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Recommendation ITU-R M.1460-2 (02/2015)

Technical and operational characteristics and protection criteria of radiodetermination radars in the frequency band 2 900-3 100 MHz

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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.1460-2*

Technical and operational characteristics and protection criteria of radiodetermination radars in the frequency band 2 900-3 100 MHz

(2000-2006-2015)

Scope

This Recommendation provides the technical and operational characteristics and protection criteria for radiodetermination systems operating in the frequency band 2 900-3 100 MHz which is allocated to the radiodetermination service on a primary basis. It was developed with the intention to support sharing studies in conjunction with Recommendation ITU-R M.1461 addressing analysis procedures for determining compatibility between radars operating in the radiodetermination service and other services.

Keywords

Radar, shipborne, land-based, characteristics, protection

Abbreviations/Glossary

$\Leftrightarrow$	correspondence (between carrier frequency and elevation angle)
AGC	automatic gain control
AIS	automatic identification system
Burn-thru	a mode in which power is concentrated in a narrow elevation sector to facilitate detection of targets under difficult conditions
BW	bandwidth or beamwidth, depending on context
CDMA	Code division multiple access
CFAR	Constant-false alarm rate
Chirp-thru	a type of burn-thru mode in which pulse compression is used to reduce return from extended clutter
Coincident video	pulse-to-pulse correlation
CSG	clean strobe generation. This is a technique for observing signals from active sources using the radar only as a receiver. It can be used with or without sidelobe blanking applied
Dicke fix	hard limiting of composite received signal (radar return plus interference) in a bandwidth substantially wider than that of the desired radar signal followed by filtering to a narrow bandwidth. This discriminates against wideband interference
ENG/OB	Electronic news gathering/outside broadcast

* This Recommendation should be brought to the attention of the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO), the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), the International Electrotechnical Commission (IEC) and the World Meteorological Organization (WMO).

f_{co}	cut-off frequency of filter
FTC	fast time constant
IF	Intermediate frequency
IMO	International Maritime Organization
INT	non-coherent (video) multiple-pulse integration
Jam strobe	similar to CSG
MTI	Moving-target indication
nm	Nautical miles
PRI	Pulse-repetition interval
PRF	Pulse-repetition frequency
PPI	Pulses per inch
PSD	Power spectral density
PW	Pulse width
QPSK	Quadrature phase shift keying
RCS	Radar cross section
STC	Sensitivity time control
WPB	Wide-pulse blanking

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 radiodetermination radars are determined by the mission of the system and vary widely even within a frequency band;
- c) that representative technical and operational characteristics of radars operating in the radiodetermination service are required to determine, if necessary, the feasibility of introducing new types of systems into frequency bands allocated to the radiodetermination service,

noting

- a) that technical and operational characteristics of maritime radar beacons operating in the frequency band 2 900-3 100 MHz are to be found in Recommendation ITU-R M.824;
- b) that technical and operational characteristics of aeronautical radionavigation radars operating in the frequency band 2 900-3 100 MHz are similar to those operating in the frequency band 2 700-2 900 MHz, which are found in Recommendation ITU-R M.1464 and ground-based meteorological radars which are found in Recommendation ITU-R M.1849;
- c) some test results illustrating susceptibility of maritime radars are contained in Report ITU-R M.2050. Excerpts of this material have been reproduced in Annex 3,

recognizing

- a) that the radionavigation service is a safety service as delineated in the Radio Regulations No. 4.10;
- b) that the required protection criteria depends upon the specific types of interfering signals such as those described in Annex 3, § 3;
- c) that the application of protection criteria may require consideration for the inclusion of the statistical nature of the criteria and other elements of the methodology for performing compatibility studies (e.g. antenna scanning and motion of the transmitter and propagation path loss). Further development of these statistical considerations may be incorporated into future revisions of this Recommendation, as appropriate,

recommends

- 1 that the technical and operational characteristics of the radiodetermination radars described in Annex 1 should be considered representative of those operating in the frequency band 2 900-3 100 MHz;
- 2 that this Recommendation along with Recommendation ITU-R M.1461 should be used as a guideline in analysing compatibility between radiodetermination radars with systems in other services;
- 3 that the criterion of interfering signal power to radar receiver noise power level, an I/N ratio of -6 dB should be used as the required protection level for the radiodetermination radars in the frequency band 2 900-3 100 MHz, even if multiple interferers are present. Further information is provided in Annex 2;
- 4 that the results of interference susceptibility trials performed on shipborne radionavigation radars operating in the frequency band 2 900-3 100 MHz, which are contained in Annex 3, should be used in assessing interference into shipborne radionavigation radars, noting that the results are for non-fluctuating targets and that radar cross-section (RCS) fluctuations should be taken into account (see also Report ITU-R M.2050).

