E3NETWORK

Energy Efficient E-band transceiver for backhaul of the future networks

DELIVERABLE D5.1

Report describing the testbed architecture, specification and planning

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EXECUTIVE SUMMARY

After the integration of the E3NETWORK transceiver done in WP4, WP5 focuses on the definition of an appropriate testbed architecture and test planning, in order to constitute a complete demonstrator of the project and validate it in real network conditions. In particular, deliverable D5.1 provides a detailed description of the specification compliance testing, conducted by ALU/NOKIA, required for the system to be considered a commercial one. It also specifies the architecture of the testbed and technical test plan of the final prototype, so that the transceiver can be connected to OTE's network, measured and compared against anticipated performances. Included tests address the general objective of the project, along with different sub-objectives of the DoW.

Task T5.1 is based on inputs from WP1 requirement deliverable and WP4 hardware deliverable. The proposed validation in D5.1 is divided in two parts. The first part consists of conformance testing for Point-to-Point (P2P) equipment according to ETSI Harmonised standard and others tests considered necessary for a complete assessment. Relevant criteria include BER at different Receiver signal level and other system characteristics such as spectral mask and spurious emissions. The second part of the validation process comprises of prototype integration in the network, and performance assessment against network related criteria.

ACRONYMS AND ABBREVIATIONS

For the purposes of the present document, the following abbreviations apply:

ADC	Analogue to Digital Converter
ATPC	Automatic Transmit Power Control
BB	Baseband
BBER	Background BER
BER	Bit Error Rate
BNG	Broadband Network Gateway
BWe	evaluation BandWidth
CE	Conformité Européenne
CEPT	European Conference of Postal and Telecommunications Administrations
C/I	Carrier to Interference
CC	Co-channel
CN	Core Network
CoS	Class of Service
CPE	Customer Premises Equipment
CPU	Central Processing Unit
CR	Complementary Requirement
CS	Channel Spacing
CT	Conformance Test
CW	Continuous Wave
Db	decibel
dBi	decibel isotropic
dBm	decibel-milliwatts
dBW	decibel watt
DFRS	Digital Fixed Radio Systems
DIA	Dedicated Internet Access
DoW	Description of Work
DSCP	Differentiated Services Code Point
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DRRS	Digital Radio Relay Systems
DTU	Data Transmission Unit
EMC	ElectroMagnetic Compatibility
EN	European Norm
ER	Essential Requirement
ERC	European Radiocommunications Committee
ETS	European Telecommunication Standard
ETSI	European Telecommunications Standards Institute
Ext.	Extreme conditions
FDD	Frequency Division Duplex
FP7	7^{th} Framework Program
GbE	Giga-bit Ethernet
HEN	Harmonised European Standard
HG	Home Gateway
Hz	Hertz
ID	Identifier
IF	Intermediate Frequency
IGMP	Internet Group Management Protocol
iMIX	Internet Mix
IP	Internet Protocol
IPTV	Internet Protocol Television
IUT	Implementation Under Test
LAN	Local Area Network
LO	Local Oscillator
Max.	Maximum

Min.	Minimum
MTU	Maximum Transmission Unit
Nom.	Nominal
NSG	Net System Gain
OR	Optional requirement
P2P	Point-to-Point
PC	Personal Computer
PE	Provider Edge
PPP	Point to Point Protocol
PPPoE	Point to Point Protocol over Ethernet
QoS	Quality of Service
Ref	Reference conditions
RF	Radio Frequency
RFC	Radio Frequency Channel
RSL	Received Signal Level
RTPC	Remote Transmit Power Control
R&TTE	Radio & Telecommunication Terminal Equipment
Rx	Receiver
SD	Supplier Declaration
SFP+	Enhanced Small Form-Factor Pluggable
STB	Set Top Box
STC	Spirent Test Centre
TMN	Telecommunications Management Network
TR	Technical Report
TR	Test Required
TTE	Telecommunication Terminal Equipment
TV	Television
Tx	Transmitter
VLAN	Virtual Local Area Network
WP	Working Package
WR	World Radiocommunications
XPIC	Cross-Polar Interference Canceller

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1. INTRODUCTION

This deliverable describes the testbed architecture, specification and planning of the transceiver demonstrator integrated in WP4. The initial testing of the demonstrator performed in D4.2 is complemented here in a more comprehensive and consistent way, in order to assess the system capability to be put on the market. Within WP%, Deliverable D4.1, which contains a detailed hardware description, is used as a manual to operate the demonstrator. The later consists of one receiver (Rx) unit and two identical transmitter (Tx) units, allowing just unidirectional configuration instead of FDD arrangement.

Section 2 outlines the R&TTE compliance tests and the tests to be conducted with prototype by ALU/NOKIA. Section 3 outlines the network tests to be conducted by OTE, in order to analyze the demonstrator's capability to transport traffic.

Figures 1 and 2 provide an overview of the transceiver demonstrator, as this was presented in D4.2.

