# Recommendation on minimum technical requirements for DAB+ signal receivers

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

# Content

# 1. Introduction

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

This document, "Recommendation on minimum technical requirements for DAB+ signal receivers" is based on relevant international standards, i.e. the requirements of the DAB+ signal receiver standards and regulations.

This recommendation describes the minimum requirements for DAB+ receivers in order to ensure a quality way of receiving basic digital terrestrial radio services on the territory of the Republic of Croatia.

### Document History

| Date | Version | Comment |
|---|---|---|
| 22.12.2020. | v.1.0 | The first release of the recommendation |

### Abbreviations used in text

AAC – Advanced Audio Coding
BER – Bit Error Rate
DAB – Digital Audio Broadcasting
DLS – Dynamic Label Service
DL+ – Dynamic Label Plus
EEP – Equal Error Correction
EPG – Electronic Programme Guide
EWF – Emergency Warning Functionality
FIC – Fast Information Channel
FIG – Fast Information Group
FM - Frequency Modulation
MPEG – Motion Picture Expert Group
MOT - Multimedia Object Transfer
SID – Service Identifier
SFN – Single Frequency Network
TPEG – Transport Protocol Experts Group
UEP – Unequal Error Protection
VHF – Very High Frequency
X-PAD – Extended Programme Associated Data

### Receiver classes

The recommendation considers three classes of receivers:

Class A – Radio receivers with basic audio functionality, with the possibility of displaying at least 8 characters on the screen.

Class M – Multifunction device with both a colour screen and improved audio and multimedia features.

Class H – Devices with integrated receiver and broadband connection for hybrid functionality.

# 2. Technical requirements

## 2.1. Frequency range

Receivers shall be capable of receiving DAB+ Digital Radio broadcasts in the frequency range 174 to 240 MHz. The centre frequencies of the transmitted signal comply with the preferred VHF Band III frequencies specified in ETSI TR 101 496[1]. The recommended frequency distribution is presented in Table 1.

Table 1: Channel distribution in the VHF III Band

| Channel | Frequency | Channel | Frequency | Channel | Frequency |
|---|---|---|---|---|---|
| 5A | 174.928 MHz | 8B | 197.648 MHz | 11C | 220.352 MHz |
| 5B | 176.640 MHz | 8C | 199.360 MHz | 11D | 222.064 MHz |
| 5C | 178.352 MHz | 8D | 201.072 MHz | 12A | 223.936 MHz |
| 5D | 180.064 MHz | 9A | 202.928 MHz | 12B | 225.648 MHz |
| 6A | 181.936 MHz | 9B | 204.640 MHz | 12C | 227.360 MHz |
| 6B | 183.648 MHz | 9C | 206.352 MHz | 12D | 229.072 MHz |
| 6C | 185.360 MHz | 9D | 208.064 MHz | 13A | 230.784 MHz |
| 6D | 187.072 MHz | 10A | 209.936 MHz | 13B | 232.496 MHz |
| 7A | 188.928 MHz | 10B | 211.648 MHz | 13C | 234.208 MHz |
| 7B | 190.640 MHz | 10C | 213.360 MHz | 13D | 235.776 MHz |
| 7C | 192.352 MHz | 10D | 215.072 MHz | 13E | 237.488 MHz |
| 7D | 194.064 MHz | 11A | 216.928 MHz | 13F | 239.200 MHz |
| 8A | 195.936 MHz | 11B | 218.640 MHz | | |

## 2.2. RF performance

Broadcast coverage planning is based on the assumption that a receiver has certain RF performance characteristics. These assumptions can be referred to as the "Receiver Model" and have been based on an assessment of receivers already in the market.

All references in this document to "adequate audio reception" are based on the reception of a 128 kbit/s DAB+ AAC audio component which has been transmitted with error protection level of EEP-3a. For test purposes this audio component shall consist of a 1 kHz monotone, at a scale of -3 dBFS. [2]

"Adequate audio reception" is considered to be achieved when the receiver is capable of reconstructing a data stream at the output of the Viterbi decoder with an error rate equal to or better than $1 \times 10^{-4}$. This threshold is measured in practical terms by observing the audio output of the receiver and observing that audio impairments are occurring with an average gap between audible impairments of approximately 10 seconds.

### 2.2.1. Gauss channel sensitivity – domestic receivers

A domestic receiver that is sold with an antenna must provide Adequate Audio Reception (as defined above) when receiving a DAB+ signal with a field strength signal greater than $FSG_{min}$ in a Gaussian transmission channel.

