

RECOMMENDATION ITU-R SM.1792-0*

Measuring sideband emissions of T-DAB and DVB-T transmitters for monitoring purposes

(2007)

Scope

This Recommendation provides guidance to measurement procedures and specifies settings in measuring emissions of terrestrial digital audio broadcasting (T-DAB) and digital video broadcasting-terrestrial (DVB-T) for conformity with the relevant spectrum masks.

Keywords

Measurement procedures, emission measurement, TDAB, DVBT

The ITU Radiocommunication Assembly,

considering

- a) that Recommendation ITU-R BS.1660 gives definitions of spectrum masks specifying limits for out-of-band (OoB) domain emissions of T-DAB (terrestrial digital audio broadcasting) transmitters;
- b) that Annex 2 of the Final Acts of RRC-06 gives definitions of spectrum masks specifying limits for OoB domain emissions of DVB-T (digital video broadcasting-terrestrial) transmitters;
- c) that the potential of imposing harmful interference to adjacent radio services from T-DAB and DVB-T emissions is especially high due to their rectangular spectrum shape which places the maximum signal level up to the edges of the assigned bandwidth;
- d) that monitoring stations have to measure the conformance with the relevant masks for any T-DAB or DVB-T transmitter, preferably off-air, to protect adjacent radio services from harmful interference;
- e) that the dynamic range of spectrum analysers is not sufficient to measure the OoB emissions from these transmitters,

recommends

1 that, when measuring conformance of T-DAB and DVB-T emissions with the relevant spectrum masks, the method described in Annex 1 should be used.

* Radiocommunication Study Group 1 made editorial amendments to this Recommendation in the year 2019 in accordance with Resolution ITU-R 1.

