

RECOMMENDATION ITU-R SM.1140*

**TEST PROCEDURES FOR MEASURING AERONAUTICAL RECEIVER CHARACTERISTICS
USED FOR DETERMINING COMPATIBILITY BETWEEN THE SOUND-BROADCASTING
SERVICE IN THE BAND OF ABOUT 87-108 MHz AND THE AERONAUTICAL
SERVICES IN THE BAND 108-118 MHz**

(Question ITU-R 201/2)

(1995)

The ITU Radiocommunication Assembly,

considering

- a) that, in order to ensure the efficiency of spectrum utilization, there is a need to assess the compatibility between the sound-broadcasting service in the band of about 87-108 MHz and the aeronautical radionavigation services in the band 108-118 MHz;
- b) that International Civil Aviation Organization (ICAO) Annex 10 (see Definitions in Annex 1, Appendix 2) does not specify the receiver interference immunity characteristics necessary to fully assess this compatibility;
- c) that the test procedures given in Annex 1 were used in the development of interference assessment criteria, appropriate to the ICAO Annex 10, 1998 receivers, as contained in Recommendation ITU-R SM.1009;
- d) that in order to refine the interference assessment criteria contained in Recommendation ITU-R SM.1009 additional tests are required on aeronautical radionavigation receivers designed to meet the ICAO Annex 10 interference immunity criteria;
- e) that there is a need for standardized test procedures,

recommends

- 1 that the test procedures given in Annex 1 should be used to determine the characteristics of typical aircraft instrument landing system (ILS) localizer “and very high frequency omni-directional radio range (VOR)” receivers with respect to compatibility with the sound-broadcasting service in the band of about 87-108 MHz;
- 2 that the results of tests performed according to the procedures given in Annex 1 be used to refine compatibility assessment criteria as may be appropriate. (see Recommendation ITU-R SM.1009.)

ANNEX 1

Test procedures

CONTENTS

- 1 Background and introduction
- 2 Interference mechanisms
- 3 Signal characteristics
- 4 Test set-up
- 5 Measurement techniques
- Appendix 1 – Test equipment
- Appendix 2 – Definitions

* Radiocommunication Study Group 1 made editorial amendments to this Recommendation.

1 Background and introduction

1.1 In the past, difficulties were experienced when making direct comparisons of test results submitted by different administrations because of various interpretations of definitions and test criteria. For example, depending on a particular interpretation, this resulted in the use of:

- a minimum localizer signal level of –86 dBm or –89 dBm;
- a localizer course deflection current (see Note 1) of 7.5 µA or 9 µA;
- a standard localizer deviation signal of 0.093 DDM (see Note 1) or 90 µA;
- an FM pre-emphasis of 50 µs or 75 µs;
- a maximum FM signal deviation of ±75 kHz peak, ±32 kHz quasi-peak or ±32 kHz peak;
- ITU-R coloured noise and pink noise sources with and without a stereo modulator.

NOTE 1 – Definitions are given in Annex 1, Appendix 2.

In addition, many test reports were limited to the use of minimum VOR/localizer signal levels and band-edge frequencies of 108.1 MHz for the localizer and 108.2 MHz for the VOR receiver.

1.2 ICAO has specified in its Annex 10, Part I (§ 3.1.4 for ILS localizer and § 3.3.8 for VOR) that:

- as from 1 January 1995, all new installations of ILS localizer and VOR receiving systems shall meet new interference immunity performance standards;
- as from 1 January 1998, all ILS localizer and VOR receiving systems shall meet new interference immunity performance standards.

The formula specified for the Type B1 interference 2-signal case is as follows:

$$2 N_1 + N_2 + 3 [24 - 20 \log (\max(0.4; 108.1 - f_1)) / 0.4] > 0$$

where:

f_1 : broadcasting frequency (MHz) closest to 108.1 MHz

N_1, N_2 : broadcasting signal levels (dBm) at the input to the aeronautical receiver for broadcasting frequencies f_1 and f_2 , respectively

f_2 : broadcasting frequency (MHz) furthest from 108.1 MHz.

However, difficulties in frequency planning and implementation were experienced in the application of this formula because:

- it does not address Type B1 interference, 3-signal intermodulation cases;
- it makes reference to the frequency 108.1 MHz rather than the actual ILS localizer and VOR systems;
- it does not take into account differences between ILS localizer and VOR systems;
- it does not contain a correction factor to account for improvement in immunity resulting from increases in wanted signal levels.

