

**Ofcom**

**DAB RF Sensitivity Measurements**

**by**

**DTG Testing Limited**

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## I Executive summary

Ofcom have commissioned a programme of radiated tests to understand the minimum RF sensitivity performance for a sample of 20 DAB receivers either supplied by Ofcom or which had previously successfully undergone DAB tick mark conformance testing.

The objective of the programme was to investigate the following:

- a) the RF sensitivity across a range of seven VHF Band III frequencies, six of which are 7D, 8A, 8B, 9A, 9B and 9C as used in the small scale DAB trial, along with 12B which is currently used for the BBC national multiplex; and
- b) the performance across 20 DAB receivers from the DTG DAB Receiver Zoo selected primarily on sales data.

The testing was carried out over two lab days at the DTGTL premises in Vauxhall on the 22<sup>nd</sup> and 23<sup>rd</sup> of March 2016.

The results showed that the large majority of measurements exceeded the minimum requirements specified for the DAB tick mark. This can be seen from the CDF plot for the radiated testing (18 out of the 20 radios) where between 82% and 100% of measurements (depending on the channel being tested) were better than the minimum threshold. These were from measurements made on mainly domestic radios (13 out of 20) but which also included an AV receiver, a Hi-Fi unit, and 3 handheld radios. In addition, conducted sensitivity measurements were made on 2 in-vehicle radios which passed the requirements across all the frequencies tested.

This shows that although the frequencies tested as part of this programme are not in widespread use in the UK currently, products are still being designed to cater for their usage. Further work may be to expand the number of products tested and include a larger sample of cheaper models, supplemented with sales data, which may not have been submitted for tick mark testing. This may highlight the potential range in performance of products in the market.

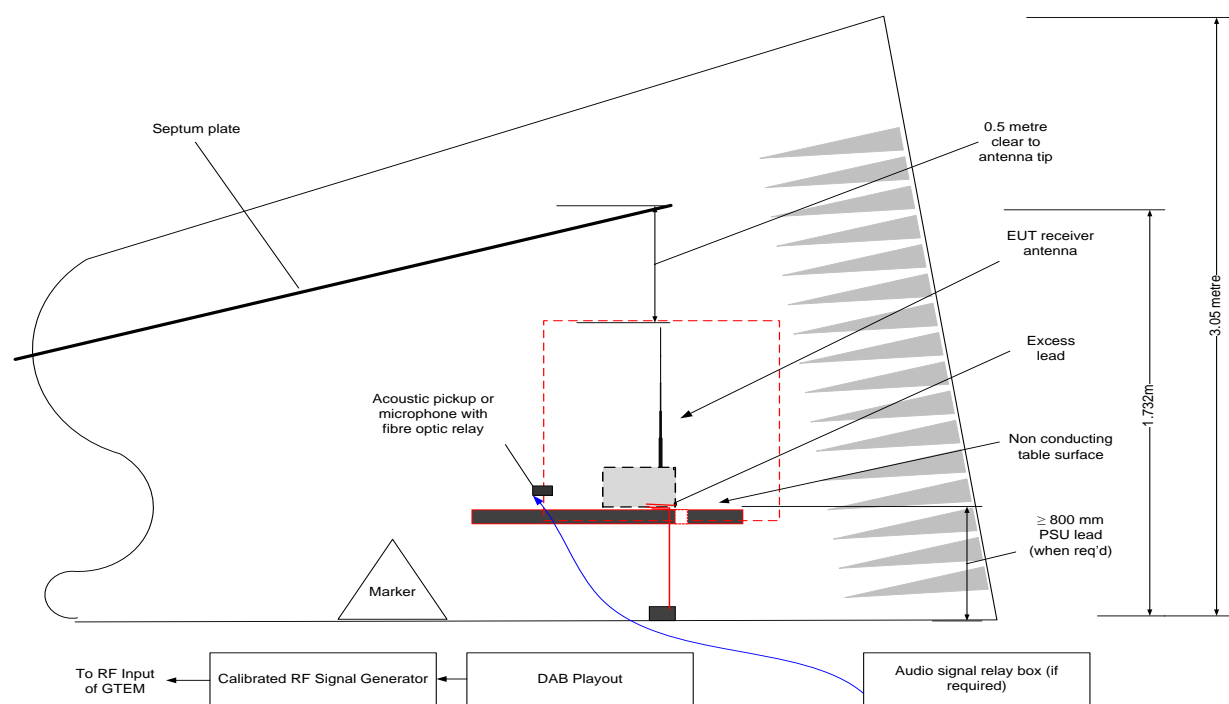
## 2 Implementation

### 2.1 Test plan

The procedure and setup used during testing was the same as that used for RF Sensitivity measurements in the DAB tick mark specification<sup>1</sup>, for which DTGTL holds ISO 17025 accreditation and against which it has tested over 200 DAB radios against to date.