The value $FSG_{min}$ is frequency dependent. It is 34.4 dBµV/m for a signal with a centre frequency of 220 MHz, and its value at other frequencies can be calculated from the following formula:

$$FSG_{min} = [34.4 + 20 \log (F / 220)]\ dB\mu V/m$$

where F is frequency in MHz.

Receivers supplied without an antenna shall be capable of providing adequate audio reception (as defined above) with an input power level of -97.7 dBm when fed by a DAB+ signal with Gaussian transmission channel characteristics.

This external antenna will require a gain of -8.1 dBi or greater to produce this power at the required minimum field strength. Domestic receivers should have an input impedance of 75 Ohms. [2]

### 2.2.2. Gauss Channel sensitivity – in-vehicle receivers

Products shall provide adequate audio reception with an input power level of -97.7 dBm when fed by a DAB+ signal with Gaussian transmission channel characteristics.

Products sold with a packaged antenna shall provide adequate audio reception of a DAB+ signal with Gaussian transmission channel characteristics with field strengths at or above the frequency dependent threshold shown in the following formula:

$$FSG_{min} = [29.2 + 20 \log (F / 220)] \; dB\mu V/m$$

where F is frequency in MHz.

The performance of the antenna and the quality of the connectors and cabling will determine the actual sensitivity experienced by the user. Assuming glass mount antennas are properly fitted in the vehicle, the experienced sensitivity will still depend on several factors, like the type of vehicle, direction of driving, interaction with the body and other components present, etc. [2]

### 2.2.3. Rayleigh Channel sensitivity – domestic receivers

Under normal "real world" reception conditions the DAB+ signal will be received via a Rayleigh transmission condition containing multiple echoes, Doppler frequency shift and often contributions from multiple SFN transmitters. Under these conditions the receiver will require a greater signal to noise ratio for normal operation.

The receiver must provide Adequate Audio Reception of a DAB+ signal with Rayleigh transmission channel characteristics with field strengths at or above the frequency dependent threshold shown in the following formula:

$$FSR_{min} = [39.\ 9 + 20 \log (F / 220)] \; dB\mu V/m$$

where F is frequency in MHz.

Receivers supplied without an antenna shall be capable of providing adequate audio reception (as defined above) with an input power level of -92.2 dBm when fed by a DAB+ signal with Rayleigh transmission channel characteristics. This external antenna will require a gain of -8.1 dBi or greater to produce this power at the required minimum field strength. [2]

### 2.2.4. Rayleigh channel sensitivity – in-vehicle receivers

Receivers shall provide adequate audio reception with an input power level of -92.2 dBm when fed by a DAB+ signal with Rayleigh transmission channel characteristics.

Products sold with a packaged antenna shall provide adequate audio reception of a DAB+ signal with Rayleigh transmission channel characteristics with field strengths at or above the frequency dependent threshold shown in the following formula:

$$FSR_{min} = [34.7 + 20 \log (F/ 220)] \ dB\mu V/m$$

where F is frequency in MHz.

The performance of the antenna and the quality of the connectors and cabling will determine the actual sensitivity experienced by the user. Assuming glass mount antennas are properly fitted in the vehicle, the experienced sensitivity will still depend on several factors, like the type of vehicle, direction of driving, interaction with the body and other components present, etc. [2]

### 2.2.5. Receiver selectivity (Adjacent channel interference)

Products shall provide adequate audio reception in the presence of interfering DAB+ signals at specified levels on other frequencies.

The wanted signal shall be a DAB+ signal at a level of -70 dBm. The interfering signal shall be a DAB+ signal with a frequency offset and amplitude as described in table 2. [2]

Table 2: Receiver selectivity requirements

| **Frequency of interfering DAB+ signal** | **Level of interfering signal, relative to wanted signal** |
|---|---|
| ±1.712 MHz relative to wanted signal | +35 dB |
| ±3.428 MHz relative to wanted signal | +40 dB |
| ±5.136 MHz relative to wanted signal | +45 dB |
| All DAB+ signals having centre frequencies with more than 6 MHz offset from the wanted signal | +45 dB |

### 2.2.6. DAB+ channel decoding

Receivers must be able to decode at least one audio subchannel.

The receiver must be able to decode the DAB+ audio component contained in a sub-channel of a size up to and including 144 capacity units (e.g. 96 kbps@EEP1A). DAB+ audio services are defined in ETSI TS 102 563[3].

### 2.2.7. Analogue radio services

Receivers, except adapters, must be able to receive FM analogue radio broadcasts, as described in ETSI ETS 300 384[4], in the frequency range 87.5 MHz to 108 MHz.

