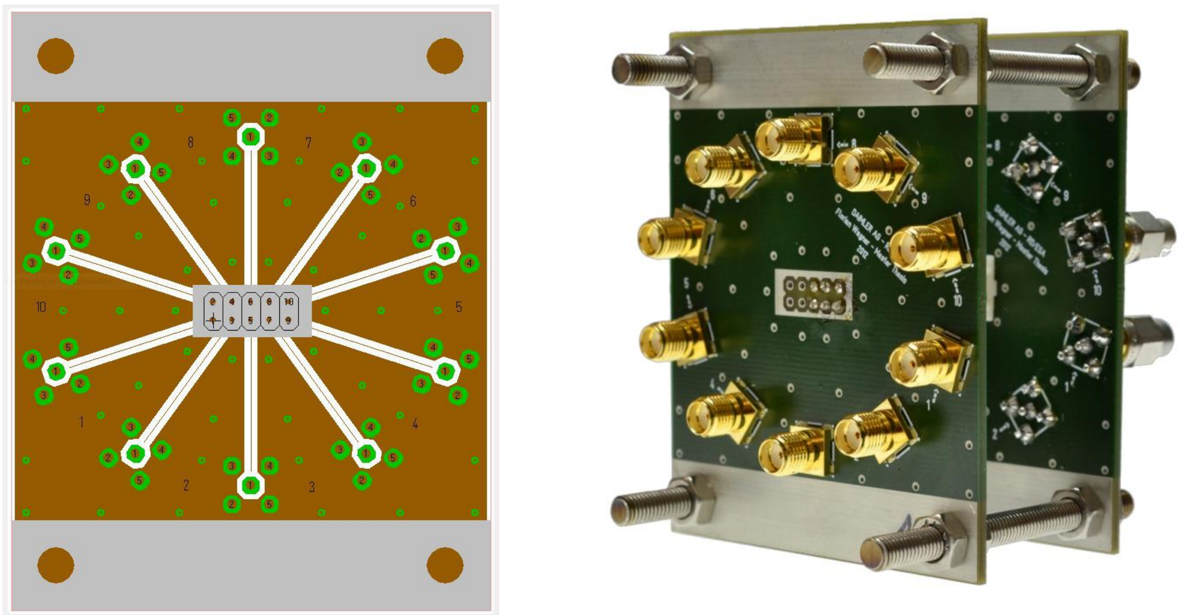


Figure A-2: Example for test fixture for connector evaluation, left top layer, right 3-D picture of connector and two test fixtures

Annex B – Correction Method for TDR Measurements

For long channels the TDR measurement technique may lead to incorrect measuring results. To prevent getting fault results the following correction procedure should be used:

a) TDR measurement from both sides of the investigated channel using system rise time 700 ps
b) If the measured CIDM value increases with a linear slope over length for both particular measurements the correction given below is applicable, otherwise the correction is not allowed.

I. Calculation of slope of measured CIDM function over time at the region of cable:
$S\ (t, CIDM_{measured}(t))$
Note: The impedance of test fixture and ECU connector must be out of focus for this calculation. Possible calculation method: EXCEL function "Slope" or comparable functions at other software tools

II. Correct slope
CIDM1(t) = CIDMmeasured(t) – S * t

III. Getting offset O at the beginning of channel (t = tDUT0)
O = CIDMmeasured (tDUT0) - CIDM1(tDUT0)
Note: Needed to avoid correction of slope in measurement cables used for connection the TDR measuring equipment with the test fixture

IV. Correct offset
$CIDM_{corrected}$ (t) = CIDM1(t) + O

The limit is valid for $CIDM_{corrected}$ (t). Both results for $CIDM_{measured}$ (t) and $CIDM_{corrected}$ (t) must be given in the resulting diagram. An Example of correction results is given in Figure B-1.