Annex 1

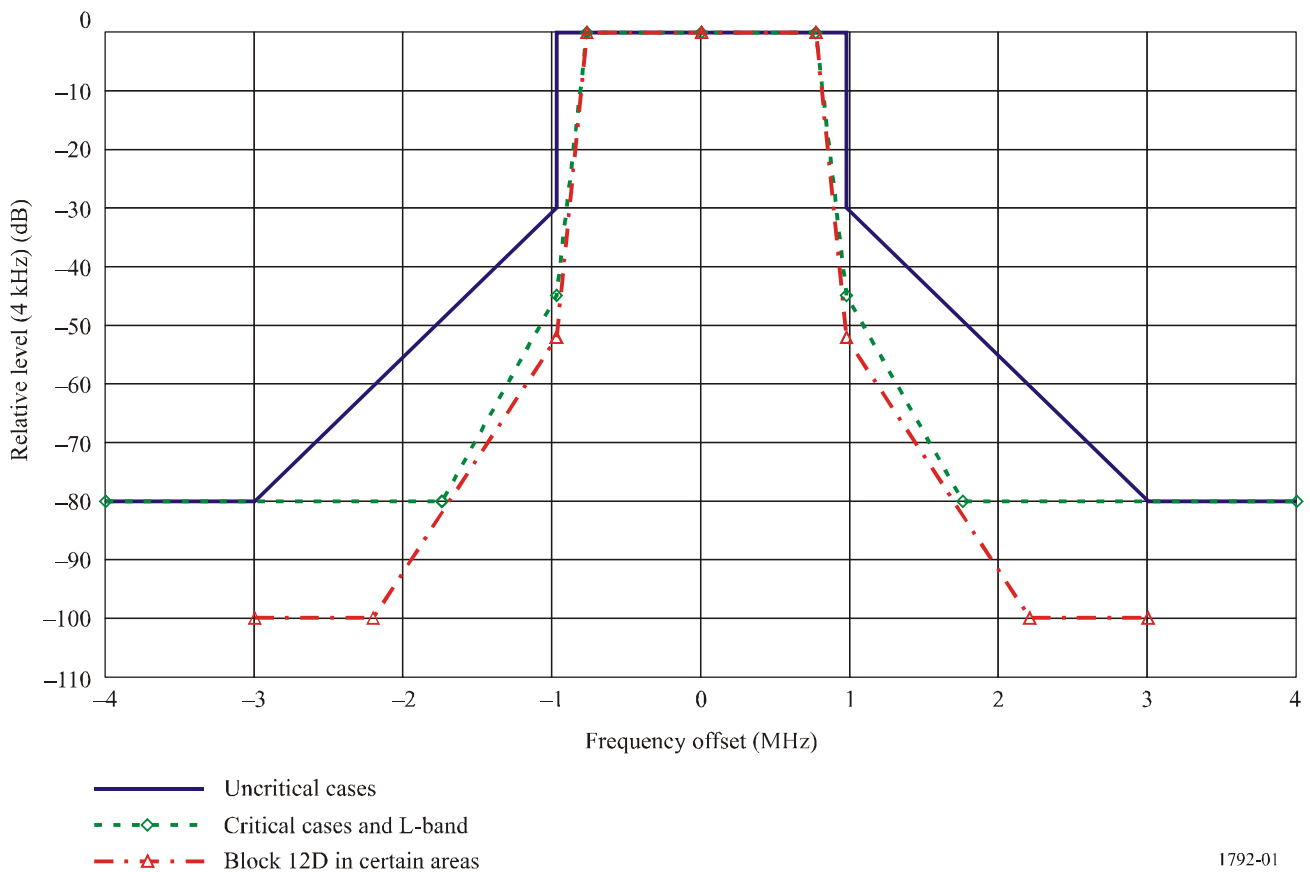
1 Spectrum masks

To protect neighbouring radio services, spectrum masks are defined in the vicinity of the main emission. The level of any OoB and spurious emission has to be lower than the mask.

1.1 T-DAB

For T-DAB transmitters, Recommendation ITU-R BS.1660 defines the following spectrum masks:

FIGURE 1
OoB emissions from T-DAB transmitters
T-DAB transmitter mask



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Note – The critical mask is to be used for the lowest and highest channel in the allocated band to protect neighbouring radio services, the uncritical mask is to be used inside the allocated band.

Uneven frequency breakpoints are ± 0.77 MHz, ± 0.97 MHz, ± 1.75 MHz and ± 2.2 MHz.

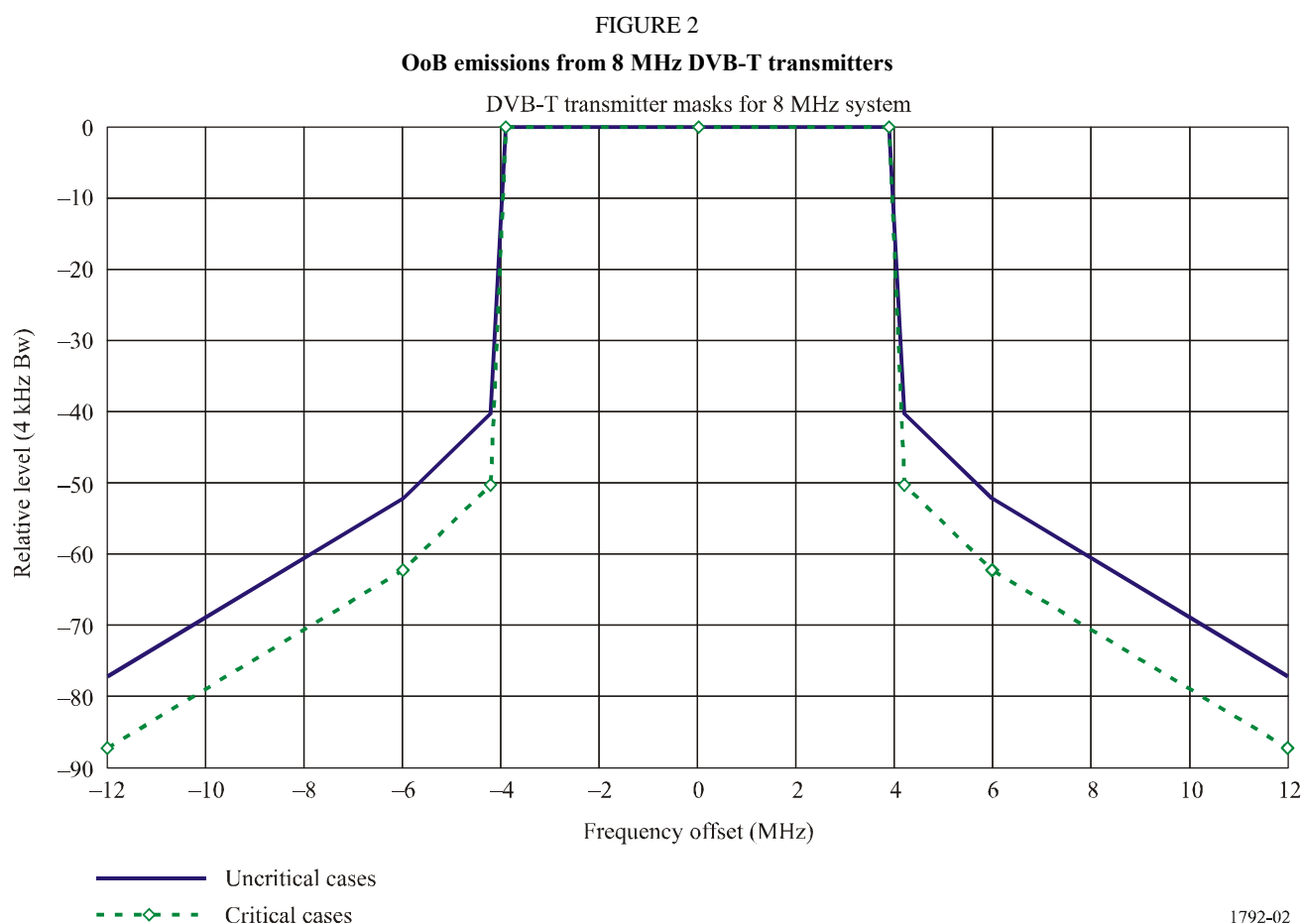
The mask assumes a 4 kHz measurement filter.

