

International Telecommunication Union

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Report ITU-R BS.2213
(05/2011)

**Impact of audio signal processing and
compression techniques on terrestrial FM
sound broadcasting emissions at VHF**

BS Series
Broadcasting service (sound)



International
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Union

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Note: This ITU-R Report was approved in English by the Study Group under the procedure detailed in Resolution ITU-R 1.

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REPORT ITU-R BS.2213

**Impact of audio signal processing and compression techniques on
terrestrial FM sound broadcasting emissions at VHF**

(2011)

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Introduction

Audio signal processing techniques have developed rapidly in the last few years based on advances in digital signal compression techniques. Applying the compressed audio signal to the FM modulator can increase the modulation power without exceeding the frequency deviation limit given in Recommendation ITU-R BS.412. The processed modulation signal can also result in an increased bandwidth so increasing interference to other VHF FM stations operating on the same or adjacent channels.

Recommendation ITU-R BS.412-9 – Planning standards for terrestrial FM sound broadcasting at VHF, provides the necessary RF protection ratios under the condition that the maximum deviation of the interferer signal is 75 kHz and its multiplex power (MPX) does not exceed 0 dBr. Field measurements show that nowadays a significant number of FM transmitters exceed the 0 dBr limit of the MPX power and have a higher potential to cause interference in the reception of other FM broadcast stations and in other radio services (e.g. air radionavigation). Recommendation ITU-R BS.412-9 specifies that in these cases the transmitted RF power should be decreased, but

does not provide quantitative figures for the necessary reductions. As the FM band is overcrowded and introduction of new digital stations is also considered, it is very important that the FM stations operate in line with the international regulations.

As proposed in Question ITU-R 129/6 measurements were carried out to study:

- What is the impact of audio signal processing and compression techniques on the average power of the complete multiplex signal and the maximum deviation of the emission?
- What techniques are available to ensure that the emission complies with the planning parameters given in Recommendation ITU-R BS.412 when audio signal processing and compression techniques are used?

This Report presents in Annex 1 a summary of measurements carried out in Hungary to investigate how it can be ensured that the emission complies with the planning parameters given in Recommendation ITU-R BS.412 when the 0 dBr MPX power limit is exceeded due to application of audio signal processing and compression techniques.

Annex 1

Measurement results on the protection levels against interferers with exceeded MPX power in the FM sound broadcasting

Introduction

Recommendation ITU-R BS.412-9 – Planning standards for terrestrial FM sound broadcasting at VHF, provides the necessary RF protection ratios under the condition that the maximum deviation of the interferer signal is 75 kHz and its multiplex power (MPX) does not exceed 0 dBr. Using modern audio processing/compressing techniques which result in an increase of the average power of the complete multiplex signal may lead to an increase in interference to sound broadcasting stations which do not use such techniques. Measurements were carried out in Hungary to investigate how can be ensured that the emission complies with the planning parameters given in Recommendation ITU-R BS.412 when the 0 dBr MPX power limit is exceeded due to application of audio signal processing and compression techniques.

Using modern audio processing/compressing techniques the 0 dBr MPX power limit can be exceeded while the 75 kHz limit for the maximum deviation is kept. The increased interference potential of the processed/compressed higher MPX power signal can be compensated either by decreasing the transmitted RF power or by reducing the maximum FM deviation of the transmitter. The aim of the measurements was to find quantitative figures for the reduction of the RF power and the peak deviation of the FM broadcast signal exceeding the 0 dBr MPX power limit, which can restore the audio signal-to-noise ratio (S/N) of the interfered FM broadcast service to the required 50 dB value.

