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Spectrum Management and Telecommunications Policy

Radio Standards Specification

Commercial Shipborne Radar in the 2900-3100 MHz, 5470-5650 MHz and 9225-9500 MHz Bands

Canada

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Preface

This first issue, Issue 1 of RSS-138 sets out minimum requirements for the certification of commercial shipborne radar operating in the maritime radionavigation service in the 2900-3100 MHz, 5470-5650 MHz and 9225-9500 MHz bands.

This new version will be in force, as of the publication date of Notice SMSE-004-04, in the Canada Gazette, Part I. Upon publication, the public has 90 days to make comments. These comments will be taken into account in the preparation of the next version of the document.

Issued under the authority of
the Minister of Industry

R.W. McCaughern
Director General
Spectrum Engineering

Table of Contents

Page

1. Scope 1

2. General Information 1
2.1 Licensing Requirements 1
2.2 Inquiries Concerning This Standard 1
2.3 Inquiries Concerning Equipment Certification 1
2.4 Related Documents 2
2.5 Availability of Documents 2
2.6 Definitions 2
2.7 Symbols 2

3. Certification Requirements 3
3.1 Application for Certification 3
3.2 Test Report 3

4. Measurement Methods 4
4.1 General 4
4.2 Pulse Characteristics 5
4.2.1 Pulse Rise Time and Pulse Width 5
4.2.2 Pulse Repetition Rate (PRR) or Pulse Repetition Frequency (PRF) 5
4.3 40 dB Bandwidth and Emission Levels 6
4.4 Frequency Stability 7
4.5 Transmitter Output Power 7
4.6 Transmitter Unwanted Emissions 8
4.7 Receiver Spurious Emissions 8

5. General Standard Specifications 9
5.1 Quality Control 9
5.2 Equipment Labels 9
5.3 External Controls 9
5.4 Exposure of Humans to Radio Frequency Fields 9

6. Transmitter and Receiver Standard Specifications 10
6.1 Pulse Length and Pulse Repetition Rate 10
6.2 Frequency Stability 10
6.3 Transmitter Output Power 10
6.4 Transmitter Unwanted Emissions 10
6.4.1 Out-of-Band Emissions 10
6.4.2 Spurious Emissions 12
6.5 Operating Characteristics and Standard Specifications 12
6.6 Receiver Spurious Emissions 12

1. Scope

This Radio Standards Specification (RSS) sets out minimum requirements for the certification of commercial shipborne radar operating in the maritime radionavigation service, hereafter referred to as 'radar' having a rated peak power ranging from 1 - 100 kW and operating in the 2900-3100 MHz, 5470-5650 MHz and 9225-9500 MHz bands.

2. General Information

A technical acceptance certificate (TAC) issued by the Certification and Engineering Bureau of Industry Canada or a certificate issued by a Recognized Certification Body (CB) is required, pursuant to section 4(2) of the *Radiocommunication Act*, and to the *Radiocommunication Regulations*.

Before certification is granted, the applicant shall demonstrate that applicable Industry Canada Standards have been complied with.

2.1 Licensing Requirements

Subject to the operating conditions detailed in the *Radiocommunication Regulations* sections 15.2, 34(1) and 34(2) and 34.2, these equipment are licence-exempt.

2.2 Inquiries Concerning This Standard

Inquiries concerning this Standard should be directed to:

Manager, Radio Equipment Standards
Industry Canada
300 Slater Street
Ottawa, Ontario
K1A 0C8
Telephone: (613) 990-4699
Fax: (613) 991-3961
E-mail: res.nmr@ic.gc.ca

2.3 Inquiries Concerning Equipment Certification

Inquiries concerning equipment certification should be directed to:

Chief, Certification and Engineering Bureau
Industry Canada
3701 Carling Avenue (Building 94)
P.O. Box 11490, Station "H",
Ottawa, Ontario

K2H 8S2
Telephone: (613) 990-4389
Fax: (613) 990-4752
E-mail: certification.bureau@ic.gc.ca

2.4 Related Documents

The following documents should be consulted.