Annex 1

Technical and operational characteristics of radiodetermination radars in the frequency band 2 900-3 100 MHz

1 Introduction

Many transportable and shipborne radars operate in the frequency band 2 900-3 100 MHz. Shipborne radiolocation radars are discussed in § 2 through 4. Shipborne radionavigation radars are discussed briefly in § 5.

2 Technical characteristics of radiolocation radars other than meteorological radars

Characteristics of six representative shipborne radiolocation radars are presented in Table 1, and those of three representative land-based radiolocation radars are presented in Table 2.

All of the radiolocation systems identified are high-powered surveillance radars. The major radiolocation radars operating in this frequency band are primarily used for detection of airborne objects. They are required to measure target altitude as well as range and bearing. Some of the airborne targets are small and some are at ranges as great as 300 nm (approximately 545 km), so these radiolocation radars must have great sensitivity and must provide a high degree of suppression for all forms of clutter return, including that from sea, land and precipitation. The radiolocation radar emissions in this frequency band are not required to trigger radar beacons.

Largely because of those mission requirements, the radiolocation radars using this frequency band tend to possess the following general characteristics:

- they tend to have high transmitter peak and average power;
- they typically use master-oscillator-power-amplifier transmitters rather than power oscillators. They are usually tuneable, and some of them are frequency-agile. Some of them use linear-FM (chirp) or phase-coded intra-pulse modulation. The solid state technologies provide very stable wideband solutions;
- they can use frequency agility to mitigate some of the effects of interference;
- some of them have multiple or elevation-steerable beams using electronic beam steering. Active electronically steerable arrays embed the individual solid state transmitters in the antenna array and typically use higher duty cycles (typically 5 to 25%) to achieve the required average power levels with lower peak power levels than is achievable with vacuum tube technologies;
- some of them incorporate power-management features, i.e. capability for reducing transmitter power in some beams or for some functions while using full power for others;
- they typically employ versatile receiving and processing capabilities, such as use of auxiliary sidelobe-blanking receiving antennas, processing of coherent-carrier pulse trains to suppress clutter return by means of moving-target indication (MTI), constant-false-alarm-rate (CFAR) techniques, and, in some cases, adaptive selection of operating frequencies based on sensing of interference on various frequencies.

Some or all of the radiolocation radars whose characteristics are presented in Table 1 and 2 possess these properties, although they do not illustrate the full repertoire of attributes that might appear in future systems.

TABLE 1

Characteristics of shipborne radiolocation radars operating in the frequency band 2 900-3 100 MHz

Characteristics	Units	Radar No. 1	Radar No. 2	Radar No. 3	Radar No 3A	Radar No. 3B	Radar No. 3C
Overall tuning range	MHz	2 910-3 100.5	Nominally 2 900-3 100	2 910-3 100.5	2 900-3 100	2 900- 3 100	2 900- 3 100
Tuning options and frequency/elevation relationship	MHz	Deterministic: High frequency $\Leftrightarrow$ low elevation angle				8 Channels 20 MHz each from 2 920 to 3 080 MHz	
Frequency at horizon	MHz	Smooth sea: 3 048-3 051	Smooth sea: 3 055	Smooth sea: 3 051	Not applicable	Not applicable	Not applicable
Coverage/ performance modes		Long-range Long-range/limited elevation Short-range Short-range/limited elevation (each with normal, coincident video, or moving target indication (MTI) beams/pulses)	Normal ($\leq 45^\circ$ elevation) 5° Burn-thru: 1 fixed 1.6° beam Chirp-thru: 1 beam with chirped waveform Long-range MTI, 3-pulse; 5° or 45° Short-range MTI, 4-pulse; 5° or 45° Passive	Long-range ($\leq 12.8^\circ$ elevation) Long-range/low-elevation ($\leq 4.8^\circ$) High-angle ($\leq 41.6^\circ$) Limited-elevation ($\leq 12.8^\circ$) High-data-rate ($\leq 41.6^\circ$) MTI ($\leq 36.9^\circ$)		Short range to 45 km (24 nm) Long range to 90 km (48 nm)	

TABLE 1 (*continued*)

