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| **Document Title:** **Recommendation ITU-R M.1796-3** - Characteristics of and protection criteria for radars operating in the radiodetermination service in the frequency band 8 500-10 680 MHz |
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| **Purpose/Objective:** The purpose of this contribution is to update Characteristics of System A13, airborne radiodetermination radars operating in the frequency band 8 500-10 680 MHz. |
| **Abstract:** This Recommendation provides the technical and operational characteristics and protection criteria for radiodetermination systems operating in the frequency band 8 500-10 680 MHz. 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. |

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| **Radiocommunication Study Groups** |  |
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| prOPOSED UPDATE TO Recommendation ITU-R M.1796-3 |
| **Characteristics of and protection criteria for radars operating in the radiodetermination service in the frequency band 8 500-10 680 MHz** |

**Introduction**

Recommendation ITU-R M.1796-3 contains the characteristics and protection criteria for several radars operating in the radiodetermination service in the frequency band 8 500-10 680 MHz. These characteristics must be kept up to date to ensure ITU-R has the latest technical data on all systems as the Recommendations are used as the basis for any sharing study.

**Proposal**

In its contribution the U.S is proposing to update some of the characteristics of radar A13 in Table 1 of the radars in the radiodetermination service in the frequency band 8 500-10 680 MHz to ensure they correctly reflect the latest version of that radar. Therefore, the United States proposes that WP 5B initiate a revision of the Recommendation. The proposed updates are shown in track changes and highlighted in yellow in the Attachment. As no revisions are proposed to any other part of the Recommendation, the Attachment only contains the material through the end of Table 1 of Annex 1.

**Attachment**: Working document towards a preliminary draft revision of Recommendation ITU-R M.1796-3

ATTACHMENT

WORKING DOCUMENT TOWARDS A PRELIMINARY DRAFT REVISION OF RECOMMENDATION ITU-R M.1796-3

**Characteristics of and protection criteria for radars operating
in the radiodetermination service in the frequency
band 8 500-10 680 MHz**

(2007-2012-2014-2022)

**Summary of the revision**

This revision provides an update in Annex 1 to some of the characteristics of radar A13 in Table 1 of the radars in the radiodetermination service in the frequency band 8 500-10 680 MHz.

**Scope**

This Recommendation provides the technical and operational characteristics and protection criteria for radiodetermination systems operating in the frequency band 8 500-10 680 MHz. 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, Protection criteria, Search radar, Interference, radiodetermination

**Abbreviations/Glossary**

AESA Active electronically scanned array

AIS Automatic identification system

ASDE Airport surface detection equipment

BW Beamwidth

CDMA Code division multiple access

CFAR Constant-false-alarm-rate

CPI Coherent processing intervals

CW Continuouswave

DAA Detect-and-avoid

DBS Doppler beam sharpening

FET Field-effect transistor

FMCW Frequency modulated continuouswave

FTC Fast-time-constant

GCA Ground-controlled approach

GPS Global positioning system

IF Interfering signal

IMO International Maritime Organization

IMPATT Impact avalanche transit time

*I*/*N* Interference-to-noise

LFM Linear frequency modulation

MGM Monopulse ground mapping

NF Noise figure

nmi Nautical miles

PPI Planned position indicator

pps pulses per second

PRF Pulse reputation frequency

RCS Radar cross-section

RF Radio-frequency

rpm revolutions per minute

SAR Synthetic-aperture radar

SL Side-lobe

SNR Signal-to-noise ratio

STC Sensitivity-time-control

SART Search and rescue transponder

UA Unmanned aircraft

WA Weather avoidance

WS Wind-shear detection

**Related ITU Recommendations and Reports**

Recommendations

ITU-R [M.628](https://www.itu.int/rec/R-REC-M.628/en) Technical characteristics for search and rescue radar transponders

ITU-R [M.824](https://www.itu.int/rec/R-REC-M.824/en) Technical parameters of radar beacons

ITU-R [M.1176](https://www.itu.int/rec/R-REC-M.1176/en) Technical parameters of radar target enhancers

ITU-R [M.1372](https://www.itu.int/rec/R-REC-M.1372/en) Efficient use of the radio spectrum by radar stations in the radiodetermination service

ITU-R [M.1461](https://www.itu.int/rec/R-REC-M.1461/en) Procedures for determining the potential for interference between radars operating in the radiodetermination service and systems in other services

ITU-R [M.1849](https://www.itu.int/rec/R-REC-M.1849/en) Technical and operational aspects of ground-based meteorological radars

ITU-R [M.1851](https://www.itu.int/rec/R-REC-M.1851/en) Mathematical models for radiodetermination radar systems antenna patterns for use in interference analyses

