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HARMONISED EUROPEAN STANDARD

Digital Terrestrial TV Transmitters;
Harmonised Standard covering the essential requirements
of article 3.2 of Directive 2014/53/EU

Reference

REN/ERM-TG17-24

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Foreword

This draft Harmonised European Standard (EN) has been produced by ETSI Technical Committee Electromagnetic compatibility and Radio spectrum Matters (ERM), and is now submitted for the combined Public Enquiry and Vote phase of the ETSI standards EN Approval Procedure.

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.3] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.2].

Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	6 months after doa
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Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

The present document has been produced to update the existing standard in line with the requirements of article 3.2 of Directive 2014/53/EU [i.2].

1 Scope

The present document applies to categories of digital terrestrial television transmitter defined according to table 1.1 and table 1.2. The output power classification (table 1.1) and emission classification (table 1.2) are combined to define a transmitter category. For example, power classification H and emission classification 0 denotes a high power transmitter (category H0) whose OOB emissions comply with a non-critical mask.

Table 1.1: Transmitter power classification

Power Class	Description	Notes
H	High power transmitter	Transmitter with an output power ≥ 25W operating in the VHF band (174 MHz to 230 MHz) or UHF band (470 MHz to 694 MHz).
L	Low power transmitter	Transmitter with an output power < 25W operating in the VHF band (174 MHz to 230 MHz) or UHF band (470 MHz to 694 MHz).

Table 1.2: Transmitter emission classification

Emission Classification	Conformance approach	Notes
0	Non critical mask	For high power transmitters, the mask defines the level of the OOB relative to the channel power (dBc). For low power transmitters the mask defines the absolute power limit of the OOB (dBm). The former approach is mandated by RRC-06 (non-critical case) [i.4] for transmitters subject to coordination.
1	Critical mask	A similar but more stringent approach based on RRC-06 (sensitive case).
2	Non-critical ACLR	A set of ACLR limits defining permitted relative emission levels into adjacent channels.
3	Critical ACLR	A set of more stringent ACLR limits defining permitted relative emission levels into adjacent channels.

The present document contains requirements to demonstrate that radio equipment both effectively uses and supports the efficient use of radio spectrum in order to avoid harmful interference.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference/.

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The following referenced documents are necessary for the application of the present document.

[1]   ETSI EN 300 744 (V1.6.2) (10-2015): "Digital Video Broadcasting (DVB); Framing structure, channel coding and modulation for digital terrestrial television".

[2]   ETSI EN 302 755 (V1.4.1) (07-2015): "Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)".

[3]   ETSI TR 100 028-1 (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 1".

[4]   ETSI TR 100 028-2 (V1.4.1) (12-2001): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics; Part 2".

[5]   CENELEC EN 55016-4-2:2004: "Specification for radio disturbance and immunity measuring apparatus and methods. Part 4-2: Uncertainties, statistics and limit modelling - Measurement instrumentation uncertainty".

[6]   Recommendation ITU-R SM.329-12 (09/2012): "Unwanted emissions in the spurious domain".

2.2   Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1]   ETSI TR 101 290 (V1.2.1) (05/2001): "Digital Video Broadcasting (DVB); Measurement guidelines for DVB systems".

[i.2]   Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.

[i.3]   Commission Implementing Decision C(2015) 5376 final of 4.8.2015 on a standardisation request to the European Committee for Electrotechnical Standardisation and to the European Telecommunications Standards Institute as regards radio equipment in support of Directive 2014/53/EU of the European Parliament and of the Council.

[i.4]   ITU RRC-06: "Final Acts of the Regional Radiocommunication Conference for planning of the digital terrestrial broadcasting service in parts of Regions 1 and 3, in the frequency bands 174-230 MHz and 470-862 MHz", Geneva, 15 May - 16 June 2006.

[i.5]   The Paris climate agreement (COP21), December 2015.

NOTE: Available at http://ec.europa.eu/clima/policies/international/negotiations/future/index_en.htm.

3   Definitions, symbols and abbreviations

3.1   Definitions

For the purposes of the present document, the following terms and definitions apply:

adjacent channel leakage ratio: ratio of the wanted mean power of the DVB-T/T2 signal to the unwanted mean power measured in the receiver bandwidth of a given adjacent victim service

antenna port: port of an apparatus intended to be connected to an antenna using coaxial cable or coaxial line; typically the output of the channel filter or combiner

carrier power: mean power supplied to the antenna port by a transmitter with COFDM

channel bandwidth: frequency band of defined width (as a multiple of the carrier grid) for operation on adjacent channels, located symmetrically around carrier frequency in the carrier grid

composite approach: measurement method whereby the power amplifier emissions are measured separately to the frequency response of subsequent frequency selective components and the overall emissions of the transmitter are calculated by combining the two sets of measurements

co-sited: DVB-T/T2 transmitters which are located at the same physical site so minimizing the effects of adjacent channel interference

dBc: decibels relative to the *mean power P* of the emission

digital signal: discretely timed signal in which information is represented by a finite number of well-defined discrete values that its characteristic quantities may take in time

digital television: television in which all information is represented by a digital signal

environmental profile: range of environmental conditions under which equipment within the scope of the present document is required to comply with the provisions of the present document

harmonic: component of order greater than 1 of the Fourier series of a periodic quantity

high power transmitter: transmitter whose conducted output power is greater than or equal to 25 W (this category of transmitter also includes medium power category of transmitters as defined in ITU-R)

intermodulation products: unwanted frequencies resulting from intermodulation between carriers or harmonics of emission, or between any oscillations generated to produce the carrier

low power transmitter: transmitter whose conducted output power is less than 25 W

mean power: average power supplied to the antenna port by a transmitter during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions

moding: operation of a coaxial component in unwanted waveguide modes (e.g. Transverse Electric (TE) or Transverse Magnetic (TM)) resulting in anomalous behaviour from that associated with the intended Transverse Electromagnetic (TEM) mode

necessary bandwidth: for a given class of emission, the width of the frequency band which is sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions

OOB emissions: unwanted emissions which fall at frequencies separated from the centre frequency of the wanted emission by less than or equal to 250 % of the channel bandwidth

output power: conducted power delivered by a transmitter under specified conditions of operation

receiver bandwidth: bandwidth used for victim service ACLR measurements, i.e. 7,6 MHz for 8 MHz DVB-T, 6,7 MHz for 7 MHz DVB-T, 7,8 MHz for 8 MHz DVB-T2, 6,8 MHz for 7 MHz DVB-T2 and 9 MHz for LTE

reference bandwidth: bandwidth in which the emission level is specified

spurious domain emissions: unwanted emissions at frequencies separated by more than 250 % of the channel bandwidth from the centre of the occupied spectrum

3.2 Symbols

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

m	milli
μ	micro
n	nano
"	inch

3.3   Abbreviations

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

ACLR   Adjacent Channel Leakage Ratio
BW   BandWidth
COFDM   Coded Orthogonal Frequency Division Multiplexing
CSV   Comma Separated Values
dB   Logarithmic ratio (tenths of a "Bel")
dBm   dB relative to one milliwatt
DIN   Deutsches Institut fur Normung
DTT   Digital Terrestrial Television
DVB   Digital Video Broadcasting
DVB-T   Digital Video Broadcast - first generation

NOTE: See ETSI EN 300 744 [1].

DVB-T2   Digital Vdeo Broadcast - second generation

NOTE: See ETSI EN 302 755 [2].

END   Equivalent Noise Degradation
EUT   Equipment Under Test
FFT   Fast Fourier Transform
GHz   GigaHertz
ITU   International Telecommunication Union
ITU-R   International Telecommunication Union - Region
kHz   kiloHertz
MER   Modulation Error Ratio
MHz   MegaHertz
OOB   out-of-band
PA   Power Amplifier
QAM   Quadrature Amplitude Modulation
RBW   Reference BandWidth
RF   Radio Frequency
RMS   Root Mean Square
RRC   Regional Radiocommunication Conference
TV   Television
UHF   Ultra High Frequency
VBW   Video BandWidth
VHF   Very High Frequency
W   Watt

4   Technical requirements specifications

4.1   Environmental profile

The technical requirements of the present document apply under the environmental profile for operation of the equipment, which shall be declared by the manufacturer. The equipment shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the declared operational environmental profile.

# 4.2 Conformance requirements

4.2.1 Introduction

To meet the requirement under article 3.2 of Directive 2014/53/EU [i.2] the essential parameter and corresponding technical requirements are shown in table 4.1. To fulfil this essential parameter the compliance with all the corresponding technical requirements in table 4.1 shall be verified.

Table 4.1: Cross references

Essential parameter	Corresponding technical requirements
Conducted emissions at the antenna port	4.2.2 Spurious emissions
	4.2.3 Out-of-band emissions (OOB)

Both spurious emission limits and OOB limits are defined in terms of conducted power at the antenna port.

The boundary between spurious domain emissions and out-of-band emissions is shown in figure 4.1.
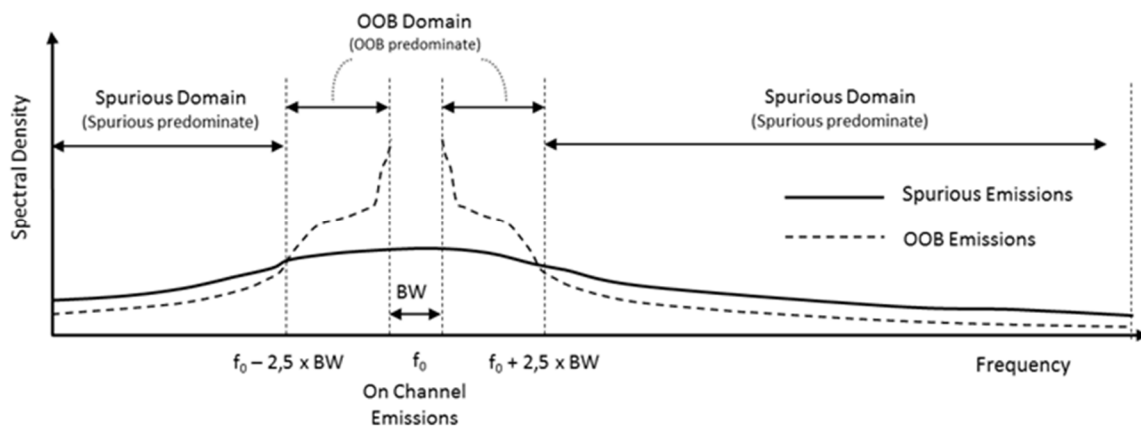
Figure 4.1: Definition of out-of-band and Spurious Domains

4.2.2 Spurious emissions

4.2.2.1 Definition

Spurious emissions are unwanted emissions at frequencies separated by more than 250 % of the channel bandwidth from the centre of the occupied spectrum. These include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out-of-band emissions.

