

RECOMMENDATION ITU-R M.1463*

**CHARACTERISTICS OF AND PROTECTION CRITERIA FOR RADARS
OPERATING IN THE RADIODETERMINATION SERVICE IN
THE FREQUENCY BAND 1 215-1 400 MHz**

(Question ITU-R 226/8)

(2000)

The ITU Radiocommunication Assembly,

considering

- a) that 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 radars operating in the radiodetermination service are determined by the mission of the system and vary widely even within a band;
- c) that the radionavigation service is a safety service as specified by RR No. S4.10 and harmful interference to it cannot be accepted;
- d) that considerable radiolocation and radionavigation spectrum allocations (amounting to about 1 GHz) have been removed or downgraded since WARC-79;
- e) that some ITU-R technical groups are considering the potential for the introduction of new types of systems (e.g. fixed wireless access and high density fixed and mobile systems) or services in bands between 420 MHz and 34 GHz used by radars in the radiodetermination service;
- f) that representative technical and operational characteristics of systems operating in bands allocated to the radiodetermination service are required to determine the feasibility of introducing new types of systems;
- g) that procedures and methodologies are needed to analyse compatibility between radars operating in the radiodetermination service and systems in other services;
- h) that the frequency bands 1 215-1 300 MHz and 1 350-1 400 MHz are allocated to the radiolocation service on a primary basis, and the frequency band 1 300-1 350 MHz is allocated to the radiolocation service on a secondary basis;
- j) that the frequency band 1 300-1 350 MHz is allocated on a primary basis to the aeronautical radionavigation service, limited to ground-based radars and associated airborne transponders;
- k) that the frequency band 1 215-1 300 MHz is additionally allocated on a primary basis to the radionavigation service in many countries;
- l) that the frequency band 1 215-1 260 MHz is allocated to the radionavigation-satellite service (space-to-Earth) on a primary basis;
- m) that the frequency band 1 215-1 300 MHz is allocated to the Earth exploration-satellite (active) and space research (active) services on a primary basis;
- n) that the frequency band 1 350-1 400 MHz is allocated to the fixed and mobile services on a primary basis, in Region 1, and that the frequency band 1 215-1 300 MHz is also allocated to the fixed and mobile services on a primary basis in the countries listed in RR No. S5.330,

* This Recommendation should be brought to the attention of Radiocommunication Study Group 7 and the International Civil Aviation Organization (ICAO).

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 1 215-1 400 MHz;
- 2 that Recommendation ITU-R M.1461 be used as a guideline in analysing compatibility between radars operating in the radiodetermination service with systems in other services;
- 3 that in the case of continuous (non-pulsed) interference, an interfering signal power to radar receiver noise power level, I/N , of -6 dB be used as the required protection level for the radiodetermination radars, and that this level represents the net protection level if multiple interferers are present;
- 4 that in the case of pulsed interference, the criteria should be based on a case-by-case analysis considering the undesired pulse train characteristics and, to the extent possible, the signal processing in the radar receiver.

NOTE 1 – This Recommendation will be revised as more detailed information becomes available.

ANNEX 1

Technical and operational characteristics of radiodetermination radars operating in the frequency band 1 215-1 400 MHz

1 Introduction

The characteristics of radiodetermination radars operating worldwide in the frequency band 1 215-1 400 MHz are presented in Table 1, and described further in the following paragraphs. Those characteristics specifically for wind profiler radars are found in § 4 of this Annex.

2 Technical characteristics

The band 1 215-1 400 MHz is used by many different types of radars on land-based fixed and transportable platforms. Radiodetermination functions performed in the band include long range search tracking and surveillance. Radar operating frequencies can be assumed to be uniformly spread throughout the band 1 215-1 400 MHz. Table 1 contains technical characteristics of representative radiolocation and radionavigation radars deployed in the 1 215-1 400 MHz band.

2.1 Transmitters

The radars operating in the 1 215-1 400 MHz band use a variety of modulations including continuous wave (CW) pulses, frequency modulated (chirped) pulses and phase coded pulses. Cross-field, linear beam and solid state output devices are used in the final stages of the transmitters. The trend in new radar systems is toward linear beam and solid state output devices due to the requirement of Doppler signal processing. Also, the radars deploying solid state output devices have lower transmitter peak output power and higher pulsed duty cycles approaching 50% when operating on a single channel (a single channel may consist of three or four discrete frequencies in a 10 MHz bandwidth). There is also a trend towards frequency agile type radar systems which will suppress or reduce interference.

Typical transmitter RF emission bandwidths of radars operating in the 1 215-1 400 MHz band range from 0.5 to 2.5 MHz. Transmitter peak output powers range from 45 kW (76.5 dBm) for solid state transmitters to 5 MW (97 dBm) for high power radars using klystrons.

