HAKOM

Recommendation on minimum receiver technical requirements for the reception of DVB-T2 signal in the Republic of Croatia

Disclaimer
Only the Croatian version of this Recommendation is to be considered official and used as a reference.

CROATIAN REGULATORY AUTHORITY FOR NETWORK INDUSTRIES

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1. INTRODUCTION

1.1. Background

The Croatian Regulatory Authority for Network Industries (HAKOM) has issued this document as a recommendation regarding the minimum technical requirements to be met by DVB-T2 receivers in order to facilitate high-quality reception of free-to-air digital terrestrial television services in the Republic of Croatia.

The Recommendation was developed as part of the round table of HAKOM by representatives of HAKOM, Agency for Electronic Media, broadcast network and multiplex operators, the public and private broadcasters and academia representatives.

The allocation of the Digital Dividend II for mobile services in most of the EU member states is expected to be finished by 30 June 2020. Consequently, it leads to the loss of frequencies above 694 MHz for the terrestrial broadcasting. In order to enable economic broadcasting of TV content in high definition ("HD") across the terrestrial broadcasting networks and to facilitate development of new services, a transition to a more efficient transmission system DVB-T2 with H.265/HEVC video coding is needed. The DVB-T2 system offers, with comparable reception conditions, more flexibility and up to 50% higher transmission capacity compared to DVB-T. The transition of free-to-air services from DVB-T to DVB-T2 in Croatia is planned to start in 2019.

1.2. Scope

This document, "The Recommendation on minimum receiver technical requirements for the reception of DVB-T2 signal in the Republic of Croatia" (hereinafter: Recommendation), is based on relevant international norms, i.e. standards and regulations.

This Recommendation describes the minimum requirements on IDTVs and set top boxes (in the following called "devices" or "receivers") designated for the reception of DVB-T2 signals in Croatia. Only devices without an integrated conditional access system are covered by this Recommendation.

Concerning the reception modes this Recommendation focusses on stationary reception with a roof-top antenna and on portable-indoor or portable-outdoor reception with non-moving antennas. The minimum requirements described in this Recommendation are based on open standards and follow NorDig Unified v.2.6 [18], and Minimum Requirements for DVB-T2 Devices in Germany [19], but include specific requirements for Croatia.

The existing document (NorDig [18] specification) can only serve as a basis document on reception development as they do not sufficiently define the technical specifications for the launch of DVB-T2 in Croatia. The special features in Croatia are for example (1) the usage of H.265/HEVC and (2) the device stability after the implementation of mobile services (e.g. LTE) in the frequency band immediate above 694 MHz.

All of the receiving units for DVB-T2 in Croatia should be compatible to this Recommendation and branded with a logo. **The receiving units that are not compatible to this Recommendation shall not be branded with a logo**.

Details regarding the logo usage and certification procedure will be released soon by HAKOM (www.hakom.hr).

It shall be possible to receive, display and use free to air DVB-T/T2 broadcast signals that are compliant with the minimum requirements of this Recommendation with receivers of the commercial (Pay TV) DVB-T2 platform.

1.3. Definitions

Each technical requirement in an individual category is marked with the following terminology.

Terminology	Definition	Explanation
shall	Requirement	Implementation mandatory
shall not	Requirement	Implementation prohibited
should	Recommendation	Implementation recommended, but not mandatory
should not	Recommendation	Implementation not recommended, but not prohibited
may	Permission	Implementation allowed
need not	Permission	Implementation not necessary

1.4. Document History

Date	Version	Comment
18.07.2017.	v.1.0	The first release of the recommendation

1.5. References

[1] ISO/IEC 14496-3 : ISO/IEC: Information technology – Coding of audio-visual objects – Part 3: Audio, 2009, including Amendment 4 and 5

[2] ISO/IEC 11172-3: "Information technology -- Generic coding of moving pictures and associated audio information -- Part 3: Audio".

[3] ETSI EN 300 743 V1.5.1: Digital Video Broadcasting (DVB): DVB Subtitling Systems

[4] ETSI EN 300 468 V1.15.1 (2016-03): Digital Video Broadcasting (DVB): Digital broadcasting systems for television, sound and data services: Specification for Service Information (SI) in Digital Video Broadcasting (DVB) systems

[5] ETSI TS 101 211 V1.12.1 (2013-12): Digital Broadcasting Systems for Television, Sound and Data Services; Guidelines on the Implementation and Usage of DVB Service Information

[6] HDMI specifications 1.4b; (2011-10)

[7] ISO/IEC 60958-1, Digital audio interface – Part 1: General; 2008

[8] Domestic and similar electronic equipment interconnection requirements: Peritelevision connector

[9] ETSI TS 101 154 v2.3.1 (2017-02) „Digital Video Broadcasting (DVB); Specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream

[10] EN 300 706 V1.5.1: Digital Video Broadcasting (DVB): Enhanced Teletext specification

