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# DAB transmitter compliance testing method

# Contents

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## Section

1. Overview	1
2. Background	2
3. General requirements	3
4. Test methodology overview	4
5. Characterising the directional coupler test point	5
6. DAB band-pass filter characterisation	7
7. Calculating the required transmitter power	10
8. DAB transmitter pre-filter measurement	13
9. $\pm 970$ kHz measurements	15
10. 243 MHz test	17
11. Spurious emissions and harmonics measurements	19

## Annex

A1. Example DAB Commissioning Form	21
A2. Calculation Tables	23

# 1. Overview

- 1.1 This document sets out a method for performing compliance testing on UK VHF band III DAB transmitters against certain technical requirements contained in (or referenced by) multiplex operators' Broadcasting Act and Wireless Telegraphy Act licences (including the relevant requirements of the [Ofcom Digital Radio Technical Code](#)).
- 1.2 This document has been issued following the publication of Ofcom's revised DAB Technical Codes in May 2023 and outlines one method for how licensees or transmission providers can conduct testing to verify that their transmitted signals meet the requirements and parameters set out in their Wireless Telegraphy Act licences. There is no regulatory requirement to use this specific method, and alternative test procedures may be used where desired or appropriate.
- 1.3 The method described in this document allows measurements to be made across a wide dynamic range by using the transmitter filter characteristics to improve the accuracy of the out-of-band measurements without the need to employ a separate notch filter. This method is typically suitable for DAB transmitter installations with effective radiated powers (ERPs) of between 25 watts and 1 kilowatt.
- 1.4 The document is primarily intended to assist operators of small-scale DAB multiplexes to carry out commissioning of their transmitter systems. This procedure allows test result data for the 'DAB commissioning checklist' to be systematically compiled ahead of submission to Ofcom.
- 1.5 The remainder of this document assumes familiarity with radio engineering principles and equipment and is not intended for the general reader. The tests described should only be carried out by competent personnel who are experienced in RF measurement techniques. Ofcom accepts no liability for any harm or damage to equipment which may occur as a direct or indirect result of carrying out the procedures described in this document.

## 2. Background

### Traditional and alternative measurement methods

- 2.1 Historically, the method which has typically been used for checking a DAB transmitter for technical compliance with the multiplex operator's licence conditions (including compliance with the relevant requirements of the Ofcom Digital Radio Technical Code) was to use a notch filter tuned to the frequency of the DAB transmitter under test.
- 2.2 The 'traditional' method involves making measurements using the notch filter attached to the forward port on a directional coupler. For the avoidance of doubt, this method is still valid and can be used if a test filter is available.
- 2.3 This document describes an alternative approach which avoids the need to use notch filters. The alternative method instead relies on using the transmitter filter characteristics to calculate the relevant system performance characteristics.
- 2.4 Although transmitter filters are generally supplied with a factory plot, the filter characteristics can often change once the filter has been shipped and installed on site. The characteristics can also change due to the on-site temperature. It is therefore important to carry out a frequency sweep of the transmitter filter performance before any tests are carried out.
- 2.5 Access to the transmitter band-pass filter ports is required to perform the measurements described in this document.

## 3. General requirements

- 3.1 As a condition of launch, all DAB transmitters must have an appropriate conformity marking. This will be a UKCA or CE mark depending on the applicable requirements<sup>1</sup>.
- 3.2 The following equipment is required to carry out the measurements set out in this guide:
- a) Calibrated spectrum analyser, with a tracking generator option;
  - b) Calibrated directional coupler;
  - c) 50 Ohm dummy load (with a power rating suitable for the transmitter system under test);
  - d) **Either** a high-pass filter **or** a tuneable band-pass filter capable of passing 243 MHz;
  - e) Fixed external attenuators: 10 dB, 20 dB, or a variable attenuator if available;
  - f) A high-pass filter (to measure spurious emissions and harmonics up to 1 GHz);
  - g) Adaptors and calibrated<sup>2</sup> interconnecting N-type cables;
  - h) Additional adaptors and cables will also be required.
- 3.3 The commissioning results should be recorded in the 'DAB commissioning checklist' form which is available on the '*Broadcast Transmitter Guidance*' section of Ofcom's [website](#). The completed form and supporting documents (plots of measurements and transmitter site photographs) must be submitted by email to Ofcom at [broadcastradiocompliance@ofcom.org.uk](mailto:broadcastradiocompliance@ofcom.org.uk) within five working days of a transmitter coming on-air.
- 3.4 Annex 1 of this document contains a copy of the DAB commissioning checklist form which has been populated with example results.

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<sup>1</sup> The UKCA (UK Conformity Assessed) marking is a UK product marking that is used for goods being placed on the market in Great Britain (England, Wales and Scotland). It covers most goods which previously required the CE marking, known as 'new approach', goods. The UKCA marking came into effect on 1 January 2021. Alternatively, CE marking will continue to be accepted for equipment placed on the market before 31 December 2024 in most cases. More information is available on the UK Government website at <https://www.gov.uk/guidance/using-the-ukca-marking>.

<sup>2</sup> Calibration means that the loss of the cables must be measured by the user at the frequency at which measurements will be made.

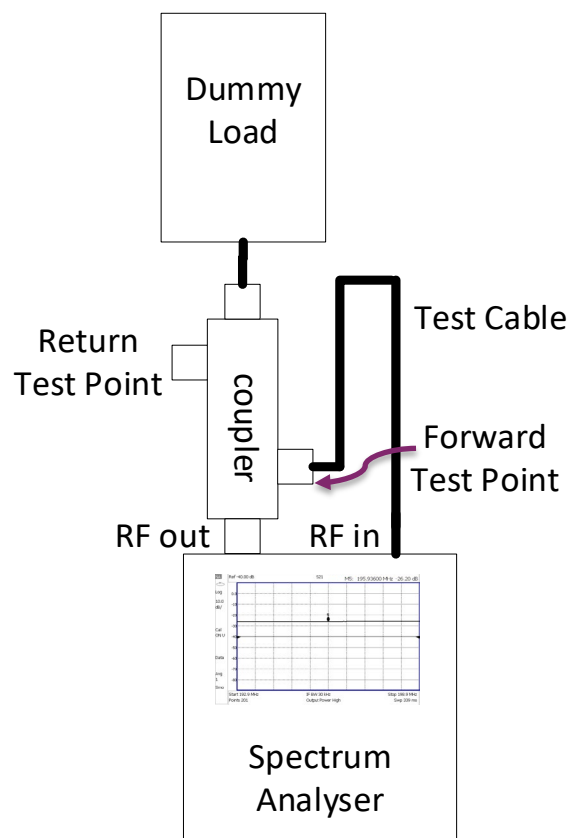
## 4. Test methodology overview

- 4.1 The test methodology comprises the following steps. Each step is described in more detail in sections 5 to 11 of this document, and these sections also include representative example measurement results and supporting data to help illustrate the process.
- Characterising the directional coupler to identify the insertion loss and coupling factor at the DAB block centre frequency.
  - Frequency-sweeping the transmitter band-pass filter, taking into account the losses of the interconnecting cables and recording the response.
  - Taking a plot of the DAB transmitter output before the band-pass filter.
  - Calculating the required transmitter power based on the system losses, antenna gain and licensed effective radiated power (ERP).
  - Measuring the antenna return loss using the directional coupler forward and return ports.
  - Evaluating the level of out of band emissions at  $\pm 1.75$  MHz and  $\pm 3$  MHz relative to the DAB block centre frequency by summing transmitter emissions and filter rejection measurements.
  - Measuring the following parameters at the forward test point of the coupler with the DAB transmitter and band-pass filter in circuit:
    - $\pm 970$  kHz performance;
    - 243 MHz measurement (using a suitable high-pass filter, if required);
    - Harmonics and Spurious Emissions (using a separate suitable high-pass filter).
- 4.2 Example measurement data is included in sections 5 to 11 of this document (where appropriate) in order to illustrate the test procedures described, and to provide inputs to worked examples of the required calculations. Unpopulated calculation tables are provided in Annex 2.