Report

ITU-R [M.2204](https://www.itu.int/pub/R-REP-M.2204) Characteristics and spectrum considerations for sense and avoid systems use on Unmanned Aircraft Systems (UAS)

The ITU Radiocommunication Assembly,

*considering*

*a)* that antenna, signal propagation, target detection, and necessary bandwidth characteristics of radars 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 ITU-R is considering the potential for the introduction of new types of systems or services in frequency bands between 420 MHz and 34 GHz used by radars in the radiodetermination service;

*d)* 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 9 300-9 500 MHz are to be found in Recommendation ITU-R M.824;

*b)* that technical parameters of radar target enhancers operating in the frequency band 9 300‑9 500 MHz are to be found in Recommendation ITU-R M.1176;

*c)* that technical and operational characteristics of search and rescue radar transponders (SART) operating in the frequency band 9 200-9 500 MHz are to be found in Recommendation ITU‑R M.628,

*considering further*

*a)* that the required protection criteria depend upon the specific types of interfering signals;

*b)* that the application of protection criteria may require consideration for the inclusion of the statistical nature of the application of those criteria and other elements of the methodology for performing compatibility studies (e.g. propagation loss). Further development of these statistical considerations, together with the required probability of detection for various maritime operational scenarios 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 8 500‑10 680 MHz;

**2** that this Recommendation, in conjunction with Recommendation ITU‑R M.1461, should be considered in analysing compatibility between radiodetermination radars and systems in other services;

**3** that the criterion of interfering signal power to radar receiver noise power level, an interference-to-noise (*I*/*N*)ratio of −6 dB, should be considered as the required protection level for radiodetermination radars in the frequency band 8 500-10 680 MHz, even if multiple interferers are present (see Annex 2);

**4** that the results of interference susceptibility trials performed on shipborne radionavigation radars operating in the frequency band 9 200-9 500 MHz, which are contained in Annex 3, should also be considered 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.

**Annex 1

Technical and operational characteristics of radars in the radiodetermination service in the frequency band 8 500-10 680 MHz**

**1 Introduction**

The characteristics of radiodetermination radars operating worldwide in the frequency band 8 500‑10 680 MHz are presented in Tables 1, 2, 3 and 4, and described further in the following paragraphs.

**2 Technical characteristics**

The frequency band 8 500-10 680 MHz is used by many different types of radars on land‑based, transportable, shipboard, and airborne platforms. Radiodetermination functions performed in the frequency band include airborne and surface search, ground-mapping, terrain-following, navigation (both aeronautical and maritime), target-identification, and meteorological (both airborne and ground-based). Other major differences among the radars include transmit duty cycles, emission bandwidths, presence and types of intra-pulse modulation, frequency-agile capabilities of some, transmitter peak and average powers, and types of transmitter RF power devices. These characteristics, individually and in combination, all have major bearing on the compatibility of the radars with other systems in their environment, while other characteristics affect that compatibility to lesser degrees. Radar operating frequencies can be assumed to be uniformly spread throughout each radar’s tuning frequency band. Tables 1, 2, 3 and 4 contain technical characteristics of representative radiolocation and radionavigation radars deployed in the frequency band 8 500‑10 680 MHz with the exception of ground based meteorological radars, which are contained in Recommendation ITU-R M.1849.

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 nautical miles (~ 556 km), so these radiolocation radars must have great sensitivity and must provide a high degree of suppression to all forms of clutter return, including that from sea, land, and precipitation. In some cases, the radar emissions in this frequency band are required to trigger radar beacons.

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

– they tend to have low to medium (from 1 W to 250 000 W) transmitter peak and average power, with notable exceptions;

– 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 – or non-linear – FM (chirp) or phase-coded intra-pulse modulation;

– some of them have antenna main beams that are steerable in one or both angular dimensions using electronic beam steering;

– they typically employ versatile receiving and processing capabilities, such as auxiliary sidelobe‑blanking receive antennas, processing of coherent-carrier pulse trains to suppress clutter return by means of moving-target-indication, constant-false-alarm-rate (CFAR) techniques, and, in some cases, adaptive selection of operating frequencies based on sensing of interference on various frequencies;

– individual radars often have numerous different pulse widths and pulse repetition frequencies; some chirp radars have a choice of chirp bandwidths; and some frequency‑agile radars have a variety of agile‑ or fixed-frequency modes. This flexibility can provide useful tools for maintaining compatibility with other radars in the environment.

Some or all of the radars whose characteristics are presented in Tables 1, 2, 3 and 4 possess these properties. Those Tables are extensive to exemplify the wide variety of radar missions, platforms, waveforms, bandwidths, duty cycles, power levels, transmitter devices, etc. found in radars using this frequency band, although they do not illustrate the full repertoire of attributes that might appear in future systems.

