RECOMMENDATION ITU-R SM.329-8

SPURIOUS EMISSIONS*

(Question ITU-R 55/1)

(1951-1953-1956-1959-1963-1966-1970-1978-1982-1986-1990-1997-2000)

The ITU Radiocommunication Assembly,

considering

a) that Recommendation ITU-R SM.328 gives definitions and explanatory notes which should be used when dealing with bandwidth, channel spacing and interference scenarios; when distinguishing between out-of-band emissions and spurious emissions; and when specifying limits for out-of-band emissions;

b) that a difficulty faced in applying the limits for spurious emissions is knowing precisely the value of the necessary bandwidth and exactly where in the spectrum the limits for spurious emissions should begin to apply, particularly for services using broadband or digitally-modulated emissions which may have both noise-like and discrete spurious components;

c) that limitation of the maximum permitted level of spurious emissions at the frequency, or frequencies, of each spurious emission is necessary to protect all radio services;

d) that stringent limits may lead to an increase in size or in complexity of radio equipment, but will in general increase protection of other radio services from interference;

e) that every effort should be made to keep limits for spurious emissions and out-of-band emissions, both for existing and new services, at the lowest possible values taking account of the type and nature of the radio services involved, economic factors, and technological limitations, and the difficulty of suppressing harmonic emissions from certain high power transmitters;

f) that there is a need to define the methods, units of measurements and bandwidth, and the bandwidths to be used for measurement of power at frequencies other than the centre frequency. This will encourage the use of rational, simple, and effective means of reducing spurious emissions;

g) that the relation between the power of the spurious emission supplied to a transmitting antenna and the field strength of the corresponding signals, at locations remote from the transmitter, may differ greatly, due to such factors as antenna characteristics at the frequencies of the spurious emissions, propagation anomalies over various paths and radiation from parts of the transmitting apparatus other than the antenna itself;

h) that field-strength or pfd measurements of spurious emissions, at locations distant from the transmitter, are recognized as the direct means of expressing the intensities of interfering signals due to such emissions;

j) that in dealing with emissions on the centre frequencies, administrations customarily establish the power supplied to the antenna transmission line, and may alternatively or in addition measure the field strength or pfd at a distance, to aid in determining when a spurious emission is causing interference with another authorized emission, and a similar, consistent procedure would be helpful in dealing with spurious emissions (see Article S15, No. S15.11, of the RR);

k) that for the most economical and efficient use of the frequency spectrum, it is necessary to establish general maximum limits of spurious emissions, while recognizing that specific services in certain frequency bands may need lower limits of spurious emissions from other services for technical and operational reasons as may be recommended in other ITU-R Recommendations (see Annex 4);

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* *Note by the Editorial Committee* – The terminology used in this Recommendation is in conformity, in the three working languages, with that of Article S1 of the RR No. S1.145, namely:

– French: *rayonnement non essentiel*
– English: *spurious emission*
– Spanish: *emisión no esencial*.

l) that transmitters operating in space stations are increasingly employing spread-spectrum and other broadband modulation techniques that can produce out-of-band and spurious emissions at frequencies far removed from the carrier frequency, and that such emissions may cause interference to passive services, including the radio astronomy service, recognizing however, that spectrum shaping techniques, which are widely used to increase the efficiency of spectral usage, result in an attenuation of side band emissions;

m) that spurious emission limits applicable to transmitters are a function of:

– the radiocommunication services involved and the minimum protection ratio determined in every frequency band;

– the type of environment where transmitters could be found (urban, suburban, rural, etc.);

– the type of transmitter;

– the minimum distance between the transmitter in question and the potential victim radio receiver;

– all possible decouplings between the antenna of the interfering transmitting antenna at the reception frequency and the receiving antenna of the radio receiver including the propagation model, polarization decoupling and other decoupling factors;

– the probability of occurrence of the spurious radiation of the transmitter when the receiver is active;

– the fact that a transmitter is active or idle, or that there are simultaneous active transmitters;

n) that some space stations have active antennas and the measurement of power as supplied to the antenna transmission line cannot cover emissions created within the antenna. For such space stations, the determination of field strength or pfd at a distance should be established by administrations to aid in determining when an emission is likely to cause interference to other authorized services;

o) that spurious emissions may exist in the whole radio spectrum, but practical difficulties may dictate a frequency limit above which they need not to be measured,

recommends

1 that the *further recommends* should be used when spurious emission limits, and their methods of measurement, are applied,

further recommends

1 Terminology and definitions

The following terms and definitions complement those already defined in the RR. (Definitions shown in *italics* are a direct quotation from the RR.)

1.1 Spurious emission (Article S1, No. S1.145 of the RR)

Emission on a frequency, or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products but exclude out-of-band emissions.

NOTE 1 – For the purpose of this Recommendation all emissions which fall at frequencies separated from the centre frequency of the emission by 250% or more of the necessary bandwidth of the emission will generally be considered spurious emissions (see *further recommends* 1.4).

NOTE 2 – In case of very narrow or wide necessary bandwidth, this definition of the boundary between out-of-band and spurious emissions might not be appropriate and Annex 8 of this Recommendation provides further guidance.

1.1.1 Harmonic emissions

Spurious emissions at frequencies which are whole multiples of the centre frequency emissions.

1.1.2 Parasitic emissions

Spurious emissions, accidentally generated at frequencies which are independent both of the carrier or characteristic frequency of an emission and of frequencies of oscillations resulting from the generation of the carrier or characteristic frequency.

1.1.3 Intermodulation products

Spurious intermodulation products result from intermodulation between:

– the oscillations at the carrier, characteristic, or harmonic frequencies of an emission, or the oscillations resulting from the generation of the carrier or characteristic frequency; and

– oscillations of the same nature, of one or several other emissions, originating from the same transmitting system or from other transmitters or transmitting systems.

1.1.4 Frequency conversion products

Spurious emissions, not including harmonic emissions, at the frequencies, or whole multiples thereof, or sums and differences of multiples thereof, of any oscillations generated to produce the carrier or characteristic frequency of an emission.

1.1.5 Broadband and narrow-band spurious emission

A broadband emission is an emission which has "a bandwidth greater than a particular measuring apparatus or receiver" (see the International Electrotechnical Vocabulary (IEV)/International Electrotechnical Commission (IEC) 161-06-11).

A narrow-band emission is an emission which has “a bandwidth less than a particular measuring apparatus or receiver” (see IEV/IEC, 161-06-13).

1.2 Out-of-band emission (Article S1, No. S1.144 of the RR)

Emission on a frequency or frequencies immediately outside the necessary bandwidth which results from the modulation process, but excluding spurious emissions.

NOTE 1 – For the purpose of this Recommendation, any unwanted emission which falls at frequencies separated from the centre frequency of the emission by less than 250% of the necessary bandwidth of the emission will generally be considered out-of-band emission (see *further recommends* 1.4).

NOTE 2 – In case of very narrow or wide necessary bandwidth, this definition of the boundary between out-of-band and spurious emissions might not be appropriate and Annex 8 of this Recommendation provides further guidance.

1.3 Unwanted emissions (Article S1, No. S1.146 of the RR)

Consist of spurious emissions and out-of-band emissions.

1.4 Necessary bandwidth (Article S1, No. S1.152 of the RR)

For a given class of emission, the width of the frequency band which is just sufficient to ensure the transmission of information at the rate and with the quality required under specified conditions.

For application to multi-channel or multi-carrier transmitters/transponders, where several carriers may be transmitted simultaneously from a final output amplifier or an active antenna, the necessary bandwidth is taken to be the transmitter or transponder bandwidth, as its 3 dB bandwidth. This does not apply to base stations in the mobile service or to fixed wireless access base stations using mobile technology.

For fixed service, Recommendation ITU-R F.1191 is to be used to calculate the necessary bandwidth in the case of digital radio-relay multi-carrier systems.

For space services transmitters using amplifiers to pass essentially an unmodulated signal (or a signal with very small bandwidth), the amplifier bandwidth is taken to be the necessary bandwidth (in calculating the regions where spurious emissions apply).

For the radiodetermination service, the necessary bandwidth of frequency-agile radars are taken to be the part of the allocated band over which those radars tune.

1.5 Active state of a transmitter

That state of a transmission station which produces the authorized emission.

1.6 Idle or standby state of a transmitter

That state of a transmission station where the transmitter is available for traffic but is not in active state.

Primary radars are not considered to operate in a standby state since the transmitter is in an active state during operation. Also, pulsed radar systems are not considered to be in the standby state during their interpulse intervals. Neither are time division communication systems to be considered to be in the idle or standby state in the interval between time slots.

2 Application of limits

2.1 The levels of spurious emissions could be expressed in terms of the peak envelope power or in terms of the mean power supplied by the transmitter to the antenna feeder line at the frequencies of the spurious emission concerned, within a defined reference bandwidth, depending on the nature of the radio service of the transmitter.

2.2 Alternatively the levels of spurious emissions could be expressed in terms of the field strength or pfd on the surface of the Earth, at the frequencies of the spurious emission concerned.

2.3 In general, spurious emission limits apply at frequencies separated from the centre frequency of the emission by 250% or more of the necessary bandwidth of the emission. However, this frequency separation may be dependent on the type of modulation used, the maximum bit rate in the case of digital modulation, the type of transmitter, and frequency coordination factors. For example, in the case of some digital, broadband or pulse-modulated systems, the frequency separation may need to differ from the ±250% factor. As the RR forbid any radio service to cause harmful interference outside its allocated band, transmitter frequencies should be determined so that out-of-band emissions do not cause harmful interference outside the allocated band in accordance with RR No. S4.5.

Alternatively, the ±250% may apply to channel separation instead of the necessary bandwidth. As an example, for frequency coordination of the digital fixed service, Recommendation ITU-R F.1191 recommends the use of ±250% of the channel separation of the relevant radio-frequency channel arrangement as frequency boundaries for spurious emission.

In case of very narrow or wide bandwidth, the definition of the boundary between out-of-band and spurious emissions might not be appropriate and Annex 8 of this Recommendation provides further guidance.

2.4 Where a transmitting system comprises more than one transmitter connected to the same antenna the limits specified in § 3 should apply, as far as practicable, to the intermodulation products related to the use of several transmitters.

2.5 Limits on spurious emissions for radio equipments are considered here to be applicable to the range 9 kHz to 300 GHz.

However, for practical measurement purposes only, the frequency range of the spurious emissions may be restricted. As guidance for practical purposes, the following frequency ranges of measurement, as given in Table 1, are normally recommended.

There will be cases where it is necessary, in order to protect specific services, to extend the range of test frequencies to the 3rd or higher harmonic for systems with fundamental frequency above 13 GHz. The parameters in Table 1 reflect the increasing practical difficulty of conducting tests by extending upwards in frequency the conventional microwave measurement techniques described in Annex 2 to frequencies above 110 GHz. At such frequencies and higher, it may be more practicable to adopt bolometric measurement techniques used at infra-red frequencies. For example, for vehicular radars at 76-77 GHz, it is appropriate that the 3rd harmonic be measured, around 220 GHz, and here, conventional microwave test methods are probably inappropriate.