1.2 DVB-T

For DVB-T transmitters, Annex 2 to the Final Acts of RRC-06 defines spectrum masks for DVB-T systems. As an example, Fig. 2 shows the mask for 8 MHz channel width.

2 Measurement of sideband emissions from T-DAB and DVB-T transmitters¹

2.1 General as to be seen from Figs. 1 and 2, the maximum level of sideband emissions from T-DAB and DVB-T transmitters may go down to a level of -101 dB, compared to the maximum power in the assigned channel, measured with the same receiver bandwidth. To reliably measure true sideband emissions, the measurement equipment has to have a dynamic range of at least 110 dB. The dynamic range of modern monitoring receivers or spectrum analysers of around 80 dB is not sufficient to directly measure conformance with the masks.



Note – The critical mask is to be used for the lowest and highest channel in the allocated band to protect neighbouring radio services, the uncritical mask is to be used inside the allocated band.

Uneven frequency breakpoints are ± 3.9 MHz and ± 4.2 MHz.

The mask assumes a 4 kHz measurement filter.

2.2 Measurement principle

To increase the dynamic range of the measurement receiver, the T-DAB or DVB-T signal has to be passed through a filter that suppresses the main signal and passes the OoB domain. The signal including one sideband in the OoB domain is scanned through this filter with a narrow resolution bandwidth (RBW) and the resulting spectral levels are recorded.

¹ Measurements for T-DAB can also be used for other systems, e.g. terrestrial digital multimedia broadcasting (T-DMB) (see Report ITU-R BT.2069).