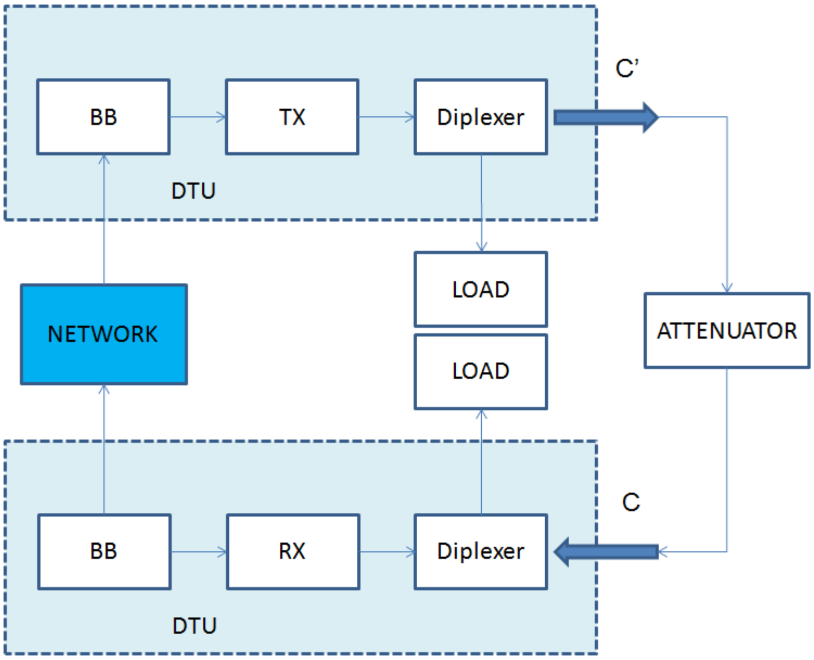

Figure 1: Simplified block diagram of the overall transceiver demonstrator

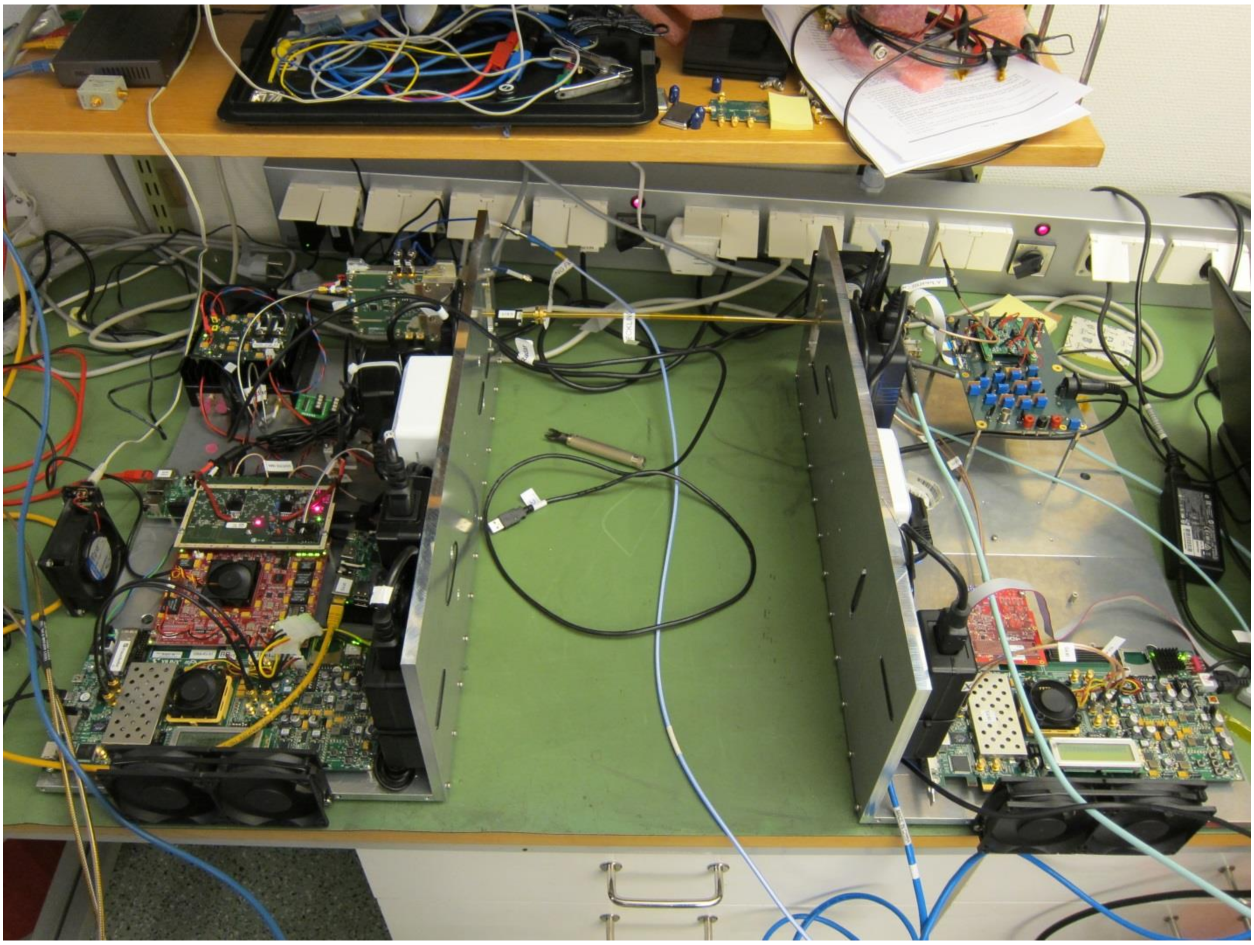

Figure 2: Photo of the overall transceiver demonstrator

2. VALIDATION TEST

2.1 Overview

This chapter presents a list of the tests that are usually carried out over a real product before it is placed on the market. The tests defined in this chapter have two main scopes: The first is to obtain the CE mark, and for this task, we have to assess the system to the mandatory test foreseen in the relevant harmonised standard, ETSI HEN 302 217 2-2. The second scope is to prove to the customer, that the equipment under test is able to work as intended. Then, in this second point, we have to test the prototype to verify the main objective defined at the beginning of the project. Finally, Sections 2.2.10 and 2.2.11 summarize the tests to be done with the prototype in WP4 and WP5. In this chapter, the list of the parameters that shall be tested and the relevant limits are based on inputs from mainly WP1 requirement deliverable (D1.2.3).

The tests shall be carried on, in principle, for both Transmitter and Receiver, in the four frequency channels defined in the project and reported below. In this project, the tests shall be carried on only at room temperature.

2.2 Parameters to be tested

In this document there is a section for each parameter and the relevant limits to be tested.

We have divided the parameters at system level, into three main categories:

- ➢ Parameters to be checked in a commercial product as essential requirements under R&TTE (described in Sections 2.2.1 to 2.2.9)
- ➢ E3NETWORK parameters already tested or verified in WP4 (summarized in Section 2.2.10)
- ➢ E3NETWORK parameters to be tested or verified in WP5 (summarized in Section 2.2.11)

All the requirements are reported with:

- The demonstrator part involved
- Its category
- A short description
- The relevant limits, the references and some considerations
- The test bench arrangement for the assessment

2.2.1. Transmitter - Frequency accuracy

This parameter is an essential parameter that has to be checked under the R&TTE certification. This parameter is essential for the Tx side and it is usually reported as Radio frequency tolerance.

The objective of this test is to verify that the Tx output frequency is within the limit. The limit that shall be fulfilled is reported into the relevant ETSI HEN 302 217-2-2 and is also reported in our limits in D.1.2.3 as mandatory requirement, but not applicable to the prototype.

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu050]	M	Radio Frequency tolerance	±50	ppm	TX	No

Table 1: Radio frequency tolerance requirements

The preferred method is to use a frequency counter capable of measuring the centre frequency of a modulated signal. Therefore, the transmitter has to be placed in the CW condition. When this type of counter is not available the LO frequency is to be measured and the output frequency is to be calculated using the relevant formula from the manufacturer. Where practical, frequency accuracy measurements are to be conducted at the lowest, mid-band and highest channel of the unit under test.

- **Test instruments:**
  - Frequency Counter.
- **Test bench configuration:**

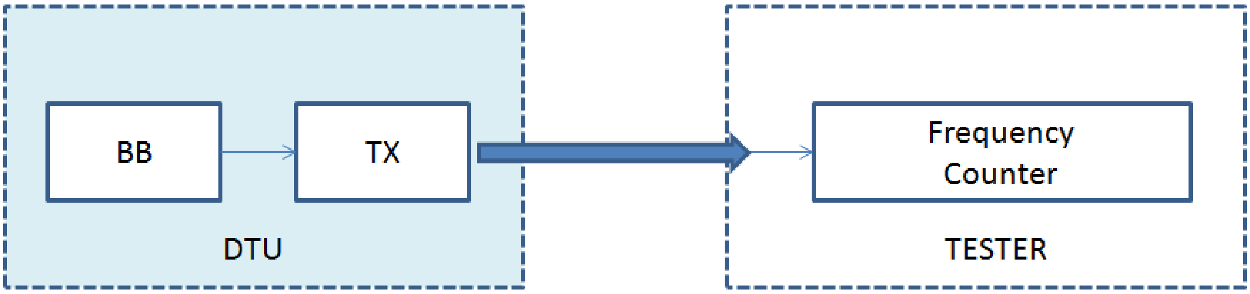

Figure 3: Frequency accuracy test bench

Diplexer can be included or not, since it has no effect on this parameter.

- **Test procedure:**

The Tx is to be operated in the CW condition and frequency measurements conducted on the channel previously selected. The measured frequency is to be within the tolerance requested.

This parameter will be not tested, because it depends to the Tx Local Oscillators stability. Provided that the Tx local oscillators stability fulfil this requirement, the Tx signal will fulfil it as well.

