Test of Digital Terrestrial TV Broadcast Receivers acc. to ETSI EN 303 340

Application Note

Products:

- R&S®BTC
- R&S®BTC-B1
- R&S®BTC-B11
- R&S®BTC-B3103
- R&S®BTC-K20
- R&S®BTC-K35
- R&S®BTC-K501
- R&S®BTC-K516

Starting from June 2017, almost all radio transmitters and receivers sold or put into operation in the European Union have to be tested for immunity against interferers in adjacent frequency bands. ETSI standard EN 303 340 defines the tests to be performed on digital television receivers and requirements to be passed.

This application note describes the test procedures and provides save-recall files and interferer signals for the Broadcast Test Center R&S®BTC.

Note:

Please find the most up-to-date document on our homepage
http://www.rohde-schwarz.com/appnote/1GP116.

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ROHDE&SCHWARZ

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1 Background

1.1 Radio Equipment Directive (RED) 2014/35/EU

Directive 2014/53/EU (THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION, 2014) “establishes a regulatory framework for the making available on the market and putting into service” “of radio equipment” ”in the [European] Union”.

All radio equipment (transmitters and receivers), sold or put into operation in the European Union must comply with the requirements set forth in this directive. Exempted is certain radio amateur equipment, certain marine equipment and airborne products, and evaluation kits for research and development facilities.

Requirement 2 of article 3 mandates the efficient use of radio spectrum and the avoidance of harmful interference.

1.2 ETSI EN 303 340

The standard ETSI EN 303 340 (ETSI, 2016) has been requested by the European Commission to support article 3.2 of the radio equipment directive. It applies to digital terrestrial television broadcast receivers for DVB-T and DVB-T2, fitted with an external antenna input, and provides test methods and requirements.

ETSI EN 303 340 considers interference from LTE transmissions in the 700 MHz and 800 MHz bands and interference of DTT transmissions in UHF band IV on UHF television reception.

1.3 Purpose of this document

This application note describes the tests defined in ETSI EN 303 340 (ETSI, 2016) and provides guidance for manual tests according to this standard, using the broadcast test center R&S® BTC.

1.4 DVB-T and DVB-T2 signal parameters

EN 303 340 specifies signal parameters for DVB-T and DVB-T2. The terminology used in the parameter list differs in part from the terminology in the standards ETS 300 744 (EBU/CENELEC/ETSI JTC, 1997) and EN 302 755 (ETSI / EBU, 2015) which define the DVB-T and DVB-T2 signals. As the user interface of the R&S® Broadcast Test Center BTC refers to those standards, a reference is given in the following tables.

1.4.1 DVB-T

DVB-T Configuration						
EN 303 340			**BTC (ETS 300 744)**			
Parameter	**Value for "7 MHz" VHF tests**	**Value for "8 MHz" UHF tests**	**Window**	**Parameter**	**Value for "7 MHz" VHF tests**	**Value for "8 MHz" UHF tests**
Bandwidth	6,66 MHz	7,61 MHz	TX SignalGenA → Coding	Used Bandwidth	6.656 250 0 MHz	7.607 142 9 MHz
FFT size	8K	8K	TX SignalGenA → Coding	FFT-Mode	8K	8K
Modulation	64-QAM	64-QAM	TX SignalGenA → Coding	Constellation	64QAM	64QAM
Hierarchy	Non-Hierarchical	Non-Hierarchical	TX SignalGenA → Coding	Hierarchy	Non Hierarchical	Non Hierarchical
Guard interval	1/4	1/4	TX SignalGenA → Coding	Guard Interval	1/4	1/4
Code rate	2/3	2/3	TX SignalGenA → Coding	Code Rate	2/3	2/3
Channel Bandwidth	7 MHz	8 MHz	TX SignalGenA → Coding	Channel Bandwidth	7 MHz	8 MHz

Table 1-1: Parameters of the DVB-T Configuration

1.4.2 DVB-T2

DVB-T2 Configuration						
EN 303 340			**BTC (EN 302 755)**			
Parameter	**Value for "7 MHz" VHF tests**	**Value for "8 MHz" UHF tests**	**Window**	**Parameter**	**Value for "7 MHz" VHF tests**	**Value for "8 MHz" UHF tests**
n.a.			TX SignalGenA → Framing&OFDM	Channel Bandwidth	7 MHz	8 MHz
Bandwidth	6,66 MHz	7,77 MHz	TX SignalGenA → Framing&OFDM	Used Bandwidth (read only)	6.656 250 0 MHz	7.767 857 Mhz
FFT	32k	32k	TX SignalGenA → Framing&OFDM	FFT Size	32K	32K Ext
Carrier mode	Normal	Extended	TX SignalGenA → Framing&OFDM	FFT Size	32K	32K Ext
SISO/MISO	SISO	SISO	TX SignalGenA → T2 System	Transmission System	SISO	SISO
Guard Interval	1/16	1/16	TX SignalGenA → Framing&OFDM	Guard Interval	1/16	1/16
Version	1.2.1	1.2.1	TX SignalGenA → T2 System	L1 T2 Version	1.2.1	1.2.1
n.a.			TX SignalGenA → Framing&OFDM	Data Symbols per T2 Frame (LData)	41	61
Number of symbols/frame (Lf)	42	62	TX SignalGenA → Framing&OFDM	OFDM Symbols per T2 Frame (LF) (read only)	42	62
Pilot pattern	PP4	PP4	TX SignalGenA → Framing&OFDM	Pilot Pattern	PP 4	PP 4
TFS	No	No	TX SignalGenA → T2 System	Time Frequency Slicing	Off	Off
FEF	Not used	Not used	TX SignalGenA → T2 System	Future Extension Frames	Off	Off
Subslices / T2 frame	1	1	TX SignalGenA → Framing&OFDM	Subslices per T2 Frame (Nsub)	1	1

Table 1-2: Parameters of the DVB-T2 Configuration (1)

DVB-T2 Configuration						
EN 303 340			**BTC (EN 302 755)**			
Parameter	**Value for "7 MHz" VHF tests**	**Value for "8 MHz" UHF tests**	**Window**	**Parameter**	**Value for "7 MHz" VHF tests**	**Value for "8 MHz" UHF tests**
Auxiliary streams	Not used	Not used	TX SignalGenA → T2 System	Num. Aux. Streams	0	0
Frames / Superframe	2	2	TX SignalGenA → Framing&OFDM	T2 Frames per Superframe (NT2)	2	2
L1 post FEC type	16k LDPC (s. note 1)	16k LDPC (s. note 1)	n.a.			
L1 repetition	0	0	TX SignalGenA → T2 System	L1 Repetition	Off	Off
L1 post extension	No	No	TX SignalGenA → T2 System	L1 Post Extension	Off	Off
L1 post extension	No	No	TX SignalGenA --> T2 System	L1 Post Extension	Off	Off
L1 post modulation	64 QAM	64 QAM	TX SignalGenA --> T2 System	L1 Post Modulation	64QAM	64QAM
L1 post scrambling	None	None	TX SignalGenA --> T2 System	L1 Post Scrambled	Off	Off
L1_ACE_MAX	0 (s. note 2)	0 (s. note 2)	n.a.		Off	Off
L1 bias balancing cells	No	No	n.a.			
PAPR	L1-ACE & TR (see note 3)	L1-ACE & TR (see note 3)	TX SignalGenA --> T2 System	Peak to Aver. Power ratio	TR	TR
PAPR: Vclip	3,1 V (see note 1)	3,1 V (see note 1)	n.a.			
PAPR: Number of iterations	10 (see note 1)	10 (see note 1)	n.a.			
TS bit rate (Mbit/s)	31,146	36,552	TX SignalGenA --> Input Signal	Max. Useful Data Rate (read only)	31.146 442 Mbit/s	36.551 906 Mbit/s
Input mode	Mode A (single PLP mode)	Mode A (single PLP mode)	TX SignalGenA --> Input Signal	T2-MI Interface	Off	Off
Number of PLPs	1	1	TX SignalGenA --> Input Signal	Number of PLPs	1	1
PLP type	Data type 1	Data type 1	TX SignalGenA --> Mode&Stream	PLP Type	D. Type 1	D. Type 1
Constellation rotation	Yes	Yes	TX SignalGenA --> BICM	Const. Rotation	On	On
PLP FEC type	64k LDPC	64k LDPC	TX SignalGenA --> BICM	FEC Frame	Normal	Normal
FEC Frame length	64 800 (see note 4)	64 800 (see note 4)	TX SignalGenA --> BICM	FEC Frame	Normal	Normal
Baseband Mode	High efficiency mode (HEM)	High efficiency mode (HEM)	TX SignalGenA --> Mode&Stream	BB Mode	HEM	HEM
ISSY	None	None	TX SignalGenA --> Mode&Stream	ISSY	Off	Off
In band signaling	Disabled	Disabled	TX SignalGenA --> Mode&Stream	In-Band Signaling A (read only)	Off	Off
Null packet deletion	Disabled	Disabled	TX SignalGenA --> Mode&Stream	Null Packet Deletion	Off	Off

Table 1-3: Parameters of the DVB-T2 Configuration (2)

NOTE 1: This parameter is preset (i.e. fixed and not available as a parameter) on some modulators.