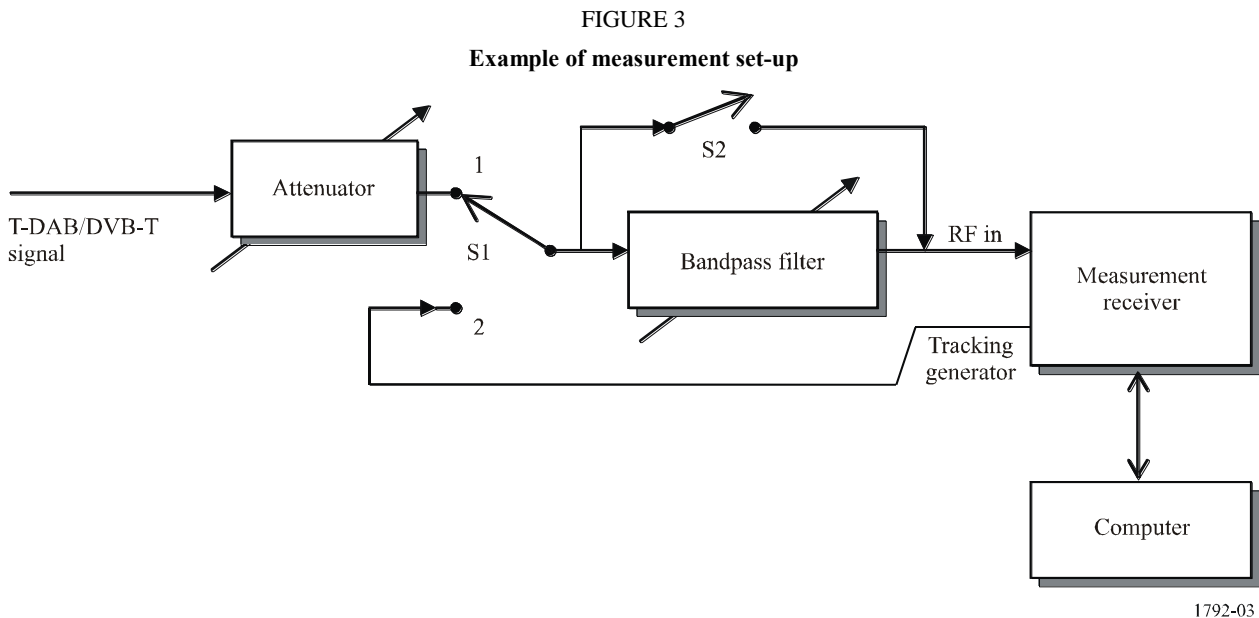
In a second scan, the frequency response of the filter (attenuation) is recorded for the same frequency range.

The filter attenuation is then added to the spectral levels from the first scan to give the true, unfiltered spectrum.

The achievable gain in measurement dynamics only depends on the sharpness of the filter.

2.3 Measurement set-up

Various different set-ups are possible to perform sideband measurements according to the described measurement principle. The following set-up is a version with separate units for receiver, filter and measurement controller:



For the measurement set-up above, the following requirements apply:

TABLE 1

Requirements for example measurement set-up

Item	Function, requirement, remarks
Attenuator	To adjust the input level of the T-DAB/DVB-T signal to the maximum that the receiver can handle without being overloaded. Adjustment steps: 1 dB
Filter	To suppress the main T-DAB/DVB-T signal while bypassing the sideband emissions. Can be a bandpass or notch filter. If a bandpass filter is used, the minimum 3 dB bandwidth has to be 8 MHz for DVB-T and 2 MHz for T-DAB measurements. The filter has to be tunable inside the desired frequency range
Receiver	To record the spectral levels. It must be equipped with a tracking generator and an interface to allow remote control and data readout. RBW has to be between 3 kHz and 8 kHz (preferably 4 kHz). Detector: preferably RMS, alternatively AV
Computer	To control the receiver and read out level data. It has to be equipped with a suitable interface to connect to the receiver (e.g. LAN or IEEE 488)

Among others, the following alternative measurement configurations are also possible:

- All units can be included in one device that is especially designed to perform automatic or semi-automatic measurements of T-DAB/DVB-T sideband emissions.
- The receiver can be a spectrum analyser.
- The receiver/analyser can include the functions of the computer.
- An external signal generator can be used instead of the built-in tracking generator. The frequency of the signal generator has to be controlled by the computer in sync with the receiver/analyser.

2.4 Measurement procedure

To clarify the measurement procedure below, we use an example where we want to measure the upper sideband of an 8 MHz wide DVB-T signal transmitting on 650 MHz.

2.4.1 Ensuring reflection-free signal reception

Measurement of the sideband emissions of T-DAB/DVB-T signals can either be made at the test output of the transmitter or off the air. To ensure enough signal level when measuring off-air, a measurement location in the main beam, close to the transmitter, is selected. However, even if there is free line-of-sight to the transmit antenna, reflections can cause frequency-selective distortion of the signal. For the sideband measurement it is necessary to have a reflection-free reception of the T-DAB/DVB-T signal. To ensure this, the signal is either displayed on a spectrum analyser, or manually scanned using the receiver. The flatness of the main T-DAB/DVB-T signal should be within 2 dB.