#### 2.1.1 Setup

The diagram below shows the generic setup for DAB RF sensitivity testing in a GTEM cell as used by DTGTL.



**Figure 1 Radiated sensitivity test setup**

The RF signal generator used is a Rohde & Schwarz SFU which allows playback of DAB ETI files at frequencies and signal levels selectable by the user. The ETI file used for testing is as specified in Appendix A of this report and was provided to DTGTL by Digital Radio UK (DRUK) in order to carry out tick mark testing.

The audio from the radio under test is relayed from the GTEM cell to a XENYX1002FX mixing desk via a microphone positioned at the viewing window of the cell. A pair of headphones is used to listen to the output of the mixing desk.

The RF output of the SFU is connected via a 3m long N-Type cable to a power splitter which is positioned just before the input to the GTEM cell. Two identical N-Type cables are connected to the output of the power splitter, one providing the input to the GTEM cell and the other connected to the input of a Rohde & Schwarz FSH4 spectrum analyser. As the RF signal level at the input to the

<sup>1</sup> <http://www.getdigitalradio.com/industry/technical-documents/>

GTEM cell is used to calculate the field strength inside based on GTEM cell calibration data, a spectrum analyser is used to ensure that an accurate reading is taken.

During the testing, sensitivity measurements were made on three handheld radios where the antenna is the set of headphones provided with the radio. The way these were tested was by a person inside the GTEM cell wearing the headphones. The reason for this was so that the effect of the person's body on the antenna/headphones could be taken into account when measuring the sensitivity.

For in-vehicle radios a conducted test is done as per the DAB tick mark specification. This is because of impracticalities in trying to set up a representative radiated test scenario for a radio being used in a vehicle with a glass mounted or mag-mount antenna. The conducted test consists of the RF output of the R&S SFU being connected directly to the input of the in-vehicle radio.

## 2.1.2 Procedure

The minimum RF sensitivity is measured using onset of impairment method (OOI) described in the DAB tick mark specification.<sup>2</sup> The OOI test calls for a 1 kHz audio signal tone to be monitored for acoustic quality over a 30 second period and for the detection of audio impairments.

An impairment is defined as any recognisable deviation from a constant amplitude, constant frequency 1 kHz audio tone; for example audio drops or gaps, or bursts of non-1 kHz signal tone – sometimes called “bubbles”, “tweets”, “chirps” or “birdies”.

**The OOI method specifies that if there are no more than three impairments observable in a 10 second time period averaged over 3 cycles (30 seconds), then the receiver has passed the test.**

The ‘Sine’ service of the ETI file plays out a 1 kHz tone which is used to assess audio glitches as described above.

A summary of the test steps are:

- 1) Carry out a check to verify the test setup is working as expected and that the radio can play the 1kHz tone without any problems – if so the tests can start
- 2) Set the generator to the required frequency and signal level
- 3) Set the analyser to the required frequency
- 4) Tune the radio and ensure the 1kHz tone can be heard without any impairments
- 5) Reduce the RF signal level using the signal generator until the OOI conditions are met
- 6) Record the RF signal level at the last point before the OOI limit was reached – this is the minimum RF sensitivity
- 7) Repeat the steps for the next frequency to test.

## 2.2 Measurements

### 2.2.1 Scope

The scope of this proposal is taken from an email to DTG on 27<sup>th</sup> April 2015 from Paul White at the Ofcom Spectrum Policy Group. This outlines the following requirements:

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<sup>2</sup> <http://www.getdigitalradio.com/industry/technical-documents/>

- Minimum RF sensitivity measurements on seven Band III frequencies of 7D, 8A, 8B, 9A, 9B, 9C and one other frequency (to be confirmed by Ofcom) that is currently covered as part of the tick mark testing;
- Tests are to be carried out on a minimum of 20 DAB receivers over 2 lab days;
- The DAB receivers will be selected from the DTGTL DAB receiver Zoo and will have passed tick mark conformance testing; and
- The selection of models from the tick mark tested radios will be based upon highest sales volumes (Ofcom to provide sales data).

In the end, Ofcom provided 7 radios from their test facility at Baldock. The remaining 13 were taken from the DTGTL receiver zoo where 7 of these were specifically listed by Ofcom and the remaining 6 out of the 13 were to be chosen by DTGTL. There were no particular criteria set by Ofcom for choosing the remaining 6 other than that anything too 'niche' should be avoided and that preferably the sample should contain an in-vehicle unit and a Hi-Fi unit. All of the 13 receivers taken from the DTGTL zoo had previously passed the DAB tick mark requirements.