The Type B2 interference criteria specified in ICAO Annex 10 also does not contain a correction factor to account for improvement in immunity resulting from increases in wanted signal levels. ICAO Annex 10 does not specify any type A1 or A2 interference criteria.

1.3 The 1998 receiver immunity standards contained in ICAO Annex 10 were used in minimum operational performance standards (MOPS) developed by RTCA Inc. in Region 2 and its counterpart, EUROCAE, in Region 1. In particular, the applicable RTCA documents are:

RTCA/DO-195: Minimum Operational Performance Standards for Airborne ILS Localizer Receiving Equipment Operating Within the Radio Frequency Range of 108-112 MHz (1986);

RTCA/DO-196: Minimum Operational Performance Standards for Airborne VOR Receiving Equipment Operating Within the Radio Frequency Range of 108-117.95 MHz (1986).

These MOPS, however, address only receiver immunity aspects for Type B2 interference (see § 2.2.3) and for the 2-signal Type B1 interference case (see § 2.2.2), for a limited set of test frequencies and signal levels.

1.4 The development of realistic compatibility assessment criteria and techniques requires that the immunity characteristics be explored for the full range of localizer frequencies (i.e. 108.10-111.95 MHz), VOR frequencies (i.e. 108.05-117.95 MHz), FM broadcasting frequencies and signal levels.

1.5 This Recommendation specifies test procedures for determining the interference immunity characteristics of ICAO Annex 10 1998 ILS localizer and VOR receivers with respect to Type A1, A2, B1, and B2 interference from broadcasting stations. These test procedures were developed by Radiocommunication Task Group 2/1 studying aeronautical/broadcasting compatibility and were used in the bench testing of the ICAO Annex 10 1998 receivers at the Federal Aviation Administration (FAA) Technical Center, Atlantic City, New Jersey, United States of America in 1993-94 and subsequent cross-check tests conducted by other organizations.

2 Interference mechanisms

2.1 Type A interference

2.1.1 Introduction

Type A interference is caused by unwanted emissions into the aeronautical band from one or more broadcasting transmitters.

2.1.2 Type A1 interference

A single transmitter may generate spurious emissions or several broadcasting transmitters may intermodulate to produce components in the aeronautical frequency bands; this is termed Type A1 interference.

2.1.3 Type A2 interference

A broadcasting signal may include non-negligible components in the aeronautical bands; this interference mechanism, which is termed Type A2 interference, will in practice arise only from broadcasting transmitters having frequencies near 108 MHz and will only interfere with ILS localizer/VOR services with frequencies near 108 MHz.

2.2 Type B interference

2.2.1 Introduction

Type B interference is that generated in an aeronautical receiver resulting from broadcasting transmissions on frequencies outside the aeronautical band.

2.2.2 Type B1 interference

Intermodulation may be generated in an aeronautical receiver as a result of the receiver being driven into non-linearity by broadcasting signals outside the aeronautical band; this is termed Type B1 interference. In order for this type of interference to occur, at least two broadcasting signals need to be present and they must have a frequency relationship which, in a non-linear process, can produce an intermodulation product within the wanted RF channel in use by the aeronautical receiver. One of the broadcasting signals must be of sufficient amplitude to drive the receiver into regions of non linearity but interference may then be produced even though the other signal(s) may be of significantly lower amplitude.

Only third-order intermodulation products are considered; they take the form of:

$$f_{intermod}: 2f_1 - f_2 \quad \text{two-signal case or}$$

$$f_{intermod}: = f_1 + f_2 - f_3 \quad \text{three-signal case}$$

where:

f_1, f_2, f_3 : broadcasting frequencies (MHz) with $f_1 \geq f_2 > f_3$

$f_{intermod}$: intermodulation product frequency (MHz)

2.2.3 Type B2 interference

Desensitization may occur when the RF section of an aeronautical receiver is subjected to overload by one or more broadcasting transmissions; this is termed Type B2 interference.

Other internal receiver mechanisms, such as spurious responses, may be incorrectly identified as B2 interference. These responses can be identified by the extremely frequency-sensitive nature of the interference when tested in the unmodulated RF mode.

3 Signal characteristics

3.1 ILS signal characteristics

The localizer portion of an ILS signal operates in the frequency range 108-111.975 MHz. The radiation from the localizer antenna system produces a composite field pattern which is amplitude modulated by a 90 Hz and a 150 Hz tone. The radiation field pattern produces a course sector with one tone predominating on one side of the course and the other tone predominating on the opposite side.