NOTE 2: This value disables L1 ACE operation.

NOTE 3: This parameter is referred to as "TR" on some modulators.

NOTE 4: This parameter is referred to as "Normal" on some modulators.

DVB-T2 Configuration						
EN 303 340			**BTC (EN 302 755)**			
Time interleaver length	3	3	TX SignalGenA --> BICM	Time Interleaver Length	3	3
Frame interval	1	1	TX SignalGenA --> BICM	Frame Interval (IJump)	1	1
Time interleaver type	0	0	TX SignalGenA --> BICM	Time Interleaver Type	0	0
T2 frames / Interleaver frame	1 (see note 5)	1 (see note 5)	n.a.			
FEC Blocks / Interleaving Frame	132	200	TX SignalGenA --> BICM	FEC Blocks per IF	132	200
Code rate	2/3	2/3	TX SignalGenA --> BICM	Code Rate	2/3	2/3
Modulation	256-QAM	256-QAM	TX SignalGenA --> BICM	Constellation	256QAM	256QAM

Table 1-4: Parameters of the DVB-T2 Configuration (3)

NOTE 5: Derived value shown for information only. Forced to 1 when time interleaver type = 0.

2 Preparations

2.1 Save-recall files

Unzip the archive file “EN303340_SaveRecallFiles.zip” and copy the following save-recall files contained therein to folder "D:\Data\EN303340" on the R&S® BTC:

EN303340 ACS1 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS1 DVBT 8Mhz BTC PathA.savrcl
EN303340 ACS1 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS1 DVBT2 8Mhz BTC PathA.savrcl
EN303340 ACS2 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS2 DVBT 8Mhz BTC PathA.savrcl
EN303340 ACS2 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS2 DVBT2 8Mhz BTC PathA.savrcl
EN303340 ACS3 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS3 DVBT 8Mz BTC PathA.savrcl
EN303340 ACS3 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS3 DVBT2 8Mhz BTC PathA.savrcl
EN303340 ACS4 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS4 DVBT 8Mhz BTC PathA.savrcl
EN303340 ACS4 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS4 DVBT2 8Mhz BTC PathA.savrcl
EN303340 ACS5 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS5 DVBT 8Mhz BTC PathA.savrcl
EN303340 ACS5 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS5 DVBT2 8Mhz BTC PathA.savrcl
EN303340 Blocking DVBT 7Mhz BTC PathA.savrcl
EN303340 Blocking DVBT 8Mhz BTC PathA.savrcl
EN303340 Blocking DVBT2 7Mhz BTC PathA.savrcl
EN303340 Blocking DVBT2 8Mhz BTC PathA.savrcl
EN303340 Overloading1 DVBT 7Mhz BTC PathA.savrcl
EN303340 Overloading1 DVBT 8Mhz BTC PathA.savrcl
EN303340 Overloading1 DVBT2 7Mhz BTC PathA.savrcl
EN303340 Overloading1 DVBT2 8Mhz BTC PathA.savrcl
EN303340 Overloading2&3 DVBT 7Mz BTC PathA.savrcl
EN303340 Overloading2&3 DVBT 8Mz BTC PathA.savrcl
EN303340 Overloading2&3 DVBT2 7Mhz BTC PathA.savrcl
EN303340 Overloading2&3 DVBT2 8Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT BW7Mhz 198_5Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT BW7Mhz 666Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT BW8Mhz 198_5Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT BW8Mhz 666Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT2 BW7Mhz 198_5Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT2 BW7Mhz 666Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT2 BW8Mhz 198_5Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT2 BW8Mhz 666Mhz BTC PathA.savrcl

2.2 Wanted signal files

The following stream files have to be present in folder “D:\TSGEN\EMC” on the R&S® BTC:

DVB-T_MPEG2_ITU-R_BT1729_25Hz_1080i.EMC_C
DVB-T2_MPEG2_ITU-R_BT1729_25Hz_1080i.EMC_C

Playback of these streams requires option R&S®LIB-K58.

2.3 Interferer files

Copy the following files to folder “D:\Arb\WAVEFORMS\EN_303340_Waveforms” on the R&S®BTC:

LTE_BS-100PC_synth_resample.wv
LTE_BS-idle_V3_synth_res_lic.wv
Short_UE-Video-Stream_V2_res_lic.wv

These files have been resampled to remove an unwanted sampling artifact . Apart from re-sampling, the signal is identical with that from the original files. The original interferer files are available from ETSI for download.

The DVB-T interferer file “DVB-T_8MHz_EN303340.wv” must be located in folder “D:\Arb\DTV_INTERFERERS”. It requires option R&S®WV-K1114.

2.4 Test setup

The following block schematic shows the test setup, which is identical for all tests. Regarding the required configuration of the Broadcast Test Center R&S®BTC, please see section 5.

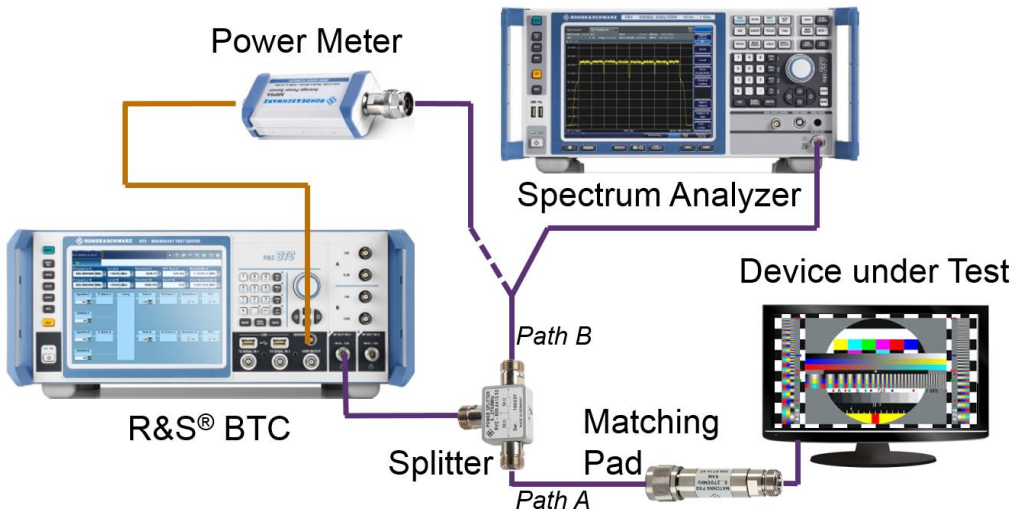

Fig. 2-1: Test setup for measurements according to EN 303 340

Power meter and spectrum analyzer can be used alternatively. At low levels, the accuracy of the power meter is limited by noise, whereas the spectrum analyzer has a higher general measurement uncertainty.

The cables from the splitter to the spectrum analyzer / power meter and to the matching pad should have equal length and attenuation. Measure the signal power at the output of each of the two cables for each signal frequency, to make sure that there is no significant difference in the attenuation from the R&S®BTC output to the input of the matching pad, and from the R&S®BTC output to the input of the power meter or spectrum analyzer.

The matching pad from 50 Ohm to 75 Ohm should be placed as close as possible to the antenna input of the device under test. The attenuation of the matching pad has to be subtracted from the level reading of the power meter or the power measurement in the spectrum analyzer in order to obtain the value of the RF level at the antenna input of the device under test.

3 Measurements

3.1 Sensitivity

Receiver sensitivity is defined in EN 303 340 as “the minimum receiver Radio Frequency (RF) input signal level or field strength able to produce a specified analogue SINAD or Bit Error Ratio (BER), or other specified output performance which depends on this input signal level”. In the context of EN 303 340, “receiver sensitivity is determined by the onset of picture degradation”.

