RECOMMENDATION ITU-R M.1640

Characteristics of, and protection criteria for sharing studies for radars operating in the radiodetermination service in the frequency band 33.4-36 GHz

(Questions ITU-R 213/7 and ITU-R 226/8)

(2003)

Summary

This Recommendation provides the technical characteristics and protection criteria for the radiodetermination systems operating in the band 33.4-36 GHz. The text was developed as a resource document intended to support sharing studies where sharing between the radiodetermination service and other services may be possible.

The ITU Radiocommunication Assembly,

considering

a) the antenna, signal propagation, target detection, and large necessary bandwidth characteristics of radar to achieve their functions are optimum in certain frequency bands;

b) that the technical characteristics of radiodetermination radars are determined by the mission of the system and vary widely even within a band;

c) that considerable radiolocation and radionavigation spectrum allocations (amounting to about 1 GHz) have been removed or downgraded since WARC-79;

d) that representative technical and operational characteristics of radars are required to determine the feasibility of introducing new types of systems into frequency bands;

e) that procedures and methodologies to analyse compatibility between radars and systems in other services are provided in Recommendation ITU-R M.1461;

f) that radiodetermination radars operate in the band 33.4-36 GHz;

g) that the frequency band 33.4-34.2 GHz is allocated to the radiolocation service on a primary basis;

h) that the frequency band 34.2-34.7 GHz is allocated to the radiolocation and space research (deep space) (Earth-to-space) services on a primary basis;

j) that the frequency band 34.7-35.2 GHz is allocated to the radiolocation service on a primary basis and to space research service on a secondary basis;

k) that the frequency band 35.2-35.5 GHz is allocated to the meteorological aids and radiolocation services on a primary basis;

l) that the frequency band 35.5-36 GHz is allocated to the meteorological aids, Earth exploration-satellite (active), radiolocation, and space research (active) services on a primary basis, *recommends*

1 that the technical and operational characteristics of the radiodetermination radars described in Annex 1 be considered representative of those operating in the frequency band 33.4-36 GHz;

2 that in the case of continuous (non-pulsed) interference, an interfering signal power to radar receiver noise power level, *I*/*N*, of –6 dB should be used as the required protection level for radiolocation systems for sharing studies in general;

3 that for studies of sharing the band 33.4-36 GHz between radars in the radiodetermination service and systems in other services, the following criteria be used:

– that for radiometric imagers the short-term protection criteria should be –137.8 dB(W/2 GHz) for not longer than 3 s, and the long-term protection criteria should be no more than –144.8 dB(W/2 GHz) for not longer than 60 s;

– that for metric radars and seekers the short-term protection criteria should be –126.2 dB(W/6 MHz) for not longer than 5 s, and the long-term protection criteria should be no more than –136.1 dB(W/6 MHz) for not longer than 60 s.

Annex 1

Characteristics of, and protection criteria for radars operating in the radiodetermination service in the frequency band 33.4-36 GHz

1 Purpose

The characteristics and protection criteria in this Recommendation have been provided for use in sharing studies called for under Resolutions 712 (WRC-2000) and 730 (WRC-2000) and to assess the compatibility between the radars and other systems operating in the band 33.4-36 GHz.

2 Background

WRC-97 was asked to consider the provision of up to 1 GHz of frequency spectrum around 35 GHz for use by space-based active earth sensors. ITU-R studied the compatibility between active spaceborne sensors and systems in the radionavigation and radiolocation services (multiple bands were considered). While studies performed prior to WRC-97 indicated that it is possible to allow active spaceborne sensors and the radar systems to co-exist in the same band without exceeding the protection criteria, WRC-97 decided to allocate 35.5-36 GHz to the SRS on a primary basis subject to No. 5.551A of the Radio Regulations (RR). WRC-2000 resolved to review this allocation, amongst others in the 35-38 GHz band, and established WRC-03 agenda item 1.12 to review this issue. This Recommendation provides the technical characteristics and protection criteria for the radiolocation systems operating in the frequency band 33.4-36 GHz.

3 Technical characteristics

Frequencies around 35 GHz and 94 GHz, correspond roughly to the first two propagation windows in the atmospheric absorption characteristics of the millimeter wave spectrum, and use of these frequencies is required by systems in the radiodetermination service in order to achieve the high measurement accuracy and target resolution possible at millimeter wavelength. Both passive and active sensors operating in the radiodetermination service around these frequencies are used for mapping, target identification, navigation, aim-point determination, test range instrumentation, etc. Table 1 summarizes technical characteristics of representative systems deployed in these bands. This information is sufficient for general calculation to assess the compatibility between these radars and other systems.