2.2.2. Transmitter – Transmitter power Level

This parameter is an essential parameter that has to be checked under the R&TTE certification. This parameter is essential for the Tx side and consists of at least two parts reported as Nominal transmitter output power and its tolerance.

Objective of this test is to verify that the maximum Nominal output average power measured at reference point C' is within the following limits:

- Nominal transmitter output power, subject to the supplier declaration
- Tolerance reported into the relevant ETSI HEN 302 217-2-2

These limits are reported in D.1.2.3 as mandatory requirements.

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu044]	M	Tx Operating power(min)	9.5	dBm	TX	Yes
[ReqEqu045]	M	Tx Power Tolerance	±3	dB	TX	No

Table 2: Transmitter power Level requirements

➢ **Test instruments:**

1) power meter;
2) power sensor.

➢ **Test configuration:**

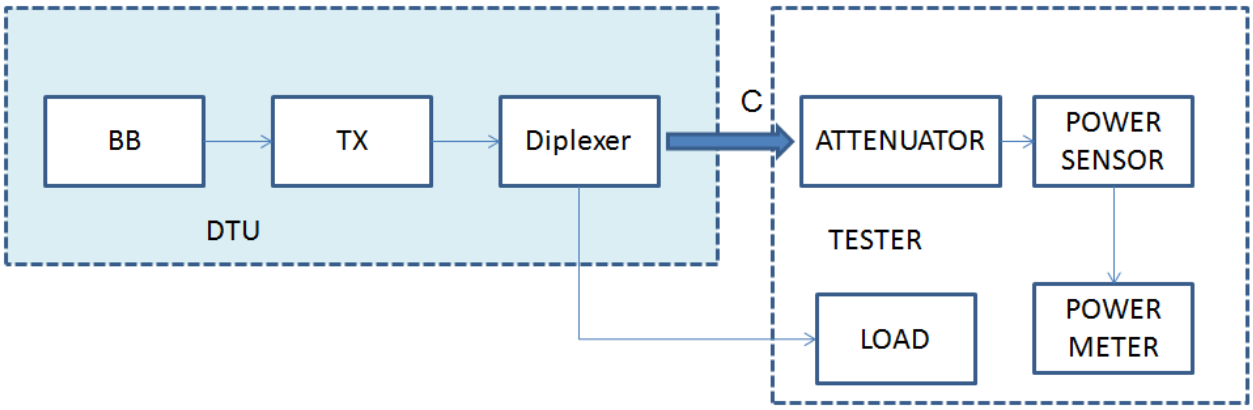

Figure 4: Transmitter power and tolerance test bench

- **Test procedure:**

With the transmitter power level set to maximum the average power output of the transmitter at point C' is to be measured. Full account shall be taken of all losses between the test point and power meter.

Regarding the nominal transmitter output power, its limits will depend on the RSL we will obtain in our receiver part. The figure here provided is related to the maximum value the Transmitter has to fulfil in case the Receiver will fulfil the minimum requirement defined according to ETSI rules. In case the receiver will perform better, this figure, in principle can be relaxed accordingly, to reach the scope of E3NETWORK.

As reference, during the measurement phase, we will take the best value we can obtain.

2.2.3. Transmitter - RF spectrum mask and Spectral lines at the symbol rate

This parameter is an essential parameter that has to be checked under the R&TTE certification. This parameter is essential for the Tx side.

The measurement shall be made with a suitable spectrum analyser connected to the transmitter port via a suitable attenuator. Where practical, RF spectrum mask measurements are to be conducted at the lowest, mid-band and highest channel of the unit under test.

Objective of this test is to verify that the output frequency spectrum is within the specified limits of the relevant standard. These limits are usually divided into the following parameters to be met:

- Transmitter Spectrum Mask [class 5L]
- Discrete CW components exceeding the spectrum mask limit at symbol rate
- Other discrete CW components exceeding the spectrum mask limit

We have reported our limits in D.1.2.3 as mandatory requirement.

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu046]	M	Discrete CW components exceeding the spectrum mask limit at symbol rate	37	dB	TX	Yes
[ReqEqu047]	M		43	dB	TX	Yes
[ReqEqu048]	M	Other discrete CW components exceeding the spectrum mask limit	11	dB	TX	Yes
[ReqEqu051]	M	5LA	3	dB	TX	Yes
			-10	dB		
			-31	dB		
			-45	dB		
			-45	dB		

Table 3: RF spectrum mask and Spectral lines at the symbol rate requirements

As alternative limits for the spectrum mask we have identified the following. The differences are mainly on:

- The alternative spectrum mask is less demanding than the above.
- The alternative spectrum mask limits are in absolute value instead of relative limits.
- System fulfilling only the alternative spectrum mask cannot be deployed only in particular cases, the market interest for such a system is limited a lot.

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu121]	M	2 and above	-25	dBW/MHz	TX	Yes
			-30	dBW/MHz		
			-45	dBW/MHz		
			-45	dBW/MHz		
			-65	dBW/MHz		
			-75	dBW/MHz		

Table 4: Alternative RF spectrum mask requirements

- **Test instruments:**

1) spectrum analyser;
2) plotter
3) attenuator (if necessary)

- **Test configuration:**

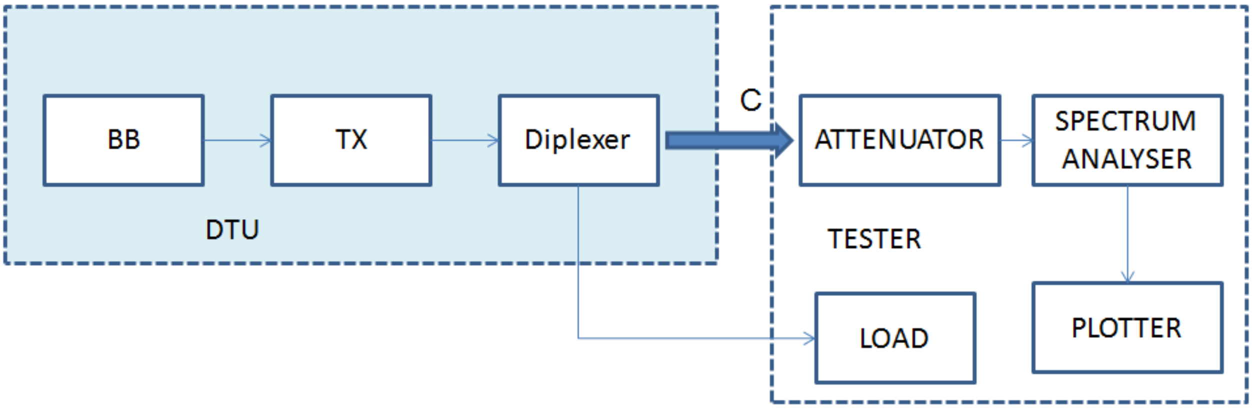

Figure 5: RF spectrum mask and Spectral lines at the symbol rate test bench

- **Test procedure:**

The transmitter output port shall be connected to either a spectrum analyser via an attenuator or an artificial load with some means of monitoring the emissions with a spectrum analyser. The spectrum analyser shall have a variable persistence display or digital storage facility. The resolution bandwidth, frequency span, scan time and video filter settings of the spectrum analyser are to be set in accordance with the relevant standard.

With the transmitter modulated by a signal having the characteristics given in the relevant standard, the Tx power density shall be measured by the spectrum analyser and plotted. Where possible, transmitter spectral power density plots at the lowest, mid-band and highest channels are to be recorded.

