International Telecommunication Union

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Radiocommunication Sector of ITU

Recommendation ITU-R M.1639-1
(06/2005)

Protection criterion for the aeronautical radionavigation service with respect to aggregate emissions from space stations in the radionavigation-satellite service in the band 1 164-1 215 MHz

M Series

Mobile, radiodetermination, amateur and related satellite services

International Telecommunication Union

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R M.1639-1*

Protection criterion for the aeronautical radionavigation service with respect to aggregate emissions from space stations in the radionavigation-satellite service in the band 1 164-1 215 MHz

(2003-2005)

Scope

This Recommendation gives the equivalent power flux-density (epfd) level which protects stations of the aeronautical radionavigation service (ARNS) from emissions of radionavigation satellites of all radionavigation-satellite service (RNSS) systems operating in the 1 164-1 215 MHz band.

The ITU Radiocommunication Assembly,

considering

a) that in accordance with the Radio Regulations (RR), the band 960-1 215 MHz is allocated on a primary basis to the aeronautical radionavigation service (ARNS) in all the ITU Regions;

b) that analyses show that radionavigation-satellite service (RNSS) signals in the 1 164-1 215 MHz band can be designed to not cause interference to the distance measuring equipment (DME)/tactical air navigation (TACAN) ARNS receivers operating in this band;

c) that the equivalent power flux-density (epfd) method assesses interference from multiple RNSS space stations into ARNS receivers more accurately than the aggregate pfd method;

d) that the signal paths of the planned RNSS (space-to-space and space-to-Earth) signals in the 1 164-1 215 MHz band will originate from the same transmission from the RNSS satellites, and thus RNSS (space-to-space) service on such systems will not increase the epfd level above that of RNSS (space-to-Earth) service;

e) that there are no known plans for any RNSS systems providing exclusively RNSS (space-to-space) service in the 1 164-1 215 MHz band, and the likelihood of such systems being developed in the future is considered to be very low;

f) that Recommendation ITU-R M.1642 contains the methodology and the reference ARNS station characteristics to be used to calculate the aggregate epfd produced by emissions from all the space stations of all radionavigation-satellite systems at any aeronautical radionavigation station,

recognizing

a) that WRC-2000 introduced a co-primary allocation for the RNSS in the frequency band 1 164-1 215 MHz, subject to conditions that require the RNSS to protect the ARNS from harmful interference;

b) that WRC-03 determined that protection of the ARNS from RNSS can be achieved if the value of the epfd produced by all the space stations of all RNSS (space-to-Earth) systems in the band 1 164-1 215 MHz does not exceed the level of –121.5 dB (W/m^2) in any 1 MHz band, and adopted Resolution 609 (WRC-03) in order to ensure that this level is not exceeded;

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* This Recommendation should be brought to the attention of the International Civil Aviation Organization (ICAO).

c) that the ARNS is a safety service in accordance with RR No. 1.59 and special measures need to be taken by administrations to protect these services from harmful interference in accordance with RR No. 4.10.

recommends

1 that the maximum allowable epfd level from all space stations of all RNSS systems should not exceed –121.5 dB(W/(m^2 · MHz)) as derived in Annex 1, in order to protect the ARNS in the band 1 164-1 215 MHz.

Annex 1

Aggregate protection criterion determination

This Annex addresses epfd level for all space-based RNSS emissions in the band 1 164-1 215 MHz, whether space-to-Earth or space-to-space RNSS, which protects the ARNS.

1 Definition of epfd

The definition is based upon RR No. 22.5C.1 as adopted at WRC-2000.

When an antenna receives power, within its reference bandwidth, simultaneously from transmitters at various distances, in various directions and at various levels of incident pfd, the epfd is that pfd which, if received from a single transmitter in the far field of the antenna in the direction of maximum gain, would produce the same power at the input of the receiver as is actually received from the aggregate of the various transmitters.

The instantaneous epfd is calculated using the following formula:

$$epfd = 10 \log_{10}\left[\sum_{i=1}^{N_a} 10^{\frac{P_i}{10}} \cdot \frac{G_t(\theta_i)}{4\pi d_i^2} \cdot \frac{G_r(\varphi_i)}{G_{r,max}}\right]$$

where:

- N_a: number of space stations that are visible from the receiver
- i: index of the space station considered
- P_i: RF power at the input of the antenna (or RF radiated power in the case of an active antenna) of the transmitting space station (dB(W/MHz))
- θ_i: off-axis angle between the boresight of the transmitting space station and the direction of the receiver
- $G_t(\theta_i)$: transmit antenna gain (as a ratio) of the space station in the direction of the receiver
- d_i: distance (m) between the transmitting station and the receiver
- φ_i: off-axis angle between the pointing direction of the receiver and the direction of the transmitting space station
- $G_r(\varphi_i)$: receive antenna gain (as a ratio) of the receiver, in the direction of the transmitting space station (see Recommendation ITU-R M.1642)
- $G_{r,max}$: maximum gain (as a ratio) of the receiver

epfd: instantaneous epfd (dB(W/(m^2 · MHz))) at the receiver.