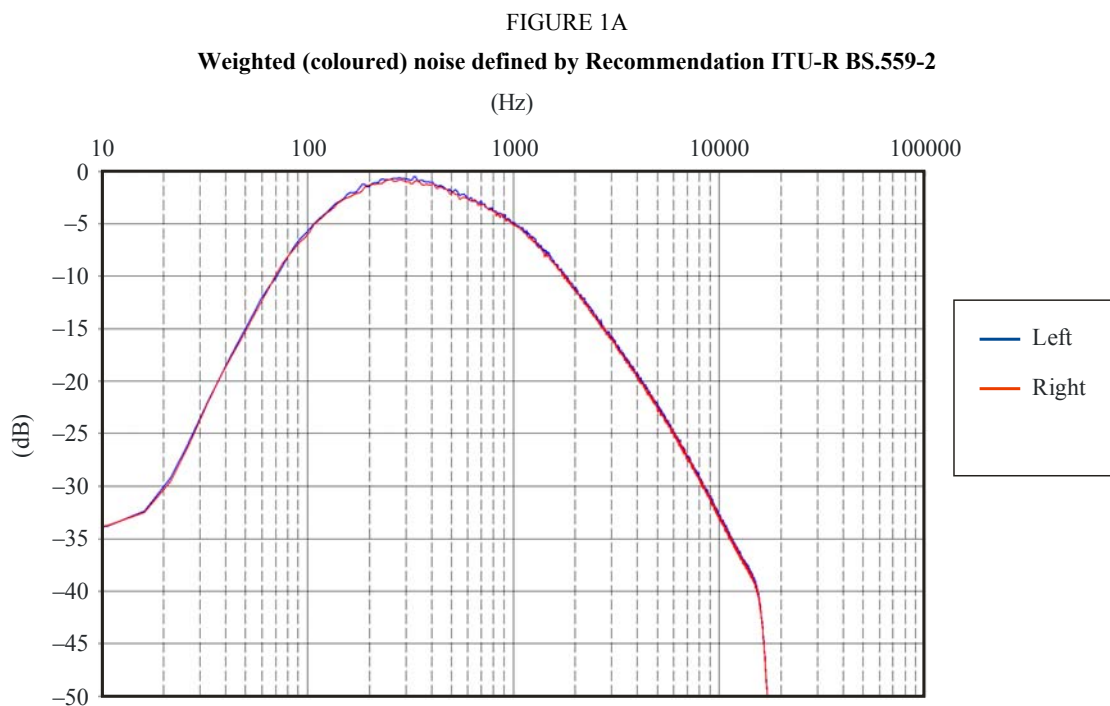
1 Measurement setup and measurement methods

The measurements were carried out using the setup shown in Fig. 1 based on Recommendation ITU-R BS.641 – Determination of radio-frequency protection ratios for frequency-modulated sound broadcasting. The list of the instruments used and the main settings can be found in the Annex.

The signals of the wanted (Generator 6) and the interfering (Generator 7) transmitters were combined and applied to the FM receiver. The output audio signal of the receiver was then measured by an audio analyzer.

The wanted signal was a stereo FM broadcast signal modulated by the output of the stereo coder while the stereo coder was driven by internal 500 Hz sinusoidal sources in both (left and right) channels. The level of the modulating signal was adjusted so that the peak FM deviation of the wanted signal was 75 kHz and it remained unchanged during the whole measurement.

The interfering transmitter was modulated by processed/compressed noise plus RDS signal. The input sound signal was a weighted (coloured) noise defined by Recommendation ITU-R BS.559-2 (see Fig. 1A), which was recorded on a CD. The level of the modulating signal was adjusted so that the peak FM deviation of the unwanted signal was 75 kHz and it was checked by the modulation meter (8). The RF level of the interferer signal could be adjusted by two cascaded step attenuators ((10) and (11)) in 1 dB steps.