TABLE 1

**Characteristics of airborne radiodetermination radars operating in the frequency band 8 500-10 680 MHz**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **System A1** | **System A2** | **System A3** | **System A4** |
| Function | Search and track radar (multifunction) | Airborne search radar | Ground-mapping and terrain-following radar (multifunction) | Track radar |
| Tuning range (MHz) | 9 300-10 000 | 8 500-9 600 | 9 240, 9 360 and 9 480 | 10 000-10 500 |
| Modulation | Pulse | Pulse | Non-coherent frequency-agile pulse-position modulation | CW, FMCW |
| Peak power into antenna (kW) | 17 | 143 (min)220 (max) | 95 | 1.5 |
| Pulse widths (μs) and pulse repetition rates (pps) | 0.285; 8200 to 23 000 | 2.5; 0.5400 and 1 600 | 0.3, 2.35, and 42 000, 425 and 250 | Not applicable |
| Maximum duty cycle | 0.0132 | 0.001 | 0.001 | 1 |
| Pulse rise/fall time (μs) | 0.01/0.01 | 0.02/0.2 | 0.1/0.1 | Not applicable |
| Output device | Travelling wave tube | Tunable magnetron | Cavity-tuned magnetron | Travelling wave tube |
| Antenna pattern type | Pencil | Fan | Pencil | Pencil |
| Antenna type | Planar array | Parabolic reflector | Flat-plate planar array | Planar array |
| Antenna polarization | Linear | Linear | Circular | Linear |
| Antenna main beam gain (dBi) | 32.5 | 34 | 28.3 | 35.5 |
| Antenna elevation beamwidth (degrees) | 4.6 | 3.8 | 5.75 | 2.5 |
| Antenna azimuthal beamwidth (degrees) | 3.3 | 2.5 | 5.75 | 2.5 |
| Antenna horizontal scan rate (degrees/s) | 236(118 scans/min) | 36 or 72(6 or 12 rpm) | Up to 106(Up to 53 scans/min) | 90 |
| Antenna horizontal scan type (continuous, random, sector, etc.) | Sector: ±60° (mechanical) | 360° (mechanical) | Sector: ±60° (mechanical) | Sector: ±60° (mechanical) |

TABLE 1 (*continued*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **System A1** | **System A2** | **System A3** | **System A4** |
| Antenna vertical scan rate (degrees/s) | 118(59 scans/min) | Not applicable | 148.42(Up to 137 scans/min) | 90 |
| Antenna vertical scan type | Sector: ±60° (mechanical) | Not applicable | Sector: +25/−40° (mechanical) | Sector: ±60° (mechanical) |
| Antenna side-lobe (SL) levels (1st SLs and remote SLs) (dBi) | 7.5 at 15° | Not specified | 5.3 at 10° | Not specified |
| Antenna height | Aircraft altitude | Aircraft altitude | Aircraft altitude | Aircraft altitude |
| Receiver IF 3 dB bandwidth (MHz) | 3.1; 0.11 | 5 | 5.0, 1.8 and 0.8 | 0.48 |
| Receiver noise figure (dB) | Not specified | Not specified | 6 | 3.6 |
| Minimum discernible signal (dBm) | −103 | −107; −101 | −101 |  |
| Total chirp width (MHz) | Not applicable | Not applicable | Not applicable | Not specified |
| RF emission bandwidth (MHz) − 3 dB− 20 dB | 3.1; 0.1122.2; 0.79 | 0.480; 2.71.5; 6.6 | (Frequency and pulse width dependent)100 to 118102 to 120 | Not specifiedNot specified |

TABLE 1 (*continued*)