NOTE 1 – It is assumed that each transmitter is located in the far field of the receiver (that is, at a distance greater than $2D^2/\lambda$, where D is the effective diameter of the receiver antenna and λ is the observing wavelength). In the case under consideration this will always be satisfied.

2 Maximum aggregate epfd (all RNSS systems) to protect the ARNS

The parameters in Table 1 identify the epfd level at which ARNS equipment will be protected from RNSS emissions in the 1 164-1 215 MHz band.

TABLE 1

Maximum allowable aggregate epfd level to protect ARNS from RNSS

	Parameter	Value	Reference
1	DME RNSS interference threshold (at antenna port)	–129 dB(W/MHz)	(See Note 1)
2	Maximum DME/TACAN antenna gain including polarization mismatch	3.4 dBi	(5.4 dBi antenna gain –2 dB polarization mismatch)
3	Effective area of 0 dBi antenna at 1 176 MHz	–22.9 dB(m^2)	
4	RNSS (all systems) aggregate epfd in 1 MHz	–109.5 dB(W/(m^2 · MHz))	Combine 1, 2 and 3 (1 minus 2 minus 3)
5	Safety margin	6 dB	Recommendation ITU-R M.1477
6	Apportionment of RNSS interference to all the interference sources	6 dB	Apportion 25% of total permissible interference to RNSS
7	Maximum RNSS aggregate epfd	–121.5 dB(W/(m^2 · MHz))	Combine 4, 5 and 6 (4 minus 5 minus 6)

NOTE 1 – This value is based on a –129 dBW CW interference threshold specified for international DME systems used by civil aviation. Measurement has demonstrated that an RNSS signal spread over 1 MHz would have the same effect as a CW signal on DME performance (see § 2.1).

2.1 Comparison between the impact of CW interference type of signal and RNSS type of interference signal on DME/TACAN on-board receivers

2.1.1 Susceptibility of DME receivers from interference by RNSS signals (spread spectrum signals)

Ground DME transponder signals of peak value –83 dBm were set as the wanted signal at the different DME interrogator/receivers.

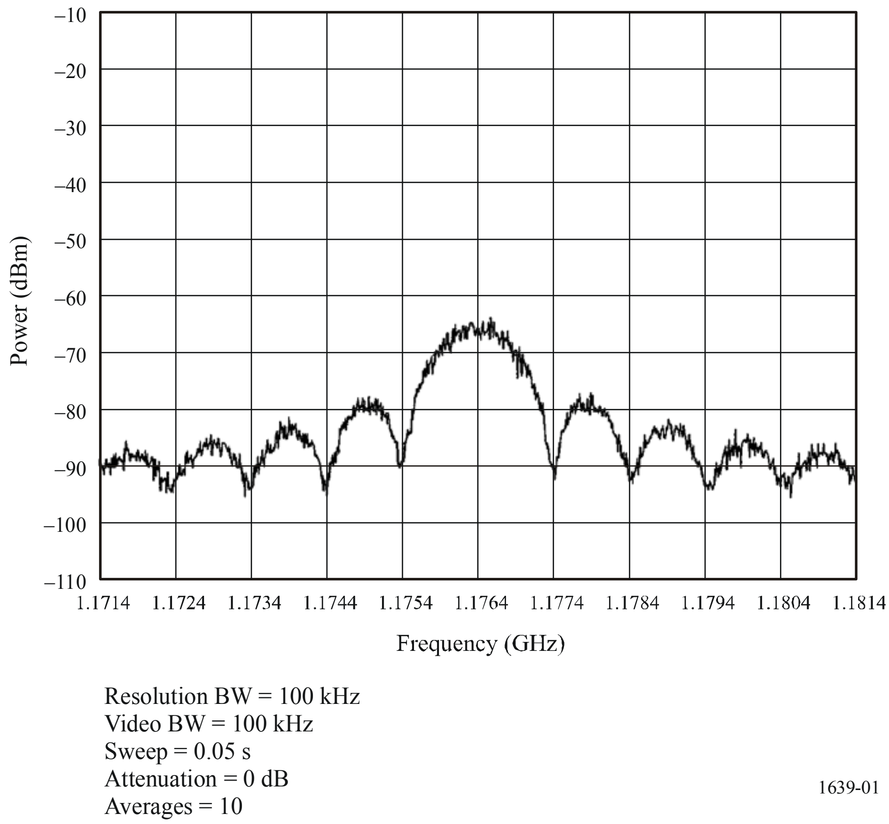
The total power of the narrow (see Fig. 1) or wideband (see Fig. 2) interference source was measured within a bandwidth of 650 kHz, and the variation in performance of a DME between CW signals and the RNSS signals was determined for a number of different DME designs and a number of DMEs of the same type. These DMEs were of the type designed for large commercial aircraft and smaller commercial aviation aircraft.

The shape of the interference signals used in the tests is given in Figs. 1 and 2.