## 5. Characterising the directional coupler test point

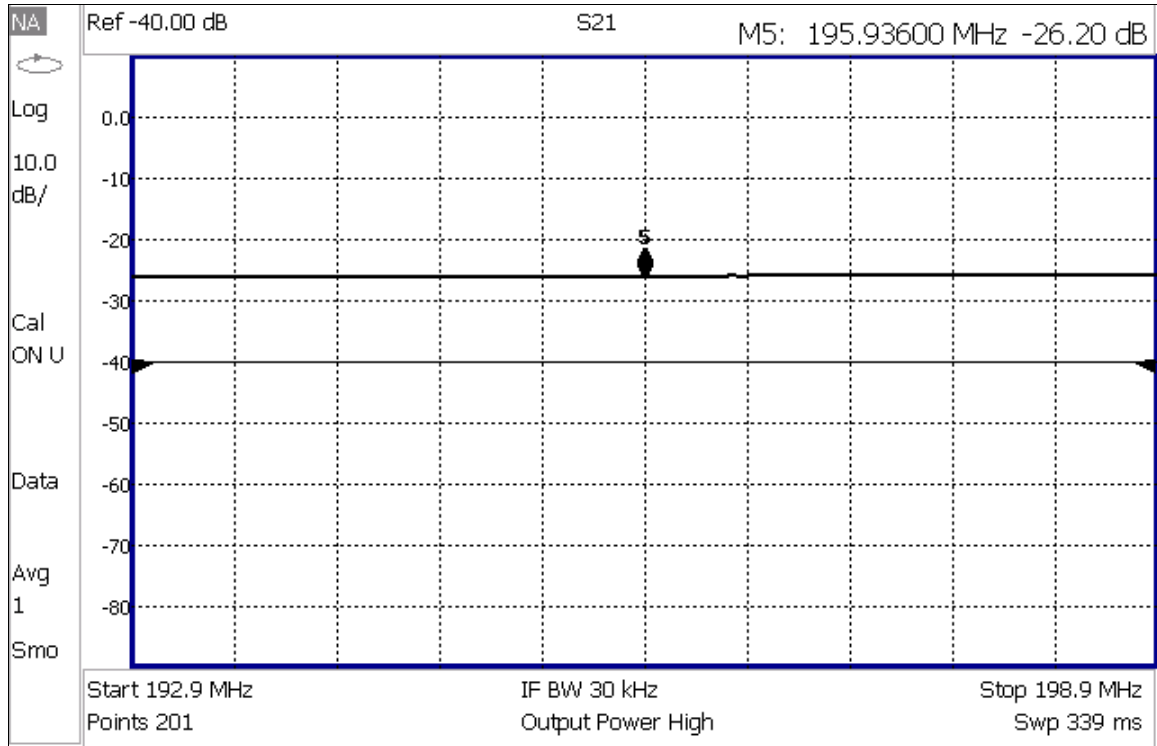
- 5.1 Connect a suitable 50 Ohm dummy load to the output of the directional coupler.
- 5.2 Connect the input and forward test points on the coupler to the spectrum analyser as shown in Figure 1. The cable that is used to connect the coupler forward test point to the spectrum analyser should be also used for the remainder of the measurements in this procedure.
- 5.3 Using the tracking generator or network analyser two port (S21) function on the spectrum analyser, frequency sweep the directional coupler to establish the coupling factor at the in-use DAB frequency.
- 5.4 Take a screenshot of the spectrum analyser display and save a plot of the result.

**Figure 1: directional coupler measurement configuration**



- 5.5 The example screenshot shown in Figure 2 shows a measurement of a typical directional coupler at a DAB block centre frequency of 195.936 MHz. The coupling factor was measured as -26.20 dBm on the forward port.

Figure 2: example plot of coupling factor





## 6. DAB band-pass filter characterisation

- 6.1 To perform this measurement, the tracking generator or network analyser two port (S21) function on the spectrum analyser is used.
- 6.2 The connecting cable losses should be accounted for by connecting them together with the N-type back-to-back connector as shown in Figure 3, then using the normalise option in the calibration function of the spectrum analyser. Figure 4 shows an example plot following normalisation.

Figure 3: calibration of cables

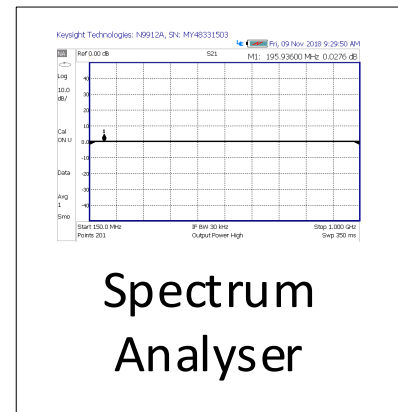
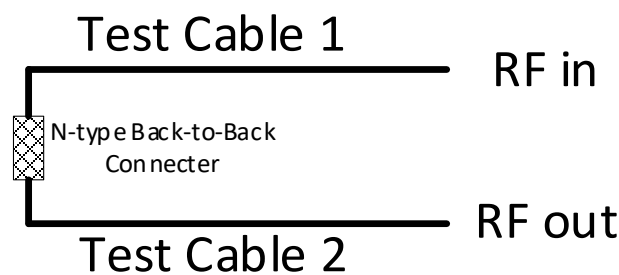
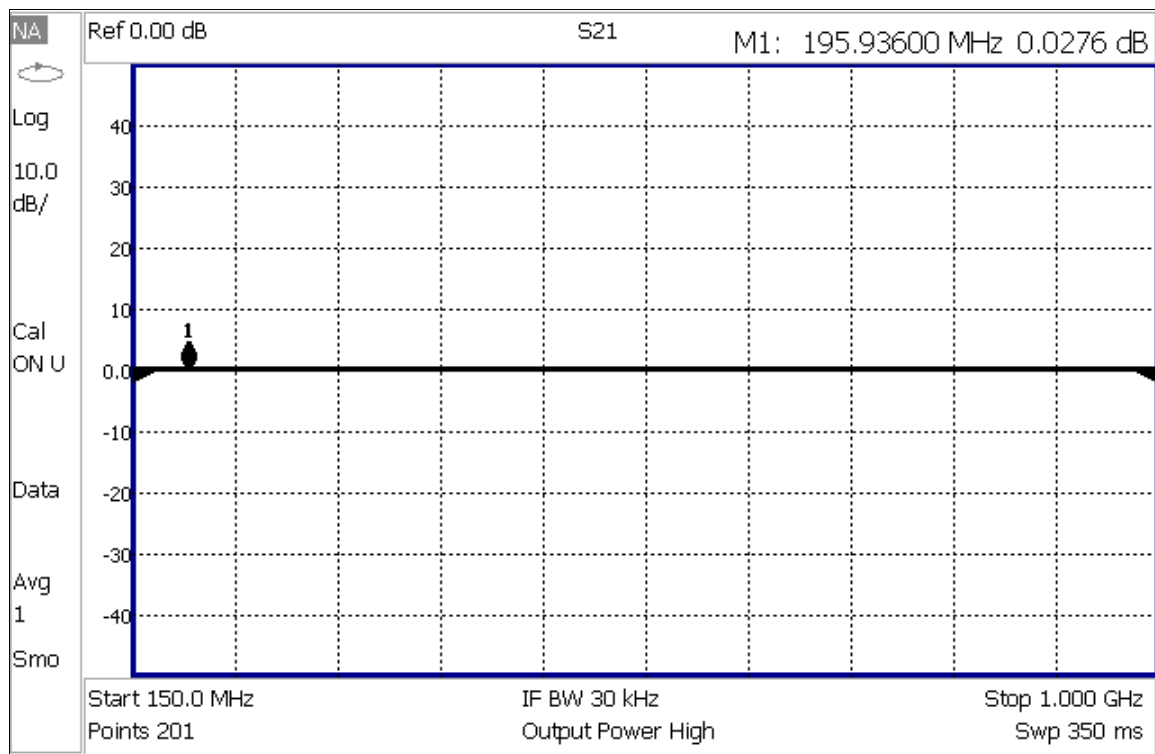
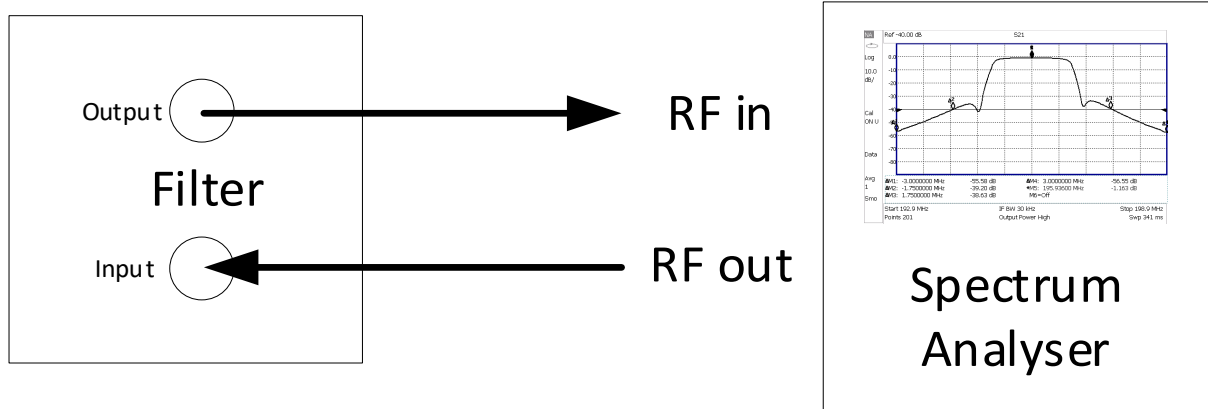