3.1.1 Signals

Sensitivity tests are specified for DVB-T and DVB-T2 at 198.5 MHz (VHF) and 666 MHz (UHF). Use the signal parameters specified in section 1.3 and wanted signal files “DVB-T_MPEG2_ITU-R_BT1729_25Hz_1080i.EMC_C” and “DVB-T2_MPEG2_ITU-R_BT1729_25Hz_1080i.EMC_C” (option R&S®LIB-K58 required).

The wanted signal has to carry a video stream containing moving images and an audio signal. This application note provides a video stream with the test signal from ITU-R BT.1729 (Radiocommunication Sector of ITU, 2013).

3.1.2 Save-Recall files

The following save-recall files are provided with this application note for sensitivity measurement:

EN303340 Sensitivity DVBT BW7Mhz 198_5Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT BW7Mhz 666Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT BW8Mhz 198_5Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT BW8Mhz 666Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT2 BW7Mhz 198_5Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT2 BW7Mhz 666Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT2 BW8Mhz 198_5Mhz BTC PathA.savrcl
EN303340 Sensitivity DVBT2 BW8Mhz 666Mhz BTC PathA.savrcl

There is one file for each of the eight combinations of standard (DVB-T or DVB-T2), bandwidth (7 MHz or 8 MHz) and frequency (198.5 MHz or 666 MHz).

3.1.3 Test procedure

3.1.3.1 Preparation

Connect the instruments and device under test as shown in figure 2-1. Configure the R&S® BTC for the desired combination of frequency and TV standard, e.g. by loading one of the save-recall files provided. Set a signal level of -50 dBm at the R&S®BTC and check the spectrum at the output, using the spectrum analyzer.

Tune the device under test to the signal frequency (198.5 MHz for VHF, 666 MHz for UHF) and verify that the test video sequence is visible on the TV screen.

After loading the save-recall file and / or setting the carrier frequency, it is recommended to adjust the modulator with “Adjust I/Q Modulator Local A” in the “Adjustment” tab of the “Setup” window.

3.1.3.2 Spectrum analyzer settings

The following settings of the spectrum analyzer are recommended for sensitivity tests:

Spectrum analyzer settings	
Parameter	**Value**
Center frequency	Signal frequency
Span	15 MHz
Resolution bandwidth	10 kHz
Video bandwidth	1 kHz
Sweep time	100 ms
Detector	RMS
Measurement	Channel power
Channel bandwidth	7 MHz or 8 MHz according to the signal bandwidth

Table 3-1: Recommended spectrum analyzer settings for sensitivity tests

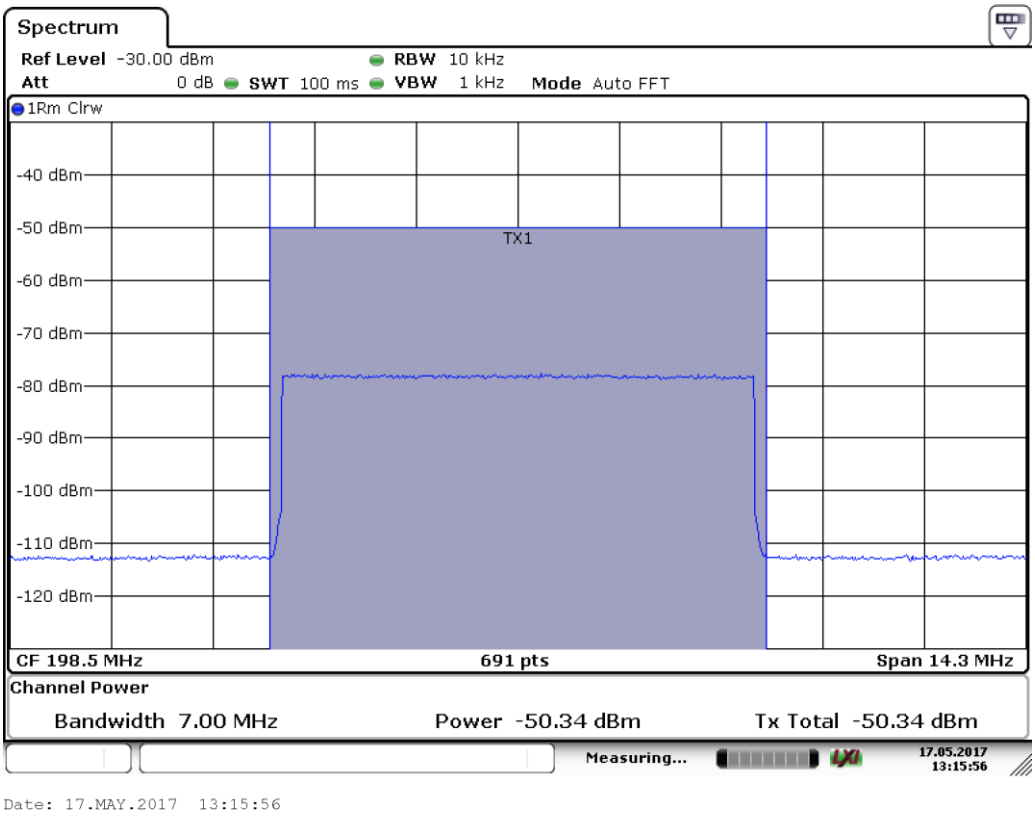

Fig. 3-1: Sample spectrum of DVB-T signal measured with Signal Analyzer R&S®FSV

3.1.3.3 Level adjustment

Perform zeroing of the power sensor with the BTC RF signal off or with the input of the power sensor terminated with a 50 Ohm termination.

For exact level adjustment, connect power sensor NRP-Z91 or NRP-Z92 instead of the spectrum analyzer and measure the average power of the digital TV signal. It is recommended to use the largest available filter length of 128 for a stable level reading. Adjust the output level of the R&S®BTC such that the power level reading from the power meter or spectrum analyzer, respectively, is

$$L = -30\ \text{dBm} + A_{MP},$$

with A_{MP} being the attenuation of the matching pad from the 50 Ohm input to the 75 Ohm output.

Verify the symmetry of splitter and cables by disconnecting the cable of path A from the matching pad and repeating the power measurement at this point. Make sure that the cable of path B is terminated properly for this measurement.

Open the “Level” sub-tab of the “TX RF A” tab on the R&S®BTC and enter an appropriate “Offset” value, such that the “Level + Offset” reading is -30 dBm.

3.1.3.4 Determining the receiver sensitivity

Decrease the generator level such that the “Level + Offset” reading is -70 dBm. Make sure that the TV reception is still without degradation. Change “Attenuator Mode” in the “Level” sub-tab of the “TX RF A” tab to “Fixed” to avoid switching of the attenuator during the subsequent level adjustment.

Reduce the level further until the picture fails completely.

Increase the level until the receiver under test re-acquires the signal. If a level higher than -70 dBm is required, it may be necessary to set the attenuator mode back to “Auto”. If this is the case reduce the “Level + Offset” back to -70 dBm and switch the attenuator mode to “Fixed” again.

Reduce the level gradually until the onset of picture degradation occurs. Note the level as measured receiver sensitivity.

It may be necessary to force the receiver to re-acquire the signal after a level change.

3.1.4 Measurement uncertainty

EN 303 340 requires a measurement uncertainty of less than ±3 dB. The value of the measurement uncertainty has to be included in the test report.

The instruments used here for this measurement have the following uncertainties:

BTC level error	< 0.5 dB
Additional level error I/Q modulation	< 0.3 dB
Attenuation tolerance in splitter R&S®RVZ	0.1 dB
Attenuation tolerance in matching pad R&S®RAM	+ 0.15 / -0.05 dB
Uncertainty R&S®NRP6A at -30 dBm (+15 °C to +35 °C)	0.081 dB
Uncertainty R&S®NRP-Z91 at -30 dBm (+15 °C to +35 °C)	0.081 dB

Uncertainty R&S®NRP-Z92 at -30 dBm (+15 °C to +35 °C)	0.106 dB
Absolute level uncertainty R&S®FSV at 64 MHz	0.2 dB
Frequency response re. 64 MHz R&S®FSV	0.3 dB
Total level measurement uncertainty R&S®FSV	0.28 dB

The level errors and attenuation errors add up as dB values.

The worst case uncertainty is the sum of all involved uncertainties. Note that the BTC level error counts twice because the level is set first at -30 dBm for the power meter measurement and then to the sensitivity value. An attenuation tolerance of 0.1 dB for splitter and cable is taken into account twice, one time for each splitter output.