3.2 VOR signal characteristics

The VOR operates in the frequency range 108-117.950 MHz and radiates a radio-frequency carrier with which are associated two separate 30 Hz modulations. One of these modulations, called the reference phase, is such that its phase is independent of the azimuth of the point of observation. The other modulation, called the variable phase, is such that its phase at the point of observation differs from that of the reference phase by an angle equal to the bearing of the point of observation with respect to the VOR.

3.3 FM broadcasting signal characteristics

FM broadcasting stations operate in the frequency range 87-108 MHz. These stations radiate a frequency modulated signal with, either:

- ± 32 kHz quasi-peak deviation with 50 μ s pre-emphasis of the baseband signal; or
- ± 75 kHz peak deviation with 75 μ s pre-emphasis of the baseband signal.

Noise modulation in accordance with Recommendation ITU-R BS.559 is used to simulate an FM broadcast audio signal.

4 Test set-up

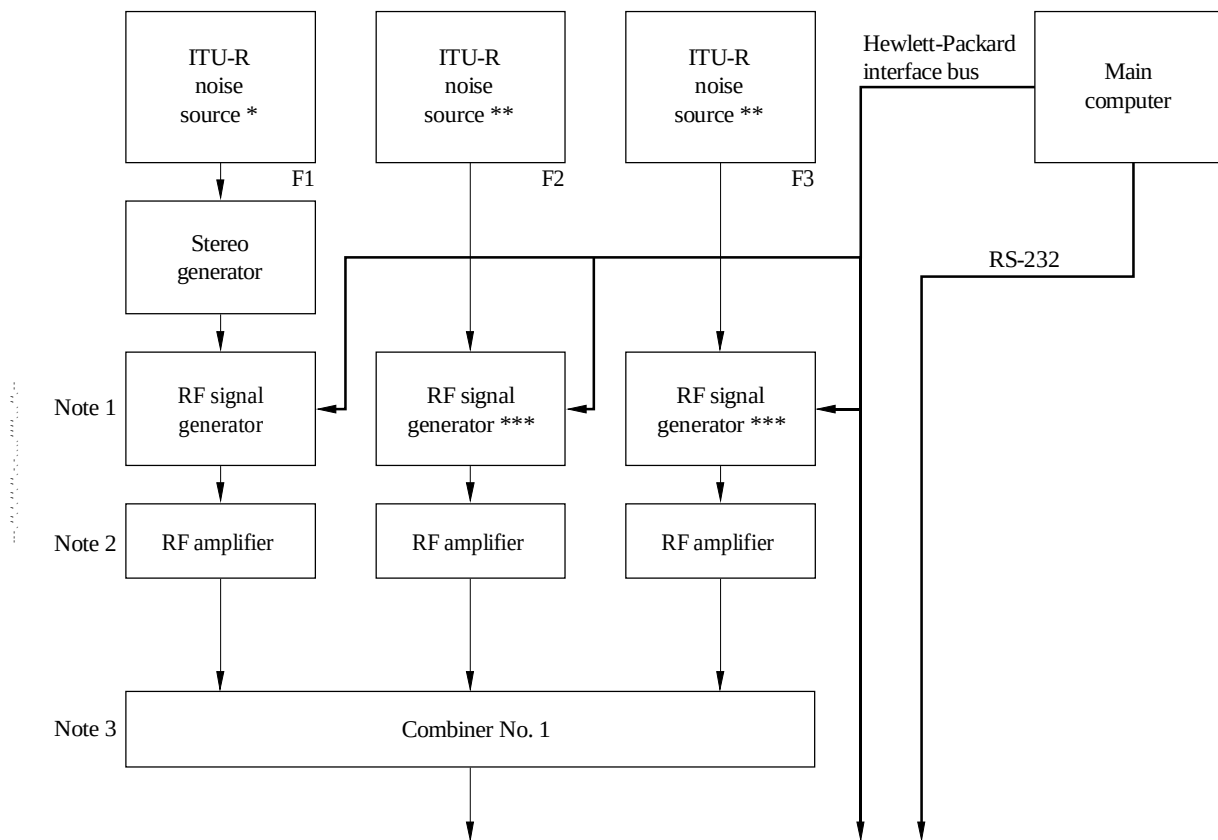
4.1 Overview of test set-up

A suitable test set-up (including important equipment characteristics) is shown in Figs. 1a, 1b and 1c.

This test should preferably utilize a semi-automated test set-up consisting of a computer for test execution, test equipment control, and data collection. The main computer should adjust both the desired and undesired signal generator outputs and provide the interface to the receiver under test to record the course deflection current and flag voltage.

Digital receiver testing may require the use of an additional computer to interface with the ARINC 429 bus.