[11] ISO/IEC 6937: Information technology — Coded graphic character set for text communication — Latin alphabet; 2001

[12] ETSI EN 302 755 1.4.1: Digital Video Broadcasting (DVB); Frame structure channel coding and modulation for a second generation digital terrestrial television broadcasting system (DVB-T2)

[13] DIGITAL EUROPE White paper: Standardized DVB-T2 RF specifications

[14] IEC 61169-2, part 2 Radio-frequency connectors. Part 2: Coaxial unmatched connector

[15] OIPF Release 2 Specification Volume 5 – Declarative Application Environment [V2.3]

[16] ETSI TS 102 796 Hybrid Broadcast Broadband TV

[17] ISO/IEC 8859-2: Information technology 8-bit single-byte coded graphic character sets, Part 2: Latin alphabet No. 2

[18] NorDig-Unified Specification v.2.6: NorDig Unified Requirements for Integrated Receiver Decoders for use in cable, satellite, terrestrial and IP-based networks, 20 January 2017

[19] Minimum Requirements for DVB-T2 Devices in Germany Date: 04 June 2015

[20] Recommendation on minimum receiver technical requirements for the reception of DVB-T and DVB-T2 signal in the Republic of Croatia, Version 1.1, 13 September 2011, (available at: https://www.hakom.hr/default.aspx?id=686)

[21] EBU Tech 3348 ‘Frequency and network planning aspects of DVB-T2’, Revision 3, Geneva, November 2013

[22] Report ITU-R BT. 2254 „Frequency and network planning aspects of DVB-T2“, 11/2013

[23] ETSI TS 102 831 V1.2.1 (2012-08): Digital Video Broadcasting (DVB); Implementation guidelines for a second generation digital terrestrial television broadcasting system (DVB-T2)

[24] ETSI TS 102 366 V1.3.1 (2014-08): Digital Video Broadcasting (DVB); Digital Audio Compression (AC-3, Enhanced AC-3) Standard

[25] NorDig Unified Test Plan for Integrated Receiver Decoders for use in cable, satellite, terrestrial and IP-based networks, NorDig Unified Test plan, ver 2.5.0

[26] EBU Tech 3344 V2.0 (2015-05): Practical guidelines for distribution systems in accordance with EBU R 128

[27] Recommendation ITU-T H.265 (04/2015): High efficiency video coding

[28] HDMI specifications 2.0b (2016)

[29] IDA/MDA TS DVB-T2 IRD (May 2014)

[30] DigitalEurope HD Ready. “HD ready” Minimum Requirements, www.digitaleurope.org

1.6. Abbreviations

AAC: Advanced Audio Coding

AC-3: Audio Coding 3 (Dolby Digital)

CAM: Conditional Access Module

CI: Common Interface

DASH: Dynamic Adaptive Streaming over Http

DRM: Digital Rights Management

DVB: Digital Video Broadcasting

E-AC-3: Enhanced AC-3 (Dolby Digital Plus)

EIT: Event Information Table

EPG: Electronic Program Guide

FEF: Future Extension Frames

FFT: Fast Fourier Transformation

HbbTV: Hybrid Broadcast Broadband Television

HDCP: High-bandwidth Digital Content Protection

HDMI: High Definition Multimedia Interface

HE AAC: High Efficiency Advanced Audio Codec

H.265/HEVC: High Efficiency Video Coding

IDTV: Integrated Decoder Television

LCN: Logical Channel Number

MPEG: Moving Pictures Expert Group

MMI: Man Machine Interface

NID: Network Identifier

NIT: Network Information Table

ONID: Original Network Identifier

OSD: On Screen Display

PLP: Physical Layer Pipe

PP: Pilot Pattern

PSK: Phase Shift Keying

QAM: Quadrature Amplitude Modulation

QPSK: Quadrature Phase Shift Keying

SDT: Service Description Table

SI: Service Information

SID: Service Identifier

STB: Set Top Box

TFS: Time Frequency Slicing

TSID: Transport Stream Identifier

TV: Television

UI: User Interface

UHDTV: Ultra-high-definition television (4K UHD and 8K UHD)

USB: Universal Serial Bus

2. HARDWARE AND SUPPLIED EQUIPMENT

2.1. Connectivity

The device shall at least have one common commercially available antenna connector. One example reference could be IEC 61169-2 [14]. It should be possible to activate 5V antenna power in device software.

The device shall support network connectivity via RJ 45 (Ethernet IEEE802.3) and/or Wi-Fi (IEEE802.11).