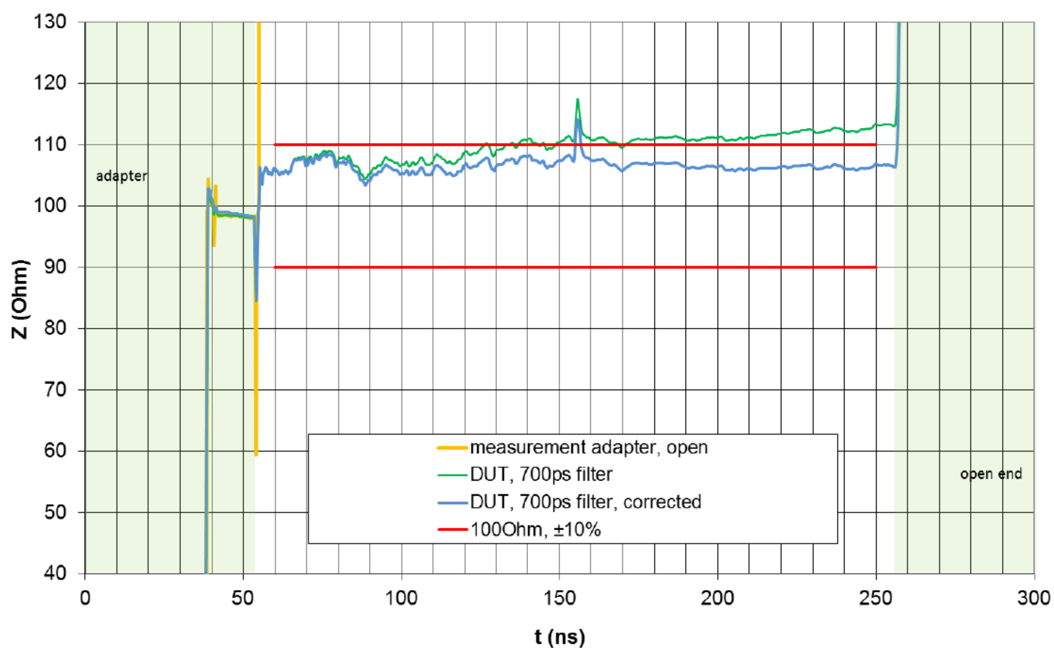


Figure B-1: Example for correction of TDR measurement results for long communication channels

Annex C – Definitions for Alien Crosstalk Setup 4 – around - 1

C.1 Test configuration

The test configuration consists of uncoiled five link segments as shown in Figure C-1. Multiport test fixtures shall be used for multiport link segments.

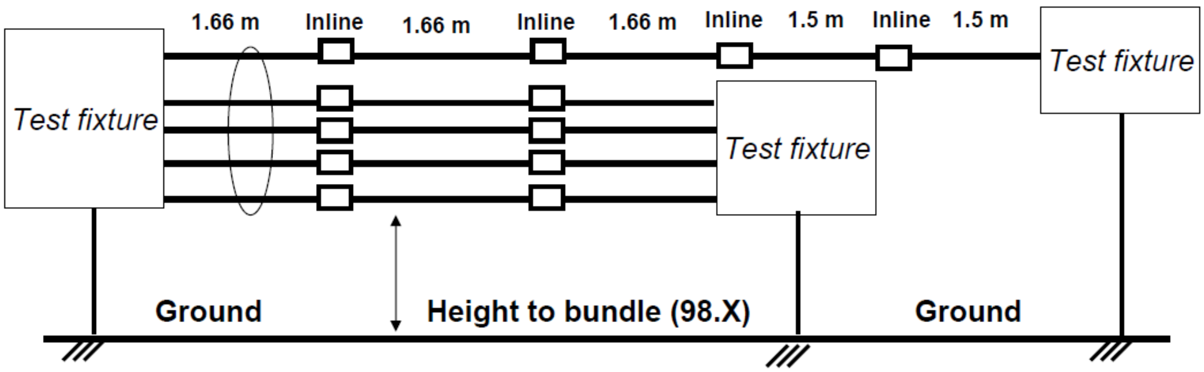


Figure C-1: Test configuration for Alien crosstalk measurements at a 4 – around – 1 link arrangement

C.2 Definition for Cable Bundle

The cable bundle shall be placed on dielectric insulation material ($\varepsilon_r \leq 1.4$) of at (10 +/- 0.1) mm height over conducting ground plane. The cables have to be placed within the alien crosstalk test configuration in a 4 – around - 1 configuration as shown in Figure C-2. The cables should be fixed in their position by means of cable straps or adhesive tape to keep the cables attached together with a maximum distance between the fixation devices of 30 cm. Cable 2 is defined as victim pair for power sum analysis.

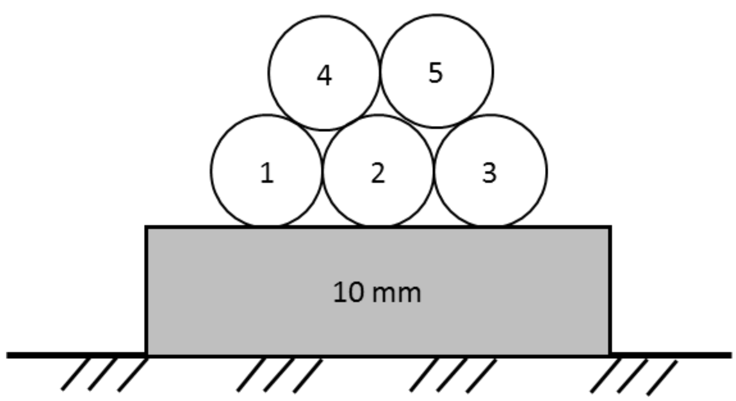


Figure C-2: Cross section of cable bundle

C.3 Test setup

In general the WCC test setup according to Figure 4-4 should be used. The 4 – around - 1 cable bundle should be placed on the (10 +/-0.1) mm isolation support. If it is necessary to split up the wiring harness at the end of the bundle in order to accommodate the measurement fixtures, the length of the area split up is limited to maximum of 30 cm. Unused wires of the UTP cable have to be terminated with a single ended impedance of 50 Ω. The measurement fixtures have to be connected to the reference ground plane by means of conducting stands, copper-braid or –foil.