CEPT/ERC Recommendation ERC 54-01 E (Funchal 1998)

**METHOD OF MEASURING THE MAXIMUM FREQUENCY DEVIATION OF
FM BROADCAST EMISSIONS IN THE BAND 87.5 MHz TO 108 MHz AT MONITORING STATIONS**

Recommendation adopted by the Working Group Frequency Management (WGFM)

INTRODUCTION

The purpose of this Recommendation is to provide a common measurement method which will enable CEPT administrations to recognise measurement results relating to the frequency deviation of FM broadcast emissions on a mutual basis.

"The European Conference of Postal and Telecommunications Administrations,

considering

a)   that frequencies in the VHF band 87.5 – 108 MHz are assigned to an increasing number of FM broadcasting stations;

b)   that protection ratios for the planning of broadcasting transmitter frequencies are based on a maximum frequency deviation of ±75 kHz and a maximum power of the modulation signal which does not exceed the power of a sinusoidal tone which causes a ±19 kHz frequency deviation;

c)   that various broadcast transmissions exceed the maximum frequency deviation owing to different types of programmes and additional components of the composite signal (e.g. radio data system (RDS));

d)   that limitation of the peak frequency deviation is required to guarantee mutual protection of broadcast services (on adjacent channels);

e)   that monitoring of broadcast emissions is necessary to prevent transmissions from exceeding the maximum frequency deviation;

f)   that common measurement procedures are necessary in order to achieve mutual acceptance of measurement results by the parties concerned, e.g. frequency managers, monitoring services and broadcasters;

g)   that the number of broadcasting stations using additional signals as RDS and high speed data signals is increasing and these systems are highly sensitive to interference from adjacent channels,

recognising

a)   that the method described in Annex 1 is a simple "go - no go" test based on a spectrum mask which cannot replace precise measurements of the frequency deviation,

recommends

1   that the method described in Annex 1 may be used as a verification to indicate whether the frequency deviation of an FM broadcasting station exceeds the limits;

2   that the method described in Annex 2 is used when the values of the deviation and modulation power are required.

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Annex 1

**SIMPLE SPECTRUM MASK BASED METHOD TO INDICATE THE EXCEEDING
OF FREQUENCY DEVIATION LIMITS**

1   REQUIREMENTS

For this measurement any suitable spectrum analyser or test receiver with analyser capabilities can be used.

2   CONNECTION BETWEEN TRANSMITTER AND SPECTRUM ANALYSER

With the aid of a measurement antenna.

3   MEASUREMENT CONDITIONS

a)   During three measurements of five minutes each, the transmitter to be judged should be modulated with a representative programme material for that particular transmitter. Additional measurements may be carried out to ensure that the programme material is truly representative;

b)   impulse interferences should not occur (for example interference from an ignition source);

c)   signal/interference+noise should be $\geq$50 dB.

4   ADJUSTMENTS OF THE SPECTRUM ANALYSER

The spectrum analyser should be adjusted as follows:

- Centre frequency = f_o (Carrier frequency of the transmitter)
- RBW 10 kHz (IF filter)
- VBW 10 kHz (Video filter)
- Span 340 kHz
- Sweeptime 340 ms (1ms/kHz)
- max hold mode
- Input attenuation is dependent on input level.

Settings for DSP (digital signal processor) analysers will be different but should provide equivalent results.

5   MEASUREMENT INSTRUCTIONS

a)   Record the transmitter signal over a five minutes period;

b)   Observation of the analyser and acoustic controls at the receiver should be used as a means to ensure that no measurement results are evaluated which have been distorted by impulse interference. For the same reason the measurement is repeated twice;

c)   Overlay the graphical measurement with the mask as described in paragraph 7;

d)   The centre of the x-axis of the mask shall correspond with the centre frequency (f_0);

e)   Adjust the reference level so that the maximum amplitude of the measurement corresponds to 0 dB;

f)   Determine whether the measurement is within the limits of the mask.

6 LIMITS

If any of the measured spectra exceeds the mask the deviation of the transmitter is assumed not to meet the requirements.

7 MASK CONSTRUCTION

a) The calibration of the mask should be consistent with the analyser settings;

b) The centre of the X-axis is aligned to f_0;

c) The top of the Y-axis corresponds with the 0 dB reference level;

d) Straight lines connect the co-ordinates:

X-axis (kHz)	Y-axis (dB)
$f_0 - 74$	0
$f_0 - 107.5$	-15
$f_0 - 124$	-30
$f_0 - 152.5$	-40

X-axis (kHz)	Y-axis (dB)
$f_0 + 74$	0
$f_0 + 107.5$	-15
$f_0 + 124$	-30
$f_0 + 152.5$	-40

The graphic display of the table is shown below.