RSP-100: *Radio Equipment Certification Procedure*
TRC-49: *Certification Fees*
Information on the Application of the Telecommunications Apparatus Technical Assessment and Testing Fees Order Made under the Financial Administration Act
RSS-102: *Evaluation Procedure for Mobile and Portable Radio Transmitters with respect to Health Canada's Safety Code 6 for Exposure of Humans to Radio Frequency Fields*

2.5 Availability of Documents

Industry Canada documents are available on the Spectrum Management and Telecommunications Web site at http://strategis.gc.ca/spectrum.

Assistance regarding this Web site is available by e-mail at spectrum pubs@ic.gc.ca.

2.6 Definitions

Occupied bandwidth: the width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to 0.5% of the emitted power. This is also known as the 99% emission bandwidth.

Emission designator: the designation of a set of characteristics of an emission by standard symbols, e.g. type of modulation of the main carrier, modulating signal, type of information to be transmitted, and also, if appropriate, any additional signal characteristics. For example, designator 20K0FID means a bandwidth of 20.0 kHz, uses Frequency Modulation, is single channel and is in the data/digital format.

2.7 Symbols

The definition for the symbols used in this document is given below:

B: emission bandwidth, in MHz.

F_o: operating frequency in MHz. For non-FM pulse radars the peak of the power spectrum; for FM pulse radars the average of the lowest and highest carrier frequencies during the pulse.

N: total number of chips (subpulses) contained in the pulse. (N = 1 for non-FM and FM pulse radars.)

PRR: pulse repetition rate, in pulses per second.

t: emitted pulse duration in μ sec. at 50% amplitude (voltage) points. For coded pulses the pulse duration is the interval between 50% amplitude points of one chip (sub-pulse). The 100% amplitude is the nominal flat top level of the pulse (see Figure 1).

t_r : emitted pulse rise time in μ sec. from the 10% to the 90% amplitude points on the leading edge (see Figure 1). For coded pulses it is the rise time of a sub-pulse; if the sub-pulse rise time is not discernible, assume that it is 40% of the time to switch from one phase or sub-pulse to the next.

t_f : emitted pulse fall time in μ sec from the 90% to the 10% amplitude points on trailing edge (see Figure 1).

3. Certification Requirements

3.1 Application for Certification

The application for certification shall be prepared and submitted in accordance with document RSP-100, or equivalent Certification Body (CB) document. A test report shall be submitted with the application for certification.

3.2 Test Report

The test report submitted with the application shall contain the following information and/or measurements:

(a) the unit's documentation (e.g. schematics, user manual, etc.);

(b) a list of all test instruments used, identifying the instrument manufacturer, type and model number;

(c) the test voltage;

(d) the test frequencies;

(e) the frequency stability and supporting information;

(f) the maximum transmitter power and testing method used;

(g) the pulse width and pulse repetition rate;

(h) the size, type, gain, beamwidths, and side and back lobe suppression values of the antenna;

(i) the occupied bandwidth and the emission designator;

(j) all measurement results that address the requirements of applicable Standard(s); and

(k) any additional information that is needed to better understand the operation of the equipment under consideration.

4. Measurement Methods

4.1 General

The test report information shall be obtained in accordance with the following methods and conditions:

(a) Tests are to be conducted in accordance with good engineering practices.

(b) Where a test method specified in this document cannot be followed, an alternative appropriate method may be used provided that it is fully described in the test report and the Certification Bureau of Industry Canada should be consulted.

(c) Test results shall be presented in graphical form wherever possible. The graph shall also include the specification limits.

(d) Associated equipment that is normally used with the equipment shall be so connected before the equipment is tested.

(e) Tests shall be performed at ambient temperature, at the manufacturer's rated supply voltage, and power, and with the transmitting modulating signals representative (i.e. typical) of those encountered in a real system operation. Special conditions apply for the frequency stability tests.