Figure 4: example cable calibration plot



- 6.3 Connect the transmitter band-pass filter to the spectrum analyser as shown in Figure 5 and perform a frequency sweep.

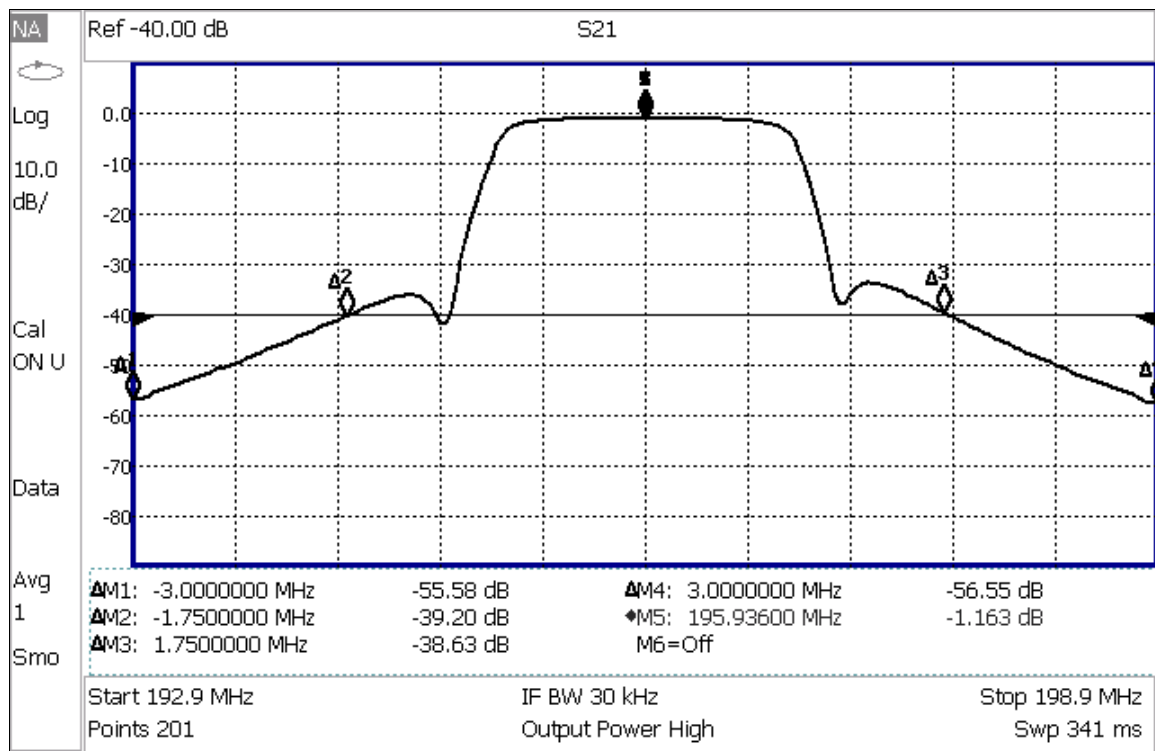
Figure 5: DAB band-pass filter characterisation



6.4 Using a 6 MHz span, place delta markers M1 to M4 at  $\pm 1.75$  MHz and  $\pm 3$  MHz referenced to the centre frequency. A normal marker M5 should also be placed at the centre frequency to measure the filter insertion loss.

6.5 An example spectrum analyser plot is shown in Figure 6. The analyser used in this example required each delta marker to be referenced individually to the centre frequency.

Figure 6: example plot of band-pass filter



6.6 Example results for each measurement point are shown in Table 1. These values will be used later in Table 4 to evaluate the transmitter’s out-of-band emissions.

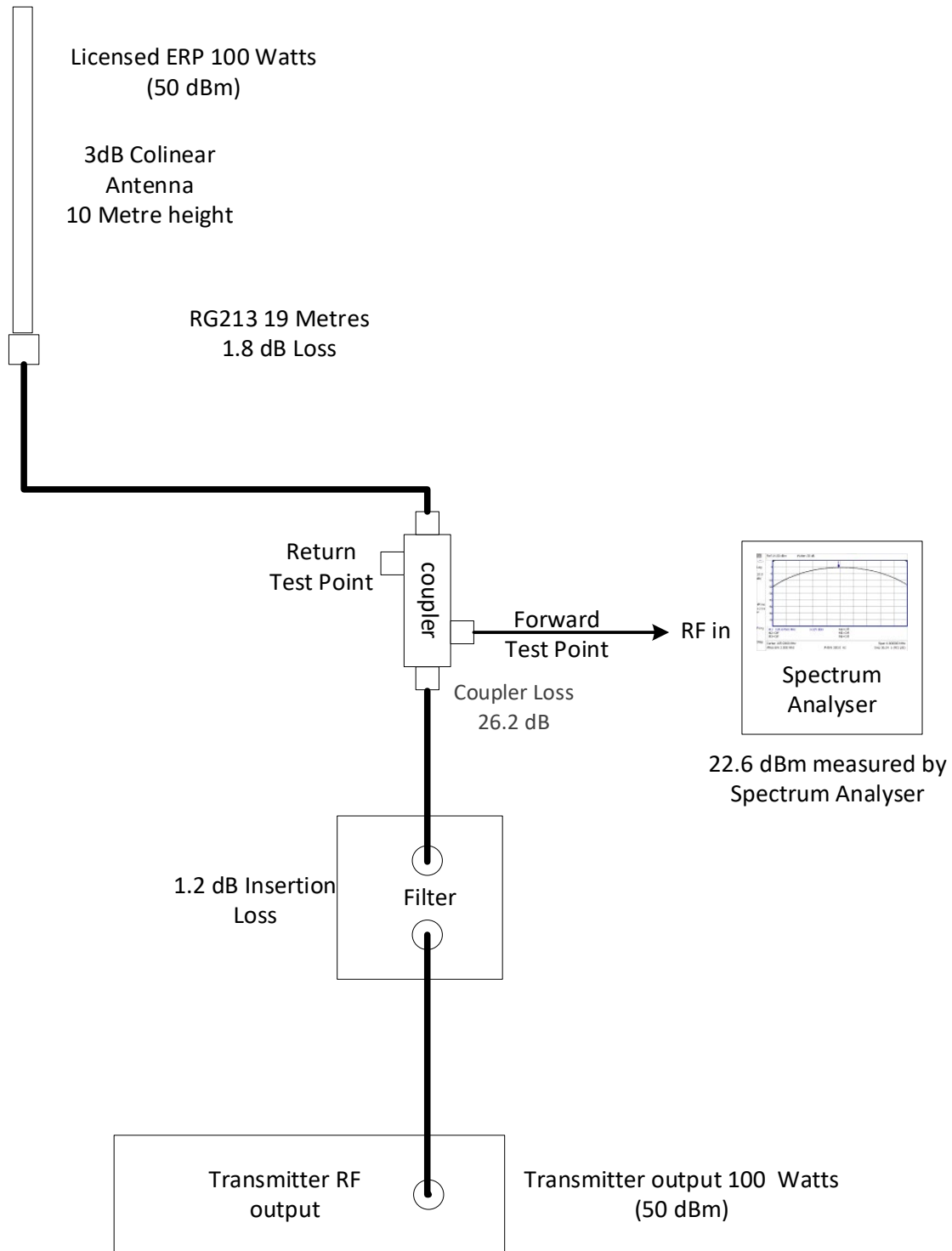
**Table 1: example band-pass marker values**