TABLE 1

Spurious frequency range

Fundamental frequency range	Spurious frequency range	
	Lower	Upper (The test should include the entire harmonic band and not be truncated at the precise upper frequency limit stated)
9 kHz-100 MHz	9 kHz	1 GHz
100 MHz-300 MHz	9 kHz	10th harmonic
300 MHz-5.2 GHz	30 MHz	5th harmonic
5.2 GHz-13 GHz	30 MHz	26 GHz
13 GHz-150 GHz	30 MHz	2nd harmonic
150 GHz-300 GHz	30 MHz	300 GHz

In any case, systems having an integral antenna incorporating a waveguide section, or with an antenna connection in such form, and of unperturbed length equal to at least twice the cut-off wavelength, do not require spurious emission measurements below 0.7 times the waveguide cut-off frequency.

2.6 Spurious emission from any part of the installation, other than the antenna system (the antenna and its feeder) should not have an effect greater than would occur if this antenna system were supplied with the maximum permissible power at that spurious emission frequency.

2.7 Transient emissions caused by switching in TDMA systems should, where possible meet the spurious emission suppression requirement.

3 Limits of spurious emissions

3.1 The limits should improve the operation of radiocommunication services in all bands.

3.2 The different units for expressing spurious emission and the conversion Table given in Annex 1 should be used.

3.3 The definition of the categories of spurious emission limits are shown below, including RR Appendix S3 limits, examples of more stringent limits and limits applying to information technology equipment (ITE).

Category A	Category A limits are the attenuation values used to calculate maximum permitted spurious emission power levels. Appendix S3 is derived from Category A limits. These limits are given in § 4.2.
Category B	Category B limits are an example of more stringent spurious emission limits than Category A limits. They are based on limits defined and adopted in Europe and used by some other countries. These limits are given in § 4.3.
Category C	Category C limits are an example of more stringent spurious emission limits than Category A limits. They are based on limits defined and adopted in the United States of America and Canada and used by some other countries. These limits are given in § 4.4.
Category D	Category D limits are an example of more stringent spurious emission limits than Category A limits. They are based on limits defined and adopted in Japan and used by some other countries. These limits are given in § 4.5.
Category Z	Radiation limits for ITE specified by the International Special Committee on Radio Interference (CISPR). These limits are given in § 4.6.

NOTE 1 – Category B, C and D limits are more stringent than Category A limits and each represents a compromise between lower unwanted emissions and the cost of equipment. Currently, all are successfully used as national or regional regulations including in areas having a high radiocommunication density and using equipment representing a significant portion of the radiocommunications manufacturing base.

Tables of emission limits (see *further recommends* 4) represent recommended limits for each of these categories by frequency band and type of transmitters for the protection of all radiocommunication services.

4 Tables of emission limits

4.1 Recommended reference bandwidths

A reference bandwidth is a bandwidth in which spurious emission levels are specified. The following reference bandwidths are recommended:

– 1 kHz between 9 and 150 kHz,

– 10 kHz between 150 kHz and 30 MHz,

– 100 kHz between 30 MHz and 1 GHz,

– 1 MHz above 1 GHz.

As a special case, the reference bandwidth of all space service spurious emissions should be 4 kHz.

For Category B limits, narrower reference bandwidth are specified close to the carrier for fixed and land mobile services.

The reference bandwidths required for proper measurement of radar spurious emissions must be calculated for each particular radar system, and the measurement methods should be guided by Recommendation ITU-R M.1177. Thus, for the three general types of radar pulse modulation utilized for radionavigation, radiolocation, acquisition, tracking and other radiodetermination functions, the reference bandwidth values should be:

– for fixed frequency or non-pulse-coded radar, one over the radar pulse length (e.g. if the radar pulse length is 1 μs, then the reference bandwidth is 1/1 μs = 1 MHz);

– for fixed frequency, phase coded pulsed radar, one over the phase chip length (e.g. if the phase coded chip is 2 μs long, then the reference bandwidth is 1/2 μs = 500 kHz);

– for frequency modulated (FM) or chirped radar, the square root of the quantity obtained by dividing the FM (Hz) by the pulse length (s) (e.g. if the FM is from 1 250 to 1 280 MHz or 30 MHz during the pulse of 10 μs, then the reference bandwidth is $(30 \text{ MHz}/10 \text{ μs})^{1/2}$ = 1.73 MHz).

4.2 Category A limits

Table 2 indicates the maximum permitted levels of spurious emissions, appearing in RR Appendix S3, in terms of power of any spurious component supplied by a transmitter to the antenna transmission line, except for space services which are currently shown as design limits; for the implementation date for the radiodetermination service; for deep space stations and for amateur stations. Some notes to Appendix S3 give specific direction on the application of the limits.

Spurious emission from any part of the installation other than the antenna and its transmission line should not have an effect greater than would occur if this antenna system were supplied with the maximum permitted power at that spurious emission frequency.

For technical or operational reasons, more stringent levels than those specified in Table 2 may be applied to protect specific services in certain frequency bands. The levels applied to protect these services should be those agreed upon by the appropriate WRC. More stringent levels may also be fixed by specific agreements between the administrations concerned. Additionally, special consideration of transmitter spurious emissions is required for protection of radioastronomy and other passive services.

Sample calculations and Category A maximum absolute spurious power levels, derived from Table 2 values, can be found in Annex 5.

TABLE 2

Spurious emission limits – Category A

(Recommended attenuation values used to calculate maximum permitted spurious emission power levels intended for use with radio equipment by all countries)

Service category in accordance with Article S1 of the RR, or equipment type (1), (2)	Attenuation (dB) below the power (W) supplied to the antenna transmission line
All services except those services quoted below	43 + 10 log *P*, or 70 dBc, whichever is less stringent
Space services (mobile earth stations)(3), (4)	43 + 10 log *P*, or 60 dBc, whichever is less stringent
Space services (fixed earth stations)(3), (4)	43 + 10 log *P*, or 60 dBc, whichever is less stringent
Space services (space stations)(3), (5), (6)	43 + 10 log *P*, or 60 dBc, whichever is less stringent
Radiodetermination(7)	43 + 10 log *PEP*, or 60 dB, whichever is less stringent
Broadcast television(8)	46 + 10 log *P*, or 60 dBc, whichever is less stringent, without exceeding the absolute mean power level of 1 mW for VHF stations or 12 mW for UHF stations. However greater attenuation may be necessary on a case-by-case basis
Broadcast FM	46 + 10 log *P*, or 70 dBc, whichever is less stringent; the absolute mean power level of 1 mW should not be exceeded
Broadcasting at MF/HM	50 dBc and the absolute mean power level of 50 mW should not be exceeded
SSB from mobile stations(9)	43 dB below PEP
Amateur services operating below 30 MHz (including with SSB)(9)	43 + 10 log *PEP*, or 50 dB, whichever is less stringent
Services operating below 30 MHz, except space, radiodetermination, broadcast, those using SSB from mobile stations, and amateur(9)	43 + 10 log *X*, or 60 dBc, whichever is less stringent where: *X* = *PEP* for SSB modulation, *X* = *P* for other modulation
Low power device radio equipment(10)	56 + 10 log *P*, or 40 dBc, whichever is less stringent
Emergency position-indicating radio beacon (EPIRB) Emergency locator transmitter (ELT) Personal location beacon (PLB) Search and rescue transponder (SART) Ship emergency, lifeboat, and survival craft transmitters Land, aeronautical or maritime transmitters when used in emergency	No limit

Notes to Table 2:

P: mean power (W) at the antenna transmission line, in accordance with RR No. S1.158. When burst transmission is used, the mean power *P* and the mean power of any spurious emissions are measured using power averaging over the burst duration.

PEP: peak envelope power (W) at the antenna transmission line, in accordance with RR No. S1.157.

When the term *P* is used, both the power supplied to the antenna transmission line and spurious emissions should be evaluated in terms of mean power and mean power in the reference bandwidth respectively. When the term PEP is used, both the power supplied to the antenna transmission line and spurious emissions should be evaluated in terms of peak envelope power and peak envelope power in the reference bandwidth respectively. However, when measurement of spurious emission in terms of PEP is difficult due to the nature of spurious emission (e.g. Gaussian noise), it is allowed to evaluate both power supplied to the antenna transmission line and spurious emission power in terms of mean power (see Annex 2).

dBc: decibels relative to the unmodulated carrier power of the emission. In the cases which do not have a carrier, for example in some digital modulation schemes where the carrier is not accessible for measurement, the reference level equivalent to dBc is decibels relative to the mean power *P*.

(1) In some cases of digital modulation and narrow-band high power transmitters for all categories of services, there may be difficulties in meeting limits close to ± 250% of the necessary bandwidth.

(2) Use the e.i.r.p. method shown in Annex 2, § 3.3, when it is not practical to access the transition between the transmitter and the antenna transmission line.

(3) Spurious emission limits for all space services are stated in a 4 kHz reference bandwidth.

(4) Amateur earth stations operating below 30 MHz are in the service category Amateur services operating below 30 MHz (including SSB).

(5) For satellites employing more than one transponder, spurious emissions from one transponder may fall on a frequency at which a companion, second transponder is transmitting. In this situation, the level of spurious emission from the first transponder is well exceeded by fundamental emissions of the second transponder. Therefore, limits should not apply to those spurious emissions on a satellite which fall within the bands where there are transmissions from the same satellite into the same service area.

(6) *Deep space* space station systems, as defined by RR Article S1 as operated beyond 2×10^6 km distance from the Earth, are exempt from spurious emission limits.

(7) Radiodetermination (radar) system spurious emission attenuation is determined for radiated emission levels, not at the antenna transmission line.

(8) For analogue television transmissions, the mean power level is defined with a specified video signal modulation. This video signal has to be chosen in such a way that the maximum mean power level (e.g., at the video signal blanking level for negatively modulated television signals) is provided to the antenna transmission line.

(9) All classes of emission using SSB are included in the category “SSB”.

(10) Low power radio device having a maximum output power of less than 100 mW and intended for short range communication or control purposes. (Such equipment is in general exempt from individual licensing.)

4.3 Category B limits

Table 3 indicates the maximum permitted levels of spurious emissions, in terms of power level, of any spurious component supplied by a transmitter to the antenna transmission line for Category B equipment. For all services/systems not quoted in this table, Category A limits are applicable.

4.4 Category C limits

Table 4 indicates the maximum permitted levels of spurious emissions, in terms of power level, of any spurious component supplied by a transmitter to the antenna transmission line for Category C equipment. For all services/systems not quoted in this table, Category A limits are applicable.