(f) If the transmitter is capable of tuning over several bands, testing at more than one carrier frequency is required to verify any change in RF characteristics.

(g) If in measuring emission power the spectrum analyser selectivity or bandwidth is insufficient, a resolution bandwidth narrower than that specified, plus numerical integration to sum the power, is permitted. The method used shall be described in the test report.

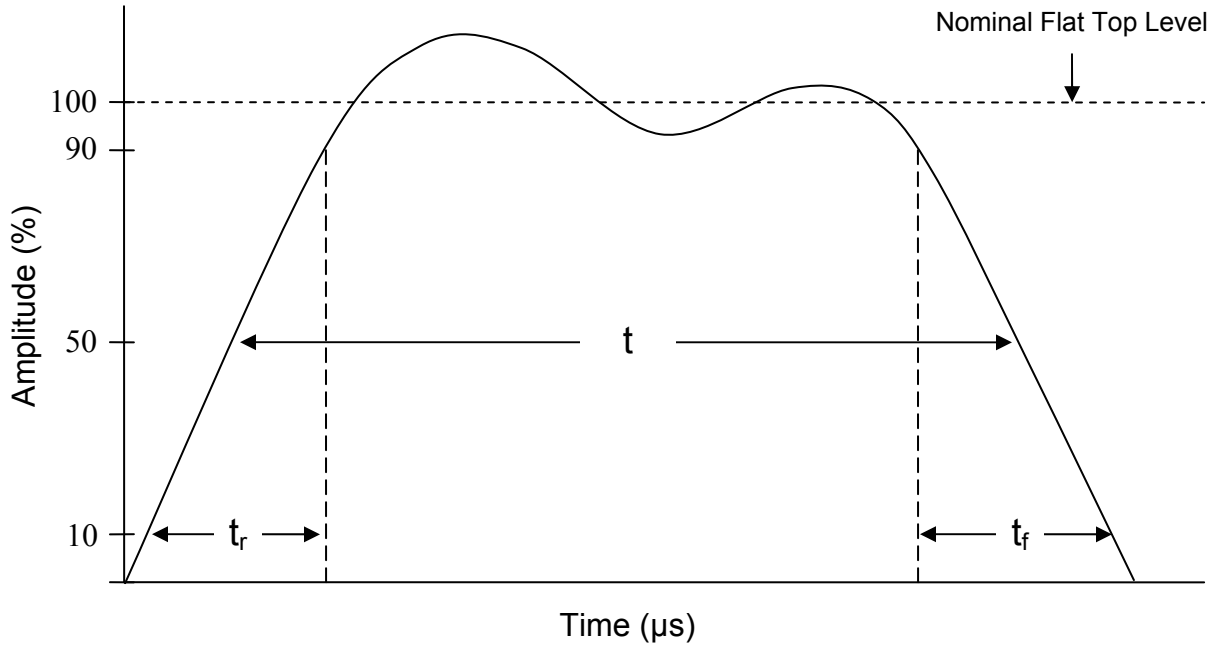
(h) Except where otherwise specified, all tests shall be conducted on a frequency that is near the middle of the frequency range within which the equipment is designed to operate.

4.2 Pulse Characteristics

4.2.1 Pulse Rise Time and Pulse Width

Figure 1 shows a radar pulse where the pulse rise time (t_r) and pulse width (t) are calculated.

Figure 1 - Determination of Pulse Width (t) and Pulse Rise Time (t_r)



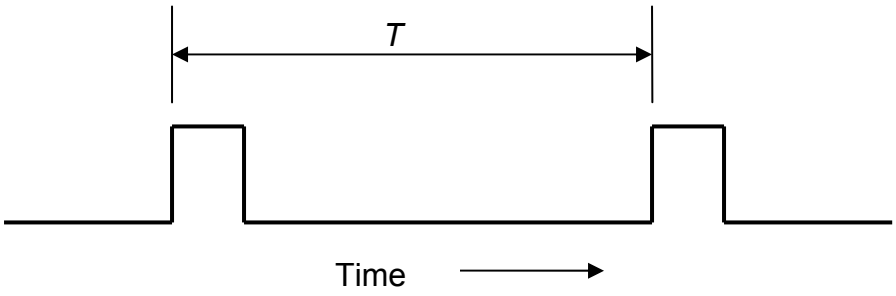
4.2.2 Pulse Repetition Rate (PRR) or Pulse Repetition Frequency (PRF)