TABLE 1

Technical characteristics of radars around 35 GHz

Parameter	Imaging	Imaging	Metric	Metric	Seeker
Sensor type	Passive	Active	Active	Active	Active
Modulation	–	Pulse	Pulse	Pulse	Linear FM
Compression ratio	–	–	–	–	200
Pulse width	–	0.05	0.25	0.05	10
Tx peak power (kW)	–	0.5	135	1	0.001
PRF (kHz)	–	30	1	50	10
RF bandwidth (MHz)	–	80	10	101	12
Antenna gain (dBi)	35	30	52	51	28.7
Beamwidth (degrees)	0.5 × 3.0	0.75 × 10	0.25 × 0.25	0.5 × 0.5	4.4 × 4.4
Rx IF bandwidth (GHz)	2	0.040	0.006	0.185	0.100
Noise temperature (K)	850	–	–	–	–
Noise figure (dB)	–	4.5	10	10	5
Rx sensitivity (dBm)	–	–81	–95	–78	–93
Tuning	Fixed	Fixed	Fixed	Frequency hop	Fixed

PRF: pulse repetition frequency

4 Protection criteria

Short-term interference criteria are developed in the following paragraphs for the terrestrial radiolocation systems given in Table 1.

4.1 Radiometric imagers

Assuming negligible system gain variation, the minimum temperature sensitivity, ΔT of a radiometric imaging system is:

$$\Delta T = \frac{T_A + T_r}{\sqrt{B \cdot t_i}} \tag{1}$$

where:

- T_A: antenna noise temperature
- T_r: receiver noise temperature
- B: RF bandwidth
- t_i: integration time.

The radiometer threshold, ΔP is given by:

$$\Delta P = k \; \Delta T \, B \tag{2}$$

where k is Boltzman's constant = 1.38 × 10^{-23}, and ΔT and B are as given above. Using equations (1) and (2), we find that a radiometer with a 2 GHz bandwidth, 850 K system noise temperature and a 1 ms integration time has ΔP = –137.8 dB(W/2 GHz).

Short-term protection criterion

Given that it is an unlikely event, an operator can accept a severely degraded image for several seconds. Permitting the unwanted signal level to approach the radiometer's threshold results in an allowed unwanted signal level of –137.8 dB(W/2 GHz) for no more than 3 s.

Long-term protection criterion

A lesser degradation may be considered for time periods lasting up to 1 min. In this case the degradation is not necessarily readily evident to an operator, but does cause some loss in image resolution. Permitting the unwanted signal to reach 20% of the radiometer's threshold yields an allowed interference level of –144.8 dB(W/2 GHz) for no more than 60 s.

4.2 Metric radars and seekers

For the case of terrestrial metric (instrumentation) radars and the seekers, we note that two important performance parameters, angular accuracy σ_θ and target detection range R, are related to the received S/N by:

$$\sigma_\theta \; \alpha \; \frac{1}{\sqrt{S/N}} \tag{3}$$

$$R \; \alpha \; \frac{1}{\sqrt[4]{S/N}} \tag{4}$$

Narrow antenna beamwidth and high angular accuracy are possible with fairly small antenna sizes at millimeter wavelengths. This characteristic, in fact, is a major reason why missile seekers and instrumentation radars have been developed at these frequencies. From equations (3) and (4) we see that the angular accuracy of the radar is more sensitive to the received *S*/*N* than is the detection range so this performance parameter will be used to determine allowed interference levels[1].

As in the case of the imaging system in the previous section, we can establish short term and long-term criteria for allowed degradation in system performance due to unwanted signals (interference).

Short-term interference is allowed to significantly degrade the system for a period of time short enough that it may be acceptable to the operator, given that it is an unlikely event. Long-term interference is allowed to incrementally degrade system performance to an extent not readily apparent to the operator, but is otherwise acceptable for the specified duration of time.

Short-term protection criterion

A degradation in the radar *S*/*N* will cause a tracking error, which can partially negate the advantage of operating at higher frequencies, and may significantly affect the radar's mission. Permitting an unwanted signal to reach the radar noise level (I/N = 0 dB) will result in a 40% increase in the angle error. We can again assume that this degradation is not overly important – given that it is an unlikely event – for periods of time less than about 5 s. The allowed unwanted signal level can then be as great as –126.2 dB(W/6 MHz) for no more than 5 s (using the radar with the narrowest bandwidth given in Table 1).

Long-term protection criterion

It would seem reasonable that the radar error becomes more important over increasingly longer periods of time. For periods up to 1 min in duration it should be assumed that an increase in the angle error, due to an unwanted signal, should not exceed 5%. The long-term criterion is then an allowed unwanted signal level of –136.1 dB(W/6 MHz) for no more than 60 s.

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[1] It is assumed here, for simplicity, that interfering signals will be interpreted by the victim receiver as an increase in the noise power in the IF stages. The actual response by radar systems may need to be considered, but is beyond the scope of this generalized treatment.