2.2. Video and Audio Interfaces

Depending on type of device (IDTV and/or STB), requirements on physical input/output interfaces are:

- STBs shall have a minimum of one HDMI 1.4b with type A output connector [6] and shall support HDCP and displays that comply with the DigitalEurope HD-Ready requirements [30] and the High Definition Multimedia Interface [6]. STBs with UHDTV support shall have a minimum of one HDMI 2.0b [28] output.
- IDTV with screen diagonal 30 cm and above shall have a minimum of one HDMI 1.4b [6] input interface in accordance with the DigitalEurope HD-Ready requirements [30]. HDMI input interface is highly recommended for IDTV-sets with smaller screen diagonal. The HDMI output interface is recommended for IDTV-sets.
- The device should have an S/PDIF Interface (either an optical or coaxial outputs), compliant with ISO/IEC 60958-1 [7].
- The device should have RCA Audio left (colour – white) and right (colour – red) connectors for analogue audio output.
- STBs should have a minimum of one component video output.
- The device should have a minimum of one SCART interface as defined in [8], or Mini DIN with SCART signalisation (and Mini DIN to SCART cable included).

3. FRONT END

3.1. DVB-T

All reception devices shall be compliant with the “Recommendation on minimum receiver technical requirements for the reception of DVB-T and DVB-T2 signal in the Republic of Croatia” [20]. In case of specific requirement for devices stated in this Recommendation does not exist in [20], it shall be applied in accordance with this Recommendation.

3.2. DVB-T2

3.2.1. General Standard Compliance

The device shall generally comply with the specifications of the DVB-T2 standard ETSI EN 302 755 [12] with the following restriction, that devices are not required to decode FEFs but they should not be disturbed by them as long they follow the pattern described in section 13 of the DIGITAL EUROPE White paper: Standardized DVB-T2 RF specifications [13].

3.2.2. Bandwidth

Device shall support 7 MHz bandwidth in VHF III and 8 MHz bandwidth in UHF IV. It is not required to support 1.7 MHz, 5 MHz, 6 MHz, or 10 MHz bandwidth signals. Device shall support Normal and Extended Carrier mode.

3.2.3. Tuning Range

The device shall support the tuning range 174 - 230 MHz (centre frequencies 177,5 MHz – 226,5 MHz) and 470 MHz – 790 MHz (centre frequencies 474 MHz – 786 MHz). Due to the allocation of the Digital Dividend II, frequencies above 694 MHz will not be used in Croatia for digital terrestrial broadcasting after DVB-T switch off. Until the end of the transition process from DVB-T to DVB-T2 in Croatia the devices shall support the entire frequency band 470 - 790 MHz. After the DVB-T switch off in Croatia, devices need not to support frequencies above 694 MHz, but should provide adequate protection against interferences from mobile services (e.g. LTE) above 694 MHz (see also section 3.2.11 Interference Immunity).

3.2.4. DVB-T2 Variants & Dynamic Changes

The device shall be capable of receiving and demodulating DVB-T2 signals with any valid combination of the following parameters as specified in Table 1 [12]:

FFT Sizes	1K, 2K, 4K, 8K, 16K and 32K
Constellations	QPSK, 16-QAM, 64-QAM and 256-QAM, all rotated and unrotated
Forward Error Correction Codes	1/2, 3/5, 2/3, 3/4, 4/5 and 5/6
Guard Intervals	1/128, 1/32, 1/16, 19/256, 1/8, 19/128 and 1/4
Pilot Patterns	PP1, PP2, PP3, PP4, PP5, PP6 and PP7
PLPs	Single PLP, Multiple PLP Type 1 and 2

Table 1 – DVB-T2 system parameters

The device shall be able to receive SISO and MISO transmissions, modulations with and without rotated constellation, and shall support the usage of extended carrier mode.

The device shall not be required to handle Time Frequency Slicing (TFS) mode.

The DVB-T2 standard ETSI EN 302 755 [12] provides the possibility of a really enormous number of modulation parameter combinations. However, only a small subset is being used in real installation or may be specified in industry specifications.

The Table 2 below contains a subset of parameter combinations identified as probably most interesting candidates. This should give the manufacturers an indication on which modes they may concentrate for more extensive testing. Data rate for DVB-T2 variants in Table 2 have been calculated according to [12] and [23].

NorDig Unified v.2.6 [18] provides a scheme (see chapter 3.4.10.3) that shall be used to derive all other required mandatory performance figures for all other DVB-T2 modes not given in examples for i.e. modes with other Pilot Pattern.

DVB-T2 Variant	FFT	Constellation	LDPC Code Rate	GI	Pilot Pattern	nTi/Lf	Data Rate [Mbit/s]
1	32Ke	64 QAM	3/5	1/16	PP2	3/64	23,87
2	32Ke	64 QAM	2/3	1/16	PP4	3/62	27,60
3	32Ke	256 QAM	2/3	19/256	PP4	3/62	36,52
4	32Ke	256 QAM	3/4	19/128	PP2	3/60	36,57
5	32Ke	64 QAM	3/4	19/256	PP4	3/62	30,71
6	32Ke	64 QAM	4/5	19/256	PP4	3/62	32,11
7	32Ke	64 QAM	2/3	19/256	PP4	3/62	27,30
8	32Ke	64 QAM	3/4	1/8	PP2	3/60	28,09
9	32Ke	64 QAM	4/5	1/8	PP2	3/60	29,97
10	32Ke	64 QAM	2/3	1/8	PP2	3/60	24,97
11	32Ke	256 QAM	3/4	19/256	PP4	3/62	41,08
12	32Ke	256 QAM	2/3	1/8	PP2	3/60	33,18

Table 2 – DVB-T2 Variants

For all DVB-T2 variants in the Table 2 non-rotated constellation, extended carrier mode and an LDPC block length of 64.800 bits is used. The L1 Information is modulated with BPSK generally.