2.2.4. Transmitter - Spurious Emissions (external)

This parameter is an essential parameter of the transmitter that has to be checked under the R&TTE certification. Objective of this test is to verify that any spurious emissions generated by the transmitter are within the limits quoted in the relevant standard. Spurious emissions are emissions outside the bandwidth necessary to transfer the input data at the transmitter to the receiver, whose level may be reduced without affecting the corresponding transfer of information.

Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products.

The frequency range to be considered for Spurious emissions-external is the band outside +/- 250% of the relevant Channel spacing (CS) respective to the central frequency.

The limit that shall be fulfilled is reported into the relevant ETSI HEN 302 217-2-2, but it is derived from the more general CEPT/ERC Recommendation 74/01. We have reported these limits in our D.1.2.3 as mandatory requirement.

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu049]	M	Spurious Emission External	-30/-50	dBm/MHz	TX	Yes

Table 5: TX spurious emission requirements

- The -50 dBm/MHz limit is applied to all the spurious emissions with a frequency lower than 21.2 GHz. Above this frequency, the limit is -30 dBm/MHz
- This parameter is asked for the RX parts as well

➢ **Test instruments:**

1) Spectrum analyser;
2) plotter

- **Test configuration:**

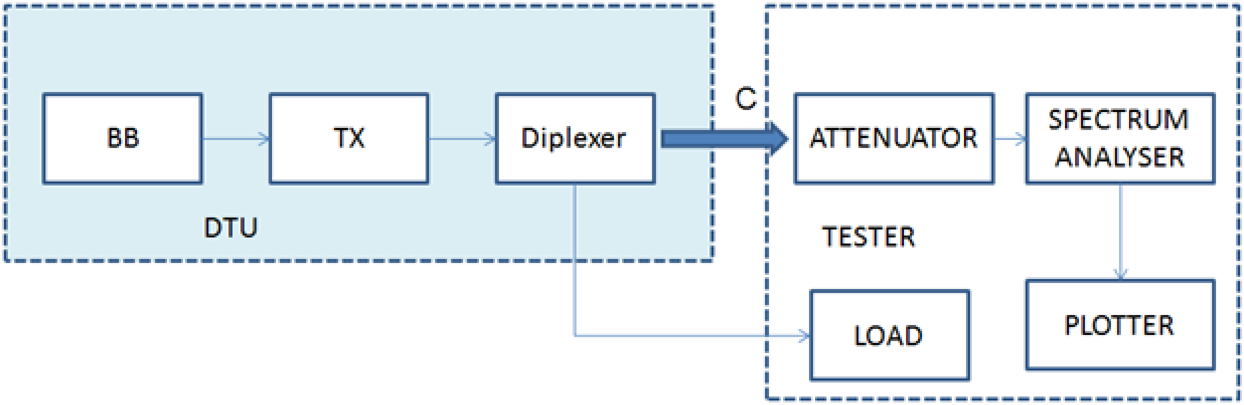

Figure 6: TX Spurious emission rate test bench

- **Test procedure:**

The transmitter output port shall be connected to either a spectrum analyser via a suitable attenuator and/or notch filter to limit the power into the front end of the analyser. In some cases, where the upper frequency limit exceeds the basic operating range of the analyser, suitable waveguide transitions and mixer will be required. It is important that the circuit between the transmitter and the input to the mixer, or spectrum analyser, is characterized over the frequency range to be measured. These losses should be used to set the limit line of the analyser to a value which ensures that the specification criteria at point C' is not exceeded.

The transmitter is to be operated at the manufacturers maximum rated output power and the level and frequency of all significant signals are to be measured and plotted throughout the frequency band quoted in the relevant specification. It is recommended that each scan be taken in 5 GHz steps below 21.2 GHz and 10 GHz steps above 21.2 GHz. However, spurious emissions close to the limit should be plotted over a restricted range which clearly demonstrates that the signal does not exceed the relevant limit.

2.2.5. Transceiver - BER as a function of Receiver input Signal Level (RSL)

This parameter is an essential parameter that has to be checked under the R&TTE certification. This parameter is essential for the whole transceiver, checking the Tx and Rx functionalities.

This parameter is usually reported as Bit Error Rate (BER) as a function of receiver input signal level (RSL). The diplexer filter shall be considered part of the Receiver, and the relevant losses shall be accounted.

This parameter is the only system parameter at the receive site, which enables to assess the co-channel rejection and the adjacent selectivity parameters.

Objective of this test is to verify that received signal level versus BER thresholds is verified.

The limit that shall be fulfilled for this parameter is usually reported into the relevant ETSI HEN 302 217-2-2, but in our specific case, this limit is derived as explained in D1.2.3, since our profile is not yet foreseen in current ETSI standard.

Requirement ID	Traceability	Category	Class	Bandwidth (GHz)	Modulation	BER	Sensitivity (dBm)	Transceiver Element	Prototype applicability
[ReqEqu083]	[ReqEqu017] [ReqEqu021]	M	5LA/5LB	2	64QAM	10^-6	-42,50	RX	Yes
[ReqEqu084]	[ReqEqu017] [ReqEqu021]	M	5LA/5LB	2	64QAM	10^-10	-38,50	RX	Yes

Table 6: BER as a function of RSL requirements

- **Test instruments:**

1) Power sensor and meter;
2) pattern generator/error detector;
3) Attenuator.

- **Test configuration:**

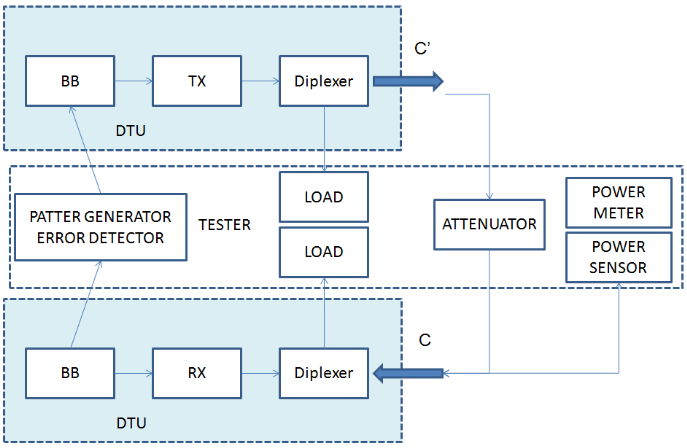

Figure 7: BER as a function of RSL test bench

- **Test procedure:**

Connect the pattern generator/error detector input to the Tx input signal connector (Tx Network interface) and the relevant pattern generator/error detector output to the RX output signal connector (Rx Network Interface).

Then take record of BER curve by varying the received field using the attenuator. Verify that the RSL, corresponding to the BER thresholds are within the specifications.

In the scope of E3NETWORK, we have not defined for the demonstrator the upper limit for the input level, but just the lower limit.

The limit we have derived by extrapolating the current ETSI RSL limits shall be considered the maximum RSL the demonstrator shall require to perform at BER better than 10^{-6}. Fulfilling this limit is mandatory to obtain the R&TTE certification and then the CE mark, enabling the system to become a real commercial product.

2.2.6. Transceiver - Co-channel interference sensitivity- external

This parameter is an essential parameter that has to be checked under the R&TTE certification. This parameter is essential for the whole transceiver, checking the Tx and Rx functionalities.

This parameter is usually reported as "*External*" Co-channel interference sensitivity. This parameter is required to define the amount of frequency reuse still assuring the required QoS for fixed radio. Therefore, this parameter is mandatory to ensure the efficient use of the spectrum.