TABLE 3

Category B limits

(See definitions in *further recommends* 3.3)

Type of equipment	Limits
Fixed service[(1) (2)]	– 50 dBm for 30 MHz ≤ f < 21.2 GHz[(3)] – 30 dBm for 21.2 GHz ≤ f < (see *further recommends* 2.5)[(3)]
Fixed service – Terminal station (out station with subscriber equipment interfaces)[(1)]	– 40 dBm for 30 MHz ≤ f < 21.2 GHz[(3)] – 30 dBm for 21.2 GHz ≤ f < (see *further recommends* 2.5)[(3)]
Land mobile service (mobiles and base stations)	– 36 dBm for 9 kHz ≤ f < 30 MHz – 36 dBm for 30 MHz ≤ f < 1 GHz[(4)] – 30 dBm for 1 GHz ≤ f < (see *further recommends* 2.5)[(4)]
VSAT (very small aperture terminal)	See limits in Recommendation ITU-R S.726
FM broadcasting	87.5 MHz ≤ f ≤ 137 MHz: – 36 dBm for P < 9 dBW 75 dBc for 9 dBW ≤ P < 29 dBW – 16 dBm for 29 dBW ≤ P < 39 dBW 85 dBc for 39 dBW ≤ P < 50 dBW –5 dBm for 50 dBW ≤ P 30 MHz < f < 87.5 MHz and 137 MHz < f < (see *further recommends* 2.5): – 36 dBm for P < 4 dBW 70 dBc for 4 dBW ≤ P < 40 dBW 0 dBm for 40 dBW ≤ P
Radar systems in the radiodetermination service: Fixed radiodetermination stations[(5), (6), (7), (8)] (wind profiler, multifrequency and active array radars are excluded)	– 30 dBm or 100 dB attenuation below the PEP, whichever is less stringent
Short range devices operating below 30 MHz	29 – 10 log(f(kHz)/9) dB(µA/m) à 10 m for 9 kHz < f < 10 MHz – 1 dB(µA/m) à 10 m for 10 MHz < f < 30 MHz – 36 dBm for 30 MHz ≤ except frequencies below < 1 GHz – 54 dBm for f within the bands 47-74 MHz, 87.5-118 MHz, 174-230 MHz, 470-862 MHz – 30 dBm for 1 GHz ≤ f < (see *further recommends* 2.5)
Short range device above 30 MHz, Radio local area networks, Citizens band (CB), cordless telephones, and radio microphones	– 36 dBm for 9 kHz ≤ except frequencies below < 1 GHz – 54 dBm for f within the bands 47-74 MHz, 87.5-118 MHz, 174-230 MHz, 470-862 MHz – 30 dBm for 1 GHz ≤ f < (see *further recommends* 2.5)

P: mean power (W) at the antenna transmission line, in accordance with RR No. S1.158. When burst transmission is used, the mean power, P and the mean power of any spurious emissions are measured using power averaging over the burst duration.

Spurious emissions should be evaluated in terms of mean power except for the radiodetermination service where spurious emission should be evaluated in terms of PEP. However, when measurement of spurious emission in terms of PEP is difficult due to the nature of spurious emission (e.g. Gaussian noise), it is allowed to evaluate both power supplied to the antenna transmission line and spurious emission power in terms of mean power (see Annex 2).

f: frequency of the spurious emissions.

(1) Fixed wireless access (FWA) systems using cellular type mobile technologies, described in Recommendation ITU-R F.757, when administrations allows their usage in the same bands locally assigned to land mobile systems or to FWA using a specific land mobile technology, should be subjected to the land mobile service spurious emission limits.

(2) Category A limits apply to HF fixed service.

(3) A reduced reference bandwidth is allowed on both sides of the emission from 250% of the necessary bandwidth (see Annex 6).

(4) A reduced reference bandwidth is allowed on both sides of the emission from 250% of the necessary bandwidth (see Annex 7).

(5) Radiodetermination (radar) system spurious emission should be determined for radiated emission levels, not at the antenna transmission line.

(6) European and some other countries have determined that insofar as they are concerned, Category B spurious emission limits for radar systems should apply to transmitters used in those countries and installed after 1 January 2006.

(7) On a site-by-site basis, administrations may permit the use of maritime mobile radar equipment in fixed installations (e.g. vessel traffic services radar), using the appropriate limits for mobile radars.

(8) Further study is to be undertaken by the relevant regional body, any interference will be handled on a case-by-case basis.

TABLE 4

Category C limits

(See definitions in *further recommends* 3.3)

Type of equipment	Attenuation below the power supplied to the antenna transmission line(1)
Land mobile service (150-174 MHz and 421-512 MHz)	50 + 10 log P or 70 dBc for 12.5 kHz channels, whichever is less stringent 55 + 10 log P or 65 dBc for 6.5 kHz channels, whichever is less stringent
Aeronautical telemetry(2)	55 + 10 log *P*
HF broadcasting	80 dBc
AM and FM broadcasting	43 + 10 log *P* or 80 dBc, whichever is less stringent
Non-GSO mobile earth terminals (mobile-satellite service, 1 610-1 660.5 MHz (limits apply to spurious emissions in the 1 559-1 605 MHz band)) (3)	–70 dB(W/MHz) e.i.r.p., and –80 dBW e.i.r.p. in any 300 Hz bandwidth

P: mean power (W) at the antenna transmission line, in accordance with RR No. S1.158. When burst transmission is used, the mean power *P* and the mean power of any spurious emissions are measured using power averaging over the burst duration.

(1) For mobile earth terminals, the limits shown represent absolute e.i.r.p. levels rather than attenuation.

(2) As a special case, the reference bandwidth should be 3 kHz.

(3) Proposed.

4.5 Category D limits

Table 5 indicates the maximum permitted levels of spurious emissions, in terms of power level, of any spurious component supplied by a transmitter to the antenna transmission line for Category D equipment. For all services/systems and output power range not quoted in the Table, Category A limits are applicable.

4.6 Category Z limits

Table 6 contains Category Z limits for Class A (industrial) and B (domestic) ITE. Category Z equipment is defined as that which combines ITE with a radio transmitting function. If the information technology portion can be detached and still operate independently, then each part should be tested separately in conformity with the pertinent ITU-R spurious emission limit or the CISPR limit. If the information technology portion cannot be independently operated, then the ITU-R Category A, B, C or D limits should be applied while testing in the transmitting mode and the CISPR limits should apply in the standby or idle mode. Values are taken from CISPR Publication No. 22 for frequencies below 1 GHz. Limits for frequencies above 1 GHz are under consideration within CISPR.

Conversion in terms of e.i.r.p. is provided for information by assuming that the maximum field strength is to be measured in a semi-anechoic chamber or in an open area test site according to the CISPR measurement method. This is approximately 4 dB above a measurement with free-space condition (this value is in agreement with CISPR studies).

TABLE 5

Category D Limits

(See definitions in *further recommends* 3.3)

Type of equipment	Limits
Fixed service	
30 MHz < f_0 ≤ 335.4 MHz	60 dBc for P < 50 W 0 dBm for 10 kW ≤ P
335.4 MHz < f_0 ≤ 470 MHz	–26 dBm for P < 25 W 70 dBc for 25 W ≤ P < 10 kW 0 dBm for 10 kW ≤ P
Maritime mobile service(1)	
30 MHz < f_0 ≤ 335.4 MHz	146 MHz < f ≤ 162.0375 MHz –26 dBm for P < 20 W 69 dBc for 20 W ≤ P < 400 W f ≤ 146 MHz and 162.0375 MHz < f –20 dBm for P < 20 W 63 dBc for 20 W ≤ P < 100 W
Aeronautical mobile service(2)	
118 MHz < f_0 ≤ 142 MHz	–16 dBm for P ≤ 25 W
335.4 MHz < f_0 ≤ 470 MHz	60 dBc for P < 50 W 0 dBm for 10 kW ≤ P
830 MHz < f_0 ≤ 887 MHz(2)	–26 dBm for P ≤ 25 W 70 dBc for 25 W < P
SSB (Fixed and land stations excluding coast stations) f_0 ≤ 30 MHz	50 dBc for P < 5 W
Land mobile service (Analogue systems for portable/automobile telephones)	60 dBc for P < 50 W
(Digital cordless telephones and PHS) 1 893.65 MHz < f_0 ≤ 1 919.45 MHz	1 893.5 MHz < f ≤ 1 919.6 MHz –36 dBm f ≤ 1 893.5 MHz and 1 919.6 MHz < f –26 dBm

P: mean power (W) at the antenna transmission line, in accordance with RR No. S1.158. When burst transmission is used, the mean power *P* and the mean power of any spurious emissions are measured using power averaging over the burst duration

f: frequency of the spurious emissions

f_0: fundamental frequency.

(1) For F3E emission and for ship stations or on-board communication stations.

(2) For aircraft radiotelephony.

TABLE 6

Category Z limits

(Radiation limits for ITE specified by CISPR)

Frequency (MHz)	E_{max} (dB(μV/m))	Distance of measurement (m)	Corresponding e.i.r.p. (dBm)
Class A: applicable to ITE intended for industrial environment			
30-230	40	10	–49
230-1 000	47	10	–42
Class B: applicable to ITE intended for a domestic environment			
30-230	30	10	–59
230-1 000	37	10	–52

5 Measurement method

The measurement methods of spurious emissions are described in detail in Annex 2.

6 Protection of radioastronomy service and space services using passive sensors

Protection criteria for the radioastronomy service and Earth exploration-satellite and meteorological satellite services using passive sensors should be taken into account when applying spurious emission limits. All of these services can be particularly sensitive to interference.

6.1 Radioastronomy service

Radioastronomy, because of its passive nature and because of the sensitivity of its measurements, needs special consideration as far as spurious emissions are concerned; radio astronomers routinely encounter signal-to-noise ratios of –30 to –60 dB using long integration intervals. Administrations are urged, as far as practicable, to take into consideration the need to avoid spurious emissions which could cause interference to radioastronomy operating in accordance with Article S29 of the RR. In bringing new satellite services into operation, administrations are urged to note that transmitters on satellites can cause severe interference to radioastronomy through their spurious and out-of-band emissions, including far sidebands which result from digital modulation techniques. The threshold levels of interference for radioastronomy as given in Recommendation ITU-R RA.769 should be taken into account. An extract from the tables of Recommendation ITU-R RA.769 is contained in Annex 3. The levels in this table are listed for reference and are not intended for general application as mandatory limits.

For transmitters on the Earth's surface, if limits on spurious emissions do not afford sufficient protection for radioastronomy, mitigation of interference can, in some cases, be provided, for example, through terrain shielding; by the establishment by administrations of coordination, protection or exclusion zones; and by other provisions of RR Articles S15 and S29 relative to radioastronomy observatories.

6.2 Earth exploration-satellite and meteorological satellite services using passive sensors

Passive remote sensing from satellites is becoming increasingly important for the retrieval of atmospheric parameters including temperature, water vapour content, concentration of ozone and other gases, as well as examination of the surface of the Earth. Recommendation ITU-R SA.1029 contains the threshold levels of interference for satellite passive remote sensing. An extract from Recommendation ITU-R SA.1029 is contained in Annex 3. The levels contained in this table are for reference and are not intended as mandatory limits.

ANNEX 1

Expression and units for spurious emissions

1 Expression of spurious emissions

Spurious emissions levels are generally expressed in terms of power, field strength measured at a given distance, or a pfd also measured at a given distance, all measured in a given bandwidth.

Even if the field strength at a given distance from the transmitting antenna is the more significant value to assess and measure spurious emissions, it is considered sufficient for a while, to identify the power parameters of the transmitters in order to work on radio interference and electromagnetic compatibility.

1.1 Power values

Many expressions related to the radiated power are useful to evaluate spurious emissions. They all present advantages and difficulties, linked to current measurement capabilities as well as to the interpretation of the measured values.

1.1.1 Power supplied to the antenna (p.s.a.)

Often used below 30 MHz and for equipment above 30 MHz having an antenna connector, this power is generally easy to measure except when a transmitter has an integral antenna or for high powered ELF/LF systems.

This power measurement represents the actual capability of the transmitter to feed an antenna with spurious signals, but does not take account of the antenna itself and its capability to radiate radio emissions at frequencies other than those for which it has been designed.