The final set of the receiver types used for the tests and the test ID given to them is shown below.

Test ID	DAB receiver type
RX1	Domestic
RX2	Domestic
RX3	Domestic
RX4	Handheld
RX5	Domestic
RX6	Domestic
RX7	Domestic
RX8	Domestic
RX9	Domestic
RX10	Domestic
RX11	Domestic
RX12	Domestic
RX13	Handheld
RX14	Handheld
RX15	Domestic
RX16	Domestic
RX17	Hi-Fi
RX18	AV Receiver
RX19	In-vehicle head-unit
RX20	In-vehicle head-unit

**Table I List of receivers used for testing**

At the time of writing the DTGTL DAB Receiver Zoo consists of 77 radios that have been tested as part of tick mark conformance. These radios are a combination of domestic, in-vehicle and handheld radios as well as AV receivers with DAB tuners. Previous results from testing can be easily referenced in order to compare and verify receiver stability.

## 2.2.2 Frequencies tested

Minimum sensitivity tests were carried out on each receiver for the following channels:

Channel	Frequency (MHz)
7D	194.064
8A	195.936
8B	197.648
9A	202.928
9B	204.64
9C	206.352
12B	225.648

**Table 2 List of frequencies tested**

Channels 7D to 9C were selected by Ofcom due to the fact they are used as part of the small scale DAB trial they are undertaking. Channel 12B was chosen by DTGTL as it is used by the BBC national multiplex and can provide a comparison between a results for a frequency currently used in the UK against results for frequencies used in the small scale trial.

## 3 Results

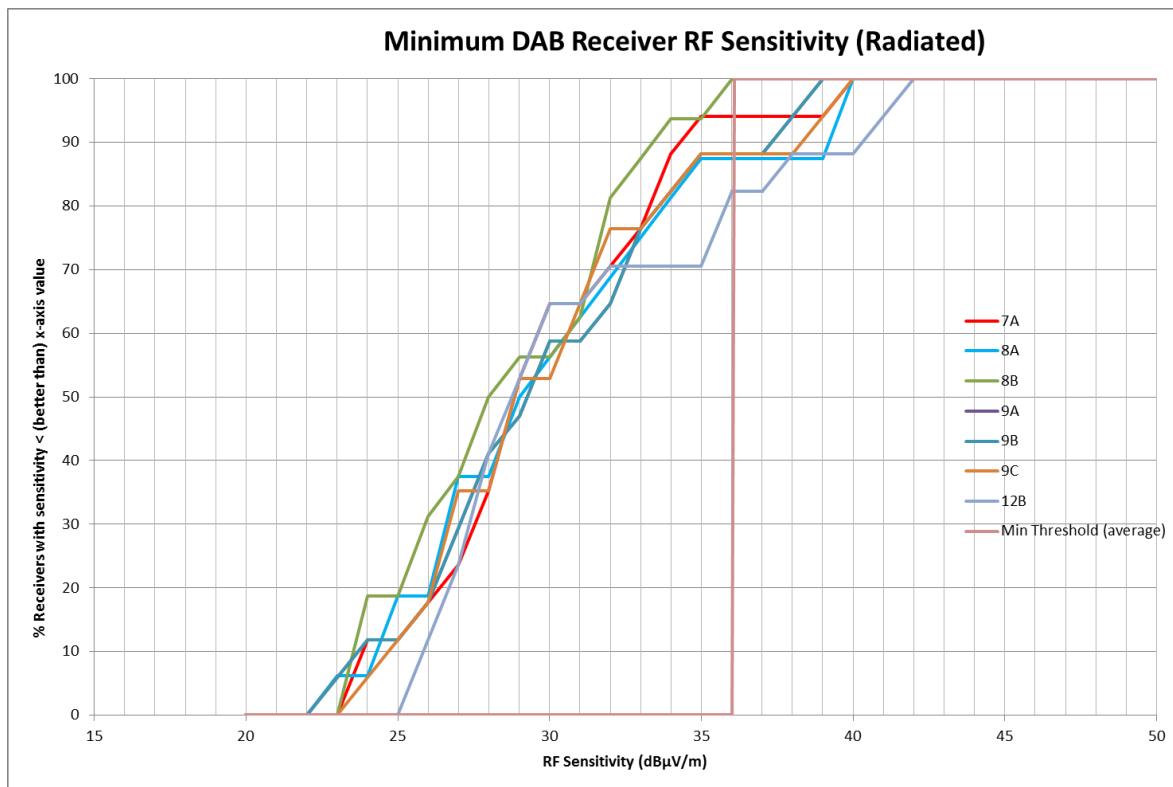
The results show that on average the receivers comfortably met the minimum sensitivity requirements as specified in the DAB tick mark, across all of the frequencies tested. This can be seen in Table 3 below.