Marker	$\Delta M1$	$\Delta M2$	Ref	$\Delta M3$	$\Delta M4$	M5 (insertion loss)
Frequency	-3.00 MHz	-1.75 MHz	Fc	1.75 MHz	3.00 MHz	195.936 MHz
Relative level	-55.58 dB	-39.20 dB	0.00 dB	-38.63 dB	-56.55 dB	-1.163 dB

## 7. Calculating the required transmitter power

7.1 Figure 7 shows the equipment arrangement for calculating the effective radiated power (ERP) of the system.

Figure 7: block diagram of typical DAB installation



- 7.2 The following process will establish the transmitter power required to operate the transmitter system at the licensed maximum ERP.
- 7.3 The parameters below are required, and the block diagram at Figure 7 contains example values for a typical DAB installation:
- a) Antenna gain (dBd)
  - b) Feeder loss (dB)
  - c) Filter losses (dB)
  - d) Interconnecting cable losses (dB)
- 7.4 To calculate the required transmitter power, use the following calculation.

$$\text{Tx Power (dBm)} = \text{Licensed ERP (dBm)} - \text{Antenna Gain (dBd)} + \text{Feeder Loss (dB)} + \text{Filter Losses (dB)} + \text{Interconnecting Cable Loss (dB)}$$

- 7.5 Table 2 contains the example values from Figure 7, which are used to derive the required transmitter power. n.b. in this example, the antenna gain (3dB) equals the loss of the filter (1.2dB) plus the loss of the feeder cable (1.8dB). Therefore the required transmitter power equals the ERP (both 100W). This will not generally be the case in practice.

**Table 2: transmitter power calculation**

Tx Power	Licensed ERP	Antenna Gain	Feeder Loss	Filter Losses	Interconnecting cable Loss
50 dBm (100 Watts)	50 dBm (100 Watts)	3 dBd	1.8 dB	1.2 dB	0 dB

- 7.6 The required power can be set initially using the transmitter’s built-in power indicator. However, it should be confirmed by using one of the following three methods:
- A power meter, **or**
  - A spectrum analyser, by either taking a measurement using the channel power option (if available), **or**
  - A spectrum analyser connected to the directional coupler forward port and set to a **2 MHz** resolution bandwidth.
- 7.7 The level at the coupler forward test point is calculated as follows:

$$\text{Required measured level at coupler forward test point (dBm)} = \text{Licensed ERP (dBm)} - \text{Antenna Gain (dB)} + \text{Feeder Loss (dB)} - \text{Coupler Loss (dB)}$$

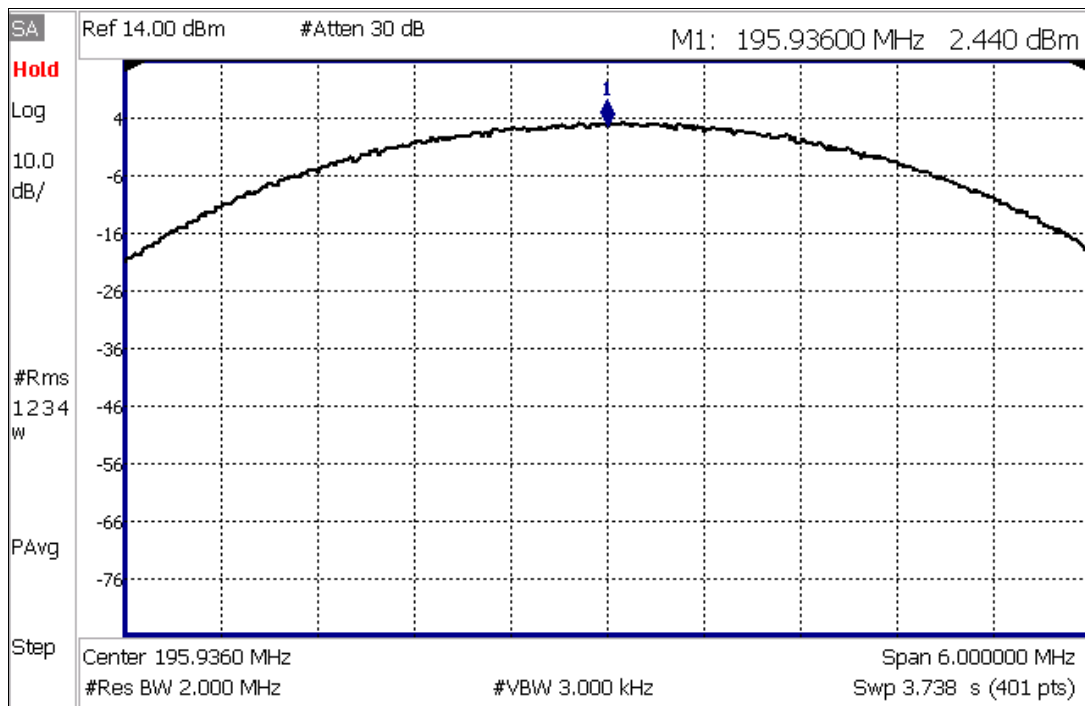
- 7.8 Table 3 contains example values for the coupler test point calculation.

**Table 3: coupler test point calculation**

Measured Coupler forward test point value	Licensed ERP	Antenna Gain	Feeder Loss	Coupler Loss
22.6 dBm	50 dBm (100 Watts)	3 dBd	1.8 dB	26.2 dB