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristics** | **System A5** | **System A6a**(1) | **System A6b**(1) |
| Function | Weather avoidance including wind-shear detection (navigation) | Weather avoidance (WA), including wind-shear detection (WS) (navigation) | Ground-mapping, including:Monopulse ground mapping (MGM) and Doppler beam sharpening (DBS) |
| Tuning range (MHz) | 9 330 | 9 305-9 410WA: frequency agile pulse-to-pulse (≤ 2 000 hops/s);WS: adaptive single frequency | 9 360 and 9 305-9 410MGM: frequency agile pulse-to-pulse (≤ 600 hops/s);DBS: single frequency (9 360) |
| Modulation | Pulse | WA: unmodulated and Barker-coded (5:1 and 13:1) pulses;WS: unmodulated pulses | MGM and DBS: Barker-coded (13:1) pulses |
| Peak power into antenna (W) | 150 | ≤ 150 | ≤ 150 |
| Pulse width (μs) andPulse repetition rate (pps) | 1 to 20180 to 9 000 | WA: 0.2-230; WS: 2WA: 2 000 pps for 0.2-6 μs pulses, decreasing to 230 pps for 230 μs pulses;WS: 3 600-3 940 pps | MGM: 1.3-260; DBS: 0.64-20MGM: 600 pps for 1.3-60 μs pulses, decreasing to 220 pps for 260 μs pulses;DBS: 700-1 600 pps for all pulse widths |
| Maximum duty cycle | Not specified | WA: 0.054;WS: 0.0076 | MGM: 0.057;DBS: 0.033 (0.024 long term) |
| Pulse rise/fall time (μs) | Not specified | WA: 0.02-0.05/0.01;WS: 0.02/0.01 | MGM: 0.01-0.02/0.01-0.02;DBS: 0.02-0.04/0.01 |
| Output device | Solid state | FET | FET |
| Antenna pattern type | Pencil | Pencil | Fan |
| Antenna type | Planar array | Planar array | Planar array |
| Antenna polarization | Not specified | Linear | Linear |
| Antenna main beam gain (dBi) | 34.4 | 32 | 28.7 |
| Antenna elevation beamwidth (degrees) | 3.5 | 4 | 42 |

TABLE 1 (*continued*)

|  |  |  |  |
| --- | --- | --- | --- |
| **Characteristics** | **System A5** | **System A6a**(1) | **System A6b**(1) |
| Antenna azimuthal beamwidth (degrees) | 3.5 | 2.7 | 2.7 |
| Antenna horizontal scan rate (degrees/s) | Not specified | ≤ 200(≤ 40 scans/min) | ≤ 200(≤ 40 scans/min) |
| Antenna horizontal scan type (continuous, random, sector, etc.) | Sector: ±30° | Sector: ±15 to ±135° (mechanical) | Sector: ±15 to ±135° (mechanical) |
| Antenna vertical scan rate | Not specified | ≤ 20 scans/min | Not applicable |
| Antenna vertical scan type (continuous, random, sector, etc.) | Not specified | 1 or 2 horizontal bars(mechanical) | Not applicable |
| Antenna side-lobe (SL) levels (1st SLs and remote SLs) (dBi) | +3.4 | 8 at 4.2° | 3.7 at 4.5° |
| Antenna height | Aircraft altitude | Aircraft altitude (wind-shear at low altitude) | Aircraft altitude |
| Receiver IF 3 dB bandwidth (MHz) | Not specified | WA: ≤ 16 for narrow pulses/subpulses, decreasing to 0.8 for wide pulses/subpulses;WS: ≥ 0.8 |  |
| Receiver noise figure (dB) | 4.0 | 5 | 5 |
| Minimum discernible signal (dBm) | −125 | ≥ −110 | ≥ −110 |
| Chirp bandwidth (MHz) | Not applicable | Not applicable | Not applicable |
| RF emission bandwidth (MHz) | Not specified | For shortest plain pulse to longest subpulse:WA: 3 dB: 5 to 0.052; 20 dB: 40.5 to 0.37;WS: 3 dB: 0.46 20 dB: 3.28 | For shortest to longest subpulses:MGM: 3 dB: 7.68 to 0.045; 20 dB: 59 to 0.31DBS: 3 dB: 18 to 0.6; 20 dB: 150 to 4.1 |

TABLE 1 (*continued*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **System A7a, A7b, and A7c**(2) | **System A7d**(2) | **System A7e and A7f**(2) | **System A8** |
| Function | Surface search and SAR imaging | Navigation | Inverse SAR imaging | Search (radiolocation)Weather |
| Tuning range (MHz) | 9 380-10 120 | Frequency agile pulse-to-pulse over 340 MHz | 9 380-10 120 | 9 250-9 440, frequency-agile pulse-to-pulse, 20 MHz steps |
| Modulation | Linear FM pulse | Linear FM pulse | Linear FM pulse | FM pulse |
| Peak power into antenna (kW) | 50 | 50 | 50 | 10 |
| Pulse width (μs) andpulse repetition rate (pps) | Search: 5 μs @ 1 600-2 000 or 10 μs @ approx. 380 SAR: 13.5 μs @ 250-750 | 10Approx. 380 | 10470, 530, 800 and 1 000 | 5 and 172 500, 1 500, 750 and 400(all pulse widths) |
| Maximum duty cycle | 0.010 (5 μs & 13.5 μs);0.004 (10 μs) | 0.004 | 0.010 | 0.04 |
| Pulse rise/fall time (μs) | 0.1/0.1 | 0.1/0.1 | 0.1/0.1 | 0.1/0.1 |
| Output device | Travelling wave tube | Travelling wave tube | Travelling wave tube | Travelling wave tube |
| Antenna pattern type | Pencil/fan | Pencil/fan | Pencil/fan | Fan |
| Antenna type | Parabolic reflector | Parabolic reflector | Parabolic reflector | Slotted array |
| Antenna polarization | Horizontal | Horizontal | Horizontal | Vertical and horizontal |
| Antenna main beam gain (dBi) | 34.5 | 34.5 | 34.5 | 32 |
| Antenna elevation beamwidth (degrees) | 4.0 | 4.0 | 4.0 | 9.0 |
| Antenna azimuthal beamwidth (degrees) | 2.4 | 2.4 | 2.4 | 1.8 |
| Antenna horizontal scan rate (degrees/s) | 36, 360, and 1 800 | 36, 360, 1 800 | 36, 360, and 1 800 | 90 or 360(15 or 60 rpm) |