The standard uncertainty is the square root of the sum of squares of all involved uncertainties. With this calculation the following values for the overall uncertainty are obtained:

Level measurement	Worst case uncertainty	Standard uncertainty
R&S®NRP6A	+1.93 dB / -2.03 dB	+0.84 dB / -0.85 dB
R&S®NRP-Z91	+1.93 dB / -2.03 dB	+0.84 dB / -0.85 dB
R&S®NRP-Z92	+1.96 dB / -2.07 dB	+0.85 dB / -0.86 dB
R&S®FSV	+2.35 dB / -2.45 dB	±0.88 dB

For details of the uncertainty calculation please see spreadsheet “EN303340_uncertainty.xlsx”.

3.1.5 Documentation

Use the template given in table C.1 of ETSI EN 303 340 V. 1.1.2 for reporting the results. The spreadsheet “EN303340_template.xlsx” can be used for entering the result values from all tests and printing them in the correct format.

Sensitivity tests

Test	Required sensitivity limit for DTT configurations in tables 2 and 3 (dBm)		Measured sensitivity for DTT configurations in tables 2 and 3 (dBm)		Test temperature °C	Test humidity %	Measurement uncertainty ±dB
	DVB-T	DVB-T2	DVB-T	DVB-T2			
1 VHF	-77	-75					
2 UHF	-77	-75					

Fig. 3-2: Measurement record for sensitivity tests

3.2 Adjacent channel selectivity

Adjacent channel selectivity (I/C) is defined in EN 303340 as “the measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted signal which differs in frequency from the wanted signal by an amount equal to the adjacent channel separation for which the equipment is intended”.

There are five different adjacent channel selectivity measurements defined in EN 303 340, two with a light load LTE interferer, one with an LTE interferer carrying a short video stream, and two with 8 MHz DVB-T interferer.

3.2.1 Signals

The interferer signal files are “LTE_BS-idle_V3_synth_res_lic.wv” (light load LTE interferer), “Short_UE-Video-Stream_V2_res_lic.wv” (short video stream LTE interferer) and “DVB-T_8MHz_EN303340.wv” (DVB-T interferer). Playback of the DVB-T interferer requires option R&S®WV-K1114.

EN 303 340 requires in Annex D the following minimum ACLR:

Required interference signal ACLR			
Test description	**Assumed AWGN C/N**	**I/C requirement**	**Recommended minimum ACLR including effect of LAPR where applicable (dB)**
Adjacent channel selectivity test 1	DVB-T C/N = 15 dB	35	48
Adjacent channel selectivity test 2		43	56
Adjacent channel selectivity test 3		33	36
Adjacent channel selectivity test 4&5		25	46
Adjacent channel selectivity test 1	DVB-T2 C/N = 19 dB	36	53
Adjacent channel selectivity test 2		43	60
Adjacent channel selectivity test 3		38	45
Adjacent channel selectivity test 4&5		25	50

Table 3-2: Required interference signal ACLR according to EN 303 340 Table F.1

The interferers generated with R&S® Broadcast Test Center BTC fulfil this requirement (see Annex A).

The wanted signal center frequencies are 786 MHz and 690 MHz for the light load LTE interferer, 690 MHz for the video stream LTE interferer and 482 MHz for the DVB-T interferer.

The wanted signal has to carry a video stream containing moving images and an audio signal. This application note provides a video stream with the test signal from ITU-R BT.1729 (option R&S®Lib-K58 required).

In order to avoid a degradation of the wanted signal by carrier leakage, the carrier frequency of the R&S®BTC is set to the interferer frequency, and the wanted signal is offset in frequency accordingly.

3.2.2 Save-Recall files

The following save-recall files are provided with this application note for adjacent channel selectivity measurements:

EN303340 ACS1 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS1 DVBT 8Mhz BTC PathA.savrcl
EN303340 ACS1 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS1 DVBT2 8Mhz BTC PathA.savrcl
EN303340 ACS2 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS2 DVBT 8Mhz BTC PathA.savrcl
EN303340 ACS2 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS2 DVBT2 8Mhz BTC PathA.savrcl

EN303340 ACS3 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS3 DVBT 8Mz BTC PathA.savrcl
EN303340 ACS3 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS3 DVBT2 8Mhz BTC PathA.savrcl
EN303340 ACS4 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS4 DVBT 8Mhz BTC PathA.savrcl
EN303340 ACS4 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS4 DVBT2 8Mhz BTC PathA.savrcl
EN303340 ACS5 DVBT 7Mhz BTC PathA.savrcl
EN303340 ACS5 DVBT 8Mhz BTC PathA.savrcl
EN303340 ACS5 DVBT2 7Mhz BTC PathA.savrcl
EN303340 ACS5 DVBT2 8Mhz BTC PathA.savrcl

There are four files for each of the five adjacent channel separation tests, one for each combination of standard (DVB-T or DVB-T2) and bandwidth of the wanted signal.

3.2.3 Test procedure

3.2.3.1 Preparation

After loading the save-recall file and / or setting the carrier frequency, it is recommended to adjust the modulator with “Adjust I/Q Modulator Local A” in the “Adjustment” tab of the “Setup” window.

Tune the device under test to the signal frequency (786 MHz for adjacent channel selectivity test 1, 690 MHz for ACS tests 2 and 3 and 482 MHz for ACS tests 4 and 5) and verify that the test video sequence is visible on the TV screen.

3.2.3.2 Spectrum analyzer settings

Spectrum analyzer settings			
Parameter	**Values test 1 & 2**	**Values test 3**	**Alternative values test 3**
Center frequency	Interferer frequency	Interferer frequency	Interferer frequency
Span	15 MHz	0 Hz	15 MHz
Resolution bandwidth	10 kHz	≥ 8 MHz	10 kHz
Video bandwidth	100 kHz	≥ 8 MHz	100 kHz
Sweep time	5 s	2 s	≥ 30 s
Number of sweep points	≥ 401	≥ 401	≥ 1250
Detector	RMS / clear write	RMS / clear write	RMS / clear write
Measurement	Channel power	Time domain power 1042 milliseconds	Channel power
Channel bandwidth	10 MHz		10 MHz

Table 3-3: Recommended spectrum analyzer settings for measuring the interferer power with channel separation and blocking tests according to (ETSI, 2016)

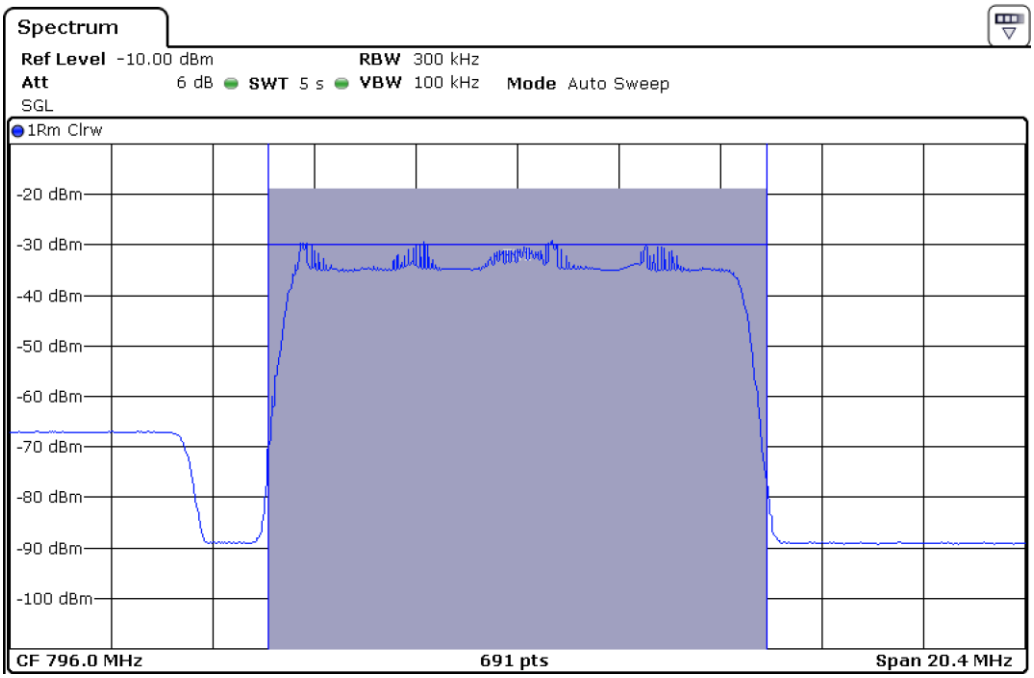

Fig. 3-3: Sample interferer spectrum of adjacent channel selectivity test 1 measured with Signal Analyzer R&S®FSV