For the purposes of the present document spurious emissions are emissions at frequencies outside the frequency range $f_0 \pm 17,5$ MHz for 7 MHz channels, $f_0 \pm 20$ MHz for 8 MHz channels, where f_0 is the centre frequency of the channel, irrespective of the number of carriers employed.

4.2.2.2 Limits

Spurious emissions shall not exceed the values set out in table 4.2 additionally shown in figure 4.2, for the frequency range 9 kHz to 3 GHz.

In the case of a DVB-T/T2 transmitter supplied without an internal bandpass output filter, the manufacturer shall specify the characteristics of the filter necessary to fulfil the spurious emission limits defined in table 4.2. The manufacturer shall include this information in the test report.

Table 4.2: Spurious emission limits for DVB-T/T2 transmitters

Frequency range of the spurious emission	Limits of the spurious emission		Reference bandwidth
9 kHz to 470 MHz	≤ -36 dBm (250 nW) for	$P \leq 69$ dBm	100 kHz
	≥ 105 dBc for	69 dBm < P	
> 470 MHz to 694 MHz	≤ -36 dBm, for	$P \leq 39$ dBm	100 kHz
	≥ 75 dBc for	39 dBm < P $\leq$ 50 dBm	
	≤ -25 dBm (3 µW) for	50 dBm < P	
> 694 MHz	≤ -36 dBm (250 nW) for	$P \leq 69$ dBm	100 kHz
	≥ 105 dBc for	69 dBm < P	
NOTE: P = mean power of the transmitter measured at the antenna port.			
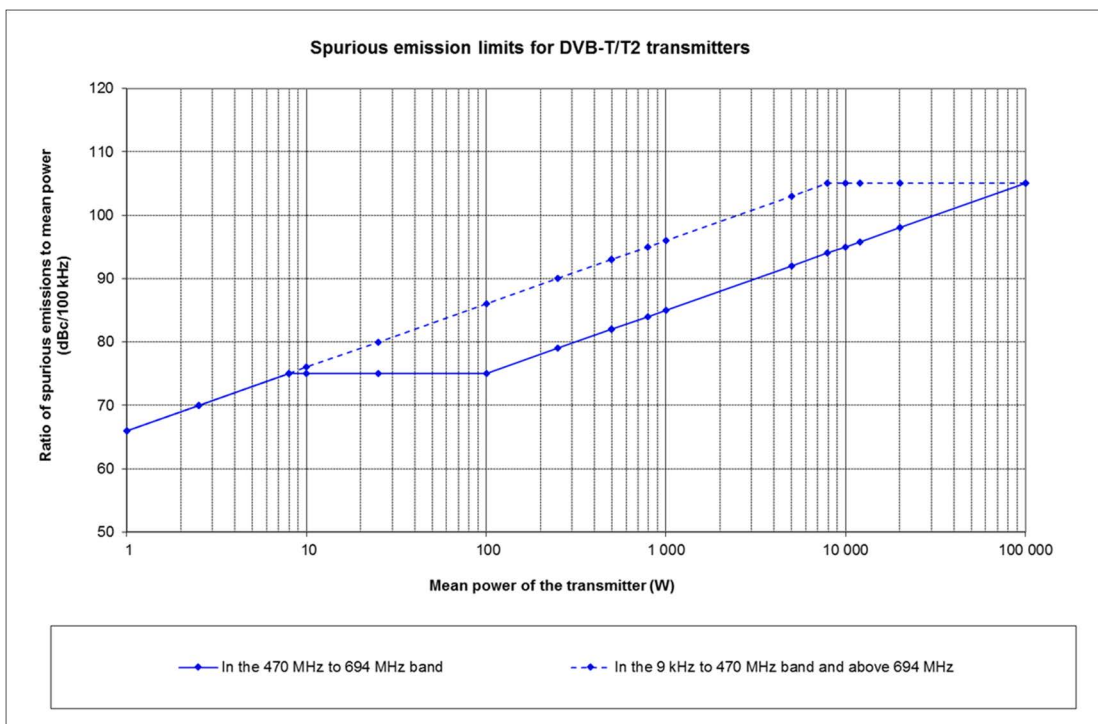
**Figure 4.2: Spurious emission limits measured at the antenna port
(100 kHz reference bandwidth)**

4.2.2.3   Conformance test

Conformance tests described in clause 5.4.1 shall be carried out.

4.2.3   Out-of-band emissions

4.2.3.1   Definition

Out-of-band emissions are unwanted emissions which fall at frequencies separated from the centre frequency of the wanted emission by less than or equal to 250 % of the channel bandwidth. For the purposes of the present document out-of-band emissions are emissions at frequencies outside the necessary bandwidth and within the frequency ranges $f_0 \pm 17,5$ MHz for 7 MHz channels, $f_0 \pm 20$ MHz for 8 MHz channels where f_0 is the centre frequency of the channel, irrespective of the number of carriers employed.

For mask-based approaches, the out-of-band emissions limits are given as mean power level measured at the antenna port in a 3 kHz bandwidth.

A transmitter system typically comprises a transmitter and a channel filter (or combiner). In the case of a transmitter supplied without an output channel filter, the manufacturer shall specify the characteristics of the filter necessary to fulfil the required out-of-band emissions defined below. The manufacturer shall include this information in their test report.

Improved transmitter electrical efficiency may have some minor impact on the OOB performance. The considered trade-off between electrical efficiency and OOB transmitter performance is further considered in annex F.

4.2.3.2   Classification of transmitters

Transmitters will be classified according to power and emissions according to table 1.1 and table 1.2.

With regard to the declaration of conformity, the manufacturer shall declare which classification the equipment complies with. For example, a transmitter conforming to classification H0 is a high power transmitter conforming to the non-critical mask.

4.2.3.3   Limits

Out-of-band emissions shall not exceed the values set out in table 4.3 to table 4.8, subject to the specifc transmitter catagory (see table 1.1 and table 1.2).

Table 4.3 sets out the limits for transmitter classification L0. Table 4.4 sets out the limits for transmitter classification L1. Table 4.5 sets out the limits for transmitter classifications L2 and L3.

Table 4.6 sets out the limits for transmitter classification H0 additionally shown in figure 4.3 and figure 4.4 for 7 MHz channels and 8 MHz channels respectively. Table 4.7 sets out the limits for transmitter classification H1 additionally shown in figure 4.5 and figure 4.6 for 7 MHz channels and 8 MHz channels respectively. Table 4.8 sets out the limits for transmitter classification H3.

Table 4.3: OOB emission limits for classification L0

Transmitter Classification	Frequency offset for 7 MHz systems (MHz)	Frequency offset for 8 MHz systems (MHz)	Absolute power level (dBm/3 kHz)
LO	±3,41	±3,9	≤ 10
	±3,7	±4,2	≤ -30
(Low power, non-critical mask)	±5,25	±6	≤ -42
	±10,5	±12	≤ -67
	±17,5	±20	≤ -67

Table 4.4: OOB emission limits for classification L1

Transmitter Classification	Frequency offset for 7 MHz systems (MHz)	Frequency offset for 8 MHz systems (MHz)	Absolute power level (dBm/3 kHz)
L1	±3,41	±3,9	≤ 10
	±3,7	±4,2	≤ -40
(Low power, critical mask)	±5,25	±6	≤ -52
	±10,5	±12	≤ -77
	±17,5	±20	≤ -77

Table 4.5: OOB limits for transmitter classification L2 and L3

Transmitter Classification	First adjacent channel ACLR (dB)	Second adjacent channel ACLR (dB)
L2	≥ 42	≥ 64
L3	≥ 55	≥ 77
NOTE 1: The first and second adjacent channel frequency offsets are defined as 8 MHz and 16 MHz respectively for UHF transmitters and 7 MHz and 14 MHz respectively for VHF transmitters.		
NOTE 2: The integration bandwidth for the victim channel is defined as 7 MHz for VHF transmitters and 8 MHz for UHF transmitters.		