TABLE 1 (*continued*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **System A7a, A7b, and A7c**(2) | **System A7d**(2) | **System A7e and A7f**(2) | **System A8** |
| Antenna horizontal scan type (continuous, random, sector, etc.) | 10° sector | 10° sector | 10° sector | 360° |
| Antenna vertical scan rate (degrees/s) | Not applicable | Not applicable | Not applicable | Not applicable |
| Antenna vertical scan type (continuous, random, sector, etc.) | Selectable tilt0°/–90° | Selectable tilt0°/–90° | Selectable tilt0°/–90° | Selectable tilt+15°/–15° |
| Antenna sidelobe (SL) levels (1st SLs and remote SLs) (dBi) | 14.5 at 12° | 14.5 at 12° | 14.5 at 12° | 20 |
| Antenna height | Aircraft altitude | Aircraft altitude | Aircraft altitude | Aircraft altitude |
| Receiver IF 3 dB bandwidth (MHz) | Not specified | Not specified | Not specified | 16 |
| Receiver noise figure (dB) | 5 | 5 | 5 | Not specified |
| Minimum discernible signal (dBm) | Depends on processing gain (34 dB (5 μs), 30 dB (10 μs) and 39.5 dB (13.5 μs) for one return pulse) | Depends on processing gain (17 dB for one return pulse) | Depends on processing gain (30 dB (100 MHz) or 33 dB (200 MHz) for one return pulse) | –98 |
| Total chirp width (MHz) | Search: 500 (5 μs) or 100 (10 μs)SAR: 660 | 5 | 100 or 200 | 10 |
| RF emission bandwidth (MHz)– 3 dB– 20 dB | Search (5 μs) Search (10 μs)SAR470 95 640540 110 730 | 4.57.3 | 100 MHz chirp95110 | 200 MHz chirp190220 | 9.312 |

TABLE 1 (*continued*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **System A9** | **System A10** | **System A11** | **System A12** |
| Function | Weather avoidance, search, ground mapping | Weather avoidance, ground mapping, search | Weather avoidance, ground mapping, search and rescue | Multipurpose surveillance, scanning, tracking, search, synthetic aperture radar (imaging) |
| Tuning range (MHz) | Radar: 9 375 ± 10;Beacon: 9 310 | Preheat pulse: 9 337 and 9 339 (precedes each operational pulse)Operational pulse: 9 344 | 9 375 ± 30 | 8 500-10 500 |
| Modulation | Pulse | Pulse | Pulse | Adaptive pulse, FM, linear FM pulse (chirp) |
| Peak power into antenna (kW) | 25 | 0.026 (14 dBW) | 2.5 to 6.0 | 0.03-10 |
| Pulse width (μs) andPulse repetition rate (pps) | 4.5, 2.4, 0.8 and 0.2 µs at 180, 350, 350 and 1 000 pps | 9 337 and 9 339 MHz: 1-29 μs at 2 200‑220 pps(dithered) for all pulse widths;9 344 MHz: 1.7-2.4, 2.4-4.8, 4.8‑9.6, 17, 19 and 29 μs at 2 200‑220 pps (dithered) | Fixed at 4 106.5 | 0.15-300 adaptive1 000-50 0000 adaptive |
| Maximum duty cycle | 0.00082 | 9 337 and 9 339 MHz: ≤ 0.0649 344 MHz: ≤ 0.011 (with 17 μs pulses) | 0.00043 | 0.01-0.8 (pulse), 1 (FM) |
| Pulse rise/fall time (μs) | Not specified | 9 337 and 9 339 MHz: 0.3/0.29 344 MHz: 0.5/0.5 | Rise time: 0.3 Fall time: 0.4 | 0.005-0.1/0.005-0.1 |
| Output device | High-reliability magnetron | IMPATT diode | Magnetron | Solid state |
| Antenna pattern type | Pencil and fan | Pencil | Pencil | Digital beamforming (see Rec. ITU-R M.1851) |
| Antenna type | Flat-plate array | Flat array | Flat array | Active array |
| Antenna polarization | Horizontal and vertical | Horizontal | Horizontal | Lin/circular |
| Antenna main beam gain (dBi) | Pencil: 30; fan: 29 | 29 | 26.7 | 35-42 |
| Antenna elevation beamwidth (degrees) | Pencil: 3; fan: 6 | < 10 | 8.1 | 1.6 @42 dBi |
| Antenna azimuthal beamwidth (degrees/s) | Pencil: 3; fan: 3 | 7 | 8.1 | 1.6 @42 dBi |