For Fig. 1, the interference source was generated from an RNSS signal simulator that produced the exact signal structure and frequency signal of an existing RNSS system. This 1.023 Mchip/s pseudo-random code division multiple access (CDMA) transmission was translated in frequency to the relevant DME receive frequency under test. The range of interfering RNSS narrow-band signals (measured in 650 kHz) applied to DMEs was –83 to –94 dBm.

FIGURE 1

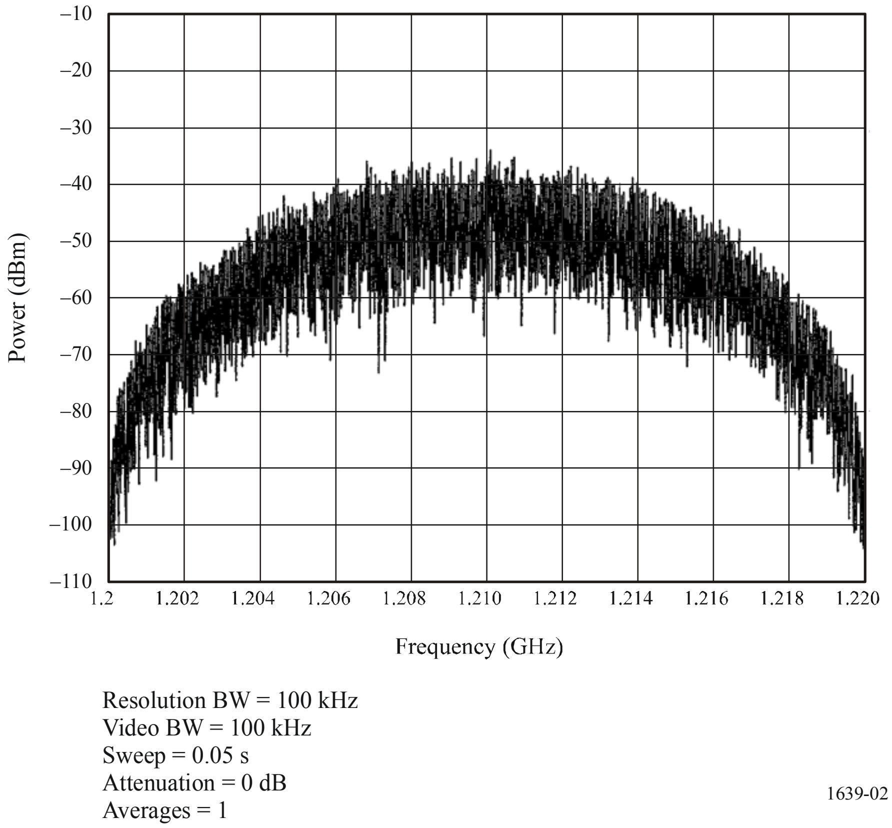
Example of RNSS narrow-band signal translated to 1 176.45 MHz



For Fig. 2, the interference source was generated from a digital signal generator, that produced a 10.23 Mchip/s pseudo-random CDMA emission similar to that proposed by the RNSS in the band 1 164-1 215 MHz. The signal was applied directly to the relevant receive DME under test. The range of interfering RNSS wideband signals (measured in 650 kHz) applied to DMEs was –81 to –93 dBm.

FIGURE 2

Example of RNSS wideband signal



2.1.2 CW RNSS measurement results

Measurement has demonstrated that an RNSS signal spread over 1 MHz would have the same effect as a CW signal on DME performance. Measurement variation of about ±1 dB was noted, as was a performance variation of about ±3 dB between the different DMEs.

2.2 Circular polarization isolation achieved by the DME antenna

A linear vertically polarized DME antenna should receive –3 dB of the total circularly polarized RNSS signal. However, RNSS emissions are observed in the side lobes, not the main beam of a DME antenna, where polarization mismatch is less certain. Some recent measurements on aircraft DME antennas have indicated a value of –2.5 dB, while other experience of aircraft polarization mismatch has observed factors of 0 dB. It was therefore considered practical to assume a polarization mismatch of –2 dB for RNSS circularly polarized signals to a DME antenna. This value should therefore be added to the effective maximum antenna gain to determine the ARNS receiver maximum antenna gain including polarization mismatch.

2.3 Apportionment of the DME maximum allowable aggregate interference level to RNSS

The chosen factor of 6 dB for the apportionment of the maximum allowable aggregate interference level, from all other interference sources to the RNSS maximum allowable aggregate interference level, recognizes that there exists the possibility of interference from other DME in the same frequency band, from the spurious and out-of-band emissions of other airborne ARNS and aeronautical mobile-satellite service (AMSS) systems and also from the bands adjacent to the ARNS. The on-board ARNS systems include multiple secondary surveillance radar transponders, multiple airborne collision avoidance systems and other DME interrogators; on-board satellite terminals in the AMSS also operate. Adjacent band sources of interference are high-powered radiolocation service radar operating just above 1 215 MHz and broadcast service transmitters operating below 960 MHz.