7.9 Figure 8 shows a screenshot of an example power measurement on a coupler.

**Figure 8: example power measurement on coupler**

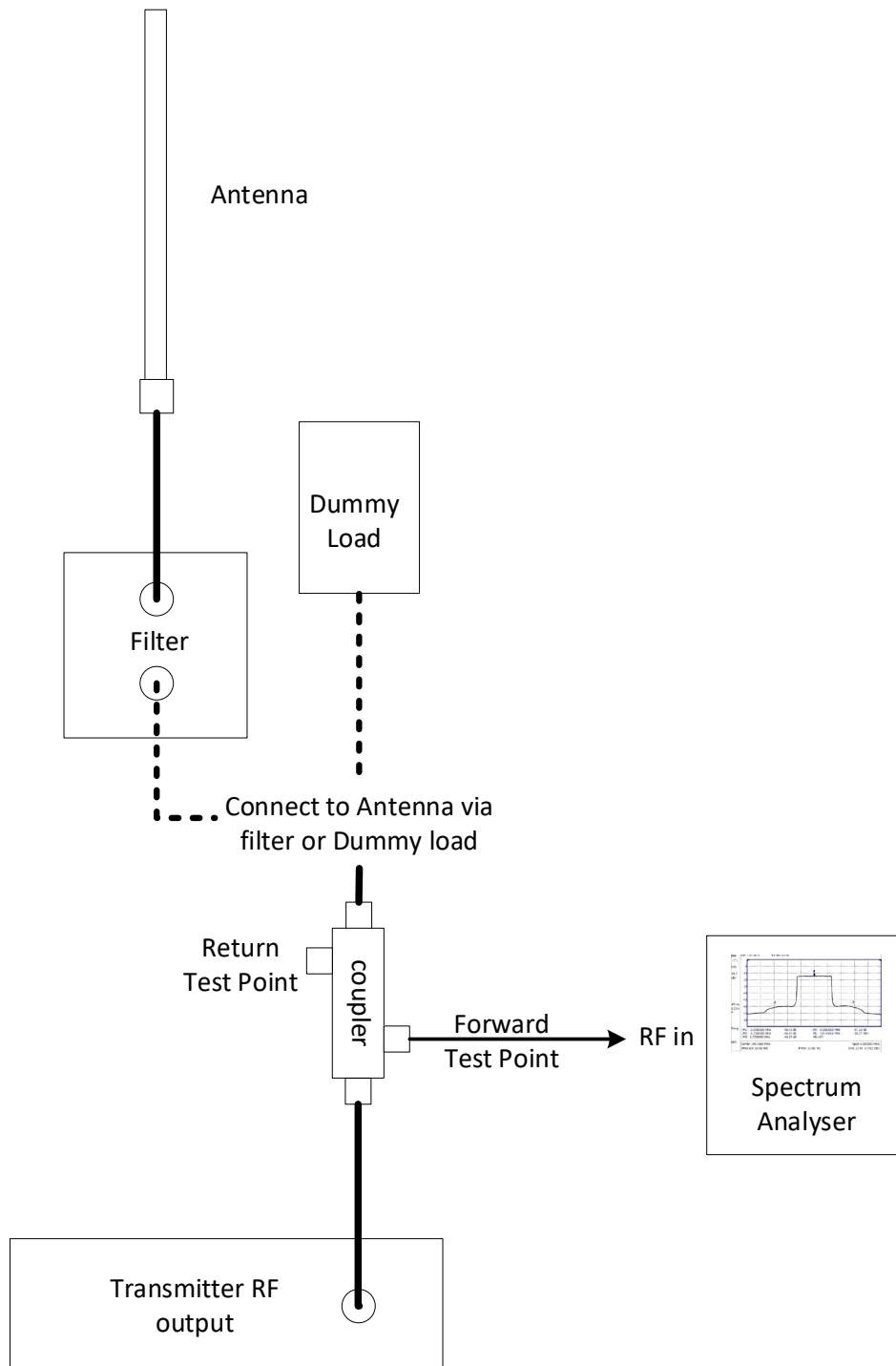


7.10 Once the transmitter power measurement is complete, confirm that the antenna return loss is greater than 14 dB by comparing the signal levels between the forward and reverse ports of the directional coupler.

## 8. DAB transmitter pre-filter measurement

- 8.1 Connect the directional coupler between the DAB transmitter and filter as shown in Figure 9.

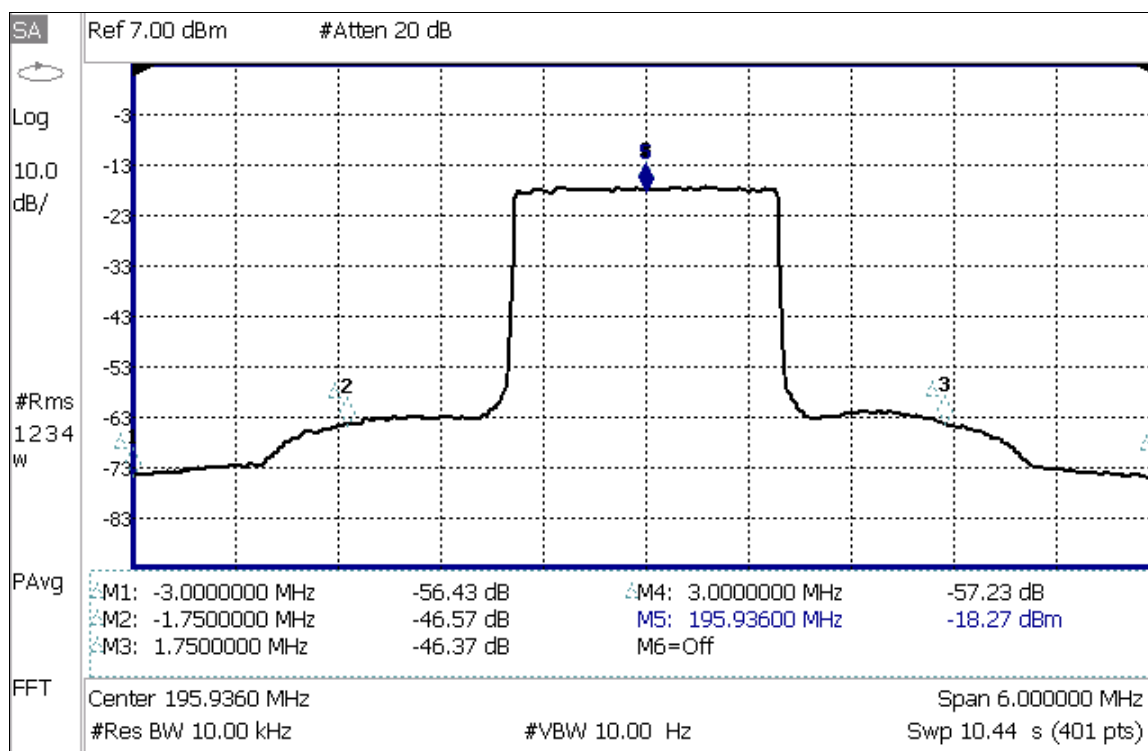
Figure 9: transmitter pre-filter diagram



- 8.2 Measure on the forward test port of the coupler. You may need an in-line 10 dB or 20 dB attenuator to prevent overloading the spectrum analyser.

- 8.3 Using a 6 MHz span and a 10 kHz resolution bandwidth, place delta markers M1 to M4 at  $\pm 1.75$  MHz and  $\pm 3$  MHz relative to the centre frequency. A normal marker should also be placed at the centre frequency.
- 8.4 Make a note of the levels at  $\pm 1.75$  MHz and  $\pm 3.00$  MHz relative to the centre frequency. An example analyser plot is shown in Figure 10.
- 8.5 Take a screenshot of the spectrum analyser and save a plot of the result.

Figure 10: example plot of transmitter pre-filter measurement



- 8.6 Next, calculate the level of out of band emissions at the  $\pm 1.75$  MHz and  $\pm 3.00$  MHz points by adding the 'transmitter' measurements outlined in this section (section 8) with the 'filter' measurements outlined in Section 6, and compare with the required limit.
- 8.7 An example of this calculation, using the example measurement values from Sections 6 and 8, is provided in Table 4 below. In this case, the measurements are within the required limits.

Table 4: examples of  $\pm 1.75$  MHz and  $\pm 3$  MHz out-of-band compliance calculations

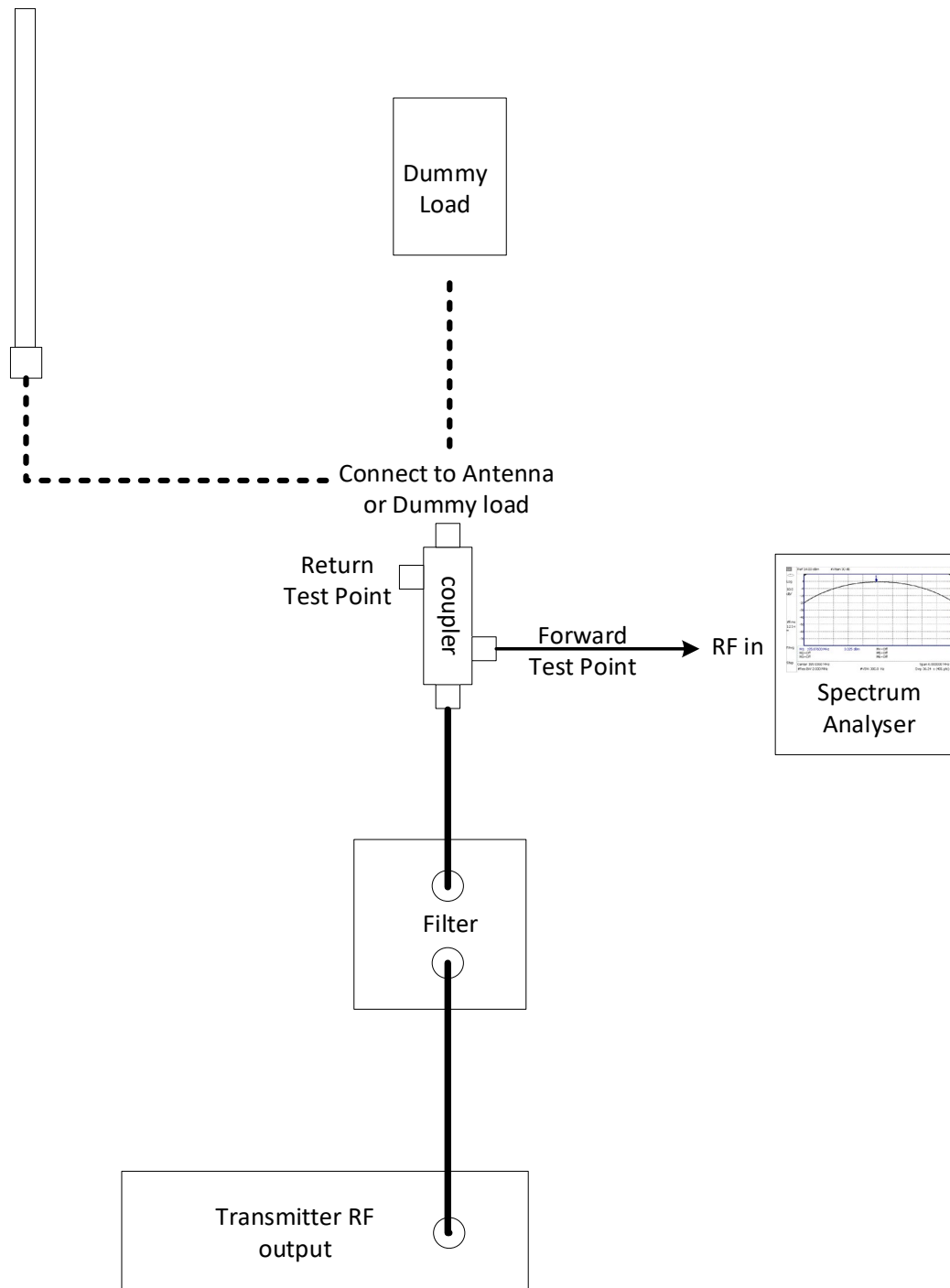
Marker	$\Delta M1$	$\Delta M2$	Ref M1	$\Delta M3$	$\Delta M4$
Frequency	-3.00 MHz	-1.75 MHz	Fc	1.75 MHz	3.00 MHz
Filter	-55.58 dBc	-39.20 dBc	0.00 dB	-38.63 dBc	-56.55 dBc
Transmitter	-56.43 dBc	-46.57 dBc	0.00 dB	-46.37 dBc	-57.23 dBc
Total	-112.01 dBc	-85.77 dBc	0.00 dB	-85.00 dBc	-113.78 dBc
Limit	-80 dBc	-80 dBc		-80 dBc	-80 dBc