1.1.2 Equivalent isotropic radiated power (e.i.r.p.)

Mainly used above 30 MHz (most of the time above 80 MHz), this power gives a better knowledge of the capability of the transmitter system (including the antenna) to radiate the power of spurious emissions and to possibly produce harmful interference to other radio services. The relation between the power at the antenna port or connector and the e.i.r.p. is not easy to derive, as the characteristics of antennas outside their design band are generally not known.

For equipment having integral antennas, it is the main known power parameter to characterize spurious emissions.

1.1.3 Effective radiated power (e.r.p.)

The only difference from e.i.r.p. is that e.r.p. refers to the radiation of a half wave tuned dipole instead of an isotropic antenna. There is a constant difference of 2.15 dB between e.i.r.p. and e.r.p.

$$e.i.r.p.\ \text{(dBm)} = e.r.p.\ \text{(dBm)} + 2.15$$

1.2 Field strength

The interfering field strength, *E* or *H*, at the victim receiver antenna is, in principle, the required characteristic for the spurious emission effect to be known. The relation, however, between the e.i.r.p. and the field strength in all possible situations is quite difficult to determine, because of radiowave propagation and other radio coupling phenomena (diffraction from buildings, effects of masks etc.), even if the derivation of spurious limits take into account only some basic/worst-case situations that can occur.

Field strength is a value that is usually measured on a test site, at a given distance. For disturbance and interference measurement purposes of non intentionally radiating devices and particularly ITE, CISPR recommends typical field-strength measurements at 10 m on a calibrated open area test site (OATS) with a reflecting ground plane.

1.3 pfd

pfd is generally evaluated and measured above 1 GHz, for satellite radio links, and radioastronomy.

2 Units

2.1 Power units

Even though the International System (IS) power unit is the Watt (W), the telecommunication publications express spurious emissions p.s.a., e.i.r.p. or e.r.p. in various units including dBpW, nW, dBm or dBW or equivalent expressions of power density per any reference bandwidth.

2.2 Field strength units

The electric field strength unit, *E*, is the V/m. Most of the telecommunication publications express electric field strength in μV/m or dB(μV/m).

The magnetic field strength unit, *H*, is the A/m. Most of the telecommunication publications express electric field strength in μA/m or dB(μA/m).

2.3 pdf units

The pfd unit is the W/m^2. Most of the telecommunication publications express pfd in dB(W/m^2) or in mW/cm^2.

3 Relation between power, electric field strength, *E*, and pfd

A simple relation can be established for perfect, ideal cases (which means free space, far field conditions) between *E* (V/m), *D* distance between the transmitting radio equipment and the point of measurement (m), e.i.r.p. (W) and pfd (W/m^2).

$$E = \frac{\sqrt{30\,(e.i.r.p.)}}{D}$$

A maximum value of *E* can be calculated, representing the maximum reading obtainable on an OATS by adjustment of the measurement antenna height. It is:

$$E_{max} \cong 1.6\,E$$

This represents a site gain of 4 dB. The field strength as *E* (V/m) can be converted to dB(μV/m) as follows:

$$E\ (\mathrm{dB}(\mu\mathrm{V/m})) = 120 + 20 \log E$$

the pfd (W/m^2) is:

$$pfd = E^2/(120\pi)$$

and the PFD (dB(W/m^2)) is:

$$PFD = 10 \log pfd$$

Table 7 shows the correspondence between the power values (e.i.r.p., e.r.p.), the field strength (E, E_{max}) and the pfd for different units.

TABLE 7

Correspondence between e.i.r.p., e.r.p., field strength, *E*, and pfd

e.i.r.p. (dBm)	e.i.r.p. (nW)	e.i.r.p. (dB(pW))	e.i.r.p. (dBW)	e.r.p. (dBm)	*E* field free space (dB(μV/m)) at 10 m	E_{max} OATS (dB(μV/m)) at 10 m	PFD free space (dB(W/m^2)) at 10 m	PFD maximum OATS (dB(W/m^2)) at 10 m
–90	0.001	0	–120	–92.15	–5.2	–1.2	–151.0	–147.0
–80	0.01	10	–110	–82.15	4.8	8.8	–141.0	–137.0
–70	0.1	20	–100	–72.15	14.8	18.8	–131.0	–127.0
–60	1	30	–90	–62.15	24.8	28.8	–121.0	–117.0
–50	10	40	–80	–52.15	34.8	38.8	–111.0	–107.0
–40	100	50	–70	–42.15	44.8	48.8	–101.0	–97.0
–30	1 000	60	–60	–32.15	54.8	58.8	–91.0	–87.0
–20	10 000	70	–50	–22.15	64.8	68.8	–81.0	–77.0
–10	100 000	80	–40	–12.15	74.8	78.8	–71.0	–67.0
0	1 000 000	90	–30	–2.15	84.8	88.8	–61.0	–57.0

ANNEX 2

Methods of measurement of spurious emissions

1 Measuring equipment

1.1 Selective measuring receiver

Either a selective receiver or a spectrum analyser may be used for the measurement of spurious power supplied to the antenna and cabinet radiation.

1.1.1 Weighting functions of measurement equipment

It is recommended that all measurement receivers be procured with both the mean and peak weighting functions.

1.1.2 Resolution bandwidths

As a general guideline, the resolution bandwidths (measured at the –3 dB points of the final IF filter) of the measuring receiver should be equal to the reference bandwidths as given in *further recommends* 4.1. To improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth can be different from the reference bandwidth. For instance, narrower resolution bandwidth is sometimes necessary for emissions close to the centre frequency. When the resolution bandwidth is smaller than the reference bandwidth, the result should be integrated over the reference bandwidth (the integration should be made on the basis of a power sum unless the spurious signal is known to be additive in voltage or with intermediate law, see Note 1). When the resolution bandwidth is greater than the reference bandwidth, the result for broadband spurious emissions should be normalized to the bandwidth ratio. For discrete (narrow-band) spurii, normalization is not applicable.

A correction factor to the resolution bandwidth should be introduced depending on the actual resolution bandwidth of the measuring receiver (e.g. –6 dB resolution bandwidth) and on the nature of the measured spurious emission (e.g. pulsed signal or Gaussian noise).

NOTE 1 – When spurious emission is measured in terms of PEP with a resolution bandwidth narrower than the reference bandwidth, the power sum might not be appropriate. If the addition rule is not known, the total spurious emission in the reference bandwidth should be evaluated using both power and voltage sum rules. In every case, if the total spurious emission using voltage sum rule is lower than the specified limit, then the limit is met. If the total spurious emission using power sum rule is higher than the specified limit, then the limit is not met.

1.1.3 Video bandwidth

The video bandwidth must be at least as large as the resolution bandwidth, and preferably be three to five times as large as the resolution bandwidth.

1.1.4 Measurement receiver filter shape factor

Shape factor is a selectivity parameter of a band-pass filter and is usually defined as the ratio of the desired rejection bandwidth to the desired pass bandwidth. In an ideal filter this ratio would be 1. However, practical filters have attenuation roll-off far from this ideal. For example, spectrum analysers which approximate Gaussian filters by using multi-tuned filters to respond to signals while in swept mode, typically define a – 60 dB to –3 dB ratio ranging from 5:1 to 15:1.

1.2 Fundamental frequency rejection filter

The ratio of the power of the fundamental frequency to the power of the spurious emissions may be of the order of 70 dB or more. A ratio of this order may often result in an input at the fundamental frequency of a sufficient level to generate non-linearities in the selective receiver. Hence, a rejection filter to attenuate the fundamental frequency at the input of the measuring device is usually required (if the spurious emission frequency is not too close to the fundamental frequency). For frequency ranges well above the fundamental frequency (for harmonic frequencies for example), it is also possible to use a band-pass or high-pass filter. The insertion loss of this filter for spurious emission frequencies must not be too high. However, the frequency response of the filter has to be very well characterized.

Typical variable frequency, lumped circuit rejection filters at the VHF/UHF range have only 3-5 dB insertion loss, and less, about 2-3 dB loss above 1 GHz.

Tuneable quarter wave bandpass cavity filters are available for frequency ranges above about 50 MHz because of their physical size and have insertion losses on the order of less than 1 dB. Cavity notch filters will have about the same loss once the frequency of interest is more than about 10% away from the notch frequency.

Receivers that have to cover many bands usually require variable filtering which tracks the tuned frequency of the system being measured. The types of variable filters that are adequate for spurious measurements are either varactor tuners or yttrium-iron-garnet (YIG) filters. These filters have more insertion loss than fixed filters, but have smaller passbands which allows measurement of signals that are closer in frequency to the transmitter frequencies.

Varactor tuners typically are recommended for frequencies between 50 MHz and 1 GHz. They provide a 3 dB bandwidth that is about 5% of the tuned frequency and have about 5-6 dB insertion loss.

YIG filters typically are recommended for frequencies between about 1-18 GHz. They provide a 3 dB bandwidth that is about 15 MHz at 2 GHz RF, and about 30 MHz wide at 18 GHz RF. The insertion loss is about 6-8 dB.

1.3 Coupling device

Measurements are made using a directional coupler capable of handling the power of the fundamental emission. The impedance of this coupler must match the transmitter impedance at the fundamental frequency.

1.4 Terminal load

To measure the power of spurious emissions, while using measurement Method 1, the transmitter shall be connected to a test load or terminal load. The level of spurious emission depends on proper impedance matching between the transmitter final stage, the transmission line and the test load.

1.5 Measuring antenna

Measurements are made with a tuned dipole antenna or a reference antenna with a known gain referenced to an isotropic antenna.

1.6 Condition of modulation

Whenever it is possible, the measurements are made in the presence of the maximum rated modulation under normal operating conditions. It may sometimes be useful to start the measurements without applying the modulation, in order to detect some particular spurious frequencies. In this case, it must be pointed out that all spurious emission frequencies may not be detected and switching the modulation on may produce other spurious frequency components.

2 Measurement limitations

2.1 Bandwidth limitations

The limits of ±250% of the necessary bandwidth establish the start of the measurement frequency band for spurious emissions in accordance with *further recommends* 2.3 of this Recommendation. In some cases this is not possible because significant measurement errors may result due to the inclusion of non-spurious emissions. In order to establish a new boundary for the spurious measurement bandwidth (BW), a new frequency separation other than ±250% of the necessary bandwidth can be justified. Alternatively a smaller resolution bandwidth may be used with the ±250% of the necessary bandwidth.

The new boundary and resolution bandwidth are related by the following equation:

$$\text{Resolution BW} \times [(\text{shape factor}) - 1)] \leq 2\ [(\text{out-of-band boundary}) - (\text{necessary BW})/2]$$

From the above equation, it is clear that if the resolution bandwidth cannot be changed, then a new out-of-band boundary should be calculated. The opposite case is also true.

Consider a signal with a 16 kHz necessary bandwidth, and a ±250% out-of-band boundary (i.e. 40 kHz) which cannot be changed. If the measuring resolution bandwidth filter has a shape factor of 15:1 and the required rejection of the carrier in-band power is 60 dB then the resolution bandwidth has to be approximately 4.5 kHz, from:

$$\text{Required resolution BW} \leq 2\ [(\text{Out-of-band boundary}) - (\text{necessary BW})/2]/(\text{shape factor} - 1)$$

therefore:

$$\text{Required resolution BW} \leq 2\ (40 - 16/2)/(15 - 1)$$

therefore:

$$\text{Required resolution BW} < 4.5\ \text{kHz}$$

On the other hand, given the same signal and measurement receiver parameters, if the resolution bandwidth is fixed at 100 kHz then a new out-of-band boundary is calculated by rearranging the above formula and solving for the new out-of-band boundary. In this case, if the resolution bandwidth is fixed at 100 kHz, then the new boundary is 708 kHz.