TABLE 1 (*continued*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **System A9** | **System A10** | **System A11** | **System A12** |
| Antenna horizontal scan rate (degrees/s) | 72 (long-range), 270 (short-range)(360°: 12 rpm (long-range), 45 rpm (short-range))Sector: not specified | 30 | 25 | Not applicable |
| Antenna horizontal scan type (continuous, random, sector, etc.) | Continuous (360°)Sector (90°) | Sector 60° or 120° | Sector volume (90° or 120°) | ±60° Electronic scan±120° with additional mechanical repositioner |
| Antenna vertical scan rate (degrees/s) | Not applicable | Not applicable | Not applicable | Not applicable |
| Antenna vertical scan type (continuous, random, sector, etc.) | Not applicable | Operator-selected tilt: ±30° | Sector volume: ±30° | ±60° Electronic scan±120° with additional mechanical repositioner |
| Antenna side-lobe (SL) levels (1st SLs and remote SLs) (dBi) | Not specified | +13.9 | +4.7 | 14-19 dB below peak gain |
| Antenna height | Aircraft altitude | Aircraft altitude | Aircraft altitude | Aircraft altitude(300-13 700 m) |
| Receiver IF 3 dB bandwidth (MHz) | Not specified | 2.0 | 1.0 | 25 |
| Receiver noise figure (dB) | 6.5 | 2 | 5 | 6 |
| Minimum discernible signal (dBm) | Not specified | –128 (detection sensitivity after processing) | –110 | –130 |
| Total chirp width (MHz) | Not applicable | Not applicable | Not applicable | Maximum 1 900 for chirp modulation  |
| RF emission bandwidth (MHz)– 3 dB– 20 dB | Not specifiedNot specified | –3 dB:9 337 and 9 339 MHz: 0.7 9 344 MHz: 0.4, 0.25, 0.150, 075, 0.08, and 0.05–20 dB:9 337 and 9 339 MHz: 3.69 344 MHz: 1.8, 1.5, 0.8, 0.375, 0.35, and 0.2 | –3 dB:0.5 –20 dB:1.5 | –3 dB: 10 MHz, 130 MHz, 1 800 MHz–20 dB: 20 MHz, 150 MHz, 1 900 MHz  |

(1) Multimode radar; also has a beacon-interrogator mode at 9 375 MHz, not described herein.

(2) Multimode radar.

TABLE 1 (*continued*)

|  |  |
| --- | --- |
| Characteristics | System A13 |
| Function | Unmanned Aircraft Detect and Avoid Radar |
| Tuning range (MHz) | 8 750-8 850 or9 300-9 500(selected to be compatible with other onboard avionics) |
| Modulation | Pulsed with intrapulse Biphase code; 3 dB bandwidth = 5 MHz |
| Peak power into antenna (kW) | <0.550 (net radiated) |
| Pulse width (μs) and pulse repetition rate (pps) | 0.2 to 30 500 to 60 000(mode-dependent) |
| Maximum duty cycle | 0.16 |
| Pulse rise/fall time (μs) | 0.1/0.1 |
| Output device | Solid-state power amplifiers |
| Antenna pattern type | Elliptical beam cross-section |
| Antenna type | Active electronically scanned array (AESA) |
| Antenna polarization | Linear vertical |
| Antenna main beam gain (dBi) | 26 |
| Antenna elevation beamwidth (degrees) | 14 at antenna broadside |
| Antenna azimuthal beamwidth (degrees) | 3 at antenna broadside |