Table 4.6: OOB emission limits for classification H0

| Transmitter Classification	Frequency offset for 7 MHz systems (MHz)	Frequency offset for 8 MHz systems (MHz)	Relative power level (dBc/3 kHz)
H0 (High power, non-critical mask)	±3,41	±3,9	≤ -34
	±3,7	±4,2	≤ -74
	±5,25	±6	≤ -86
	±10,5	±12	≤ -111
	±17,5	±20	≤ -111
NOTE: The limits for UHF transmitters using 8 MHz channels are plotted in figure 4.4. The limits for VHF transmitters using 7 MHz channels are plotted in figure 4.3.			
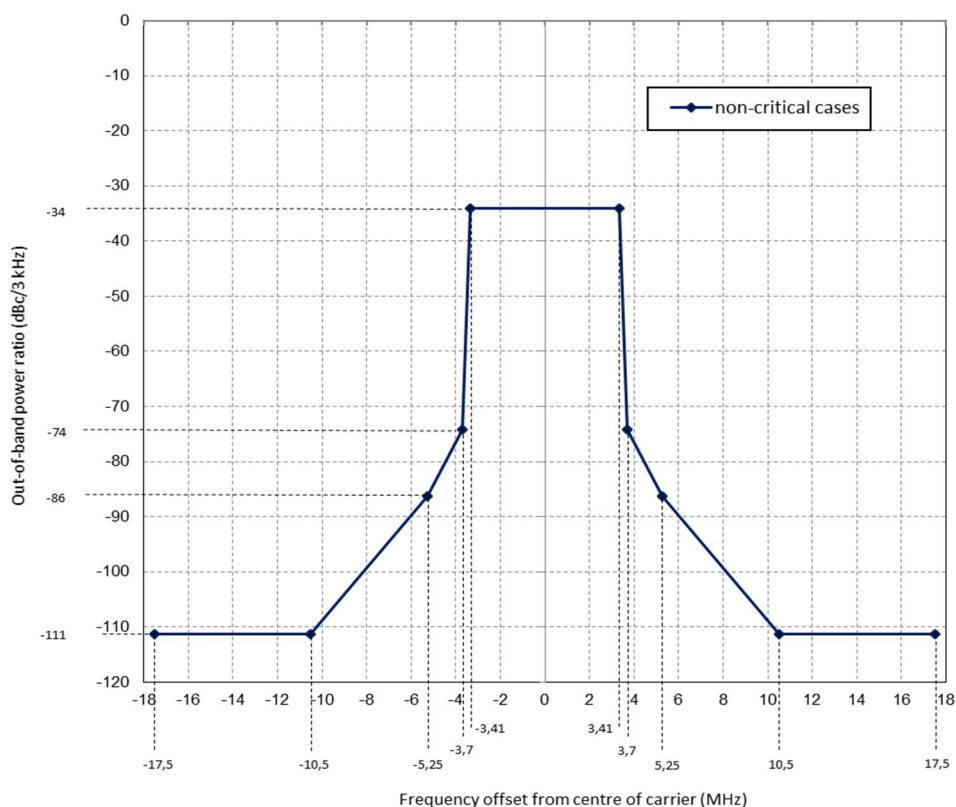
Figure 4.3: Out-of-band limits for transmitter classification H0 using 7 MHz channels
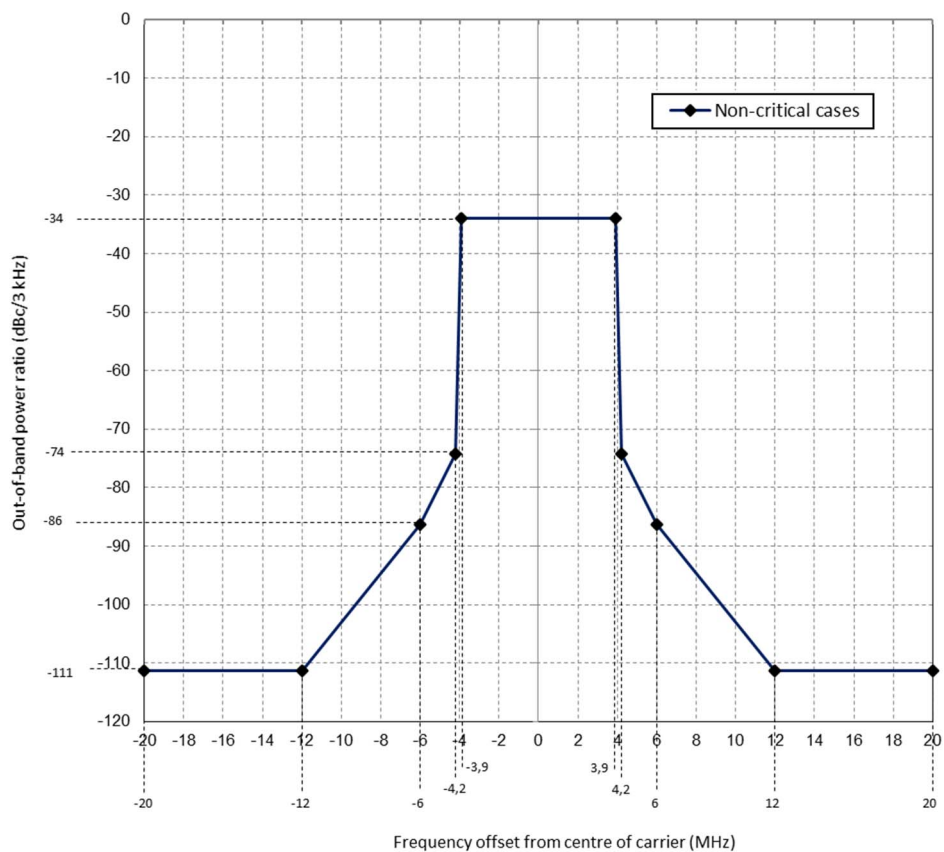
Figure 4.4: Out-of-band limits for transmitter classification H0 using 8 MHz channels

Table 4.7: OOB emission limits for classification H1

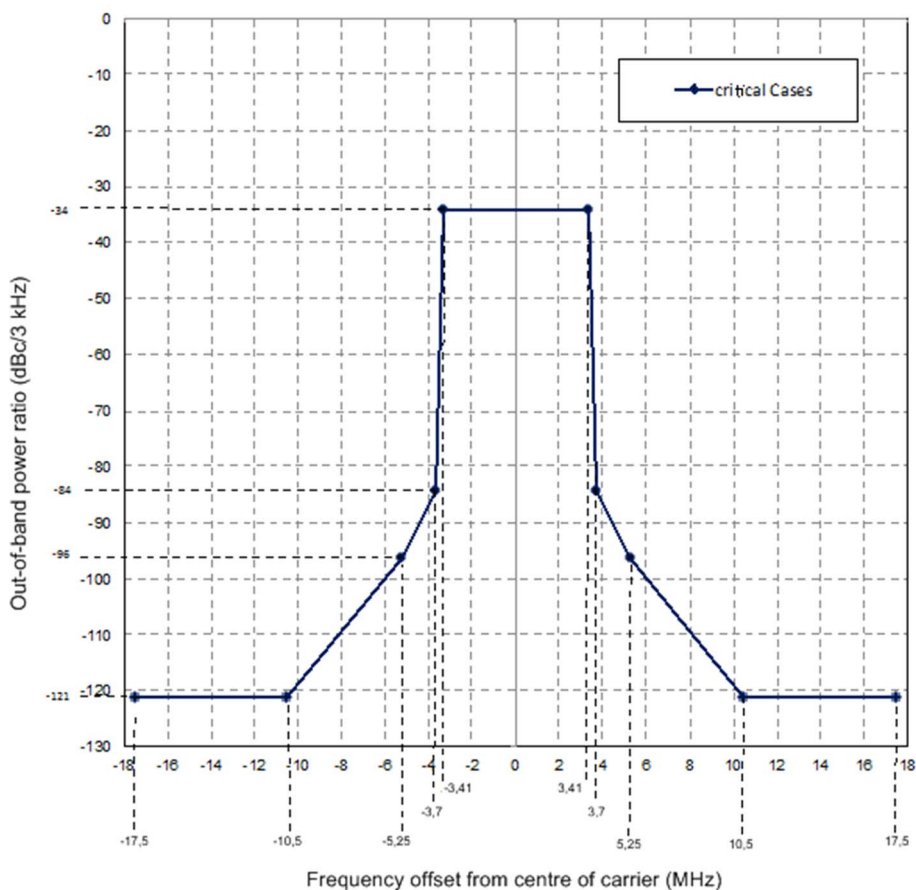| Transmitter Classification	7 MHz Channel, frequency difference from the centre frequency (MHz)	8 MHz Channel, frequency difference from the centre frequency (MHz)	Relative level (dBc/3 kHz)
H1 (High power, critical mask)	±3,41	±3,9	≤ -34
	±3,7	±4,2	≤ -84
	±5,25	±6	≤ -96
	±10,5	±12	≤ -121
	±17,5	±20	≤ -121
NOTE: The limits for UHF transmitters using 8 MHz channels are plotted in figure 4.6 and the limits for VHF transmitters using 7 MHz channels are plotted in figure 4.5.			

Figure 4.5: Out-of-band limits for transmitter classification H1 using 7 MHz channels
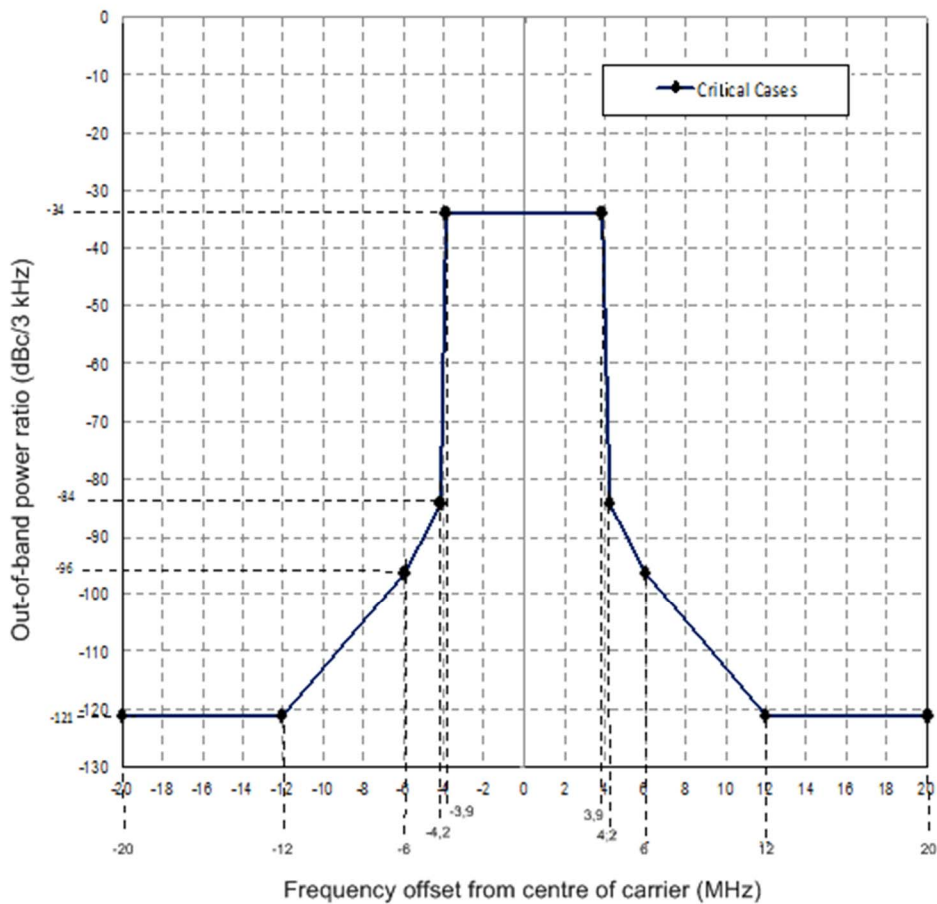
Figure 4.6: Out-of-band limits for transmitter classification H1 using 8 MHz channels