2.2 Sensitivity limitation

Under certain conditions, the sensitivity of commercially available spectrum analysers, together with transition and cable losses might lead to insufficient measurement sensitivity. This may be overcome by the use of a low noise amplifier.

In extreme cases, typically above 26 GHz and mostly due to the use of external mixers in the test set-up, it still may not be possible to achieve enough sensitivity to verify that the equipment under test (EUT) conforms to the specification requirement under modulated condition. The spurious emission measurement in the CW condition may be corrected, for those emissions that are subject to the modulation process, by an amount equal to the modulation loss of the EUT.

2.3 Time limitations

For any desired signal, where the output amplitude changes with time (e.g. non constant envelope modulation), ten or more averaged measurement may be used for consistency.

3 Methods of measurement

3.1 Introduction

There are two methods for measurement of spurious emissions described in this Annex. Method 2 is described in CISPR Publication No. 16. Care must be taken with Methods 1 and 2 that emissions from the test do not cause interference to systems in the environment, and care must also be taken to utilize the weighting function (see § 1.1.1 above) that matches the power specified in Categories A, B, C, D and Z.

– Method 1 is the measurement of spurious emission power supplied to the antenna port of the EUT. This method should be used whenever it is practical and appropriate.

– Method 2 is the measurement of the spurious e.i.r.p., using a suitable test site.

Systems using waveguides should use Method 2, since terminating waveguides in a transition device can cause many testing problems. If the antenna port is a waveguide flange, distant spurious emissions might be greatly attenuated by the waveguide to coaxial transition, unless specific tapered waveguide sections are placed in the measurement line so that Method 1 may be utilized. Similarly, VLF/LF band transmitters should also be measured using Method 2 since the boundary between the transmitter, feeder cable and antenna is not always clearly defined.

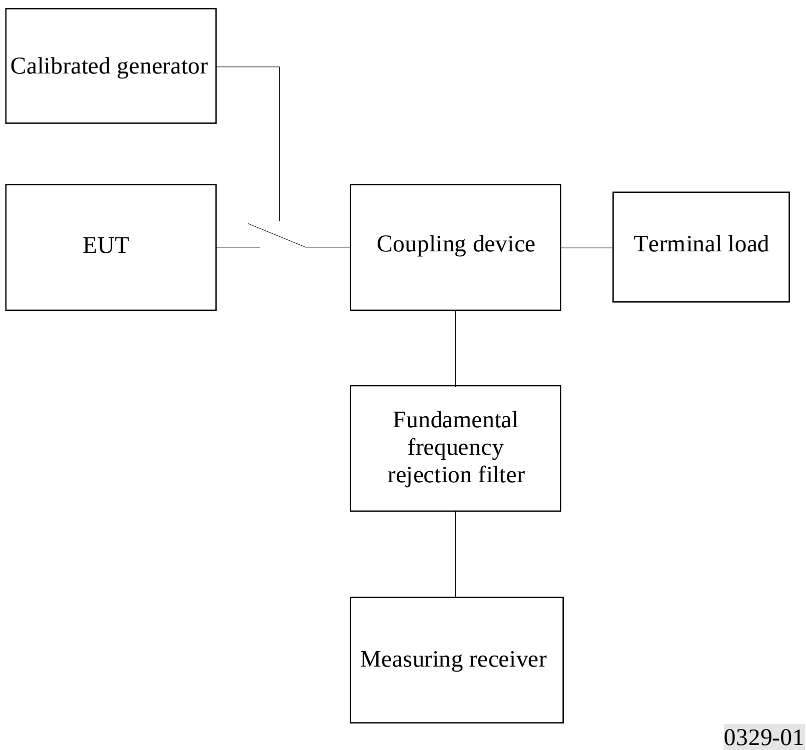
The measurement method for radar systems should be guided by Recommendation ITU-R M.1177. For those systems for which acceptable methods of measurement do not exist, all practical measures should be taken to meet the appropriate limits of the power of spurious emissions.

3.2 Method 1 – Measurement of the spurious emission power supplied to the antenna port

No particular test site or anechoic chamber is required and electromagnetic interference (EMI) should not affect the results of the tests. Whenever it is possible, the measurement should include the feeder cable. This method does not take into account attenuation due to antenna mismatch and radiation inefficiencies presented to any spurii, or the active generation of spurii by the antenna itself. The block-diagram of the measurement set-up for the spurious emission power to the antenna port is shown in Fig. 1.

FIGURE 1

Measurement set-up for the spurious emission power to the antenna port



3.2.1 Direct conducted approach

In this approach, it is required to calibrate all the measuring components individually (filter(s), coupler, cables), or to calibrate these connecting devices as a whole. In either case, the calibration is performed by using a calibrated adjustable level generator at the input of the measurement receiver. At each frequency, f, the calibration factor k_f is then determined as follows:

$$k_f = I_f - O_f$$

where:

k_f: calibration factor (dB) at the frequency, f

I_f: input power (delivered by the calibrated generator) (dBW) or (dBm), at the frequency, f

O_f: output power (determined by the measurement receiver) in the same unit as I_f, at the frequency, f.

This calibration factor represents the total insertion loss of all the devices connected between the generator and the measurement receiver.

If making individual device calibration measurements, calibration of the whole measurement set-up is derived by using the following formula:

$$k_{ms,f} = \sum_i k_{i,f}$$

where:

$k_{ms,f}$: calibration factor (dB) of the measurement set-up, at the frequency, f

$k_{i,f}$: individual calibration factor (dB) of each device in the measurement chain, at the frequency, f.

During measurement of actual spurious levels, $P_{r,f}$ (dBW) or (dBm) is the power (read on the measuring receiver) from the spurious emission at the frequency, f, the spurious emission power, $P_{s,f}$ (same unit as $P_{r,f}$) at the frequency, f, is calculated by using the following equation:

$$P_{s,f} = P_{r,f} + k_{ms,f}$$

3.2.2 Substitution approach

This method does not require calibration of all measuring components. Instead, the spurious output power is recorded from the measuring device. Then this power level is matched by a signal from a calibrated signal generator which is substituted for the EUT. The power supplied by the generator is then equal to the power of the spurious emission.

3.3 Method 2 – Measurement of the spurious e.i.r.p.

The block-diagram of the measuring set-up for the spurious emission e.i.r.p. is shown in Fig. 2.

The measurements must be made in the far field, which is often difficult for very low frequencies or for certain combinations of frequency and antenna size (e.g. transmissions at 14 GHz using a 1.2 m dish requires about 140 m to reach the far field). The measurements of the e.i.r.p. of the spurious emissions in any direction, in several polarizations and for any frequency could be very time consuming, although techniques to check compliance may reduce this workload. The use of this method to measure radars should be guided by Recommendation ITU-R M.1177.

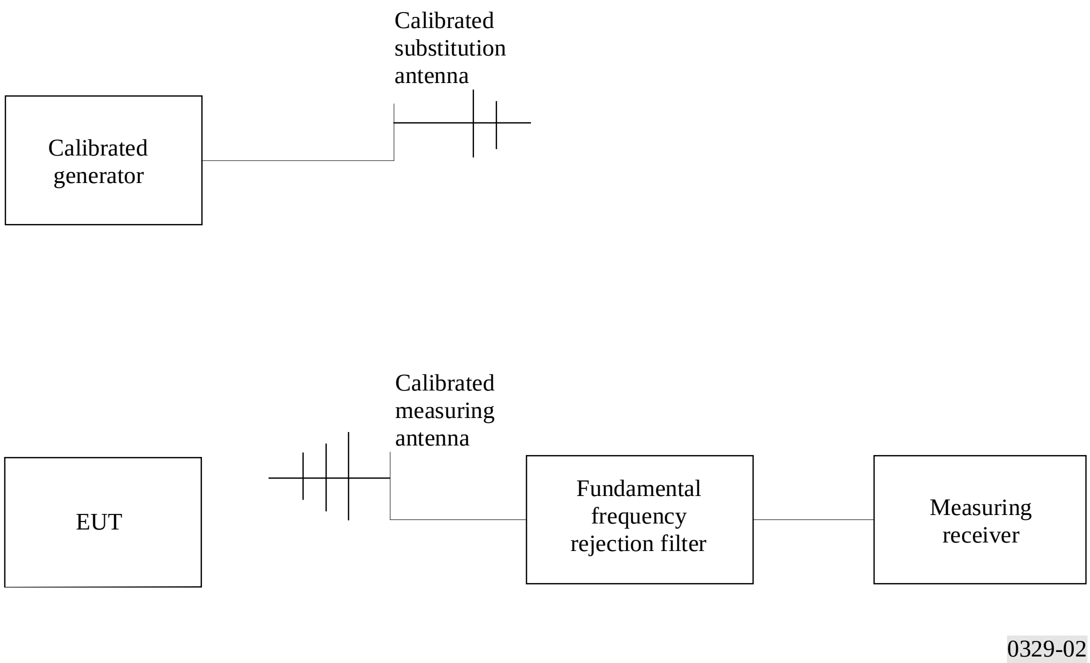
3.3.1 Measurement site for radiated measurements

Test sites shall be validated by making site attenuation measurements for both horizontal and vertical polarization fields. A measurement site shall be considered acceptable if the horizontal and vertical site attenuation measurements are within ±4 dB of the theoretical site attenuation.

The test site shall characteristically be flat, free of overhead wires and nearby reflecting structures, sufficiently large to permit antenna placement at the specified distance and provide adequate separation between antenna, EUT and reflecting structures. Reflecting structures are defined as those whose construction material is primarily conductive. The test site shall be provided with a horizontal metal ground-plane. The test site shall satisfy the site attenuation requirements of IEC/CISPR Publication No. 16-1 for OATS.

FIGURE 2

Measuring set-up for the spurious emission e.i.r.p.



Tests may also be conducted in absorber lined shielded room. In that case, the walls of a shielded room are covered with absorber materials that ensure no wave reflection. Validation measurements of such anechoic chambers are very important to ensure that the site attenuation measurements can be performed within the ±4 dB criteria (see also IEC/CISPR Publication No. 22).

A conducting ground-plane shall extend at least 1 m beyond the periphery of the EUT and the largest measuring antenna, and cover the entire area between the EUT and the antenna. It should be of metal with no holes or gaps, having dimensions larger than one tenth of the wavelength at the highest frequency of measurement. A larger size conducting ground-plane may be required if the site attenuation requirements of the test site are not satisfied. These requirements are also applicable in the case of semi-anechoic chambers.

Additional equipment is becoming available as the site for spurious emission measurements. These are various chambers, such as stirred mode chambers (SMC), and transverse electromagnetic (TEM) or Gigahertz TEM (GTEM) systems. The SMC is described in IEC/CISPR Publication. These relatively new measurement systems are not universally accepted as yet by all standardization bodies. The techniques used with these systems should be re-examined when this Recommendation is updated in the future, with a view towards incorporating details of their use.