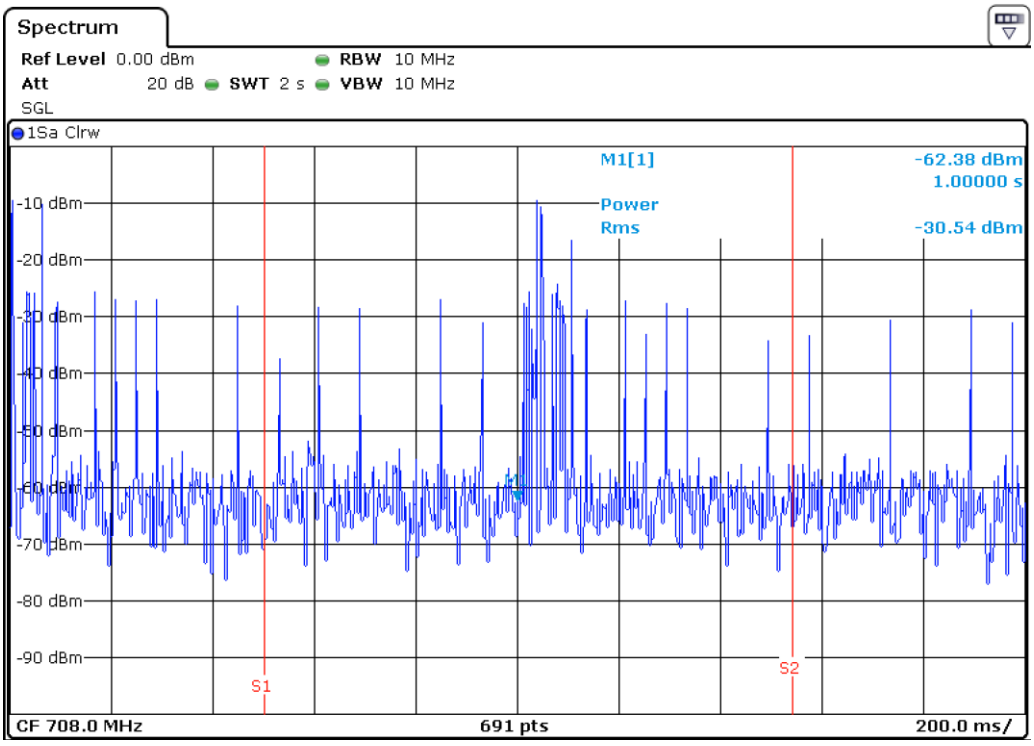

Fig. 3-4: Sample zero-span trace of interferer of adjacent channel selectivity test 3 with time-domain power measurement on Signal Analyzer R&S®FSV

For viewing the spectrum and measuring the power of the wanted signal and of the DVB-T interferer (tests 4 and 5) use the settings from Table 3-1.

3.2.3.3 Interferer level adjustment

First the interferer signal level is adjusted to the specified I_{rms} at the receiver input.

Perform zeroing of the power sensor with the BTC RF signal off or with the input of the power sensor terminated with a 50 Ohm termination.

Set the wanted signal level to -80 dBm. Adjust the interferer level of the R&S® BTC such that the power reading is

$$L_{Irms} + A_{MP},$$

with A_{MP} being the attenuation of the matching pad from the 50 Ohm input to the 75 Ohm output. L_{Irms} is -23.3 dBm for adjacent channel selectivity tests 1 and 2, -42.7 dBm for ACS test 3 and -30 dBm for ACS tests 4 and 5.

Verify the symmetry of splitter and cables by disconnecting the cable of path A from the matching pad and repeating the power measurement at this point. Make sure that the cable of path B is terminated properly for this measurement.

3.2.3.4 Adjustment of the wanted signal level

Set the wanted signal level to -40 dBm. Make sure that the receiver under test receives the test stream without degradation. Reduce the wanted signal level in 1 dB steps until the onset of picture degradation. Increase the wanted signal level by 1 dB. Make sure that the test stream is again received without degradation and reduce the level in 0.1 dB steps until the onset of picture degradation. Increase the wanted signal level again by 0.1 dB and make sure that the test stream is received again without degradation.

It may be necessary to force the receiver to re-acquire the signal after a level change.

3.2.3.5 Measurement of the wanted signal level

Turn the interferer off (state = off with the respective column in the “TX Interferer A” tab), increase the wanted signal level at the BTC output by 30 dB and measure the level of the wanted signal with the power meter.

$$L_{Crms} = L_{measured} + A_{MP},$$

with A_{MP} being the attenuation of the matching pad from the 50 Ohm input to the 75 Ohm output.

With low signal levels where the zero offset and noise of the power meter limit the measurement accuracy, the BTC output level has to be increased by 30 dB for the level measurement. In this case the wanted signal level is calculated as

$$L_{Crms} = L_{measured} + A_{MP} \text{ -30 dB}.$$

This is recommended for ACS tests 2 and 3, and with high power sensors like R&S®NRP-Z92 also for ACS tests 4 and 5.

Alternatively the wanted signal level can be measured using the channel power measurement of a spectrum analyzer.

3.2.4 Measurement uncertainty

For general remarks on the measurement uncertainty see section 3.1.4.

With the adjacent channel separation test the BTC level error has no influence because each level is directly measured with the power meter. Only if the power measurement is done at an increased level, the BTC level error counts twice. The attenuation tolerances of the matching pad and the splitter have no direct influence on the ratio because they are sufficiently equal for both wanted signal and interferer. The measurement uncertainty of the power meter counts twice. It depends on the measured signal level because the zero offset and noise are absolute errors on top of the relative uncertainty. Thus the following values for the overall uncertainty are obtained:

Test 1

Level measurement	Worst case uncertainty	Standard uncertainty
R&S®NRP6A	+0.29 dB / -0.32 dB	±0.17 dB
R&S®NRP-Z91	+0.41 dB / -0.45 dB	+0.27 dB / -0.28 dB
R&S®NRP-Z92	+0.87 dB / -1.29 dB	+0.68 dB / -0.79 dB
R&S®FSV	±1.00 dB	±0.40 dB

Test 2

Level measurement	Worst case uncertainty	Standard uncertainty
R&S®NRP6A	±1.76 dB	±0.83 dB
R&S®NRP-Z91	±1.76 dB	±0.83 dB
R&S®NRP-Z92	±1.82 dB	±0.84 dB
R&S®FSV	±1.00 dB	±0.40 dB

Test 3 (DVB-T)

Level measurement	Worst case uncertainty	Standard uncertainty
R&S®NRP6A	+1.79 dB / -1.78 dB	±0.83 dB
R&S®NRP-Z91	+1.81 dB / -1.80 dB	±0.83 dB
R&S®NRP-Z92	+1.99 dB / -1.92 dB	+0.85 dB / -0.84 dB
R&S®FSV	±1.00 dB	±0.40 dB

Test 3 (DVB-T2)

Level measurement	Worst case uncertainty	Standard uncertainty
R&S®NRP6A	+1.79 dB / -1.78 dB	±0.83 dB
R&S®NRP-Z91	±1.81 dB	±0.83 dB
R&S®NRP-Z92	+2.00 dB / -1.94 dB	+0.85 dB / -0.84 dB
R&S®FSV	±1.00 dB	±0.40 dB

Test 4 and 5

Level measurement	Worst case uncertainty	Standard uncertainty
R&S®NRP6A	+0.47 dB / -0.54 dB	+0.33 dB / -0.34 dB
R&S®NRP-Z91	+0.77 dB / -0.85 dB	+0.61 dB / -0.62 dB
R&S®NRP-Z92	±1.83 dB	±0.84 dB
R&S®FSV	±1.00 dB	±0.40 dB

For details of the uncertainty calculation please see spreadsheet "EN303340_uncertainty.xlsx".

3.2.5 Documentation

Use the template given in the lower half of table C.2 of ETSI EN 303 340 V. 1.1.2 for reporting the results. The spreadsheet "EN303340_template.xlsx" can be used for entering the result values from all tests and printing them in the correct format.