2.4.2 Determining the maximum signal level

In a first test, the maximum level of T-DAB/DVB-T signal that the receiver can handle without being overloaded has to be measured. This level cannot be taken out of the receiver specifications because they only specify the dynamic range for unmodulated carriers. For broadband modulated signals such as T-DAB or DVB-T, the maximum level is considerably lower. To determine it, the T-DAB/DVB-T signal is connected to the receiver (without the filter, switch 2 in Fig. 3 closed), but after the adjustable attenuator. The receiver is adjusted to the same RBW and detector as for the actual measurement (e.g. 3 kHz RMS). IF and RF attenuation have to be set to 0 dB. If present, a preamplifier has to be switched on.

The most critical frequency range where receiver overloading takes place is the range just outside the “edge” frequencies of the T-DAB/DVB-T block.

TABLE 2

“Edge” frequencies of T-DAB and DVB-T emissions

System/bandwidth	“Edge” frequency (offset from centre frequency)
T-DAB/1.5 MHz	±775 kHz
DVB-T/7 MHz	±3.3 MHz
DVB-T/8 MHz	±3.8 MHz

The receiver is tuned to a frequency 100 kHz above the upper or 100 kHz below the lower edge frequency, depending on the sideband to be measured. In our measurement example (see § 2.4), this frequency would be $650 \text{ MHz} + 3.8 \text{ MHz} + 100 \text{ kHz} = 653.9 \text{ MHz}$.

Using the adjustable attenuator, the signal is adjusted to a level just below that which overloads the receiver. This can be verified by changing the attenuation 1 dB up and down. When the receiver is not overloaded, the indicated level also rises or falls by exactly 1 dB. The minimum attenuation that ensures this behaviour has to be found.

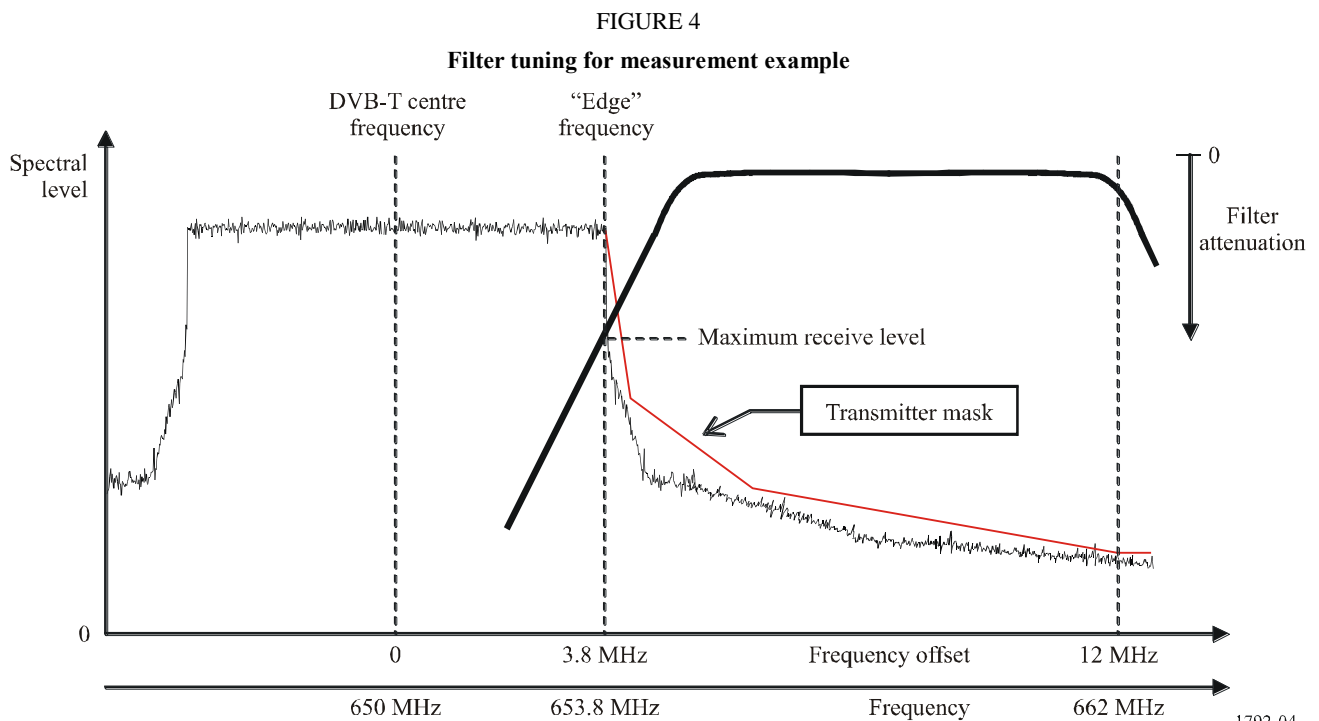
With this attenuator setting, the receiver is tuned to the T-DAB/DVB-T centre frequency. The indicated level is noted as the “maximum receive level”.