## 9. $\pm 970$ kHz measurements

9.1 The  $\pm 970$  kHz compliance measurement is performed by connecting the spectrum analyser to the coupler forward test port as shown in Figure 11, using an attenuator if required.

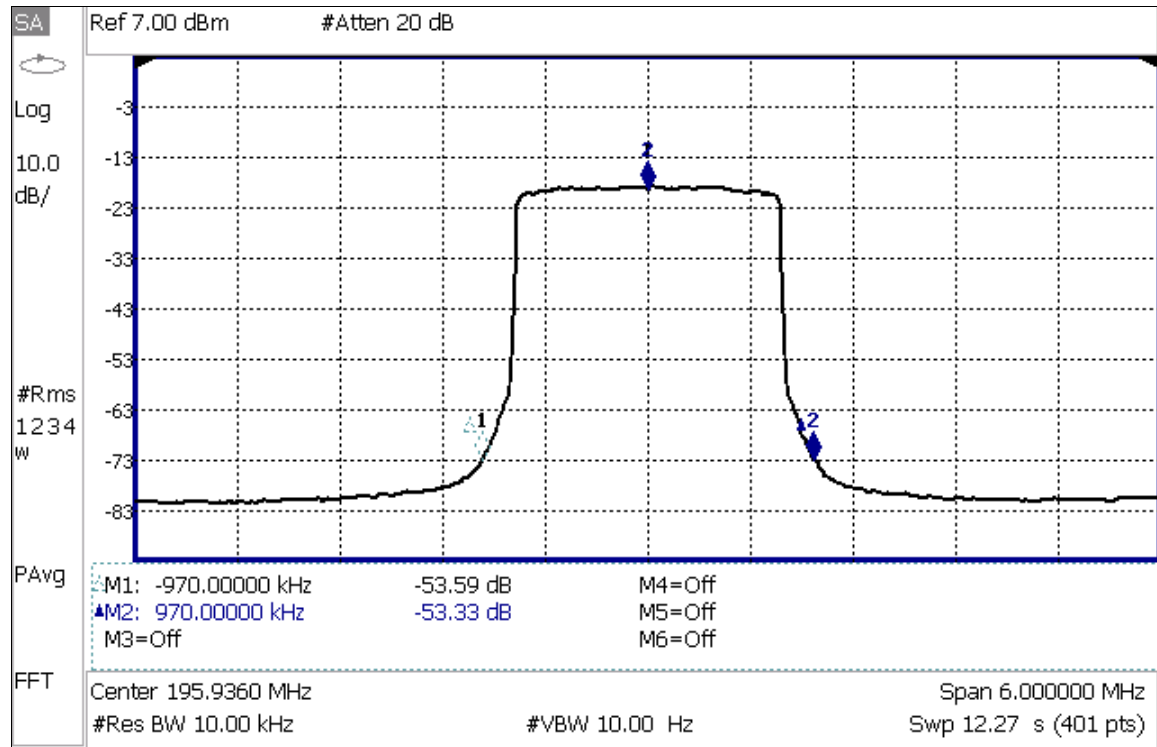
Figure 11: equipment arrangement for  $\pm 970$  kHz measurements



9.2 A plot of the DAB signal with markers at  $\pm 970$  kHz should be saved.

9.3 The example plot in Figure 12 shows that the levels of -53.59 dBc and -53.33 dBc at the marker frequencies and referenced to the DAB block centre level are below the required limit of -45 dBc.