Table 4.8: OOB emission limits for classification H3

Transmitter Classification	UHF DVB-T/T2 ACLR limits (see note 1)		VHF DVB-T/T2 ACLR limits (see note 2)		LTE-800 ACLR limits (see note 3)		LTE-700 ACLR limits (see note 3)	
	Offset (MHz)	ACLR (dB)	Offset (MHz)	ACLR (dB)	Offset (MHz)	ACLR (dB)	Offset (MHz)	ACLR (dB)
H3	±8	≥ 61	±7	≥ 61	+10	≥ 68	+18	≥ 86
(critical ACLR)	±16	≥ 87	±14	≥ 87	+20	≥ 86	N/A	N/A
NOTE 1: The ACLR limits are derived by integration of the critical mask defined in table 4.6 over the victim DVB-T/T2 bandwidth of 8 MHz.								
NOTE 2: For VHF DVB-T2 systems (7 MHz channels) the victim DVB-T/T2 service integration bandwidth is 7 MHz.								
NOTE 3: These values apply only for UHF transmitters. The victim service integration bandwidth is 10 MHz.								

4.2.3.4   Conformance test

Conformance tests described in clause 5.4.2 shall be carried out.

5   Testing for compliance with technical requirements

5.1   Environmental conditions for testing

Tests defined in the present document shall be carried out at representative points within the boundary limits of the declared operational environmental profile for the transmitter system.

Where technical performance varies subject to environmental conditions, tests shall be carried out under a sufficient variety of environmental conditions (within the boundary limits of the declared operational environmental profile) to give confidence of compliance for the affected technical requirements.

5.2   Interpretation of the measurement results

The interpretation of the results recorded in a test report for the measurements described in the present document shall be as follows:

- the measured value related to the corresponding limit will be used to decide whether an equipment meets the requirements of the present document;

- the value of the measurement uncertainty for the measurement of each parameter shall be included in the test report;

- the recorded value of the measurement uncertainty shall for each measurement be equal to or lower than the figures in table 5.1.

For the test methods, according to the present document, the measurement uncertainty figures shall be calculated and shall correspond to an expansion factor (coverage factor) $k = 1,96$ or $k = 2$ (which provide confidence levels of respectively 95 % and 95,45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian)). Principles for the calculation of measurement uncertainty are contained in ETSI TR 100 028-1 [3] and ETSI TR 100 028-2 [4].

Table 5.1 is based on such expansion factors.

Table 5.1: Maximum measurement uncertainty

Parameter	Condition	Uncertainty
Spurious emissions (Conducted emissions)	f ≤ 2,2 GHz	2,5 dB
	2,2 GHz < f ≤ 3 GHz	3,0 dB
Out-of-band emissions (Conducted emissions)		2,5 dB
NOTE: Please refer to EN 55016-4-2 [5], clause 4.1, table 1.		

5.3   Test conditions

5.3.1   Test frequency range

Limits on unwanted emissions for radio equipment are considered to be applicable to the range 9 kHz to 3 GHz as per ITU-R Radio Regulations, Recommendation ITU-R SM.329-12 [6].

Before starting the testing procedure measurement uncertainty of the equipment in use, including cables and couplers shall be established and stated in the test report. Where measurement uncertainty within the limits contained in table 5.1 cannot be achieved the test report shall state the limiting circumstances.

The following reference bandwidths are to be used:

For spurious emissions:

- 100 kHz.

For out-of-band emissions:

- 3 kHz.

5.3.2   Test modulation signal

System integrators should use the DVB-T or DVB-T2 mode as licensed by the local regulator.

Transmitter manufacturers should use the following modulation parameters for their tests.

Table 5.2: Test Signal Configuration

DVB-T		
Channel bandwidth	7 MHz	8 MHz
Receiver bandwidth	6,7 MHz	7,6 MHz
Modulation scheme	64-QAM	64-QAM
FFT size	8k	8k
DVB-T2		
Channel bandwidth	7 MHz	8 MHz
Receiver bandwidth	6,8 MHz	7,8 MHz
Modulation scheme	256-QAM	256-QAM
FFT size	32k	32k
Carrier mode	Extended	Extended

5.4   Essential radio test suites

5.4.1   Introduction

Compliance with the present document shall be demonstrated by measurements by both the equipment (transmitter) manufacturer and the system integrator of the final installation.

For the purpose of the test conducted by the equipment manufacturer, if the transmitter does not include any output +channel filter, the equipment manufacturer has two options:

- Physically add an external output channel filter after the transmitter. The filter shall be representative of the multiplexer or filter existing in operational conditions and viewed by the transmitted output when installed. In this case the antenna port measurements shall be performed at the output of this extra filter.

- Use the composite approach to account for the response of the final channel/combiner filter.

As the output channel filter/combiner cannot increase the level of spurious emissions, it is possible for an equipment manufacturer to demonstrate compliance with the spurious emission limits by direct measurements on the equipment.

5.4.2   Spurious emissions

5.4.2.1   Measurement approaches

There are two practical approaches for the measurement of spurious emissions:

- Direct measurement using a high power attenuator between the antenna port and the spectrum analyser. Here a composite approach to take into account the response of the measurement filter could be used (as described in annex C).

- Measurements using a coupling device between the antenna port and the spectrum analyser. Here a composite approach to take into account the response of both the measurement filter and the coupling device should be used.

If measurements are made using a high power attenuator, they should be carried out across the full spurious emission frequency range.

Where it is necessary to use a directional coupler the measurement frequency range may be restricted (see annex C).

5.4.2.2   Initial conditions

Test environment:

- The normal operating environment, as declared by the equipment manufacturer.

The manufacturer shall test at the following frequencies:

1) the lowest operating frequency of the EUT;

2) the highest operating frequency of the EUT;

3) a frequency corresponding to the arithmetic mean between 1) and 2) above, rounded to the nearest broadcast channel.

For the purposes of this test, the manufacturer shall ensure that the full rated output power of the transmitter will be maintained during this test with the modulation defined in clause 5.3.2.

A system integrator shall repeat the test at the frequency and power licensed by the national regulator. This condition will be maintained during the test.
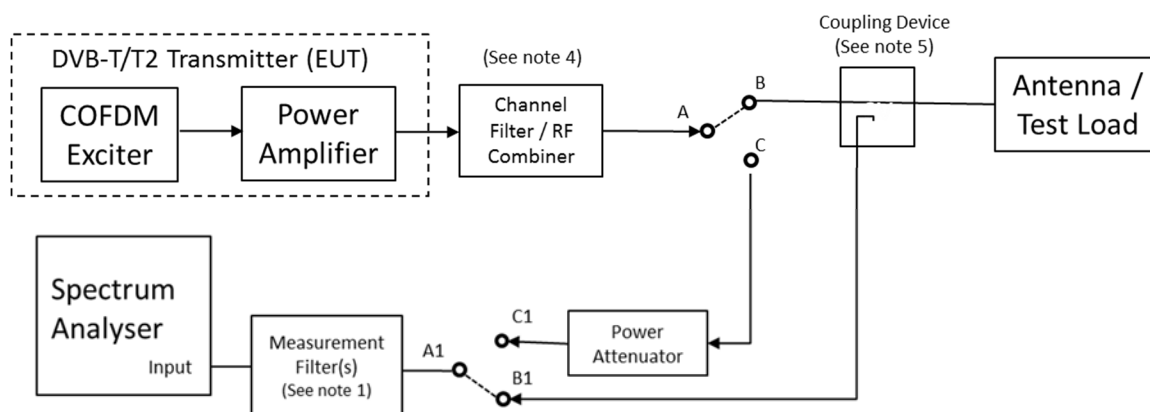
5.4.2.3   Test procedure

1) operate the EUT at each of the test frequencies as defined in clause 5.4.2.2;

2) measure the results on the spectrum analyser as described in clause 5.4.2.5, figure 5.1, note 1, note 2, note 3, note 4 and note 5.

5.4.2.4   Test requirements

The results obtained shall be compared to the limits in clause 4.2.2 in order to demonstrate compliance.

5.4.2.5   Test arrangement

NOTE 1:   The measurement filter should suppress the wanted output signal so that no intermodulation products are generated by the spectrum analyser. The insertion loss throughout the measuring range should be known.

NOTE 2:   For high power transmitters the preferred set up would require A to be connected to B and A1 to be connected to B1.

NOTE 3:   For low power transmitters the preferred set up would require A to be connected to C and A1 to be connected to C1.

NOTE 4:   The transmitter manufacturer can conduct this test using either an output channel filter or using the composite approach (see annex C). The filter shall be representative of the multiplexer or filter existing in operational conditions and viewed by the transmitted output when installed. In this case the antenna port measurements shall be performed at the output of this extra filter. For the composite approach, the filter response data shall be representative of the type used in operational conditions.

NOTE 5:   The characteristics of the coupler will be frequency dependent and the coupling factor typically increases 6 dB/octave. Moding in high power coaxial feeders may prevent reliable measurements at high frequencies (see annex C). At low frequencies, the low coupling ratio may cause dynamic range concerns (see annex C).

Figure 5.1: Test arrangement for spurious emissions

5.4.3   Out-of-band emissions

5.4.3.1   Initial conditions

Test environment:

- The normal operating environment, as declared by the equipment manufacturer.