TABLE 1 (*end*)

|  |  |
| --- | --- |
| Characteristics | System A13 |
| Antenna horizontal scan rate (degrees/s) | Raster: 8 frames/min with interleaved track updates as required |
| Antenna horizontal scan type (continuous, random, sector, etc.) (degrees) | Sector: ±110, electronically scanned (2 antennas are used) |
| Antenna vertical scan rate (degrees/s) | Raster: 8 frames/min with interleaved track updates as required |
| Antenna vertical scan type (continuous, random, sector, etc.) (degrees) | Sector: ±15 (search), ±45 (track);electronically scanned; field of regard is electronically stabilized with respect to a local horizontal plane |
| Antenna side-lobe (SL) levels (1st SLs and remote SLs) (dBi) | <15, first sidelobe;<11, outer sidelobes;(applies to transmit sidelobe levels with uniform weighting; receive sidelobe levels are lower) |
| Antenna height | equal to aircraft altitude |
| Receiver IF 3 dB bandwidth (MHz) | 5-10(mode-dependent) |
| Receiver noise figure (dB) | 4.4 (system NF) |
| Minimum discernible signal (dBm) | −129 for 10 dB SNR (equivalent signal power at the output of a lossless passive receive antenna, excluding antenna gain) |
| Total chirp width (MHz) |  NA |
| RF emission bandwidth (MHz) – 3 dB – 20 dB | 5-10 25 |

TABLE 2

**Characteristics of shipborne radiodetermination radars operating in the frequency band 8 500-10 680 MHz**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Characteristics** | **System S1** | **System S2** | **System S3** | **System S4** | **System S5** |
| Function | Search and navigation radar | Track radar | Low altitude and surface search radar (multifunction) | Maritime radionavigation radar(3) | Surface surveillance and navigation radar |
| Platform type | Shipborne, shore training sites | Shipborne | Shipborne | Shipborne | Shipborne |
| Tuning range (MHz) | 8 500-9 600 | 10 000-10 500 | 8 500-10 000 | 9 225-9 500 | 9 300-9 500 |
| Modulation | Pulse | CW, FMCW | Frequency-agile pulse(4) | Pulse | FMCW |
| Peak power into antenna (kW) | 35 | 13.3 | 10 | 5 (min) | 50 (max) | 1 10−6 to 10−3 |
| Pulse width (μs) and pulse repetition rate (pps) | 0.1; 0.51 500; 750 | Not applicableNot applicable | 0.56 to 1.0; 0.2419 000 to 35 000;4 000 to 35 000 | 0.03 (min) at 4 000 (max) | 1.2 (max) at 375 (min) | Not applicable1 000(5) |
| Maximum duty cycle | 0.00038 | 1 | 0.020 | 0.00045 | 1 |
| Pulse rise/fall time (μs) | 0.08/0.08 | Not applicable | 0.028/0.03; 0.038/0.024 | Not specified | Not applicable |
| Output device | Magnetron | Travelling wave tube | Travelling wave tube | Magnetron | Solid state |
| Antenna pattern type | Fan | Pencil | Pencil | Fan | Fan |
| Antenna type | Horn array | Planar array | Slotted array | Slotted array | Slotted waveguide |
| Antenna polarization | Linear | Linear | Linear | Not specified | Linear |
| Antenna main beam gain (dBi) | 29 | 43 | 39 | 27 (min) | 32 (max) | 30 |

TABLE 2 *(continued)*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Characteristics** | **System S1** | **System S2** | **System S3** | **System S4** | **System S5** |
| Antenna elevation beamwidth (degrees) | 13 | 1 | 1 | 20.0 (min) | 26.0 (max) | 20 |
| Antenna azimuthal beamwidth (degrees) | 3 | 1 | 1.5 | 0.75 (min) | 2.3 (max) | 1.4 |
| Antenna horizontal scan rate (degrees/s) | 57 | 90 | 180 | 120 (min) | 360 (max) | 144 |
| Antenna horizontal scan type (continuous, random, sector, etc.) (degrees) | 360 (mechanical) | 360 (mechanical) | 360 or sector search/track (mechanical) | 360 | 360 |
| Antenna vertical scan rate (degrees/s) | Not applicable | 90 | Not applicable | Not applicable | Not applicable |
| Antenna vertical scan type | Not applicable | Sector: +83/–30° (mechanical) | Not applicable | Not applicable | Not applicable |
| Antenna side-lobe (SL) levels (1st SLs and remote SLs) (dBi) | Not specified | 23 (1st SL) | 23 (1st SL) | 4 at ≤ 10° (min)3 at ≥ 10° (max) | 9 at ≤ 10° (max)2 at ≥ 10° (max) | 5 (1st SL) |
| Antenna height | Mast/deck mount | Mast/deck mount | Mast/deck mount | Mast/deck mount | Mast/deck mount |
| Receiver IF  | Not specified | Not specified | Not specified | 45 (min) | 60 (max) |  |
| Receiver IF 3 dB bandwidth (MHz) | 12 | 0.5 | 2.5; 4; 12 | 6; 2.5 (min)(short and long pulse, resp.) | 28; 6 (max)(short and long pulse, resp.) | 0.5 |
| Receiver noise figure (dB) | Not specified | 3.5 | 9 | 3.5 (min) | 8.5 (max) | 3.5 |
| Minimum discernible signal (dBm) | −96 | −113 | −102; −100; −95 | −106 (min) | −91 (max) | −113 |
| Chirp bandwidth (MHz) | Not applicable | Not specified | Not applicable | Not applicable | 1.7 to 54 |
| RF emission bandwidth (MHz)– 3 dB– 20 dB | 10; 580; 16 | Not specifiedNot specified | 1.6; 4.210; 24 | Not specifiedNot specified | Not specifiedNot specified |