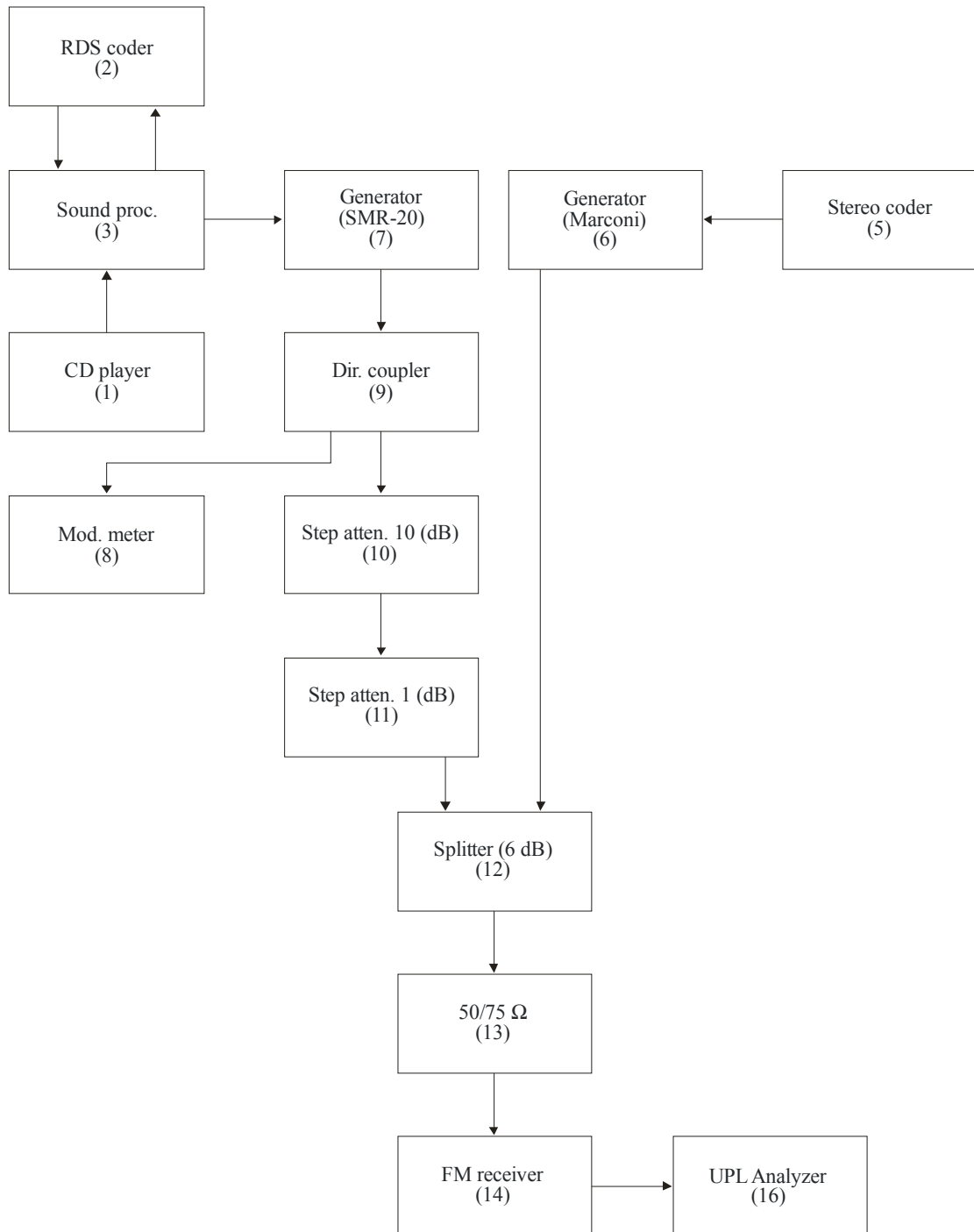


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The S/N ratio was observed at the audio output of the FM receiver (based on the specifications of Recommendation ITU-R BS.468-4 – Measurement of audio-frequency noise voltage level in sound broadcasting). The reference level of the signal was the level of the demodulated 500 Hz wave measured at 75 kHz peak deviation while the unwanted signal (interferer transmitter) was switched off. The level of the noise was measured using quasi-peak detector at the audio output of the FM receiver while the 500 Hz modulation of the wanted transmitter was switched off. Then the S/N ratio was calculated.

FIGURE 1

Measurement setup (the numbers in bracket refer to the list of equipment in Table 5)



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The RF level of the wanted transmitter at the input of the FM receiver was set to 49 dB(μ V). It was the lowest RF level where the S/N ratio at the output of the receiver reached the required 56 dB while the interferer transmitter was switched off.