Channel	Frequency (MHz)	PASS/FAIL target threshold (dB $\mu$ V/m) for OOI test including measurement uncertainty	Average measured radiated sensitivity (dB $\mu$ V/m)	Difference between average and pass/fail (dB)
7D	194.064	35.5	29.1	-6.4
8A	195.936	35.6	29.1	-6.4
8B	197.648	35.6	27.7	-8.0
9A	202.928	35.9	29.2	-6.7
9B	204.64	35.9	29.4	-6.6
9C	206.352	36.0	29.4	-6.6
12B	225.648	36.8	30.2	-6.6

**Table 3 Average measured radiated sensitivity**

Individual results for the receivers can be seen in Appendix B of this report but out of the 18 receivers that underwent radiated sensitivity measurements, 4 failed to meet the minimum requirements on some of the frequencies tested. These were receivers RX1, RX2, RX4 and RX5.

The CDF plot below shows what this means in terms of percentages of receivers that met requirements across each frequency tested.



**Figure 2 CDF of measured radiated sensitivity**

Similarly for the conducted tests carried out on the in-vehicle radios, the receivers were able to meet the requirements although RX20 only marginally passed the requirement for channel 9A by 0.3dB. As only 2 radios were tested in this way the individual results are given below in Table 4.



Channel	Frequency (MHz)	PASS / FAIL target threshold (dBm) for conducted test*	PASS/FAIL target threshold (dBm) for conducted test including measurement uncertainty	Level at which OOI test Impairment recorded (dBm at input to receiver)	
				RX19	RX20
7D	194.064	-97.7	-98.6	-100	-100.2
8A	195.936	-97.7	-98.6	-100	-99.5
8B	197.648	-97.7	-98.6	-100.5	-99.8
9A	202.928	-97.7	-98.6	-99.8	-98.9
9B	204.64	-97.7	-98.6	-99.5	-99
9C	206.352	-97.7	-98.6	-99.7	-99.5
12B	225.648	-97.7	-98.6	-99.5	-99.3

**Table 4 Measured conducted sensitivity**

## 4 Conclusion

Overall, the large majority of measurements exceeded the minimum requirements specified for the DAB tick mark. This can be seen from the CDF plot for the radiated testing (18 out of the 20 radios) where between 82% and 100% of measurements (depending on the channel being tested) were better than the minimum threshold. These were from measurements made on mainly domestic radios (13 out of 20) but which also included an AV receiver, a Hi-Fi, and 3 handheld radios. In addition, conducted sensitivity measurements were made on 2 in-vehicle radios which passed the requirements across all the frequencies tested.

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## Appendix A – Details of test stream

DRAP-TEG-TESTSTREAM-001\_V0.5.eti

This file contains a 120 minute long ETI (NI) test stream and contains the following sub-channels. (Note that there will be a stream discontinuity at the end of the 120 minute play out file, which will create an audible “glitch” artefact. The stream may be restarted to ensure the stream provides due continuity during the test period.)

The DLS string in SID C000 contains the code 0x0B (end of headline) at the 32nd position and 0x0A (preferred line break) at the 15th position and 0x1f (preferred word break) at the 12th position; and code 0x1f every eight characters from position 33 to the end.

**LABEL:** DRAPMUX1 **EID:** C555

Service label / SID	Short Label	Bit rate / Codec	Audio Content	DLS (note: this is not required for in-vehicle receivers)
Sine / C000	Sine	128k / MP2/ EEP-3A	1kHz tone	“ABCDEFGHIJKLMNOPQRSTUVWXYZabcdefghijklmnopqrstuvwxyz0123456789£%&!."(),”
OOI Music* / C001	OOIMusic	128k / MP2/ UEP-3	Royalty free music*	“OOI Music Source 128k MP2 UEP-3 Stereo”
AHBGCFDEED FCGBHA/ C002	ABCDEFGH	128k / MP2	1.5kHz tone	“MP2 128kbps 1.5kHz tone”
IPJOKNLMMLN KOJPI / C003	IJKLMNOP	96k / AAC	2kHz tone	“AAC 96kbps 2kHz tone”
QXRWSVTUUT VSWRXQ / C004	QRSTUVWX	96k / AAC	3kHz tone	“AAC 96kbps 3kHz tone”

\* The music file is AKMusic AK033-“Good Time Grooves - Jazz n Funk”, track 11 “newyorkskyline”

## Appendix B – Results for radiated testing