TABLE 2 (*continued*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **System S6** | **System S7** | **System S8** | **System S9** |
| Function | Maritime radionavigation radar | Navigation and search | Maritime radionavigation radar(6) | Maritime radionavigation radar(7) |
| Platform type | Shipborne | Shipborne | Shipborne | Shipborne |
| Tuning range (MHz) | 9 380-9 440 | 9 300-9 500 | 9 225-9 500 | 9 225-9 500 | 9 445 ± 30 |
| Modulation | Pulse | Pulse | Pulse | Pulse |
| Peak power into antenna (kW) | 25 | 1.5 | 5 | 1.5 to 10 |
| Pulse width (μs) and pulse repetition rate (pps) | 0.08, 0.2, 0.4, 0.7, and 1.22 200 (0.08 μs); 1 800,1 000 and 600 (1.2 μs) | 0.08, 0.25, and 0.52 250, 1 500 and 750 | 0.05, 0.18, and 0.53 000 pps at 0.05 μs to 1 000 pps at 0.5 μs | 0.08 (min) at 3 600 pps | 1.2 (max) at 375 pps |
| Maximum duty cycle | 0.00072 | 0.000375 | 0.0005 | 0.00045 |
| Pulse rise/fall time (μs) | 0.010/0.010 | 0.01/0.05 | Not specified | Not specified |
| Output device | Magnetron | Magnetron | Magnetron | Magnetron |
| Antenna pattern type | Fan | Fan | Fan | Fan |
| Antenna type | End-fed slotted array | Centre-fed slotted waveguide | Slotted array | Slotted/patch array or horn |
| Antenna polarization | Horizontal | Horizontal | Horizontal | Horizontal |
| Antenna main beam gain (dBi) | 31 | 23.9 | 30 | 22-30 |
| Antenna elevation beamwidth (degrees) | 20 | 25 | 26 | 24-28 |
| Antenna azimuthal beamwidth (degrees) | 0.95 | 6 | 0.95 | 1.9-7 |
| Antenna horizontal scan rate (degrees/s) | 144 | 144 | 180 | 144 |
| Antenna horizontal scan type (continuous, random, sector, etc.) (degrees) | 360 | 360 | 360 | 360 |

TABLE 2 (*continued*)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Characteristics** | **System S6** | **System S7** | **System S8** | **System S9** |
| Antenna vertical scan rate (degrees/s) | Not applicable | Not applicable | Not applicable | Not applicable |
| Antenna vertical scan type | Not applicable | Not applicable | Not applicable | Not applicable |
| Antenna side-lobe (SL) levels (1st SLs and remote SLs) (dBi) | Not specified | +2.9 | < 5 within 10°;≤ 2 outside 10° | 22 main beam:3 to 4 within 10°;0 to 3 outside 10°30 main beam:7 to 10 within 10°;–2 to +7 outside 10° |
| Antenna height | Mast | Mast | Mast | Mast |
| Receiver IF (MHz) | Not specified | Not specified | 50 | 45-60 |
| Receiver IF 3 dB bandwidth (MHz) | 15 | 10 and 3 | 15-25 | 2.5-25 |
| Receiver noise figure (dB) | 6 | 6 | 6 | 4 to 8 |
| Minimum discernible signal (dBm) | –97 (noise floor) | –102 (noise floor) | Not specified | Not specified |
| Total chirp width (MHz) | Not applicable | Not applicable | Not applicable | Not applicable |
| RF emission bandwidth (MHz)– 3 dB– 20 dB | 1443 | 2055 | Not specified | Not specified |
| (3) IMO category – including fishing.(4) Uncompressed pulse, pseudo-random frequency-agile.(5) Frequency sweep rate (sweep/s).(6) River category.(7) Pleasure craft category. |

[USA NOTE: No changes are proposed in the remainder of the document.]