1.1 Measurement of RF protection curves

The measurement procedure of the RF protection curves was as follows. The multiplex power of the interferer signal was set at the sound processor and was checked by the modulation and MPX power meter (8). The interferer transmitter was tuned to the required frequency distance from the wanted transmitter. The audio S/N ratio was observed at the output of the receiver and the step attenuators were adjusted until the S/N ratio was set to 50 dB. The actual value of the RF protection ratio was the difference in dB-s between the RF signal levels of the two transmitters. The measurement was repeated with different frequency distances and with different multiplex powers.

1.2 Measurement of the reduction of the peak deviation that can compensate the effect of the higher MPX power

The measurement setup was almost the same as in Fig. 1, except that a different type of audio analyzer (UPA) was used (for availability reasons). This measurement was completed only for 100 kHz frequency difference between the two transmitters. The RF level of the interferer signal was 33 dB below the wanted signal.

First the peak deviation of the interferer signal was set to 75 kHz in the test mode of the audio processor. The processor keeps this peak value in normal operation mode regardless of the parameters of the input sound signal and the programmed multiplex power. After setting a certain value of the MPX power the signal-to-noise ratio was observed at the audio output of the FM receiver. Then the level of the modulating signal at the output of the audio processor was adjusted until the observed S/N ratio became 50 dB. This adjustment caused of course a change in the peak deviation of the FM signal as well. The processor was then switched to test mode and the peak deviation was checked by the modulation meter (8).

2 Measurement results

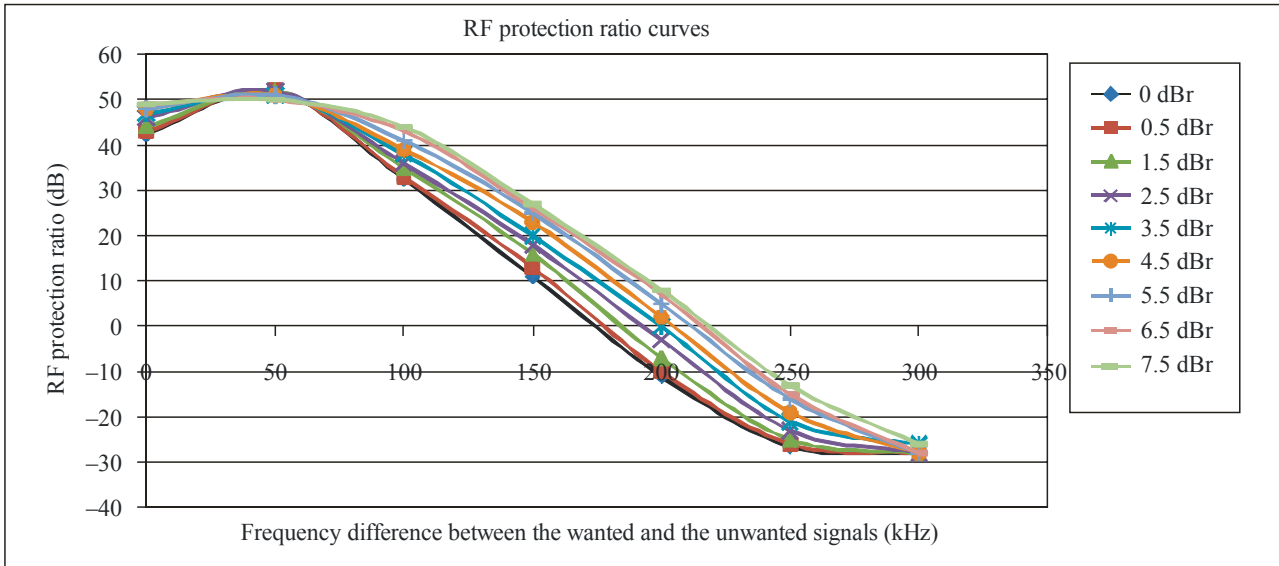
2.1 Measurement of RF protection curves

The results of the RF protection curve measurements are summarized in Table 1 and Fig. 2.