Adjacent channel selectivity tests

Test (see note)	Minimum required I/C limit for DTT configurations in tables 2 and 3 (dB)		Measured I/C for DTT configurations in tables 2 and 3 (see note 2) (dB)		Test temperature °C	Test humidity %	Measurement uncertainty ±dB
	DVB-T	DVB-T2	DVB-T	DVB-T2			
1 (see note 1)	35	36					
2	43	43					
3	33	38					
4	25	25					
5	25	25					
Test (see note)	Equivalent wanted signal level C_{rms} for DTT configurations in tables 2 and 3		Measured wanted signal level C_{rms} for DTT configurations in tables 2 and 3 (see note 2)		Test temperature °C	Test humidity %	Measurement uncertainty ±dB
	DVB-T	DVB-T2	DVB-T	DVB-T2			
1 (see note 1)	-50	-51					
2	-58	-58					
3	-58	-63					
4	-55	-55					
5	-55	-55					
NOTE1: For devices that do not receive DVB-T/T2 signals above 698 MHz, test 1 is not applicable NOTE2: It is only necessary to record either I/C or wanted signal level.							

Fig. 3-5: Measurement record for adjacent channel selectivity tests

3.3 Blocking

Blocking is defined in EN 303340 as " the measure of the capability of the receiver to receive a wanted modulated signal without exceeding a given degradation due to the presence of an unwanted signal at any frequency other than those of the spurious responses or of the adjacent channels". In the context of EN 303 340, "receiver sensitivity is determined by the onset of picture degradation".

3.3.1 Signals

The interferer signal is a fully loaded LTE base station signal at 763 MHz center frequency. The waveform file is “LTE_BS-100PC_synth_resample.wv ”.

Required interference signal ACLR		
Test description	**Assumed AWGN C/N**	**Recommended minimum ACLR including effect of LAPR where applicable (dB)**
Blocking test 1	DVB-T C/N = 15 dB	67
Blocking test 2	DVB-T2 C/N = 19 dB	69

Table 3-4: Required interference signal ACLR according to EN 303 340 Table F.1

The interferers generated with R&S® Broadcast Test Center BTC fulfil this requirement (see Annex A).

The wanted signal center frequency is 690 MHz.

The wanted signal has to carry a video stream containing moving images and an audio signal. This application note provides a video stream with the test signal from ITU-R BT.1729.

In order to avoid a degradation of the wanted signal by carrier leakage, the carrier frequency of the R&S®BTC is set to the interferer frequency, and the wanted signal is offset in frequency accordingly.

3.3.2 Save-Recall files

The following save-recall files are provided with this application note for blocking tests:

EN303340 Blocking DVBT 7Mhz BTC PathA.savrcl
EN303340 Blocking DVBT 8Mhz BTC PathA.savrcl
EN303340 Blocking DVBT2 7Mhz BTC PathA.savrcl
EN303340 Blocking DVBT2 8Mhz BTC PathA.savrcl

3.3.3 Test procedure

3.3.3.1 Preparation

After loading the save-recall file and / or setting the carrier frequency, it is recommended to adjust the modulator with “Adjust I/Q Modulator Local A” in the “Adjustment” tab of the “Setup” window.

Tune the device under test to the wanted signal frequency (690 MHz) and verify that the test video sequence is visible on the TV screen.

3.3.3.2 Spectrum analyzer settings

Spectrum analyzer settings	
Parameter	**Value**
Center frequency	Signal frequency / Interferer frequency
Span	15 MHz
Resolution bandwidth	10 kHz
Video bandwidth	1 kHz
Sweep time	100 ms
Detector	RMS
Measurement	Channel power
Channel bandwidth	7 MHz or 8 MHz according to the signal bandwidth / 10 MHz for interferer measurement

Table 3-5: Recommended spectrum analyzer settings for blocking tests

3.3.3.3 Wanted signal level adjustment

Perform zeroing of the power sensor with the BTC RF signal off or with the input of the power sensor terminated with a 50 Ohm termination.

Turn the interferer off (state = off with the respective column in the “TX Interferer A” tab).

Connect power sensor NRP-Z91 or NRP-Z92 to the second splitter output and measure the average power of the digital TV signal. It is recommended to use the largest available filter length of 128 for a stable level reading. Adjust the output level of the R&S®BTC such that the power reading is

-30 dBm + A_{MP},

with A_{MP} being the attenuation of the matching pad from the 50 Ohm input to the 75 Ohm output.

Open the “Level” sub-tab of the “TX RF A” tab and enter an appropriate “Offset” value, such that the “Level + Offset” reading is -30 dBm.

Reduce the level by 41 dB for the DVB-T signal or by 39 dB for the DVB-T2 signal, respectively, such that the “Level + Offset” reading is -71 dBm or -69 dBm, respectively.

3.3.3.4 Adjustment of the interferer level

Turn the interferer on at a level of -50 dBm. Increase the interferer level in 1 dB steps until the onset of picture degradation. Reduce the interferer level by 1 dB. Make sure that the test stream is again received without degradation and increase the level in 0.1 dB steps until the onset of picture degradation. Reduce the interferer level again by 0.1 dB and make sure that the test stream is received again without degradation.

It may be necessary to force the receiver to re-acquire the signal after a level change.

3.3.3.5 Measurement of the interferer level

Set the wanted signal level to -80 dBm and measure the level of the interferer with the power meter.

$L_{Irms} = L_{measured} + A_{MP}$,

with A_{MP} being the attenuation of the matching pad from the 50 Ohm input to the 75 Ohm output.

Alternatively the interferer level can be measured using the channel power measurement of a spectrum analyzer. This avoids the necessity to reduce the wanted signal level, but the measurement uncertainty is higher than with the power meter.

3.3.4 Measurement uncertainty

For general remarks on the measurement uncertainty see section 3.1.4.

The instruments used for this measurement have the following uncertainties:

BTC level error	< 0.5 dB
Additional level error I/Q modulation	< 0.3 dB
Uncertainty R&S®NRP6A at -30 dBm (+15 °C to +35 °C)	0.081 dB
Uncertainty R&S®NRP-Z91 at -30 dBm (+15 °C to +35 °C)	0.081 dB
Uncertainty R&S®NRP-Z92 at -30 dBm (+15 °C to +35 °C)	0.106 dB
Absolute level uncertainty R&S®FSV at 64 MHz	0.2 dB
Frequency response re. 64 MHz R&S®FSV	0.3 dB
Total level measurement uncertainty R&S®FSV	0.28 dB

The tolerance of the matching pad attenuation has the same impact on both wanted signal level and interferer level and has therefore no significant influence on the overall result. The total uncertainty is comprised of twice the level measurement uncertainty, twice the BTC level error and twice the splitter attenuation error. The attenuation tolerances of the matching pad and the splitter have no direct influence on the ratio because they are sufficiently equal for both wanted signal and interferer. With this calculation the following values for the overall uncertainty are obtained:

Level measurement	Worst case uncertainty	Standard uncertainty
R&S®NRP6A	±1.76 dB	±0.69 dB
R&S®NRP-Z91	±1.60 dB	±0.68 dB
R&S®NRP-Z92	±1.83 dB	±0.70 dB
R&S®FSV	±1.00 dB	±0.40 dB

For details of the uncertainty calculation please see spreadsheet “EN303340_uncertainty.xlsx”.

3.3.5 Documentation

Use the template given in the lower half of table C.3 of ETSI EN 303 340 V. 1.1.2 for reporting the results. The spreadsheet “EN303340_template.xlsx” can be used for entering the result values from all tests and printing them in the correct format

Blocking test

Test	Required blocking level I_{rms} for DTT configurations in tables 2 and 3 (dBm)		Measured blocking level I_{rms} for DTT configurations in tables 2 and 3 (dBm)		Test temperature °C	Test humidity %	Measurement uncertainty ±dB
	DVB-T	DVB-T2	DVB-T	DVB-T2			
1	-25			N/A			
2		-25	N/A				

Fig. 3-6: Measurement record for blocking test

3.4 Overloading

The overload level is defined in EN 303 340 as “the interfering signal level in dBm, above which the receiver begins to lose its ability to discriminate against interfering signals at frequencies differing from that of the wanted signal due to the onset of strong non-linear behavior”. In the context of EN 303 340, “the overload level is determined by the onset of picture degradation”.

3.4.1 Signals

The signals are the same as in 3.3.1(blocking tests), albeit at higher levels. For the overloading tests the useful signal level is -35 dBm instead of -71 dBm or -69 dBm, respectively. Therefore the interferer level will also be considerably higher.