3.3.2 Direct approach

In this approach, it is required to calibrate all the measuring components individually (filter(s), cables), or to calibrate the whole measuring set. See § 3.2.1 on direct approach for the determination of the calibration factor of the measuring set at the frequency, *f*.

The spurious emission e.i.r.p., $P_{s,f}$, at the frequency *f*, is given for free space conditions by the following equation:

$$P_{s,f} = P_{r,f} + k_{ms,f} - G_f + 20 \log f + 20 \log d - 27.6$$

where:

- $P_{r,f}$: power of the spurious emission read on the measuring receiver at the frequency, *f* (dBW or dBm, same units as $P_{s,f}$)
- $k_{ms,f}$: calibration factor of the measuring set-up at the frequency, *f* (dB)
- G_f: gain of the calibrated measuring antenna at the frequency, *f* (dBi)
- f: frequency of the spurious emission (MHz)
- d: distance (m) between the transmitting antenna and the calibrated measuring antenna.

3.3.3 Substitution approach

In this approach, a calibrated substitution antenna and a calibrated generator are used, the test source being adjusted for the same received spurious signal.

3.4 Special cabinet radiation measurement

To provide a means of measuring cabinet radiation, Method 2 can be used to measure transmitter cabinet spurious radiation. This method requires replacing the EUT antenna with a calibrated terminal load, and proceeding with the approaches listed above for Method 2, to obtain case e.i.r.p. The terminating dummy load should be placed in a small, separate shielded enclosure so that re-radiation from the load does not interfere with the measuring of radiation from the cabinet under test. Additionally, connecting cables may radiate and adversely affect the measurements, so care must be taken to prevent this by using double shielded cables or using the shielded enclosure for the cables also.

ANNEX 3

Threshold levels of interference for the radio astronomy service and space services using passive sensors

1 Introduction

Threshold levels of interference for the radio astronomy service, Earth exploration-satellite and meteorological-satellite services using passive sensors can be found in Recommendations ITU-R RA.769 and ITU-R SA.1029. This Annex summarizes the levels provided in these Recommendations.

2 Radio astronomy service (Recommendation ITU-R RA.769)

Table 8 gives the threshold levels of pfd for interference detrimental to the radio astronomy service as it appears in Recommendation ITU-R RA.769 for those frequency bands listed in this Recommendation; this includes all bands allocated to the radio astronomy service on a primary basis, except the eight bands allocated via RR No. S5.555. These are calculated for observations with a single antenna and reception in sidelobes of gain 0 dBi and an integration time of 2 000 s. The values of pfd given in Table 8 apply generally, except for GSO satellites for which the pfd is 15 dB more stringent than shown (see Recommendation ITU-R RA.769).

Annex 1 to Recommendation ITU-R RA.769 describes the methodology for calculating the sensitivity of various radio astronomy systems currently in use. It also provides, for assumed values of system parameters, tabulated levels of aggregate interference which are detrimental to both continuum and spectral-line measurements for various bands allocated to the radio astronomy service.

The assumed parameters used to derive these levels are representative of many types of radio astronomy systems and measurements and are an agreed acceptable standard within the radio astronomy service. However, there may be circumstances in coordination with a specific radio astronomy system, operating at a particular time and location in a particular band, where other values of these parameters may be used with the same methodology to derive a more appropriate level of detrimental interference. In addition, for consideration of interference from specific types of systems (e.g. GSO satellites or multiple-satellite systems) a systematic adjustment of the levels in Recommendation ITU-R RA.769 may be warranted. Accordingly, when the levels contained in Table 8 are applied or referred to, account should be taken of the assumptions used to derive them.

TABLE 8

Threshold levels of pfd of interference detrimental to the radio astronomy service*

	Continuum observations		Spectral lines observations	
Radio astronomy band(1) (MHz)	PFD (dB(W/m^2))	Assumed bandwidth (MHz)	PFD (dB(W/m^2))	Assumed spectral line channel bandwidth (kHz)
13.36-13.41	–201	0.05	(2)	(2)
25.55-25.67	–199	0.120	(2)	(2)
73.0-74.6	–196	1.6	(2)	(2)
150.05-153.0	–194	2.95	(2)	(2)
322.0-328.6	–189	6.6	–204	10
406.1-410.0	–189	3.9	(2)	(2)
608-614	–185	6	(2)	(2)
1 400-1 427	–180	27	–196	20
1 610.6-1 613.8	(3)	(3)	–194	20
1 660-1 670	–181	10	–194	20
2 690-2 700	–177	10	(2)	(2)
4 990-5 000	–171	10	(2)	(2)
(GHz)				
10.6-10.7	–160	100	(2)	(2)
15.35-15.4	–156	50	(2)	(2)
22.21-22.5	(3)	(3)	–162	250
23.6-24.0	–147	400	–161	250
31.3-31.8	–141	500	(2)	(2)
42.5-43.5	–137	1 000	–153	500
86-92	–125	6 000	–144	1 000
105-116	–121	11 000	–141	1 000
164-168	–120	4 000	(2)	(2)
182-185	(3)	(3)	–136	1 500
217-231	–114	14 000	–133	2 500
265-275	–113	10 000	–131	2 500

* The levels are calculated under specific assumptions given in Recommendation ITU-R RA.769, in particular with an integration time of 2 000 s.

(1) These are the frequency bands listed in Recommendation ITU-R RA.769; eight further bands are allocated to the radio astronomy service on a primary basis via RR No. S5.555.

(2) Not listed in Table 2 of Recommendation ITU-R RA.769.

(3) Not listed in Table 1 of Recommendation ITU-R RA.769.

3 Earth exploration-satellite and meteorological-satellite passive sensing (Recommendation ITU-R SA.1029)

The permissible interference levels given in Table 9 are based on Recommendation ITU-R SA.1029. They refer to power levels at the receiver input and do not include characteristics of the receiving antenna. The gain of the receiving antenna may be inferred from the values of resolution (km) given in Table 2 of Recommendation ITU-R SA.515 and the knowledge that a typical orbital altitude for spaceborne remote sensors can be taken as 500 km. Note that for spaceborne remote sensing, the sensor antenna is normally directed at the Earth's surface. Note that the levels in Table 9 are described as permissible in the context that they meet the interference criteria of passive sensors. However, use of permissible may not necessarily conform with a strict regulatory definition.

TABLE 9

Permissible interference levels at the receiver input for passive sensing

Frequency (GHz)	Interference level (dBW)	Interference reference bandwidth (MHz)
1.4-1.427	–171	27
2.69-2.7	–174	10
4.2-4.4	–161	100
6.5-6.7	–164	100
10.6-10.7	–163	20
15.2-15.4	–166	50
18.6-18.8	–155(1)	100
21.2-21.4	–163	100
22.21-22.5	–160	100
23.6-24	–163	100
31.3-31.8	–163	100
36-37	–156	100
50.2-50.4	–161/–166(2)	100
52.6-59	–161/–166(2)	100
60.3-61.3	–161/–166(2)	100
86-92	–153	200
100-102	–160	200
105-126	–160	200
150-151	–160	200
155.5-158.5	–160	200
164-168	–160	200
175-192	–160	200
200-202	–160	200
217-231	–160	200
235-238	–160	200
250-252	–160	200
275-277	–160	200
300-302	–160	200
324-326	–160	200
345-347	–160	200
363-365	–160	200
379-381	–160	200

(1) This value is under study.

(2) Second number for pushbroom sensors.

ANNEX 4

List of ITU-R Recommendations relating to spurious emissions for some specific services

Recommendation ITU-R SM.239	Spurious emissions from sound and television broadcast receivers
Recommendation ITU-R S.726	Maximum permissible level of spurious emissions from very small aperture terminals (VSATs)
Recommendation ITU-R RA.611	Protection of the radioastronomy service from spurious emissions
Recommendation ITU-R M.1177	Techniques for measurement of spurious emissions of radar systems
Recommendation ITU-R F.1191	Bandwidths and unwanted emissions of digital radio-relay systems
Recommendation ITU-R BT.803	The avoidance of interference generated by digital television studio equipment
Recommendation ITU-R M.478	Technical characteristics of equipment and principles governing the allocation of frequency channels between 25 and 3 000 MHz for the FM land mobile service
Recommendation ITU-R M.1343	Essential technical requirements of mobile earth stations for global non-geostationary mobile-satellite service systems in the bands 1-3 GHz

ANNEX 5

Examples of applying 43 + 10 log *P* to calculate attenuation requirements

All spurious emissions are to be at least x dB down from the total mean power P, i.e. $–x$ dBc. The power P (W) is to be measured in a bandwidth wide enough to include the total mean power. The spurious emissions are to be measured in the reference bandwidths given in this Recommendation. The measurement of the spurious emission power is independent of the value of necessary bandwidth. Note that the attenuation of 43 + 10 log P always results in an absolute spurious emission power level of –43 dBW or –13 dBm. Because this absolute emission power limit can become too stringent for high power transmitters, alternate relative powers are also provided in Table 2.

Example 1:

A land mobile transmitter, with any value of necessary bandwidth, must meet a spurious emission attenuation of 43 + 10 log P, or 70 dBc, whichever is less stringent. To measure spurious emissions in the frequency range between 30 and 1 000 MHz, *further recommends* 4.1 indicates use of a reference bandwidth of 100 kHz. For other frequency ranges, the measurement must use the appropriate reference bandwidths given in *further recommends* 4.1.

With a measured total mean power of 10 W:

Attenuation relative to total mean power = 43 + 10 log 10 = 53 dB

The 53 dBc is less stringent than 70 dBc, so the 53 dBc value is used.

Therefore:

Spurious emissions must not exceed 53 dBc in a 100 kHz reference bandwidth, or converting to an absolute level

Spurious emissions must not exceed 10 dBW – 53 dBc = –43 dBW in a 100 kHz reference bandwidth.

With a measured total mean power of 1 000 W:

Attenuation relative to total mean power = 43 + 10 log 1 000 = 73 dB

The 73 dBc is more stringent than 70 dBc limit, so the 70 dBc value is used.

Therefore:

Spurious emissions must not exceed 70 dBc in a 100 kHz reference bandwidth, or converting to an absolute level

Spurious emissions must not exceed 30 dBW – 70 dBc = –40 dBW in a 100 kHz reference bandwidth.

Example 2:

A space services transmitter, with any value of necessary bandwidth, must meet a spurious emission attenuation of 43 + 10 log *P*, or 60 dBc, whichever is less stringent. To measure spurious emissions at any frequency, footnote (3) of Table 2 indicates using a reference bandwidth of 4 kHz.

With a measured total mean power of 20 W:

Attenuation relative to total mean power = 43 + 10 log 20 = 56 dB

The 56 dBc is less stringent than the 60 dBc limit, so the 56 dBc value is used.

Therefore:

Spurious emissions must not exceed 56 dBc in a 4 kHz reference bandwidth or converting to an absolute level

Spurious emissions must not exceed 13 dBW – 56 dBc = –43 dBW in a 4 kHz reference bandwidth.