TABLE 1
RF protection ratios for different multiplex power and frequency difference values

Δf (kHz)	Multiplex power (dBr)								
	0	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5
0	42.5	43	44	46	47	48	48	49	49
50	52	52	52	52	51	51	51	50	50
100	32.5	33	35	36	38	39	41	43	44
150	11	13	16	18	20	23	25	26	27
200	-11	-10	-7	-3	0	2	5	7	8
250	-26.5	-26	-25	-23	-21	-19	-16	-15	-13
300	-28	-28	-28	-28	-26	-28	-28	-28	-26

FIGURE 2
RF protection ratios for different multiplex power and frequency difference values



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It can be seen that – in spite of certain expectations – the measured 0 dBr protection curve is not identical with the S1 curve shown in Recommendation ITU-R BS.412-9. The most likely reasons of the difference is that the S1 curve of Recommendation ITU-R BS.412-9:

- a) represents an average of the measurements made on great number of different consumer radio sets while for the present measurements only two different, medium quality radio sets were used; and
- b) it was measured with an interferer signal with less than 0 dBr MPX power.

However, the curves clearly indicate the tendency that the higher the MPX power the more protection is needed against it.

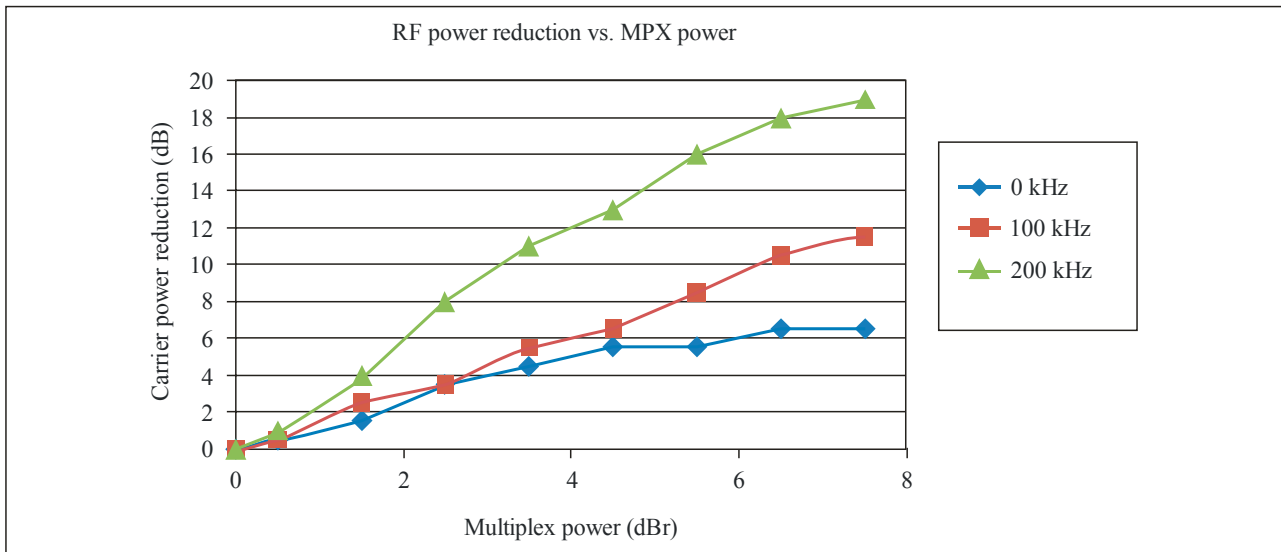
From the above results we can also derive curves that show how much reduction of the RF power level of an interferer signal can compensate its increased interfering effect if its MPX power exceeds 0 dBr, keeping the baseband audio *S/N* ratio at the required 50 dB. The three curves on Fig. 3 refer to the 0 kHz, 100 kHz and 200 kHz difference between the carrier frequencies of the wanted and the unwanted signal.