The pulse repetition rate (PRR), which is also known as the pulse repetition frequency (PRF), is the rate at which the radar's pulses are transmitted or the number of pulses per second. Another measure of pulse rate is the period between the start of one pulse and the start of the next pulse. This is called the *interpulse period* (T) or the *pulse repetition interval* (PRI). The interpulse period is related to the pulse repetition rate by the following equation:

$$T = \frac{1}{f_r}$$

Figure 2 shows two radar pulses and where the interpulse period is calculated. The time between pulses is interpulse period *T*. The number of pulses transmitted per second is the pulse repetition rate PRR.

Figure 2 – The Interpulse Period



4.3 40 dB Bandwidth and Emission Levels

Out-of-band limits for radars are based on the 40 dB bandwidth (B_{-40}) of the spectrum of the transmitted waveform.

The formulas for calculating B_{-40} of primary radar transmitters are described below:

A. Non-FM Pulse Radars (including spread spectrum or coded pulse radars)

For non-FM pulse radars, including spread spectrum or coded pulse radars, the bandwidth is the lesser of:

$$B_{-40} = \frac{7.6}{\sqrt{t \cdot t_r}} \text{ or } \frac{64}{t}$$

The latter expression applies if the rise time t_r[1] is less than about $0.014t$.

B. FM-Pulse Radars (intentional FM)

For FM-pulse radars, the 40 dB bandwidth is:

$$B_{-40} = \frac{7.6}{\sqrt{t \cdot t_r}} + 2\left(B_c + \frac{0.0065}{t_r}\right)$$

For radars with multiple pulse waveforms, the B_{-40} dB bandwidth should be calculated for each individual pulse type and the maximum B_{-40} dB bandwidth obtained shall be used to establish the shape of the emission mask.

[1] If t_f is less than t_r as defined in Section 2.7, t_f is to be used in place of t_r when performing the emission bandwidth calculations.

Figure 3 (Section 6.4.1) shows the radar emission bandwidth for the radar covered in this specification.

4.4 Frequency Stability

Frequency stability is a measure of the frequency drift due to temperature and supply voltage variations, with reference to the frequency measured at +20°C and rated supply voltage.

The operating carrier frequency shall be set up in accordance with the manufacturer's published operation and instruction manual prior to the commencement of these tests. No adjustment of any frequency determining circuit element shall be made subsequent to this initial set-up.

The unmodulated carrier frequency shall be measured under the conditions specified below. A sufficient stabilization period at each temperature shall be used prior to each frequency measurement:

(a) at temperatures of –30°C, +20°C and +50°C, and at the manufacturer's rated supply voltage; and
(b) at 85% and at 115% of the manufacturer's rated supply voltage, when the temperature is at +20°C.

If an unmodulated carrier is not available, the mean frequency of a modulated carrier can be obtained by using a frequency counter with gating time set to an appropriate large multiple of bit periods (gating time depends on the required accuracy). Full details on the choice of values shall be included in the test report.

If the frequency stability limit is only met at a different temperature range than that indicated in (a), the frequency stability requirement will be deemed to have been met if the transmitter is automatically inhibited from operating outside that different temperature range and the published equipment operating characteristics are revised to reflect this different temperature range.

4.5 Transmitter Output Power

This measurement shall be carried out before the unwanted emissions test. The transmitter output power value obtained from this test is the reference level used for the determination of the unwanted emission.

If the RF output power is internally or externally adjustable or remotely controllable, set or control it to the maximum rated power of the range for which equipment certification is sought.