Objective of this test is to verify that the BER of the receiver under test remains below the relevant specification limit in the presence of an interfering like modulated signal on the same channel. The signal levels of the wanted and interfering signals at point C shall be set at the levels given in the specification.

The limit that shall be fulfilled is reported into the relevant ETSI HEN 302 217-2-2. We have as well reported these limits in D.1.2.3 as mandatory requirement

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu073]	M	Co-channel "external" interference sensitivity	33,5@1dB	dB	RX	No
			29,5@3dB	dB		

Table 7: Co-Channel external interference sensitivity requirements

It has been reported as not applicable to the prototype, but this was a typo in the report.

- **Test instruments**
  1) Pattern generator/error detector
  2) power sensor and meter
- **Test configuration:**

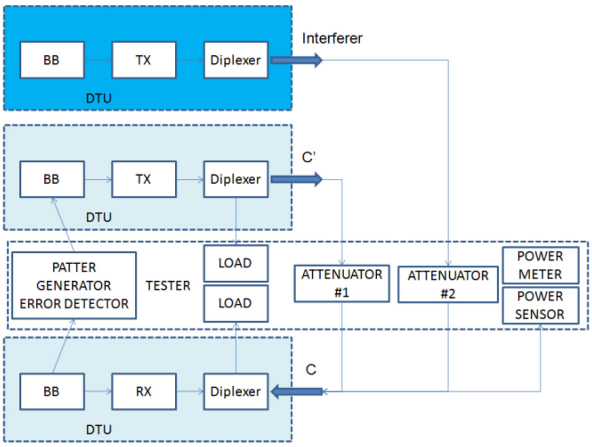

Figure 8: Co-channel interference sensitivity test bench

- **Test procedure:**

During this test both transmitters shall transmit on the same channel and be modulated with signals that have the same characteristics.

Connect power meter at point C of the Rx. Switch on Tx under test (or wanted signal) and adjust attenuator 1 to set the wanted signal to the level required by the standard for BER 10^{-6}. Decrease attenuator 1 by 1 dB (or 3 dB) and record its setting.

Switch on the Tx interferer (or unwanted signal) and reduce attenuator 2 to achieve a BER of 10^{-6} (or 10^{-3}) on the error detector.

Switch both transmitters off, record the setting of attenuator 2. Switch Tx under test on and reduce attenuator 1 to produce a wanted signal level within the calibrated range of the power meter to record the power level and reduction in attenuation.

- Calculate $Power_{wanted\ signal}$ = Measured power level - change in attenuation.
- Switch off Tx. 1, switch on Tx. 2 and repeat the procedure to calculate the $Power_{unwanted\ signal}$.

The maximum co-channel C/I value for 1 dB or 3 dB degradation on 10^{-6} or 10^{-3} is:

- $C/I = Power_{wanted\ signal} - Power_{unwanted\ signal}$

This test is possible only if a second transmitter chain is provided.

2.2.7. Transceiver - Adjacent channel selectivity

This parameter is an essential parameter that has to be checked under the R&TTE certification. This parameter is essential for the whole transceiver, checking the Tx and Rx functionalities.

This parameter is usually reported as Adjacent channel interference sensitivity. This parameter is required for frequency coordination among different links. It defines the amount of frequency separation or the amount of geographical separation for adjacent channel, still assuring the required QoS for the link. Therefore, this parameter is mandatory to ensure the efficient use of the spectrum.

Objective of this test is to verify that the BER of the receiver under test remains below the relevant specification limit in the presence of an interfering like modulated signal on the adjacent channel. The signal levels of the wanted and interfering signals at point C shall be set at the levels given in the relevant specification.

The limit that shall be fulfilled is reported into the relevant ETSI HEN 302 217-2-2. We have as well reported these limits in D.1.2.3 as mandatory requirement

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu074]	M	Adjacent channel interference sensitivity	3@1dB	dB	RX	No
			-1@3dB	dB		

Table 8: Adjacent channel interference sensitivity requirements

- **Test instruments**
  1) Pattern generator/error detector
  2) power sensor and meter
- **Test configuration:**

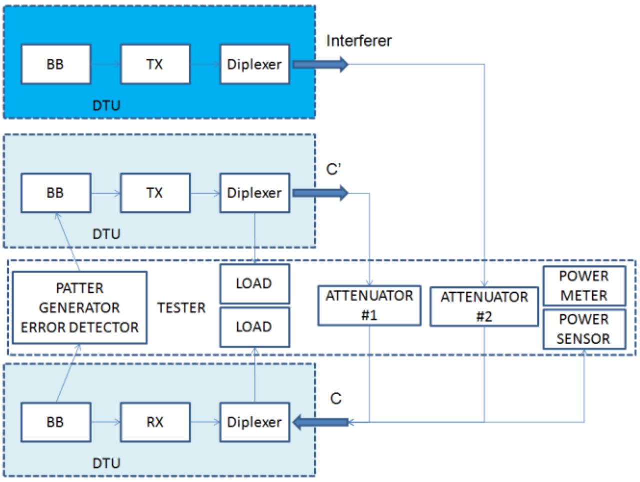

Figure 9: Adjacent-channel interference selectivity test bench

- **Test procedure:**

During this test the interferer transmitter (Unwanted signal) shall transmit on the adjacent channel respective to the channel used by the wanted signal and be modulated with signals that have the same characteristics.

Connect power meter at point C of the Rx. Switch on Tx under test (or wanted signal) and adjust attenuator 1 to set the wanted signal to the level required by the standard for BER 10^{-6}. Decrease attenuator 1 by 1 dB (or 3 dB) and record its setting.
Switch on the Tx interferer (or unwanted signal) and reduce attenuator 2 to achieve a BER of 10^{-6} (or 10^{-3}) on the error detector.
Switch both transmitters off, record the setting of attenuator 2. Switch Tx under test on and reduce attenuator 1 to produce a wanted signal level within the calibrated range of the power meter to record the power level and reduction in attenuation.

- Calculate $Power_{wanted\ signal}$ = Measured power level - change in attenuation.
- Switch off Tx. 1, switch on Tx. 2 and repeat the procedure to calculate the $Power_{unwanted\ signal}$.

The maximum co-channel C/I value for 1 dB or 3 dB degradation on 10^{-6} or 10^{-3} is:

- $C/I = Power_{wanted\ signal} - Power_{unwanted\ signal}$

This test is possible only if a second transmitter chain is provided.

2.2.8. Transceiver - CW spurious interference

This parameter is an essential parameter that has to be checked under the R&TTE certification. This parameter is essential for the whole transceiver, checking the Tx and Rx functionalities. This parameter is relevant for showing the receiver capability of supporting interference at frequencies far away from the adjacent channel.

Objective: this test is designed to identify specific frequencies at which the receiver may have a spurious response e.g. image frequency, harmonic response of the receive filter, etc. The frequency range of the test and the limits to be fulfilled is reported into the relevant ETSI HEN 302 217-2-2. We have as well reported these limits in D.1.2.3 as mandatory requirement.