2.4.3 Tuning the filter

To increase the dynamic range for the measurement, the filter is used to provide the necessary attenuation of the main T-DAB/DVB-T signal instead of the attenuator used in § 2.4.2.

To adjust the filter frequency, the receiver is tuned to a frequency just inside the edge frequency. In our example (see § 2.4), this frequency would be just below 653.8 MHz ($650 \text{ MHz} + 3.8 \text{ MHz}$).

This is the frequency where the receiver will get the maximum level during the actual measurement. The filter is now tuned in such a way that the indicated level is equal to the maximum receive level determined in § 2.4.2, and the filter attenuation increases towards the centre frequency of the T-DAB/DVB-T emission. Figure 4 shows the filter tuning for our measurement example.



If a notch filter is used, it is also adjusted in such a way that the receive level at the edge frequency measured in § 2.4.2 is not exceeded, starting from the T-DAB/DVB-T centre frequency.

2.4.4 Determining the receiver noise level

Because the actual measurement cannot distinguish between the noise-like sideband emissions of the T-DAB/DVB-T transmitter and receiver noise, it is important to know the receiver noise level. To measure it, the receiver is again adjusted to the same RBW and detector as for the actual measurement (e.g. 3 kHz RMS). IF and RF attenuations have to be set to 0 dB. If present, a preamplifier has to be switched on. The signal is disconnected and the receiver input is terminated with 50 Ω . The indicated receive level is noted as the receiver noise level.

2.4.5 Performing the actual measurement

Using the set-up in Fig. 3, the computer program is started to scan the relevant frequency range. The measurement has to start well inside the main T-DAB/DVB-T channel in order to have a reference for the spectrum masks. The stop frequency depends on the end on the spectrum mask definition and the passband range of the filter. In our example (see § 2.4), we start recording 2 MHz off the DVB-T centre frequency at 652 MHz and stop at 662 MHz, which is the end of the spectrum mask definition (see Fig. 2). The measured spectral levels are recorded in a file, together with the current receiver frequency.

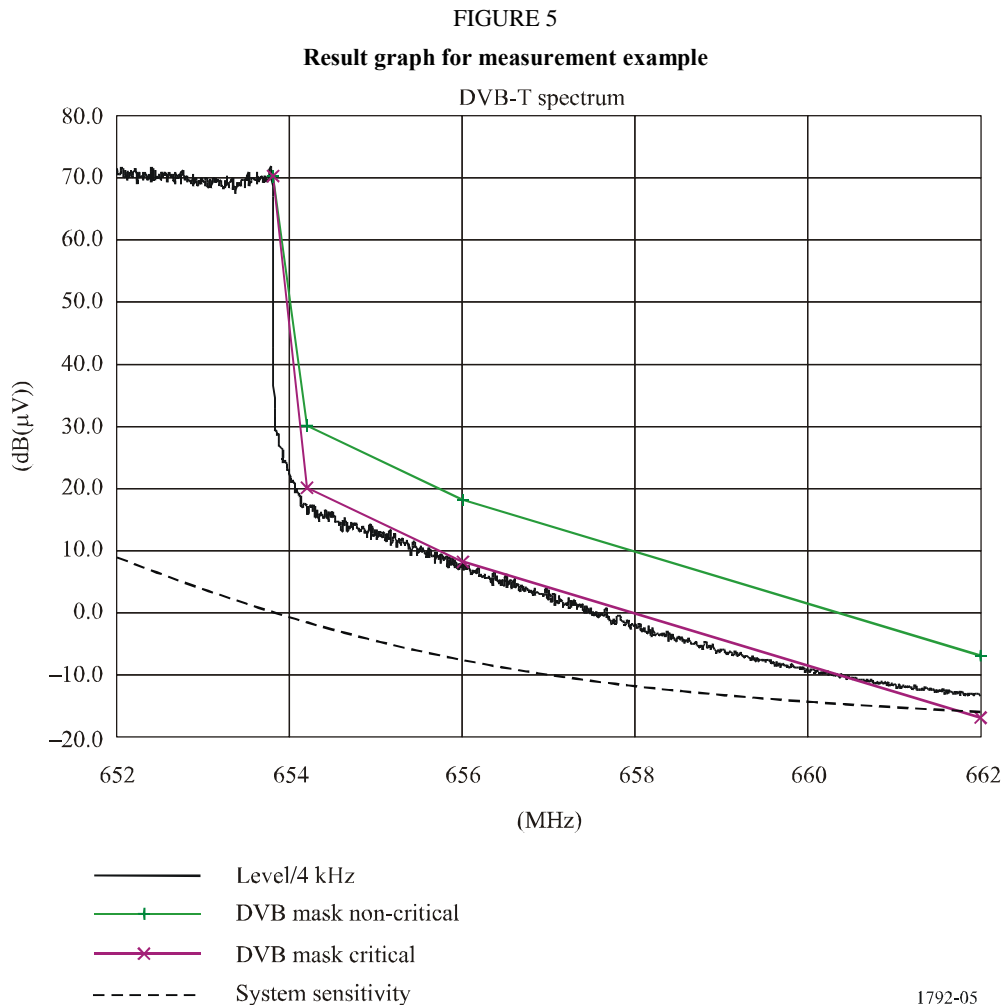
Then, the tracking generator is connected to the receiver input (S1 in Fig. 3 to position 2) and the scan is repeated for the same frequency range. The measured attenuation is recorded in a second file, together with the current receiver frequency.