TABLE 2
RF power reduction that can compensate the effect of the higher MPX power of the unwanted transmitter

Δf (kHz)	MPX power (dBr)							
	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5
0	0.5	1.5	3.5	4.5	5.5	5.5	6.5	6.5
100	0.5	2.5	3.5	5.5	6.5	8.5	10.5	11.5
200	1	4	8	11	13	16	18	19

FIGURE 3

RF power reduction that can compensate the effect of the higher MPX power of the unwanted transmitter



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2.2 Measurement of the reduction of the peak deviation that can compensate the effect of the higher MPX power of the unwanted transmitter

The higher interference potential of a signal exceeding 0 dBr multiplex power can also be compensated by the proportional reduction of the FM deviation. Table 3 and Fig. 4 show the applicable maximum deviations as a function of the original MPX power (before decreasing the peak deviation). The two curves refer to the “on” and “off” state of the RDS signal.

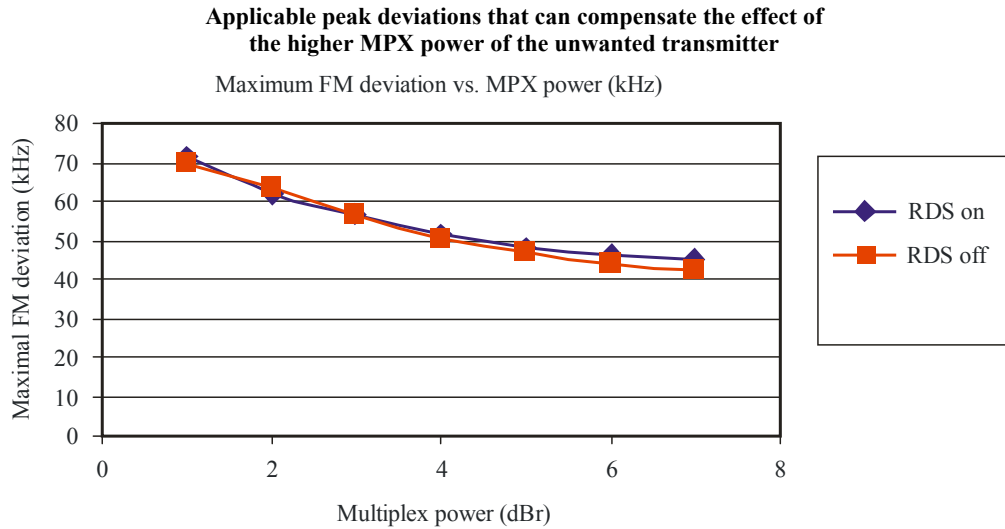
The results of the measurements of the maximum applicable peak deviation are summarized in Table 3 and Fig. 4.

TABLE 3

Peak deviations for different MPX power values

Maximum applicable FM deviation (kHz)		
Multiplex power (dBr)	RDS on	RDS off
1	71.5	69.7
2	61.5	63.3
3	56.8	56.8
4	51.6	50.4
5	48	46.9
6	46.3	43.9
7	45.1	42.2

FIGURE 4



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The measurements were carried out both in the “on” and “off” state of the RDS signal. It was found that this causes only a very slight difference.

The above results can be expressed in the reduction of the peak deviation – relative to the nominal 75 kHz – as well.