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu072]	M	CW spurious interference	30	dBc	RX	Yes

Table 9: CW spurious interference requirements

- **Test instruments**

1) Pattern generator/error detector
2) power sensor and meter
3) CW signal generator

- **Test configuration:**

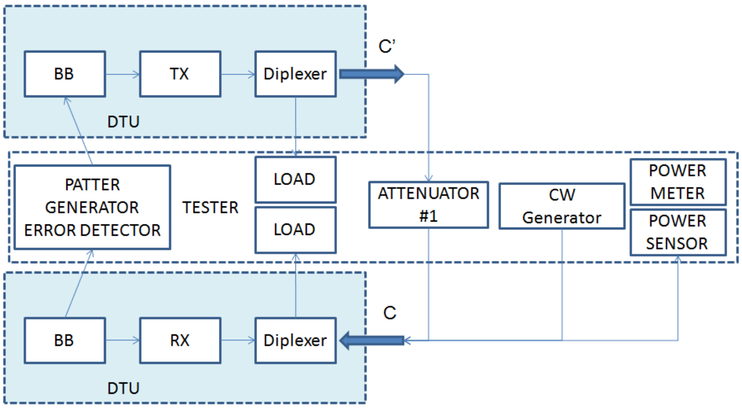

Figure 10: CW spurious interference test bench

- **Test procedure:**

With the CW signal generator output turned off, measure the transmitter RF output power at point C using a suitable power sensor, with a known level of attenuation. Replace the power sensor with the receiver under test, and increase the level of attenuation until the level required by the standard is measured. Record the BER for this receiver level (dBm) where applicable.

Switch off the transmitter and replace the receiver under test with a power sensor. Calibrate the signal generator across the frequency range required by the standard at a level x dB above the level (dBm), where x is the required increase in level for the interfering CW signal.

Replace the power sensor with the receiver under test and confirm the BER level has not changed. Sweep the signal generator through the required frequency range at the calibrated level, taking into account any exclusion band stated in the relevant EN/ETS.

Any frequencies which cause the BER to exceed the level stated in the standard shall be recorded. It is recommended that the calibration be rechecked at these frequencies.

2.2.9. Receiver - Spurious emissions

This parameter is an essential parameter has to be checked under the R&TTE certification. This parameter is essential for the Receiver part only, even if a similar test is required for the Transmitter part as well. This parameter is usually reported as Spurious emissions-external, to identify the spurious emission limits, when these emissions are outside 250% of the relevant Channel spacing (CS).

The limit to be fulfilled is reported into the relevant ETSI HEN 302 217-2-2, but it is derived from the more general CEPT/ERC Recommendation 74/01. We have as well reported it in our limits in D.1.2.3 as mandatory requirement.

Requirement ID	Category	Parameter	Typ	Units	Transceiver Element	Prototype applicability
[ReqEqu071]	M	Spurious Emission External	-30/-50	dBm/MHz	RX	Yes

Table 10: RX Spurious emission requirements

- The -50 dBm/MHz limit is applied to all the spurious emission with a frequency lower than 21.2 GHz. Above this frequency, the limit is -30 dBm/MHz.

➢ **Test instruments:**

1) Spectrum analyser;
2) plotter

➢ **Test configuration:**

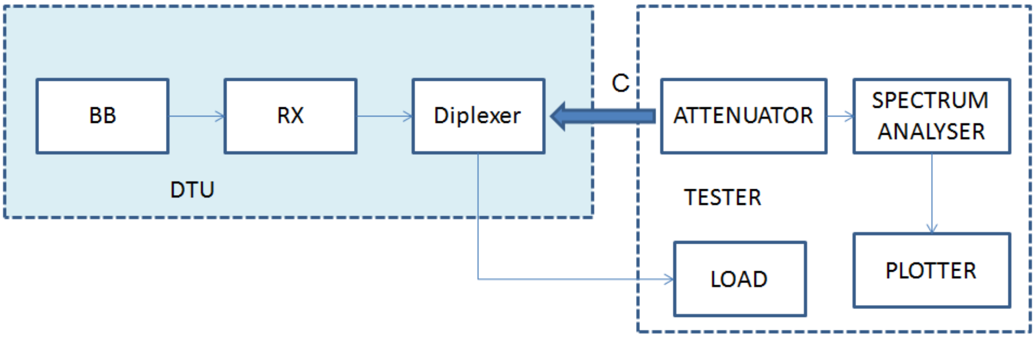

Figure 11: RX Spurious emissions test bench

➢ **Test procedure:**

The Receiver output port shall be connected to a spectrum analyser. In some cases, where the upper frequency limit exceeds the basic operating range of the analyser, suitable waveguide transitions and mixer will be required. It is important that the circuit between the transmitter and the input to the mixer, or spectrum analyser, is characterized over the frequency range to be measured. These losses should be used to set the limit line of the analyser to a value which ensures that the specification criteria at point C is not exceeded.

The receiver is to be operated as intended. It is recommended that each scan be taken in 5 GHz steps below 21.2 GHz and 10 GHz steps above 21.2 GHz. However, spurious emissions close to the limit should be plotted over a restricted range which clearly demonstrates that the signal does not exceed the relevant limit.

This parameter is asked for the Tx parts as well.

2.2.10. Transceiver - E3NETWORK parameters already tested or verified in WP4

Here below, the list of parameters subject to supplier declaration. These parameters are already tested or verified in WP4 and are reported here for completeness.

Requirement ID	Category	Parameter	Min	Typ	Max	Unit	Transceiver Element	Prototype applicability
[ReqEqu003]	M	Frequency bands	71-76		81-86	GHz	TX/RX	Yes
[ReqEqu007]	M	TX/RX center Frequency	72,125 82,125		74,875 84,875	GHz	TX/RX	Yes
[ReqEqu010]	M	RF Interface	FDD				TX/RX	Yes
[ReqEqu011]	M	transceiver and network	Ethernet 10 Gbps (10GbE)				TX/RX	Yes
[ReqEqu012]	M	Interface between diplexer and antenna	WR12				TX/RX	Yes

Table 11. E3network parameters #1 - requirements

The capability of the demonstrator to work on the frequency band, in the defined channel spacing is discussed and tested in WP4.

The operation in FDD is not tested here, but is ensured by the results obtained in WP4 by the diplexer filters. As shown in D2.4, the diplexer filter fulfils the limits required.

The network interface is already tested in WP4 as Ethernet 10 Gbps, fulfils this requirement.

The mechanic arrangement of diplexer is confirmed to be WR12.

2.2.11. Transceiver – E3NETWORK parameters to be tested or verified in WP5

In this section, we will summarize the tests to be done WP5 that are considered the most significant tests for the E3Network prototype within those defined in Sections 2.2.1 to 2.2.9. For the transmitter, the **Transmitter power level** (as defined in Section 2.2.2) and the **RF spectrum mask** (as defined in Section 2.2.3) are considered the most significant parameters. For the whole transceiver, the **BER as a function of the RSL** (as defined in Section 2.2.5) is selected as the most significant parameter. Additionally, the **Ethernet packet rate, throughput** and **Latency** should also be provided in WP5. For the measurement of these three parameters, the network test setup defined in chapter 3 will be used.

3. NETWORK TEST

3.1 Assessment process

After the definition of the test plan related to standardization conformance, it is essential for the transceiver demonstrator to be integrated in a real network topology configuration, in order to assess its functionality and performance in network traffic conditions.

The purpose of the test environment is twofold, regarding achievement of project objectives on one hand and examination of possible impact to OTE's services on the other.

3.2 Testbed design

The test will be conducted in OTE's lab environment, by adding the demonstrator transceiver inside the network deployment model that is used to offer a wide range of services to customers, such as IPTV and Internet Feed. Two 25dBi WR12 horn antennas will be used to interconnect the transmitter (Tx) and receiver (Rx) of Figure 12. The transceiver will be connected to the network through its SFP+ interface.