The output power shall be measured when the transmitter is operating at the manufacturer's rated power and modulated with signal representative of those encountered in a real system operation. The measurements of emission power shall be in peak power in measuring both the unwanted emission and the transmitter power.

When the antenna is detachable, the transmitter output power may be measured at the antenna port.

When the antenna is not detachable, field strength measurement should be made using a calibrated open area test site.

The following formula may be used to convert field strength (FS) in volts/metre to transmitter output power (TP) in watts:

$$TP = (FS \times D)^2 / (30 \times G)$$

where D is the distance in metres between the two antennas and G is the antenna numerical gain referenced to isotropic gain.

4.6 Transmitter Unwanted Emissions

Unwanted emissions comprise of out-of-band emissions (emissions on a frequency or frequencies immediately outside the necessary bandwidth), spurious emissions and harmonics. They are to be measured when the transmitter is operating at the manufacturer's rated power and modulated with signals representative as specified in Section 4.1.

The search for unwanted emissions shall be from the lowest frequency internally generated or used in the device (local oscillator, intermediate or carrier frequency), or from 30 MHz, whichever is the lowest frequency, to the 5th harmonic of the highest frequency generated or used, without exceeding 40 GHz.

The spectrum plots shall comply with the masks specified in Section 6.4.

4.7 Receiver Spurious Emissions

A detailed test report is not necessary for receiver certification; it is only required to report the receiver tuning range or ranges, and the spurious emission level.

The receiver shall be operated in the normal receive mode near the mid-point of the band over which the receiver is designed to operate.

Radiated emission measurement is the standard method (with the device's antenna in place). Radiated emission measurements are to be performed using a calibrated open-area test site.

As an alternative, the Conducted measurement method may be used when the antenna is detachable. In such a case, the receiver spurious signal may be measured at the antenna port. Even though antenna conducted measurement is permitted, if a receiver’s radiated emissions cause harmful interference, Industry Canada may require that the receiver be modified to comply with the radiated emission limits. Therefore manufacturers should check the radiated emission limit wherever possible.

For either method, the search for spurious emissions shall be from the lowest frequency internally generated or used in the receiver (local oscillator frequency, intermediate frequency or carrier frequency), or 30 MHz, whichever is the higher, to at least three times the highest tunable or local

oscillator frequency, whichever is the higher, without exceeding 40 GHz.

5. General Standard Specifications

5.1 Quality Control

Periodic testing shall be carried out by the manufacturer or importer to ensure continuing compliance (with the standards) of the newly manufactured/imported equipment intended for sale in Canada. The manufacturer or importer shall correct non-compliance problems. Industry Canada will conduct audit checks, from time to time, to ensure compliance.

5.2 Equipment Labels

Equipment that is certified under this Specification shall be permanently labelled on each item or as an inseparable combination. The label shall contain the following information:

(a) the certification number, prefixed by the term "IC:";
(b) the manufacturer's name, trade name or brand name; and
(c) a model name or number.

Equipment for which a certificate has been issued is not considered certified if it is not properly labelled.

Note: The information on the Canadian label can be combined with the manufacturer’s other labelling requirements.

5.3 External Controls

The device shall not have any external controls accessible to the user that enables the device to be adjusted, selected or programmed to operate in violation of the limits prescribed in this Standard. Furthermore, information on internal adjustments, reconfiguration or programmability of the device shall only be made available to service depots and agents of the equipment supplier and NOT to the public.

5.4 Exposure of Humans to Radio Frequency Fields

Before equipment certification is granted, the requirements of RSS-102 shall be met, as applicable.

6. Transmitter and Receiver Standard Specifications

6.1 Pulse Length and Pulse Repetition Rate

The transmitter pulse length and pulse repetition rate must meet the limits given in Table 1 (Section 6.5).

6.2 Frequency Stability

The carrier frequency shall not depart from the reference frequency in excess of the value given in Table 1 (Section 6.5).

6.3 Transmitter Output Power

The output power shall not be below the minimum or exceed the maximum limits given in Table 1 (Section 6.5).