## 2.3. Functional specifications

### 2.3.1. Retuning

A receiver which has a stored list of service labels must provide the user with the option of scanning the whole VHF III band to update its stored service list when required. This feature must either be initiated by the press of a single button on the device or, if it is a feature in a menu structure, it must be in the top level of the menu, or one level down. This rescan / retune feature must be able to cope with the following changes:

1. Service moves to a different multiplex

2. New multiplex launches

3. Multiplex changes its frequency

4. New service appears

5. Service changes name

6. Service disappears

7. Multiple instances of the same program content with the same Service ID on different frequencies and with varying signal levels

The band scan feature shall ensure that all services, and service components currently on-air that the receiver is able to decode are added to the service list. Multiple instances of the same service (i.e. same SID) on different ensembles, or on the same ensemble but at different frequencies, shall produce only a single entry in the service list which shall contain at least the source of the service, at the best signal quality, at the time of scanning. Additional sources may also be stored.

The band scan feature may clear the service list of all entries before performing the scan. Alternatively, the band scan feature shall ensure that previously stored service list entries that are not found during the band scan are suitably marked or removed.

Since the available services may change after performing a band scan, the effect on pre-set buttons should be carefully considered.

DAB+ ensembles change their configuration from time to time. It is recommended that products update their stored service list by constantly checking the FIC of the ensemble to which they are currently tuned. Background scanning (for example, immediately after switch-off) to maintain an up-to-date service list is recommended.

### 2.3.2. Text display

The receiver must have a means of displaying text to the user.

The text display shall display the audio service name (the Component Label). The text display must be able to display the following graphic symbols, correctly mapped, visually well-formed, and clear:

ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789

Lower case characters may be mapped to upper case equivalents and therefore show only:

ABCDEFGHIJKLMNOPQRSTUVWXYZ0123456789

Note: It is likely that Broadcasters will also use the following characters: % & !? ."() ,

For displays wishing to display the full range of Dynamic Label text, including these symbols, this is specified in ETSI EN 300 401 [5].

For any of these characters which cannot be shown correctly, the graphical symbol shown should be a “space” or “□” or, in any case, a similar distinctly non alphanumeric character.

In the territory of the Republic of Croatia, characters Š, Đ, Č, Ć, Ž, š, đ, č, ć, ž may be used, and if used must be displayed correctly on the receiver screen. In the case of alphanumeric displays, diacritics that the screen cannot display due to its construction should be replaced with an appropriate character without a diacritics, e.g. č or ć -> c; š -> s, ž -> z, đ -> d.

Receivers shall receive labels from ensembles and audio services and display long form labels in preference to short form labels.

The receiver shall display the Component Label, in preference to the Service Label, as it is possible to have two audio channels sharing the same Service Label. If a Component Label is not broadcast, the Service Label shall be used.

The text display must display the Component label in either its short form (8 characters long) or its long form (16 characters long). It is not permissible for the receiver to truncate the label to any other length.

The text display shall display the name of the audio components available for selection. Receivers shall display the complete label whenever possible. The label shall not be reduced in length except by applying the character selection provided in the flag field of a FIG type 1 label. It is not permissible for the receiver to reduce the length of the label in any other manner.

Receivers shall display the service label when a primary audio component is selected. Products shall display the service component label when a secondary audio component is selected.

Receivers shall decode the dynamic label from the X-PAD (short X-PAD, variable length X-PAD, whether the dynamic label is the only PAD application or if it is one of a number of PAD applications) of the currently selected service and display it to the user legibly. Receivers shall act upon the command to remove the label from the display by immediately removing the label, even if it has only been partially displayed.

It is accepted that different displays will have different text rendering capabilities. Receivers shall have a display capable of rendering all the characters from the Complete EBU Latin based repertoire character set, as defined in ETSI TS 101 756 [2], annex C, correctly mapped, visually well-formed, and clear.

The EECC Directive 2018/1972 [10], annex XI, 3, requires that "Any car radio receiver integrated in a new vehicle of category M which is made available on the market for sale or rent in the Union from 21 December 2020 shall comprise a receiver capable of receiving and reproducing at least radio services provided via digital terrestrial radio broadcasting"; such receivers shall support the All Europe regional profile (see ETSI TS 101 756, annex E).

### 2.3.3. Dynamic reconfiguration

If a selected primary or secondary service changes its audio configuration, audible artefacts shall be kept to a minimum (e.g. by muting if necessary). A receiver shall detect and handle changes of sub-channel allocation, sub-channel identifier of the ongoing audio service and audio bit-rate as seamless as possible if the reconfiguration occurs with correct signalling of 'current/next' configuration as defined in ETSI EN 300 401, clause 6.5 and ETSI TS 102 563 clause 7, IEC 62104 clause 4.5.