Data Rates and Pilot Pattern are given for SISO Modulation. Tone Reservation for PAPR reduction is not considered. High Efficiency Mode (HEM) is considered, Null Packet Deletion is not considered.

3.2.5. Performance Requirement

The NF (noise figure) and C/N values together determine the minimum signal level provided in section 3.2.8 as an essential requirement.

The performance requirements for DVB-T2 with respect to C/N are based on computer simulations plus a reasonable implementation margin. The specified performance figures will be reviewed for a future update of this Recommendation, when more information about realistic receiver performance is available from laboratory and field tests. The review may result in modifications of the specified figures and in additional requirements (see also NorDig Unified v.2.6 [18], Chapter 3.4.10.1).

First measurement results from lab and from field tests (see e.g. also [21], Annex A4.2) give the following indication: For the Gaussian channel, the calculated C/Ns are 1.5 - 2.0 dB higher than the measured. A similar tendency can be observed for the static Rayleigh channel, where the calculated values are about 1 dB higher than the measured values.

3.2.6. Receiver Noise Figure

The tuner noise figure shall be 6 dB or better in accordance with NorDig Unified v.2.6 [18]. The noise figure is already included in the values of section 3.2.8.

3.2.7. C/N Performance

The device shall comply with the C/N values for Gaussian channels as required by NorDig Unified v.2.6 [18] in chapter 3.4.10.3 and NorDig Unified Test plan, ver 2.5.0 (Table 2.3 and Table 2.4) [25].

In addition the device should comply with C/N values in Table 3 from chapter 3.2.10.1. (columns C/N Rice[dB] and C/N Rayleigh[dB]) for Rice and Rayleigh channels derived from the methodology described in Report ITU-R BT.2254 [22]. The channel models for Rice and static Rayleigh profile should be applied as defined in ETSI TS 102 831 [23]. These C/N values may be used as an orientation for network planners and manufacturers and offers the possibility to produce feedback for future adjustments. For the 21 path Ricean fading profile defined in [23] Table 39, path 20 may be omitted for practical tests using fading simulators providing only 20 paths.

3.2.8. Minimum Input Levels

The device shall be compliant with performance requirements as derived in chapter 3.4.10.4 in NorDig Unified 2.6 [18] for the required minimum input levels.

3.2.9. Maximum Input Level

The device shall support the maximum input level of -25 dBm in the receiving channel as specified in [19].

3.2.10. Multipath Operation

3.2.10.1. Tolerance to Equal Amplitude SFN Signals

The device shall comply with specification of NorDig Unified v.2.6 [18] chapter 3.4.10.3 Table 3.11 and NorDig Unified Test plan, ver 2.5.0 (Table 2.3 and Table 2.4) [25] respectively for C/N values for the 0 dB echo channel.

The wanted signal includes the direct path signal and an echo. The echo has the same power (0 dB echo) as the direct path signal and is delayed from 1.95 μs to 0.95 times the guard interval length and has 0 degree phase at the channel centre.

Table 3 includes concrete values for DVB-T2 variants (column C/N0 dB [dB]).

DVB-T2 variant	C/NGauss [dB]	C/N0 dB [dB]	C/NRice [dB]	C/NRayleigh [dB]
1	14,8	18,0	15,1	16,9
2	15,7	19,2	16,1	17,9
3	20,4	24,7	20,8	23,0
4	22,9	28,0	23,2	25,9
5	17,3	21,6	17,6	20,0
6	18,3	23,6	18,9	21,6
7	15,8	19,3	16,1	17,9
8	17,7	22,1	18,0	20,4
9	18,8	24,1	19,3	22,1
10	16,2	19,7	16,5	18,3
11	22,5	27,4	22,8	25,5
12	20,9	25,3	21,2	23,4

Table 3 – C/N values for different channel profiles and DVB-T2 variants

3.2.10.2. Presence of Echoes

The device shall comply with specification of NorDig Unified v.2.6 [18]. The same C/N0 values as described in section 3.2.10.1 shall be obtained when the channel contains two static paths with a relative delay from 1.95 μs to 0.95 times the guard interval length, independently of the relative amplitudes and phases of the two paths.

For specific echo attenuation, the required C/N shall not be more than 1 dB higher compared to the median value when calculated for the required C/N values over the echo delays from 1.95 μs up to 0.95 times guard interval length.