2.4.6 Presentation of the results

The computer has to add the measured level from file 1 and the attenuation from file 2 for each frequency step. The result is the actual spectrum of the T-DAB/DVB-T signal with eliminated filter distortion. For quick evaluation, the relevant spectrum masks from Figs. 1 and 2 should be included in the graphical presentation.

Because usually the filter can only be optimized for either the upper or lower sideband, two separate measurements have to be performed if full compliance with the spectrum mask has to be checked.

The following is a possible result of the measurement from our example (see § 2.4). A common spreadsheet program has been used to control the receiver and draw the graphics using a macro language.



It can be seen that the critical mask is exceeded from 660 MHz on.

2.4.7 Considering the system sensitivity

Especially far from the T-DAB/DVB-T centre frequency, spectral levels from the transmitter will be very weak and may fall at or below the receiver noise level. Because the result presentation does not allow distinguishing between transmitter sideband emissions and receiver noise, the limits within which the measurement is valid have to be established manually. For a reasonably reliable result, the spectral level of transmitter sideband emissions, received through the filter, has to be at least 3 dB above the receiver noise. The system sensitivity is the noise level measured in § 2.4.4, increased by the filter attenuation at each frequency within the scan range. It is preferable to include the system sensitivity in the presentation graph like in Fig. 5.

In our measurement example, the 3 dB margin between measured signal level and system sensitivity is reached at around 662 MHz. The validity range of the measurement has to be clearly indicated in the presentation graph, either by marking the respective frequencies or by scaling the x-axis in a way that only valid results are displayed, like in Fig. 5.

2.5 Practical considerations

Although in principle the method described here allows sideband emission measurements for all T-DAB and DVB-T transmitters, there are a few aspects that have to be considered:

- The adverse requirements for the filter to be both steep and easily tunable result in a compromise. Experience shows that with bandpass filters having a 3 dB width of 1% of the

tuned frequency are suitable to evaluate even the critical mask of T-DAB/DVB-T emissions up to about 800 MHz. At the same time, they can be tunable with only one knob, because all cavities can be mounted on the same axis.

- The most difficult part when performing sideband measurements is to get enough signal level from the receiving antenna. Again, experience shows that only the non-critical spectrum masks can be evaluated off-air. Even then, a directional antenna with high gain, such as a yagi, has to be used and placed in the optimal distance to the transmitter where maximum field strength can be expected. To evaluate the critical masks, the measurement has to be performed at the test output of the transmitter itself.
 - Due to the very limited choice of optimal receiving places, this measurement usually has to be performed in mobile monitoring units. Stationary or remote-controlled equipment will not receive enough field strength in most cases.
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