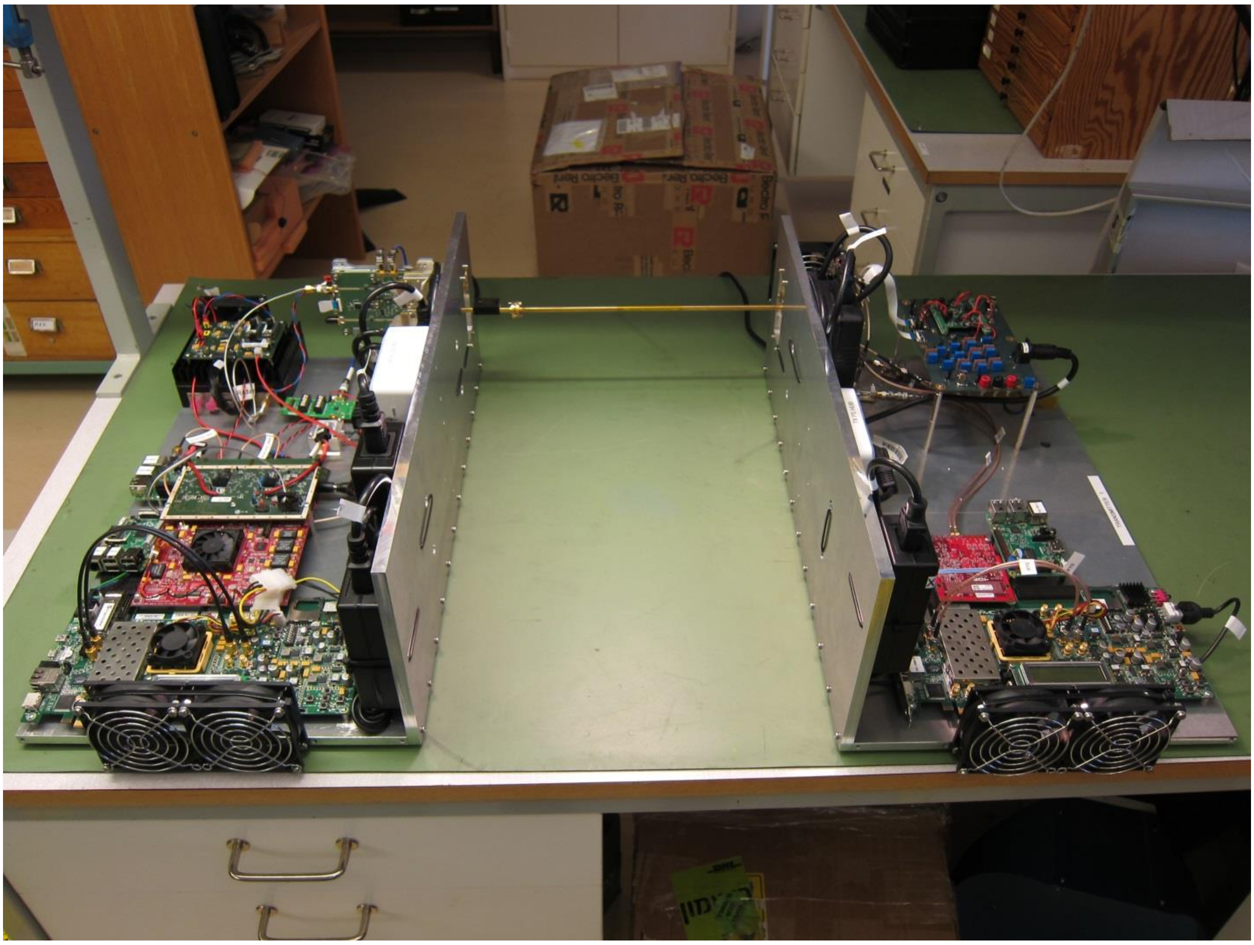

Figure 12: Picture of the E3NETWORK demonstrator to be used

Figure 13 depicts a small picture of OTE's live network.

The CPE (Customer Premise Equipment) represents the triple play service, namely voice (phone), video (Set Top Box) and data (PC). The individual subscriber devices connect to a HG (Home Gateway) over a DSL (Digital Subscriber Line) connection. The HG connects into the nearest DSLAM (Digital Subscriber Line Access Multiplexer), and a switch serves to aggregate traffic from multiple DSLAMs located in different areas. The BNG (Broadband Network Gateway) router is the access point for the subscribers, where PPPoE sessions are terminated. When a connection is established between BNG and CPE, the subscriber can access the broadband services provided by the service provider. BNG connects to OTE's Core network (CN), from where the IPTV platform serves the multicast/unicast content to the subscribers. The PE (Provider Edge) is a router between OTE’s area and areas administered by other network providers.

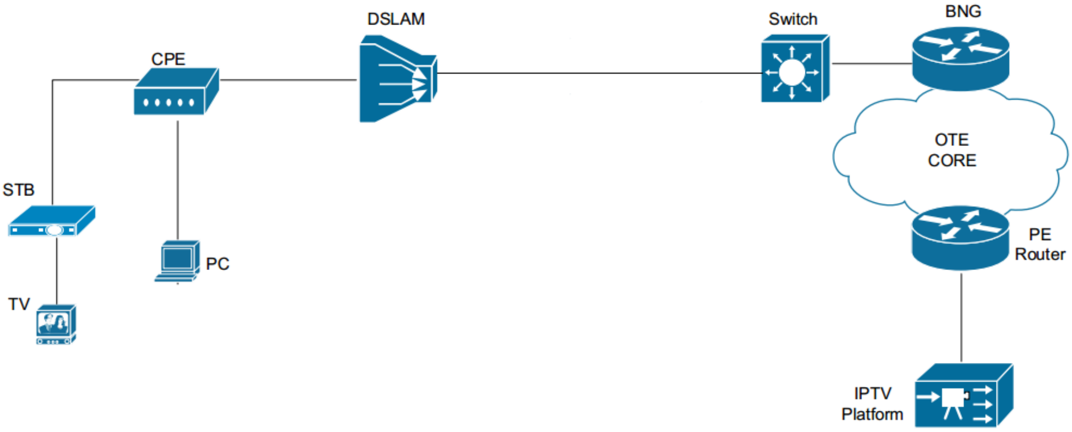

Figure 13: OTE network topology

The transceiver demonstrator is introduced in the path as depicted in Figure 14. The Spirent Test Center (STC) can be connected in different points of the path in order to measure performance characteristics. Spirent Test Center will also be used to introduce high and complex traffic to the network and assess the corresponding behavior of the demonstrator.