3.2.10.3. Presence of Echoes outside the guard interval

The device shall comply with specification of NorDig Unified v.2.6 [18] chapter 3.4.10.10. For echoes outside the guard interval, QEF reception should be possible with echo levels up to the values presented in chapter 3.4.10.10 of NorDig Unified v.2.6 [18], particularly with regard to Table 3.23.

The device shall be able to correctly equalise the signal (referred to as interval of correct equalization) for an echo range (i.e. distance from first to last echo) up to 57/64 (≈89,1%) of the Nyquist time for the scattered pilots (after time interpolation) for a particular FFT size, pilot pattern and RF bandwidth, independently of the echo profile.

Neglecting other interference sources, the equivalent total available C/(N+I) in a given location can be determined by the formula given in [18] Annex B.

For echoes outside the guard interval, QEF reception should be possible with echo levels up to the values presented in Table 4. Table 4 shows echo attenuation for earlier mentioned DVB-T2 variants. The underlying concept is based on Table 3.23 from NorDig Unified v.2.6 [18]. Deviating from the methodology applied by NorDig Unified v.2.6 [18], the echo attenuation in Table 4 is calculated by assuming the C/N values for 0 dB echo channel from Table 3, column $C/N_{0\ dB}$[dB]. Echo attenuation was calculated using [18], Annex B, formula A.4, where EPT (Effective Protection Target) has been calculated as C/N_{Rice} [dB] from Table 3, as lower limit of EPT for fixed reception [18], Annex B, formula A.5. Variants are shown only when their interval of correct equalization is larger than their guard interval and if echo attenuation is above 0 dB.

	Echo attenuation (dB)								
Delay (μs)	290	320	350	380	410	440	470	500	530
DVB-T2 Variant									
1	1.6	4.1	5.6	6.8	7.6	8.4	9	9.5	10
8	-	-	-	-	-	-	-	3	5.7
9	-	-	-	-	-	-	-	4.3	6.8
10	-	-	-	-	-	-	-	1.8	4.7
12	-	-	-	-	-	-	2.2	7.2	9.4

Table 4 – Echo attenuation for DVB-T2 variants

3.2.11. Interference Immunity

The device shall comply with the interference immunity as outlined in NorDig Unified v.2.6 [18] chapter 3.4.10.7.

4. SERVICE DISCOVERY FOR DIGITAL TERRESTRIAL TELEVISION

4.1. LCN Support

The device shall support Logical Channel Numbering at least version 1 as described in the technical specification NorDig Unified v.2.6 Requirements [18].

All services, collected from all receivable NIT of the actual network and flagged as “visible”, shall be displayed in the service list(s), sorted according to logic_channel_number and be addressed with a number in the service list equal to the logic_channel_number, as far as possible.

The use of NorDig Logical Channel Descriptor is always in accordance with NorDig 12.1.3 clause. This requires the inclusion of the private data specifier descriptor carrying the NorDig private data specifier value (0x00000029) prior to the LCN descriptor.

Services on networks where ONID is not equal 0x20BF shall be recognized as services broadcasted outside Croatian territory and shall be put at the end of service list and shall not be listed according to its LCN values.

4.2. Service List Management

4.2.1. Case of Identical Services

If there are multiple identical services, then the instance of the service with the highest signal quality shall be granted the channel number according to the broadcast LCN. If several instances of the same service have the same quality level, then the instance with the highest signal level shall be granted the channel number according to the broadcast LCN. It is assumed that identical services will have the same broadcast LCN.

4.2.2. Services with LCN 0 or Hidden Services

Services marked as “hidden” in the LCN descriptor or where the LCN is zero (0) shall be stored but should not be visible in the service list presented to the viewer.

4.3. Update of Service Lists

The device shall be capable of automatically detecting changes in the services configuration of each broadcast transport stream provided that such changes are implemented by the broadcaster in accordance to ETSI TS 101 211 [5].

The intent of this requirement is to allow the broadcaster to vary the services offering within the relevant broadcast transport stream(s) or change the frequency and other parameters of the terrestrial network over night without the viewer needing to rescan the device.

User defined channel lists shall be updated (with or without confirmation by the user) in a way that services that have been moved and which still can be received are kept at the same position of the list(s). For this purpose, services shall be identified by the Original Network ID (ONID) and Service ID (SID).

Changes should be processed within 24 hours of the presence of correct SI signalling including NIT for the actual networks and NIT for the other networks.

For service identification during the initialization process, it is recommended to use Original Network ID (ONID), Transport Stream ID (TSID) and Service ID (SID).

Broadcasters shall keep the Service ID (SID) unique within the terrestrial delivery network identified by its Original Network ID (ONID), regardless of the Transport Stream ID (TSID) of the

channel that carries the service. Moving a service from one transport stream to another one, or receiving duplicates of the same service through multiple channels, involves a change of the TSID. For the purpose of identifying identical or moved service offerings, the receiver shall evaluate the pair ONID/SID. Receiver internal databases may still make use or require the complete DVB-triple (ONID/TSID/SID).