TABLE 10

Absolute levels of spurious emissions – Category A

Service category in accordance with RR Article S1 or equipment type(1), (2)	Maximum permitted spurious emission power in the relevant reference bandwidth (see *further recommends* 4.1) (dBm) with *P*, *PEP* or *X* (W)	
All services except those services quoted below	–13 dBm 10 log *P* – 40	if *P* ≤ 500 W if *P* > 500 W
Space services (mobile earth stations)(3), (4)	–13 dBm 10 log *P* – 30	if *P* ≤ 50 W if *P* > 50 W
Space services (fixed earth stations)(3), (4)	–13 dBm 10 log *P* – 30	if *P* ≤ 50 W if *P* > 50 W
Space services space stations(3), (5), (6)	–13 dBm 10 log *P* – 30	if *P* ≤ 50 W if *P* ≥ 50 W
Radiodetermination(7)	–13 dBm 10 log *PEP* – 30	if *PEP* ≤ 50 W if *PEP* > 50 W
Broadcast TV(8) VHF transmitters	–16 dBm 10 log *P* – 30 0 dBm	if *P* ≤ 25 W if 25 W < *P* ≤ 1 000 W if *P* > 1 000 W
Broadcast TV(8) UHF transmitters	–16 dBm 10 log *P* – 30 10.8 dBm	if *P* ≤ 25 W if 25 W < *P* ≤ 12 000 W if *P* > 12 000 W
Broadcast FM	–16 dBm 10 log *P* – 40 0 dBm	if *P* ≤ 250 W if 250 W < *P* ≤ 10 000 W if *P* > 10 000 W
Broadcast MF/HF	10 log *P* – 20 17 dBm	if *P* ≤ 5 000 W if *P* > 5 000 W

TABLE 10 (*end*)

Service category in accordance with RR Article S1 or equipment type(1), (2)	Maximum permitted spurious emission power in the relevant reference bandwidth (see *further recommends* 4.1) (dBm) with *P*, *PEP* or *X* (W)	
SSB from mobile stations(9)	10 log *PEP* – 13	
Amateur services operating below 30 MHz (including with SSB)(9)	–13 dBm	if *PEP* ≤ 5 W
	10 log *PEP* – 20	if *PEP* > 5 W
Services operating below 30 MHz, except space, radiodetermination, broadcast, those using SSB from mobile stations, and amateur (9)	–13 dBm	if *X* ≤ 50 W
	10 log *X* – 30	if *X* > 50 W
	where:	
		X = *PEP* for SSB modulation
		X = *P* for other modulation
Low power device radio equipment(10)	–26 dBm	if *P* ≤ 0.025 W
	10 log *P* – 10	if 0.025 W < *P* < 0.100 W
EPIRB, ELT, PLB, SART, ship emergency, lifeboat, and survival craft transmitters, land, aeronautical or maritime transmitters when used in emergency	No limit	

P: mean power (W) at the antenna transmission line, in accordance with RR No. S1.158. When burst transmission is used, the mean power *P* and the mean power of any spurious emissions are measured using power averaging over the burst duration.

PEP: peak envelope power (W) at the antenna transmission line, in accordance with RR No. S1.157.

When the term *P* is used, both the power supplied to the antenna transmission line and spurious emissions should be evaluated in terms of mean power and mean power in the reference bandwidth respectively. When the term PEP is used, both the power supplied to the antenna transmission line and spurious emissions should be evaluated in terms of peak envelope power and peak envelope power in the reference bandwidth respectively. However, when measurement of spurious emission in terms of PEP is difficult due to the nature of spurious emission (e.g. Gaussian noise), it is allowed to evaluate both power supplied to the antenna transmission line and spurious emission power in terms of mean power (see Annex 2).

dBc: decibels relative to the unmodulated carrier power of the emission. In the cases which do not have a carrier, for example in some digital modulation schemes where the carrier is not accessible for measurement, the reference level equivalent to dBc is decibels relative to the mean power, *P*.

(1) In some cases of digital modulation and narrow-band high power transmitters for all categories of services, there may be difficulties in meeting limits close to ±250% of the necessary bandwidth.

(2) Use the e.i.r.p. method shown in Annex 2, § 3.3, when it is not practical to access the transition between the transmitter and the antenna transmission line.

(3) Spurious emission limits for all space services are stated in a 4 kHz reference bandwidth.

(4) Amateur earth stations operating below 30 MHz are in the service category Amateur services operating below 30 MHz (including SSB).

(5) For satellites employing more than one transponder, spurious emissions from one transponder may fall on a frequency at which a companion, second transponder is transmitting. In this situation, the level of spurious emission from the first transponder is well exceeded by fundamental emissions of the second transponder. Therefore, limits should not apply to those spurious emissions on a satellite which fall within the bands where there are transmissions from the same satellite into the same service area.

(6) Deep space space station systems, as defined by RR Article S1 as operated beyond 2×10^6 km distance from the Earth, are exempt from spurious emission limits.

(7) Radiodetermination (radar) system spurious emission attenuation shall be determined for radiated emission levels, not at the antenna transmission line.

(8) For analogue television transmissions, the mean power level is defined with a specified video signal modulation. This video signal has to be chosen in such a way that the maximum mean power level (e.g., at the video signal blanking level for negatively modulated television signals) is provided to the antenna transmission line.

(9) All classes of emission using SSB are included in the category SSB.

(10) Low power radio device having a maximum output power of less than 100 mW and intended for short range communication or control purposes (Such equipment is in general exempt from individual licensing.)..

ANNEX 6

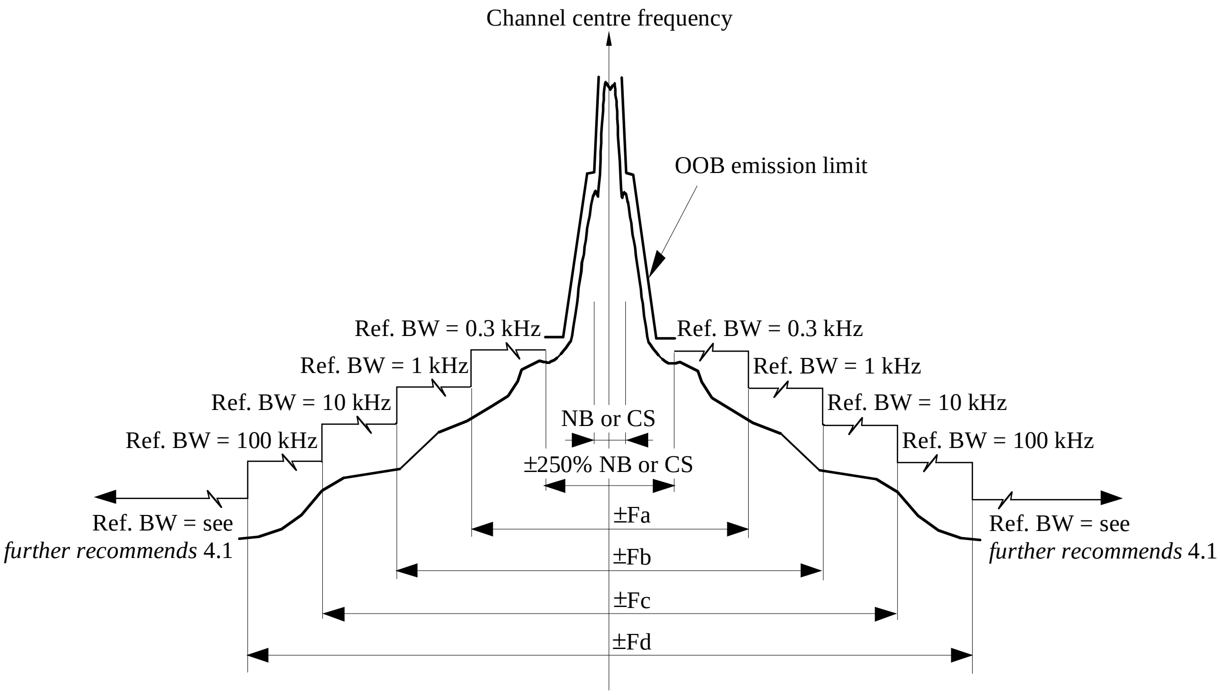
Reference bandwidth for Category B limits
Case of the fixed service

Analogue and digitally modulated radio-relays although generally providing a good spectrum efficiency, are unable to comply with the Category B limits for close-in frequencies due to the wideband noise generated by such systems. It is therefore necessary to provide generic steps of reference bandwidth in order to produce suitable transition area for the spectral density.

The generic reference mask is shown in Fig. 3, with breakpoints function of the channel separation (CS) or the necessary bandwidth (NB) referred to in Table 11.

FIGURE 3

Generic spurious emission mask for Category B fixed service stations
(refer to Table 11)



Note 1 – ±Fd frequency steps are not applicable if lower than 1 GHz.
±Fc frequency steps are not applicable if lower than 30 MHz.
±Fb frequency steps are not applicable if lower than 150 kHz.

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TABLE 11

Generic spurious emission mask for Category B fixed service stations
(refer to Fig. 3)

Fundamental emission frequency	CS (MHz)	Typical symbol frequency (~Mbit/s)	Ref. BW 0.3 kHz	Ref. BW 1 kHz	Ref. BW 10 kHz	Ref. BW 100 kHz
			Fa (MHz)	Fb (MHz)	Fc (MHz)	Fd (MHz)
Below 21.2 GHz (terminal stations)	0.01 ≤ CS < 1	Fs ≅ 0.006 – 0.8	–	–	14	70
	1 ≤ CS < 10	Fs ≅ 0.6 – 8	–	–	28	70
	CS ≥ 10	Fs ~ > 6	–	–	49(1)	70(1)
Below 21.2 GHz (other stations)	0.01 ≤ CS < 1	Fs ≅ 0.006 – 0.8	3.5	7	14	70
	1 ≤ CS < 10	Fs ≅ 0,6 – 8	–	14(1)	28	70
	CS ≥ 10	Fs ~ > 6	–	–	49(1)	70(1)
Above 21.2 GHz (all stations)	1 ≤ CS < 10	Fs ≅ 0,6 – 8	–	–	–	70
	CS ≥ 10	Fs > ~ 6	–	–	–	–

(1) Not applicable for CS which 250% exceed these values.

ANNEX 7

Reference bandwidth for Category B limits
Case of the land mobile service

Narrow-band analogue modulated systems of the land mobile service, with output power higher than 1 W and operated above 30 MHz, and digitally modulated systems of the land mobile service, although generally providing a good spectrum efficiency, are unable to comply with the Category B limits for close-in frequencies due to the wideband noise generated by such systems. It is therefore necessary to provide generic steps of reference bandwidth in order to produce suitable transition area for the spectral density.

The generic reference bandwidth mask is shown in Fig. 4, with breakpoints function of the CS or the NB referred to in Table 12, for frequency below 1 GHz and in Fig. 5, with breakpoints function of the CS or the NB referred to in Table 13, for frequency above 1 GHz.

These masks shall apply to both mobile terminals and base stations.