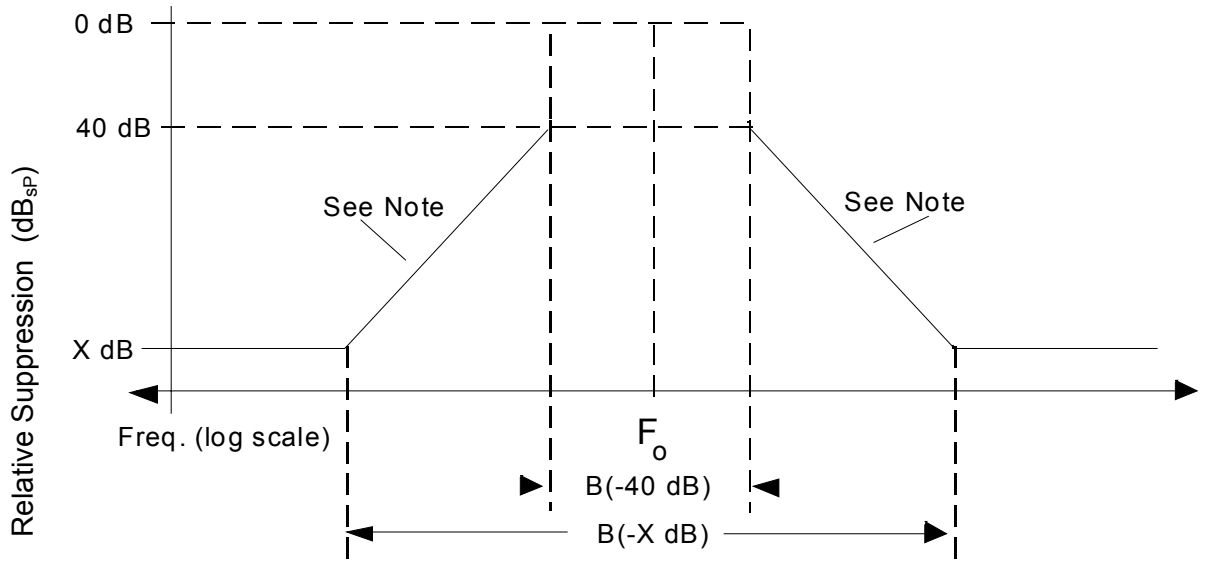
6.4 Transmitter Unwanted Emissions

The boundary between the out-of-band and spurious domains in the case of primary radars in the radiodetermination service and other relevant services can be defined as separated from the assigned frequency by 5 times the -40 dB bandwidth ($5xB_{-40}$).

6.4.1 Out-of-Band Emissions

Figure 3 shows the radar emission bandwidth and emission levels for the radar covered in this specification.

Figure 3 - Radar Emission Bandwidth and Emission Levels



The Relative Suppression values are specified in terms of dB with respect to Power Spectral Density (psd) or dB_{sp}.

Note: In Figure 3, the roll-off slope, S, from the -40 dB to -X dB points is at 20 dB per decade for maritime radionavigation radar. The maximum emission spectrum level between the -40 dB and -X dB points for S dB per decade slope is described by the formula:

$$Suppressio\ n\ (dB) = -\ S\ *\ \log\left|\frac{F - F_o}{\frac{1}{2}B(-40\ dB)}\right| - 40$$

$$Where:\quad \frac{1}{2}B(-40\ dB) \quad \leq \quad \left|F - F_o\right| \quad \leq \frac{1}{2}B(-XdB)$$