Shape of the Mask

dB (relative to peak)

frequency separation from
carrier (kHz)
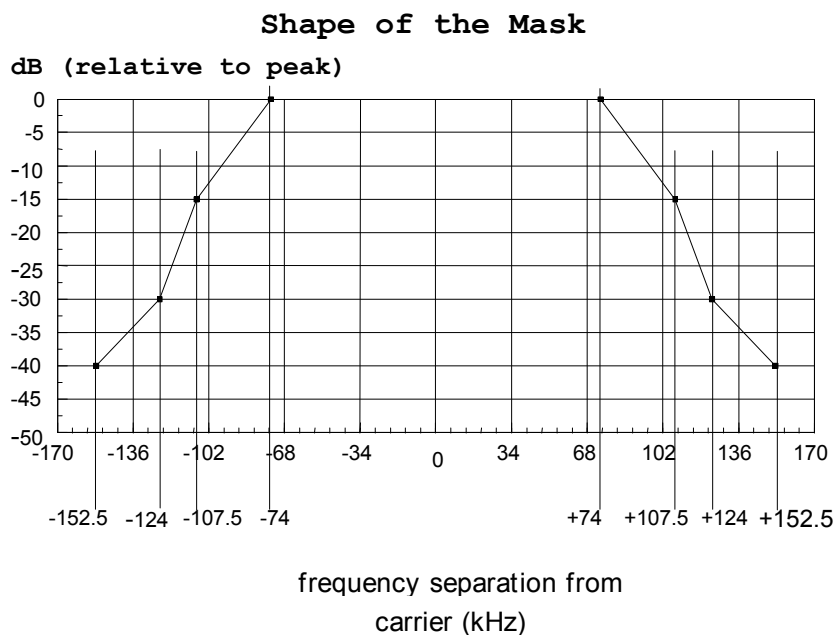
Annex 2

METHOD OF MEASURING THE MAXIMUM FREQUENCY DEVIATION OF
FM BROADCAST EMISSIONS AT MONITORING STATIONS

1   GENERAL

1.1   Definitions

Frequency deviation:	In the case of frequency modulation, the deviation of the frequency from the frequency of the unmodulated carrier f_0.
Instantaneous deviation:	In the case of frequency modulation, the instantaneous deviation $\Delta f(t)$ is the difference between the unmodulated carrier frequency (f_0) and the instantaneous frequency at any given time (t). The instantaneous frequency is: $f(t) = f_0 + \Delta f(t)$.
Peak deviation:	In the case of frequency modulation, the peak deviation ΔF is the absolute maximum of the difference between the unmodulated carrier frequency (f_0) and the instantaneous frequency f(t). In the case of frequency modulation with sinusoidal signals. The instantaneous frequency is: $f(t) = f_0 + \Delta F * \sin(\omega t)$.
Composite signal:	This signal includes all stereo information (including the pilot tone) and may also include the traffic radio signal, the RDS signal and other additional signals.
Modulation power:	The relative power averaged over 60 s of the modulation signal according to the formula: modulation power = $10 \log \{(2/60\ s) \int (\Delta f(t)/19\ kHz)^2\ dt\}$ [dBr]
0 dBr:	is the average power of a signal equivalent to the power of a sinusoidal tone which causes a peak deviation of ± 19 kHz.

1.2   Introduction

There are various reasons, such as a reduction in the time required for the measurements, which make it seem sensible to carry out frequency deviation measurements in the field and not directly at the transmitter output. Compliance by the signal to be measured with the characteristics listed below is required in addition to compliance by the measuring equipment with the requirements described in paragraph 3 in order to avoid measurement uncertainties.

1.3   Limits

The protection ratios specified in Recommendation ITU-R BS.412 for the planning of FM sound broadcasting transmitters apply on the condition that a peak deviation of ± 75 kHz is not exceeded and that the average modulation power over any interval of 60 s does not exceed that of a single sinusoidal tone which causes a peak deviation of ± 19 kHz.

1.4   Observation time

The measurement should represent typical modulation of the programme material of the broadcasting station. The observation time should be at least 15 minutes or in some cases one hour may be required to be sure to measure representative programme material.

2 REQUIRED CONDITIONS FOR MEASUREMENTS

2.1 Required wanted-to-unwanted RF signal level ratio E_n/E_s at the measurement equipment

This ratio depends on the characteristics of the equipment used for the measurements and on the required accuracy. The measurement equipment shall have a sufficient IF bandwidth to enable the measurement of frequency deviation according to the requirements given in Section 3. In the case of equipment which meets the "Characteristics of FM sound broadcasting receivers for planning purposes" as specified in Recommendation ITU-R BS.704, the E_n/E_s ratio given in Recommendation ITU-R BS.412, **Figure 1**, Curve S1 is considered to be sufficient for these measurements and for frequency separations ≥200 kHz. Owing to the necessary IF bandwidth and the required accuracy, the E_n/E_s for co-channel and adjacent channel interference shall be at least 15 dB above the given values.