Characteristics	Units	Radar No. 1	Radar No. 2	Radar No. 3	Radar No 3A	Radar No. 3B	Radar No. 3C
Tx pulse waveform-type		Unmodulated	Normal, 5°, and MTI modes: 9 stepped-frequency sub-pulses (1.5 MHz between adjacent subpulses); Burn-thru mode: unmodulated Chirp-thru mode: linear FM	Unmodulated	Non Linear FM	Non-Linear FM	FM
Tx RF output device(s)		Klystron	Cross-field amplifier (amplitron)	Klystron	Solid state	Solid state	Solid state
Tx filter			High-pass; $f_{co} \geq 2\,840$ MHz			Not applicable	
Tx maximum peak power	kW	900-1 000 at horizon to 35°	2 200 at horizon to 5°	1 000-1 500 at horizon to 35°	200	170	4-90
Tx peak powers at higher elevations and/or reduced-range modes	kW	Power decreases smoothly from circa 1 000 at 35° to 300 at 41.6°	600 at 5.5° to 21°; 60 above 21° and at horizon in most MTI pulses	Power decreases smoothly from circa 1 000 at 35° to 300 at 41.6°		Power can be reduced to 0.033	
Tx pulse/subpulse width	µs	Early units: 4 and 3 or 2 Later units: 10, 4.6, and 2.5	Normal, 5°, and MTI: 27 (9 contiguous 3 µs sub-pulses); Burn-thru and chirp-thru: 27	Long-range and long-range/low-elevation: 10 High-angle and limited-elevation: 4.6 High-data-rate and MTI: 2.5	0.1 to 1 000	0.1, 5 and 33	0.1 to 100 Duty cycle < 20%

TABLE 1 (*continued*)

Characteristics	Units	Radar No. 1	Radar No. 2	Radar No. 3	Radar No 3A	Radar No. 3B	Radar No. 3C
Pulse-compression ratio		Not applicable	Normal, MTI, and burn-thru: not applicable Chirp-thru: 9	Not applicable	Up to 20 000	100, 660	Up to 400
Tx 3 dB bandwidth	MHz	10 μ s PW: approximately 0.1 4.6 μ s PW: approximately 0.225 2.5 μ s PW: approximately 0.7	Normal and MTI: 0.3/ sub-pulse Chirp-thru: 0.3 Burn-thru: 0.034	10 μ s PW: approximately 0.1 4.6 μ s PW: approximately 0.225 2.5 μ s PW: approximately 0.7	25	15 for short range, 20 for long range	15 or 3
Tx 20 dB bandwidth	MHz		Normal and MTI: 2/ sub-pulse Chirp-thru: 0.7 Burn-thru: 0.24			18 for short range and 22 for long range	
PRI ⁽¹⁾	μ s	Varied: 2 050 to 500 (2 050 at horizon) Fixed: 2 116	Normal: variable 2 830-732 (2 830 at horizon) Burn-thru, chirp-thru, and low-elevation: fixed at 2 830, 4 850, or 6 180	Varied: 3 106-426 (3 106 at horizon)	Varied: 3 000-100	12 for short range 64 for medium range and 365 for long range	2000-100

TABLE 1 (*continued*)

Characteristics	Units	Radar No. 1	Radar No. 2	Radar No. 3	Radar No 3A	Radar No. 3B	Radar No. 3C
Average PRI of full-power pulses containing horizon-level beams	µs		Normal mode: 5 120 5° mode: 4 977 Long-range 3-pulse MTI: 5°: 4 357 45°: 6 760 Short-range 4-pulse MTI: 5°: 10 534 45°: 19 695 (1 or 2 subpulses/pulse reach horizon)	Long-range: 7 491 Long-range/low-elevation: 6 190 High-angle: 10 972 Limited-elevation: 7 383 High-data-rate: 14 020 MTI: 9 886 or 10 903 (on alternate azimuth scans)		Not applicable	Not applicable
Polarization		Horizontal					Vertical
Antenna gain	dBi	Early units: 33.5 Later units: 37	38.5	37	40	27.5	Up to 40
Antenna beamwidths	degrees	Azimuth: 1.9 Elevation: 2.25	Azimuth: 1.5 Elevation: 1.6	Azimuth: 1.9 Elevation: 2.25	Azimuth: 1.1 to 5.0	2 in Azimuth 26.5 in Elevation	Azimuth: 1.5 to 6 Elevation: 4 to 20
Frequency shift for 1/2 BW elevation change		2.25 MHz (0.5° per MHz)	4.1 MHz (0.39° per MHz)	2.25 MHz (0.5° per MHz)		Not applicable	Not applicable
1st side-lobe suppression	dB	Early units: Azimuth: 16 Elevation: 20 Later units: Azimuth: 25 Elevation: 25	Azimuth: 25 Elevation: 15	Azimuth: 25 Elevation: 25		At least 28 dB from peak	
Remote side-lobe suppression		Often limited by structure scattering				At least 28 dB from peak	
Antenna azimuth scan type	degrees	Continuous 360				Not applicable	Continuous 360