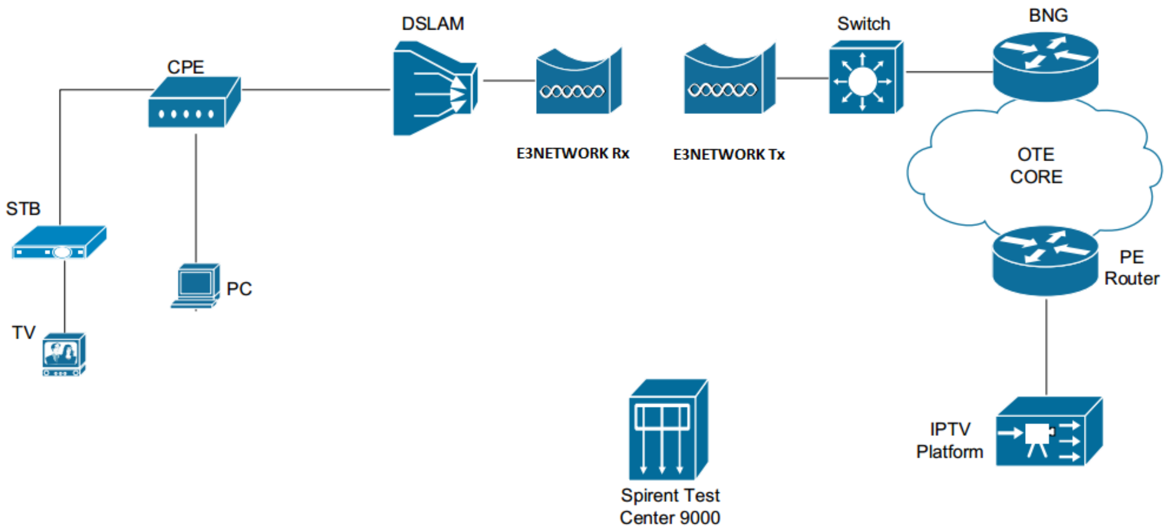

Figure 14: OTE testbed topology with E3NETWORK transceiver

3.3 Testing related to project objectives

Relative to the network testbed are project objectives O1 and O2, concerning respectively throughout and latency. Spirent Traffic Generator and Analysis Tool can enable the creation of completely customized traffic patterns, constructing raw frames and setting specific values for every single field of a frame, such as QoS values, Time to Live parameters, MTU size and so on. Furthermore, customized representation of traffic results is supported, providing statistics and in-depth analysis of the generated traffic.

3.3.1. Throughput testing

"O1. Modern digital multi-level modulation and demodulation methods and novel digital processing methods will be applied. These modern modulation techniques will increase the spectral efficiency of the E-band link providing an augmented backhaul capacity. The project targets a capacity for the wireless link of at least 10 Gbps."

Requirement ID	Category	Parameter	Min	Typ	Max	Unit	Transceiver Element	Prototype applicability
[ReqDoW001]	M	Throughput in each direction (up and down link)		10		Gbps	TX/RX	Yes
[ReqNet021]	M	Ethernet packet rate	710108			Packets/s	TX/RX	Yes
[ReqEqu026]	M	Minimum RIC for class 5L and 2GHz channel	8400			Mbits/s	TX/RX	Yes

Table 12: Throughout – requirements

In the test planning procedure, the link is charged with variable traffic from the traffic generator, up to its maximum capacity.

The achieved throughput is measured to check whether it reaches the anticipated value of 10Gbps as per D.1.2.3 ReqDoW001. This throughout shall be achieved over the air and corresponds to a Raw data rate value of 10.435 Gbit/s, a Net data rate value of 8.669 Gbit/s, according to Table 23 of D1.2.3. Additionally, a minimum RIC of 8.4 Gbits/s shall be achieved according to [ReqEqu026] defined in Table 25 of D1.2.3.

3.3.2. Latency testing

"O2. The developed transceiver will be able to meet the timing requirements of both IP backhauling and CPRI interconnect. Therefore, the latency of the E3NETWORK transceiver will be well below one millisecond."

Requirement ID	Category	Parameter	Min	Typ	Max	Unit	Transceiver Element	Prototype applicability
[ReqDoW004]	M	Latency of the whole system			1	ms	TX/RX	Yes
[ReqNet004]	M	Latency of the whole system			30	us	TX/RX	Yes

Table 13: Latency - requirements

The test planning procedure includes mixed different traffic shapes fed to the experimental setup.

Spirent Test Center is used to provide latency measurements, validate its maximum anticipated value, as per D.1.2.3. ReqDoW004 and ReqNet004 and verify that even the traffic most sensitive to latency is not affected by the demonstrator transceiver.

3.4 Testing related to network stability

Furthermore, in order for the testbed topology of Figure 14 to work without problems, all devices in the path must meet certain requirements regarding delay, jitter, throughput and multicast capability. So, apart from the transceiver requirements' fulfillment, the implementation of the following test scenarios would be of great interest from an operator's point of view. These are optional scenarios for the demonstrator, but will provide us a feedback of the usability of the current prototype.

3.4.1. Capability to transport IPTV traffic

Verification that multicast traffic coming from the IPTV platform passes correctly through the demonstrator transceiver. Verification that IGMP join - and leave- messages are correctly forwarded back and forth.

Spirent Test Center will be used as a traffic generator for testing various types of traffic. The STC can play the role not only of the streamer but also of the CPE. At first it should be tested that the STB can receive correctly the IPTV service of OTE if the E3NETWORK demonstrator is introduced between the DSLAM and the distribution switch. Channel zapping timers can also be measured. OTE services are split in VLANs with each VLAN being a different service. For IPTV VLAN 99 is forwarding Multicast traffic while VLAN 609 is responsible for assigning IP address to the CPE. We should test the capability of the E3NETWORK transceiver to create VLANs needed for each service and be able to transport specific traffic in each of them. So for VLAN 609 broadcasts should be allowed to pass in order for the CPE to retrieve its IP address it is going to use.

3.4.2. Capability to support different traffic patterns

Performance assessment regarding various kinds of traffic patterns, such as small packets, large packets or iMIX traffic.

We will use the STC to generate many kinds of traffic on a specific rate to measure the performance of the E3NETWORK transceiver. Because OTE is using many services in its network we need to make sure that various types of traffic are correctly forwarded. With the STC in place performance counters will be measured along with E3NETWORK demonstrator CPU's consumption. One end of the STC will send the traffic while the other end of the STC will receive it. Traffic patterns that OTE is using for iMIX traffic are 58.33% of small packets with Ethernet frame of 64 bytes, 33.33% of medium packets with frame length of 594 and lastly large packets with frame length of 1518.

3.4.3. Capability to support QoS and prioritization mechanisms

Verification if there is any QoS mechanism that can be implemented on the transceiver. With multiple services exist on OTE's network it is essential to verify that all those services can coexist together without introducing any problems to the end users. These services like Dedicated Internet Access or DIA, IPTV and voice should be able to pass through E3NETWORK demonstrator transceiver without causing problems to the high demanding ones.

STC will be used to send traffic of those services but with different DSCP values or CoS bits that the transceiver should trust. When there is a congestion of the traffic, priority must be given to traffic with higher DSCP or CoS values. If there is no congestion, traffic should be forwarded as expected.

4. CONCLUSIONS

In this deliverable, the necessary testing and validation procedure of the designed demonstrator is specified. D5.1 describes the mandatory tests such a system should pass to confirm standards harmonization and obtain the CE mark.

More specifically in the first part of the deliverable, all the RTT&E compliance tests are detailed after which the prototype demonstrator can be considered as a commercial product. Additionally, a list of parameters to be tested in WP5 is defined, to prove proper functionality of the transceiver and achievement of the project's main objectives.

The second part of the document extends the proposed validation procedure in a real network environment, in order to assess the transceiver's performance against actual traffic conditions. The demonstrator is integrated in a typical network topology, thus, allowing for the use of appropriate monitoring equipment to validate achievement of desired objectives. Finally, some optional tests are proposed to check the usability of the E3Network prototype from the point of view of the operator. In these optional tests, the capability of the prototype to transport IPTV traffic, to support different traffic patterns and to support QoS mechanisms will be analysed.

5. REFERENCES

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