FIGURE 4

Generic spurious emission mask for Category B land mobile service stations
(refer to Table 12)

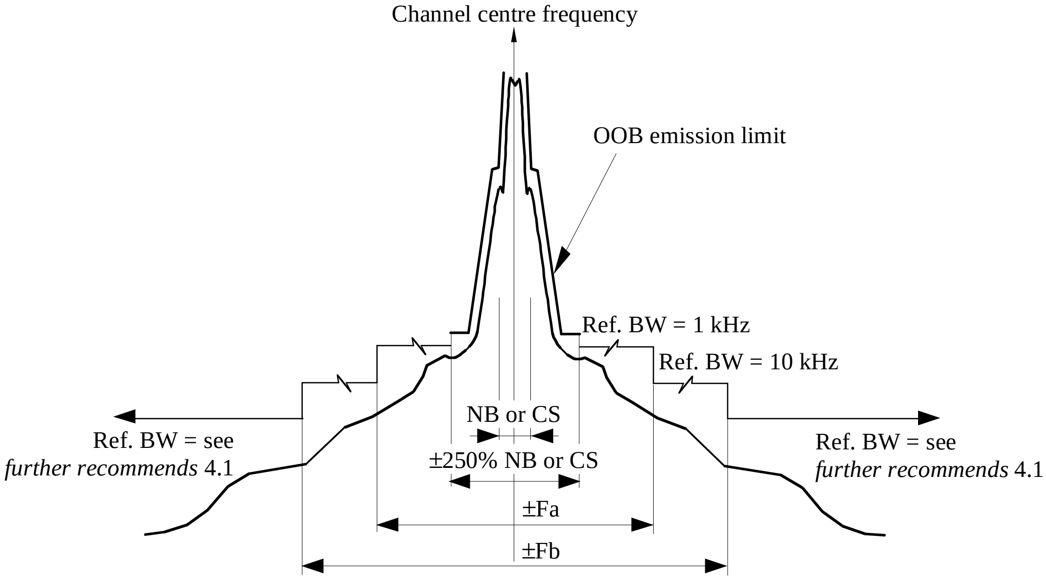

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TABLE 12

Generic spurious emission mask for Category B land mobile service stations
(refer to Fig. 4)

Fa	100 kHz or 4 times NB, whichever is the greater
Fb	500 kHz or 10 times NB, whichever is the greater

FIGURE 5

Generic spurious emission mask for Category B land mobile service stations
(refer to Table 13)

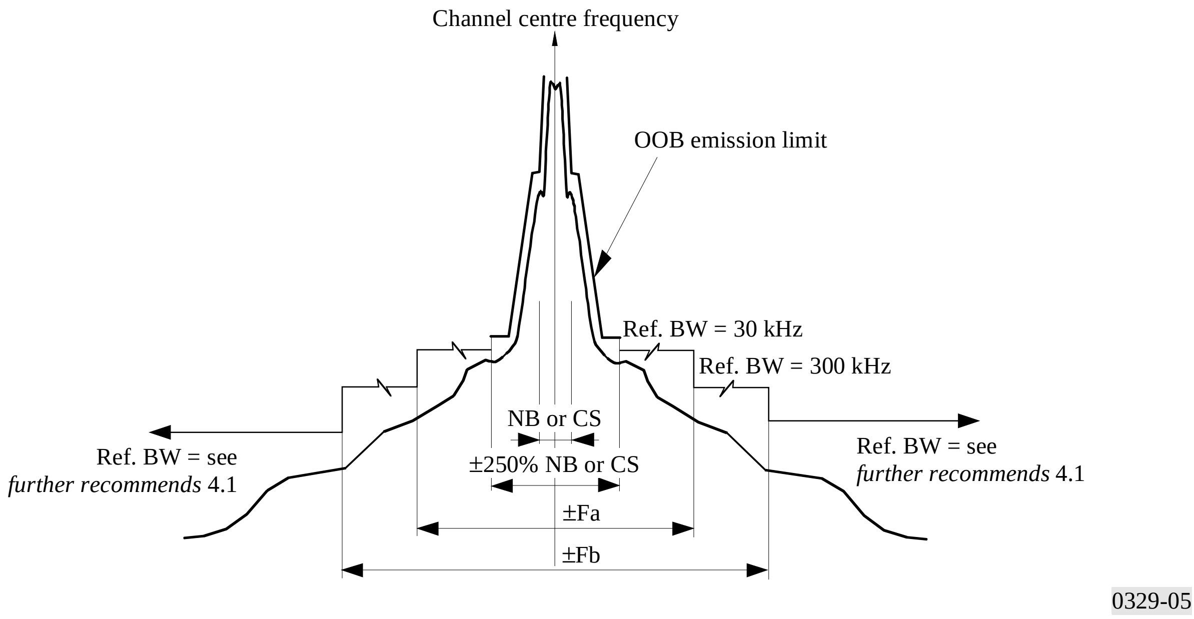

TABLE 13

Generic spurious emission mask for Category B land mobile service stations
(refer to Fig. 5)

Fa	500 kHz or 10 times NB, whichever is the greater
Fb	1 MHz or 12 times NB, whichever is the greater

ANNEX 8

Variation of the boundary between OOB and spurious emissions

1 Introduction

As stated in *further recommends* 1.2 and 2.3 of this Recommendation, the general definition that the spurious domain begins at a 250% spacing needs to be modified for narrow-band and wideband (including multicarrier) systems, and certain other situations. This Annex provides:

– a definition to provide a variation in the 250% boundary;

– a set of guidelines on values of bandwidths across the spectrum at which the general definition needs to be varied; and

– a set of known situations in which additional guidelines are required.

2 Upper and lower thresholds for necessary bandwidth

The definition and use of the upper and lower thresholds for necessary bandwidth are given in § 2.1 and the general guidelines for values of the thresholds are given in § 2.2. At the end of § 2.2 some examples are provided to demonstrate the use of these thresholds in practice.

2.1 Definition and use of upper and lower thresholds for necessary bandwidth

For some narrow-band emissions, it is appropriate to have a lower threshold for the necessary bandwidth to avoid specifying out-of-band and spurious emissions in very narrow bandwidths near to the emission, which will usually be under the control of the same operator. On the other hand, it is necessary to restrict the linear growth of the out-of-band domain versus necessary bandwidth for wideband emissions, in order to restrict the incursion of the out-of-band domain into adjacent bands.

In the normal case of the 250% value, the extremities of the out-of-band domains are only a function of the necessary bandwidth, B_N, as shown in the middle row of Table 14. However, two parameters called lower threshold for necessary bandwidth B_{NL} and upper threshold for necessary bandwidth B_{NU} are defined. As can be seen from Table 14 below, the out-of-band domain is modified by these parameters to achieve the effect required.

Table 14 defines the use of B_{NU} and B_{NL} for narrow-band and wideband systems as given in the left-hand column.

TABLE 14

Type of emission	If necessary bandwidth B_N is	Offset (±) from the centre of the necessary bandwidth for the boundary between OOB and spurious emissions
Narrow-band	$< B_{NL}$	$2.5\ B_{NL}$
Normal	B_{NL} to B_{NU}	$2.5\ B_N$
Wideband	$> B_{NU}$	$B_{NU} + 1.5\ B_N$

It should be noted that for emissions which are asymmetric, Table 14 can apply since the offset is specified based on the centre of the necessary bandwidth. For situations where the boundary is not defined in terms of necessary bandwidth, see § 3.

2.2 Guideline values for B_{NU} and B_{NL} versus frequency range

Guideline values for B_{NU} and B_{NL} are as follows (see Notes 1, 2 and 3):

TABLE 15

Frequency range	B_{NU}	B_{NL}
9 kHz < f_c < 150 kHz	10 kHz	250 Hz
150 kHz < f_c < 30 MHz	100 kHz	4 kHz
30 MHz < f_c < 1 GHz	10 MHz	25 kHz
1 GHz < f_c < 3 GHz	50 MHz	100 kHz
3 GHz < f_c < 10 GHz	100 MHz	100 kHz
10 GHz < f_c < 15 GHz	250 MHz	100 kHz
15 GHz < f_c < 26 GHz	500 MHz	100 kHz
26 GHz < f_c	500 MHz	1 MHz

NOTE 1 – In Table 15, f_c is the centre frequency of the emission. If the assigned frequency band of the emissions extends across a break in the frequency range (i.e. 150 kHz, 30 MHz, etc.) then the values above the break frequency may be used for the whole assignment.

NOTE 2 – For situations in which the above guidelines are not applicable, additional guidelines are provided in § 3.

NOTE 3 – Further studies need to be conducted within the ITU-R to confirm the values of B_{NU} and B_{NL} in Table 15.

Example 1: The actual necessary bandwidth of an emission at 26 MHz is 1.8 kHz. From Table 15, a B_{NL} of 4 kHz applies. From Table 14, the onset of the spurious domain is 2.5×4 kHz = 10 kHz each side of the centre of the necessary bandwidth.

Example 2: The actual necessary bandwidth of an emission at 8 GHz is 200 MHz. From Table 15, a B_{NU} of 100 MHz applies. From Table 14, the onset of the spurious domain is 100 MHz + (1.5×200) MHz = 400 MHz each side of the centre of the necessary bandwidth. Without this factor it would have extended to 2.5×200 MHz = 500 MHz either side.

3 Situations where additional guidelines are required

The above definitions and guidelines are suitable for general application but specific cases where further guidelines are necessary are given in the following sections.

3.1 Situations where the boundary is not defined in terms of necessary bandwidth

Some systems specify OOB emissions relative to channel bandwidth, or channel spacing. These may be used as a substitute for the necessary bandwidth in § 2.

3.2 Particular service types and bands

The values of B_{NU} and B_{NL} are selected to cover most, but not all situations. Rather than set those values at the worst case in each range, it is more realistic to use a more stringent value, and list those cases requiring different values separately. Table 16 shows those cases which have been identified.

TABLE 16

System or service	Frequency range (GHz)	Appropriate value of B_{NU} and B_{NL} (MHz)
FSS	3.4-4.2/5.925-6.725	B_{NU} = 250
FSS	7.25-7.75/7.9-8.4	B_{NU} = 250
FSS	10.7-12.7	B_{NU} = 500

NOTE 1 – Examples of systems or services where a value of B_{NL} would be appropriate have yet to be identified.

3.3 Primary radars in the radiodetermination and other services

According to *further recommends* 2.3 of this Recommendation and RR Appendix S3, the spurious emission region generally begins at a frequency separation equal to 250% of the necessary bandwidth, with exceptions for certain kinds of systems, including those with digital or pulsed modulation. However, it is difficult to apply the general boundary concept of 250% of the necessary bandwidth to primary radar stations in the radiodetermination and other services, such as the meteorological aids service, space research service and the Earth exploration-satellite service.

At the same time, if the necessary bandwidth is required to determine the boundary for primary radars, attention should be drawn to the fact that the calculation of the necessary bandwidth of a radar system in Recommendation ITU-R SM.1138 (which is incorporated in the RR by reference) contains an uncertainty factor of 1 to 10.

The boundary between the out-of-band emission and spurious emission 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:

$$\alpha \times 2.5\, B_N$$

where B_N is the necessary bandwidth and α is a boundary correction factor depending on the total system configuration, in particular the modulation waveform and modulating technique, the radar output device, waveguide components and the antenna type and its frequency dependent characteristics. Alpha (α) will also depend on the way the necessary bandwidth is evaluated.

Assuming that the necessary bandwidth is evaluated as the 20 dB bandwidth, technical information available so far has indicated that, for existing and planned primary radars, the value of α would range from 1 to 10, or more.

From the standpoint of effective use of spectrum, it can be questioned:

– whether the future primary radars will be able to meet an α value closer to 1 or not;

– whether α should be different or not for cases where the boundary between the out-of-band and spurious emission domains will be inside, outside or close to a primary radar allocated band.

Further studies need to be conducted within ITU-R to specify the definition of the necessary bandwidth to be used in the calculation of the boundary and to define the values of α for the different type of radars, missions and platforms.