If services appear during a reconfiguration that are not in the service list, the receiver shall add the new services. Where secondary service components are used and later stop transmitting, the radio shall fall back to the primary component of this service.

A receiver shall follow a service even during multiplex or service reconfigurations or changes to the audio parameters.

### 2.3.4. Notifications and alarm announcements

Receivers shall support announcement switching for alarms and (in-vehicle receivers) "Road Traffic Flash" announcements as defined in ETSI EN 300 401, clause 8.1.6.2 (i.e. same ensemble only). This feature allows a listener to be temporarily re-directed from the currently selected audio service component to another audio service component that provides a (largely) spoken message in the form of a short announcement.

Receivers shall switch from the selected service component to a signalled "Alarm" announcement when all the conditions specified in ETSI TS 103 176, clause 7.6 are met.

In-vehicle receivers shall switch from the selected service component to a signalled "Road Traffic flash" announcement when all the conditions specified in ETSI TS 103 176, clause 7.4 are met. Activation of traffic announcements may be subject to a user setting.

For the activation of alarms, all requirements and conditions of ETSI TS 103 176, clause 7 shall apply.

When the announcement type 'Road Traffic flash' is detected, the receiver switches to the selected sub-channel from all services that belong to the signalled cluster. If a DAB or DAB+ audio service is decoded, the announcement must be derived from the corresponding FIG. The response to a signalled announcement may be subject to a user setting. Support for announcement types other than "Road Traffic Flash" and Other Ensemble Announcements is optional. These requirements are specified in ETSI EN 300 401 and ETSI TS 103 176, clause 7.

Receivers shall support Tuned Ensemble Alarm Announcements. Receivers must evaluate the Alarm Flag in FIG 0/0. Signalling for Alarm Announcements shall be ignored when the Alarm Flag is not set. Switching to the target sub-channel shall perform synchronization between signalling and audio. An Alarm Announcement takes precedence over any regular announcement. Only one Alarm Announcement shall be active at any time. Receiver response to Alarm Announcements shall not be subject to a user setting. Receivers shall meet all requirements in ETSI TS 103 176, clause 7.6.

Other types of notifications are not mandatory for DAB+ receivers. Some of these notifications are listed below.

Test Alarms provide confirmation of the entire Alarm infrastructure. When a listener can receive a Test Alarm, it is confirmed that Alarm signalling in emergency situations can be received. Other Ensemble Alarms (OE Alarm) provide a signalling to another ensemble for an Alarm Announcement. If the receiver supports Other Ensemble Alarms, the following provisions shall apply

EWF is based on Alarm Announcements as described above and contains additional mandatory service components (Dynamic Label and Journaline) as well as an optional Wakeup Function. Receivers supporting EWF (Emergency Warning Functionality), shall implement Audio, Dynamic Label and Journaline, to support a combination of short information via audio and dynamic label plus detailed multilingual text information via Journaline.

### 2.3.5. Additional requirements for 'adapters'

The term "adapter" refers to DAB+ receivers intended to connect to existing vehicle radio receivers.

Connecting adapters to existing radio receivers can be performed in several ways – via audio "aux" input, Bluetooth technology, FM broadcasting inside the vehicle or USB port.

Adapters should support predefined sets of functions (pre-set), which can be accessed through physical buttons, and also with a menu with settings of a broader set of functionality (e.g. service following, frequency adjustment, AUX/FM output, Bluetooth, factory reset, traffic notifications, alarm announcements, automatic adjustments).

Service list display – a list of stations in alphabetical order, in the case of multiple sources of reception display only those stations with the strongest signal; display of DAB+ information (station name) on the display of an existing in-vehicle receiver, e.g. via RDS in case of FM connection.

Securing the possibility of DAB+ reception for adapters – using an existing antenna in the vehicle, or through the installation of an additional antenna (roof antenna or antenna on the vehicle glass); if small-size antennas or gains are used, it is necessary to use high quality preamplifiers with noise figure below 2 dB. Amplification should be minimal, compensating for the smaller dimensions of the antenna and the cable attenuation, avoiding receiver saturation in the case of high receiving levels. The antenna diagram should be without strong directivity.