TABLE 4

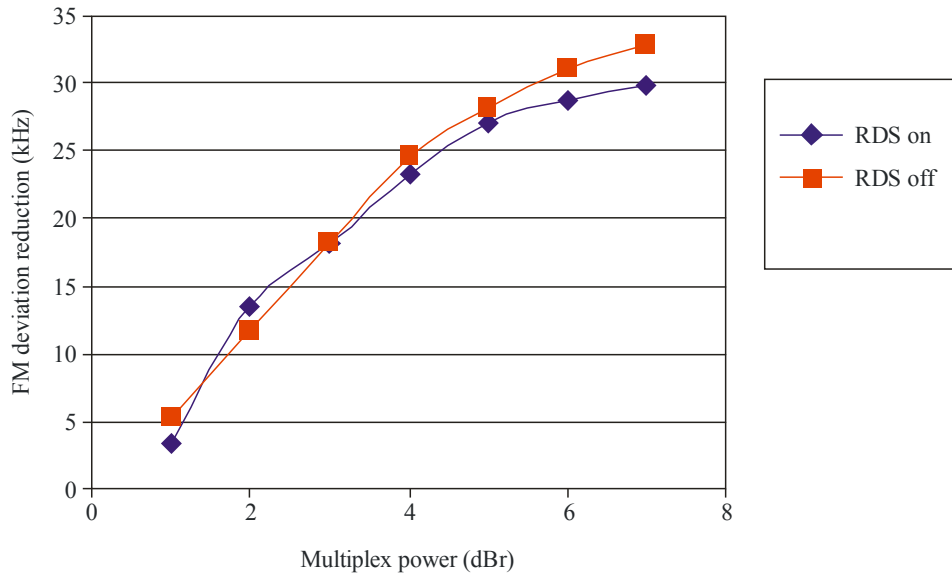
Reduction of the peak deviations that can compensate the effect of the higher MPX power of the unwanted transmitter (relative to 75 kHz)

Reduction of the peak FM deviation (kHz)		
Multiplex power (dBr)	RDS on	RDS off
1	3.5	5.3
2	13.5	11.7
3	18.2	18.2
4	23.4	24.6
5	27	28.1
6	28.7	31.1
7	29.9	32.8

FIGURE 5

Reduction of the peak deviations that can compensate the effect of the higher MPX power of the unwanted transmitter (relative to 75 kHz)

Reduction of FM deviation vs. MPX power (kHz)



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Conclusion

The laboratory measurements confirmed that FM broadcast signals with higher multiplex power can cause higher degradation in the quality of the interfered FM broadcast signal. This degradation can be compensated by decreasing either the RF level or the peak deviation of the interferer signal. The above described measurements provide quantitative figures for the amount of these reductions.

Appendix to Annex 1

List of instruments

TABLE 5

List of instruments

No.	Equipment/type	Serial or Reg. No.
1	CD player (in an industrial PC)	L0064576
2	RDS coder	
3	Audio processor Orban 5300 FM	53000135
4	Function generator Tektronix AFG 3252	
5	Stereo coder R&S MSC-2	890340/017
6	Signal generator Marconi 2031 (wanted transm.)	119848/053
7	Signal generator R&S SMR-20 (unwanted transm.)	11040002.20
8	Modulation (and MPX) meter Audemat Aztek FM-MC4	L0062277
9	High power directional coupler C5091(Werlaton)	10279
10	Step attenuator 8496A 110 dB	3308A14564
11	Step attenuator 8494A 11 dB	3308A32544
12	Resistive power splitter Aeroplex 1870A	8134
13	50/75 Ohm match RAM	100131
14	Radio set Sony S-master CMT-CPZ1	122234
15	Radio set Denon DN-U100	
16	UPL Audio Analyzer R&S DC...110 kHz	100091
17	UPA Audio Analyzer R&S 10 Hz 100 kHz	

Signal and instrument settings

Signal level of the wanted transmitter at the receiver input: 49 dB(μ V)

Pilot signal: 9%

FM deviation caused by the RDS signal: 3 kHz

UPL audio analyzer

Low-pass filter: on (15 kHz)

Detector: quasy-peak

Weighting filter: on (weighting characteristics according to Recommendation ITU-R BS.468-4)

UPA audio analyzer

Low-pass filter: on (22 kHz)

Detector: quasy-peak

Weighting filter: on (weighting characteristics according to Recommendation ITU-R BS.468-4)

Audemat Aztec FM-MC4 modulation (and MPX) analyzer

Mode of operation: MPX Analysis Mode (In this mode the averaging time is automatically set to 200 ms and the MPX processing mode to “linear”).

Orban 5300 FM audio processor

Applied factory preset: “Extreme”.

