RECOMMENDATION ITU-R SM.1268*

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

(Question ITU-R 67/1)

(1997)

The ITU Radiocommunication Assembly,

considering

a) that frequencies in the frequency band between 66 and 108 MHz are assigned to an increasing number of FM broadcasting stations;

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

c) that limitation of the peak frequency deviation is required owing to mutual protection of broadcast planning;

d) that protection curves for the planning of broadcasting transmitter frequencies and sites 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;

e) 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;

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

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,

recognizing

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;

3 that further studies should be carried out to determine the necessary sampling rate and other parameters which may influence the precision of frequency deviation measurements.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 10.

ANNEX 1

Simple spectrum mask based method to indicate the exceeding of frequency deviation limits

1 Requirements

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

2 Connection transmitter and spectrum analyser

"Off air" with the aid of a measurement antenna.

3 Measurement conditions

– During three measurements of 5 min each, the transmitter to be judged should be modulated with a representative programme material for that particular transmitter;

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

– signal/interference + noise should be ≥50 dB.

4 Adjustments of the spectrum analyser

The spectrum analyser should be adjusted as follows:

– Centre frequency (CF): f_0 (carrier frequency of the transmitter)

– RBW 10 kHz (IF filter)

– VBW 10 kHz (video filter)

– Span: 340 kHz

– Sweeptime: 340 ms (1 ms/kHz)

– Input attenuation is dependent on input level.

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

5 Measurement instruction

Step 1: Record the transmitter signal in the max-hold function over a 5 min period.

Step 2: Overlay the graphical measurement with the mask as described in § 7.

Step 3: The centre of the x-axis of the mask shall correspond with the centre frequency (f_0).

Step 4: Adjust the reference level so that the maximum amplitude of the measurement corresponds to 0 dB.

Step 5: Determine whether the measurement is within the limits of the mask.

Step 6: Repeat the above steps more than once.

6 Limits

If any of the measured spectra exceeds the mask, the transmitter deviation does not meet the requirements.

7 Mask construction

– The calibration of the mask should be consistent with the analyser settings.

– The centre of the x-axis is f_0.

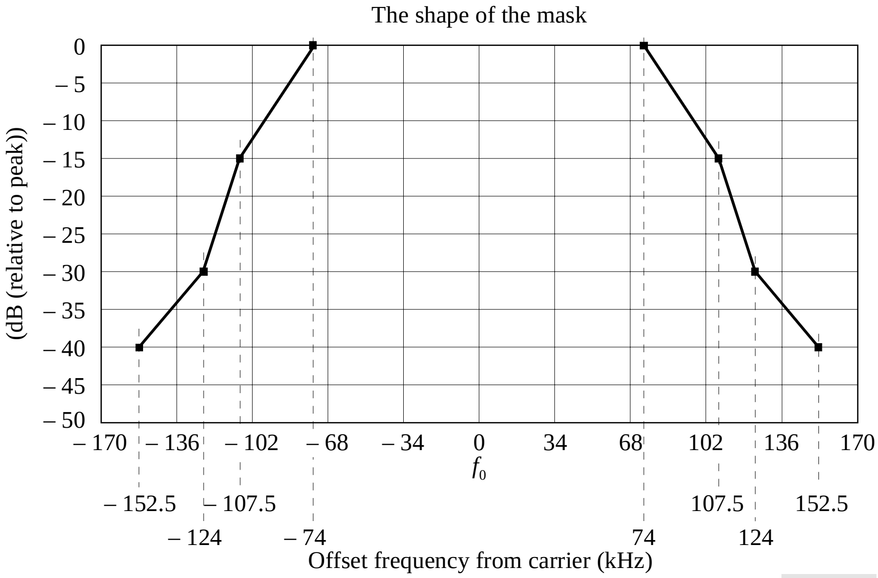
– The top of the y-axis corresponds with the 0 dB reference level.

– Straight lines connect the coordinates:

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.



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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 FM, the deviation of the frequency from the frequency of the unmodulated carrier f_0.

Instantaneous deviation: in the case of FM, 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 FM, 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 FM 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:

$$\text{Modulation power} = 10 \log \left[(2/60 \text{ s}) \int \left(\Delta f(t) / 19 \text{ kHz} \right)^2 \, \mathrm{d}t \right] \qquad \text{dBr}$$

0 dBr: 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 § 3 in order to avoid measurement uncertainties.

1.3 Limits

The protection curves 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 min or in some cases 1 h may be required.

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 § 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, Fig. 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:

$$(U_r / U_d) \; \tau < 320\% \;\; \mu\text{s}$$

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:

$$d(U_r / U_d) / \mathrm{d}f < 2\%/\mathrm{kHz}$$

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

3 Characteristics of suitable measuring equipment

3.1 Frequency deviation measurements

The measuring equipment used should be able to measure instantaneous 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.