5. SERVICE PLAY

5.1. H.265/HEVC Video Support

The device shall fulfil the requirements from "Recommendation on minimum receiver technical requirements for the reception of DVB-T and DVB-T2 signal in the Republic of Croatia" [20].

The device shall fulfil the requirements for 50 Hz H.265/HEVC HDTV 8-bit devices as defined in ETSI TS 101 154 [9]. The luminance resolutions that shall be supported for Full-screen Display from devices are shown in Table 5. To fulfil the above requirements the device shall decode and display correctly H.265/HEVC bitstreams that are in compliance with the Main Profile, Main Tier, Level 4.1 as defined in Recommendation ITU-T H.265 [27].

Luminance resolution		Scan (progressive)	Aspect ratio
Horizontal	Vertical		
1920	1080	p50	16:9
1280	720	p50	16:9
960	540	p50	16:9

Table 5 – Resolutions for Full-screen Display from H.265/HEVC HDTV devices

Additionally device should decode and display correctly H.265/HEVC bitstreams, with Luminance resolution as follows:

Luminance resolution		Scan (progressive)	Aspect ratio
Horizontal	Vertical		
1920	1080	p25	16:9
1280	720	p25	16:9
960	540	p25	16:9

Table 6 – Optional resolutions for Full-screen Display from H.265/HEVC HDTV devices

Output Aspect Ratio

The DVB-T2 IRD shall provide convenient user control for appropriate aspect ratio switching between 4:3 and 16:9 to adapt to display in different size and aspect ratio.

Active Format Description (AFD)

When AFD is used, the DVB-T2 IRD shall present the video aspect ratio properly according to the current AFD value and response in next frame as defined in the ETSI EN 101 154 Annex B [9] and IDA/MDA TS DVB-T2 IRD Annex A.

The device should fulfil the requirements for 50 Hz H.265/HEVC UHDTV (HDR+HFR) 10-bit devices according to ETSI TS 101 154 v2.3.1. [9]. This optional UHDTV support should be branded by manufacturer preference in order to differentiate the devices that support UHDTV.

5.2. Audio Support

The device shall always have at least a stereo audio signal present on any output.

If a service provides more than one audio bitstream, the device shall select the appropriate audio bitstream according to NorDig Unified v.2.6, section 6.5 [18].

The device shall be able to gracefully handle dynamic changes in the bitstream according to NorDig Unified v.2.6, section 6.9 [18].

5.2.1. Codecs

The device shall be able to decode or transcode the following incoming audio stream formats:

- MPEG-1 Layer II [2] as specified in TS 101 154, section 6.1 [9]
- E-AC-3 as specified in TS 101 154, section 6.2 [9]
- MPEG-4 HE-AAC Profile Level 4 [1] as specified in TS 101 154, section 6.4 [9].

The audio decoders shall support sampling rates as of NorDig Unified v.2.6 [18], section 6.2.

5.2.2. Audio Output Formats, Transcoding and AV Synchronisation

A STB shall have an HDMI output and should have an S/PDIF output. An IDTV shall have an HDMI ARC or S/PDIF output. The decoding or transcoding for HDMI, HDMI ARC and S/PDIF outputs shall be performed according to NorDig Unified v.2.6, section 6.6 and section 6.8.2 [18].

An incoming mono bitstream shall be output as dual-stereo signal.

If the device is equipped with analogue outputs (e.g. SCART and/or RCA and/or headphone output), it shall behave as described in NorDig Unified v.2.6, section 6.8.1 [18]. Built-in speakers of an IDTV and headphone outputs of a device (if available) should be handled like analogue outputs.

The user shall be able to choose if the device outputs a stereo signal (Stereo mode) or a multichannel signal (Multichannel mode) via the digital outputs.

The device shall be capable of transcoding E-AC-3 according to NorDig Unified v.2.6, section 6.2.2 and section 6.6 [18]. The device shall be capable of transcoding HE-AAC according to NorDig, section 6.2.3 and section 6.6 [18].

The device shall meet the requirements for audio/video synchronization as specified in NorDig, section 6.7 [18].

5.2.3. Metadata and Loudness

For decoding and transcoding E-AC-3 the device shall support the use of a complete set of Dolby Metadata according to TS 102 366 [24]. For decoding and transcoding HE-AAC the device shall at least support the AAC metadata parameters according to NorDig Unified v.2.6, section 6.2.3.2 [18]. If metadata is available for an incoming bitstream format, it shall be applied to the audio signal by the device during decoding and/or down mixing.

For HE-AAC bitstreams, which do not contain metadata, the device shall use default values according TS 101 154 [9], annex C.5.2.8. In accordance with TS 101 154, section 6.4.3 [9] a Program Reference Level of -23dBFS shall be assumed as default.