The manufacturer shall test at the following frequencies:

1)   the lowest operating frequency of the EUT;

2)   the highest operating frequency of the EUT;

3)   a frequency corresponding to the arithmetic mean between 1) and 2) above, rounded to the nearest broadcast channel.

For the purposes of this test, the manufacturer shall ensure that the full rated output power of the transmitter will be maintained during this test with the modulation defined in clause 5.3.2.

A system integrator shall repeat the test at the frequency and power licensed by the national regulator. This condition will be maintained during the test.
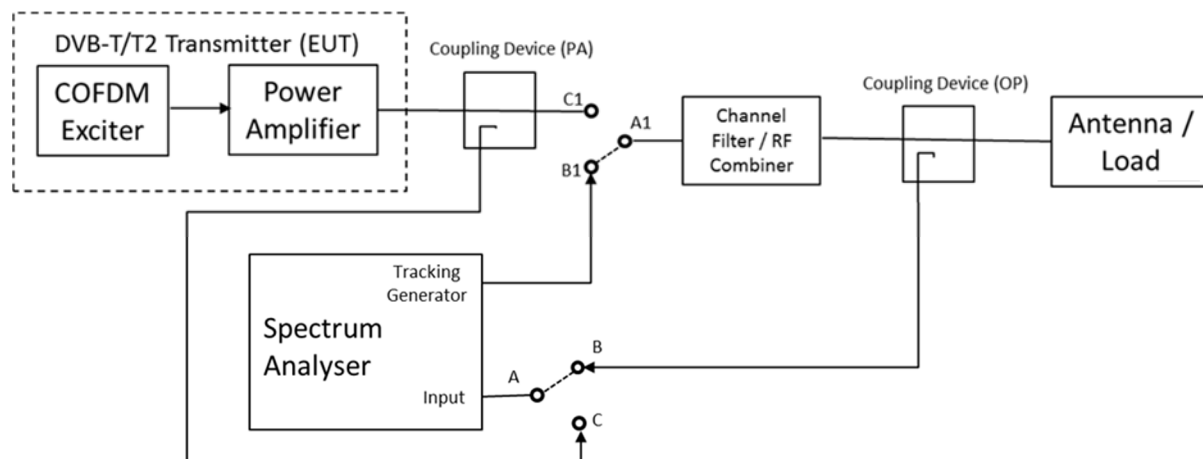
5.4.3.2   Test procedure

1)   Operate the EUT at each of the test frequencies as defined in clause 5.4.3.1.

2)   Measure the results on the spectrum analyser as described in notes 1 to 6 of clause 5.4.3.4.

5.4.3.3   Test requirements

The results obtained shall be compared to the limits in clause 4.2.3.3 in order to demonstrate compliance.

5.4.3.4   Test arrangement

NOTE 1:   To overcome dynamic range limitations of typical spectrum analysers a composite measurement approach
          is proposed (see annex D) whereby the response of the output filter is characterized separately.
NOTE 2   With appropriate safety procedures in place, disconnect the power amplifier from the output filter. Care is
          required as this is an intrusive test.
NOTE 3:   The frequency response of the output channel filter shall be measured and recorded (Connections A-B,
          A1-B1).
NOTE 4:   The spectrum of the DVB-T/T2 signal at the output of the power amplifier shall be measured and recorded
          (Connections A-C, A1-C1).
NOTE 5:   The out-of-band spectrum of the DVB-T/T2 signal shall be calculated by applying the recorded frequency
          response of the output channel filter to the recorded spectrum of the DVB-T/T2 signal.
NOTE 6:   The transmitter manufacturer can conduct this test using either an output channel filter or using the
          composite approach (see annex D). The filter shall be representative of the multiplexer or filter existing in
          operational conditions and viewed by the transmitted output when installed. In this case the antenna port
          measurements shall be performed at the output of this extra filter. For the composite approach, the filter
          response data shall be representative of the type used in operational conditions.

Figure 5.2: Testing arrangement for out-of-band emissions

Annex A (normative):
Relationship between the present document and the essential requirements of Directive 2014/53/EU

The present document has been prepared under the Commission's standardisation request C(2015) 5376 final [i.3] to provide one voluntary means of conforming to the essential requirements of Directive 2014/53/EU on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC [i.2].

'Once the present document is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of the present document given in table A.1 confers, within the limits of the scope of the present document, a presumption of conformity with the corresponding essential requirements of that Directive, and associated EFTA regulations.

**Table A.1: Relationship between the present document and
the essential requirements of Directive 2014/53/EU**

Harmonised Standard ETSI EN 302 296				
The following requirements are relevant to the presumption of conformity under the article 3.2 of Directive 2014/53/EU [i.2]				
Requirement			Requirement Conditionality	
No	Description	Reference: Clause No	U/C	Condition
1	Spurious emissions	4.2.2.2	U	
2	Out-of-band emissions	4.2.3.3	U	

Key to columns:

Requirement:

No A unique identifier for one row of the table which may be used to identify a requirement.

Description A textual reference to the requirement.

Clause Number Identification of clause(s) defining the requirement in the present document unless another document is referenced explicitly.

Requirement Conditionality:

U/C Indicates whether the requirement shall be unconditionally applicable (U) or is conditional upon the manufacturers claimed functionality of the equipment (C).

Condition Explains the conditions when the requirement shall or shall not be applicable for a requirement which is classified "conditional".

Presumption of conformity stays valid only as long as a reference to the present document is maintained in the list published in the Official Journal of the European Union. Users of the present document should consult frequently the latest list published in the Official Journal of the European Union.

Other Union legislation may be applicable to the product(s) falling within the scope of the present document.

Annex B (informative):
Void.

Annex C (informative):
Practical measurement of spurious domain emissions for broadcast transmitters

C.0   Introduction

The accurate measurement of spurious domain emissions is typically limited by the dynamic range of the spectrum analyser. It is usually necessary to use additional band-reject, low pass or high pass filters to remove the fundamental signal in order to reveal the unwanted spurious domain emissions.
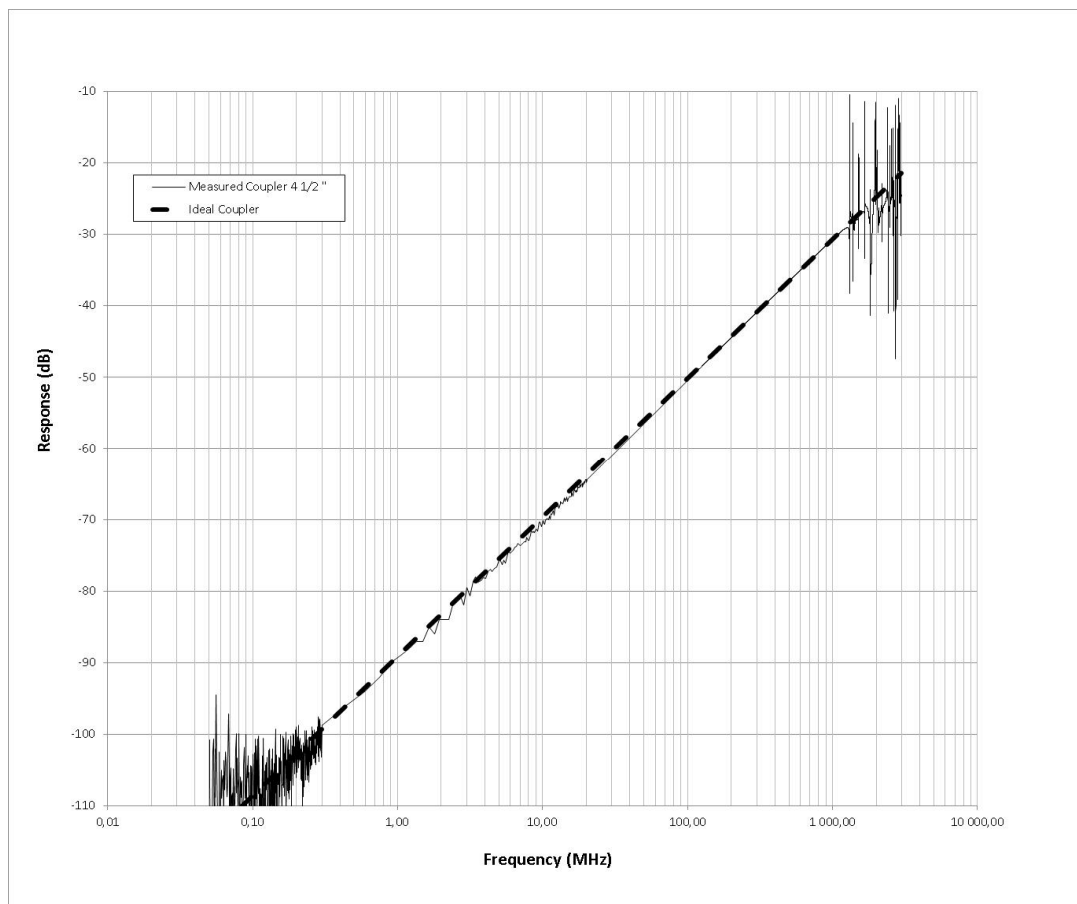
C.1   Directional coupler issues