TABLE 1

Instrument accuracy for deviation measurements

Instantaneous deviation (kHz)	Required accuracy
≤ 80	±2 kHz
> 80	±5%

3.2 Modulation power measurements

The modulation power (dBr) is specified according to § 1.1. The measuring equipment shall be able to measure modulation powers 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 (dBr)	Required accuracy (dB)
< –2	±0.4
–2 to +2	±0.2
> 2	±0.4

3.3 Measurement of frequency deviation and modulation power distribution

The frequency deviation can be displayed either in a max-hold mode so that the maximum instantaneous deviation during the observation time is given or as deviation over time similar to an oscilloscope. Both methods do not however provide information about the probability that the instantaneous deviation meets a specific range. Much more information can be obtained from histograms. They are processed as follows:

Step 1: Sample instantaneous deviation for the required time and obtain *N* samples of instantaneous deviation.

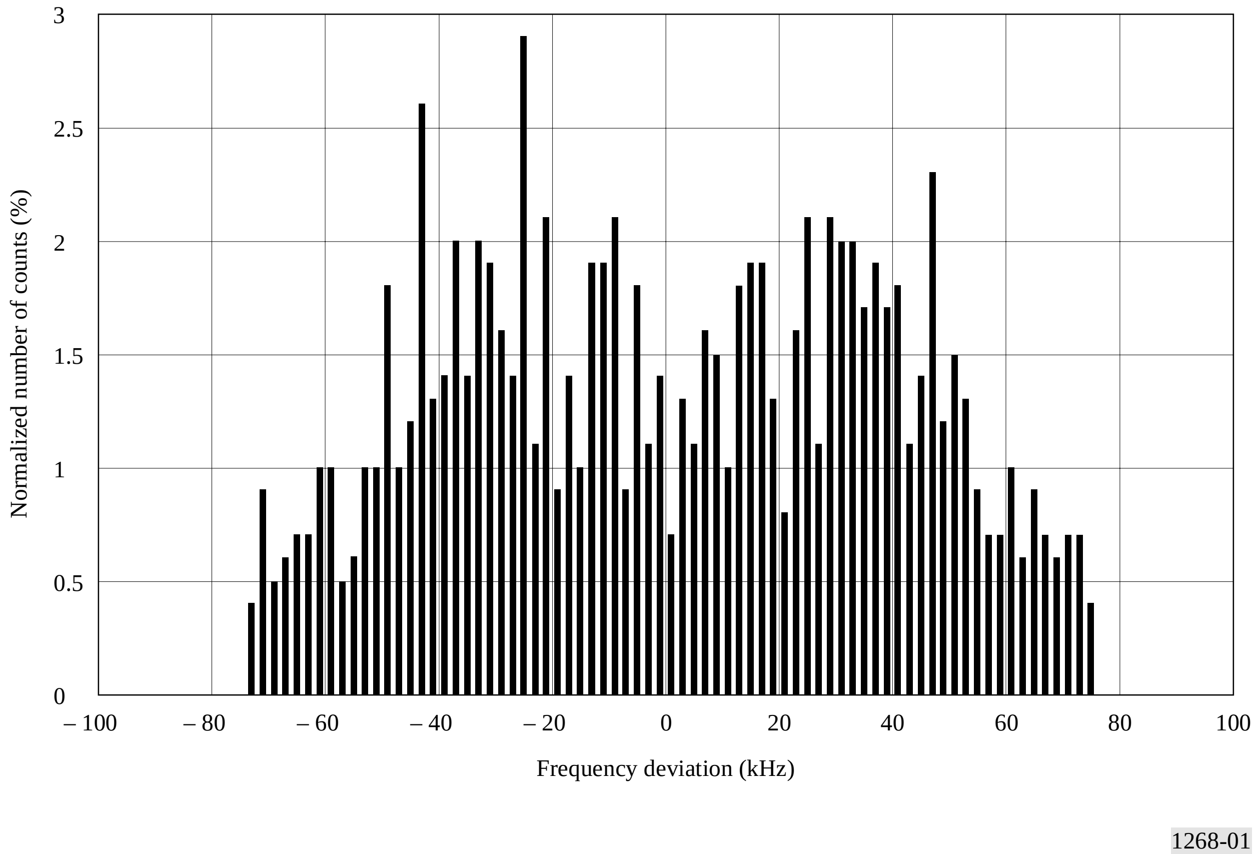
Step 2: Divide the range of frequency deviation of interest (i.e. ±100 kHz) into the desired resolution (for example 0.1 kHz) to give the number of bins (in this case 2 000 bins).

Step 3: For each bin, count the number of samples which have a value (instantaneous deviation) within the bin.

Step 4: Normalize the counts of all bins by *N*. The result is a distribution plot of the instantaneous deviation as shown in Fig. 1.

FIGURE 1

Distribution plot of instantaneous deviation



Step 5: Add counts in each bin from left to right and normalize by *N*. The result is a plot of the accumulated distribution as shown in Fig. 2 which starts with a probability of 0% from left side and will finish with a probability of 100% at right side.

4 Further studies

Further studies should be carried out to determine the necessary sampling rate and other parameters which may influence the precision of frequency deviation measurements.

FIGURE 2

Accumulated distribution plot of instantaneous deviation