Devices shall support DRC presentation mode as defined in TS 101 154 section C5.4 [9]. If "DRC presentation mode" is not indicated in the bitstream the device shall apply metadata as per "DRC presentation mode 1".

The device shall provide a consistent loudness experience according to NorDig Unified v.2.6, section 6.13 [18] and should be fully compliant to EBU Tech 3344 [26].

5.2.4. Supplementary Audio Stream

The device shall support supplementary audio services according to NorDig Unified v.2.6, section 6.11 [18], particularly section 6.11.6 and TS 101 154, annex E [9] including pan & fade control. Both, broadcast-mixed and receiver-mixed Supplementary Audio shall be supported for all mandatory codecs. Receiver mixing requirement is only applicable if "normal" and Supplementary Audio streams are of the same codec family, sampling rate and on two different PIDs.

The device shall support supplementary audio settings as specified in NorDig Unified v.2.6, section 6.11.3 [18]. The device shall be able to mix the "normal" audio stream together with a Supplementary Audio stream according to the receiver-mixing specifications in NorDig Unified v.2.6, section 6.11.6 [18].

The user should be able to enable / disable supplementary audio, change the default Audio Type (stored in the device), temporarily change the audio type and separately adjust the audio mixing level of the receiver mixed audio relative to the "normal" audio via easy accessible remote control functions. When supplementary audio mode is active it should remain active when channels are changed.

Devices with head-phones output should additionally offer a separate receiver-mixed Supplementary Audio stream selectable on the head-phones interface as specified in NorDig Unified v.2.6, section 6.11.7 [18] and at the same time presenting the "normal" audio on its own on the other main audio outputs (HDMI, S/PDIF etc.). This should be selectable by the user as an alternative to the ordinary receiver mix.

Devices may optionally support Advanced Clean Audio Services as specified in TS 101 154, section E7.4 [9] or a receiver-side post-processing for Dialogue Enhancement. Devices may optionally support metadata according to TS 102 366, Annex H [24].

Account should be taken in the design of controls that many users of audio description are visually impaired. It is therefore highly recommended that audio description can be switched on and off from the remote control and, in the case of button-based remote controls, ideally by using a dedicated (sole purpose) button.

5.3. Broadcast Service Access

5.3.1. Favourite Lists

The device should support at least one favourite list.

The device should offer the possibility to create / modify favourite lists.

The device should offer the possibility to add / remove services from the favourite lists.

The device should offer the possibility to rename the favourite lists.

The favourite list(s) should be under full control of the user and independent of the LCN mechanism.

5.4. Dynamic PSI & SI

The device shall be able to manage changes in PSI in the PMT, CAT and PAT (like changes of PIDs and availability of components) in a graceful way for the user.

Device shall be able to manage changes in SDT, NIT of the actual networks and NIT of the other networks according to 4.3.

The device shall be able to handle dynamic changes in the Program Map Table (PMT).

A practical use case for dynamic PMT changes is for example the requirement to support switching on and off regional variants of programs by a broadcaster.

The device shall handle dynamic PMT changes in the correct manner. Dynamic changes in the PMT shall not produce any disturbances in the Audio/Video output.

5.5. Character Sets for DVB Service Information, EPG, Teletext and Subtitles

The default Character set of the device shall be the “ISO/IEC 8859-2” as specified in ETSI EN 300 468 Annex A [4].

The device shall also support UTF-8 table to display internet and web related content. Support of UTF-8 is only required for content accessed by a web or HbbTV browser.

5.6. Teletext

The device shall include a Teletext decoder as defined by ETSI standard EN 300 706 Enhanced Teletext Specification [10] including up to Teletext level 1.5. A suitable (virtual) remote control key must be provided to launch the Teletext OSD display. The device shall be able to cache at least 200 decoded pages in order to improve the access time for frequently used pages.

The receiver should offer both of following options for presentation of Teletext:

- By insertion of the Teletext data in the VBI of the analogue CVBS video output. Insertion should conform to ITU-R BT.653-3 and to requirements for level 1.5 defined in EN 300 706;
- By presentation of Teletext within the navigator of the receiver.

5.7. Subtitles

The device shall support EBU and DVB subtitles as defined in [3].

The device shall select available subtitles based on the user preferences settings automatically (see 5.8). When subtitle mode is active it should remain active when channels are changed.

5.8. Language Selection

Croatian shall be selected as primary and secondary language by country default.

5.9. EPG

Manufacturer is free to design device based EPG. The device shall support an EPG application based on DVB-SI according to ETSI EN 300 468 [4].

Programmes that carry DVB subtitles for hard of hearing people and/or supplementary audio should be clearly indicated in the EPG and/or mini guide displays in a manner that the user can identify them without having to hunt for them: e.g. they can be highlighted directly on the EPG.

5.10. Service and Event Information processing

The device should support service and event information processing.