$$and:\quad F\ is\ the\ frequency\ at\ which\ Suppressio\ n\ is\ calculated$$

$$and:\quad B(-XdB) \quad = \quad (10^{a})B(-40\ dB)$$

$$a \quad = \quad \frac{X - 40}{S}$$

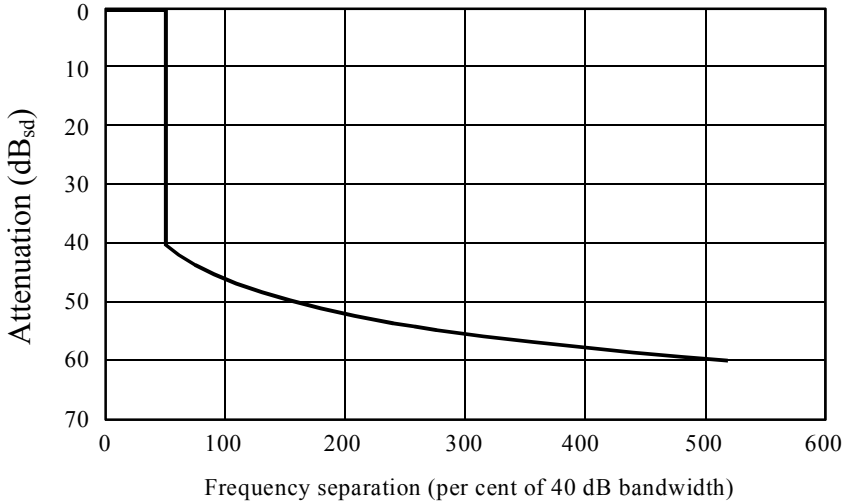
Any emission outside the -40 dB bandwidth which occurs in the frequency range separated from the assigned frequency of the emission by less than $5B_{-40}$ of the emission will be considered an emission in the out-of-band domain.

The measured power spectral density of the radar out-of-band emission level at the antenna must be attenuated below the maximum spectral power density by at least (see Figure 3):

(1) 20 dB per decade (S=20) between the ±B(-40dB)/2 and ±B(-XdB)/2 frequencies from F_o, and
(2) 60 dB at and beyond the frequencies ±B(-XdB)/2 from F_o

Figure 4 shows the out-of-band mask for radars related to percentage of frequency separation from the assigned frequency F_o.

Figure 4 – Out-Of-Band Mask for Radars



6.4.2 Spurious Emissions

For the purpose of this RSS all emissions, including intermodulation products, conversion products and parasitic emissions, which fall at frequencies separated from the centre frequency of the emission by $5B_{-40}$ or more, will generally be considered as emissions in the spurious domain. However, this frequency separation may be dependent on the type of modulation, the type of transmitter, and frequency coordination factors.

The maximum permitted spectral density for spurious emissions must be attenuated below the maximum power spectral density by 60 dB.

6.5 Operating Characteristics and Standard Specifications

Commercial shipborne radars' operating parameters must comply with the limits given in Table 1.

Table 1 - Operating Characteristics for Commercial Shipborne Radar

Transmitter Characteristic	2900-3100 MHz		5470-5650 MHz		9225-9500 MHz	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
Antenna Gain (dB)	35	20	35	20	35	20
Tx Peak power (kW)	100	1	100	1	100	1
Frequency (MHz)	3100	2900	5650	5470	9500	9225
Pulse length (µs)	1.5	0.03	1.7	0.05	1.5	0.02
Pulse repetition rate (Hz)	4000	300	4000	300	4000	300
Frequency Tolerance (ppm)	800		1250		1250	

6.6 Receiver Spurious Emissions

(a) If a radiated emission measurement is made, the field strength of any spurious frequency generated by the receiver in the vertical and horizontal polarization, measured at a distance of 3 metres from the antenna, shall comply with the limits of Table 2. The resolution bandwidth of the spectrum analyser shall be 100 kHz for measuring spurious emissions below 1.0 GHz, and 1.0 MHz for above 1.0 GHz.

Table 2 - Spurious Emission Limits for Receivers

Spurious Frequency (MHz)	Field Strength (microvolts/m) at 3 Metres
30-88	100
88-216	150
216-960	200
960-1610	500
Above 1610	1000

(b) If a conducted measurement method is made, the emission power in any 4 kHz measured at the antenna connector shall not exceed 2 nanowatts in the band 30-1000 MHz or 5 nanowatts (above 1 GHz).