Required interference signal ACLR		
Test description	**Assumed AWGN C/N**	**Recommended minimum ACLR including effect of LAPR where applicable (dB)**
Overloading test 1	DVB-T C/N = 15 dB	52
Overloading test 1	DVB-T2 C/N = 19 dB	56

Table 3-6: Required interference signal ACLR according to EN 303 340 Table F.1

3.4.2 Test procedure

3.4.2.1 Preparation

After loading the save-recall file and / or setting the carrier frequency, it is recommended to adjust the modulator with “Adjust I/Q Modulator Local A” in the “Adjustment” tab of the “Setup” window.

Tune the device under test to the wanted signal frequency (690 MHz) and verify that the test video sequence is visible on the TV screen.

3.4.2.2 Spectrum analyzer settings

The recommended spectrum analyzer settings are the same as for blocking tests (3.3.3.2).

3.4.2.3 Wanted signal level adjustment

Perform zeroing of the power sensor with the BTC RF signal off or with the input of the power sensor terminated with a 50 Ohm termination.

Turn the interferer off (state = off with the respective column in the “TX Interferer A” tab).

Connect power sensor NRP-Z91 or NRP-Z92 to the second splitter output and measure the average power of the digital TV signal. It is recommended to use the largest available filter length of 128 for a stable level reading. Adjust the output level of the R&S®BTC such that the power reading is

-35 dBm + A_{MP},

with A_{MP} being the attenuation of the matching pad from the 50 Ohm input to the 75 Ohm output.

3.4.2.4 Adjustment of the interferer level

Turn the interferer on at a level of -20 dBm. Increase the interferer level in 1 dB steps until the onset of picture degradation. Reduce the interferer level by 1 dB. Make sure that the test stream is again received without degradation and increase the level in 0.1 dB steps until the onset of picture degradation. Reduce the interferer level again by 0.1 dB and make sure that the test stream is received again without degradation.

It may be necessary to force the receiver to re-acquire the signal after a level change.

3.4.2.5 Measurement of the interferer level

Set the wanted signal level to -50 dBm and measure the level of the interferer with the power meter.

$I_{rms} = L_{measured} + A_{MP}$,

with A_{MP} being the attenuation of the matching pad from the 50 Ohm input to the 75 Ohm output.

Alternatively the interferer level can be measured using the channel power measurement of a spectrum analyzer. This avoids the necessity to reduce the wanted signal level, but the measurement uncertainty is higher than with the power meter.

3.4.3 Measurement uncertainty

For general remarks on the measurement uncertainty see section 3.1.4.

As both the wanted signal level and the interferer level are measured directly, the total measurement uncertainty is the combined uncertainty of two power measurements. The BTC level error has no influence on the total measurement uncertainty. The tolerance of the matching pad attenuation affects both power measurements in identical way. The tolerance of the useful signal power either has minor influence on the resulting interferer level or even reduces the error introduced by the tolerance of the matching pad attenuation on the interferer level measurement. For this reason the

attenuation tolerance of the matching pad is taken into account once. An attenuation tolerance of 0.1 dB for splitter and cable is taken into account twice.

Level measurement	Worst case uncertainty	Standard uncertainty
R&S®NRP6A	+0.42 dB / -0.52 dB	+0.19 dB / -0.24 dB
R&S®NRP-Z91	+0.42 dB / -0.51 dB	+0.19 dB / -0.23 dB
R&S®NRP-Z92	+0.49 dB / -0.58 dB	+0.21 dB / -0.26 dB
R&S®FSV	+1.25 dB / -1.35 dB	+0.42 dB / -0.45 dB

For details of the uncertainty calculation please see spreadsheet “EN303340_uncertainty.xlsx”.

3.4.4 Documentation

Use the template given in table C.4 of ETSI EN 303 340 V. 1.1.2 for reporting the results. The spreadsheet “EN303340_template.xlsx” can be used for entering the result values from all tests and printing them in the correct format.

Overloading test

Test					Test temperature °C	Test humidity %	Measurement uncertainty ±dB
	DVB-T	DVB-T2	DVB-T	DVB-T2			
1	-12	-12					
2	-4	-4					
3	-4	-4					

Fig. 3-7: Measurement record for overloading test05_gERBR

4 Bibliography

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5 Ordering Information

Designation	Type	Order No.
Broadcast Test Center	R&S®BTC	2114.3000.02
Baseband Generator, 1st channel	R&S®BTC-B1	2114.3500.02
Baseband Main Module, one I/Q path to RF	R&S®BTC-B11	2114.6500.02
Frequency range 100 kHz up to 3 GHz	R&S®BTC-B3103	2114.3100.02
Multimedia Generation Suite	R&S®BTC-K20	included in base unit
Multi ARB Waveform Generator, (SL)	R&S®BTC-K35	2114.6974.02
DVB-T/DVB-H Coder	R&S®BTC-K501	2114.6980
DVB-T2 Coder	R&S®BTC-K516	2114.7035
Digital TV Interferers	R&S®WV-K1114	2116.9964.02
EMC Streams	R&S®Lib-K58	2116.9435.02
Power measurements	R&S®BTC-K2055	2114.7258.02
Average Power Sensor	R&S®NRP6A (supported from BTC firmware version 02.20)	1424.6796.02
Six-Pole Interface Cable, length: 1.50 m (Accessory to R&S®NRP6A)	R&S®NRP-ZK6	1419.0664.02
Alternatively: Average Power Sensor	R&S®NRP-Z91 (discontinued)	1168.8004.02
Signal and Spectrum Analyzer	R&S®FSV4	1321.3008.04
Preamplifier, 9 kHz to 4 GHz	R&S®FSV4-B22	1310.9600.02
Matching Pad 0 … 2700 MHz	R&S®RAM	358.5414.02
Power Splitter	R&S®RVZ	0800.6612.52

Appendix

A Measurement of adjacent channel leakage power ratio (ACLR)

A.1 Method

The ACLR of the interferer can be checked with the following procedure:

- Load the respective BTC save-recall file.
- Set the interferer level to the specified value or expected adjustment result, respectively
- Reduce the wanted signal level to 70 dB below the interferer level. For the ACLR measurement on the blocking test interferer, change the frequency offset of the wanted signal additionally to -80 MHz.
- Set the spectrum analyzer as recommended above for the respective signal (see 3.2.3.2, 3.3.3.2 or 3.4.2.2, respectively. No zero span!).
- Switch on the preamplifier in the spectrum analyzer.
- Set an appropriate reference level.
- Configure the ACLR measurement according to the signal constellation for the respective test.
- According to the frequency relation between interferer and useful signal, either the lower or the upper ACLR value applies.
- Switch on the noise correction. It is recommended to perform the reference measurement for the noise correction with a 50 Ohm termination at the spectrum analyzer input.

For ACS test 3 two separate measurements at zero span should be considered alternatively.