If the device supports service and event information processing, then

- “Now/Next” information for use in an on-screen banner shall be derived using information from DVB SI EITp/f tables defined in [4].
- The EPG “Now and Next” should be displayed for a short period when the user changes service and shall also be launched using the “Info” (virtual) button on the remote control unit.

- Changes of the "Now/Next" event information using the Current_next_indicator shall result in an immediate change of the "Now" event as described in [4] 5.1.1e.
- The following items for “Now/Next” information should be displayed:
    - Current time
    - Start time of now and next programme
    - End time or durations of now and next programme
    - Logical Channel Number of current service
    - Service Name
    - Icon or message for parental locked services and events.
- Linkage Descriptor as in [4], section 6.2.19 and Event Linkage as in [4], section 6.2.19.2 shall be processed in order to save bandwidth by avoiding multiple repetitions of EIT-content e.g. in regional services.
- The processing of the component_descriptor [4], section 6.2.8 shall support the transmission of event informations in SDT.
- Multiple sections starting per transport stream packet shall be supported, thus allowing utilisation of the complete transport stream body data ("optimized EIT packetisation"). Even sections starting with only the first byte at the end of a transport stream packet and the remaining data continuing in the next transport stream packet shall be supported.
- EPG preview of 8 days, derived by the EIT-schedule sections, should be supported.
- The component descriptor may be placed either in the EIT or SDT. In both cases, the descriptor shall be evaluated and/or displayed to the user. In case that one service has descriptions for the same component_tag in both, the SDT and the EIT, the description carried in the EIT shall take precedence.

5.11. Parental Control

The receiver shall provide a PIN-controlled Parental Control menu to perform the following functions:

- setting age thresholds (at least for 15 and 18 years) for viewing single events
- changing the PIN value
- activating/deactivating parental control

The PIN value shall be explicitly set by the user during installation procedure.

The receiver shall provide a parental rating functionality that, when enabled, blanks video and mutes sound out of the receiver whenever the incoming rating value in the parental rating descriptor of the EIT data of current viewed programme event (present event) is higher than receiver user setting. The user shall be able to enable and disable the parental functionality and when enabled to configure a minimum age/level (in years). It should make use of 4 digits pin code or similar to access and change settings (a technique that prevent easy access for a child).

The receiver should start/(stop) its blanking video and muting audio within 1 second after reception of selected service's present event information containing parental rating higher/(equal or lower) than its user settings but shall at least within 10 seconds react after reception of parental rating information in the EIT data.

The receiver shall exercise parental control at event level only if there is an EIT associated to it, with a meaningful Parental_rating_descriptor.

5.12. Zapping time for TV services

Zapping time for the services shall satisfy the requirements given in Table 7. The figures in Table 7 shall be met for an input signal which has the following parameters:

- video GOP length of 12
- a repetition rate of ECM of 2 per second (for scrambled services)
- repetition rate of PAT and PMT of 10 times per second and
- maximum PTS-to-PCR relative delay shall be 700ms.

The picture on the display during the zapping time shall be either frozen or black and the sound shall be muted until the new session has been stabilised.

The figures in the table are valid for two services on one multiplex as well as for two multiplexes and for both scrambled and unscrambled (FTA) services.

IRD Type	Average max zapping time
IRD with embedded CAS	2.5 seconds
IRD with CI and using a CAM	3.5 seconds

Table 7. Maximum zapping time

6. USER INTERFACE

6.1. Support Languages and Character Sets

The device shall, as a minimum, support the following menu and UI languages: Croatian, English.

The device shall support the language characters ISO/IEC 6937 [11] and ISO/IEC 8859-2 [17].

7. COMMON INTERFACE PLUS

The IDTV shall include at least one common interface slot with an associated software stack compliant with EN 50221, TS 101 699 and CI Plus according to the regime under CI Plus License Agreement with CI Plus LLP.

Compliance to CI+1.3 specifications includes:

- MMI, which allows the CAM to display messages (depending on the CAM capabilities) including any error messages, the Smartcard-ID and the CAM-ID.

TV services which are broadcasted unencrypted shall be usable without restrictions.

IDTV supporting CI Plus shall support Specific Application Support (SAS) Interface defined in section 11.4 of [CI+1.3] that will allow an HbbTV application on the Host (IDTV) to access functionality on the CICAM.

8. INTERACTIVE SUPPORT

8.1. HbbTV Middleware

The device shall support network connectivity, as specified in chapter 2.1., and shall support HbbTV as hybrid IRD in accordance with NorDig Unified v.2.6, section 15.2.

Certification procedure will be specified by HAKOM, as stated in chapter 1.2.

8.2. Display of Subtitles and Applications

The device shall support simultaneous display of application and subtitles, as it is stated in [15] Annex H.1.

8.3. DRM Support

The device shall support at least one DRM when the A/V content is delivered by using MPEG DASH. Microsoft PlayReady shall be supported at least.

9. SOFTWARE SYSTEM UPGRADE

The device shall support system software update. How the software update is implemented is manufacturer’s preference.