Measurements on live equipment connected to broadcast antennas are further complicated by practical issues relating to the couplers used to probe the transmitter output signal. These typically exhibit a frequency dependent response which should be accounted for in the measurement. Directional couplers usually exhibit a response whereby the coupling factor increases 6 dB octave as shown in figure C.1 for a device for use with a 1 5/8" feeder.
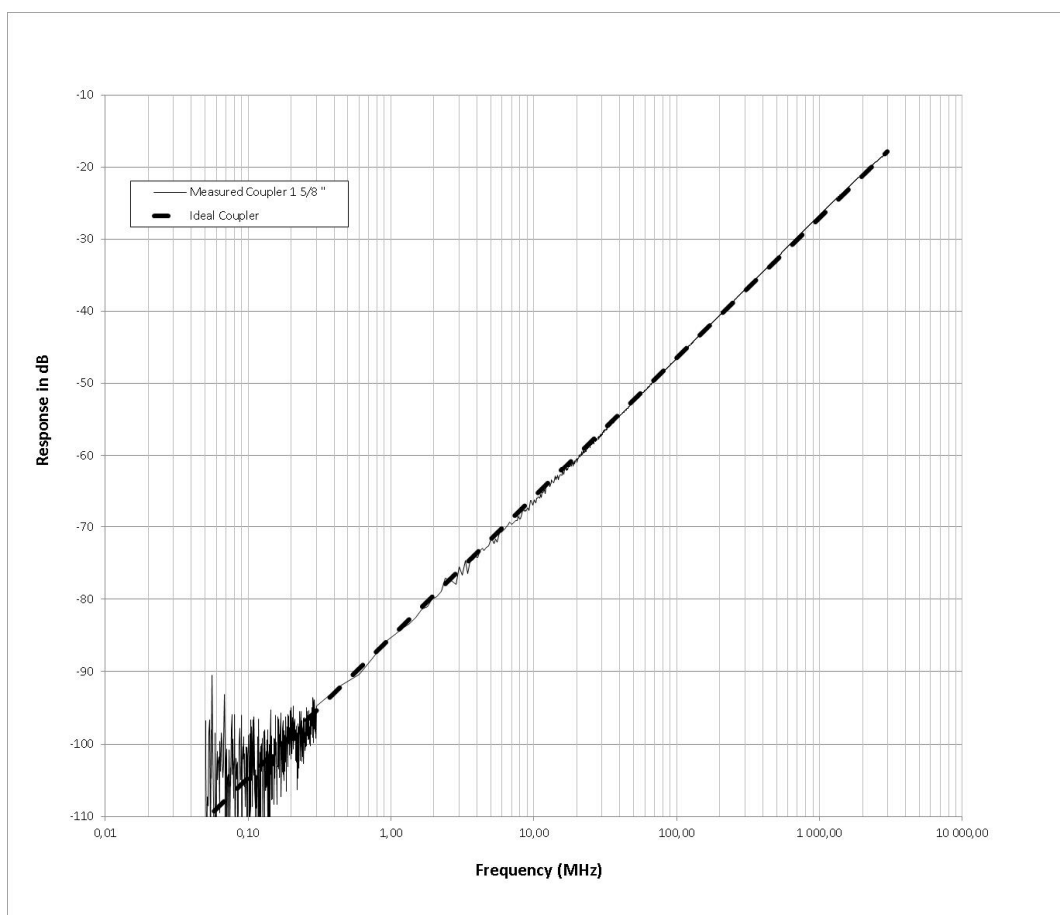
Figure C.1: Typical Measured Directional Coupler Frequency Response (1 5/8" feeder)

At low frequencies, the decreasing coupling factor results in a low signal level and the spurious domain measurement will typically be limited by the noise floor of the spectrum analyser (see figure C.1). So called 'hot couplers' with higher coupling ratio can be used to extend the measurement range, but great care is needed to avoid damage to test equipment.

For high power transmitters, where large diameter coaxial connections are used to handle the signals, the propagation of higher order waveguide modes within the couplers and feeders results in anomalous responses and impedance mismatches which cannot be accounted for by calibration. Such behaviour sets an upper bound on the frequency of measurement. Typical moding behaviour for a 4 1/2 " coupler is shown in figure C.2 and results in unpredictable behaviour above 1,2 GHz. Table C.1 shows maximum operating frequencies for common line sizes.

Figure C.2: Directional Coupler Frequency Response due to Moding (4 1/2"" feeder)

Table C.1: Cut-off Frequencies for Common Line Sizes

Line Size	Recommended Maximum Frequency(MHz)
N	18 000
7 16 (DIN)	8 300
1 5/8 "	3 200
3 1/8 "	1 600
4 1/2 "	1 200
6 1/8 "	830

C.2   Spectrum analyser settings

The accuracy of the spurious measurement is influenced by the configuration of the spectrum analyser. The parameters in table C.2 are suggested as a starting point appropriate for typical spectrum analysers.

Table C.2: Suggested spectrum analyser settings for spurious measurements

Parameter	Setting
Resolution Bandwidth (RBW)	100 kHz
Detector	RMS
Sweep time (s)	Span (MHz) / 25
Number of Measurement Points	35 × Span (MHz)
Video Bandwidth (VBW)	100 kHz
Trace averaging	Off
Trace mode	Clear-Write

C.3   Composite measurement of spurious emissions

The RF transmission response seen in figure C.1 and figure C.2 show very low coupling factors at low frequencies and higher coupling factors at frequencies above the operating channel.

In order to overcome this effect a composite measurement approach can be adopted as follows:

The levels of the spurious emissions at the output of the channel filter/RF combiner may be calculated by weighting the measured result with the frequency response of the coupler. This calculation can be carried out off-line.

Annex D (informative):
Practical Measurement of out-of-band Domain Emissions

D.1   Composite measurement of out-of-band emissions

It is recognized that the absolute signal range associated with the OOB mask (or ACLR limit) will exceed the dynamic range measurement capability of most modern RF spectrum analysers. Since typical transmitter systems comprise a power amplifier (PA) and an output channel filter, the dynamic range restriction can be overcome by a composite measurement technique whereby:

1)   The response of the output channel filter is first measured using a spectrum analyser equipped with a tracking generator. The log-magnitude response, *H(f)*, is typically stored either in the instrument or as a text file (typically comma-separated variable (CSV) or as S-parameters). Some instruments allow the filter response to be stored internally for later use.

2)   The out of block emissions are measured at a coupler connected between the output of the power amplifier and the input to the channel filter. The log-magnitude response, *P(f)*, can typically be stored as a CSV text file.

3)   The spectrum of the out-of-band emissions at the antenna port is calculated by weighting the PA measurement 2) by the response of the channel filter 1). This calculation (*P'(f) = P(f) + H(f)*) can be either carried out off-line (e.g. in a computer spread sheet), or automatically using a suitably equipped spectrum analyser. The latter is typically implemented using 'trace math' functions which allow the log-magnitude response measured in 1) to be added to the PA spectrum response measured in 2).

4)   The ACLR is defined as the ratio of the wanted mean power of the DVB-T/T2 signal to the unwanted mean power measured in the receiver bandwidth of a given adjacent victim service. These two quantities can be calculated from the spectrum of the out-of-band emissions *P'(f)* 3). This can be achieved directly on some analysers, or off-line by a numerical linear power sum of the composite trace data.

5)   The ACLR can be estimated from the spectrum analyser trace data, P_i, using the following summation:

$$ACLR = 10 \times log_{10} \left\{ \frac{\kappa_w \times \sum_{i=w_l}^{w_u} 10^{\frac{P_i'(f_i)}{10}}}{\kappa_v \times \sum_{i=v_l}^{v_u} 10^{\frac{P_i'(f_i)}{10}}} \right\} \approx 10 \times log_{10} \left\{ \frac{\sum_{i=w_l}^{w_u} 10^{\frac{P_i'(f_i)}{10}}}{\sum_{i=v_l}^{v_u} 10^{\frac{P_i'(f_i)}{10}}} \right\}$$

Where:

$P_i(f_i)$ is the the measured power of the ith measurement point in the spectrum analyser trace data at frequency f_i expressed in dBm. This will be measured in a bandwidth determined by the resolution bandwidth setting of the analyser;

$H(f_i)$ is the measured response of the channel filter at frequency f_i expressed in dB;

$P_i'(f_i)$ is the the calculated power of the ith measurement point at frequency f_i expressed in dBm given by $P_i'(f_i) = P_i(f_i) + H(f_i)$;

κ_w, κ_v are scaling factors relating the numerical summation in the above equation to the effective power in the wanted and adjacent channels. They are dependent on the spectrum analyser filter characteristics and the number of measurement points. Given a sufficiently high number of measurement points, $\kappa_w = \kappa_v$;

w_l is the index of the measurement point corresponding to the lower frequency bound of the wanted signal;

w_u is the index of the measurement point corresponding to the upper frequency bound of the wanted signal;

v_l is the index of the measurement point corresponding to the lower frequency bound of the adjacent victim signal;

v_u is the index of the measurement point corresponding to the upper frequency bound of the adjacent victim signal.

For a set of N measurement points across a frequency sweep of f_{span}, the required measurement point indices are given by:

$$w_l = ceiling\left(\frac{\left\{\frac{f_{span}}{2} - \frac{B_w}{2}\right\}}{\Delta f}\right)$$

$$w_u = floor\left(\frac{\left\{\frac{f_{span}}{2} + \frac{B_w}{2}\right\}}{\Delta f}\right)$$

$$v_l = ceiling\left(\frac{\left\{\frac{f_{span}}{2} + f_{offset,v} + \frac{B_v}{2}\right\}}{\Delta f}\right)$$

$$v_u = floor\left(\frac{\left\{\frac{f_{span}}{2} + f_{offset,v} - \frac{B_v}{2}\right\}}{\Delta f}\right)$$

Where:

f_{span} is the frequency span of the spectrum analyser sweep;

$f_{offset,v}$ is the frequency offset of the centre frequency of the victim channel from the wanted DTT channel;

B_v is the bandwidth of the victim service;

B_w is the bandwidth of the wanted service;

Δf is the frequency interval between spectrum analyser measurement points, $(\frac{f_{span}}{N})$;

N is the number of measurement points (typically 501 for ACLR calculations).