2.2 Multipath propagation

Delayed signals shall be small enough to ensure that measurement results are not influenced by the effects of multipath propagation. It is considered to be sufficient if the product of delay time and amplitude ratio is:

$$(U_r/U_d) * \tau < 320\% * \mu s$$

where

U_r is the amplitude of the reflected signal;
U_d is the amplitude of the direct signal;
τ is the time delay.

This product is proportional to the maximum gradient of the dependence of RF amplitude on RF frequency caused by multipath propagation which is easily measurable (even when there is more than one delayed signal). The corresponding gradient for stereophonic reception is:

$$d(U_r/U_d)/df < 2\%/kHz$$

2.3 Wanted signal level at the receiver input

To ensure a sufficient AF signal-to-noise ratio, the wanted signal input level for the receiver should be at least 43 dBpW.[**]

3 CHARACTERISTICS OF SUITABLE MEASURING EQUIPMENT

To ensure that all the peaks of the frequency deviations are captured, the equipment must be able to detect the deviation caused by the highest component of the base band signal or composite signal. For this reason, if digital measuring equipment is used, it must have a sampling rate of 200 kHz or higher depending on the maximum composite signal frequency.

3.1 Frequency deviation measurements

The measuring equipment used should be able to measure deviations of 100 kHz or higher. In addition the measuring equipment must possess such characteristics that take into account the required measurement bandwidth, filter shape factor, etc. to ensure that nonlinearity and distortion do not lead to an inaccuracy greater than specified in **Table 1**.

[**] This corresponds to a field strength of about 68 dBμV/m using an antenna as recommended in Recommendation ITU-R BS.599, Figure 1, Curve B (12 dB front-to-back ratio).

TABLE 1

Instrument accuracy for deviation measurements

Instantaneous deviation	required accuracy
≤80 kHz	±2 kHz
>80 kHz	±5 %

3.2 Modulation power measurements

The modulation power is specified in dBr according to Section 1.1. The measuring equipment shall be able to measure modulation power in the range from -6 dBr to +6 dBr. The instrument accuracy shall at least meet the values specified in Table 2.

TABLE 2

Instrument accuracy for modulation power measurements

Modulation power	required accuracy
<-2 dBr	±0.4 dB
-2 dBr to + 2 dBr	±0.2 dB
>2 dBr	±0.4 dB

4 PRESENTATION OF MEASUREMENT RESULTS

4.1 Modulation power

The modulation power shall be presented as a function of time during the measurement interval.

4.2 Frequency deviation

To provide more information the deviation is better represented by histograms and as a function of time rather than only displaying the highest value in a **"Max Hold"** mode over a certain period of time. Histograms of frequency deviation are processed as follows:

a) Obtain N peak hold values of the deviation each taken during a measuring time of 50ms. The measuring time has influence on the distribution plot and hence must be standardised in order to ensure repeatability. The 50 ms ensures that the peak values of the deviation are captured even at modulating frequencies as low as 20 Hz;

b) Divide the range of frequency deviation of interest (i.e. 150 kHz) into the desired resolution (for example 1 kHz) to give the number of bins (in this case 150 bins);

c) For each bin, count the number of samples which have a value within the bin. The result is a distribution plot of the deviation as shown in **Figure 1**;

d) Add counts in each bin from left to right and normalise by N. The result is a plot of the accumulated distribution as shown in **Figure 2** which starts with a probability of 100% from the left side and will finish with a probability of 0% at the right side;

e) Additionally the N peak hold values of the frequency deviation shall be presented as a function of time during the measurement interval.
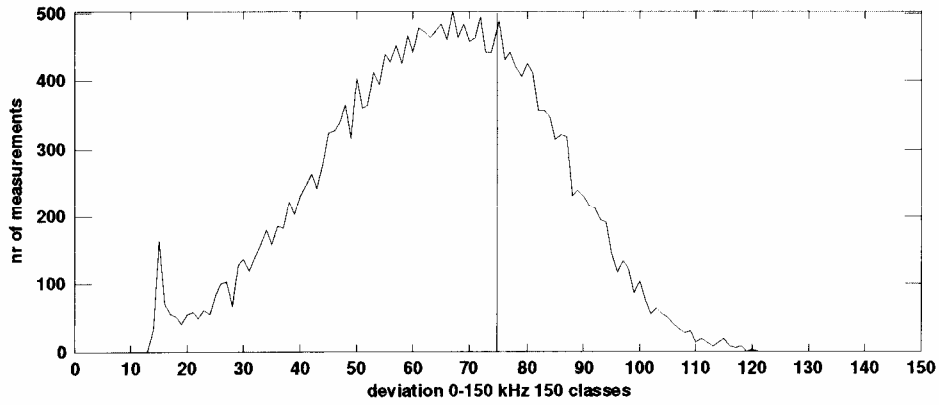
FIGURE 1

Distribution plot of deviation

FIGURE 2

Accumulated distribution plot of deviation

22 % > 75 kHz
12 % > 80 kHz
8 % > 85 kHz