2.2 Receivers

The newer generation radar systems use digital signal processing after detection for range, azimuth and Doppler processing. Generally, included in the signal processing are techniques used to enhance the detection of desired targets and to produce target symbols on the display. The signal processing techniques used for the enhancement and

identification of desired targets also provides some suppression of low-duty cycle interference, less than 5%, that is asynchronous with the desired signal.

Also, the signal processing in the newer generation radars using chirped and phase coded pulses produces a processing gain for the desired signal and may also provide suppression of undesired signals.

Some of the newer low power solid state transmitters use high-duty cycle multiple receiver channel signal processing to enhance the desired signal returns. Some radar receivers have the capability to identify RF channels that have low undesired signals and command the transmitter to transmit on those RF channels.

2.3 Antennas

A variety of types of antennas are used on radars operating in the 1 215-1 400 MHz band. Newer generation radars using reflector type antennas have multiple horns. Dual horn are used for transmit and receive to improve detection in surface clutter. Also, multiple horn, stack beam, reflector antennas are used for three-dimensional radars. The multiple horn antennas will reduce the level of interference. Distributed phased array antennas are also used on some radars in the band 1 215-1 400 MHz. The distributed phase array antennas have transmit/receive modules mounted on the antenna. Also, radars using phased array antennas generally have lower side-lobe levels than reflector type antennas, and have a narrow scanning beam in elevation.

Since the radars in the 1 215-1 400 MHz band perform search, track, and long range surveillance functions the antennas scan 360° in the horizontal plane. Horizontal, vertical and circular polarizations are used.

TABLE 1

1 215-1 400 MHz radiodetermination system characteristics

Parameter	System 1	System 2	System 3	System 4
Peak power into antenna (dBm)	97	80	76.5	80
Pulse duration (μs)	2	88.8; 58.8 (Note 1)	0.4; 102.4; 409.6 (Note 2)	39 single frequency 26 and 13 dual frequency (Note 3)
Pulse repetition rate (pps)	310-380 staggered	291.5 or 312.5 average	200-272 long range 400-554 short range	774 average
Chirp Bandwidth for frequency modulated (chirped) pulses	Not applicable	770 kHz for both pulse widths	2.5 MHz for 102.4 μs 625 kHz pour 409.6 μs	Not applicable
Phase-coded sub-pulse width (μs)	Not applicable			1
Compression ratio	Not applicable	68.3:1 and 45.2:1	256:1 for both pulses	
RF emission bandwidth (3 dB) (MHz)	0.5	1.09	2.2; 2.3; 0.58;	1
Output device	Klystron	Transistor		Cross field amplifier

TABLE 1 (*end*)

Parameter	System 1	System 2	System 3	System 4
Antenna type	Horn-fed reflector	Stack beam reflector	Rotating phased array	Parabolic cylinder
Antenna polarization	Horizontal, vertical, LHCP, RHCP	Vertical, circular	Horizontal	Vertical
Antenna maximum gain (dBi)	34.5, transmit 33.5, receive	32.4-34.2, transmit 31.7-38.9, receive	38.9, transmit 38.2, receive	32.5
Antenna elevation beamwidth (degrees)	3.6 shaped to 44	3.63-5.61, transmit 2.02-8.79, receive	1.3	4.5 shaped to 40
Antenna azimuthal beamwidth (degrees)	1.2	1.4	3.2	3.0
Antenna horizontal scan characteristics (rpm)	360° mechanical at 5 rpm		360° mechanical at 6 rpm for long range and 12 rpm for short range	360° mechanical at 6, 12 or 15 rpm
Antenna vertical scan characteristics	Not applicable	−7° to +30° in 12.8 or 13.7 ms	−1° to +19° in 73,5 ms	Not applicable
Receiver IF bandwidth	780 kHz	0.69 MHz	4.4 to 6.4 MHz	1.2 MHz
Receiver noise figure (dB)	2		4.7	3.5
Platform type	Fixed		Transportable	
Percentage of time system operates (%)	100			

NOTE 1 – The radar has 44 RF channel pairs with one of 44 RF channel pairs selected in normal mode. The transmitted waveform consists of a 88.8 μ s pulse at frequency f_1 followed by a 58.8 μ s pulse at frequency f_2 . Separation of f_1 and f_2 is 82.854 MHz.

NOTE 2 – The radar has 20 RF channels in 8.96 MHz increments. The transmitted waveform group consists of one 0.4 μ s P0 pulse (optional) which is followed by one 102.4 μ s linear frequency modulated pulse (if 0.4 μ s P0 is not transmitted) of 2.5 MHz chirp which may be followed by one to four long range 409.6 μ s linear frequency modulated pulses each chirped 625 kHz and transmitted on different carriers separated by 3.75 MHz. Normal mode of operation employs frequency agility whereby the individual frequencies of each waveform group are selected in a pseudo-random manner from one of the possible 20 RF channels within the 1 215-1 400 MHz band.