D.2   System considerations

The precise response of the output channel filter is typically affected by the impedance of the antenna and channel combiner which will have a finite return loss. For final measurements by the system integrator it is recommended that the response of the output channel filter is measured when connected to the broadcast antenna as shown in figure D.1.
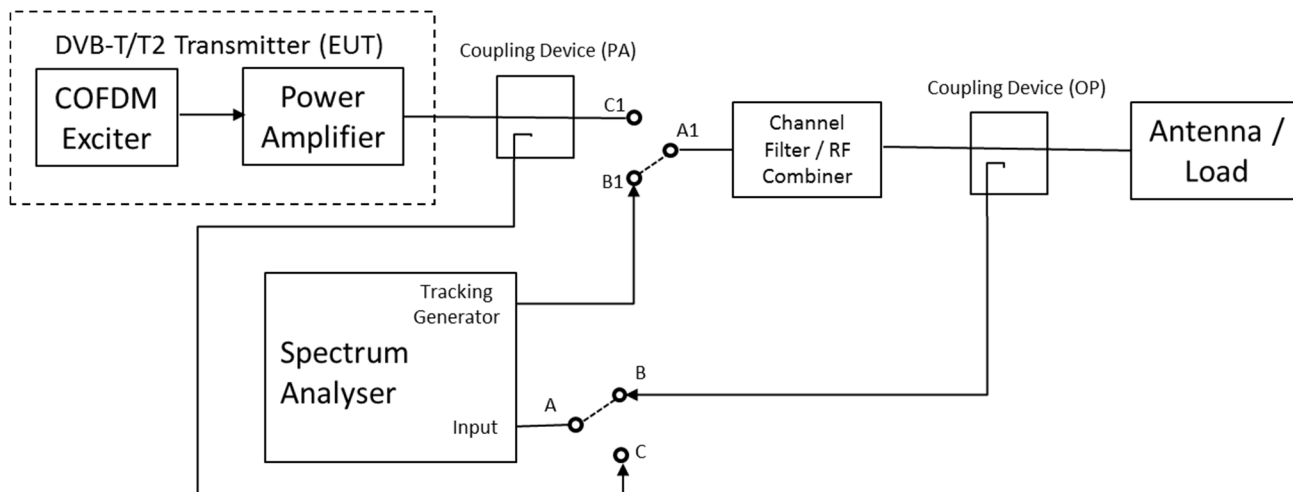
Figure D.1: Practical arrangement for measuring response of Channel Filter

D.3   Spectrum analyser settings for OOB measurements

The accuracy of the OOB emissions measurement is influenced by the configuration of the spectrum analyser. The following parameters are suggested as a starting point appropriate for typical spectrum analysers.

Table D.1: Suggested spectrum analyser settings for OOB emissions measurements

Parameter	Setting
Resolution Bandwidth (RBW)	3 kHz
Detector	RMS
Span	40 MHz
Sweep time	30 s
Number of Measurement Points (see note 1 and note 2)	501
Video Bandwidth (VBW)	3 kHz
Trace averaging	Off
Trace mode	Clear-Write
NOTE 1: OOB mask tests: It may be desirable to increase the number of points to 801 for mask compliance testing. NOTE 2: Narrow band victim services will require an increased number of measurement points, typically N > 10 across the bandwidth of the victim service for ~1 dB precision. Increasing the number of analyser points will improve the precision.	

D.4   OOB domain emissions - typical spectrum analyser traces

Plot 1 to plot 3 below show example spectrum analyser measurement traces from the methodology described in clause D.1, clause D.2 and clause D.3 above.

Plot 1 shows the RF filter transmission loss.

Plot 2 shows the Transmitter performance before RF Filter/combiner.

Plot 3 shows the Composite trace derived from the addition of plot 1 and plot 2. Note the Non critical mask is also displayed on this plot.
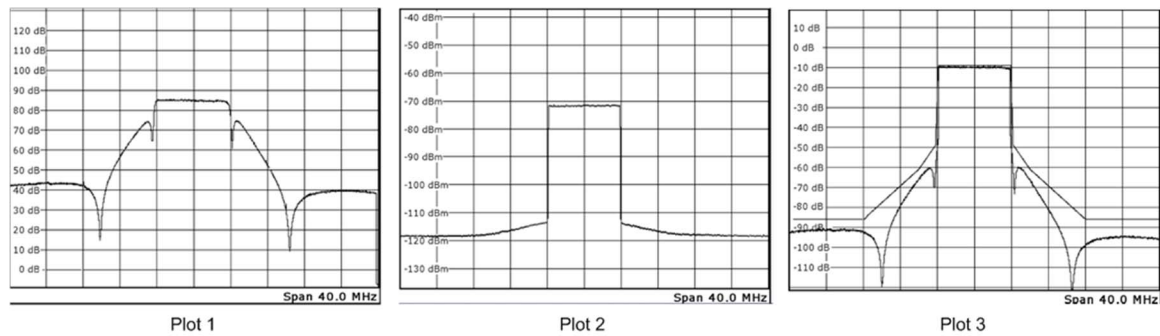
Plot 1   Plot 2   Plot 3

Figure D.2: Typical RF Analyser Traces

D.5   ACLR measurement

Figure D.3 shows an example DVB-T2 ACLR measurement of first and second adjacent 7,8 MHz victim channels in 8 MHz spacing. In this case the ACLR values are automatically calculated in the instrument from the OOB composite plot.
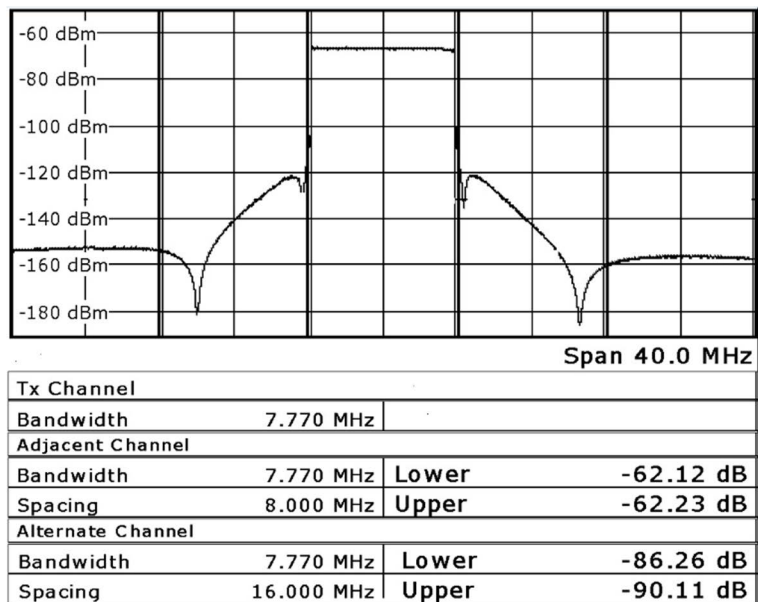

Tx Channel			
Bandwidth	7.770 MHz		
Adjacent Channel			
Bandwidth	7.770 MHz	Lower	-62.12 dB
Spacing	8.000 MHz	Upper	-62.23 dB
Alternate Channel			
Bandwidth	7.770 MHz	Lower	-86.26 dB
Spacing	16.000 MHz	Upper	-90.11 dB

Figure D.3: ACLR Composite Trace Measurement

Annex E (informative):
Impact of ACLR of low power broadcast transmitters on adjacent DVB-T/T2 services for co-sited networks

E.0   Introduction

ACLR limits included in clause 4.2.3.3, table 4.5, were derived from a series of bench tests, designed to record the impact for a range of DVB-T/T2 transmitter ACLR values on equal power adjacent DVB-T/T2 transmitters (e.g. for a co-sited network). In this case the ACLR (in dB) is defined as the ratio between the integrated power in adjacent DVB-T/T2 channel to the mean power in the wanted channel. For co-sited, 8 MHz DVB-T (DVB-T2) networks, the adjacent victim channel offset is 8 MHz in-line with the UHF channel raster, with a 7,6 MHz (7,8 MHz) receiver bandwidth.

Network operators and broadcasters define a minimum MER (Modulation Error Ratio) performance limits for transmitters in a network. Typical MER values range from 30 to 36 dB dependent upon the modulation scheme and other network considerations such as low power secondary network transmitters (e.g. transposers). A reduction in MER increases the required C/N for a given modulation scheme, and consequently reduces the broadcast cell radius. This effect is commonly known as Equivalent Noise Degradation (END, dB) [i.1].

Reducing the ACLR of an adjacent DVB-T/T2 signal will further impact the MER of the victim service by the addition of out-of-band noise into the victim signal.

The tests described below were designed to investigate the impact for a range of ACLR levels on the MER of adjacent victim DVB-T services.

E.1   Equipment Configuration

Figure E.1 shows the test equipment setup used, this represents a co-sited transmitter system where all transmitters are connected into a single combiner and connected to a single antenna. The mean conducted power for each transmitter was equal and the modulation settings for both transmitters were configured to be the same in accordance to table 5.2.
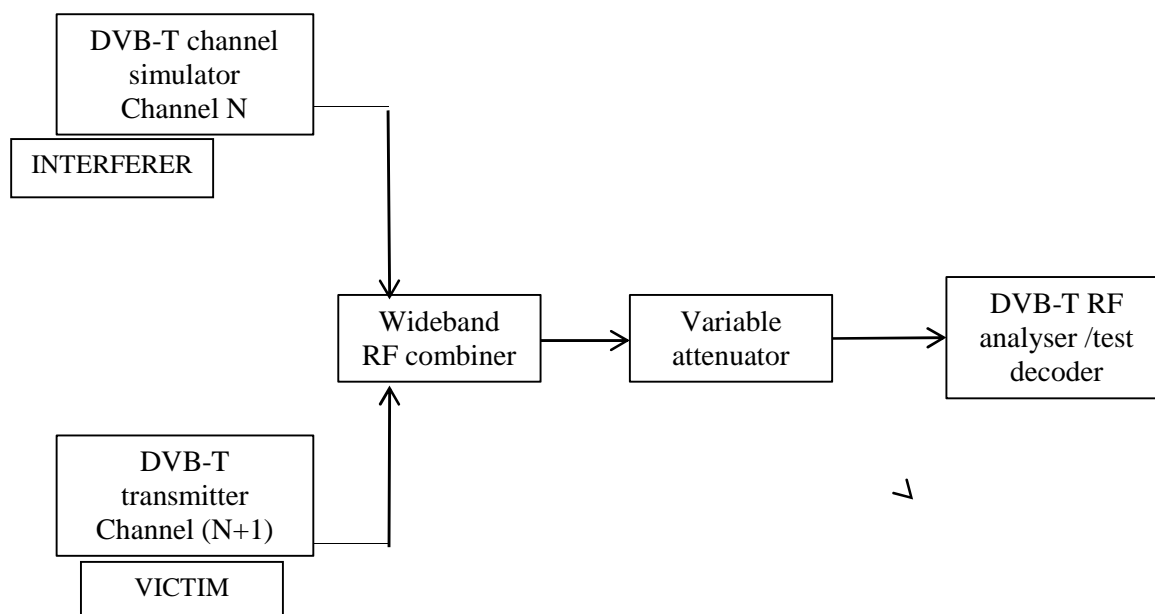
Figure E.1: Test Equipment Setup for ACLR Measurements

- Two tests were conducted representing two target MER values. The victim transmitter was configured to have an MER of 35,1 for test 1 and an MER of 35,9 dB for test 2.