A.2 Sample results

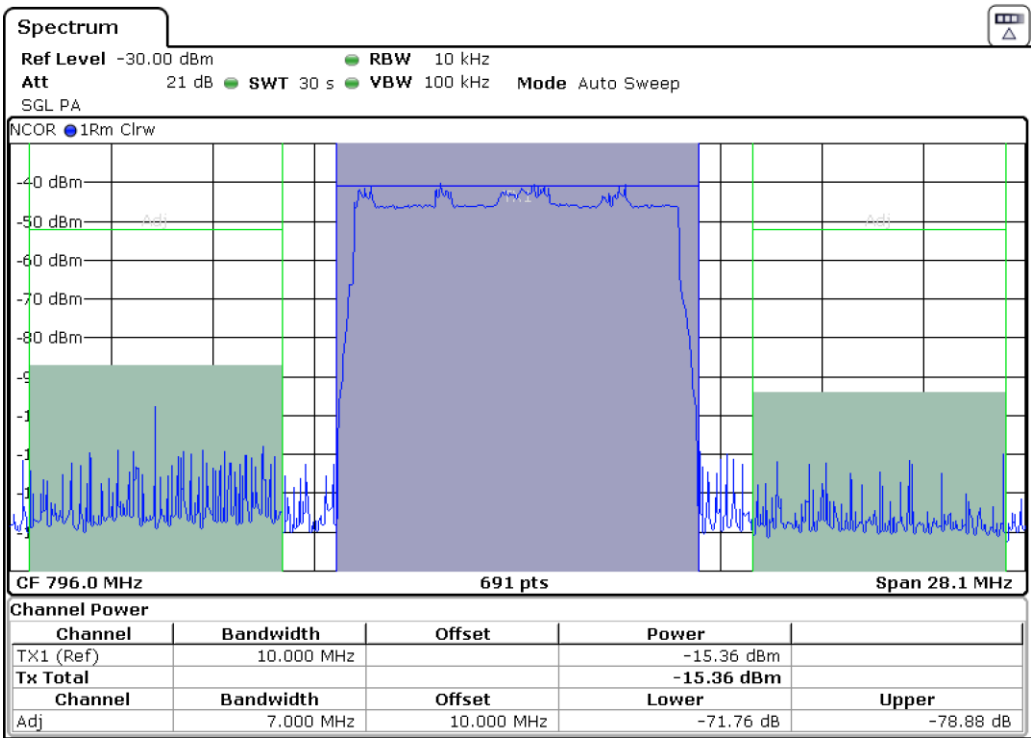

Fig. A-1: ACLR measurement for adjacent channel separation test 1

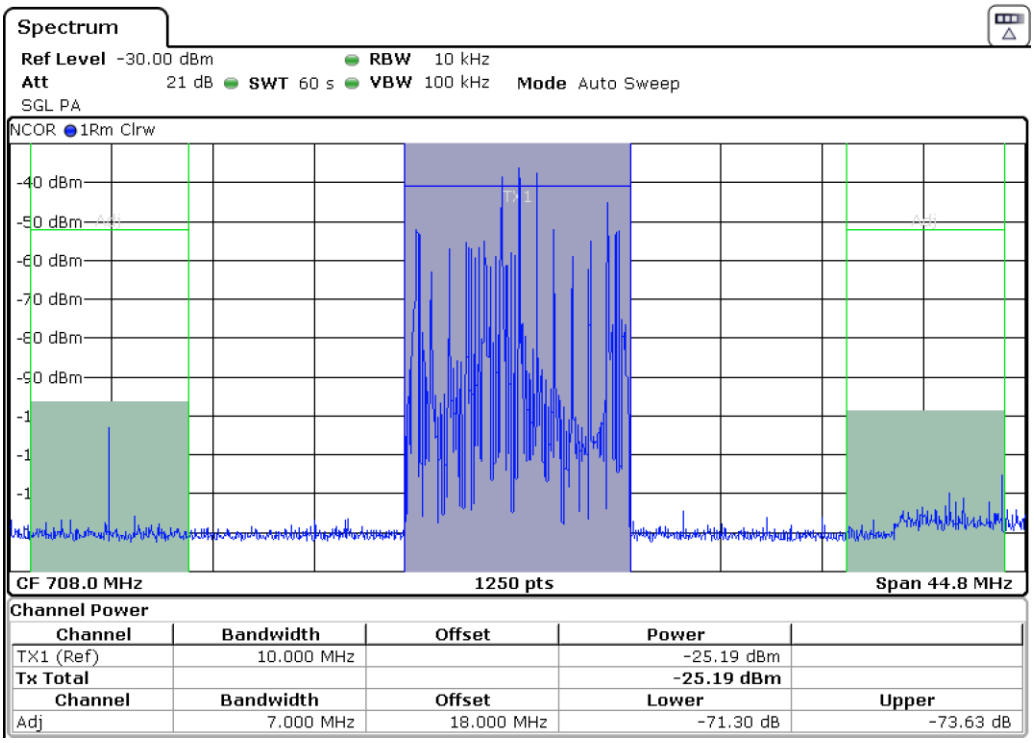

Fig. A-2: ACLR measurement for adjacent channel separation test 3

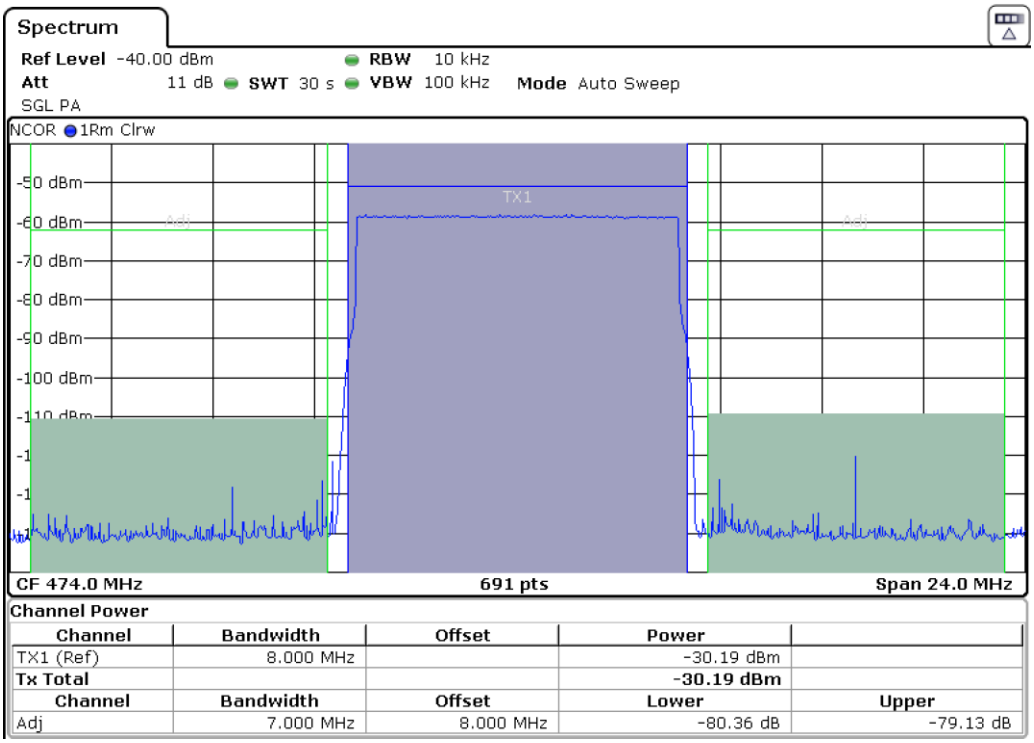

Fig. A-3: ACLR measurement for adjacent channel separation test 4

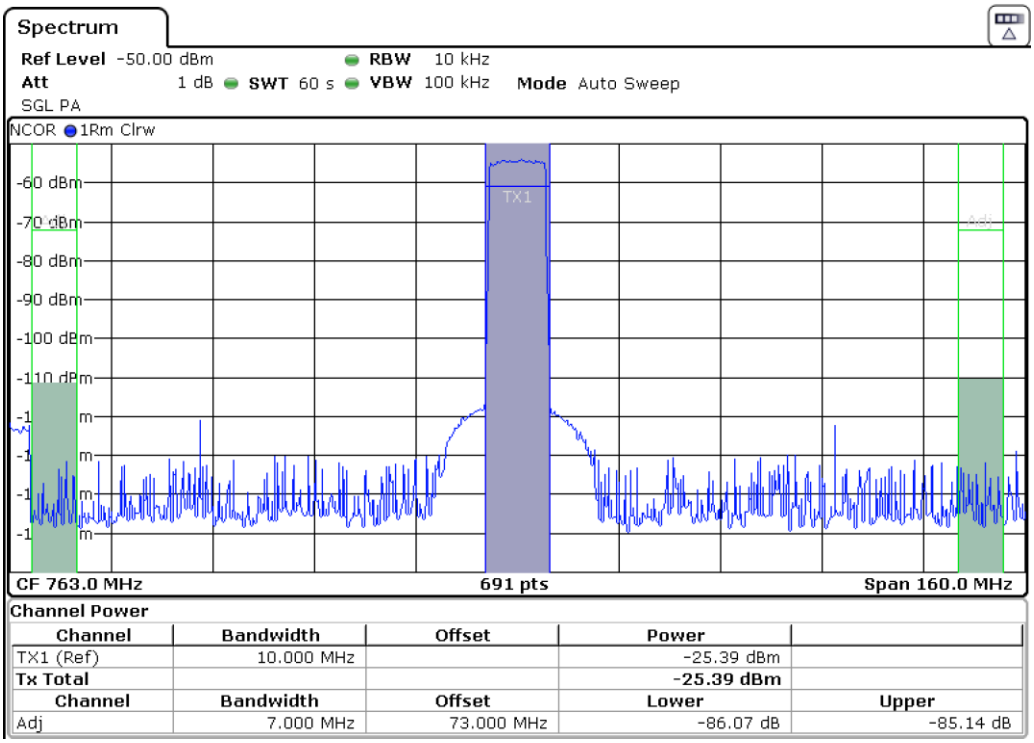

Fig. A-4: ACLR measurement for blocking test

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Sustainable product design

- Environmental compatibility and eco-footprint
- Energy efficiency and low emissions
- Longevity and optimized total cost of ownership

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