The power supply for the adapter is provided via USB port or via standard 12 V port in the vehicle; it should be done in such a way as to avoid electromagnetic interference, i.e. to make the impact of the additionally generated noise as low as possible (-106 dBm causes 3 dB of reception performance degradation); the power supply for the antenna preamplifier must be ensured. [9]

## 2.4. Requirements for different classes of receivers

| Function | | Class A | Class M | Class H |
|---|---|---|---|---|
| Analog reception | FM band (87.5 – 108 MHz) | Required | Required | Required |
| | RDS | Required for vehicle receivers, optional for other | | |
| Digital reception | VHF III band (174-240 MHz, channels 5A-13F) | Required | Required | Required |
| | Channel decoding | 1 subchannel, minimum 144 CU for DAB+ | Minimum 4 subchannels, minimum 288 CU total) | Minimum 4 subchannels, minimum 288 CU total) |
| Choice of service | Dynamic reconfiguration | Required | Required | Required |
| | Service list: The receiver selects the service of the best quality if there are multiple variants of the same service | | | |
| | Service Following | Required for vehicle receivers, optional for other | Required for vehicle receivers, optional for other | Required for vehicle receivers, optional for other |
| | Service Linking | | | |
| Service Information | Service code: Long format required if the screen has more than 16 characters | Required | Required | Required |
| Announcements | Road Traffic Flash | Required for vehicle receivers, optional for other | Required for vehicle receivers, optional for other | Required for vehicle receivers, optional for other |
| | Alarm announcements | Required | Required | Required |
| | Emergency Warning Functionality | Optional | Optional | Optional |
| Audio | MPEG-4, HE AACv2 | Required | Required | Required |
| Text | Dynamic Label Segment (DLS): If the entire label does not fit on the screen, it should scroll | Required (for receivers that support 16 or more characters at the same time) | - | - |
| | Extended Dynamic Label (DL+): Supported object types according to DL+ subset | Optional | Required (includes DLS functionality) | Required (includes DLS functionality) |
| | Journaline | | Optional for vehicle receivers, required for other | Optional for vehicle receivers, required for other |
| MOT | MOT transport | Optional | Required | Required |
| | EPG transport | | | |
| | EPG programme information | | Optional for vehicle receivers, required for other | Optional for vehicle receivers, required for other |
| | EPG service information | | Required | Required |
| | Station logo | | | |
| | Slideshow | | | |
| Hybrid broadcast broadband | Feedback / interactivity (wired or wireless network connectivity) | Optional | Optional | Required |
| | RadioDNS (RadioTAG) | | | |
| Screen | Alphanumeric display (support for extended RDS character set) | Required | - | - |
| | Colour Graphic Display | Optional | Required | Required |
| | External display interface | | Optional; must be required if the receiver does not have a built-in display | Optional; must be required if the receiver does not have a built-in display |
| Mobility | TPEG (if the device supports the navigation system) | Optional | Required for vehicle receivers, optional for other | Required for vehicle receivers, optional for other |

# 3. References

[1] ETSI TR 101 496 "Digital Audio Broadcasting (DAB); Guidelines and rules form implementation and operation"; (Parts 1 and 2).

[2] ETSI TS 103 461 (V1.2.2): "Digital Audio Broadcasting (DAB); Domestic and in-vehicle digital radio receivers; Minimum requirements and Test specifications for technologies and products".

[3] ETSI TS 102 563 (V2.1.1) "Digital Audio Broadcasting (DAB); Transport of Advanced Audio Coding (AAC) audio"

[4] ETSI ETS 300 384: "Radio broadcasting systems; Very High Frequency (VHF), frequency modulated, sound broadcasting transmitters".

[5] ETSI EN 300 401 (V2.1.1): "Radio Broadcasting Systems; Digital Audio Broadcasting (DAB) to mobile, portable and fixed receivers".

[6] ETSI TS 101 756 (V2.4.1): "Digital Audio Broadcasting (DAB); Registered Tables".

[7] IEC 62104, "Characteristics of DAB receivers – Second Edition", International Electrotechnical Commission, Switzerland.

[8] ETSI TS 103 176 (V2.4.1): "Digital Audio Broadcasting (DAB); Rules of implementation; Service information features".

[9] "WorldDAB Aftermarket Device Guidelines", Public v1.3, December 2019

[10] Directive (EU) 2018/1972 of the European Parliament and of the Council of 11 December 2018 establishing the European Electronic Communications Code (Recast).

**Other references**

DRAP-TEG-002 "Minimum Specifications for DAB and DAB+ Personal and Domestic Digital Radio Receivers", Department for Culture, Media and Sport, United Kingdom.

"Digital Radio Receiver Classes", https://www.dabplus.de/haendler/

ETSI ETS 300 799: "Digital Audio Broadcasting (DAB); Distribution interfaces; Ensemble Transport Interface (ETI)".