- The interfering signal ACLR was varied in the range of between 32 dB to 57 dB.

- The MER of the victim signal was measured on the RF analyser as the ACLR of the interferer was varied.

The composite output of both the victim and interfering signals after the wide-band coupler can be seen in figure E.2.
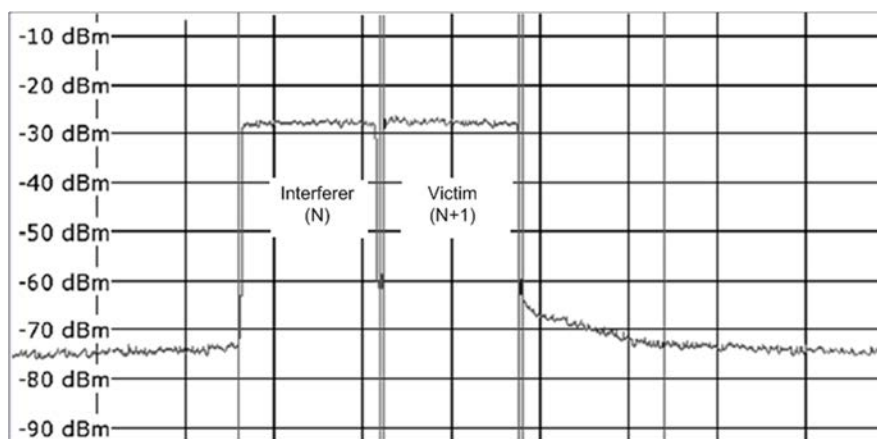

Figure E.2: Composite Output from the Wide-band Combiner

E.2   Results

The effective MER resulting from the increase of the ACLR from the adjacent signal into the victim signal can be seen in figure E.3.
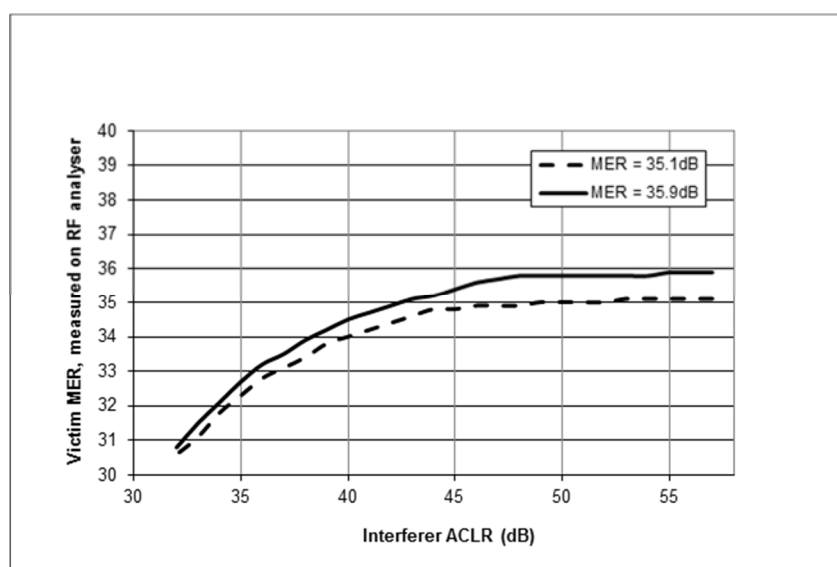

Figure E.3: Victim MER vs ACLR

E.3   Theoretical impact of MER on END

Figure E.4 shows the theoretical relationship between MER and END expressed in dB for the modulation schemes described in clause 5.3.2. END is a useful parameter which directly expresses the impact on the reduction of MER on the transmitted signal in terms of transmission loss (dB).
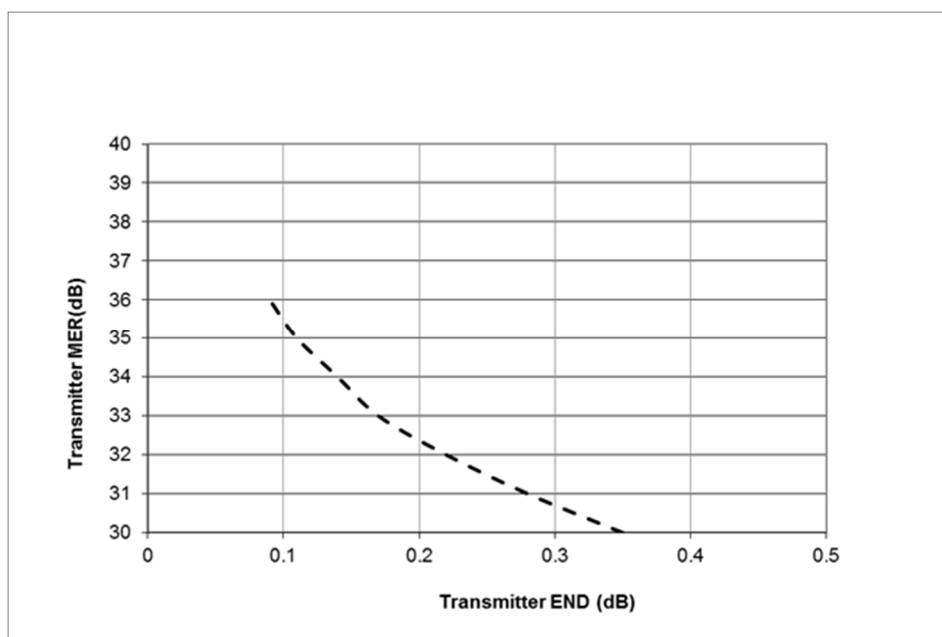
Figure E.4: MER vs. END

E.4   Conclusions

The above tests are for co-sited DVB-T/T2 networks and record the impact for a range of ACLR values from an adjacent DVB-T transmitter into a victim DVB-T service. The measured reduction in MER as a result in the change of the ACLR and the calculated END are also presented.

Figure E.3 shows that as the ACLR reduces there is a direct impact on the MER of the adjacent victim service. For both tests (MER configured to be at 35,1 dB and 35,9 dB), and with an adjacent ACLR of $\geq$ 42 dB, there is < 1 dB reduction in the received MER of the victim service.

Figure E.4 shows that within the selected operating victim receiver MER boundaries of this test (36 dB with no ACLR from the interferer to 31 dB MER with 33 dB ACLR from the interferer), the END for a 1 dB reduction in MER is increased by < 0,06 dB. This will have no impact on broadcast cell coverage.

Annex F (informative):
Energy Efficiency and the impact on unwanted Out of Block Emissions

The Paris climate agreement (COP21), December 2015 [i.5], has introduced legally binding measures designed to combat global climate changes in an attempt to limit significant increases to global temperatures. In the UK, broadcasters have been encouraged to review the overall energy consumption of broadcast transmitters.

Significant energy efficiency improvements have been made whilst maintaining transmitter RF performance parameters to within acceptable targets. Power savings have been achieved by lowering the available headroom in the transmitter high power amplifier stages. This has been accomplished by lowering the amplifier rail voltage.

It should be recognized that any reduction in power amplifier headroom will yield higher overall electrical efficiency. However, higher electrical efficiency will inevitably generate higher OOB intermodulation levels. This trade-off is well understood and can be managed by regulators by setting acceptable target MER and associated intermodulation levels in order to contribute towards COP21 objectives.

The most noticeable effect of the trade-off between electrical efficiency and transmitter OOB intermodulation performance can be seen around the ±4,2 MHz breakpoints for an 8 MHz UHF channel (±3,7 MHz for a 7 MHz channel). At these breakpoints, the transmission loss of the filter is generally low and the shoulder performance of the amplifier will largely determine the overall OOB performance of the transmitter system (however specific tuning of the transmitter channel/combiner filter may improve the rejection at these break-points). At frequencies extending beyond the first OOB mask break points the influence of the filter suppression will become more significant due to the rapid roll-off of the filter and the introduction of energy efficiency techniques at these higher frequency offsets is unlikely to have any significant impact on OOB mask limits for co-ordinated DVB-T/T2 networks. For co-sited DVB-T/T2 installations, such reductions would have minimal or no impact on the quality of transmission.

Annex G (informative):
Bibliography

Recommendation ITU-R SM.328-10: "Spectra and bandwidth of emissions".

ETSI TR 101 190: "Digital Video Broadcasting (DVB); Implementation guidelines for DVB terrestrial services; Transmission aspects".

ETSI TS 102 831: "Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)".

CEPT/ERC/REC 74-01E: "Unwanted Emissions In The Spurious Domain", January 2011.

Recommendation ITU-R SM.1541-6 (08/2015): "Unwanted emissions in the out-of-band domain".

Recommendation ITU-R BT.1206-2 (06/2014): "Spectrum limit masks for digital terrestrial television broadcasting".

ECC Recommendation (02)05: "Unwanted Emissions", March 2012.

Annex H (informative):
Change History

Version	Information about changes
2.1.1	First published version covering Directive 2014/53/EU [i.7]. Major changes are: • The introduction of ACLR limits for the OOB domain for DVB-T/DVB-T2 transmitters.

History

Document history		
V1.1.1	January 2005	Publication
V1.2.1	May 2011	Publication as ETSI EN 302 296 Part 2
V2.0.2	October 2016	EN Approval Procedure AP 20170115: 2016-10-17 to 2017-01-16