FIGURE 1a

**Note 1**

Noise floor, $F = -136$ dBc/Hz
 Maximum RF, $M = +8.0$ dBm
 Noise level, $N = -128$ dBm/Hz

Note 2

Gain = 22 dB
 Noise figure = 7.0 dB
 Maximum output = +30 dBm
 Reverse isolation = 55 dB

$M = +30$ dBm
 $N = -99$ dBm/Hz

Note 3

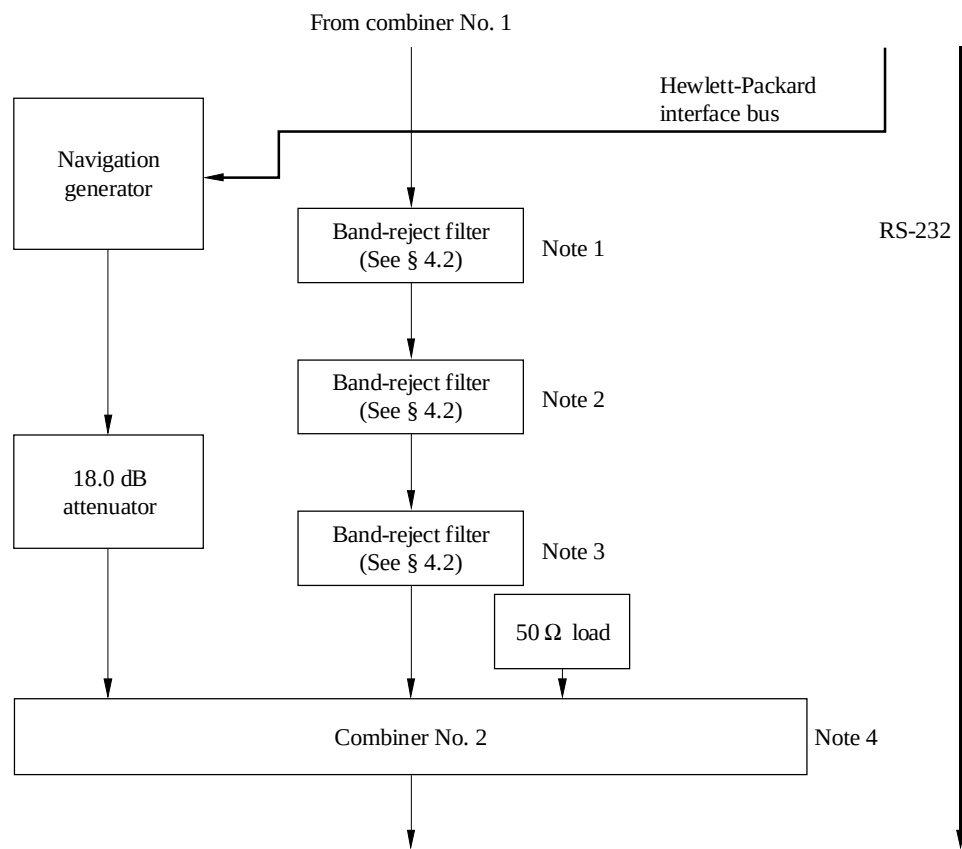
Insertion loss = 5 dB
 Isolation ≥ 20.0 dB

$M = +25$ dBm
 $N = -104$ dBm/Hz

- * Modulation off for B2 tests
 - ** Used for B1 offset only
 - *** Signal off for A1, A2 and B1 tests
- $F1 > F2 > F3$

D01

FIGURE 1b



Note 1
Tuned-cavity filter
Insertion loss = 0.5 dB
Rejection = 18 dB
3 dB bandwidth = 0.2 MHz
 $M = +24.5 \text{ dBm}$
 $N = -122.5 \text{ dBm/Hz}$