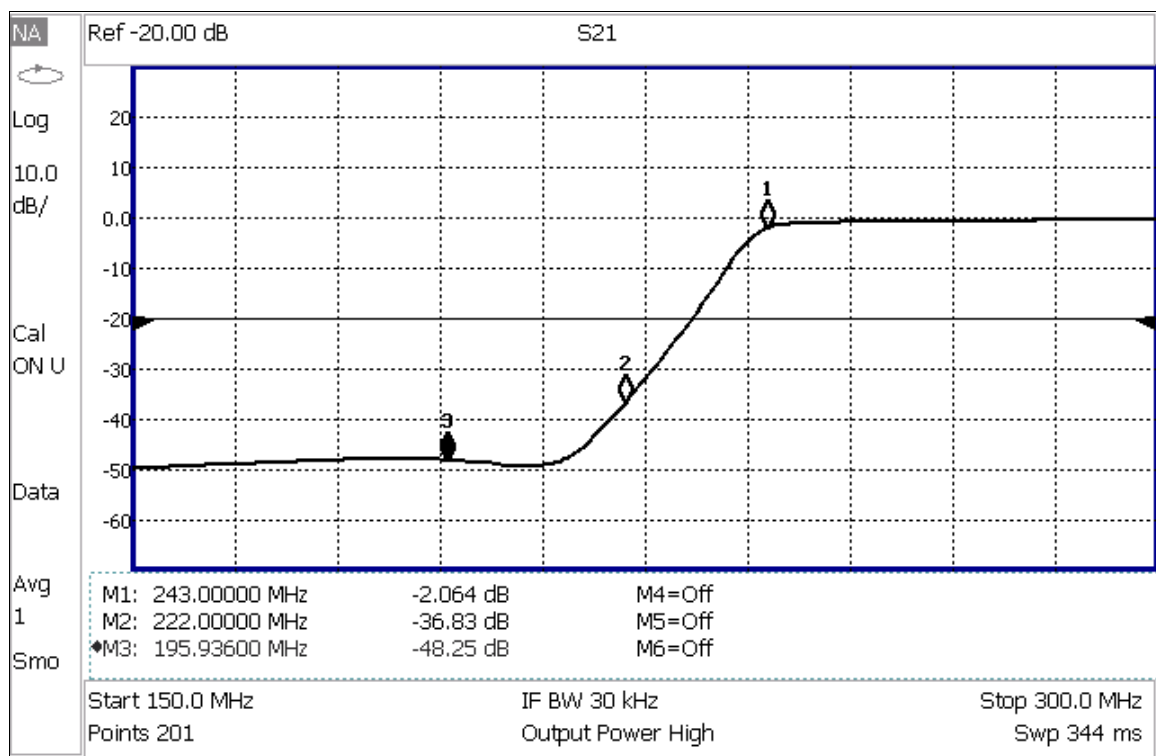
Figure 12: example  $\pm 970$  kHz plot



## 10. 243 MHz test

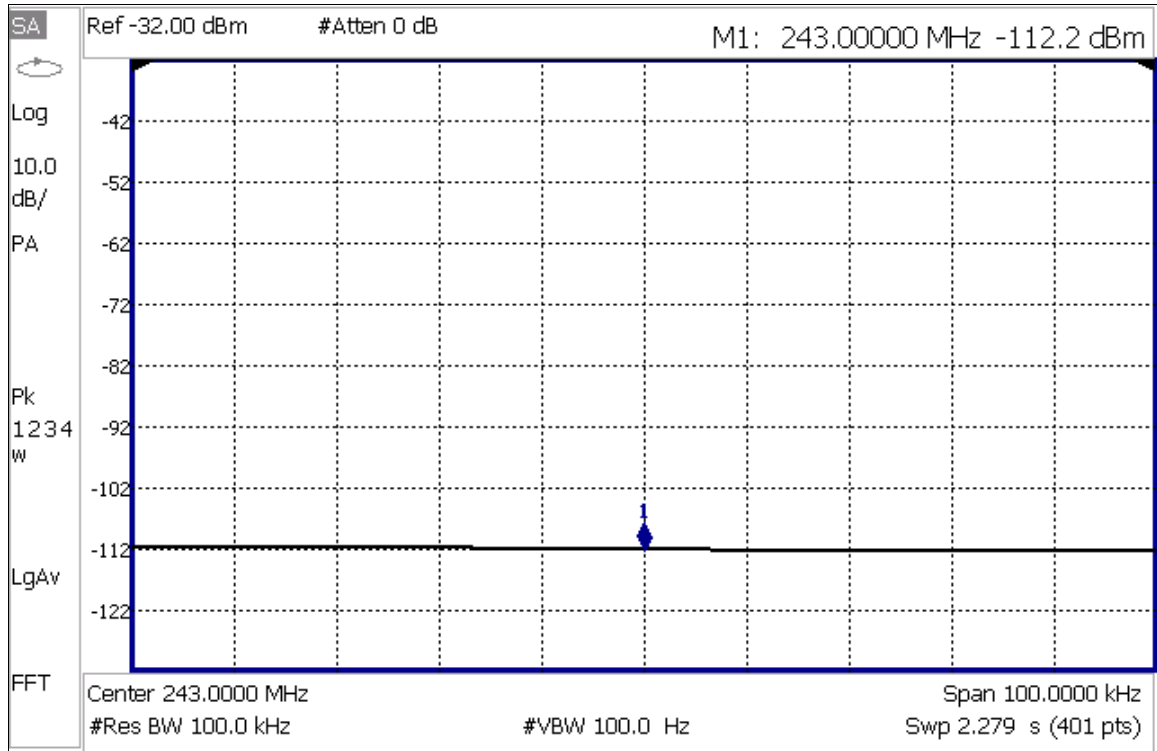
- 10.1 The equipment arrangement for 243 MHz test is similar to the 970 kHz equipment arrangement shown in figure 11, except a high-pass filter may need to be connected between the forward port of the directional coupler and the spectrum analyser. If required, this filter should have a characteristic similar to the one in figure 13 below.
- 10.2 If used, the filter should be connected between the forward port of the directional coupler and the RF input of the spectrum analyser. The purpose of including a filter is to attenuate the level of the DAB transmitter's output frequency and avoid overloading the analyser, while presenting minimal attenuation to any power on 243 MHz.
- 10.3 Figure 13 shows an example plot of the characteristic of a high-pass filter which is suitable for performing the 243 MHz measurement. The example filter gives 46 dB attenuation at 195.936 MHz - the block centre frequency of the DAB transmitter under test.

Figure 13: example 243 MHz filter characteristic



- 10.4 Using either a 243 MHz high-pass filter, or a tuneable band-pass filter connected to the forward port of the coupler as shown in Figure 11, set a centre frequency of 243 MHz.

Figure 14: example 243 MHz measurement plot using high-pass filter

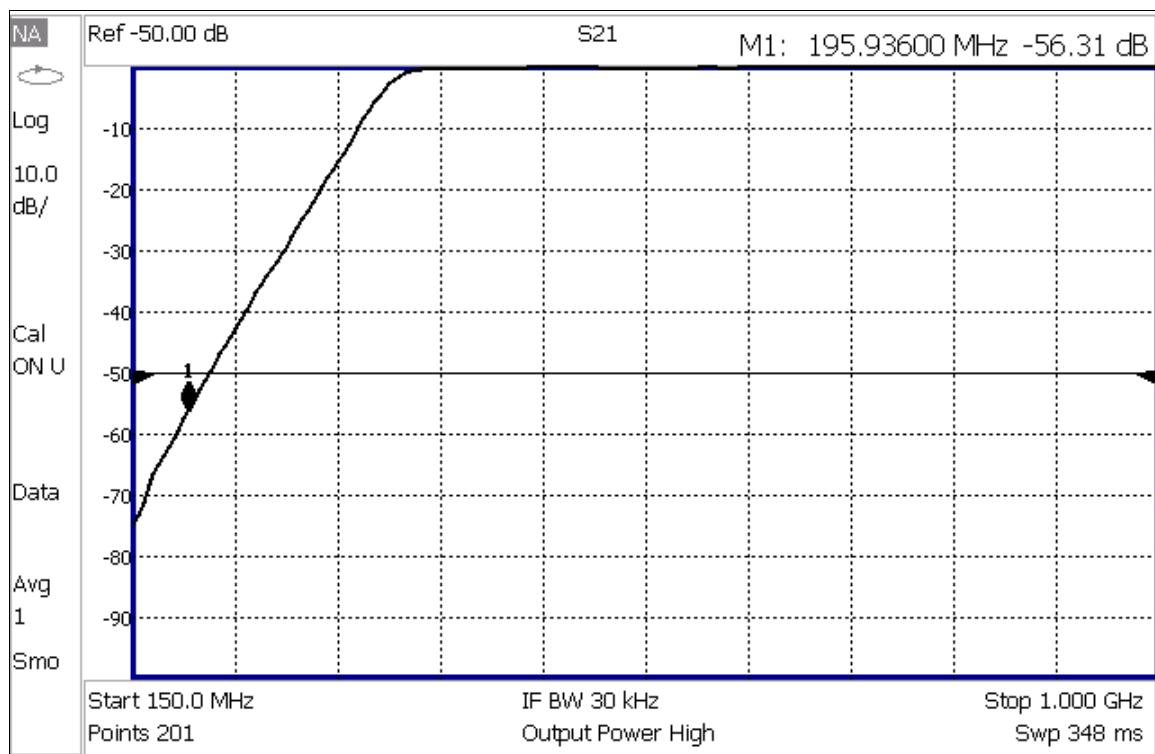


10.5 In the example plot in Figure 14, the measured level at 243 MHz is below the -112.8 dBm noise floor which is less than the specified limit -50 dBm.