NOTE 3 – The radar has the capability of operating single frequency or dual frequency. Dual RF channels are separated by 60 MHz. The single channel mode uses the 39 μ s pulse width. In the dual channel mode, the 26 μ s pulse is transmitted at frequency f , followed by the 13 μ s pulse transmitted at $f + 60$ MHz.

3 Protection criteria

The desensitizing effect, on radiodetermination radars from other services of a CW or noise-like type modulation is predictably related to its intensity. In any azimuth sectors in which such interference arrives, its power spectral density can, to within a reasonable approximation, simply be added to the power spectral density of the radar receiver thermal noise. If power spectral density of radar-receiver noise in the absence of interference is denoted by N_0 and that of noise-like interference by I_0 , the resultant effective noise power spectral density becomes simply $I_0 + N_0$. An increase of about 1 dB would constitute significant degradation, equivalent to a detection-range reduction of about 6%. Such an increase corresponds to an $(I + N)/N$ ratio of 1.26, or an I/N ratio of about –6 dB. This represents the aggregate effect of multiple interferers, when present; the tolerable I/N ratio for an individual interferer depends on the number of interferers and their geometry, and needs to be assessed in the course of analysis of a given scenario. If CW interference were received from most azimuth directions, a lower I/N ratio would need to be maintained.

The aggregation factor can be very substantial in the case of certain communication systems in which a great number of stations can be deployed.

The effect of pulsed interference is more difficult to quantify and is strongly dependent on receivers/processor design and mode of operation. In particular, the differential processing gains for valid-target return, which is synchronously pulsed, and interference pulses, which are usually asynchronous, often have important effects on the impact of given levels of pulsed interference. Several different forms of performance degradation can be inflicted by such desensitization. Assessing it will be an objective for analyses of interactions between specific radar types. In general, numerous features of radiodetermination radars can be expected to help suppress low-duty cycle pulsed interference, especially from a few isolated sources. Techniques for suppression of low-duty cycle pulsed interference are contained in Recommendation ITU-R M.1372 – Efficient use of the radio spectrum by radar stations in the radiodetermination service.

4 Wind profiler radars

A wind profiler radar is a Doppler radar for measuring wind from the ground, utilizing the radar echo from clear-air turbulence. Clear-air turbulence causes the fluctuation of the refractive index in which the scale is half the radar wavelength (Bragg scattering). A wind profiler radar uses a number of skyward pointing antenna beams. From the Doppler shift along an antenna beam direction, the wind velocity along the radar beam can be measured. Assuming horizontal homogeneity of the wind field, three components of a wind vector can be measured by at least three beam observations. Observable height range of radars depends upon transmit power, antenna size and radar frequency as well as the magnitude of refractivity fluctuation of the atmosphere.

Currently several frequencies are used for wind profiler radars, including 50 MHz, 400 MHz, 900 MHz, and 1 300 MHz. There are advantages and disadvantages relating to the use of each of these frequencies. Usually systems operating near 400 MHz with large antenna apertures are used to observe the wind at upper troposphere or lower stratosphere. In contrast, systems operating at 900 MHz or higher can measure only up to several kilometres in height. However, the advantage of higher frequency systems are compact antenna size and shorter “blind” range, which means that these systems are suitable for boundary layer wind measurements and for low-cost implementation. Table 2 contains the characteristics of wind profiler radars specifically operating in the frequency range 1 300–1 375 MHz. Recommendation ITU-R M.1227 contains additional information and characteristics of wind profiler radars, to include those operating around 1 000 MHz.

TABLE 2

Characteristics of wind profiler radars operating in 1 300-1 375 MHz

Parameter	Value
Peak power into antenna	1 kW (60 dBm)
Pulse duration (μ s)	0.5, 1, 2
Pulse repetition rate (kHz)	1-25
RF emission bandwidth (MHz)	8
Transmitter output device	Transistor
Antenna type	Parabolic reflector
Antenna polarization	Horizontal
Antenna maximum gain (dB)	33.5
Antenna elevation beamwidth (degrees)	3.9
Antenna azimuthal beamwidth (degrees)	3.9
Antenna horizontal scan	Not applicable
Antenna vertical scan	-15° to $+15^{\circ}$ (approximately 15 s)
Receiver IF bandwidth (MHz)	2.5
Receiver noise figure (dB)	1.5
Platform type	Fixed site
Percentage of time system operates (%)	100