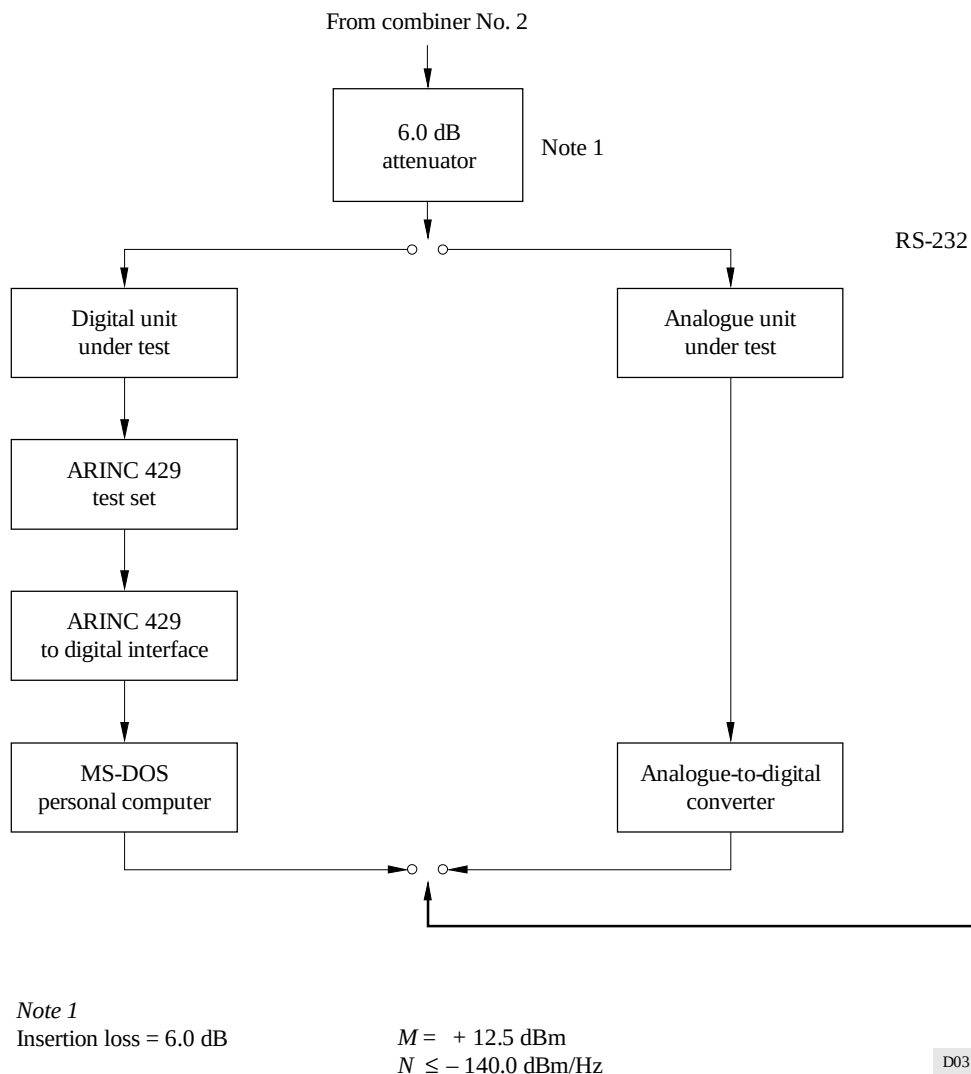
Note 2
Tuned-cavity filter
Insertion loss = 0.5 dB
Rejection = 18 dB
3 dB bandwidth = 0.2 MHz
 $M = +24 \text{ dBm}$
 $N \leq -140.0 \text{ dBm/Hz}$

Note 3
Tuned-cavity filter
Insertion loss = 0.5 dB
Rejection = 18 dB
3 dB bandwidth = 0.2 MHz
 $M = +23.5 \text{ dBm}$
 $N \leq -140.0 \text{ dBm/Hz}$

Note 4
Insertion loss = 5.0 dB
Isolation = 20 dB
 $M = +18.5 \text{ dBm}$
 $N \leq -140.0 \text{ dBm/Hz}$

D02

FIGURE 1c



4.2 Test set-up description

4.2.1 The ITU-R noise source for the stereo signal is composed of a white noise generator, a Recommendation ITU-R BS.559 noise filter, and a 50 or 75 μs pre-emphasis filter.

4.2.2 In either case, the noise signal, S_1 , should be fed to the stereo generator with the left channel signal level in phase with, but 6 dB greater than, the right channel. It is then modulated to give an FM stereo signal. This stereo signal (f_1) should be used in the A1, A2, and B1 tests (see Fig. 1a).

4.2.3 Frequencies f_2 and f_3 are used only during B₁ testing. During the B₁ coincident tests, f_2 and f_3 are unmodulated. For the B₁ offset test, both f_2 and f_3 are monaural signals from the ITU-R noise source described above. The frequency modulation function is performed by the RF signal generators.

4.2.4 The B2 tests should use an unmodulated RF signal f_1 .

4.2.5 The high signal levels required by the ICAO future immunity criteria receivers necessitate additional amplification which should be provided by RF amplifiers. A maximum signal level of at least +15 dBm at the receiver's input should be used during these tests.