## 11. Spurious emissions and harmonics measurements

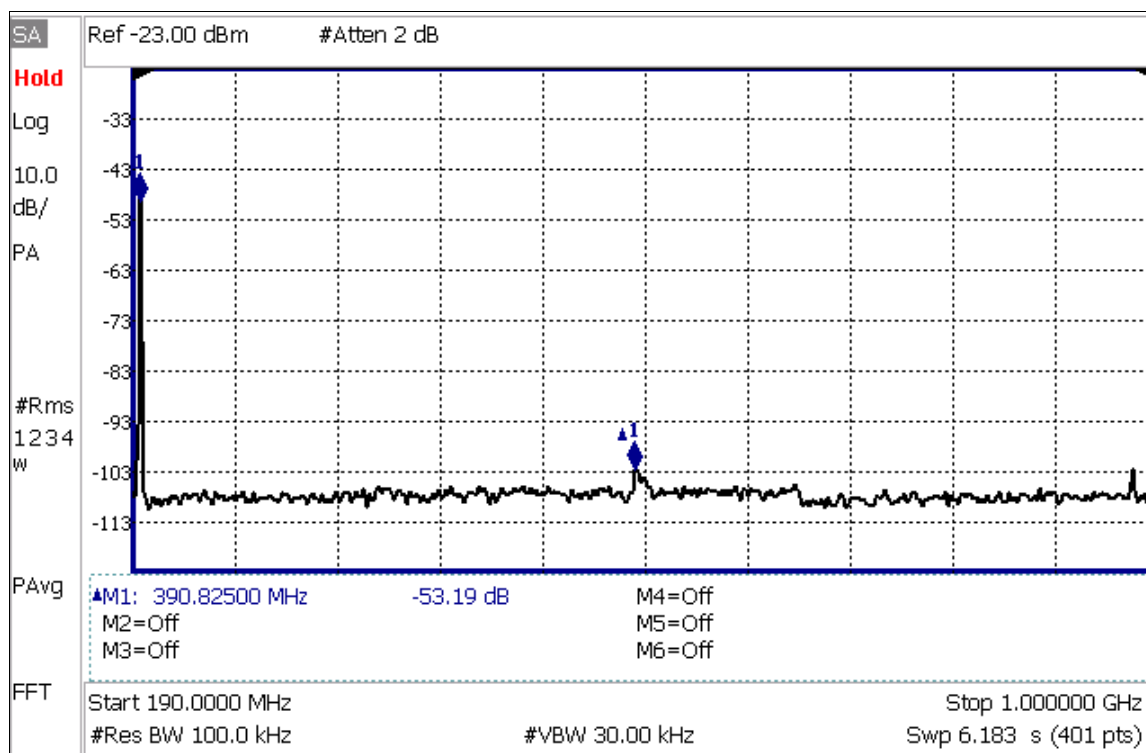
- 11.1 Measurement of spurious emissions and harmonics may require the use of a high-pass filter in the path between the directional coupler and the spectrum analyser. This arrangement will attenuate the DAB transmitter's 'wanted' output and avoid overloading the analyser.
- 11.2 Figure 15 shows an example plot of a DAB high-pass filter which is suitable for measuring spurious emissions and harmonics. In this example, the filter being used gives 56.31 dB attenuation at the DAB block centre frequency (195.936 MHz).

Figure 15: example plot of high-pass filter



- 11.3 Using the spectrum analyser, run a frequency sweep between 190 MHz and 1.0 GHz and check for any harmonics or spurious emissions (this is especially important if site-sharing with other users). Set up the spectrum analyser with reference to Figure 16 (resolution bandwidth 100 kHz, video bandwidth 30 kHz, stop frequency of at least 1 GHz).

Figure 16 example Spurious Emissions and Harmonics plot



- 11.4 Figure 16 is an example of the spurious emissions and harmonics measured on the coupler forward test point of the DAB transmitter with a high-pass filter in circuit.
- 11.5 The delta marker M1 is referenced to the DAB block centre frequency of 195.936 MHz.
- 11.6 To compensate for the filter attenuation at the DAB block centre frequency shown in Figure 15, the attenuation value of 56.31 dB is deducted from the level measured at marker M1 as shown in Table 5.
- 11.7 The true value of the spurious emissions and harmonics is a summation of the marker value in Figure 15 and any markers from Figure 16. Any harmonics or spurious emissions must be suppressed by at least 80dB below that of the DAB signal (i.e. below -80dBc).

Table 5: example harmonic and spurious emissions correction calculation

Harmonic / spurious marker Frequencies	Delta Marker M1 from Error! Reference source not found.	Attenuation of DAB block from Error! Reference source not found.	Corrected value of DAB Block
390.825 MHz (M1)	-53.19 dBc	-56.31 dB	- 109.5 dBc
<b>(Any further harmonic/spurious frequencies should be recorded separately)</b>			

## A1. Example DAB Commissioning Form

- A1.1 The table below has been populated with typical commissioning information and results, and is an illustrative example only.
- A1.2 Users should record their own results (which will be specific to the site being commissioned) in the pro-forma which is available in the 'Broadcast Transmitter Guidance' section of the Ofcom website at <https://www.ofcom.org.uk/spectrum/information>. The completed form (along with the required plots of measurements, site pictures and calibration information) should be submitted to Ofcom by email at [broadcastradiocompliance@ofcom.org.uk](mailto:broadcastradiocompliance@ofcom.org.uk)

DAB Commissioning checklist form. Version 1.0	Screen shot or photo required?	Result
Licence area name		Anytown
Date of commissioning		01/01/2023
Engineer name		Joe Bloggs
Site name and postal address		site address
Site NGR confirmation to 8 figures		TL2844 3555
Centre frequency of DAB block (MHz)		195.936 MHz
Antenna type description (include a model if mounted on a mast or building)		3 dB gain collinear
Measured loss of transmitter filter (dB)		1 dB
Antenna in use height above ground level (metres)		10 metres
Antenna gain (dBd)		3 dBd
Feeder type including interconnecting cables and calculated total feeder loss (dB)		RG213, 11 metres, 1 dB
Calculated transmitter power (dBm) (= Licensed ERP (dBm) - Antenna Gain (dBd) + Feeder Loss (dB) + Filter Losses (dB) + Interconnecting Cable Loss (dB))		50 dBm (100 watts)
Licensed ERP (watts)		100 watts (50 dBm)
Directional coupler type (manufacturer / model) used for measurements		Brand A
Directional coupling factor at in use frequency (dB)	Yes	26.55 dB
Transmitter / modulator/ SDR type		Example 1
Power amplifier type		PA Example 1
Transmitter filter type		Band-pass Example 1
Transmitter $\pm 970$ kHz measured (6 MHz span, RBW 10 kHz, VBW 100 Hz) - If using traditional method		N/A
Transmitter $\pm 1.75$ MHz measured (6 MHz span RBW 10 kHz VBW 100 Hz)	Yes	-46.57 dBc and -46.37 dBc
Transmitter $\pm 3$ MHz measured (6 MHz span RBW 10 kHz VBW 100 Hz)	Yes	-56.43 dBc and -57.23 dBc

DAB transmitter compliance testing method

Filter output $\pm 970\text{kHz}$ (spec: -45dBc)	Yes	-53.59 dBc and -53.33 dBc
Filter output $\pm 1.75\text{MHz}$ (spec: -80dBc)	Yes	-39.20 dBc and -38.63 dBc
Filter output $\pm 3\text{MHz}$ (spec: -80dBc)	Yes	-55.58 dBc and -56.55 dBc
Total calculated $\pm 1.75\text{ MHz}$ levels		-85.77 dBc and -85.00 dBc
Total calculated $\pm 3\text{ MHz}$ levels.		-112.01 dBc and -113.78 dBc
Measured harmonics up to 1GHz (spec: -80dBc)	Yes	-109.5 dBc
243MHz measured (use high-pass filter if required, and 100kHz RBW, 100kHz span: -50 dBm max)	Yes	-112 dBm
Return loss of antenna (minimum 14dB)		20 dB
EMF compliance distance (metres): see Ofcom website ( <a href="https://static.ofcom.org.uk/static/emf/index.html#/">https://static.ofcom.org.uk/static/emf/index.html#/</a> ) for online and offline calculators.		
TII code allocated to this site (if used)		
Site photographs showing antenna installation and transmitter rack respectively.	Yes	
Current calibration certificate for spectrum analyser	Yes	



## A2. Calculation Tables

A2.1 The following tables may be used to record data from the measurements made during the commissioning activity.

**Table 6: compliance measurement record calculation table**

<i>Document section</i>	<b>Marker</b>	$\Delta M1$	$\Delta M2$	<b>Ref M1</b>	$\Delta M3$	$\Delta M4$	<b>M5 (insertion loss)</b>
	<b>Frequency</b>	<b>-3.00 MHz</b>	<b>-1.75 MHz</b>	<b>Fc</b>	<b>1.75 MHz</b>	<b>3.00 MHz</b>	
6	Filter						
8	Transmitter						
8	Total						
	<i>Limit</i>	<i>80 dBc</i>	<i>80 dBc</i>		<i>80 dBc</i>	<i>80 dBc</i>	

**Table 7: transmitter power calculation**

Tx Power (dBm) = Licensed ERP (dBm) - Antenna Gain (dBd) + Feeder Loss (dB) + Filter Losses (dB) + Interconnecting Cable Loss (dB)

<b>Tx Power</b>	<b>Licensed ERP</b>	<b>Antenna Gain</b>	<b>Feeder Loss</b>	<b>Filter Losses</b>	<b>Interconnecting cable Loss</b>

**Table 8: harmonic and spurious emissions correction calculation**

<i>Document Section</i>	<b>Harmonic / Spurious marker Frequencies</b>	<b>Delta Marker M1 from Error!</b> Reference source not found.	<b>Attenuation of DAB block from Error!</b> Reference source not found.	<b>Corrected value of DAB Block</b>
11				
11				
11				